

NPS Workshop on Interactive Reporting with R

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Chapter 1

Overview

This is the landing site for our workshop materials. Google Drive (folders, docs, slides, sheets, etc.) allows us to be agile with adapting content on the fly. The rest of the content in this site is generated using the techniques taught: R + markdown = Rmarkdown, git, Github, etc.

1.1 Google Drive Content

- **workshop/**
 - **agenda**
 - **notes**
 - **presentations/**
 - **data/**

1.2 Resources

- R for Data Science
- Spatial Data Analysis and Modeling with R
- Introduction to GIS - slides

Chapter 2

Collaborate: git, github

This section is paired with:

- Data Wrangling in the R Tidyverse - Google Slides

The two main tools you'll learn about to start are:

- **Git** is a version control system that lets you track changes to files over time. These files can be any kind of file (eg doc, pdf, xls), but free text differences are most easily visible (eg txt, csv, md). You can rollback changes made by you, or others. This facilitates a playground for collaboration, without fear of experimentation (you can always rollback changes).
- **Github** is a website for storing your git versioned files remotely. It has many nice features to be able visualize differences between images, rendering & diffing map data files, render text data files, and track changes in text.

Steps:

1. Create Github login
2. Create project website with Github Pages
3. Edit README.md in Markdown
4. Create HTML website content with R Markdown

2.1 Setup Github & Git

1. Create **Github** account at <http://github.com>, if you don't already have one. For username, I recommend all lower-case letters, short as you can. If you use an email ending in **.edu**, you can request free private repositories via GitHub Education discount.
2. Configure **git** with global commands. Open up the Bash version of Git and type the following:

```
# display your version of git
git --version

# replace USER with your Github user account
git config --global user.name USER

# replace USER@SOMEWHERE.EDU with the email you used to register with Github
git config --global user.email USER@SOMEWHERE.EDU
```

```
# list your config to confirm user.* variables set
git config --list
```

2.2 Github Workflows

The two most common workflow models for working Github repositories is based on your permissions:

1. **writable**: Push & Pull (simplest)
2. **read only**: Fork & Pull Request (extra steps)

We will only go over the first writable mode. For more on the second mode, see [Forking Projects · GitHub Guides](#).

2.2.1 Push & Pull

repo location	initialize	edit	update
github.com/OWNER/REPO	create		
~/github/REPO	clone	commit , push	pull

Note that OWNER could be either an individual USER or group ORGANIZATION, which has member USERS.

2.3 Create Repository nps-demo

Now you will create a Github repository for a project.

1. Create a repository called **my-project**.

Please be sure to tick the box to **Initialize this repository with a README**. Otherwise defaults are fine.

2. Create a branch called **gh-pages**.

Per pages.github.com, since this will be a project site only web files in the **gh-pages** branch will show up at <http://USER.github.io/REPO>. For a user (or organization) site, the REPO must be named **USER.github.io** (or **ORG.github.io**) and then the default **master** branch will contain the web files for the website <http://USER.github.io> (or <http://ORG.github.io>). See also [User](#), [Organization](#), and [Project Pages - Github Help](#).

3. Set the default branch to **gh-pages**, NOT the default **master**.
4. Delete the branch **master**, which will not be used.

2.3.1 Edit README.md in Markdown

Commit your first change by editing the **README.md** which is in **markdown**, simple syntax for conversion to HTML. Now update the contents of the **README.md** with the following, having a link and a numbered list:

```
# nps-demo
```


Wrangling data with R.

Introduction

This repository demonstrates **software** and `_formats_`:

1. **Git**
1. **Github**
1. `_Markdown_`
1. `_Rmarkdown_`

Conclusion

Now click on the Preview changes to see the markdown rendered as HTML:

Notice the syntax for:

- **numbered list** gets automatically sequenced: 1., 1.
- **headers** get rendered at multiple levels: #, ##
- **link**: [](http://...)
- **image**:
- *italics*: `_word_`
- **bold**: **`**word**`**

See Mastering Markdown · GitHub Guides and add some more personalized content to the README of your own, like a bulleted list or blockquote.

2.4 Create index.html

By default `index.html` is served up. Go ahead and create a new file named `index.html` with the following basic HTML:

```
<!DOCTYPE html>
<html>
<body>

<h1>My First Heading</h1>

<p>My first paragraph.</p>

</body>
</html>
```

You'll be prompted to clone this repository into a folder on your local machine.

See GitHub Desktop User Guides for more. You could also do this from the Bash Shell for Git with the command `git clone https://github.com/USER/REPO.git`, replacing `USER` with your Github username and `REPO` with `my_project`. Or you can use the Github Desktop App menu File -> Clone Repository...

2.5 Create RStudio Project with Git Repository

Next, you will clone the repository onto your local machine using RStudio. I recommend creating it in a folder `github` under your user or Documents folder.

Open RStudio and under the menu File -> New Project... -> Version Control -> git and enter the URL with the `.git` extension (also available from the repository's Clone button):

If it all works correctly then you should see the files downloaded and showing up in the Files pane of RStudio. If RStudio is configured correctly to work with Git, then you should also see a Git pane.

2.6 Create `index.Rmd` in Rmarkdown

Back in RStudio, let's create a new Rmarkdown file, which allows us to weave markdown text with chunks of R code to be evaluated and output content like tables and plots.

File -> New File -> Rmarkdown... -> Document of output format HTML, OK.

You can give it a Title of "My Project". After you click OK, most importantly File -> Save as `index` (which will get named with the filename extension `index.Rmd`).

Some initial text is already provided for you. Let's go ahead and "Knit HTML".

Notice how the markdown is rendered similar to as before + **R code chunks** are surrounded by 3 backticks and `{r LABEL}`. These are evaluated and return the output text in the case of `summary(cars)` and the output plot in the case of `plot(pressure)`.

Notice how the code `plot(pressure)` is not shown in the HTML output because of the R code chunk option `echo=FALSE`.

Before we continue exploring Rmarkdown, visit the Git pane, check all modified (M) or untracked (?) files, click Commit, enter a message like "added index" and click the "Commit" button. Then Push (up green arrow) to push the locally committed changes on your laptop up to the Github repository online. This will update <https://github.com/USER/nps-demo>, and now you can also see your project website with a default `index.html` viewable at <http://USER.github.io/nps-demo>

For more on Rmarkdown:

- [rmarkdown cheatsheet.pdf](#)
- [rmarkdown.rstudio.com](#)
- [knitr in a knutshell - Karl Broman](#)

A more advanced topic worth mentioning is dealing merge conflicts

2.7 Exercise: Intertidal Sites Dataset

Gil Rilov shared the following dataset for us to play with:

- [Israel sites fall 2015-16.xlsx](#)

Please download and open this dataset. Your task is to investigate this dataset and prepare it for submission to OBIS.

2.7.1 Task: Provide Excel cell ranges for how you would divide data into tables?

For reading and wrangling data in R, please see cheat sheets and resources mentioned in:

- Data Wrangling in the R Tidyverse - Google Slides

Chapter 3

Manipulate: `tidyr`, `dplyr`

Data scientists, according to interviews and expert estimates, spend from 50 percent to 80 percent of their time mired in the mundane labor of collecting and preparing data, before it can be explored for useful information. - NYTimes (2014)

Today we're going to learn about a package by Hadley Wickham called `dplyr` and how it will help you with simple data exploration, and how you can use it in combination with the `%>%` operator for more complex wrangling (including a lot of the things you would use for loops for).

And we're going to do this in Rmarkdown in the `my-project` repository we created this morning.

Here are the steps:

1. Open RStudio
2. Make sure you're in your `my-project` repo (and if not, get there)
3. New > Rmarkdown... (defaults are fine)
4. Save as `gapminder-dplyr.rmd`
5. Our workflow together will be to write some description of our analysis in Markdown for humans to read, and we will write all of our R code in the 'chunks'. Get ready for the awesomeness, here we go...

Today's materials are again borrowing from some excellent sources, including

- Dr. Jenny Bryan's lectures from STAT545 at UBC: Introduction to `dplyr`
- Software Carpentry's R for reproducible scientific analysis materials: Dataframe manipulation with `dplyr`

3.1 install our first package: `dplyr`

Packages are bundles of functions, along with help pages and other goodies that make them easier for others to use, (ie. vignettes).

So far we've been using packages included in 'base R'; they are 'out-of-the-box' functions. You can also install packages from online. The most traditional is CRAN, the Comprehensive R Archive Network. This is where you went to download R originally, and will go again to look for updates.

