Geographical Maps with ggplot2

```
# load dplyr package
library(dplyr)
```

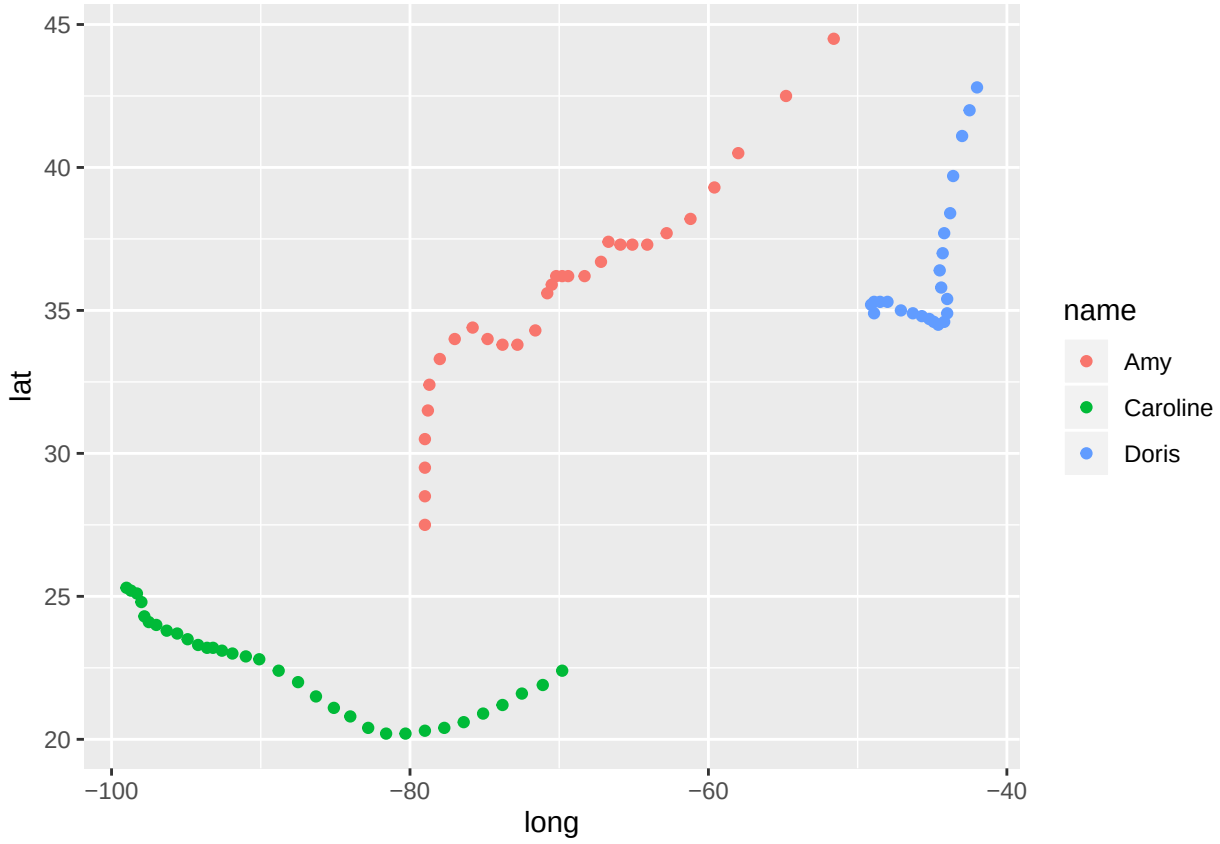
```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

```
storms75 <- filter(storms, year == 1975)
head(storms75)
```

```
## # A tibble: 6 x 13
##   name   year month   day  hour   lat  long status category  wind pressure
##   <chr> <dbl> <dbl> <int> <dbl> <dbl> <dbl> <chr>  <ord>    <int>    <int>
## 1 Amy    1975     6    27     0  27.5 -79   tropi~ -1          25     1013
## 2 Amy    1975     6    27     6  28.5 -79   tropi~ -1          25     1013
## 3 Amy    1975     6    27    12  29.5 -79   tropi~ -1          25     1013
## 4 Amy    1975     6    27    18  30.5 -79   tropi~ -1          25     1013
## 5 Amy    1975     6    28     0  31.5 -78.8 tropi~ -1          25     1012
## 6 Amy    1975     6    28     6  32.4 -78.7 tropi~ -1          25     1012
## # ... with 2 more variables: ts_diameter <dbl>, hu_diameter <dbl>
```

```
ggplot(storms75, aes(x = long, y = lat)) + geom_point(aes(color = name))
```




```
# alternative ways to write equivalent commands
# ggplot(data = storms75) +  geom_point(aes(x = long, y = lat, color = name))
# ggplot() +  geom_point(data = storms75, aes(x = long, y = lat, color = name))
```

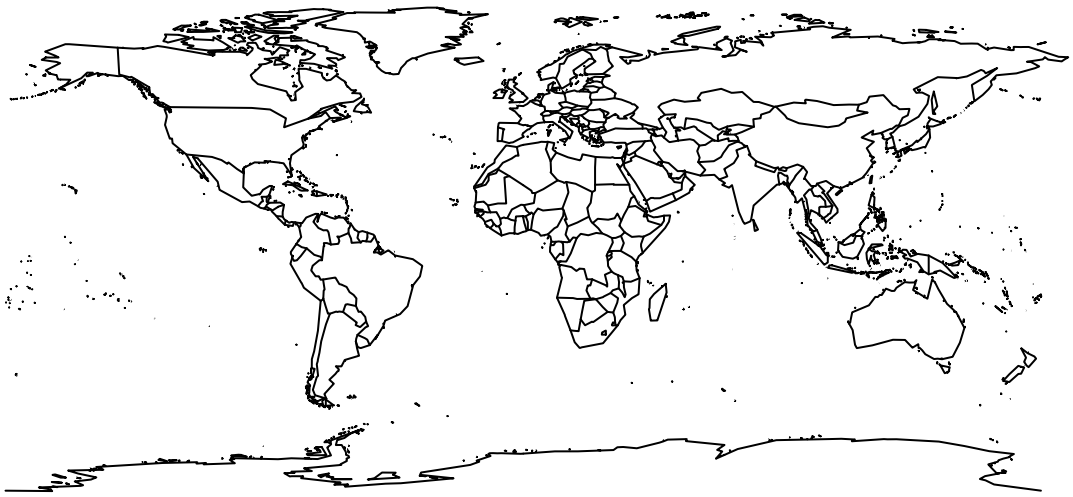
But where is it? We need an image of world map.

Using `maps` package

```
# install maps package
# install.packages("maps")

