EDS 230: Assignment 5

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Part 1: Combined metric

This code calculates the mean error for the peak and minimum flow across water years.

```
# Source our R script with our function (a combination of at least two performance measures)
# WHY THESE MEASURES: We have chosen our two measures (relative error for max flow and relative error f
source("R/compute_extremes.R")

# Read in sager data
sager = read.table("Data/sager.txt", header=T)
head(sager)
```

```
##       model       obs month day year   wy wyd
## 1 0.4238063 0.3358678    10   1 1965 1966   1
## 2 0.4133587 0.3208737    10   2 1965 1966   2
## 3 0.4032640 0.3058796    10   3 1965 1966   3
## 4 0.3935287 0.2968832    10   4 1965 1966   4
## 5 0.3841480 0.2968832    10   5 1965 1966   5
## 6 0.3751000 0.2968832    10   6 1965 1966   6
```

```
# Add date
sager = sager %>% mutate(date = paste(day,month,year, sep="/"))
sager$date = as.Date(sager$date,"%d/%m/%Y")

# Sample output (sager must be read in first)
compute_extremes(m = sager$model, o = sager$obs, wy = sager$wy)
```

```
## $min_err_trans
## [1] 0.8078483
##
## $max_err_trans
## [1] 0.6957233
##
## $combined
## [1] 0.7517858
```

```
# First value is error for minimum flow averaged across water years
# Second value is error for maximum flow averaged across water years
# Third value is error as a combined metric of the first two (equally weighted by default)
```

Part 2: Calibration

```
# multiple results - lets say we've run the model for multiple years,
#each column  is streamflow for a different parameter set
msage = read.table("Data/sagerm.txt", header=T)

# keep track of number of simulations (e.g results for each parameter set)
# use as a column names
nsim = ncol(msage)
snames = sprintf("S%d",seq(from=1, to=nsim))
colnames(msage)=snames


# lets say we know the start date from our earlier output
msage$date = sager$date
msage$month = sager$month
msage$year = sager$year
msage$day = sager$day
msage$wy = sager$wy

# lets add observed
msage = left_join(msage, sager[,c("obs","date")], by=c("date"))

head(msage)
```

```
##           S1        S2         S3        S4         S5        S6        S7
## 1 0.07191767 0.3316747 0.04331200 0.1875757 0.07469700 0.2454343 0.1347037
## 2 0.06689267 0.3179167 0.04020500 0.1819137 0.06790767 0.2412470 0.1286780
## 3 0.06221900 0.3047440 0.03732067 0.1764227 0.06173567 0.2371983 0.1229220
## 4 0.05787167 0.2921237 0.03464333 0.1710973 0.05612433 0.2332663 0.1174237
## 5 0.05382833 0.2800427 0.03215800 0.1659330 0.05102333 0.2294617 0.1121710
## 6 0.05006733 0.2684613 0.02985100 0.1609243 0.04638600 0.2257630 0.1071530
##             S8        S9         S10       S11       S12        S13         S14
## 1 0.0003533333 0.2383413 0.003331333 0.2431933 0.3644930 0.05328633 0.005250000
## 2 0.0003400000 0.2321840 0.003039333 0.2355610 0.3583200 0.05014967 0.004755333
## 3 0.0003273333 0.2261857 0.002773000 0.2281683 0.3522187 0.04719767 0.004307333
## 4 0.0003150000 0.2203423 0.002530000 0.2210077 0.3463190 0.04441933 0.003901333
## 5 0.0003033333 0.2146500 0.002308333 0.2140717 0.3404873 0.04180433 0.003533667
## 6 0.0002920000 0.2091047 0.002106333 0.2073533 0.3347960 0.03934333 0.003200667
##         S15         S16       S17        S18        S19       S20       S21
## 1 0.5948570 0.012760333 0.2362903 0.01888033 0.12594367 0.4374097 0.2176843
## 2 0.5860857 0.011643667 0.2341553 0.01800533 0.11671333 0.4312180 0.2053780
## 3 0.5774453 0.010624667 0.2320393 0.01717100 0.10815933 0.4251140 0.1937673
## 4 0.5689357 0.009695000 0.2299423 0.01637500 0.10023233 0.4190963 0.1828130
## 5 0.5605520 0.008846667 0.2278643 0.01561600 0.09288633 0.4131640 0.1724780
## 6 0.5522937 0.008072333 0.2258053 0.01489200 0.08607867 0.4073157 0.1627270
##          S22        S23       S24        S25        S26        S27        S28
## 1 0.03378267 0.06285833 0.1675450 0.01840800 0.07664567 0.08750367 0.06550033
## 2 0.03198167 0.05886167 0.1607863 0.01818167 0.07178267 0.07925833 0.06094633
## 3 0.03027667 0.05511900 0.1543007 0.01795833 0.06722800 0.07178967 0.05670900
## 4 0.02866267 0.05161433 0.1480763 0.01773767 0.06296233 0.06502500 0.05276633
## 5 0.02713500 0.04833233 0.1421033 0.01752000 0.05896733 0.05889767 0.04909767
```

