


ENVIRONMENTAL DATA ANALYTICS

WEEK 3 – M2 – CODING BASICS AND REPRODUCIBILITY

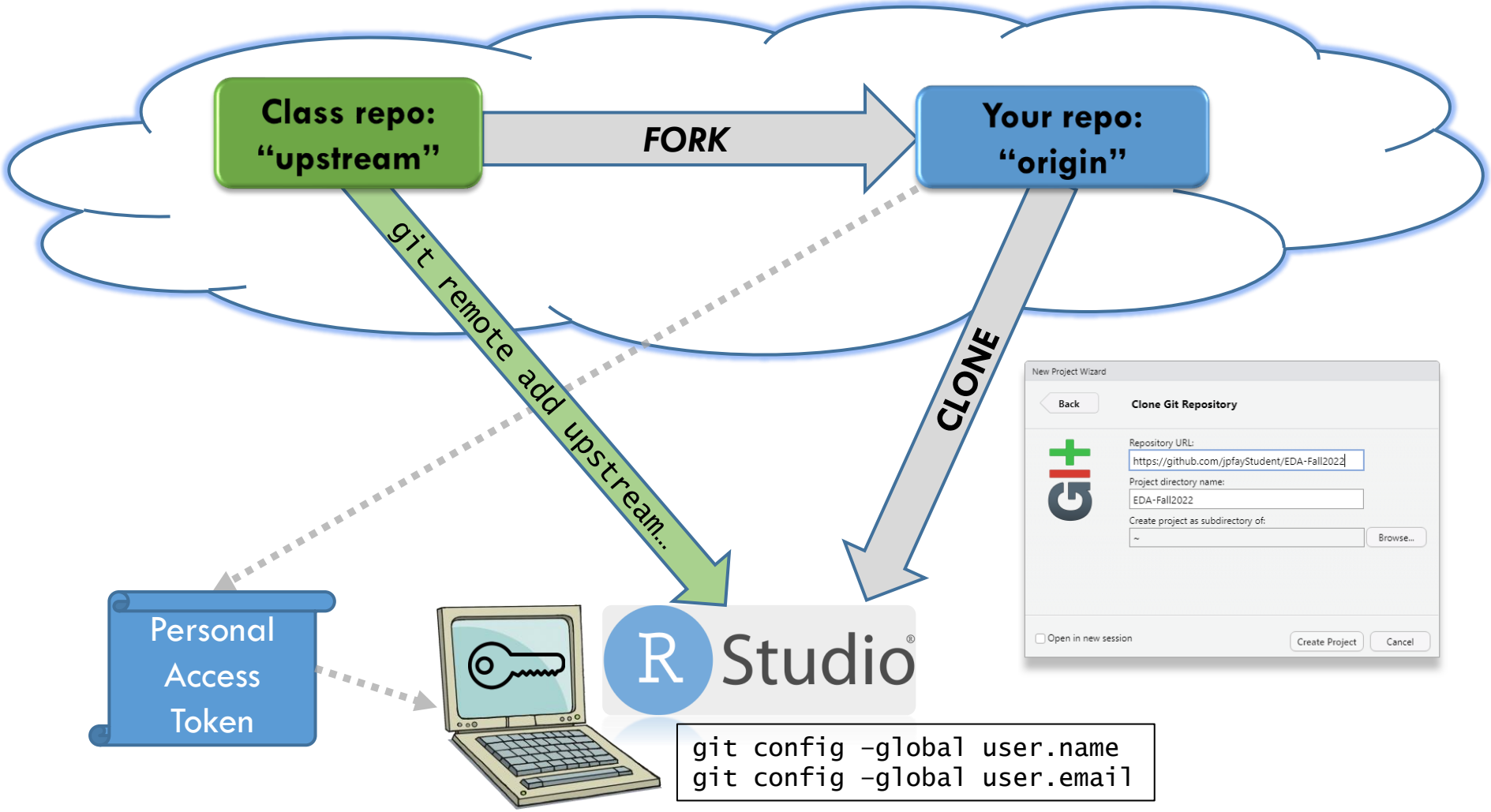
Fall 2023

Nicholas School of the Environment - Duke University

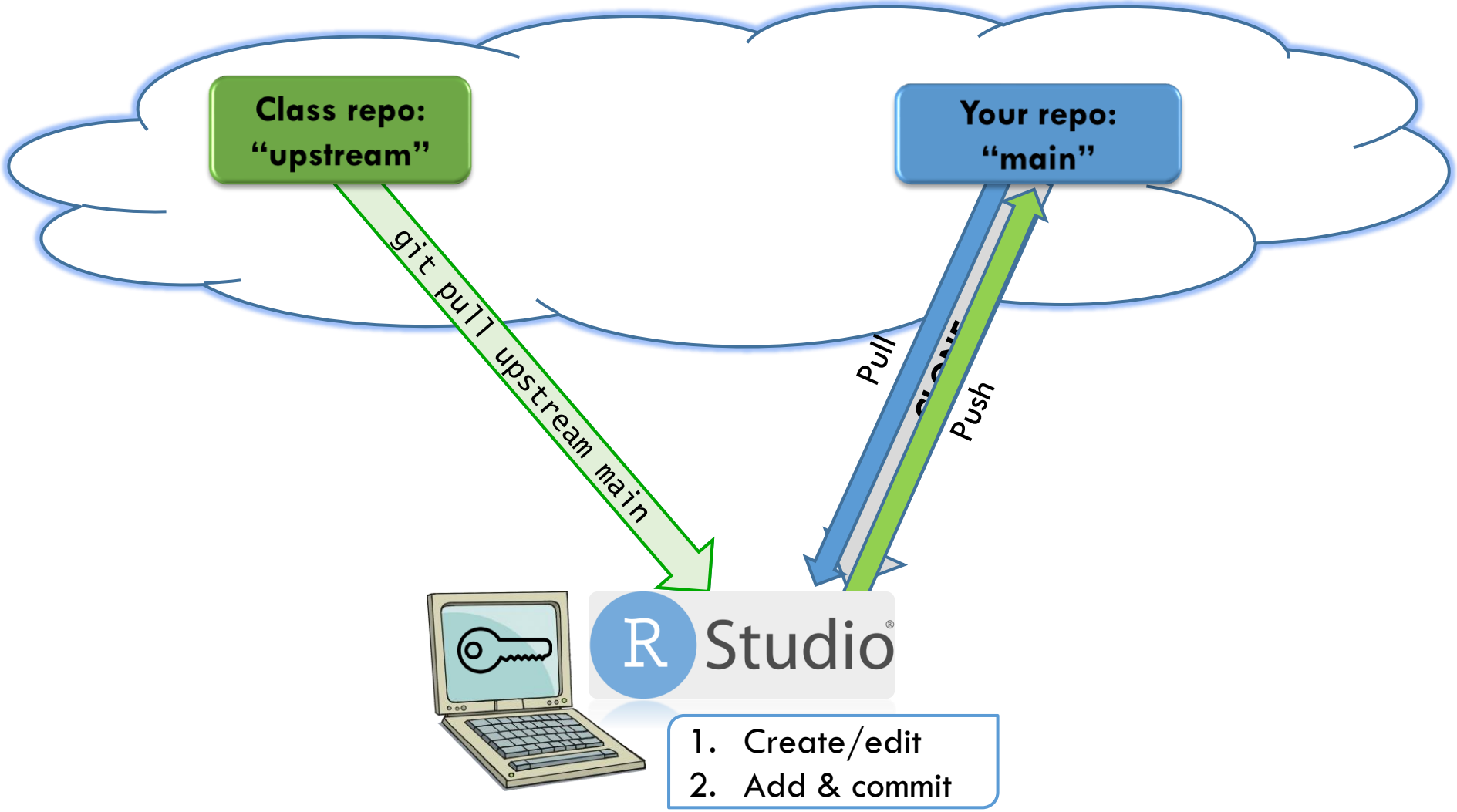
Week 3 - Agenda

- Questions – M1 & A1
  - Git/GitHub…
  - What is “Data Analytics”
- Overview M2
  - Questions – M2 videos
- Intro to Data frame in R
- A2 posted and due on Thursday @ 5pm

