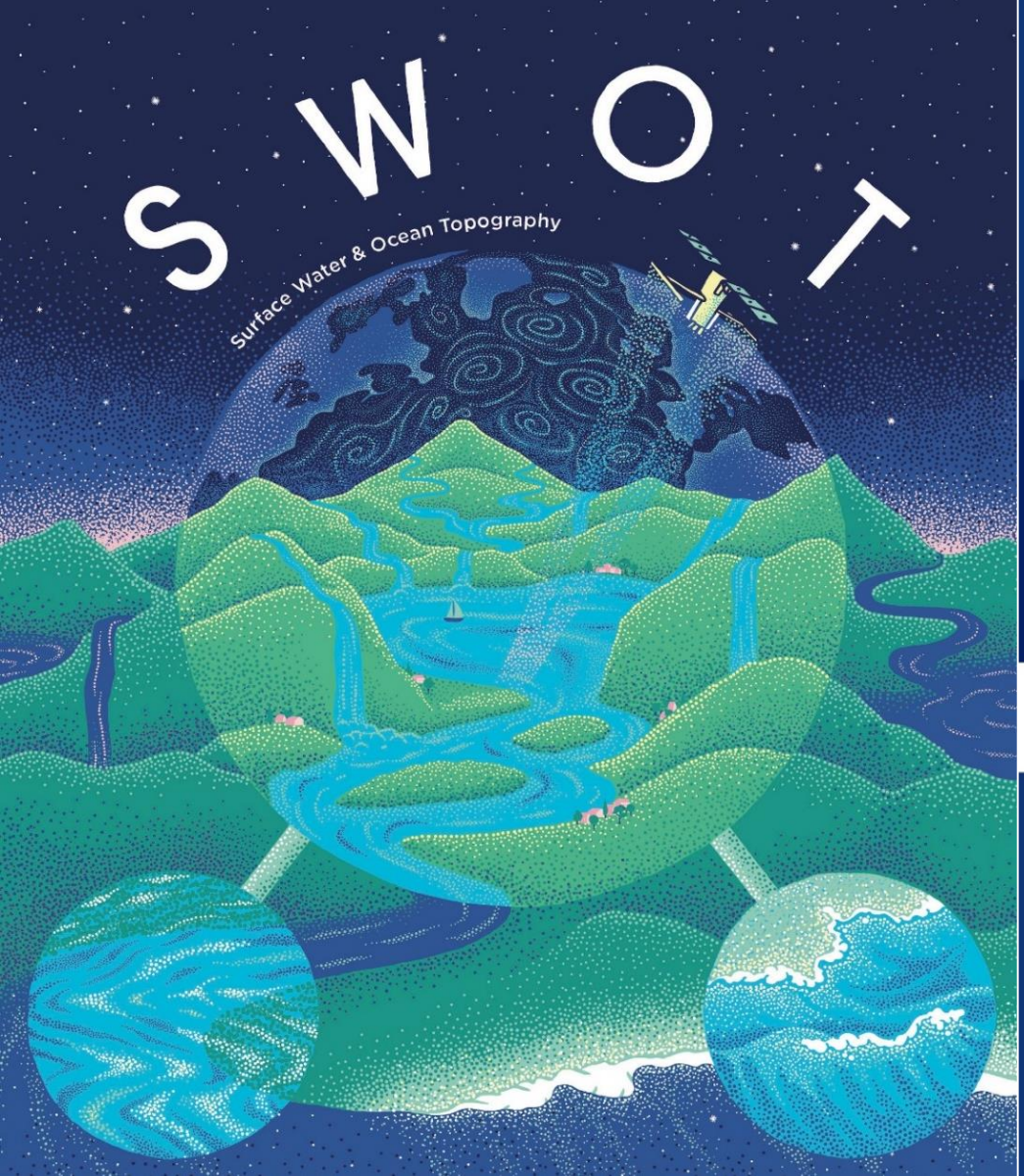


Assessing and Improving SWOT's Hydraulic Visibility on French narrow rivers (20-100 m):

Precision Flow Lines and Slope variation in different flow condition.

Ledauphin T, Garambois P-A, Azzoni M, Samine Montazem A, Piasny G, Larnier K, Amzil S, Picot N., Fjortoft R, Maxant J, Yesou H.

INRAE Sertit ICUBE Université de Strasbourg Hydromatters

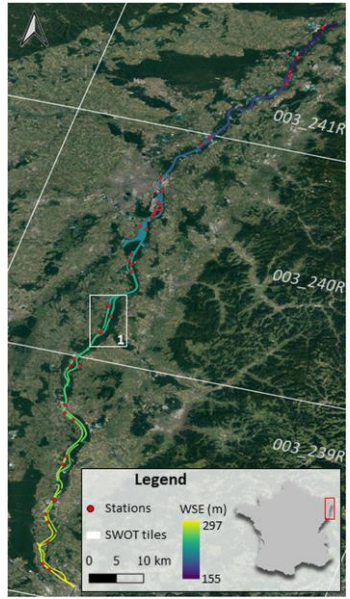
Prendre la mesure de l'eau Hydrology from space to society

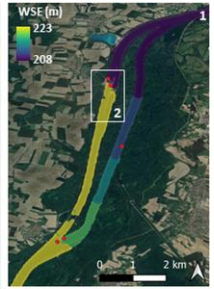
16/10/2025 – 11:10

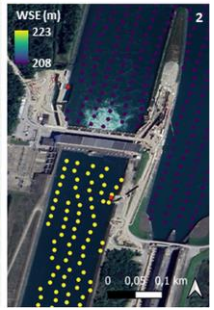
cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

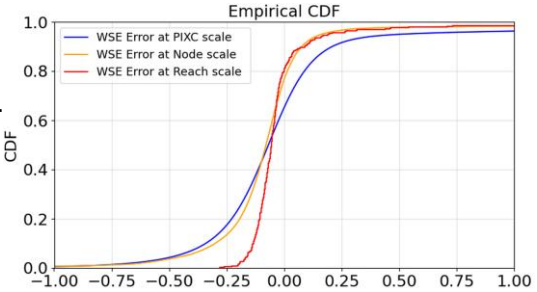
Context

- **CalVal period** : assessing SWOT data over a part of the Franco German Rhine River.
- **180 km** validated at **PIXC, Nodes** and **Reaches** scale with **44** water level **gauges** stations.
- Canalized and natural part of the Rhine, with :
  - Identification of hydraulical structures
  - Relationship between the topography of the river surface observed by SWOT and the topography of the river
  - Better understanting of river flow









Scale	Number of comparisons	Median	Standard deviation	1 Sigma ad
WSE error at PIXC scale	1,205,076	−0.05 m	0.46 m	0.17 m
WSE error at Node scale	25,868	−0.07 m	0.13 m	0.12 m
WSE error at Reach scale	557	−0.06 m	0.43 m	0.10 m

➔ Presentation at Chapell Hill SWOT ST 2024.
➔ Recent publication on Earth and Space Science (AGU)

