Integrating Deep Learning to GIS Modelling

An Efficient Approach to Predict Sediment Discharge at Water Treatment Plant Under Different Land-Use Scenarios

Edouard Patault (*ECSTS) – EGU2020-467
edouard.patault1@univ-rouen.fr
@EdouardPatault

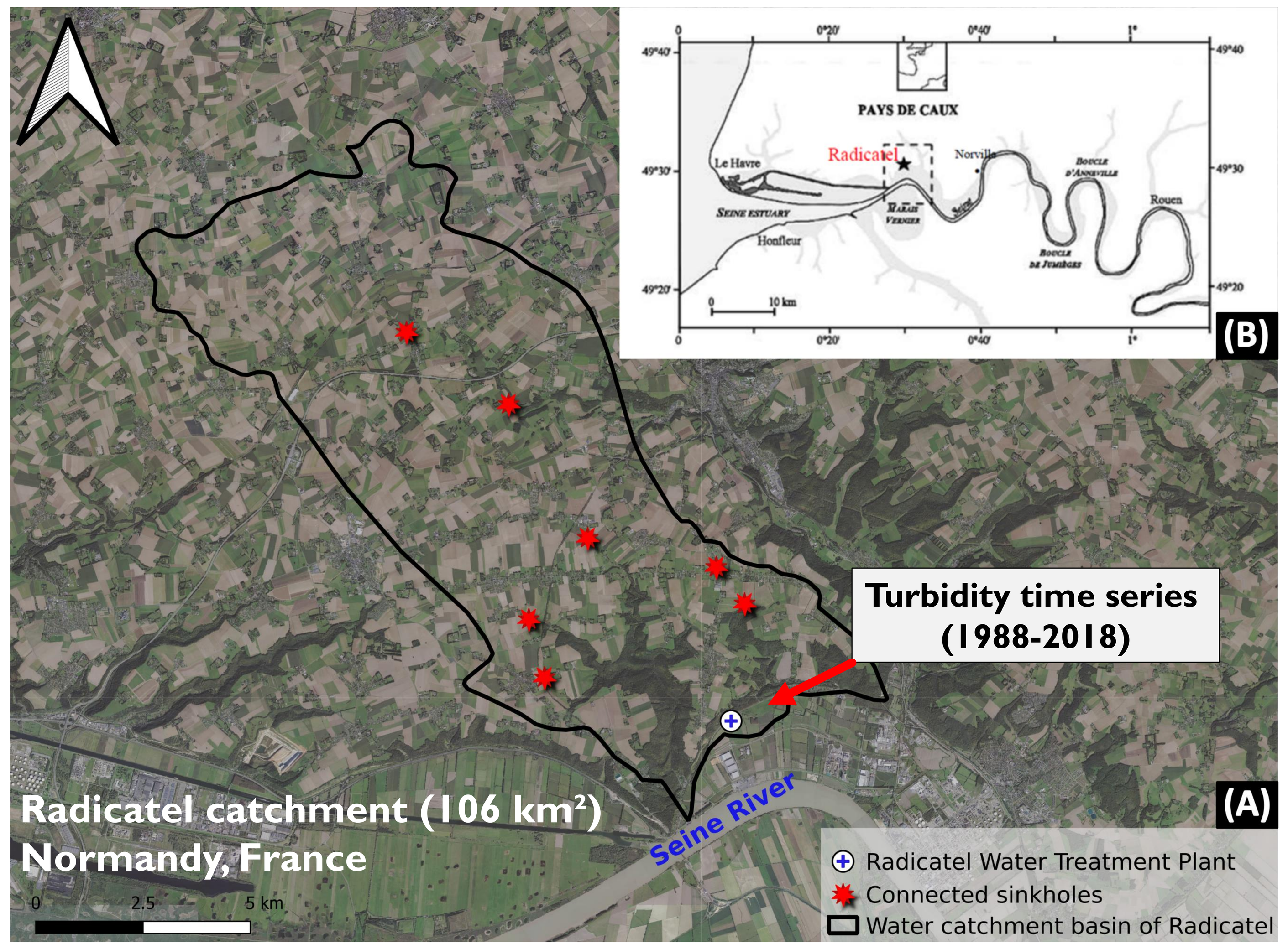
Background

- In karstic environment, erosion and runoff can lead to excessive transfer of sediments in raw water
- Excessive sediment supply can be highly disruptive
  - Additionnal water treatment
  - Temporary shut down of water treatment plant
  - Restrictions on the use of drinking water (Cost ~ € 5M between 1992-2018 in Upper-Normandy France; *Patault et al., 2019*)

Scientific questions ?

