CSHS Workshop: R for hydrologists - functions, projects and packages

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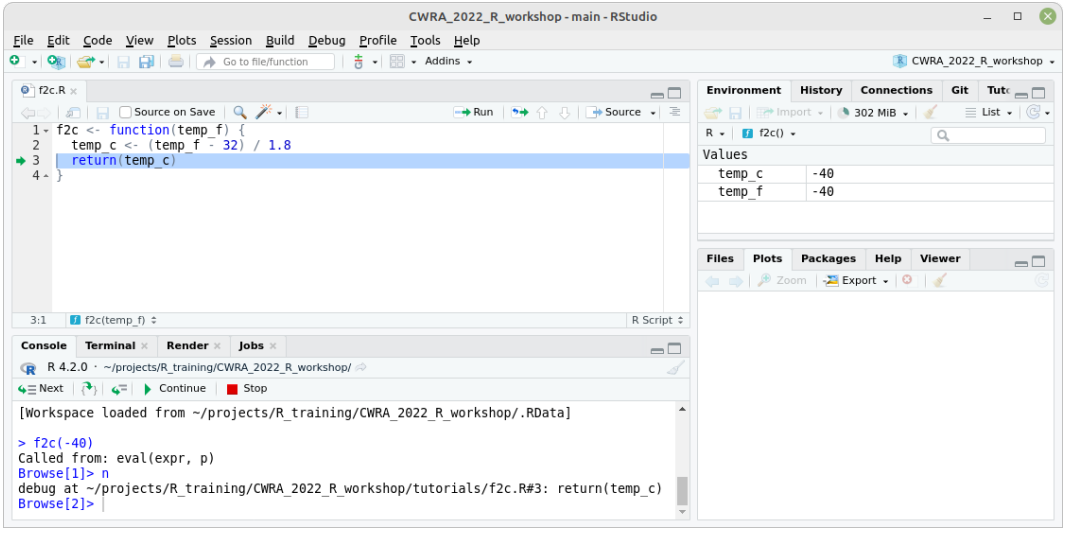
Efficiency, safety and reproducibility

- Objectives of this presentation and exercises
- Want to make you a better **R** user
- Will show you tools that
  - will make you more efficient
  - make your work safer
  - make your code more reproducible

Functions

- Very important for efficiency, safety and reproducibility
- Once a function has been debugged and tested, you can use it with some confidence
- **R** has a built-in debugger which only works with functions
- Always a very good idea to have someone else check your code
  - functions make this much easier
- Functions work very well with Notebooks
- Functions are only way of putting code into packages

Debugger


CWRA_2022_R_workshop - main - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
CWRA_2022_R_workshop
f2c.R
Source on Save
Run
Source
1 f2c <- function(temp_f) {
2 temp_c <- (temp_f - 32) / 1.8
3 return(temp_c)
4 }
3:1
f2c(temp_f)
R Script
Console
Terminal
Render
Jobs
R 4.2.0 · ~/projects/R_training/CWRA_2022_R_workshop/
Next
Continue
Stop
[Workspace loaded from ~/projects/R_training/CWRA_2022_R_workshop/.RData]
> f2c(-40)
Called from: eval(expr, p)
Browse[1]> n
debug at ~/projects/R_training/CWRA_2022_R_workshop/tutorials/f2c.R#3: return(temp_c)
Browse[2]>
Environment
History
Connections
Git
Import
302 MiB
List
R
f2c()
Values
temp_c -40
temp_f -40
Files
Plots
Packages
Help
Viewer
Zoom
Export

Function documentation

- It's critical that you document what your function does
- You won't be able to remember in the future
- No-one likes writing documentation, but it needs to be done
- If you have **devtools** installed then you can use `roxygen` to insert a skeleton for the documentation
  - once skeleton is created, you can edit the tags
  - **roxygen** tags area used by **R** to create package documentation
- Still need to add comments to describe what your code is doing

Exercise

- Load the file "f2c.R" into your workspace
- Place your cursor anywhere inside the function
- Click on **Code** | **Insert Roxygen Skeleton**

```
#' Title
#'
#' @param temp_f
#'
#' @return
#' @export
#'
#' @examples
f2c <- function(temp_f) {
  temp_c <- (temp_f - 32) / 1.8
  return(temp_c)
}
```

Projects

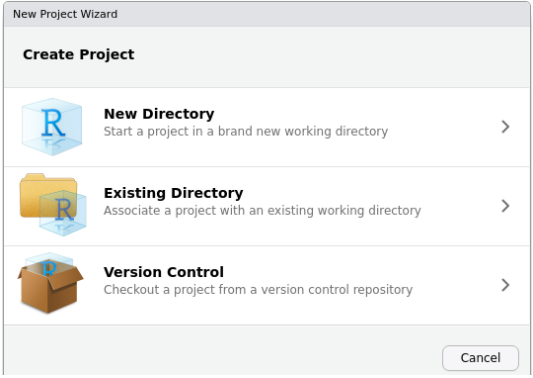
- A project is a collection of **R** files
- Has its own directory
- Increases efficiency, safety and reproducibility
- Can have its own set of options

Why create a project?

