

# Binder for fully reproducible research in R (data, code, and computational environment).

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Inspired by The Turing Way  
<https://github.com/alan-turing-institute/the-turing-way>

# Open and Reproducible Research

- Shared Data - we already know this is important for reproducibility.
- Shared Code - we already know this is important for reproducibility.
- Shared Computational environment - why is this important and how do we do it?

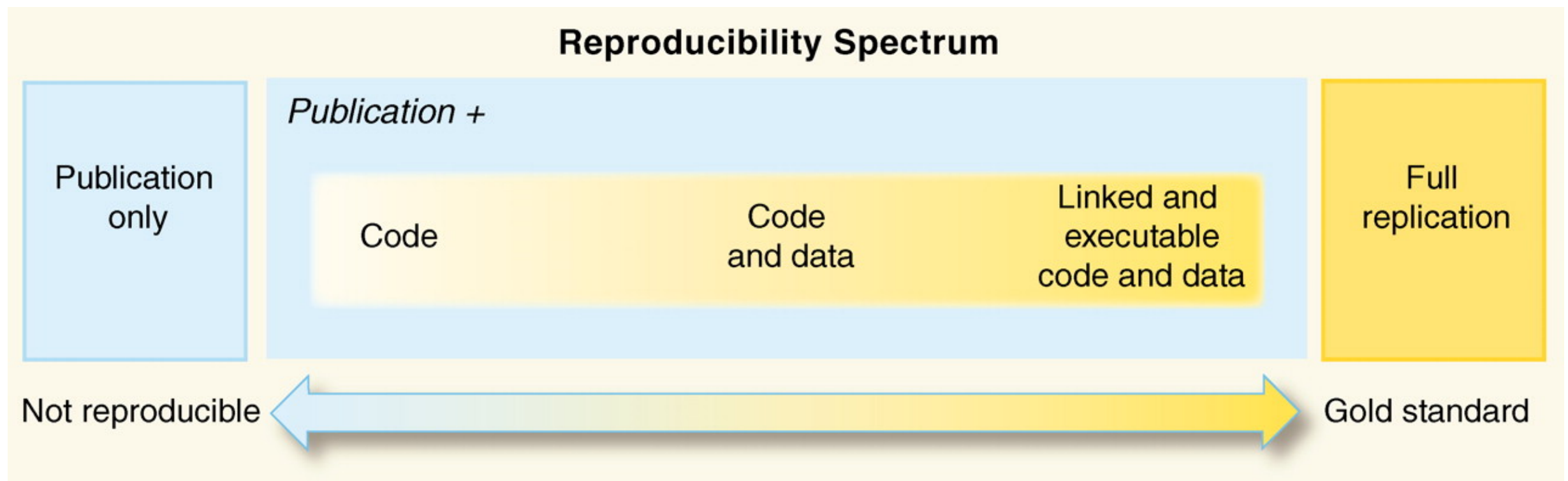
PERSPECTIVE

# Reproducible Research in Computational Science

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DOI: 10.1126/science.1213847



# Why do we need to reproduce the computational environment?

- Quite often analysis code ‘breaks’ - often in one of two ways:
- Code that worked previously now doesn’t - maybe a function in an R package was updated (e.g., `lsmeans` became `emmeans` so old code using `lsmeans` wouldn’t now run).
- Code that worked previously still works - but produces a slightly different result or now throws a warning where it didn’t previously (e.g., convergence/singular fit warnings in `lme4` version 1.1-19 vs. version 1.1-20).

