



# Workshop Series: Reusable Research Data Made Shiny

Ontario Dairy Research Centre | Online  
February 21<sup>st</sup> - 24<sup>th</sup>, 2023





Welcome Back!

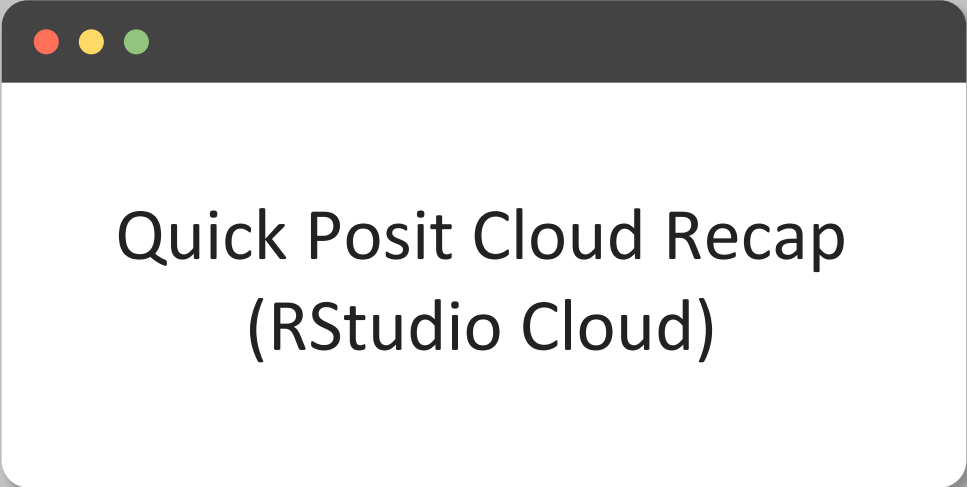
Session 1

Session 2

Session 3

Session 4

Wrap-up!

A dark gray rectangular frame with rounded corners, containing three small colored circles (red, yellow, green) in the top-left corner, mimicking a standard OS window header.

## Quick Posit Cloud Recap (RStudio Cloud)



# What is Posit cloud?

R Studio IDE in the cloud!

Using server hosted on the internet rather than a  
local computer or server





Welcome Back!

Session 1

Session 2

Session 3

Session 4

Wrap-up!

## Posit Cloud Recap

posit.cloud/content/5260296

**Start coding directly from  
your browser!**

File Edit Code View Plots Session Build Debug Profile

Go to file/function Addins

Greenhouse\_analysis.R data1 field\_Passess.R Untitled1 data

Run Source

1

R 4.2.2

Environment History Connections Tutorial

Import Dataset 486 MiB

R Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

Console Terminal Background Jobs

R 4.2.2 . /cloud/project/

>



# Posit cloud set-up

- Work along (if you haven't activated RStudio)
- Remember to use your stickers to indicate your progress/you need help



## Welcome email

### You should have received a welcome email

Hello,

We are excited to have you for our 4-day Reusable Research Data Made help you make your research data reusable and shiny!

Quick notes about the workshop:

The workshop will run from Feb 21<sup>st</sup> to Feb 24<sup>th</sup> from 9:00 AM EDT to 4:

If you registered to attend **in-person**:

- The Ontario Dairy Research Centre is located at: [6185 2nd Line Ea](#)
- Breakfast will be served daily at the Research Centre at 8:30 AM.

If you registered to attend **on-line**:

- Click [here](#) to attend the meeting on MS Teams
- Note that the first session of the day starts at 9:00 AM, but feel fr

Click [here](#) to get started on the workshop, learn where to find the mater

Have a great long weekend and see you at the workshop!

- Workshop Organizing Committee



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Workshop  
GitHub page

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Workshop  
GitHub page

README.md

### How to get started on this Workshop

#### GitHub and Posit Cloud

By Busayo Kodaolu

2023-02-17

#### Navigating Github

Okay, I know it sounds too "techy". To keep it simple, developers use GitHub to share codes, collaborate and keep track of changes to their codes. In this workshop, we are using it as a repository to share the workshop materials. Click [here](#) to access the materials and you should see a screen like the one below:





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Workshop  
GitHub page

Instructions on how to download workshop materials and setup the free Posit Cloud account

README.md

### How to get started on this Workshop

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By Busayo Kodaolu

2023-02-17

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## Downloading workshop materials

The screenshot shows the GitHub interface for the repository `agrifooddatacanada / RRDMS_Workshop`. The repository is public and has 0 forks and 0 stars. The `Code` button is circled in red, and a red arrow points from it to the `Download ZIP` option in the dropdown menu, which is also circled in red.

