Estimation of ungauged braided river discharge and spatially distributed hydraulic controls from historical & SWOT altimetry

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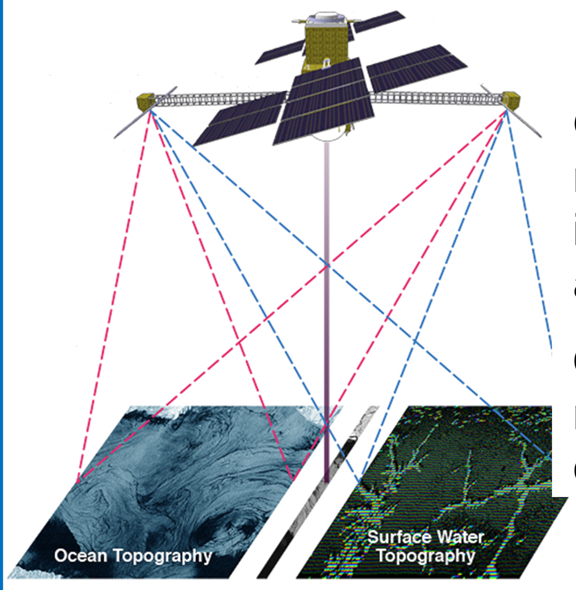
Context: hydraulic visibility of large worldwide rivers, braided reaches



NASA/CNES Surface Water and Ocean Topography (SWOT) satellite mission. Global measurements of inland water surfaces elevation, width and slope with temporal revisits.

Goal for hydrology : inversion method(s) for global river discharge estimation

Challenging question: inference of worldwide river discharge from Water surface (WS) observables (unknown river bathymetry and friction)

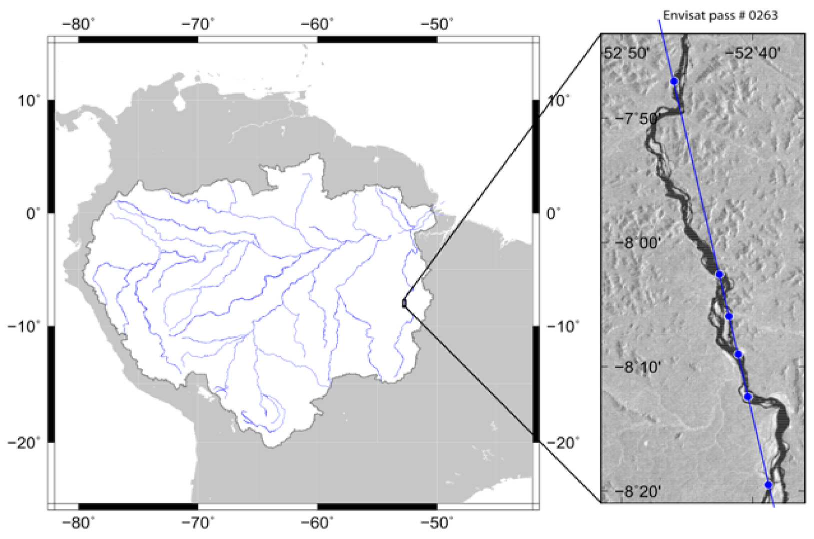
→ Ill-posed hydraulic inverse problem,

→ Key issue to take advantage of the forthcoming SWOT observations of worldwide rivers wider than 100m

Present focus: Is it possible to infer discharge and effective hydraulic parameters distributions on braided rivers?

Building hydraulic models in a satellite reference: case of the Xingu River (Amazon basin)

Six virtual stations (blue dots) along the Rio Xingu : intersection with a single Envisat track over a hundred of kilometers



Hydraulic visibility of a slope break in WS (75 Envisat passes, 2002-2010) (cf. Garambois et al. 2017, Montazem et al. (revised))