Explaining Git/GitHub: *Setup*



Explaining Git/GitHub: *Use*



Explaining Git/GitHub: *Workflow*

https://git-school.github.io/visualizing-git

- Single repository…
- Remotes repositories…
- Upstream changes…
- Explaining merges & divergent branches

Changes | History | main | (all commits) | Search

Subject	Author	Date (UTC)	SHA
HEAD -> refs/heads/main origin/main origin/HEAD Add Lesson 8 completed docs	jpfayStudent <johnpfay@gmail.com>	2022-11-14	a641e8b3
Merge branch 'main' of https://github.com/ENV872/EDA-Fall2022	jpfayStudent <johnpfay@gmail.com>	2022-11-14	c30d3bd9
Create 09_Lab_Data_Scraping.Rmd	John Fay <john.fay@duke.edu>	2022-11-14	e6dfb61b
Add Data Scraping Rmd (09)	John Fay <john.fay@duke.edu>	2022-11-10	9902a016
Add Assignment 8: Spatial Analysis	johnpfay <john.fay@duke.edu>	2022-11-07	63c383ee

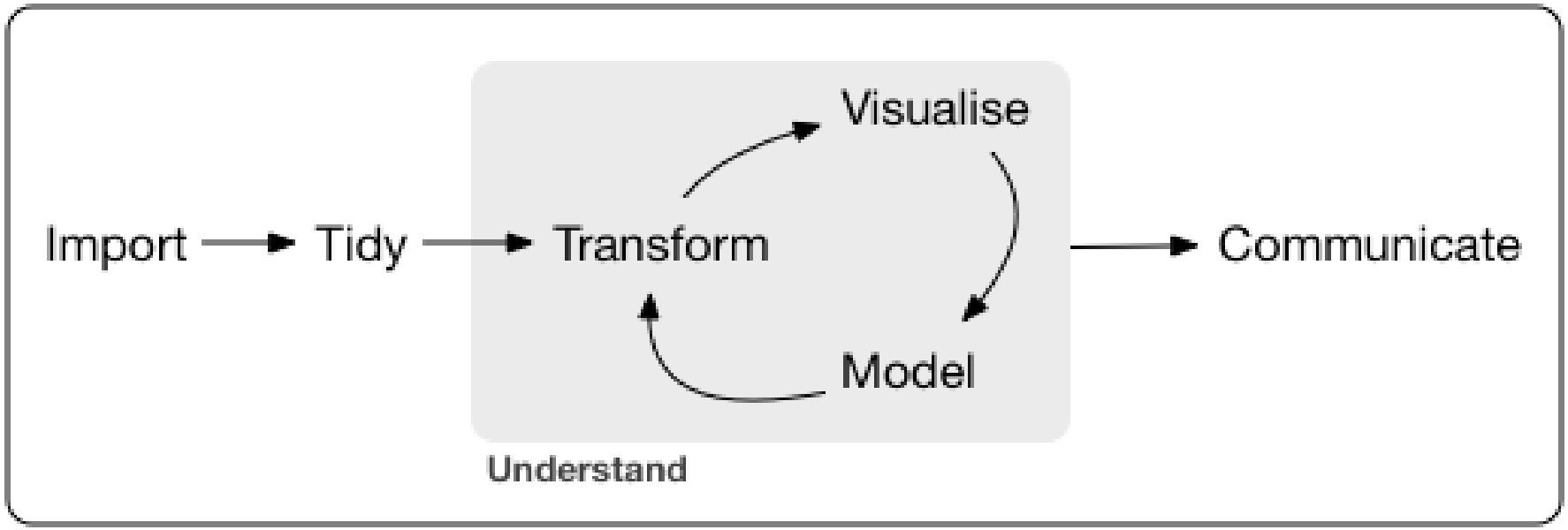
Explaining Git/GitHub: *Terms*

- Repository
- Git vs GitHub
- Fork vs Clone
- Staging vs Committing
- SHA vs Commit message
- Push vs Pull
- `git pull` vs `git pull upstream main`
- Merge

