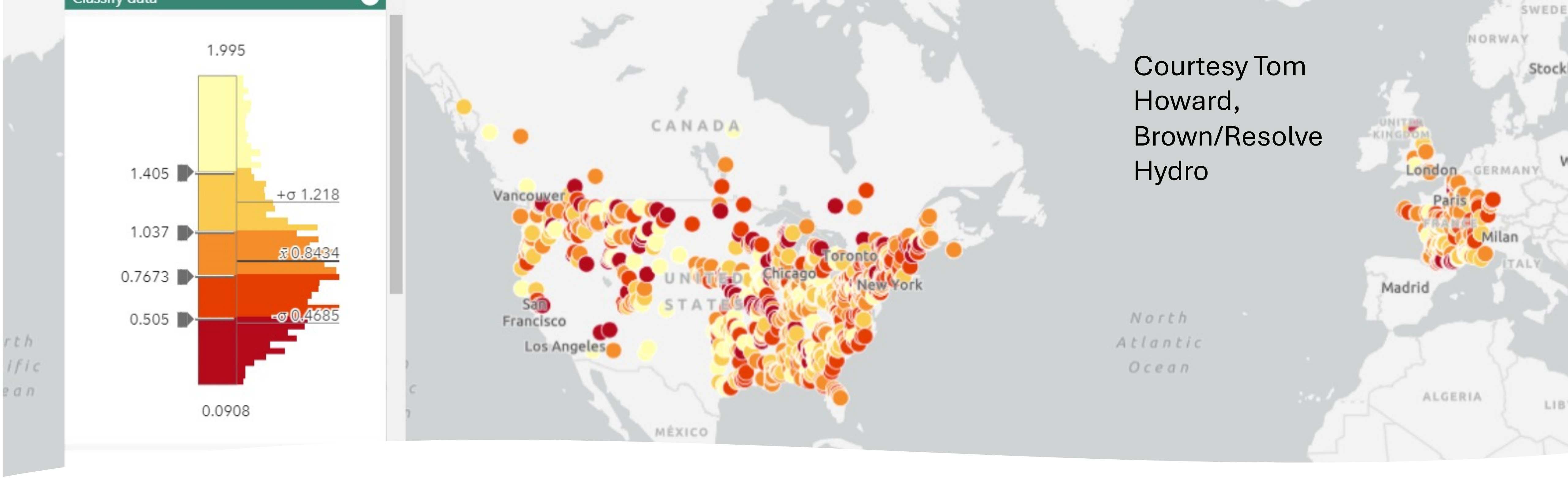
The Future of the Discharge Algorithm Working Group

Mike Durand, Pierre Olivier Malaterre, Kevin Larnier

SWOT Science Team Meeting

June 20, 2024



Courtesy Tom Howard, Brown/Resolve Hydro

Recap of where we're at

- First SWOT discharge comparing against 100s of gages!
- Discharge variability is surprisingly not being tracked well, apparently due to noise in widths. We are adapting Confluence to better filter data
- First full global run coming soon. We are preparing for initial parameter delivery

Immediate next step: adapt Confluence for how data are filtered

- Option 1: use an aggressive filter on SWOT data and only compute discharge there. Results will be good but available on a small number places (n~300?).
- Option 2: Let each algorithm developer decide how to filter data. Assess output results based on differing flags.
- Proposal: Use option 1 in near term. Move towards option 2 as needed.