- Can we predict the variability of the sediment discharge induced by heavy rainfall at a water treatment plant ?
- Impacts of different land-use scenarios ?

Study site



Method

- Coupled modelling approach
  - WaterSed (Landemaine, 2016) : Raster-based distributed model
    - WaterSed outputs are extracted at connected sinkholes and used as inputs in the DNN
  - Deep Neural Network
    - WaterSed outputs are used as inputs in the DNN
    - 41 neurons; 3 hidden layers; activation function = ReLU

Land-use Scenarios

- **S_base** : Land Cover 2016 + existing erosion control measures
- **S_grass** : 33% of grasslands ploughed-up
- **S_engi** : 181 fascines + 13.1 ha of grass strips
- **S_farm** : +15% infiltration on 50% of the cultivated plots

2050

Our modelling results suggest that adoption of **best farming practices** on catchment can **significantly decrease sediment discharge** at sinkholes and thus, **reduce impacts at water treatment plant** (up to **61%**)

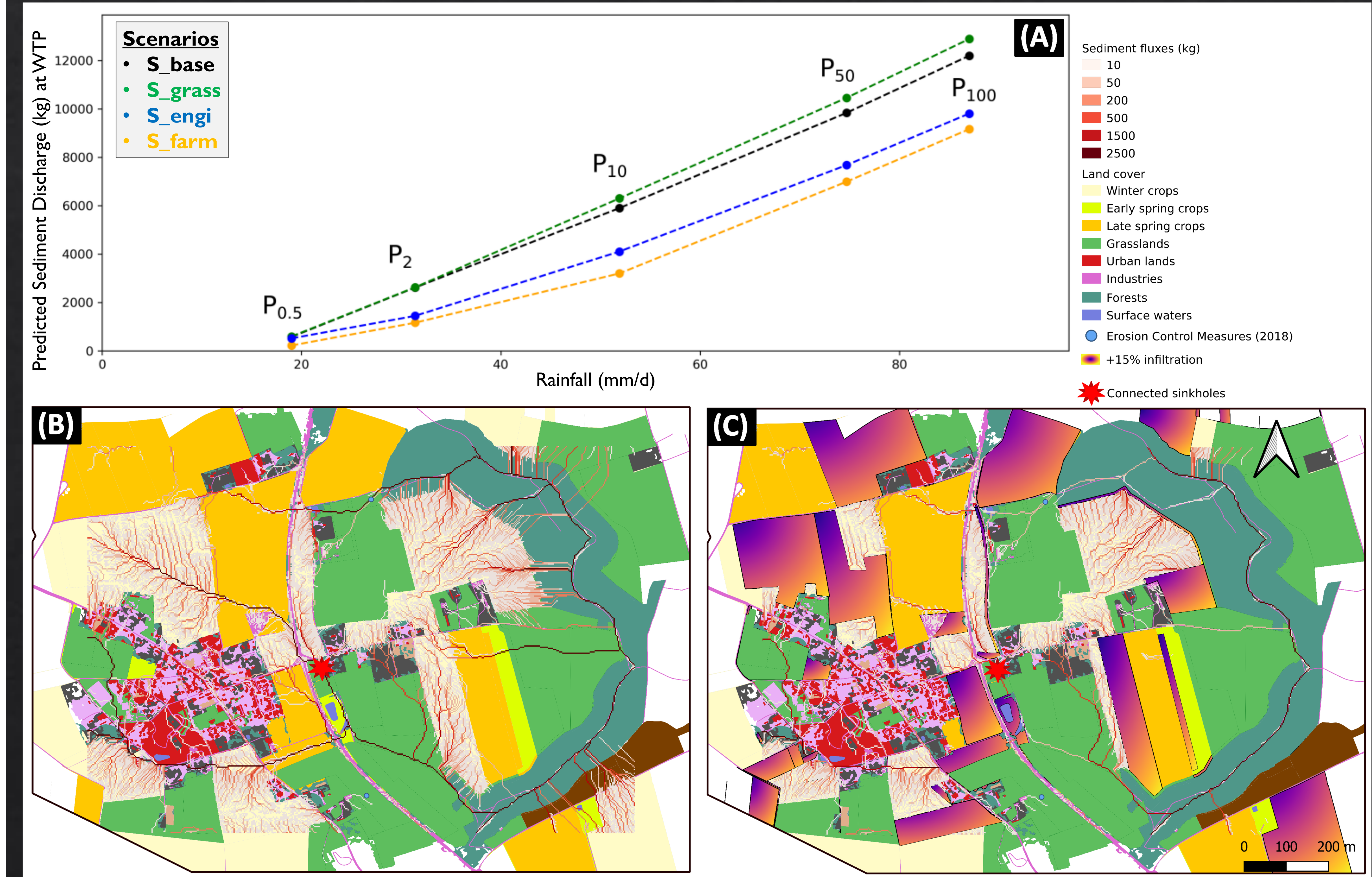


Fig: (A) Predicted sediment discharge at the water treatment plant (Radicatel, Normandy, France) by the coupled model (GIS-DNN) on five designed storm project and four land-use scenarios; (B) Simulated flow paths on the baseline scenario; (C) Simulated flow paths when considering best farming practices on 50% of the plots for which the capacity infiltration has been increased by +15%.

