R Training Session

Plot Together: Temperatures in Blacksburg

Erod Baybay

Overview

- Useful functions for data manipulation and plotting
- The ‘hierarchy of aesthetics’ in ggplot2 (I made that term up)
- The troubleshooting and problem solving workflow for presenting data

Loading Packages

- **tidyverse** – For data organization, ‘ggplot2’, dplyr, etc.’

```
library(tidyverse)    # install.packages("tidyverse")
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Importing Data

- **Weather_Data_Blacksburg.csv** – Record temperatures for Blacksburg, Virginia from the National Weather Service

```
weather <- read.csv("https://raw.githubusercontent.com/erodb/datasets/master/Weather_Data_Blacksburg.csv")
```

Viewing the Data

Organized in rows for each day of the year, and columns with individual temperature statistics about that day

```
> colnames(weather)
 [1] "Day"                  "High_Temp_Hottest"    "High_Temp_Hottest_Year" "High_Temp_Coldest"    "High_Temp_Coldest_Year" "Low_Temp_Coldest"     "Low_Temp_Coldest_Year"  "Low_Temp_Hottest"     "Low_Temp_Hottest_Year"
[10] "Normal_High"          "Normal_Low"           "Mean_Temp"              "Heating_Days"         "Cooling_Days"
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> dim(weather)
[1] 365  14
>
> class(weather)
[1] "data.frame"
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> summary(weather)
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 (Other):359
  Cooling_Days
 Min.   :0.000
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Organized in rows for each day of the year, and columns with individual temperature statistics about that day

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 [1] "Day"                  "High_Temp_Hottest"    "High_Temp_Hottest_Year" "High_Temp_Coldest"    "High_Temp_Coldest_Year" "Low_Temp_Coldest"     "Low_Temp_Coldest_Year"  "Low_Temp_Hottest"     "Low_Temp_Hottest_Year"
[10] "Normal_High"          "Normal_Low"           "Mean_Temp"              "Heating_Days"         "Cooling_Days"
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```
> colnames(weather)
```

Gives column names of a data frame

Viewing the Data

Organized in rows for each day of the year, and columns with individual temperature statistics about that day

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```
> dim(weather)
```

Gives dimensions of a data frame

Viewing the Data

Organized in rows for each day of the year, and columns with individual temperature statistics about that day

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> colnames(weather)
 [1] "Day"                  "High_Temp_Hottest"    "High_Temp_Hottest_Year" "High_Temp_Coldest"    "High_Temp_Coldest_Year" "Low_Temp_Coldest"     "Low_Temp_Coldest_Year"  "Low_Temp_Hottest"     "Low_Temp_Hottest_Year"
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> summary(weather)
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```
> class(weather)
```

Gives the object (data type) of an object

Viewing the Data

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```

```
> summary(weather)
```

Gives a column by column summary of a dataframe

Cleaning Up Data

Manipulating data to be easier to work with.

```
weather <- na.omit(weather)
```

na.omit() returns the input where the incomplete rows are removed. Any rows with NA are removed.

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Is the same as:

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weather <- separate(weather, Day, sep = '-', c('Day', 'Month'))
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```

Is the same as:

```
weather <- separate(weather, Day, sep = '-', c('Day', 'Month'))
weather <- mutate(weather, Day = as.numeric(Day))
```

Notice how we have **weather** as the first parameter in **mutate()** and **separate()**
The first parameter is usually the input parameter - The pipe operator handles the input for us

We use the pipe operator if we want to do a series of operations to a single piece of data – like a conveyor belt

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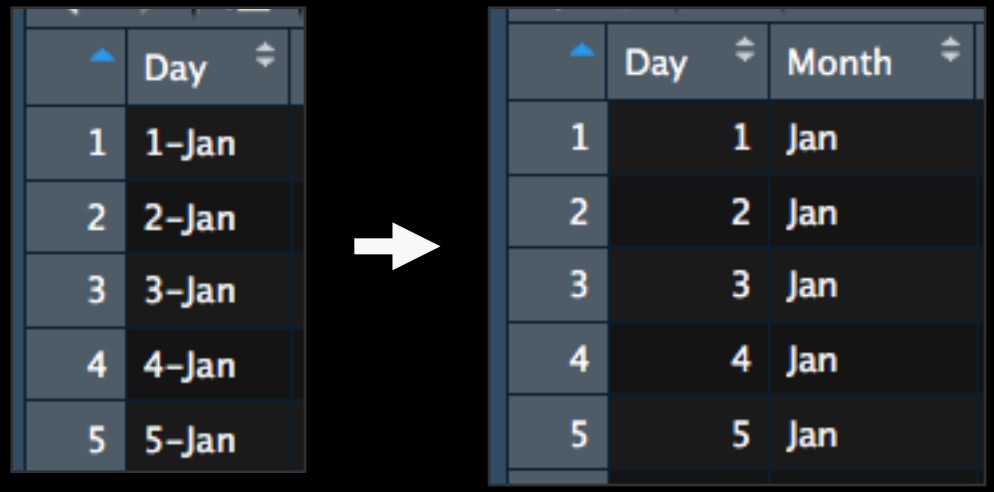
```

separate() takes a column, and splits it into multiple columns based on a delimiter (in this case, '-')



	Day
1	1-Jan
2	2-Jan
3	3-Jan
4	4-Jan
5	5-Jan

	Day	Month
1	1	Jan
2	2	Jan
3	3	Jan
4	4	Jan
5	5	Jan

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```
weather <- weather %>% separate(Day, sep = '-', c('Day', 'Month')) %>% mutate(Day = as.numeric(Day))
```

mutate() can alter, manipulate, and create columns while keeping the input dataset

In this case we do something uneventful

Alternative: transmute() can alter, manipulate, and create columns while deleting the input dataset

Exercise 1

Separate and Mutate (and also Pipes)

A tibble (fancier data frame) is made as follows:

```
myData <- tibble('AB' = c('1:5','2:3','4:9','1:0','5:4'))
```

Exercise 1

Separate and Mutate (and also Pipes)

A tibble (fancier data frame) is made as follows:

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myData <- tibble('AB' = c('1:5','2:3','4:9','1:0','5:4'))
```

How would you perform the transformation below?

	AB
1	1:5
2	2:3
3	4:9
4	1:0
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	A	B	A+B
1	1	5	6
2	2	3	5
3	4	9	13
4	1	0	1
5	5	4	9

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3	4	9	13
4	1	0	1
5	5	4	9

A

```
myData <- myData %>%
  mutate('A+B' = as.numeric(A) + as.numeric(B)) %>%
  separate('AB', sep = ':', c('A','B'))
```

B

```
myData <- myData %>%
  separate('AB', sep = ':', c('A','B')) %>%
  mutate('A+B' = as.numeric(A) + as.numeric(B))
```

C

```
myData <- myData %>% ddapply(separate('AB', sep = ':', c('A','B')),
                             mutate('A+B' = as.numeric(A) + as.numeric(B)),
                             mode = 'simultaneous')
```

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3	4	9	13
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A

```
myData <- myData %>%
  mutate('A+B' = as.numeric(A) + as.numeric(B)) %>%
  separate('AB', sep = ':', c('A','B'))
```

Wrong order

B

```
myData <- myData %>%
  separate('AB', sep = ':', c('A','B')) %>%
  mutate('A+B' = as.numeric(A) + as.numeric(B))
```

C

```
myData <- myData %>% ddapply(separate('AB', sep = ':', c('A','B')),
                             mutate('A+B' = as.numeric(A) + as.numeric(B)),
                             mode = 'simultaneous')
```

ddapply() isn't even a function

Initial Plotting

Visualizing our data

We begin by piping in our dataset (weather)

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
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ggplot() initializes the canvas of our plot

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```

ggplot() initializes the canvas of our plot

aes() assigns aesthetics to our plot based on our input (position, color, size on our plot) This is called Mapping

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geom_segment() creates line segments

Draws a line segment from **(x,y)** to **(xend, yend)**

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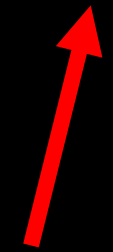
geom_segment() creates line segments

