A Short Workflow Exercise with RavenR v1.3

Dr. James R. Craig, Robert Chlumsky

May 2019

This short document is intended to get you started with using RavenR to aid your analysis with the Raven model. This will get you up and running with the RavenR package and comfortable running a few commands. Some knowledge or R is presumed in this document. If you are not comfortable with R, take a look at any number of R training and Introductory resources, such as the tRaining repository) on Github.

This exercise will use the Nith River modelled output available from within the RavenR package, thus the functions to read in data from csv files are not required. However, it is recommended that you download the Nith river model files, and try to both run the model and read in the output files. The Nith river model can be downloaded from the Raven Tutorial #2.

As you go through this tutorial, don't just follow along blindly. Try to pay attention to what you are doing and how you are doing it.

Getting Acquainted with RavenR

Start a new Rstudio session by opening RStudio. If you don't have RavenR yet installed in your R library, run the following commands to install the latest version of RavenR from Github (you will need the **devtools** library to be installed and loaded as well, so install this library first if you haven't yet).

```
# install.packages("devtools")
library(devtools)
devtools::install_github("rchlumsk/RavenR")
```

Load the RavenR library from the console and view its contents with the following commands:

```
library(RavenR)
ls("package:RavenR") # view all functions in RavenR
```

You can look at what any one of these functions does by typing out the name of the function beginning with a question mark, which will show the help information at the right of the RStudio environment.

```
?flow.scatterplot
```

Now you are ready to start using RavenR to directly visualize and manipulate model output. The sample data set from the RavenR package can be loaded in using the data function, e.g.,

```
data(forcing.data)
```

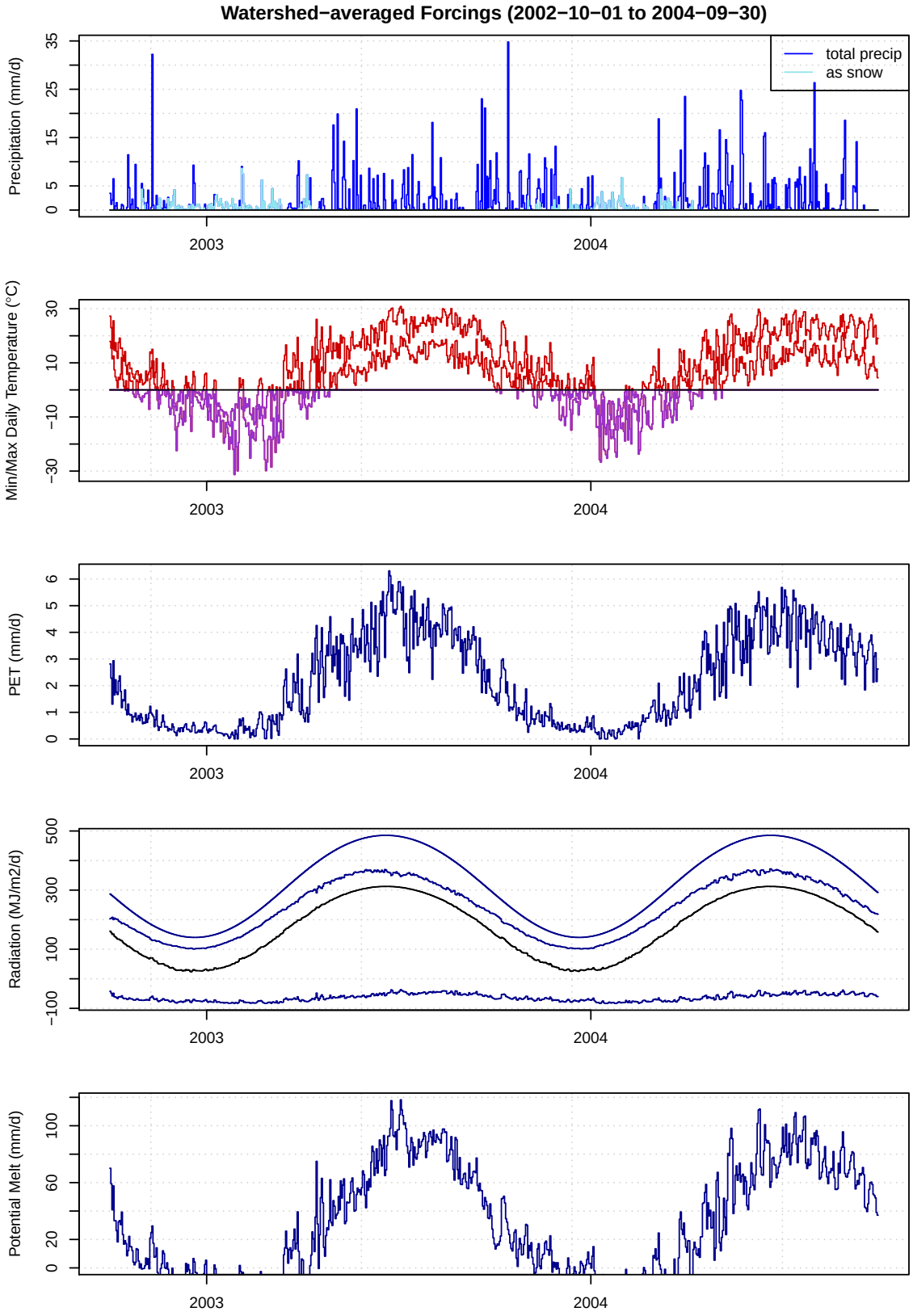
We will store the packaged forcing.data into an object called ff (and obtain just the subobject using the '$' operator), and then view the first few rows using the head function. We will show only the first few columns of the data for brevity.

```
ff <- forcing.data$forcings
head(ff[,1:6])
```

```
##            day_angle     rain snow    temp temp_daily_min temp_daily_max
## 2002-10-01   4.70809 3.468690    0 22.5956       17.92510        27.2662
## 2002-10-02   4.70809 3.468690    0 22.5956       17.92510        27.2662
## 2002-10-03   4.72530 1.189180    0 19.2076       15.40780        23.0075
## 2002-10-04   4.74251 2.083260    0 13.3714       11.49870        15.2440
## 2002-10-05   4.75973 6.474310    0 19.0304       12.50970        25.5510
## 2002-10-06   4.77694 0.125591    0 11.0186        7.43466        14.6024
```

