SWOT issues and questions in the Coastal-Estuary-River continuums

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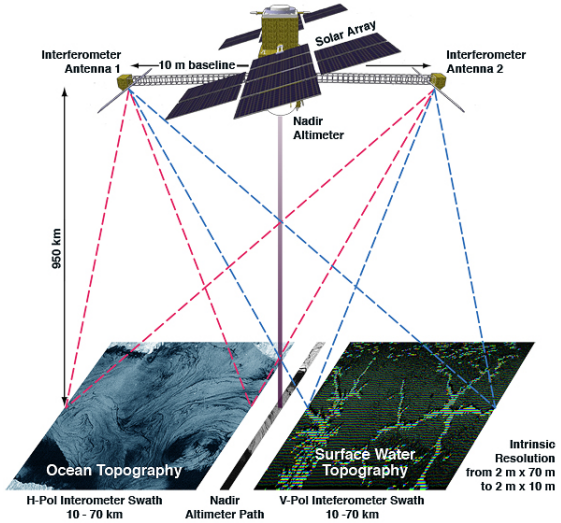


Coastal zones (including estuaries & deltas) : Definition

Definitions of the coastal zones:

The coast can range from a few hundred meters to several kilometers on either side of the land-sea interface : shelf, nearshore zone, coastline & river mouths (estuaries & deltas)







The coastal zones & river mouths = environments with geomorphological, sedimentary, hydrodynamic & biological contexts very diverse & complex

estuaries, deltas, bays, shelfs, rocky coasts with cliffs, beaches with sand (with dunes or not), gravel, pebbles or mud…, & the wetlands (mangroves, coastal marshes, swamps…)

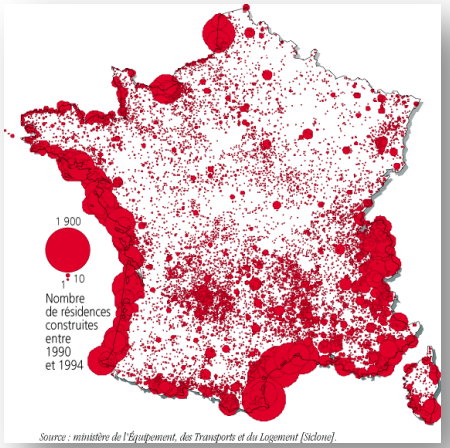
Difficult balance between economic and ecological issues

= Among the most productive ecosystems on the planet, regulate water flow & mass (i.e., nutrient, carbon, salt), filter pollutants & contaminants

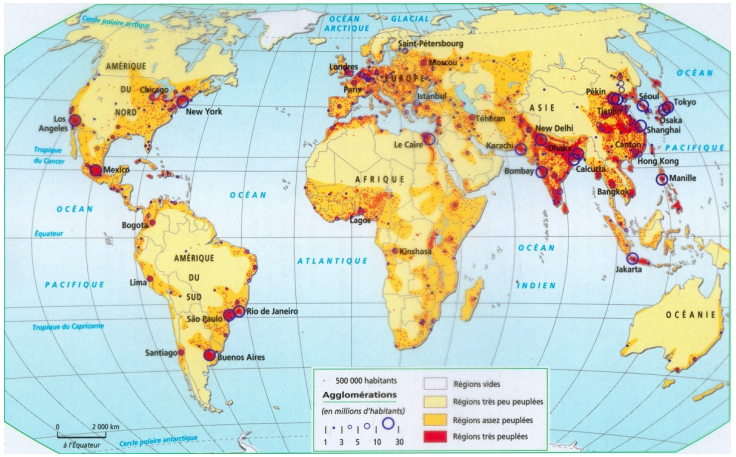
Human impact & Climate change

These environments = among the most affected by human impact & climate change

High urbanization & strong harbour, industrial & tourism activities
➔ pollutions, changes of flow, morphology & sedimentation



Population density in coastal regions: 3 times higher than the global average



Climate change = these are the most vulnerable regions

to the sea level rise, storm surges & river floods ➔ increase of disasters: inondations & shoreline retreat

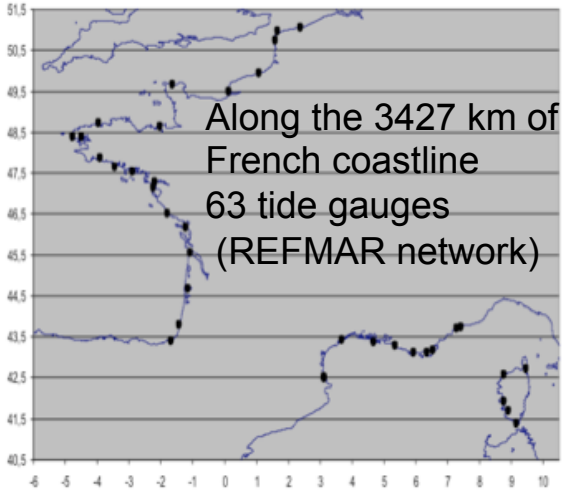
Complex hydrodynamics

Coastal & estuary zones (location at the land-sea interface)
➔ large variations of water level,
in connection with hydro-meteo-marine phenomena:
offshore currents, wind-driven shelf circulation & waves, tides, storm surges, sea level rise & inputs from streamflow & groundwater