# load maps package
library(maps)
```

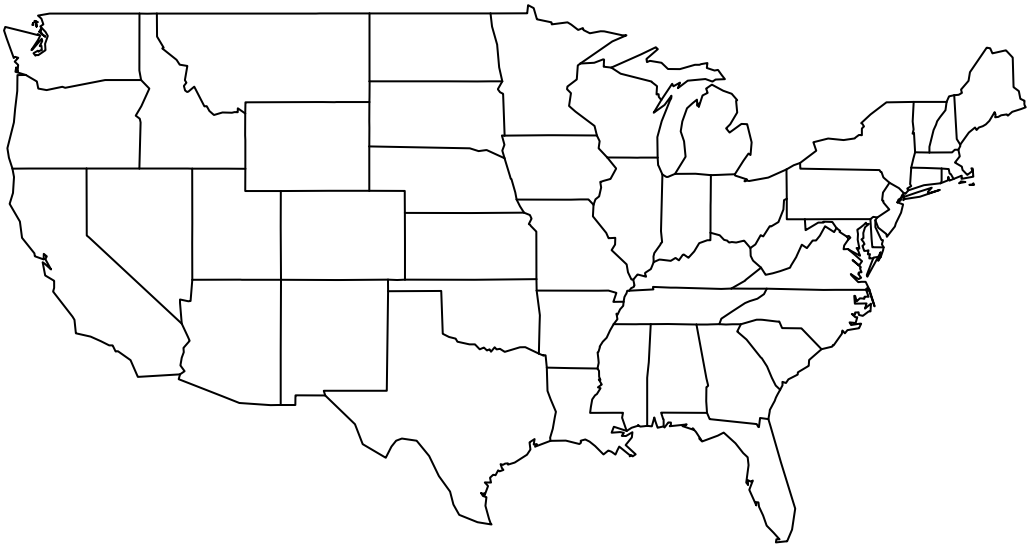
`map()` plots geographical maps.

```
# world map
map("world")
```

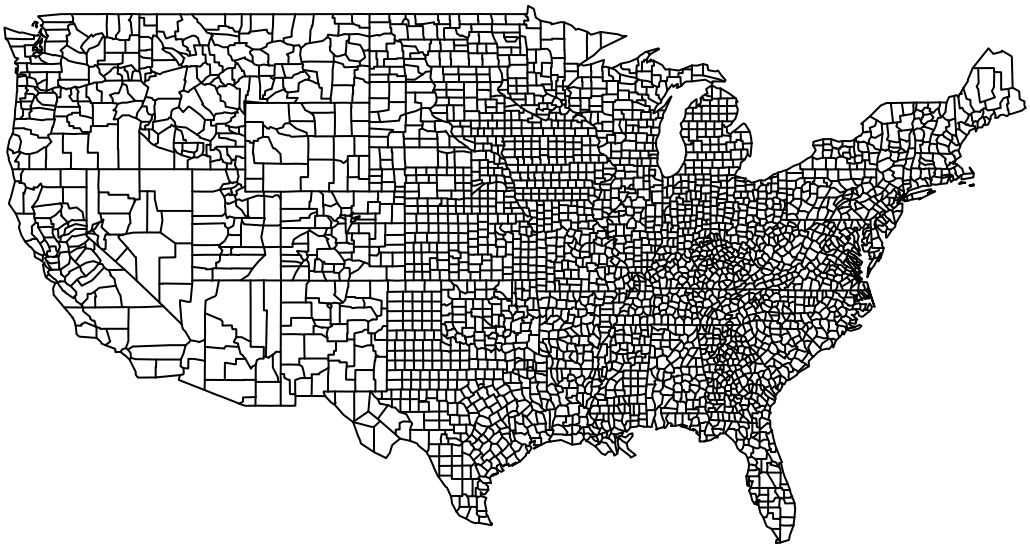


```
# usa map
map("usa")
```

```
# usa states
map("state")
```



```
# usa counties
map("county")
```



To use ggplot2 to map map objects, first we need to convert a map object to a dataframe object.

```
world_map <- map_data("world")
head(world_map)
```

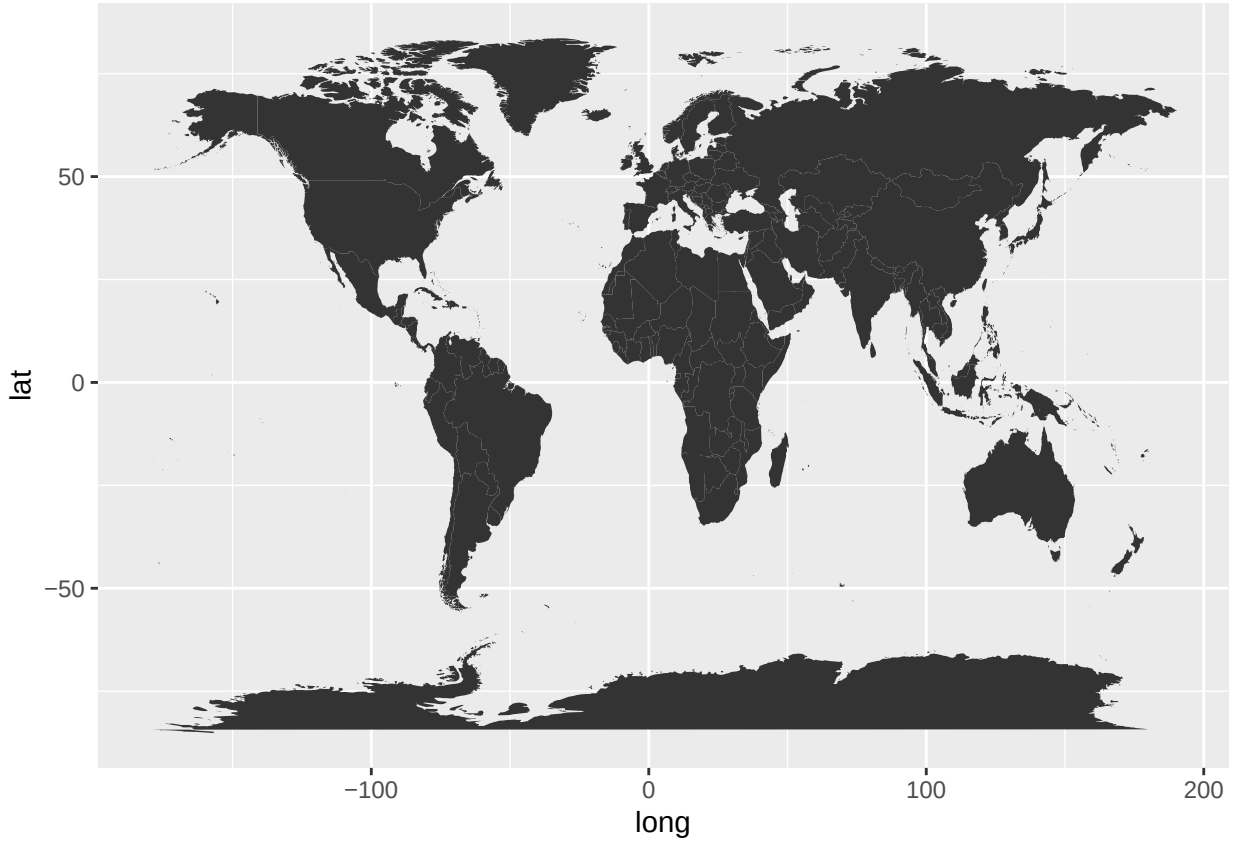
```
##        long      lat group order region subregion
## 1 -69.89912 12.45200     1     1  Aruba      <NA>
## 2 -69.89571 12.42300     1     2  Aruba      <NA>
## 3 -69.94219 12.43853     1     3  Aruba      <NA>
## 4 -70.00415 12.50049     1     4  Aruba      <NA>
## 5 -70.06612 12.54697     1     5  Aruba      <NA>
## 6 -70.05088 12.59707     1     6  Aruba      <NA>
```

