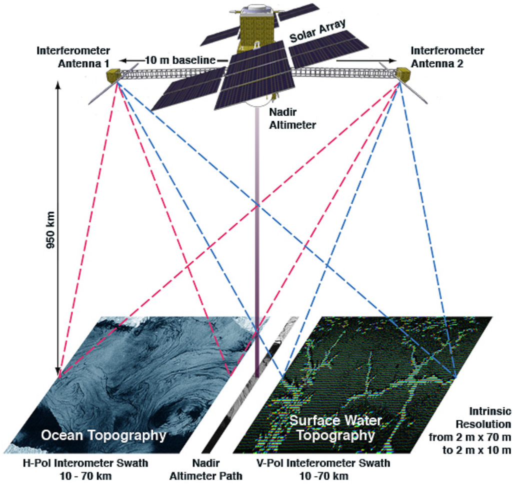
SWOT Science Team Meeting 2017, June 26-29

Hydrodynamic modeling and SWOT simulation in the estuarine and coastal environments

L. Chevalier, I. Turki, B. Laignel, F. Lyard, D. Desroches, D. Allain, F. Soulat, P. Dubois, G. Bracher

M2C, Rouen
CLS, Toulouse
CNES, Toulouse
LEGOS, Toulouse



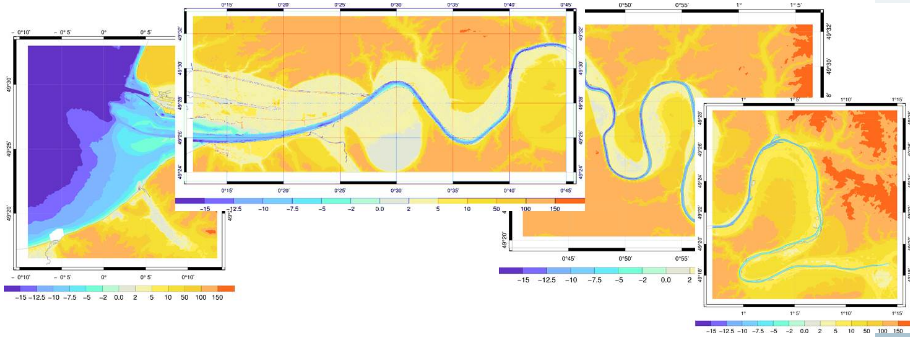
HYDRODYNAMIC MODELLING OF THE SEINE ESTUARY (T-UGOm)

Input data

Boundary conditions

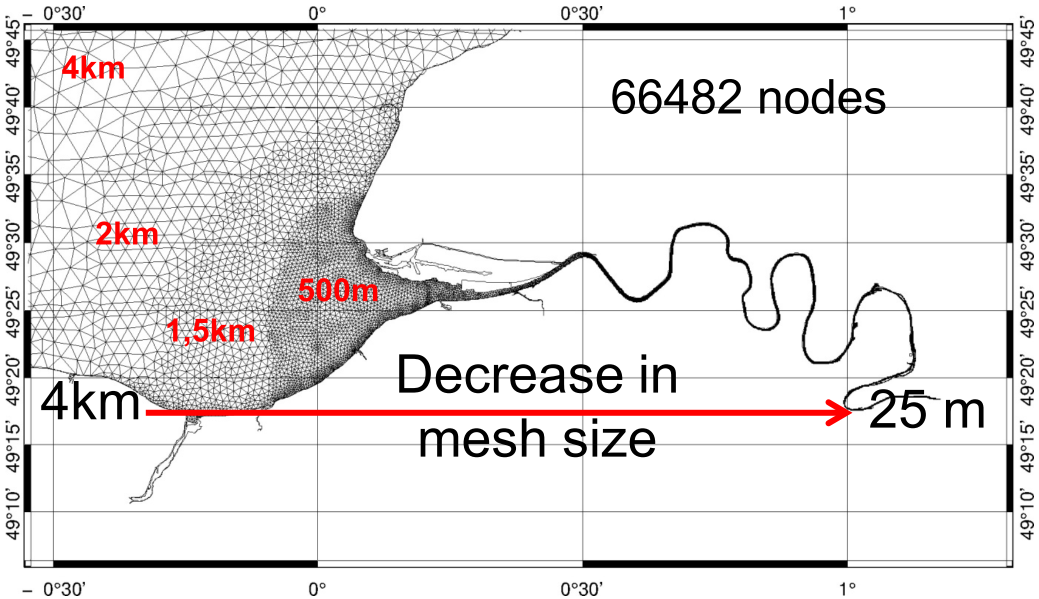
-tide gauges data in the upstream of the estuary
-data of the tide atlas (global tides *atlas FES2012*) associated to a surges global model (ex: Dynamic Atmospheric Correction, ERA-Interim) in the downstream of estuary

Bathymetry



Bathymetry based on: LIDAR data and MNT
Vertical reference: MSS
Resolution 3 m

Meshgrid



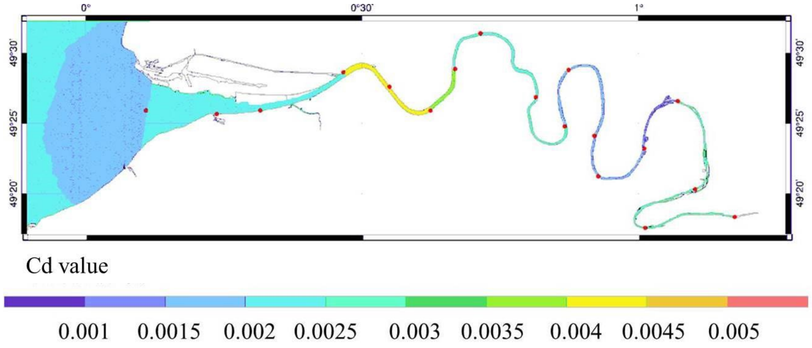
Meshgrid of Seine estuary

The meshgrid is performed from the bathymetry and shoreline & estuary limit

Seine estuary:
-meshgrid varies from 25 m in the estuary to 4 km in the Channel
-high resolution meshgrid with 66482 nodes

HYDRODYNAMIC MODELLING OF THE SEINE ESTUARY (T-UGOm)

