Investigating SWOT observations for river hydrodynamics: A case study from the Po River

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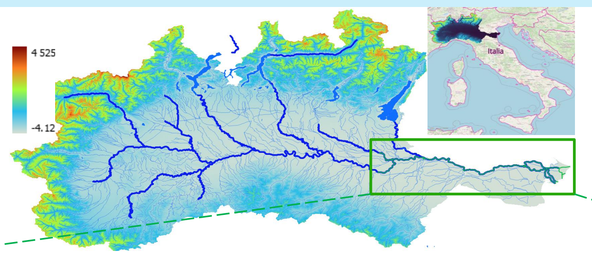
Objectives

- Evaluation of the accuracy of RiverSP WSE data, compared to the gauge measurements and hydraulic model simulations over ~300 km of the Po River, from Jul 2023 to Dec 2024;
- Assessing the impact of SWOT data quality levels on the reliability of satellite observations for river monitoring

Study Area

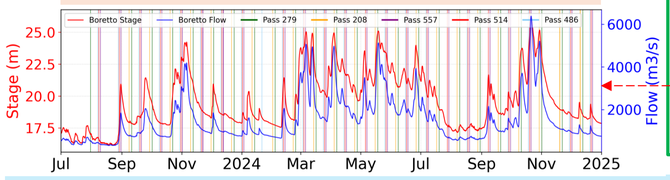


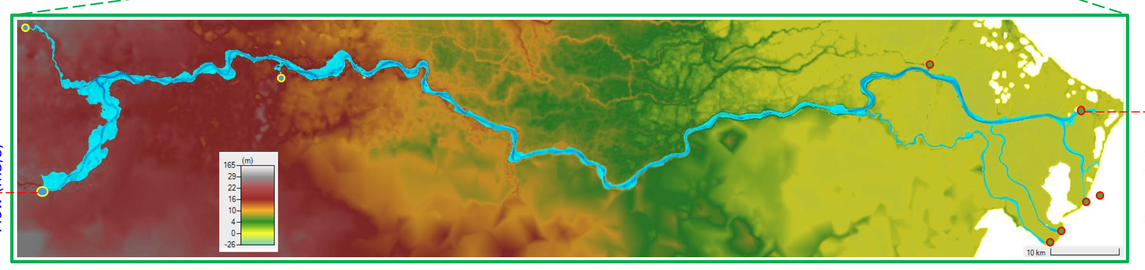
A **~300-km** stretch of the most downstream part of the **Po River,** where the river flows into Adriatic Sea (green box in figure):

- Relatively uniform, single-channel structure with channel widths ranging from 200 to 300 m, reaching up to 500 m;
- Along this portion, the lateral floodplains are delimited by a system of major embankments and may reach an extent of 5 km.

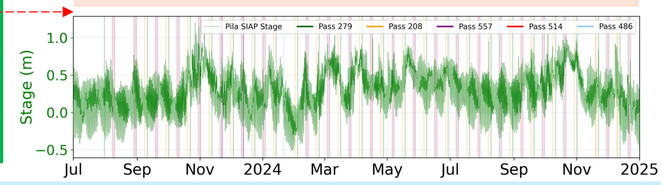
Study time window: 07/2023 – 12/2024

Upstream B.C. + SWOT Passes





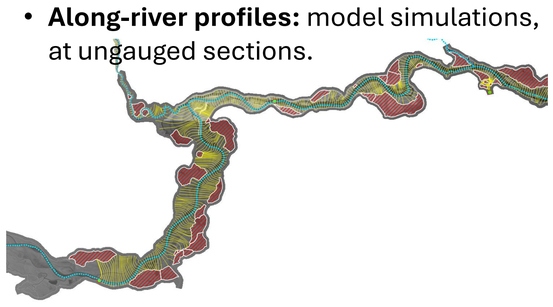
Downstream B.C. + SWOT Passes



Hydraulic Model

Twofold validation of RiverSP WSE

- **Ground-truth:**discrete gauged stations;
- **Along-river profiles:** model simulations, at ungauged sections.

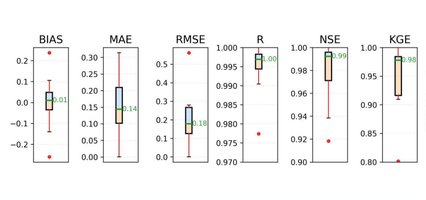


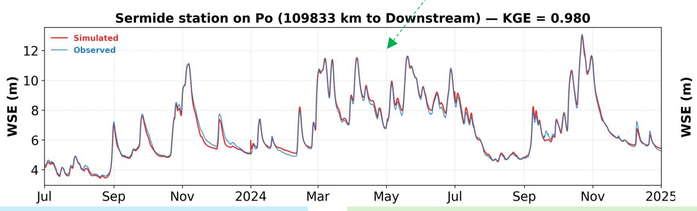
A combined 1D/2D HEC-RAS model is developed and calibrated using hourly data, to simulate the river stretch and tributaries. ~50 floodplain storage areas are linked to 865 1D cross-sections (aligned with SWORD nodes), extracted from 1 m LiDAR. The delta bathymetry and floodplain is built using over 500 recently surveyed cross-sections.

