Using SWOT Data to Improve FM Global's Worldwide Flood Hazard Model

Alain Dib

Jeff McCollum

12-07-2023

Commercial and Industrial Property Insurance Company

Engineering-based and Research-based Approaches

Insuring More Than One-third of Fortune 1000 Companies

Majority of Loss is Preventable

Mitigating Risk

- Fire and Explosion Hazards
- Structures and Geohazards
- Climate Risk and Resilience
- Equipment, Systems, and Cyber Related Hazards

Worldwide Flood Map

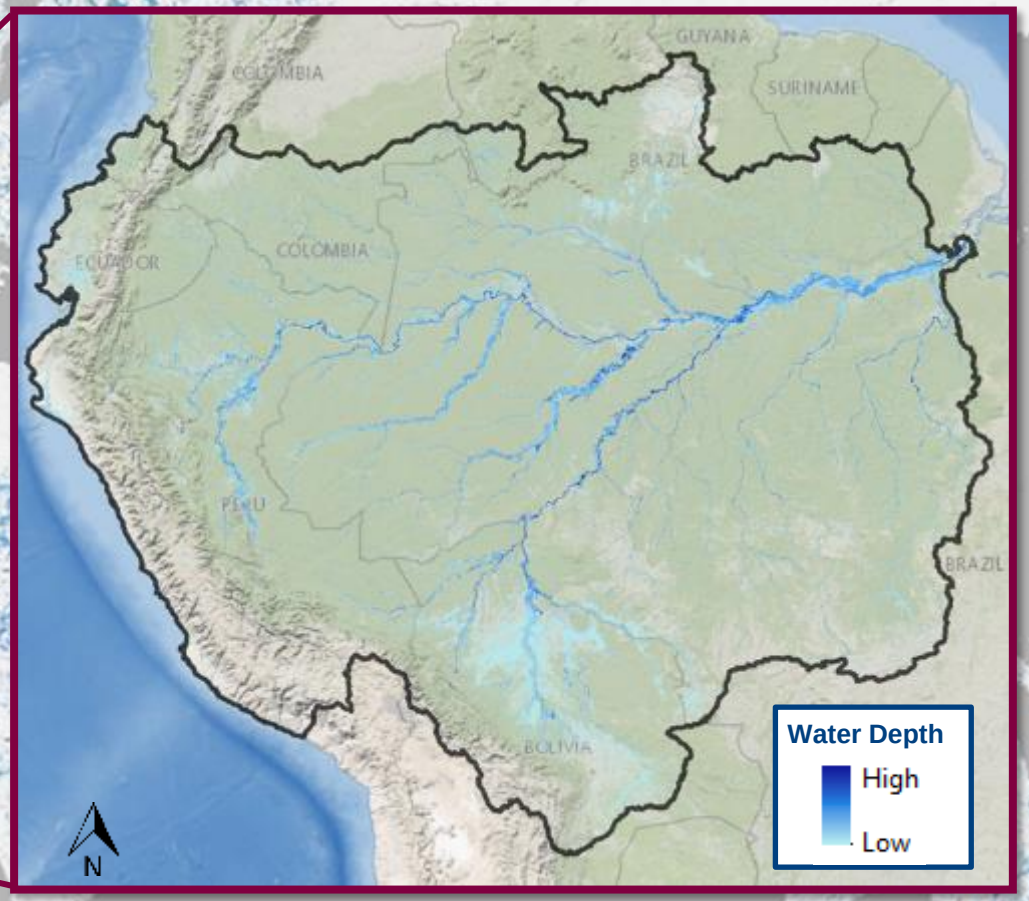
Identify areas exposed to moderate- or high-hazard flooding on a global scale