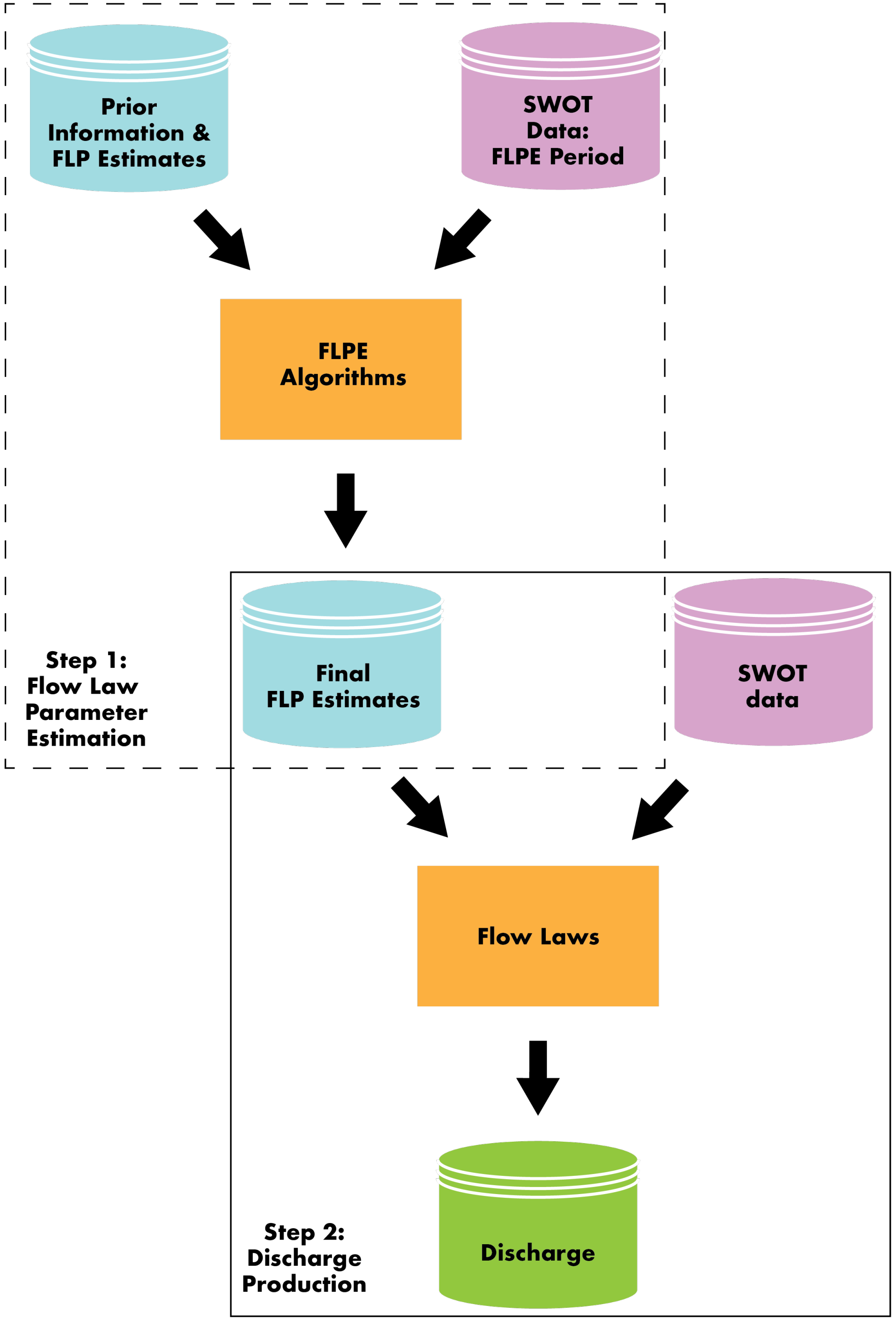
lifewire.com

Stuurman Standard Filter (SSF)

- Prior width > 80 m
- Reach length > 7 km
- 10 km < |Cross track distance| < 60 km
- Bitwise quality <15
- Reach quality < 3
- Dark fraction < 0.5

Parameter Delivery

- The DAWG is obliged to deliver flow law parameters to space agencies
- Current plan: deliver FLPs on ~10% of global reaches October 1
- Deliver FLPs on global reaches on new version of SWORD (v17) enabling algorithm to improve discharge bias at basin scale as soon as new version of SWOT is available (summer 2025)
- Note: discharge will be available in meantime as SoS as explained by Nikki & Victoria



Publications

- Congrats to Kostas on completing and submitting first DAWG paper!
- We made lists of papers, and will revisit these on coming DAWG calls (posted to the blog today – go read!)
- What papers would you prioritize next? (for discussion)

