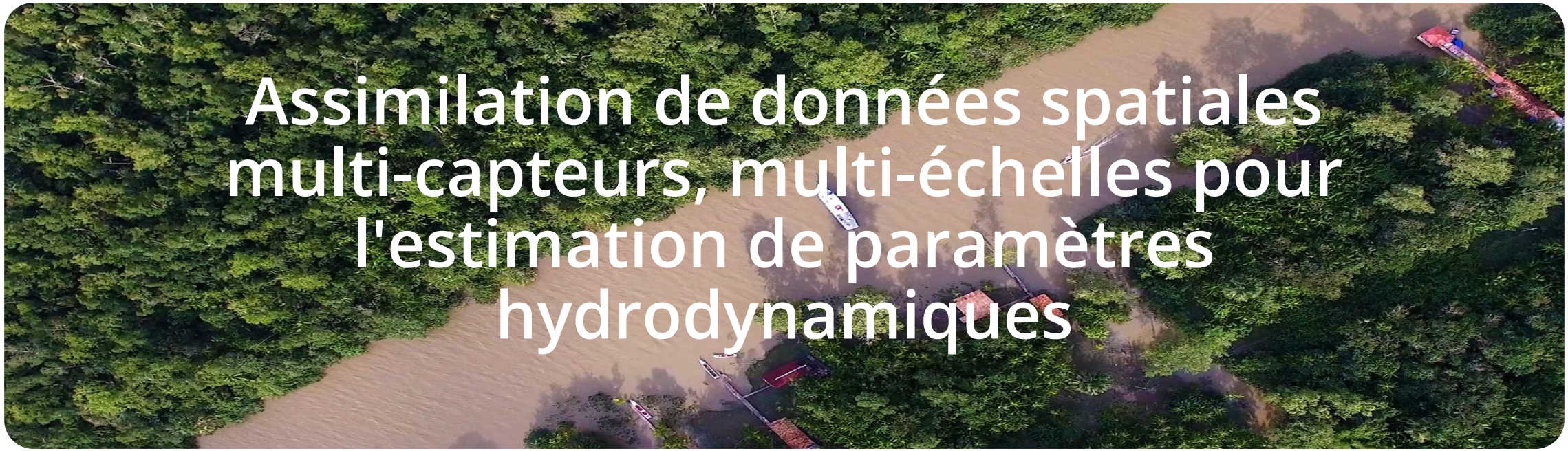


Assimilation de données spatiales multi-capteurs, multi-échelles pour l'estimation de paramètres hydrodynamiques

K. Larnier, Hydro Matters

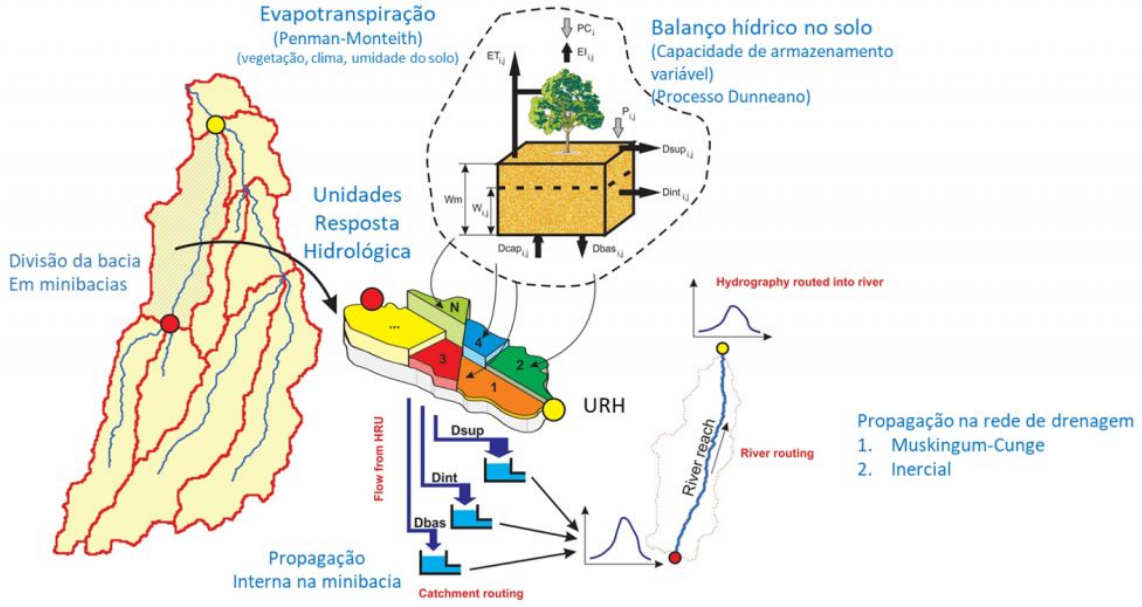
CONTEXT & OBJECTIVES

- **Context**
  - Steady decrease of in-situ stations over the past 3 decades
  - Real time monitoring using dense in situ data only available in developed countries
  - Strong potential benefits of remote sensing in developing countries such as in Africa
  - Copernicus Sentinels constellation
  - The SWOT mission