```r
# check if world_map is really a dataframe object
class(world_map)
```

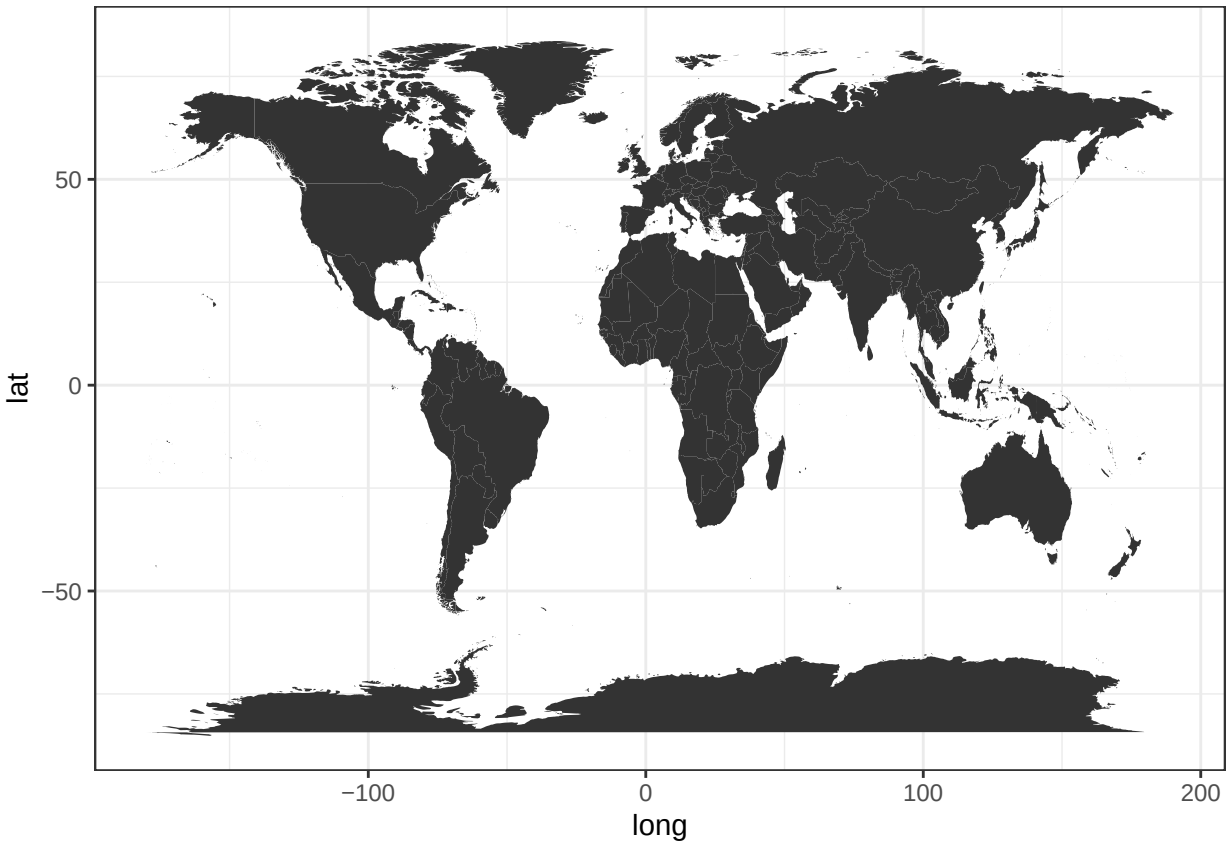
```
## [1] "data.frame"
```

Use `geom_polygon()` to draw a map. `theme_bw()` changes the map to black-white.

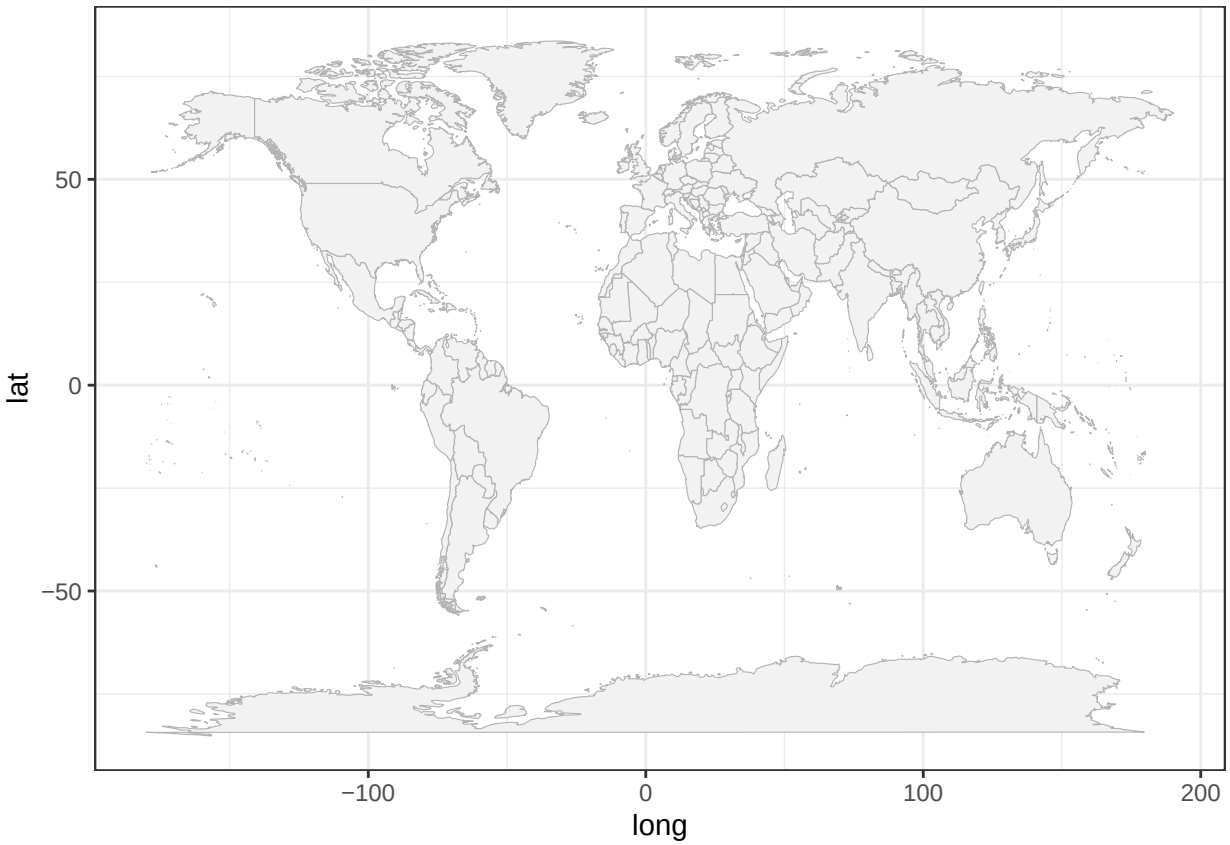
```r
ggplot() +
  geom_polygon(data = world_map, aes(x = long, y = lat, group = group))
```




```r
# use theme_bw()
# the background changes to white
ggplot() +
  geom_polygon(data = world_map, aes(x = long, y = lat, group = group)) +
  theme_bw()
```

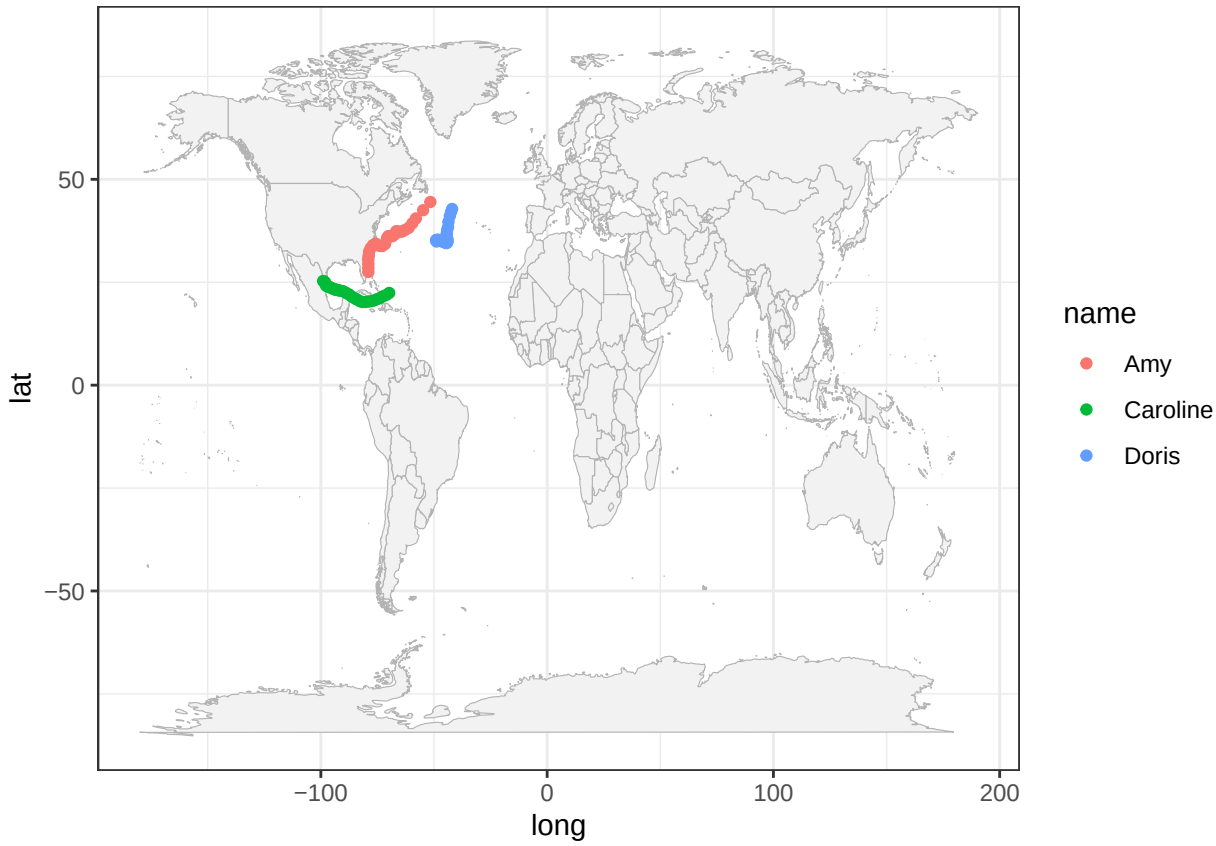



