Zehui Yin

First-year PhD Student in Geography at SEES

- Email: yinz39@mcmaster.ca
 - Please use your McMaster email address.
 - Please put the course code *ENVSOCTY* 4GA3 in the subject line.
 - Please include your name and student number in the body of the email.
 - I will try to reply within 24 hours (please expect longer delays during weekends/holidays).
- Personal Website: zehuiyin.github.io
- **Research Interests:** Spatial Analysis, Transportation, Travel Behaviour, Public Transit, Shared Mobility

Agenda for today

- Introduction to basic concepts for coding in R
- Getting a flavor of R syntax and style
- Setting up R and reproducible environment on your personal computer

R and RStudio

- R is a free and open-source programming language for statistical computing and graphics.
- RStudio is an integrated development environment (IDE) for coding in R.
 - An IDE is a set of tools that helps you code.
- We use RStudio to write our R codes.

R packages

- R packages are the fundamental units of reproducible R code.
- They can include functions, data, or both, along with documentation.
- Think of them as plug-ins that enhance the functionality of existing software.
- For example, web browser extensions like ad blockers add additional features that the original browser doesn't have.

Reproducible environment

- An environment is the system where a program is run, including hardware and software such as operating system dependencies, programming language, packages, their configuration, and versions.
- Just as running 1000 meters affects individuals differently, running code on different computers or with different package versions can produce varied results.
- A reproducible environment ensures that everyone gets the same result by keeping the environment consistent.

renv package



- renv is an R package that helps create reproducible environments for R projects.
- It records the R version and all R packages along with their versions in a lockfile.
 - A lockfile is a text file that stores all the environment information.

Code hosting and Github

- Code hosting involves storing code online to facilitate sharing, management, and collaboration with others.
 - One of the most popular code hosting platforms is GitHub (owned by Microsoft).
 - Both the textbook and the companion R package used in this course are hosted on GitHub.
 - GitHub is like a cloud drive (similar to OneDrive or Dropbox) but specialized for storing code, including R scripts.

R Markdown vs. R

File	Edit	Code	View	Plots	Session	Build	Debug	Profile	Tools	Help	
N	ew File						>	R Scri	pt		Ctrl+Shift+N
N	ew Pro pen Fil	ject e				Ctr	·l+0	Quart Quart	o Docur o Preser	ment ntation	
0	pen Fil	e in Ne	w Colui	mn							
Re	eopen	with En	coding.					R Mar	kdown		
Re	ecent F	iles					>	R Not	ebook		
0	pen Pr pen Pr	oject oject in	New S	ession				Shiny Plumb	Web Ap oer API	эр	
Re	ecent P	rojects					>	C File			
In	nport [)ataset					>	C++F Heade	ile er File		
Sa	ave					Ct	rl+S				
Sa	ave As.							Marko	iown Fil	e	
Re	ename							HIML	File		
Sa	ave wit	h Encod	ling					CSS Fi	le		
Sa	ave All					Alt+Ct	rl+S	D3 Sci	ript File	2	
Re	ender l	Docume	nt		C	Ctrl+Shi	ft+K	Dutho	n Scrint		
P	ublish							Shell S	Script		
Pi	rint							SQL S Stan F	cript ile		
C	ose					Ctr	+W	Text F	ile		
C	lose Al	l			Ct	trl+Shift	+W	R Swe	ave		
C	lose Al	Except	Curren	it	Alt+Ct	trl+Shift	+W	R HTN	/L		
C	lose Pr	oject						R Doc	umenta	tion	

- R Markdown is a file format that combines R code, its results, and accompanying text.
- It uses the file extension . Rmd and essentially is a plain text file integrating markdown and R.
- You can start by creating an Rmd file on the lab computer.

