



SWOT Variational Data Assimilation: Po and Sacramento case

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Many thanks to:

M. Durand, R. Wui, A. Domeneghetti, F. Mercier





Methodology

- Data Assimilation (from water level to discharge, bathymetry, roughness)
 - Variational "4D-Var" type
 - Several features adapted to river hydraulics & SWOT context
 - Based on a full 1.5D Saint-Venant hydraulic model
 - SIC² (Irstea), including its tangent linear and adjoint models
 - allows cross devices (weirs, dams, locks), tributaries, etc.
 - Sequential version: sliding temporal window
 - allowing any duration: several years
 - Robust algorithm
 - tested on 3 real sites **without any in-situ data**
 - initialization** of the bathymetry and roughness with:
 - Q_{average} (cf. Wikipedia),
 - A_0, n (cf. M Durand & al),
 - Z_w , Width, Slope (cf. SWOT data at time 0)

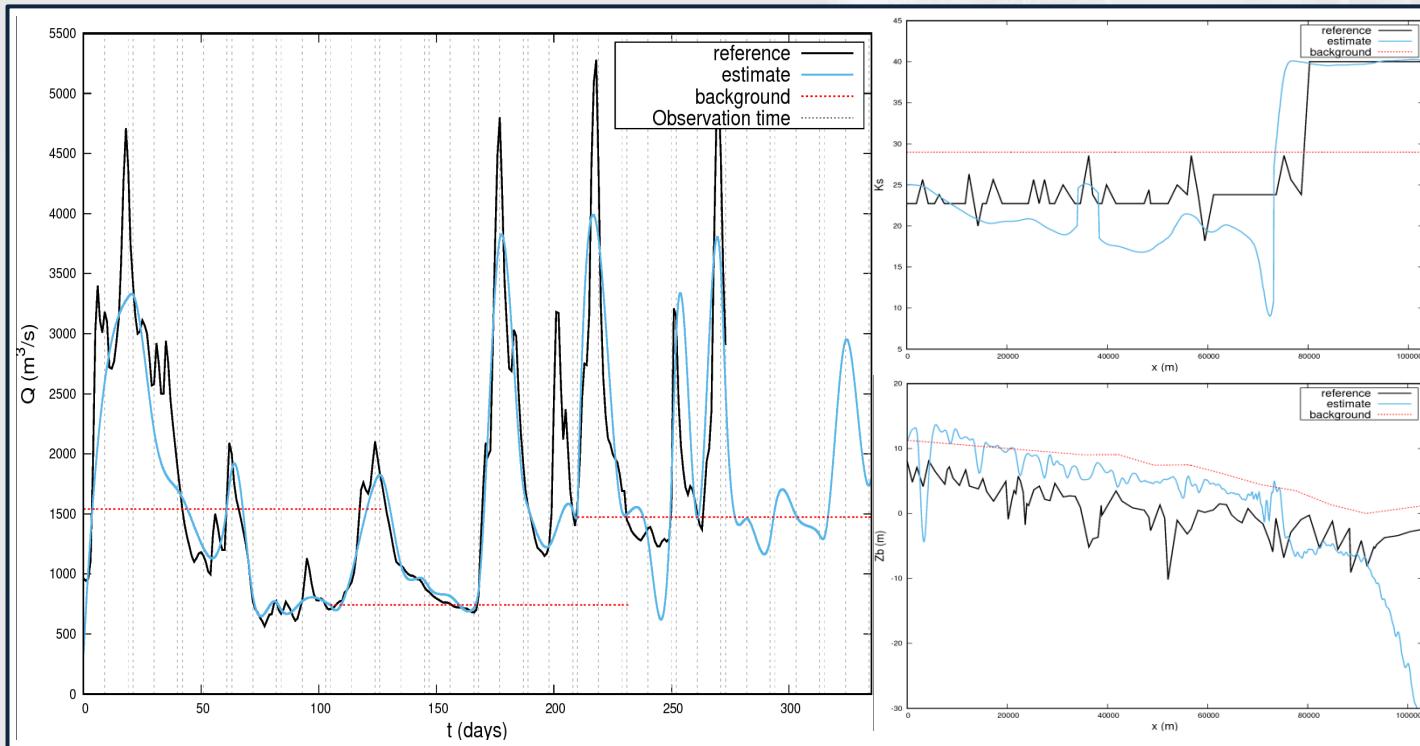
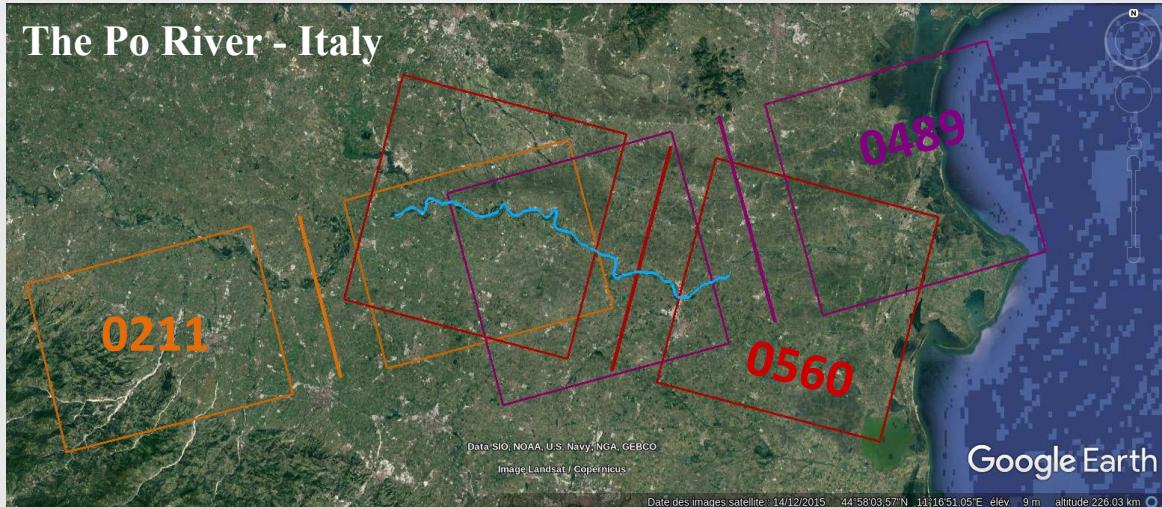