Draws a line segment from **(x,y)** to **(xend, yend)**

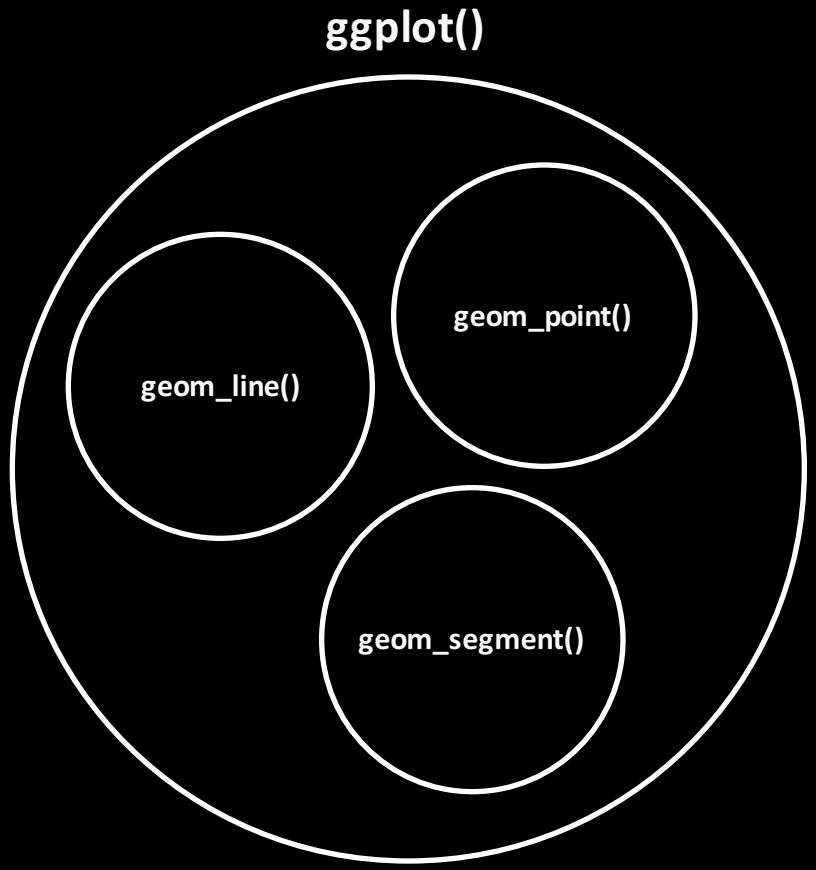


Also note how **Month** is mapped to **color**

Line thickness (size) is fixed to 3

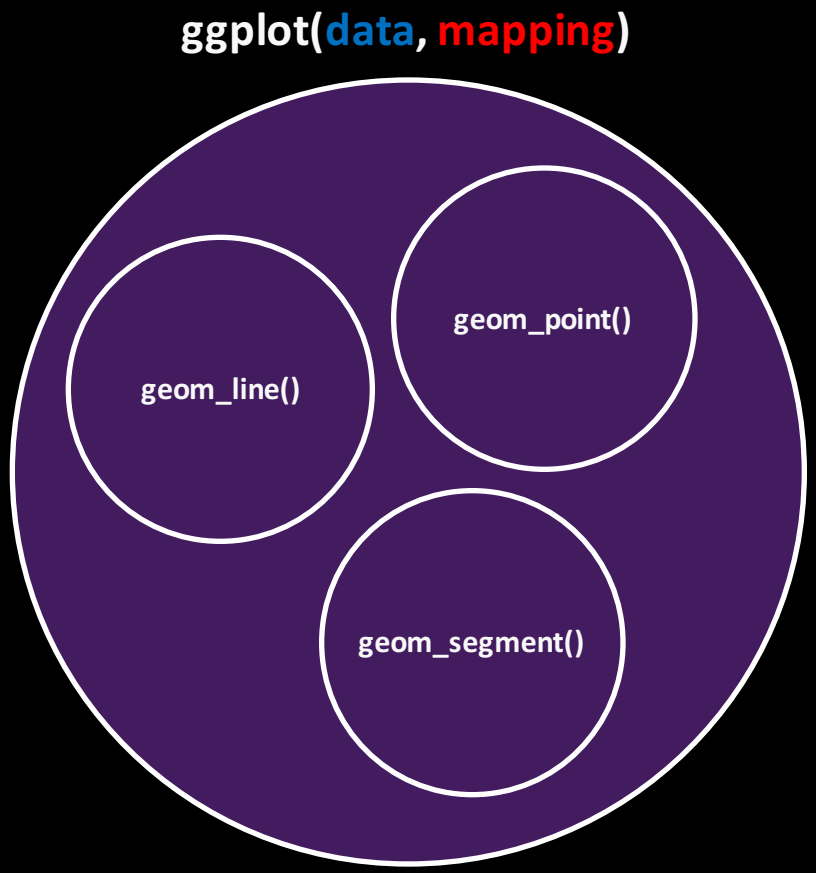
Initial Plotting

Hierarchy of Aesthetics



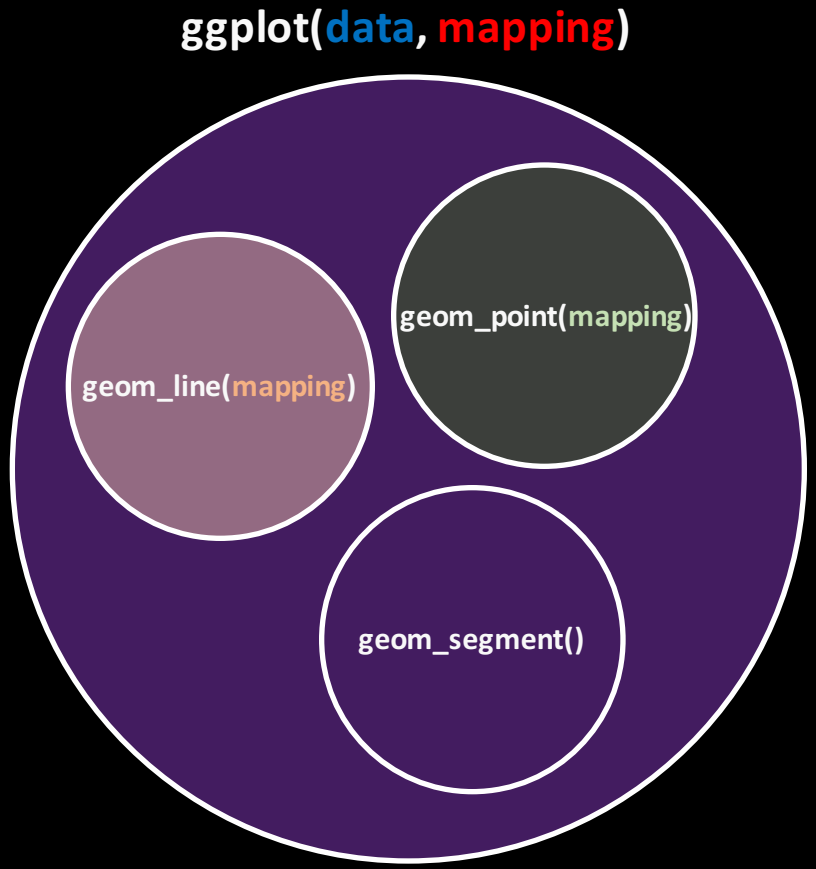
Initial Plotting

Hierarchy of Aesthetics



Initial Plotting

Hierarchy of Aesthetics



Initial Plotting

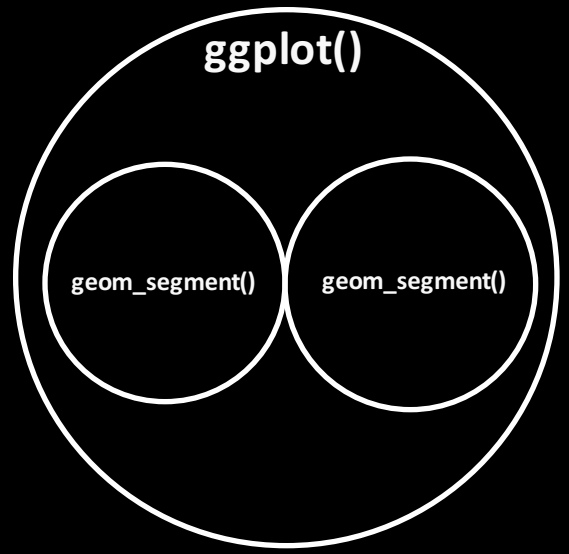
Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

Initial Plotting

Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

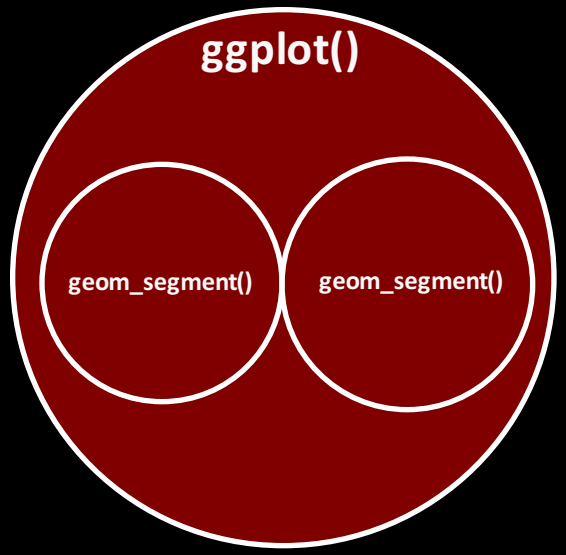


Initial Plotting

Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

This mapping is preserved across all geometries



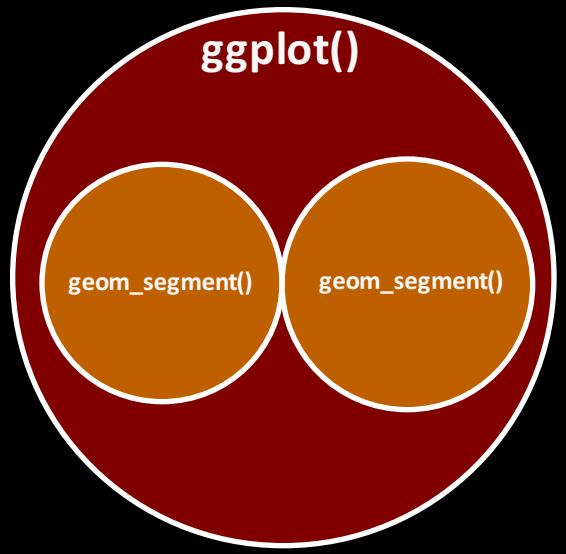
Initial Plotting

Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

This mapping is preserved across all geometries

These mappings apply only to their respective geometries



Initial Plotting

Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

What will we get if we run this?

