IDENTIFICATION OF PRIORITY ZONES FOR RIPARIAN BUFFER ENROLLMENT UNDER THE SEASONAL RIPARIAN AREA MANAGEMENT PROGRAM USING SWAT+

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OUTLINE OF PRESENTATION

- Introduction
- Research Objectives
- Study Area
- Research Methodology
- Results and Discussion
- Conclusion
- Future Research Work
- References

INTRODUCTION

Problem
Site in 2013

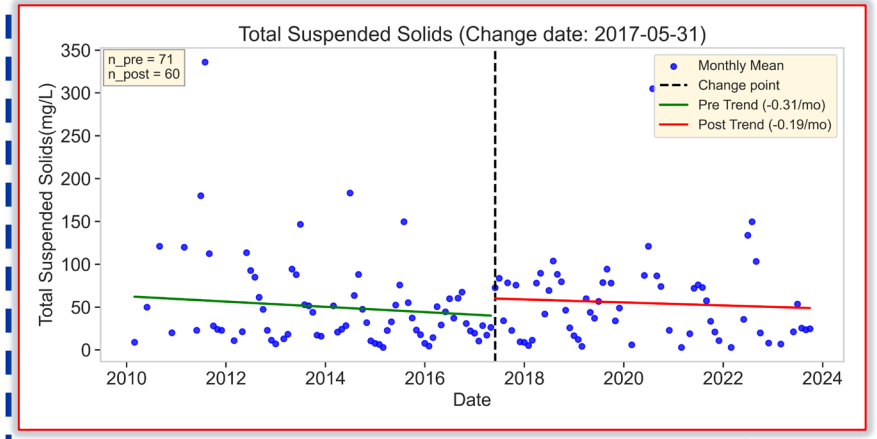
Motivation
Site in 2023

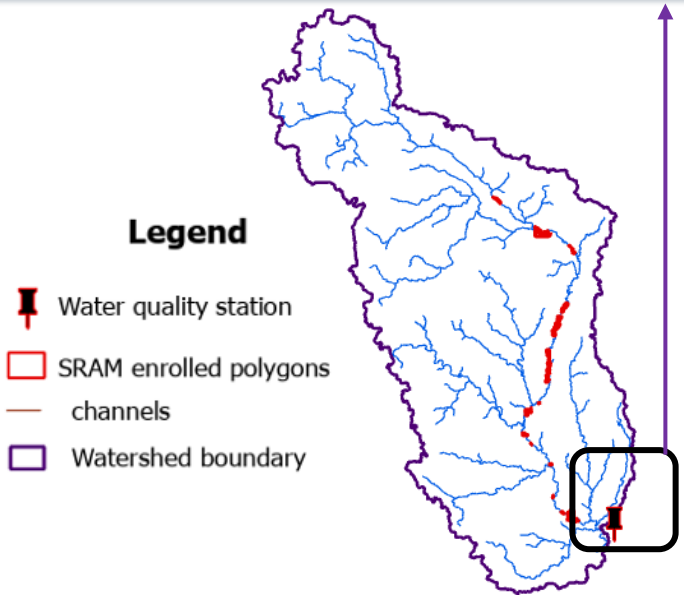
Until 2023, around 114 different areas were enrolled in the SRAM program.

Picture credits: 2023 Marks the 10-Year Anniversary of the Seasonal Riparian Area Management Program

RESEARCH GAP

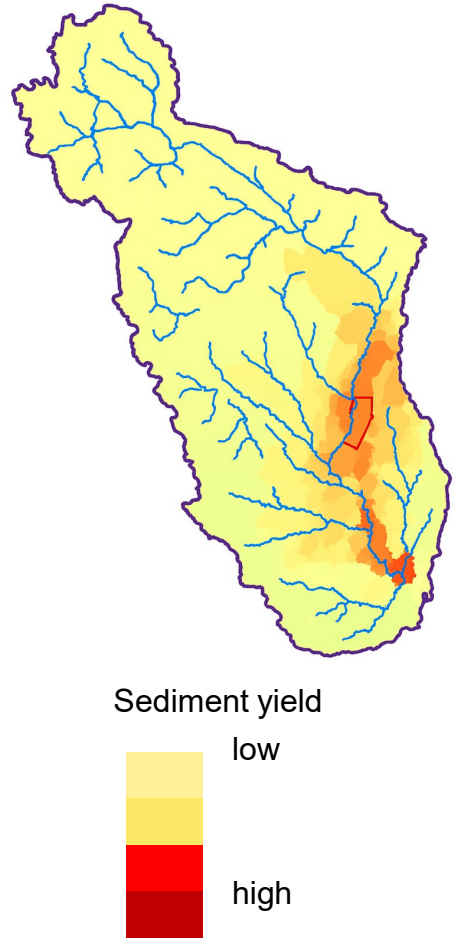
Previous Studies





- Existing water-quality analysis was limited to a few downstream stations, capturing only overall watershed responses.
- This approach cannot distinguish which SRAM-enrolled polygons most influence sediment or nutrient loads.
- Therefore, a process-based modeling approach with SWAT+ is needed to identify sediment hotspots and evaluate the effectiveness of SRAM practices (based on their position) across the watershed.

