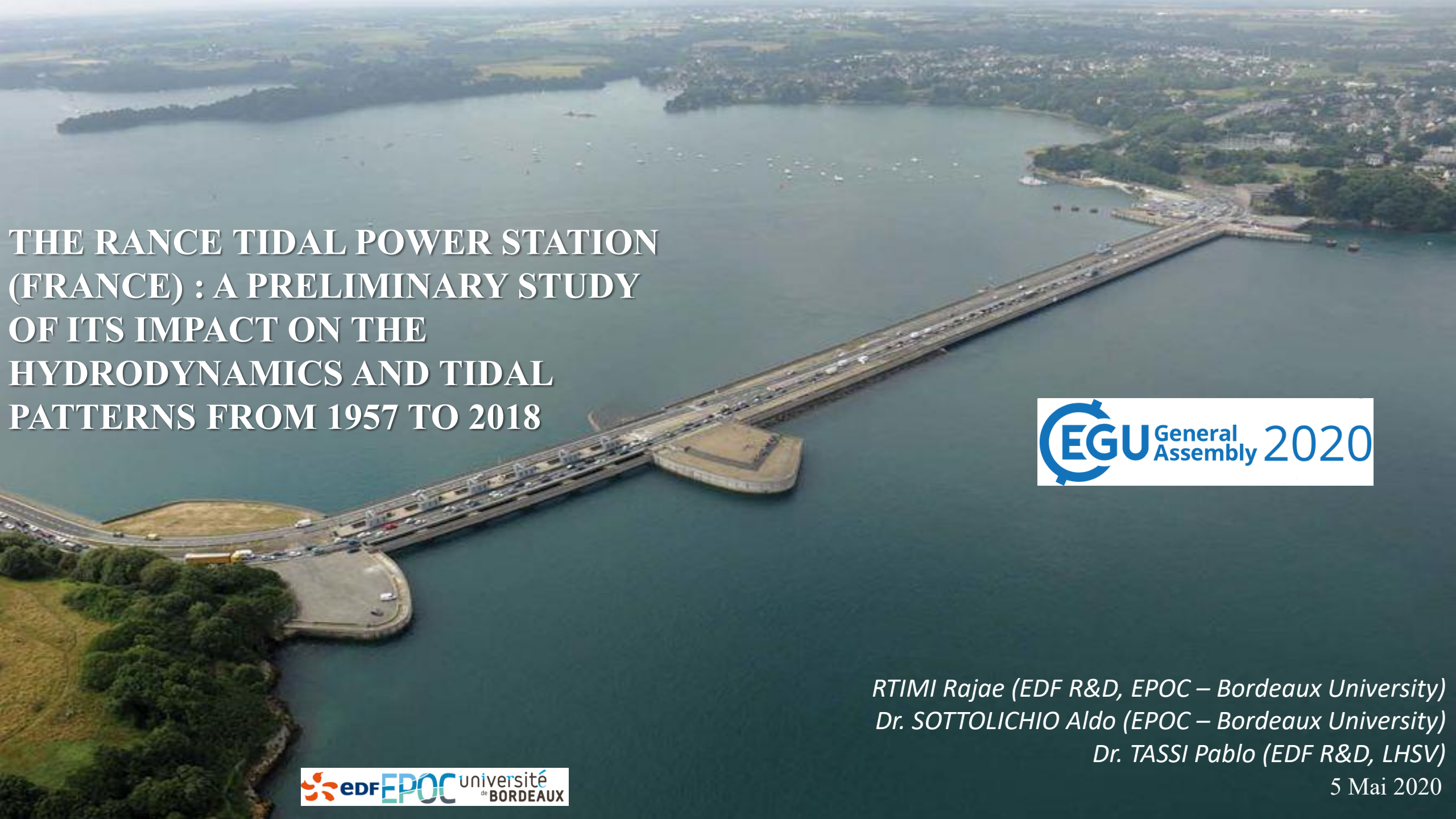

# THE RANCE TIDAL POWER STATION (FRANCE) : A PRELIMINARY STUDY OF ITS IMPACT ON THE HYDRODYNAMICS AND TIDAL PATTERNS FROM 1957 TO 2018

EGU General Assembly 2020

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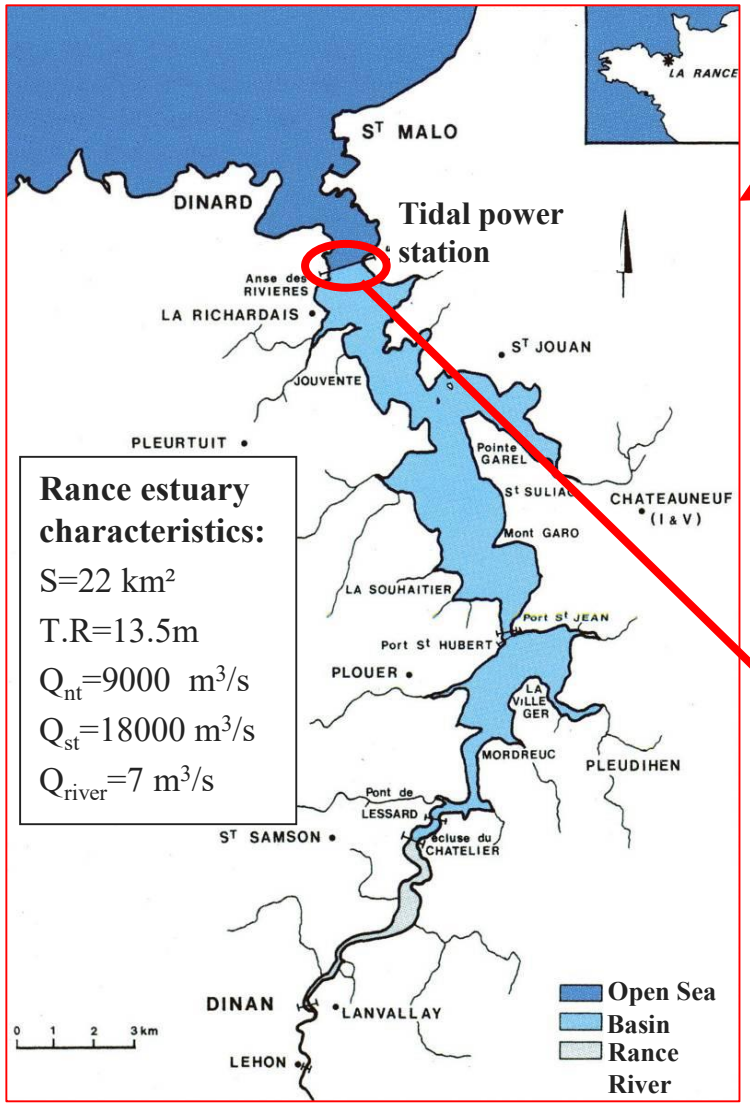
5 Mai 2020

