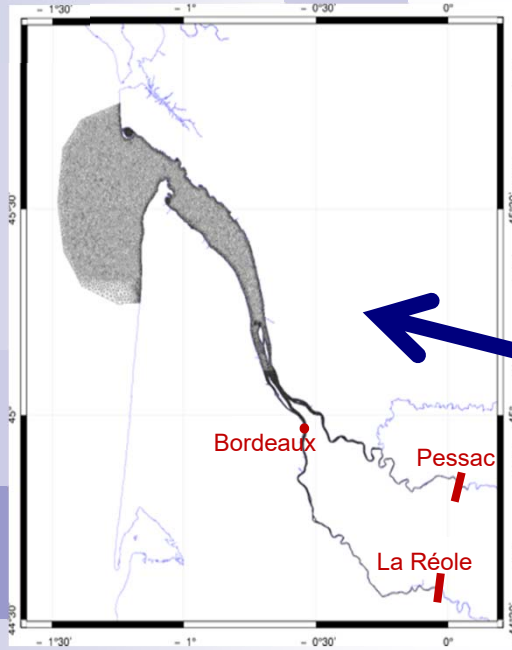
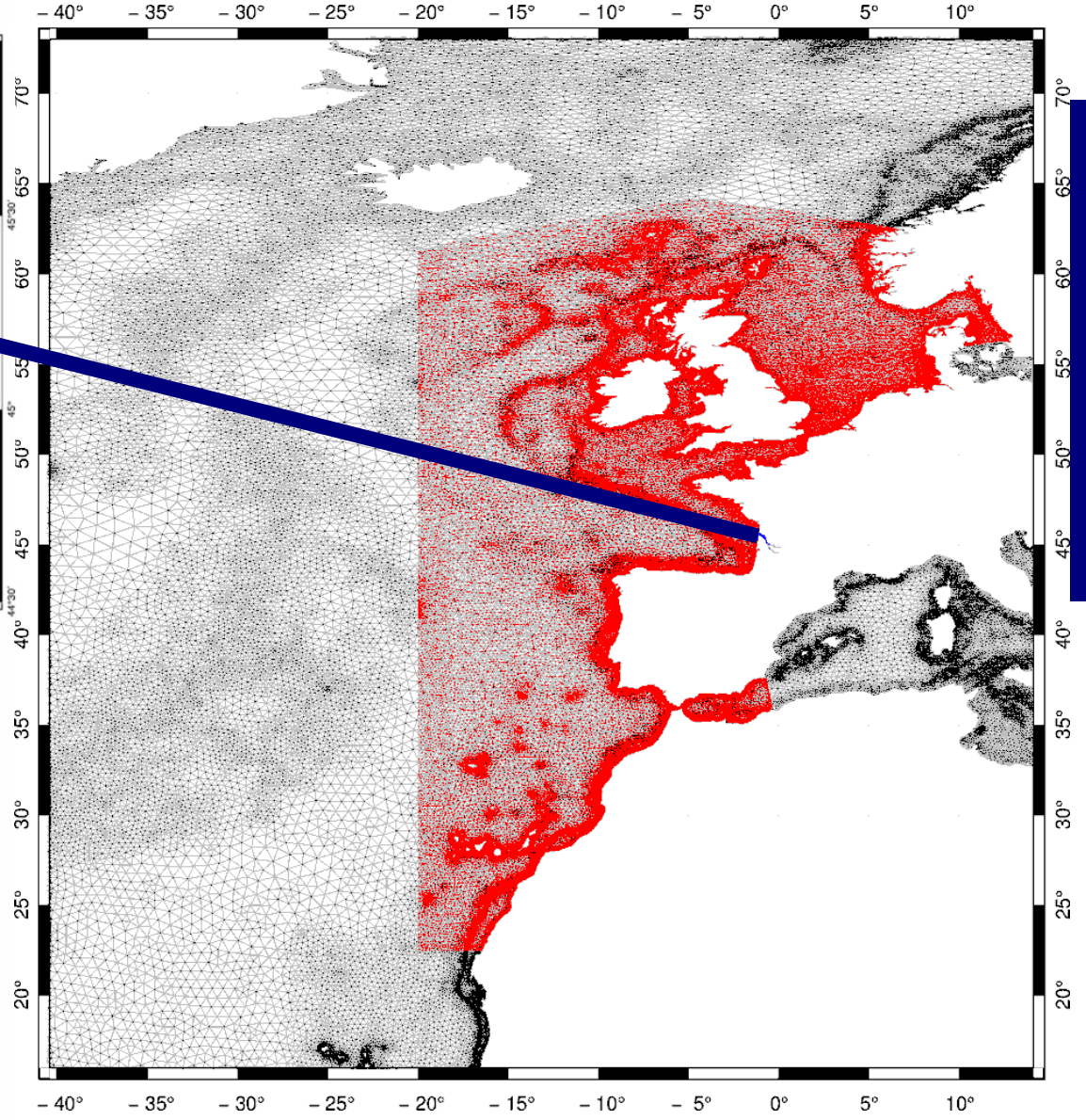
Estuarine hydrodynamic modelling: tides/river interaction





