ARIMA models Morrison Bridge

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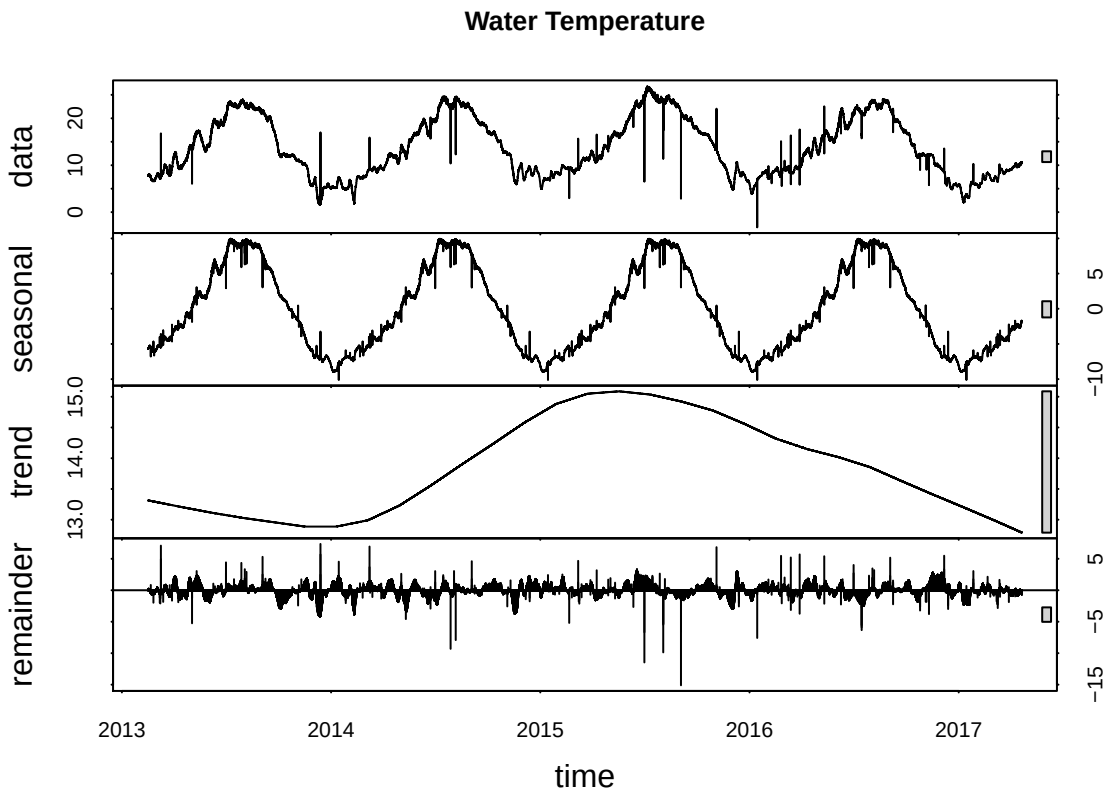
- Includes data from 2/15/2013 forward, and Amelia imputed values.

```
data.MBts <- read.csv(filename)
data.MBts <- data.MBts[-c(73191:nrow(data.MBts)),]
# manage dates
data.MBts[, c(17:18)] <- lapply(data.MBts[, c(17:18)], as.character)
data.MBts$DateTime <- chron(dates=data.MBts$Date.chron, times=data.MBts$Time.chron,
                            format=c('m/d/y', 'h:m:s'))
data.MBts$Date.chron <- chron(dates=data.MBts$Date.chron, format=c('m/d/y'))
data.MBts$Time.chron <- chron(times=data.MBts$Time.chron, format=c('h:m:s'))
```

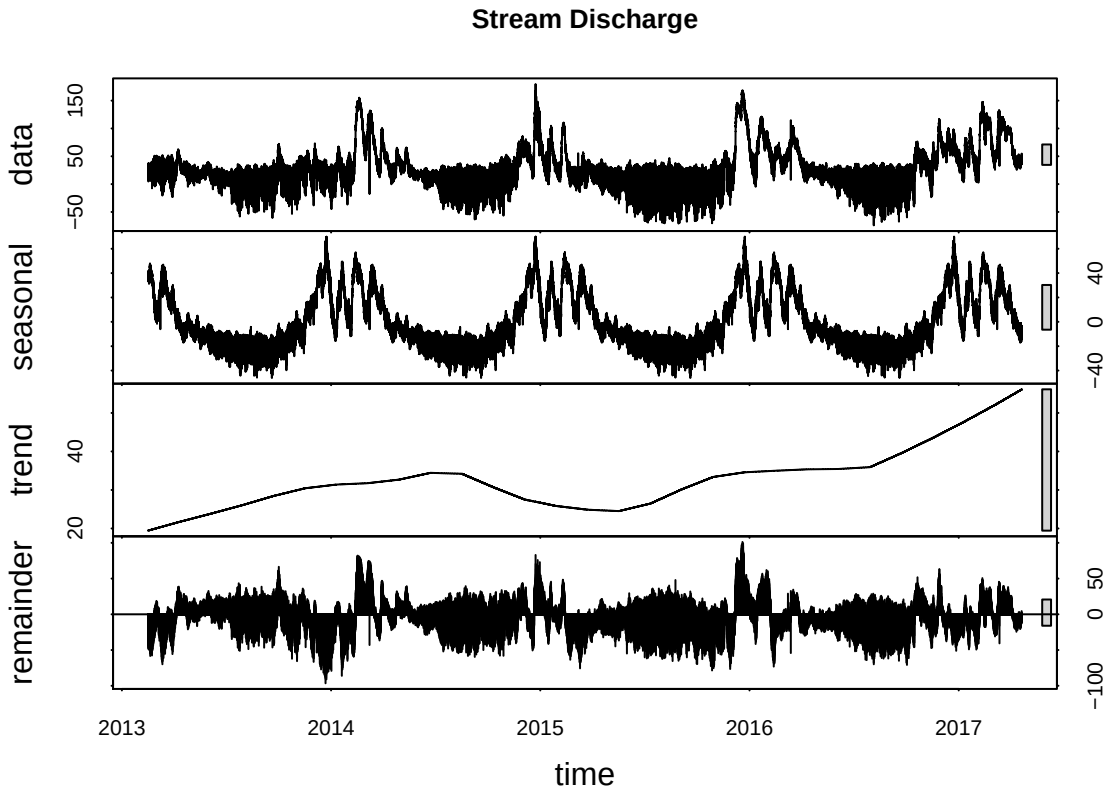
```
temp<-ts(data.MBts$WaterTemp,start = 2013.125 , frequency = 17520)
disc<-ts(data.MBts$Discharge,start = 2013.125, frequency = 17520)
velo<-ts(data.MBts$StreamVelocity,start = 2013.125, frequency = 17520)
gage<-ts(data.MBts$GageHeight,start = 2013.125, frequency = 17520)
depth<-ts(data.MBts$SensorDepth,start = 2013.125, frequency = 17520)
do2<-ts(data.MBts$DissolvedO2,start = 2013.125, frequency = 17520)
o2sat<-ts(data.MBts$O2Saturation,start = 2013.125, frequency = 17520)
ph<-ts(data.MBts$pH,start = 2013.125, frequency = 17520)
conduct<-ts(data.MBts$Conductance,start = 2013.125, frequency = 17520)
turbid<-ts(data.MBts$Turbidity,start = 2013.125, frequency = 17520)
secchi<-ts(data.MBts$SecchiDepth,start = 2013.125, frequency = 17520)
chloro<-ts(data.MBts$Chlorophyll,start = 2013.125, frequency = 17520)
phyco<-ts(data.MBts$Phycocyanin,start = 2013.125, frequency = 17520)
fdom<-ts(data.MBts$fDOM,start = 2013.125, frequency = 17520)
nitr<-ts(data.MBts$Nitrate,start = 2013.125, frequency = 17520)
```

```
decomp.temp<-stl(temp, s.window = "periodic")
decomp.disc<-stl(disc, s.window = "periodic")
decomp.velo<-stl(ts(data.MBts$StreamVelocity,start = 2013.125, frequency = 17520), s.window = "periodic
decomp.gage<-stl(ts(data.MBts$GageHeight,start = 2013.125, frequency = 17520), s.window = "periodic")
decomp.depth<-stl(depth, s.window = "periodic")
decomp.do2 <-stl(do2, s.window = "periodic")
decomp.o2sat<-stl(o2sat, s.window = "periodic")
decomp.ph<-stl(ph, s.window = "periodic")
decomp.conduct<-stl(conduct, s.window = "periodic")
decomp.turbid<-stl(turbid, s.window = "periodic")
decomp.secchi<-stl(secchi, s.window = "periodic")
decomp.chloro<-stl(chloro, s.window = "periodic")
decomp.phyco<-stl(phyco, s.window = "periodic")
decomp.fdom<-stl(fdom, s.window = "periodic")
decomp.nitr<-stl(nitr, s.window = "periodic")
```