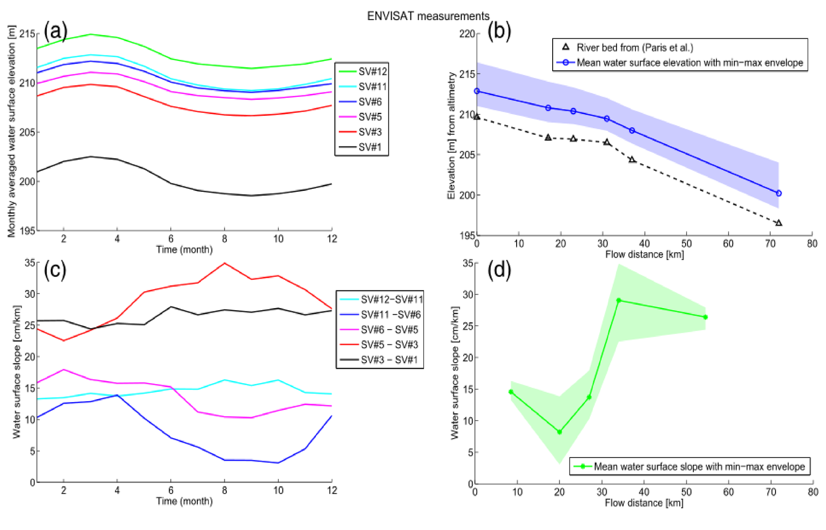
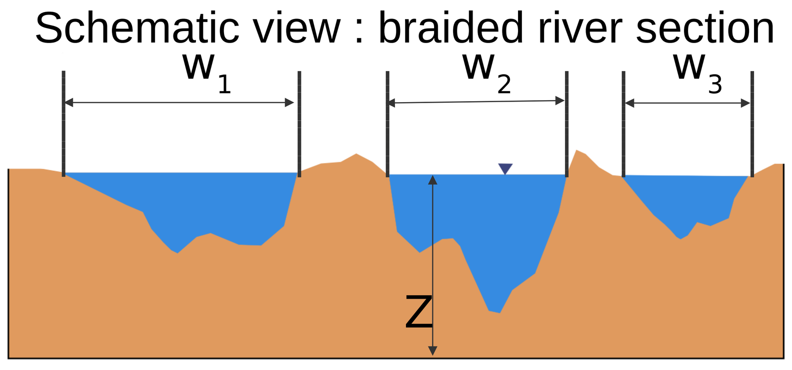


FIGURE 4 Analysis of ENVISAT data: (a) monthly average for water surface elevation at each virtual stations (VS); (b) mean, minimum, and maximum (blue envelope) water surface elevation with river bed elevation Z_b according to Paris et al. (2016); (c) monthly average for the water surface slope for each reach between two VS; and (d) mean, minimum and maximum (green envelope) water surface slope

