An example R Markdown file

Illustrating use of R, bash, Python, and Julia code chunks

Christopher Paciorek

2022-02-01

1) How to generate a document from this file

From within R, you can run the document through the either the *rmarkdown* or *knitr* package for R to generate an html file, or through the *rmarkdown* package to generate PDF or Word (the latter being useful at times but hopefully avoidable).

```
library(quarto); quarto_render('demo-Rmd.Rmd', 'html')
library(quarto); quarto_render('demo-Rmd.Rmd', 'pdf')
library(rmarkdown); render('demo-Rmd.Rmd', 'pdf_document')
library(rmarkdown); render('demo-Rmd.Rmd', 'html_document')
library(rmarkdown); render('demo-Rmd.Rmd', 'word_document')
library(knitr); knit2html('demo-Rmd.Rmd')
```

Or in RStudio, click on the 'Knit' pull-down menu and choose to knit to HTML, PDF, or Word (for R Markdown) or use the 'Render' button in more recent versions of RStudio.

Alternatively, from the UNIX command line, run one of these:

```
quarto render demo-Rmd.Rmd --to html  # HTML
quarto render demo-Rmd.Rmd --to pdf  # pdf
Rscript -e "library(rmarkdown); render('demo-Rmd.Rmd', 'pdf_document')"  # PDF
Rscript -e "library(rmarkdown); render('demo-Rmd.Rmd', 'html_document')"  # HTML
Rscript -e "library(rmarkdown); render('demo-Rmd.Rmd', 'word_document')"  # Word
Rscript -e "library(knitr); knit2html('demo-Rmd.Rmd')"  # HTML alternative
```

2) Some basic Markdown formatting

Here's an *introduction* to our **critical** discovery. Here we have some code to display inline but not evaluate: `exp(7)` and we can embed the code in a static code block as follows:

```
a = 7 %% 5
b = exp(a)
```

This document will focus on embedding math and code and not on standard Markdown formatting. There are lots of sources of information on Markdown. RStudio has good information on R Markdown (including Markdown formatting).

For documents whose output format is HTML, you can use HTML formatting within your Markdown-based text.

3) Embedding equations using LaTeX

This can be done with the following syntax. Note that you can't have a space after the initial $ for the inline equations.

Here is an inline equation $f(x) = \int f(y, x)dy$.

Here's a displayed equation

$$f_\theta(x) = \int f_\theta(y, x)dy.$$

4) Embedding R code

Here's an R code chunk

```
a <- c(7, 3)
mean(a)
```

```
[1] 5
```

```
b <- a + 3
mean(b)
```

```
[1] 8
```

Here's another chunk:

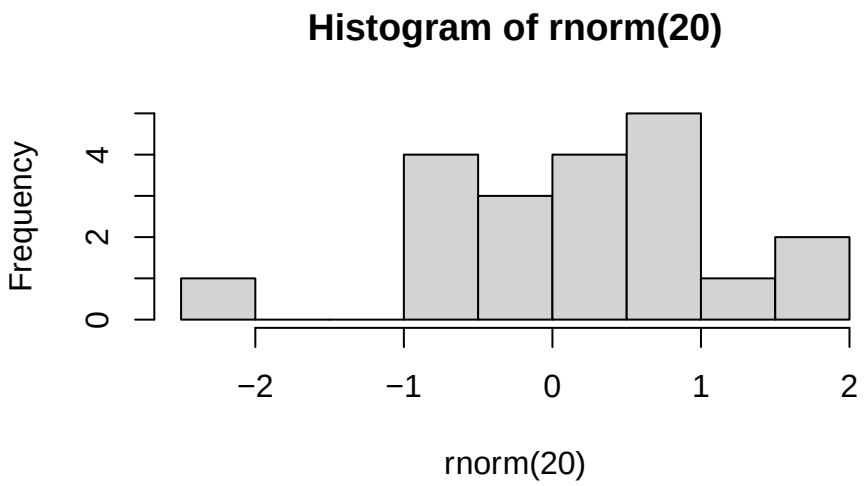
```
mean(b)
```

```
[1] 8
```

When running R code, output is printed interspersed with the code, as one would generally want. Also, later chunks have access to result from earlier chunks (i.e., state is preserved between chunks).

Let's make a plot:

```
hist(rnorm(20))
```



And here's some inline R code: What is 3 plus 5? 8.

5) Controlling code chunk behavior

You have control over whether code in chunks is echoed into the document and evaluated using the `include`, `echo`, and `eval` tags.