- **Objectives**
  - Develop an automatic method to setup coupled hydrology-hydrodynamic models using fusion of EO Open-Data products for basins with sparse in-situ data
  - Analyze the assimilation of conventional altimetry and/or SWOT river L2 products

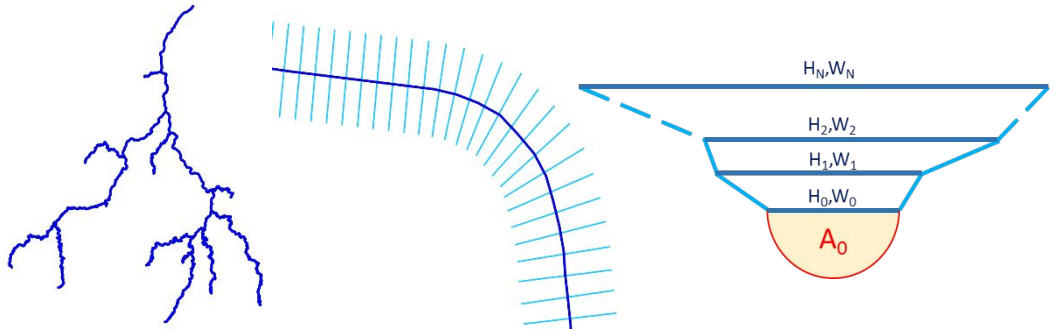
METHODS

- **What do we need to setup a coupled hydrological-hydrodynamic model ?**



MGB-IPH LSM [Collischonn et al, 2011]

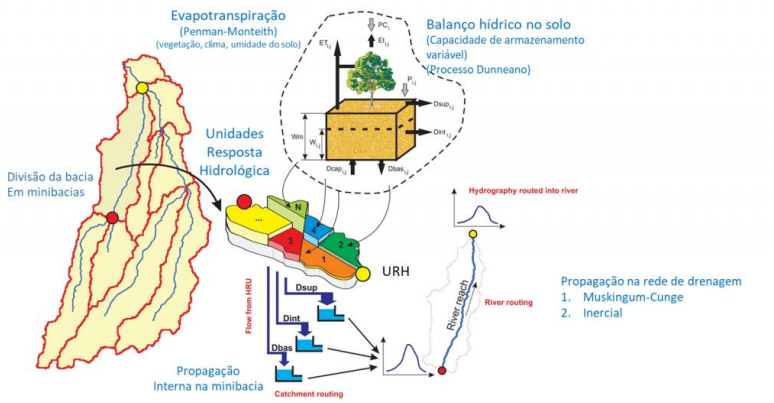
$$\begin{cases} \dfrac{\partial A}{\partial t} + \dfrac{\partial Q}{\partial x} = q_L \\ \dfrac{\partial Q}{\partial t} + \dfrac{\partial UA}{\partial x} + g\left(\dfrac{\partial Z}{\partial x} - Sf\right) = v_L q_L \end{cases}$$