Now we can plot the forcing data using the forcings.plot function. This creates an output of the five main forcings from the data set.

```
forcings.plot(ff)
```


Watershed−averaged Forcings (2002−10−01 to 2004−09−30)
Precipitation (mm/d)
0
5
15
25
35
total precip
as snow
2003
2004
Min/Max Daily Temperature (°C)
−30
−10
10
30
2003
2004
PET (mm/d)
0
1
2
3
4
5
6
2003
2004
Radiation (MJ/m2/d)
−100
100
300
500
2003
2004
Potential Melt (mm/d)
0
20
60
100
2003
2004

This is typically a reasonable reality check on the model forcings. We can similarly access the hydrograph fit. Here the hydrograph sample data is set to the 'hy' object (normally read in from the Hydrographs.csv file using the hyd.read function). The flows from a specific subbasin can be extracted using the hyd.extract function, which is done here for subbasin 36. The precipitation can be extracted similarly.

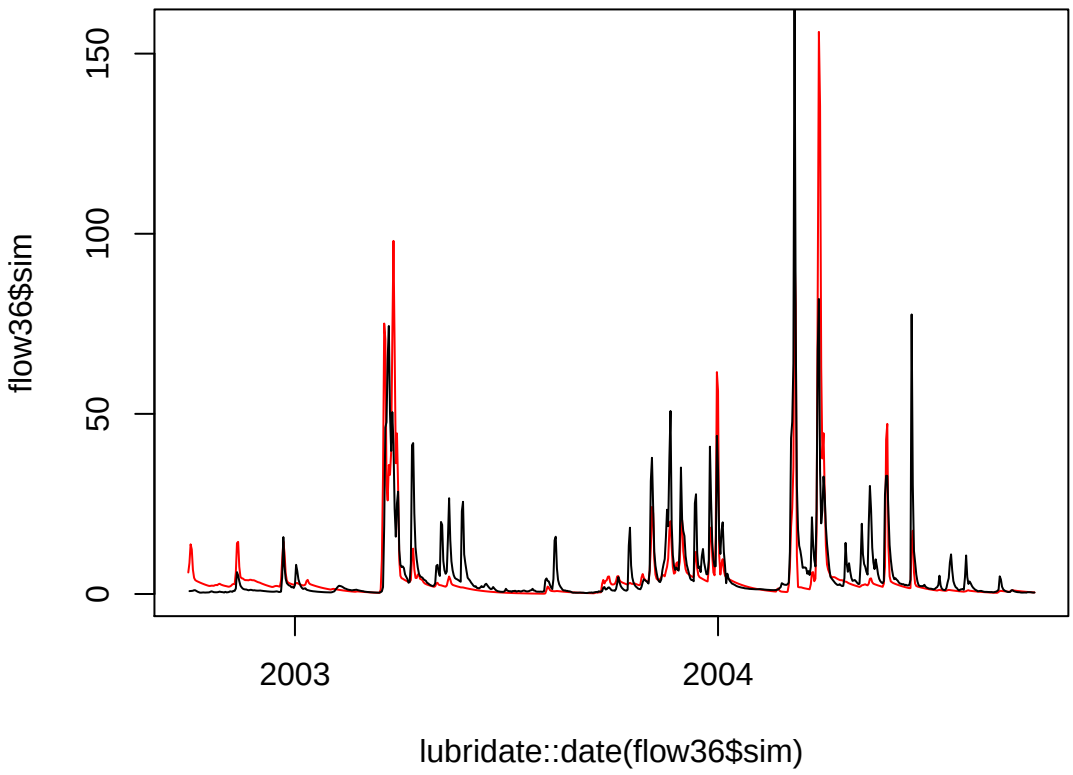
```
data(hydrograph.data)
hy <- hydrograph.data
head(hy$hyd)
```

```
##              precip    Sub36 Sub36_obs   Sub43 Sub43_obs
## 2002-10-01       NA  5.96354        NA 11.2505        NA
## 2002-10-02 3.468690  8.62464     0.801 13.3816      3.07
## 2002-10-03 1.189180 13.79200     0.828 16.6012      2.99
## 2002-10-04 2.083260 12.38190     0.860 17.4037      3.06
## 2002-10-05 6.474310  6.72838     0.903 18.7587      2.93
## 2002-10-06 0.125591  4.49263     1.040 16.3449      3.15
```

```
flow36 <- hyd.extract("Sub36",hy)
precip <- hyd.extract("precip",hy)$sim
```