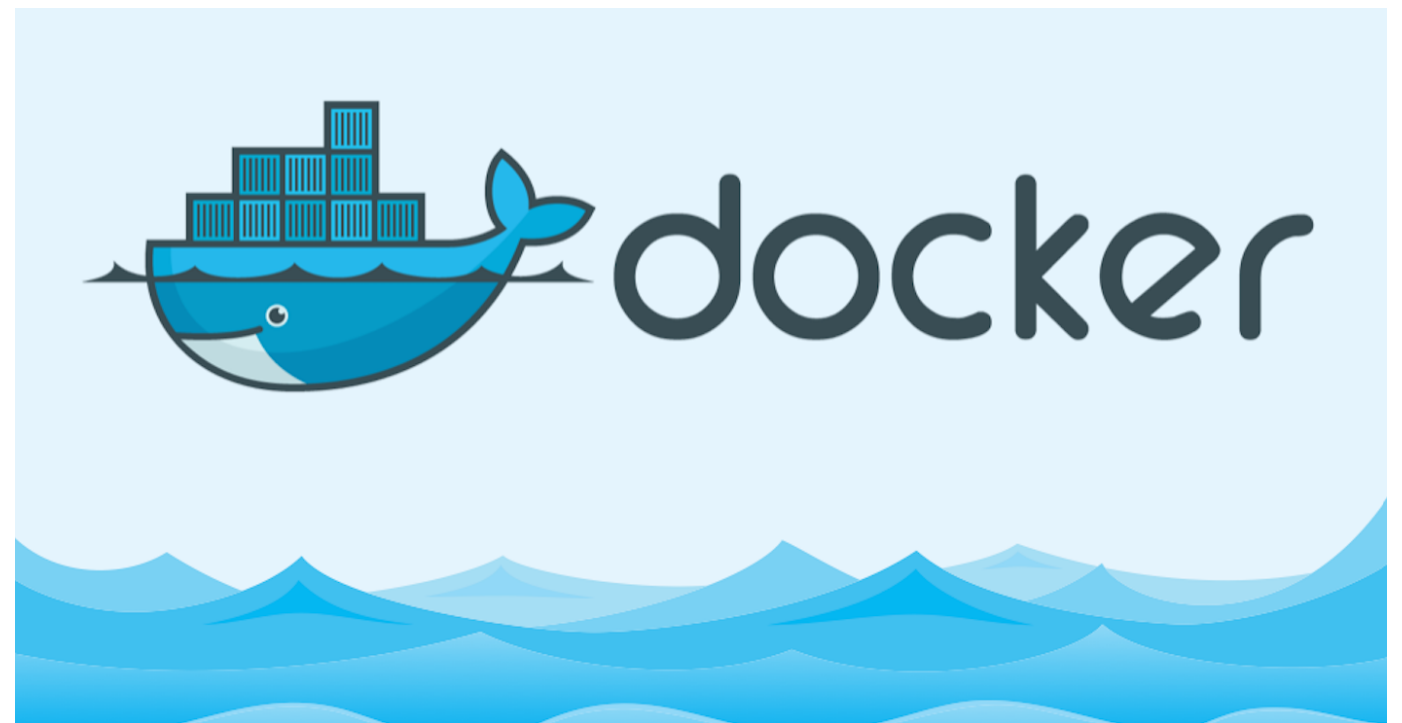
# Capturing your local computational environment

- You need to capture the versions of the different R packages (plus their dependencies).
- May sound trivial but trying running some old R code and be amazed at how many things now don't work as they once did!

# Docker for beginners

Docker packages your data, code and all its dependencies in the form called a docker container to ensure that your application works seamlessly in any environment.

When you run a docker container it's like running your analysis on a virtual computer that has the same configuration as our own one at the point in time when you ran the analysis.



<https://medium.com/the-andela-way/docker-for-beginners-61e8e0ce6a19>

# So what's Binder?

- Binder allows you to create custom computing environments (a Docker image) and share them to be used by others anywhere in the world.
- Binder is powered by BinderHub, which is an open-source tool that deploys the Binder service in the cloud.
- Binder works by pulling information from a repository that you set up on GitHub. Think of a repository as a folder containing your R code, your data, and a few other small bits and pieces - but it sits in the cloud rather than on your computer.

github.com/ajstewartlang/Turing\_way2

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Code Issues 0 Pull requests 1 Projects 0 Wiki Insights Settings

