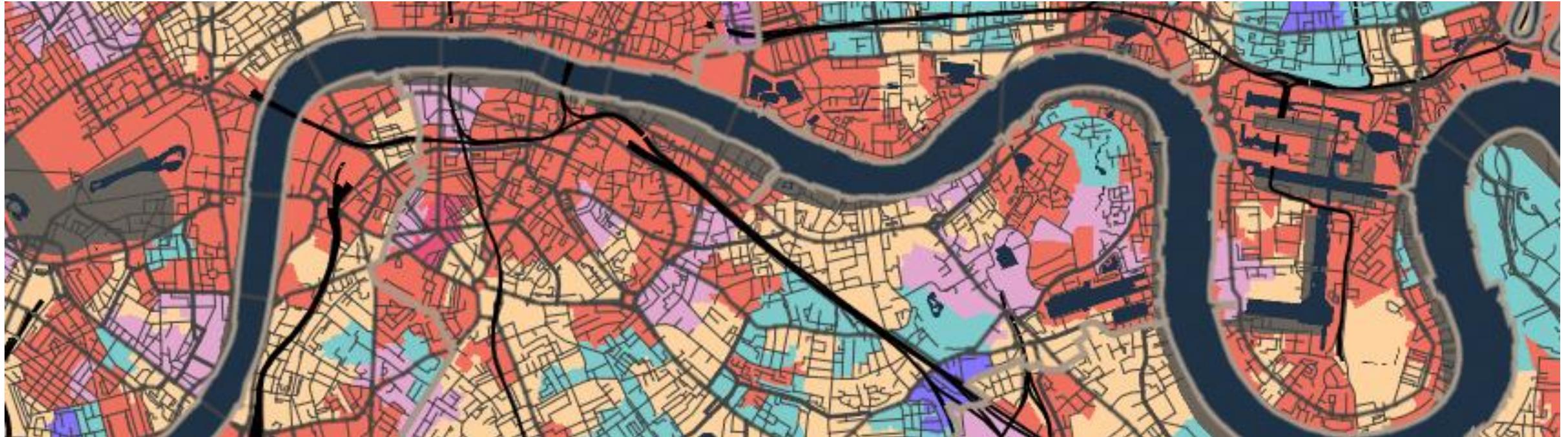


# SA-TIED Geospatial Analysis Workshop

## Overview



 Dr Justin van Dijk  
 j.t.vandijk@ucl.ac.uk



# Objectives

We will explore the following topics:

- Fundamentals of using R for data analysis.
- Creating thematic maps using R.
- Quantifying the degree of spatial dependence in a dataset.
- Incorporating space into statistical models.

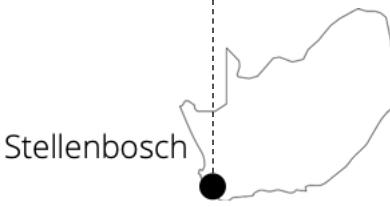
# Schedule

Day 1 - Morning	R for Data Analysis
Day 1 - Afternoon	R for Spatial Analysis
Day 2 - Morning	Spatial Autocorrelation
Day 2 - Afternoon	Spatial Models

# Background



B.Sc. Human Geography and Planning  
M.Sc.. Human Geography and Planning



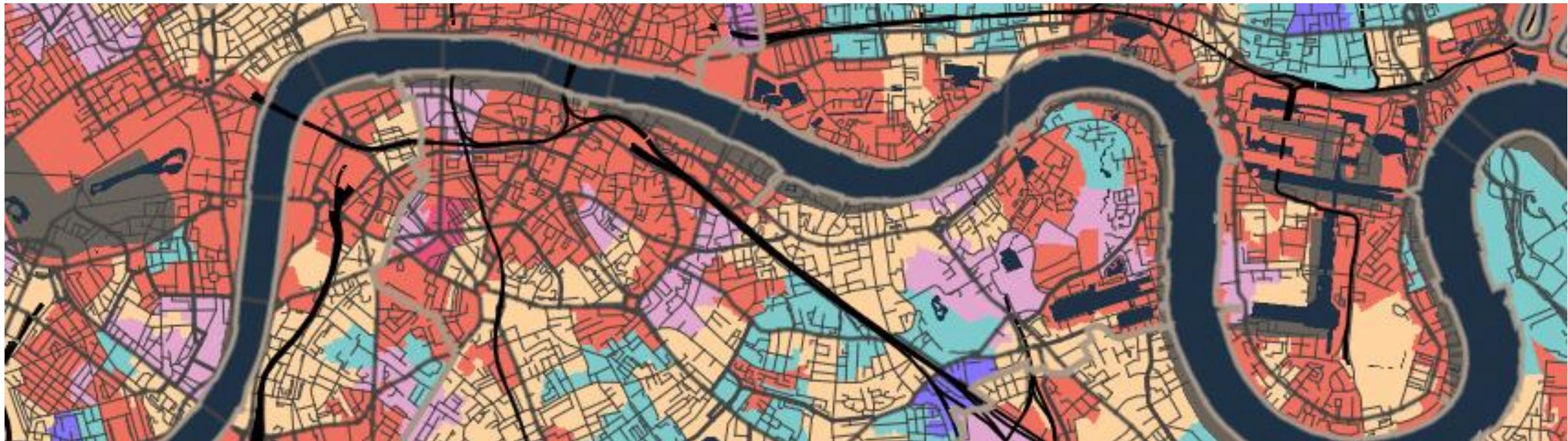
Ph.D. Transport Economics



Lecturer in Social and Geographic  
Data Science

# SA-TIED Geospatial Analysis Workshop

## S01 – R for Data Analysis



# This session

- What is a programming language?
- A gentle introduction to working with R.
- Why use R for data analysis?

# Programming languages

- Consist of a formal set of instructions that you can use to write software or perform computational tasks.
- Require users to write code, which involves typing commands in a text-based environment.
- Are highly flexible and powerful, allowing for custom solutions, automation, and complex operations.

# Programming languages

- Identifiers and primitive data types
- Assignment, arithmetic, logical and relational operators
- Expression and statements, debugging
- Flow of control: selection and repetition
- Functions, parameters passing, call by value and reference
- Object-oriented programming
- 1/2 dimensional arrays, strings and data structures

# Programming languages

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# Programming languages

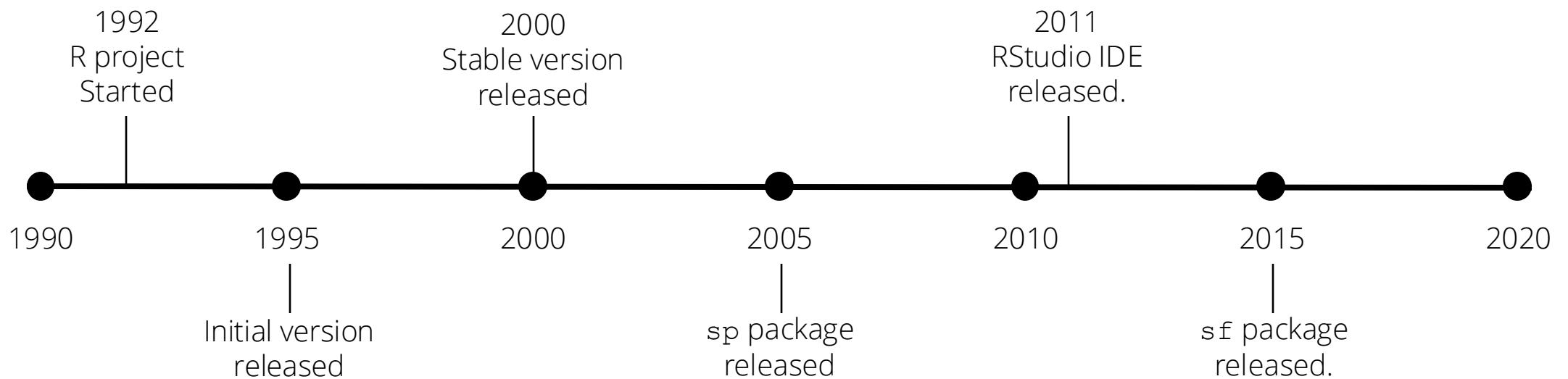
- Ιδεντιφιερς ανδ πριμιτι~~fe~~ δατα τψπες
- Ασσιγνμεντ, αριτημετιξ, λογιξαλ ανδ ρελατιοναλ οπερατορς
- Εχπρεσσιον ανδ στατεμεντς, δεβυγγινγ
- Φλω~~o~~ οφ ξοντρολ· σελεξτιον ανδ ρεπετιτιον
- Φυνξτιονς, παραμετερς πασσινγ, ξαλλ βψ α~~f~~λυε ανδ ρεφερενξε
- Οβσεξτ-οριεντεδ προγραμμινγ
- 1/2 διμενσιοναλ αρραψς, στρινγς ανδ δατα στρυξτυρες

