

Hydrology Analysis

Installation

Only necessary to run this cell once to set up local machine

```
install.packages('tidyverse', repos='http://cran.us.r-project.org')
```

```
##  
## The downloaded binary packages are in  
## /var/folders/r_/4w9b5lnx7n542qjy74wfz0hr0000gn/T//RtmptW0eY6/downloaded_packages
```

Set up Environment

Loads the Tidyverse and imports necessary functions

```
library(tidyverse)
```

```
## -- Attaching packages ----- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.3      v purrr   0.3.4  
## v tibble  3.1.1      v dplyr  1.0.5  
## v tidyr   1.1.3      v stringr 1.4.0  
## v readr   2.1.2      v forcats 0.5.1
```

```
## -- Conflicts ----- tidyverse_conflicts() --  
## x dplyr::filter() masks stats::filter()  
## x dplyr::lag()     masks stats::lag()
```

```
source('./Rcode/utils.R')
```

```
##  
## Attaching package: 'lubridate'  
  
## The following objects are masked from 'package:base':  
##  
##     date, intersect, setdiff, union
```

Read Data

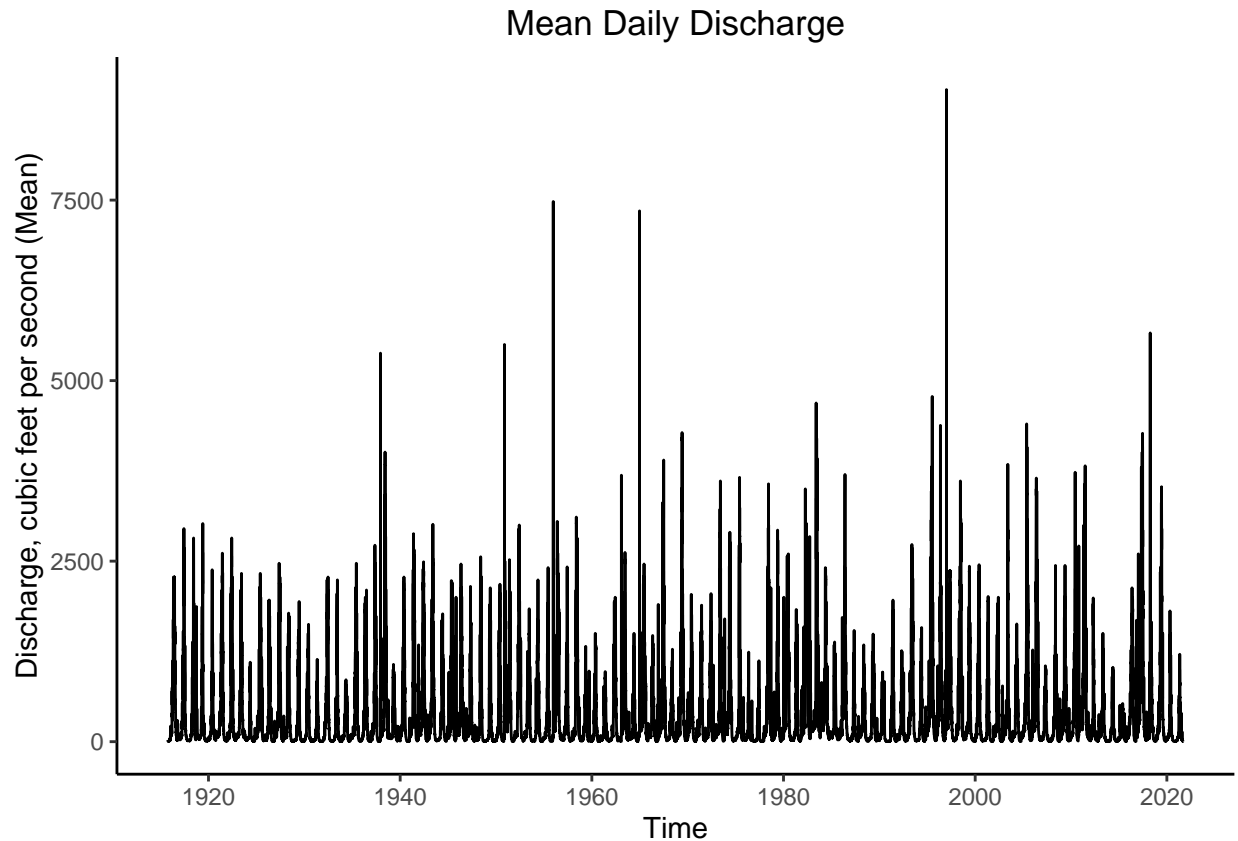
To run the programs on your desired file, set `inputFile` to the appropriate file path

```
inputFile <- './Data_Raw/MercedHI_Q_T_2022023.txt' # Set to appropriate file  
data <- readUsgsData(inputFile, startDate = ymd('1915-10-01'))
```

```
## Rows: 38755 Columns: 2-- Column specification -----  
## Delimiter: "\t"  
## dbl (1): X12  
## date (1): X3  
## i Use 'spec()' to retrieve the full column specification for this data.  
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.
```