Proposed approach



RESEARCH OBJECTIVES

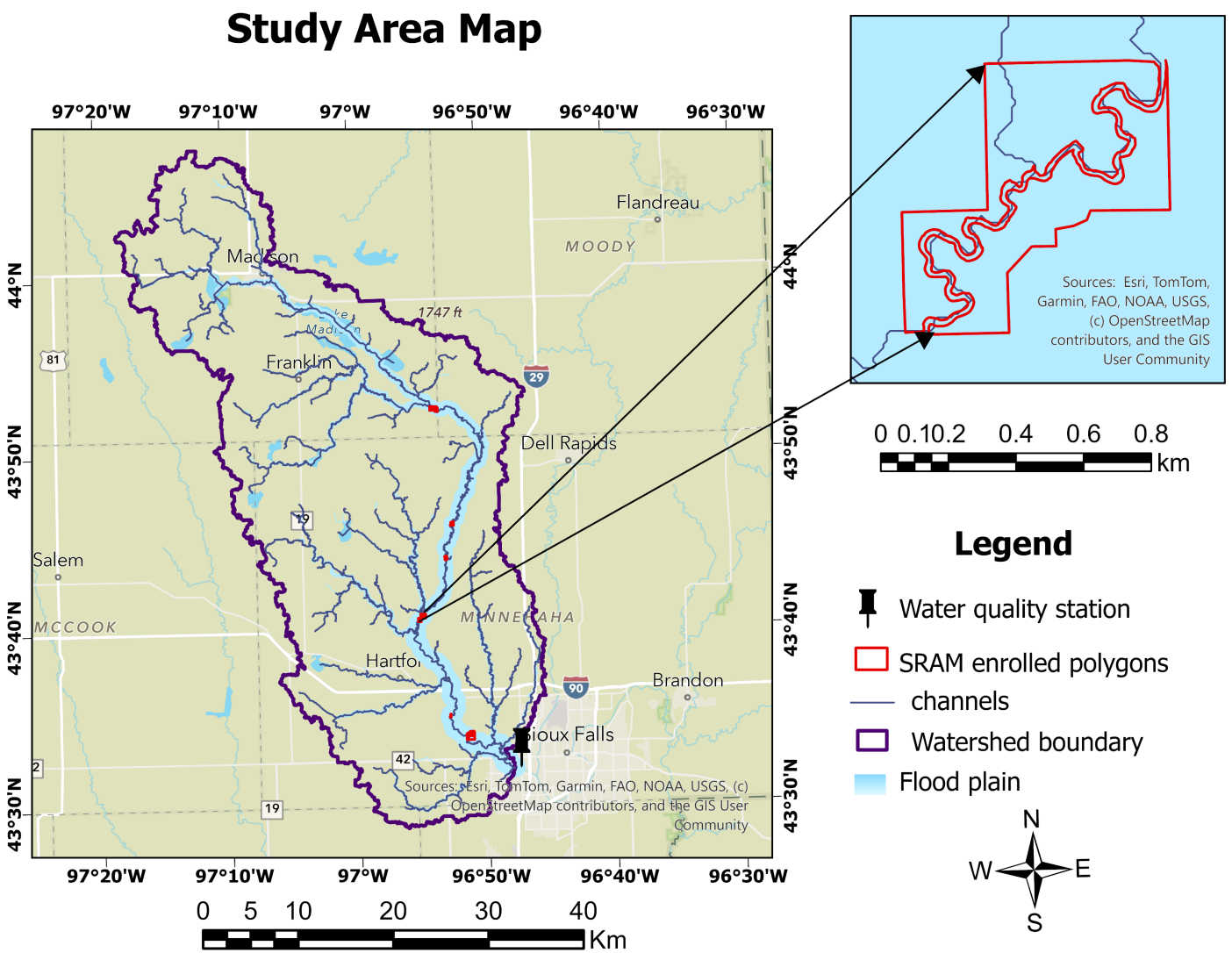
Objective #1

To set up a calibrated and validated SWAT+ hydrological model for simulating streamflow, river sediments, and nitrate-N in the Skunk Creek Watershed.

Objective #2

To identify sediment and nutrient hotspot areas and evaluate their spatial relationship with SRAM-enrolled polygons, highlighting regions where no SRAM practices exist but significant loads originate.

STUDY AREA



- Watershed area= 620 square mile
- Major tributary of Big Sioux River Supplies 60% of the municipal water to Sioux Falls

- Precipitation = 29 inches (2004-2022)
- Temperature = -31 to 104 °F (2004-2022)
- Major land use = approx. 40 % corn and 36% soybean
- ET = 26 inches

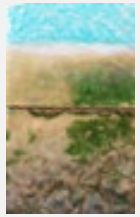
Figure 1: Study Area Map showing Skunk Creek Riparian Zone, SRAM defined polygons, River channels, and downstream water quality station.

DATA ACQUISITION

Soil Map

Product: SSURGO
Source: USDA (NRCS)
https://websoilsurvey.sc.egov.usda.gov/
Scale: 1:12,000 to 1:63,360
Spatial resolution: 30m
Data duration: Static

Land use data



Spatial resolution: 30 m
Temporal resolution: yearly
Data duration: 2018
Source: Crop data layer (CDL)
Variables: LULC

Water quality Data

Variables: (NO_3 + NO_2) as N, TSS
Source: SD DANR
Temporal resolution: monthly

Data Collection

Digital Elevation Model

Product: (3D Elevation Program)
Source: USGS
https://apps.nationalmap.gov/downloader/
Spatial Resolution = 30 m
Data duration: Static

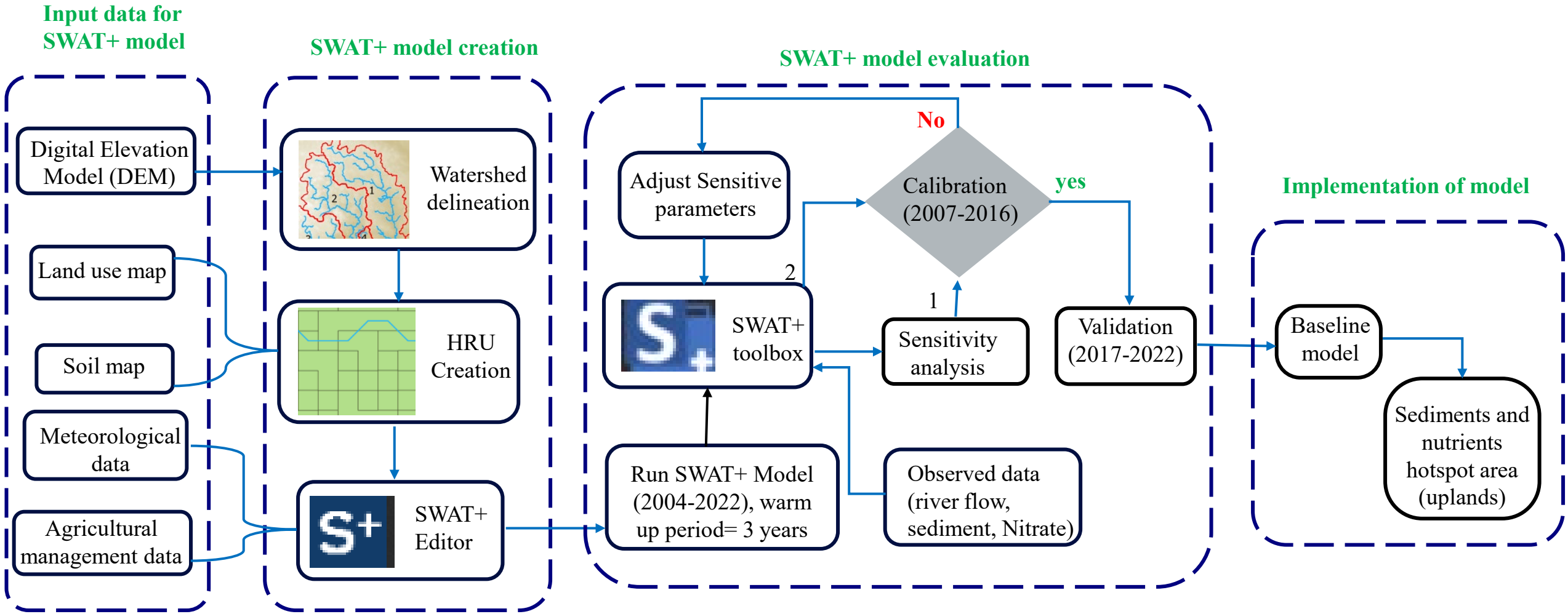
Stream flow data

Temporal resolution: Daily
Data duration: 2007-2022
Sources: USGS
Variable: Discharge (m^3/s)
Station ID = Skunk Creek at Sioux Falls, SD 6481500

