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Towards integrating Pixel Cloud HR SWOT data into a hydrogeological model

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Introduction

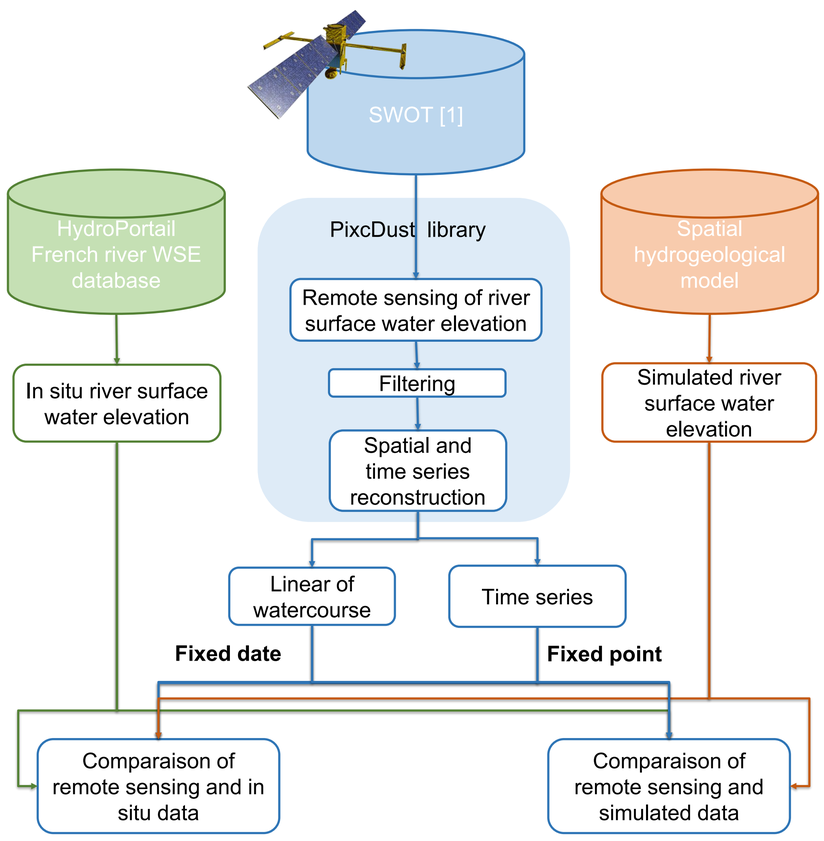
Hydrogeological models :

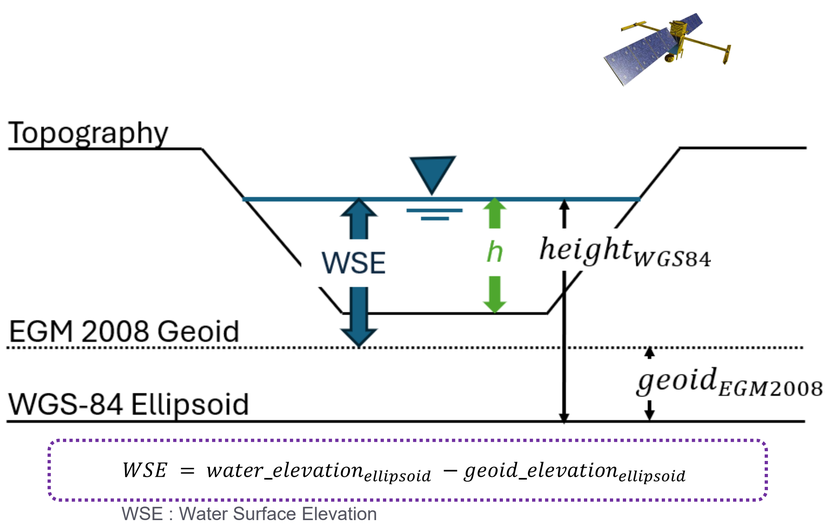
- **need to be improved** to manage water resources
- integrate a wide range of **geomorphological data**
- **simulate groundwater and surface water interaction** along the watercourse. These interactions **depend on river and groundwater surfaces elevations**
- **need complementary data to evaluate the simulated outputs where no in situ data is available**

Aims

- Access the feasibility of using SWOT satellite data as a complementary tool for building and evaluating reagional hydrogeological models.

