



Automated detection of key contamination points and surface water quality monitoring using remote sensing and artificial intelligence

Exploitation of data from the M.A.R.U./Brazil and Bio Plateaux (French Guiana/Brazil/Suriname) projects

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OiEau's key figures

 **150**
employees

4 sites in
France 

4
Complementary
domains of expertise

17 M€ Revenue
from
activities

150 
Partner organisations

80 
countries of
operation

TRAINING & EDUCATIONNAL ENGINEERING

Supporting professionals in the process of improving and acquiring the knowledge and know-how of their teams, for efficient and sustainable water management

MANAGEMENT & DEVELOPMENT OF WATER STAKEHOLDER NETWORKS

Coordinating and leading networks of stakeholders, in France and internationally, to contribute to the sustainable management of water and ecosystems

INSTITUTIONAL & TECHNICAL COOPERATION

To support water and environment stakeholders in the strategic and operational implementation of integrated, sustainable, ecosystem-based and innovative water management.

DATA, KNOWLEDGE DEVELOPMENT & INFORMATION SYSTEMS

To promote access to technical and scientific data and information for all those involved in water and the environment, in order to consolidate their knowledge and facilitate decision-making.

ENSAM

Ecole Nationale Supérieure
des Arts et Métiers

8 campus
3 institutes



15 Research labs and teams

RESEARCH CONTEXT

- Low Data Limit
- Real Time
- Interpretability & Explainability
- High Precision
- Physical Consistency

METHODS

- Data Simulations and Experiments
- Data Reduction (PCA, RRAE, etc.)
- Regression and Classification Models

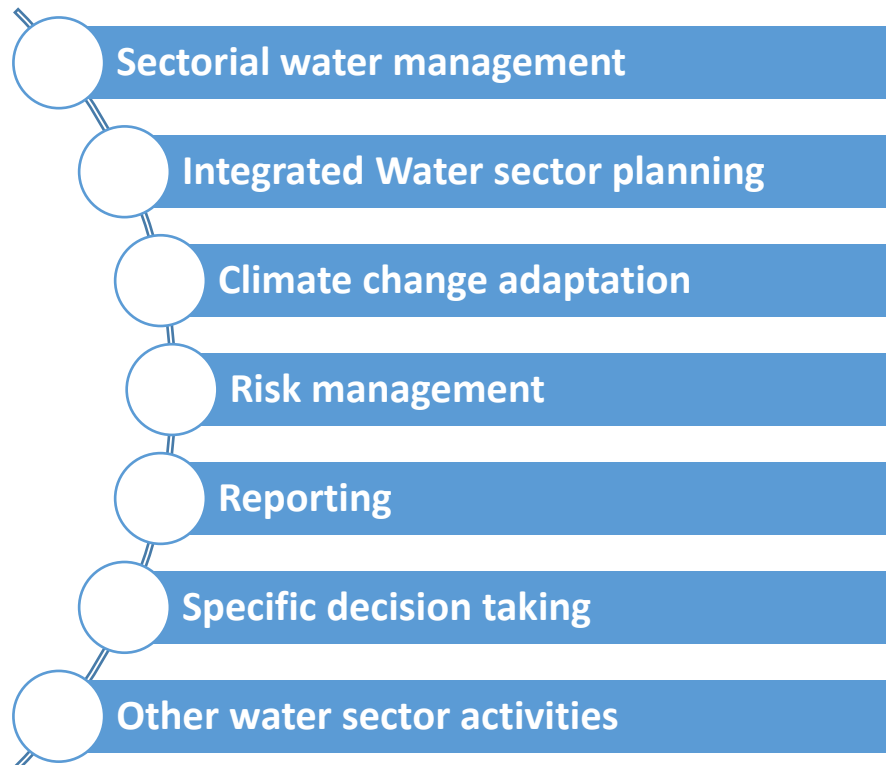
NUMERICAL TECHNIQUES

- Data Types (lists, images, graphs, curves, time series)
- DOE (Active Learning, ANOVA, etc.)
- Machine Learning (SVM, RF, SPGD, etc.)
- Deep Learning (CNN, GNN, RNN, LSTM, etc.)
- Generative (GAN, LLM, etc.)
- Physical Informed (Neural ODE, PINN, TINN, etc.)

