DEPARTMENT OF STATISTICAL & ACTUARIAL SCIENCES
The University of Western Ontario

EXPLORATORY ANALYSIS OF ACCIDENT/DRINKING TIME SERIES

Prepared by
A.I. McLeod, E. Vingilis, R. Mann and J. Seeley

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CONTENTS

Exploratory Analysis of Motor Vehicle, Trauma, Assault and Alcohol

Introduction

This report is also available in Adobe PDF format on the companion CD under the root directory as `ExploratoryAnalysis.pdf`.

Datasets compiled in SPSS by Jane Seeley, UWO, Faculty of Medicine are analyzed. These datasets provide information of monthly numbers of fatalities, trauma and arrests for impaired driving and assault. Data on traffic counts and annual alcohol consumption is also briefly examined. The datasets examined are listed below.

Code	**Name**	**#records**	**Description**
A	ALCOHOL	11	Annual consumption of alcohol, Canada, 1989 to 1999
B	TRAFFIC	1,680	MTO traffic counts, Ontario, 1992.1 – 1996.12
C	TIRF	434	Traffic Injury Research Foundation, Alcohol Fatalities, Manitoba & Ontario, 1992.1 – 1998.12
D	MTO	26026	MTO highway driver injury and deaths, Ontario, 1992.1 – 1998.12
E	MVA	84	Ontario Trauma Registry, motor vehicle accidents, May 1992 – April 1999
F	OTR	84	Ontario Trauma Registry, all cases, May 1992 – April 1999
G	LPS	8,920	London Police, Arrests for assault & impaired driving, 1992.5 – 1999.5
H	WPS	2,943	Windsor Police, Arrests for assault & impaired driving, 1994.1 – 1998.12
I	FARS	3,956	Fatal Accident Reporting System, Michigan & New York, 1992.5 – 1999.12
J	MISTPOL	164,931	Police Accident Reports, 3 counties, Michigan, 1992.5 – 1999.12

These datasets were supplied in SPSS format. They were then converted into tab-delimited ascii files using Perl. These data files where input to S-Plus (Version 6 for Windows was used). The location of these files on the companion CD is shown in the table below:

File or Directory Location	Description
EXPLORATORYREPORT.PDF	this report
SPSS	SPSS data files
SPSS\DAT	ASCII tab-delimited data files
REPORT	MS Word 2000 files used to create this report
REPORT\RTF	Above files converted to RTF format for compatibility
MISC	S-Plus Chapter
ALCOHOL	S-Plus Chapter
TRAFFIC	S-Plus Chapter
TIRF	S-Plus Chapter
MTO	S-Plus Chapter
MVA	S-Plus Chapter
OTR	S-Plus Chapter
LPS	S-Plus Chapter
WPS	S-Plus Chapter
FARS	S-Plus Chapter
MISTPOL	S-Plus Chapter

In datasets B through J, the `wkgrp` variable is defined as a factor with two levels "`SunWed`" and "`ThuSat`". The "`SunWed`" level corresponds to all counts which occur from 11PM on Sunday until Thursday 3AM (4AM for G,H). The complement of this forms the "`ThuSat`" factor values.

In our analysis tables and figures are usually labelled with numbers. Because the numerous iterations involved in the analysis some figures and/or tables are not shown. For example, you find Figure 1, 2, 4, 5 with no Figure 3. I hope this causes no confusion.

Methods of Exploratory Analysis

Crosstabs Analysis

With crosstabs and frequency analysis we compare the relative proportions of two factors as well as their possible association. For example in MISTPOL we find that 24% of all accidents for which drinking status is reported have `drink=yes` but when we look at drinking status and injury class we find the following percentages for `drink=yes` 74.8%, 49.6%, 48.7%, 21.1% and 20.3% for fatal, incapacitating, non-capacitating, possible-injury and no-injury accidents respectively. Clearly drinking status and accident severity are strongly associated. The Pearson chi-square goodness-of-fit test is used to test statistically the null hypothesis of no association between the factors. In some of the datasets the degrees of freedom is very large so even very unimportant differences could be significant. On the other hand, some of the categories in the tables have sometimes have expectations less than 5 and this means that the chi-square test which is an approximation may be inaccurate. In this case we could resort to bootstrapping could get a more exact answer (this has not yet been done in this report).

With each crosstabs analysis we also examine two additional tables:

(i) `Contribution to the Chi-Square`, `(observed-expected)/√expected`. This table helps to pinpoint the cells that contribute to the Pearson chi-square goodness of fit test.

(ii) `Percentage Error, (observed-expected)/expected`. This table helps to pinpoint that may be of interest too.

Time Series Plots, Loess Smoothing, Mann-Kendall Trend Tests

Trellis graphics were introduced by Cleveland (1993). The theory of trellis graphics is further developed in Becker et. al (1996). Trellis graphics, available in S-Plus, represent one of the biggest advances in multivariable data visualization in the last ten years.

Trellis plots are coordinated multi-panel displays of data. Three possible choices for the scales used for the panel axes are:

(i) same scale
(ii) sliced scale
(iii) independent scale

Each method is useful but in particular situations. If the data in each panel vary over roughly the same region then using (i) small scale is a good idea. In this case accurate visual comparisons can quickly be made between panels. However if the data vary across quite different scales, as in the case of fatality rates by drinking status, then using (i) may spoil the resolution on either or both panels. If the resolution is degraded like this it is better to use (ii) or (iii). If the variability in the data is similar in different panels then sliced scaling (ii) is a good idea. Sliced scaling means that the number of data units per centimeter on the graph is kept the same in all panels. For example one panel may have data varying between from 50 to 150 and another panel 450 to 550. Sliced scaling allows for good data resolution and allows one to compare the variability across panels. However with sliced scaling you must pay closer attention to the indicated axes tick lables to interpret which panel is larger whereas with (i) it is visually obvious. If the variability is very different between panels, as for example is the case when the MISTPOL accidents are compared across injury class then in order to achieve good data resolution it may be necessary to use method (iii) independent scaling. With independent scaling, the scaling is chosen separately for each panel in order that the data region fills up the space available in each panel. With independent scaling, it is crucial that the indicated axes tick marks be carefully examined when interpreting the display.

Data resolution can also be degraded by outliers. It is very important to know about outliers since they may be of great interest in their own right but outliers can also squish the bulk of the data into a small region. To overcome this difficulty we can use a monotonic transformation such as logarithms. This is much preferable to allowing the scale to change as is sometimes seen in scientific journals.

The importance of the choice of aspect-ratio for data visualization was extensively researched by Cleveland and is discussed in his books Cleveland (1993, 1994) and also in our **Appendix 1**. In most of the examples we have chosen to use an aspect-ratio of one since this seems to provide a reasonable comprise to visualizing the trend (which would often require a more extreme aspect-ratio much larger than one if banking to 45° is used) and visualizing the time series itself (which typically implies an aspect-ratio less than one if banking to 45° is used).

The robust loess locally linear smoother, introduced by Cleveland and discussed in his books (Cleveland, 1993, 1994) is used for trend assessment. The application of robust loess to trend assessment of environmental time series was discussed by McLeod et al. (1990). A brief overview of loess is given in **Appendix 2**.

The Mann-Kendall trend test (Mann, 1945), described in **Appendix 3** in more detail, is used to assess the statistical significance of monotonic trends. This test consists of computing the Kendall rank correlation of the time series with the observation number. When seasonality is present we can use the Seasonal-Mann-Kendall test of Hirsch et al. (1982) to test for long-term monotonic trend. We can also apply the regular Mann-Kendall trend test to the STL deseasonalized data. The exact algorithm of Panneton & Robillard (1972a, 1972b) is used to evaluate the significance level of the Mann-Kendall test. The significance level of the Seasonal Mann-Kendall test is evaluated using a normal approximation. It should be noted that this trend test is of limited relevance since the major focus of this investigation is not monotonic trend but rather on the possible changes in trend that have occurred over the period 1992 to 1999. For this reason, the loess analysis, which is the visualization approach, is expected to be more useful.

STL Analysis

The STL or seasonal-trend loess decomposition (Cleveland et al., 1991; Cleveland, 1993) is used to examine the trend and seasonal pattern in various time series. STL is based on loess smoothers and provides an excellent tool for the estimation of a dynamic and changing seasonal component. STL provides the following decomposition of the data,

`DATA = TREND + SEASONAL + REMAINDER`

Additional components may also be added to this model to remove other sources of variation.

Given an STL decomposition the deseasonalized series is defined by,

`DESEASONALIZED SERIES = DATA – SEASONAL`

The deasonalized series may be tested for trend using the Mann-Kendall trend test.

For the STL analysis eight graphical displays were examined:
(i) SLT decomposition
(ii) Monthplot display of the `SEASONAL` component.
(iii) Time series plot of deseasonalized series
(iv) Autocorrelation plot of deseasonalized series
(v) Autocorrelation plots of the `REMAINDER` term
(vi) Normal probability plot of the `REMAINDER` term
(vii) Residual-Fit or RF-Spread Plot
(viii) Spread-Location or SL-Plot

The basic STL graphical display is comprised of four panels showing a time series trace plot of the original data along with its decomposition into three or more components. The scales in each panel are independent to permit maximum graphical resolution but a bar at the right side of each panel provides an indication of the scaling in each panel.

The monthplot (Cleveland & Terpenning, 1984; Cleveland, 1993) of the `SEASONAL` component is used for visualizing the seasonal effects and how they evolve over time. The monthplot shows the mean level of the seasonal component for each month as a horizontal bar. A time series trace shows the fluctuations over time around this horizontal bar. In this way we can see how the seasonal component changes over time.

The `REMAINDER` term is like a residual component and should not contain any significant trend or seasonality. In practice the autocorrelation present in the `REMAINDER` term is close to zero for lower order lags. Also in practice the `REMAINDER` term is often normally distributed but again this is not required. However if the `REMAINDER` term is normally distributed and is not autocorrelated then the STL decomposition extracts all information in the data in the sense that what is left over is informationless white noise. STL like most other seasonal adjustments methods overcorrects for seasonality in the sense that the spectral density of the remainder process has a deficiency at the seasonal frequency and this implies that one can expect a small negative autocorrelation at lag 12 in the `REMAINDER` term. It is thus information to look at autocorrelation plots of the `REMAINDER` term. Likewise it is also information to examine a normal probability plot of the residuals. Outliers are always of interest. They can point to possible interesting new phenomenon. The normal probability plot display also includes 0.5% significance limits given by Royston (1993), the W-test for normality (Royston, 1982) and the skewness test for normality.

The RF-Spread Plot (Cleveland, 1993) enables one to visualize how much of the variation in the data is explained by the model. This has traditionally been done using the coefficient of determination, R^2, but the RF-Spread Plot is more informative. The RF-Spread Plot is a trellis display comprised of two Quantile Plots. Given some data $X_1, \ldots, X_n$, let $X_{(1)}, \ldots, X_{(n)}$ denote the data re-arranged in ascending order so that $X_{(1)} \le X_{(2)} \le \ldots \le X_{(n)}$, then the Quantile Plot is simply the scatterplot of $X_{(1)}$ vs. f_i where $f_I = (i-1/2)/n$. This is quite similar to the empirical distribution function plot but it is quite different in both construction and spirit. The first panel of the RF-Spread Plot shows the Quantile Plot for the fitted values with the mean subtracted out and the second panel shows on the same scale the Quantile Plot for the remainder or residual. By comparing the panels, we can see at a glance the amount of variation accounted for by our model.

The SL-Plot (Cleveland, 1993) has been further developed by McLeod (1996, 1999). The purpose of the SL-Plot is to detect montone spread. Monotone spread occurs when the variability of the data increases systematically with the location or level of the data. Montone spread can usually be corrected by a suitable power transformation such as a log or square root or reciprocal. In modelling situations montone spread sometimes indicates an important inadequacy. Also if montone spread is present, data visualization can often be improved by making a suitable power transformation.

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A. Alcohol Dataset

Overview and Summary
1989 to 1999 (annual)

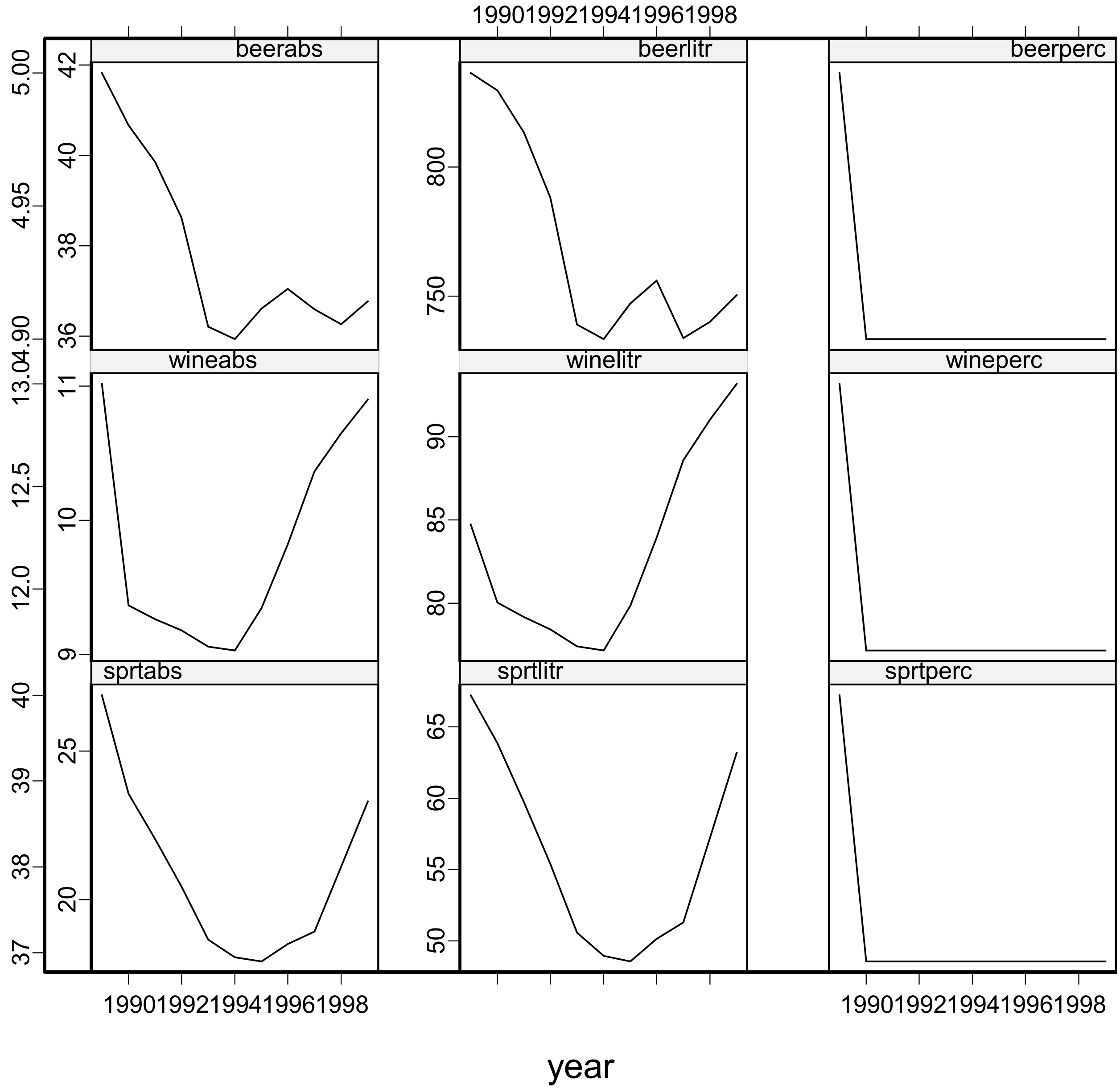
Source: *Volume of sales of alcoholic beverages and per capita 15 years and over*
The numbers are the volume of sales in thousands of litres.
Population is not included.

	year	sprtlitr	sprtperc	sprtabs	winelitr	wineperc	wineabs	beerlitr	beerperc	beerabs
1	1989	67227	40.0	26890.80	84741	13.0	11016.330	836569	5.0	41828.45
2	1990	63866	36.9	23566.55	80051	11.7	9365.967	829824	4.9	40661.38
3	1991	59700	36.9	22029.30	79166	11.7	9262.422	813304	4.9	39851.90
4	1992	55389	36.9	20438.54	78442	11.7	9177.714	788218	4.9	38622.68
5	1993	50565	36.9	18658.48	77417	11.7	9057.789	738902	4.9	36206.20
6	1994	48955	36.9	18064.40	77174	11.7	9029.358	733285	4.9	35930.96
7	1995	48551	36.9	17915.32	79861	11.7	9343.737	747182	4.9	36611.92
8	1996	50131	36.9	18498.34	83946	11.7	9821.682	756023	4.9	37045.13
9	1997	51270	36.9	18918.63	88591	11.7	10365.147	733674	4.9	36596.19
10	1998	57223	36.9	21115.87	91019	11.7	10649.220	740017	4.9	36260.83
11	1999	63173	36.9	23310.84	93168	11.7	10900.660	750435	4.9	36771.32

Variables:
-sprtlitr, winelitr, and beerlitr
are just the total volumes
-sprtperc, wineperc, and beerperc
are the estimated % of alcohol for each category
-sprtabs, wineabs, and beerabs
are the volumes multiplied by the % alcohol to calculate
the volume of sales in thousands of litres of absolute alcohol
(the standard without the population calculation)

Conclusions:
consumption of beer has decreased
consumption of spirit alcohol decreased and then increased
consumption of wine decreased and increased back to 1989 levels
total consumption of alcohol has decreased and is now increasing again

Consumption of Spirits, Wine and Beer



litr and abs are in millions of litres, perc are percentage

B. Traffic Dataset

Overview and Summary

Traffic counts for Ontario, January 1992 to December 1996. `TRAFFIC.SAV` has 420 records corresponding to each weekday for 5 years (5×12×7=420). The weekday data was aggregated to the level of `wkgrp` using the definition that `SunWed` is comprised of all counts starting on Sun at 11PM and running through to Thursday 3AM and the rest is in the `ThuSat` group. Note that there is no data for 1997 and 1998.

A regression analysis of the log counts on the variables `wkgrp, hour, month` and `year` accounts for 96.4% of the variation. However `year` is still very significant even when it is entered last into the regression. This suggests that it would be very desirable to obtain data for 1997 and 1998.

The STL visualization indicates that the effect of the missing values in the years 1992 and 1996 is quite large (Figure STL).

The traffic counts are split very nearly evenly between the ThuSat and SunWed weekgroups. However there is significant variation in traffic counts over the other variables `hour, month` and `year`.

With respect to `hour` and `month` we show that the proportions remain relatively stable over the years and so we create a proxy for the traffic counts using the fitted values from the regression for the year 1994.

Instead of this proxy it would be very desirable to get the complete data from 1992 to 1998.

If it can be assumed that the annual total traffic counts are relatively constant from year to year then the proxy variable we have defined is adequate. Furthermore since the regression of log counts on the variables `wkgrp, hour, month` and `year` accounts for 96.4% of the variation it would be expected that the proxy variable will not be needed in developing statistical models for traffic fatalities since it is so closely related to the other variables.

Analysis: Regression

We investigated the possible use of a regression model to fill in the missing data. It was found that a log transformation of the counts was helpful in reducing skewness of the residuals and reducing monotone spread. The regression was fit using the year variable last and is summarized below:

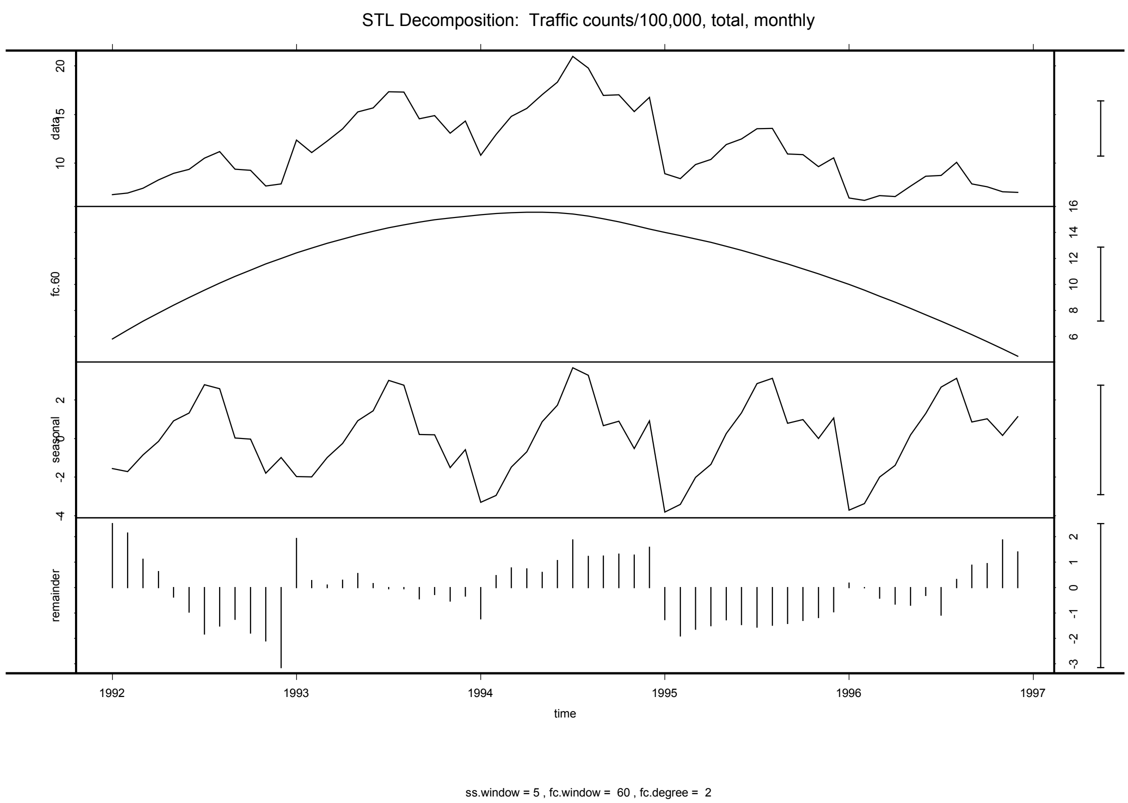
```
> lm.traffic4_lm(log(counts)~hour+wkgrp+month+year, data=traffic.df)
Residual standard error: 0.1071 on 460 degrees of freedom
Multiple R-Squared: 0.964

> anova(lm.traffic4)
Analysis of Variance Table

Response: log(counts)

Terms added sequentially (first to last)
           Df Sum of Sq  Mean Sq  F Value       Pr(F)
     hour   3  93.16887 31.05629 2706.031 0.000000000
    wkgrp   1   0.12913  0.12913   11.251 0.000861592
    month  11   9.20136  0.83649   72.886 0.000000000
     year   4  39.05929  9.76482  850.840 0.000000000
Residuals 460   5.27928  0.01148
```

Notice the fit is quite good in terms of the R-squared but that the year variable is quite important. The variation over years is summarized below in the STL analysis and in the crosstab analysis.

Seasonal-Trend Loess Analysis

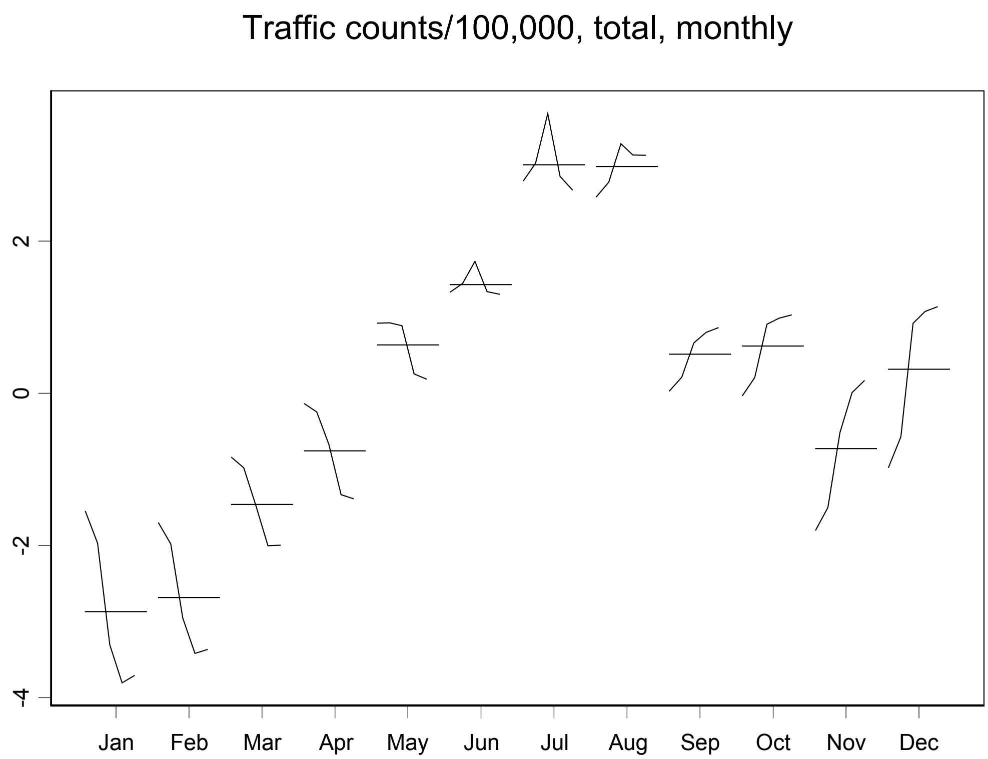
The seasonal-trend analysis shows the strong seasonal period and remarkable variation in the traffic counts. I now think the low values for 1992 and 1996 are due to the missing stations.

Figure STL



Monthplot Analysis

There are no surprises here. We would expect July and August to have the largest values.



Crosstab Analysis: year

```
> crosstabs(counts~year, data=traffic.df)
Call:
crosstabs(counts ~ year, data = traffic.df)
69372946 cases in table
+-------+
|N      |
|N/Total|
+-------+
year   |
-------+--------+
1992   |10371415|
       |0.15    |
-------+--------+
1993   |17176609|
       |0.25    |
-------+--------+
1994   |19633001|
       |0.28    |
-------+--------+
1995   |13124602|
       |0.19    |
-------+--------+
1996   | 9067319|
       |0.13    |
-------+--------+
```

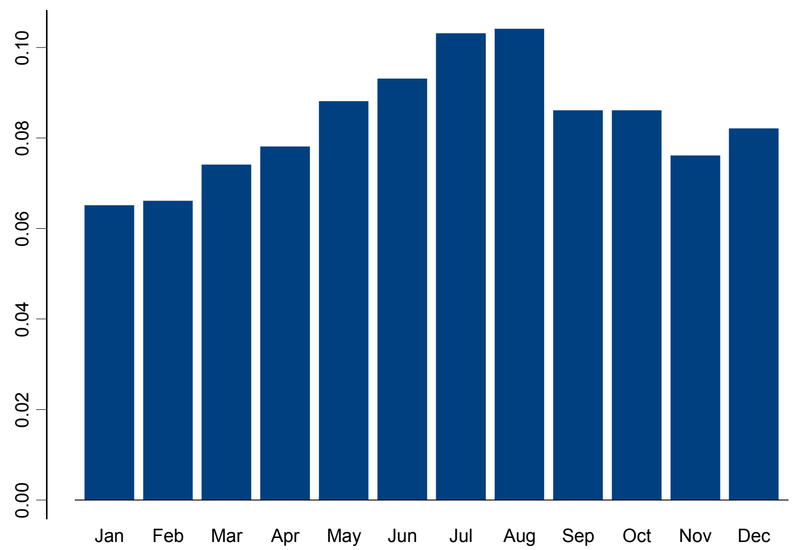
Notice that that there was approximately twice as much traffic in 1994 than in 1992 and 1996. This indicates traffic intensities can vary significantly from year to year. However it may be that relationship between traffic intensities and the covariates wkgrp, hour and month remains linear. In this case a proxy variable for traffic intensity may be useful. This is investigated in the crosstabs analysis in the next section.

Crosstab Analysis: wkgrp, hour and month

The analysis below suggests that the split between SunWed and ThuSat is very close to 50% over the years. Because of the large sample size the factors are not independent but the percentage error between observed and expected under the independence assumption is very small.

A similar story holds for the crosstabs analysis of year with the hour groups. In this case the split over the hour groups “11PM”, “12AM”, “1AM”, “2AM” is very close to 0.42, 0.27, 0.18, 0.13 over all the years.

The crosstabs analysis of year and month does indicate some association between the factors but again it is quite small. The traffic intensity as a percentage of the annual totals are shown in the plot below.



We conclude from the analysis that a proxy variable for the traffic intensity developed from the regression model may be useful.

```
> crosstabs(counts~year+hour, data=traffic.df)
Call:
crosstabs(counts ~ year + hour, data = traffic.df)
69372946 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
year    |hour
        |11PM    |12AM    |1AM     |2AM    |RowTotl |
--------+--------+--------+--------+-------+--------+
1992    |4195735 |2796368 |1978224 |1401088|10371415|
        |0.405   |0.270   |0.191   |0.135  |0.15    |
        |0.145   |0.147   |0.155   |0.160  |        |
        |0.060   |0.040   |0.029   |0.020  |        |
--------+--------+--------+--------+-------+--------+
1993    |7181935 |4743985 |3146447 |2104242|17176609|
        |0.418   |0.276   |0.183   |0.123  |0.25    |
        |0.249   |0.249   |0.247   |0.241  |        |
        |0.104   |0.068   |0.045   |0.030  |        |
--------+--------+--------+--------+-------+--------+
1994    |8228684 |5431360 |3579725 |2393232|19633001|
        |0.419   |0.277   |0.182   |0.122  |0.28    |
        |0.285   |0.285   |0.281   |0.274  |        |
        |0.119   |0.078   |0.052   |0.034  |        |
--------+--------+--------+--------+-------+--------+
1995    |5449697 |3598054 |2409970 |1666881|13124602|
        |0.415   |0.274   |0.184   |0.127  |0.19    |
        |0.189   |0.189   |0.189   |0.191  |        |
        |0.079   |0.052   |0.035   |0.024  |        |
--------+--------+--------+--------+-------+--------+
1996    |3789281 |2478192 |1621661 |1178185|9067319 |
        |0.418   |0.273   |0.179   |0.130  |0.13    |
        |0.131   |0.130   |0.127   |0.135  |        |
        |0.055   |0.036   |0.023   |0.017  |        |
--------+--------+--------+--------+-------+--------+
ColTotal|28845332|19047959|12736027|8743628|69372946|
        |0.42    |0.27    |0.18    |0.13   |        |
--------+--------+--------+--------+-------+--------+
Test for independence of all factors
        Chi^2 = 21954.57 d.f.= 12 (p=0)
        Yates' correction not used
> get.crosstabs.percenterror(counts~year+hour)
     [,1] [,2] [,3] [,4]
[1,]   -3   -2    4    7
[2,]    1    1    0   -3
[3,]    1    1   -1   -3
[4,]    0    0    0    1
[5,]    1    0   -3    3
```

```
> crosstabs(counts~year+wkgrp, data=traffic.df)
Call:
crosstabs(counts ~ year + wkgrp, data = traffic.df)
69372946 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
year    |wkgrp
        |SunWed  |ThuSat  |RowTotal|
--------+--------+--------+--------+
1992    |5242486 |5128929 |10371415|
        |0.505   |0.495   |0.15    |
        |0.152   |0.147   |        |
        |0.076   |0.074   |        |
--------+--------+--------+--------+
1993    |8317516 |8859093 |17176609|
        |0.484   |0.516   |0.25    |
        |0.241   |0.254   |        |
        |0.120   |0.128   |        |
--------+--------+--------+--------+
1994    |9683588 |9949413 |19633001|
        |0.493   |0.507   |0.28    |
        |0.280   |0.286   |        |
        |0.140   |0.143   |        |
--------+--------+--------+--------+
1995    |6618902 |6505700 |13124602|
        |0.504   |0.496   |0.19    |
        |0.192   |0.187   |        |
        |0.095   |0.094   |        |
--------+--------+--------+--------+
1996    |4680669 |4386650 |9067319 |
        |0.516   |0.484   |0.13    |
        |0.136   |0.126   |        |
        |0.067   |0.063   |        |
--------+--------+--------+--------+
ColTotal|34543161|34829785|69372946|
        |0.5     |0.5     |        |
--------+--------+--------+--------+
Test for independence of all factors
        Chi^2 = 31245.03 d.f.= 4 (p=0)
        Yates' correction not used

> get.crosstabs.percenterror(counts~year+wkgrp)
     [,1] [,2]
[1,]    2   -2
[2,]   -3    3
[3,]   -1    1
[4,]    1   -1
[5,]    4   -4
```

```
               > crosstabs(counts~year+month, data=traffic.df)
Call:
crosstabs(counts ~ year + month, data = traffic.df)
69372946 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
year   |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
1992   | 678080| 694308| 743627| 828565| 896208| 936492|1052864|1118057| 940336| 928126| 767040| 787712|10371415|
       |0.0654 |0.0669 |0.0717 |0.0799 |0.0864 |0.0903 |0.1015 |0.1078 |0.0907 |0.0895 |0.0740 |0.0760 |0.15    |
       |0.1495 |0.1522 |0.1456 |0.1522 |0.1473 |0.1452 |0.1480 |0.1554 |0.1573 |0.1555 |0.1453 |0.1393 |        |
       |0.0098 |0.0100 |0.0107 |0.0119 |0.0129 |0.0135 |0.0152 |0.0161 |0.0136 |0.0134 |0.0111 |0.0114 |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
1993   |1237462|1109775|1227746|1353591|1527770|1568314|1732532|1731086|1455842|1490490|1308602|1433399|17176609|
       |0.0720 |0.0646 |0.0715 |0.0788 |0.0889 |0.0913 |0.1009 |0.1008 |0.0848 |0.0868 |0.0762 |0.0835 |0.25    |
       |0.2727 |0.2432 |0.2403 |0.2486 |0.2511 |0.2431 |0.2435 |0.2407 |0.2436 |0.2498 |0.2478 |0.2535 |        |
       |0.0178 |0.0160 |0.0177 |0.0195 |0.0220 |0.0226 |0.0250 |0.0250 |0.0210 |0.0215 |0.0189 |0.0207 |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
1994   |1082227|1296710|1480860|1562039|1704066|1830829|2096297|1975855|1695305|1702239|1529692|1676882|19633001|
       |0.0551 |0.0660 |0.0754 |0.0796 |0.0868 |0.0933 |0.1068 |0.1006 |0.0863 |0.0867 |0.0779 |0.0854 |0.28    |
       |0.2385 |0.2842 |0.2899 |0.2869 |0.2800 |0.2838 |0.2947 |0.2747 |0.2837 |0.2852 |0.2897 |0.2966 |        |
       |0.0156 |0.0187 |0.0213 |0.0225 |0.0246 |0.0264 |0.0302 |0.0285 |0.0244 |0.0245 |0.0221 |0.0242 |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
1995   | 893728| 843964| 986904|1040057|1192341|1248936|1356326|1357078|1096141|1089316| 965416|1054395|13124602|
       |0.0681 |0.0643 |0.0752 |0.0792 |0.0908 |0.0952 |0.1033 |0.1034 |0.0835 |0.0830 |0.0736 |0.0803 |0.19    |
       |0.1970 |0.1850 |0.1932 |0.1910 |0.1960 |0.1936 |0.1907 |0.1887 |0.1834 |0.1825 |0.1828 |0.1865 |        |
       |0.0129 |0.0122 |0.0142 |0.0150 |0.0172 |0.0180 |0.0196 |0.0196 |0.0158 |0.0157 |0.0139 |0.0152 |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
1996   | 645575| 617684| 669201| 660020| 764507| 865842| 875961|1010758| 788548| 757592| 709502| 702129|9067319 |
       |0.0712 |0.0681 |0.0738 |0.0728 |0.0843 |0.0955 |0.0966 |0.1115 |0.0870 |0.0836 |0.0782 |0.0774 |0.13    |
       |0.1423 |0.1354 |0.1310 |0.1212 |0.1256 |0.1342 |0.1231 |0.1405 |0.1319 |0.1269 |0.1344 |0.1242 |        |
       |0.0093 |0.0089 |0.0096 |0.0095 |0.0110 |0.0125 |0.0126 |0.0146 |0.0114 |0.0109 |0.0102 |0.0101 |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
ColTotl|4537072|4562441|5108338|5444272|6084892|6450413|7113980|7192834|5976172|5967763|5280252|5654517|69372946|
       |0.065  |0.066  |0.074  |0.078  |0.088  |0.093  |0.103  |0.104  |0.086  |0.086  |0.076  |0.082  |        |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+--------+
Test for independence of all factors
       Chi^2 = 103146.1 d.f.= 44 (p=0)
       Yates' correction not used
get.crosstabs.percenterror(counts ~ year + month, d
ata = traffic.df)
> get.crosstabs.percenterror(counts~year+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]    0    2   -3    2   -1   -3   -1    4    5     4    -3    -7
[2,]   10   -2   -3    0    1   -2   -2   -3   -2     1     0     2
[3,]  -16    0    2    1   -1    0    4   -3    0     1     2     5
[4,]    4   -2    2    1    4    2    1    0   -3    -4    -3    -1
               [5,]    9    4    0   -7   -4    3   -6    8    1    -3     3    -5
```

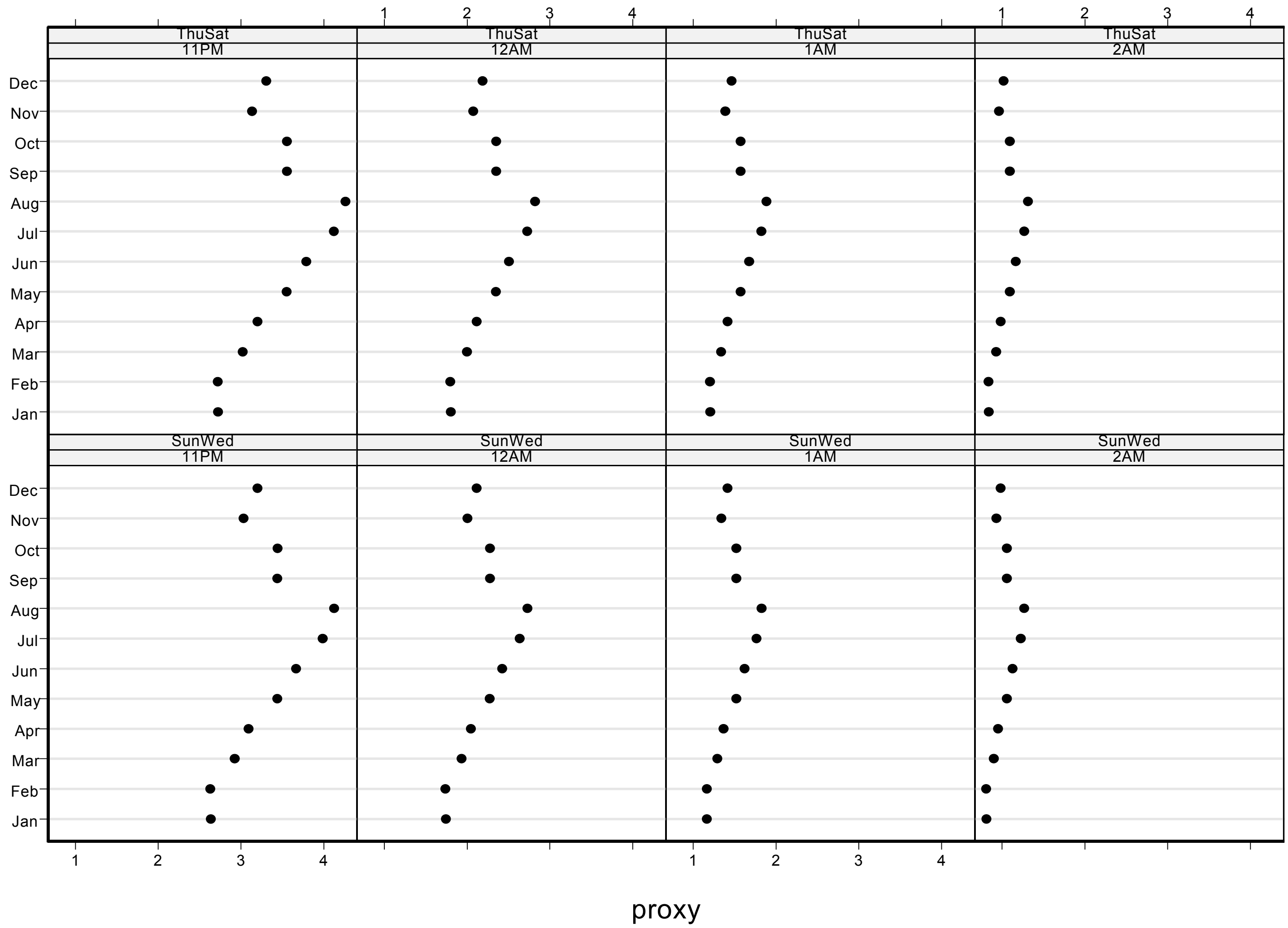
Proxy Variable

Since no data is available for 1997 and 1998 we have decided to use a proxy variable for the traffic counts. Alternatively if traffic could be predicted for 1997 and 1998 we could use the predicted traffic intensities to supplement the original data. However since there is a great deal of variation and no simple trend present, we have decided to replace the original data with a proxy.

The proxy variable we use is developed from a regression of the log of the traffic counts regressed on wkgrp, hour, month and year. The expected traffic count for a given set of covariates is then obtained by the transformation,

$$Y = \exp(y+\sigma^2/2),$$

where y is the predicted log count, σ^2 is the residual variance and Y is estimated expected traffic count. For the proxy we take year=1994 and we use $Y/10^5$. The proxy values are visualized using a dotchart below.


ThuSat
11PM
ThuSat
12AM
ThuSat
1AM
ThuSat
2AM
SunWed
11PM
SunWed
12AM
SunWed
1AM
SunWed
2AM
Dec
Nov
Oct
Sep
Aug
Jul
Jun
May
Apr
Mar
Feb
Jan
1
2
3
4
proxy

C. TIRF Dataset - Introduction

Introduction

TIRF, Traffic Injury Research Foundation, provided this data on fatal car accidents in Manitoba and Ontario from January 1,1992 to December 31, 1998. This data is for automobile driver deaths only. The data is analyzed in two parts. First the **Late Night Subset** and second **TIRF – All Times**

Late Night Subset

The Late Night Subset of the TIRF data set contains 434 records.
The variables of interest in original data set are shown in the table below..

Variables of interest:

`drink`	alcohol consumption, factor: `yes, no, unknown`
`year`	ordered factor, 7 levels:1992 to 1998
`month`	ordered factor, 12 levels: January to December
`wkgrp`	ordered factors of week group, 2 levels: SunWed, ThuSat
`hour`	ordered factors, 5 levels: 11PM, 12AM, 1AM, 2AM, 3AM
`prov`	factor: Manitoba, Ontario

In the SPSS file the variable is `bacpos` and the variable `drink` in our analysis is definied by:

```
drink = yes if bacpos = 7777 or 8888 or 1
drink = no if bacpos= -7 or 0
drink = unknown, otherise
```

Missing Data:

There are 434 cases in the original SPSS file but case 343 is missing date and hour so it was deleted. Also hour was missing in additional 33 cases so these records were also deleted. This leaves 400 cases for our analysis. In the remaining 400 cases, there are 44 cases with `drink=unknown` in Ontario and 2 cases in Manitoba. Of the 400 cases, there are 347 in Ontario and 53 in Manitoba.

TIRF – All Hours (TIRFALL)

There were 2234 cases in the original SPSS datafile. Record 1765 was incomplete with respect to `moyr` so this record was omitted. Also record 1990 missing crsw (day of week).

An ordered factor hour was created defined by the hour in which the accident occurred. There are 24 levels to this ordered factor. All accidents occurring from 0000 to 0059 were put in 12PM, 0100 to 0159 in 1AM, etc.

Variables of interest:

`drink`	alcohol consumption, factor: `yes, no, unknown`
`year`	ordered factor, 7 levels:1992 to 1998
`month`	ordered factor, 12 levels: January to December
`wkgrp`	ordered factors of week group, 2 levels: SunWed, ThuSat
`hour`	ordered factors, 24 levels: 12PM, 1AM, …, 11PM.
`prov`	factor: Manitoba, Ontario

Missing Variables

There are 2233 cases in the S-Plus dataframe. We see there are 33 cases were `hour` is missing and 342 cases where `drink` is `unknown`.

```
> dim(tirfall.df)
[1] 2233   10
> sum(tirfall.df$drink=="unknown")
[1] 342
> sum(is.na(tirfall.df$hour))
[1] 33
```

C. TIRF Late-Night Subset - Crosstabs

Summary

TIRF data set contains 434 observations of car fatality accidents from January 1992 to December 1998 in Ontario (376) and Manitoba (58). Each case represents one driver fatality. After deleting all cases where the hour variable was missing we were left with 400 cases. Of these 400 cases, 347 were in Ontario and 53 were in Manitoba.

DRINK-HOUR. In Ontario, about 70% of fatalities involve alcohol. Although the association between alcohol fatalities and hour is not statistically significant (p=18%) we see that there is a slight increase in alcohol usage associated with deaths at 2AM (11% extra) and 3AM (13% extra). In Manitoba about 77% of fatalities are alcohol associated. Again the association with hour does not appear to be statistically significant but there is a 15% excess of alcohol fatalities in the 3AM window.

WKGRP. The car fatality accidents in SunWed group count for 62% of total accidents while 38% in ThuSat group. If accidents were uniformly distributed over the weekdays then the expected number of accidents in the SunWed group would be (233+142)×4/7 = 214.28 with a binomial standard deviation of 9.583. So the departure from uniformity is just significant at the 5% level on a two-sided test.

DRINK-WKGRP are associated in Ontario but probably not in Manitoba. Among the accidents, in Ontario, in SunWed group 75% of them were owing to driving after drinking while 63% of the accidents in ThuSat group were owing to drinking. It implies that drunken driving more likely happened in Sunday through Wednesday.

DRINK-MONTH are not associated. There are more car fatality accidents in warm season than in cold season. This is also true in alcohol level.

DRINK-YEAR might be associated. The annual car fatality accidents fluctuated over years. There are more accidents in 1994 (17.5%) and fewest in 1998 (7.6%). The percentage of accidents with drink=yes for 1998 is relatively high in both Ontario and Manitoba. Figure 0 shows there is considerable variation here. One explanation is that with the increased use of seatbelts, daytime running lights and airbags only very serious crashes with often involve alcohol result in fatalities.

HOUR-WKGRP are likely unassociated. There are 25% more fatalities in the ThuSat-11PM slot and 28% fewer in the ThuSat-3AM slot than expected under the assumption of independence but the difference is not statistically significant.

HOUR-MONTH are not likely associated. However, in Ontario, there are 231% more fatalities than expected in the 2AM-April slot than would be expected under independence.

HOUR-YEAR are associated in Ontario but probably not in Manitoba. Hour and year are associated. There seems to be an excess of fatalities in the 2AM-1998 and 3AM-1997 windows (97% and 110% respectively).

WKGRP-MONTH are associated in Ontario. In Ontario, there are increased fatalities in ThuSat-Feb (65%) and ThuSat-Dec (58%) and decreased fatalities in ThuSat-May (42%) and ThuSat-Nov (56%).

WKGRP-YEAR are not associated.

Frequency Analysis of Drink

In Ontario out of a total of 375 cases, there are 44 cases where `drink=unknown` and only 2 cases in Manitoba. Thus in Ontario there remain 331 cases.

```
>crosstabs(~drink, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink, data = tirf.df, subset = province == "Ontario",
       na.action = na.exclude)
375 cases in table
+-------+
|N      |
|N/Total|
+-------+
drink  |
-------+-------+
unknown| 44    |
       |0.12   |
-------+-------+
no     |107    |
       |0.29   |
-------+-------+
yes    |224    |
       |0.6    |
-------+-------+
> crosstabs(~drink, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink, data = tirf.df, subset = province == "Manitoba", na.action
= na.exclude)
58 cases in table
+-------+
|N      |
|N/Total|
+-------+
drink  |
-------+-------+
unknown| 2     |
       |0.034  |
-------+-------+
no     |12     |
       |0.21   |
-------+-------+
yes    |44     |
       |0.76   |
-------+-------+
```

Drink and hour are independent

Ontario

About 70% of fatalities involve alcohol. Although the association between alcohol fatalities and hour is not statistically significant (p=18%) we see that there is a slight increase in alcohol usage associated with deaths at 2AM (11% extra) and 3AM (13% extra).

```
> crosstabs(~drink+hour, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ drink + hour, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
316 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
no     |27     |18     |27     |14     |10     |96     |
       |0.281  |0.188  |0.281  |0.146  |0.104  |0.3    |
       |0.370  |0.305  |0.360  |0.226  |0.213  |       |
       |0.085  |0.057  |0.085  |0.044  |0.032  |       |
-------+-------+-------+-------+-------+-------+-------+
yes    |46     |41     |48     |48     |37     |220    |
       |0.209  |0.186  |0.218  |0.218  |0.168  |0.7    |
       |0.630  |0.695  |0.640  |0.774  |0.787  |       |
       |0.146  |0.130  |0.152  |0.152  |0.117  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|73     |59     |75     |62     |47     |316    |
       |0.23   |0.19   |0.24   |0.20   |0.15   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 6.251495 d.f.= 4 (p=0.1811372)
    Yates' correction not used
> get.crosstabs.percenterror(~drink+hour)
      [,1] [,2] [,3] [,4] [,5]
[1,]   22    0   18  -26  -30
[2,]   -9    0   -8   11   13
```

Manitoba

In Manitoba about 77% of fatalities are alcohol associated. Again the association with hour does not appear to be statistically significant but there is a 15% excess of alcohol fatalities in the 3AM window.

```
> crosstabs(~drink+hour, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ drink + hour, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
53 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
no     | 4     | 2     | 3     | 2     | 1     |12     |
       |0.333  |0.167  |0.250  |0.167  |0.083  |0.23   |
       |0.235  |0.222  |0.273  |0.286  |0.111  |       |
       |0.075  |0.038  |0.057  |0.038  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+
yes    |13     | 7     | 8     | 5     | 8     |41     |
       |0.317  |0.171  |0.195  |0.122  |0.195  |0.77   |
       |0.765  |0.778  |0.727  |0.714  |0.889  |       |
       |0.245  |0.132  |0.151  |0.094  |0.151  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|17     |9      |11     |7      |9      |53     |
       |0.32   |0.17   |0.21   |0.13   |0.17   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 0.9669428 d.f.= 4 (p=0.9147664)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~drink+hour)
     [,1] [,2] [,3] [,4] [,5]
[1,]    4   -2   20   26  -51
[2,]   -1    1   -6   -8   15
```

Drink and wkgrp are associated

Ontario

```
> crosstabs(~wkgrp, data=tirf.df, subset=province=="Ontario")
Call:
crosstabs( ~ wkgrp, data = tirf.df, subset = province == "Ontario")
375 cases in table
+-------+
|N      |
|N/Total|
+-------+
wkgrp  |
-------+-------+
SunWed |233    |
       |0.62   |
-------+-------+
ThuSat |142    |
       |0.38   |
-------+-------+
```

The car fatality accidents in SunWed group count for 62% of total accidents while 38% in ThuSat group. If accidents were uniformly distributed over the weekdays then the expected number of accidents in the SunWed group would be (233+142)×4/7 = 214.28 with a binomial standard deviation of 9.583. So the departure from uniformity is just significant at the 5% level on a two-sided test.

Among the accidents in SunWed group 75% of them were owing to driving after drinking while 63% of the accidents in ThuSat group were owing to drinking. It implies that drunken driving more likely happened in Sunday through Wednesday.

```
> crosstabs(~drink+wkgrp, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ drink + wkgrp, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
331 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
no     | 56    | 51    |107    |
       |0.52   |0.48   |0.32   |
       |0.27   |0.42   |       |
       |0.17   |0.15   |       |
-------+-------+-------+-------+
yes    |154    | 70    |224    |
       |0.69   |0.31   |0.68   |
       |0.73   |0.58   |       |
       |0.47   |0.21   |       |
-------+-------+-------+-------+
ColTotl|210    |121    |331    |
       |0.63   |0.37   |       |
-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 8.411244 d.f.= 1 (p=0.003729074)
    Yates' correction not used
> get.crosstabs.percenterror.ont(~drink+wkgrp)
     [,1] [,2]
[1,]  -18   30
[2,]    8  -15
```

Manitoba

In Manitoba there is no association and the pattern is different from Ontario. In Manitoba 79% of fatalities involve drinking as compared with 68% in Ontario and 73% of accidents occur in the SunWed wkgrp as compared with 63% in Ontario.

```
> get.crosstabs.percenterror.ont(~drink+wkgrp)
     [,1] [,2]
[1,]  -18   30
[2,]    8  -15
> crosstabs(~drink+wkgrp, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ drink + wkgrp, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
56 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
no     | 9     | 3     |12     |
       |0.750  |0.250  |0.21   |
       |0.220  |0.200  |       |
       |0.161  |0.054  |       |
-------+-------+-------+-------+
yes    |32     |12     |44     |
       |0.727  |0.273  |0.79   |
       |0.780  |0.800  |       |
       |0.571  |0.214  |       |
-------+-------+-------+-------+
ColTotl|41     |15     |56     |
       |0.73   |0.27   |       |
-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 0.0248337 d.f.= 1 (p=0.8747821)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~drink+wkgrp)
     [,1] [,2]
[1,]    2   -7
[2,]   -1    2
```

Drink and month are not associated

Ontario

There are more car fatality accidents in warm season than in cold season. This is also true in alcohol level.

```
> crosstabs(~drink+month, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ drink + month, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
331 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     | 6     | 6     | 9     | 2     |11     |11     |13     | 7     | 9     |14     | 8     |11     |107    |
       |0.056  |0.056  |0.084  |0.019  |0.103  |0.103  |0.121  |0.065  |0.084  |0.131  |0.075  |0.103  |0.32   |
       |0.429  |0.300  |0.391  |0.100  |0.367  |0.314  |0.361  |0.200  |0.281  |0.359  |0.308  |0.524  |       |
       |0.018  |0.018  |0.027  |0.006  |0.033  |0.033  |0.039  |0.021  |0.027  |0.042  |0.024  |0.033  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    | 8     |14     |14     |18     |19     |24     |23     |28     |23     |25     |18     |10     |224    |
       |0.036  |0.062  |0.062  |0.080  |0.085  |0.107  |0.103  |0.125  |0.103  |0.112  |0.080  |0.045  |0.68   |
       |0.571  |0.700  |0.609  |0.900  |0.633  |0.686  |0.639  |0.800  |0.719  |0.641  |0.692  |0.476  |       |
       |0.024  |0.042  |0.042  |0.054  |0.057  |0.073  |0.069  |0.085  |0.069  |0.076  |0.054  |0.030  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|14     |20     |23     |20     |30     |35     |36     |35     |32     |39     |26     |21     |331    |
       |0.042  |0.060  |0.069  |0.060  |0.091  |0.106  |0.109  |0.106  |0.097  |0.118  |0.079  |0.063  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 13.11596 d.f.= 11 (p=0.2858142)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.ont(~drink+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]   33   -7   21  -69   13   -3   12  -38  -13    11    -5    62
[2,]  -16    3  -10   33   -6    1   -6   18    6    -5     2   -30
```

Manitoba

Less data but otherwise similar to Ontario.

```
> crosstabs(~drink+month, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ drink + month, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
56 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     |2      |1      |0      |0      |1      |0      |2      |2      |2      |0      |2      |0      |12     |
       |0.167  |0.083  |0.000  |0.000  |0.083  |0.000  |0.167  |0.167  |0.167  |0.000  |0.167  |0.000  |0.21   |
       |0.500  |0.500  |0.000  |0.000  |0.167  |0.000  |0.286  |0.222  |0.400  |0.000  |0.222  |0.000  |       |
       |0.036  |0.018  |0.000  |0.000  |0.018  |0.000  |0.036  |0.036  |0.036  |0.000  |0.036  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    |2      |1      |1      |1      |5      |2      |5      |7      |3      |8      |7      |2      |44     |
       |0.045  |0.023  |0.023  |0.023  |0.114  |0.045  |0.114  |0.159  |0.068  |0.182  |0.159  |0.045  |0.79   |
       |0.500  |0.500  |1.000  |1.000  |0.833  |1.000  |0.714  |0.778  |0.600  |1.000  |0.778  |1.000  |       |
       |0.036  |0.018  |0.018  |0.018  |0.089  |0.036  |0.089  |0.125  |0.054  |0.143  |0.125  |0.036  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|4      |2      |1      |1      |6      |2      |7      |9      |5      |8      |9      |2      |56     |
       |0.071  |0.036  |0.018  |0.018  |0.107  |0.036  |0.125  |0.161  |0.089  |0.143  |0.161  |0.036  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 8.051178 d.f.= 11 (p=0.7087121)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~drink+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]  133  133 -100 -100  -22 -100   33    4   87  -100     4  -100
[2,]  -36  -36   27   27    6   27   -9   -1  -24    27    -1    27
       >
```

Drink and year are perhaps associated (p=10%).

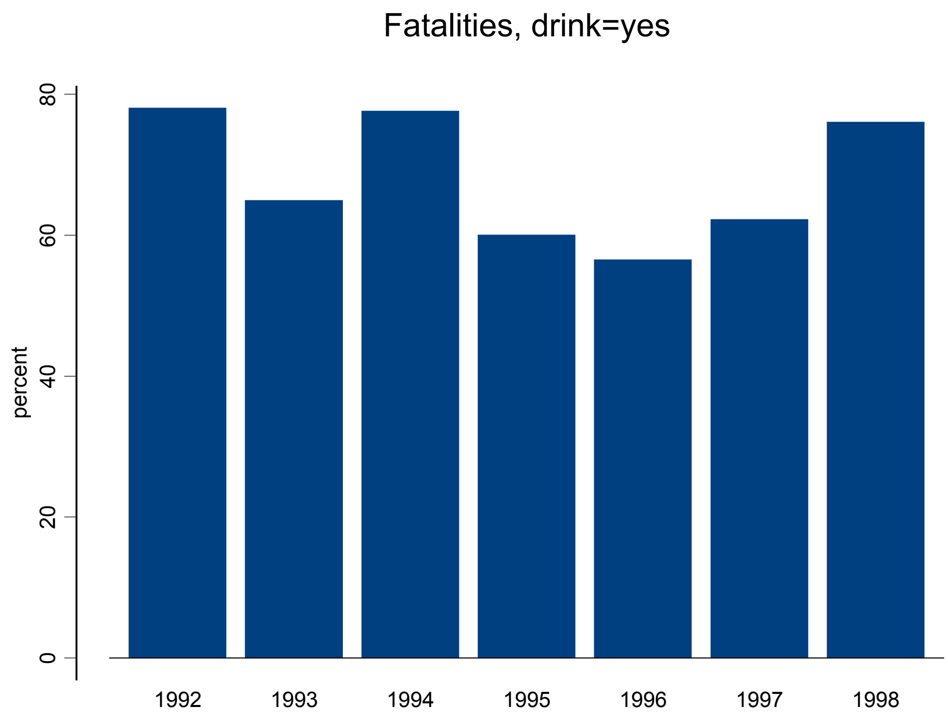
Ontario

The annual car fatality accidents fluctuated over years. There are more accidents in 1994 (17.5%) and fewest in 1998 (7.6%).

Although there are fewest accidents in 1998, 76% are associated with drinking alcohol. This suggests that the reduction in deaths is more due to improved car design, day time running lights and air bags than is due to the effectiveness of anti-drinking campaigns.

```
> get.crosstabs.percenterror.man(~drink+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]  133  133 -100 -100  -22 -100   33    4   87  -100     4  -100
[2,]  -36  -36   27   27    6   27   -9   -1  -24    27    -1    27
> crosstabs(~drink+year, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ drink + year, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
331 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     |11     |20     |13     |20     |20     |17     | 6     |107    |
       |0.103  |0.187  |0.121  |0.187  |0.187  |0.159  |0.056  |0.32   |
       |0.220  |0.351  |0.224  |0.400  |0.435  |0.378  |0.240  |       |
       |0.033  |0.060  |0.039  |0.060  |0.060  |0.051  |0.018  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    |39     |37     |45     |30     |26     |28     |19     |224    |
       |0.174  |0.165  |0.201  |0.134  |0.116  |0.125  |0.085  |0.68   |
       |0.780  |0.649  |0.776  |0.600  |0.565  |0.622  |0.760  |       |
       |0.118  |0.112  |0.136  |0.091  |0.079  |0.085  |0.057  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|50     |57     |58     |50     |46     |45     |25     |331    |
       |0.151  |0.172  |0.175  |0.151  |0.139  |0.136  |0.076  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 10.60544 d.f.= 6 (p=0.1013636)
    Yates' correction not used
> get.crosstabs.percenterror.ont(~drink+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]  -32    9  -31   24   34   17  -26
[2,]   15   -4   15  -11  -16   -8   12
```

Figure 0. Percent of fatalities with drink=yes in Ontario



Manitoba

The pattern observed in Ontario appears again. Although 1998 had the fewest number of fatalities, 100% of the fatalities were associated with drinking but there were only a total of 5 fatalities recorded in Manitoba for 1998. There is not enough data for the standard test to obtain an accurate p-value.

```
> crosstabs(~drink+year, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ drink + year, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
56 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     |1      |1      |2      |1      |3      |4      |0      |12     |
       |0.083  |0.083  |0.167  |0.083  |0.250  |0.333  |0.000  |0.21   |
       |0.167  |0.111  |0.182  |0.200  |0.375  |0.333  |0.000  |       |
       |0.018  |0.018  |0.036  |0.018  |0.054  |0.071  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    |5      |8      |9      |4      |5      |8      |5      |44     |
       |0.114  |0.182  |0.205  |0.091  |0.114  |0.182  |0.114  |0.79   |
       |0.833  |0.889  |0.818  |0.800  |0.625  |0.667  |1.000  |       |
       |0.089  |0.143  |0.161  |0.071  |0.089  |0.143  |0.089  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|6      |9      |11     |5      |8      |12     |5      |56     |
       |0.107  |0.161  |0.196  |0.089  |0.143  |0.214  |0.089  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 4.325773 d.f.= 6 (p=0.6326814)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~drink+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]  -22  -48  -15   -7   75   56 -100
[2,]    6   13    4    2  -20  -15   27
> |
```

Hour and wkgrp are independent (p-value=17%)

Ontario

There are 25% more fatalities in the ThuSat-11PM slot and 28% fewer in the ThuSat-3AM slot than expected under the assumption of independence but the difference is not statistically significant.

```
> crosstabs(~wkgrp+hour, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + hour, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
347 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |44     |46     |50     |45     |37     |222    |
       |0.198  |0.207  |0.225  |0.203  |0.167  |0.64   |
       |0.550  |0.676  |0.602  |0.682  |0.740  |       |
       |0.127  |0.133  |0.144  |0.130  |0.107  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |36     |22     |33     |21     |13     |125    |
       |0.288  |0.176  |0.264  |0.168  |0.104  |0.36   |
       |0.450  |0.324  |0.398  |0.318  |0.260  |       |
       |0.104  |0.063  |0.095  |0.061  |0.037  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|80     |68     |83     |66     |50     |347    |
       |0.23   |0.20   |0.24   |0.19   |0.14   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 6.38332 d.f.= 4 (p=0.1722922)
    Yates' correction not used
> get.crosstabs.percenterror.ont(~wkgrp+hour)
     [,1] [,2] [,3] [,4] [,5]
[1,]  -14    6   -6    7   16
[2,]   25  -10   10  -12  -28
```

Manitoba

As in Ontario there are much fewer (55% here) fatalities in the ThuSat-3AM slot but the numbers are small and the difference does not appear to be statistically significant.

```
> crosstabs(~wkgrp+hour, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + hour, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
53 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |13     | 7     | 7     | 5     | 8     |40     |
       |0.325  |0.175  |0.175  |0.125  |0.200  |0.75   |
       |0.765  |0.778  |0.636  |0.714  |0.889  |       |
       |0.245  |0.132  |0.132  |0.094  |0.151  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat | 4     | 2     | 4     | 2     | 1     |13     |
       |0.308  |0.154  |0.308  |0.154  |0.077  |0.25   |
       |0.235  |0.222  |0.364  |0.286  |0.111  |       |
       |0.075  |0.038  |0.075  |0.038  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|17     |9      |11     |7      |9      |53     |
       |0.32   |0.17   |0.21   |0.13   |0.17   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 1.804387 d.f.= 4 (p=0.7716796)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~wkgrp+hour)
     [,1] [,2] [,3] [,4] [,5]
[1,]    1    3  -16   -5   18
[2,]   -4   -9   48   16  -55
```

Hour and Month

Ontario

Overall there is no strong indication of associated. However there are 231% more fatalities than expected in the 2AM-April slot than would be expected under independence.

```
> crosstabs(~hour+month, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ hour + month, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
347 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |month
|Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   | 2     | 4     | 6     | 5     | 6     |12     | 9     | 9     | 7     |10     | 6     | 4     |80     |
|0.0250 |0.0500 |0.0750 |0.0625 |0.0750 |0.1500 |0.1125 |0.1125 |0.0875 |0.1250 |0.0750 |0.0500 |0.23   |
|0.1538 |0.1905 |0.2727 |0.2174 |0.1935 |0.3077 |0.2432 |0.2195 |0.2258 |0.2439 |0.2400 |0.1739 |       |
|0.0058 |0.0115 |0.0173 |0.0144 |0.0173 |0.0346 |0.0259 |0.0259 |0.0202 |0.0288 |0.0173 |0.0115 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   | 4     | 4     | 3     | 1     | 6     | 9     |10     | 8     | 5     | 8     | 5     | 5     |68     |
|0.0588 |0.0588 |0.0441 |0.0147 |0.0882 |0.1324 |0.1471 |0.1176 |0.0735 |0.1176 |0.0735 |0.0735 |0.20   |
|0.3077 |0.1905 |0.1364 |0.0435 |0.1935 |0.2308 |0.2703 |0.1951 |0.1613 |0.1951 |0.2000 |0.2174 |       |
|0.0115 |0.0115 |0.0086 |0.0029 |0.0173 |0.0259 |0.0288 |0.0231 |0.0144 |0.0231 |0.0144 |0.0144 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    | 4     | 8     | 8     | 1     | 9     | 4     |11     |11     | 9     | 8     | 5     | 5     |83     |
|0.0482 |0.0964 |0.0964 |0.0120 |0.1084 |0.0482 |0.1325 |0.1325 |0.1084 |0.0964 |0.0602 |0.0602 |0.24   |
|0.3077 |0.3810 |0.3636 |0.0435 |0.2903 |0.1026 |0.2973 |0.2683 |0.2903 |0.1951 |0.2000 |0.2174 |       |
|0.0115 |0.0231 |0.0231 |0.0029 |0.0259 |0.0115 |0.0317 |0.0317 |0.0259 |0.0231 |0.0144 |0.0144 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    | 1     | 4     | 1     |13     | 7     | 6     | 4     | 8     | 7     | 7     | 2     | 6     |66     |
|0.0152 |0.0606 |0.0152 |0.1970 |0.1061 |0.0909 |0.0606 |0.1212 |0.1061 |0.1061 |0.0303 |0.0909 |0.19   |
|0.0769 |0.1905 |0.0455 |0.5652 |0.2258 |0.1538 |0.1081 |0.1951 |0.2258 |0.1707 |0.0800 |0.2609 |       |
|0.0029 |0.0115 |0.0029 |0.0375 |0.0202 |0.0173 |0.0115 |0.0231 |0.0202 |0.0202 |0.0058 |0.0173 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    | 2     | 1     | 4     | 3     | 3     | 8     | 3     | 5     | 3     | 8     | 7     | 3     |50     |
|0.0400 |0.0200 |0.0800 |0.0600 |0.0600 |0.1600 |0.0600 |0.1000 |0.0600 |0.1600 |0.1400 |0.0600 |0.14   |
|0.1538 |0.0476 |0.1818 |0.1304 |0.0968 |0.2051 |0.0811 |0.1220 |0.0968 |0.1951 |0.2800 |0.1304 |       |
|0.0058 |0.0029 |0.0115 |0.0086 |0.0086 |0.0231 |0.0086 |0.0144 |0.0086 |0.0231 |0.0202 |0.0086 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|13     |21     |22     |23     |31     |39     |37     |41     |31     |41     |25     |23     |347    |
|0.037  |0.061  |0.063  |0.066  |0.089  |0.112  |0.107  |0.118  |0.089  |0.118  |0.072  |0.066  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
Chi^2 = 53.12007 d.f.= 44 (p=0.1630167)
Yates' correction not used
Some expected values are less than 5, don't trust stated p-value
```

Manitoba

```
> get.crosstabs.percenterror.ont(~hour+month)
[,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]  -33  -17   18   -6  -16   33    6   -5   -2     6     4   -25
[2,]   57   -3  -30  -78   -1   18   38    0  -18     0     2    11
[3,]   29   59   52  -82   21  -57   24   12   21   -18   -16    -9
[4,]  -60    0  -76  197   19  -19  -43    3   19   -10   -58    37
[5,]    7  -67   26   -9  -33   42  -44  -15  -33    35    94    -9
> crosstabs(~hour+month, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ hour + month, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
53 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |month
|Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |2      |0      |0      |0      |2      |1      |2      |4      |2      |3      |1      |0      |17     |
|0.118  |0.000  |0.000  |0.000  |0.118  |0.059  |0.118  |0.235  |0.118  |0.176  |0.059  |0.000  |0.32   |
|0.500  |0.000  |0.000  |0.000  |0.400  |0.500  |0.286  |0.444  |0.667  |0.375  |0.111  |0.000  |       |
|0.038  |0.000  |0.000  |0.000  |0.038  |0.019  |0.038  |0.075  |0.038  |0.057  |0.019  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |0      |1      |0      |0      |0      |1      |3      |1      |0      |1      |1      |1      |9      |
|0.000  |0.111  |0.000  |0.000  |0.000  |0.111  |0.333  |0.111  |0.000  |0.111  |0.111  |0.111  |0.17   |
|0.000  |0.500  |0.000  |0.000  |0.000  |0.500  |0.429  |0.111  |0.000  |0.125  |0.111  |0.500  |       |
|0.000  |0.019  |0.000  |0.000  |0.000  |0.019  |0.057  |0.019  |0.000  |0.019  |0.019  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |0      |0      |1      |0      |1      |0      |2      |3      |0      |1      |2      |1      |11     |
|0.000  |0.000  |0.091  |0.000  |0.091  |0.000  |0.182  |0.273  |0.000  |0.091  |0.182  |0.091  |0.21   |
|0.000  |0.000  |1.000  |0.000  |0.200  |0.000  |0.286  |0.333  |0.000  |0.125  |0.222  |0.500  |       |
|0.000  |0.000  |0.019  |0.000  |0.019  |0.000  |0.038  |0.057  |0.000  |0.019  |0.038  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |2      |0      |0      |0      |0      |0      |0      |0      |0      |1      |4      |0      |7      |
|0.286  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.143  |0.571  |0.000  |0.13   |
|0.500  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.125  |0.444  |0.000  |       |
|0.038  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.000  |0.019  |0.075  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    |0      |1      |0      |1      |2      |0      |0      |1      |1      |2      |1      |0      |9      |
|0.000  |0.111  |0.000  |0.111  |0.222  |0.000  |0.000  |0.111  |0.111  |0.222  |0.111  |0.000  |0.17   |
|0.000  |0.500  |0.000  |1.000  |0.400  |0.000  |0.000  |0.111  |0.333  |0.250  |0.111  |0.000  |       |
|0.000  |0.019  |0.000  |0.019  |0.038  |0.000  |0.000  |0.019  |0.019  |0.038  |0.019  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|4      |2      |1      |1      |5      |2      |7      |9      |3      |8      |9      |2      |53     |
|0.075  |0.038  |0.019  |0.019  |0.094  |0.038  |0.132  |0.170  |0.057  |0.151  |0.170  |0.038  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
Chi^2 = 48.19941 d.f.= 44 (p=0.3068645)
Yates' correction not used
Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~hour+month)
[,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]   56 -100 -100 -100   25   56  -11   39  108    17   -65  -100
[2,] -100  194 -100 -100 -100  194  152  -35 -100   -26   -35   194
[3,] -100 -100  382 -100   -4 -100   38   61 -100   -40     7   141
[4,]  279 -100 -100 -100 -100 -100 -100 -100 -100    -5   237  -100
[5,] -100  194 -100  489  136 -100 -100  -35   96    47   -35  -100
```

Hour and year are associated in Ontario

Ontario

Hour and year are associated. There seems to be an excess of fatalities in the 2AM-1998 and 3AM-1997 windows (97% and 110% respectively).

```
| > crosstabs(~hour+year, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ hour + year, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
347 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |12     |10     |14     |14     |15     |11     | 4     |80     |
       |0.1500 |0.1250 |0.1750 |0.1750 |0.1875 |0.1375 |0.0500 |0.23   |
       |0.2105 |0.1639 |0.2500 |0.2800 |0.3261 |0.2075 |0.1667 |       |
       |0.0346 |0.0288 |0.0403 |0.0403 |0.0432 |0.0317 |0.0115 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |18     | 7     | 8     |11     | 9     |13     | 2     |68     |
       |0.2647 |0.1029 |0.1176 |0.1618 |0.1324 |0.1912 |0.0294 |0.20   |
       |0.3158 |0.1148 |0.1429 |0.2200 |0.1957 |0.2453 |0.0833 |       |
       |0.0519 |0.0202 |0.0231 |0.0317 |0.0259 |0.0375 |0.0058 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |11     |24     |15     |12     |12     | 4     | 5     |83     |
       |0.1325 |0.2892 |0.1807 |0.1446 |0.1446 |0.0482 |0.0602 |0.24   |
       |0.1930 |0.3934 |0.2679 |0.2400 |0.2609 |0.0755 |0.2083 |       |
       |0.0317 |0.0692 |0.0432 |0.0346 |0.0346 |0.0115 |0.0144 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |10     |10     |15     |10     | 3     | 9     | 9     |66     |
       |0.1515 |0.1515 |0.2273 |0.1515 |0.0455 |0.1364 |0.1364 |0.19   |
       |0.1754 |0.1639 |0.2679 |0.2000 |0.0652 |0.1698 |0.3750 |       |
       |0.0288 |0.0288 |0.0432 |0.0288 |0.0086 |0.0259 |0.0259 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    | 6     |10     | 4     | 3     | 7     |16     | 4     |50     |
       |0.1200 |0.2000 |0.0800 |0.0600 |0.1400 |0.3200 |0.0800 |0.14   |
       |0.1053 |0.1639 |0.0714 |0.0600 |0.1522 |0.3019 |0.1667 |       |
       |0.0173 |0.0288 |0.0115 |0.0086 |0.0202 |0.0461 |0.0115 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|57     |61     |56     |50     |46     |53     |24     |347    |
       |0.164  |0.176  |0.161  |0.144  |0.133  |0.153  |0.069  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 51.37488 d.f.= 24 (p=0.0009432535)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.ont(~hour+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]   -9  -29    8   21   41  -10  -28
[2,]   61  -41  -27   12    0   25  -57
[3,]  -19   64   12    0    9  -68  -13
[4,]   -8  -14   41    5  -66  -11   97
[5,]  -27   14  -50  -58    6  110   16
```

Manitoba

The crosstabs are included for Manitoba but since the numbers are so small we can't make any reliable conclusion.

```
> crosstabs(~hour+year, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ hour + year, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
53 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |0      |2      |6      |1      |2      |6      |0      |17     |
       |0.000  |0.118  |0.353  |0.059  |0.118  |0.353  |0.000  |0.32   |
       |0.000  |0.222  |0.600  |0.200  |0.250  |0.500  |0.000  |       |
       |0.000  |0.038  |0.113  |0.019  |0.038  |0.113  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |1      |0      |3      |2      |1      |0      |2      |9      |
       |0.111  |0.000  |0.333  |0.222  |0.111  |0.000  |0.222  |0.17   |
       |0.200  |0.000  |0.300  |0.400  |0.125  |0.000  |0.500  |       |
       |0.019  |0.000  |0.057  |0.038  |0.019  |0.000  |0.038  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |1      |5      |0      |1      |2      |2      |0      |11     |
       |0.091  |0.455  |0.000  |0.091  |0.182  |0.182  |0.000  |0.21   |
       |0.200  |0.556  |0.000  |0.200  |0.250  |0.167  |0.000  |       |
       |0.019  |0.094  |0.000  |0.019  |0.038  |0.038  |0.000  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |0      |1      |1      |0      |1      |3      |1      |7      |
       |0.000  |0.143  |0.143  |0.000  |0.143  |0.429  |0.143  |0.13   |
       |0.000  |0.111  |0.100  |0.000  |0.125  |0.250  |0.250  |       |
       |0.000  |0.019  |0.019  |0.000  |0.019  |0.057  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    |3      |1      |0      |1      |2      |1      |1      |9      |
       |0.333  |0.111  |0.000  |0.111  |0.222  |0.111  |0.111  |0.17   |
       |0.600  |0.111  |0.000  |0.200  |0.250  |0.083  |0.250  |       |
       |0.057  |0.019  |0.000  |0.019  |0.038  |0.019  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|5      |9      |10     |5      |8      |12     |4      |53     |
       |0.094  |0.170  |0.189  |0.094  |0.151  |0.226  |0.075  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 35.74037 d.f.= 24 (p=0.05815202)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~hour+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,] -100  -31   87  -38  -22   56 -100
[2,]   18 -100   77  136  -26 -100  194
[3,]   -4  168 -100   -4   20  -20 -100
[4,] -100  -16  -24 -100   -5   89   89
[5,]  253  -35 -100   18   47  -51   47
>
```

Wkgrp and month are associated in Ontario (p-value ≈ 1%)

Ontario

There are increased fatalities in ThuSat-Feb (65%) and ThuSat-Dec (58%) and decreased fatalities in ThuSat-May (42%) and ThuSat-Nov (56%).

```
> crosstabs(~wkgrp+month, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + month, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
375 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed | 9     | 9     |13     |16     |25     |27     |24     |29     |19     |27     |25     |10     |233    |
       |0.039  |0.039  |0.056  |0.069  |0.107  |0.116  |0.103  |0.124  |0.082  |0.116  |0.107  |0.043  |0.62   |
       |0.562  |0.375  |0.542  |0.667  |0.781  |0.692  |0.632  |0.659  |0.514  |0.643  |0.833  |0.400  |       |
       |0.024  |0.024  |0.035  |0.043  |0.067  |0.072  |0.064  |0.077  |0.051  |0.072  |0.067  |0.027  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat | 7     |15     |11     | 8     | 7     |12     |14     |15     |18     |15     | 5     |15     |142    |
       |0.049  |0.106  |0.077  |0.056  |0.049  |0.085  |0.099  |0.106  |0.127  |0.106  |0.035  |0.106  |0.38   |
       |0.438  |0.625  |0.458  |0.333  |0.219  |0.308  |0.368  |0.341  |0.486  |0.357  |0.167  |0.600  |       |
       |0.019  |0.040  |0.029  |0.021  |0.019  |0.032  |0.037  |0.040  |0.048  |0.040  |0.013  |0.040  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|16     |24     |24     |24     |32     |39     |38     |44     |37     |42     |30     |25     |375    |
       |0.043  |0.064  |0.064  |0.064  |0.085  |0.104  |0.101  |0.117  |0.099  |0.112  |0.080  |0.067  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 24.726 d.f.= 11 (p=0.00999656)
    Yates' correction not used
> get.crosstabs.percenterror.ont(~wkgrp + month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]   -9  -40  -13    7   26   11    2    6  -17     3    34   -36
[2,]   16   65   21  -12  -42  -19   -3  -10   28    -6   -56    58
```

Manitoba

The numbers are too small to draw any conclusion.

```
> crosstabs(~wkgrp+month, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + month, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
58 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed |4      |2      |1      |1      |5      |2      |6      |6      |4      |4      |5      |1      |41     |
       |0.098  |0.049  |0.024  |0.024  |0.122  |0.049  |0.146  |0.146  |0.098  |0.098  |0.122  |0.024  |0.71   |
       |1.000  |1.000  |1.000  |0.500  |0.833  |1.000  |0.857  |0.667  |0.800  |0.500  |0.500  |0.500  |       |
       |0.069  |0.034  |0.017  |0.017  |0.086  |0.034  |0.103  |0.103  |0.069  |0.069  |0.086  |0.017  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat |0      |0      |0      |1      |1      |0      |1      |3      |1      |4      |5      |1      |17     |
       |0.000  |0.000  |0.000  |0.059  |0.059  |0.000  |0.059  |0.176  |0.059  |0.235  |0.294  |0.059  |0.29   |
       |0.000  |0.000  |0.000  |0.500  |0.167  |0.000  |0.143  |0.333  |0.200  |0.500  |0.500  |0.500  |       |
       |0.000  |0.000  |0.000  |0.017  |0.017  |0.000  |0.017  |0.052  |0.017  |0.069  |0.086  |0.017  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|4      |2      |1      |2      |6      |2      |7      |9      |5      |8      |10     |2      |58     |
       |0.069  |0.034  |0.017  |0.034  |0.103  |0.034  |0.121  |0.155  |0.086  |0.138  |0.172  |0.034  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 9.781977 d.f.= 11 (p=0.5500987)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~wkgrp + month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]   41   41   41  -29   18   41   21   -6   13   -29   -29   -29
[2,] -100 -100 -100   71  -43 -100  -51   14  -32    71    71    71
```

Wkgrp and year are not associated

Ontario

```
> crosstabs(~wkgrp+year, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + year, data = tirf.df, subset = province == "Ontario", na.action = na.exclude)
375 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed |37     |41     |42     |30     |30     |34     |19     |233    |
       |0.159  |0.176  |0.180  |0.129  |0.129  |0.146  |0.082  |0.62   |
       |0.607  |0.631  |0.677  |0.556  |0.625  |0.586  |0.704  |       |
       |0.099  |0.109  |0.112  |0.080  |0.080  |0.091  |0.051  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat |24     |24     |20     |24     |18     |24     | 8     |142    |
       |0.169  |0.169  |0.141  |0.169  |0.127  |0.169  |0.056  |0.38   |
       |0.393  |0.369  |0.323  |0.444  |0.375  |0.414  |0.296  |       |
       |0.064  |0.064  |0.053  |0.064  |0.048  |0.064  |0.021  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|61     |65     |62     |54     |48     |58     |27     |375    |
       |0.163  |0.173  |0.165  |0.144  |0.128  |0.155  |0.072  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 2.988713 d.f.= 6 (p=0.8102621)
    Yates' correction not used
> get.crosstabs.percenterror.ont(~wkgrp+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]   -2    2    9  -11    1   -6   13
[2,]    4   -2  -15   17   -1    9  -22
```

Manitoba

```
> crosstabs(~wkgrp+year, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs( ~ wkgrp + year, data = tirf.df, subset = province == "Manitoba", na.action = na.exclude)
58 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed |5      |5      |7      |4      |7      |9      |4      |41     |
       |0.122  |0.122  |0.171  |0.098  |0.171  |0.220  |0.098  |0.71   |
       |0.833  |0.556  |0.636  |0.667  |0.875  |0.692  |0.800  |       |
       |0.086  |0.086  |0.121  |0.069  |0.121  |0.155  |0.069  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat |1      |4      |4      |2      |1      |4      |1      |17     |
       |0.059  |0.235  |0.235  |0.118  |0.059  |0.235  |0.059  |0.29   |
       |0.167  |0.444  |0.364  |0.333  |0.125  |0.308  |0.200  |       |
       |0.017  |0.069  |0.069  |0.034  |0.017  |0.069  |0.017  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|6      |9      |11     |6      |8      |13     |5      |58     |
       |0.103  |0.155  |0.190  |0.103  |0.138  |0.224  |0.086  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 3.082463 d.f.= 6 (p=0.798428)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror.man(~wkgrp+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]   18  -21  -10   -6   24   -2   13
[2,]  -43   52   24   14  -57    5  -32
>
```

C. TIRF Dataset: Late Night Subset

TIME SERIES

Summary

TIRF data set contains 400 observations of car-driver fatality accidents from January 1992 to December 1998. There were actually 434 cases in the original SPSS file but after deleting all cases where the hour variable was missing we were left with 400 cases. Of these 400 cases, 347 were in Ontario and 53 were in Manitoba.

Figure 1 and Table 1 show time series of total car fatality accidents per month for January 1992 to December 1998. In Manitoba there are fewer fatalities and there no noticeable change over time. In Ontario there is an increasing trend for about the first two years and this is followed by a decreasing trend starting around 1994. The table below indicates the death rate has been halved.

Estimated mean death rate/month from loess smooth.

	Beginning of 1992	End of 1998	Percentage Change
Ontario	4.5	2.3	49
Manitoba	0.32	0.37	-13

Figure 2 shows that in Ontario there was a marked downward trend starting around 1995 in fatalities with drink=yes. There also appears a slight decline in Manitoba for fatalities with drink=yes but the numbers are smaller and there is a lot of variability. The number of fatalities in Ontario with drink=no has also started to decline since about 1995 or 1996.

Figure 3a&b. The comparisons between driving with drink and without drink within drink factor, and between `ThuSat` and `SunWed` within `wkgrp` factor are shown in Fig 3 (a) and (b). There more fatalities with drink=yes and there are are more accidents in `SunWed`. In Ontario, both `SunWed` and `ThuSat` have a downward trend.

Figure 6a,b-I,b-ii, fatalities by hour, drink and province. In each hour slot the accidents are larger in drinking alcohol group than no drinking alcohol group. In Figure 4b-ii, there is an increasing trend in Ontario in the 2AM slot and decreasing trends at 11PM, 12AM and 1AM.

Figure 4a and 4b are the fatalities by wkgrp and hour. In each hour slot the accidents are larger in SunWed group than in ThuSat group. There are declining trends at 1AM in both weekgroups. At 2AM-ThuSat there is a downward trend. The other panels do not exhibit noticeable trends.

Tables 5a-5d. Monthly time series, deaths by province, hour and wkgrp. Mann-Kendall tests. Ontario 1AMSunWed and 2AMThuSat downward trend (<5%) and Manitoba 2AMSunWed upward trend (<5%).

Tables 7a-d. Annual total fatalities are decomposed by hour, wkgrp and drink for Ontario and Manitoba. Table 6b shows that there has been a shift in fatalities from early evening to late evening starting around 1996. The Mann-Kendall trend test is statistically significant on a two-sided test for Ontario fatalities with drink=yes for Total, 11PM, 1AM, SunWed and ThuSat and in all cases the sign of tau indicates a downward trend. The trend test is not significant for drink=no in Ontario. There are no trends in Manitoba for either drink=yes or drink=no.

No Figure 7 in this report.

Figures 8a,b,c,d. STL analysis for monthly time series with `drink=yes` and `drink=no` in Ontario. For `drink=yes`, a change occurred in 1996 and this is reflected in the trend and seasonal component. The peaks are higher in the seasonal after 1996 and the troughs are lower pre-1996. The shape of the seasonal component has changed. The seasonal component shows fatalities with drink peak in Aug and reach a minimum in Jan. There is a secondary peak in Oct. The trend is upward for Sep, Oct and Jan but is elsewhere downward and or level.

Figures 9a,b,c,d. STL analysis, Ontario, `drink=no`, downward trend since 1996. Although Mann-Kendall test is not significant the loess trend indicates a downward trend in recent years (Figure 9d) Seasonal component is very irregular and changing. Peak in July and trough in Apr. There is a lot of change over time.

Figures 10a,b 11a,b STL analysis for monthly time series with drink=yes and drink=no in Manitoba.

Data Visualization
1. All fatalities, Ontario and Manitoba

In the data visualization plots we have used a 60% robust linear smoother.

Table 1a. Monthly fatalities, Ontario

```
> tirf.ont.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   4   4   4   6  10   3   3   5   6   5   6
1993:   4   4   4   4   6   9   8   9   2   5   3   3
1994:   2   5   5   5   4   4   7   5   4   7   5   3
1995:   1   2   1   3   5   6   5   6   7   7   2   5
1996:   1   2   5   2   7   3   6   8   3   7   2   0
1997:   2   4   3   3   1   4   7   8   6   6   6   3
1998:   2   0   0   2   2   3   1   2   4   3   2   3
> sum(tirf.ont.ts)= 347
> SeasonalMannKendall(tirf.ont.ts)
tau = -0.287,   sl =0.2497%
```

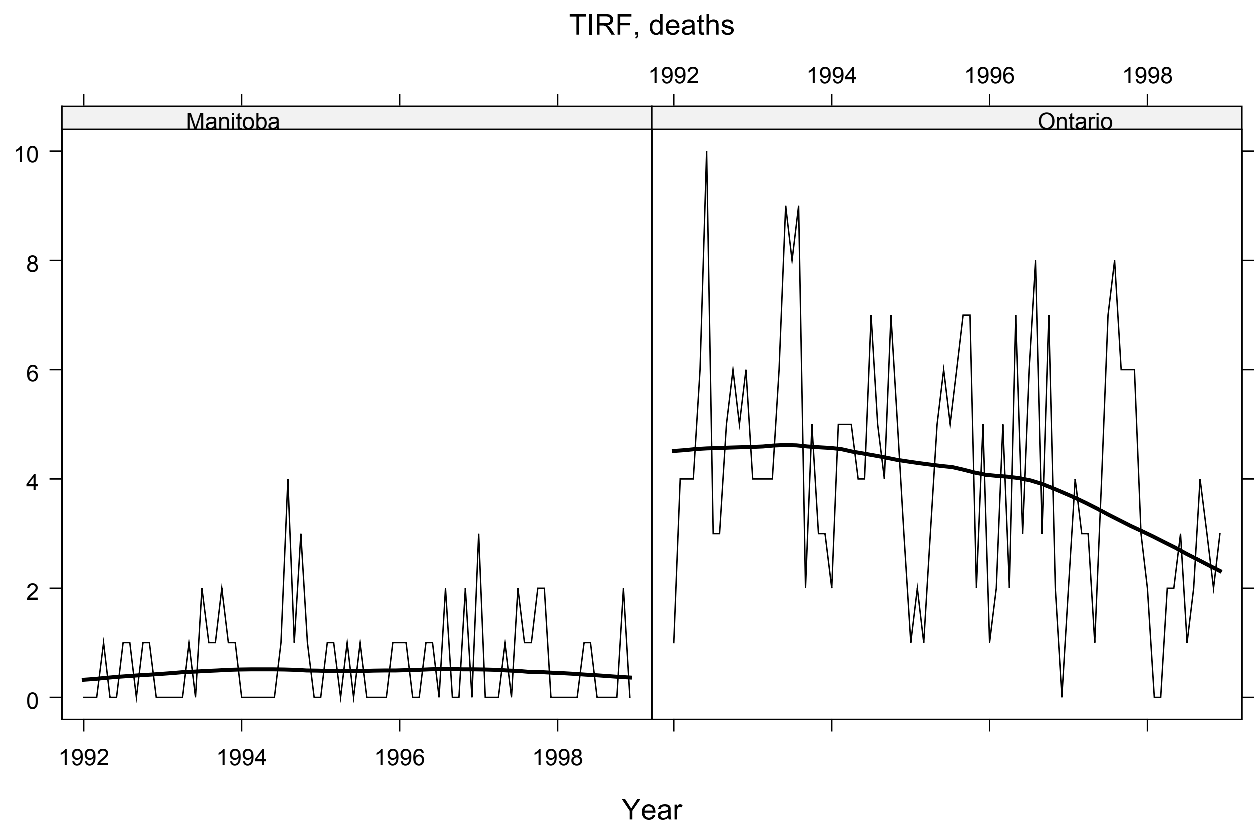
Table 1b. Monthly fatalities, Manitoba

```
> tirf.man.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   1   0   0   1   1   0   1   1   0
1993:   0   0   0   0   1   0   2   1   1   2   1   1
1994:   0   0   0   0   0   0   1   4   1   3   1   0
1995:   0   1   1   0   1   0   1   0   0   0   0   1
1996:   1   1   0   0   1   1   0   2   0   0   2   0
1997:   3   0   0   0   1   0   2   1   1   2   2   0
1998:   0   0   0   0   1   1   0   0   0   0   2   0
> sum(tirf.man.ts)
[1] 53
> SeasonalMannKendall(tirf.man.ts)
tau = 0.0324,   sl =74.96%

> pc.change(tirf.ont.ts)
[1]  4.512848  2.311812 48.772666
[1]  3.783476  1.935217 48.850810
> pc.change(tirf.man.ts)
[1]   0.3246352   0.3678582 -13.3143284
> aggregate(tirf.ont.ts,1,mean)
> aggregate(tirf.ont.ts,1,mean)
1992: 4.750000 5.083333 4.666667 4.166667 3.833333 4.416667 2.000000
> aggregate(tirf.man.ts,1,mean)
1992: 0.4166667 0.7500000 0.8333333 0.4166667 0.6666667 1.0000000 0.3333333
> MannKendall(tirf.ont.ts)
[1] -0.20029531  0.01088074
> MannKendall(tirf.man.ts)
[1] 0.01823654 0.83558142
```

Table 1c-i. Estimated mean death rate/month from loess smooth.

	Beginning of 1992	End of 1998	Percentage Change
Ontario	4.5	2.3	49
Manitoba	0.32	0.37	-13

Figure 1. Time series trellis plot of total car fatality accidents per month for January 1992 to December 1998. In Manitoba there are fewer fatalities and there no noticeable change over time. In Ontario there is an increasing trend for about the first two years and this is followed by a decreasing trend starting around 1994. Because of the extremely low death rates for car fatalities in Manitoba, it does not seem to provide any useful information. It just gets in the way of understanding the Ontario data so it will be omitted from further graphical displays.



2. Fatalities by hour

Table 2. Time series tabulation by province and hour

```
> ont.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   2   0   1   2   1   0   1   1   3
1993:   1   0   0   1   1   2   1   2   1   1   0   0
1994:   0   1   3   0   1   1   2   1   2   2   1   0
1995:   0   0   1   1   0   4   1   2   3   1   0   1
1996:   0   1   2   0   4   2   1   0   1   2   2   0
1997:   0   1   0   1   0   1   2   2   0   2   2   0
1998:   1   0   0   0   0   1   0   1   0   1   0   0
> SeasonalMannKendall(ont.11PM.ts)
tau = -0.127,   sl =20.06%
> ont.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   2   0   4   5   0   1   0   1   2   2
1993:   2   0   0   0   0   3   2   0   0   0   0   0
1994:   0   2   0   0   1   0   0   1   0   2   2   0
1995:   0   0   0   0   1   1   2   0   3   3   0   1
1996:   1   0   1   1   0   0   1   4   0   1   0   0
1997:   1   1   0   0   0   0   5   1   1   1   1   2
1998:   0   0   0   0   0   0   0   1   1   0   0   0
> SeasonalMannKendall(ont.12AM.ts)
tau = -0.129,   sl =19.43%
> ont.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   2   0   1   1   1   1   4   0   0   0
1993:   1   3   2   0   3   2   4   5   1   3   0   0
1994:   1   2   2   0   2   1   1   1   1   1   2   1
1995:   1   1   0   0   0   0   2   2   0   2   1   3
1996:   0   1   2   0   2   0   3   1   2   1   0   0
1997:   1   0   0   1   0   0   0   1   1   0   0   0
1998:   0   0   0   0   1   0   0   0   0   1   2   1
> SeasonalMannKendall(ont.1AM.ts)
tau = -0.283,   sl =0.4093%
> ont.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   2   1   1   0   0   1   2   1   1
1993:   0   1   1   3   1   1   1   1   0   0   0   1
1994:   1   0   0   4   0   2   2   1   1   2   0   2
1995:   0   1   0   2   3   0   0   1   1   1   1   0
1996:   0   0   0   0   1   0   0   1   0   1   0   0
1997:   0   1   0   0   0   1   0   4   2   0   0   1
1998:   0   0   0   2   1   1   1   0   2   1   0   1
> SeasonalMannKendall(ont.2AM.ts)
tau = -0.129,   sl =20.03%
> ont.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   0   0   2   0   0   0   2   1   0
1993:   0   0   1   0   1   1   0   1   0   1   3   2
1994:   0   0   0   1   0   0   2   1   0   0   0   0
1995:   0   0   0   0   1   1   0   1   0   0   0   0
1996:   0   0   0   1   0   1   1   2   0   2   0   0
1997:   0   1   3   1   1   2   0   0   2   3   3   0
1998:   1   0   0   0   0   1   0   0   1   0   0   1
> SeasonalMannKendall(ont.3AM.ts)
tau = 0.0634,   sl =52.9%
> sum(ont.11PM.ts+ont.12AM.ts+ont.1AM.ts+ont.2AM.ts+ont.3AM.ts)
[1] 347
```

```
man.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   0   0   2   0   0   0   2   1   0
1993:   0   0   1   0   1   1   0   1   0   1   3   2
1994:   0   0   0   1   0   0   2   1   0   0   0   0
1995:   0   0   0   0   1   0   0   1   0   0   0   0
1996:   0   0   0   1   0   1   1   2   0   2   0   0
1997:   0   1   3   0   1   2   0   0   2   2   3   0
1998:   1   0   0   0   0   1   0   0   1   0   0   1
> MannKendall(man.11PM.ts)
tau = 0.042,   sl =62.88%
> man.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   1   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   1   1   0   1   0   0
1995:   0   0   0   0   0   0   1   0   0   0   0   1
1996:   0   1   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   1   0   0   0   0   1   0
> MannKendall(man.12AM.ts)
tau = 0.0306,   sl =73.94%
> man.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   1   0
1993:   0   0   0   0   0   0   2   1   0   1   0   1
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   1   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   2   0   0   0   0
1997:   0   0   0   0   1   0   0   0   0   0   1   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.1AM.ts)
tau = -0.0729,   sl =41.86%
> man.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   1   0
1994:   0   0   0   0   0   0   0   0   0   0   1   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   1   0
1997:   2   0   0   0   0   0   0   0   0   1   0   0
1998:   0   0   0   0   0   0   0   0   0   0   1   0
> MannKendall(man.2AM.ts)
tau = 0.119,   sl =18.7%
> man.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   1   0   0   0   1   0   1   0   0
1993:   0   0   0   0   0   0   0   0   0   1   0   0
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   1   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   1   0   0   0   0   0   1   0
1997:   0   0   0   0   0   0   0   0   1   0   0   0
1998:   0   0   0   0   1   0   0   0   0   0   0   0
> MannKendall(man.3AM.ts)
tau = -0.0554,   sl =54.36%
```

Figure 2a. Time series line plot by hour

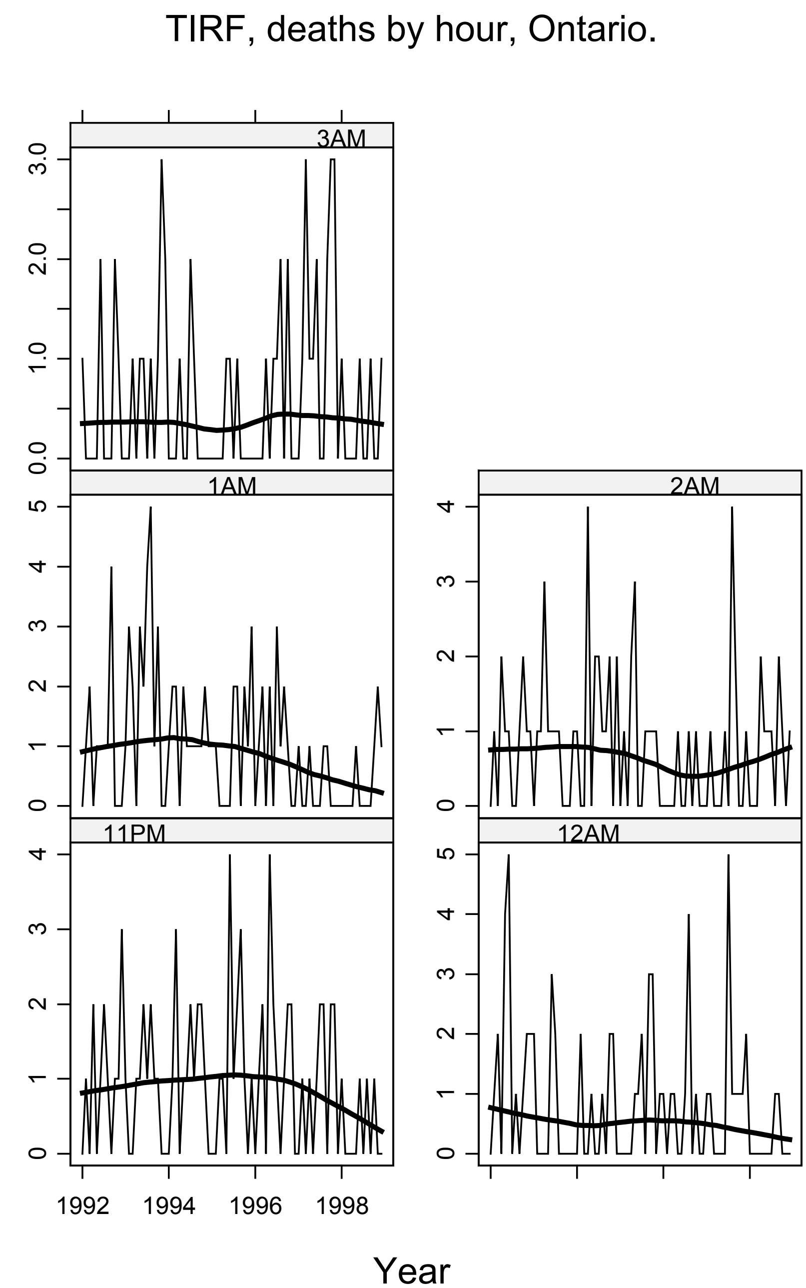
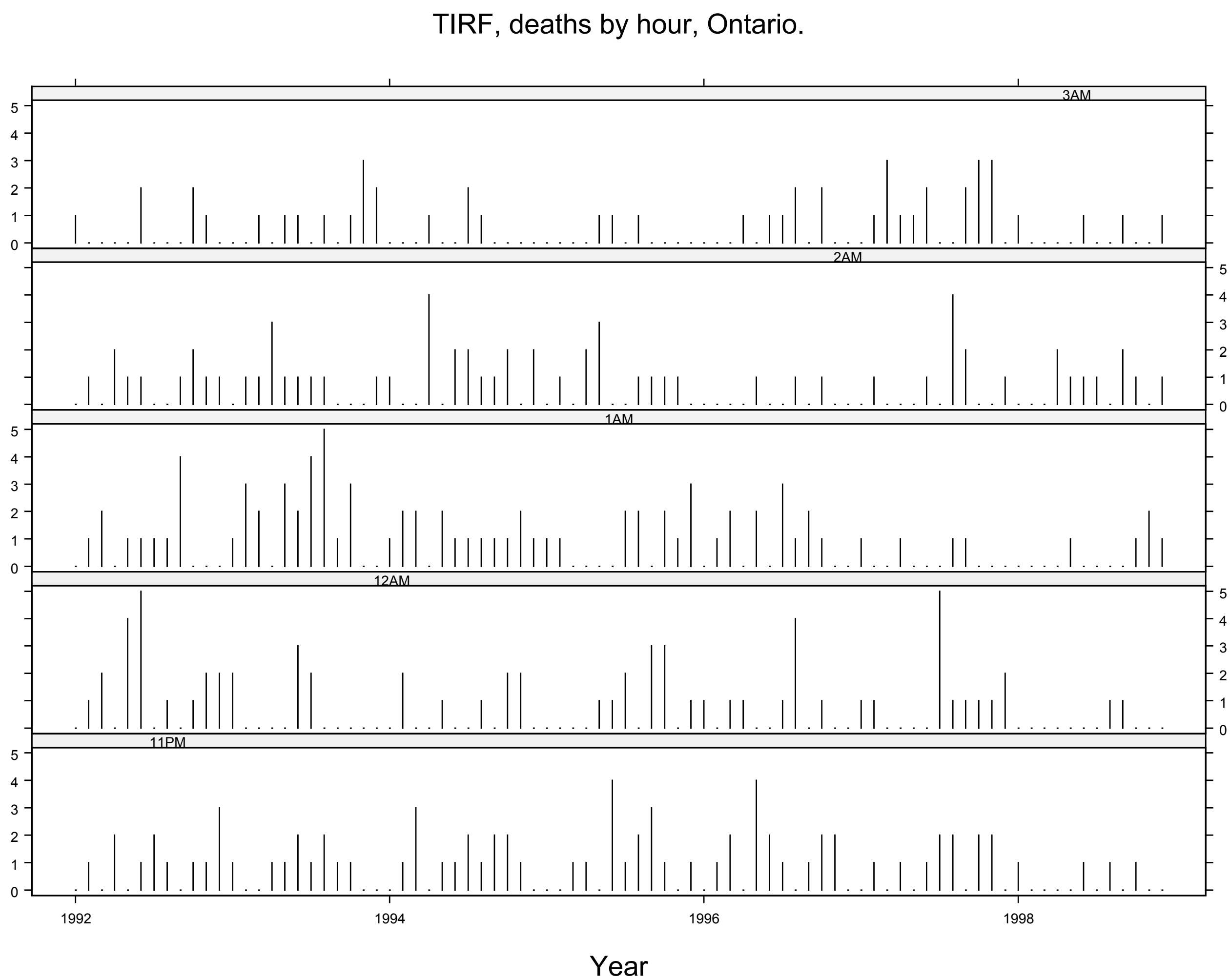


Figure 2b. Time series loess analysis by hour



3. Fatalities by wkgrp

```
> ont.ThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   2   2   2   2   1   2   0   3   2   0   4
1993:   1   2   2   2   0   4   3   3   0   2   1   2
1994:   1   3   3   2   1   1   2   1   1   0   0   1
1995:   0   2   1   0   2   4   1   2   5   2   0   2
1996:   0   2   2   0   1   1   3   3   2   4   0   0
1997:   2   1   1   0   0   1   3   5   2   4   0   2
1998:   0   0   0   1   1   0   0   1   1   0   0   2
> SeasonalMannKendall(ont.ThuSat.ts)
tau = -0.243,   sl =1.29%

> ont.SunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   2   2   2   4   9   1   3   2   4   5   2
1993:   3   2   2   2   6   5   5   6   2   3   2   1
1994:   1   2   2   3   3   3   5   4   3   7   5   2
1995:   1   0   0   3   3   2   4   4   2   5   2   3
1996:   1   0   3   2   6   2   3   5   1   3   2   0
1997:   0   3   2   3   1   3   4   3   4   2   6   1
1998:   2   0   0   1   1   3   1   1   3   3   2   1
> SeasonalMannKendall(ont.SunWed.ts)
tau = -0.228,   sl =1.836%

> sum(ont.SunWed.ts+ont.ThuSat.ts)
[1] 347
```

Figure 3a. Time series line plot by wkgrp

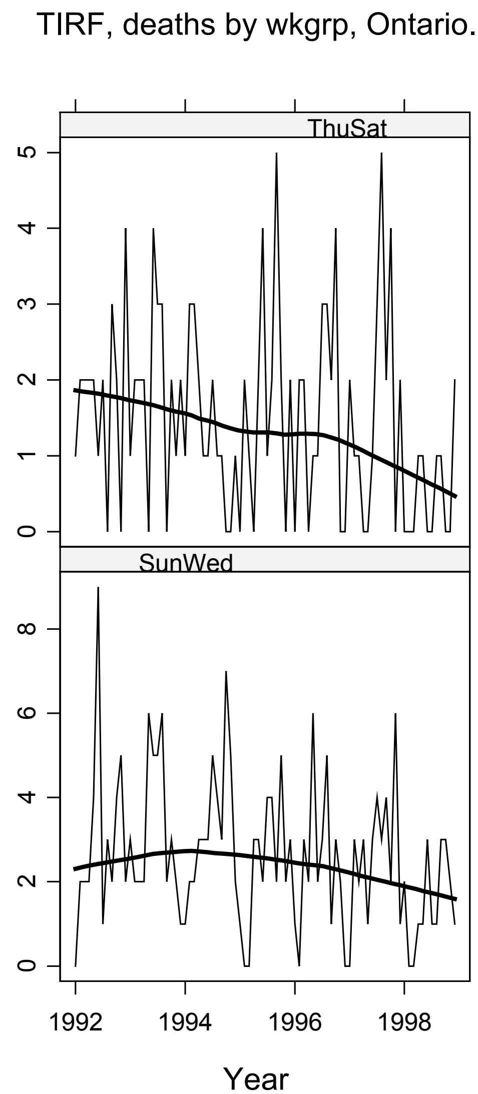
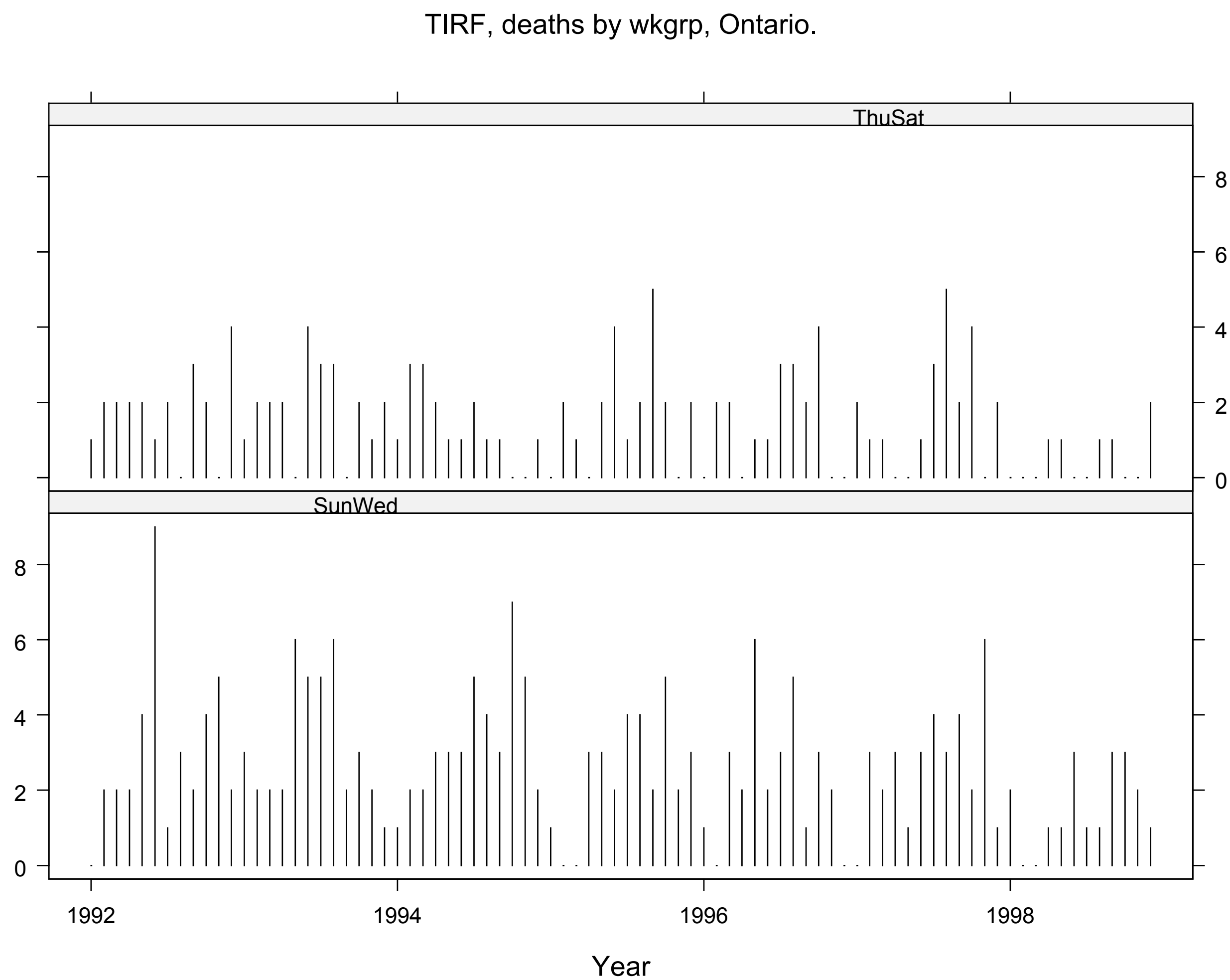


Figure 3b. Time series line plot.



4. Fatalities by hour and wkgrp

Figure 4a and 4b are the fatalities by wkgrp and hour. There are declining trends at 1AM in both weekgroups. At 2AM-ThuSat there is a downward trend. The other panels do not exhibit noticeable trends.

Figure 4a. Loess analysis

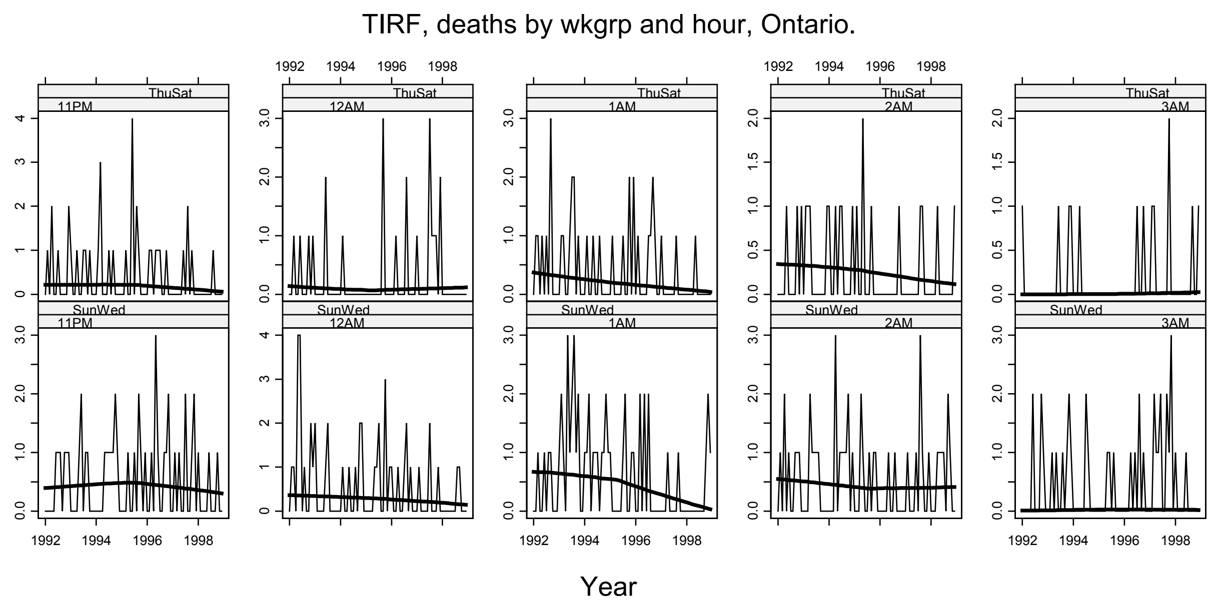


Figure 4b. Line plot of time series

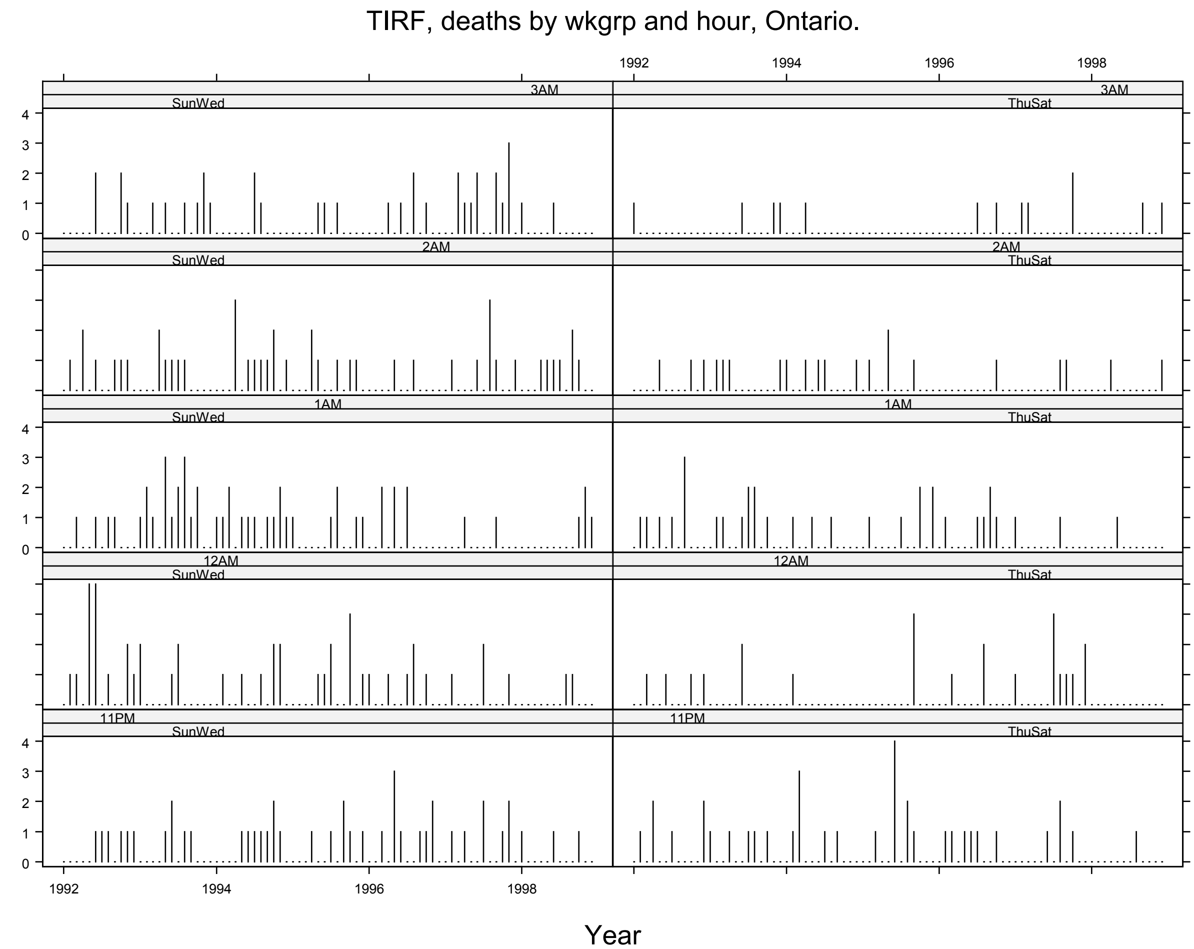


Table 5a to 5d

Monthly time series, deaths by province, hour and wkgrp. Mann-Kendall tests.

Ontario `12AMSunWed, 1AMSunWed` and `1AMThuSat` downward trend (<5%) and Manitoba 2AMSunWed upward trend (<5%).

Table 4a. Ontario-SunWed

```
> ont.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   1   1   1   0   1   1   1
1993:   0   0   0   0   1   2   0   1   1   0   0   0
1994:   0   0   0   0   1   1   1   1   1   2   1   0
1995:   0   0   0   1   0   0   1   0   2   1   0   1
1996:   0   0   1   0   3   1   0   0   1   1   2   0
1997:   0   1   0   1   0   0   2   0   0   1   2   0
1998:   1   0   0   0   0   1   0   0   0   1   0   0
> SeasonalMannKendall(ont.11PMSunWed.ts)
tau = -0.0605,   sl =55.25%
> ont.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   0   4   4   0   1   0   0   2   1
1993:   2   0   0   0   0   1   2   0   0   0   0   0
1994:   0   1   0   0   1   0   0   1   0   2   2   0
1995:   0   0   0   0   1   1   2   0   0   3   0   1
1996:   1   0   0   1   0   0   1   2   0   1   0   0
1997:   0   1   0   0   0   0   2   0   0   0   1   0
1998:   0   0   0   0   0   0   0   1   1   0   0   0
> SeasonalMannKendall(ont.12AMSunWed.ts)
tau = -0.207,   sl = 4.165%
> ont.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   1   0   1   1   0   0   0
1993:   1   2   1   0   3   1   2   3   1   2   0   0
1994:   1   1   2   0   1   1   1   0   1   1   2   1
1995:   1   0   0   0   0   0   1   2   0   0   1   1
1996:   0   0   2   0   2   0   2   0   0   0   0   0
1997:   0   0   0   1   0   0   0   0   1   0   0   0
1998:   0   0   0   0   0   0   0   0   0   1   2   1
> SeasonalMannKendall(ont.1AMSunWed.ts)
tau = -0.239,   sl = 1.727%
> ont.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   2   0   1   0   0   1   1   1   0
1993:   0   0   0   2   1   1   1   1   0   0   0   0
1994:   0   0   0   3   0   1   1   1   1   2   0   1
1995:   0   0   0   2   1   0   0   1   0   1   1   0
1996:   0   0   0   0   1   0   0   1   0   0   0   0
1997:   0   1   0   0   0   1   0   3   1   0   0   1
1998:   0   0   0   1   1   1   1   0   2   1   0   0
> SeasonalMannKendall(ont.2AMSunWed.ts)
tau = -0.0434,   sl =69.51%
> ont.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   2   0   0   0   2   1   0
1993:   0   0   1   0   1   0   0   1   0   1   2   1
1994:   0   0   0   0   0   0   2   1   0   0   0   0
1995:   0   0   0   0   1   1   0   1   0   0   0   0
1996:   0   0   0   1   0   1   0   2   0   1   0   0
1997:   0   0   2   1   1   2   0   0   2   1   3   0
1998:   1   0   0   0   0   1   0   0   0   0   0   0
> SeasonalMannKendall(ont.3AMSunWed.ts)
tau = 0.0247,   sl =81.7%
```

Table 5b. Ontario-ThuSat

```
ont.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   2   0   0   1   0   0   0   0   2
1993:   1   0   0   1   0   0   1   1   0   1   0   0
1994:   0   1   3   0   0   0   1   0   1   0   0   0
1995:   0   0   1   0   0   4   0   2   1   0   0   0
1996:   0   1   1   0   1   1   1   0   0   1   0   0
1997:   0   0   0   0   0   1   0   2   0   1   0   0
1998:   0   0   0   0   0   0   0   1   0   0   0   0
> MannKendall(ont.11PMThuSat.ts)
tau = -0.125,   sl =15.5%
> ont.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   1   0   0   0   1   0   1
1993:   0   0   0   0   0   2   0   0   0   0   0   0
1994:   0   1   0   0   0   0   0   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   3   0   0   0
1996:   0   0   1   0   0   0   0   2   0   0   0   0
1997:   1   0   0   0   0   0   3   1   1   1   0   2
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(ont.12AMThuSat.ts)
tau = 0.00359,   sl =97.22%
> ont.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   0   1   0   1   0   3   0   0   0
1993:   0   1   1   0   0   1   2   2   0   1   0   0
1994:   0   1   0   0   1   0   0   1   0   0   0   0
1995:   0   1   0   0   0   0   1   0   0   2   0   2
1996:   0   1   0   0   0   0   1   1   2   1   0   0
1997:   1   0   0   0   0   0   0   1   0   0   0   0
1998:   0   0   0   0   1   0   0   0   0   0   0   0
> MannKendall(ont.1AMThuSat.ts)
tau = -0.192,   sl =2.867%
> ont.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   1   0   0   0   0   1   0   1
1993:   0   1   1   1   0   0   0   0   0   0   0   1
1994:   1   0   0   1   0   1   1   0   0   0   0   1
1995:   0   1   0   0   2   0   0   0   1   0   0   0
1996:   0   0   0   0   0   0   0   0   0   1   0   0
1997:   0   0   0   0   0   0   0   1   1   0   0   0
1998:   0   0   0   1   0   0   0   0   0   0   0   1
> MannKendall(ont.2AMThuSat.ts)
tau = -0.114,   sl =20.46%
> ont.3AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   1   0   0   0   0   1   1
1994:   0   0   0   1   0   0   0   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   1   0   0   1   0   0
1997:   0   1   1   0   0   0   0   0   0   2   0   0
1998:   0   0   0   0   0   0   0   0   1   0   0   1
> MannKendall(ont.3AMThuSat.ts)
tau = 0.0693,   sl =44.35%
```

Table 5c. Manitoba-SunWed

```
man.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   1   0   0   0   1   0   0   0
1994:   0   0   0   0   0   0   0   3   1   1   0   0
1995:   0   0   0   0   1   0   0   0   0   0   0   0
1996:   1   0   0   0   0   1   0   0   0   0   0   0
1997:   1   0   0   0   0   0   2   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.11PMSunWed.ts)
tau = -0.0179,   sl =84.69%
> man.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   1   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   1   0   0   1   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   1
1996:   0   1   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   1   0   0   0   0   1   0
> MannKendall(man.12AMSunWed.ts)
tau = 0.0489,   sl =59.33%
> man.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   2   1   0   0   0   0
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   1   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   1   0   0   0   0
1997:   0   0   0   0   1   0   0   0   0   0   1   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.1AMSunWed.ts)
tau = 0.0195,   sl =83.5%
> man.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   1   0
1997:   2   0   0   0   0   0   0   0   0   1   0   0
1998:   0   0   0   0   0   0   0   0   0   0   1   0
> MannKendall(man.2AMSunWed.ts)
tau = 0.193,   sl =3.221%
> man.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   1   0   0   0   1   0   1   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   1   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   1   0   0   0   0   0   1   0
1997:   0   0   0   0   0   0   0   0   1   0   0   0
1998:   0   0   0   0   1   0   0   0   0   0   0   0
> MannKendall(man.3AMSunWed.ts)
tau = -0.0302,   sl =74.32%
```

Table 5d. Manitoba-ThuSat

```
man.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   0   0   0   1   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   1   0   1   1   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.11PMThuSat.ts)
tau = 0.138,   sl =12.78%
> man.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   0   1   0   0   0   0
1995:   0   0   0   0   0   0   1   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.12AMThuSat.ts)
tau = -0.0265,   sl =78.05%
> man.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   1   0
1993:   0   0   0   0   0   0   0   0   0   1   0   1
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   1   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.1AMThuSat.ts)
tau = -0.108,   sl =23.53%
> man.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   1   0
1994:   0   0   0   0   0   0   0   0   0   0   1   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.2AMThuSat.ts)
tau = -0.0714,   sl =43.69%
> man.3AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   1   0   0
1994:   0   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(man.3AMThuSat.ts)
tau = -0.0762,   sl =40.95%
```

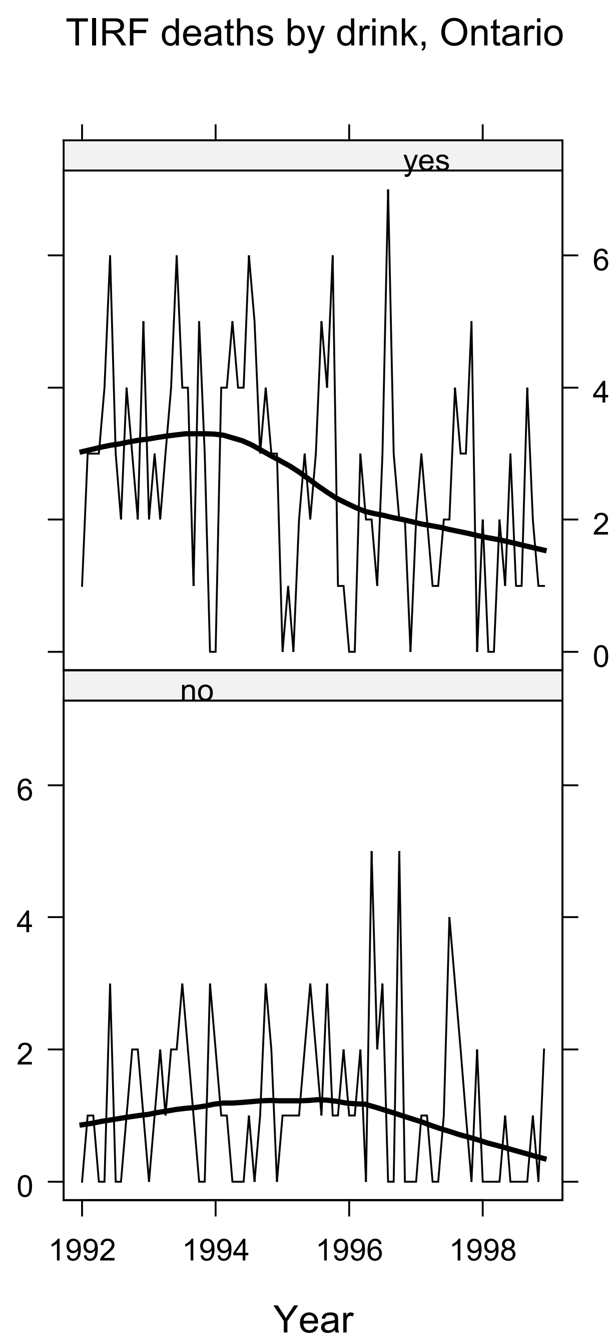
6. Fatalities by drink

Table 6. Time series tabulation and Mann-Kendall trend test for fatalities by province (ont or man) and drinking class (yes or no)

```
> ont.yes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   3   3   3   4   6   3   2   4   3   2   5
1993:   2   3   2   3   4   6   4   4   1   5   3   0
1994:   0   4   4   5   4   4   6   5   3   4   3   3
1995:   0   1   0   2   3   2   3   5   4   6   1   1
1996:   0   0   3   2   2   1   3   7   3   2   2   0
1997:   2   3   2   1   1   2   2   4   3   3   5   0
1998:   2   0   0   2   1   3   1   1   4   2   1   1
> SeasonalMannKendall(ont.yes.ts)
tau = -0.336,   sl =0.0459%
> ont.no.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   0   0   3   0   0   1   2   2   1
1993:   0   1   2   1   2   2   3   2   1   0   0   3
1994:   2   1   1   0   0   0   1   0   1   3   2   0
1995:   1   1   1   1   2   3   2   1   3   1   1   2
1996:   1   1   2   0   5   2   3   0   0   5   0   0
1997:   0   1   1   0   0   1   4   3   2   1   0   2
1998:   0   0   0   0   1   0   0   0   0   1   0   2
> SeasonalMannKendall(ont.no.ts)
tau = -0.147,   sl =13.3%
> man.yes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   1   0   0   1   1   0   1   0   0
1993:   0   0   0   0   1   0   2   1   1   2   0   1
1994:   0   0   0   0   0   0   1   3   0   3   1   0
1995:   0   1   1   0   1   0   0   0   0   0   0   1
1996:   0   0   0   0   1   1   0   1   0   0   2   0
1997:   2   0   0   0   0   0   1   1   0   2   2   0
1998:   0   0   0   0   1   1   0   0   0   0   2   0
> SeasonalMannKendall(man.yes.ts)
tau = -0.029,   sl =77.77%
> man.no.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   1   0
1993:   0   0   0   0   0   0   0   0   0   0   1   0
1994:   0   0   0   0   0   0   0   1   1   0   0   0
1995:   0   0   0   0   0   0   1   0   0   0   0   0
1996:   1   1   0   0   0   0   0   1   0   0   0   0
1997:   1   0   0   0   1   0   1   0   1   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> SeasonalMannKendall(man.no.ts)
tau = 0.0843,   sl =53.38%
```

Figure 5.

Figure 5 shows that in Ontario there was a marked downward trend starting around 1994 in fatalities with drink=yes. . The number of fatalities in Ontario with drink=no has also started to decline since about 1995 or 1996.