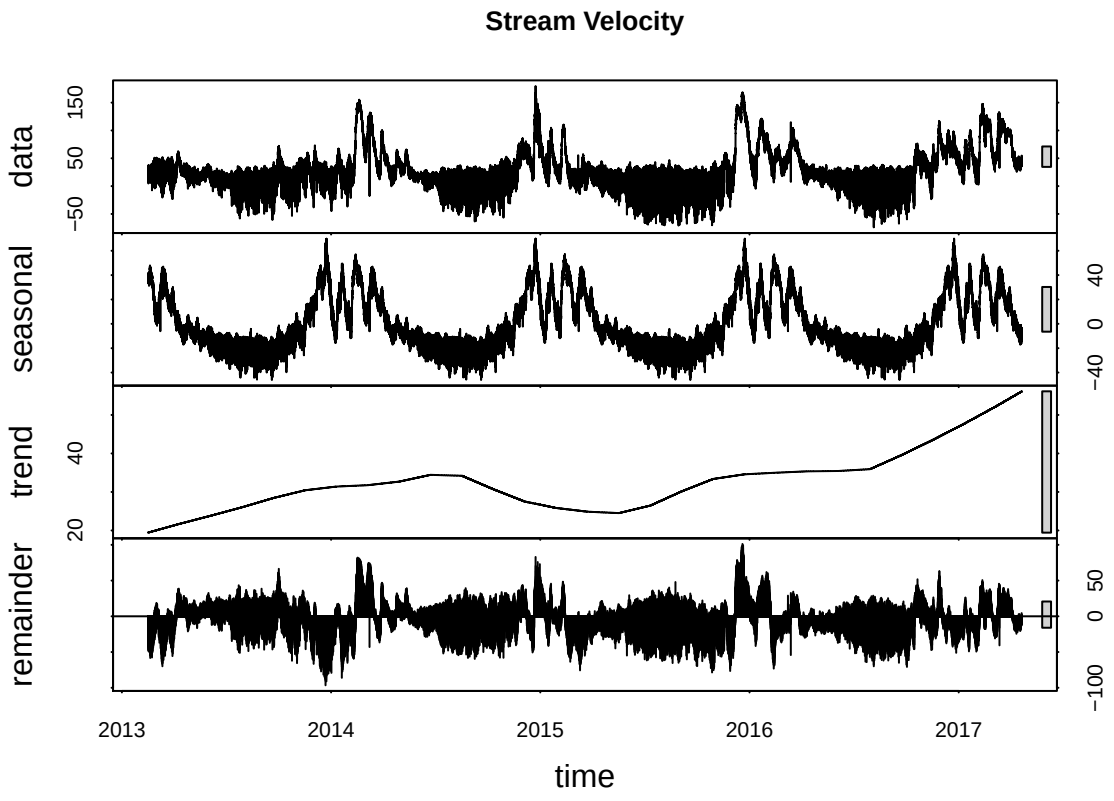
```
plot(decomp.temp, main = "Water Temperature")
```



