Calibriation

Carlo, Ata, Hailey

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```
library(sensitivity)
```

```
## Registered S3 method overwritten by 'sensitivity':
##   method    from
##   print.src dplyr
```

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
```

```
## v ggplot2 3.4.1     v purrr   1.0.1
## v tibble  3.2.1     v dplyr   1.1.2
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x tidyr::extract() masks sensitivity::extract()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## x dplyr::src()     masks sensitivity::src()
```

```
library(lubridate)
```

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

```
library(reldist)
```

```
## reldist: Relative Distribution Methods
## Version 1.7-2 created on 2023-02-16.
## copyright (c) 2003, Mark S. Handcock, University of California-Los Angeles
##  For citation information, type citation("reldist").
##  Type help(package="reldist") to get started.
```

```
library(purrr)
library(ggpubr)
library(dplyr)
library(lubridate)
library(patchwork)
```

Assignment

Final piece will be to produce a graph of maximum likelihood estimate given you acceptable parameters!

To hand in - an Rmarkdown and R function. Please knit and turn in either an html or pdf of the markdown.

Part 1 from above: R function that codes a metric for performance evaluation

- must be a combination of at least two performance measures
- include some comments that explain 'why' this metric

As a group we wanted to see if the model was getting things right on average but we thought that an annual metric would loose some of the seasonal variability, so we created three indicators that measure monthly average model performance and combined them. We made a monthly NSE metric, a monthly error metric, and a monthly KGE metric. The Kling-Gupta Efficiency KGE metric is similar to the NSE, but it is based on Euclidean distance between points.

```
# Create a custom performance metric
combined_performance_metric = function(m, o, month) {

  # Create a dataframe to get the averages for the modeled values and the observation values
  df = data.frame(m, o, month) |>
    group_by(month) |>
    summarise(ave_m = mean(m), ave_o = mean(o),
              sd_m = sd(m), sd_o = sd(o))

  # Calculate the monthly average NSE score
  err = df$ave_m - df$ave_o
  meanobs = mean(df$ave_o)
  mse = sum(err*err)
  ovar = sum((df$ave_o-meanobs)*(df$ave_o-meanobs))
  monthly_nse = 1.0-mse/ovar

  # Calculate the monthly error and normalize
  month_error = sum(df$ave_m - df$ave_o)
  month = abs(month_error)
  month_error = exp(-month)

  # Calculate the average monthly KGE (Kling-Gupta Efficiency) metric
  beta = sum(df$ave_m/df$ave_o)
  alpha = sum(df$sd_m/df$sd_o)
  r = cor(m, o, method = "pearson")
  kge = 1.0 - sqrt(((r - 1)^2) + ((alpha - 1)^2) + ((beta - 1)^2))
```

```
  kge_norm = exp(-abs(kge))

  # Multiply the performance metrics together to get a combined metric
  combined = monthly_nse * month_error * kge_norm

  # Return the combined metric
  return(combined)
}
```

Part 2:

Apply your performance function to a subset of the Sagehen data set (with multiple simulations) that you want to use for calibration

Summarize the performance over the calibration period in 1-2 graphs; you can decide what is useful

Record your 'best' and 'worst' parameter set in this spreadsheet and in your Rmd

Worst Simulation: S95

Best Simulation: S49

```
# Read in the data
sager <- read.table("sager.txt", header=T)

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

# Read in model data
msage <- read.table("sagerm.txt", header=T)

# Rename columns
nsim <- ncol(msage)
snames <- sprintf("S%d",seq(from=1, to=nsim))
colnames(msage) <- snames

# 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

# Add sager observation data
msage <- left_join(msage, sager[,c("obs","date")], by=c("date"))
```

```
combined_performance_metric(m = sager$model,o = sager$obs, month = sager$month)
```

```
## [1] 6.364662e-08
```

```
# Map the the performance of the different models
res <- msage %>% select(!c("date", "month", "year", "day", "wy", "obs")) %>%
  map_dbl(combined_performance_metric, month = msage$month, o = msage$obs)
```

