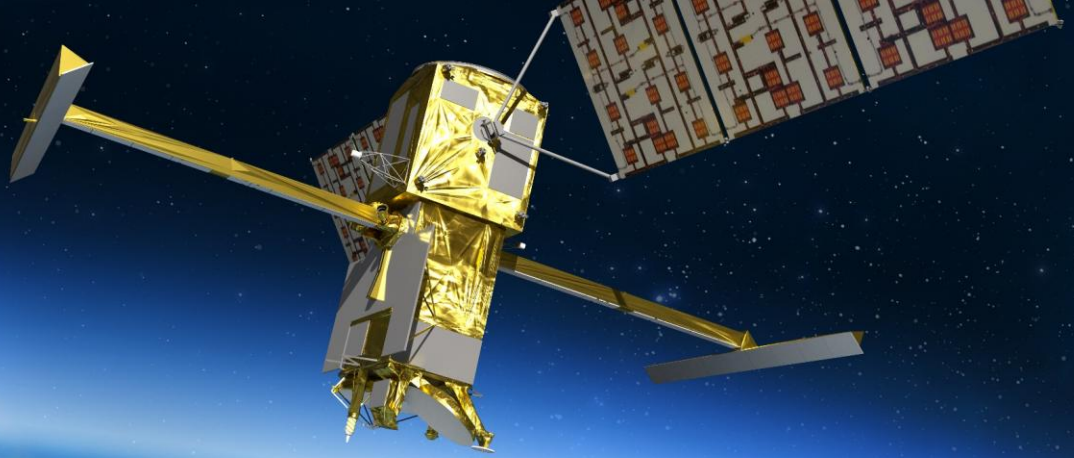
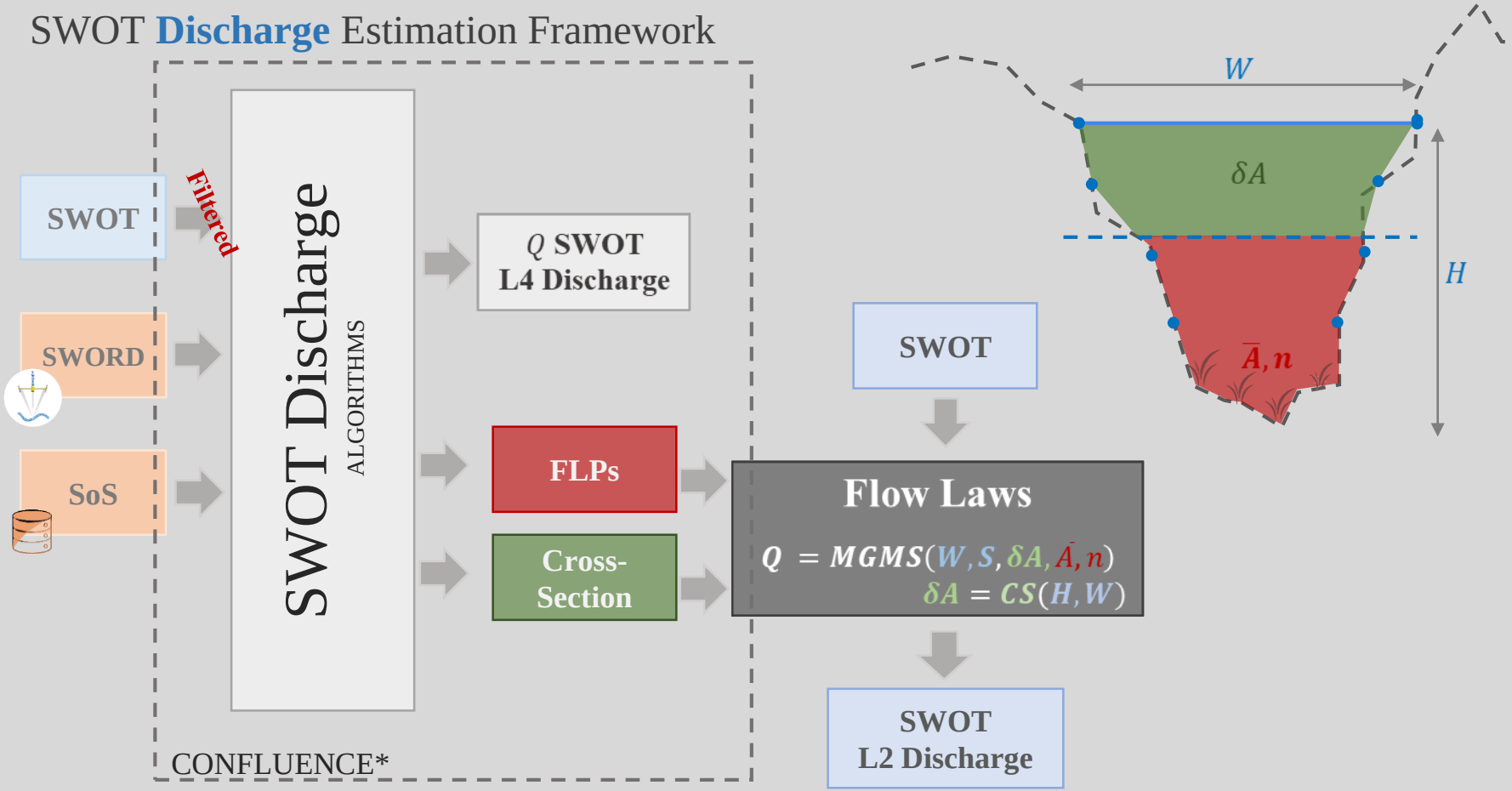


