Seasonal Models

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In this lesson we'll learn the how to implement Seasonal Models in R.

Additional packages needed

To run the code you may need additional packages.

- If necessary install the followings packages.

```
install.packages("ggplot2");
install.packages("forecast");
source(url("http://lib.stat.cmu.edu/general/tsa2/Rcode/itall.R"))
```

```
library(ggplot2)
library(forecast)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: timeDate
```

```
## This is forecast 7.3
```

```
source(url("http://lib.stat.cmu.edu/general/tsa2/Rcode/itall.R"))
```

```
##   itall has been installed
```

Data

We will be using U.S. Department of the Interior monthly flow data for the Colorado River. see
http://www.usbr.gov/lc/region/g4000/NaturalFlow/documentation.html

```
data_url <-
'http://nikbearbrown.com/YouTube/MachineLearning/M11/colorado_river.csv
'
data<-read.csv(url(data_url))
head(data)
```

```
##   month year      flow
## 1     1   71  26635.42
## 2     2   71  21825.23
## 3     3   71  36031.57
## 4     4   71  43874.54
## 5     5   71  90616.44
## 6     6   71 146125.61
```

```
names(data)
```

```
## [1] "month" "year"  "flow"
```

Seasonal Models

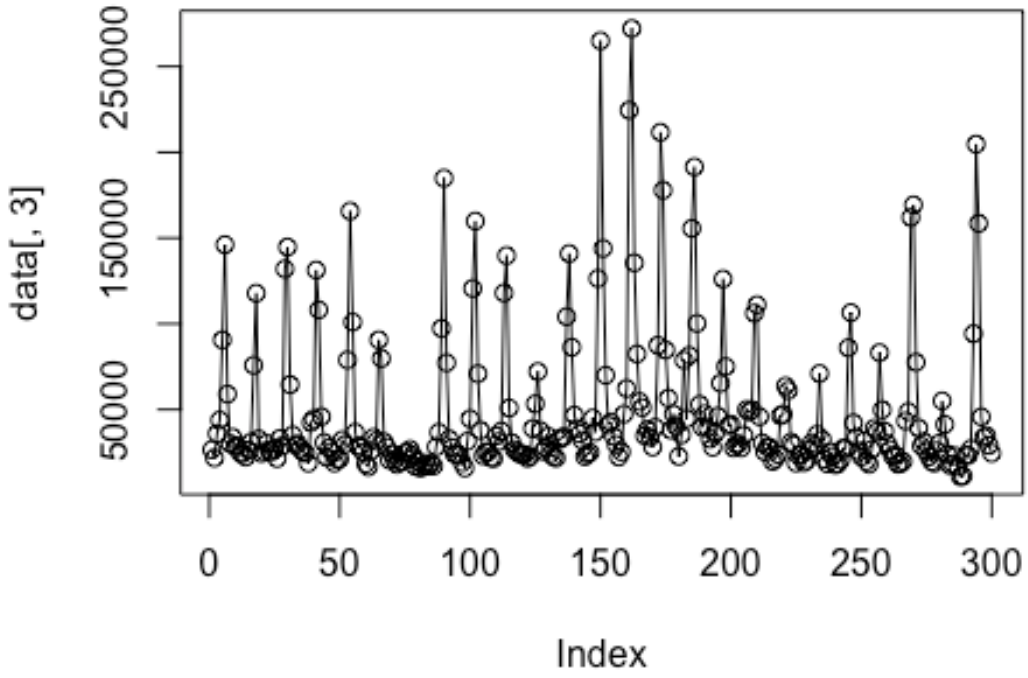
When there are patterns that repeat over known, fixed periods of time (i.e. day, week, month, quarter, year, etc.) within the data set it is considered to be seasonal variation. One has a model for the periodic fluctuations based on knowledge of the domain.

The seasonal ARIMA model incorporates both non-seasonal and seasonal factors in a multiplicative model. In a seasonal ARIMA model, seasonal parameters predict xt using data values and errors at times with lags that are multiples of S (the span of the seasonality). Before we model for a given data set, one must have an initial guess about the data generation process, that is the span of the seasonality (i.e.day, week, month, quarter, year, etc.)