**Repository Details:**

- Repository: `agrifooddatacanada / RRDMS_Workshop` (Public)
- Notifications: 0
- Fork: 0
- Star: 0

**Code**

- main (1 branch, 0 tags)
- Go to file
- Code** (circled in red)

**Download ZIP** (circled in red)

**Files:**

File	Commit
00_Start_Here	Initial commit
Day_1	Folders reorganized
Day_2	Folders reorganized
Day_3	Folders reorganized
Day_4	Folders reorganized
.gitignore	Update .gitignore
README.md	Update README.md

**README.md**

**About**

- Reusable Research Data Made Shiny Workshop
- Readme
- 0 stars
- 2 watching
- 0 forks

**Releases**

- No releases published

**Packages**

- No packages published



## Posit cloud set-up --> Invitation email

### Email inviting you into the workshop space

Lucas Alcantara has invited you to access a space on Posit Cloud  Inbox x



**Posit Cloud** <noreply@posit.cloud>  
to me ▾

11:46 AM (2 hours ago)

Hello

Click the link below to sign up now:

[https://login.posit.cloud/invite?code=rcAonX6wVLaspTNvKXMA3\\_UJPbi82PcRozyAQS7r&space\\_name=Reusable+Research+Data+Made+Shiny](https://login.posit.cloud/invite?code=rcAonX6wVLaspTNvKXMA3_UJPbi82PcRozyAQS7r&space_name=Reusable+Research+Data+Made+Shiny)

Click

This message was sent by Posit Cloud on behalf of Lucas Alcantara.



## Log In or Sign Up



You have been invited to join an account on Posit

|

Please log in or sign up to continue.

Log In

Don't have an account?  
Sign Up

Email

Continue

[Forgot your password?](#)

or



Log In with Google



Log In with GitHub



## Log In or Sign Up



You have been invited to join an account on Posit

Please log in or sign up to continue.

Log In

Don't have an account?  
Sign Up

Continue

[Forgot your password?](#)

or



Log In with Google



Log In with GitHub





## Log In or Sign Up



You have been invited to join an account on Posit

Please log in or sign up to continue.

Log In

Don't have an account?  
Sign Up

Continue

[Forgot your password?](#)

or



Log In with Google



Log In with GitHub



Reusable Research Data Ma...  
University of Guelph - Workshop

Content Members About

All Content (9)

ACCESS \* SORT A 2 Q

New Project

D3S1\_Introduction\_to\_R **START**  
RStudio Project Lucas Alcantara Space members Created Feb 17, 2023 7:06 AM

**D3S2\_Tidyverse\_1 **CONTINUE****  
RStudio Project Lucas Alcantara Space members Created Feb 16, 2023 9:19 AM 1 derived project

D3S2\_Tidyverse\_1  
RStudio Project Busayo Kodaolu Private Created Feb 17, 2023 2:36 PM Derived from: D3S2\_Tidyverse\_1 by Lucas Alcantara

D3S3\_Tidyverse\_2 **START**  
RStudio Project Lucas Alcantara Space members Created Feb 17, 2023 7:06 AM

D3S4\_Intro\_to\_Shiny **START**  
RStudio Project Lucas Alcantara Space members Created Feb 17, 2023 7:06 AM

D4S1\_Intro\_to\_Shiny **START**

**This represents material for day 3 section 2**



## D3S2\_Project files preloaded

Reusable Research Data Made Shiny / D3S2\_Tidyverse\_1

RAM ⚙️ ⋮ BK Busayo Kodaolu ⌵

The screenshot displays the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The top toolbar contains icons for saving, opening, and running files. The main editor window shows a blank R script file named 'Untitled1'. The Environment pane on the right indicates that the environment is empty. The Files pane on the left, which is highlighted with a red box, shows the project structure. It includes a table of files and folders with columns for Name, Size, and Modified. The files listed are .Rhistory, .Rprofile, D3S2\_Tidyverse\_1.pdf, D3S2\_Tidyverse\_1.R, data, project.Rproj, renv, and renv.lock. The console at the bottom shows the R version 4.2.2 and the project path /cloud/project/.

Name	Size	Modified
..		
.Rhistory	0 B	Feb 16, 2023, 9:19 AM
.Rprofile	26 B	Feb 16, 2023, 9:22 AM
D3S2_Tidyverse_1.pdf	1.5 MB	Feb 16, 2023, 9:20 AM
D3S2_Tidyverse_1.R	5.9 KB	Feb 16, 2023, 9:25 AM
data		
project.Rproj	205 B	Feb 17, 2023, 4:32 PM
renv		
renv.lock	12.1 KB	Feb 16, 2023, 9:22 AM

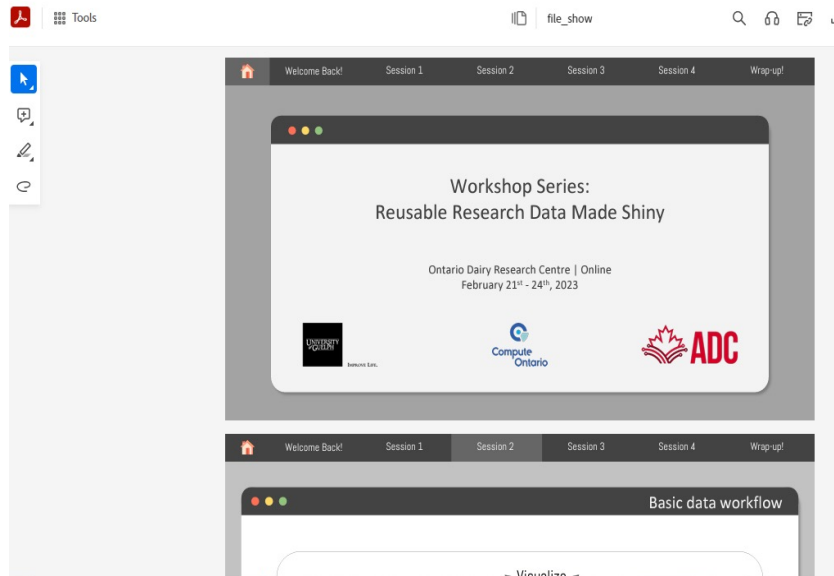
R version 4.2.2 (2022-10-31) -- "Innocent and Trusting"  
Copyright (C) 2022 The R Foundation for Statistical Computing  
Platform: x86\_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.