If Git goes totally sideways…

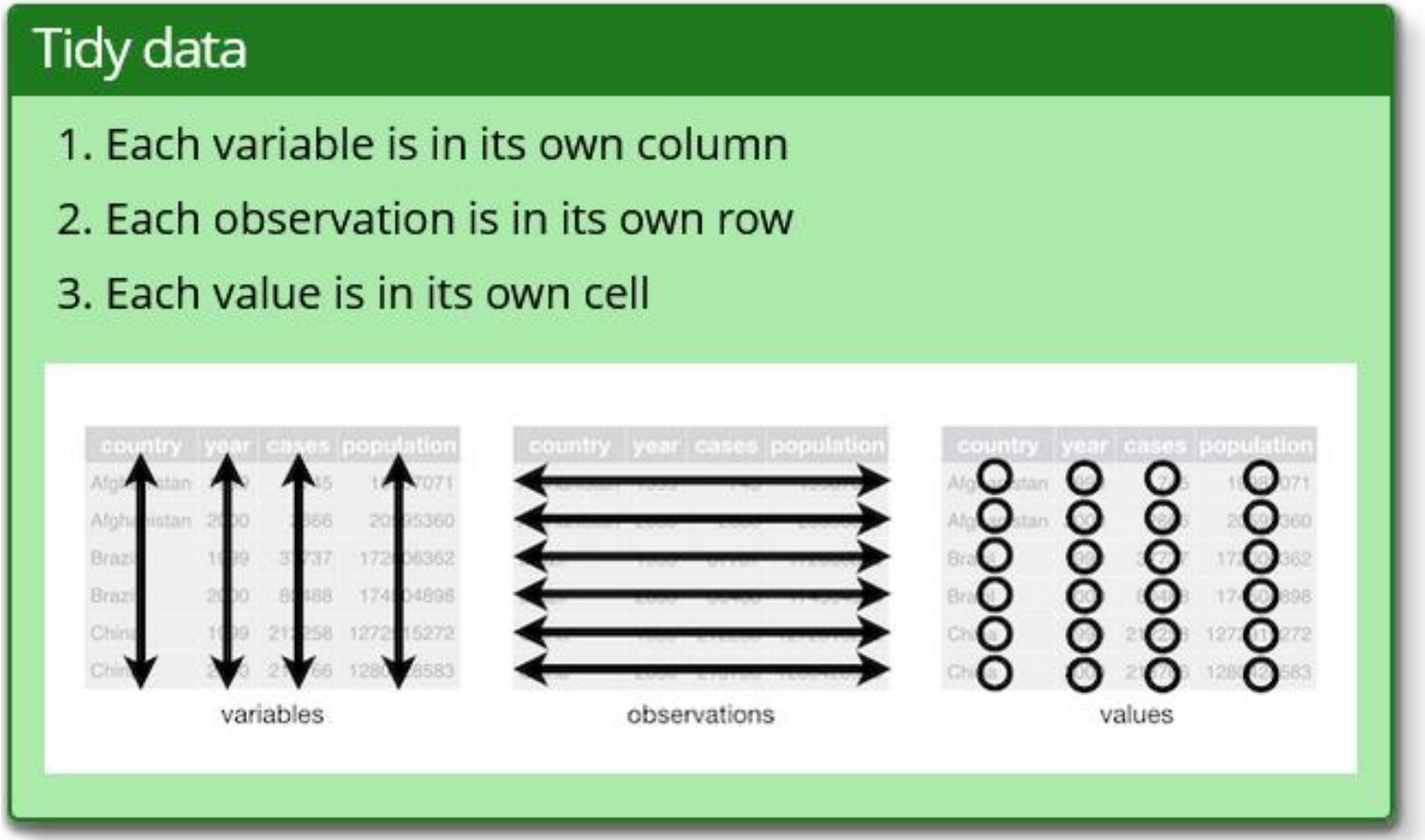
- Make a back up (e.g. zip) of you project folder
- Close RStudio project and rename project folder
- Create a new project linked to your forked repo
- Link to upstream remote, as before
- Copy over any missing items from your renamed folder to your newly cloned repository