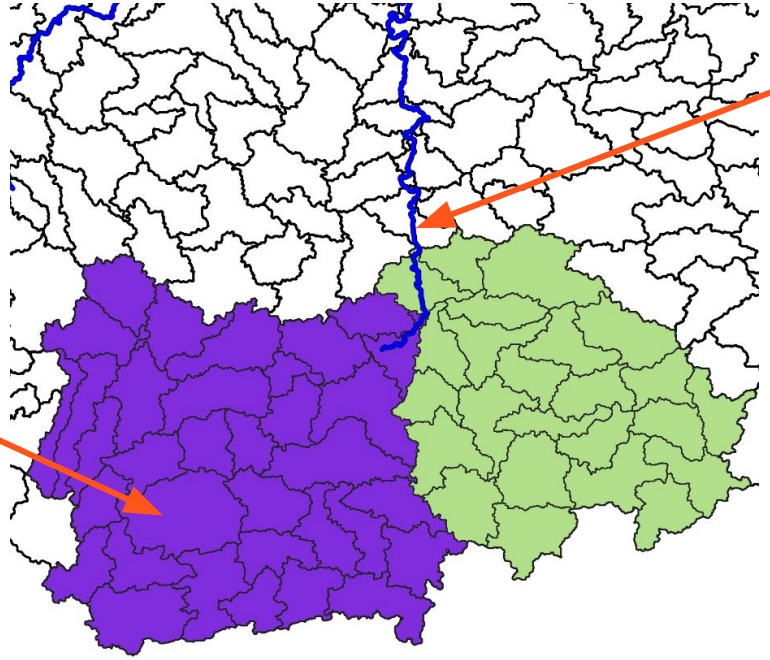


DassFlow-1D [Larnier et al, 2020]
Part of the DassHydro project

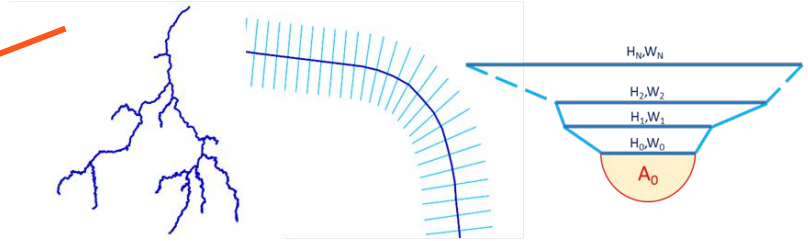
METHODS

- **What do we need to setup a coupled hydrological-hydrodynamic model ?**



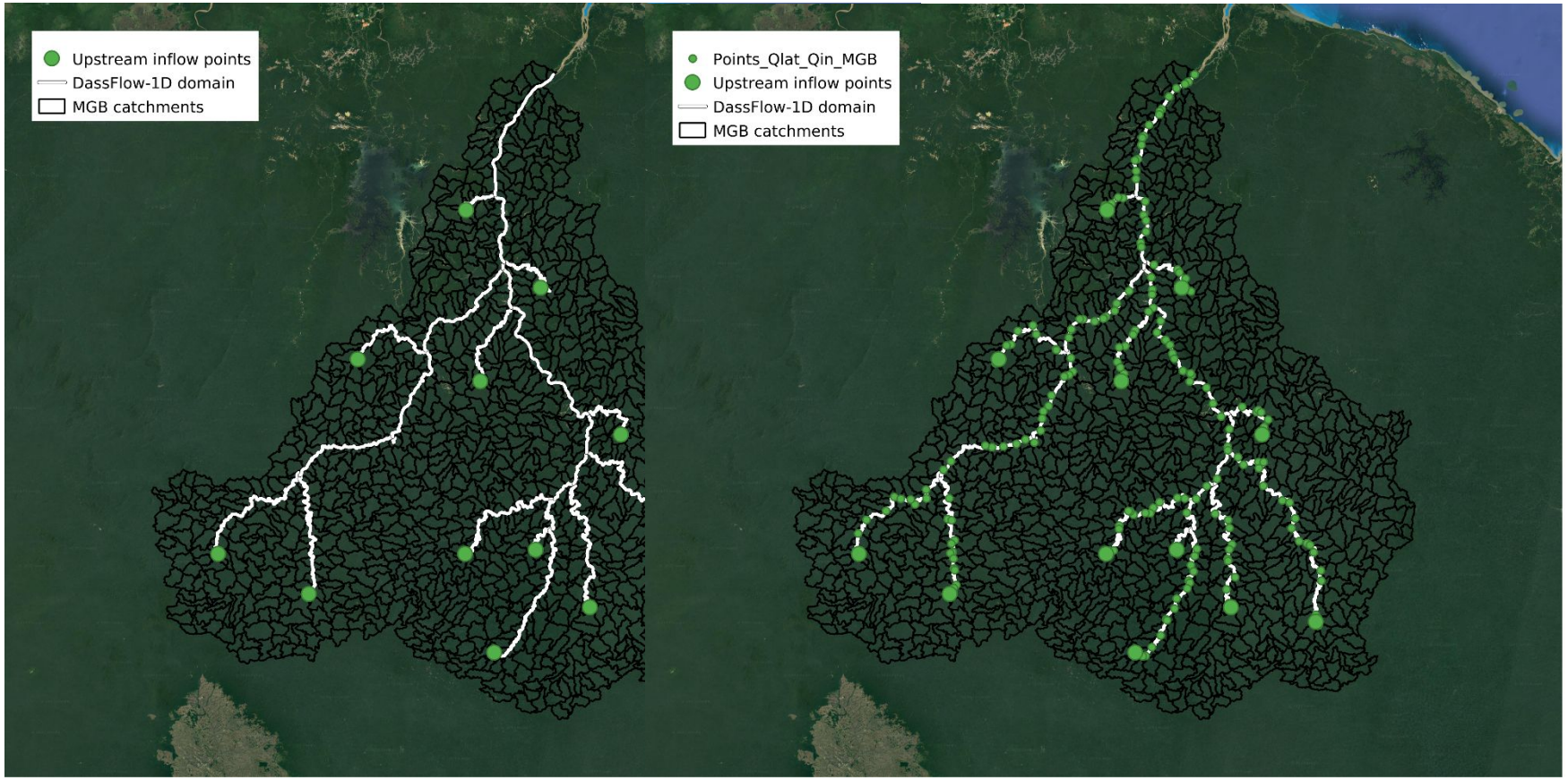


$$\begin{cases} \dfrac{\partial A}{\partial t} + \dfrac{\partial Q}{\partial x} = q_L \\ \dfrac{\partial Q}{\partial t} + \dfrac{\partial UA}{\partial x} + g\left(\dfrac{\partial Z}{\partial x} - Sf\right) = v_L q_L \end{cases}$$