Zonation of bottom friction



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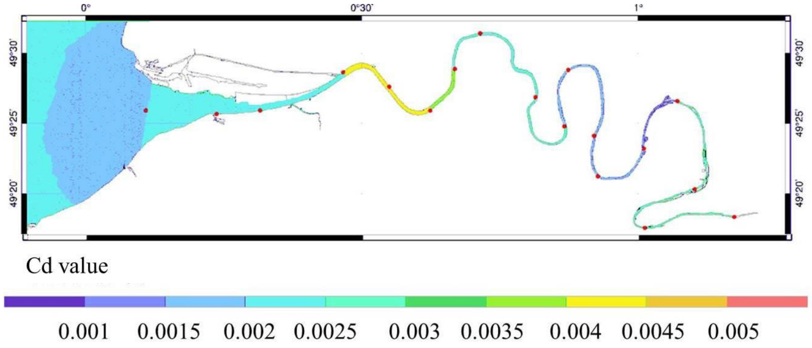

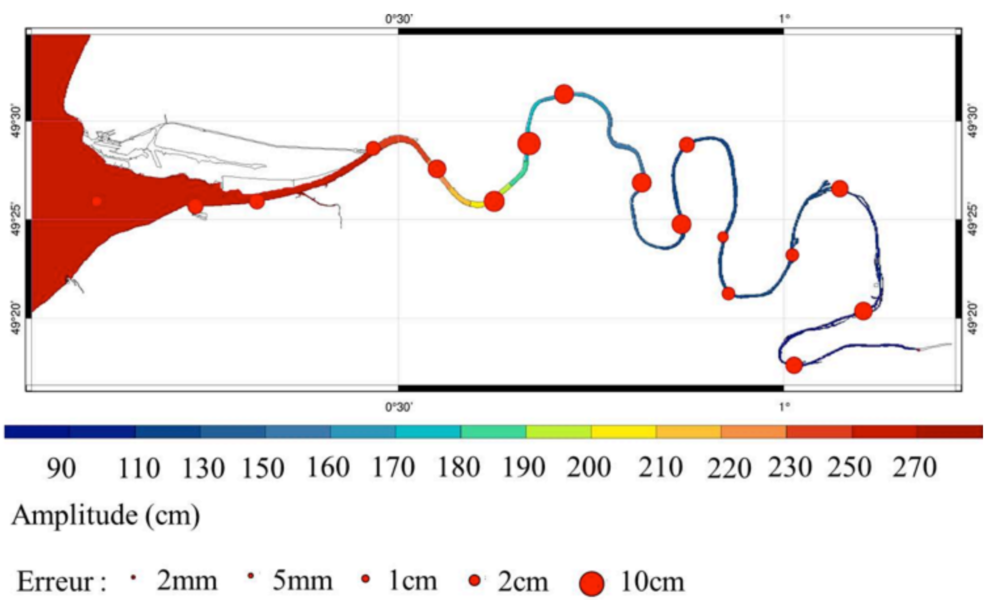

Error of M2 amplitude less than 10 cm for 17 tide-gauges

HYDRODYNAMIC MODELLING OF THE SEINE ESTUARY (T-UGOm)

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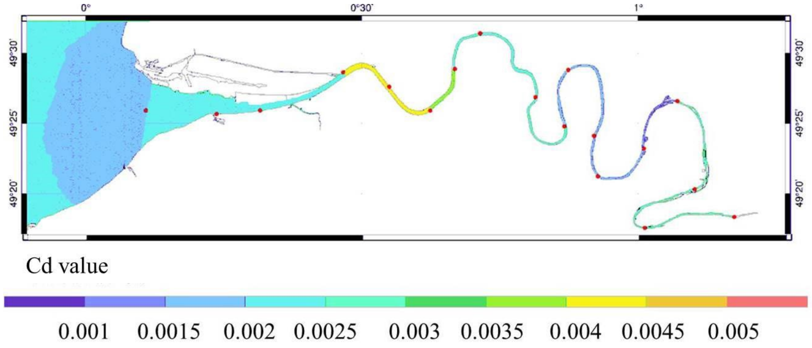
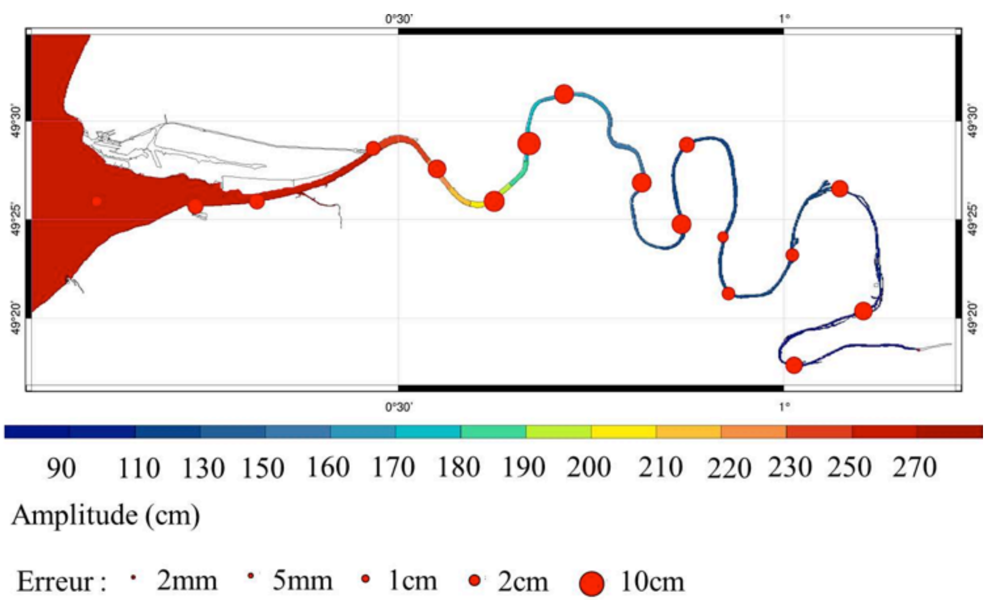
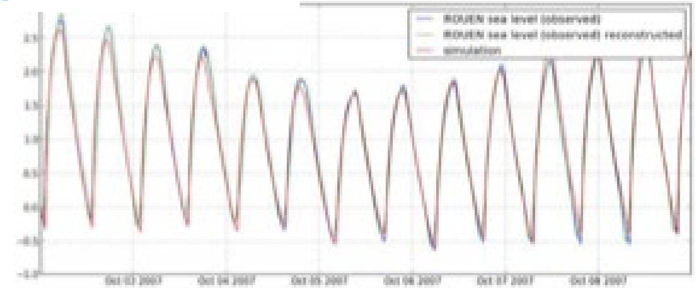




