

Time Series Analysis

ARMA Models

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ARIMA Modeling:

Data Example

About This Lesson



Emergency Department Care

Have you ever experienced long waits in the Emergency Department?

- Good predictions of daily inflow in an emergency department can assist in staffing and diversion
- Time series modeling can be useful in achieving good predictions.



Differencing Time Series

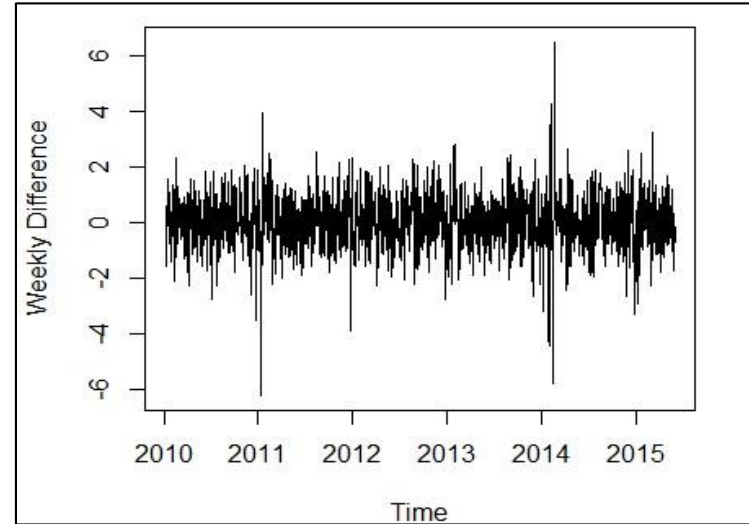
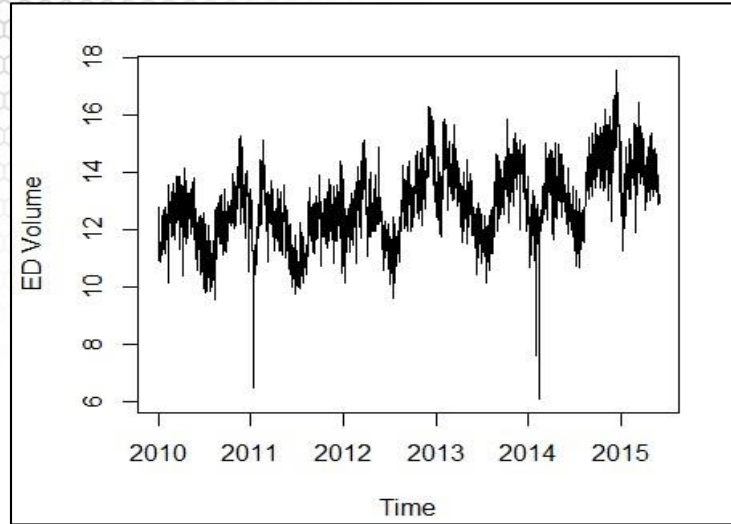
Take the difference: weekly seasonality

```
volume.ts = ts(Volume.tr,start=c(2010,1,1),frequency=365.25)  
dvolume7=diff(volume.ts,7)
```

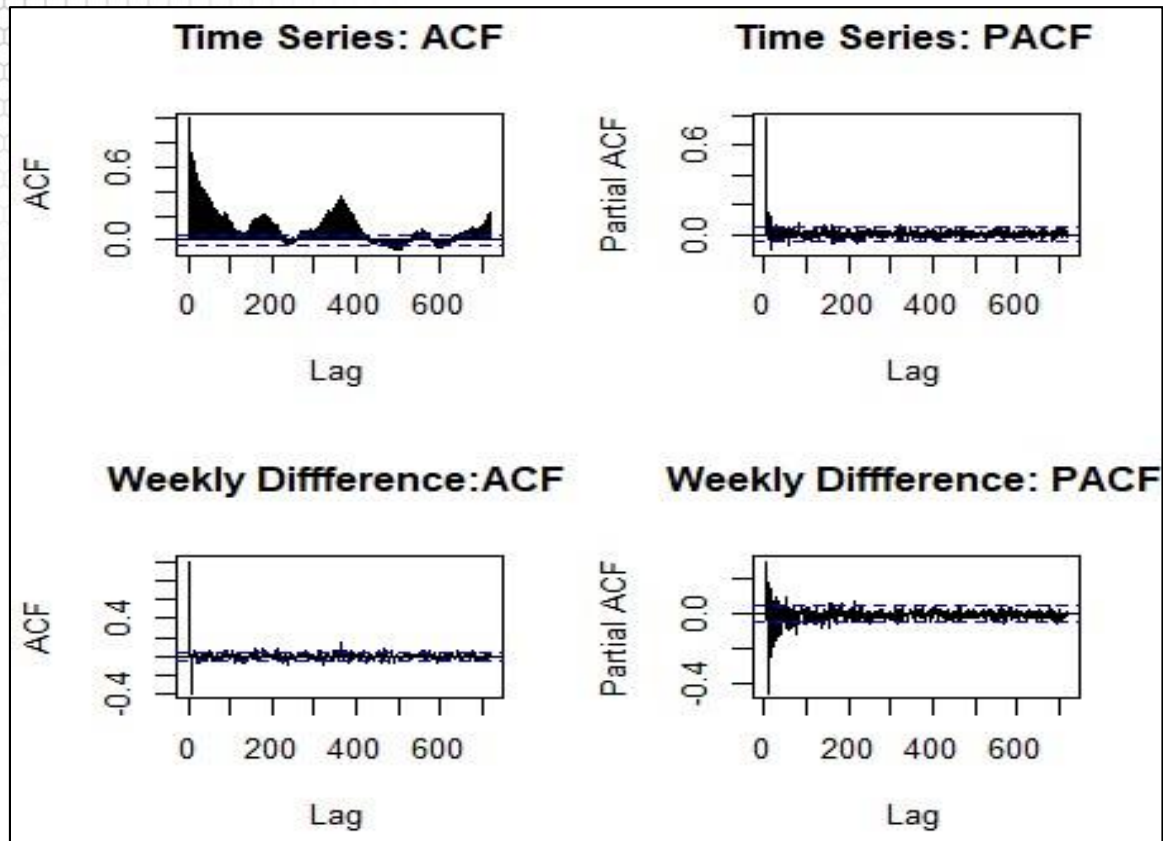
```
par(mfrow=c(2,1))  
ts.plot(volume.ts,ylab="ED Volume")  
ts.plot(dvolume7,ylab="Weekly difference")
```

```
par(mfrow=c(2,2))  
acf(as.vector(volume.ts), main='Time Series: ACF',lag.max=360*2)  
acf(as.vector(volume.ts),type="partial", main='Time Series: PACF',lag.max=360*2)  
acf(as.vector(dvolume7) , main='Weekly Difference:ACF',lag.max=360*2)  
acf(as.vector(dvolume7),type="partial", main='Weekly  
Difference:ACF',lag.max=360*2)
```

