### **Capstone Exercise**

The final exercise for this course involves performing a time series analysis on real-world data: Carbon Dioxide concentration at the Mauna Loa Observatory, from early 1959 to Present. You'll go through the process of importing the data, converting to a time series object (with zoo), imputing missing values, and plotting the resulting data. Additionally, you will create an aggregate of the data, as well as a rolling window average of the data.

#### **Importing the Data**

```
# The following libraries are included for you

library(zoo)
# Sample data from the Mauna Loa Observatory
# https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_mm_mlo.csv

# Data is already pre-processed as a `zoo` object. It contains missing values,
# so we'll need to impute those!

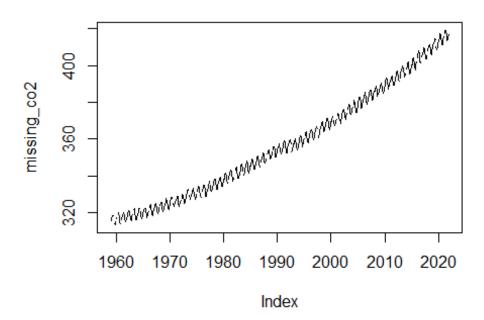
# This will be hidden from the users, of course.
missing_co2 <- readRDS("data/missing.Rds")</pre>
```

#### **Visualizing the Data**

Perform basic data exploration by:

- 1. Printing the first 20 observations with head(), and,
- 2. Creating a plot of the data with plot()

```
head(missing_co2, n = 20)
## Jan 1959 Feb 1959 Mar 1959 Apr 1959 May 1959 Jun 1959 Jul 1959 Aug 1959
              316.48
                        316.65
                                          318.29
                                                    318.15
##
     315.58
                                 317.72
                                                                 NA
## Sep 1959 Oct 1959 Nov 1959 Dec 1959 Jan 1960 Feb 1960 Mar 1960 Apr 1960
              313.33
                                                   316.98
     313.84
                       314.81
                                     NA
                                          316.43
                                                                 NA
                                                                          NA
## May 1960 Jun 1960 Jul 1960 Aug 1960
     320.04
              319.59
                       318.18
                                 315.90
##
plot(missing co2)
```

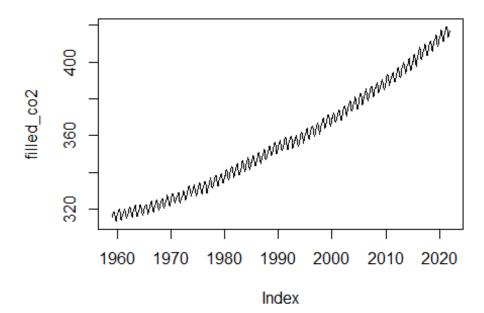


Notice that there are "holes" in the data? this suggests that we've got NA values, which is apparent when we view the first few observations with head().

## **Imputing the Missing Values**

Impute the missing values with a *cubic spline* interpolation, then plot the results

```
filled_co2 <- na.spline(missing_co2)
plot(filled_co2)</pre>
```



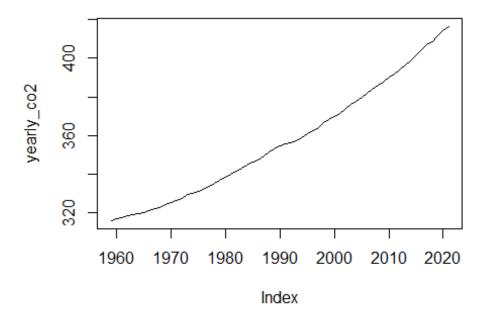
## **Yearly Aggregate**

Using aggregate(), create a yearly mean of the data, then plot the data

\*Hint: use lubridate::year()

```
yearly_co2 <- aggregate(filled_co2,
   by = lubridate::year,
   FUN = mean
)

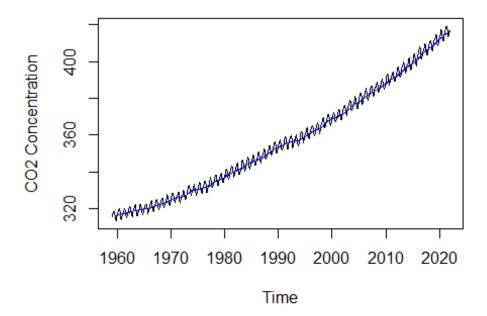
plot(yearly_co2)</pre>
```



#### **Rolling Window**

Calculate a 12-month rolling window average of the data, then overlay the results (in blue) on top of the original data. Label the x-axis as "Time" and the y-axis as "CO2 Concentration", and give your graph the title "Monthly CO2 Concentration at Mauna Loa Observatory"

# CO2 Concentration at Mauna Loa Observatory



#### **Given Code**

The following code is given to the learners at the beginning of the exercise:

```
# Question 1: Explore the Data
___(missing_co2, ___ = ___)
___(missing_co2)
# Question 2: Impute Missing Values
filled_co2 <- ___(___)
___(filled_co2)
# Question 3: Find Yearly Mean Aggregate
yearly_co2 = aggregate(___, by = ___, FUN = ___)
___(___)
# Question 4: Calculate a Rolling Window
roll <- rollapplyr(filled_co2, FUN = ___, width = 12)</pre>
plot(___,
    xlab = ____,
     ylab =
     main = "CO2 Concentration at Mauna Loa Observatory")
lines(___, col = ___)
```