

4.6: Adding a second Y axis

Introduction

Scatter plots are used to show association between two continuous variables. However, it is not uncommon to have a third variable for which association between the same X variable is expected. Thus, a common scatter plot type includes a second Y axis. These graphs are a bit more involved to make, regardless of which application used. The purpose of this short section is to provide a way to create a plot with two Y axes against a common X axis. Additional plotting options are also provided and explained.

The data set

As I write this note it is September 4, 2019, peak time for hurricanes. Hurricane Dorian passed the Bahamas as a category 4 storm heading for Florida. For context I include a screenshot of imagery from [NOAA](#); you can see Dorian along the Florida coastline as well as four additional storms lined up from the coast of Africa across the Atlantic Ocean (Fig. 4.6.1).



Figure 4.6.1: Screenshot from [NOAA GOES-East – Sector view: Tropical Atlantic – GeoColor](#), 4 September 2019.

The data set here is simply the number of Atlantic Ocean Category 1, 2, 3, 4, or 5 storms since 1900, tabulated by decade. Storms are categorized by wind speed according to the [Saffir-Simpson Hurricane Wind Scale](#), or SSHWS. Additional data of the average levels of carbon dioxide (CO₂), a [greenhouse gas](#), measured at [Mauna Loa](#) and average global temperature index from NOAA were also acquired for the same period. (The temperature index is called anomaly data, as it is the difference of temperature between the average temperatures between 1950 and 1980).

```
#Create the time data, 12 decades, with 2010 based on 8 years only -- up to 2018
decade <- seq(1900,2010, by = 10)
#Saffir-Simpson Hurricane Wind Scale; compiled from Wikipedia, checked against NOAA
cat01 <- c(2,0,1,3,0,9,4,11,18,11,27,46)
cat02 <- c(2,0,1,3,10,4,5,4,3,13,9,8)
cat03 <- c(7,2,3,1,4,10,9,5,4,12,11,7)
cat04 <- c(1,6,5,8,9,10,9,5,5,10,15,8)
cat05 <- c(0,0,2,6,0,2,4,3,3,2,9,4)
#land ocean anomaly temperature index, NOAA
tempIndex <- c(-0.317,-0.329,-0.241,-0.123,0.042,-0.048,-0.028,0.034,0.247,0.387,0.5)
#mauna kea CO2, mean by decade, record starts 1958
co2 <- c(NA,NA,NA,NA,NA,NA,316.0,320.3,330.9,345.5,360.5,378.6,399.0)
```

Combine all of the variables into a single data frame.

```
storms <- data.frame(decade, tempIndex, cat01, cat02, cat03, cat04, cat05, co2)
head(storms)
```

Output from R should look like

	decade	tempIndex	cat01	cat02	cat03	cat04	cat05	co2
1	1900	-0.317	2	2	7	1	0	NA
2	1910	-0.329	0	0	2	6	0	NA
3	1920	-0.241	1	1	3	5	2	NA
4	1930	-0.123	3	3	1	8	6	NA
5	1940	0.042	0	10	4	9	0	NA
6	1950	-0.048	9	4	10	10	2	316

Create a new variable with all categories of storms summed by decade.

```
#Sum all of the storms
allHur <- cat01+cat02+cat03+cat04+cat05
#Add new variable to the data frame
storms$allHur <- allHur
#Attach the data frame so you don't have to keep referring to the data frame when you
attach(storms)
```

Now, create a simple scatter plot of number of hurricanes by decade (Fig. 4.6.2).

```
plot(decade, allHur, pch=16)
```

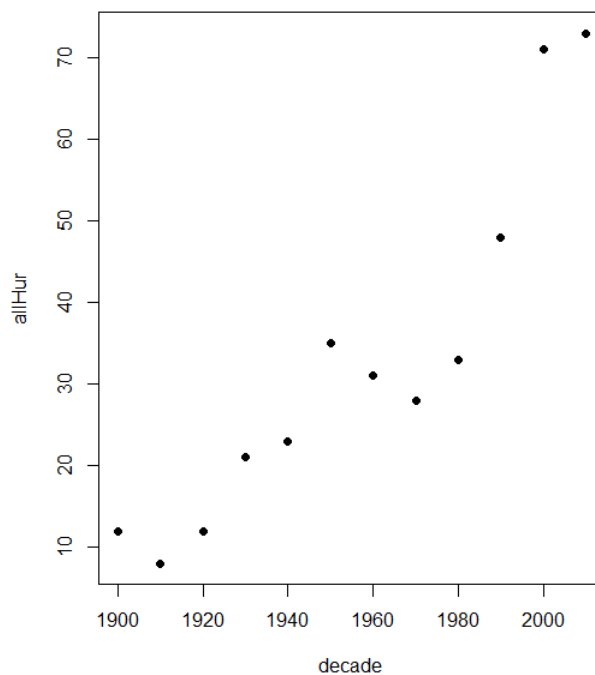


Figure 4.6.2: Plot of hurricanes from 1900 to present by decade.

A note on data management

This note is not needed for the plots. However, it's as good a place as any to comment about how to work with your data in R. For the hurricane data, I set the data frame `storms` as an unstacked (wide) worksheet. The code that follows shows how to use the `reshape2` package, part of the `tidyverse` set of packages for data manipulation, to convert the data frame from unstacked (wide) to stacked (long).

```
#code modified from examples presented at https://seananderson.ca/2013/10/19/reshape/
library(reshape2)
library(dplyr)
tryMe <- melt(storms, id.vars=c("decade", "tempIndex", "co2"), variable.name = "SSHWS")
head(tryMe)
```

You can also take a stacked (long) worksheet and convert it to unstacked (wide) with `dcast()`.

```
tryAgain <- dcast(tryMe, decade + tempIndex + co2 ~ SSHWS)
```

Make the plots

At last, here's the code for adding a second Y axis. Code modified from <https://www.r-bloggers.com/r-single-plot-with-two-different-y-axes/>. The work flow begins by setting parameters of the plotting window, creating the first plot, followed up by adding the second plot (`par=TRUE`), setting graphing elements, then adding labels and a legend.