Meteorological data

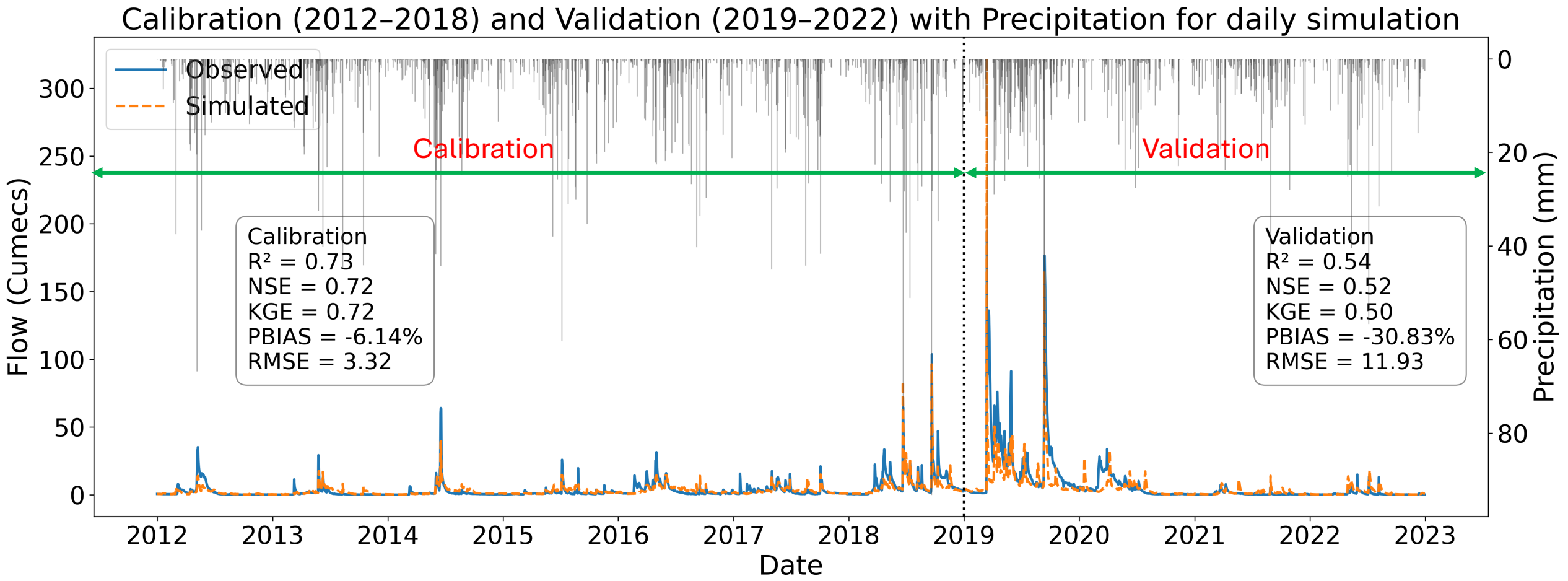
Spatial resolution: 1 km, 800m
Temporal resolution: Daily
Data duration: 2007-2022
Sources: PRISM (800 m)
https://prism.oregonstate.edu/downloads/
Variables: PRCP, tmax, tmin

RESEARCH METHODOLOGY



RESULTS AND DISCUSSION

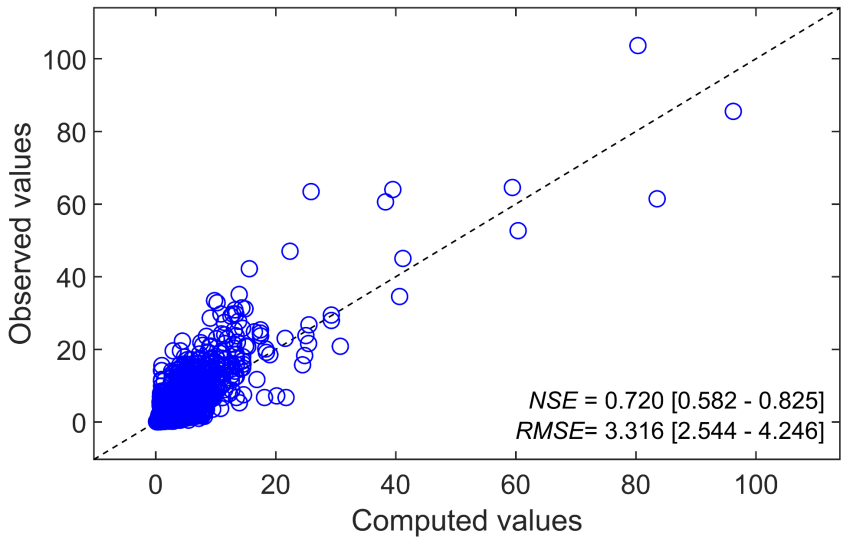
Result of objective 1: Calibration and validation of daily stream flow

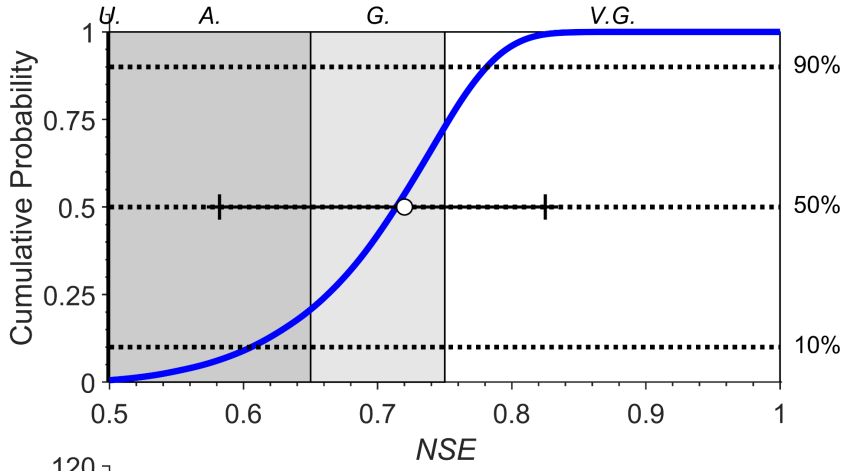


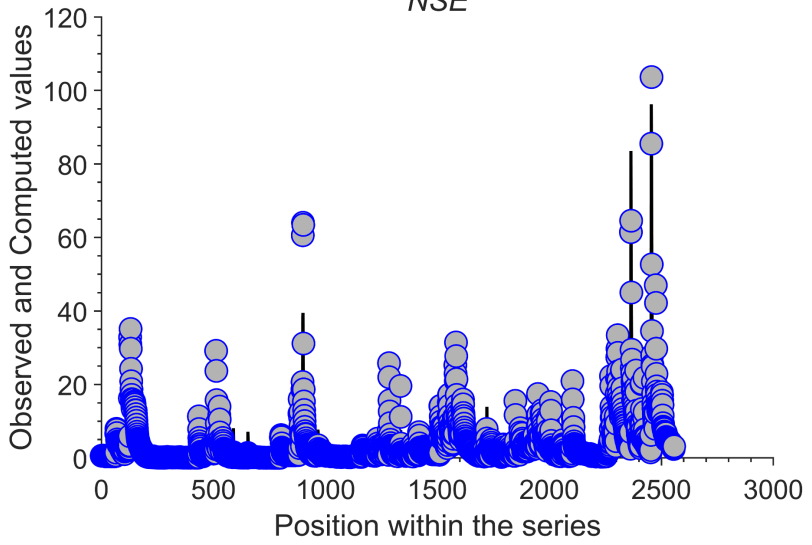
Performance metrics details: (Moriasi et al., 2014)

