Coastal dynamics in the Bay of Biscay and in the Gulf of Tonkin

Nadia Ayoub et P. De Mey-Frémaux

with contribution from the COCTO project team

F. Lyard, M. Herrmann, G. Charria, P. Marsaleix, V. Piton, A. Ayouche, S. Barbot, F. Toublanc, M. Ghantous, T. Nguyen, S. Theetten, D. Allain, T. Duhaut

LEGOS, Toulouse, France

Laboratoire d'Aérologie, Toulouse, France

LOPS/IFREMER, Brest, France

USTH, Hanoi, Vietnam

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on behalf of the COCTO project team

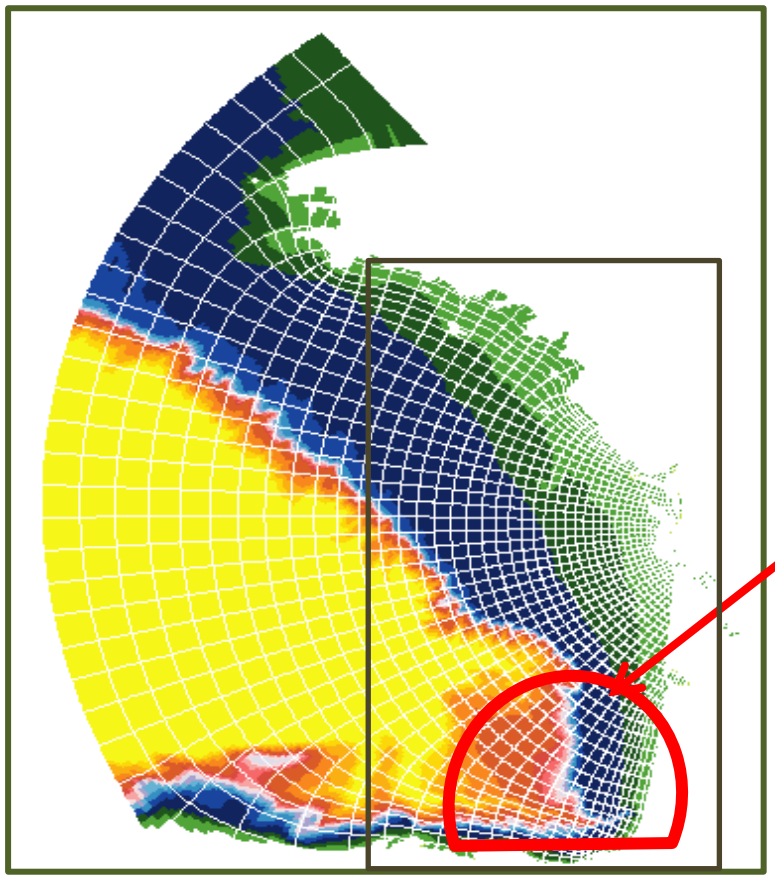
Objectives

- what are the **processes** governing : 1) **small-scale dynamics over the shelf**, 2) **plume dynamics**, 3) **cross-shelf exchanges** of water and heat ?
- what is the **signature in SSH** of these processes ?

Study based on numerical simulations + SWOT simulator

Observability of coastal circulation from HR modeling in the Bay of Biscay

Numerical **3D coastal model: SYMPHONIE** (Marsaleix et al., 2008, 2012)
variable mesh configuration, realistic forcing (Toublanc et al., Ocean Mod. 2018)



hourly outputs of a 2-year simulation 2011-2012

- detided SSH using harmonic analysis + 25-hour average
→ used to compute geostrophic currents

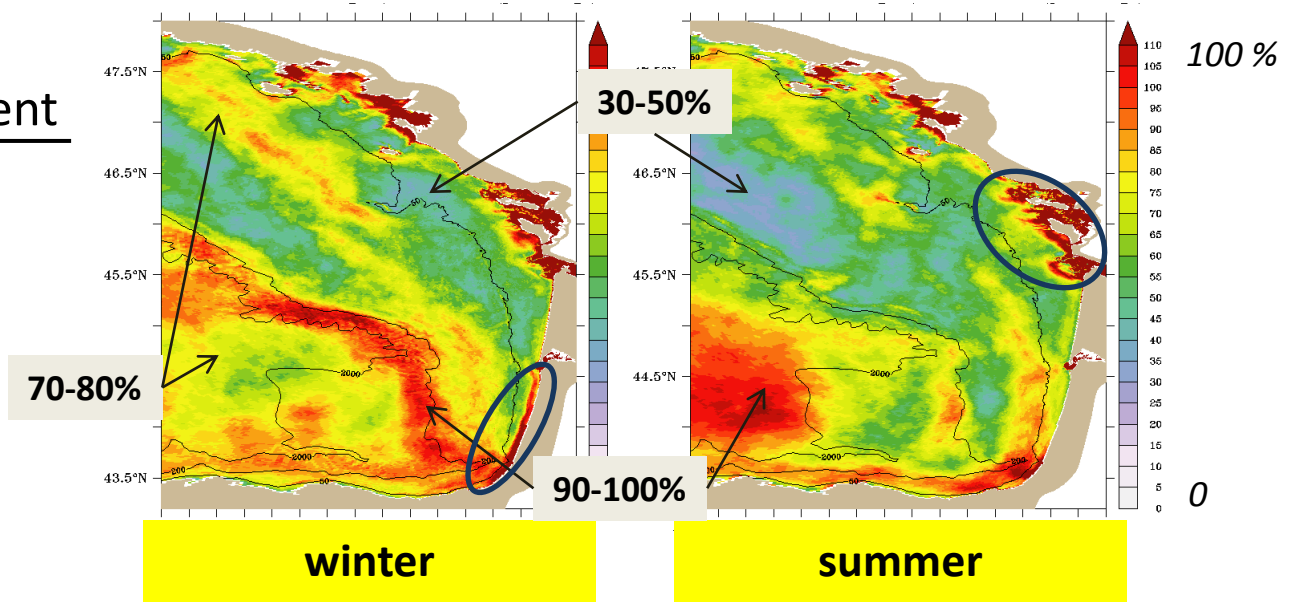
- surface current filtered with a 48-hour cut-off frequency
+ daily averages

comparisons with HF radar
in coll. with A. Caballero, A. Rubio (AZTI/San Sebastian)
& S. Mulet (CLS)
within Copernicus CMEMS project 'COMBAT'