Q&A: What is Data Analytics



https://vita.had.co.nz/papers/tidy-data.pdf

Tidy Data



http://garrettgman.github.io/tidying/

Tidy Data

	Site_ID	State Code	County Code	Site Number	Month1	Month2	Month3	Month4	Month5	Month6	Month7	Month8	Month9	Month10	Month11	Month12
1	010030010	01	003	0010	7.366667	7.211111	8.1625	6.93	6.736364	6.85	8.36	8.24	6.78	6.444444	8.43	5.86
2	010270001	01	027	0001	5.77	5.144444	7.875	6.9625	6.85	6.975	7.65	8.59	6.5125	6.388889	6.91	6.07
3	010491003	01	049	1003	8.07	6.228571	7.12	7.7625	7.472727	7.24	10.18	9.38	6.925	6.8	7.688889	7.55
4	010550010	01	055	0010	8.31	7.571429	8.54	8.91	7.890909	7.425	10.133333	9.5	7.77	10.05	<Null>	7.923183
5	010730023	01	073	0023	9.580169	12.099422	11.653191	12.961716	11.564921	10.522225	12.110792	14.396602	13.992682	13.834073	11.500682	12.58887
6	010731005	01	073	1005	7.46	6.75	9.76	7.12	7.48	6.88	8.6	11.84	8.32	8.52	10.28	4.84
7	010731010	01	073	1010	6.94	6.328571	9.09	7.84	7.94	6.98	8.89	9.6875	8.57	9.491667	8.48	4.49
8	010732003	01	073	2003	7.586667	8.272727	9.493333	8.4	8.04	8.01875	9.773333	9.038462	8.386667	9.689474	9.993333	7.22

	Site_ID	State Code	County Code	Site Number	Month	Mean_SO2_ppm
1	010030010	01	003	0010	1	7.366667
2	010030010	01	003	0010	2	7.211111
3	010030010	01	003	0010	3	8.1625
4	010030010	01	003	0010	4	6.93
5	010030010	01	003	0010	5	6.736364
6	010030010	01	003	0010	6	6.85
7	010030010	01	003	0010	7	8.36
8	010030010	01	003	0010	8	8.24

Basics of Data Analytics

- Understand what it means to "tidy" data
- Differentiate "primary" and "secondary" data
- Differentiate "qualitative" and "quantitative" data
- Identify different file types used in data analytics and discuss why some formats are better than others in terms of transparency and reproducibility
- Describe the various data structures used in data analytics and what each are used for: *Vectors*, *matrices*, *arrays*, *data frames*, *lists*
- Understand the difference between *R* and *RStudio*
- Become familiar with the typical layout of an RStudio session

Reproducibility & Coding Basics

Reproducibility

- Raw data are always separated from processed data; Raw datasets are NEVER changed
- Cleaning/transformations done through coding, not by editing (e.g., within Excel)
- Edits are documented by well-commented code
- Open-source formats are used wherever possible

Often, you'll spend the majority in the data processing phase (cleaning & wrangling data)

Navigating RStudio

Environmental_Data_Analytics_2022 - main - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function | Addins | Environmental_Data_Analytics_2022 — V:

02_Reproducibility_CodingBasics.Rmd

Knit on Save | Knit | Run

```
1  ---
2  title: "2: Reproducibility and Coding Basics"
3  author: "Environmental Data Analytics | John Fay and Luana Lima | Developed by Kateri
   Salk"
4  date: "Spring 2022"
5  output: pdf_document
6  geometry: margin=2.54cm
7  editor_options:
8    chunk_output_type: console
9  ---
10
11 ## Objectives
12
13 1. Discuss the benefits and approach for reproducible data analysis
14 2. Perform simple operations using R coding syntax
15 3. Call and create functions in R
16
17 ## Reproducible Data Analysis
18
19 ### Fundamentals of reproducibility
20
21 **Reproducibility**: when someone else (e.g., future self) can obtain the same
   outcomes from the same dataset and analysis
22
23 * Raw data are always separate from processed data
24 * Link data transformations with a reproducible pipeline
25 * Raw datasets NEVER changed
26 * Cleaning/transformations done through coding, not by editing within Excel
```

1:1 | 2: Reproducibility and Coding Basics | R Markdown

Console | Terminal | Jobs

R 4.1.2 · V:/Environmental_Data_Analytics_2022/

```
> meal <- recipe4(4); meal
[1] 2
> meal2 <- recipe4(2); meal2
[1] 4
> meal3 <- recipe5(3); meal3
[1] 3
>
> recipe6 <- function(x){
+   ifelse(x<3, x*2, x/2) #log_exp, if TRUE, if FALSE
+
+ }
>
> meal4 <- recipe6(4); meal4
[1] 2
> meal5 <- recipe6(2); meal5
[1] 4
>
> # chunk 12
> ??seq
>
```

Environment | History | Connections | Git | Tutorial

Import Dataset | 121 MiB | List

R | Global Environment

Data

doublecomplexm...	List of 2
doublesimpleme...	List of 2

Values

long_name_for_...	11
meal	2
meal2	4
meal3	3
meal4	2
meal5	4
simplemeal	10
ten_sequence	int [1:10] 1 2 3 4 5 6 7 8 9 10
x	12

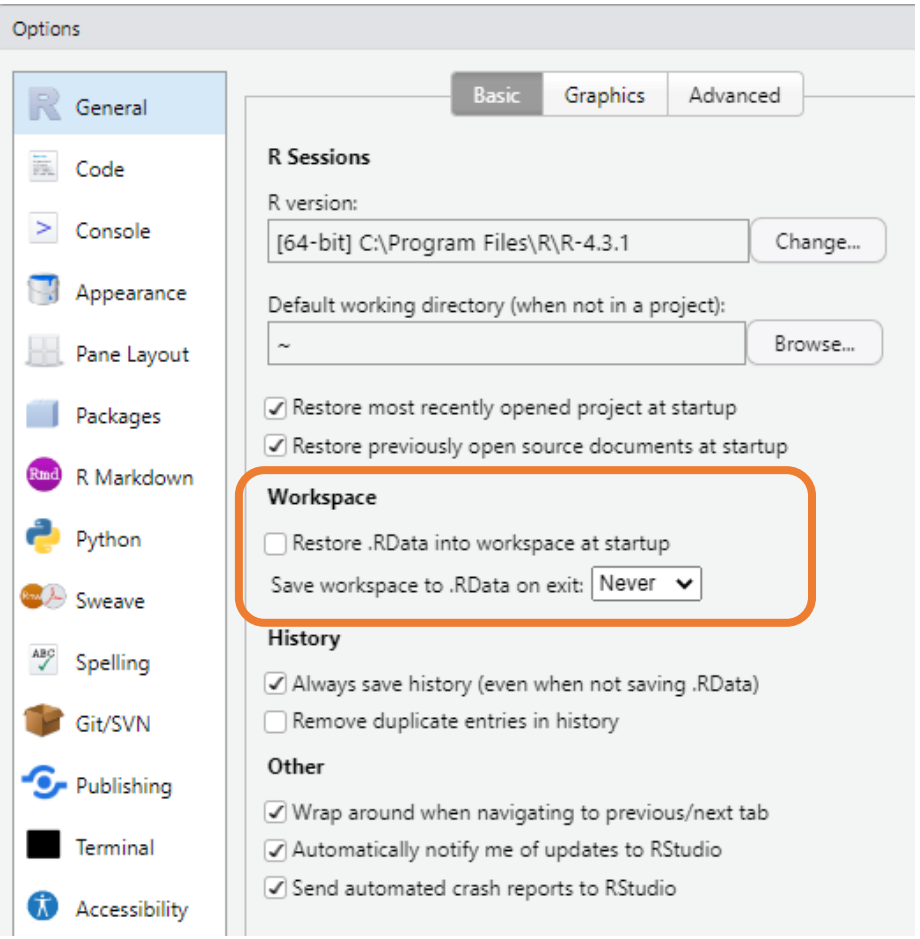
Files | Plots | Packages | Help | Viewer