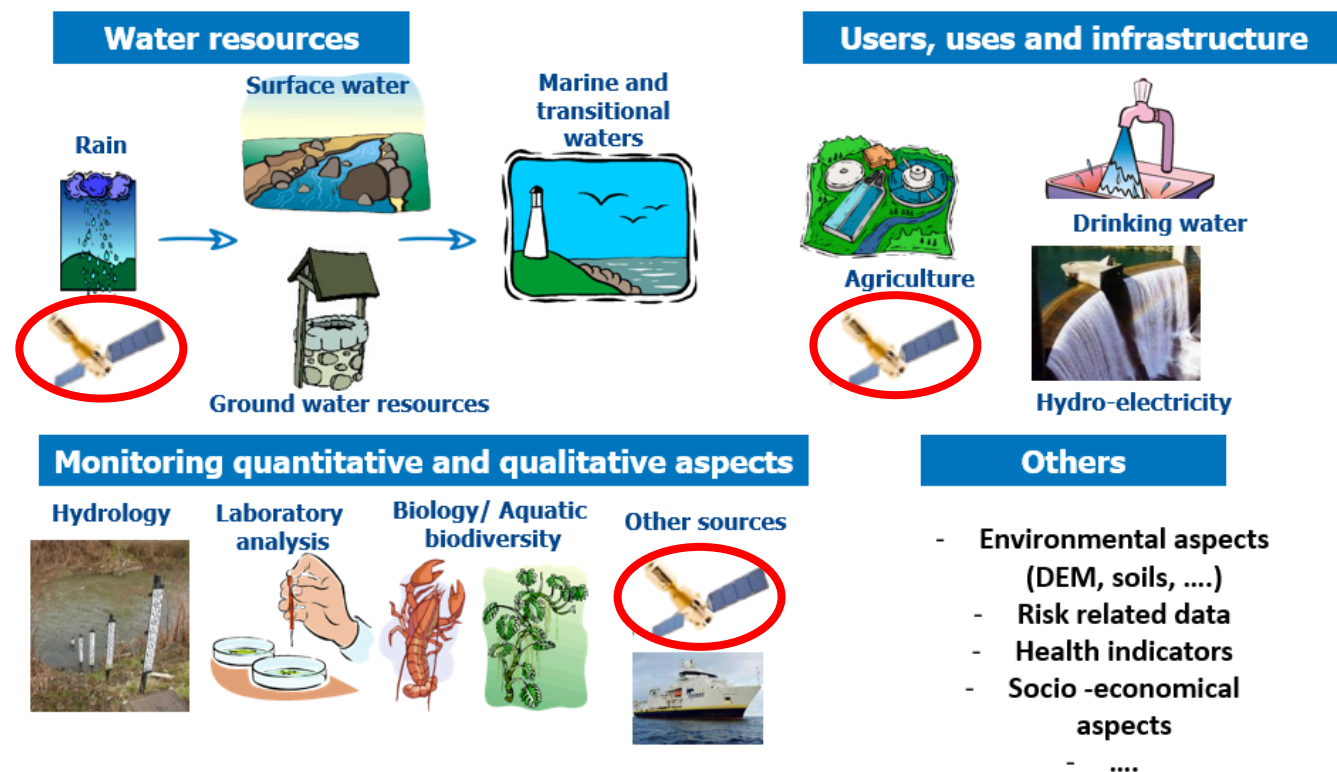
Context

Water resource management requires data on many topics for many uses

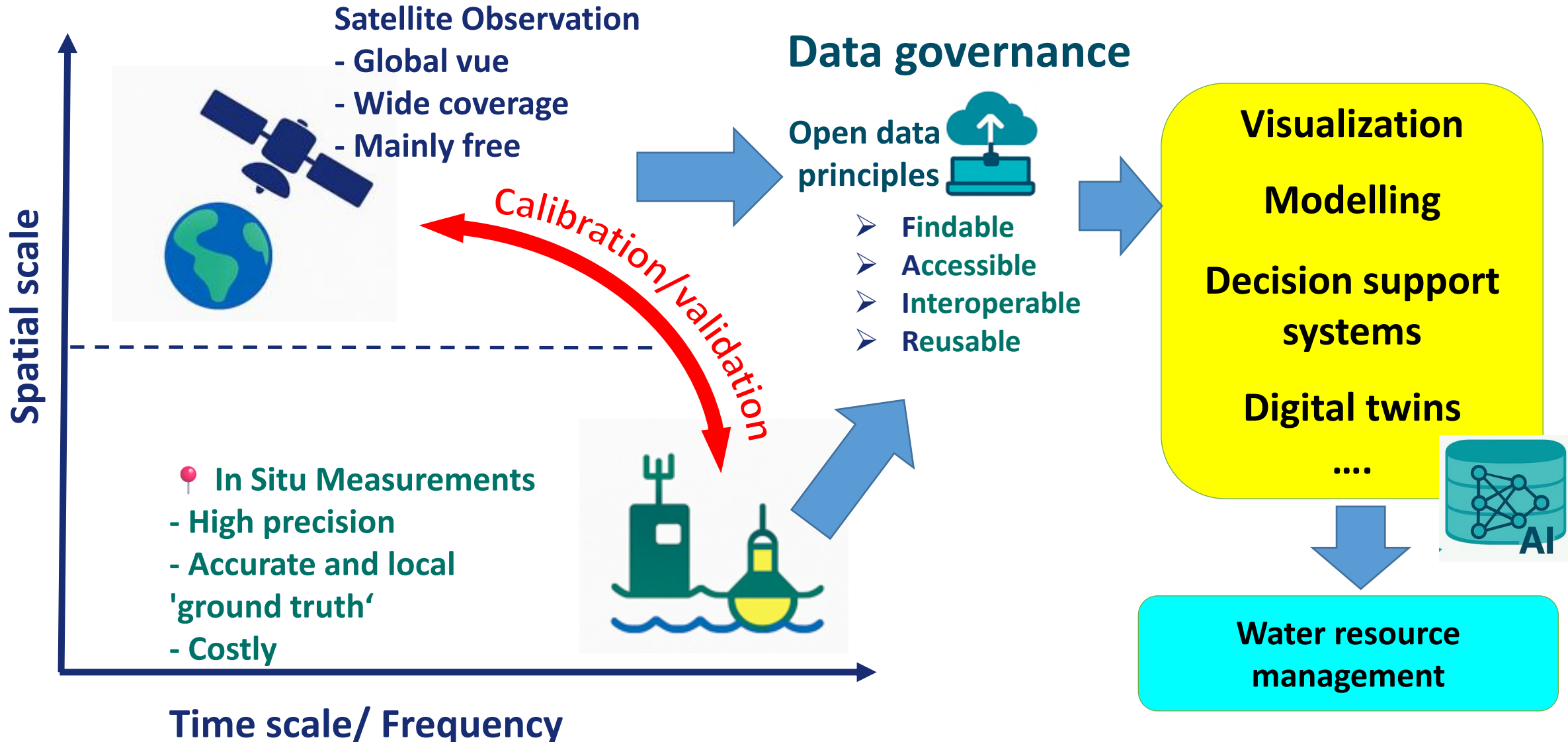
Data and information
particularly needed for



Many data topics
Many data producers



Complementarity of satellite observation and in situ data for water resource management



Example of water quality monitoring in Brazil using satellite data (MARU)

