SWOT Applications in Alaska

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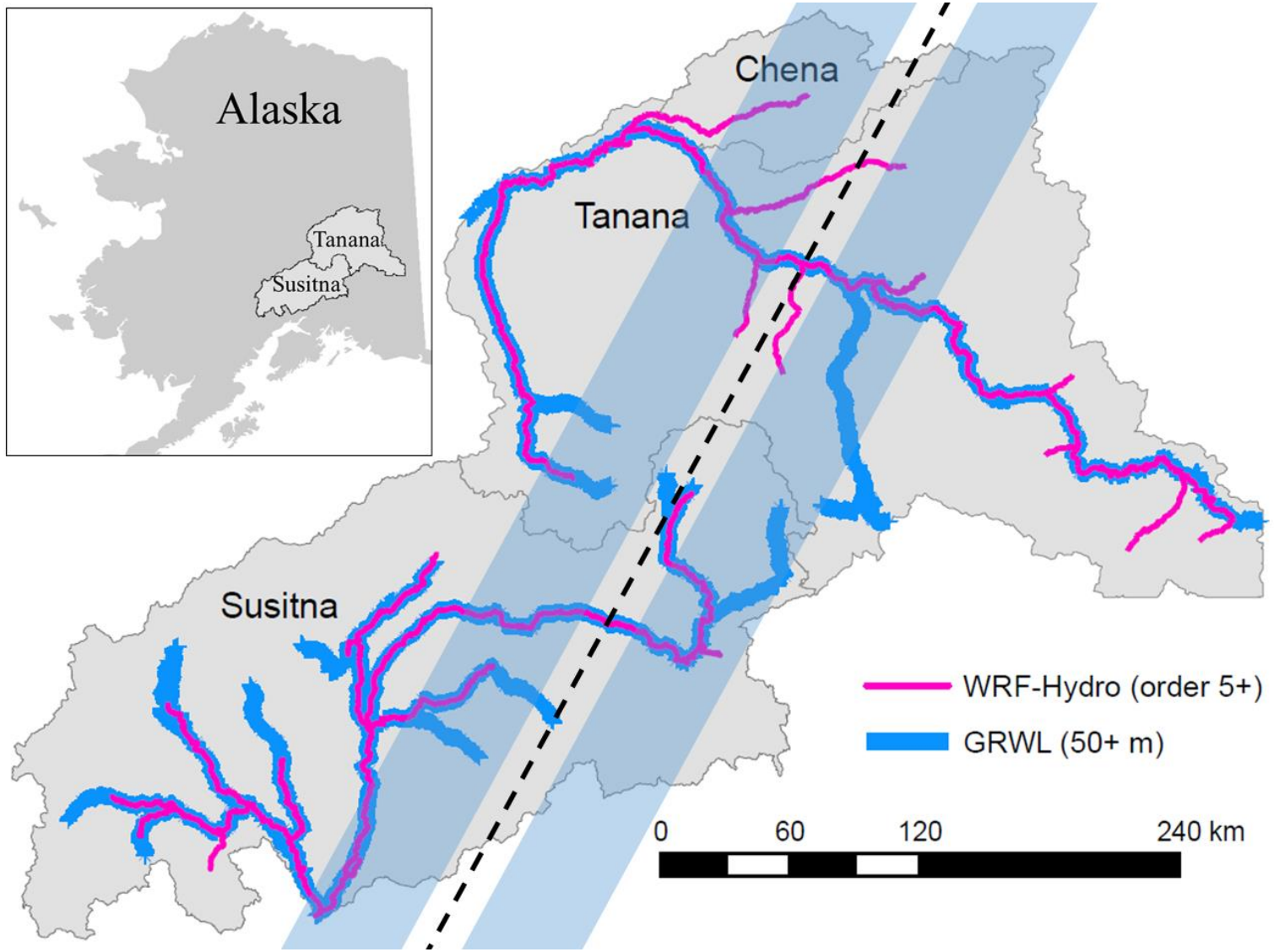
Introduction and Motivation

- Increasing number of impactful flood and drought events on national and global scale in recent years
- Flood events well-predicted by weather models, but **limited guidance of flooding and inundation is available**
- Skill of flood and drought forecasts lag behind skill of operational weather forecasts due to **lack of hydrologic data** (Lui et al., 2012)
- **Need for quality, high-resolution observations** with which to initialize land surface and hydrologic models