- Makes your code more reproducible
- Keeps code separate from other projects
- Lets your code work with `git` and GitHub or GitLab
  - a very good idea for code safety and reliability
- Basis for creating packages

How to create a project

- Command is **File** | **New Project**
- Several alternatives appear



Decisions, decisions. . . .

- New Directory
  - allows you to create any type of project, including packages
  - can use **git** (always a good idea), *but*
  - *won't* work with **GitHub**
- Existing Directory
  - only creates a simple project
  - doesn't set up **git**, but you can add it later
  - *won't* work with **GitHub**
- Version Control
  - clones a project from a repository like **GitHub** or **GitLab**
  - project has to be set up on the repository *first*

.Rproj file

- Every project contains a project file (`project_name.Rproj`)
  - a text file which contains the project settings
- Double-clicking on the file in your file manager will load **RStudio** with the project
  - default directory will be set to the project directory
- Can also load a project manually in **RStudio** using
  File | **Open Project** or
  File | **Recent Projects**
- You can only have one project open at a time
  - opening a project will close your current project

git

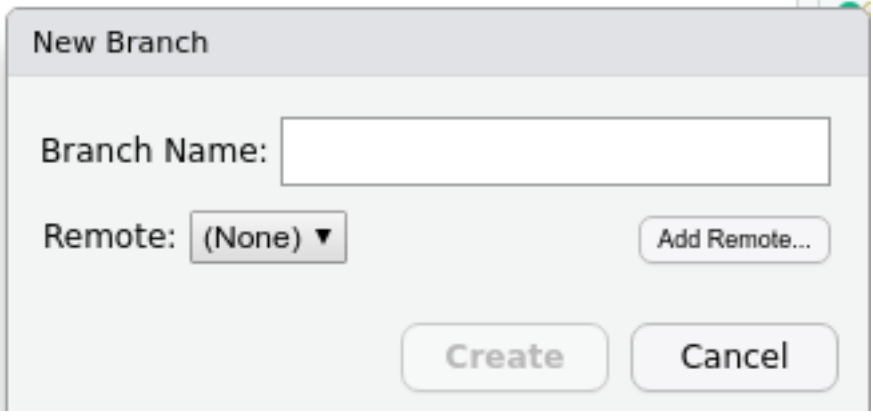
- **git** is a program for version control
- Created by Linus Torvalds (creator of Linux)
- Allows you to manage versions of your documents
- **RStudio** allows you to do most operations without typing commands
  - if you screw up, you *will* have to type **git** commands
- Can sync with **GitHub**

Working with git

- **git** is based on *branches*
  - each branch is a separate set of files
- There is always a **main** (or **master**) branch
  - best version of the files
- When a branch is ready, it can be merged into the **main** branch
- You can switch between branches at any time

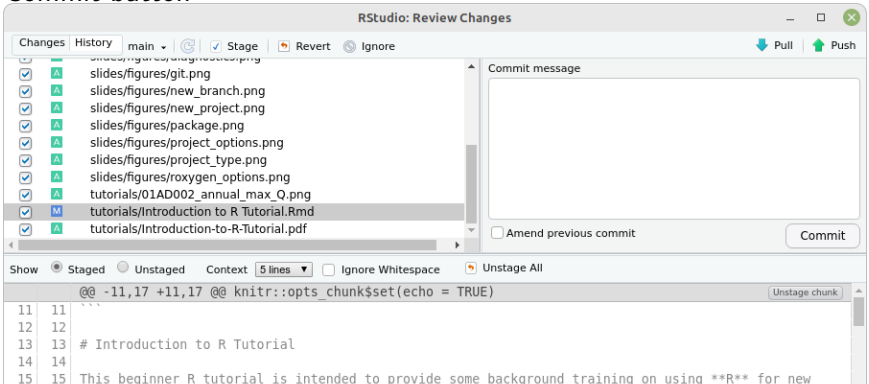
git branches

- *ALWAYS* create a new branch before working on a project
  - if you don't it will be a huge PITA
- Click on **New Branch** button in the **Git** tab



Committing

- When you have finished some work, you can commit your changes by
- selecting the files to commit and
- clicking on **Commit** in the **Git** tab
- You will then see a window which lets you review your changes
- You **must** type a Commit message describing your changes before clicking on the Commit button