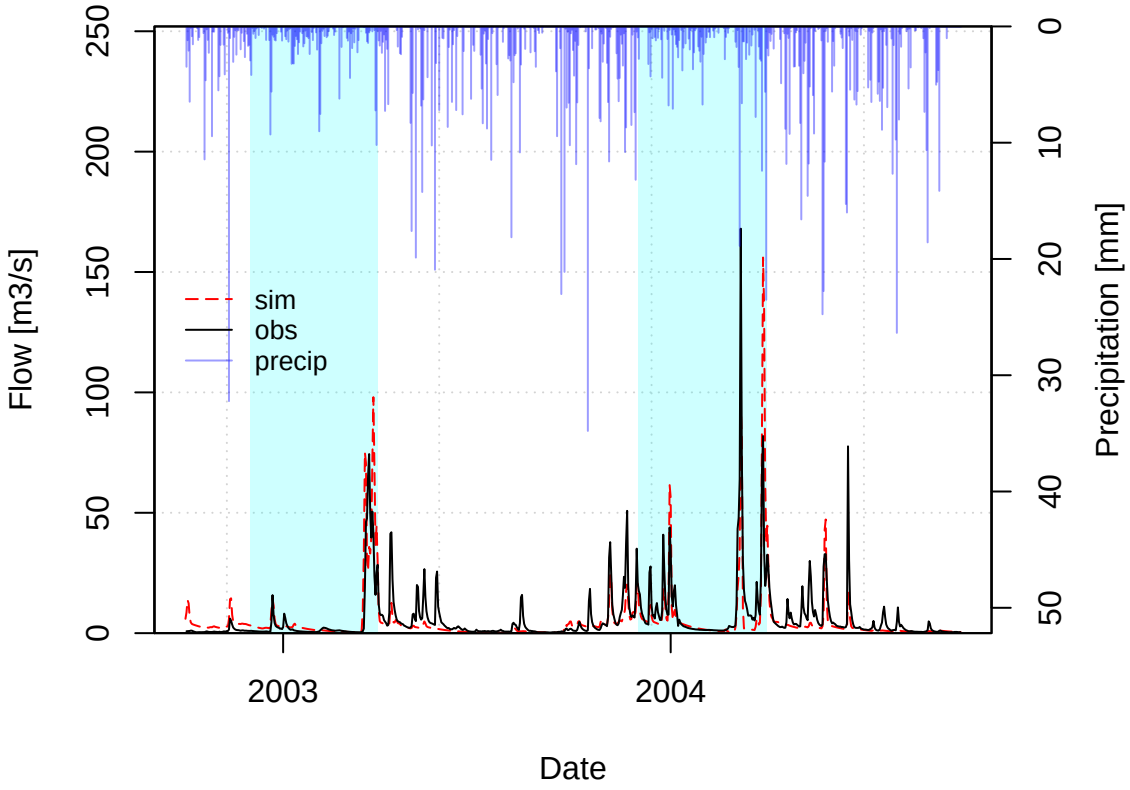
The hydrograph object flow3 now stores the simulated hydrograph (`flow36$sim`) and the observed hydrograph (`flow36$obs`), and the null subobject (`flow36$inflow`). The precip object stores the entire time series of watershed-averaged precip (`precip$sim`). We can plot the simulated and observed hydrograph with the simple commands:

```
plot(lubridate::date(flow36$sim),flow36$sim,col='red',type='l')
lines(lubridate::date(flow36$obs),flow36$obs,col='black')
```



Or using the special hydrograph plot function, which is part of the RavenR library.

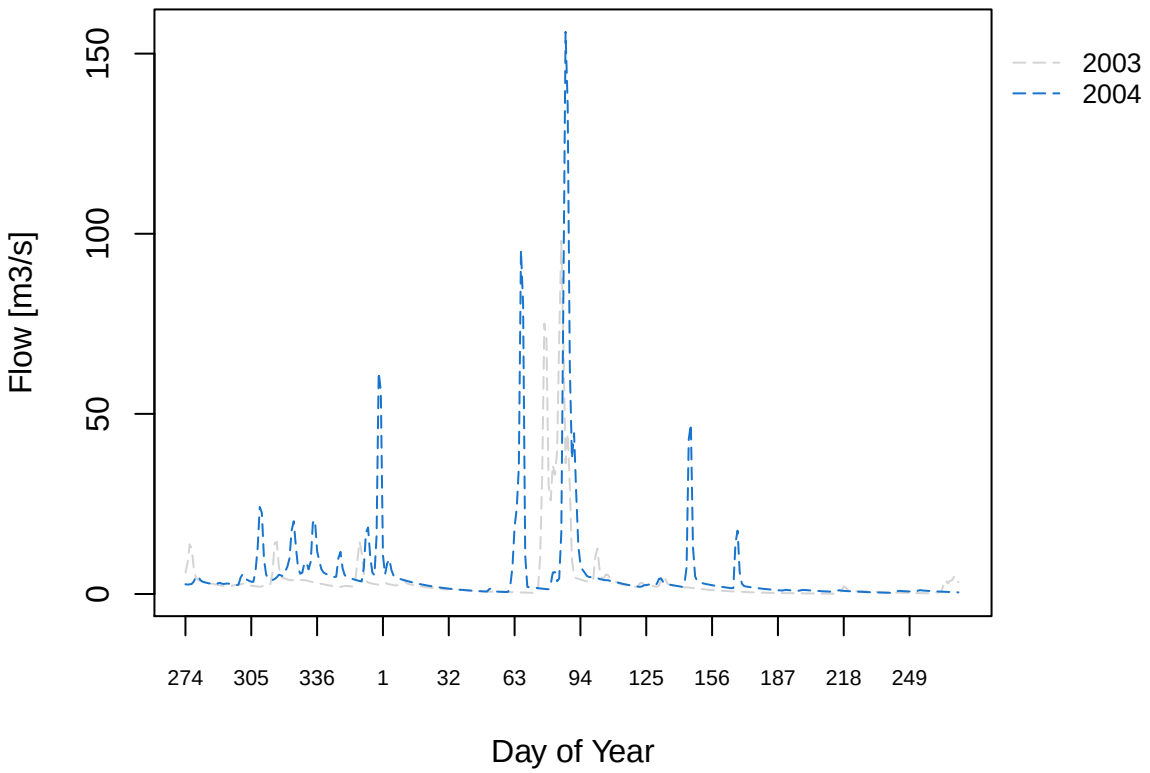
```
hyd.plot(sim=flow36$sim, obs=flow36$obs, precip=precip)
```




```
## [1] TRUE
```