6. Fatalities by drink and hour

Figure 6, fatalities by hour, drink and province. In each hour slot the accidents are larger in drinking alcohol group than no drinking alcohol group. There is an increasing trend in Ontario in the 2AM slot and decreasing trends at 11PM, 12AM and 1AM.

```
> ont.11PMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   1   0   0   0   0   0   1
1993:   0   0   0   0   1   1   0   1   1   0   0   0
1994:   0   0   1   0   0   0   0   0   1   1   0   0
1995:   0   0   1   1   0   3   0   1   1   0   0   0
1996:   0   1   0   0   4   1   0   0   0   1   0   0
1997:   0   0   0   0   0   1   0   1   0   1   0   0
1998:   0   0   0   0   0   0   0   0   0   1   0   0
> MannKendall(ont.11PMno.ts)
tau = -0.0276,   sl =76.11%
> ont.12AMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   0   0   1   0   0   0   1   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   0   0   0   0   0   0   0   0   0   1   1   0
1995:   0   0   0   0   0   0   1   0   1   0   0   0
1996:   1   0   1   0   0   0   0   0   0   1   0   0
1997:   0   1   0   0   0   0   4   0   1   0   0   1
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(ont.12AMno.ts)
tau = -0.0277,   sl =76.17%
> ont.1AMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   1   0   0   1   0   0   0
1993:   0   1   1   0   1   1   2   1   0   0   0   0
1994:   1   1   0   0   0   0   0   0   0   1   1   0
1995:   1   1   0   0   0   0   1   0   0   1   1   2
1996:   0   0   1   0   1   0   2   0   0   1   0   0
1997:   0   0   0   0   0   0   0   1   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   1
> MannKendall(ont.1AMno.ts)
tau = -0.127,   sl =15.37%
> ont.2AMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   1   1   0
1993:   0   0   1   1   0   0   1   0   0   0   0   1
1994:   1   0   0   0   0   0   0   0   0   0   0   0
1995:   0   0   0   0   2   0   0   0   1   0   0   0
1996:   0   0   0   0   0   0   0   0   0   0   0   0
1997:   0   0   0   0   0   0   0   1   1   0   0   1
1998:   0   0   0   0   1   0   0   0   0   0   0   0
> MannKendall(ont.2AMno.ts)
tau = -0.0659,   sl =46.61%
> ont.3AMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   0   0   1   0
1993:   0   0   0   0   0   0   0   0   0   0   0   2
1994:   0   0   0   0   0   0   1   0   0   0   0   0
1995:   0   0   0   0   0   0   0   0   0   0   0   0
1996:   0   0   0   0   0   1   1   0   0   2   0   0
1997:   0   0   1   0   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   1
> MannKendall(ont.3AMno.ts)
tau = 0.0531,   sl =55.78%
```

```
ont.11PMyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   1   0   0   2   1   0   1   1   2
1993:   1   0   0   1   0   1   1   0   0   1   0   0
1994:   0   1   2   0   1   1   2   1   1   1   1   0
1995:   0   0   0   0   0   1   1   1   2   1   0   0
1996:   0   0   2   0   0   1   1   0   1   1   2   0
1997:   0   1   0   0   0   0   1   1   0   0   1   0
1998:   1   0   0   0   0   1   0   1   0   0   0   0
> MannKendall(ont.11PMyes.ts)
tau = -0.153,   sl =8.147%
> ont.12AMyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   3   3   0   1   0   0   1   2
1993:   0   0   0   0   0   3   1   0   0   0   0   0
1994:   0   2   0   0   1   0   0   1   0   1   1   0
1995:   0   0   0   0   1   1   1   0   2   3   0   1
1996:   0   0   0   1   0   0   1   4   0   0   0   0
1997:   1   0   0   0   0   0   1   0   0   1   1   0
1998:   0   0   0   0   0   0   0   0   1   0   0   0
> MannKendall(ont.12AMyes.ts)
tau = -0.129,   sl =13.79%
> ont.1AMyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   2   0   1   0   1   0   3   0   0   0
1993:   1   2   1   0   2   0   2   3   1   3   0   0
1994:   0   1   2   0   2   1   1   1   1   0   1   1
1995:   0   0   0   0   0   0   1   2   0   1   0   0
1996:   0   0   1   0   1   0   1   0   2   0   0   0
1997:   1   0   0   1   0   0   0   0   0   0   0   0
1998:   0   0   0   0   1   0   0   0   0   1   1   0
> MannKendall(ont.1AMyes.ts)
tau = -0.257,   sl =0.2899%
> ont.2AMyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   2   0   1   0   0   1   0   0   1
1993:   0   1   0   2   1   1   0   0   0   0   0   0
1994:   0   0   0   4   0   2   2   1   1   2   0   2
1995:   0   1   0   2   1   0   0   1   0   1   1   0
1996:   0   0   0   0   1   0   0   1   0   1   0   0
1997:   0   1   0   0   0   0   0   3   1   0   0   0
1998:   0   0   0   2   0   1   1   0   2   1   0   1
> MannKendall(ont.2AMyes.ts)
tau = -0.0267,   sl =76.04%
> ont.3AMyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   0   0   2   0   0   0   2   0   0
1993:   0   0   1   0   1   1   0   1   0   1   3   0
1994:   0   0   0   1   0   0   1   1   0   0   0   0
1995:   0   0   0   0   1   0   0   1   0   0   0   0
1996:   0   0   0   1   0   0   0   2   0   0   0   0
1997:   0   1   2   0   1   2   0   0   2   2   3   0
1998:   1   0   0   0   0   1   0   0   1   0   0   0
> MannKendall(ont.3AMyes.ts)
tau = 0.0195,   sl =82.67%
```

Figure 6a. Loess Analysis

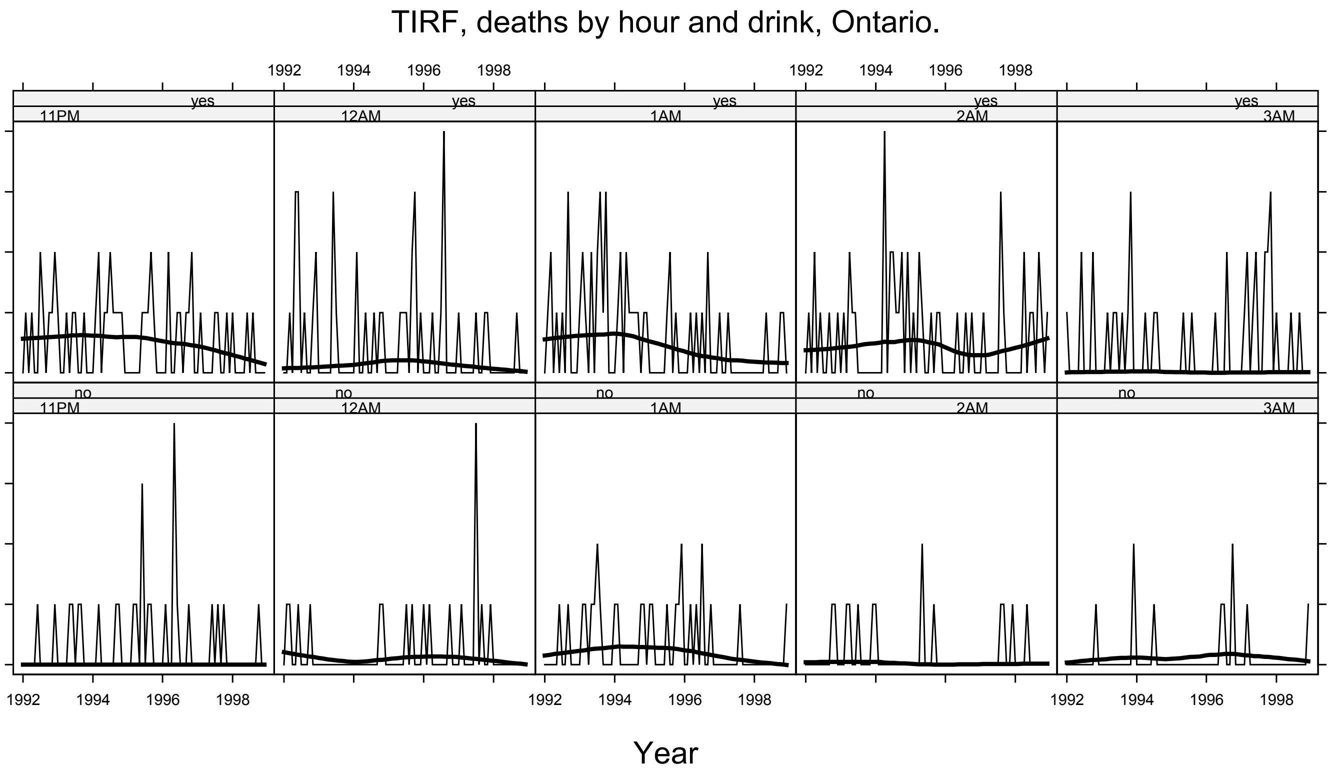
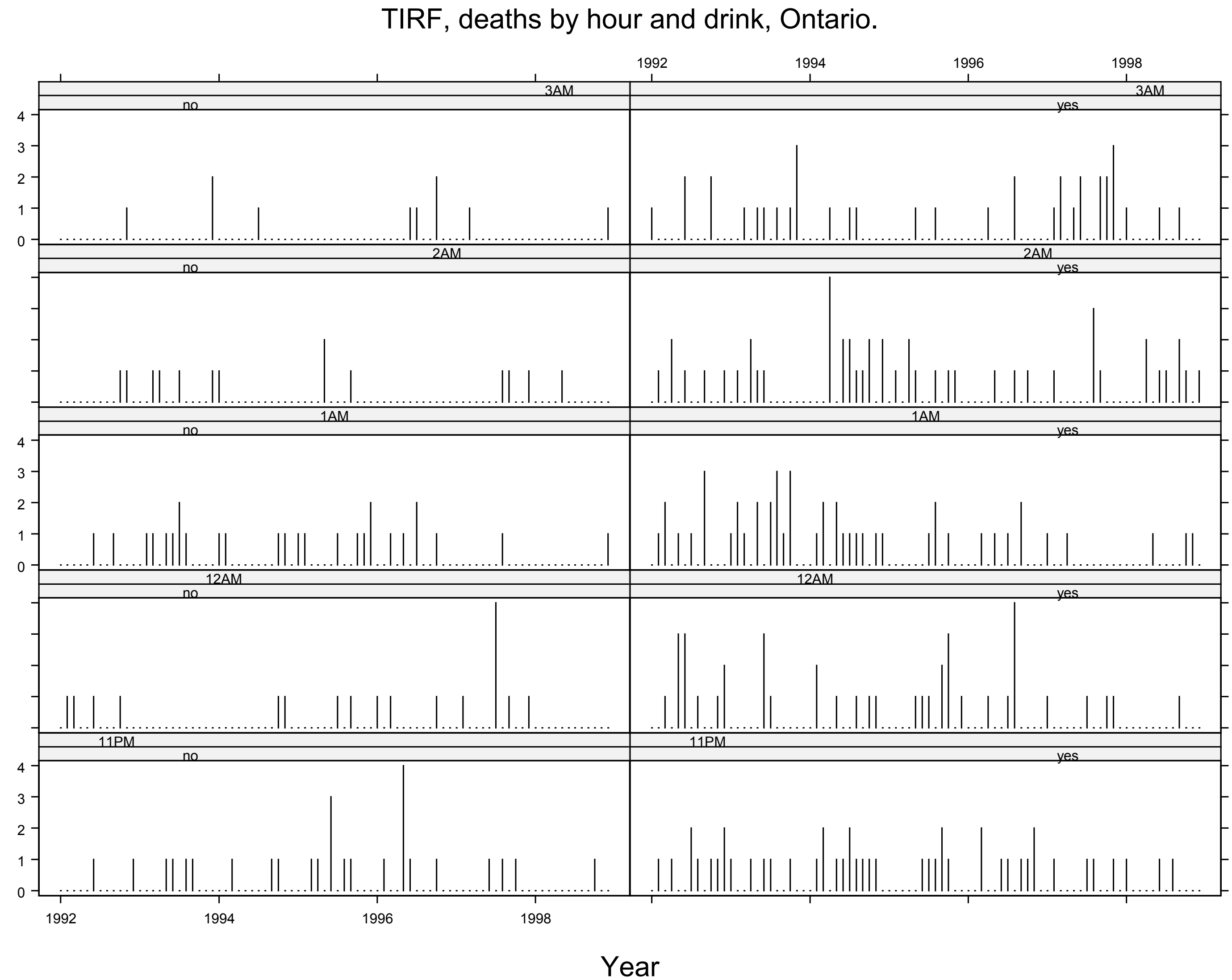


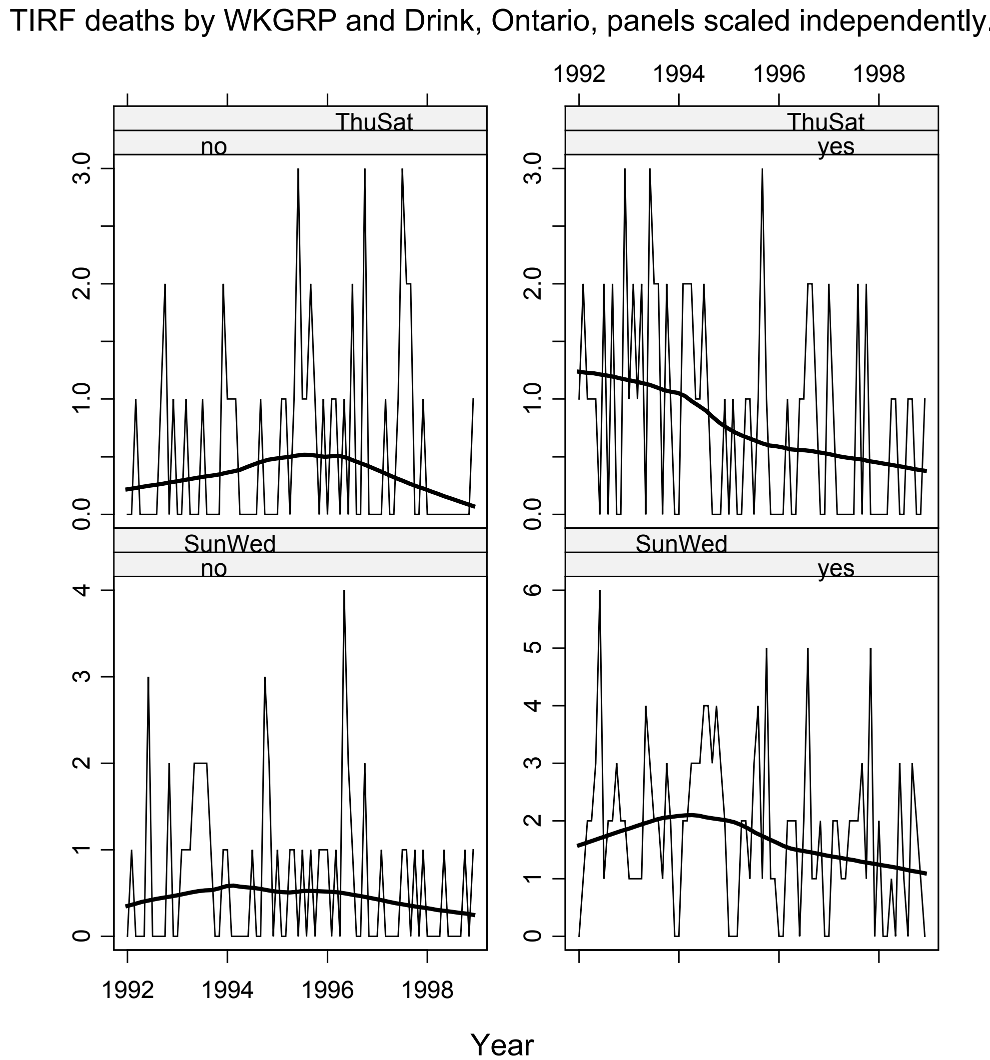
Figure 6b. Line plot of time series



7. Fatalities by drink and wkgrp

```
> ont.SunWedno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   0   0   3   0   0   0   0   2   0
1993:   0   1   1   1   2   2   2   2   1   0   0   1
1994:   1   0   0   0   0   0   1   0   0   3   2   0
1995:   1   0   0   1   1   0   1   0   1   0   1   1
1996:   1   0   1   0   4   2   1   0   0   2   0   0
1997:   0   1   0   0   0   0   1   1   0   1   0   1
1998:   0   0   0   0   1   0   0   0   0   1   0   1
> MannKendall(ont.SunWedno.ts)
tau = -0.0886,   sl =30.53%
> ont.ThuSatno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   0   0   0   1   2   0   1
1993:   0   0   1   0   0   0   1   0   0   0   0   2
1994:   1   1   1   0   0   0   0   0   1   0   0   0
1995:   0   1   1   0   1   3   1   1   2   1   0   1
1996:   0   1   1   0   1   0   2   0   0   3   0   0
1997:   0   0   1   0   0   1   3   2   2   0   0   1
1998:   0   0   0   0   0   0   0   0   0   0   0   1
> MannKendall(ont.ThuSatno.ts)
tau = 0.0129,   sl =88.56%
> ont.1AMno.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   1   0   0   1   0   0   0
1993:   0   1   1   0   1   1   2   1   0   0   0   0
1994:   1   1   0   0   0   0   0   0   0   1   1   0
1995:   1   1   0   0   0   0   1   0   0   1   1   2
1996:   0   0   1   0   1   0   2   0   0   1   0   0
1997:   0   0   0   0   0   0   0   1   0   0   0   0
1998:   0   0   0   0   0   0   0   0   0   0   0   1

ont.SunWedyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   2   2   3   6   1   2   2   3   2   2
1993:   1   1   1   1   4   3   2   2   1   3   2   0
1994:   0   2   2   3   3   3   4   4   3   4   3   2
1995:   0   0   0   2   2   1   3   4   1   5   1   1
1996:   0   0   2   2   2   0   2   5   1   1   2   0
1997:   0   2   2   1   1   2   2   2   3   1   5   0
1998:   2   0   0   1   0   3   1   0   3   2   1   0
> MannKendall(ont.SunWedyes.ts)
tau = -0.147,   sl =7.105%
> ont.ThuSatyes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   2   1   1   1   0   2   0   2   0   0   3
1993:   1   2   1   2   0   3   2   2   0   2   1   0
1994:   0   2   2   2   1   1   2   1   0   0   0   1
1995:   0   1   0   0   1   1   0   1   3   1   0   0
1996:   0   0   1   0   0   1   1   2   2   1   0   0
1997:   2   1   0   0   0   0   0   2   0   2   0   0
1998:   0   0   0   1   1   0   0   1   1   0   0   1
> MannKendall(ont.ThuSatyes.ts)
tau = -0.239,   sl =0.4885%
```

Figure 7. The comparisons between driving with drink and without drink within drink factor, and between `ThuSat` and `SunWed` within `wkgrp` factor are shown in Fig 3. There are more fatalities with drink=yes and there are are more accidents in `SunWed`. In Ontario, both `SunWed` and `ThuSat` have a downward trend.



8. Annual Time Series

Table 8a. Annual fatalities, Ontario and Manitoba. There are 347 deaths in Ontario and 53 in Manitoba. The death rate for Total in Ontario has declined from 57 to 24 which represents an average annual rate of decrease of about 13%.

```
> tirf.annual.ont
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992    57   12   18  11  10   6     36     21
1993    61   10    7  24  10  10     39     22
1994    56   14    8  15  15   4     40     16
1995    50   14   11  12  10   3     29     21
1996    46   15    9  12   3   7     28     18
1997    53   11   13   4   9  16     32     21
1998    24    4    2   5   9   4     18      6
> MannKendallMatrix(tirf.annual.ont)
    Total   PM11   AM12    AM1    AM2 AM3 SunWed ThuSat
tau -0.71  -0.10  -0.14  -0.49  -0.48   0  -0.52  -0.41
sl%  3.55  87.93  76.39  17.16  20.40 100  13.31  27.23



tirf.annual.man
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992     5    0    1   1   0   3      4      1
1993     9    2    0   5   1   1      5      4
1994    10    6    3   0   1   0      7      3
1995     5    1    2   1   0   1      4      1
1996     8    2    1   2   1   2      7      1
1997    12    6    0   2   3   1      9      3
1998     4    0    2   0   1   1      4      0
> MannKendallMatrix(tirf.annual.man)
    Total  PM11 AM12    AM1   AM2    AM3 SunWed ThuSat
tau     0  0.10    0  -0.10  0.47  -0.17   0.26  -0.37
sl%   100 87.64  100  87.64 23.45  73.77  52.54  34.08

Annual rate of decline in Total fatalities in Ontario
> 1-(24/57)^(1/6)
[1] 0.1342562
```

Tables 8b(i)-(iv). Annual total fatalities are decomposed by hour, wkgrp and drink for Ontario and Manitoba. Table 8b might suggest that there has been a shift in fatalities from early evening to late evening starting around 1996. The Mann-Kendall trend test is statistically significant on a two-sided test for Ontario fatalities with drink=yes for Total, 11PM, 1AM, SunWed and ThuSat and in all cases the sign of tau indicates a downward trend. The trend test is not significant for drink=no in Ontario. There are no trends in Manitoba for either drink=yes or drink=no.

Table 8b(i). Annual Fatalities, Ontario, drink=no

```
> tirf.drink.no.annual.ont[,-1]
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992    11    2    4   2   2   1      6      5
1993    17    4    0   7   4   2     13      4
1994    11    3    2   4   1   1      7      4
1995    19    7    2   7   3   0      7     12
1996    19    7    3   5   0   4     11      8
1997    15    3    7   1   3   1      5     10
1998     4    1    0   1   1   1      3      1
> MannKendallAnnual(tirf.drink.no.annual.ont[,-1])
          Total        PM11       AM12        AM1        AM2         AM3     SunWed ThuSat
tau -0.05006262 -0.05006262 0.05006262 -0.3504383 -0.2503131 -0.05634362 -0.3903600      0
 sl  1.00000000  1.00000000 1.00000000  0.3564410  0.5387009  1.00000000  0.2876112      1
```

Table 8b(ii). Annual Fatalities, Ontario, drink=yes

```
> tirf.drink.yes.annual.ont[,-1]
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992    39    9   11   8   6   5     26     13
1993    37    5    4  15   5   8     21     16
1994    45   11    6  11  14   3     33     12
1995    28    6    9   4   7   2     20      8
1996    25    8    6   5   3   3     17      8
1997    28    4    4   2   5  13     21      7
1998    18    3    1   3   8   3     13      5
> MannKendallAnnual(tirf.drink.yes.annual.ont[,-1])
         Total        PM11       AM12         AM1 AM2        AM3      SunWed       ThuSat
tau -0.6831300 -0.52380949 -0.5506887 -0.61904758   0 -0.1028689 -0.58554000 -0.878310025
 sl  0.0482861  0.06904757  0.1243064  0.03015876   1  0.8753926  0.09471773  0.009809151
```

Table 8b(iii). Annual Fatalities, Manitoba, drink=no

```
> tirf.drink.no.annual.man[,-1]
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992     1    0    0   1   0   0      0      1
1993     1    0    0   0   1   0      0      1
1994     2    2    0   0   0   0      2      0
1995     1    0    1   0   0   0      0      1
1996     3    1    1   1   0   0      3      0
1997     4    1    0   1   1   1      4      0
1998     0    0    0   0   0   0      0      0
> MannKendallAnnual(tirf.drink.no.annual.man[,-1])
        Total      PM11      AM12 AM1 AM2       AM3    SunWed     ThuSat
tau 0.2057378 0.1166424 0.1380131   0   0 0.3563483 0.3944053 -0.6299408
 sl 0.6380424 0.8651347 0.8464506   1   1 0.4532547 0.3150597  0.1116118
```

Table 8b(iv). Annual Fatalities, Manitoba, drink=yes

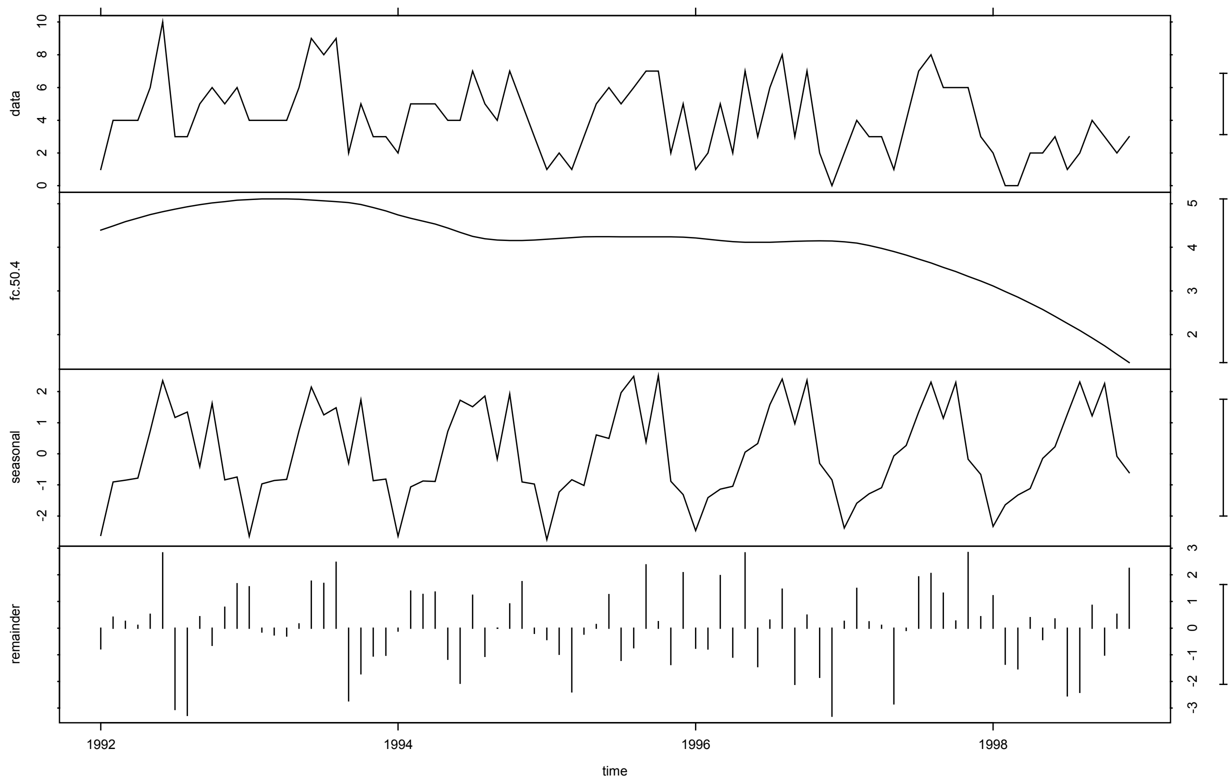
```
> tirf.drink.yes.annual.man[,-1]
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1992     4    0    1   0   0   3      4      0
1993     8    2    0   5   0   1      5      3
1994     8    4    3   0   1   0      5      3
1995     4    1    1   1   0   1      4      0
1996     5    1    0   1   1   2      4      1
1997     8    5    0   1   2   0      5      3
1998     4    0    2   0   1   1      4      0
> MannKendallAnnual(tirf.drink.yes.annual.man[,-1])
          Total       PM11        AM12         AM1       AM2        AM3     SunWed      ThuSat
tau -0.05634362 0.05006262 -0.05292561 -0.05634362 0.6197798 -0.2646281 -0.1259882 -0.05634362
 sl  1.00000000 1.00000000  1.00000000  1.00000000 0.1001784  0.5253584  0.8596838  1.00000000
```

9. STL Analysis

R-sq = 53.9 %

Figure 9a.

STL TIRF deaths, Ontario



ss.window = 7 ,ss.robust = TRUE , fc.window = 50.4 , fc.degree = 2

Figure 9b. Monthplot of Seasonal Component. May through October are high and November through April are relatively lower. Upward trends exist in August and September and to a lesser extent in January and November.

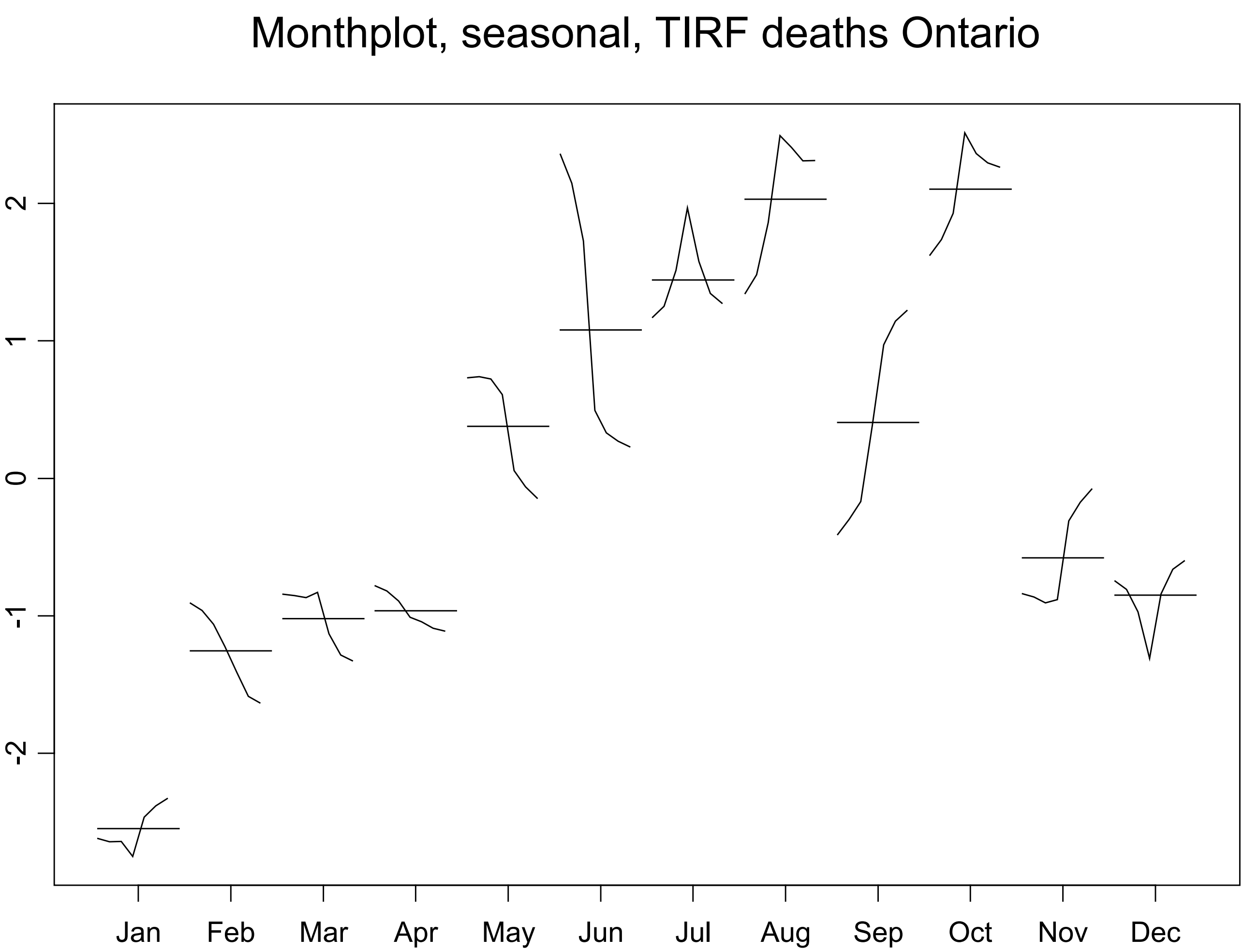
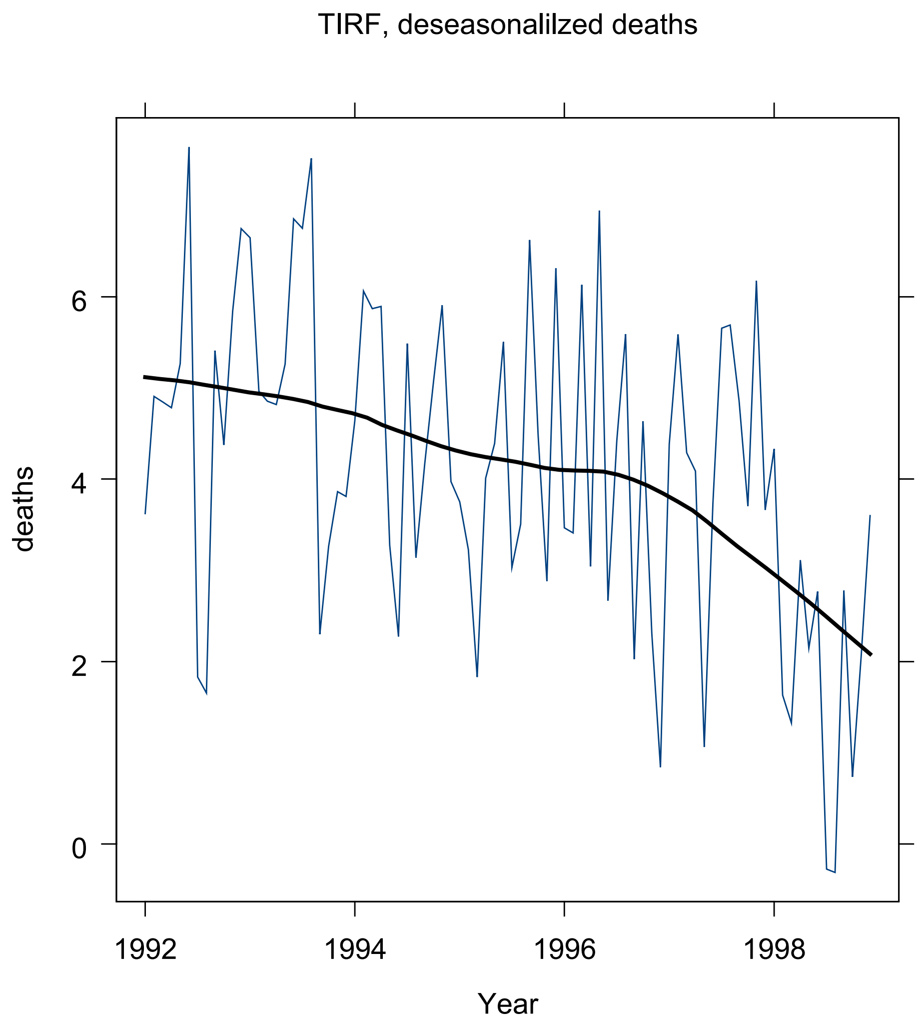


Figure 9c. Loess trend analysis of deseasonalized TIRF.

```
tau = -0.28,   sl =0.01655%
```

The loess trend line has decreased from a monthly death-rate of 4.32 in January 1992 to 1.78 in December 1998. This corresponds to an annual rate of decrease of 12%.

```
> pc.change(tirf.deseasonalized.ts)
[1]  5.117620  2.086254 59.233909
> 1-(2.086254/5.117620)^(1/7)
[1] 0.1203124
```



C. TIRF All Hours - Crosstabs

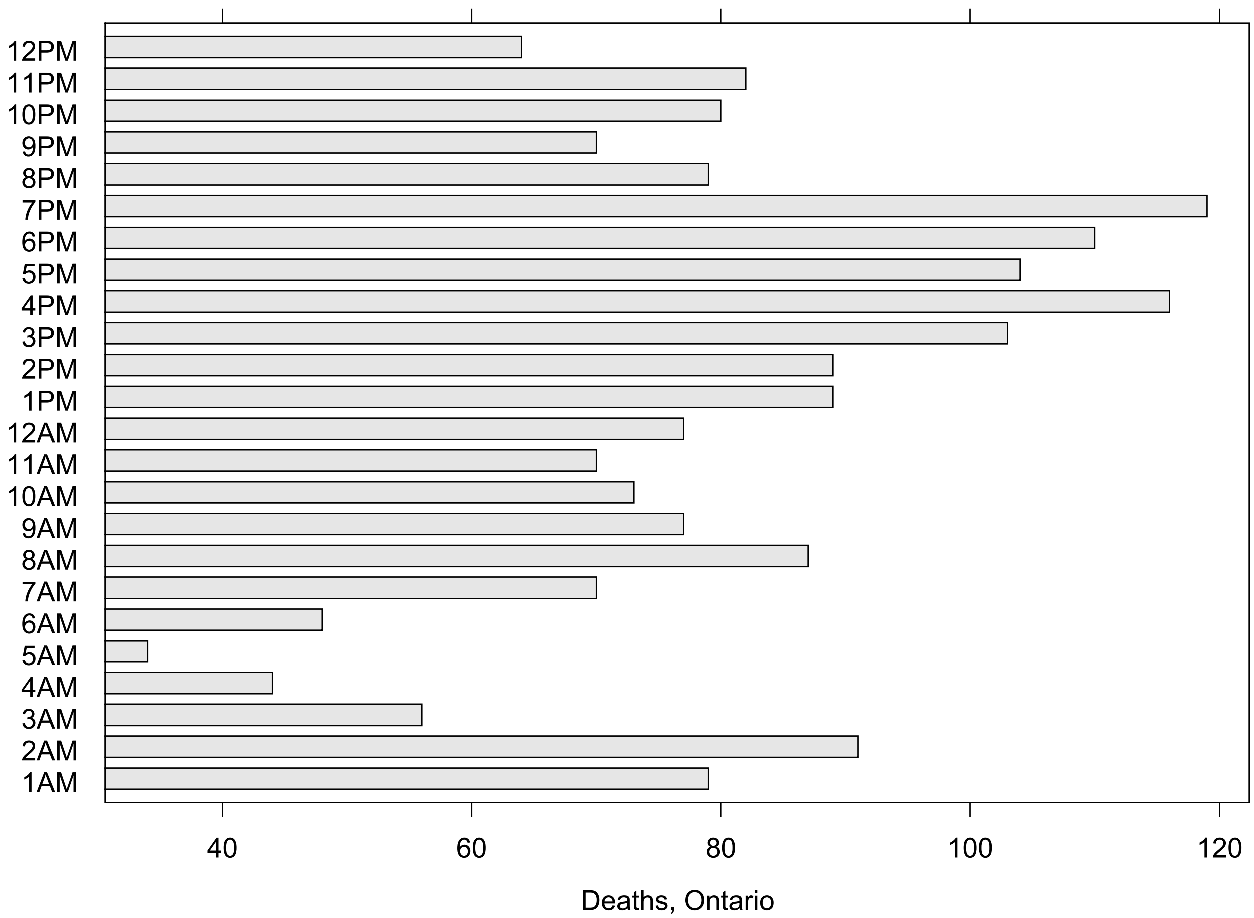
Frequency Analysis of Drink Variable

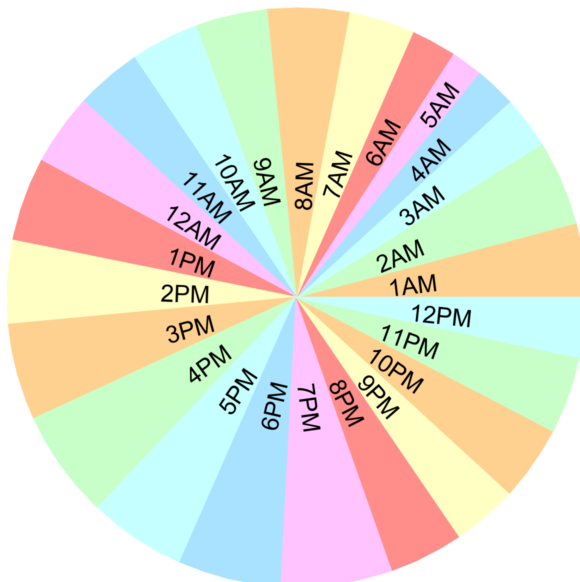
In Ontario out of a total of 375 cases, there are 44 cases where `drink=unknown` and only 2 cases in Manitoba. Thus in Ontario there remain 331 cases.

```
>crosstabs(~drink, data=tirf.df, subset=province=="Ontario", na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink, data = tirf.df, subset = province == "Ontario",
       na.action = na.exclude)
375 cases in table
+-------+
|N      |
|N/Total|
+-------+
drink  |
-------+-------+
unknown| 44    |
       |0.12   |
-------+-------+
no     |107    |
       |0.29   |
-------+-------+
yes    |224    |
       |0.6    |
-------+-------+
> crosstabs(~drink, data=tirf.df, subset=province=="Manitoba", na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink, data = tirf.df, subset = province == "Manitoba", na.action
= na.exclude)
58 cases in table
+-------+
|N      |
|N/Total|
+-------+
drink  |
-------+-------+
unknown| 2     |
       |0.034  |
-------+-------+
no     |12     |
       |0.21   |
-------+-------+
yes    |44     |
       |0.76   |
-------+-------+
```

Frequency Analysis of Hour Variable
Ontario

```
> barchart.hour()
 1AM 2AM 3AM 4AM 5AM 6AM 7AM 8AM 9AM 10AM 11AM 12AM 1PM 2PM 3PM 4PM 5PM 6PM 7PM 8PM 9PM 10PM 11PM 12PM
  79  91  56  44  34  48  70  87  77   73   70   77  89  89 103 116 104 110 119  79  70   80   82   64
```

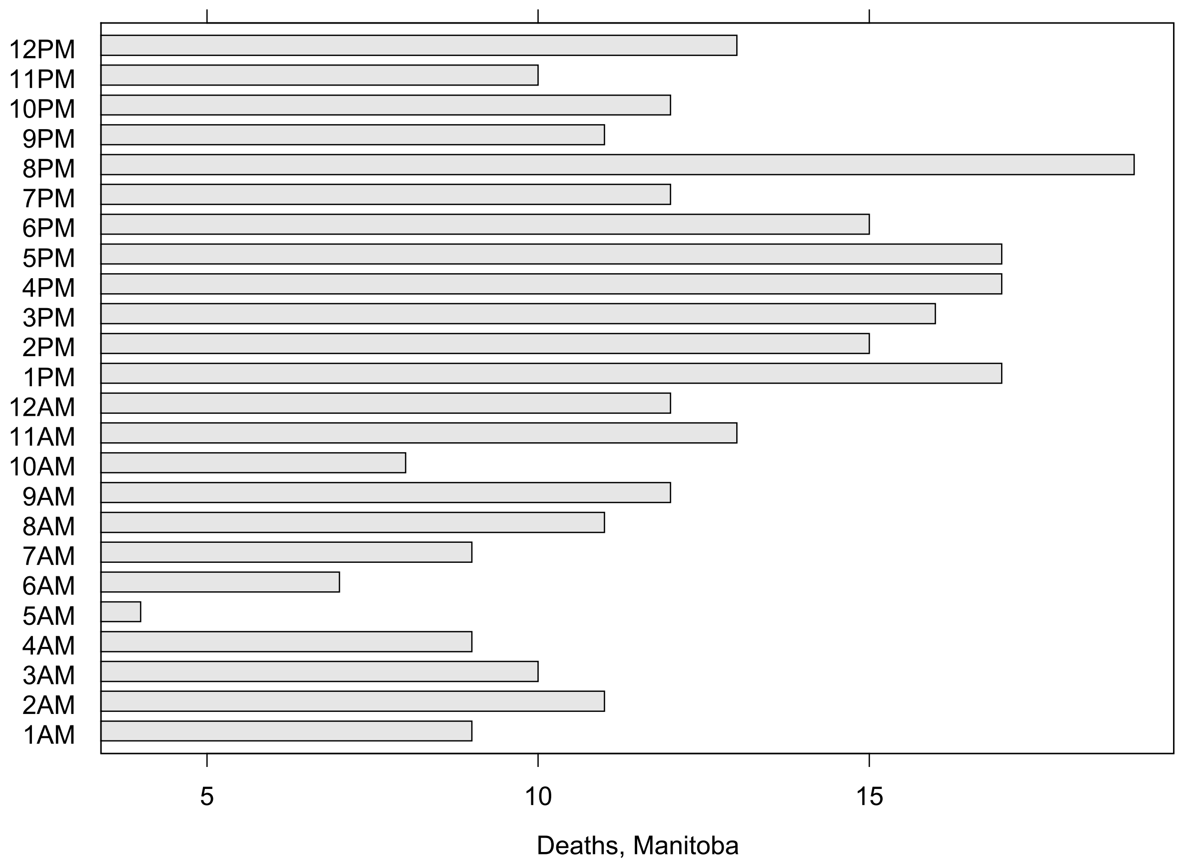




Deaths, Ontario

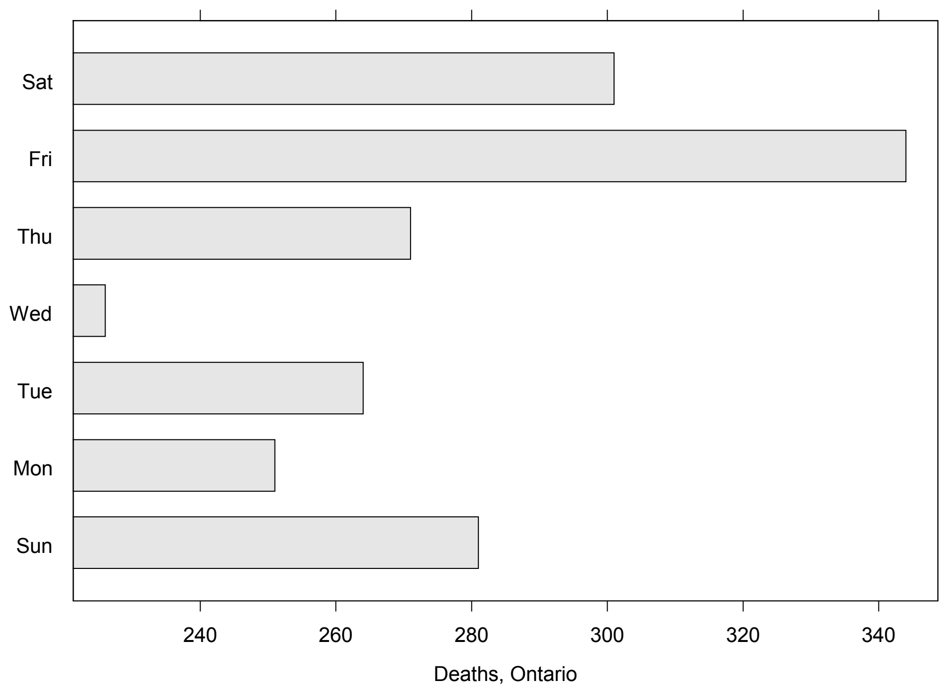
Frequency Analysis, hour, Manitoba

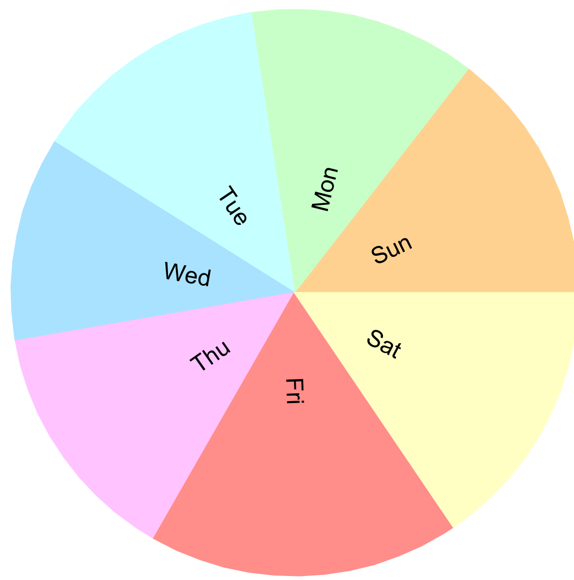
```
> barchart.hour.man()
 1AM 2AM 3AM 4AM 5AM 6AM 7AM 8AM 9AM 10AM 11AM 12AM 1PM 2PM 3PM 4PM 5PM 6PM 7PM 8PM 9PM 10PM 11PM 12PM
   9  11  10   9   4   7   9  11  12    8   13   12  17  15  16  17  17  15  12  19  11   12   10   13
```



Frequency Analysis of Day Variable, Ontario

```
> barchart.day()
 Sun Mon Tue Wed Thu Fri Sat
 281 251 264 226 271 344 301
```

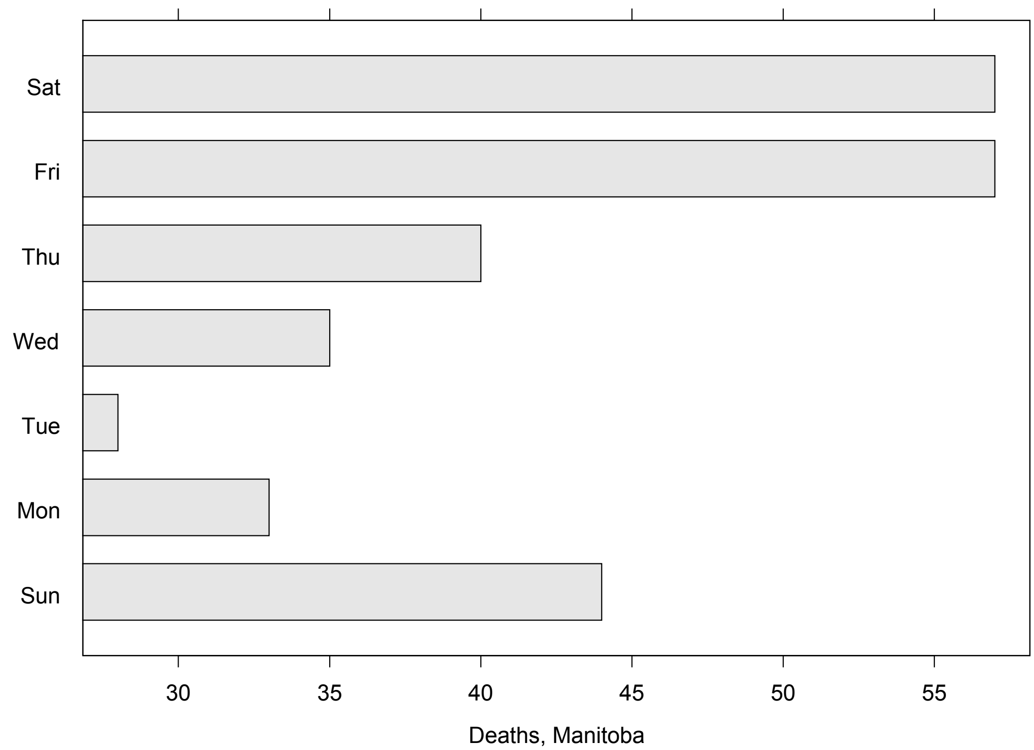


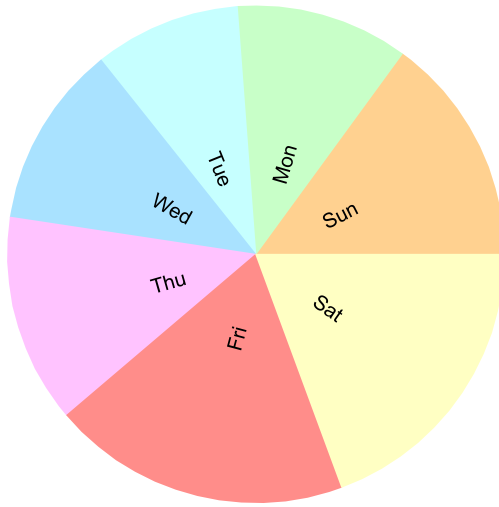


Deaths, Ontario

Frequency Analysis of Day Variable, Manitoba

```
> barchart.day.man()
 Sun Mon Tue Wed Thu Fri Sat
  44  33  28  35  40  57  57
```





Deaths, Manitoba

Frequency Analysis of Drink Variable, Ontario

In Ontario 53.2% of drivers who are killed had been drinking while in Manitoba, 83.5% of drivers who are killed had been drinking.

```
> barchart.drink()
 unknown   no yes
     303 1068 568

>barchart.drink.man()
 unknown  no yes
      39 139 116
```

Drink and hour are not independent

Ontario

It is clear that drinking is more involved with late-night accidents.

```
> crosstabs(~hour+drink, data=tirfall.df, subset=prov=="Ont", na.action=na.exclude)
Call:
crosstabs(formula =  ~ hour + drink, data = tirfall.df, subset = prov == "Ont", na.action =
    na.exclude)
1911 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |drink
       |unknown|no     |yes    |RowTotl|
-------+-------+-------+-------+-------+
1AM    | 9     |21     |49     |79     |
       |0.11   |0.27   |0.62   |0.041  |
       |0.031  |0.02   |0.087  |       |
       |0.0047 |0.011  |0.026  |       |
-------+-------+-------+-------+-------+
2AM    | 7     |28     |56     |91     |
       |0.077  |0.31   |0.62   |0.048  |
       |0.024  |0.026  |0.099  |       |
       |0.0037 |0.015  |0.029  |       |
-------+-------+-------+-------+-------+
3AM    | 5     |12     |39     |56     |
       |0.089  |0.21   |0.7    |0.029  |
       |0.017  |0.011  |0.069  |       |
       |0.0026 |0.0063 |0.02   |       |
-------+-------+-------+-------+-------+
4AM    | 2     |10     |32     |44     |
       |0.045  |0.23   |0.73   |0.023  |
       |0.0069 |0.0095 |0.057  |       |
       |0.001  |0.0052 |0.017  |       |
-------+-------+-------+-------+-------+
5AM    | 2     |13     |19     |34     |
       |0.059  |0.38   |0.56   |0.018  |
       |0.0069 |0.012  |0.034  |       |
       |0.001  |0.0068 |0.0099 |       |
-------+-------+-------+-------+-------+
6AM    | 3     |28     |17     |48     |
       |0.062  |0.58   |0.35   |0.025  |
       |0.01   |0.026  |0.03   |       |
       |0.0016 |0.015  |0.0089 |       |
-------+-------+-------+-------+-------+
7AM    |13     |44     |13     |70     |
       |0.19   |0.63   |0.19   |0.037  |
       |0.045  |0.042  |0.023  |       |
       |0.0068 |0.023  |0.0068 |       |
-------+-------+-------+-------+-------+
8AM    |14     |62     |11     |87     |
       |0.16   |0.71   |0.13   |0.046  |
       |0.048  |0.059  |0.02   |       |
       |0.0073 |0.032  |0.0058 |       |
-------+-------+-------+-------+-------+
9AM    |16     |58     | 3     |77     |
       |0.21   |0.75   |0.039  |0.04   |
       |0.055  |0.055  |0.0053 |       |
       |0.0084 |0.03   |0.0016 |       |
-------+-------+-------+-------+-------+
10AM   |16     |49     | 8     |73     |
       |0.22   |0.67   |0.11   |0.038  |
       |0.055  |0.046  |0.014  |       |
       |0.0084 |0.026  |0.0042 |       |
-------+-------+-------+-------+-------+
```

11AM	18	45	7	70
	0.26	0.64	0.1	0.037
	0.062	0.043	0.012	
	0.0094	0.024	0.0037	
12AM	8	63	6	77
	0.1	0.82	0.078	0.04
	0.028	0.06	0.011	
	0.0042	0.033	0.0031	
1PM	25	59	5	89
	0.28	0.66	0.056	0.047
	0.086	0.056	0.0089	
	0.013	0.031	0.0026	
2PM	22	58	9	89
	0.25	0.65	0.1	0.047
	0.076	0.055	0.016	
	0.012	0.03	0.0047	
3PM	16	72	15	103
	0.16	0.7	0.15	0.054
	0.055	0.068	0.027	
	0.0084	0.038	0.0078	
4PM	22	74	20	116
	0.19	0.64	0.17	0.061
	0.076	0.07	0.035	
	0.012	0.039	0.01	
5PM	16	72	16	104
	0.15	0.69	0.15	0.054
	0.055	0.068	0.028	
	0.0084	0.038	0.0084	
6PM	22	69	19	110
	0.2	0.63	0.17	0.058
	0.076	0.065	0.034	
	0.012	0.036	0.0099	
7PM	12	71	36	119
	0.1	0.6	0.3	0.062
	0.041	0.067	0.064	
	0.0063	0.037	0.019	
8PM	16	28	35	79
	0.2	0.35	0.44	0.041
	0.055	0.026	0.062	
	0.0084	0.015	0.018	
9PM	3	38	29	70
	0.043	0.54	0.41	0.037
	0.01	0.036	0.051	
	0.0016	0.02	0.015	
10PM	12	28	40	80
	0.15	0.35	0.5	0.042
	0.041	0.026	0.071	
	0.0063	0.015	0.021	
11PM	7	36	39	82
	0.085	0.44	0.48	0.043
	0.024	0.034	0.069	
	0.0037	0.019	0.02	
12PM	4	19	41	64
	0.062	0.3	0.64	0.033
	0.014	0.018	0.073	
	0.0021	0.0099	0.021	
ColTotl	290	1057	564	1911

```
       |0.15   |0.55   |0.3    |       |
-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 453.8353 d.f.= 46 (p=0)
    Yates' correction not used
> x<-get.crosstabs.contrib.ont(~hour+drink)
Contribution to chi-sq:
> dimnames(x)_list(levels(tirfall.df$hour), levels(tirfall.df$drink))
> x
     unknown    no   yes
 1AM   -0.86 -3.43  5.32
 2AM   -1.83 -3.15  5.62
 3AM   -1.20 -3.41  5.53
 4AM   -1.81 -2.91  5.28
 5AM   -1.39 -1.34  2.83
 6AM   -1.59  0.28  0.75
 7AM    0.73  0.85 -1.69
 8AM    0.22  2.00 -2.90
 9AM    1.26  2.36 -4.14
10AM    1.48  1.36 -2.92
11AM    2.26  1.01 -3.01
12AM   -1.08  3.13 -3.51
 1PM    3.13  1.39 -4.15
 2PM    2.31  1.25 -3.37
 3PM    0.09  1.99 -2.79
 4PM    1.05  1.23 -2.43
 5PM    0.05  1.91 -2.65
 6PM    1.30  1.05 -2.36
 7PM   -1.43  0.64  0.15
 8PM    1.16 -2.37  2.42
 9PM   -2.34 -0.12  1.84
10PM   -0.04 -2.44  3.37
11PM   -1.54 -1.39  3.01
12PM   -1.83 -2.76  5.09
>
```

Manitoba

Accidents involving alcohol tend to happen more in late night hours in Manitoba too.

We exclude drink=”unknown” since there are so few cases.

```
> crosstabs(~hour+drink, data=tirfall.df, subset=(prov=="Man")&drink!="unknown",
    na.action=na.exclude)
Call:
crosstabs(formula =  ~ hour + drink, data = tirfall.df, subset = (prov == "Man") & drink !=
    "unknown", na.action = na.exclude)
252 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |drink
       |no     |yes    |RowTotl|
-------+-------+-------+-------+
1AM    | 2     | 7     |9      |
       |0.22   |0.78   |0.036  |
       |0.014  |0.062  |       |
       |0.0079 |0.028  |       |
-------+-------+-------+-------+
2AM    | 3     | 8     |11     |
       |0.27   |0.73   |0.044  |
       |0.022  |0.071  |       |
       |0.012  |0.032  |       |
-------+-------+-------+-------+
3AM    | 2     | 8     |10     |
       |0.2    |0.8    |0.04   |
       |0.014  |0.071  |       |
       |0.0079 |0.032  |       |
-------+-------+-------+-------+
4AM    | 2     | 7     |9      |
       |0.22   |0.78   |0.036  |
       |0.014  |0.062  |       |
       |0.0079 |0.028  |       |
-------+-------+-------+-------+
5AM    | 0     | 4     |4      |
       |0      |1      |0.016  |
       |0      |0.035  |       |
       |0      |0.016  |       |
-------+-------+-------+-------+
6AM    | 2     | 5     |7      |
       |0.29   |0.71   |0.028  |
       |0.014  |0.044  |       |
       |0.0079 |0.02   |       |
-------+-------+-------+-------+
7AM    | 6     | 3     |9      |
       |0.67   |0.33   |0.036  |
       |0.043  |0.027  |       |
       |0.024  |0.012  |       |
-------+-------+-------+-------+
8AM    | 6     | 2     |8      |
       |0.75   |0.25   |0.032  |
       |0.043  |0.018  |       |
       |0.024  |0.0079 |       |
-------+-------+-------+-------+
9AM    | 8     | 2     |10     |
       |0.8    |0.2    |0.04   |
       |0.058  |0.018  |       |
       |0.032  |0.0079 |       |
-------+-------+-------+-------+
10AM   | 4     | 3     |7      |
       |0.57   |0.43   |0.028  |
       |0.029  |0.027  |       |
```

```
       |0.016  |0.012  |       |
-------+-------+-------+-------+
11AM   | 8     | 4     |12     |
       |0.67   |0.33   |0.048  |
       |0.058  |0.035  |       |
       |0.032  |0.016  |       |
-------+-------+-------+-------+
12AM   | 8     | 2     |10     |
       |0.8    |0.2    |0.04   |
       |0.058  |0.018  |       |
       |0.032  |0.0079 |       |
-------+-------+-------+-------+
1PM    |12     | 3     |15     |
       |0.8    |0.2    |0.06   |
       |0.086  |0.027  |       |
       |0.048  |0.012  |       |
-------+-------+-------+-------+
2PM    | 8     | 2     |10     |
       |0.8    |0.2    |0.04   |
       |0.058  |0.018  |       |
       |0.032  |0.0079 |       |
-------+-------+-------+-------+
3PM    |11     | 2     |13     |
       |0.85   |0.15   |0.052  |
       |0.079  |0.018  |       |
       |0.044  |0.0079 |       |
-------+-------+-------+-------+
4PM    | 9     | 2     |11     |
       |0.82   |0.18   |0.044  |
       |0.065  |0.018  |       |
       |0.036  |0.0079 |       |
-------+-------+-------+-------+
5PM    |10     | 3     |13     |
       |0.77   |0.23   |0.052  |
       |0.072  |0.027  |       |
       |0.04   |0.012  |       |
-------+-------+-------+-------+
6PM    | 8     | 3     |11     |
       |0.73   |0.27   |0.044  |
       |0.058  |0.027  |       |
       |0.032  |0.012  |       |
-------+-------+-------+-------+
7PM    | 8     | 3     |11     |
       |0.73   |0.27   |0.044  |
       |0.058  |0.027  |       |
       |0.032  |0.012  |       |
-------+-------+-------+-------+
8PM    | 7     | 9     |16     |
       |0.44   |0.56   |0.063  |
       |0.05   |0.08   |       |
       |0.028  |0.036  |       |
-------+-------+-------+-------+
9PM    | 5     | 6     |11     |
       |0.45   |0.55   |0.044  |
       |0.036  |0.053  |       |
       |0.02   |0.024  |       |
-------+-------+-------+-------+
10PM   | 5     | 7     |12     |
       |0.42   |0.58   |0.048  |
       |0.036  |0.062  |       |
       |0.02   |0.028  |       |
-------+-------+-------+-------+
11PM   | 3     | 7     |10     |
       |0.3    |0.7    |0.04   |
       |0.022  |0.062  |       |
       |0.012  |0.028  |       |
-------+-------+-------+-------+
12PM   | 2     |11     |13     |
       |0.15   |0.85   |0.052  |
       |0.014  |0.097  |       |
       |0.0079 |0.044  |       |
```

```
-------+-------+-------+-------+
ColTotl|139    |113    |252    |
       |0.55   |0.45   |       |
-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 62.88204 d.f.= 23 (p=0.00001448521)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> x<-get.crosstabs.contrib.man(~hour+drink)
Contribution to chi-sq:
> dimnames(x)_list(levels(tirfall.df$hour), levels(tirfall.df$drink)[2:3])
> x
        no   yes
 1AM -1.33  1.48
 2AM -1.25  1.38
 3AM -1.50  1.66
 4AM -1.33  1.48
 5AM -1.49  1.65
 6AM -0.95  1.05
 7AM  0.46 -0.52
 8AM  0.76 -0.84
 9AM  1.06 -1.17
10AM  0.07 -0.08
11AM  0.54 -0.60
12AM  1.06 -1.17
 1PM  1.30 -1.44
 2PM  1.06 -1.17
 3PM  1.43 -1.59
 4PM  1.19 -1.32
 5PM  1.06 -1.17
 6PM  0.78 -0.87
 7PM  0.78 -0.87
 8PM -0.61  0.68
 9PM -0.43  0.48
10PM -0.63  0.70
11PM -1.07  1.19
12PM -1.93  2.14>
```

Drink and day are associated

Ontario

There are more fatalities on Saturday and Sunday and fewer on Wednesday.

```
> crosstabs(~drink+day, data=tirfall.df, subset=(prov=="Ont")&drink!="unknown",
na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink + day, data = tirfall.df, subset = (prov == "Ont") & drink !=
"unknown", na.action = na.exclude)
1635 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |day
       |Sun    |Mon    |Tue    |Wed    |Thu    |Fri    |Sat    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     |128    |157    |178    |141    |160    |171    |132    |1067   |
       |0.12   |0.15   |0.17   |0.13   |0.15   |0.16   |0.12   |0.65   |
       |0.53   |0.74   |0.78   |0.77   |0.69   |0.62   |0.51   |       |
       |0.078  |0.096  |0.11   |0.086  |0.098  |0.1    |0.081  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    |114    | 55    | 50    | 42    | 71    |107    |129    |568    |
       |0.2    |0.097  |0.088  |0.074  |0.12   |0.19   |0.23   |0.35   |
       |0.47   |0.26   |0.22   |0.23   |0.31   |0.38   |0.49   |       |
       |0.07   |0.034  |0.031  |0.026  |0.043  |0.065  |0.079  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|242    |212    |228    |183    |231    |278    |261    |1635   |
       |0.15   |0.13   |0.14   |0.11   |0.14   |0.17   |0.16   |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 79.46879 d.f.= 6 (p=4.551914e-015)
       Yates' correction not used
> fix(get.crosstabs.contrib.ont)
> x<-get.crosstabs.contrib.ont(~drink+day)
Contribution to chi-sq:
> dimnames(x)_list(levels(tirfall.df$drink)[2:3],levels(tirfall.df$day))
> x
      Sun   Mon   Tue   Wed   Thu   Fri   Sat
 no -2.38  1.59  2.39  1.97  0.75 -0.77 -2.94
yes  3.26 -2.17 -3.28 -2.71 -1.03  1.06  4.03
```

Manitoba

There are more fatalities on Saturday and fewer on Wednesday.

```
> crosstabs(~drink+day, data=tirfall.df, subset=(prov=="Man")&drink!="unknown",
    na.action=na.exclude)
Call:
crosstabs(formula =  ~ drink + day, data = tirfall.df, subset = (prov == "Man") & drink !=
    "unknown", na.action = na.exclude)
255 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |day
       |Sun    |Mon    |Tue    |Wed    |Thu    |Fri    |Sat    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+
no     |19     |15     |12     |25     |22     |27     |19     |139    |
       |0.14   |0.11   |0.086  |0.18   |0.16   |0.19   |0.14   |0.55   |
       |0.49   |0.56   |0.6    |0.81   |0.61   |0.52   |0.38   |       |
       |0.075  |0.059  |0.047  |0.098  |0.086  |0.11   |0.075  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
yes    |20     |12     | 8     | 6     |14     |25     |31     |116    |
       |0.17   |0.1    |0.069  |0.052  |0.12   |0.22   |0.27   |0.45   |
       |0.51   |0.44   |0.4    |0.19   |0.39   |0.48   |0.62   |       |
       |0.078  |0.047  |0.031  |0.024  |0.055  |0.098  |0.12   |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|39     |27     |20     |31     |36     |52     |50     |255    |
       |0.15   |0.11   |0.078  |0.12   |0.14   |0.2    |0.2    |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
 Chi^2 = 15.59117 d.f.= 6 (p=0.01612495)
 Yates' correction not used
> x<-get.crosstabs.contrib.man(~drink+day)
Contribution to chi-sq:
> dimnames(x)_list(levels(tirfall.df$drink)[2:3],levels(tirfall.df$day))
> x
      Sun   Mon   Tue   Wed   Thu   Fri   Sat
 no -0.49  0.07  0.33  1.97  0.54 -0.25 -1.58
yes  0.54 -0.08 -0.36 -2.16 -0.59  0.28  1.73
```

C. TIRF Dataset: All Hours Dataset
TIME SERIES

Monthly Time Series

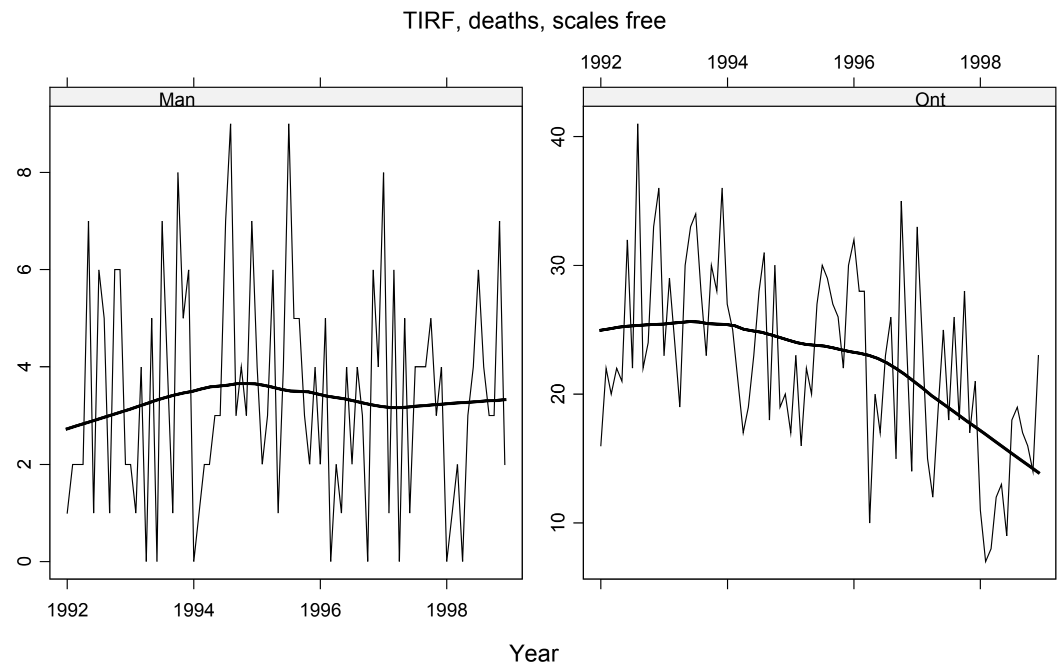
There is an estimated 44% decline in death-rate per month in Ontario but no decline in Manitoba.

Ontario
```
> tirf.ont.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  16  22  20  22  21  32  22  41  22  24  33  36
1993:  23  29  24  19  30  33  34  28  23  30  28  36
1994:  27  25  21  17  19  23  28  31  18  30  19  20
1995:  17  23  16  22  20  27  30  29  27  26  22  30
1996:  32  28  28  10  20  17  23  26  15  35  24  14
1997:  33  24  15  12  19  25  18  26  18  28  17  21
1998:  11   7   8  12  13   9  18  19  17  16  14  23
> sum(tirf.ont.ts)
[1] 1910
> SeasonalMannKendall(tirf.ont.ts)
tau = -0.424,   sl =4.404e-4%
> pc.change(tirf.ont.ts)
[1] 25.03410 13.91354 44.42162
```

Manitoba
```
tirf.man.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   2   2   2   7   1   6   5   1   6   6   2
1993:   2   1   4   0   5   0   7   4   1   8   5   6
1994:   0   1   2   2   3   3   7   9   3   4   3   7
1995:   4   2   3   6   1   4   9   5   5   3   2   4
1996:   2   5   0   2   1   4   2   4   3   0   6   4
1997:   8   1   6   0   5   1   4   4   4   5   3   4
1998:   0   1   2   0   3   4   6   4   3   3   7   2
> sum(tirf.man.ts)
[1] 289
> SeasonalMannKendall(tirf.Man.ts)
Problem: Object "tirf.Man.ts" not found
> SeasonalMannKendall(tirf.man.ts)
tau = -0.0833,   sl =38.47%
> pc.change(tirf.man.ts)
[1]   2.733141   3.326042 -21.693007
>
```

Estimated mean death rate/month from loess smooth.

	Beginning of 1992	End of 1998	Percentage Change
Ontario	25.0	13.9	44
Manitoba	0.32	0.37	-13


TIRF, deaths, scales free
Man
Ont
0
2
4
6
8
10
20
30
40
1992
1994
1996
1998
Year

Drink Time Series, Ontario

All series show declines.

drink = no

```
> ont.no.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  11  10   7  10   4  18  10  19  14  13  20  18
1993:  12  13  12  10  18  16  15   7   8  12  14  27
1994:  19  13   7   8   8  13  16  17  13  16  11  10
1995:  14  14  13  14  10  16  16  15  15  14  18  18
1996:  27  20  14   6  11  12  12   9   7  24  15  10
1997:  20  17   9   8   7  12  13  12  12  15   7  12
1998:   6   2   4   6   7   4  11  12  11  11   9  16
> SeasonalMannKendall(ont.no.ts)
tau = -0.187,   sl =4.367%
> sum(ont.no.ts)
[1] 1056
```

drink = yes

```
> ont.yes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   3   7   8  10  13  11   9  13   7   6   9  10
1993:   6   9   7   7   7   8  11  12  10  15   7   2
1994:   4  10   7   8   6   8  12  11   5  10   8   6
1995:   3   3   3   7   9   6   7   9  10  10   3   4
1996:   1   5  10   3   7   5   8  11   7   9   5   2
1997:   7   5   4   1   5   5   3  10   5   9   8   6
1998:   4   1   4   5   4   4   6   4   6   3   2   4
> SeasonalMannKendall(ont.yes.ts)
tau = -0.491,   sl =1.488e-5%
> sum(ont.yes.ts)
[1] 564
```

drink = unknown

```
> ont.unknown.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   5   5   2   4   3   3   9   1   5   4   8
1993:   5   7   5   2   5   9   8   9   5   3   7   7
1994:   4   2   7   1   5   2   0   3   0   4   0   4
1995:   0   6   0   1   1   5   7   5   2   2   1   8
1996:   4   3   4   1   2   0   3   6   1   2   4   2
1997:   6   2   2   3   7   8   2   4   1   4   2   3
1998:   1   4   0   1   2   1   1   3   0   2   3   3
> SeasonalMannKendall(ont.unknown.ts)
tau = -0.315,   sl =0.08059%
> sum(ont.unknown.ts)
[1] 290
```

Drink Time Series, Manitoba

drink = no

```
man.no.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   1   1   1   4   0   2   1   1   0   3   2
1993:   1   1   2   0   1   0   3   1   0   4   3   2
1994:   0   1   0   1   3   1   3   2   2   0   1   4
1995:   3   1   1   3   0   2   5   1   0   2   2   1
1996:   2   5   0   1   0   0   0   2   1   0   2   3
1997:   5   1   6   0   3   1   2   3   2   1   1   2
1998:   0   1   1   0   1   1   5   3   2   3   3   2
> SeasonalMannKendall(man.no.ts)
tau = 0.125,   sl =20.16%
> sum(man.no.ts)
[1] 139
```

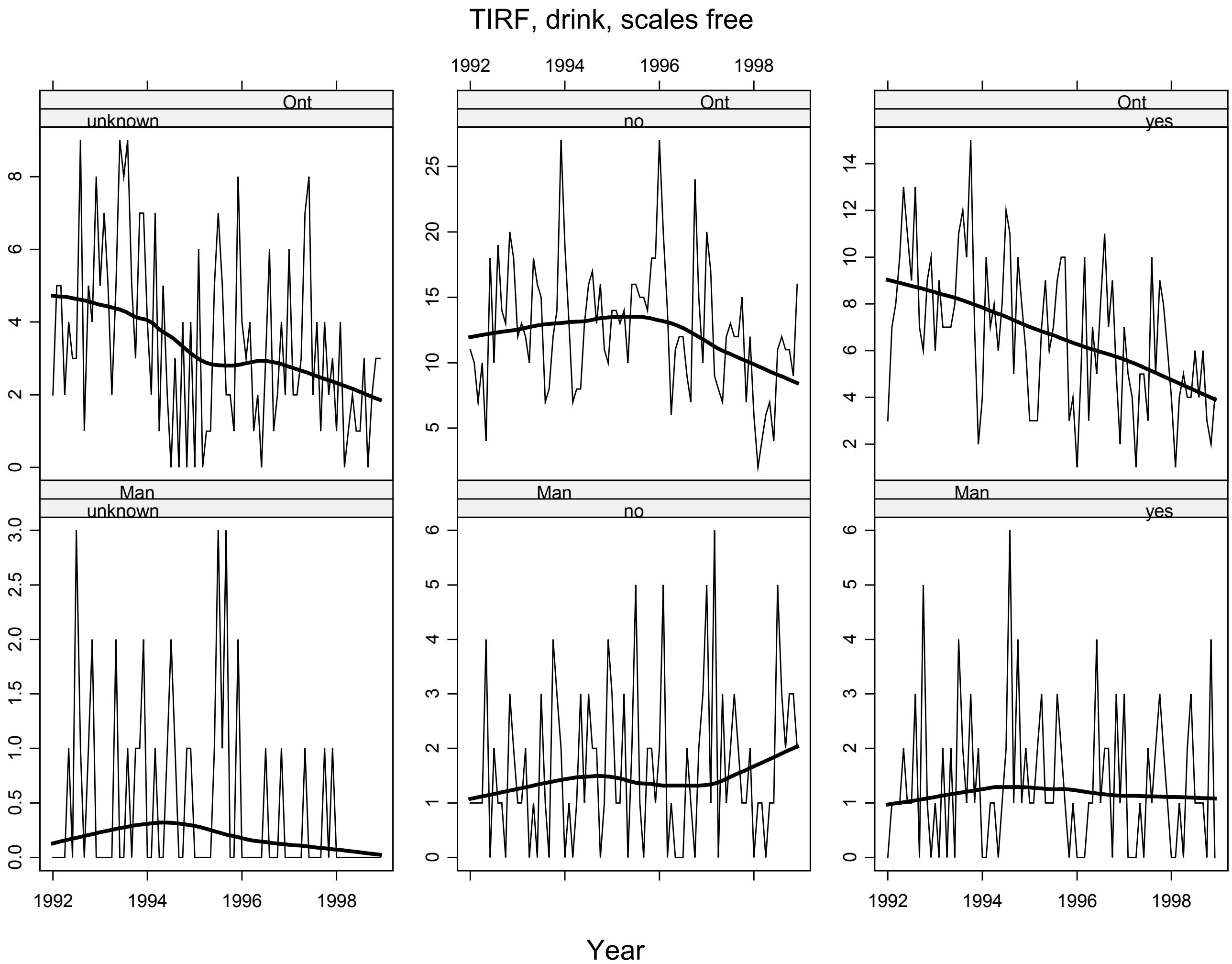
drink = yes

```
> man.yes.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   1   2   1   1   3   0   5   1   0
1993:   1   0   2   0   2   0   4   2   1   3   1   2
1994:   0   0   1   1   0   1   2   6   1   4   1   2
1995:   1   1   2   3   1   1   1   3   2   1   0   1
1996:   0   0   0   1   1   4   1   2   2   0   3   1
1997:   3   0   0   0   1   0   2   1   2   3   2   1
1998:   0   0   1   0   2   3   1   1   1   0   4   0
> SeasonalMannKendall(man.yes.ts)
tau = -0.125,   sl =20.23%
> sum(man.yes.ts)
[1] 113
```

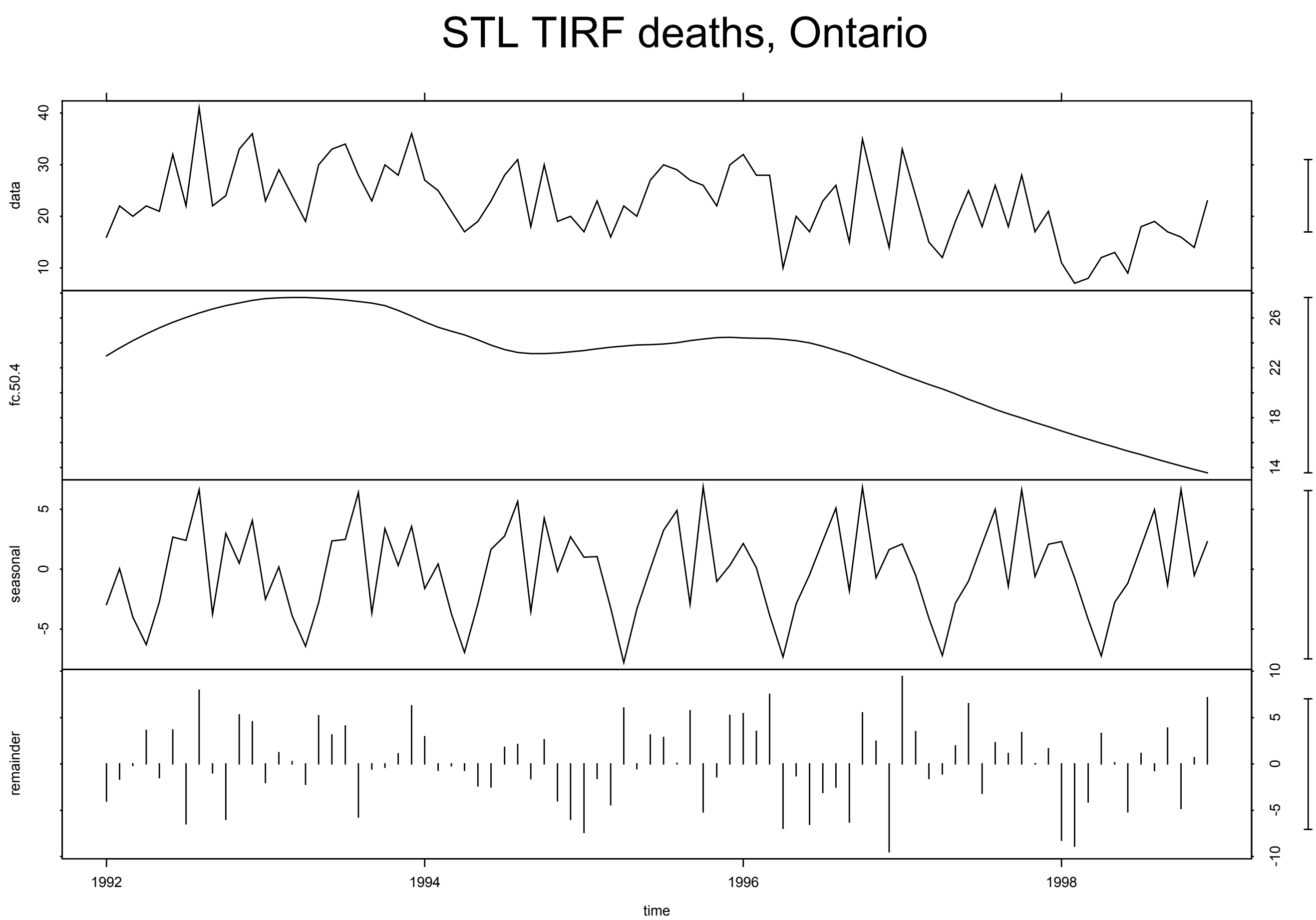
drink = unknown

```
> man.unknown.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   1   0   3   1   0   1   2   0
1993:   0   0   0   0   2   0   0   1   0   1   1   2
1994:   0   0   1   0   0   1   2   1   0   0   1   1
1995:   0   0   0   0   0   1   3   1   3   0   0   2
1996:   0   0   0   0   0   0   1   0   0   0   1   0
1997:   0   0   0   0   1   0   0   0   0   1   0   1
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> SeasonalMannKendall(man.unknown.ts)
WARNING: Error exit, tauk2. IFAULT =  12
WARNING: Error exit, tauk2. IFAULT =  12
WARNING: Error exit, tauk2. IFAULT =  12
tau = -0.383,   sl =0.1075%
> sum(man.unknown.ts)
[1] 37
```

Clear downward trends in Ontario. The downward trend starts around 1996 for `drink=no` in Ontario. There may be a small downward trend for `drink=unknown` in Manitoba and a possible recent upward swing in `drink=no` in Manitoba.



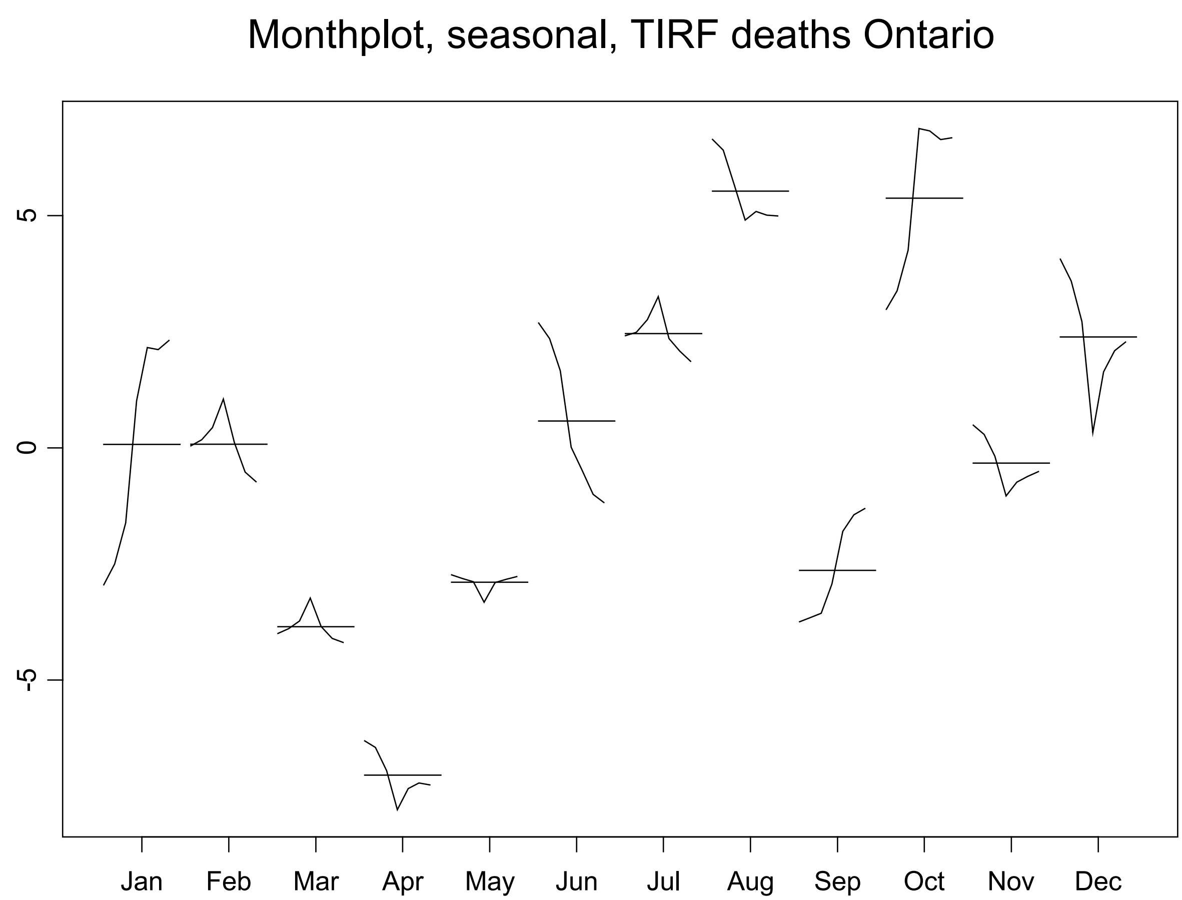
STL Analysis
R-sq = 63.4 %



ss.window = 7 ,ss.robust = TRUE , fc.window = 50.4 , fc.degree = 2

Monthplot of Seasonal Component

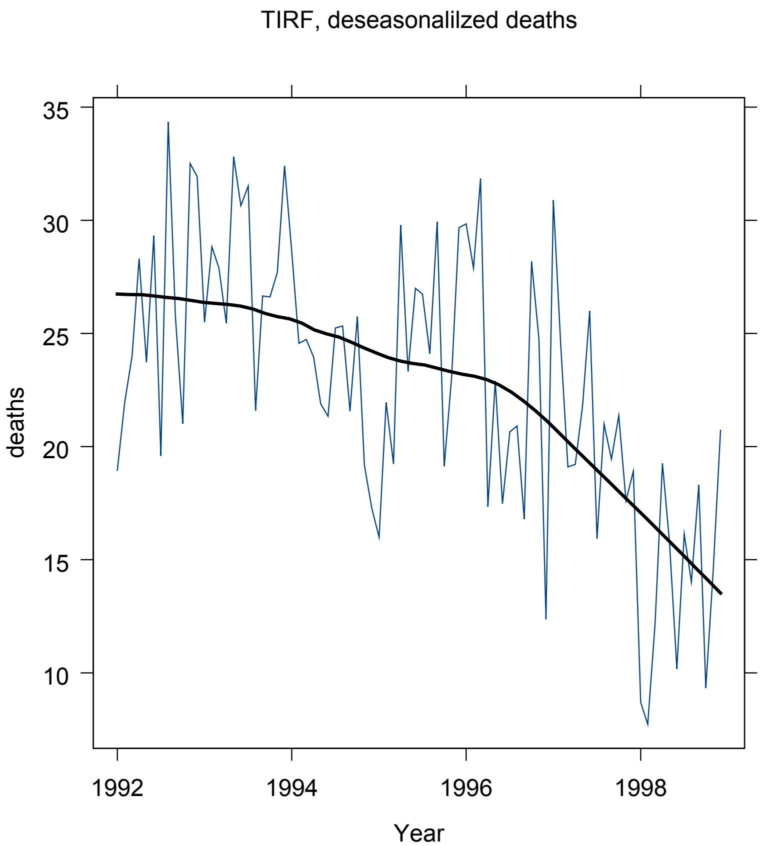
Decreasing trend in June and increasing trends in January, September and October. Seasonal minimum in April and local minimum in September. Seasonal maximum in August and in October.



Loess Trend Analysis of Deasonalized Series

```
tau = -0.412,    sl =2.964e-6%
```

In summary there appears to be a gradual decline starting in 1992 which turns into a steeper drop starting in the first quarter of 1996.



D. MTO Dataset

Summary

The data set of Ministry of Transportation Collision of Ontario, from January 1992 to December 1998, was analyzed by using crosstabs and data visualization.

There are 26,026 records. Each record corresponds to an injured driver in a traffic accident on Ontario's highways (only non-emergency, motorized, highway vehicles). There are four injury classes: mimimal (48.3%), minor (39.8%), major (9.7%) and fatal (2.3%). The four injury classes should be analyzed separately.

All injury classes show increases from 1992 up to 1995 and then a decline. In the fatal accidents the decline post 1995 is much less steep than for the other three injury classes. See fatal, major, minor and minimal time series plots.

There is an increase in deaths in the 2AM-ThuSat window and corresponding decreases in 1AM-ThuSat and 12AM-ThuSat. Also there is a decrease in deaths in 1AM-SunWed window. See trellis plot and Mann-Kendall tests.

Major Injuries decreased in the 12AM and 1AM for both weekgroups but the decrease was stronger in the ThuSat window. See trellis plot and Mann-Kendall tests.

Minor injuries showed decreased slightly in the 12AM-SunWed window. There were strong decreases also in the 1AM SunWed and ThuSat windows. There was a strong increase in the 2AM SunWed window. See trellis plot and Mann-Kendall tests.

Minimal injuries decreased strongly in the 1AM window for both SunWed and ThuSat. There was a strong increase in the 2AM SunWed window and a slight increase in the 2AM ThuSat window. See trellis plot and Mann-Kendall tests.

The mixture of increasing and decreasing trends in the Minor and Minimial injuries could possibly be caused by a change in drinking habits.

STL Analysis of Fatilities suggests a sharply increasing trend to 1995 followed by a decline. The seasonal component quite variables and changing. July and August have the highest deaths. The trend is mildly down for July and sharply increasing for August. See STL and Monthplot.

STL Analysis of Major Injuries shows an increasing trend to about 1995 followed a shart drop to a new low. The seasonal pattern is fairly stable. Highest number of injuries are in July and August. There is an increasing trend in April and decreasing trend in March. See STL and Monthplot.

Frequencies

Injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Minimal	12576	48.3	48.3	48.3
	Minor	10348	39.8	39.8	88.1
	Major	2512	9.7	9.7	97.7
	Fatal	590	2.3	2.3	100.0
	Total	26026	100.0	100.0	

Vehicle Province or State

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Alberta	38	.1	.1	.1
	British Columbia	33	.1	.1	.3
	Manitoba	38	.1	.1	.4
	New Brunswick	18	.1	.1	.5
	Newfoundland	5	.0	.0	.5
	Nova Scotia	19	.1	.1	.6
	Ontario	25072	96.3	96.3	96.9
	Prince Edward Island	3	.0	.0	96.9
	Quebec	270	1.0	1.0	98.0
	Saskatchewan	13	.0	.0	98.0
	Yukon and North West Territories	2	.0	.0	98.0
	U.S.A.	284	1.1	1.1	99.1
	Other Foreign	1	.0	.0	99.1
	Unknown	230	.9	.9	100.0
	Total	26026	100.0	100.0	

Crosstabs

Vehicle Province or State * Injury Crosstabulation

Count

		Injury				Total
		Minimal	Minor	Major	Fatal	
Vehicle Province or State	Alberta	16	16	5	1	38
	British Columbia	10	17	6		33
	Manitoba	22	14	1	1	38
	New Brunswick	7	7	4		18
	Newfoundland	3	1	1		5
	Nova Scotia	9	7	2	1	19
	Ontario	12146	9969	2392	565	25072
	Prince Edward Island		2	1		3
	Quebec	129	109	27	5	270
	Saskatchewan	7	4	2		13
	Yukon and North West Territories	1		1		2
	U.S.A.	138	111	27	8	284
	Other Foreign			1		1
	Unknown	88	91	42	9	230
Total		12576	10348	2512	590	26026

Injury * Late Night Time Period Crosstabulation

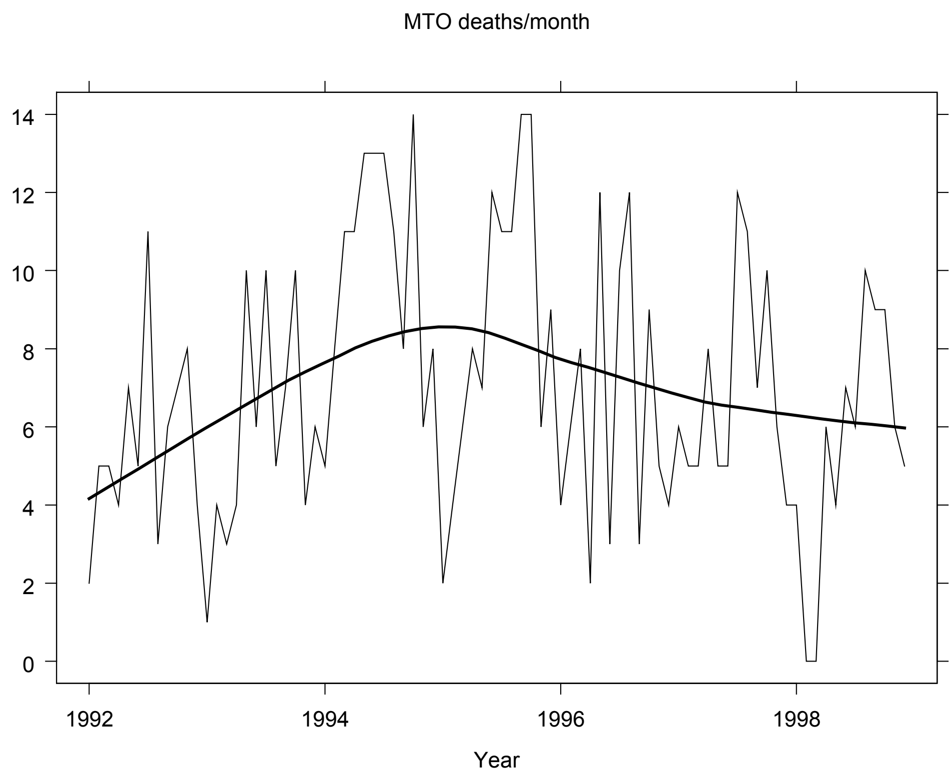
Count

		Late Night Time Period				Total
		Midnight to 1 am	One am to 2 am	Two am to 3 am	Eleven to Midnight	
Injury	Minimal	2836	3052	2451	4237	12576
	Minor	2308	2684	2165	3191	10348
	Major	580	708	591	633	2512
	Fatal	130	162	144	154	590
Total		5854	6606	5351	8215	26026

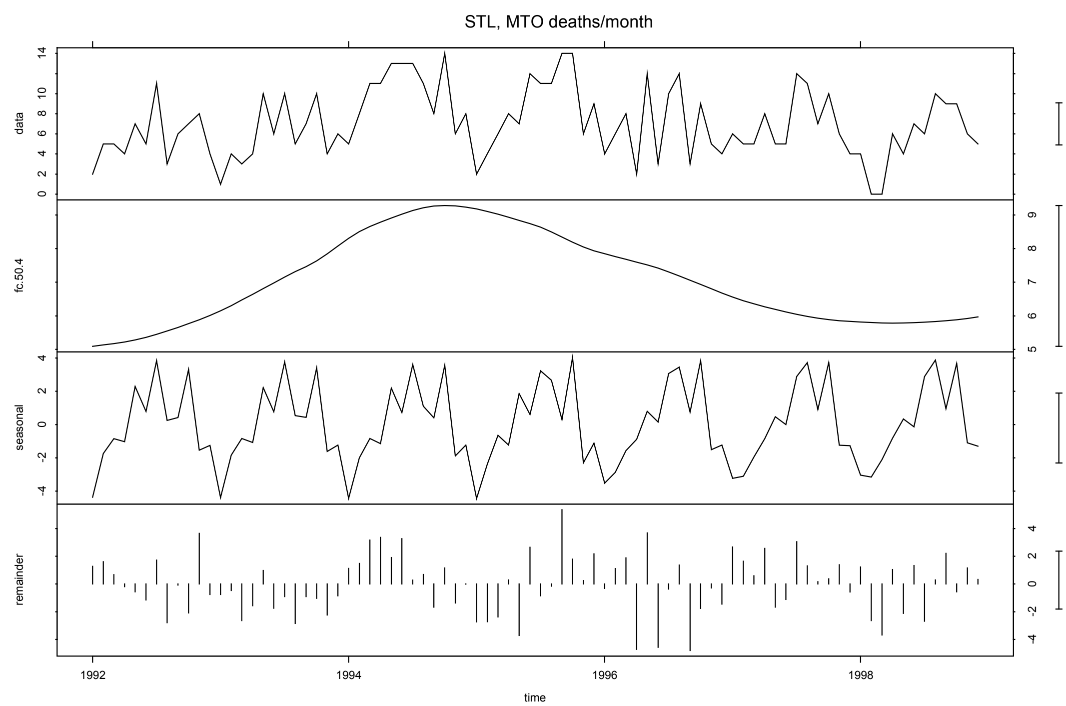
Fatalities

Monthly Overall Deaths

```
> mto4.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:    2   5   5   4   7   5  11   3   6   7   8   4
1993:    1   4   3   4  10   6  10   5   7  10   4   6
1994:    5   8  11  11  13  13  13  11   8  14   6   8
1995:    2   4   6   8   7  12  11  11  14  14   6   9
1996:    4   6   8   2  12   3  10  12   3   9   5   4
1997:    6   5   5   8   5   5  12  11   7  10   6   4
1998:    4   0   0   6   4   7   6  10   9   9   6   5
```

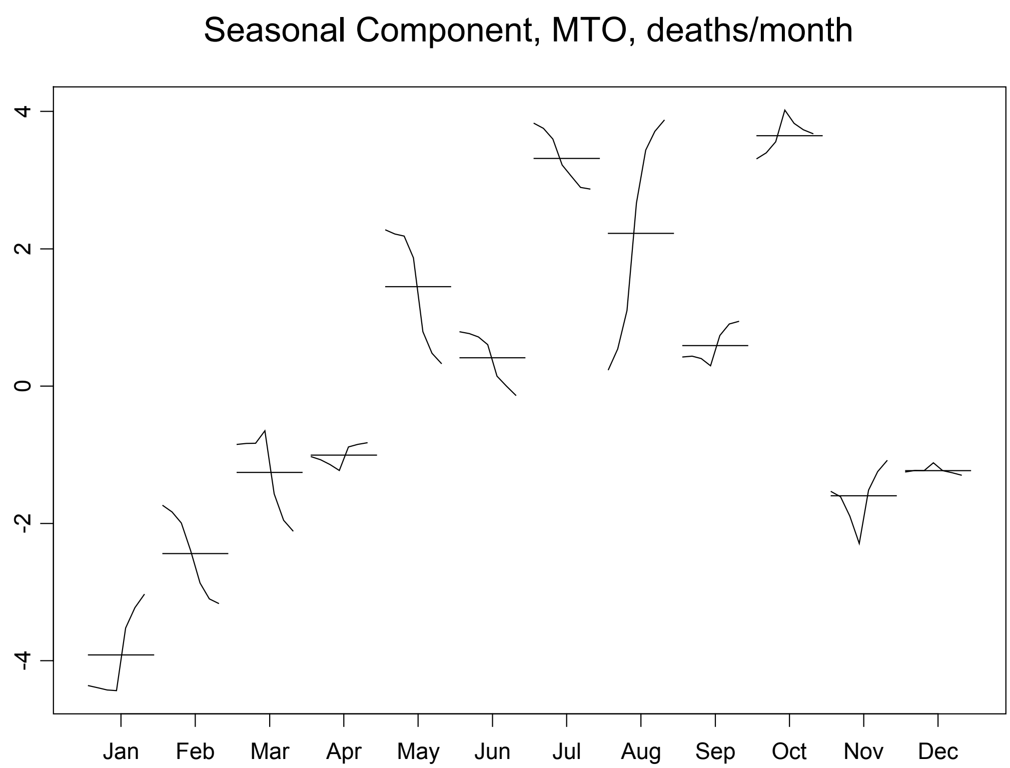


STL Analysis: Fatalities



ss.window = 7 ,ss.robust = TRUE , fc.window = 50.4 , fc.degree = 2 , lambda = 1

Seasonal Component Plot



Weekgroup & Hour Time Series: Fatalities

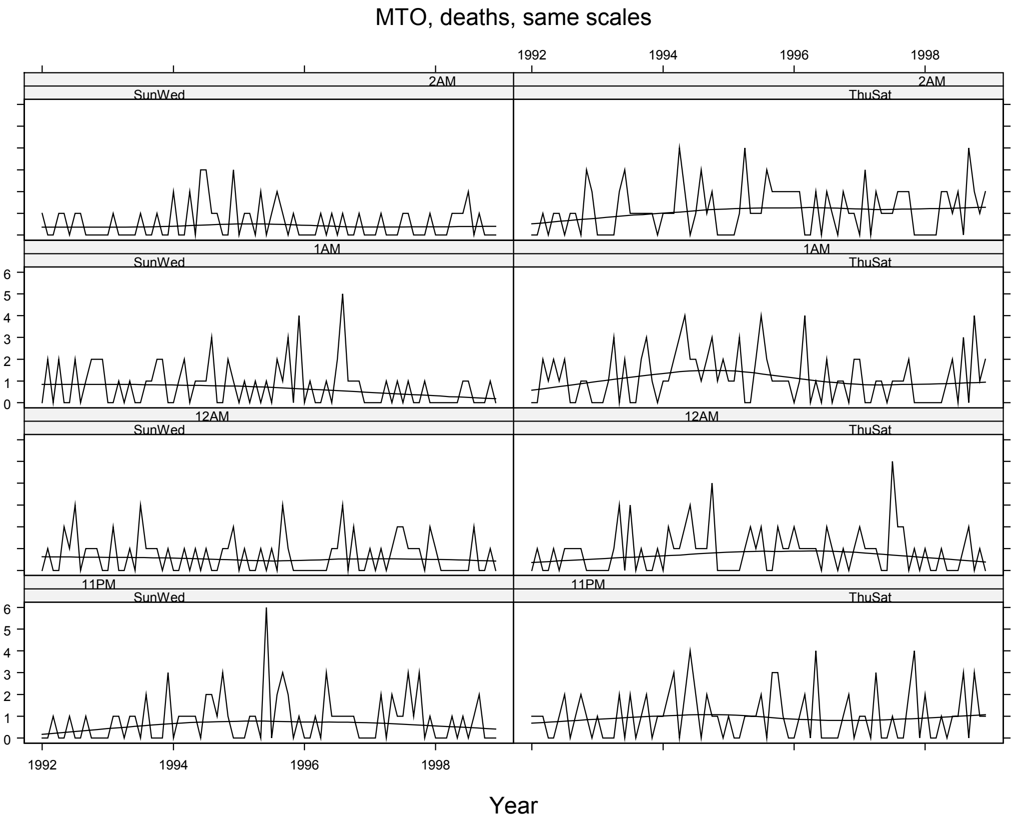
```
> mto4.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   1   0   0   1   0   0   0
1993:   0   1   1   0   1   1   0   2   0   0   0   3
1994:   0   1   1   1   1   0   2   2   1   3   1   0
1995:   0   0   1   1   0   6   0   2   3   2   0   1
1996:   0   0   1   0   3   1   1   1   1   1   0   0
1997:   0   0   2   0   2   1   1   3   1   3   0   1
1998:   0   0   0   1   0   1   0   1   2   0   0   0
> MannKendall(mto4.11PMSunWed.ts)
tau = 0.0745,   sl =38.24%
> mto4.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   0   2   1   3   0   1   1   1   0
1993:   0   2   0   0   1   0   3   1   1   1   0   1
1994:   0   0   1   0   1   0   1   0   0   1   1   2
1995:   0   1   0   0   1   0   1   0   3   1   0   0
1996:   0   0   0   0   0   1   1   3   0   2   0   0
1997:   1   0   1   0   1   2   2   1   1   1   0   2
1998:   1   0   0   0   0   0   0   2   0   0   1   0
> MannKendall(mto4.12AMSunWed.ts)
tau = -0.0582,   sl =50.03%
> mto4.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   2   0   2   0   0   2   0   1   2   2   2
1993:   0   0   1   0   1   0   0   1   1   2   2   0
1994:   0   1   2   0   1   1   1   3   0   0   2   1
1995:   0   1   0   1   0   1   0   2   1   3   0   4
1996:   0   1   0   0   1   0   2   5   1   1   1   0
1997:   0   0   0   1   0   1   0   1   0   0   1   0
1998:   0   0   0   0   0   1   1   0   0   0   1   0
> MannKendall(mto4.1AMSunWed.ts)
```

tau = -0.174,   sl =4.123%

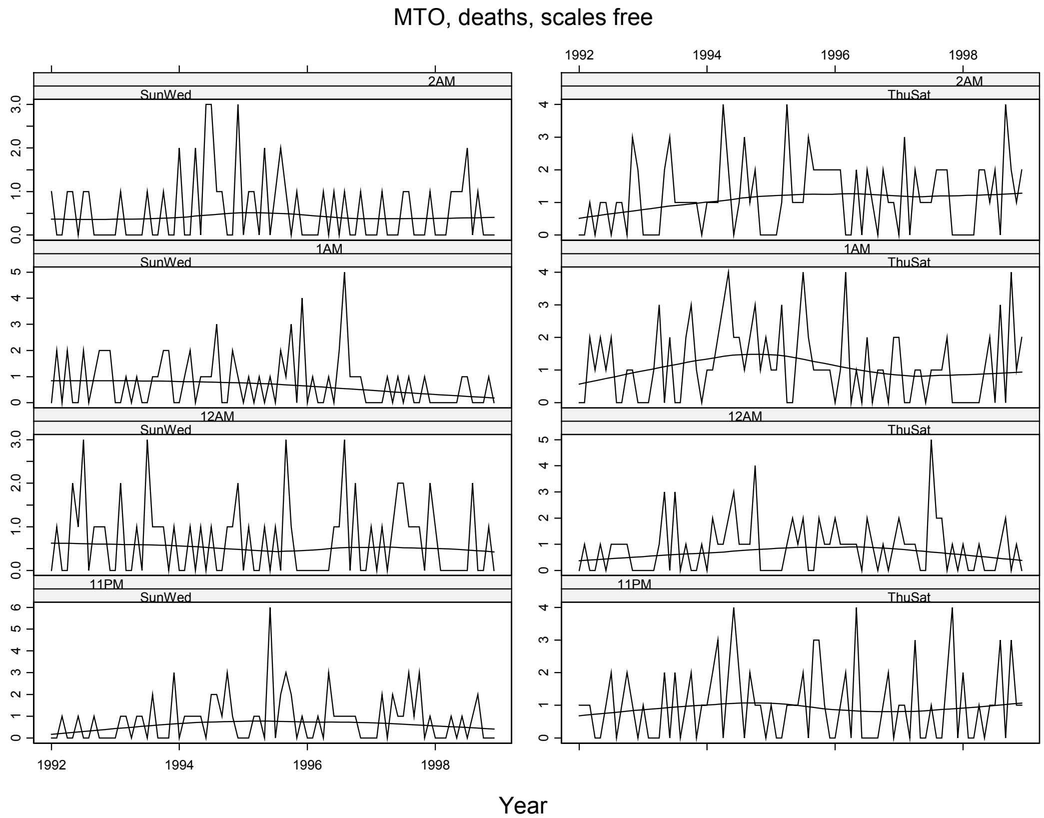
```
> mto4.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   1   1   0   1   1   0   0   0   0
1993:   0   1   0   0   0   0   1   0   0   1   0   0
1994:   2   0   0   2   0   3   3   1   1   0   0   3
1995:   0   1   1   0   2   0   1   2   1   0   1   0
1996:   0   0   0   1   0   1   0   1   0   0   1   0
1997:   0   0   1   0   0   0   1   1   0   0   0   1
1998:   0   0   0   1   1   1   2   0   1   0   0   0
> MannKendall(mto4.2AMSunWed.ts)
tau = -0.023,   sl =79.43%
```

```
mto4.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   1   1   0   0   1   2   0   1   2   1   0
1993:   1   0   0   0   2   0   2   0   1   2   0   1
1994:   1   2   3   0   2   4   2   0   2   1   1   0
1995:   1   0   0   1   1   1   2   0   3   3   1   0
1996:   0   1   2   0   4   0   0   0   0   1   2   0
1997:   1   1   0   3   0   0   1   0   0   2   4   0
1998:   2   0   0   1   0   1   1   3   0   3   1   1
> MannKendall(mto4.11PMThuSat.ts)
tau = 0.00375,   sl =96.74%
> mto4.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   0   1   0   1   1   1   1   0   0
1993:   0   0   0   1   3   0   3   0   1   0   0   1
1994:   0   2   1   1   2   3   1   1   1   4   0   0
1995:   0   0   0   1   2   1   2   0   0   2   1   1
1996:   2   1   1   1   1   0   2   1   0   1   0   1
1997:   2   1   1   1   0   0   5   2   2   0   1   0
1998:   1   0   0   1   0   0   0   1   2   0   1   0
> MannKendall(mto4.12AMThuSat.ts)
tau = 0.0321,   sl =70.79%
> mto4.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   2   1   2   1   2   0   0   1   1   0
1993:   0   0   1   3   0   2   0   0   2   3   1   0
1994:   1   1   2   3   4   2   2   1   2   3   1   2
1995:   1   1   3   0   0   2   4   2   1   1   1   1
1996:   0   1   4   0   1   0   2   0   1   1   0   2
1997:   2   0   0   1   1   0   1   1   1   2   0   0
1998:   0   0   0   0   1   2   0   3   0   4   1   2
> MannKendall(mto4.1AMThuSat.ts)
tau = -0.0472,   sl =57.12%
> mto4.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   1   1   0   1   1   0   3   2
1993:   0   0   0   0   2   3   1   1   1   1   1   0
1994:   1   1   1   4   2   0   1   3   1   2   0   0
1995:   0   0   1   4   1   1   1   3   2   2   2   2
1996:   2   2   0   0   2   0   2   1   0   2   1   1
1997:   0   3   0   2   1   1   1   2   2   2   0   0
1998:   0   0   0   2   2   1   2   0   4   2   1   2
> MannKendall(mto4.2AMThuSat.ts)
tau = 0.132,   sl =11.38%
```

Time series trellis plot. Fatalities. Same scales.



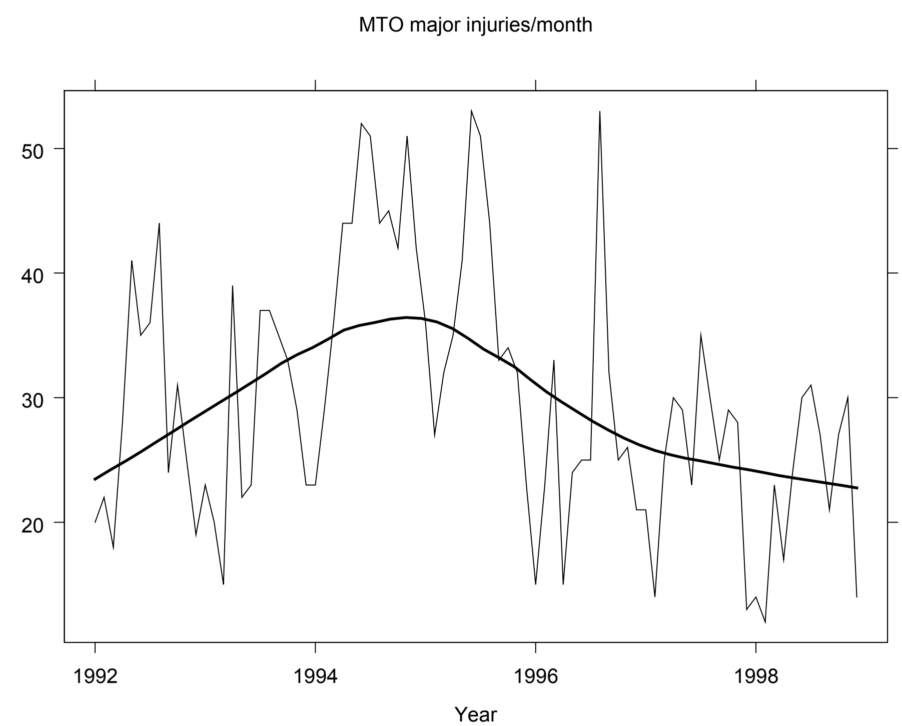
Time series trellis plot. Fatalities. Scales free.



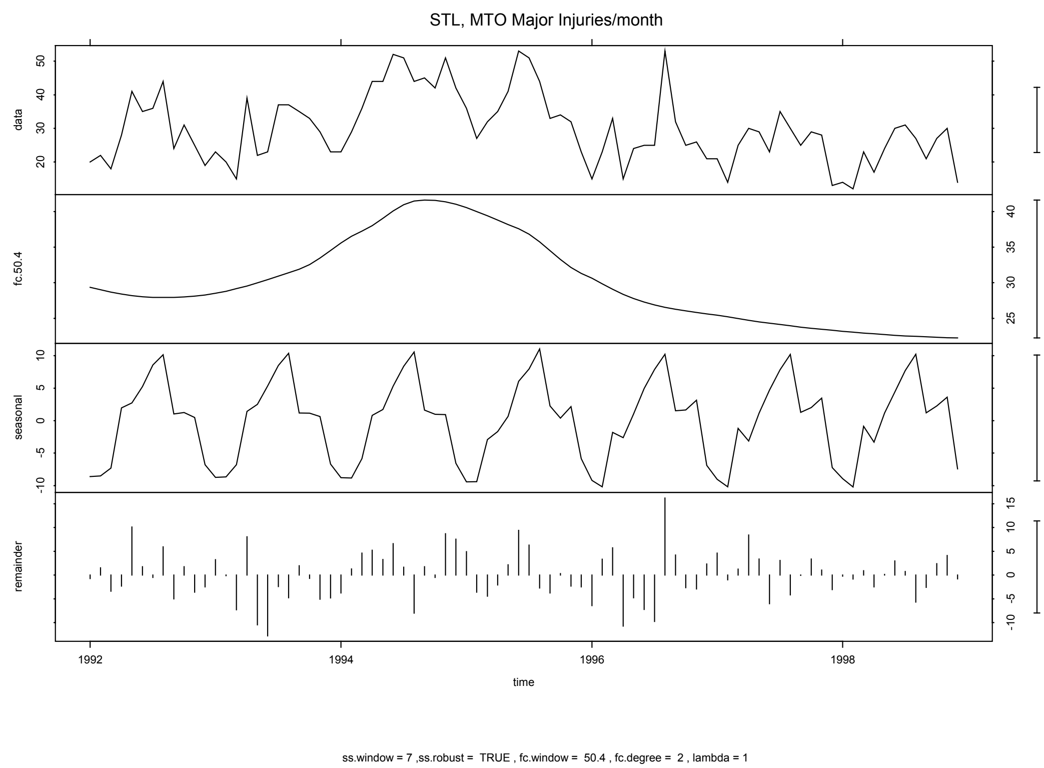
Major Injuries

Monthly Overall Major Injuries

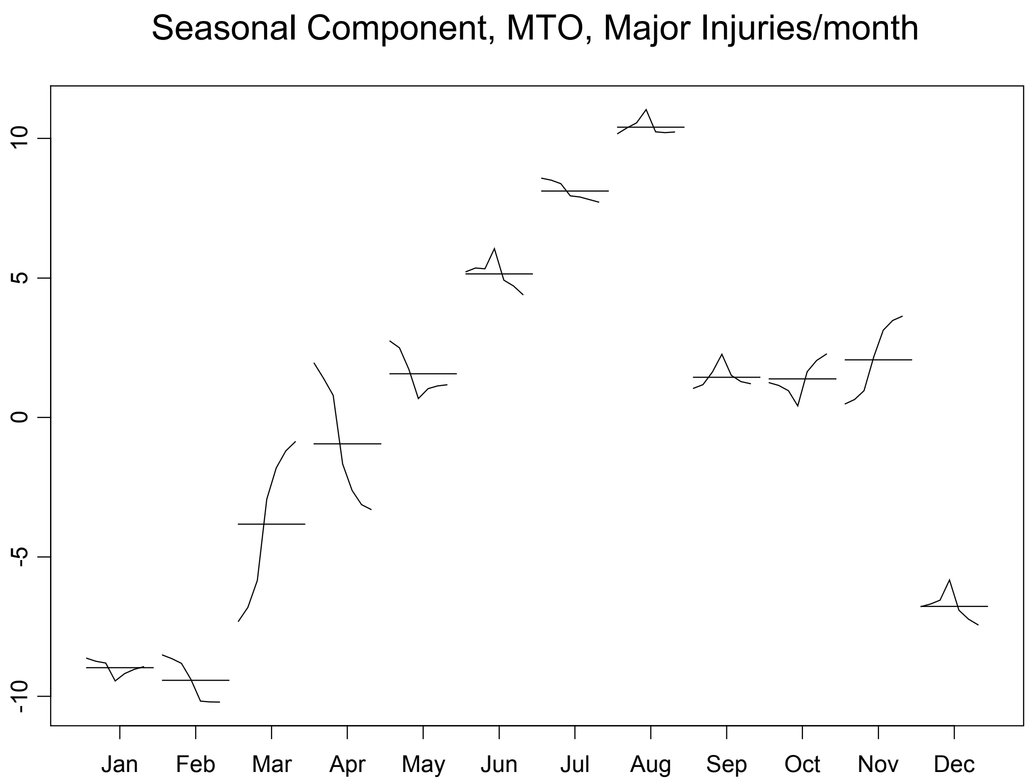
```
> mto3.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   20  22  18  28  41  35  36  44  24  31  25  19
1993:   23  20  15  39  22  23  37  37  35  33  29  23
1994:   23  29  36  44  44  52  51  44  45  42  51  42
1995:   36  27  32  35  41  53  51  44  33  34  32  23
1996:   15  23  33  15  24  25  25  53  32  25  26  21
1997:   21  14  25  30  29  23  35  30  25  29  28  13
1998:   14  12  23  17  24  30  31  27  21  27  30  14
```



STL: Major Injuries



Seasonal Component: Major Injuries



Weekgroup & Hour Time Series: Major Injuries

```
> mto3.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   0   3   2   8   9   2   1   1   5   3
1993:   3   2   0   1   1   6   6   3   6   5   2   3
1994:   2   6   5   7   2   7  10   7   5   4   3   4
1995:   3   3   2   3   7   9   2   6   1   2   6   1
1996:   3   6   3   1   3   3   3   6   8   1   1   3
1997:   6   0   2   5   2   0   6   4   1   3   3   3
1998:   2   1   3   3   3   6   7   4   4   3   5   1
> MannKendall(mto3.11PMSunWed.ts)
tau = 0.0226,   sl =77.76%
> mto3.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   2   2   3   5   1   5   6   4   7   2   2
1993:   1   1   0   4   3   1   4   5   2   2   1   2
1994:   5   2   3   2   4   5   2   1   4   6   5   4
1995:   3   2   3   4   5   6   6   6   3   0   3   5
1996:   0   0   4   1   2   2   3   5   3   0   0   4
1997:   2   2   2   4   0   2   3   1   4   2   1   1
1998:   1   3   2   3   4   1   3   1   2   2   1   2
> MannKendall(mto3.12AMSunWed.ts)
```

tau = -0.133,   sl =9.555%

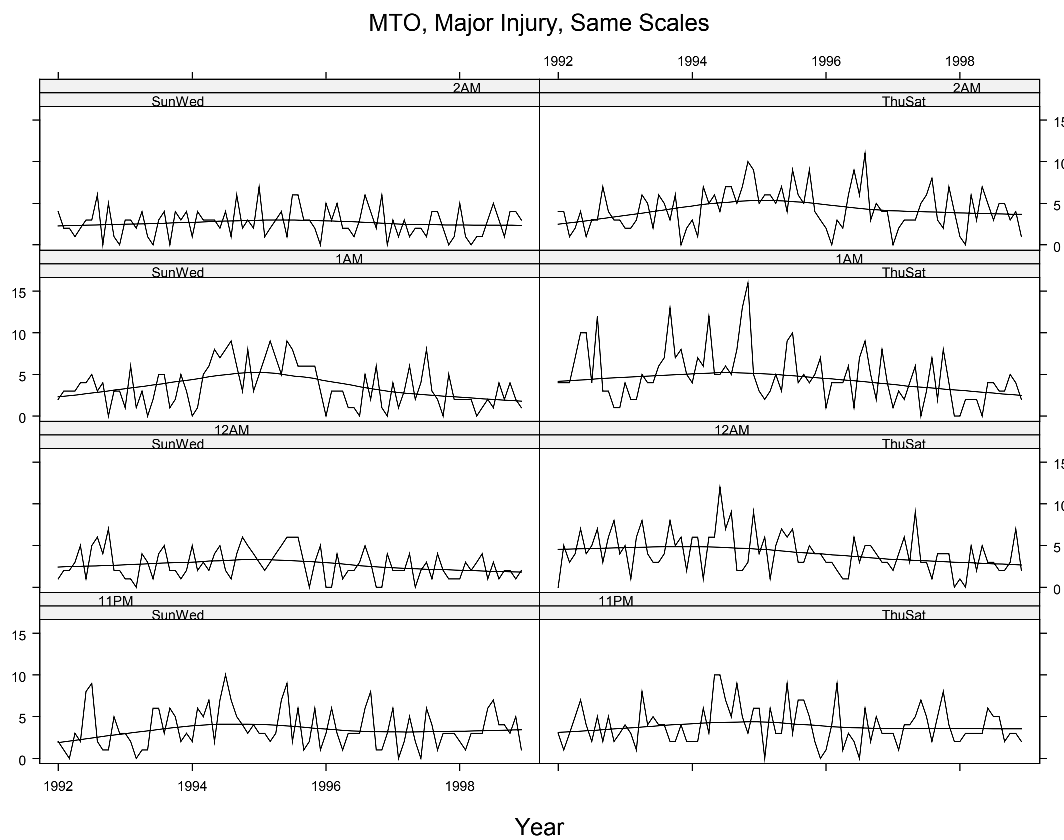
```
> mto3.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   3   3   3   4   4   5   3   4   0   3   3
1993:   1   6   1   3   0   2   5   5   1   2   5   3
1994:   0   1   5   6   8   7   8   9   6   3   8   3
1995:   5   7   9   7   5   9   8   6   6   6   6   3
1996:   0   3   3   3   1   1   0   5   2   6   1   0
1997:   4   1   3   6   2   4   8   3   2   0   5   2
1998:   2   2   2   0   1   2   1   4   2   4   2   1
> MannKendall(mto3.1AMSunWed.ts)
```

tau = -0.122,   sl =11.97%

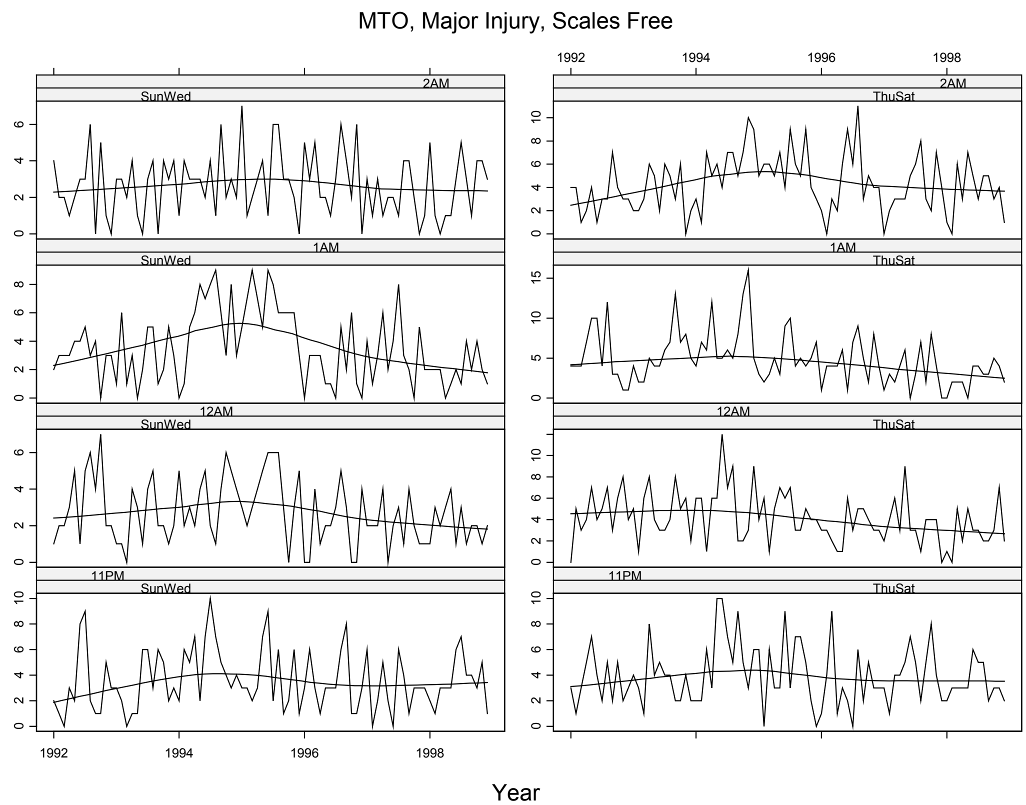
```
> mto3.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   2   2   1   2   3   3   6   0   5   1   0
1993:   3   3   2   4   1   0   3   4   0   4   3   4
1994:   1   4   3   3   3   2   4   1   6   2   3   2
1995:   7   1   2   3   4   1   6   6   3   3   2   0
1996:   5   3   5   2   2   1   3   6   4   2   6   0
1997:   3   1   3   1   2   2   1   4   4   2   0   1
1998:   5   1   0   1   1   3   5   3   1   4   4   3
> MannKendall(mto3.2AMSunWed.ts)
tau = -0.0206,   sl =79.84%
```

```
> #
mto3.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   3   1   3   5   7   4   2   5   2   5   2   3
1993:   4   3   1   8   4   5   4   4   2   2   4   2
1994:   2   2   6   3  10  10   7   5   9   5   3   6
1995:   6   0   6   3   3   9   3   7   7   5   2   0
1996:   1   4   9   1   3   2   0   6   2   5   3   3
1997:   3   1   4   4   5   7   5   2   5   8   4   2
1998:   2   3   3   3   3   6   5   5   2   3   3   2
> MannKendall(mto3.11PMThuSat.ts)
tau = -0.0243,   sl =76.01%
> mto3.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   5   3   4   7   4   5   7   3   6   8   4
1993:   5   1   6   8   4   3   3   4   8   5   6   2
1994:   6   6   1   6   6  12   7   9   2   2   3   9
1995:   4   6   1   5   7   6   7   3   3   5   4   4
1996:   3   3   2   1   1   6   3   5   5   4   3   3
1997:   2   4   6   3   9   3   3   1   4   4   4   0
1998:   1   0   5   2   5   3   3   2   2   3   7   2
> MannKendall(mto3.12AMThuSat.ts)
tau = -0.218,   sl =0.5365%
> mto3.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   4   4   7  10  10   4  12   3   3   1   1
1993:   4   2   2   5   4   4   6   7  13   7   8   5
1994:   4   7   6  12   5   5   6   5   8  13  16   5
1995:   3   2   3   5   3   9  10   4   5   4   5   7
1996:   1   4   4   4   6   1   7   9   5   2   8   4
1997:   1   3   2   4   6   0   3   7   2   8   4   0
1998:   0   2   2   2   0   4   4   3   3   5   4   2
> MannKendall(mto3.1AMThuSat.ts)
tau = -0.214,   sl =0.5954%
> mto3.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   4   1   2   4   1   3   3   7   4   3   3
1993:   2   2   3   6   5   2   6   5   3   6   0   2
1994:   3   1   7   5   6   4   7   7   5   7  10   9
1995:   5   6   6   5   7   4   9   6   5   9   4   3
1996:   2   0   3   2   6   9   6  11   3   5   4   4
1997:   0   2   3   3   3   5   6   8   3   2   7   4
1998:   1   0   6   3   7   5   3   5   5   3   4   1
> MannKendall(mto3.2AMThuSat.ts)
tau = 0.0335,   sl =67.06%
```

Time series trellis plot. Major injury. Same scales.



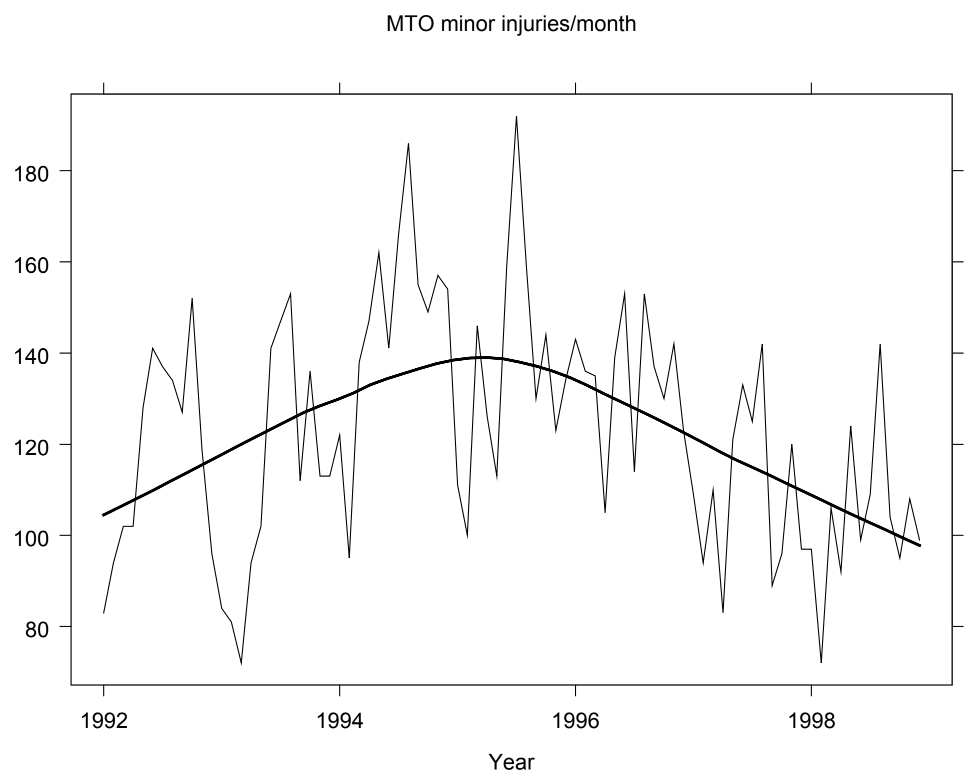
Time series trellis plot. Major injury. Scales free.



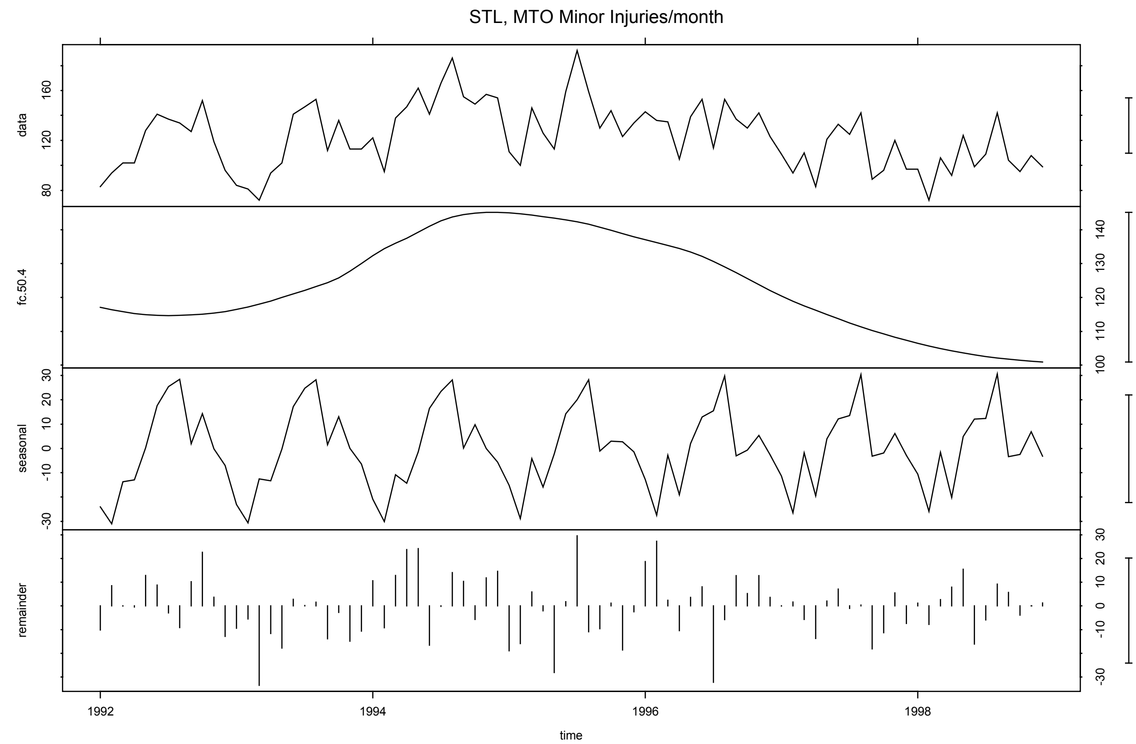
Minor Injuries

Monthly Overall Minor Injuries

```
> mto2.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  83  94 102 102 128 141 137 134 127 152 119  96
1993:  84  81  72  94 102 141 147 153 112 136 113 113
1994: 122  95 138 147 162 141 166 186 155 149 157 154
1995: 111 100 146 126 113 159 192 159 130 144 123 134
1996: 143 136 135 105 139 153 114 153 137 130 142 123
1997: 109  94 110  83 121 133 125 142  89  96 120  97
1998:  97  72 106  92 124  99 109 142 104  95 108  99
```

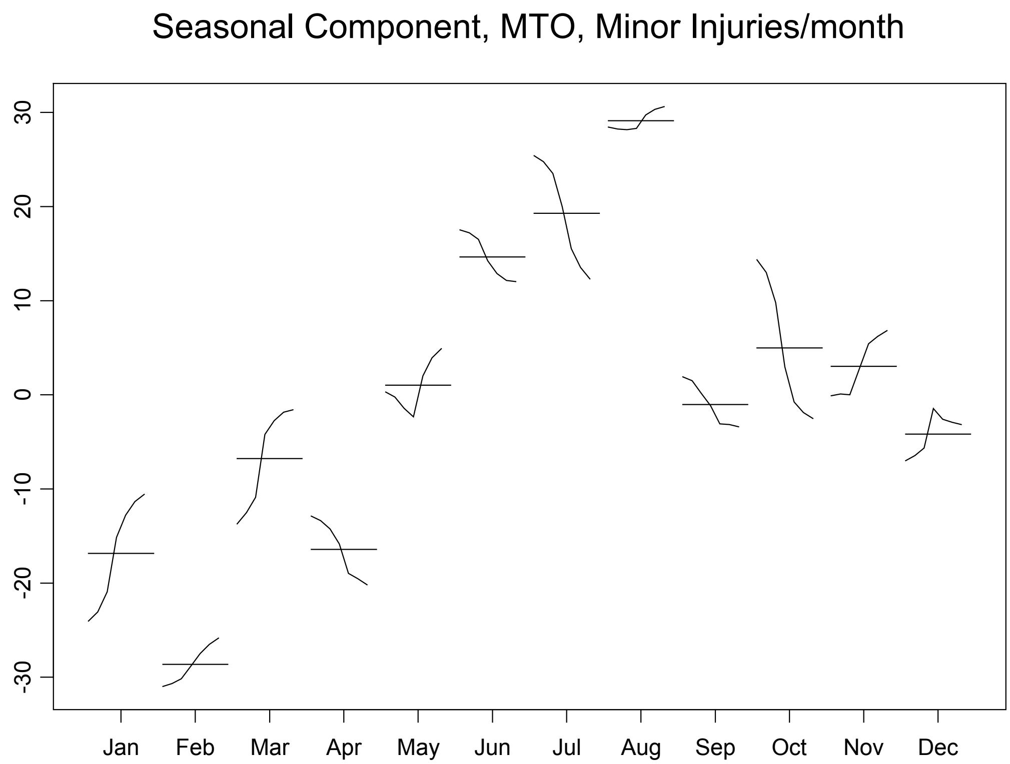


STL Analysis – Minor Injuries



ss.window = 7 ,ss.robust = TRUE , fc.window = 50.4 , fc.degree = 2 , lambda = 1

Seasonal Component – Minor Injuries

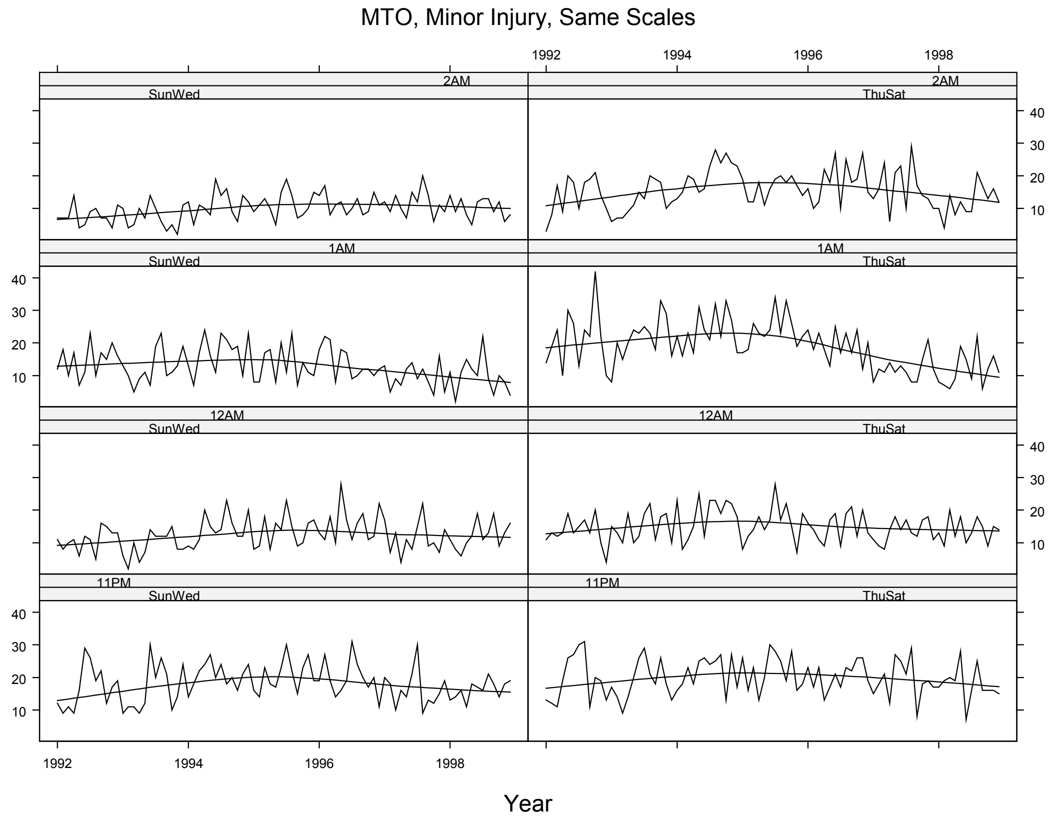


Weekgroup & Hour Time Series: Minor Injuries

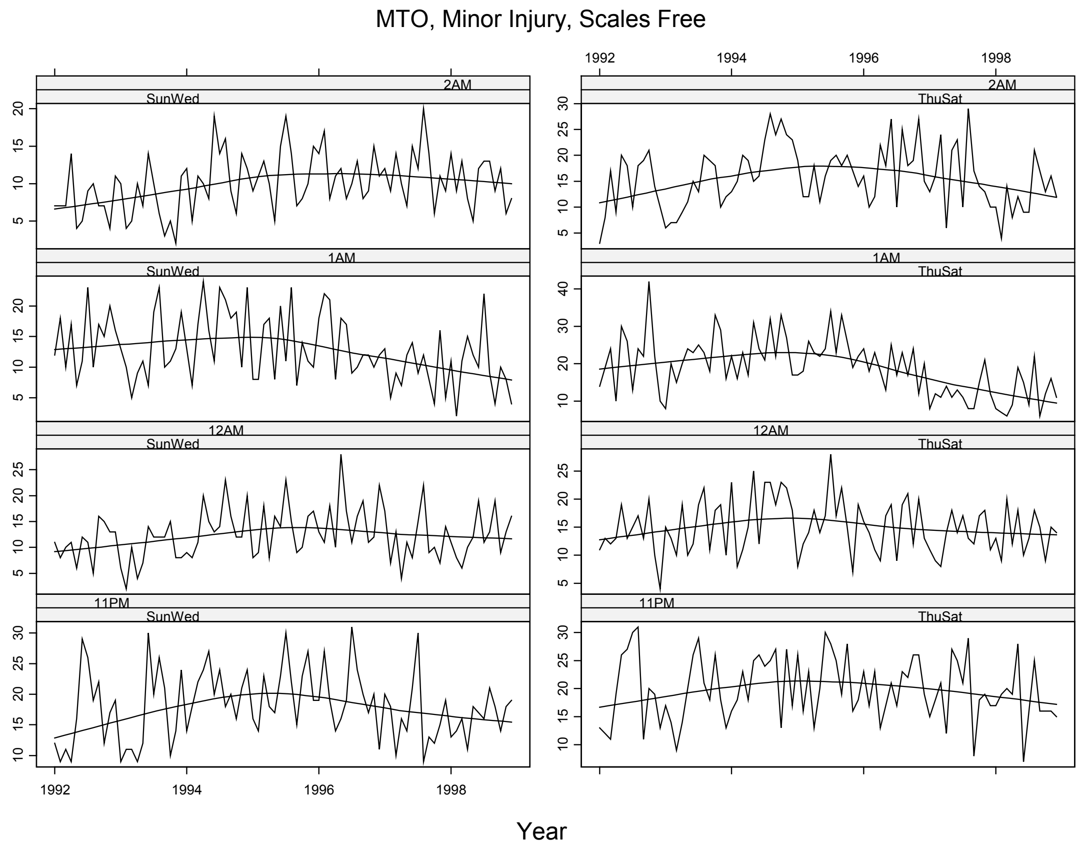
```
> mto2.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  12   9  11   9  16  29  26  19  22  12  17  19
1993:   9  11  11   9  12  30  20  26  21  10  14  24
1994:  14  18  22  24  27  20  24  18  20  16  21  24
1995:  16  14  23  18  17  23  30  22  15  23  27  19
1996:  19  27  19  14  16  19  31  24  20  17  20  11
1997:  20  18  10  16  14  21  30   9  13  12  15  19
1998:  13  14  16  11  18  17  16  21  18  14  18  19
> MannKendall(mto2.11PMSunWed.ts)
tau = -0.0112,   sl =88.61%
> mto2.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  11   8  10  11   6  12  11   5  16  15  13  13
1993:   6   2  10   4   7  14  12  12  12  15   8   8
1994:   9   8  11  20  15  13  14  23  16  12  12  20
1995:   8   9  18   8  16  14  23  15   9  10  16  17
1996:  13  11  18  10  28  17  11  16  19  11  12  22
1997:  17   7  13   4  11   8  15  22   9  10   7  14
1998:  11   8   6  10  12  19  11  13  19   9  13  16
> MannKendall(mto2.12AMSunWed.ts)
tau = 0.124,   sl =10.53%
> mto2.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  12  18  10  17   7  11  23  10  17  15  20  16
1993:  13  10   5   9  11   7  19  23  10  11  13  19
1994:  13   7  17  24  16  11  23  21  18  19  10  23
1995:   8   8  17  18   8  20  11  23   7  14  11  10
1996:  18  22  21   8  18  17   9  10  12  12  10  12
1997:  13   5   9   7  12  14   9  12   8   4  16   5
1998:  11   2  11  15  12  10  22   9   4  10   8   4
> MannKendall(mto2.1AMSunWed.ts)
tau = -0.203,   sl =0.7782%
> mto2.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   7   7   7  14   4   5   9  10   7   7   4  11
1993:  10   4   5  10   7  14  10   6   3   5   2  11
1994:  12   5  11  10   8  19  14  16   9   6  14  12
1995:   9  11  13  10   5  15  19  14   7   8  10  15
1996:  14  17   8  11  12   8  10  13   8   9  15  11
1997:  12   9  14  10   7  15  12  20  14   6  11   9
1998:  14   9  13   8   5  12  13  13   9  12   6   8
> MannKendall(mto2.2AMSunWed.ts)
tau = 0.2,   sl =0.9057%
```

```
> #
mto2.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  13  12  11  19  26  27  30  31  11  20  19  13
1993:  17  14   9  14  20  26  29  21  18  26  18  13
1994:  16  18  23  18  25  26  24  25  27  13  27  17
1995:  26  16  23  13  20  30  28  25  19  28  16  18
1996:  23  17  23  13  17  21  17  23  22  26  26  19
1997:  15  18  21  12  27  25  21  29   8  18  19  17
1998:  17  19  20  19  28   7  16  25  16  16  16  15
> MannKendall(mto2.11PMThuSat.ts)
tau = -0.0344,   sl =65.33%
> mto2.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  11  13  12  13  19  13  15  17  13  20  10   4
1993:  15  13  10  19  10  12  19  22  11  18  19  10
1994:  23   8  11  15  25  12  23  23  19  23  22  18
1995:   8  12  14  18  14  17  28  17  22  15   7  19
1996:  16  14  11   9  17  19   9  19  21  12  20  13
1997:  11   9   8  14  18  14  17  13  12  17  18  11
1998:  13   9  20  12  18  10  13  18  15   9  15  14
> MannKendall(mto2.12AMThuSat.ts)
tau = -0.0346,   sl =65.31%
> mto2.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  14  19  24  10  30  26  13  24  22  42  22  10
1993:   8  20  15  20  24  23  25  23  18  33  29  16
1994:  22  16  23  17  31  24  21  32  22  33  27  17
1995:  17  18  26  23  22  24  34  23  33  26  19  22
1996:  24  18  23  18  13  25  17  23  17  24  12  20
1997:   8  12  11  14  11  13  11   8   8  15  21  12
1998:   8   7   6   9  19  15   9  22   6  12  16  11
> MannKendall(mto2.1AMThuSat.ts)
tau = -0.327,   sl =0.001491%
> mto2.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   3   8  17   9  20  18  10  18  19  21  14  10
1993:   6   7   7   9  11  15  13  20  19  18  10  12
1994:  13  15  20  19  15  16  23  28  24  27  24  23
1995:  19  12  12  18  11  16  19  20  18  20  17  14
1996:  16  10  12  22  18  27  10  25  18  19  27  15
1997:  13  16  24   6  21  23  10  29  17  14  13  10
1998:  10   4  14   8  12   9   9  21  17  13  16  12
> MannKendall(mto2.2AMThuSat.ts)
tau = 0.022,   sl =77.45%
```

Time series trellis plot. Minor injury. Same scales.