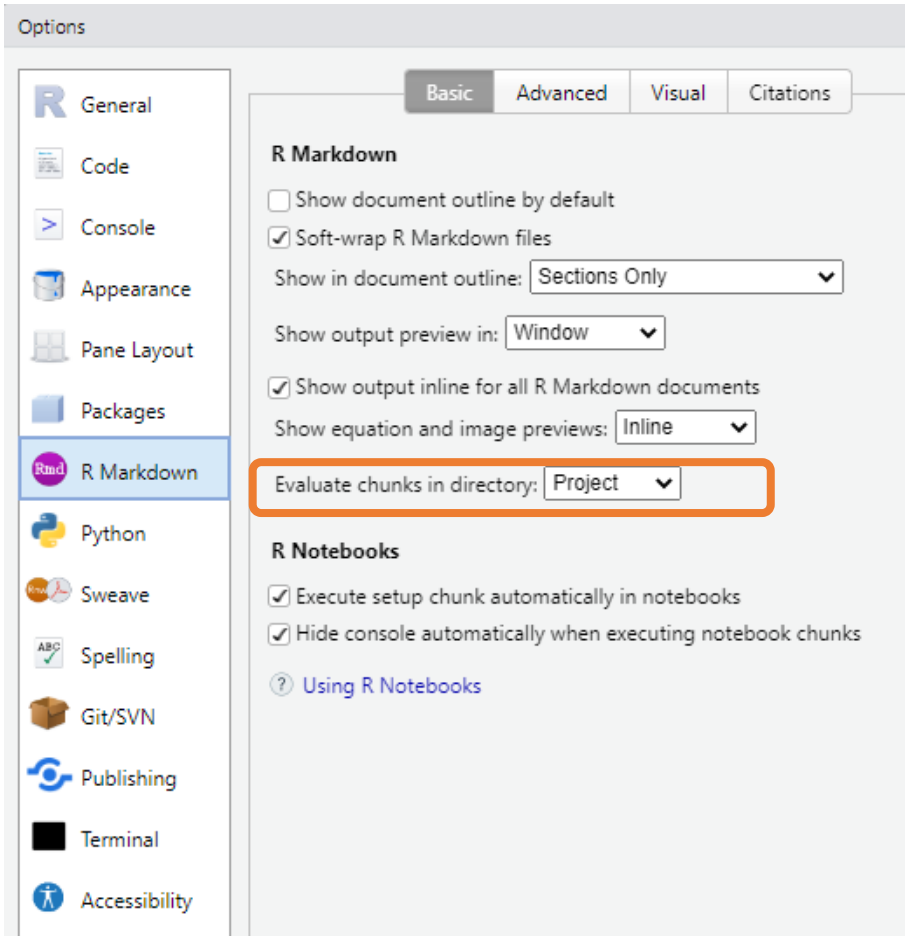
New Folder | Delete | Rename | More

V: > Environmental_Data_Analytics_2022

Name	Size	Modified
..		
.gitignore	636 B	Jan 13, 2022, 9:16 AM
.Rhistory	0 B	Jan 13, 2022, 10:00 AM
Assignments		
Environmental_Data_Analytics_2022...	218 B	Jan 14, 2022, 8:26 AM
Lessons		
LICENSE	35 KB	Jan 13, 2022, 9:16 AM
README.md	150 B	Jan 13, 2022, 9:17 AM
Resources		

