Analysis of Climate Warming

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2020/9/26

Load and Clean Data

Assemble the data into a single data frame for analysis.

```
dt <- data.table()
fileList <- list.files("D:/R_17/data/data")
for (fileName in fileList) {
  setwd("D:/R_17/data/data")
  dtSingle = fread(fileName)
  dt <- rbind(dt,dtSingle,fill=TRUE)
}
head(dt)
```

```
##    YYYY MM DD hh  WD WSPD GST WVHT   DPD  APD MWD    BAR ATMP WTMP DEWP
## 1: 1999  1  1  0 221  5.4 7.2 0.33 11.11 5.25 999 1017.4 -4.3  5.6  999
## 2: 1999  1  1  1 218  5.6 7.3 0.31 11.11 5.51 999 1016.5   -4  5.7  999
## 3: 1999  1  1  2 226  5.7   7 0.32  12.5 6.53 999 1015.8 -3.9  5.7  999
## 4: 1999  1  1  3 228  5.7 7.3 0.31 11.11 6.17 999 1015.3 -3.9  5.7  999
## 5: 1999  1  1  4 237  5.9 7.7 0.39 11.11 5.02 999 1015.0 -3.8  5.6  999
## 6: 1999  1  1  5 235  5.7 7.5 0.42 11.11 4.81 999 1014.9 -3.9  5.6  999
##    VIS TIDE   mm  #YY WDIR PRES
## 1:  99 <NA> <NA> <NA> <NA> <NA>
## 2:  99 <NA> <NA> <NA> <NA> <NA>
## 3:  99 <NA> <NA> <NA> <NA> <NA>
## 4:  99 <NA> <NA> <NA> <NA> <NA>
## 5:  99 <NA> <NA> <NA> <NA> <NA>
## 6:  99 <NA> <NA> <NA> <NA> <NA>
```

Transform the date-time data into posix numbers using lubridate and make substitutions for NA data.

```
dt$Year <- paste0(dt$YYYY,dt$`#YY`)
dt$Year <- str_replace(dt$Year,"NA","")
dt$date <- as.Date(paste0(dt$Year,"-",dt$MM,"-",dt$DD))
# Transform the date-time data into  posix  numbers using  lubridate
dt$date <- as_datetime(dt$date)
```

Make a Backup file.

```
dtBackup <- dt
```

Determine month frequency.

```
dt <- dtBackup[,c("date","ATMP","WTMP")]
dt[,":="(ATMP=as.numeric(ATMP),
         WTMP=as.numeric(WTMP))]
dt$ATMP[dt$ATMP==999]=NA
dt$WTMP[dt$WTMP==999]=NA
dt$ym <- as.yearmon(dt$date)
dt <- na.omit(dt)
dtMonth <- dt[,.(ATMP=mean(ATMP,na.rm = T),
              WTMP=mean(WTMP,na.rm = T)),by=ym]
length(unique(dtMonth$ym))
```