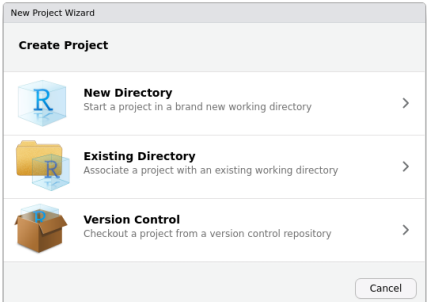


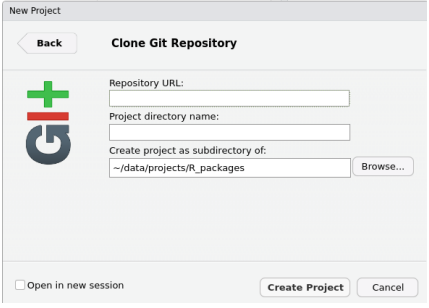
Exercise

- Create a new project in a new directory
- Check "Create a git repository"
- Don't check "Use renv with this project"
  - **renv** is a package which keeps copies of all of the packages that you use with the project
- Quit **RStudio**
- Copy the file "f2c.R" to the project directory
- Copy the file "Introduction_to_R_Tutorial.Rmd" to the project directory
- Go to your file manager and double-click on the ".Rproj" file in the new directory
  - you should now see "f2c.R" in the Files tab
- Create a new branch in the Git tab
  - load "f2c.R"
  - make an edit to the file "f2c.R"
  - commit the change
- In **RStudio** click on **File** | **Recent Projects** to re-load *this* project

GitHub/GitLab

- You can sync your project with an online repository at GitHub or GitLab
- Have to set up the online repo *first*
  - need an account (which you should have)
  - have to have **ssh** set up on your computer, and to tell GitHub your **ssh** key
- When you create a project, you select Version Control and then indicate the source to clone from





R Packages

- **R** packages are a special type of project
- Only hold functions - do *not* use them for Notebooks
- Great for distributing your work to others
- Also useful for making your own work more reproducible
- *Must* contain documentation for all functions
- Can also contain test data sets

Why create a package?

- The best way to distribute **R** code
- Makes your code reproducible
  - makes code reusable
- Improves code quality
- Takes care of dependencies
- Self-documenting
- Should work for anyone, on any computer

Building a package

- All components are text files
  - You could build them manually
- **DON'T!**
- Use the package **devtools**
  - makes it *much* easier
- Need packages **roxygen2**, and **rmarkdown**
- Need LaTex installed to create manuals
- Also, make sure to have **git** installed on your system

Mandatory package components

- 2 Files
  - DESCRIPTION
  - NAMESPACE
- 2 directories are mandatory
  - `/R` – contains code .R files
  - `/man` – contains documentation .Rd files
- may have other directories

DESCRIPTION

- Contains package description
- Has to have a specific format
- Has to indicate the packages required by your package
- You can see the DESCRIPTION file for any package on your system

Exercise

- In the Packages tab, click on **CSHShydRology**
- Then select the **DESCRIPTION file**

NAMESPACE

- Contains detailed information about imports and exports of each function
- Do NOT create or edit this file
  - **roxygen2** will automatically create and maintain it

R directory

- Contains the **R** code
- Code must be written as functions
- Each function must be in a separate file
  - file name is same as function name
  - file extension must be **.R**

man directory

- Contains the documentation files
- Creates the help system for the package
- Also creates the manual
- Each .R file has a .Rd file in **man**
  - Don't create these files manually

roxygen2

- Used by **devtools**, installed by it
- Automatically creates the .Rd files
  - uses comments at the beginning of each **.R** file

Example

- All lines begin with #'
- First line contains a 1 line description of the file
- Should not end with a period!
- Example:

Tags

Formatting

- Documentation can include formatting codes

Example

Package function

- You should create a function that has the name of your package
- Example: CSHShydRology-package.R
- Gives overview of the package and what it's for
- Contains information to create NAMESPACE