# OUTLINE

1. Context
2. 2DH Hydrodynamic model
3. Conclusions

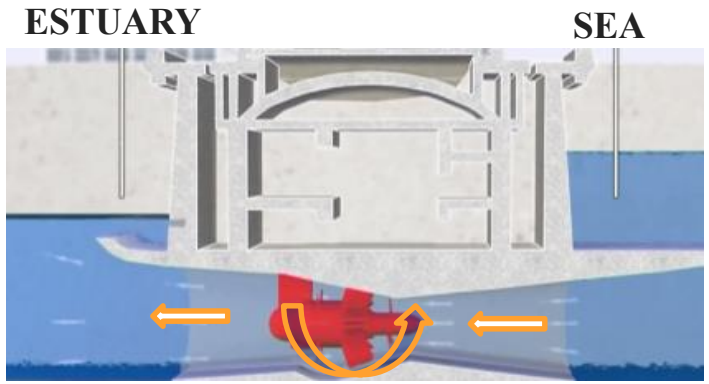
# CONTEXT



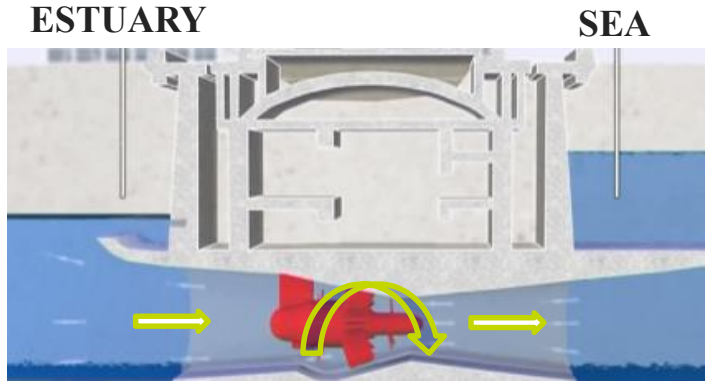

*The Rance estuary. [C. BONNOT-COURTOIS,2002]*


## The Rance tidal power station :

- Opened in 1966 as the world's first and biggest tidal power station in the world
- Peak capacity 240 MW, equivalent to electricity consumption of a city with 215 400 people

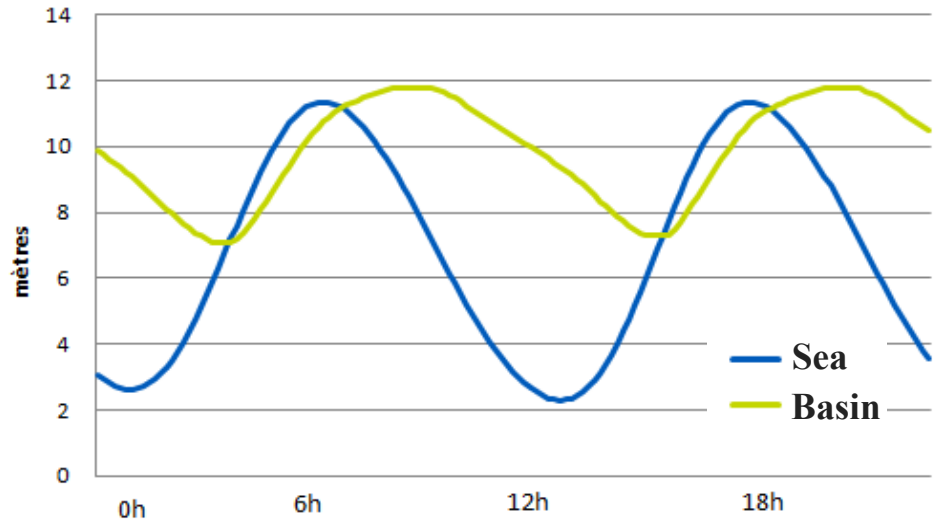



High tide




Low tide

# CONTEXT




The reported consequences of the tidal power station artificial forcing are :

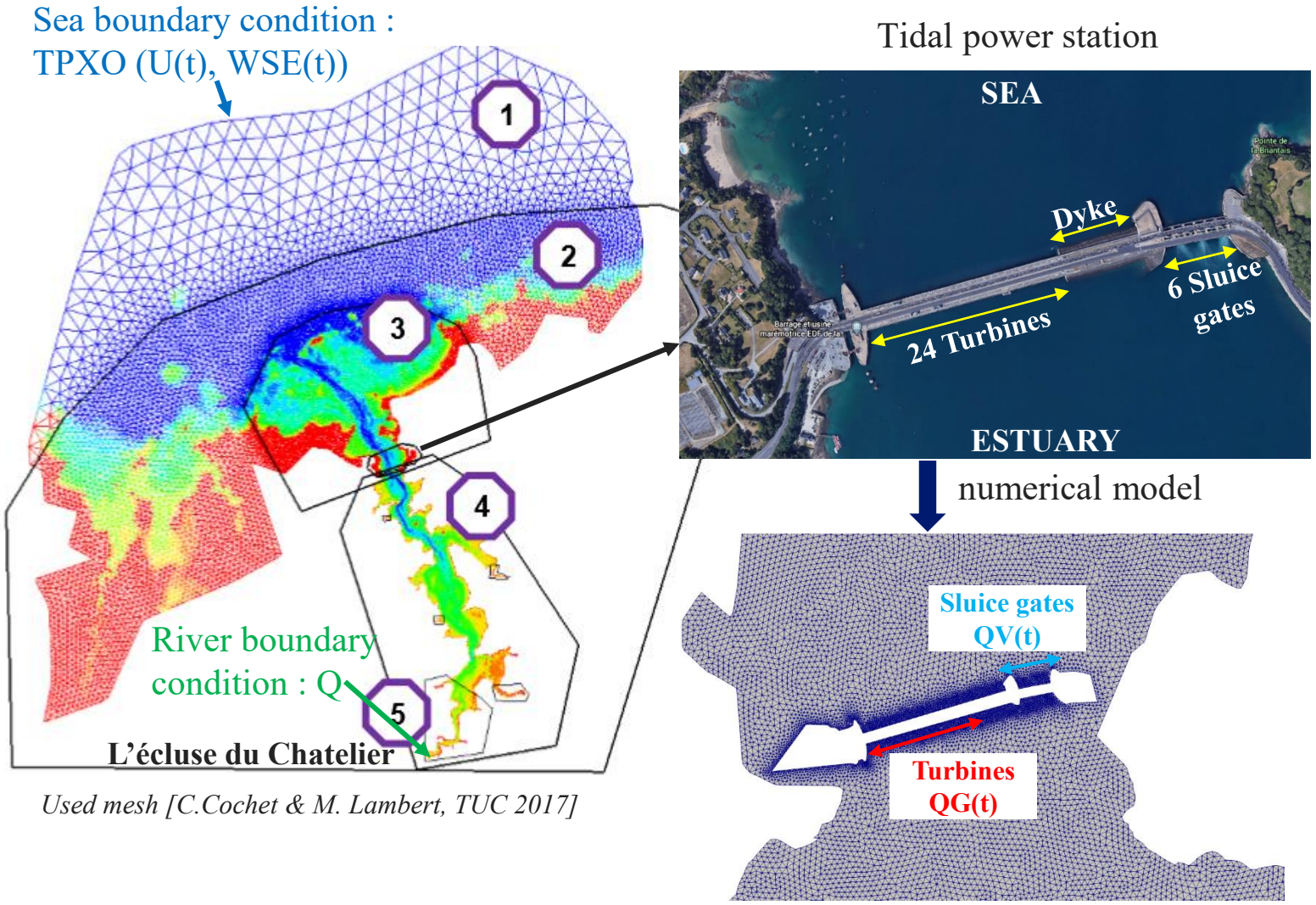
- damping of the estuarine water level
- observations of net siltation in the estuary

However, there is no specific knowledge on the role of the plant on the propagation of the tidal wave and currents nor on sedimentation.