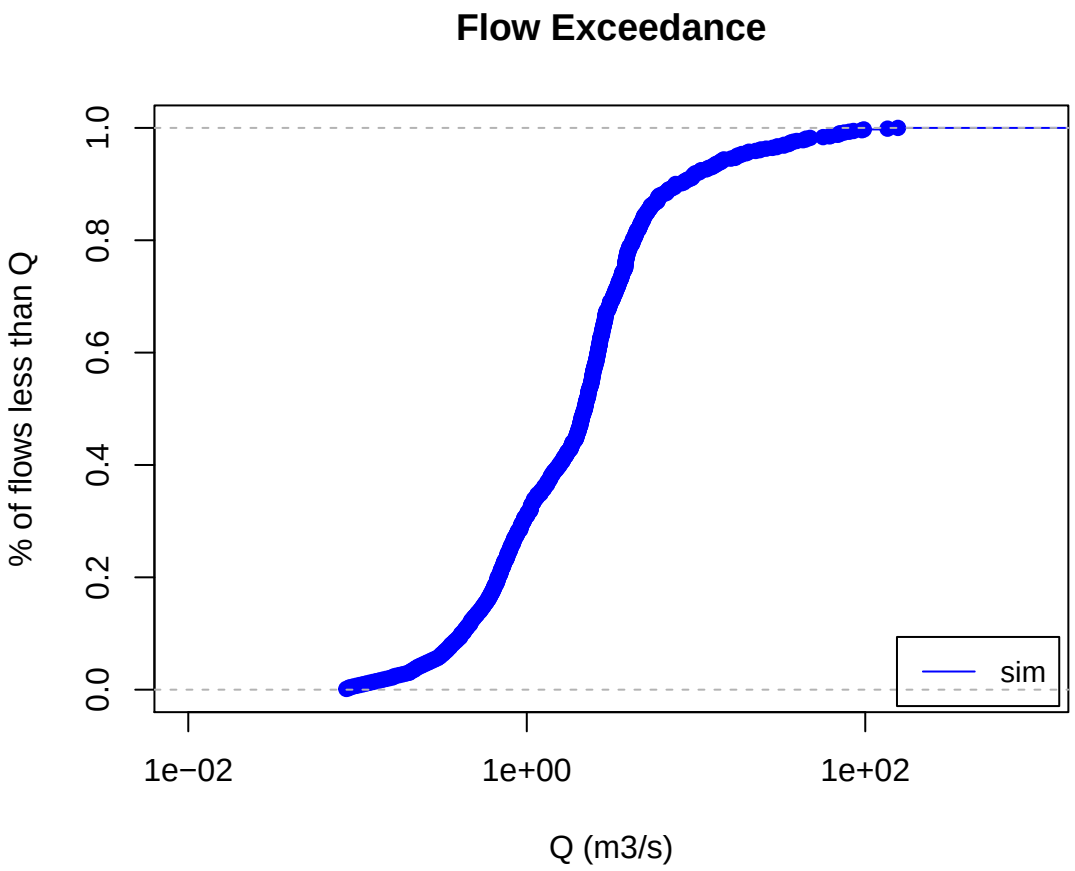
There are some other helpful functions in RavenR for understanding our hydrographs.

```
flow.spaghetti(flow36$sim)
```