SWOT River Bathymetry Products

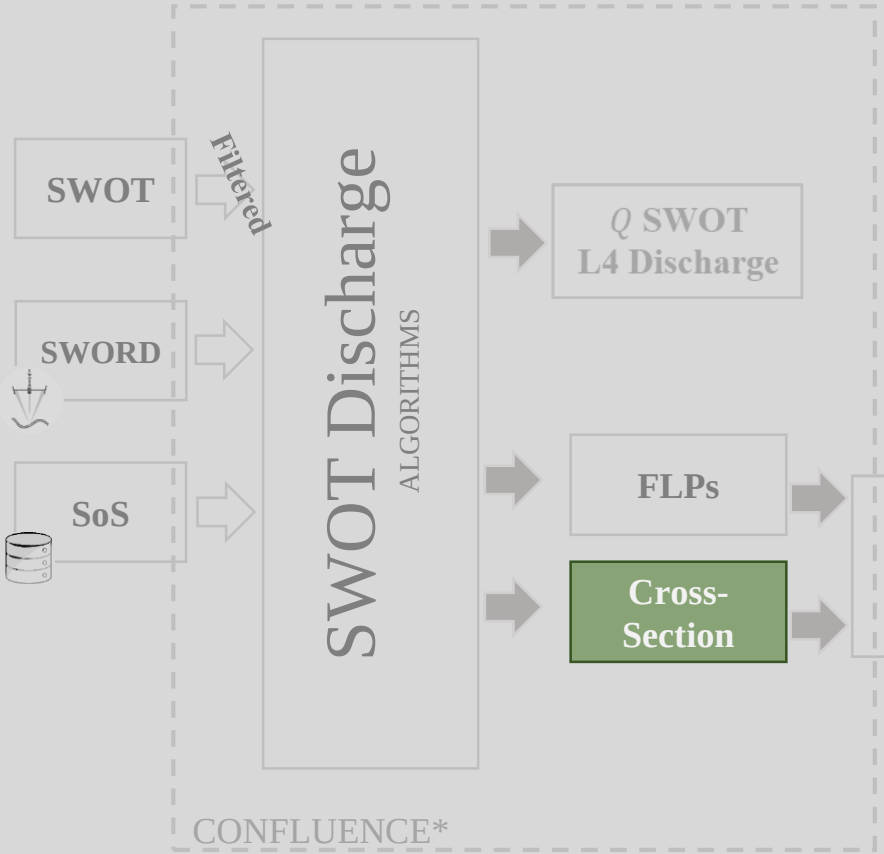
Hind Oubanas and Jeffrey Neal
P.-O. Malaterre, M. Durand, P. Bates, S. Chuter, C. Gleason, I. Rezende

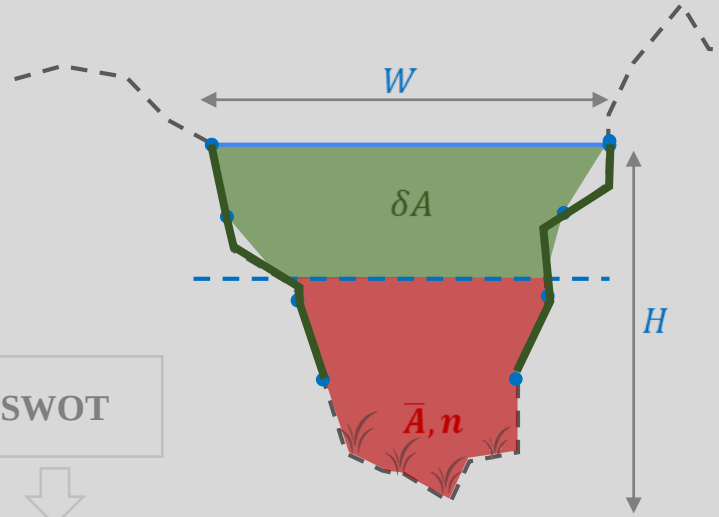
SWOT **Discharge** Estimation Framework



* Add a few more layers

SWOT **Discharge** Estimation Framework





SWOT

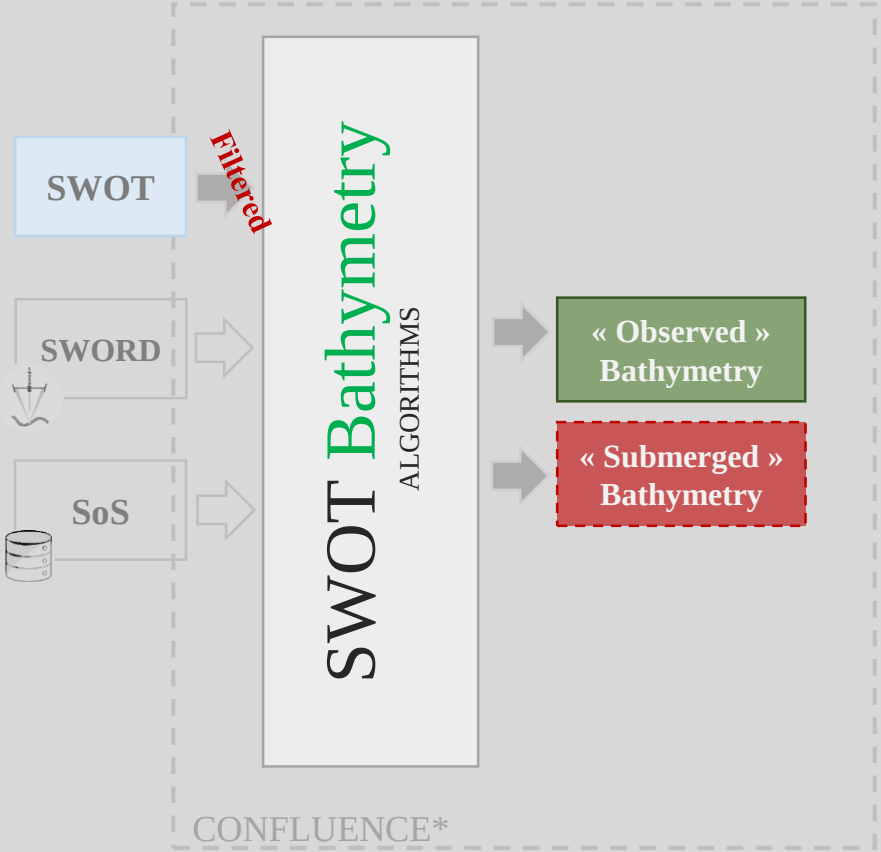
Flow Laws

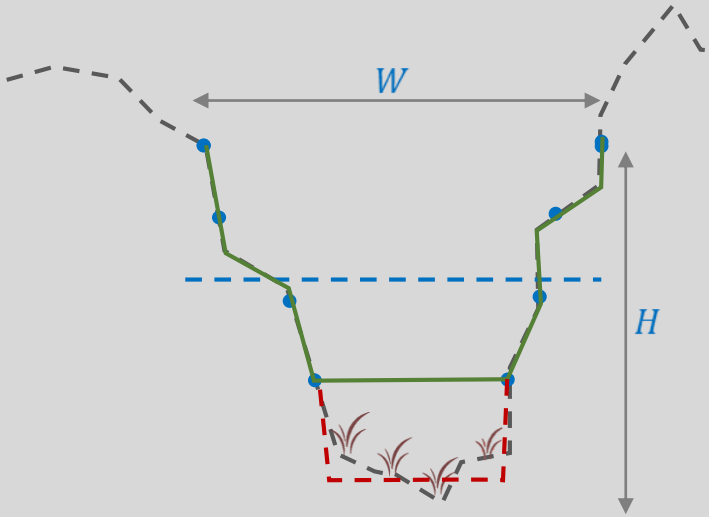
$$Q = MGMS(W, S, \delta A, \bar{A}, n)$$
$$\delta A = CS(H, W)$$