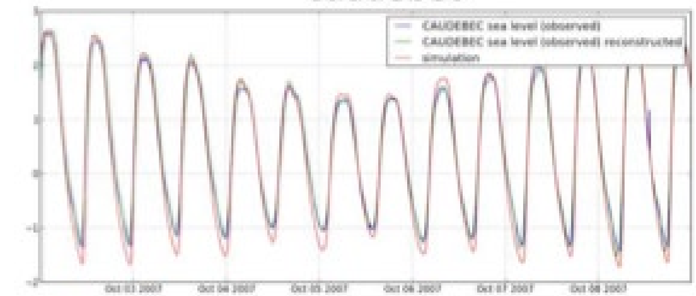
Error of M2 amplitude less than 10 cm for 17 tide-gauges

Upstream

Rouen

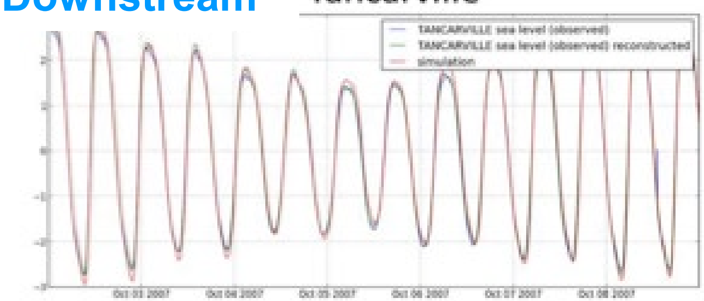


Caudebec



Downstream

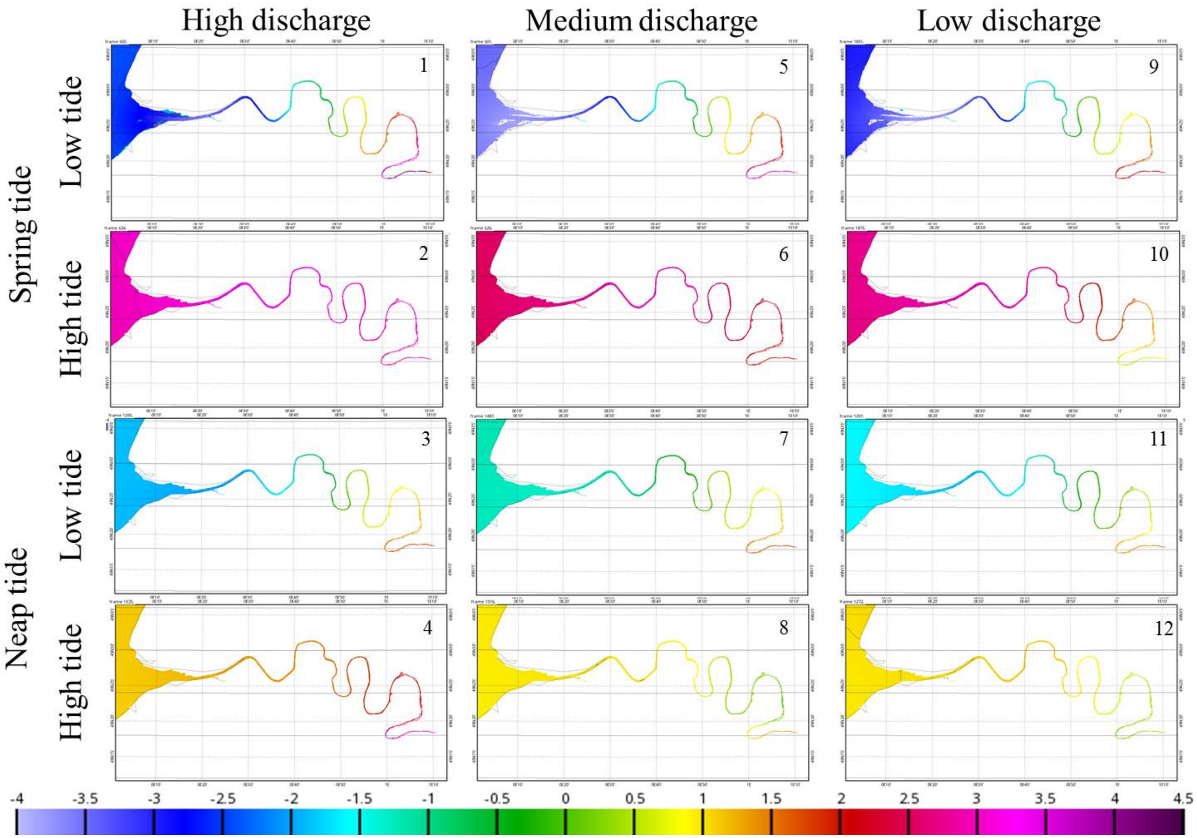
Tancarville



Temporal variability of water level and its amplitude are reproduce well along the estuary

HYDRODYNAMIC MODELLING OF THE SEINE ESTUARY (T-UGOm)

Twelve different hydrodynamic contexts were calculated by T-UGOm according to tide and discharges (Neap/Spring tide, High/Low tide, High/Medium/Low discharges)



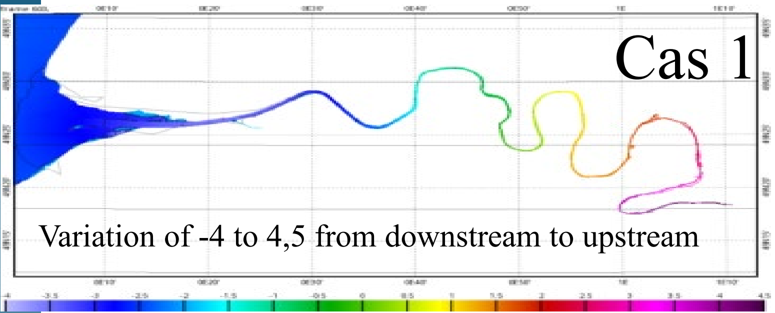
The water levels are spatially, highly variable in :

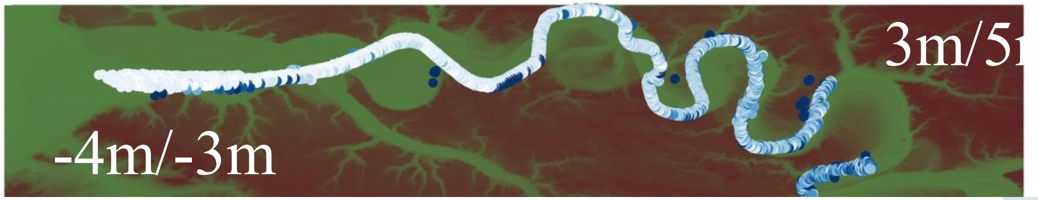
- different hydrodynamic conditions
- specific hydrodynamic condition (ex 1: 8 m of difference from upstream to downstream of estuary, (160km) &sometimes 1 m of difference along a section of 10 km)