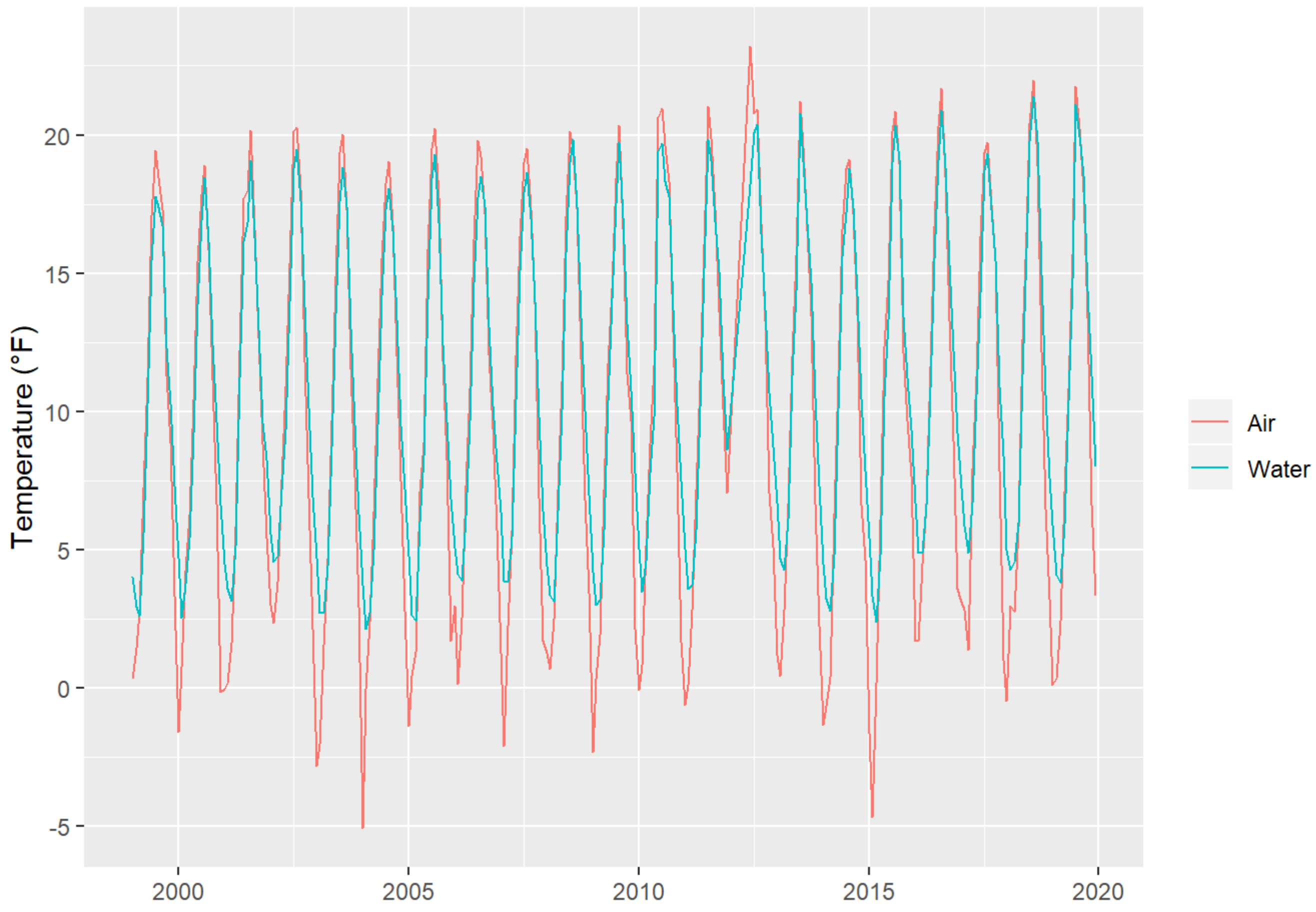
```
## [1] 247
```

```
names(dtMonth) <- c("ym","Air","Water")
dtMonth <- na.omit(dtMonth)
```

Visualization

Compare temperature change in air vs water.