Main research question :

- What is the impact of the tidal power station on the hydrodynamics and tidal patterns of the Rance estuary ?

# 2DH HYDRODYNAMIC MODEL




*Used mesh [C.Cochet & M. Lambert, TUC 2017]*

Tidal power station




numerical model



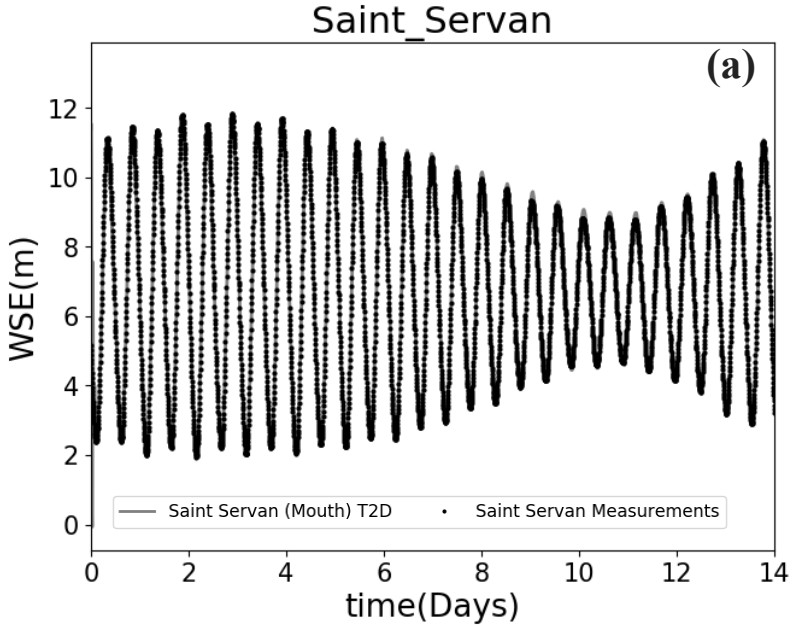

- Modelling system : TELEMAC 2D

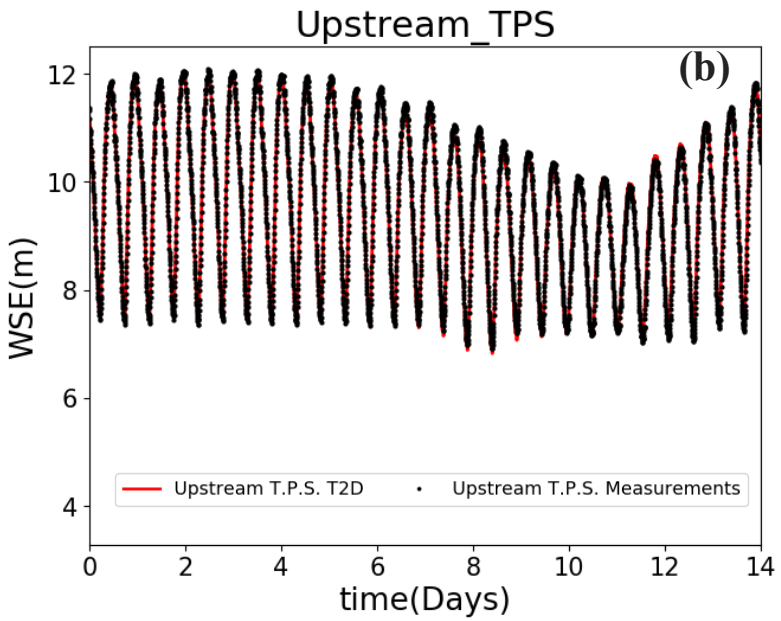
| Zone | Cell size |
|---|---|
| 1 | 1 km |
| 2 | 250 m |
| 3 | 50 m |
| 4 | 20 m |
| 5 | 5 m |

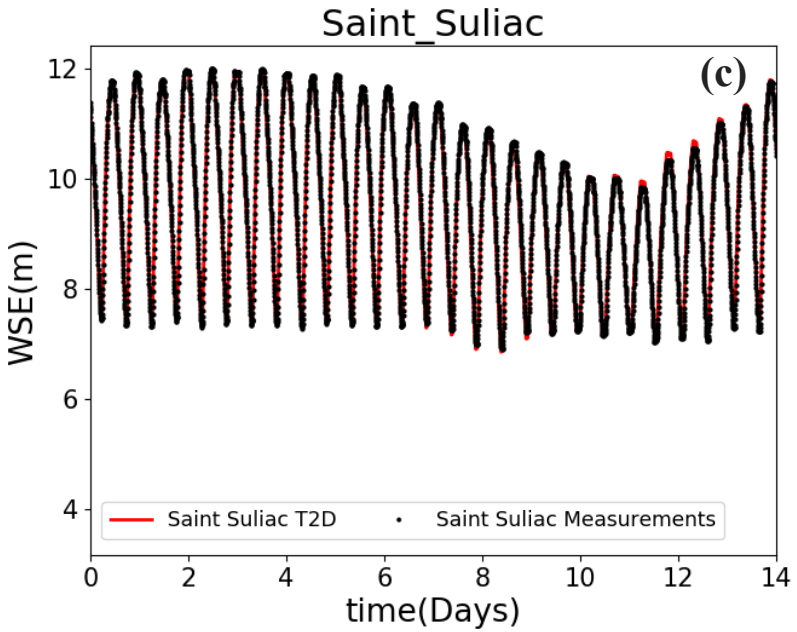
- Numerical model validation

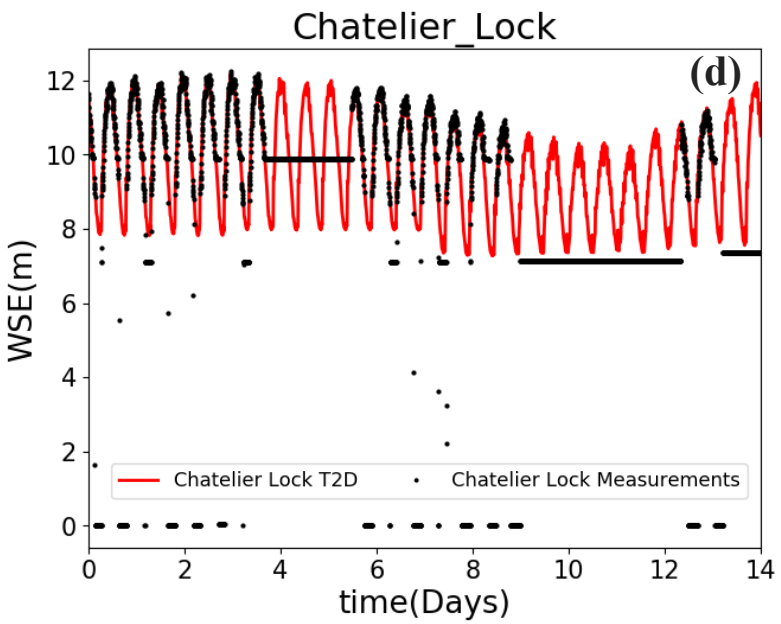
| Period | Bathymetry |
|---|---|
| 15/08/2019 - 28/08/2019 | 2018 |