R Markdown syntax

```
(1)
 2 title: "Untitled"
   author: "Zehui Yin"
   output: html_document
 5
 6
                                                                                        (2)
   # Heading level 1
 7
   ## Heading level 2
8
   text...text...text
 9
   **bold** __bold___
10
   *italic* italic
11
12
  ```{r}
 (3)
13
 print("Hello world!)
14
15
```

**1** YAML header: stores settings or meta information

- ② Markdown text: contains plain text in markdown format.
- <sup>③</sup> **R code chunk**: contains R code to be executed

## **R** basics: arthmatic operations

You can start by trying out R on the lab computer. Later, we'll set it up on your personal computer.

R can be used as a calculator, using intuitive symbols for these operations:

1 <b>1</b> + 5	
[1] 6	
1 8 - 3	
[1] 5	
1 3 * 4	
[1] 12	
1 9 / 3	
[1] 3	

# R basics: assigning values

One of the cornerstones of programming languages is assignment. You can assign a value/object to a name using <-(suggested R style) or = ("Python" style).

1 a <- 1	
2 b <- 3 3 a + b	3
[1] 4	
1 c = 7	
2 d = 5	
3 c * d	

[1] 35

## **R** basics: built-in functions

R comes with many built-in functions. The calling syntax is function(parameter1, parameter2, ...). Additionally, with extra R packages, there are even more functions you can use.

```
1 values <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
```

```
2 sum(values)
```

[1] 55

```
1 mean(values)
```

[1] 5.5

- 1 library(MASS)
- 2 # integrate the sin function from 0 to pi.

```
3 area(sin, 0, pi)
```

[1] 2

## **R** basics: indexing

Indexing is the process of selecting specific values from an object based on their index location. Whenever you see [] or \$ in R, some form of indexing is happening.

1 v <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

	1	2	3	4	5	6	7	8	9	10
--	---	---	---	---	---	---	---	---	---	----

1 v[2]

[1] 2

1 v[2:4]

[1] 2 3 4

1 v[c(TRUE, T, T, T, T, TRUE, 2 FALSE, F, FALSE, F)]

[1] 1 2 3 4 5 6

## **R** basics: indexing

<pre>1 df &lt;- data.frame(col1 =</pre>	c(1, 2, 3),	
2 col2 =	c(4, 5, 6))	
	col1	
	COLL	COIZ
	1	Δ
	<b>⊥</b>	Т
	2	5
		•
	3	6
1 df[1, 2]		
[1] 4		
1 df[, "col2"]		
[1] 4 5 6		
1 df\$col1		
[1] 1 2 3		

## R basics: flow control

Flow control is an important component of any programming language. In R, the if-else statement and loops work as follows:

```
1 x <- 6
2 if (x > 5) {
3 print("Greater than 5")
4 } else {
5 print("Less or equal to 5")
6 }
```

[1] "Greater than 5"

```
1 for (i in 1:3) {
2 print(i)
3 }
```

[1] 1

[1] 2

[1] 3

## **R** basics: custom functions

To define your own function in R, you can use the following syntax. Note that the last line of code is automatically returned by R, though a "Python" style return statement is also valid in R.

```
1 add <- function(a, b) {
2 a + b
3 }
4
5 add(1, 4)</pre>
```

#### [1] 5

[1] 5