# The absolute basics

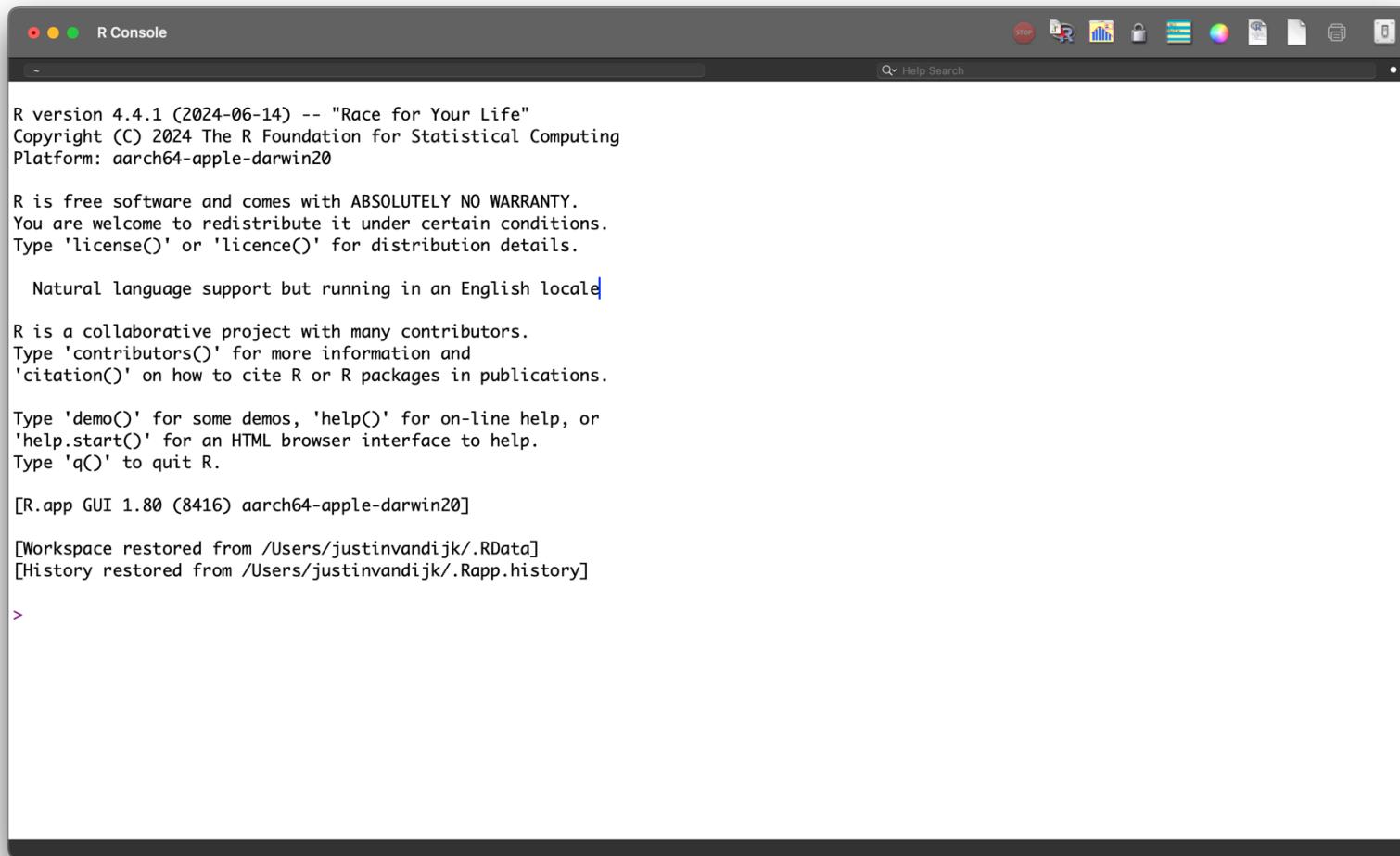
- R is primarily used through interactive command-line interfaces and scripts.
- R is the programming language, but we can interact with it using other software.
- R efficiently handles various data types, particularly vectors and tables.
- R's functionality can be extended through a vast ecosystem of packages.
- R is free and open source.

# A little history

- R is programming language originally developed for statistical purposes.
- 1975: Bell Labs develops a language for Statistical Analysis ("S").
- 1992: Ross Ihaka and Robert Gentleman develop opensource version of "S".



# Working with R



R version 4.4.1 (2024-06-14) -- "Race for Your Life"  
Copyright (C) 2024 The R Foundation for Statistical Computing  
Platform: aarch64-apple-darwin20

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.

Natural language support but running in an English locale

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.

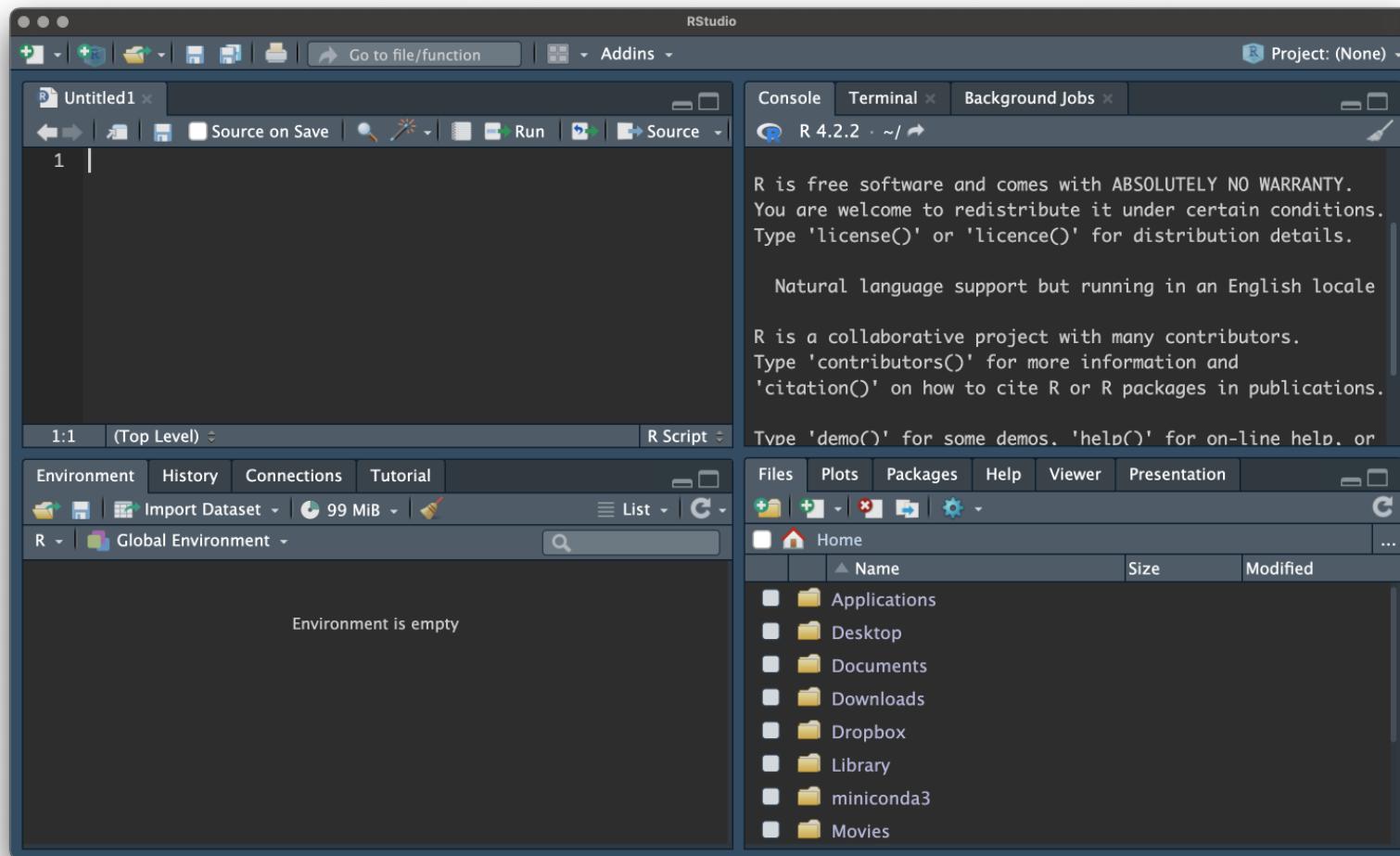
Type 'demo()' for some demos, 'help()' for on-line help, or  
'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.

[R.app GUI 1.80 (8416) aarch64-apple-darwin20]