Importance of the high spatial resolution of SWOT to understand and model these energy transitions

=> T-UGOm outputs were used as input data in the HR simulator for the twelve cases

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

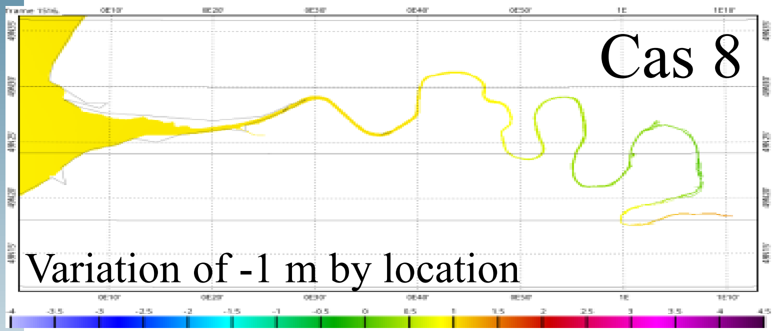


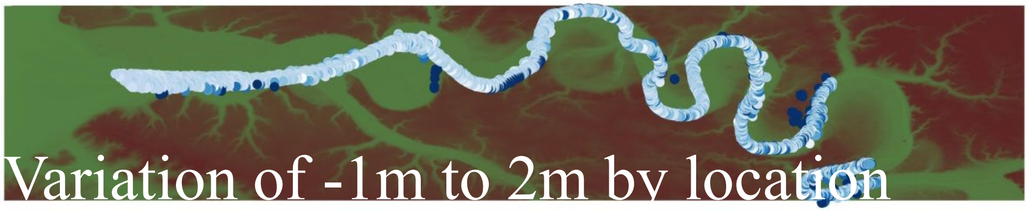


Legend

DEM
-11.517200
45.218867
101.954933
158.691000

cas6_pcg_height
-4 - -3
-3 - -2
-2 - -1
-1 - 0
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 8
8 - 10
10 - 12
12 - 14
> 14



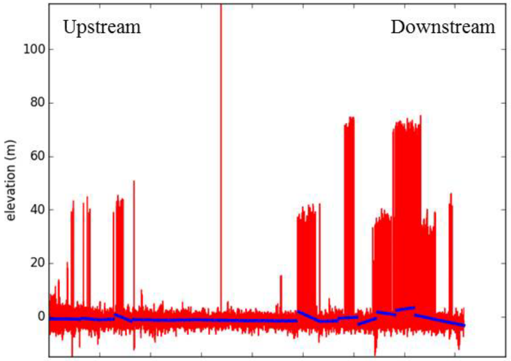


After application of geolocated correction method (Desroches), all of SWOT measurement points are in the channel & HR simulator shows a good restitution of the spatial variability of the water level along the estuary from the downstream to upstream (length: 160 km)

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

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

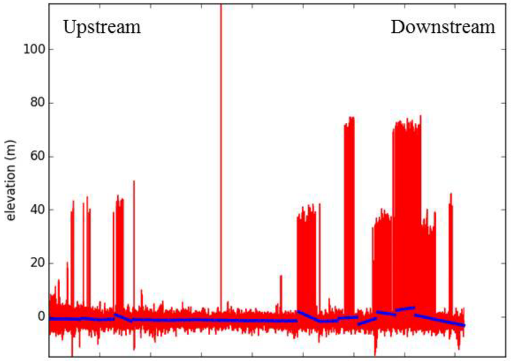
Profile of water height with geolocation corrected



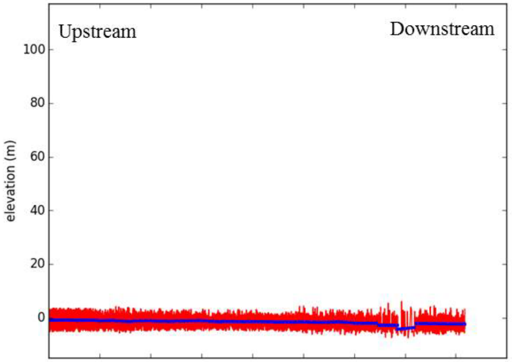
Then this example provided after the geolocation correction illustrates a strong errors of SWOT measurements.

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

Profile of water height with geolocation corrected



Profile of filtered water height with geolocation corrected

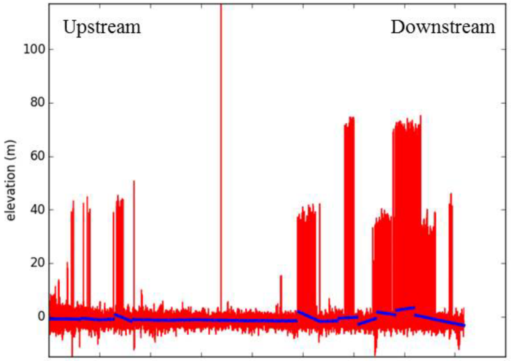


Then this example provided after the geolocation correction illustrates a strong errors of SWOT measurements.

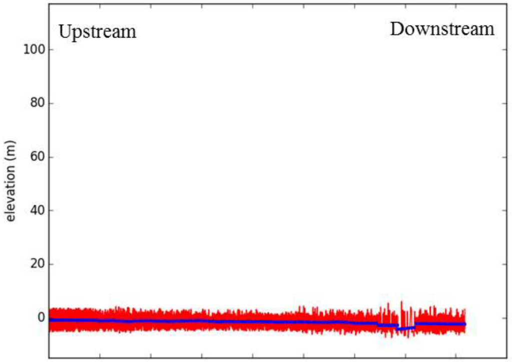
For this reason a filtering process are needed which will be used in the next step.

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

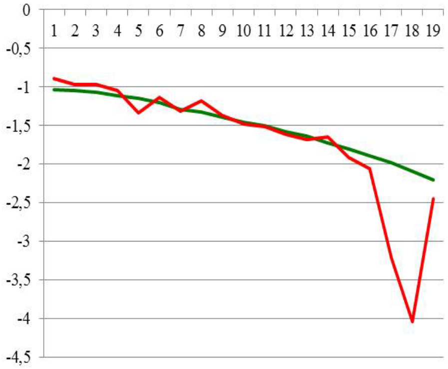
Profile of water height with geolocation corrected



Profile of filtered water height with geolocation corrected



Average water height of T-UGOm and SWOT data for 1km section



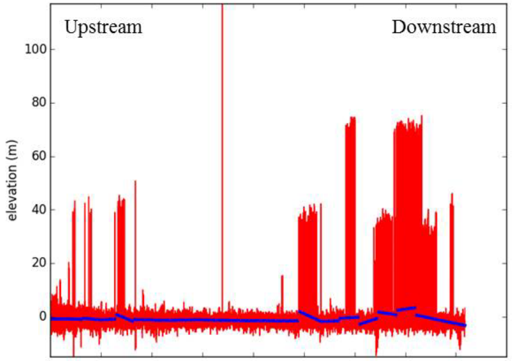
Then this example provided after the geolocation correction illustrates a strong errors of SWOT measurements.