```
1 add <- function(a, b) {
2 return(a + b)
3 }
4
5 add(1, 4)</pre>
```

## **Download R version 4.4.2**

## mirror.csclub.uwaterloo.ca/CRAN



CRAN Mirrors What's new? Search CRAN Team

About R <u>R Homepage</u> <u>The R Journal</u>

Software <u>R Sources</u> <u>R Binaries</u> <u>Packages</u> <u>Task Views</u> <u>Other</u>

Documentation Manuals FAQs Contributed

Donations Donate The Comprehensive R Archive Network

Download and Install R

Precompiled binary distributions of the base system and contributed packages, Windows and Mac users most likely want one of these versions of R:

- Download R for Linux (Debian, Fedora/Redhat, Ubuntu)
- Download R for macOS
- <u>Download R for Windows</u>

R is part of many Linux distributions, you should check with your Linux package management system in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- The latest release (2024-10-31, Pile of Leaves) R-4.4.2.tar.gz, read what's new in the latest version.
- The CRAN directory <u>src/base-prerelease</u> contains R alpha, beta, and rc releases as daily snapshots in time periods before a planned release.
- Between releases, the same directory <u>src/base-prerelease</u> contains snapshots of current patched and development versions.

Please read about new features and bug fixes before filing corresponding feature requests or bug reports.

- · Alternatively, daily snapshots are available here.
- Source code of older versions of R is available here.
- · Contributed extension packages.

## **Download RStudio**

## posit.co/download/rstudio-desktop

posit products v open source v use cases v partners v learn & support v about v

DOWNLOAD

#### RStudio Desktop

Used by millions of people weekly, the RStudio integrated development environment (IDE) is a set of tools built to help you be more productive with R and Python.

Don't want to download or install anything? Get started with RStudio on <u>Posit Cloud for free</u>. If you're a professional data scientist looking to download RStudio and also need common enterprise features, don't hesitate to <u>book a call with us</u>.

Want to learn about core or advanced workflows in RStudio? Explore the <u>RStudio User Guide</u> or the <u>Getting Started</u> section.

#### 1: Install R

RStudio requires R 3.6.0+. Choose a version of R that matches your computer's operating system.

*R* is not a Posit product. By clicking on the link below to download and install *R*, you are leaving the Posit website. Posit disclaims any obligations and all liability with respect to *R* and the *R* website.

#### 2: Install RStudio

DOWNLOAD RSTUDIO DESKTOP FOR WINDOWS

Size: 265.27 MB | <u>SHA-256: SEFCD188</u> | Version: 2024.12.0+467 | Released: 2024-12-16

#### DOWNLOAD AND INSTALL R

2025 Zehui Yin

Q

# **Restoring the environment**

Download the Applied-Spatial-Statistics zip file from Avenue and unzip it. You should then have a folder with the following structure:

Applied-Spatial-Statistics/

- renv/
- --- .gitignore
- --- .Rprofile
- Applied-Spatial-Statistics.Rproj
- ---- README.Rmd
- renv.lock
- Double-click the Applied-Spatial-Statistics.Rproj file to open the R project.

## **RTools 4.4 for Windows users**

## mirror.csclub.uwaterloo.ca/CRAN/bin/windows/Rtools

RTools: Toolchains for building R and R packages from source on Windows

Choose your version of Rtools:

<u>RTools 4.4</u>	for R versions from 4.4.0 (R-release and R-devel)
RTools 4.3	for R versions 4.3.x (R-oldrelease)
<u>RTools 4.2</u>	for R versions 4.2.x
<u>RTools 4.0</u>	for R from version 4.0.0 to 4.1.3
old versions of RTools	for R versions prior to 4.0.0

- Ensure you download the Rtools version that matches your installed R version.
- Rtools is a set of programs required on **Windows** to build R packages from source.
- Note: If you are using Mac or Linux, Rtools is **not** required.

## **Xcode and GNU Fortran for Mac users**

### mac.r-project.org/tools

#### Tools

#### Mandatory tools

In order to compile R for macOS, you will need the following tools:

• Xcode developer tools from Apple Xcode can be obtained from Apple AppStore and the Xcode developer page. Older versions are available in the "more" section of the Developer pages (Apple developer account necessary). On modern macOS versions you can simply use

sudo xcode-select --install

which installs Xcode command line tools which are sufficient to build R (however, if you want to also build the R.app GUI you do need the full Xcode installation).

