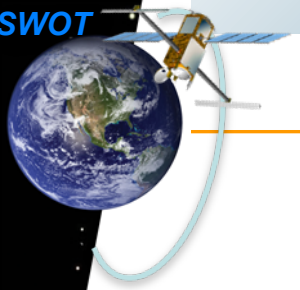

Potential use of the SWOT satellite to characterize the hydrodynamic of the estuaries and coasts

Laignel B.[1], Turki I.[1], Chevalier L.[1], Salameh E.[1,2], Soloy A.[1], Lyard F.[2], Frappart F.[2], Desroches D.[3], Cherchali S.[3], Escudier P.[3]

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2: UMR 5566 LEGOS, Observatoire Midi-Pyrénées, 14 Avenue Edouard Belin, 31400 Toulouse
3: CNES, 18 Avenue Edouard Belin, 31400 Toulouse

TOSCA-CNES program

UMR CNRS 6143 M2C

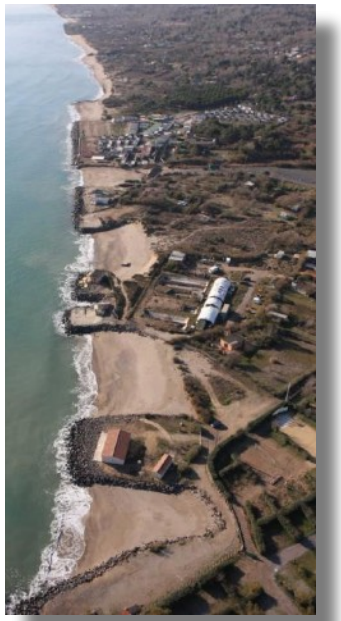
UNIVERSITE DE ROUEN Normandie

Coastal zones (including estuaries & deltas)

The coastal zones = 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…)




= Among the most affected by human impact (High urbanization & strong harbour, industrial & tourism activities)

= Among the most affected by climate change (sea level rise, storm surges & river floods)

SWOT

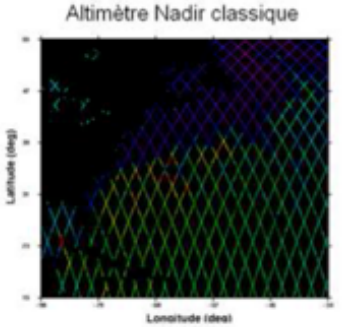
Complex hydrodynamics and satellites measurements

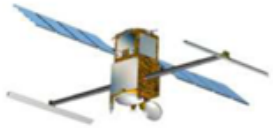
Spatialized monitoring of hydrodynamics = essential for a good managment of the coastal environments, but it is difficult:

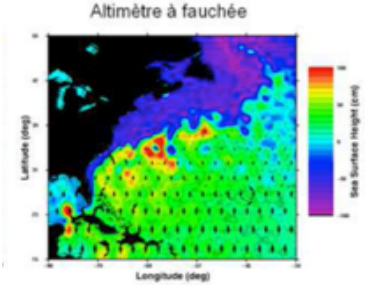
- Complex hydrodynamic in connection with many hydro-meteo-marine phenomena (offshore currents, waves, tides, storm surges, sea level rise (climate change), streamflow)
- Effects of the phenomena and their interactions are different according to very diverse morphology, sedimentary & climate contexts
- Tide gauges are sparsed and located in sheltered areas (such as harbours)

Remote sensing observations can provide critical information on the spatial variability of water surface elevations
But radar altimeters encounter many problems in the coastal environments:

- 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

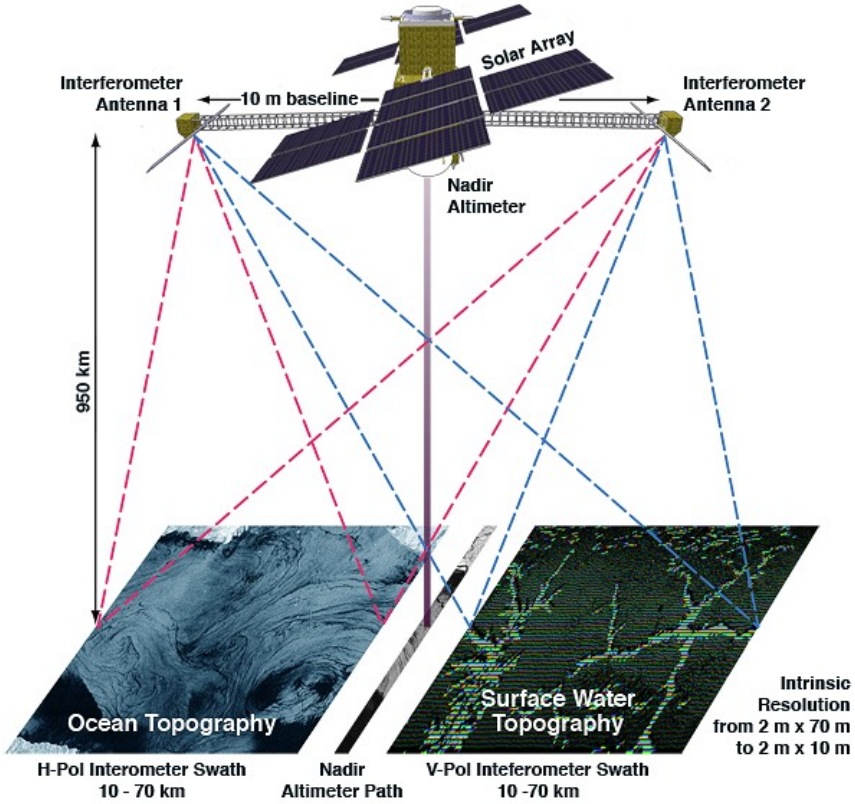






SWOT SAR-interferometric altimeter: higher spatial resolution & excellent global coverage ➔ resolve the problems of the conventional altimeters & fundamental data:
to map the spatial variability of water surface elevations under different hydrodynamic conditions & at different scales (local, regional and global)
➔ to improve our knowledge of the complexity of the physical processes & their interactions in the coastal & estuarine systems