For this reason a filtering process are needed which will be used in the next step.

Then averages of SWOT measurements are performed for each section of 1 km and these averages were compared with T-UGOm values.

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

Profile of water height with geolocation corrected



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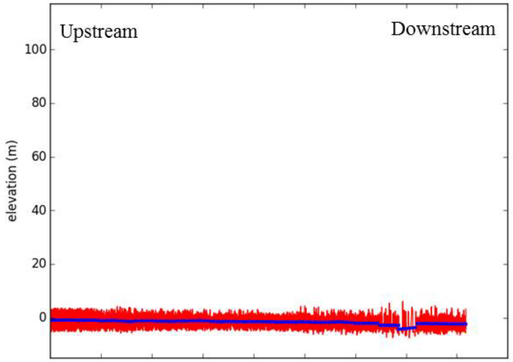
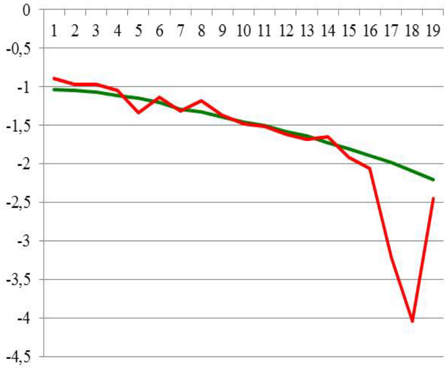


Average water height of T-UGOm and SWOT data for 1km section



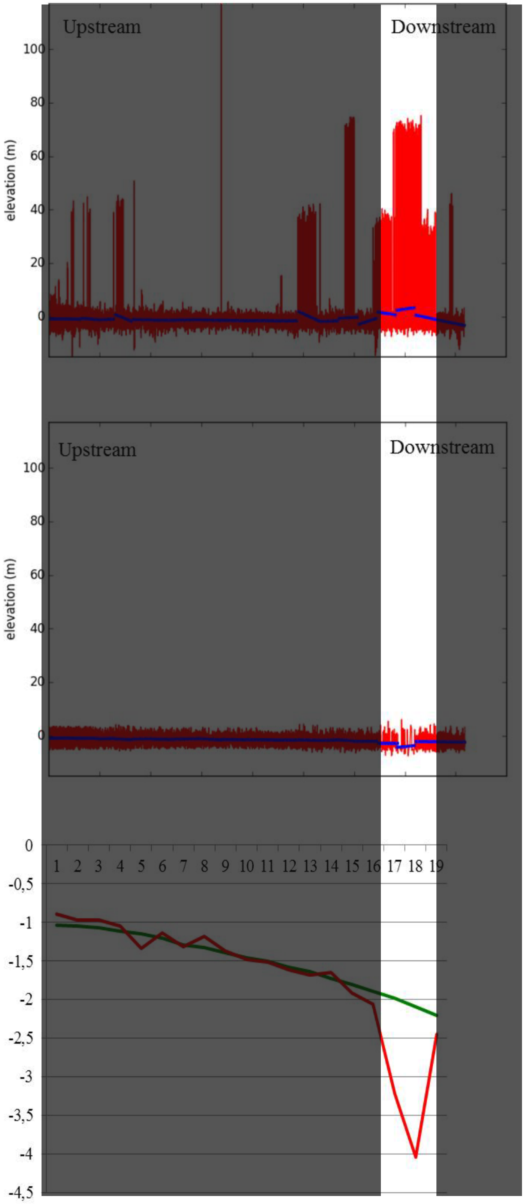
Differences between T-UGOm values and SWOT data are evaluated between 0,3 cm and 20 cm, except for one case where the difference is of 2m due to layover effect of the cliff.

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

Profile of water height with geolocation corrected

Profile of filtered water height with geolocation corrected

Average water height of T-UGOm and SWOT data for 1km section



Differences between T-UGOm values and SWOT data are evaluated between 0,3 cm and 20 cm, except for one case where the difference is of 2m due to layover effect of the cliff.

After, filtered process, if sections contain - a little data, the difference between T-UGOm values and SWOT data for 1 km section will be large

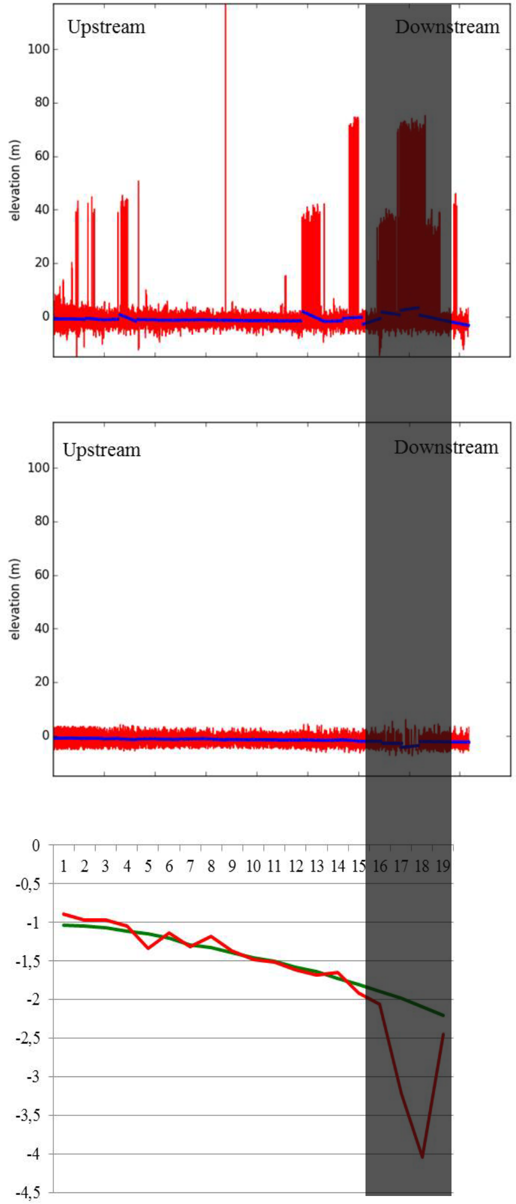
Chevalier et al., in prep

MODELLING/SWOT HR SIMULATOR IN THE SEINE ESTUARY

Profile of water height with geolocation corrected

Profile of filtered water height with geolocation corrected

Average water height of T-UGOm and SWOT data for 1km section



Differences between T-UGOm values and SWOT data are evaluated between 0,3 cm and 20 cm, except for one case where the difference is of 2m due to layover effect of the cliff.