```
# store the ggplot to a variable
gg_world <- ggplot() +
  geom_polygon(data = world_map,
               aes(x = long, y = lat, group = group),
               fill = "gray95", colour = "gray70", size = 0.2) +
  theme_bw()

gg_world
```

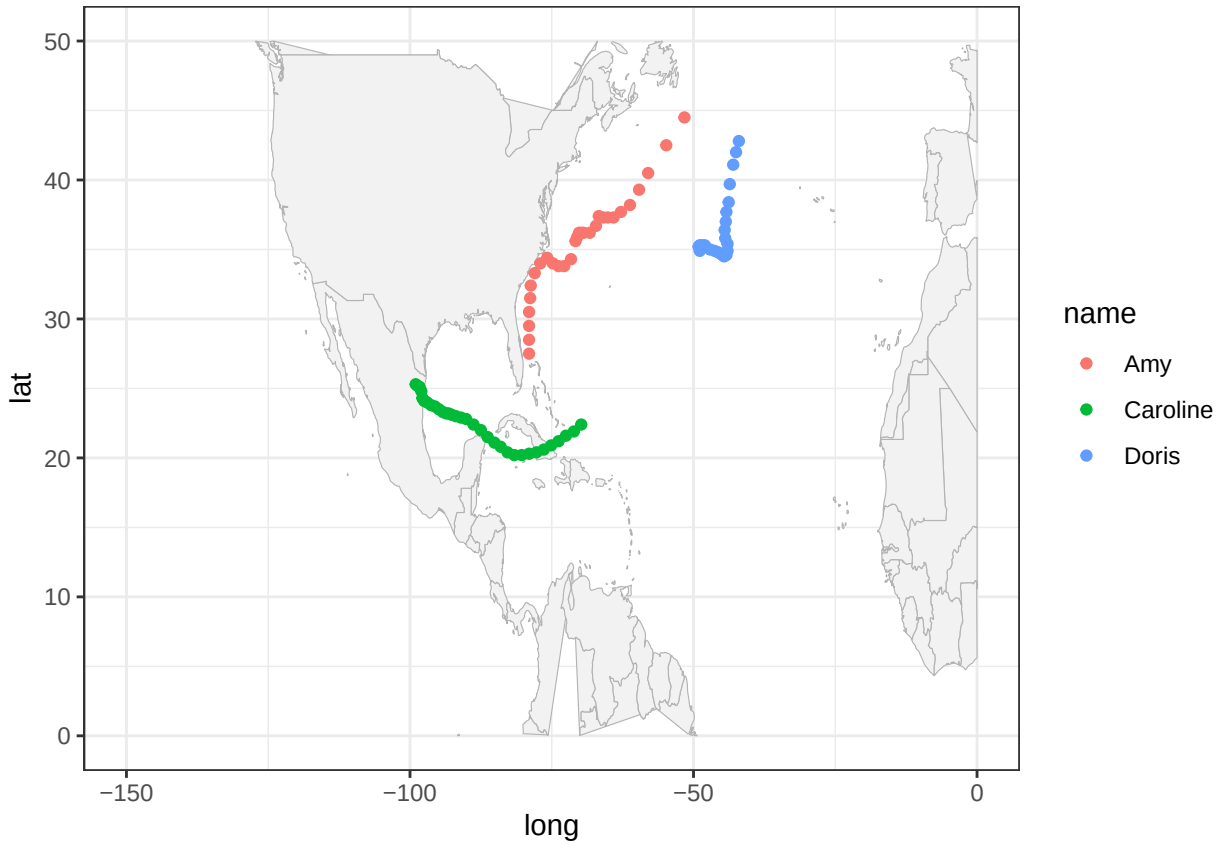


Let's add the points of the storm records. Use `xlim()` and `ylim()` to specify the range of longitude and latitude for zooming-in.

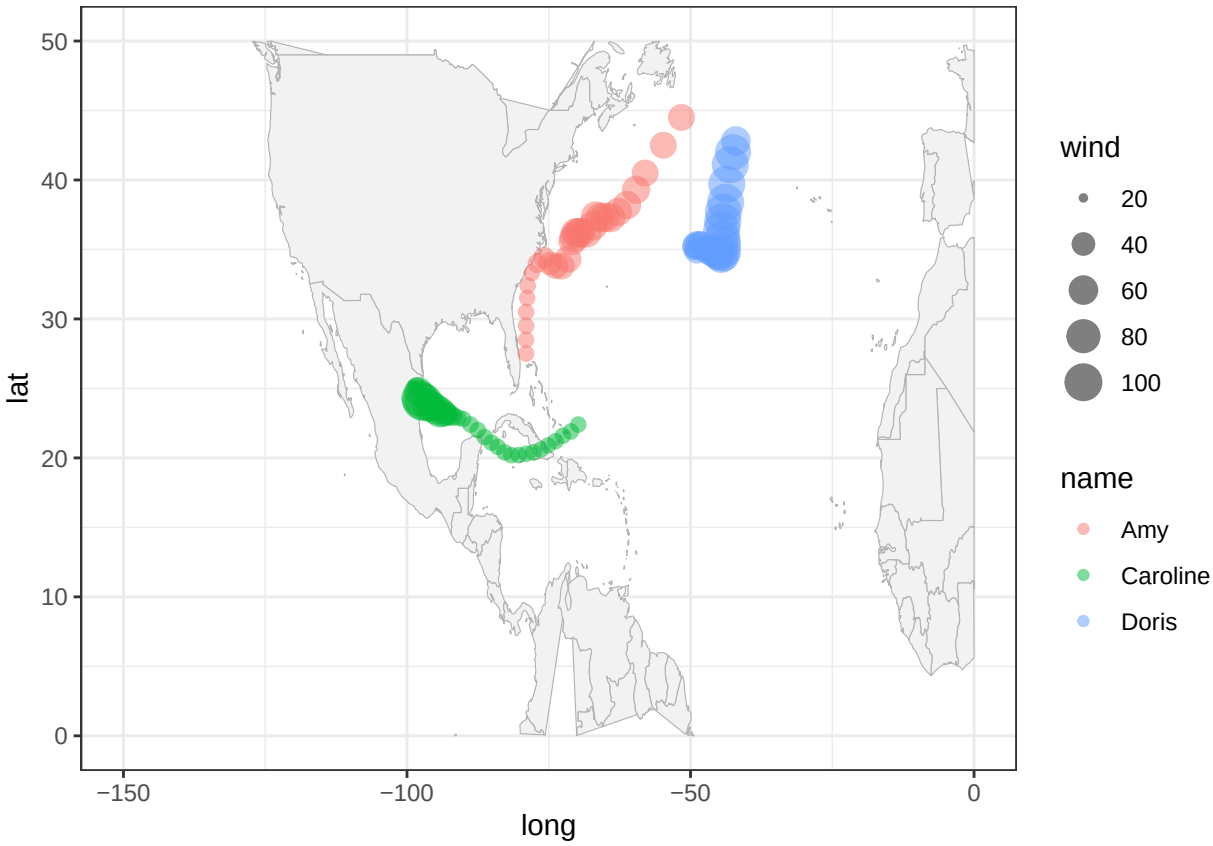
```
gg_world + geom_point(data = storms75, aes(x = long, y = lat, color = name))
```




```
# zoom-in
gg_world + geom_point(data = storms75, aes(x = long, y = lat, color = name)) +
  xlim(c(-150, 0)) +
  ylim(c(0, 50))
```

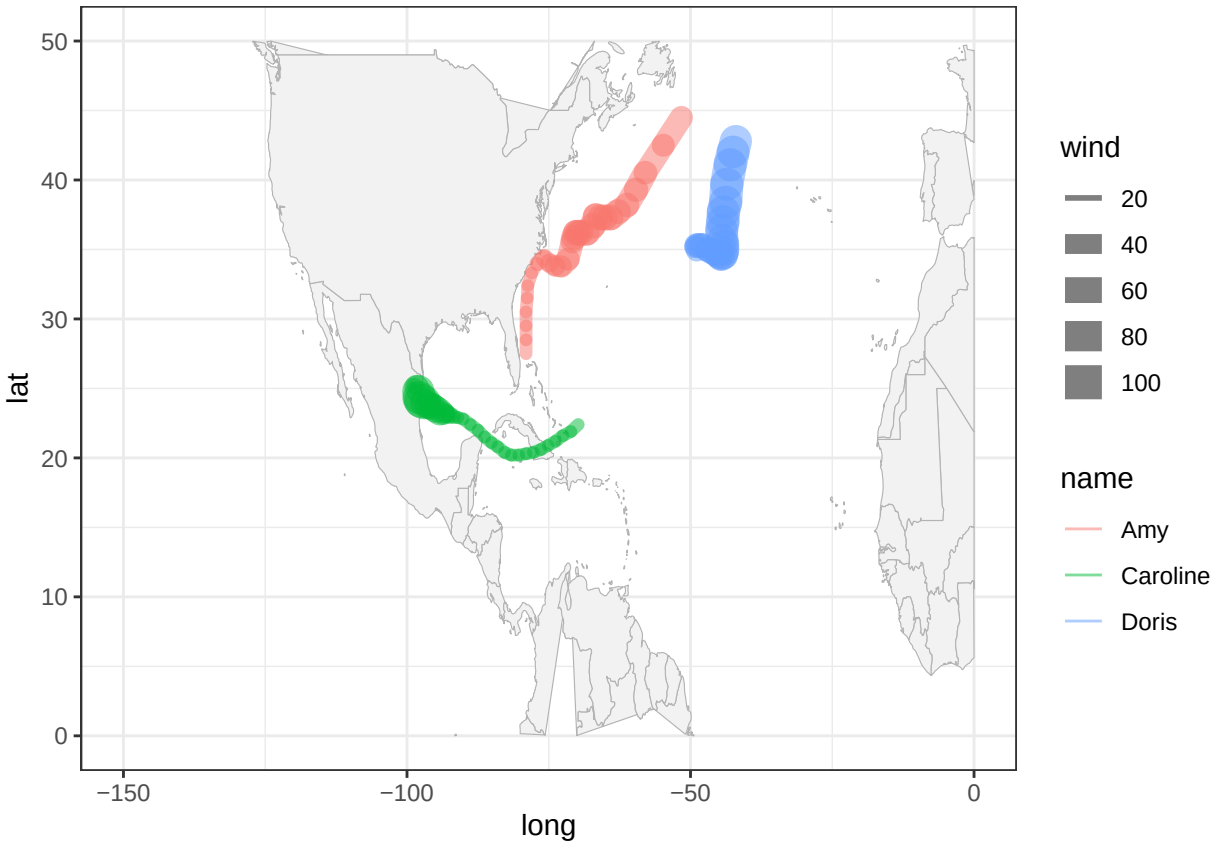