SWOT : Surface Water and Ocean Topography = New generation of Altimeter very innovative



Swot produces:
Heights & co-registered all-weather imagery

SWOT Originality
Ka-band SAR interferometric innovative system with 2 swaths
Width observed on the ground: 140 km
Complete coverage of the globe in one cycle of 21-22 days

Spatial resolution:
Ocean 1 km
River width: 100 m (50 m)
Lake 250m x 250 m (100x100m)
Vertical accuracy of water level:
Ocean ~1 to 3 cm
Continental water ~ <10 to 18 cm

cnes

NASA

UK SPACE AGENCY

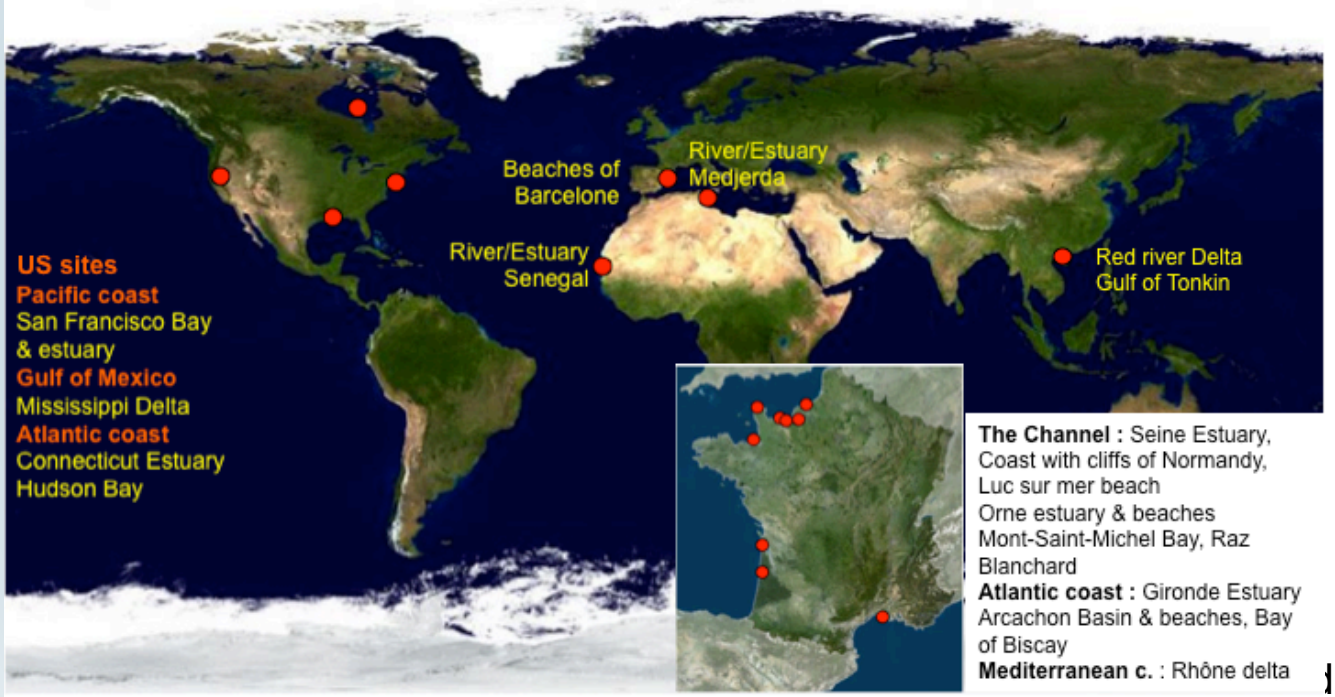
CSA ASC

Cycle of 21-22 days with 1-7 passages according to the location
1 day orbit during 3 months for some sites
Launch in 2021

Objective and Approaches

To study the ability of SWOT to reproduce the spatial and temporal variability of the hydrodynamic in the coastal and estuarine environments

Two approaches applied on 16 study sites



16 study sites
Selected in different tide contexts (macro, meso & microtidal), diverse morphologies (estuary, delta, bay, coast with sandy beaches or cliffs, shelf), different climates (temperate, mediterranean, tropical, arctic…)

l signal processing methods

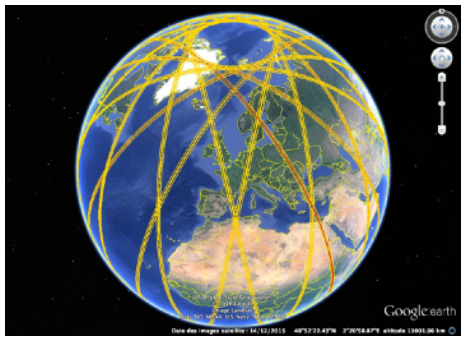
= Study of the SWOT ability to reproduce the hydrodynamic temporal variability

