

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

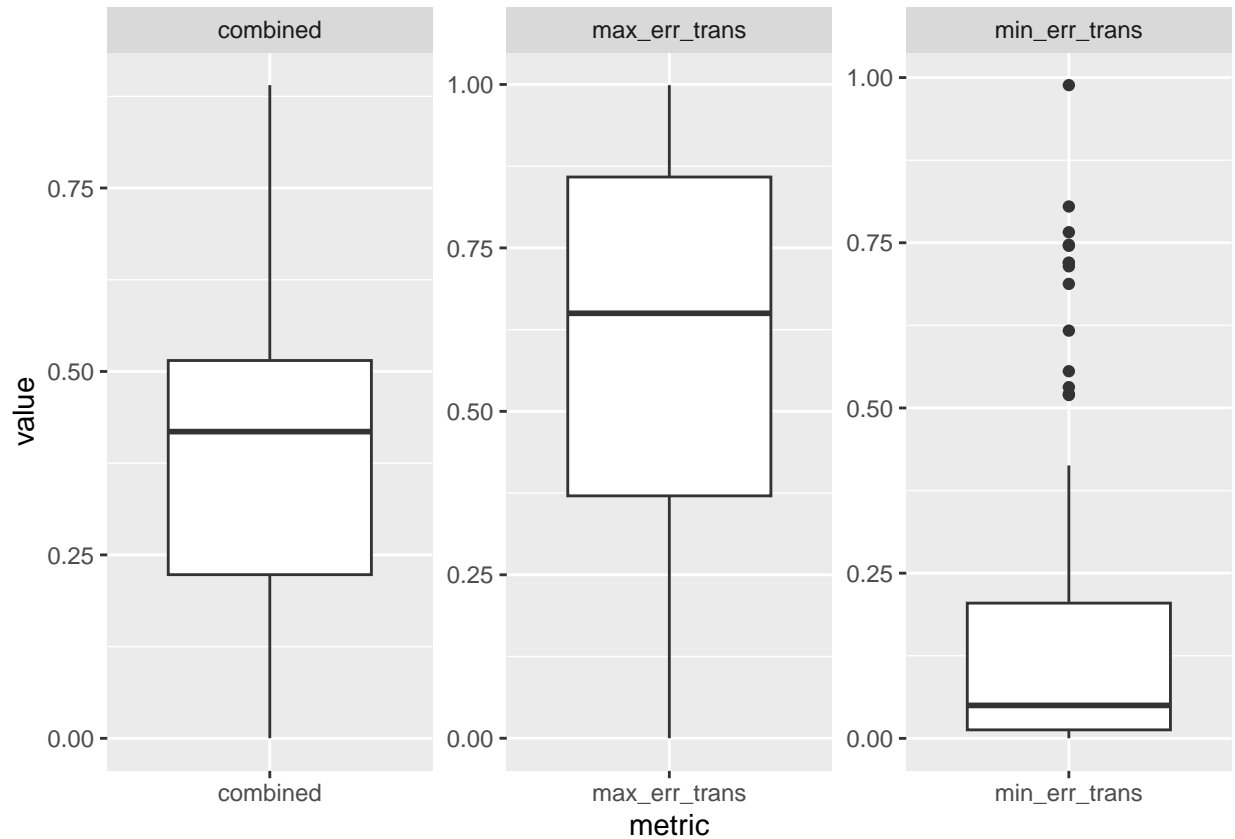
# interesting to look at range of metrics - could use this to decide on
# acceptable values
summary(res)
```

```
## 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"))
```

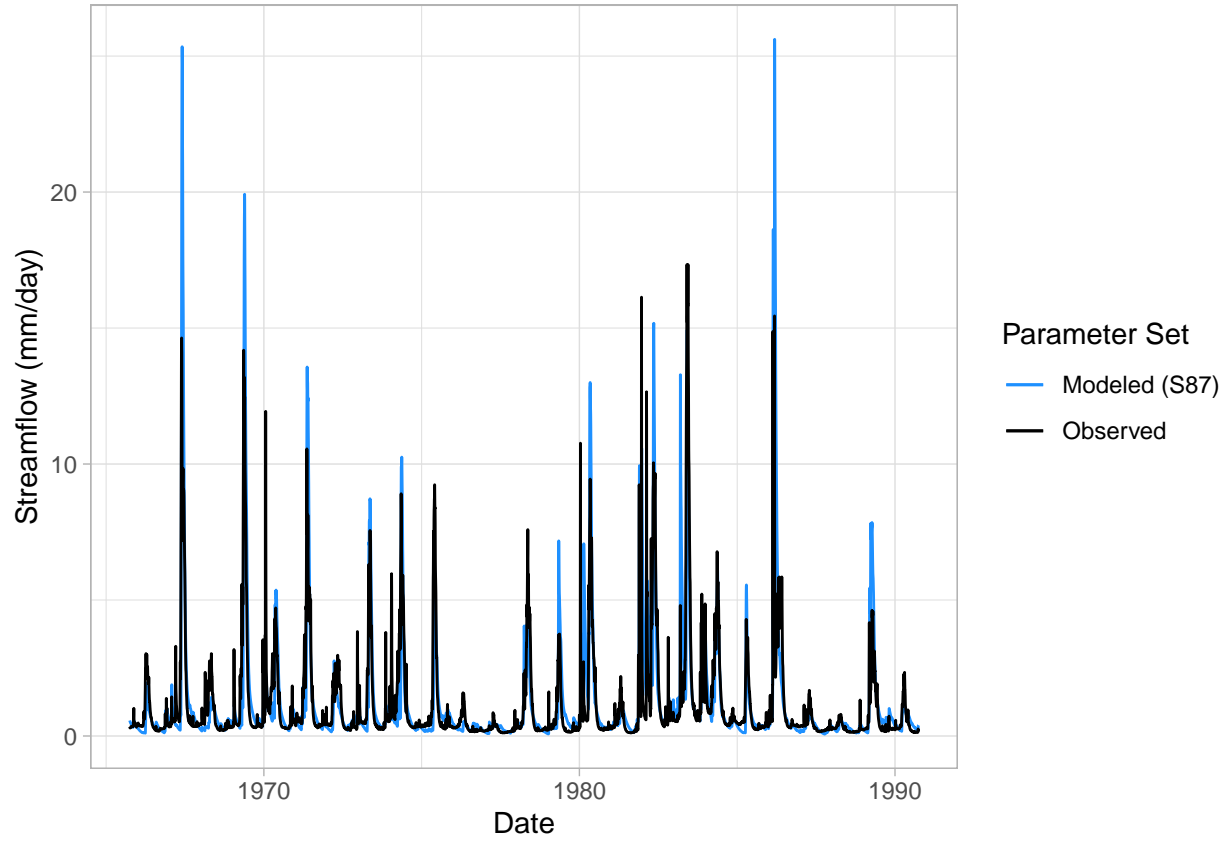


Figure 2. Stream flow estimates from the best performing parameter set (S87) compared to the observed stream flow.

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.