## Slides and R-script for that section



```
Untitled1 x D352_Tidyverse_1.R x
17 # install.packages("tidyr")
18 # install.packages("lubridate")
19
20 # Load required packages ----
21 library(dplyr)
22 library(readr)
23 library(skimr)
24 library(lubridate)
25
26 # Toy data ----
27 ## Load with readr ----
28 env_data <- read_csv("data/environmental_data.csv")
29
30 ## Take a look at the data with skimr ----
31 env_data
32 skim(env_data)
33
34 # filter() ----
35 ## Example ----
36 ### Filter for lactating barn temperatures only ----
37 filter(env_data, barn == "lactating")
38
39 ## Your turn ----
40 ### From inside the barn ----
41 filter(env_data, location == "inside")
42 ### Above 30C ----
43 filter(env_data, temp > 30)
44 ### Between 0 and 10C inside the replacement barn ----
45 filter(env_data, temp >= 0, temp <= 10, location == "inside",
```





## Workspaces?

### Shared workspace/classroom





## Workspaces?

**Shared workspace/classroom**



**Personal workspace/office**





## Workspaces?

**Shared workspace/classroom**




**Personal workspace/office**



**Both can be made  
public or private**



## Your workspaces?

[Plans & Pricing](#)[Plans](#)[Compare Plans](#) Busayo Kodaolu

Cloud

Free

Cloud

Premium

Cloud

Instructor

Cloud

Organization

### Cloud Free

YOUR CURRENT PLAN







If you make limited, occasional use of Posit Cloud, or have your usage covered by your school/organization or an instructor, our free plan is all you need.

If you need additional time, consider our **Plus** plan. For \$5 / month, get 75 compute hours per month - and you can use additional hours as needed for 10¢ per hour.



Plus

### Key Features

- ✓ Up to 50 projects total 
- ✓ 1 shared space (5 members and 10 projects max) 
- ✓ 25 compute hours per month 
- ✓ Up to 1 GB RAM per project 
- ✓ Up to 1 CPU per project 
- ✓ Up to 1 hour background execution time 



## Your workspaces?

Plans & Pricing

Plans

Compare Plans

Cloud

Free

Cloud

Premium

### Cloud Free

If you make limited, occasional use of Posit Cloud, or have your usage covered by your school/organization or an instructor, our free plan is all you need.

If you need additional time, consider our **Plus** plan. For \$5 / month, get 75 compute hours per month - and you can use additional hours as needed for 10¢ per hour.



Plus

#### YOUR PERSONAL ACCOUNT

PLAN

Cloud Free

CURRENT USAGE PERIOD

Jan 20, 2023 - Feb 20, 2023

USAGE

Projects: 2 of 50



Compute hours: 12.6 of 25



Busayo Kodaolu

#### BUSAYO KODAOLU

Log Out

Profile

Account

Authentication

Credentials

#### ORGANIZATIONS

University of Guelph - Workshop

✓ Up to 1 GB RAM per project



✓ Up to 1 CPU per project




✓ Up to 1 hour background execution time





## Your workspaces?

[Click here](#) Plans & Pricing

Plans

Compare Plans

Cloud

Free

Cloud

Premium

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Plus

YOUR CURRENT

## YOUR PERSONAL ACCOUNT

PLAN

Cloud Free

CURRENT USAGE PERIOD

Jan 20, 2023 - Feb 20, 2023

USAGE

Projects: 2 of 50



Compute hours: 12.6 of 25



## BUSAYO KODAOLU

 Log Out Profile Account Authentication Credentials

## ORGANIZATIONS

 University of Guelph - Workshop

✓ Up to 1 GB RAM per project



✓ Up to 1 CPU per project



✓ Up to 1 hour background execution time





## Your workspaces?

Click here

The screenshot displays the Posit Cloud user interface. On the left, a sidebar menu is visible with the following items: "Plans & Pricing" (highlighted), "Spaces", "Your Workspace", "Reusable Research Data M" (University of Guelph - Workshop), and "New Space". A red box with the text "Click here" points to the "Plans & Pricing" menu item. The main content area is titled "Plans & Pricing" and shows a comparison of plans. The "Cloud Free" plan is selected, and the "Premium" plan is highlighted. The "Premium" plan details include: "YOUR PERSONAL ACCOUNT", "PLAN", "Cloud Free", "CURRENT USAGE PERIOD", "Jan 20, 2023 - Feb 20, 2023", "USAGE", "Projects: 2 of 50", "Compute hours: 12.6 of 25", and a "YOUR CURRENT PLAN" section. A toggle switch for "Plus" is visible. On the right, the user's profile "BUSAYO KODAOLU" is shown with options for "Log Out", "Profile", "Account", "Authentication", and "Credentials". Below this, the "ORGANIZATIONS" section lists "University of Guelph - Workshop". At the bottom, a list of features is shown with checkmarks and information icons: "Up to 1 GB RAM per project", "Up to 1 CPU per project", and "Up to 1 hour background execution time".