Here we print the code but don't evaluate it by setting `eval` to `false`.

```
cat("This code is not evaluated, but the code itself is printed in the document.")
```

Here is the result of running the code in a chunk but not printing the code by setting `eval` to `false`.

```
This code is not printed in the document, but results of evaluating the code are printed.
```

And here is a chunk that is evaluated, but neither the code nor the result of evaluating the code is printed in the rendered document. This is achieved by setting `include` to `false`.

Results of intensive calculations can be saved using the `cache=TRUE` tag so they don't need to be rerun every time you compile the document.

```
a <- mean(rnorm(5e7))
a
```

```
[1] 8.562798e-05
```

You can use R variables to control the chunk options. Note that the variable `myControlVar` is defined in the first chunk of this document. Here it is used to turn off evaluation of the chunk code.

```
print("hi")
```

An alternative, nice way to specify chunk options is within the chunk, like this:

```
cat("This code is printed in the document, but the code is not evaluated.")
```

6) Embedding bash and Python code

6.1) bash

A bash chunk:

```
ls -l
df -h
cd /tmp
pwd
```

```
total 1290
drwxr-sr-x 6 paciorek scfstaff      8 Feb 25 14:37 assets
drwxr-sr-x 2 paciorek scfstaff     10 Feb  1  2022 cache
-rw-r--r-- 1 paciorek scfstaff    394 Feb 25 14:37 _config.yml
-rw-r--r-- 1 paciorek scfstaff    150 Sep 27  2023 demo2.R
```

```
-rw-r--r-- 1 paciorek scfstaff    252 Sep 27  2023 demo2.R~
-rw-r--r-- 1 paciorek scfstaff   8083 Feb 25 14:37 demo-bash.ipynb
-rw-r--r-- 1 paciorek scfstaff  48673 Feb 25 14:37 demo-bash.pdf
drwxr-sr-x 7 paciorek scfstaff      7 Aug 31  2022 demo_cache
-rw-r--r-- 1 paciorek scfstaff  22979 Feb  3  2022 demo.docx
drwxr-sr-x 8 paciorek scfstaff      8 Feb 27 16:54 demo_files
-rw-r--r-- 1 paciorek scfstaff  83214 Feb 27 16:54 demo.html
-rw-r--r-- 1 paciorek scfstaff  24939 Feb 25 14:37 demo.lyx
-rw-r--r-- 1 paciorek scfstaff  74674 Feb 27 16:54 demo.pdf
-rw-r--r-- 1 paciorek scfstaff    218 Feb 25 14:37 demo.py
-rw-r--r-- 1 paciorek scfstaff    150 Sep 27  2023 demo.py~
drwxr-sr-x 3 paciorek scfstaff      3 Feb 27 16:21 demo-python_files
-rw-r--r-- 1 paciorek scfstaff   6936 Feb 25 14:37 demo-python.ipynb
-rw-r--r-- 1 paciorek scfstaff  49626 Feb 25 14:37 demo-python.pdf
-rw-r--r-- 1 paciorek scfstaff   3662 Jan 27  2022 _demo-python.qmd
drwxr-sr-x 4 paciorek scfstaff      4 Sep 27  2023 demo-q_cache
drwxr-sr-x 5 paciorek scfstaff      5 Feb 25 14:37 demo-q_files
-rw-r--r-- 1 paciorek scfstaff  68377 Feb 25 14:37 demo-q.html
-rw-r--r-- 1 paciorek scfstaff  17774 Feb 27 16:48 demo.qmd
-rw-r--r-- 1 paciorek scfstaff  13004 Aug 18  2022 demo.qmd~
-rw-r--r-- 1 paciorek scfstaff  79811 Feb 25 14:37 demo-q.pdf
-rw-r--r-- 1 paciorek scfstaff    252 Feb 25 14:37 demo.R
-rw-r--r-- 1 paciorek scfstaff 124604 Feb 25 14:37 demo-R.ipynb
drwxr-sr-x 4 paciorek scfstaff      4 Feb 27 16:38 demo-Rmd_cache
drwxr-sr-x 4 paciorek scfstaff      4 Feb 27 16:38 demo-Rmd_files
-rw-r--r-- 1 paciorek scfstaff  14376 Feb 27 16:54 demo-Rmd.rmarkdown
-rw-r--r-- 1 paciorek scfstaff  14217 Feb 27 16:38 demo-Rmd.Rmd
-rw-r--r-- 1 paciorek scfstaff  10853 Nov  6  2019 demo.Rmd.save
