

# CSHS Workshop: R for hydrologists

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# Introduction

- ▶ This workshop is intended for all users of hydrological, hydrometric and other environmental data
- ▶ We don't assume any background in **R**
- ▶ The workshop will consist of several different topics
  - ▶ each will be introduced with a short slide presentation
  - ▶ followed by a tutorial for you to work through step by step

- ▶ The workshop is based on the new **\*\*R\*** package CSHShydRology
- ▶ Developed by Canadian hydrologists for Canadian users
  - ▶ works with Canadian data sets
  - ▶ provides a “home” for Canadian hydrological **R** code

# Getting started

- ▶ This workshop requires that you have installed
  - ▶ **R**
  - ▶ **RStudio** - IDE for R
  - ▶ **CSHShydRo1ogy** - also requires many other packages to be installed

# What is R?

- ▶ A command-line program
- ▶ A programming language
- ▶ *Much* more than a statistics program
- ▶ A general-purpose scientific program

# Why “R”?

- ▶ S-plus is a proprietary statistics program
  - ▶ used the S language
- ▶ R is a Free Open Source Software (FOSS) implementation of the S language
- ▶ Developed by Ihaka and Gentleman in 1996:

Ihaka, R., Gentleman, R., 1996. R: A Language for Data Analysis and Graphics. *Journal of Computational and Graphical Statistics*, vol. 5, no. 3, p 299–314.

- ▶ Now one of the most used computer languages in the world

# Why use R?

- ▶ Powerful
- ▶ Excellent for
  - ▶ statistics
  - ▶ data processing
  - ▶ graphing
  - ▶ analysis, including GIS
- ▶ Free Open Source Software (FOSS)
  - ▶ you can see, test, and trust the code
  - ▶ no licensing issues
  - ▶ works with standard file formats - no lock in
  - ▶ rapid development, widely used
    - ▶ huge amount of resources available

## Why use R? (continued)

- ▶ Works well with other programs
  - ▶ interfaces with other languages including C, C++, Python and Fortran
  - ▶ can read/write Excel files directly using packages like **xlsx**
  - ▶ can read many other files such as netcdf, shapefiles, databases
- ▶ Platform independent
  - ▶ works the same on Windows, MacOS and Linux
- ▶ Makes your work **reproducible**



# R is great for hydrology!

- ▶ Data wrangling
  - ▶ acquiring and formatting data
- ▶ Model pre- and post- processing
- ▶ Statistical analyses
- ▶ “Big data” processing
- ▶ Machine learning models
- ▶ Publication quality graphing
- ▶ GIS
- ▶ many, many more

# Packages

- ▶ **R** has thousands of built in functions
- ▶ Many more are available as downloadable packages
- ▶ Each package contains:
  - ▶ functions
  - ▶ documentation
  - ▶ sample data
  - ▶ working examples
- ▶ Packages are downloaded directly through **R**
  - ▶ very easy, handles all dependencies

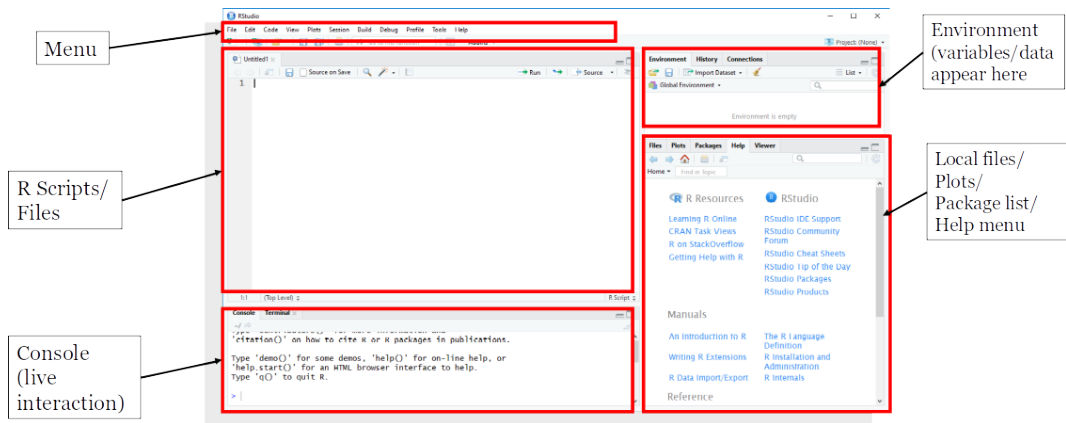
# CRAN packages

- ▶ Most packages are stored at **CRAN** (Comprehensive R Archive Network)  
cran.r-project.org
- ▶ Very rigorous submission process
  - ▶ high quality packages
- ▶ Number of packages is growing exponentially - currently  $> 18,000$
- ▶ Very easy to install in **R**

Example

```
install.packages("ggplot2")
```

# Opening RStudio



# Working with notebooks

- ▶ Notebooks are the best way to work with **R**
- ▶ Allow you to work interactively
  - ▶ they save your work so you can see it later
  - ▶ they also let you document your work
- ▶ R code is stored in chunks
  - ▶ each chunk can be run separately, or together
  - ▶ click on the green arrow to execute each chunk

```
1 ---
2 title: "R Notebook"
3 output: html_notebook
4 |---
5
6 This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute code
7 within the notebook, the results appear beneath the code.
8
9 Try executing this chunk by clicking the *Run* button within the chunk or by placing
10 your cursor inside it and pressing *Ctrl+Shift+Enter*.
11
12 ```{r}
13 plot(cars)
14
15 Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing
16 *Ctrl+Alt+I*.
```

# Loading and creating notebooks

- ▶ To load a Notebook, double-click on the file or
  - ▶ select **File|Open File**
- ▶ To create a new Notebook
  - ▶ select **File|New File|R Notebook**
  - ▶ will create a skeleton Notebook containing text and chunks of **R** code
  - ▶ remember to save the Notebook!
- ▶ When all the code is working, click on the Knit button to run the whole Notebook and create the output

The file `Introduction_to_R_Tutorial.Rmd` contains exercises to work through.

- ▶ If you haven't used **R** very much, start at the beginning
- ▶ If you are finding these too easy, skip to the **Advanced R** section

# How to run the tutorials

It's probably best to run the examples by

1. reading the text before each one
2. executing each line one at a time by putting your cursor in the line and hitting [Ctrl][Enter]

rather than by just executing the chunks.

When you are finished, you can `knit` the tutorial. You will get a `.pdf` which can be a manual.



# Getting help

- ▶ There is a lot of help in **RStudio**
- ▶ For online help, use <https://rseek.org/>.
- ▶ Check the R reference card in the /data directory