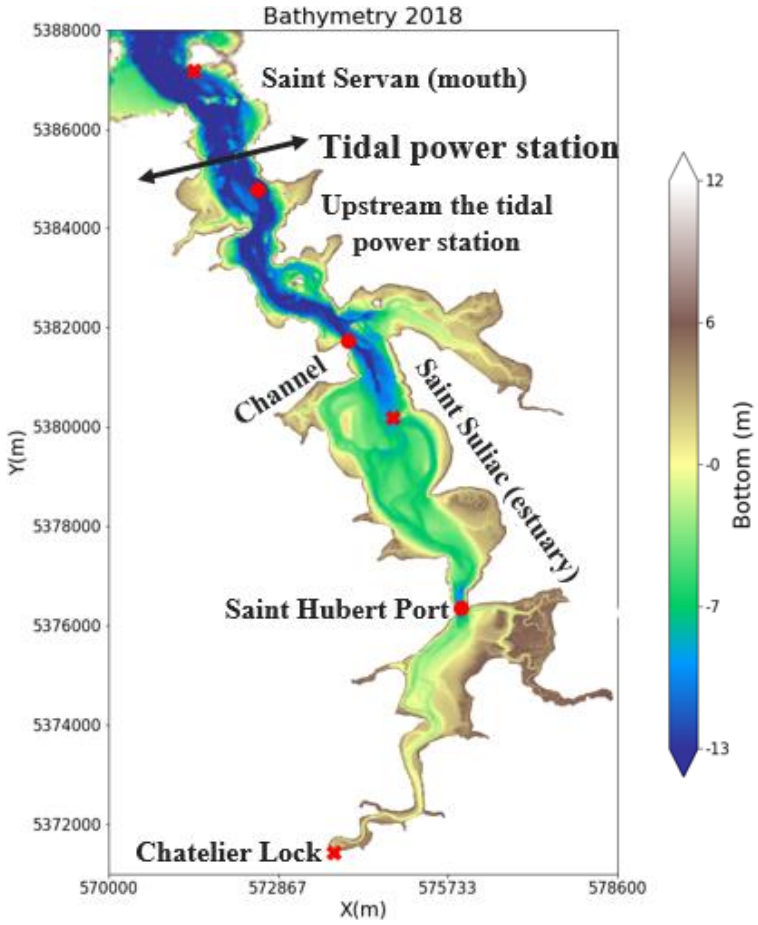
# VALIDATION OF 2DH HYDRODYNAMIC MODEL



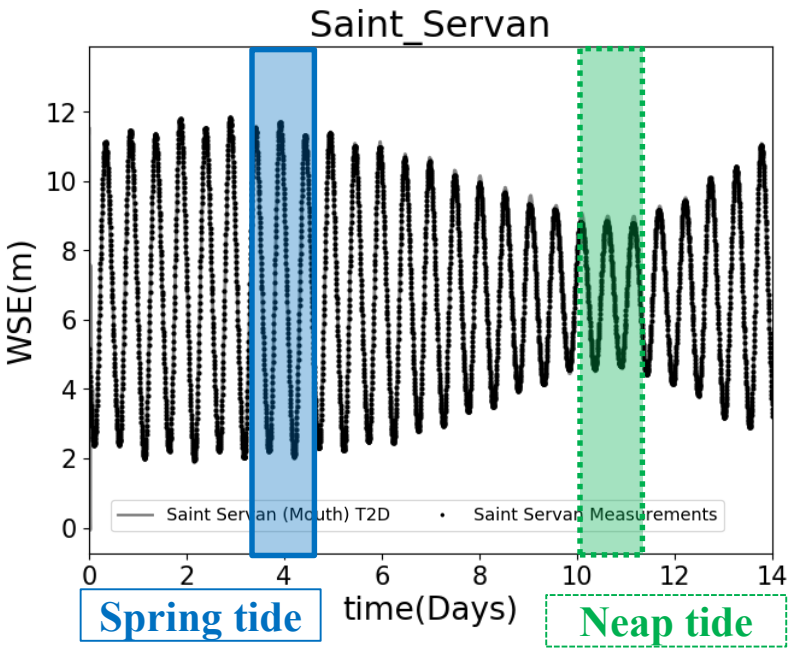



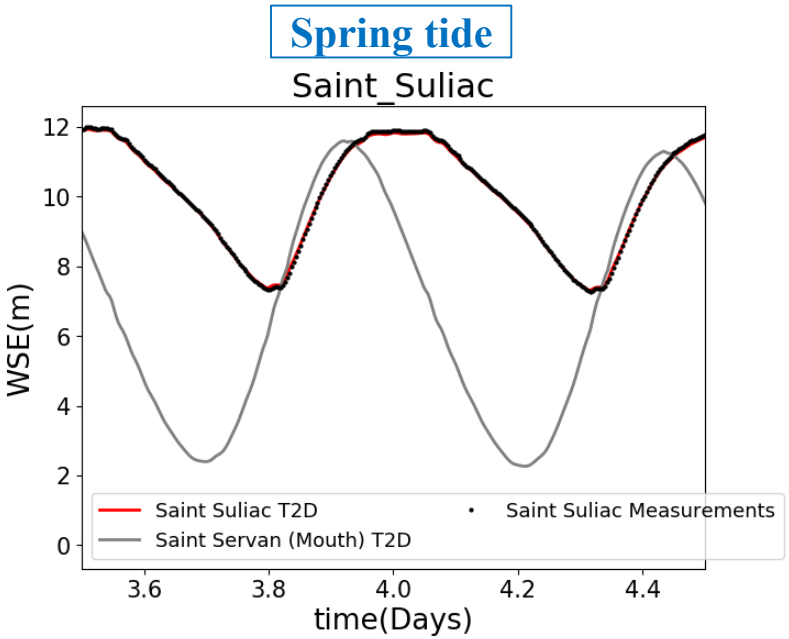



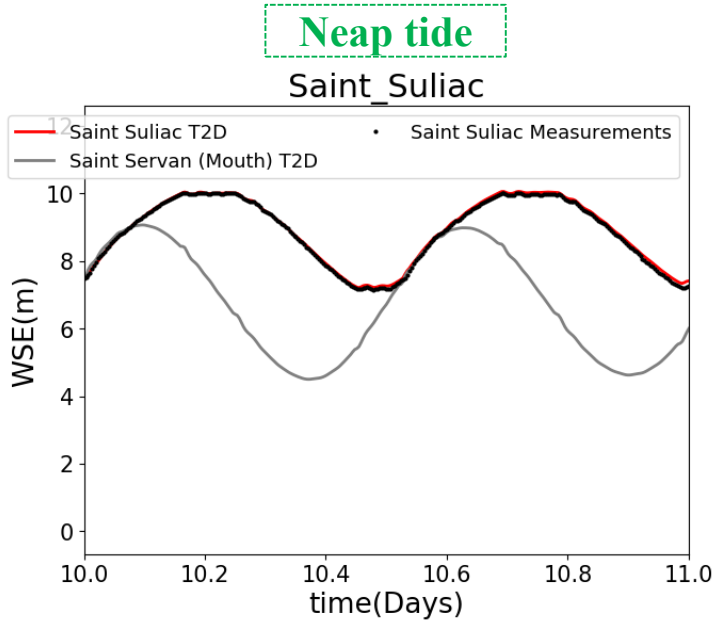




| Location | St Servan | Upstream TPS | St Suliac | Chatelier Lock |
|---|---|---|---|---|
| RMSE(cm) | 6.22 | 6.47 | 6.75 | xx |