Materials and methods





$$WSE = water\_elevation_{ellipsoid} - geoid\_elevation_{ellipsoid}$$

WSE : Water Surface Elevation

Conclusion

First results of this project show :

- Satisfactory classification and differentiation of points associated with water and land in the Landes region and the alluvial plains of Tarn-et-Garonne (Figures 1b and 2d) and more difficult in the Somme region (Figure 1a) ;
- Some limits of SWOT data in highly urbanized areas (Figures 1a and 2a) ;
- Less variability in SWOT data on lake sections than on the canal sections separating the lakes (Figures 2b and 2c) ;
- Variability in SWOT data consistent with variability in In situ data (Figure 2e).

➔ The large lakes of the Landes region and the alluvial plains of Tarn-and-Garonne appear to be ideal areas for **evaluating SWOT data and comparing it with data simulated by hydrogeological models**.

References

- [1] Source of SWOT data : https://hydroweb.next.theia-land.fr/
- [2] Bardeau M., Le Cointe P. (2016) – Gestion des systèmes aquifères alluviaux dans le bassin AdourGaronne – Résultats de la modélisation et outil de gestion des prélèvements dans le Tarn-et-Garonne. Rapport BRGM/RP-65583-FR, 358 p., 138 ill., 35 tabl., 26 ann., CD.
- [3] Thiéry D. and Picot-Colbeaux (2020) – Guidelines for MARTHE v7.8 computer code for hydro-systems modelling (English version). Report BRGM/RP-69660-FR. http://infoterre.brgm.fr/rapports//RP-69660- FR.pdf

Study cases

Several areas were targeted during this project in order to evaluate the satellite data in different hydrographic and hydrogeological contexts.

To this end, three areas were selected in France for **their strong interactions between groundwater and surface water**: the *Somme watershed*, the four large lakes in the *Landes region* and the *Tarn-et-Garonne model area*.

The characteristics of the sites and the quality of the SWOT satellite data on them are presented below :

Area characteristics

Somme watershed

- 30 meter-wide river
- Numerous tributaries
- Highly channelized river
- Highly urbanized surrounding area (housing, railroad tracks, etc.)
- Area subject to numerous risks (flooding, droughts due to heavy agricultural water use, uncertainties about climate change)

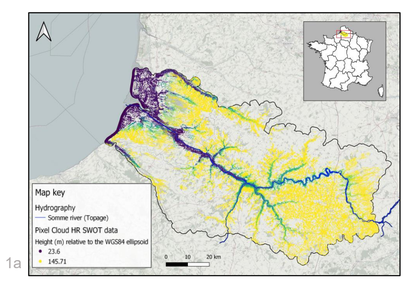
Landes region

- Four large lakes (from 75 ha to 55 m² in size)
- 30-meter-wide waterways connecting lakes. Highly urbanized (dams)
- Dense vegetation in the surrounding area (pine forests)

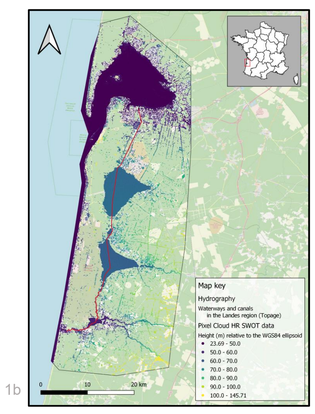
Tarn-et-Garonne model area

- Confluence of three main rivers approximately 100 m-wide
- Numerous tributaries less than 50 m wide
- Alluvial geology with strong groundwater-river interactions
- Heavy groundwater and river withdrawals

