ENV 790.30 - Time Series Analysis for Energy Data | Spring 2021

Assignment 2 - Due date 01/26/22

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R packages

```
library(tidyverse)
library(forecast)
library(tseries)
library(readxl)
library(lubridate)
```

Data set information

I'll read in the data using the `read_excel` function from the `readxl` package because this function allows me to specify the sheet that I want to read from the `.xlsx` file. Though not specified in the assignment, I'll use the `Monthly Data`. The amount of data is still pretty small, and I can always aggregate to the annual view, if needed.

```
# Read in data
file_path = paste0('../Data/Table_10.1_Renewable_Energy_Production_and',
                   '_Consumption_by_Source.xlsx')
data <- read_excel(path = file_path, sheet = "Monthly Data", skip = 10,
                   na = "Not Available")

# Remove first row, which contains units for each column
# Remove second row, which does not specify a date for the data (though Jan
# 1973 seems likely)
data <- data[-1, ]
```

Question 1

You will work only with the following columns: Total Biomass Energy Production, Total Renewable Energy Production, Hydroelectric Power Consumption. Create a data frame structure with these three time series only. Use the command head() to verify your data.

```
# Select columns
data_q1 <- data %>%
  select('Total Biomass Energy Production', 'Total Renewable Energy Production',
         'Hydroelectric Power Consumption')

# Make column names shorter and remove spaces
data_q1 <- data_q1 %>%
  rename(Biomass_prod = 'Total Biomass Energy Production',
         Renewable_prod = 'Total Renewable Energy Production',
         Hydro_consumption = 'Hydroelectric Power Consumption')
```

```r
# Convert data types to numeric
data_q1 <- sapply(data_q1, as.numeric) %>%
  as_tibble()

# Show first six rows
head(data_q1)
```

```
## # A tibble: 6 x 3
##   Biomass_prod Renewable_prod Hydro_consumption
##          <dbl>          <dbl>             <dbl>
## 1         130.           404.              273.
## 2         117.           361.              242.
## 3         130.           400.              269.
## 4         126.           380.              253.
## 5         130.           392.              261.
## 6         126.           377.              250.
```

Question 2

Transform your data frame in a time series object and specify the starting point and frequency of the time series using the function ts().

```r
# Frequency of 12 chosen to represent monthly data
data_ts <- ts(data = data_q1, start = c(1973, 1), end = c(2021, 9),
              frequency = 12)

# Display result
head(data_ts)
```

```
##          Biomass_prod Renewable_prod Hydro_consumption
## Jan 1973      129.787        403.981           272.703
## Feb 1973      117.338        360.900           242.199
## Mar 1973      129.938        400.161           268.810
## Apr 1973      125.636        380.470           253.185
## May 1973      129.834        392.141           260.770
## Jun 1973      125.611        377.232           249.859
```

Question 3

Compute mean and standard deviation for these three series.

```r
# Define function that returns mean and standard deviation
mean_sd <- function(x) {
  c(mean(x), sd(x))
}

# Calculate mean and standard deviation for each column
mean_sd_results <- sapply(data_ts, mean_sd)

# Rename rows
row.names(mean_sd_results) <- c('Mean', 'Standard_deviation')

# Display results
mean_sd_results
```

```
##                    Biomass_prod Renewable_prod Hydro_consumption
```

```
## Mean                  273.78392       581.1708         235.96526
## Standard_deviation     89.42852       177.5607          44.01749
```