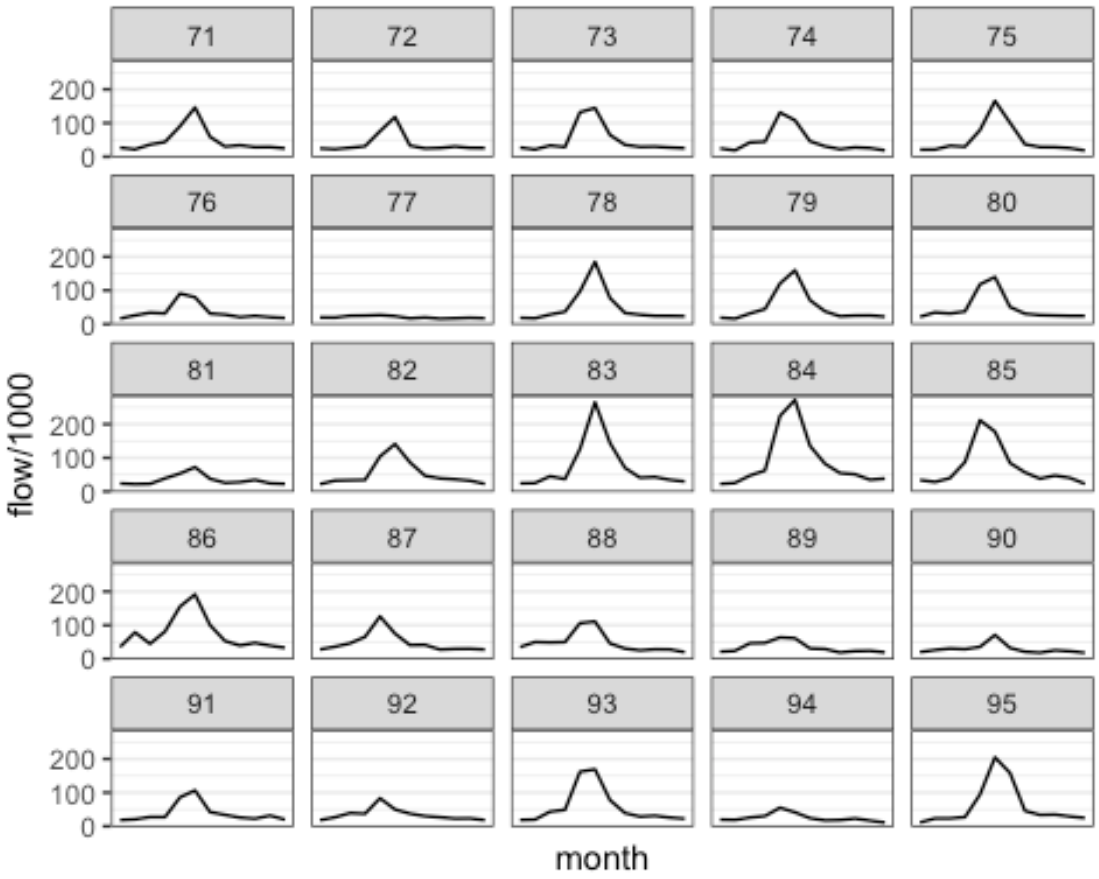
Seasonal Models in R

Here we are using an ARIMA model to identify seasonality trends by looking for signficant seasonal differences.