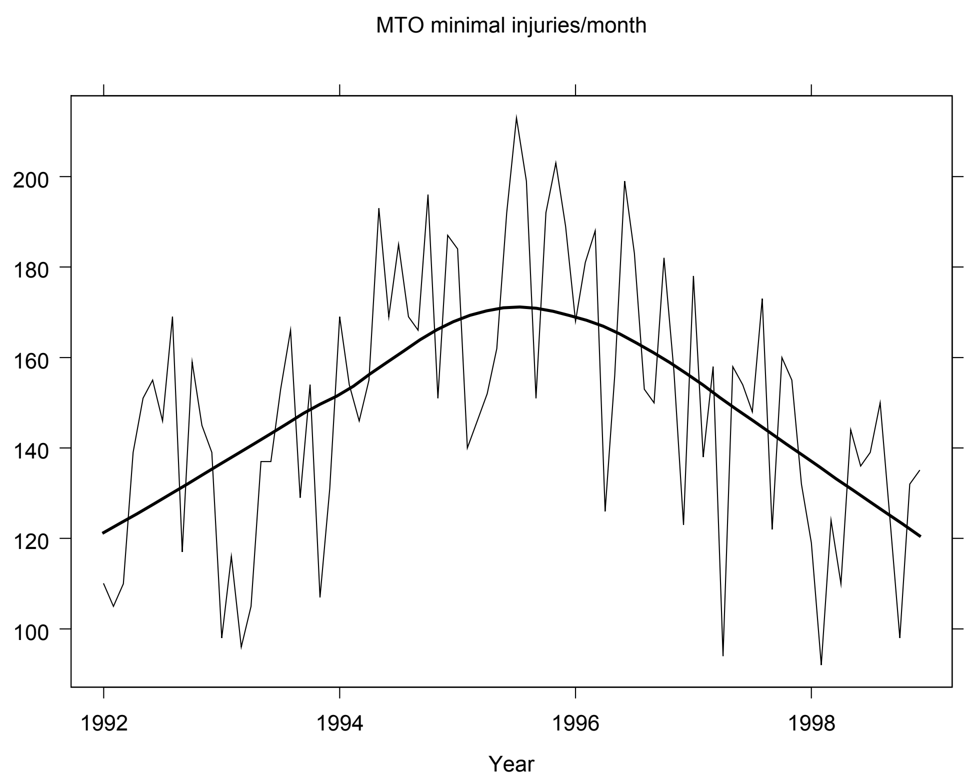
Time series trellis plot. Minor injury. Scales free.



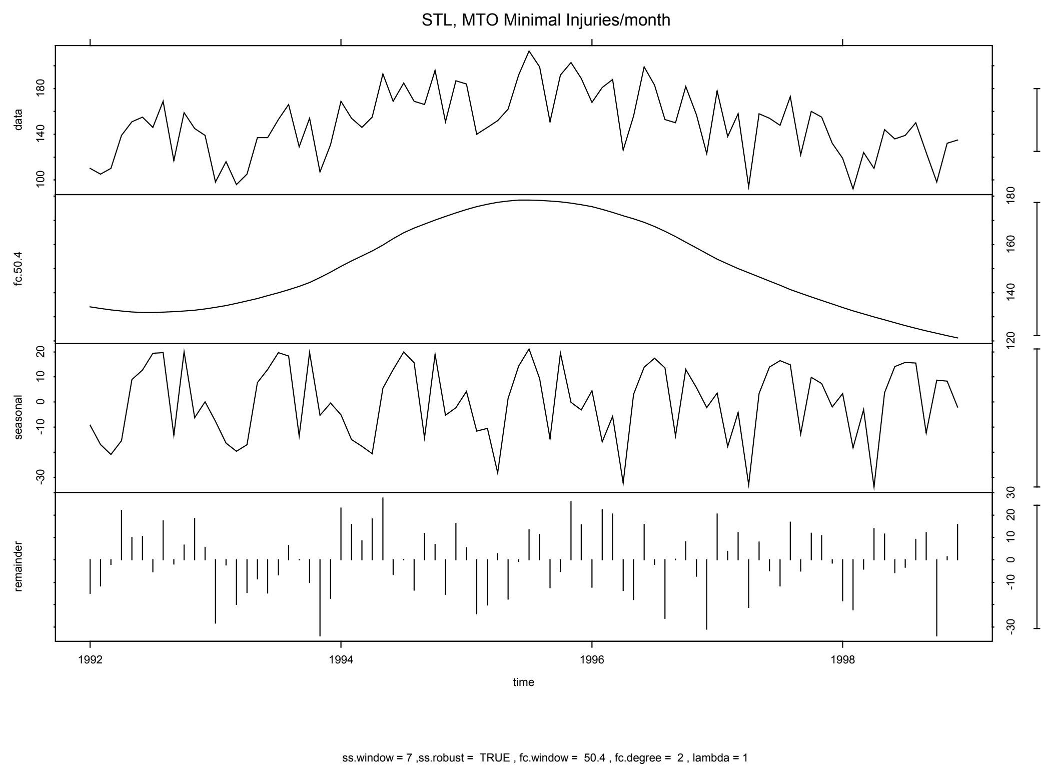
Minimal Injuries

Monthly Overall Minimal Injuries

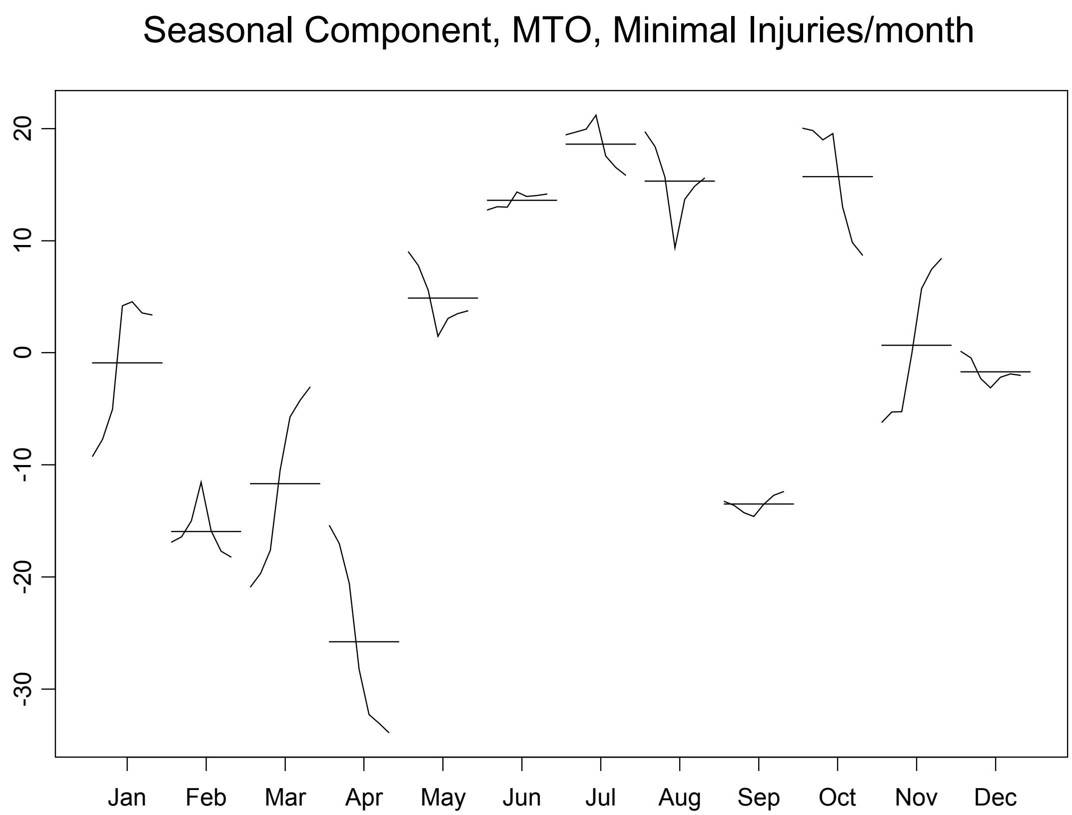
```
> mto1.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992: 110 105 110 139 151 155 146 169 117 159 145 139
1993:  98 116  96 105 137 137 153 166 129 154 107 131
1994: 169 154 146 155 193 169 185 169 166 196 151 187
1995: 184 140 146 152 162 192 213 199 151 192 203 189
1996: 168 181 188 126 156 199 183 153 150 182 157 123
1997: 178 138 158  94 158 154 148 173 122 160 155 132
1998: 119  92 124 110 144 136 139 150 124  98 132 135
```



STL: Minimal Injuries



Seasonal Component: Minimal Injuries

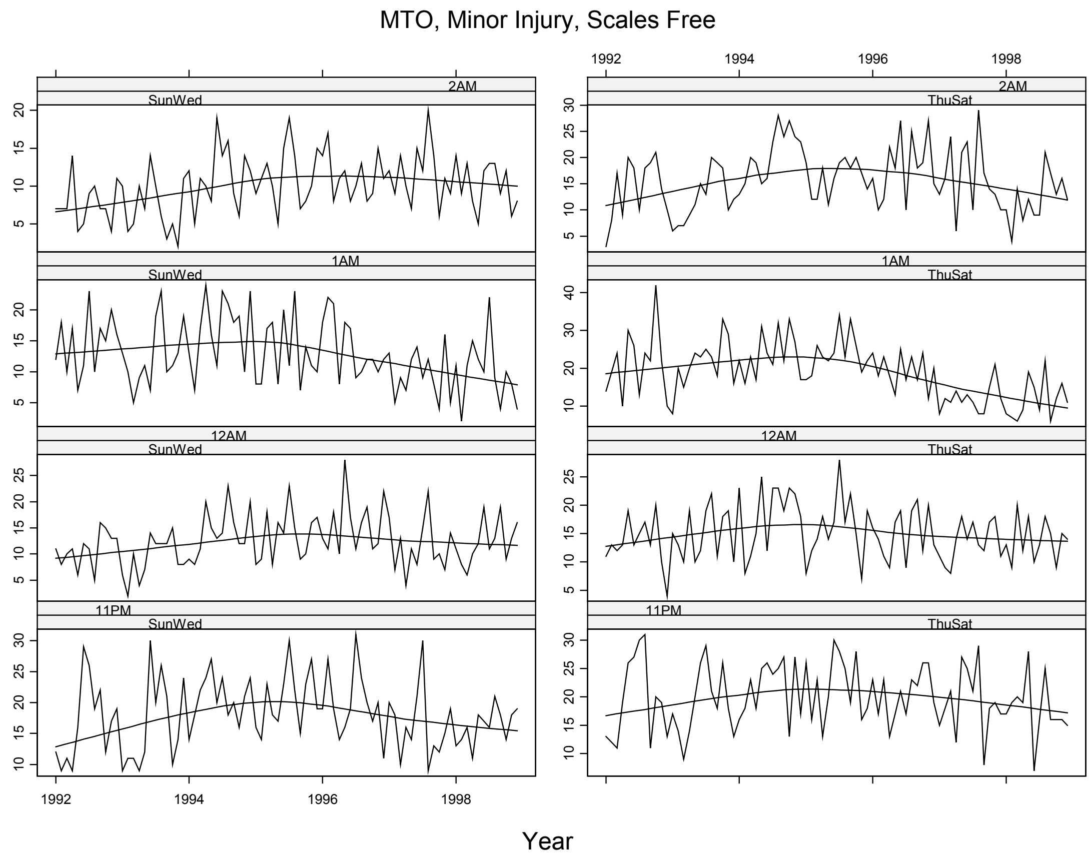


Weekgroup & Hour Time Series: Minimal Injuries

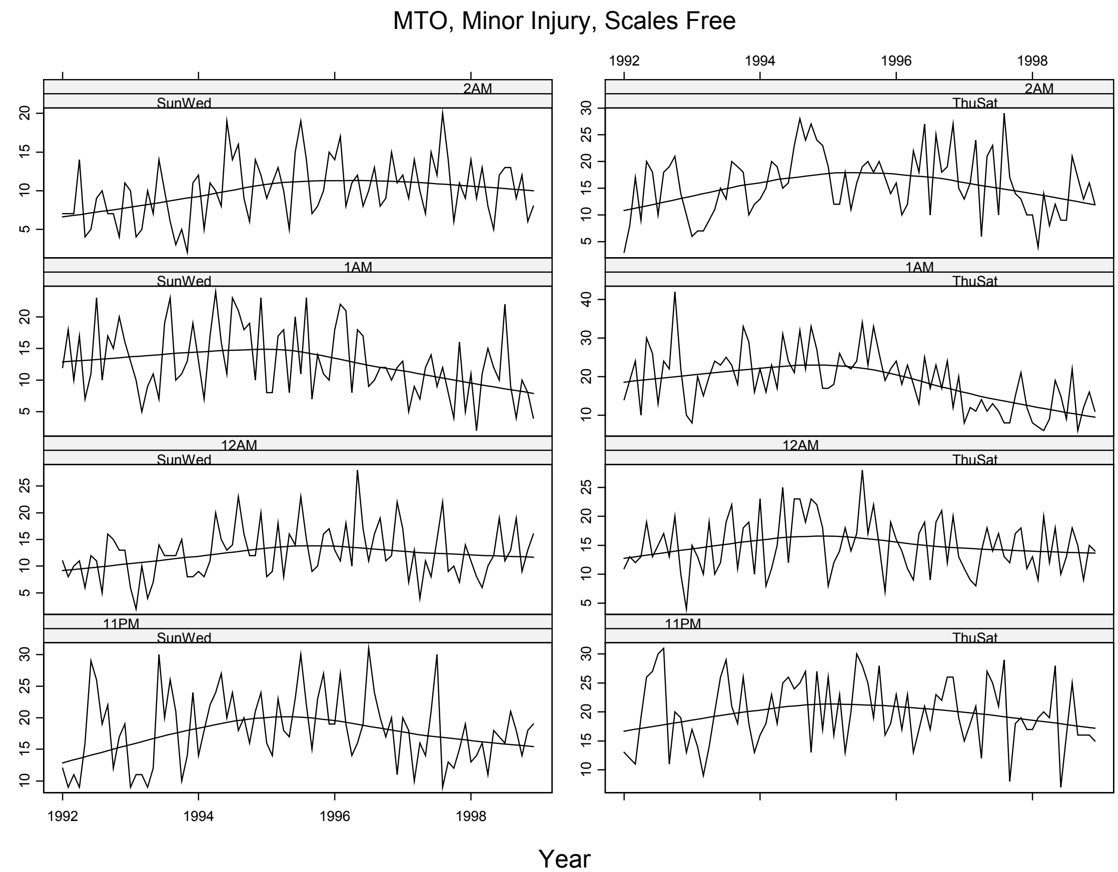
```
> mto1.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  11  16  15  28  13  26  25  25  10  18  24  32
1993:  13  12  12  18  26  16  18  27  18  16  13  27
1994:  29  33  27  21  28  27  24  25  20  30  24  27
1995:  19  33  30  23  31  25  41  47  23  26  46  25
1996:  25  26  40  18  29  32  44  23  16  26  30  14
1997:  50  16  24  15  18  26  31  30  19  17  17  28
1998:  18  19  21  16  20  36  28  22  17  14  18  26
> MannKendall(mto1.11PMSunWed.ts)
tau = 0.0894,   sl =23.79%
> mto1.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  10   8   7  14  10  12  11  18   7  17  25  22
1993:  14  11  24  15   9  20  17  18  14  12   8  21
1994:  15  10  17  12  18  18  18  22  18  10  18  24
1995:  13  19  15  21  20  19  23  23  20  14  29  21
1996:  11  17  27  15  17  18  23  18   7  19  12  13
1997:  23  11  15  11   8  11  23  17  12  34  21  11
1998:  16   8  12  14   9  12  19  10   9  11  12  17
> MannKendall(mto1.12AMSunWed.ts)
tau = 0.00619,   sl =93.82%
> mto1.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  17  13   9  15  11  22  15  17  13  14  13  12
1993:   9   8   9  12   8  15  20  12  16  17   4  14
1994:  19  21  17  18  20  23  24  22  17  17  15  18
1995:  15  14  21  14  20  25  17  22  14   6  17  20
1996:  21  25  17  15   8  13  12  18  10  23  13   8
1997:  19   6  20  11   8  15  11  13  10  10  11  13
1998:  12   3  13  13   6  11  13   4   4  12   8  13
> MannKendall(mto1.1AMSunWed.ts)
tau = -0.18,   sl =1.826%
> mto1.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   8   3   9   4   6   6   7   7   8  10   5  13
1993:   7   6   5  10  12  11  11   9  13   5  11   9
1994:  11  14  14  12   6  10  17  11  12  15   8   9
1995:  11   7  10  12  11  15  13  15   6  11  15  12
1996:  12  11  13  10  16  11  18  24  11  17  14  17
1997:   9  14   9  11  14  21  16  18   8  15  11  12
1998:  13   9   8  11  11   6  11  13   7   6  11   9
> MannKendall(mto1.2AMSunWed.ts)
tau = 0.253,   sl =0.1032%
```

```
> #
mto1.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  23  15  25  30  25  33  26  32  19  26  24  21
1993:  17  23  13  15  25  18  33  26  17  32  20  18
1994:  32  25  17  30  38  28  31  27  34  34  27  35
1995:  37  26  21  24  25  34  40  21  26  25  32  31
1996:  26  26  30  22  32  49  26  19  33  31  23  28
1997:  36  31  27  13  34  30  29  32  18  25  23  26
1998:  25  25  21  20  43  27  23  25  36  13  28  14
> MannKendall(mto1.11PMThuSat.ts)
tau = 0.064,   sl =40.07%
> mto1.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   7  13  10  12  26  22  17  24   7  21  16  13
1993:  21  16   9   7  18  15  21  25  19  25  19  17
1994:  23  14  13  20  30  18  20  22  21  28  14  26
1995:  15  14  12  19  27  26  26  27  19  32  16  19
1996:  25  15  16   9  21  22  15  14  18  23  23  10
1997:  13  18  19   7  27  12  13  18  14  12  16  18
1998:  11   8  15  13  20  23  16  25  22  16  23  21
> MannKendall(mto1.12AMThuSat.ts)
tau = 0.0111,   sl =88.61%
> mto1.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  17  27  22  22  35  15  24  32  32  34  20  14
1993:  11  26  14  16  24  25  20  26  20  29  20  13
1994:  21  23  25  23  33  27  26  24  25  41  25  26
1995:  27  12  23  30  14  25  34  26  21  45  28  35
1996:  33  37  21  24  16  26  28  20  30  25  19  15
1997:  11  18  23  13  20  25  10  21  19  21  27  10
1998:  12   8  24  13  14  12  16  23  10  15  10  13
> MannKendall(mto1.1AMThuSat.ts)
tau = -0.226,   sl =0.2818%
> mto1.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  17  10  13  14  25  19  21  14  21  19  18  12
1993:   6  14  10  12  15  17  13  23  12  18  12  12
1994:  19  14  16  19  20  18  25  16  19  21  20  22
1995:  47  15  14   9  14  23  19  18  22  33  20  26
1996:  15  24  24  13  17  28  17  17  25  18  23  18
1997:  17  24  21  13  29  14  15  24  22  26  29  14
1998:  12  12  10  10  21   9  13  28  19  11  22  22
> MannKendall(mto1.2AMThuSat.ts)
tau = 0.123,   sl =10.47%
```

Time series trellis plot. Minimal injury. Same scales.



Time series trellis plot. Minimal injury. Scales free.



D. MTO DRC Dataset: Crosstabs

Summary

MTODRC dataset is the MTO dataset with the added variable, `driver`, which has two values, `sober` or `drunk`. The database given has 26,026 records. Each record contains the variable `injury` which is the driver injury in one of four categories: `minimal, minor, major, killed`. Another variable, prov, indicates the license plate on the vehicle. The frequency tabulation indicates the number of accidents involving each value of the prov variable. After Ontario the next two are USA and "unknown" code `= -1.`

`Driver+Injury`: Drunk drivers tend not to be involved in minimal injury accidents and are more likely to be involved in major injury or fatal accidents. Overall, for about 30% of all accidents, the driver is drunk. Overall about 48%, 40%, 10% and 2% of accidents are respectively minimal injury, minor injury, major injury and fatal.

`Driver+Wkgrp`: As expected drunk drivers are relatively more common in the ThuSat weekgroup. Overall, about 43% and 57% of all accidents occur respectively in the SunWed and ThuSat weekgroups.

`Driver + Hour`: Drunk drivers are more prevalent at 1AM and 2AM. Overall about 32%, 22%, 25% and 21% of accidents in the respective hour windows beginning at 11PM, 12AM, 1AM and 2AM.

`Driver + Province`: USA and Quebec drivers involved in accidents tend to be relatively more sober. Drivers in the "unknown" vehicle province category tend to be relatively more drunk.

Frequencies: Province

After Ontario the next two are USA and "unknown" code = `-1.`

Vehicle Province or State

		Frequency	Percent
Valid	-1	230	.9
	Alberta	38	.1
	British Columbia	33	.1
	Manitoba	38	.1
	New Brunswick	18	.1
	Newfoundland	5	.0
	Nova Scotia	19	.1
	Ontario	25072	96.3
	Prince Edward Island	3	.0
	Quebec	270	1.0
	Saskatchewan	13	.0
	Yukon and North West Territories	2	.0
	U.S.A.	284	1.1
	Other Foreign	1	.0
	Total	26026	100.0

Driver + Injury

Drunk drivers tend not to be involved in minimal injury accidents and are more likely to be involved in major injury or fatal accidents.

```
Call:
crosstabs(formula =  ~ driver + injury, data = mto.df, na.action =
na.exclude)
26026 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
driver |injury
       |minimal|minor  |major  |killed |RowTotl|
-------+-------+-------+-------+-------+-------+
sober  |9628   |6912   |1284   | 197   |18021  |
       |0.53   |0.38   |0.071  |0.011  |0.69   |
       |0.77   |0.67   |0.51   |0.33   |       |
       |0.37   |0.27   |0.049  |0.0076 |       |
-------+-------+-------+-------+-------+-------+
drunk  |2948   |3436   |1228   | 393   |8005   |
       |0.37   |0.43   |0.15   |0.049  |0.31   |
       |0.23   |0.33   |0.49   |0.67   |       |
       |0.11   |0.13   |0.047  |0.015  |       |
-------+-------+-------+-------+-------+-------+
ColTotl|12576  |10348  |2512   |590    |26026  |
       |0.48   |0.4    |0.097  |0.023  |       |
-------+-------+-------+-------+-------+-------+
Test for independence of all factors
      Chi^2 = 1088.853 d.f.= 3 (p=0)
      Yates' correction not used
 Chi-sq decomposition: (obs-exp)/sqrt(exp)
      minimal minor  major killed
sober    9.86 -2.99 -10.92 -10.47
drunk  -14.79  4.49  16.38  15.70
```

Driver + Wkgrp

As expected drunk drivers are relatively more common in the ThuSat weekgroup.

```
Call:
crosstabs(formula =  ~ driver + wkgrp, data = mto.df, na.action =
na.exclude)
26026 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
driver |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
sober  |8051   |9970   |18021  |
       |0.45   |0.55   |0.69   |
       |0.72   |0.67   |       |
       |0.31   |0.38   |       |
-------+-------+-------+-------+
drunk  |3191   |4814   |8005   |
       |0.4    |0.6    |0.31   |
       |0.28   |0.33   |       |
       |0.12   |0.18   |       |
-------+-------+-------+-------+
ColTotl|11242  |14784  |26026  |
       |0.43   |0.57   |       |
-------+-------+-------+-------+
Test for independence of all factors
      Chi^2 = 52.3307 d.f.= 1 (p=4.689582e-013)
      Yates' correction not used
 Chi-sq decomposition: (obs-exp)/sqrt(exp)
      SunWed ThuSat
sober   3.02  -2.64
drunk  -4.54   3.96
```

Driver + Hour

Drunk drivers are more prevalent at 1AM and 2AM.

```
Call:
crosstabs(formula =  ~ driver + hour, data = mto.df, na.action =
na.exclude)
26026 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
driver |hour
       |11PM   |12AM   |1AM    |2AM    |RowTotl|
-------+-------+-------+-------+-------+-------+
sober  |6581   |4192   |4069   |3179   |18021  |
       |0.37   |0.23   |0.23   |0.18   |0.69   |
       |0.8    |0.72   |0.62   |0.59   |       |
       |0.25   |0.16   |0.16   |0.12   |       |
-------+-------+-------+-------+-------+-------+
drunk  |1634   |1662   |2537   |2172   |8005   |
       |0.2    |0.21   |0.32   |0.27   |0.31   |
       |0.2    |0.28   |0.38   |0.41   |       |
       |0.063  |0.064  |0.097  |0.083  |       |
-------+-------+-------+-------+-------+-------+
ColTotl|8215   |5854   |6606   |5351   |26026  |
       |0.32   |0.22   |0.25   |0.21   |       |
-------+-------+-------+-------+-------+-------+
Test for independence of all factors
      Chi^2 = 895.2281 d.f.= 3 (p=0)
      Yates' correction not used
 Chi-sq decomposition: (obs-exp)/sqrt(exp)
        11PM  12AM    1AM    2AM
sober  11.84  2.18  -7.47  -8.64
drunk -17.76 -3.27  11.21  12.97
```

Driver + Province

USA and Quebec drivers involved in accidents tend to be relatively more sober. Drivers in the "unknown" vehicle province category tend to be relatively more drunk.

```
Call:
crosstabs(formula =  ~ prov + driver, data = mto.df, na.action = na.exclude)
26026 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
prov    |driver
        |sober      |drunk      |RowTotl|
--------+-----------+-----------+-------+
Al      |  24       |  14       |38     |
        |0.63       |0.37       |0.0015 |
--------+-----------+-----------+-------+
BC      |  24       |   9       |33     |
        |0.73       |0.27       |0.0013 |
--------+-----------+-----------+-------+
Man     |  31       |   7       |38     |
        |0.82       |0.18       |0.0015 |
--------+-----------+-----------+-------+
NB      |  10       |   8       |18     |
        |0.56       |0.44       |6.9e-4 |
--------+-----------+-----------+-------+
NWFLD   |   4       |   1       |5      |
        |0.8        |0.2        |1.9e-4 |
--------+-----------+-----------+-------+
NS      |  10       |   9       |19     |
        |0.53       |0.47       |7.3e-4 |
--------+-----------+-----------+-------+
Ont     |173397733  |25072  |
        |0.69       |0.31       |0.96   |
--------+-----------+-----------+-------+
PEI     |   1       |   2       |3      |
        |0.33       |0.67       |1.2e-4 |
--------+-----------+-----------+-------+
Que     | 212       |  58       |270    |
        |0.79       |0.21       |0.01   |
--------+-----------+-----------+-------+
Sask    |  11       |   2       |13     |
        |0.85       |0.15       |5.e-4  |
--------+-----------+-----------+-------+
YNWT    |   1       |   1       |2      |
        |0.5        |0.5        |7.7e-5 |
--------+-----------+-----------+-------+
USA     | 225       |  59       |284    |
        |0.79       |0.21       |0.011  |
--------+-----------+-----------+-------+
Other   |   0       |   1       |1      |
        |0          |1          |3.8e-5 |
--------+-----------+-----------+-------+
Unknown | 129       | 101       |230    |
        |0.56       |0.44       |0.0088 |
--------+-----------+-----------+-------+
ColTotal|18021      |8005       |26026  |
        |0.69       |0.31       |       |
--------+-----------+-----------+-------+
```

```
Test for independence of all factors
       Chi^2 = 56.71319 d.f.= 13 (p=2.017336e-007)
       Yates' correction not used
       Some expected values are less than 5, don't trust stated p-value
 Chi-sq decomposition: (obs-exp)/sqrt(exp)
        sober drunk
     Al -0.45  0.68
     BC  0.24 -0.36
    Man  0.91 -1.37
     NB -0.70  1.05
  NWFLD  0.29 -0.43
     NS -0.87  1.31
    Ont -0.16  0.24
    PEI -0.75  1.12
    Que  1.83 -2.75
   Sask  0.67 -1.00
   YNWT -0.33  0.49
    USA  2.02 -3.03
  Other -0.83  1.25
Unknown -2.40  3.60
```

D. MTO DRC Dataset: Time Series

Summary

Fatalities: Data and Trellis
Upward trend in `2AMSunWedSober` and **downward** in `1AMSatThuDrunk`. Data are small counts, mostly 0 some 1's 2's 3's and 4's.

Major Injury: Data and Trellis
Downward trends: `12AMSunWed.drunk.ts, 1AMSunWed.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts.`

Minor Injury: Data and Trellis
Upward trend: `12AMSunWed.sober.ts, 2AMSunWed.sober.ts`
Downward trend: `12AMThuSat.sober.ts, 1AMThuSat.sober.ts, 1AMSunWed.drunk.ts, 11PMThuSat.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts`

Minimal Injury Data and Trellis
upward trend: `11PMSunWed.sober.ts, 2AMSunWed.sober.ts, 11PMThuSat.sober.ts, 2AMThuSat.sober.ts, 2AMSunWed.drunk.ts`
downward trend: `1AMThuSat.sober.ts, 11PMSunWed.drunk.ts, 12AMSunWed.drunk.ts, 1AMSunWed.drunk.ts, 11PMThuSat.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts`

Fatalities

Upward trend in `2AMSunWedSober` and downward in `1AMSatThuDrunk`. Data are small counts, mostly 0 some 1's 2's 3's and 4's.

Data Listing

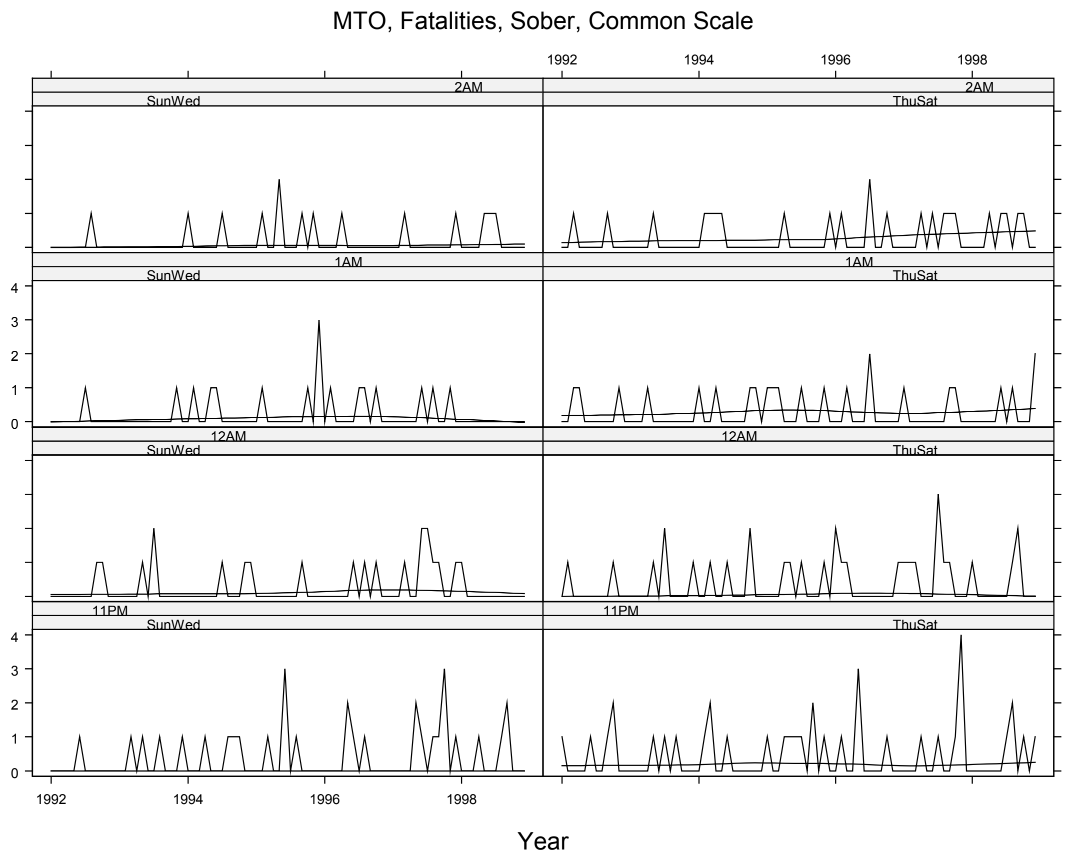
```
> mto4.11PMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   1   0   0   0   0   0   0
1993:   0   0   1   0   1   0   0   1   0   0   0   1
1994:   0   0   0   1   0   0   0   1   1   1   0   0
1995:   0   0   1   0   0   3   0   1   0   0   0   0
1996:   0   0   0   0   2   1   0   1   0   0   0   0
1997:   0   0   0   0   2   1   0   1   1   3   0   1
1998:   0   0   0   1   0   0   0   1   2   0   0   0
> MannKendall(mto4.11PMSunWed.sober.ts)
tau = 0.125,   sl =15.8%
> mto4.12AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   0   1   1   0   0
1993:   0   0   0   0   1   0   2   0   0   0   0   0
1994:   0   0   0   0   0   0   1   0   0   0   1   1
1995:   0   0   0   0   0   0   0   0   1   0   0   0
1996:   0   0   0   0   0   1   0   1   0   1   0   0
1997:   0   0   1   0   0   2   2   1   1   0   0   1
1998:   1   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(mto4.12AMSunWed.sober.ts)
tau = 0.0825,   sl =35.62%
> mto4.1AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   1   0   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   1   0
1994:   0   1   0   0   1   1   0   0   0   0   0   0
1995:   0   1   0   0   0   0   0   0   0   1   0   3
1996:   0   1   0   0   0   0   1   1   0   1   0   0
1997:   0   0   0   0   0   1   0   1   0   0   1   0
1998:   0   0   0   0   0   0   0   0   0   0   0   0
> MannKendall(mto4.1AMSunWed.sober.ts)
tau = 0.035,   sl =70.03%
> mto4.2AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   0   0   0   1   0   0   0   0
1993:   0   0   0   0   0   0   0   0   0   0   0   0
1994:   1   0   0   0   0   0   1   0   0   0   0   0
1995:   0   1   0   0   2   0   0   0   1   0   1   0
1996:   0   0   0   1   0   0   0   0   0   0   0   0
1997:   0   0   1   0   0   0   0   0   0   0   0   1
1998:   0   0   0   0   1   1   1   0   0   0   0   0
> MannKendall(mto4.2AMSunWed.sober.ts)
tau = 0.112,   sl =21.21%
```

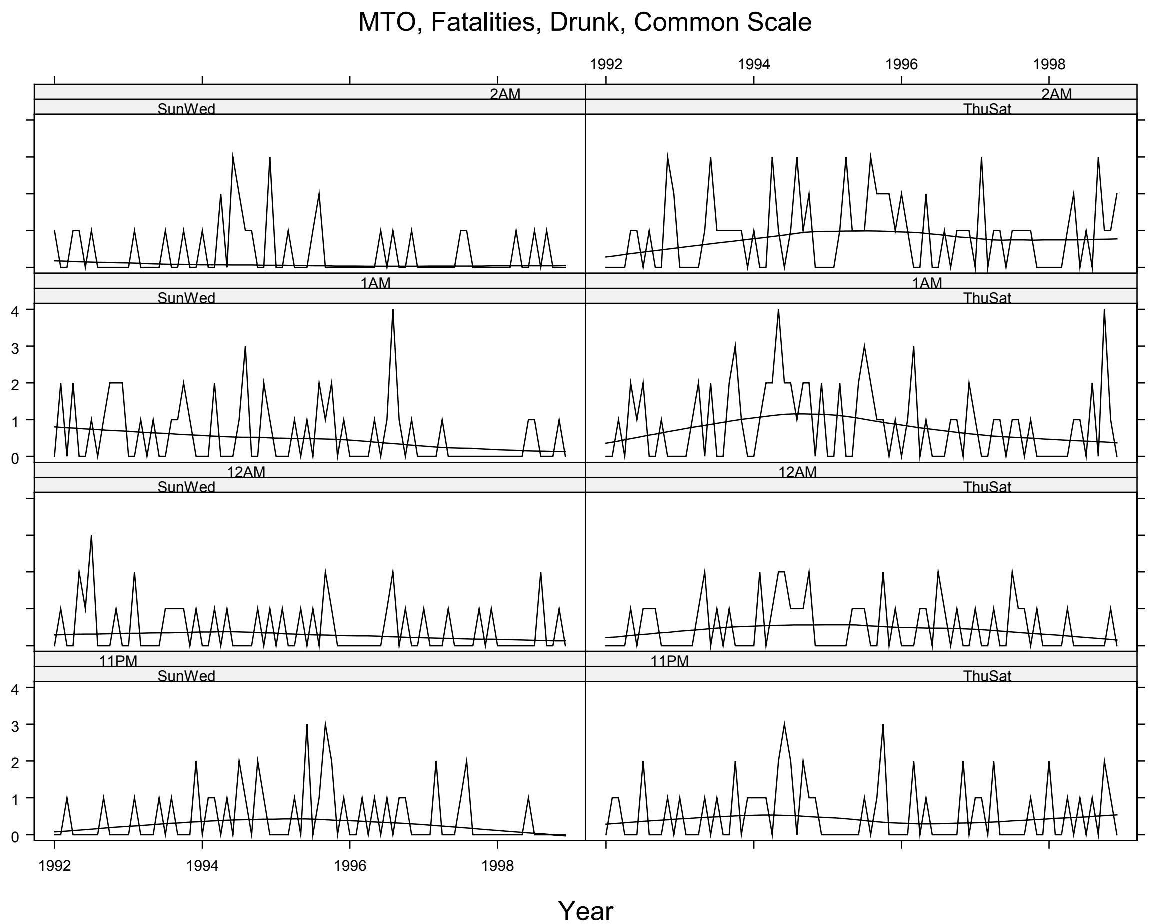
```
> #
mto4.11PMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   0   0   1   0   0   1   2   0   0
1993:   0   0   0   0   1   0   1   0   1   0   0   0
1994:   0   1   2   0   0   1   0   0   0   0   0   0
1995:   1   0   0   1   1   1   1   0   2   0   1   0
1996:   0   1   0   0   3   0   0   0   0   1   0   0
1997:   0   0   0   1   0   0   1   0   0   1   4   0
1998:   0   0   0   0   0   0   1   2   0   1   0   1
> MannKendall(mto4.11PMThuSat.sober.ts)
tau = 0.0348,   sl =69.44%
> mto4.12AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   0   0   0   0   0   0   1   0   0
1993:   0   0   0   0   1   0   2   0   0   0   0   1
1994:   0   0   1   0   0   1   0   0   0   2   0   0
1995:   0   0   0   1   1   0   1   0   0   0   1   0
1996:   2   1   1   0   0   0   0   0   0   0   0   1
1997:   1   1   1   0   0   0   3   1   1   0   0   0
1998:   1   0   0   0   0   0   0   1   2   0   0   0
> MannKendall(mto4.12AMThuSat.sober.ts)
tau = 0.095,   sl =28.25%
> mto4.1AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   1   0   0   0   0   0   0   1   0
1993:   0   0   0   1   0   0   0   0   0   0   0   0
1994:   1   0   0   1   0   0   0   0   0   1   1   0
1995:   1   1   1   0   0   0   1   0   0   0   1   0
1996:   0   0   1   0   0   0   2   0   0   0   0   0
1997:   1   0   0   0   0   0   0   0   1   1   0   0
1998:   0   0   0   0   0   1   0   1   0   0   0   2
> MannKendall(mto4.1AMThuSat.sober.ts)
tau = 0.0271,   sl =76.53%
> mto4.2AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   0   0   0   1   0   0   0
1993:   0   0   0   0   1   0   0   0   0   0   0   0
1994:   0   1   1   1   1   0   0   0   0   0   0   0
1995:   0   0   0   1   0   0   0   0   0   0   0   1
1996:   0   1   0   0   0   0   2   0   0   1   0   0
1997:   0   0   0   1   0   1   0   1   1   1   0   0
1998:   0   0   0   1   0   1   1   0   1   1   0   0
> MannKendall(mto4.2AMThuSat.sober.ts)
tau = 0.171,   sl =5.763%
```

```
> #
mto4.11PMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   0   0   0   0   1   0   0   0
1993:   0   1   0   0   0   1   0   1   0   0   0   2
1994:   0   1   1   0   1   0   2   1   0   2   1   0
1995:   0   0   0   1   0   3   0   1   3   2   0   1
1996:   0   0   1   0   1   0   1   0   1   1   0   0
1997:   0   0   2   0   0   0   1   2   0   0   0   0
1998:   0   0   0   0   0   1   0   0   0   0   0   0
> MannKendall(mto4.11PMSunWed.drunk.ts)
tau = -0.0479,   sl =58.54%
> mto4.12AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   0   0   2   1   3   0   0   0   1   0
1993:   0   2   0   0   0   0   1   1   1   1   0   1
1994:   0   0   1   0   1   0   0   0   0   1   0   1
1995:   0   1   0   0   1   0   1   0   2   1   0   0
1996:   0   0   0   0   0   0   1   2   0   1   0   0
1997:   1   0   0   0   1   0   0   0   0   1   0   1
1998:   0   0   0   0   0   0   0   2   0   0   1   0
> MannKendall(mto4.12AMSunWed.drunk.ts)
tau = -0.124,   sl =15.76%
> mto4.1AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   2   0   2   0   0   1   0   1   2   2   2
1993:   0   0   1   0   1   0   0   1   1   2   1   0
1994:   0   0   2   0   0   0   1   3   0   0   2   1
1995:   0   0   0   1   0   1   0   2   1   2   0   1
1996:   0   0   0   0   1   0   1   4   1   0   1   0
1997:   0   0   0   1   0   0   0   0   0   0   0   0
1998:   0   0   0   0   0   1   1   0   0   0   1   0
> MannKendall(mto4.1AMSunWed.drunk.ts)
tau = -0.203,   sl =1.872%
> mto4.2AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   0   1   1   0   1   0   0   0   0   0
1993:   0   1   0   0   0   0   1   0   0   1   0   0
1994:   1   0   0   2   0   3   2   1   1   0   0   3
1995:   0   0   1   0   0   0   1   2   0   0   0   0
1996:   0   0   0   0   0   1   0   1   0   0   1   0
1997:   0   0   0   0   0   0   1   1   0   0   0   0
1998:   0   0   0   1   0   0   1   0   1   0   0   0
> MannKendall(mto4.2AMSunWed.drunk.ts)
tau = -0.0967,   sl =27.39%
```

```
> #
mto4.11PMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   1   1   0   0   0   2   0   0   0   1   0
1993:   1   0   0   0   1   0   1   0   0   2   0   1
1994:   1   1   1   0   2   3   2   0   2   1   1   0
1995:   0   0   0   0   0   0   1   0   1   3   0   0
1996:   0   0   2   0   1   0   0   0   0   0   2   0
1997:   1   1   0   2   0   0   0   0   0   1   0   0
1998:   2   0   0   1   0   1   0   1   0   2   1   0
> MannKendall(mto4.11PMThuSat.drunk.ts)
tau = -0.0137,   sl =87.72%
> mto4.12AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   1   0   1   1   1   0   0   0
1993:   0   0   0   1   2   0   1   0   1   0   0   0
1994:   0   2   0   1   2   2   1   1   1   2   0   0
1995:   0   0   0   0   1   1   1   0   0   2   0   1
1996:   0   0   0   1   1   0   2   1   0   1   0   0
1997:   1   0   0   1   0   0   2   1   1   0   1   0
1998:   0   0   0   1   0   0   0   0   0   0   1   0
> MannKendall(mto4.12AMThuSat.drunk.ts)
tau = -0.0465,   sl =59.68%
> mto4.1AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   1   0   2   1   2   0   0   1   0   0
1993:   0   0   1   2   0   2   0   0   2   3   1   0
1994:   0   1   2   2   4   2   2   1   2   2   0   2
1995:   0   0   2   0   0   2   3   2   1   1   0   1
1996:   0   1   3   0   1   0   0   0   1   1   0   2
1997:   1   0   0   1   1   0   1   1   0   1   0   0
1998:   0   0   0   0   1   1   0   2   0   4   1   0
> MannKendall(mto4.1AMThuSat.drunk.ts)
tau = -0.0691,   sl =41.4%
> mto4.2AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   0   1   1   0   1   0   0   3   2
1993:   0   0   0   0   1   3   1   1   1   1   1   0
1994:   1   0   0   3   1   0   1   3   1   2   0   0
1995:   0   0   1   3   1   1   1   3   2   2   2   1
1996:   2   1   0   0   2   0   0   1   0   1   1   1
1997:   0   3   0   1   1   0   1   1   1   1   0   0
1998:   0   0   0   1   2   0   1   0   3   1   1   2
> MannKendall(mto4.2AMThuSat.drunk.ts)
tau = 0.0719,   sl =39.75%
```

Trellis Time Series Plots. Same Scale on Each Page.




MTO, Fatalities, Drunk, Common Scale
2AM
SunWed
ThuSat
1AM
12AM
11PM
1992
1994
1996
1998
0
1
2
3
4
Year

Major Injury

Downward trends: 12AMSunWed.drunk.ts, 1AMSunWed.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts

Data Listing

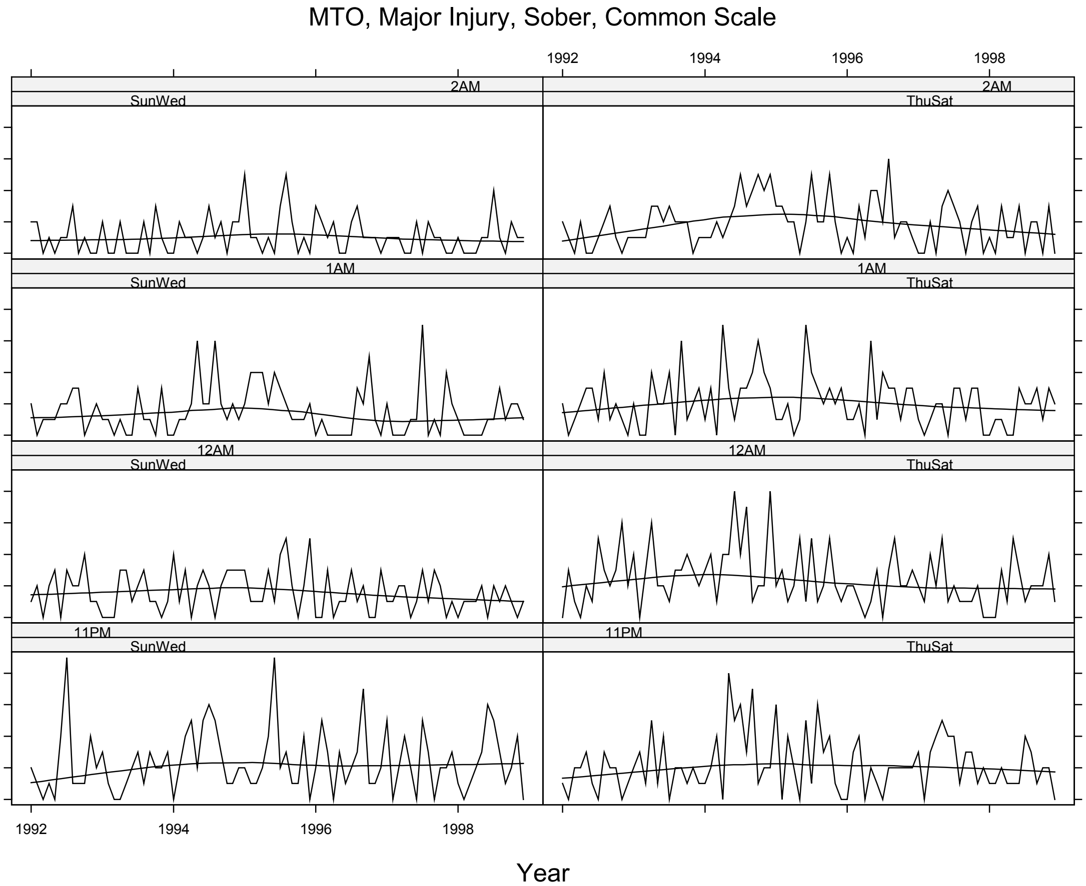
```
> mto3.11PMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   0   1   0   4   9   1   1   1   4   2
1993:   3   1   0   0   1   2   3   1   3   2   2   3
1994:   0   2   4   5   2   5   6   5   3   1   1   2
1995:   2   1   1   2   4   9   2   3   1   1   4   0
1996:   2   5   3   0   3   1   2   3   7   1   1   2
1997:   5   0   2   4   2   0   5   3   0   2   2   3
1998:   1   0   1   2   3   6   5   3   1   2   4   0
> MannKendall(mto3.11PMSunWed.sober.ts)
tau = 0.069,   sl =38.87%
> mto3.12AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   2   0   2   3   0   3   2   2   4   1   1
1993:   0   0   0   3   3   1   2   3   1   1   0   1
1994:   4   1   3   0   2   3   2   0   2   3   3   3
1995:   3   1   1   1   3   1   4   5   2   0   2   5
1996:   0   0   3   0   1   1   3   1   2   0   0   3
1997:   1   1   2   2   0   1   3   1   3   2   0   1
1998:   0   1   1   1   2   0   2   1   2   1   0   1
> MannKendall(mto3.12AMSunWed.sober.ts)
tau = -0.1,   sl =22.11%
> mto3.1AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   0   1   1   1   2   2   3   3   0   1   2
1993:   1   1   0   1   0   0   3   1   1   0   3   0
1994:   0   1   1   2   6   2   2   6   2   1   2   1
1995:   2   4   4   4   2   4   3   2   1   1   1   2
1996:   0   1   0   0   0   0   0   3   2   5   1   0
1997:   2   0   0   0   1   1   7   0   1   0   4   2
1998:   1   0   0   0   0   1   1   3   1   2   2   1
> MannKendall(mto3.1AMSunWed.sober.ts)
tau = -0.0698,   sl =39.45%
> mto3.2AMSunWed.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   2   0   1   0   1   1   3   0   1   0   0
1993:   2   0   0   2   0   0   0   2   0   3   1   0
1994:   0   2   1   1   0   1   3   1   2   0   2   2
1995:   5   1   1   0   1   0   3   5   2   0   1   0
1996:   3   2   1   2   0   0   2   3   1   1   1   0
1997:   1   1   1   0   0   2   0   2   1   1   0   0
1998:   1   0   0   0   1   1   4   1   0   2   1   1
> MannKendall(mto3.2AMSunWed.sober.ts)
tau = -0.00304,   sl =97.4%
```

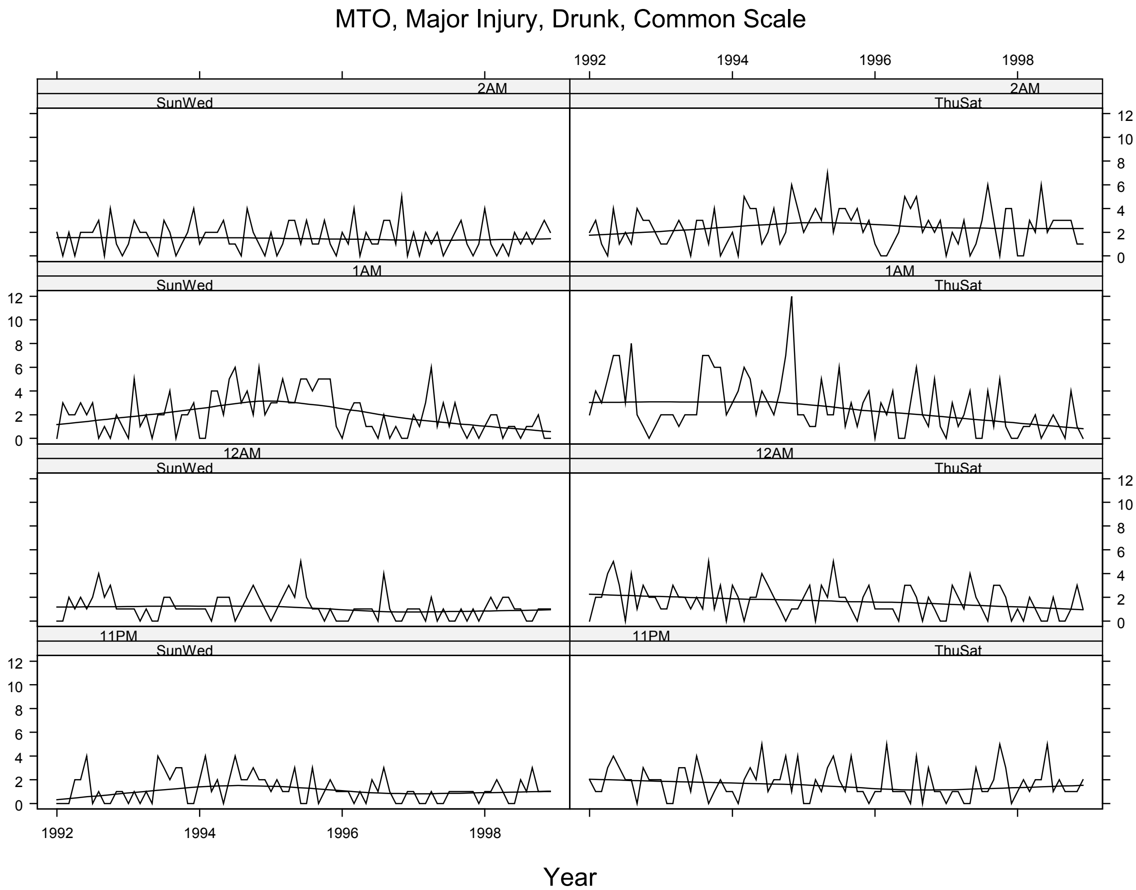
```
> #
mto3.11PMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   0   2   2   3   1   0   3   2   2   0   1
1993:   2   3   1   5   1   4   0   2   2   1   2   1
1994:   1   2   4   0   8   5   6   3   7   1   2   2
1995:   6   0   4   2   0   5   1   6   3   4   1   0
1996:   0   3   4   0   2   1   0   2   2   2   2   2
1997:   3   0   3   4   5   4   4   1   3   3   1   2
1998:   1   1   2   1   1   1   4   3   1   2   2   0
> MannKendall(mto3.11PMThuSat.sober.ts)
tau = 0.018,   sl =82.52%
> mto3.12AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   3   1   0   2   1   5   3   2   3   6   2
1993:   4   0   3   6   2   2   1   3   3   4   3   2
1994:   3   4   1   4   4   8   4   7   1   2   2   8
1995:   2   3   1   2   5   1   5   1   2   5   2   1
1996:   2   2   1   0   1   3   0   3   5   2   2   3
1997:   2   1   4   2   5   1   2   1   1   1   2   0
1998:   0   0   3   1   5   3   1   2   2   2   4   1
> MannKendall(mto3.12AMThuSat.sober.ts)
tau = -0.127,   sl =11.19%
> mto3.1AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   0   1   2   3   3   1   4   1   2   1   0
1993:   2   0   0   4   2   2   4   0   6   1   2   3
1994:   1   3   0   7   3   1   3   3   4   6   4   3
1995:   1   1   2   0   1   7   4   3   2   3   2   3
1996:   1   1   2   0   6   1   4   3   3   1   3   3
1997:   1   0   1   2   2   0   3   3   1   3   3   0
1998:   0   1   1   0   0   3   2   2   3   1   3   2
> MannKendall(mto3.1AMThuSat.sober.ts)
tau = -0.0385,   sl =63.51%
> mto3.2AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   0   2   0   0   1   2   3   1   0   1
1993:   1   1   1   3   3   2   3   2   2   2   0   1
1994:   1   1   2   1   2   3   5   3   4   5   4   5
1995:   3   3   2   2   0   2   5   2   2   5   2   0
1996:   1   0   3   1   4   4   2   6   1   2   2   1
1997:   0   0   2   0   3   4   3   2   0   2   3   0
1998:   1   0   3   1   1   3   0   2   2   0   3   0
> MannKendall(mto3.2AMThuSat.sober.ts)
tau = 0.0112,   sl =89.3%
```

```
> #
mto3.11PMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   0   2   2   4   0   1   0   0   1   1
1993:   0   1   0   1   0   4   3   2   3   3   0   0
1994:   2   4   1   2   0   2   4   2   2   3   2   2
1995:   1   2   1   1   3   0   0   3   0   1   2   1
1996:   1   1   0   1   0   2   1   3   1   0   0   1
1997:   1   0   0   1   0   0   1   1   1   1   1   0
1998:   1   1   2   1   0   0   2   1   3   1   1   1
> MannKendall(mto3.11PMSunWed.drunk.ts)
tau = -0.062,   sl =45.63%
> mto3.12AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   0   2   1   2   1   2   4   2   3   1   1
1993:   1   1   0   1   0   0   2   2   1   1   1   1
1994:   1   1   0   2   2   2   0   1   2   3   2   1
1995:   0   1   2   3   2   5   2   1   1   0   1   0
1996:   0   0   1   1   1   1   0   4   1   0   0   1
1997:   1   1   0   2   0   1   0   0   1   0   1   0
1998:   1   2   1   2   2   1   1   0   0   1   1   1
> MannKendall(mto3.12AMSunWed.drunk.ts)
tau = -0.147,   sl =8.024%
> mto3.1AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   3   2   2   3   2   3   0   1   0   2   1
1993:   0   5   1   2   0   2   2   4   0   2   2   3
1994:   0   0   4   4   2   5   6   3   4   2   6   2
1995:   3   3   5   3   3   5   5   4   5   5   5   1
1996:   0   2   3   3   1   1   0   2   0   1   0   0
1997:   2   1   3   6   1   3   1   3   1   0   1   0
1998:   1   2   2   0   1   1   0   1   1   2   0   0
> MannKendall(mto3.1AMSunWed.drunk.ts)
tau = -0.142,   sl =7.573%
> mto3.2AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   0   2   0   2   2   2   3   0   4   1   0
1993:   1   3   2   2   1   0   3   2   0   1   2   4
1994:   1   2   2   2   3   1   1   0   4   2   1   0
1995:   2   0   1   3   3   1   3   1   1   3   1   0
1996:   2   1   4   0   2   1   1   3   3   1   5   0
1997:   2   0   2   1   2   0   1   2   3   1   0   1
1998:   4   1   0   1   0   2   1   2   1   2   3   2
> MannKendall(mto3.2AMSunWed.drunk.ts)
tau = -0.0241,   sl =77.07%
```

```
> #
mto3.11PMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   1   3   4   3   2   2   0   3   2   2
1993:   2   0   0   3   3   1   4   2   0   1   2   1
1994:   1   0   2   3   2   5   1   2   2   4   1   4
1995:   0   0   2   1   3   4   2   1   4   1   1   0
1996:   1   1   5   1   1   1   0   4   0   3   1   1
1997:   0   1   1   0   0   3   1   1   2   5   3   0
1998:   1   2   1   2   2   5   1   2   1   1   1   2
> MannKendall(mto3.11PMThuSat.drunk.ts)
tau = -0.0872,   sl =28.45%
> mto3.12AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   0   2   2   4   5   3   0   4   1   3   2   2
1993:   1   1   3   2   2   1   2   1   5   1   3   0
1994:   3   2   0   2   2   4   3   2   1   0   1   1
1995:   2   3   0   3   2   5   2   2   1   0   2   3
1996:   1   1   1   1   0   3   3   2   0   2   1   0
1997:   0   3   2   1   4   2   1   0   3   3   2   0
1998:   1   0   2   1   0   0   2   0   0   1   3   1
> MannKendall(mto3.12AMThuSat.drunk.ts)
tau = -0.197,   sl =1.555%
> mto3.1AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   4   3   5   7   7   3   8   2   1   0   1
1993:   2   2   2   1   2   2   2   7   7   6   6   2
1994:   3   4   6   5   2   4   3   2   4   7  12   2
1995:   2   1   1   5   2   2   6   1   3   1   3   4
1996:   0   3   2   4   0   0   3   6   2   1   5   1
1997:   0   3   1   2   4   0   0   4   1   5   1   0
1998:   0   1   1   2   0   1   2   1   0   4   1   0
> MannKendall(mto3.1AMThuSat.drunk.ts)
tau = -0.301,   sl =0.01401%
> mto3.2AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   3   1   0   4   1   2   1   4   3   3   2
1993:   1   1   2   3   2   0   3   3   1   4   0   1
1994:   2   0   5   4   4   1   2   4   1   2   6   4
1995:   2   3   4   3   7   2   4   4   3   4   2   3
1996:   1   0   0   1   2   5   4   5   2   3   2   3
1997:   0   2   1   3   0   1   3   6   3   0   4   4
1998:   0   0   3   2   6   2   3   3   3   3   1   1
> MannKendall(mto3.2AMThuSat.drunk.ts)
tau = 0.0399,   sl =62%
```

Trellis Time Series Plots: Common scale on each page.




MTO, Major Injury, Drunk, Common Scale
2AM
SunWed
ThuSat
1AM
12AM
11PM
0
2
4
6
8
10
12
1992
1994
1996
1998
Year

Minor Injury

Upward trend: 12AMSunWed.sober.ts, 2AMSunWed.sober.ts
Downward trend: 12AMThuSat.sober.ts, 1AMThuSat.sober.ts, 1AMSunWed.drunk.ts, 11PMThuSat.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts

Data Tabulation

> mto2.11PMSunWed.sober.ts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	10	8	10	9	12	23	16	16	17	6	15	13
1993:	8	9	10	6	7	20	18	21	15	7	10	18
1994:	13	17	17	21	22	14	19	13	18	13	19	20
1995:	13	13	20	15	13	18	25	17	11	17	25	16
1996:	13	27	15	11	14	18	26	20	18	11	14	10
1997:	17	15	8	12	11	18	23	8	9	8	13	15
1998:	12	11	12	9	17	12	12	18	15	13	14	15

> MannKendall(mto2.11PMSunWed.sober.ts)
tau = 0.0177, sl =81.92%
> mto2.12AMSunWed.sober.ts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	10	5	8	9	3	6	8	3	9	9	7	10
1993:	5	2	8	2	5	10	10	10	8	7	6	4
1994:	7	7	6	16	12	13	13	14	11	7	9	17
1995:	6	8	5	8	9	9	16	8	6	6	14	16
1996:	10	9	14	7	23	12	10	12	19	9	8	18
1997:	13	6	11	1	8	6	13	20	4	9	6	10
1998:	8	7	4	8	10	12	8	9	15	5	10	12

> MannKendall(mto2.12AMSunWed.sober.ts)
tau = 0.161, sl =3.675%
> mto2.1AMSunWed.sober.ts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	6	11	4	8	3	7	13	5	9	9	13	12
1993:	9	3	3	6	7	2	8	9	3	6	6	10
1994:	11	2	8	11	9	8	13	14	7	7	6	15
1995:	4	5	11	11	3	13	3	12	2	8	9	6
1996:	12	11	13	3	11	11	7	4	6	9	7	10
1997:	11	5	6	3	4	10	8	5	4	3	10	5
1998:	8	1	7	11	9	10	16	8	2	8	7	2

> MannKendall(mto2.1AMSunWed.sober.ts)
tau = -0.0459, sl =55.27%
> mto2.2AMSunWed.sober.ts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	3	5	3	8	3	3	5	9	5	4	0	2
1993:	6	2	1	4	4	10	4	3	2	1	0	9
1994:	10	2	9	6	5	11	9	9	4	4	9	11
1995:	7	6	8	5	1	7	13	12	6	4	4	6
1996:	9	11	2	8	9	5	3	7	5	5	9	8
1997:	8	3	8	7	4	7	7	13	10	4	8	6
1998:	7	5	9	5	3	6	11	7	5	7	5	6

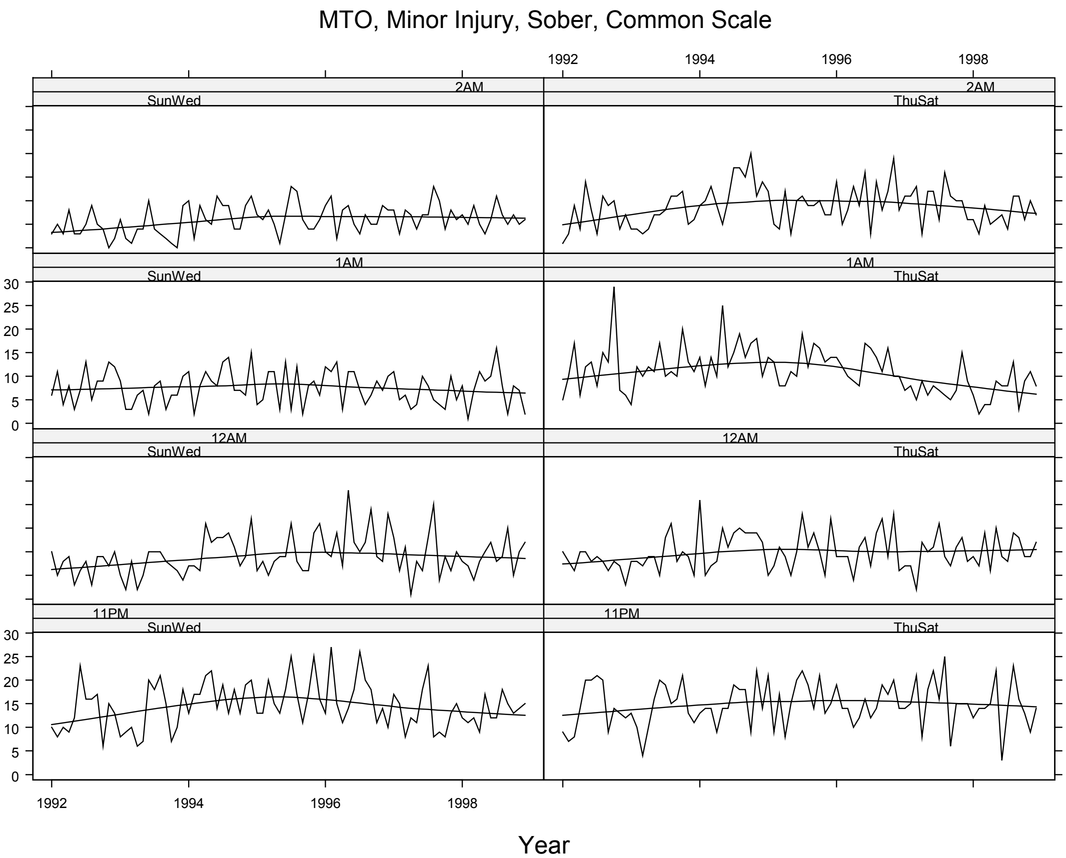
> MannKendall(mto2.2AMSunWed.sober.ts)
tau = 0.186, sl =1.634%

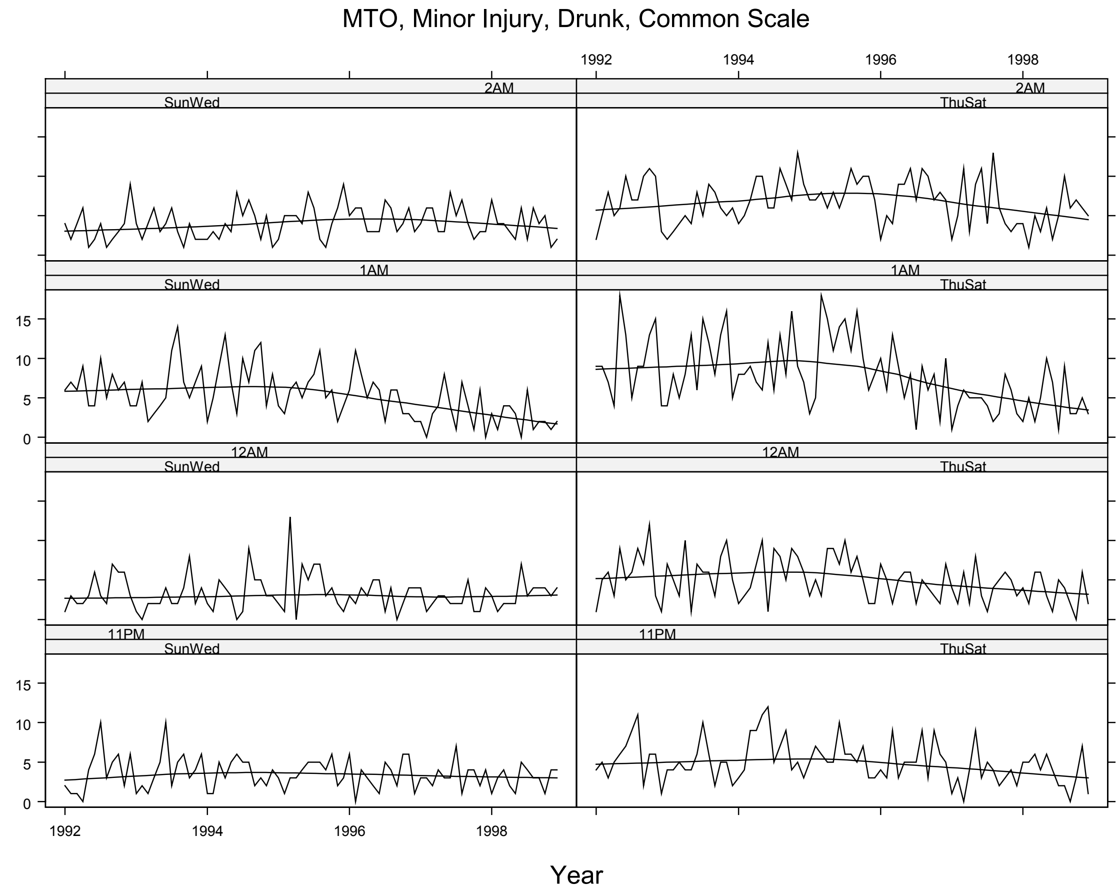
```
> #
mto2.11PMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   9   7   8  14  20  20  21  20   9  14  13  12
1993:  13  10   4  10  16  20  19  15  16  21  13  11
1994:  13  14  14   9  14  14  19  18  18   9  22  14
1995:  21   9  17   8  15  20  22  19  14  21  13  15
1996:  19  14  14  10  12  16  12  14  19  17  20  14
1997:  14  15  21   8  18  22  16  25   6  15  15  15
1998:  12  14  14  15  22   3  14  23  16  13   9  14
> MannKendall(mto2.11PMThuSat.sober.ts)
tau = 0.079,   sl =30.48%
> mto2.12AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  10   8   6  10  10   8   9   8   6   8   7   3
1993:   8   8   7   9   9   5  13  16   8  10   9   5
1994:  21   5   7   8  15  11  14  15  14  14  14  12
1995:   5   7  11   9   5  10  18  11  14  10   5  17
1996:   9   9   9   4  11  13   7  14  17   9  18   6
1997:   7   7   2  12  10  11  16   9   7  11  13   8
1998:   9   7  14   6  15   9   8  14  13   9   9  12
> MannKendall(mto2.12AMThuSat.sober.ts)
tau = 0.117,   sl =13.07%
> mto2.1AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   5  10  17   6  12  13   8  15  13  29   7   6
1993:   4  12  10  12  11  17  10  11  10  20  13  11
1994:  14   8  14  10  25  12  15  19  14  17  18  10
1995:  14  13   8   8  11  10  19  12  17  16  13  14
1996:  14  12  10   9   8  17  16  14  11  16  10  10
1997:   7   8   5   9   6   8   7   6   5   7  15   9
1998:   6   2   4   4   9   8   8  13   3   9  11   8
> MannKendall(mto2.1AMThuSat.sober.ts)
tau = -0.239,   sl =0.1736%
> mto2.2AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   3   9   4  14   8   3  11   9  10   4   7
1993:   4   4   3   4   7   7   8  11  11  12   5   6
1994:   9  10  13   9   5  10  17  17  15  20  11  14
1995:  12   5   4  12   3  10  11   9   9  10   7   7
1996:  14   5   8  13   9  16   3  14   8  12  19   8
1997:  11  11  13   3  12  12   6  16  11  10  10   6
1998:   6   3   9   5   6   7   4  11  11   6  10   7
> MannKendall(mto2.2AMThuSat.sober.ts)
tau = 0.0881,   sl =25.11%
```

```
> #
mto2.11PMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   1   0   4   6  10   3   5   6   2   6
1993:   1   2   1   3   5  10   2   5   6   3   4   6
1994:   1   1   5   3   5   6   5   5   2   3   2   4
1995:   3   1   3   3   4   5   5   5   4   6   2   3
1996:   6   0   4   3   2   1   5   4   2   6   6   1
1997:   3   3   2   4   3   3   7   1   4   4   2   4
1998:   1   3   4   2   1   5   4   3   3   1   4   4
> MannKendall(mto2.11PMSunWed.drunk.ts)
tau = -0.0508,   sl =52.32%
> mto2.12AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   3   2   2   3   6   3   2   7   6   6   3
1993:   1   0   2   2   2   4   2   2   4   8   2   4
1994:   2   1   5   4   3   0   1   9   5   5   3   3
1995:   2   1  13   0   7   5   7   7   3   4   2   1
1996:   3   2   4   3   5   5   1   4   0   2   4   4
1997:   4   1   2   3   3   2   2   2   5   1   1   4
1998:   3   1   2   2   2   7   3   4   4   4   3   4
> MannKendall(mto2.12AMSunWed.drunk.ts)
tau = -9.32e-4,   sl =99.37%
> mto2.1AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   6   7   6   9   4   4  10   5   8   6   7   4
1993:   4   7   2   3   4   5  11  14   7   5   7   9
1994:   2   5   9  13   7   3  10   7  11  12   4   8
1995:   4   3   6   7   5   7   8  11   5   6   2   4
1996:   6  11   8   5   7   6   2   6   6   3   3   2
1997:   2   0   3   4   8   4   1   7   4   1   6   0
1998:   3   1   4   4   3   0   6   1   2   2   1   2
> MannKendall(mto2.1AMSunWed.drunk.ts)
tau = -0.341,   sl =0.001058%
> mto2.2AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   2   4   6   1   2   4   1   2   3   4   9
1993:   4   2   4   6   3   4   6   3   1   4   2   2
1994:   2   3   2   4   3   8   5   7   5   2   5   1
1995:   2   5   5   5   4   8   6   2   1   4   6   9
1996:   5   6   6   3   3   3   7   6   3   4   6   3
1997:   4   6   6   3   3   8   5   7   4   2   3   3
1998:   7   4   4   3   2   6   2   6   4   5   1   2
> MannKendall(mto2.2AMSunWed.drunk.ts)
tau = 0.103,   sl =19.35%
```

```
> #
mto2.11PMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   5   3   5   6   7   9  11   2   6   6   1
1993:   4   4   5   4   4   6  10   6   2   5   5   2
1994:   3   4   9   9  11  12   5   7   9   4   5   3
1995:   5   7   6   5   5  10   6   6   5   7   3   3
1996:   4   3   9   3   5   5   5   9   3   9   6   5
1997:   1   3   0   4   9   3   5   4   2   3   4   2
1998:   5   5   6   4   6   4   2   2   0   3   7   1
> MannKendall(mto2.11PMThuSat.drunk.ts)
tau = -0.186,   sl =1.792%
> mto2.12AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   5   6   3   9   5   6   9   7  12   3   1
1993:   7   5   3  10   1   7   6   6   3   8  10   5
1994:   2   3   4   7  10   1   9   8   5   9   8   6
1995:   3   5   3   9   9   7  10   6   8   5   2   2
1996:   7   5   2   5   6   6   2   5   4   3   2   7
1997:   4   2   6   2   8   3   1   4   5   6   5   3
1998:   4   2   6   6   3   1   5   4   2   0   6   2
> MannKendall(mto2.12AMThuSat.drunk.ts)
tau = -0.209,   sl =0.7314%
> mto2.1AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   9   9   7   4  18  13   5   9   9  13  15   4
1993:   4   8   5   8  13   6  15  12   8  13  16   5
1994:   8   8   9   7   6  12   6  13   8  16   9   7
1995:   3   5  18  15  11  14  15  11  16  10   6   8
1996:  10   6  13   9   5   8   1   9   6   8   2  10
1997:   1   4   6   5   5   5   4   2   3   8   6   3
1998:   2   5   2   5  10   7   1   9   3   3   5   3
> MannKendall(mto2.1AMThuSat.drunk.ts)
tau = -0.316,   sl =0.003663%
> mto2.2AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   5   8   5   6  10   7   7  10  11  10   3
1993:   2   3   4   5   4   8   5   9   8   6   5   6
1994:   4   5   7  10  10   6   6  11   9   7  13   9
1995:   7   7   8   6   8   6   8  11   9  10  10   7
1996:   2   5   4   9   9  11   7  11  10   7   8   7
1997:   2   5  11   3   9  11   4  13   6   4   3   4
1998:   4   1   5   3   6   2   5  10   6   7   6   5
> MannKendall(mto2.2AMThuSat.drunk.ts)
tau = -0.0346,   sl =65.77%
```

Trellis Time Series Plots





MTO, Minor Injury, Drunk, Common Scale
2AM
SunWed
2AM
ThuSat
1AM
SunWed
1AM
ThuSat
12AM
SunWed
12AM
ThuSat
11PM
SunWed
11PM
ThuSat
1992
1994
1996
1998
0
5
10
15
Year

Minimal Injury

upward trend: `11PMSunWed.sober.ts, 2AMSunWed.sober.ts, 11PMThuSat.sober.ts, 2AMThuSat.sober.ts, 2AMSunWed.drunk.ts`

downward trend: `1AMThuSat.sober.ts, 11PMSunWed.drunk.ts, 12AMSunWed.drunk.ts, 1AMSunWed.drunk.ts, 11PMThuSat.drunk.ts, 12AMThuSat.drunk.ts, 1AMThuSat.drunk.ts`

Data Tabulation

`> mto1.11PMSunWed.sober.ts`

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	10	13	11	23	8	21	23	17	7	14	19	29
1993:	10	10	10	14	25	14	13	20	16	13	11	22
1994:	27	30	24	20	25	20	23	21	20	27	18	22
1995:	16	30	26	21	30	21	35	40	18	23	44	18
1996:	22	22	35	14	27	29	38	17	15	24	28	12
1997:	50	15	23	12	16	26	29	30	17	15	16	27
1998:	17	16	21	11	17	35	26	19	14	14	18	25

`> MannKendall(mto1.11PMSunWed.sober.ts)`
`tau = 0.158,    sl =3.673%`

`> mto1.12AMSunWed.sober.ts`

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	8	7	5	9	8	9	7	14	5	12	19	19
1993:	12	9	20	10	6	12	11	12	11	8	7	14
1994:	14	9	15	9	16	11	12	17	9	5	10	16
1995:	11	16	10	16	18	14	19	14	16	10	24	19
1996:	10	14	24	12	13	17	18	13	6	17	10	13
1997:	20	10	12	10	7	10	15	16	12	28	17	11
1998:	13	8	10	9	7	11	14	6	6	8	10	15

`> MannKendall(mto1.12AMSunWed.sober.ts)`
`tau = 0.0858,    sl =26.26%`

`> mto1.1AMSunWed.sober.ts`

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	12	10	8	6	5	18	10	11	8	9	5	12
1993:	4	4	5	7	1	9	9	7	8	11	2	12
1994:	16	19	10	8	12	18	17	16	13	11	11	11
1995:	11	12	13	6	16	17	12	13	8	6	12	17
1996:	15	14	15	11	6	10	11	15	7	14	11	6
1997:	15	4	15	8	7	14	9	10	6	7	8	10
1998:	11	3	10	10	5	8	9	4	2	11	8	12

`> MannKendall(mto1.1AMSunWed.sober.ts)`
`tau = -0.0302,    sl =69.53%`

`> mto1.2AMSunWed.sober.ts`

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:	5	3	4	2	4	3	3	4	4	6	5	5
1993:	5	5	4	8	8	9	9	6	9	4	6	4
1994:	9	9	12	10	5	8	8	8	8	8	5	7
1995:	9	4	5	9	4	11	10	7	4	9	11	10
1996:	9	9	9	8	13	8	14	18	6	13	14	14
1997:	6	11	6	9	9	17	12	13	6	11	9	7
1998:	6	4	4	6	5	4	8	9	4	6	8	5

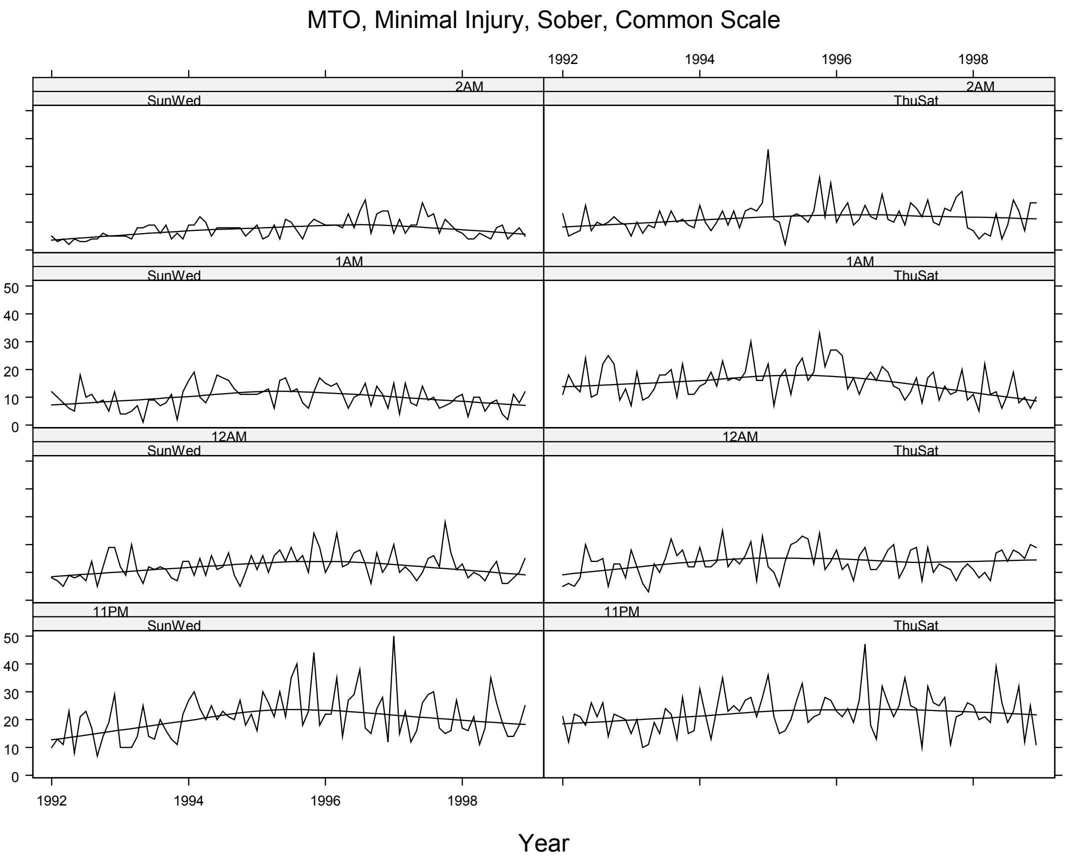
`> MannKendall(mto1.2AMSunWed.sober.ts)`
`tau = 0.252,    sl =0.1183%`

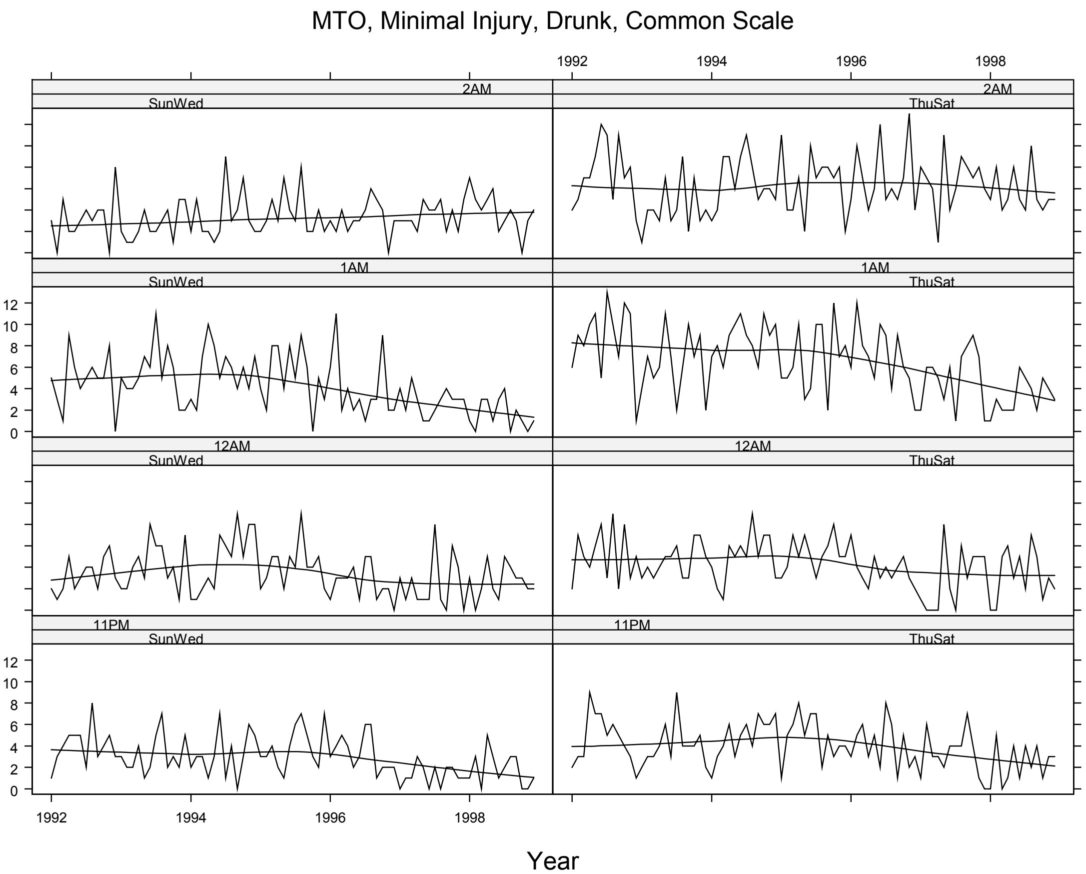
```
> #
mto1.11PMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  21  12  22  21  18  26  21  26  14  22  21  20
1993:  15  20  10  11  19  15  24  22  13  28  15  16
1994:  31  22  13  24  35  23  25  23  27  28  21  28
1995:  36  21  15  16  20  27  33  19  21  22  28  27
1996:  23  21  24  19  27  47  18  13  32  26  21  25
1997:  35  25  24  10  32  26  25  28  11  21  22  26
1998:  25  20  21  19  39  26  19  23  32  12  25  11
> MannKendall(mto1.11PMThuSat.sober.ts)
tau = 0.139,   sl =6.696%
> mto1.12AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   5   6   5   8  20  14  14  15   5  13  13   8
1993:  18  12   6   3  13  10  15  22  16  18  12  12
1994:  19  12  12  14  25  12  15  13  16  21   7  23
1995:  12  10   5  14  20  21  23  22  13  24  11  14
1996:  18  11  13   7  16  19  11  11  14  18  20   8
1997:  12  18  19   7  19  10  13  12  11   7  11  13
1998:  11   8  10   7  17  18  14  18  17  15  20  19
> MannKendall(mto1.12AMThuSat.sober.ts)
tau = 0.0881,   sl =24.83%
> mto1.1AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  11  18  14  12  24  10  11  22  25  22   9  13
1993:   7  19   9  10  13  18  18  20  10  22  11  11
1994:  14  15  19  14  23  16  17  16  19  30  16  16
1995:  22   7  17  20  11  21  24  16  19  33  21  27
1996:  27  25  13  17  11  16  19  16  21  19  14  13
1997:   9  12  17   8  17  19   9  14  11  12  20   9
1998:  11   5  22  11  12   6  11  19   8  10   6  10
> MannKendall(mto1.1AMThuSat.sober.ts)
tau = -0.134,   sl =7.736%
> mto1.2AMThuSat.sober.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:  13   5   6   7  16   7  10   9  10  12  10   9
1993:   5  10   6   9   8  14   9  14  10  11   9   8
1994:  16  10   7  10  14   9  14   8  14  15  14  17
1995:  36  11  10   2  12  13  12  10  14  26  12  24
1996:  10  14  17   9  11  16  12  11  20  11  10  14
1997:   9  17  15  12  18  10   9  15  14  19  21   8
1998:   7   4   6   5  13   4   9  18  14   7  17  17
> MannKendall(mto1.2AMThuSat.sober.ts)
tau = 0.173,   sl =2.367%
```

```
> #
mto1.11PMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   1   3   4   5   5   5   2   8   3   4   5   3
1993:   3   2   2   4   1   2   5   7   2   3   2   5
1994:   2   3   3   1   3   7   1   4   0   3   6   5
1995:   3   3   4   2   1   4   6   7   5   3   2   7
1996:   3   4   5   4   2   3   6   6   1   2   2   2
1997:   0   1   1   3   2   0   2   0   2   2   1   1
1998:   1   3   0   5   3   1   2   3   3   0   0   1
> MannKendall(mto1.11PMSunWed.drunk.ts)
tau = -0.273,   sl =0.05639%
> mto1.12AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   1   2   5   2   3   4   4   2   5   6   3
1993:   2   2   4   5   3   8   6   6   3   4   1   7
1994:   1   1   2   3   2   7   6   5   9   5   8   8
1995:   2   3   5   5   2   5   4   9   4   4   5   2
1996:   1   3   3   3   4   1   5   5   1   2   2   0
1997:   3   1   3   1   1   1   8   1   0   6   4   0
1998:   3   0   2   5   2   1   5   4   3   3   2   2
> MannKendall(mto1.12AMSunWed.drunk.ts)
tau = -0.156,   sl =4.74%
> mto1.1AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   5   3   1   9   6   4   5   6   5   5   8   0
1993:   5   4   4   5   7   6  11   5   8   6   2   2
1994:   3   2   7  10   8   5   7   6   4   6   4   7
1995:   4   2   8   8   4   8   5   9   6   0   5   3
1996:   6  11   2   4   2   3   1   3   3   9   2   2
1997:   4   2   5   3   1   1   2   3   4   3   3   3
1998:   1   0   3   3   1   3   4   0   2   1   0   1
> MannKendall(mto1.1AMSunWed.drunk.ts)
tau = -0.352,   sl =6.086e-4%
> mto1.2AMSunWed.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   3   0   5   2   2   3   4   3   4   4   0   8
1993:   2   1   1   2   4   2   2   3   4   1   5   5
1994:   2   5   2   2   1   2   9   3   4   7   3   2
1995:   2   3   5   3   7   4   3   8   2   2   4   2
1996:   3   2   4   2   3   3   4   6   5   4   0   3
1997:   3   3   3   2   5   4   4   5   2   4   2   5
1998:   7   5   4   5   6   2   3   4   3   0   3   4
> MannKendall(mto1.2AMSunWed.drunk.ts)
tau = 0.157,   sl =4.957%
```

```
> #
mto1.11PMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   3   3   9   7   7   5   6   5   4   3   1
1993:   2   3   3   4   6   3   9   4   4   4   5   2
1994:   1   3   4   6   3   5   6   4   7   6   6   7
1995:   1   5   6   8   5   7   7   2   5   3   4   4
1996:   3   5   6   3   5   2   8   6   1   5   2   3
1997:   1   6   3   3   2   4   4   4   7   4   1   0
1998:   0   5   0   1   4   1   4   2   4   1   3   3
> MannKendall(mto1.11PMThuSat.drunk.ts)
tau = -0.189,   sl =1.594%
> mto1.12AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   2   7   5   4   6   8   3   9   2   8   3   5
1993:   3   4   3   4   5   5   6   3   3   7   7   5
1994:   4   2   1   6   5   6   5   9   5   7   7   3
1995:   3   4   7   5   7   5   3   5   6   8   5   5
1996:   7   4   3   2   5   3   4   3   4   5   3   2
1997:   1   0   0   0   8   2   0   6   3   5   5   5
1998:   0   0   5   6   3   5   2   7   5   1   3   2
> MannKendall(mto1.12AMThuSat.drunk.ts)
tau = -0.191,   sl =1.527%
> mto1.1AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   6   9   8  10  11   5  13  10   7  12  11   1
1993:   4   7   5   6  11   7   2   6  10   7   9   2
1994:   7   8   6   9  10  11   9   8   6  11   9  10
1995:   5   5   6  10   3   4  10  10   2  12   7   8
1996:   6  12   8   7   5  10   9   4   9   6   5   2
1997:   2   6   6   5   3   6   1   7   8   9   7   1
1998:   1   3   2   2   2   6   5   4   2   5   4   3
> MannKendall(mto1.1AMThuSat.drunk.ts)
tau = -0.317,   sl =0.003898%
> mto1.2AMThuSat.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:   4   5   7   7   9  12  11   5  11   7   8   3
1993:   1   4   4   3   7   3   4   9   2   7   3   4
1994:   3   4   9   9   6   9  11   8   5   6   6   5
1995:  11   4   4   7   2  10   7   8   8   7   8   2
1996:   5  10   7   4   6  12   5   6   5   7  13   4
1997:   8   7   6   1  11   4   6   9   8   7   8   6
1998:   5   8   4   5   8   5   4  10   5   4   5   5
> MannKendall(mto1.2AMThuSat.drunk.ts)
tau = 0.0118,   sl =88.24%
```

Trellis Time Series Plots




MTO, Minimal Injury, Drunk, Common Scale
2AM
SunWed
ThuSat
1AM
12AM
11PM
1992
1994
1996
1998
0
2
4
6
8
10
12
Year

E. MVA Dataset

Summary

The MVA dataset is comprised of 84 records over the period May 1992 to April 1999 of serious trauma caused by motor vehicle accidents in Ontario. The data are obtained from the Ontario Trauma Registry. About 45% of OTR cases occur in the 3AMPlus group. Since we are primarily interested in the other groups, the data corresponding to this subgroup was analysed separately.

HOUR: The uniformity hypothesis is rejected by a chi-square test at less than 0.04%. The major departure is due to fewer than expected traumas in the 12AM and 1AM windows.

June-to-Sep June-to-Sep account for 45% so these months have a much higher share. Assuming cases are uniformly distributed over the months, yields an observed chi-squared goodness-of-fit statistic of 73.79 on 11 df which is statistically significant at less than 10^{-10}..

Hour and month are not associated

Hour and year are may be associated The largest departures from expected occur in the hourly windows in 1999.

Figure 1a. MVA counts/month (excluding 3AMPlus) show an initial upward trend followed by a downward trend starting about 1995

Figure 1b. MVA counts/month 3AMPlus show an initial upward trend to about 1995 and a downward trend post-1995.

Figure 2a and Figure 2b show there has been a strong downward trend since about 1995 for each hour 11AM, 12PM, 1AM, 2AM.

Table 2. Counts by hour – monotonic trend not detected at 12AM and 2AM.

Figure 3a STL, MVA. A peak is reached in 1995 is followed by a downward trend.

Figure 3b. MVA Seasonal The seasonal has a well defined peak in August, smaller peak in Nov and minimum in February. There is a downward trend in Apr and an upward trend Jul. and Nov

Figure 4a. STL, MVA, 3AMPlus. Increasing trend to 1995 and decreasing thereafter. The seasonal pattern changes in 1996 with the Jul-Aug peak becoming less prominent and the smaller Oct peak increasing.

Figure 4b. MVA, 3AMPlus Seasonal. Well defined peaks in Mar, Aug and Oct and minimum in Feb, Apr and Sep. The Oct peak has increased since 1996 and the Aug peak has decreased since 1996.

Introduction

The data set of Ontario Trauma Registry (OTR) contains the both motor vehicle accident and non motor vehicle accident cases (ISS Scale > 12, severe injury) from May 1992 to April 1999.

The hour factor variable includes 11:00pm-12:00am, 12:00am-1:00am, 1:00am-2:00am, 2:00am - 3:00am and 3:00am -10:59pm.

Variables of interest:

counts	number of mva cases with ISS Scale > 12 (severe injury)
year	ordered factor, 8 levels: 1992 to 1999
month	ordered factor, 12 levels: January to December
hour	ordered factor with 5 levels: "11PM", "12AM", "1AM", "2AM", "3AMPlus"

About 44% of MVA cases occur in the 3AMPlus group. Since we are primarily interested in the other groups, the data corresponding to this subgroup was analysed separately. Also notice that there is no wkgrp variable for this data.

```
> crosstabs(counts~hour, data=mva.df)
Call:
crosstabs(counts ~ hour, data = mva.df)
1964 cases in table
+--------+
|N       |
|N/Total|
+--------+
hour    |
-------+-------+
11PM    |285    |
        |0.15   |
-------+-------+
12AM    |220    |
        |0.11   |
-------+-------+
1AM     |318    |
        |0.16   |
-------+-------+
2AM     |271    |
        |0.14   |
-------+-------+
3AMPlus|870    |
        |0.44   |
-------+-------+
```

Crosstabs Analysis

Hour

The uniformity hypothesis is rejected by a chi-square test at less than 0.04%. The major departure is due to fewer than expected traumas in the 12AM and 1AM windows.

```
> crosstabs(counts~hour, data=mva1.df)
Call:
crosstabs(counts ~ hour, data = mva1.df)
1094 cases in table
+-------+
|N      |
|N/Total|
+-------+
hour   |
-------+-------+
11PM   |285    |
       |0.26   |
-------+-------+
12AM   |220    |
       |0.20   |
-------+-------+
1AM    |318    |
       |0.29   |
-------+-------+
2AM    |271    |
       |0.25   |
-------+-------+
> cs.test(c(285,220,318,271))
$Xsq:
[1] 18.21207
$Pval:
[1] 0.0003976996
$Decomp:
[1]  0.48354662 10.46526508  7.24040219  0.02285192
```

Hour and month are not associated (p-value=0.8024353)

June-to-Sep account for 45% so these months have a much higher share. Assuming cases are uniformly distributed over the months, yields an observed chi-squared goodness-of-fit statistic of 73.79 on 11 df which is statistically significant at less than 10^{-10}.

There is no dependence between hour and month.

```
> crosstabs(counts~hour+month, data=mva.df, subset=!mva.df$hour=="3AMPlus")
Call:
crosstabs(counts ~ hour + month, data = mva.df, subset = !(mva.df$hour == "3AMPlus"))
1094 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |15     |19     |17     |16     |22     |29     |33     |30     |32     |23     |28     |21     |285    |
       |0.0526 |0.0667 |0.0596 |0.0561 |0.0772 |0.1018 |0.1158 |0.1053 |0.1123 |0.0807 |0.0982 |0.0737 |0.26   |
       |0.2632 |0.3519 |0.2429 |0.1951 |0.2558 |0.2636 |0.2481 |0.2174 |0.2857 |0.2706 |0.3111 |0.2727 |       |
       |0.0137 |0.0174 |0.0155 |0.0146 |0.0201 |0.0265 |0.0302 |0.0274 |0.0293 |0.0210 |0.0256 |0.0192 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |14     | 5     |14     |15     |22     |20     |23     |28     |20     |17     |23     |19     |220    |
       |0.0636 |0.0227 |0.0636 |0.0682 |0.1000 |0.0909 |0.1045 |0.1273 |0.0909 |0.0773 |0.1045 |0.0864 |0.20   |
       |0.2456 |0.0926 |0.2000 |0.1829 |0.2558 |0.1818 |0.1729 |0.2029 |0.1786 |0.2000 |0.2556 |0.2468 |       |
       |0.0128 |0.0046 |0.0128 |0.0137 |0.0201 |0.0183 |0.0210 |0.0256 |0.0183 |0.0155 |0.0210 |0.0174 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |15     |16     |21     |36     |23     |33     |44     |35     |32     |24     |19     |20     |318    |
       |0.0472 |0.0503 |0.0660 |0.1132 |0.0723 |0.1038 |0.1384 |0.1101 |0.1006 |0.0755 |0.0597 |0.0629 |0.29   |
       |0.2632 |0.2963 |0.3000 |0.4390 |0.2674 |0.3000 |0.3308 |0.2536 |0.2857 |0.2824 |0.2111 |0.2597 |       |
       |0.0137 |0.0146 |0.0192 |0.0329 |0.0210 |0.0302 |0.0402 |0.0320 |0.0293 |0.0219 |0.0174 |0.0183 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |13     |14     |18     |15     |19     |28     |33     |45     |28     |21     |20     |17     |271    |
       |0.0480 |0.0517 |0.0664 |0.0554 |0.0701 |0.1033 |0.1218 |0.1661 |0.1033 |0.0775 |0.0738 |0.0627 |0.25   |
       |0.2281 |0.2593 |0.2571 |0.1829 |0.2209 |0.2545 |0.2481 |0.3261 |0.2500 |0.2471 |0.2222 |0.2208 |       |
       |0.0119 |0.0128 |0.0165 |0.0137 |0.0174 |0.0256 |0.0302 |0.0411 |0.0256 |0.0192 |0.0183 |0.0155 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|57     |54     |70     |82     |86     |110    |133    |138    |112    |85     |90     |77     |1094   |
       |0.052  |0.049  |0.064  |0.075  |0.079  |0.101  |0.122  |0.126  |0.102  |0.078  |0.082  |0.070  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
      Chi^2 = 29.64457 d.f.= 33 (p=0.6349629)
      Yates' correction not used
> get.crosstabs.percenterror(counts~hour+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]    1   35   -7  -25   -2    1   -5  -17   10     4    19     5
[2,]   22  -54   -1   -9   27  -10  -14    1  -11    -1    27    23
[3,]   -9    2    3   51   -8    3   14  -13   -2    -3   -27   -11
[4,]   -8    5    4  -26  -11    3    0   32    1     0   -10   -11
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
[1,]  0.04  1.32 -0.29 -1.16 -0.09  0.06 -0.28 -0.99  0.52  0.18  0.94  0.21
[2,]  0.75 -1.78 -0.02 -0.37  1.13 -0.45 -0.72  0.05 -0.53 -0.02  1.15  0.89
[3,] -0.39  0.08  0.14  2.49 -0.40  0.18  0.86 -0.81 -0.10 -0.14 -1.40 -0.50
[4,] -0.30  0.17  0.16 -1.18 -0.50  0.14  0.01  1.85  0.05 -0.01 -0.49 -0.47
```

Hour and year are may be associated (p-value about 10%)

The largest departures from expected occur in the hourly windows in 1999.

```
> crosstabs(counts~hour+year, data=mva.df, subset=!mva.df$hour=="3AMPlus")
Call:
crosstabs(counts ~ hour + year, data = mva.df, subset = !(mva.df$hour == "3AMPlus"))
1094 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |30     |50     |47     |44     |44     |35     |27     | 8     |285    |
       |0.10526|0.17544|0.16491|0.15439|0.15439|0.12281|0.09474|0.02807|0.26   |
       |0.30928|0.31056|0.23383|0.22564|0.27329|0.22436|0.25472|0.47059|       |
       |0.02742|0.04570|0.04296|0.04022|0.04022|0.03199|0.02468|0.00731|       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |13     |27     |39     |46     |41     |34     |19     | 1     |220    |
       |0.05909|0.12273|0.17727|0.20909|0.18636|0.15455|0.08636|0.00455|0.20   |
       |0.13402|0.16770|0.19403|0.23590|0.25466|0.21795|0.17925|0.05882|       |
       |0.01188|0.02468|0.03565|0.04205|0.03748|0.03108|0.01737|0.00091|       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |30     |47     |68     |62     |38     |40     |26     | 7     |318    |
       |0.09434|0.14780|0.21384|0.19497|0.11950|0.12579|0.08176|0.02201|0.29   |
       |0.30928|0.29193|0.33831|0.31795|0.23602|0.25641|0.24528|0.41176|       |
       |0.02742|0.04296|0.06216|0.05667|0.03473|0.03656|0.02377|0.00640|       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |24     |37     |47     |43     |38     |47     |34     | 1     |271    |
       |0.08856|0.13653|0.17343|0.15867|0.14022|0.17343|0.12546|0.00369|0.25   |
       |0.24742|0.22981|0.23383|0.22051|0.23602|0.30128|0.32075|0.05882|       |
       |0.02194|0.03382|0.04296|0.03931|0.03473|0.04296|0.03108|0.00091|       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|97     |161    |201    |195    |161    |156    |106    |17     |1094   |
       |0.089  |0.147  |0.184  |0.178  |0.147  |0.143  |0.097  |0.016  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 30.08949 d.f.= 21 (p=0.09020436)
    Yates' correction not used
    Some expected values are less than 5, don't trust stated p-value
> get.crosstabs.percenterror(counts~hour+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]   19   19  -10  -13    5  -14   -2   81
[2,]  -33  -17   -4   17   27    8  -11  -71
[3,]    6    0   16    9  -19  -12  -16   42
[4,]    0   -7   -6  -11   -5   22   29  -76
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,]  0.94  1.24 -0.74 -0.95  0.32 -0.88 -0.12  1.70
[2,] -1.47 -0.94 -0.22  1.08  1.52  0.47 -0.50 -1.31
[3,]  0.34  0.03  1.25  0.71 -1.29 -0.79 -0.87  0.93
[4,] -0.01 -0.46 -0.40 -0.76 -0.30  1.34  1.51 -1.56
```

Data Visualization

In our time series plots we use a 60% robust locally linear smoother to visualize the trend except in the STL analysis where a 60% robust locally quadratic smoother is used for trend. Monotonic trend test significant in both cases.

Table 1a.
OTR monthly time series, excluding 3AMPlus window.

```
> mva.tot.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  13  15  13  10  12  12   7  15
1993:   5  13   4  18  15  18  12  21  22  10  14   9
1994:   7   7  14  21  15  12  25  24  19  20  17  20
1995:  17   8  17  12  14  25  28  29  16   7  13   9
1996:   7  10  16   8  13  11  20  24  18  12  15   7
1997:  10   6  14  13  11  18  16  19  13  11  15  10
1998:   5   5   4   5   5  11  19  11  12  13   9   7
1999:   6   5   1   5
> SeasonalMannKendall(mva.tot.ts)
tau = -0.262,   sl =0.4841%
```

Table 1b
MVA monthly time series, 3AMPlus window.

```
> mva0.tot.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  14  11  16  17  15  16  14  16
1993:  13  12  11  15  15  16  23  22  16  17  20  16
1994:  15  13  14  15  19  22  20  25  21  23  19  16
1995:  18  17  20  18  19  23  25  25  21  20  19  20
1996:  16  15  21  15  21  23  22  23  20  20  22  16
1997:  15  17  17  12  19  20  21  21  18  22  14  17
1998:  15  14  14  18  19  20  23  22  21  23  17  20
1999:  16  12  12  14
> SeasonalMannKendall(mva0.tot.ts)
tau = 0.249,   sl =0.8697%
```

Figure 1a. MVA counts/month (excluding 3AMPlus) show an initial upward trend followed by a downward trend starting about 1995.

Figure 1a.

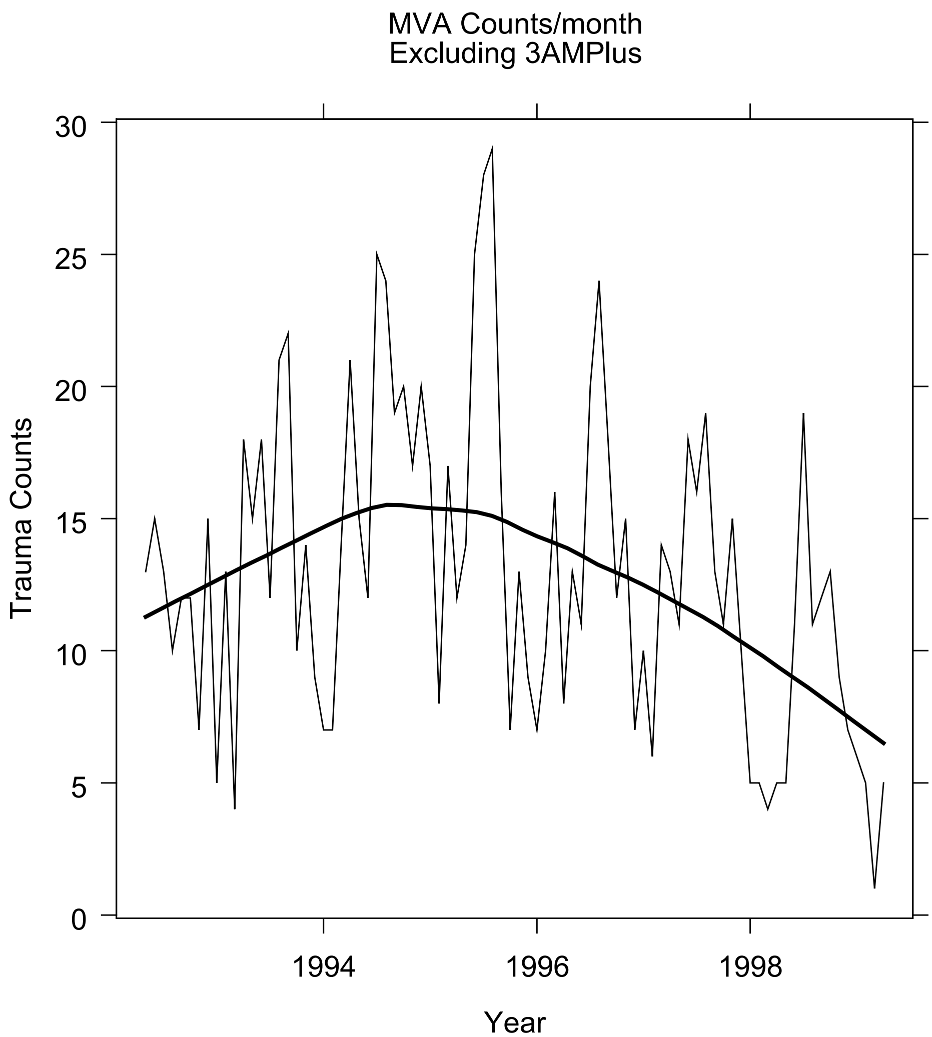


Figure 1b. MVA counts/month 3AMPlus show an initial upward trend to about 1995 and a downward trend post-1995.

Figure 1b.

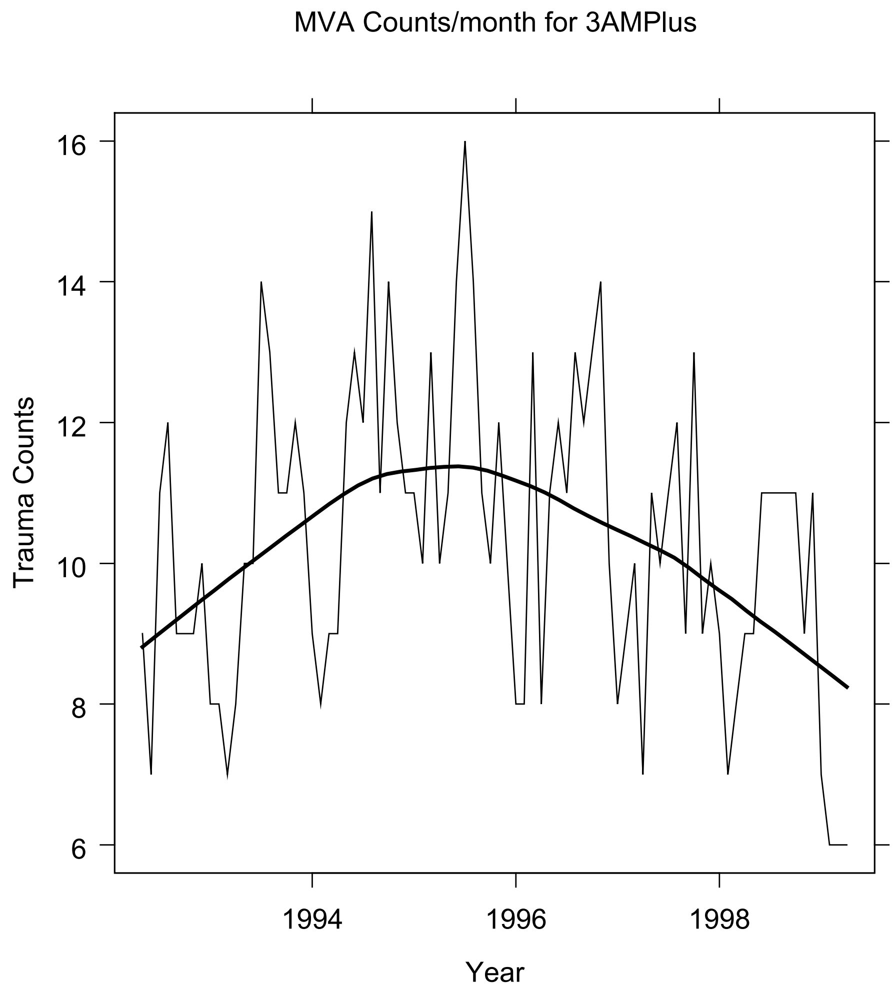


Figure 2a.
MVA counts by hour. Common scale.
The downward trend does not appear as step in the 2AM window.

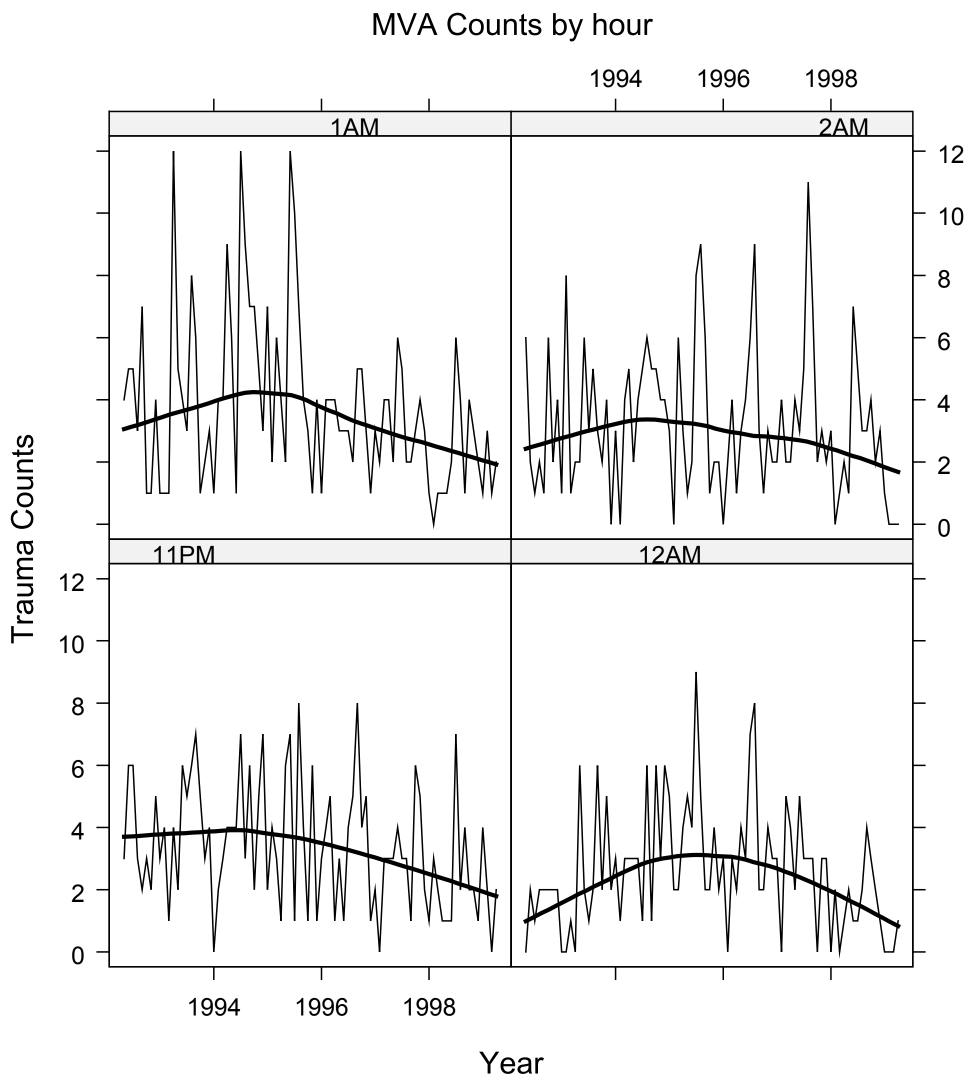
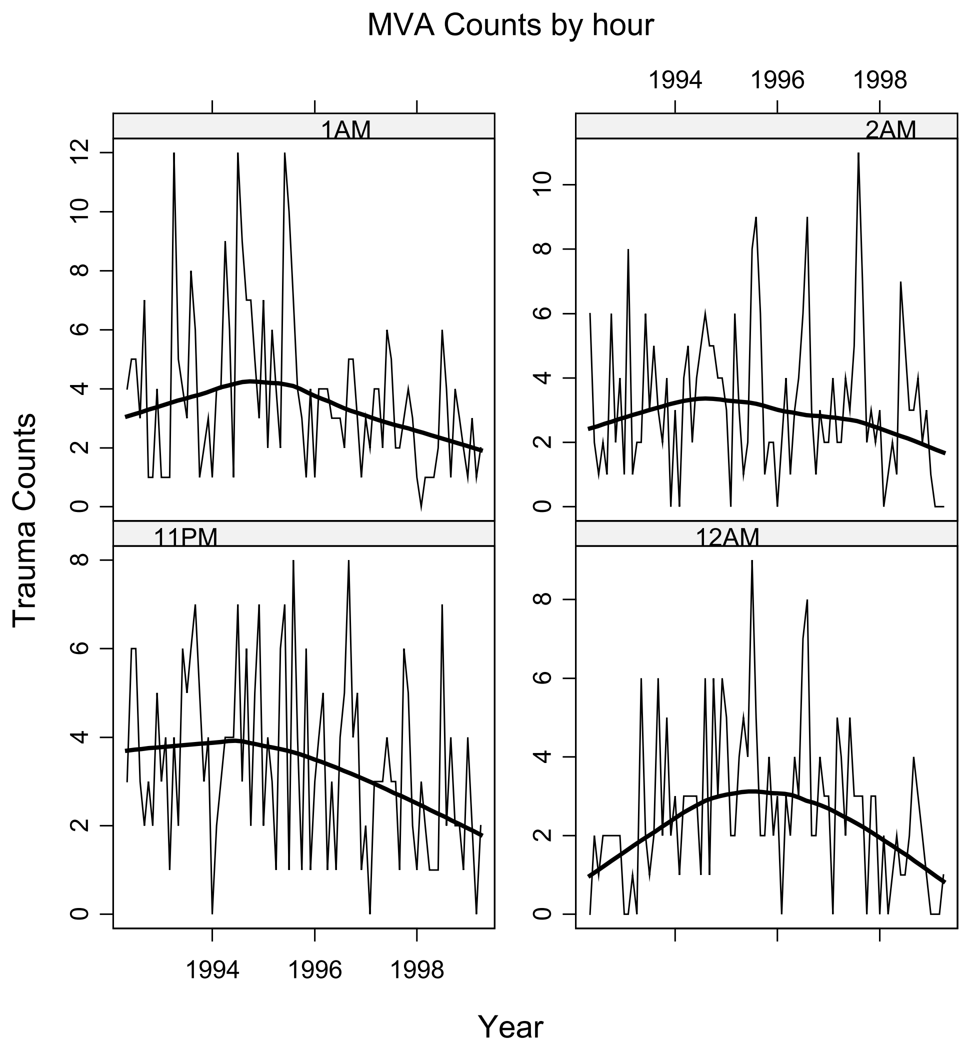


Figure 2b.



Independent vertical scale.

Table 2. Tabulations and Seasonal Mann-Kendall Tests

Monotonic trend test significant for 11PM and 1AM at <5% but not for 12AM and 2AM.

```
> count.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   3   6   6   3   2   3   2   5
1993:   3   4   1   4   2   6   5   6   7   5   3   4
1994:   0   2   3   4   4   4   7   3   6   2   5   7
1995:   2   4   3   1   6   7   1   8   4   1   6   1
1996:   3   4   5   1   3   1   4   5   8   4   5   1
1997:   2   0   3   3   3   4   3   3   1   6   5   2
1998:   1   3   2   1   1   1   7   2   4   2   2   1
1999:   4   2   0   2
> SeasonalMannKendall(count.11PM.ts)
```

tau = -0.195,   sl =3.875%

```
> count.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   0   2   1   2   2   2   2   2
1993:   0   0   1   0   6   2   1   2   6   2   5   2
1994:   3   1   3   3   3   3   1   6   1   6   3   6
1995:   5   2   2   4   5   4   9   5   2   2   4   2
1996:   3   0   3   2   4   3   7   8   2   2   4   3
1997:   3   0   5   4   2   5   3   3   3   0   3   3
1998:   0   2   0   1   2   1   1   2   4   3   2   1
1999:   0   0   0   1
> SeasonalMannKendall(count.12AM.ts)
tau = -0.0132,   sl =89.06%
```

```
> count.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   5   5   3   7   1   1   4
1993:   1   1   1  12   5   4   3   8   6   1   2   3
1994:   1   4   4   9   6   1  12   9   7   7   5   3
1995:   7   2   6   4   2  12  10   7   4   3   1   4
1996:   1   4   4   4   3   3   3   2   5   5   3   1
1997:   3   2   4   4   2   6   5   2   2   3   4   3
1998:   1   0   1   1   1   2   6   4   1   4   3   2
1999:   1   3   1   2
> SeasonalMannKendall(count.1AM.ts)
```

tau = -0.231,   sl =1.457%

```
> count.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   6   2   1   2   1   6   2   4
1993:   1   8   1   2   2   6   3   5   3   2   4   0
1994:   3   0   4   5   2   4   5   6   5   5   4   4
1995:   3   0   6   3   1   2   8   9   6   1   2   2
1996:   0   2   4   1   3   4   6   9   3   1   3   2
1997:   2   4   2   2   4   3   5  11   7   2   3   2
1998:   3   0   1   2   1   7   5   3   3   4   2   3
1999:   1   0   0   0
> SeasonalMannKendall(count.2AM.ts)
tau = -0.0387,   sl =68.38%
```

A peak is reached in 1995 is followed by a downward trend. There is a change in the shape of the seasonal component occuring in 1996.

```
R-sq =  69.2 %
```

Figure 3a

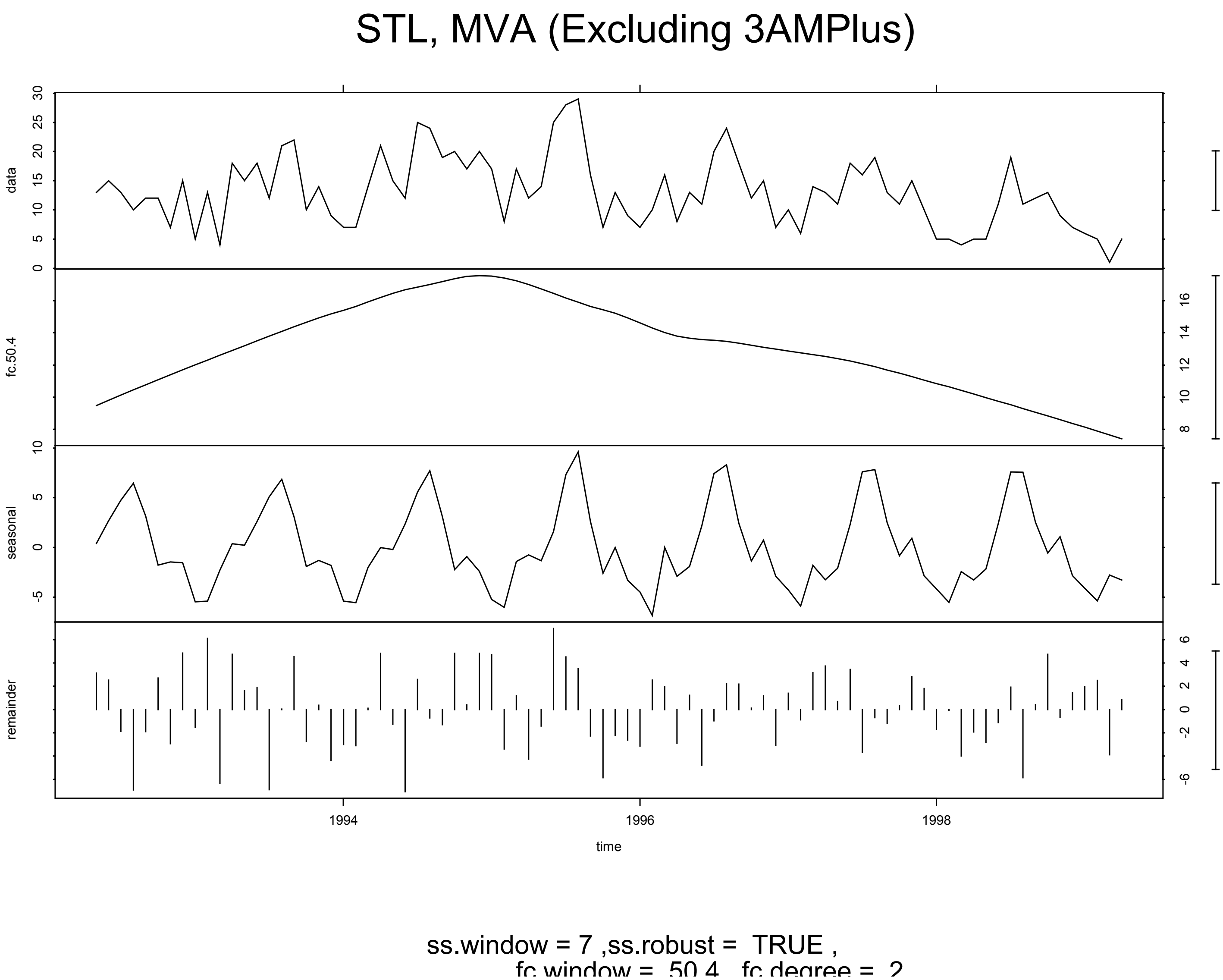


Figure 3b. The seasonal has a well defined peak in August, smaller peak in Nov and minimum in February. There is a downward trend in Apr and an upward trend Jul. and Nov

Figure 3b.

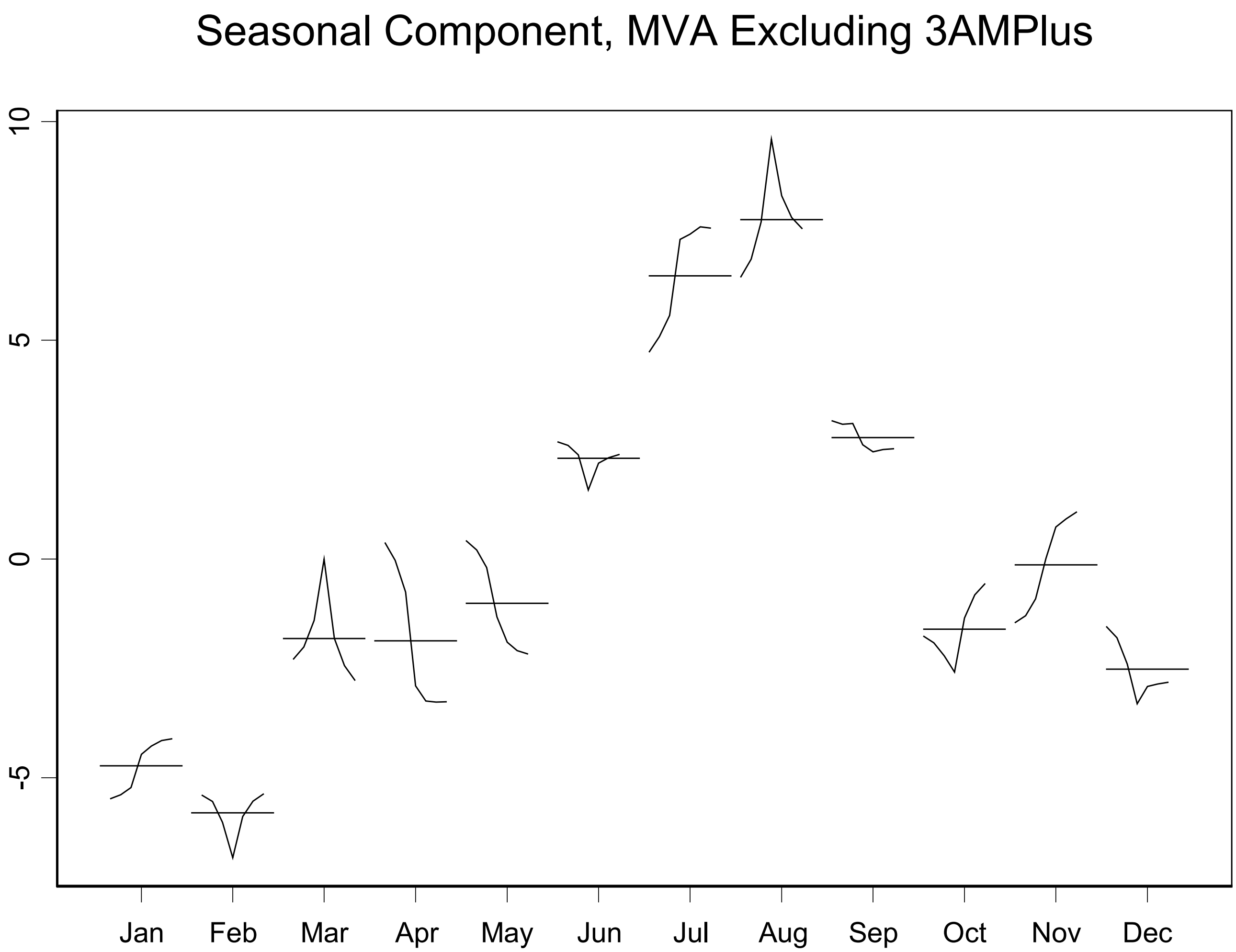


Figure 3c. Normal probability plot.

Reasonably normal. No strong indication of outliers.

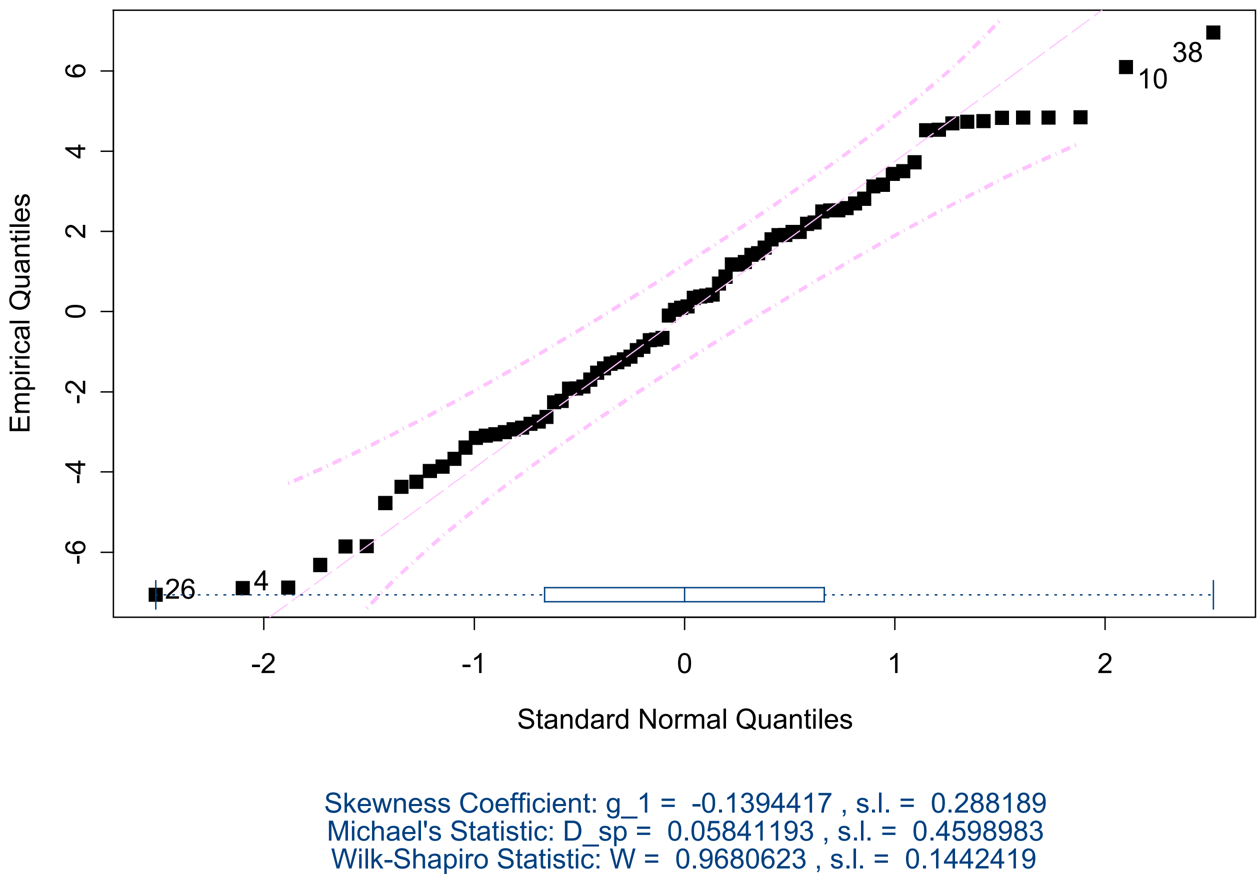
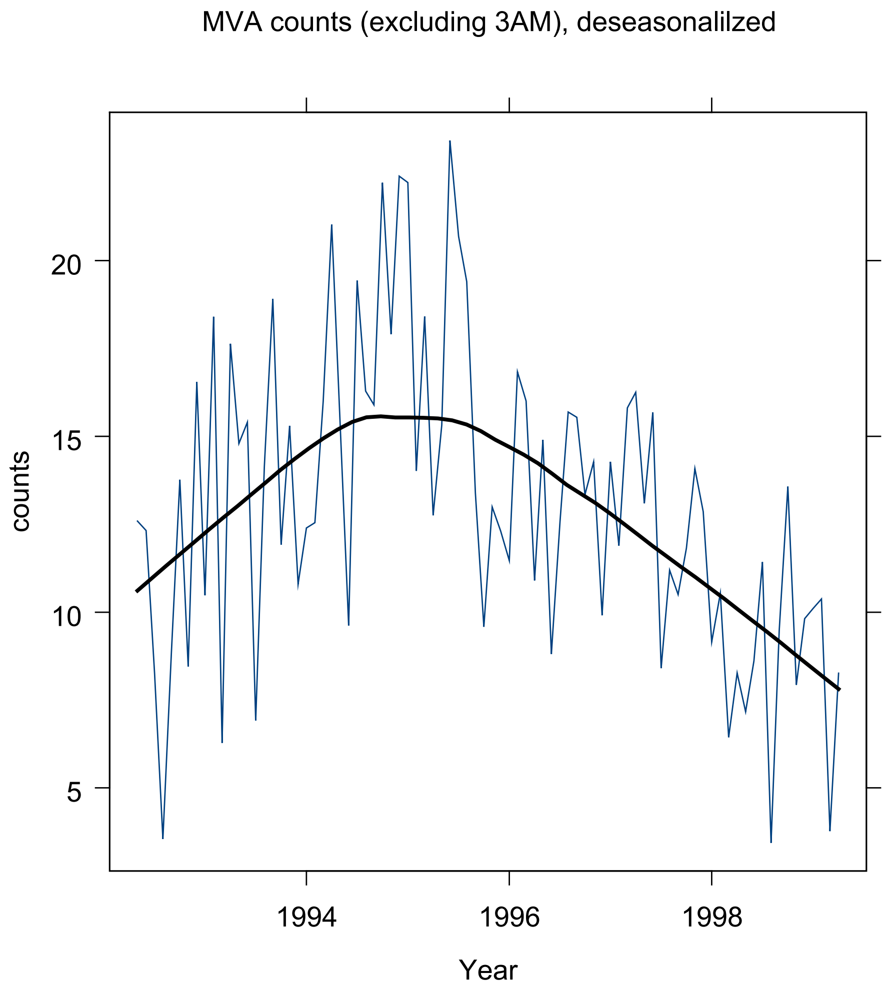


Figure 3d.

Deseasonalized series. Strong downward trend since 1995. Mann-Kendall test highly significant.

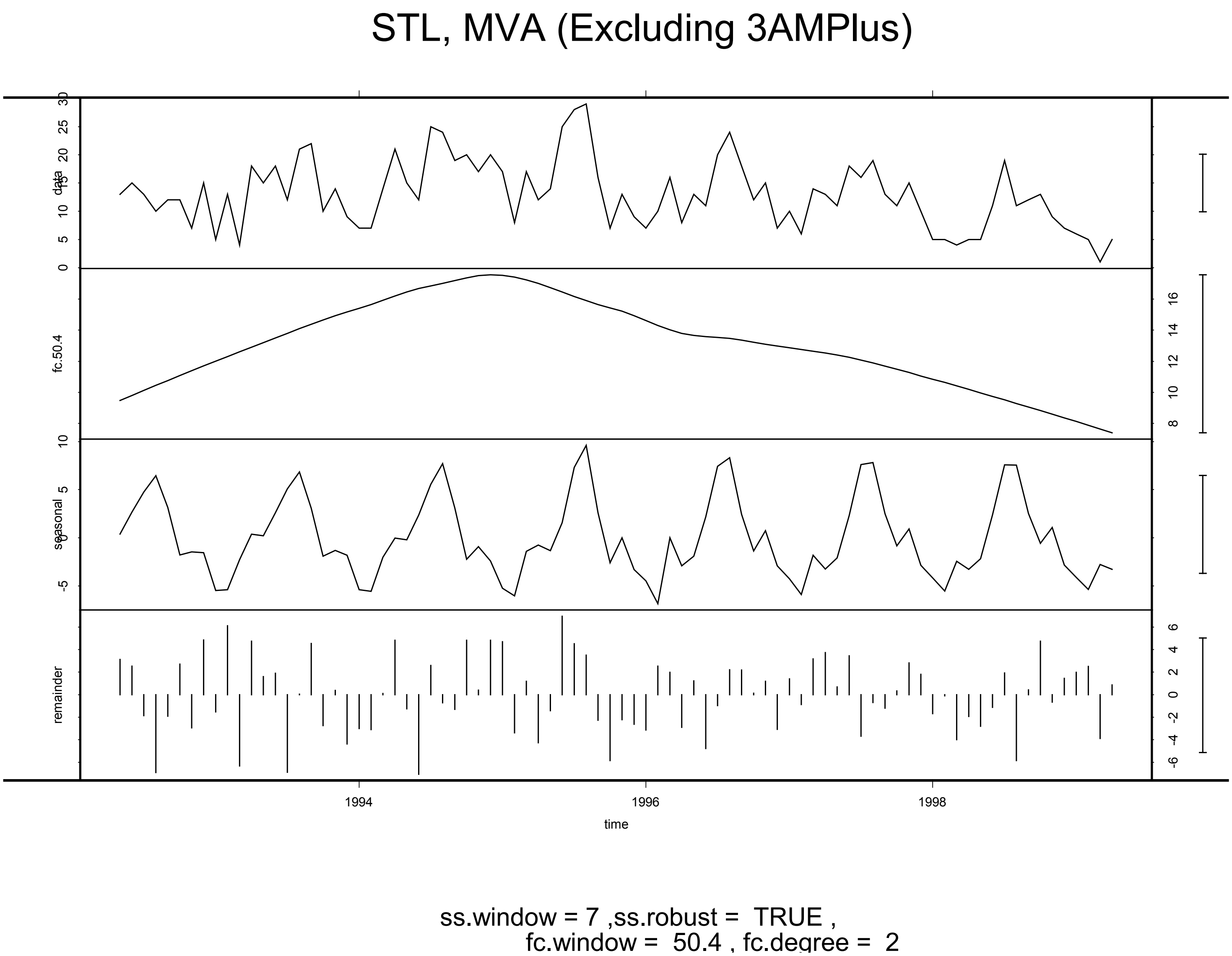
`tau = -0.226,   sl =0.2146%`



STL Decomposition, OTR Excluding `3AMPlus`

Figure 4a. A peak is reached in 1995 is followed by a downward trend. There is a change in the shape of the seasonal component occuring in 1996.

Figure 4a.



STL Decomposition, OTR `3AMPlus`

Figure 4a. Increasing trend to 1995 and decreasing thereafter. The seasonal pattern changes in 1996 with the Jul-Aug peak becoming less prominent and the smaller Oct peak increasing.