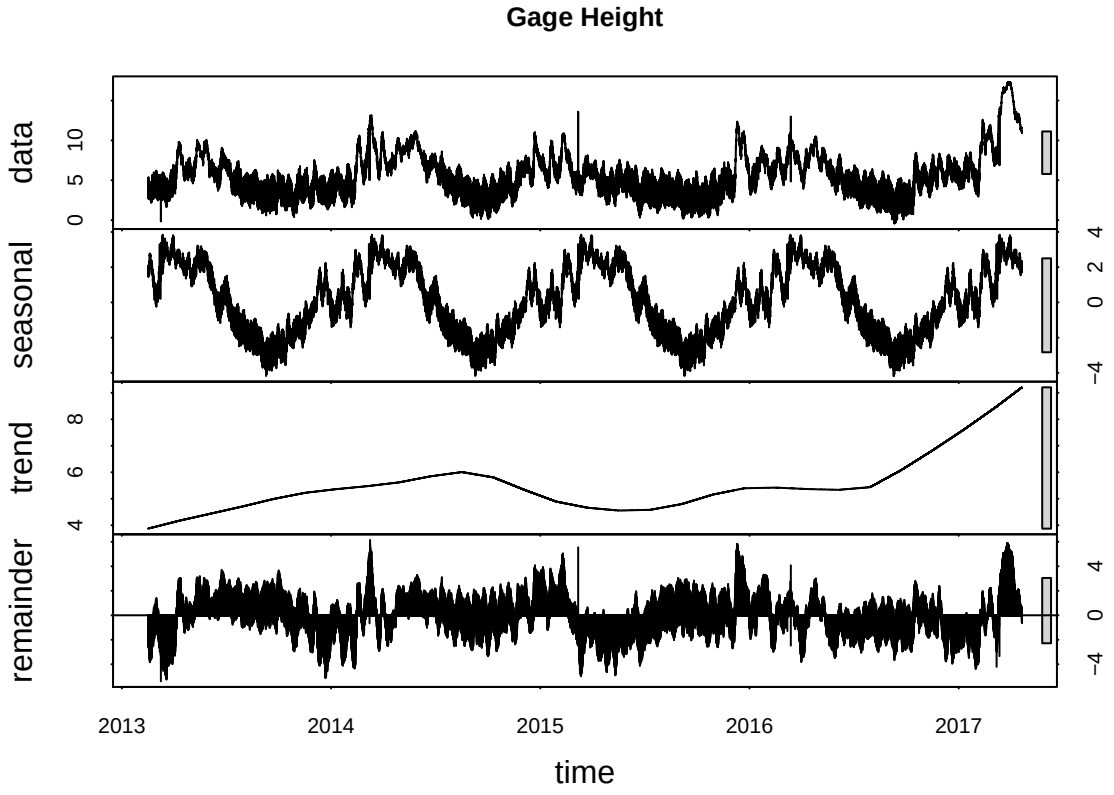

```
plot(decomp.disc, main = "Stream Discharge")
```



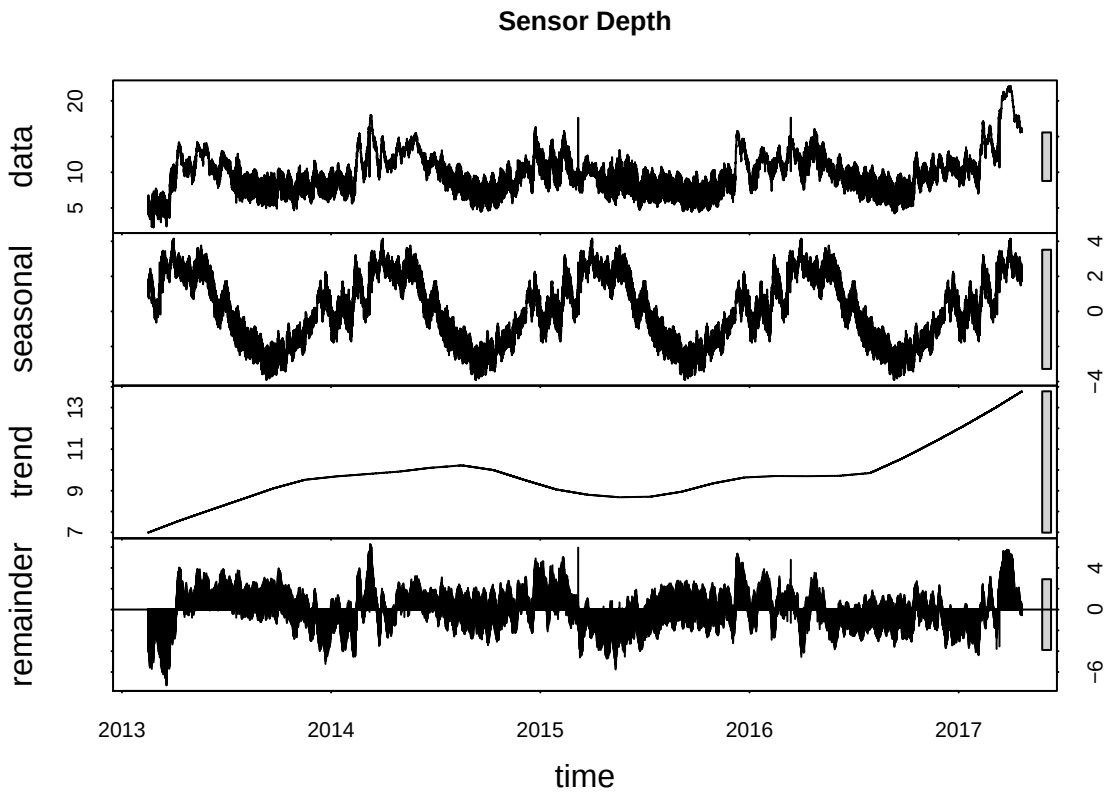

```
plot(decomp.disc, main = "Stream Velocity")
```