Sentinel 2



CNES/IRD
data
processing



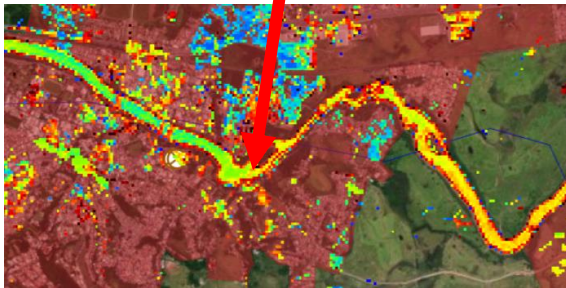
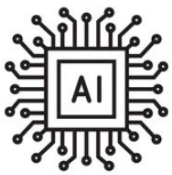
4 parameters:

- Chlorophyll a

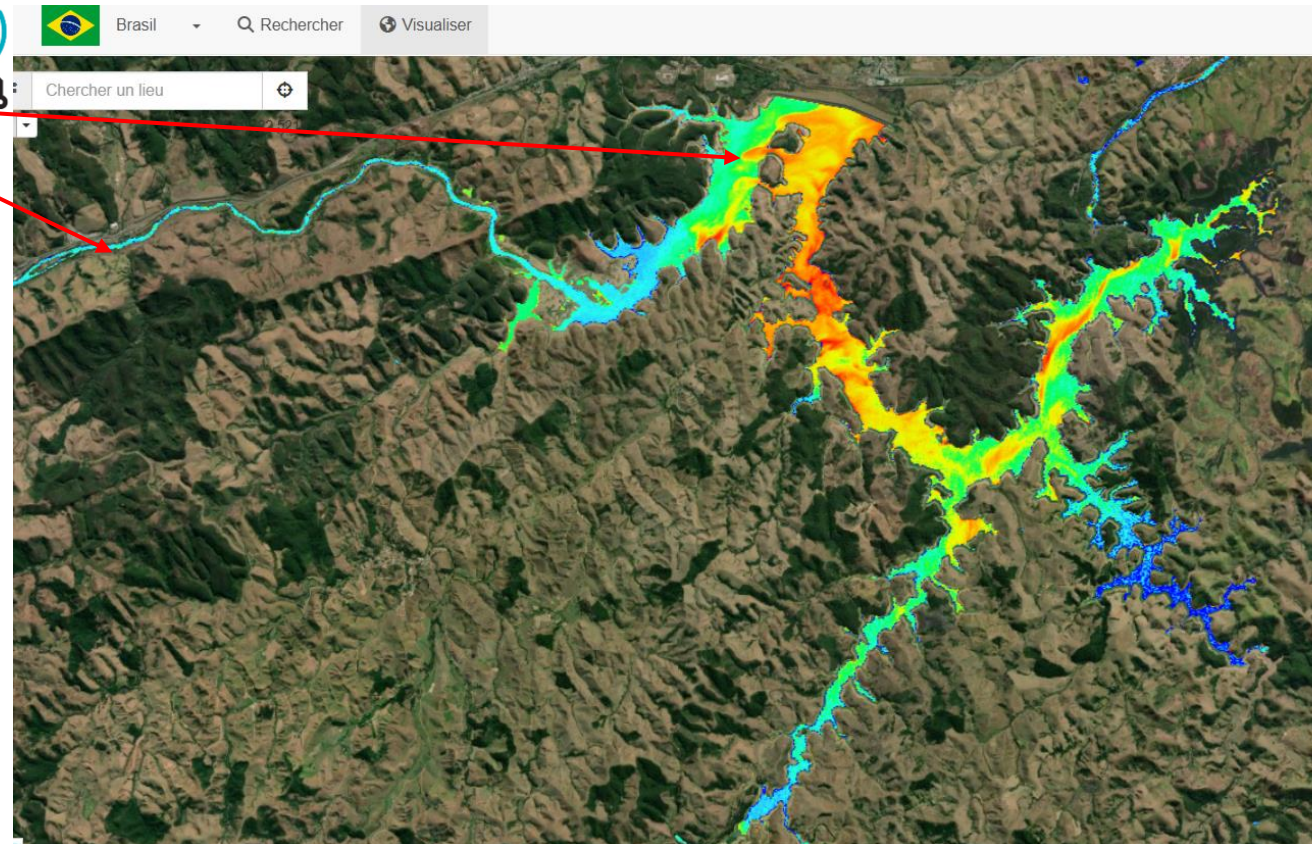
- Suspended matters

- Dissolved organic matter

- Turbidity



Though automatic
detection of pollution
emission points

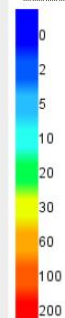


Gérer les couches

☒ BR_MO_SAT_23KNR_Clorofila-a (micro-g/L)CHL

Légende Information sur la couche Paramètres

14-08-2022



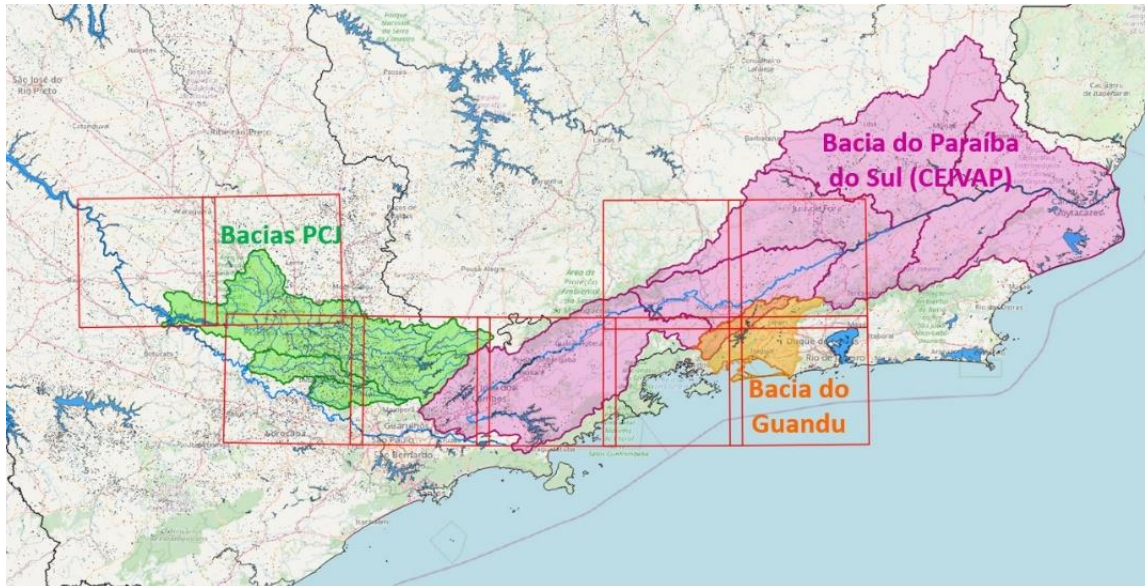
☐ BR_MO_SAT_23KNR_Mat orga dissolvida (m-1) CDOM

☐ BR_MO_SAT_23KNR_Solido Susp Tot (mg/L) SPM

☐ BR_MO_SAT_23KNR_Turbidez (NFU) TURB

Area of surface water quality monitoring using remote sensing on the 2 projects

M.A.R.U project (Brazil)



BIO-PLATEAUX project (French Guiana/Brazil/Suriname)



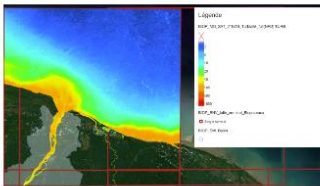
Processed satellite images to monitor surface water quality

Identifying impact location/extent of mining activities (Bio-Plateaux)

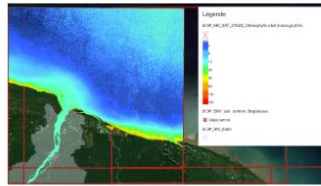
21 NZG



Carte Interactive 21NZG
Turbidité (NFU)



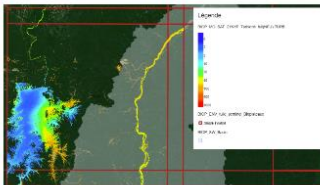
Carte Interactive 21NZG CHL



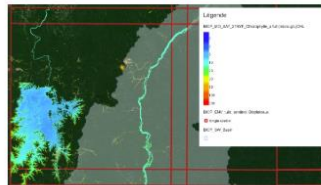
21 NYF



Carte Interactive 21NYF
Turbidité (NFU)