Time Series: Weekly Seasonality



Differencing Time Series: ACF & PACF



Seasonal ARIMA Model Fit

Model Fitting ARIMA(5,1,5)+seasonal ARMA(1,1)

```
mod = arima(volume.ts, order = c(5, 1, 5), seasonal = list(order =  
c(1, 0, 1), period=7), method = "ML")
```

```
plot(resid(mod), ylab='Standardized Residuals', type='o', main="Residual Plot")
```

```
abline(h=0)
```

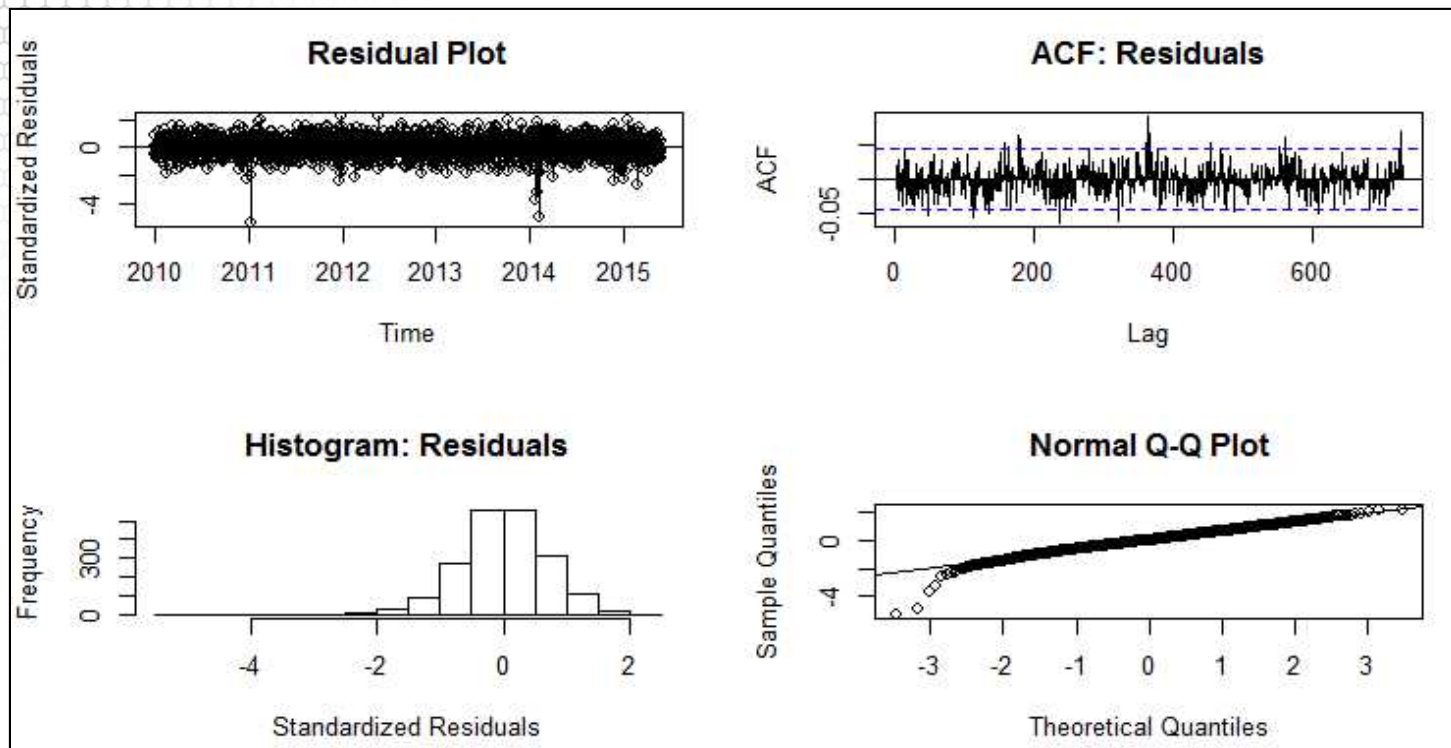
```
acf(as.vector(resid(mod)), lag.max=365*2, main="ACF: Residuals")
```

```
hist(resid(mod), xlab='Standardized Residuals', main='Histogram: Residuals')
```

```
qqnorm(resid(mod))
```

```
qqline(resid(mod))
```