Earth and Space Science

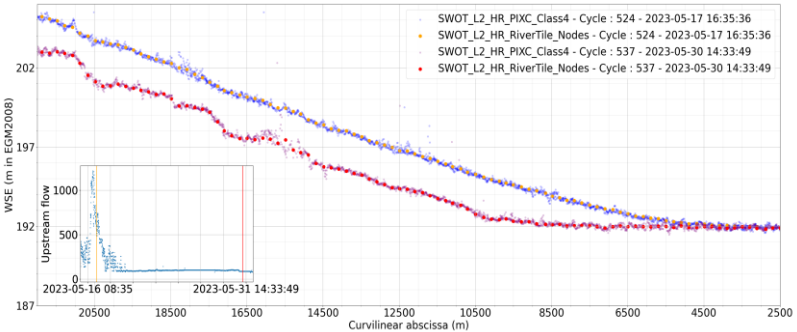
Volume 12, Issue 7
July 2025
e2025EA004309

Research Article | Open Access

Assessing SWOT's Hydraulic Visibility on the Rhine: Precision Flow Lines and Slope-Based Flood Wave Propagation Signatures

T. Ledauphin, P.-A. Garambois, K. Larnier, M. Azzoni, C. Emery, N. Picot, S. Amzil, R. Fjørtoft, J. Maxant, H. Yésou

First published: 30 June 2025 | https://doi.org/10.1029/2025EA004309



Objectives

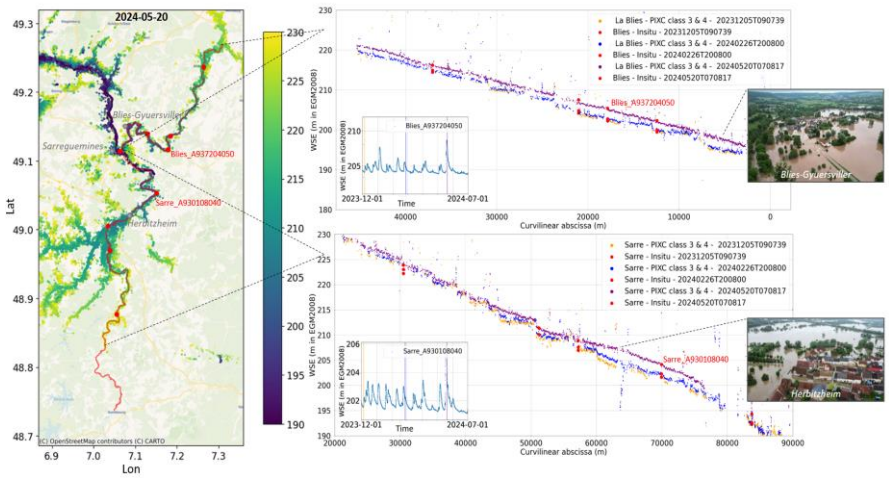
Goal : Assess SWOT Science Orbit detection capabilities for relatively narrow rivers

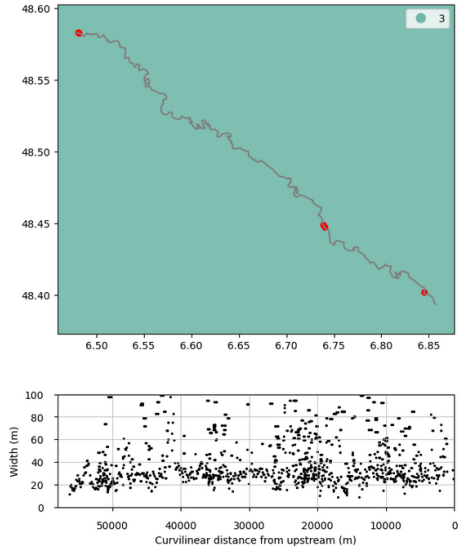
- Z accuracy: median bias and standard deviation.
- Spatio-temporal profile analysis: using a hydraulic model.
- Fine-scale slope calculation: accounting for spatio-temporal variability of measurement noise.

Methodology : Selected study **sites** with reference **data enabling comparison**, use a **wavelet-based denoising algorihtm** adapted to the node product (Montazem et al. 2025) for slope calculation.

Selected sites :

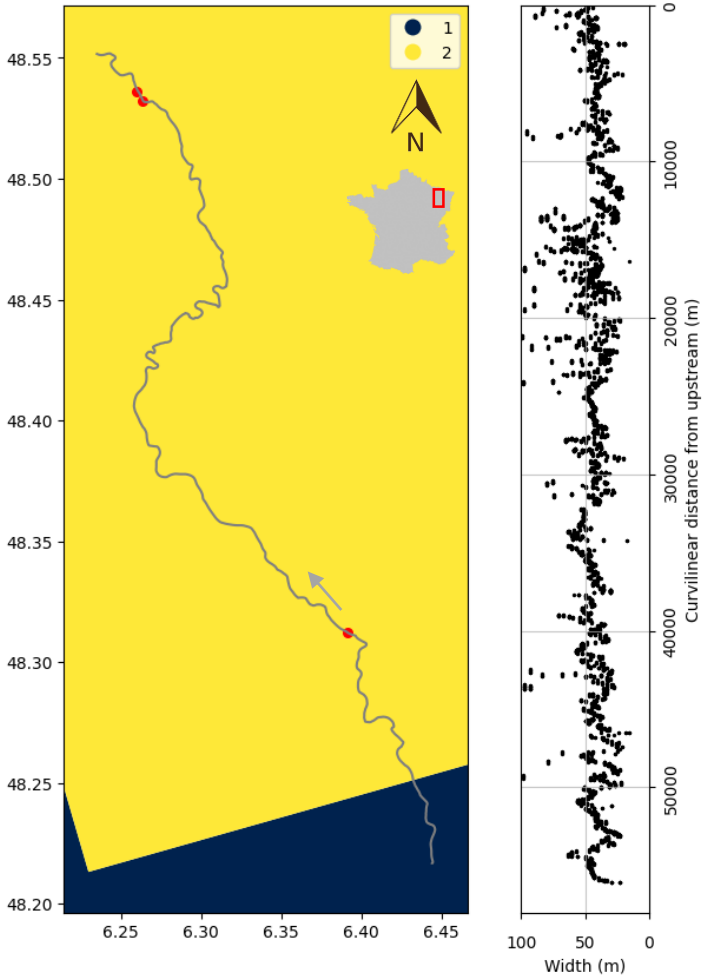
- **Moselle River** : 25 - 100 meters width : **Work present Today**
- Meurthe river : 20 - 60 meters width : *In progress*
- Sarre river : Variation of the river topography during major flood event : *In progress*