Carte Interactive 21NYF CHL



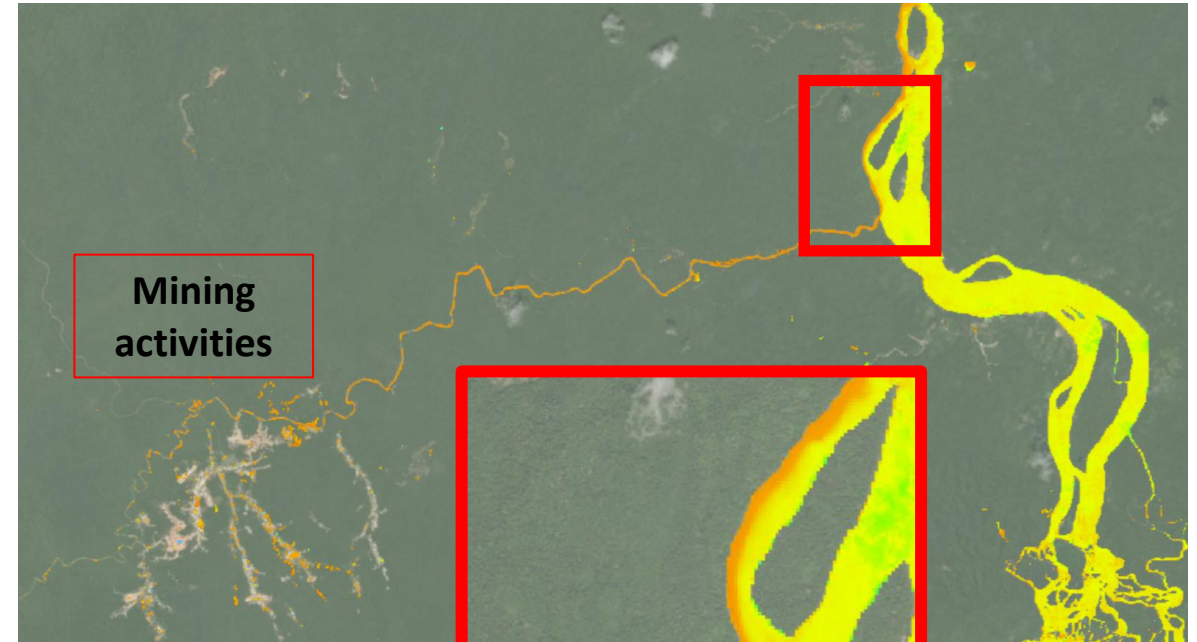
21 NXE



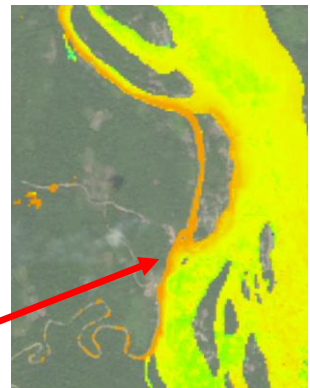
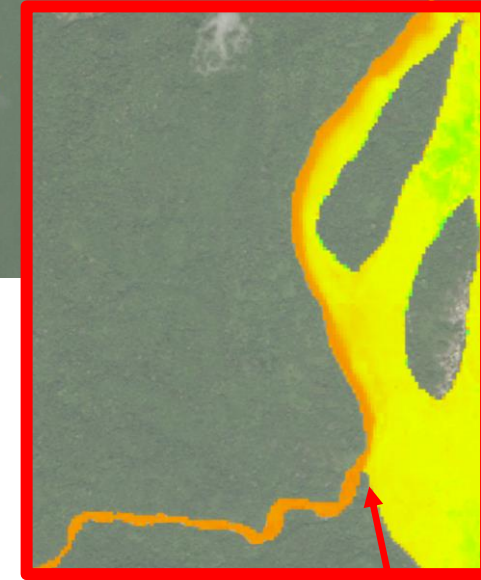
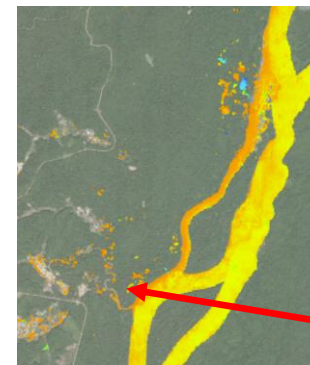
Carte Interactive 21NXE
Turbidité (NFU)



Carte Interactive 21NXE CHL



**Mining
activities**



**AI for automatic detection
of pollution points**

Main stages of the treatment process for pollution points identification

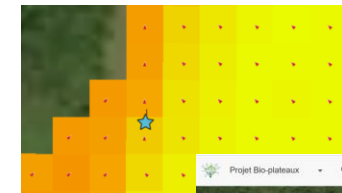
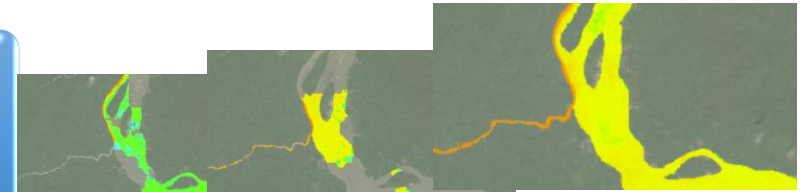
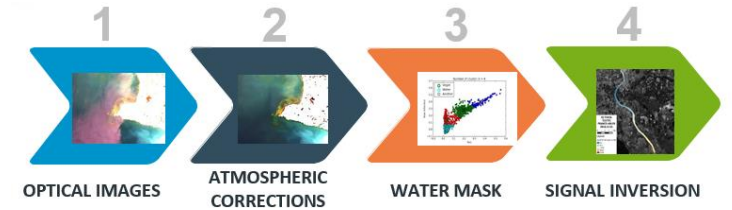
Sentinel-2 image processing / generation of one .tiff file per tile/ per parameters/ per date (IRD/CNES)