SWOT
L2 Discharge

* Add a few more layers

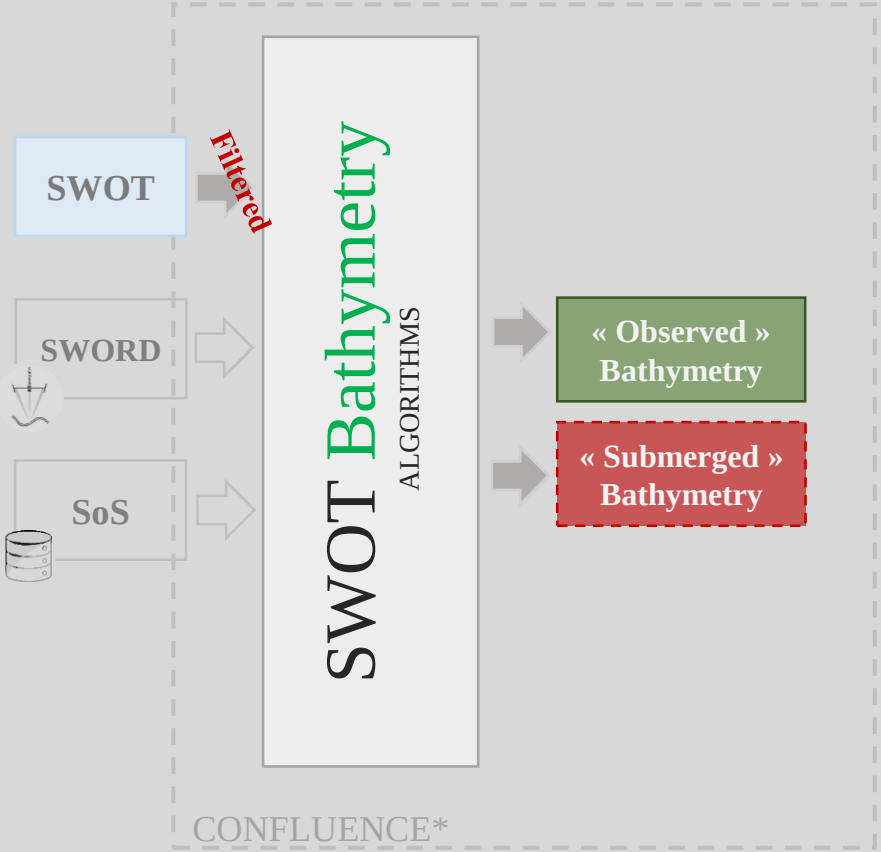
SWOT **Bathymetry** Estimation Framework

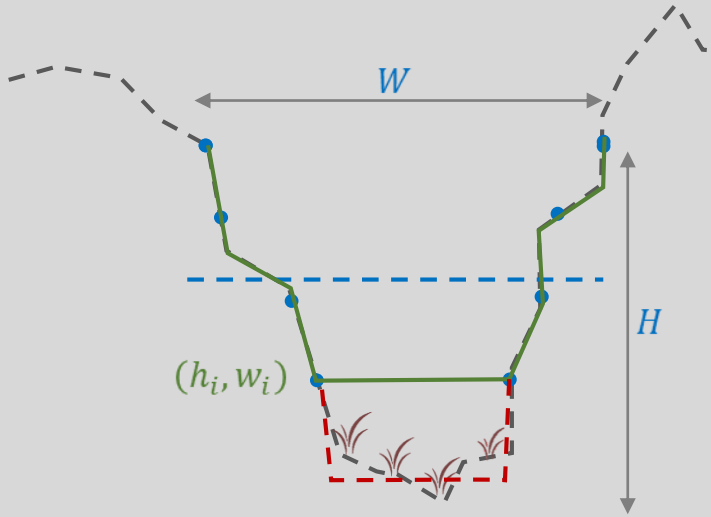




* Add a few more layers

SWOT **Bathymetry** Estimation Framework





Outputs/Format :

- Optimized nodes/reaches cross-section profils.
- Approximated Hypsometry curves.
- Cross-section variability with the reach.
- Other?

* Add a few more layers

Different approaches already exist …

We hope to get your feedback on the usefulness of such product, and recommendations on product format

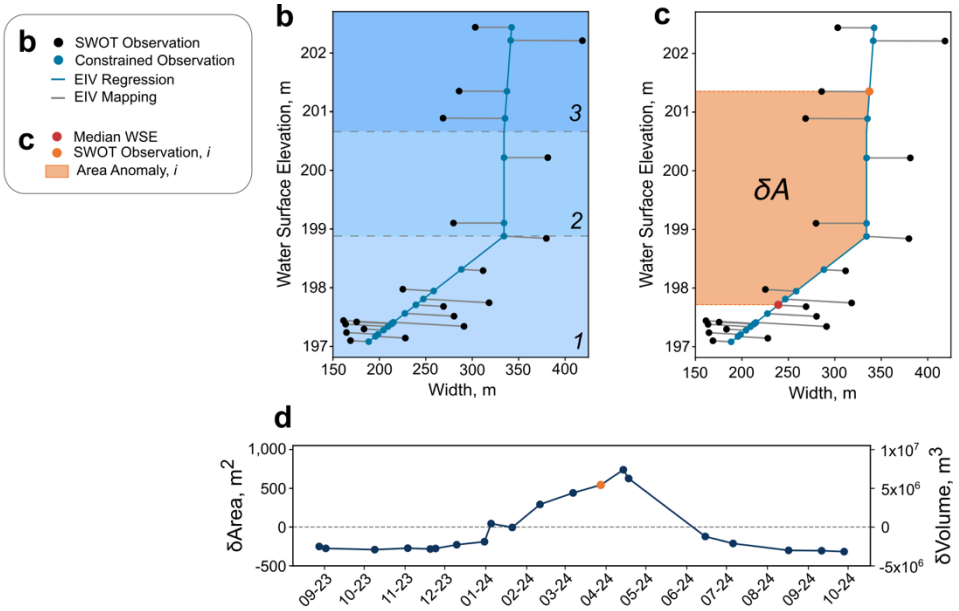
THE OHIO STATE UNIVERSITY

Estimating reach-scale bathymetry

The observed bathymetry can be estimated by computing the WSE-width relationship (river hypsometry, Durand et al. 2024)