You don't need to go to CRAN's website to install packages, we can do it from within R with the command `install.packages("package-name-in-quotes")`.

```
## from CRAN:
```

```
#install.packages("dplyr") ## do this once only to install the package on your computer.
```

```
library(dplyr) ## do this every time you restart R and need it
```

What's the difference between `install.packages()` and `library()`? Here's my analogy:

- `install.packages()` is setting up electricity for your house. Just need to do this once (let's ignore monthly bills).
- `library()` is turning on the lights. You only turn them on when you need them, otherwise it wouldn't be efficient. And when you quit R, and come back, you'll have to turn them on again with `library()`, but you already have your electricity set up.

3.2 Use `dplyr::filter()` to subset data row-wise.

First let's read in the gapminder data.

```
# install.packages('gapminder') # instead of reading in the csv
```

```
library(gapminder) # this is the package name
```

```
str(gapminder) # and it's also the data.frame name, just like yesterday
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame': 1704 obs. of 6 variables:
```

```
## $ country : Factor w/ 142 levels "Afghanistan",...: 1 1 1 1 1 1 1 1 1 1 ...
```

```
## $ continent: Factor w/ 5 levels "Africa","Americas",...: 3 3 3 3 3 3 3 3 3 3 ...
```

```
## $ year : int 1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 ...
```

```
## $ lifeExp : num 28.8 30.3 32 34 36.1 ...
```

```
## $ pop : int 8425333 9240934 10267083 11537966 13079460 14880372 12881816 13867957 16317921 22...
```

```
## $ gdpPercap: num 779 821 853 836 740 ...
```

`filter()` takes logical expressions and returns the rows for which all are TRUE. Visually, we are doing this (thanks RStudio for your cheatsheet):

Subset Observations (Rows)



```
filter(gapminder, lifeExp < 29)
```

```
filter(gapminder, country == "Rwanda")
```

```
filter(gapminder, country %in% c("Rwanda", "Afghanistan"))
```

Compare with some base R code to accomplish the same things

```
gapminder[gapminder$lifeExp < 29, ] ## repeat `gapminder`, [i, j] indexing is distracting
```

```
subset(gapminder, country == "Rwanda") ## almost same as filter ... but wait ...
```

3.3 Meet the new pipe operator

Before we go any further, we should exploit the new pipe operator that `dplyr` imports from the `magrittr` package by Stefan Bache. **This is going to change your data analytical life.** You no longer need to

enact multi-operation commands by nesting them inside each other. This new syntax leads to code that is much easier to write and to read.

Here's what it looks like: `%>%`. The RStudio keyboard shortcut: Ctrl + Shift + M (Windows), Cmd + Shift + M (Mac).

Let's demo then I'll explain:

```
gapminder %>% head
```

This is equivalent to `head(gapminder)`. This pipe operator takes the thing on the left-hand-side and **pipes** it into the function call on the right-hand-side – literally, drops it in as the first argument.

Never fear, you can still specify other arguments to this function! To see the first 3 rows of Gapminder, we could say `head(gapminder, 3)` or this:

```
gapminder %>% head(3)
```

I've advised you to think “gets” whenever you see the assignment operator, `<-`. Similarly, you should think “then” whenever you see the pipe operator, `%>%`.

You are probably not impressed yet, but the magic will soon happen.

3.4 Use `dplyr::select()` to subset the data on variables or columns.

Back to dplyr ...

Use `select()` to subset the data on variables or columns. Visually, we are doing this (thanks RStudio for your cheatsheet):

Subset Variables (Columns)



Here's a conventional call:

```
select(gapminder, year, lifeExp)
```

But using what we just learned, with a pipe, we can do this:

```
gapminder %>% select(year, lifeExp)
```

Let's write it again but using multiple lines so it's nicer to read. And let's add a second pipe operator to pipe through `head`:

```
gapminder %>%
  select(year, lifeExp) %>%
  head(4)
```

```
## # A tibble: 4 x 2
##   year lifeExp
##   <int>   <dbl>
## 1  1952    28.8
## 2  1957    30.3
## 3  1962    32.0
## 4  1967    34.0
```

Think: “Take `gapminder`, then select the variables `year` and `lifeExp`, then show the first 4 rows.”

3.5 Revel in the convenience

Let’s do a little analysis where we calculate the mean gdp for Cambodia.

Here’s the `gapminder` data for Cambodia, but only certain variables:

```
gapminder %>%
  filter(country == "Cambodia") %>%
  # select(country, year, pop, gdpPercap) ## entering 4 of the 6 columns is tedious
  select(-continent, -lifeExp) # you can use - to deselect columns
```

and what a typical base R call would look like:

```
gapminder[gapminder$country == "Cambodia", c("country", "year", "pop", "gdpPercap")]
```

```
## # A tibble: 12 x 4
##   country year      pop gdpPercap
##   <fct>   <int>   <int>   <dbl>
## 1 Cambodia 1952  4693836    368.
## 2 Cambodia 1957  5322536    434.
## 3 Cambodia 1962  6083619    497.
## 4 Cambodia 1967  6960067    523.
## 5 Cambodia 1972  7450606    422.
## 6 Cambodia 1977  6978607    525.
## 7 Cambodia 1982  7272485    624.
## 8 Cambodia 1987  8371791    684.
## 9 Cambodia 1992 10150094    682.
## 10 Cambodia 1997 11782962    734.
## 11 Cambodia 2002 12926707    896.
## 12 Cambodia 2007 14131858   1714.
```

or, possibly?, a nicer look using base R’s `subset()` function:

```
subset(gapminder, country == "Cambodia", select = c(country, year, pop, gdpPercap))
```

```
## # A tibble: 12 x 4
##   country year      pop gdpPercap
##   <fct>   <int>   <int>   <dbl>
## 1 Cambodia 1952  4693836    368.
## 2 Cambodia 1957  5322536    434.
## 3 Cambodia 1962  6083619    497.
## 4 Cambodia 1967  6960067    523.
## 5 Cambodia 1972  7450606    422.
## 6 Cambodia 1977  6978607    525.
## 7 Cambodia 1982  7272485    624.
## 8 Cambodia 1987  8371791    684.
```



```
## 9 Cambodia 1992 10150094      682.
## 10 Cambodia 1997 11782962      734.
## 11 Cambodia 2002 12926707      896.
## 12 Cambodia 2007 14131858     1714.
```

3.6 Use `mutate()` to add new variables

Imagine we wanted to recover each country's GDP. After all, the Gapminder data has a variable for population and GDP per capita. Let's add a new column and multiply them together.

Visually, we are doing this (thanks RStudio for your cheatsheet):

Make New Variables



```
gapminder %>%
  mutate(gdp = pop * gdpPercap)
```

Exercise: how would you add that to the previous `filter` and `select` commands we did with Cambodia:

```
gapminder %>%
  filter(country == "Cambodia") %>%
  select(-continent, -lifeExp)
```

Answer:

```
gapminder %>%
  filter(country == "Cambodia") %>%
  select(-continent, -lifeExp) %>%
  mutate(gdp = pop * gdpPercap)
```

3.7 `group_by` and `summarize`

Great! And now we want to calculate the mean gdp across all years (Let's pretend that's a good idea statistically)

Visually, we are doing this (thanks RStudio for your cheatsheet):

Summarise Data



```
gapminder %>%
  filter(country == "Cambodia") %>%
  select(-continent, -lifeExp) %>%
  mutate(gdp = pop * gdpPerCap) %>%
  group_by(country) %>%
  summarize(mean_gdp = mean(gdp)) %>%
  ungroup() # if you use group_by, also use ungroup() to save heartache later
```

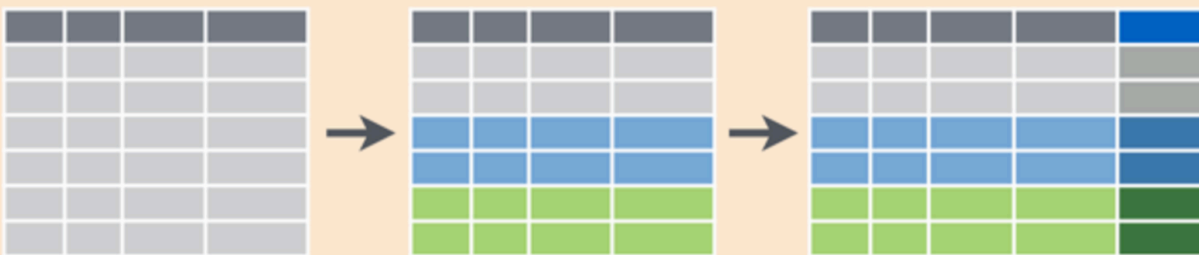
3.8 Remember our for loop?

And how would you then do this for every country, not just Cambodia? Well, yesterday we would have been thinking about putting this whole analysis inside a for loop, replacing “Cambodia” with a new name each time we iterated through the loop. But today, we have it already, just need to *delete* one line from our analysis—we don’t need to filter out Cambodia anymore!!