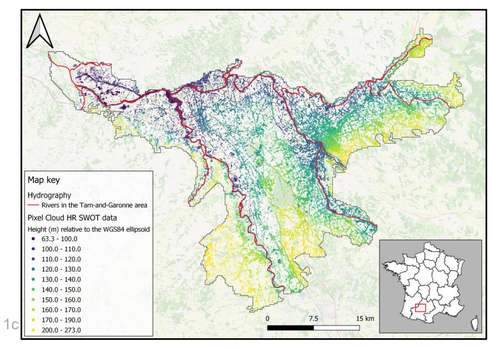
Surface elevation relative to the WGS84 ellipsoid



1a



1b



1c

River course and time series

Somme

- ➢ Coverage of the area in several satellite passes (two dates minimum)
- ➢ Selection of water-related points could be improved
  - ✓ Highlighting of significant variations in topography
  - ✓ Presence of data on the tributaries of the Somme
  - X Water points retained well beyond the river (extending over the Somme alluvial plain and highly agricultural areas upstream of the watershed)

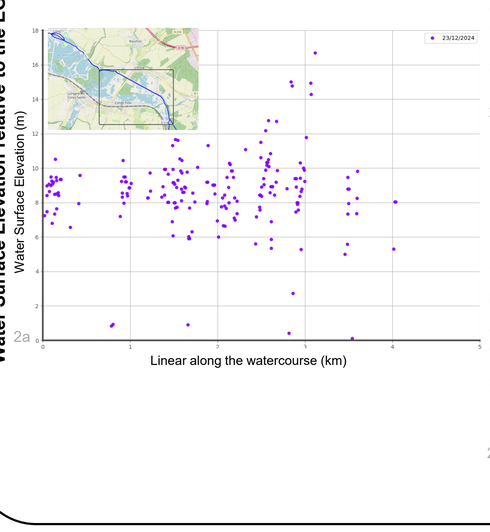
Landes

- ➢ Coverage of the area in a single satellite pass
- ➢ **Satisfactory** selection of points associated with water
  - ✓ Clear delineation of lakes
  - ✓ Highlighting of land areas within the Arcachon basin
  - X Preservation of points located directly above cities

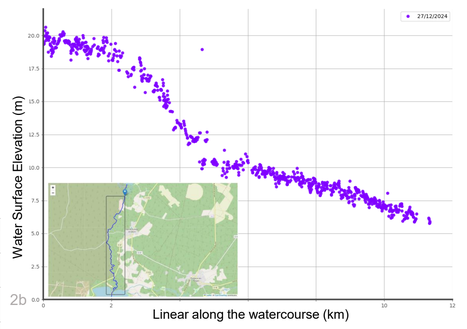
Tarn-et-Garonne

- ➢ Coverage of the area in a single satellite pass
- ➢ **Satisfactory** selection of points associated with major waterways
  - ✓ Highlighting of the three main waterways
  - X Influence of filtering on the visibility of secondary waterways

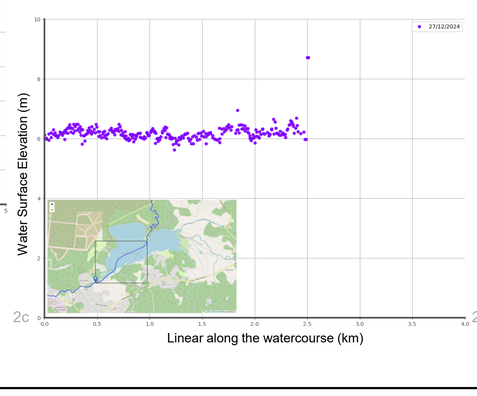
Water Surface Elevation relative to the EGM2008 geoid