Calibration & Validation

- Inputs : P (mm/d); P48 (mm/d); runoff (m^3) and sediment discharge at connected sinkholes (kg)
- Outputs : sediment discharge (kg) at water treatment plant
- Calibration dataset: two hydrologic years (n = 731 daily events)

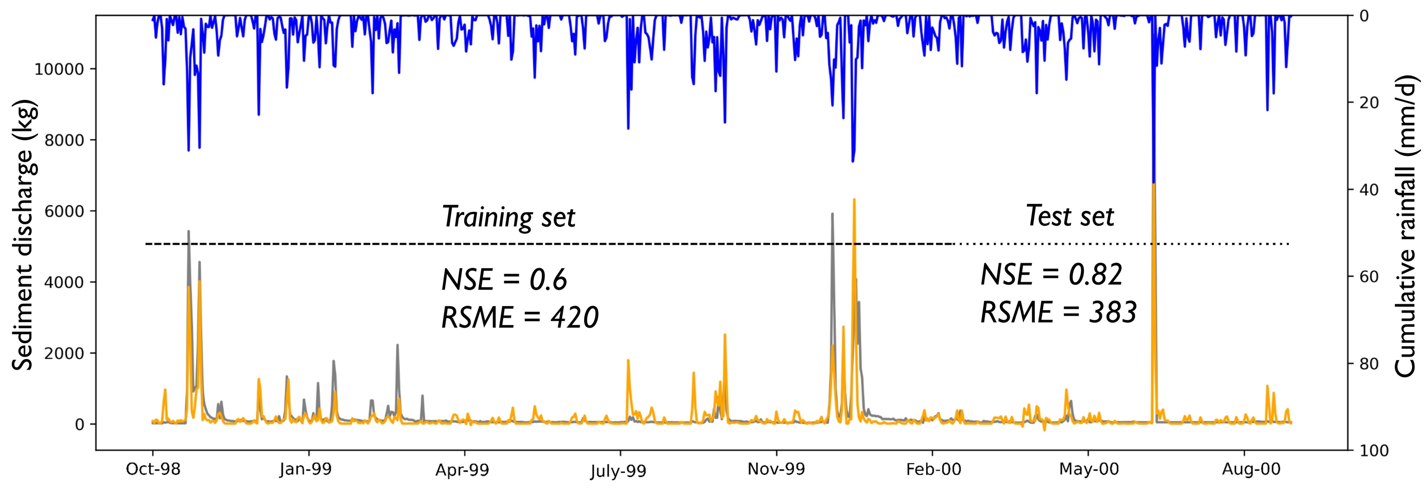


Fig: Observed and predicted sediment discharge (kg) at the water treatment plant using the DNN model.

- Comparison with « Generalized Extreme Value » distribution
  - Designed Storm Project = 19; 31; 52; 75; 87 mm/d