Observability of coastal circulation from HR modeling in the Bay of Biscay

1. What is the geostrophic contribution to the surface current ?

$$\text{ratio} = \frac{\text{geostrophic current}}{\text{total current}}$$



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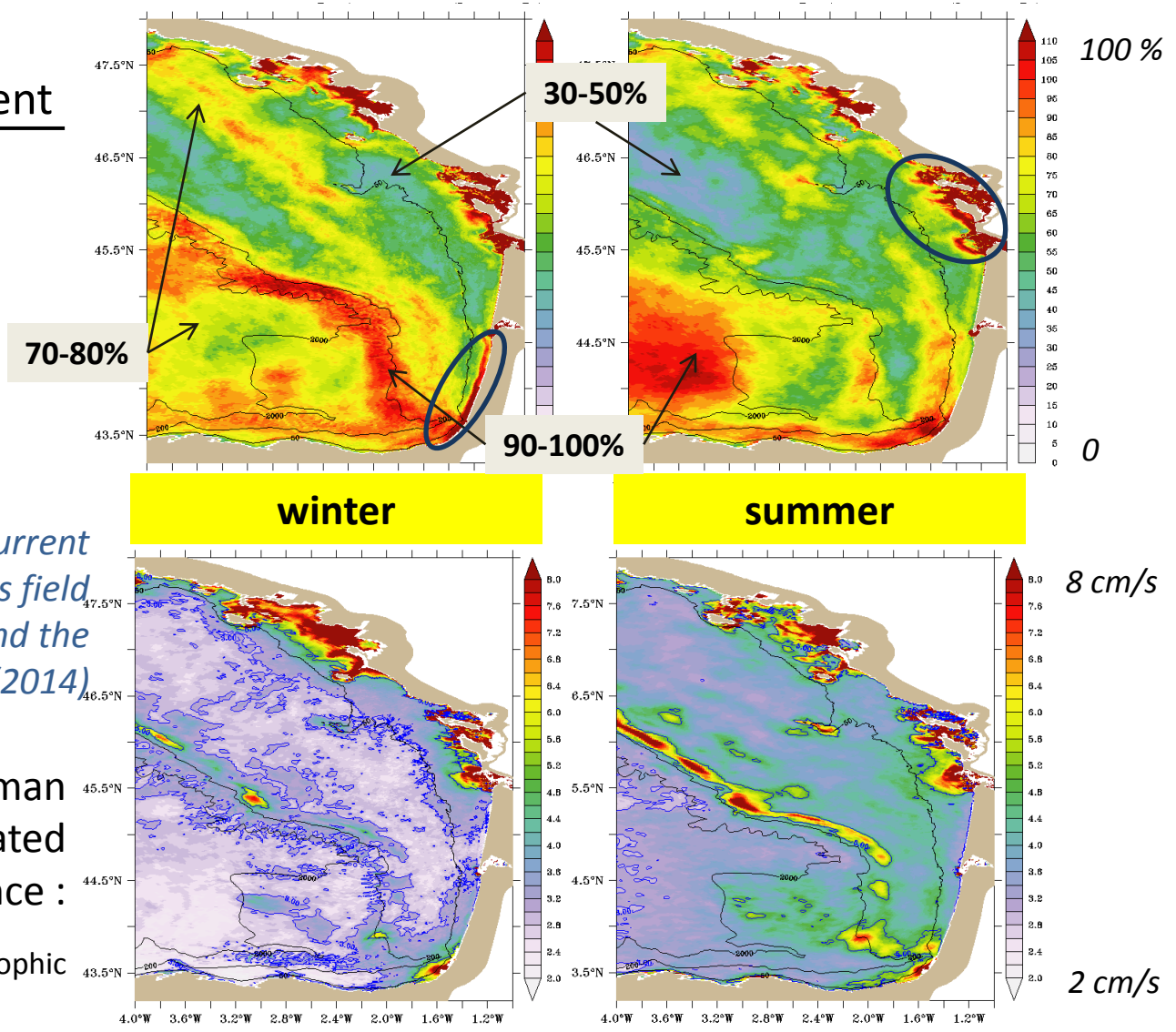


estimate the surface Ekman current from the ECMWF wind stress field used to force SYMPHONIE and the method of Rio et al. (2014)

RMS of the non-Ekman ageostrophic motion estimated as the difference :

$u_{Total} - u_{Ekman} - u_{Geostrophic}$

Small-scales instabilities in river plumes

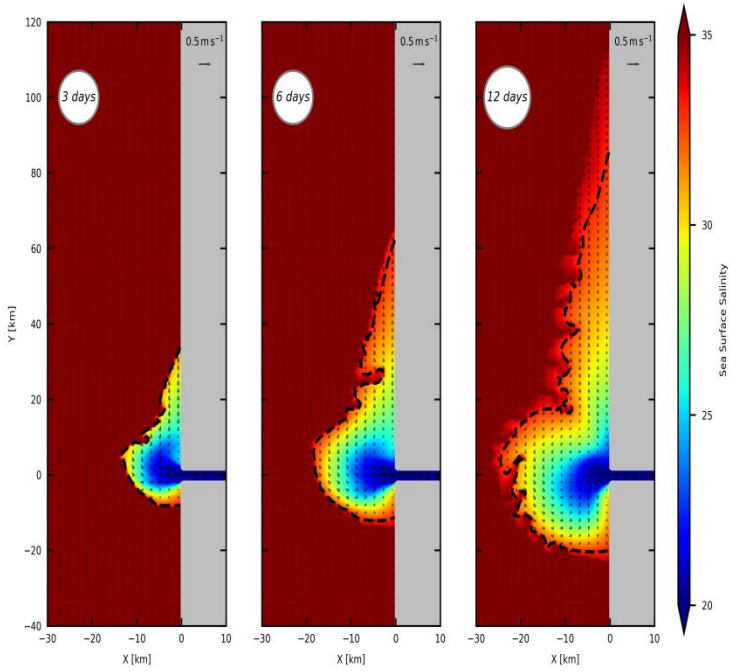
PhD thesis of A. Ayouche (work in progress)

Process study of the plume dynamics in idealized numerical experiments

- sensitivity of the plume to tides, wind forcing, shelf bathymetry
- analysis of the instabilities that develop at the edge of the plume

What is the signature of such processes in SSH ?

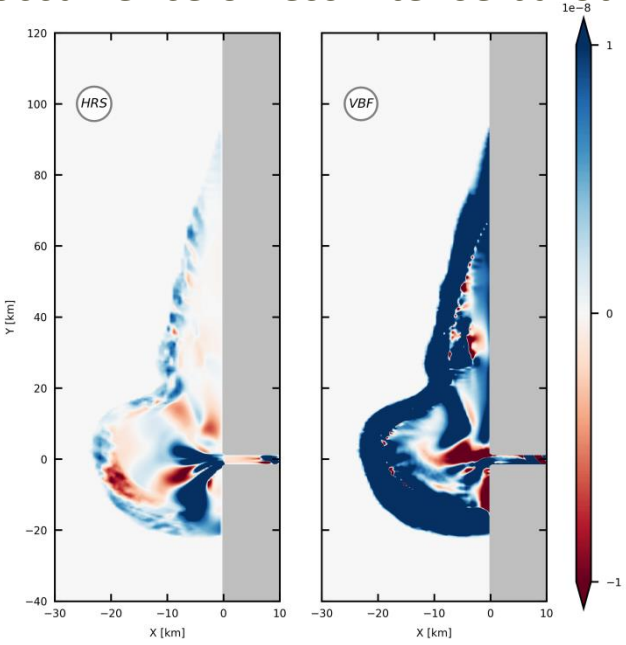
Mean sea surface salinity



CROCO/ROMS model (500 m) in an idealized configuration

at the edge of the river plume:

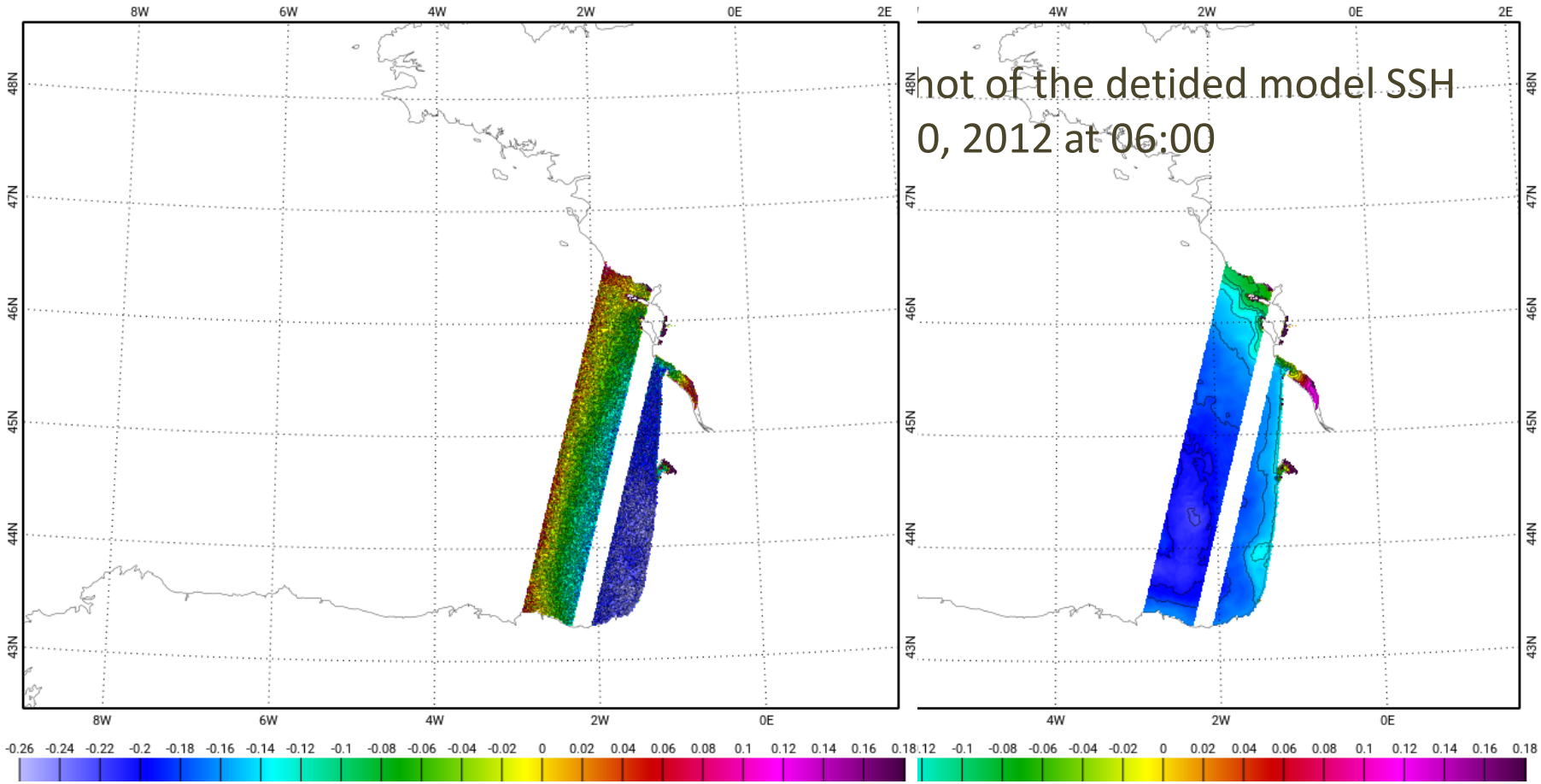
- development of small-scale baroclinic instabilities
- occurrence of less intense barotropic instabilities



Energy transfer (Horizontal Reynolds Shear Stress - HRS - and Vertical Buoyancy Flux - VBF)

Observability of coastal circulation from HR modeling in the Bay of Biscay

2. What would be seen by SWOT ?



hot of the detided model SSH

0, 2012 at 06:00

-26 cm

18 cm

Observability of coastal circulation from HR modeling in the Bay of Biscay

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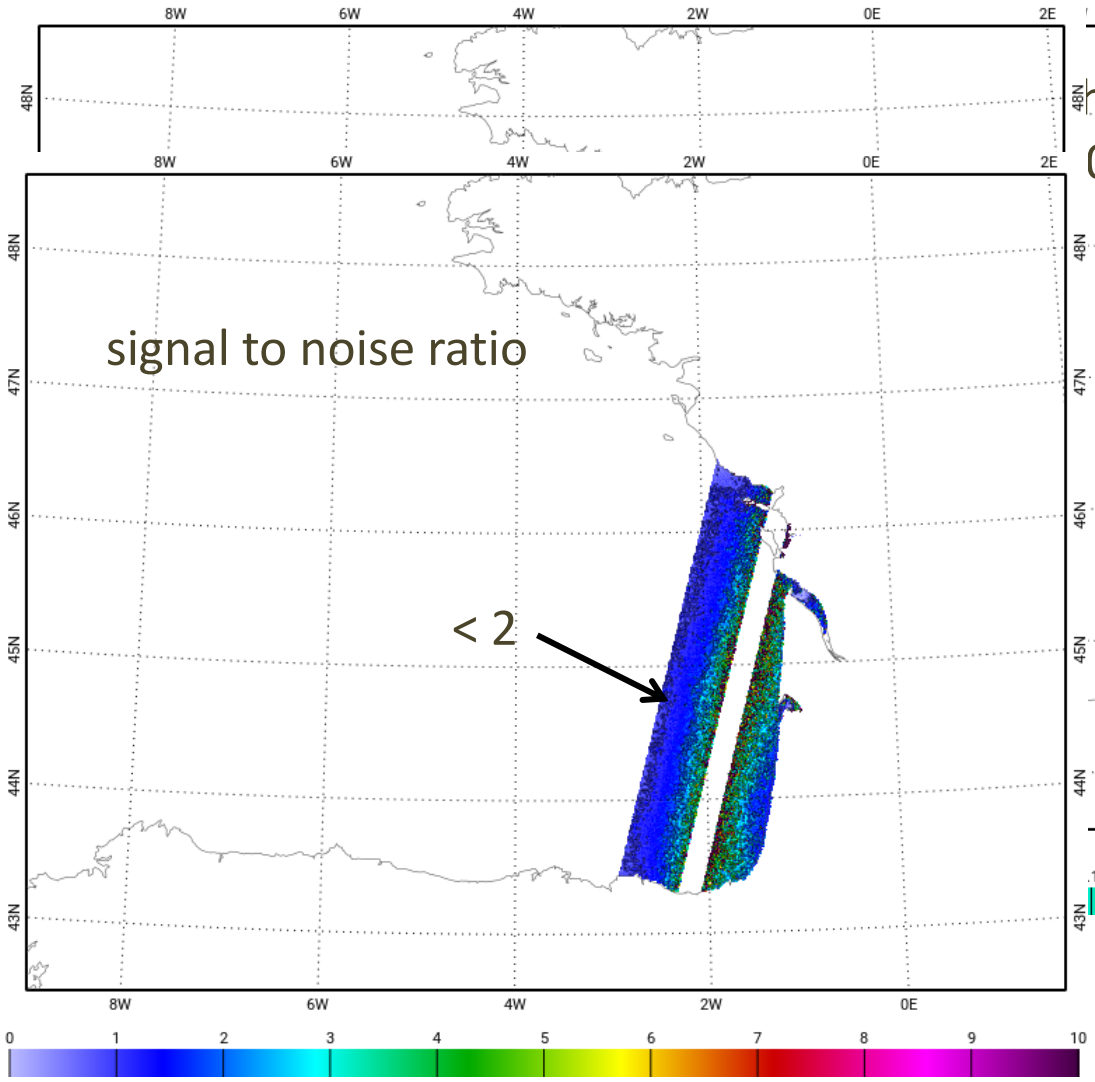