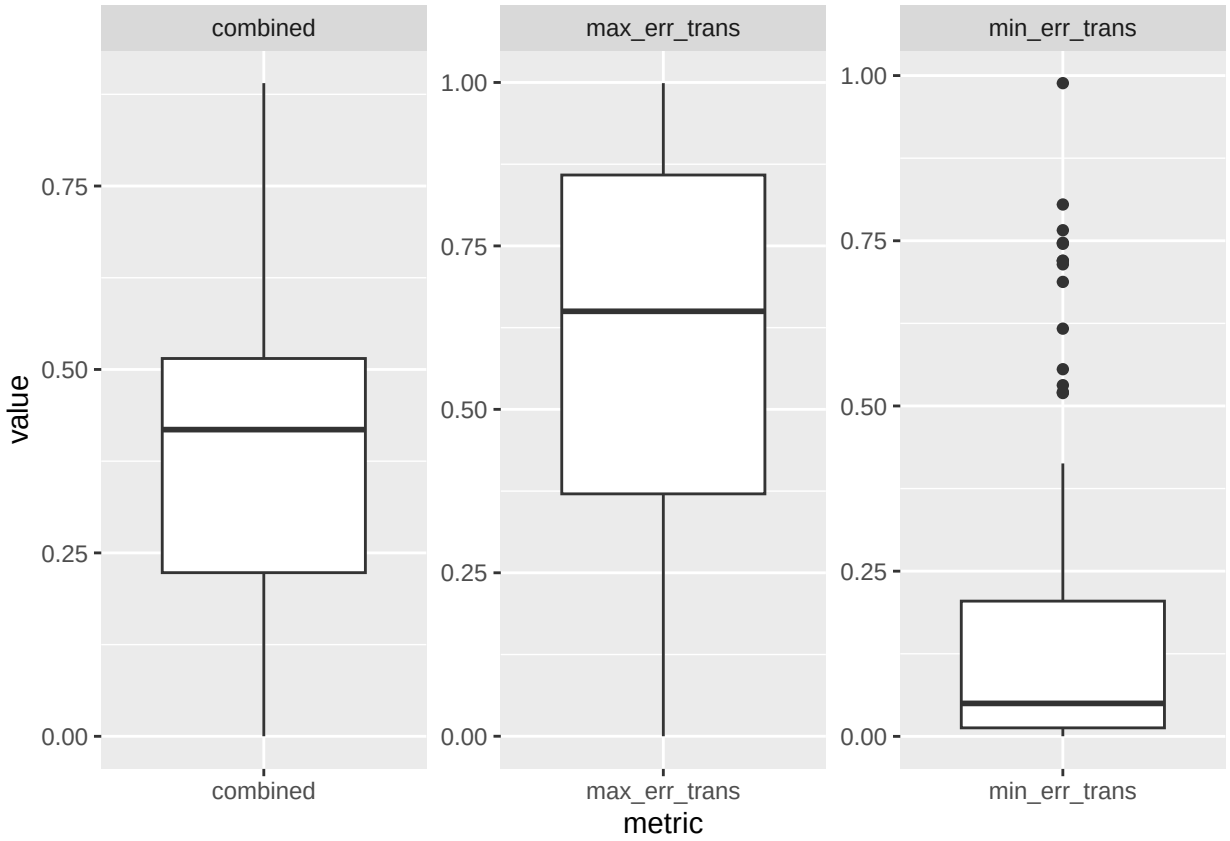
```
## 6 0.02568833 0.04525933 0.1363710 0.01730467 0.05522600 0.05334767 0.04568400
##         S29       S30       S31       S32       S33       S34        S35
## 1 0.4238063 0.1451923 0.2529733 0.5392687 0.2826070 0.3202217 0.09478400
## 2 0.4133587 0.1420453 0.2425717 0.5297423 0.2725720 0.3132013 0.08795600
## 3 0.4032640 0.1389667 0.2325977 0.5207750 0.2628933 0.3063350 0.08161967
## 4 0.3935287 0.1359547 0.2230337 0.5123903 0.2535583 0.2996190 0.07573967
## 5 0.3841480 0.1330080 0.2138630 0.5044643 0.2445547 0.2930503 0.07028333
## 6 0.3751000 0.1301250 0.2050693 0.4969153 0.2358707 0.2866257 0.06522000
##          S36        S37        S38        S39      S40       S41          S42
## 1 0.06635500 0.11842967 0.06669433 0.04664267 0.300477 0.2028417 0.012289333
## 2 0.06367833 0.11037967 0.06533933 0.04223633 0.294672 0.1982920 0.011173667
## 3 0.06110933 0.10287700 0.06401167 0.03824633 0.289076 0.1938443 0.010159667
## 4 0.05864433 0.09588400 0.06271100 0.03463333 0.283719 0.1894963 0.009237667
## 5 0.05627867 0.08936667 0.06143667 0.03136167 0.278557 0.1852460 0.008399333
## 6 0.05400833 0.08329200 0.06018833 0.02839900 0.273602 0.1810907 0.007637000
##          S43        S44       S45       S46       S47       S48       S49
## 1 0.06128400 0.02764267 0.1804390 0.2829493 0.1520090 0.2241143 0.7156417
## 2 0.06053600 0.02508200 0.1691530 0.2743833 0.1437337 0.2130743 0.7082513
## 3 0.05979700 0.02275867 0.1585730 0.2660767 0.1359090 0.2025780 0.7009373
## 4 0.05906700 0.02065067 0.1486547 0.2580213 0.1285100 0.1925987 0.6936990
## 5 0.05834567 0.01873767 0.1393567 0.2502097 0.1215140 0.1831110 0.6865357
## 6 0.05763333 0.01700167 0.1306403 0.2426347 0.1148987 0.1740907 0.6794463
##         S50       S51        S52        S53        S54        S55          S56
## 1 0.2459190 0.2593303 0.04046233 0.10185033 0.06195833 0.10997067 0.009269667
## 2 0.2405390 0.2468773 0.03690200 0.09695700 0.05648833 0.10079000 0.008794000
## 3 0.2352767 0.2350223 0.03365500 0.09229867 0.05150133 0.09237700 0.008343000
## 4 0.2301293 0.2237367 0.03069367 0.08786433 0.04695433 0.08466767 0.007915000
## 5 0.2250950 0.2129927 0.02799267 0.08364300 0.04280867 0.07760267 0.007509000
## 6 0.2201707 0.2027647 0.02552933 0.07962467 0.03902933 0.07112800 0.007123667
##          S57        S58       S59        S60       S61        S62        S63
## 1 0.08622433 0.10054867 0.2285157 0.08376633 0.5664663 0.10368200 