Integration / generation of monthly and multi-year products / visualization (OiEau)

Generation of flow direction masks per pixel (OiEau)

Automated identification of major pollution points (ENSAM)

Integration and visualization of results (OiEau)



Generation of flow direction masks per pixel

Input Data

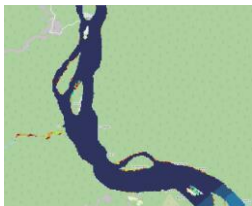
Water mask binary
from the turbidity tiff



Multiline layer of the river

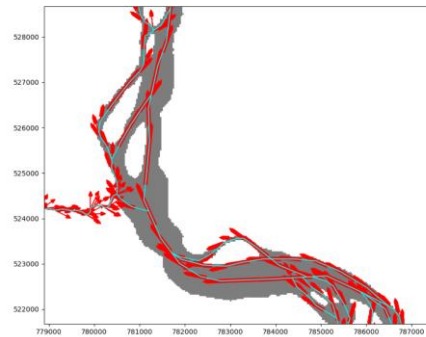


DEM



Python script

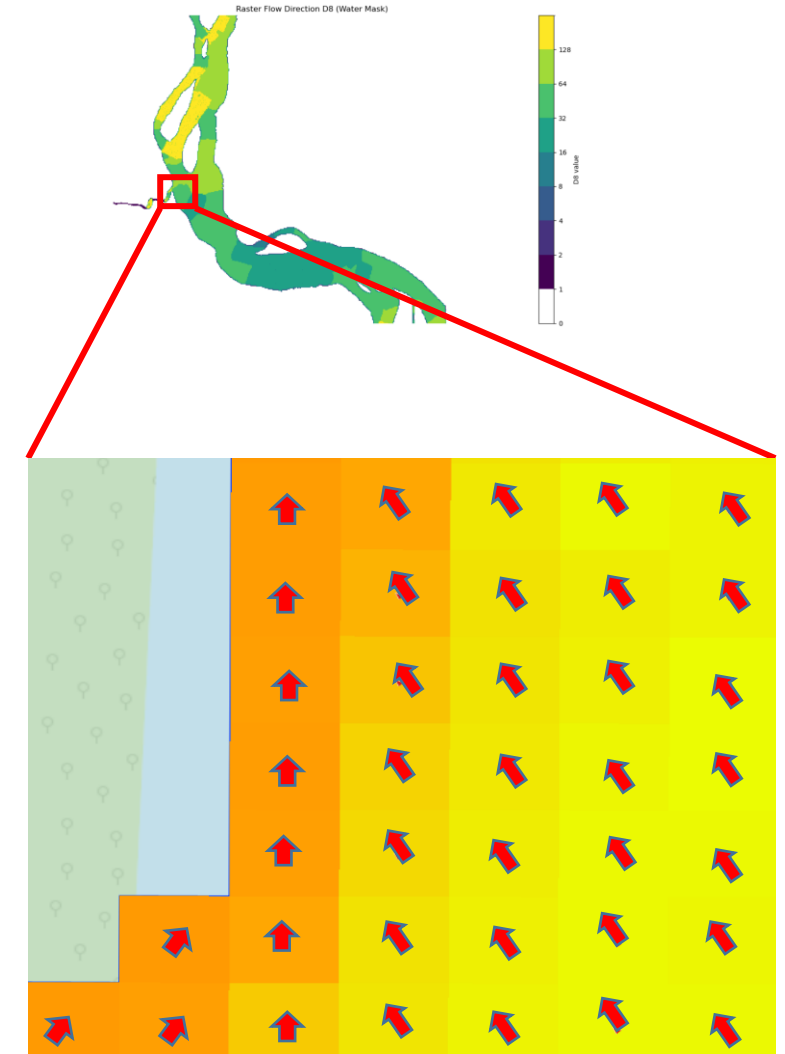
Cross section at given intervals and
calculation of the normal direction