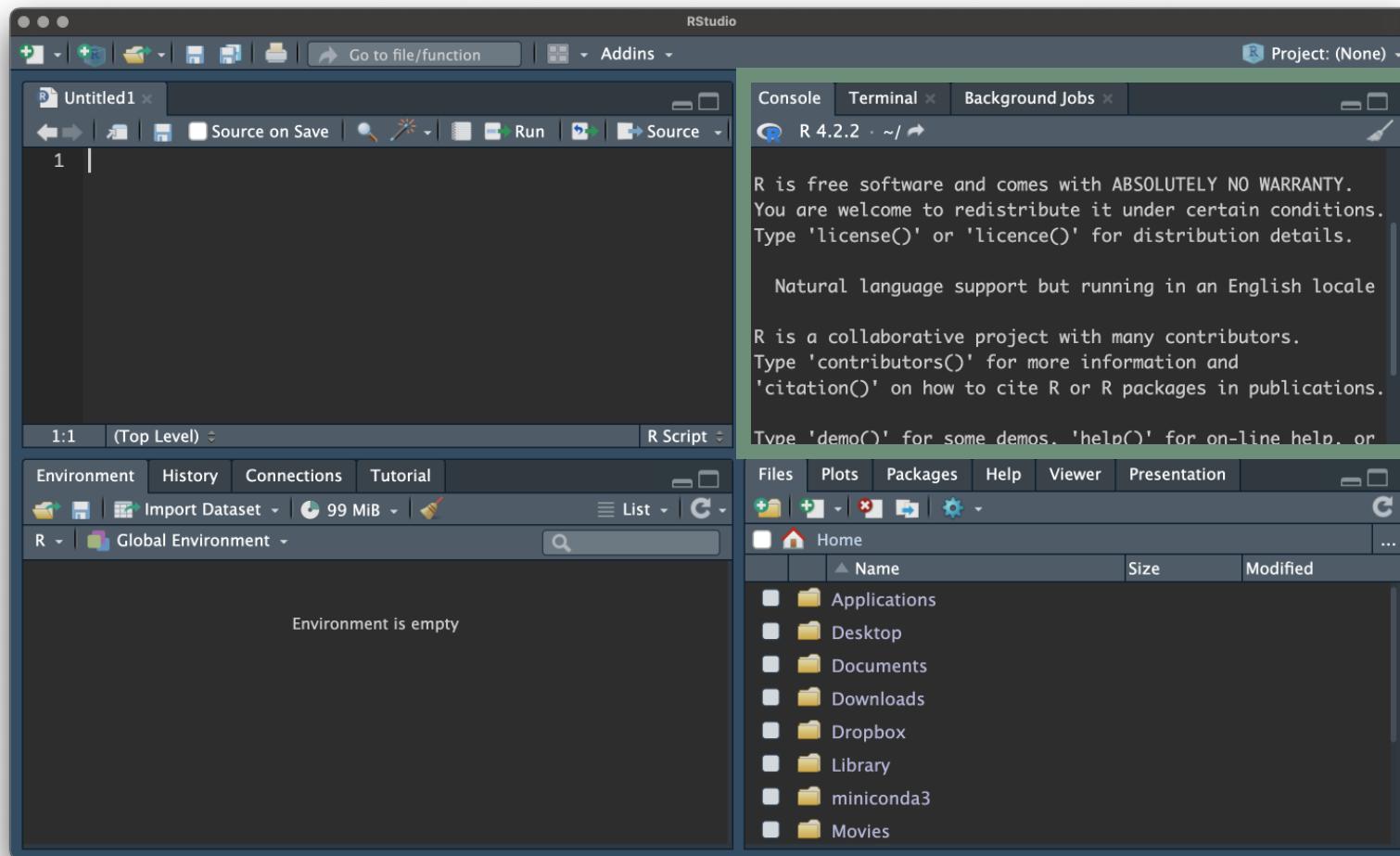
[Workspace restored from /Users/justinvandijk/.RData]  
[History restored from /Users/justinvandijk/.Rapp.history]