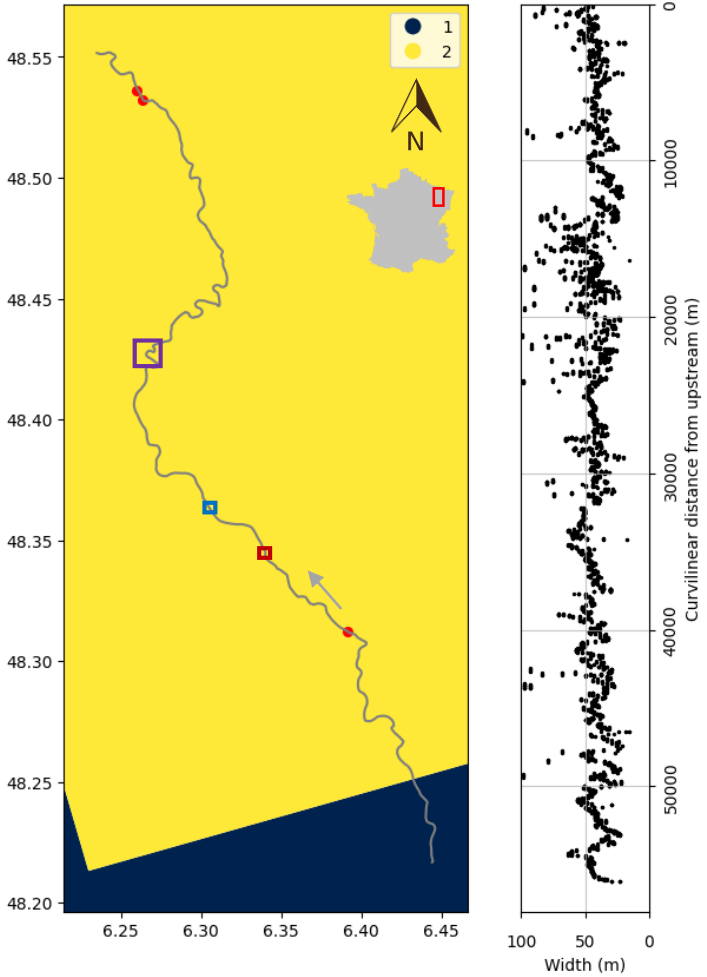
Moselle River :

- Width : **25 – 100 m**



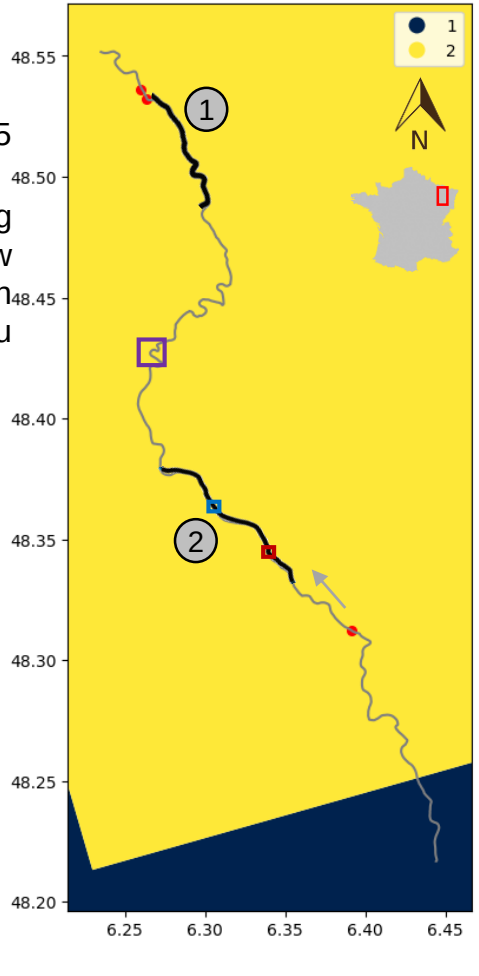
Moselle River :

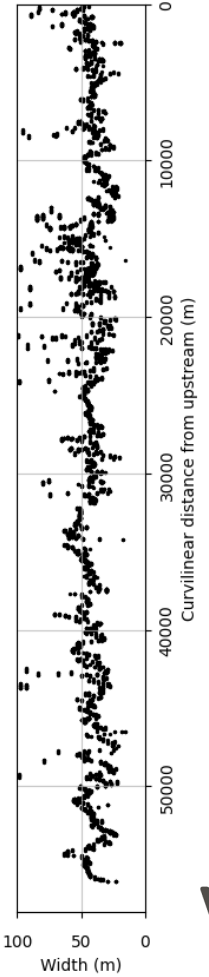
- Width : **25 – 100 m**
- Interesting morphology (dams, weirs, meanders, ..)

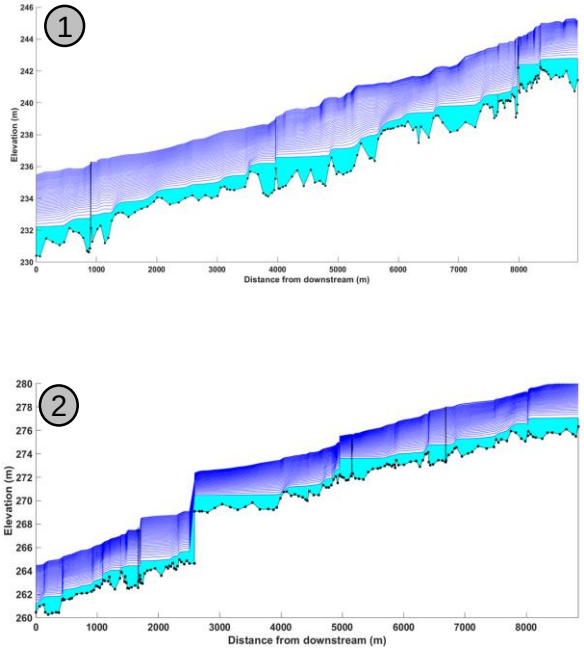


Moselle River :

- Width : **25 – 100 m**
- Interesting morphology (dams, weirs, meanders, ..)
- **Gauges:** 3 stations (WSE and discharge every 5 minutes) from Vigicrues
- **Water surface elevation profiles:** Produced using a 1D HEC-RAS hydraulic model for different flow conditions, as part of Guillaume Piasny's PhD on hydro-sedimentary modeling with dense in situ surveys.