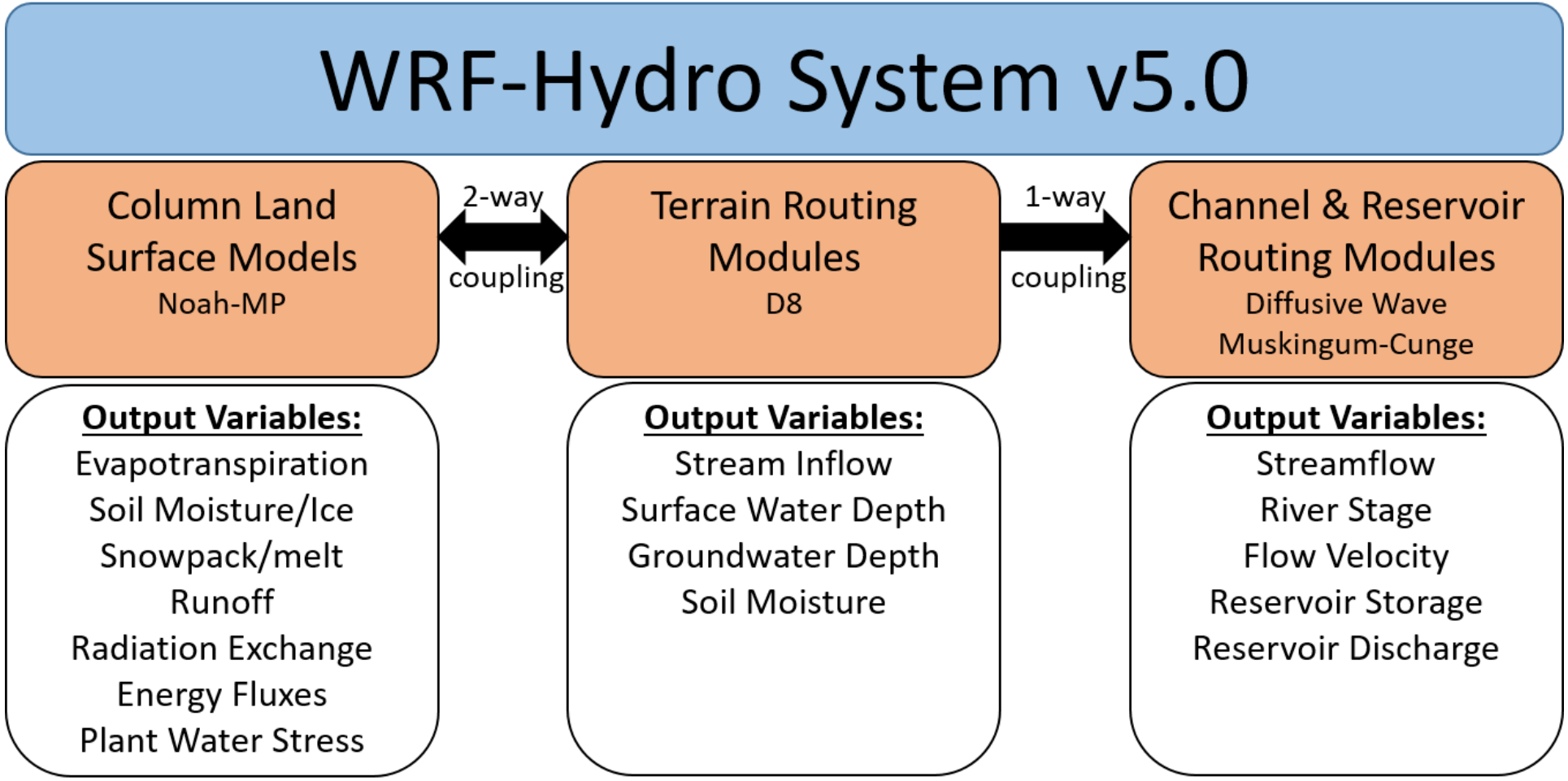
Hurricane Harvey, Houston, TX (2017)

NASA SWOT Mission

- NASA is launching the Surface Water Ocean Topography (SWOT) satellite mission in early 2022
- SWOT will provide **near-global measurements of river water surface elevation** (WSE)
- SWOT provides much-needed observations in regions with limited in situ (ground-based) measurements (e.g., Alaska)