Paper 3

Purpose: In a timely way, evaluate the discharge product

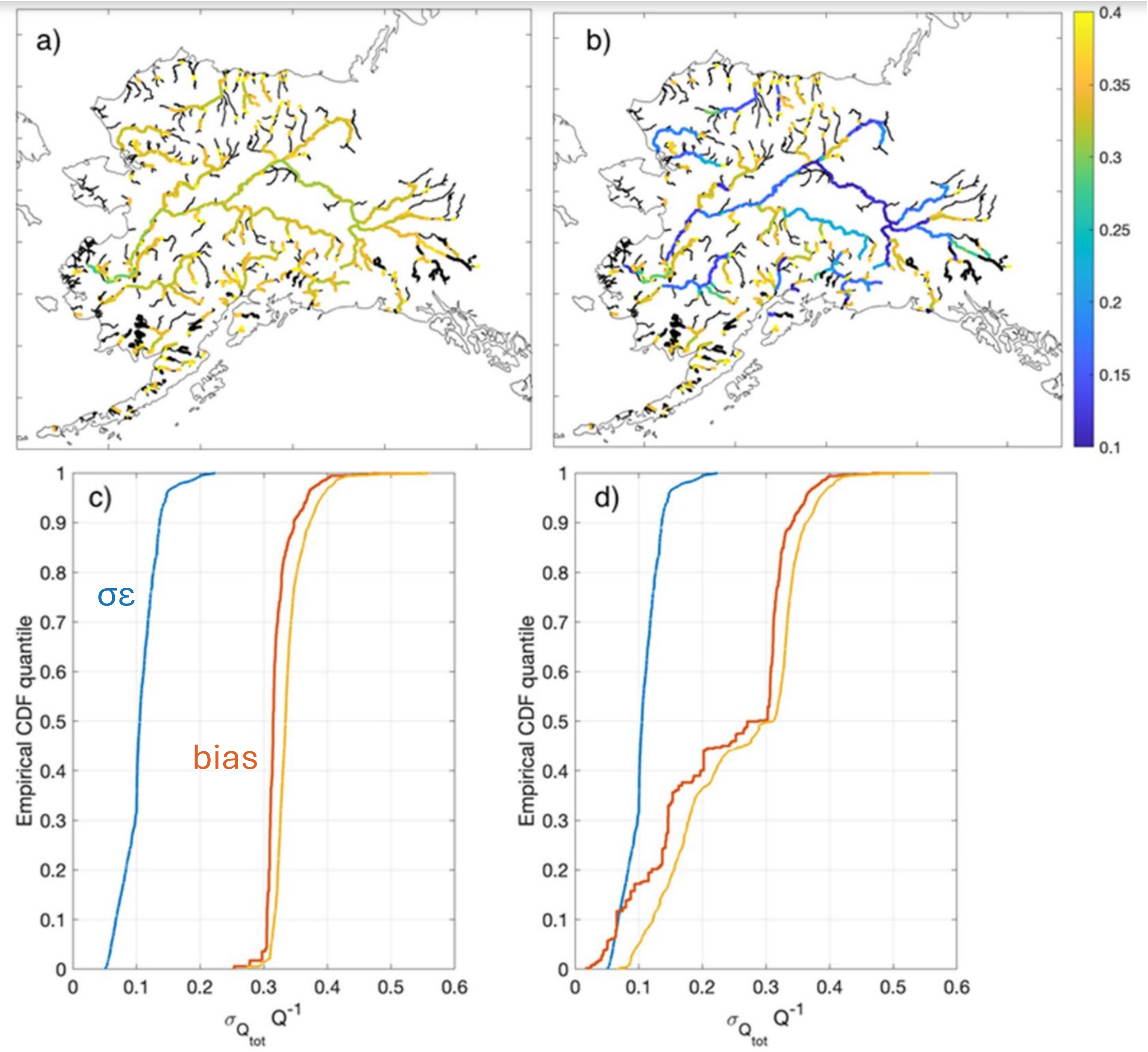
Format / Target Journal: WRR or other crunchy hydro

Scope: Global

Topic	Lead Author
SWOT discharge over entire river network: can SWOT deliver a consistent picture?	Siqi Ke
Reanalysis from SWOT Cal-Val observations for uncertainty quantification	Igor Gejadze
Global evaluation of SWOT discharge accuracy	Durand lab
Comparing observed, simulated and remotely sensed river discharges	Jaclyn Gehring
Validating SWOT discharge uncertainty estimates	Renato Frasson
Comparison of discharge with ADCP measurements at cal/val sites, and/or at the THP22-funded field sites	Merritt Harlan
Related Papers	
Explore applications using the SWOT measurements of width, slope etc. as they relate to accuracy	Dave Bjerklie