Plans & Pricing

Plans Compare Plans

posit Cloud

Spaces

Your Workspace

Reusable Research Data M  
University of Guelph - Workshop

+ New Space

Cloud  
Premium

YOUR PERSONAL ACCOUNT

PLAN  
Cloud Free

CURRENT USAGE PERIOD  
Jan 20, 2023 - Feb 20, 2023

USAGE  
Projects: 2 of 50

Compute hours: 12.6 of 25

YOUR CURRENT PLAN

personal use of Posit Cloud, or have your usage covered by  
nstructor, our free plan is all you need.

consider our **Plus** plan. For \$5 / month, get 75 compu  
hours per month - and you can use additional hours as needed for 10¢ per hour.

Plus

BUSAYO KODAOLU

Log Out

Profile

Account

Authentication

Credentials

ORGANIZATIONS

University of Guelph - Workshop

✓ Up to 1 GB RAM per project

✓ Up to 1 CPU per project

✓ Up to 1 hour background execution time



## Your workspaces?

Click here

Plans & Pricing

Plans

Compare Plans



Spaces

Your Workspace

Reusable Research Data M  
University of Guelph - Workshop

New Space

2 accounts

(Can create more  
but there is limit for  
the free account)

Cloud  
Premium

YOUR PERSONAL ACCOUNT

PLAN

Cloud Free

CURRENT USAGE PERIOD

Jan 20, 2023 - Feb 20, 2023

USAGE

Projects: 2 of 50

Compute hours: 12.6 of 25

YOUR CURRE

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Busayo Kodaolu

BUSAYO KODAO LU

Log Out

Profile

Account

Authentication

Credentials

ORGANIZATIONS

University of Guelph - Workshop

✓ Up to 1 GB RAM per project



✓ Up to 1 CPU per project



✓ Up to 1 hour background execution time







Welcome Back!

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Session 4

Wrap-up!

## Your workspaces?

≡ Your Workspace  
Busayo Kodaolu

Content

Usage

About

BK Busayo Kodaolu ^

📁 Your Content

📁 Archive

🗑️ Trash

Your Content (2)

New Project ▾

ACCESS



SORT



project



RStudio Project



Private

Created Jan 20, 2023 12:04 PM



shinyApp



RStudio Project



Private

Created Feb 9, 2023 1:08 PM





Welcome Back!

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Wrap-up!

Your workspaces?

≡ Your Workspace  
Busayo Kodaolu

Content

Usage

About

🗄 Your Content

📁 Archive

🗑 Trash

Your Content (2)

New Project ▾

ACCESS

\* ▾

SORT

A  
Z ▾



project



RStudio Project



Private

Created Jan 20, 2023 12:04 PM



shinyApp



RStudio Project



Private

Created Feb 9, 2023 1:08 PM



Click here  
to start a  
project

Your Workspace / Untitled Project *+ Click to name your project*

Busayo Kodaolu



File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

R 4.2.2

Console Terminal Background Jobs

R 4.2.2 . /cloud/proje

R version 4.2.2 (2022) (64-bit)  
Copyright (C) 2022 The R Foundation for Statistical Computing  
Platform: x86\_64-pc-linux-gnu

R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or  
'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.

&gt; |

Brings you to  
RStudio IDE like the  
RStudio Desktop

Environment History Connections Tutorial

Import Dataset 123 MiB

R Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

Cloud &gt; project

	Name	Size	Modified
	..		
<input type="checkbox"/>	.Rhstory	0 B	Feb 15, 2023, 11:24 AM
<input type="checkbox"/>	project.Rproj	205 B	Feb 15, 2023, 11:24 AM

[Click here](#)Your Workspace / Untitled Project *+ Click to name your project*

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

Console Terminal Background Jobs

R 4.2.2 . /cloud/proje

RStudio IDE like the RStudio Desktop

R version 4.2.2 (2022) Copyright (C) 2022 The R Foundation for Statistical Computing Platform: x86\_64-pc-l

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&gt; |

Environment History Connection

Global Environment

Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

Cloud &gt; project

	Name	Size	Modified
	..		
<input type="checkbox"/>	.Rhistory	0 B	Feb 15, 2023, 11:24 AM
<input type="checkbox"/>	project.Rproj	205 B	Feb 15, 2023, 11:24 AM



Busayo Kodaolu



Info

Access

Resources

System

ACCESS

Who can view this

Everyone (all Cloud users)



Welcome Back!

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Wrap-up!



# Introduction to R and RStudio



## R Programming Language

R, developed by Ross Ihaka and Robert Gentleman at the University of Auckland, New Zealand in the mid-1990s, is a programming language for mostly statistical computing and graphics.

IEEE publishes a list of the most popular programming languages each year. R was ranked 5th in 2016, up from 6th in 2015. Due to its expressive syntax and easy-to-use interface, it has grown in popularity in recent years.

R provides tools and techniques for

- Linear and nonlinear modeling
- Time-series analysis
- Classification and Clustering
- Graphical Representation of data
- etc.