After, filtered process, if sections contain
- a little data, the difference between T-UGOm values and SWOT data for 1 km section will be large
- a lot of data, the difference between T-UGOm values and SWOT data for 1km section will be an average of 8cm

Chevalier et al., in prep

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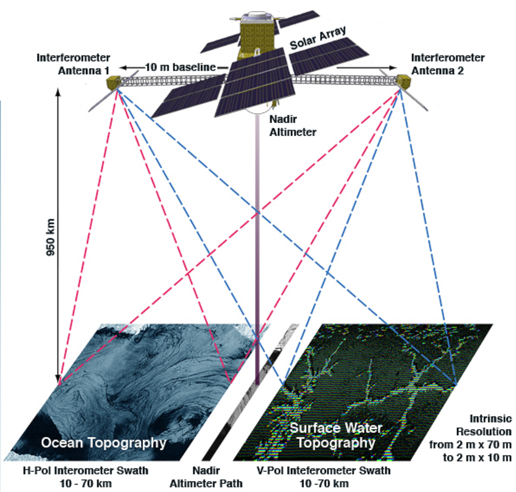
Hydrodynamic modeling and SWOT simulation in the estuarine and coastal environments

SOME ASPECTS OF HYDRODYNAMIC SWOT MEASUREMENTS IN COASTAL ZONES



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MOTIVATIONS

DATA ASSIMILATION: IMPORTANT FOR COASTAL APPLICATIONS AS EXTREME EVENTS

In situ data provided by tide gauges mainly implemented in Confined Environments: measurements are not well sparse and couldn't represent the global variability of sea states.

The Need of Altimetry with important Spatial and Temporal coverage For Data Assimilation with the aim to:

1. ***Simulation of Extreme Events.***

2. ***Data synthesis/reanalysis.***

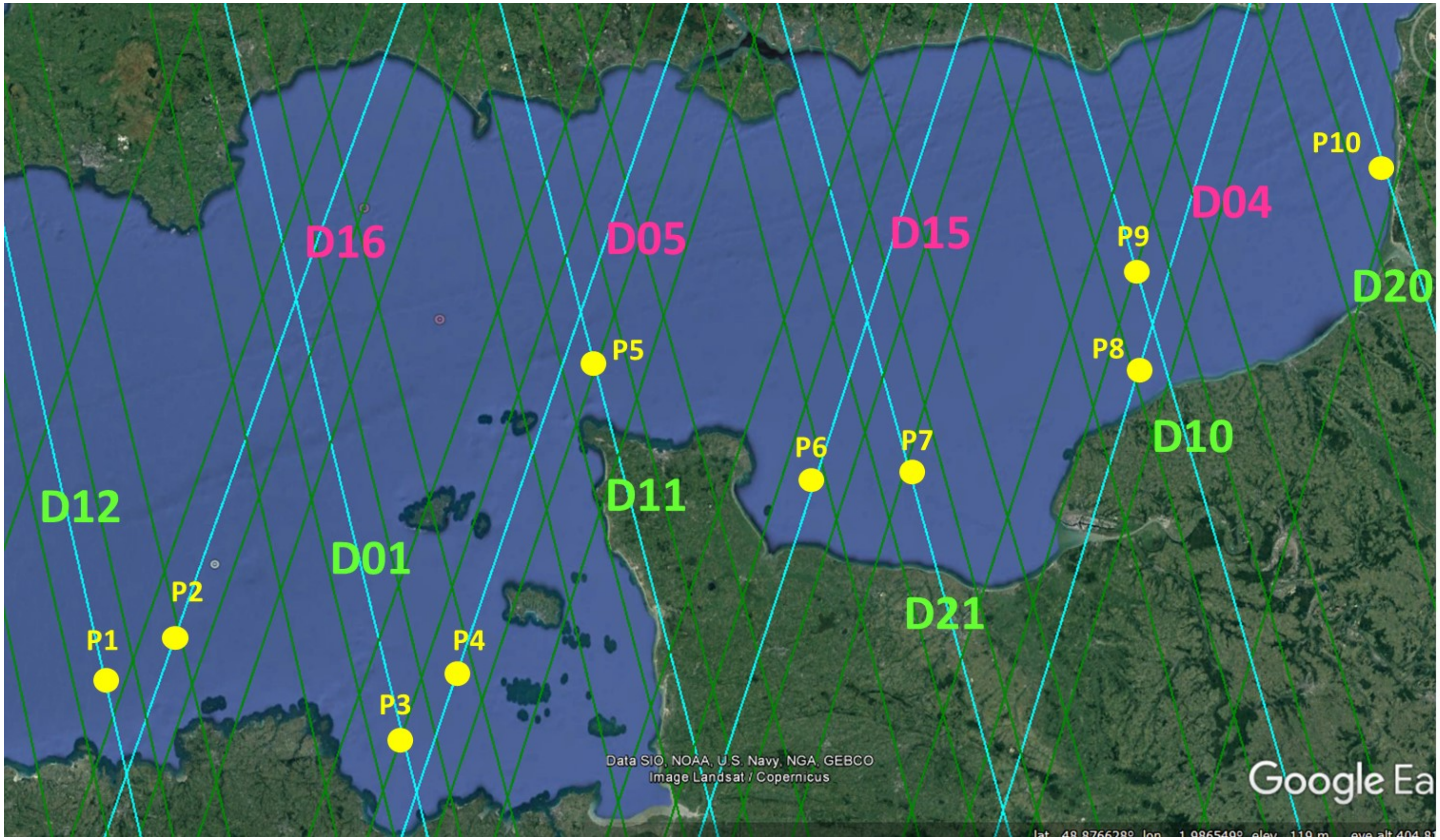
3. ***Seasonal-decadal forecasting in the context of Climate Change.***

How SWOT covers the hydrodynamic variability?

What is its performance?