The hypsometric curve fits are already running in Confluence

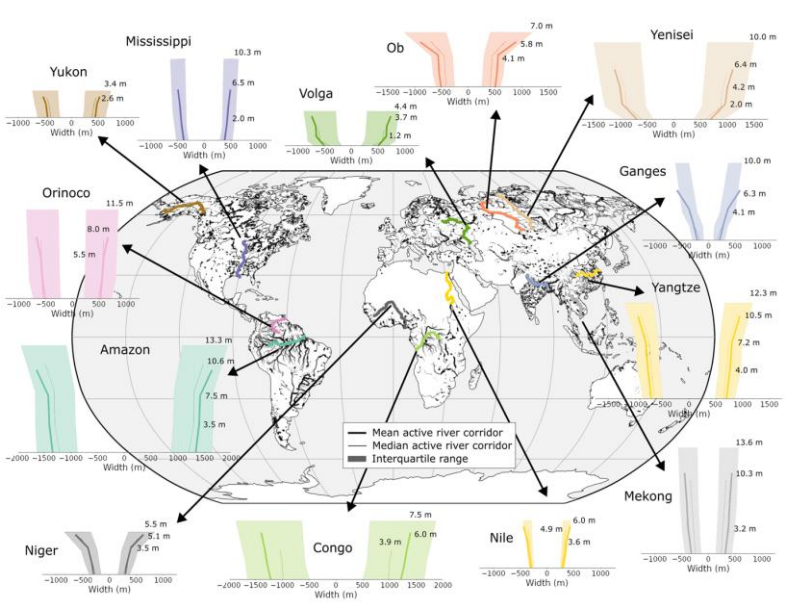
Caveat: they estimate the whole river width, so this would give you a symmetrical bathymetry on each side

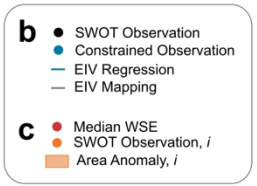


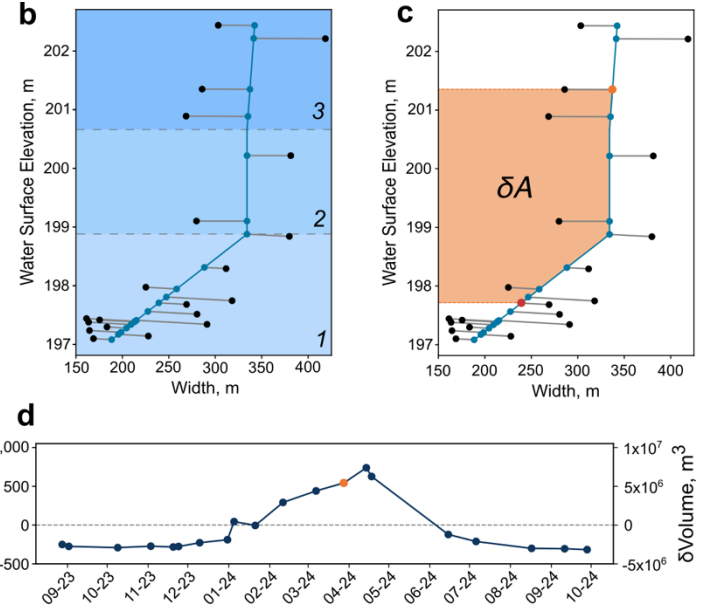
Durand, M., Dai, C., Moortgat, J., Yadav, B., Frasson, R. P. de M., Li, Z., et al. (2024). Using river hypsometry to improve remote sensing of river discharge. Remote Sensing of Environment, 315, 114455. https://doi.org/10.1016/j.rse.2024.114455

THE OHIO STATE UNIVERSITY

Estimating reach-scale bathymetry







Wade, J., Cerbelaud, A., David, C., Durand, M., Frasson, R., Pavelsky, T., Oubanas, H. "Wide-Swath Altimetry Maps Bank Shapes and Storage Changes in Global Rivers". In review.

Durand, M., Dai, C., Moortgat, J., Yadav, B., Frasson, R. P. de M., Li, Z., et al. (2024). Using river hypsometry to improve remote sensing of river discharge. Remote Sensing of Environment, 315, 114455. https://doi.org/10.1016/j.rse.2024.114455

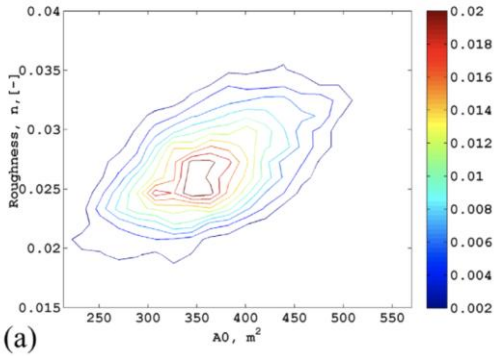
THE OHIO STATE UNIVERSITY

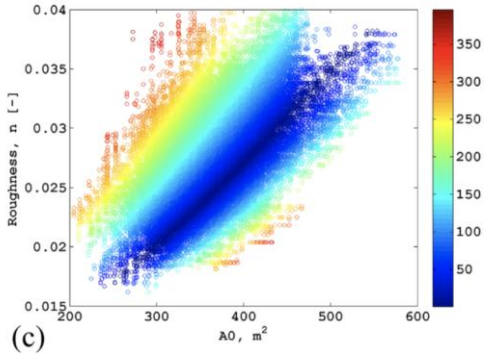
Caveat: Equifinality at reach-scale

Pre-launch studies (e.g. Yoon et al. 2016) confirmed that at least at reach-scale, multiple values of resistance (Manning's n, Strickler's K, etc) and submerged bathymetry yield are equally like (a).

This does not affect discharge accuracy (b), and such a bathymetry product may still be valuable.