-rw-r--r-- 1 paciorek scfstaff  12462 Feb 25 14:37 demo.Rnw
-rw-r--r-- 1 paciorek scfstaff  59736 Feb 25 14:37 demo-R.pdf
-rw-r--r-- 1 paciorek scfstaff  12890 Feb 25 14:37 demo.Rtex
drwxr-sr-x 3 paciorek scfstaff      3 Jan  6  2023 demo-with-interactive_files
-rw-r--r-- 1 paciorek scfstaff  17113 Jan  6  2023 demo-with-interactive.html
-rw-r--r-- 1 paciorek scfstaff    343 Feb 25 14:37 _demo-with-interactive.qmd
-rw-r--r-- 1 paciorek scfstaff    269 Jan  6  2023 demo-with-interactive.qmd~
drwxr-sr-x 2 paciorek scfstaff      5 Jul 30  2015 figure
drwxr-sr-x 2 paciorek scfstaff      3 Feb 25 14:37 _includes
-rw-r--r-- 1 paciorek scfstaff  10676 Feb 27 16:48 index.qmd
-rw-r--r-- 1 paciorek scfstaff  10222 Nov  5 15:35 index.qmd~
drwxr-sr-x 2 paciorek scfstaff      4 Feb 25 14:37 _layouts
-rw-r--r-- 1 paciorek scfstaff    377 Feb 27 16:25 license.qmd
-rw-r--r-- 1 paciorek scfstaff     68 Feb 25 14:37 macros.md
-rw-r--r-- 1 paciorek scfstaff     40 Sep 28  2023 macros.md~
```

```
-rw-r--r-- 1 paciorek scfstaff     61 Feb 25 14:37 macros.tex
-rw-r--r-- 1 paciorek scfstaff     40 Sep 28  2023 macros.tex~
-rw-r--r-- 1 paciorek scfstaff    463 Feb 25 14:37 Makefile
-rw-r--r-- 1 paciorek scfstaff 171796 Feb 25 14:37 python-in-RStudio.pdf
-rw-r--r-- 1 paciorek scfstaff   2055 Feb 25 14:37 python-in-RStudio.Rmd
-rw-r--r-- 1 paciorek scfstaff    918 Feb 27 16:53 _quarto.yml
-rw-r--r-- 1 paciorek scfstaff    876 Feb 27 16:47 _quarto.yml~
-rw-r--r-- 1 paciorek scfstaff    831 Feb 25 14:37 README.md
-rw-r--r-- 1 paciorek scfstaff  14902 Feb 25 14:37 refs.bib
drwxr-sr-x 2 paciorek scfstaff      7 Feb 25 14:37 _sass
drwxr-sr-x 7 paciorek scfstaff     30 Feb 27 16:39 _site
drwxr-sr-x 7 paciorek scfstaff      7 Feb 27 16:54 site_libs
drwxr-sr-x 3 paciorek scfstaff      3 Feb 25 14:40 test_files
-rw-r--r-- 1 paciorek scfstaff   7167 Jul 17  2015 test-line-formatting.Rnw
-rw-r--r-- 1 paciorek scfstaff  14477 Sep 28  2023 test.pdf
drwxr-sr-x 3 paciorek scfstaff      3 Sep 27  2023 testq_cache
drwxr-sr-x 4 paciorek scfstaff      4 Sep 27  2023 testq_files
-rw-r--r-- 1 paciorek scfstaff  64072 Sep 27  2023 testq.html
-rw-r--r-- 1 paciorek scfstaff    387 Sep 27  2023 test.qmd~
-rw------- 1 paciorek scfstaff   5285 Sep 28  2023 test.tex~
-rw-r--r-- 1 paciorek scfstaff    390 Feb 27 16:53 tmp.txt
Filesystem                          Size  Used Avail Use% Mounted on
/dev/sda2                            59G   32G   25G  57% /
tmpfs                                16G  126M   16G   1% /dev/shm
tmpfs                               3.2G  3.4M  3.2G   1% /run
tmpfs                               5.0M  4.0K  5.0M   1% /run/lock
/dev/sdb1                           111G  489M  105G   1% /tmp
/dev/sda1                           499M  6.1M  493M   2% /boot/efi
/dev/sda3                            59G   47G  9.3G  84% /var
/dev/sda5                           2.6T  1.3T  1.2T  53% /var/tmp
oz.berkeley.edu:/pool0/accounts      67T   23T   45T  34% /accounts
tmpfs                               3.2G  132K  3.2G   1% /run/user/3189
oz.berkeley.edu:/pool0/system       6.0T  4.9T  1.2T  81% /system
oz.berkeley.edu:/pool0/scratch       37T   35T  2.5T  94% /scratch
/tmp
```

Unfortunately, output from bash chunks occurs after all the code is printed. Also, state is not preserved between chunks.