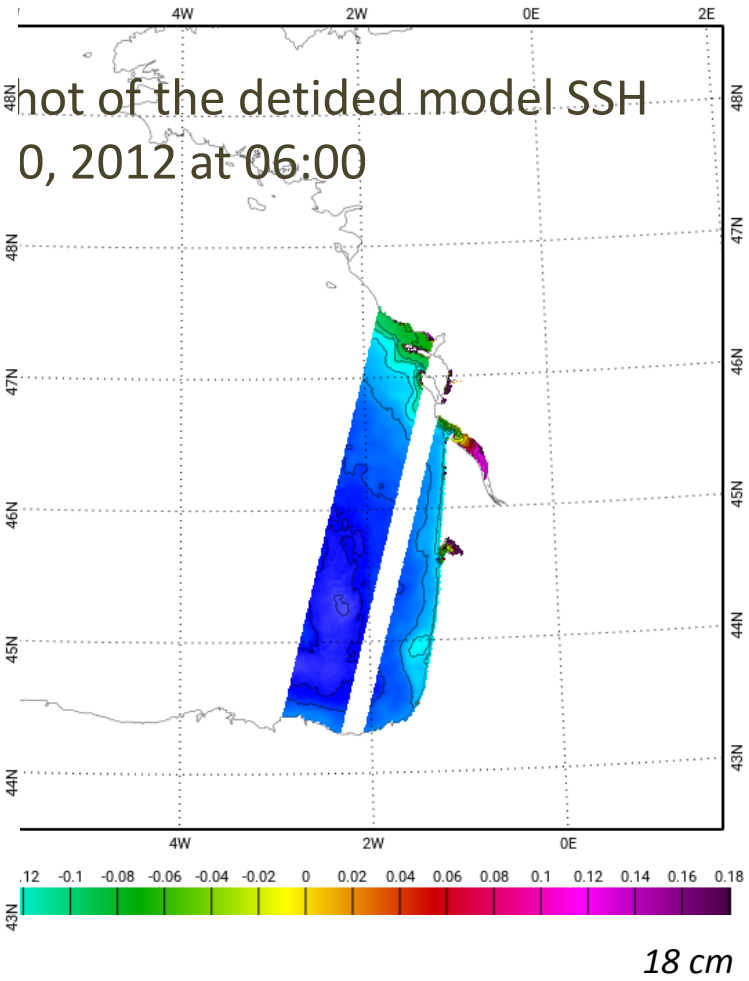

Observability of coastal circulation from HR modeling in the Bay of Biscay

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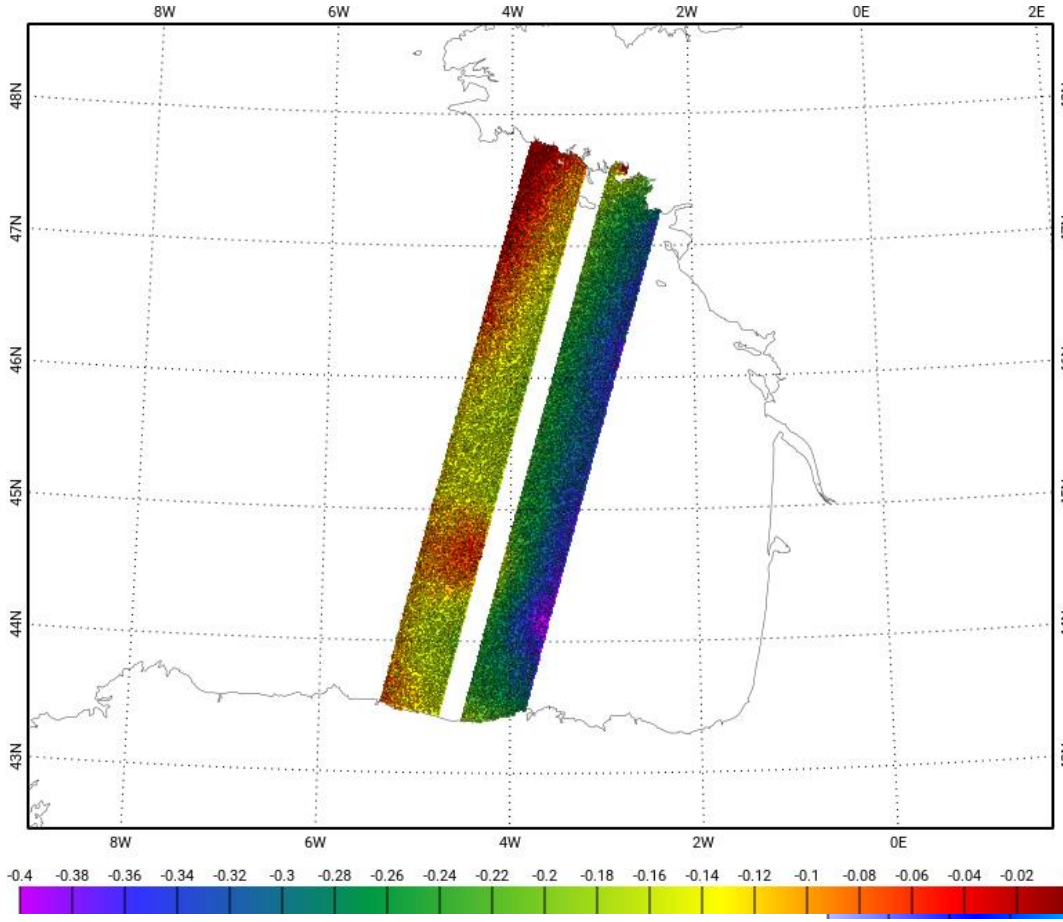
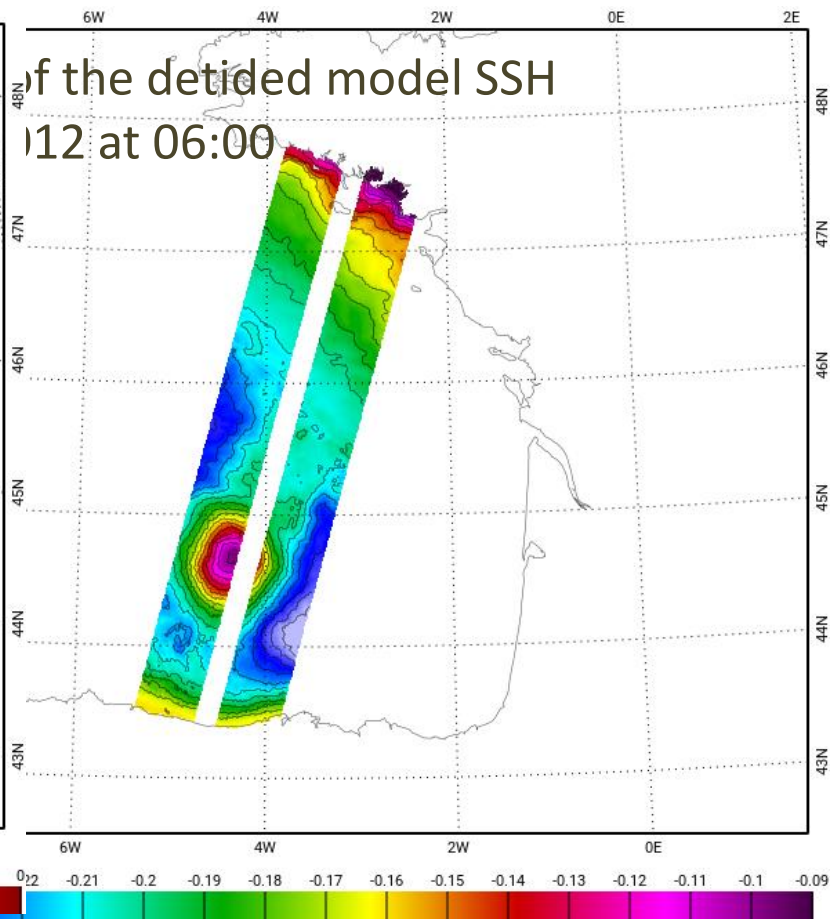


