Lecture 5: 3D and Interactive graphics

October 17, 2017

Packages:

- **`plotly`** - package translates ‘ggplot2’ graphs to an interactive web-based version and/or create custom interactive web-based visualizations directly from R.
- **`heatmaply`** - package for generating interactive heatmaps
- **`ggmap`** - package that let you retrieve maps from popular online mapping services like Google Maps, OpenStreetMap, Stamen Maps, and plot them using the ggplot2 framework

Install the packages

```r
# Install packages:
.packages <- c("ggplot2", "plotly", "heatmaply", "ggmap", "dplyr")
lapply(.packages, install.packages, dependencies = TRUE)
```

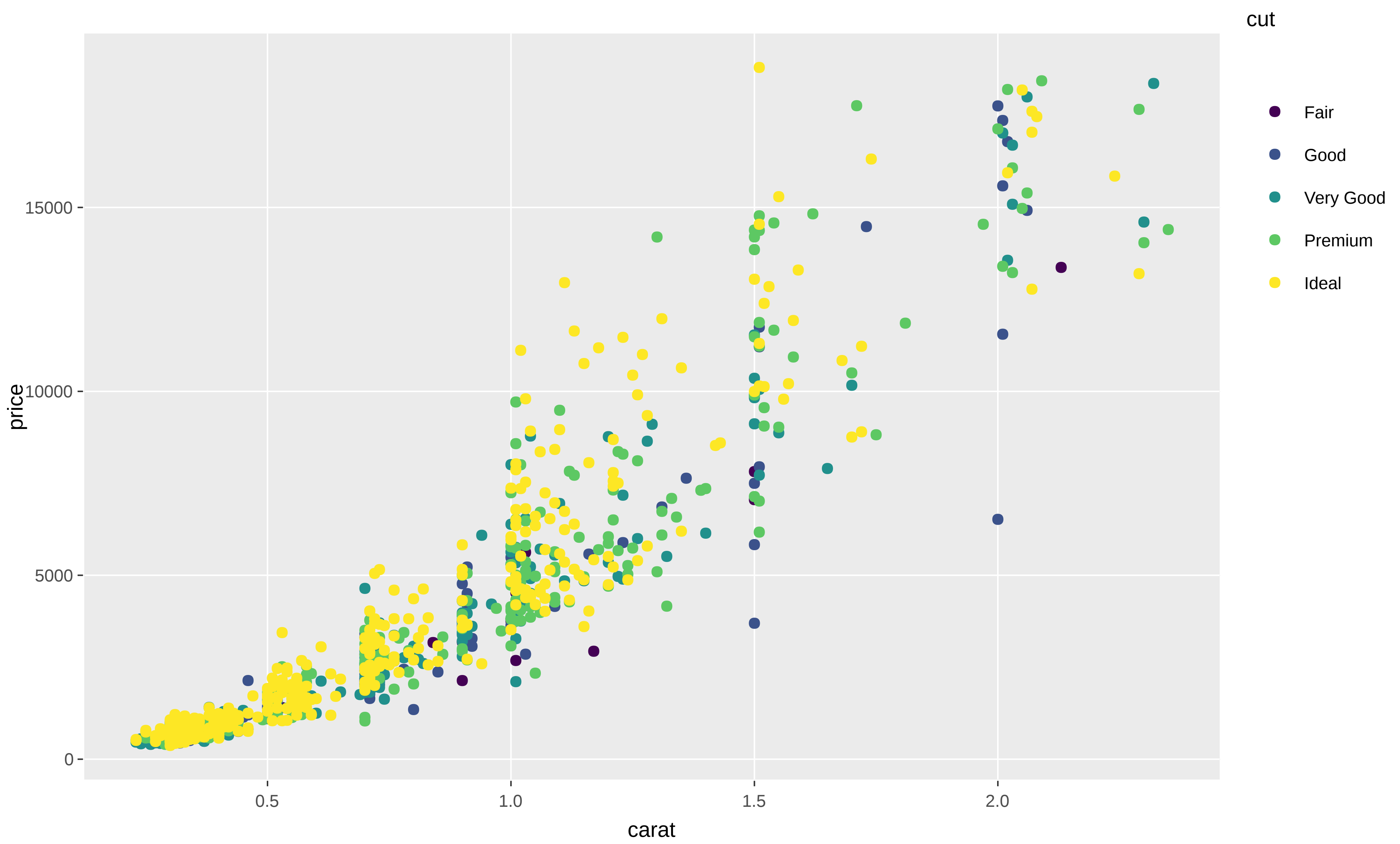
plotly

`plotly` package

- `plotly` is **a package for visualization** and a collaboration platform for data science
- Available in **R, python, MATLAB, scala**.
- You can produce **interactive graphics including 3D plots** (with zooming and rotating).
- You can open a **'plotly' account** to upload 'plotly' graphs and view or modify them in a web browser.
- Resources: cheatsheet, book

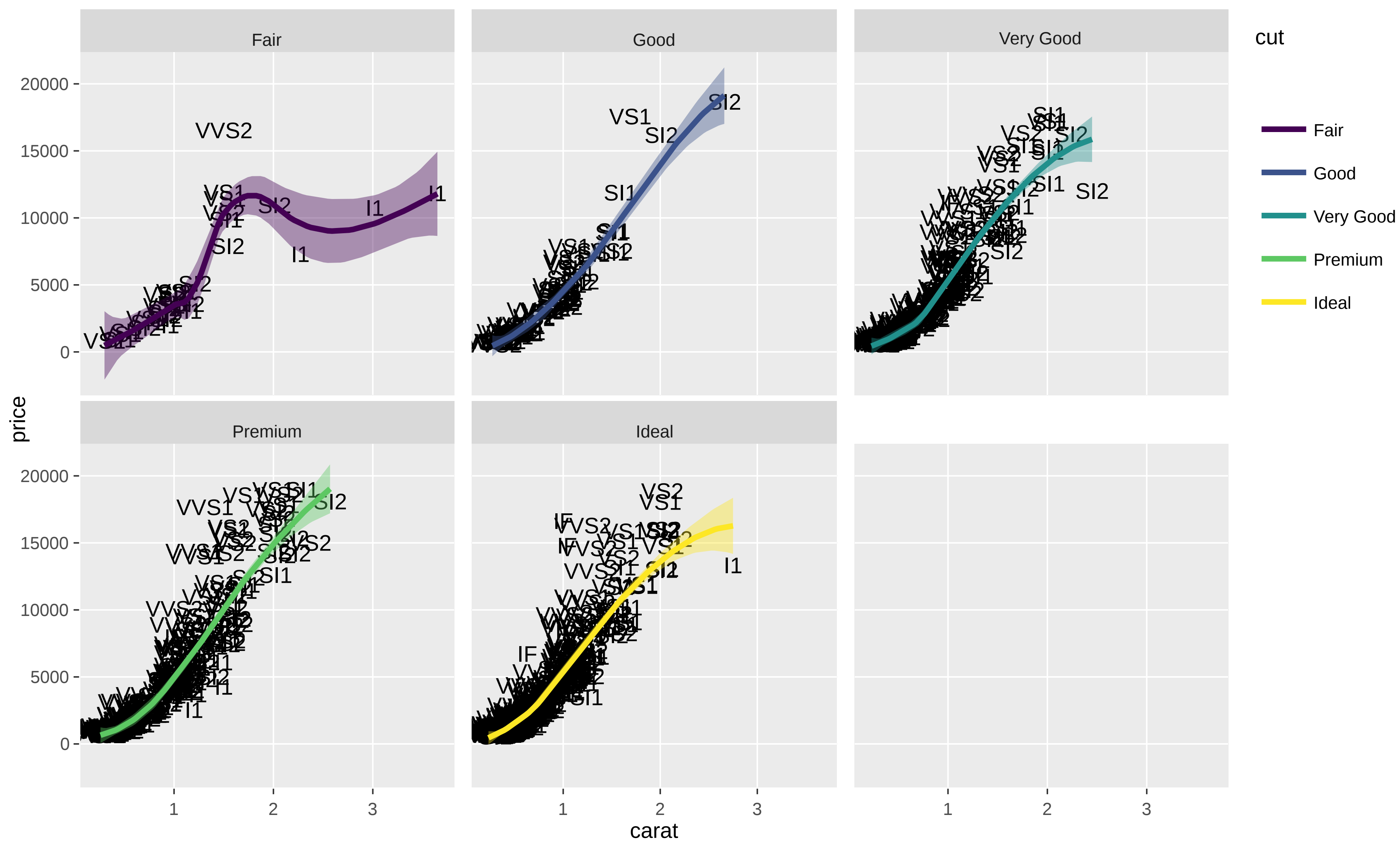
plotly integration with ggplot2

```
library(plotly); library(ggplot2); library(dplyr)
plt <- ggplot(diamonds %>% sample_n(1000), aes(x = carat, y = price)) +
  geom_point(aes(color = cut))
ggplotly(plt)
```