⬇

Combined effects of these complex phenomena
on the spatial and temporal variation of water levels
& their impacts on inundations & coastal morphological evolution
not well known & difficult to model
because of:

- sparse in situ observations of water levels
- tide gauges are located in sheltered areas (harbours)
- the effects of the phenomena and their interactions are different according to the morphology, sedimentary & climate contexts



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Spatial variability of the hydrodynamic is generally studied by numerical simulations (i.e., modeling), along with dedicated field studies of specific regions & processes

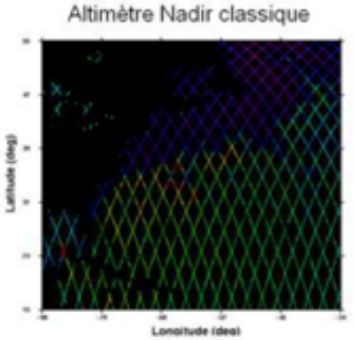
Contributions of satellites and SWOT to study the hydrodynamics in the coastal and estuary zones

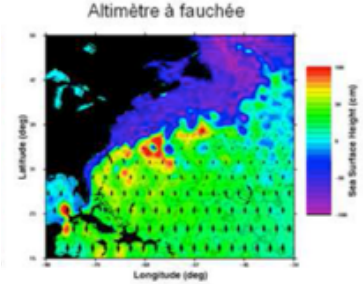
Remote sensing observations can provide critical information on the spatial variability of water surface elevations under different hydrodynamic conditions

But radar altimeters encounter many problems in the coastal environments:

- a rapid degradation of the data accuracy when approaching the coast
- nadir altimeter missions have an inter-track spacing which limits their ability to map smaller-scale features in the coastal zone

(shelf tides, coastal tides, the effect of winds and storm surges, etc…)



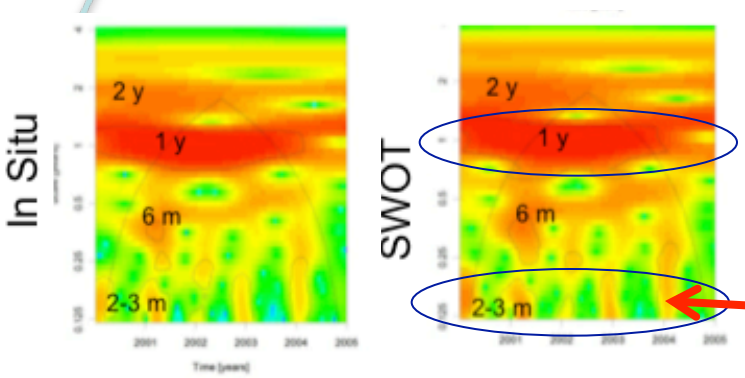


SWOT SAR-interferometric altimeter: higher spatial resolution & excellent global coverage ➔ resolve the problems of the conventional altimeters & fundamental data:

- to map the spatial variability of water surface elevations under different hydrodynamic conditions & at different scales (local, regional and global)
- to validate & calibrate our models (SWOT data assimilation in models)

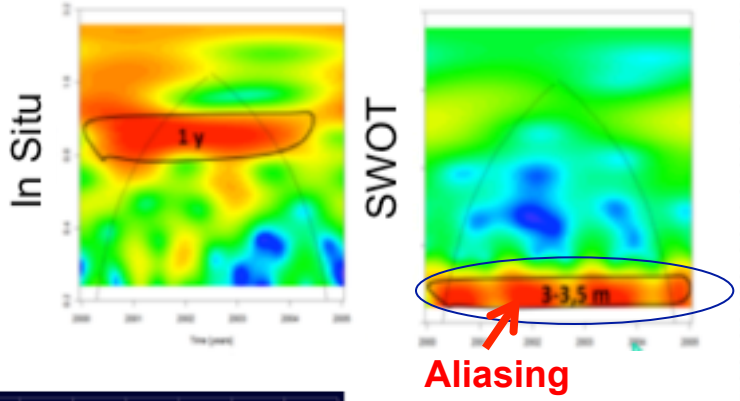
➔ to improve our knowledge of the complexity of the physical processes & their interactions in the coastal & estuarine systems

Main results of the previous studies on SWOT use in the coastal & estuary zones (2013-2015): macrotidal contexts

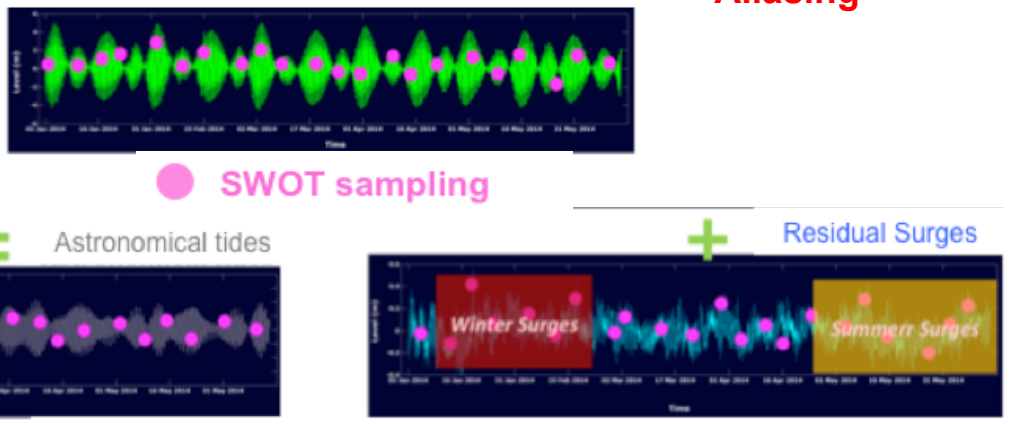


SWOT ability to reproduce the annual & seasonnal hydrological variability (flood periods) in the river & upstream estuary

