Reproducible, Open-Source, Transparent Data Analysis (and more) in Python and R

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About me

Hydrogeology PhD (expected March 2020),

University of California Davis *[Advisor: Dr. Graham Fogg]*

Domain interests: Groundwater quantity/quality, numerical modeling of groundwater flow and contaminant transport, impact of drought and climate change on disadvantaged populations, remote sensing.

Method interests: AI (machine & deep learning), spatial statistics, data science, reproducible research, interactive web application development, sensor networks, automation.

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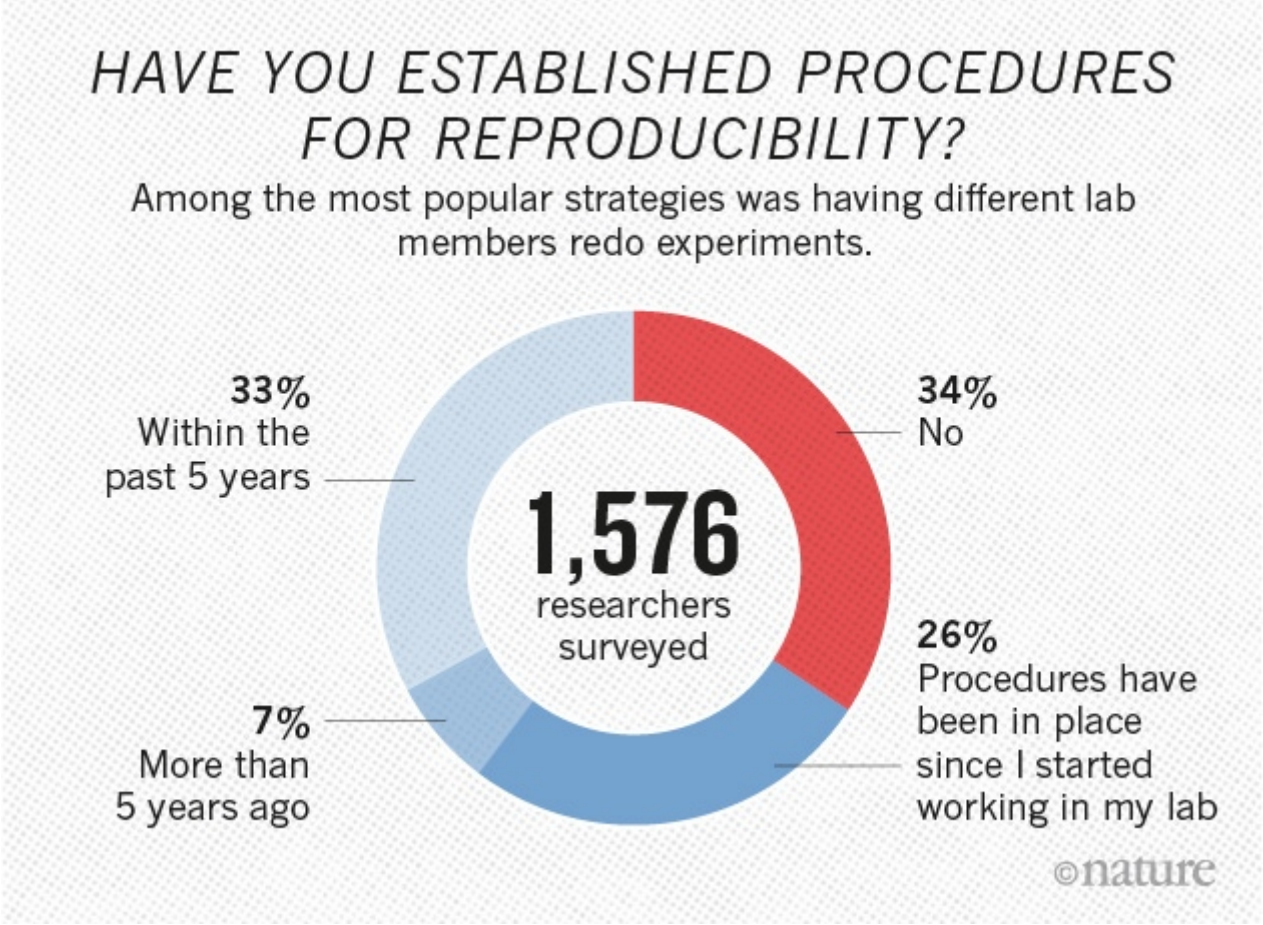
Agenda

- Motivation
- Why Python and R?
- Jupyter and Github for sharing analysis and version control
- (and more) What else can I do with Python and R?
- Live Coding

Motivation

- Reproducibility crisis in science *(Baker, 2016; Munafò, 2017).*
  - More than 70% of researchers have tried and failed to reproduce another scientist's experiments, and more than half have failed to reproduce their own experiments.
- Towards reproducible, transparent, open-source analysis *(Kanterakis et al, 2018, Lowndes, 2017).*
- Ease of reproducibility and collaboration (including self).