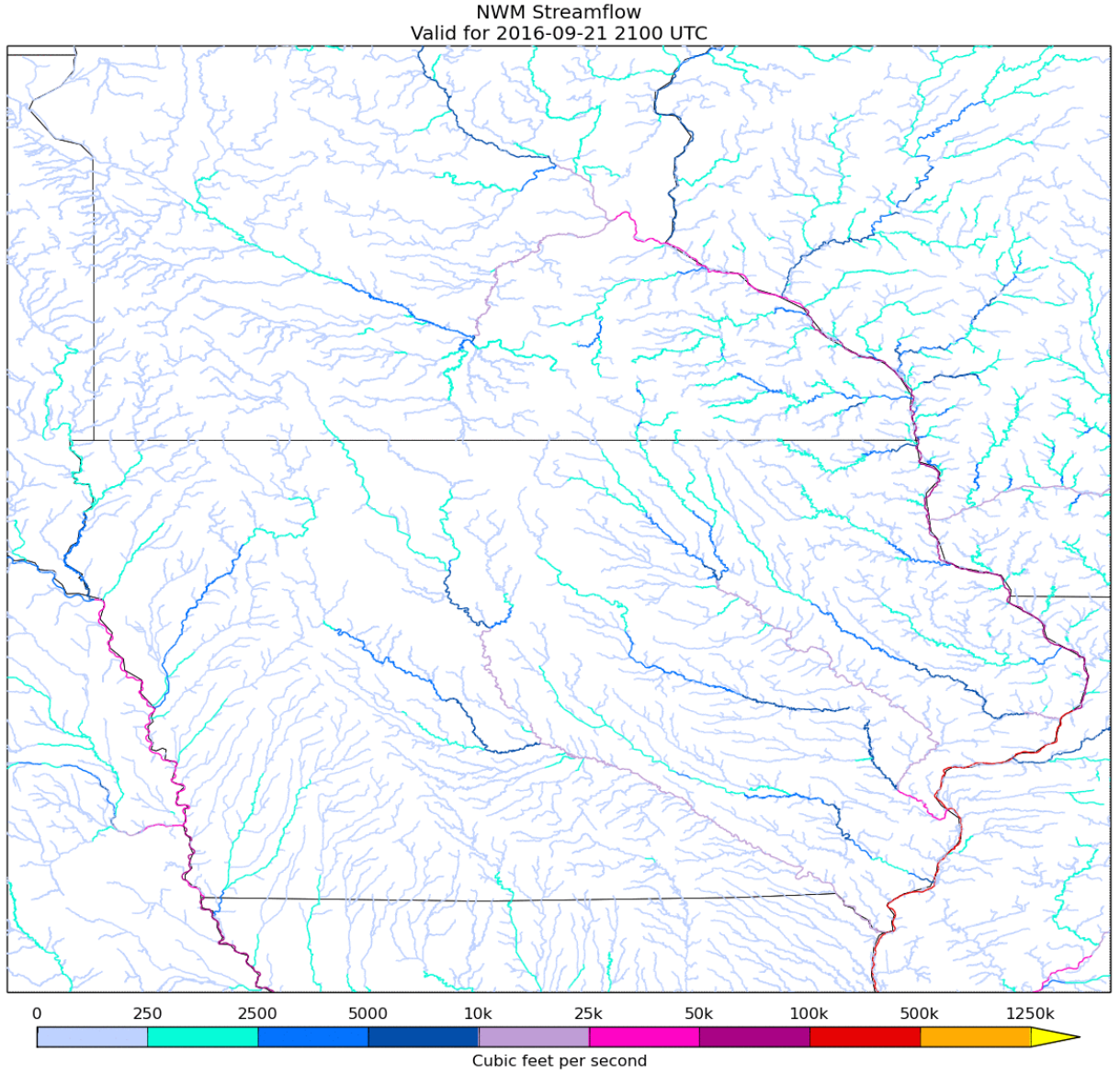
Alaska study domain comparing two river databases: one generated for WRF-Hydro (model used in this study) and GRWL (river database for SWOT river products). SWOT swath shown in blue. Figure from Elmer et al. [2020a].