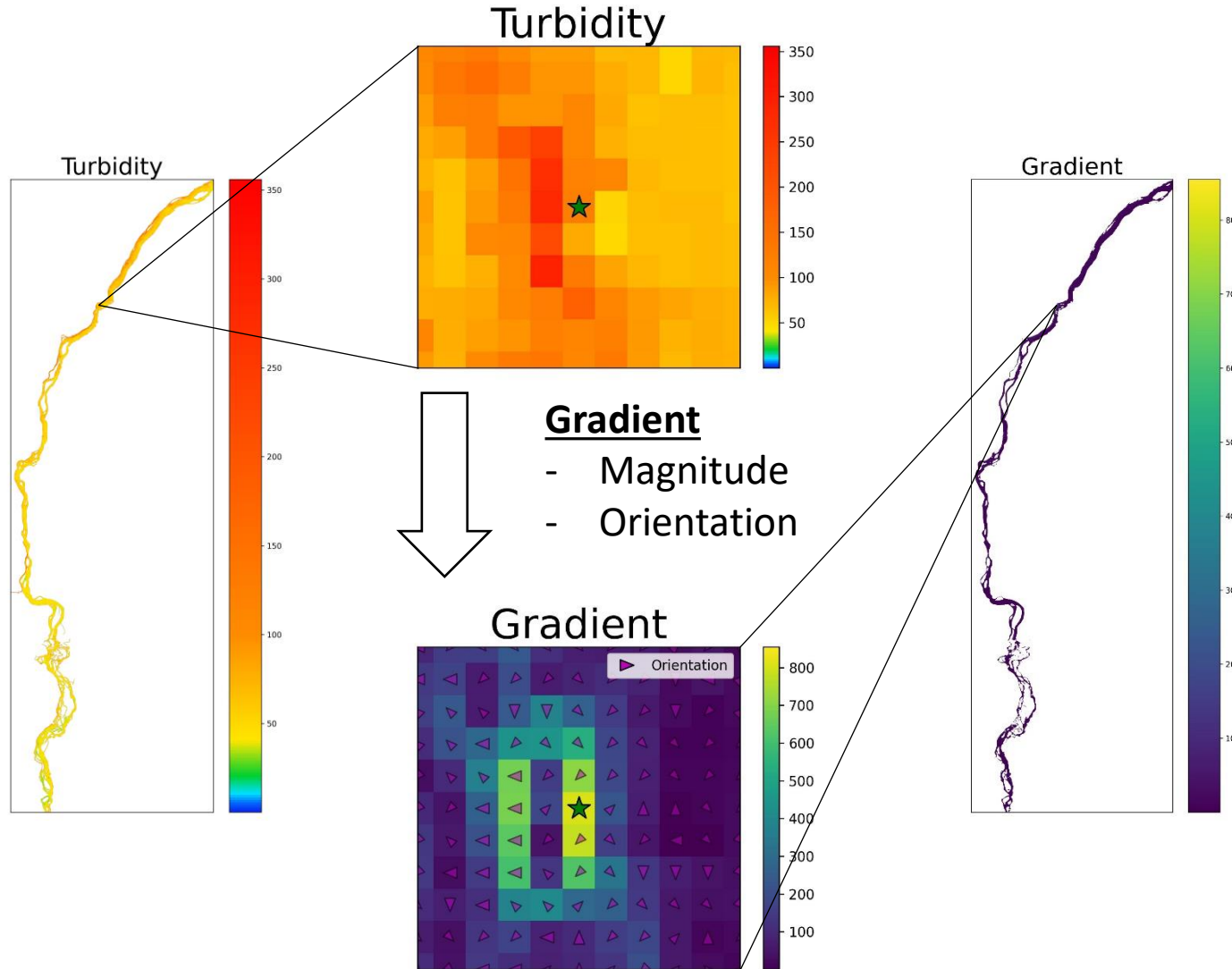
D8 encoding method

32 (2 ⁵)	64 (2 ⁶)	128 (2 ⁷)
16 (2 ⁴)		1 (2 ⁰)
8 (2 ³)	4 (2 ²)	2 (2 ¹)

Output raster direction and visualization



Identifying pollution points using a gradient analysis



Gradient

- Level difference in adjacent pixels
- Magnitudes in x and y directions
- Vector with norm and orientation