```
# add wind speed feature by setting size argument
gg_world +
  geom_point(data = storms75,
             aes(x = long, y = lat, color = name, size = wind), alpha = 0.5) +
  xlim(c(-150, 0)) +
  ylim(c(0, 50))
```



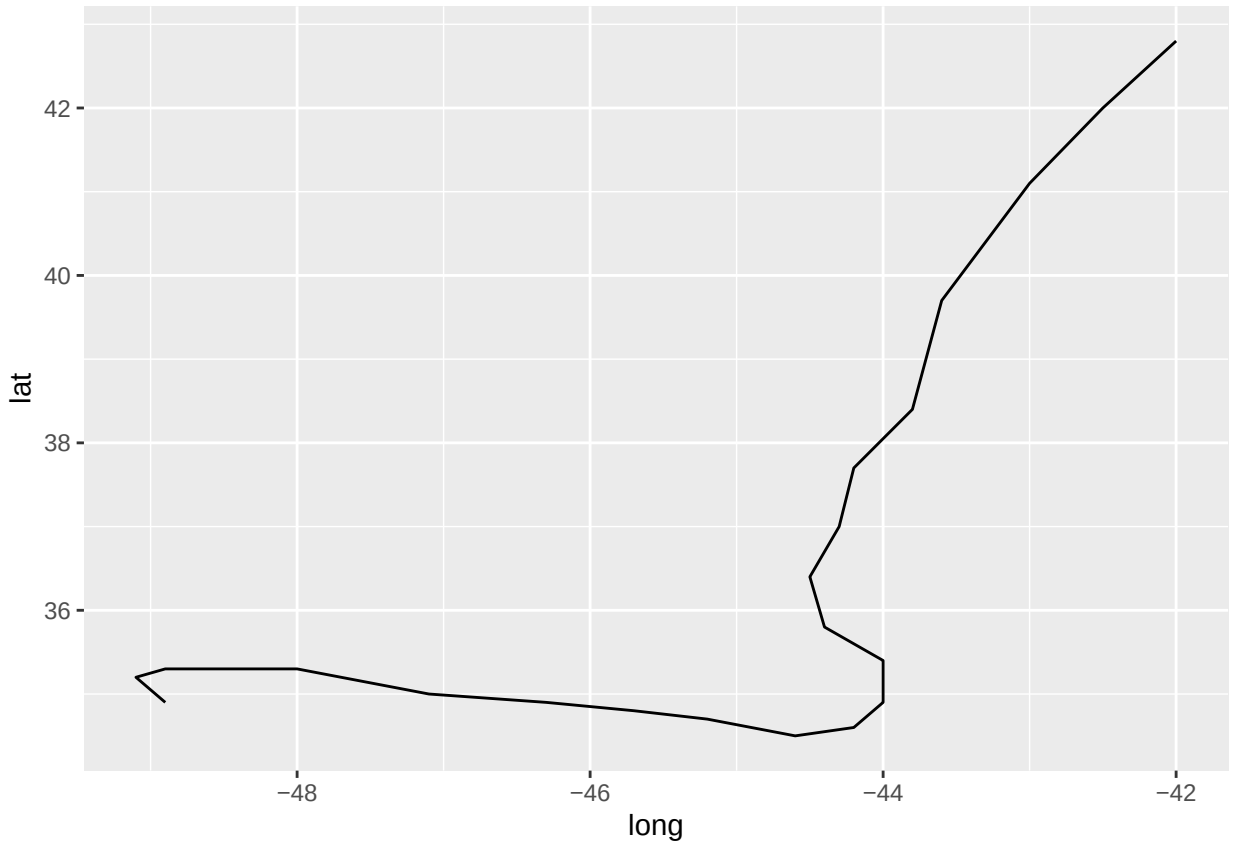
`geom_path()` acts like `geom_point()`. It connects points but it's more like a "path" of the points.

```
# similar result
gg_world +
  geom_path(data = storms75,
            aes(x = long, y = lat, color = name, size = wind),
            alpha = 0.5, lineend = "round") +
  xlim(c(-150, 0)) +
  ylim(c(0, 50))
```

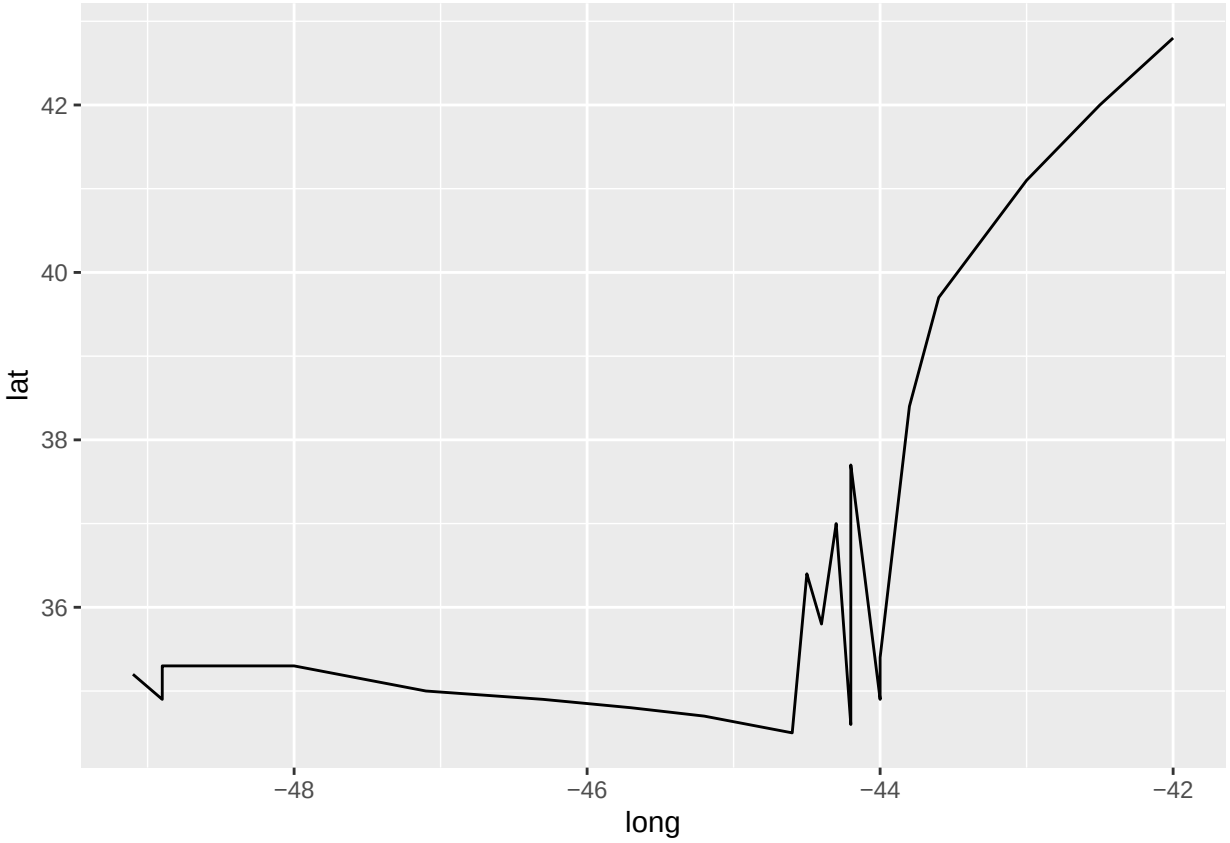


See the difference between `geom_line()` and `geom_path()` Both connects points but there's a big difference.