markdown\_for\_Turing\_Way Edit

Manage topics

6 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

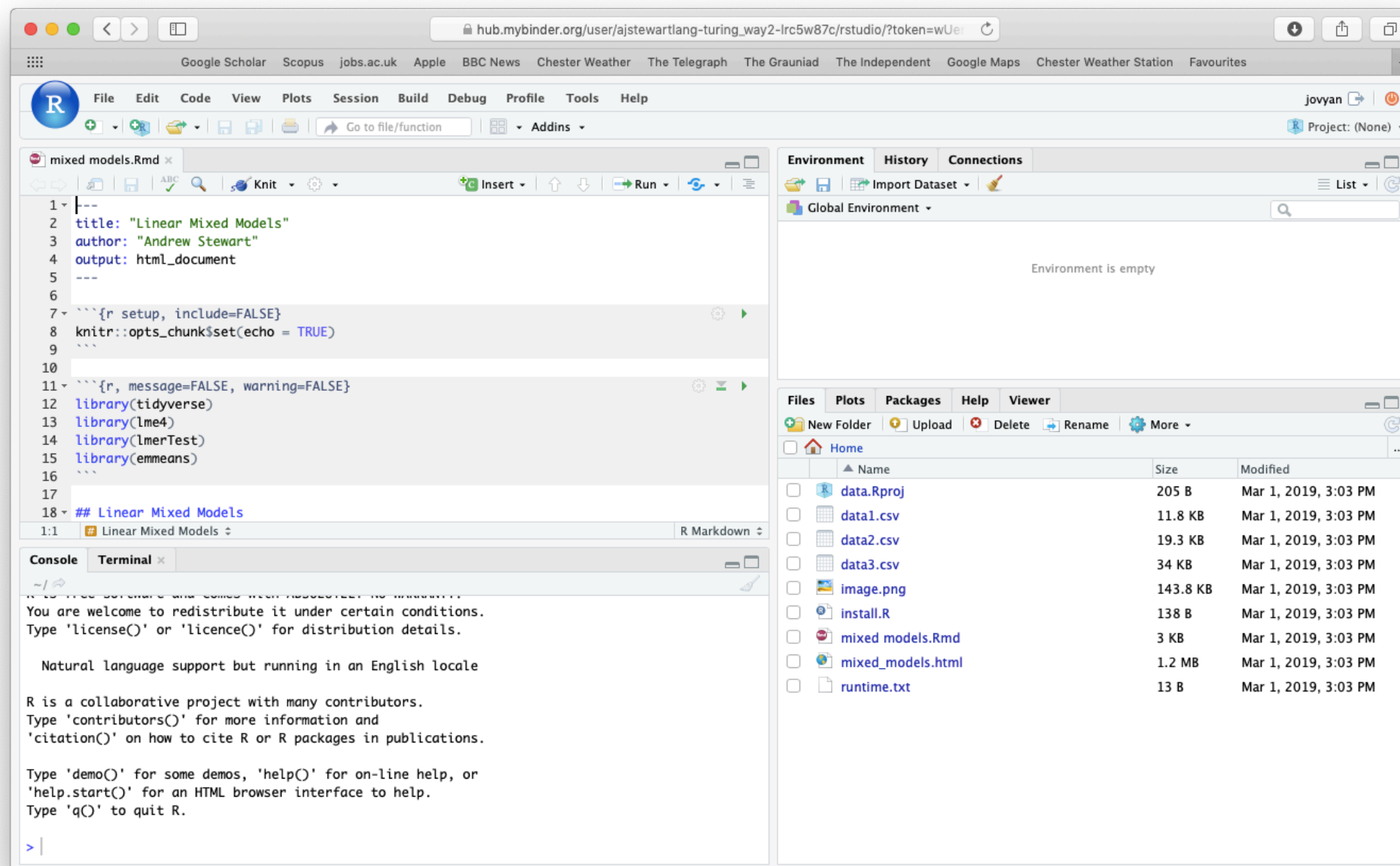
ajstewartlang Create install.R		Latest commit 36d3181 2 hours ago
.Rproj.user	commit	2 hours ago
data.Rproj	first commit	3 hours ago
data1.csv	first commit	3 hours ago
data2.csv	first commit	3 hours ago
data3.csv	first commit	3 hours ago
image.png	first commit	3 hours ago
install.R	Create install.R	2 hours ago
mixed models.Rmd	commit	2 hours ago
mixed_models.html	first commit	3 hours ago
runtime.txt	Update runtime.txt	2 hours ago

GitHub Desktop

My R code and data files.