# VALIDATION OF 2DH HYDRODYNAMIC MODEL



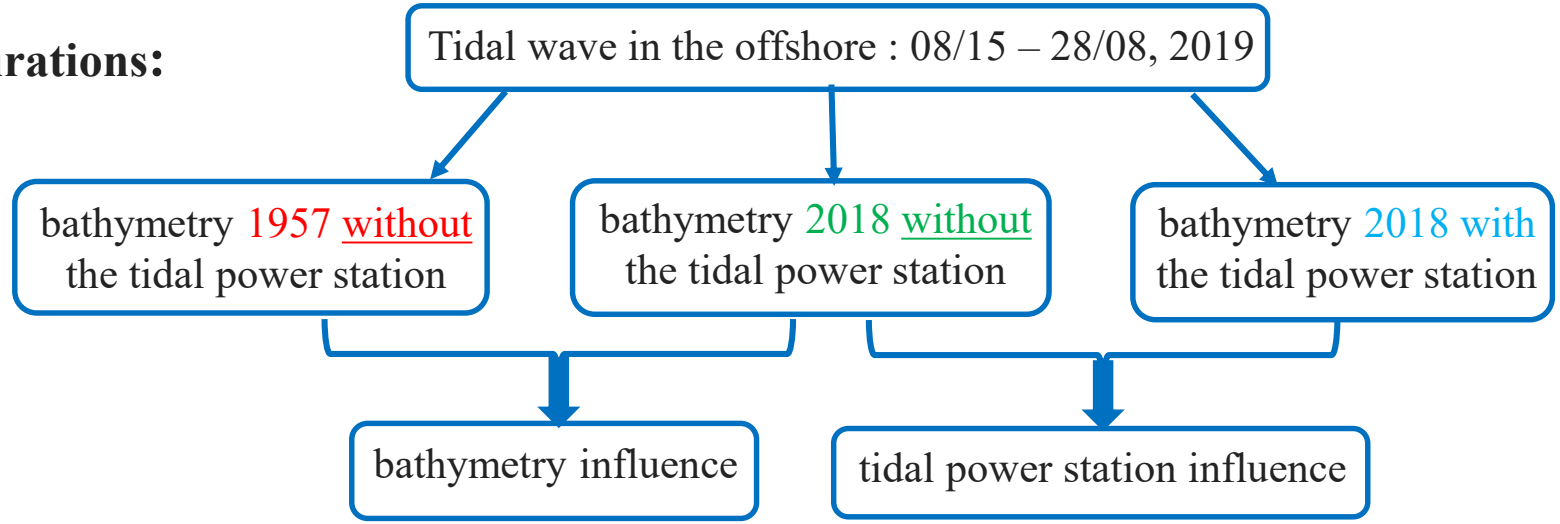



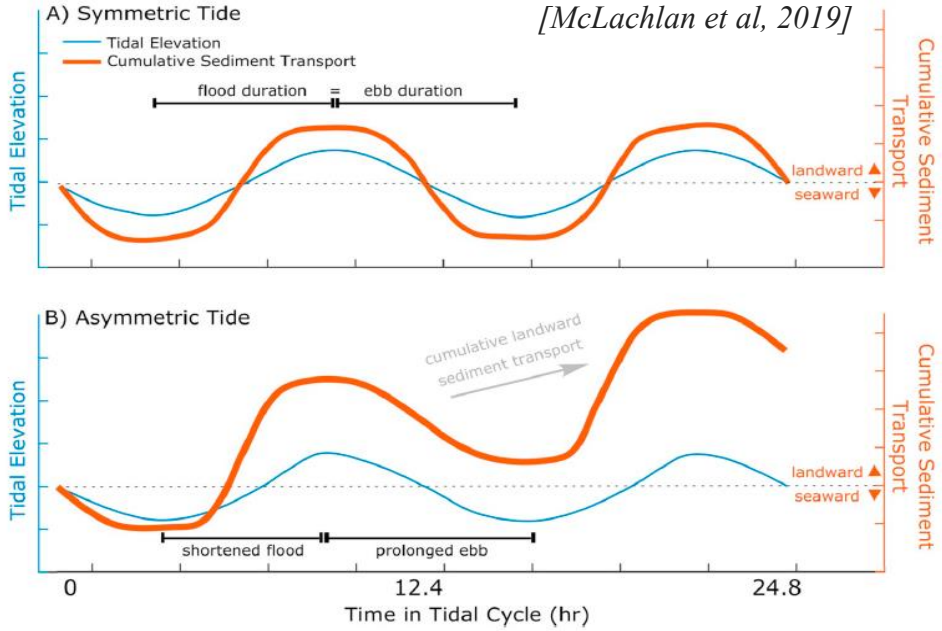

The tidal power station :

- reduces the tidal range in the estuary
- rises the mean level in the estuary
- extends the ebb duration and high/low water slack
- amplifies the water level in neap tides