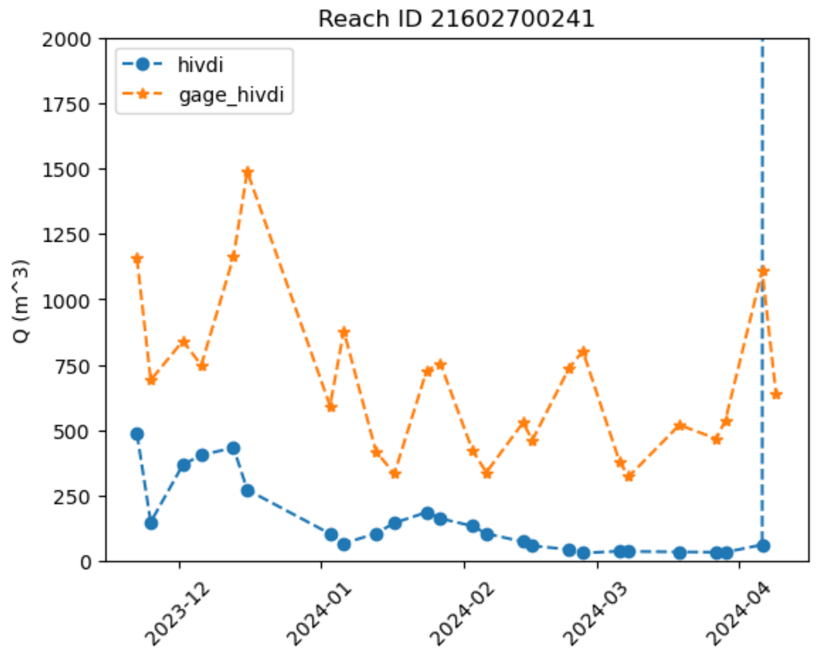
Target Discharge Accuracy

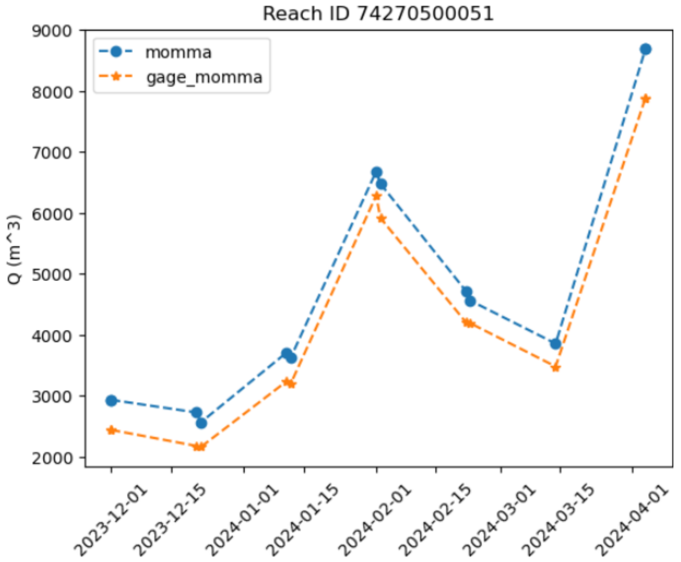
- The DAWG community WRR paper says: accuracy target is 30%, with most of it bias.
- We're currently at 100%, and not tracking Q variations.
- We will get to the theoretical accuracy! Or we will lose sleep trying. How will we do it?



Key future improvements: SWOT Data

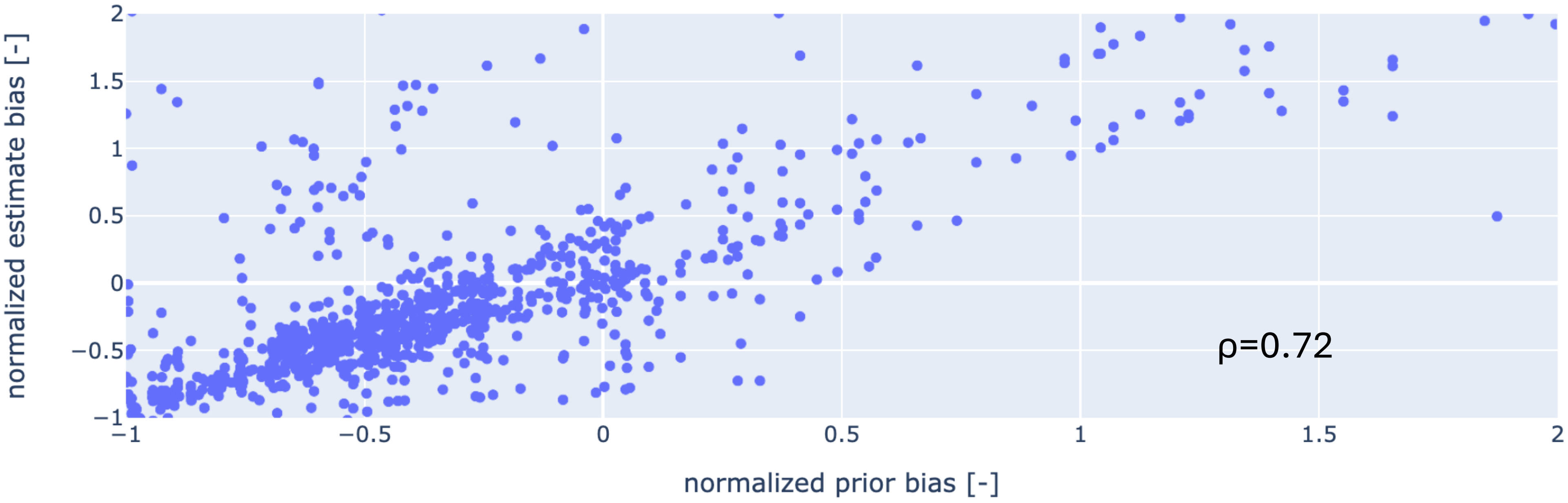
- In the near term, Conflunece must learn to better filter SWOT data
- In the longer term (next year) the width data must be improved, in order to avoid either decimating our spatial coverage, or tanking discharge accuracy
- Additionally the SWOT datatimeseries will continue to grow, enabling better ability to filter





Key future algorithm improvements: Priors

Prior bias is a one determinant of algorithm skill.