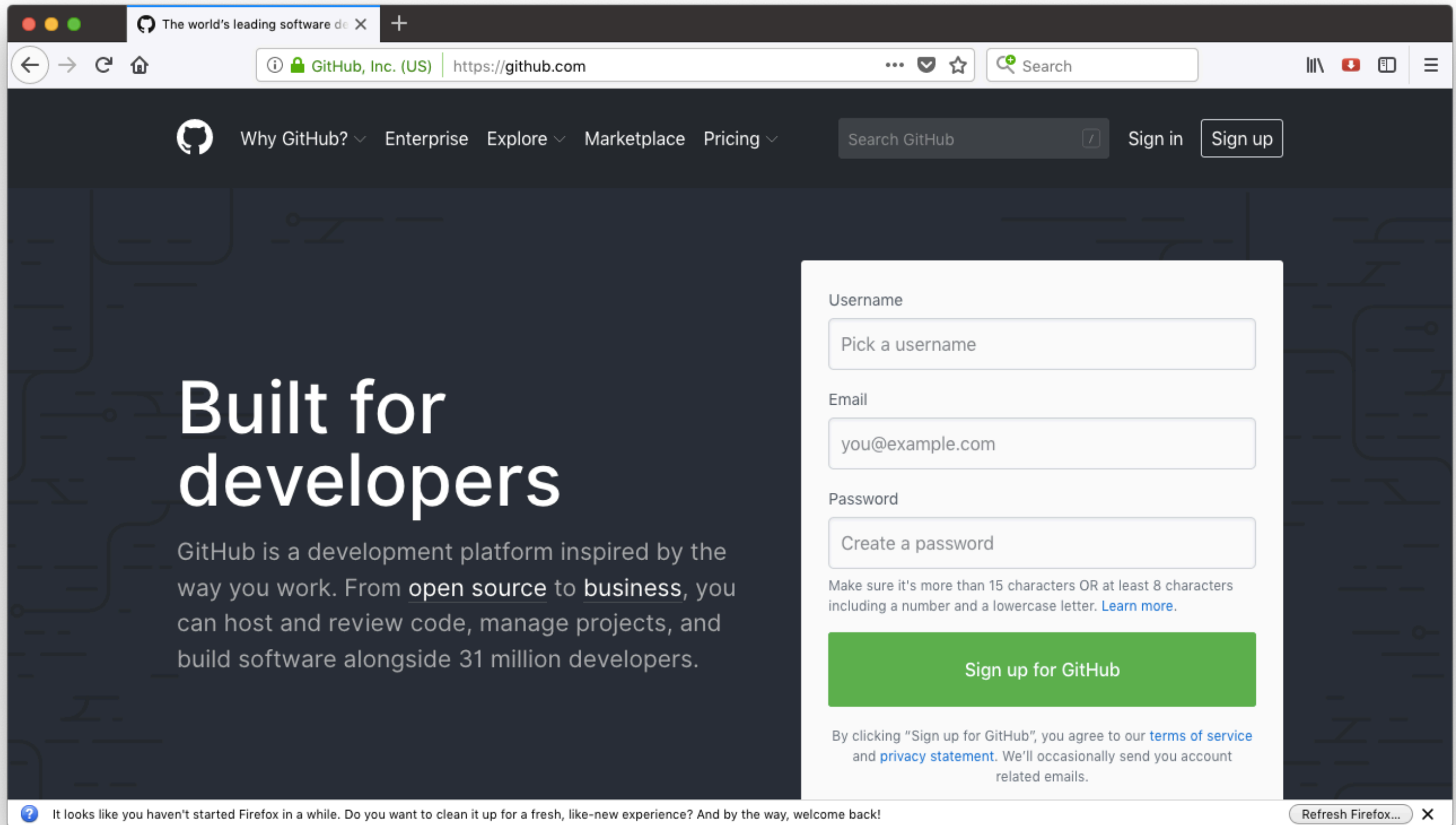


- When I link my GitHub repository to Binder and launch it I then get the following in my web browser.
- This is RStudio running the cloud using my code, my data and the appropriate versions of the packages that I was using when I did the analysis originally!



[https://mybinder.org/v2/gh/ajstewartlang/Turing\\_way2/master?urlpath=rstudio](https://mybinder.org/v2/gh/ajstewartlang/Turing_way2/master?urlpath=rstudio)

# Step 1 - Set up a GitHub account



The screenshot shows the GitHub homepage in a web browser. The browser's address bar displays "https://github.com". The page features a dark blue header with the GitHub logo, navigation links ("Why GitHub?", "Enterprise", "Explore", "Marketplace", "Pricing"), a search bar, and "Sign in" and "Sign up" buttons. The main content area has a large heading "Built for developers" and a subheading "GitHub is a development platform inspired by the way you work. From open source to business, you can host and review code, manage projects, and build software alongside 31 million developers." On the right side, there is a white sign-up form with fields for "Username", "Email", and "Password". The "Username" field contains the placeholder "Pick a username". The "Email" field contains "you@example.com". The "Password" field contains the placeholder "Create a password". Below the password field, there is a note: "Make sure it's more than 15 characters OR at least 8 characters including a number and a lowercase letter. [Learn more.](#)". A green button labeled "Sign up for GitHub" is positioned below the form. At the bottom of the form, there is a disclaimer: "By clicking 'Sign up for GitHub', you agree to our [terms of service](#) and [privacy statement](#). We'll occasionally send you account related emails." At the very bottom of the browser window, a Firefox notification bar states: "It looks like you haven't started Firefox in a while. Do you want to clean it up for a fresh, like-new experience? And by the way, welcome back!" with a "Refresh Firefox..." button and a close icon.

Username

Pick a username

Email

you@example.com

Password

Create a password

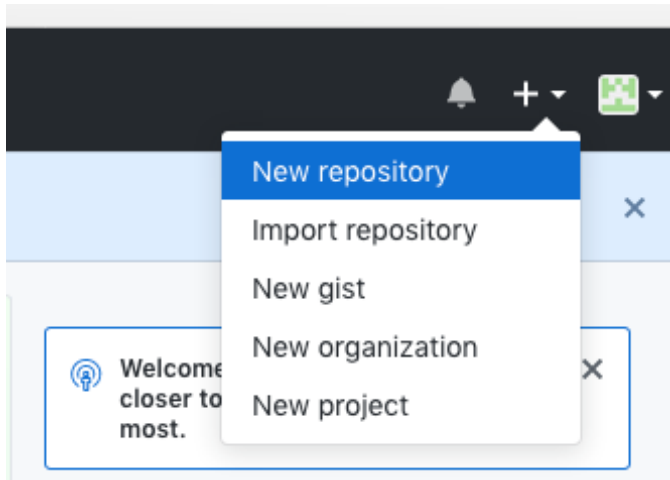
Make sure it's more than 15 characters OR at least 8 characters including a number and a lowercase letter. [Learn more.](#)

Sign up for GitHub

By clicking "Sign up for GitHub", you agree to our [terms of service](#) and [privacy statement](#). We'll occasionally send you account related emails.

It looks like you haven't started Firefox in a while. Do you want to clean it up for a fresh, like-new experience? And by the way, welcome back! Refresh Firefox... X

# Step 2 - Create a new repository



Give it a name,  
set it to public  
and tick  
“Initialise this  
repository with a  
README”.

## Create a new repository

A repository contains all project files, including the revision history.