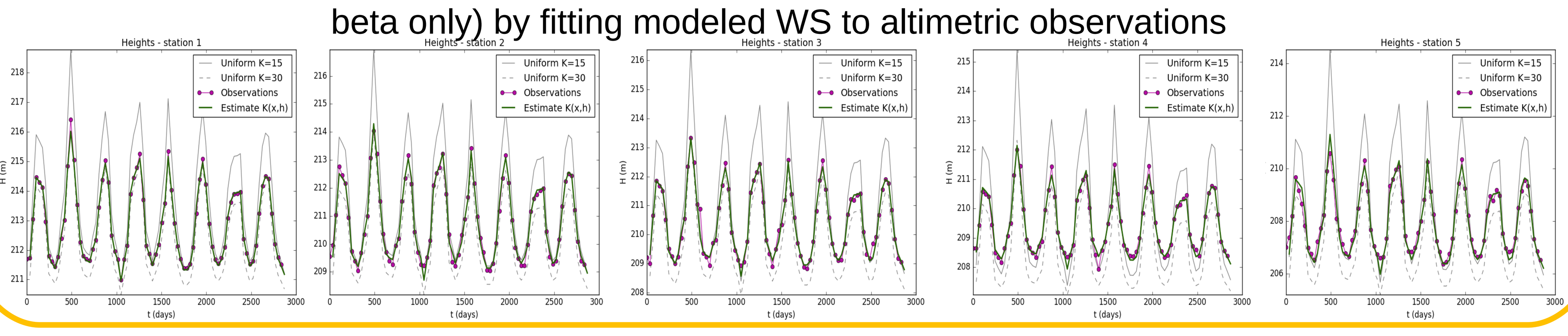
Schematic view : braided river section

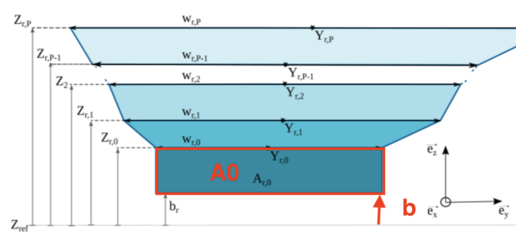


Effective hydraulic modeling

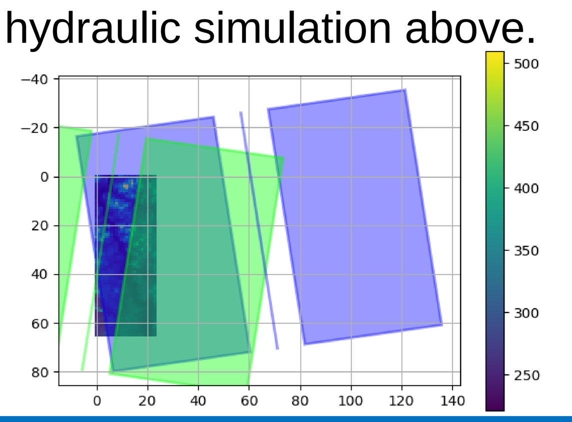
- Single thread representation of braided sections with width from JERS images (low-high flows) and effective bottom elevation from altimetric rating curves (Paris et al. 2016)
- Effective roughness law $K(x,h) = \alpha(x)h^{\beta(x)}$ to account for variability across flow regimes and misrepresentation of braided sections with 1D model (Garambois et al. 2017)
- Discharge from MGB model (Paiva et al. 2013)

« reference hydraulic model »: calibration by VDA of distributed roughness (alpha and beta only) by fitting modeled WS to altimetric observations





SWOT swath over the study zone used to generate SWOT obs (LR) from the reference hydraulic simulation above.



Flow models, variational method and sought hydraulic parameters

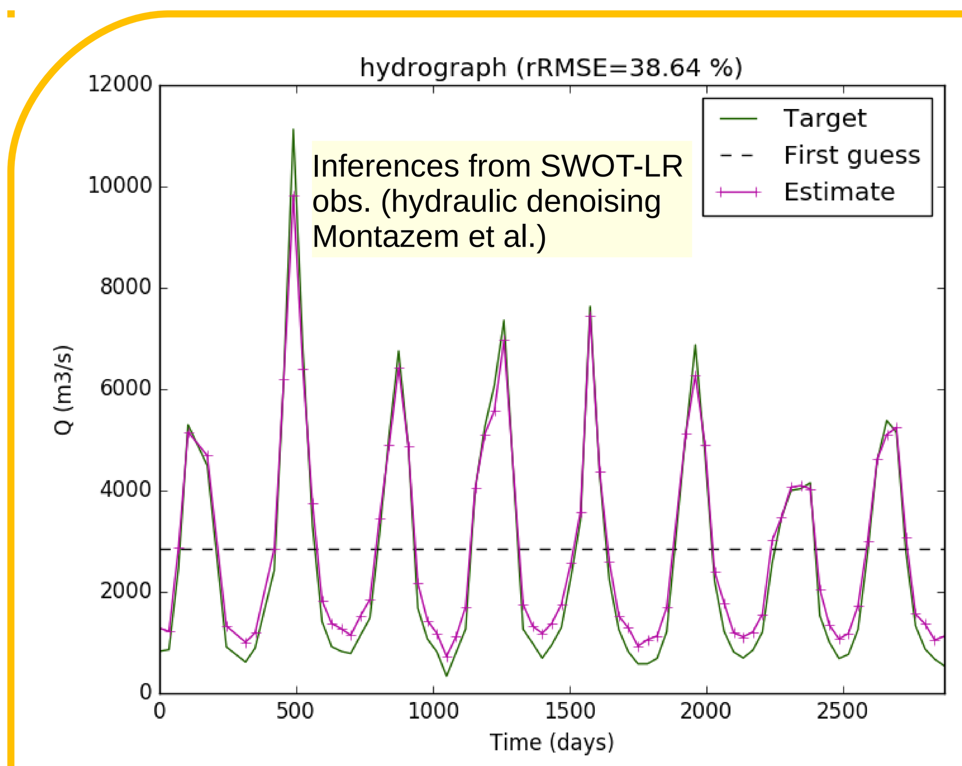
- **Method:** "Hierarchical Variational Discharge estimation", HiVDI algorithm (Larnier et al. (revised), **cf. Poster Larnier et al.**) + dedicated bathymetry-friction treatment
- **Obs:** Water surface elevations ; **obs. cost function**: $j_{obs}(c) = \frac{1}{2}\|(Z(c) - Z_{obs})\|^2_{\mathcal{O}}$
- **Sought (1D) parameters** (control vector c): $Q(t),\ K(x,h) = \alpha(x)h^{\beta(x)},\ b(x)$
- **Inverse problem**: $c^* = \operatorname{argmin} j(c)$ solved with $\nabla j(c)$ computed by adjoint method (HiVDI)

