

## 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](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")
```

## Visualizing the Data

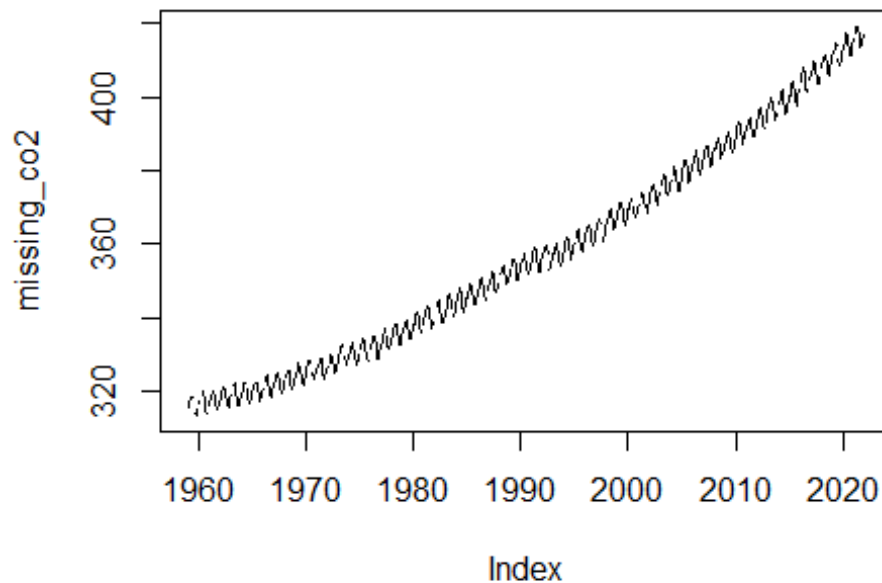
Perform basic data exploration by:

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
## 315.58 316.48 316.65 317.72 318.29 318.15 NA NA
## Sep 1959 Oct 1959 Nov 1959 Dec 1959 Jan 1960 Feb 1960 Mar 1960 Apr 1960
## 313.84 313.33 314.81 NA 316.43 316.98 NA NA
## May 1960 Jun 1960 Jul 1960 Aug 1960
## 320.04 319.59 318.18 315.90
```

```
plot(missing_co2)
```

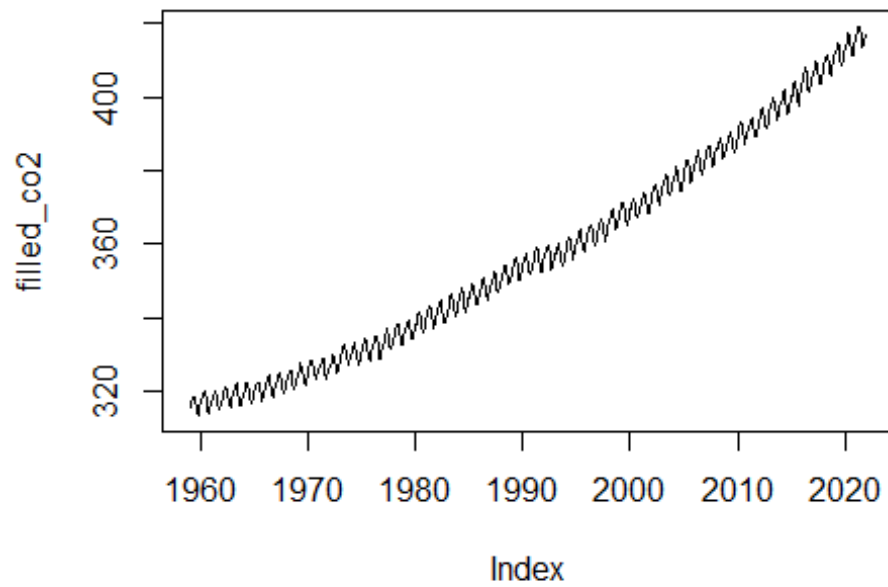


Notice that there are “holes” in the data? this suggests that we’ve got NA values, which is apparent when we view the first few observations with `head()`.