HEC-RAS hydraulic model from Guillaume Piasny's PhD 2024

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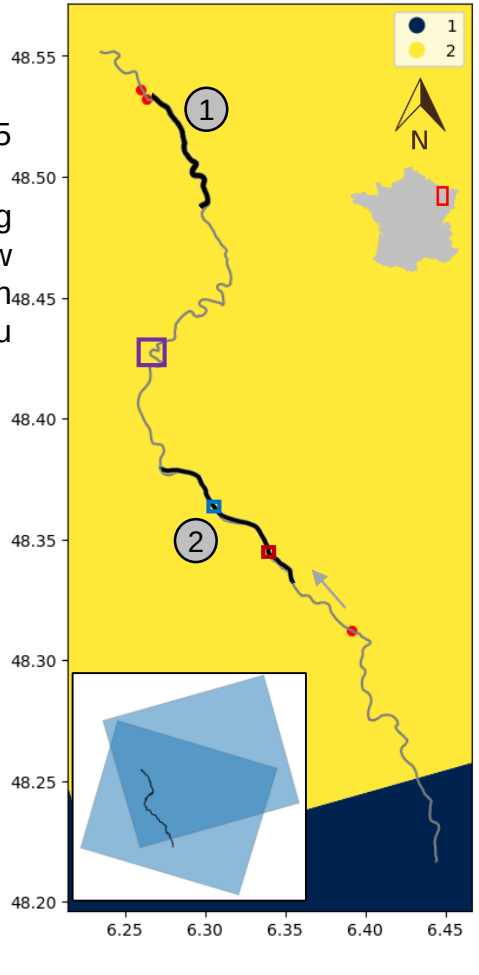
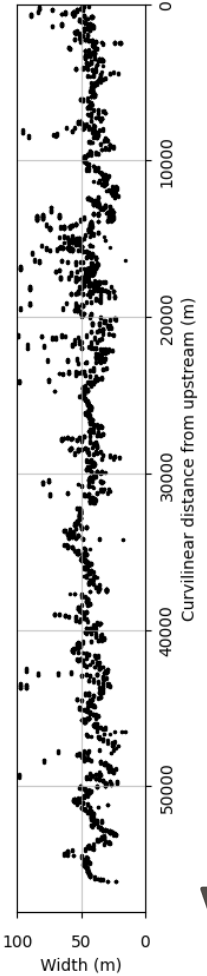
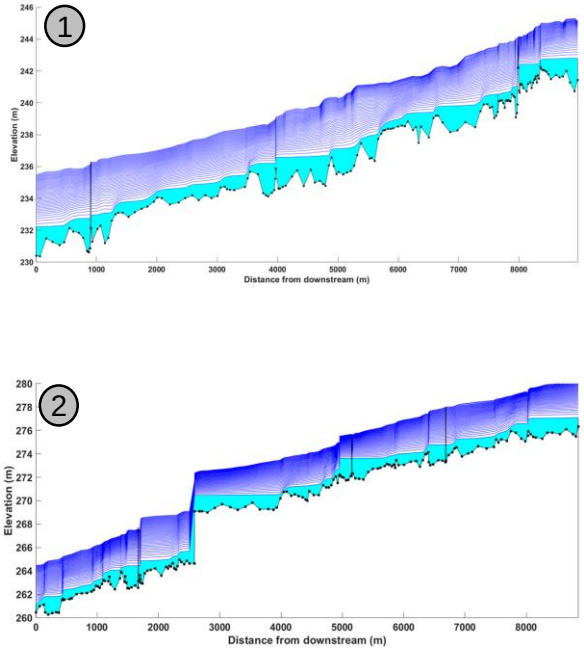
- Science Orbit : **07/2023 to 05/2025**
- **2 SWOT overpasses (tiles)** kept









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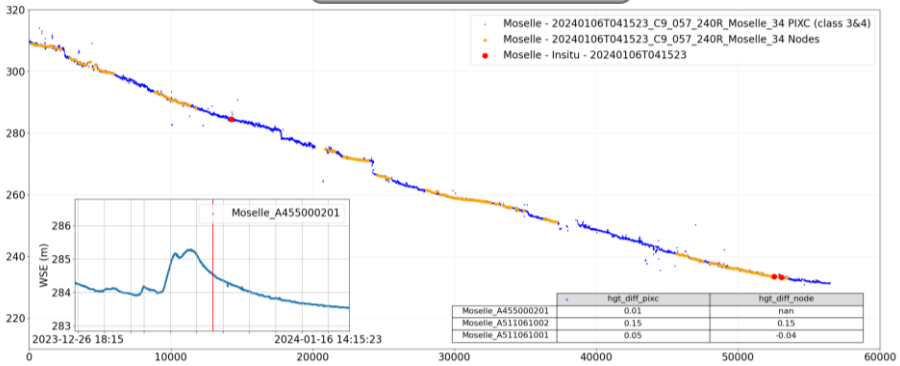
SWOT Products - Richness of PIXC

- **River SP** products are **incomplete** over this site compared to **the richness of PIXC**
- Analysis of **PIXC** version C - **classes 3 & 4**
- Including PIXC class 3 increases point cloud density over this narrow river.
- Additional corrections are applied to adjust WSE to EGM 2008.

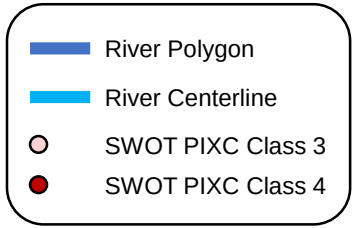
Nodes vs PIXC at one date (high water level)



- **Filtering needed :**
  - Intersection with minor bed polygon
  - PIXC points flagged as bad are removed (geoloc & classif quality flags) and cross track dist < 10 km & > 60 km