(Baker, 2016)

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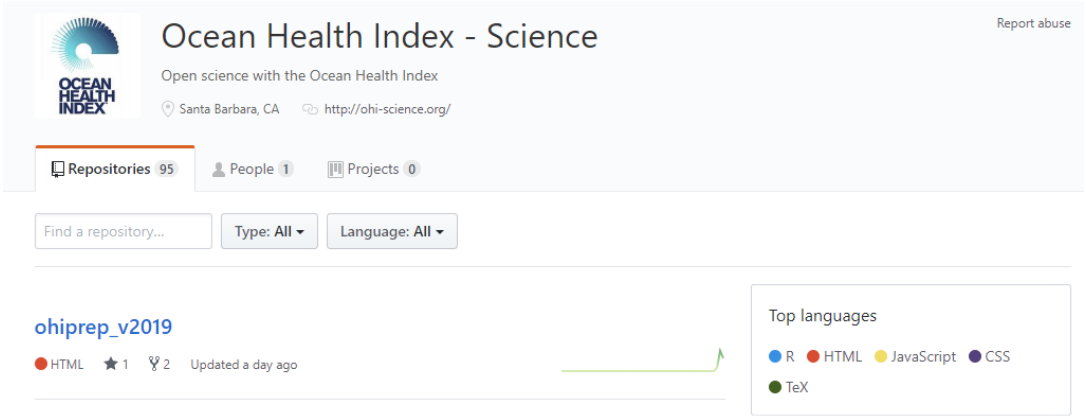

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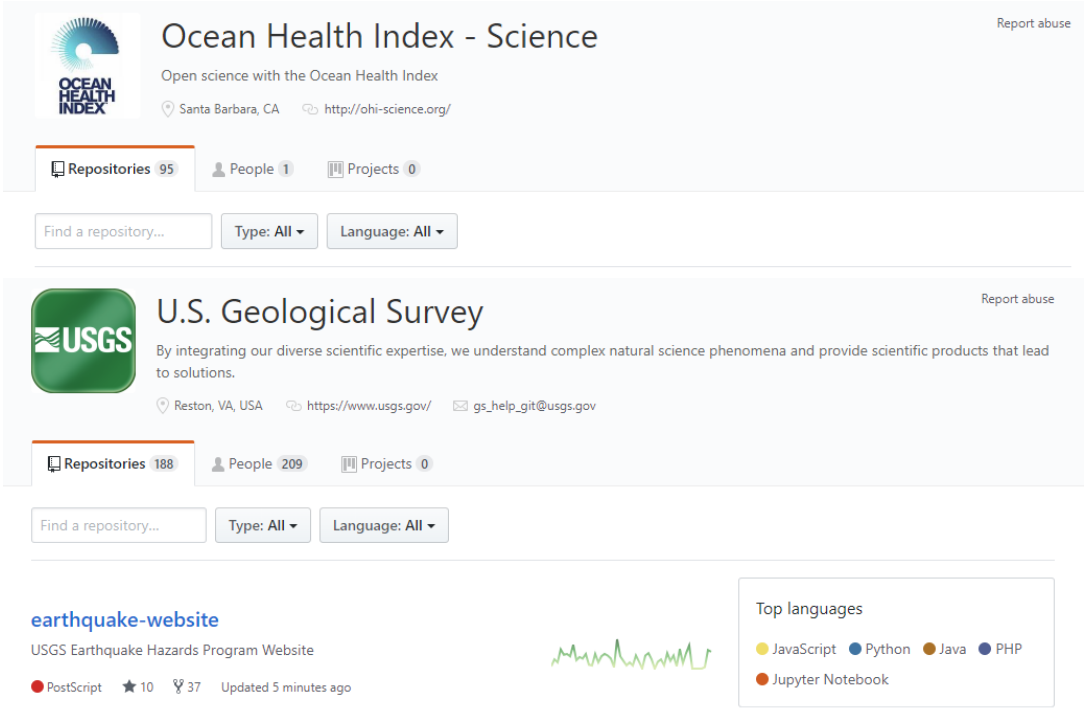