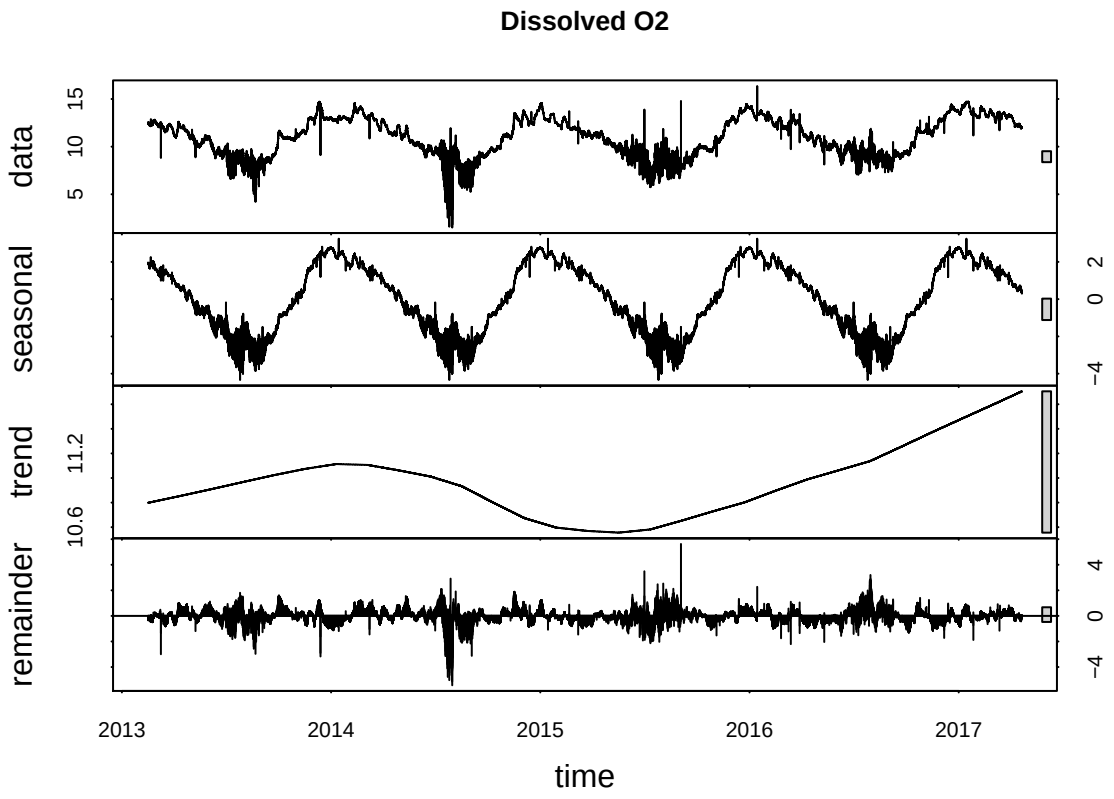

```
plot(decomp.gage, main = "Gage Height")
```



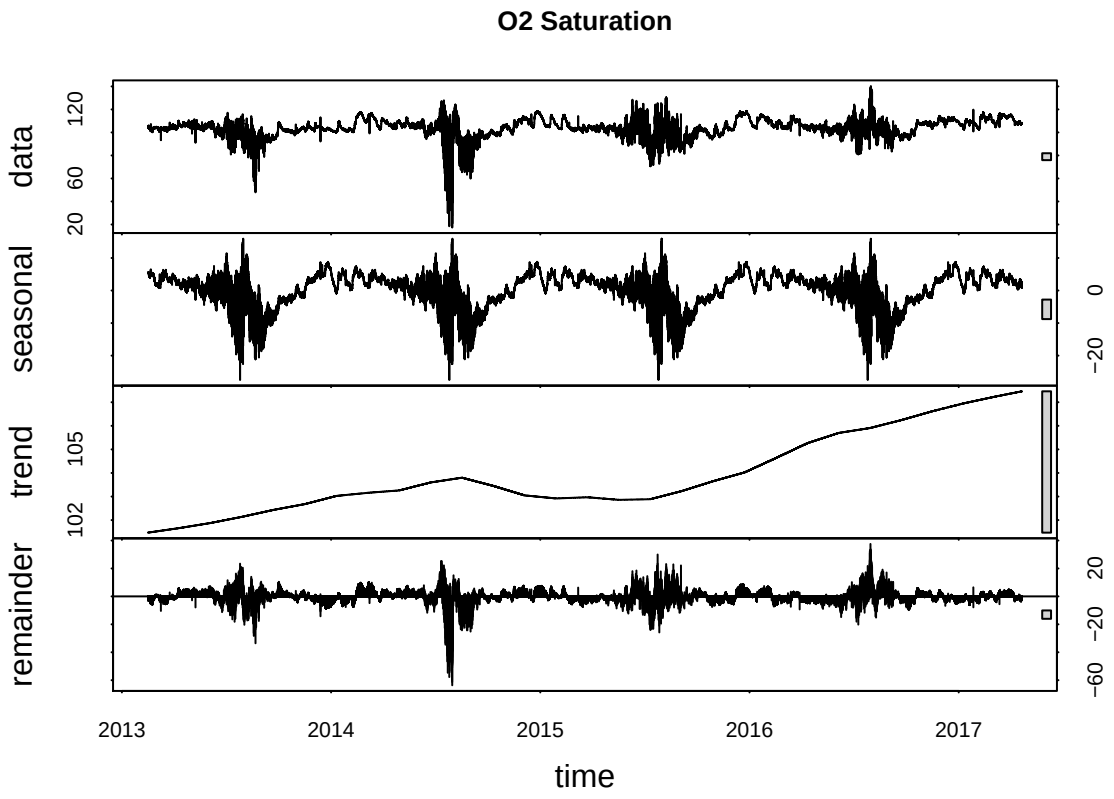

```
plot(decomp.depth, main = "Sensor Depth")
```



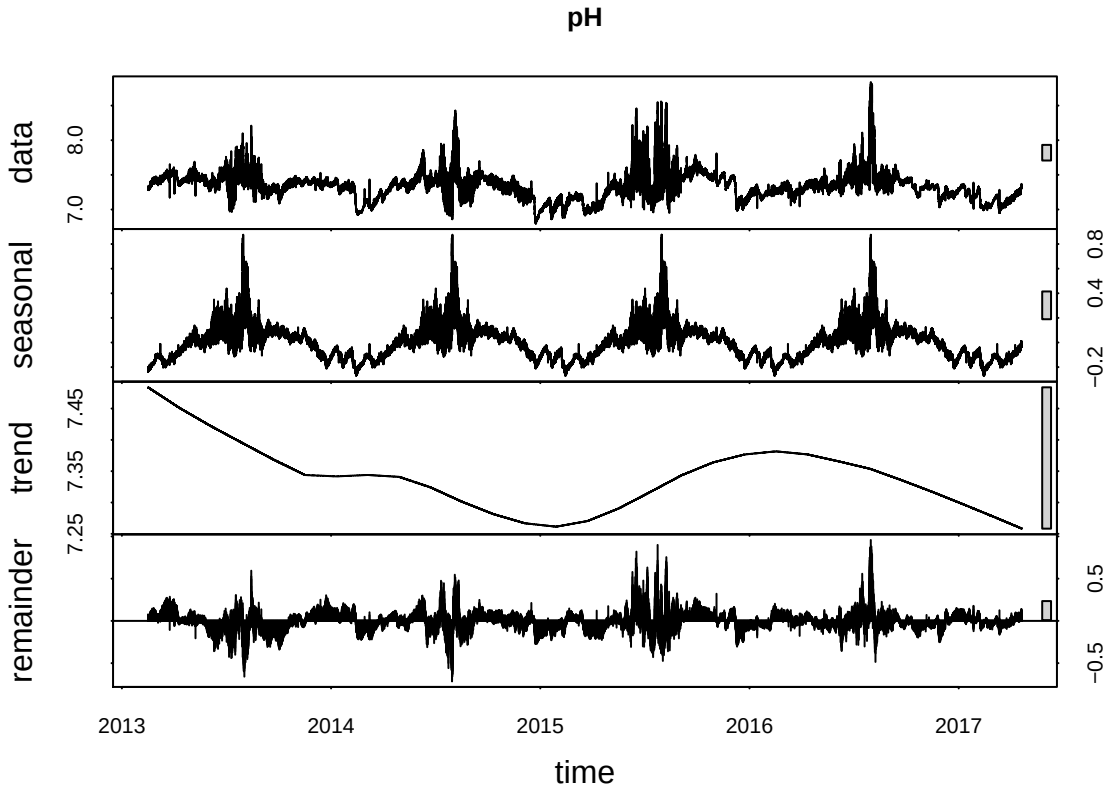

```
plot(decomp.do2, main ="Dissolved O2")
```