Visually, we are doing this (thanks RStudio for your cheatsheet):

Group Data

Compute new variables by group.



```
gapminder %>%
  select(-continent, -lifeExp) %>%
  mutate(gdp = pop * gdpPerCap) %>%
  group_by(country) %>%
  summarize(mean_gdp = mean(gdp)) %>%
  ungroup() # if you use group_by, also use ungroup() to save heartache later
```

So we have done a pretty incredible amount of work in a few lines. Our whole analysis is this. Imagine the

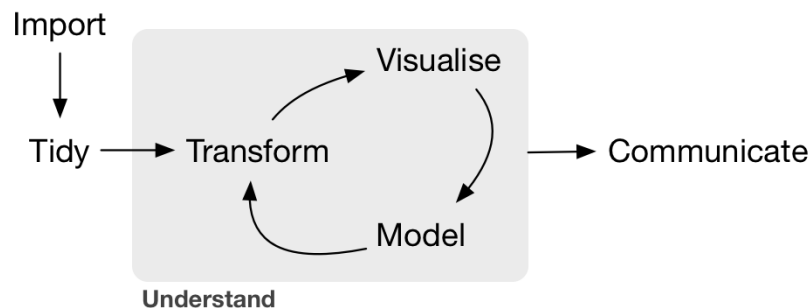
possibilities from here.

```
library(dplyr)

gapminder %>%
  read.csv('data/gapminder-FiveYearData.csv') %>%
  select(-continent, -lifeExp) %>%
  mutate(gdp = pop * gdpPerCap) %>%
  group_by(country) %>%
  summarize(mean_gdp = mean(gdp)) %>%
  ungroup() # if you use group_by, also use ungroup() to save heartache later
```

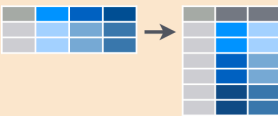



3.9 Summary

This has been the ‘Transform’ or Wrangling part of this cycle.



Importing and tidying is also a HUGE part of this process, and we don’t have time to get into it today. But look at the cheatsheet, and watch the webinar. cheatsheet and webinar. Watch this 1 hour webinar and follow along in RStudio and your science will be forever changed. Again!

Reshaping Data - Change the layout of a data set

 <p>tidyr::gather(cases, "year", "n", 2:4) Gather columns into rows.</p>	 <p>tidyr::spread(pollution, size, amount) Spread rows into columns.</p>	<p>dplyr::data_frame(a = 1:3, b = 4:6) Combine vectors into data frame (optimized).</p> <p>dplyr::arrange(mtcars, mpg) Order rows by values of a column (low to high).</p> <p>dplyr::arrange(mtcars, desc(mpg)) Order rows by values of a column (high to low).</p> <p>dplyr::rename(tb, y = year) Rename the columns of a data frame.</p>
 <p>tidyr::separate(storms, date, c("y", "m", "d")) Separate one column into several.</p>	 <p>tidyr::unite(data, col, ..., sep) Unite several columns into one.</p>	

3.10 Further materials as reference...

3.10.1 Rationale

When performing data analysis in R, code can become quite messy, making it hard to revisit and determine the sequence of operations. Commenting helps. Good variable names help. Still, at least two common issues make code difficult to understand: **multiple variables** and **nested functions**. Let's examine these issues by approaching an analysis presenting both problems, and finally see how `dplyr` offers an elegant alternative.

For example, let's ask of the `surveys.csv` dataset: *How many observations of a certain thing you're interested in appear each year?*

3.10.2 Pseudocode

You can write the logic out as **pseudocode** which can become later comments for the actual code:

```
# read in csv
# view data
# limit columns to species and year
# limit rows to just species "NL"
# get count per year
# write out csv
```

3.10.3 Summary

The `tidyr` and `dplyr` packages were created by Hadley Wickham of `ggplot2` fame. The “gg” in `ggplot2` stands for the “grammar of graphics”. Hadley similarly considers the functionality of the two packages `dplyr` and `tidyr` to provide the “grammar of data manipulation”.

Next, we'll explore the data wrangling lessons that Remi contributed to Software Carpentry.

3.10.4 dplyr

`dplyr` - Software Carpentry

3.10.5 tidyr

`tidyr` - Software Carpentry

3.10.6 Other links

- Tidying up Data - Env Info - Rmd
- Data wrangling with `dplyr` and `tidyr` - Tyler Clavelle & Dan Ovando - Rmd

Chapter 4

Visualize: ggplot2, plotly, tmap

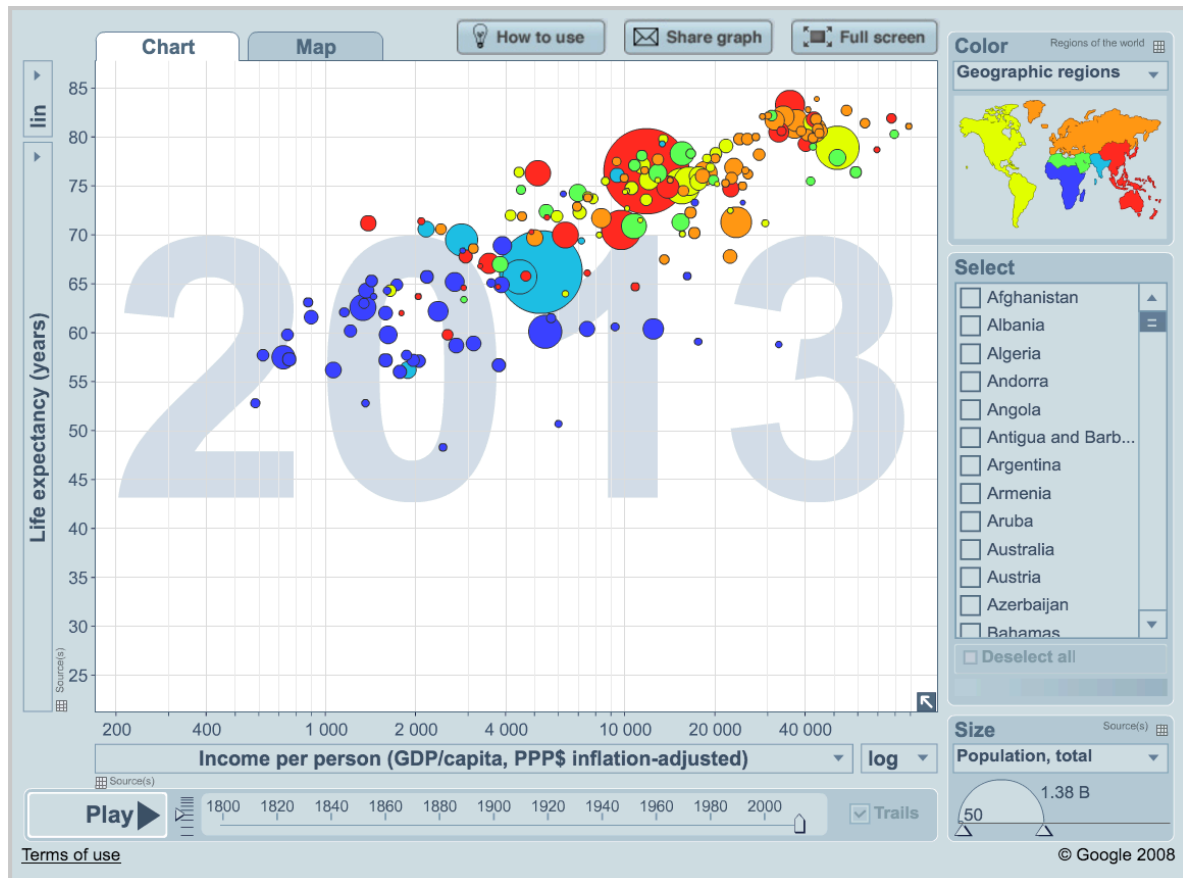
4.1 Plot

Inspiring people:

- **Hadley Wickham:** grammar of graphics
- **Hans Rosling:** Gapminder



Gapminder World - Wealth & Health of Nations



4.1.1 Static: ggplot

- Creating publication quality graphics - Software Carpentry

4.1.1.1 Scatterplot

```
library(dplyr)
library(ggplot2)
library(gapminder)

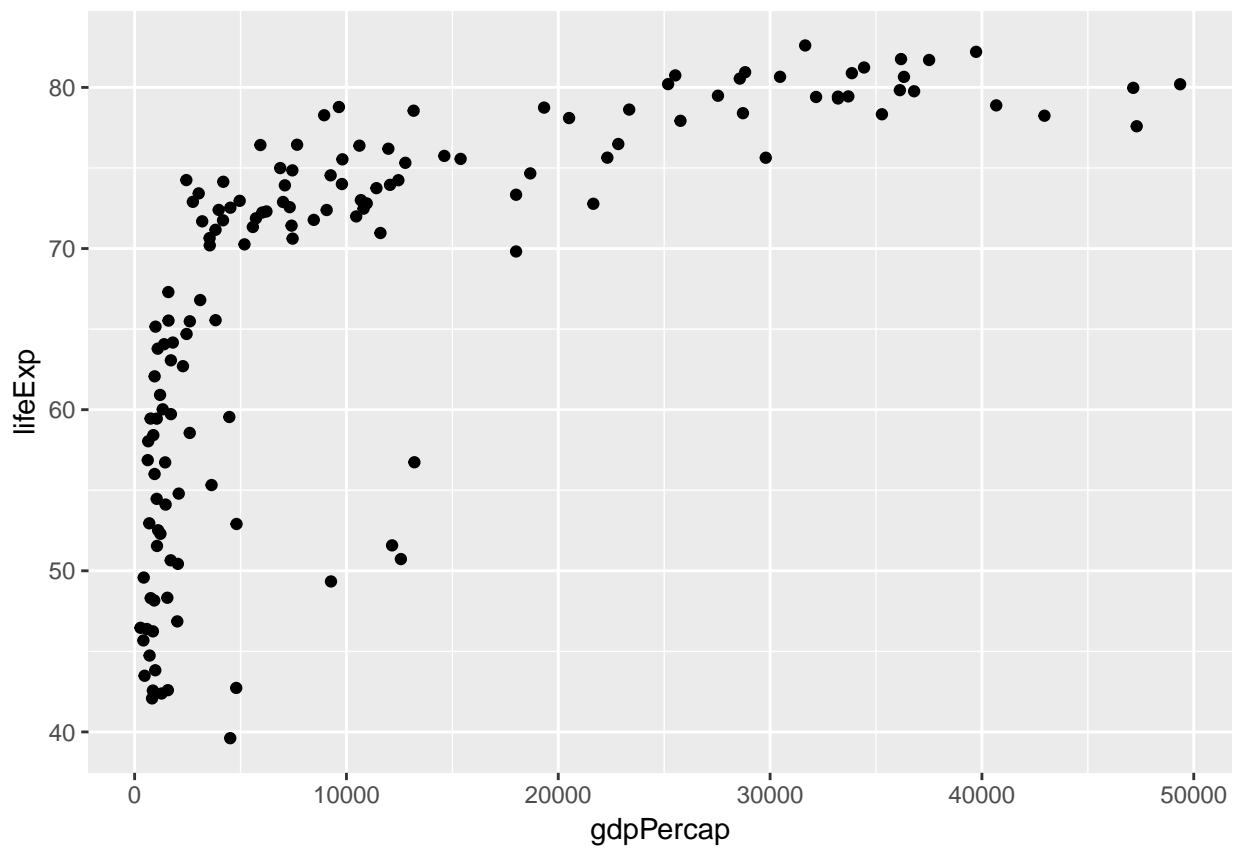
# preview data
gapminder

# get range of available data
summary(gapminder)

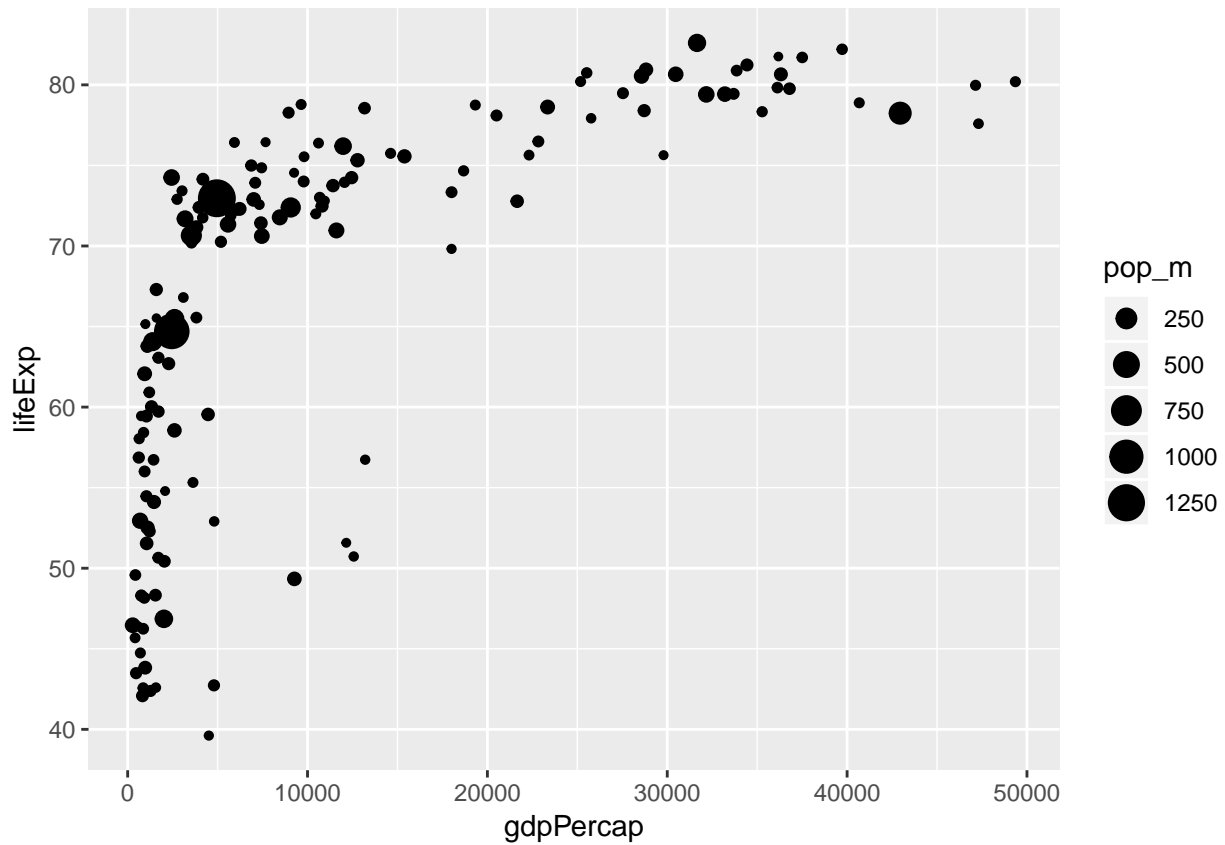
# setup dataframe
g = gapminder %>%
  filter(year==2007) %>% # most recent year
  mutate(pop_m = pop/1e6) # population, millions

# plot scatterplot of most recent year
s = ggplot(g, aes(x=gdpPercap, y=lifeExp)) +
```