0.06505233
## 2 0.07895133 0.09925867 0.2167053 0.07812267 0.5552560 0.09547367 0.06421500
## 3 0.07229167 0.09798533 0.2055057 0.07285900 0.5442673 0.08791533 0.06338833
## 4 0.06619400 0.09672833 0.1948847 0.06795000 0.5334960 0.08095500 0.06257267
## 5 0.06061067 0.09548733 0.1848123 0.06337167 0.5229380 0.07454600 0.06176733
## 6 0.05549833 0.09426233 0.1752607 0.05910200 0.5125890 0.06864433 0.06097233
##          S64       S65        S66       S67       S68        S69        S70
## 1 0.03208967 0.1484727 0.02082133 0.1788070 0.2103860 0.05299600 0.08575100
## 2 0.02934900 0.1428527 0.01943867 0.1768543 0.2058670 0.05246267 0.08295733
## 3 0.02684233 0.1374453 0.01814767 0.1749230 0.2015403 0.05194533 0.08025467
## 4 0.02454967 0.1322427 0.01694233 0.1730127 0.1974167 0.05144067 0.07764000
## 5 0.02245300 0.1272373 0.01581733 0.1711233 0.1934500 0.05095233 0.07511067
## 6 0.02053500 0.1224213 0.01476667 0.1692543 0.1896473 0.05047133 0.07266367
##          S71           S72       S73        S74       S75       S76       S77
## 1 0.08208500 0.0007126667 0.3321513 0.08189933 0.3378253 0.1432480 0.7430853
## 2 0.07795867 0.0006753333 0.3250353 0.07565067 0.3255447 0.1332823 0.7382633
## 3 0.07404000 0.0006400000 0.3180720 0.06987867 0.3137103 0.1240100 0.7334727
## 4 0.07031800 0.0006063333 0.3112577 0.06454733 0.3023063 0.1153827 0.7287130
## 5 0.06678333 0.0005746667 0.3045897 0.05962267 0.2913170 0.1073557 0.7239843
## 6 0.06342633 0.0005446667 0.2980643 0.05507367 0.2807270 0.0998870 0.7192863
##         S78       S79        S80       S81       S82        S83       S84
## 1 0.1609307 0.1326143 0.08507667 0.5321190 0.6998950 0.06295467 0.4064717
## 2 0.1496117 0.1302127 0.07844300 0.5224367 0.6909930 0.05740367 0.4009937
## 3 0.1390887 0.1278543 0.07232633 0.5129303 0.6822040 0.05234233 0.3955893
```

```
## 4 0.1293057 0.1255390 0.06668667 0.5035970 0.6735270 0.04772733 0.3902580
## 5 0.1202110 0.1232657 0.06148667 0.4944333 0.6649603 0.04351900 0.3849987
## 6 0.1117560 0.1210333 0.05669233 0.4854367 0.6565027 0.03968167 0.3798100
##         S85         S86       S87        S88       S89       S90       S91
## 1 0.1612057 0.011333000 0.5693913 0.10873833 0.3803070 0.5337300 0.1945403
## 2 0.1501753 0.010880000 0.5595980 0.10389400 0.3671423 0.5310793 0.1823263
## 3 0.1398997 0.010444667 0.5499730 0.09926567 0.3544333 0.5284417 0.1708793
## 4 0.1303273 0.010027000 0.5405137 0.09484367 0.3421643 0.5258170 0.1601510
## 5 0.1214097 