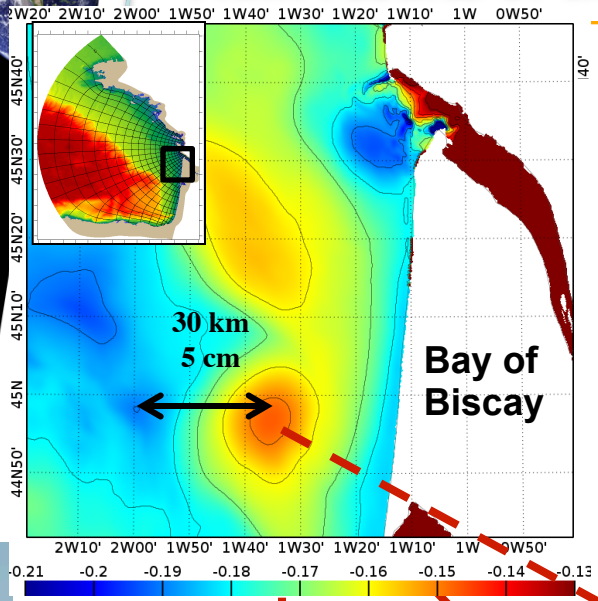
In the downstream estuary & coastal zones difficulties to reproduce the annual & seasonnal hydrological variability because of the aliasing phenomenon between the passage frequency of the satellite & ternary component of the tide



After tide filtering: SWOT can record a part of the hydrodynamics in relation with storm surges



Main results of the previous studies (2013-2015): Coastal Ocean



Daily mean sea surface elevation (m)
August 2012

Identification of coastal structures linked to plume-circulation interactions
(SYMPHONIE circulation model)
Calculation of the associated geostrophic currents

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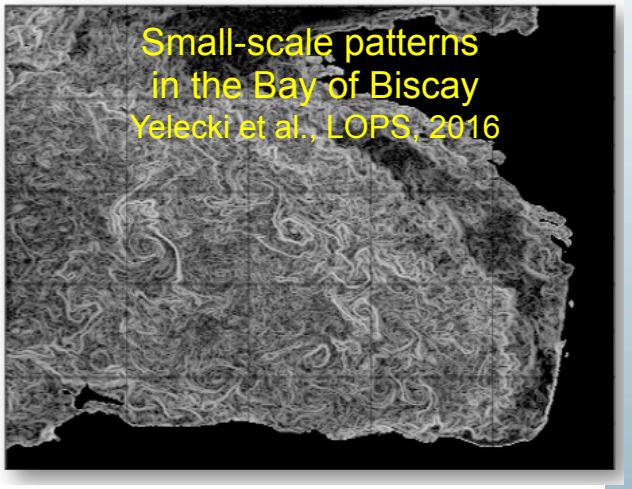
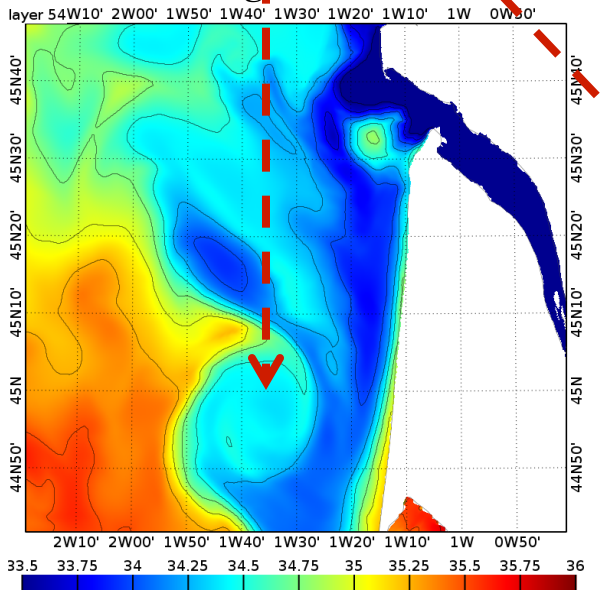
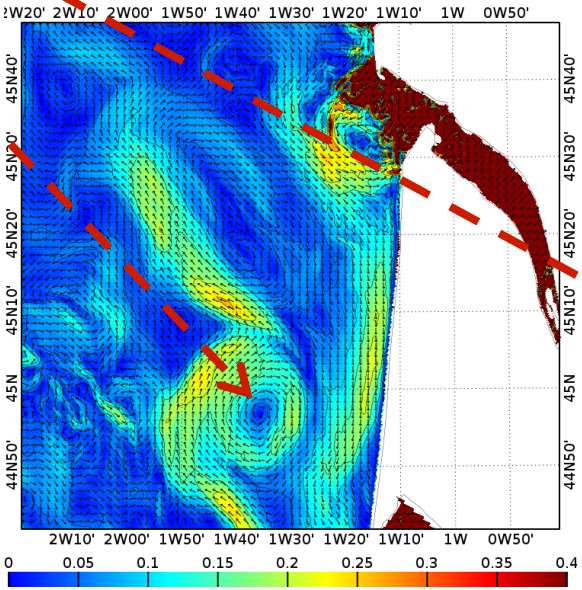
Importance of SWOT resolution to see these structures