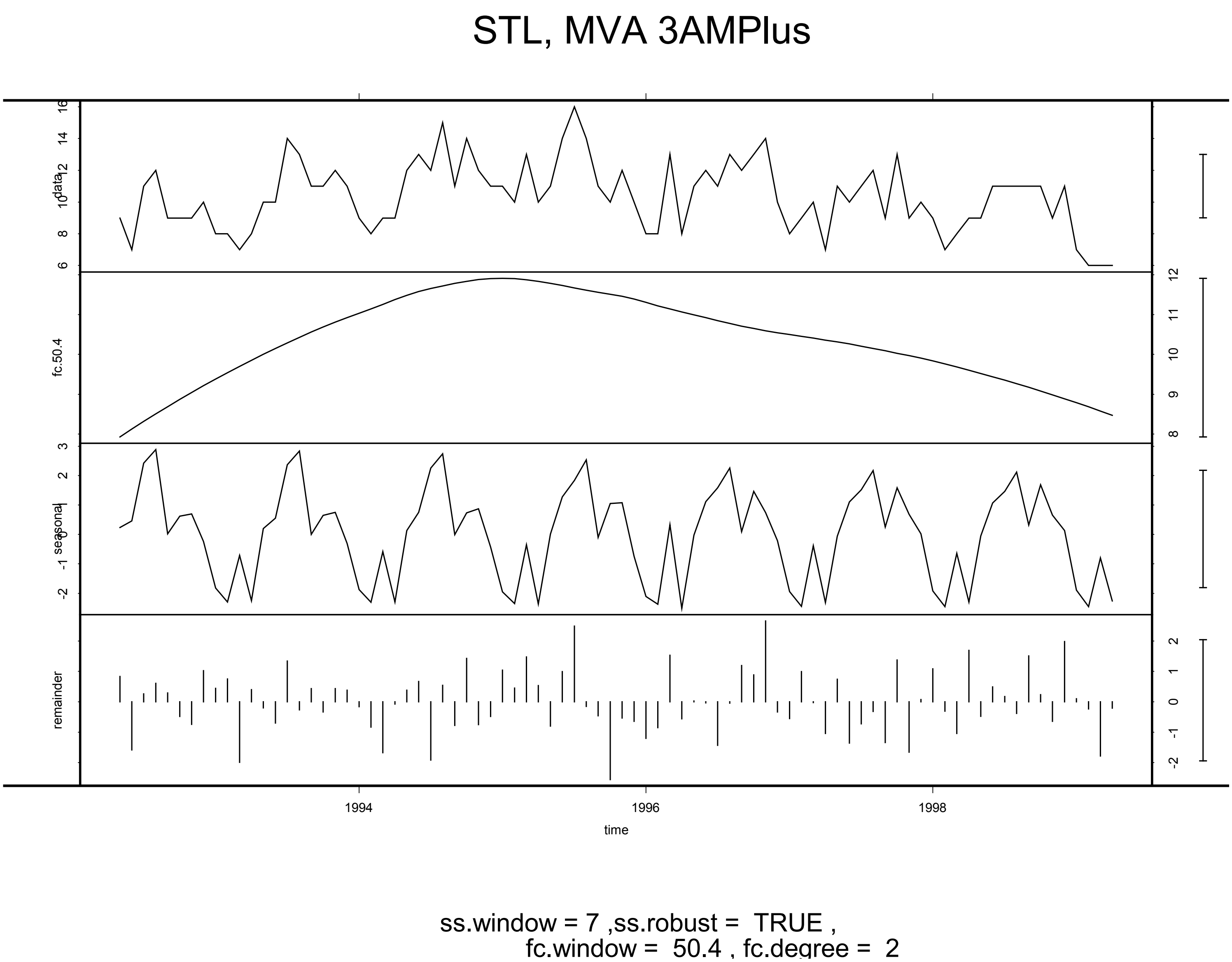
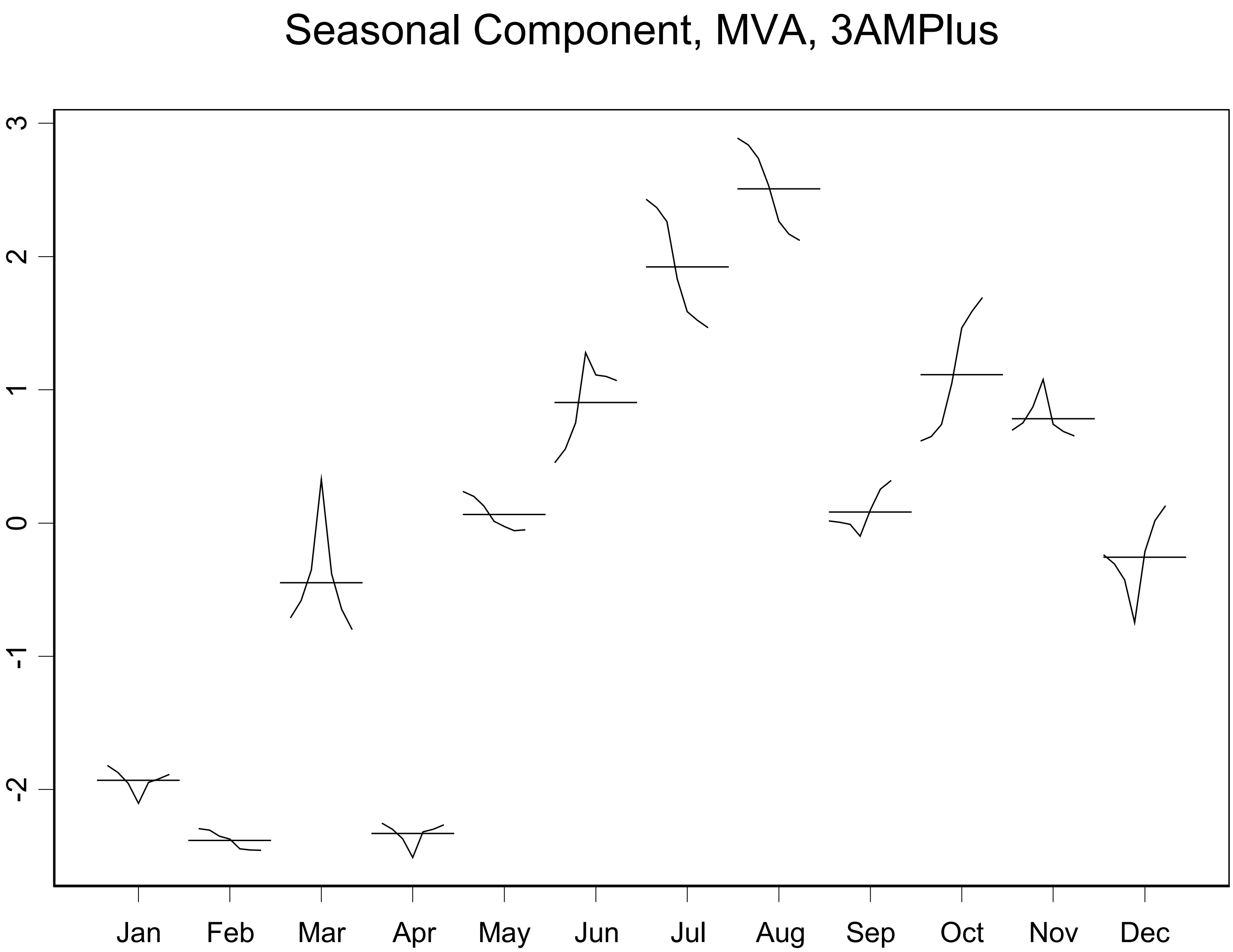


Figure 4b. Well defined peaks in Mar, Aug and Oct and minimum in Feb, Apr and Sep. The Oct peak has increased since 1996 and the Aug peak has decreased since 1996.



F. OTR Dataset

Summary

The data of both motor vehicle accident and non-motor vehicle trauma cases in Ontario from May 1992 to April 1999. About 45% of OTR cases occur in the 3AMPlus group. Since we are primarily interested in the other groups, the data corresponding to this subgroup was analysed separately.

HOUR: The uniformity hypothesis is rejected by a chi-square test at less than 0.1%. The major departure is due to fewer than expected trauma's in the 12AM window.

June-to-Sep account for 42% so these months have a much higher share. Assuming cases are uniformly distributed over the months, yields an observed chi-squared goodness-of-fit statistic of 73.79 on 11 df which is statistically significant at less than 10^{-10}.

Hour and month are not associated

Hour and year are not associated

Figure 1a. OTR counts/month (excluding 3AMPlus) show a convex pattern of an initial upward trend followed by a downward trend starting about 1995. No monotonic trend so Mann-Kendall not significant as expected – Table 1a.

Figure 1b. OTR counts/month 3AMPlus show an initial upward trend to 1996 and a flattening out. Seasonal Mann-Kendall test is significant at less than 1% indicating an upward trend – Table 1b.

Table 2. Time series disaggregated into hourly windows. No monotonic trends indicated by Seasonal Mann-Kendall tests.

Figure 2a and Figure 2b: nearly flat for 2AM but others show an upward movement followed by downward.

Figure 3a. STL, OTR. A peak is reached in 1995 is followed by a downward trend. There is a change in the shape of the seasonal component occuring in 1996.

Figure 3b. OTR. The seasonal has a well defined peak in August and minimum in February. There is a downward trend in Apr and an upward trend Jul. and Nov This results in two peaks after about 1996 – the second peak being in Nov.

Figure 4a. OTR, 3AMPlus. A gradual increase until it levels off in 1996. Slight change in seasonal shape after 1996

Figure 4b. OTR, 3AMPlus. Well defined peaks in Aug and Oct and minimum in Feb. The Oct peak has increased since 1996 and the Aug peak has decreased since 1996.

Figure 4d – loess analysis of deseasonalized OTR, 3AMPlus is similar to Figure 1b as expected.

Introduction

The data set of Ontario Trauma Registry (OTR) contains the both motor vehicle accident and non motor vehicle accident cases (ISS Scale > 12, severe injury) from May 1992 to April 1999.

The hour factor variable includes 11:00pm-12:00am, 12:00am-1:00am, 1:00am-2:00am, 2:00am - 3:00am and 3:00am -10:00am

Variables of interest:

`counts`	number of mva cases with ISS Scale > 12 (severe injury)
`year`	ordered factor, 8 levels: 1992 to 1999
`month`	ordered factor, 12 levels: January to December
`hour`	ordered factor with 5 levels: “11PM”, “12AM”, “1AM”, “2AM”, “3AMPlus”

About 45% of OTR cases occur in the 3AMPlus group. Since we are primarily interested in the other groups, the data corresponding to this subgroup was analysed separately. Also notice that there is no wkgrp variable for this data.

```
> crosstabs(counts~hour, data=otr.df)
Call:
crosstabs(counts ~ hour, data = otr.df)
3368 cases in table
+-------+
|N      |
|N/Total|
+-------+
hour   |
-------+-------+
11PM   | 492   |
       |0.15   |
-------+-------+
12AM   | 394   |
       |0.12   |
-------+-------+
1AM    | 500   |
       |0.15   |
-------+-------+
2AM    | 473   |
       |0.14   |
-------+-------+
3AMPlus|1509   |
       |0.45   |
-------+-------+
```

Crosstabs Analysis

Hour

The uniformity hypothesis is rejected by a chi-square test at less than 0.1%. The major departure is due to fewer than expected traumas in the 12AM window.

```
> crosstabs(counts~hour, data=otr1.df)
Call:
crosstabs(counts ~ hour, data = otr1.df)
1859 cases in table
+-------+
|N      |
|N/Total|
+-------+
hour   |
-------+-------+
11PM   |492    |
       |0.26   |
-------+-------+
12AM   |394    |
       |0.21   |
-------+-------+
1AM    |500    |
       |0.27   |
-------+-------+
2AM    |473    |
       |0.25   |
-------+--------
```

Hour and month are not associated (p-value=0.8024353)

June-to-Sep account for 42% so these months have a much higher share. Assuming cases are uniformly distributed over the months, yields an observed chi-squared goodness-of-fit statistic of 73.79 on 11 df which is statistically significant at less than 10^{-10}.

There is no dependence between hour and month.

```
> crosstabs(counts~hour+month, data=otr.df, subset=!mva.df$hour=="3AMPlus")
Call:
crosstabs(counts ~ hour + month, data = otr.df, subset = !(mva.df$hour == "3AMPlus"))
1859 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |39     |34     |28     |37     |39     |48     |49     |49     |54     |32     |46     |37     |492    |
       |0.079  |0.069  |0.057  |0.075  |0.079  |0.098  |0.100  |0.100  |0.110  |0.065  |0.093  |0.075  |0.26   |
       |0.300  |0.318  |0.207  |0.278  |0.247  |0.286  |0.241  |0.222  |0.310  |0.225  |0.324  |0.253  |       |
       |0.021  |0.018  |0.015  |0.020  |0.021  |0.026  |0.026  |0.026  |0.029  |0.017  |0.025  |0.020  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |32     |19     |30     |24     |35     |34     |45     |50     |33     |32     |32     |28     |394    |
       |0.081  |0.048  |0.076  |0.061  |0.089  |0.086  |0.114  |0.127  |0.084  |0.081  |0.081  |0.071  |0.21   |
       |0.246  |0.178  |0.222  |0.180  |0.222  |0.202  |0.222  |0.226  |0.190  |0.225  |0.225  |0.192  |       |
       |0.017  |0.010  |0.016  |0.013  |0.019  |0.018  |0.024  |0.027  |0.018  |0.017  |0.017  |0.015  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |31     |30     |39     |46     |46     |43     |60     |53     |42     |38     |30     |42     |500    |
       |0.062  |0.060  |0.078  |0.092  |0.092  |0.086  |0.120  |0.106  |0.084  |0.076  |0.060  |0.084  |0.27   |
       |0.238  |0.280  |0.289  |0.346  |0.291  |0.256  |0.296  |0.240  |0.241  |0.268  |0.211  |0.288  |       |
       |0.017  |0.016  |0.021  |0.025  |0.025  |0.023  |0.032  |0.029  |0.023  |0.020  |0.016  |0.023  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |28     |24     |38     |26     |38     |43     |49     |69     |45     |40     |34     |39     |473    |
       |0.059  |0.051  |0.080  |0.055  |0.080  |0.091  |0.104  |0.146  |0.095  |0.085  |0.072  |0.082  |0.25   |
       |0.215  |0.224  |0.281  |0.195  |0.241  |0.256  |0.241  |0.312  |0.259  |0.282  |0.239  |0.267  |       |
       |0.015  |0.013  |0.020  |0.014  |0.020  |0.023  |0.026  |0.037  |0.024  |0.022  |0.018  |0.021  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|130    |107    |135    |133    |158    |168    |203    |221    |174    |142    |142    |146    |1859   |
       |0.070  |0.058  |0.073  |0.072  |0.085  |0.090  |0.109  |0.119  |0.094  |0.076  |0.076  |0.079  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
      Chi^2 = 28.33842 d.f.= 33 (p=0.6985065)
      Yates' correction not used
```

Hour and year are independent

There are 62% more in the 11PM-1999 window than might be expected under independence but the result is only significant at about 12.5%.

```
> crosstabs(counts~hour+year, data=otr.df, subset=!otr.df$hour=="3AMPlus")
Call:
crosstabs(counts ~ hour + year, data = otr.df, subset = !(otr.df$hour ==
   "3AMPlus"))
1859 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour    |year
        |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM    |37     |75     |79     |88     |73     |66     |53     |21     |492    |
        |0.0752 |0.1524 |0.1606 |0.1789 |0.1484 |0.1341 |0.1077 |0.0427 |0.26   |
        |0.2450 |0.3036 |0.2516 |0.2716 |0.2786 |0.2324 |0.2325 |0.4286 |       |
        |0.0199 |0.0403 |0.0425 |0.0473 |0.0393 |0.0355 |0.0285 |0.0113 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM    |31     |45     |70     |73     |63     |56     |47     | 9     |394    |
        |0.0787 |0.1142 |0.1777 |0.1853 |0.1599 |0.1421 |0.1193 |0.0228 |0.21   |
        |0.2053 |0.1822 |0.2229 |0.2253 |0.2405 |0.1972 |0.2061 |0.1837 |       |
        |0.0167 |0.0242 |0.0377 |0.0393 |0.0339 |0.0301 |0.0253 |0.0048 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM     |42     |70     |90     |95     |60     |77     |54     |12     |500    |
        |0.0840 |0.1400 |0.1800 |0.1900 |0.1200 |0.1540 |0.1080 |0.0240 |0.27   |
        |0.2781 |0.2834 |0.2866 |0.2932 |0.2290 |0.2711 |0.2368 |0.2449 |       |
        |0.0226 |0.0377 |0.0484 |0.0511 |0.0323 |0.0414 |0.0290 |0.0065 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM     |41     |57     |75     |68     |66     |85     |74     | 7     |473    |
        |0.0867 |0.1205 |0.1586 |0.1438 |0.1395 |0.1797 |0.1564 |0.0148 |0.25   |
        |0.2715 |0.2308 |0.2389 |0.2099 |0.2519 |0.2993 |0.3246 |0.1429 |       |
        |0.0221 |0.0307 |0.0403 |0.0366 |0.0355 |0.0457 |0.0398 |0.0038 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|151     |247    |314    |324    |262    |284    |228    |49     |1859   |
        |0.081  |0.133  |0.169  |0.174  |0.141  |0.153  |0.123  |0.026  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
   Chi^2 = 28.56446 d.f.= 21 (p=0.1248566)
   Yates' correction not used
> get.crosstabs.percenterror(counts~hour+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]   -7   15   -5    3    5  -12  -12   62
[2,]   -3  -14    5    6   13   -7   -3  -13
[3,]    3    5    7    9  -15    1  -12   -9
[4,]    7   -9   -6  -18   -1   18   28  -44
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,] -0.47  1.19 -0.45  0.24  0.44 -1.06 -0.95  2.23
[2,] -0.18 -1.02  0.42  0.52  1.00 -0.54 -0.19 -0.43
[3,]  0.22  0.44  0.60  0.84 -1.25  0.07 -0.94 -0.32
[4,]  0.42 -0.74 -0.55 -1.59 -0.08  1.50  2.10 -1.55
```

Data Visualization

In our time series plots we use a 60% robust locally linear smoother to visualize the trend except in the STL analysis where a 60% robust locally quadratic smoother is used for trend. Monotonic trend test is significant at <1% for 3AMPlus for not for aggregated 11PM-to-2AM windows. Upward trend for 3AMPlus.

Table 1a.
OTR monthly time series, excluding 3AMPlus window.

```
> otr.tot.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  21  23  18  19  20  19  11  20
1993:  12  20   6  27  22  24  23  26  31  18  20  18
1994:  20  13  26  28  25  15  35  40  29  32  20  31
1995:  25  19  30  23  27  40  37  43  21  17  23  19
1996:  15  21  24  11  22  22  27  38  28  17  21  16
1997:  22  11  27  22  23  29  23  31  24  21  28  23
1998:  20  11  14   9  18  15  40  24  21  18  19  19
1999:  16  12   8  13
> SeasonalMannKendall(otr.tot.ts)
tau = -0.0567,   sl =54%
```

Table 1b.
OTR monthly time series, 3AMPlus window.

```
> otr0.tot.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  14  11  16  17  15  16  14  16
1993:  13  12  11  15  15  16  23  22  16  17  20  16
1994:  15  13  14  15  19  22  20  25  21  23  19  16
1995:  18  17  20  18  19  23  25  25  21  20  19  20
1996:  16  15  21  15  21  23  22  23  20  20  22  16
1997:  15  17  17  12  19  20  21  21  18  22  14  17
1998:  15  14  14  18  19  20  23  22  21  23  17  20
1999:  16  12  12  14
> SeasonalMannKendall(otr0.tot.ts)
tau = 0.249,   sl =0.8697%
```

Figure 1a. OTR counts/month (excluding 3AMPlus) show a convex pattern of an initial upward trend followed by a downward trend starting about 1995.

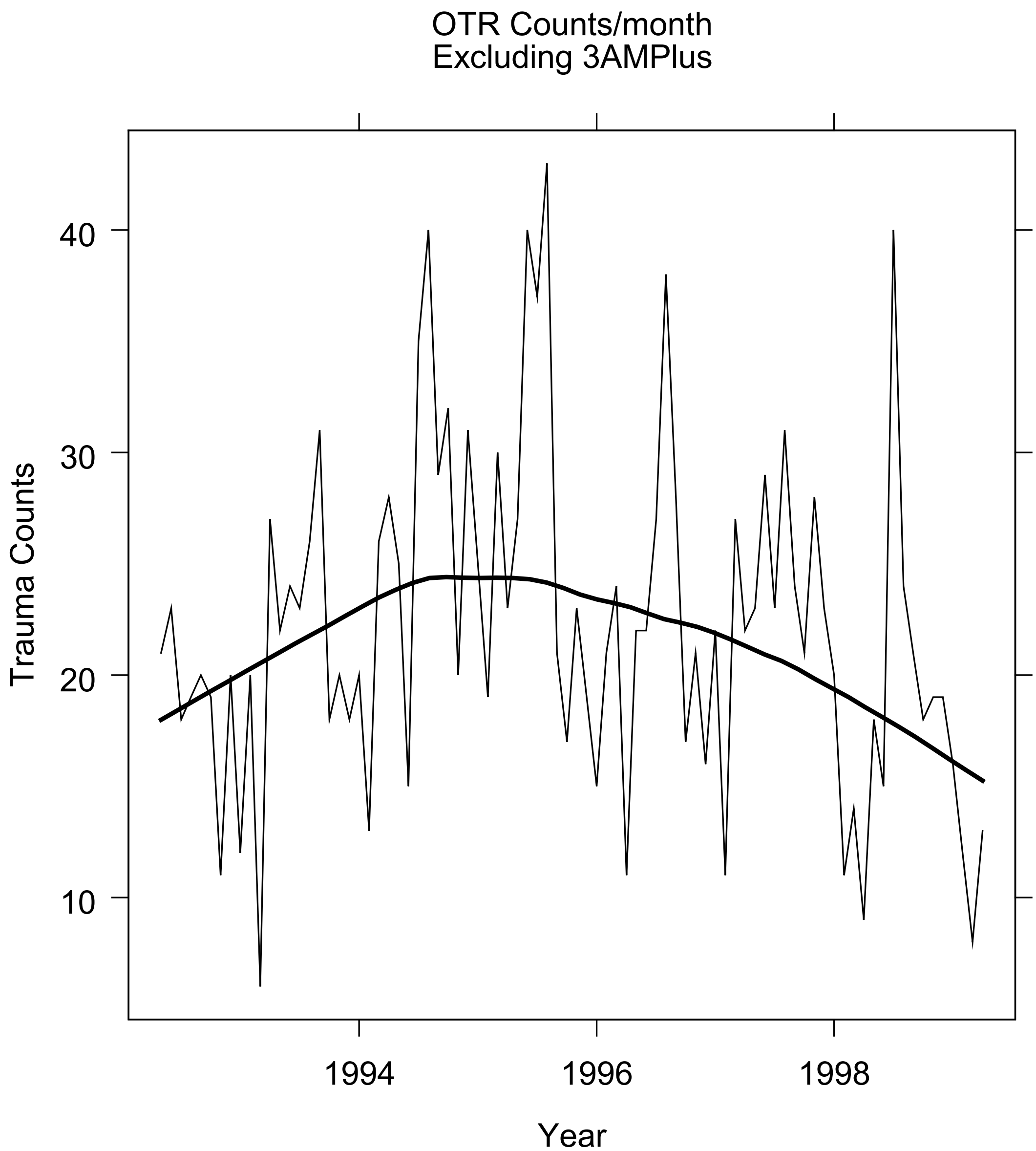


Figure 1b. OTR counts/month 3AMPlus show an initial upward trend to 1996 and a less step downward trend post-1996.

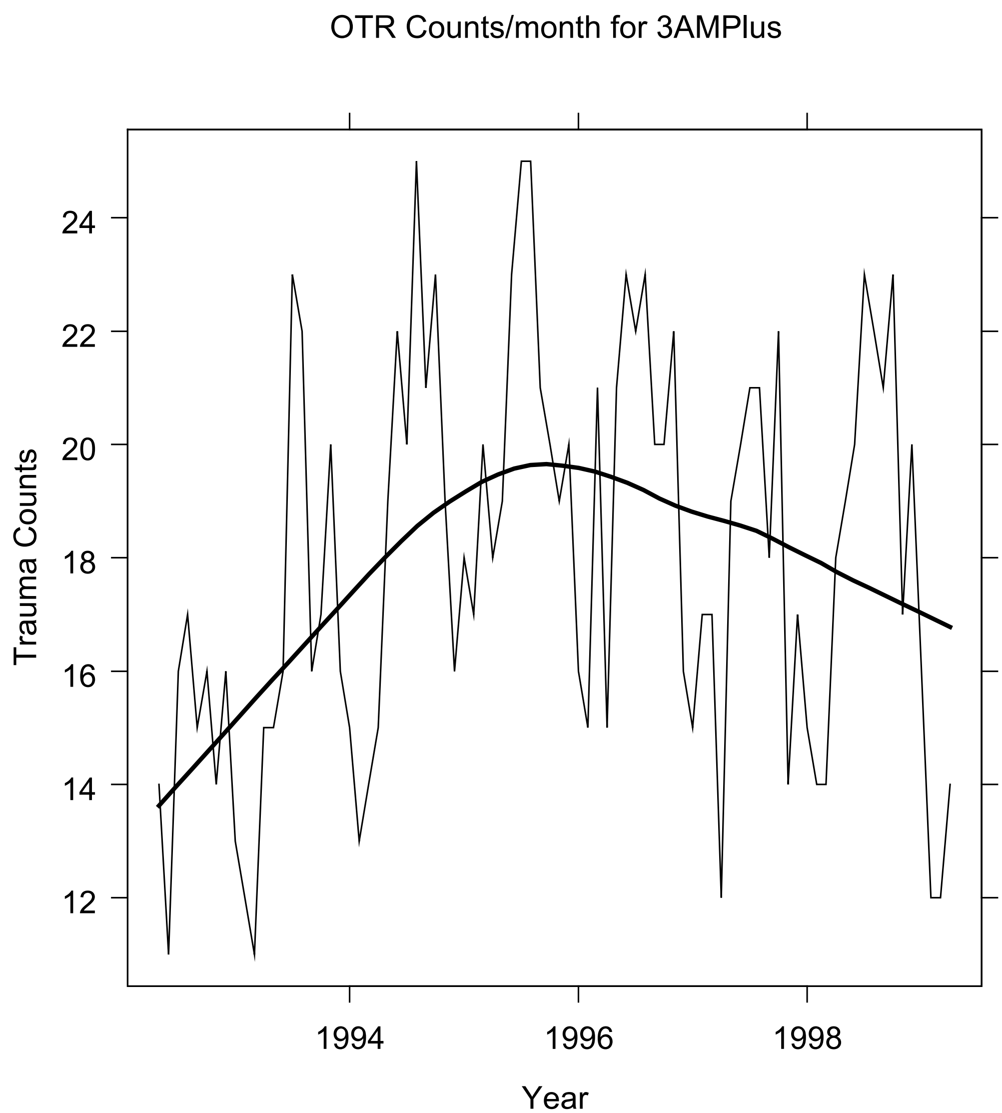


Figure 2a
OTR by hour with common scale.
Nearly flat for 2AM but others show an upward movement followed by downward.

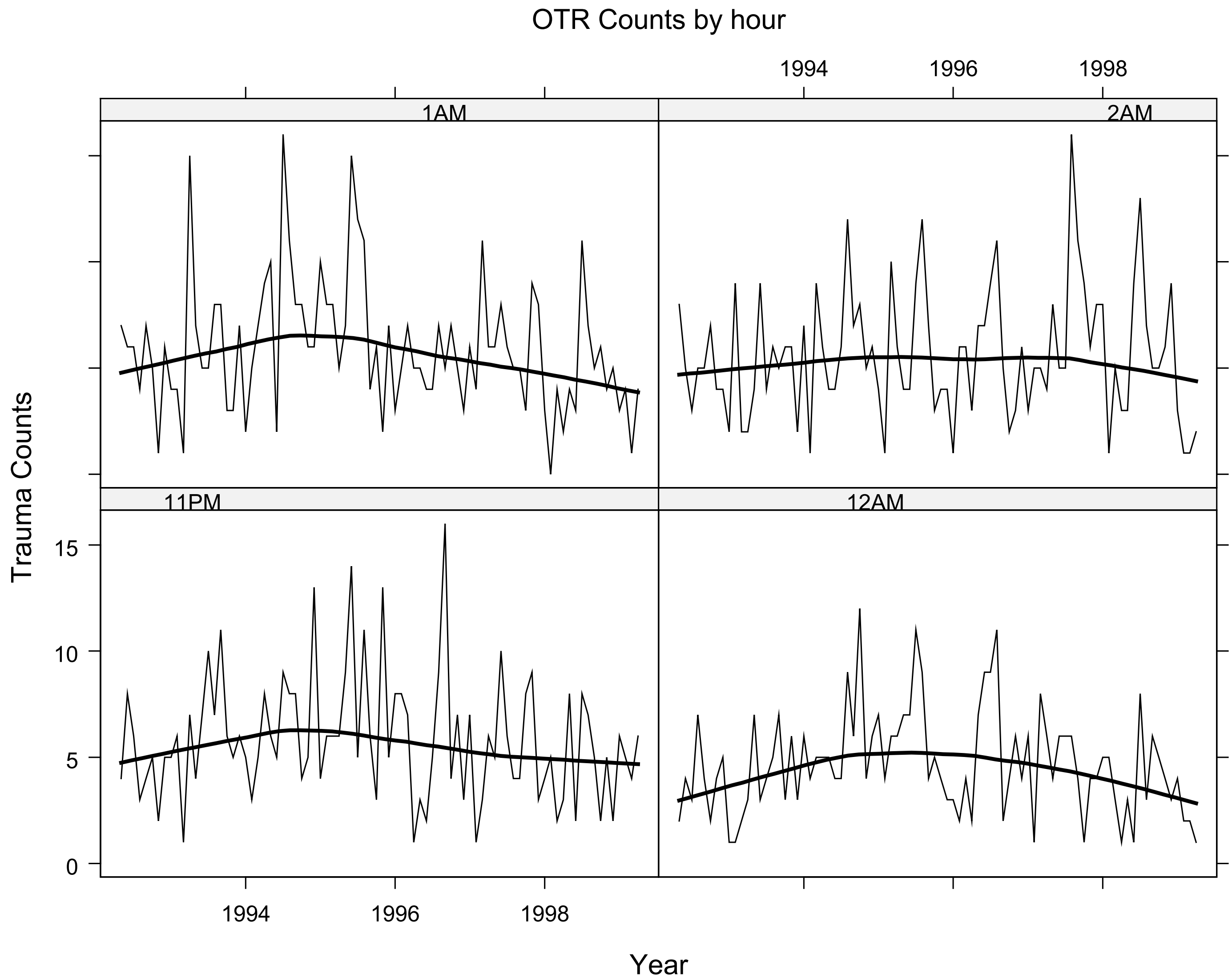


Figure 2b.
Independent scaling.

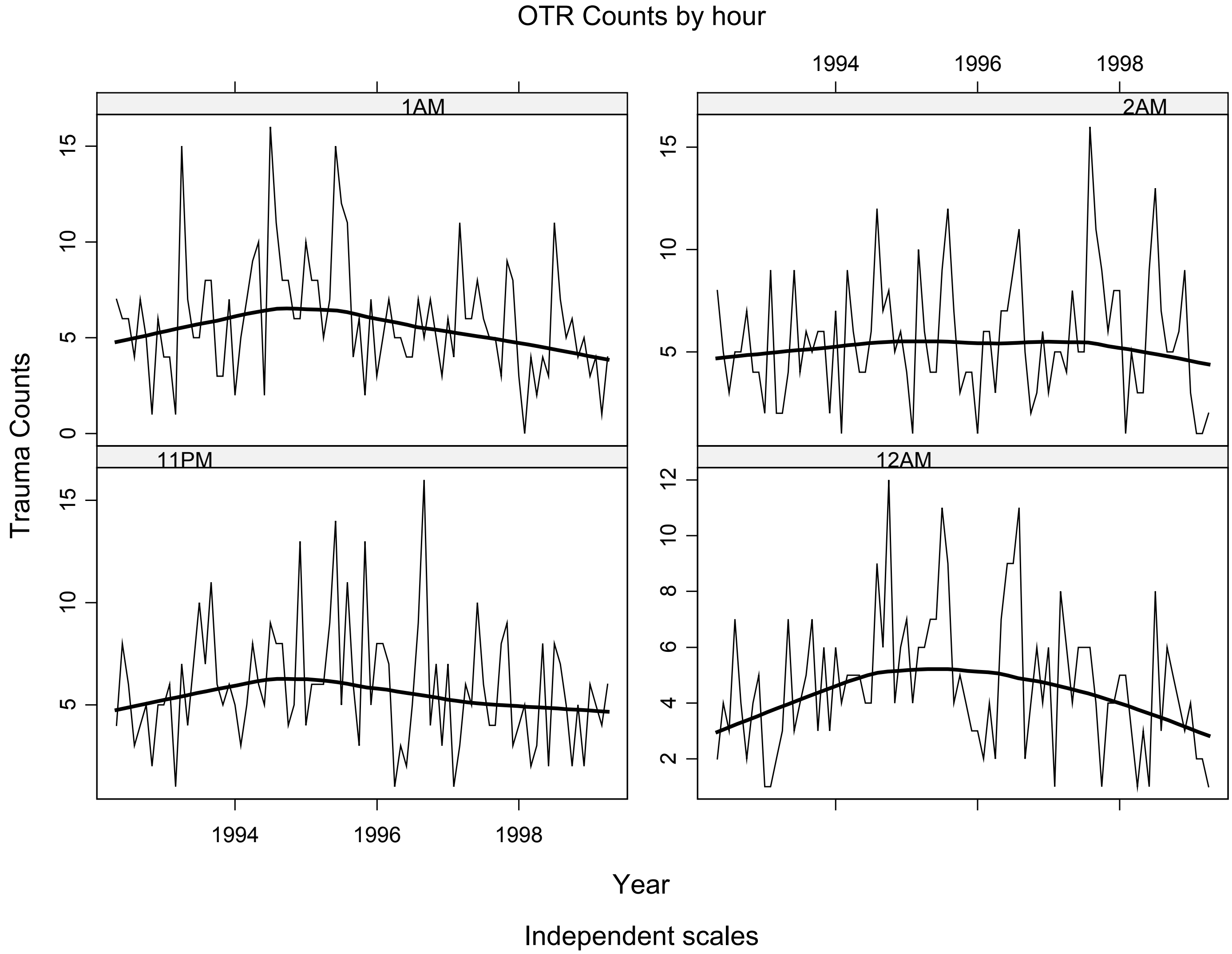


Table 2. Data tabulations and Seasonal Mann-Kendall tests
No monotonic trend significant at 5%

```
> count.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   8   6   3   4   5   2   5
1993:   5   6   1   7   4   7  10   7  11   6   5   6
1994:   5   3   5   8   6   5   9   8   8   4   5  13
1995:   4   6   6   6   9  14   5  11   6   3  13   5
1996:   8   8   7   1   3   2   5   9  16   4   7   3
1997:   7   1   3   6   5  10   6   4   4   8   9   3
1998:   4   5   2   3   8   2   8   7   5   2   5   2
1999:   6   5   4   6
> SeasonalMannKendall(count.11PM.ts)
tau = -0.0867,   sl =35.32%
> count.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   4   3   7   4   2   4   5
1993:   1   1   2   3   7   3   4   5   7   3   6   3
1994:   6   4   5   5   5   4   4   9   6  12   4   6
1995:   7   4   6   6   7   7  11   9   4   5   4   3
1996:   3   2   4   2   7   9   9  11   2   4   6   4
1997:   6   1   8   6   4   6   6   6   4   1   4   4
1998:   5   5   3   1   3   1   8   3   6   5   4   3
1999:   4   2   2   1
> SeasonalMannKendall(count.12AM.ts)
tau = -0.0299,   sl =75.19%
> count.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   7   6   6   4   7   5   1   6
1993:   4   4   1  15   7   5   5   8   8   3   3   7
1994:   2   5   7   9  10   2  16  11   8   8   6   6
1995:  10   8   8   5   7  15  12  11   4   6   2   7
1996:   3   5   7   5   5   4   4   7   5   7   5   3
1997:   6   4  11   6   6   8   6   5   5   3   9   8
1998:   3   0   4   2   4   3  11   7   5   6   4   5
1999:   3   4   1   4
> SeasonalMannKendall(count.1AM.ts)
tau = -0.159,   sl =9.095%
> count.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   8   5   3   5   5   7   4   4
1993:   2   9   2   2   4   9   4   6   5   6   6   2
1994:   7   1   9   6   4   4   6  12   7   8   5   6
1995:   4   1  10   6   4   4   9  12   7   3   4   4
1996:   1   6   6   3   7   7   9  11   5   2   3   6
1997:   3   5   5   4   8   5   5  16  11   9   6   8
1998:   8   1   5   3   3   9  13   7   5   5   6   9
1999:   3   1   1   2
> SeasonalMannKendall(count.2AM.ts)
tau = 0.0981,   sl =29.99%
```

STL Decomposition, OTR Excluding `3AMPlus`

Figure 3a. A peak is reached in 1995 is followed by a downward trend. There is a change in the shape of the seasonal component occuring in 1996. R-sq = 62.5 %

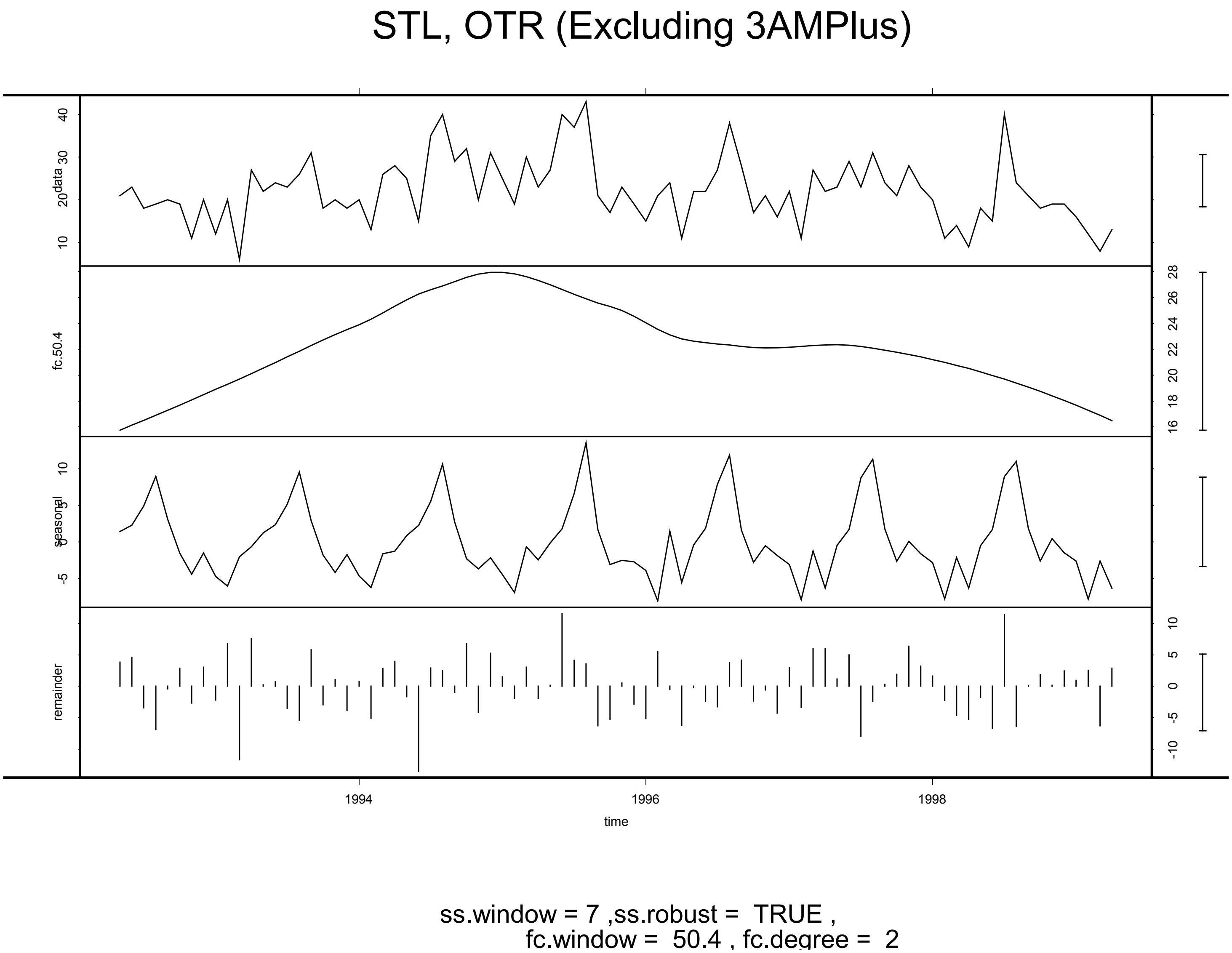


Figure 3b. The seasonal has a well defined peak in August and minimum in February. There is a downward trend in Apr and an upward trend Jul. and Nov This results in two peaks after about 1996 – the second peak being in Nov.

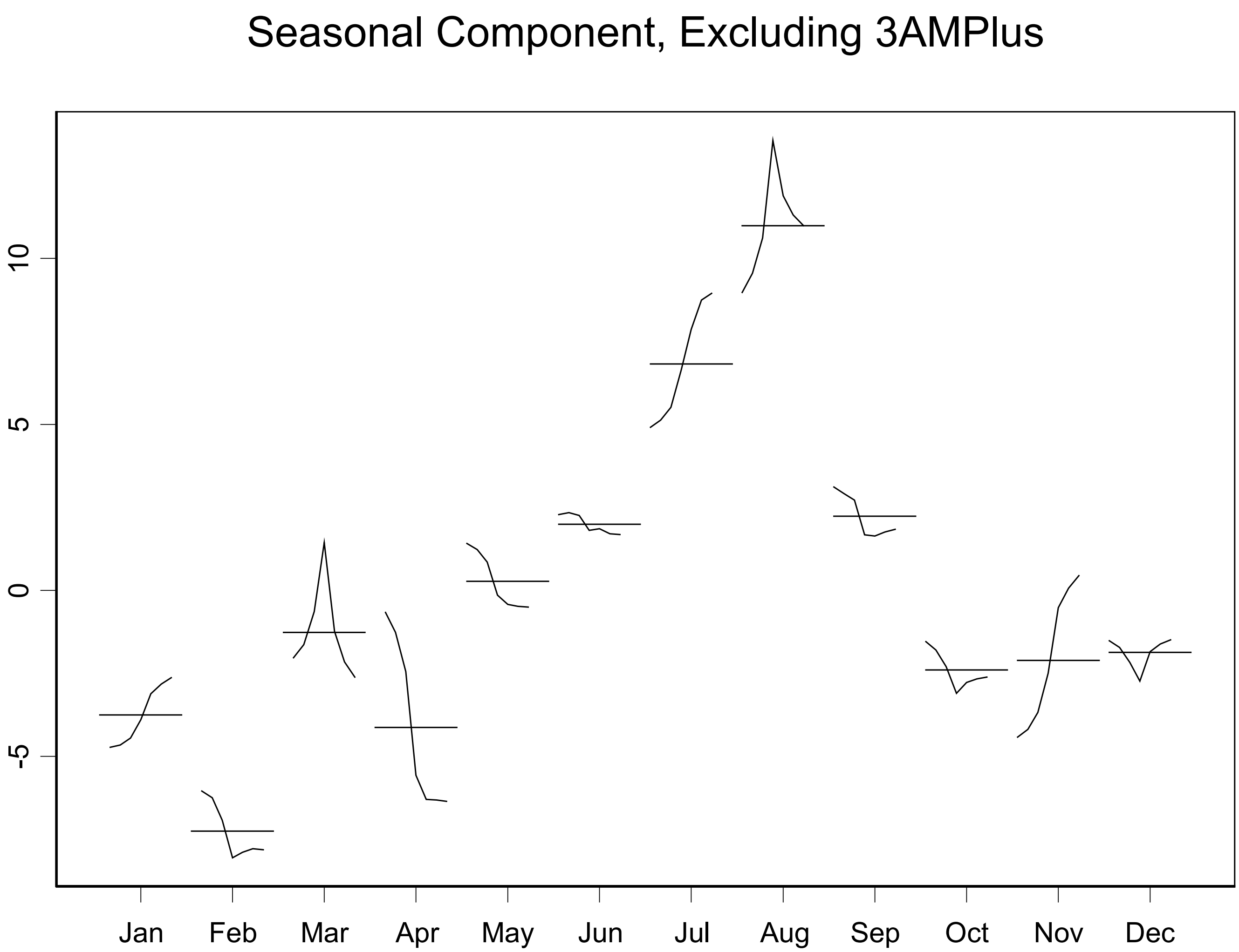


Figure 3c. Normal proablity plot of remainder component and normality tests suggest the normal approximation is adequate.

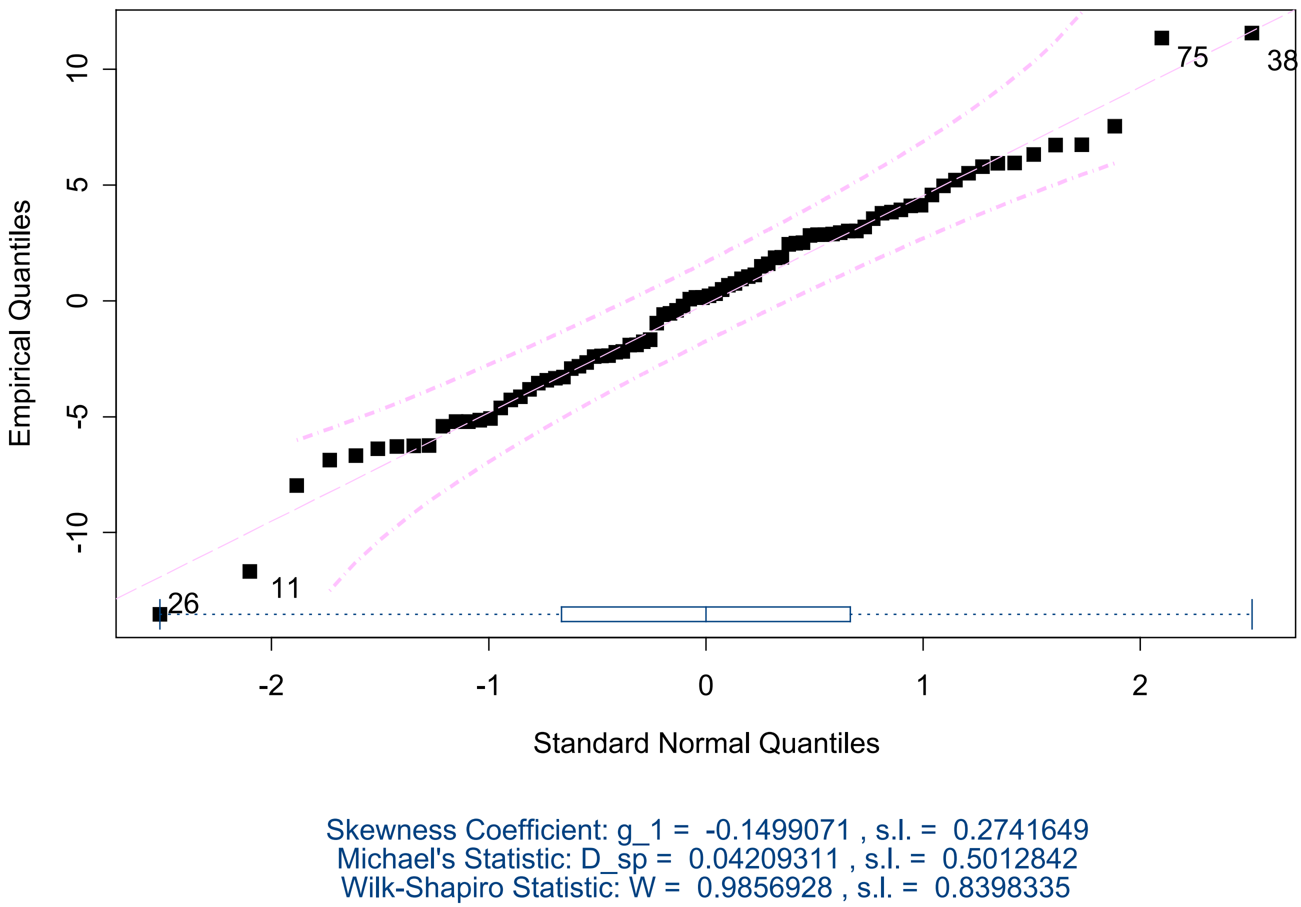
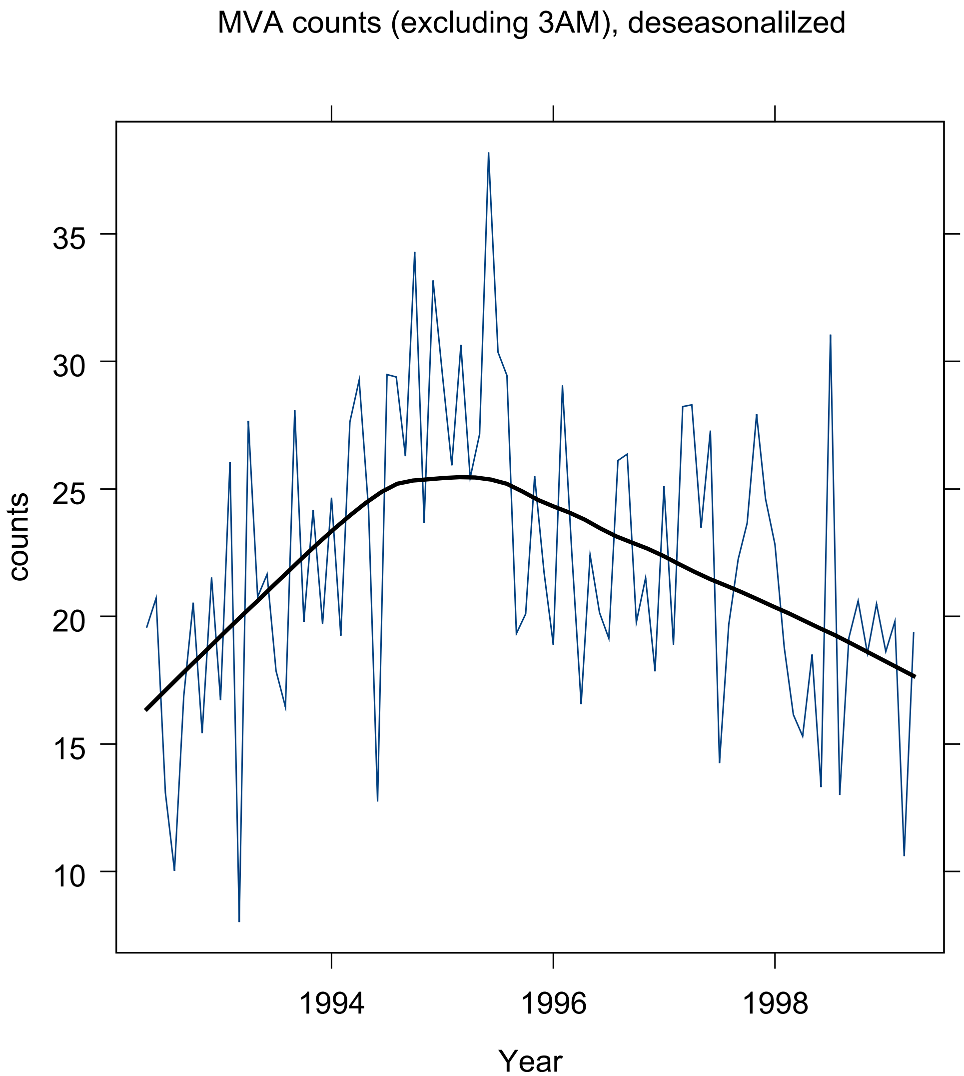


Figure 3d. Loess trend analysis of deseasonalized data and Mann-Kendall test.

tau = -0.0666, sl =36.92%



STL Decomposition, OTR `3AMPlus`

Figure 4a. A gradual increase until it levels off in 1996. Slight change in seasonal shape after 1996. Seasonal peak has decreased. R-sq = 80.3 %. There is a significant upward trend.

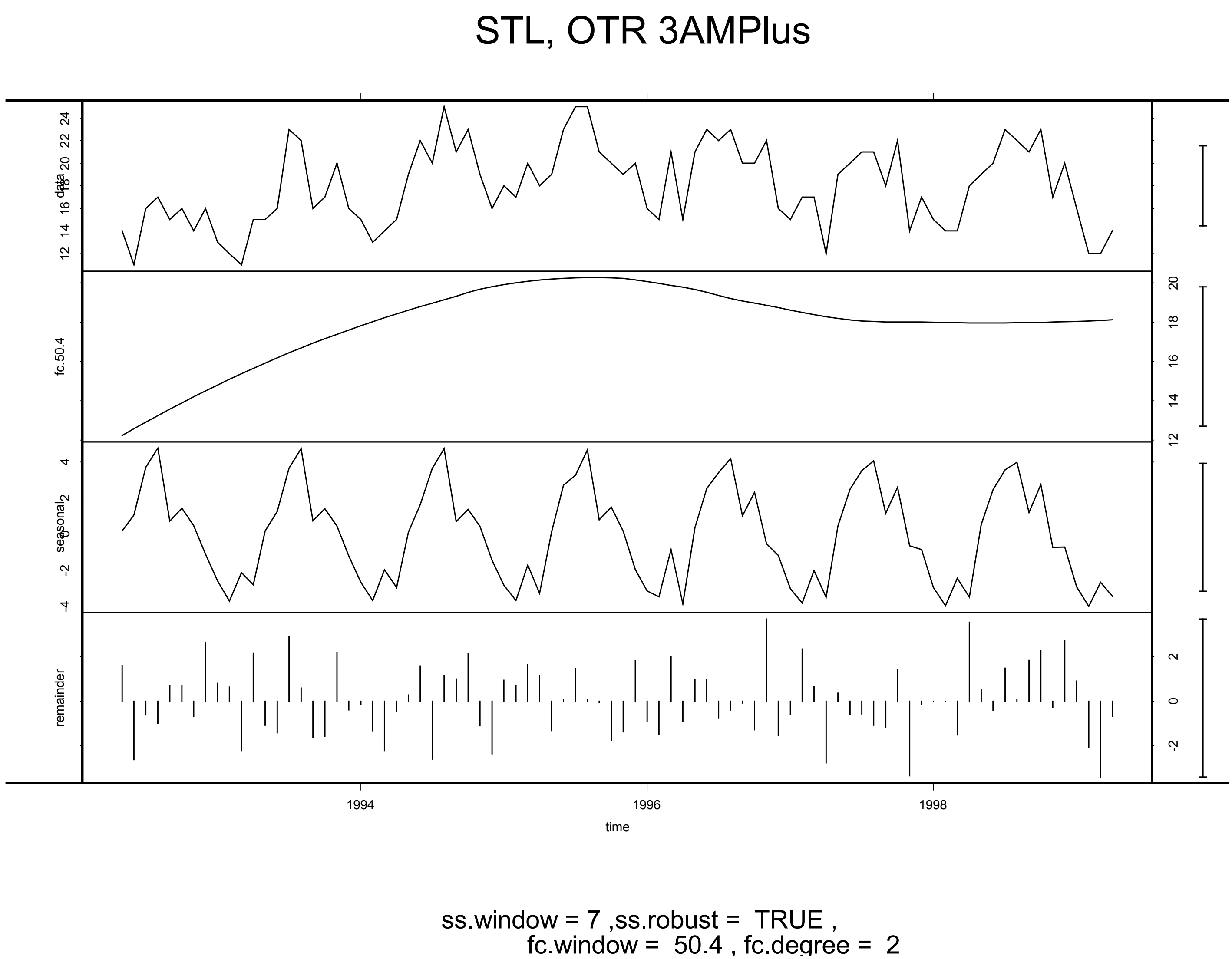


Figure 4b. Well defined peaks in Aug and Oct and minimum in Feb. The Oct peak has increased since 1996 and the Aug peak has decreased since 1996.

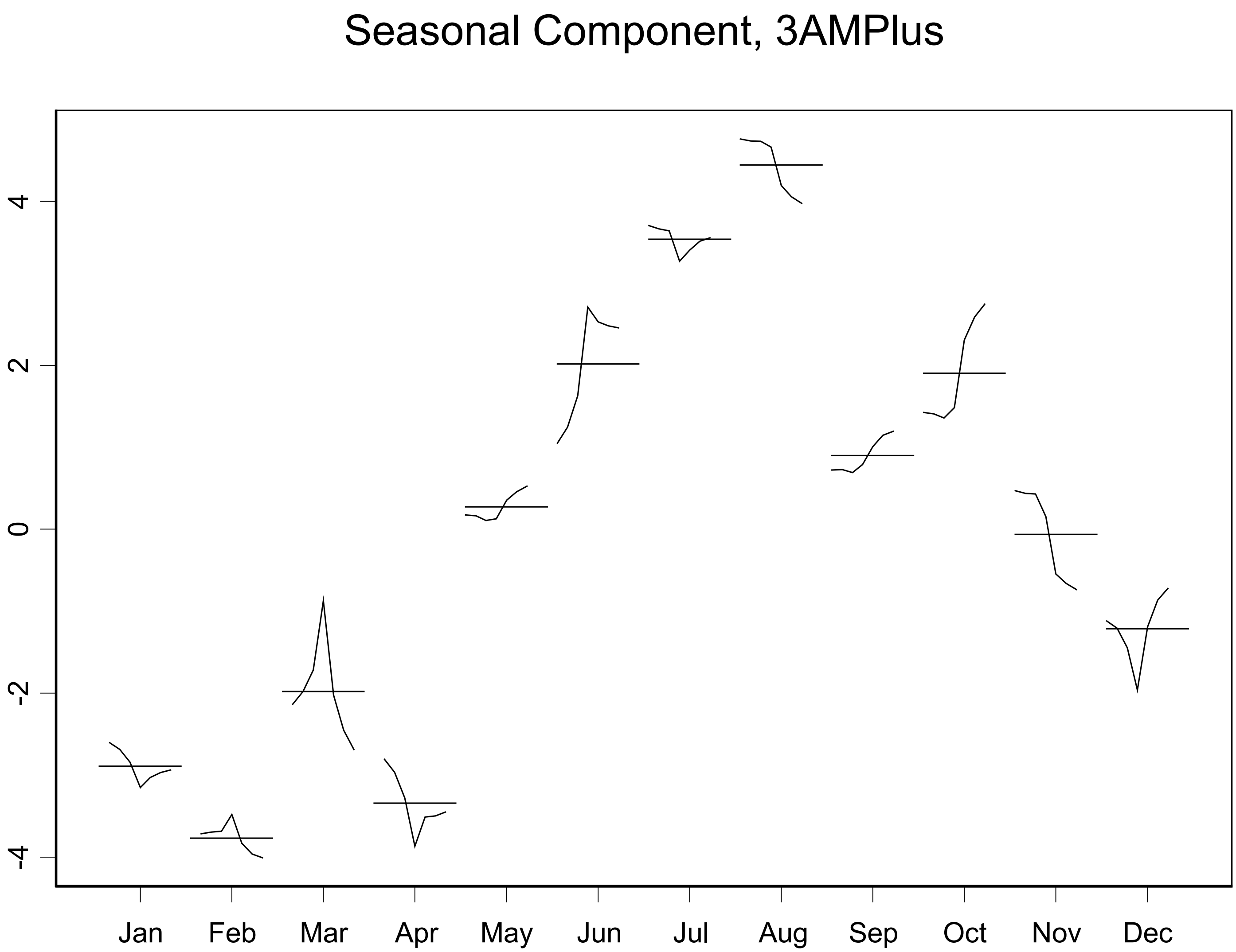


Figure 4c.
Normal probability plot – no outiers or non-normality evident.

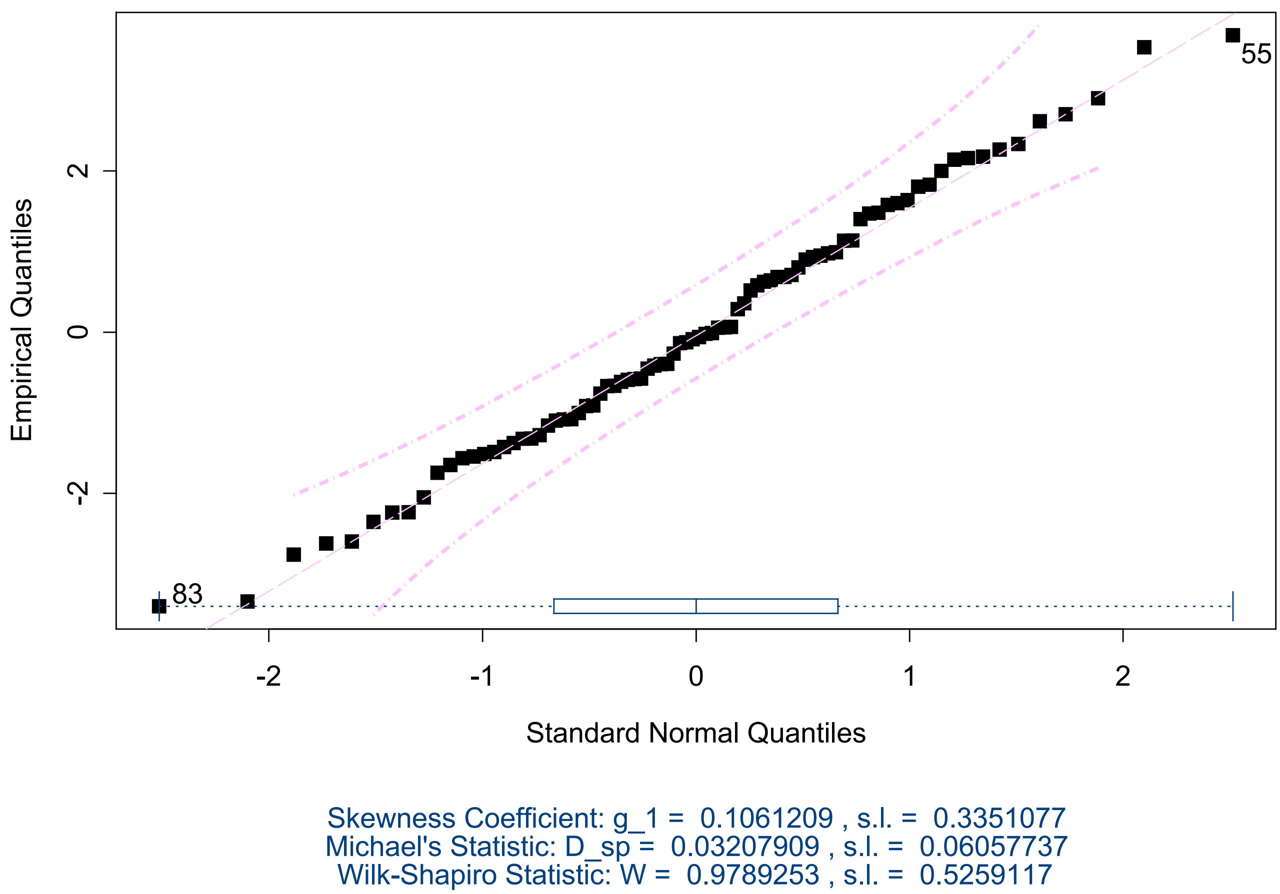
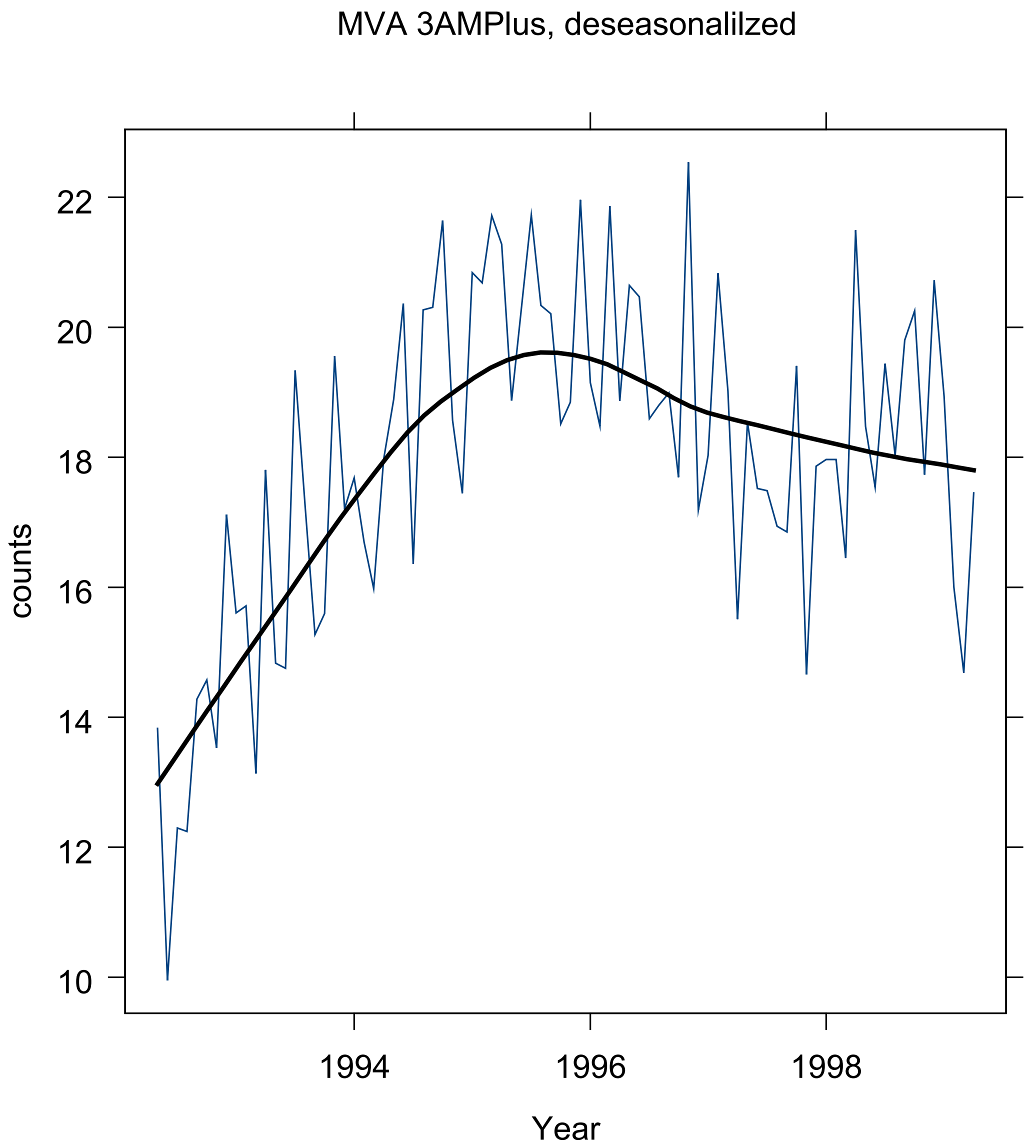


Figure 4d.
Trend analysis of deseasonalized series. Upward trend detected but it levels off.
`tau = 0.212,    sl =0.4091%`



G. LPS Dataset

Introduction

London Police Data set contains 8920 observations regarding with person being charged due to assault or impaired driving from May 1992 to May 1999. There are 3257 assault charges and 5663 impaired driving charges.

And only cases from 11:00pm to 4:00am are analyzed. The time of charge happened, such as hour, week, month and year, was also recorded.

Variables of interests in the data set

`persons`	person number (1 for first person, 2 for second, etc)
`counts`	number of charges
`type`	factor with 2 levels: "assault", "impaired"
`wkgrp`	ordered factor with 2 levels: "SunWed", "ThuSat"
`hour`	ordered factor with 5 levels: "11PM", "12AM", "1AM", "2AM", "3AM"
`year`	ordered factor with 8 levels: 1992 to 1999
`month`	ordered factor with 12 levels: January to December

The distribution of the number of person charged is shown in the table below.

```
> table(lps.df$persons,lps.df$type)
persons     assault impaired
1              3079     5654
2              138        9
3              35         0
4              4          0
5              1          0
```

The following table shows the 4 incidents where 4 persons were charged with assault.

```
> lps.df[ind1&ind2,]
     persons counts    type concord  wkgrp hour month day year charges
7517       4      1 assault    1420 SunWed 12AM   Feb Thu 1996       4
8093       4      2 assault    1430 ThuSat 12AM   Sep Sat 1998       8
8094       4      2 assault    1430 ThuSat 12AM   Sep Sat 1998       8
8102       4      1 assault    1420 SunWed  3AM   Sep Mon 1998       4
```

The response variable chosen to analyze was `counts`.

G. LPS Dataset: Assaults

Summary

The LPS assault data include sexual assault. There were 3257 assault cases in London from May of 1992 to May of 1999. Table 1. There was an extreme outlier in March 1999. To improve data visualization a log transformation has been used.

Crosstabs. Assaults are more frequent ThuSat (62%) than in SunWed (38%). Assaults from 1:00am to 2:00am count for most cases (24%) while 3:00am to 4:00am only 13%. Assaults are more frequent ThuSat (63%) than in SunWed (37%). In SunWed slot, there are 17% more assaults than expected in 11PM and 11% and 17% fewer than expected in the 2AM and 3AM slots respectively. As might be expected from the loess analysis, hour and year are related. See Figure 3b.

Figure 1a. and Figure 1b. Assaults decreased slighly to about mid-1994 and have remained flat since.

Figure 2. Since 1996 there has been a slight decline in SunWed and slight increase in ThuSat.

Figure 3b. Loess analysis by hour show there is an upward trend in 2AM and 3AM and a downward trend in 1AM and 12AM. Monotonic trend tests are significant for 2AM and 1AM. The trend at 1AM accelerates after 1996.

Figure 4b From Figure 4b we see that since 1996 there has been an upward shift at 2AM and 3AM and a downward trend at 1AM for both SunWed and ThuSat. For 11PM-SunWed the downward trend in progress before 1996 flattened out after 1996 while for 11PM-ThuSat this downward trend switched to an increase after 1996. For 12AM-SunWed there is a slight downward trend for post-1996 and an apparent shift downward for 12AM-ThuSat.

Figure 5a. STL: The logged data is used. The seasonal component is very unstable and increases in amplitude after 1996. R-sq = 52.5%

Figure 5b. The overall seasonal pattern is with a March maximum and with November minimum. Large trend upward in March and large downward in May. Smaller downward trends in October and November. July and August are relatively high and don't vary much.

Figure 5c. Tests for normality are fine. The two largest and smallest values in the normal probability plot are indicated -- see also Table 1.

Crosstabs Analysis

Hour and wkgrp are associated

Assaults are more frequent ThuSat (62%) than in SunWed (38%). Assaults from 1:00am to 2:00am count for most cases (24%) while 3:00am to 4:00am only 13%. Assaults are more frequent ThuSat (63%) than in SunWed (37%). In `SunWed` slot, there are 17% more assaults than expected in 11PM and 11% and 17% fewer than expected in the 2AM and 3AM slots respectively.

```
Call:
crosstabs(formula = counts ~ wkgrp + hour, data = lps.df, subset = lps.df$type ==
"assault",
       na.action = na.exclude)
3301 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |265    |321    |287    |231    |136    |1240   |
       |0.21   |0.26   |0.23   |0.19   |0.11   |0.38   |
       |0.44   |0.4    |0.37   |0.34   |0.31   |       |
       |0.08   |0.097  |0.087  |0.07   |0.041  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |340    |477    |486    |458    |300    |2061   |
       |0.16   |0.23   |0.24   |0.22   |0.15   |0.62   |
       |0.56   |0.6    |0.63   |0.66   |0.69   |       |
       |0.1    |0.14   |0.15   |0.14   |0.091  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|605    |798    |773    |689    |436    |3301   |
       |0.18   |0.24   |0.23   |0.21   |0.13   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 24.84403 d.f.= 4 (p=0.00005407599)
       Yates' correction not used
> get.crosstabs.percenterror(counts~wkgrp+hour)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]   17    7   -1  -11  -17
[2,]  -10   -4    1    6   10
> contrib(counts~wkgrp+hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  2.50  1.23 -0.20 -1.73 -2.17
[2,] -1.94 -0.95  0.15  1.34  1.68
```

Hour and Year are associated

As might be expected from the loess analysis, hour and year are related. See Figure 3b.

```
> crosstabs(counts~hour+year, data=lps.df, na.action=na.exclude, subset=lps.df$type=="assault")
Call:
crosstabs(formula = counts ~ hour + year, data = lps.df, subset = lps.df$type == "assault",
    na.action = na.exclude)
3301 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   | 66    | 83    | 80    | 70    |106    | 64    |102    | 34    |605    |
       |0.11   |0.14   |0.13   |0.12   |0.18   |0.11   |0.17   |0.056  |0.18   |
       |0.2    |0.17   |0.19   |0.16   |0.22   |0.15   |0.22   |0.15   |       |
       |0.02   |0.025  |0.024  |0.021  |0.032  |0.019  |0.031  |0.01   |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   | 62    |112    |109    |119    |131    | 90    | 98    | 77    |798    |
       |0.078  |0.14   |0.14   |0.15   |0.16   |0.11   |0.12   |0.096  |0.24   |
       |0.19   |0.23   |0.26   |0.27   |0.27   |0.21   |0.21   |0.35   |       |
       |0.019  |0.034  |0.033  |0.036  |0.04   |0.027  |0.03   |0.023  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |103    |138    | 95    |114    |109    | 95    | 88    | 31    |773    |
       |0.13   |0.18   |0.12   |0.15   |0.14   |0.12   |0.11   |0.04   |0.23   |
       |0.31   |0.28   |0.23   |0.26   |0.22   |0.22   |0.19   |0.14   |       |
       |0.031  |0.042  |0.029  |0.035  |0.033  |0.029  |0.027  |0.0094 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    | 56    | 91    | 79    | 97    | 95    |116    |112    | 43    |689    |
       |0.081  |0.13   |0.11   |0.14   |0.14   |0.17   |0.16   |0.062  |0.21   |
       |0.17   |0.18   |0.19   |0.22   |0.19   |0.27   |0.24   |0.19   |       |
       |0.017  |0.028  |0.024  |0.029  |0.029  |0.035  |0.034  |0.013  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    | 48    | 69    | 57    | 44    | 47    | 61    | 73    | 37    |436    |
       |0.11   |0.16   |0.13   |0.1    |0.11   |0.14   |0.17   |0.085  |0.13   |
       |0.14   |0.14   |0.14   |0.099  |0.096  |0.14   |0.15   |0.17   |       |
       |0.015  |0.021  |0.017  |0.013  |0.014  |0.018  |0.022  |0.011  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|335    |493    |420    |444    |488    |426    |473    |222    |3301   |
       |0.1    |0.15   |0.13   |0.13   |0.15   |0.13   |0.14   |0.067  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 90.20904 d.f.= 28 (p=1.838906e-008)
    Yates' correction not used
> get.crosstabs.percenterror(counts~hour+year)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]    7   -8    4  -14   19  -18   18  -16
[2,]  -23   -6    7   11   11  -13  -14   43
[3,]   31   20   -3   10   -5   -5  -21  -40
[4,]  -20  -12  -10    5   -7   30   13   -7
[5,]    8    6    3  -25  -27    8   17   26
> contrib(counts~hour+year)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,]  0.59 -0.77  0.34 -1.26  1.75 -1.59  1.64 -1.05
[2,] -2.11 -0.66  0.74  1.13  1.20 -1.28 -1.53  3.18
[3,]  2.77  2.10 -0.34  0.98 -0.49 -0.48 -2.16 -2.91
[4,] -1.67 -1.17 -0.93  0.45 -0.68  2.87  1.34 -0.49
[5,]  0.56  0.48  0.20 -1.91 -2.17  0.63  1.33  1.42
```

LPS Assault Data

There is a mild decrease from 1992 to mid-1994 and then leveling off. There is an exception outlier occurring in March of 1999. The two largest and smallest values in the normal probablity plot of the remainder component in the STL analysis of the logged series are shown in bold -- see Figure 5c.

Table 1.

```
> assault.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  57  38  44  45  38  42  39  32
1993:  49  32  32  34  34  55  42  49  49  44  30  43
1994:  32  29  35  32  40  33  51  31  36  35  34  32
1995:  28  31  37  35  56  33  45  52  28  29  28  42
1996:  37  51  63  30  28  44  34  40  43  43  31  44
1997:  31  22  48  40  27  44  50  47  21  30  30  36
1998:  32  35  45  46  36  47  43  46  39  33  32  39
1999:  45  35  76  33  33
> SeasonalMannKendall(assault.ts)
tau = 0.0195,   sl =83.07%
```

March 1999

Investigating why March 1999 had 76 assault charges, we found that there were numerous cases of large numbers of assaults occuring on ThuSat-12AM slot. There were a total of 74 records corresponding to March 1999 in the original database and 50 of these records correspond to `ThuSat.` The distribution is summarized below:

counts	1	2	6	9
# records	44	2	2	2

Because ThuSat-12AM-March 1999 is such a large outlier, all crosstabs involving these categories are highly significant at much less than 1%.

Figure 1.

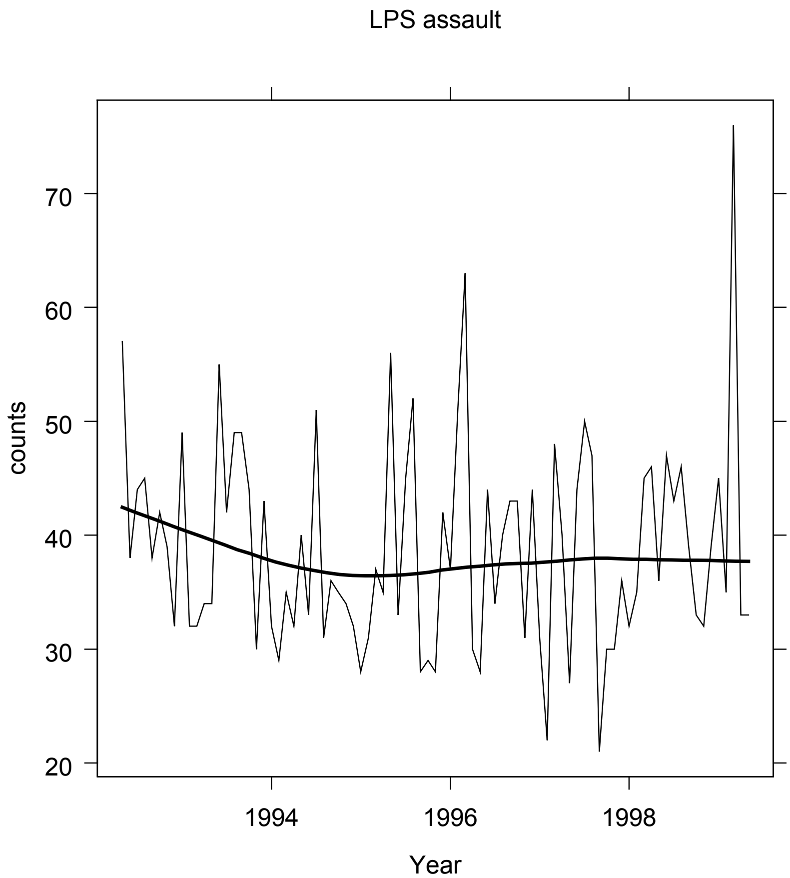


Figure 1b. Logged series

The outlier in March 1999 has the effect of squishing the data into a smaller area on the graph. Graphical resolution is improved by using a log transformation. Specifically a log to the base 2 transformation. This particular version of the log transformation means that we can interpret a one unit change as a doubling.

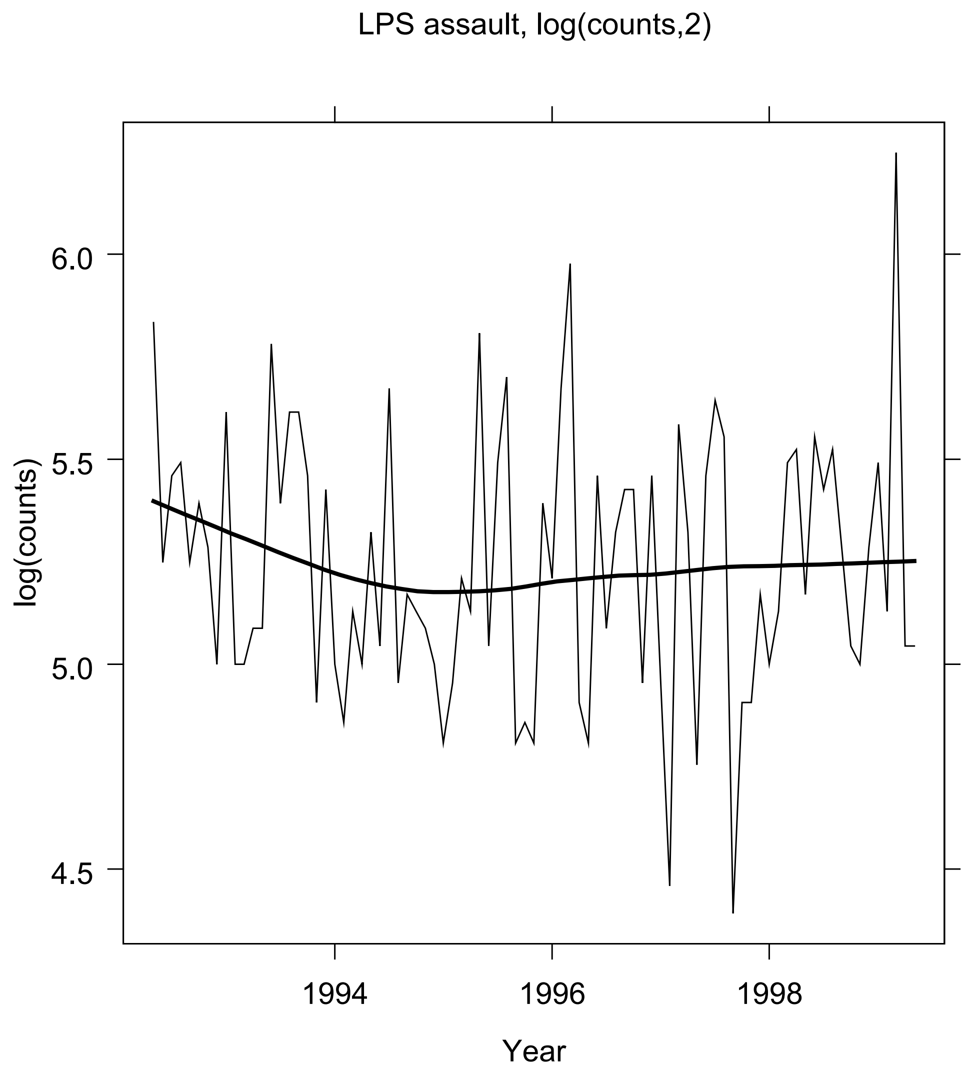


Figure 2. By wkgrp.

There is a very small downward trend in SunWed group.

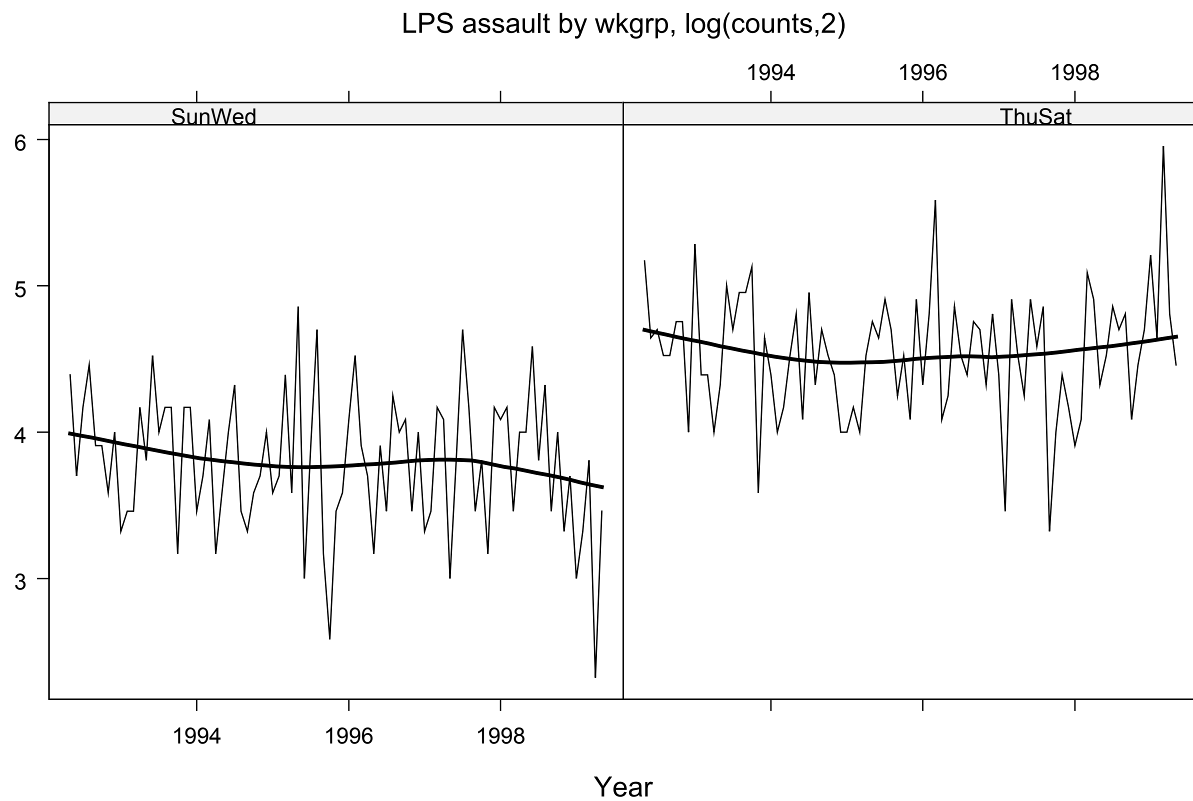


Table 2.

```
> assault.SunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  21  13  18  22  15  15  12  16
1993:  10  11  11  18  14  23  16  18  18   9  18  18
1994:  11  13  17   9  12  16  20  11  10  12  13  16
1995:  12  13  21  12  29   8  15  26   9   6  11  12
1996:  17  23  15  13   9  15  11  19  16  17  11  16
1997:  10  11  18  17   8  14  26  18  11  14   9  18
1998:  17  18  11  16  16  24  14  20  11  16  10  13
1999:   8  10  14   5  11
> SeasonalMannKendall(assault.SunWed.ts)
tau = -0.131,   sl =15.57%

> assault.ThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  36  25  26  23  23  27  27  16
1993:  39  21  21  16  20  32  26  31  31  35  12  25
1994:  21  16  18  23  28  17  31  20  26  23  21  16
1995:  16  18  16  23  27  25  30  26  19  23  17  30
1996:  20  28  48  17  19  29  23  21  27  26  20  28
1997:  21  11  30  23  19  30  24  29  10  16  21  18
1998:  15  17  34  30  20  23  29  26  28  17  22  26
1999:  37  25  62  28  22
> SeasonalMannKendall(assault.ThuSat.ts)
tau = 0.0277,   sl =76.33%
```

Figure 3a. By hour. Common Scaling

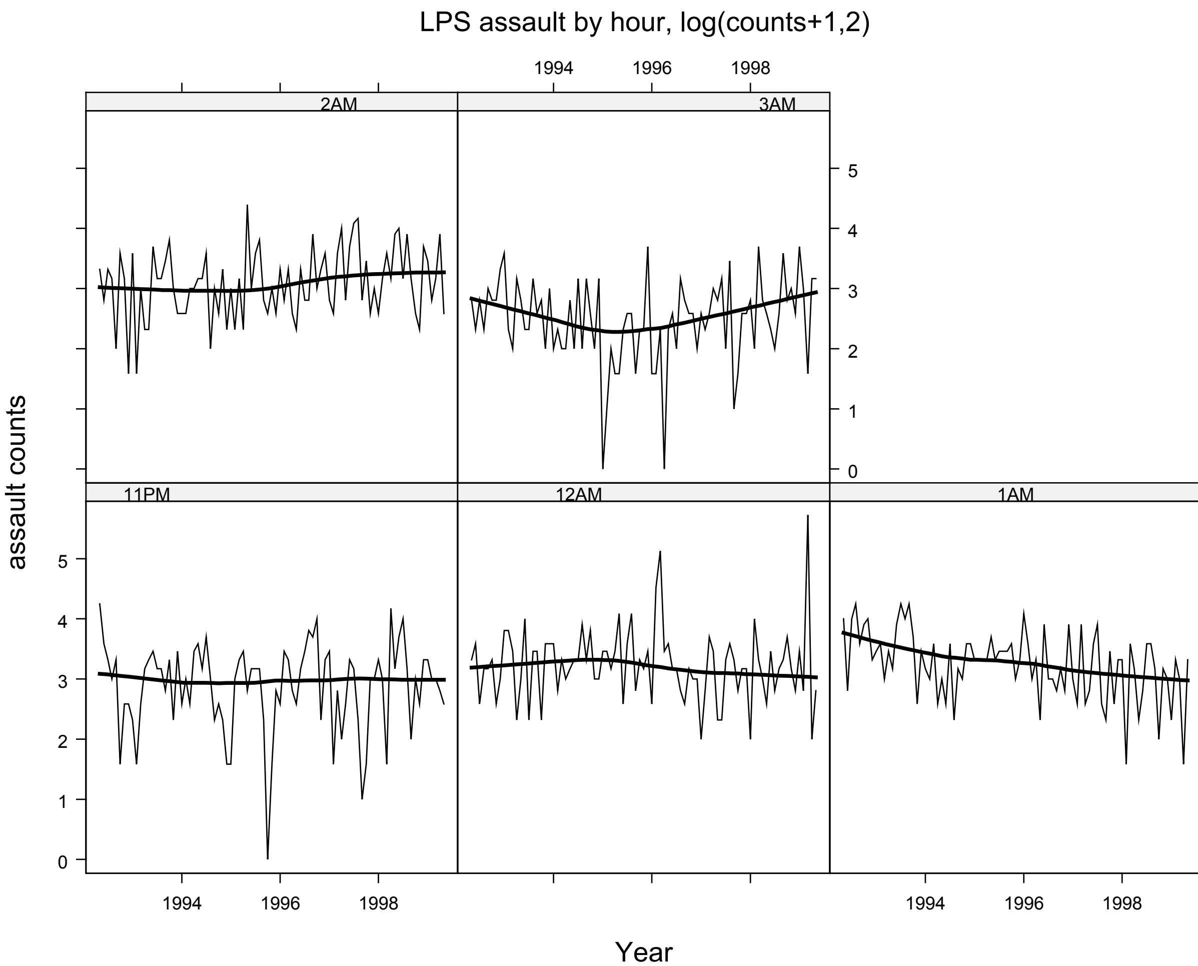
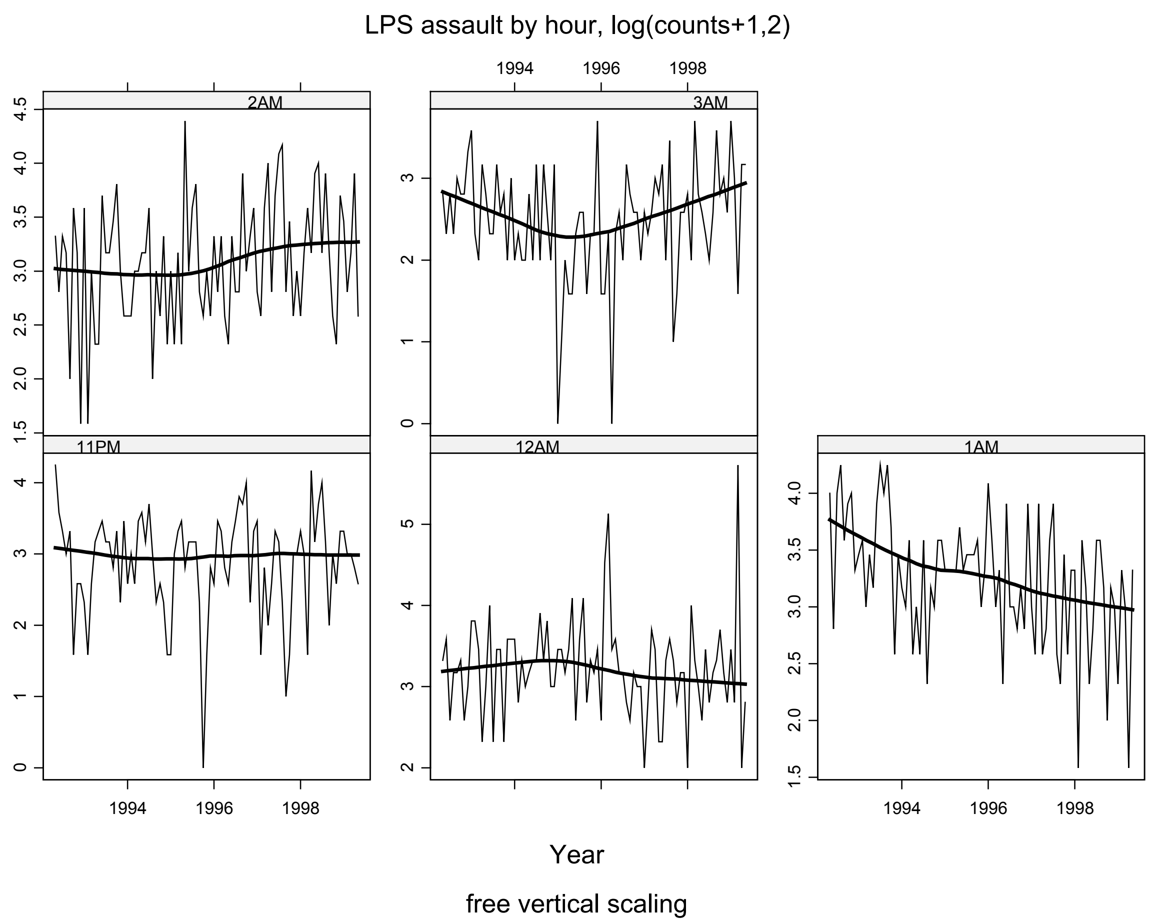


Figure 3b. By hour. Independent vertical scaling.

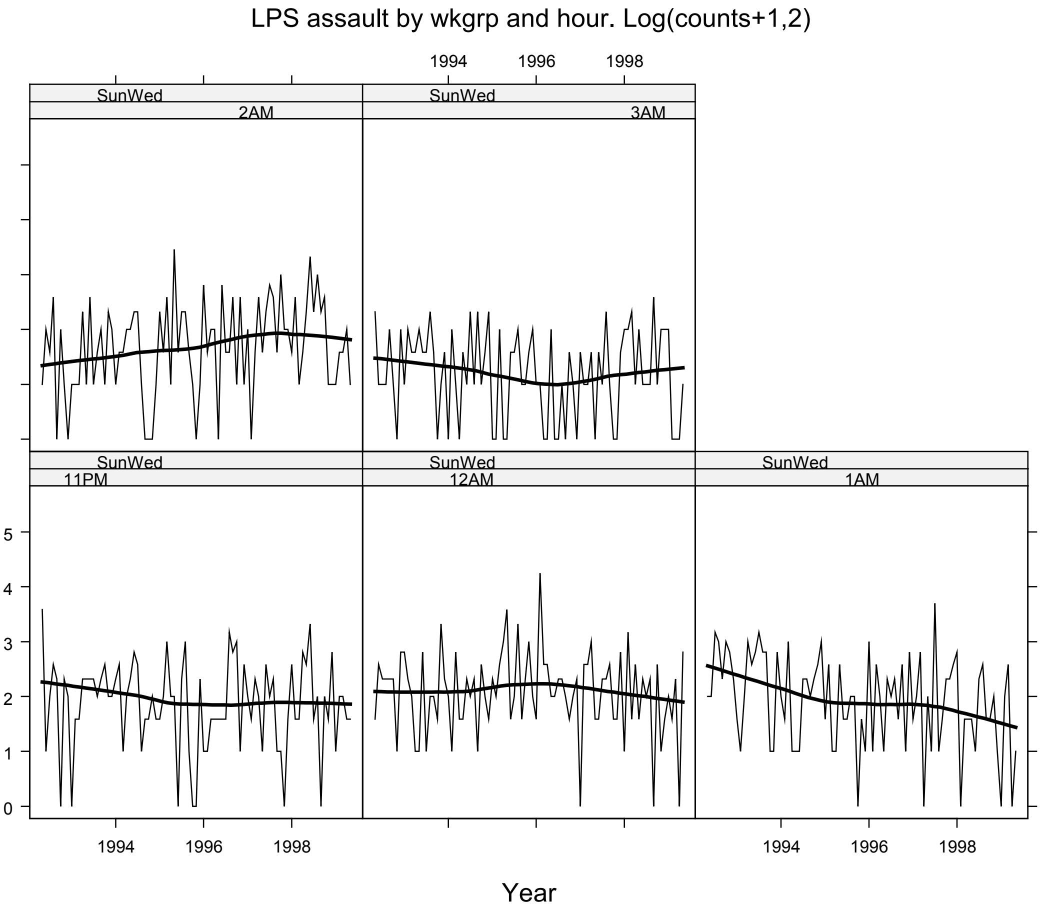
Loess analysis by hour show there is an upward trend in 2AM and 3AM and a downward trend in 1AM and 12AM. Monotonic trend tests are significant for 2AM and 1AM. The trend at 1AM accelerates after 1996.



Tabulation and Mann-Kendall Tests

```
> assault.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  18  11   9   7   9   2   5   5
1993:   4   2   5   8   9  10   8   8   6   9   4  10
1994:   5   7   5  10  11   8  12   7   4   5   4   2
1995:   2   7   9  10   6   8   8   8   4   0   2   6
1996:   5  10   9   6   5   8  10  13  12  15   4   9
1997:  10   2   6   3   5   9   8   4   1   2   7   7
1998:   9   7   2  17   8  12  15   8   3   7   5   9
1999:   9   7   7   6   5
> SeasonalMannKendall(assault.11PM.ts)
tau = 0.0166,   sl =86%
> assault.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   9  11   5   8   8   9   5   7
1993:  13  13  10   4   7  15   4  10  10   4  11  11
1994:  11   6   9   7   8   9   9  14   9  13   7   7
1995:  10  10   8  10  16   5  11  16   6   9   8  10
1996:   5  22  34  10  11   8   8   6   5   8   7   7
1997:   3   6  12  10   4   4   9  11   9   6   8   8
1998:   3  15   9   7   5  10   6   8   9  12   8   6
1999:  10   6  52   3   6
> SeasonalMannKendall(assault.12AM.ts)
tau = -0.105,   sl =25.72%
> assault.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  15   6  15  18  11  14  15   9
1993:  10  11   7  10   8  14  18  15  18  12   5  10
1994:   8   7  11   5   7   5  11   4   8   7  11  11
1995:   9   9   9   9  12   9  10  10  10  11   7   9
1996:  16  11   7   9   4  14   7   7   6   8   6  14
1997:   7   5  14   5   6  11  14   5   4  10   5   9
1998:   9   2  11   8   4   6  11  11   8   3   8   7
1999:   4   9   7   2   9
> SeasonalMannKendall(assault.1AM.ts)
tau = -0.34,   sl =0.02337%
> assault.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   9   6   9   8   3  11   8   2
1993:  11   2   7   4   4  12   8   8  10  13   7   5
1994:   5   5   7   7   8   8  11   3   7   5   9   4
1995:   7   4   8   4  20   7  11  13   6   5   7   5
1996:   9   6   9   5   4   9   6   6  14   7   9  11
1997:   6   5  11  15   6  12  16  17   6  10   5   7
1998:   5   8  11   8  14  15   8  14   8   5   4  12
1999:  10   6   8  14   5
> SeasonalMannKendall(assault.2AM.ts)
tau = 0.241,   sl =0.9375%
> assault.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   6   4   6   4   7   6   6   9
1993:  11   4   3   8   6   4   4   8   5   6   3   7
1994:   3   4   3   3   6   3   8   3   8   5   3   8
1995:   0   1   3   2   2   4   5   5   2   4   4  12
1996:   2   2   4   0   4   5   3   8   6   5   5   3
1997:   5   4   5   7   6   8   3  10   1   2   5   5
1998:   6   3  12   6   5   4   3   5  11   6   7   5
1999:  12   7   2   8   8
> SeasonalMannKendall(assault.3AM.ts)
tau = 0.0659,   sl =48.04%
```

Figure 4a. By hour and wkgrp. Common Scaling.



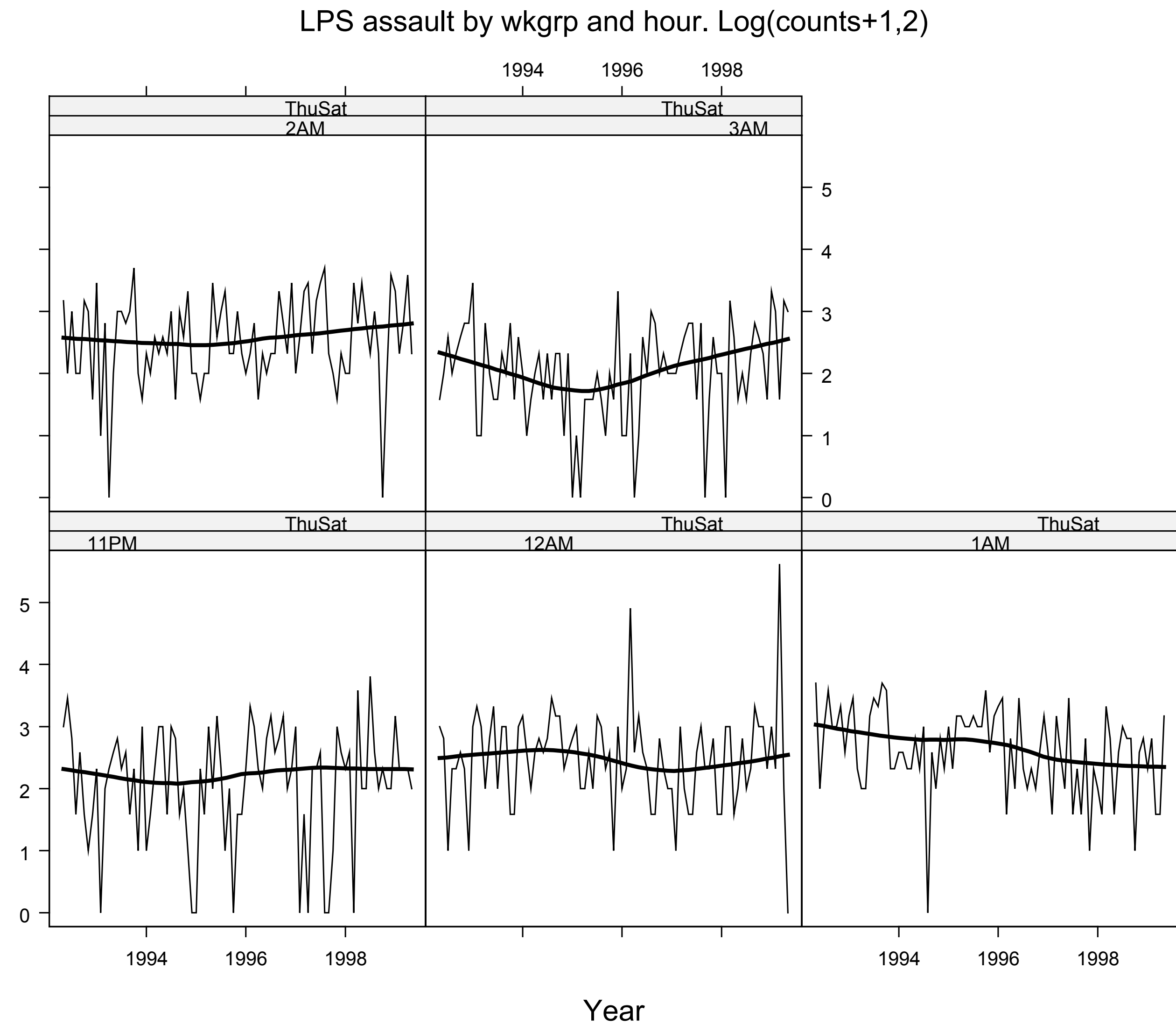
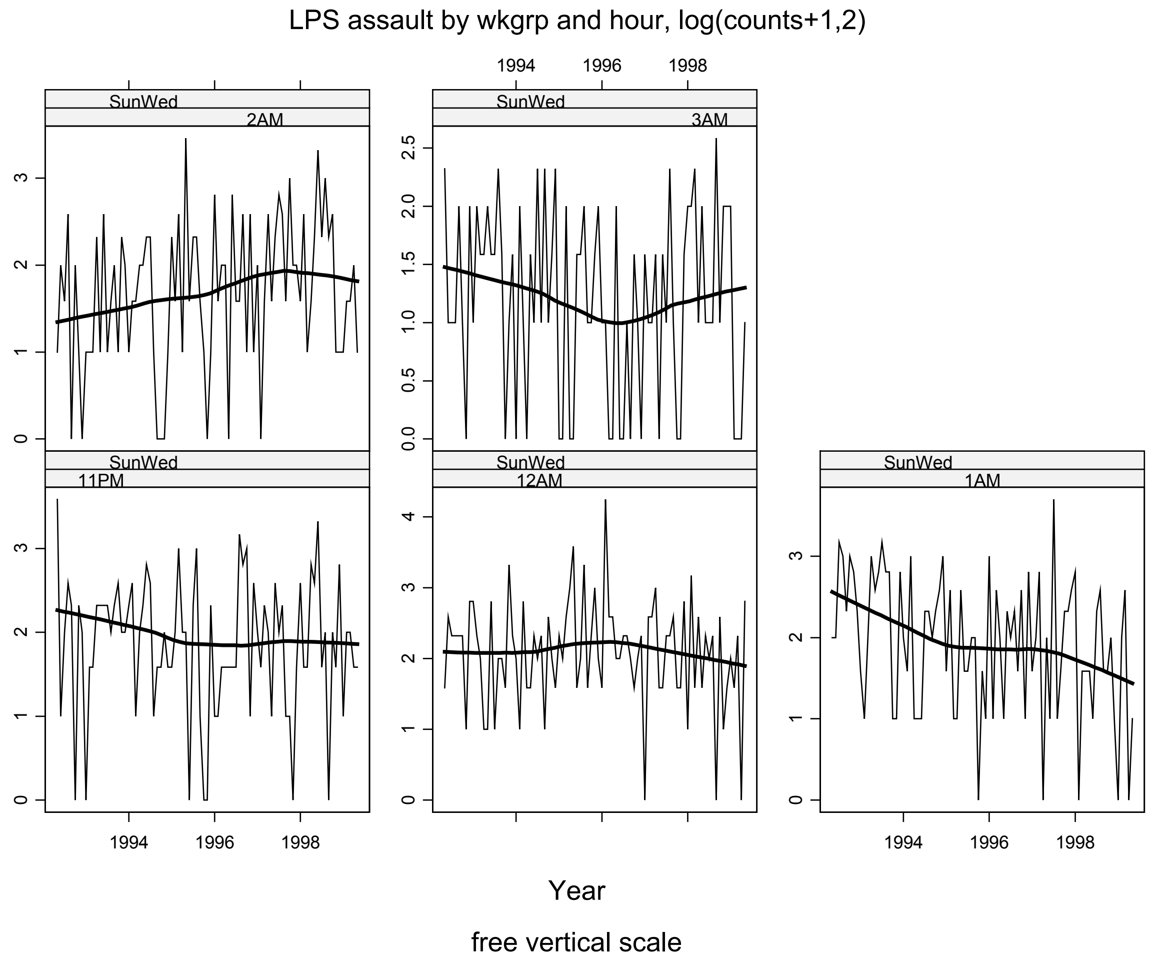
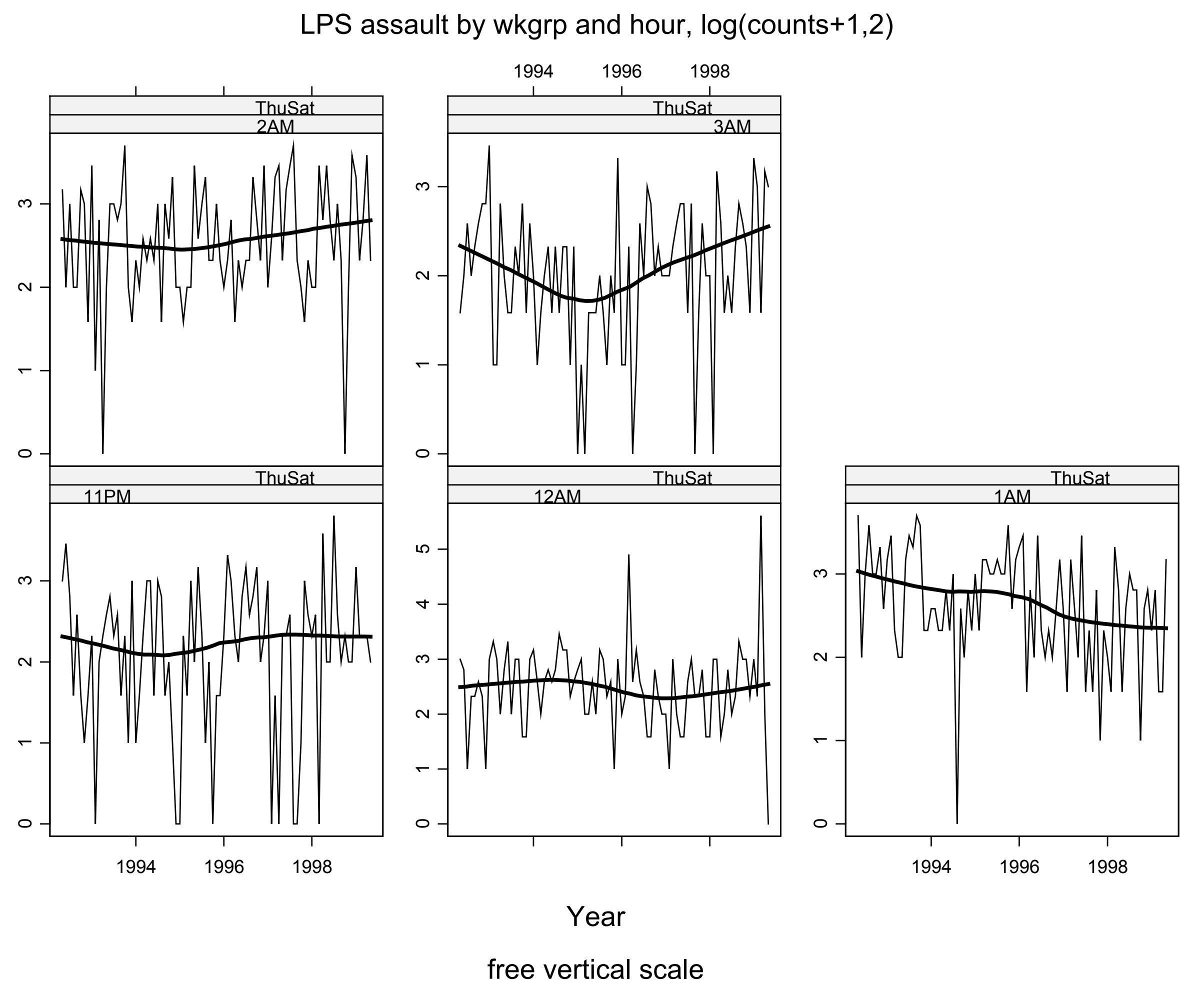

LPS assault by wkgrp and hour. Log(counts+1,2)
ThuSat
2AM
ThuSat
3AM
ThuSat
11PM
ThuSat
12AM
ThuSat
1AM
1994
1996
1998
0
1
2
3
4
5
Year

Figure 4b. By hour and wkgrp. Independent Scaling.

From Figure 4b we see that since 1996 there has been an upward shift at 2AM and 3AM and a downward trend at 1AM for both SunWed and ThuSat. For 11PM-SunWed the downward trend in progress before 1996 flattened out after 1996 while for 11PM-ThuSat this downward trend switched to an increase after 1996. For 12AM-SunWed there is a slight downward trend for post-1996 and an apparent shift downward for 12AM-ThuSat.




LPS assault by wkgrp and hour, log(counts+1,2)
ThuSat
2AM
3AM
11PM
12AM
1AM
1994
1996
1998
Year
free vertical scale

Tabulations and Seasonal Mann-Kendall Tests

```
> assault.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  11   1   3   5   4   0   4   3
1993:   0   2   2   4   4   4   4   3   4   5   3   3
1994:   4   5   1   3   4   6   5   1   2   2   3   2
1995:   2   3   7   3   3   0   4   7   1   0   0   4
1996:   1   1   2   2   2   2   2   8   6   7   1   5
1997:   3   2   4   3   1   5   3   4   1   1   0   2
1998:   5   2   2   6   5   9   2   3   0   3   2   6
1999:   1   3   3   2   2
> SeasonalMannKendall(assault.11PMSunWed.ts)
tau = -0.0894,   sl =33.74%
> assault.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   5   4   4   4   4   1   6
1993:   6   4   3   1   1   6   1   3   3   2   9   4
1994:   3   1   6   2   2   4   3   4   1   5   3   2
1995:   4   3   5   7  11   2   3   9   2   4   7   3
1996:   2  18   5   5   3   3   4   4   3   2   3   4
1997:   0   5   5   7   2   2   4   4   5   2   2   6
1998:   1   8   2   5   2   4   3   4   0   5   1   2
1999:   3   2   4   0   6
> SeasonalMannKendall(assault.12AMSunWed.ts)
tau = -0.0929,   sl =32.52%
> assault.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   3   3   8   7   4   7   6   4
1993:   2   1   3   7   5   6   8   6   6   1   1   6
1994:   3   2   7   1   1   1   4   4   3   4   5   7
1995:   2   5   1   1   5   2   2   3   3   0   2   1
1996:   7   1   5   3   1   4   3   4   2   5   1   6
1997:   2   3   6   0   3   1  12   1   2   4   4   5
1998:   6   0   2   2   2   1   4   5   2   2   3   1
1999:   0   3   5   0   1
> SeasonalMannKendall(assault.1AMSunWed.ts)
tau = -0.278,   sl =0.2954%
> assault.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   3   2   5   0   3   1   0
1993:   1   1   1   4   1   5   1   2   3   1   4   3
1994:   1   2   2   3   3   4   4   1   0   0   0   1
1995:   4   2   5   1  10   2   4   4   2   1   0   1
1996:   6   2   3   3   0   6   2   2   5   1   5   1
1997:   3   0   2   5   2   4   6   5   2   7   3   3
1998:   2   5   1   2   4   9   4   7   4   5   1   1
1999:   1   2   2   3   1
> SeasonalMannKendall(assault.2AMSunWed.ts)
tau = 0.206,   sl =2.901%
> assault.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   1   1   1   3   1   0   3
1993:   1   3   2   2   3   2   2   4   2   0   1   2
1994:   0   3   1   0   2   1   4   1   4   1   2   4
1995:   0   0   3   0   0   2   2   3   1   1   2   3
1996:   1   1   0   0   3   0   0   1   0   2   1   0
1997:   2   1   1   2   0   2   1   4   1   0   0   2
1998:   3   3   4   1   3   1   1   1   5   1   3   3
1999:   3   0   0   0   1
> SeasonalMannKendall(assault.3AMSunWed.ts)
tau = -0.0434,   sl =65.08%
```

```
assault.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   7  10   6   2   5   2   1   2
1993:   4   0   3   4   5   6   4   5   2   4   1   7
1994:   1   2   4   7   7   2   7   6   2   3   1   0
1995:   0   4   2   7   3   8   4   1   3   0   2   2
1996:   4   9   7   4   3   6   8   5   6   8   3   4
1997:   7   0   2   0   4   4   5   0   0   1   7   5
1998:   4   5   0  11   3   3  13   5   3   4   3   3
1999:   8   4   4   4   3
> SeasonalMannKendall(assault.11PMThuSat.ts)
tau = 0.0577,   sl =53.79%
> assault.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   7   6   1   4   4   5   4   1
1993:   7   9   7   3   6   9   3   7   7   2   2   7
1994:   8   5   3   5   6   5   6  10   8   8   4   5
1995:   6   7   3   3   5   3   8   7   4   5   1   7
1996:   3   4  29   5   8   5   4   2   2   6   4   3
1997:   3   1   7   3   2   2   5   7   4   4   6   2
1998:   2   7   7   2   3   6   3   4   9   7   7   4
1999:   7   4  48   3   0
> SeasonalMannKendall(assault.12AMThuSat.ts)
tau = -0.0989,   sl =29.1%
> assault.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  12   3   7  11   7   7   9   5
1993:   8  10   4   3   3   8  10   9  12  11   4   4
1994:   5   5   4   4   6   4   7   0   5   3   6   4
1995:   7   4   8   8   7   7   8   7   7  11   5   8
1996:   9  10   2   6   3  10   4   3   4   3   5   8
1997:   5   2   8   5   3  10   2   4   2   6   1   4
1998:   3   2   9   6   2   5   7   6   6   1   5   6
1999:   4   6   2   2   8
> SeasonalMannKendall(assault.1AMThuSat.ts)
tau = -0.215,   sl =2.088%
> assault.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   8   3   7   3   3   8   7   2
1993:  10   1   6   0   3   7   7   6   7  12   3   2
1994:   4   3   5   4   5   4   7   2   7   5   9   3
1995:   3   2   3   3  10   5   7   9   4   4   7   4
1996:   3   4   6   2   4   3   4   4   9   6   4  10
1997:   3   5   9  10   4   8  10  12   4   3   2   4
1998:   3   3  10   6  10   6   4   7   4   0   3  11
1999:   9   4   6  11   4
> SeasonalMannKendall(assault.2AMThuSat.ts)
tau = 0.132,   sl =15.84%
> assault.3AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   3   5   3   4   5   6   6
1993:  10   1   1   6   3   2   2   4   3   6   2   5
1994:   3   1   2   3   4   2   4   2   4   4   1   4
1995:   0   1   0   2   2   2   3   2   1   3   2   9
1996:   1   1   4   0   1   5   3   7   6   3   4   3
1997:   3   3   4   5   6   6   2   6   0   2   5   3
1998:   3   0   8   5   2   3   2   4   6   5   4   2
1999:   9   7   2   8   7
> SeasonalMannKendall(assault.3AMThuSat.ts)
tau = 0.0371,   sl =69.19%
```

Figure 5a. STL Analysis

The seasonal component is very unstable and increases in amplitude after 1996.

R-sq = 52.5%

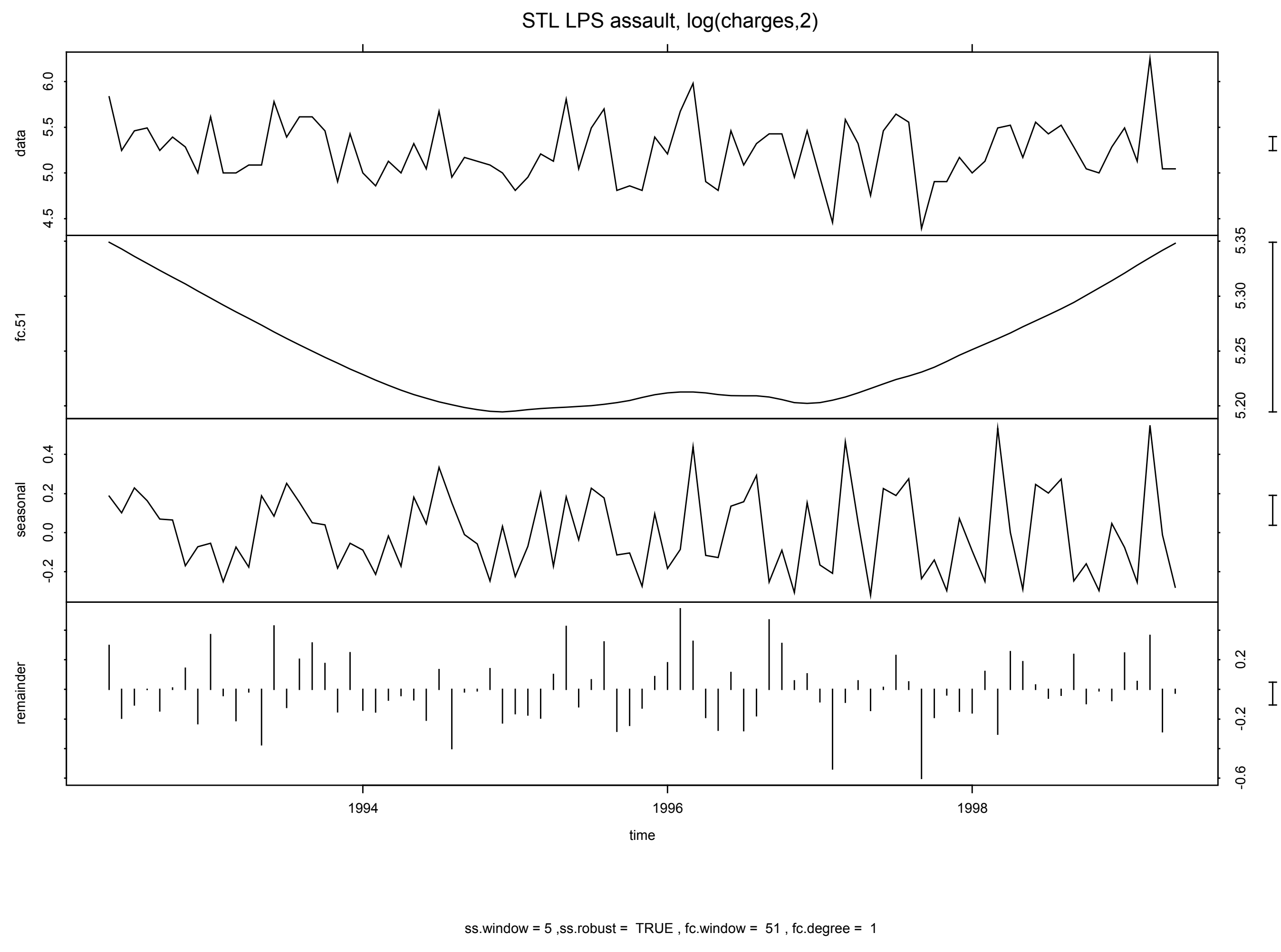


Figure 5b. Monthplot of Seasonal Component

The overall seasonal pattern is with a March maximum and with November minimum. Large trend upward in March and large downward in May. Smaller downward trends in October and November. July and August are relatively high and don't vary as much.

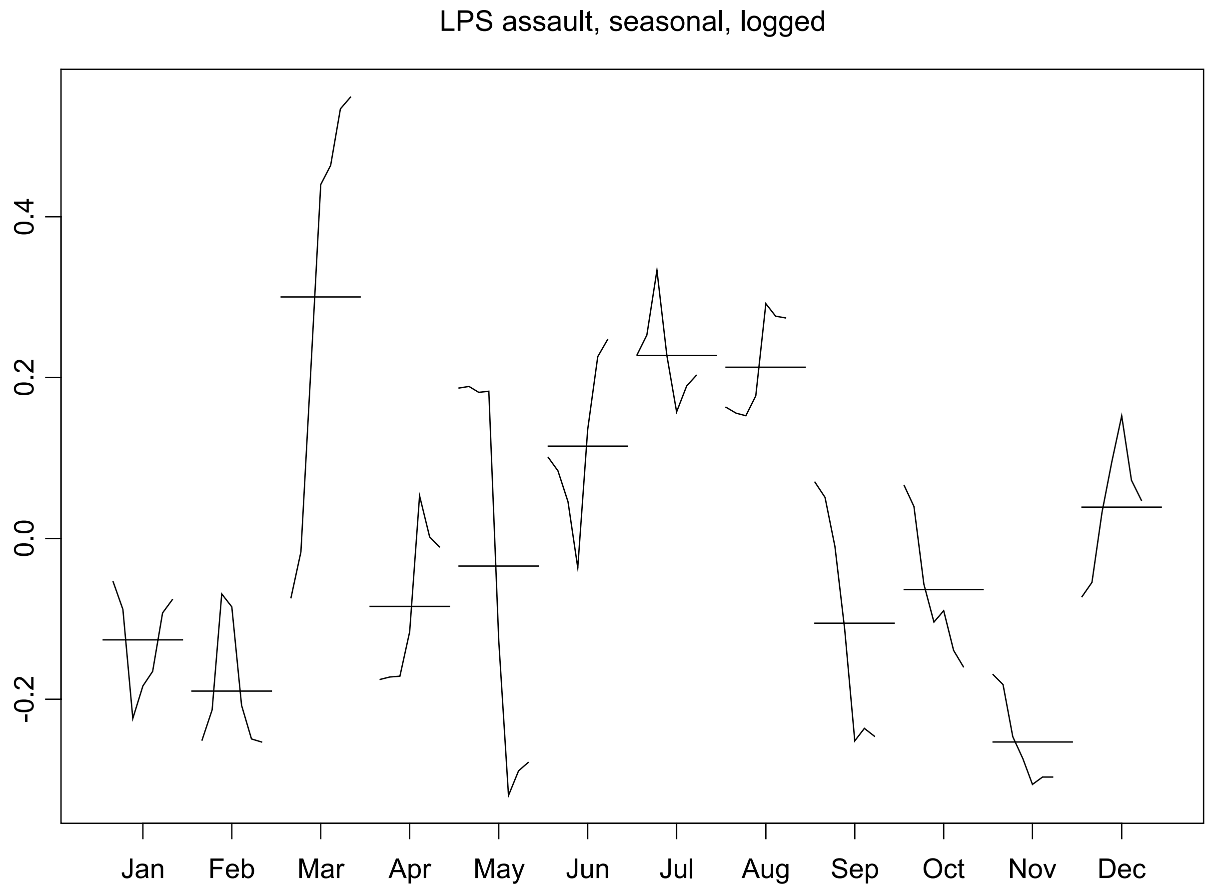
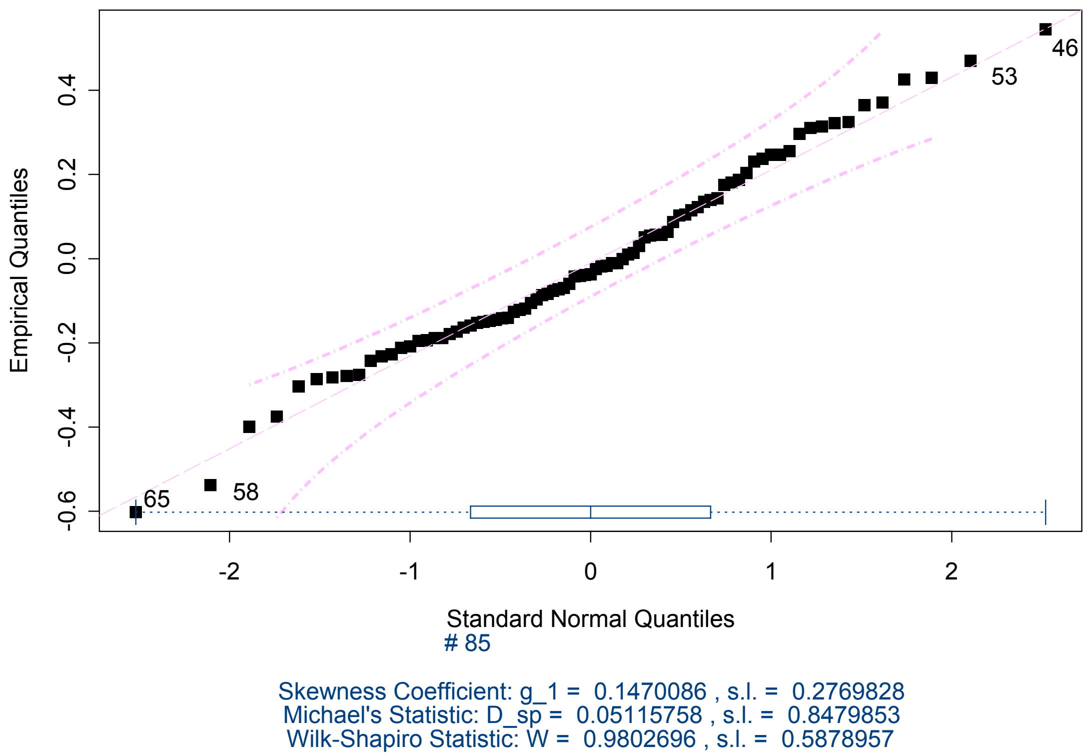


Figure 5c. Normal Probability Plot
Several outliers are noted

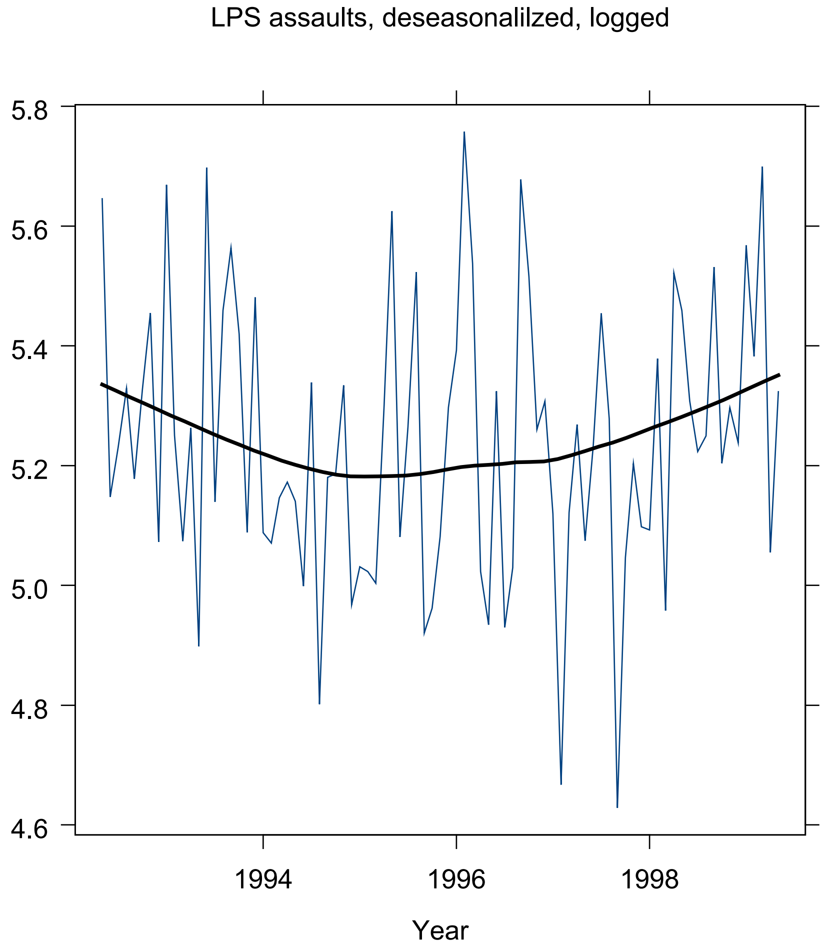


> counter.ts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:					1	2	3	4	5	6	7	8
1993:	9	10	11	12	13	14	15	16	17	18	19	20
1994:	21	22	23	24	25	26	27	28	29	30	31	32
1995:	33	34	35	36	37	38	39	40	41	42	43	44
1996:	45	**46**	47	48	49	50	51	52	**53**	54	55	56
1997:	57	**58**	59	60	61	62	63	64	**65**	66	67	68
1998:	69	70	71	72	73	74	75	76	77	78	79	80
1999:	81	82	83	84	85							

See Table 1.

Figure 5d.
Loess analysis of deseasonalized series
`Mann-Kendall test: tau = 0.0213,   sl =77.59%`



G. LPS Dataset: Impaired

Summary

There were 5663 impaired driving charges in London from May of 1992 to May of 1999. Table 1.

Crosstabs. The ThuSat slot accounts for 65% of the impaired charges. About 33% of charges were in the 1AM slot and only 9.6% in the 3AM

HOUR-WKGP: There is a 9% excess of charges in the 3AM-SunWed group but overall hour-wkgrp are not associated (not statistically significant at 10%).

HOUR-YEAR: As would be expected from our loess analysis in Figure 3b and Figure 3c there has been a swing to later hours post 1996.

Figure 1a. and Figure 1b. Impaired driving charges are declining linearly on a log-scale. The rate of decline is about 13% per year. Because the log transformation simplifies the change to an almost linear decrease, all the data were logged for the remainder of the analysis.

Figure 2. Both SunWed and ThuSat exhibit a nearly linear downward slope on log scale. The downward slope for ThuSat is slightly greater. The table below shows the slope of the linear least squares fit to each group.

Wkgrp	Slope of fit to log(data,2)	Annual rate of decrease %
SunWed	-0.173	11%
ThuSat	-0.229	15%

.

Figure 3a. For the hour window only 12AM looks linear on a log scale. The curves are all different. It is interesting that 3AM actually increases after 1996 and the rate of decline for 2AM is much slower than at other hours.

Figure 3b. When the scale is free, we see that the 1AM has had a much faster rate of decline since 1996 than that of the data as whole (Figure 1b).

Figure 4b From Figure 4b we see that the SunWed-3AM has had the biggest increase since 1996 For both SunWed and ThuSat there is a shift from early evening to late evening post 1996. This is seen not only in the case of SunWed-3AM where an actual increase has occurred but also in the much smaller slope or rate of decline in the 2AM-SunWed, 2AM-ThuSat and 3AM-ThuSat than indicated for the overall series in Figure 1b. It is intended to model this further using intervention analysis.

Figure 5a. There is a linear downward trend on the log scale. The seasonal component has lots of local maxima and minima.
R-sq = 81.6%

Figure 5b. Local maximum in February, May and October and local minimum in December, April and July. But the seasonal component is variable and shows a lot of changes over time. There is an increasing trend for December, January, May and August.

Figure 5c. The normality tests indicate no significant departure from normality in the remainder component.

Figure 5d. Loess analysis of deseasonalized series. The thicker line shows the linear least-squares fit and the thinner line shows the loess curve. The least-squares line has a slope of 0.200 almost the same as in Figure 1b. A slight lack of fit of the linear least-squares line is evident at the beginning and end of the series. The residuals from the least-squares line are approximately normally distributed with no evident outliers. However further diagnostic checks indicate that the variablility about the line increases with Year.

Crosstabs Analysis

Hour and wkgrp are not associated

The ThuSat slot accounts for 65% of the impaired charges. About 33% of charges were in the 1AM slot and only 9.6% in the 3AM.

There is a 9% excess of charges in the 3AM-SunWed group but overall hour-wkgrp are not associated (not statistically significant at 10%).

```
> crosstabs(charges~wkgrp+hour, data=lps.df, subset=lps.df$type=="impaired",
na.action=na.omit)
Call:
crosstabs(formula = charges ~ wkgrp + hour, data = lps.df, subset = lps.df$type ==
       "impaired", na.action = na.omit)
5674 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed | 271   | 397   | 620   | 478   | 206   |1972   |
       |0.14   |0.2    |0.31   |0.24   |0.1    |0.35   |
       |0.35   |0.34   |0.33   |0.36   |0.38   |       |
       |0.048  |0.07   |0.11   |0.084  |0.036  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat | 510   | 769   |1251   | 832   | 340   |3702   |
       |0.14   |0.21   |0.34   |0.22   |0.092  |0.65   |
       |0.65   |0.66   |0.67   |0.64   |0.62   |       |
       |0.09   |0.14   |0.22   |0.15   |0.06   |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|781    |1166   |1871   |1310   |546    |5674   |
       |0.14   |0.21   |0.33   |0.23   |0.096  |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 6.282868 d.f.= 4 (p=0.178996)
       Yates' correction not used

> get.crosstabs.percenterror(charges~wkgrp+hour)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]    0   -2   -5    5    9
[2,]    0    1    2   -3   -5
> contrib(charges~wkgrp+hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,] -0.03 -0.41 -1.19  1.06  1.18
[2,]  0.02  0.30  0.87 -0.78 -0.86
```

Hour and Year are associated: As would be expected from our loess analysis in Figure 3b and Figure 3c there has been a swing to later hours post 1996.

```
> crosstabs(charges~hour+year, data=lps.df, subset=lps.df$type=="impaired", na.action=na.omit)
Call:
crosstabs(formula = charges ~ hour + year, data = lps.df, subset = lps.df$type ==
    "impaired", na.action = na.omit)
5674 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |119    |131    |151    | 86    |103    | 75    | 82    | 34    |781    |
       |0.15   |0.17   |0.19   |0.11   |0.13   |0.096  |0.1    |0.044  |0.14   |
       |0.14   |0.13   |0.16   |0.12   |0.13   |0.12   |0.16   |0.15   |       |
       |0.021  |0.023  |0.027  |0.015  |0.018  |0.013  |0.014  |0.006  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   |181    |249    |174    |144    |166    |112    |101    | 39    |1166   |
       |0.16   |0.21   |0.15   |0.12   |0.14   |0.096  |0.087  |0.033  |0.21   |
       |0.21   |0.24   |0.19   |0.2    |0.21   |0.18   |0.2    |0.17   |       |
       |0.032  |0.044  |0.031  |0.025  |0.029  |0.02   |0.018  |0.0069 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |328    |366    |346    |282    |230    |154    |127    | 38    |1871   |
       |0.18   |0.2    |0.18   |0.15   |0.12   |0.082  |0.068  |0.02   |0.33   |
       |0.38   |0.36   |0.37   |0.38   |0.3    |0.25   |0.25   |0.17   |       |
       |0.058  |0.065  |0.061  |0.05   |0.041  |0.027  |0.022  |0.0067 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |191    |200    |174    |166    |194    |187    |128    | 70    |1310   |
       |0.15   |0.15   |0.13   |0.13   |0.15   |0.14   |0.098  |0.053  |0.23   |
       |0.22   |0.2    |0.19   |0.23   |0.25   |0.31   |0.25   |0.31   |       |
       |0.034  |0.035  |0.031  |0.029  |0.034  |0.033  |0.023  |0.012  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    | 51    | 77    | 82    | 57    | 80    | 82    | 74    | 43    |546    |
       |0.093  |0.14   |0.15   |0.1    |0.15   |0.15   |0.14   |0.079  |0.096  |
       |0.059  |0.075  |0.088  |0.078  |0.1    |0.13   |0.14   |0.19   |       |
       |0.009  |0.014  |0.014  |0.01   |0.014  |0.014  |0.013  |0.0076 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|870    |1023   |927    |735    |773    |610    |512    |224    |5674   |
       |0.15   |0.18   |0.16   |0.13   |0.14   |0.11   |0.09   |0.039  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 185.3234 d.f.= 28 (p=0)
    Yates' correction not used
> get.crosstabs.percenterror(charges~hour+year)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]   -1   -7   18  -15   -3  -11   16   10
[2,]    1   18   -9   -5    5  -11   -4  -15
[3,]   14    8   13   16  -10  -23  -25  -49
[4,]   -5  -15  -19   -2    9   33    8   35
[5,]  -39  -22   -8  -19    8   40   50   99
> contrib(charges~hour+year)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,] -0.07 -0.83  2.07 -1.51 -0.33 -0.98  1.37  0.57
[2,]  0.17  2.67 -1.20 -0.57  0.57 -1.19 -0.41 -1.04
[3,]  2.43  1.56  2.31  2.55 -1.56 -3.32 -3.22 -4.17
[4,] -0.70 -2.35 -2.74 -0.28  1.16  3.89  0.90  2.54
[5,] -3.58 -2.16 -0.76 -1.63  0.65  3.04  3.52  4.62
```

LPS IMPAIRED Data

There is a mild decrease from 1992 to mid-1994 and then leveling off. Possible outliers detected in logged series, [Figure 5c](#), are in bold font below – although they are not significant at 10% on the normality tests for skewness, Michael's test and the Wilk-Shapiro test.

Table 1.

```
> imp.ts
```

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:					107	118	128	121	107	138	81	70
1993:	90	81	95	85	88	77	75	86	78	105	82	81
1994:	83	93	88	73	79	99	73	58	74	83	71	53
1995:	**42**	70	64	71	69	66	65	42	65	59	74	48
1996:	62	57	76	57	82	58	48	63	64	84	86	36
1997:	43	67	63	46	51	45	43	72	56	48	36	40
1998:	60	41	37	**26**	51	45	46	36	39	50	30	51
1999:	49	46	28	**54**	47							

```
> SeasonalMannKendall(imp.ts)
tau = -0.725,   sl =1.776e-13%
```

.

Figure 1.

