Assignment 6: Time Series Analysis

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OVERVIEW

This exercise accompanies the lessons in Hydrologic Data Analysis on time series analysis

Directions

1. Change "Student Name" on line 3 (above) with your name.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single pdf file.
5. After Knitting, submit the completed exercise (pdf file) to the dropbox in Sakai. Add your last name into the file name (e.g., "A06_Salk.html") prior to submission.

The completed exercise is due on 11 October 2019 at 9:00 am.

Setup

1. Verify your working directory is set to the R project file,
2. Load the tidyverse, lubridate, trend, and dataRetrieval packages.
3. Set your ggplot theme (can be theme_classic or something else)
4. Load the ClearCreekDischarge.Monthly.csv file from the processed data folder. Call this data frame ClearCreekDischarge.Monthly.

```
getwd()
```

```
## [1] "Z:/Hydrologic_Data_Analysis"
```

```
library(tidyverse)
```

```
## -- Attaching packages -------------------------------------------------------------------------

## v ggplot2 3.2.1     v purrr   0.3.2
## v tibble  2.1.3     v dplyr   0.8.3
## v tidyr   0.8.3     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.4.0

## -- Conflicts -------------------------------------------------------------------------------
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(lubridate)
```

```
##
## Attaching package: 'lubridate'

## The following object is masked from 'package:base':
##
##     date
```

```
library(trend)
library(dataRetrieval)

theme_set(theme_classic())
```

```
ClearCreekDischarge.Monthly <- read_csv("Data/Processed/ClearCreekDischarge.Monthly.csv")
```

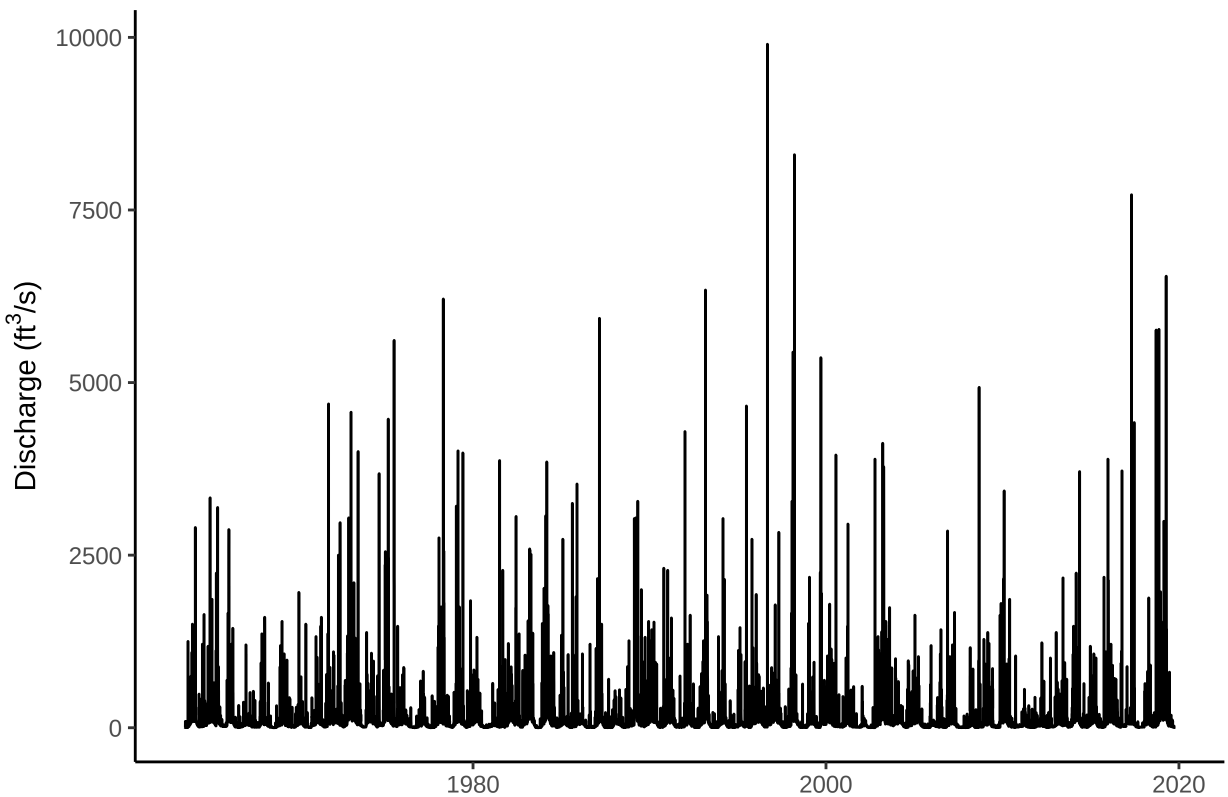
```
## Parsed with column specification:
## cols(
##   Year = col_double(),
##   Month = col_double(),
##   Discharge = col_double()
## )
```