Initial Plotting

Visualizing our data

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

What will we get if we run this?

Spoiler: It won't be a useful plot

Exercise 2

Line Segments and Aesthetics

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

geom_segment() creates line segments

Draws a line segment from **(x,y)** to **(xend, yend)**

Are the lines vertical or horizontal? How many **colors** will there be on our plot?

Exercise 2

Line Segments and Aesthetics

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

geom_segment() creates line segments

Draws a line segment from **(x,y)** to **(xend, yend)**

Are the lines vertical or horizontal? How many **colors** will there be on our plot?

A vertical, 12

B vertical, 31

C horizontal, 12

D horizontal, 31

Exercise 2

Line Segments and Aesthetics

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3)
```

geom_segment() creates line segments

Draws a line segment from **(x,y)** to **(xend, yend)**

Are the lines vertical or horizontal? How many **colors** will there be on our plot?

```
x = Day, xend = Day,
```

```
color = Month
```

A vertical, 12

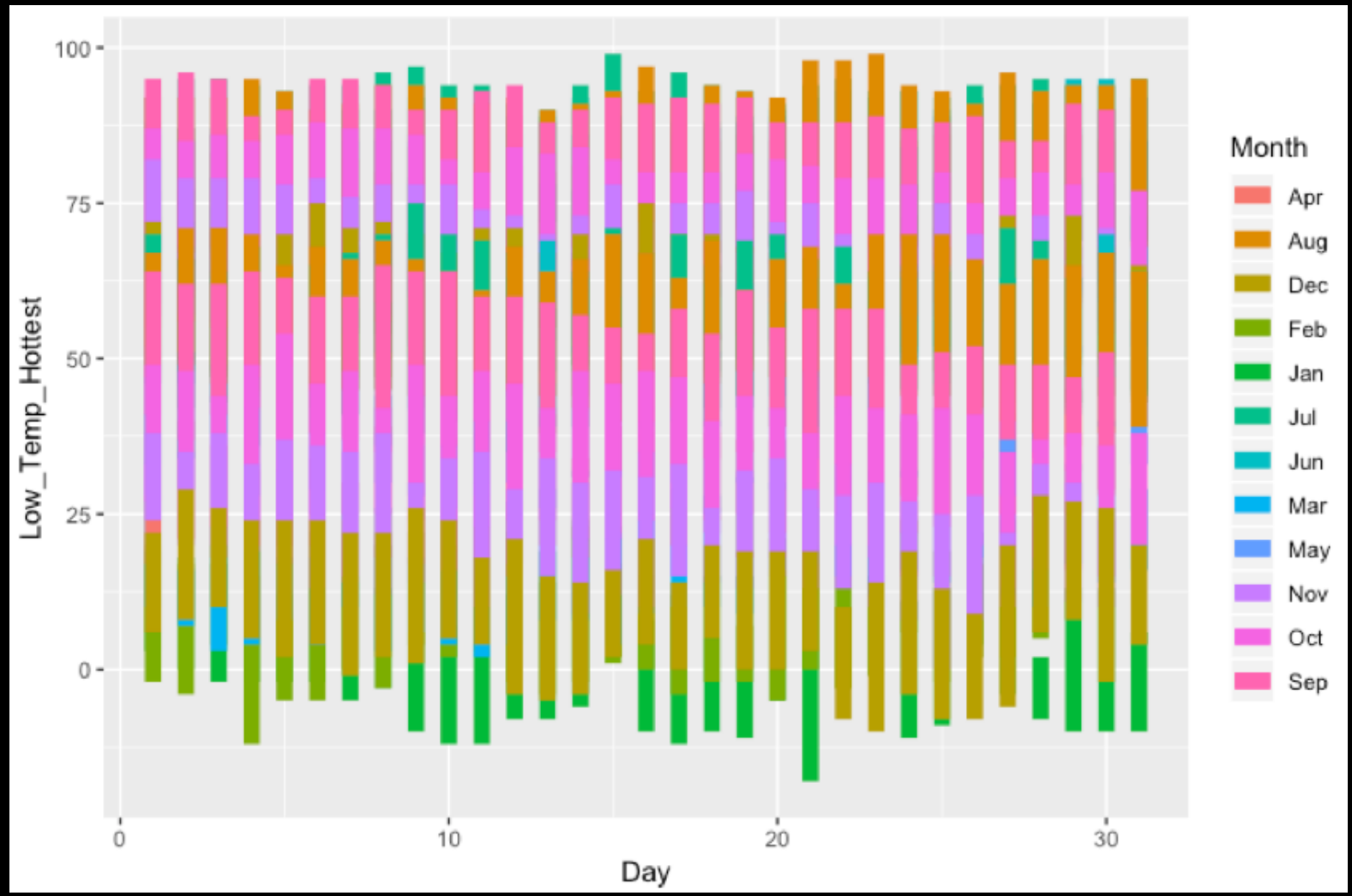
B vertical, 31

C horizontal, 12

D horizontal, 31

Initial Plotting

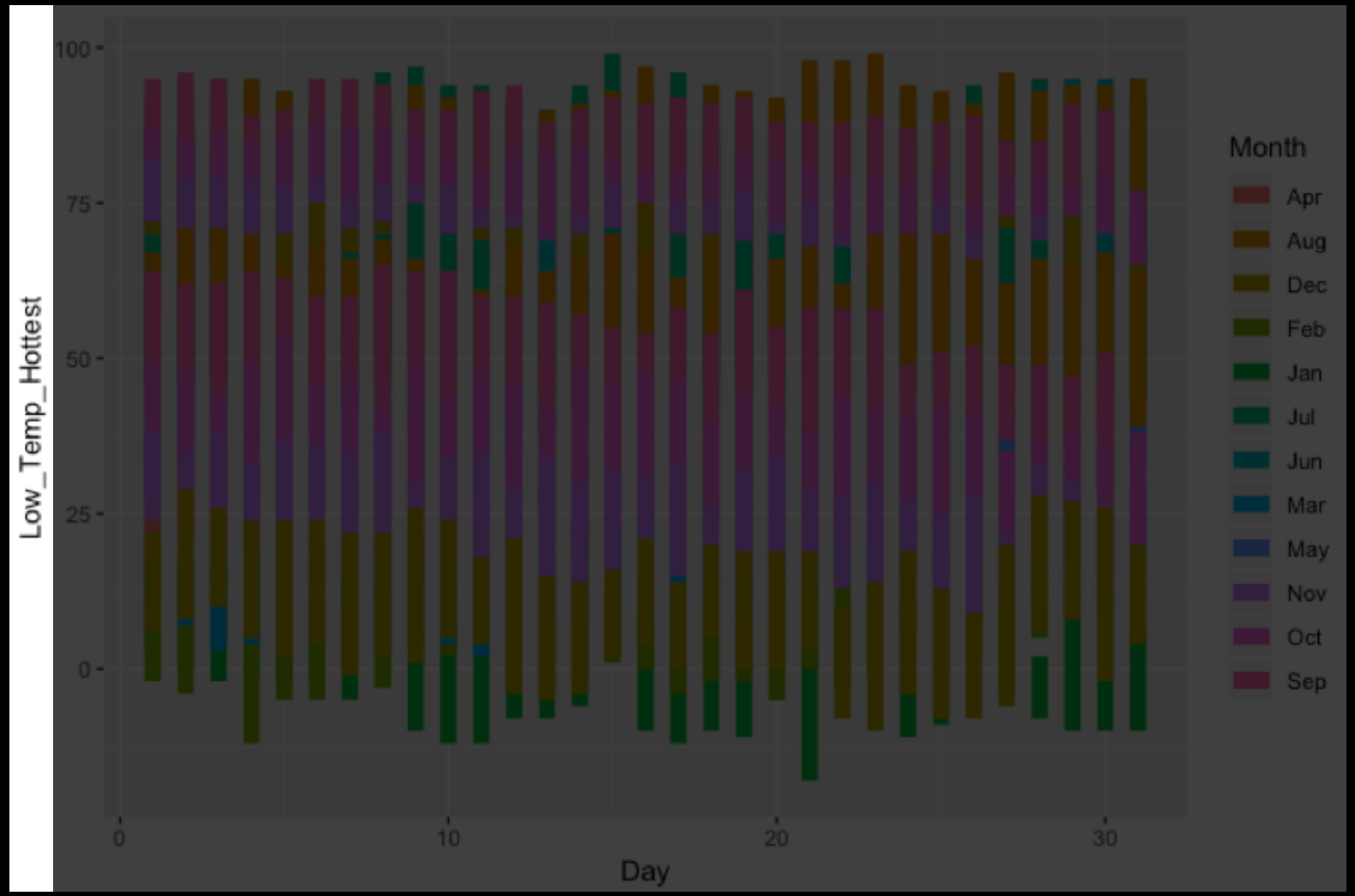
Visualizing our data



Initial Plotting

Visualizing our data

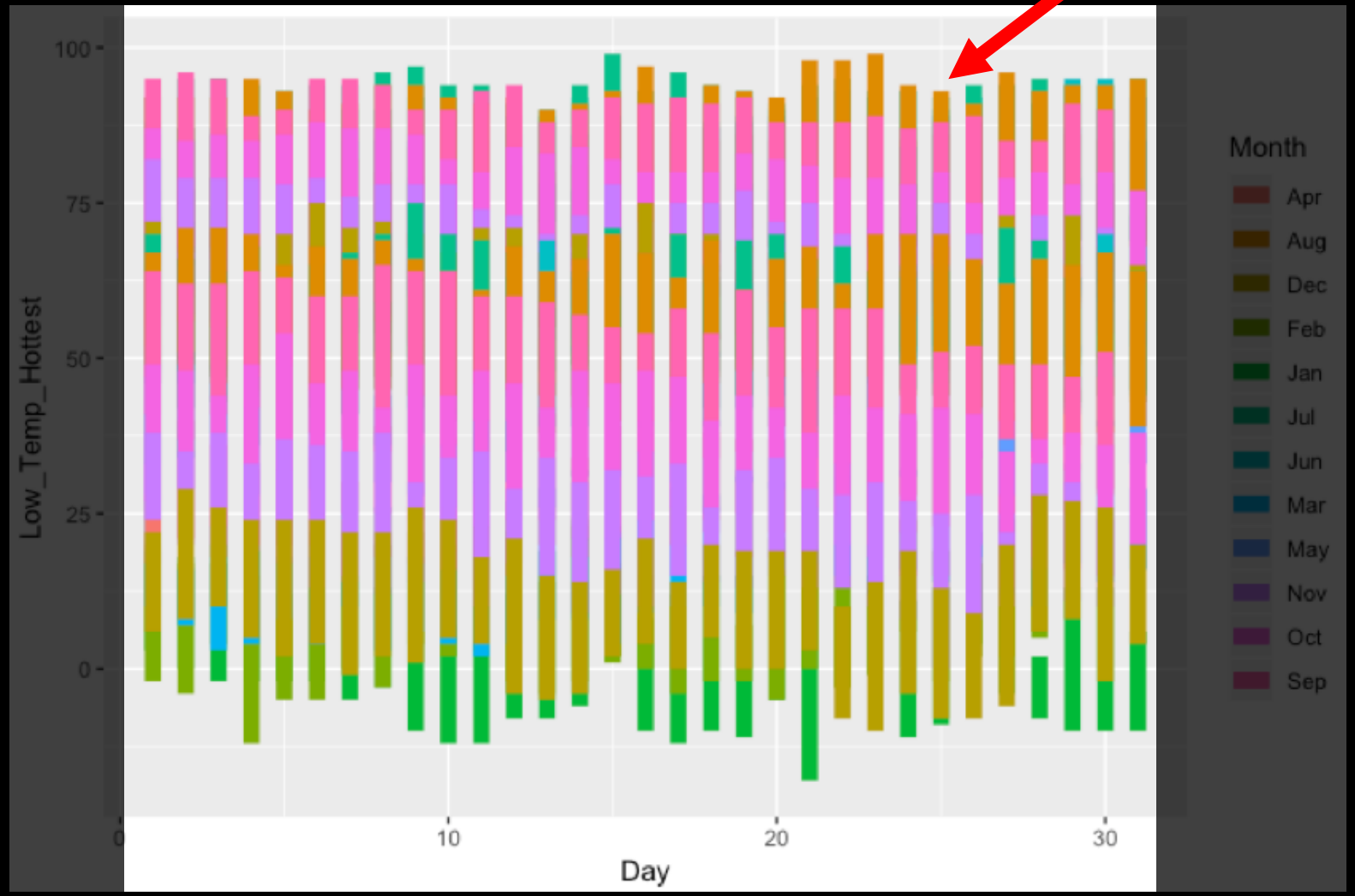
Axis Title
isn't correct



Initial Plotting

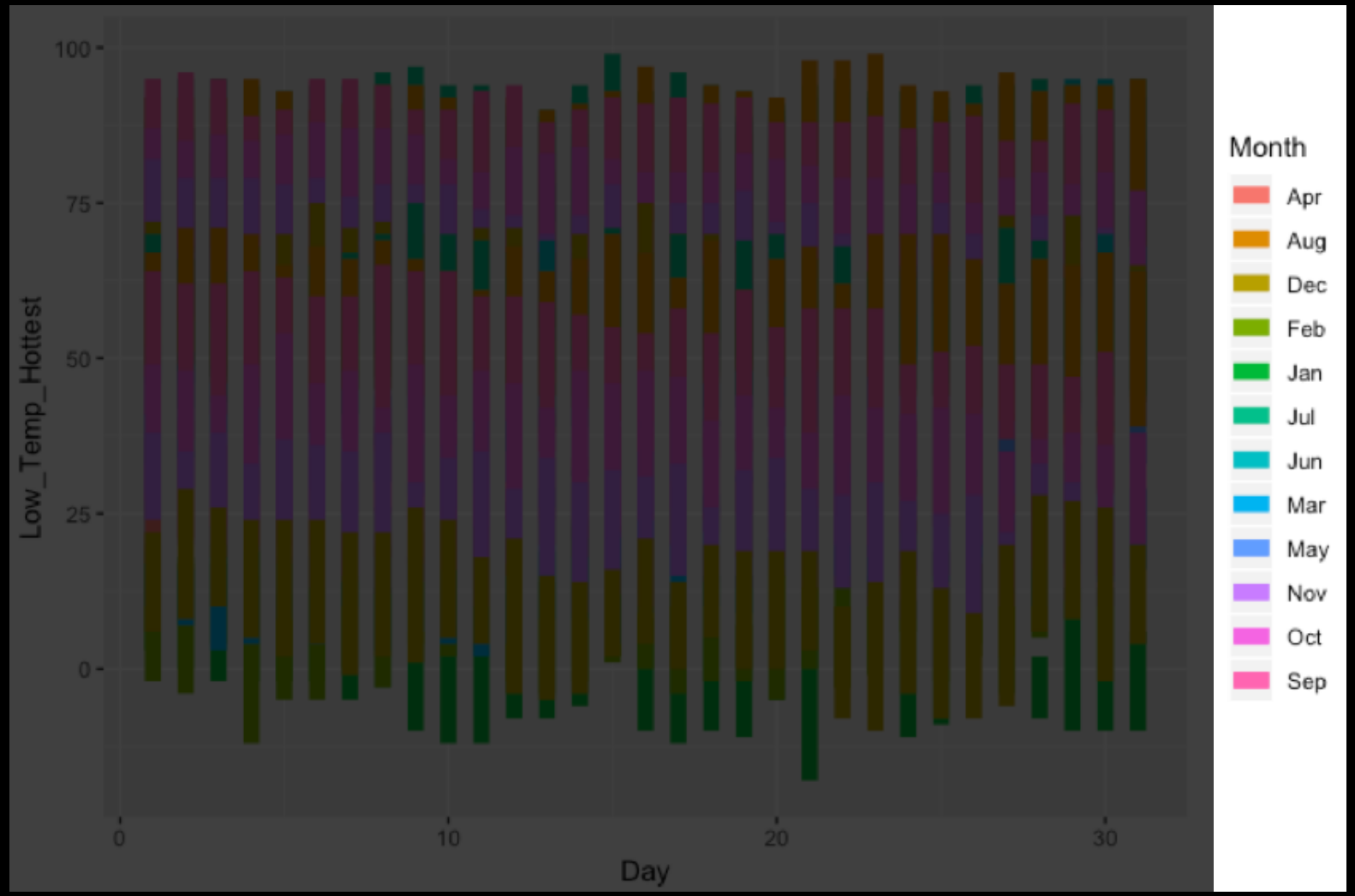
Visualizing our data

Excess overlapping data
We can't distinguish between highs and lows



Initial Plotting

Visualizing our data



Alphabetical,
Not Chronological

Better Plotting

Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~Month, nrow = 1, strip.position = "top")
```