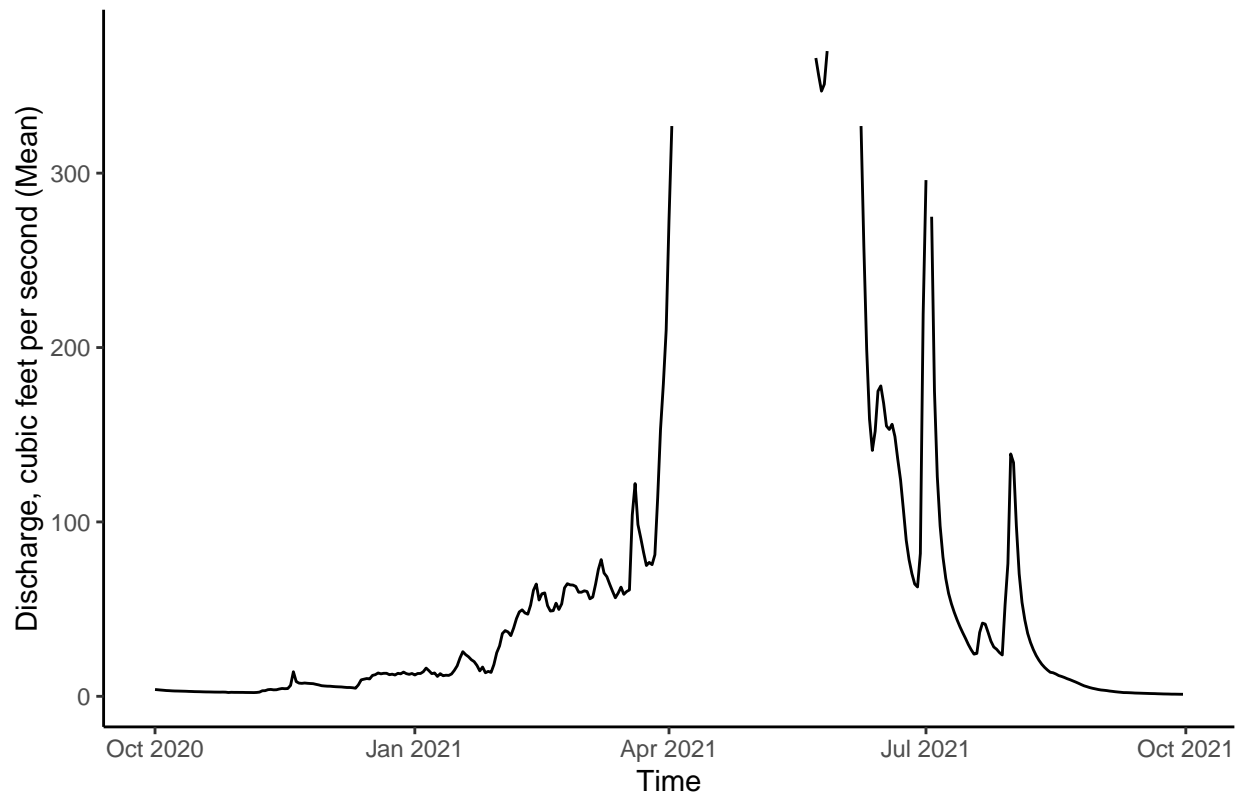
Visualize Input Data

```
ggplot(data, aes(x=date, y=dmq, group=1)) +  
  geom_line() +  
  theme_classic() +  
  ggtitle("Mean Daily Discharge") +  
  theme(plot.title = element_text(hjust = 0.5)) +  
  xlab("Time") +  
  ylab("Discharge, cubic feet per second (Mean)")
```