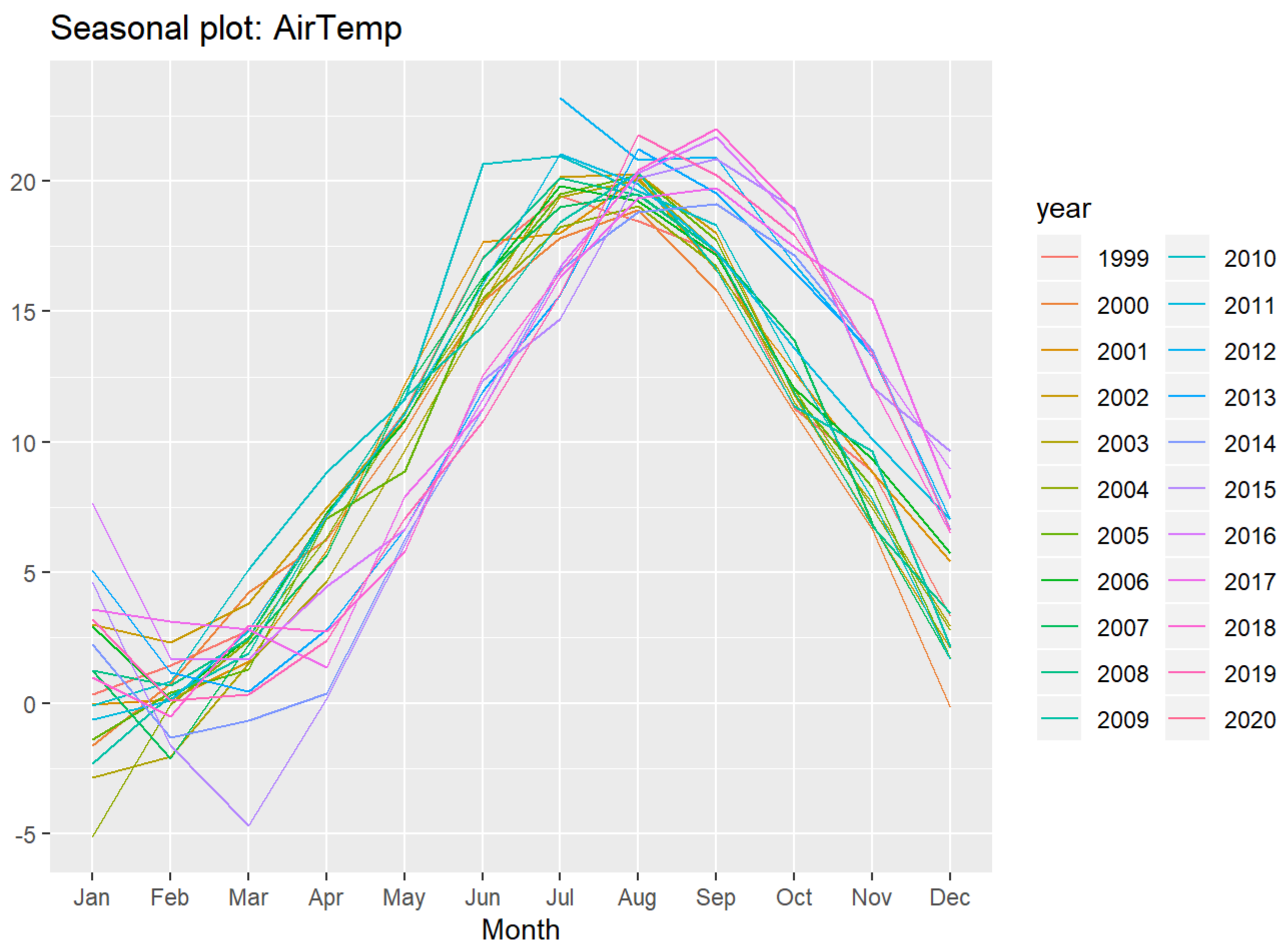
```
dtMP <- melt(dtMonth,id.vars = "ym")
ggplot(dtMP,aes(ym,value,color=variable))+
  geom_line()+
  labs(x="",y="Temperature (° F)")+
  theme(legend.title = element_blank())
```



Seasonal of air temperature.