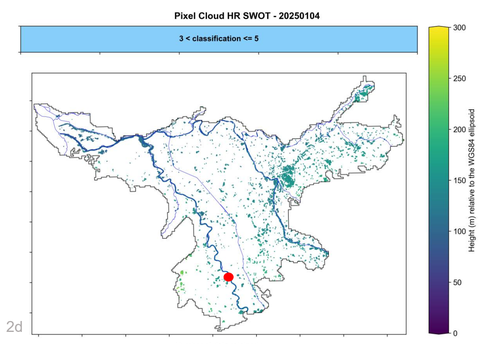
2a



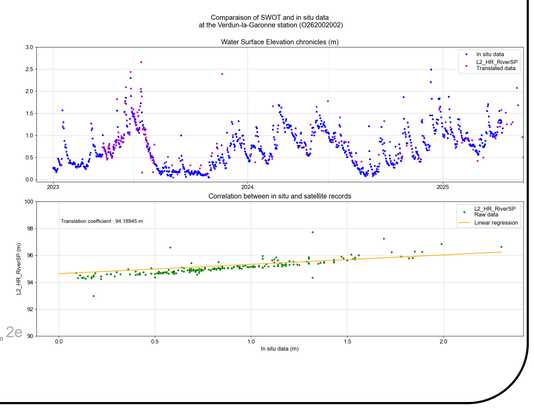
2b



2c



2d

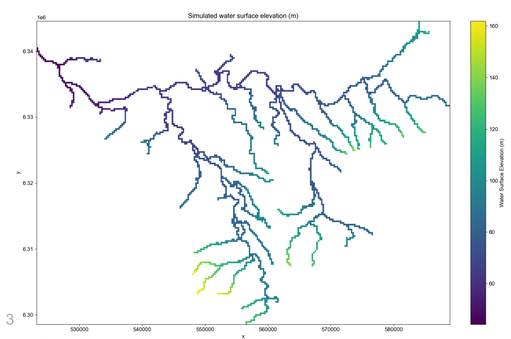


2e

Future work

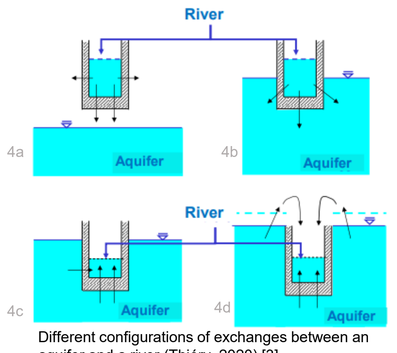
The next steps will be to use water surface elevations from Pixel Cloud HR SWOT to **evaluate hydrogeological models**.

- ➔ Comparison of water surface elevations measured by SWOT satellite and simulated by the hydrogeological model (Figure 3);
- ➔ Study of the influence of river surface elevations on variations in water level in the aquifer. In the hydrogeological model, the exchange rate between surface water and groundwater depends on:
  - → the difference in elevation between the groundwater level and the river surface elevation ;
  - → the hydraulic conductivity and the thickness of the river bed (Figure 4).



3

Example of input data for a hydrogeological model. Case study: initial surface water levels in the Tarn-et-Garonne area.



4a 4b 4c 4d

Different configurations of exchanges between an aquifer and a river (Thiéry, 2020) [3]

4a $Q_{Percol} = AREA_{Exch}\ K_R\ \frac{(H_R - H_b)}{Thickn}$

4b 4c $Q_{Exch} = AREA_{Exch}\ K_R\ \frac{(H_R - H_G)}{Thickn}$

4d $Q_{Overfl} = (AREA_{cell} - L\ W)\ K_R\ \frac{(H_G - H_{Topo})}{Thickn}$

L = Length of the river reach
W = Width of the river reach
K_R = Hydraulic conductivity of the river bed and river banks
Thickn = Thickness of the river bed (and the river banks)
H_R = Absolute elevation of the free water surface in the river
H_G = Hydraulic head in the underlying groundwater
H_b = Elevation of the bottom of the river bed
H_{Topo} = Elevation of the topographic surface of the cell containing the reach
$AREA_{cell}$ = Horizontal area of the cell in which the reach is located
$AREA_{Exch}$ = Area of the groundwater-river exchange