```
# just an example
doris75 <- filter(storms75, name == "Doris")

# geom_path()
ggplot(data = doris75, aes(x = long, y = lat)) + geom_path()
```




```
# geom_line()
ggplot(data = doris75, aes(x = long, y = lat)) + geom_line()
```



Using `rnaturalearth` package

```
# install rnaturalearth package
# install.packages("rnaturalearth)
# may need additional packages
# install.packages(c("rnaturalearthdata", "rgeos"))

# load rnaturalearth package
library(rnaturalearth)

# library(rnaturalearthdata)
# library(rgeos)
```

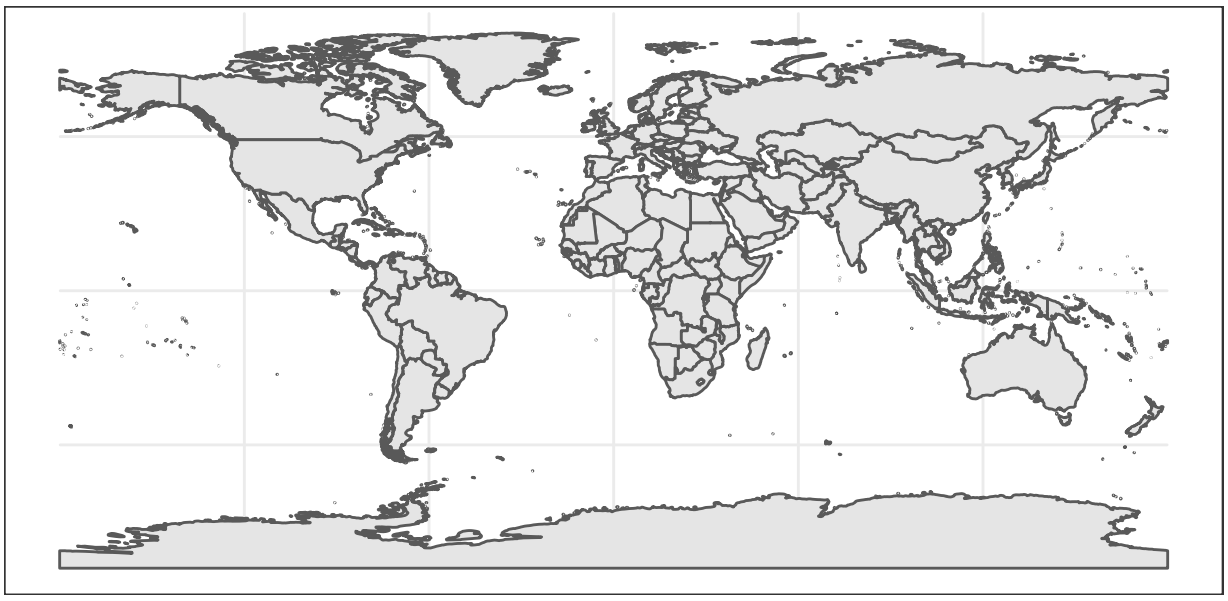
`ne_countries()` gets world map polygons.

```
world_df <- ne_countries(scale = "medium", returnclass = "sf")
class(world_df)
```

```
## [1] "sf"         "data.frame"
```

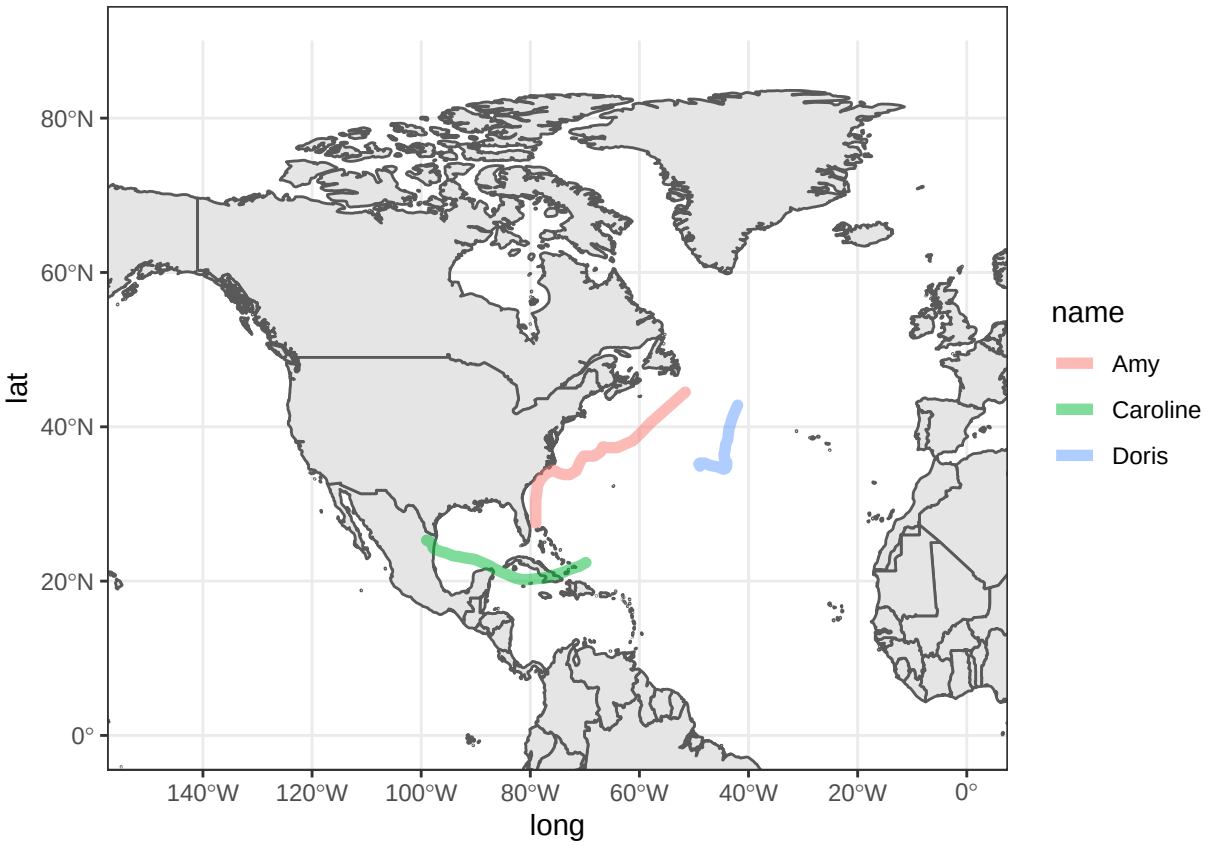
`geom_sf()` visualizes simple feature objects `sf`,