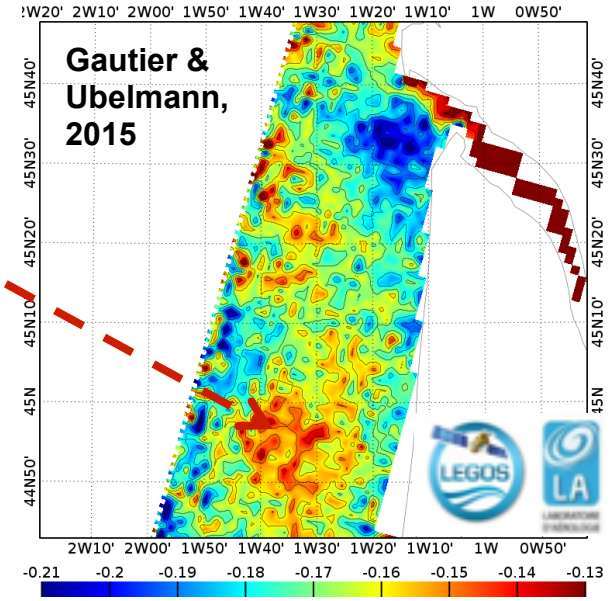
F. Toublanc et al., 2016



Daily mean sea surface salinity (psu)



Geostrophic currents calculated from the ssh gradient (m/s)



Results from the SWOT simulator(m)

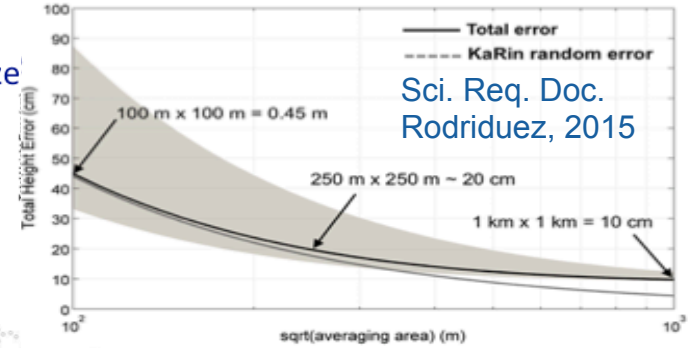
Main results of the previous studies on SWOT use in the coastal & estuary zones (2013-2015)

The hydrodynamics modeling in the estuaries, coastlines, bays & shelfs :
Water levels are spatially highly variable in different hydrodynamic conditions & in specific condition

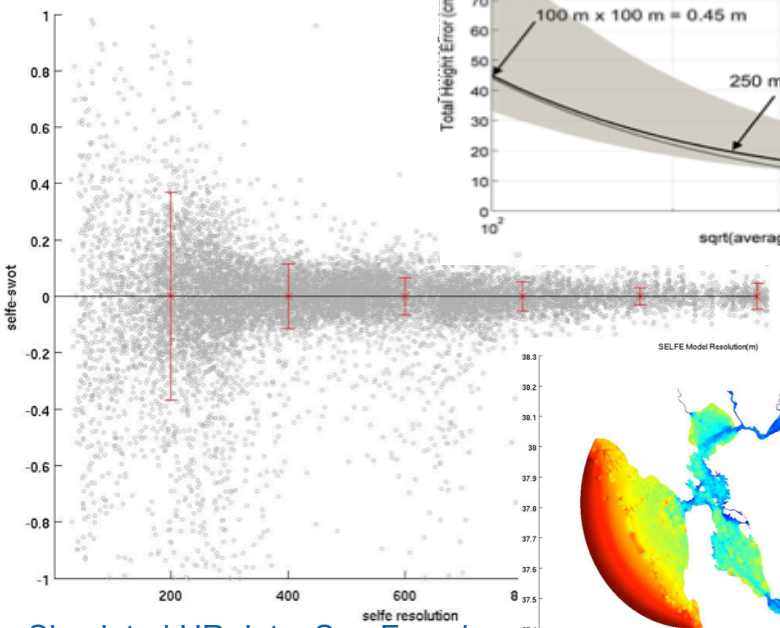
➔ Importance of the high spatial resolution of SWOT to observe these transitions & better understand & model these spatial variations

➔ Resolutions of 100 m in estuaries & 250 m in coastline, bay & shelf seems the best compromise between the spatial resolution & vertical precision to observe the major physical processes