We can see that state is not preserved here, where the current working directory is NOT the directory that we changed to in the chunk above.

```
pwd  # result would be /tmp if state were preserved
```

```
/accounts/vis/paciorek/staff/tutorials/tutorial-dynamic-docs
```

Inline bash code won't work: `bash wc demo-Rmd.Rmd`, unlike with R code.

6.2) Embedding Python code

You can embed Python code. As with R, state is preserved so later chunks can use objects from earlier chunks.

```
import numpy as np
x = np.array((3, 5, 7))
print(x.sum())
```

```
15
```

```
x.min()    # this will print with more recent versions of rmarkdown
```

```
3
```

```
try:
        print(x[0])
except NameError:
       print('state is not preserved: x does not exist')
```

```
3
```

There is no facility for inline Python code: `python print(3+5)`

6.3) Embedding Julia code

You can embed Julia code. As with R and Python, state is preserved so later chunks can use objects from earlier chunks.

```
x = [3, 5, 7];
x[2]
```

```
5
```

```
try
    println("state is preserved if we see the value of `x[2]` next")
    print(x[2])
catch
    print("state is not preserved: x does not exist")
end
```

```
state is preserved if we see the value of `x[2]` next
5
```

There is no facility for inline Julia code: `julia print(3+5)`

7) Reading code from an external file

It's sometimes nice to draw code in from a separate file. Before invoking a chunk, we need to read the chunks from the source file, which contains the chunks tagged with some special formatting. Note that a good place for reading the source file via `read_chunk()` is in an initial setup chunk at the beginning of the document.

```
a <- 7
cat("a is ", a, ".\n", sep = "")
```

```
a is 7.
```

```
a <- 9
cat("Now, a is ", a, ".\n", sep = "")
```

```
Now, a is 9.
```

8) Formatting of long lines of code and of output

8.1) R code

Having long lines be nicely formatted and other aspects of formatting can be a challenge. Also, results can differ depending on your output format (e.g., PDF vs. HTML). In general the code in this section will often overflow the page width in PDF but not in HTML, but even in the HTML the line breaks may be awkwardly positioned.

Here are some examples that overflow in PDF output.

```
b <- "Statistics at UC Berkeley: We are a community engaged in research and education in prob
## Statistics at UC Berkeley: We are a community engaged in research and education in probab

## This should work to give decent formatting in HTML but doesn't in PDF.
cat(b, fill = TRUE)
```

```
Statistics at UC Berkeley: We are a community engaged in research and education in probabilit
```

```
vecWithALongName = rnorm(100)
a = length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) + vecWithALon
a = length(mean(5 * vecWithALongName + vecWithALongName)) # this is a comment that goes over
a = length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) + vecWithALon
```

In contrast, long output is usually fine, even in PDF.

```
rnorm(30)
```

```
 [1]  0.47485053 -0.53300834 -0.69385985 -1.30288852 -1.14076964 -1.04437702
 [7]  0.51995461  0.15155954  0.55836893 -1.87940055 -0.99908618 -0.47083913
[13]  0.88461719 -2.47235000  1.55333948  1.41114869  1.91056609 -0.62932679
[19]  1.22380063  1.12960580 -0.84659648 -0.65229492  1.83760743 -1.32678114
[25]  0.50964439 -0.80747544 -0.03085863 -0.91200119  0.82473210  0.70518136
```

Adding the `tidy=TRUE` chunk option and setting the width (as shown in the Rmd version of this document) can help with long comment lines or lines of code, but doesn't help for some of the cases above.

```
## Long strings and long comments:

b <- "Statistics at UC Berkeley: We are a community engaged in research and education in prob
## Statistics at UC Berkeley: We are a community engaged in research and
## education in probability and statistics. In addition to developing
## fundamental theory and methodology, we are actively

## This should work to give decent formatting in HTML but doesn't in PDF:

cat(b, fill = TRUE)
```

```
Statistics at UC Berkeley: We are a community engaged in research and education in probabili
```

```
## Now consider long lines of code:

vecWithALongName <- rnorm(100)
a <- length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) +
    vecWithALongName * vecWithALongName, na.rm = TRUE))
a <- length(mean(5 * vecWithALongName + vecWithALongName))  # this is a comment that goes ove
a <- length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) +
    vecWithALongName, na.rm = TRUE))  # this is a comment that goes over the line by a good
```