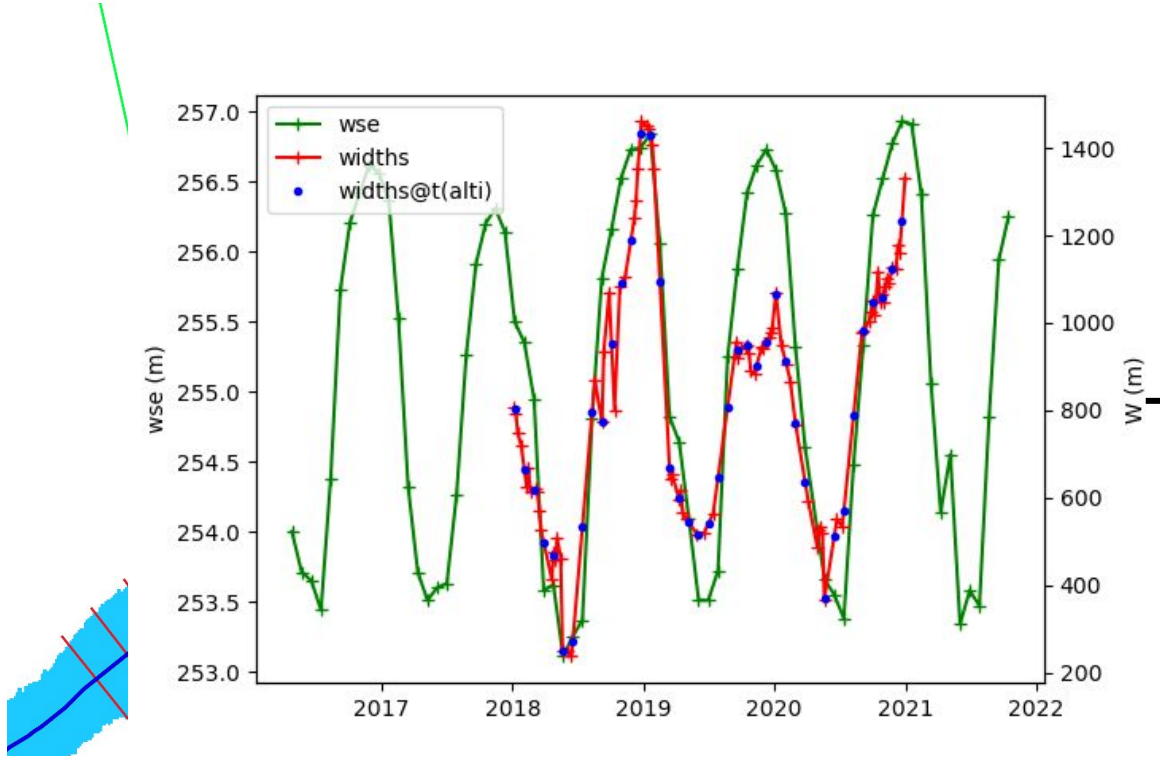
METHODS

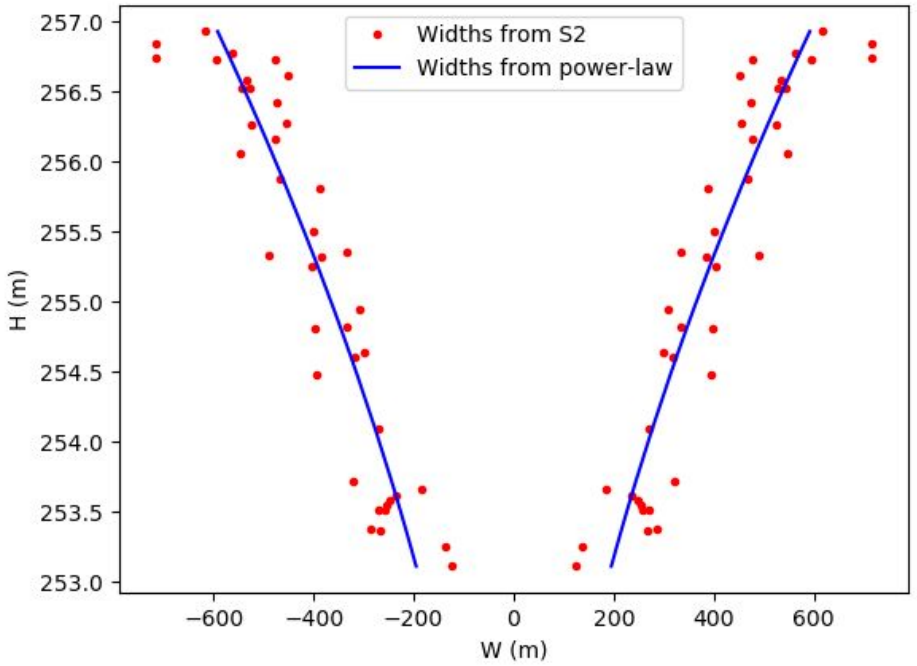
- **Automatic setup of the connectivity table for coupling**



METHODS

- **Estimation of the effective cross-sections**





METHODS

- **Data assimilation framework**
  - 4D-VAR, embedded in DassFlow-1D software.
  - The inverse problem to solve is:

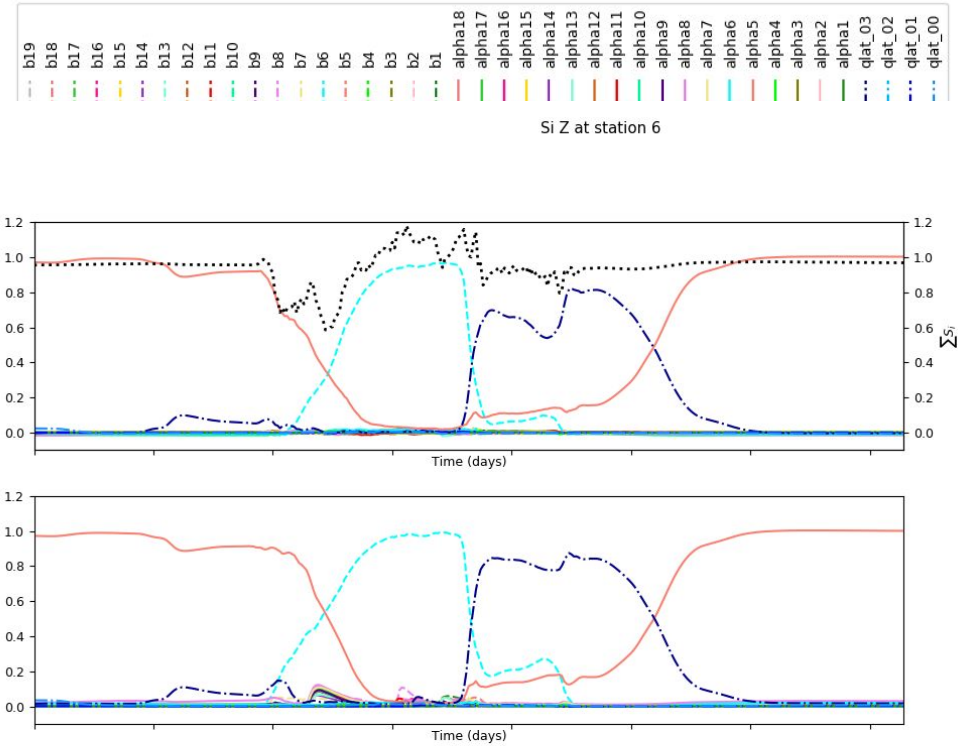
$$\min\big(j(c)\big) \text{ with } j(c) = \|Z(c) - Z_{obs}\|_R$$

$$c = (Q_{in}(t), \{Q^k_{trib}(t)\}_k, b(x), \alpha(x), \beta(x))$$

  - Preconditioning using change of variable and covariance matrix

$$k = B^{1/2}\big(c - c^{(0)}\big) \text{ with } B = diag(\{B_X\}_X),\ B_X = \sigma_X^2 \exp\left(-\frac{|x_i - x_j|}{L_X}\right)$$

  - Sensitivity analysis (ANOVA) to get:
    - estimation of correlations length (L_X)
    - Multi-steps optimization

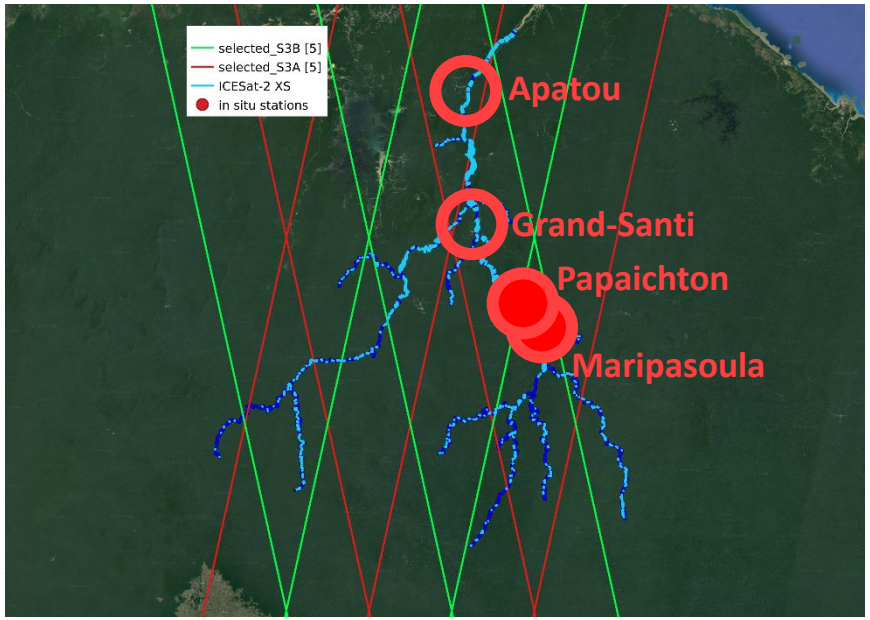


EXPERIMENTS

Case	Période	Setup dataset	Assimilation dataset
Maroni	2019-2021	ICESat-2 x ExtractEO (S1)	ICESat-2 + S3
Maroni	2019-2021	ICESat-2 x ExtractEO (S1)	ICESat-2+S3+in-situ (2)
Maroni	2023 (CalVal)	ICESat-2 x ExtractEO (S1)	ICESat-2+S3+in-situ (2)
Maroni	2023 (CalVal)	SWOT (nodes, 1day)	SWOT (nodes, 1day)