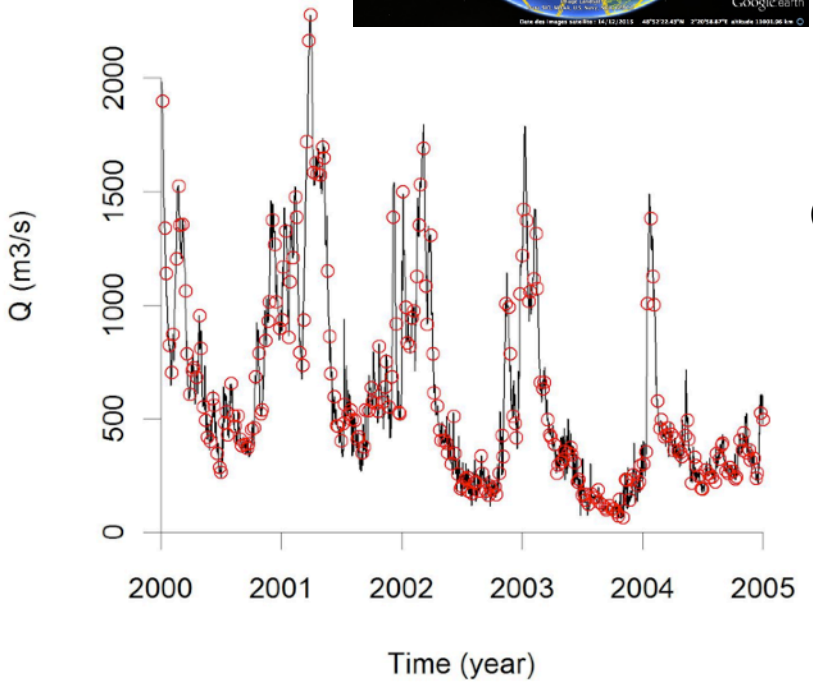
- Combining of hydrodynamic modeling (T-UGO, DELFT-3D models) and SWOT simulator HR & LR (High and Low Resolution) = Study of the SWOT ability to reproduce the hydrodynamic spatial variability

Simulation of the temporal SWOT data

Débits	Lat	Long	SWOT Passage (in hours)			
Seine	49,310815	1,236246	100,575	277,6056	362,9861	
		Days	4,190625	11,5669	15,1244208333	

Exemple SWOT orbite : 891





Simulate SWOT data without error & with white noise (erreur hauteur) :

From the SWOT orbit

↓

We sample the time series of water level or discharge during 5 years according to the passage frequency of SWOT

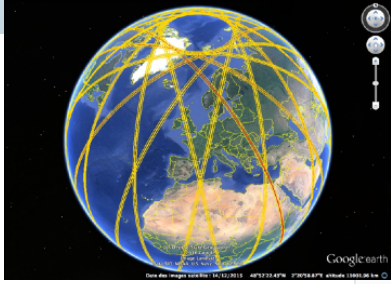
↓

Comparison of the temporal hydrological variability in situ and simulated SWOT data from several analyses (trend, loess, wavelet analysis…)

↓

Impact of SWOT revisit on its ability to restitute the temporal hydro. variability

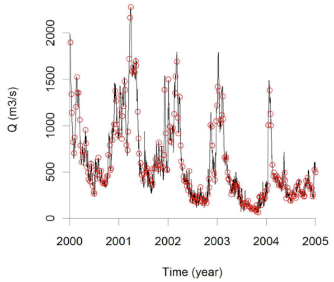
Temp. hydrodynamic reproduction by SWOT in the estuaries



Microtidal Macrotidal

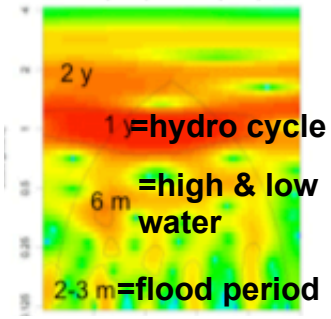
		Wavelet coherence
Seine	upstream	87
	downstream	62
Gironde	upstream	87
	downstream	50
Connecticut	center	90-95
	Bay	73
Mississippi	upstream	88
	downstream	82

- Best reproduction by SWOT in microtidal (73-90) than macrotidal context (50-87)
- Decrease of the coherence from upstream (87-90) to downstream(50-82) = tide influence

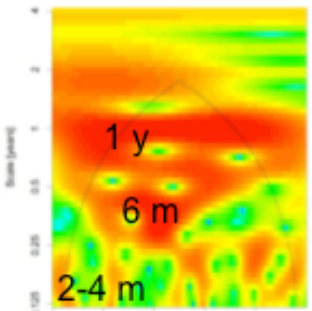


- Good reproduction in upstream estuary
= similar to the river
Hydro cycle, seasonal variability, flood period

In Situ

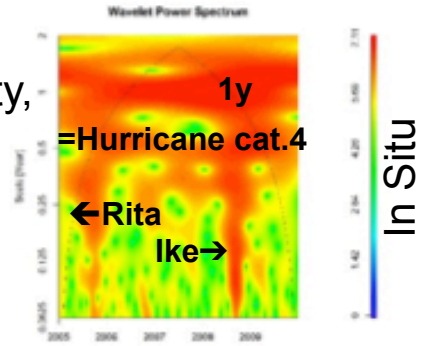


Upstream Estuary



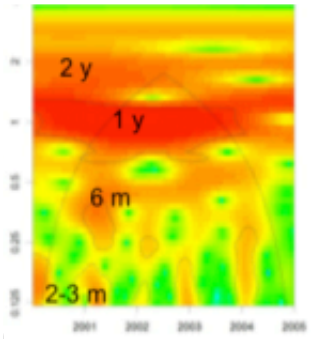
Downstream Estuary

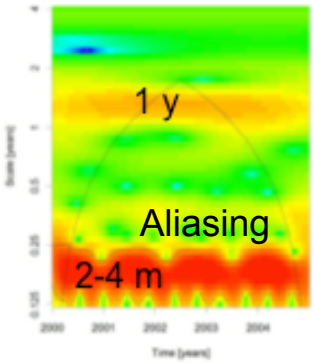
- Reproduction more heterogeneous & difficult in downstream estuary
Difference according to the ide & river context
(Aliasing in macrotidal context, Turki et al., 2015)