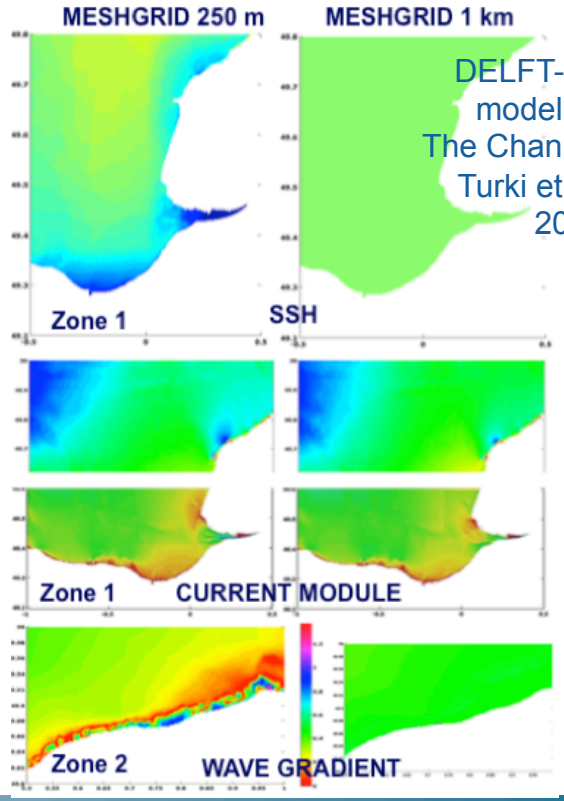
SSH Error as a function of grid size



Sci. Req. Doc. Rodriduez, 2015



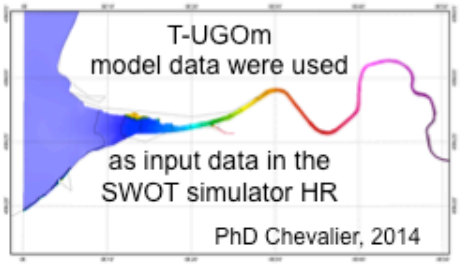
Simulated HR data: San Francisco Bay/Estuary case – Y Chao, 2015



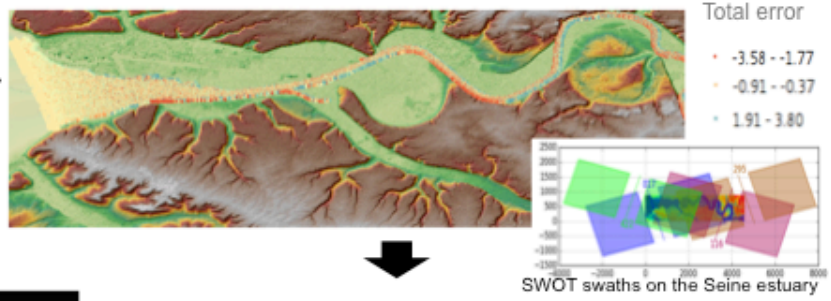
DELFT-3D modeling The Channel Turki et al, 2015

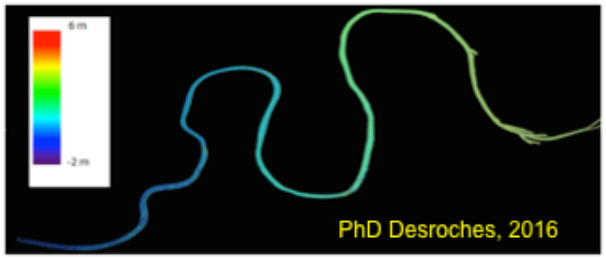
Main results of the previous studies on SWOT use in the coastal & estuary zones (2013-2015): SWOT simulator

HR Simulator in the Seine estuary

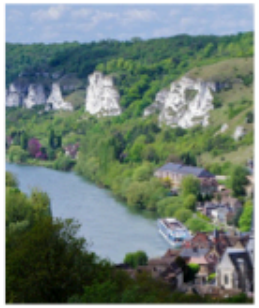


First result of the HR Simulator in the Seine estuary
(swath n°17 left) - medium conditions of discharges and tide

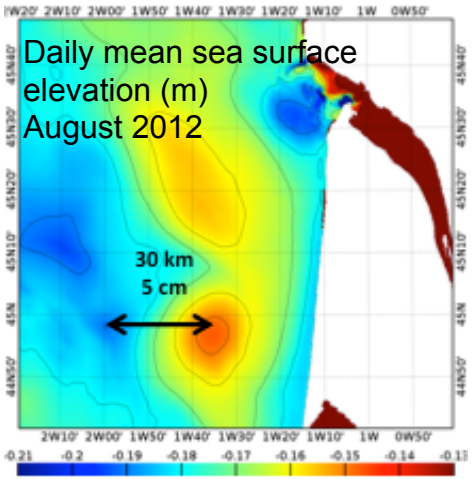


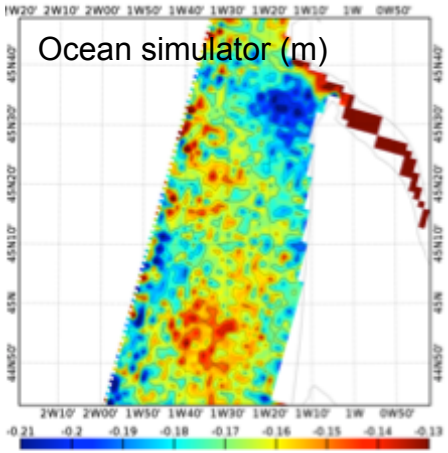


The improved geolocation method of the HR simulator reproduces well the spatial variability of water level along the Seine estuary