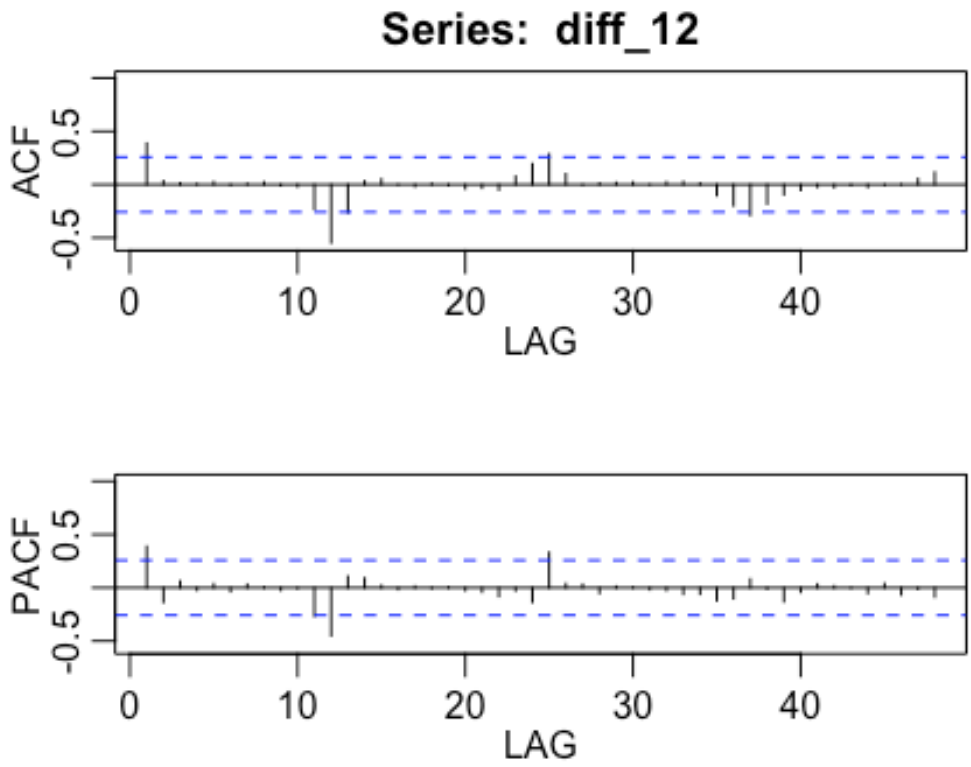
```
plot(data[,3], type='o')
```




```
#  it is difficult to identify seasonality trends here
# So,aggregate the data by month to better understand this trend
ggplot(data, aes(x=month, y=flow/1000))+
  stat_summary(geom = 'line', fun.y='mean')+            # take the
mean of each month
  scale_x_discrete(breaks=seq(1,12,1), labels=seq(1,12,1))+
  theme_bw()+ # add a little style
  facet_wrap(~year) # visualize year by year
```




```
#Since we hypothesize that there is seasonality,
#we can take the seasonal difference (create a variable that gives the
12TH differences), then look at the ACF and PACF.
mydata<-ts(data[1:72,][,3])
diff_12 <- diff(mydata, 12)
acf2(diff_12, 48)
```