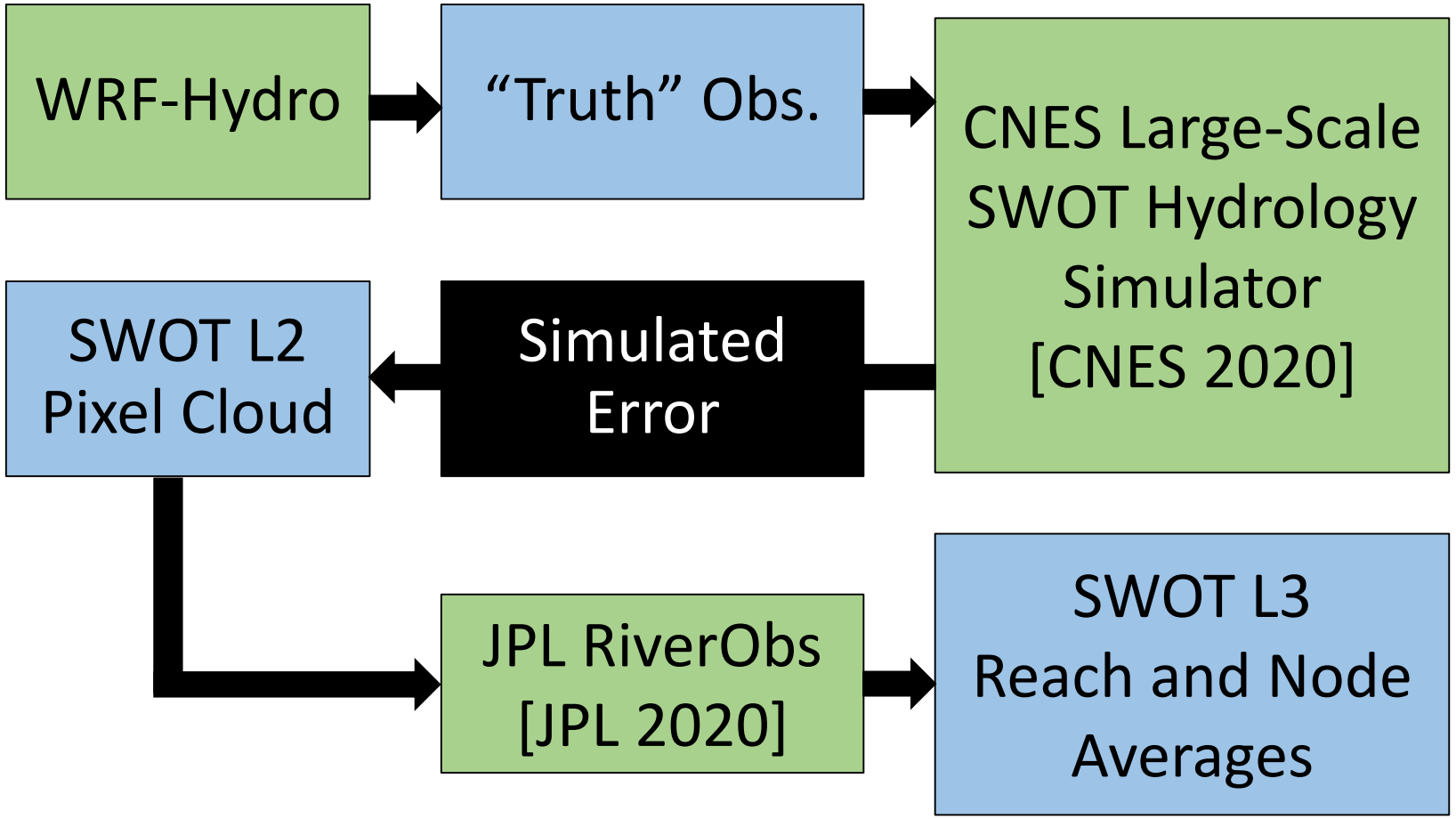
- Weather Research and Forecasting Hydrological extension package (WRF-Hydro; Gochis et al. 2018)
- Hydrological model combining land surface, terrain routing, and channel routing models to represent full water budget