Better Plotting

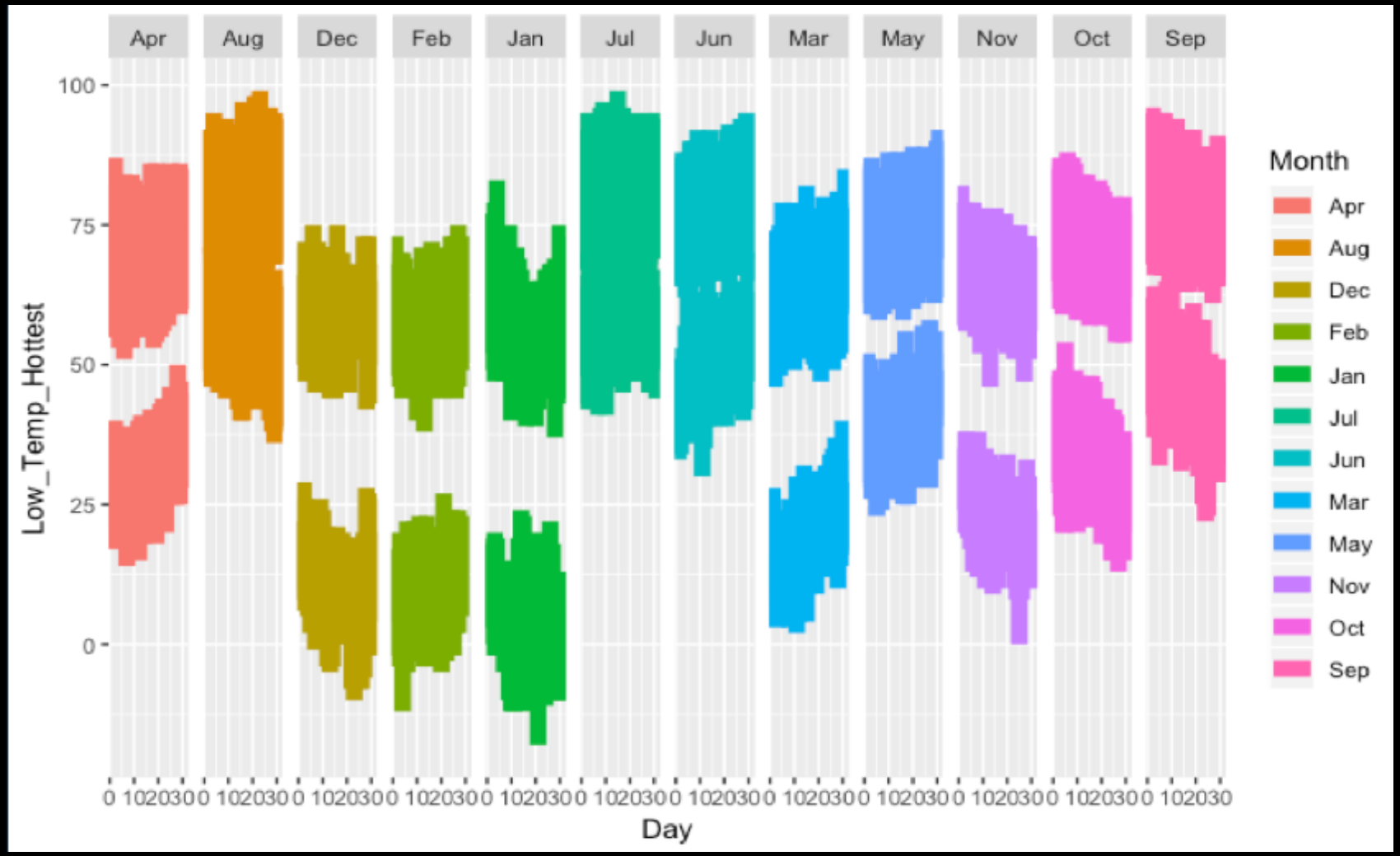
Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~Month, nrow = 1, strip.position = "top")
```

facet_wrap() splits up a single plot into multiple plots, labeled by data type

Better Plotting

Making a clearer plot



Better Plotting

Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

Better Plotting

Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

factor() converts a vector into a factor

Factors are objects that categorize data into a way that stores levels

Better Plotting

Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

unique() returns all unique names in a factor in the order that they appear

Better Plotting

Making a clearer plot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = Month), size = 3) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = Month), size = 3) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

unique() returns all unique names in a factor in the order that they appear

This forces **facet_wrap()** to maintain the original order of the dataset, by altering the levels parameter

Exercise 3

Playing with Factors

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

Exercise 3

Playing with Factors

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would **unique()** return?

Exercise 3

Playing with Factors

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would **unique()** return?

A

```
> unique(myData)
[1] E D C B A
Levels: A B C D E
```

B

```
> unique(myData)
[1] A B C D E
Levels: A B C D E
```

C

```
> unique(myData)
[1] A E B C D
Levels: A B C D E
```

Exercise 3

Playing with Factors

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would **unique()** return?

A

```
> unique(myData)
[1] E D C B A
Levels: A B C D E
```

B

```
> unique(myData)
[1] A B C D E
Levels: A B C D E
```

C

```
> unique(myData)
[1] A E B C D
Levels: A B C D E
```

Exercise 4

Playing with Factors… again

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would the **levels()** function on **factor(myData, levels = unique(myData))** return?

Exercise 4

Playing with Factors… again

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would the **levels()** function on **factor(myData, levels = unique(myData))** return?

A

```
> levels(factor(myData, levels = unique(myData)))
[1] "E" "D" "C" "B" "A"
```

B

```
> levels(factor(myData, levels = unique(myData)))
[1] "A" "E" "B" "C" "D"
```

C

```
> levels(factor(myData, levels = unique(myData)))
[1] "A" "B" "C" "D" "E"
```

Exercise 4

Playing with Factors… again

We create a factor comprised of a series of letters

```
myData <- factor(c("A","A","E","B","B","C","D"))
```

The **levels()** function returns this:

```
> levels(myData)
[1] "A" "B" "C" "D" "E"
```

What would the **levels()** function on **factor(myData, levels = unique(myData))** return?

A

```
> levels(factor(myData, levels = unique(myData)))
[1] "E" "D" "C" "B" "A"
```

B