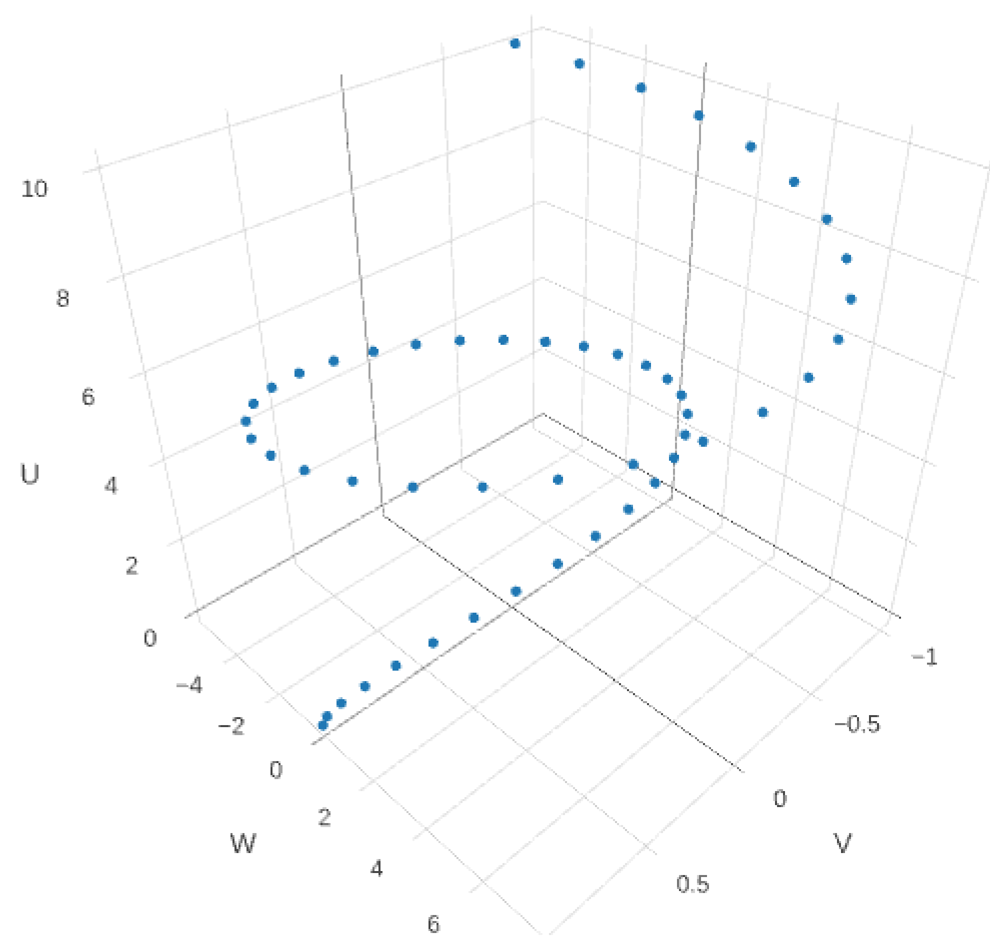
```r
plt <- ggplot(diamonds %>% sample_n(1000), aes(x = carat, y = price)) +
  geom_text(aes(label = clarity), size = 4) +
  geom_smooth(aes(color = cut, fill = cut)) +
  facet_wrap(~cut)
ggplotly(plt)
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

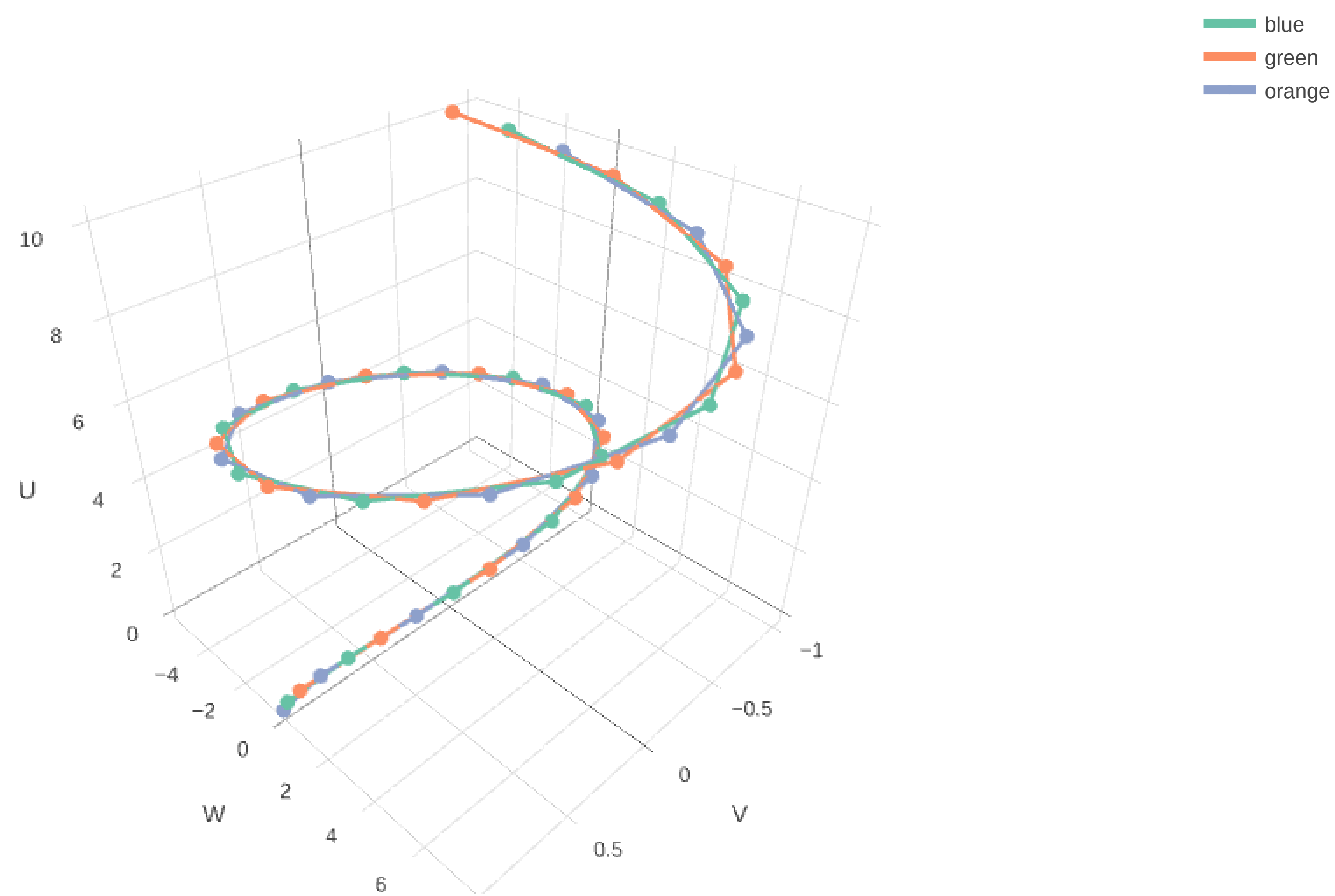


3D Scatter plots

```
theta <- seq(0, 10, 0.2);
df <- data.frame(U = theta, V =  cos(theta), W = sin(theta)*theta)
plot_ly(df, x = ~V, y = ~W, z = ~U, type = "scatter3d", mode = "markers",
        marker = list(size = 3))
```

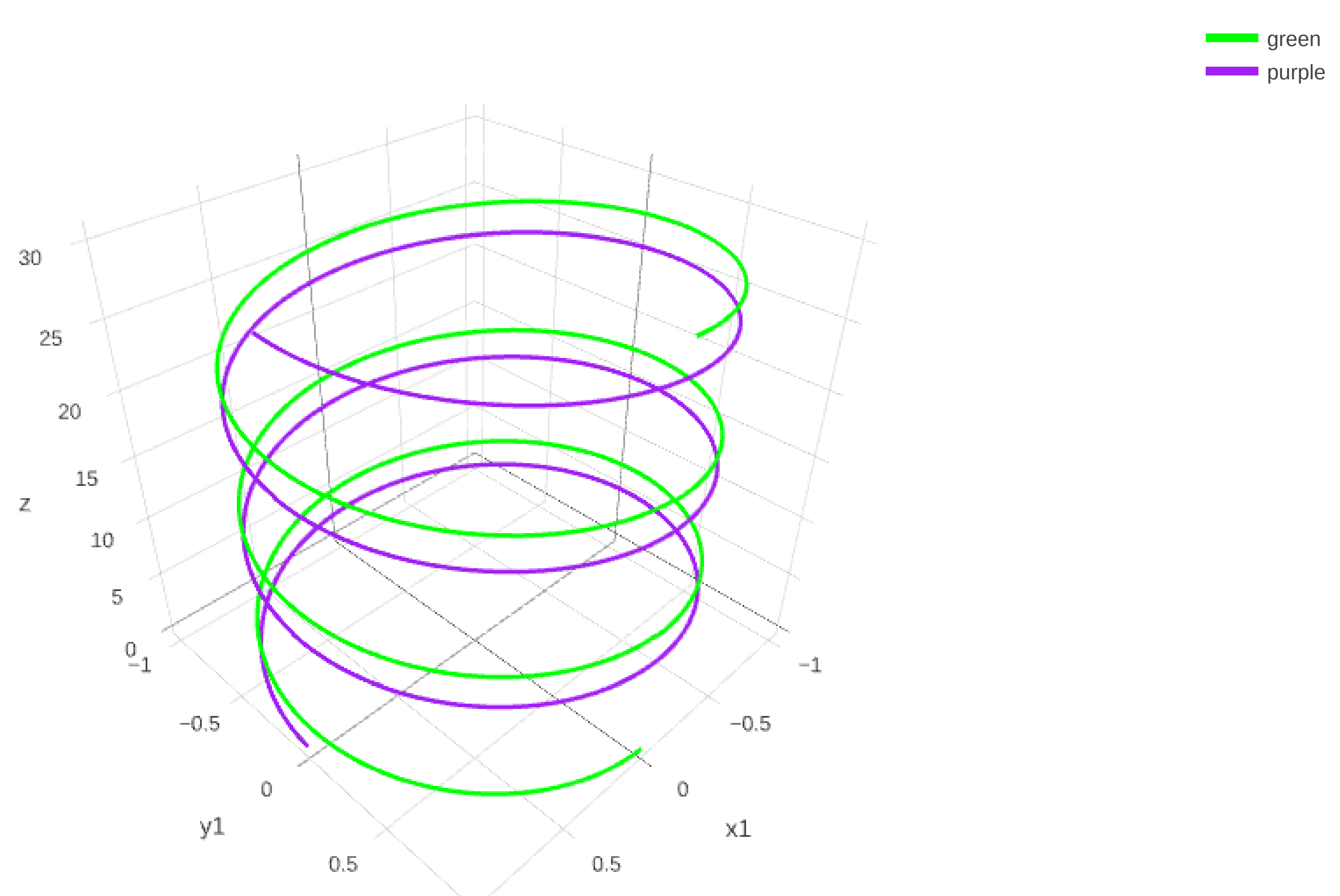