## Why R Language?

### Why R?

- R is open-source and free
- R runs on all platforms (Windows, Linux and Mac)
- R has lots of packages
  - ✓ R language has more than 10,000 packages stored in the CRAN repository, and the number is continuously increasing.
- R facilitates quality plotting and graphing.
  - ✓ The popular libraries like *ggplot2* and *plotly* are used for visually appealing graphs that makes R outstanding from other programming languages.
- R is Highly Compatible
  - ✓ R can be paired with many other programming languages like C, C++, Java, and Python.

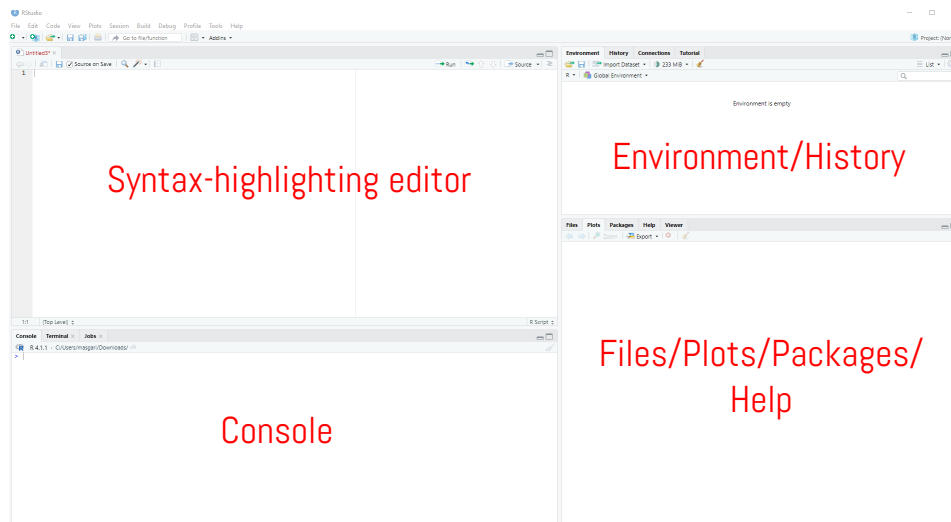


## What is RStudio?

 **RStudio** is a free and open-source Integrated Development Environment (IDE) for R

RStudio is available in two editions:

- **RStudio Desktop:** the program is run locally as a regular desktop application;
- **RStudio Server:** allows accessing RStudio using a web browser while it is running on a remote Linux server.







## RStudio Projects

Creating a project in RStudio is a good practice for several reasons:

- **Organization:** By creating a project, you can keep all your R scripts, R markdown documents, R functions and data together in one place. This makes it easier to keep track of your progress, collaborate with others, and share your work.
- **Isolation:** R projects are self-contained. It means the libraries, packages, and environment variables that you use in one project will not interfere with other projects.
- **Reproducibility:** Projects in RStudio allow you to save your workspace and the state of your environment, so that you can easily reproduce your analysis later.

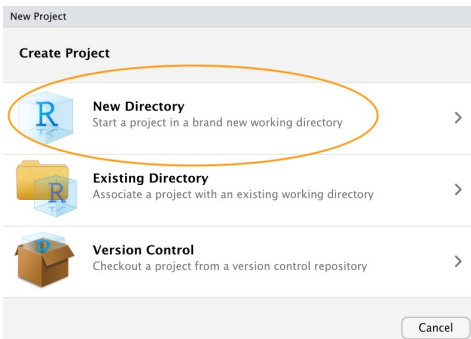
All in all, creating a project in RStudio provides a streamlined workflow that helps you stay organized, focused, and productive while working on your data analysis projects.



## RStudio Projects

### How to create an RStudio Project?

- Open RStudio and click on "File" from the top menu bar, then click "New Project".
- In the "New Project" window, select the type of project you want to create. You can choose from a variety of project types, such as "New Directory", "Existing Directory", "Version Control", or "Package".

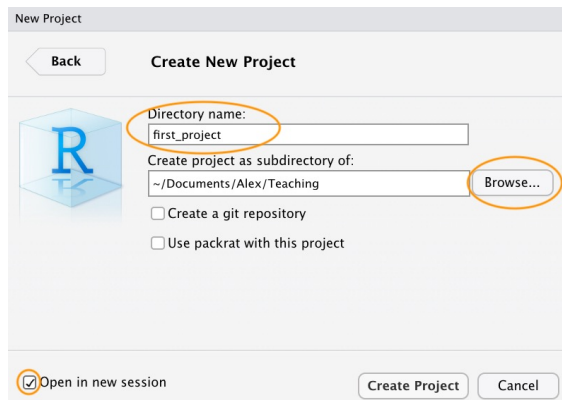




## RStudio Projects

### How to create an RStudio Project?

- Next, you'll need to specify the project directory and location. Choose a name for your project and select the directory where you want to save your project files. You can create a new directory or choose an existing one.

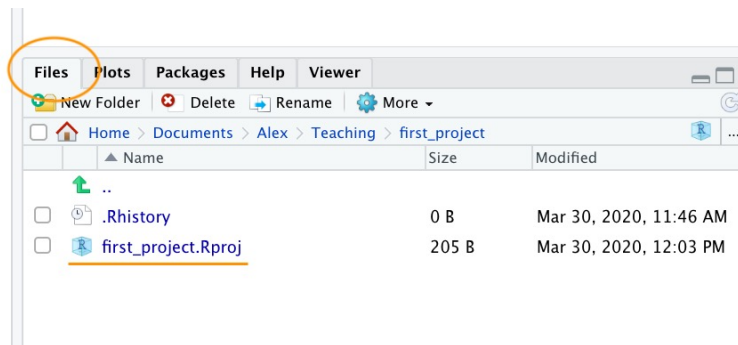




## RStudio Projects

How to create an RStudio Project?