```
ggplot(data = world_df) + geom_sf() + theme_bw()
```



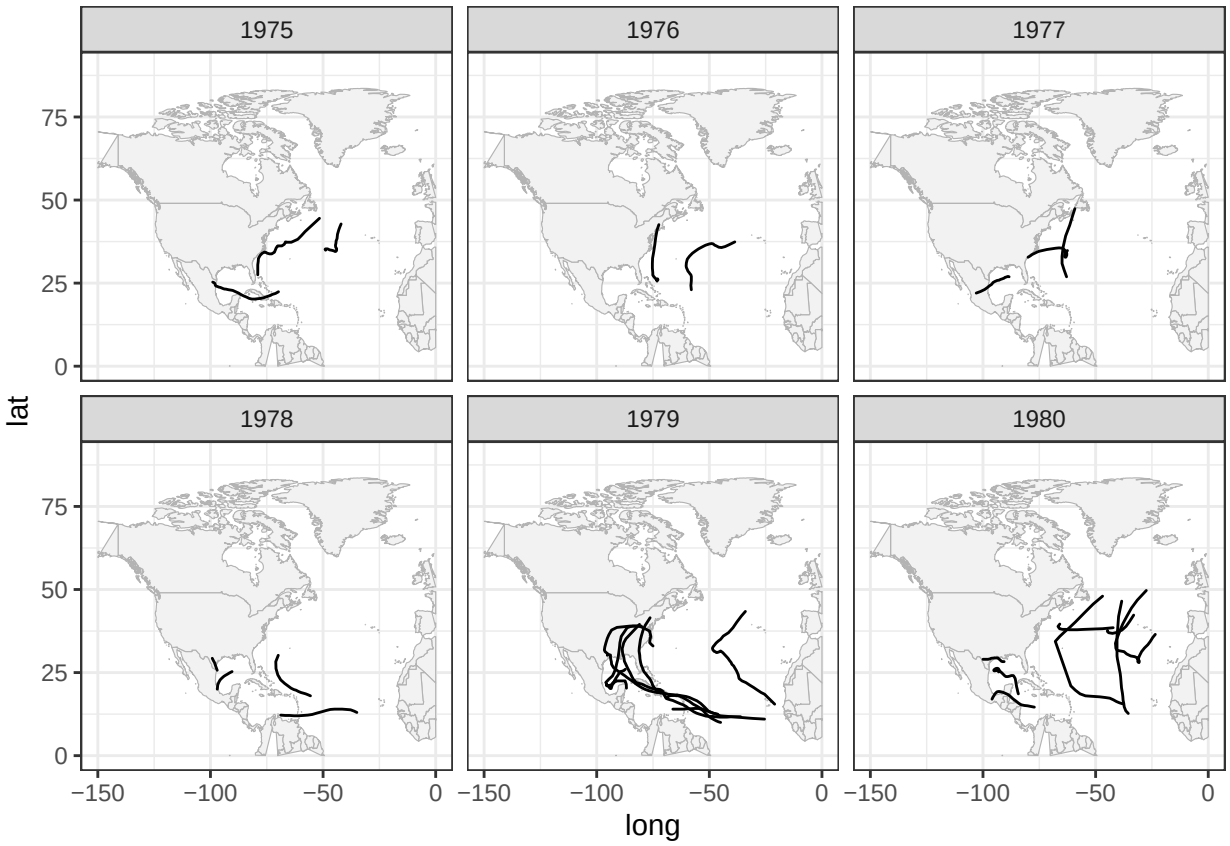
We can set specify the region using `coord_sf()`, instead of using `xlim()` and `ylim()`.

```
gg_world2 <- ggplot(data = world_df) +
  geom_sf() +
  coord_sf(xlim = c(-150, 0), y = c(0, 90), expand = TRUE) +
  theme_bw()

gg_world2 +
  geom_path(data = storms75,
            aes(x = long, y = lat, color = name),
            lineend = "round", size = 2, alpha = 0.5)
```



Facet by year from 1975 to 1980.

```
storms_75_80 <- filter(storms, year %in% 1975:1980)

gg_world + geom_path(data = storms_75_80,
                     aes(x = long, y = lat, group = name),
                     lineend = "round") +
  xlim(c(-150, 0)) + ylim(c(0, 90)) +
  facet_wrap((~ year))
```



Exercises

1) Filter storms in the 1980's decade (1980 - 1989) and make a plot, with facets by month.year‘

```
storms80s <- filter(storms, year %in% 1980:1989)
head(storms80s)
```

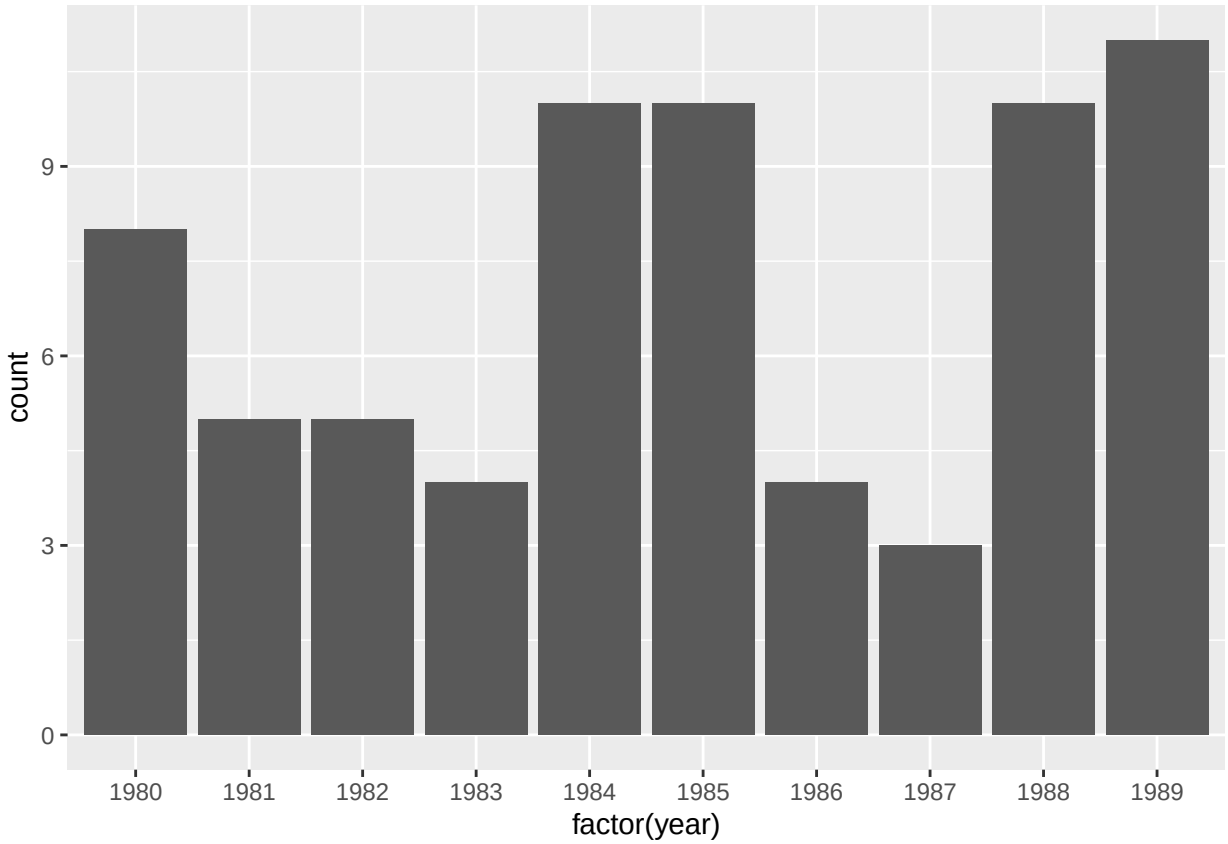
```
## # A tibble: 6 x 13
##   name   year month   day  hour   lat  long status category  wind pressure
##   <chr> <dbl> <dbl> <int> <dbl> <dbl> <dbl> <chr>  <ord>    <int>    <int>
## 1 Bonn~  1980     8    14     0  12.7 -35.5 tropi~ -1          25     1010
## 2 Bonn~  1980     8    14     6  13.5 -36.6 tropi~ -1          30     1008
## 3 Bonn~  1980     8    14    12  14.7 -37.3 tropi~ 0           35     1005
## 4 Bonn~  1980     8    14    18  15.7 -37.5 tropi~ 0           45     1000
## 5 Bonn~  1980     8    15     0  16.7 -37.8 tropi~ 0           45     1000
## 6 Bonn~  1980     8    15     6  17.7 -37.9 tropi~ 0           45     1000
## # ... with 2 more variables: ts_diameter <dbl>, hu_diameter <dbl>
```

Which year seems to have the largest number of storms? Which year seems to have the smallest number of storms? Does it seem to be a pattern (e.g. increasing number of storms over years)?