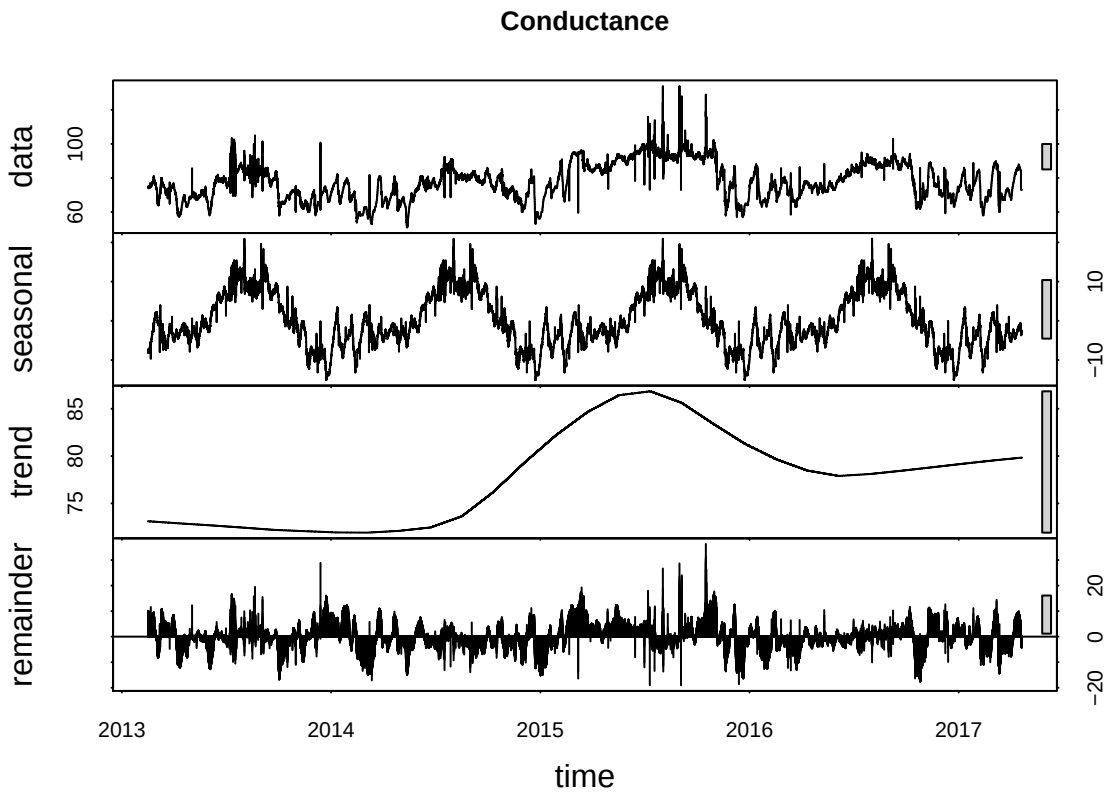

```
plot(decomp.o2sat, main = "O2 Saturation")
```