- Now, you have a new folder on your computer containing an RStudio project file called `first_project.Rproj`. This `.Rproj` file contains various project options and can also be used as a shortcut for opening the project directly from the file system (just double click on it).
- You can check this out in the 'Files' tab in RStudio.





## RStudio Projects

How to create an RStudio Project?

- Once your project is created, you can start coding by opening a new R script file or opening an existing R script file.
- You can also use RStudio's other features, such as the console, the environment tab, and the plot tab, to analyze and visualize your data.



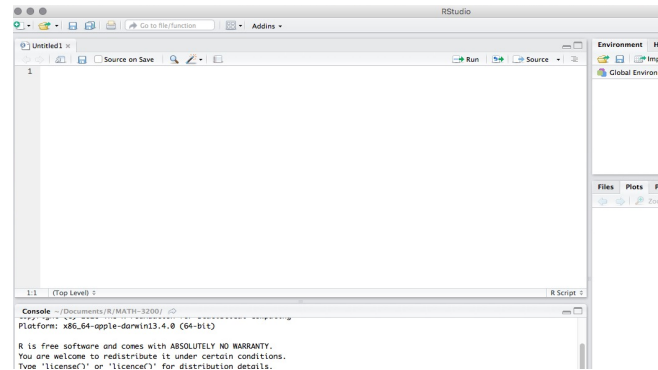
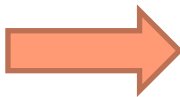
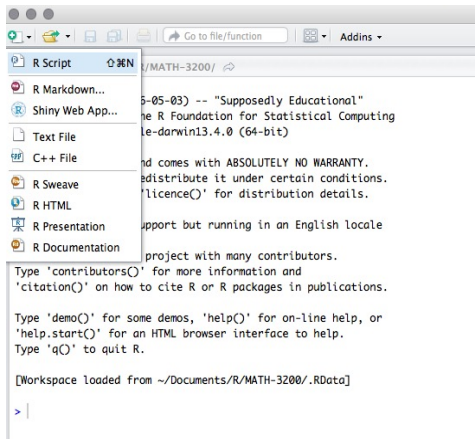
## R Scripts

Creating, opening, and running R scripts are important tasks in R programming.

Creating a new R script:

In RStudio, click on "File" from the top menu bar and select "New File". From the dropdown menu, select "R Script" and click "OK".

A new blank R script will appear in the editor window. You can start writing your code in this file

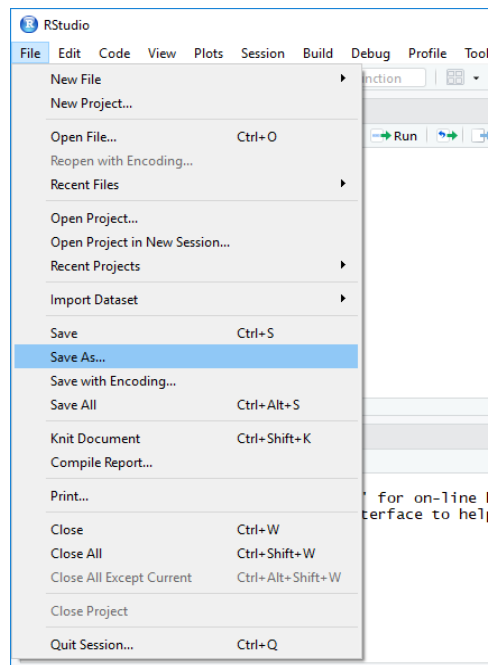




## R Scripts

Creating a new R script:

If you want to save the changes you made to an existing R script, simply click on "File" from the top menu bar and select "Save".

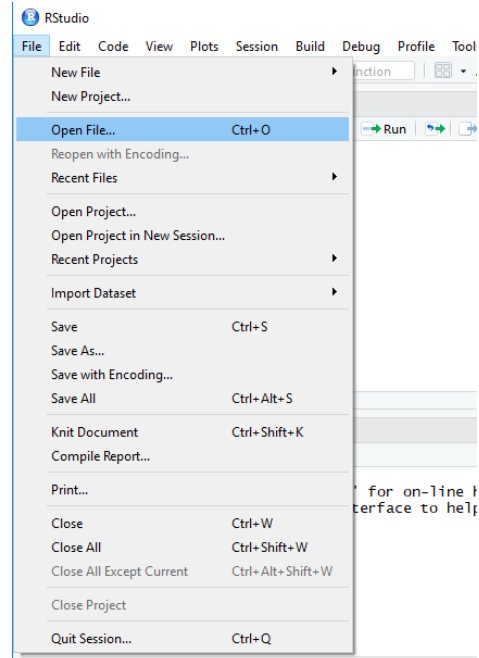




## R Scripts

### Opening an existing R script:

- In RStudio, click on "File" from the top menu bar and select "Open File".
- Navigate to the location of the R script on your computer and select it.
- The R script will open in a new tab in the editor window, and you can start working with the code.