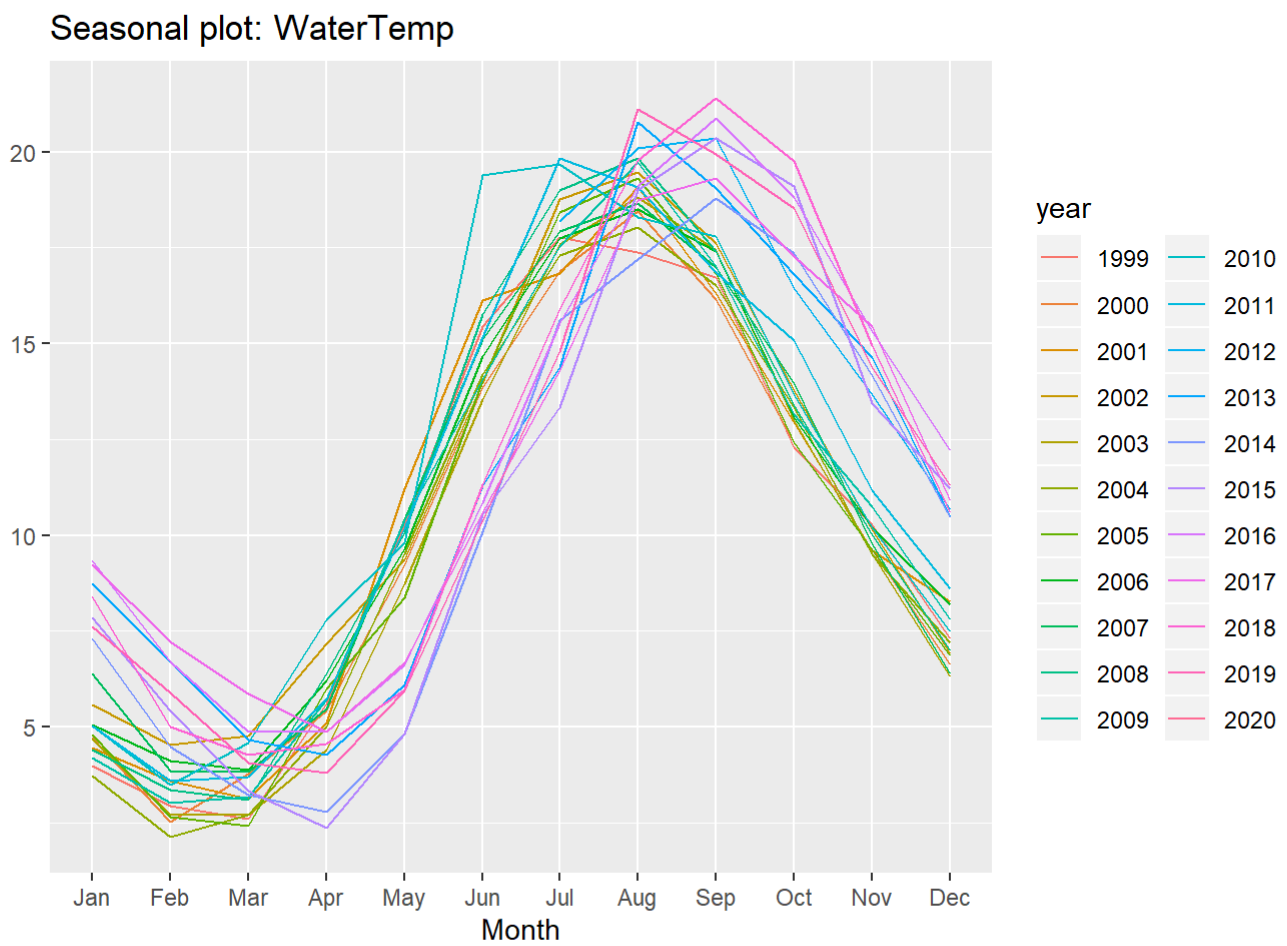
```
AirTemp <- ts(c(dtMonth$Air[c(1:156)],
                rep(NA,6),
                dtMonth$Air[c(157:247)]),
              start = 1999,
              frequency = 12)
```

```
ggseasonplot(AirTemp)
```