# EVALUATION OF CHANGES OCCURRED IN THE ESTUARY

- **Simulation of three different configurations:**




*[McLachlan et al, 2019]*

- **Currents and tidal asymmetry analysis:** *[Nidzieko & Ralston, 2012]*

$$\gamma_0 \equiv \frac{\mu_3}{\mu_2^{3/2}}$$

$$\mu_m = \frac{1}{N-1}\sum_{i=1}^{N}(n_i)^m$$

$$n = u, \quad \gamma_0(u)$$

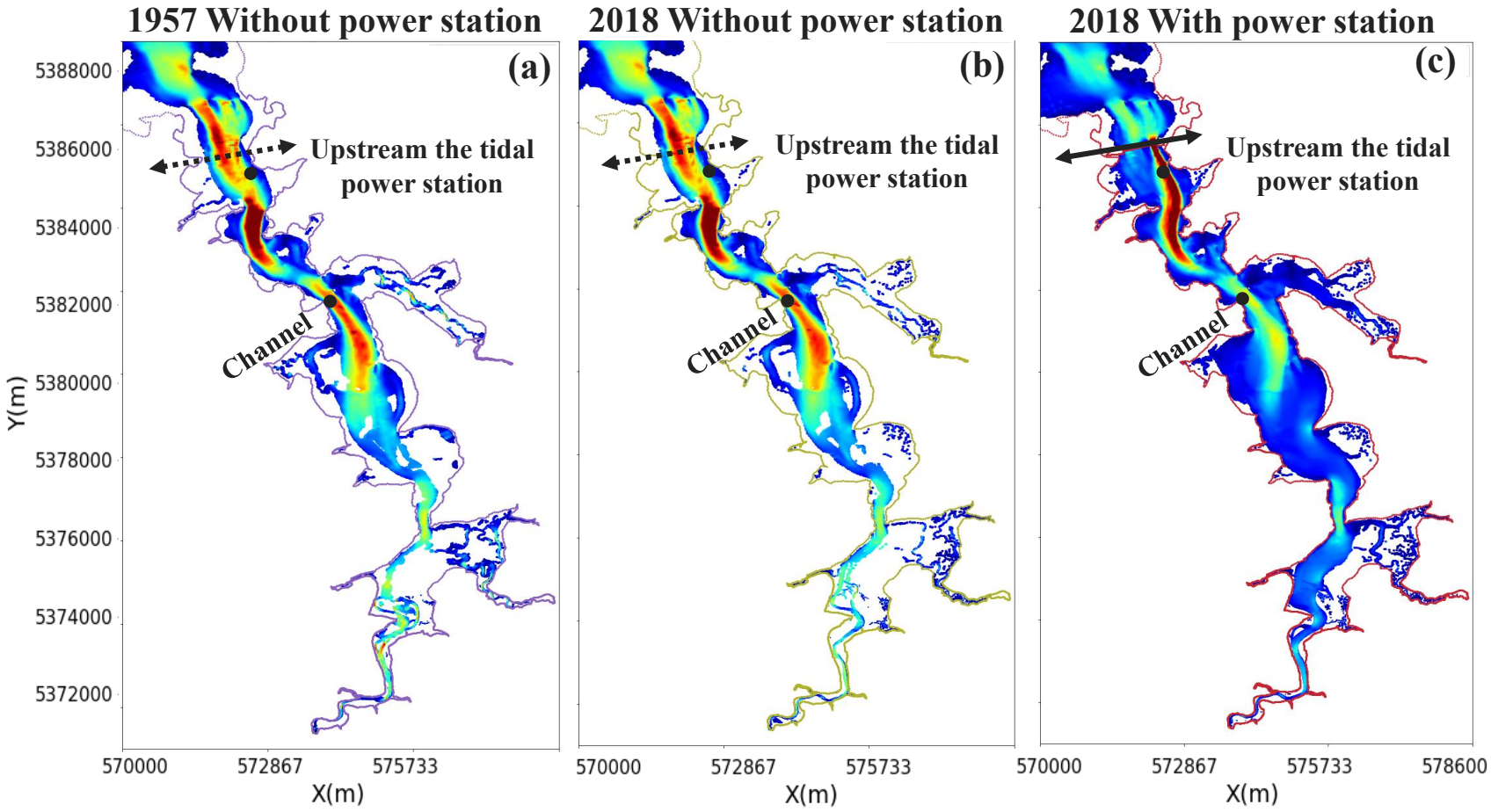
-> Ebb/flood dominant zones

$$n = \frac{d\varsigma}{dt}, \quad \gamma_0(\frac{d\varsigma}{dt})$$

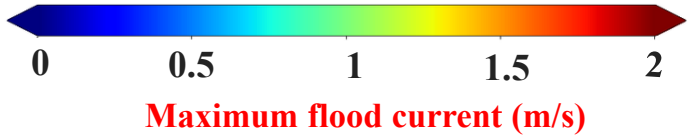
-> Duration of falling water is longer/shorter than rising water