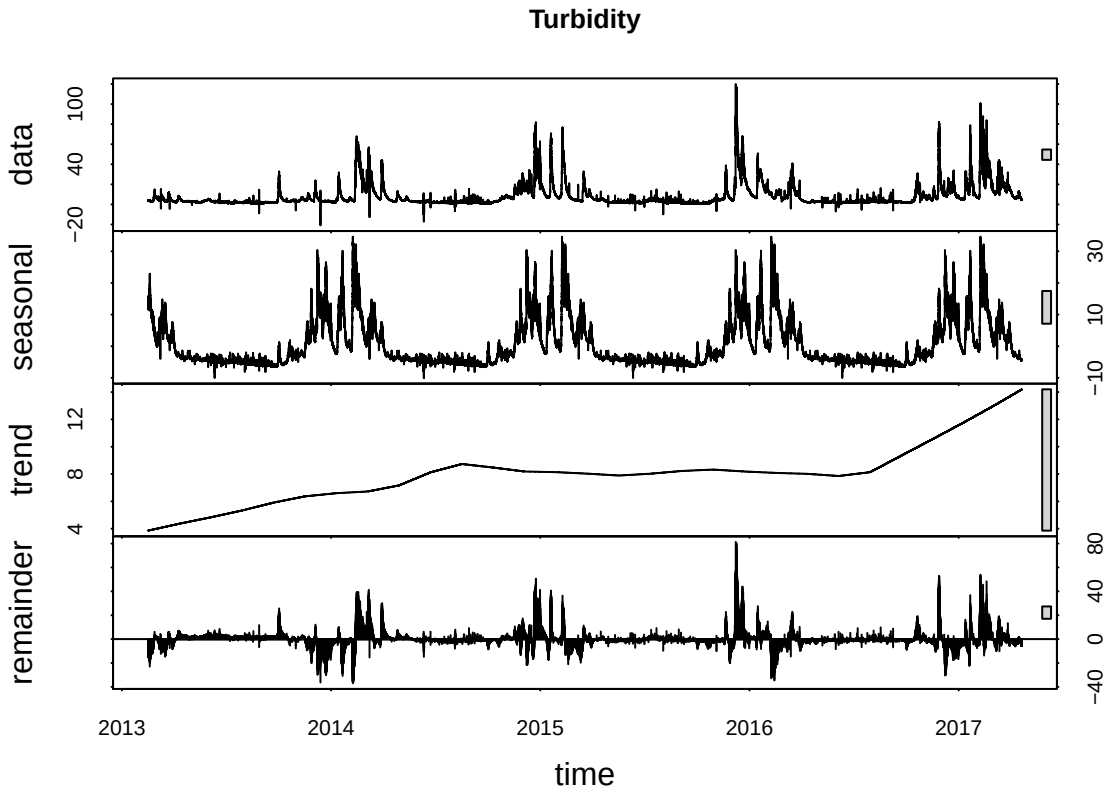

```
plot(decomp.ph, main = "pH")
```



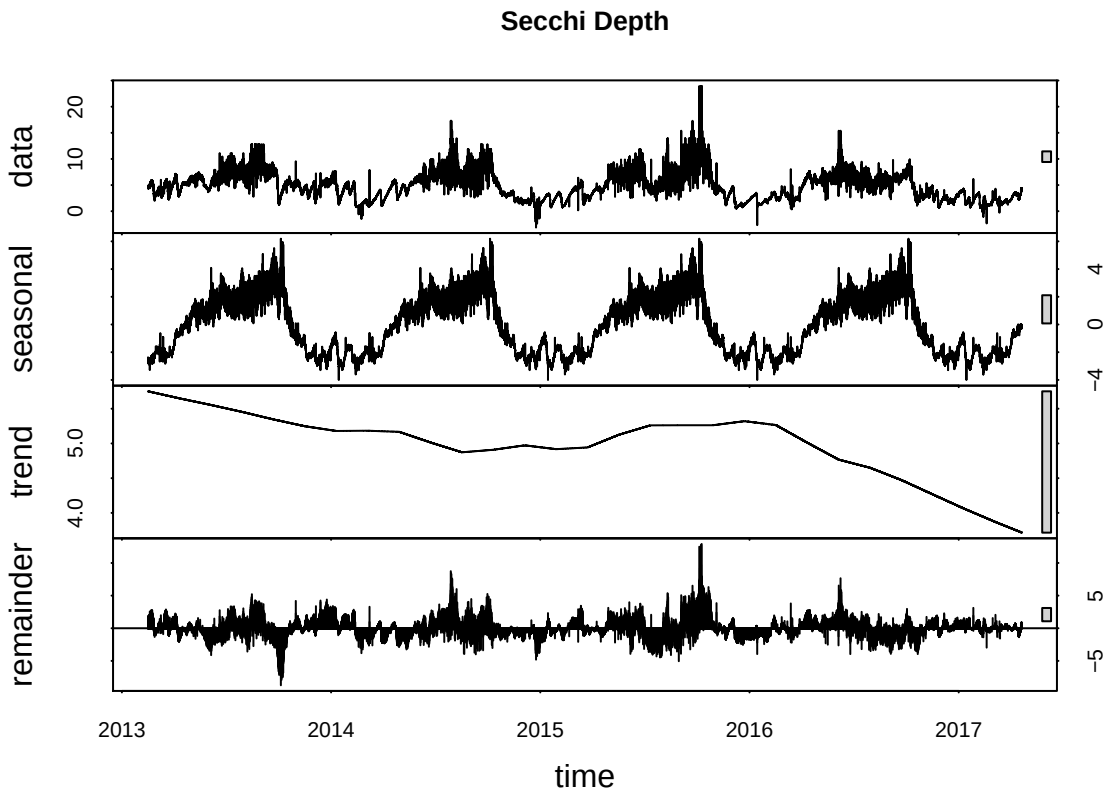

```
plot(decomp.conduct, main = "Conductance")
```



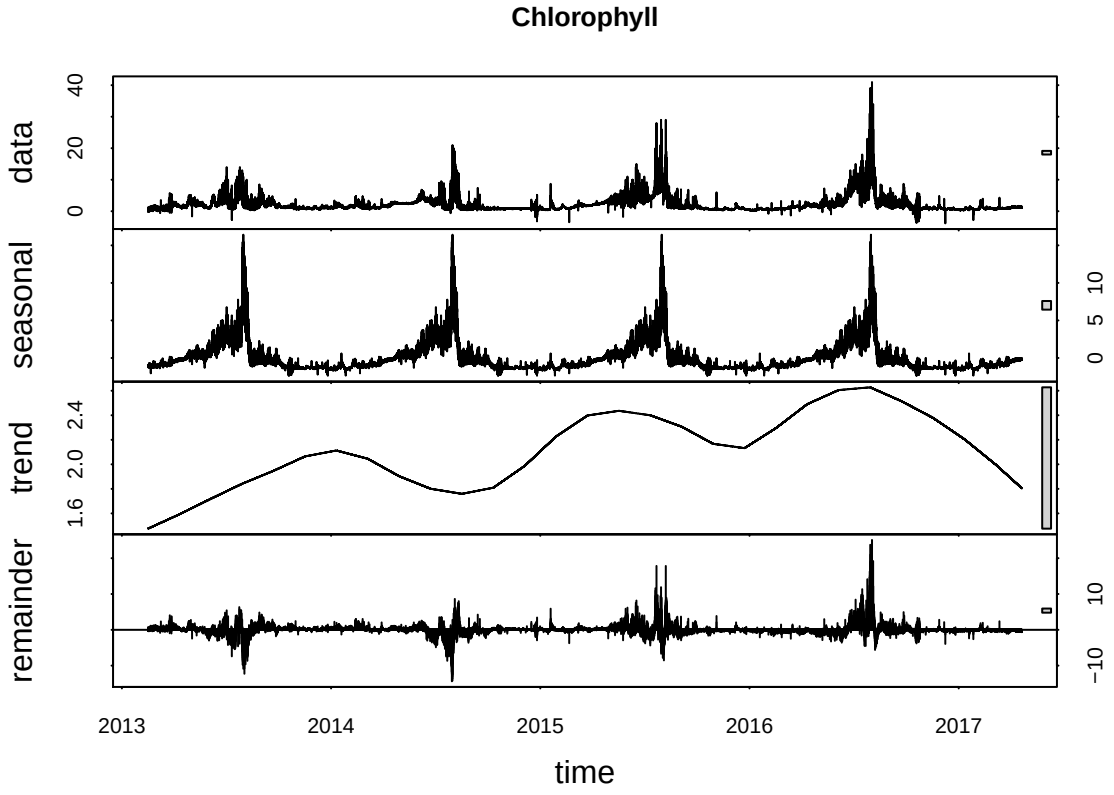

```
plot(decomp.turbid, main = "Turbidity")
```