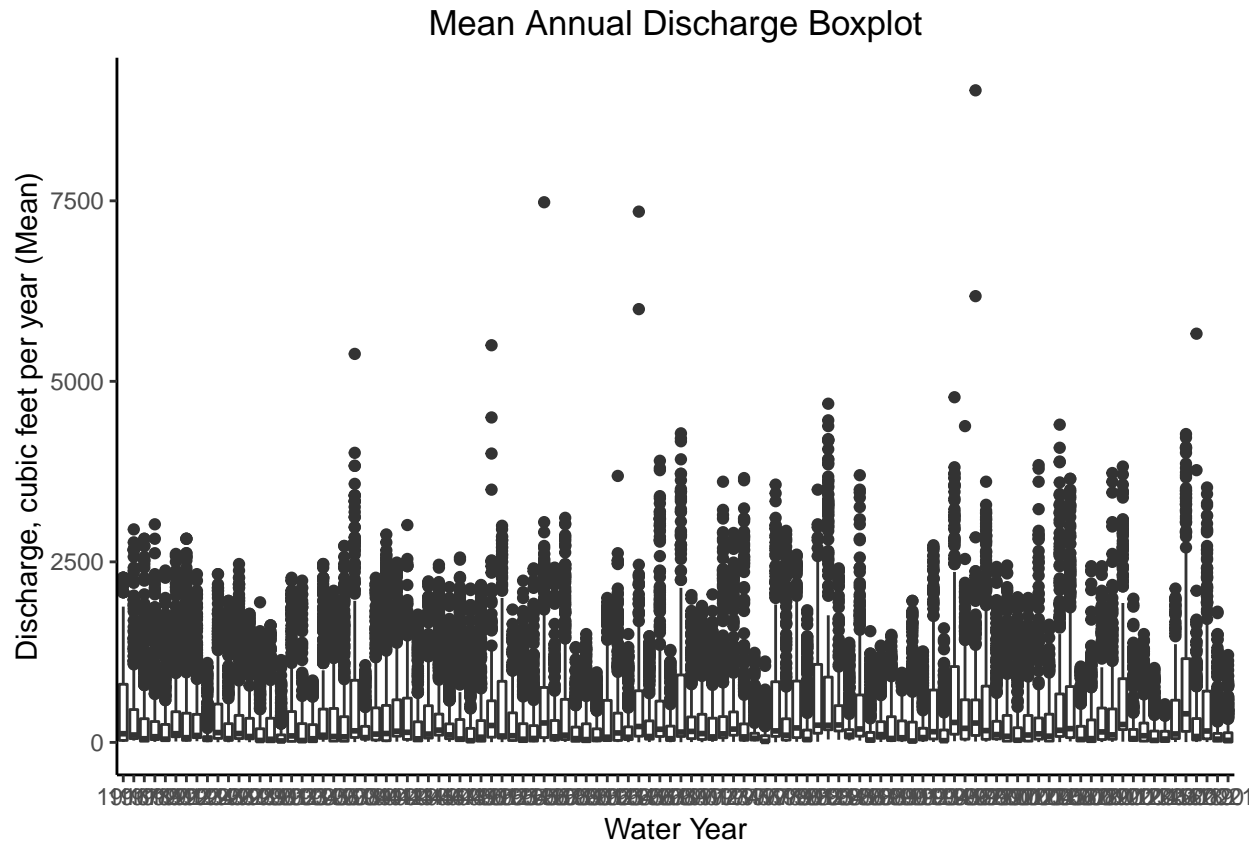


```
ggplot(data %>% filter(ifelse(mth >= 10, yr + 1, yr) == 2021), aes(x=date, y=dmq, group=1)) +  
  geom_line() +  
  ylim(NA, 375) +  
  theme_classic() +  
  ggtitle("Mean Daily Discharge (WY2021)") +  
  theme(plot.title = element_text(hjust = 0.5)) +  
  xlab("Time") +  
  ylab("Discharge, cubic feet per second (Mean)")
```