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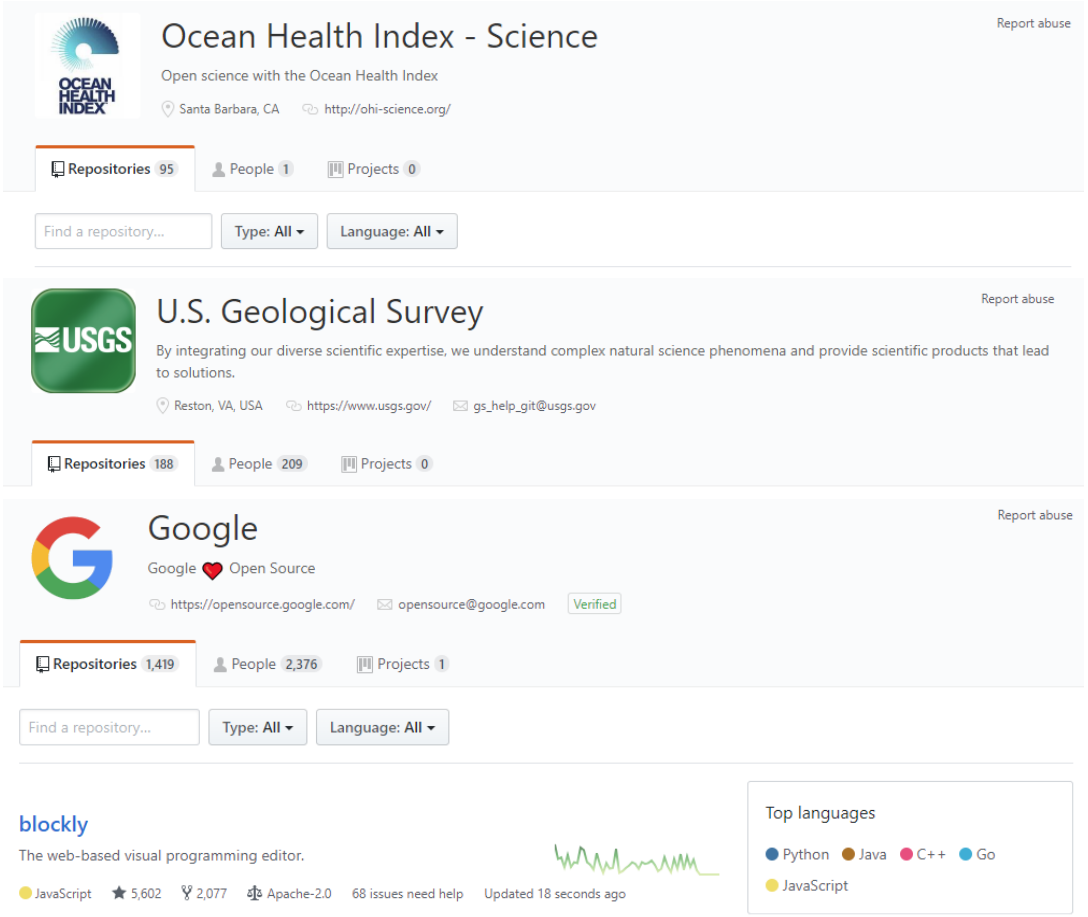

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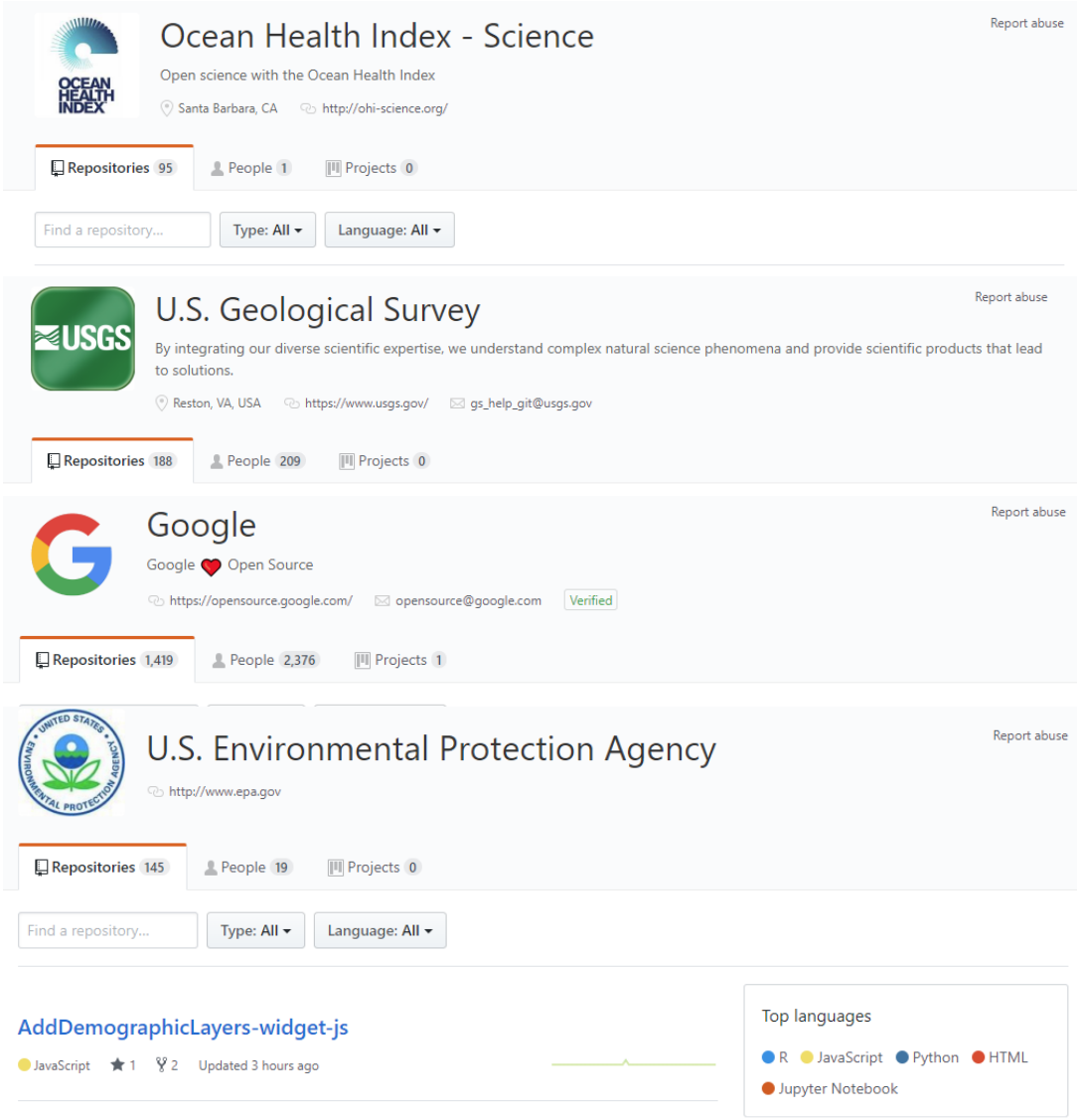