```
> levels(factor(myData, levels = unique(myData)))
[1] "A" "E" "B" "C" "D"
```

C

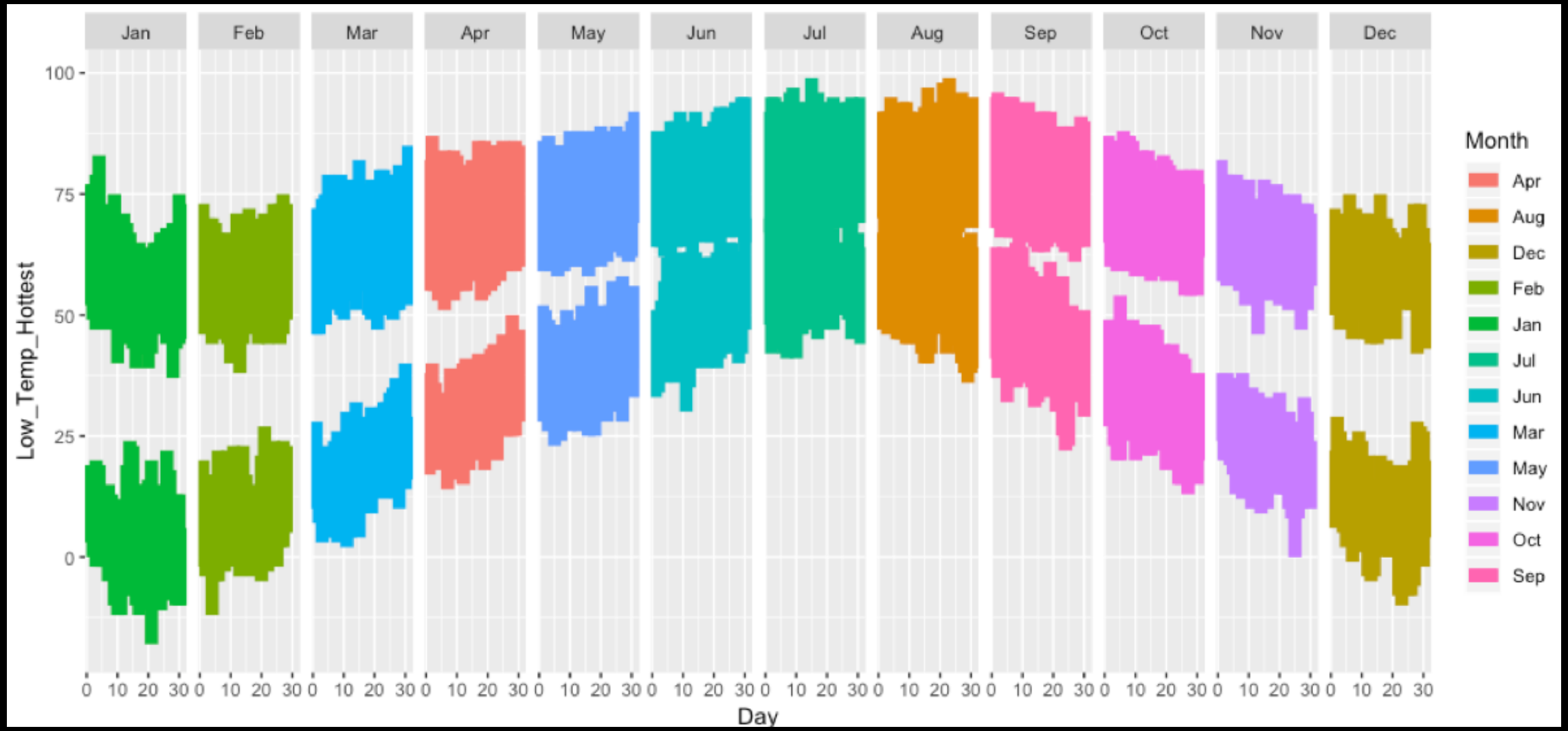
```
> levels(factor(myData, levels = unique(myData)))
[1] "A" "B" "C" "D" "E"
```

We've simply set the levels to be the same as what unique(myData) would return

Better Plotting

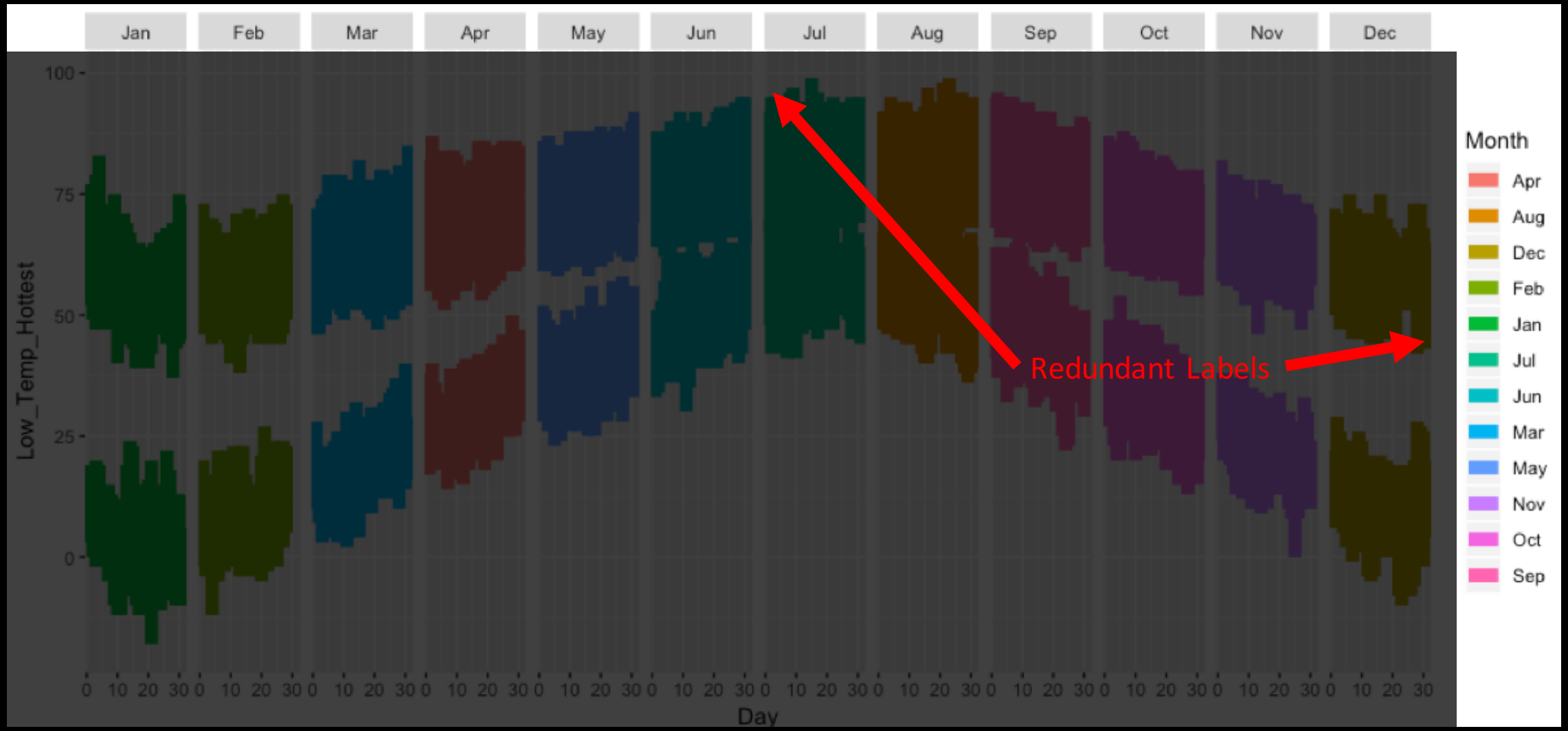
Making a clearer plot

```
facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```



Better Plotting

Making a clearer plot



Better Plotting

Let's add more information

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

Better Plotting

Let's add more information

Color parameter is no longer inside aes()

Decoupled the color from the data,
Color is now coupled to the geometry

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

Better Plotting

Let's add more information

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```
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  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top")
```

Let's plot the average highs and lows too

Exercise 5

Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

Exercise 5

Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We can plot this data with

```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = category))
```

Exercise 5

Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We can plot this data with

```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = category))
```

How many colors will be on this new plot?

A	3
B	5
C	1

Exercise 5

Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

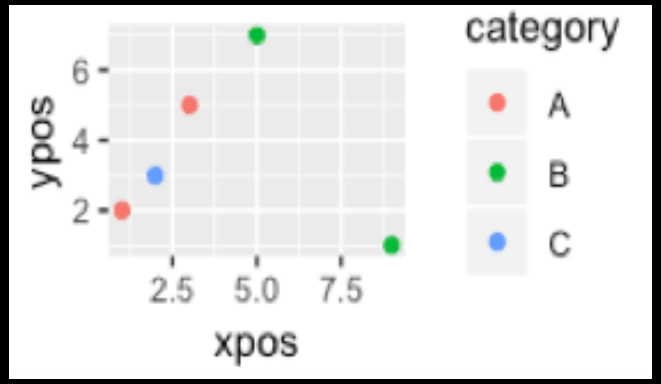
	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We can plot this data with

```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = category))
```

How many colors will be on this new plot?

A	3
B	5
C	1



Exercise 6

More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = 'category'))
```

Exercise 6

More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = 'category'))
```

How many colors will be on this new plot?

A 3

B 5

C 1

Exercise 6

More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

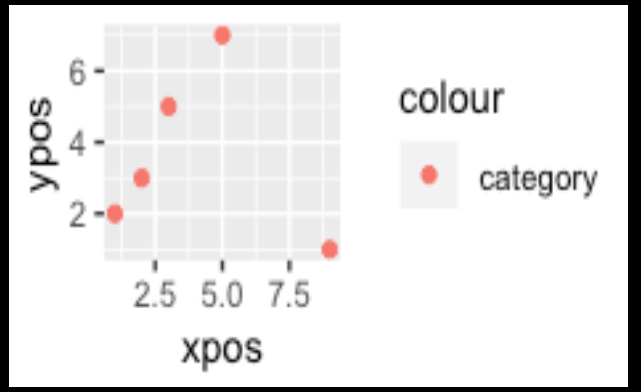
```
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, color = 'category'))
```

How many colors will be on this new plot?

A 3

B 5

C 1



Exercise 7

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos), color = category)
```

Exercise 7

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos), color = category)
```

Will there be a legend on this plot?

A Yes

B No

Exercise 7

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

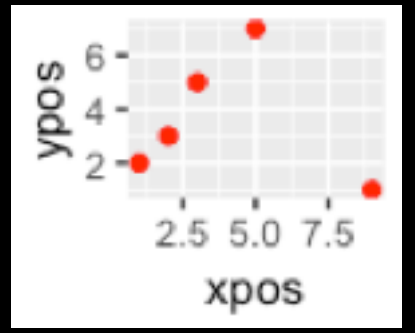
We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos), color = category)
```

Will there be a legend on this plot?

A Yes

B No



Legends only appear for mappings inside aes()
Not parameters outside of aes()

Exercise 8

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, size = category), color = category)
```

Exercise 8

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, size = category), color = category)
```

Will there be a legend on this plot?

A Yes

B No

Exercise 8

Even More Colors and Aesthetics in ggplot

Given the dataset:

```
myData <- tibble('xpos' = c(1,3,5,9,2),
                 'ypos' = c(2,5,7,1,3),
                 'category' = c('A','A','B','B','C'))
```

	xpos	ypos	category
1	1	2	A
2	3	5	A
3	5	7	B
4	9	1	B
5	2	3	C

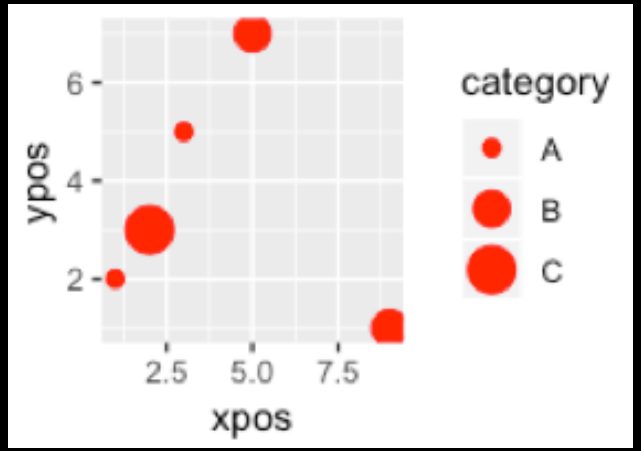
We instead plot this data with

```
category = 'red'
ggplot(data = myData) +
  geom_point(aes(x = xpos, y = ypos, size = category), color = category)
```

Will there be a legend on this plot?