- Continue to incorporate more gages and field data (e.g. THP22)
- A near-real-time discharge feed (RAPID NRT?) could also help reduce bias for constrained roduct (Cedric David)

Key future algorithm improvements: flow laws

- We now have the ability to study flow laws directly with matched thousands of gages and SWOT reaches
- This allows revisiting key questions such as those posed by Ernesto's 2020 WRR paper
- We could update our flow laws as well: e.g. Toby Minear's proposes a slightly modified flow law for improved sediment transport estimates

'Classic' SWOT discharge algorithm

$$Q_t = \frac{1}{n_t}(\bar{A} + A'_t)^{\frac{5}{3}} (W_t)^{\frac{-2}{3}} (S_t)^{\frac{1}{2}}$$

Durand et al. 2023

Using the following definition

$$\tau_0 = \rho {u_*}^2 = \rho g d S = \rho C_f U^2$$

SWOT discharge algorithm for sediment transport

$$Q_t = \frac{1}{(C_f)^{\frac{1}{2}}}(\bar{A} + A'_t)^{\frac{3}{2}} (W_t)^{\frac{-1}{2}} (g S_t)^{\frac{1}{2}}$$

Key areas for algorithm improvements: reach-scale FLPEs

Water Resources Research

RESEARCH ARTICLE

10.1029/2020WR028519

Key Points:

- The ability of algorithms to produce improved discharge estimates is related to measurable hydraulic properties of the domain
- Sampling frequency had little impact on algorithm performance. Algorithms based on unsteady continuity equation experienced bigger impacts

Exploring the Factors Controlling the Error Characteristics of the Surface Water and Ocean Topography Mission Discharge Estimates

Renato Prata de Moraes Frasson[1,2], Michael T. Durand[2,3], Kevin Larnier[4,5], Colin Gleason[6], Konstantinos M. Andreadis[6], Mark Hagemann[7], Robert Dudley[8], David Bjerklie[8], Hind Oubanas[9], Pierre-André Garambois[10], Pierre-Olivier Malaterre[9], Peirong Lin[11], Tamlin M. Pavelsky[12], Jérôme Monnier[5], Craig B. Brinkerhoff[6], and Cédric H. David[1]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [2]Byrd Polar and Climate Research

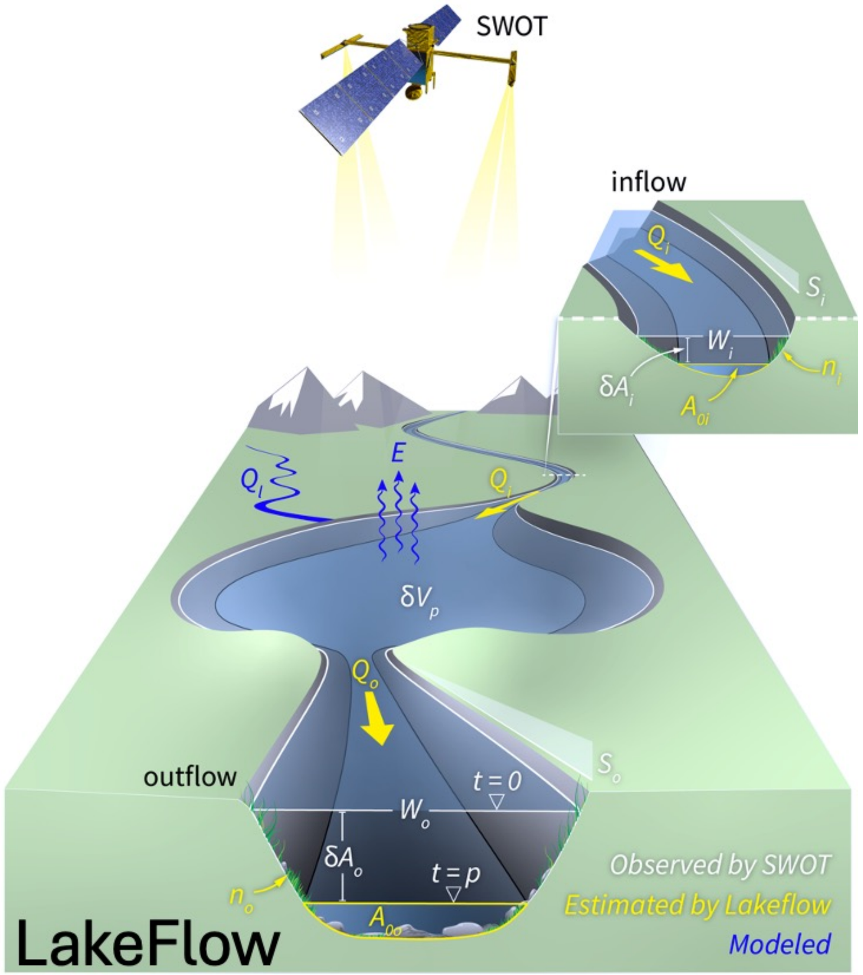
- Similar to flow laws, we now have the data to refine and compare reach-scale FLPEs: we could do Pepsi3! (2016, 2021…)
- Many ideas: machine learning, making a dynamic version of the integrator, improve algorithms to filter and density height width data