# RESULTS : CURRENTS

**Flood**

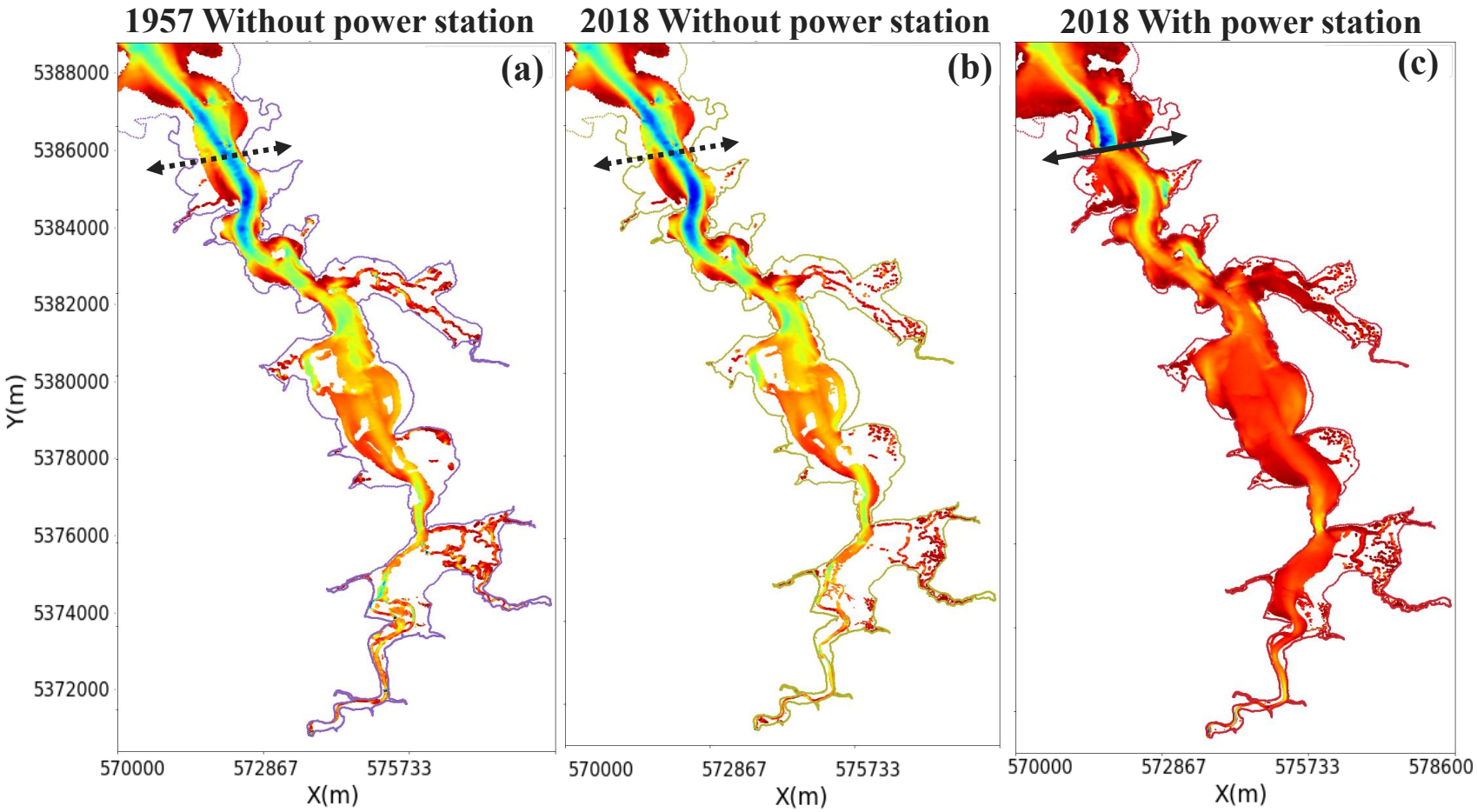



- The bathymetry doesn't seem to have any major impact on the currents
- Flood currents are amplified by the tidal power station upstream the sluice gates and then reduced in the main channels of the estuary

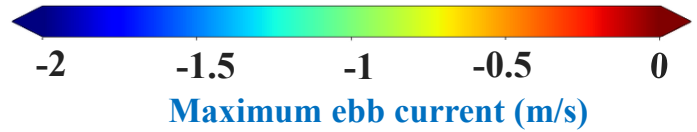


# RESULTS : CURRENTS

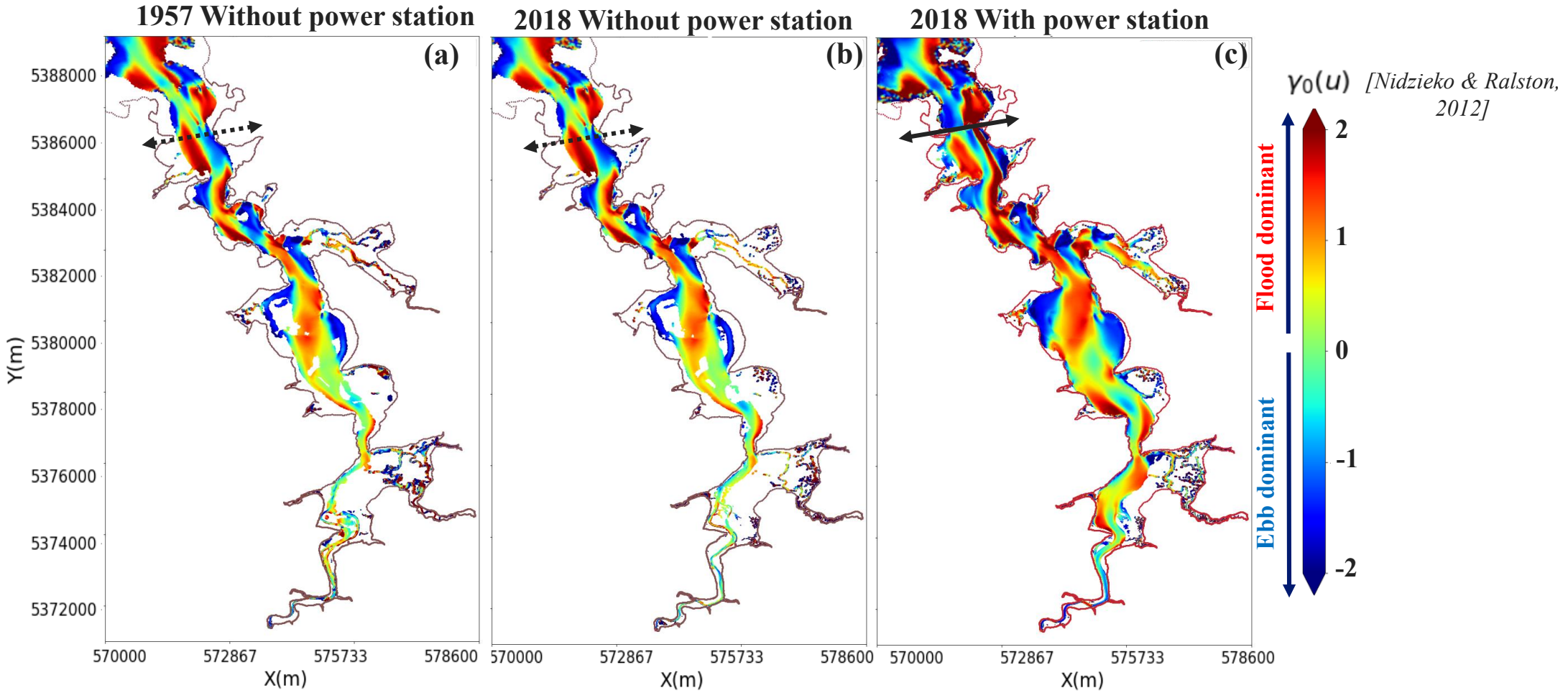
**Ebb**




- The bathymetry doesn't seem to have any major impact on the currents
- Ebb currents are amplified by the tidal power station downstream the turbines and then reduced in the main channels of the estuary