A Yes

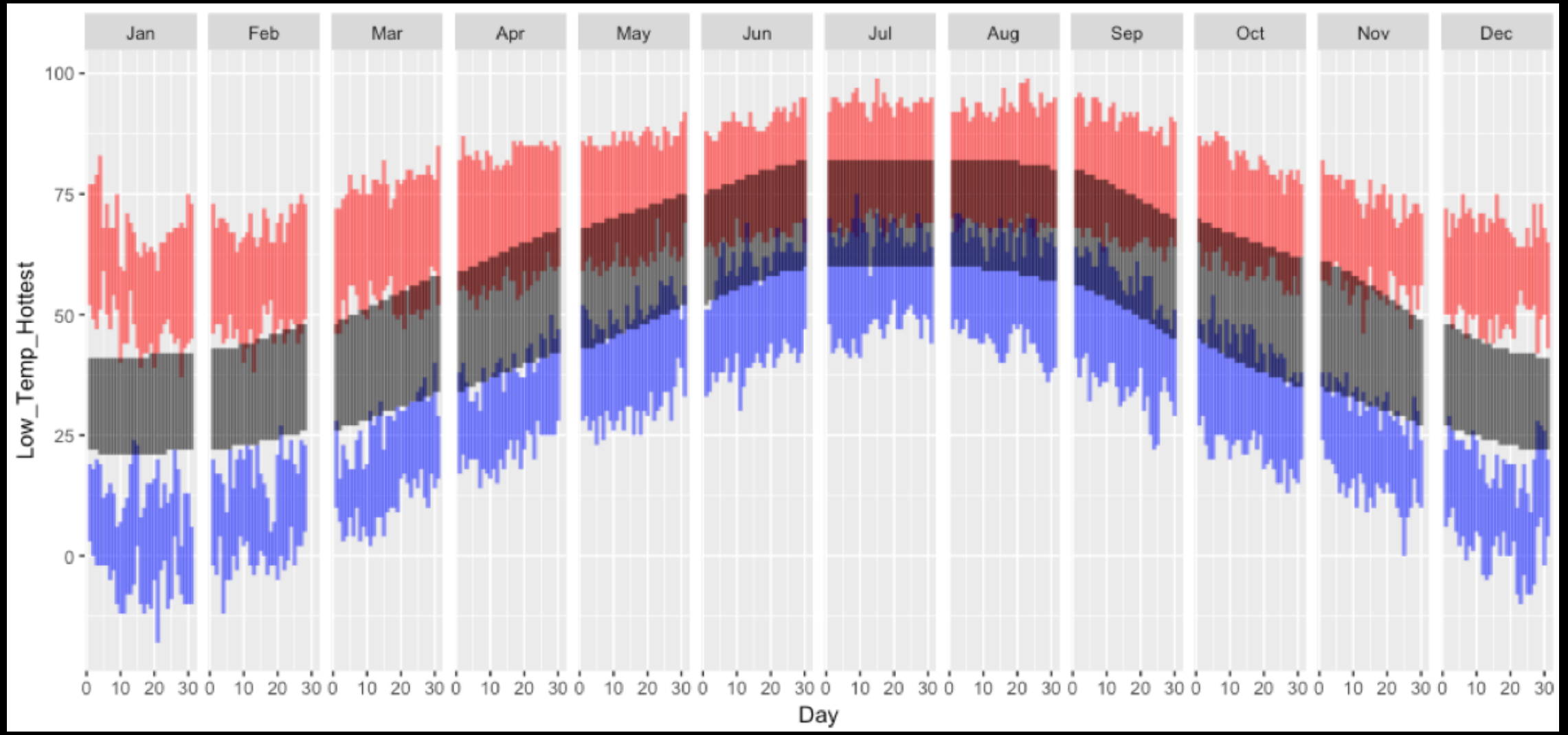
B No



Size is inside the aes() parameter
Therefor it contributes to the legend

Better Plotting

Let's add more information



Cosmetic Adjustment

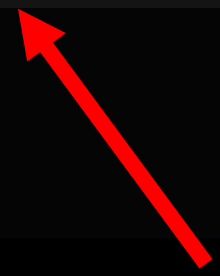
Finishing Touches

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       y = "Temperature [°F]", x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```

Cosmetic Adjustment

Finishing Touches

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       y = "Temperature [°F]", x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```



Add a second y-axis scale

Cosmetic Adjustment

Finishing Touches

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       y = "Temperature [°F]", x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```

Add a second y-axis scale

*We still want to keep the Fahrenheit scale so that the plot remains American compatible

Cosmetic Adjustment

Finishing Touches

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       y = "Temperature [°F]", x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```

Change labels with labs()

Cosmetic Adjustment

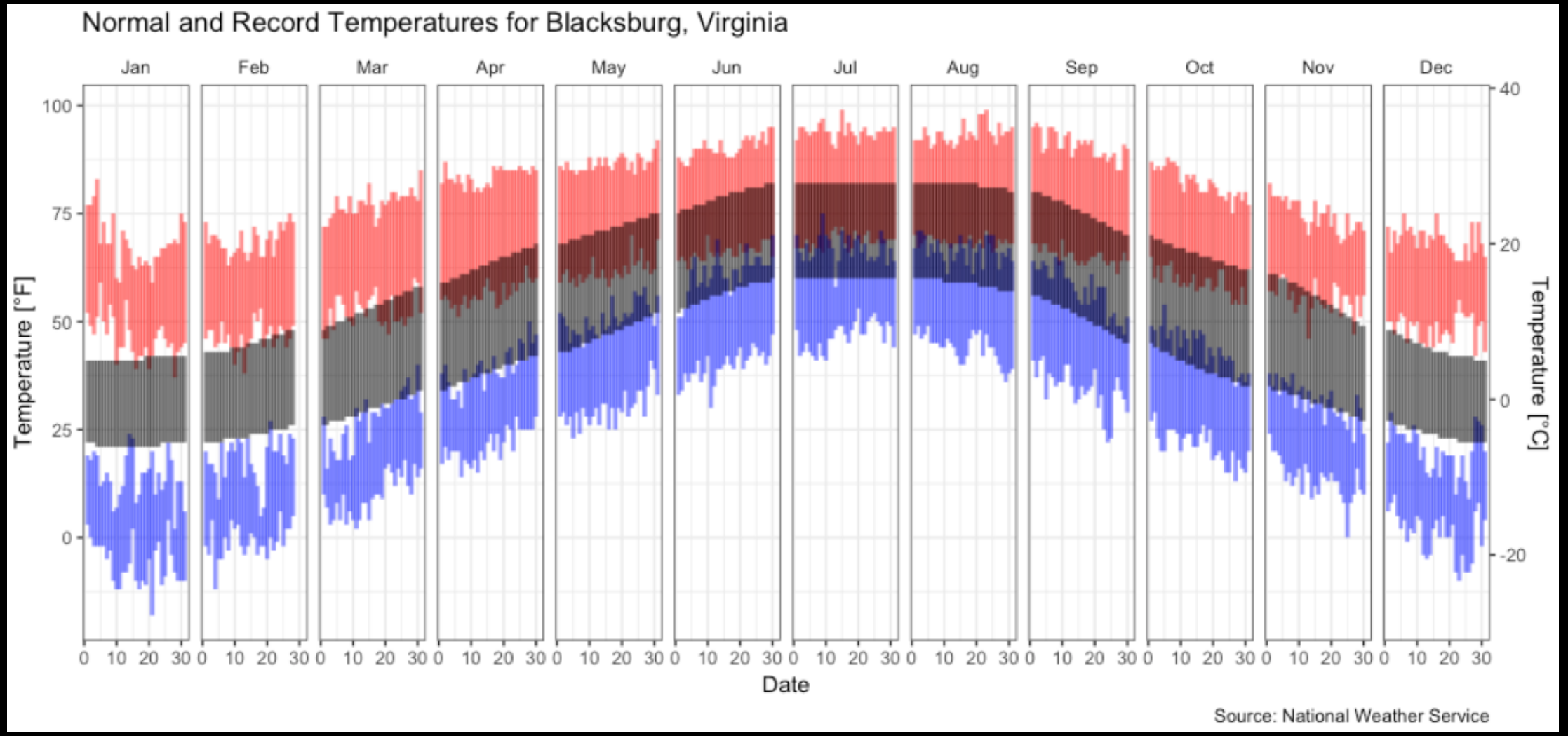
Finishing Touches

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest), size = 1, color = 'red', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest), size = 1, color = 'blue', alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High), size = 1, color = 'black', alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       y = "Temperature [°F]", x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```