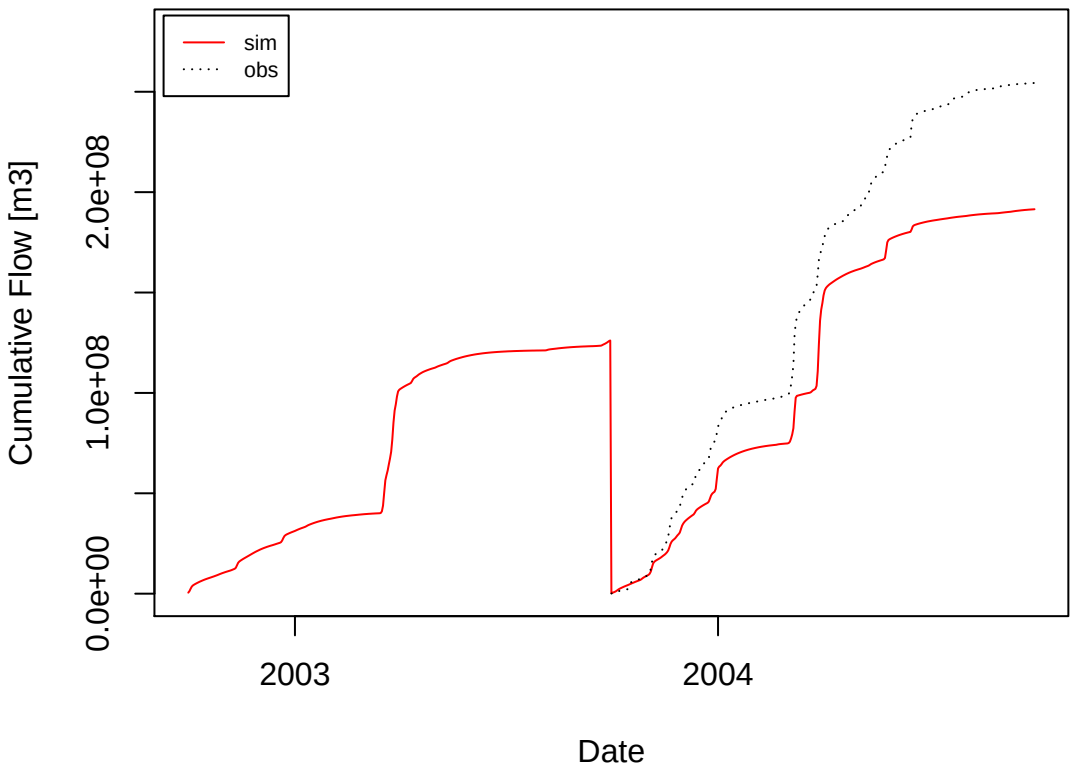

```
## [1] TRUE
```

```
flowdurcurve.plot(flow36$sim)
```