RESULTS AND DISCUSSION

Result of objective 1: FITEVAL Result for daily Calibration (2012-2018)





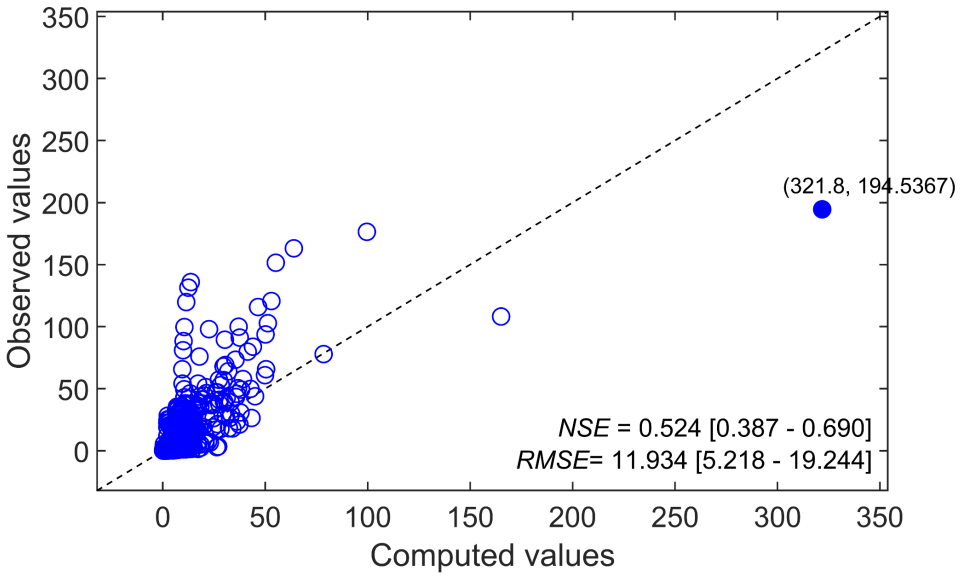


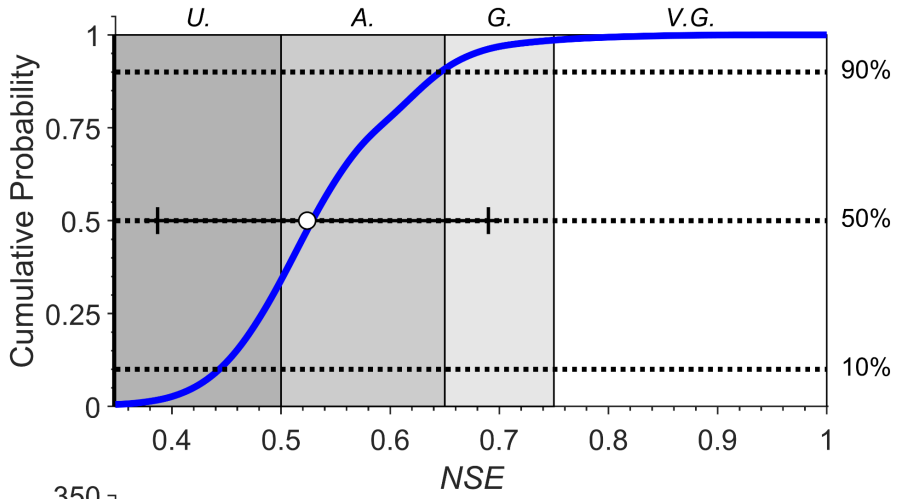
========== GOODNESS-OF-FIT EVALUATION ==========
Evaluation of *NSE*: **From ACCEPTABLE to VERY GOOD**
Probability of fit being:
- *Very good* (*NSE* = 0.750 - 1.000): 27.8%
- *Good* (*NSE* = 0.650 - 0.749): 51.8%
- *Acceptable* (*NSE* = 0.500 - 0.649): 19.9%
- ***Unsatisfactory* (*NSE* < 0.500): 0.5% (p-value: 0.005)**

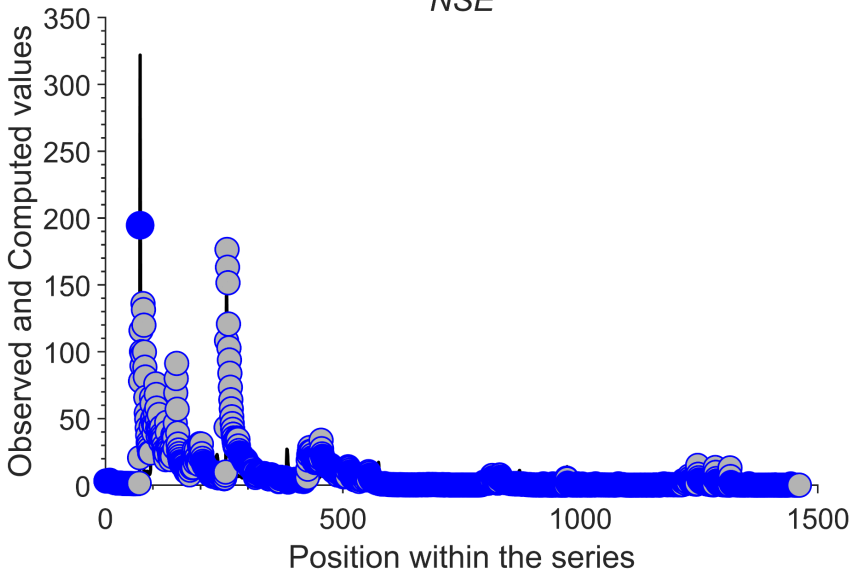
NRMSE=100·*RMSE*/*SD*=53%; ***KGE*=0.727 [0.552 - 0.860]**; *N*=2557
Presence of outliers (Q-test): NO
Model bias: NO

RESULTS AND DISCUSSION

Result of objective 1: FITEVAL Result for daily validation (2019-2022)