## 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)
```



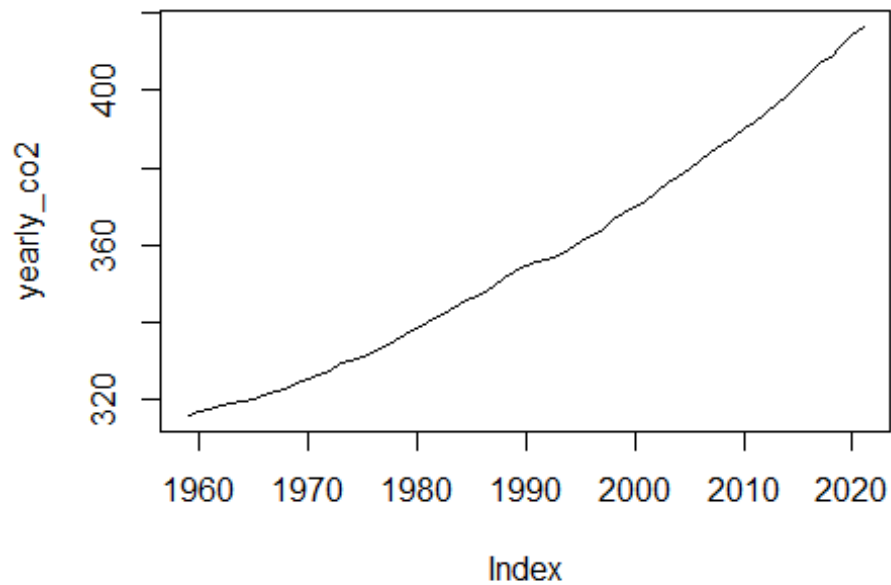
## Yearly Aggregate

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  
)
```

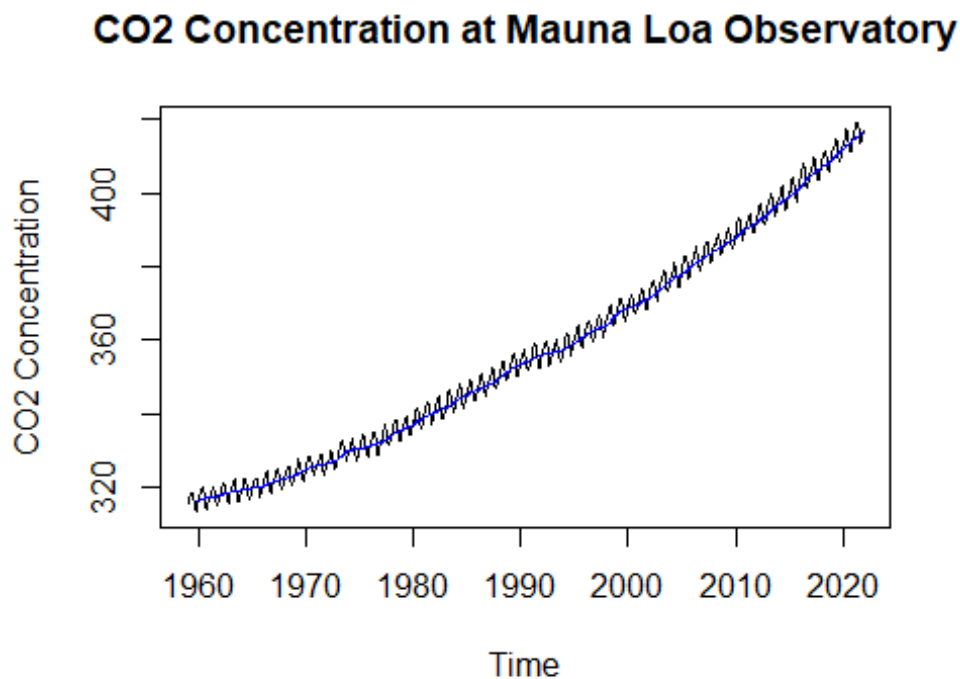
```
plot(yearly_co2)
```



## 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”

```
roll <- rollapplyr(filled_co2,  
  FUN = mean,  
  width = 12  
)  
  
plot(filled_co2,  
  xlab = "Time",  
  ylab = "CO2 Concentration",  
  main = "CO2 Concentration at Mauna Loa Observatory")  
  
lines(roll, col = "blue")
```



## 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)

plot(__,
     xlab = __,
     ylab = __,
     main = "CO2 Concentration at Mauna Loa Observatory")

lines(__, col = __)
```