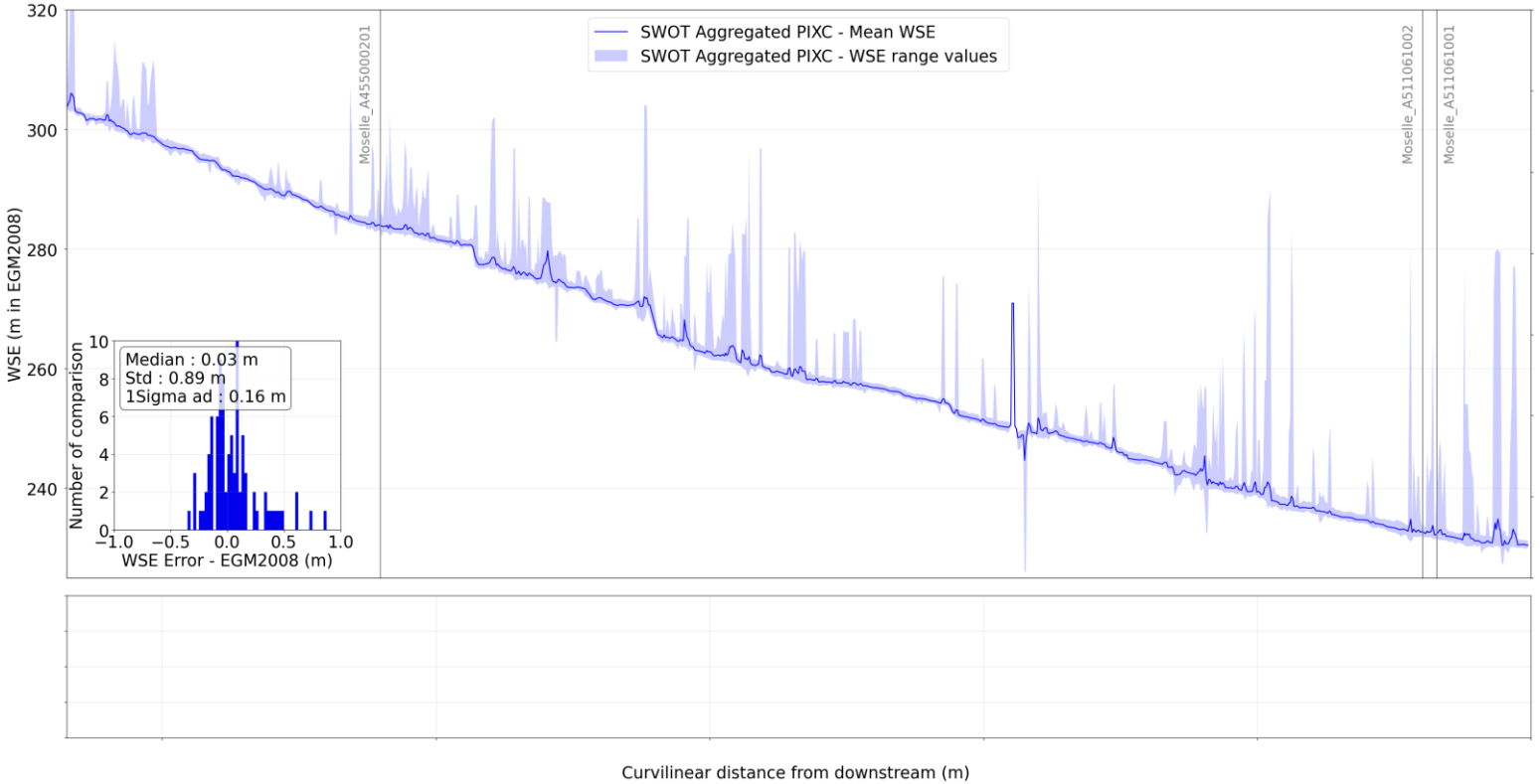
SWOT PIXC Classes 3 &4

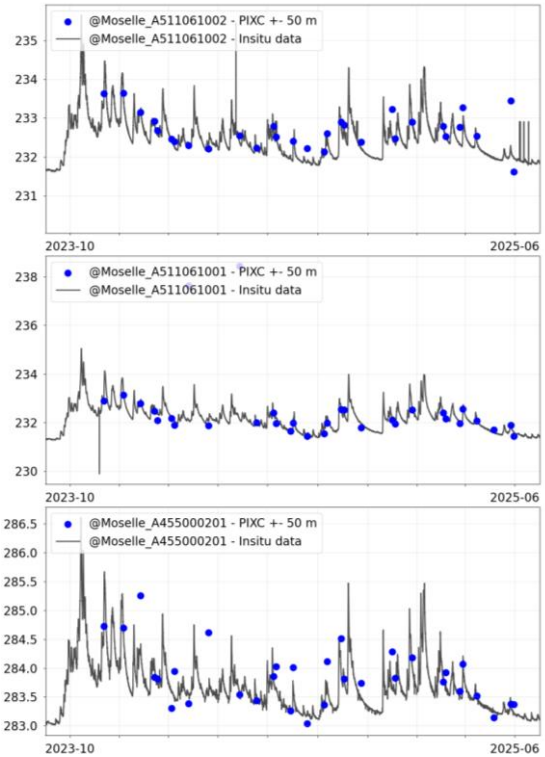
Apply flag filters & Polygon intersection



SWOT PIXC C data - Science period - Raw

- **Jul 2023 – May 2025** : 2 passes (tiles), **32 cycles** retained; acquired **under different flow rates** and **water levels**
- **Aggregation**: PIXC data aggregated at 50 m reach intervals to **visualize spatial variation ➔ Noisy with outliers**
- **Comparison**: **In situ** measurements vs **PIXC data** within ±50 m of each gauge for each cycle ➔ **Good results locally**





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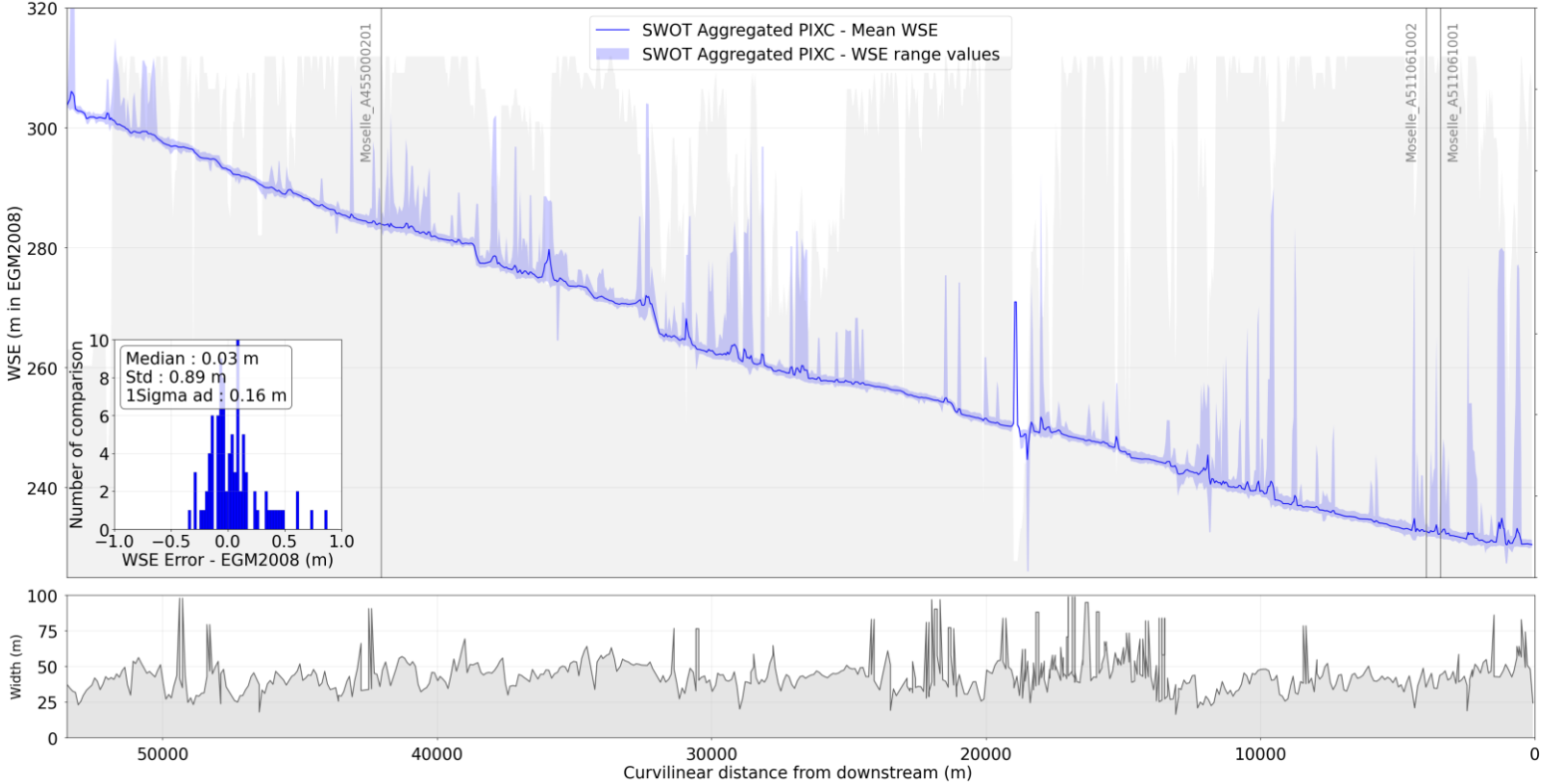
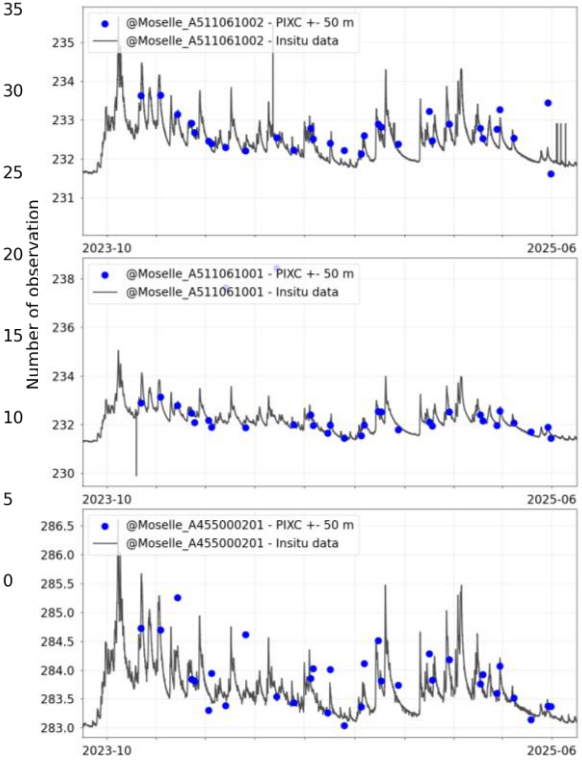
- Noise vs **River width** (from minor bed polygon) and **number of cycles with available data**