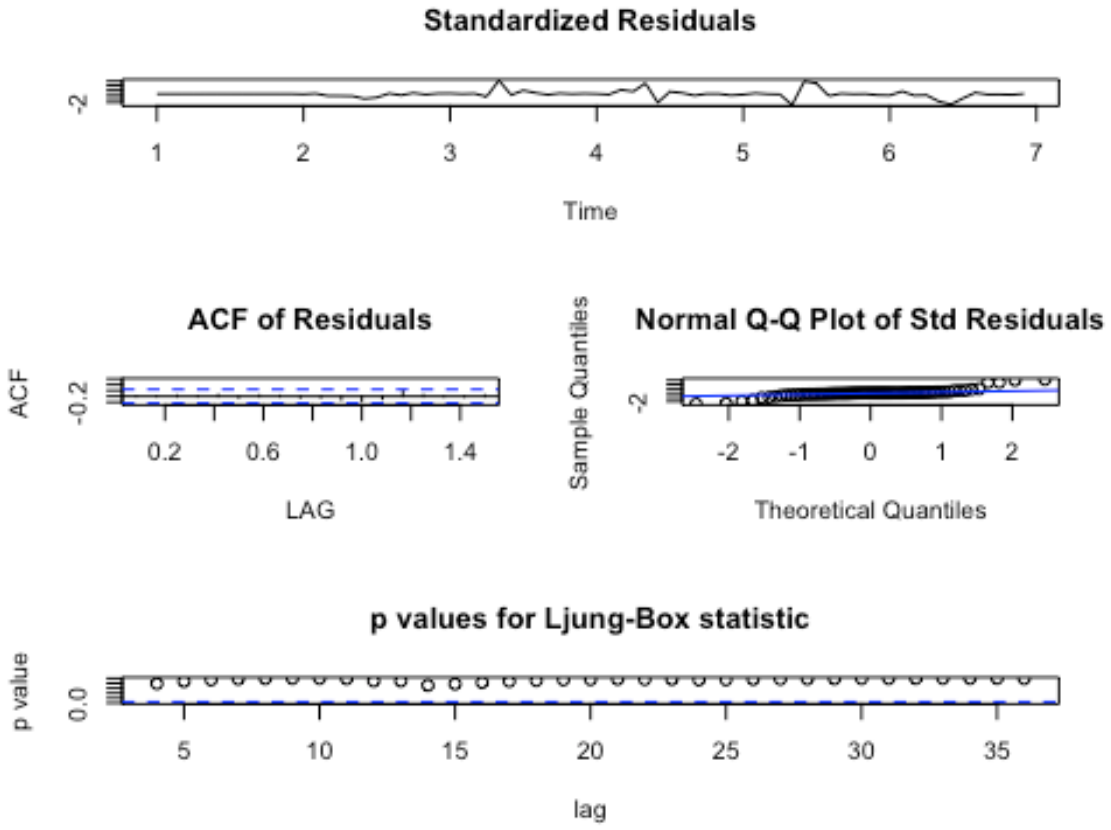

```
##          ACF  PACF
##  [1,]  0.39  0.39
##  [2,]  0.03 -0.14
##  [3,]  0.01  0.06
##  [4,]  0.01 -0.02
##  [5,]  0.02  0.04
##  [6,] -0.01 -0.04
##  [7,]  0.01  0.03
##  [8,]  0.02  0.01
##  [9,] -0.01 -0.02
## [10,] -0.02 -0.01
## [11,] -0.23 -0.27
## [12,] -0.55 -0.45
## [13,] -0.26  0.11
## [14,]  0.03  0.09
## [15,]  0.05  0.02
## [16,]  0.00 -0.02
## [17,] -0.02  0.01
## [18,]  0.01  0.00
## [19,] -0.01  0.00
## [20,] -0.04 -0.03
## [21,] -0.03 -0.04
## [22,] -0.05 -0.08
```

```
## [23,]  0.08 -0.03
## [24,]  0.19 -0.14
## [25,]  0.29  0.33
## [26,]  0.10  0.04
## [27,]  0.00  0.03
## [28,]  0.01 -0.05
## [29,]  0.02  0.01
## [30,]  0.02  0.00
## [31,]  0.00 -0.02
## [32,]  0.02 -0.02
## [33,]  0.03 -0.06
## [34,]  0.01 -0.06
## [35,] -0.10 -0.12
## [36,] -0.20 -0.10
## [37,] -0.29  0.08
## [38,] -0.18 -0.01
## [39,] -0.09 -0.13
## [40,] -0.05 -0.04
## [41,] -0.02  0.03
## [42,] -0.03  0.01
## [43,] -0.01  0.00
## [44,] -0.03 -0.05
## [45,]  0.00  0.04
## [46,]  0.00 -0.07
## [47,]  0.05 -0.01
## [48,]  0.11 -0.09
```

```
#we see that for both the ACF and PACF we have significant
autocorrelation at seasonal (12, 24, 36) lags. The ACF has a cluster
around 12,
#and not much else besides a tapering pattern throughout. Further, the
PACF also has spikes on two multiples of S, AR(2)
# Try, ARIMA (1,0, 0) x (2, 1, 0)12
mydata<-ts(mydata, freq=12)
mod1<-sarima(mydata, 1,0,0,2,1,0,12)
```

```
## initial  value 10.165417
## iter   2 value 9.844064
## iter   3 value 9.816870
## iter   4 value 9.779773
## iter   5 value 9.769839
## iter   6 value 9.767267
## iter   7 value 9.766853
## iter   8 value 9.766852
## iter   9 value 9.766852
## iter   9 value 9.766852
## iter   9 value 9.766852
## final  value 9.766852
## converged
## initial  value 9.722784
```