```r
df$cols <- rep_len(c("orange", "blue", "green"), length.out = length(theta))
(plt <- plot_ly(df, x = ~V, y = ~W, z = ~U, color = ~cols,
        type = "scatter3d", mode = "markers+lines",
        marker = list(size = 5), line = list(width = 5)))
```



Adding layers

```
dbl.helix <- data.frame(t = rep(seq(0, 2*pi, length.out = 100), 3)) %>%
  mutate(x1 = sin(t), y1 = cos(t), z = (1:length(t))/10,
         x2 = sin(t + pi/2), y2 = cos(t + pi/2))
plot_ly(dbl.helix, x = ~x1, y = ~y1, z = ~z, type = "scatter3d", mode = "lines",
        color = "green", colors = c("green", "purple"), line = list(width = 5))
  add_trace(x = ~x2, y = ~y2, z = ~z+0.2, color = "purple")
```



Volcano dataset

- **`volcano`** - a built-in dataset storing topographic information for Maunga Whau (Mt Eden), one of 50 volcanos in Auckland, New Zealand.
- It consist of a 87 x 61 matrix with entries corresponding to the mountain's atlitutes [m] on a 10m by 10m grid.
- rows run east to west, and columns south to north

```r
dim(volcano)
```

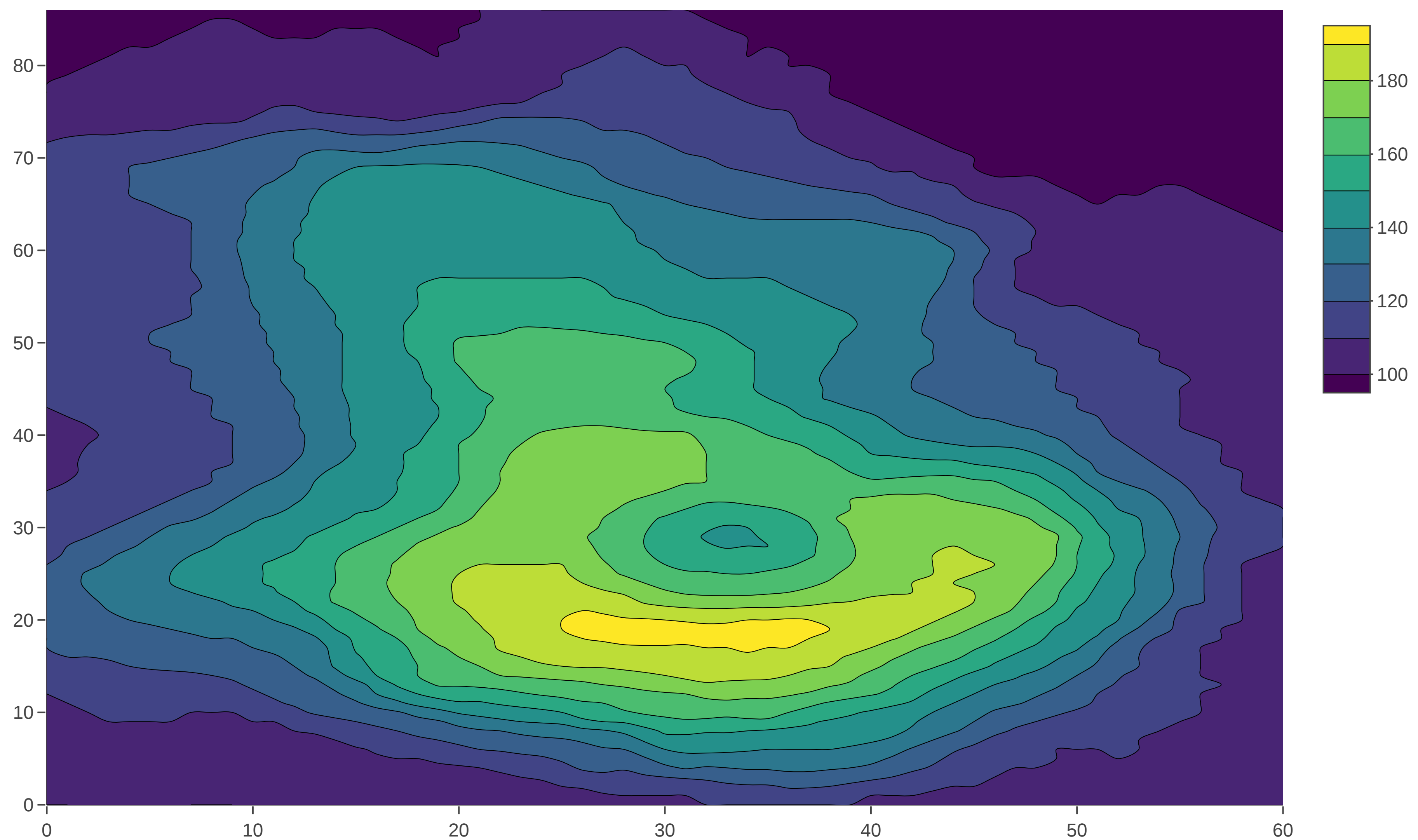
```
## [1] 87 61
```

```r
volcano[1:5, 1:5]
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  100  100  101  101  101
## [2,]  101  101  102  102  102
## [3,]  102  102  103  103  103
## [4,]  103  103  104  104  104
## [5,]  104  104  105  105  105
```

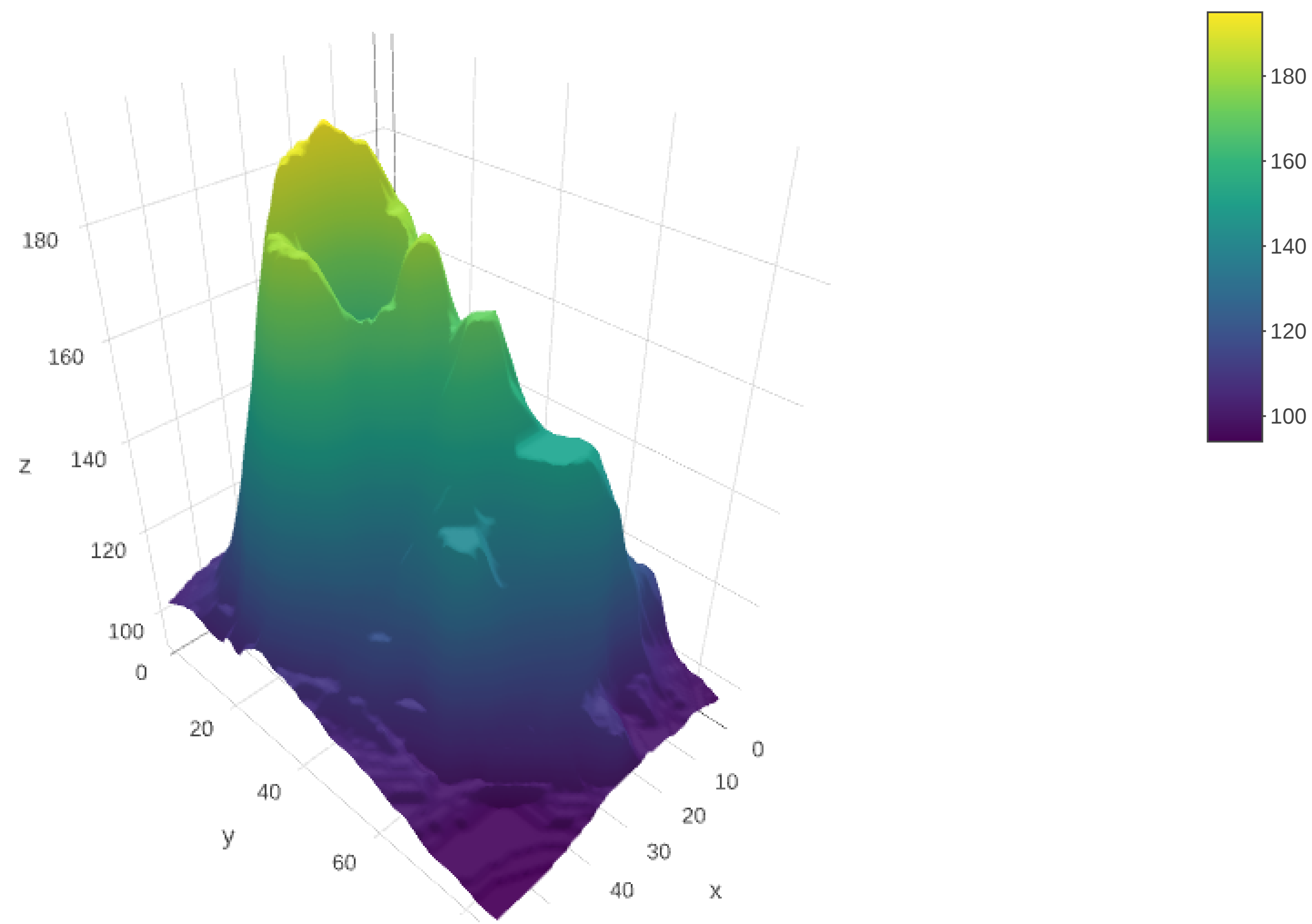
2D contour plots