Application

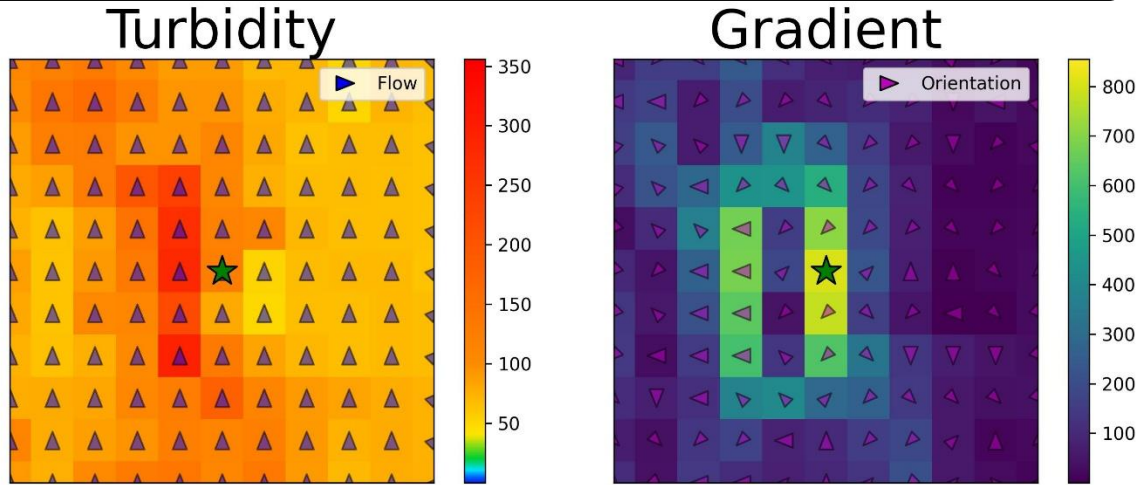
- Detect and sort points with **maximum gradient magnitude**
- List of **pollution points candidates**

Next Steps

- Needs to be filtered by different **criteria**

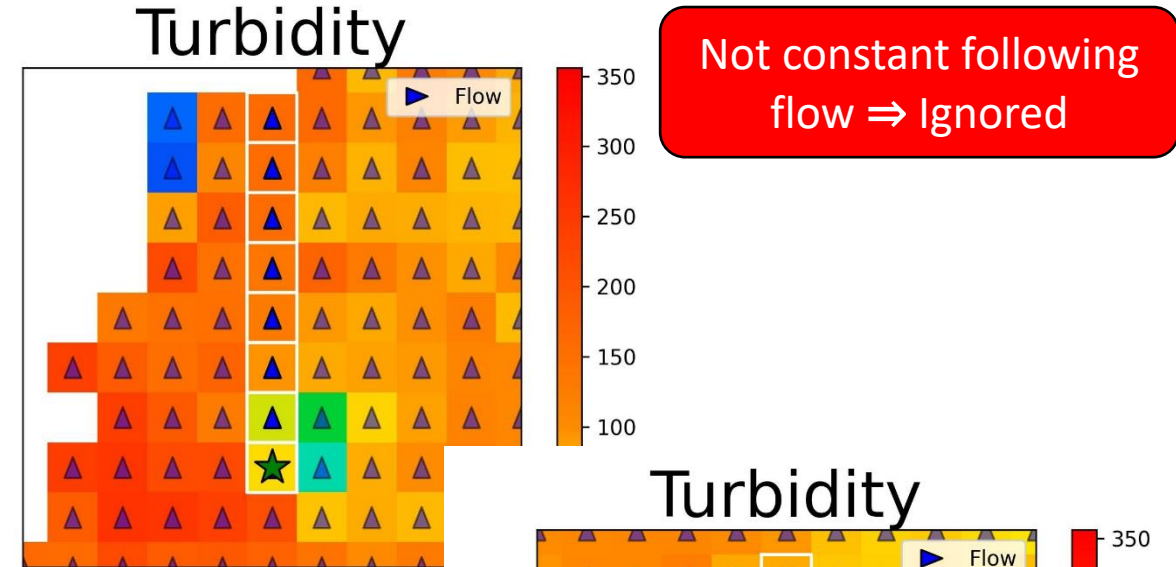
Filter pollution points candidates using an adaptative window based on flow directions

Flow Direction $\neq$ Gradient Orientation $\Rightarrow$ Ignored



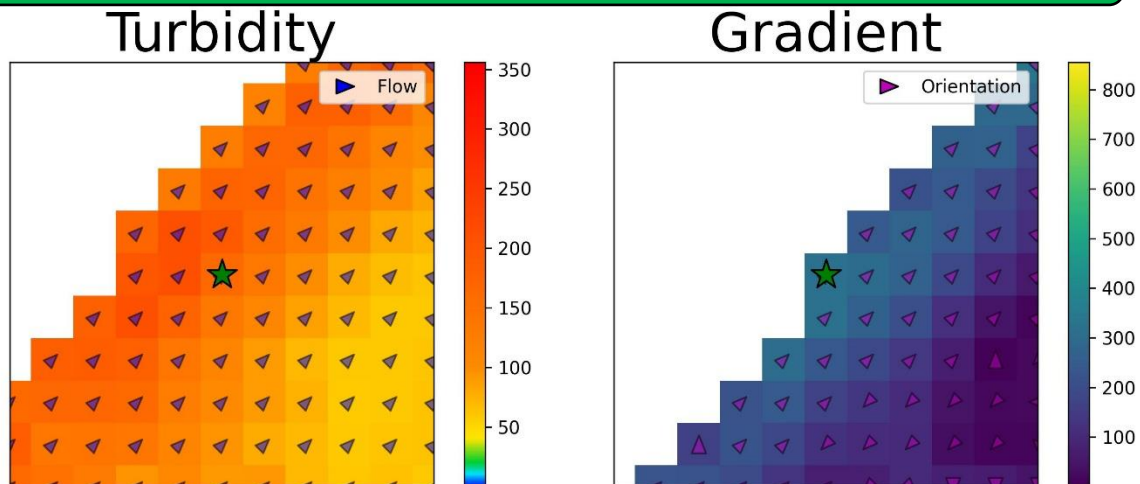
Avoid False Positives

Is turbidity constant in next pixels following the flow direction?