>

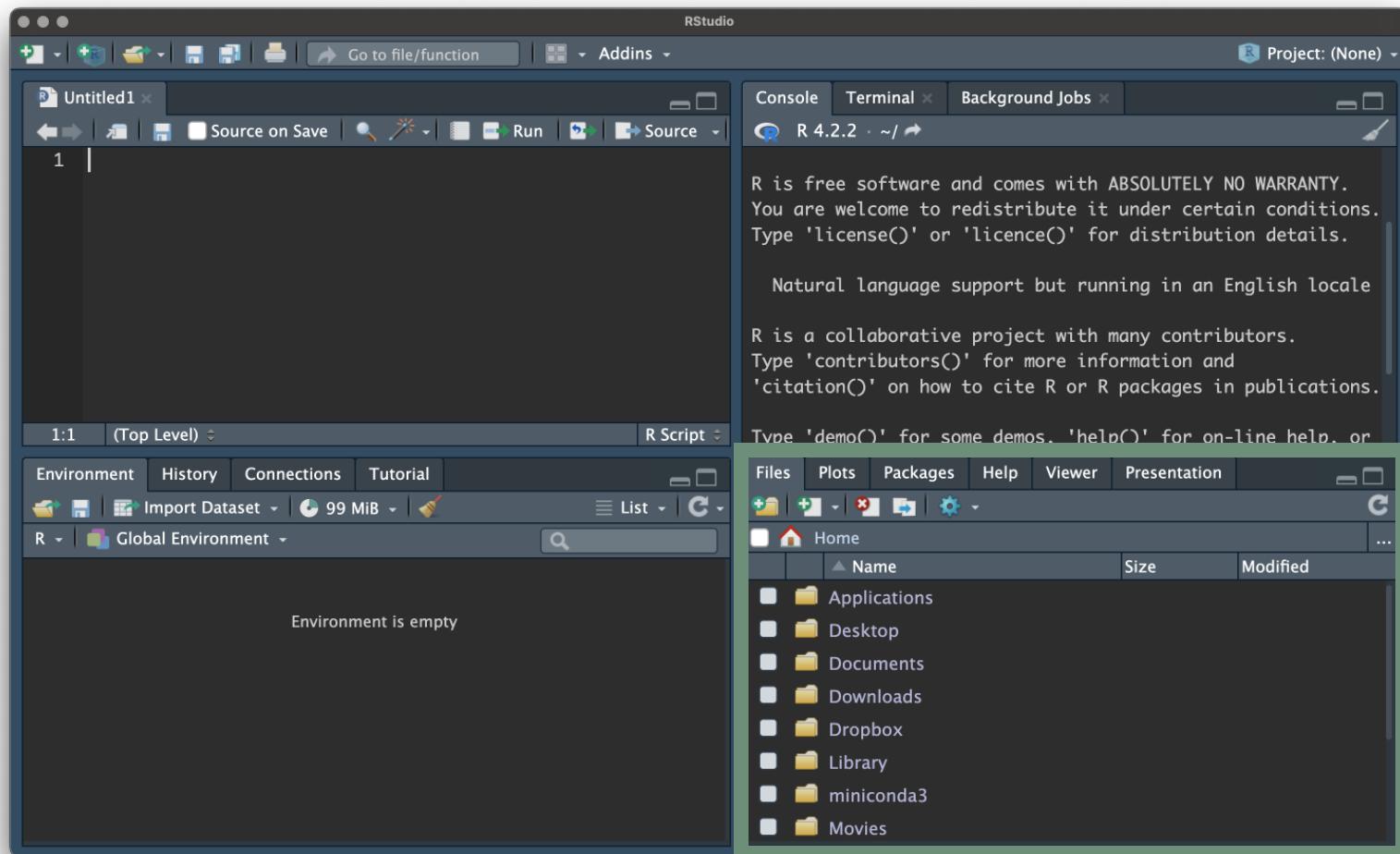
# Working with R



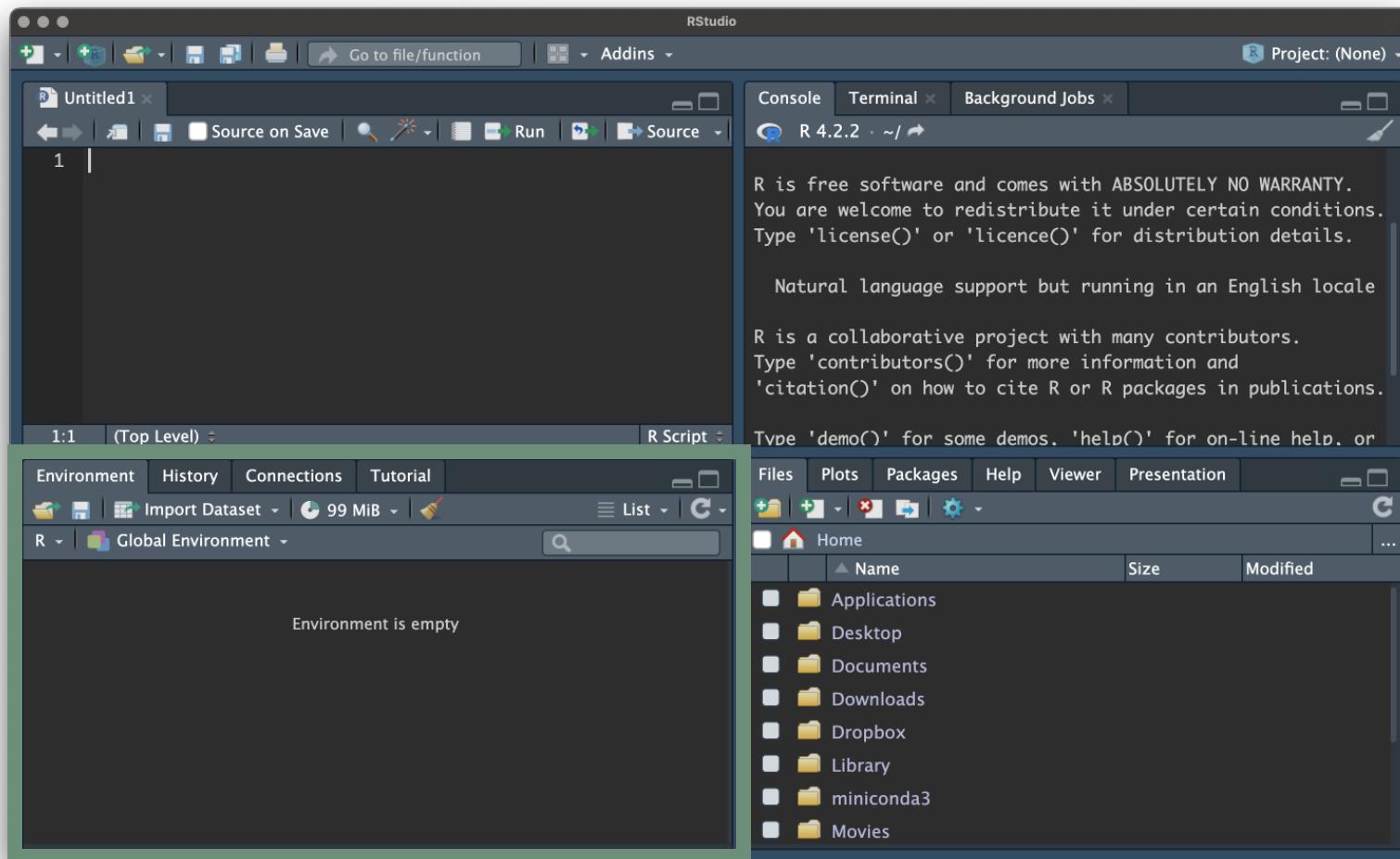
# Working with R



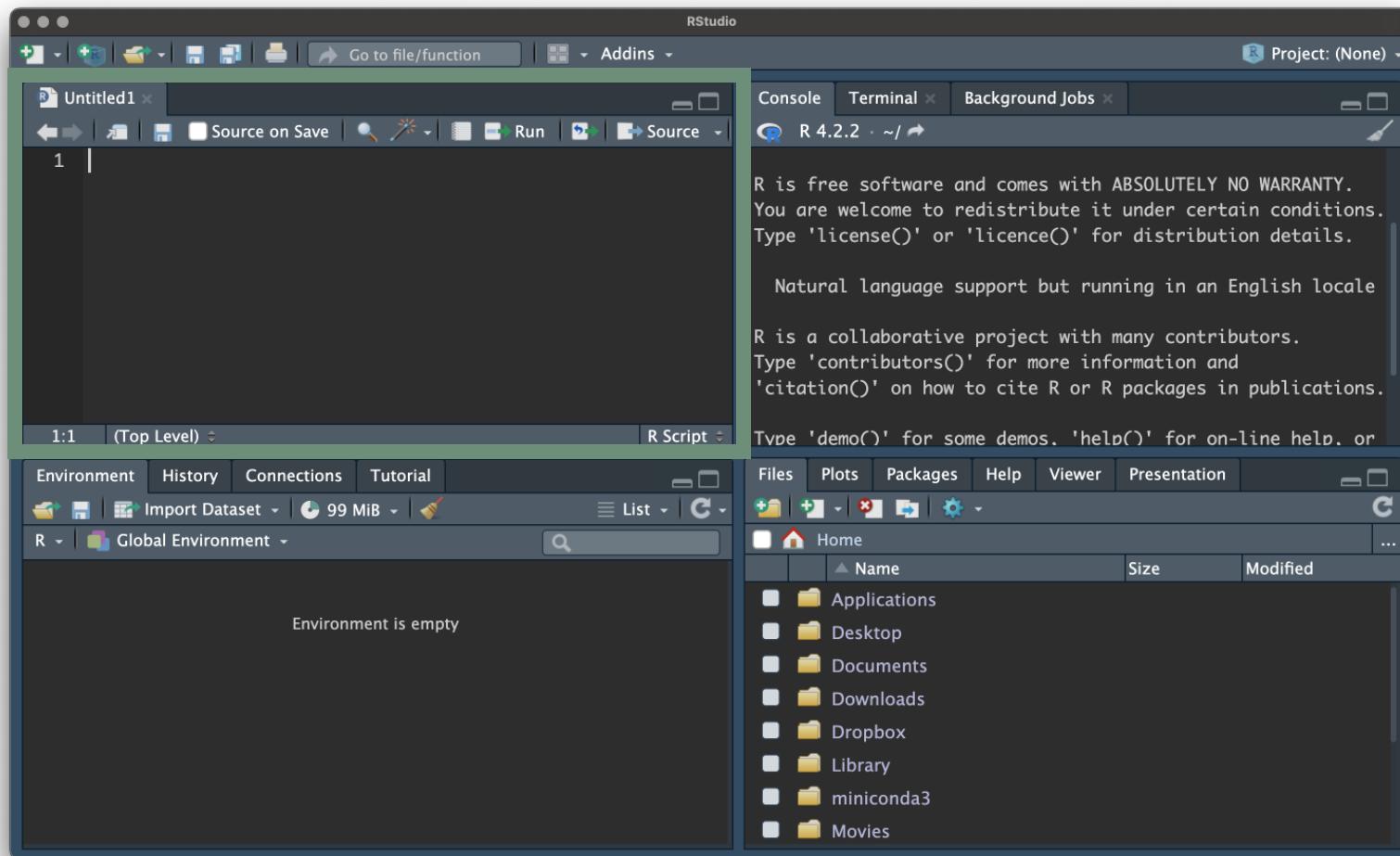
# Working with R



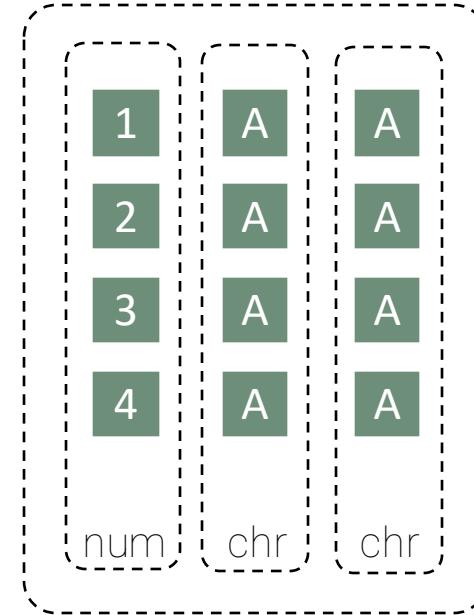
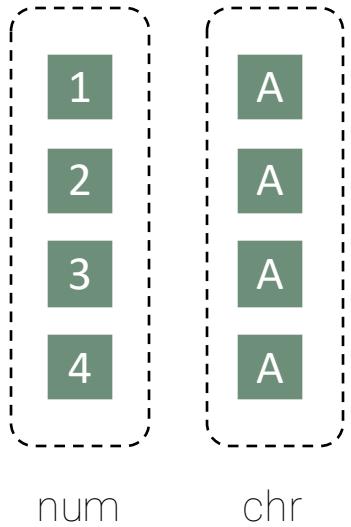
# Working with R



# Working with R



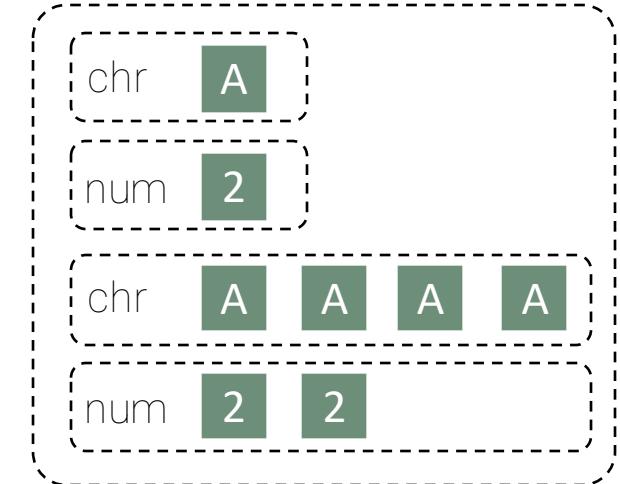
# Principles of R: Data types



Scalar

Vector

Dataframe



List

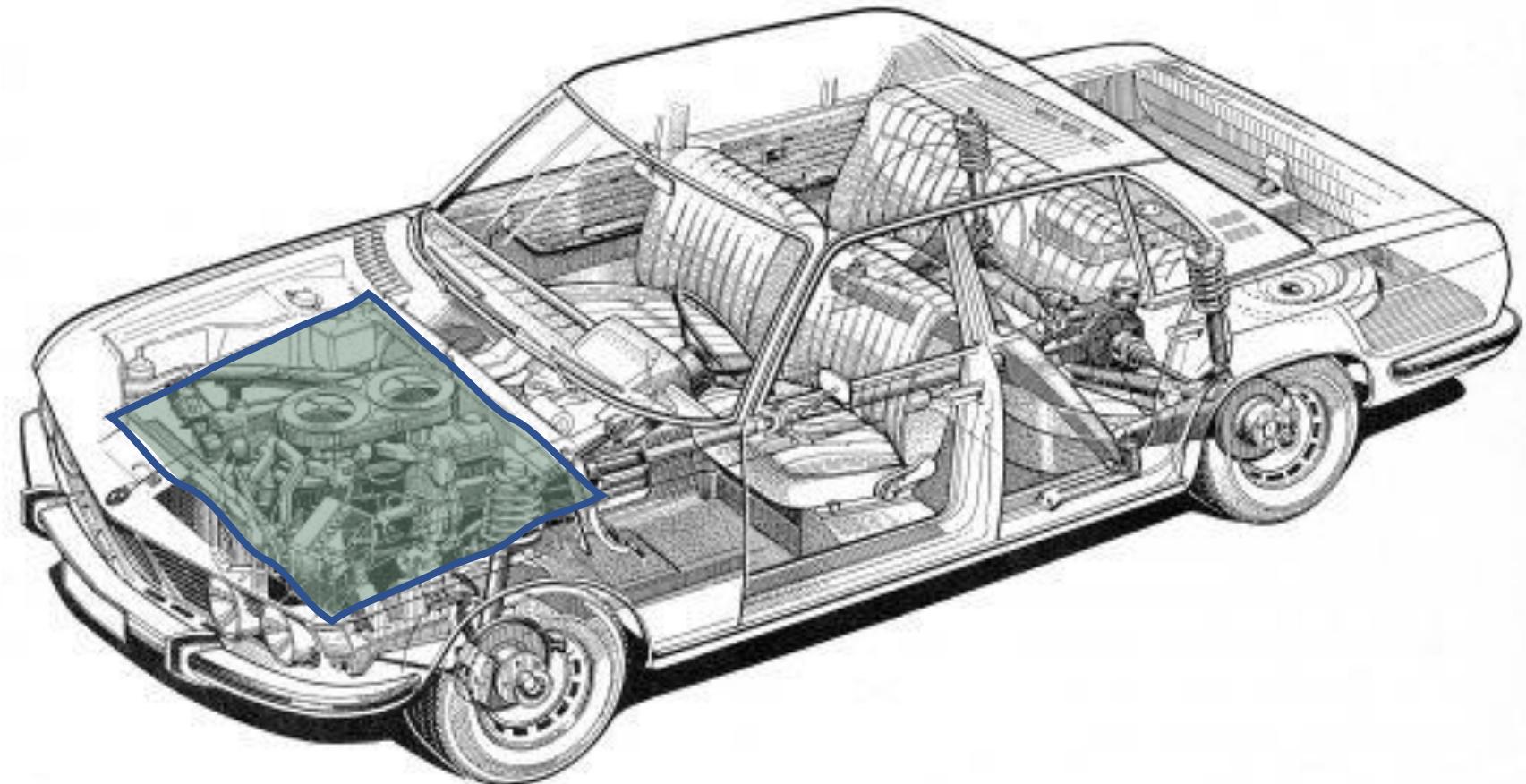
# Principles of R: Variables

- All scalars, vectors, tables, and lists can be assigned to a variable.
- Variables are used to store information to be referenced and manipulated in a computer programme.