Majority of the SWOT measurement points in the channel, with low water level error (centimetric),
but some are outside & the error can be plurimetric for points outside or on the edge of the channel
= Layover in relation with the cliffs along the Seine estuary & thermal noise





Ocean Simulator in the Bay of Biscay

LEGOS — LA LABORATOIRE D'AÉROLOGIE

F. Toublanc et al., 2016

Applications of SWOT in coastal and estuary zones

Previous studies in collaboration with the French Water Agencies & harbours

The monitoring & mapping of water levels & morphological changes associated = essential support for the implementation of strategies for navigation, economic development & security of property and people (inundations, coastal retreat…)

✔ Identification, survey & mapping of seasonal & interannual variability of water level & inundations (river flood & storm surge), including flood extent & support for modeling of the inundations propagation

Xynthia, 2010, Vendée

✔ Understanding of the interactions between different water bodies & their impact on the water level & changes in the estuary zonation related to the sea level rise

should be confirmed from the SWOT products & more discussion

Applications of SWOT in coastal and estuary zones

✔ Survey & mapping of the islands & channels changes in estuaries & deltas

✔ Survey & mapping of the seasonal & interannual changes of water areas in the wetlands for a best management of water level for several using (agriculture, nature reserves, leisure centers…)

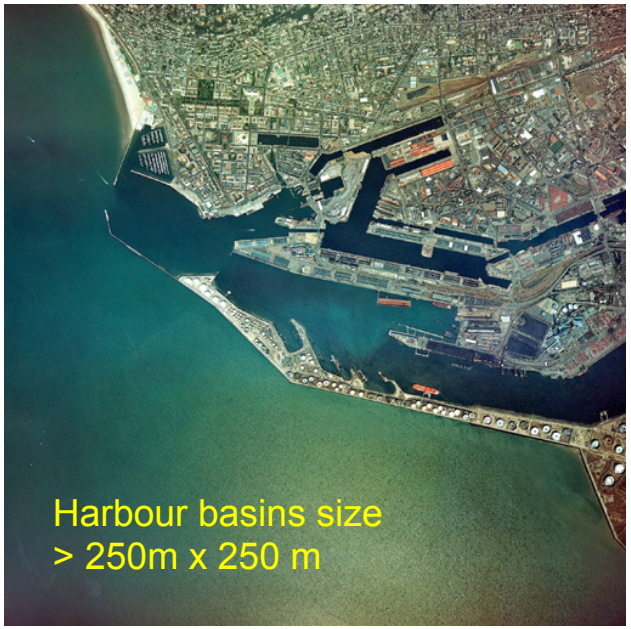
✔ Survey of evolution of fauna & flora & their habitats in relation to the water level… required data for a best ecological conservation & restoration

✔ Survey of the water quality in relation to the hydrodynamic conditions, to:

- survey the evolution of the salinity gradient & high turbidity zone
- prevention of low water thresholds leading to the decrease of oxygen in estuaries
- prevention of flood thresholds leadind to the turbidity plumes into the sea

✔ Survey of the water level in the major big harbours…

Harbour of Le Havre



Remaining Questions/Topics

SWOT ability to reproduce the hydrodynamics in the coastal zones was studied mainly in macrotidal context

Now:

Important to work in other environments with different tidal contexts in various climatic, morphological & sedimentological contexts representative of the earth ➔ global & regional rules

- Choice of the 100 m resolution in the estuaries & 250 m in the coastal zones in the macrotidal environments to reach a better compromise between the spatial resolution & vertical precision ➔ must be confirmed in the other environments

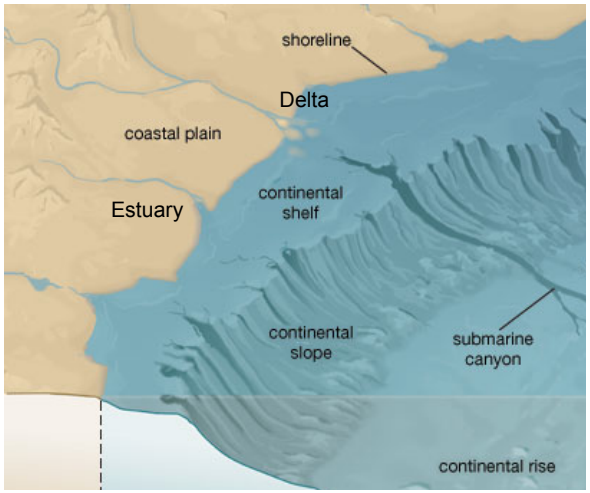
- SWOT ability to reproduce the spatial variability of the water level in different hydrodynamic conditions & in different contexts by using the SWOT simulator: neap/spring tide, high/low tide, with or without storm surge for the coastal zones and add strong/medium/low discharge for the estuary

- SWOT ability to reproduce the temporal hydrological variability according to temporally irregular sampling & the aliasing problem in different contexts