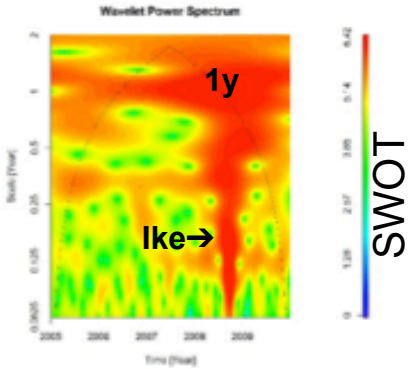
Mississippi Delta

SWOT





- Possibility to observe the energy of some hurricanes & storms in microtidal context

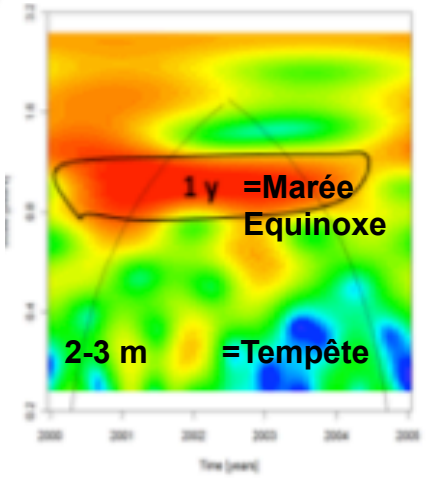


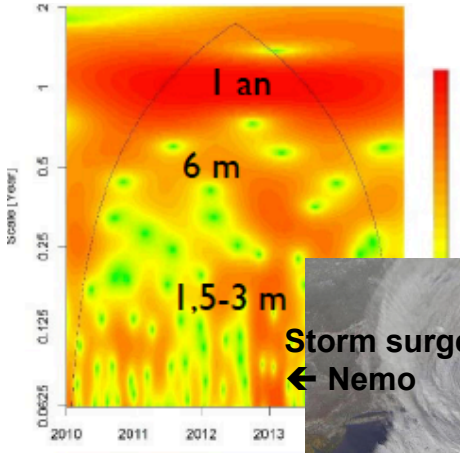
SWOT ability to reproduce the temporal variation of the sea level in the coastal zones & aliasing phenomenon