SWOT

SWOT TRACKS: CASE OF ENGLISH CHANNEL



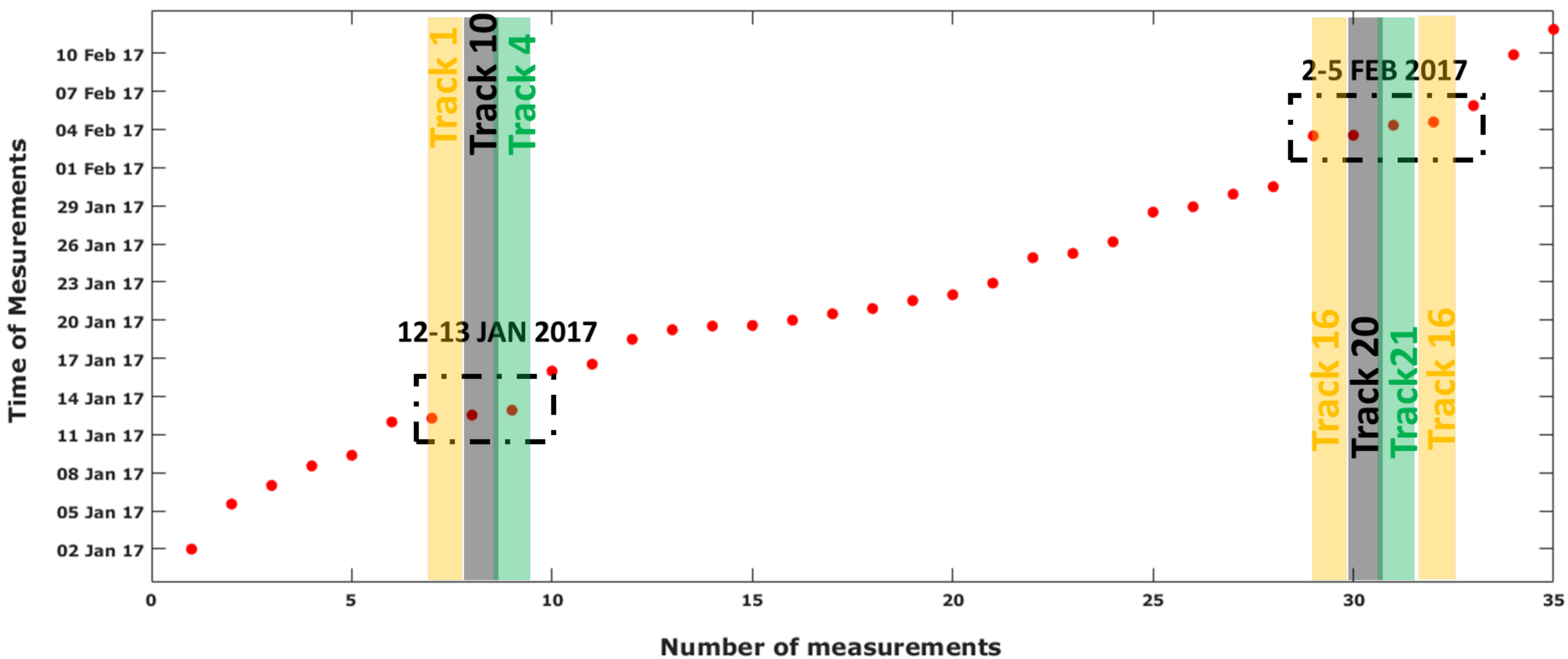
ASCENDING TRACKS: D16 D05 D15 D04

DESCENDING TRACKS: D12 D01 D11 D21 D10 D20

From P1 to P10: between three and five overpasses per repeat orbit

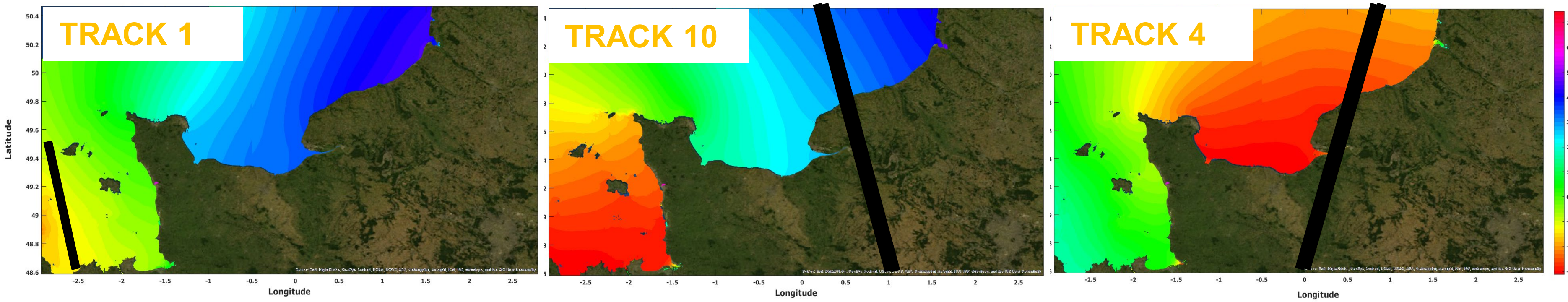
SPATIAL AND TEMPORAL COVERAGE:

A period of resolution: 45 days.
35 measurements in different time and space scales
2 Extreme Events: 12-13 JAN 2017; 2-5 FEV 2017