Owner

 andrewstewarttest ▾


Repository name \*

first\_binder ✓

Great repository names are short and memorable. Need inspiration? How about [probable-funicular?](#)

Description (optional)


☒  **Public**  
Anyone can see this repository. You choose who can commit.

☐  **Private**  
You choose who can see and commit to this repository.

☒ **Initialize this repository with a README**

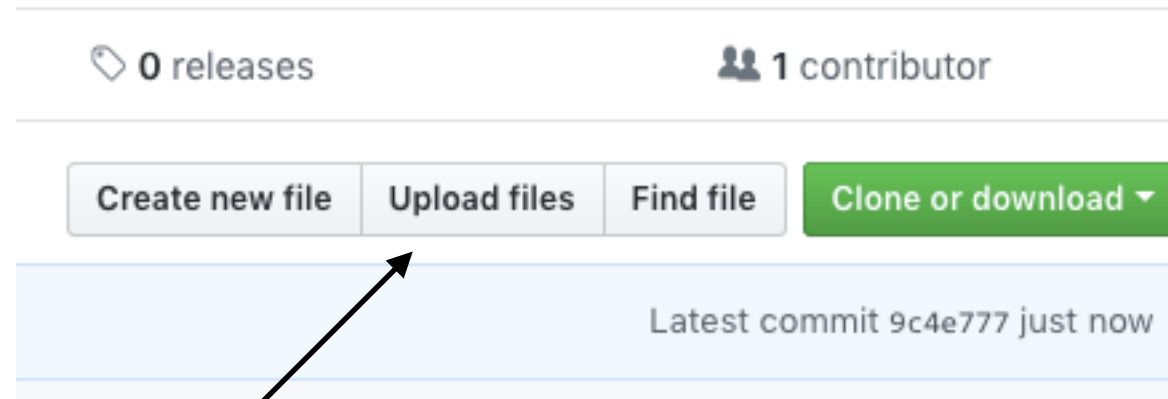
This will let you immediately clone the repository to your computer. Skip this step if you're importing an existing repository.