Equifinality may have less impact on node-estimates of bathymetry

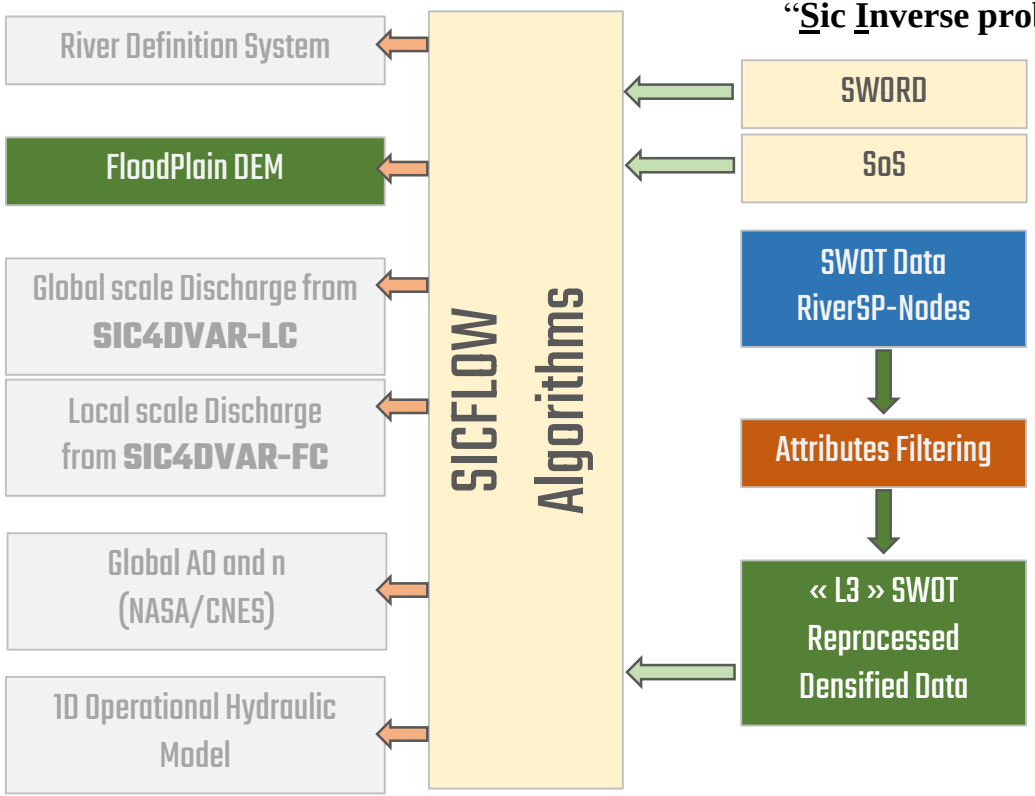


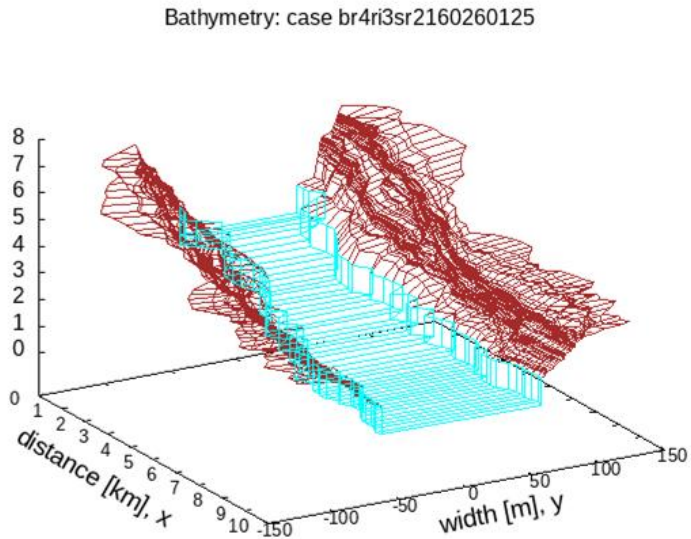


Yoon, Y., Garambois, P., Paiva, R. C. D., Durand, M., Roux, H., & Beighley, E. (2016). Improved error estimates of a discharge algorithm for remotely sensed river measurements: Test cases on Sacramento and Garonne Rivers. Water Resources Research, 52(1), 278 294. https://doi.org/10.1002/2015wr017319

SICFLOW

"**Sic Inverse problem Capabilities for river FLOW dynamics**"





Estimating **node-scale** bathymetry

SICFLOW

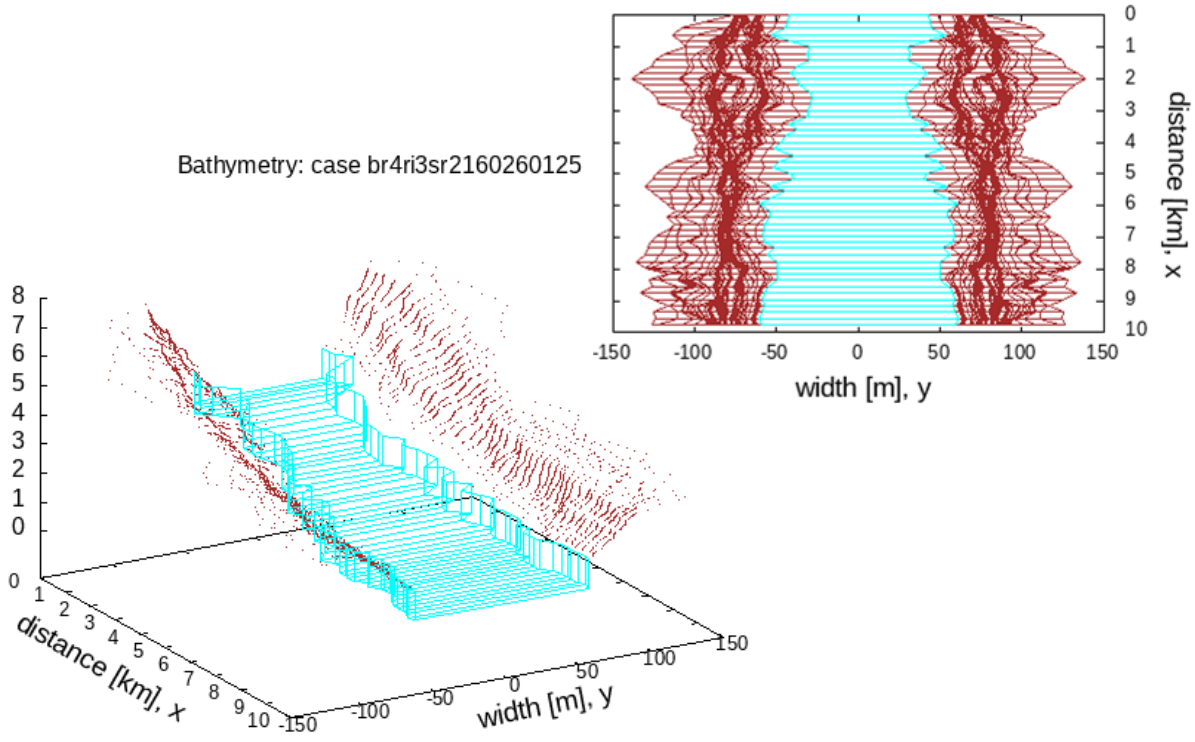
"**Sic Inverse problem Capabilities for river FLOW dynamics**"

Estimation Approach :

- **Observed Bathymetry** : Double sweep for smoothed parametric curve w(h) enforcing continuous increase condition.
- **Submerged Bathymetry** : **SIC4DVAR** Discharge Estimation (combined estimation of bed level and friction).

Output Format :

- Node Level Product
- **Observed Bathymetry** : Cross-section approximation with pairs of (h_i, w_i) with optimized number of points.
- **Submerged Bathymetry** : Bed-level and min-width for simplified rectangular shape.