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Highly demanding configurations

- Estuarine dynamics specificities
  - Strongly non-linear
  - Tidal wave deformation/loss of harmonic approach efficiency
  - Strong currents (>>1m/s)
  - Rapid changes in free surface/currents
  - Tidal variability
  - Different upper/lower estuary regimes
  - Time varying bathymetry (sediment transport, maritime channels deepening)
  - Fluxes dominated by tides in the lower estuary (mean fluxes of second order)

- Upper estuary boundary conditions
  - Prescribed from observations at upper estuary limit:
    - Beyond tidal influence (river regime)
    - Inside tidal influence
  - Missing data in observations are a critical issue
    - Difficult to reconstruct tidal signal
    - Anthropogenic impact (water release from dams)

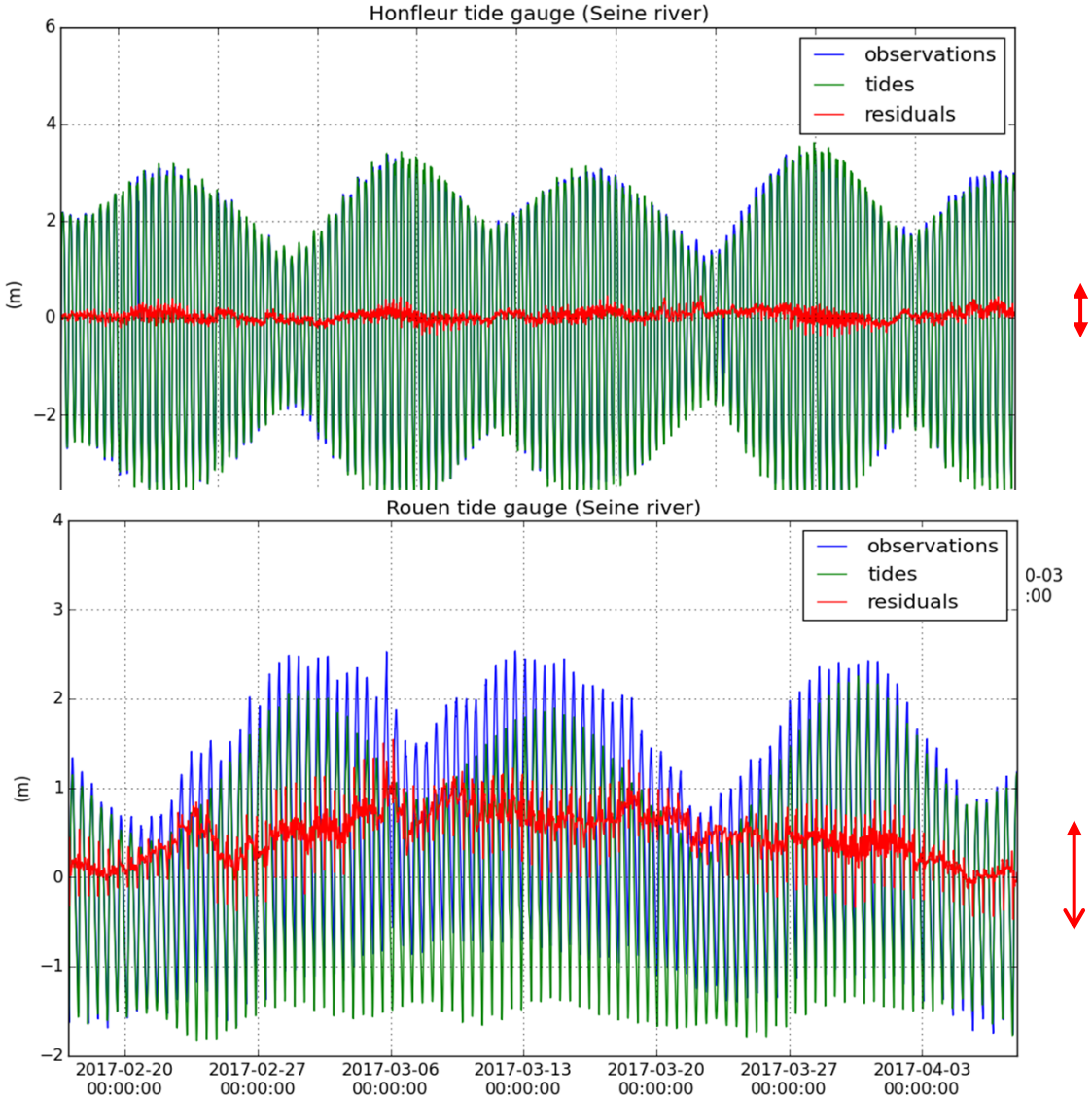
- Lower estuary boundary conditions
  - gravity waves prescribed from high resolution regional modelling (2D)
    - Provide a full non-linear tidal spectrum
    - Storm surges
    - Surface waves?
  - Hydrographic conditions from high resolution regional modelling (3D)