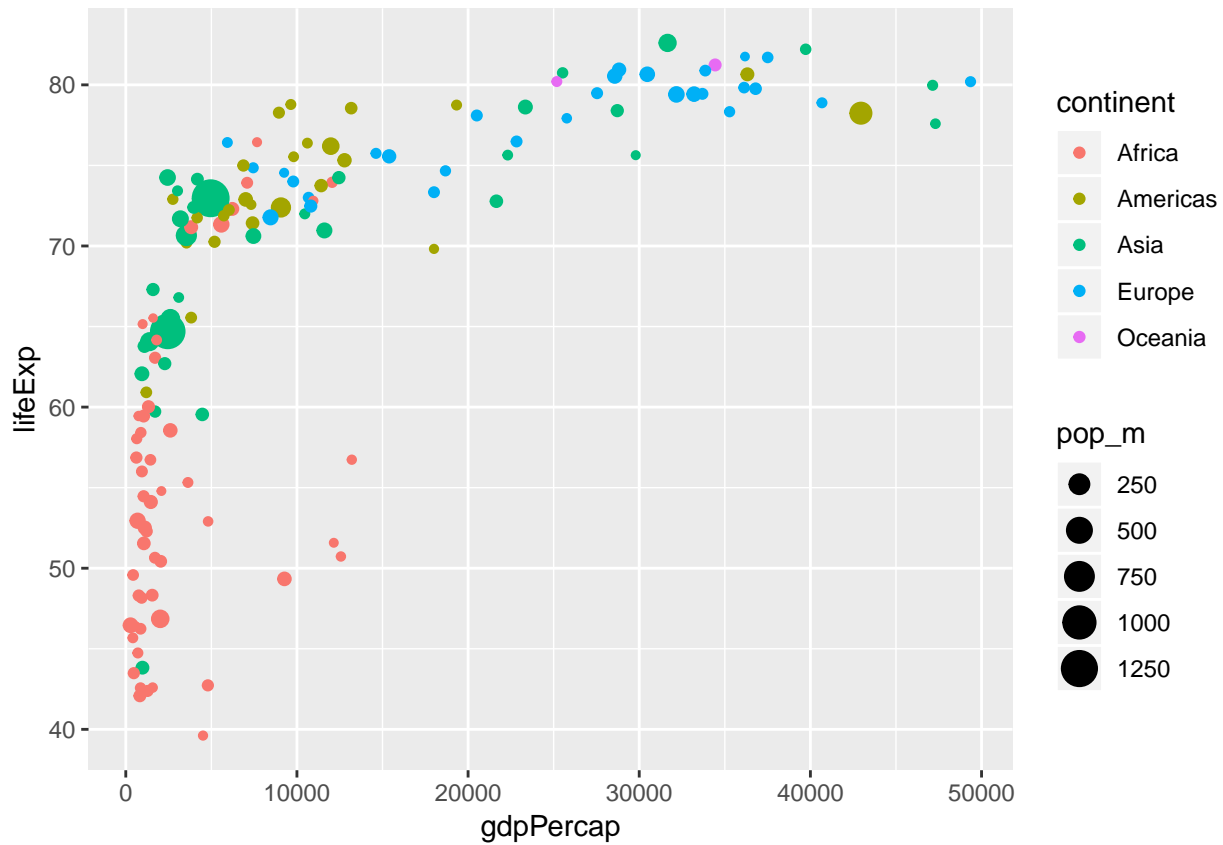
```
geom_point()  
s
```



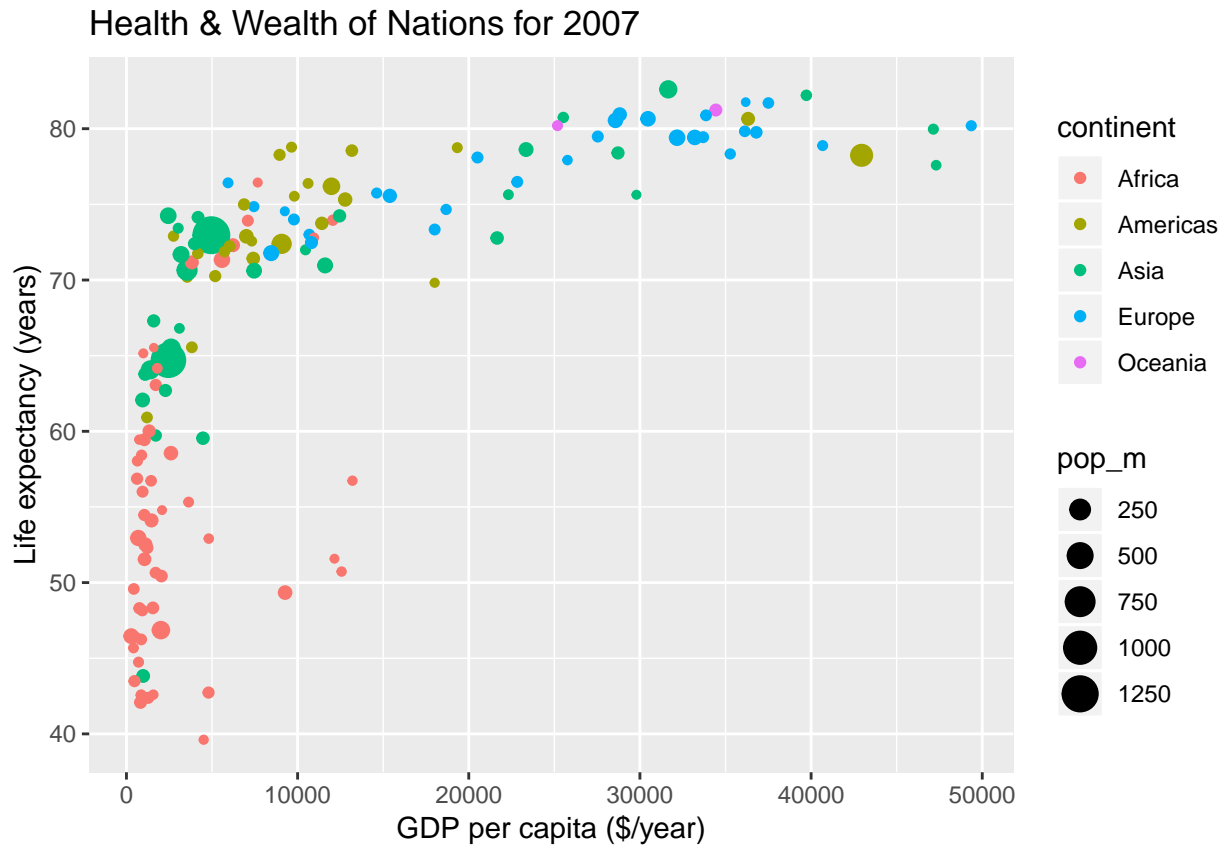
```
# add aesthetic of size by population  
s = s +  
  aes(size=pop_m)  
s
```



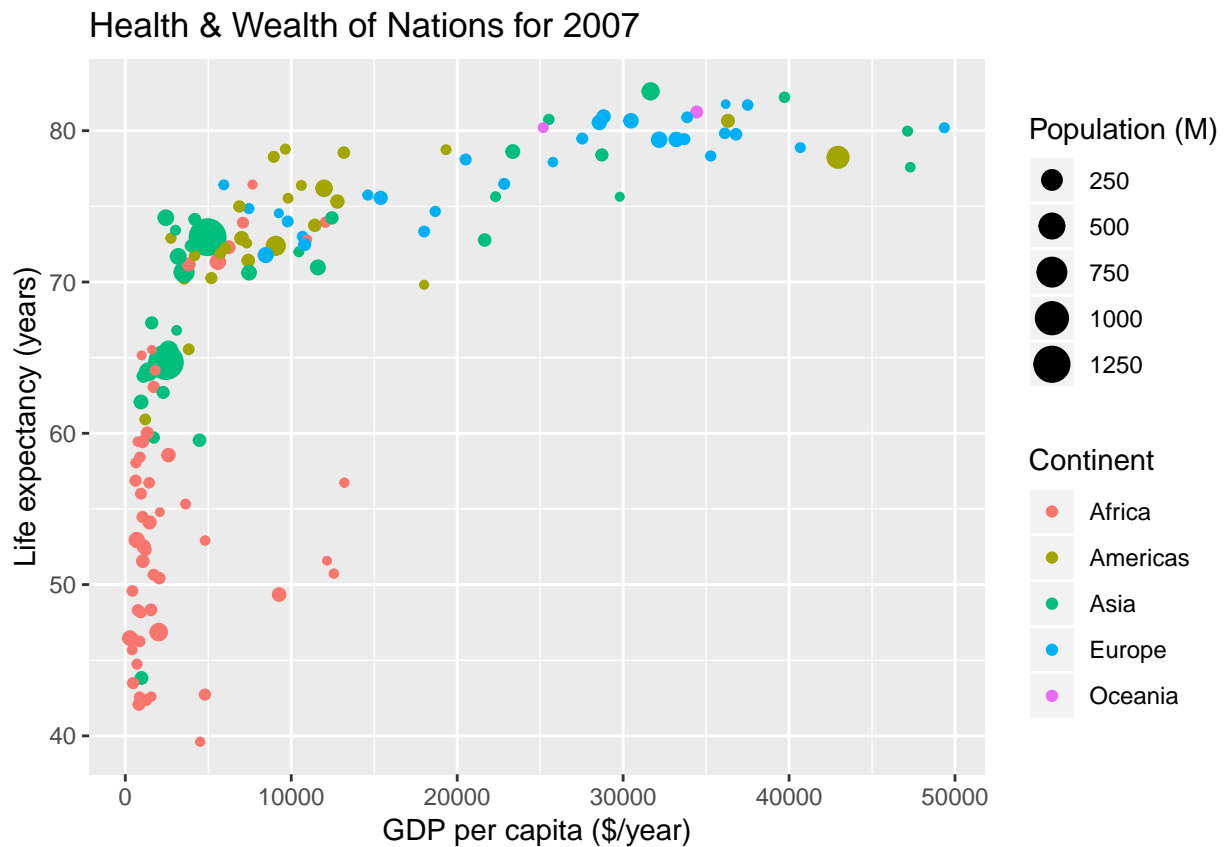
```
# add aesthetic of color by continent  
s = s +  
  aes(color=continent)  
s
```

```
# add title, update axes labels
s = s +
  ggtitle('Health & Wealth of Nations for 2007') +
  xlab('GDP per capita ($/year)') +
  ylab('Life expectancy (years)')
s
```



```
# label legend
s = s +
  scale_colour_discrete(name='Continent') +
  scale_size_continuous(name='Population (M)')
s
```