To address the problems seen above, sometimes you can format things manually for better results. You may need to tag the chunk with `tidy=FALSE`, but I have not done that here.

```
## Breaking up a string:

b <- "Statistics at UC Berkeley: We are a community engaged in research
 and education in probability and statistics. In addition to developing
fundamental theory and methodology, we are actively"

## Breaking up a comment:

## Statistics at UC Berkeley: We are a community engaged in research and
## education in probability and statistics. In addition to developing
## fundamental theory and methodology, we are actively

## Breaking up code lines:

vecWithALongName = rnorm(100)
a <- length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) +
```

```
    vecWithALongName * vecWithALongName, na.rm = TRUE))
a <- length(mean(5 * vecWithALongName + vecWithALongName)) # this is a comment that
    ## goes over the line by a good long ways
a <- length(mean(5 * vecWithALongName + vecWithALongName - exp(vecWithALongName) +
    vecWithALongName, na.rm = TRUE)) # this is a comment that goes over the line
    ## by a good long long long long long long long long ways
```

8.2) bash code

In bash, we have similar problems with lines overflowing in PDF output, but bash allows us to use a backslash to break lines of code. However that strategy doesn't help with long lines of output.

```
echo "Statistics at UC Berkeley: We are a community engaged in research and education in prob

echo "Second try: Statistics at UC Berkeley: We are a community engaged \
in research and education in probability and statistics. In addition to \
developing fundamental theory and methodology, we are actively" \
>> tmp.txt

cat tmp.txt
```

```
Statistics at UC Berkeley: We are a community engaged in research and education in probabili
Second try: Statistics at UC Berkeley: We are a community engaged in research and education
```

We also have problems with long comments, so we would need to manually format them.

Here is a long comment line that overflows in PDF:

```
# asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla lakjsdf aljdkfad kljafda kaljdf afdll
```

Instead manually break the comment into multiple lines:

```
# asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla
# lakjsdf aljdkfad kljafda kaljdf afdlkja lkajdfsa lajdfa
# adlfjaf jkladf afdl
```

8.3) Python code

In Python, there is similar trouble with lines overflowing in PDF output too.

```
# This overflows the page:

b = "asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla lakjsdf aljdkfad kljafda kaljdf a
print(b)
```

```
asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla lakjsdf aljdkfad kljafda kaljdf afdlkj
```

```
# This code overflows the page:

zoo = {"lion": "Simba", "panda": None, "whale": "Moby", "numAnimals": 3, "bear": "Yogi", "ki
print(zoo)
```

```
{'lion': 'Simba', 'panda': None, 'whale': 'Moby', 'numAnimals': 3, 'bear': 'Yogi', 'killer w
```

To fix the issue, we can manually break the code into multiple lines, but long output still overflows.

```
zoo = {"lion": "Simba", "panda": None, "whale": "Moby",
       "numAnimals": 3, "bear": "Yogi", "killer whale": "shamu",
       "bunny:": "bugs"}
print(zoo)
```

```
{'lion': 'Simba', 'panda': None, 'whale': 'Moby', 'numAnimals': 3, 'bear': 'Yogi', 'killer w
```

Long comments overflow as well, but you can always manually break into multiple lines.

```
# asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla lakjsdf aljdkfad kljafda kaljdf afdl

# asdl lkjsdf jklsdf kladfj jksfd alkfd klasdf klad kla lakjsdf aljdkfad
# kljafda kaljdf afdlkja lkajdfsa lajdfa adlfjaf jkladf afdl
```

9) References

We'll just see how you use BibTeX style references. Banerjee et al. (2008) proposed a useful method. This was confirmed (Cressie and Johannesson 2008).

Note the indication of the `refs.bib` file in the initial lines of this document so that the bibliographic information for these citations can be found.

The list of references is placed at the end of the document. You'd presumably want a section header like this:

Literature cited

Banerjee, S., A. E. Gelfand, A. O. Finley, and H. Sang. 2008. "Gaussian Predictive Process Models for Large Spatial Data Sets." *Journal of the Royal Statistical Society B* 70 (4): 825–48.

Cressie, N., and G. Johannesson. 2008. "Fixed Rank Kriging for Very Large Spatial Data Sets." *Journal of the Royal Statistical Society B* 70 (1): 209–26.