Tidal anomalies in estuaries

> **deficient harmonic method to analyze/predict tides**

> low tides not modified in spring/neap cycle

> **tide modulation by river discharge fluctuations (increase of tidal residual)**



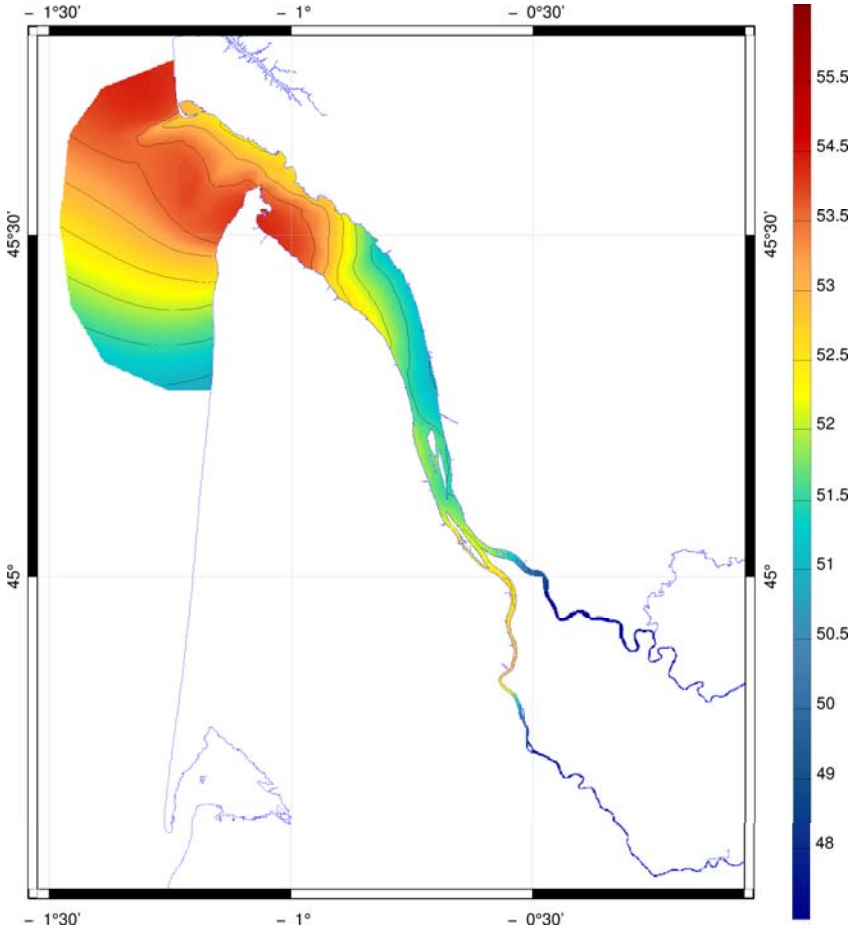
~10 cm Lower estuary (Seine)