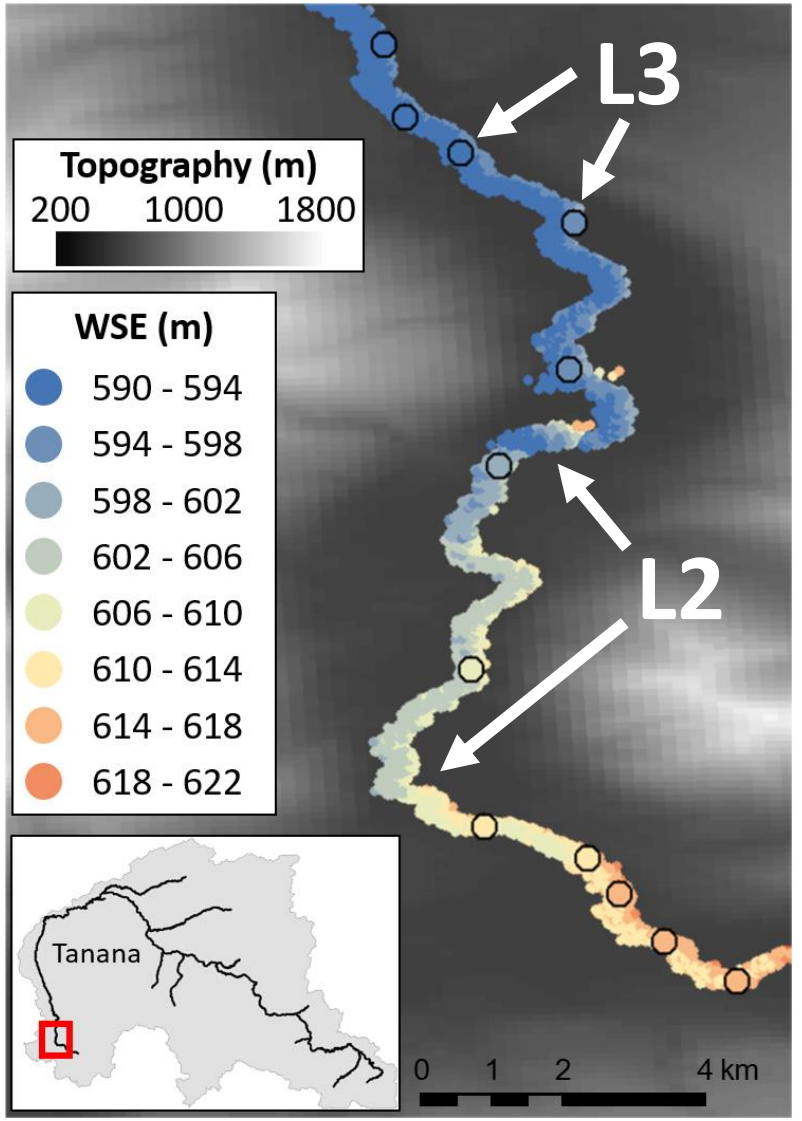
National Water Model

- WRF-Hydro is the backbone of **operational NOAA National Water Model** in U.S.
- **Can SWOT measurements support improved forecasting?**



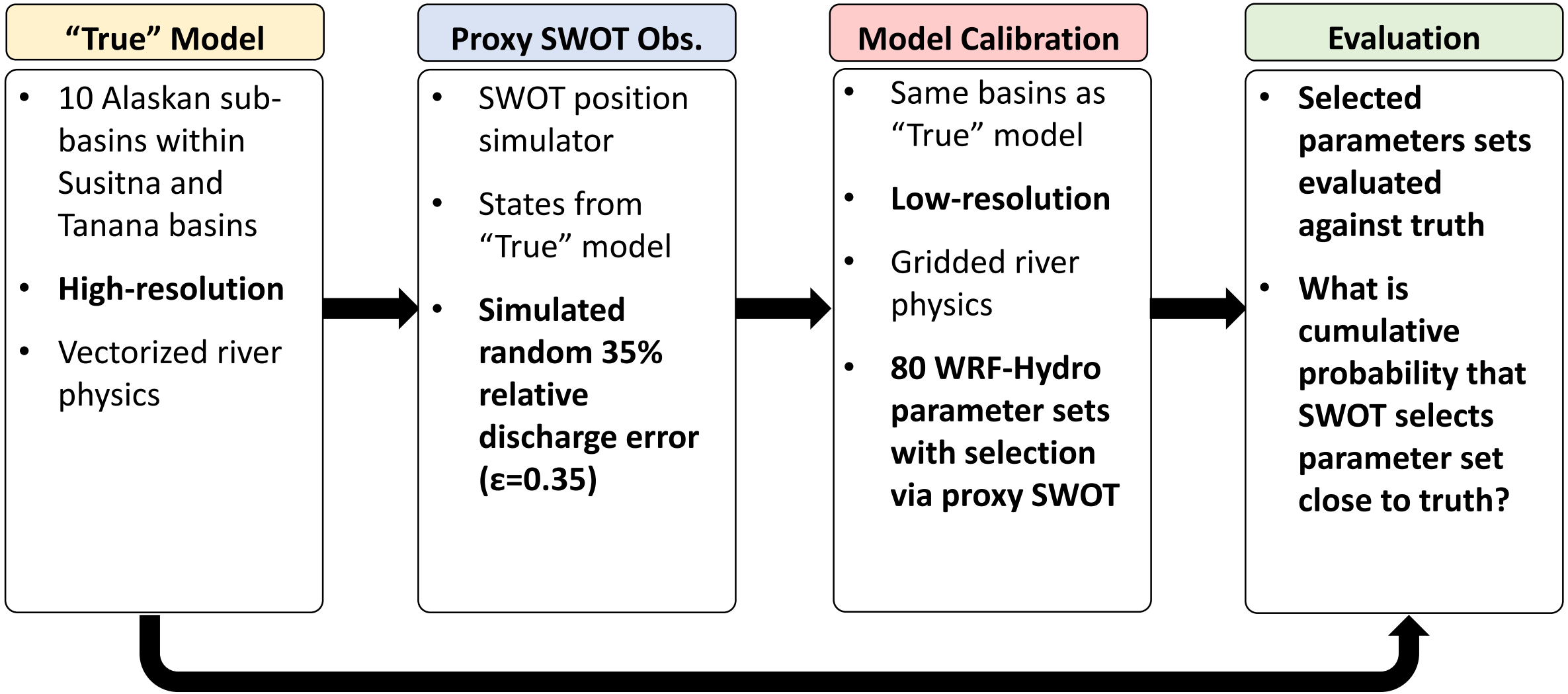
Using WRF-Hydro to create proxy SWOT obs.