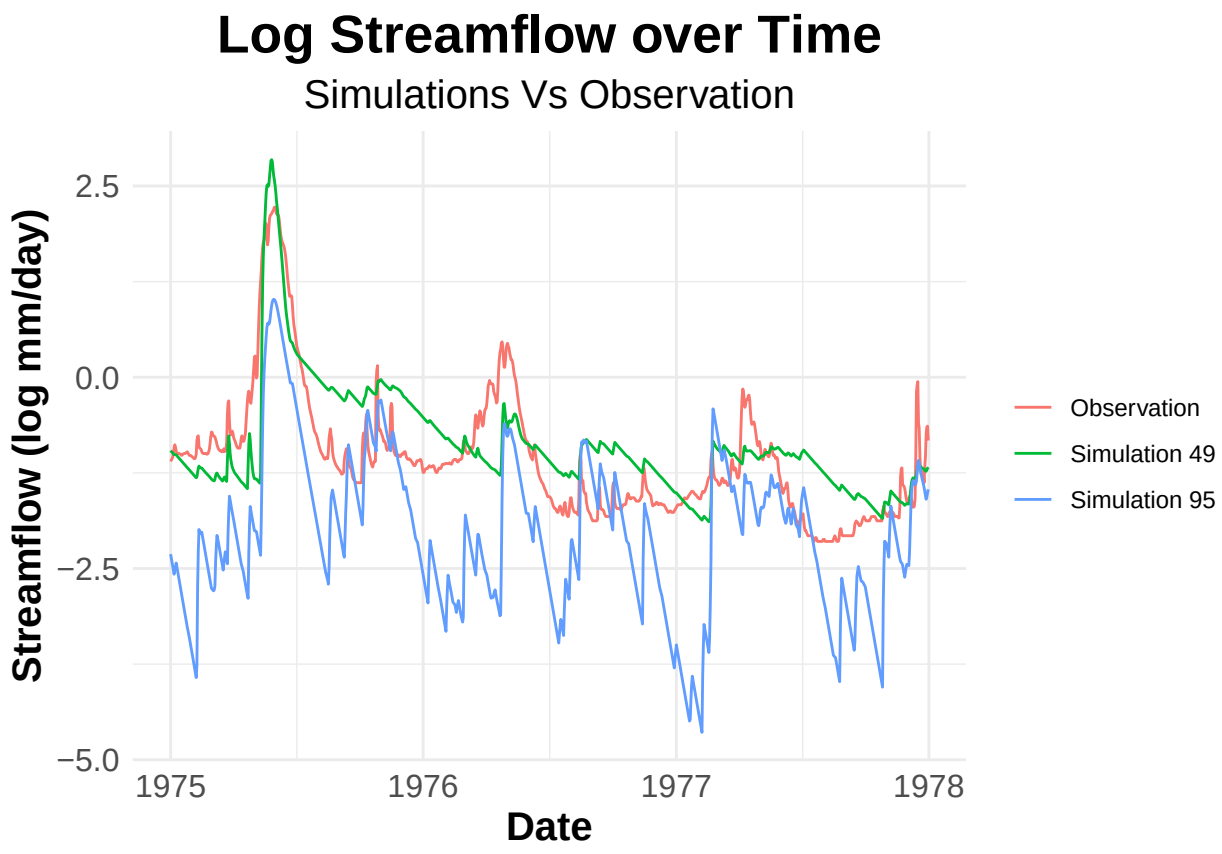
```r
# Make the output of the map function a dataframe
res <- as.data.frame(res)

# Put the names of the models on the data frame
res$sim <- snames

# Get the best and word performing models
highest_row <- which.max(res$res)
lowest_row <- which.min(res$res)
highest_sim <- res$sim[highest_row]
lowest_sim <- res$sim[lowest_row]
```

```r
# put worst and best model outputs into a df
best_worst_output <- msage |>
  select(S95, S49)

# add the time and observations for the outputs
best_worst_data <-  msage %>%
  select(c("date","month",
           "year","day","wy",
           "obs")) |>
  cbind(best_worst_output)

# create the graphing df by pivoting longer and filtering by date
ggplot_df <- best_worst_data %>%
  pivot_longer(cols=!c(date, month, year, day, wy),
               names_to="sim",
               values_to="flow") %>%
  filter(year(date) >= 1975, year(date) <= 1977)
```