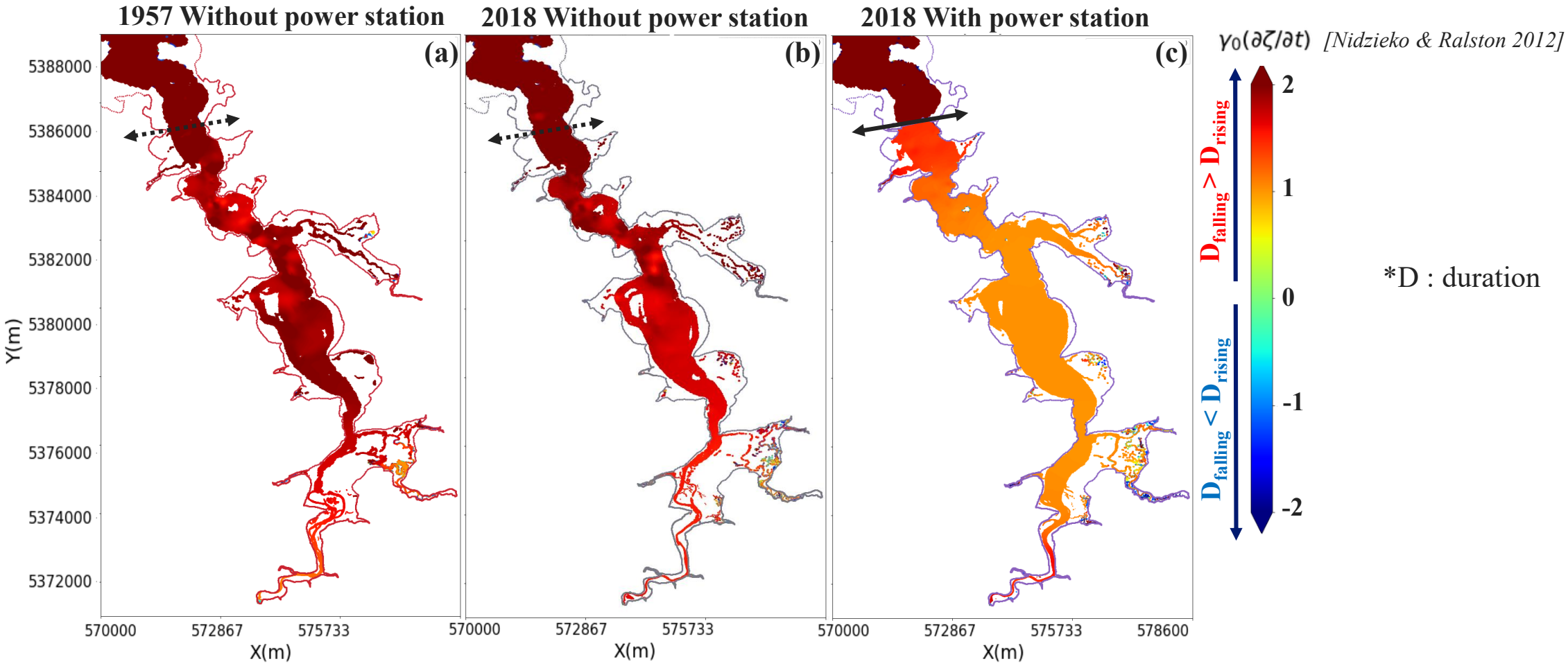


# RESULTS: TIDES' ASYMMETRY ANALYSIS




- With and without the tidal power station, the Rance estuary is a mainly a flood dominant system
- Close to the tidal power station, the zone upstream the sluice gates is switched from ebb dominant to flood dominant by the presence of the TPS. Also the zone downstream the turbines is switched from flood dominant to ebb dominant by the presence of the TPS

# RESULTS: TIDES' ASYMMETRY ANALYSIS




- With and without the tidal power station, the duration of falling water is longer the duration of rising water
- The tidal power station extends the high and low water slack also the ebb duration. Therefore the amplitude of the asymmetry parameter is reduced by the presence of the tidal power station

# CONCLUSIONS & WHAT'S NEXT ?

## Conclusions :

The main impacts of the tidal power stations on the hydrodynamics and tidal patterns in the estuary are :

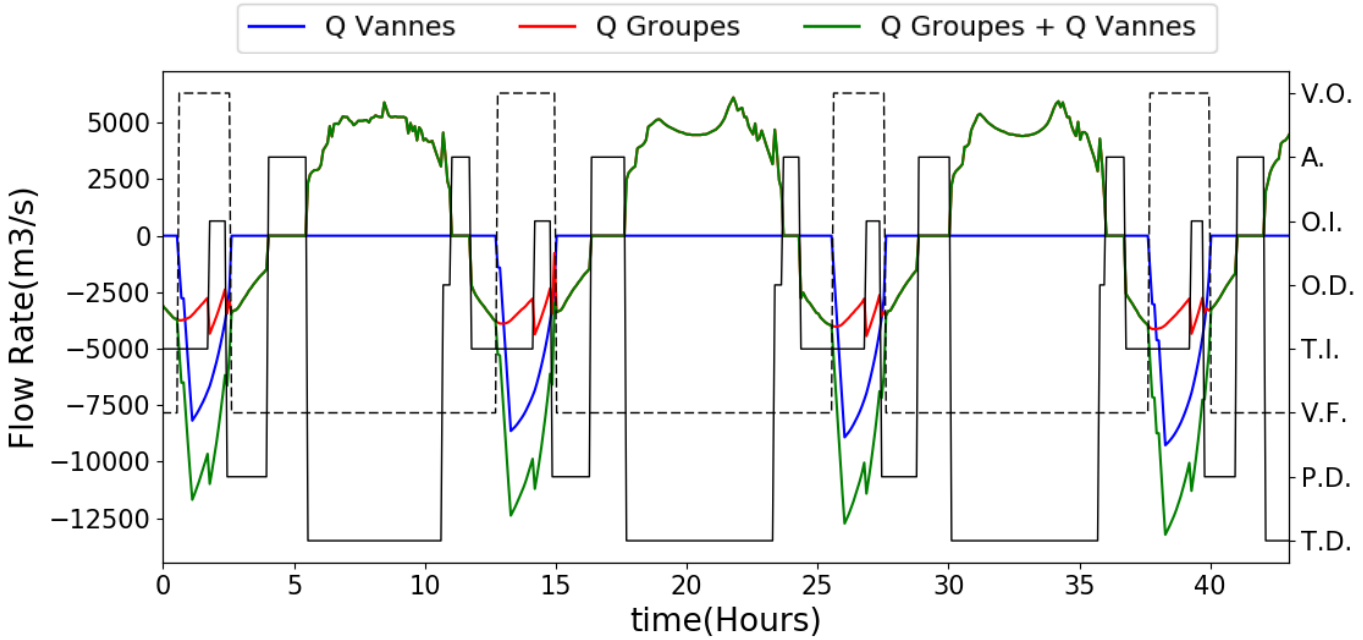
- Reduction of the tidal wave and prolongation of high water slack inside the estuary
- Flood currents amplification upstream the sluice gates
- Ebb currents amplification downstream the turbines
- Reduction of the currents far from the tidal power station zone
- With and without the tidal power station the Rance estuary exhibits a flood dominant system, that enhances the sediment transport from the coast toward the estuary

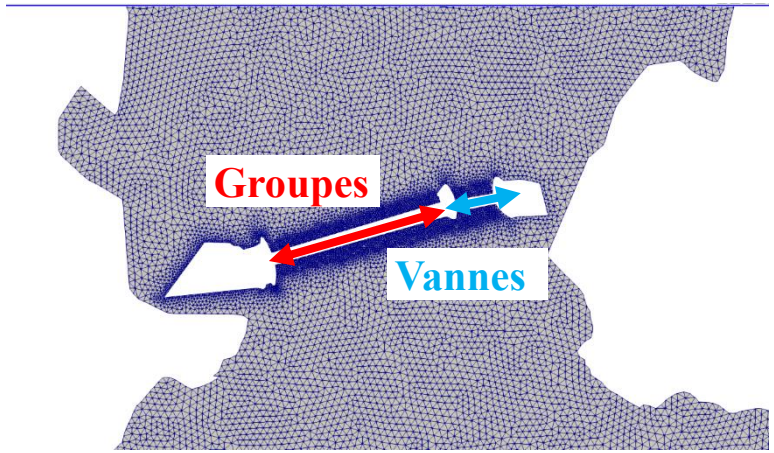
## What's next ?

- 3D hydrodynamic model of the Rance estuary with the presence of the tidal power station
- 3D hydro-sedimentary model for short term simulations

# APPENDIX

# 2DH HYDRODYNAMIC MODEL




**L_Groupes = 323 m**
**L_Vannes = 114 m**

Si les vannes sont ouvertes:
**V_Vannes > V_Groupes**