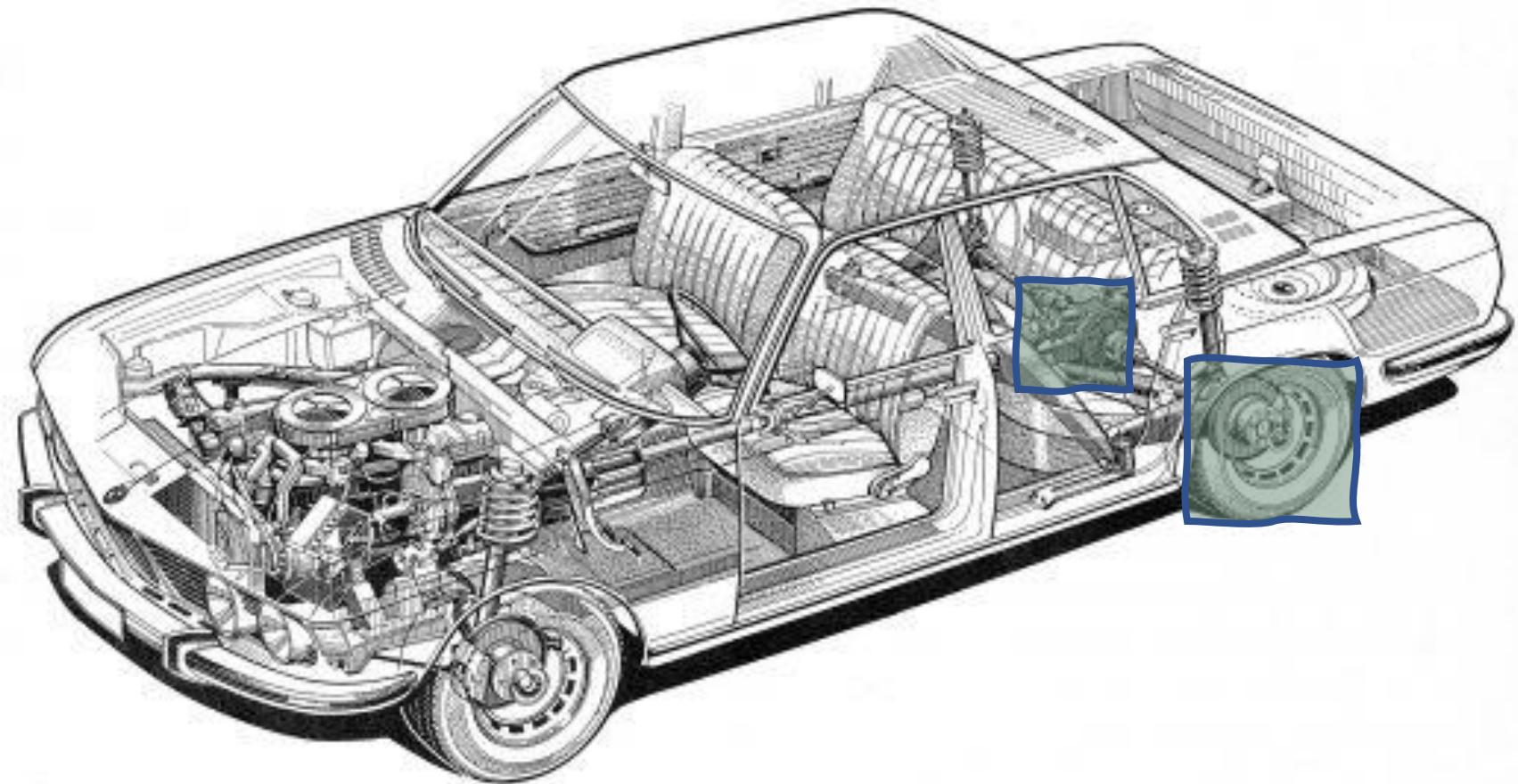
# Principles of R: Functions

- Variables can be used as an input for functions.
- Functions are pieces of code designed to accomplish specific tasks.
- Once a function is written, it can be reused.