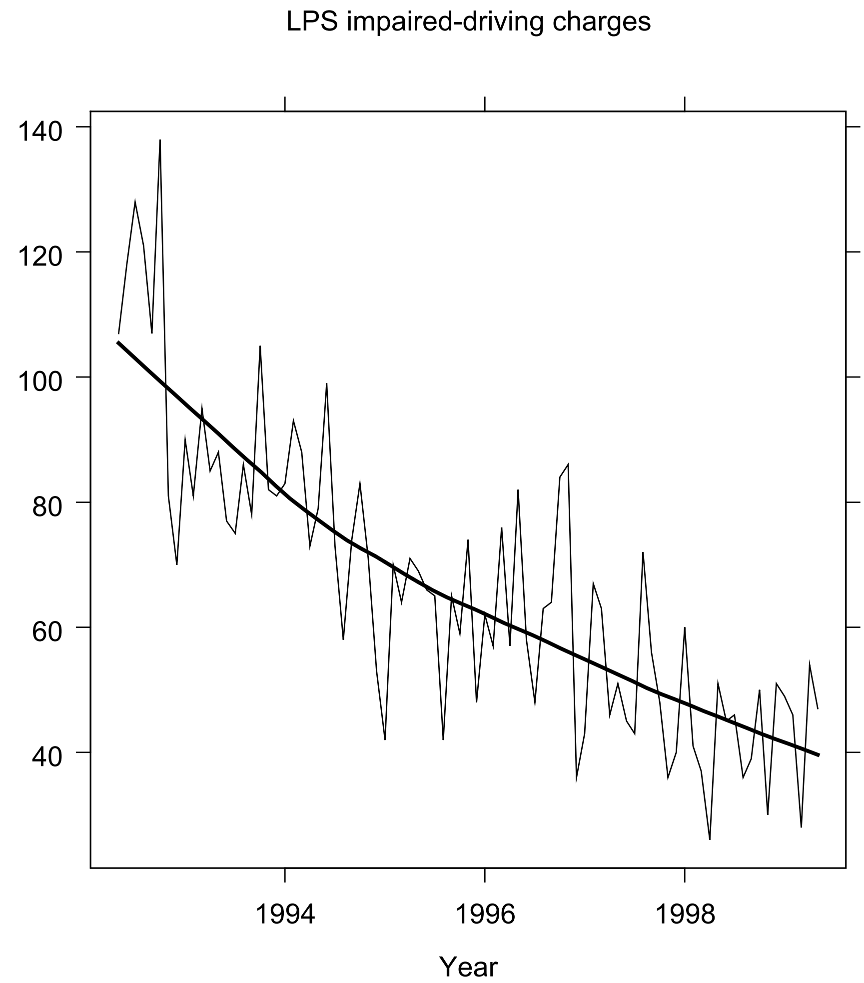

LPS impaired-driving charges
140
120
100
80
60
40
1994
1996
1998
Year

Figure 1b. Logged series

Figure 1b shows the time series after a log transformation. Specifically a log to the base 2 transformation. This particular version of the log transformation means that we can interpret a one unit change as a doubling and an increase by 0.5 units on the vertical scale corresponds to an increase of about 41% in the original data.

The transformation reveals that the decline in impaired charges is almost linear. Figure 1b shows a thicker line that corresponds to the least squares linear fit. The loess curve is the thinner line which stops at the last observed data value. There is a slight lack of fit of the least-squares line at the very beginning and very end of the series. The slope of the least-squares line is about `-0.202` which implies that impaired charges have been declining at the rate of about 13% per year over 1992 to 1999.
Note: $2^{-0.202} \approx 0.869$

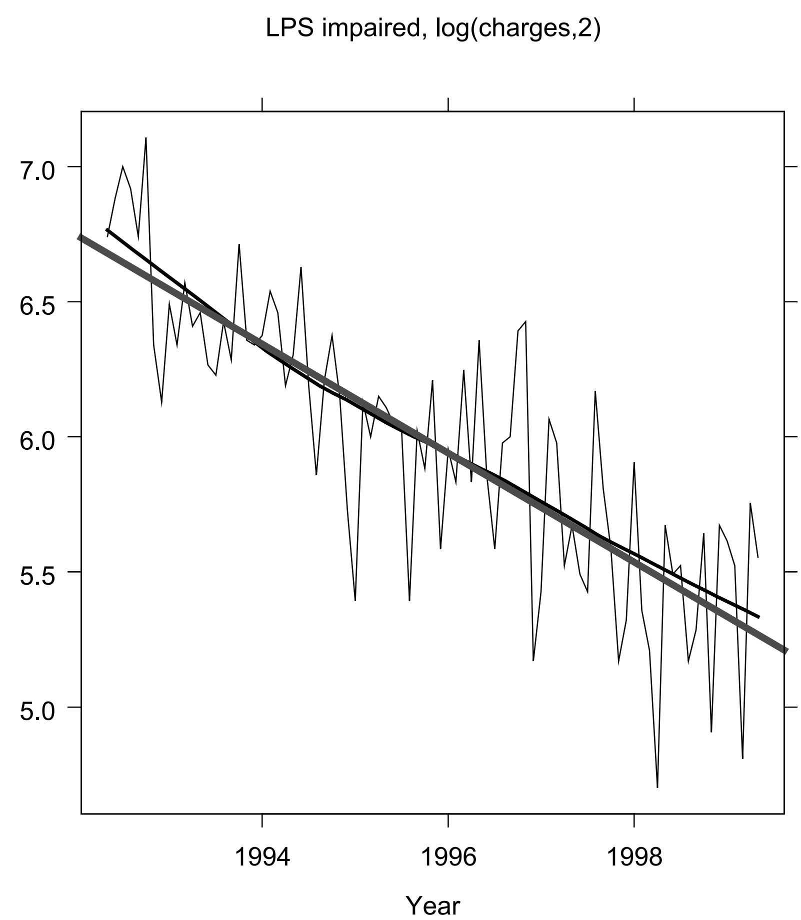


Figure 2. By wkgrp.

Both exhibit a nearly linear downward slope on log scale. The downward slope for ThuSat is slightly greater. The table below shows the slope of the linear least squares fit to each group.

Wkgrp	Slope of fit to log(data,2)	Annual rate of decrease %
SunWed	-0.173	11%
ThuSat	-0.229	15%

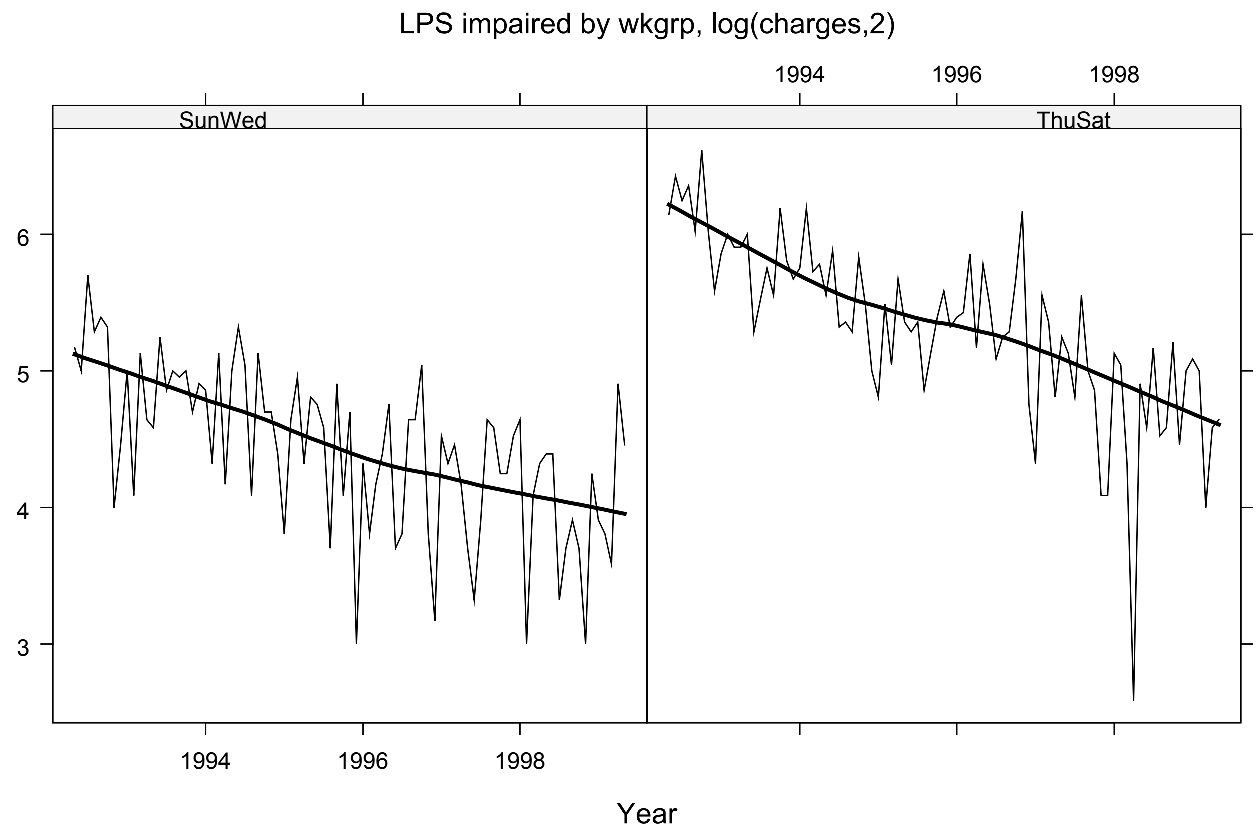


Table 2.

```
> imp.SunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  36  32  52  39  42  40  16  22
1993:  32  17  35  25  24  38  29  32  31  32  26  30
1994:  29  20  35  18  32  40  33  17  35  26  26  21
1995:  14  25  31  20  28  27  24  13  30  17  26   8
1996:  20  14  18  21  27  13  14  25  25  33  14   9
1997:  23  20  22  18  13  10  15  25  24  19  19  23
1998:  25   8  17  20  21  21  10  13  15  13   8  19
1999:  15  14  12  30  22
> SeasonalMannKendall(imp.SunWed.ts)
tau = -0.508,   sl =3.036e-6%

> imp.ThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  71  86  76  82  65  98  65  48
1993:  58  64  60  60  64  39  46  54  47  73  56  51
1994:  54  73  53  55  47  59  40  41  39  57  45  32
1995:  28  45  33  51  41  39  41  29  35  42  48  40
1996:  42  43  58  36  55  45  34  38  39  51  72  27
1997:  20  47  41  28  38  35  28  47  32  29  17  17
1998:  35  33  20   6  30  24  36  23  24  37  22  32
1999:  34  32  16  24  25
> SeasonalMannKendall(imp.ThuSat.ts)
tau = -0.707,   sl =8.438e-13%
```

Figure 3a. By hour. Common Scaling

For the hour window only 12AM looks linear on a log scale. The curves are all different. It is interesting that 3AM actually increases after 1996 and the rate of decline for 2AM is much slower than at other hours.

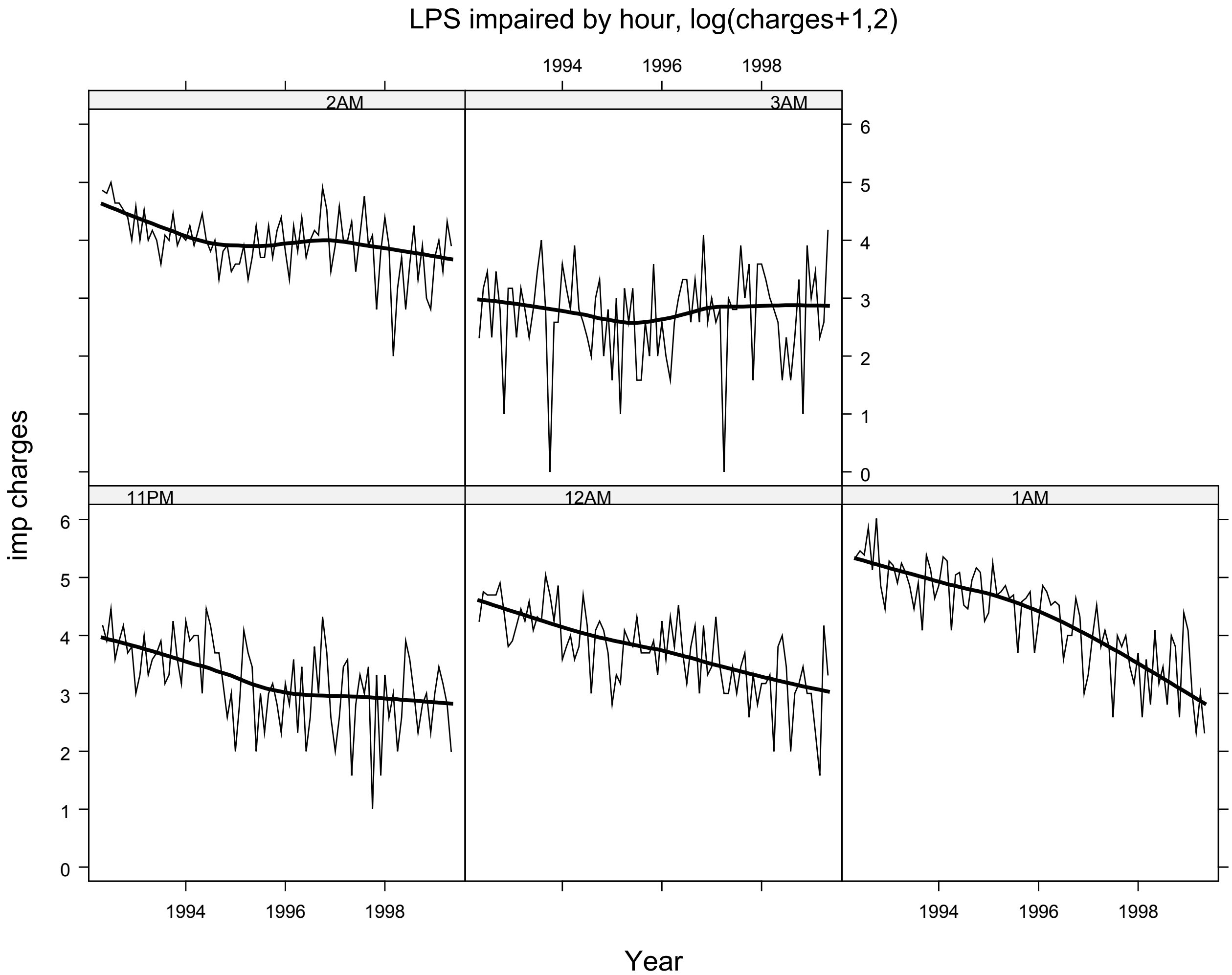


Figure 3b. By hour. Independent vertical scaling.

When the scale is free, we see that the 1AM has had a much faster rate of decline since 1996 than that of the data as whole (Figure 1b).

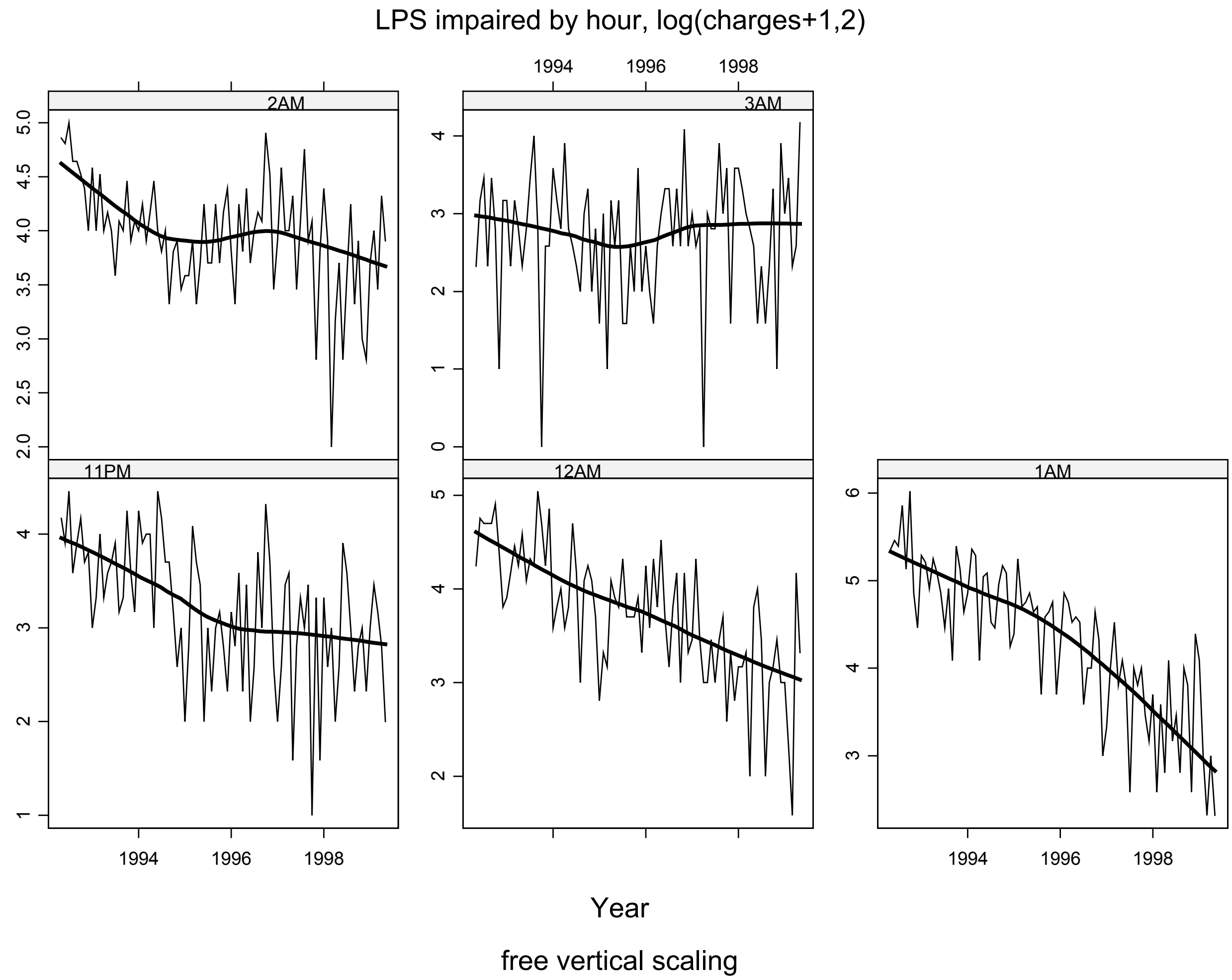
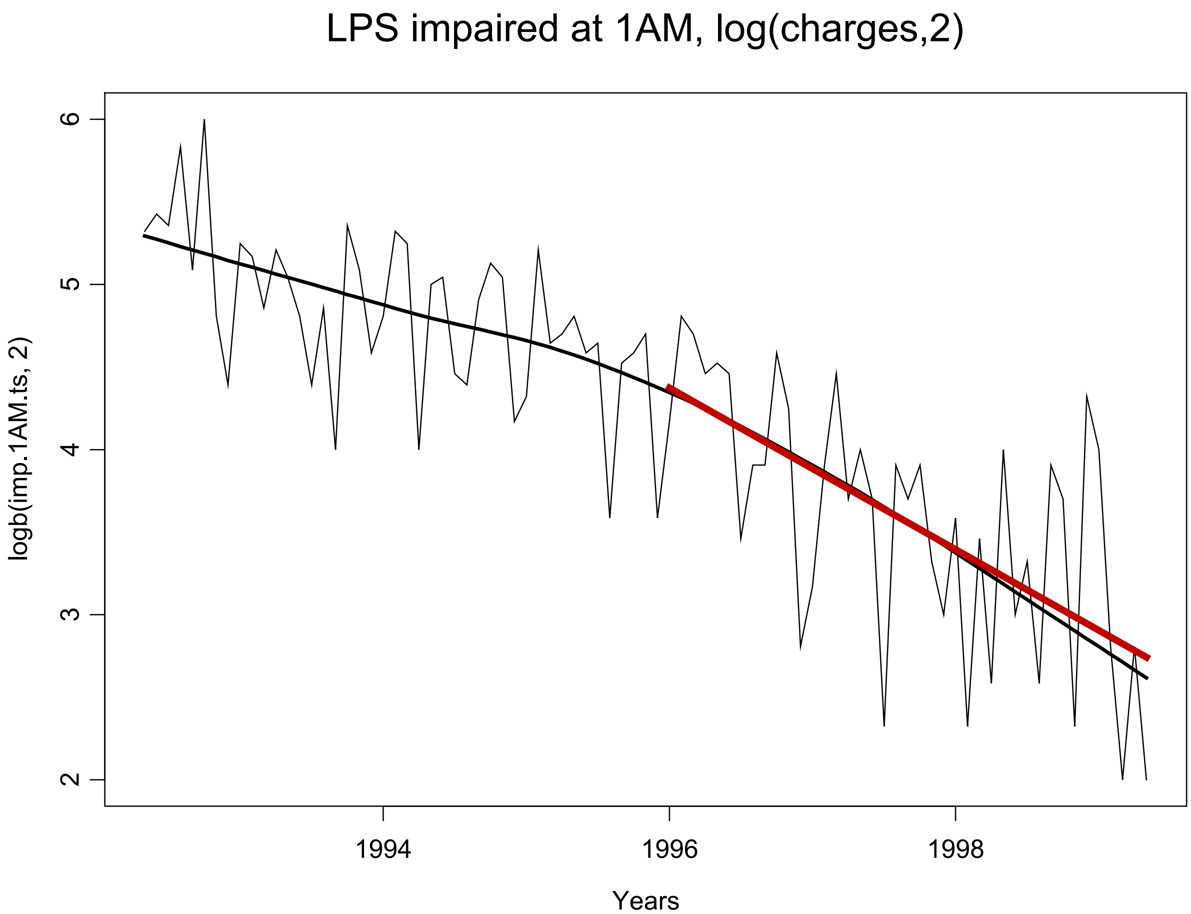


Figure 3c.

Least square line fit (thick red line) to data from 1996 to present. The slope of the least squares line to post-1996 is –0.489 which corresponds to a annual rate of decrease of about 28.7%. Since 1998, the actual impaired driving charges are decreasing slightly faster than this.

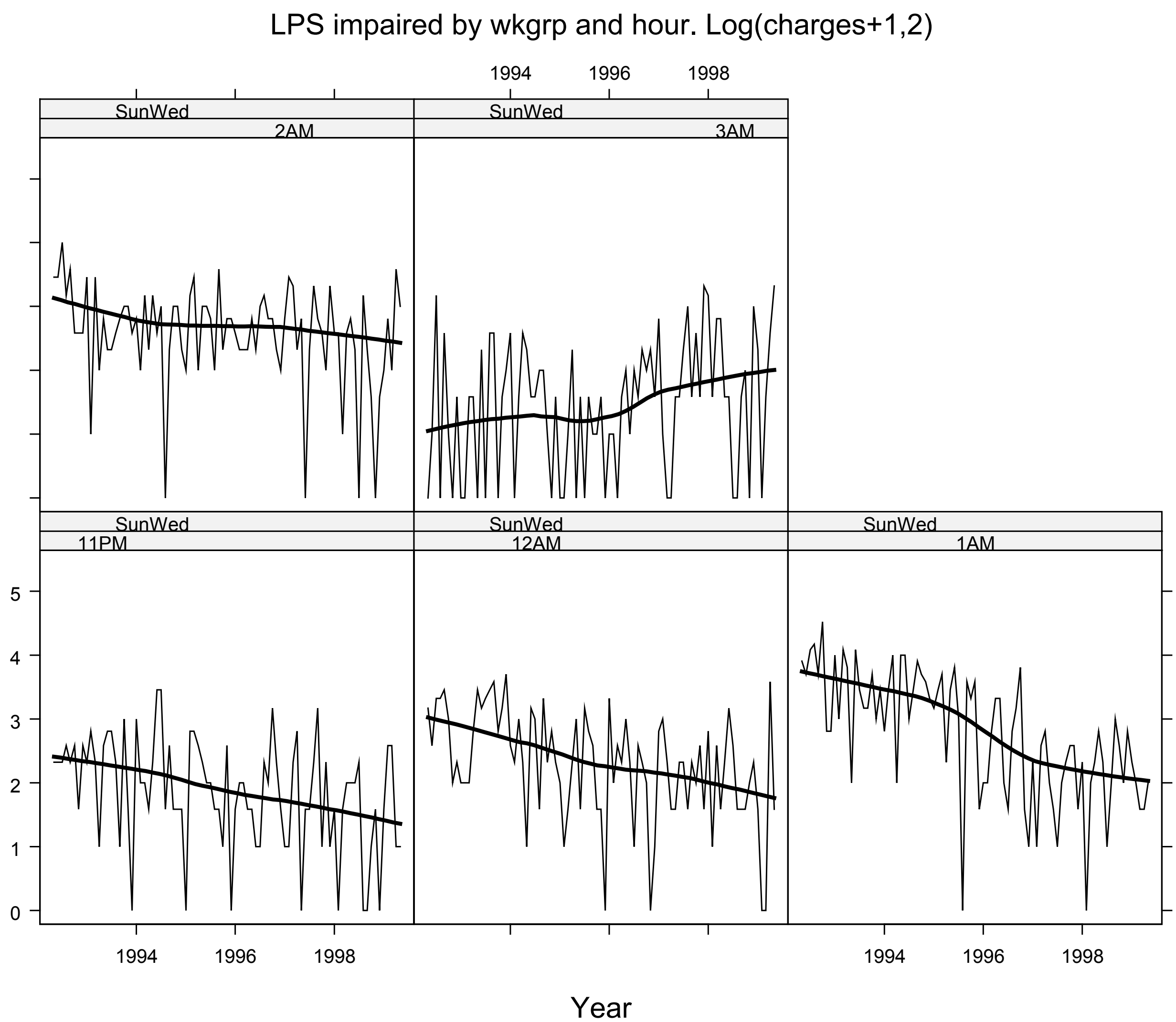
```
> 1-2^-0.489
[1] 0.2874812
```



Tabulation and Mann-Kendall Tests

```
> imp.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  17  14  21  11  14  17  12  13
1993:   7   9  15   9  11  12  14   8   9  18  11   8
1994:  18  14  15  15   7  21  17  12  12   8   5   7
1995:   3   6  16  12  10   3   7   4   7   8   6   4
1996:   8   6  11   4  10   3   5  13   7  19  12   5
1997:   3   5  10  11   2   6   9   7  10   1   9   2
1998:   9   5   7   3   5  14  11   7   4   6   7   4
1999:   7  10   8   6   3
> SeasonalMannKendall(imp.11PM.ts)
tau = -0.42,   sl =5.079e-4%
> imp.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  18  26  25  25  25  29  20  13
1993:  14  17  21  18  23  16  19  18  32  25  18  28
1994:  11  13  15  11  13  25  17   7  16  18  16  12
1995:   6   9   8  16  14  13  19  12  12  12  14   9
1996:  18  11  19  13  22  12   8  13  17   7  17   9
1997:  10  19  10   7   7  10   7  10  12   5   9   6
1998:   8   8   9   3  13  15  10   3   7   8  10   7
1999:   7   4   2  17   9
> SeasonalMannKendall(imp.12AM.ts)
tau = -0.603,   sl =3.71e-9%
> imp.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  40  43  41  57  34  64  28  21
1993:  38  36  29  37  33  28  21  29  16  41  34  24
1994:  28  40  38  16  32  33  22  21  30  35  33  18
1995:  20  37  25  26  28  24  25  12  23  24  26  12
1996:  18  28  26  22  23  22  11  15  15  24  19   7
1997:   9  15  22  13  16  13   5  15  13  15  10   8
1998:  12   5  11   6  16   8  10   6  15  13   5  20
1999:  16   7   4   7   4
> SeasonalMannKendall(imp.1AM.ts)
tau = -0.767,   sl =0%
> imp.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  28  27  31  24  24  22  20  15
1993:  23  15  22  15  17  15  11  16  15  21  14  16
1994:  15  18  14  17  21  15  13  15   9  13  14  10
1995:  11  11  14   9  12  18  12  12  18  12  17  20
1996:  13   9  18  13  20  12  15  17  16  29  22  10
1997:  14  23  15  15  19  10  16  26  14  16   6  13
1998:  20  14   3   8  12   6  11  18   9  14   7   6
1999:  12  15  10  19  14
> SeasonalMannKendall(imp.2AM.ts)
tau = -0.283,   sl =0.2022%
> imp.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   8  10   4  10   6   1   8
1993:   8   4   8   6   4   6  10  15   6   0   5   5
1994:  11   8   6  14   6   5   4   3   7   9   3   6
1995:   2   7   1   8   5   8   2   2   5   3  11   3
1996:   5   3   2   5   7   9   9   5   9   5  16   5
1997:   7   5   6   0   7   6   6  14   7  11   2  11
1998:  11   9   7   6   5   2   4   2   4   9   1  14
1999:   7  10   4   5  17
> SeasonalMannKendall(imp.3AM.ts)
tau = 0.016,   sl =86.28%
```

Figure 4a. By hour and wkgrp. Common Scaling.



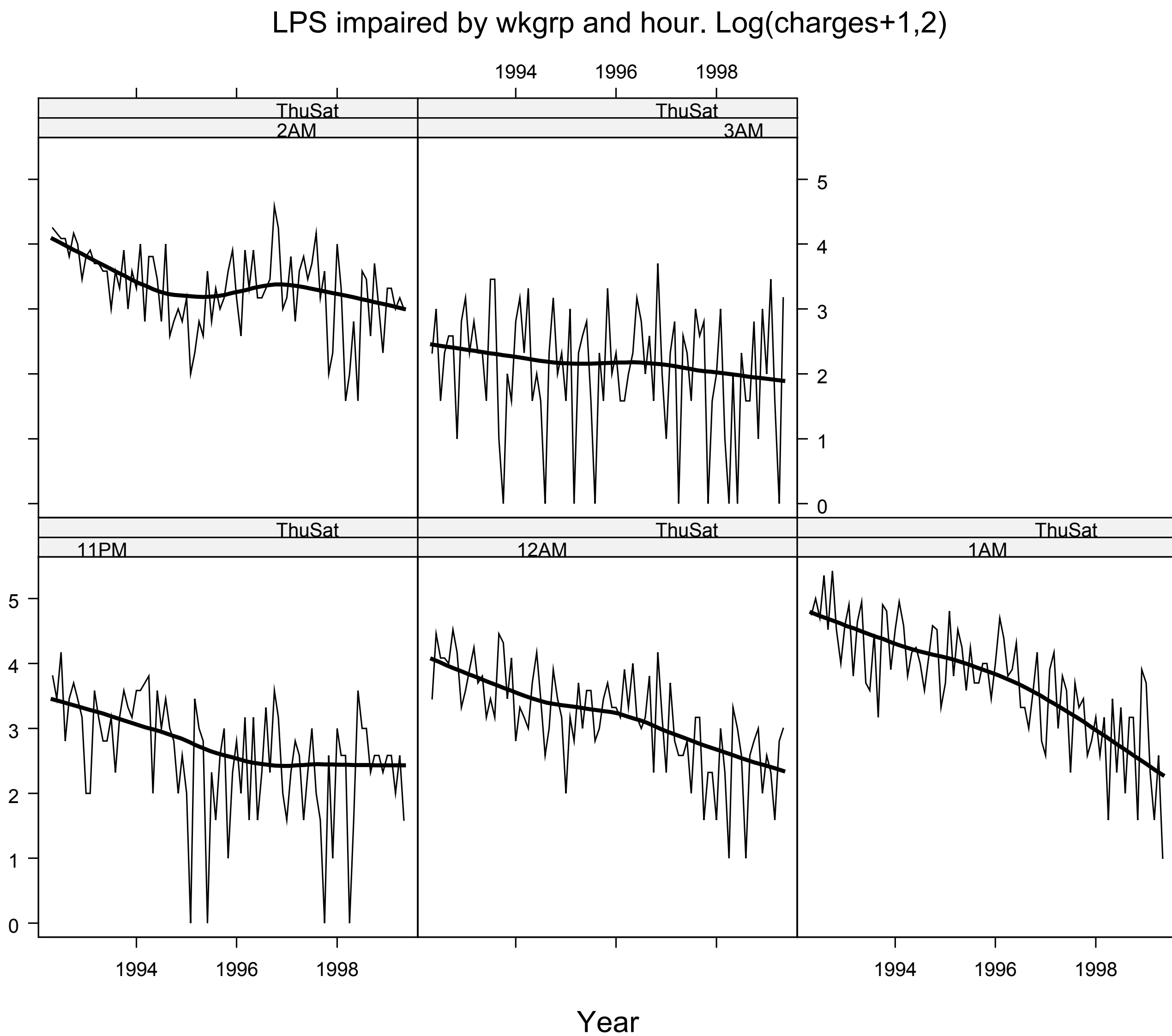
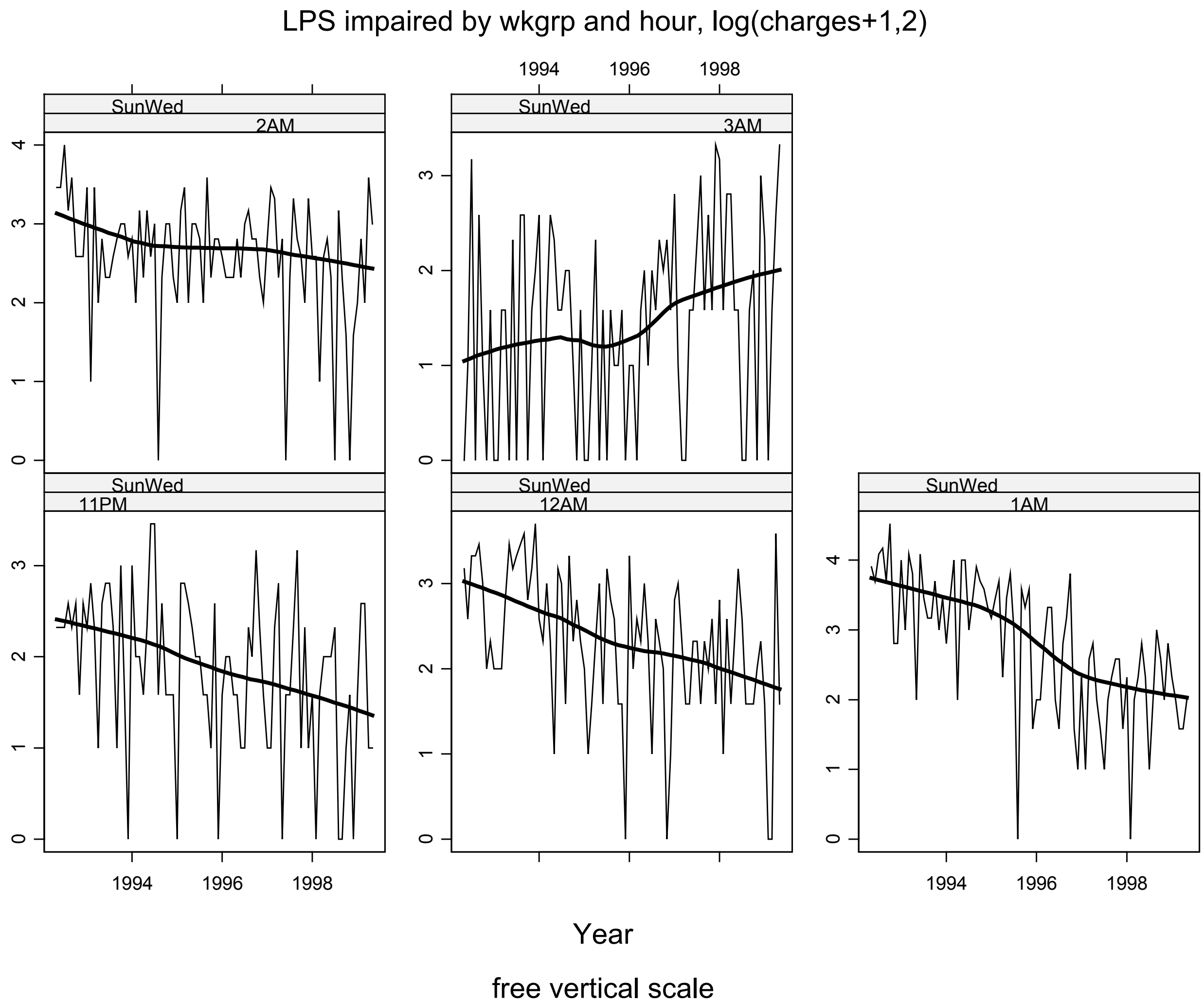
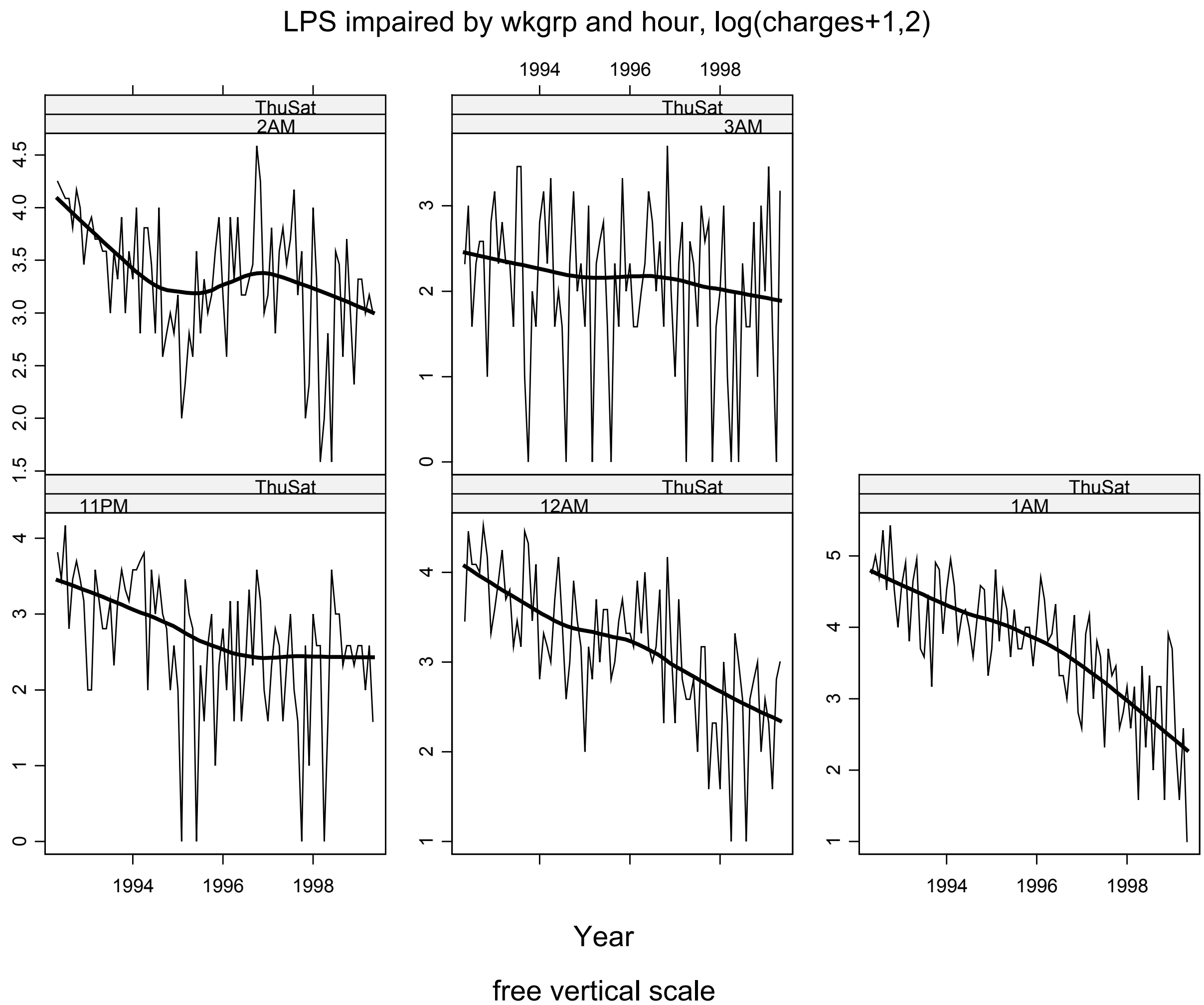

LPS impaired by wkgrp and hour. Log(charges+1,2)
ThuSat
2AM
ThuSat
3AM
ThuSat
11PM
ThuSat
12AM
ThuSat
1AM
0
1
2
3
4
5
1994
1996
1998
Year

Figure 4b. By hour and wkgrp. Independent Scaling.

From Figure 4b we see that the SunWed-3AM has had the biggest increase since 1996 For both SunWed and ThuSat there is a shift from early evening to late evening post 1996. This is seen not only in the case of SunWed-3AM where an actual increase has occurred but also in the much smaller slope or rate of decline in the 2AM-SunWed, 2AM-ThuSat and 3AM-ThuSat than indicated for the overall series in Figure 1b. It is intended to model this further using intervention analysis.




LPS impaired by wkgrp and hour, log(charges+1,2)
ThuSat
2AM
ThuSat
3AM
ThuSat
11PM
ThuSat
12AM
ThuSat
1AM
1994
1996
1998
Year
free vertical scale

Tabulations and Seasonal Mann-Kendall Tests

```
> imp.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   4   4   5   4   5   2   5
1993:   4   6   4   1   5   6   6   4   1   7   2   0
1994:   7   3   3   2   4  10  10   2   5   2   2   2
1995:   0   6   6   5   4   3   3   2   2   1   5   0
1996:   2   3   3   2   2   1   1   4   3   8   4   2
1997:   1   1   4   6   0   2   2   4   8   1   4   1
1998:   2   0   2   3   3   3   4   0   0   1   2   0
1999:   2   5   5   1   1
> SeasonalMannKendall(imp.11PMSunWed.ts)
tau = -0.26,   sl =0.5501%
> imp.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   8   5   9   9  10   7   3   4
1993:   3   3   3   6  10   8   9  10  11   6   8  12
1994:   5   4   7   4   1   8   7   2   9   4   6   4
1995:   3   1   2   4   7   2   8   6   5   2   2   0
1996:   9   3   5   4   7   4   1   5   4   3   0   1
1997:   6   7   4   2   2   4   4   2   4   3   5   2
1998:   6   1   5   2   4   8   5   2   2   2   3   4
1999:   2   0   0  11   2
> SeasonalMannKendall(imp.12AMSunWed.ts)
tau = -0.387,   sl =0.003343%
> imp.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  14  12  16  17  12  22   6   6
1993:  15   7  16  13   3  16  10   8   8  12   7  10
1994:   6  10  15   3  15  15   7  10  14  12  11   9
1995:   8  10  12   4  10  13   7   0  11   9  11   2
1996:   3   3   6   9   9   3   2   6   8  13   2   1
1997:   4   1   5   6   3   2   1   3   4   5   5   2
1998:   4   0   3   4   6   4   1   3   7   5   3   6
1999:   4   3   2   2   3
> SeasonalMannKendall(imp.1AMSunWed.ts)
tau = -0.573,   sl =6.011e-8%
> imp.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  10  10  15   8  11   5   5   5
1993:  10   1  10   3   6   4   4   5   6   7   7   5
1994:   6   3   8   4   8   5   7   0   4   7   7   4
1995:   3   8  10   3   7   7   6   3  11   4   6   6
1996:   5   4   4   4   6   4   7   8   6   6   4   3
1997:   6  10   9   4   6   0   4   9   6   5   3   9
1998:   5   5   1   5   6   4   0   8   4   2   0   2
1999:   3   6   3  11   7
> SeasonalMannKendall(imp.2AMSunWed.ts)
tau = -0.227,   sl =1.543%
> imp.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   0   1   8   0   5   1   0   2
1993:   0   0   2   2   0   4   0   5   5   0   2   3
1994:   5   0   2   5   4   2   2   3   3   1   0   2
1995:   0   0   1   4   0   2   0   2   1   1   2   0
1996:   1   1   0   2   3   1   3   2   4   3   4   2
1997:   6   1   0   0   2   2   4   7   2   5   2   9
1998:   8   2   6   6   2   2   0   0   2   3   0   7
1999:   4   0   2   5   9
> SeasonalMannKendall(imp.3AMSunWed.ts)
tau = 0.17,   sl =7.306%
```

```
imp.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  13  10  17   6  10  12  10   8
1993:   3   3  11   8   6   6   8   4   8  11   9   8
1994:  11  11  12  13   3  11   7  10   7   6   3   5
1995:   3   0  10   7   6   0   4   2   5   7   1   4
1996:   6   3   8   2   8   2   4   9   4  11   8   3
1997:   2   4   6   5   2   4   7   3   2   0   5   1
1998:   7   5   5   0   2  11   7   7   4   5   5   4
1999:   5   5   3   5   2
> SeasonalMannKendall(imp.11PMThuSat.ts)
tau = -0.412,   sl =8.248e-4%
> imp.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  10  21  16  16  15  22  17   9
1993:  11  14  18  12  13   8  10   8  21  19  10  16
1994:   6   9   8   7  12  17  10   5   7  14  10   8
1995:   3   8   6  12   7  11  11   6   7  10  12   9
1996:   9   8  14   9  15   8   7   8  13   4  17   8
1997:   4  12   6   5   5   6   3   8   8   2   4   4
1998:   2   7   4   1   9   7   5   1   5   6   7   3
1999:   5   4   2   6   7
> SeasonalMannKendall(imp.12AMThuSat.ts)
tau = -0.576,   sl =4.119e-8%
> imp.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  26  31  25  40  22  42  22  15
1993:  23  29  13  24  30  12  11  21   8  29  27  14
1994:  22  30  23  13  17  18  15  11  16  23  22   9
1995:  12  27  13  22  18  11  18  12  12  15  15  10
1996:  15  25  20  13  14  19   9   9   7  11  17   6
1997:   5  14  17   7  13  11   4  12   9  10   5   6
1998:   8   5   8   2  10   4   9   3   8   8   2  14
1999:  12   4   2   5   1
> SeasonalMannKendall(imp.1AMThuSat.ts)
tau = -0.689,   sl =5.906e-12%
> imp.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  18  17  16  16  13  17  15  10
1993:  13  14  12  12  11  11   7  11   9  14   7  11
1994:   9  15   6  13  13  10   6  15   5   6   7   6
1995:   8   3   4   6   5  11   6   9   7   8  11  14
1996:   8   5  14   9  14   8   8   9  10  23  18   7
1997:   8  13   6  11  13  10  12  17   8  11   3   4
1998:  15   9   2   3   6   2  11  10   5  12   7   4
1999:   9   9   7   8   7
> SeasonalMannKendall(imp.2AMThuSat.ts)
tau = -0.267,   sl =0.3793%
> imp.3AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   7   2   4   5   5   1   6
1993:   8   4   6   4   4   2  10  10   1   0   3   2
1994:   6   8   4   9   2   3   2   0   4   8   3   4
1995:   2   7   0   4   5   6   2   0   4   2   9   3
1996:   4   2   2   3   4   8   6   3   5   2  12   3
1997:   1   4   6   0   5   4   2   7   5   6   0   2
1998:   3   7   1   0   3   0   4   2   2   6   1   7
1999:   3  10   2   0   8
> SeasonalMannKendall(imp.3AMThuSat.ts)
tau = -0.0616,   sl =51%
```

Figure 5a. STL Analysis

There is a linear downward trend on the log scale. The seasonal component has lots of local maxima and minima.

`R-sq =  81.6%`

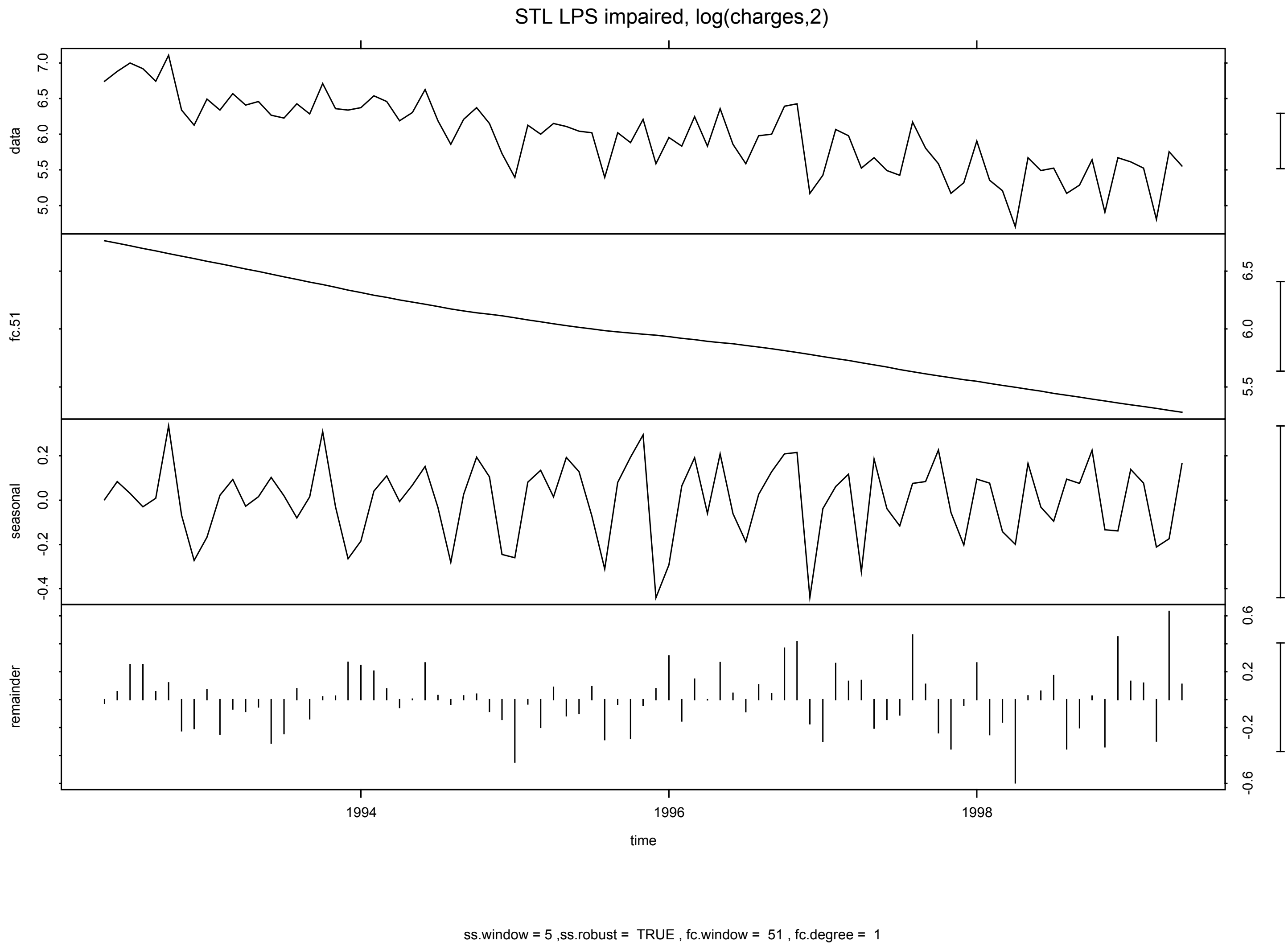


Figure 5b. Monthplot of Seasonal Component

Local maximum in February, May and October and local minimum in December, April and July. But the seasonal component is variable and shows a lot of changes over time. There is an increasing trend for December, January, May and August.

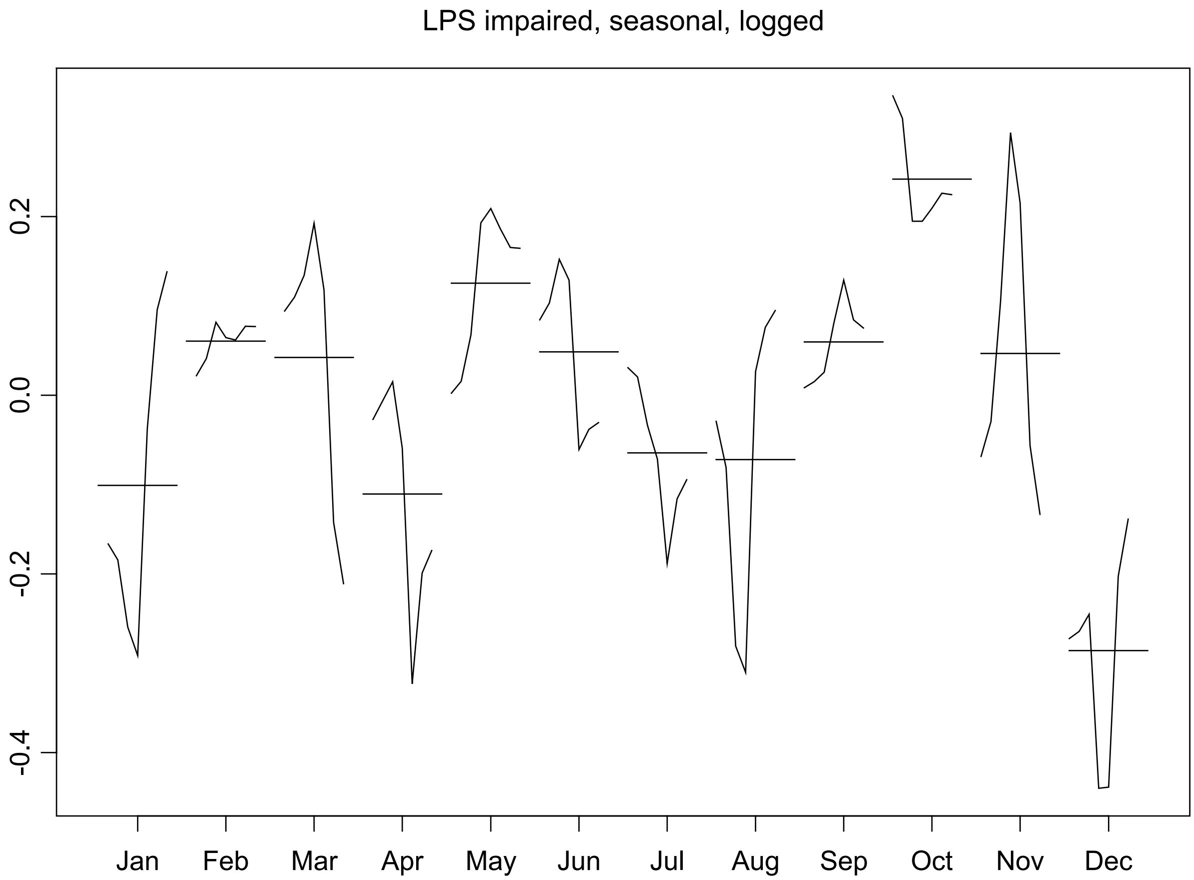
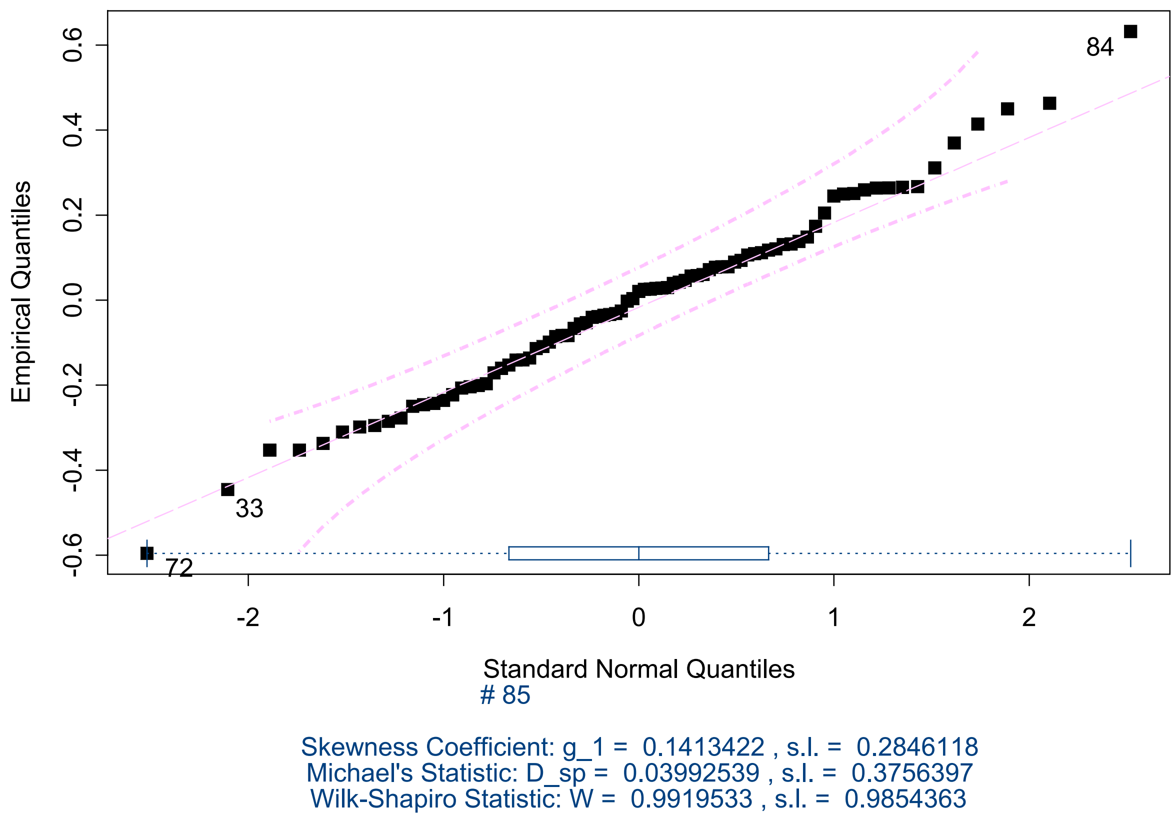


Figure 5c. Normal Probability Plot

The normality tests indicate no significant departure from normality in the remainder component.

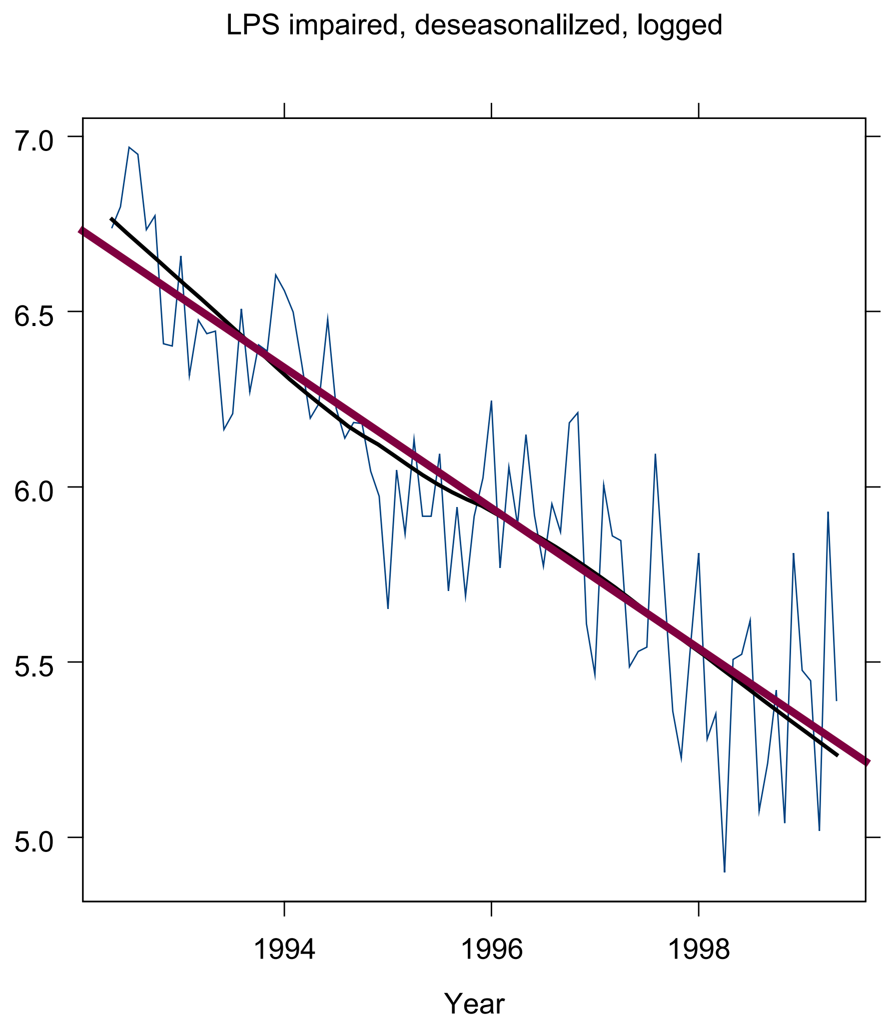



```
> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   3   4   5   6   7   8
1993:   9  10  11  12  13  14  15  16  17  18  19  20
1994:  21  22  23  24  25  26  27  28  29  30  31  32
1995:  33  34  35  36  37  38  39  40  41  42  43  44
1996:  45  46  47  48  49  50  51  52  53  54  55  56
1997:  57  58  59  60  61  62  63  64  65  66  67  68
1998:  69  70  71  72  73  74  75  76  77  78  79  80
1999:  81  82  83  84  85
```

See Table 1.

Figure 5d.
Loess analysis of deseasonalized series
Mann-Kendall test: `tau = -0.711,   sl =0%`

The thicker line shows the linear least-squares fit and the thinner line shows the loess curve. The least-squares line has a slope of `-0.200` almost the same as in Figure 1b. A slight lack of fit of the linear least-squares line is evident at the beginning and end of the series. The residuals from the least-squares line are approximately normally distributed with no evident outliers. However further diagnostic checks indicate that the variablility about the line increases with Year.



H. WPS Dataset

Introduction

WPS (Windsor Police dataset) is comprised of 2943 records covering January 1994 to December 1998. There are 1370 arrests for assault and 1573 arrests for impaired driving. Only data in hourly windows from 11PM to 3:59AM is included.

The WPS dataset differs slightly in structure from the LPS dataset. One difference is that the WPS assaults do not include sexual assault whereas LPS does. Our response variable is simply `counts`.

Variables of interests in the WPS dataset

`counts`	number of charges
`type`	factor with 2 levels: "assault", "impaired"
`wkgrp`	ordered factor with 2 levels: "SunWed", "ThuSat"
`hour`	ordered factor with 5 levels: "11PM", "12AM", "1AM", "2AM", "3AM"
`year`	ordered factor with 8 levels: 1994 to 1999
`month`	ordered factor with 12 levels: January to December

Note that there are only five complete years of data.

H. WPS Dataset: Assaults

Summary

The WPS assaults do not include sexual assaults. There were 1370 assault cases in the Windsor area from May of 1992 to May of 1999. Table 1.

Crosstabs. In `SunWed` slot, there are 30% more assaults than expected in 11PM and fewer than expected in the 1AM, 2AM and 3AM slots. In 1994 there were more than the usual number of assaults in the 1AM window.

Figure 1a. and Figure 1b. Assault rate has not changed much over 1994 to 1998.

Figure 2. There is a very small downward trend in SunWed group starting around 1996.

Figure 3b. Since 1996 there have been assaults have increased at 2AM and also at 3AM and have decreased at 11PM and held steady at 12AM. There is a slight decrease in recent assaults at 1AM.

Figure 4b From Figure 4b we see that since 1996 there has been an upward shift at 2AM and 3AM and a downward trend at 11PM for both SunWed and ThuSat. For both weekgroups, 11PM and 12PM are relatively flat. The upward shifts are larger with the ThuSat group.

Figure 5a. The seasonal component is reasonably stable. There is a slight increase in amplitude of the seasonal oscillations.

Figure 5b. The overall seasonal pattern is with March, July and December maxima and with January, May and September minimum. The seasonal is relatively stable. There are trends up in June and down in September and October..

Figure 5c Several possible outliers are noted but all statistical tests for normality are fine.. See also Table 1. I think that perhaps there could be an error and that some 1996 assaults in June and July were mis-recorded as occuring in 1997.

Crosstabs Analysis

Hour and wkgrp are associated

In `SunWed` slot, there are 30% more assaults than expected in 11PM and fewer than expected in the 1AM, 2AM and 3AM slots.

```
> crosstabs(counts~wkgrp+hour, data=wps.df, na.action=na.exclude,
subset=wps.df$type=="assault")
Call:
crosstabs(formula = counts ~ wkgrp + hour, data = wps.df, subset = wps.df$type ==
"assault", na.action = na.exclude)
1612 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |190    |151    |132    |112    | 56    |641    |
       |0.3    |0.24   |0.21   |0.17   |0.087  |0.4    |
       |0.52   |0.45   |0.33   |0.34   |0.31   |       |
       |0.12   |0.094  |0.082  |0.069  |0.035  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |178    |185    |269    |214    |125    |971    |
       |0.18   |0.19   |0.28   |0.22   |0.13   |0.6    |
       |0.48   |0.55   |0.67   |0.66   |0.69   |       |
       |0.11   |0.11   |0.17   |0.13   |0.078  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|368    |336    |401    |326    |181    |1612   |
       |0.23   |0.21   |0.25   |0.2    |0.11   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 43.1059 d.f.= 4 (p=9.837309e-009)
       Yates' correction not used

> get.crosstabs.percenterror(counts~wkgrp+hour)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]   30   13  -17  -14  -22
[2,]  -20   -9   11    9   15
> contrib(counts~wkgrp+hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  3.61  1.50 -2.17 -1.55 -1.88
[2,] -2.93 -1.22  1.77  1.26  1.53
```

Hour and Year are associated

In 1994 there were more than the usual number of assaults in the 1AM window.

```
> crosstabs(counts~hour+year, data=wps.df, na.action=na.exclude, subset=wps.df$type=="assault")
Call:
crosstabs(formula = counts ~ hour + year, data = wps.df, subset = wps.df$type == "assault",
    na.action = na.exclude)
1612 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
11PM   | 87    | 69    | 84    | 72    | 56    |368    |
       |0.24   |0.19   |0.23   |0.2    |0.15   |0.23   |
       |0.27   |0.22   |0.27   |0.2    |0.18   |       |
       |0.054  |0.043  |0.052  |0.045  |0.035  |       |
-------+-------+-------+-------+-------+-------+-------+
12AM   | 59    | 78    | 75    | 55    | 69    |336    |
       |0.18   |0.23   |0.22   |0.16   |0.21   |0.21   |
       |0.18   |0.25   |0.24   |0.16   |0.22   |       |
       |0.037  |0.048  |0.047  |0.034  |0.043  |       |
-------+-------+-------+-------+-------+-------+-------+
1AM    |107    | 75    | 61    | 89    | 69    |401    |
       |0.27   |0.19   |0.15   |0.22   |0.17   |0.25   |
       |0.33   |0.24   |0.2    |0.25   |0.22   |       |
       |0.066  |0.047  |0.038  |0.055  |0.043  |       |
-------+-------+-------+-------+-------+-------+-------+
2AM    | 43    | 55    | 55    | 87    | 86    |326    |
       |0.13   |0.17   |0.17   |0.27   |0.26   |0.2    |
       |0.13   |0.18   |0.18   |0.25   |0.27   |       |
       |0.027  |0.034  |0.034  |0.054  |0.053  |       |
-------+-------+-------+-------+-------+-------+-------+
3AM    | 27    | 34    | 33    | 49    | 38    |181    |
       |0.15   |0.19   |0.18   |0.27   |0.21   |0.11   |
       |0.084  |0.11   |0.11   |0.14   |0.12   |       |
       |0.017  |0.021  |0.02   |0.03   |0.024  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|323    |311    |308    |352    |318    |1612   |
       |0.2    |0.19   |0.19   |0.22   |0.2    |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 58.5987 d.f.= 16 (p=8.997489e-007)
    Yates' correction not used
> get.crosstabs.percenterror(counts~hour+year)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]   18   -3   19  -10  -23
[2,]  -12   20   17  -25    4
[3,]   33   -3  -20    2  -13
[4,]  -34  -13  -12   22   34
[5,]  -26   -3   -5   24    6
> contrib(counts~hour+year)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  1.54 -0.24  1.63 -0.93 -1.95
[2,] -1.01  1.64  1.35 -2.14  0.33
[3,]  2.97 -0.27 -1.78  0.15 -1.14
[4,] -2.76 -1.00 -0.92  1.87  2.70
[5,] -1.54 -0.16 -0.27  1.51  0.38
```

LPS Assault Data

Possible outliers detected in logged series, Figure 5c, are in bold font below.

Table 1.

```
> assault.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1994:   22   24   25   28   30   25   45   22   18   29   33   22
1995:   27   23   19   21   19   34   44   41   24   18   18   23
1996:   16   35   33   18   25   14   16   29   25   25   31   41
1997:   26   18   33   35   16   49   50   31   15   20   29   30
1998:   30   33   19   30   27   28   40   34   18   19   26   14

> SeasonalMannKendall(assault.ts)
tau = -0.00844,   sl =94.32%
```

Figure 1.

Assault rate has not changed much over 1994 to 1998.

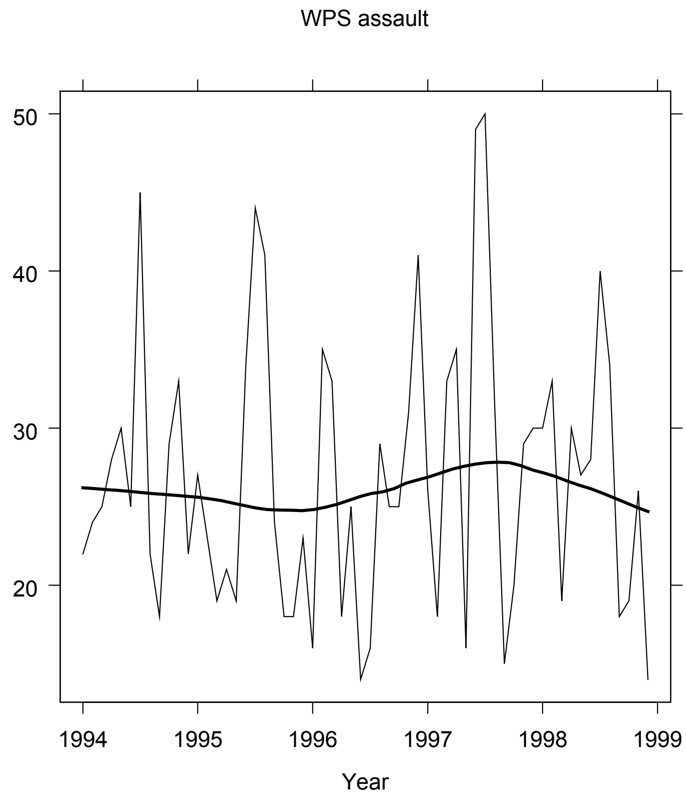


Figure 2. By wkgrp.

There is a very small downward trend in SunWed group starting around 1996.

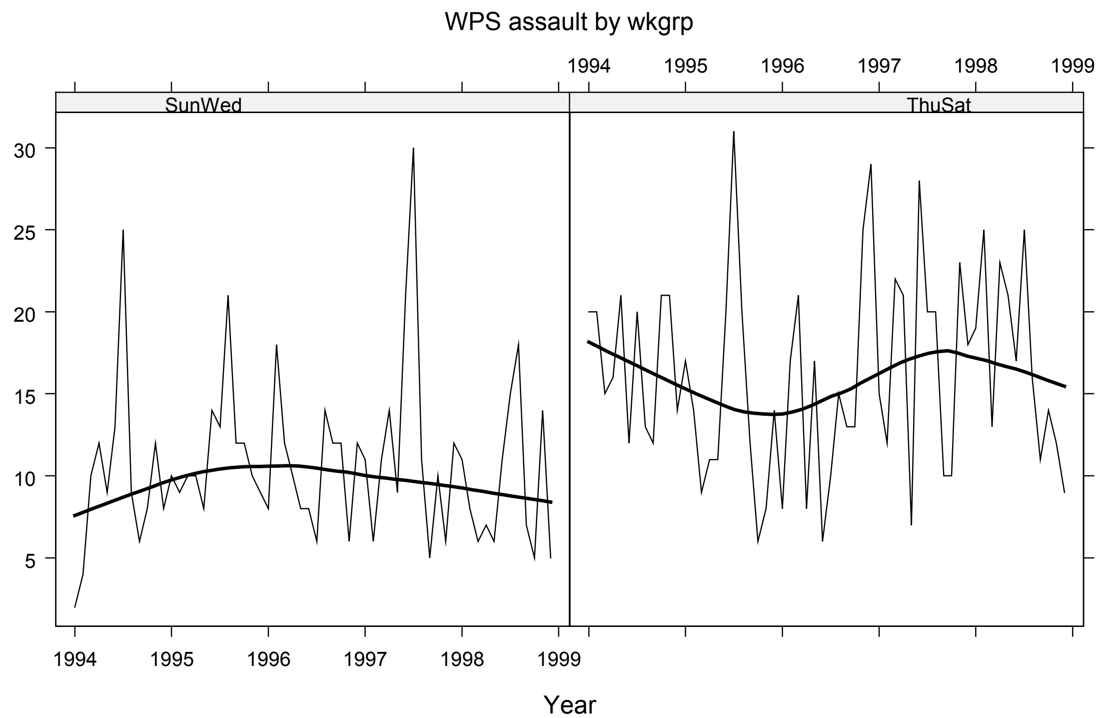


Table 2.

```
> assault.SunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   2   4  10  12   9  13  25   9   6   8  12   8
1995:  10   9  10  10   8  14  13  21  12  12  10   9
1996:   8  18  12  10   8   8   6  14  12  12   6  12
1997:  11   6  11  14   9  21  30  11   5  10   6  12
1998:  11   8   6   7   6  11  15  18   7   5  14   5
> SeasonalMannKendall(assault.SunWed.ts)
tau = -0.00867,   sl =94.23%
```

```
> assault.ThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  20  20  15  16  21  12  20  13  12  21  21  14
1995:  17  14   9  11  11  20  31  20  12   6   8  14
1996:   8  17  21   8  17   6  10  15  13  13  25  29
1997:  15  12  22  21   7  28  20  20  10  10  23  18
1998:  19  25  13  23  21  17  25  16  11  14  12   9
> SeasonalMannKendall(assault.ThuSat.ts)
tau = 0.0426,   sl =72.03%
```

Figure 3a. By hour. Common Scaling

Since 1996 there have been assaults have increased at 2AM and also at 3AM and have decreased at 11PM and held steady at 12AM. There is a slight decrease in recent assaults at 1AM.

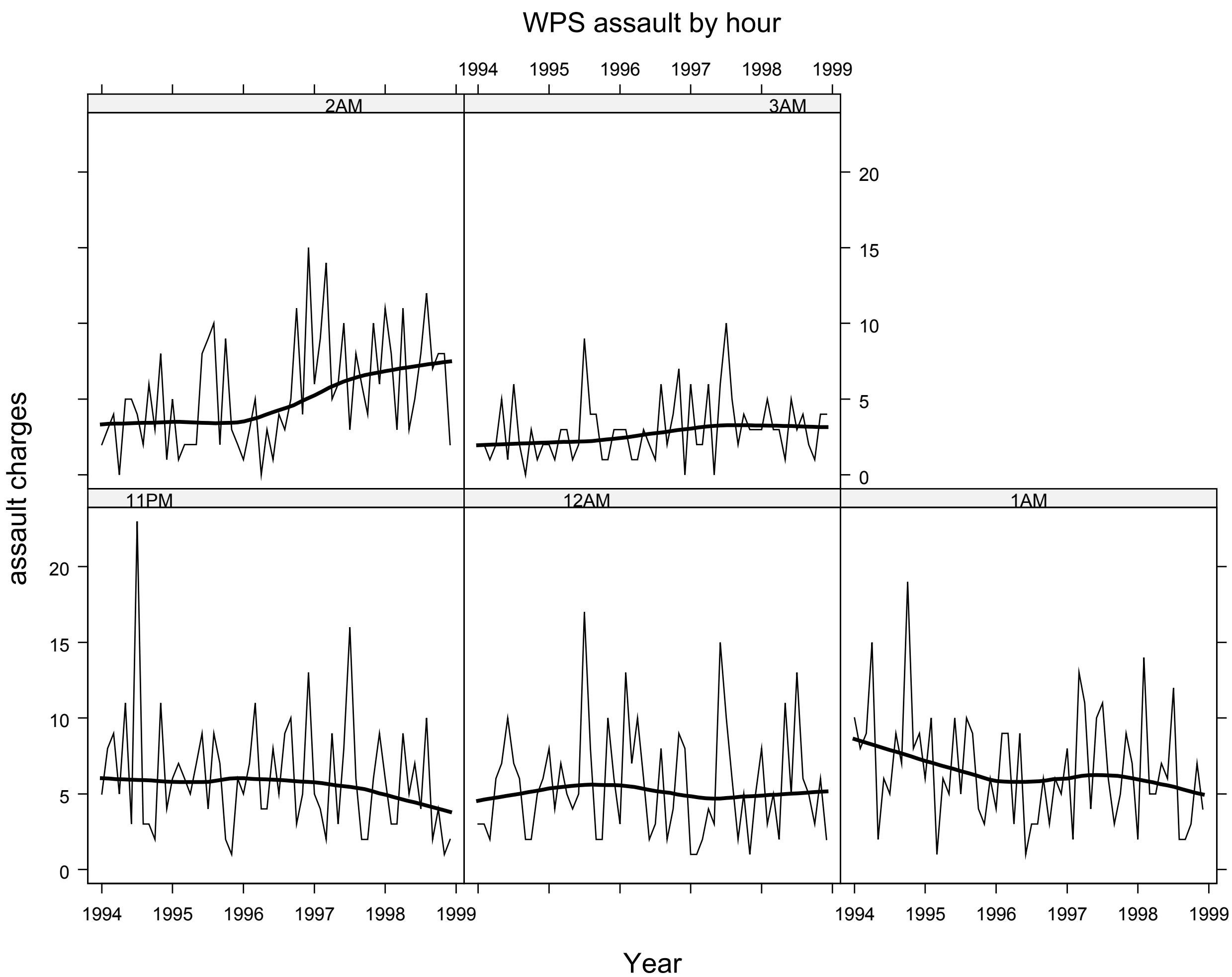
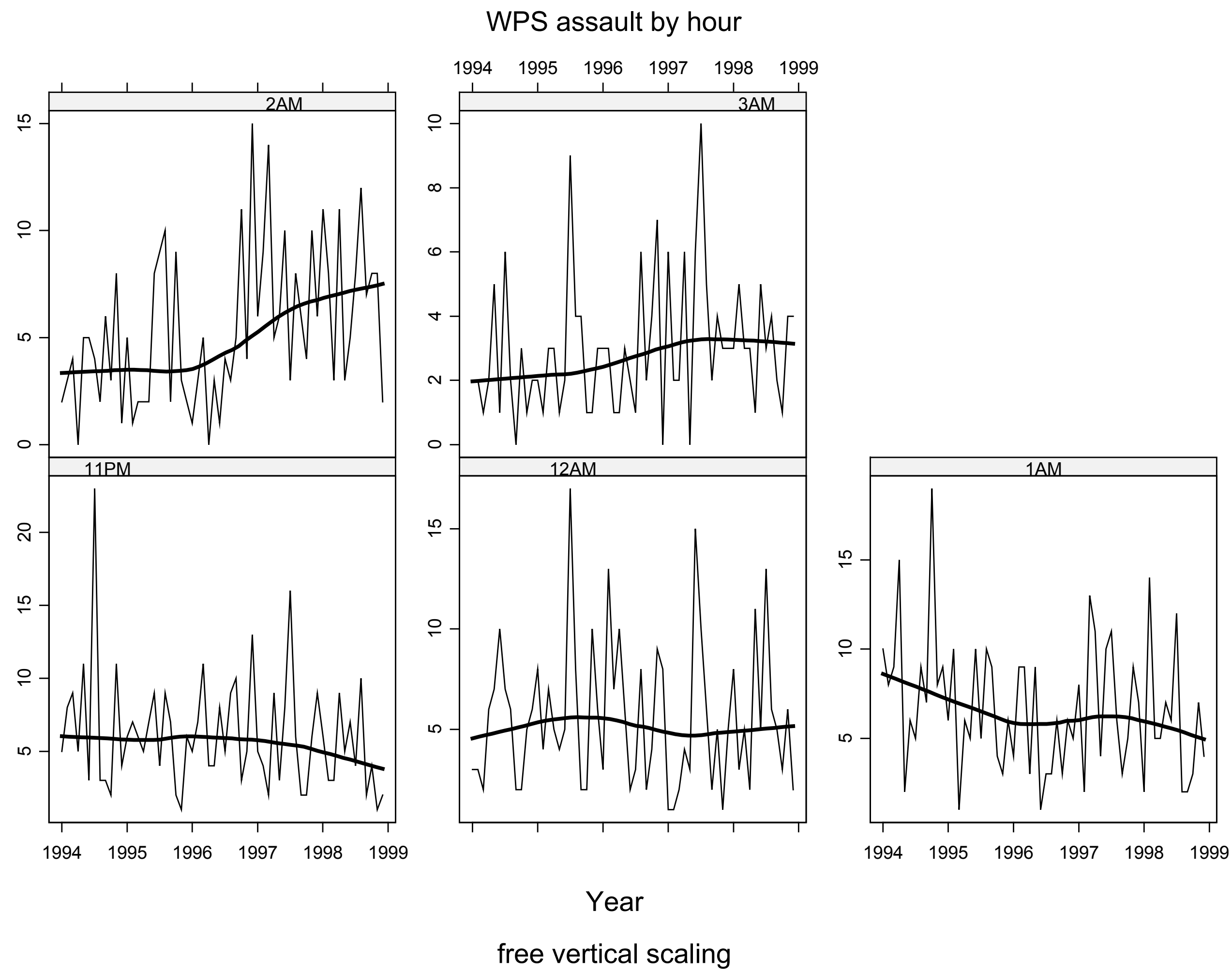


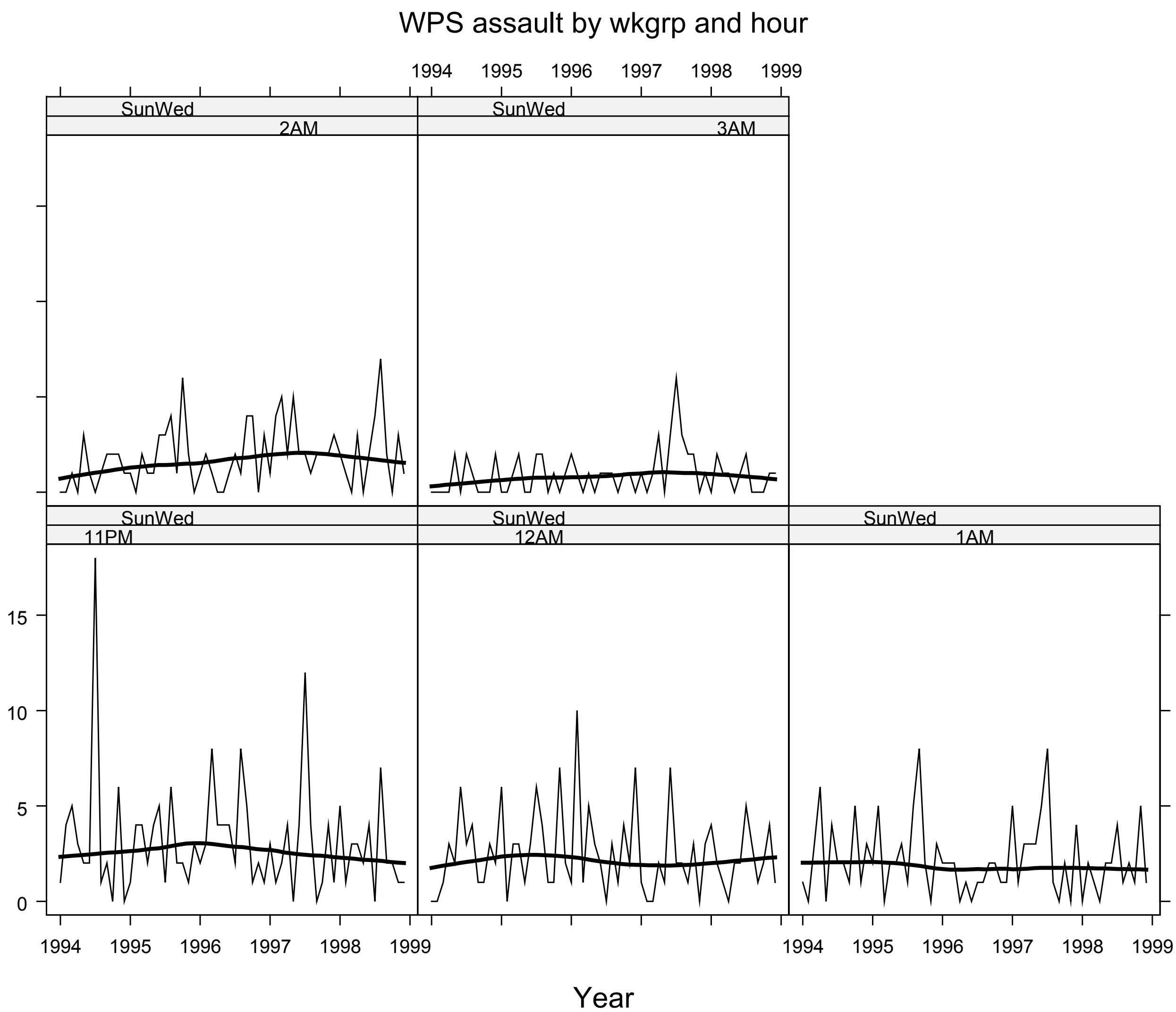
Figure 3b. By hour. Independent vertical scaling.



Tabulation and Mann-Kendall Tests

```
> assault.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   5   8   9   5  11   3  23   3   3   2  11   4
1995:   6   7   6   5   7   9   4   9   7   2   1   6
1996:   5   7  11   4   4   8   5   9  10   3   5  13
1997:   5   4   2   9   3   8  16   6   2   2   6   9
1998:   6   3   3   9   5   7   4  10   2   4   1   2
> SeasonalMannKendall(assault.11PM.ts)
tau = -0.116,   sl =33.74%

> assault.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   3   3   2   6   7  10   7   6   2   2   5   6
1995:   8   4   7   5   4   5  17   8   2   2  10   6
1996:   3  13   7  10   6   2   3   8   2   4   9   8
1997:   1   1   2   4   3  15  10   6   2   5   1   5
1998:   8   3   5   2  11   5  13   6   5   3   6   2
> SeasonalMannKendall(assault.12AM.ts)
tau = -0.0546,   sl =65.35%

> assault.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  10   8   9  15   2   6   5   9   7  19   8   9
1995:   6  10   1   6   5  10   5  10   9   4   3   6
1996:   4   9   9   3   9   1   3   3   6   3   6   5
1997:   8   2  13  11   4  10  11   6   3   5   9   7
1998:   2  14   5   5   7   6  12   2   2   3   7   4
> SeasonalMannKendall(assault.1AM.ts)
tau = -0.179,   sl =13.26%

> assault.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   2   3   4   0   5   5   4   2   6   3   8   1
1995:   5   1   2   2   2   8   9  10   2   9   3   2
1996:   1   3   5   0   3   1   4   3   5  11   4  15
1997:   6   9  14   5   6  10   3   8   6   4  10   6
1998:  11   8   3  11   3   5   8  12   7   8   8   2
> SeasonalMannKendall(assault.2AM.ts)
tau = 0.345,   sl =0.3892%

> assault.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   2   2   1   2   5   1   6   2   0   3   1   2
1995:   2   1   3   3   1   2   9   4   4   1   1   3
1996:   3   3   1   1   3   2   1   6   2   4   7   0
1997:   6   2   2   6   0   6  10   5   2   4   3   3
1998:   3   5   3   3   1   5   3   4   2   1   4   4
> SeasonalMannKendall(assault.3AM.ts)
tau = 0.305,   sl =1.204%
```

Figure 4a. By hour and wkgrp. Common Scaling.



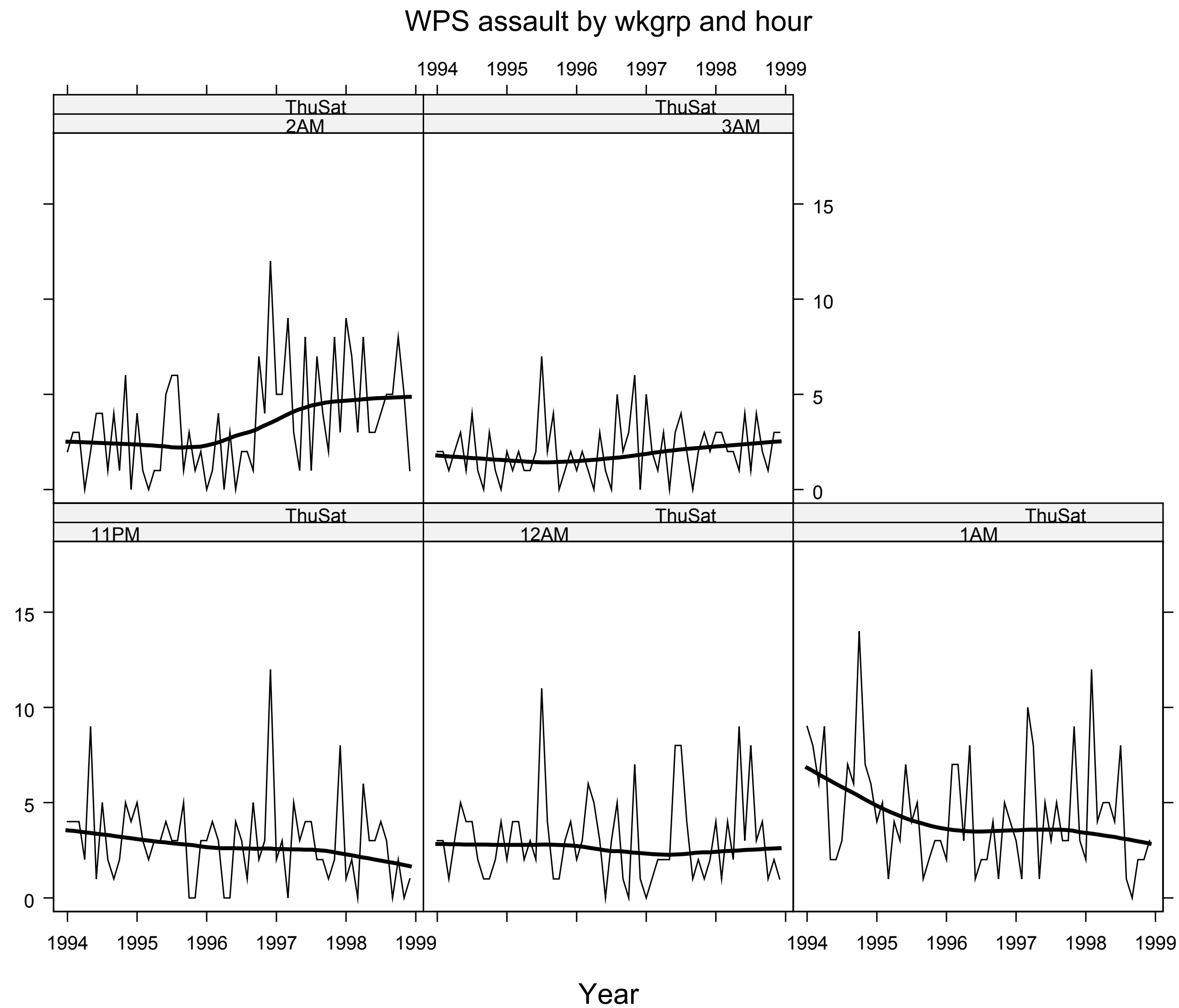
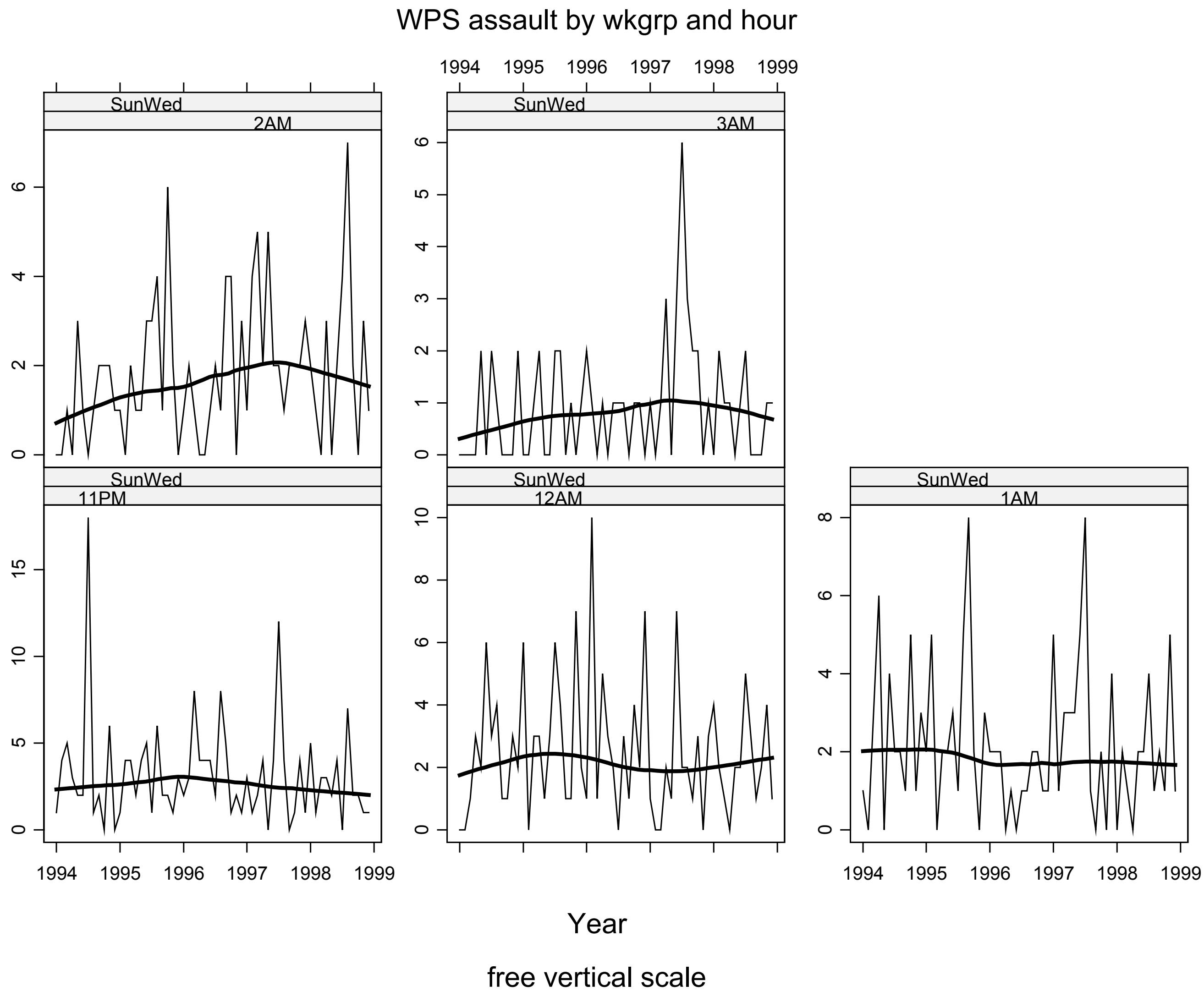
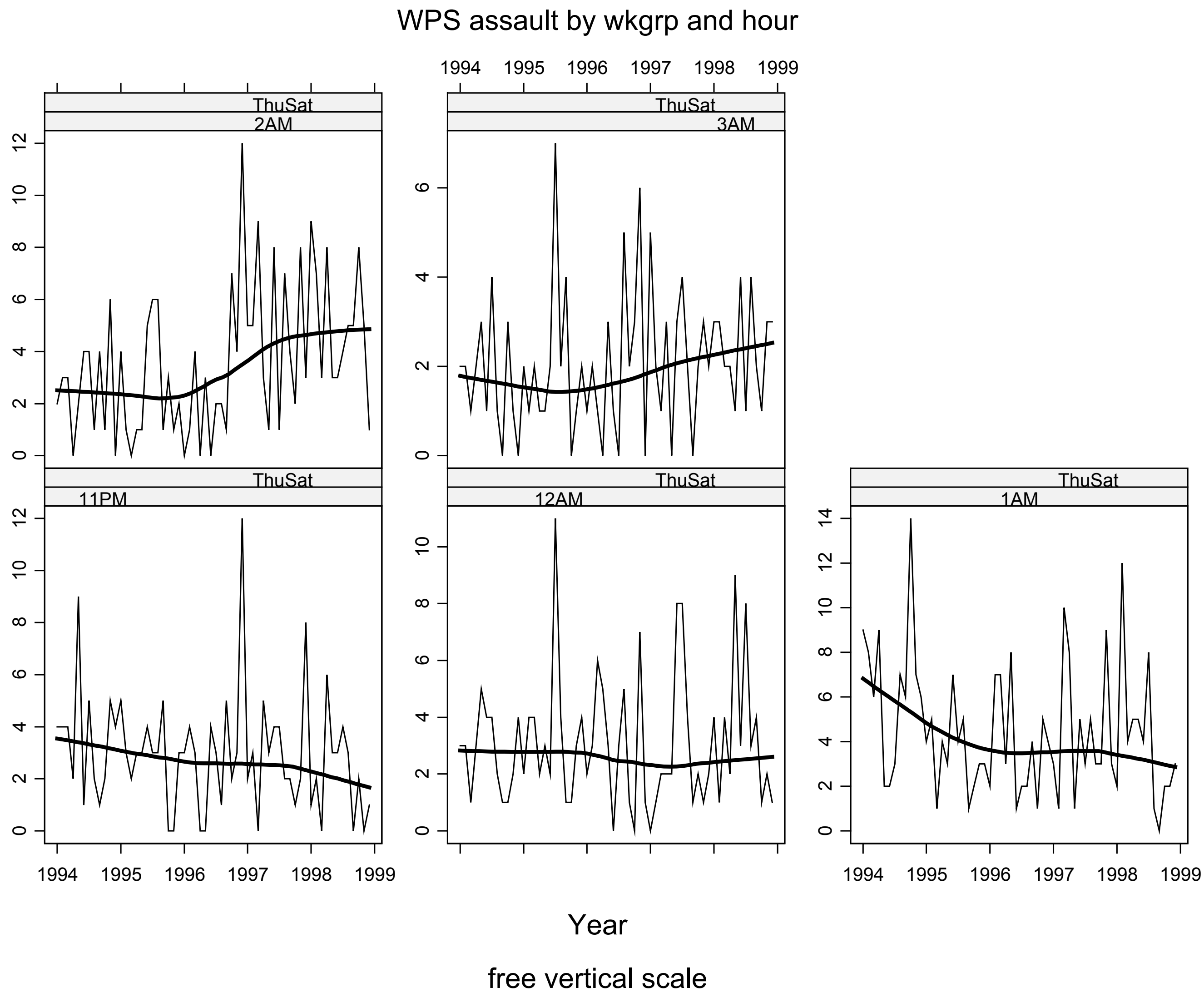

WPS assault by wkgrp and hour
ThuSat
2AM
ThuSat
3AM
ThuSat
11PM
ThuSat
12AM
ThuSat
1AM
0
5
10
15
1994
1995
1996
1997
1998
1999
Year

Figure 4b. By hour and wkgrp. Independent Scaling.

From Figure 4b we see that since 1996 there has been an upward shift at 2AM and 3AM and a downward trend at 11PM for both SunWed and ThuSat. For both weekgroups, 11PM and 12PM are relatively flat. The upward shifts are larger with the ThuSat group.




WPS assault by wkgrp and hour
ThuSat
2AM
3AM
11PM
12AM
1AM
1994
1995
1996
1997
1998
1999
Year
free vertical scale

Tabulations and Seasonal Mann-Kendall Tests

```
> assault.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   1   4   5   3   2   2  18   1   2   0   6   0
1995:   1   4   4   2   4   5   1   6   2   2   1   3
1996:   2   3   8   4   4   4   2   8   5   1   2   1
1997:   3   1   2   4   0   4  12   4   0   1   4   1
1998:   5   1   3   3   2   4   0   7   2   2   1   1
> SeasonalMannKendall(assault.11PMSunWed.ts)
tau = -0.0091,   sl =94.04%

> assault.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   0   0   1   3   2   6   3   4   1   1   3   2
1995:   6   0   3   3   1   3   6   4   1   1   7   2
1996:   1  10   1   5   3   2   0   3   1   4   2   7
1997:   1   0   0   2   1   7   2   2   1   3   0   3
1998:   4   2   1   0   2   2   5   3   1   2   4   1
> SeasonalMannKendall(assault.12AMSunWed.ts)
tau = -0.108,   sl =39.47%

> assault.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   1   0   3   6   0   4   2   2   1   5   1   3
1995:   2   5   0   2   2   3   1   5   8   2   0   3
1996:   2   2   2   0   1   0   1   1   2   2   1   1
1997:   5   1   3   3   3   5   8   1   0   2   0   4
1998:   0   2   1   0   2   2   4   1   2   1   5   1
> SeasonalMannKendall(assault.1AMSunWed.ts)
tau = -0.0991,   sl =41.44%

> assault.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   0   0   1   0   3   1   0   1   2   2   2   1
1995:   1   0   2   1   1   3   3   4   1   6   2   0
1996:   1   2   1   0   0   1   2   1   4   4   0   3
1997:   1   4   5   2   5   2   2   1   2   2   2   3
1998:   2   1   0   3   0   2   4   7   2   0   3   1
> SeasonalMannKendall(assault.2AMSunWed.ts)
tau = 0.24,   sl =4.958%

> assault.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   0   0   0   0   2   0   2   1   0   0   0   2
1995:   0   0   1   2   0   0   2   2   0   1   0   1
1996:   2   1   0   1   0   1   1   1   0   1   1   0
1997:   1   0   1   3   0   3   6   3   2   2   0   1
1998:   0   2   1   1   0   1   2   0   0   0   1   1
> SeasonalMannKendall(assault.3AMSunWed.ts)
tau = 0.203,   sl =10.55%
```

```
assault.11PMThuSat.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:    4   4   4   2   9   1   5   2   1   2   5   4
1995:    5   3   2   3   3   4   3   3   5   0   0   3
1996:    3   4   3   0   0   4   3   1   5   2   3  12
1997:    2   3   0   5   3   4   4   2   2   1   2   8
1998:    1   2   0   6   3   3   4   3   0   2   0   1
> SeasonalMannKendall(assault.11PMThuSat.ts)
tau = -0.217,   sl =7.364%
> assault.12AMThuSat.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:    3   3   1   3   5   4   4   2   1   1   2   4
1995:    2   4   4   2   3   2  11   4   1   1   3   4
1996:    2   3   6   5   3   0   3   5   1   0   7   1
1997:    0   1   2   2   2   8   8   4   1   2   1   2
1998:    4   1   4   2   9   3   8   3   4   1   2   1
> SeasonalMannKendall(assault.12AMThuSat.ts)
tau = -0.0742,   sl =54.42%
> assault.1AMThuSat.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:    9   8   6   9   2   2   3   7   6  14   7   6
1995:    4   5   1   4   3   7   4   5   1   2   3   3
1996:    2   7   7   3   8   1   2   2   4   1   5   4
1997:    3   1  10   8   1   5   3   5   3   3   9   3
1998:    2  12   4   5   5   4   8   1   0   2   2   3
> SeasonalMannKendall(assault.1AMThuSat.ts)
tau = -0.215,   sl =7.144%
> assault.2AMThuSat.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:    2   3   3   0   2   4   4   1   4   1   6   0
1995:    4   1   0   1   1   5   6   6   1   3   1   2
1996:    0   1   4   0   3   0   2   2   1   7   4  12
1997:    5   5   9   3   1   8   1   7   4   2   8   3
1998:    9   7   3   8   3   3   4   5   5   8   5   1
> SeasonalMannKendall(assault.2AMThuSat.ts)
tau = 0.328,   sl =0.6099%
> assault.3AMThuSat.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:    2   2   1   2   3   1   4   1   0   3   1   0
1995:    2   1   2   1   1   2   7   2   4   0   1   2
1996:    1   2   1   0   3   1   0   5   2   3   6   0
1997:    5   2   1   3   0   3   4   2   0   2   3   2
1998:    3   3   2   2   1   4   1   4   2   1   3   3
> SeasonalMannKendall(assault.3AMThuSat.ts)
tau = 0.211,   sl =8.443%
```

Figure 5a. STL Analysis

The seasonal component is reasonably stable. There is a slight increase in amplitude of the seasonal oscillations.

`R-sq = 43%`

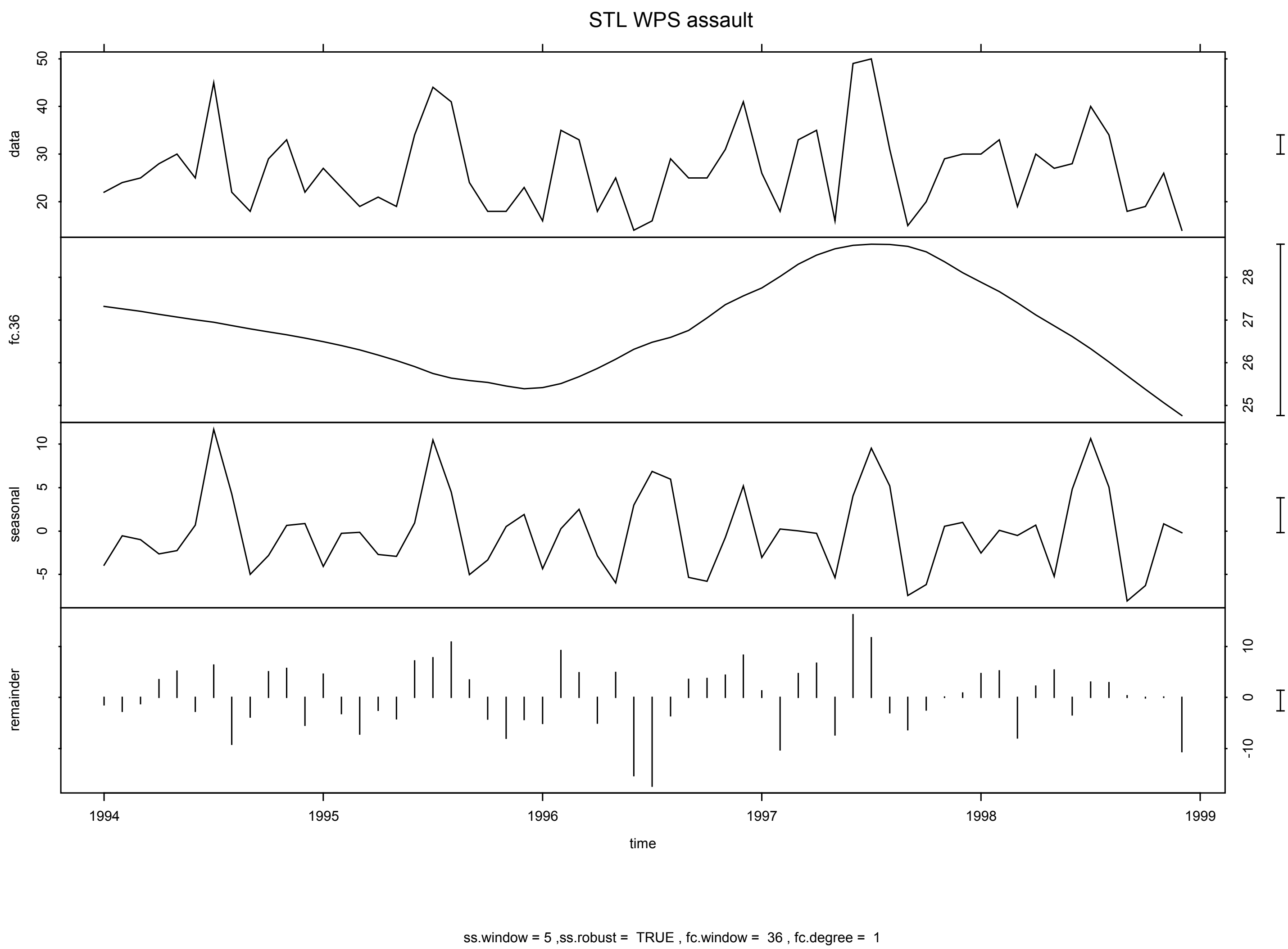


Figure 5b. Monthplot of Seasonal Component

The overall seasonal pattern is with March, July and December maxima and with January, May and September minimum. The seasonal is relatively stable. There are trends up in June and down in September and October.

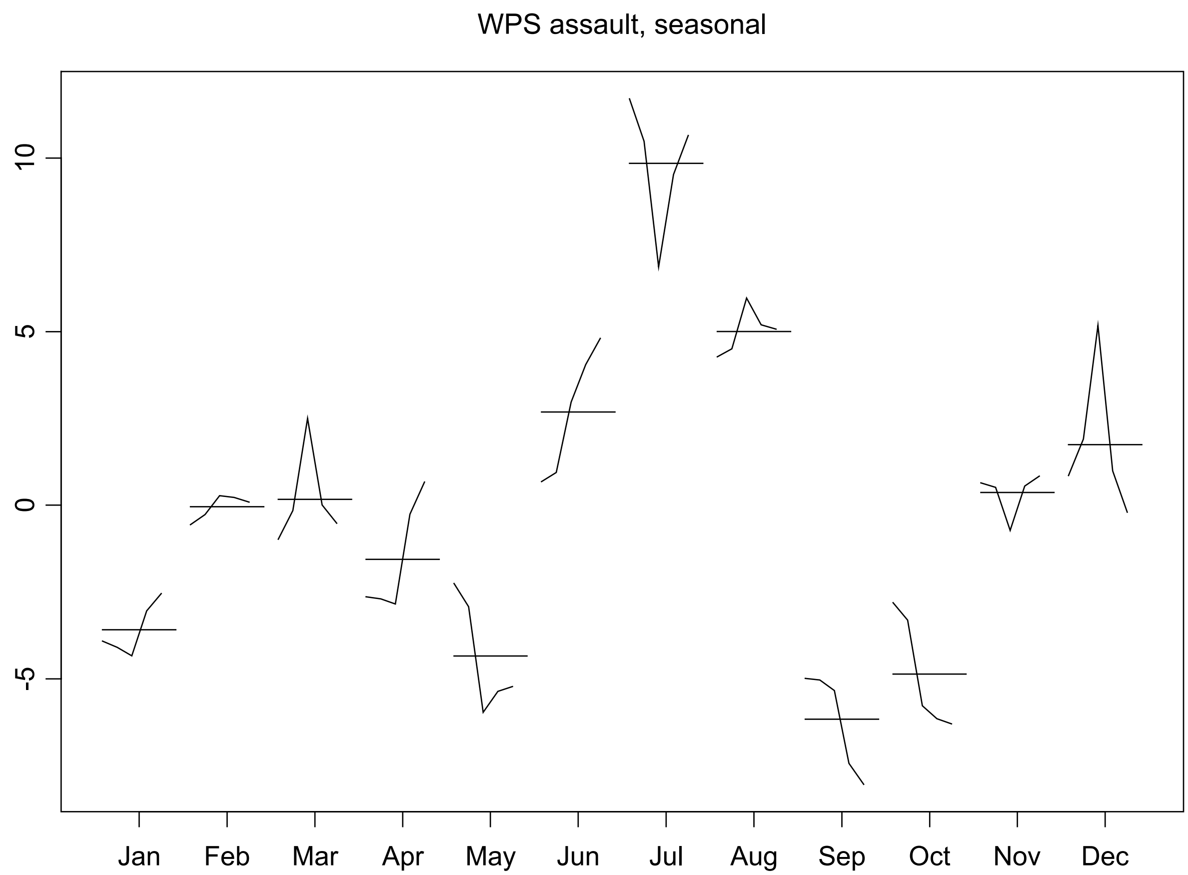
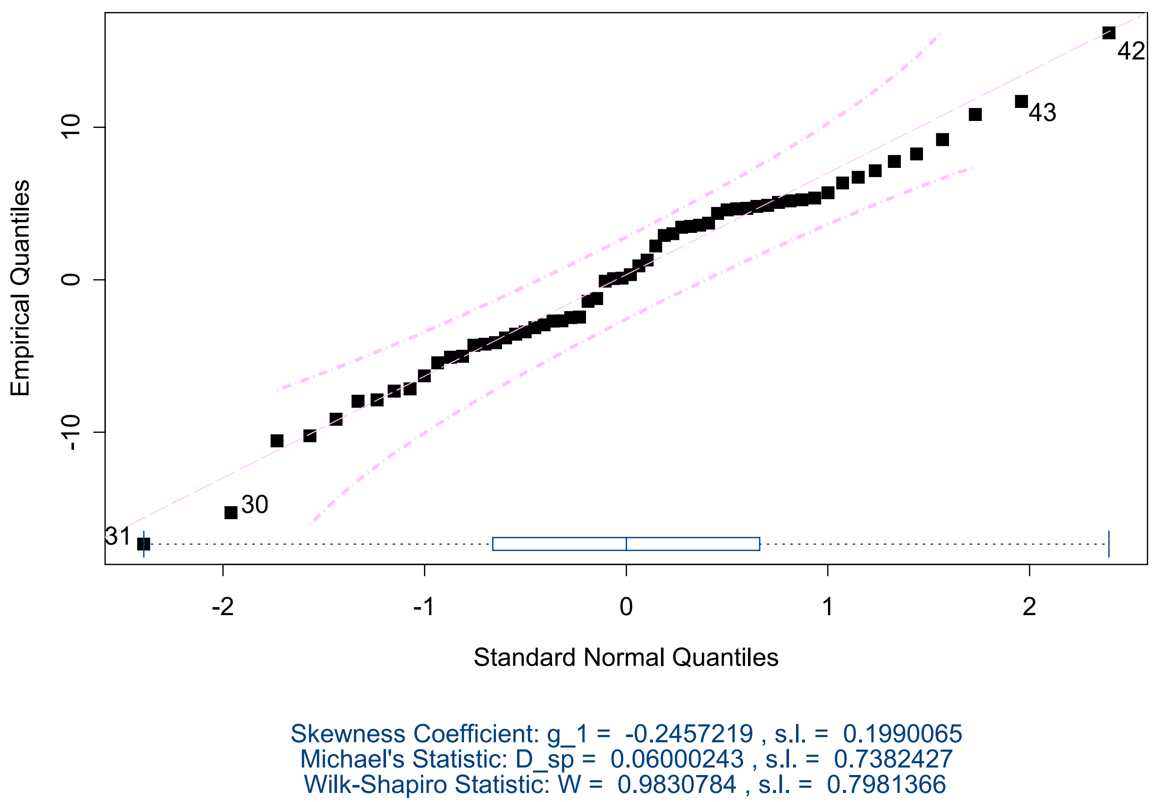


Figure 5c. Normal Probability Plot

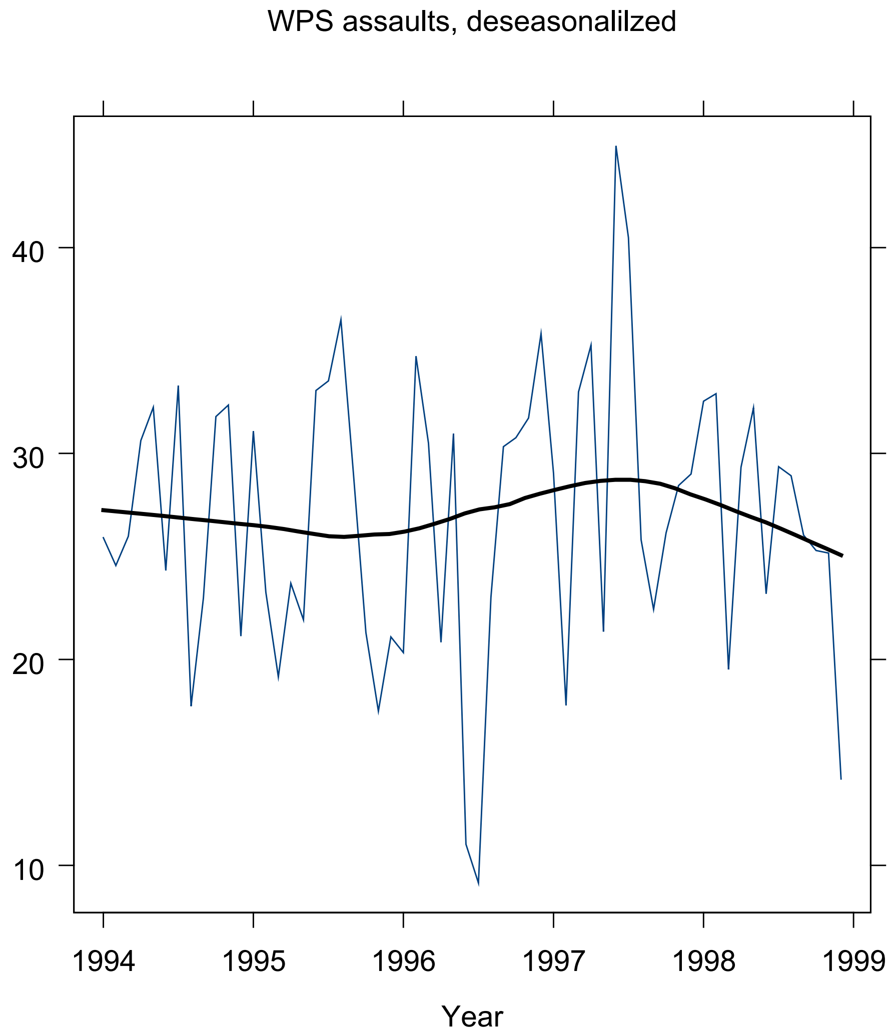
Several possible outliers are noted but all statistical tests for normality are fine.




```
> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   1   2   3   4   5   6   7   8   9  10  11  12
1995:  13  14  15  16  17  18  19  20  21  22  23  24
1996:  25  26  27  28  29  30  31  32  33  34  35  36
1997:  37  38  39  40  41  42  43  44  45  46  47  48
1998:  49  50  51  52  53  54  55  56  57  58  59  60
```

See Table 1.

Figure 5d.
Loess analysis of deseasonalized series
Mann-Kendall test: tau = 0.00565, sl =95.42%



H. WPS Dataset: Impaired

Summary

There were 1573 impaired driving charges in Windsor from January 1994 to December 1998.. Table 1.

Crosstabs. The ThuSat slot accounts for 56% of the impaired charges. About 33% of charges were in the 1AM slot and only 10% in the 3AM. Almost the same as with LPS impaired.

HOUR-WKGP: Unlike the LPS impaired the association between hour and wkgrp is statistically significant at less than 1%. SunWed at 1AM window has more than expected and SunWed at 2AM has fewer than expected if these factors were independent.

HOUR-YEAR: As would be expected from our loess analysis in Figure 3b and Figure 3c there has been a swing to later hours post 1996.

Figure 1a. and Figure 1b. In order to facilitate comparison with the LPS IMPAIRED series we will again use a log transformaton. The slope of the least-squares line is about -0.113619 which implies that impaired charges have been declining at the rate of about 7.6% per year over 1994 to 1998. There is a slight lack of fit of the least-squares line post 1996.

Figure 2. Both exhibit a nearly linear downward slope on log scale. The downward slope for SunWed is slightly greater. The table below shows the slope of the linear least squares fit to each group. Seasonal Mann-Kendall test is significant at <<1% for both cases.

Wkgrp	Slope of fit to log(data,2)	Annual rate of decrease %
SunWed	-0.119	7.9%
ThuSat	-0.109	7.3%

Figure 3a. and Figure 3b. The curves are all different. It is interesting that 2AM and 3AM actually increases after 1996 and the rate of decline for 1AM seems to have increased after 1996. I intend to model this data further with an intervention analysis.

Figure 4a and Figure 4b For SunWed 2AM and 3AM windows show an initial increase post-1996 but then a decline in recent years. SunWed 12AM the decline starting in 1994 flattens out in post-1996. SunWed-1AM there is a drop after 1996 but then it levels off. ThuSat shows strong monotonic decrease at 1AM and the rate seemed to increase slighlty post-1996. ThuSat also shows a strong increase at 2AM post-1996 and a small increase post-1996 for the ThuSat-3AM window. The linear decrease for ThuSat at 12AM seems to have flattened out post-1996 for both 11PM and 12AM.

Figure 5a. There is a linear downward trend on the log scale. The seasonal component has lots of local maxima and minima. R-sq = 63.4%

Figure 5b. Local maximum in January, March, April, August-September and November and local minimum in February, April, July and December. But the seasonal component is variable and shows a lot of changes over time. There is are increasing trends for February and March and a decreasing trend for October.

Figure 5c. The normality tests indicate no significant departure from normality in the remainder component.

Figure 5d. Deseasonalized time series trend analysis. Mann-Kendall test: `tau = -0.424, sl =1.779e-4%` The thicker line shows the linear least-squares fit and the thinner line shows the loess curve. The least-squares line has a slope of `-0.1129019` almost the same as in Figure 1b. A slight lack of fit of the linear least-squares line is evident. The residuals from the least-squares line are approximately normally distributed with no evident outliers and spread-level diagnostics do not reveal any monotone spread.

Crosstabs Analysis

Hour and wkgrp are associated

The `ThuSat` slot accounts for 56% of the impaired charges. About 33% of charges were in the 1AM slot and only 10% in the 3AM. Almost the same as with LPS impaired.

Unlike the LPS impaired the association between hour and wkgrp is statistically significant at less than 1%. SunWed at 1AM window has more than expected and SunWed at 2AM has fewer than expected if these factors were independent.

```
> crosstabs(counts~wkgrp+hour, data=wps.df, subset=wps.df$type=="impaired",
na.action=na.omit)
Call:
crosstabs(formula = counts ~ wkgrp + hour, data = wps.df, subset = wps.df$type ==
"impaired", na.action = na.omit)
2855 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |163    |209    |463    |296    |119    |1250   |
       |0.13   |0.17   |0.37   |0.24   |0.095  |0.44   |
       |0.48   |0.41   |0.49   |0.39   |0.41   |       |
       |0.057  |0.073  |0.16   |0.1    |0.042  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |178    |301    |486    |468    |172    |1605   |
       |0.11   |0.19   |0.3    |0.29   |0.11   |0.56   |
       |0.52   |0.59   |0.51   |0.61   |0.59   |       |
       |0.062  |0.11   |0.17   |0.16   |0.06   |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|341    |510    |949    |764    |291    |2855   |
       |0.12   |0.18   |0.33   |0.27   |0.1    |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 22.39313 d.f.= 4 (p=0.0001673517)
       Yates' correction not used

> get.crosstabs.percenterror(counts~wkgrp+hour)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]    9   -6   11  -12   -7
[2,]   -7    5   -9    9    5

> contrib(counts~wkgrp+hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  1.12 -0.96  2.33 -2.11 -0.74
[2,] -0.99  0.84 -2.06  1.86  0.66
```

Hour and Year are associated: As would be expected from our loess analysis in Figure 3b and Figure 3c there has been a swing to later hours post 1996.

```
> > crosstabs(counts~hour+year, data=wps.df, subset=wps.df$type=="impaired", na.action=na.omit)
Call:
crosstabs(formula = counts ~ hour + year, data = wps.df, subset = wps.df$type == "impaired",
    na.action = na.omit)
2855 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1994   |1995   |1996   |1997   |1998   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
11PM   | 81    | 85    | 60    | 48    | 67    |341    |
       |0.24   |0.25   |0.18   |0.14   |0.2    |0.12   |
       |0.12   |0.14   |0.1    |0.092  |0.14   |       |
       |0.028  |0.03   |0.021  |0.017  |0.023  |       |
-------+-------+-------+-------+-------+-------+-------+
12AM   |138    |108    | 86    | 88    | 90    |510    |
       |0.27   |0.21   |0.17   |0.17   |0.18   |0.18   |
       |0.21   |0.18   |0.15   |0.17   |0.18   |       |
       |0.048  |0.038  |0.03   |0.031  |0.032  |       |
-------+-------+-------+-------+-------+-------+-------+
1AM    |276    |241    |189    |127    |116    |949    |
       |0.29   |0.25   |0.2    |0.13   |0.12   |0.33   |
       |0.41   |0.41   |0.33   |0.24   |0.24   |       |
       |0.097  |0.084  |0.066  |0.044  |0.041  |       |
-------+-------+-------+-------+-------+-------+-------+
2AM    |124    |106    |185    |187    |162    |764    |
       |0.16   |0.14   |0.24   |0.24   |0.21   |0.27   |
       |0.19   |0.18   |0.32   |0.36   |0.33   |       |
       |0.043  |0.037  |0.065  |0.065  |0.057  |       |
-------+-------+-------+-------+-------+-------+-------+
3AM    | 50    | 53    | 59    | 74    | 55    |291    |
       |0.17   |0.18   |0.2    |0.25   |0.19   |0.1    |
       |0.075  |0.089  |0.1    |0.14   |0.11   |       |
       |0.018  |0.019  |0.021  |0.026  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|669    |593    |579    |524    |490    |2855   |
       |0.23   |0.21   |0.2    |0.18   |0.17   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
    Chi^2 = 141.2984 d.f.= 16 (p=0)
    Yates' correction not used
> get.crosstabs.percenterror(counts~hour+year)
Crosstabs - percentage error: 100*(Obs-Exp)/Exp,
     [,1] [,2] [,3] [,4] [,5]
[1,]    1   20  -13  -23   14
[2,]   15    2  -17   -6    3
[3,]   24   22   -2  -27  -29
[4,]  -31  -33   19   33   24
[5,]  -27  -12    0   39   10
> contrib(counts~hour+year)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  0.12  1.68 -1.10 -1.84  1.11
[2,]  1.69  0.20 -1.71 -0.58  0.26
[3,]  3.60  3.13 -0.25 -3.57 -3.67
[4,] -4.11 -4.18  2.41  3.95  2.70
[5,] -2.20 -0.96  0.00  2.82  0.72
```

WPS Impaired Data

The normality tests on the remainder component indicate the data may be assumed normal with no outliers. However the observations corresponding to the largest and smallest two residuals are identified below in bold red. Test for monotonic trend is significant at <<1%.

Table 1.

```
> imp.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   66  47  47  81  47  47  66  51  63  46  56  52
1995:   66  45  46  51  55  40  37  46  57  65  49  36
1996:   50  43  51  38  50  53  37  49  45  54  69  40
1997:   63  49  55  27  49  38  28  46  30  50  56  33
1998:   47  42  48  51  33  22  43  39  33  37  51  44

> SeasonalMannKendall(imp.ts)
tau = -0.4,   sl =0.07634%
```

.

Figure 1.

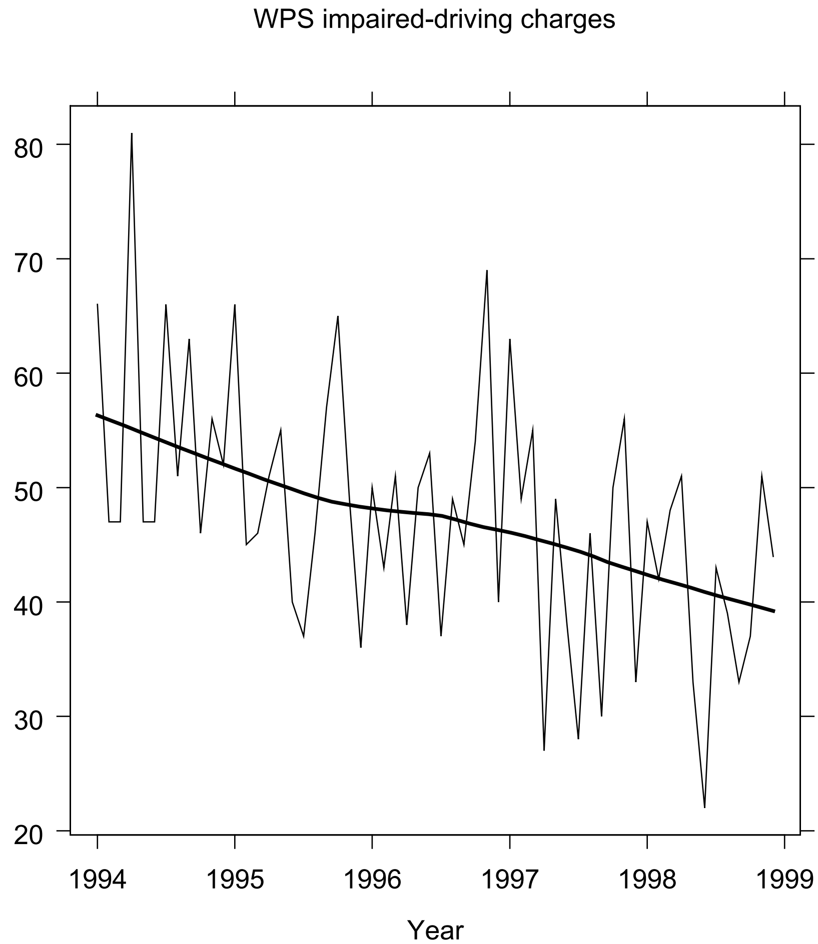

WPS impaired-driving charges
80
70
60
50
40
30
20
1994
1995
1996
1997
1998
1999
Year

Figure 1b. Logged series

In order to facilitate comparison with the LPS IMPAIRED series we will again use a log transformaton. Figure 1b shows the time series after a log transformation. Specifically a log to the base 2 transformation. This particular version of the log transformation means that we can interpret a one unit change as a doubling and an increase by 0.5 units on the vertical scale corresponds to an increase of about 41% in the original data.

The transformation reveals that the decline in impaired charges is almost linear. Figure 1b shows a thicker line that corresponds to the least squares linear fit. The loess curve is the thinner line which stops at the last observed data value. There is a slight lack of fit of the least-squares line post 1996. The slope of the least-squares line is about `-0.113619` which implies that impaired charges have been declining at the rate of about 7.6% per year over 1994 to 1998.
Note: $1-2^{-0.113619} \approx 0.07573337$

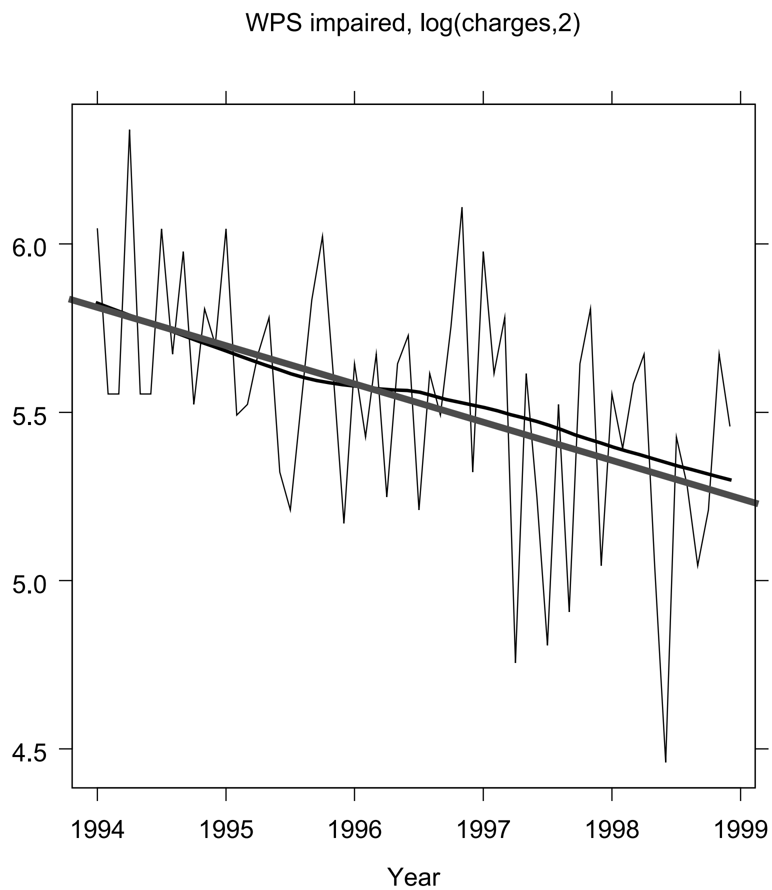


Figure 2. By wkgrp.

Both exhibit a nearly linear downward slope on log scale. The downward slope for SunWed is slightly greater. The table below shows the slope of the linear least squares fit to each group. Seasonal Mann-Kendall test is significant at <<1% for both cases.

Wkgrp	Slope of fit to log(data,2)	Annual rate of decrease %
SunWed	-0.119	7.9%
ThuSat	-0.109	7.3%

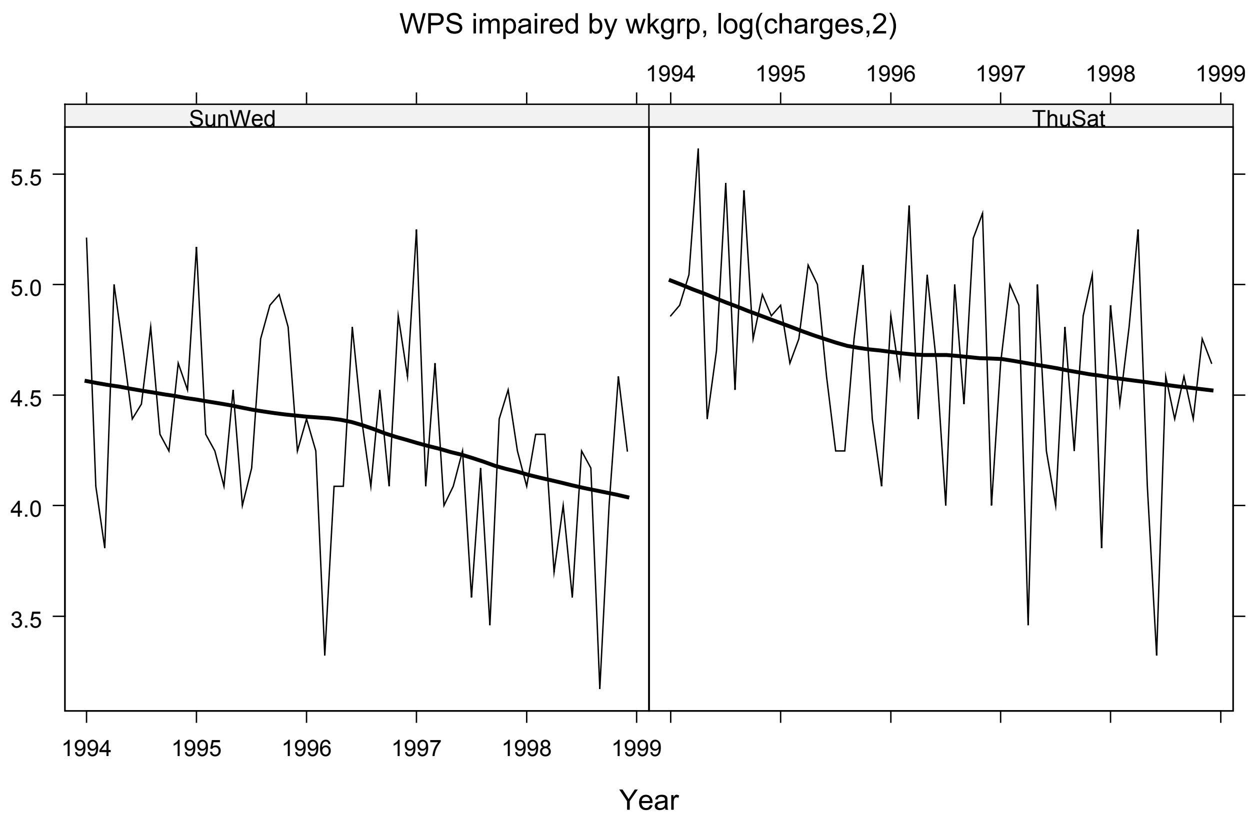


Table 2.

```
> imp.SunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  37  17  14  32  26  21  22  28  20  19  25  23
1995:  36  20  19  17  23  16  18  27  30  31  28  19
1996:  21  19  10  17  17  28  21  17  23  17  29  24
1997:  38  17  25  16  17  19  12  18  11  21  23  19
1998:  17  20  20  13  16  12  19  18   9  16  24  19
> SeasonalMannKendall(imp.SunWed.ts)
tau = -0.38,   sl =0.1468%

> imp.ThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  29  30  33  49  21  26  44  23  43  27  31  29
1995:  30  25  27  34  32  24  19  19  27  34  21  17
1996:  29  24  41  21  33  25  16  32  22  37  40  16
1997:  25  32  30  11  32  19  16  28  19  29  33  14
1998:  30  22  28  38  17  10  24  21  24  21  27  25
> SeasonalMannKendall(imp.ThuSat.ts)
tau = -0.288,   sl =1.516%
```

Figure 3a. By hour. Common Scaling

The curves are all different. It is interesting that 2AM and 3AM actually increases after 1996 and the rate of decline for 1AM seems to have increased after 1996. I intend to model this data further with an intervention analysis.

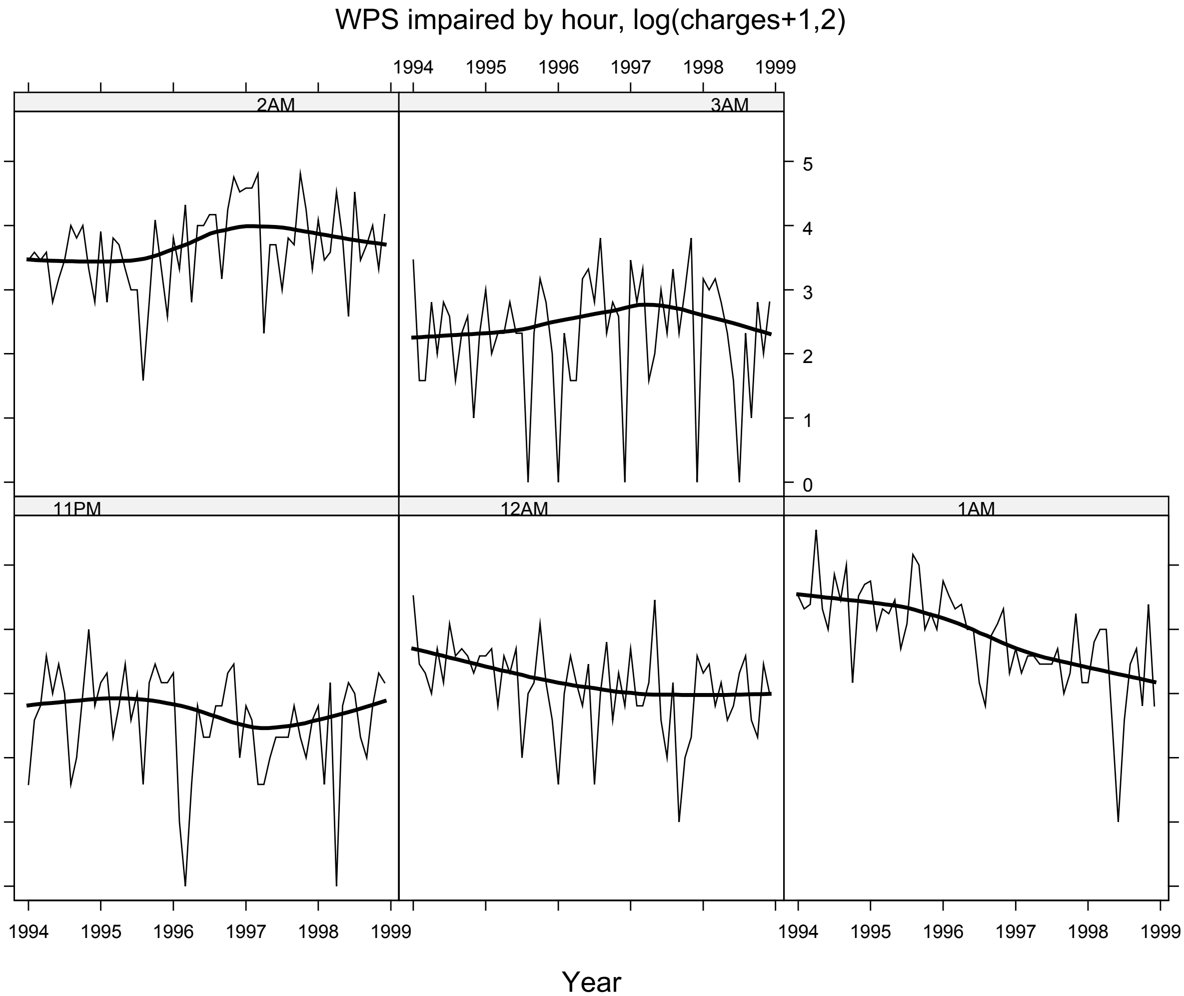


Figure 3b. By hour. Independent vertical scaling.