-26 cm



9 cm

Observability of coastal circulation from HR modeling in the Bay of Biscay

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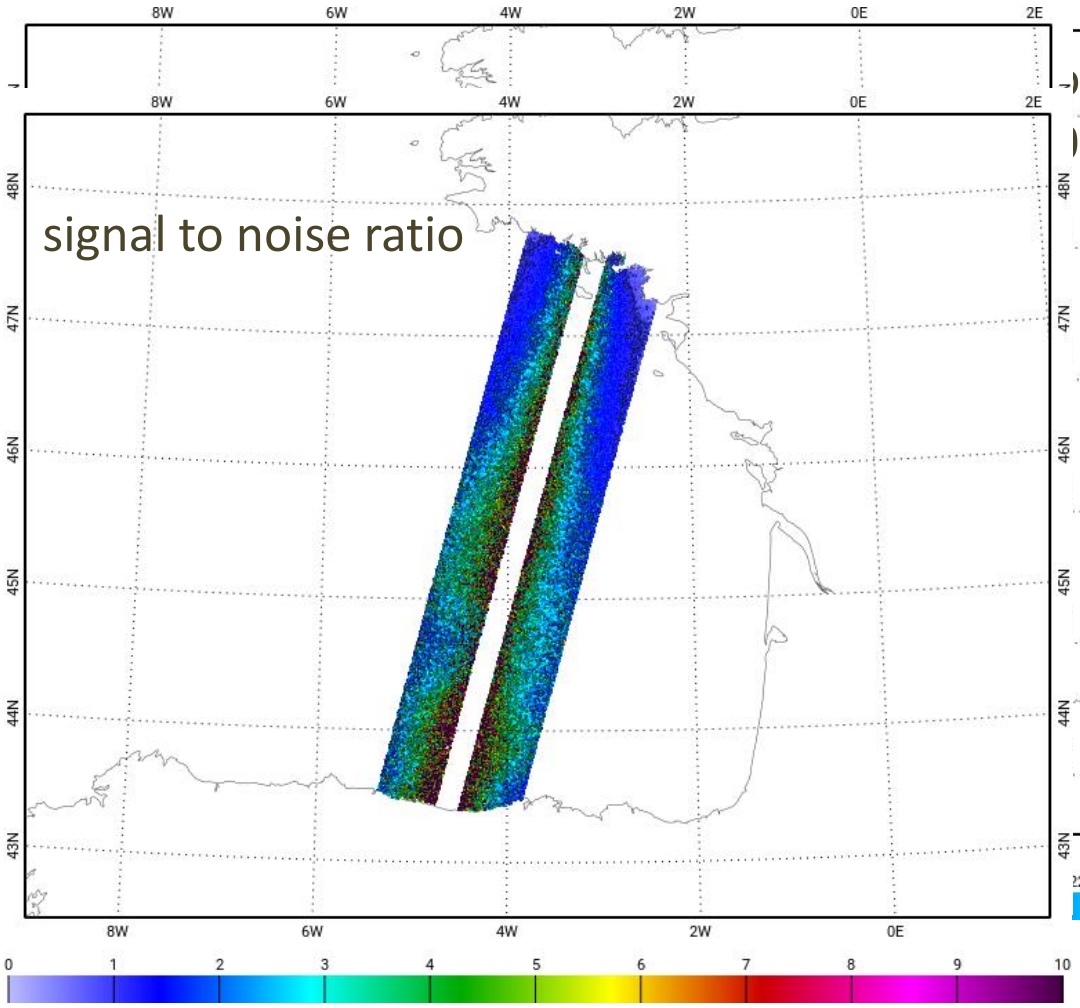

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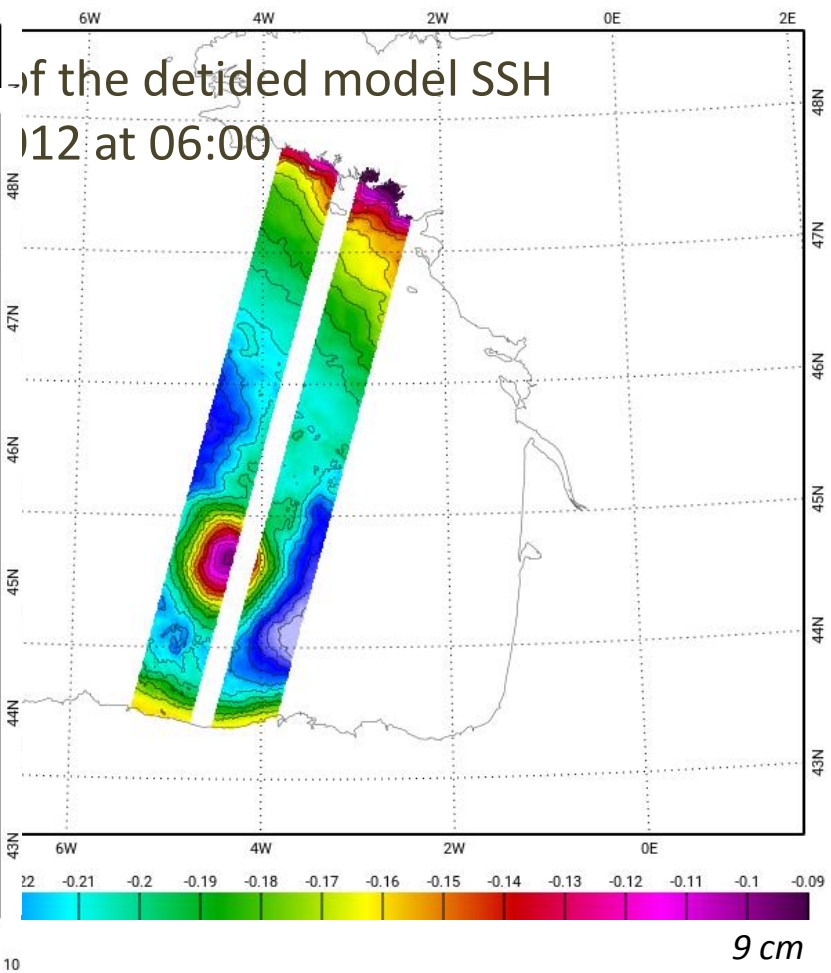