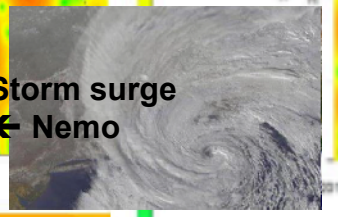
The Channel
Macrotidal

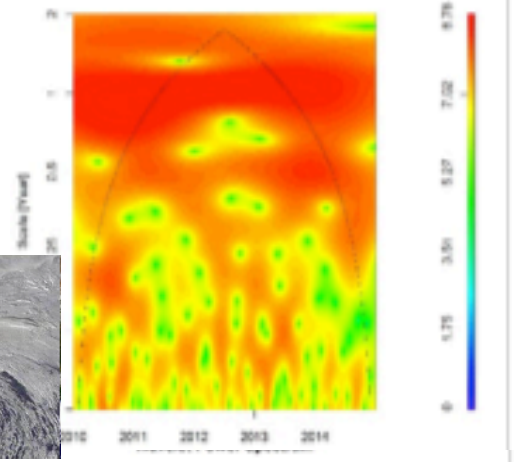
Atlantic-Connecticut bay
Microtidal

Gulf of Mexico-Mississippi coast
Microtidal

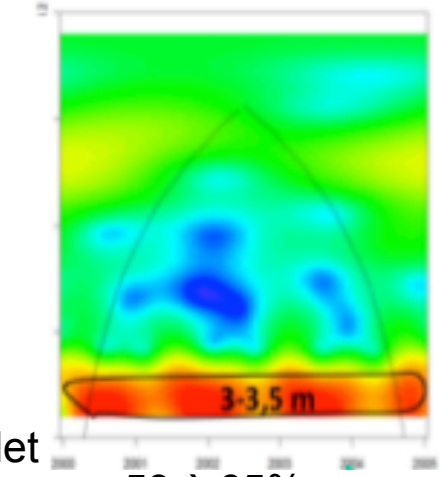


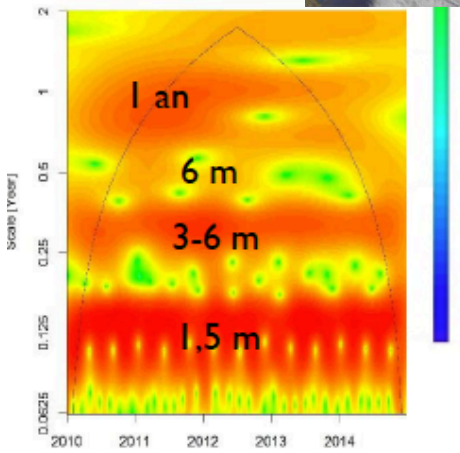


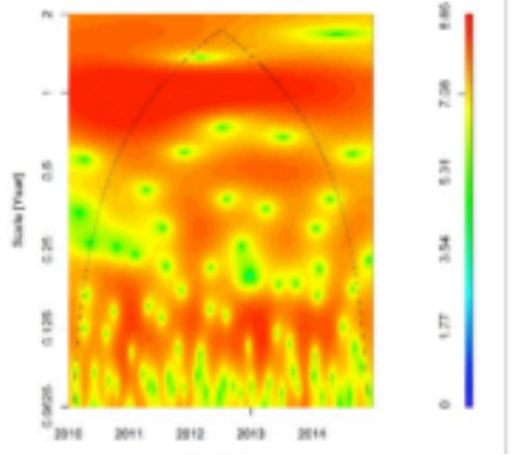




SWOT







Wavelet Coherence

53 à 65%

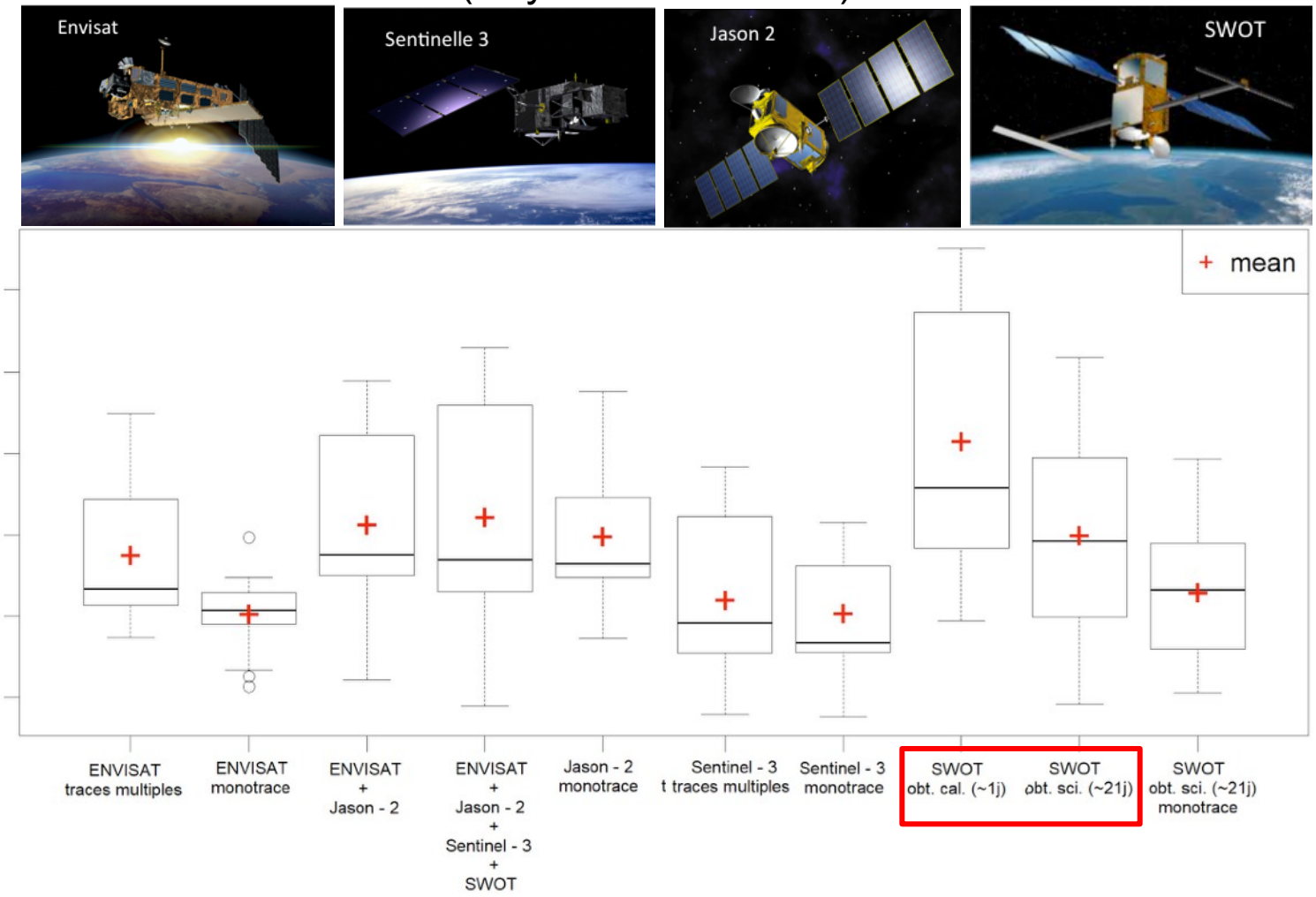
73%

82%

Best reproduction in the coastal zones of Mississippi & Connecticut than the Channel: according to tide context
Exaggeration of the variability mode 2-4m = Aliasing between SWOT revisit and some components of the tide