Riverine flooding

100-yr and 500-yr return periods

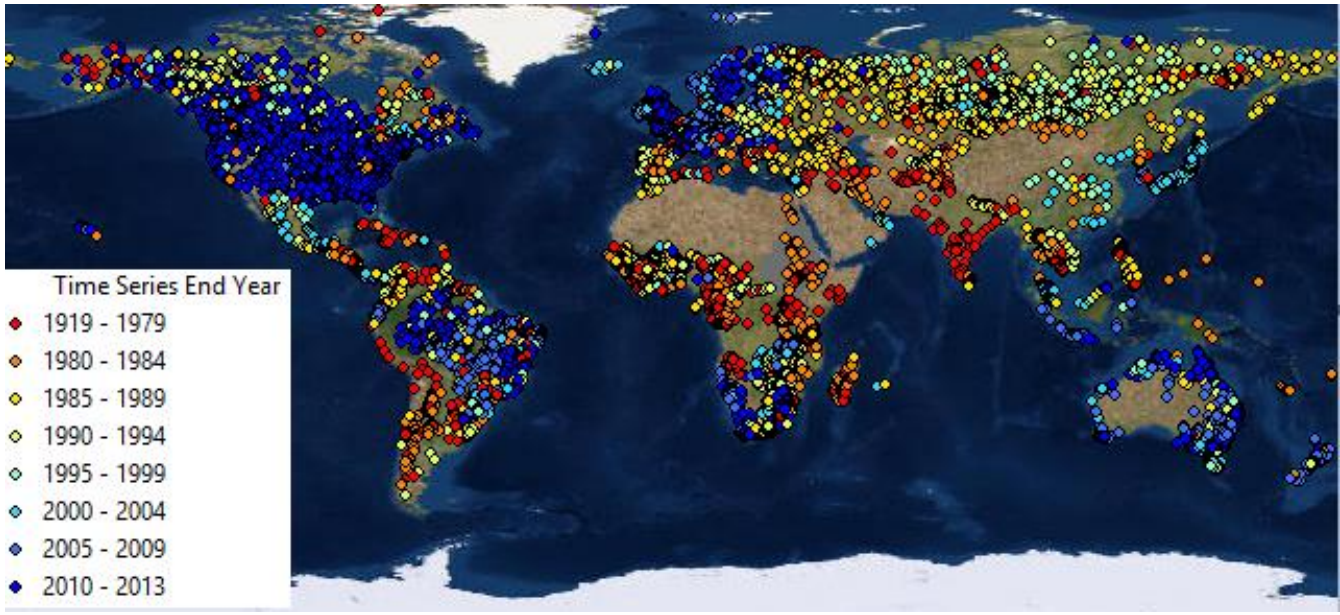
Physically-based modeling system

Calibration of Hydrologic Model



Global Stream Gauge Data

- Calibration requires observed data
- Stream gauges are prime source of such observations
- Inadequate stream gauge network in many parts of the world
- Many basins left ungauged
  - Catchment similarity

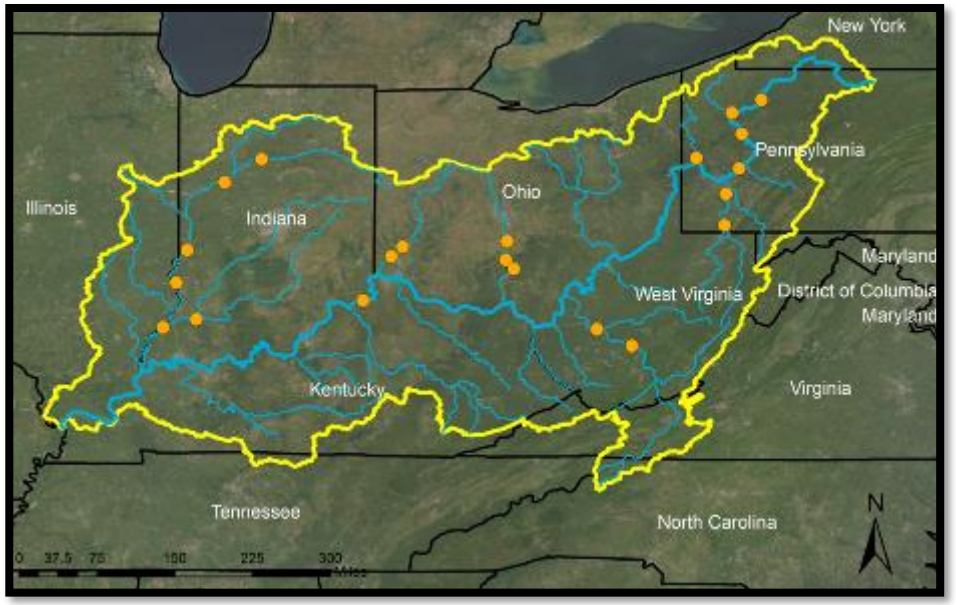


Attributes
- Land Cover
- Climate
- Soil
- Topography
- Catchment size

Objective: *Using SWOT Mission's Hydrology Products to obtain additional data/observations to help improve model calibration, especially at ungauged basins*

First Study

- Assessment of calibrating a hydrologic model using SWOT (synthetic) data versus continuous gauge data
  - Ohio River Basin
  - 21 stream gauges
  - Over a 6-year period