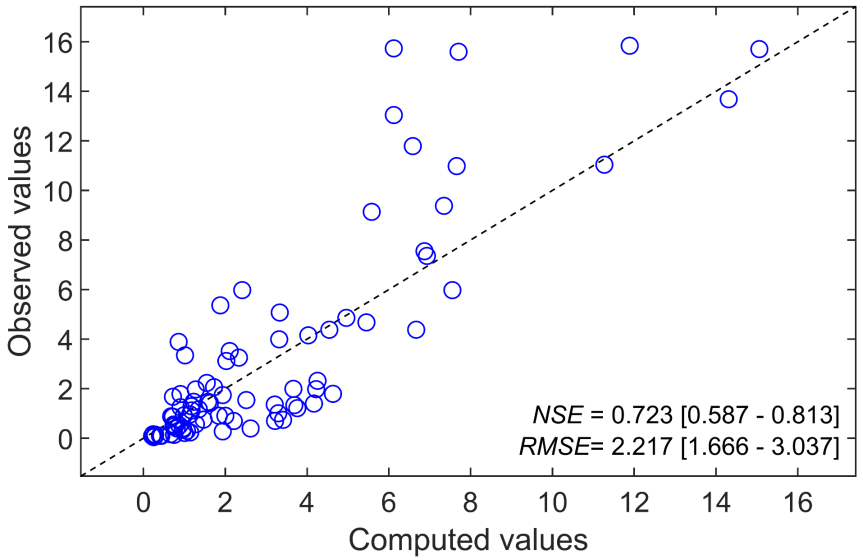


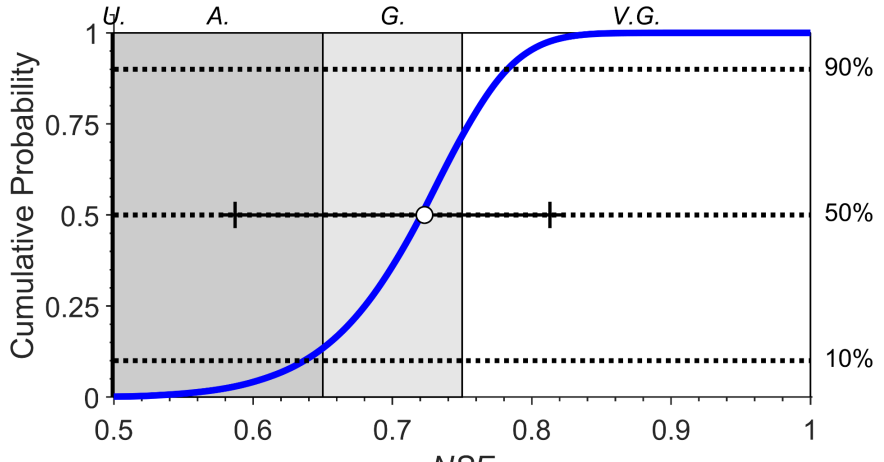
========== GOODNESS-OF-FIT EVALUATION ==========
Evaluation of *NSE*: **From UNSATISFACTORY to GOOD**
Probability of fit being:
- *Very good* (*NSE* = 0.750 - 1.000): 1.4%
- *Good* (*NSE* = 0.650 - 0.749): 8%
- *Acceptable* (*NSE* = 0.500 - 0.649): 57.2%
- ***Unsatisfactory* (*NSE* < 0.500): 33.4% (p-value: 0.334)**

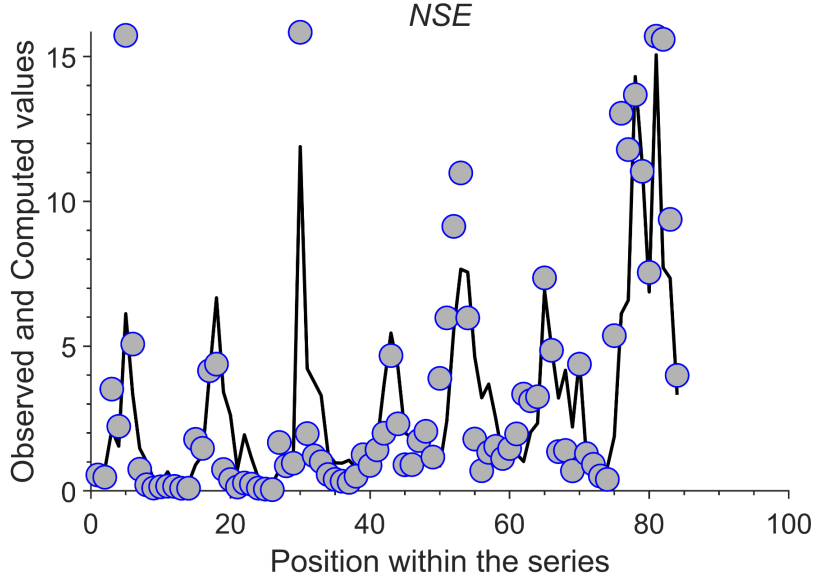
NRMSE=100·*RMSE*/*SD*=69%; ***KGE*=0.587 [0.522 - 0.814]**; *N*=1461
Presence of outliers (Q-test): present and maybe affecting indicators
Potential outlier at: (321.8,194.5367)
Model bias: Underprediction by -30.8% of the mean
(*NSE* may be influenced by model bias)

RESULTS AND DISCUSSION

Result of objective 1: FITEVAL Result for monthly calibration (2012-2018)