Estimating **node-scale** bathymetry

SICFLOW

"**Sic Inverse problem Capabilities for river FLOW dynamics**"

Estimation Approach :

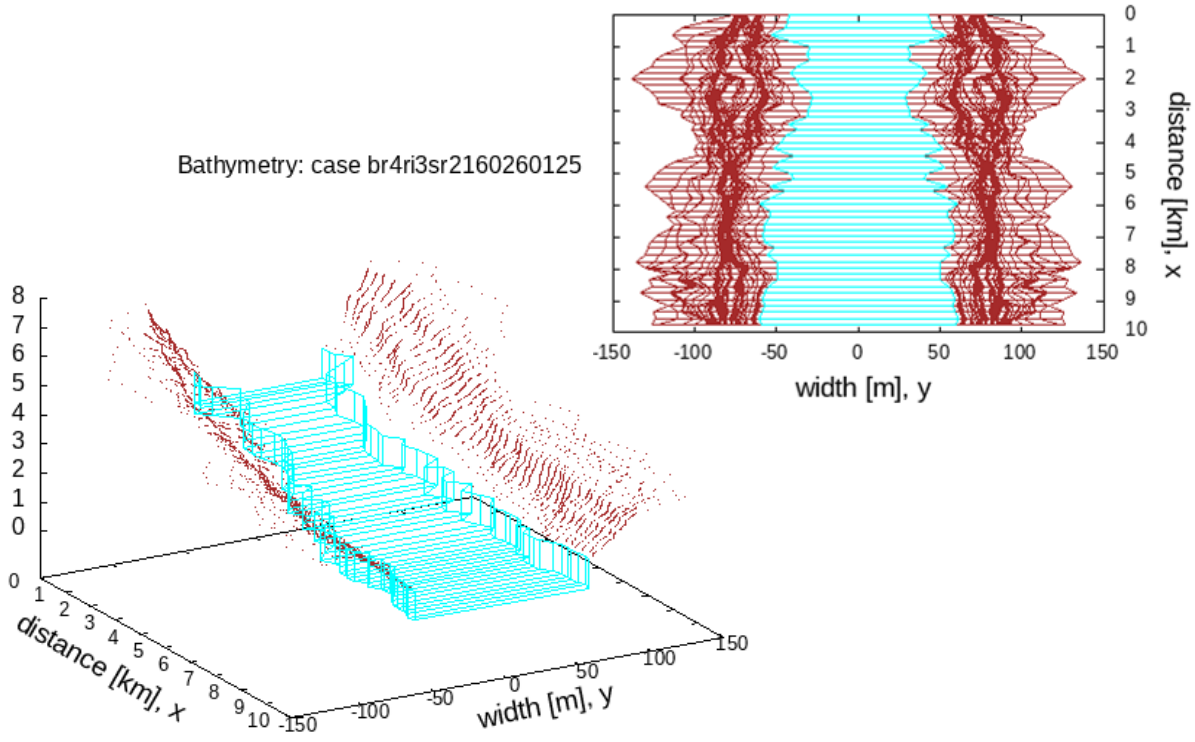
- **Observed Bathymetry** : Double sweep for smoothed parametric curve w(h) enforcing continuous increase condition.
- **Submerged Bathymetry** : **SIC4DVAR** Discharge Estimation (combined estimation of bed level and friction).

Output Format :

- Node Level Product
- **Observed Bathymetry** : Cross-section approximation with pairs of (h_i, w_i) with optimized number of points.
- **Submerged Bathymetry** : Bed-level and min-width for simplified rectangular shape.

Availability :
Outputs **already available globally** in L4 SoS (SIC4DVAR's outputs)

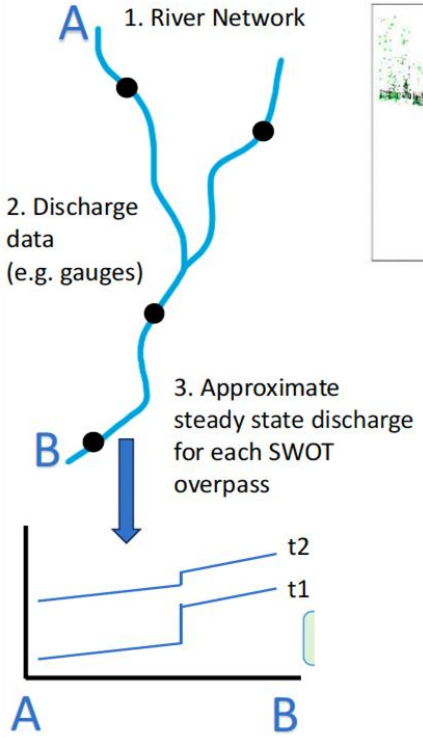
Validation : Validation has been performed through discharge. Validation using Lidar/Optical data is On-going.

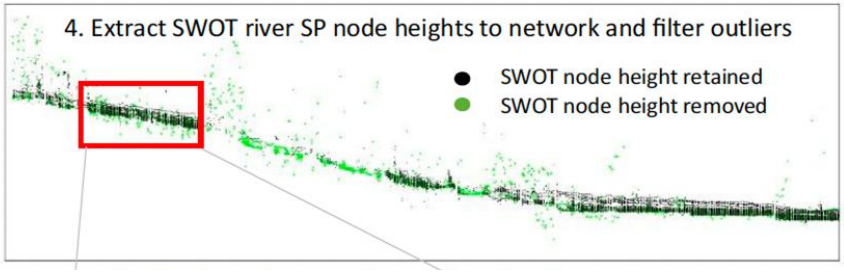


Estimating **node-scale** bathymetry

University of BRISTOL

Inversion of 1D Gradually Varied Flow equations to solve for bed given a set of SWOT overpasses