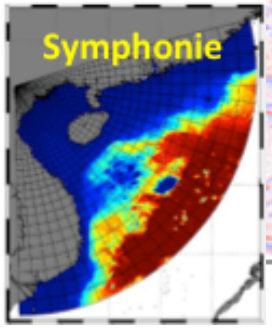
Remaining Questions/Topics

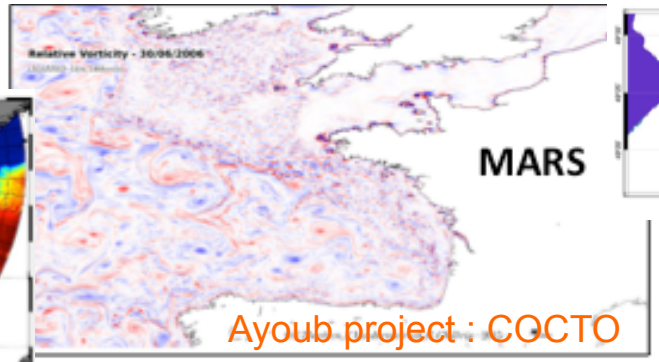
- Better understand the dynamics at the small scale & SWOT ability to reproduce the dynamics (from SWOT data assimilation in the models):
- In each coastal environments (estuaries, deltas, bays, shelfs, shelf break, rocky coasts with cliffs, beaches with sand, coastal wetlands)
- Dynamics & exchanges in the continuum of different environments:

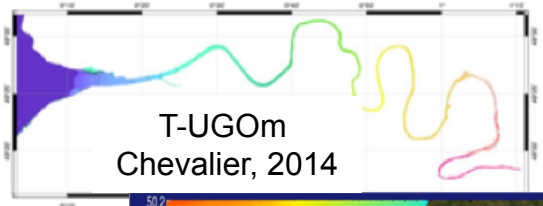
River-estuary-mouth-shelf- continental slope-deep ocean c.
Shoreline-neashore-shelf continuum
Wetland-estuary channels continuum
Wetland-shoreline-sea continuum…

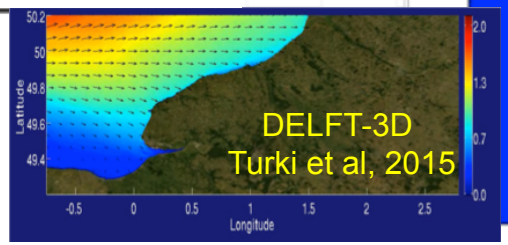


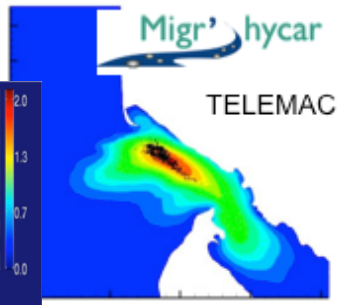
- Propose a methodology to assimilate simulated SWOT data to improve coastal tide models or hydrological models in estuaries, wetlands, shoreline/neashore & shelfs











Remaining Questions/objectives

- Examine utility of SWOT to observe storm surges in the coastal zones, combined effect of the storm surges & river floods in the estuaries

- Capabilities & limitations of SWOT to measure water level in tide-impacted wetlands located in estuaries & along coastlines (Limitations of SWOT measurements in the presence of vegetation & impact of the vegetation on layover)

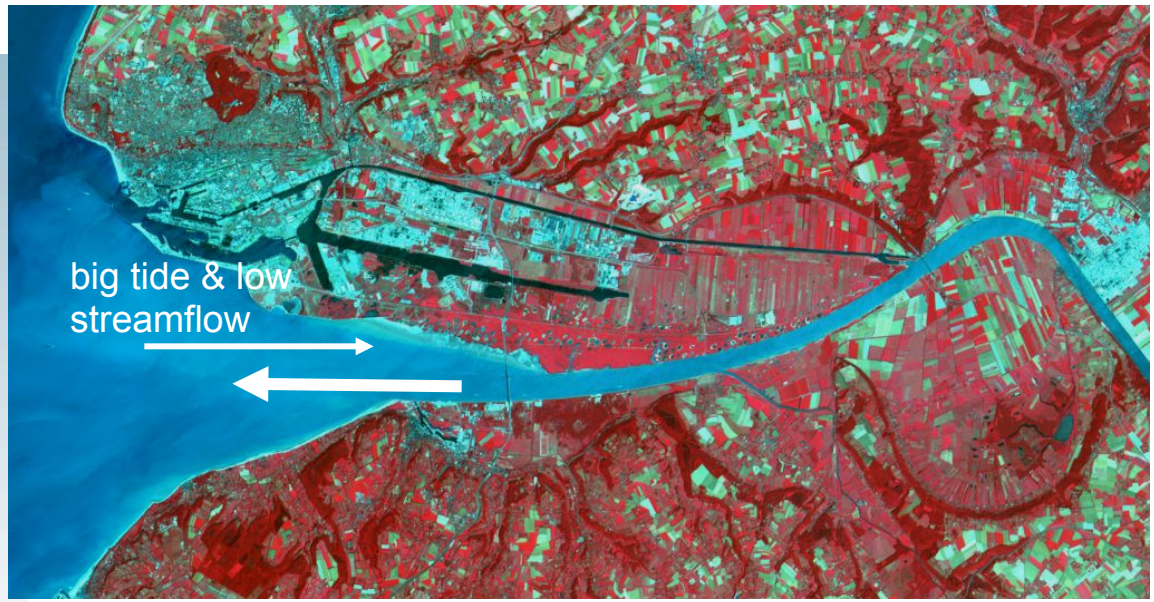
- Improve knowledge of coastal & submesoscale processes & explore utility of SWOT in these coastal processes