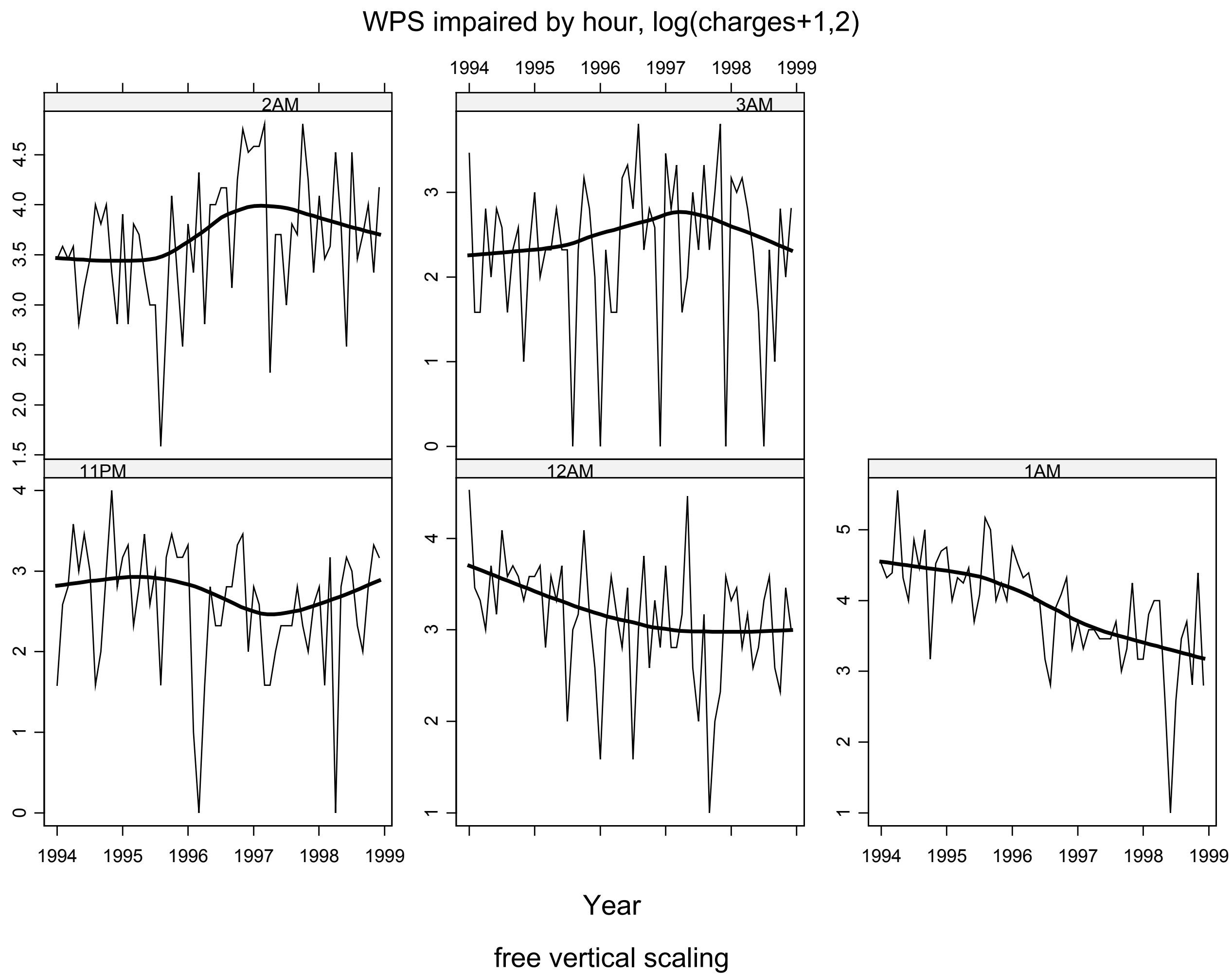
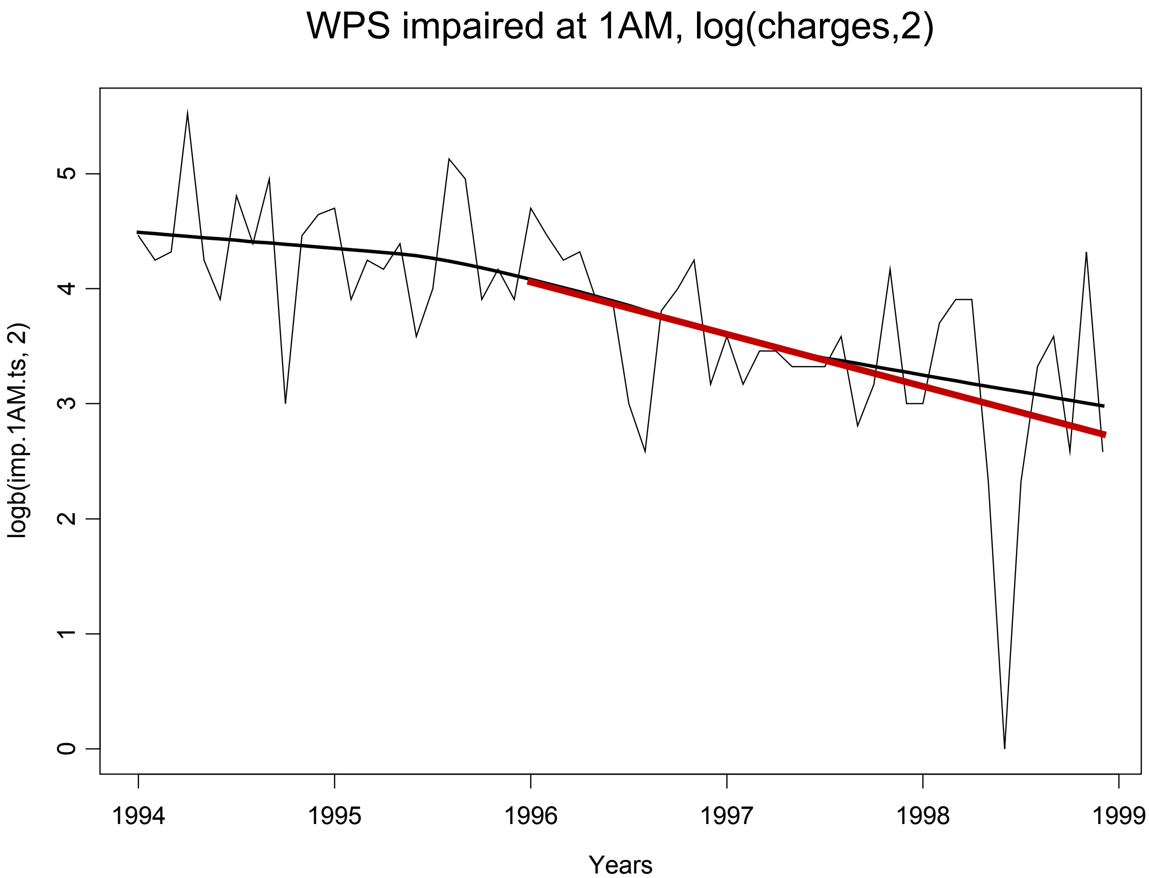


Figure 3c.

Least square line fit (thick red line) to data from 1996 to present. The slope of the least squares line to post-1996 is -0.453 which corresponds to a annual rate of decrease of about 27.0%. Since 1998, the actual impaired driving charges are decreasing slightly slower than this.

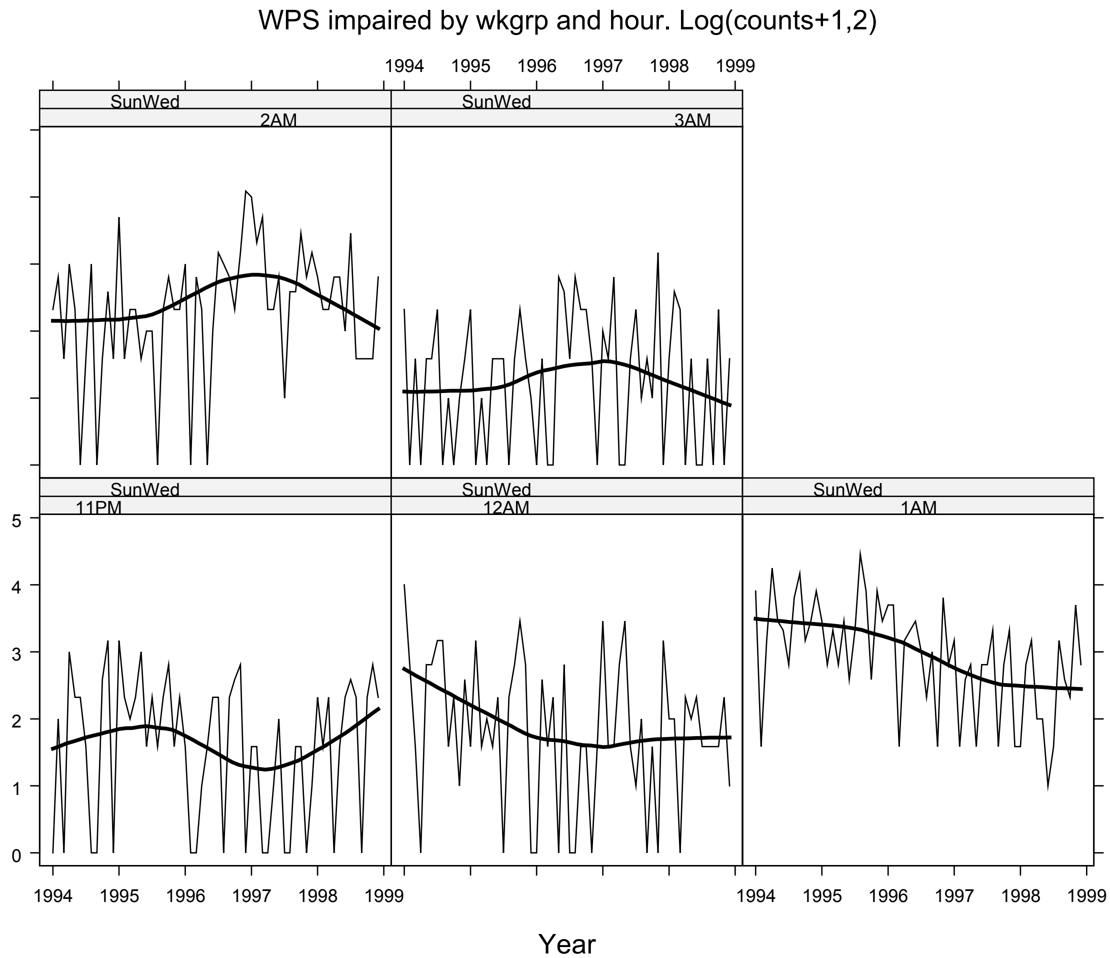


Tabulation and Mann-Kendall Tests

```
> imp.11PM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   2   5   6  11   7  10   7   2   3   7  15   6
1995:   8   9   4   6  10   5   7   2   8  10   8   8
1996:   9   1   0   2   6   4   4   6   6   9  10   3
1997:   6   5   2   2   3   4   4   4   6   4   3   5
1998:   6   2   8   0   6   8   7   4   3   6   9   8
> SeasonalMannKendall(imp.11PM.ts)
tau = -0.231,   sl =5.615%

> imp.12AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  22  10   9   7  12   8  16  11  12  11   9  11
1995:  11  12   6  11   9  12   3   7   8  16   8   5
1996:   2   7  11   8   6  10   2   7  13   5   9   6
1997:  12   6   6   8  21   5   3   8   1   3   4  11
1998:   9  10   6   8   5   6   9  11   5   4  10   7
> SeasonalMannKendall(imp.12AM.ts)
tau = -0.211,   sl =7.898%

> imp.1AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  22  19  20  46  19  15  28  21  31   8  22  25
1995:  26  15  19  18  21  12  16  35  31  15  18  15
1996:  26  22  19  20  15  15   8   6  14  16  19   9
1997:  12   9  11  11  10  10  10  12   7   9  18   8
1998:   8  13  15  15   5   1   5  10  12   6  20   6
> SeasonalMannKendall(imp.1AM.ts)
tau = -0.588,   sl =7.765e-5%

> imp.2AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  10  11  10  11   6   8  10  15  13  15   9   6
1995:  14   6  13  12   9   7   7   2   6  16   9   5
1996:  13   9  19   6  15  15  17  17   8  18  26  22
1997:  23  23  27   4  12  12   7  13  12  27  18   9
1998:  16  10  11  22  13   5  22  10  12  15   9  17
> SeasonalMannKendall(imp.2AM.ts)
tau = 0.223,   sl =6.15%

> imp.3AM.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  10   2   2   6   3   6   5   2   4   5   1   4
1995:   7   3   4   4   6   4   4   0   4   8   6   3
1996:   0   4   2   2   8   9   6  13   4   6   5   0
1997:  10   6   9   2   3   7   4   9   4   7  13   0
1998:   8   7   8   6   4   2   0   4   1   6   3   6
> SeasonalMannKendall(imp.3AM.ts)
tau = 0.0535,   sl =65.77%
```

Figure 4a. By hour and wkgrp. Common Scaling.

For SunWed 2AM and 3AM windows show an initial increase post-1996 but then a decline in recent years. SunWed 12AM the decline starting in 1994 flattens out in post-1996. SunWed-1AM there is a drop after 1996 but then it levels off.



ThuSat shows strong monotonic decrease at 1AM and the rate seemed to increase slighlty post-1996. ThuSat also shows a strong increase at 2AM post-1996 and a small increase post-1996 for the ThuSat-3AM window. The linear decrease for ThuSat at 12AM seems to have flattened out post-1996 for both 11PM and 12AM.

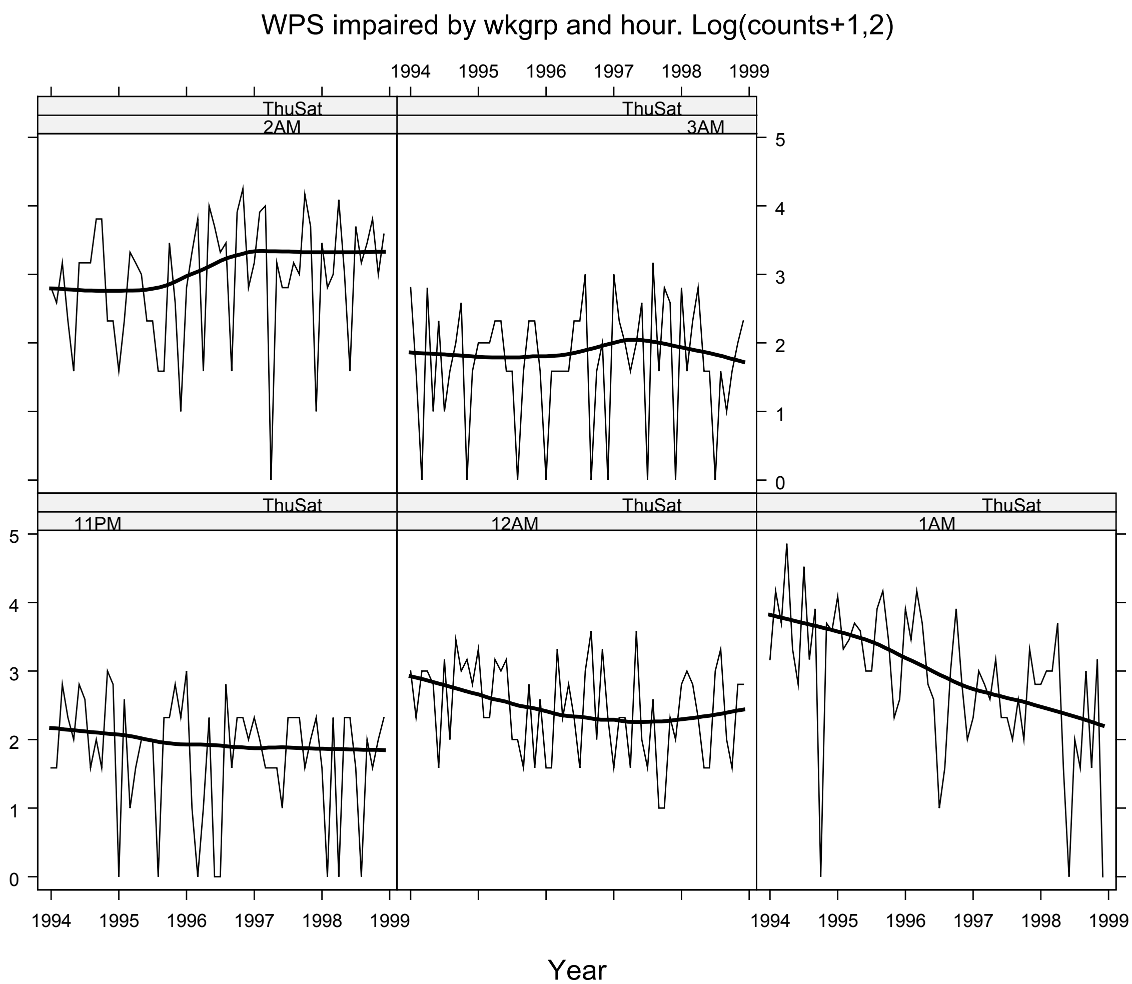
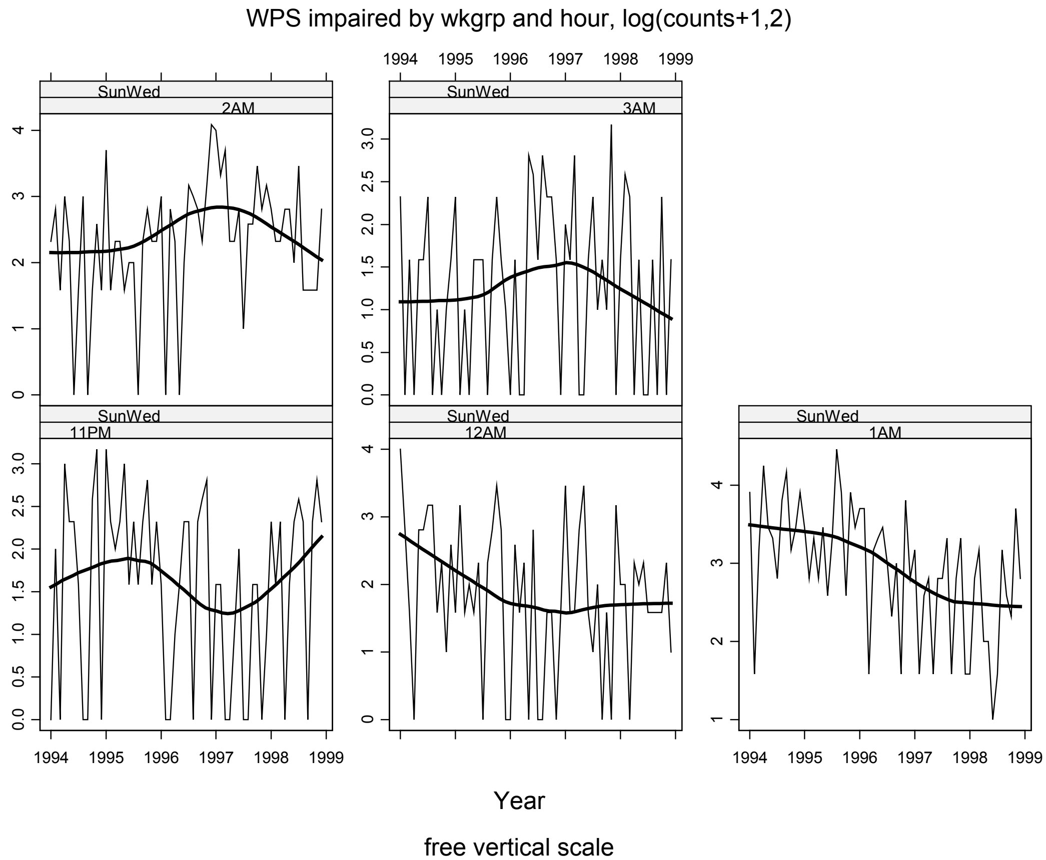
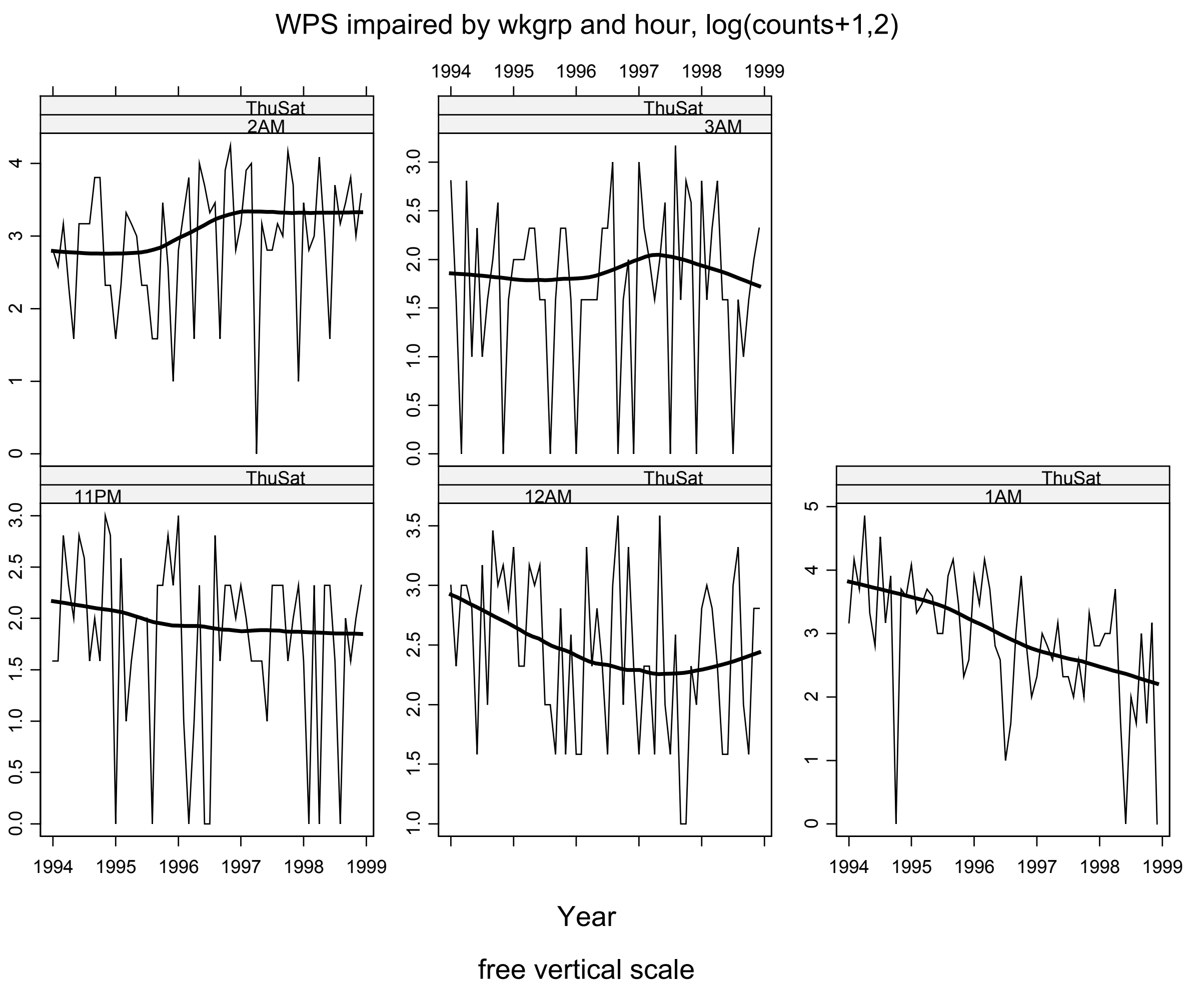


Figure 4b. By hour and wkgrp. Independent Scaling.

Cf. Figure 1b




WPS impaired by wkgrp and hour, log(counts+1,2)
ThuSat
2AM
3AM
11PM
12AM
1AM
Year
free vertical scale

Tabulations and Seasonal Mann-Kendall Tests

```
> imp.11PMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   0   3   0   7   4   4   2   0   0   5   8   0
1995:   8   4   3   4   7   2   4   2   4   6   2   4
1996:   2   0   0   1   2   4   4   0   4   5   6   0
1997:   2   2   0   0   1   3   0   0   2   2   0   1
1998:   4   2   4   0   2   4   5   4   0   4   6   4
> SeasonalMannKendall(imp.11PMSunWed.ts)
tau = -0.0914,   sl =45.35%
```

```
> imp.12AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  15   6   2   0   6   6   8   8   2   4   1   5
1995:   2   8   2   3   2   4   0   4   6  10   6   0
1996:   0   5   2   4   0   6   0   0   2   2   0   2
1997:  10   2   2   6  10   2   1   3   0   2   0   8
1998:   3   3   0   4   3   4   2   2   2   2   4   1
> SeasonalMannKendall(imp.12AMSunWed.ts)
```
tau = -0.208,   sl =8.56%

```
> imp.1AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:  14   2   8  18  10   9   6  13  17   8  10  14
1995:  10   6   9   6  10   5   9  21  14   5  14  10
1996:  12  12   2   8   9  10   7   4   7   2  13   6
1997:   8   2   5   6   2   6   6   9   2   6   9   2
1998:   2   6   8   3   3   1   2   8   5   4  12   6
> SeasonalMannKendall(imp.1AMSunWed.ts)
```
tau = -0.473,   sl =0.007527%

```
> imp.2AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   4   6   2   7   4   0   2   7   0   2   5   2
1995:  12   2   4   4   2   3   3   0   4   6   4   4
1996:   7   0   6   4   0   3   8   7   6   4   8  16
1997:  15   9  12   4   4   6   1   5   5  10   6   8
1998:   6   4   4   6   6   3  10   2   2   2   2   6
> SeasonalMannKendall(imp.2AMSunWed.ts)
tau = 0.174,   sl =14.54%
```

```
> imp.3AMSunWed.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   4   0   2   0   2   2   4   0   1   0   1   2
1995:   4   0   1   0   2   2   2   0   2   4   2   1
1996:   0   2   0   0   6   5   2   6   4   4   2   0
1997:   3   2   6   0   0   2   4   1   2   1   8   0
1998:   2   5   4   0   2   0   0   2   0   4   0   2
> SeasonalMannKendall(imp.3AMSunWed.ts)
tau = 0.03,   sl =81.39%
```

```
imp.11PMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   2   2   6   4   3   6   5   2   3   2   7   6
1995:   0   5   1   2   3   3   3   0   4   4   6   4
1996:   7   1   0   1   4   0   0   6   2   4   4   3
1997:   4   3   2   2   2   1   4   4   4   2   3   4
1998:   2   0   4   0   4   4   2   0   3   2   3   4
> SeasonalMannKendall(imp.11PMThuSat.ts)
tau = -0.259,   sl =3.237%

> imp.12AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   7   4   7   7   6   2   8   3  10   7   8   6
1995:   9   4   4   8   7   8   3   3   2   6   2   5
1996:   2   2   9   4   6   4   2   7  11   3   9   4
1997:   2   4   4   2  11   3   2   5   1   1   4   3
1998:   6   7   6   4   2   2   7   9   3   2   6   6
> SeasonalMannKendall(imp.12AMThuSat.ts)
tau = -0.166,   sl =16.62%

> imp.1AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   8  17  12  28   9   6  22   8  14   0  12  11
1995:  16   9  10  12  11   7   7  14  17  10   4   5
1996:  14  10  17  12   6   5   1   2   7  14   6   3
1997:   4   7   6   5   8   4   4   3   5   3   9   6
1998:   6   7   7  12   2   0   3   2   7   2   8   0
> SeasonalMannKendall(imp.1AMThuSat.ts)
tau = -0.479,   sl =0.005638%

> imp.2AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   6   5   8   4   2   8   8   8  13  13   4   4
1995:   2   4   9   8   7   4   4   2   2  10   5   1
1996:   6   9  13   2  15  12   9  10   2  14  18   6
1997:   8  14  15   0   8   6   6   8   7  17  12   1
1998:  10   6   7  16   7   2  12   8  10  13   7  11
> SeasonalMannKendall(imp.2AMThuSat.ts)
tau = 0.242,   sl =4.295%

> imp.3AMThuSat.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1994:   6   2   0   6   1   4   1   2   3   5   0   2
1995:   3   3   3   4   4   2   2   0   2   4   4   2
1996:   0   2   2   2   2   4   4   7   0   2   3   0
1997:   7   4   3   2   3   5   0   8   2   6   5   0
1998:   6   2   4   6   2   2   0   2   1   2   3   4
> SeasonalMannKendall(imp.3AMThuSat.ts)
tau = 0.027,   sl =82.42%
```

Figure 5a. STL Analysis

There is a linear downward trend on the log scale. The seasonal component has lots of local maxima and minima.

`R-sq =  63.4%`

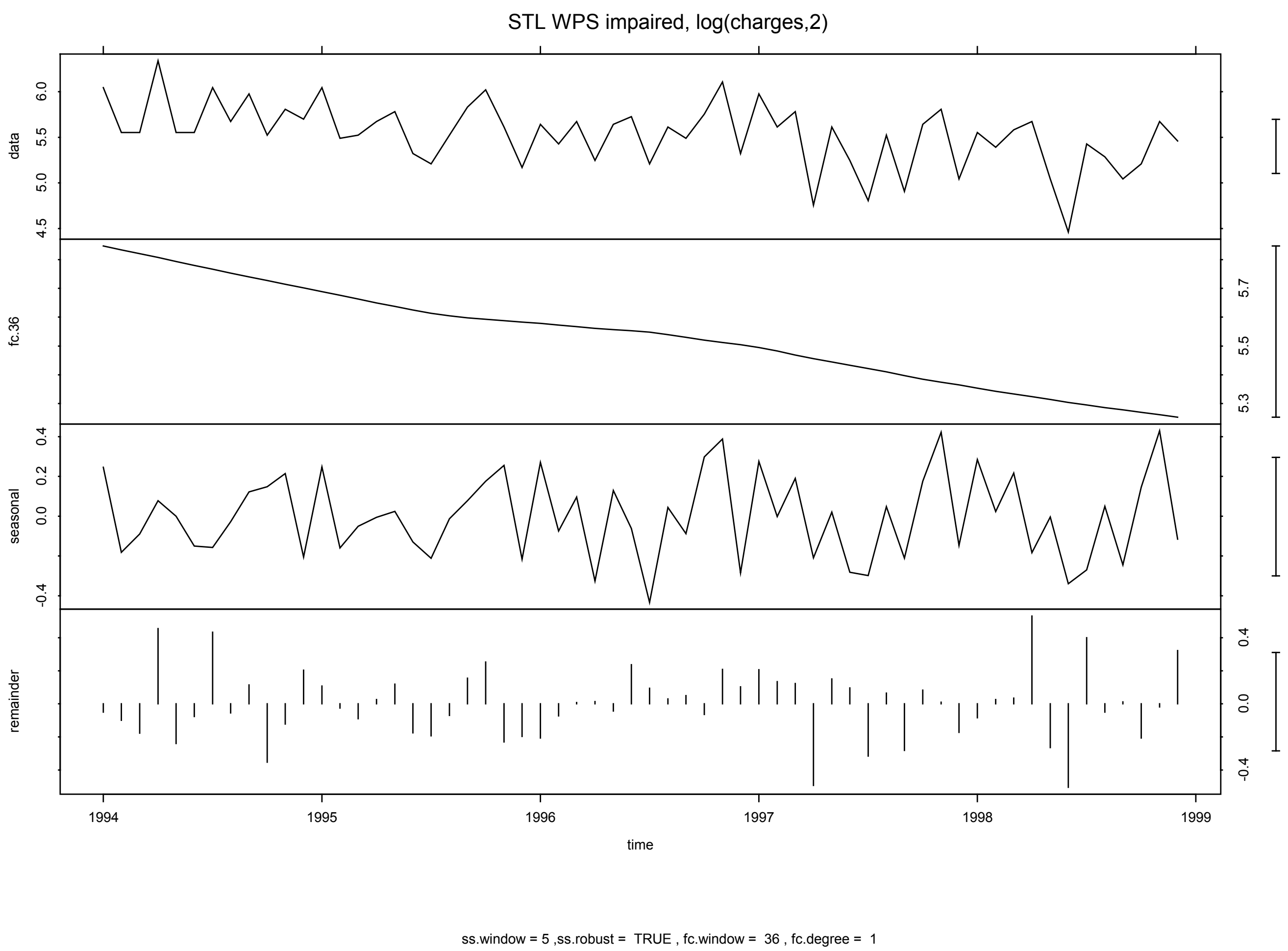


Figure 5b. Monthplot of Seasonal Component

Local maximum in January, March, April, August-September and November and local minimum in February, April, July and December. But the seasonal component is variable and shows a lot of changes over time. There is are increasing trends for February and March and a decreasing trend for October.

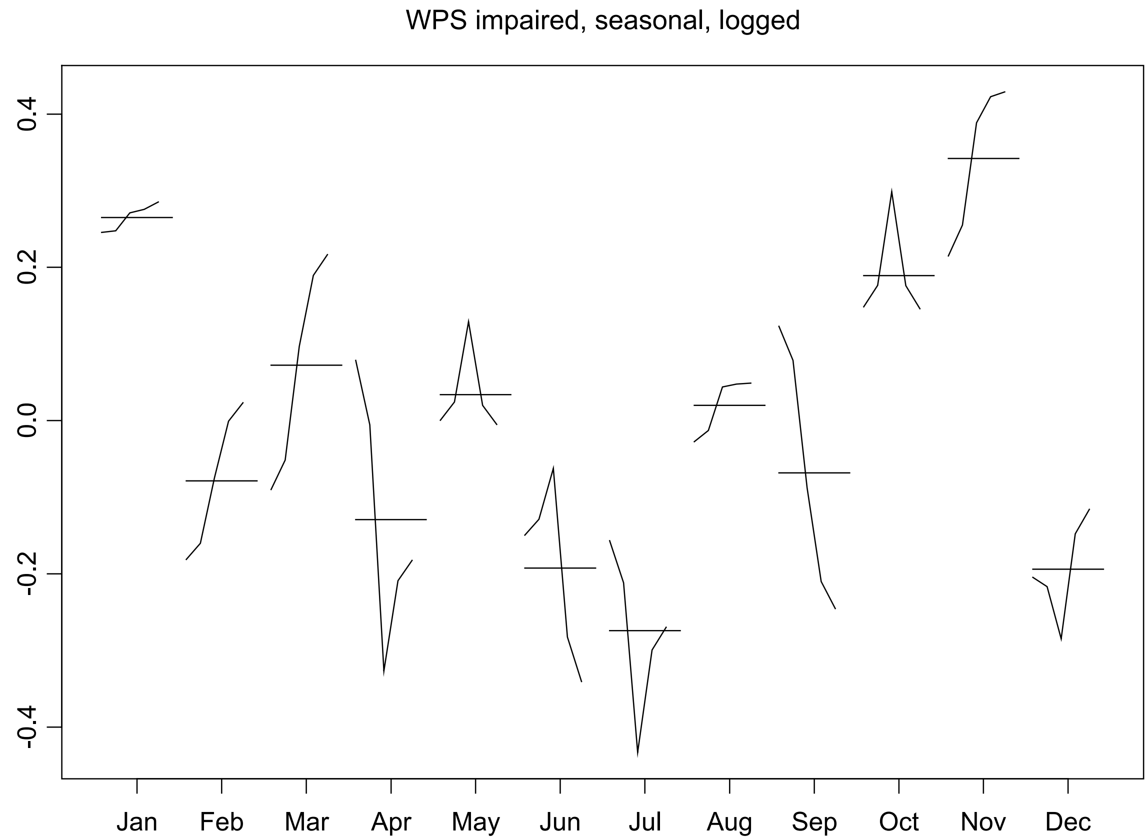
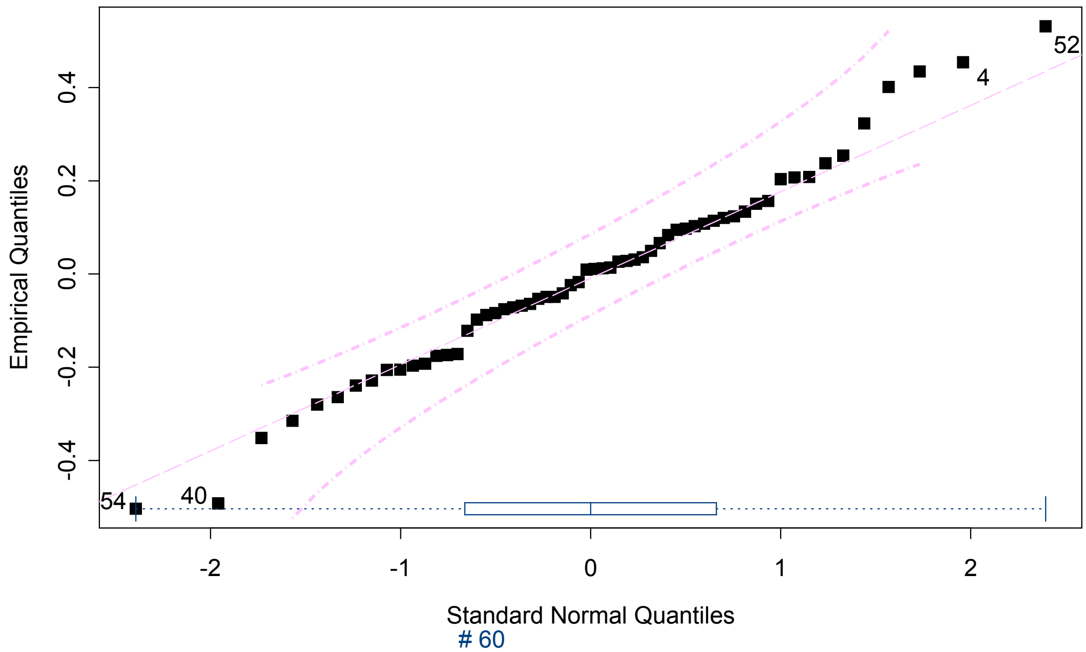


Figure 5c. Normal Probability Plot

The normality tests indicate no significant departure from normality in the remainder component.



Skewness Coefficient: g_1 = 0.1242394 , s.l. = 0.3333537
Michael's Statistic: D_sp = 0.0486953 , s.l. = 0.580161
Wilk-Shapiro Statistic: W = 0.982025 , s.l. = 0.7582085

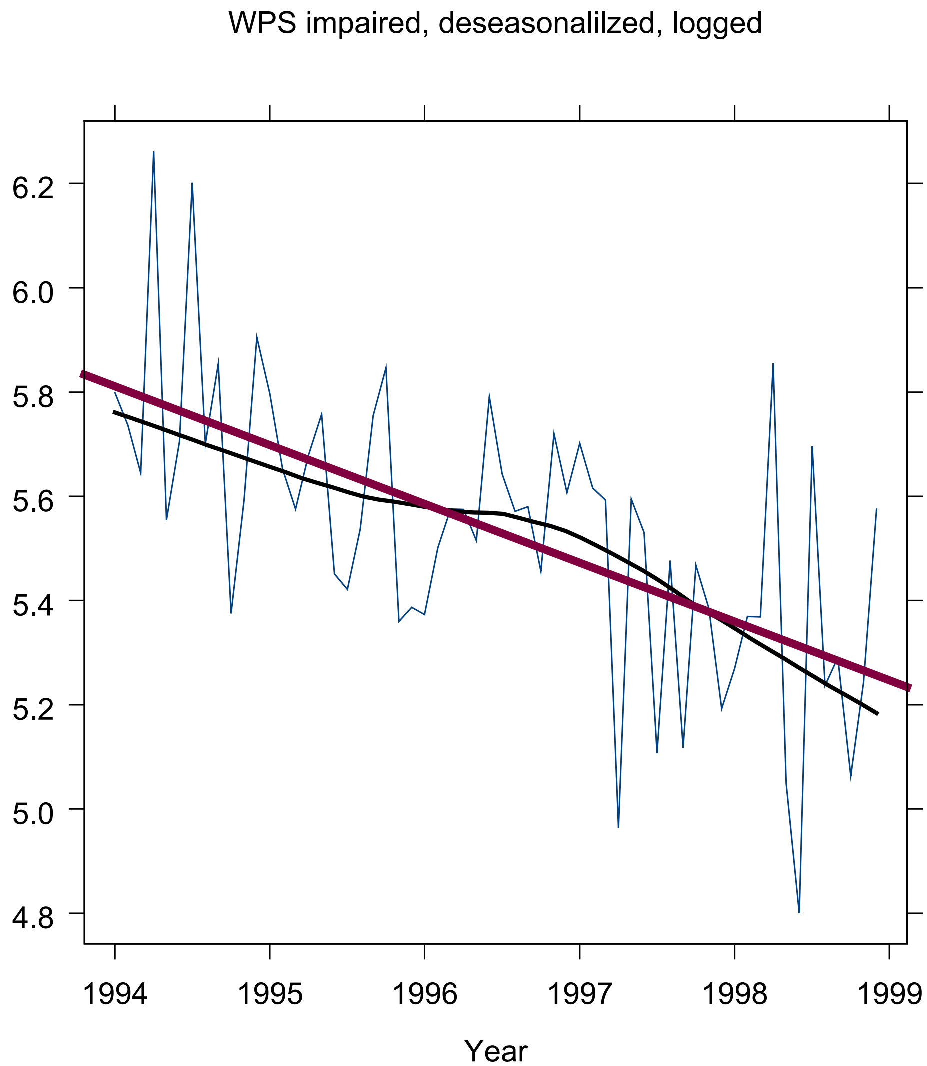
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994:	1	2	3	**4**	5	6	7	8	9	10	11	12
1995:	13	14	15	16	17	18	19	20	21	22	23	24
1996:	25	26	27	28	29	30	31	32	33	34	35	36
1997:	37	38	39	**40**	41	42	43	44	45	46	47	48
1998:	49	50	51	**52**	53	**54**	55	56	57	58	59	60

See Table 1.

Figure 5d.
Loess analysis of deseasonalized series

Mann-Kendall test: `tau = -0.424, sl =1.779e-4%`

The thicker line shows the linear least-squares fit and the thinner line shows the loess curve. The least-squares line has a slope of `-0.1129019` almost the same as in Figure 1b. A slight lack of fit of the linear least-squares line is evident. The residuals from the least-squares line are approximately normally distributed with no evident outliers and spread-level diagnostics do not reveal any monotone spread.



I. FARS Dataset

Introduction

Fatality Accident Reporting System (FARS)
Michigan and New York States
May 1992 to December 1999, 3956 records
Each record in the database corresponds to an accident in which one or more fatalities occurred between the hours of 11PM and 4AM. The number of fatalities is in the field occ#. This field was used to compute the number of deaths in an aggregated dataset. This aggregated datasets gives the number of deaths for each combination of the following factors:

Factors/Covariates of Interest:
`year` - year of accident (ordered factor)
`month` - month of accident (ordered factor)
`wkgrp` - ordered factor variable with labels "SunWed" and "ThuSat"
`hour` - ordered factor with levels "11PM", "12AM", "1AM", "2AM", "3AM"
`bacfactor` - levels: "absent", "present"

Response Variables:
FARS Deaths (Totals)
FARS Deaths with bacfactor present
FARS Deaths with bacfactor absent
It should be noted that Totals is not just the sum of the other two. There are 45% more data in the totals because so many BAC measurements are missing.

I. FARS Dataset

Summary

ThuSat accounts for 86% of deaths. Among the hour groups 2AM slot (ie. 2AM to 3AM) accounted for most deaths (24%) while 3AM to 4AM (16%) the least and deaths where uniformly distributed over 11PM to 2AM. Of course the traffic intensities might be expected to be less in some cases. The larger number of deaths in the 2AM slot could be due to the patrons of bars leaving at closing time.

BAC is missing in 38% of the records which corresponds to 45% of the deaths. For the remaining 3205 deaths, alcohol was involved about 70% of the time. Crosstabs analysis shows that this percentage, 70%, has not changed over the years. This suggests that the no-drinking & driving campaigns have not been very effective and improvements are due to other safety factors such as day-time running lights, increased use of seatbealts and airbags and improved car design.

Many of the crosstab analyses that were done are statistically significant.

Crosstab Analysis

Wkgrp and hour not independent (significant at 0.09%).

The SunWed group has the strongest interactions with hour. There are 20% more deaths at in the 12AM slot in SunWed than would be expected under the hypothesis of independence. Recall this actually means deaths on Monday not Sunday.

```
Call:
crosstabs(deaths ~ wkgrp + hour, data = fars.df, na.action = na.exclude)
5794 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed | 156   | 195   | 180   | 173   | 109   |813    |
       |0.192  |0.240  |0.221  |0.213  |0.134  |0.14   |
       |0.131  |0.169  |0.159  |0.122  |0.121  |       |
       |0.027  |0.034  |0.031  |0.030  |0.019  |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |1038   | 959   | 952   |1242   | 790   |4981   |
       |0.208  |0.193  |0.191  |0.249  |0.159  |0.86   |
       |0.869  |0.831  |0.841  |0.878  |0.879  |       |
       |0.179  |0.166  |0.164  |0.214  |0.136  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|1194   |1154   |1132   |1415   |899    |5794   |
       |0.21   |0.20   |0.20   |0.24   |0.16   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 18.59653 d.f.= 4 (p=0.0009431474)
       Yates' correction not used
```

```
>Contribution to chi-sq:
       [,1]  [,2]  [,3]  [,4]  [,5]
[1,] -0.89  2.60  1.68 -1.81 -1.53
[2,]  0.36 -1.05 -0.68  0.73  0.62
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~wkgrp+hour)
     [,1] [,2] [,3] [,4] [,5]
[1,]   -7   20   13  -13  -14
[2,]    1   -3   -2    2    2
```

Bacfactor is missing in about 38% of the cases but in the remaining 3205 deaths where bacfactor is available, 70% are with bacfactor at a positive level.

```
> sum(is.na(fars.df$bacfactor))/nrow(fars.df)
[1] 0.3789181
```

alcohol is present in 70% of the deaths

```
Call:
crosstabs(deaths ~ bacfactor, data = fars.df, na.action = na.exclude)
3205 cases in table

+-------+
|N      |
|N/Total|
+-------+
bacfactor|
-------+-------+
absent | 969   |
       |0.3    |
-------+-------+
present|2236   |
       |0.7    |
-------+-------+
```

Bacfactor and hour are not independent

The most marked effect is occurs with bacfactor interaction with 11PM. There are 40% more deaths with bacfactor absent at 11PM than would be expected under independence of the classifications.

```
Call:
crosstabs(deaths ~ bacfactor + hour, data = fars.df, na.action = na.exclude)
3205 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
bacfactor|hour
       |11PM   |12AM   |1AM    |2AM    |3AM    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
absent |266    |175    |179    |213    |136    |969    |
       |0.275  |0.181  |0.185  |0.220  |0.140  |0.3    |
       |0.423  |0.282  |0.275  |0.268  |0.266  |       |
       |0.083  |0.055  |0.056  |0.066  |0.042  |       |
-------+-------+-------+-------+-------+-------+-------+
present|363    |445    |471    |582    |375    |2236   |
       |0.162  |0.199  |0.211  |0.260  |0.168  |0.7    |
       |0.577  |0.718  |0.725  |0.732  |0.734  |       |
       |0.113  |0.139  |0.147  |0.182  |0.117  |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|629    |620    |650    |795    |511    |3205   |
       |0.20   |0.19   |0.20   |0.25   |0.16   |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 54.40057 d.f.= 4 (p=4.338307e-011)
       Yates' correction not used
```

```
Contribution to chi-sq:
       [,1]  [,2]  [,3]  [,4]  [,5]
[1,]  5.50 -0.91 -1.25 -1.76 -1.49
[2,] -3.62  0.60  0.82  1.16  0.98
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~bacfactor+hour)
     [,1] [,2] [,3] [,4] [,5]
[1,]   40   -7   -9  -11  -12
[2,]  -17    3    4    5    5
```

Bacfactor and wkgrp are nearly independent.

Although, bacfactor and wkgrp are statistically not independent (at 5% just), the degree of dependence is very small. There are 14% fewer deaths in the SunWed group with bacfactor absent than would be expected.

```
Call:
crosstabs(deaths ~ bacfactor + wkgrp, data = fars.df, na.action = na.exclude)
3205 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
bacfactor|wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
absent | 111   | 858   |969    |
       |0.115  |0.885  |0.3    |
       |0.261  |0.309  |       |
       |0.035  |0.268  |       |
-------+-------+-------+-------+
present| 314   |1922   |2236   |
       |0.140  |0.860  |0.7    |
       |0.739  |0.691  |       |
       |0.098  |0.600  |       |
-------+-------+-------+-------+
ColTotl|425    |2780   |3205   |
       |0.13   |0.87   |       |
-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 3.936043 d.f.= 1 (p=0.04726182)
       Yates' correction not used
```

```
> contrib(deaths~bacfactor+wkgrp)
Contribution to chi-sq:
      [,1] [,2]
[1,] -1.54  0.6
[2,]  1.02 -0.4
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~bacfactor+wkgrp)
     [,1] [,2]
[1,]  -14    2
[2,]    6   -1
```

Month and bacfactor are independent. The last table on this page shows that there are 18% more deaths in BAC absent in Jun than expected. But the overall test is not close to being significant.

```
> crosstabs( deaths~bacfactor+month, data = fars.df, na.action = na.exclude)
Call:
crosstabs(deaths ~ bacfactor + month, data = fars.df, na.action = na.exclude)
3205 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
bacfactor|month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
absent | 50    | 49    | 58    | 78    | 91    |106    |108    |115    | 94    | 94    | 67    | 59    |969    |
       |0.052  |0.051  |0.060  |0.080  |0.094  |0.109  |0.111  |0.119  |0.097  |0.097  |0.069  |0.061  |0.3    |
       |0.286  |0.262  |0.283  |0.328  |0.302  |0.358  |0.314  |0.330  |0.311  |0.276  |0.264  |0.276  |       |
       |0.016  |0.015  |0.018  |0.024  |0.028  |0.033  |0.034  |0.036  |0.029  |0.029  |0.021  |0.018  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
present|125    |138    |147    |160    |210    |190    |236    |234    |208    |246    |187    |155    |2236   |
       |0.056  |0.062  |0.066  |0.072  |0.094  |0.085  |0.106  |0.105  |0.093  |0.110  |0.084  |0.069  |0.7    |
       |0.714  |0.738  |0.717  |0.672  |0.698  |0.642  |0.686  |0.670  |0.689  |0.724  |0.736  |0.724  |       |
       |0.039  |0.043  |0.046  |0.050  |0.066  |0.059  |0.074  |0.073  |0.065  |0.077  |0.058  |0.048  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|175    |187    |205    |238    |301    |296    |344    |349    |302    |340    |254    |214    |3205   |
       |0.055  |0.058  |0.064  |0.074  |0.094  |0.092  |0.107  |0.109  |0.094  |0.106  |0.079  |0.067  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
  Chi^2 = 12.27257 d.f.= 11 (p=0.3435074)
  Yates' correction not used
```

```
> contrib(deaths~bacfactor+month)
Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4] [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
[1,] -0.40 -1.00 -0.51  0.71    0  1.74  0.39  0.92  0.28 -0.87 -1.12 -0.71
[2,]  0.26  0.66  0.33 -0.47    0 -1.15 -0.26 -0.61 -0.19  0.57  0.74  0.47
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~bacfactor+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]   -5  -13   -6    8    0   18    4    9    3    -9   -13    -9
[2,]    2    6    3   -4    0   -8   -2   -4   -1     4     6     4
```

Month and hour are not independent. In the 11PM slot there are more deaths in Jan, Mar & Dec and fewer in October. The largest difference is the excess deaths in Jun in the 3AM to 4AM slot (38% difference between observed and expected). See table at bottom for more comparisons.

```
> crosstabs( deaths~hour+month, data = fars.df, na.action = na.exclude)
Call:
crosstabs(deaths ~ hour + month, data = fars.df, na.action = na.exclude)
5794 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour    |month
        |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM    | 86    | 52    | 98    | 81    |117    | 98    |135    |124    |106    | 89    | 97    |111    |1194   |
        |0.0720 |0.0436 |0.0821 |0.0678 |0.0980 |0.0821 |0.1131 |0.1039 |0.0888 |0.0745 |0.0812 |0.0930 |0.21   |
        |0.2552 |0.1775 |0.2841 |0.2177 |0.2143 |0.1728 |0.2119 |0.1959 |0.1910 |0.1471 |0.2055 |0.2569 |       |
        |0.0148 |0.0090 |0.0169 |0.0140 |0.0202 |0.0169 |0.0233 |0.0214 |0.0183 |0.0154 |0.0167 |0.0192 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM    | 72    | 71    | 80    | 75    |131    |125    |100    |127    |108    |120    | 78    | 67    |1154   |
        |0.0624 |0.0615 |0.0693 |0.0650 |0.1135 |0.1083 |0.0867 |0.1101 |0.0936 |0.1040 |0.0676 |0.0581 |0.20   |
        |0.2136 |0.2423 |0.2319 |0.2016 |0.2399 |0.2205 |0.1570 |0.2006 |0.1946 |0.1983 |0.1653 |0.1551 |       |
        |0.0124 |0.0123 |0.0138 |0.0129 |0.0226 |0.0216 |0.0173 |0.0219 |0.0186 |0.0207 |0.0135 |0.0116 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM     | 47    | 64    | 47    | 91    |106    | 85    |146    |103    |147    |131    | 86    | 79    |1132   |
        |0.0415 |0.0565 |0.0415 |0.0804 |0.0936 |0.0751 |0.1290 |0.0910 |0.1299 |0.1157 |0.0760 |0.0698 |0.20   |
        |0.1395 |0.2184 |0.1362 |0.2446 |0.1941 |0.1499 |0.2292 |0.1627 |0.2649 |0.2165 |0.1822 |0.1829 |       |
        |0.0081 |0.0110 |0.0081 |0.0157 |0.0183 |0.0147 |0.0252 |0.0178 |0.0254 |0.0226 |0.0148 |0.0136 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM     | 85    | 63    | 72    | 60    |123    |134    |163    |184    |120    |186    |133    | 92    |1415   |
        |0.0601 |0.0445 |0.0509 |0.0424 |0.0869 |0.0947 |0.1152 |0.1300 |0.0848 |0.1314 |0.0940 |0.0650 |0.24   |
        |0.2522 |0.2150 |0.2087 |0.1613 |0.2253 |0.2363 |0.2559 |0.2907 |0.2162 |0.3074 |0.2818 |0.2130 |       |
        |0.0147 |0.0109 |0.0124 |0.0104 |0.0212 |0.0231 |0.0281 |0.0318 |0.0207 |0.0321 |0.0230 |0.0159 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM     | 47    | 43    | 48    | 65    | 69    |125    | 93    | 95    | 74    | 79    | 78    | 83    |899    |
        |0.0523 |0.0478 |0.0534 |0.0723 |0.0768 |0.1390 |0.1034 |0.1057 |0.0823 |0.0879 |0.0868 |0.0923 |0.16   |
        |0.1395 |0.1468 |0.1391 |0.1747 |0.1264 |0.2205 |0.1460 |0.1501 |0.1333 |0.1306 |0.1653 |0.1921 |       |
        |0.0081 |0.0074 |0.0083 |0.0112 |0.0119 |0.0216 |0.0161 |0.0164 |0.0128 |0.0136 |0.0135 |0.0143 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|337    |293    |345    |372    |546    |567    |637    |633    |555    |605    |472    |432    |5794   |
       |0.058  |0.051  |0.060  |0.064  |0.094  |0.098  |0.110  |0.109  |0.096  |0.104  |0.081  |0.075  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
  Chi^2 = 170.65 d.f.= 44 (p=1.110223e-016)
  Yates' correction not used

Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
[1,]  1.99 -1.08  3.19  0.50  0.42 -1.74  0.33 -0.56 -0.78 -3.20 -0.03  2.33
[2,]  0.60  1.65  1.36  0.11  2.13  1.14 -2.39  0.08 -0.24 -0.05 -1.65 -2.05
[3,] -2.32  0.89 -2.49  2.15 -0.07 -2.45  1.93 -1.86  3.70  1.18 -0.65 -0.59
[4,]  0.30 -1.01 -1.34 -3.24 -0.90 -0.38  0.60  2.37 -1.33  3.15  1.65 -1.31
[5,] -0.73 -0.37 -0.76  0.96 -1.71  3.95 -0.59 -0.32 -1.31 -1.53  0.56  1.95
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
11PM	22	-16	34	4	2	-18	1	-7	-9	-30	-2	22
12AM	7	20	15	1	20	10	-22	1	-3	0	-17	-23
1AM	-30	8	-32	23	-3	-25	15	-18	32	9	-8	-9
2AM	5	-11	-14	-33	-6	-2	7	21	-10	29	18	-12
3AM	-13	-9	-14	10	-21	38	-9	-6	-17	-18	4	19

Wkgrp and month are not independent. The last table shows the percentage differences between observed and expected. There are larger fluctuations in the SunWed group, for example there are 34% more deaths in March than would be expected if the classifications SunWed and Month were independent.

```
Call:
crosstabs(deaths ~ wkgrp + month, data = fars.df, na.action = na.exclude)
5794 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |month
       |Jan    |Feb    |Mar    |Apr    |May    |Jun    |Jul    |Aug    |Sep    |Oct    |Nov    |Dec    |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed | 35    | 43    | 65    | 54    | 99    | 64    | 82    | 82    | 80    |108    | 57    | 44    |813    |
       |0.0431 |0.0529 |0.0800 |0.0664 |0.1218 |0.0787 |0.1009 |0.1009 |0.0984 |0.1328 |0.0701 |0.0541 |0.14   |
       |0.1039 |0.1468 |0.1884 |0.1452 |0.1813 |0.1129 |0.1287 |0.1295 |0.1441 |0.1785 |0.1208 |0.1019 |       |
       |0.0060 |0.0074 |0.0112 |0.0093 |0.0171 |0.0110 |0.0142 |0.0142 |0.0138 |0.0186 |0.0098 |0.0076 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat |302    |250    |280    |318    |447    |503    |555    |551    |475    |497    |415    |388    |4981   |
       |0.0606 |0.0502 |0.0562 |0.0638 |0.0897 |0.1010 |0.1114 |0.1106 |0.0954 |0.0998 |0.0833 |0.0779 |0.86   |
       |0.8961 |0.8532 |0.8116 |0.8548 |0.8187 |0.8871 |0.8713 |0.8705 |0.8559 |0.8215 |0.8792 |0.8981 |       |
       |0.0521 |0.0431 |0.0483 |0.0549 |0.0771 |0.0868 |0.0958 |0.0951 |0.0820 |0.0858 |0.0716 |0.0670 |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|337    |293    |345    |372    |546    |567    |637    |633    |555    |605    |472    |432    |5794   |
       |0.058  |0.051  |0.060  |0.064  |0.094  |0.098  |0.110  |0.109  |0.096  |0.104  |0.081  |0.075  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
  Chi^2 = 37.14727 d.f.= 11 (p=0.0001088637)
  Yates' correction not used
```

```
> contrib(deaths~wkgrp+month)
Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
[1,] -1.79  0.29  2.38  0.25  2.56 -1.74 -0.78 -0.72  0.24  2.51 -1.13 -2.13
[2,]  0.72 -0.12 -0.96 -0.10 -1.03  0.70  0.32  0.29 -0.10 -1.01  0.46  0.86
```

(Observed-Expected)/Expected times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~wkgrp+month)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[1,]  -26    5   34    3   29  -20   -8   -8    3    27   -14   -27
[2,]    4   -1   -6   -1   -5    3    1    1    0    -4     2     4
```

Bacfactor and year.
There are no statistically significant changes over time.

```
Call:
crosstabs(deaths ~ bacfactor + year, data = fars.df, na.action = na.exclude)
3205 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
bacfactor|year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
absent |102    |154    |149    |148    |126    | 98    |100    | 92    |969    |
       |0.105  |0.159  |0.154  |0.153  |0.130  |0.101  |0.103  |0.095  |0.3    |
       |0.266  |0.301  |0.333  |0.304  |0.316  |0.288  |0.316  |0.287  |       |
       |0.032  |0.048  |0.046  |0.046  |0.039  |0.031  |0.031  |0.029  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
present|281    |357    |299    |339    |273    |242    |216    |229    |2236   |
       |0.126  |0.160  |0.134  |0.152  |0.122  |0.108  |0.097  |0.102  |0.7    |
       |0.734  |0.699  |0.667  |0.696  |0.684  |0.712  |0.684  |0.713  |       |
       |0.088  |0.111  |0.093  |0.106  |0.085  |0.076  |0.067  |0.071  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|383    |511    |448    |487    |399    |340    |316    |321    |3205   |
       |0.120  |0.159  |0.140  |0.152  |0.124  |0.106  |0.099  |0.100  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 5.645549 d.f.= 7 (p=0.5816909)
       Yates' correction not used
```

```
> contrib(deaths~bacfactor+year)
Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,] -1.28 -0.04  1.16  0.06  0.49 -0.47  0.46 -0.51
[2,]  0.84  0.03 -0.77 -0.04 -0.32  0.31 -0.30  0.34
```

(Observed-Expected)/Expected times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~bacfactor+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]  -12    0   10    1    4   -5    5   -5
[2,]    5    0   -4    0   -2    2   -2    2
```

Wkgrp and Year.

There are 24% more deaths in the SunWed group in 1996 than expected but overall the dependence between wkgrp and year is not statistically significant at 5%.

```
Call:
crosstabs(deaths ~ wkgrp + year, data = fars.df, na.action = na.exclude)
5794 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
SunWed | 79    |113    | 93    |100    |128    |101    | 85    |114    |813    |
       |0.097  |0.139  |0.114  |0.123  |0.157  |0.124  |0.105  |0.140  |0.14   |
       |0.134  |0.131  |0.131  |0.132  |0.174  |0.133  |0.126  |0.162  |       |
       |0.014  |0.020  |0.016  |0.017  |0.022  |0.017  |0.015  |0.020  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ThuSat |509    |752    |615    |656    |608    |660    |591    |590    |4981   |
       |0.102  |0.151  |0.123  |0.132  |0.122  |0.133  |0.119  |0.118  |0.86   |
       |0.866  |0.869  |0.869  |0.868  |0.826  |0.867  |0.874  |0.838  |       |
       |0.088  |0.130  |0.106  |0.113  |0.105  |0.114  |0.102  |0.102  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|588    |865    |708    |756    |736    |761    |676    |704    |5794   |
       |0.10   |0.15   |0.12   |0.13   |0.13   |0.13   |0.12   |0.12   |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 12.89018 d.f.= 7 (p=0.07482989)
       Yates' correction not used
```

```
> contrib(deaths~wkgrp+year)
Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,] -0.39 -0.76 -0.64 -0.59  2.43 -0.56 -1.01  1.53
[2,]  0.16  0.31  0.26  0.24 -0.98  0.23  0.41 -0.62
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~wkgrp+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]   -4   -7   -6   -6   24   -5  -10   15
[2,]    1    1    1    1   -4    1    2   -3
```

Hour and year are not independent.
But I don't see any interesting trends. The changes seem to be strongest in the 11PM and 12AM slots. The largest effect occurred in 1999 when there was a 32% excess of deaths in the 12AM slot.

```
Call:
crosstabs(deaths ~ hour + year, data = fars.df, na.action = na.exclude)
5794 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |year
       |1992   |1993   |1994   |1995   |1996   |1997   |1998   |1999   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
11PM   |145    |167    |161    |135    |184    |136    |150    |116    |1194   |
       |0.121  |0.140  |0.135  |0.113  |0.154  |0.114  |0.126  |0.097  |0.21   |
       |0.247  |0.193  |0.227  |0.179  |0.250  |0.179  |0.222  |0.165  |       |
       |0.025  |0.029  |0.028  |0.023  |0.032  |0.023  |0.026  |0.020  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
12AM   | 97    |162    |121    |169    |123    |180    |117    |185    |1154   |
       |0.084  |0.140  |0.105  |0.146  |0.107  |0.156  |0.101  |0.160  |0.20   |
       |0.165  |0.187  |0.171  |0.224  |0.167  |0.237  |0.173  |0.263  |       |
       |0.017  |0.028  |0.021  |0.029  |0.021  |0.031  |0.020  |0.032  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
1AM    |120    |144    |151    |156    |141    |139    |146    |135    |1132   |
       |0.106  |0.127  |0.133  |0.138  |0.125  |0.123  |0.129  |0.119  |0.20   |
       |0.204  |0.166  |0.213  |0.206  |0.192  |0.183  |0.216  |0.192  |       |
       |0.021  |0.025  |0.026  |0.027  |0.024  |0.024  |0.025  |0.023  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
2AM    |138    |241    |179    |178    |162    |199    |148    |170    |1415   |
       |0.098  |0.170  |0.127  |0.126  |0.114  |0.141  |0.105  |0.120  |0.24   |
       |0.235  |0.279  |0.253  |0.235  |0.220  |0.261  |0.219  |0.241  |       |
       |0.024  |0.042  |0.031  |0.031  |0.028  |0.034  |0.026  |0.029  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
3AM    | 88    |151    | 96    |118    |126    |107    |115    | 98    |899    |
       |0.098  |0.168  |0.107  |0.131  |0.140  |0.119  |0.128  |0.109  |0.16   |
       |0.150  |0.175  |0.136  |0.156  |0.171  |0.141  |0.170  |0.139  |       |
       |0.015  |0.026  |0.017  |0.020  |0.022  |0.018  |0.020  |0.017  |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
ColTotl|588    |865    |708    |756    |736    |761    |676    |704    |5794   |
       |0.10   |0.15   |0.12   |0.13   |0.13   |0.13   |0.12   |0.12   |       |
-------+-------+-------+-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 86.38715 d.f.= 28 (p=7.19933e-008)
       Yates' correction not used

> contrib(deaths~hour+year)
Contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]
[1,]  2.16 -0.84  1.25 -1.67  2.63 -1.66  0.91 -2.41
[2,] -1.86 -0.78 -1.69  1.50 -1.95  2.31 -1.52  3.78
[3,]  0.48 -1.92  1.08  0.68 -0.23 -0.79  1.21 -0.22
[4,] -0.47  2.05  0.46 -0.49 -1.32  0.96 -1.33 -0.15
[5,] -0.34  1.45 -1.32  0.06  1.10 -1.02  0.99 -1.07
```

(Observed-Expected)/Expected Times 100 rounded to nearest integer:

```
> get.crosstabs.percenterror(deaths~hour+year)
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
[1,]   20   -6   10  -13   21  -13    8  -20
[2,]  -17   -6  -14   12  -16   19  -13   32
[3,]    4  -15    9    6   -2   -7   11   -2
[4,]   -4   14    4   -4  -10    7  -10   -1
[5,]   -4   13  -13    1   10   -9   10  -10
```

I. FARS Dataset – Time Series

Summary

There are downward trends in FARS deaths, death with BAC positive and deaths with BAC negative.

Table 1. FARS deaths per month for (a) totals, (b) BAC positive and (c) BAC negative. Note that (b) + (c) ≠ (a) since BAC is n/a for about 38% of the records.

Figure 1. Deaths per Month Time Series Plot. The lowess trend line decreases from 73.4 deaths per month to 57.7 deaths per month which corresponds to an average annual rate of decrease of 3.1%.

Figure 2. Fars Deaths with BAC Present. The lowess trend line decreases from 32.9 deaths per month to 17.7 deaths per month which corresponds to an average annual rate of about 7.8%.

Figure 3. Fars Deaths with BAC Absent. The lowess trend line decreases from 13.0 deaths per month to 6.0 deaths per month which corresponds to about 9.6% per year.

Figure 3Bi and 3Bii. The rate of decrease is higher in both cases with BAC present and BAC absent. There must be some sort of selection effect.

Table 2. Mean monthly death rates, percentage change and Mann-Kendall trend tests. Remark: the mean monthly Total is not the sum of the mean monthly values for BAC present and absent since BAC is missing in about 38% of the cases. The magnitude of the downward trend is the same in both BAC present and absent but is somewhat less than in Total.

	1993	1998	%change	tau	sl
Total	72.1	58.7	18.6	-0.14	5%
BAC Present	29.8	19.1	35.8	-0.38	$<10^{-6}$
BAC Absent	12.8	7.7	40.2	-0.27	$<10^{-4}$

Table 4a Annual deaths and Mann-Kendall Trend Tests, 2AM and ThuSat have significant downward trends at 7% and 3% significance levels on a two-sided Mann-Kendall trend test.

Figure 4a, 4b show trellis time series displays of the annual deaths.

Figure 5 shows a drop in the deaths starting in 1996 in both cases (BAC present and BAC absent). The decline in BAC present deaths is very large but is actually less than the decline in BAC absent. But these declines are in reality perhaps not so important because the percentage decline in FARS deaths totals is much less (recall that BAC is missing in 45% of the deaths). This summarized:

Year	**1993**	**1999**	**% change**
Total	865	704	19%
Bac present	357	229	35%
Bac absent	154	92	40%

Multipanel trellised time series plots showing the monthly time series of deaths totals, deaths with BAC present and deaths BAC absent were constructed for each combination of the factors `wkgrp` and `hour`. Robust loess locally-linear 60% smooth trend lines are drawn on the plots. Each trellis plot decomposes the aggregated time series according to the factor levels. Two types of trellis plots are used:

(i) the scales are kept the same on each trellis plot to make comparisons between the different panels easy

(ii) the deaths are log transformed and separate scaling is used on the vertical axis to allow better visualization of the trend

Figure 6a-ii, FARS deaths exhibit a downward trend for `11PM` both `SunWed` and `ThuSat`, an upward trend for `SunWed` 3AM and an upward trend for `ThuSat-2AM`. There are many more deaths in the `ThuSat` weekgroup.

Comparison of panels for 3AM-ThuSat and 2AM-ThuSat in Figure 6a-i suggest that some spikes occur at common times. Such an temporal association could be caused by poor driving conditions on particular nights. However closer investigation shows that there is really no apparent association, see Figure 6a-iiiα and Figure 6a-iiiβ which shows comparsions when the aspect-ratio is reduced to improve visualization on the horizontal scale and a log transformation is made to reduce the effect of outliers on the resolution.

Figure 6b-ii, FARS deaths with BAC present, exhibits a downward trend for `ThuSat` at `2AM` and `12AM` and possibly also `SunWed` at `2AM`.

Figure 6c-ii, FARS deaths with BAC absent shows a downward trend for all levels of `hour` for `ThuSat` but little change for `SunWed`.

Seasonal-Trend-Loess Decompositions were examined. For all series, the downward trend is evident as well as a change in the seasonal pattern occurring in 1996 (Figures 7, 9, 11).

Figures 7a,b. STL FARS deaths. Peak in July and reach minimum in February. These deaths are relatively high from May through to October. $R^2 =$ 53.4%.

Figure 7c. The deseasonalized series showns an apparent change in variability around 1997. The trend is highly significant with Mann-Kendall test, `tau = -0.214,    sl =1.261%.` The loess trend declines from about 70.5 deaths/month at the beginning of 1992 to 56.7 deaths/month by the end of 1999. This corresponds to a percentage annual rate of decline of about 2.8%.

Figures 8a,b STL FARS deaths with BAC present. Peak in October and are a minimum in Jan. These deaths are also relatively high in July and August. There are strong increasing trends in February and September and a decreasing trend in October and to a lesser extend in March and April too. $R^2 =$ 90.5%.

Figure 8c. Trend in the deseasonalized component is obviously significant. Mann-Kendall trend test: `tau = -0.461, sl =8.001e-6%.` The loess trend declines from about 70.5 deaths/month at the beginning of 1992 to 56.7 deaths/month by the end of 1999 which corresponds to a percentage annual rate of decline of about 2.8%.

Figures 9a,b. STL FARS deaths with BAC absent. Peak in August but are relatively high from April through to October and are relatively low in December, January, February and March. There has been a sharp downward trend in deaths in Nov. $R^2 =$ 93.2%.

Figure 9c. There is a significant downward trend. The Mann-Kendall test yields, `tau = -0.338, sl =0.008465`%. The deseasonalized FARS BAC absent deaths decline from about 12.7 at the beginning of 1992 to about 7.2% by the end of 1999. The average annual percentage decrease is about 7.2%.

Figure 9d. There are some outliers evident. Observations 31 and 85 corresond to Nov. 1994 and May 1999 respectively. See Table 1c.

Time Series: Tables and Plots

Monthly time series are plotted and a 60% locally linear robust smoothed trend line is shown.

Table 1a. FARS, deaths, total number of deaths per month

```
> deaths.fars.ts
```

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:					89	94	73	77	72	73	48	62
1993:	66	52	67	46	82	60	99	95	72	107	62	57
1994:	41	16	31	73	54	61	92	49	57	95	84	55
1995:	42	36	85	77	66	48	86	93	78	57	35	53
1996:	48	46	33	38	74	102	59	74	67	74	68	53
1997:	60	47	50	53	71	66	85	71	70	79	55	54
1998:	39	46	46	39	47	65	83	73	77	48	70	43
1999:	41	50	33	46	63	71	60	101	62	72	50	55

Table 1b. FARS, deaths BAC present, deaths per month

```
> deaths.farsbacp.ts
```

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:					47	39	42	41	29	38	24	21
1993:	23	25	34	22	27	22	31	36	26	53	34	24
1994:	18	10	20	25	32	31	30	25	20	45	23	20
1995:	27	16	32	46	30	14	37	33	28	27	23	26
1996:	19	26	16	9	21	26	23	29	31	20	29	24
1997:	10	18	20	17	20	19	31	22	37	22	19	7
1998:	14	17	19	23	15	19	25	14	18	19	21	12
1999:	14	26	6	18	18	20	17	34	19	22	14	21

Table 1c. FARS, deaths BAC absent, deaths per month

```
> deaths.farsbaca.ts
```

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992:					12	22	9	11	20	7	10	11
1993:	9	11	17	15	15	12	11	19	12	17	8	8
1994:	8	2	8	16	6	13	22	9	7	19	**32**	7
1995:	7	11	11	18	7	10	12	26	23	7	5	11
1996:	9	5	4	14	18	25	12	10	8	12	2	7
1997:	8	11	6	8	16	8	7	12	3	9	4	6
1998:	5	3	5	6	14	12	23	8	9	4	4	7
1999:	4	6	7	1	**3**	4	12	20	12	19	2	2

Nov. 1994 (observation 31) and May 1999 (observation 85) seem to be outliers in Table 1c – see STL Analysis.

Table 2. Mean monthly death rates, percentage change and Seasonal Mann-Kendall trend tests. Remark: the mean monthly Total is not the sum of the mean monthly values for BAC present and absent since BAC is missing in about 38% of the cases. The magnitude of the downward trend is the same in both BAC present and absent but is somewhat less than in Total.

	1993	1998	%change	tau	sl
Total	72.1	58.7	18.6	-0.18	4%
BAC Present	29.8	19.1	35.8	-0.42	$<10^{-6}$
BAC Absent	12.8	7.7	40.2	-0.30	$<10^{-4}$

```
Seasonal Mann-Kendall Tests
> SeasonalMannKendall(deaths.fars.ts)
tau = -0.181,   sl =3.668%
> SeasonalMannKendall(deaths.farsbacp.ts)
tau = -0.425,   sl =9.23e-5%
> SeasonalMannKendall(deaths.farsbaca.ts)
tau = -0.295,   sl =0.07391%

Annual Series
> aggregate(deaths.fars.ts,1,mean)
1993: 72.08333 59.00000 63.00000 61.33333 63.41667 56.33333 58.66667
 start deltat frequency
  1993      1         1
> pc.diff(aggregate(deaths.fars.ts,1,mean))
[1] 0.1861272

> aggregate(deaths.farsbacp.ts,1,mean)
1993: 29.75000 24.91667 28.25000 22.75000 20.16667 18.00000 19.08333
 start deltat frequency
  1993      1         1
> pc.diff(aggregate(deaths.farsbacp.ts,1,mean))
[1] 0.3585434

> aggregate(deaths.farsbaca.ts,1,mean)
1993: 12.833333 12.416667 12.333333 10.500000  8.166667  8.333333  7.666667
 start deltat frequency
  1993      1         1
> pc.diff(aggregate(deaths.farsbaca.ts,1,mean))
[1] 0.4025974
```

Figure 1: Deaths per Month Time Series Plot

The lowess trend line decreases from 73.4 deaths per month to 57.7 deaths per month which corresponds to an average annual rate of decrease of 3.1%.

```
> 1-(57.7/73.4)^(1/(92/12))
[1] 0.03090372
```

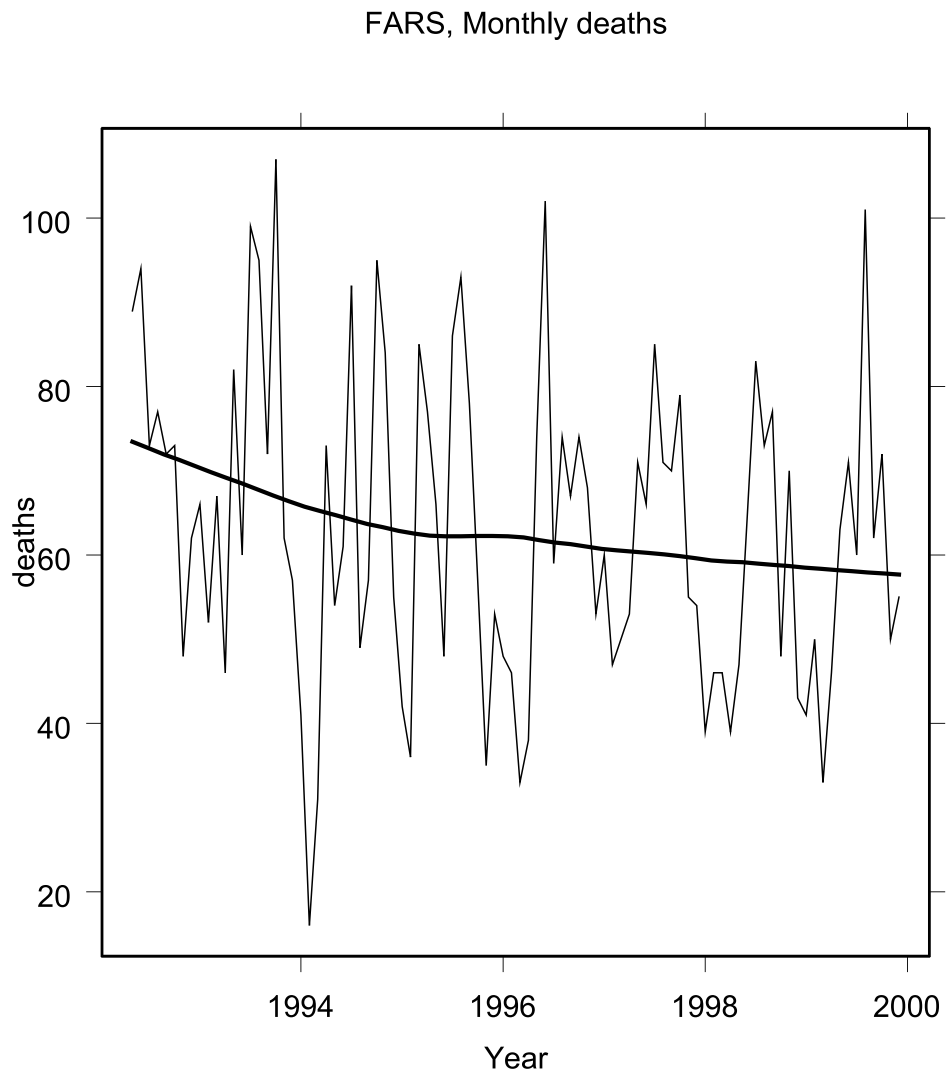


Figure 2: Fars Deaths with BAC Present

The lowess trend line decreases from 32.9 deaths per month to 17.7 deaths per month which corresponds to an average annual rate of about 7.8%.

```
>  1-(17.7/32.9)^(1/(92/12))
[1] 0.07767495
```

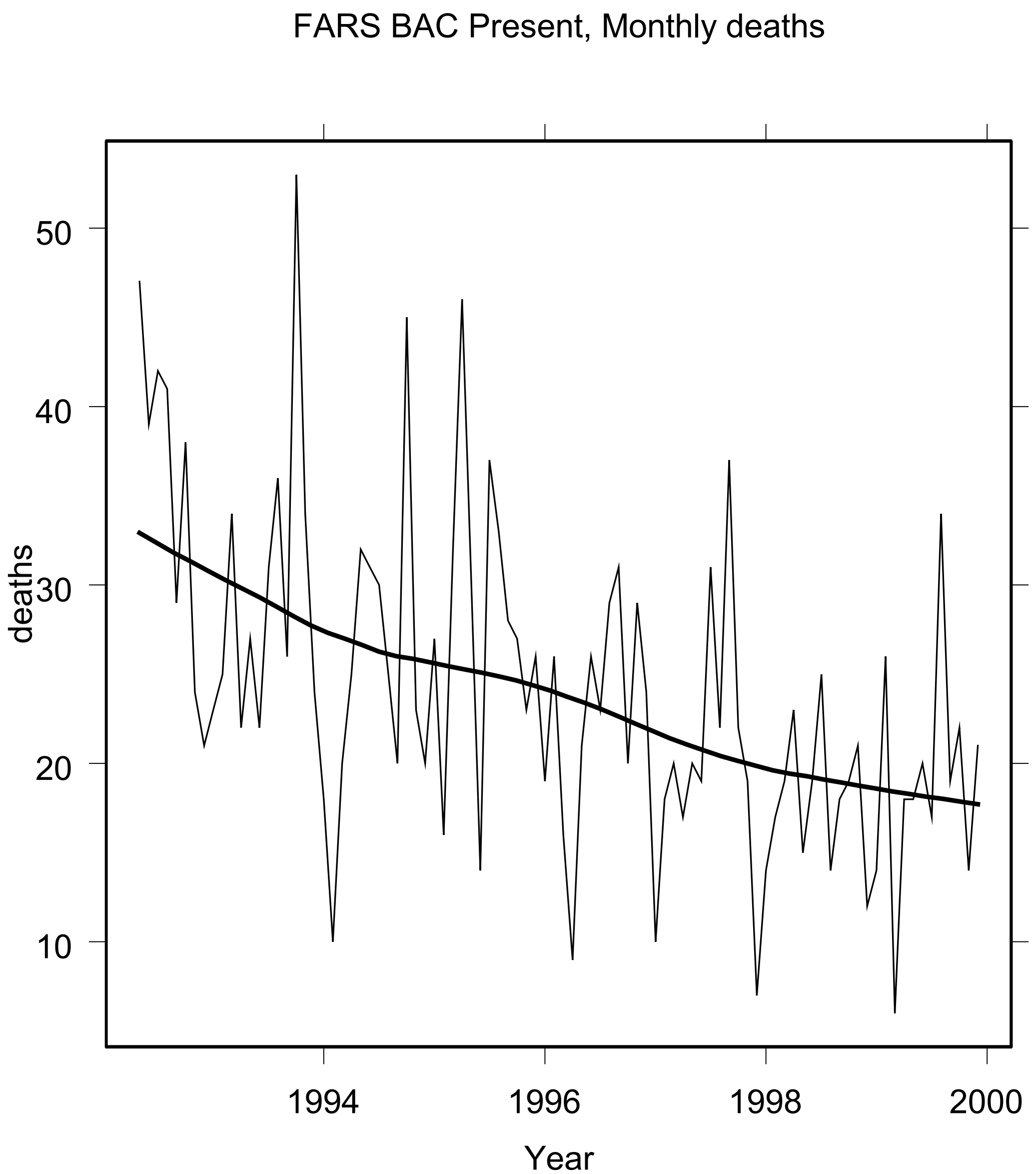


Figure 3: Fars Deaths with BAC Absent

The lowess trend line decreases from 13.0 deaths per month to 6.0 deaths per month which corresponds to about 9.6% per year.

```
>   1-(6.0/13.0)^(1/(92/12))
[1] 0.09593214
```

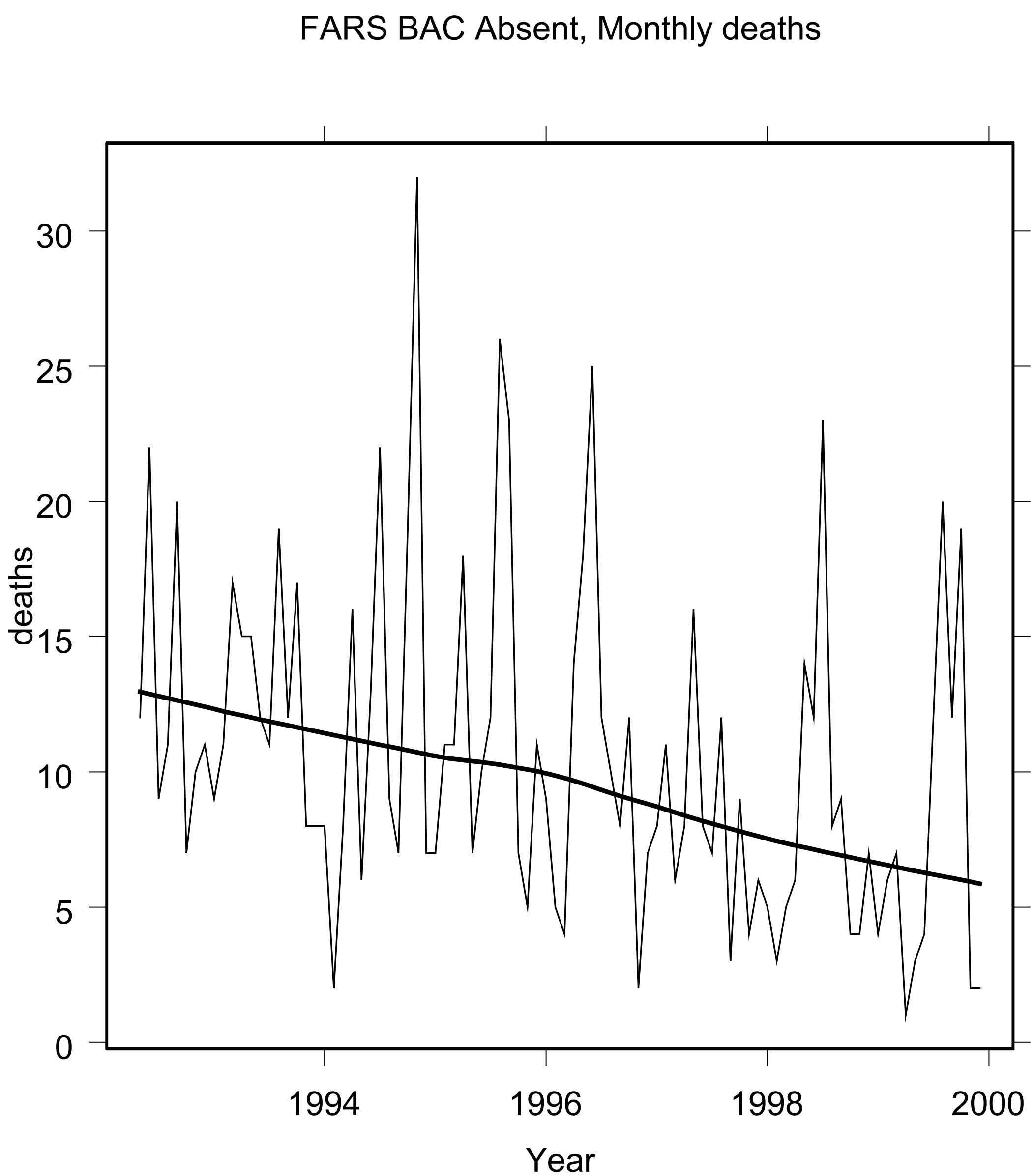


Figure 3Bi. Comparison of FARS deaths for total, BAC Present and BAC Absent. Same scale.

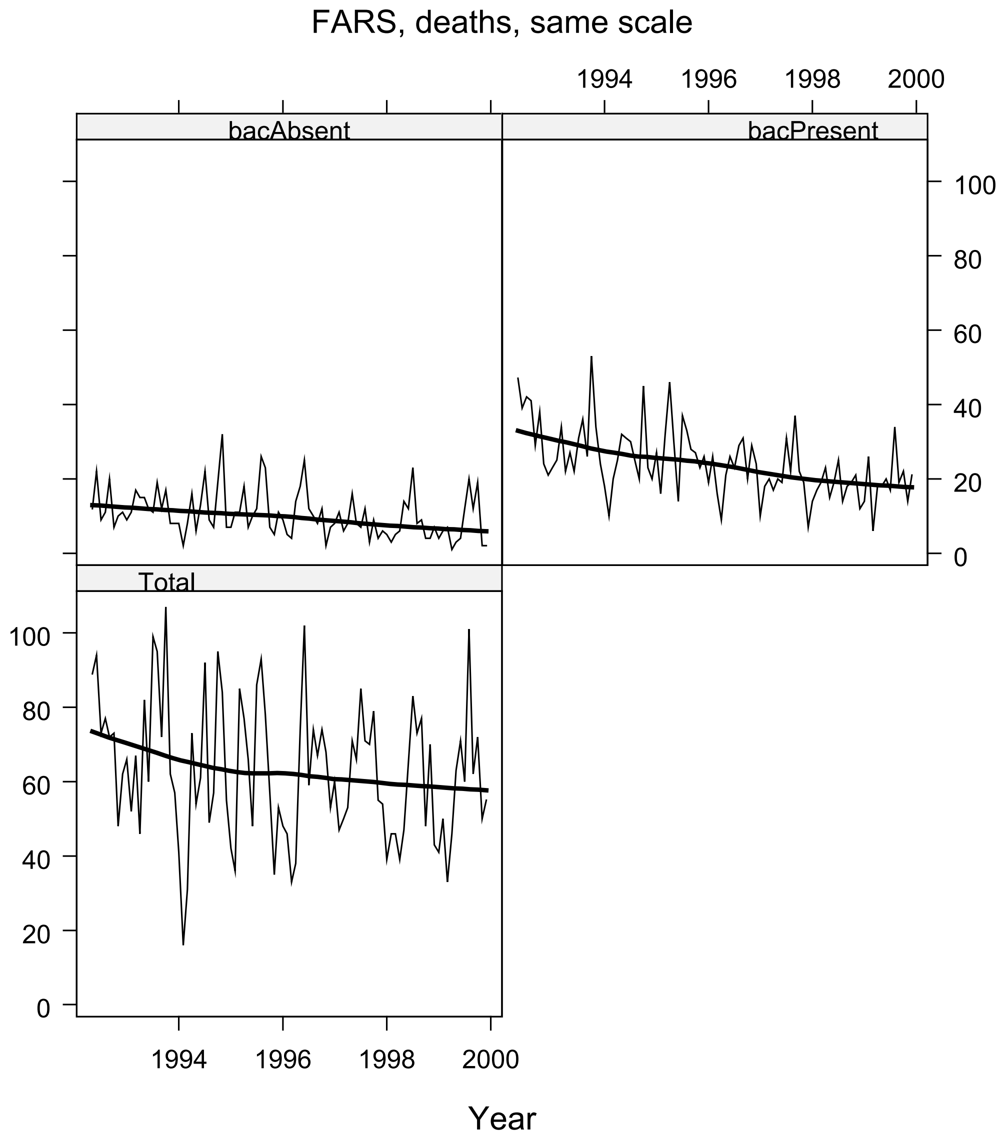
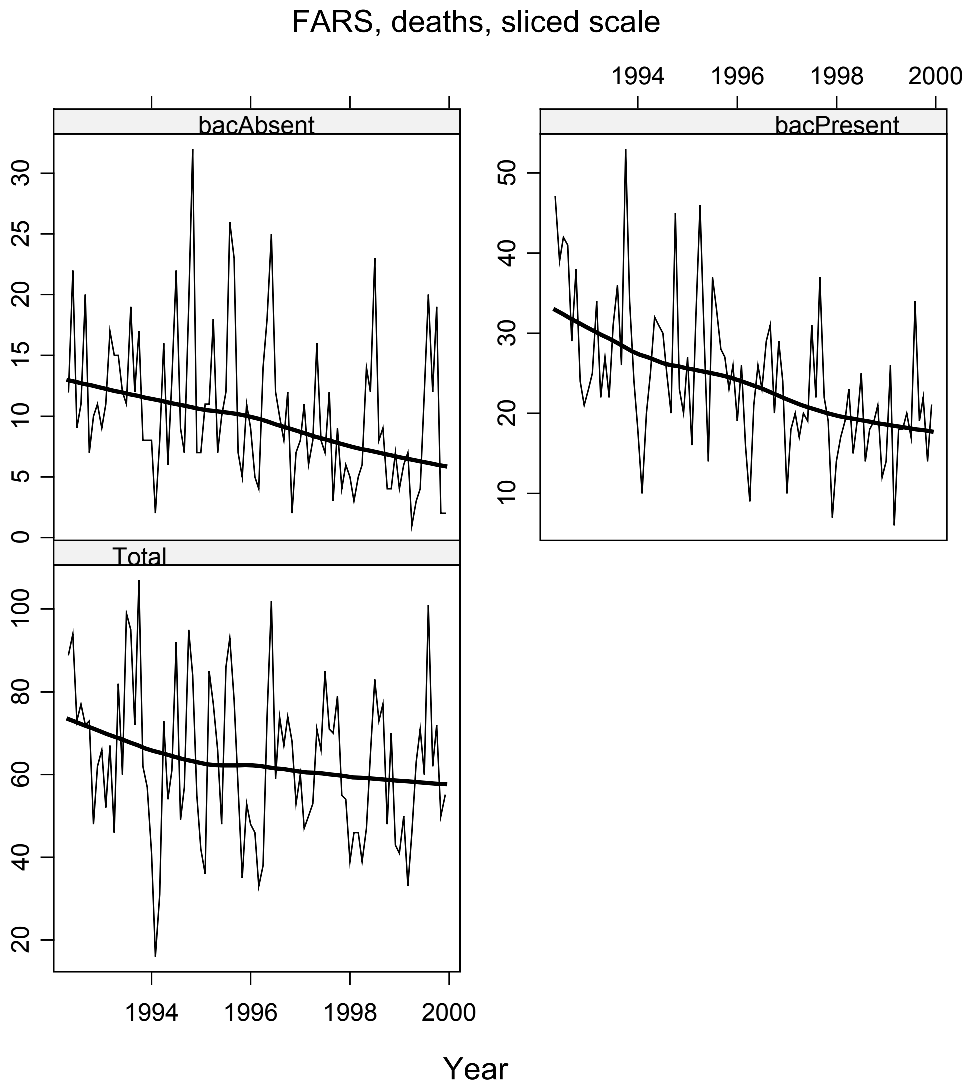


Figure 3Bii. Comparison of FARS deaths for total, BAC Present and BAC Absent. Sliced scale.

With the sliced scale the slopes are comparable since the number of data units per inch is the same on each graph. We clearly see that the slopes are greater in bacAbsent and bacPresent .



Annual Totals

Table 4a. Annual deaths and Mann-Kendall Trend Tests, 2AM and ThuSat have significant downward trends at 7% and 3% significance levels on a two-sided Mann-Kendall trend test.

Aggregate annual number of deaths

```
> (fars.death.annual[,-1])
     Total PM11 AM12 AM1 AM2 AM3 SunWed ThuSat
1993   865  167  162 144 241 151    113    752
1994   708  161  121 151 179  96     93    615
1995   756  135  169 156 178 118    100    656
1996   736  184  123 141 162 126    128    608
1997   761  136  180 139 199 107    101    660
1998   676  150  117 146 148 115     85    591
1999   704  116  185 135 170  98    114    590 >
MannKendallAnnual(fars.death.annual[,-1])
         Total       PM11      AM12        AM1         AM2        AM3     SunWed      ThuSat
tau -0.4285714 -0.4285714 0.2380952 -0.4285714 -0.52380949 -0.3333333 0.04761904 -0.61904758
 sl  0.1361111  0.1361111 0.5619048  0.1361111  0.06904757  0.2388889 1.00000000  0.03015876
```

Figure 4a: Annual Deaths

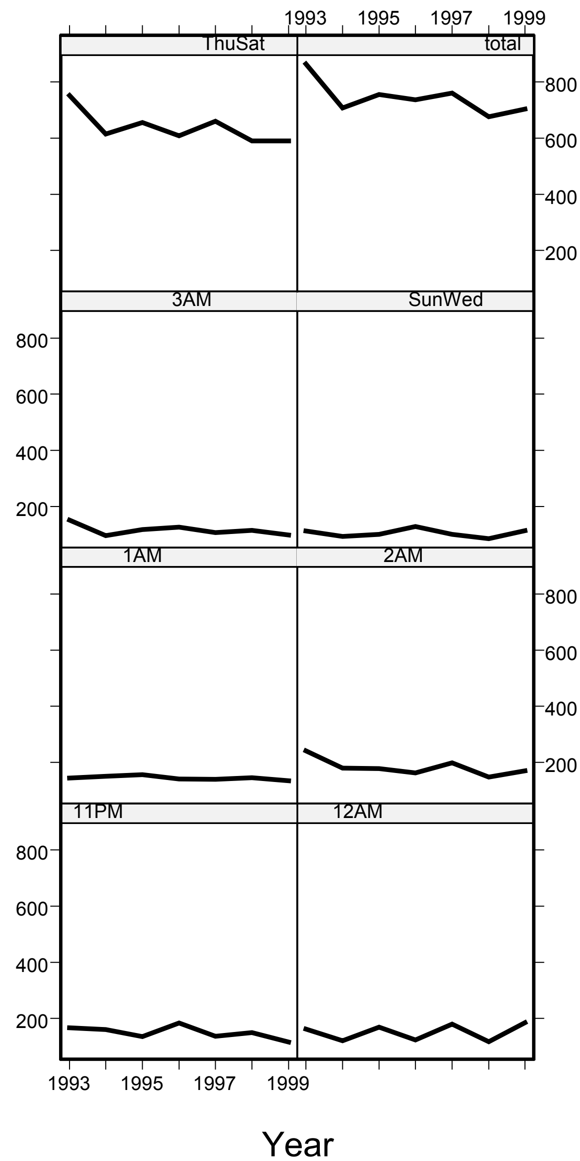


Figure 4b: Annual Deaths (Panels Scaled Independently)

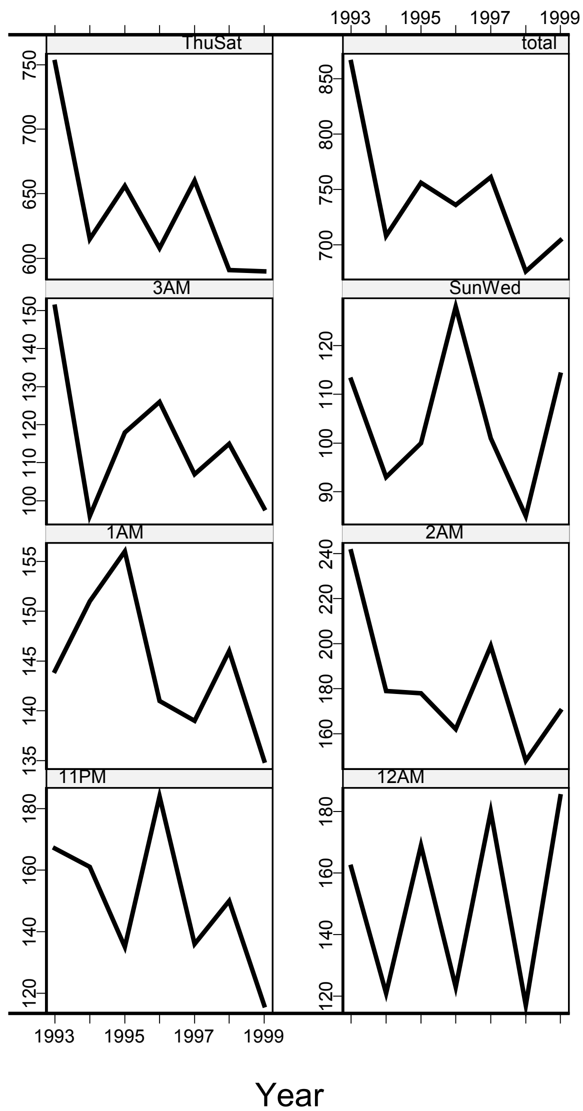
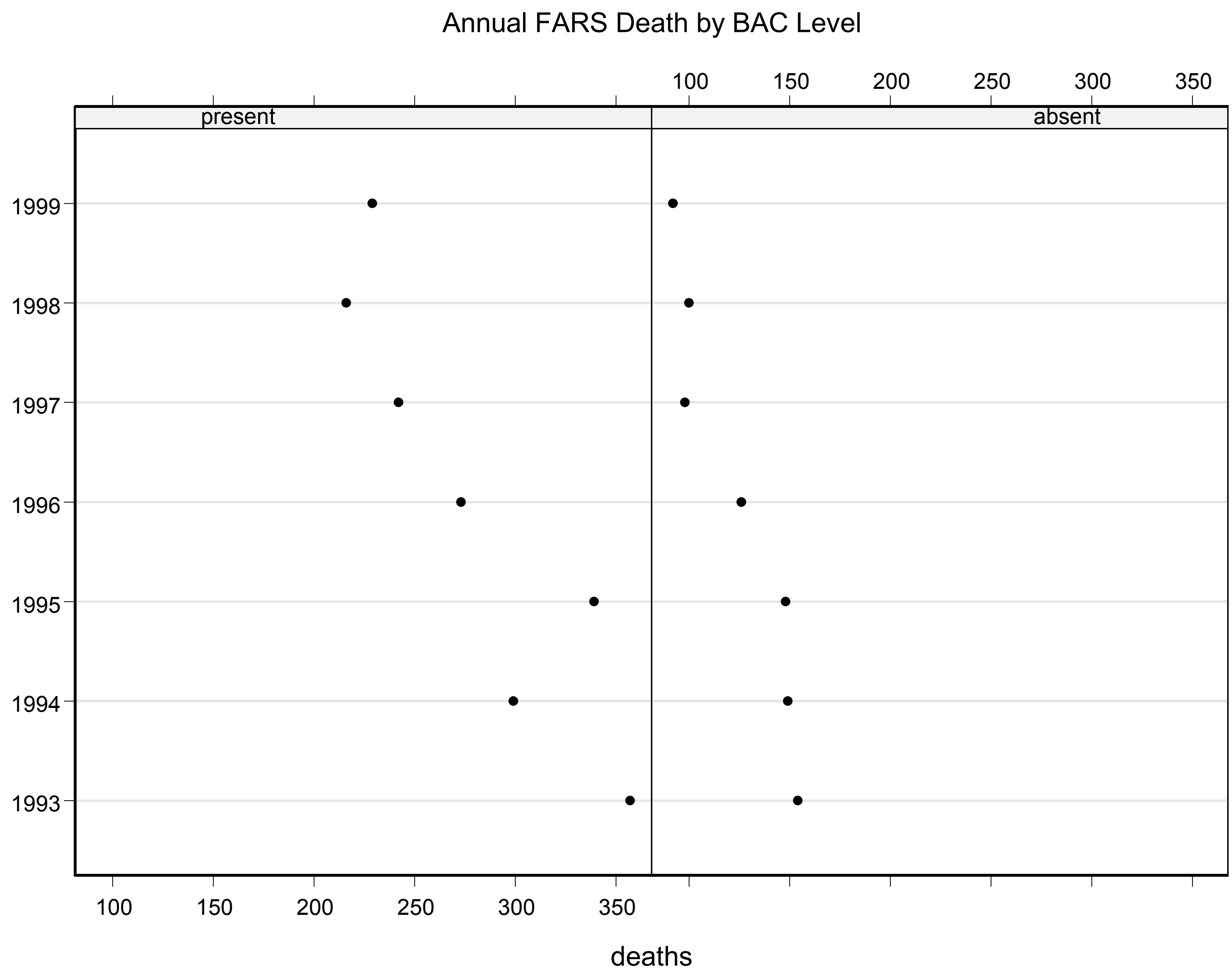


Figure 5: Annual FARS Deaths, Comparison BAC Absent and Present

Number of Deaths, FARS, BAC Absent, 1993 to 1999
> aggregate(deaths.farsbaca.ts, ndeltat=1)
1993: 154 149 148 126 98 100 92

Number of Deaths, FARS, BAC Present, 1993 to 1999
> aggregate(deaths.farsbacp.ts, ndeltat=1)
1993: 357 299 339 273 242 216 229

Figure 6 shows a drop in the deaths starting in 1996 in both cases (BAC present and BAC absent).



Trellis Time Series Plots by wkgrp and hour

There are many more deaths in the `ThuSat` weekgroup. There may be some temporal relationships between the series which could be due to weather and bad driving conditions. But on further investigation there was found to be no significant cross-correlation between the series and Figure 6a-iiiα and Figure 6a-iiiβ shows comparsions when the aspect-ratio is reduced to improve visualization on the horizontal scale and a log transformation is made to reduce the effect of outliers on the resolution.

Figure 6a-i. FARS deaths. Common Scale.
Comparison of panels for 3AM-ThuSat and 2AM-ThuSat in Figure 6a-i suggest that some spikes occur at common times. Such an temporal association could be caused by poor driving conditions on particular nights. However closer investigation shows that there is really no apparent association, see Figure 6a-iiiα and Figure 6a-iiiβ.

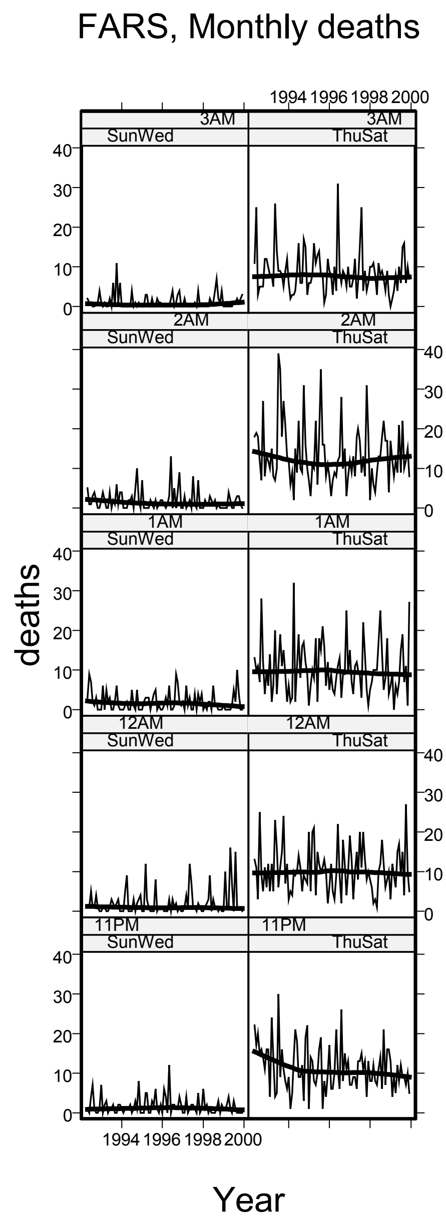


Figure 6a-ii. FARS deaths. Logged and Scaled Independently
FARS deaths exhibit a downward trend for `11PM` both `SunWed` and `ThuSat`, an upward trend for `SunWed` 3AM and an upward trend for `ThuSat-2AM`.

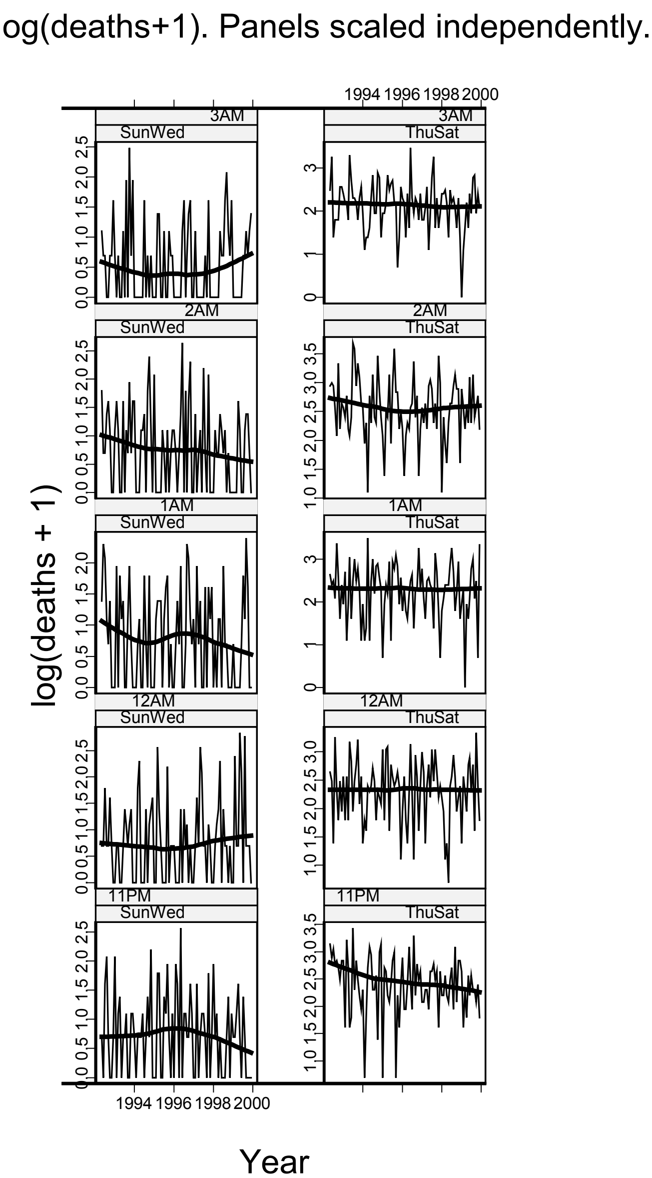


Figure 6a-iiiα FARS deaths, `SunWed`, small aspect-ratio and log transformation

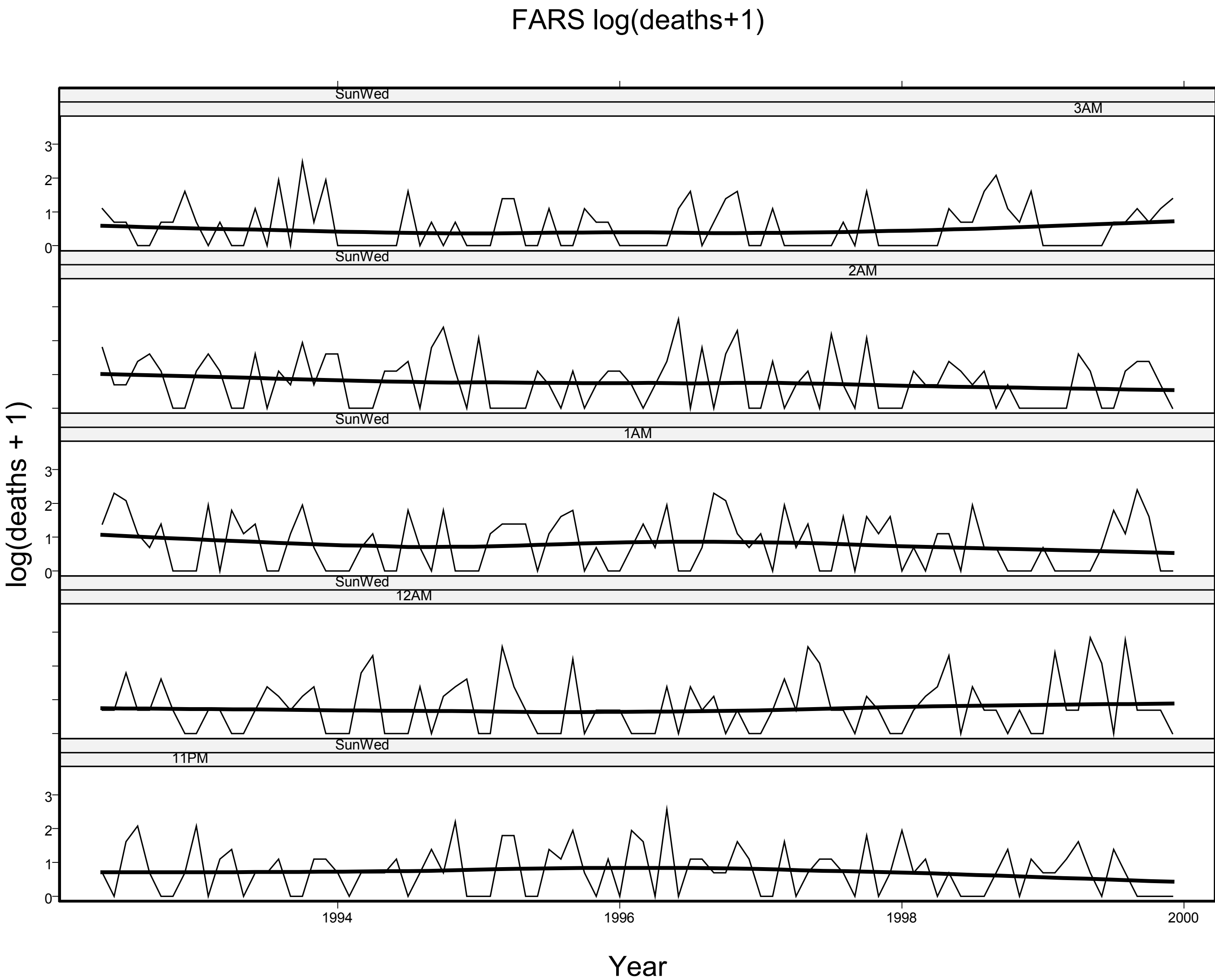


Figure 6a-iiiβ FARS deaths, `ThuSat`, small aspect-ratio and log transformation

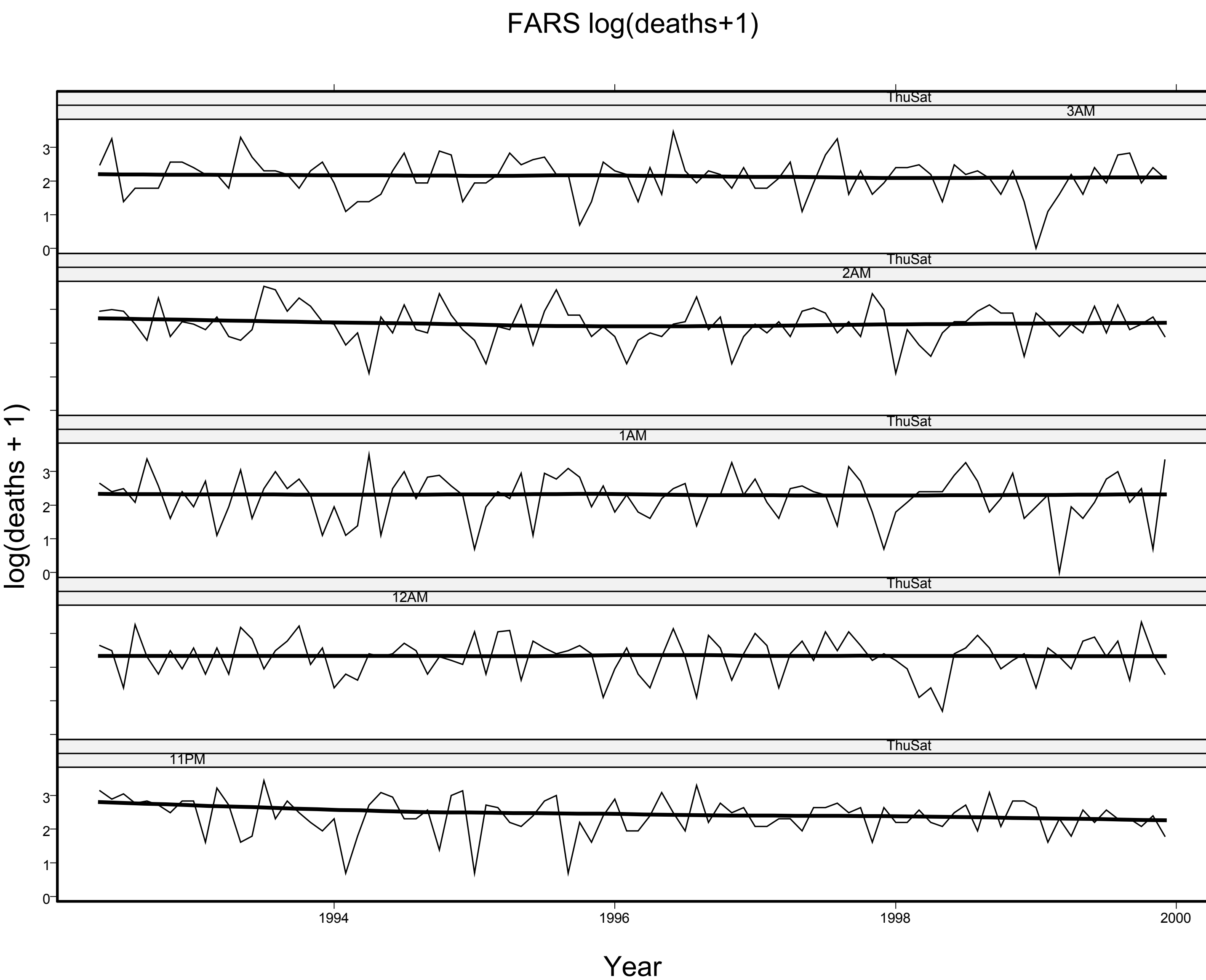


Figure 6b-i. Deaths with BAC present. Common Scaling

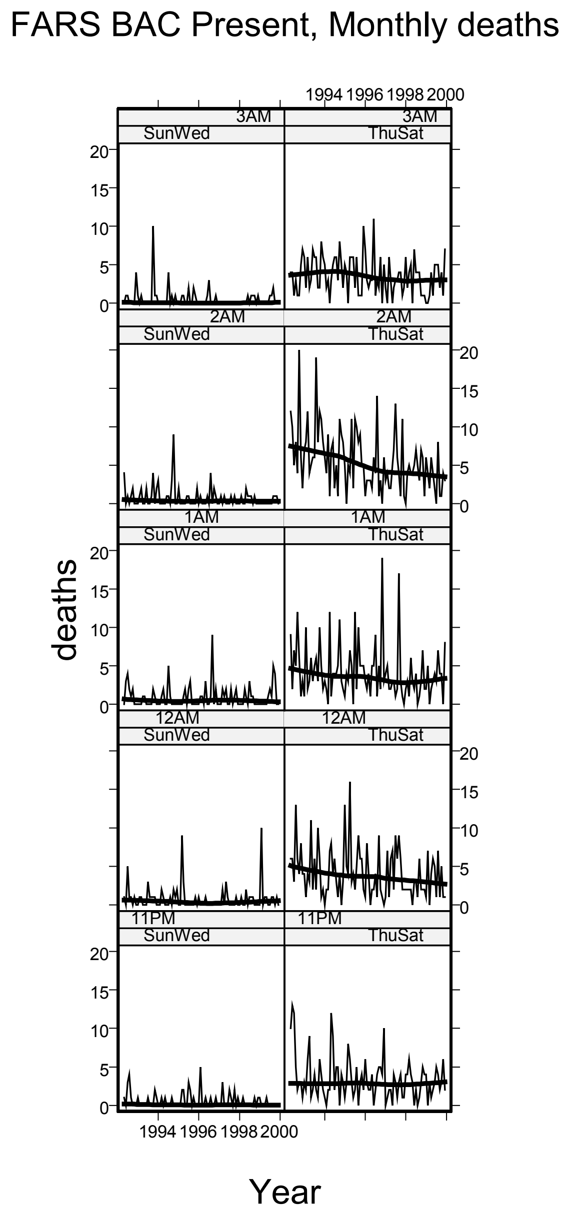


Figure 6b-ii. Deaths with BAC present. Logged and Scaled Independently
Figure 6b-ii, FARS deaths with BAC present, exhibits a downward trend for ThuSat at 2AM and 12AM and possibly also SunWed at 2AM.

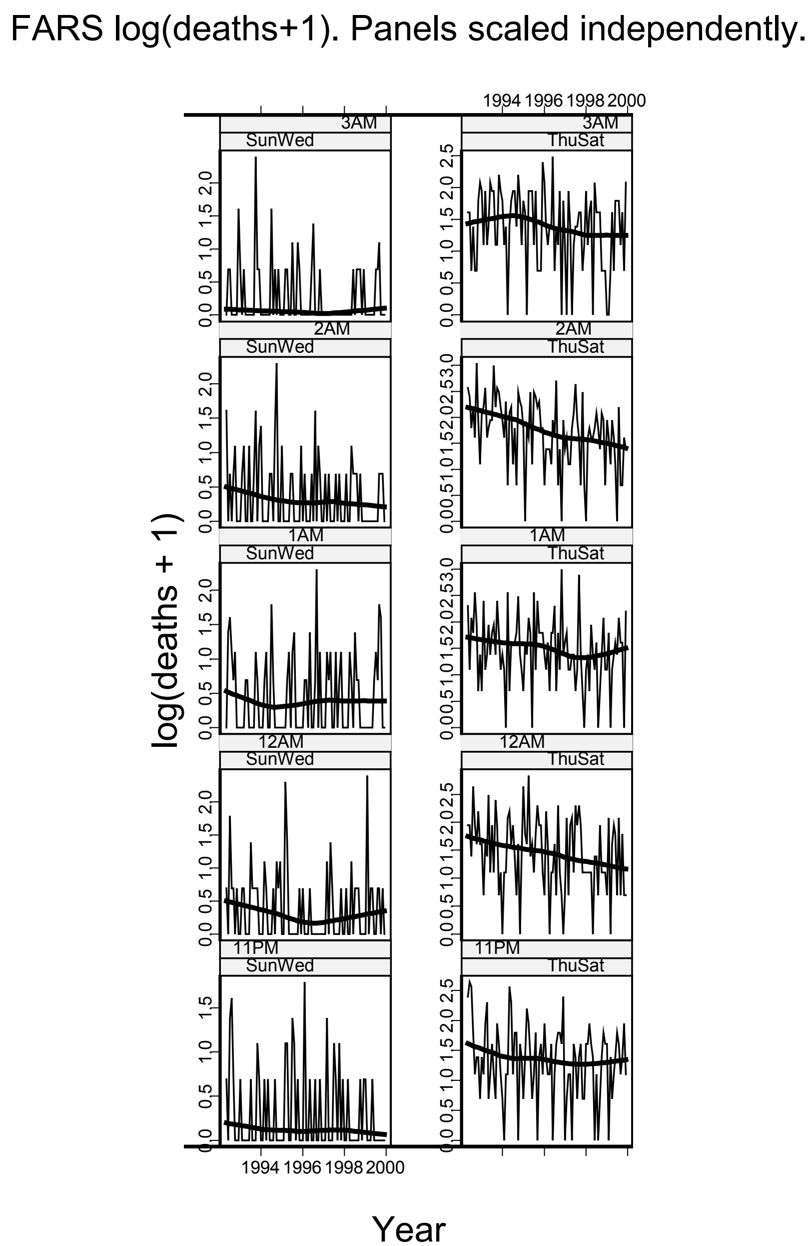


Figure 6c-i. Deaths with BAC absent.

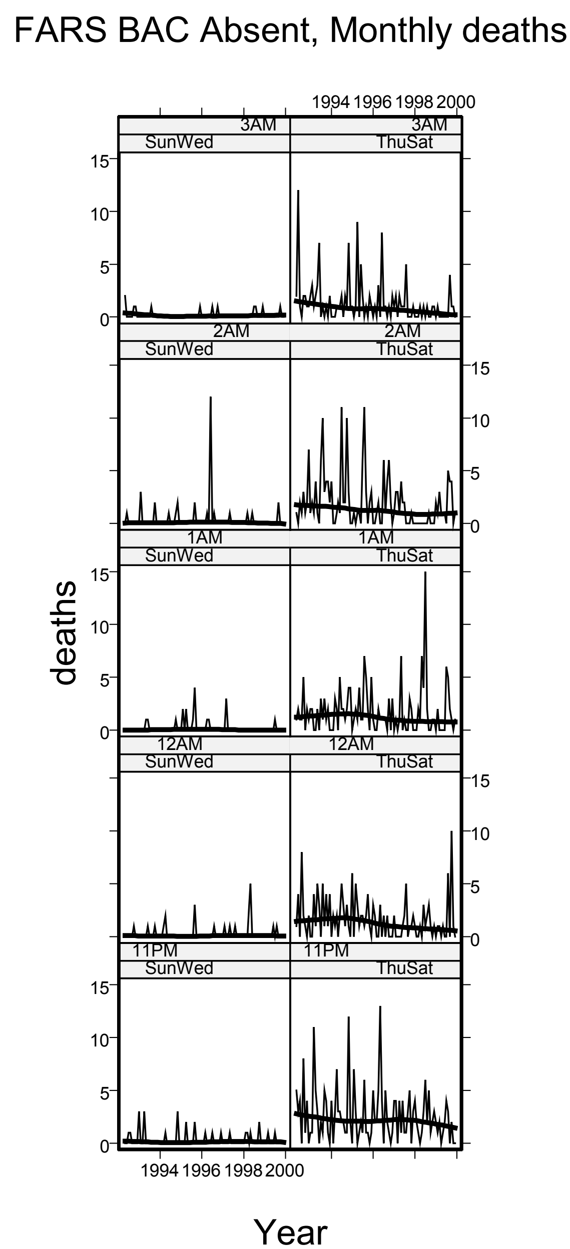
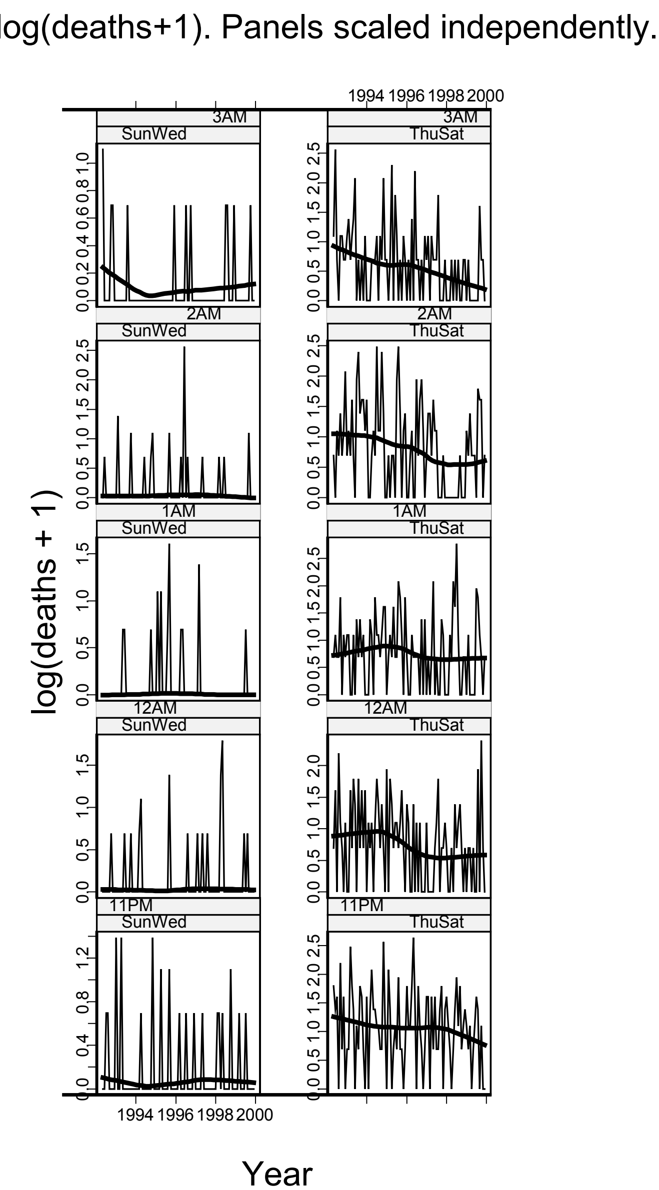


Figure 6c-ii. Deaths with BAC absent. Logged and Scaled Independently.
Figure 6c-ii, FARS deaths with BAC absent shows a downward trend for all levels of `hour` for `ThuSat` but little change for `SunWed`.



STL Analysis

The changes in seasonal patterns may be of interest. An additive robust decomposition of the time series into trend, seasonal and remainder was done for each of the monthly time series. A robust locally quadratic 60% smoother was used for trend estimation.

For all series, a change in the seasonal pattern occurs in 1996.

Notice for FARS Deaths BAC Present the seasonal component has shifted so there have been large increases in February and September while July and August have consistently remained high. This information may be useful for planning traffic safety campaigns.

Figure 7a: STL - All Deaths

R^2 = 53.4%

There was a slight hump in 1997 followed by decrease. The seasonality and variability of the data changed in about August 1996.

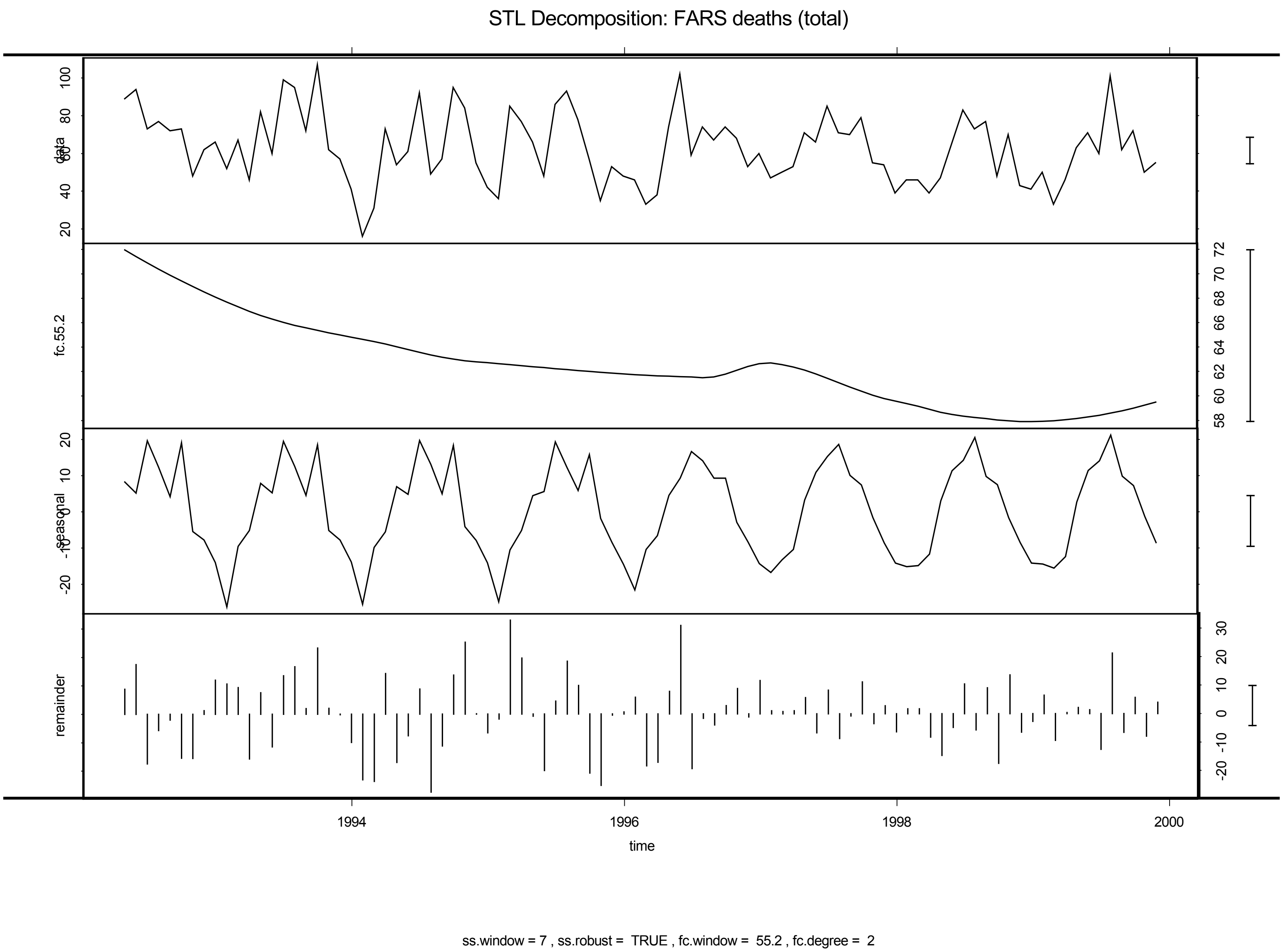


Figure 7b: Monthplot, FARS, totals

FARS deaths totals peak in Jul and reach minimum in Feb. These deaths are relatively high from May through to October (Figure 8).

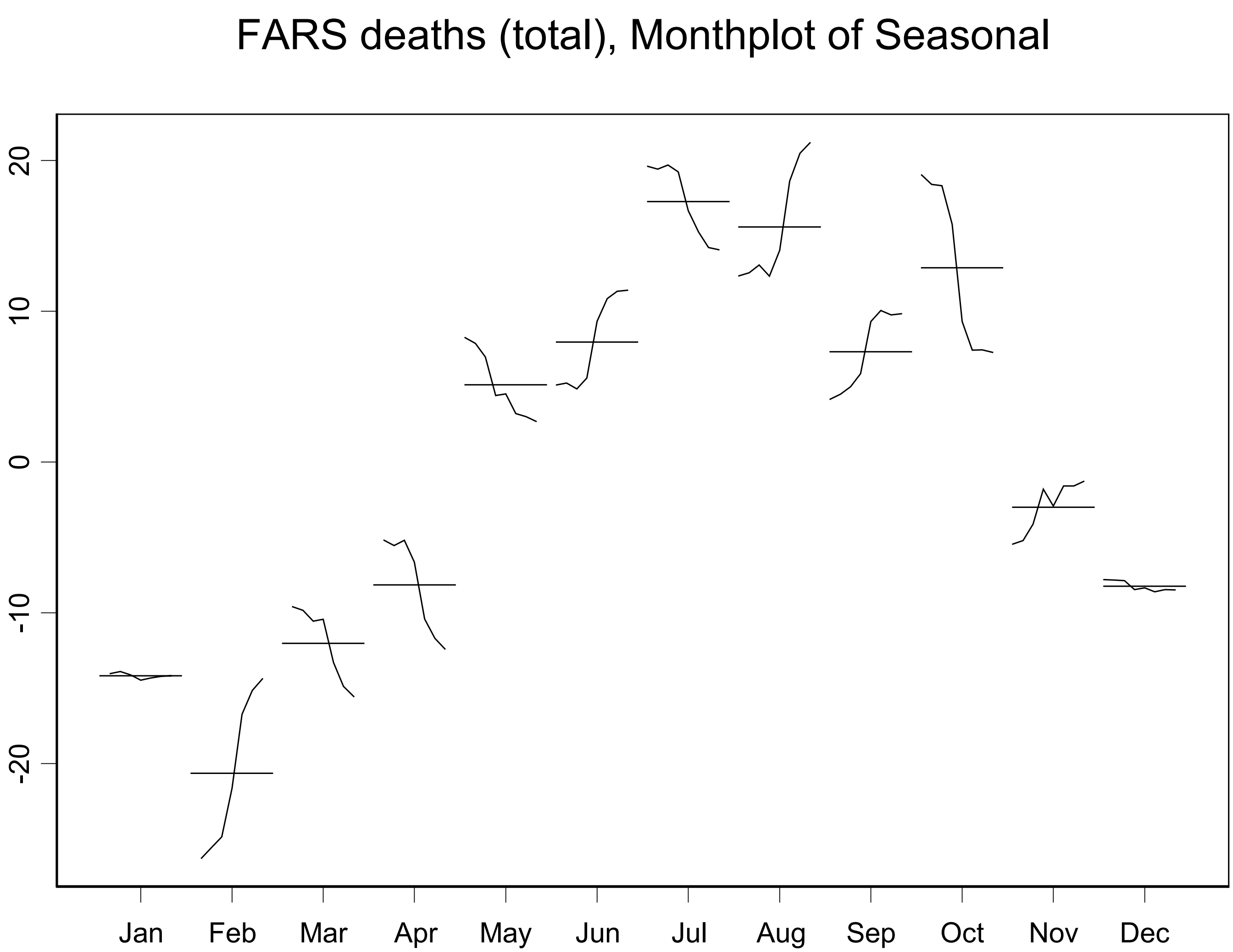


Figure 7c. The deseasonalized series showns an apparent change in variability around 1997. The trend is highly significant with Mann-Kendall test, `tau = -0.214,    sl =1.261%`. The loess trend declines from about 70.5 deaths/month to 56.7 deaths/month which corresponds to a percentage annual rate of decline of about 2.8%.