RESULTS

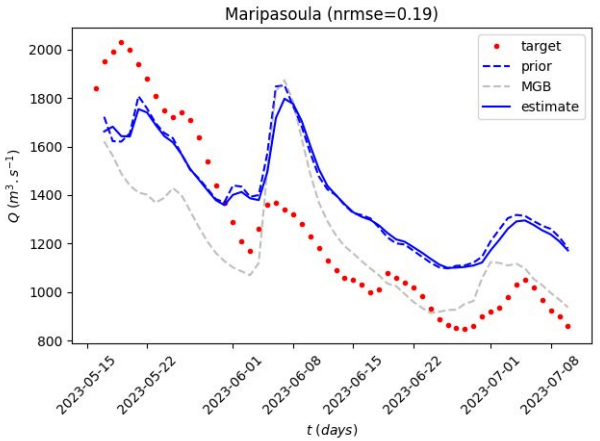
- **Experiment #3**

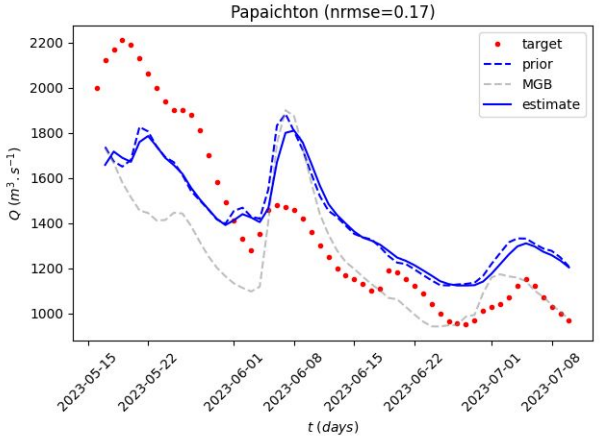


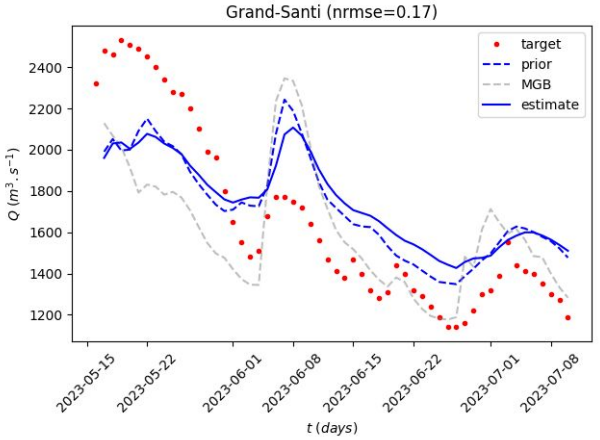
16-05-2023 - 11-07-2023

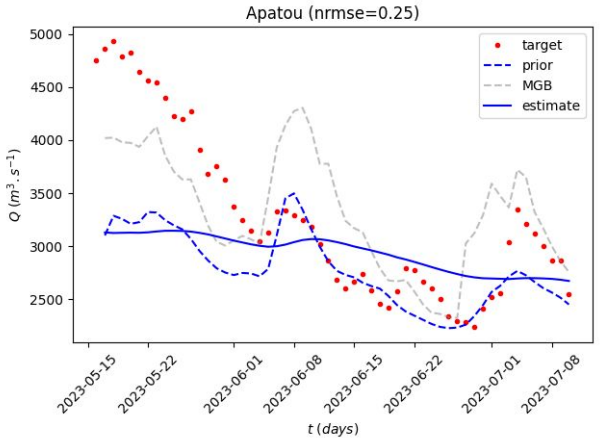
219 ICESat-2 VS
19 S3A/B VS

Maroni	ICESat-2 x ExtractEO (S1)	ICESat-2 + S3 + in-situ (2)