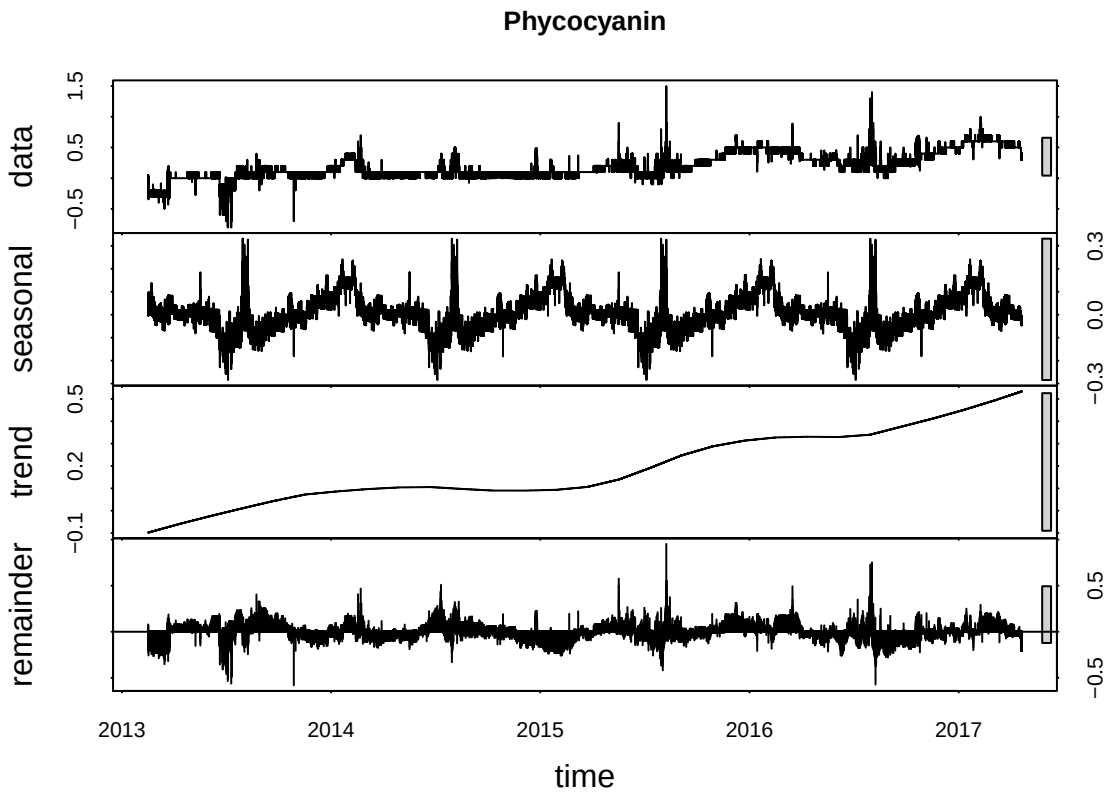

```
plot(decomp.secchi, main = "Secchi Depth")
```



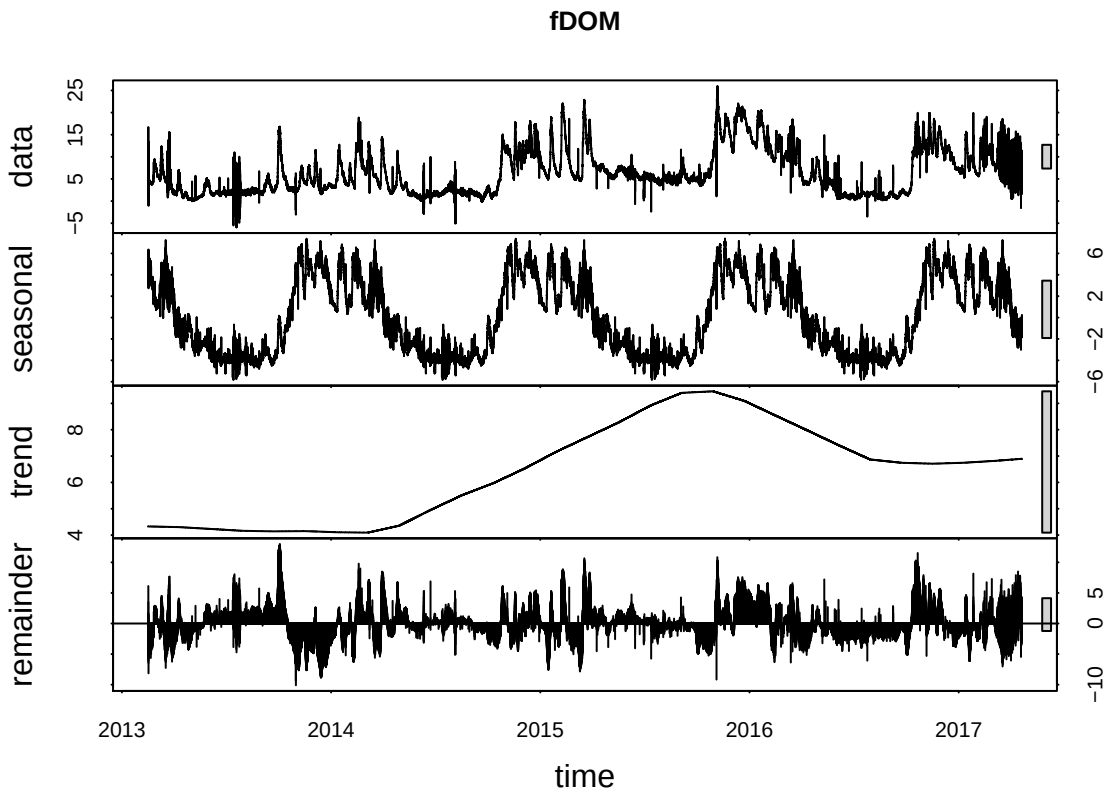

```
plot(decomp.chloro, main = "Chlorophyll")
```