Key areas for algorithm improvements: Integrator and Lake Flow

$$Q_i - Q_o = \delta V_p + Q_l - E$$

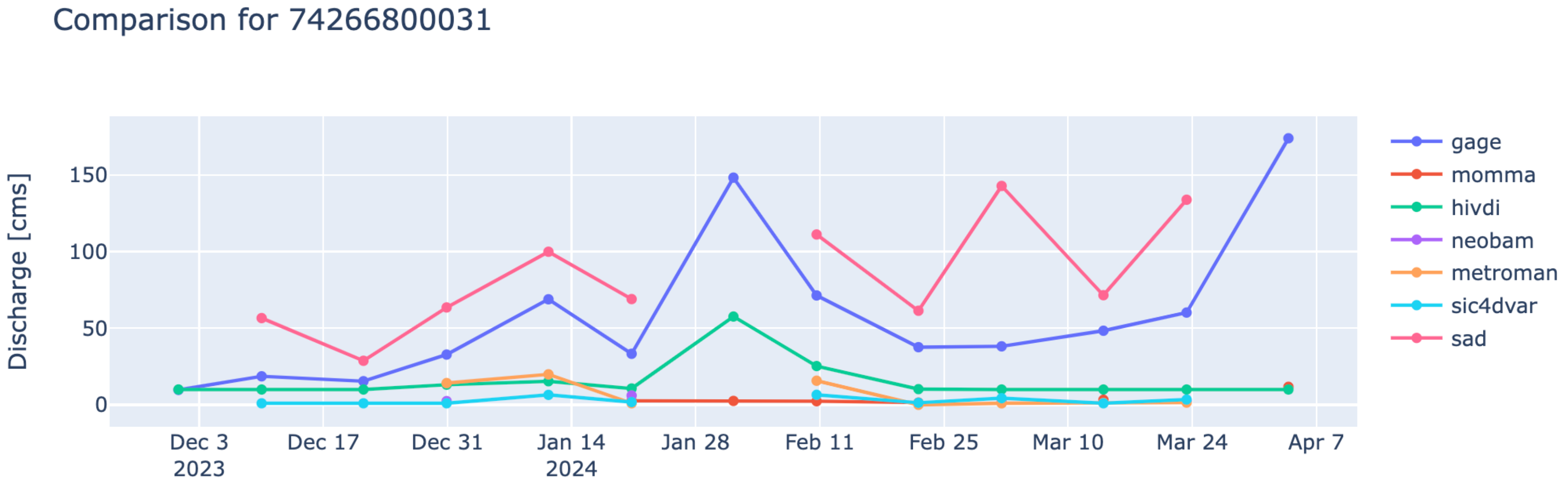
- The integrator reduces makes discharge consistent at basin scale, and reduces bias in discharge. Must validate its uncertainty estimates

- Lake Flow must be fully onboarded into Confluence. It will improve Confluence operations and discharge estimates