Mean Daily Discharge (WY2021)



```
ggplot(data %>% groupByWaterYear(), aes(x=as.character(waterYear), y=dmq)) +
  geom_boxplot() +
  theme_classic() +
  ggtitle("Mean Annual Discharge Boxplot") +
  theme(plot.title = element_text(hjust = 0.5)) +
  xlab("Water Year") +
  ylab("Discharge, cubic feet per year (Mean)")
```



Generate and Analyze Output

There are two cells each R program: the first will generate output and store it in the `./Output/` folder, and the second gives space to produce visualizations of the output

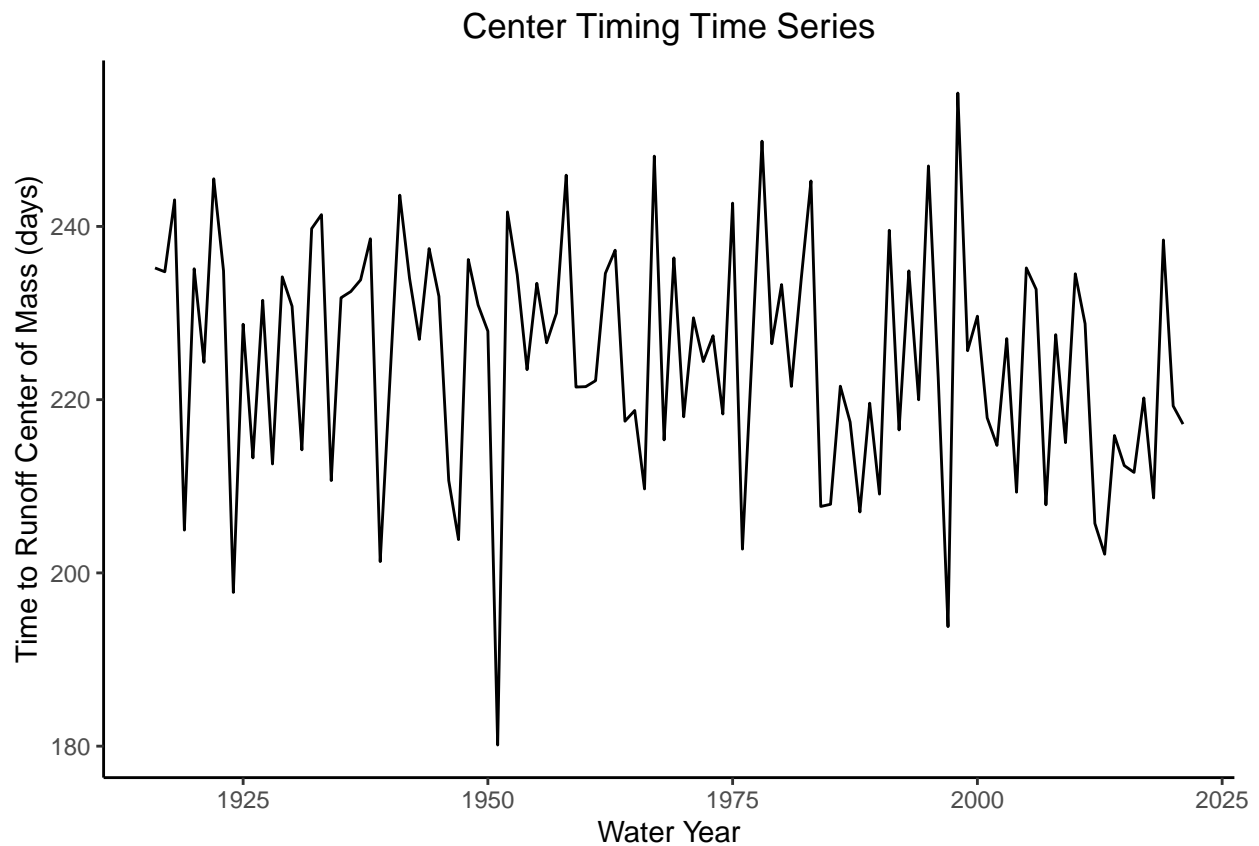
surfwtr.R Generate output

```
source('./Rcode/surfwtr.R')
surfwtrOutput <- surfwtr(data)
summarizeOutput(surfwtrOutput)
```

```
##           mean      stdDev      min      median      max
## waterYear 1968.500000  30.7435630 1916.000000 1968.500000 2021.000000
## dur       365.2547170   0.4377719  365.000000  365.000000  366.000000
## mdq       353.3120778 163.4815032   84.9175342 329.5944906 876.9132329
## cmt       224.8202139  13.5844564  180.1297975 226.5101810 255.3947903
## frsmq      0.8304872   0.0641086   0.5979763   0.8389947   0.9469093
## # A tibble: 6 x 5
##   waterYear  dur  mdq  cmt frsmq
##   <dbl> <int> <dbl> <dbl> <dbl>
## 1    1916   366  460.  235. 0.860
## 2    1917   365  405.  235. 0.853
## 3    1918   365  334.  243. 0.897
## 4    1919   365  308.  205. 0.824
```

```
## 5      1920    366  255.  235. 0.896
## 6      1921    365  396.  224. 0.813
```

```
# Space to visualize surfwtrOutput
ggplot(surfwtrOutput, aes(x=waterYear, y=cmt)) +
  geom_line() +
  theme_classic() +
  ggtitle("Center Timing Time Series") +
  theme(plot.title = element_text(hjust = 0.5)) +
  xlab("Water Year") +
  ylab("Time to Runoff Center of Mass (days)")
```