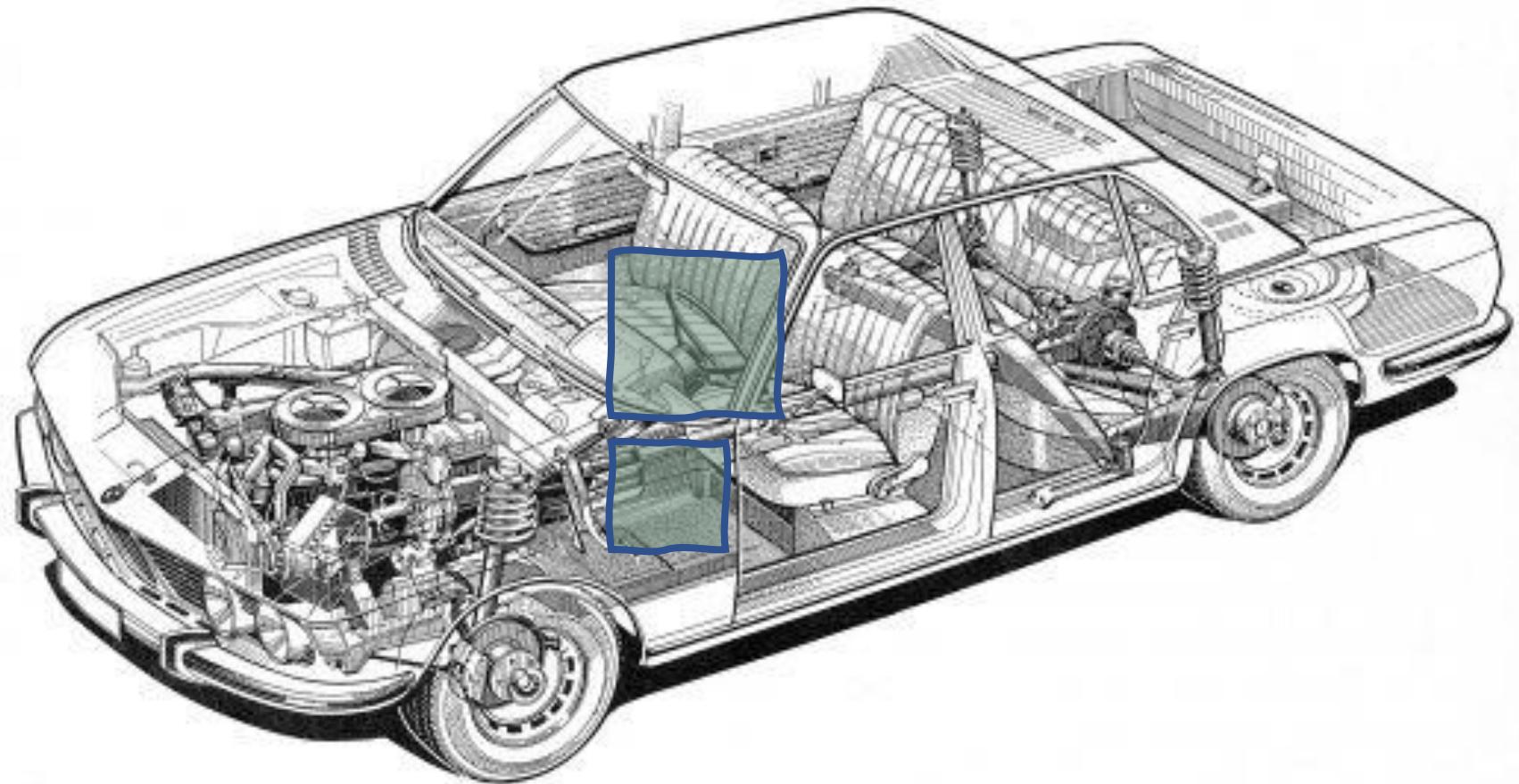
# Principles of R: Extensions



# Principles of R: Extensions



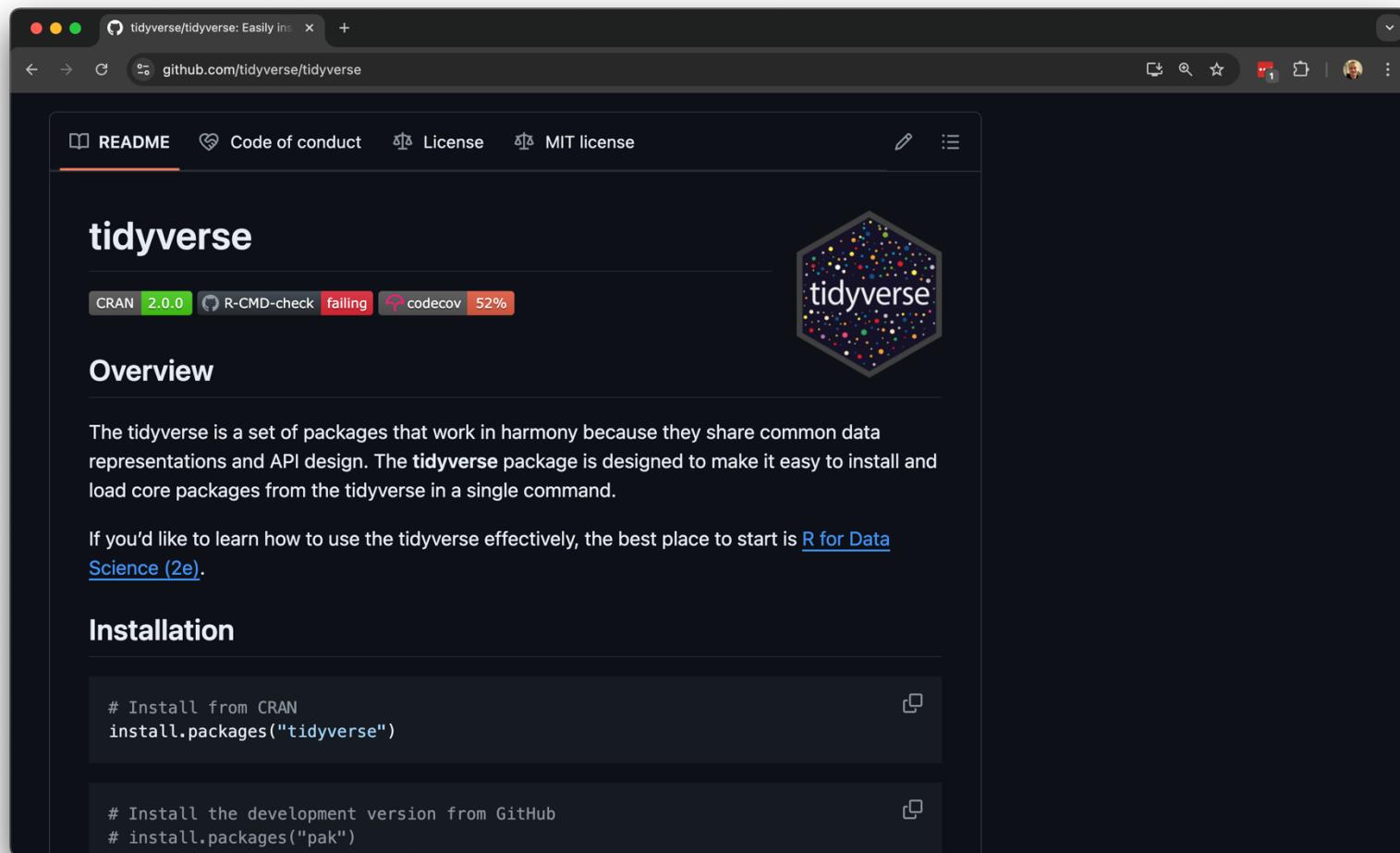
# Principles of R: Extensions



# Principles of R: Extensions

- Available on The Comprehensive R Archive Network: CRAN
- CRAN is a repository for R packages and software.
- Currently CRAN features over 21,140 available packages (22/08/2024).
- Allows developers to submit and maintain their own R packages.

# tidyverse



A screenshot of a web browser displaying the GitHub README page for the `tidyverse` repository. The page has a dark theme. At the top, there are navigation links for `README`, `Code of conduct`, `License`, and `MIT license`. Below these, the word `tidyverse` is displayed in large white letters. To the right is a hexagonal logo filled with small colored dots. Below the title, there are three status badges: CRAN 2.0.0 (green), R-CMD-check failing (red), and codecov 52% (orange). A section titled `Overview` contains text about the tidyverse being a set of packages that work in harmony. It also mentions the `tidyverse` package for installing core packages and provides a link to [R for Data Science \(2e\)](#). A section titled `Installation` shows two code snippets for installing the package from CRAN and GitHub respectively.

```
# Install from CRAN  
install.packages("tidyverse")
```

```
# Install the development version from GitHub  
# install.packages("pak")
```

# Simple Features

A screenshot of a web browser displaying the GitHub README page for the `r-spatial/sf` repository. The page title is "Simple Features for R".

The page content includes:

- A brief description: "A package that provides [simple features access](#) for R."
- Links to external resources: [Blogs](#), [links](#), [Cheatsheet](#), [Installing](#), [Contributing](#), [Acknowledgment](#), and [How to cite](#).
- A section titled "Package sf:" listing the package's features:
  - represents simple features as records in a `data.frame` or `tibble` with a geometry list-column
  - represents natively in R all 17 simple feature types for all dimensions (XY, XYZ, XYM, XYZM)
  - interfaces to [GEOS](#) for geometrical operations on projected coordinates, and (through R package [s2](#)) to [s2geometry](#) for geometrical operations on ellipsoidal coordinates
  - interfaces to [GDAL](#), supporting all driver options, `Date` and `POSIXct` and list-columns
  - interfaces to [PROJ](#) for coordinate reference system conversion and transformation
  - uses [well-known-binary](#) serialisations written in C++/Rcpp for fast I/O with GDAL and GEOS
  - reads from and writes to spatial databases such as [PostGIS](#) using [DBI](#)
  - is extended by
    - [lwgeom](#) for selected liblwgeom/PostGIS functions
    - [stars](#) for raster data, and raster or vector data cubes (spatial time series)

The page also features a logo consisting of the letters "sf" in blue, enclosed within a hexagonal grid pattern.

At the bottom of the page, there is a link to a gist: [network data](https://gist.github.com/edzer/f461a3a95570c4ab7edf3125c2f19d20).

# tmap

github.com/r-tmap/tmap

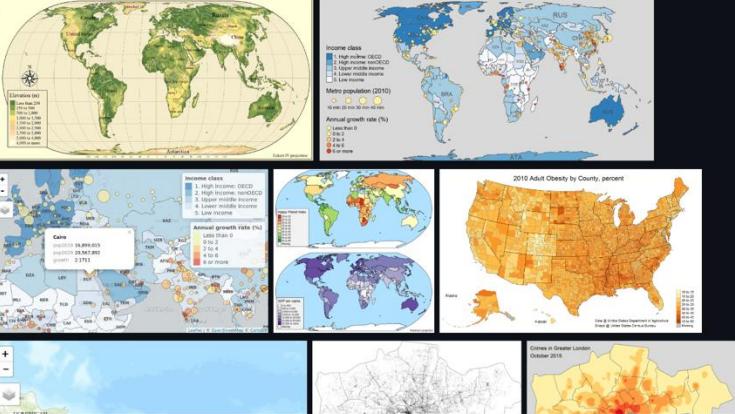
[README](#) [GPL-3.0 license](#)

## tmap: thematic maps in R

[R-CMD-check passing](#) [codecov 12%](#) [CRAN 3.3-4](#) [CRAN checks](#)  
[Downloads](#) [License GPL v3](#) [r-universe 3.99.9002](#)



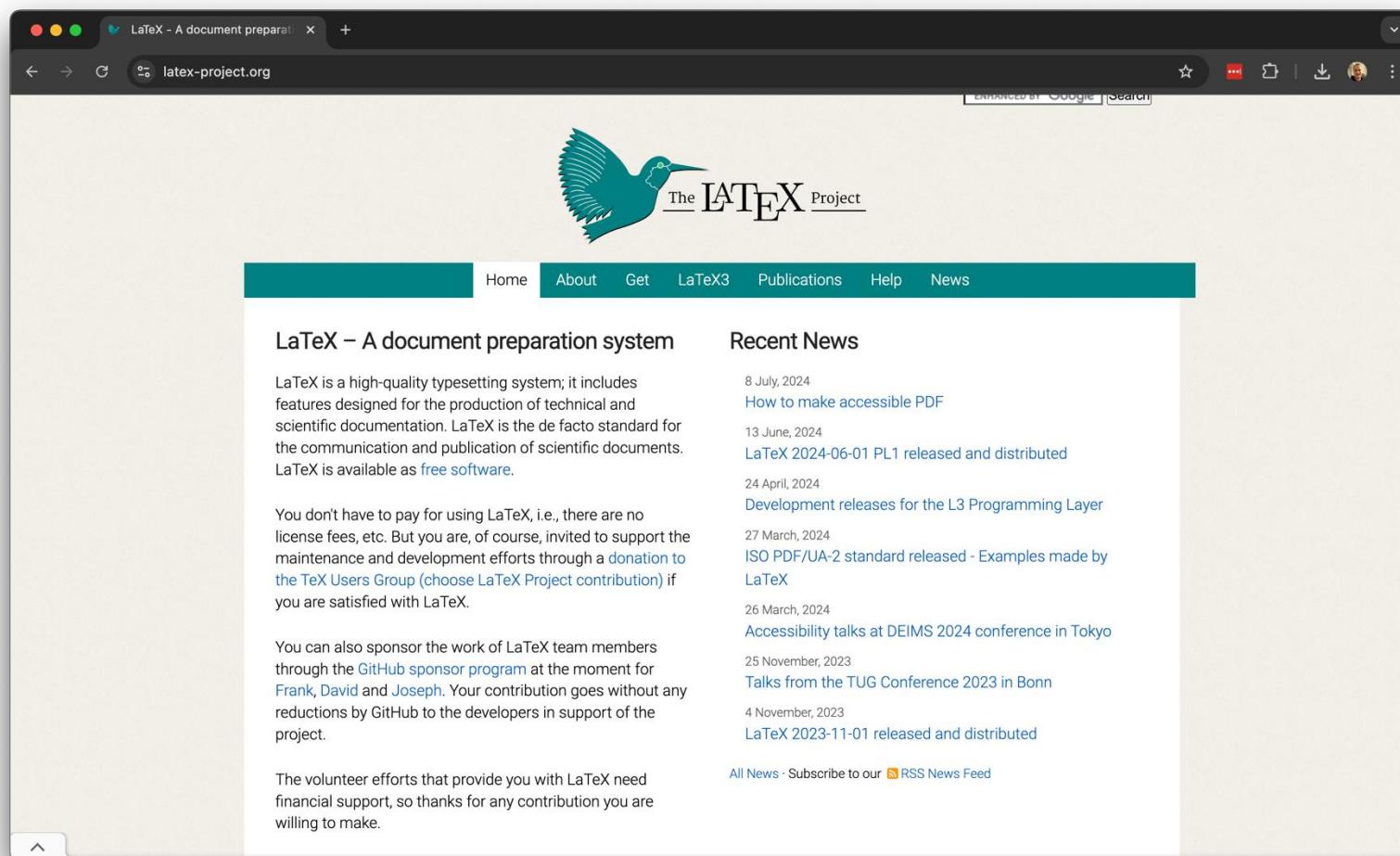
`tmap` is an actively maintained open-source R-library for drawing thematic maps. The API is based on [A Layered Grammar of Graphics](#) and resembles the syntax of [ggplot2](#), a popular R-library for drawing charts.