Riggs et al. (2023) *Geophys. Res. Lett.*

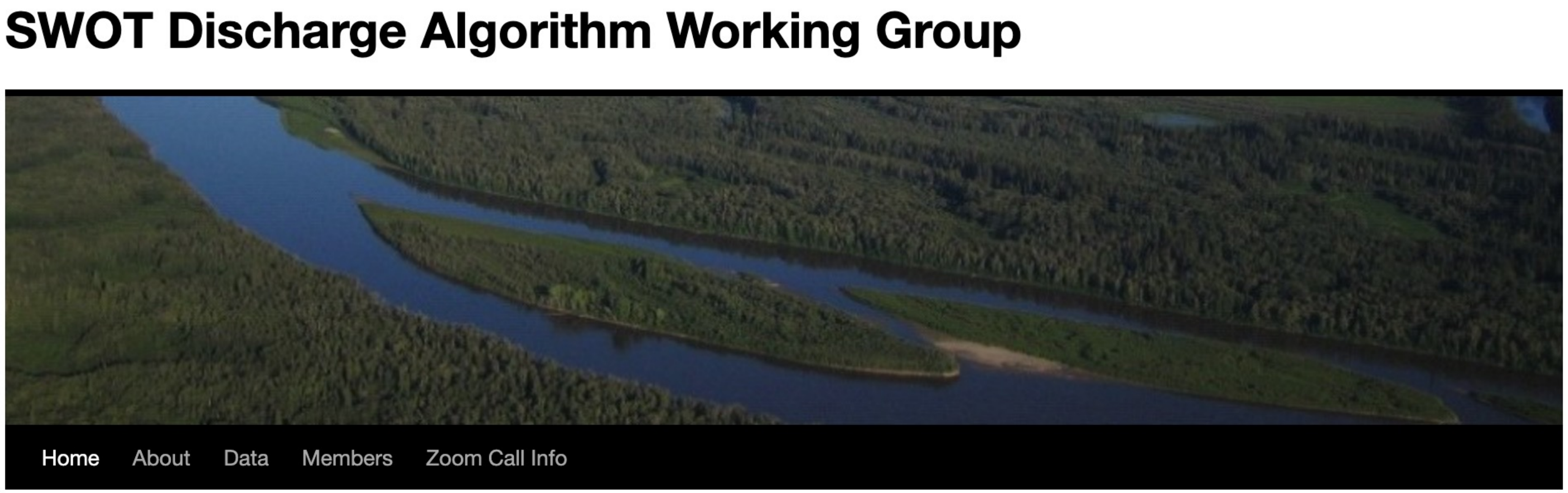
Key areas for algorithm improvements: Consensus and Uncertainty estimates



- The consensus algorithm computed as the median of the six stage 2 discharge estimates. Must be further tested and improved
- We additionally must assess the accuracy of the uncertainty estimates themselves, e.g. via qq plots

Changing our mode of the biweekly meetings

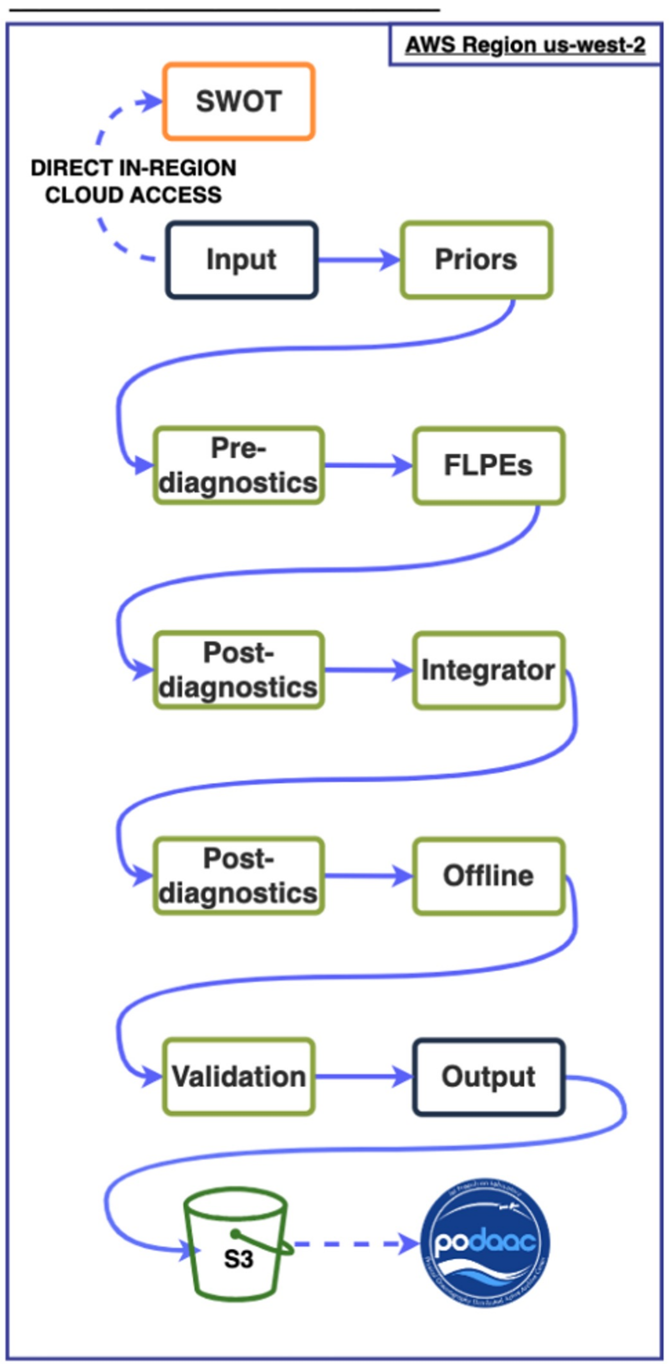
Please join the DAWG! We'd love to have you



- Focus shifts from doing first runs, to understanding them
- Will work more with other parts of the Science Team
- We should also include presentations on how discharge is being used, e.g. efforts to assimilate discharge in HH models
- Let's do more crowdsourcing of validation efforts!