Experiments

1. Twin Experiments (Garonne)
2. SWOT simulation (Po & Sacramento)

River discharge estimation under uncertainties from SWOT simulations using variational data assimilation – The Po River (133km)

- SWOT Simulator JPL
- RiverObs: Nodes Product $\sim 200 \text{ m}$
- Observation error: $\sigma = 2.5 \text{ m}$
- Irregular observation temporal frequency (3 revisits/cycle)
- Unknown bathymetry \Rightarrow Trapezoidal approximation
- Prior/background information computed using the SWOT obs. only



$rRMSE[Q]$

RMSE **297.5**

$rRMSE$ **14.5%**

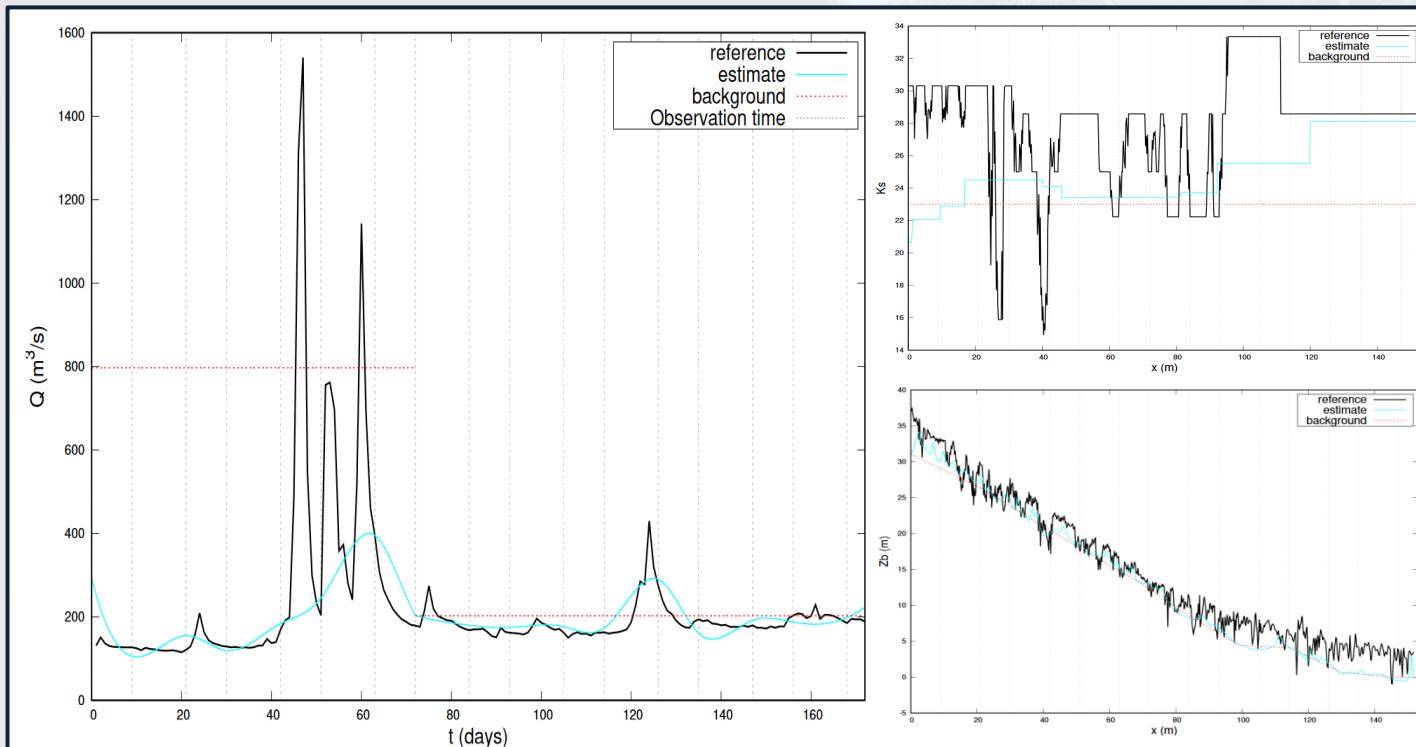
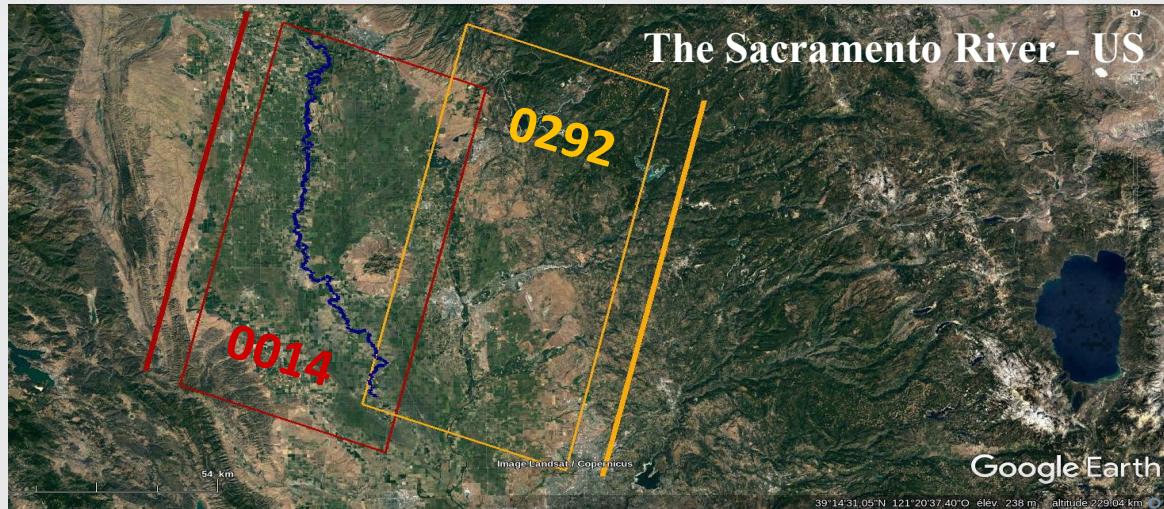
$NRMSE$ **16.4%**