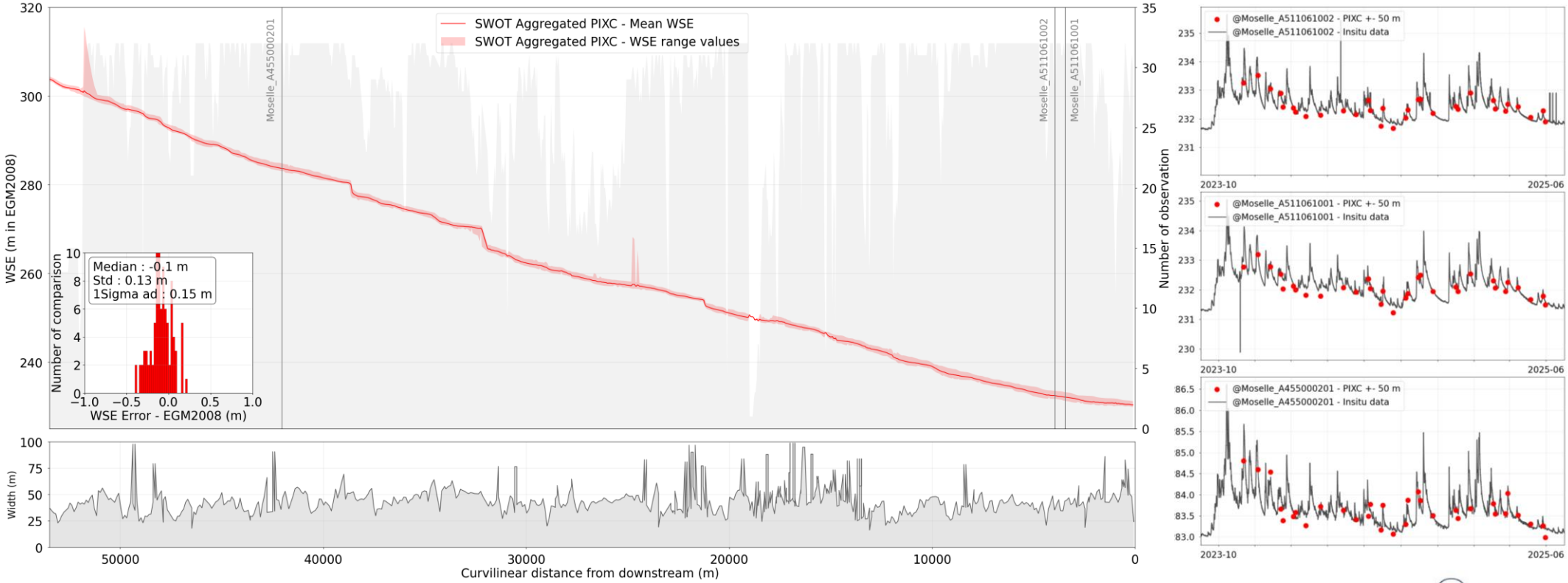
SWOT PIXC - Denoising

Wavelet-Based Algorithm for Hydraulic Signature Preservation and Slope Estimation from 1D SWOT Flowlines

Amanda Samine Montazem, Pierre-André Garambois, Kevin Larnier, Stéphane Calmant

Paper recently submitted to EMS

- **Application of a Wavelet-based denoising algorithm :**
  - High-quality longitudinal processing: **preserves the signal.**
  - **Noise reduction**: maintains multiscale **hydraulic coherence**
  - Profiles well denoised: significant **reduction** in **standard deviation**.