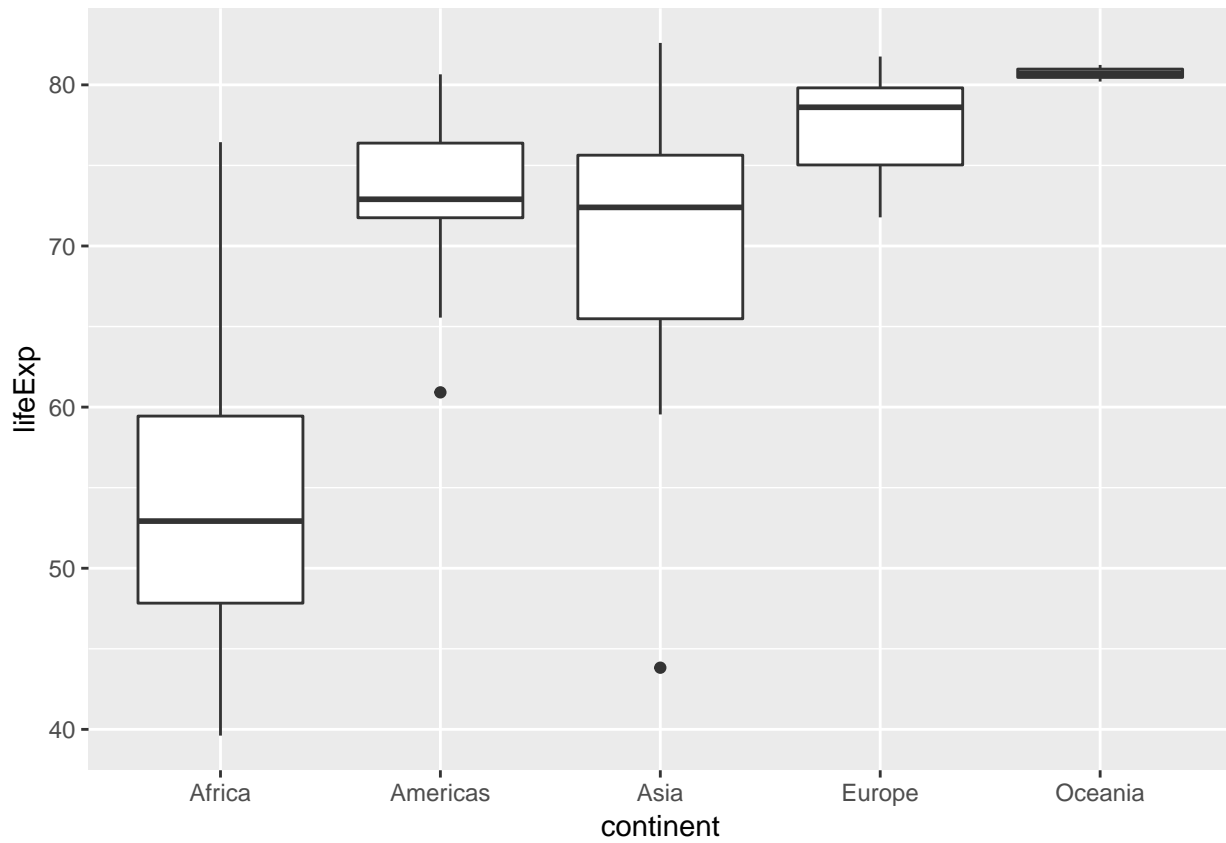
Your Turn

Now with country emissions datasets...

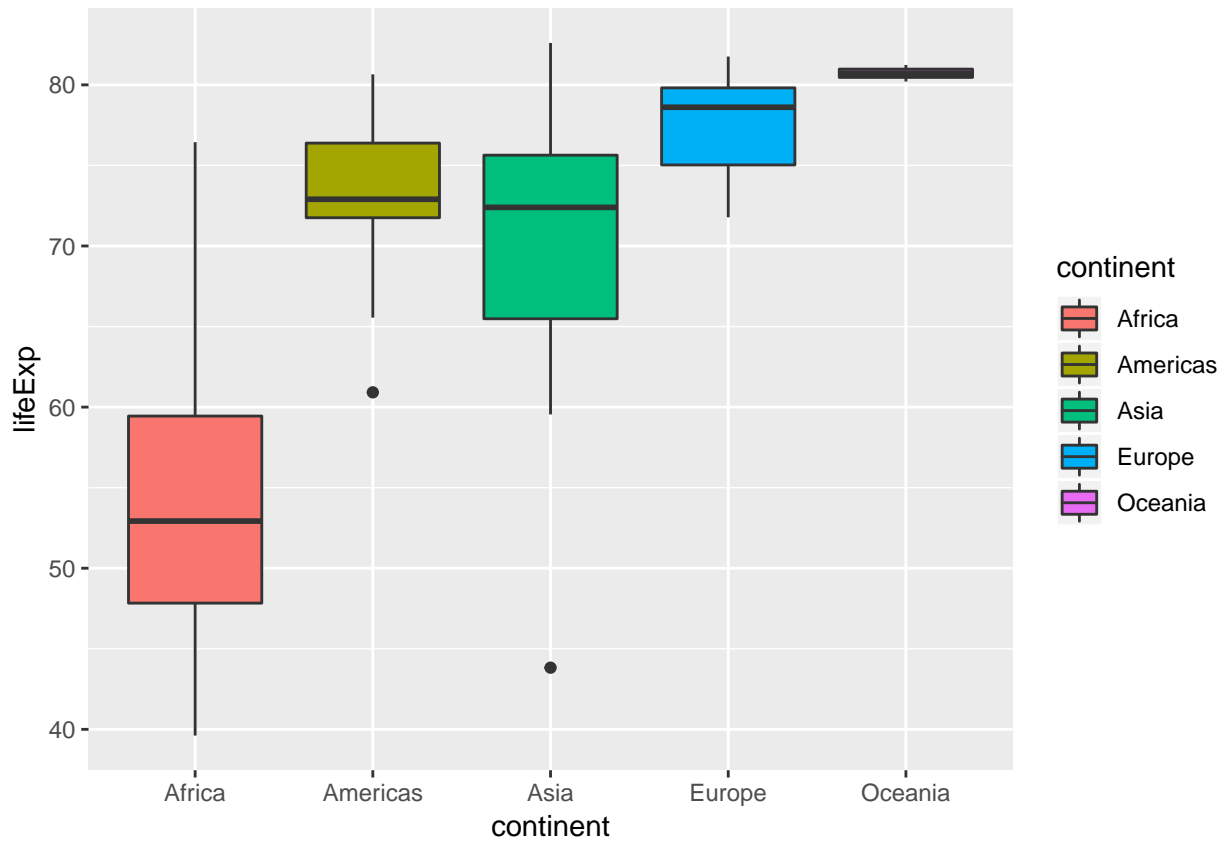
- CO2 Emissions from Fossil Fuels since 1751, By Nation - Dataset - Frictionless Open Data
- datasets/gdp

4.1.1.2 Boxplot

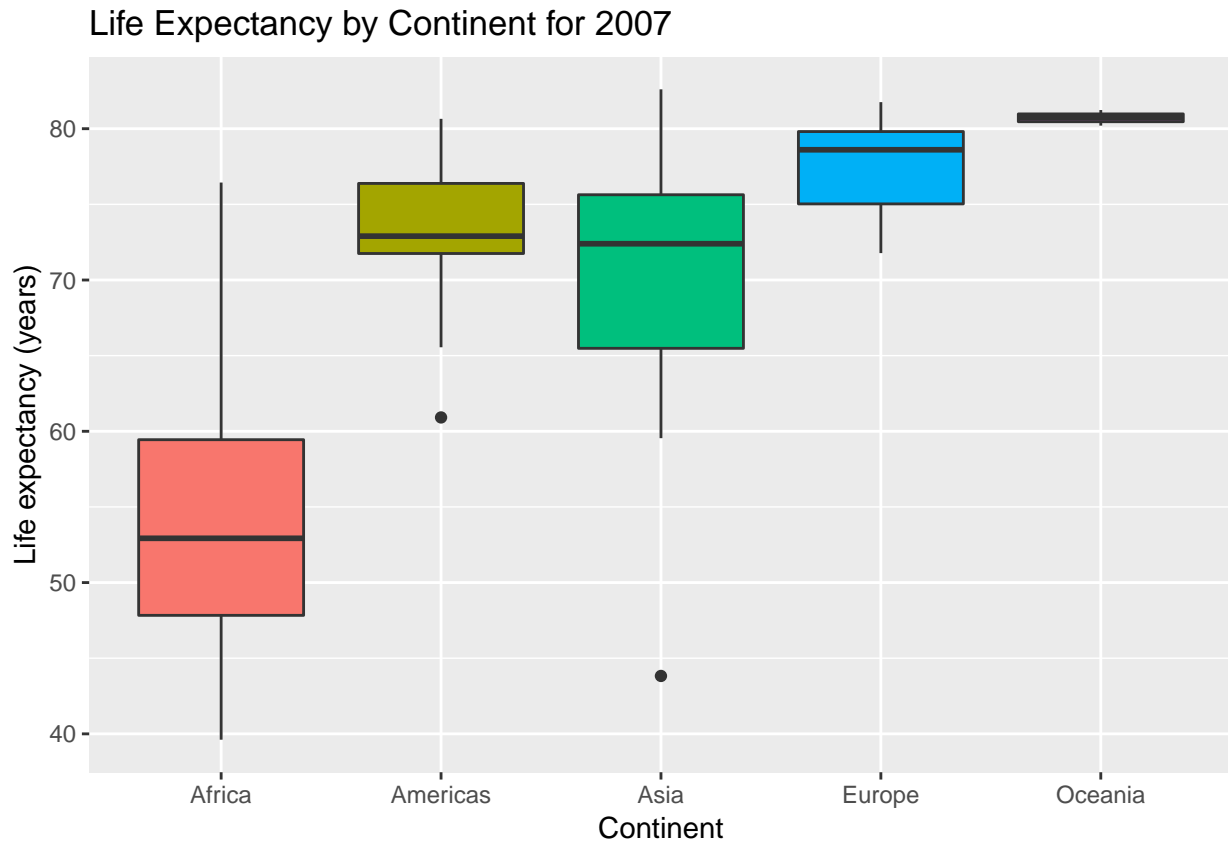
```
# boxplot by continent
b = ggplot(g, aes(x=continent, y=lifeExp)) +
  geom_boxplot()
b
```



```
# match color to continents, like scatterplot
b = b +
  aes(fill=continent)
b
```



```
# drop legend, add title, update axes labels
b = b +
  theme(legend.position='none') +
  ggtitle('Life Expectancy by Continent for 2007') +
  xlab('Continent') +
  ylab('Life expectancy (years)')
b
```