# Reproducibility with R Markdown

- Markdown is a lightweight **markup language** designed for creating formatted text using a plain-text editor. It allows you to write in a simple, readable format that can be easily converted to HTML, PDF, or other formats.
- R Markdown extends Markdown by integrating R code with the text. This allows you to: embed code, execute code, create dynamic reports, format and typeset your content.

# Reproducibility with R Markdown



The screenshot shows a web browser window displaying the LaTeX Project homepage at [latex-project.org](https://www.latex-project.org). The page features a large teal bird logo above the text "The LATEX Project". A navigation bar at the top includes links for Home, About, Get, LaTeX3, Publications, Help, and News. The main content area has two columns. The left column contains text about LaTeX's purpose, its availability as free software, and sponsorship options. The right column displays a "Recent News" section with several entries, each with a date, title, and a brief description.

**LaTeX – A document preparation system**

LaTeX is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation. LaTeX is the de facto standard for the communication and publication of scientific documents. LaTeX is available as [free software](#).

You don't have to pay for using LaTeX, i.e., there are no license fees, etc. But you are, of course, invited to support the maintenance and development efforts through a [donation to the TeX Users Group \(choose LaTeX Project contribution\)](#) if you are satisfied with LaTeX.

You can also sponsor the work of LaTeX team members through the [GitHub sponsor program](#) at the moment for [Frank](#), [David](#) and [Joseph](#). Your contribution goes without any reductions by GitHub to the developers in support of the project.

The volunteer efforts that provide you with LaTeX need financial support, so thanks for any contribution you are willing to make.

**Recent News**

8 July, 2024  
[How to make accessible PDF](#)

13 June, 2024  
[LaTeX 2024-06-01 PL1 released and distributed](#)

24 April, 2024  
[Development releases for the L3 Programming Layer](#)

27 March, 2024  
[ISO PDF/UA-2 standard released - Examples made by LaTeX](#)

26 March, 2024  
[Accessibility talks at DEIMS 2024 conference in Tokyo](#)

25 November, 2023  
[Talks from the TUG Conference 2023 in Bonn](#)

4 November, 2023  
[LaTeX 2023-11-01 released and distributed](#)

[All News](#) · [Subscribe to our RSS News Feed](#)

# Reproducibility with R Markdown

This is the basic model for Quarto publishing—take a source document and render it to a variety of output

The screenshot shows the Quarto RStudio extension interface. On the left, the RStudio sidebar displays navigation links: 'Get Started', 'Tutorial: Hello, Quarto', 'Tutorial: Computations', and 'Tutorial: Authoring'. The main RStudio area shows an R Markdown file named 'hello.qmd' with the following content:

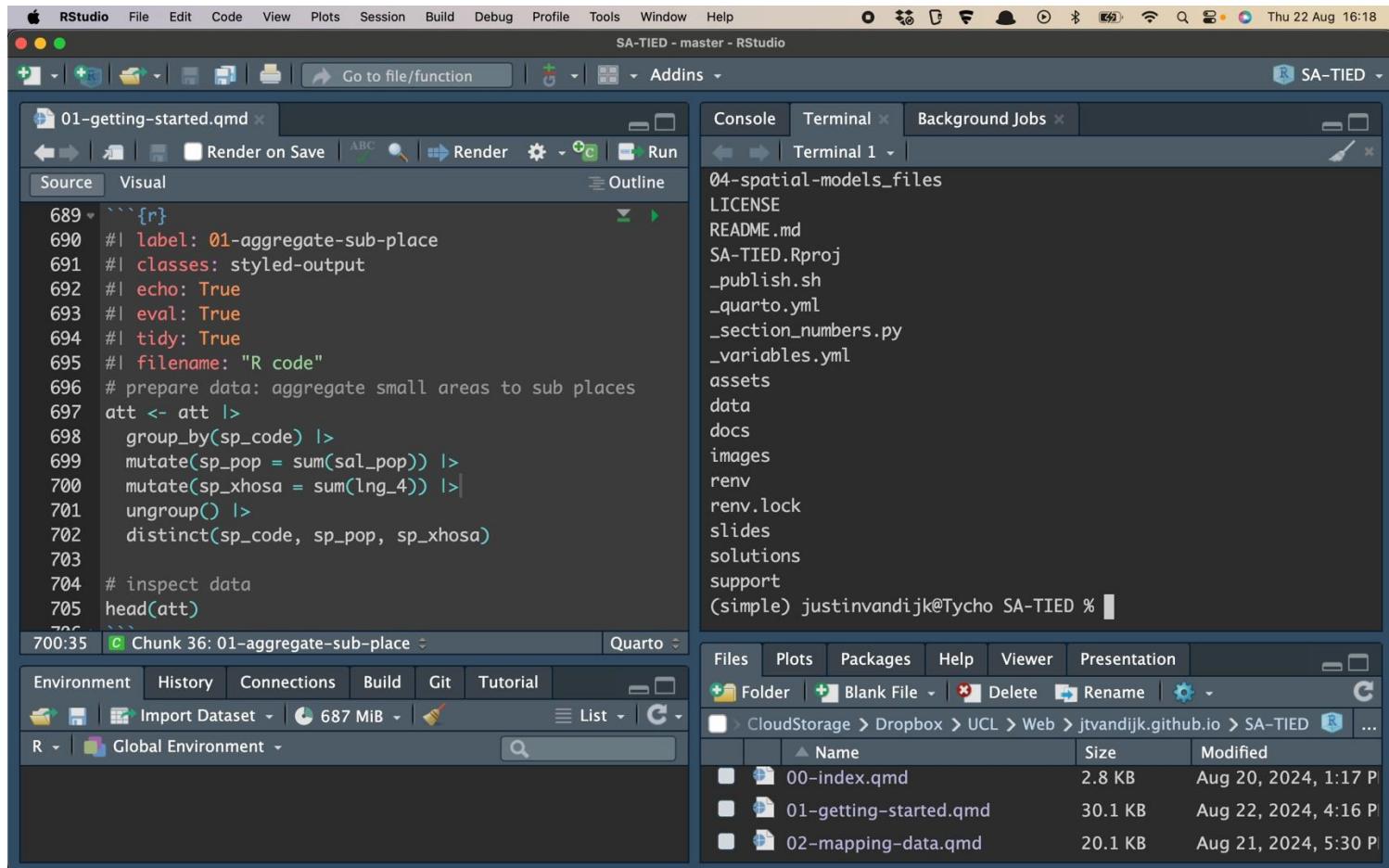
```
---
title: "Hello, Quarto"
format: html
editor: visual
---

{r}
#| label: load-packages
#| include: false

library(tidyverse)
library(palmerpenguins)
```

Below the code, there are two sections: 'Meet Quarto' and 'Meet the penguins'. The 'Meet Quarto' section contains text about Quarto's weaving capabilities and a link to <https://quarto.org>. The 'Meet the penguins' section contains text about the 'palmerpenguins' package and a plot titled 'Flipper and bill length Dimensions for penguins at Palmer Station LTER'. The plot shows the relationship between flipper length (mm) on the x-axis and bill depth (mm) on the y-axis, with data points colored by species: Adelie (orange), Chinstrap (purple), and Gentoo (teal). Three penguins are illustrated above the plot, labeled CHINSTRAP, GENTOO, and ADÉLIE.