SWOT PIXC - Denoising

Hydromatters INRAE Sertit ICUBE

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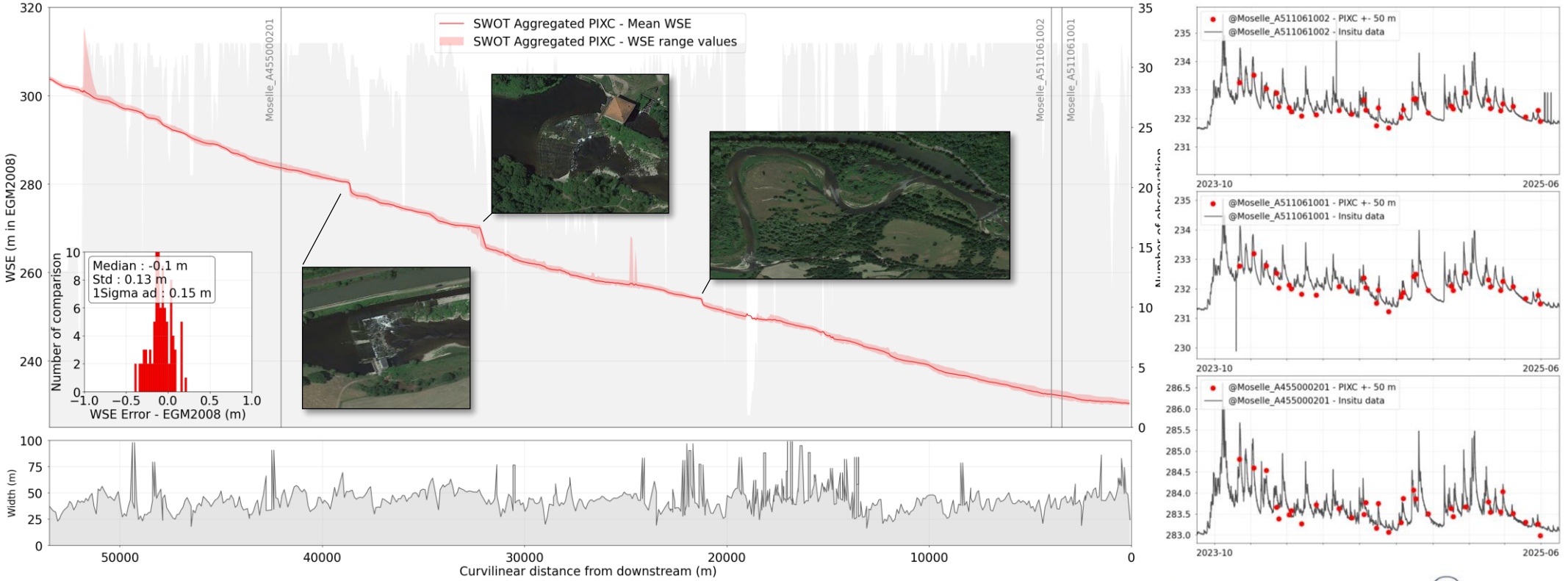
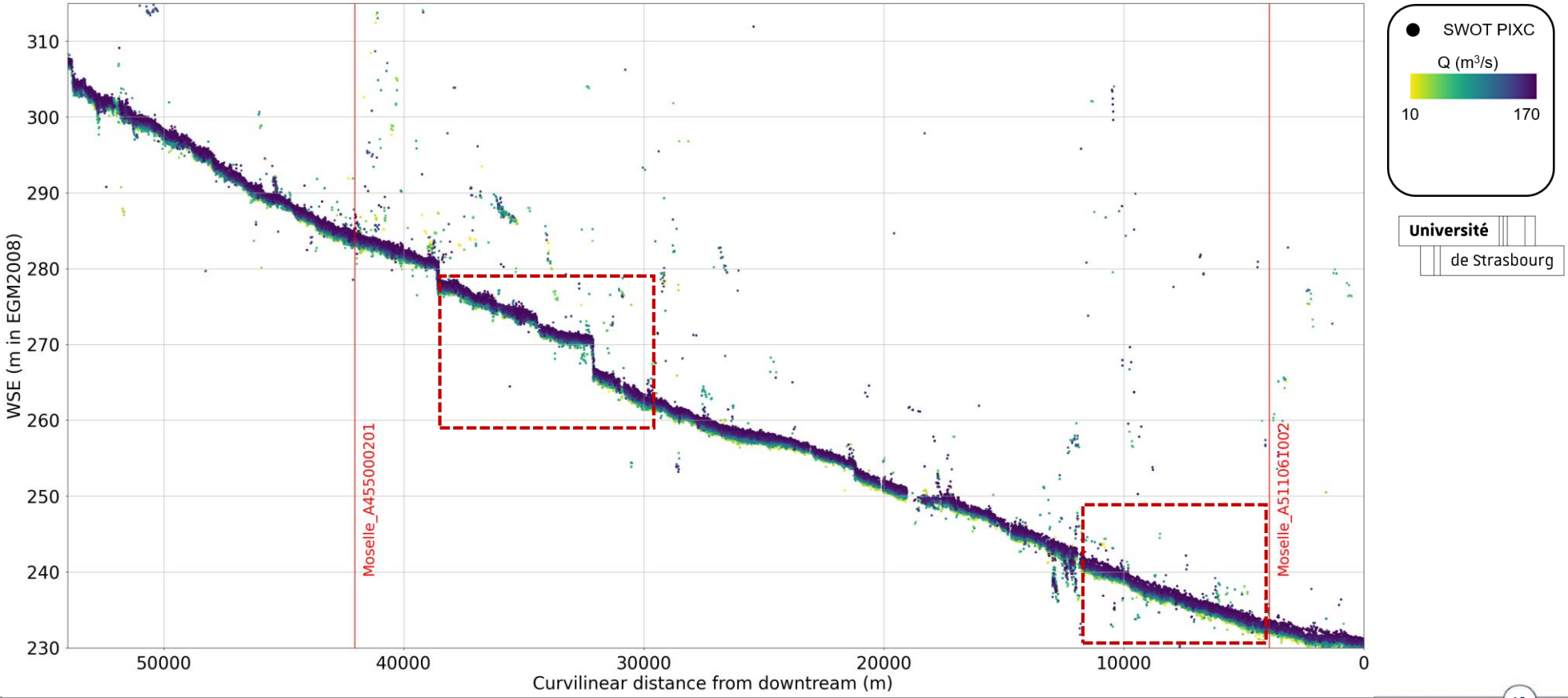


Raw PIXC vs Model

- **Two parts of the rivers** with river profiles from **1D Model** – 2 x 8 km
- **Associated a discharge (*Q*)** with **each profile** for the 32 SWOT acquisitions, **using the nearest gauge** (upstream gauge for the upstream modeled section and downstream gauge for the downstream section).