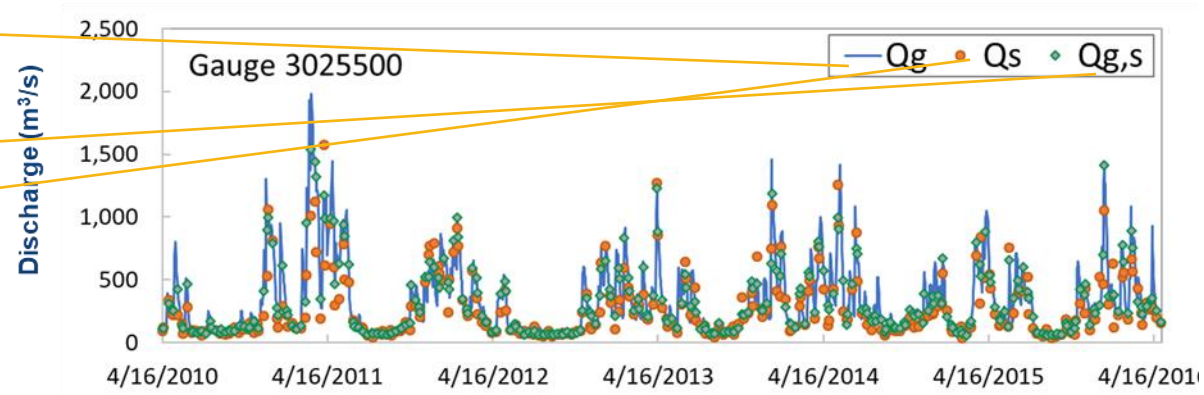


Calibrate the hydrologic model using all 3 datasets

A. Continuous USGS gauge data (Qg) **(baseline)**

B. USGS gauge data at SWOT dates (Qg,s)

C. SWOT synthetic data (Qs)



First Study

Calibrate the hydrologic model using all 3 datasets

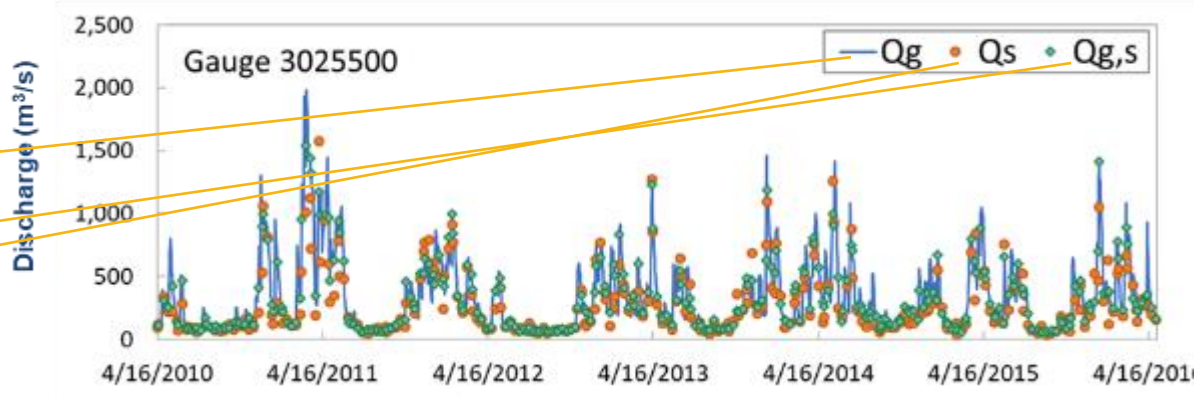
A. Continuous USGS gauge data (Qg) **(baseline)**

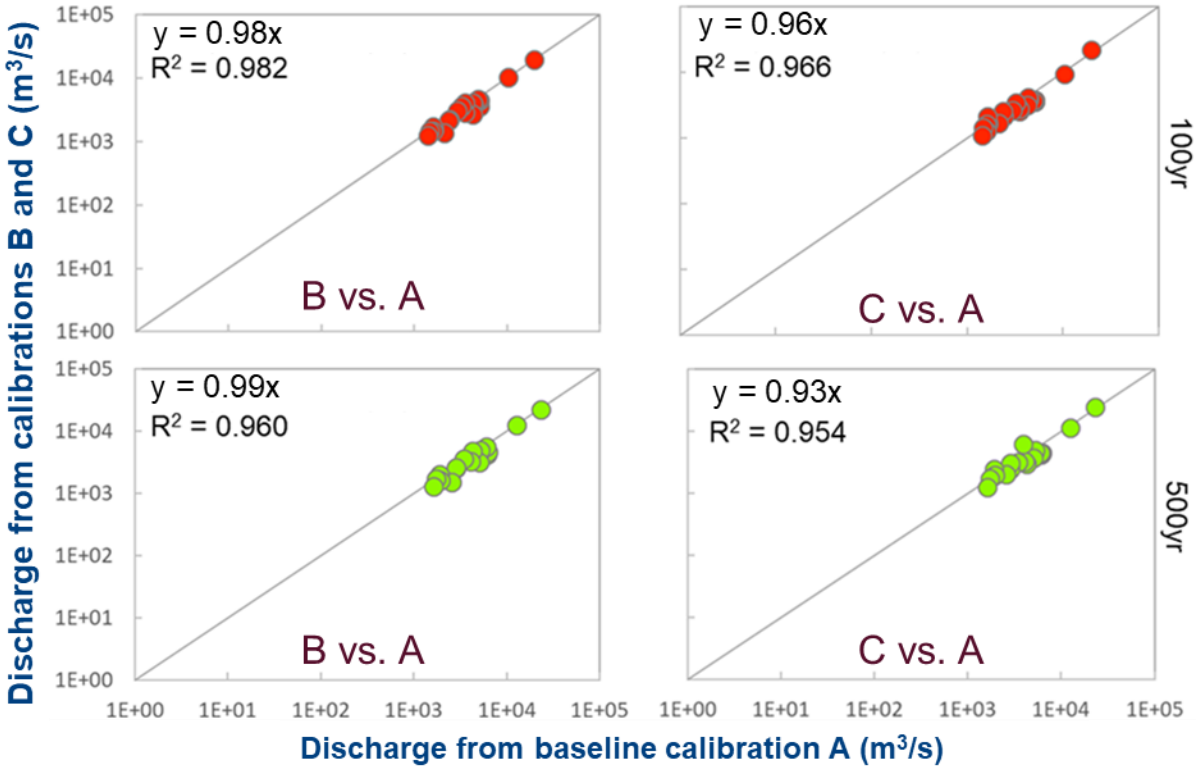
B. USGS gauge data at SWOT dates (Qg,s)