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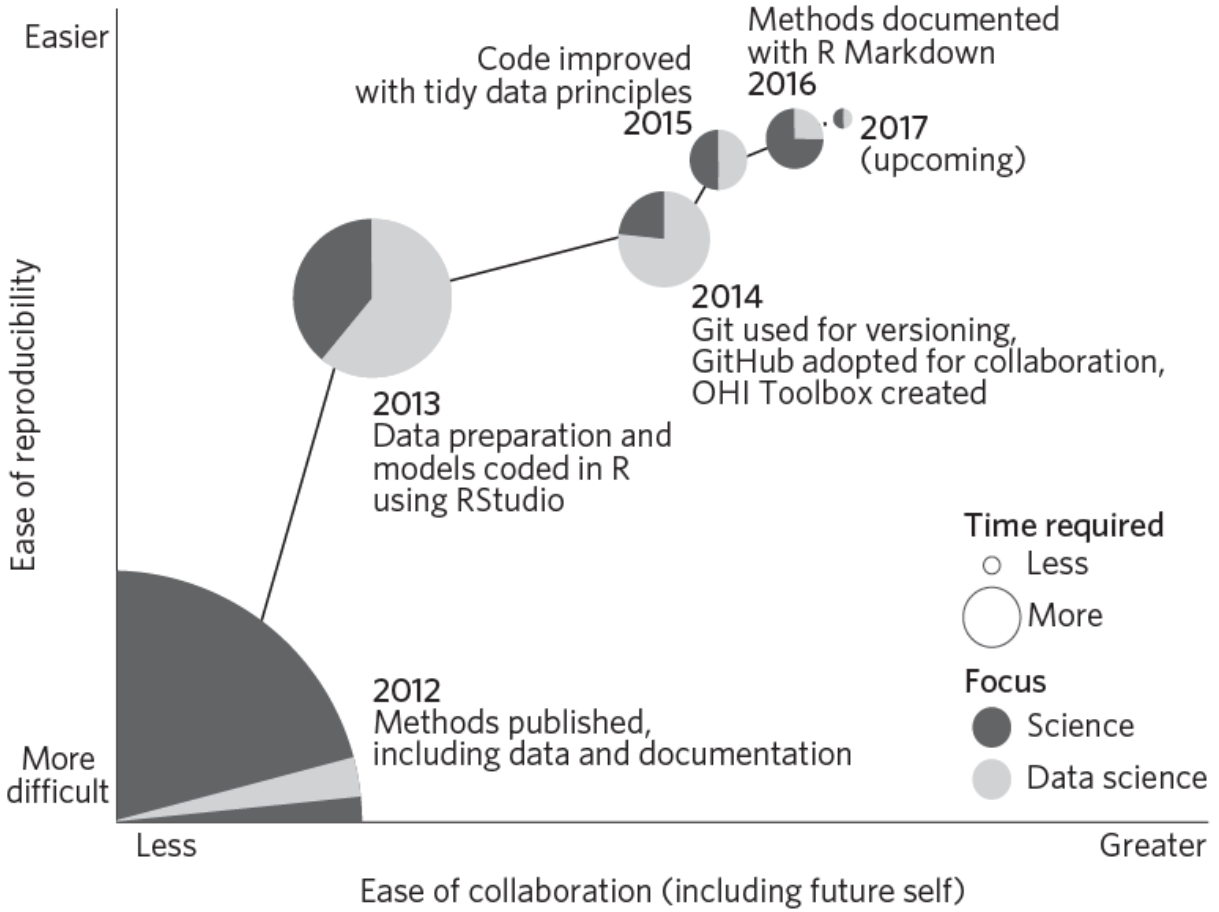

(Lowndes, 2017)

Why Python and R?