0.009626000 0.5312170 0.09061867 0.3303200 0.5232057 0.1500963
## 6 0.1131023 0.009241333 0.5220803 0.08658167 0.3188857 0.5206070 0.1406727
##          S92       S93       S94       S95        S96       S97       S98
## 1 0.02710667 0.1718877 0.2836493 0.1334437 0.07881167 0.2935460 0.2200570
## 2 0.02649667 0.1624967 0.2761773 0.1266033 0.07252633 0.2823550 0.2093427
## 3 0.02590033 0.1536187 0.2689023 0.1201153 0.06674233 0.2715907 0.1991500
## 4 0.02531767 0.1452257 0.2618187 0.1139563 0.06141933 0.2612367 0.1894533
## 5 0.02474800 0.1372913 0.2549220 0.1081093 0.05652100 0.2512777 0.1802290
## 6 0.02419133 0.1297903 0.2482067 0.1025590 0.05201333 0.2416983 0.1714537
##           S99       S100       S101       date month year day   wy       obs
## 1 0.011247667 0.07537933 0.04625600 1965-10-01    10 1965   1 1966 0.3358678
## 2 0.010750333 0.07278433 0.04515367 1965-10-02    10 1965   2 1966 0.3208737
## 3 0.010282667 0.07027900 0.04407767 1965-10-03    10 1965   3 1966 0.3058796
## 4 0.009823000 0.06785967 0.04302733 1965-10-04    10 1965   4 1966 0.2968832
## 5 0.009406333 0.06552400 0.04200200 1965-10-05    10 1965   5 1966 0.2968832
## 6 0.008985333 0.06326867 0.04100100 1965-10-06    10 1965   6 1966 0.2968832
```

```
# subset for split sample calibration
short_msage = subset(msage, wy < 1975)

res = short_msage %>% select(-date, -month, -day, -year, -wy, -obs ) %>%
  map_df(compute_extremes, o=short_msage$obs, wy=short_msage$wy)
# note here we use map_df to get a dataframe back

# interesting to look at range of metrics - could use this to decide on
# acceptable values
summary(res)
```

```
##  min_err_trans       max_err_trans       combined
##  Min.   :0.0002052   Min.   :0.0000   Min.   :0.0001026
##  1st Qu.:0.0128956   1st Qu.:0.3707   1st Qu.:0.2230391
##  Median :0.0498848   Median :0.6500   Median :0.4179960
##  Mean   :0.1669457   Mean   :0.5746   Mean   :0.3707610
##  3rd Qu.:0.2046798   3rd Qu.:0.8585   3rd Qu.:0.5149185
##  Max.   :0.9885311   Max.   :0.9990   Max.   :0.8902135
```

```
# we can add a row that links with simulation number
res$sim = snames

# graph range of performance measures
resl = res %>% pivot_longer(-sim, names_to="metric", values_to="value")

ggplot(resl, aes(metric, value))+geom_boxplot()+facet_wrap(~metric, scales="free")
```




```
# select the best and worst ones based on the combined metric
best = res[which.max(res$combined),] # S87

worst = res[which.min(res$combined),] # S8
```