~100 cm Upper estuary (Seine)

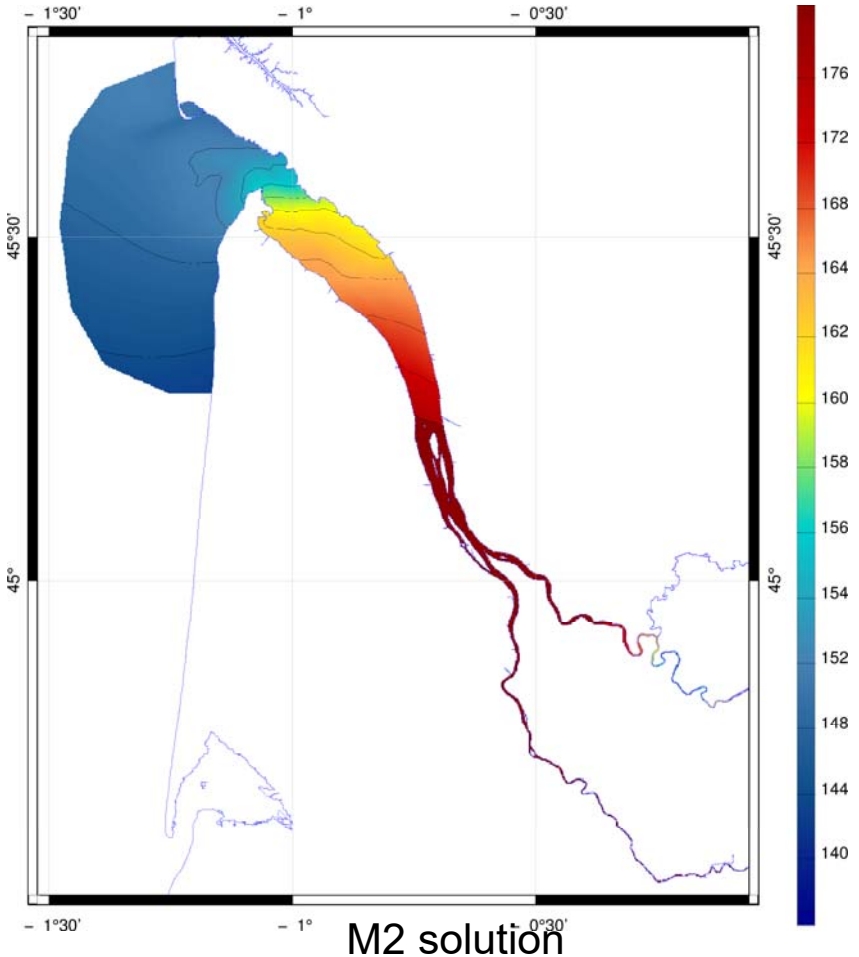
Tidal anomalies in estuaries

> **due to friction, M2 behave differently compare to other constituents**

> Minor constituents inference (spectrum extension) will fail



S2, (other semi-diurnals…) solutions
Amplitude (cm)