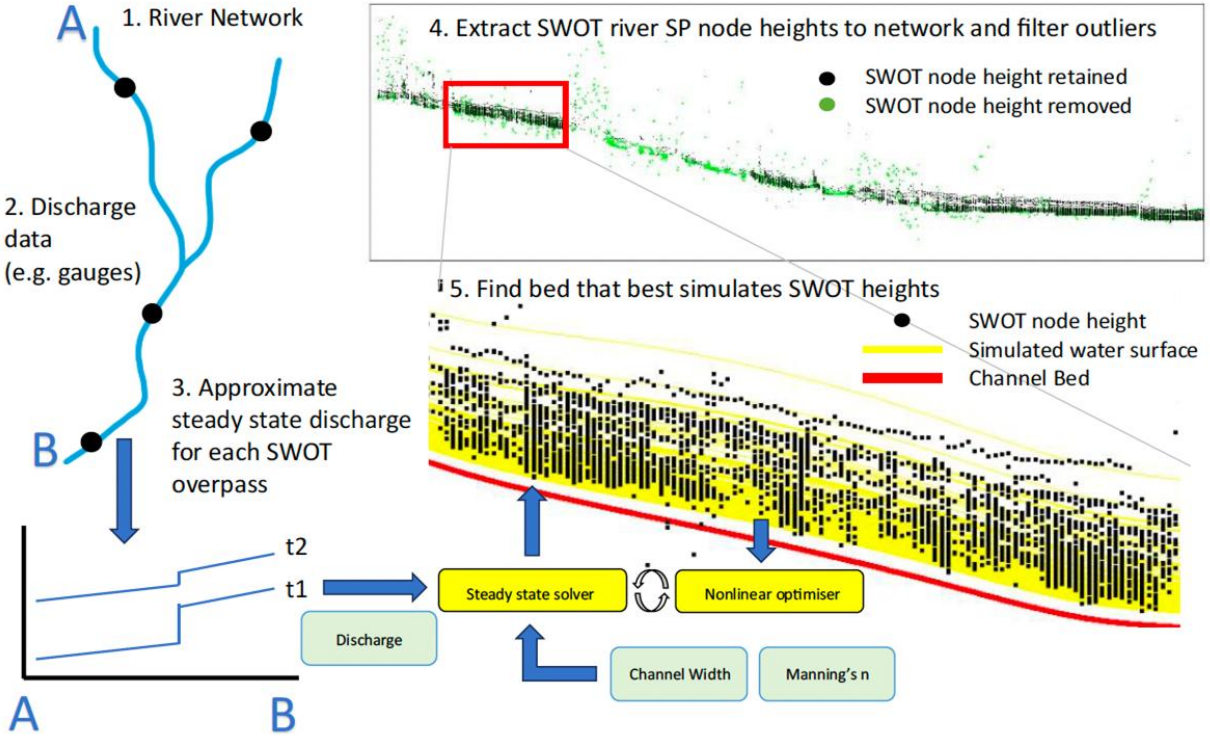


University of BRISTOL

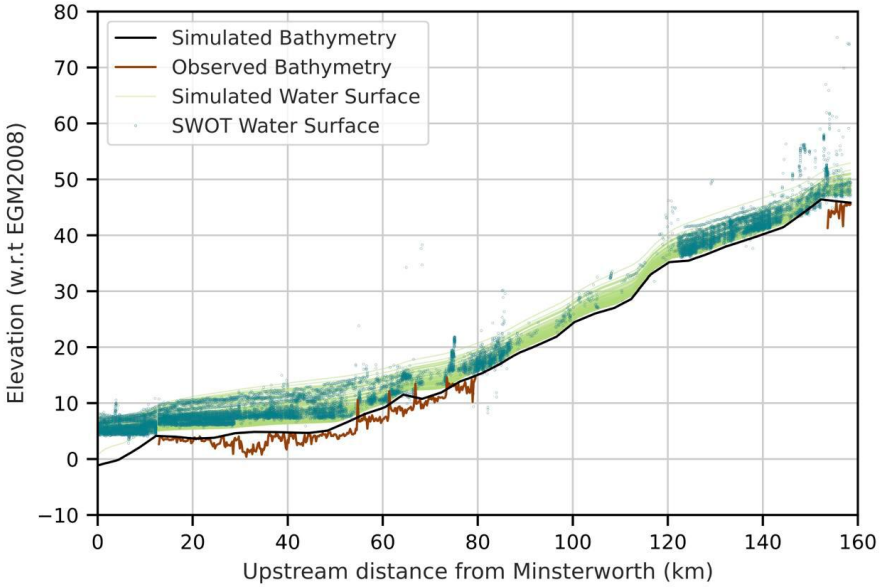
Inversion of 1D Gradually Varied Flow equations to solve for bed given a set of SWOT overpasses

Two methods:

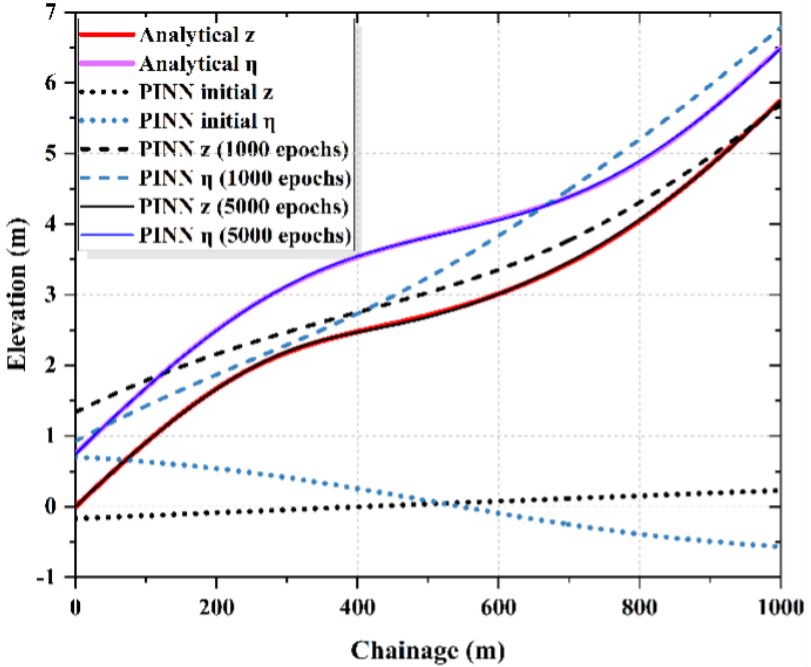
1. Non-linear optimiser (Neal et al., in review)
2. Physics-Informed Neural Network (PINN) (Rong et al., about to be submitted)



University of BRISTOL



(i) Non-linear optimiser
PINN



(ii)

University of BRISTOL

University of Massachusetts Amherst

Co-solve for discharge and bathymetry:

Under GVF, and given a Q and channel, height is exactly specify. Solve for Q and channel geometry to match SWOT observations