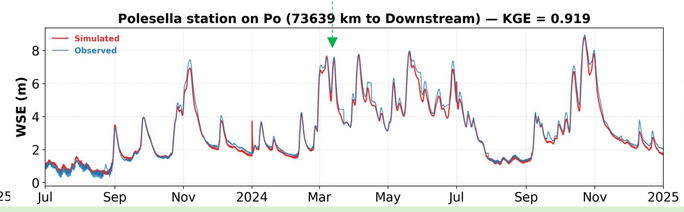
Model Performance

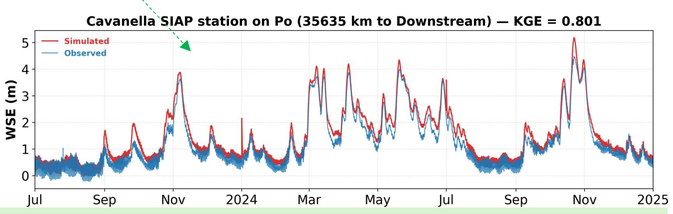
Horizontally and vertically variable Manning's roughness coefficients were used to account for hydraulic behavior according to the land use and flow levels. Manning's n ranged from 0.075 to 0.105 for floodplains, and from 0.02 to 0.034 for riverbanks, based on land cover characteristics and model performance.

Model performance is assessed by comparing the simulated WSE hydrograph with those of the gauging stations along the river. KGEs range from 0.997 to 0.91 before the delta section:



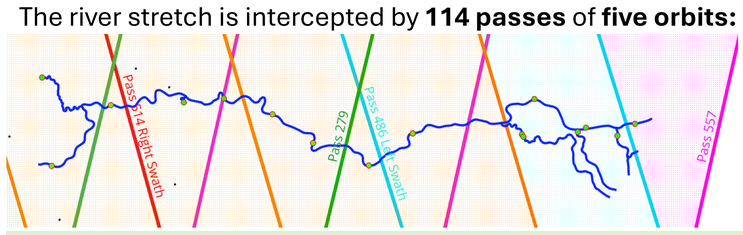






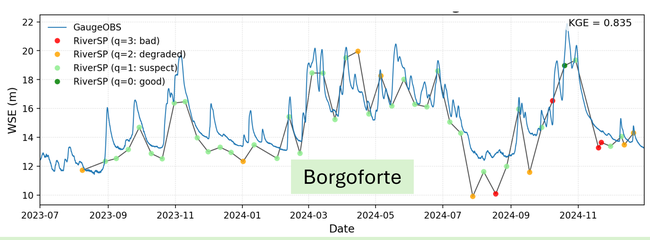
SWOT Passes

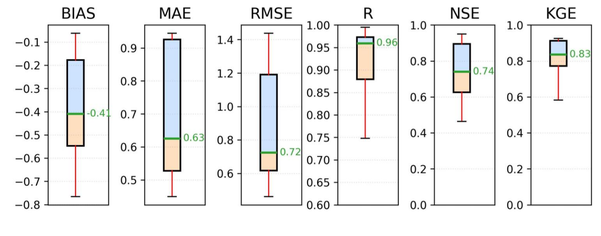
The river stretch is intercepted by **114 passes** of **five orbits:**



WSE Hydrograph Comparison

WSE hydrograph of RiverSP compared to gauge observations (example of Borgoforte), and the boxplots of metrics over all gauging stations:





Preliminary Results - Simulation vs. RiverSP (quality-flagged)

Comparing quality-aware RiverSP WSE profiles with the simulated WSE values, on the SWOT pass times (examples of pass 208, cycles 20 to 23) with gauge measurements as triangles:

- ➢ RiverSP "good" and "suspect" data (dark and light green) closely follow the model results and WSE profile (generally within ±0.5–0.8 m), with lower number of occurrences;
- ➢ "degraded" and "bad" data exhibit larger discrepancies;
- ➢ WSE variation plots summarize the difference of RiverSP WSE against model results for the same passes as the profiles, excluding low-quality observations, with black lines showing the variations against the gauge observation;
- ➢ Scatterplots, show for the same examples, the 1-to-1 match between simulation results and RiverSP WSE, differentiated by quality-colored points.