9 cm

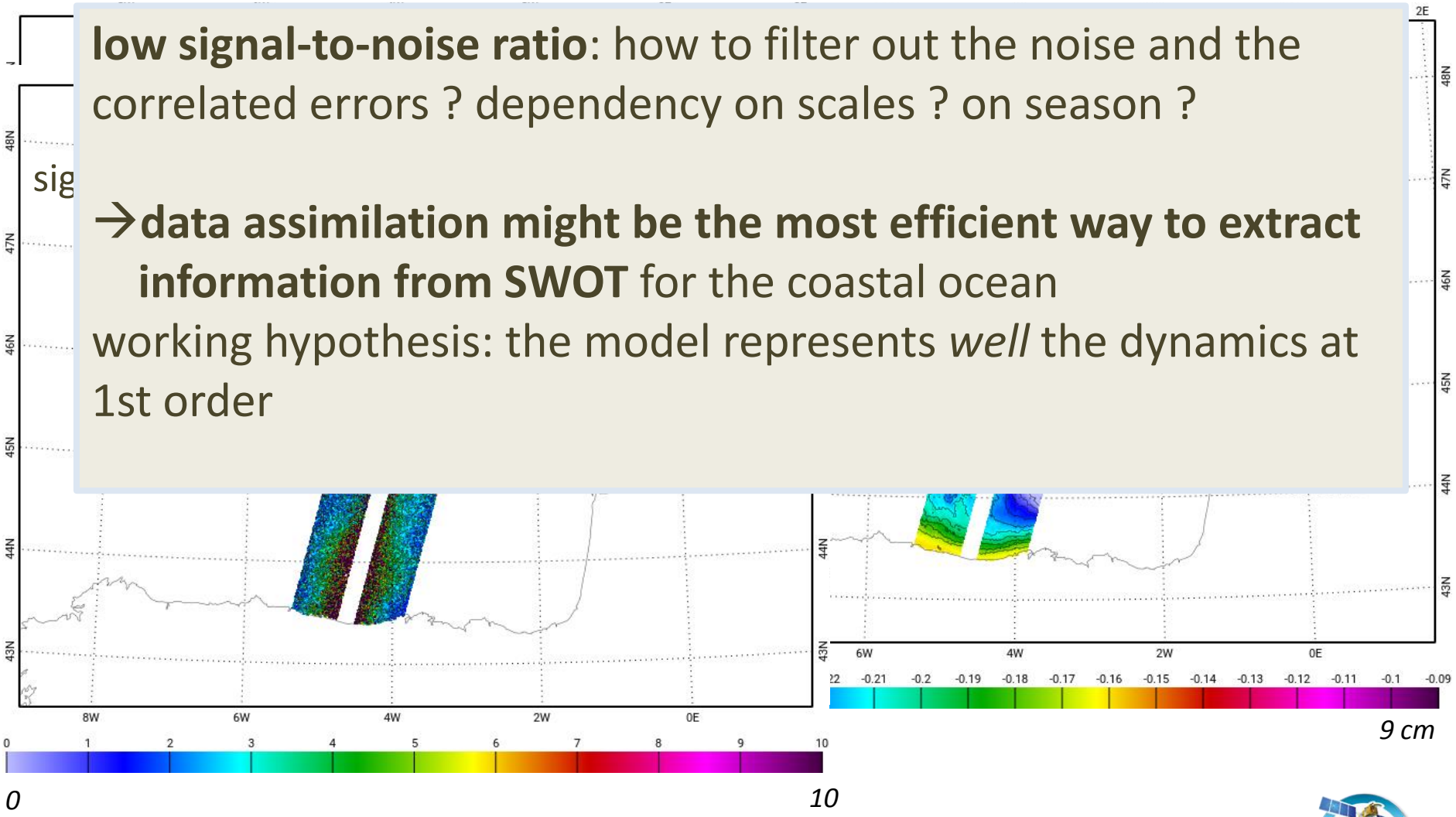
Observability of coastal circulation from HR modeling in the Bay of Biscay

2. What would be seen by SWOT ?

low signal-to-noise ratio: how to filter out the noise and the correlated errors ? dependency on scales ? on season ?

→**data assimilation might be the most efficient way to extract information from SWOT** for the coastal ocean

working hypothesis: the model represents *well* the dynamics at 1st order

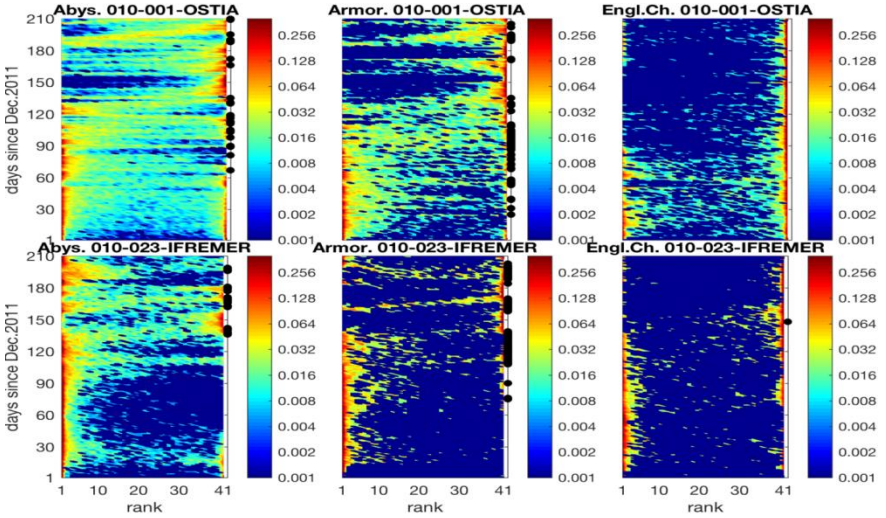


Uncertainties quantification and data assimilation

- **Quantifying the model uncertainties** is essential to specify the model errors in DA
- **Ensemble generation** for coastal models : complicated by the need to take into account **small spatial scales and high-frequency processes**
- Other complications due to **downscaling** errors
- SWOT data will be useful to **verify the model uncertainties estimated from ensembles**

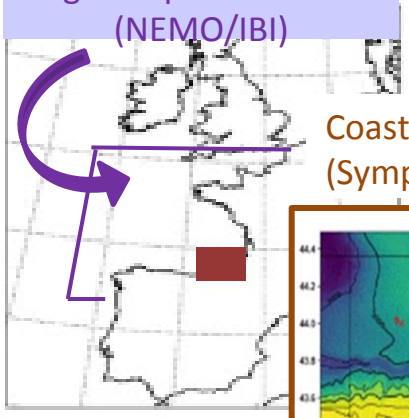
Empirical validation of SST uncertainties (ensemble variance) using satellite obs.

Talagrand diagrams

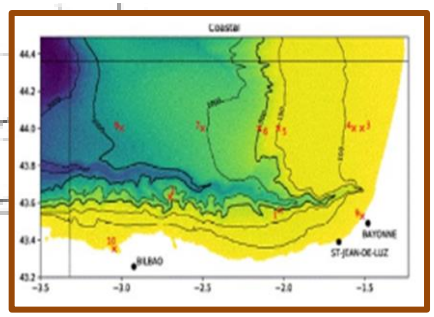


Vervatis, De Mey, Ayoub et al., in revision

Regional parent model (NEMO/IBI)