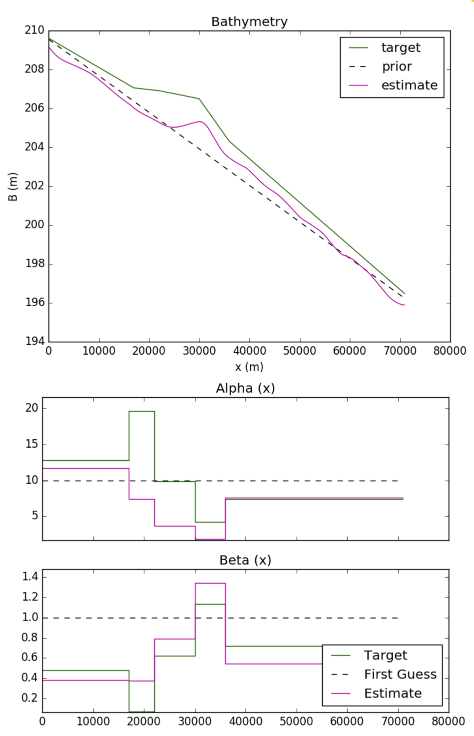
Variational assimilation of ENVISAT or SWOT altimetric observations

Obs: 75 ENVISAT passes or synthetic SWOT-LR (8 years)