R Configuration tips





Coding Basics: R-Markdown

- Creating an RMarkdown document
- What is the **header portion** called? What is its purpose?
- What is the difference between **text/markdown** and **code**
- Creating code cells/code chunks; components of a code cell
- Knitting - reports
- Folding code, contents

Coding Basics: Elements of R

- **Values**
  - 25, “Environment”, False, July 4, 1776

- **Objects** - A “container” that holds a value or values

```
mpg <- 42
my_dog <- "Rover"
colors <- c("Red", "Blue", "Green")
```

- **Functions** – instructions applied to values/object

```
mean(2, 5, 19, 20)
```

Review

- Which of these are numbers?

11	"11" "eleven"	eleven
number	value (string)	object

Coding Basics

- Console vs scripts
- Running commands (console|script)
- Variable assignments & naming strategies
- Comments
- Functions
  - Structure
  - Invoking existing functions
  - Creating new functions

Coding Basics: Data Structures

Vectors

- 1-dimensional sequence of data elements
- All items have of the same data type (e.g. int, chr)

Matrices

- 2-dimensional sequence of data elements
- Allows matrix multiplication and other linear algegbra operations

Arrays

- Includes vectors and matrices, includes > 2 dimensions

Coding Basics: Data Structures (cont'd)

Data Frames

- Stores data in 2 dimensions: rows and columns
- Each column is a "named vector" (same data type)

Lists

- Ordered collection of objects (mixed data types)

Coding Basics: Data Frames

- What does a dataframe consist of?
- Difference between *dataframe* and a *matrix*
- Advantages of a dataframe?

x

Filter

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Mazda RX4	21.0	6	160.0	110	3.90	2.620	16.46	0	1	4	4
Mazda RX4 Wag	21.0	6	160.0	110	3.90	2.875	17.02	0	1	4	4
Datsun 710	22.8	4	108.0	93	3.85	2.320	18.61	1	1	4	1
Hornet 4 Drive	21.4	6	258.0	110	3.08	3.215	19.44	1	0	3	1
Hornet Sportabout	18.7	8	360.0	175	3.15	3.440	17.02	0	0	3	2
Valiant	18.1	6	225.0	105	2.76	3.460	20.22	1	0	3	1
Duster 360	14.3	8	360.0	245	3.21	3.570	15.84	0	0	3	4
Merc 240D	24.4	4	146.7	62	3.69	3.190	20.00	1	0	4	2
Merc 230	22.8	4	140.8	95	3.92	3.150	22.90	1	0	4	2
Merc 280	19.2	6	167.6	123	3.92	3.440	18.30	1	0	4	4
Merc 280C	17.8	6	167.6	123	3.92	3.440	18.90	1	0	4	4
Merc 450SE	16.4	8	275.8	180	3.07	4.070	17.40	0	0	3	3
Merc 450SL	17.3	8	275.8	180	3.07	3.730	17.60	0	0	3	3
Merc 450SLC	15.2	8	275.8	180	3.07	3.780	18.00	0	0	3	3

Coding Basics (Hands on)

- Coding with dataframes
  - Referencing columns
  - Creating dataframes
  - Properties of dataframes
  - Extracting data from dataframes

Up next: M3

More on coding basics/Data exploration:

- Loading data into R
  - Data types; dealing with pesky dates
- Exploring data with R: structure and values
- *Visually* exploring data with plots
  - Bar plots, histograms, scatterplots, etc.

The class “rhythm”

Each week = 1 module = {recordings + exercise + assignment}

- <u>Recordings:</u>
  - Watch recordings <u>prior</u> to class
- <u>In class:</u>
  - Ask questions about recordings and about assignment
  - Group exercises to re-inforce concepts (+ some new concepts)
- <u>Assignments:</u>
  - Made available after class discussion
    - A01 made available after class session last week; A02 available now
  - Due on Thursday @ 5pm