#### GNU Fortran compiler

R and some contributed package require a FORTRAN compiler. Unfortunately Xcode doesn't contain a Fortran compiler, therefore you will have to install one. R 4.3.0 and higher uses universal GNU Fortran 12.2 compiler. You can download an installer package gfortran-12.2-universal.pkg (242MB) - for more details and other download options see R-macos GNU Fortran releases on GitHub.

*NOTE*: In order to retain compatibility with native R we recommend using above tools. Although it is possible to compile R using tools from other package managers such as Homebrew, MacPorts or Fink, such binaries are by definition incompatible with macOS native libraries and applications. If you choose one of those package managers, make sure you compile *everything* using those tools including R and all packages and libraries you intend to use.

Additional information on the **OpenMP page** is available for those interested in OpenMP support which is not supported by Apple, but still possible with additional libraries.

• In order to compile R for macOS, you will need **both** Xcode and GNU Fortran compiler.

2025 Zehui Yin

## Homebrew and GDAL for Mac users

Next, use macOS Terminal to install Homebrew, and subsequently, GDAL.

brew.sh

formulae.brew.sh/formula/gdal



## **Restoring the environment**

Environment	History	Connections	Tutorial	_	I
😭 🔒 🖙	Import Data	set 👻 🚺 140	≣ List ◄ 🕲	•	
R 🔹 🛑 Glot	Q,				

Environment is empty

			RestoreLibr	ary			
Plots Packag	ges Help Viewer Presenta	ation	The follow	ing changes will be made	e to the project library.		
tall 💿 Update	e 📕 renv 👻	Q,	Package	Library Version	Lockfile Version	Action	
lame	D Introduction to renv	Version Lockfile Sour	abind	[Not installed]	1.4-8	Install 'abind' [1.4-8]	
t Library			AsioHead	lers [Not installed]	1.22.1-2	Install 'AsioHeaders' [1.22.1-2]	
bind	N Snapshot Library	1.4-8	askpass	[Not installed]	1.2.1	Install 'askpass' [1.2.1]	
sioHeaders	N Restore Library	1.22.1-2	backports	s [Not installed]	1.5.0	Install 'backports' [1.5.0]	
skpass	Not installed	1.2.1	base64en	c [Not installed]	0.1-3	Install 'base64enc' [0.1-3]	
ackports	Not installed	1.5.0	BH	[Not installed]	1.87.0-1	Install 'BH' [1.87.0-1]	
ase64enc	Not installed	0.1-3	bit	[Not installed]	4.5.0.1	Install 'bit' [4.5.0.1]	
H	Not installed	1.87.0-1	bit64	[Not installed]	4.5.2	Install 'bit64' [4.5.2]	
oit	Not installed	4.5.0.1	blob	[Not installed]	1.2.4	Install 'blob' [1.2.4]	
oit64	Not installed	4.5.2	bookdow	n [Not installed]	0.41	Install 'bookdown' [0.41]	
lob	Not installed	1.2.4	boot	1.3-29	1.3-31	Upgrade 'boot' [1.3-29 -> 1.3-31]	
ookdown	Not installed	0.41	broom	[Not installed]	1.0.7	Install 'broom' [1.0.7]	
proom	Not installed	1.0.7	bslib	[Not installed]	0.8.0	Install 'bslib' [0.8.0]	
slib	Not installed	0.8.0	ca	[Not installed]	0.71.1	Install 'ca' [0.71.1]	
a	Not installed	0.71.1	cachem	[Not installed]	1.1.0	Install 'cachem' [1.1.0]	
achem	Not installed	1.1.0	callr	[Not installed]	3.7.6	Install 'callr' [3.7.6]	
allr	Not installed	3.7.6	cartogran	n [Not installed]	0.3.0	Install 'cartogram' [0.3.0]	
artogram	Not installed	0.3.0	cellrange	r [Not installed]	1.1.0	Install 'cellranger' [1.1.0]	
ellranger	Not installed	1.1.0	checkmat	e [Not installed]	2.3.2	Install 'checkmate' [2.3.2]	
heckmate	Not installed	2.3.2	chromote	e [Not installed]	0.3.1	Install 'chromote' [0.3.1]	
hromote	Not installed	0.3.1	class	7.3-22	7.3-23	Upgrade 'class' [7.3-22 -> 7.3-23]	
lassInt	Not installed	0.4-10	classInt	[Not installed]	0.4-10	Install 'classInt' [0.4-10]	-
li	Not installed	3.6.3					
lipr	Not installed	0.8.0				Restore	Cancel

- Navigate to the bottom right panel.
- Click the Packages tab, then the renv button, and finally select the Restore Library Option.
- Click the Restore button in the pop-up panel.

# Install $LAT_E X$

 $L\!\!\!\!AT_E\!X$  is a high-quality typesetting system. While it may seem as a language, understanding it isn't necessary for our purposes. We will use it to export Rmd files with results into PDF files.

If you already use  $LAT_EX$  and have it installed through MiKTeX or TeX Live, you can skip this step.

1 tinytex::install\_tinytex()

## Lab slides



- You can access all the lab slides by scanning the QR code or by visiting the URL directly.
- zehuiyin.github.io/ENVSOCTY4GA3

## References

- https://r-pkgs.org/
- https://book.the-turing-way.org/reproducibleresearch/renv.html
- https://rstudio.github.io/renv/articles/renv.html