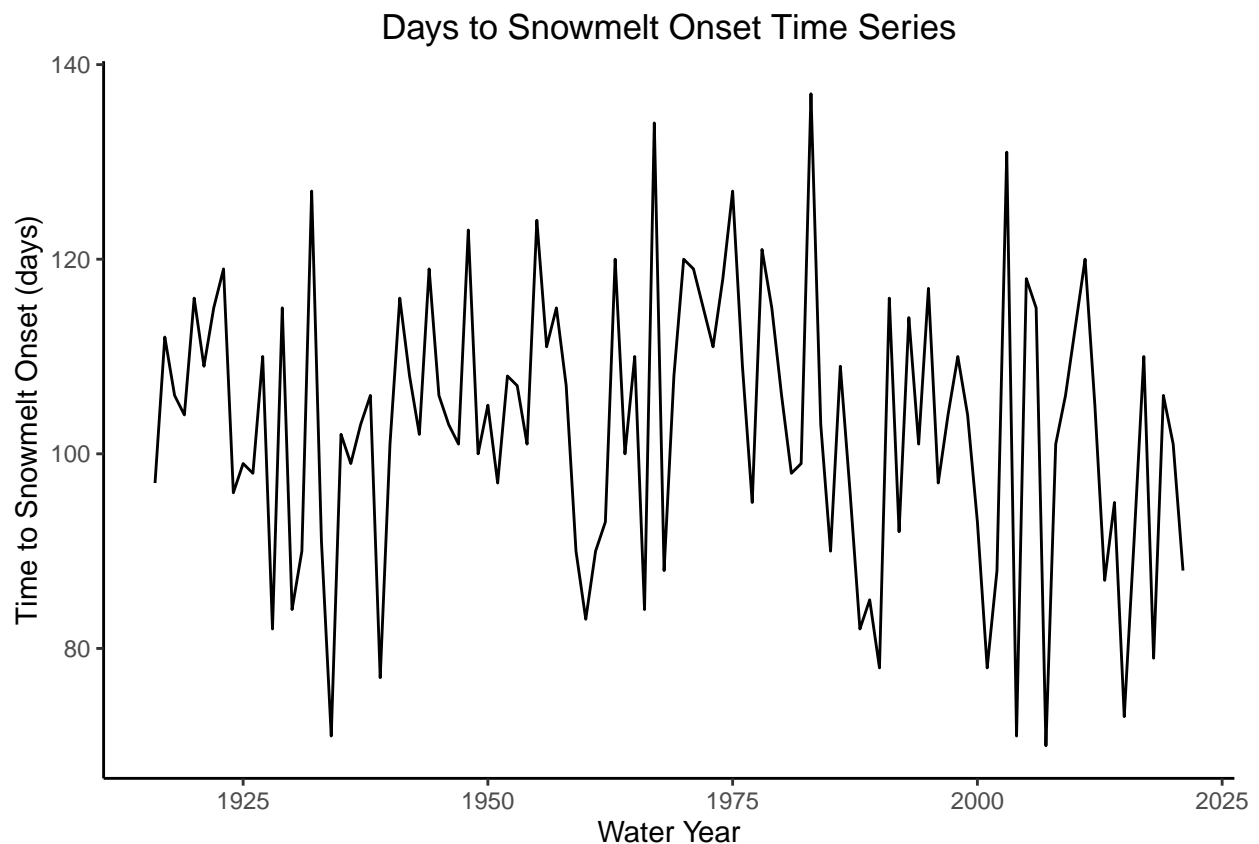
snwpulse.R Generate output

```
source('./Rcode/snwpulse.R')
snwpulseOutput <- snwpulse(data)
summarizeOutput(snwpulseOutput)
```

```
##           mean      stdDev      min      median      max
## waterYear 1968.5000  30.74356 1916.0000 1968.5000 2021.000
## mdq       507.3037  232.28708  123.0429  478.3146 1235.983
## snwpulse -34097.7462 19398.92110 -111131.2500 -30359.0792 -4456.488
## dypulse   102.9151   14.25423   70.0000   104.0000  137.000
## # A tibble: 6 x 4
```

```
##   waterYear   mdq snwpulse dypulse
##      <dbl> <dbl>    <dbl>   <dbl>
## 1    1916  691.  -42860.     97
## 2    1917  574.  -46141.    112
## 3    1918  483.  -37868.    106
## 4    1919  414.  -29451.    104
## 5    1920  377.  -29746.    116
## 6    1921  565.  -34475.    109
```

```
# Space to visualize snwpulseOutput
ggplot(snwpulseOutput, aes(x=waterYear, y=dypulse)) +
  geom_line() +
  theme_classic() +
  ggtitle("Days to Snowmelt Onset Time Series") +
  theme(plot.title = element_text(hjust = 0.5)) +
  xlab("Water Year") +
  ylab("Time to Snowmelt Onset (days)")
```