Comparison of the SWOT potentiality with the other satellites

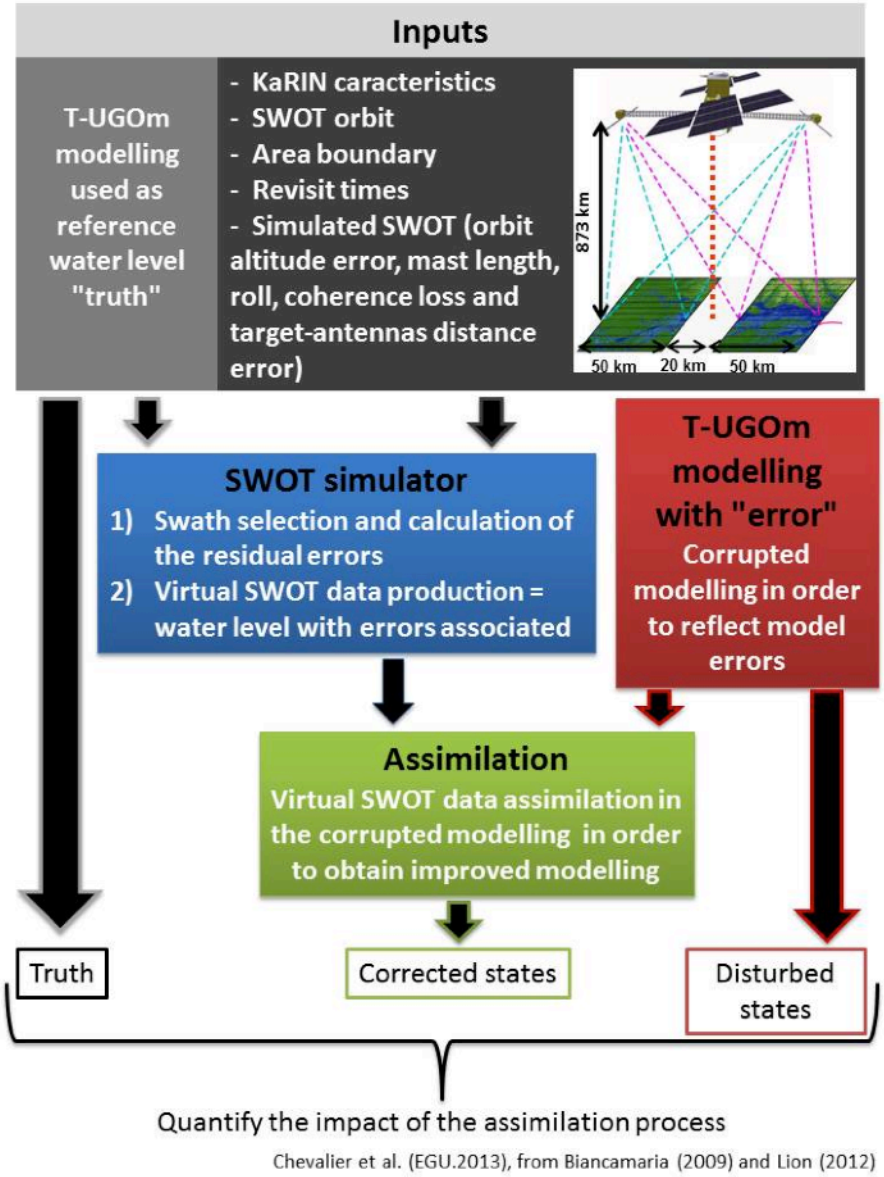
Wavelet coherence between in situ and satellites signals on 6 sites (Bays and Estuaries)



Best coherence between in situ and satellites signals : SWOT 1 & 21 days

Soloy et al., Submitted

Modeling - SWOT HR and LR simulator



Chevalier et al. (EGU.2013), from Biancamaria (2009) and Lion (2012)

Accurate modeling of the spatial & temporal variability of water level

T-UGOm, DELFT-3D, TELEMAC

↓

Coupling of the model data (as input data) & the SWOT HR & LR simulator

In different hydrodynamic conditions

Coastline: Neap tide/Spring tide,High/Low tide, with or without storm surges

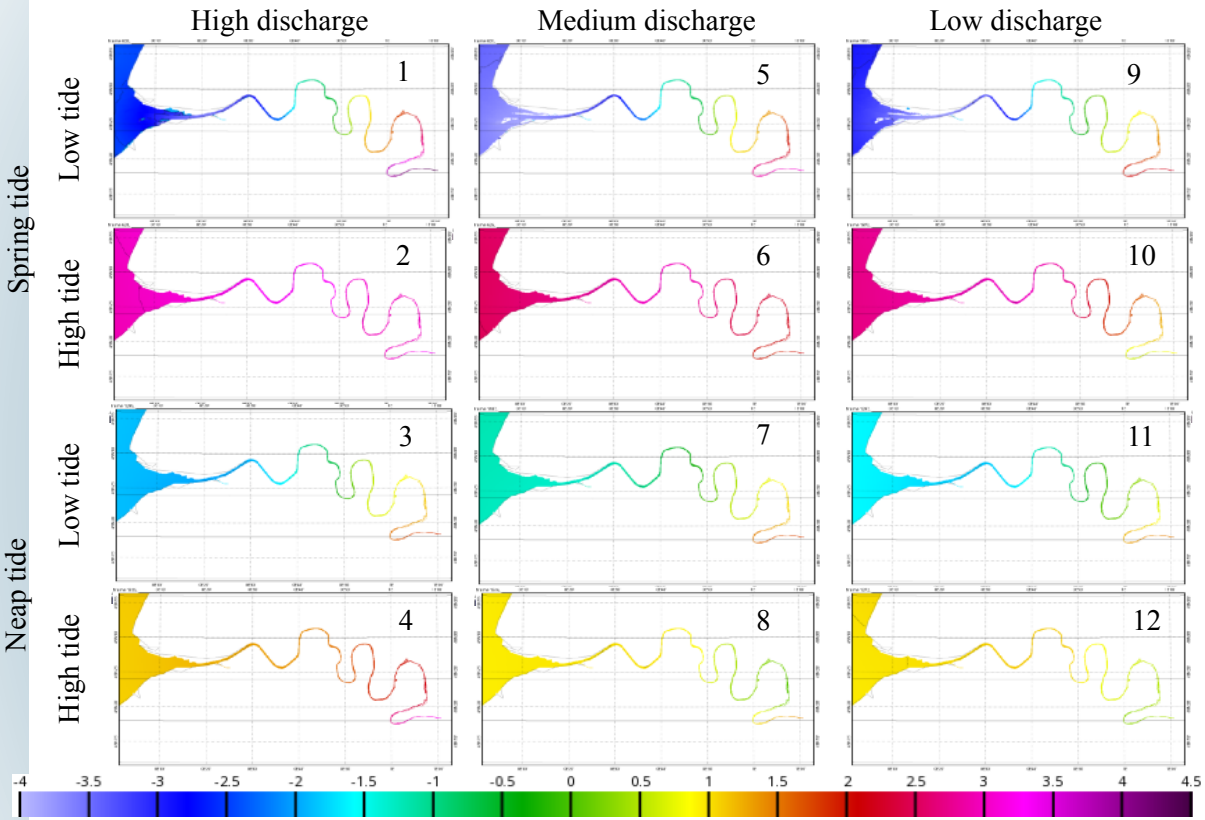
Estuary : Neap tide/Spring tide,High/Low tide, high/Medium/Low discharge