```
plot_ly(z = volcano) %>% add_contour()
```



3D surface plots

```r
plot_ly(z = volcano) %>% add_surface()
```



Heatmaps

Heatmap

- *A heatmap* is a popular graphical method for **visualizing high-dimensional data (table or matrix format)**
- Heatmaps display data (variables, correlations, sparsity/missing data pattern) as a grid of colored cells.
- They are commonly used in genomics papers to show **gene expression levels**,

> *The rows and the columns of the heatmaps are usually ordered to highlight the patterns in the data, and are usually accompanied by dendograms.*

Scale `mtcars` data

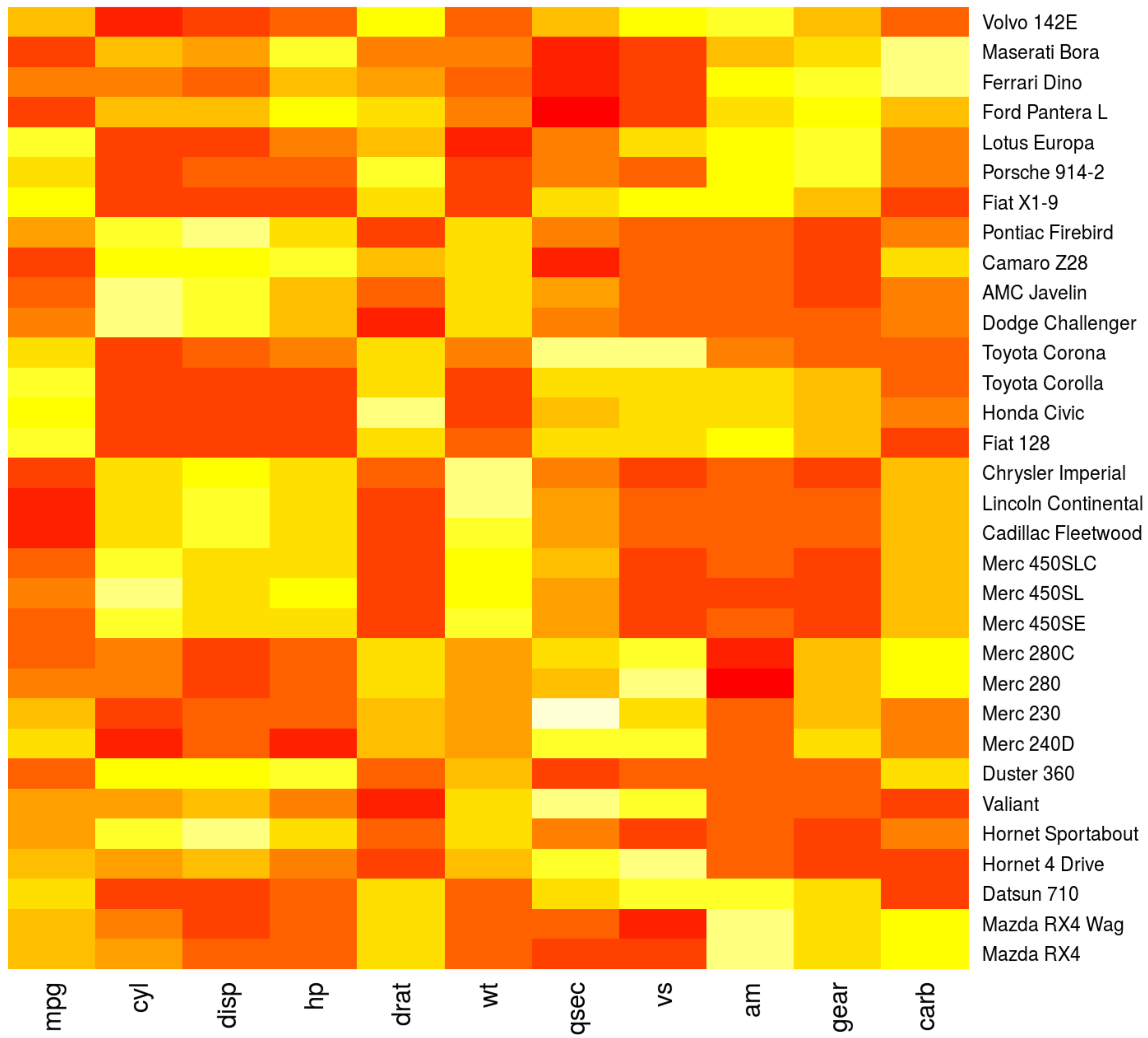
We convert each variable (column) in `mtcars` to Z-scores, i.e. we subtract the column mean and scale by its standard deviation.

```r
mtscaled <- as.matrix(scale(mtcars))
head(mtscaled)
```

```
##                          mpg        cyl        disp         hp       drat
## Mazda RX4          0.1508848 -0.1049878 -0.57061982 -0.5350928  0.5675137
## Mazda RX4 Wag      0.1508848 -0.1049878 -0.57061982 -0.5350928  0.5675137
## Datsun 710         0.4495434 -1.2248578 -0.99018209 -0.7830405  0.4739996
## Hornet 4 Drive     0.2172534 -0.1049878  0.22009369 -0.5350928 -0.9661175
## Hornet Sportabout -0.2307345  1.0148821  1.04308123  0.4129422 -0.8351978
## Valiant           -0.3302874 -0.1049878 -0.04616698 -0.6080186 -1.5646078
##                             wt       qsec         vs         am       gear
## Mazda RX4         -0.610399567 -0.7771651 -0.8680278  1.1899014  0.4235542
## Mazda RX4 Wag     -0.349785269 -0.4637808 -0.8680278  1.1899014  0.4235542
## Datsun 710        -0.917004624  0.4260068  1.1160357  1.1899014  0.4235542
## Hornet 4 Drive    -0.002299538  0.8904872  1.1160357 -0.8141431 -0.9318192
## Hornet Sportabout  0.227654255 -0.4637808 -0.8680278 -0.8141431 -0.9318192
## Valiant            0.248094592  1.3269868  1.1160357 -0.8141431 -0.9318192
##                         carb
## Mazda RX4          0.7352031
## Mazda RX4 Wag      0.7352031
## Datsun 710        -1.1221521
## Hornet 4 Drive    -1.1221521
## Hornet Sportabout -0.5030337
## Valiant           -1.1221521
```

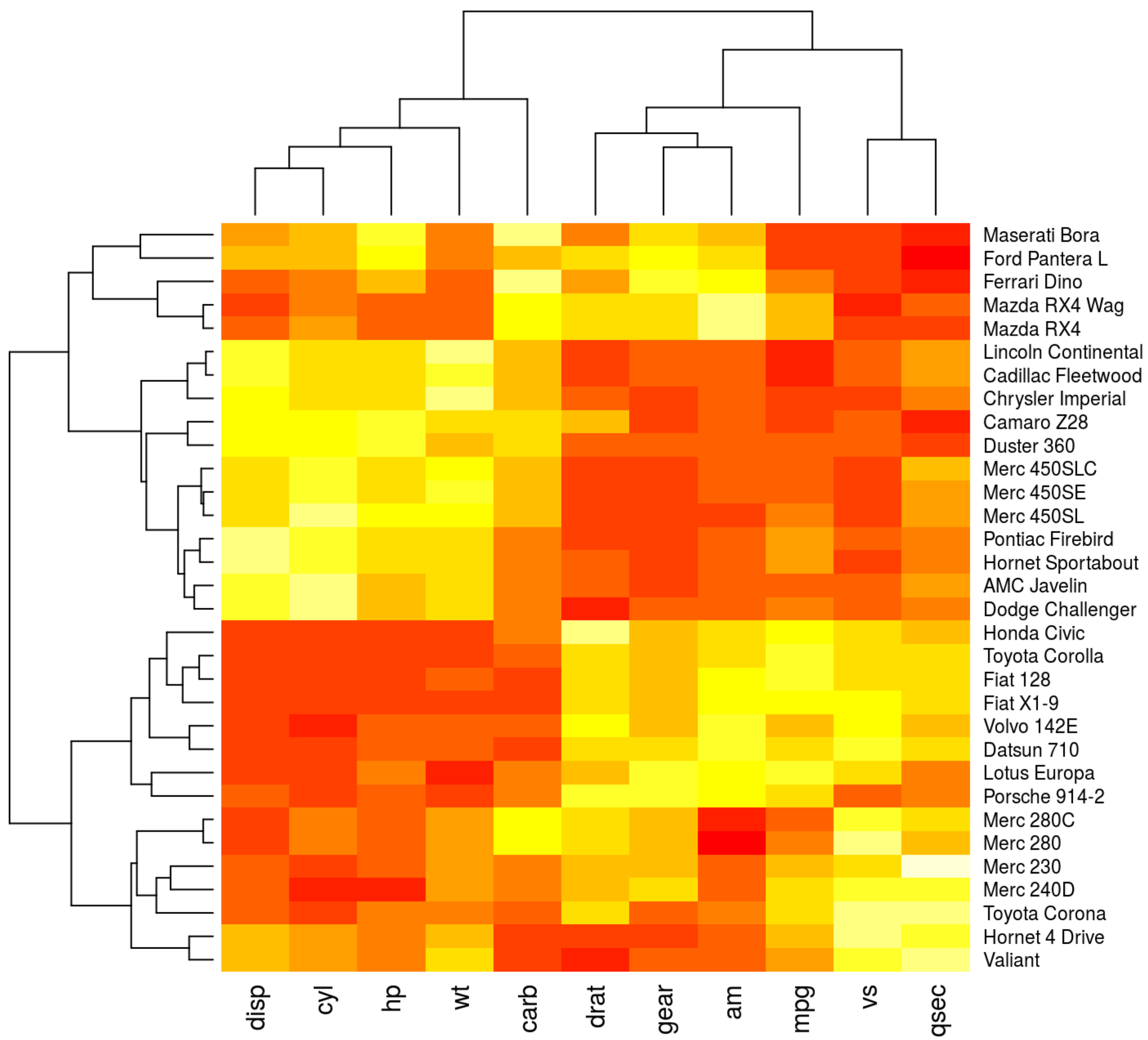
Generate a basic heatmap