A cleaner theme

Cosmetic Adjustment

Finishing Touches



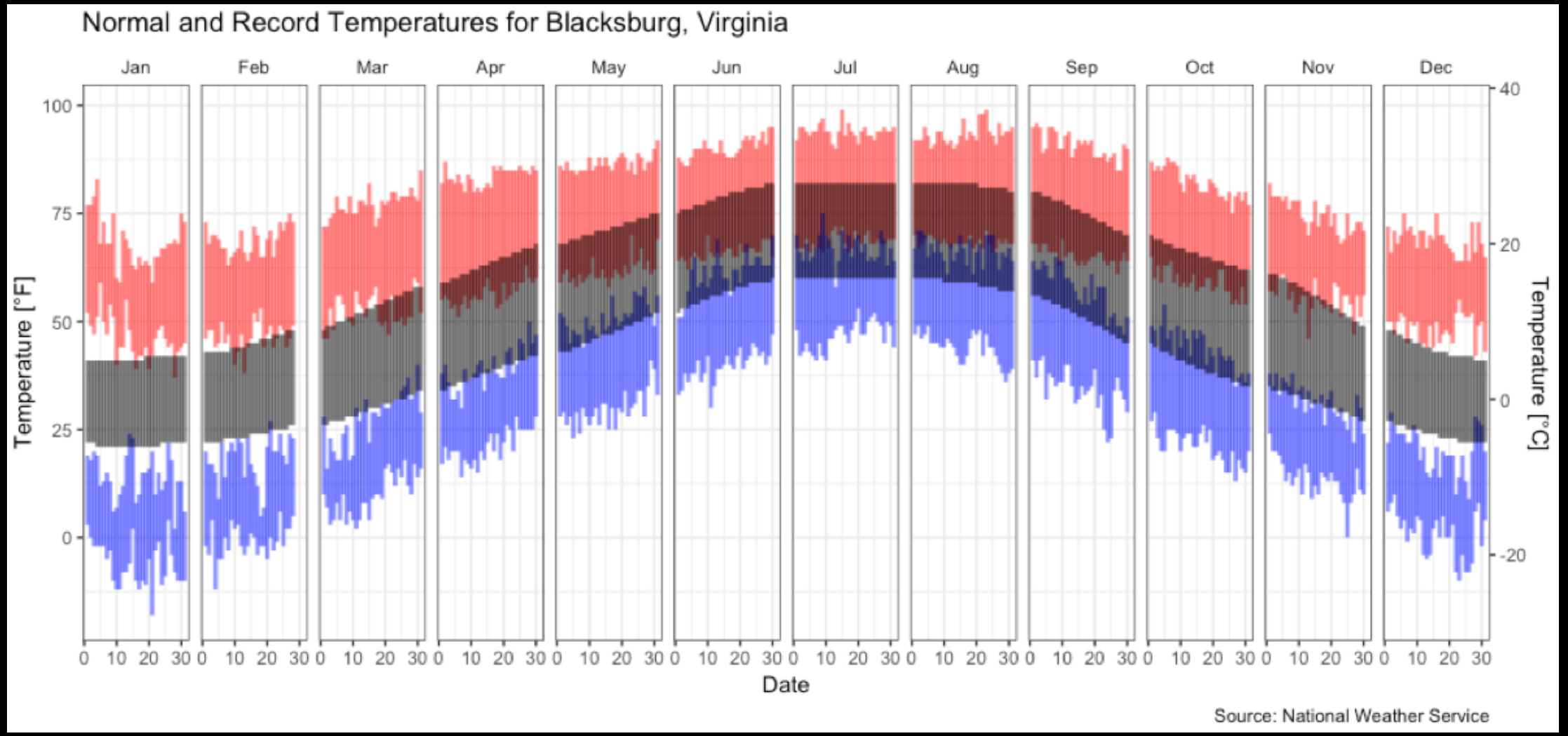
Even Better Plotting

Adding what we forgot

We forgot some things

Even Better Plotting

Adding what we forgot



Where's the legend?

Even Better Plotting

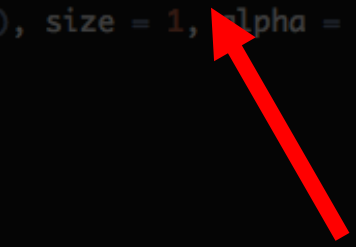
Adding what we forgot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```

Even Better Plotting

Adding what we forgot

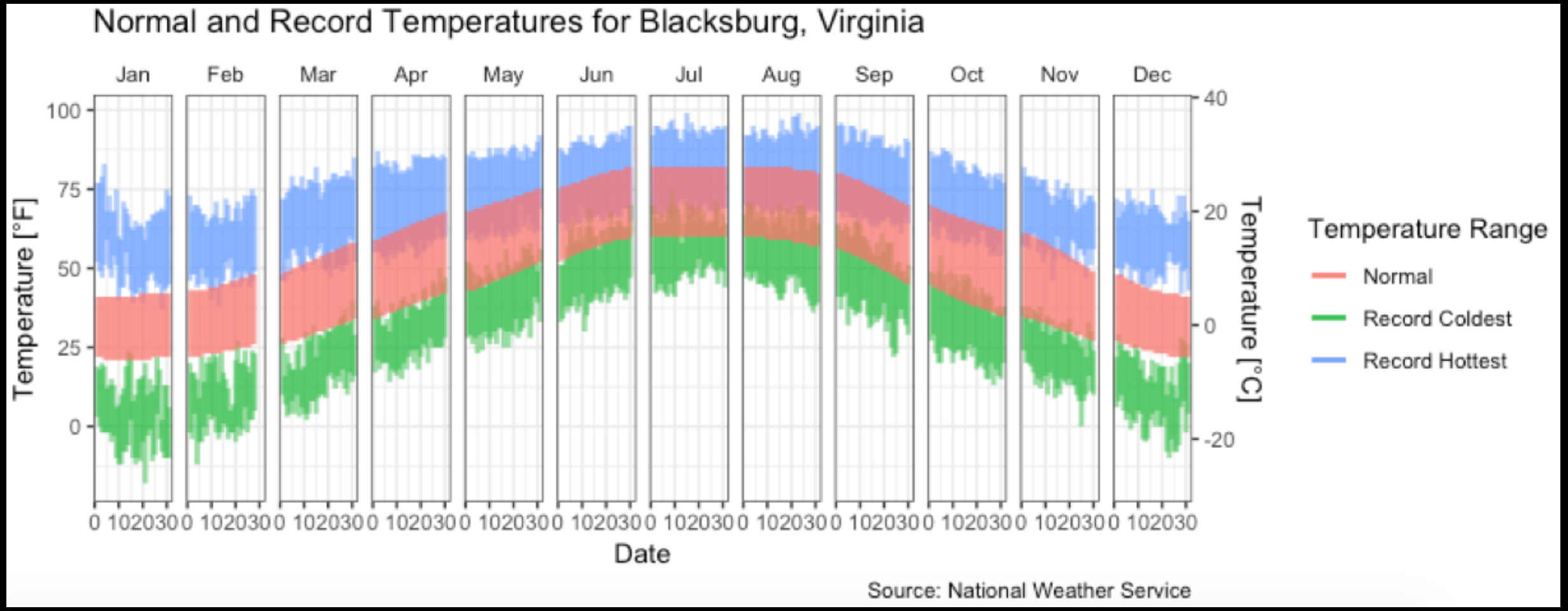
```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank())
```



Recouple the color parameter to aes()

Even Better Plotting

Adding what we forgot



Even Better Plotting

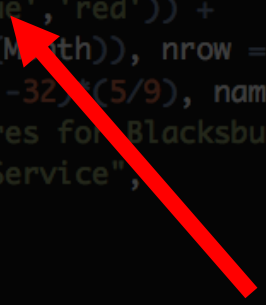
Adding what we forgot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  geom_hline(aes(yintercept = 32), alpha = 0.3) +
  scale_color_manual(values = c('black','blue','red')) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank(),
        legend.position = 'bottom',
        legend.text = element_text(size = 8))
```

Even Better Plotting

Adding what we forgot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  geom_hline(aes(yintercept = 32), alpha = 0.3) +
  scale_color_manual(values = c('black','blue','red')) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank(),
        legend.position = 'bottom',
        legend.text = element_text(size = 8))
```



Add a horizontal line for freezing point

Even Better Plotting

Adding what we forgot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  geom_hline(aes(yintercept = 32), alpha = 0.3) +
  scale_color_manual(values = c('black','blue','red')) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 4, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank(),
        legend.position = 'bottom',
        legend.text = element_text(size = 8))
```

Manually adjust the color scale back to our original colors

Even Better Plotting

Adding what we forgot

```
weather %>%
  ggplot(aes(group = Month)) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Hottest, yend = High_Temp_Hottest, color = 'Record Hottest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Low_Temp_Coldest, yend = High_Temp_Coldest, color = 'Record Coldest'), size = 1, alpha = 0.5) +
  geom_segment(aes(x = Day, xend = Day, y = Normal_Low, yend = Normal_High, color = 'Normal'), size = 1, alpha = 0.5) +
  geom_hline(aes(yintercept = 32), alpha = 0.3) +
  scale_color_manual(values = c('black','blue','red')) +
  facet_wrap(~factor(Month, levels = unique(Month)), nrow = 1, strip.position = "top") +
  scale_y_continuous(sec.axis = sec_axis(~(.-32)*(5/9), name = "Temperature [°C]")) +
  labs(title = "Normal and Record Temperatures for Blacksburg, Virginia",
       caption = "Source: National Weather Service",
       color = "Temperature Range",
       y = "Temperature [°F]",
       x = "Date") +
  theme_bw() +
  theme(strip.background = element_blank(),
        legend.position = 'bottom',
        legend.text = element_text(size = 8))
```

Reposition the Legend

Even Better Plotting

Adding what we forgot