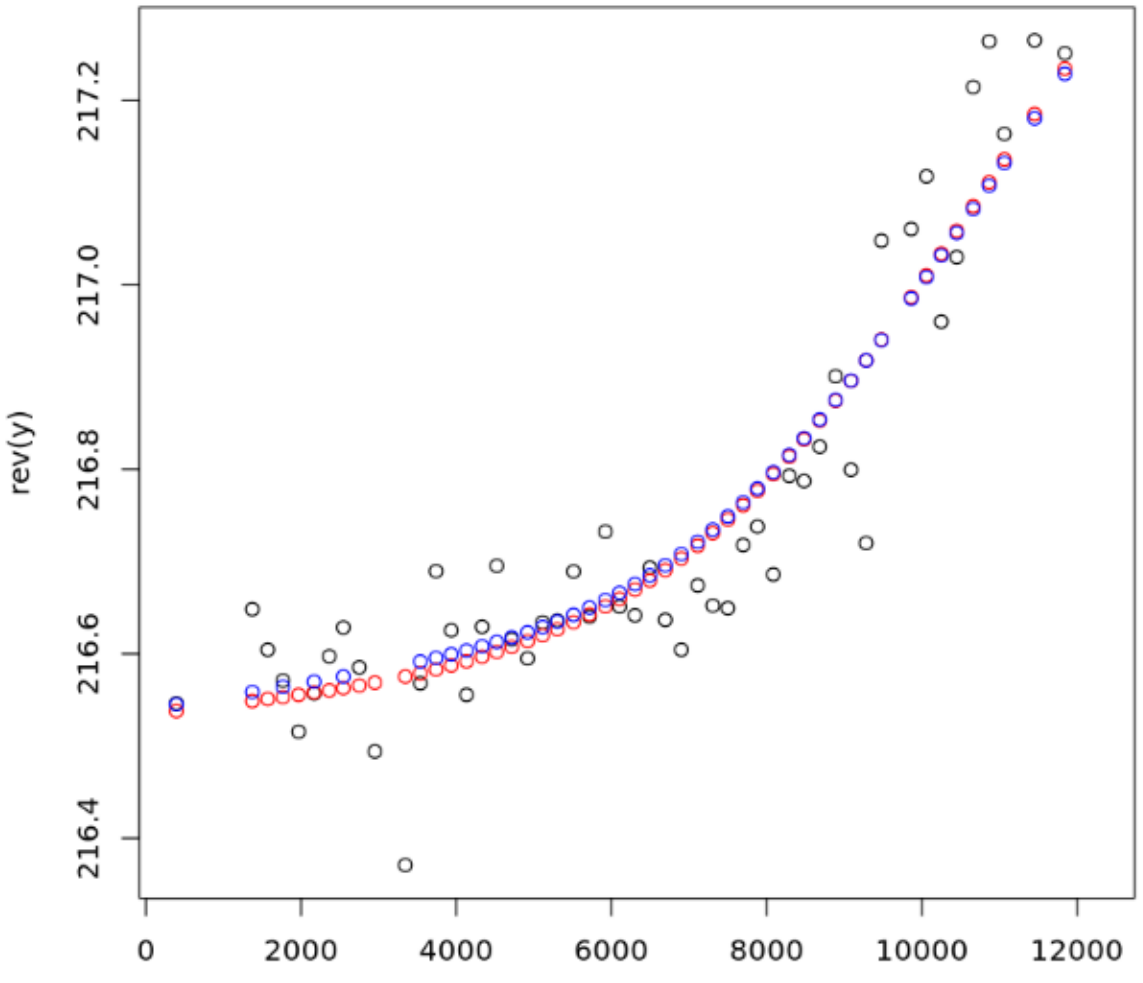
University of BRISTOL

University of Massachusetts Amherst

Black- filtered SWOT data

Red- first filter

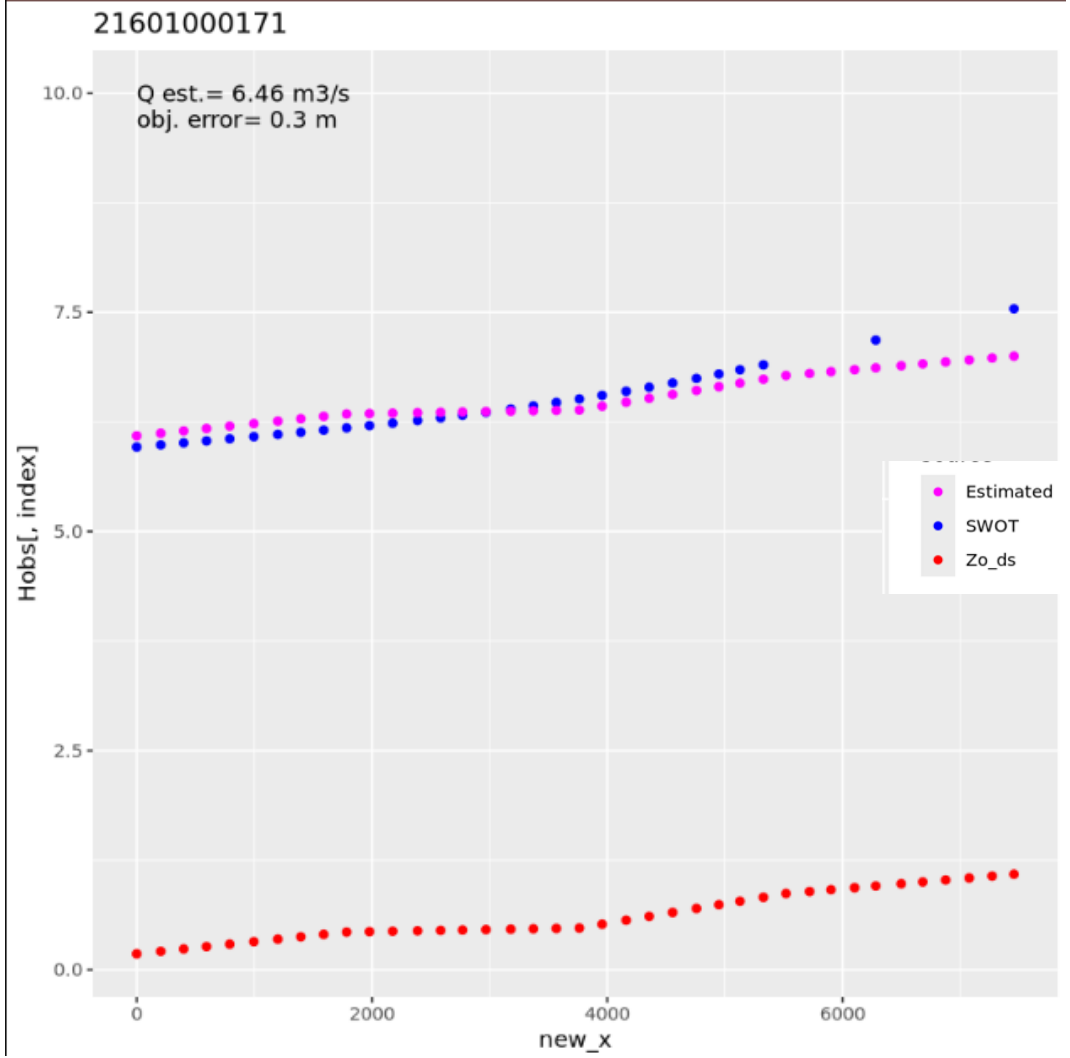
Blue- 2nd filter



University of BRISTOL

University of Massachusetts Amherst

Given these filtered and smoothed water surfaces from SWOT, solve for a Q and parameter set (from the triplets) that best reconstructs the water surface under GVF



Perspectives/Objectives

SWOT Bathymetry offline WG to standardize algorithms outputs and define relevant variables.

Bathymetry benchmark for inter-comparison (Gather Bathymetry data).

Define a Validation framework for 1D-simplified product.

Framework for global production (Confluence already has some of the algorithms).


Merci! Thank you
©CNES / MIRA PRODUCTIONS
SWOT