lwflow.R Generate output

```
source('./Rcode/lwflow.R')
lwflowOutputs <- lwflow(data) # Returns list of tables
invisible(lapply(lwflowOutputs, summarizeOutput))
```

```
##           mean   stdDev      min   median      max
```

```

## waterYear 1968.5000 30.74356 1916.00000 1968.5000 2021.0000
## amQ 353.3121 163.48150 84.91753 329.5945 876.9132
## # A tibble: 6 x 2
## waterYear amQ
## <dbl> <dbl>
## 1 1916 460.
## 2 1917 405.
## 3 1918 334.
## 4 1919 308.
## 5 1920 255.
## 6 1921 396.
## mean stdDev min median max
## waterYear 1968.50000 30.743563 1916.000000 1968.500000 2021.0000
## m3w 33.97025 32.825692 2.900000 21.166667 159.3333
## m7w 35.03976 33.962962 3.000000 21.500000 165.0000
## m14w 36.54613 36.081029 3.135714 21.378571 164.7857
## m3s 17.29513 20.972600 1.186667 9.426667 151.3333
## m7s 19.22662 23.904462 1.240000 10.290000 170.5714
## m14s 22.30961 26.810415 1.385000 12.249286 175.1429
## m7dw 83.28302 21.982571 61.000000 76.500000 152.0000
## m7ds 359.72642 7.234222 331.000000 364.000000 364.0000
## # A tibble: 6 x 9
## waterYear m3w m7w m14w m3s m7s m14s m7dw m7ds
## <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 1916 9 8.74 8.87 18 20.6 28.4 61 356
## 2 1917 26 27 28.2 27.7 31.6 36.4 105 364
## 3 1918 10.7 11.7 12.2 26 27.6 36.4 103 347
## 4 1919 34 34.9 35.3 7 7.29 7.96 126 361
## 5 1920 13.3 11.2 10.8 23.3 23.4 24.5 61 357
## 6 1921 67.3 69.3 70.6 13 14.4 16 69 364
## mean stdDev min median max
## exp 0.50000 0.287323 0.009345794 0.500000 0.9906542
## m3w 33.97025 32.825692 2.900000000 21.166667 159.3333333
## m7w 35.03976 33.962962 3.000000000 21.500000 165.0000000
## m14w 36.54613 36.081029 3.135714286 21.378571 164.7857143
## m3s 17.29513 20.972600 1.186666667 9.426667 151.3333333
## m7s 19.22662 23.904462 1.240000000 10.290000 170.5714286
## m14s 22.30961 26.810415 1.385000000 12.249286 175.1428571
## # A tibble: 6 x 7
## exp m3w m7w m14w m3s m7s m14s
## <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 0.00935 2.90 3 3.14 1.19 1.24 1.38
## 2 0.0187 4.13 4.40 4.86 1.57 1.90 2.58
## 3 0.0280 4.23 4.94 4.91 1.77 2.03 2.59
## 4 0.0374 4.88 5.10 5 2.33 2.63 2.98
## 5 0.0467 4.93 5.14 5.36 2.47 2.71 3.08
## 6 0.0561 5 5.33 5.50 2.60 2.72 3.22
## mean stdDev min median max
## xxp 0.3062217 0.3393862 0.020000 0.121450 0.95000
## m3w 21.9347409 28.1079826 4.147333 6.780387 102.33333
## m7w 23.2319348 30.6565110 4.476000 6.982052 115.25714
## m14w 24.9434792 34.6168486 4.864143 7.345129 133.71071
## m3s 11.3906927 16.8285757 1.594667 3.456343 62.31167
## m7s 12.8140452 19.2882475 1.918000 3.740108 71.22143