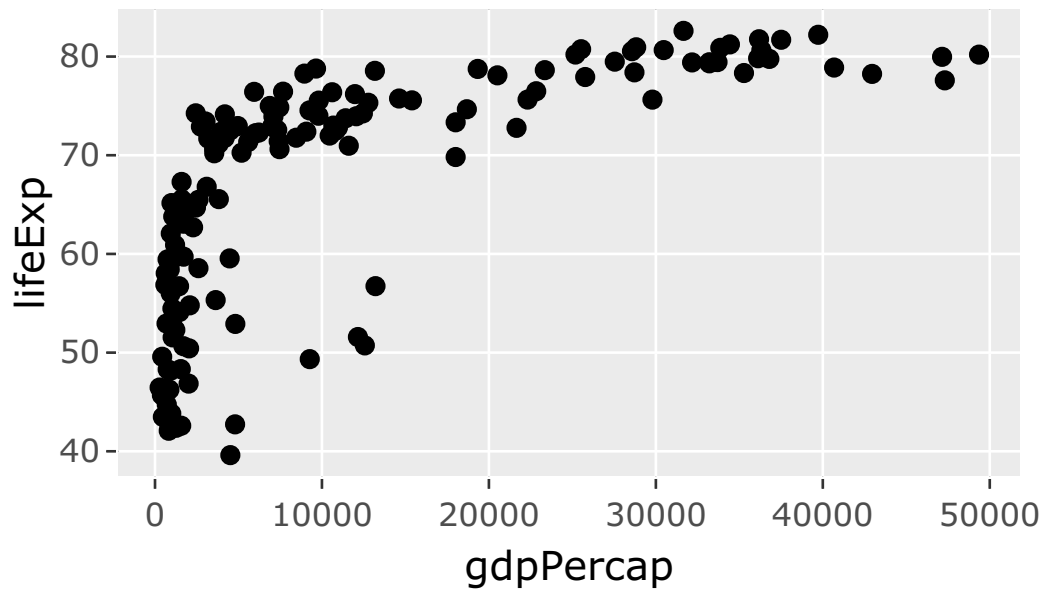
Your Turn: Make a similar plot but for `gdpPercap`. Be sure to update the plot's aesthetic, axis label and title accordingly.

4.1.2 Interactive: plotly

ggplot2 | plotly

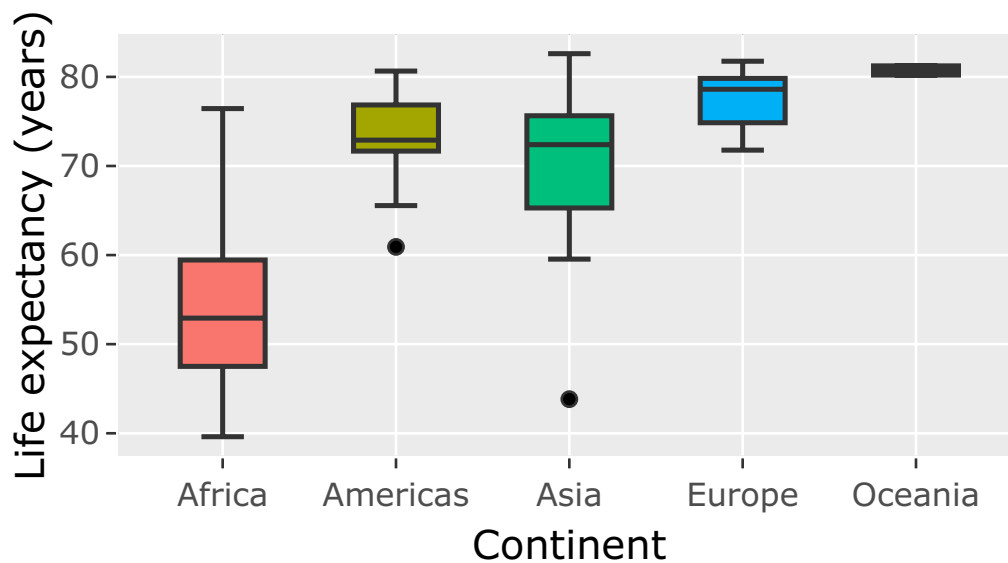
```
library(plotly) # install.packages('plotly')

# scatterplot (Note: key=country shows up on rollover)
s = ggplot(g, aes(x=gdpPercap, y=lifeExp, key=country)) +
  geom_point()
ggplotly(s)
```



```
# boxplot
ggplotly(b)
```

Life Expectancy by Continent for 2007



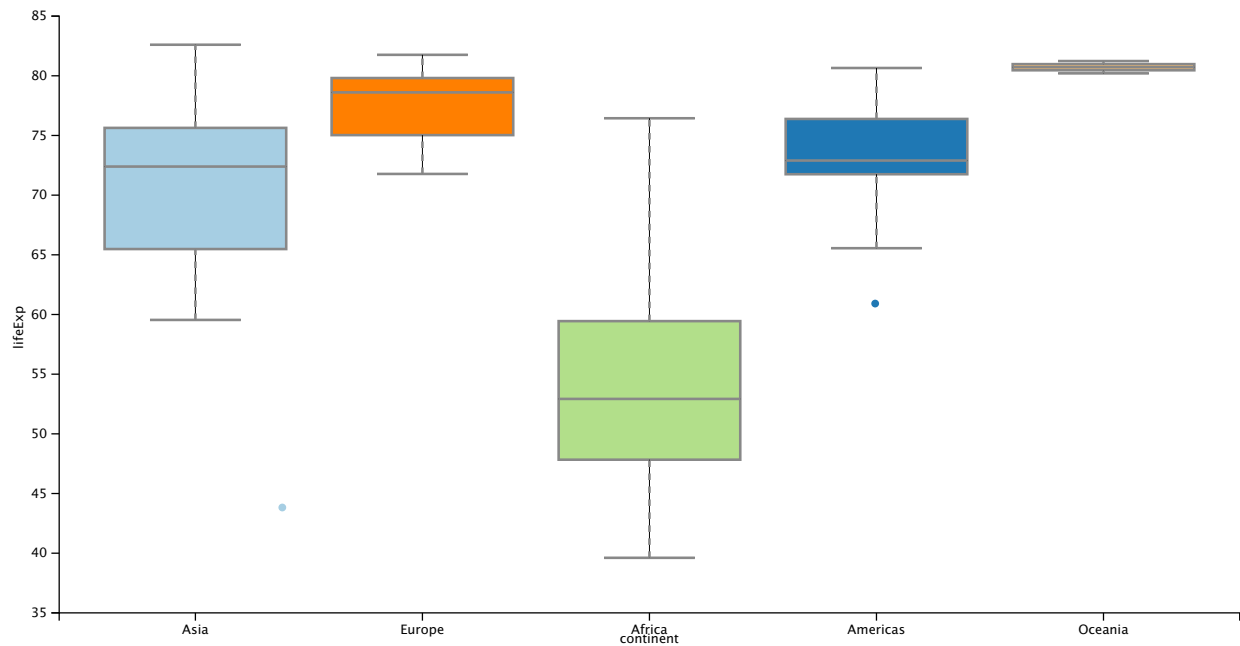
Your Turn: Expand the interactive scatterplot to include all the other bells and whistles of the previous plot in one continuous set of code (no in between setting of s).