Time Series Decomposition

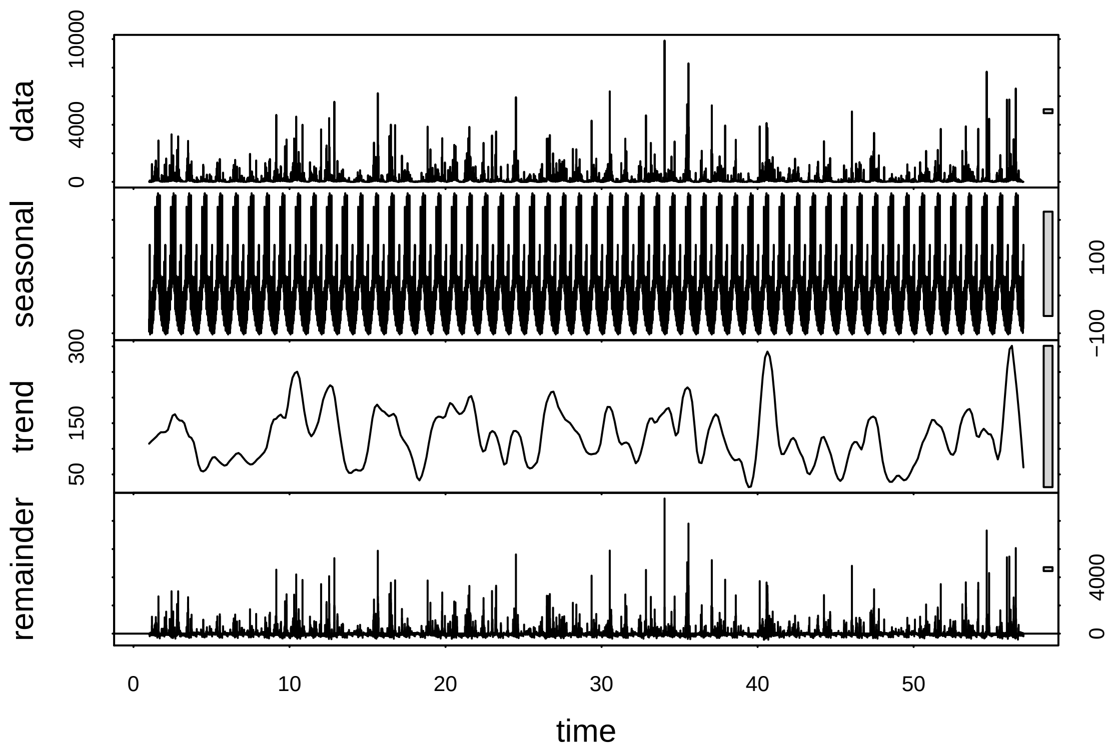
5. Create a new data frame that includes daily mean discharge at the Eno River for all available dates (`siteNumbers = "02085070"`). Rename the columns accordingly.
6. Plot discharge over time with geom_line. Make sure axis labels are formatted appropriately.
7. Create a time series of discharge
8. Decompose the time series using the `stl` function.
9. Visualize the decomposed time series.

```
Eno.Discharge <- readNWISdv(siteNumbers = "02085070",
                            parameterCd = "00060",
                            startDate = "",
                            endDate = "")
names(Eno.Discharge) [4:5] <- c("Discharge", "Approval.Code")


EnoDischargePlot <-
  ggplot(Eno.Discharge, aes(x = Date, y = Discharge)) +
  geom_line() +
  labs(x = "", y = expression("Discharge (ft"^3*"/s)")) +
  theme(axis.title.x = element_text(size = 16))
print(EnoDischargePlot)
```




```
Eno.ts <- ts(Eno.Discharge[[4]], frequency = 365)
Eno.Decomposed <- stl(Eno.ts, s.window = "periodic")
plot(Eno.Decomposed)
```



10. How do the seasonal and trend components of the decomposition compare to the Clear Creek discharge dataset? Are they similar in magnitude?