↓

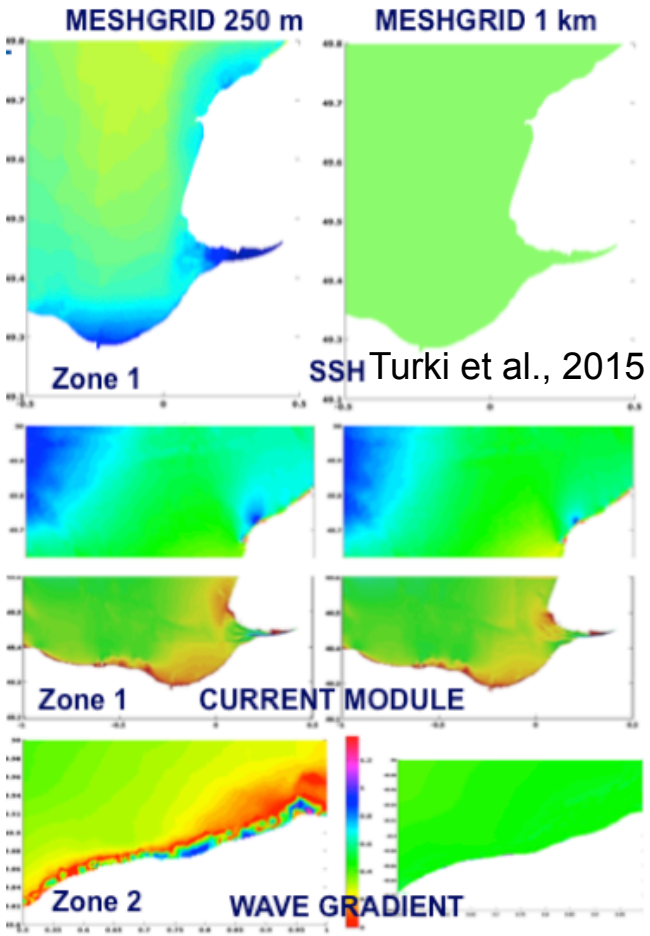
SWOT ability to reproduce the spatial hydrological variability in different hydrodynamic conditions

Hydrodynamic modeling in the estuary and coast

T-UGOm in the Seine estuary

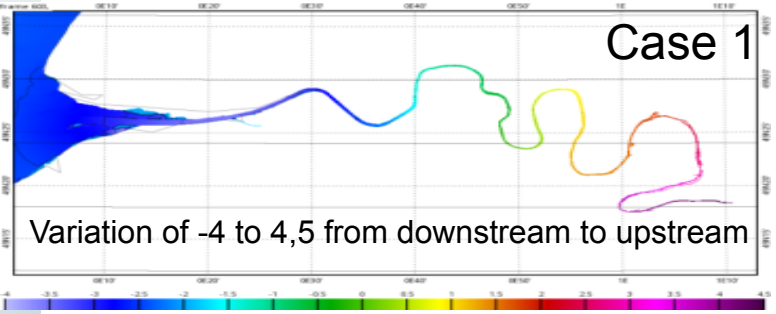


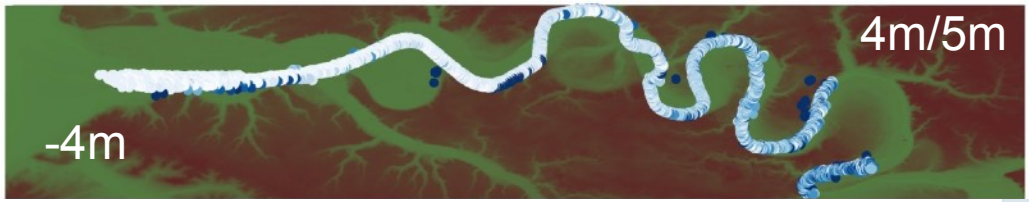
DELFT-3D in The Channel



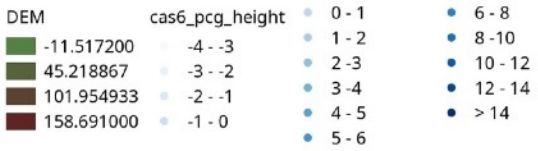
The hydrodynamic modeling in the estuaries and coasts :
Water levels are spatially highly variable in different hydrodynamic conditions & in specific hydro. condition
➔ Resolutions of 100 m in estuaries & 250 m in coastline, bay & shelf seems the best compromise between the spatial resolution & vertical precision to observe the major physical processes
➔ Importance of the high spatial resolution of SWOT to observe these transitions & better understand & model these spatial variations

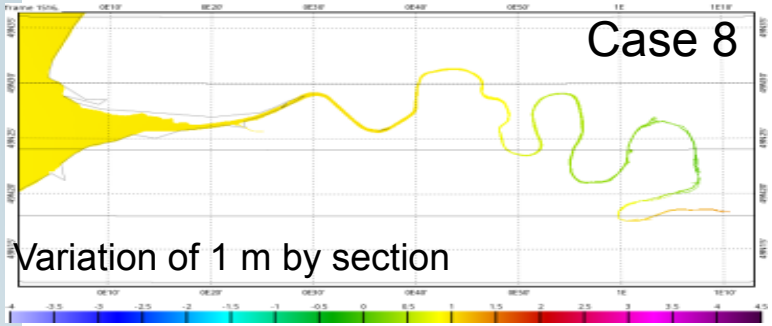
Coupling of modeling/SWOT HR simulator in the seine estuary