4.1.3 Interactive: Exploding Boxplot

```
library(explodingboxplotR) # devtools::install_github('timelyportfolio/explodingboxplotR')

exploding_boxplot(g,
  y = 'lifeExp',
  group = 'continent',
```

```
color = 'continent',
label = 'country')
```



4.1.4 Interactive: Motion Plot

The `googleVis` package ports most of the Google charts functionality.

For every R chunk must set option `results='asis'`, and once before any `googleVis` plots, set `op <- options(gvis.plot.tag='chart')`.

- Rmarkdown and `googleVis`
- `googleVis` examples

```
suppressPackageStartupMessages({
  library(googleVis) # install.packages('googleVis')
})
op <- options(gvis.plot.tag='chart')

m = gvisMotionChart(
  gapminder %>%
    mutate(
      pop_m = pop / 1e6,
      log_gdpPercap = log(gdpPercap)),
  idvar='country',
  timevar='year',
  xvar='log_gdpPercap',
  yvar='lifeExp',
  colorvar='continent',
  sizevar='pop_m')
plot(m)
```

Your Turn: Repeat the motion chart with the country having the highest `gdpPercap` filtered out.

4.2 Map

Thematic maps **tmap**:

- tmap in a nutshell
- tmap modes: plot and interactive view

4.2.1 Static

```
library(sf)
library(tmap) # install.packages('tmap')

# load world spatial polygons
data(World)

# inspect values in World
World %>% st_set_geometry(NULL)

# gapminder countries not in World. skipping for now
g %>%
  anti_join(World, by=c('country'='name')) %>%
  arrange(desc(pop))

# World countries not in gapminder. skipping for now
World %>%
  anti_join(g, by=c('name'='country')) %>%
  arrange(desc(pop_est)) %>%
  select(iso_a3, name, pop_est)

# join gapminder data to World
World = World %>%
  left_join(g, by=c('name'='country'))

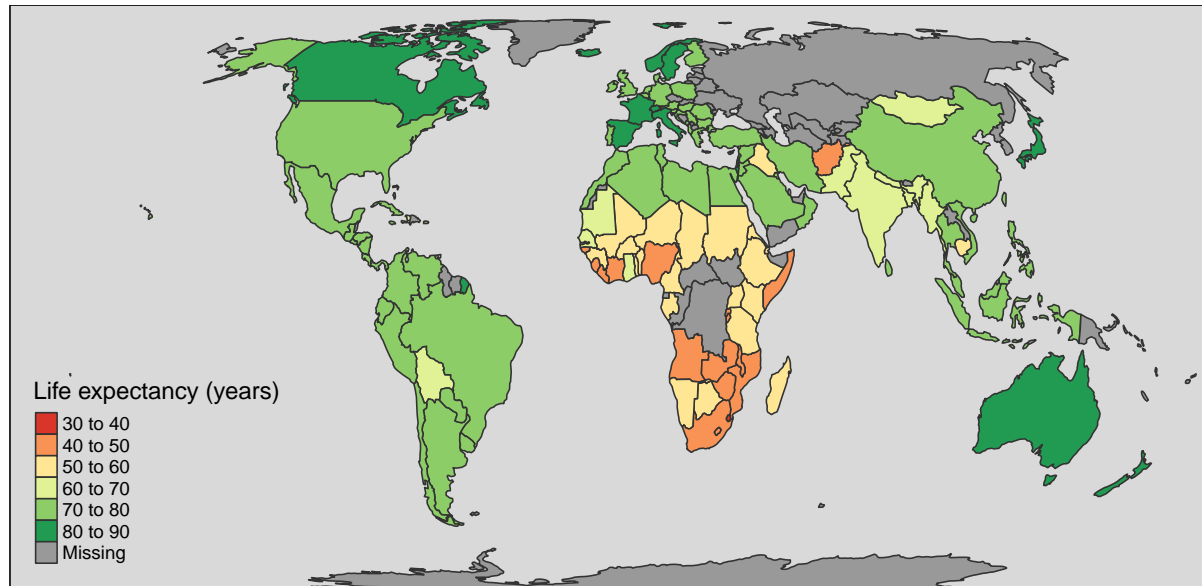
# make map
m = tm_shape(World) +
  tm_polygons('lifeExp', palette='RdYlGn', id='name', title='Life expectancy (years)', auto.palette.mapping=TRUE) +
  tm_style_gray() + tm_format_World()

## Warning: The argument auto.palette.mapping is deprecated. Please use
## midpoint for numeric data and stretch.palette for categorical data to
## control the palette mapping.

## Warning in tm_style_gray(): tm_style_gray is deprecated as of tmap version
## 2.0. Please use tm_style("gray", ...) instead

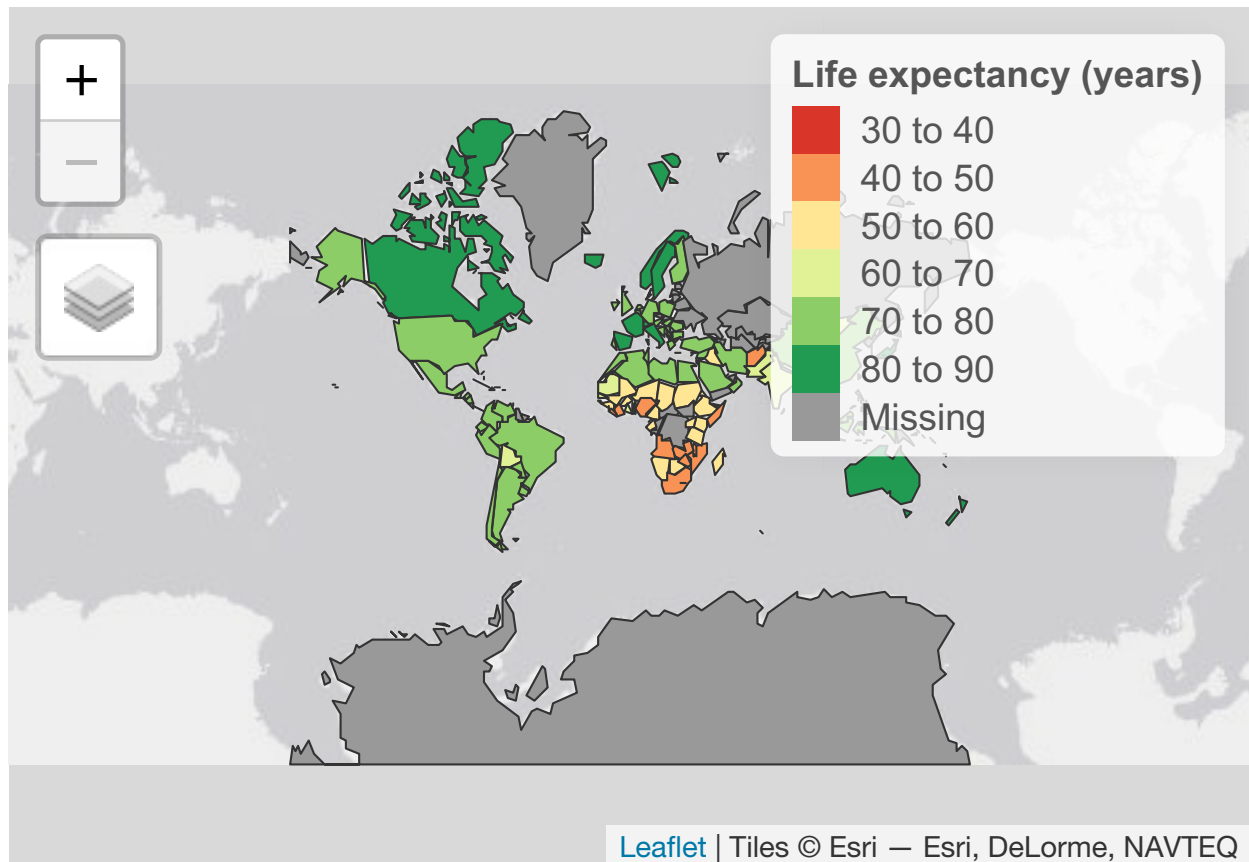
## Warning in tm_format_World(): tm_format_World is deprecated as of tmap
## version 2.0. Please use tm_format("World", ...) instead
```

```
m
```



4.2.2 Interactive

```
# show interactive map  
tmap_leaflet(m)
```



4.3 References

- [ggplot2-cheatsheet-2.0.pdf](#)
- Interactive Plots and Maps - Environmental Informatics
- Graphs with ggplot2 - Cookbook for R
- ggplot2 Essentials - STHDA
- NEON Working with Geospatial Data