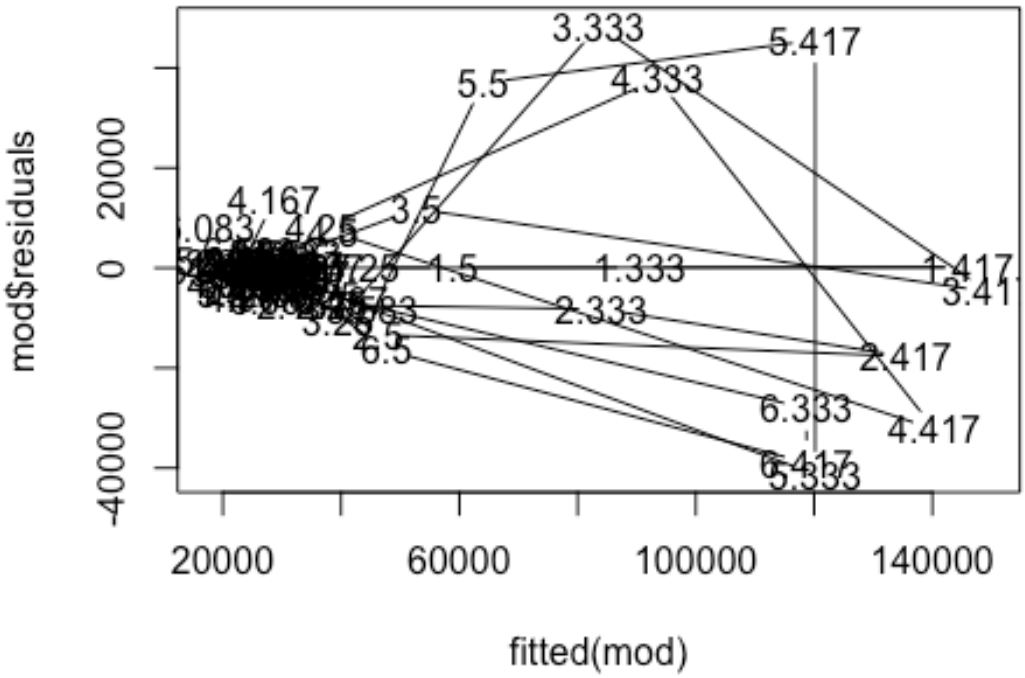
```
## iter   2 value 9.719603
## iter   3 value 9.711661
## iter   4 value 9.709954
## iter   5 value 9.709280
## iter   6 value 9.709266
## iter   7 value 9.709265
## iter   7 value 9.709265
## iter   7 value 9.709265
## final  value 9.709265
## converged
```



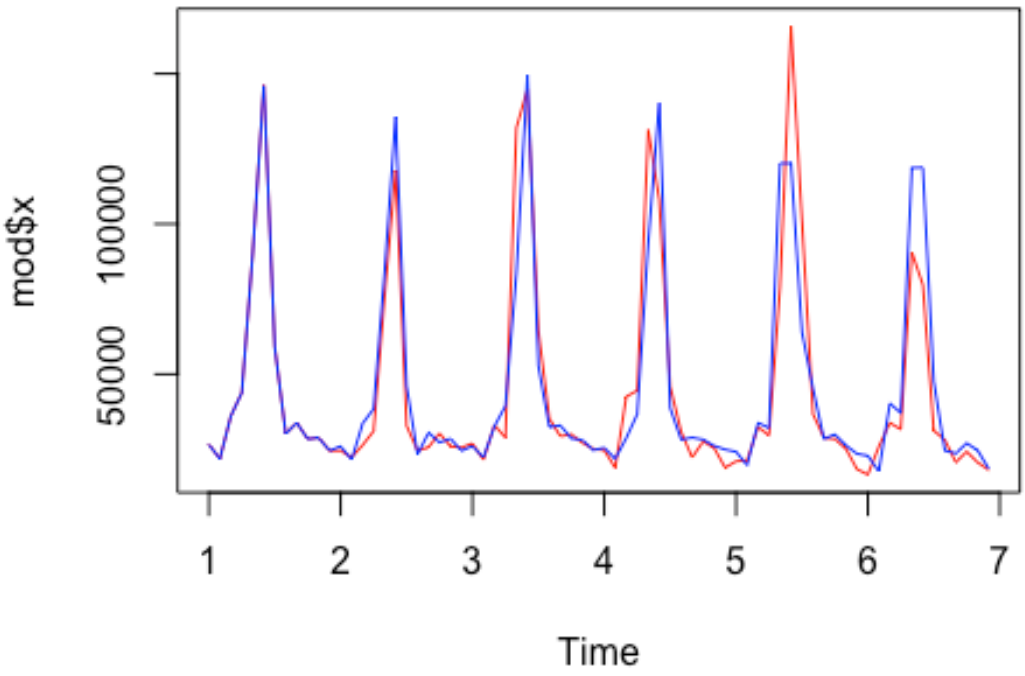

```
# install.packages("forecast")
# Fit the Model
mod<-Arima(mydata,order=c(1, 0, 0),
           seasonal=list(order=c(2, 1, 0), period=12))
mod

## Series: mydata
## ARIMA(1,0,0)(2,1,0)[12]
##
## Coefficients:
##          ar1     sar1     sar2
##       0.2806  -0.7924  -0.1932
```

```
## s.e.  0.1336   0.1323   0.1676
##
## sigma^2 estimated as 250742540:  log likelihood=-667.78
## AIC=1343.57   AICc=1344.29   BIC=1351.94
```