```
> pc.change(deaths.fars.deseasonalized.ts)
    start      end  change% annual.rate%
 70.46393 56.71454 19.51266     2.791644
```

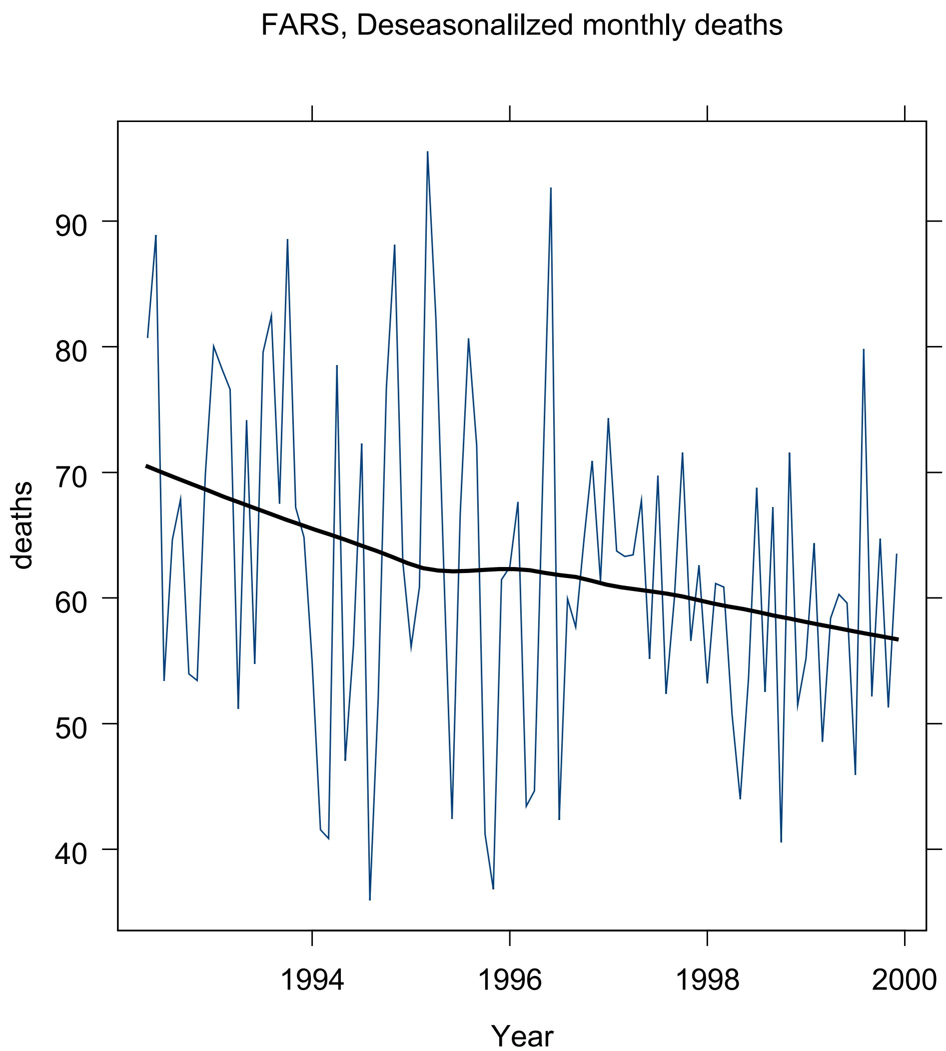
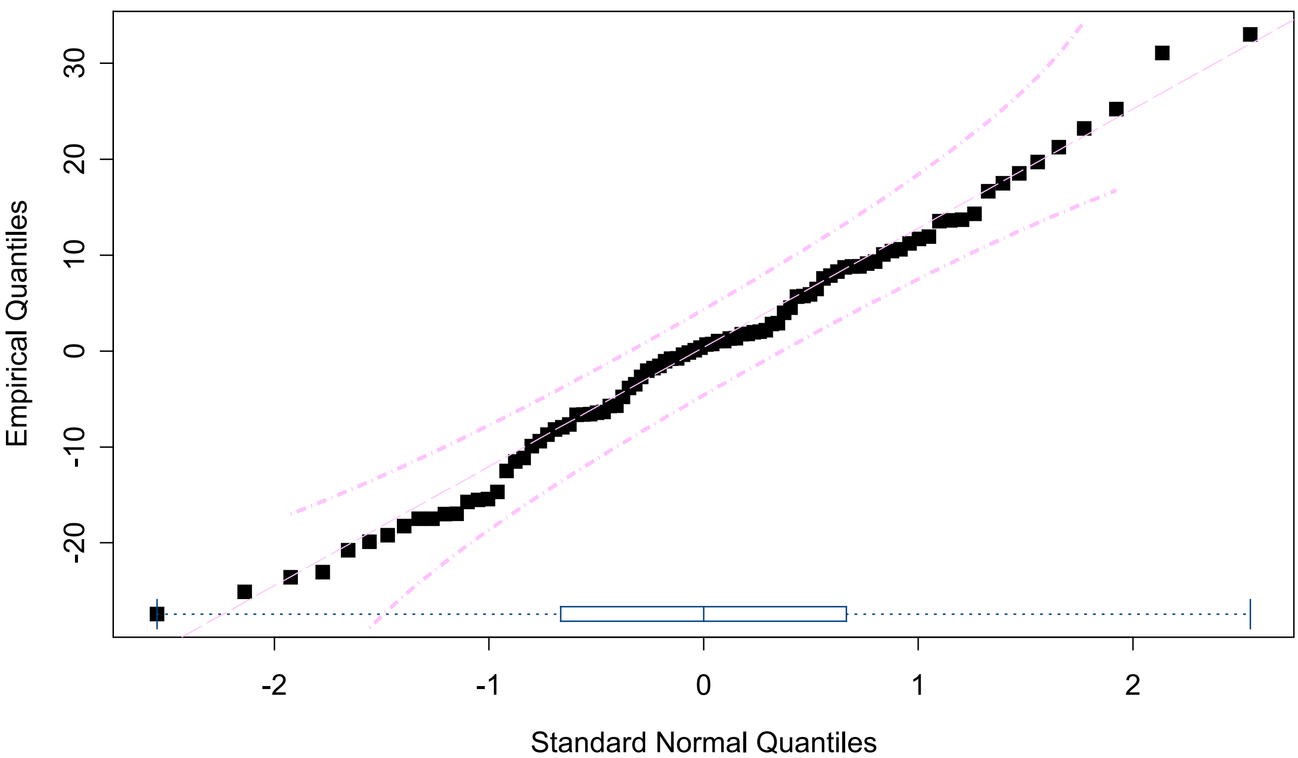


Figure 7d.
Remainder term is normally distributed.



Skewness Coefficient: g_1 = 0.113532 , s.l. = 0.3177048
Michael's Statistic: D_sp = 0.0422705 , s.l. = 0.609863
Wilk-Shapiro Statistic: W = 0.9802573 , s.l. = 0.5645543

Figure 8a: STL, FARS Deaths, BAC Present
R-sq = 60 %

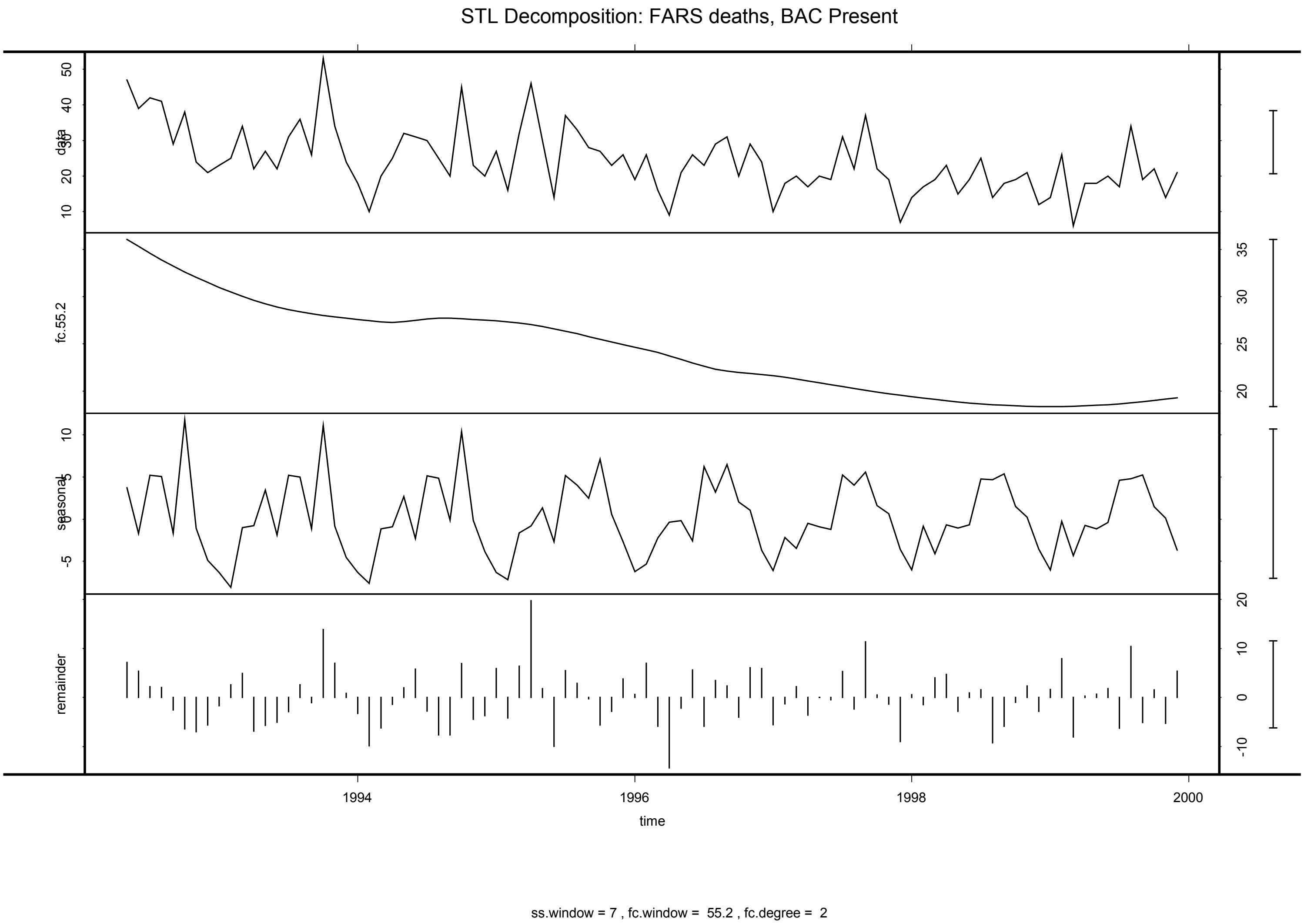


Figure 8b: Monthplot, FARS, BAC Present
FARS deaths with BAC Present (Fig 10) peak in October and are a minimum in Jan. These deaths are also relatively high in Jul and Aug. There are strong increasing trends in Feb and Sep and a decreasing trend in Oct and to a lesser extend in Mar and Apr too.

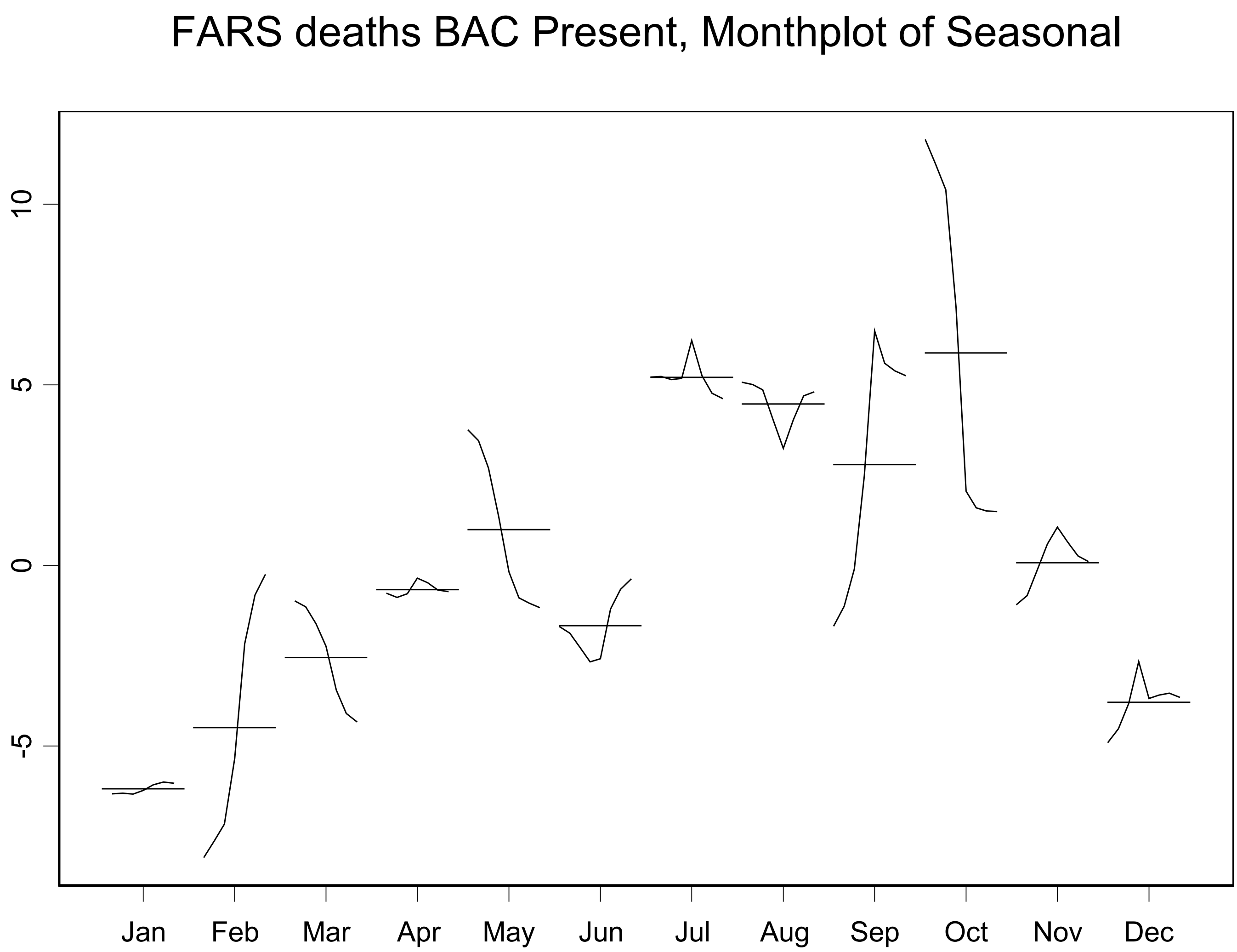


Figure 8c.
Trend in the deseasonalized component is obviously significant.
Mann-Kendall trend test: `tau = -0.461,   sl =8.001e-6%`

```
> pc.change(deaths.fars.deseasonalized.ts)
    start      end  change% annual.rate%
 32.52797 17.38038 46.56791     7.849873
```

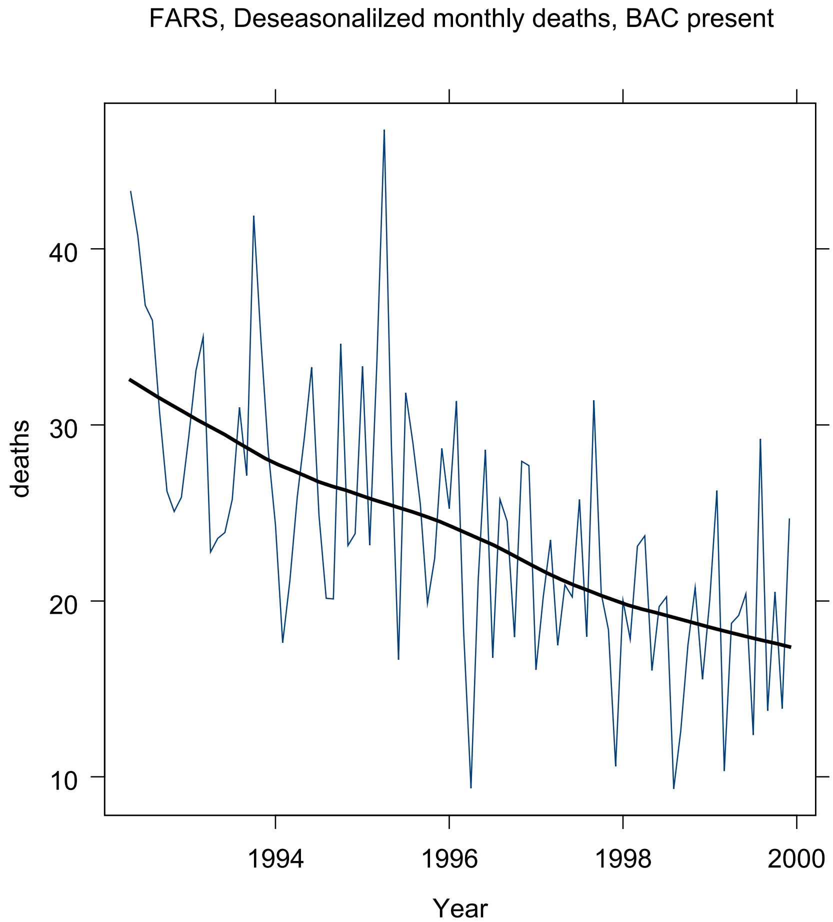


Figure 9a: STL FARS Deaths: BAC Absent

$R^2 =$ 38.3%

Mann-Kendall trend test: `tau = -0.338,   sl =0.008465%`

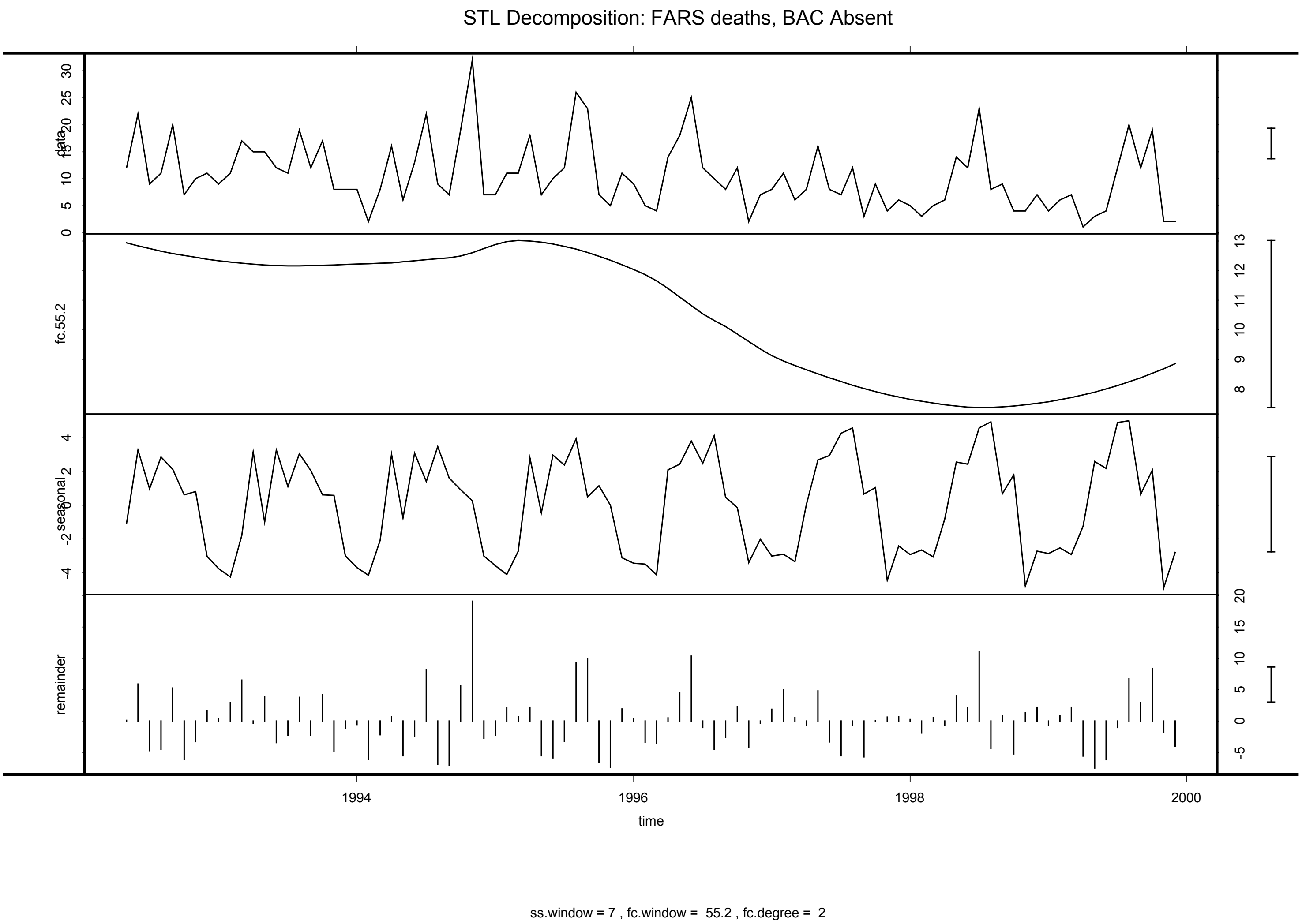


Figure 9b: Monthplot, FARS, BAC absent

FARS deaths with BAC absent peak in Aug but are relatively high from Apr through to Oct and are relatively low in Dec, Jan, Feb and Mar. There has been a sharp downward trend in deaths in Nov (Figure 12).

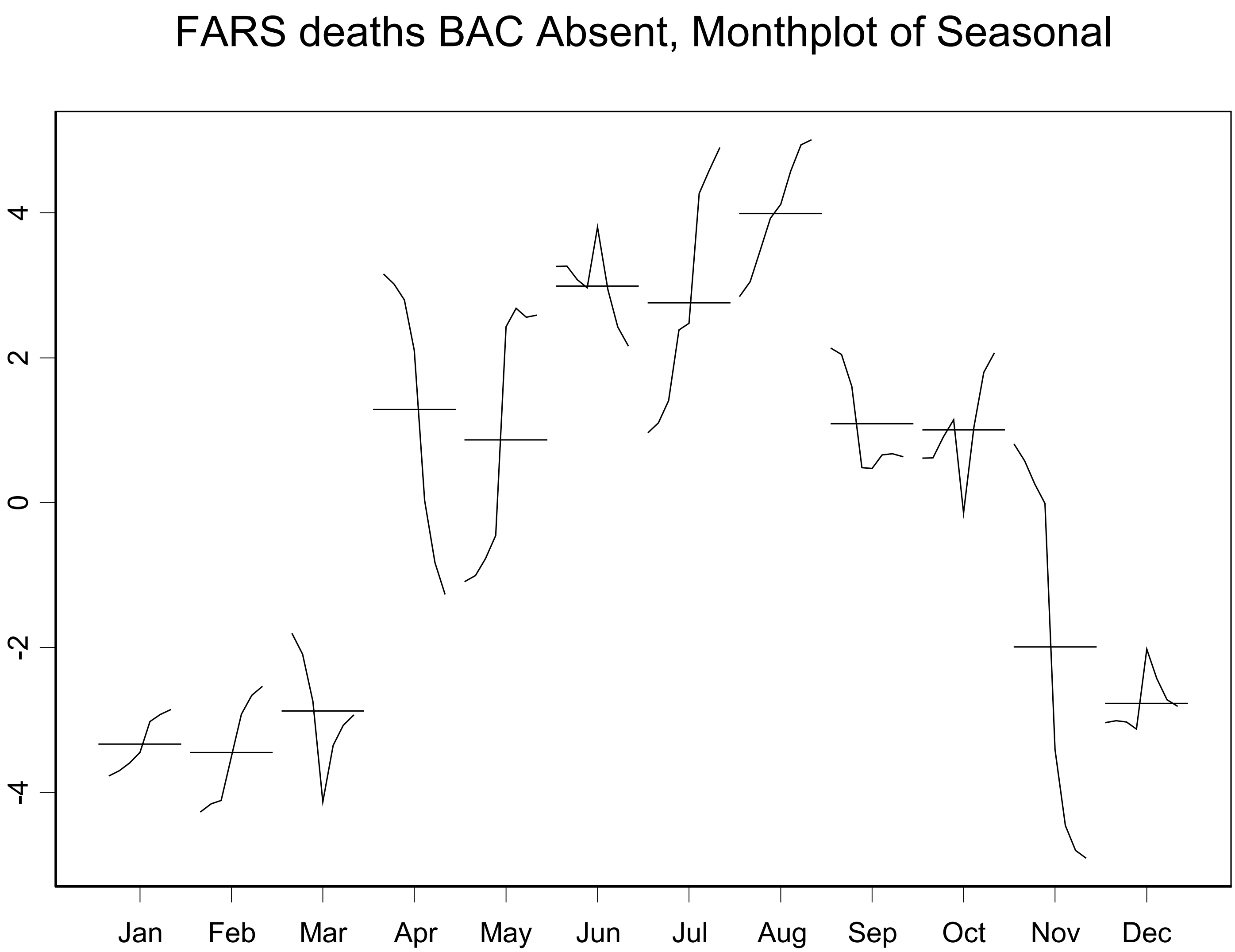


Figure 9c.
There is a significant downward trend. The Mann-Kendall test yields, `tau = -0.338, sl =0.008465`%. The deseasonalized FARS BAC absent deaths decline from about 12.7 at the beginning of 1992 to about 7.2% by the end of 1999. The average annual percentage decrease is about 7.2%.

```
> pc.change(deaths.fars.deseasonalized.ts)
    start      end change% annual.rate%
 12.74778 7.199321 43.5249     7.181718
```

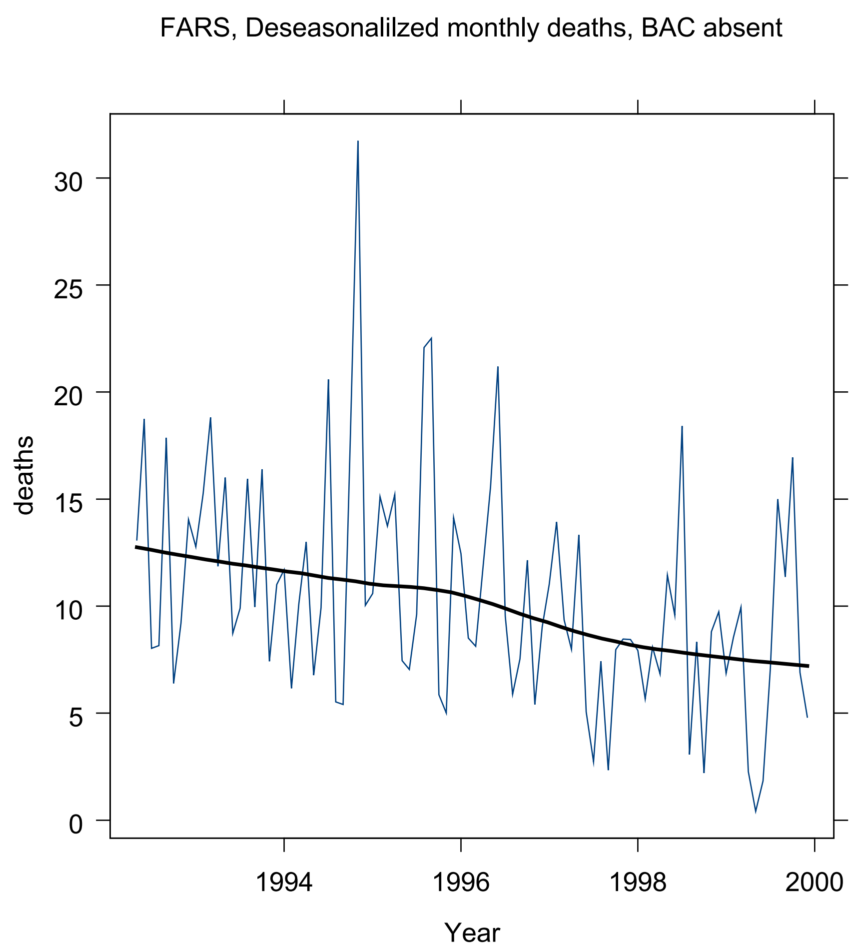
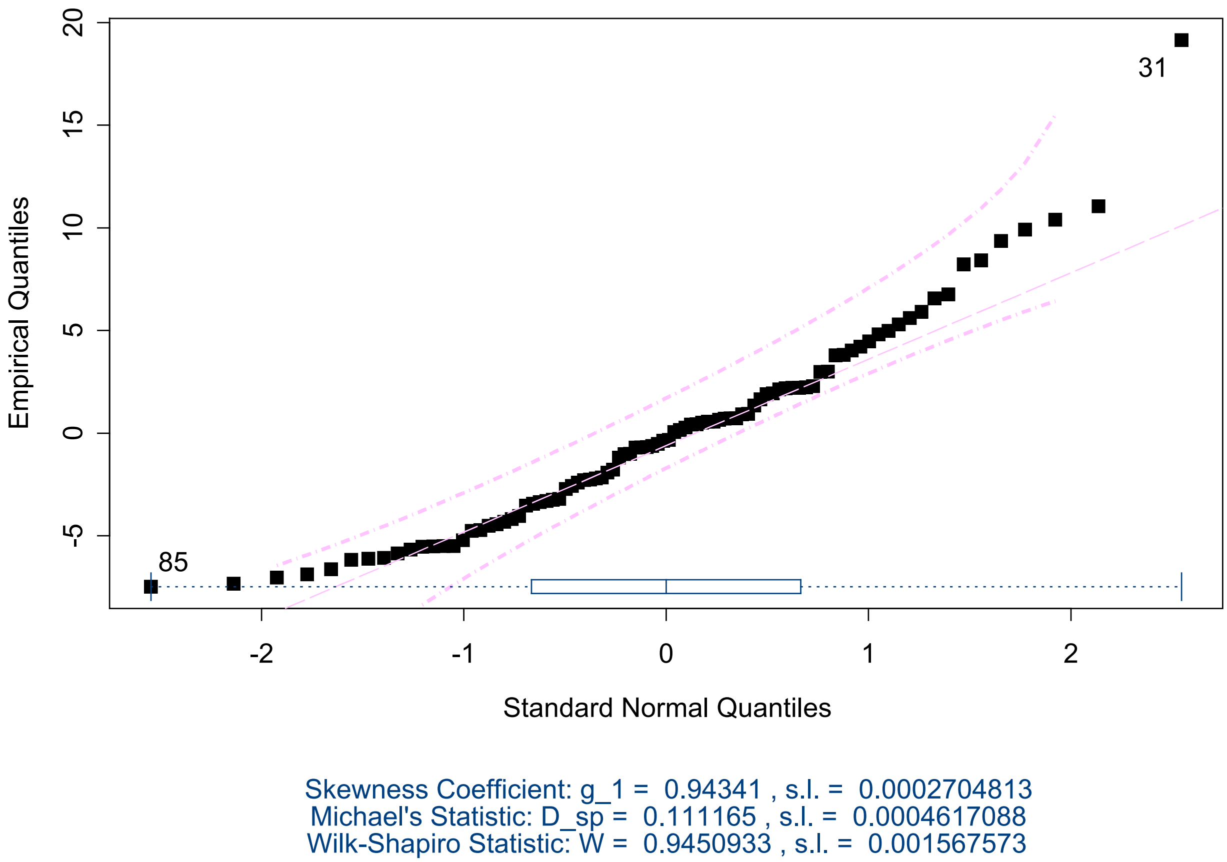


Figure 9d
There are some outliers evident. Observations 31 and 85 corresond to Nov. 1994 and May 1999 respectively. See Table 1c.



J. MISTPOL Dataset

Introduction

Data on 164,931 car accidents from three counties in Michigan for the period January 1992 to December 1999 are available, broken down by county below,

County	Frequency	Percent
Macomb	23725	14.4
Oakland	31936	19.4
Wayne	109270	66.3
Total	164931	100.0

The day, month and year were available for all but 45 of these accidents. In addition the following variables of possible interest were observed for many of these accidents.

Factor	Levels	% missing
hour	11PM, 12AM, 1AM, 2AM	0
wkgrp	SunWed, ThuSat	0.02
sex	male, female	28.1
drink	yes, no	47.6
injury	fatal, incapacitating, non-incapacitating, none	29.6

The data after May 1999 appear to be incomplete so our analysis was based on the data from May 1992 to April 1999. After removing records from May 1999 onwards there remained 155,207 records.

Three separate datasets were analyzed:

(a) All Accidents (155207 records)
(b) Fatal Accidents (465 records)
(c) Incapacitating Accidents (4516 records)

J. MISTPOL Dataset
All Accidents

Summary

Figure 1. Montly number of accidents, in thousands. Seasonal Mann-Kendall test not significant. The trend line suggests a 4% drop from 1.78 to 1.70 thousands of accidents per month from May 1992 to April 1999. It is clear that the total number accidents increased and has now begun to decrease. There are some outliers in 1992 in May, Jul, Nov and Dec.

There is a mild upward trend to about 1997 and then a steeper downward trend (Figure 2, 3). Seasonal maximums occur in Jun-Jul and also in Dec-Jan (Fig. 4).

`Drink-Hour` are associated: there are fewer deaths in `11PM-YES` and more in `2AM-YES` than expected under independence.

`Drink-Weekgroup` are associated: there are slightly more (5%) in the `ThuSat-YES` group than expected under independence.

`Drink and Injury` are associated: there is great increase in the frequency of drinking with fatal and more serious accidents.

`Drink-Gender` are not independent since drinking males are more frequently in accidents than drinking females.

`Hour-Injury` are associated: more serious accidents (fatalities, incapacitating and noncapacitating) tend to happen later in the 2AM window.

`Weekgroup-Injury` are independent.

`Gender-Injury` are associated since males tend to be more involved in fatal accidents.

Figure 4 shows that ThuSat group has more accidents. There is an evident downward trend starting around 1996 in SunWed and shortly after in ThuSat.

No significant trends are present in the trellis plots for `hour` (Figure 6).

Figure 7 shows there has been a downward trend in incapacitating and non-incapacitating accidents but little other trends in the trellis plots for `injury`.

Figure 8 shows accidents by males more frequent and there is a downward trend in both groups but more pronounced for males.

The trellis plot for drink shows that both the yes and no groups show a trend downward but the yes group has a more pronounced trend (Figure 9). This suggests that perhaps there has been a downward trend in the number of accidents where alcohol testing has been done as well as perhaps some decrease in drinking-and-driving.

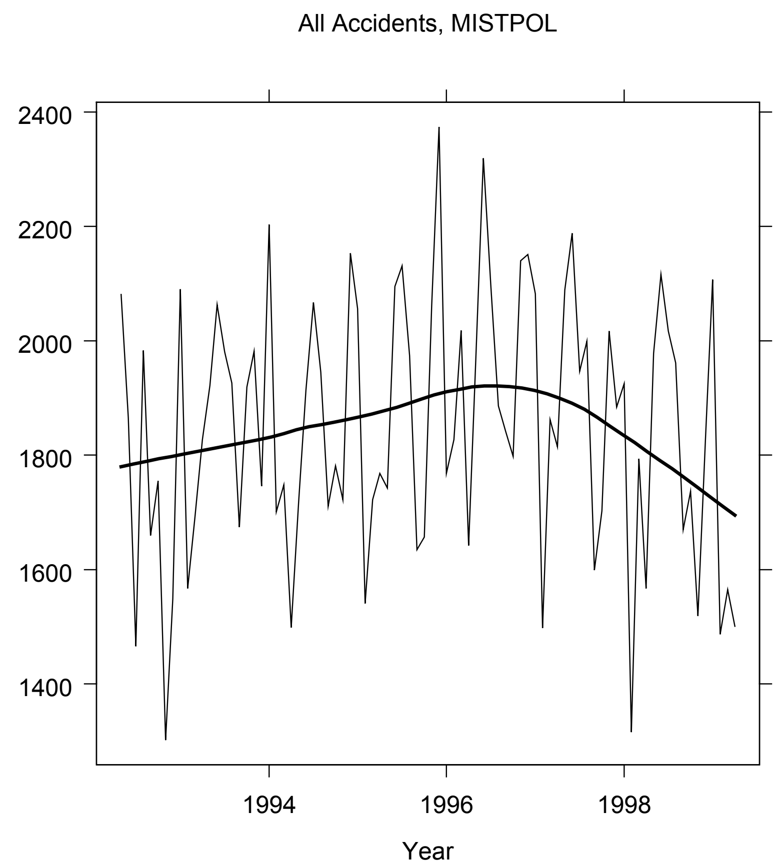
An STL analysis of accidents with drinking indicates a downward trend which increases after 1996 (Figure 10). The seasonal variation in accidents with drinking involved is complicated (Figure 10, 11): there are two peaks one in Jul and the other in Dec. The July peak shows little variation in its amplitude over the years. The troughs are in Feb and Sep.

Time Series Plots

Montly number of accidents, in thousands. Seasonal Mann-Kendall test not significant. The trend line suggests a 4% drop from 1.78 to 1.70 thousands of accidents per month from May 1992 to April 1999. It is clear that the total number accidents increased and has now begun to decrease. There are some outliers in 1992 in May, Jul, Nov and Dec.

```
> accidents.mistpol.total.ts
        Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
1992:                         2.081 1.865 1.466 1.983 1.660 1.755 1.302 1.549
1993: 2.090 1.567 1.693 1.827 1.922 2.063 1.981 1.926 1.674 1.919 1.982 1.746
1994: 2.203 1.701 1.748 1.499 1.716 1.913 2.067 1.945 1.711 1.781 1.722 2.153
1995: 2.056 1.541 1.722 1.768 1.743 2.095 2.131 1.974 1.635 1.657 2.061 2.374
1996: 1.768 1.827 2.018 1.642 1.984 2.319 2.095 1.886 1.842 1.798 2.140 2.151
1997: 2.082 1.498 1.862 1.815 2.089 2.188 1.947 1.999 1.599 1.703 2.017 1.884
1998: 1.925 1.316 1.794 1.567 1.978 2.116 2.017 1.961 1.670 1.737 1.519 1.827
1999: 2.107 1.487 1.565 1.501
> print.Kendall(SeasonalMannKendall(accidents.mistpol.total.ts))
tau = 0.0159,   sl =86.23%
> pc.change(accidents.mistpol.total.ts)
[1] 1.779563 1.695388 4.730113
```

Figure 1.



STL Analysis
There is a upward trend to 1996 followed by a downward trend.
R-sq = 65.9 %
Figure 2a.

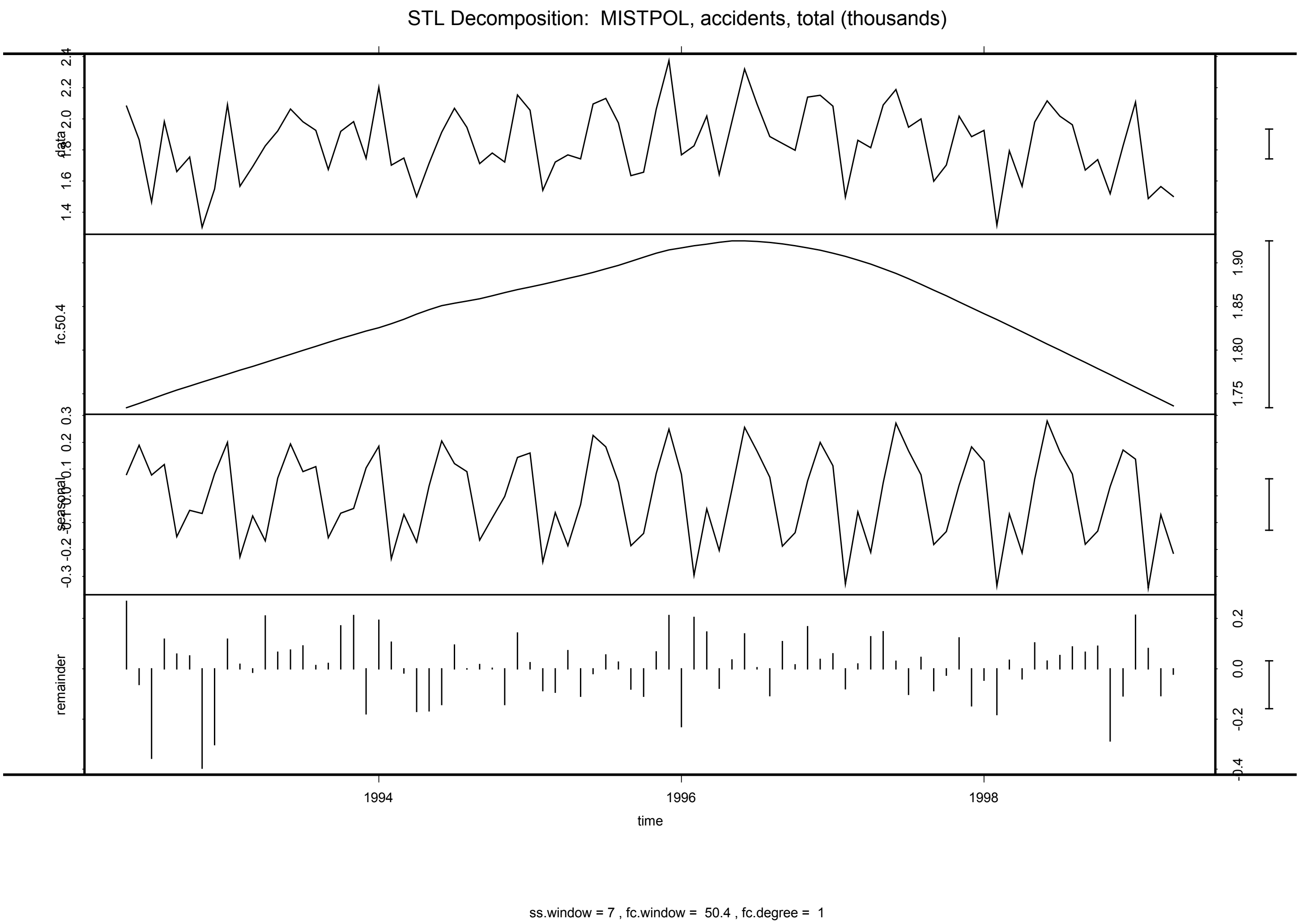


Figure 2b. Seasonal maxima in Jun-Jul and also in Dec-Jan (Fig. 4).

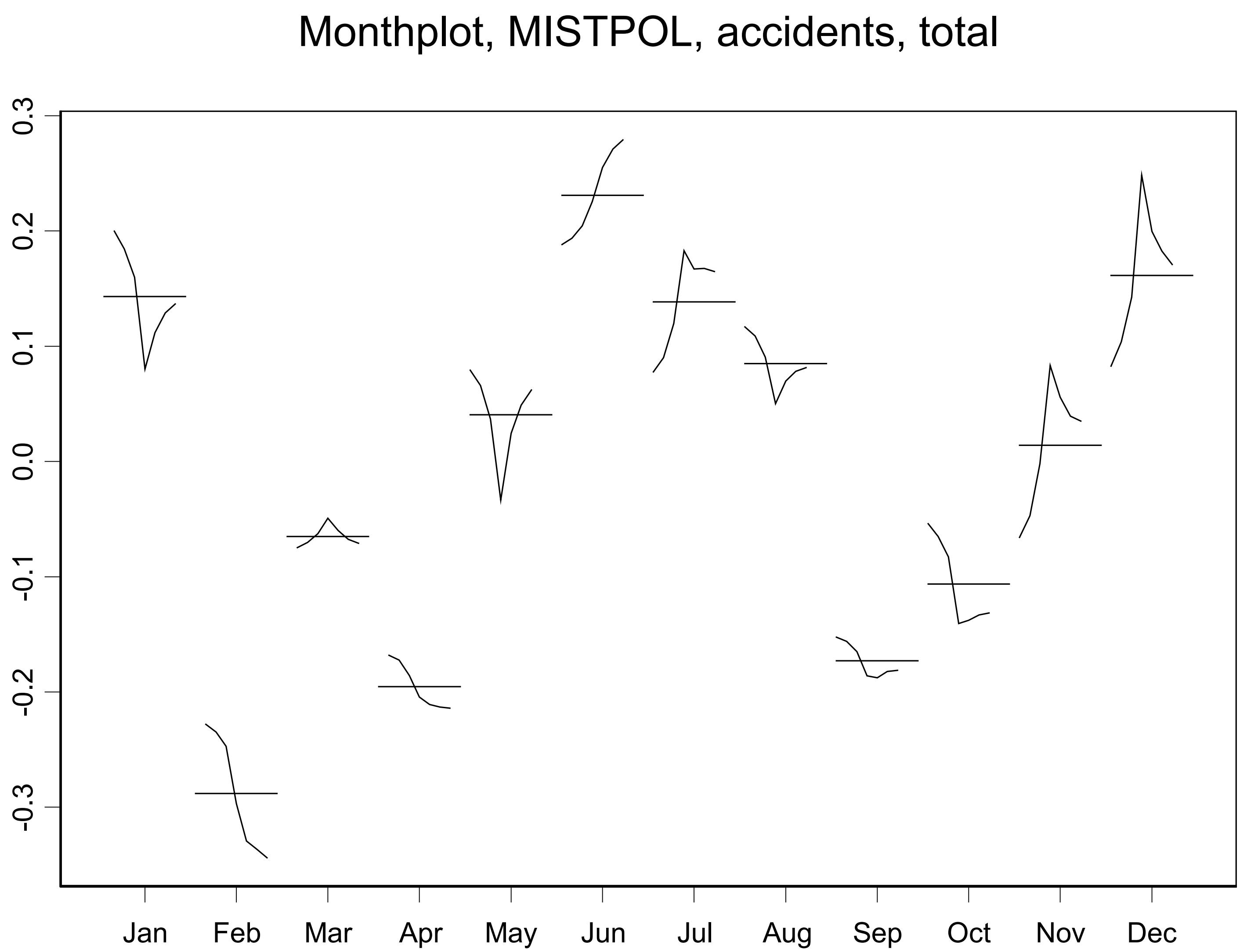


Figure 2c. Trend Analysis of the Deseasonalized Series

`Mann-Kendall: tau = 0.0321,   sl =66.9%`

However there is clearly a downward trend evident in the last 2 years. Outliers at the beginning are also evident.

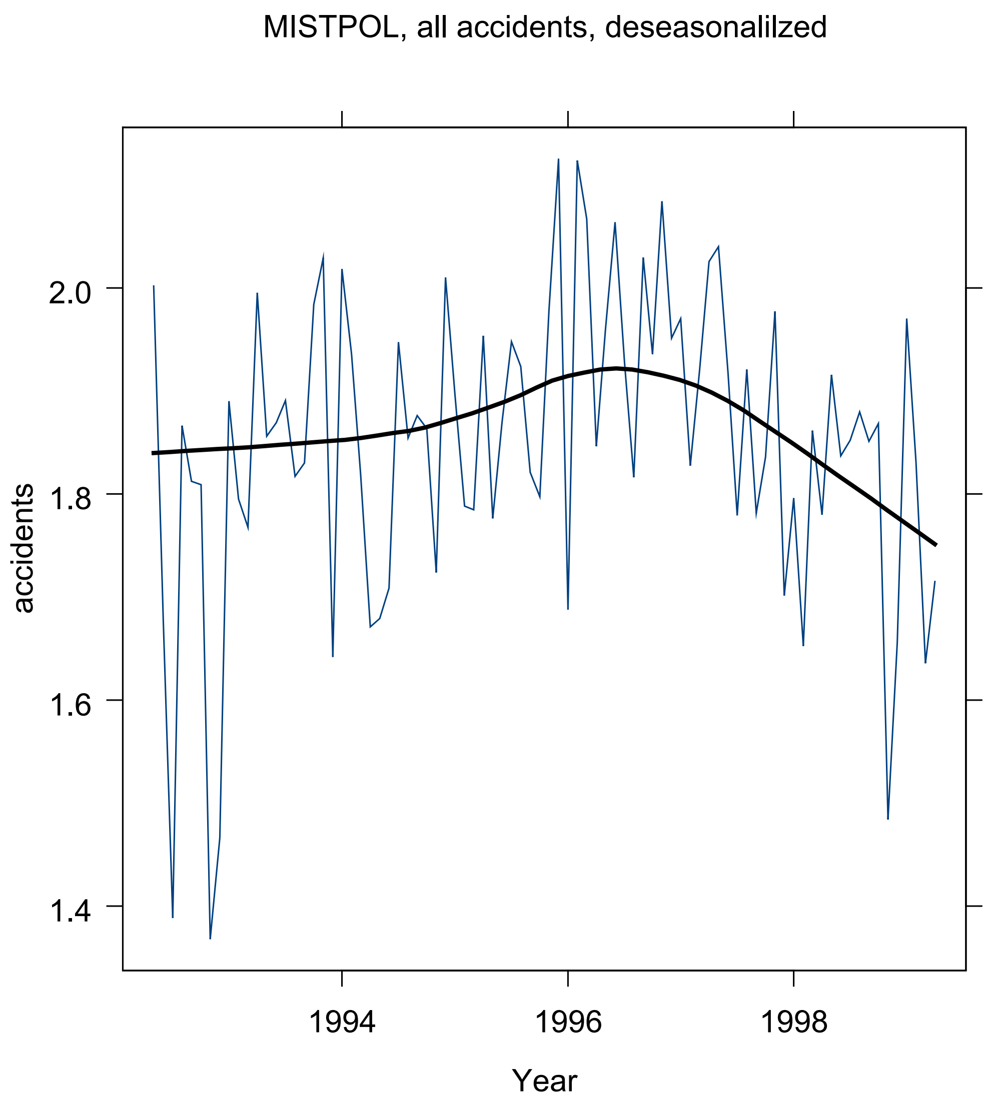
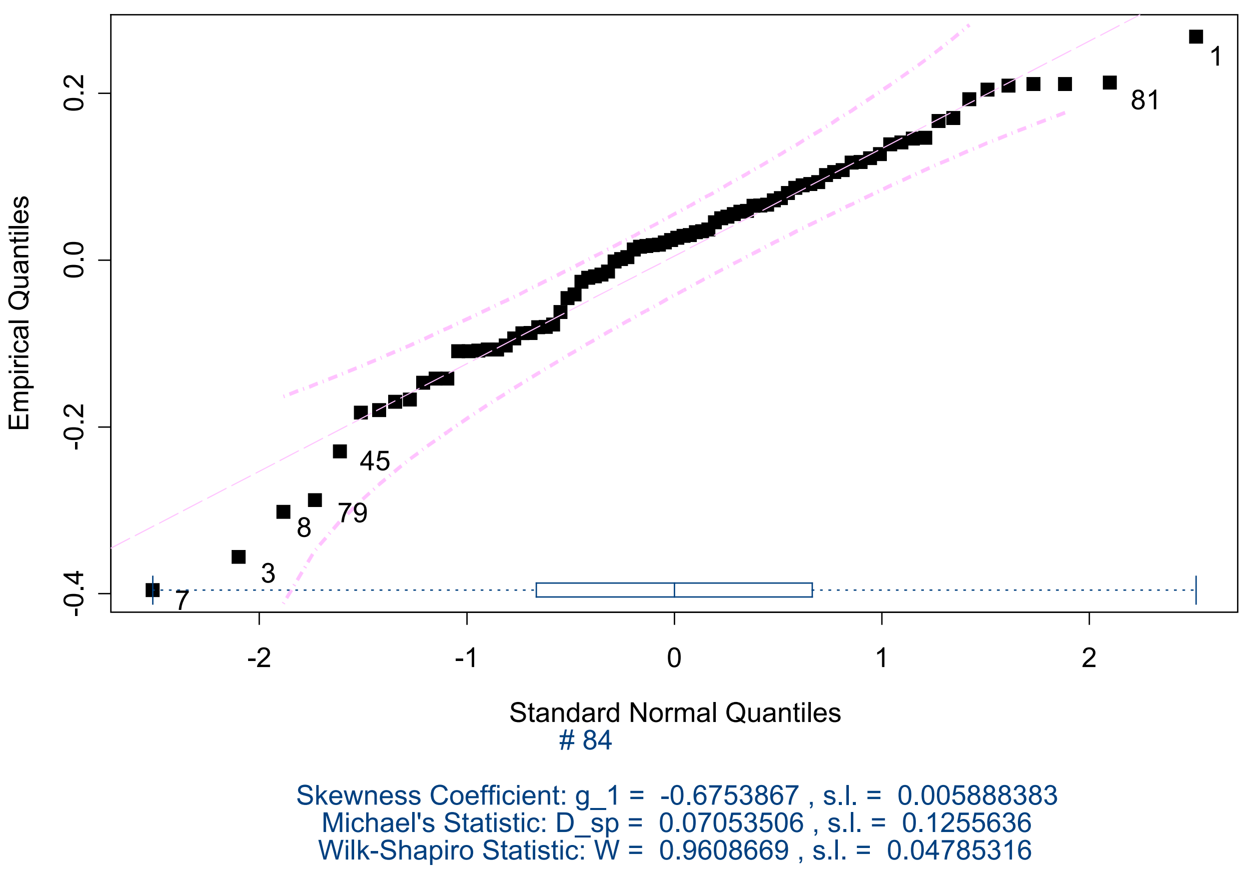


Figure 2d. Normal Probability Plot of Remainder

There are some outliers in 1992 in May, Jul, Nov and Dec.

```
> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   3   4   5   6   7   8
1993:   9  10  11  12  13  14  15  16  17  18  19  20
1994:  21  22  23  24  25  26  27  28  29  30  31  32
1995:  33  34  35  36  37  38  39  40  41  42  43  44
1996:  45  46  47  48  49  50  51  52  53  54  55  56
1997:  57  58  59  60  61  62  63  64  65  66  67  68
1998:  69  70  71  72  73  74  75  76  77  78  79  80
1999:  81  82  83  84
```



Drink and Hour

There are fewer accidents in 11PM-YES and more in 2AM-YES than expected under independence.

```
Call:
crosstabs( ~ drink + hour, data = mistpol.df, na.action = na.exclude)
86376 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |hour
       |11PM   |12AM   |1AM    |2AM    |RowTotl|
-------+-------+-------+-------+-------+-------+
yes    | 4696  | 4546  | 4786  | 6536  |20564  |
       |0.228  |0.221  |0.233  |0.318  |0.24   |
       |0.154  |0.217  |0.282  |0.365  |       |
       |0.054  |0.053  |0.055  |0.076  |       |
-------+-------+-------+-------+-------+-------+
no     |25840  |16386  |12208  |11378  |65812  |
       |0.393  |0.249  |0.185  |0.173  |0.76   |
       |0.846  |0.783  |0.718  |0.635  |       |
       |0.299  |0.190  |0.141  |0.132  |       |
-------+-------+-------+-------+-------+-------+
ColTotl|30536  |20932  |16994  |17914  |86376  |
       |0.35   |0.24   |0.20   |0.21   |       |
-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 3011.41 d.f.= 3 (p=0)
       Yates' correction not used
contribution to chi-sq:
        [,1]  [,2]   [,3]   [,4]
[1,] -29.49 -6.08  11.55  33.73
[2,]  16.54  3.41  -6.48 -18.92
```

Drink and Weekgroup

There are more in the `ThuSat-YES` group than expected under independence. So we see there tends to be a higher proportion of drunk driving accidents in the `ThuSat` wkgrp.

```
Call:
crosstabs( ~ drink + wkgrp, data = mistpol.df, na.action = na.exclude)
86340 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
yes    | 7007  |13551  |20558  |
       |0.341  |0.659  |0.24   |
       |0.218  |0.250  |       |
       |0.081  |0.157  |       |
-------+-------+-------+-------+
no     |25111  |40671  |65782  |
       |0.382  |0.618  |0.76   |
       |0.782  |0.750  |       |
       |0.291  |0.471  |       |
-------+-------+-------+-------+
ColTotl|32118  |54222  |86340  |
       |0.37   |0.63   |       |
-------+-------+-------+-------+
Test for independence of all factors
        Chi^2 = 112.1013 d.f.= 1 (p=0)
        Yates' correction not used
```

```
contribution to chi-sq:
        [,1]  [,2]
[1,] -7.20  5.51
[2,]  4.04 -3.09
```

Drink and Injury

An great increase in the frequency of drinking with fatal and more serious accidents.

```
Call:
crosstabs( ~ drink + injury, data = mistpol.df, na.action = na.exclude)
84421 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |injury
       |fatal  |incpctt|noncap |possibl|none   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
yes    |  273  | 1672  | 2942  | 2372  |12902  |20161  |
       |0.0135 |0.0829 |0.1459 |0.1177 |0.6399 |0.24   |
       |0.7479 |0.4963 |0.4867 |0.2114 |0.2034 |       |
       |0.0032 |0.0198 |0.0348 |0.0281 |0.1528 |       |
-------+-------+-------+-------+-------+-------+-------+
no     |   92  | 1697  | 3103  | 8847  |50521  |64260  |
       |0.0014 |0.0264 |0.0483 |0.1377 |0.7862 |0.76   |
       |0.2521 |0.5037 |0.5133 |0.7886 |0.7966 |       |
       |0.0011 |0.0201 |0.0368 |0.1048 |0.5984 |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|365    |3369   |6045   |11219  |63423  |84421  |
       |0.0043 |0.0399 |0.0716 |0.1329 |0.7513 |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 4275.379 d.f.= 4 (p=0)
       Yates' correction not used
```

```
contribution to chi-sq:
       [,1]   [,2]   [,3]  [,4]   [,5]
[1,]  19.24  29.98  38.58 -6.04 -17.74
[2,] -10.82 -16.85 -21.69  3.40   9.97
```

Drink and Gender

Drinking and gender are not independent. Drinking males are more frequently in accidents than drinking females.

```
Call:
crosstabs( ~ drink + sex, data = mistpol.df, na.action = na.exclude)
83792 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |sex
       |male   |female |RowTotl|
-------+-------+-------+-------+
yes    |16033  | 4129  |20162  |
       |0.795  |0.205  |0.24   |
       |0.276  |0.161  |       |
       |0.191  |0.049  |       |
-------+-------+-------+-------+
no     |42157  |21473  |63630  |
       |0.663  |0.337  |0.76   |
       |0.724  |0.839  |       |
       |0.503  |0.256  |       |
-------+-------+-------+-------+
ColTotl|58190  |25602  |83792  |
       |0.69   |0.31   |       |
-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 1270.155 d.f.= 1 (p=0)
       Yates' correction not used
contribution to chi-sq:
        [,1]   [,2]
[1,]  16.66 -25.16
[2,]  -9.41  14.21
```

Hour and Injury

The 2AM window has a higher than expected share of the three most serious injury classes and correspondingly the 11PM windows has fewer of the three most serious injury classes and more of the none-injury accidents.

```
Call:
crosstabs( ~ hour + injury, data = mistpol.df, na.action = na.exclude)
116099 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
hour   |injury
       |fatal  |incpctt|noncap |possibl|none   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
11PM   |  129  | 1285  | 2122  | 5010  |31546  |40092  |
       |0.0032 |0.0321 |0.0529 |0.1250 |0.7868 |0.35   |
       |0.2575 |0.2689 |0.2782 |0.3385 |0.3569 |       |
       |0.0011 |0.0111 |0.0183 |0.0432 |0.2717 |       |
-------+-------+-------+-------+-------+-------+-------+
12AM   |  117  | 1170  | 1747  | 3512  |21091  |27637  |
       |0.0042 |0.0423 |0.0632 |0.1271 |0.7631 |0.24   |
       |0.2335 |0.2449 |0.2290 |0.2373 |0.2386 |       |
       |0.0010 |0.0101 |0.0150 |0.0303 |0.1817 |       |
-------+-------+-------+-------+-------+-------+-------+
1AM    |  120  |  983  | 1702  | 3070  |17686  |23561  |
       |0.0051 |0.0417 |0.0722 |0.1303 |0.7506 |0.20   |
       |0.2395 |0.2057 |0.2231 |0.2074 |0.2001 |       |
       |0.0010 |0.0085 |0.0147 |0.0264 |0.1523 |       |
-------+-------+-------+-------+-------+-------+-------+
2AM    |  135  | 1340  | 2057  | 3208  |18069  |24809  |
       |0.0054 |0.0540 |0.0829 |0.1293 |0.7283 |0.21   |
       |0.2695 |0.2805 |0.2697 |0.2168 |0.2044 |       |
       |0.0012 |0.0115 |0.0177 |0.0276 |0.1556 |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|501    |4778   |7628   |14800  |88392  |116099 |
       |0.0043 |0.0412 |0.0657 |0.1275 |0.7614 |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 510.2645 d.f.= 12 (p=0)
       Yates' correction not used
contribution to chi-sq:
      [,1]  [,2]   [,3]  [,4]  [,5]
[1,] -3.36 -8.47  -9.85 -1.25  5.64
[2,] -0.24  0.84  -1.33 -0.09  0.25
[3,]  1.82  0.40   3.86  1.26 -1.88
[4,]  2.75  9.49  10.15  0.46 -5.60
```

Weekgroup and Injury

Injury and weekgroup are not associated.

```
Call:
crosstabs( ~ wkgrp + injury, data = mistpol.df, na.action = na.exclude)
116063 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
wkgrp  |injury
       |fatal  |incpctt|noncap |possibl|none   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
SunWed |  188  | 1764  | 2863  | 5642  |33072  |43529  |
       |0.0043 |0.0405 |0.0658 |0.1296 |0.7598 |0.38   |
       |0.3752 |0.3693 |0.3756 |0.3813 |0.3743 |       |
       |0.0016 |0.0152 |0.0247 |0.0486 |0.2849 |       |
-------+-------+-------+-------+-------+-------+-------+
ThuSat |  313  | 3012  | 4760  | 9156  |55293  |72534  |
       |0.0043 |0.0415 |0.0656 |0.1262 |0.7623 |0.62   |
       |0.6248 |0.6307 |0.6244 |0.6187 |0.6257 |       |
       |0.0027 |0.0260 |0.0410 |0.0789 |0.4764 |       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|501    |4776   |7623   |14798  |88365  |116063 |
       |0.0043 |0.0412 |0.0657 |0.1275 |0.7614 |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 3.344447 d.f.= 4 (p=0.501921)
       Yates' correction not used
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]  [,5]
[1,] -0.02 -0.94 -0.28  1.31 -0.24
[2,]  0.02  0.72  0.21 -1.01  0.18
```

Gender and Injury

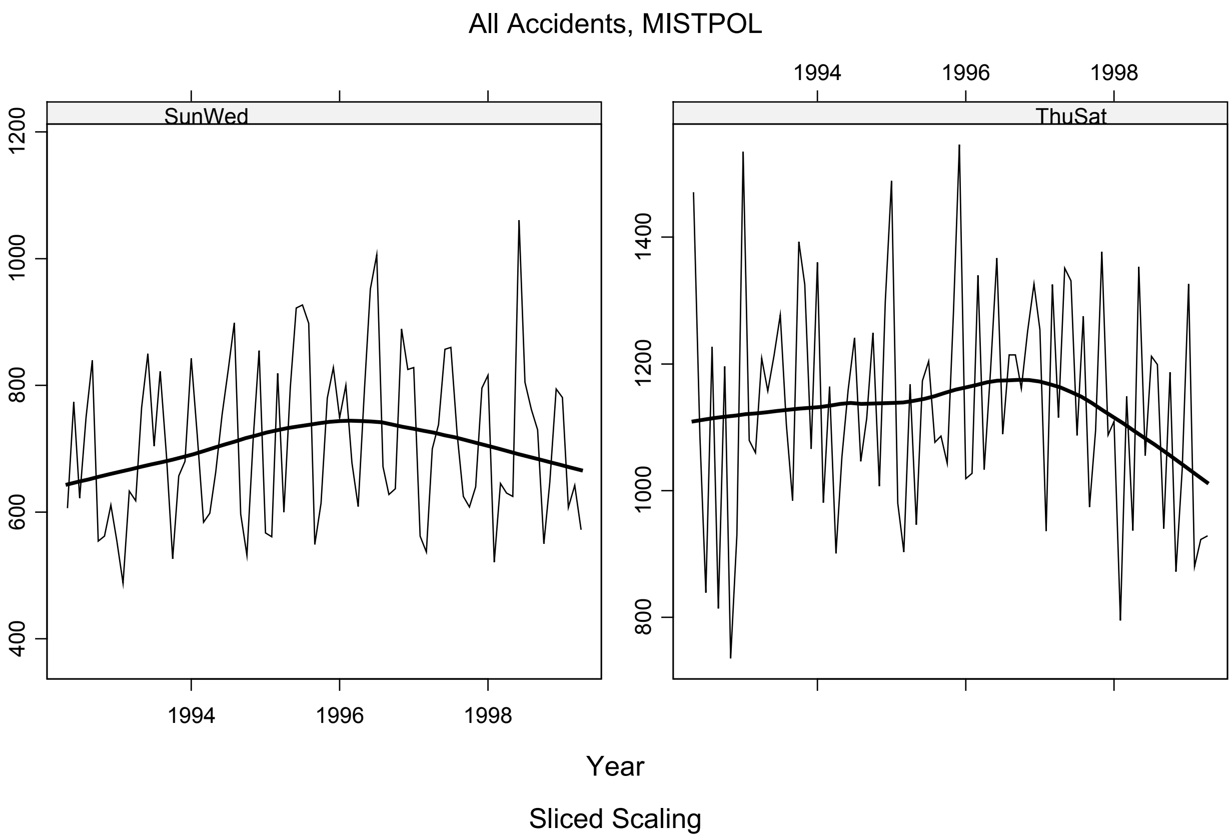
Males tend to be more involved in fatal accidents. The biggest contribution to the gender difference though comes from the possibly-injury accidents where males account for only 60.2% whereas for all accidents they account for 69%. So there contribution to minor accidents is much less than females.

```
Call:
crosstabs( ~ sex + injury, data = mistpol.df, na.action = na.exclude)
109948 cases in table

+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
sex    |injury
       |fatal  |incpctt|noncap |possibl|none   |RowTotl|
-------+-------+-------+-------+-------+-------+-------+
male   |  386  | 3303  | 5342  | 8706  |58346  |76083  |
       |0.00507|0.04341|0.07021|0.11443|0.76687|0.69   |
       |0.79261|0.70865|0.71772|0.60182|0.70389|       |
       |0.00351|0.03004|0.04859|0.07918|0.53067|       |
-------+-------+-------+-------+-------+-------+-------+
female |  101  | 1358  | 2101  | 5760  |24545  |33865  |
       |0.00298|0.04010|0.06204|0.17009|0.72479|0.31   |
       |0.20739|0.29135|0.28228|0.39818|0.29611|       |
       |0.00092|0.01235|0.01911|0.05239|0.22324|       |
-------+-------+-------+-------+-------+-------+-------+
ColTotl|487    |4661   |7443   |14466  |82891  |109948 |
       |0.0044 |0.0424 |0.0677 |0.1316 |0.7539 |       |
-------+-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 659.1499 d.f.= 4 (p=0)
       Yates' correction not used
contribution to chi-sq:
      [,1]  [,2]  [,3]   [,4]  [,5]
[1,]  2.47  1.10  2.66 -12.80  4.13
[2,] -3.72 -1.65 -3.99  19.23 -6.20
```

Time Series Trellis Plots of Weekgroup

Figure 4 shows that ThuSat group has more accidents. There is an evident downward trend starting around 1996 in SunWed and shortly after in ThuSat.

Figure 4. Sliced vertical scale.



Wkgrp time series and seasonal Mann-Kendall trends

```
> mistpol.total.SunWed.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1992:                      607  774  622  750  840  554  562  611
1993:  555  488  633  618  765  850  704  822  690  526  657  680
1994:  843  720  584  598  663  754  826  899  597  532  715  855
1995:  567  561  819  600  797  922  927  898  549  614  780  828
1996:  749  800  678  609  793  952 1006  672  628  637  889  825
1997:  828  562  537  700  738  857  860  724  625  608  640  796
1998:  816  521  645  630  625 1061  805  762  730  550  647  794
1999:  781  607  642  573
> SeasonalMannKendall(mistpol.total.SunWed.ts)
tau = 0.143,   sl =11.86%

> mistpol.total.ThuSat.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1992:                     1470 1085  839 1227  814 1196  735  930
1993: 1535 1079 1060 1209 1157 1213 1277 1104  984 1393 1325 1066
1994: 1360  981 1164  901 1053 1159 1241 1046 1114 1249 1007 1298
1995: 1489  980  903 1168  946 1173 1204 1076 1086 1043 1281 1546
1996: 1019 1027 1340 1033 1191 1367 1089 1214 1214 1161 1251 1326
1997: 1254  936 1325 1115 1351 1331 1087 1275  974 1095 1377 1088
1998: 1109  795 1149  937 1353 1055 1212 1199  940 1187  872 1033
1999: 1326  880  923  928
> SeasonalMannKendall(mistpol.total.ThuSat.ts)
tau = -0.111,   sl =22.48%
```

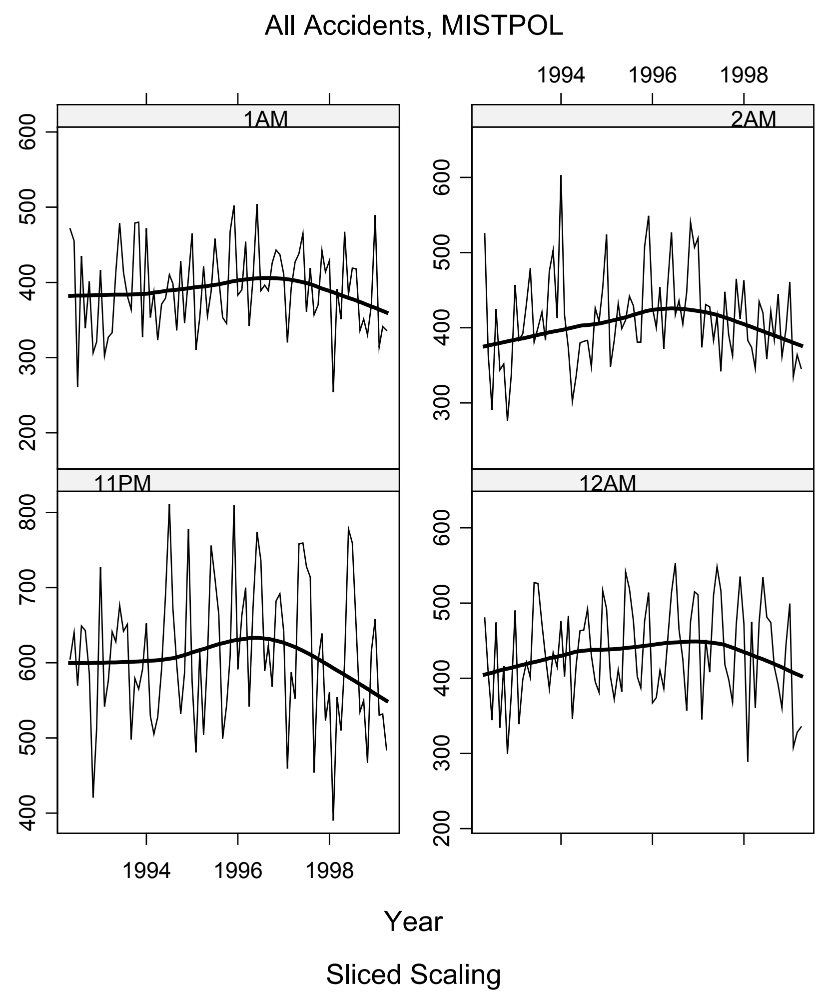
Time Series Trellis Plots of Hour

Here is a breakdown by hour from the original SPSS dataset. The 1474 accidents recorded at Midnight were put in the "12AM" group.

	Frequency	Percent
12 mid.-1:00 a.m.	37279	22.6
1:00-2:00 a.m.	34966	21.2
2:00-3:00 a.m.	36834	22.3
11:00 p.m. - 12 mid	54378	33.0
Midnight	1474	.9

No significant trends are present in the trellis plots for `hour`.

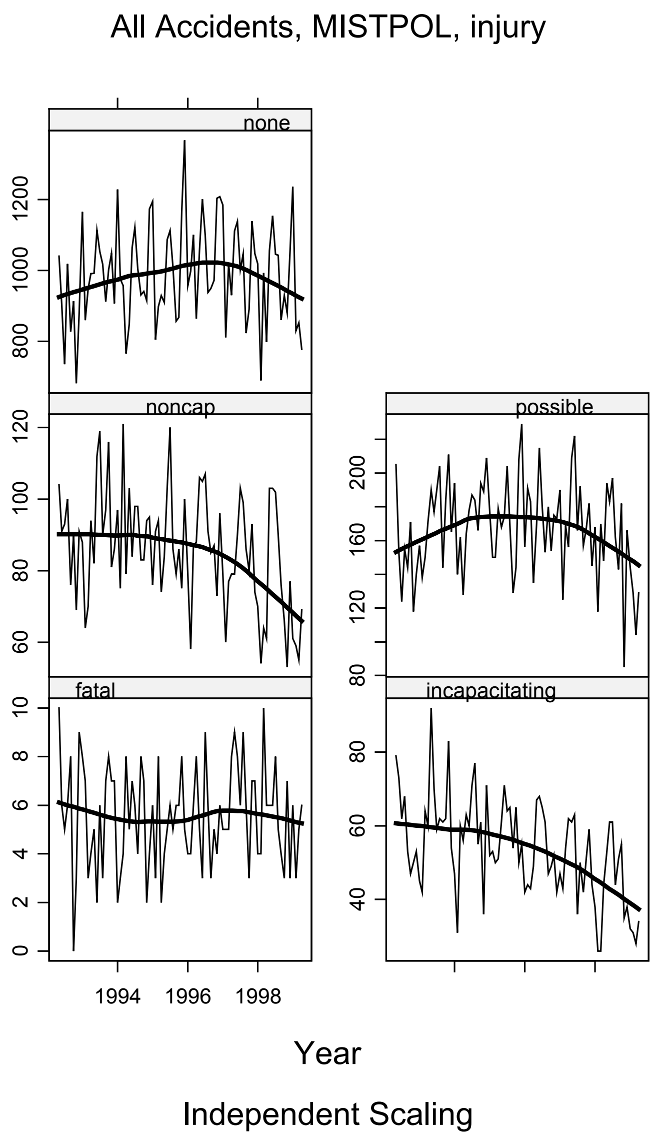
Figure 6.



Time Series Trellis Plots of Injury Class

From the crosstab analysis below, there were 109,948 records that contained information of injury. Since there were 164,931 records in total, this means that the injury was reported in only about 2/3 of the accidents. Figure 7 shows there has been a downward trend in incapacitating and non-incapacitating accidents but little other trends. Note that each panel was scaled independently.

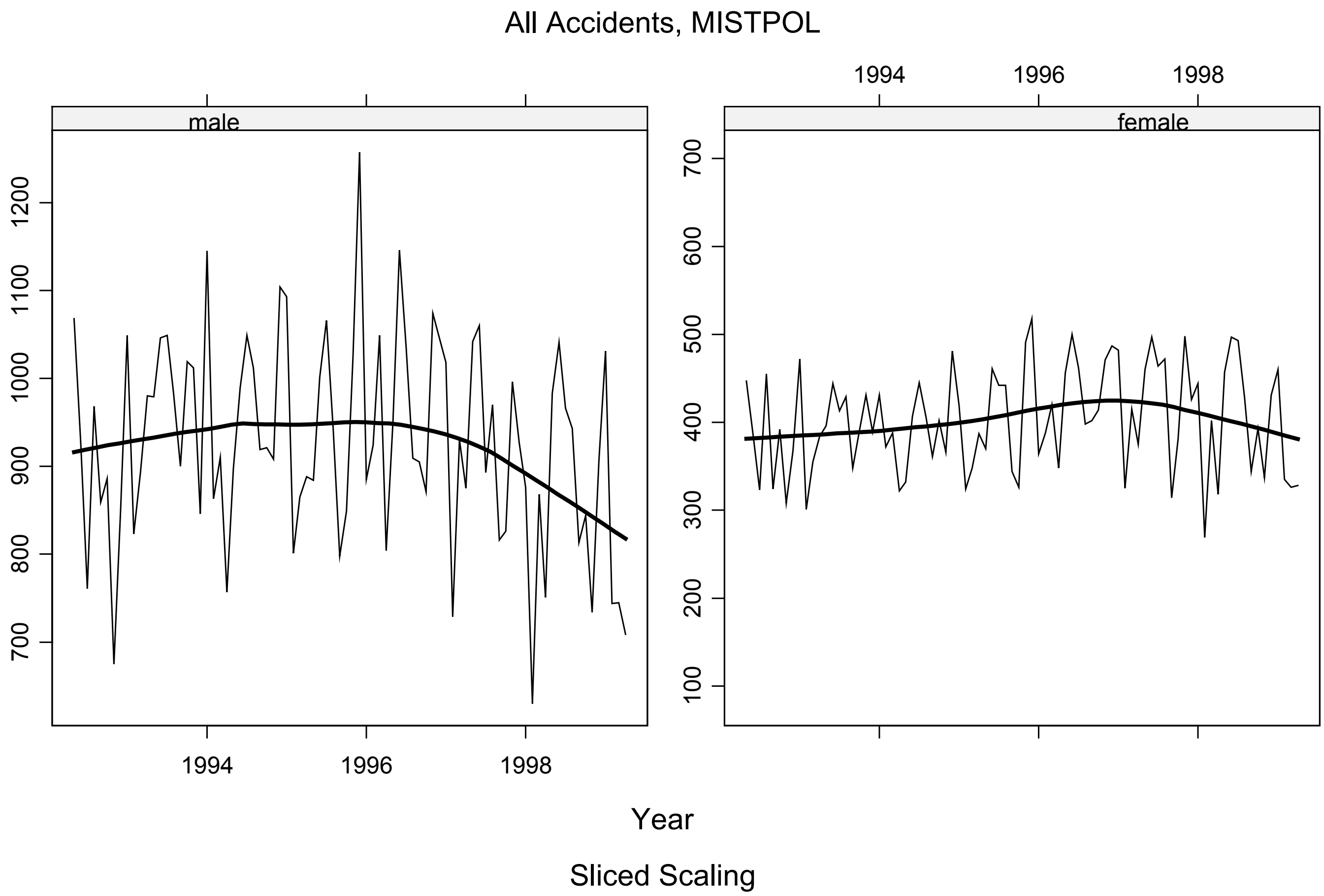
Figure 7. Independent vertical scale.



Time Series Trellis Plots of Gender

Figure 8 shows accidents by males more frequent and there is a downward trend in both groups but more pronounced for males.

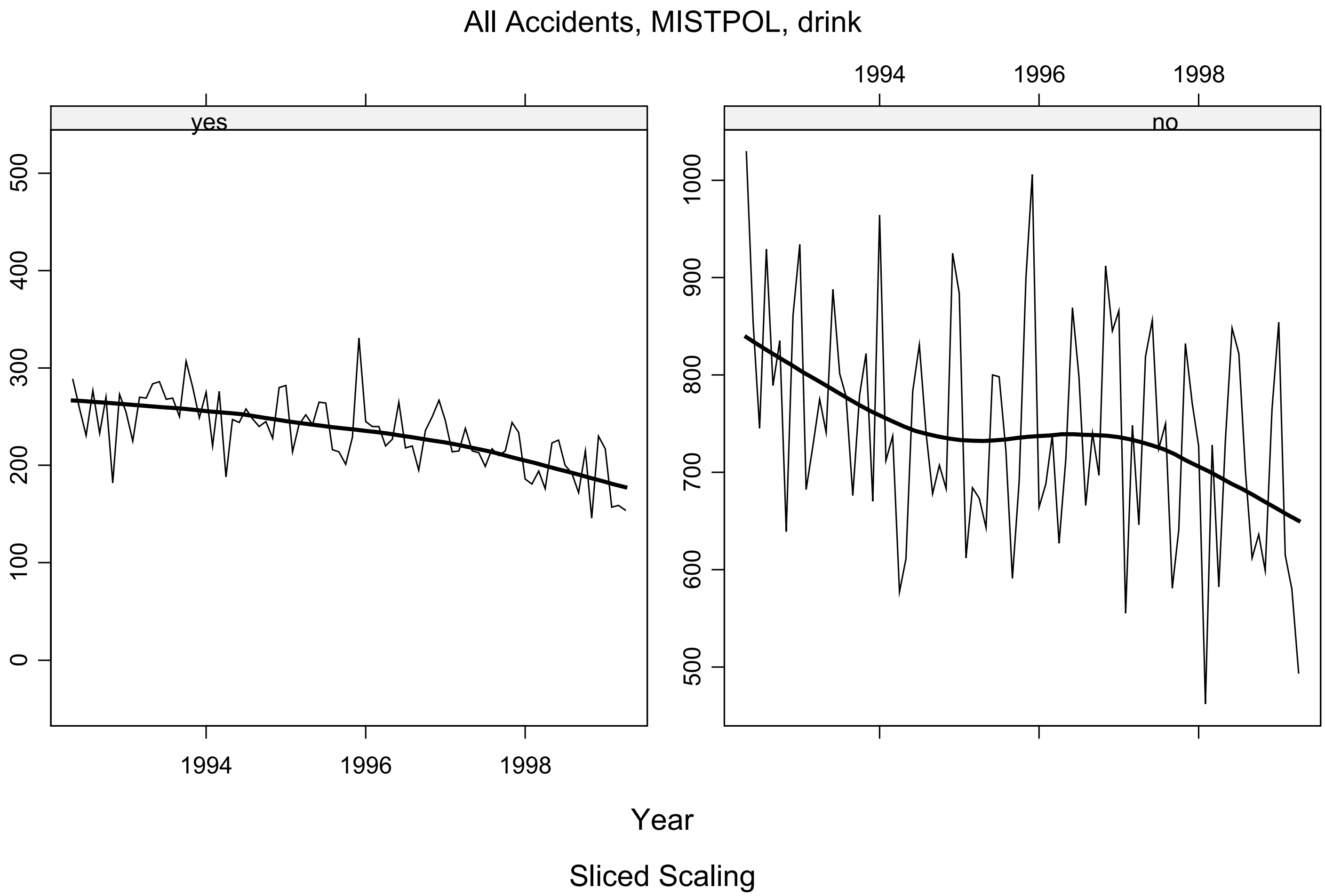
Figure 8. Sliced vertical scale.



Time Series Trellis Plots of Drink

In 52.4% of the accidents, drinking information was obtained. Our analysis indicates a significant downward trend in the number of accidents with drinking and without drinking. The downward trend is more pronounced among the drinking group.

Figure 9. Sliced vertical scale.



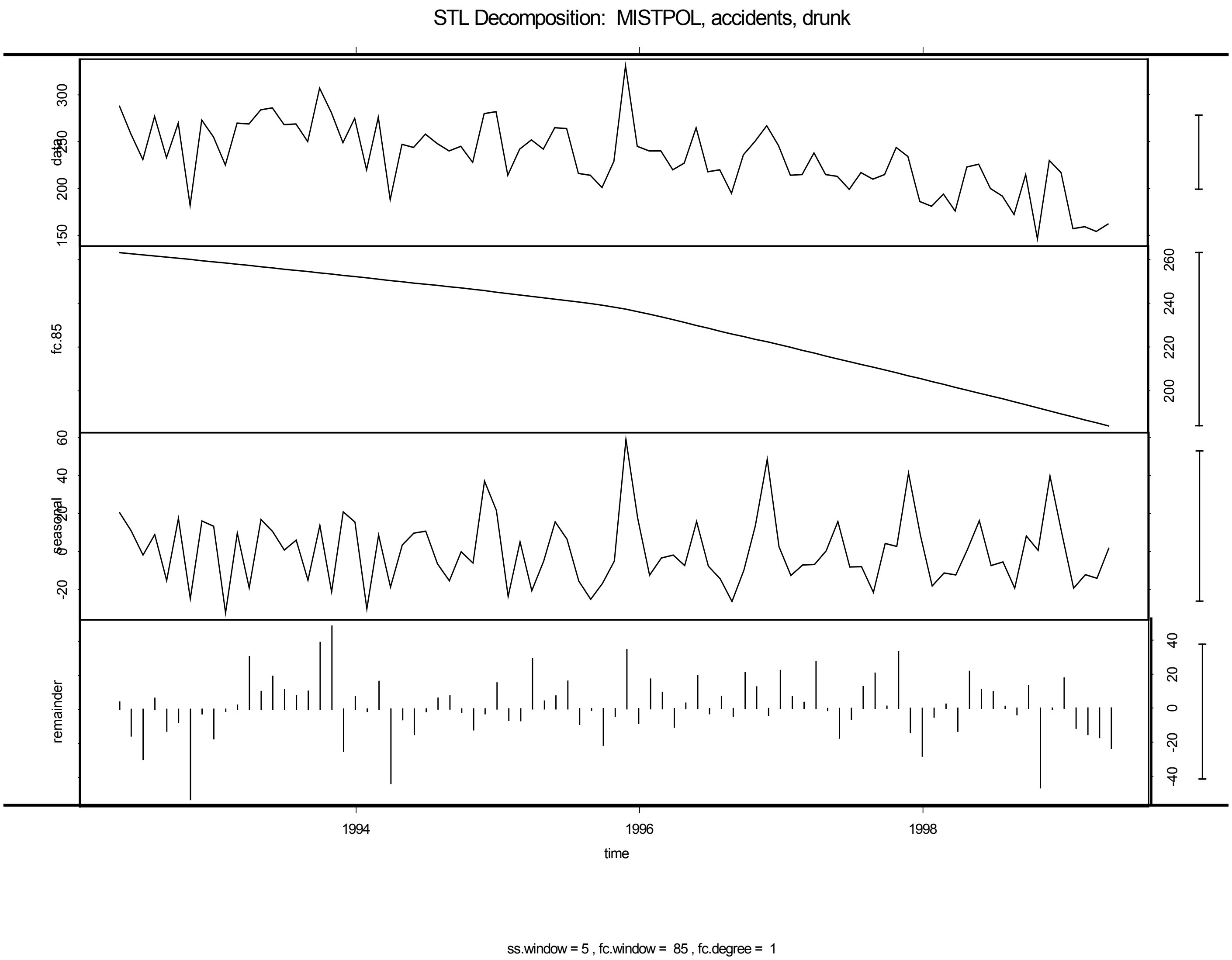
Tables and Seasonal Mann-Kendall test for total accidents by drinking group.

```
> accidents.mistpol.sober.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1992:                     1029  854  745  929  789  835  639  861
1993:  934  682  727  775  741  888  801  778  676  779  822  670
1994:  964  712  737  577  611  783  831  740  678  707  683  925
1995:  884  612  684  673  643  800  798  722  591  691  900 1006
1996:  664  688  738  627  714  869  798  666  740  697  912  845
1997:  866  555  748  646  819  856  724  750  581  641  832  771
1998:  727  462  728  582  731  848  822  703  612  636  599  764
1999:  854  615  580  494  564
> SeasonalMannKendall(accidents.mistpol.sober.ts)
tau = -0.325,   sl =0.03499%

> accidents.mistpol.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                 288 258 231 277 233 270 182 273
1993: 255 225 270 269 284 286 268 269 250 307 281 249
1994: 275 220 276 188 247 244 258 248 240 245 228 280
1995: 282 214 242 252 242 265 264 216 214 201 229 331
1996: 245 240 240 220 227 265 218 220 195 236 250 267
1997: 246 214 215 238 215 213 199 217 210 215 244 234
1998: 186 181 194 176 223 226 200 192 172 215 146 230
1999: 217 157 159 154 162
> SeasonalMannKendall(accidents.mistpol.drunk.ts)
tau = -0.606,   sl =2.894e-9%
```

STL Analysis of Accidents with Drinking

There is a downward trend over 1992 to 1999 which is more pronounced after 1996. The seasonal cycle is complicated and shows a lot of variability. R-sq = 74.9 % so pretty good fit.

Figure 10a



The seasonal variation is not very stable. There are two peaks one in Jul and the other in Dec. The July peak shows little variation in its amplitude over the years. The troughs are in Feb and Sep.

Figure 10b.

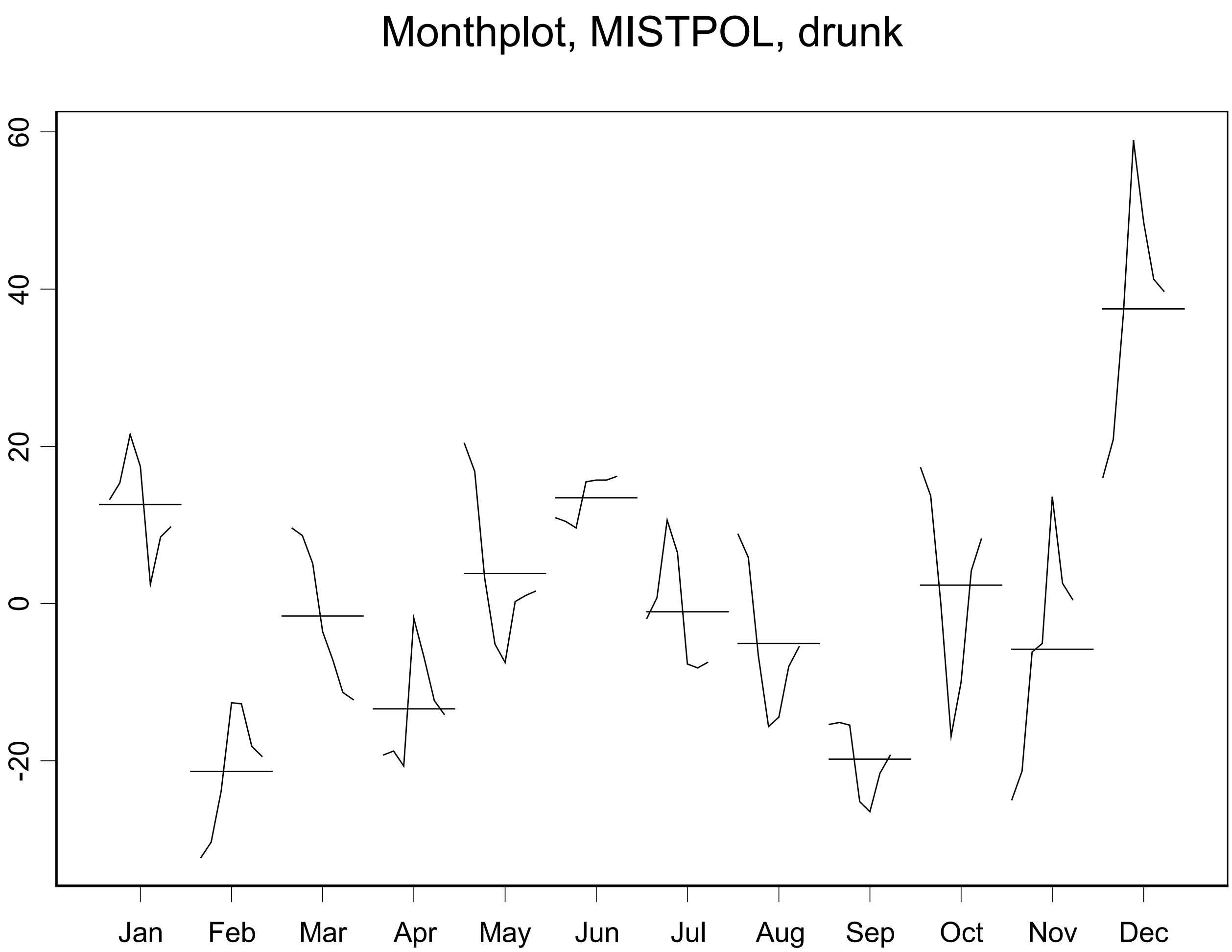


Figure 10c. Loess trend analysis of deseasonalized series.

tau = -0.58, sl =2.22e-14%

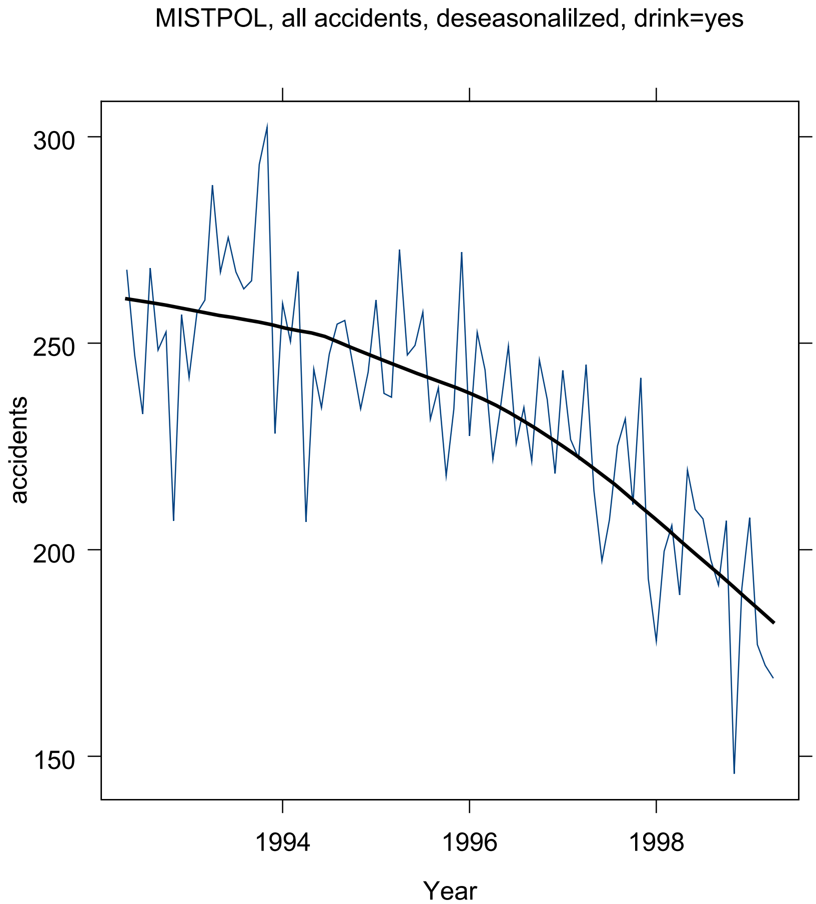
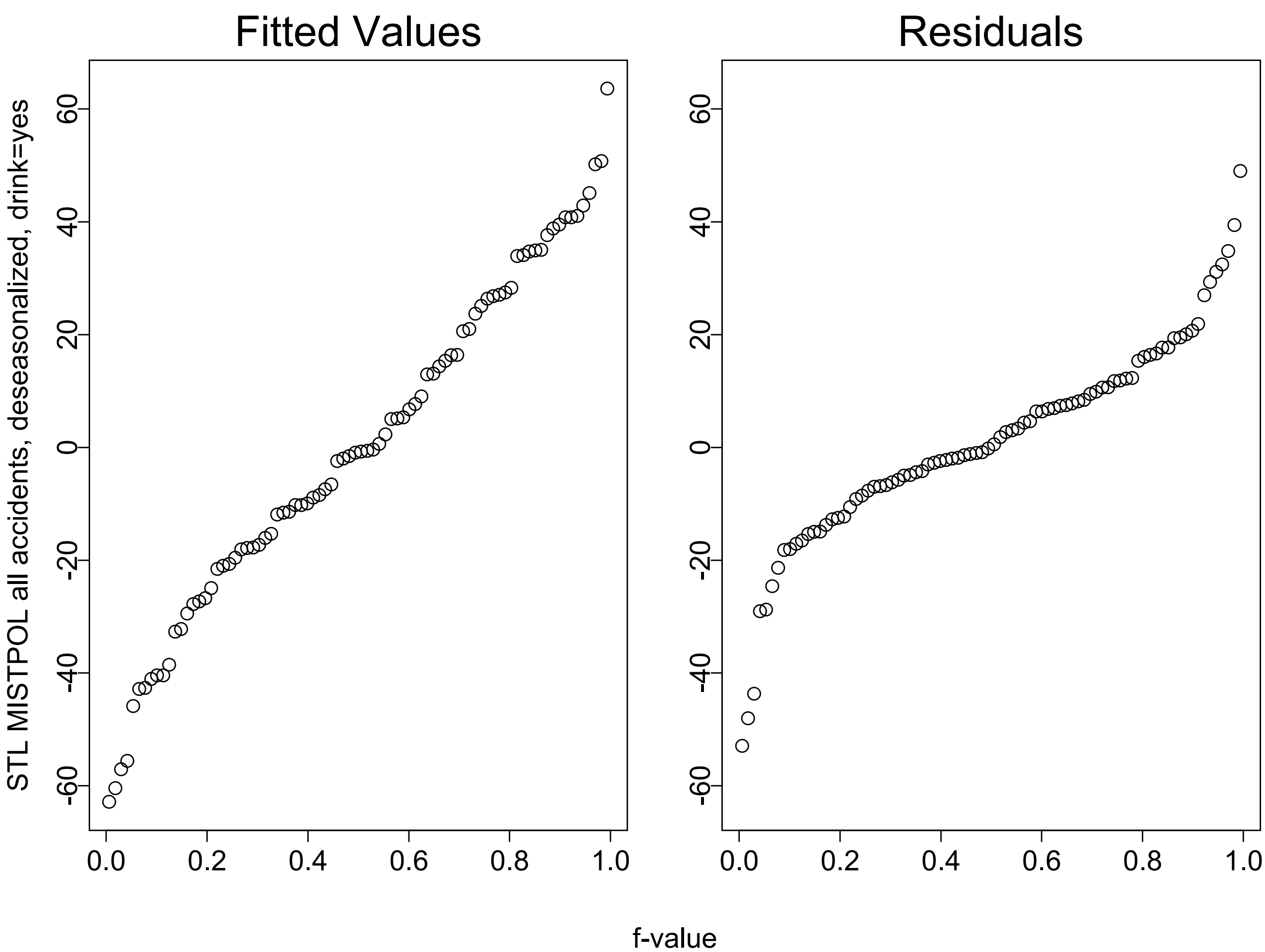


Figure 10d. RF-spread,

R-sq = 74.9 %



J. MISTPOL Dataset
Fatal Accidents
Summary

No much sign of any trend in the number of fatal accidents per month (Fig 1).

STL analysis confirms no trend and unstable seasonal component is seen (Figure 2a and Figure 2b). There is a peak in Jul but Mar though May is also quite high and there is a minimum in Jan-Feb (Figure 2b). Some outliers were detected Figure 2d and Table 1. Low value, `R-sq = 37.4 %,` means a lot of unexplained variation.

`Drink-Hour` are not associated.

`Drink-Weekgroup:` there are slightly more (17%) in the `ThuSat-YES` group than expected under independence but this excess is not statistically significant.

`Drink-Gender`: males are strongly associated with more fatal accidents involving drinking.

Figure 4 shows that ThuSat group has more accidents and there is a small downward trend starting around 1996 in ThuSat.

No monotonic trend but loess shows a slight increasing trend at `1AM` and `11PM` windows in recent years (Figure 5).

Males have more fatal accidents. No trend in fatalities with males or females (Figure 6).

There has been a striking increase in fatalities involving drinking since 1996 (Figure 7a and Figure 7b). Also confirmed by Seasonal Mann-Kendall test - see Table.

STL analysis confirms that fatal accidents with drinking have risen since 1994 (Figure 8a). Also see loess trend analysis and Mann-Kendall test for deseasonalized fatal accident with drinking – Figure 8e. The R-sq = 50.8 % is better than in Figure 2a.

Time Series Plots

No much sign of any trend (Fig 1). There is no significant lag one autocorrelation but seasonality is evident in the lag 12 autocorrelation of 0.92. The data are approximately Poisson distributed with mean of 5.5.

The discreteness of the data is evident from the normal probability plot but otherwise the normal distribution is not too bad.

Figure 1.

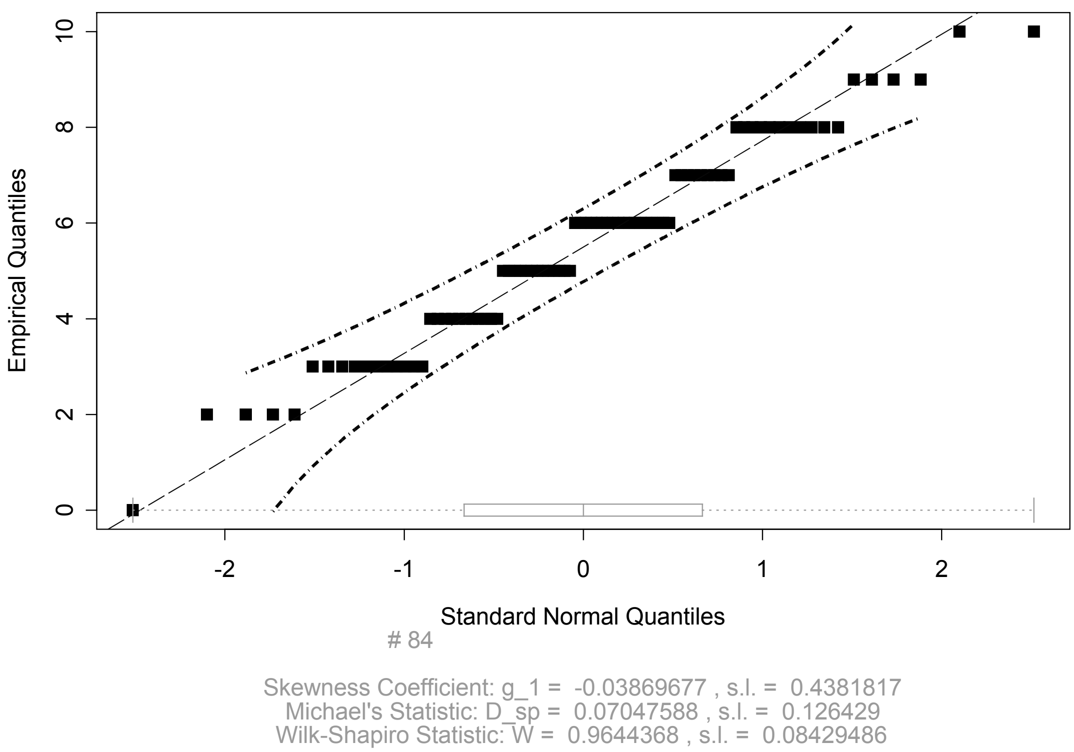
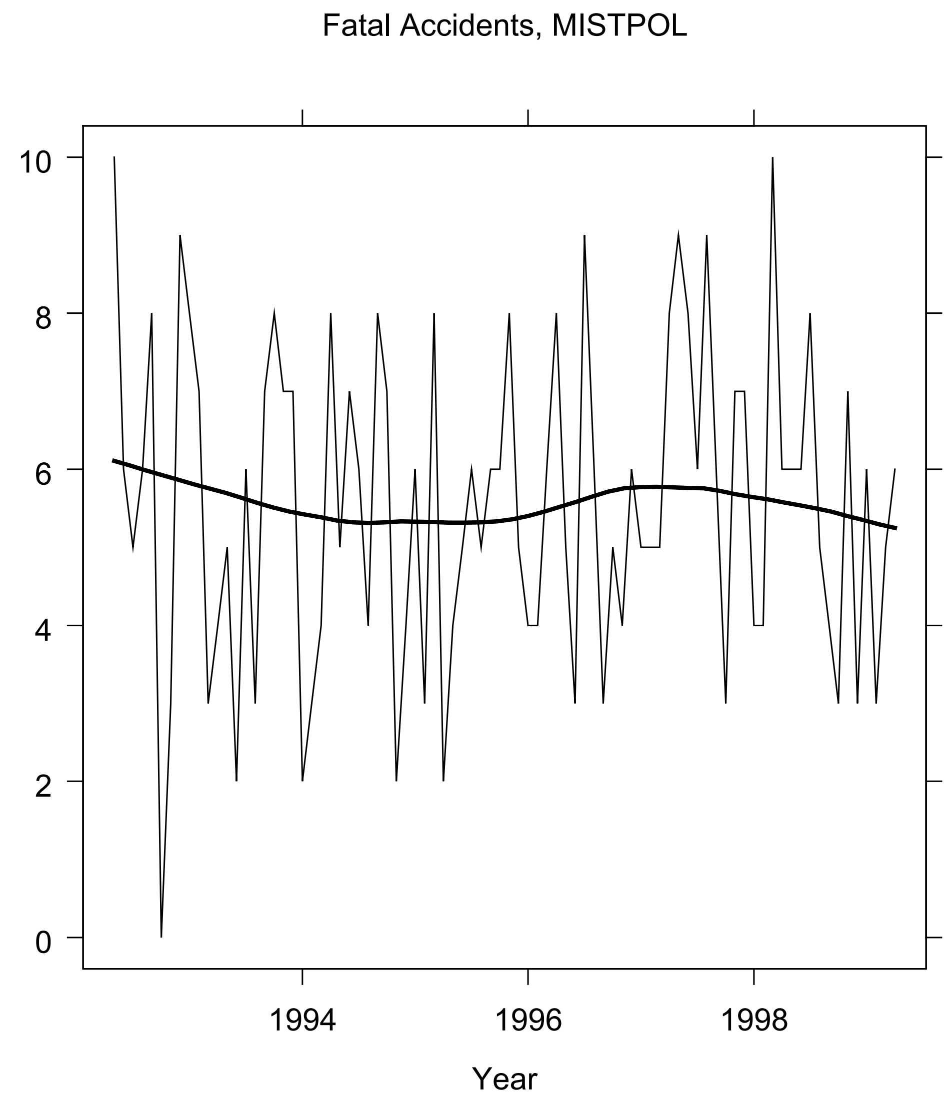


Table 1.
Time series tabulation & outliers.

Outliers discovered in Figure 2d and 2f are shown.

```
> accidents.mistpol.death.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  10   6   5   6   8   0   3   9
1993:   8   7   3   4   5   2   6   3   7   8   7   7
1994:   2   3   4   8   5   7   6   4   8   7   2   4
1995:   6   3   8   2   4   5   6   5   6   6   8   5
1996:   4   4   6   8   5   3   9   6   3   5   4   6
1997:   5   5   5   8   9   8   6   9   6   3   7   7
1998:   4   4  10   6   6   6   8   5   4   3   7   3
1999:   6   3   5   6
> SeasonalMannKendall(accidents.mistpol.death.ts)
tau = 0.0169,   sl =85.76%

> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   3   4   5   6   7   8
1993:   9  10  11  12  13  14  15  16  17  18  19  20
1994:  21  22  23  24  25  26  27  28  29  30  31  32
1995:  33  34  35  36  37  38  39  40  41  42  43  44
1996:  45  46  47  48  49  50  51  52  53  54  55  56
1997:  57  58  59  60  61  62  63  64  65  66  67  68
1998:  69  70  71  72  73  74  75  76  77  78  79  80
1999:  81  82  83  84
```

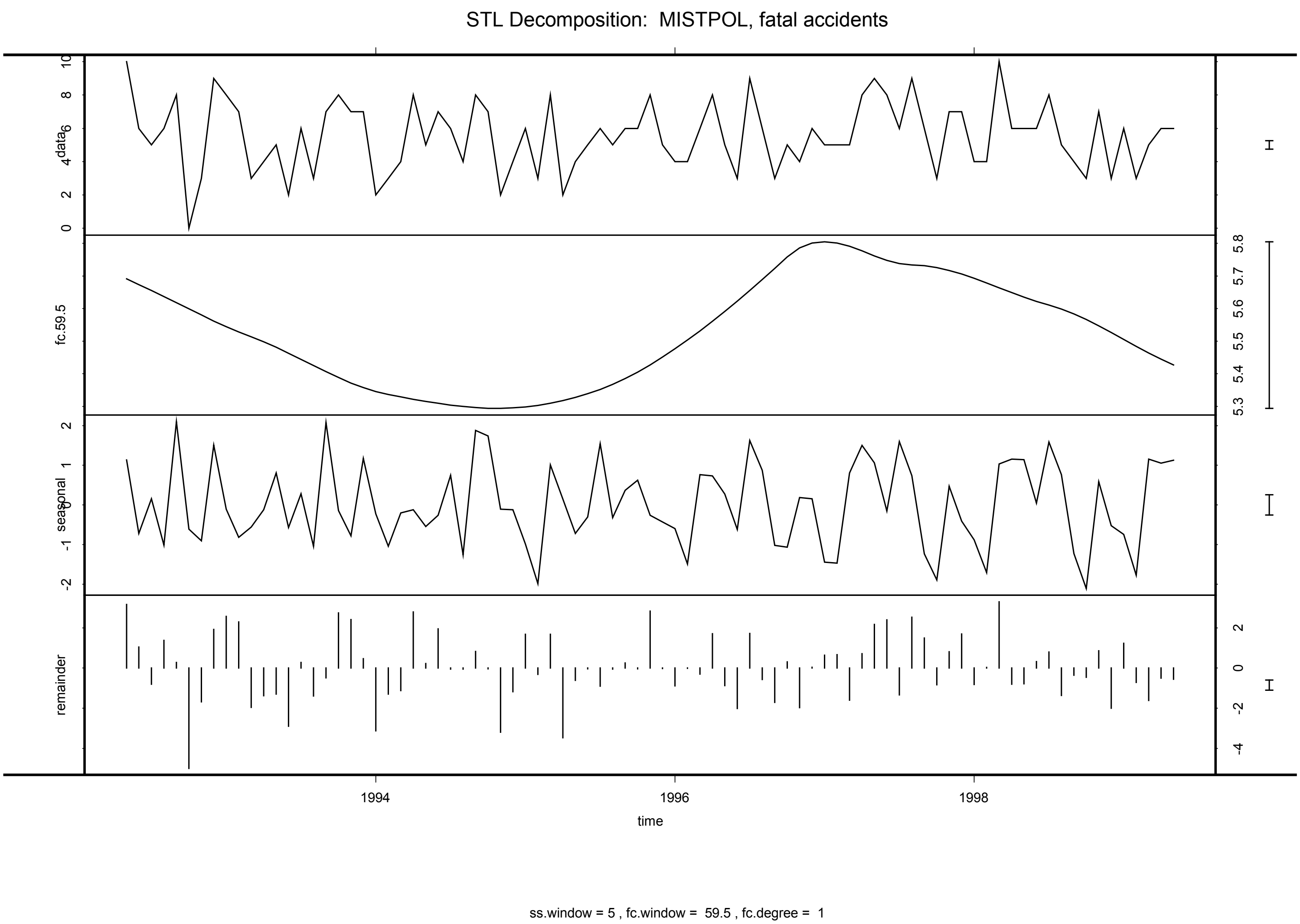
Figure 1.
No monotonic trend.



STL Analysis

STL analysis indicates no monotonic trend. Unstable seasonal component.
R-sq = 37.4 %

Figure 2a.



There is a lot of variability in the seasonal component. There is a peak in Jul but Mar though May is also quite high and there is a minimum in Jan-Feb (Figure 2b).

Figure 2b.

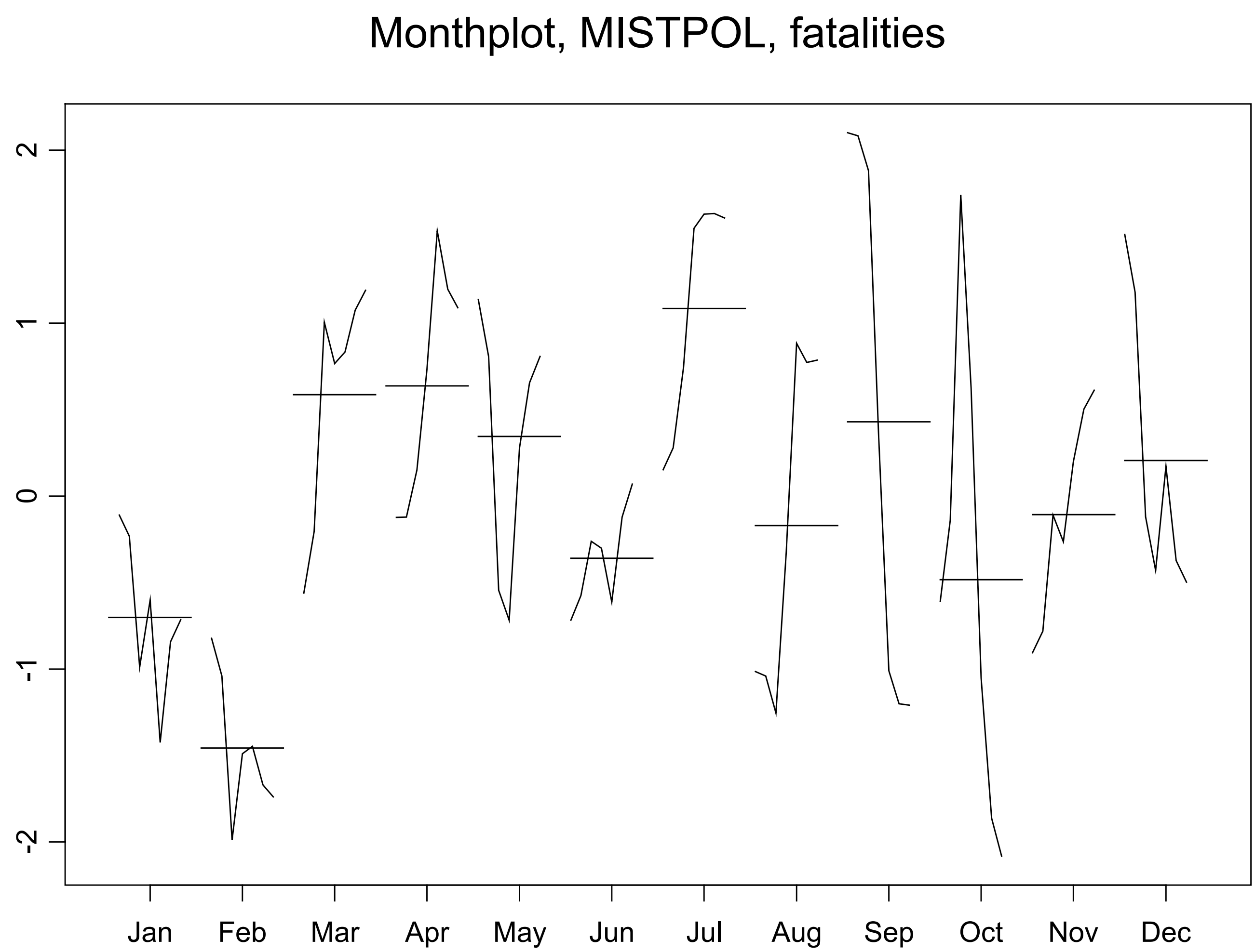


Figure 2c.

No unexpected autocorrelation in the remainder term.

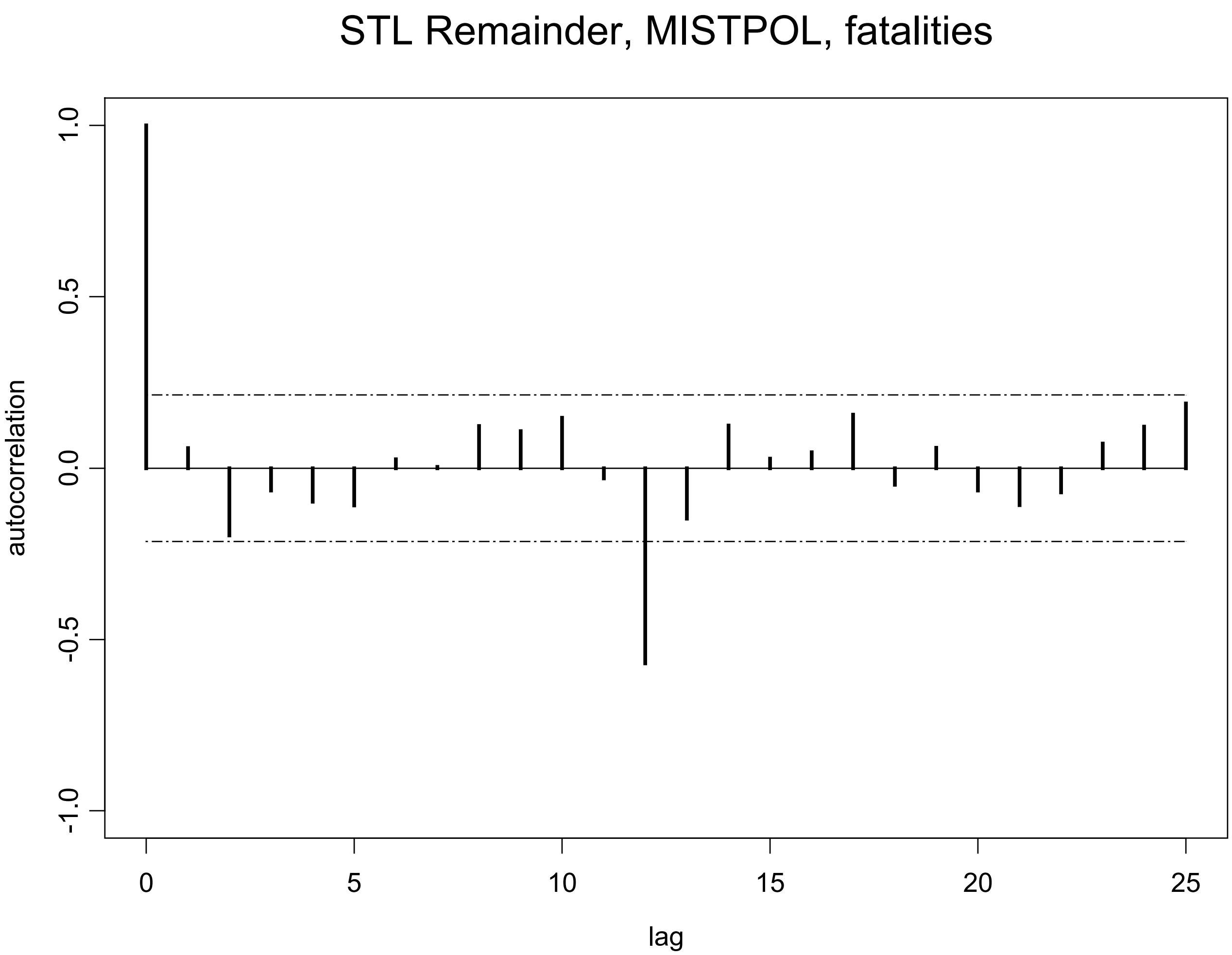
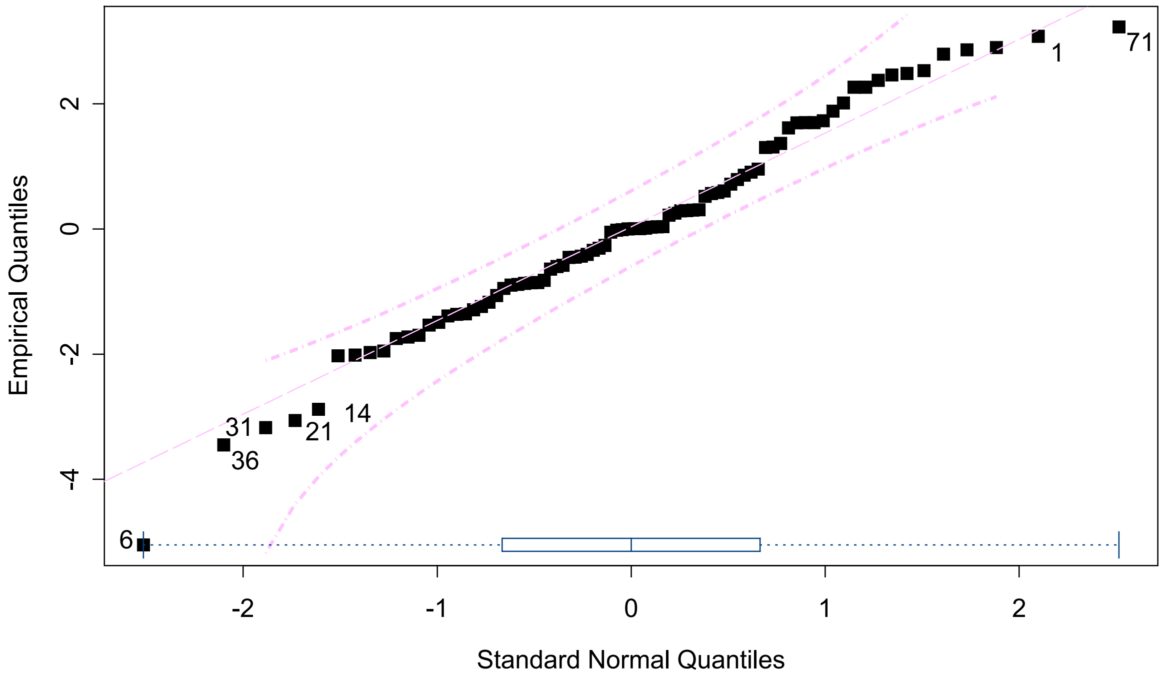


Figure 2d
Normal probability plot of remainder indicates some outliers.



Skewness Coefficient: g_1 = -0.1824367 , s.l. = 0.2329958
Michael's Statistic: D_sp = 0.05067573 , s.l. = 0.8947265
Wilk-Shapiro Statistic: W = 0.9766002 , s.l. = 0.4186626

```
> counter.ts
       Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                    1   2   3   4   5   6   7   8
1993:    9  10  11  12  13  14  15  16  17  18  19  20
1994:   21  22  23  24  25  26  27  28  29  30  31  32
1995:   33  34  35  36  37  38  39  40  41  42  43  44
1996:   45  46  47  48  49  50  51  52  53  54  55  56
1997:   57  58  59  60  61  62  63  64  65  66  67  68
1998:   69  70  71  72  73  74  75  76  77  78  79  80
1999:   81  82  83  84
```

Figure 2e.

The loess trend analysis of the deseasonalized series, MISTPOL, fatalities.
There is no montonic trend.

`tau = 0.0212,   sl =77.86%`

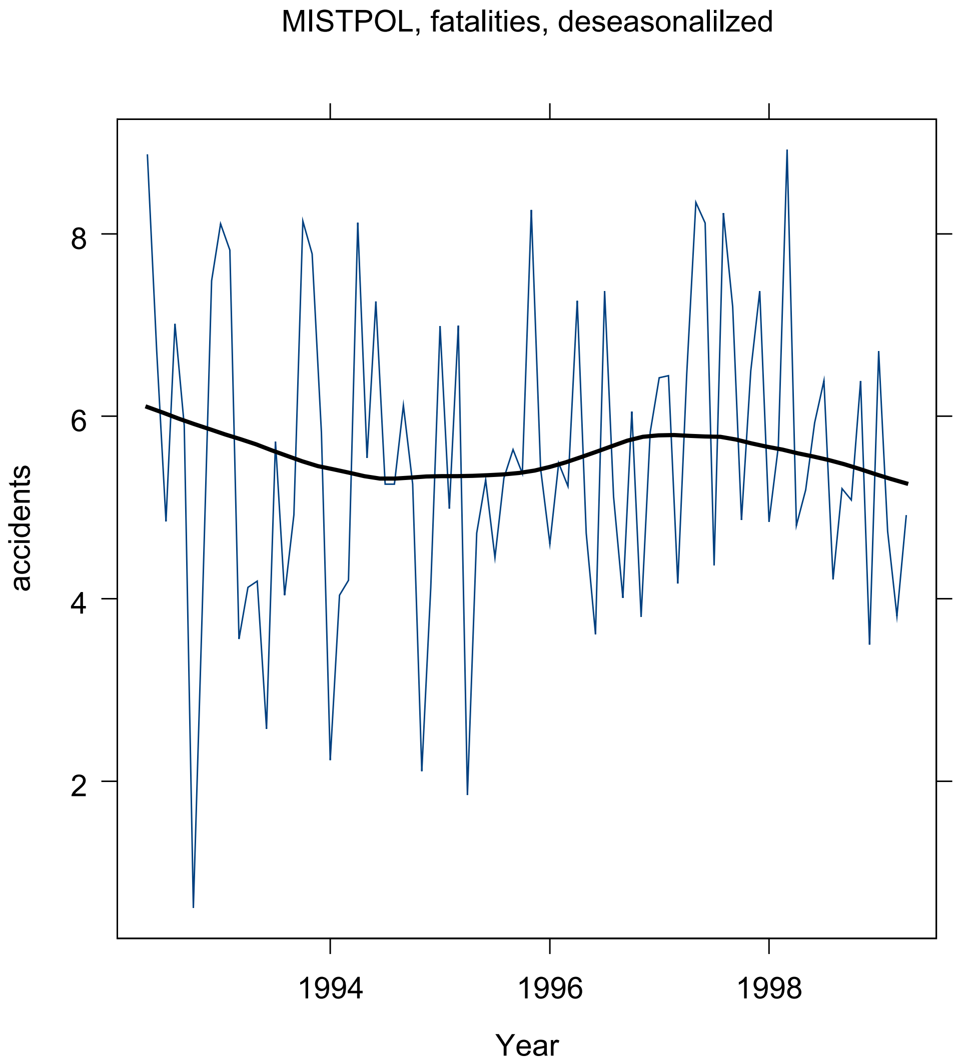
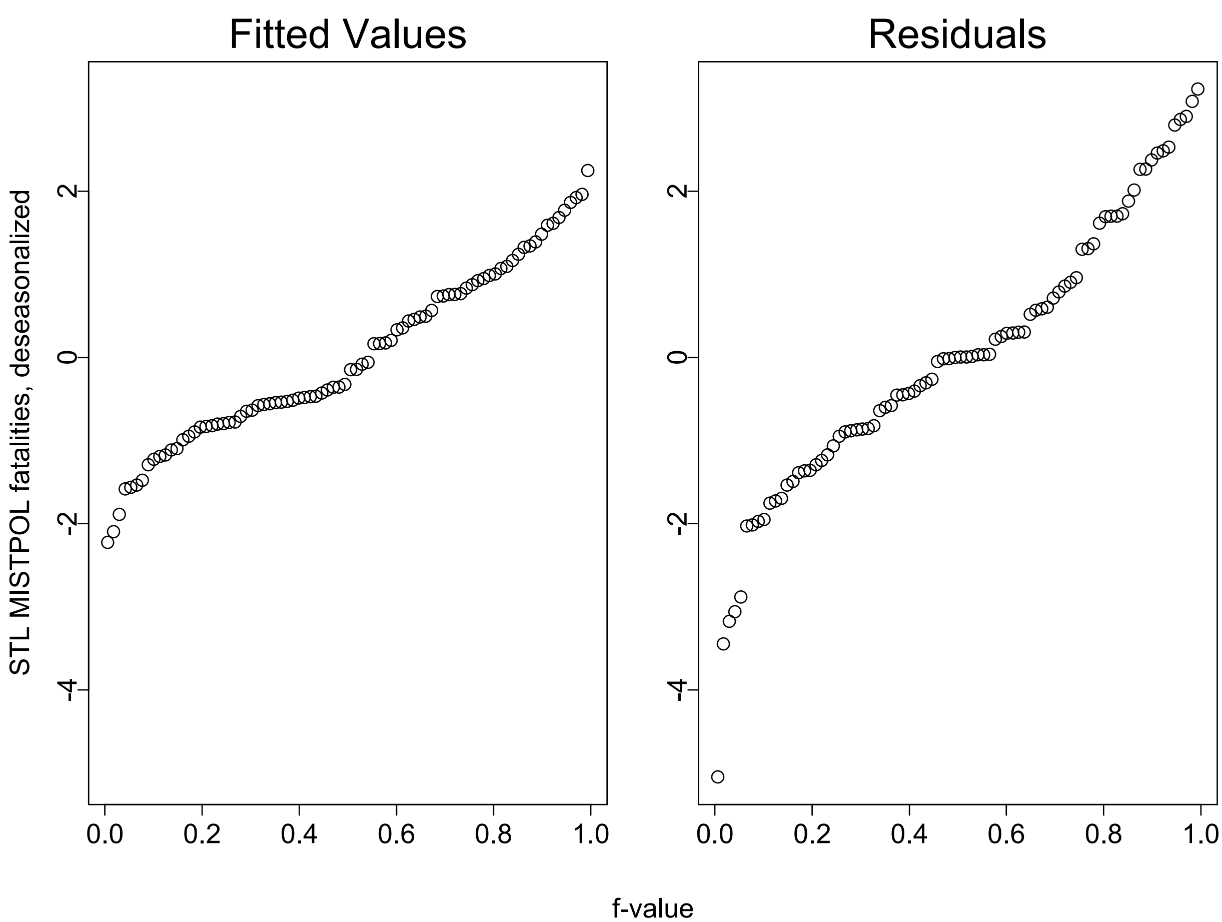


Figure 2f.
RF-spread shows there are several outliers in the bottom left-corner.
This accounts for the R-sq, `R-sq =  37.4 %`



Crosstab Analysis

Drink and Hour

`Drink-Hour` are not associated.

```
> crosstabs( ~ drink + hour, data = mistpol.fatal.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + hour, data = mistpol.fatal.df, na.action =
       na.exclude)
333 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |hour
       |11PM   |12AM   |1AM    |2AM    |RowTotl|
-------+-------+-------+-------+-------+-------+
yes    |58     |58     |60     |76     |252    |
       |0.23   |0.23   |0.24   |0.3    |0.76   |
       |0.69   |0.77   |0.75   |0.81   |       |
       |0.17   |0.17   |0.18   |0.23   |       |
-------+-------+-------+-------+-------+-------+
no     |26     |17     |20     |18     |81     |
       |0.32   |0.21   |0.25   |0.22   |0.24   |
       |0.31   |0.23   |0.25   |0.19   |       |
       |0.078  |0.051  |0.06   |0.054  |       |
-------+-------+-------+-------+-------+-------+
ColTotl|84     |75     |80     |94     |333    |
       |0.25   |0.23   |0.24   |0.28   |       |
-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 3.504304 d.f.= 3 (p=0.3202043)
       Yates' correction not used

> get.crosstabs.percenterror( ~ drink + hour)
     [,1] [,2] [,3] [,4]
[1,]   -9    2   -1    7
[2,]   27   -7    3  -21

> contrib( ~ drink + hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]
[1,] -0.70  0.17 -0.07  0.58
[2,]  1.23 -0.29  0.12 -1.02
```

Drink and Weekgroup

There are slightly more (17%) in the `ThuSat-YES` group than expected under independence but this excess is not statistically significant.

```
> crosstabs( ~ drink + wkgrp, data = mistpol.fatal.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + wkgrp, data = mistpol.fatal.df, na.action = na.exclude)
333 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
yes    | 89    |163    |252    |
       |0.35   |0.65   |0.76   |
       |0.71   |0.79   |       |
       |0.27   |0.49   |       |
-------+-------+-------+-------+
no     | 37    | 44    |81     |
       |0.46   |0.54   |0.24   |
       |0.29   |0.21   |       |
       |0.11   |0.13   |       |
-------+-------+-------+-------+
ColTotl|126    |207    |333    |
       |0.38   |0.62   |       |
-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 2.797941 d.f.= 1 (p=0.09438545)
       Yates' correction not used

> get.crosstabs.percenterror( ~ drink + wkgrp)
     [,1] [,2]
[1,]   -7    4
[2,]   21  -13

> contrib( ~ drink + wkgrp)
contribution to chi-sq:
      [,1]  [,2]
[1,] -0.65  0.51
[2,]  1.15 -0.90
```

Drink and Gender

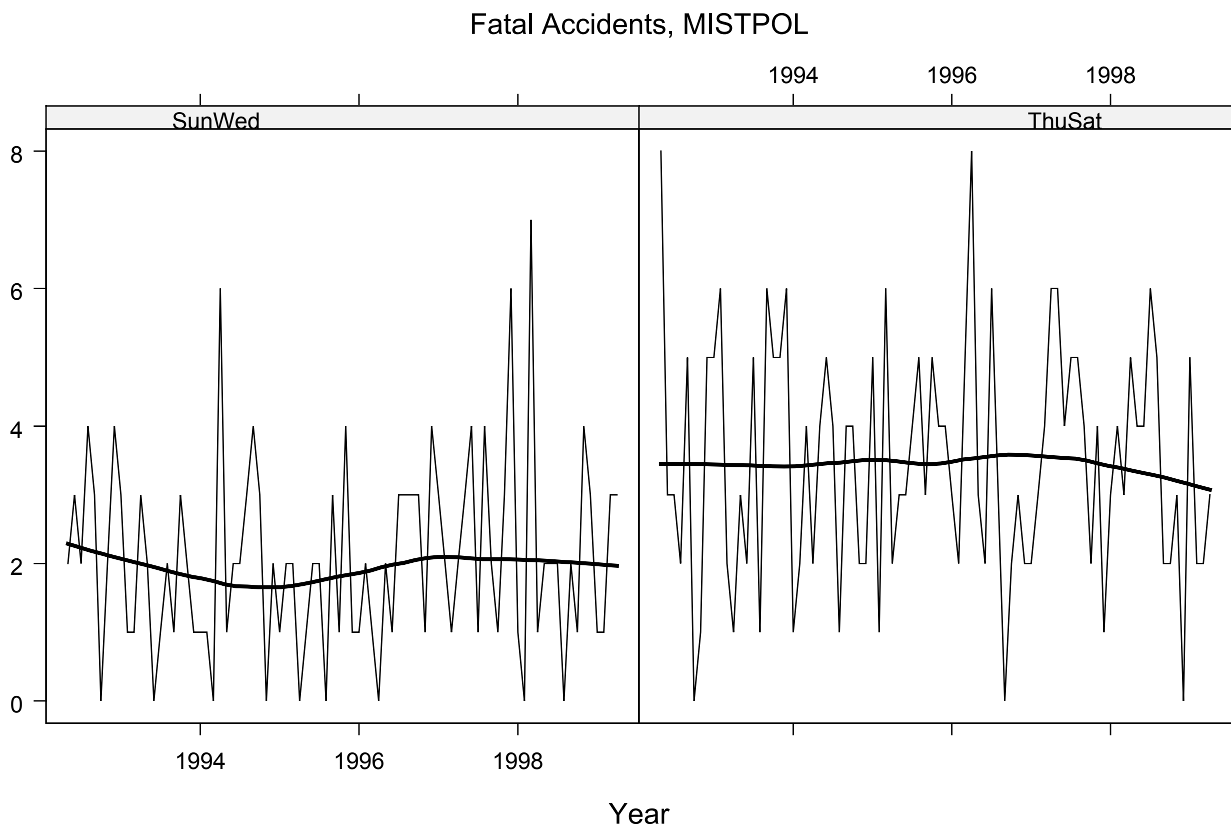
Males are strongly associated with more fatal accidents involving drinking.