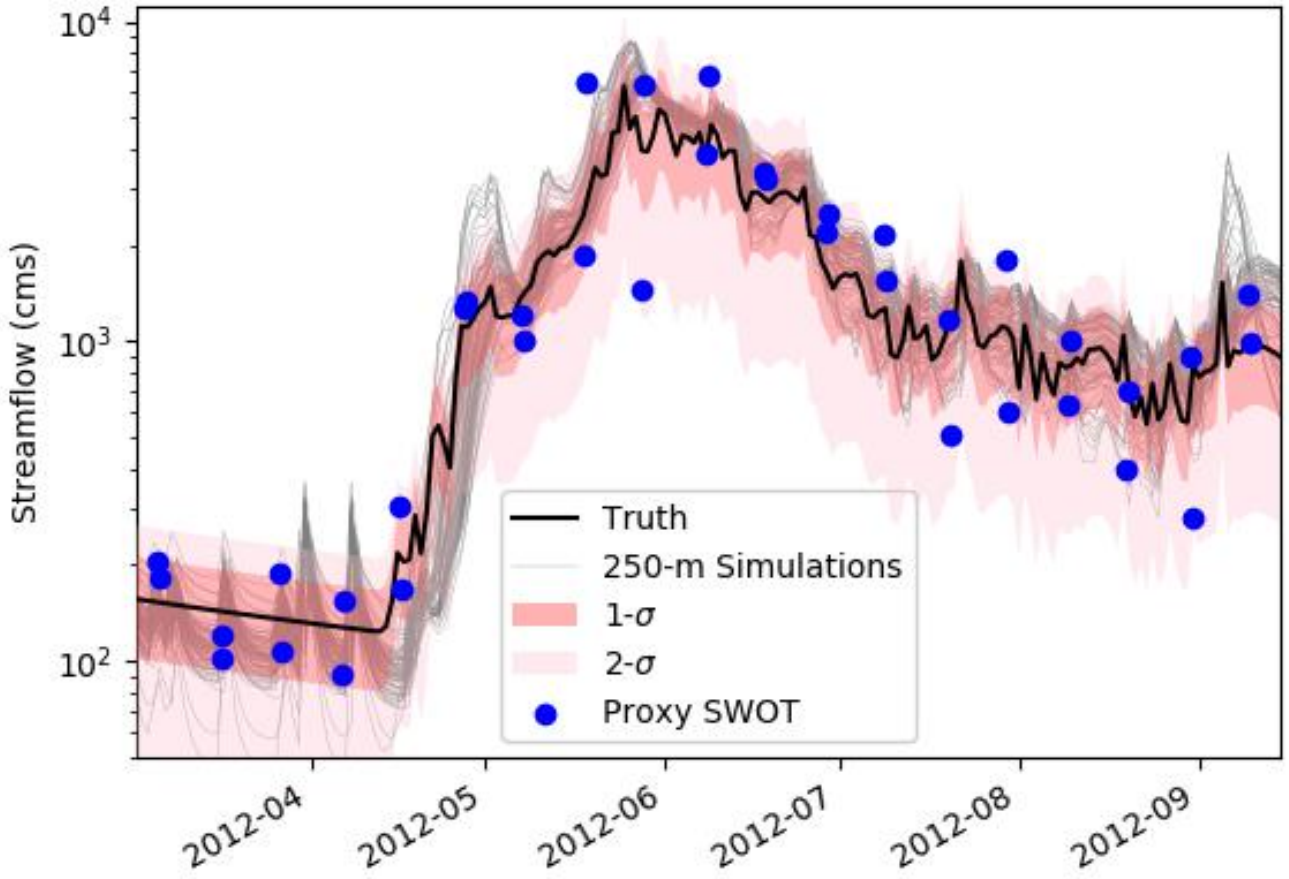
Elmer, N. J., C. R. Hain, F. Hossain, D. Desroches, C. Pottier (2020a), Generating proxy SWOT water surface elevations using WRF-Hydro and the CNES SWOT Hydrology Simulator, Water Resources Research, accepted.

Calibration (tuning WRF-Hydro parameters) with SWOT



Calibration in ungauged basins with SWOT obs.