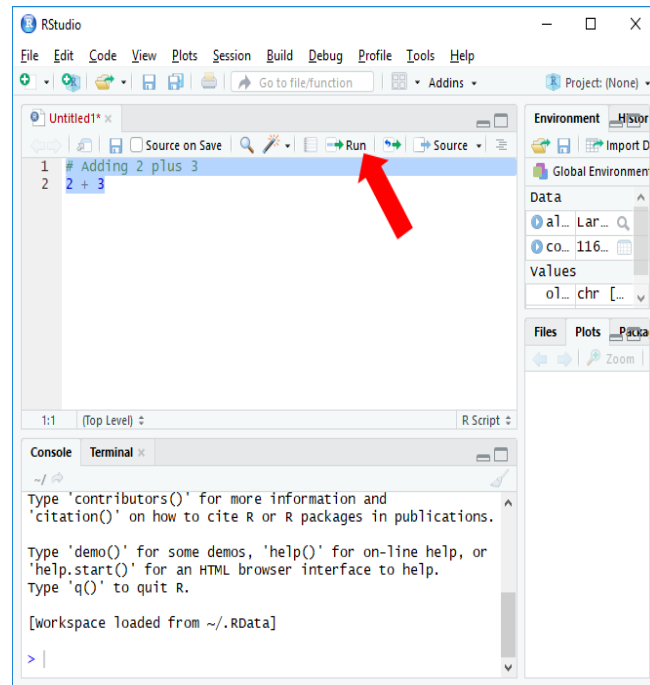




# R Scripts

## Running an R script:

- In the editor window of RStudio, select the code you want to run.
- Click on the "Run" button located in the top-right corner of the editor window.
- The output of your code will appear in the console window at the bottom of the screen.





## Navigating the tree of directory

Get the path of the current directory with **getwd()** (get working directory)

- `getwd()`

Change working directory with **setwd()** (set working directory)

- `setwd("~/Rcourse")`



## Variables in Programming

In programming languages, a **Variable** is a named location in memory that can hold a value. Variables are used to store data that can be manipulated and processed by the program.

Variables are defined using a **Name** and a **Data Type**.

- The name of the variable is used to refer to the data stored in the memory location, and the data type specifies the type of data that can be stored in the variable.

Variables can be assigned a value using an assignment operator (=) (and/or (<-) (leftward) in R programming language).

For example, in R programming, you can define a variable named "x" to hold a numeric value using the following syntax:

```
x <- 10 or x = 10
```



## Variables in Programming

Variables can be used in a program to

- Store Input Data
- Perform various operations, such as arithmetic, comparison, and logical operations.
- Store the results of a computation or to pass data between functions or modules within the program.

You can also view information on the variable by looking in your Environment window in the upper right-hand corner of the RStudio interface.

Environment History	
Global Environment	
Values	
x	3
y	5

The screenshot shows the RStudio interface. The script editor on the left contains the following R code:

```
1 #Customer 1
2 billAmt <- 1000
3 tax <- 200
4 totalAmt <- billAmt + tax
5 totalAmt
```

The console window on the right shows the execution of the code:

```
> billAmt <- 1000
> tax <- 200
> totalAmt <- billAmt + tax
> totalAmt
[1] 1200
>
```



## Variables in Programming

### Tips on Variable Names

- Make your names explicit and not too long
- Avoid names starting with a number (2x is not valid, but x2 is)
- Avoid names of fundamental functions in R (*e.g.*, if, else, for). When in doubt check the help to see if the name is already in use
- Avoid dots (.) within a variable name as in my.dataset
- Use nouns for object names
- Keep in mind that R is case sensitive



## Basic Data Types

R supports various data types. Some of the basic data types in R are:

1. **Numeric:** This data type represents numeric values, including integers and real numbers.
  - Numeric values can be positive, negative, or zero
  - They are represented as double precision floating-point values by default.
2. **Character:** This data type represents textual data, such as names, sentences, and paragraphs. In R, character values are enclosed in quotes, either single (") or double (").
3. **Logical:** This data type represents Boolean values, which are either TRUE or FALSE.



## Programming Operators

Operators are used for operations on data. We have Arithmetic, Comparison, Logical, and Assignment operations.

- **Arithmetic Operators:** These are used to perform **Mathematical Calculations** on numeric values.

+	Addition →	<code>X &lt;- 2+2</code>
-	Subtraction →	<code>X &lt;- 2-2</code>
*	Multiplication →	<code>X &lt;- 2*2</code>
/	Division →	<code>X &lt;- 2/2</code>
^	Exponentiation →	<code>X &lt;- 2^2</code>
%%	Remainder after division →	<code>X &lt;- 2%%2</code>



## Programming Operators

Operators are used for operations on data. We have Arithmetic, Comparison, Logical, and Assignment operations.

- **Comparison Operators:** These are used to compare two values and return a logical value (TRUE or FALSE).

< Less than →	2<3	return: TRUE
> Greater than →	2>3	return: FALSE
<= Less than or equal to →	2<=3	return: TRUE
>= Greater than or equal to →	2>=3	return: TRUE
== Equal to →	2==3	return: FALSE
!= Not equal to →	2!=3	return: TRUE





## Programming Operators

Operators are used for operations on data. We have Arithmetic, Comparison, Logical, and Assignment operations.

- **Logical Operators:** These are used to combine or negate logical values.