```r
# Using basic `stats::heatmap` function:
heatmap(mtscaled, Rowv = NA, Colv = NA)
```



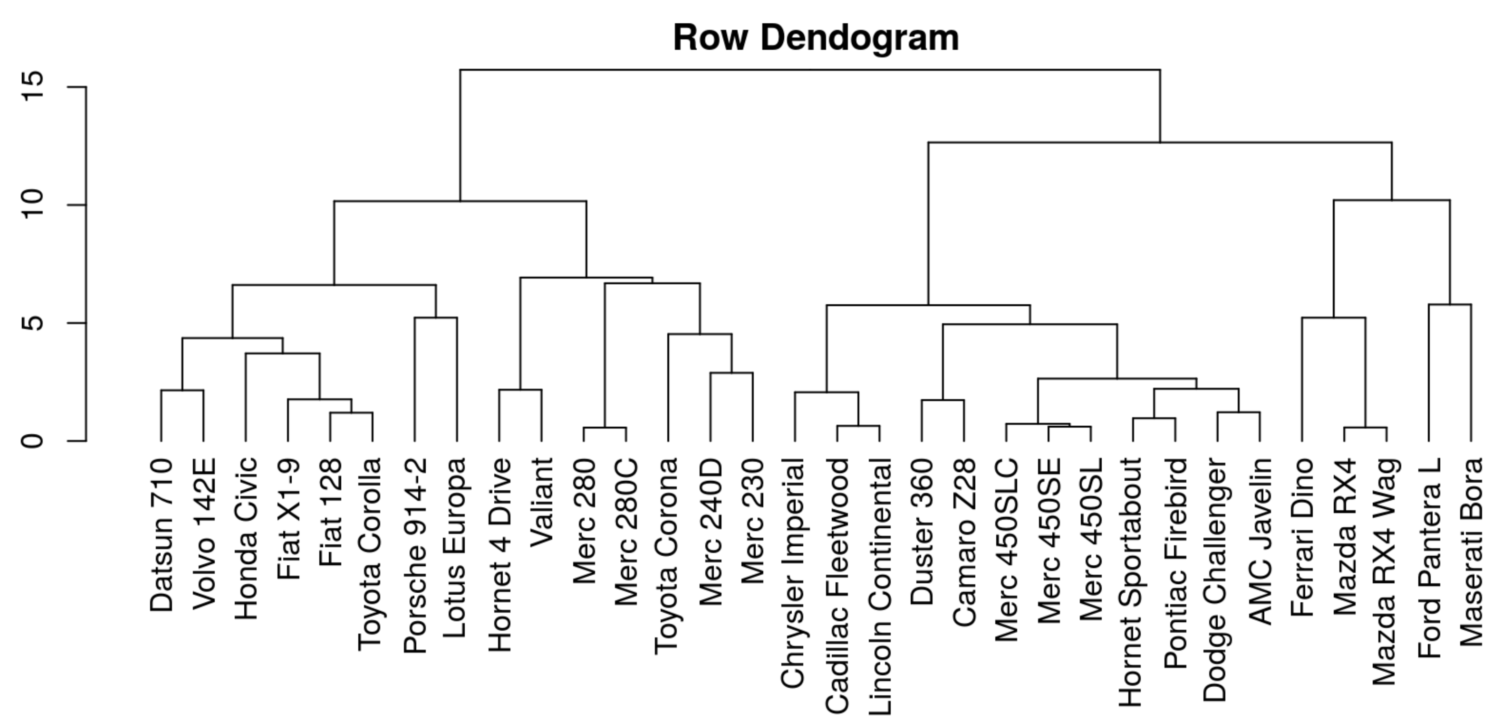
Heatmap with dendograms

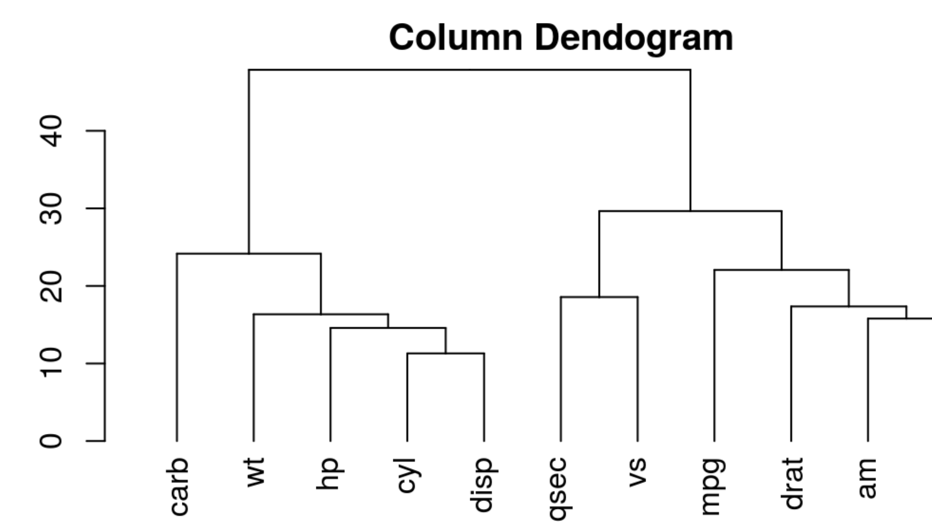
```r
# heatmaps with dendograms and rows and columns reoredered by means
heatmap(mtscaled)
```



Compute dendograms

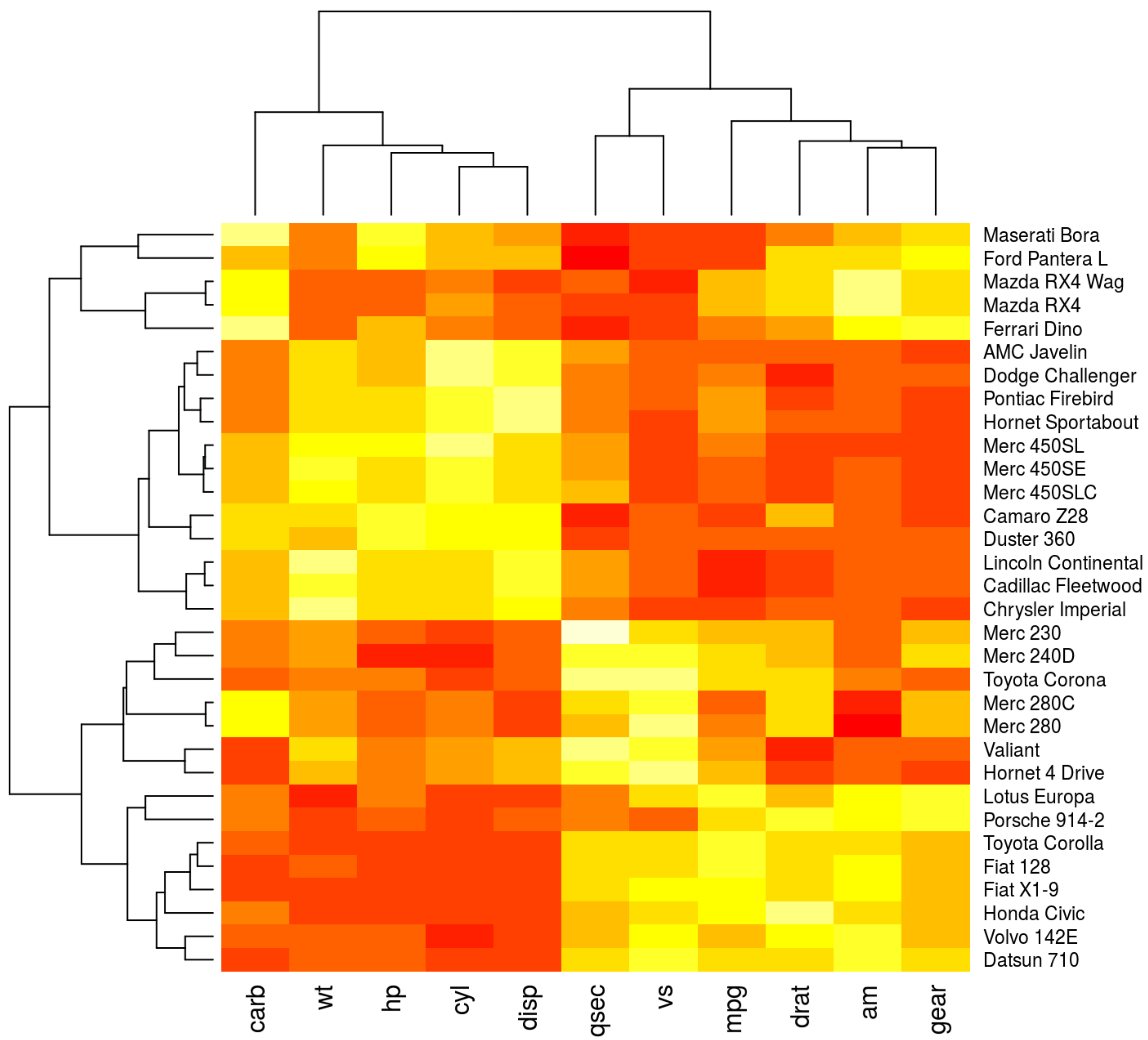
```
# Cluster rows (by default healmaps uses method = "euclidean")
row.clus <- hclust(dist(mtscaled, method = "manhattan") , "aver")
row.dend <- as.dendrogram(row.clus)