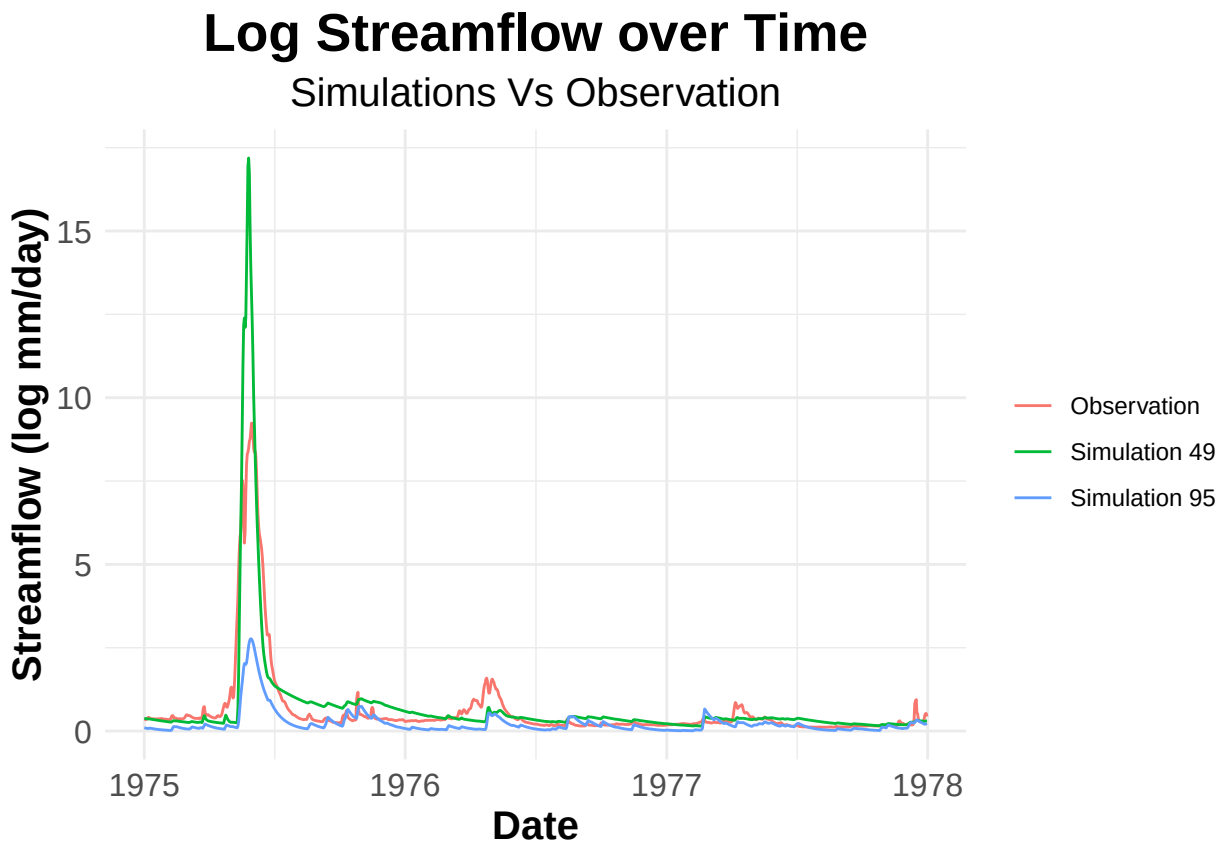
```r
# Make log flow line graph
ggplot(ggplot_df, aes(x = date, y = log(flow), color = sim)) +
  geom_line(size = 0.5) + # set line size to be very skinny
  scale_color_discrete(labels = c("Observation", "Simulation 49", "Simulation 95")) +
  theme_minimal() +
  theme(
    plot.title = element_text(hjust = 0.5, face = "bold", size = 20),
    plot.subtitle = element_text(hjust = 0.5, size = 15),
    axis.title = element_text(face = "bold", size = 15),
    axis.text = element_text(size = 12),
    legend.title = element_blank() # removes the legend title
  ) +
  labs(
    title = "Log Streamflow over Time",
    subtitle = "Simulations Vs Observation",
    x = "Date",
    y = "Streamflow (log mm/day)"
  )
```

```
## Warning: Using ‘size‘ aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use ‘linewidth‘ instead.
## This warning is displayed once every 8 hours.
## Call ‘lifecycle::last_lifecycle_warnings()‘ to see where this warning was
```