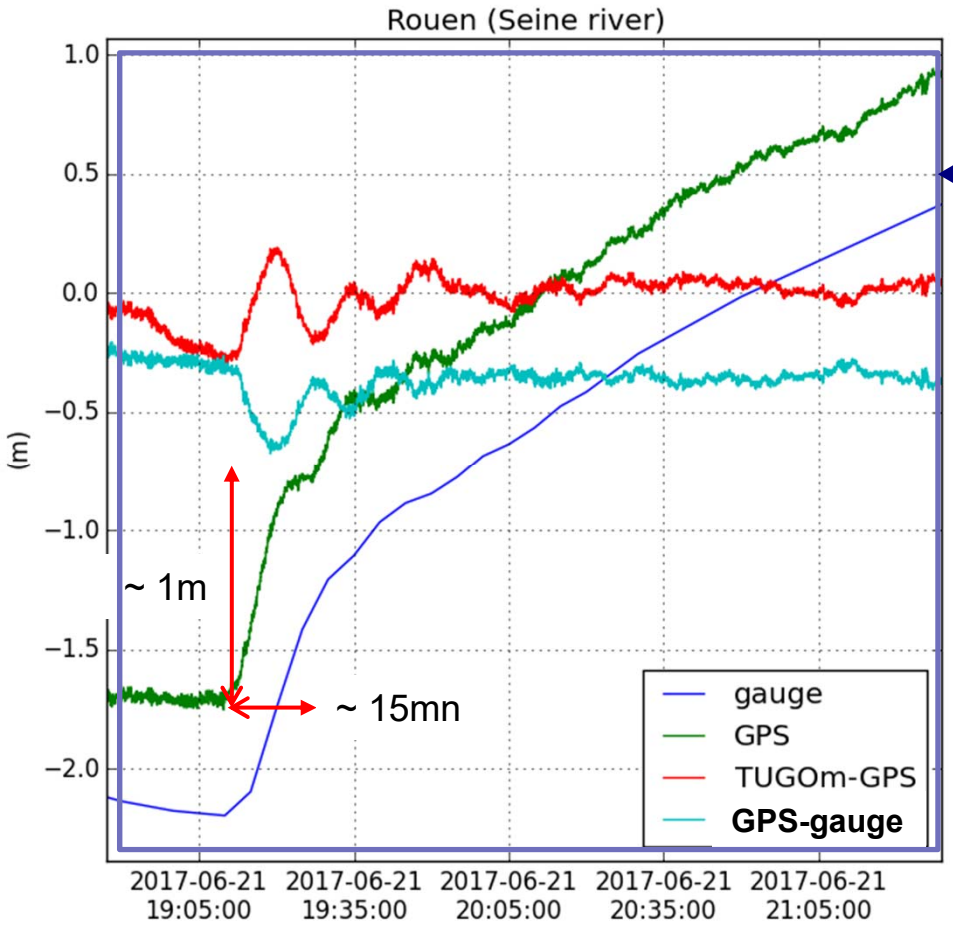
M2 solution
Amplitude (cm)

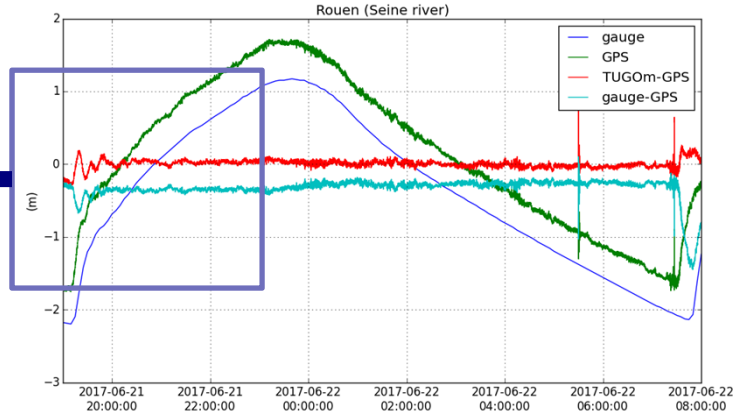
Tidal modelling accuracy

> rapid change of level at ebb/flood transition

> needs data assimilation (tide gauges)

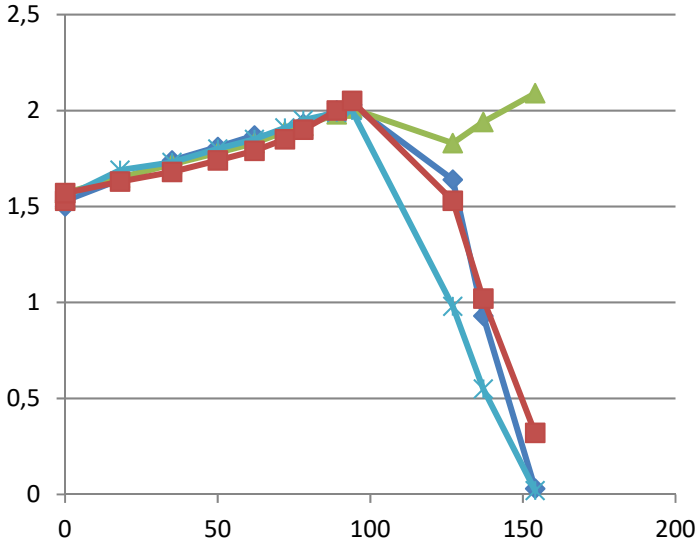
> with 1 mn time sampling (local resonance oscillation not captured at 5 mn sampling)