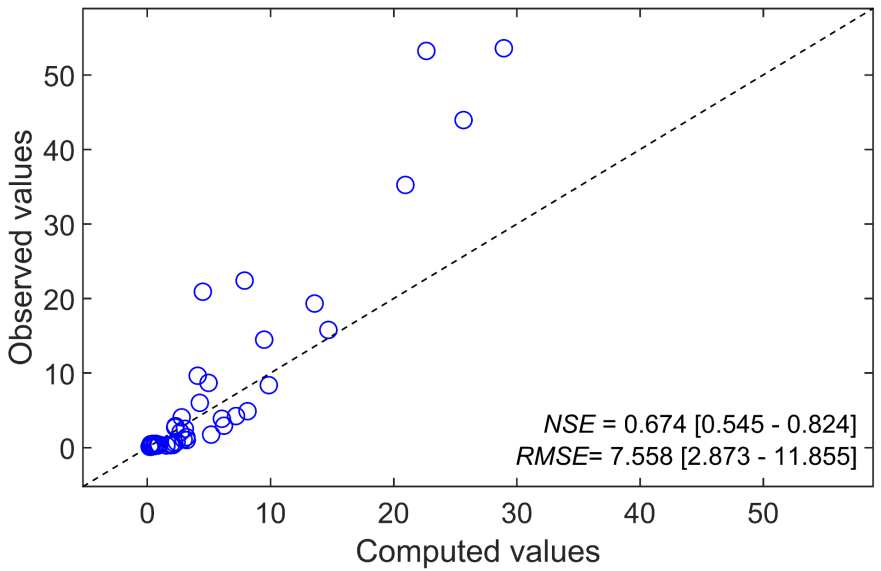


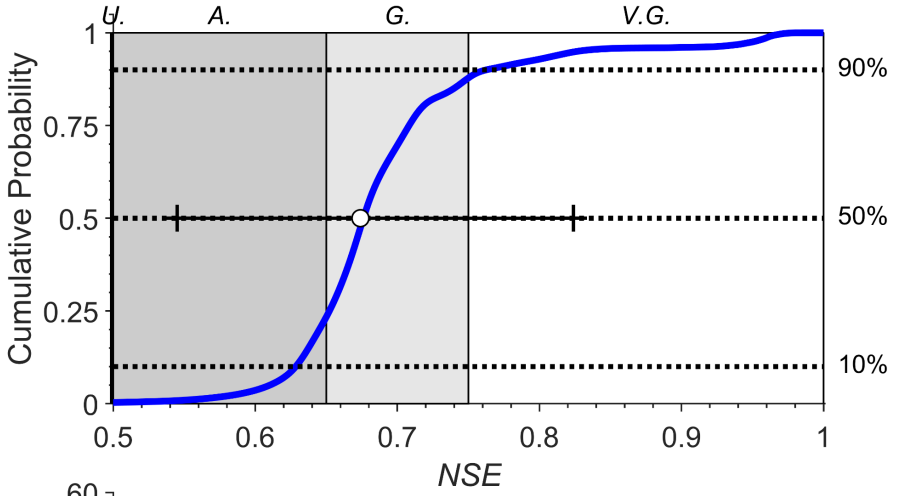
========== **GOODNESS-OF-FIT EVALUATION** ==========
Evaluation of *NSE*: **From ACCEPTABLE to VERY GOOD**
Probability of fit being:
- *Very good* (*NSE* = 0.750 - 1.000): 29%
- *Good* (*NSE* = 0.650 - 0.749): 57.9%
- *Acceptable* (*NSE* = 0.500 - 0.649): 13%
- ***Unsatisfactory* (*NSE* < 0.500): 0.1% (p-value: 0.001)**

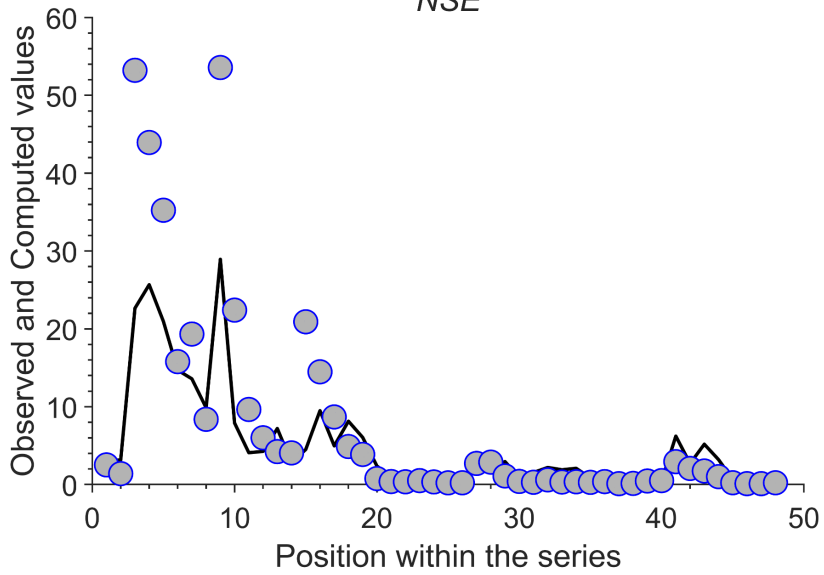
NRMSE=100·*RMSE*/*SD*=52%; ***KGE*=0.696 [0.576 - 0.797]**; *N*=84
Presence of outliers (Q-test): NO
Model bias: NO

RESULTS AND DISCUSSION

FITEVAL Result for monthly validation (2019-2022)







========== **GOODNESS-OF-FIT EVALUATION** ==========

Evaluation of *NSE*: **From ACCEPTABLE to VERY GOOD**

Probability of fit being:

- *Very good* (*NSE* = 0.750 - 1.000): 12.5%
- *Good* (*NSE* = 0.650 - 0.749): 64.8%
- *Acceptable* (*NSE* = 0.500 - 0.649): 22.4%
- ***Unsatisfactory* (*NSE* < 0.500): 0.3% (p-value: 0.003)**

NRMSE=100·*RMSE*/*SD*=56%; ***KGE*=0.483 [0.391 - 0.615]**; *N*=48

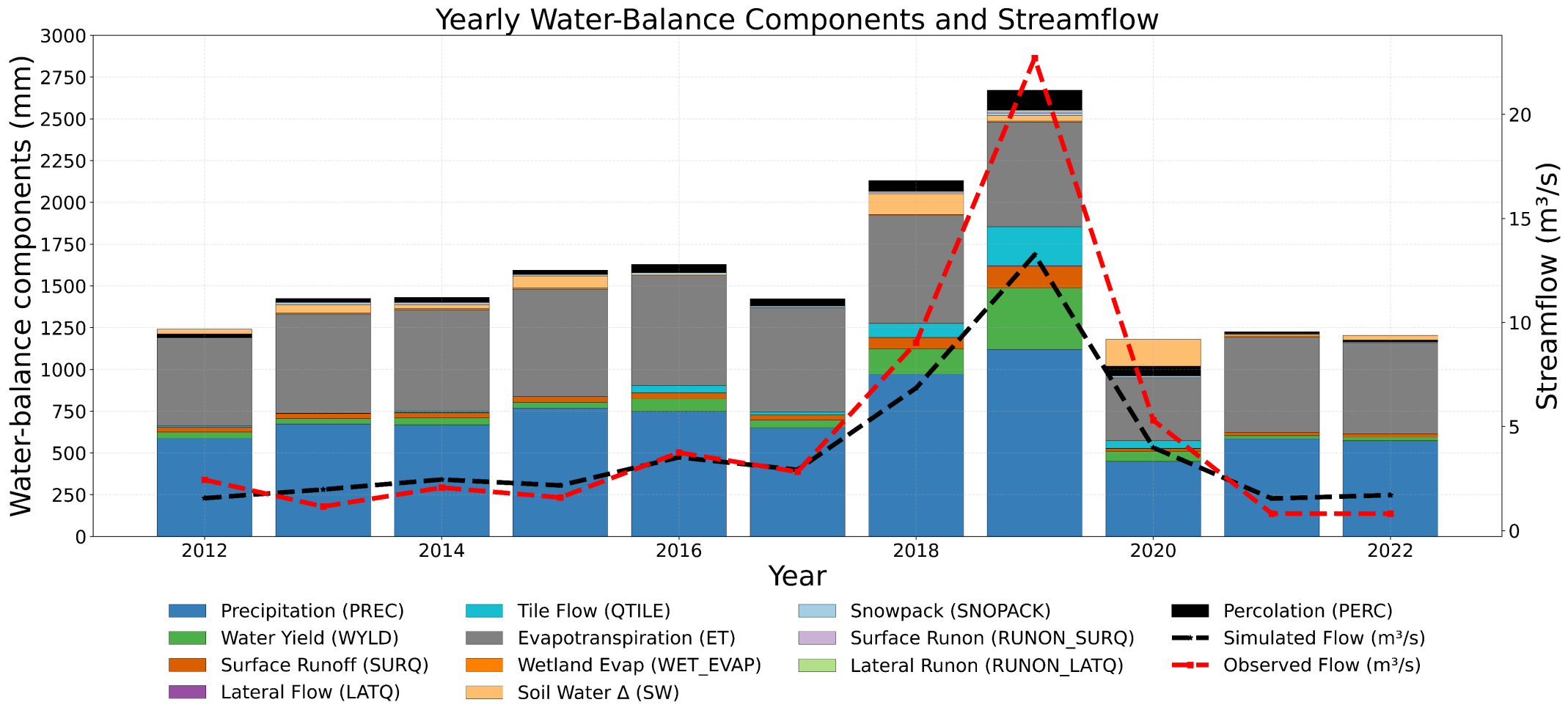
Presence of outliers (Q-test): NO

Model bias: Underprediction by -30.8% of the mean

(*NSE* may be influenced by model bias)