# Cluster columns
col.clus <- hclust(dist(t(mtscaled), method = "manhattan"), "aver")
col.dend <- as.dendrogram(col.clus)

# Plot dendograms:
layout(matrix(c(1,2),nrow=1), widths=c(3,2)); par(mar = c(8,4,1,1))
plot(row.dend, xlab = "", main = "Row Dendogram", sub = "")
plot(col.dend, xlab = "", main = "Column Dendogram", sub = "")
```



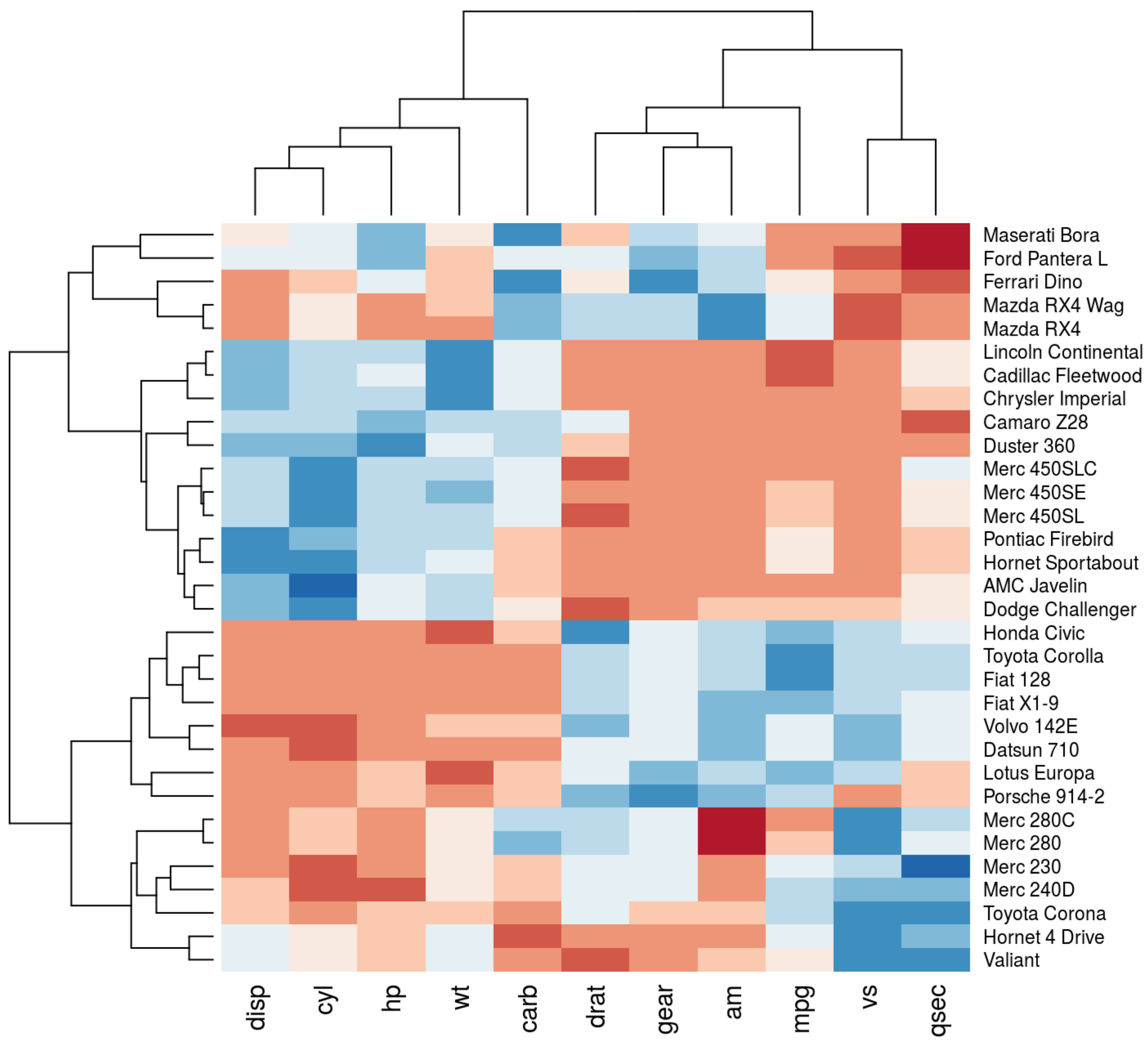


Heatmaps with customized dendograms

```r
# heatmaps with dendograms and reordered (by means) rows and columns
heatmap(mtscaled, Rowv = row.dend, Colv = col.dend)
```

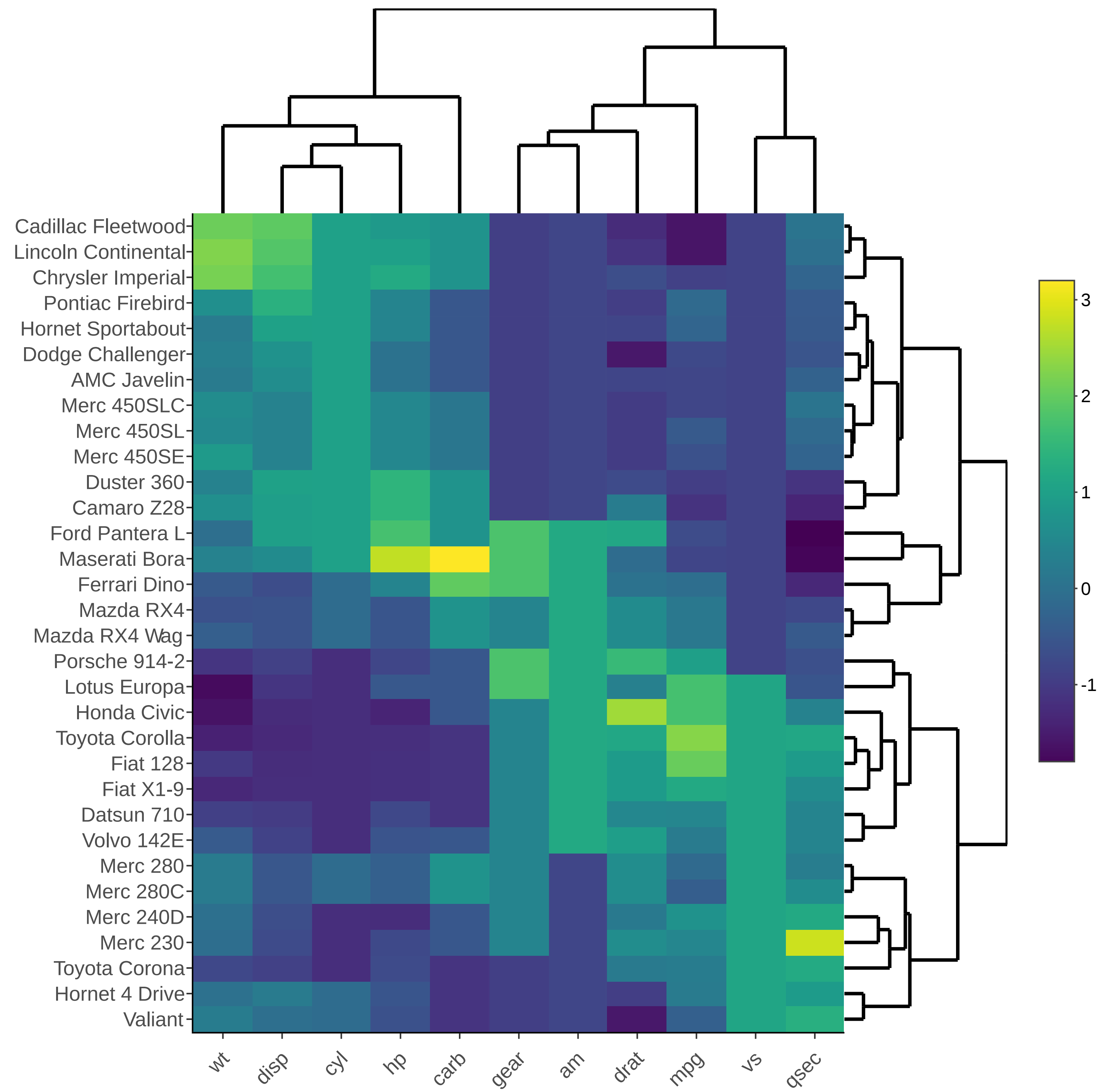