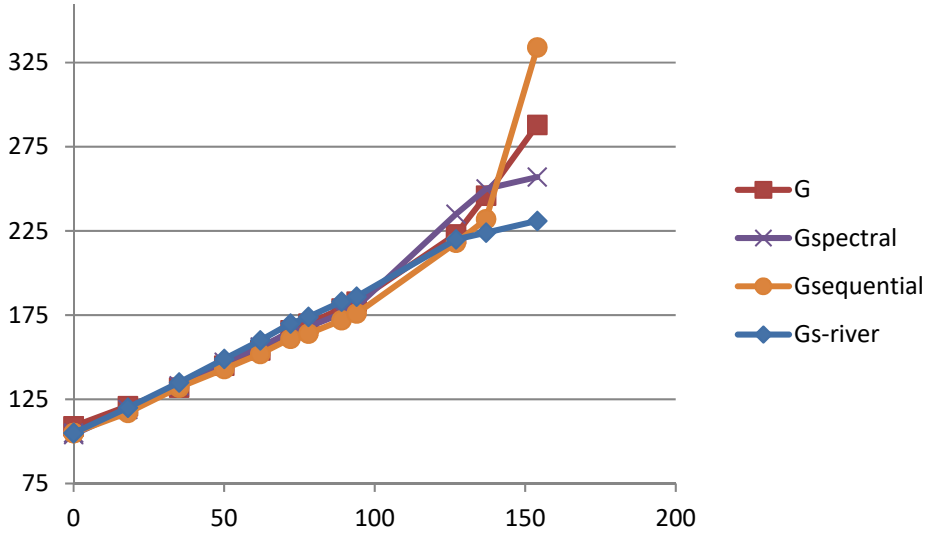




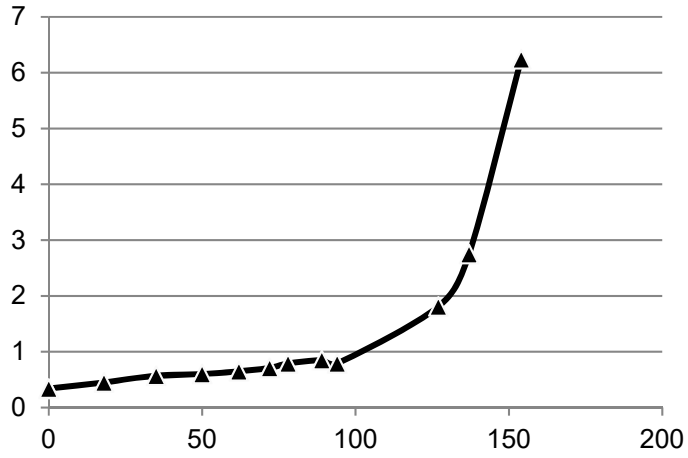
Upper estuary conditions (distorded tides):

- o tide gauge data assimilated in T-UGOm run
- o but… comparison with GPS buoy show a large misfit at flood start, including oscillations
- o due to tide gauge unsufficient time sampling