NSE **0.93**

VE **0.89**

River discharge estimation under uncertainties from SWOT simulations using variational data assimilation – The Sacramento River (153km)

- SWOT Simulator JPL
- RiverObs: Nodes Product $\sim 200\text{ m}$
- Observation error: $\sigma = 2.5\text{ m}$
- Irregular observation temporal frequency (2 revisits/cycle)
- Unknown bathymetry \Rightarrow Trapezoidal approximation
- Prior/background information computed using the SWOT obs. only



- Discharge estimation using SWOT simulated data and simplified initial bathymetry shows very promising results, which emphasize the application of such method to **any ungauged river channel**
- Very robust and **fast convergence**: just 5 iterations
- Successful estimation of discharge from the SWOT simulations at the **nodes scale** of RiverObs (14,5% and 12,3% for the Po and Sacramento Rivers, respectively)
- The estimates of the spatially distributed functions ($n(x), Z_b(x)$) have been **locally improved** during the minimization process leading to an **optimal accuracy** of discharge estimate
- Perspectives (just a few, but many more ...):
 - improvement of the algorithm
 - Pepsi & DA Pepsi Challenge
 - application to the Congo river (& Ubangui) using existing VS (ENV, SRL, J2)
(and latter on using SWOT data when available ...)

Thank you

Papers:

- Gejadze, I. Y., P.-O. Malaterre (2016), Design of the control set in the framework of variational data assimilation, *Journal of Computational Physics*, 325, 358–379.
- Gejadze, I. Y., P.-O. Malaterre (2017), Discharge estimation under uncertainty using variational methods with application to the full Saint-Venant hydraulic network model, *International Journal for Numerical Methods in Fluids*, 83(5), 405–430.
- Gejadze, I. Y., Oubanas, H., V. Shutyaev (2017), Implicit treatment of the model error using a modified observation covariance, *Quarterly Journal of the Royal Meteorological Society* (in press)
- Oubanas, H., I. Y. Gejadze, P-O. Malaterre, F. Mercier (2017), River discharge estimation from synthetic SWOT-type observations using variational data assimilation and the full Saint-Venant model, *Journal of Hydrology* (under review)
- Oubanas, H., I. Y. Gejadze, P-O. Malaterre, M. Durand, R. Frasson, R. Wui, A. Domeneghetti, (2017), SWOT mission for discharge estimation under uncertainties using variational data assimilation, *Water Resources Research* (submission very soon).

Conference (some):

- Oubanas, H., Gejadze, I., Malaterre, P.-O., Mercier F., "River discharge estimation under uncertainty from in-situ and remote sensing data using variational data assimilation and a full Saint-Venant hydraulic model", 12th HIC2016, Korea.
- Oubanas, H., Gejadze, I., Malaterre, P.-O., Durand, M., Wui, R., Domeneghetti, A. "Simultaneous estimation of inflow discharge, river bathymetry and friction from synthetic SWOT data using variational data assimilation." AGU Fall Meeting, San Francisco, California, USA, 12/2016.