C. SWOT synthetic data (Qs)

- Run hydrologic model for 1979-2009 (31 years) using
  - Calibration parameters from A
  - Calibration parameters from B
  - Calibration parameters from C
- Estimate 100-yr and 500-yr discharges for A, B, and C (Q100 and Q500)
- Compare B vs. A and C vs. A

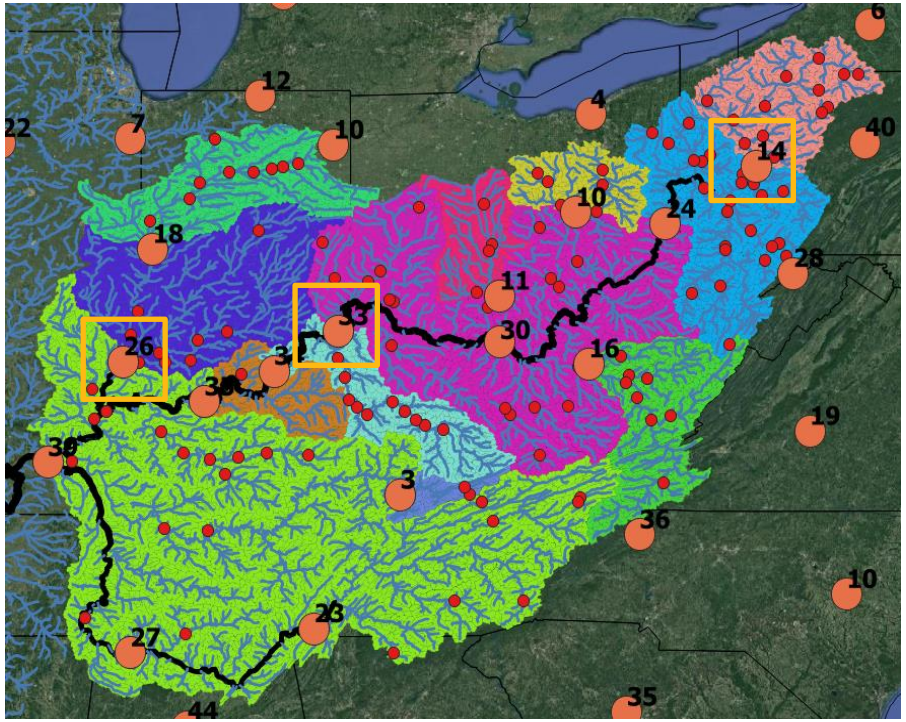
Using SWOT (synthetic) data to calibrate hydrologic model over same period gives comparable Q100 and Q500 discharges as its counterpart continuous data





Second Study

- Assessment of hydrologic model calibration using SWOT (synthetic) data over small time periods
  - Ohio River Basin
  - 44+ stream gauges
  - Over 3-year periods within 1979 – 2017



Calibrate the hydrologic model at multiple gauges over 3 time periods

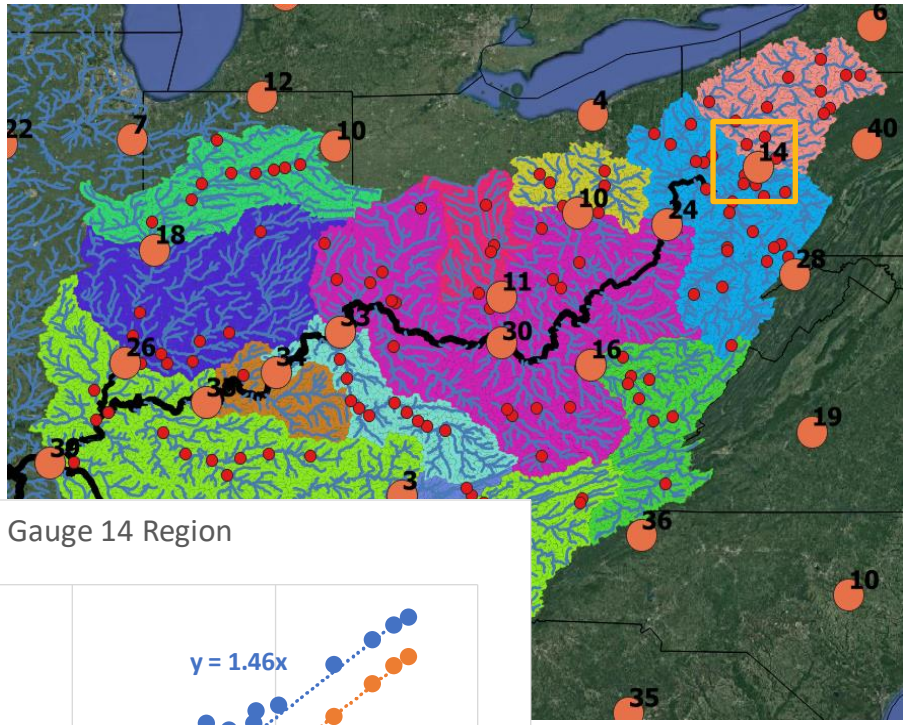
- 39-year period (1979-2017) using continuous discharge data (Calibration A) **(baseline)**
- 3-year period (1979-1981) using SWOT synthetic data (Calibration S79-81)
- 3-year period (1982-1985) using SWOT synthetic data (Calibration S82-85)