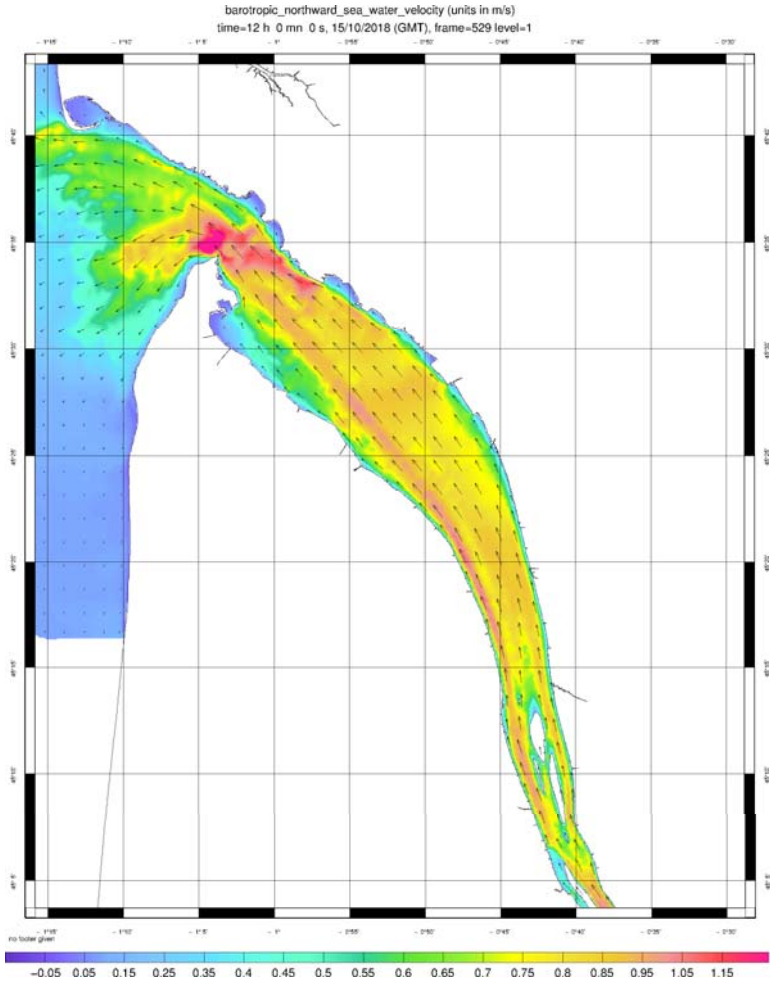
Mean free surface // geoid



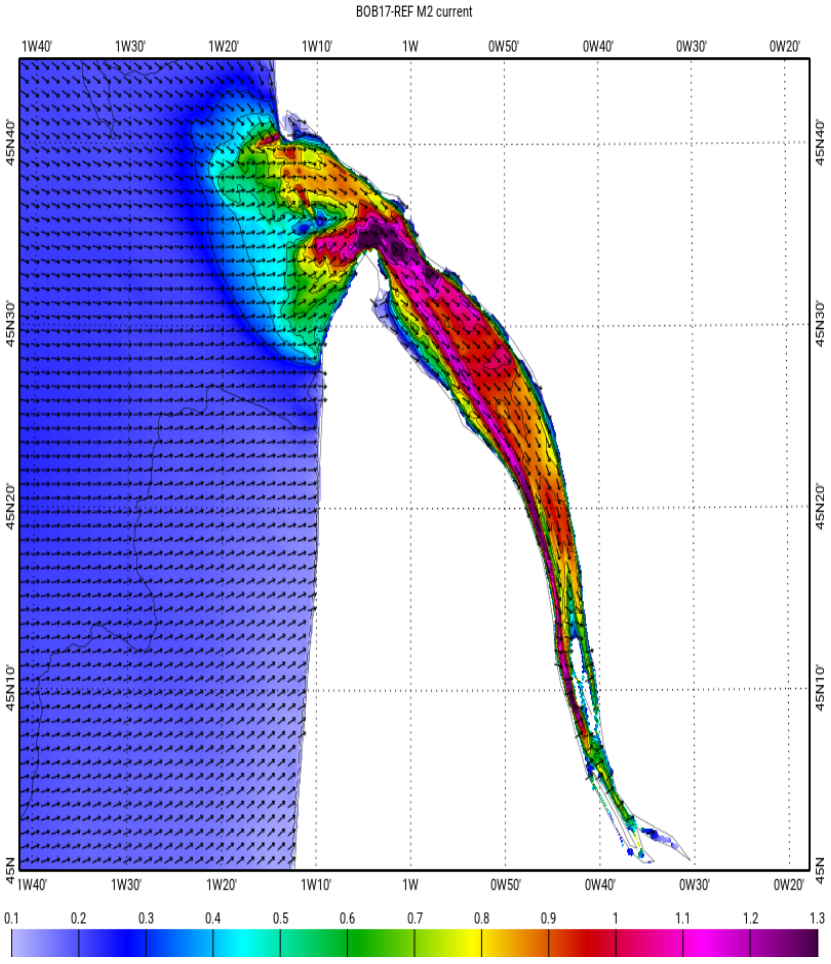
- River free surface slope and friction will damp tidal amplitude
- During flooding event, river flow will inhibate tides in the upper estuary (no more tidal reading in tide gauges during the event, no current reversal)