```
num_of_storms80s <- distinct(group_by(storms80s, year, name), year)
num_of_storms80s
```

```
## # A tibble: 70 x 2
## # Groups:   year, name [70]
##     year name
##    <dbl> <chr>
##  1  1980 Bonnie
##  2  1980 Charley
##  3  1980 Georges
##  4  1980 Danielle
##  5  1980 Hermine
##  6  1980 Ivan
##  7  1980 Jeanne
##  8  1980 Karl
##  9  1981 Emily
## 10  1981 Floyd
## # ... with 60 more rows
```

```
# by the bar plot, 1989 had the largest number of storms
# and 1987 had the smallest number of storms
ggplot(data = num_of_storms80s, aes(x = factor(year))) + # factor year to set label with only integers
  geom_bar()
```



The number of storms increased since 1980, but there seems no particular pattern over the period.

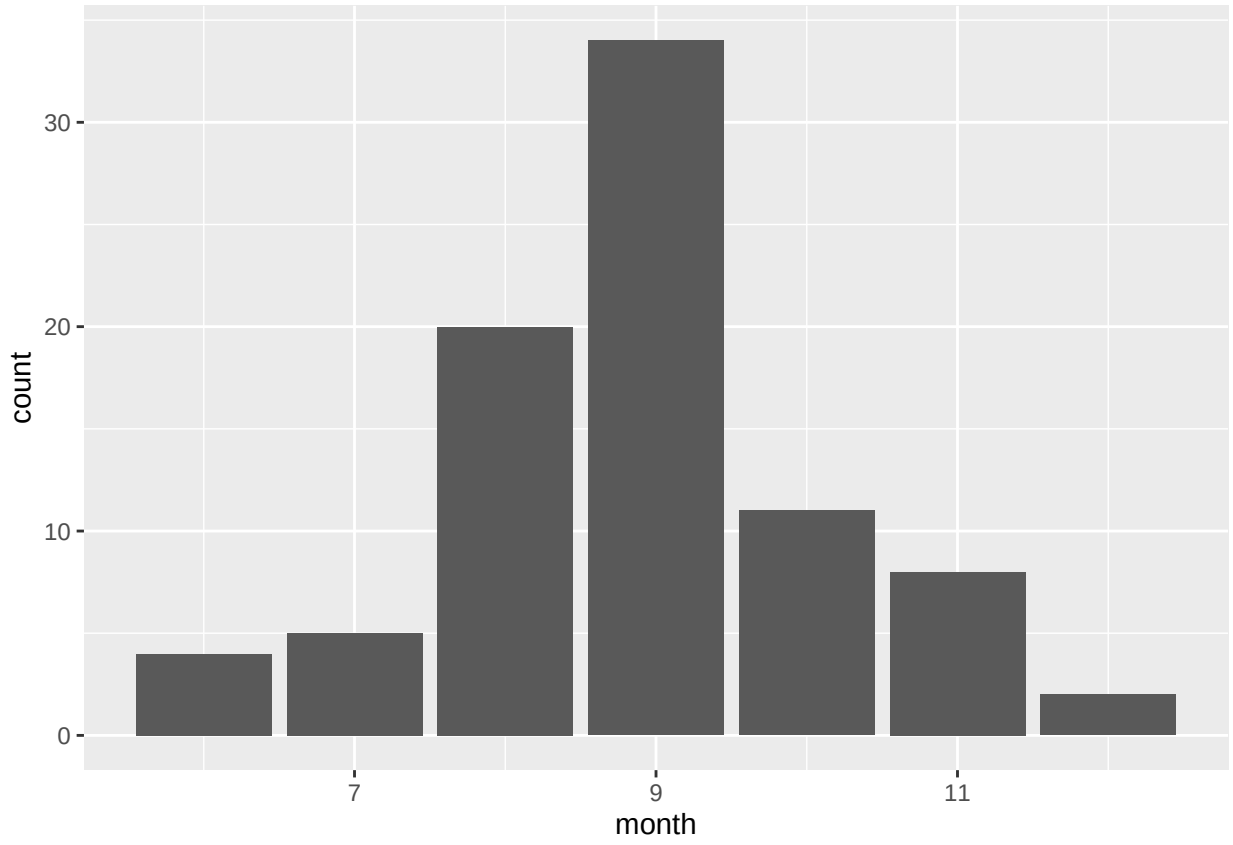
2) Take the previous data, storms in the 1980's decade, and make a plot, with but this time with facets by month.

What is the most active month? What is the least active month? Are there months without any storms?

```
num_storms_month <- distinct(group_by(storms80s, year, name, month), month)
num_storms_month
```

```
## # A tibble: 84 x 3
## # Groups:   year, name, month [84]
##    month  year name
##    <dbl> <dbl> <chr>
##  1     8  1980 Bonnie
##  2     8  1980 Charley
##  3     9  1980 Georges
##  4     9  1980 Danielle
##  5     9  1980 Hermine
##  6    10  1980 Ivan
##  7    11  1980 Jeanne
##  8    11  1980 Karl
##  9     9  1981 Emily
## 10     9  1981 Floyd
## # ... with 74 more rows
```

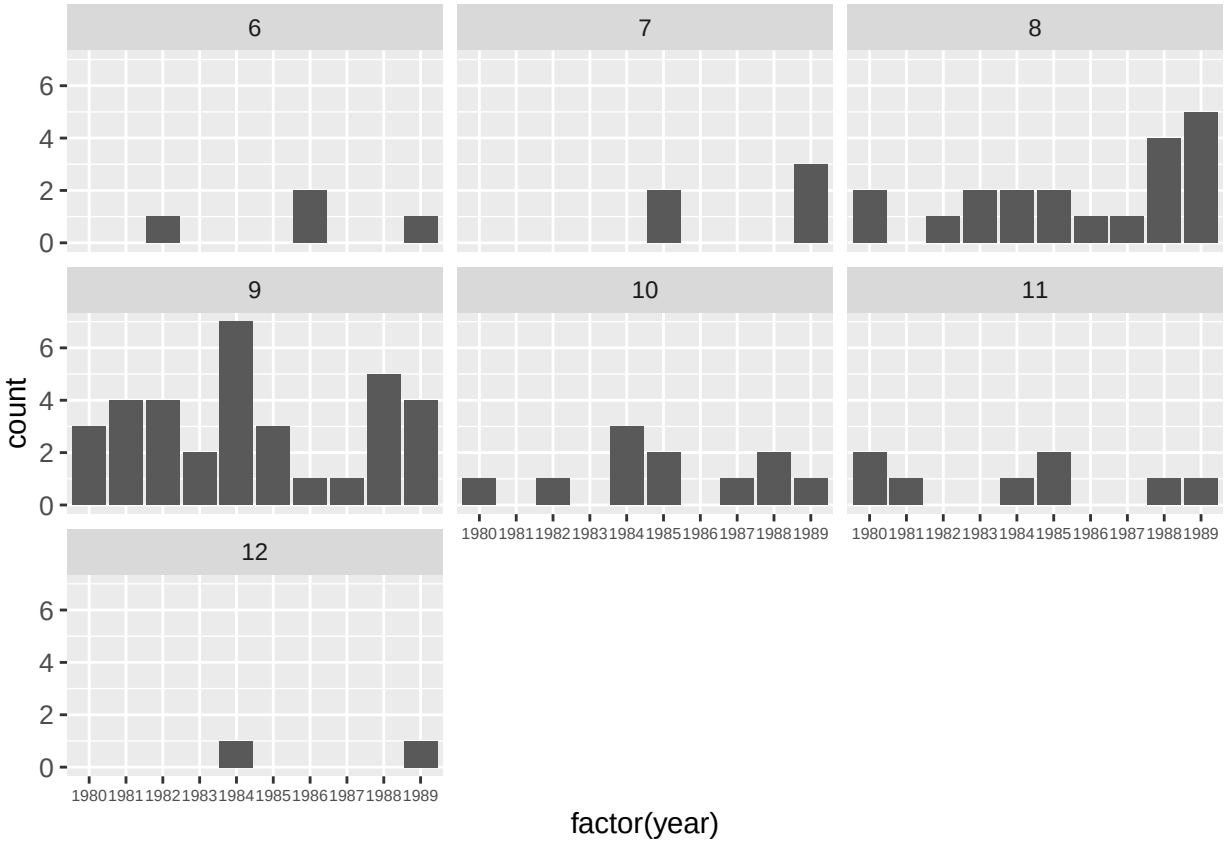
```
ggplot(data = num_storms_month, aes(x = month)) + geom_bar()
```




```
# facet by month but also year
num_storms_year_month <- distinct(group_by(storms80s, year, name, month), year, month)
num_storms_year_month
```

```
## # A tibble: 84 x 3
## # Groups:   year, name, month [84]
##     year month name
##    <dbl> <dbl> <chr>
##  1  1980     8 Bonnie
##  2  1980     8 Charley
##  3  1980     9 Georges
##  4  1980     9 Danielle
##  5  1980     9 Hermine
##  6  1980    10 Ivan
##  7  1980    11 Jeanne
##  8  1980    11 Karl
##  9  1981     9 Emily
## 10  1981     9 Floyd
## # ... with 74 more rows
```

```
ggplot(data = num_storms_year_month, aes(x = factor(year))) +
  geom_bar() +
  facet_wrap(~ month) +
  theme(axis.text.x = element_text(size=6),axis.text.y = element_text(size=10)) # avoid overlapping lab
```



The most active month is September and lest active month is December. No storms: January through May.