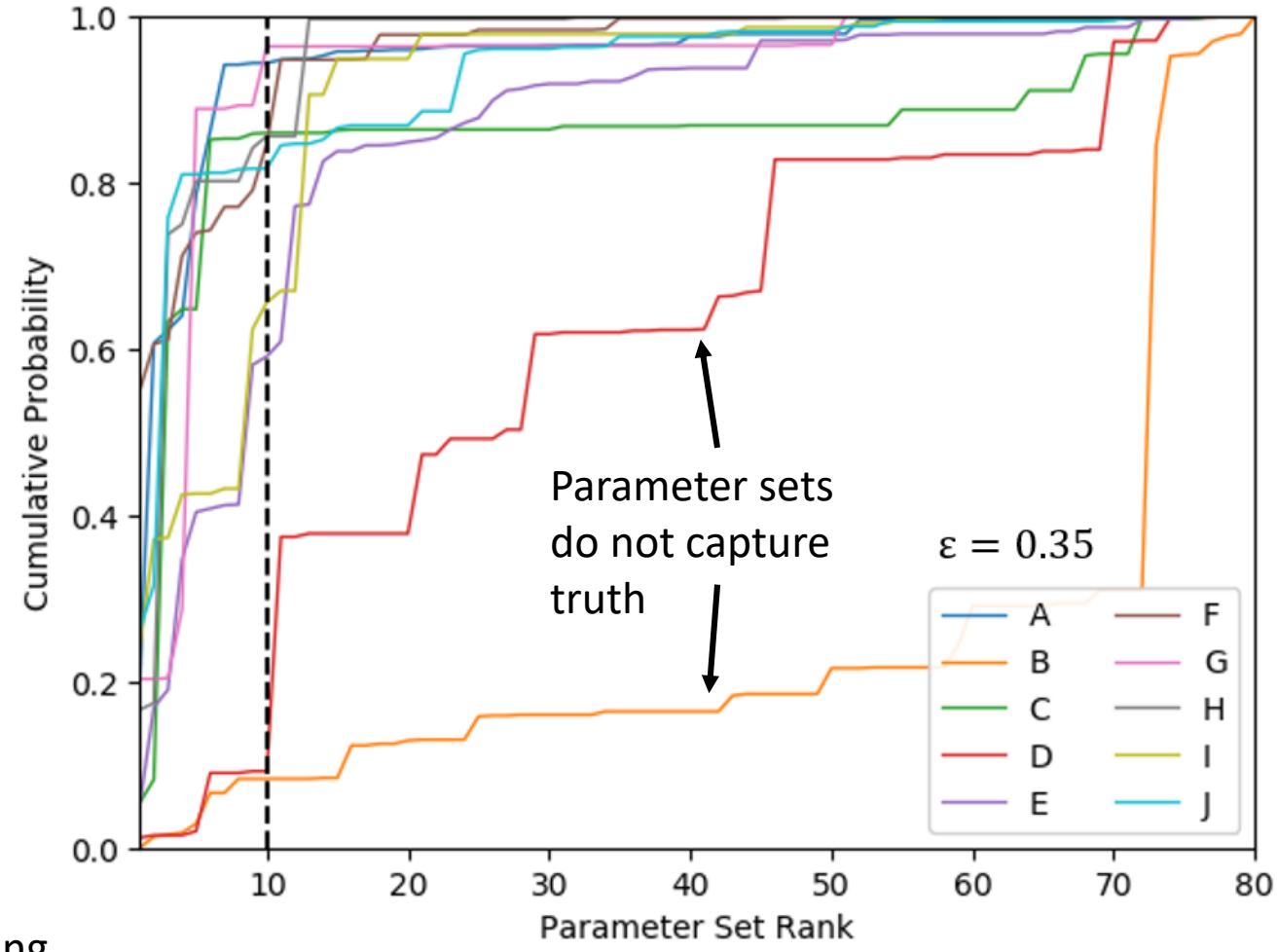
- Figure illustrates one set of proxy SWOT discharge estimates, truth, and simulations for one basin point
- To fully sample SWOT error distribution, employed **Monte Carlo methods** to create **10,000 proxy SWOT observation sets**
- What is **cumulative probability that SWOT selects a parameter set similar to truth**?



Elmer, N. J., J. McCreight, and C. R. Hain (2020b), Calibrating WRF-Hydro in ungauged basins using SWOT discharge estimates, Water Resources Research, submitted.

Calibration in ungauged basins with SWOT obs.