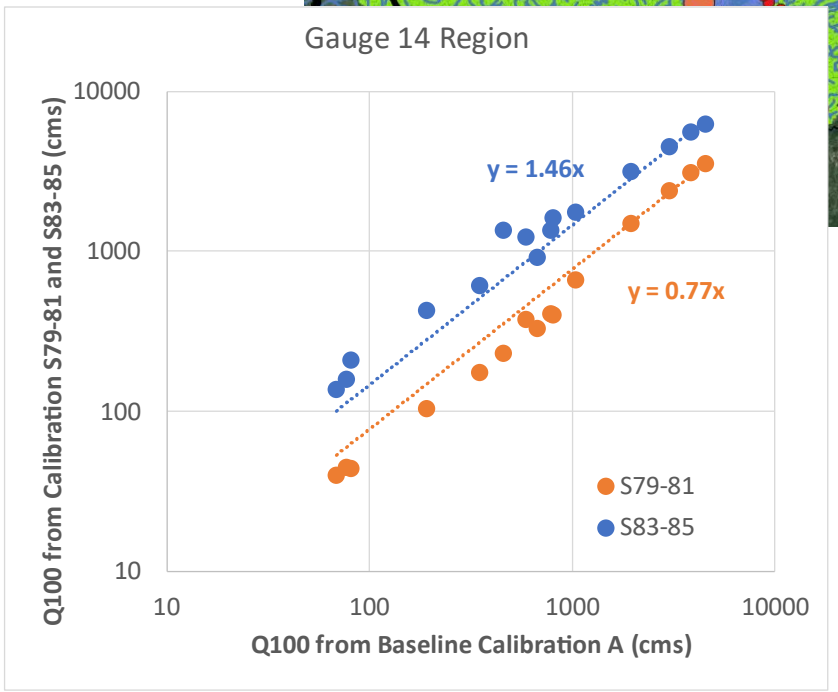
Second Study

- Gauge #14 region (23,000 km^2)

- 1st comparison: Q100 at outlet
  - Calibration S79-81: Q100 is 0.1x higher than baseline A
  - Calibration S83-85: Q100 is 0.4x higher than baseline A

- 2nd comparison: Q100 at 15 upstream gauges
  - Calibration S79-81: Q100 is 0.23x lower than baseline A
  - Calibration S83-85: Q100 is 0.46x higher than baseline A

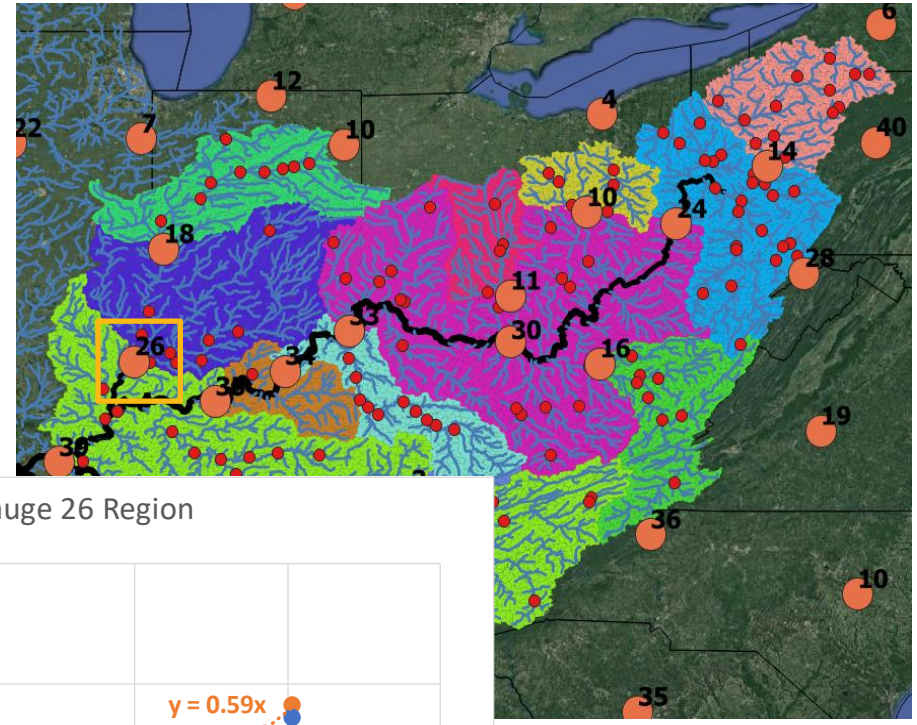




A: 39-year period (1979-2017) continuous
S79-81: 3-year period (1979-1981) SWOT
S83-85: 3-year period (1982-1985) SWOT