Figure 1. The distribution of the performance measures for stream flow metrics using 101 different parameter sets.

```
# streamflow estimates from best performing parameter set
ggplot(msage, aes(date, msage[,best$sim])) +
  geom_line(aes(col = "Modeled (S87)")) +
  geom_line(aes(date, obs, col = "Observed"))  +
  theme_light() +
  labs(x = "Date",
       y = "Streamflow (mm/day)",
       col = "Parameter Set") +
  scale_color_manual(values = c("dodgerblue", "black"))
```

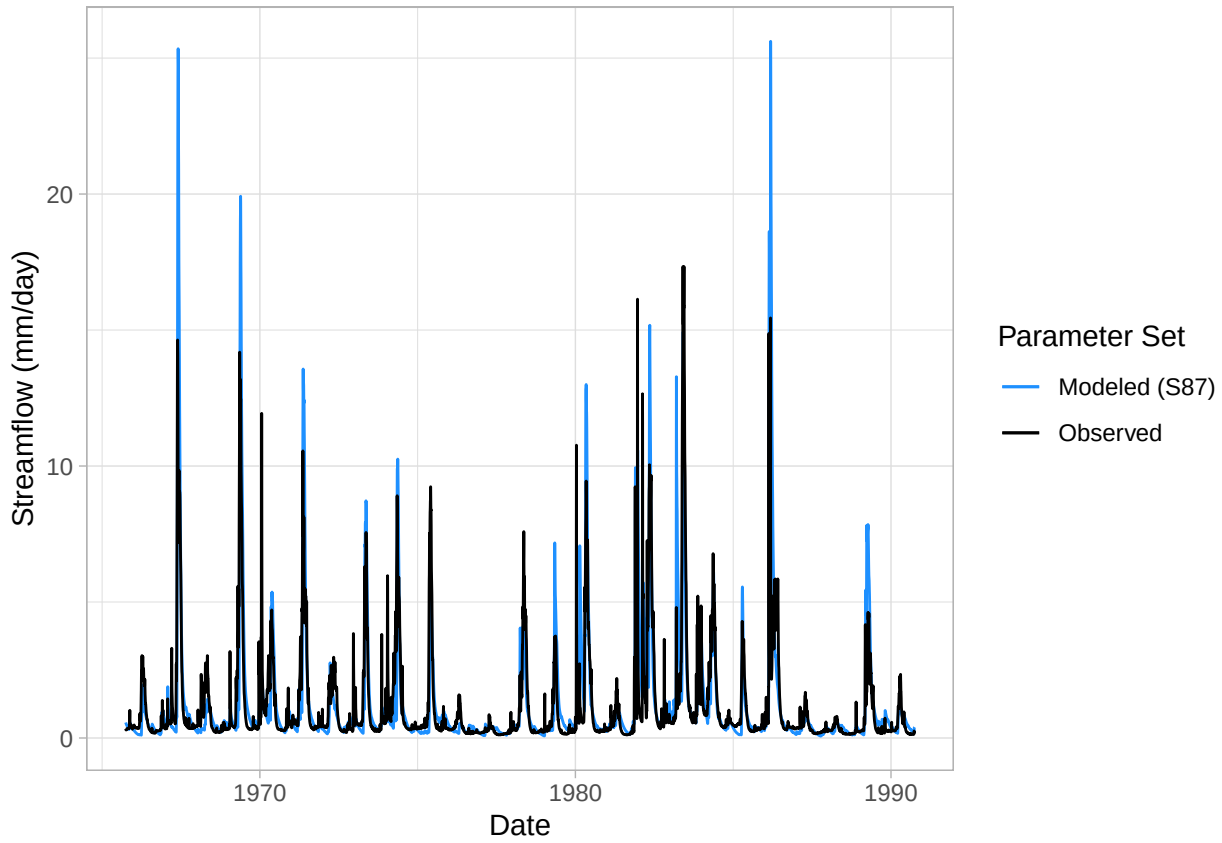


Figure 2. Stream flow estimates from the best performing parameter set (S87) compared to the observed stream flow.

Conclusion

We found our best parameter set was S87 and worst parameter set was S8, based on our combined metric using the difference between observed and modeled extreme wet and dry water years. We chose these metrics because we wanted to include the extreme stream flow conditions in water years.