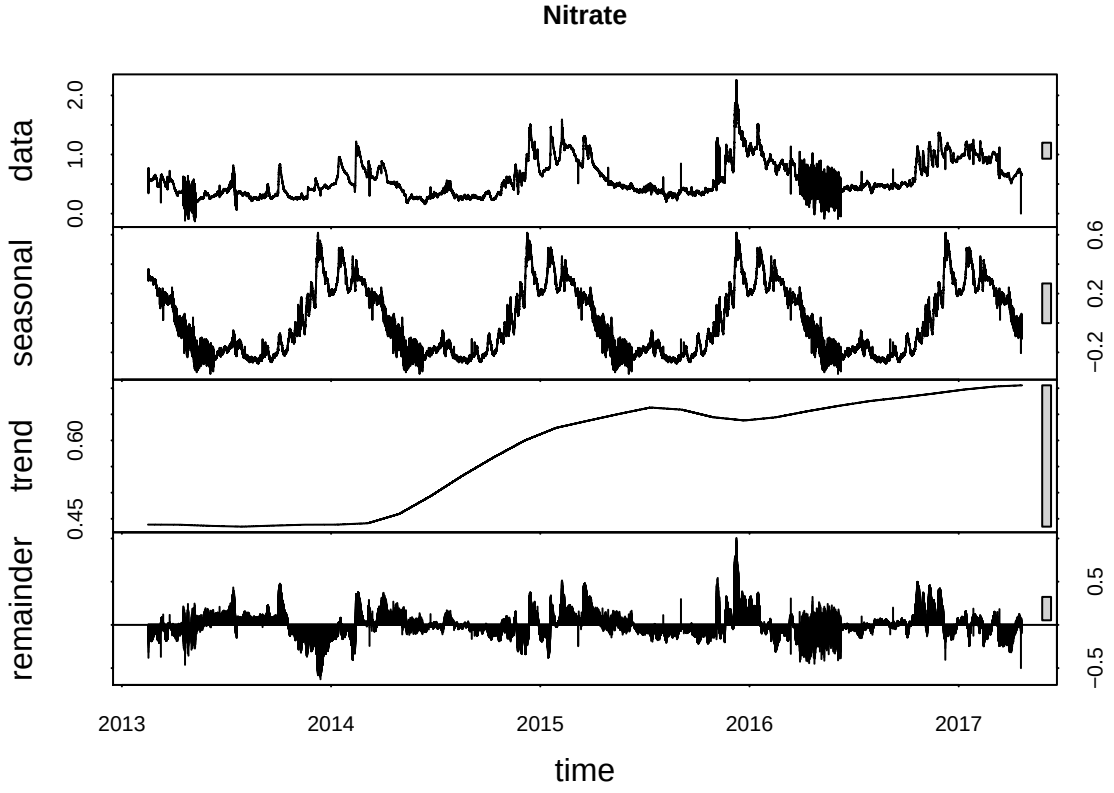

```
plot(decomp.phyco, main = "Phycocyanin")
```




```
plot(decomp.fdom, main ="fDOM")
```




```
plot(decomp.nitr, main ="Nitrate")
```




```
X<-list(temp,disc,velo,gage,depth,do2,o2sat,ph,conduct,turbid,secchi,chloro,phyco,fdom,nitr)
adf.test(temp,alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  temp
## Dickey-Fuller = -1.2686, Lag order = 41, p-value = 0.8909
## alternative hypothesis: stationary
```

```
adf.test(disc,alternative = "stationary")
```

```
## Warning in adf.test(disc, alternative = "stationary"): p-value smaller than
## printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  disc
## Dickey-Fuller = -5.8819, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(velo,alternative = "stationary")
```

```
## Warning in adf.test(velo, alternative = "stationary"): p-value smaller than
## printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
```

```
##
## data:  velo
## Dickey-Fuller = -6.0405, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(gage,alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  gage
## Dickey-Fuller = -2.4548, Lag order = 41, p-value = 0.3849
## alternative hypothesis: stationary
```

```
adf.test(depth,alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  depth
## Dickey-Fuller = -3.587, Lag order = 41, p-value = 0.03276
## alternative hypothesis: stationary
```

```
adf.test(do2,alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  do2
## Dickey-Fuller = -2.0373, Lag order = 41, p-value = 0.563
## alternative hypothesis: stationary
```

```
adf.test(o2sat,alternative = "stationary")
```

```
## Warning in adf.test(o2sat, alternative = "stationary"): p-value smaller
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  o2sat
## Dickey-Fuller = -5.8147, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(ph,alternative = "stationary")
```

```
## Warning in adf.test(ph, alternative = "stationary"): p-value smaller than
## printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  ph
## Dickey-Fuller = -4.4427, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(conduct,alternative = "stationary")
```

```
## Warning in adf.test(conduct, alternative = "stationary"): p-value smaller
```

```
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  conduct
## Dickey-Fuller = -4.8038, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(turbid,alternative = "stationary")
```

```
## Warning in adf.test(turbid, alternative = "stationary"): p-value smaller
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  turbid
## Dickey-Fuller = -12.511, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(secchi,alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  secchi
## Dickey-Fuller = -3.7907, Lag order = 41, p-value = 0.01873
## alternative hypothesis: stationary
```

```
adf.test(chloro,alternative = "stationary")
```

```
## Warning in adf.test(chloro, alternative = "stationary"): p-value smaller
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  chloro
## Dickey-Fuller = -4.752, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(phyco,alternative = "stationary")
```

```
## Warning in adf.test(phyco, alternative = "stationary"): p-value smaller
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  phyco
## Dickey-Fuller = -4.4907, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(fdom,alternative = "stationary")
```

```
## Warning in adf.test(fdom, alternative = "stationary"): p-value smaller than
## printed p-value
```

```
##
```

```
##  Augmented Dickey-Fuller Test
##
## data:  fdom
## Dickey-Fuller = -5.6171, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(nitr,alternative = "stationary")
```

```
## Warning in adf.test(nitr, alternative = "stationary"): p-value smaller than
## printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  nitr
## Dickey-Fuller = -5.1233, Lag order = 41, p-value = 0.01
## alternative hypothesis: stationary
```

With an $\alpha = .05$:

Stationary: Discharge, Velocity, Sensor Depth, O2 Saturation, pH, Conductivity, Turbidity, Secchi Depth, Chlorophyll, Phycocyanin, fDOM, and Nitrate.

Non-Stationary: Water Temperature, Gage Height, and Dissolved O2.

Non-stationary parameters cannot be modelled using a basic ARIMA model. However we can use differencing to fix this.

```
#diff.temp<-diff(temp)
#diff.gage<-diff(gage)
#diff.do2<-diff(do2)

#adf.test(diff.temp, alternative = "stationary")
#adf.test(diff.gage, alternative = "stationary")
#adf.test(diff.do2, alternative = "stationary")
```

So first order differencing makes the rest of our factors stationary!

```
#fipronil.model<-gamm()
```