Add .gitignore: **None** ▾

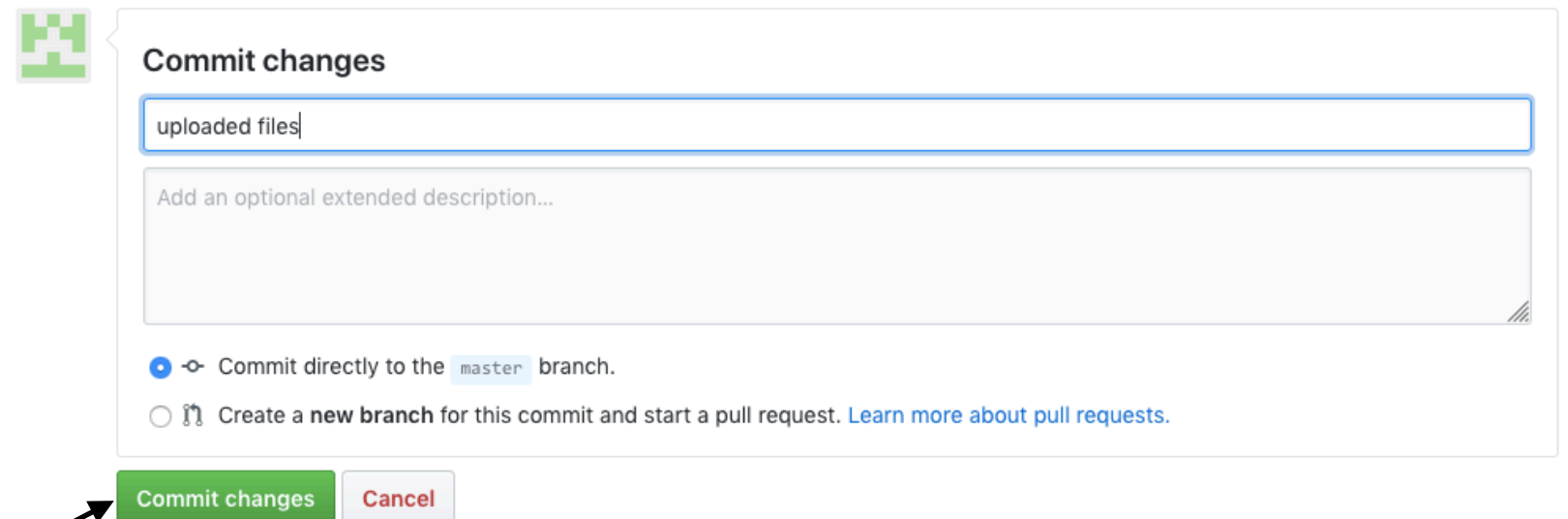
Add a license: **None** ▾ 

Create repository

# Step 3 - Upload your R script and data and make your first “Commit”



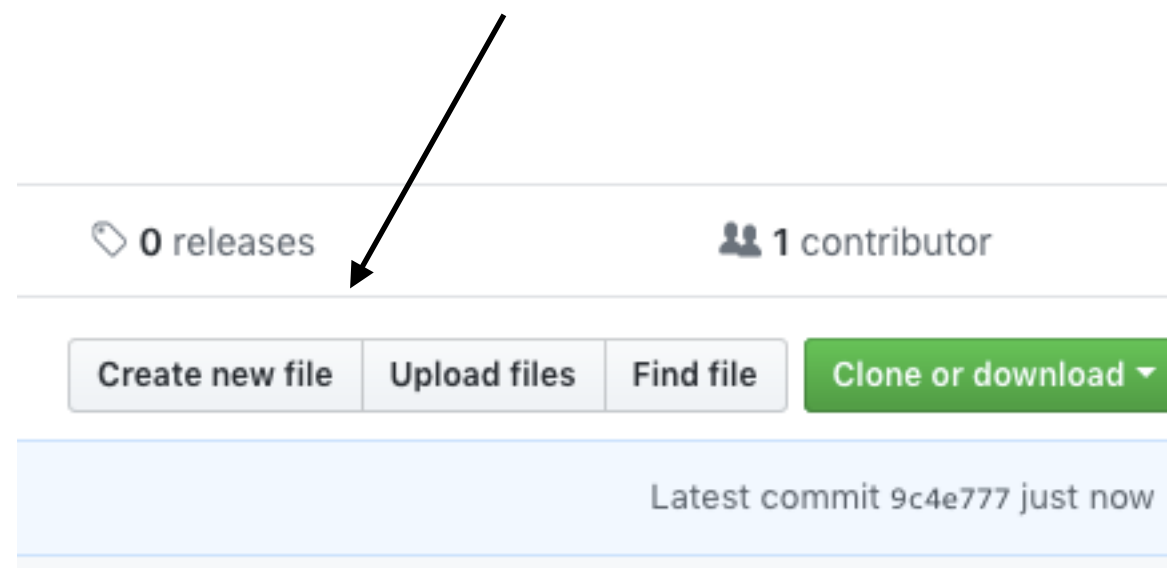
Click here to upload



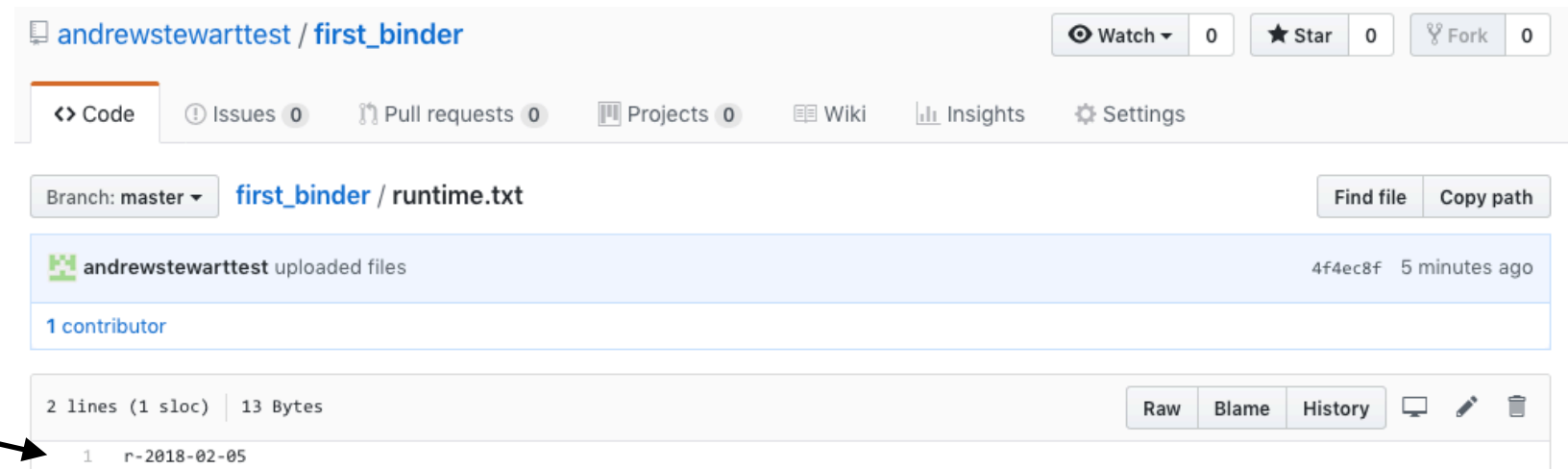
Click here to Commit

# Step 3 - Upload your R script and data and make your first “Commit”

- We need two other files at this point - one is called “runtime.txt” and contains the date of R and its associated packages that you want to simulate.
- The other is called “install.R” and contains the list of R packages that need to be installed in order for your script to run.
- To create a new file select “Create new file”