```r
library(RColorBrewer)
# Define color scheme
scaleredblues <- colorRampPalette(colors = brewer.pal(9, "RdBu"))(10)
#  "#B2182B" "#D25849" "#ED9576" "#FAC9B0" "#F9EAE1" "#E6EFF3" "#BCDAEA" "#80B9D8
heatmap(as.matrix(mtscaled), col = scaleredblues)
```



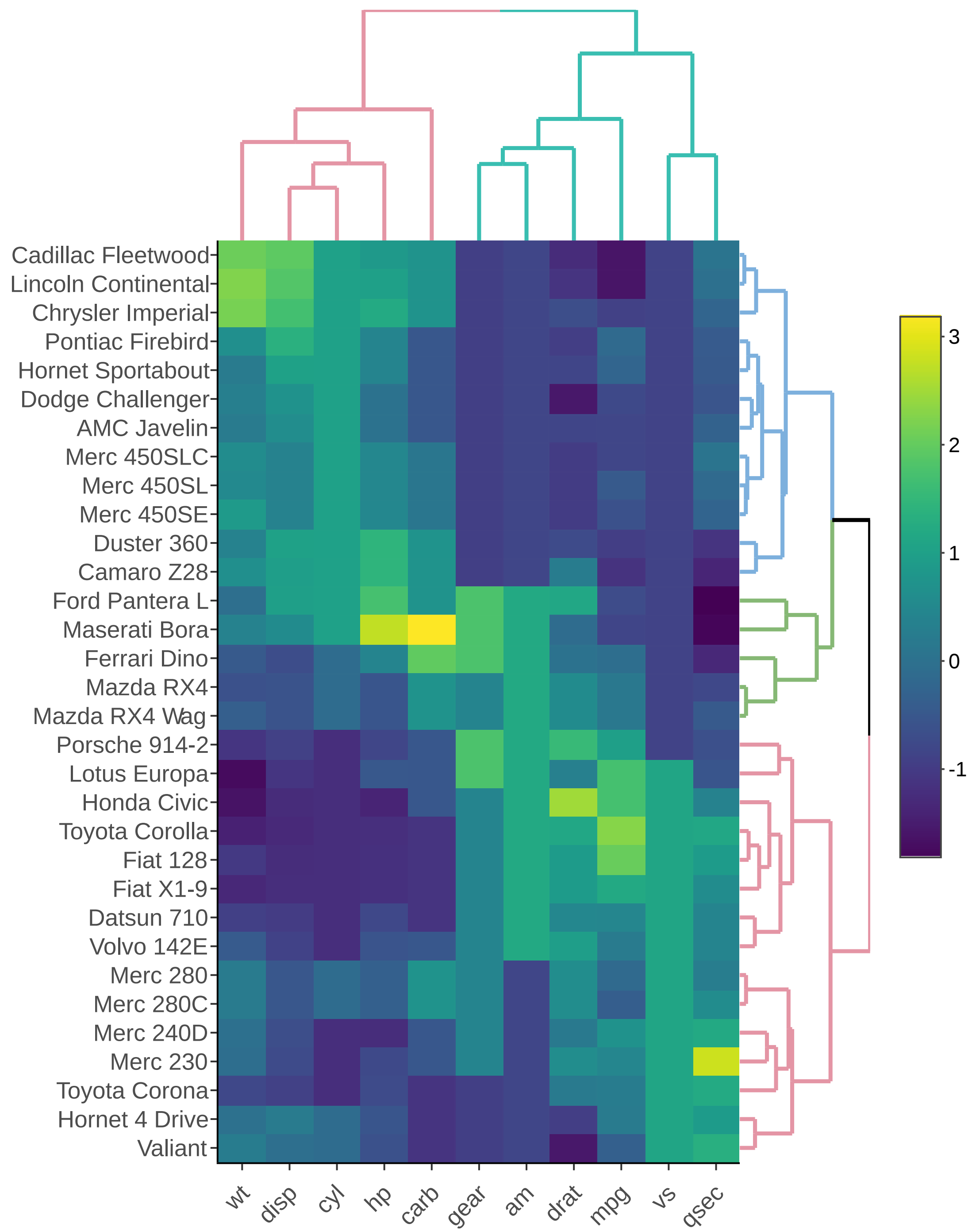
heatmaply package for interactive heatmap

```
library(heatmaply)
heatmaply(mtscaled) %>% layout(margin = list(l = 150, b = 50))
```



Color the dendogram branches:

```
heatmaply(mtscaled, k_col = 2, k_row = 3) %>%
  layout(margin = list(l = 150, b = 50), autosize = F, width = 600, height = 70(
```



ggmap for visualizing spatial data

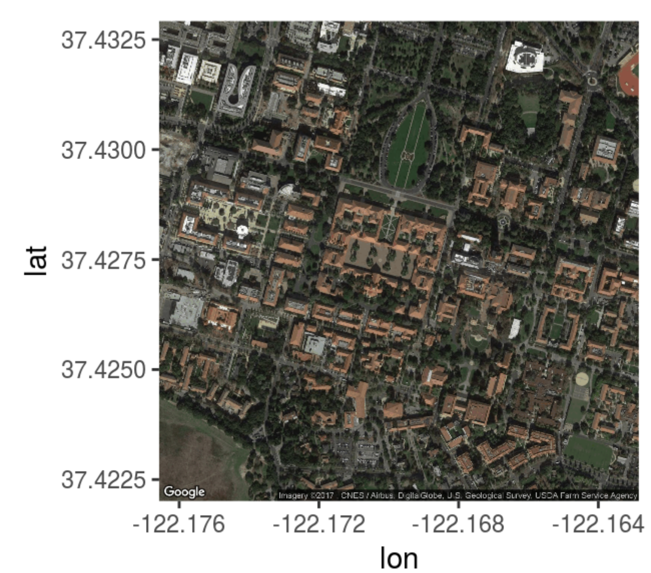
`ggmap` for plotting maps

1. Define location: 3 ways
   - location/address
   - lat/long
   - bounding box
2. Define map source, type, and color with `get_map()`:
   - Google Maps ("google"),
   - OpenStreetMap ("osm"),
   - Stamen Maps ("stamen"),
   - CloudMade maps ("cloudmade")
3. You can set **the scale of the map using zoom**. `get_map()` takes a guess at the zoom level, but you can alter it.
   - 3 (continent) to 21 (building), default value 10 (city).
   - "openstreetmap" and "stamen" limit is 0-18.