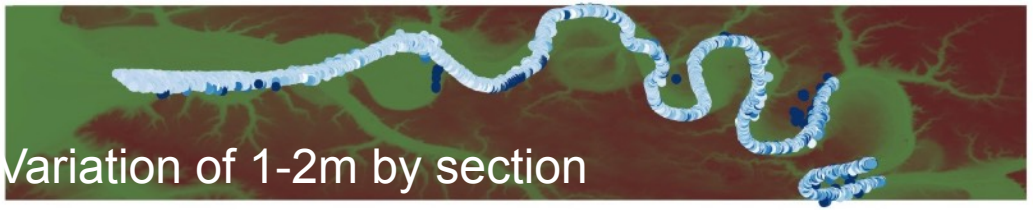




Chevalier et al., Soumis







All of SWOT measurement points are in the channel
HR simulator shows a good restitution of the spatial variability of the water level along the estuary from the downstream to upstream (length: 160 km)

Ex 1 (high variability): simulator reproduces well the 8 m of difference of water level from upstream to downstream
Ex 8 (low variability): simulator reproduces well the 1 meter of difference of water level by section

Conclusion

The SWOT satellite (Surface Water and Ocean Topography; NASA and CNES mission; launch in 2021) is a new generation of altimeter very innovative

SWOT will offer new opportunities to survey the hydrodynamic in the coastal environments

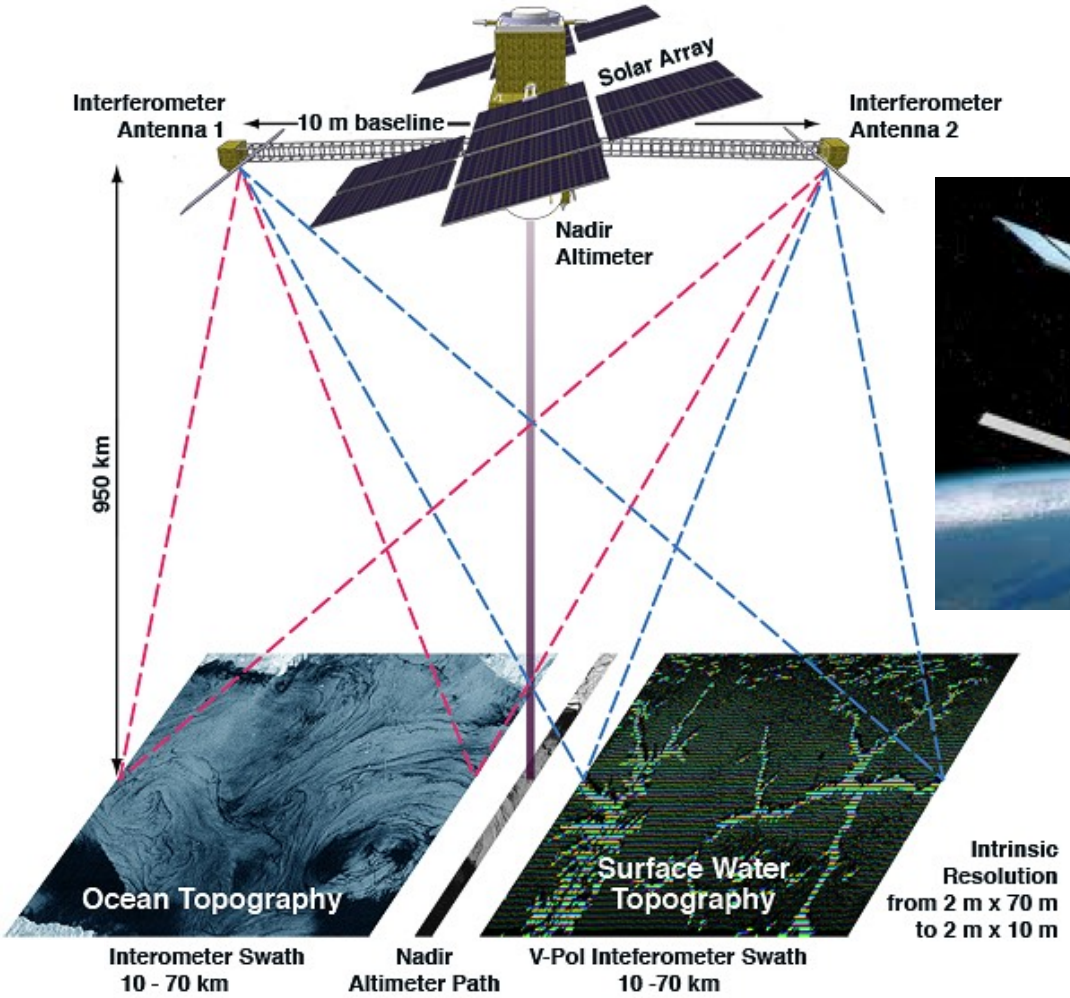
because it will provide data on the water level with an high spatial resolution (oceans: 1 km, rivers: 100 m of width) and with a global cover

The results of our study in 16 coastal and estuarine sites show:

- a best reproduction by SWOT in microtidal (wavelet coherence: 73-90) than macrotidal contexts (50-87)
- a decrease of the reproduction from upstream (87-90) to downstream estuary and coast (50-82)
- an aliasing problem mainly in macrotidal context
- the observation of some hurricanes, storms & floods
- a good restitution of the spatial variability of the water level along the estuary in 12 different hydrodynamic conditions (high/low tide, neap/spring tide, high-medium-low discharge) by the combining of modeling and SWOT simulator HR

SWOT

Thank you



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