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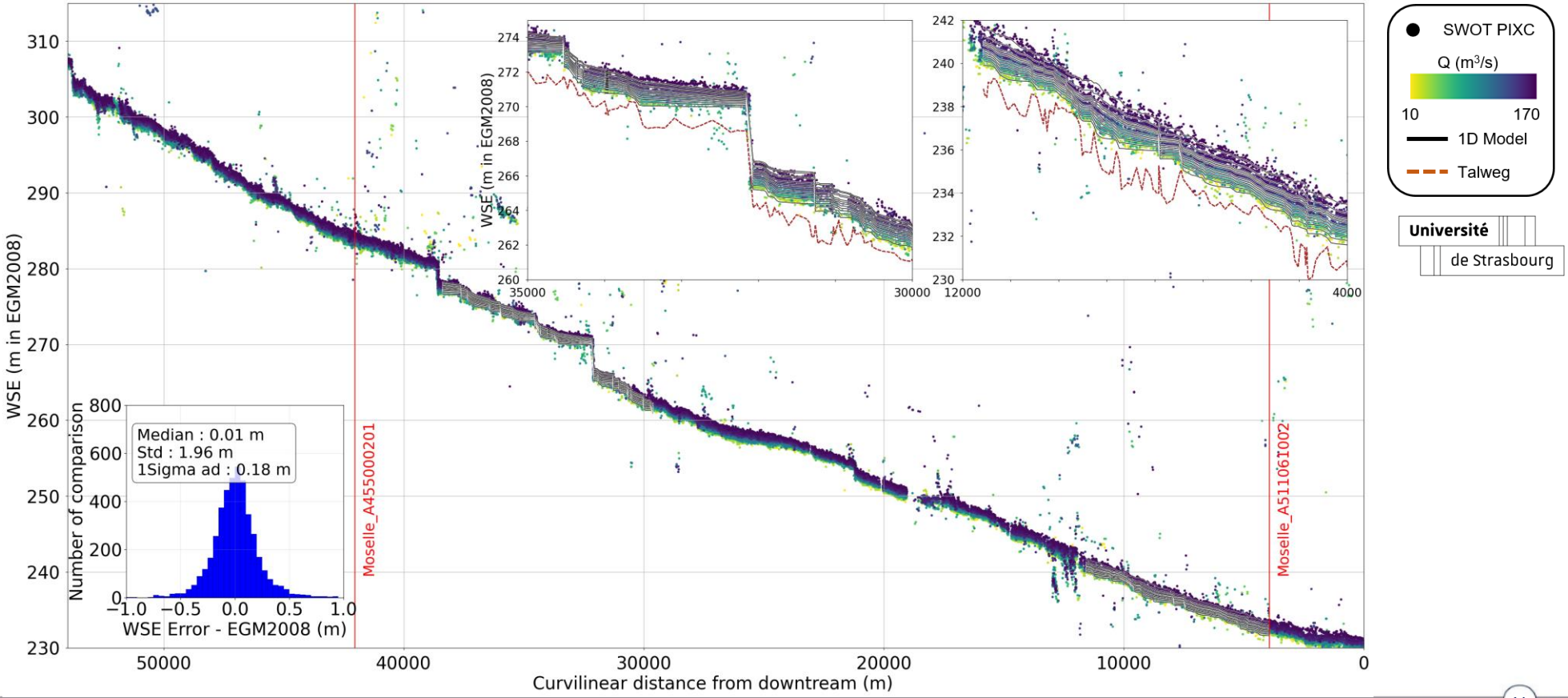
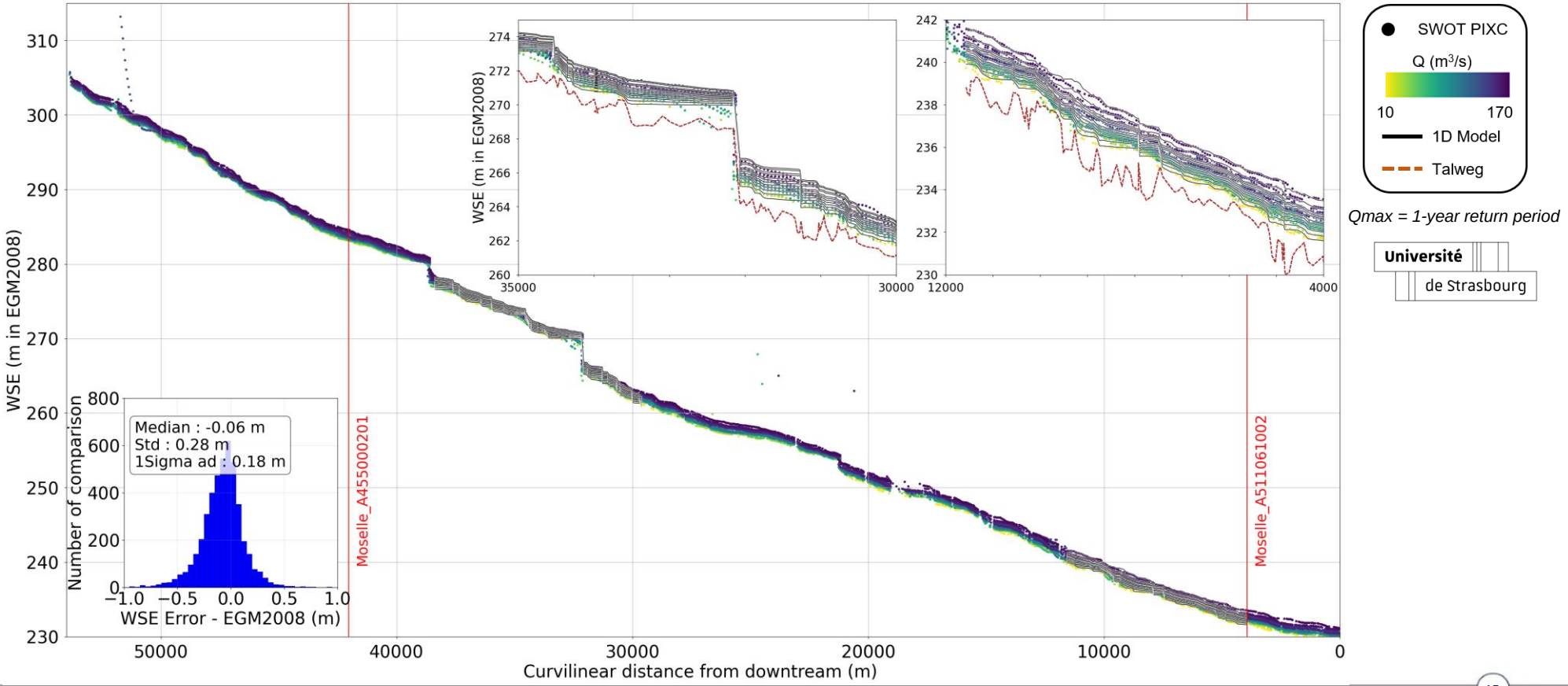
- **Associated a discharge (*Q*)** with **each profile** for the 32 SWOT acquisitions, **using the nearest gauge** (upstream gauge for the upstream modeled section and downstream gauge for the downstream section).
- Compared SWOT profiles to the corresponding **1D profile** modeled at an **equivalent flow.**



Denoised PIXC vs Model

- Same methodology for the denoised data association
- Significant **reduction** in **standard deviation**
- **Multi-temporal validation**: using a **high-resolution model**
- Overall assessment: very **effective method** to see the effect of the denoising method



- **Spatio-temporal SWOT information** can be **denoised**, even on small rivers (**denoising algorithm applied without tuning - method transferable**).
- **Excellent fit** between **hydraulic model** and **denoised SWOT** product for various discharges.
- **Longitudinal signal preserved at multiple scales including on fine hydraulic signatures.**

- Method currently applied at the Garonne basin scale (Hydr'Avatar ESA project) and other studies over the Sarre and Meurthe rivers.
- **Accurate slope calculation under study at node scale (Montazem et al.).**
- NB. Optimal combination of noisy SWOT data and more or less uncertain hydraulics requires data assimilation approach.