```
library(ggmap)
geocode("Stanford University")
```

```
##          lon      lat
## 1 -122.1697 37.42747
```

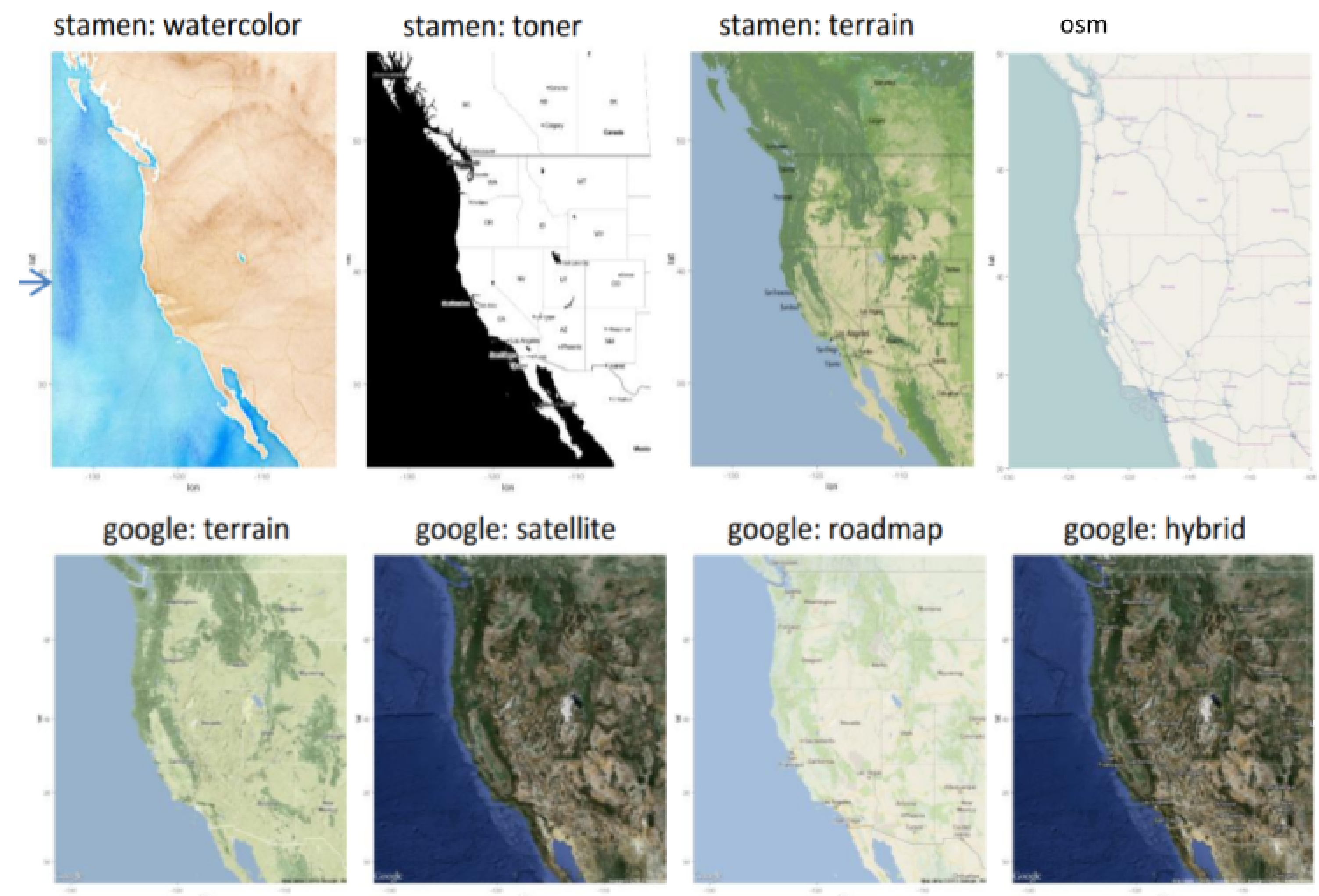
```
myLoc <- "Stanford University" # or myLoc <- c(-125,
# or myLoc <- c(lon = -122.1697, lat = 37.42747)
myMap <- get_map(location = myLoc, crop = TRUE, zoom
                 source = "google", maptype="satellit
ggmap(myMap)
```



Map sources

There are different map sources to obtain a map raster, and each of these sources has multiple "map types". Here we show examples of maps from:

- **stamen:** maptype = c("terrain", "toner", "watercolor")
- **google:** maptype = c("roadmap", "terrain", "satellite", "hybrid")
- **osm:** open street map

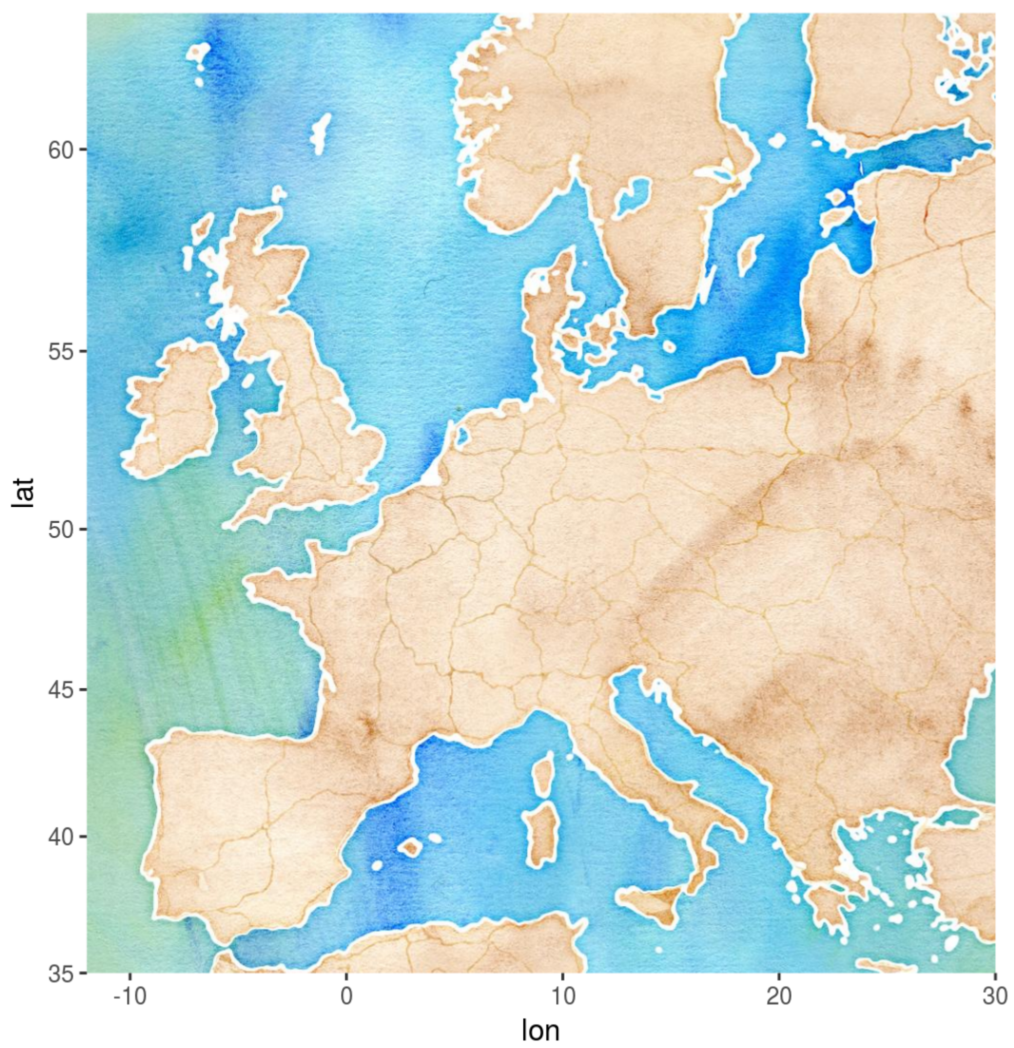


```r
US <- c(left = -125, right = -67, bottom = 25.75, top = 49)
us_map <- get_map(location = US, source = "stamen", maptype = "toner-lite", zoo
class(us_map)
```

```
## [1] "ggmap"  "raster"
```

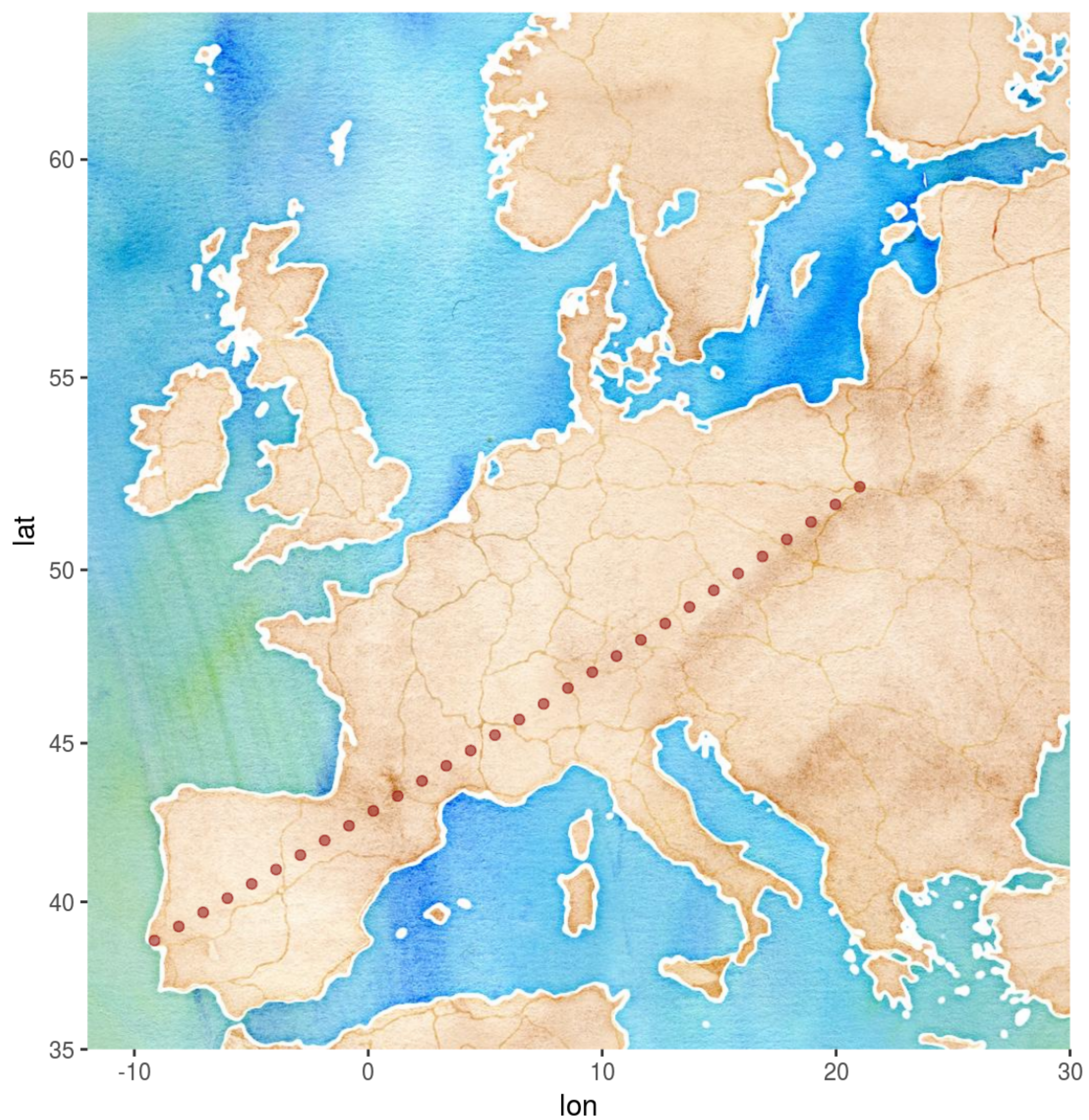
```r
ggmap(us_map)
```

```r
europe <- c(left = -12, right = 30,  bottom = 35.0, top = 63)
europe_map <- get_stamenmap(bbox = europe, zoom = 5, maptype = "watercolor")
ggmap(europe_map)
```



Adding data

```
Lisbon <- geocode("Lisbon")
Warsaw <- geocode("Warsaw")
road <- data.frame(latitude = seq(Lisbon$lat, Warsaw$lat, length.out =30),
                   longitude = seq(Lisbon$lon, Warsaw$lon, length.out = 30))
ggmap(europe_map)+
 geom_point(data = road, aes(x = longitude, y = latitude),
            alpha = .5, color="darkred")
```



Exercises

- Go to the “Lec5_Exercises.Rmd” file, which can be downloaded from the class website under the Lecture tab.
- Complete all exercises.