Seasonal ARIMA Model Fit



Forecasting with ARIMA

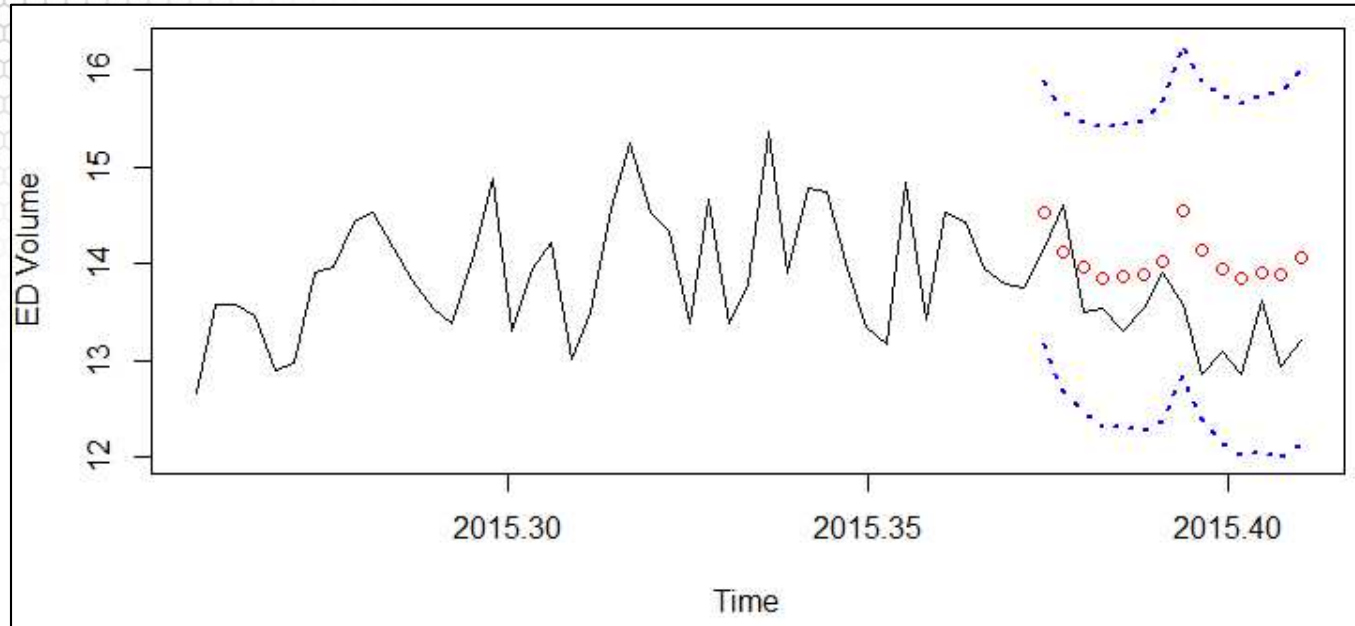
Forecasting with ARIMA: 2 Weeks Ahead

```
n = length(volume.ts); nfit = n-14
outvol = arima(volume.ts[1:nfit], order = c(5,1,5),seasonal = list(order =
c(1,0,1),period=7),method = "ML")
out_pred = as.vector(predict(outvol,n.ahead=14))
```

Compare prediction vs observed including confidence bands

```
timevol=time(volume.ts)
ubound = out_pred$pred+1.96*out_pred$se
lbound = out_pred$pred-1.96*out_pred$se
ymin = min(lbound)
ymax = max(ubound)
plot(timevol[(n-56):n],volume.ts[(n-56):n],type="l", ylim=c(ymin,ymax), xlab="Time",
ylab="ED Volume")
points(timevol[(nfit+1):n],out_pred$pred,col="red")
lines(timevol[(nfit+1):n],ubound,lty=3,lwd= 2, col="blue")
lines(timevol[(nfit+1):n],lbound,lty=3,lwd= 2, col="blue")
```

Forecasting with ARIMA



Summary