RESULTS AND DISCUSSION

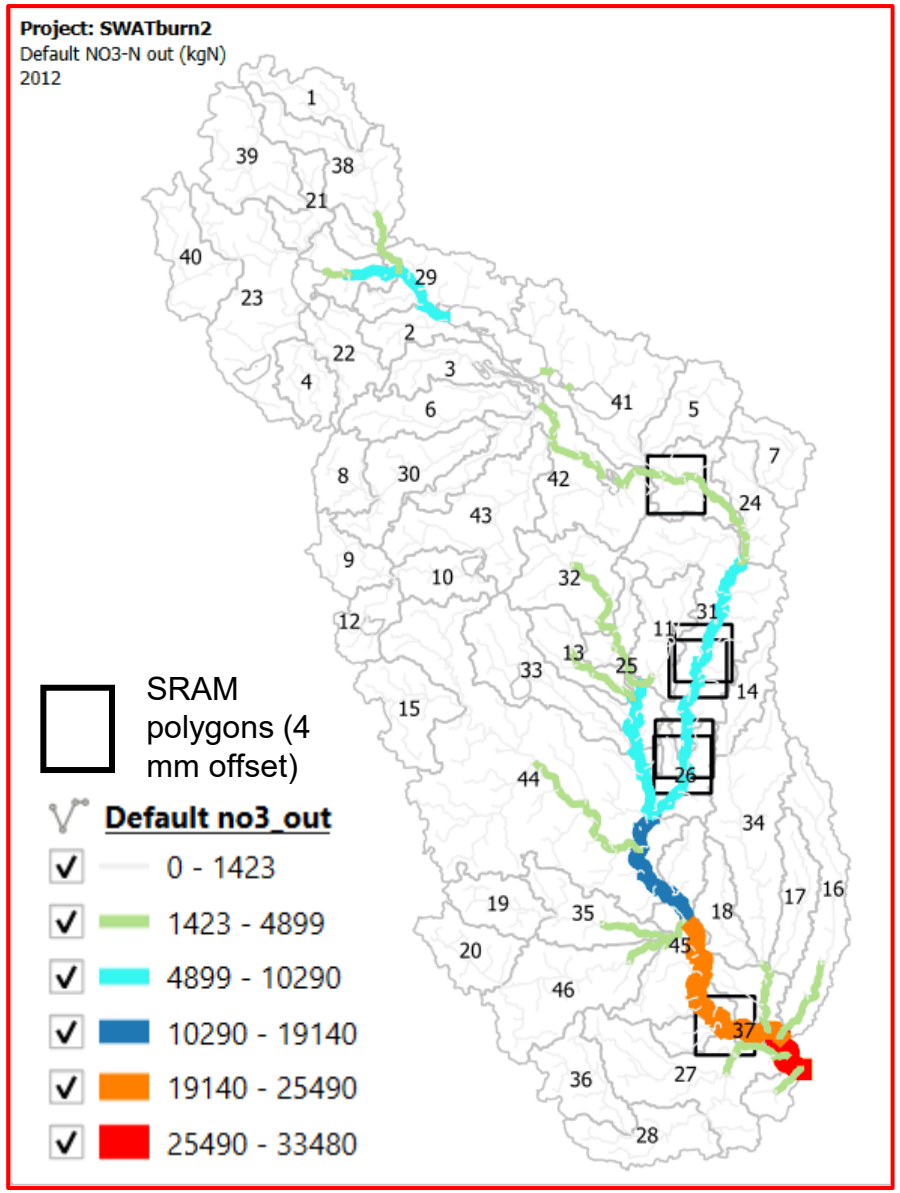
Basin water balance components



RESULTS AND DISCUSSION

Result of objective 2 : Nitrate-N hotspots area u/s of SRAM enrolled polygons

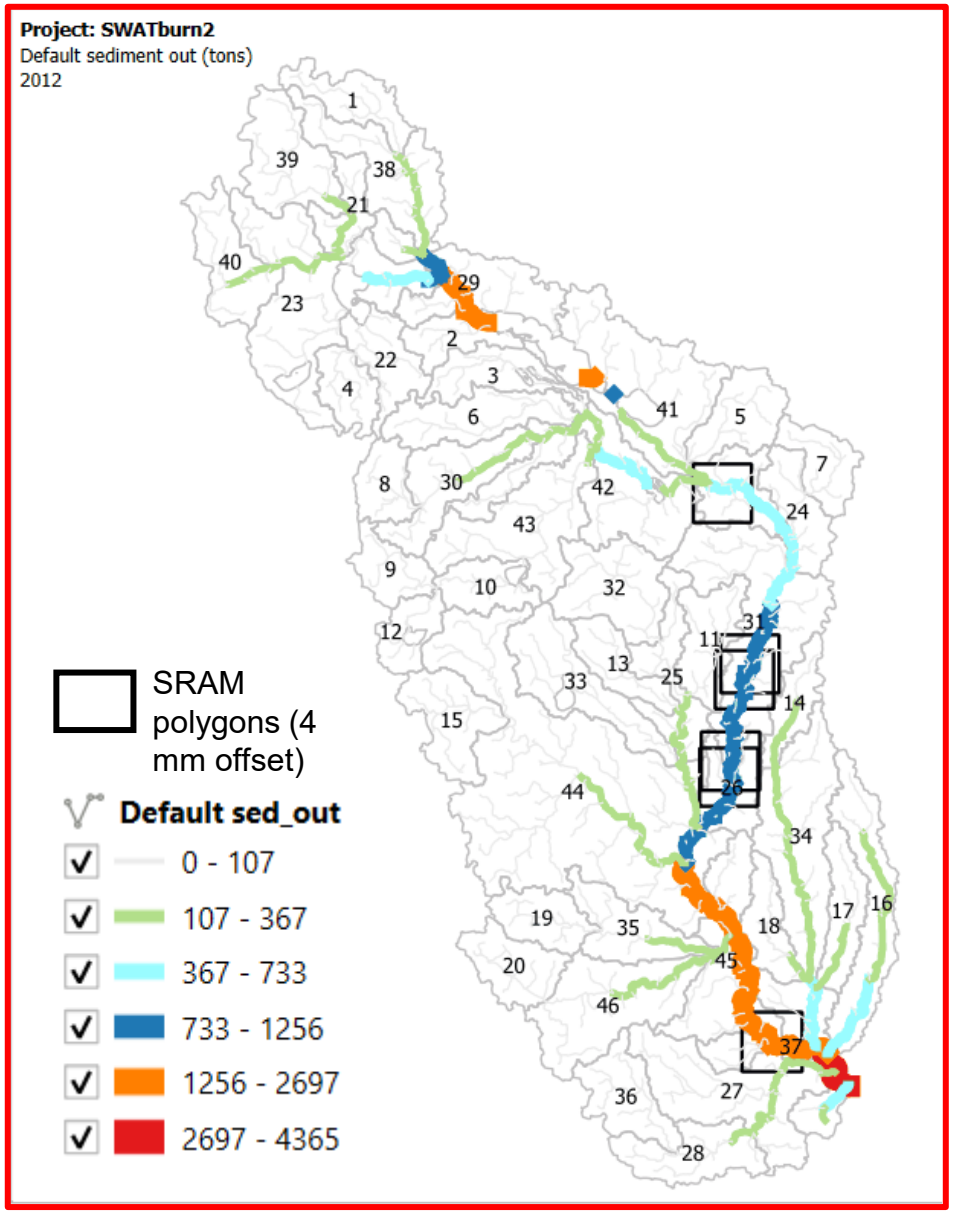
Yearly Nitrate (NO_3-N) movement from each subbasin into main-stream with and with out crossing SRAM polygons (2012 to 2022).