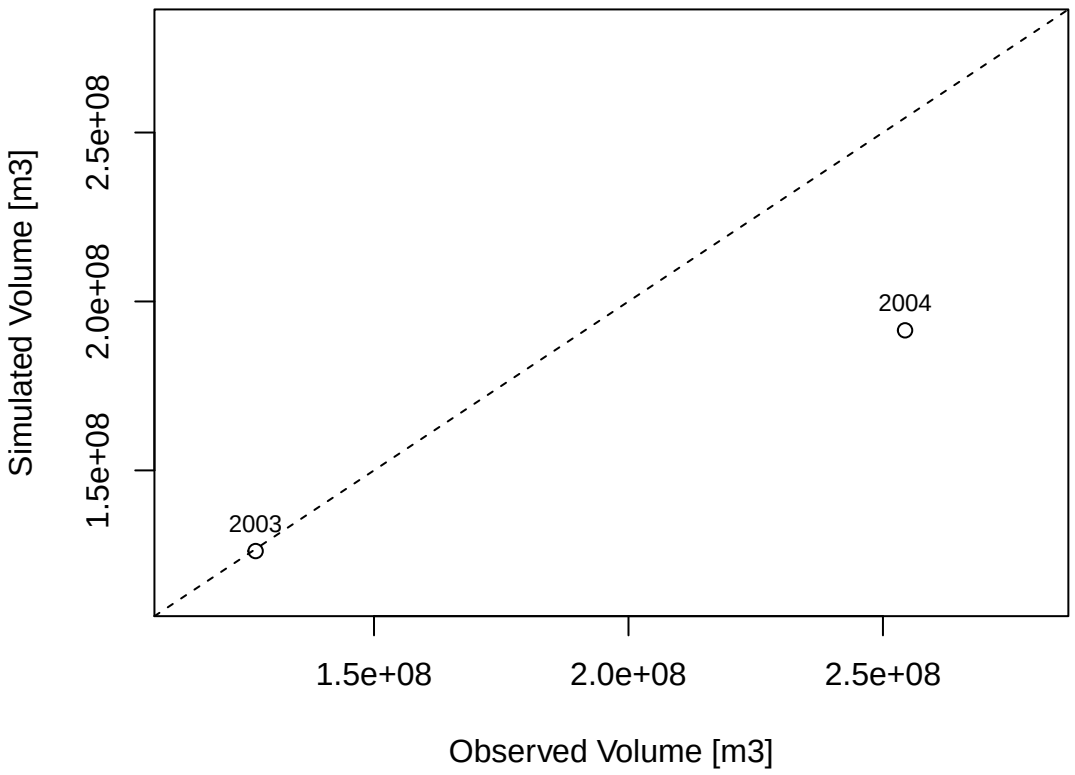
We can also use some of the Raven plots to get some diagnostics and comparisons on the simulated and observed hydrographs.

```
cum.plot.flow(flow36$sim, obs=flow36$obs)
```




```
## [1] TRUE
```

```
annual.volume(flow36$sim, flow36$obs)
```




```
##     date.end   sim.vol   obs.vol
## 1 2003-10-01 126117174 126733075
## 2 2004-09-30 191449625 254344147
```

The RavenR library can be explored to see what other functions are available in the package.

```
ls("package:RavenR")
```

Using the ?help option (where help is the name of a RavenR command), figure out how to plot:

1. a comparison of annual peak flows, and
2. the mean and median annual observed flow using the barplot() function (hint: use the apply.wyearly function to calculate annual mean and median)

Building a model workflow script

Now we will build a simple script which will provide a bunch of visualizations that we can use to look at the Nith river model each time we run it. This can be made as complex as you want.

Start with a new script. From RStudio, go to the main menu. `Choose File -> New File -> R Script`. Populate the script with the following. You can find the Nith model files in the Raven Tutorials.

```
# Load the RavenR sample data
# ====================================================
indir <- "C:/temp/Nith/"
outdir <- "C:/temp/Nith/output/"
fileprefix <- "Nith"

if (dir.exists(outdir)==FALSE) {
  dir.create(outdir)
}

setwd(outdir)

# RUN RAVEN
# ====================================================
# writes complete command prompt command
# > Raven.exe [filename] -o [outputdir]
RavenCMD <-paste(indir,"Raven.exe ",indir,fileprefix," -o ",outdir,sep="")
system(RavenCMD) # this runs raven from the command prompt
```

Once the model is run, we can read in the output (or use the package data) and save some of the plots to file.

```
# GENERATE OUTPUT PLOTS
# ====================================================
# use the package data, or read in the model output files

# ff<-forcings.read("ForcingFunctions.csv")
pdf("forcings.pdf") # create a pdf file to direct plot to
forcings.plot(ff$forcings)
dev.off() #finishes writing plot to .pdf file

data(watershed.data)
mywshd <- watershed.data$watershed.storage
#mywshd <- RavenR::watershed.read("WatershedStorage.csv")$watershed.storage
png("snowpack.png") # create a png file to direct plot to
plot(mywshd$snow)
dev.off() #finishes writing plot to .png file
```

Modify the script

Modify the above script to generate png image plots of monthly subbasin-averaged PET in Subbasin 43 using the :CustomOutput option (you will have to add a :CustomOutput command to the Raven input rvi file). You will also want to use the RavenR `custom.read()` and `customoutput.plot()` commands.

More exercises

This short exercise is meant to serve as a brief introduction to the RavenR package. The complete RavenR Tutorial can be found on the Raven downloads page or on the RavenR Github page. If you have any comments, suggestions or bug reports, please email the authors of the package or feel free to let us know on the Raven forum.