```

```
## m14s 15.1748391 23.0126182 2.579571 4.235216 82.99786
## # A tibble: 6 x 7
##      xxp    m3w    m7w   m14w    m3s    m7s   m14s
##    <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1  0.95 102.  115.  134.  62.3  71.2  83.0
## 2  0.9   71.4  74.6  80.4  44.5  51.9  65.1
## 3  0.8   52.9  54.9  57.4  25.3  26.7  30.7
## 4  0.7   42.2  41.7  40.1  17    19.5  22.4
## 5  0.6   30.7  32    34.6  12.3  13.1  15.1
## 6  0.5   21.2  21.5  21.4  9.43  10.3  12.2
```

```
# Space to visualize lwflowOutputs
```

hiflow.R Generate output

```
source('./Rcode/hiflow.R')
hiflowOutputs <- hiflow(data) # Returns list of tables
invisible(lapply(hiflowOutputs, summarizeOutput))
```

```
##           mean      stdDev      min  median      max
## waterYear 1968.5000   30.74356 1916.0000 1968.500 2021.000
## m3        2365.0031 1037.74536  500.6667 2253.333 6016.667
## m7        2099.5418  837.44642  469.8571 2086.429 4167.143
## m10       1979.1019  788.69941  466.5000 1907.000 3836.000
## m14       1870.8497  756.25014  436.6429 1784.286 3672.143
## m3d        231.8396   34.74345   52.0000  237.000  283.000
## m14d       244.5566   16.23170  199.0000  245.000  283.000
## # A tibble: 6 x 7
##   waterYear    m3     m7    m10    m14    m3d   m14d
##     <dbl> <dbl> <dbl> <dbl> <dbl> <int> <int>
## 1    1916 2247.  2180  2130  2088.   256   262
## 2    1917 2797.  2511.  2444  2446.   253   263
## 3    1918 2787.  2670  2586  2409.   256   261
## 4    1919 2660.  2440.  2361.  2133.   241   242
## 5    1920 2330  2039.  1817  1791.   234   243
## 6    1921 2563.  2409.  2271  2004.   255   258
##           mean      stdDev      min  median      max
## exp      0.500    0.287323 9.345794e-03   0.500   0.9906542
## m3  2365.003 1037.745358 5.006667e+02 2253.333 6016.6666667
## m7  2099.542  837.446425 4.698571e+02 2086.429 4167.1428571
## m10 1979.102  788.699406 4.665000e+02 1907.000 3836.0000000
## m14 1870.850  756.250135 4.366429e+02 1784.286 3672.1428571
## # A tibble: 6 x 5
##   exp    m3     m7    m10    m14
##   <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 0.991  501.  470.  466.  437.
## 2 0.981  835  697.  686.  644.
## 3 0.972  900.  788.  728.  726
## 4 0.963  917.  812.  760.  743.
## 5 0.953  947  821  763.  761.
## 6 0.944  967.  854.  807.  776.
##           mean      stdDev      min  median      max
```



```
## xxp      0.3062217    0.3393862    0.0200    0.12145    0.950
## m3  3326.5968944 1429.1417443 954.1167 3724.31217 5142.533
## m7  2814.4638810 1115.1541440 832.6000 3243.94243 3981.943
## m10 2664.9860772 1059.4310570 778.7350 3051.53490 3758.220
## m14 2542.6053381 1021.2499294 766.4679 2940.01882 3591.271
## # A tibble: 6 x 5
##   xxp      m3      m7      m10     m14
##   <dbl> <dbl> <dbl> <dbl> <dbl>
## 1  0.95  954.  833.  779.  766.
## 2  0.9 1123.  991.  951.  886.
## 3  0.8 1430 1307. 1212. 1163.
## 4  0.7 1780. 1561. 1510. 1409.
## 5  0.6 2007. 1839. 1766 1670.
## 6  0.5 2253. 2086. 1907 1784.
```

```
# Space to visualize hiflowOutputs
```

fldur.R Generate output

```
source('./Rcode/fldur.R')
fldurOutput <- fldur(data) %>% ungroup()
summarizeOutput(fldurOutput)
```

```
##           mean      stdDev      min      median      max
## pbs      50.000000  42.757843 0.010000000  50.000000  99.99000
## qfd 1166.215466 1739.821524 1.236154000 100.000000 6329.99400
## dqfd   3.301077   4.924721 0.003499045   0.283059  17.91761
## # A tibble: 6 x 3
##   pbs    qfd    dqfd
##   <dbl> <dbl> <dbl>
## 1  0.01 6330. 17.9
## 2  0.03 4475. 12.7
## 3  0.05 4206. 11.9
## 4  0.1  3873. 11.0
## 5  0.5  3120   8.83
## 6  1    2720   7.70
```

```
# Space to visualize fldurOutput
```