RESULTS AND DISCUSSION

Result of objective 2: Sediment hotspots area u/s of SRAM enrolled polygons

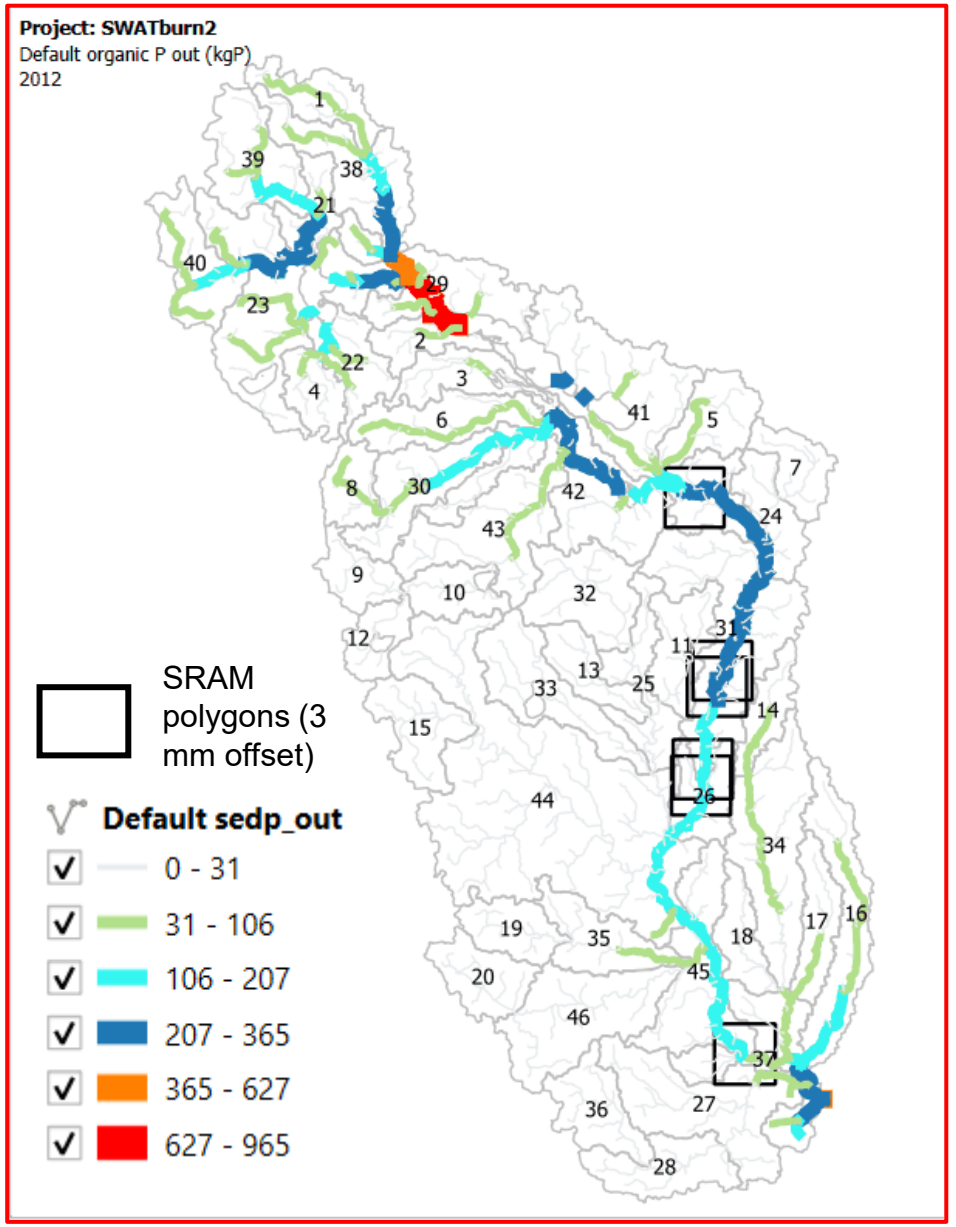
Yearly Sediment movement from each subbasin into main-stream with and without crossing SRAM polygons (2012 to 2022)



RESULTS AND DISCUSSION

Result of objective 2: Sediment phosphorous hotspots area u/s of SRAM enrolled polygons

Yearly Sediment (organic) phosphorous movement from each subbasin into main-stream with and with out crossing SRAM polygons (2012 to 2022).



CONCLUSIONS

1. The SWAT+ model was successfully calibrated and validated using observed streamflow data. The FITEVAL evaluation confirmed overall statistical reliability, with most daily NSE values rated good to very good.

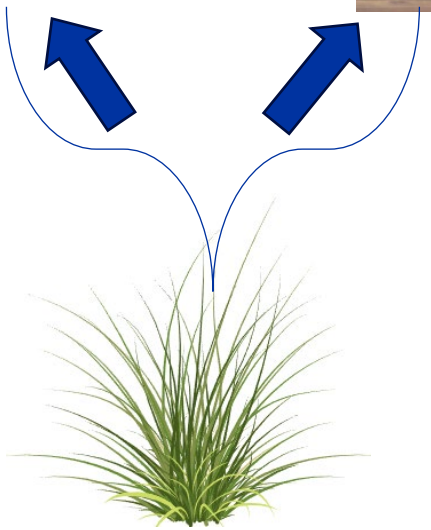
2. The water balance analysis indicated that precipitation drives the hydrological cycle, with major losses through evapotranspiration and percolation, while surface runoff and lateral flow contribute to streamflow variability accurately represented by the model.

3. Sediment and nutrient hotspot mapping identified several high-loading zones upstream of SRAM-enrolled polygons. This shows that while SRAM practices are effective locally, unmanaged upland areas remain key sources of sediment and nutrient export.

FUTURE RESEARCH WORKS

- Future calibration and validation will be extended to include sediment and nitrate-N (as nitrogen) components to improve model comprehensiveness.

- The updated model will then be used to simulate BMP scenarios, such as vegetation buffers and deferred grazing, for evaluating potential reductions in sediment and nutrient export.



THANK YOU SO MUCH !