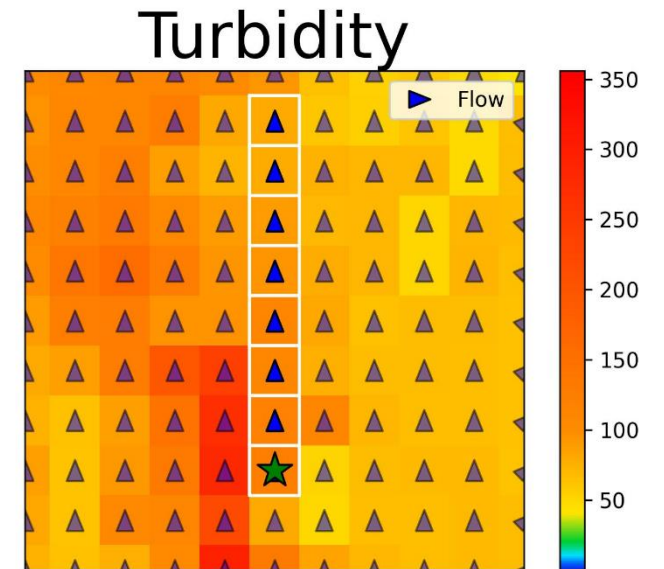


Not constant following
flow $\Rightarrow$ Ignored

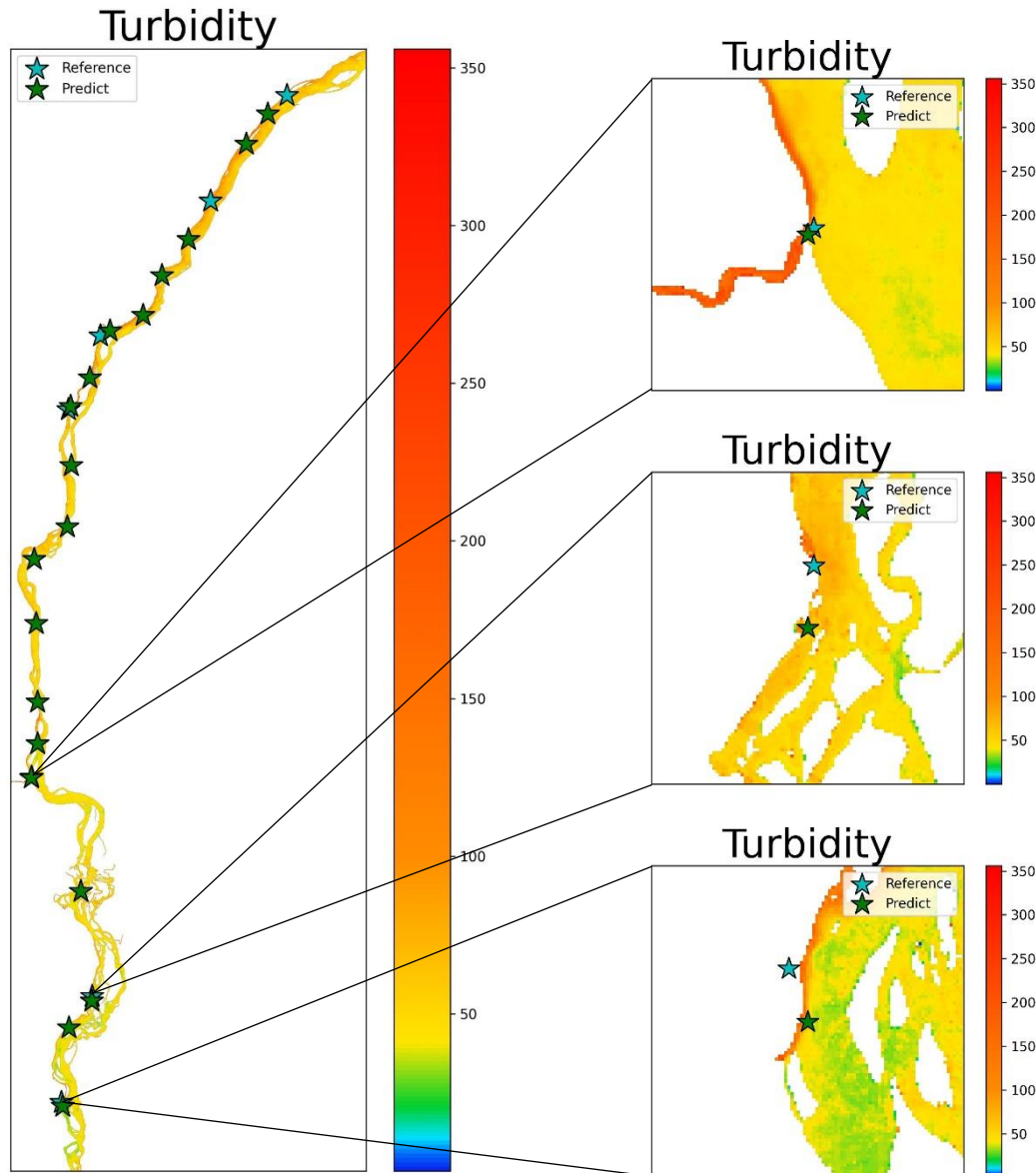
Flow Direction = Gradient Orientation $\Rightarrow$ Selected



Constant following flow
 $\Rightarrow$ Selected



Results identifying pollution points on an adaptative window based on flow directions and gradient analysis



Validation

- Comparison between **predicted** pollution points and manually identified **reference** pollution points
- An Artificial Intelligent **unsupervised algorithm** to automatically detect pollution points

Perspectives

- Improving criteria to filter false positive pollution points
- Confronting multiple parameters (other than turbidity)
- Using the predicted points to help reference correct pollution points
- Create a dataset for a **training a supervised model**