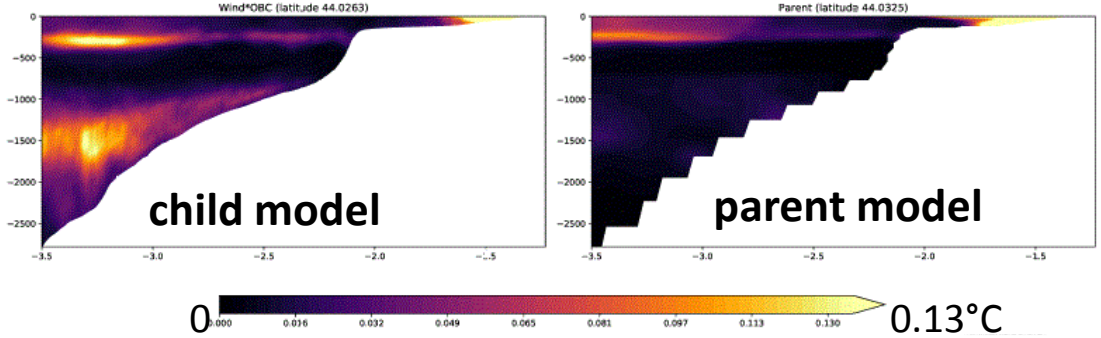


Coastal child model (Symphonie) 500mx500m

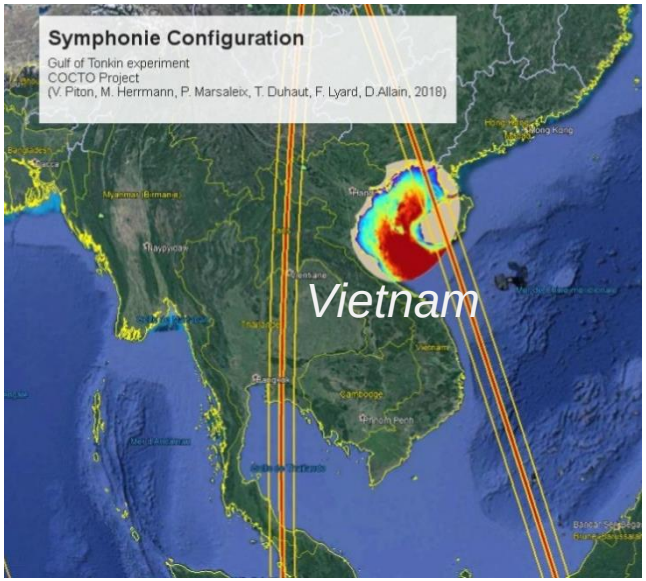


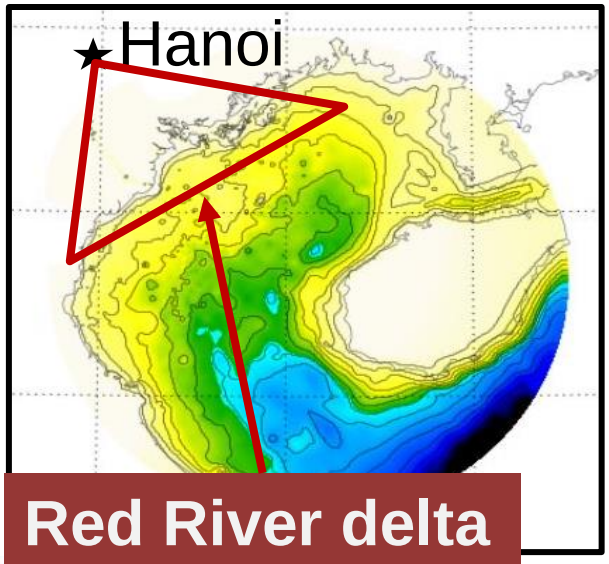
Spread in temperature at 44°N from a 50-member ensemble

Ghantous, et al, in revision



2. Hydrodynamics in the Gulf of Tonkin and lower Red River delta





LOTUS

V. Piton (PhD), M. Herrmann, P. Marsaleix, S. Ouillon

- **shallow** shelf seas (max depth < 80m)
- **macrotidal** area
- **Red River delta** irrigating a **crucial socio-economic area**
- **many factors of natural variability**
- highly populated area with **major societal issues**

- ➢ Study of the coastal circulation variability from daily to interannual time scales
- ➢ Focus on the Van Uc river (one main branch of the delta): water and matter transport
- ➢ Use of the coastal Symphonie model and T-UGO model for tides

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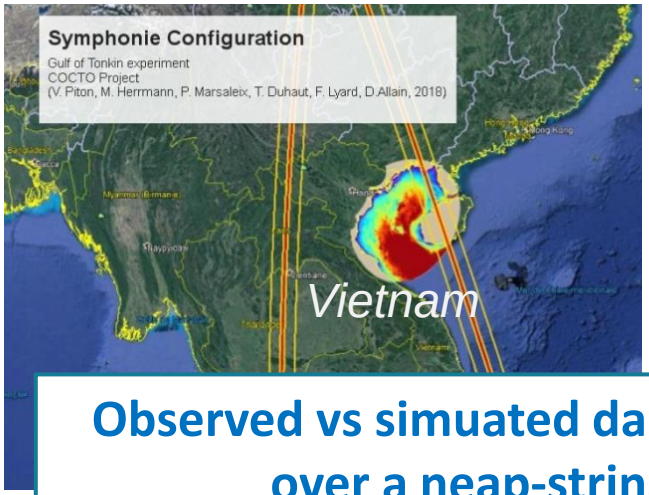
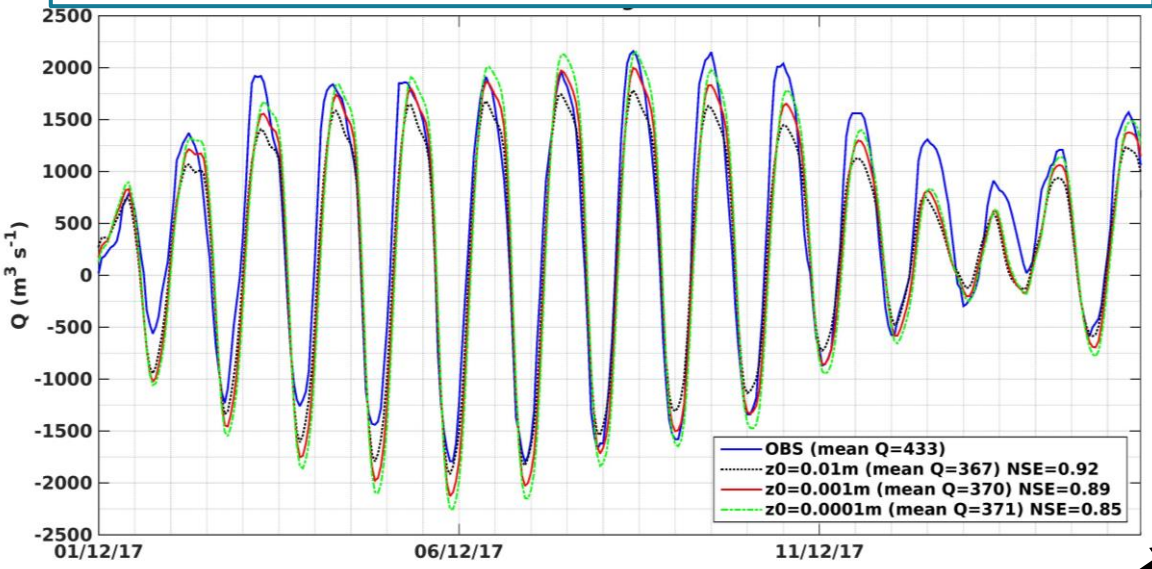
Tidal hydrodynamics in a branch of the Red River delta