- REPRODUCIBLE = programmatic workflow
- OPEN-SOURCE = free software
- TRANSPARENT = contains end-to-end workflow:
  - Download
  - Cleaning / Transformation
  - Analysis / Modeling
  - Plotting / Map making
  - Report Writing
- Version control (i.e. - no need for “analysis_v12_RP_BV_FINAL.xlsx”)
- Scales to big data (i.e. - won’t fit in: a spreadsheet, your computer)
- User community:
  - Thousands of packages for many kinds of analysis
  - Active StackOverflow Q & A communities

```r
library(rvest)
library(magrittr)
library(ggplot2)
library(plotly)
library(dplyr)
library(zoo)
library(scales)

url <- "https://cran.r-project.org/web/packages/available_packages_by_date.html"

page <- read_html(url)
pkgs <- page %>% html_node("table") %>% html_table() %>%
  mutate(count = rev(1:nrow(.)), Date = as.Date(Date), Month = format(Date, format="%Y-%m")) %>%
  group_by(Month) %>% summarise(published = min(count)) %>% mutate(Date = as.Date(as.yearmon(Month)))

ggplot(pkgs, aes(Date, published)) + geom_line() +
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  scale_y_continuous(label = comma) +
  labs(title = "Exponential Growth of packages published to CRAN", y = "Count") +
  theme_minimal()
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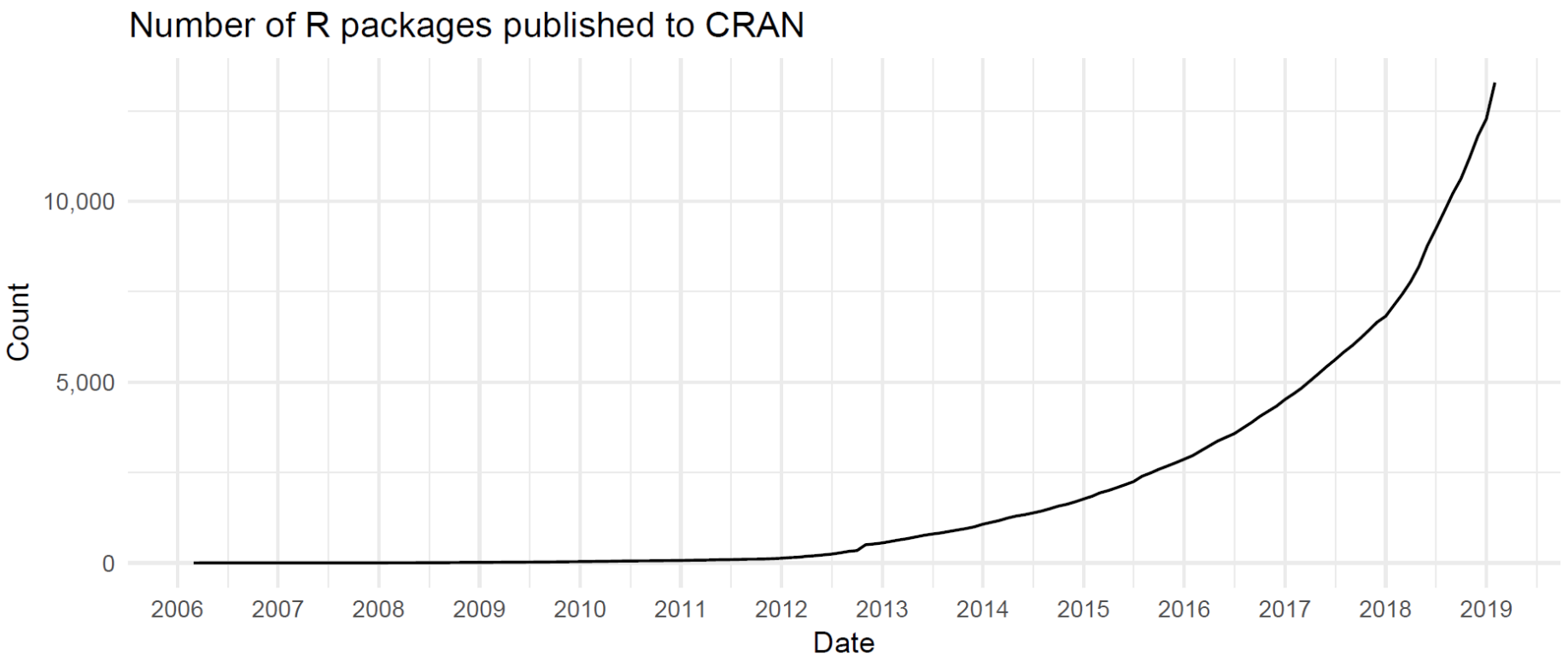

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Jupyter

- Interactive development environment (IDE)
  - data analysis
  - easily share on Github

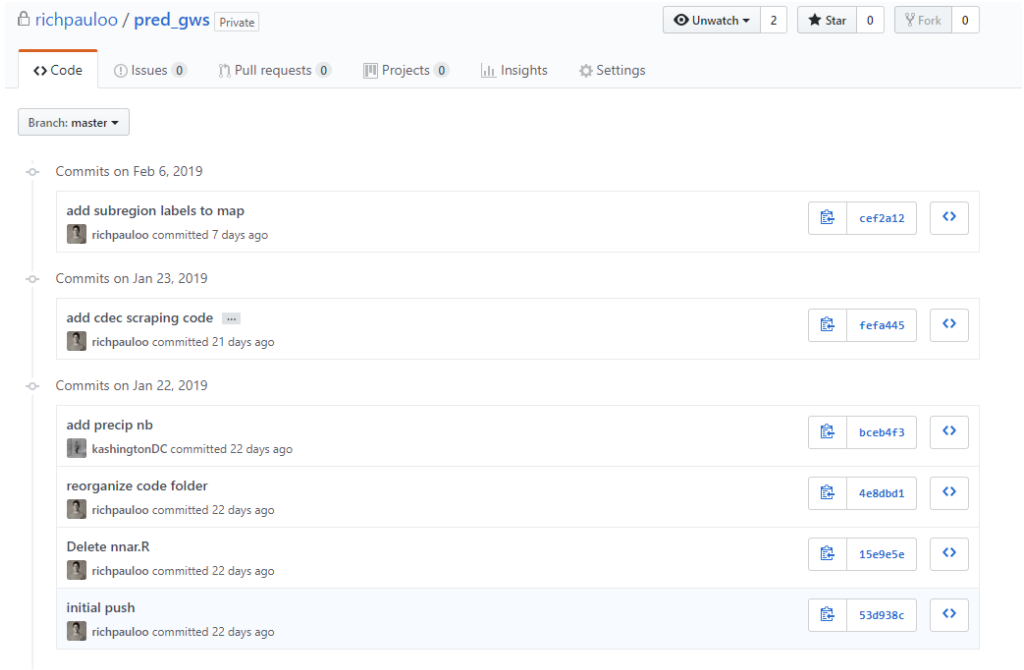
```
In [3]: # read water budget for entire cv
        d <- read_xlsx("C:/Users/rpauloo/Desktop/pred_gws/data/C2VSimFG-BETA_PublicRelease/Excel/C2VSimFG_GWBudget.xlsx",
                       sheet = 22,
                       skip = 4)