    Seasonal: Seasonally, the Eno's cycle is much more chaotic than the Clear Creek seasonal discharge. The Eno still has a seasonal cycle present, that much is clear, but there is a lot more noise within the cycle. It obviously is not subject to the straightfoward pattern of snowmelt that Clear Creek experiences.The magnitude is different between the two, as well - the Eno is operating on a considerably larger one than clear Creek.

    Trend: As for trend, I'd say that both locations are similar. Neither seem to be seeing an obvious, prolonged increase or decrease. Both of their trends change year after year without any sort of pattern. Both trend magnitudes are similar, too.

Trend Analysis

Research question: Has there been a monotonic trend in discharge in Clear Creek over the period of study?

11. Generate a time series of monthly discharge in Clear Creek from the ClearCreekDischarge.Monthly data frame. This time series should include just one column (discharge).
12. Run a Seasonal Mann-Kendall test on the monthly discharge data. Inspect the overall trend and the monthly trends.

```
ClearCreek.ts <- ts(ClearCreekDischarge.Monthly[[3]], frequency = 12)

ClearCreekTrend <- smk.test(ClearCreek.ts)

ClearCreekTrend
```

```
##
```

```
##  Seasonal Mann-Kendall trend test (Hirsch-Slack test)
##
## data:  ClearCreek.ts
## z = 1.6586, p-value = 0.09719
## alternative hypothesis: true S is not equal to 0
## sample estimates:
##      S   varS
##    590 126102
```

```r
summary(ClearCreekTrend)
```

```
##
##  Seasonal Mann-Kendall trend test (Hirsch-Slack test)
##
## data: ClearCreek.ts
## alternative hypothesis: two.sided
##
## Statistics for individual seasons
##
## H0
##                      S  varS    tau      z Pr(>|z|)
## Season 1:   S = 0   64 11154  0.062  0.597 0.550828
## Season 2:   S = 0   24 10450  0.024  0.225 0.821984
## Season 3:   S = 0   30 10450  0.030  0.284 0.776650
## Season 4:   S = 0   35 10449  0.035  0.333 0.739425
## Season 5:   S = 0    4 10450  0.004  0.029 0.976588
## Season 6:   S = 0  204 10450  0.206  1.986 0.047054 *
## Season 7:   S = 0  230 10450  0.232  2.240 0.025081 *
## Season 8:   S = 0  148 10450  0.149  1.438 0.150434
## Season 9:   S = 0   94 10450  0.095  0.910 0.362951
## Season 10:   S = 0 -54 10450 -0.055 -0.518 0.604135
## Season 11:   S = 0 -99 10449 -0.100 -0.959 0.337703
## Season 12:   S = 0 -90 10450 -0.091 -0.871 0.383958
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

13. Is there an overall monotonic trend in discharge over time? If so, is it positive or negative?

    No, we cannot definitively say that there has been an overall monotonic trend in discharge over time.

14. Are there any monthly monotonic trends in discharge over time? If so, during which months do they occur and are they positive or negative?

    Yes, there seem to be monthly monotonic trends in discharge over time in the months of June and July, and they are both positive.

Reflection

15. What are 2-3 conclusions or summary points about time series you learned through your analysis?

    I learned that it is possible to see a clear seasonal discharge pattern even in rivers/watersheds that do not experience snowmelt. I also learned that it is possible to see monotonic trends in discharge in individual months, even if there is none (conclusively) over the entire year.

16. What data, visualizations, and/or models supported your conclusions from 12?

The Eno time series decomposition helped me with this I gathered this from the monthly Seasonal Mann-Kendall test I did for Clear Creek.

17. Did hands-on data analysis impact your learning about time series relative to a theory-based lesson? If so, how?

    Yes, it helped me actually care about what I was visualizing, and it helped me understand some of the background theory that goes into the code.

18. How did the real-world data compare with your expectations from theory?

    I would say that real-world data diverged a little from my theoretical expectations - because theoretically, there should be no particular trend in discharge over time, barring outside factors.