Prior: mean Q (from MGB hydrological model), K and b from tables/databases

Inference of hydraulic controls assessed under various scenario





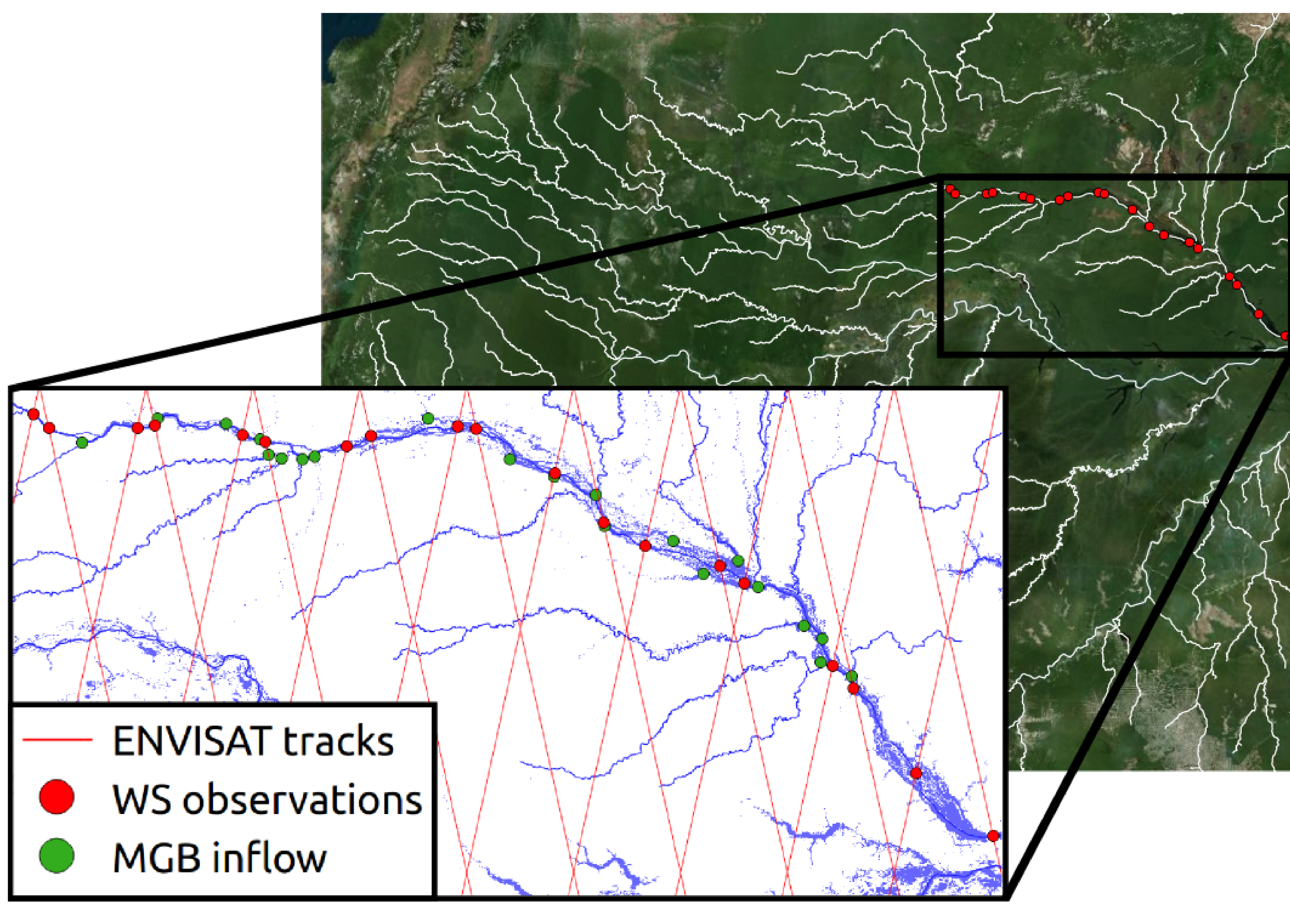
- Inference of discharge and spatially distributed controls is quite robust and accurate under the tested configurations

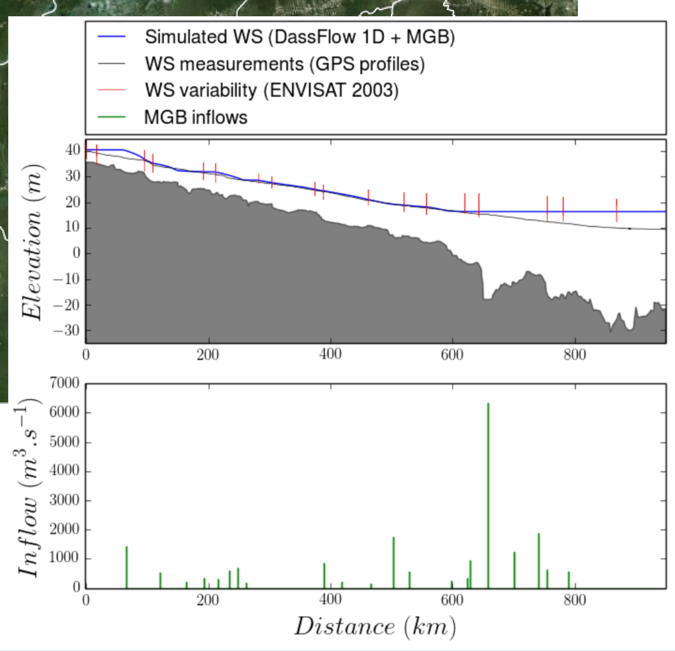
(Garambois et al. in prep.)

Hydraulic/hydrological coupling and multisatellites data Case: ~1000km of the Negro River (Amazon basin)

Obs: Multisatellites, water masks (Pekel here, GRWL from Allen et al. (2018) in situ GPS flow lines ADCP measurements (Moreira et al. CPRM)

Models: Q (from MGB hydrological model) coupled to HiVDI chain (dassFlow-1D, SW model)





(Pujol et al. in Prep)

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