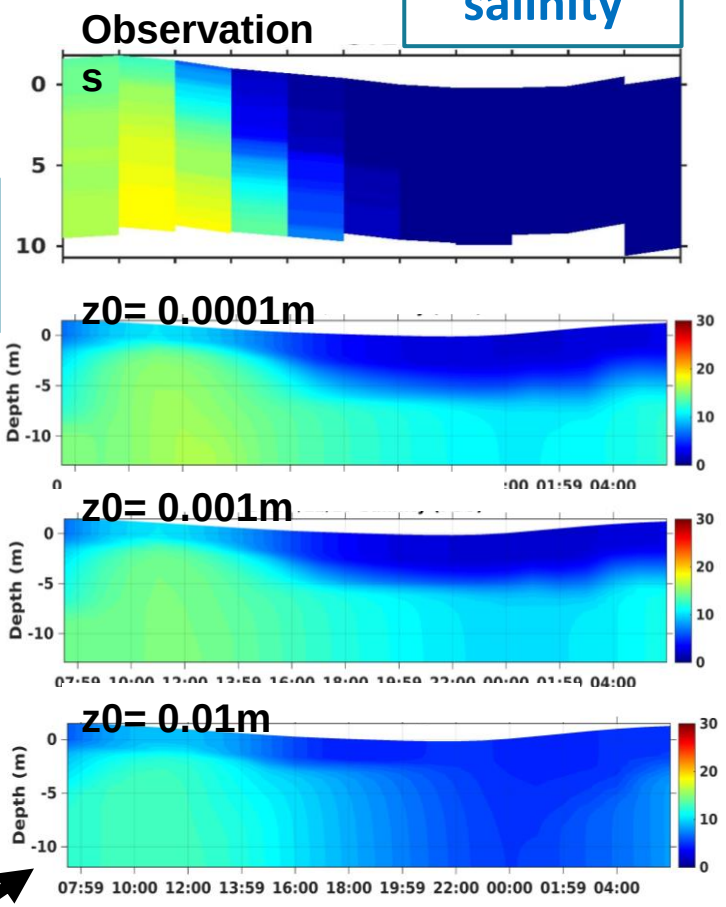
LOTUS

V. Piton et al. in revision, 2019

Observed vs simuated daily water discharges over a neap-string tidal cycle



salinity

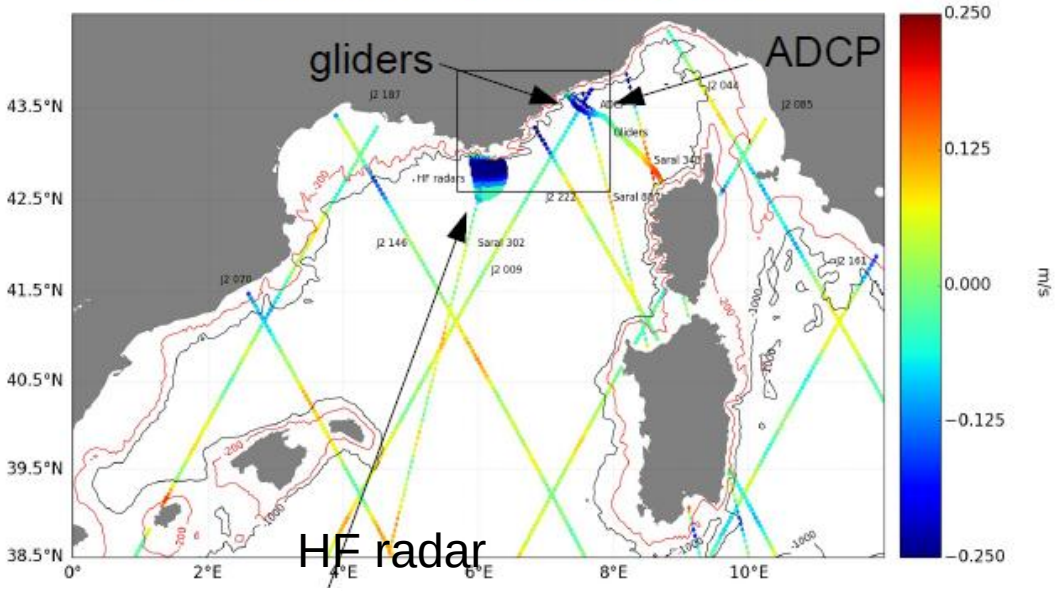


Van Uc branch of the delta

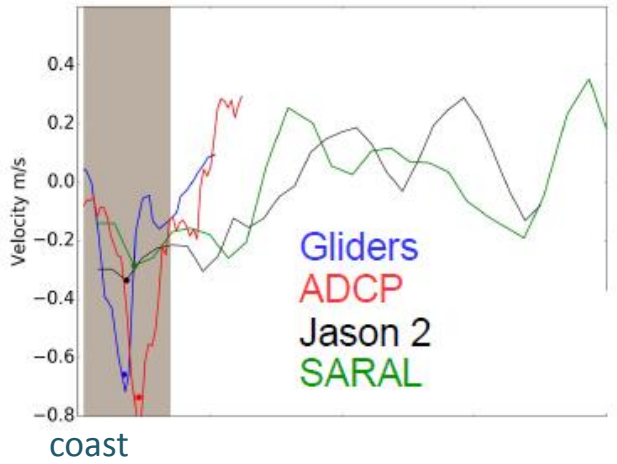
Large sensitivity of the salinity intrusion in the delta to the model parameterizations (here bottom friction)

Coherence and complementarity of in situ and altimetry observations in the North-Western Mediterranean Sea

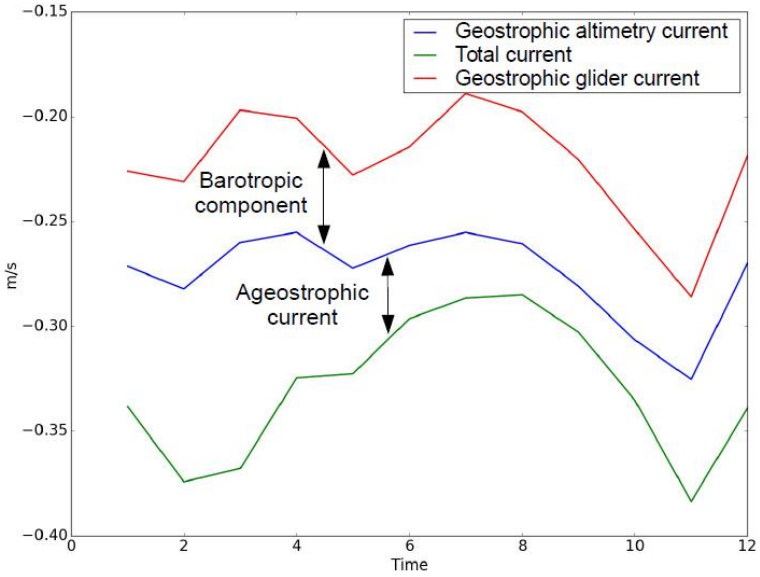
Mean current during a common period



Along-shore current in spring (m/s)



Analysis of the differences between the North Current estimates from the different data sets based on the SYMPHONIE model outputs



- Differences in the seasonal average → 0.06 m/s for the barotropic component ; 0.03 to 0.1 m/s for the ageostrophic component
- Seasonal variations in the differences

Carret et al., 2019

Concluding remarks – work so far

In this project: the Gironde estuary and lower Red River delta are considered as part of **a continent-ocean continuum → single modelling paradigm**

Gironde estuary and lower Red River delta: tides and hydrodynamics

- **complex 2D & 3D model configs** (bathymetry, shorelines, runoff, bottom friction..)
- **tides and river flow interactions** → asymmetric, non-stationary tidal signals
- impact of tides on **salinity intrusion** (potential critical issue for ecosystem & population)
- impact of stratification and hydrosedimentary processes on dynamics ?
- → **need of accurate tidal modelling in the estuary and intertidal zones**

Small scale dynamics over the shelf in the Bay of Biscay and Gulf of Tonkin

- **large ageostrophic contribution** to the surface current
- **seasonal variability of the observability** of the circulation
- **impact of tides on the plume and interaction with the small-scale dynamics** over the shelf and shelf-break → leads to HF signals that impact the observability
- **Sensitivity studies and state estimation based on ensemble methods** + use of simulator have already brought insightful complementary results but must be continued.

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Outlook

- Dual site approach (Gironde+Red River) fruitful; might consider other sites via collaborations
- Plenty of work still remains to understand coastal continuum processes (e.g. previous slides) and their observability with SWOT
- Tidal signal must be considered together with rest of dynamics
  - This makes DA complicated; need to revisit DA in that context
- In coastal regions, we don't know yet if SWOT data will be able to validate models, or if models will allow understanding of SWOT signals – or (more likely) both!
  - Towards a synergistic "SWOT" + "HR modelling" integrated framework
  - "Quantitative" (stochastic, error-qualified) modelling approach to validate/invalidate hypotheses on processes (assuming we get reliable error estimates for SWOT)