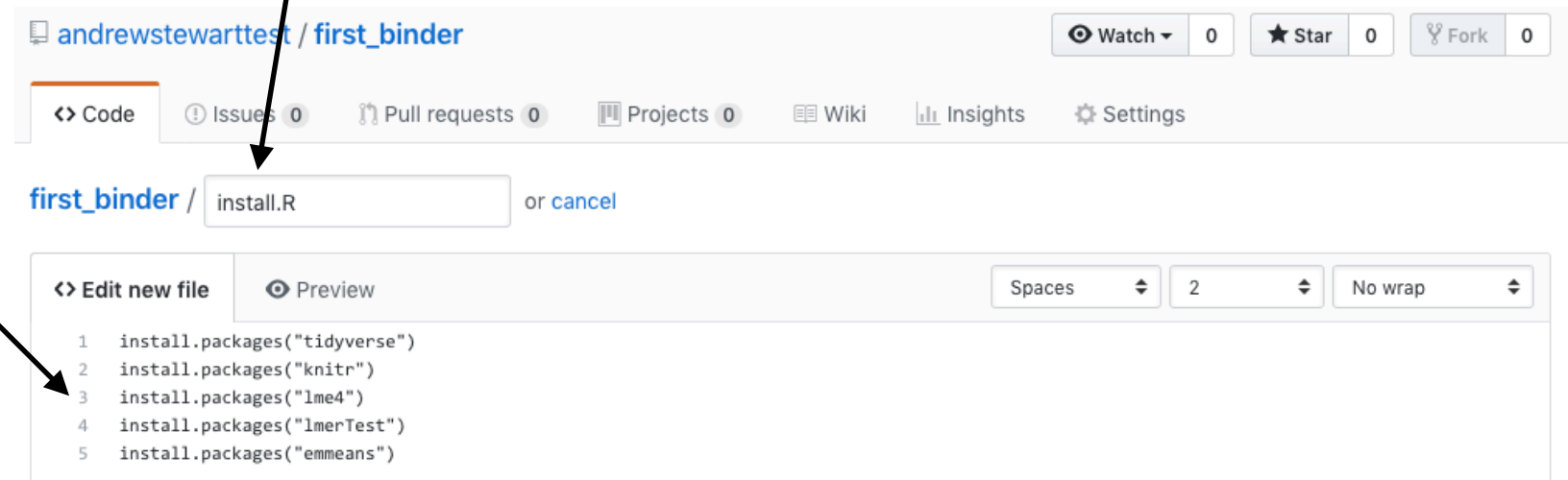
In the  
runtime.txt file  
type the date  
you want in the  
format r-YYYY-  
MM-DD



The screenshot shows the GitHub interface for a repository named 'first\_binder' by user 'andrewstewarttest'. The file 'runtime.txt' is selected, showing its content: 'r-2018-02-05'. The file is 13 bytes and has 2 lines. The interface includes tabs for Code, Issues, Pull requests, Projects, Wiki, Insights, and Settings. A 'Find file' button and 'Copy path' link are visible. The file was uploaded 5 minutes ago by the user.

Name your file

List your  
packages like  
this in the  
install.R file



The screenshot shows the GitHub interface for a repository named 'first\_binder' by user 'andrewstewarttest'. The file 'install.R' is selected, showing its content: 'install.packages("tidyverse")', 'install.packages("knitr")', 'install.packages("lme4")', 'install.packages("lmerTest")', and 'install.packages("emmeans")'. The file is 13 bytes and has 5 lines. The interface includes tabs for Code, Issues, Pull requests, Projects, Wiki, Insights, and Settings. A 'Find file' button and 'Copy path' link are visible. The file was uploaded 5 minutes ago by the user.

Don't forget to click "Commit" after you've created each file!

# Step 5 - Now we need to link our repo to Binder (mybinder.org)



Turn a Git repo into a collection of interactive notebooks

Have a repository full of Jupyter notebooks? With Binder, open those notebooks in an executable environment, making your code immediately reproducible by anyone, anywhere.

A screenshot of the Binder website's "Build and launch a repository" form. The form has several input fields and a "launch" button. Arrows from the numbered instructions point to specific parts of the form: 1. Points to the "GitHub repository name or URL" field, which contains "https://github.com/andrewstewarttest/first\_binder". 2. Points to the "URL to open (optional)" field, which contains "rstudio". 3. Points to the orange "launch" button. 4. Points to the "Copy the URL below and share your Binder with others:" section, which displays a long URL: "https://mybinder.org/v2/gh/andrewstewarttest/first\_binder/master?urlpath=rstudio". Below this, there is a section for a README badge with a "launch binder" button and a blue arrow icon.