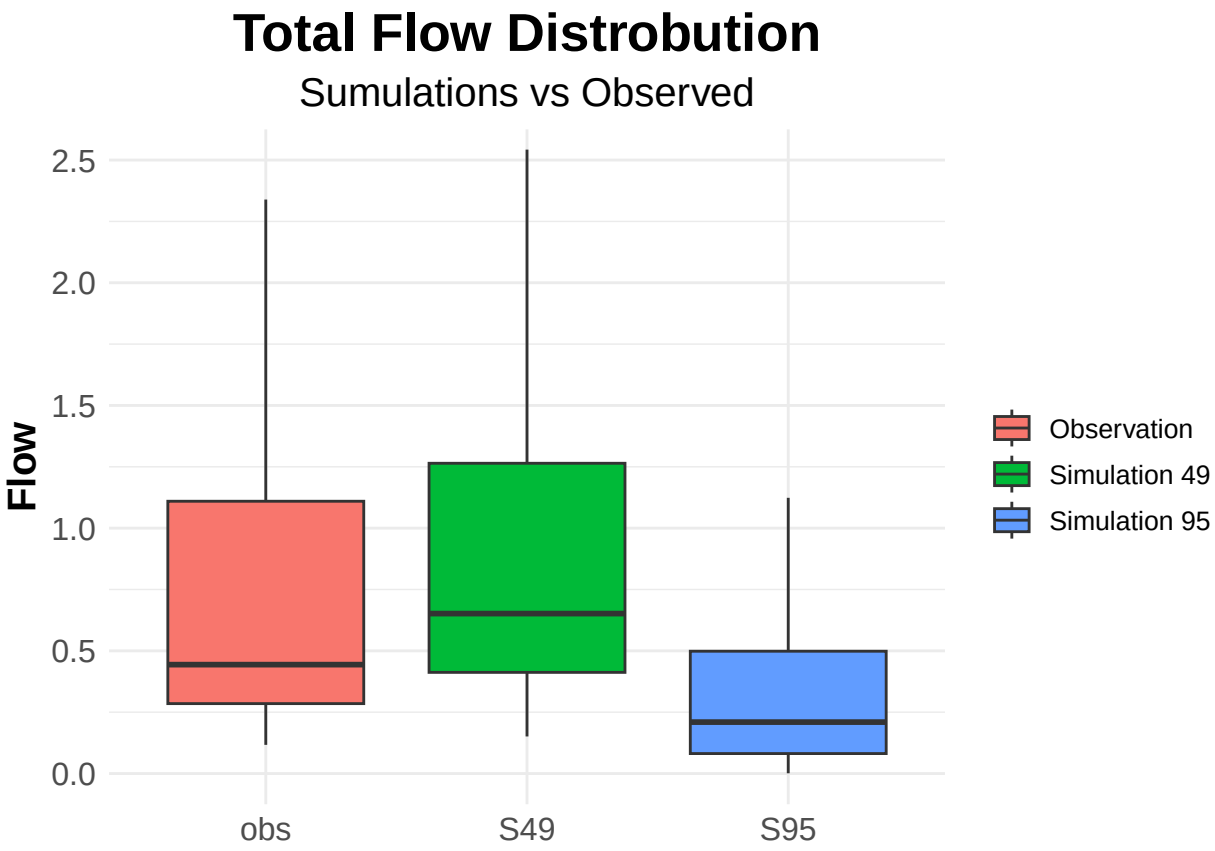
```
## generated.
```




```r
# Make flow line graph
ggplot(ggplot_df, aes(x = date, y = flow, color = sim)) +
  geom_line(size = 0.5) +
  scale_color_discrete(labels = c("Observation", "Simulation 49", "Simulation 95")) +
  theme_minimal() +
  theme(
    plot.title = element_text(hjust = 0.5, face = "bold", size = 20),
    plot.subtitle = element_text(hjust = 0.5, size = 15),
    axis.title = element_text(face = "bold", size = 15),
    axis.text = element_text(size = 12),
    legend.title = element_blank() # removes the legend title
  ) +
  labs(
    title = "Log Streamflow over Time",
    subtitle = "Simulations Vs Observation",
    x = "Date",
    y = "Streamflow (log mm/day)"
  )
```




```r
# make dataframe for boxplot
boxplot_df  =  best_worst_data %>%
  pivot_longer(cols=!c(date, month, year, day, wy),
               names_to="sim",
               values_to="flow")

# make boxplot
ggplot(boxplot_df, aes(sim, flow, fill = sim)) +
  geom_boxplot(outlier.shape = NA) +
  scale_fill_discrete(labels = c("Observation", "Simulation 49", "Simulation 95")) +
  coord_cartesian(ylim = c(0, 2.5)) +
  theme_minimal() +
  theme(
    plot.title = element_text(hjust = 0.5, face = "bold", size = 20),
    plot.subtitle = element_text(hjust = 0.5, size = 15),
    axis.title = element_text(face = "bold", size = 15),
    axis.text = element_text(size = 12),
    legend.title = element_blank(),
    legend.text = element_text(size = 10)
  ) +
  labs(
    title = "Total Flow Distrobution",
    subtitle = "Sumulations vs Observed",
    x = NULL,
    y = "Flow"
  )
```


Total Flow Distrobution
Sumulations vs Observed
Flow
2.5
2.0
1.5
1.0
0.5
0.0
obs
S49
S95
Observation
Simulation 49
Simulation 95