Other folders

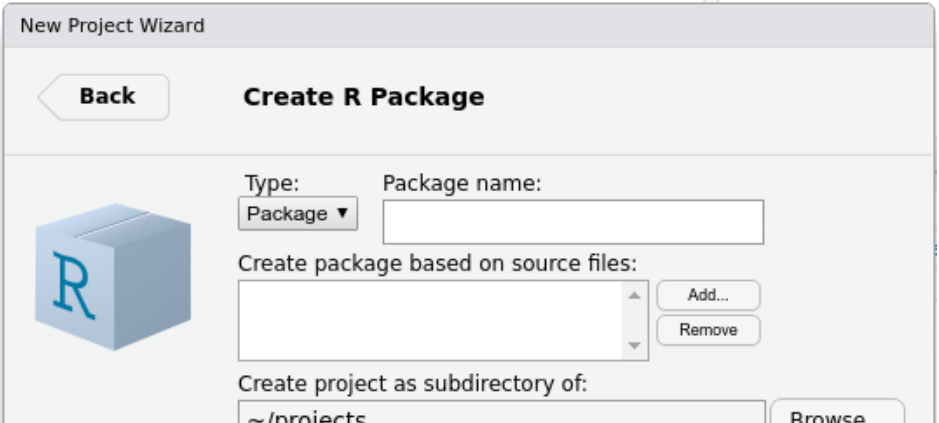
- You may see these folders in packages:
  - /data, data files used by the package
  - /vignettes, documentation written in Markdown
  - /inst, contains the file CITATION showing how to cite the package
  - /src, source code written in C, C++ or Fortran

Workflow

1. Create the package
2. Add code
3. Build package
4. Check package
5. Create package file

1. Creating the package

- Create a new project in a new directory
  - **File**|**New Project**
  - select **R Package**
  - then give your package a name and a location
- Make sure to use **git**!

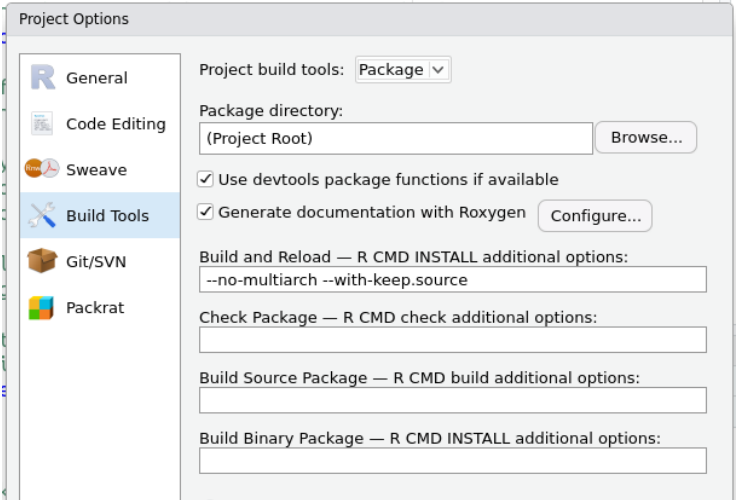


New package

- R studio will create all of the files and directories
  - /R
  - /man
  - DESCRIPTION
  - NAMESPACE
- Also creates a sample file **hello.R** in `/R`
- Adds folders and files for **git**

Setting up roxygen

- Not enabled by default
- Set it up using **Tools|Project Options**



2. Adding R code

- Put your R code files in /R
- Must be functions
  - one function per file
- Add the roxygen skeleton to your code for each file
  - **Code|Insert Roxygen Skeleton**
- Fill in skeleton

Converting your R code

- You will ned to make some changes to your code
- Don't use the **library()** function to load packages
  - package importation handled by `NAMESPACE`
- Specify the name of the package in every function (outside of your package and Base R) call
  - syntax is **package::function**

3. Building package

- Use command **Build | Clean and Rebuild**
- Expect to get error messages!
- Fix until package builds
- If the package builds, it will be added to your list of packages

4. Checking the package

- Just because a package can build, doesn't mean that it is good!
- Use command **Build|Check**
  - does a detailed check of entire package
  - can be slow for large packages
  - tries to run your examples
  - *very* picky
  - you will probably get many, many errors, warnings and notes at first
  - eliminating all warnings and notes really improves your code

5. Creating the package file

- 2 options:
  - **Build** | **Build Source Package** - contains source code (all languages)
  - **Build** | **Build Binary Package** - contains compiled Fortran, C, C++ code
- Reason is that Windows computers usually don't have compilers
- If just using **R** code, make it a source package
- If you are using Fortran, C, C++, create both types

Building the manual .pdf

- When the package is built, should also create the .pdf
- Must have LaTex installed
- For some reason, this doesn't work for me
  - have to do it manually
  - type in this command in the **R** console:

```
system("R CMD Rd2pdf mypackage")
```

Unit tests

- New feature, part of **devtools**
  - tests the results of functions
  - compares function outputs to known values
  - allows automated testing of functions

Exercise

- Create a package from scratch
- Build the package
- Copy some functions into the `/R` directory
- Add the **roxygen** skeleton to the functions
- See if you can get the package to build properly

Summary

- Learning to code in functions will take some time but is worth the investment
  - improves your code quality
  - makes code more reliable
  - makes *you* more efficient
- Creating an **R** project should be your first step when starting a new task
- Creating your own **R** packages, when using **git**, is the ultimate way to ensure efficiency, safety and reproducibility