In [4]: head(d); tail(d)
```

Time	Percolation	Beginning Storage (+)	Ending Storage (-)	Deep Percolation (+)	Gain from Stream (+)	Recharge (+)	Gain from Lake (+)	Boundary Inflow (+)	Subsidence (+)	Subsurface Irrigation (+)
1973-10-31	817622.6	4575168754	4575555111	543864.7	-152956.8	86155.80	0	229874.4	0	0
1973-11-30	827360.9	4575555111	4578075790	2114095.9	391909.9	35303.47	0	227418.0	0	0
1973-12-31	1102666.2	4578075790	4581297108	2857326.3	244139.3	26615.45	0	226741.3	0	0
1974-01-31	1235043.9	4581297108	4585170011	3150737.9	496860.6	108291.29	0	230756.7	0	0
1974-02-28	701306.1	4585170011	4588180232	3126878.7	-107853.2	86778.34	0	233714.9	0	0
1974-03-31	867709.8	4588180232	4591566945	2827869.0	440654.7	136912.71	0	242601.6	0	0

Github

- Cloud-based version control software
  - creates “save points”
  - workflow for collaborating on code



What Else can I do with Python & R?

- Query Databases (SQL, PostgreSQL, etc.)
- Web scraping
- Text Processing
- Image Processing
- Geospatial Data Processing
- Rapid Interactive App Development with Shiny (R) and Flask (Dash)
  - Django Web Development in Python
- R & Python interfaces to popular ML, AI libraries
- And more

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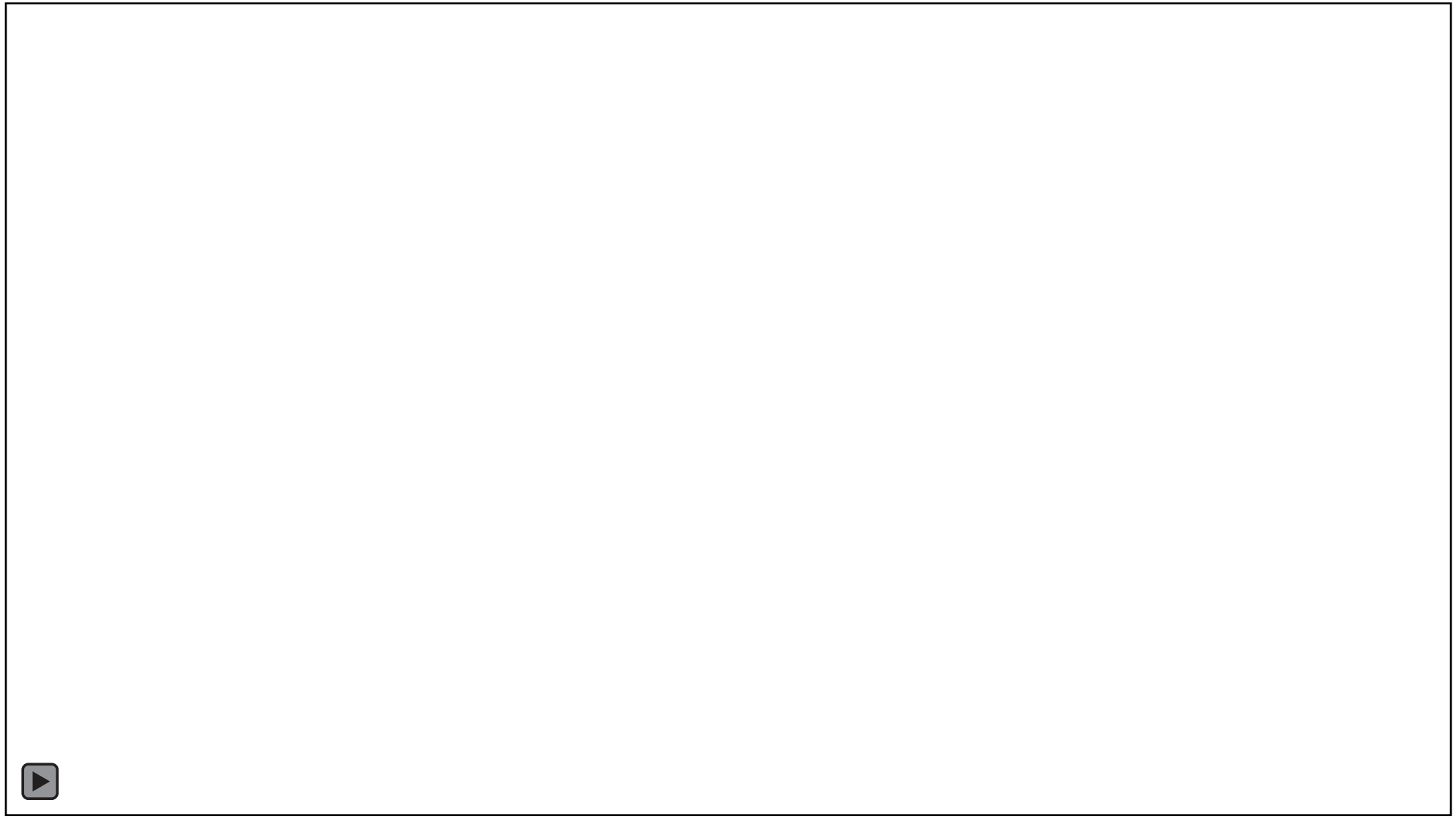
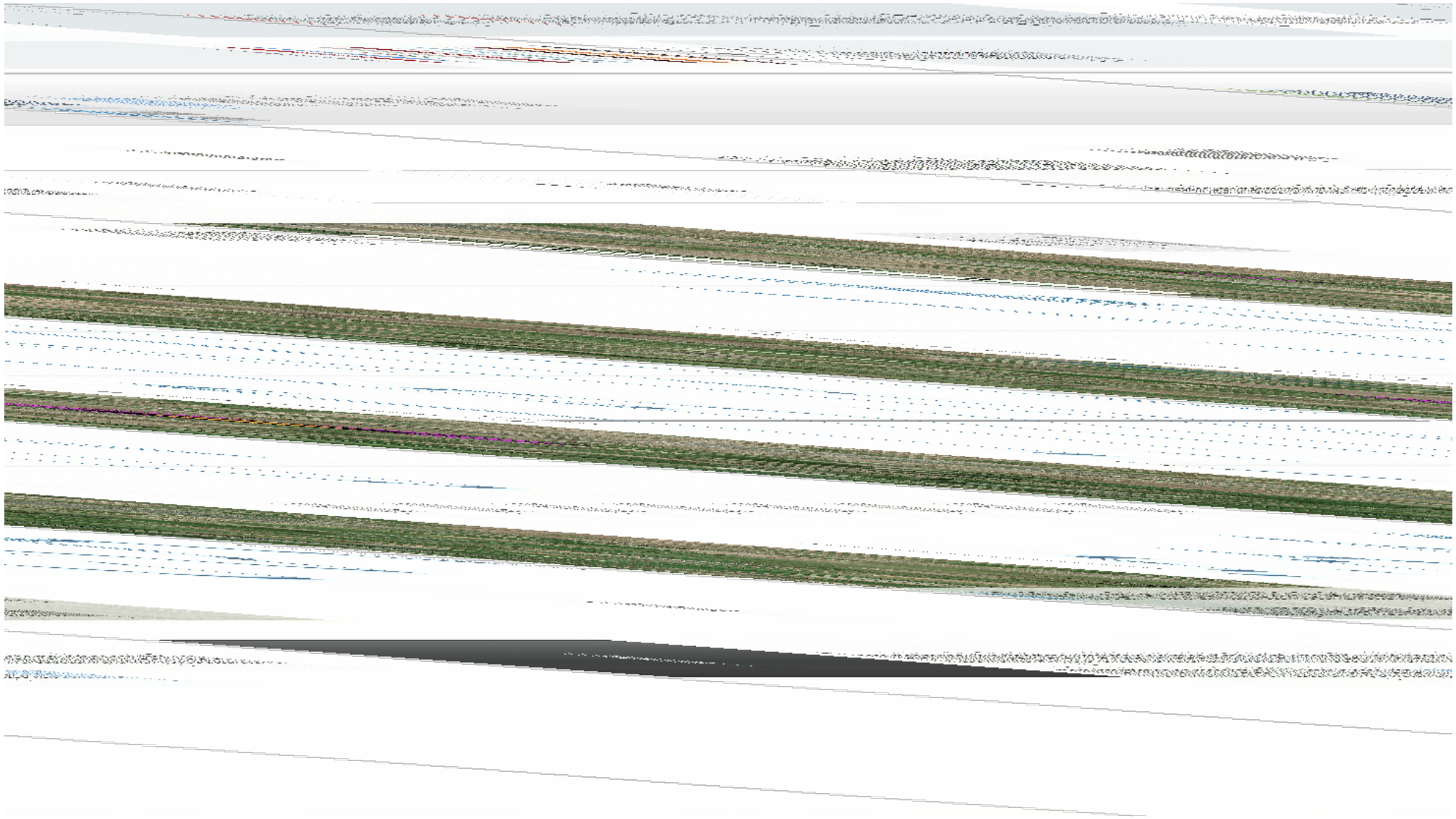
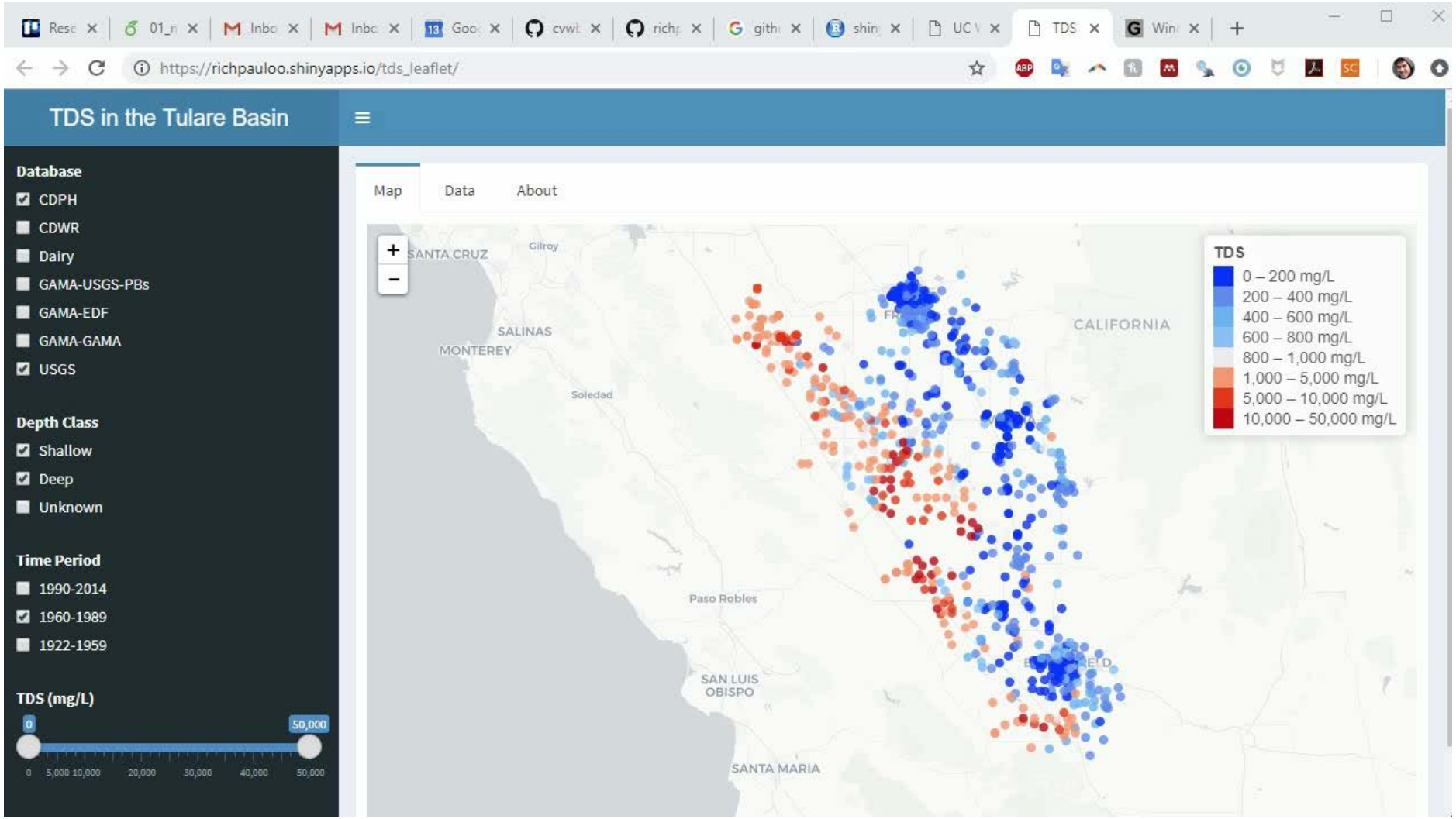
Example: R Shiny: ucwater.org/oswcr/



Example: R Shiny: ucwater.org/gw_obs/



Example: R Shiny: richpauloo.shinyapps.io/tds_leaflet/



Example: Webscrape CDEC Reservoir Storage

- It’s been raining recently.
- How has daily precipitation and reservoir storage at Folsom (FOL) and Shasta (SHA) changed?

Example: Postprocess C2VSim budget

- Geospatial data!
- What's the historical Central Valley, Hydrologic Region, and Subbasin-level change in storage?

Example: Image Process Google Earth Engine

- Tons of Satellite Data out there.
- How do we load just one image?
- What's the evapotranspiration over California according to MODIS?
  - Aakash Ahmed, Stanford University

Thanks for your attention!

Free Online Resources

- Python Data Science Handbook
- R for Data Science
- Datacamp: R and Python online lessons

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References

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4. Lowndes, J. S. S., Best, B. D., Scarborough, C., Afflerbach, J. C., Frazier, M. R., O'Hara, C. C., … Halpern, B. S. (2017). Our path to better science in less time using open data science tools. *Nature Ecology and Evolution*, *1*(6). https://doi.org/10.1038/s41559-017-0160