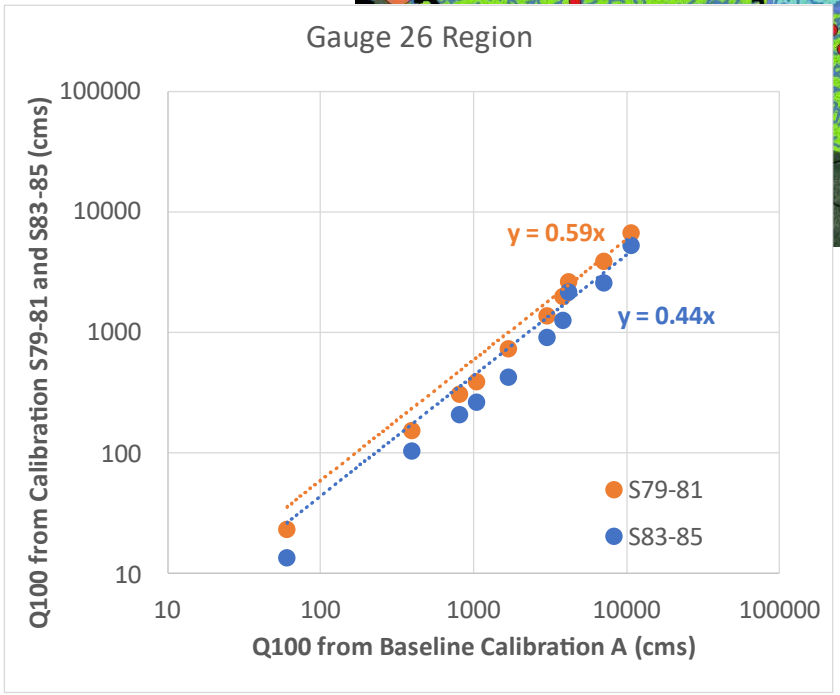
Second Study

- Gauge #26 region (75,000 km^2)



- 1st comparison: Q100 at outlet
  - Calibration S79-81: Q100 is 0.4x lower than baseline A
  - Calibration S83-85: Q100 is 0.5x lower than baseline A

- 2nd comparison: Q100 at 10 upstream gauges
  - Calibration S79-81: Q100 is 0.41x lower than baseline A
  - Calibration S83-85: Q100 is 0.56x lower than baseline A



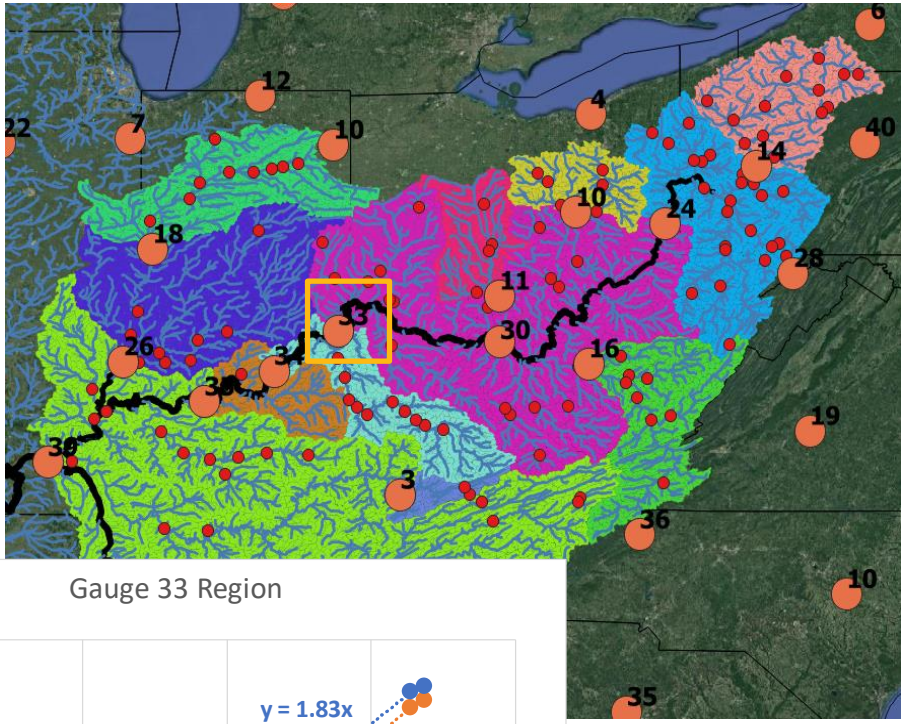
A: 39-year period (1979-2017) continuous
S79-81: 3-year period (1979-1981) SWOT
S83-85: 3-year period (1982-1985) SWOT