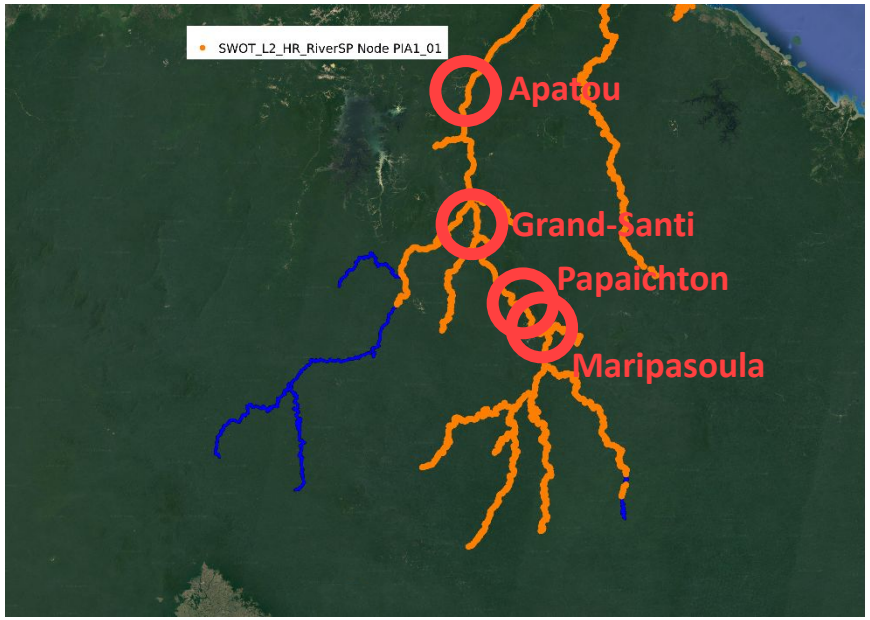


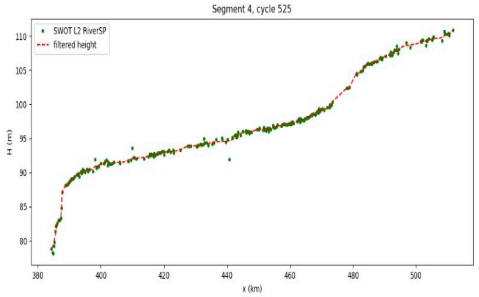


RESULTS

- **Experiment #4**

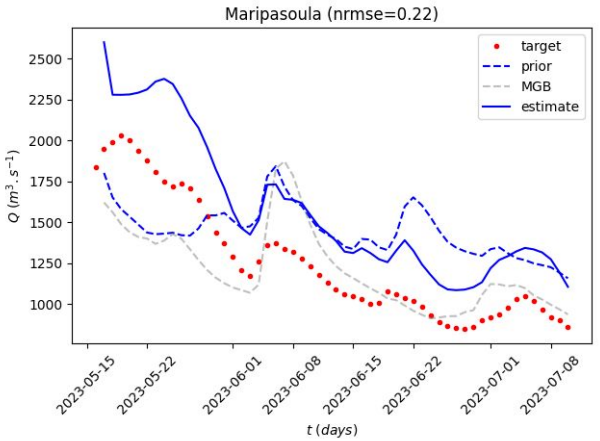
Maroni	ICESat-2 x ExtractEO (S1)	SWOT (nodes, 1day orbit)