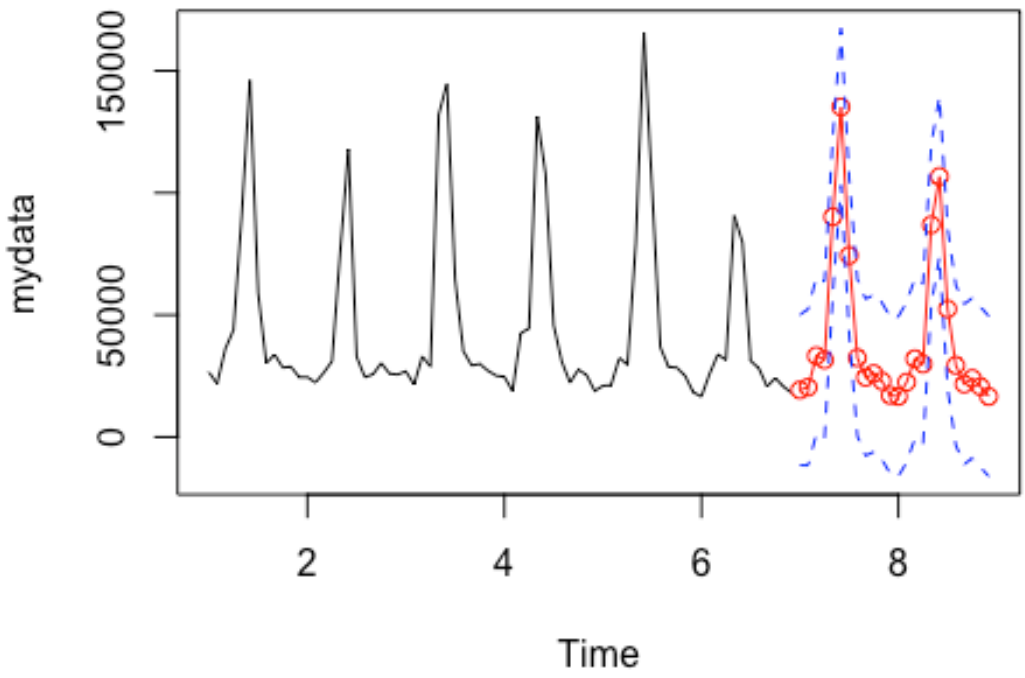
```
plot(fitted(mod), mod$residuals)
```




```
plot(mod$x, col='red')
lines(fitted(mod), col='blue')
```




```
# Now, we have a reasonable prediction, we can forecast the model, say
24 months into the future.
sarima.for(mydata, 24, 1,0,0,2,1,0,12)
```




```
## $pred
##          Jan       Feb       Mar       Apr       May       Jun
Jul
## 7  19280.41  20375.61  33258.81  31599.55  90175.30 135176.30
74346.53
## 8  16643.94  22493.80  32055.86  29896.44  86925.76 106695.30
52426.14
##          Aug       Sep       Oct       Nov       Dec
## 7  32455.48  24461.92  26000.24  22917.53  17066.97
## 8  29367.63  21679.08  24035.64  20627.54  16596.45
##
## $se
##        Jan      Feb      Mar      Apr      May      Jun      Jul
Aug
## 7 15418.48 16002.65 16046.86 16050.27 16050.54 16050.56 16050.56
16050.56
## 8 16374.13 16398.84 16400.75 16400.90 16400.91 16400.91 16400.91
16400.91
##        Sep      Oct      Nov      Dec
## 7 16050.56 16050.56 16050.56 16050.56
## 8 16400.91 16400.91 16400.91 16400.91
```

```
predict(mod, n.ahead=24)
```

```
## $pred
##          Jan       Feb       Mar       Apr       May       Jun
Jul
## 7  20255.41  21600.16  34566.44  32926.83  91479.84 136741.26
75871.08
## 8  18181.32  24104.77  33671.14  31514.60  88541.37 108213.01
53968.18
##          Aug       Sep       Oct       Nov       Dec
## 7  33820.25  25825.51  27353.24  24271.39  18409.99
## 8  30981.40  23293.94  25653.80  22244.57  18220.17
##
## $se
##        Jan      Feb      Mar      Apr      May      Jun      Jul
Aug
## 7 15834.85 16446.23 16493.39 16497.10 16497.39 16497.41 16497.41
16497.41
## 8 16821.60 16846.86 16848.84 16849.00 16849.01 16849.01 16849.01
16849.01
##        Sep      Oct      Nov      Dec
## 7 16497.41 16497.41 16497.41 16497.41
## 8 16849.01 16849.01 16849.01 16849.01
```