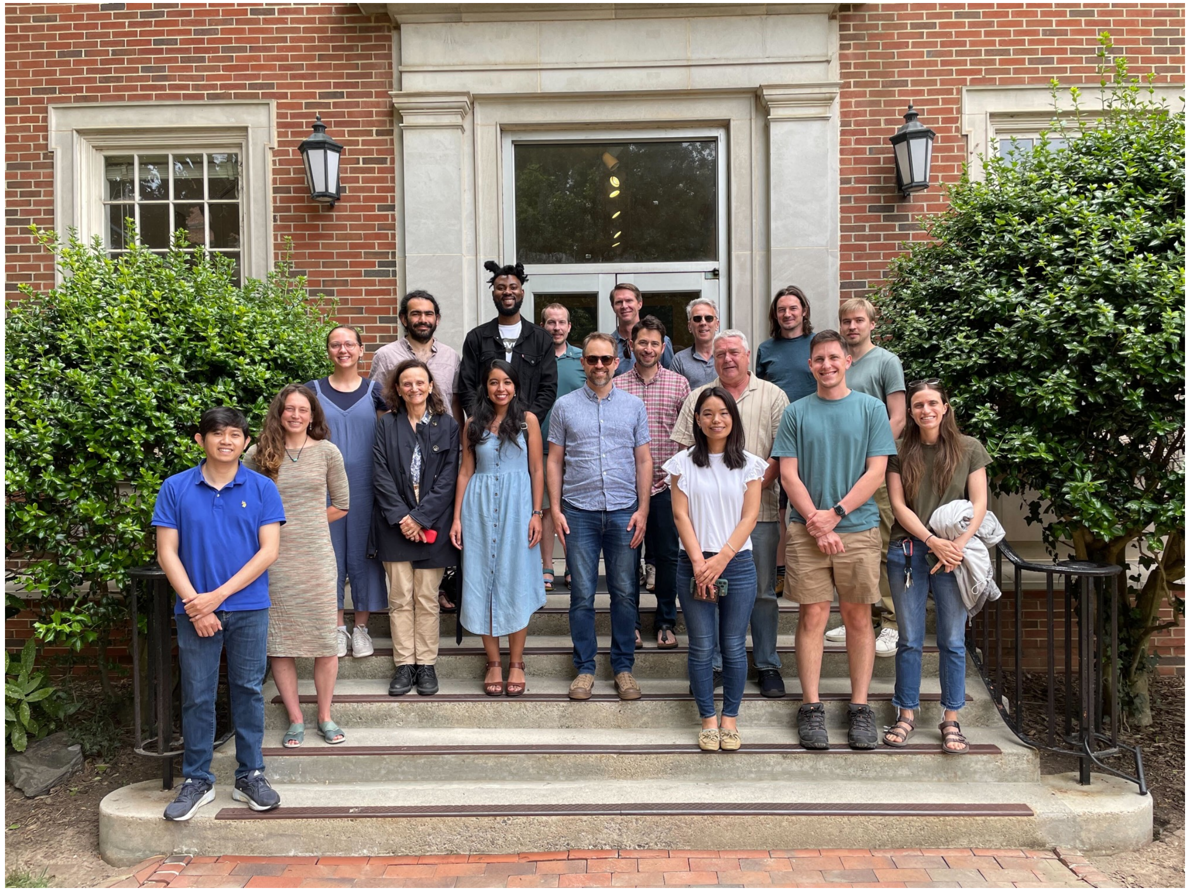
Future of Confluence

- By next June, PO.DAAC will be operationally ready to run Confluence, via the AIST program
- PO.DAAC and the project have agreed to run Confluence going forward. Mission will pay for Confluence runs with some periodicity
- U Mass team will handle future Confluence changes, but at a lower frequency.



Conclusion

- SWOT discharge is up and running!
- We have major milestones upcoming: first flow law parameter delivery
- Continued development will lead to continued discharge accuracy improvements
- In-person DAWG workshop: nominally targeting winter somewhere in Europe



DAWG Workshop at Chapel Hill, June 16, 2024