- Define the SWOT science products specific to the coastal & estuary zones for the scientific community & users/stakeholders

SWOT Products in the coastal and estuary zones

Geolocated heights, slope

Slope = very important to define:
- flow direction in the estuary: inversions of the flow direction (from the sea to the estuary) according to the hydrodynamic conditions (big tide (neap tide or equinoxe tide) & low streamflow)
- flow direction in the wetlands & exchanges between the wetlands & the channels in the estuaries & between the wetlands & the sea along the coast



SWOT Products in the coastal and estuary zones

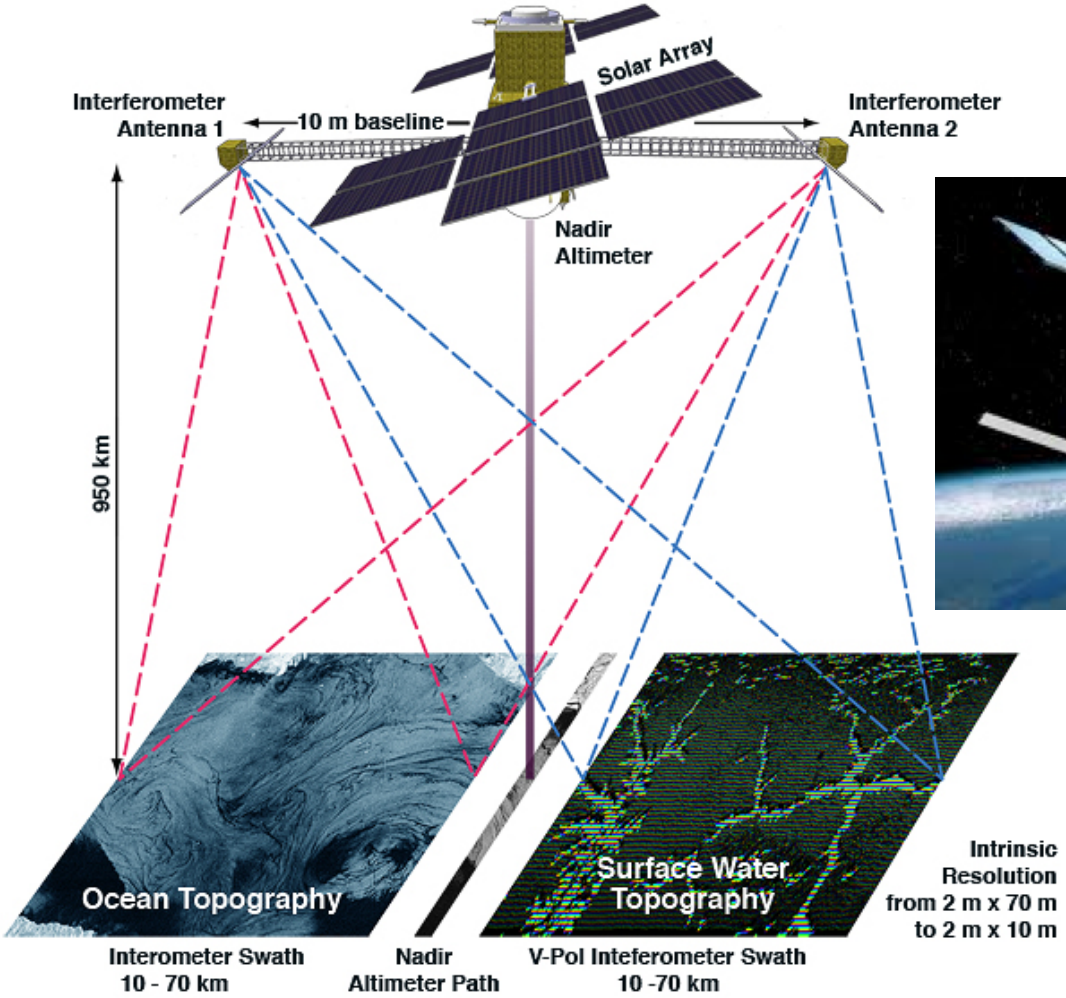
Examples of potential derived products:

- wind speed, waves
- Maps of water level & water surface in different hydrodynamic conditions (Combination of neap/spring tide, high/low tide, storm surges or not, high/medium/low flow) and at different scales (local, regional, global) with different resolutions
- Map of the water level amplitude in relation with the tide, storm surge & river flood
- Floodplain DEM
- Flood extent and water level associated
- Sheet flows through wetlands
- Flooded vegetation in the coastal wetlands…

= Preliminary examples & we must think about the derived product adapted to these environments

SWOT

Thanks



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