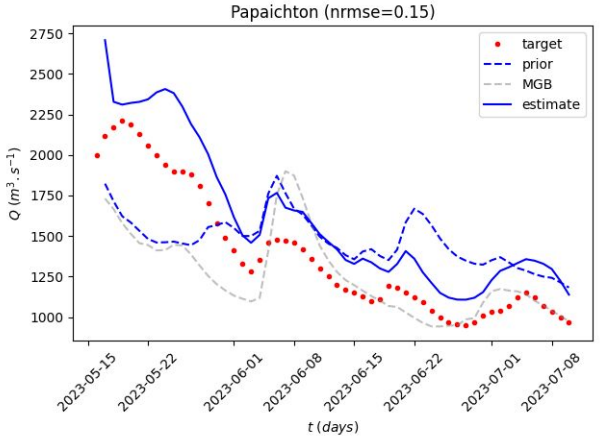


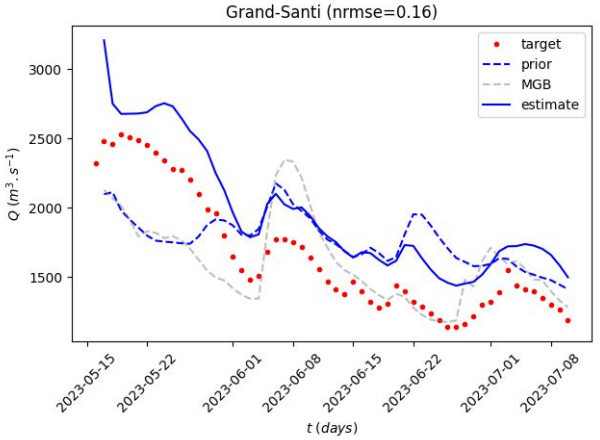


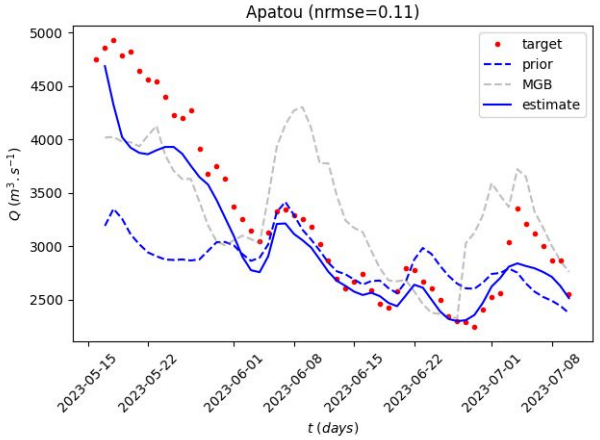
16-05-2023 - 11-07-2023

5572 nodes
312032 observations







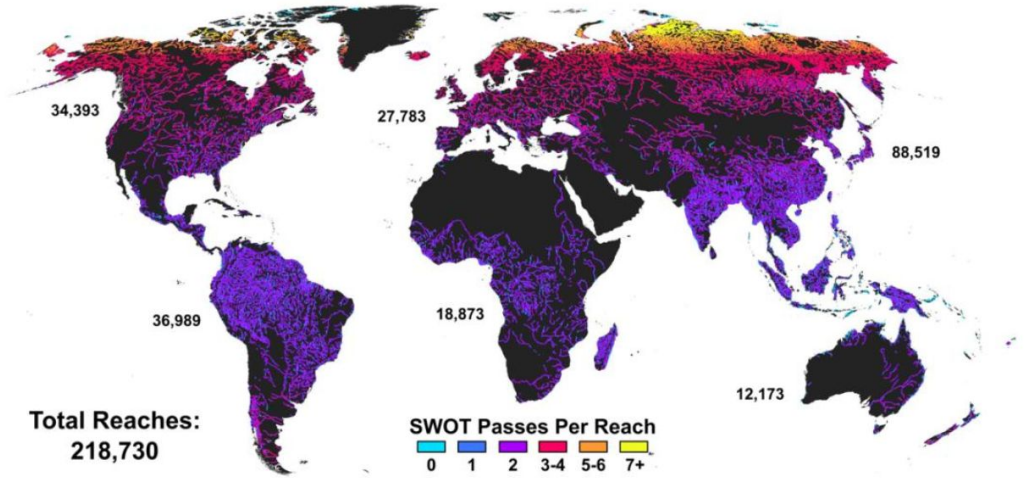


CONCLUSION & PERSPECTIVES

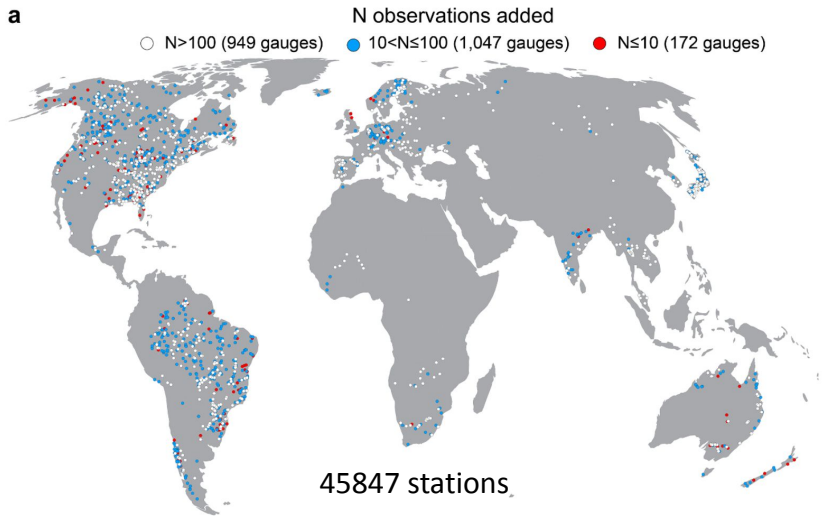
- **Conclusion**
  - Automatic setup of coupled hydrological-hydrodynamic model on a river network
  - 4DVar data assimilation to estimate:
    - Multiple inflow discharge time series
    - Roughness parameters
    - Riverbed elevation
    - On a full river network
  - SWOT ready, results are promising !

CONCLUSION & PERSPECTIVES

- **Perspectives**
  - Going global using SWOT L2 river products – Sience orbit
  - Fusion with historical altimetry missions
  - Learnable parameters



SWORD Dataset [Altenau et al, 2021]

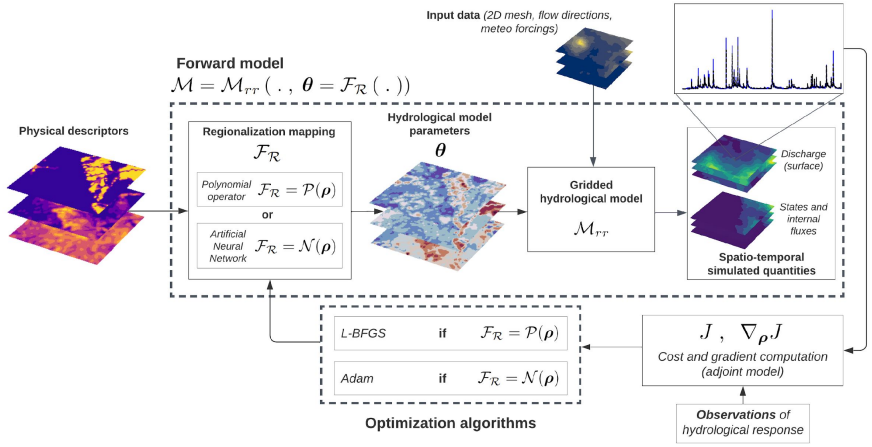


CARAVAN Dataset [Riggs et al, 2023]

CONCLUSION & PERSPECTIVES

- **Perspectives**
  - Going global using SWOT L2 river products – Science orbit
  - Fusion with historical altimetry missions
  - Learnable parameters
  - Hybrid learnable hydrological-hydrodynamic models

    ANITI Chair PILearnWater + TOSCA-ROSES project Hydro2Learning



SMASH hydrid regionalization framework
[Garambois et al, in prep]

Thank you