Across estuary variability: currents

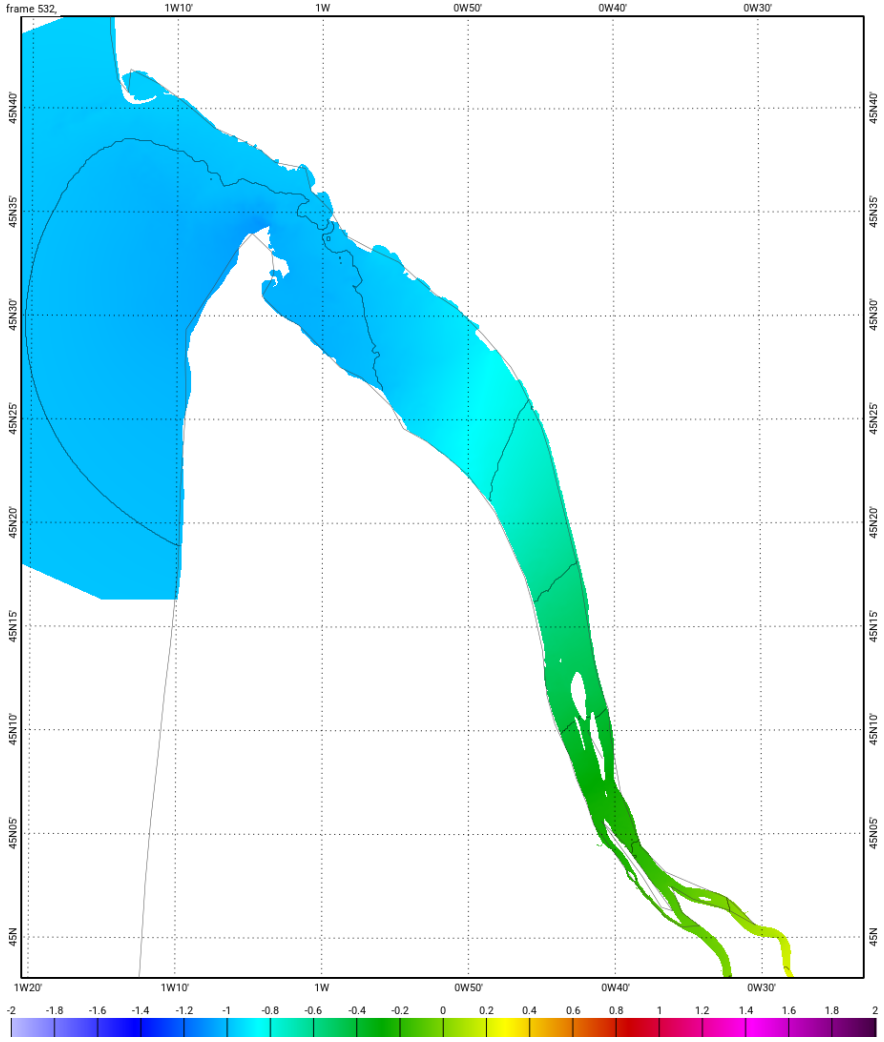
Unstructured 2D model (T-UGOm)



Structured 3D model (symphonie)



Across estuary variability: surface elevation



Are estuaries SWOT last frontier?

- Tidal signal analysis/prediction/assimilation
  - signal reconstruction needed for (river) open boundary conditions (and data assimilation)
  - data qualification
  - which data assimilation approach ? (fast, accurate)

- Tide gauges network consolidation
  - Improve reliability (continuous acquisition, accuracy, proper vertical reference)
  - **1 mn sampling**

- Ocean open boundary accuracy issue
  - Depends upon global/regional configurations
  - **SWOT should provide estuary application-compliant tides and storm surges (~1 km resolution, extensive non-linear tides spectrum, …)**

- Work load is high, manpower is low
  - Ocean to estuary scales efforts
  - We need more field campains (see P. Bonnefond talk)
  - **Need to put priority to fulfill ALSO science requirements, not only operational ones**
  - Resolution and complexity of systems are increasing, computational power too, but not available human brain time
  - Targets priority?