```
> crosstabs( ~ drink + sex, data = mistpol.fatal.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + sex, data = mistpol.fatal.df, na.action = na.exclude)
326 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |sex
       |male   |female |RowTotl|
-------+-------+-------+-------+
yes    |200    | 46    |246    |
       |0.81   |0.19   |0.75   |
       |0.8    |0.6    |       |
       |0.61   |0.14   |       |
-------+-------+-------+-------+
no     | 49    | 31    |80     |
       |0.61   |0.39   |0.25   |
       |0.2    |0.4    |       |
       |0.15   |0.095  |       |
-------+-------+-------+-------+
ColTotl|249    |77     |326    |
       |0.76   |0.24   |       |
-------+-------+-------+-------+
Test for independence of all factors
        Chi^2 = 13.45292 d.f.= 1 (p=0.000244625)
        Yates' correction not used

> get.crosstabs.percenterror( ~ drink + sex)
     [,1] [,2]
[1,]    6  -21
[2,]  -20   64

> contrib( ~ drink + sex)
contribution to chi-sq:
      [,1]  [,2]
[1,]  0.88 -1.59
[2,] -1.55  2.78
```

Time Series Trellis Plots of Weekgroup

Figure 4 shows that ThuSat group has more accidents. There is a very small downward trend starting around 1996 in ThuSat.

Figure 4.



Tables and Seasonal Mann-Kendall test for fatal accidents by wkgrp

```
> accidents.fatal.SunWed
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   3   2   4   3   0   2   4
1993:   3   1   1   3   2   0   1   2   1   3   2   1
1994:   1   1   0   6   1   2   2   3   4   3   0   2
1995:   1   2   2   0   1   2   2   0   3   1   4   1
1996:   1   2   1   0   2   1   3   3   3   3   1   4
1997:   3   2   1   2   3   4   1   4   2   1   3   6
1998:   1   0   7   1   2   2   2   0   2   1   4   3
1999:   1   1   3   3   5
> SeasonalMannKendall(accidents.fatal.SunWed)
tau = 0.0919,   sl =33.8%

> accidents.fatal.ThuSat
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   8   3   3   2   5   0   1   5
1993:   5   6   2   1   3   2   5   1   6   5   5   6
1994:   1   2   4   2   4   5   4   1   4   4   2   2
1995:   5   1   6   2   3   3   4   5   3   5   4   4
1996:   3   2   5   8   3   2   6   3   0   2   3   2
1997:   2   3   4   6   6   4   5   5   4   2   4   1
1998:   3   4   3   5   4   4   6   5   2   2   3   0
1999:   5   2   2   3   1
> SeasonalMannKendall(accidents.fatal.ThuSat)
tau = -0.0206,   sl =82.61%
```

Time Series Trellis Plots of Hour

Increasing trend at 1AM and 11PM in recent years (Figure 5)

.

Figure 5.

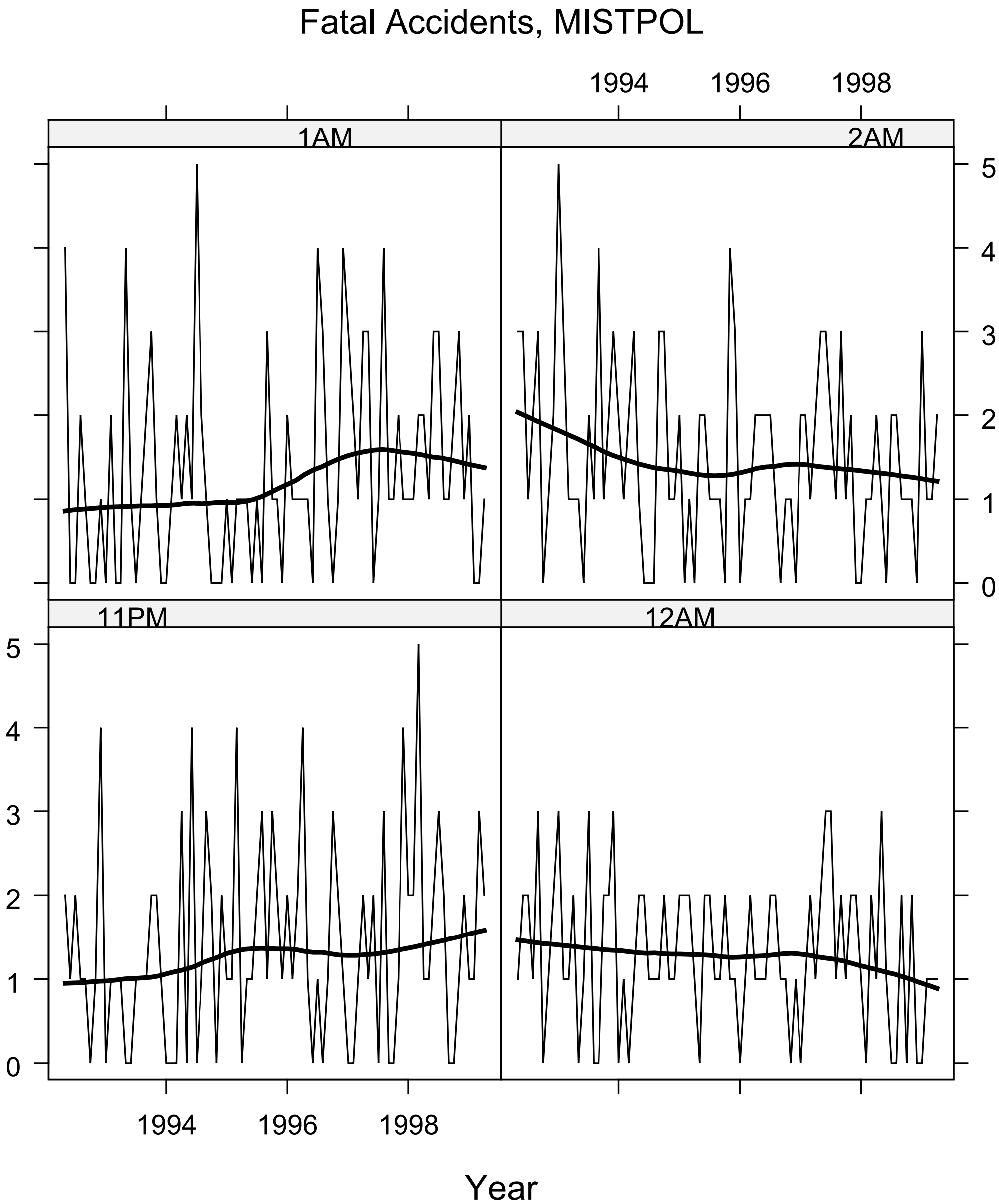


Table and Mann-Kendall test, fatal accidents by hour

```
> accidents.fatal.11PM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   1   2   1   1   0   1   4
1993:   0   1   1   1   0   0   1   1   1   2   2   1
1994:   0   0   0   3   0   4   0   1   3   2   0   2
1995:   1   1   4   0   1   1   2   3   1   3   2   1
1996:   2   1   2   4   1   0   1   0   1   3   2   1
1997:   0   0   1   2   1   2   0   3   0   0   1   4
1998:   2   2   5   1   1   2   3   2   0   0   1   2
1999:   1   1   3   2   3
> SeasonalMannKendall(accidents.fatal.11PM)
tau = 0.122,   sl =20.4%

> accidents.fatal.12AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   2   1   3   0   1   2
1993:   3   1   1   2   0   1   3   0   0   2   2   3
1994:   0   1   0   1   2   2   1   1   1   2   1   1
1995:   2   2   2   1   0   2   2   1   1   2   1   1
1996:   0   1   2   1   1   1   2   2   1   1   0   1
1997:   0   1   2   1   2   3   3   1   2   1   2   2
1998:   1   0   2   1   3   1   0   0   2   0   2   0
1999:   0   1   1   1   2
> SeasonalMannKendall(accidents.fatal.12AM)
tau = -0.056,   sl =56.73%

> accidents.fatal.1AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   0   0   2   1   0   0   1
1993:   0   2   0   0   4   1   0   1   2   3   1   0
1994:   0   1   2   1   2   1   5   2   1   0   0   0
1995:   1   0   1   1   1   0   1   0   3   1   1   0
1996:   2   1   1   1   1   0   4   3   1   0   1   4
1997:   3   2   1   3   3   0   1   4   1   1   2   1
1998:   1   1   2   2   1   3   3   1   1   2   3   1
1999:   2   0   0   1   1
> SeasonalMannKendall(accidents.fatal.1AM)
tau = 0.15,   sl =11.81%

> accidents.fatal.2AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   3   3   1   2   3   0   1   2
1993:   5   3   1   1   1   0   2   1   4   1   2   3
1994:   2   1   2   3   1   0   0   0   3   3   1   1
1995:   2   0   1   0   2   2   1   1   1   0   4   3
1996:   0   1   1   2   2   2   2   1   0   1   1   0
1997:   2   2   1   2   3   3   2   1   3   1   2   0
1998:   0   1   1   2   1   0   2   2   1   1   1   0
1999:   3   1   1   2   0
> SeasonalMannKendall(accidents.fatal.2AM)
tau = -0.102,   sl =29.61%
```

Time Series Trellis Plots of Gender

Males have more fatal accidents. No trend in fatalities with males or females (Figure 6a and Figure 6b).

Figure 6a. Common scale.

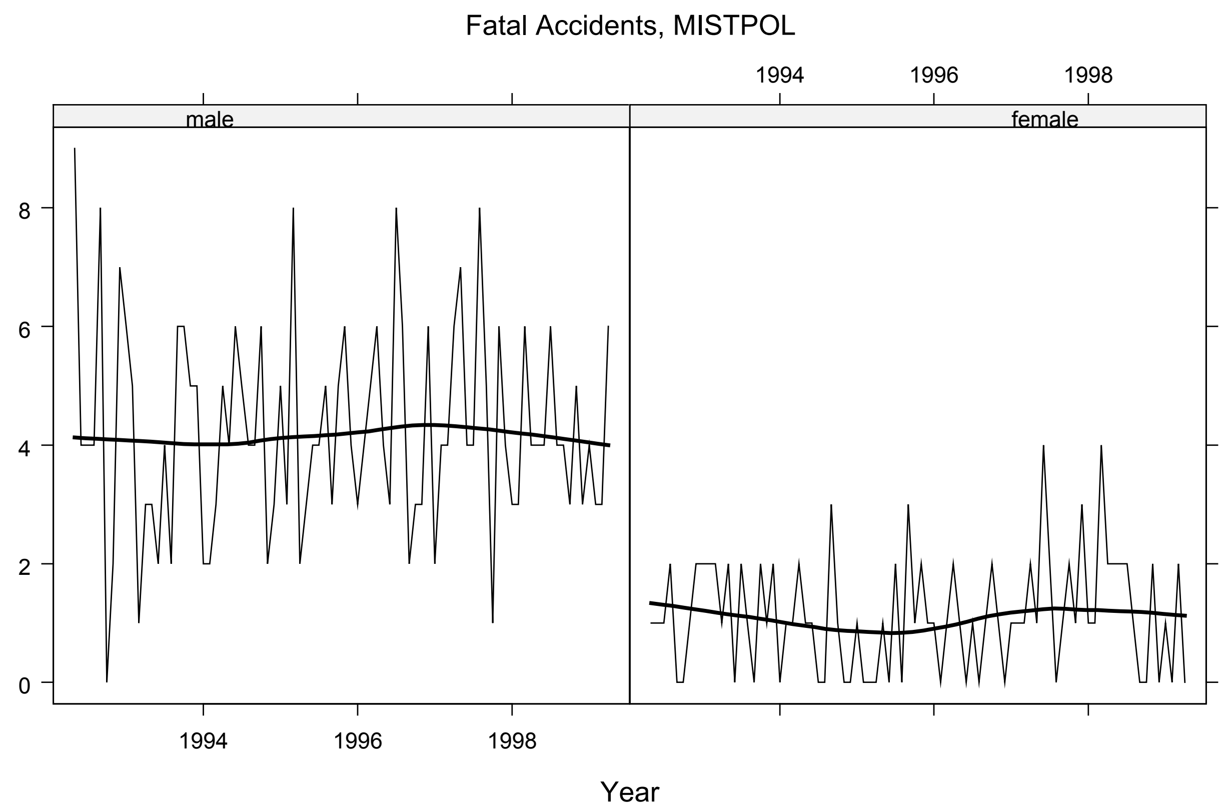
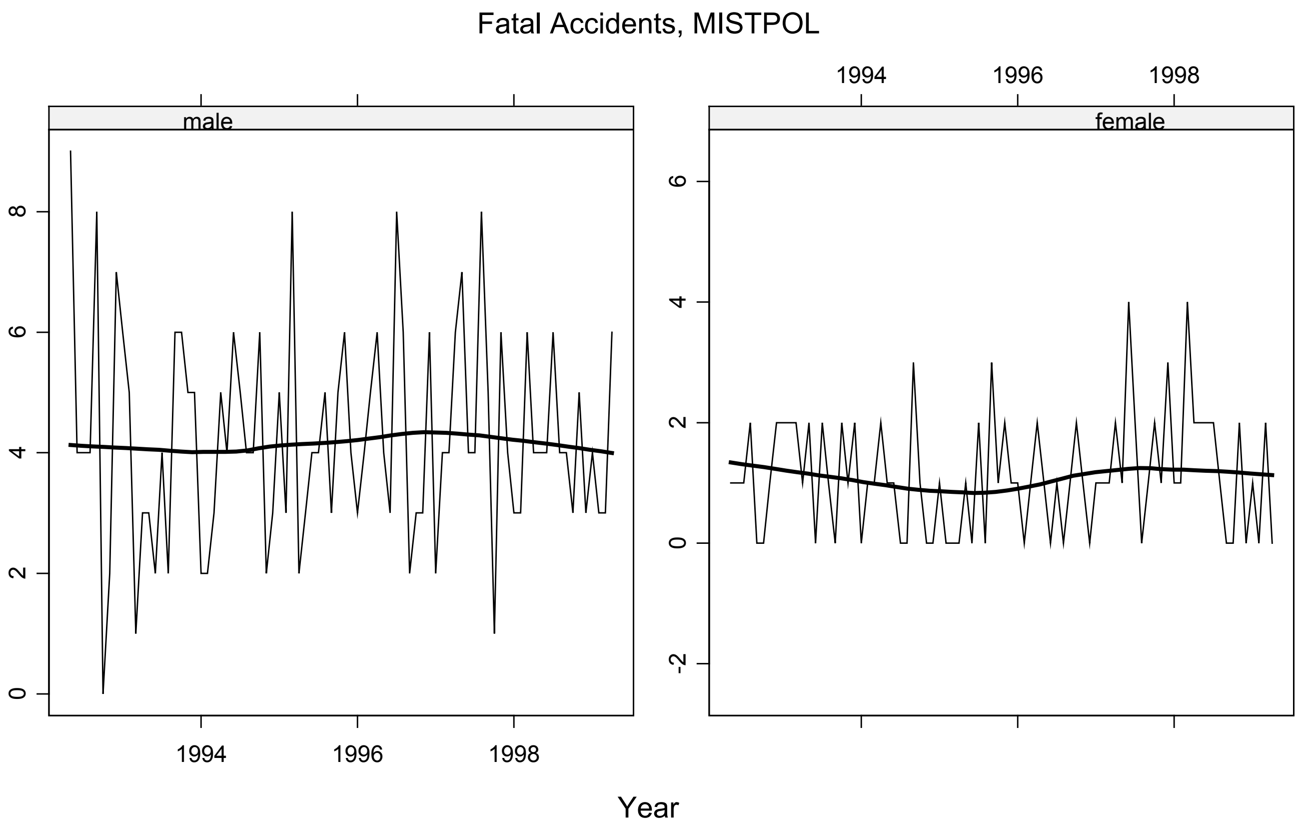


Figure 6b. Sliced vertical scale.

The plot is redone allowing sliced scaling on the vertical axis between the panels.



Tables and Seasonal Mann-Kendall tests

```
accidents.fatal.male
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   9   4   4   4   8   0   2   7
1993:   6   5   1   3   3   2   4   2   6   6   5   5
1994:   2   2   3   5   4   6   5   4   4   6   2   3
1995:   5   3   8   2   3   4   4   5   3   5   6   4
1996:   3   4   5   6   4   3   8   6   2   3   3   6
1997:   2   4   4   6   7   4   4   8   5   1   6   4
1998:   3   3   6   4   4   4   6   4   4   3   5   3
1999:   4   3   3   6   6
> SeasonalMannKendall(accidents.fatal.male)
tau = 0.0501,   sl =59.44%


> accidents.fatal.female
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   1   1   2   0   0   1   2
1993:   2   2   2   1   2   0   2   1   0   2   1   2
1994:   0   1   1   2   1   1   0   0   3   1   0   0
1995:   1   0   0   0   1   0   2   0   3   1   2   1
1996:   1   0   1   2   1   0   1   0   1   2   1   0
1997:   1   1   1   2   1   4   2   0   1   2   1   3
1998:   1   1   4   2   2   2   2   1   0   0   2   0
1999:   1   0   2   0   0
> SeasonalMannKendall(accidents.fatal.female)
tau = 0,   sl =100%
```

Time Series Trellis Plots of Drink

There has been a striking increase in fatalities involving drinking since 1996 (Figure 7a and 7b).

Figure 7a. Fatal accidents by drinking. Common scale.

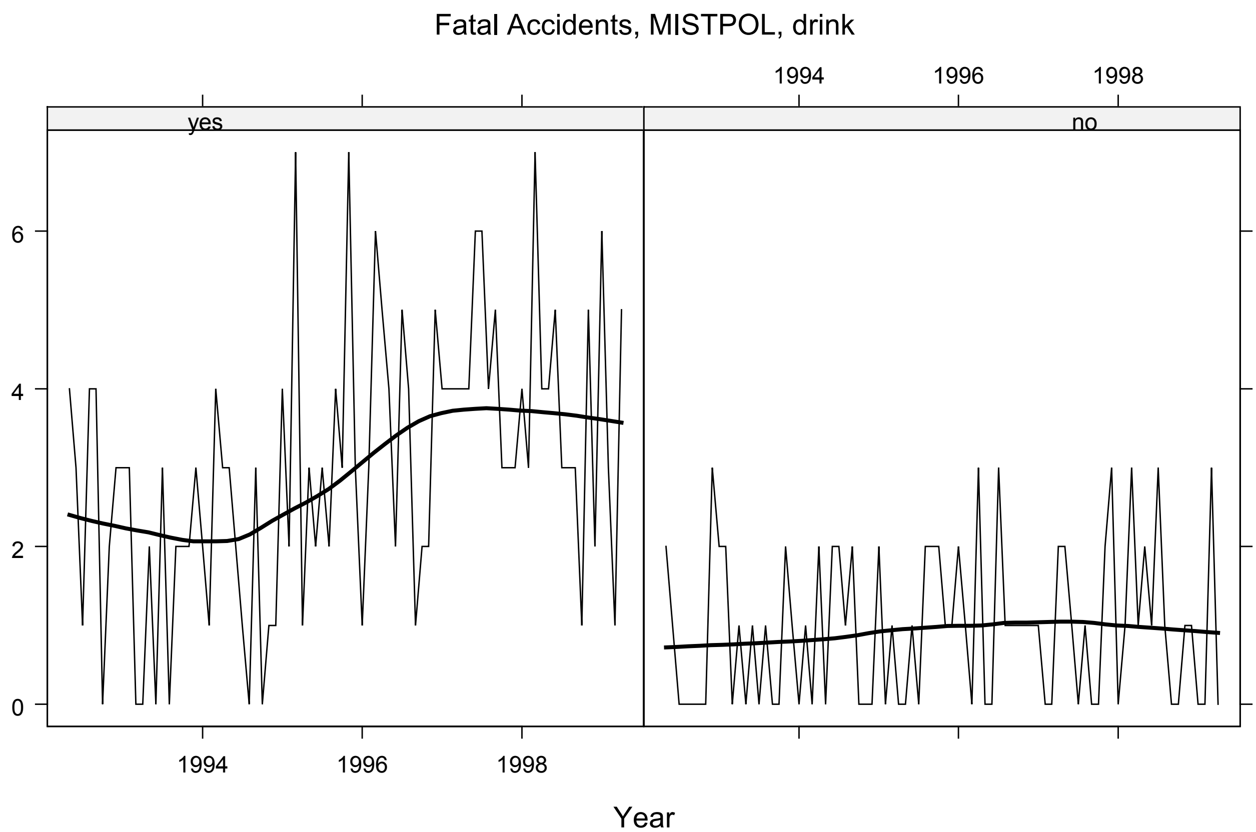
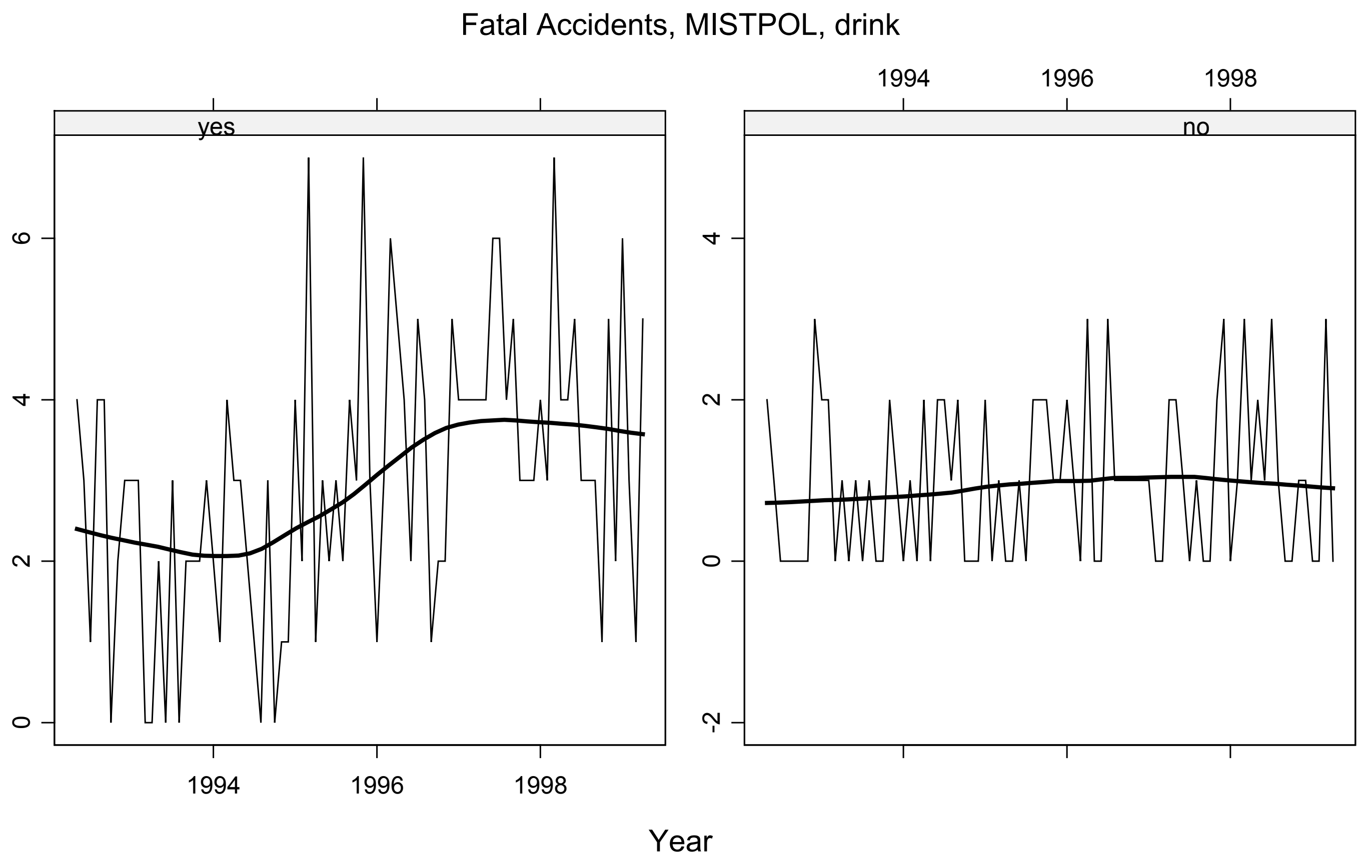


Figure 7b. Fatal accidents by drinking with sliced vertical scales.



Tables and Trend Tests: fatal accidents

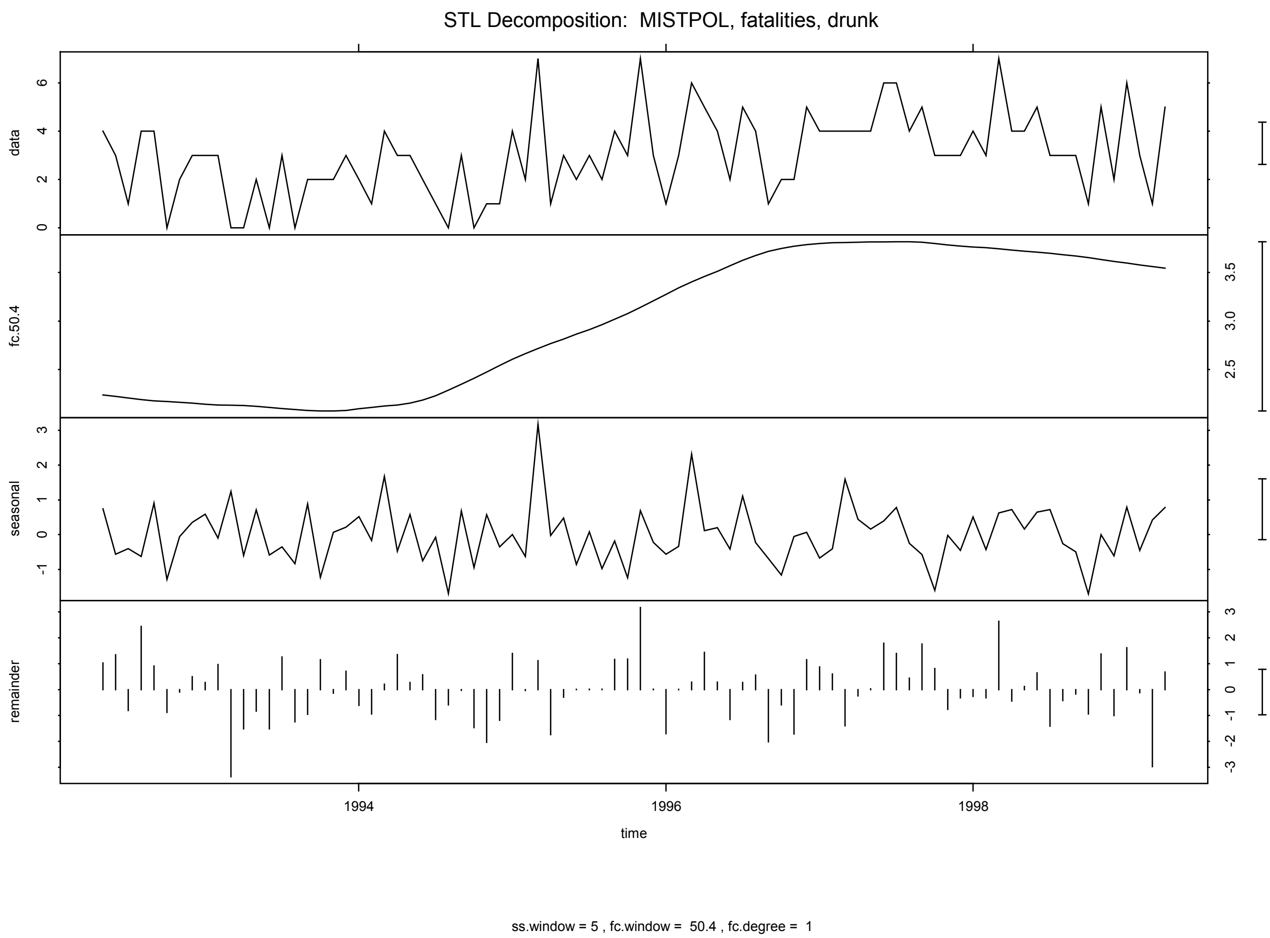
There is an alarming upward trend in fatal accidents associated with drinking. No trend in other.

```
> accidents.fatal.yes
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   4   3   1   4   4   0   2   3
1993:   3   3   0   0   2   0   3   0   2   2   2   3
1994:   2   1   4   3   3   2   1   0   3   0   1   1
1995:   4   2   7   1   3   2   3   2   4   3   7   3
1996:   1   3   6   5   4   2   5   4   1   2   2   5
1997:   4   4   4   4   4   6   6   4   5   3   3   3
1998:   4   3   7   4   4   5   3   3   3   1   5   2
1999:   6   3   1   5   4
> SeasonalMannKendall(accidents.fatal.yes)
tau = 0.352,   sl =0.02077%

> accidents.fatal.no
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   2   1   0   0   0   0   0   3
1993:   2   2   0   1   0   1   0   1   0   0   2   1
1994:   0   1   0   2   0   2   2   1   2   0   0   0
1995:   2   0   1   0   0   1   0   2   2   2   1   1
1996:   2   1   0   3   0   0   3   1   1   1   1   1
1997:   1   0   0   2   2   1   0   1   0   0   2   3
1998:   0   1   3   1   2   1   3   1   0   0   1   1
1999:   0   0   3   0   2
> SeasonalMannKendall(accidents.fatal.no)
tau = 0.0527,   sl =59.31%
```

STL Analysis of Fatal Accidents with Drinking

Fatal accidents with drinking have risen since 1994 (Figure 8). This analysis is based on very small counts. There is no significant lag one autocorrelation but seasonality is evident in the lag 12 autocorrelation of 0.92. The data are approximately Poisson distributed with mean of 3.5.
`R-sq = 50.8 %.` No monotone spread.

Figure 8a.



The seasonal variation is not very stable (Figure 8b).

Figure 8b.

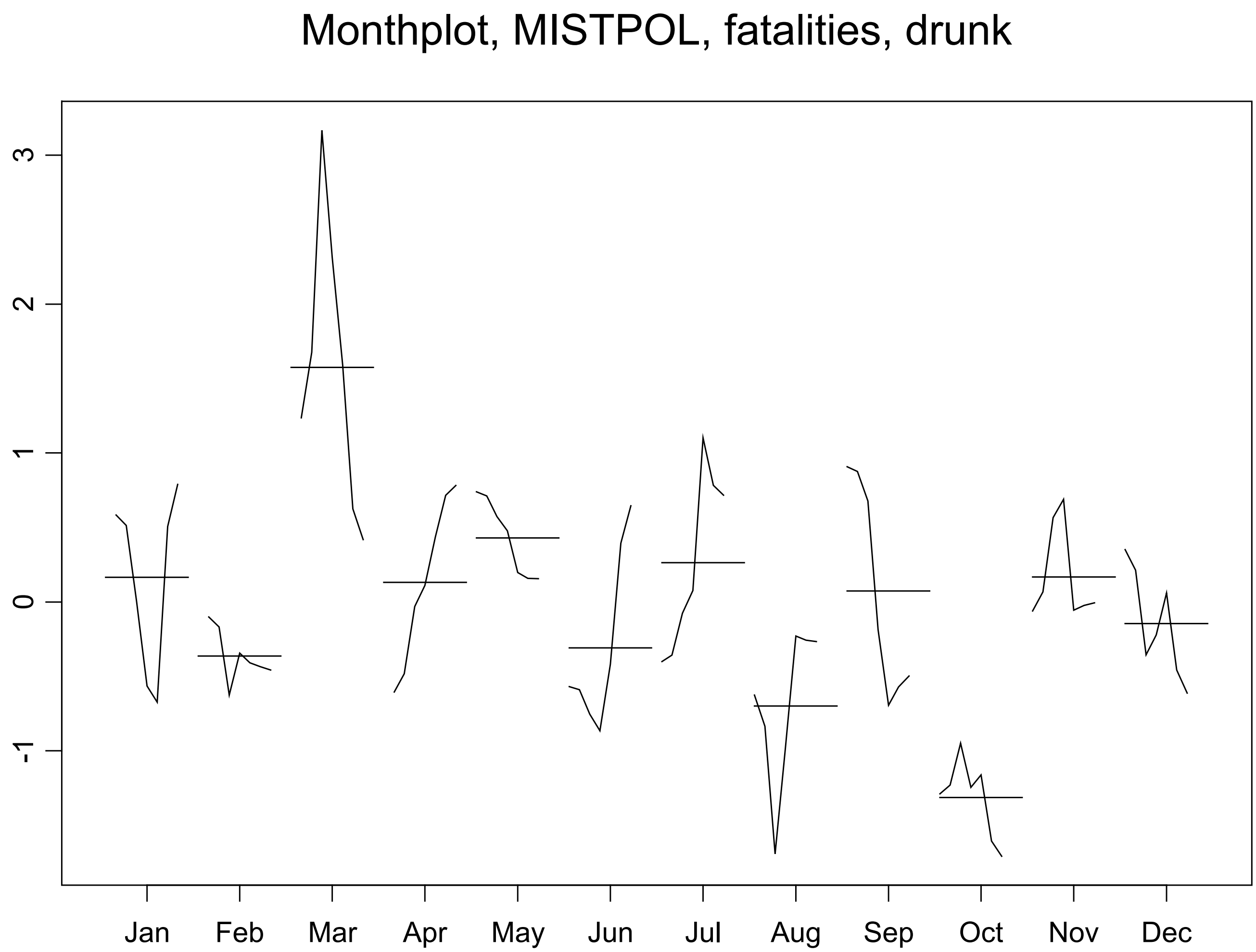
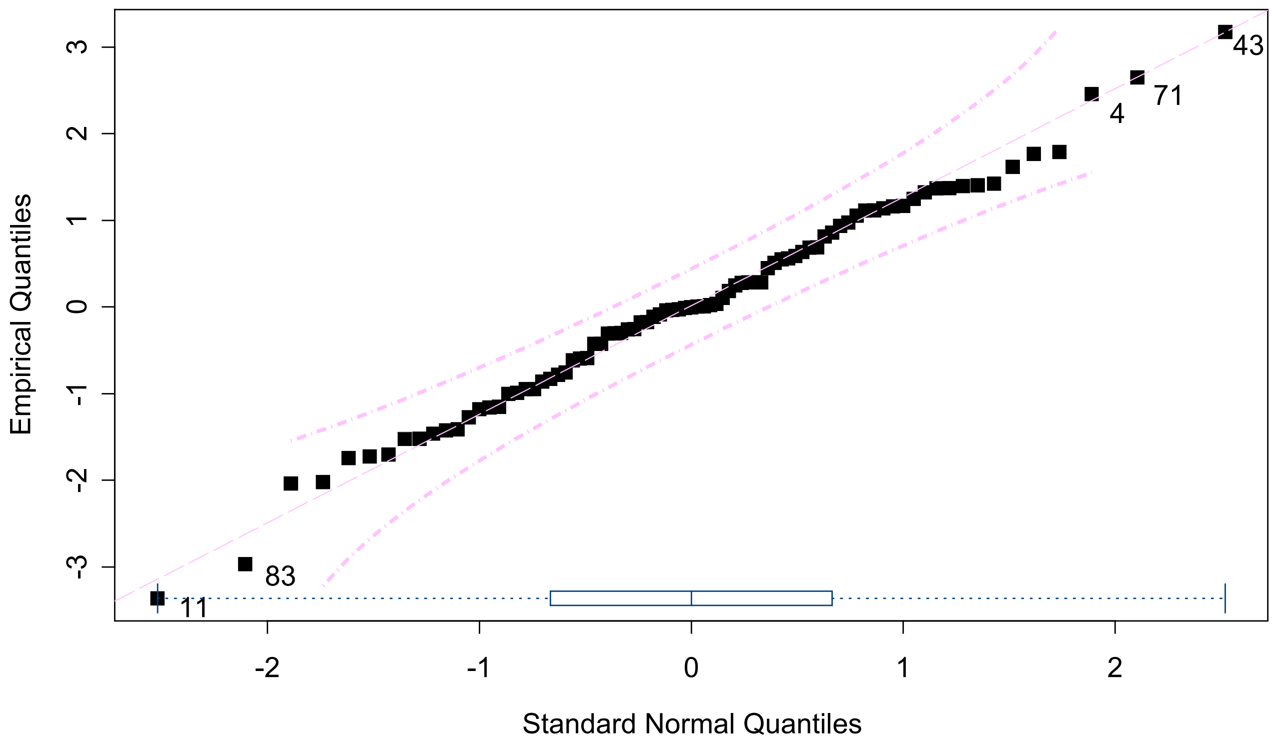


Figure 8c. The remainder component is approximately normally distributed.



Skewness Coefficient: g_1 = -0.1005119 , s.l. = 0.3425395
Michael's Statistic: D_sp = 0.04366982 , s.l. = 0.6218337
Wilk-Shapiro Statistic: W = 0.9896425 , s.l. = 0.9538782

Figure 8d. The remainder term has no unusual autocorrelation.

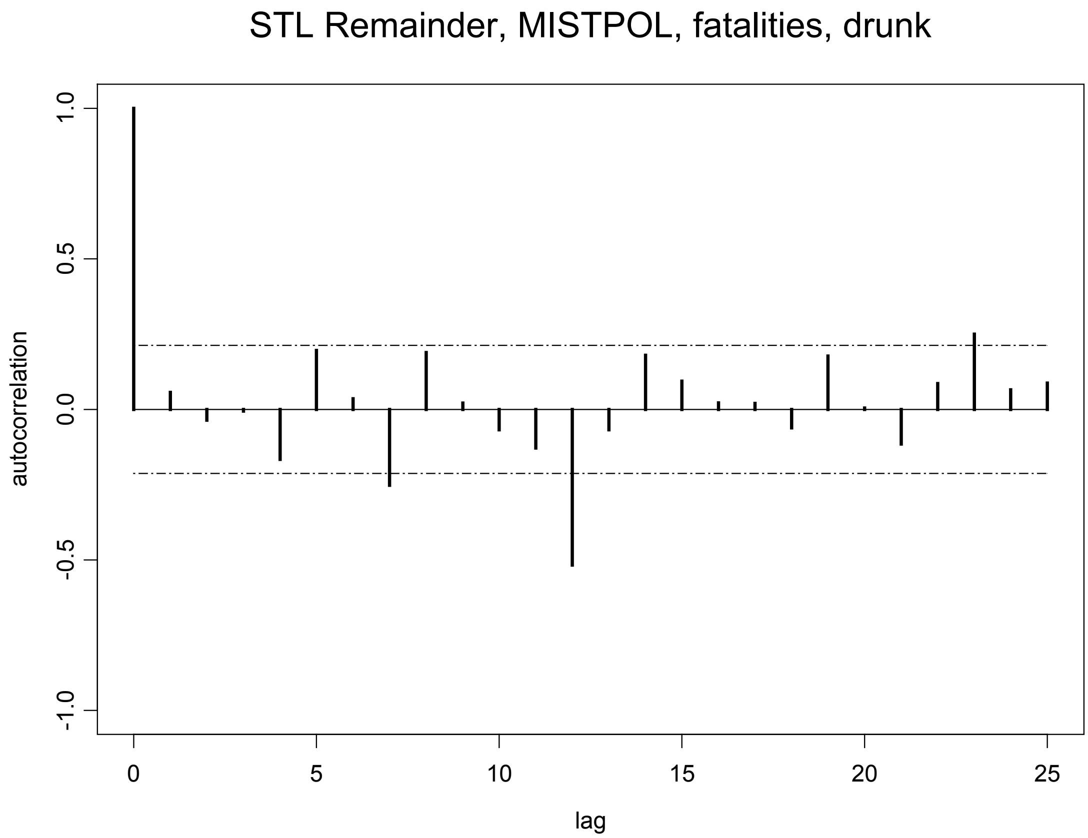


Figure 8e. Loess trend analysis of the deseasonalized series.
`Mann-Kendall test: tau = 0.329,   sl =6.569e-4%`

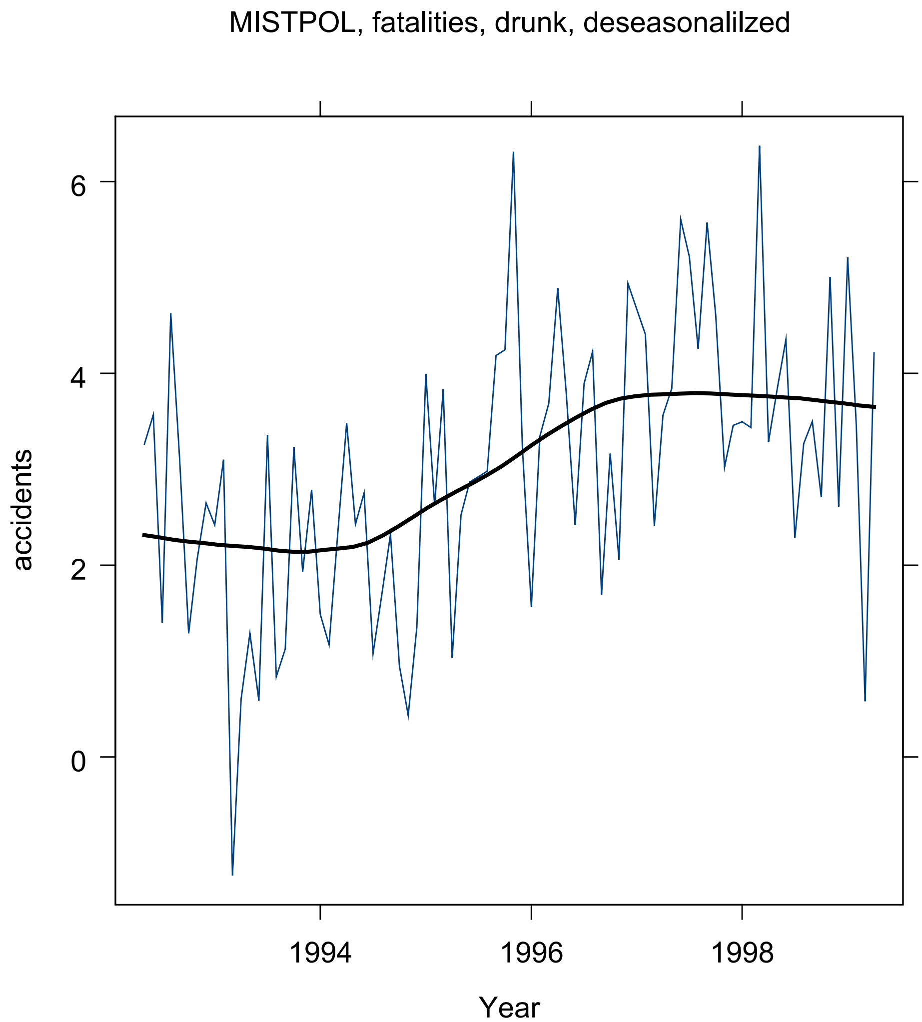
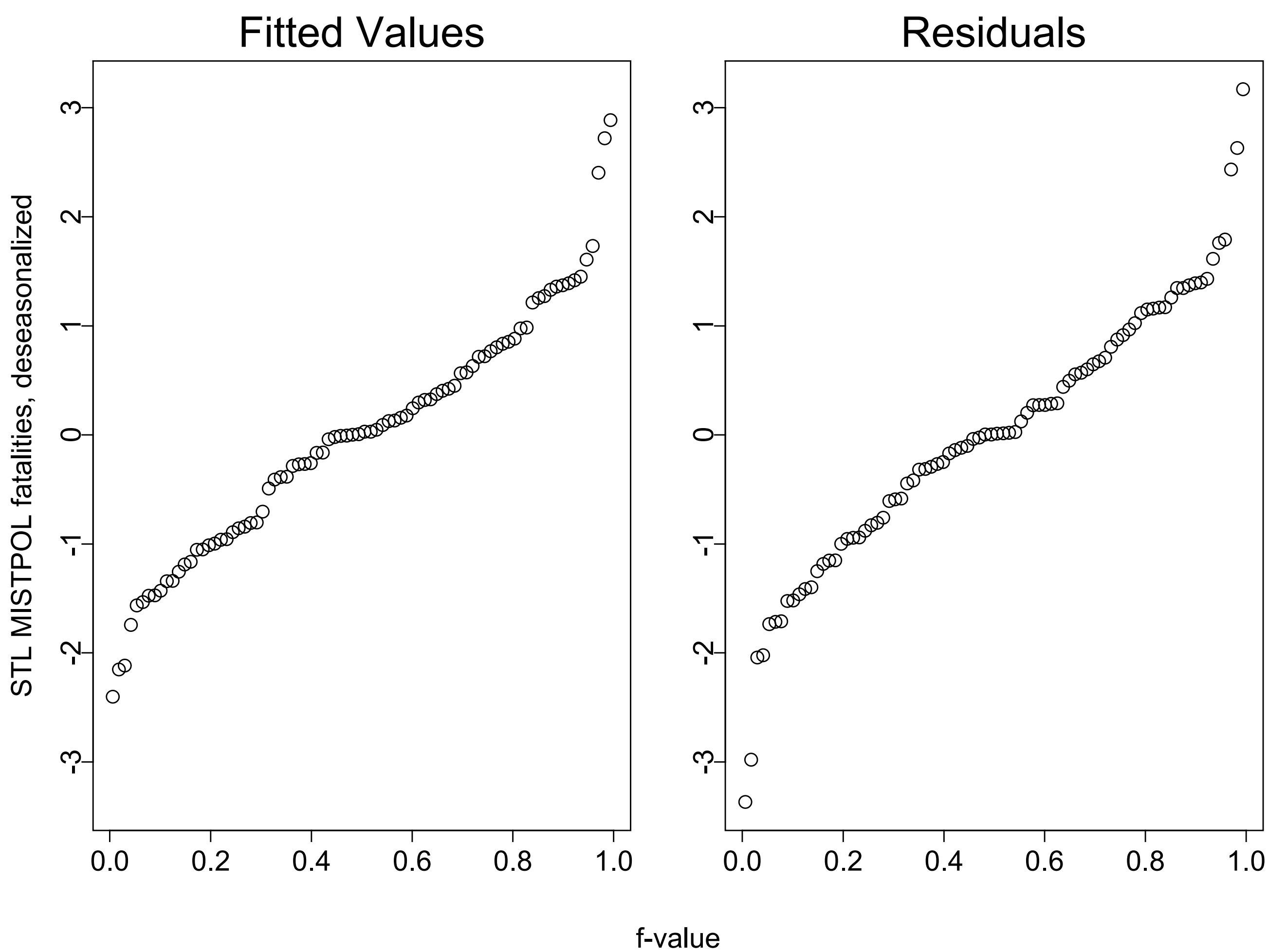


Figure 8f. RF spread plot.
Agrees with `R-sq =  50.8 %.`



J. MISTPOL Dataset
Incapacitating Accidents

Summary

Figure 1. There is a clear downward trend in the number of incapacitating accidents (Fig. 1). Since May 1992 the trend line has declined from 60.6 to 37.4 by April 1999. The average annual rate of decline is about 6.7%. The decline is much steeper during the second half of the series (ie. from 1996). Seasonal Mann-Kendall indicates strong trend. Possible outliers noted (Figure 3c and Figure 3e).

The data are approximately Gaussian distributed with mean of 53.7 (Figure 2).

STL analysis confirms the downward trend and shows a change in the seasonal pattern occurred after 1996 (Figure 3a). There is a lot of variability in the seasonal component. There is a peak in May-Jun, Jun-Aug are also high and there is a minimum in Jan-Feb and in Sep (Figure 3b).

`Drink-Hour` are dependent: there are fewer `YES-11PM` and more `YES-2AM`.

`Drink-Weekgroup` are associated – there are less `YES-SunWed` as might be supposed.

`Drink-Gender` are associated: males are strongly associated with more incapacitating accidents involving drinking.

Figure 4 shows that ThuSat group has more incapacitating accidents. There is an evident downward trend in both groups.

By hour. Downward trend in all panels but the slope seems to decrease as it gets later (Figure 5) and the downward trend for 2AM does not start until after 1996. Monotonic trend not significant for 2AM, Table 5.

Males have more incapacitating accidents. Much greater downward trend for males (Figure 6). Monotonic trend for males but not females – Table 6. Test for monotonic trend significant for males bu not significant for females. The loess trend line for incapacitating accidents by males has declined from about 43.0 per month in May 1992 to about 25.3 per month by April 1999. The average annual rate of decline is about 7.3%. It is clear that there is no change for females until after 1996 and then only a very small decline.

Both drinking and non-drinking have downward strong trends (Figure 7).

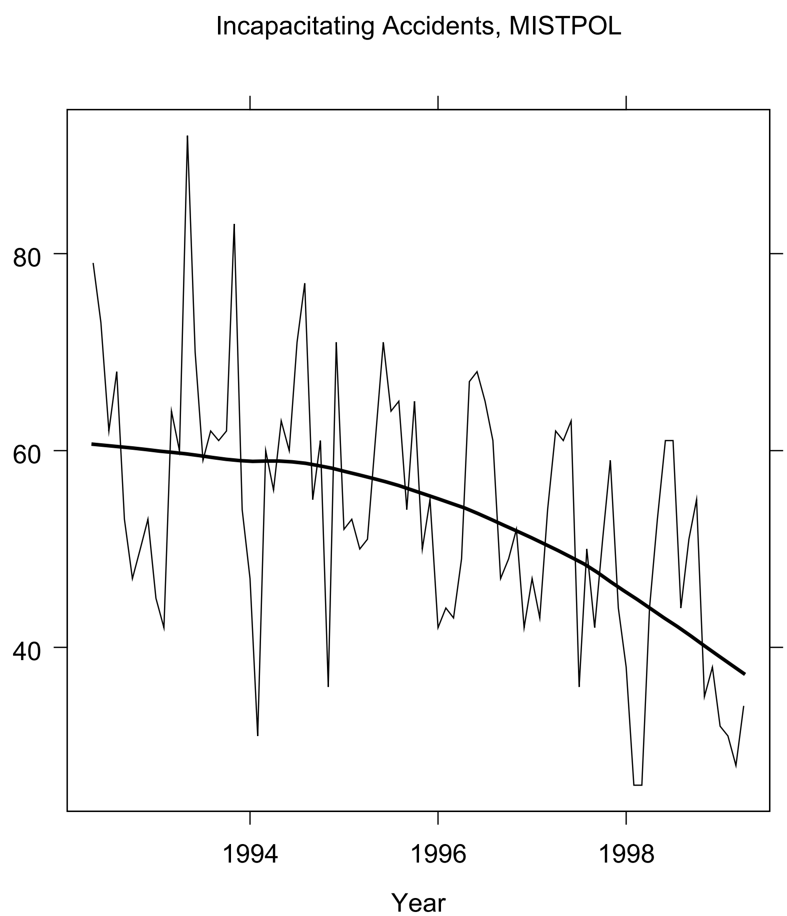
Strong downward trend in incapacitating accidents involving drinking. Seasonal component has changed since about 1995 and is very changeable (Figure 8a). R-sq = 65.4 %Possible outliers May 1993 `(+)`, Nov 1993 `(+)` and Feb 1994 `(-)` – see Figures 8c and 8e. Figure 8b, Apr-Aug and Oct are relatively high and Dec is also relatively low.

Time Series Tabulation and Loess Analysis

There is a clear downward trend in the number of incapacitating accidents (Fig. 1). Since May 1992 the trend line has declined from 60.6 to 37.4 by April 1999. The average annual rate of decline is about 6.7%. The decline is much steeper during the second half of the series (ie. from 1996). Seasonal Mann-Kendall indicates strong trend. Possible outliers noted (Figure 3c and Figure 3e).

```
> accidents.mistpol.incap.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  79  73  62  68  53  47  50  53
1993:  45  42  64  60  92  70  59  62  61  62  83  54
1994:  47  31  60  56  63  60  71  77  55  61  36  71
1995:  52  53  50  51  61  71  64  65  54  65  50  55
1996:  42  44  43  49  67  68  65  61  47  49  52  42
1997:  47  43  54  62  61  63  36  50  42  51  59  44
1998:  38  26  26  44  53  61  61  44  51  55  35  38
1999:  32  31  28  34
> SeasonalMannKendall(accidents.mistpol.incap.ts)
tau = -0.432,   sl =2.6e-4%
> pc.change(accidents.mistpol.incap.ts)
    start      end  change% annual.rate%
 60.65727 37.36547 38.39903      6.68723
```

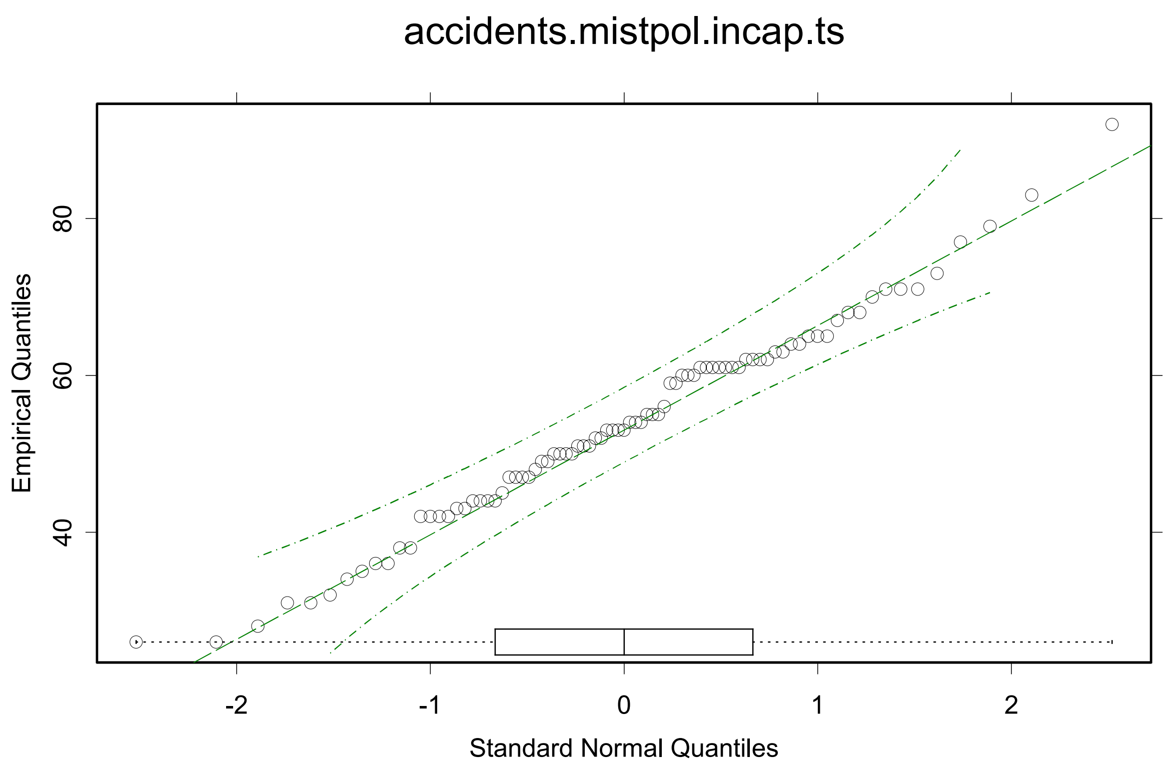
Figure 1.



Normal Probability Plot

There is no significant lag one autocorrelation but seasonality is evident in the lag 12 autocorrelation of 0.92. The data are approximately Gaussian distributed with mean of 53.7 (Figure 2).

Figure 2

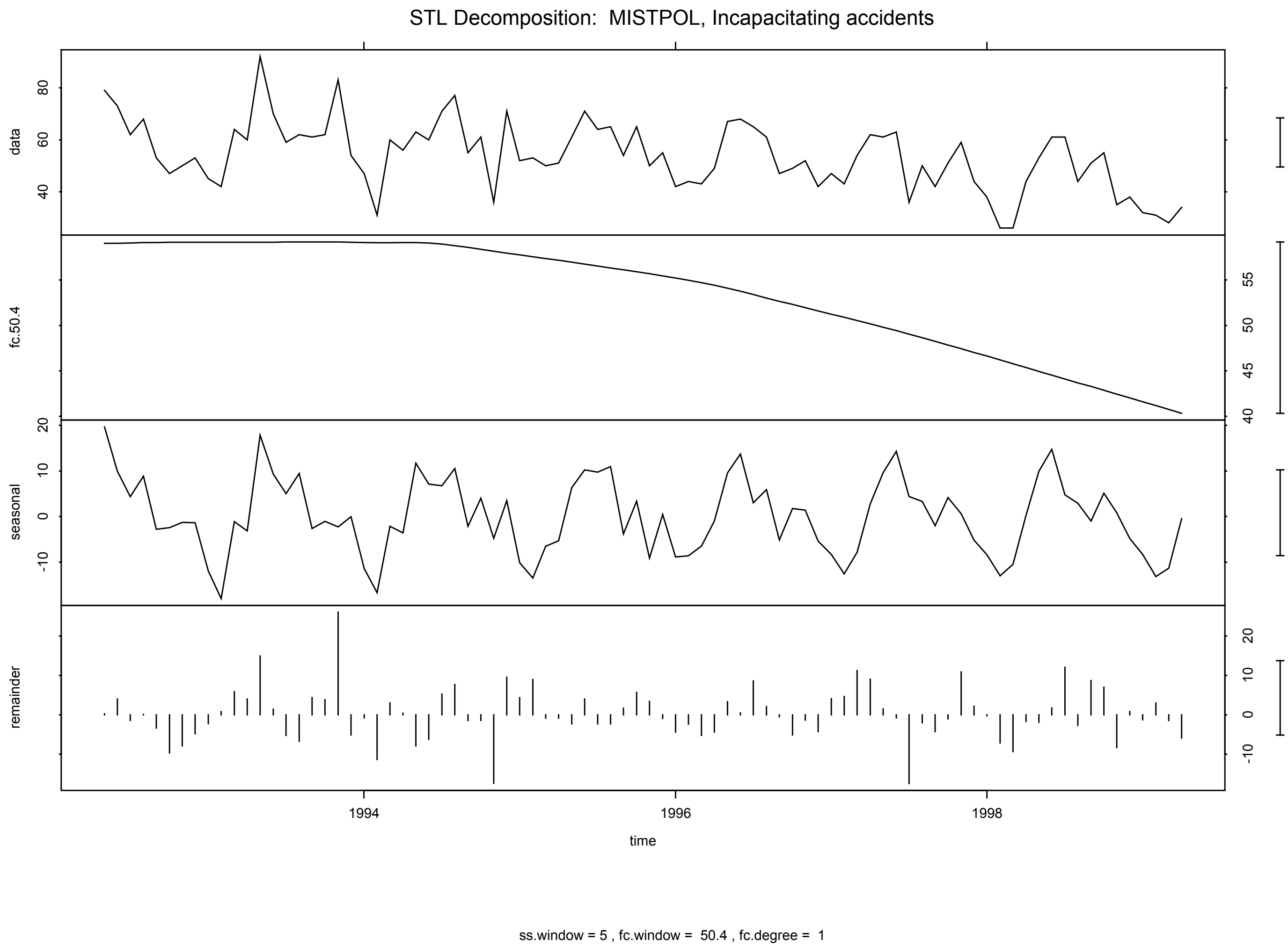


Skewness Coefficient: g_1 = 0.1004565 , s.l. = 0.3426213
Michael's Statistic: D_sp = 0.04588675 , s.l. = 0.7811733
Wilk-Shapiro Statistic: W = 0.9823758 , s.l. = 0.6912928

STL Analysis

STL analysis confirms the downward trend and shows a change in the seasonal pattern occurred after 1996 (Figure 3a). R-sq = 74.5 %

Figure 3a.



There is a lot of variability in the seasonal component. There is a peak in May-Jun, Jun-Aug are also high and there is a minimum in Jan-Feb and in Sep (Figure 3b).

Figure 3b.

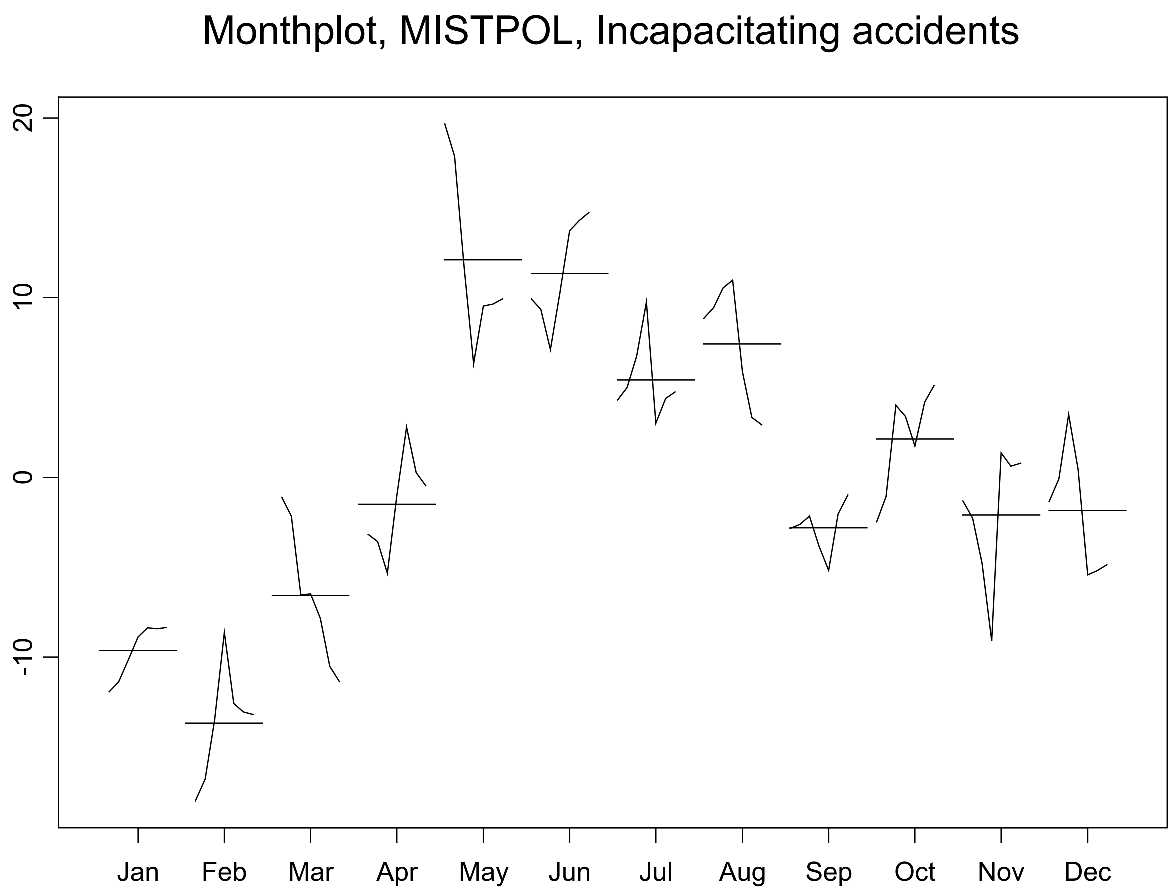
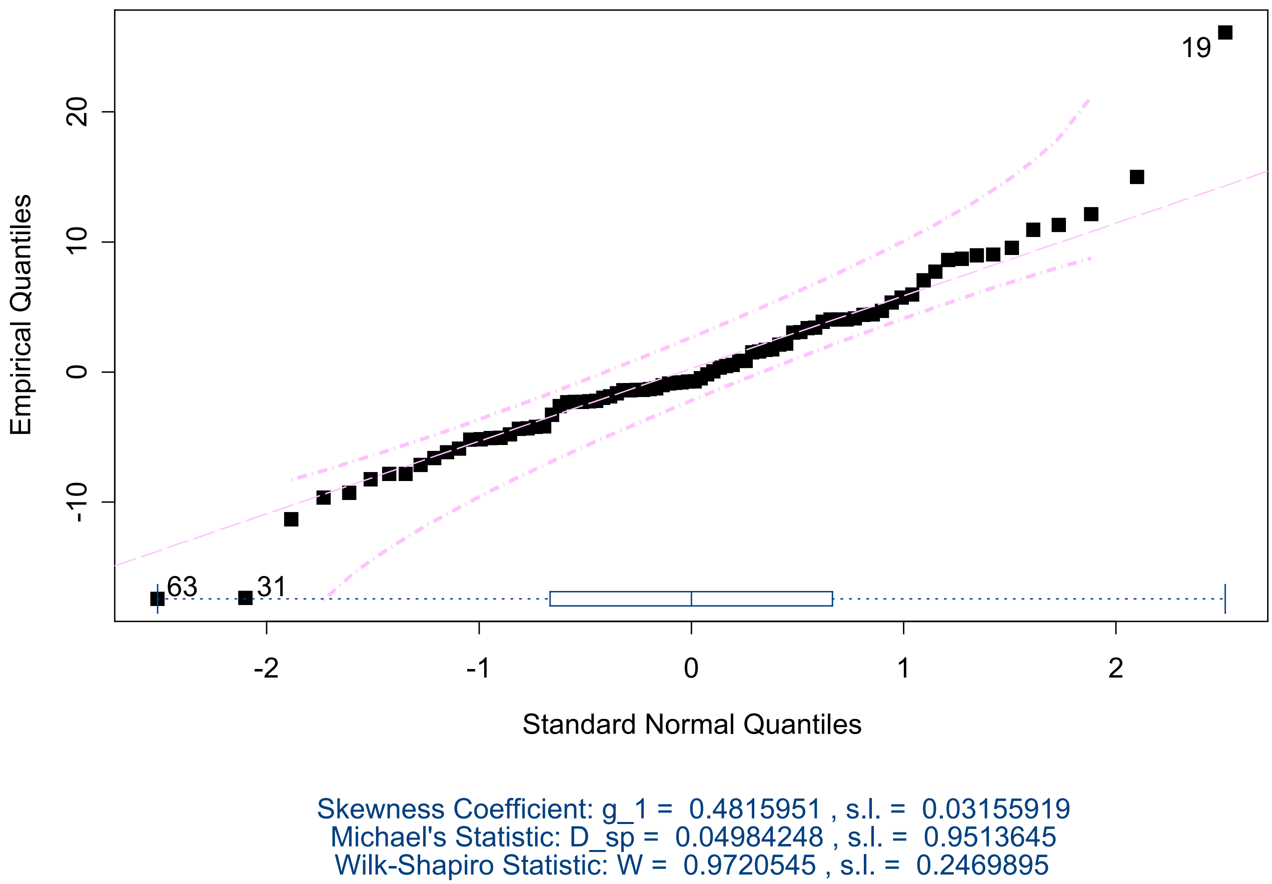


Figure 3c.

Remainder term is reasonably normal. Some possible outliers noted.




```
> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   3   4   5   6   7   8
1993:   9  10  11  12  13  14  15  16  17  18  19  20
1994:  21  22  23  24  25  26  27  28  29  30  31  32
1995:  33  34  35  36  37  38  39  40  41  42  43  44
1996:  45  46  47  48  49  50  51  52  53  54  55  56
1997:  57  58  59  60  61  62  63  64  65  66  67  68
1998:  69  70  71  72  73  74  75  76  77  78  79  80
1999:  81  82  83  84
```

Figure 3d.

Strong downward trend in deseasonalized series.

tau = -0.468, sl =0%

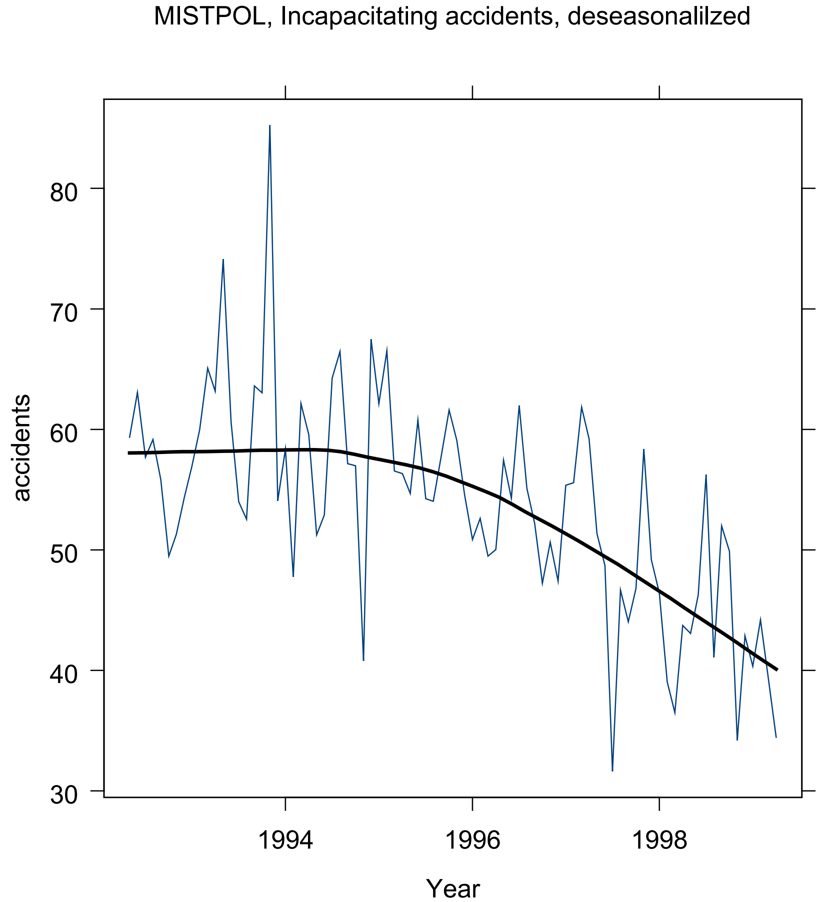
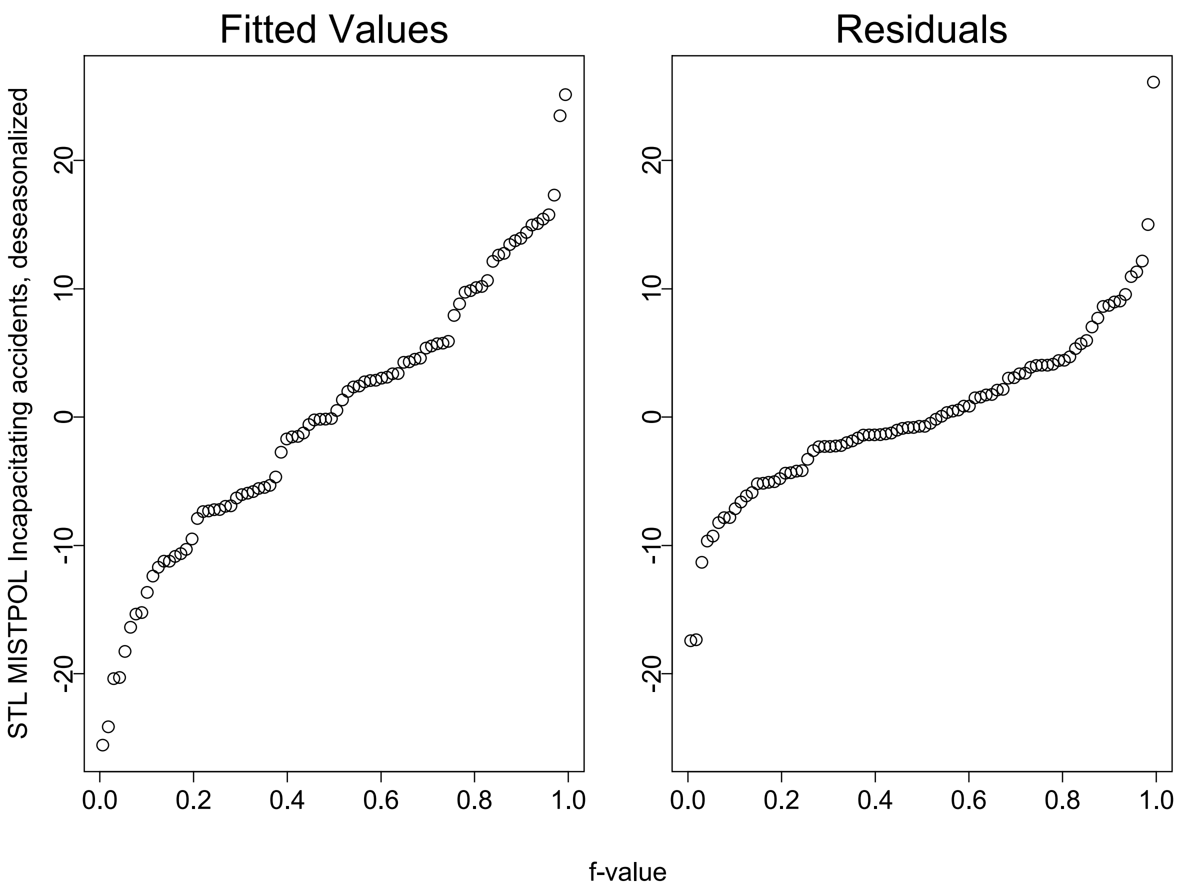


Figure 3e. RF-spread plot

Outliers are evident otherwise agrees more or less with `R-sq =  74.5 %`



Crosstab Analysis

Drink and Hour

`Drink-Hour` are dependent: there are **fewer** `YES-11PM` and **more** `YES-2AM`.

```
> crosstabs( ~ drink + hour, data = mistpol.incap.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + hour, data = mistpol.incap.df, na.action = na.exclude)
3210 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |hour
       |11PM   |12AM   |1AM    |2AM    |RowTotl|
-------+-------+-------+-------+-------+-------+
yes    |322    |345    |373    |563    |1603   |
       |0.2    |0.22   |0.23   |0.35   |0.5    |
       |0.37   |0.45   |0.56   |0.62   |       |
       |0.1    |0.11   |0.12   |0.18   |       |
-------+-------+-------+-------+-------+-------+
no     |540    |423    |294    |350    |1607   |
       |0.34   |0.26   |0.18   |0.22   |0.5    |
       |0.63   |0.55   |0.44   |0.38   |       |
       |0.17   |0.13   |0.092  |0.11   |       |
-------+-------+-------+-------+-------+-------+
ColTotl|862    |768    |667    |913    |3210   |
       |0.27   |0.24   |0.21   |0.28   |       |
-------+-------+-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 122.0984 d.f.= 3 (p=0)
       Yates' correction not used
> get.crosstabs.percenterror( ~ drink + hour)
     [,1] [,2] [,3] [,4]
[1,]  -25  -10   12   23
[2,]   25   10  -12  -23
> contrib( ~ drink + hour)
contribution to chi-sq:
      [,1]  [,2]  [,3]  [,4]
[1,] -5.23 -1.97  2.19  5.01
[2,]  5.22  1.96 -2.18 -5.01
```

Drink and Weekgroup

`Drink-Weekgroup` are associated – there are less `YES-SunWed` as might be supposed.

```
> crosstabs( ~ drink + wkgrp, data = mistpol.incap.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + wkgrp, data = mistpol.incap.df, na.action = na.exclude)
3208 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |wkgrp
       |SunWed |ThuSat |RowTotl|
-------+-------+-------+-------+
yes    | 547   |1055   |1602   |
       |0.34   |0.66   |0.5    |
       |0.46   |0.52   |       |
       |0.17   |0.33   |       |
-------+-------+-------+-------+
no     | 639   | 967   |1606   |
       |0.4    |0.6    |0.5    |
       |0.54   |0.48   |       |
       |0.2    |0.3    |       |
-------+-------+-------+-------+
ColTotl|1186   |2022   |3208   |
       |0.37   |0.63   |       |
-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 10.96149 d.f.= 1 (p=0.0009302476)
       Yates' correction not used
> get.crosstabs.percenterror( ~ drink + wkgrp)
     [,1] [,2]
[1,]   -8    4
[2,]    8   -4
> contrib( ~ drink + wkgrp)
contribution to chi-sq:
      [,1]  [,2]
[1,] -1.86  1.42
[2,]  1.86 -1.42
```

Drink and Gender

`Drink-Gender` are associated: males are strongly associated with more incapacitating accidents involving drinking.

```
> crosstabs( ~ drink + sex, data = mistpol.incap.df, na.action = na.exclude)
Call:
crosstabs(formula =  ~ drink + sex, data = mistpol.incap.df, na.action = na.exclude)
3169 cases in table
+----------+
|N         |
|N/RowTotal|
|N/ColTotal|
|N/Total   |
+----------+
drink  |sex
       |male   |female |RowTotl|
-------+-------+-------+-------+
yes    |1241   | 340   |1581   |
       |0.78   |0.22   |0.5    |
       |0.56   |0.36   |       |
       |0.39   |0.11   |       |
-------+-------+-------+-------+
no     | 986   | 602   |1588   |
       |0.62   |0.38   |0.5    |
       |0.44   |0.64   |       |
       |0.31   |0.19   |       |
-------+-------+-------+-------+
ColTotl|2227   |942    |3169   |
       |0.7    |0.3    |       |
-------+-------+-------+-------+
Test for independence of all factors
       Chi^2 = 102.054 d.f.= 1 (p=0)
       Yates' correction not used
> get.crosstabs.percenterror( ~ drink + sex)
     [,1] [,2]
[1,]   12  -28
[2,]  -12   28
> contrib( ~ drink + sex)
contribution to chi-sq:
      [,1]  [,2]
[1,]  3.90 -5.99
[2,] -3.89  5.98
```

Time Series Trellis Plots of Weekgroup

Figure 4 shows that ThuSat group has more incapacitating accidents. There is an evident downward trend in both groups.

Figure 4.

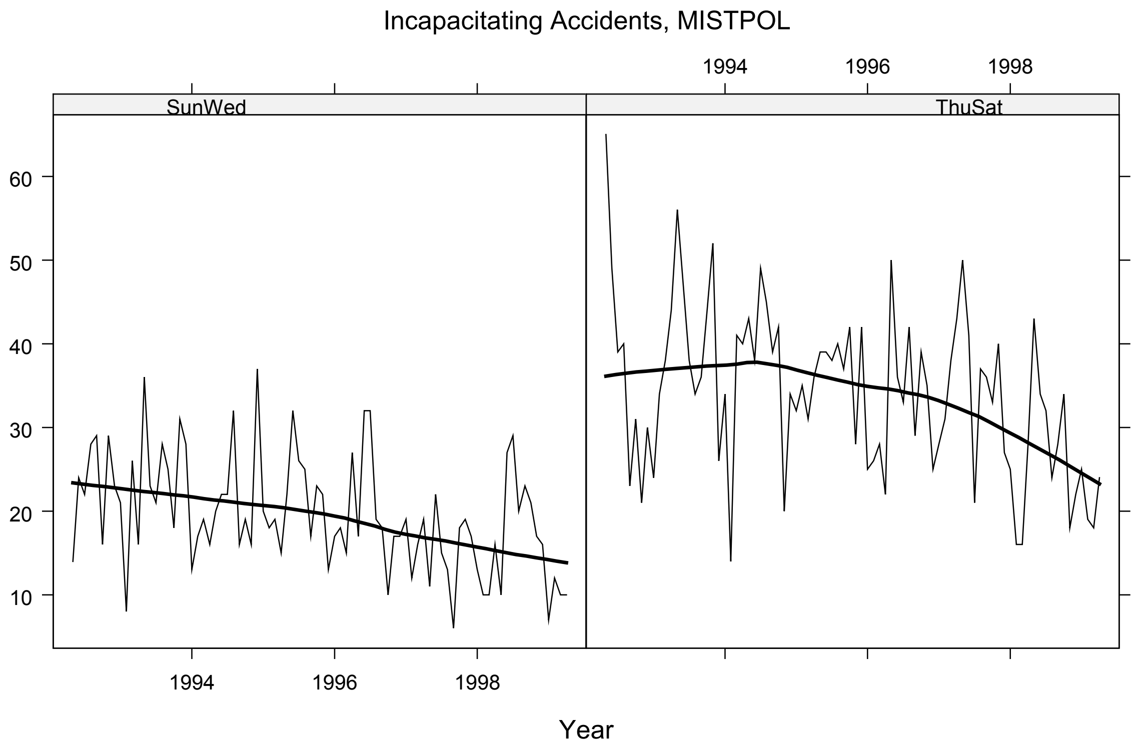


Table 4

Data and Seasonal Mann-Kendall Tests for Incapacitating Accidents by WKGRP

```
> accidents.incap.SunWed
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  14  24  22  28  29  16  29  23
1993:  21   8  26  16  36  23  21  28  25  18  31  28
1994:  13  17  19  16  20  22  22  32  16  19  16  37
1995:  20  18  19  15  22  32  26  25  17  23  22  13
1996:  17  18  15  27  17  32  32  19  18  10  17  17
1997:  19  12  16  19  11  22  15  13   6  18  19  17
1998:  13  10  10  16  10  27  29  20  23  21  17  16
1999:   7  12  10  10
> SeasonalMannKendall(accidents.incap.SunWed)
tau = -0.274,   sl =0.3193%

> accidents.incap.ThuSat
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  65  49  39  40  23  31  21  30
1993:  24  34  38  44  56  47  38  34  36  44  52  26
1994:  34  14  41  40  43  38  49  45  39  42  20  34
1995:  32  35  31  36  39  39  38  40  37  42  28  42
1996:  25  26  28  22  50  36  33  42  29  39  35  25
1997:  28  31  38  43  50  41  21  37  36  33  40  27
1998:  25  16  16  28  43  34  32  24  28  34  18  22
1999:  25  19  18  24
> SeasonalMannKendall(accidents.incap.ThuSat)
tau = -0.365,   sl =0.00809%
```

Time Series Trellis Plots of Hour

Downward trend in all panels but the slope seems to decrease as it gets later (Figure 5) and the downward trend for 2AM does not start until after 1996.

Figure 5.

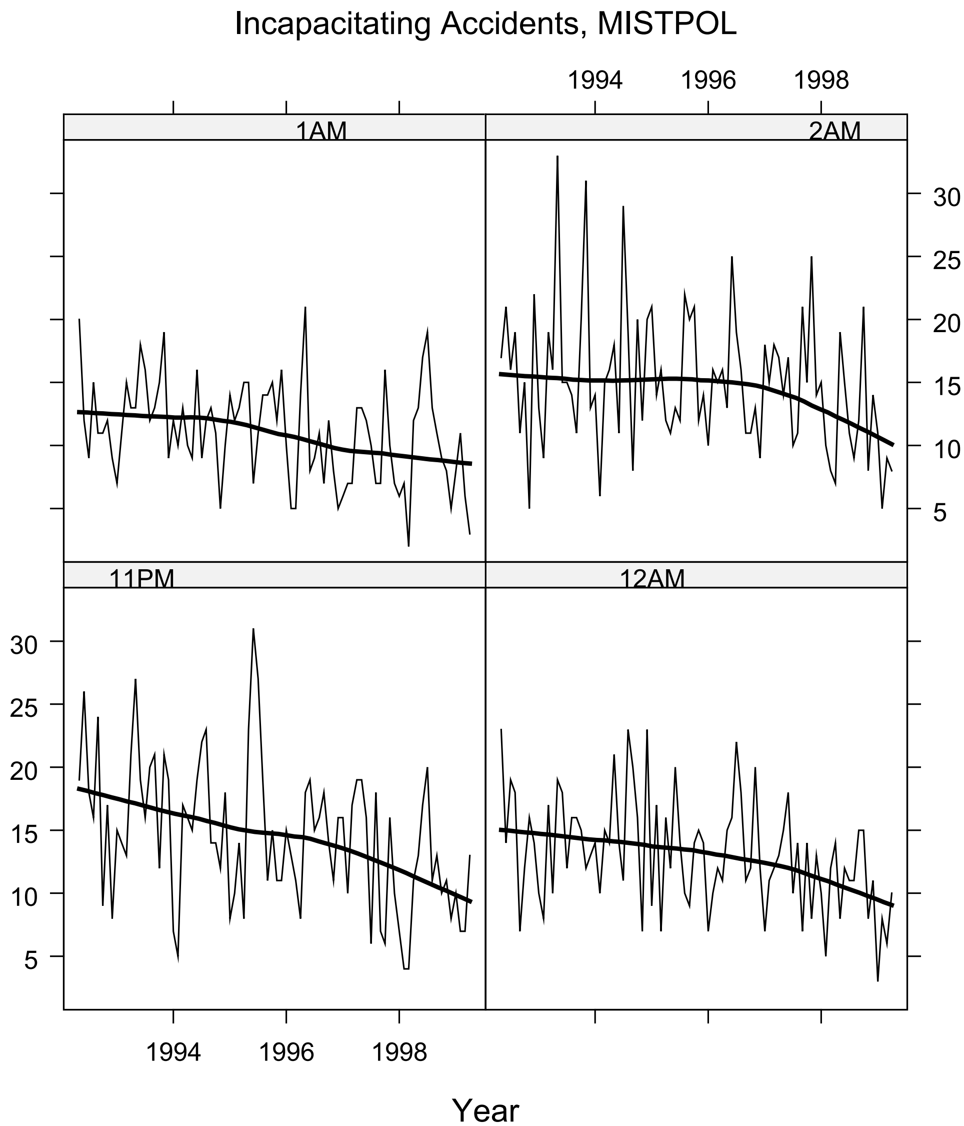


Table 5. Incapacitating Accidents by Hour.
Significant downward trend except for 2AM.

```
> accidents.incap.11PM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  19  26  18  16  24   9  17   8
1993:  15  14  13  21  27  19  16  20  21  12  21  19
1994:   7   5  17  16  15  19  22  23  14  14  12  18
1995:   8  10  14   8  23  31  27  19  11  15  11  11
1996:  15  13  11   8  18  19  15  16  18  14  11  16
1997:  16  10  17  19  19  16   6  18   7   6  16  10
1998:   7   4   4  11  13  17  20  11  13  10  11   8
1999:  10   7   7  13
> SeasonalMannKendall(accidents.incap.11PM)
tau = -0.323,   sl =0.05035%
> accidents.incap.12AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  23  14  19  18   7  12  16  14
1993:  10   8  17  10  19  18  12  16  16  15  12  13
1994:  14  10  15  14  21  14  11  23  20  16   7  23
1995:   9  17   7  16  12  20  14  10   9  14  15  14
1996:   7  10  12  11  15  16  22  18  11  12  20  12
1997:   7  11  12  13  15  18  10  14   7  14   8  13
1998:  10   5  12  14   8  12  11  11  15  15   8  11
1999:   3   8   6  10
> SeasonalMannKendall(accidents.incap.12AM)
tau = -0.286,   sl =0.2255%
> accidents.incap.1AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  20  12   9  15  11  11  12   9
1993:   7  11  15  13  13  18  16  12  13  15  19   9
1994:  12  10  13  10   9  16   9  12  13  11   5  10
1995:  14  12  13  15  15   7  11  14  14  15  12  16
1996:  10   5   5  14  21   8   9  11   7  12   8   5
1997:   6   7   7  13  13  12  10   7   7  16  10   7
1998:   6   7   2  12  13  17  19  13  11   9   8   5
1999:   8  11   6   3
> SeasonalMannKendall(accidents.incap.1AM)
tau = -0.216,   sl =2.113%
> accidents.incap.2AM
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  17  21  16  19  11  15   5  22
1993:  13   9  19  16  33  15  15  14  11  20  31  13
1994:  14   6  15  16  18  11  29  19   8  20  12  20
1995:  21  14  16  12  11  13  12  22  20  21  12  14
1996:  10  16  15  16  13  25  19  16  11  11  13   9
1997:  18  15  18  17  14  17  10  11  21  15  25  14
1998:  15  10   8   7  19  15  11   9  12  21   8  14
1999:  11   5   9   8
> SeasonalMannKendall(accidents.incap.2AM)
tau = -0.123,   sl =18.58%
```

Time Series Trellis Plots of Gender

Males have more incapacitating accidents. Much greater downward trend for males (Figure 6a and 6b). Downward trend for females starts after 1996.

Figure 6. Common Scale.

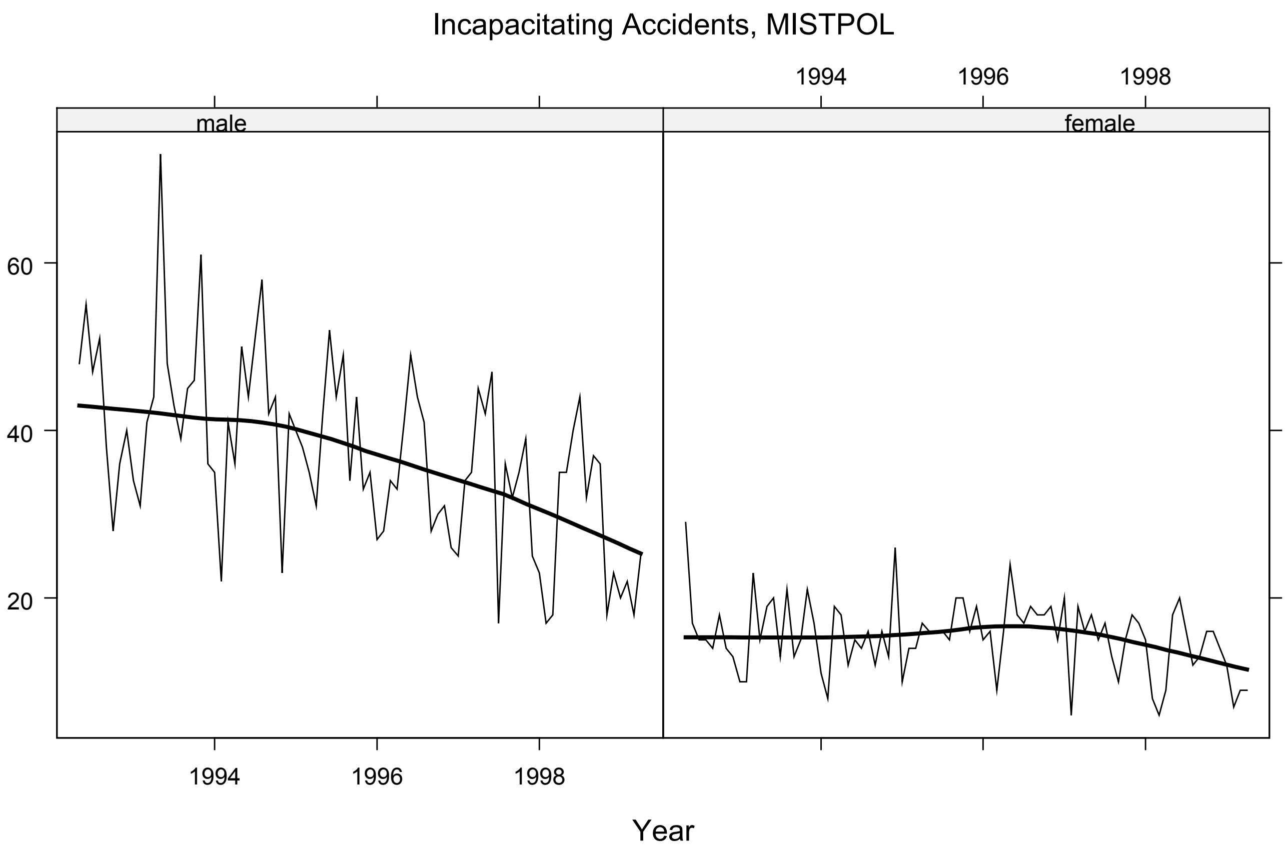


Figure 6b. Sliced Vertical Scale.

It is clear that there is no change for females until after 1996 and then only a very small decline.

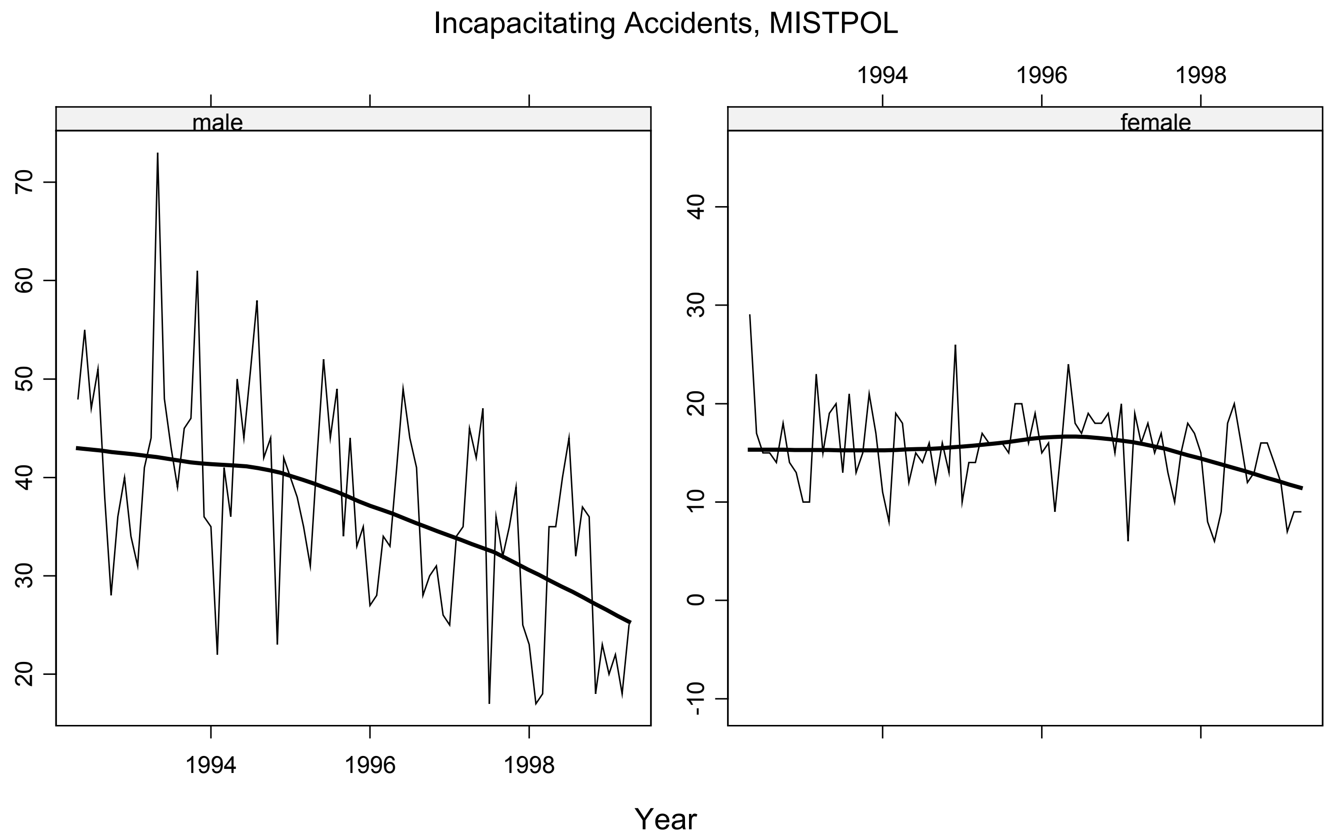


Table 6. Incapacitating Accidents by Gender.

Test for monotonic trend significant for males bu not significant for females. The loess trend line for incapacitating accidents by males has declined from about 43.0 per month in May 1992 to about 25.3 per month by April 1999. The average annual rate of decline is about 7.3%.

```
> accidents.incap.male
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  48  55  47  51  38  28  36  40
1993:  34  31  41  44  73  48  43  39  45  46  61  36
1994:  35  22  41  36  50  44  51  58  42  44  23  42
1995:  40  38  35  31  42  52  44  49  34  44  33  35
1996:  27  28  34  33  41  49  44  41  28  30  31  26
1997:  25  34  35  45  42  47  17  36  32  35  39  25
1998:  23  17  18  35  35  40  44  32  37  36  18  23
1999:  20  22  18  25
> SeasonalMannKendall(accidents.incap.male)
tau = -0.497,   sl =7.373e-6%
> pc.change(accidents.incap.male)
    start      end  change% annual.rate%
 42.98232 25.33472 41.05781     7.273524

> accidents.incap.female
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  29  17  15  15  14  18  14  13
1993:  10  10  23  15  19  20  13  21  13  15  21  17
1994:  11   8  19  18  12  15  14  16  12  16  13  26
1995:  10  14  14  17  16  16  16  15  20  20  16  19
1996:  15  16   9  16  24  18  17  19  18  18  19  15
1997:  20   6  19  16  18  15  17  13  10  15  18  17
1998:  15   8   6   9  18  20  16  12  13  16  16  14
1999:  12   7   9   9
> SeasonalMannKendall(accidents.incap.female)
tau = -0.12,   sl =20.04%
```

Time Series Trellis Plots of Drink

Both drinking and non-drinking have downward strong trends (Figure 7).

Figure 7.

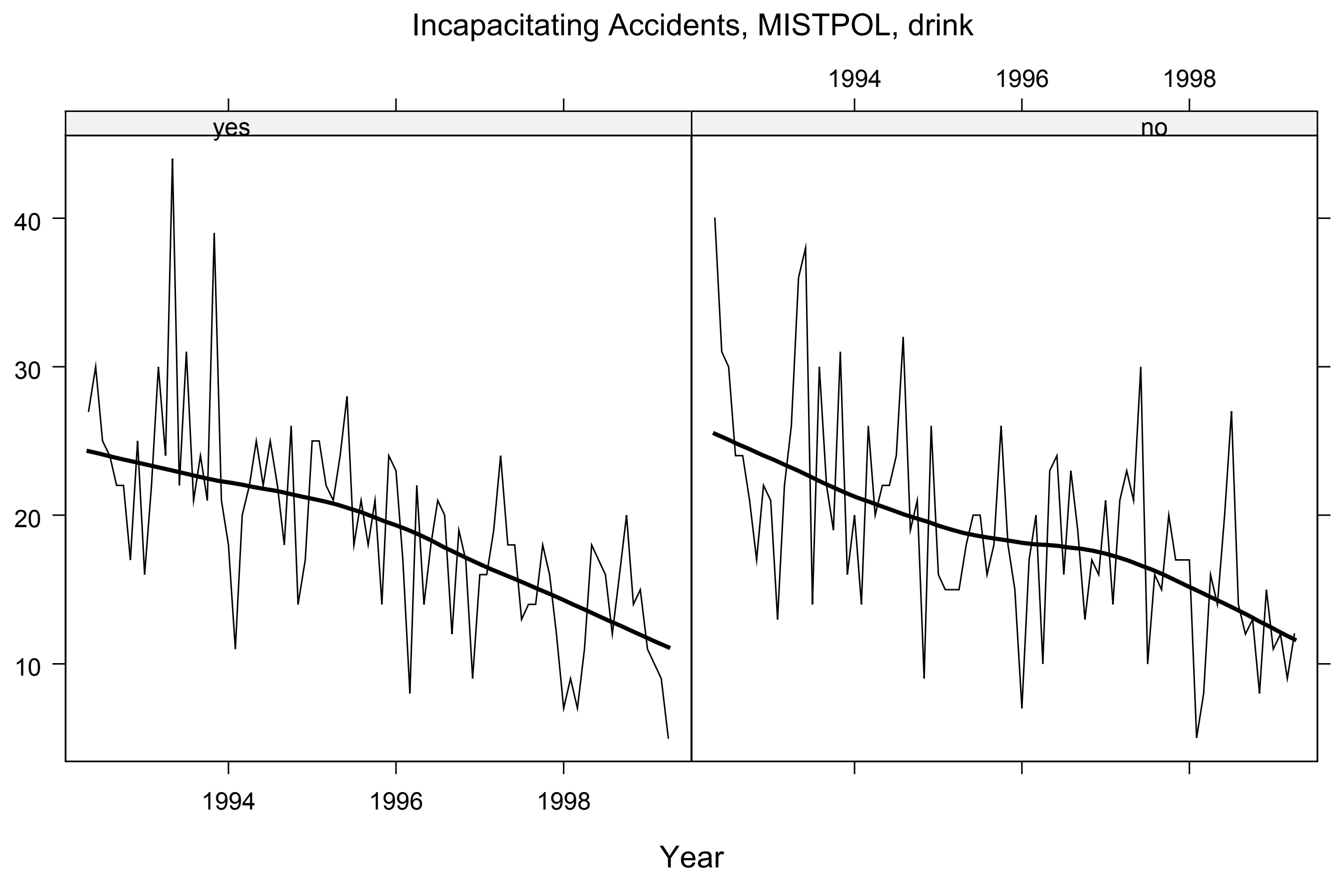


Table 7.
Incapacitating accidents by drinking status.
Highly significant downward trends in both groups.

```
> accidents.incap.yes
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  27  30  25  24  22  22  17  25
1993:  16  22  30  24  44  22  31  21  24  21  39  21
1994:  18  11  20  22  25  22  25  22  18  26  14  17
1995:  25  25  22  21  24  28  18  21  18  21  14  24
1996:  23  17   8  22  14  18  21  20  12  19  17   9
1997:  16  16  19  24  18  18  13  14  14  18  16  12
1998:   7   9   7  11  18  17  16  12  16  20  14  15
1999:  11  10   9   5
> SeasonalMannKendall(accidents.incap.yes)
tau = -0.596,   sl =1.372e-8%
> pc.change(accidents.incap.yes)
    start      end  change% annual.rate%
 24.33004 11.10531 54.35555     10.59926
```

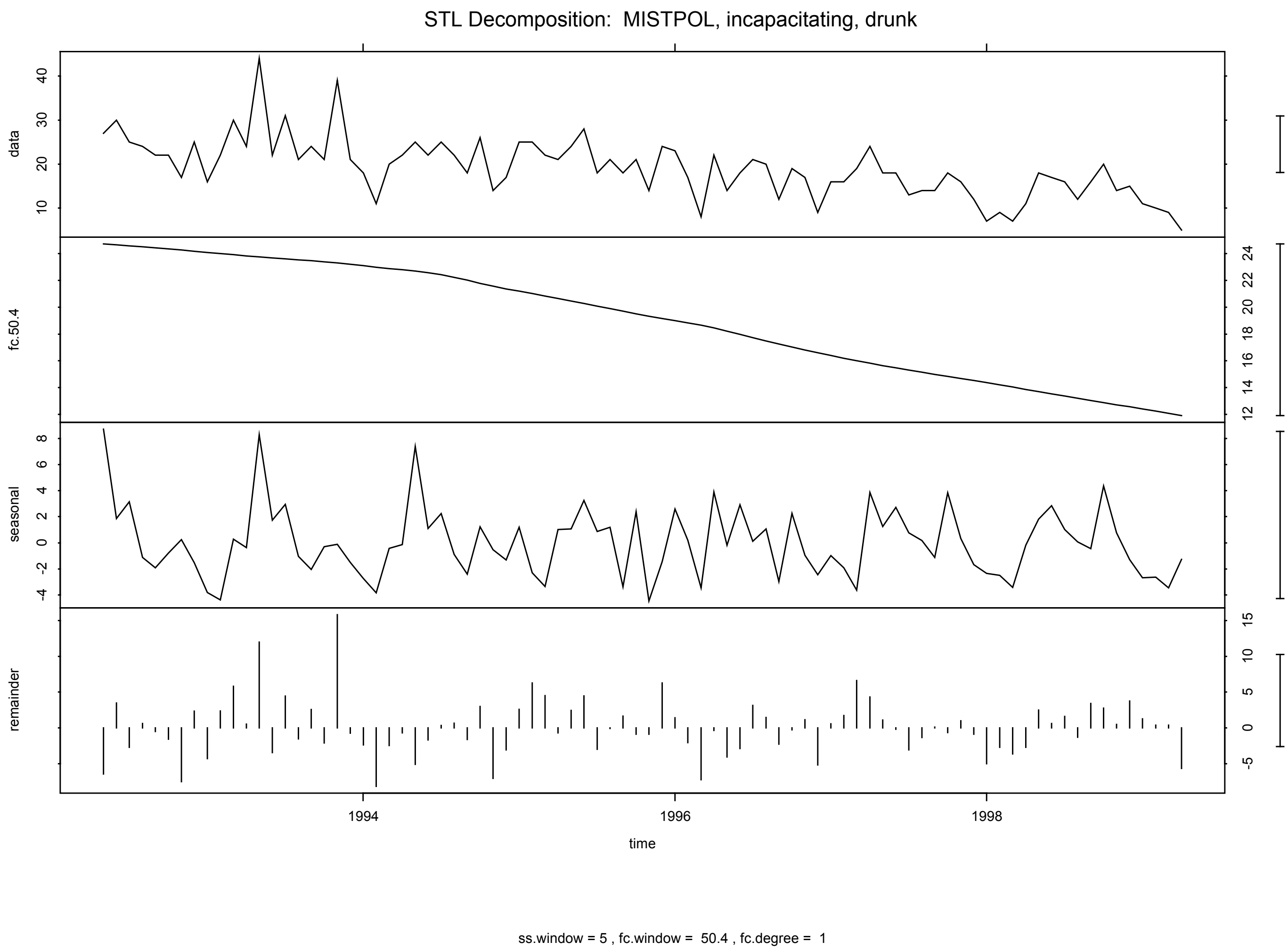
```
> accidents.incap.no
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  40  31  30  24  24  21  17  22
1993:  21  13  22  26  36  38  14  30  22  19  31  16
1994:  20  14  26  20  22  22  24  32  19  21   9  26
1995:  16  15  15  15  18  20  20  16  18  26  18  15
1996:   7  17  20  10  23  24  16  23  19  13  17  16
1997:  21  14  21  23  21  30  10  16  15  20  17  17
1998:  17   5   8  16  14  20  27  14  12  13   8  15
1999:  11  12   9  12
> SeasonalMannKendall(accidents.incap.no)
tau = -0.456,   sl =8.893e-5%
> pc.change(accidents.incap.no)
    start      end change% annual.rate%
 25.66869 11.66655 54.5495     10.65362
```

STL Analysis of Incapacitating Accidents with Drinking

Strong downward trend in incapacitating accidents involving drinking. Seasonal component has changed since about 1995 and is very changeable (Figure 8). R-sq = 65.4 %
Possible outliers May 1993 `(+)`, Nov 1993 `(+)` and Feb 1994 `(-)` – see Figures 8c and 8e.

```
> accidents.mistpol.incap.drunk.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                  27  30  25  24  22  22  17  25
1993:  16  22  30  24  44  22  31  21  24  21  39  21
1994:  18  11  20  22  25  22  25  22  18  26  14  17
1995:  25  25  22  21  24  28  18  21  18  21  14  24
1996:  23  17   8  22  14  18  21  20  12  19  17   9
1997:  16  16  19  24  18  18  13  14  14  18  16  12
1998:   7   9   7  11  18  17  16  12  16  20  14  15
1999:  11  10   9   5   9
> SeasonalMannKendall(accidents.mistpol.incap.drunk.ts)
tau = -0.608,   sl =4.274e-9%
> pc.change(accidents.mistpol.incap.drunk.ts)
    start      end  change% annual.rate%
 24.33004 11.10531 54.35555     10.59926
```

Figure 8a.



The seasonal variation is not very stable (Figure 9). Apr-Aug and Oct are relatively high and Dec is also relatively low.

Figure 8b

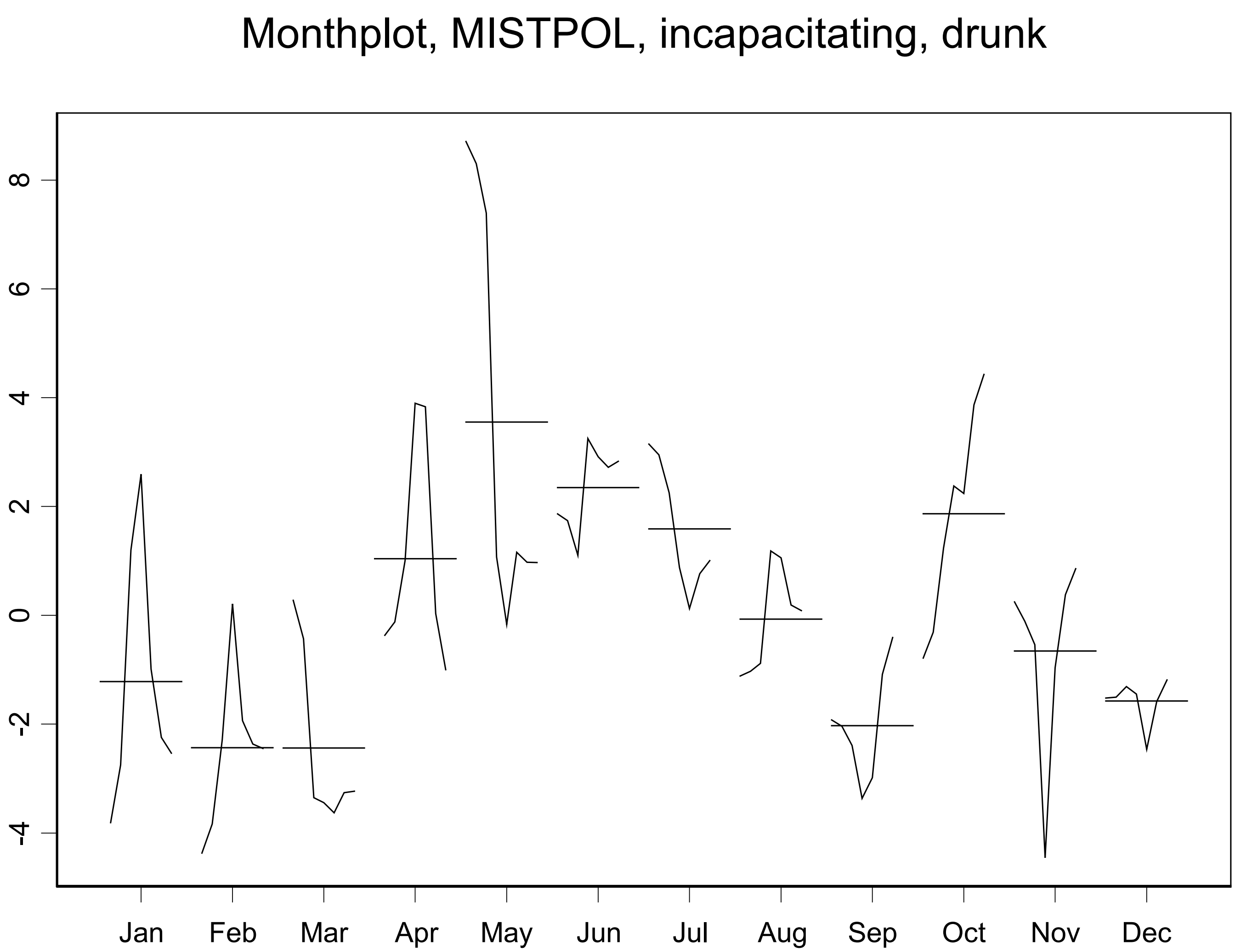
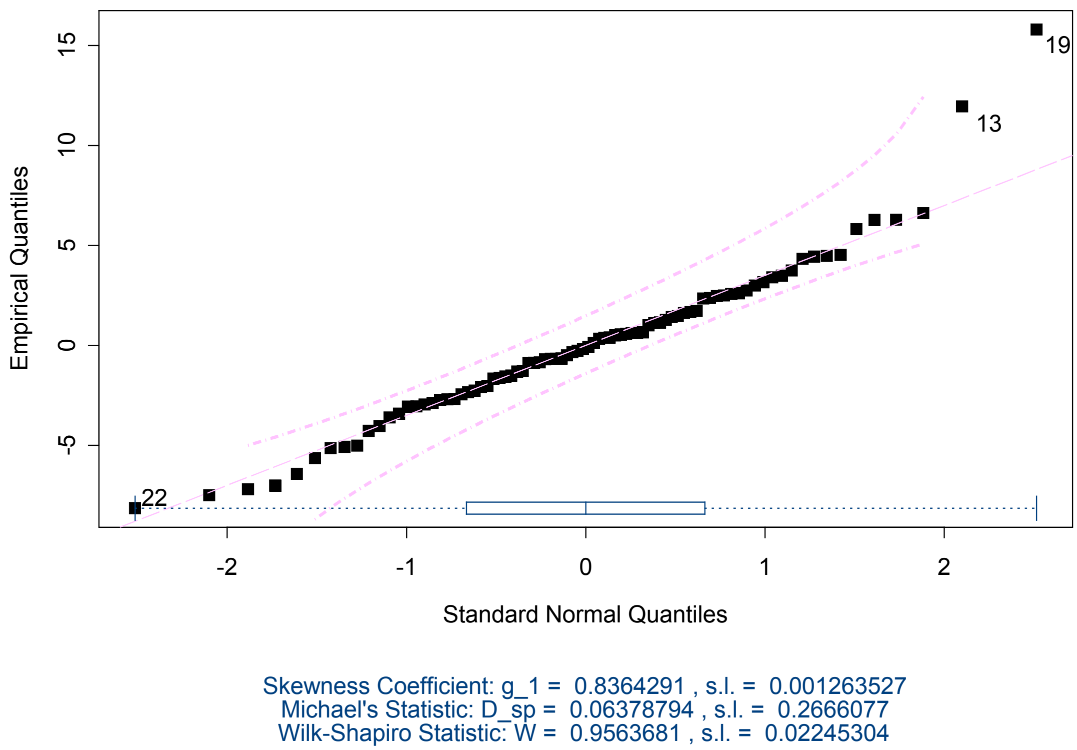


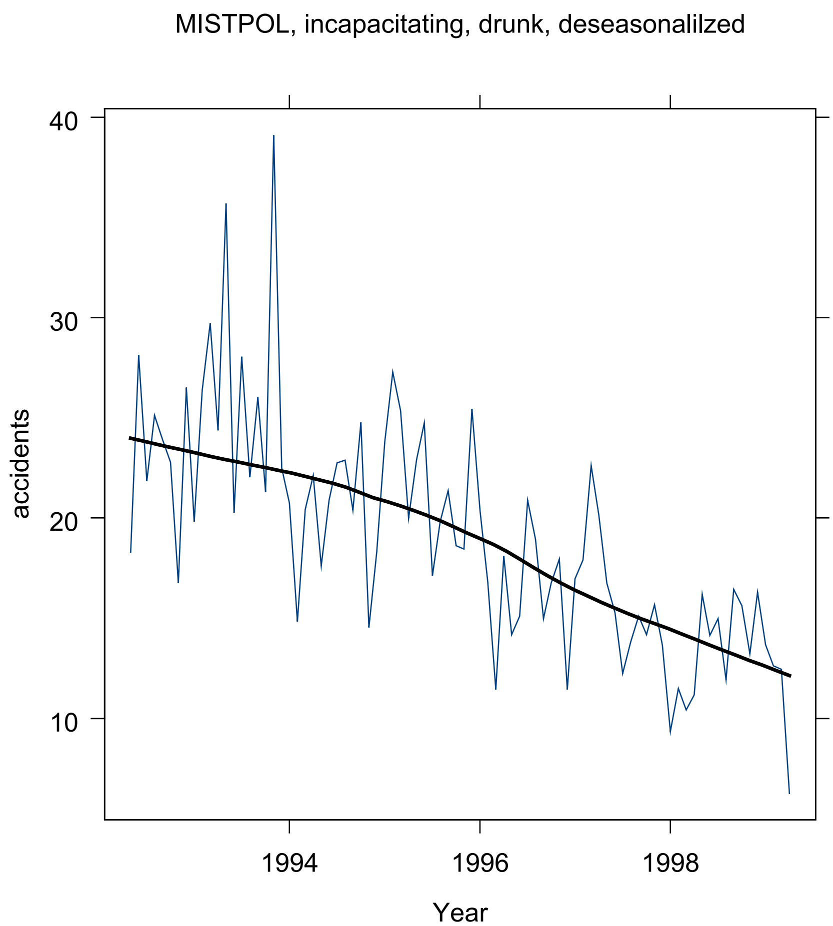
Figure 8c.
Normal probability plot of remainder component.
Some outliers evident.




```
> counter.ts
      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1992:                   1   2   3   4   5   6   7   8
1993:   9  10  11  12  13  14  15  16  17  18  19  20
1994:  21  22  23  24  25  26  27  28  29  30  31  32
1995:  33  34  35  36  37  38  39  40  41  42  43  44
1996:  45  46  47  48  49  50  51  52  53  54  55  56
1997:  57  58  59  60  61  62  63  64  65  66  67  68
1998:  69  70  71  72  73  74  75  76  77  78  79  80
1999:  81  82  83  84
```

Figure 8d.
Loess trend analysis of deasonalized component.

```
                tau = -0.557,   sl =0%
> pc.change(deseasonalized.ts)
    start      end  change% annual.rate%
 23.99675 12.13592 49.42682      9.28003
```



Wkgrp time series and seasonal Mann-Kendall trends

```
> mistpol.total.SunWed.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1992:                      607  774  622  750  840  554  562  611
1993:  555  488  633  618  765  850  704  822  690  526  657  680
1994:  843  720  584  598  663  754  826  899  597  532  715  855
1995:  567  561  819  600  797  922  927  898  549  614  780  828
1996:  749  800  678  609  793  952 1006  672  628  637  889  825
1997:  828  562  537  700  738  857  860  724  625  608  640  796
1998:  816  521  645  630  625 1061  805  762  730  550  647  794
1999:  781  607  642  573
> SeasonalMannKendall(mistpol.total.SunWed.ts)
tau = 0.143,   sl =11.86%

> mistpol.total.ThuSat.ts
       Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
1992:                     1470 1085  839 1227  814 1196  735  930
1993: 1535 1079 1060 1209 1157 1213 1277 1104  984 1393 1325 1066
1994: 1360  981 1164  901 1053 1159 1241 1046 1114 1249 1007 1298
1995: 1489  980  903 1168  946 1173 1204 1076 1086 1043 1281 1546
1996: 1019 1027 1340 1033 1191 1367 1089 1214 1214 1161 1251 1326
1997: 1254  936 1325 1115 1351 1331 1087 1275  974 1095 1377 1088
1998: 1109  795 1149  937 1353 1055 1212 1199  940 1187  872 1033
1999: 1326  880  923  928
> SeasonalMannKendall(mistpol.total.ThuSat.ts)
tau = -0.111,   sl =22.48%
```

Appendix 1: Aspect-Ratio, Trend and Time Series Visualization

Aspect Ratio

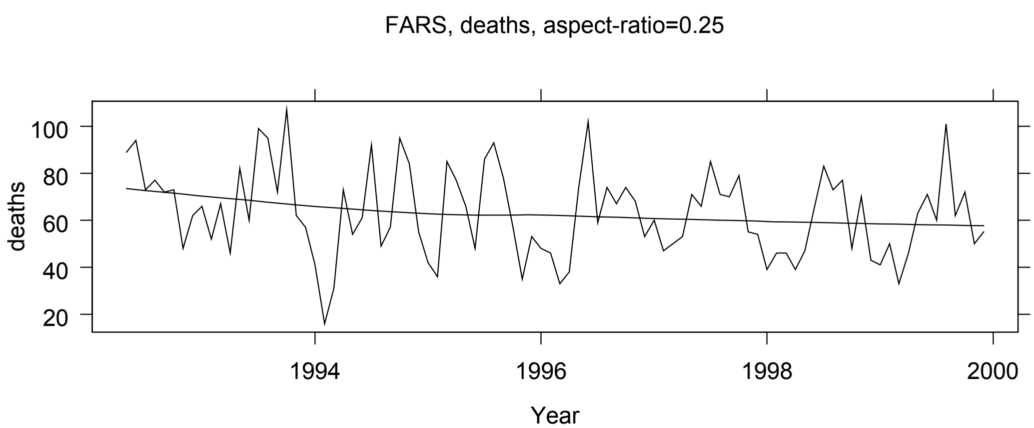
The aspect-ratio is defined as

(physical length of vertical axis)÷(physical length of horizontal axis)

The aspect-ratio for some displays is shown in the table below.

	Horizontal	Vertical	Aspect-ratio
My TV	19.5 inches	25.5 inches	0.46
Video formatted for movie theatre on my TV	11 5/8 inches	25.5 inches	0.76
My Computer Display	1200 pixels	1600 pixels	0.75

As an illustrative example the aspect-ratio in Figure 1 is chosen to be 0.25.
Figure 1. FARS deaths, Aspect-ratio is 0.25



Golden Ratio

Mathematica uses by default an aspect-ratio which is the reciprocal of the Golden Ratio, approximately 0.61803. The Golden Ratio may be defined as the proportion of the division of a line so that the larger is to the smaller as the the smaller is to the whole. Let the smaller line segment have length one and the larger line segment have length Y then the golden ratio is the positive solution of the equation,

$$1/Y = Y/(Y+1) \qquad (1)$$

this may also be written

$$Y = 1 + 1/Y \qquad (2)$$

or

$$1/Y = Y-1 \qquad (3)$$

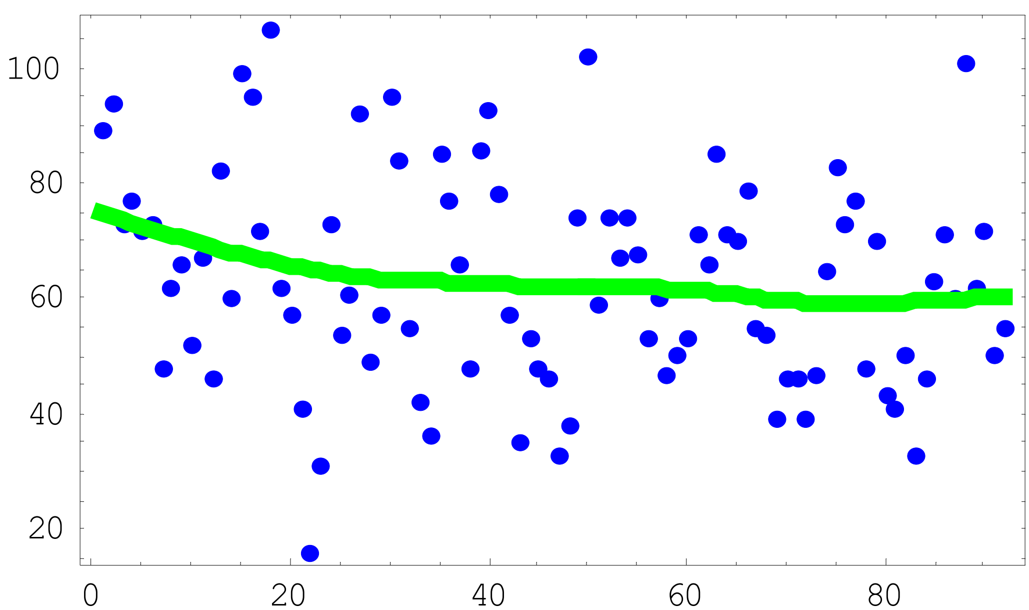
An equivalent definition is for rectangles. In this case the golden ratio is the ratio of the difference between the sides of the rectangle and the smaller side is equal to the ratio of the smaller side to the larger side. Let Y denote the larger side and letting the smaller side have unit length then we see that this is expressed by equation (3).

The golden ratio is denoted by $\varphi = (1 + \sqrt{5})/2$, with numerical value approximately 1.61803 which has reciprocal value approximately equal to 61803.

The aspect ratio is supposed in classical asthetic theory to be uniquely pleasing to the eye.

By default, *Mathematica* uses the reciprocal of the Golden Ratio as the default aspect ratio. Below is a plot of the FARS deaths with a locally-linear robust loess 60% smoother drawn in Mathematica.

Figure 2.

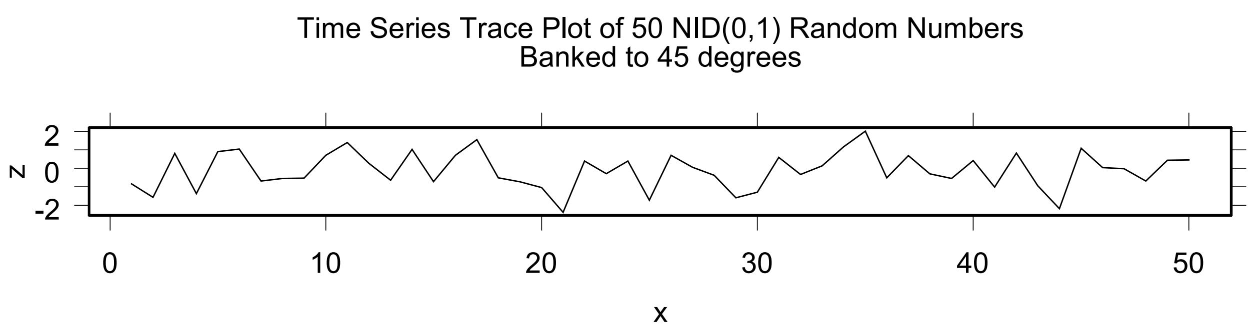


The Banking to 45° Principle

Cleveland (Elements of Graphing Data, 1994; Visualizing Data, 1993) developed a more scientific approach to the choice of aspect-ratio for data visualization. Cleveland's suggestion, which he calls banking to is to 45°, is to choose the aspect-ratio so the average absolute weighted of what is of interest is approximately 45°. Banking to 45° improves the accuracy of our visualization of data and trends. This has been demonstrated experimentally and also using Cleveland's theory of graphical perception (Cleveland, 1994, Ch. 4).

If you have a stationary time series (with essentially zero slope) and you bank to 45° all the successive line segments joining the individual values then the aspect-ratio will be a very small number, typically << 0.25. On the other hand if you bank to 45° the estimated trend which itself has slope close to zero then the aspect-ratio will be a large number >>4. Sometimes this automatic principle gives aspect-ratios which are too small or too large for the resolution or size of the paper or display. In this case we just regard the optimal aspect-ratio, obtained by banking to 45°, as a general indication for what direction we should move in choose an aspect-ratio for our plot. Another problem is that banking to a loess curve may sometimes be at the expense of good data resolution.

Figure 3. Banking a stationary time series trace plot to 45°.



Illustrative FARS Time Series Examples

Figure 4 below shows the FARS deaths time series in which the successive line segments joining the data values are banked to 45°. This is very different from the case of a stationary time series due to the presence of seasonality.

Figure 4. The data is banked to 45° to choose the aspect-ratio.

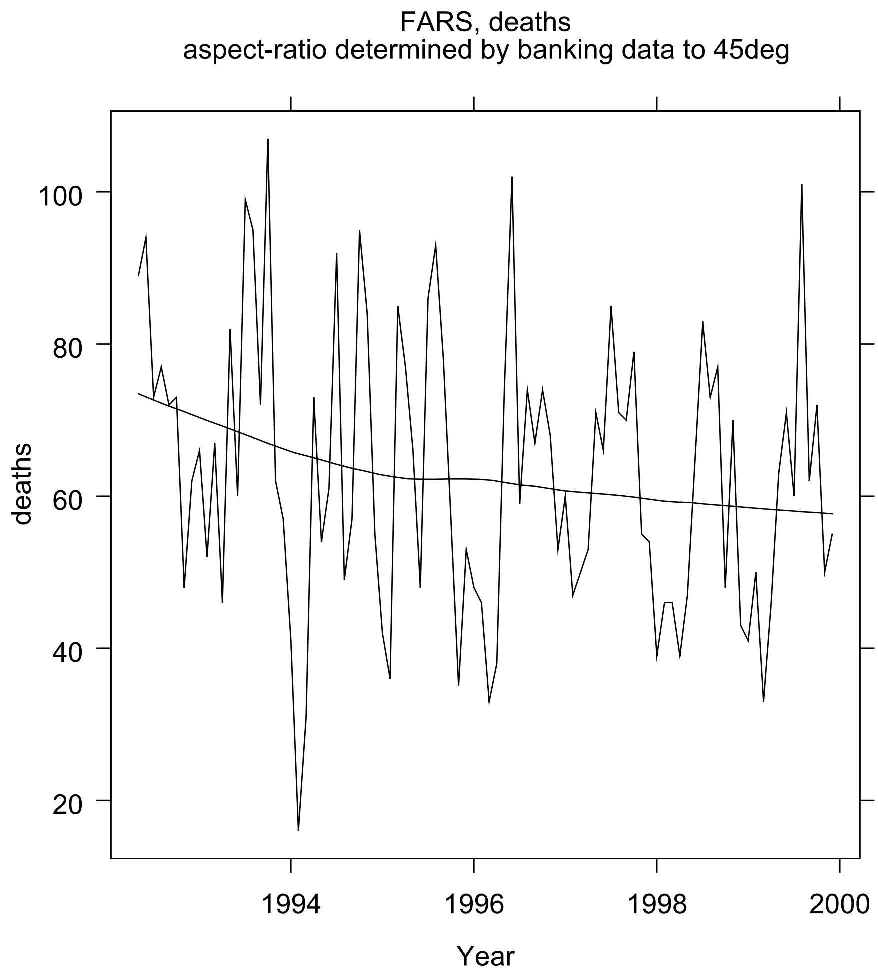
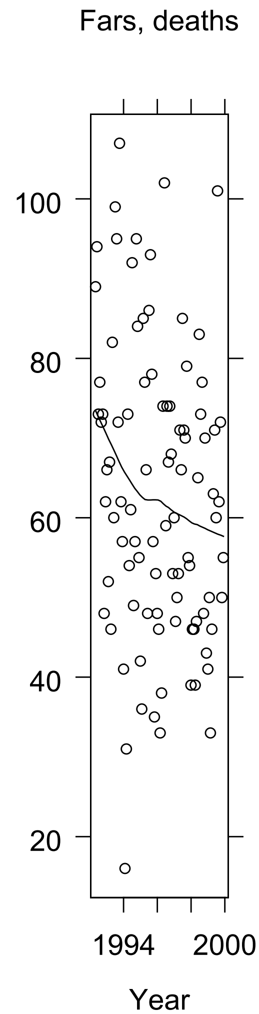


Figure 5 below shows the FARS deaths with an aspect-ratio chosen to bank the loess trend line to 45°. This aspect ratio optimizes our visualization of the trend line but since it compresses the data area into a small rectangle, data visualization is impaired.

Figure 5. The aspect ratio is choose by banking to 45° the locally-linear loess trend curve.



Conclusion

A square aspect ratio (aspect-ratio of 1) provides good data visualization as well as a reasonable visualization of the trend. It is very important when when interpreting these graphs to note the tick mark labels on the vertical axes. So for example, in Figure 6, we see that initially the loess trend starts in 1992 at around 74 deaths per month and decreases to about 58 deaths per month. There is a lot of variability about the trend line. In general we will use an aspect-ratio of 1 as our default for this project.

Figure 6. Aspect-ratio is 1.0

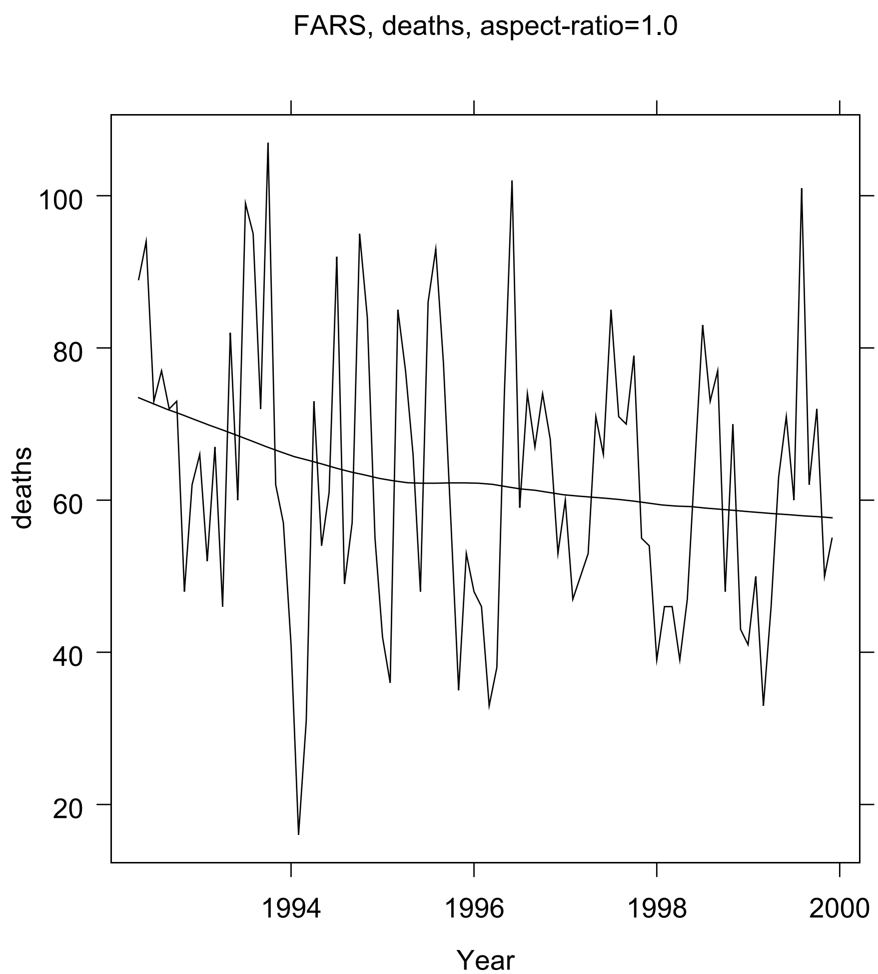
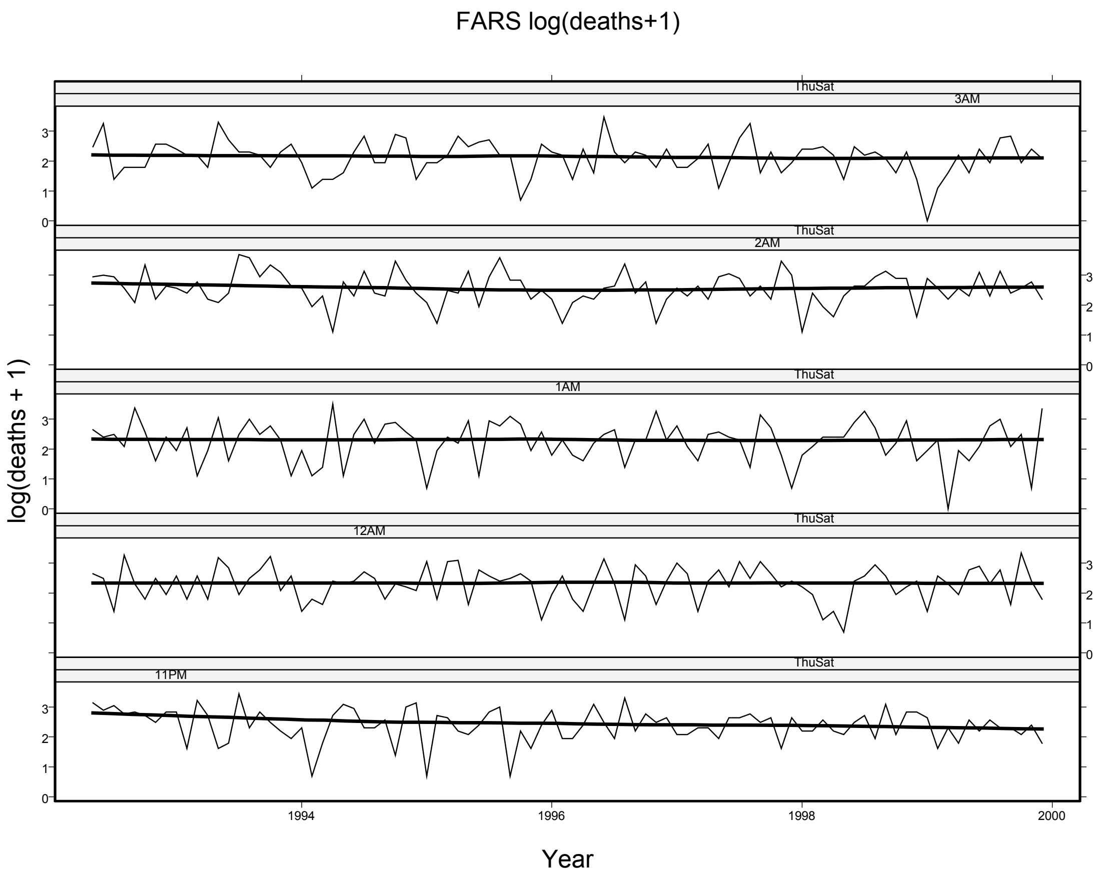


Figure 7 below illustrates an exception to the 45° banking rule. We have delibrated chosen a reduced aspect ratio of to improve visualization on the horizontal scale so that we can look for temporal associations between the panels. If a square aspect-ratio were used we would not be able to see so well that there does not appear to be any association between the panels. We have also used a log transformation to improve the data visualiation. Without a log transformation the bulk of the data would be squished into a relatively small area of the panel and the resolution of individual data points would not be satisfactory.

Figure 7. Common scales used in panels.



Appendix 2: Loess

Gaussian Case

Given bivariate observations $(x_i,\ y_i),\ i = 1, 2, \ldots, n$, the basic model that can be fit may be written,

$$y_i = g(x_i) + \epsilon_i,\ i = 1, \ldots, n.$$

where $e_i \sim \text{NID}(0,\ \sigma^2)$ and $g(x)$ is a local linear polynomial of degree $\lambda \geq 0$. The local linear polynomial may be written,

$$g(x) = \beta_0^{(x)} + \beta_1^{(x)}\,x + \ldots + \beta_\lambda^{(x)}\,x^\lambda$$

The parameters $\beta_0^{(x)},\ \beta_1^{(x)},\ \ldots,\ \beta_\lambda^{(x)}$ are estimated by weighted least squares for each value of x. The weight function weights the data, $(x_i,\ y_i)$, so that data values near to x have greater weight than those farther away from x. Following Cleveland (1996) we use the tricube weight function,

$$T(z) = \begin{matrix} (1 - |z|^3)^3 & |z| \leq 1 \\ 0 & |z| > 1 \end{matrix}$$

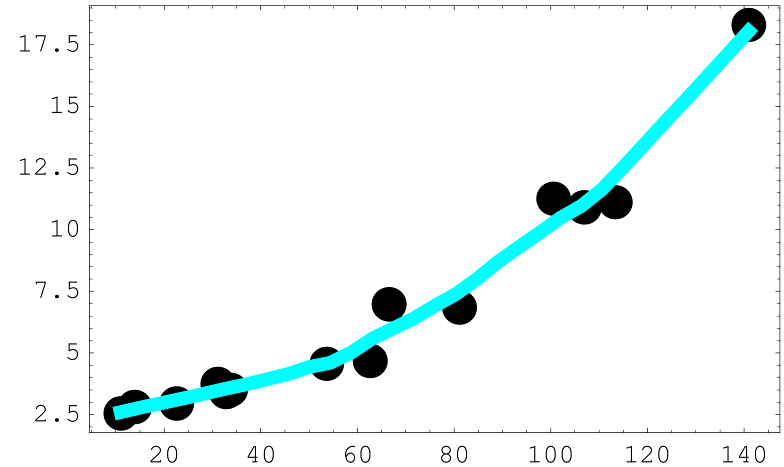
to define the local neighborhood weights for the data at the point x,

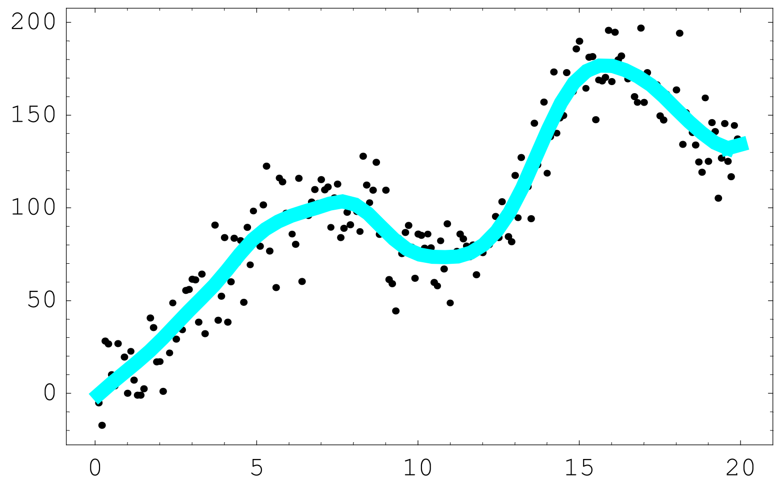
$$w_i(x) = T(\Delta_i(x) / \Delta(x,\ \alpha)),$$

where $\Delta_i(x) = |x - x_i|$ and $\Delta(x,\ \alpha)$ controls the amount smoothing. Larger values of $\Delta(x,\ \alpha)$ result in more smoothing. As $\Delta(x,\ \alpha) \to \infty$, $w_i(x) \to 1$ for each $i = 1, 2, \ldots, n$ and the local linear model reduces to the standard parametric polynomial regression. For $0 < \alpha \leq 1$, $\Delta(x,\ \alpha)$ is the distance to the q-th nearest neighbor where $q = [\alpha\, n]$, where $[\bullet]$ is the integer part. Hence, $\Delta(x,\ \alpha) = \Delta_{(q)}(x)$, where $\Delta_{(q)}(x)$ denotes the q-th largest value of $\Delta_i(x),\ i = 1, \ldots, n$. For $\alpha > 1$, $\Delta(x,\ \alpha) = \alpha\, \Delta_{(n)}(x)$. It follows that as $\alpha \to \infty$, the local linear model reduces to a parametric polynomial regression of degree λ.

Approximate statistical inference methods are available for Gaussian loess models (Cleveland and Devlin, 1988).

Here are two examples of loess fit first to a small dataset of 13 points and then second to a dataset with 200 points.





Robust or Symmetric Errors Case

In the robust case it is only assumed that the errors are symmetric. Hence for data (x_i, y_i), $i = 1, 2, \ldots, n$, the basic model that can be fit may be written,

$$y_i = g(x_i) + \epsilon_i,\ i = 1, \ldots, n.$$

where $e_i \sim \text{IID}(0, \sigma^2)$ with a symmetric distribution and $g(x)$ is again a local linear polynomial of degree $\lambda \geq 0$.

The model is fit to each of the n observed data values using a Iteratively Reweighted Least Squares (IRWLS) algorithm. Each iteration fits the model using the current weights which are the product of the robustness weights times the local neighborhood weights. So for fitting at the point x_j the weights are given by $w_i(x_j)\,r_j$, $j = 1, \ldots, n$.

An additional set of weights are used to provide robustness. Given the residuals from the last fit, $\hat{\epsilon}_i$, $i = 1, \ldots, n$, the robustness weights are then defined by

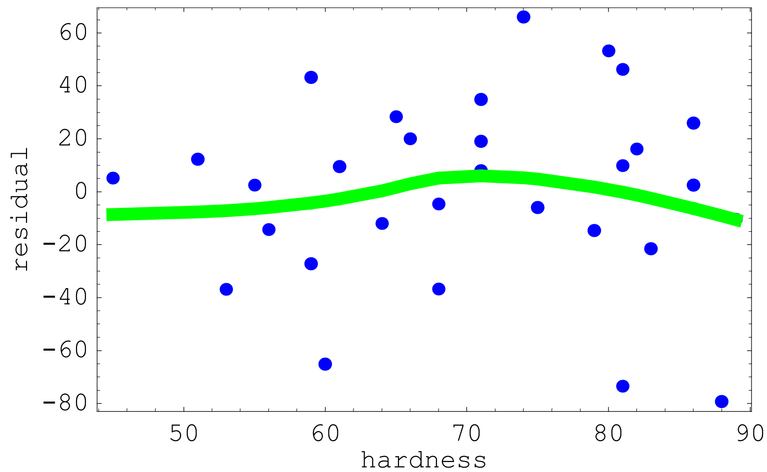
$$r_i = B\left(\frac{\hat{\epsilon}_i}{6\,s}\right)$$

where $s = \text{median}\{\,|\,\hat{\epsilon}_1\,|, \ \ldots, \ |\,\hat{\epsilon}_n\,|\}$ and $B(z)$ is the bisquare function,

$$B(z) \;=\; \begin{array}{ll} (1-z^2)^2 & |\,z\,| \leq 1 \\ 0 & |\,z\,| > 1 \end{array}$$

Robust loess fits are often used for preliminary investigations of a dataset to guard against outliers and for the purpose of detecting outliers. In various types of residual analysis plots with many types of other models such as in linear models it is useful to use a robust loess curve. For example in a residual dependency plot the residuals are plotted against some covariate. A trend in the loess curve in this plot would indicate that the model could be improved.

Here is an an example of a residual dependency plot. Since the trend line is curved a little in the middle of the plot there is a small amount of dependency on the variable `hardness` remaining in the residuals.



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Appendix 3: Mann-Kendall Trend Tests

Introduction
Hipel & McLeod (1994) and McLeod et al. (1990) have used the Mann-Kendall trend test in the analysis of various types of environmental data.

Kendall Rank Correlation
Let $(X_1, Y_1), \cdots, (X_n, Y_n)$ be a bivariate random sample of size n. The Pearson correlation coefficient provides an optimal measure of the degree of association between the X's and the Y's when the sample is drawn from a bivariate normal distribution. The Pearson correlation coefficient is reasonably robust for many other distributions as well.
The Kendall correlation coefficient, denoted by τ, provides a more general non-parametric measure of monotonic association. It is said to be monotonic since making a monotonic transformation on either the X's or the Y's does not change the numerical value of τ.
Kendall's rank correlation coefficient (Kendall, 1970, equation 1.5) may be written,

$$\tau = \frac{S}{D}. \tag{2}$$

where S, is the Kendall score given by

$$S = \sum_{i>j} \operatorname{sign}(X_j - X_i)\operatorname{sign}(Y_j - Y_i), \tag{1}$$

where sign(•) denotes the sign function and D is the maximum possible value of S. In the case where there are no ties among either the X's or the Y's,

$$D = \binom{n}{2}.$$

More generally, if there are n_x distinct ties of extent $t_i, i = 1, ..., n_x$ among the X's and n_y distinct ties of extent $u_i, i = 1, ..., n_y$ among the Y's then

$$D = \sqrt{\left(\binom{n}{2} - T\right)\left(\binom{n}{2} - U\right)},$$

where

$$T = \frac{1}{2}\sum_{i=1}^{n_x} t_i(t_i - 1),$$

and

$$U = \frac{1}{2}\sum_{i=1}^{n_y} u_i(u_i - 1).$$

In the case where there are no ties in either ranking, it is known (Kendall, 1975, p.51) that under the null hypothesis, the distribution of S may be well approximated by a normal distribution with mean zero and variance,

$$\mathrm{Var}\,(S) = \frac{1}{18}n(n-1)(2n+5),$$

provided that $n \geq 10$. Valz and McLeod (1990) have given a simplified derivation of this formula for $\mathrm{Var}\,(S)$.
In the case of ties, the variance of S is more complicated,

$$\begin{aligned}\mathrm{Var}\,(S) = \{\frac{1}{18}n(n-1)(2n+5) - \sum t_i(t_i-1)(2t_i+5) - \sum u_i(u_i-1)(2u_i+5)\} \\ + \frac{1}{9n(n-1)(n-2)}\{\sum t_i(t_i-1)(t_i-2)\}\{\sum u_i(u_i-1)(u_i-2)\} \\ + \frac{1}{2n(n-1)}\{\sum t_i(t_i-1)\}\{\sum u_i(u_i-1)\}.\end{aligned}$$

Valz, McLeod and Thompson (1994) have examined the adequacy of the normal approximation in this general case.
The test of the null hypothesis $\mathcal{H}_0 : \tau = 0$ is equivalent to testing $\mathcal{H}_0 : S = 0$. If there are no ties and if $n \geq 10$ the normal approximation based on $\mathrm{Var}\,(S)$ is adequate. When $n \leq 10$ and there are ties present in only of the variables then the efficient exact algorithm of Panneton & Robillard (1972a, 1972b) may be used. Otherwise if ties are present in both variables then the exact enumeration algorithm given by Valz (1990) may be used or alternatively bootstrapping (Efron and Tibshirani, 1993). Our S-Plus function `Kendall` implements these algorithms for computing τ and its significance level under a two-sided test.

Mann-Kendall Trend Test
Given n consecutive observations of a time series $z_t, t = 1, \cdots, n$, Mann (1945) suggested using the Kendall rank correlation of z_t with $t, t = 1, \cdots, n$ to test for monotonic trend. The null hypothesis of no trend assumes that the $z_t, t = 1, \cdots, n$ are independently distributed. Our S-Plus function, `MannKendall(z)` implements the Mann-Kendall test using `Kendall(x, y)` to compute τ and its signficance level under the null hypothesis.
The Mann-Kendall trend test has some desirable features. In the simple linear trend model with independent Gaussian errors, $z_t = \alpha + \beta t + e_t$, where e_t is Gaussian white noise, it is known that the Mann-Kendall trend test has 98% efficiency relative to the usual least squares method of testing $\beta = 0$. Also, an empirical simulation study of Hipel, McLeod and Fosu (1986) showed that the Mann-Kendall test outperformed the lag one autocorrelation test for detecting a variety of deterministic trends such as a step-intervention or a linear trend.

In the case of no ties in the values of $z_t, t = 1, \cdots, n$ the Mann-Kendall rank correlation coefficient τ has an interesting interpretation. In this case, the Mann-Kendall rank correlation for a trend test can be written

$$\tau = \frac{S}{\binom{n}{2}},$$

where

$$S = 2P - \binom{n}{2},$$

where P is the number of times that $z_{t_2} > z_{t_1}$ for all $t_1, t_2 = 1, \ldots, n$ such that $t_2 > t_1$. Thus $\tau = 2\pi_c - 1$, where π_c is the relative frequency of positive concordance, i.e., the proportion of time for which $z_{t_2} > z_{t_1}$ when $t_2 > t_1$. Equivalently, the relative frequency of positive concordance is given by $\pi_c = 0.5(\tau + 1)$.

The Mann-Kendall test is essentially limited to testing the null hypothesis that the data are independent and identically distributed. Our time series data may diverge from this assumption in two ways. First there may be autocorrelation and second may be a seasonal component. To eliminate these factors we can use annual data but this has the effect of reducing the power. For strong positive autocorrelation in the series, the effect of using annual totals will reduce the effect of this autocorrelation substantially and the loss of power is, perhaps, not expected to be too much — this is something we will investigate further in a methodological study.

The method of Brillinger (1989) deals with both the problems of seasonality and autocorrelation but it also requires an estimate of the spectral density at zero. However the test of Brillinger (1989) is not suitable for testing for long-term trend with monthly data with a strong seasonal component since the running-average smoother used will not be useful in this case. Another model-building approach to trend analysis is intervention analysis (Box & Tiao, 1975; Hipel & McLeod, 1994) which can also handle both seasonality and autocorrelation. This assumes a known intervention time and the development of a suitable time series model.

Seasonal Mann-Kendall Trend Test

The Seasonal-Mann-Kendall trend test is a test for monotonic trend in a time series with seasonal variation. Hirsch et al. (1982) developed such a test by computing the Kendall score separately for each month. The separate monthly scores are then summed to obtain the test statistic. The variance of the test statistic is obtained by summing the variances of the Kendall score statistic for each month. The normal approximation may then be used to evaluate significance level. In this test, the null hypothesis is that the time series is of the form $z_t = \mu_m + e_t$ where e_t is white noise error and μ_m represents the mean for period m. The τ coefficient is defined by

$$\tau = \frac{\sum_{i=1}^{s} S_i}{\sum_{i=1}^{s} D_i},$$

where $S_i, D_i, i = 1, \cdots, s$ denote the Kendall scores and denominators for the i-th season and s is the seasonal period. We implemented this procedure in S-Plus in our function `SeasonalMannKendall(z)`

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