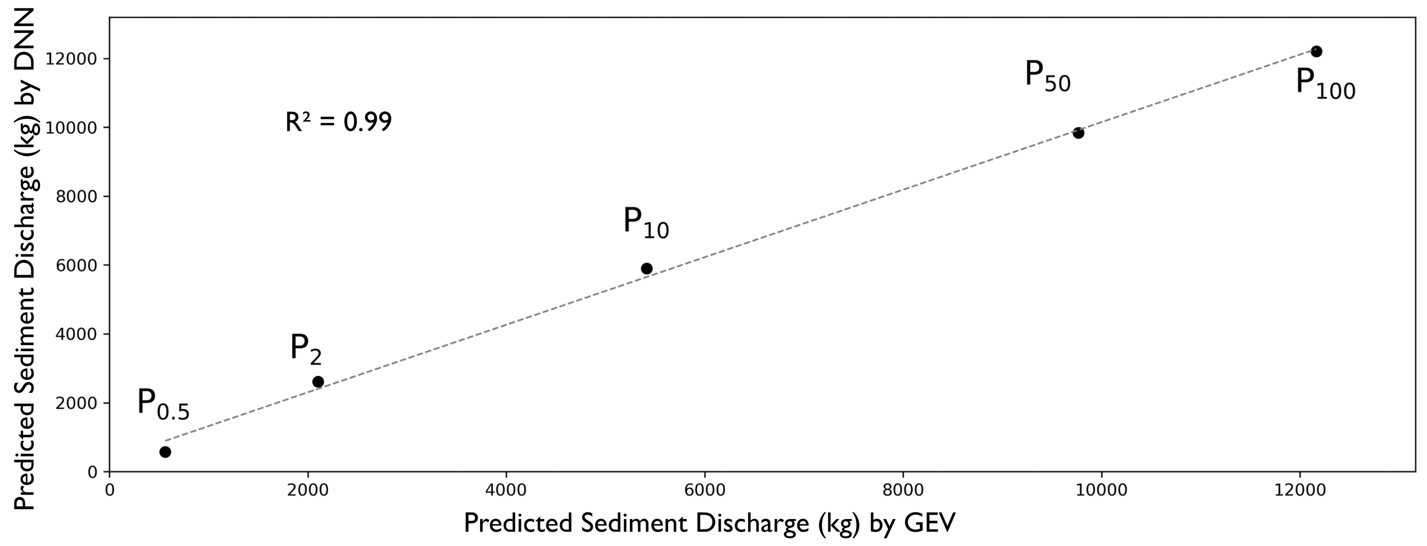


Fig: Comparison of predicted sediment discharge (kg) at the water treatment plant for the five designed storm project and the land-use baseline scenario using GEV and DNN modelling.

Generalization

- Month backward-chaining nested cross-validation (n = 12)

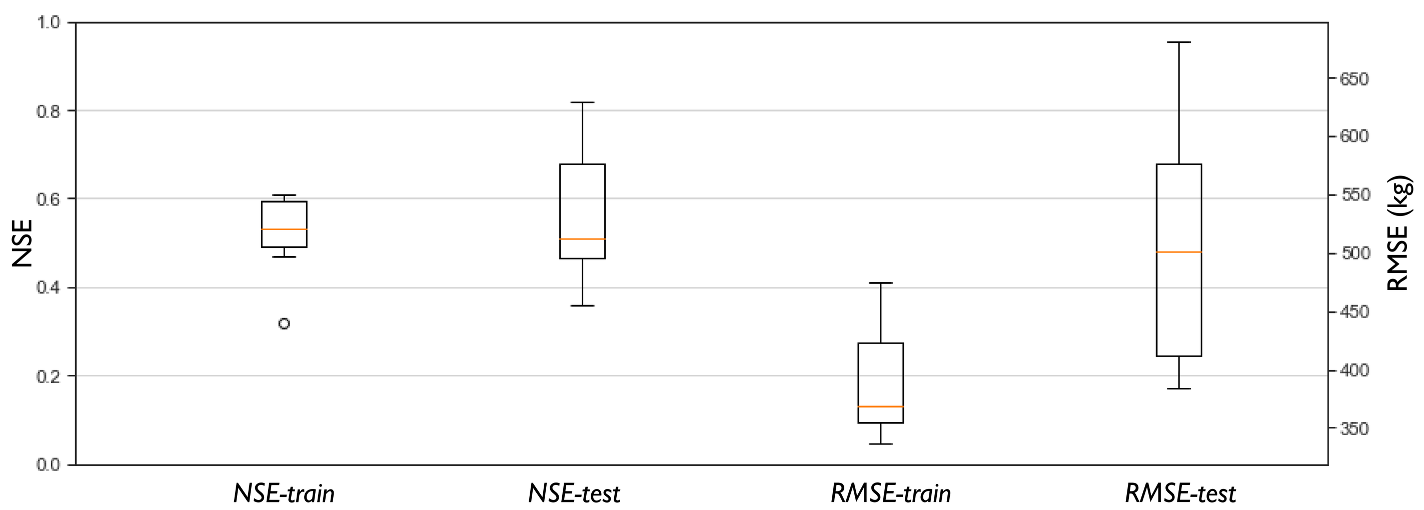


Fig: Boxplots of the performance metrics over the training and the test set using the month backward-chaining nested cross-validation.

Conclusions

- Coupling GIS and DNN can predict sediment discharge variability at water treatment plant
- Impacts of land use-scenarios on sediment discharge at water treatment plant (by mean vs baseline scenario):
  - **S_grass = +4.5%; S_engi = -25%; S_farm = -43%**

Patault, E., Landemaine, V., Ledun, J., Soulignac, A., Fournier, M., Ouvry, J-F., Cerdan, O., Laignel, B.