Resources

- Seasonal ARIMA models | STAT 510
- Identifying Seasonal Models and R Code | STAT 510
- Seasonal ARIMA models | OTexts
- General seasonal ARIMA models
- Modeling Seasonal Time Series - Hu-berlin.de

References

The data, R code and lessons are based upon:

1. Time Series Analysis :

Data Source: http://www.geophysics.geol.uoa.gr/catalog/catgr_20002008.epi

Code References :

Book : Mastering Predictive Analytic with R
Author: Rui Miguel Forte
https://www.safaribooksonline.com/library/view/mastering-predictive-analytics/9781783982806/

Chapter 9: Time series Analysis

http://www.statoek.wiso.uni-goettingen.de/veranstaltungen/zeitreihen/sommer03/ts_r_intro.pdf

http://www.stat.pitt.edu/stoffer/tsa3/R_toot.htm

http://www.statoek.wiso.uni-goettingen.de/veranstaltungen/zeitreihen/sommer03/ts_r_intro.pdf

2. Trend Analysis

Code References :

Book : Mastering Predictive Analytic with R
Author: Rui Miguel Forte
https://www.safaribooksonline.com/library/view/mastering-predictive-analytics/9781783982806/

http://www.r-bloggers.com/seasonal-trend-decomposition-in-r/

3. Seasonal Models

Code references :

Book: Time Series Analysis and Its Applications
Author: Robert H. Shumway . David S. Stoffer
Link:
http://www.springer.com/us/book/9781441978646#otherversion=9781461427599

http://a-little-book-of-r-for-time-series.readthedocs.org/en/latest/src/timeseries.html

https://onlinecourses.science.psu.edu/stat510/?q=node/47

https://rpubs.com/ryankelly/tsa5

https://onlinecourses.science.psu.edu/stat510/node/68

Data Reference :
https://github.com/RMDK/TimeSeriesAnalysis/blob/master/colorado_river.csv

4. Spectral Analysis

Code References:
Book:
Modern Applied Statistics with S Fourth edition
Author: W. N. Venables and B. D. Ripley
Link: Modern Applied Statistics with S Fourth edition

http://www.maths.adelaide.edu.au/patty.solomon/TS2004/tsprac3_2004.pdf