& Element-wise logical AND  $\rightarrow (X > 30 \ \& \ Y < 15)$

| Element-wise logical OR  $\rightarrow (X > 30 \ | \ Y < 15)$

! Element-wise logical NOT

&& Short-circuiting logical AND

|| Short-circuiting logical OR



## DataFrames in R

In R, a data frame is a two-dimensional object for storing data tables in rows and columns. The columns should have the same size, but they can store different data types.

A data frame in R can be created using the **data.frame()** function. For example, to create a data frame with three columns, "Name", "Age", and "ClassA", we can use the following code:

```
1 Students <- data.frame (  
2   Name = c("Lily", "Ben", "Tony"),  
3   Age = c(20, 16, 31),  
4   ClassA = c(TRUE, TRUE, FALSE)  
5 )
```



```
> Students  
  Name Age ClassA  
1 Lily  20   TRUE  
2 Ben  16   TRUE  
3 Tony 31  FALSE
```

- `c()` function: Creates a vector of objects with the same datatypes.
- All columns have the same length.
- The name of data frame is "Students".
- Students have columns with Numeric, character and logical datatypes.



## DataFrames in R

You can access the elements of a data frame using the `$` operator or the square bracket `[]` operator.

- For example, to access "Name" column of the "Students" data frame we can use the following code:

```
Students $Name
```

- To access the second row of the "Students" data frame , we can use the following code:

```
Students[2, ]
```

You can also use logical operators to select specific rows or columns based on a condition. For example, to select all rows where the Age is greater than 15, you can use the following code:

```
Students[Students$Age > 15, ]
```

Get first rows of a DataFrame: **head()** → head(Students)

Get last rows of a DataFrame: **tail()** → tail(Students)



## Basic Built-in Functions in R

Some basic Functions in R:

- `print()` - Prints the specified input to the console.
- `sum()` - Returns the sum of numeric data.
- `mean()` - Returns the mean of a numeric vector.
- `sd()` - Returns the standard deviation of a numeric vector.
- `seq()` - Generates a sequence of numbers.

```
1  
2 print("hello world!")  
3
```

```
1  
2 sum(1+2+9+8)  
3
```

```
1  
2 mean(c(1, 2, 9, 8))  
3
```

```
1  
2 sd(c(1, 2, 9, 8))  
3
```

```
1  
2 seq(0, 10)  
3
```



## Basic Built-in Functions in R

Some basic Functions in R:

- `length()` - Returns the length of a vector.
- `max()` - Returns the maximum value of a vector.
- `min()` - Returns the minimum value of a vector.

```
1  
2 length(c(1, 2, 9, 8))  
3  
1  
2 max(c(1, 2, 9, 8))  
3  
1  
2 min(c(1, 2, 9, 8))  
3
```



## Calling Functions in R

Built-in functions: In R, you can call a function by typing the name of the function followed by parentheses containing any necessary arguments.

### Functions in Packages

#### 1 - Explicitly loading the package:

In R, you can call a function from a package by **first loading the package into your R session** using the **library()** or **require()** functions, and then calling the function using the function name.

```
library(ggplot2)
```

```
MyGraph <- ggplot(....)
```



## Calling Functions in R

Built-in functions: In R, you can call a function by typing the name of the function followed by parentheses containing any necessary arguments.

### Functions in Packages

#### 2 - Without loading the package:

In R, you can call a function from a package without explicitly loading the package by using the double colon operator ::

The double colon operator allows you to access functions and objects in a package without loading the entire package into the current R session.

```
MyGraph <- ggplot2::ggplot(...)
```



## Commenting in R

Comments are generic English sentences, mostly written in a program to explain what it does or what a piece of code is supposed to do. More specifically, information that programmer should be concerned with, and it has nothing to do with the logic of the code. They are completely ignored by the compiler and are thus never reflected on to the input.

Comments are generally used for the following purposes:

- Code Readability
- Explanation of the code or Metadata of the project
- Prevent execution of code
- To include resources





## Commenting in R

There are two types of comments in R: **single-line comments** and **multi-line comments**. Single-line comments start with the **# symbol** and continue until the end of the line.

```
# This is a single-line comment
```

Multi-line comments are enclosed in **/\* \*/** symbols. For example:

```
/*  
This is a multi-line comment  
It can span across multiple lines  
*/
```

It is good practice to include comments in your code to make it easier to understand and maintain. It is also important to keep your comments up to date as you make changes to your code.



## Some RStudio Useful Shortcuts

Description	Windows & Linux	Mac
Clear console	Ctrl+L	Ctrl+L
Change working directory	Ctrl+Shift+H	Ctrl+Shift+H
Save all documents	Ctrl+Alt+S	Cmd+Option+S
Undo	Ctrl+Z	Cmd+Z
Redo	Ctrl+Shift+Z	Cmd+Shift+Z
Indent	Tab (at beginning of line)	Tab (at beginning of line)
Outdent	Shift+Tab	Shift+Tab
Search R Help	Ctrl+Alt+F1	Ctrl+Option+F1
Save RScripts	Ctrl+S	Cmd+S
Comment/uncomment a Line	Ctrl+Shift+C	Cmd+Shift+C
Run Codes	Ctrl+Enter	Cmd+Enter



Welcome Back!

Session 1

Session 2

Session 3

Session 4

Wrap-up!

# Coffee Break!