# Reproducibility with R Markdown



# Reproducibility with R Markdown

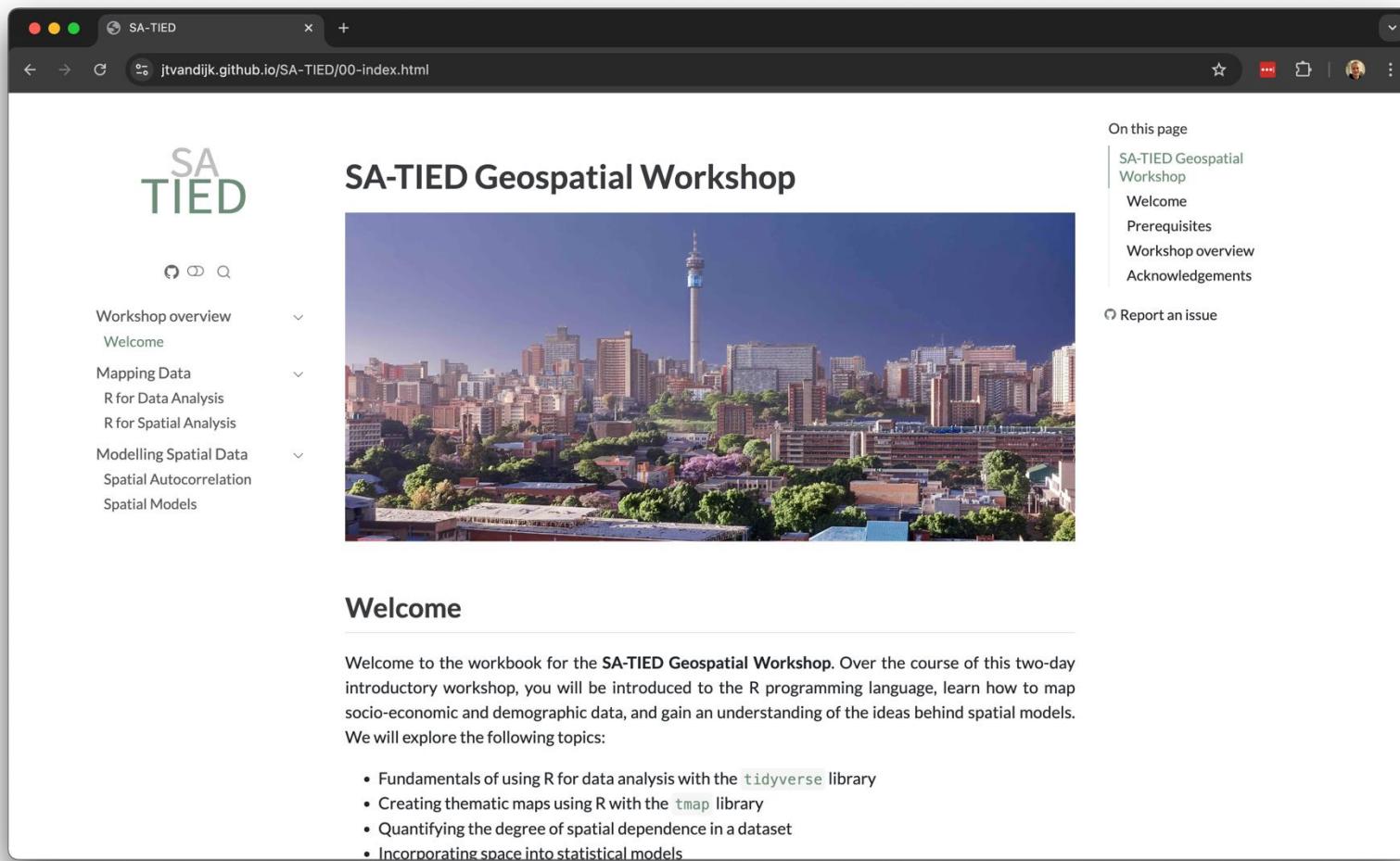
A screenshot of a GitHub repository page for "jtvdijk / SA-TIED". The repository is public and contains 1 branch and 0 tags. The "Code" tab is selected. A recent commit by "jtvdijk" titled "render workbook" is shown, along with a list of rendered files in the ".Rproj.user" folder. The repository has 51 commits in total. The "About" section describes the repository as generating a workbook for the SA-TIED Geospatial Workshop in Pretoria, with a link to <https://jtvdijk.github.io/SA-TIED/>. The "Releases" section indicates no releases have been published.

This GitHub repository generates the workbook for the SA-TIED Geospatial Workshop in Pretoria. The workbook can be found here:  
<https://jtvdijk.github.io/SA-TIED/>

No releases published

File	Action	Time
..Rproj.user	render workbook	6 minutes ago
00-index_cache/html	render workbook	6 minutes ago
01-getting-started_cache/html	render workbook	6 minutes ago
01-getting-started_files/figure-html	render workbook	6 minutes ago
02-mapping-data_cache/html	render workbook	6 minutes ago
02-mapping-data_files/figure-html	start session 03	2 days ago
03-spatial-autocorrelation_cache/ht...	render workbook	6 minutes ago
03-spatial-autocorrelation_files/figu...	render workbook	6 minutes ago

# Reproducibility with R Markdown



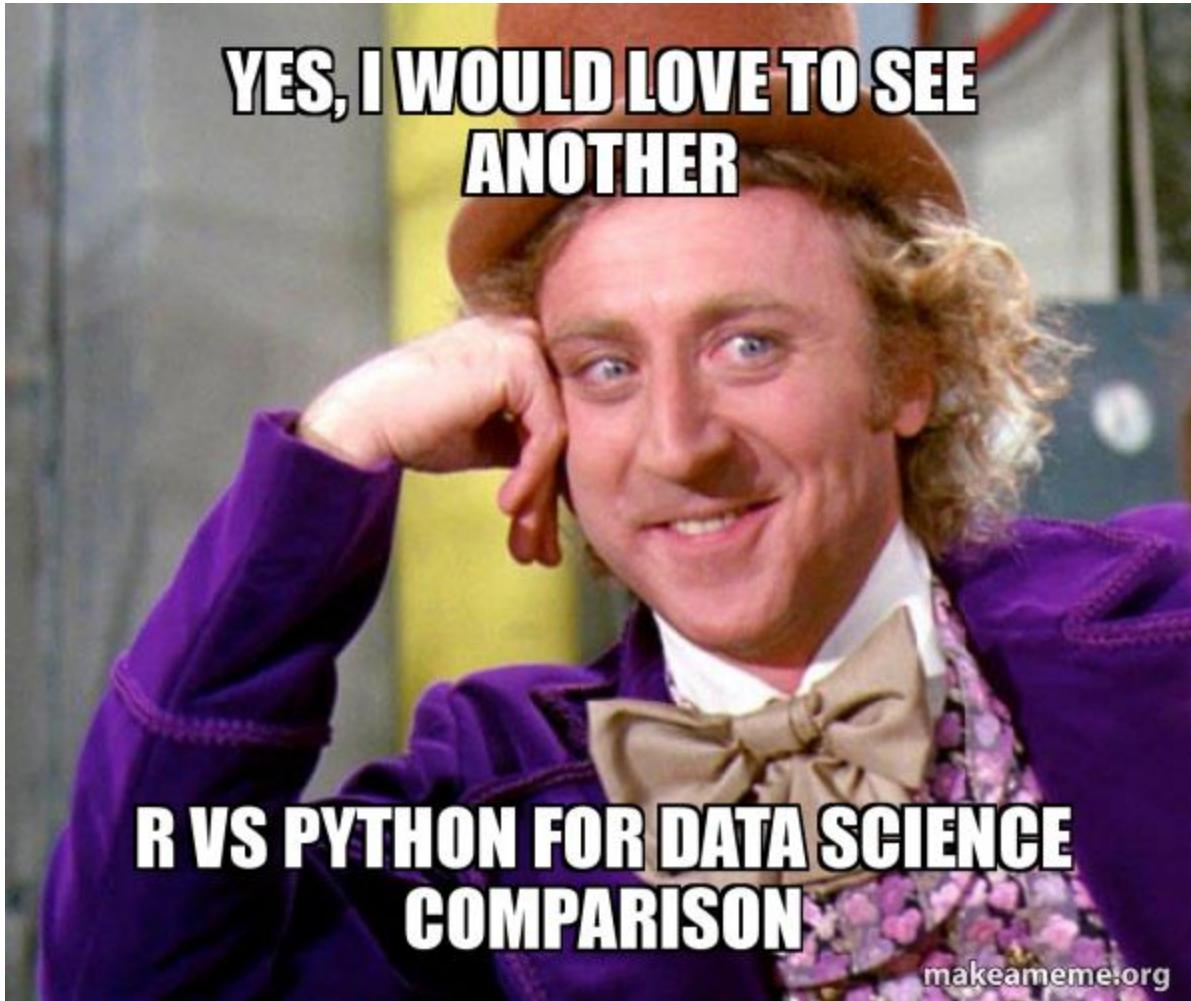
The screenshot shows a web browser window for the "SA-TIED Geospatial Workshop". The title bar says "SA-TIED" and the address bar shows "jtvdijk.github.io/SA-TIED/00-index.html". The page features a large header "SA-TIED Geospatial Workshop" with a city skyline image below it. To the left is a sidebar with navigation links for "Workshop overview", "Welcome", "Mapping Data", "R for Data Analysis", "R for Spatial Analysis", "Modelling Spatial Data", "Spatial Autocorrelation", and "Spatial Models". On the right, there's a "On this page" sidebar with links to "SA-TIED Geospatial Workshop", "Welcome", "Prerequisites", "Workshop overview", and "Acknowledgements". A "Report an issue" button is also present.

## Welcome

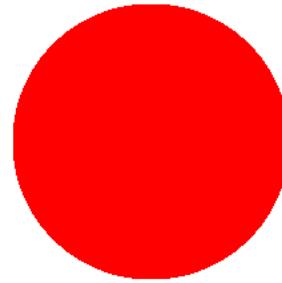
Welcome to the workbook for the **SA-TIED Geospatial Workshop**. Over the course of this two-day introductory workshop, you will be introduced to the R programming language, learn how to map socio-economic and demographic data, and gain an understanding of the ideas behind spatial models. We will explore the following topics:

- Fundamentals of using R for data analysis with the `tidyverse` library
- Creating thematic maps using R with the `tmap` library
- Quantifying the degree of spatial dependence in a dataset
- Incorporating space into statistical models

Python?



# Demonstration



LIVE

# Conclusion

- R is primarily used through interactive command-line interfaces and scripts.
- R is the programming language, but we can interact with it using other software.
- R efficiently handles various data types, particularly vectors and tables.
- R's functionality can be extended through a vast ecosystem of packages.
- R is free and open source.

# Questions

Justin van Dijk

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