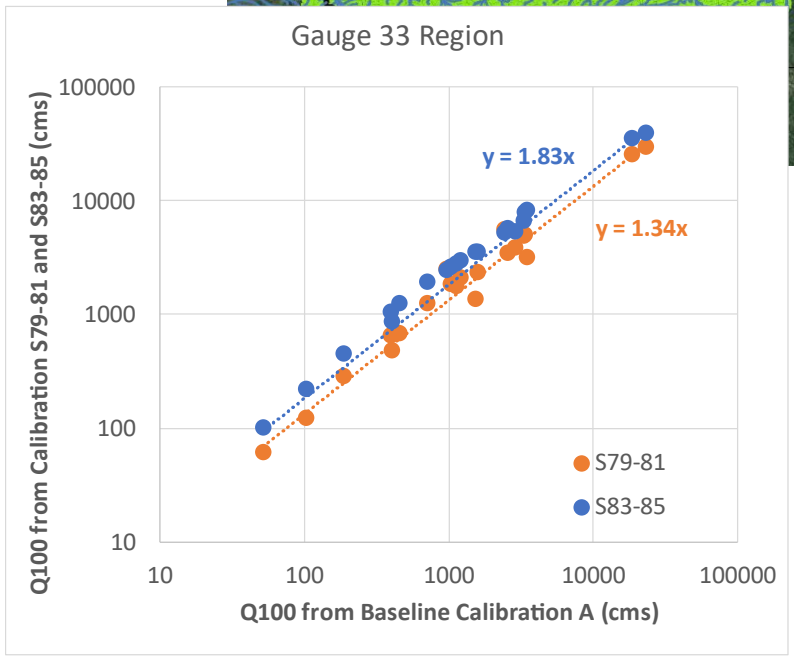
Second Study

- Gauge #33 region (215,000 km^2)

- 1st comparison: Q100 at outlet
  - Calibration S79-81: Q100 is 0.13x lower than baseline A
  - Calibration S83-85: Q100 is 0.74x higher than baseline A

- 2nd comparison: Q100 at 20 upstream gauges
  - Calibration S79-81: Q100 is 0.34x higher than baseline A
  - Calibration S83-85: Q100 is 0.83x higher than baseline A





A: 39-year period (1979-2017) continuous
S79-81: 3-year period (1979-1981) SWOT
S83-85: 3-year period (1982-1985) SWOT