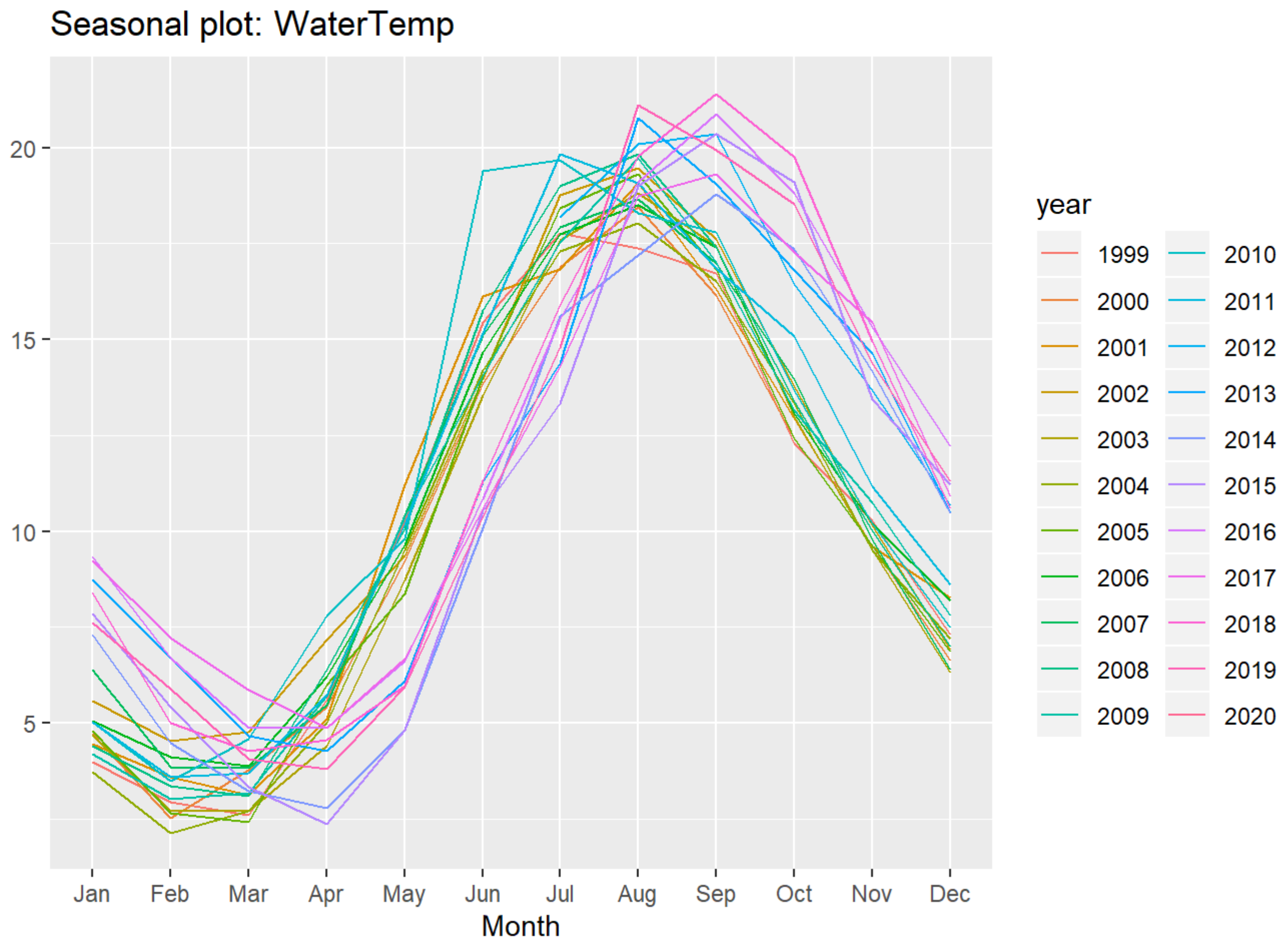


Seasonal of water temperature.

```
WaterTemp <- ts(c(dtMonth$Water[c(1:156)],
                rep(NA,6),
                dtMonth$Water[c(157:247)]),
              start = 1999,
              frequency = 12)
ggseasonplot(WaterTemp)
```




```
WaterTemp <- ts(c(dtMonth$Water[c(1:156)],
                  rep(NA,6),
                  dtMonth$Water[c(157:247)]),
                start = 1999,
                frequency = 12)
ggseasonplot(WaterTemp)
```



test

Before use Mann-Kendall trend test we need check whether there is seasonal in data or not.

```
isSeasonal(WaterTemp, freq = 12)
```

```
## [1] TRUE
```

The result indicated that there is seasonal in data.
So we use Seasonal Mann-Kendall trend test to a test for monotonic trend in a time series.

```
SeasonalMannKendall(WaterTemp)
```

```
## tau = 0.277, 2-sided pvalue =1.8516e-09
```

```
SeasonalMannKendall(AirTemp)
```

```
## tau = 0.128, 2-sided pvalue =0.0054209
```

Conclusion

As p-value is smaller than 0.05, we reject H0 and determine that there are monotonic trend in both air and water temperature from 1999 to 2009.