Question 4

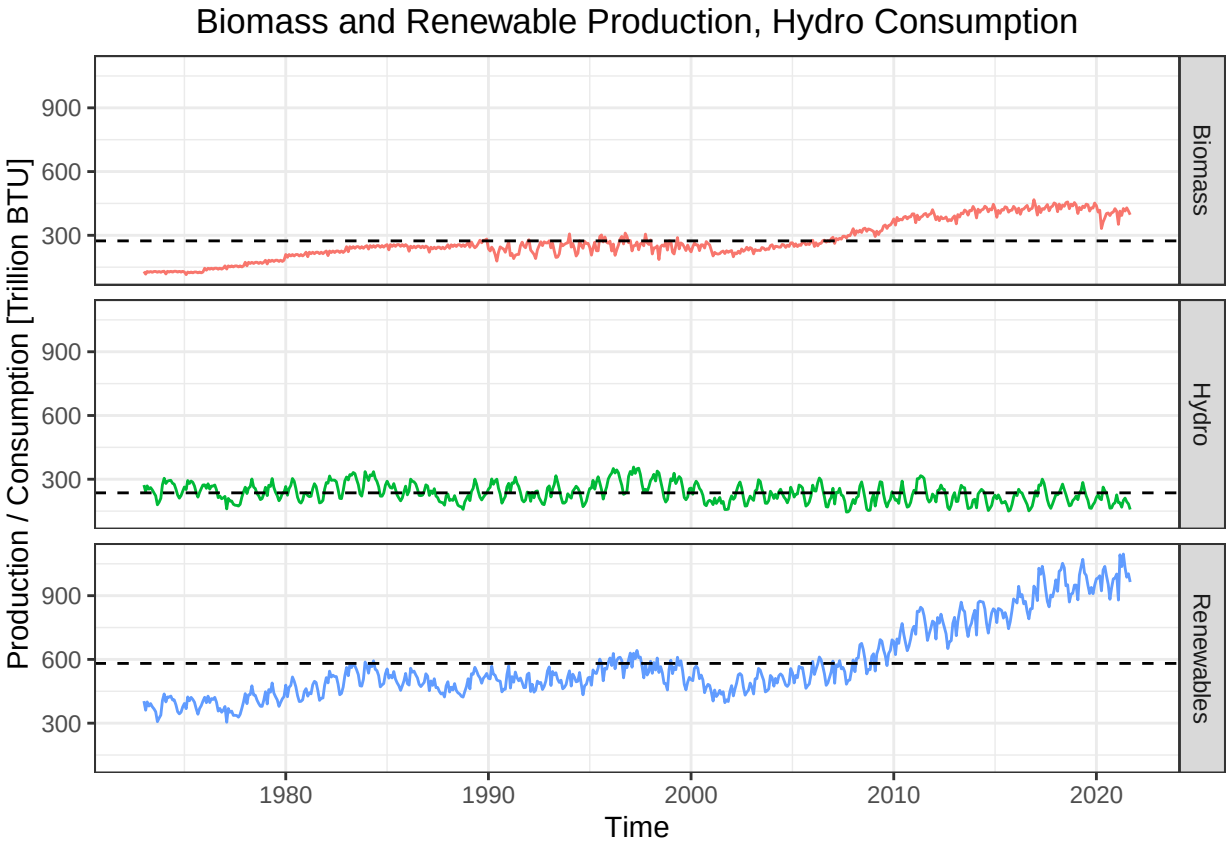
Display and interpret the time series plot for each of these variables.

For this question, I decided to make a faceted plot and denote the mean value of each time series with a dashed black line. A few observations are apparent:

- While Total `Renewable Energy Production` and `Total Biomass Energy Production` rose substantially from 1973-2021, `Hydroelectric Power Consumption` decreased
- Given the rise of `Total Biomass Energy Production` and the stagnation of `Hydroelectric Power Consumption`, the mean biomass production is greater than the mean hydroelectric consumption over the given time period. The mean value of `Total Renewable Energy Production` is obviously the highest of the three categories shown, given that the biomass and hydroelectric variables are two of the inputs of the sum that produces `Total Renewable Energy Production`
- The gap between `Renewable Energy Production` and `Total Biomass Energy Production` + `Hydroelectric Power Consumption` grew over time, denoting the rise of other renewable energy technologies (e.g., wind, solar)

```r
# Create dataframe with means
mean_df <- data.frame(name = c('Biomass', 'Renewables', 'Hydro'),
                      means = mean_sd_results[1,])

# Generate requested plot
data %>%
  select(Month, 'Total Biomass Energy Production',
         'Total Renewable Energy Production',
         'Hydroelectric Power Consumption') %>%
  rename(Biomass = 'Total Biomass Energy Production',
         Renewables = 'Total Renewable Energy Production',
         Hydro = 'Hydroelectric Power Consumption') %>%
  pivot_longer(cols = !Month) %>%
  mutate(Month = ymd(Month), value = as.numeric(value)) %>%
  ggplot(mapping = aes(x = Month, y = value, color = name)) +
  geom_line() +
  facet_grid(name~.) +
  geom_hline(data = mean_df, mapping = aes(yintercept = means),
             color = 'black', linetype = 2) +
  labs(x = 'Time', y = 'Production / Consumption [Trillion BTU]',
       title = 'Biomass and Renewable Production, Hydro Consumption') +
  theme_bw() +
  theme(plot.title = element_text(hjust = 0.5), legend.position = "None")
```



Question 5

Compute the correlation between these three series. Are they significantly correlated? Explain your answer.

Question 6

Compute the autocorrelation function from lag 1 up to lag 40 for these three variables. What can you say about these plots? Do the three of them have the same behavior?

Question 7

Compute the partial autocorrelation function from lag 1 to lag 40 for these three variables. How these plots differ from the ones in Q6?