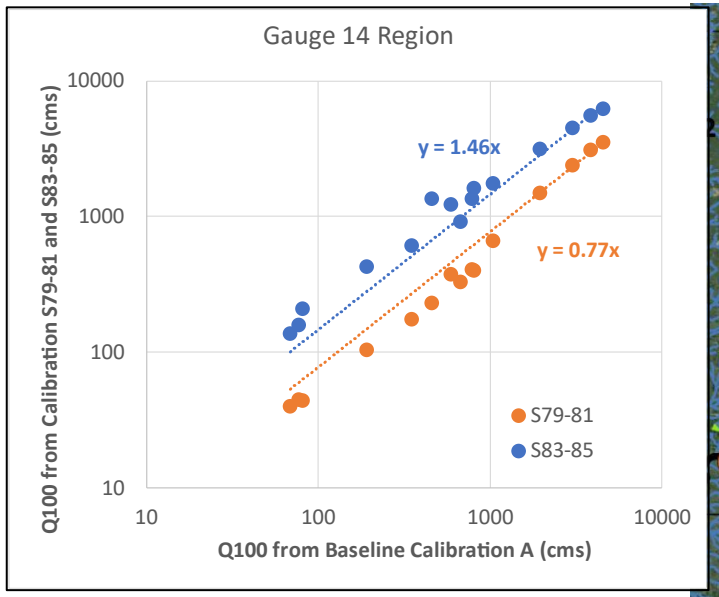
Second Study

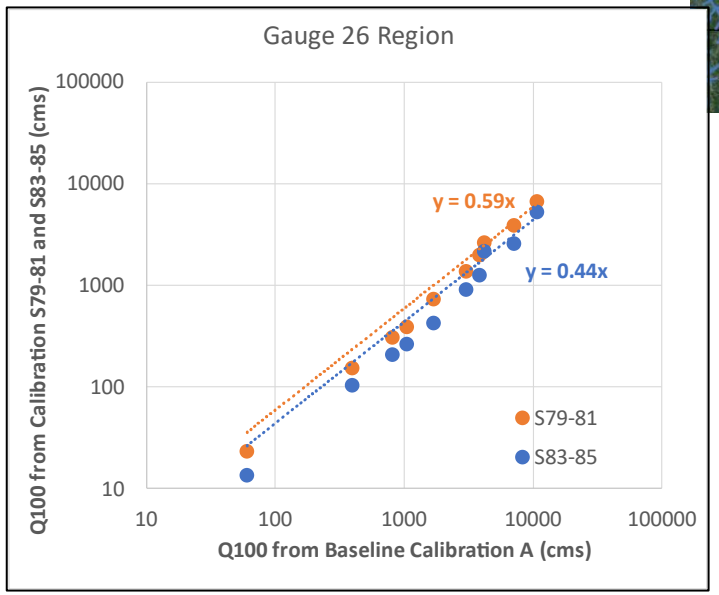
Calibrating using 3 years of SWOT data

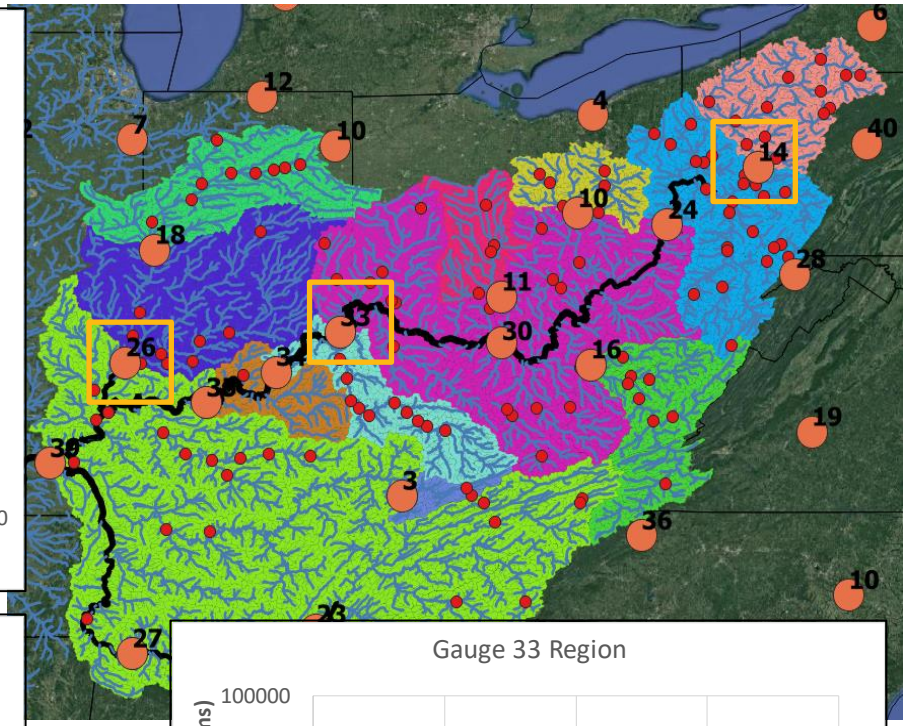
- Ohio River Basin
- 3-year samples
  - 1979-1981
  - 1983-1985

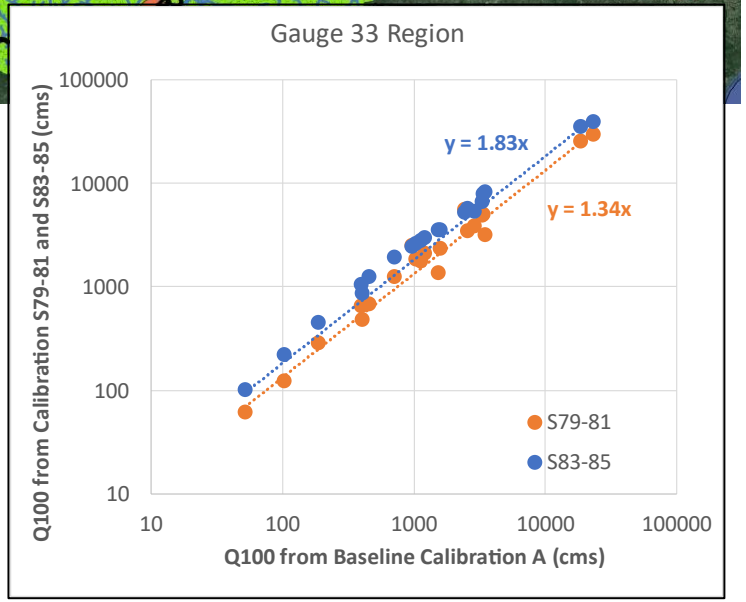
Outcomes

- ~<2x uncertainty
- Potential to provide better insights into hydrology of ungauged basins compared to other methods









A: 39-year period (1979-2017) continuous
S79-81: 3-year period (1979-1981) SWOT
S83-85: 3-year period (1982-1985) SWOT

Conclusions

- **1st study:** Using SWOT (synthetic) data to calibrate a hydrologic model over same period gives comparable 100-yr and 500-yr discharges as its counterpart continuous data

- **2nd study:** For the three regions tested, using 3 years of SWOT data for calibration
  - May lead to ~<2x uncertainty in 100-yr discharge estimation
  - Have the potential to provide better insights into hydrology of ungauged basins compared to other methods

- There is opportunity in using SWOT data to calibrate global hydrologic models, especially in ungauged or data-sparse basins

- A longer period of SWOT data (> 3 years) would be greatly advantageous in calibrating such models while reducing the uncertainty in discharge estimation

THANK YOU!