First plot example: Total number of hurricanes by decades, with Temperature Index by decades. Number of hurricanes represented on first (left) axis and Temperature Index represented on second (right) axis (Fig. 4.6.3).

```
par(mar = c(5,5,2,5))
#Create the first plot
plot(tryAgain$decade, tryAgain$allHur, pch=16, cex=1.5, col="black", xlab="Decades",
```

the syntax `par(mar = c(bottom, left, top, right))`

```
#Add the second plot
par(new=T)
plot(tryAgain$decade, tryAgain$tempIndex, type="l", lty="dashed", lwd=2, col="red3",
axis(side=4)
mtext(side=4,line=3,"Temperature Index")

#Add a legend
legend("topleft",legend=c("Hurricanes", "Temperature Index"),lty=c(0,2), pch=c(16,NA))
```

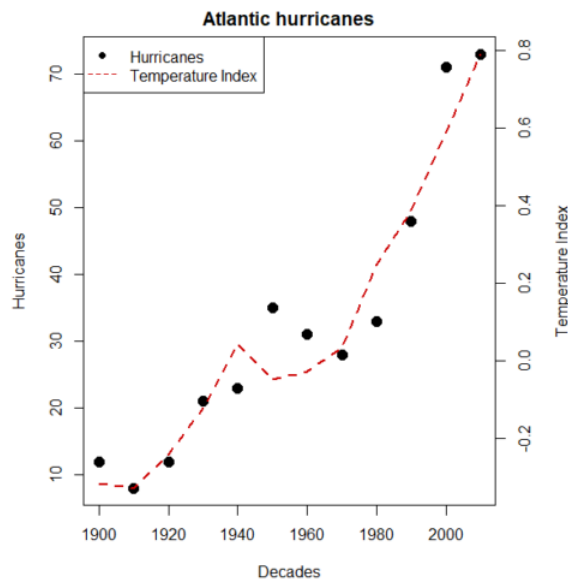


Figure 4.6.3: Total number of hurricanes by decades, with Temperature Index by decades. Number of hurricanes represented on first (left) axis and Temperature Index represented on second (right) axis.

Next plot example: Total number of hurricanes by decades, with Atmospheric CO₂ measured at Mauna Loa by decades. Number of hurricanes represented on first (left) axis and Atmospheric CO₂ represented on second (right) axis (Fig. 4.6.4).

```
par(mar = c(5,5,2,5))
plot(tryAgain$decade, tryAgain$allHur, pch=16, cex=1.5, col="black", xlab="Decades",
```

Create space for the second plot in the same frame (use T or TRUE, both work).

```
par(new=T)
```

Code for the second plot. Note that `axes=F` ("F" or "FALSE" works) is used to suppress printing axes — Recall that lines were already created by the first plot; if you do not add this, then additional lines are added to the plot. "NA" is used to suppress adding labels; if you do not add this code, then labels will be printed over the existing labels created for the first plot. The code `axis=4` sets the right-hand Y axis to active. The next code, `mtext()` is used to place the axis label for the second Y axis.

```
plot(tryAgain$decade, tryAgain$co2, type="l", lty="dashed", lwd=2, col="red3", axes=F,
axis(side=4)
mtext(side=4,line=3,"Mean CO2, ppm")
```

Add the legend.

```
legend("topleft",legend=c("Hurricanes", "CO2"),lty=c(0,2), pch=c(16,NA), col=c("black", "red3"))
```

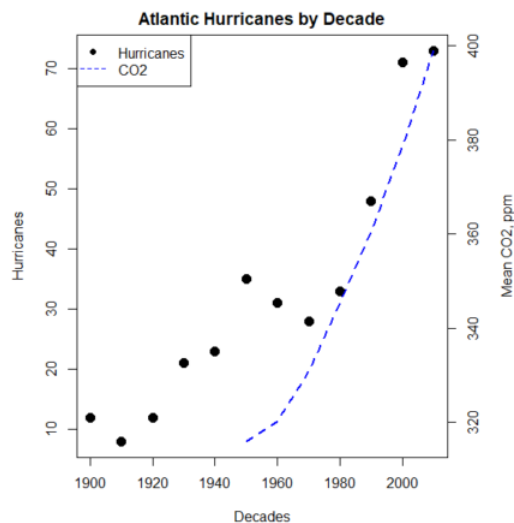


Figure 4.6.4: Total number of hurricanes by decades, with Atmospheric CO₂ measured at Mauna Kea by decades. Number of hurricanes represented on first (left) axis and Atmospheric CO₂ represented on second (right) axis.

Go ahead and try these plots. Change the settings (e.g., `lty`, `pch`, `cex`, `col`), and note how the graphs look.

Questions

- Using the `plot()` command, make the following graphs:
 - One scatter plot for each category of storm by decade
 - Explore the kinds of graph elements available by changing `pch` values. Create your own
 - Change point size by changing valued for `cex`
- Create a new plot with Decade on X axis, Temperature Index on first Y axis, and CO₂ on the second Y axis.
 - Include a legend for the plot.

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