1. Paste the link to your repo here.

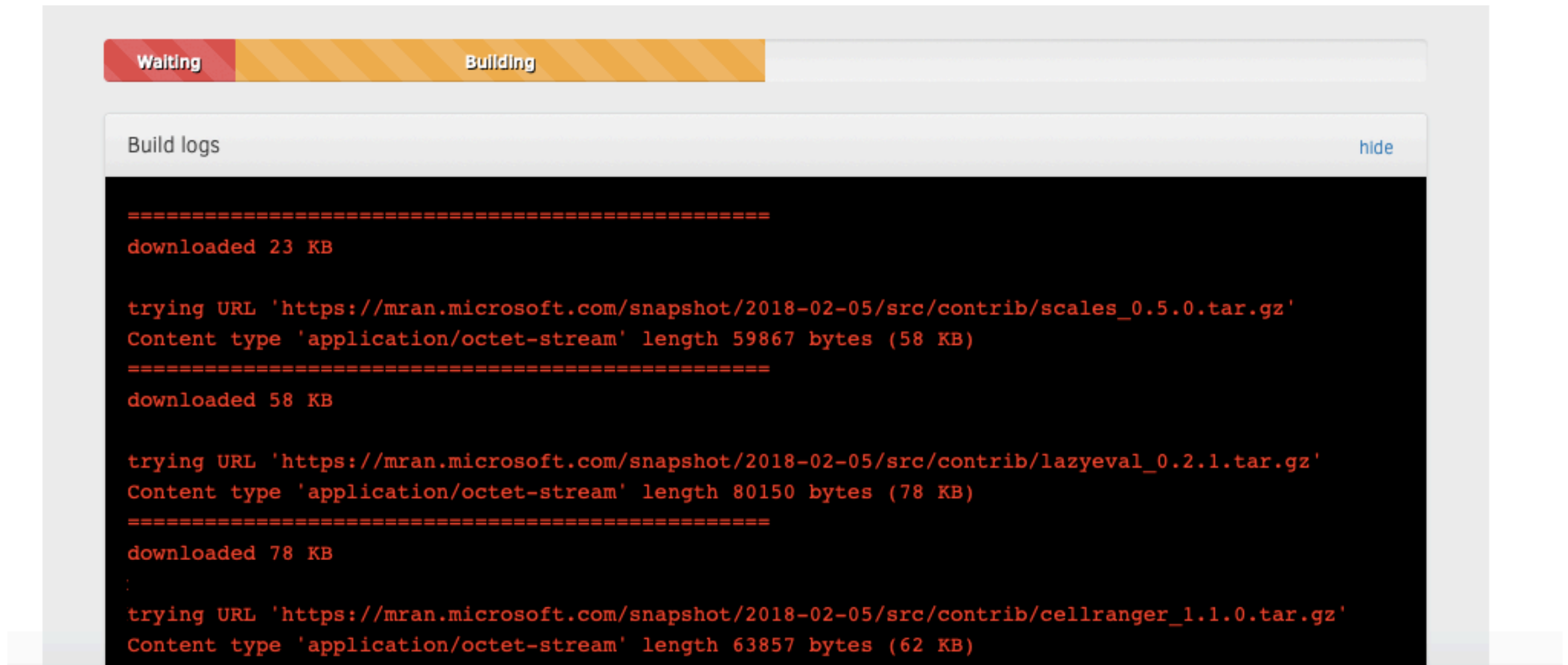
2. Add "rstudio" here with the URL option selected.

3. Then click on "launch"

4. This is the URL to share with others.



# And wait...



You can check the progress of the build by clicking on the “Build logs” bar.



**And wait...**

# And then...

The screenshot displays the RStudio web interface running on mybinder.org. The browser address bar shows the URL: `hub.mybinder.org/user/andrewstewarttest-first_binder-z4kwp6gl/rstudio/?token=`. The RStudio interface includes a menu bar (File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help) and a toolbar with icons for file operations and running code. The main editor window shows a file named `mixed models.Rmd` with the following R Markdown code:

```
1 ---
2 title: "Linear Mixed Models"
3 author: "Andrew Stewart"
4 output: html_document
5 ---
6
7 ```{r setup, include=FALSE}
8 knitr::opts_chunk$set(echo = TRUE)
9 ```
10
11 ```{r, message=FALSE, warning=FALSE}
12 library(tidyverse)
13 library(lme4)
14 library(lmerTest)
15 library(emmeans)
16 ```
17
18 ## Linear Mixed Models
```

The console window at the bottom shows the R startup messages:

```
~/
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.

> |
```

The file explorer on the right shows the following files and folders:

Name	Size	Modified
data.Rproj	205 B	Mar 1, 2019, 5:39 PM
data1.csv	11.8 KB	Mar 1, 2019, 5:39 PM
data2.csv	19.3 KB	Mar 1, 2019, 5:39 PM
data3.csv	34 KB	Mar 1, 2019, 5:39 PM
image.png	143.8 KB	Mar 1, 2019, 5:39 PM
install.R	138 B	Mar 1, 2019, 5:39 PM
mixed models.Rmd	3 KB	Mar 1, 2019, 5:39 PM
mixed_models.html	1.2 MB	Mar 1, 2019, 5:39 PM
README.md	14 B	Mar 1, 2019, 5:39 PM
runtime.txt	13 B	Mar 1, 2019, 5:39 PM