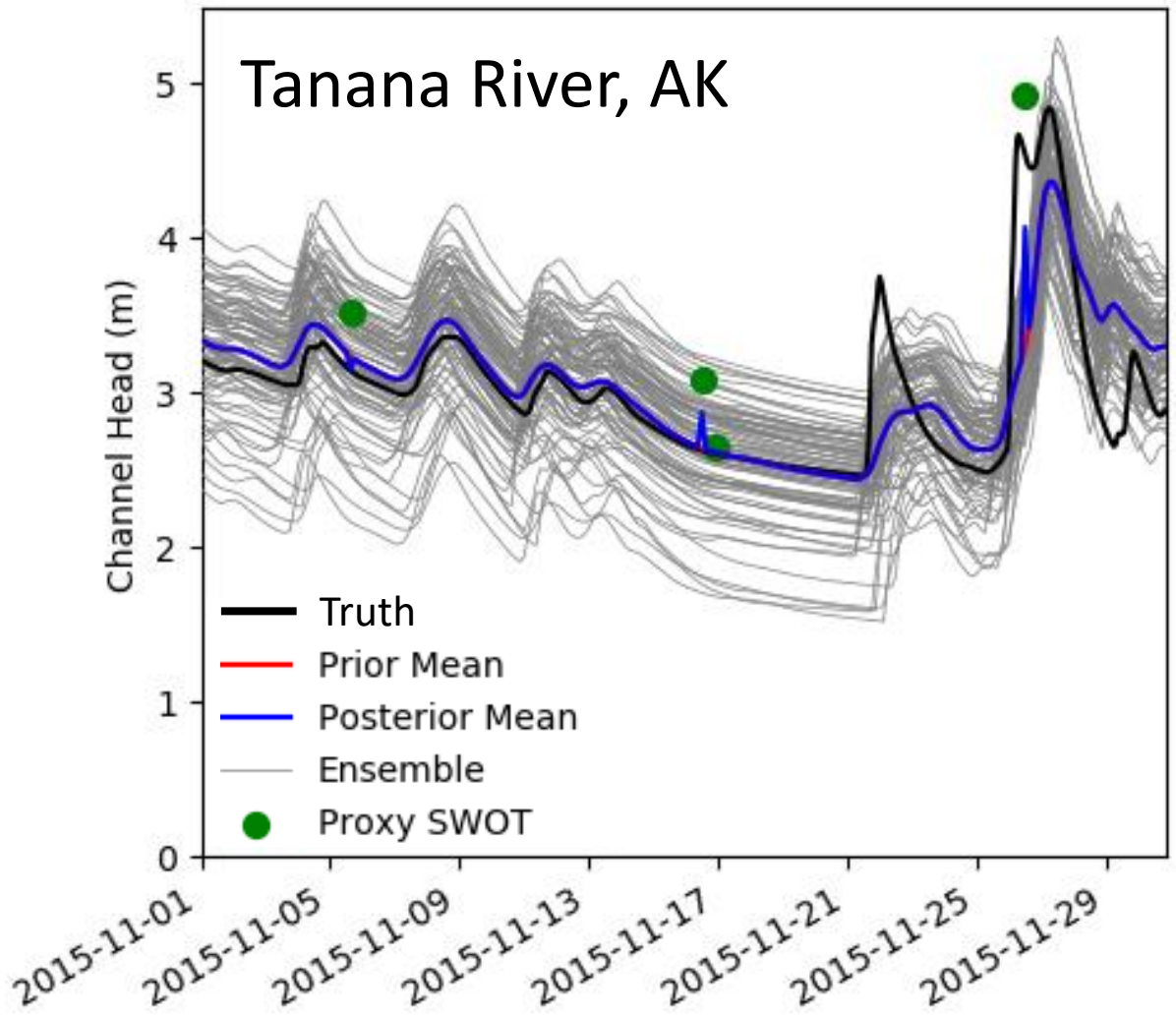
- Cumulative probability that parameter set selected by SWOT ranks in the **top ten** with respect to truth (=success)
- Vertical dotted line indicates marks top ten ranking of parameter set
- **Successful calibration obtained in 60% of basins**



Cumulative probability of selecting n-ranked parameter set with respect to NSE_{TRUTH} for sub-basins A-J.

Elmer, N. J., J. McCreight, and C. R. Hain (2020b), Calibrating WRF-Hydro in ungauged basins using SWOT discharge estimates, Water Resources Research, submitted.

SWOT Data Assimilation into WRF-Hydro



- **Data assimilation updates/adjusts model with observations during runtime**
- **Assimilating SWOT WSE using Ensemble Kalman Filter** to update channel flow
- Assimilation improves model at time of analysis, but **impacts are abrupt and short-lived**
- Planning to use Ensemble Kalman Smoother in future to address this issue

Summary

- Use of SWOT to improve hydrological forecasts via model calibration and assimilation are encouraging, but further work is needed:
  - Account for uncertainty in meteorological forcing (calibration)
  - Apply Ensemble Kalman Smoother (data assimilation)
- Lessons learned can inform development of operational NOAA National Water Model Alaskan domain and other SWOT applications

References

CNES (2020), SWOT Hydrology Toolbox, https://github.com/CNES/swot-hydrology-toolbox.

Elmer, N. J., C. R. Hain, F. Hossain, D. Desroches, C. Pottier (2020a), Generating proxy SWOT water surface elevations using WRF-Hydro and the CNES SWOT Hydrology Simulator, Water Resources Research, in press.

Elmer, N. J., J. McCreight, and C. R. Hain (2020b), Calibrating WRF-Hydro in ungauged basins using SWOT discharge estimates, Water Resources Research, submitted.

Gochis, D.J., M. Barlage, A. Dugger, K. FitzGerald, L. Karsten, M. McAllister, J. McCreight, J. Mills, A. RafieeiNasab, L. Read, K. Sampson, D. Yates, W. Yu, (2018). The WRF-Hydro modeling system technical description, (Version 5.0). NCAR Technical Note. 107 pages. Available online at https://ral.ucar.edu/sites/default/files/public/WRF-HydroV5TechnicalDescription.pdf. Source Code DOI:10.5065/D6J38RBJ.

JPL (2020), RiverObs, https://github.com/SWOTAlgorithms/RiverObs.