SPATIAL COVERAGE: 12-13 JAN 2017

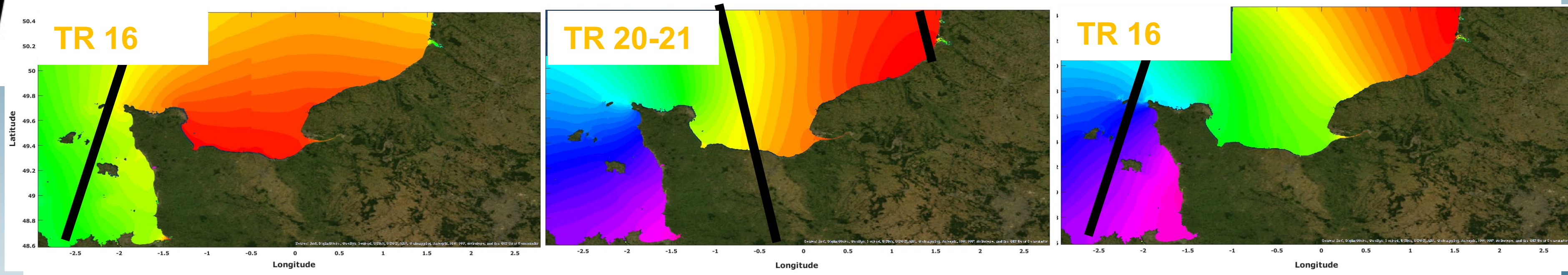
SEA LEVEL: SSH



Storm evolution

SPATIAL COVERAGE: 3-5 FEB 2017

SEA LEVEL: SSH

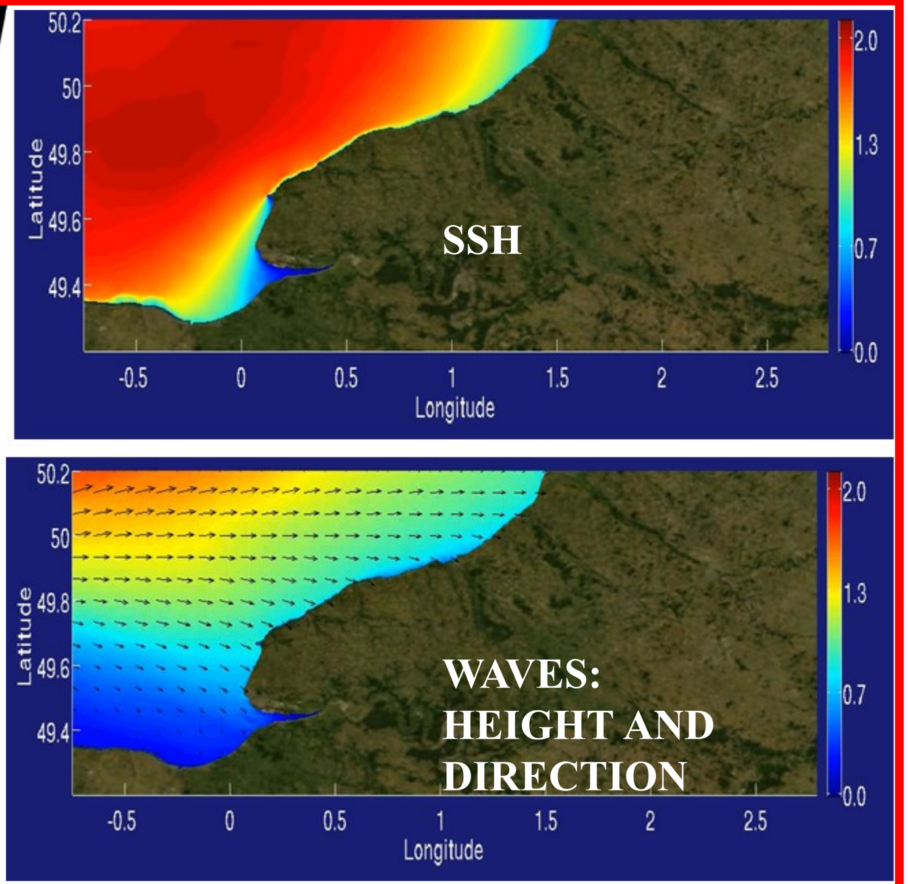


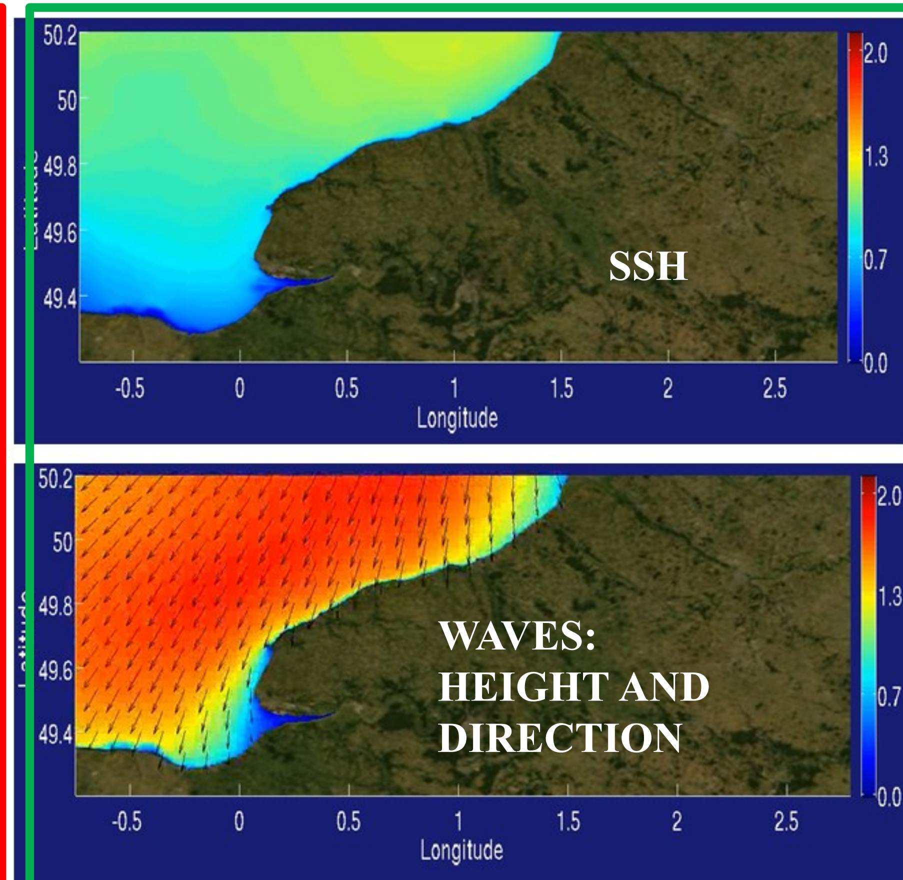
Storm evolution

The use of SWOT measurements from different tracks for assimilating the temporal evolution of extremes

WAVES ARE THE KEY OF HYDRODYNAMIC VARIABILITY: INTERACTION OF WAVES WITH SSH

EXEMPLES OF SEA STATES



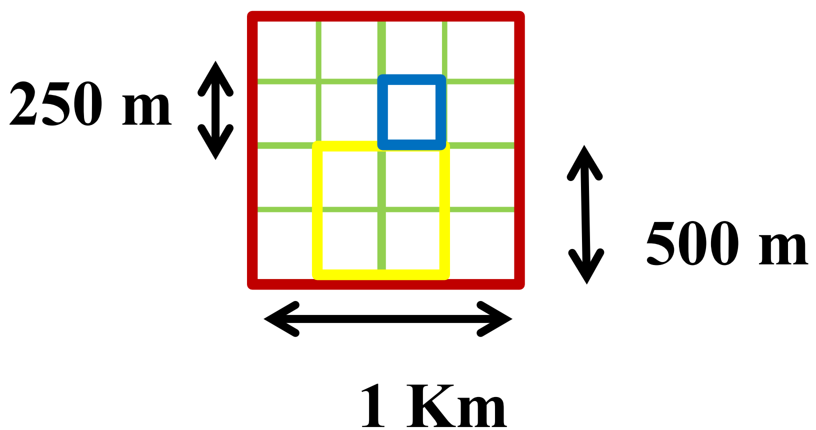


SPATIAL RESOLUTION OF SWOT MEASUREMENTS

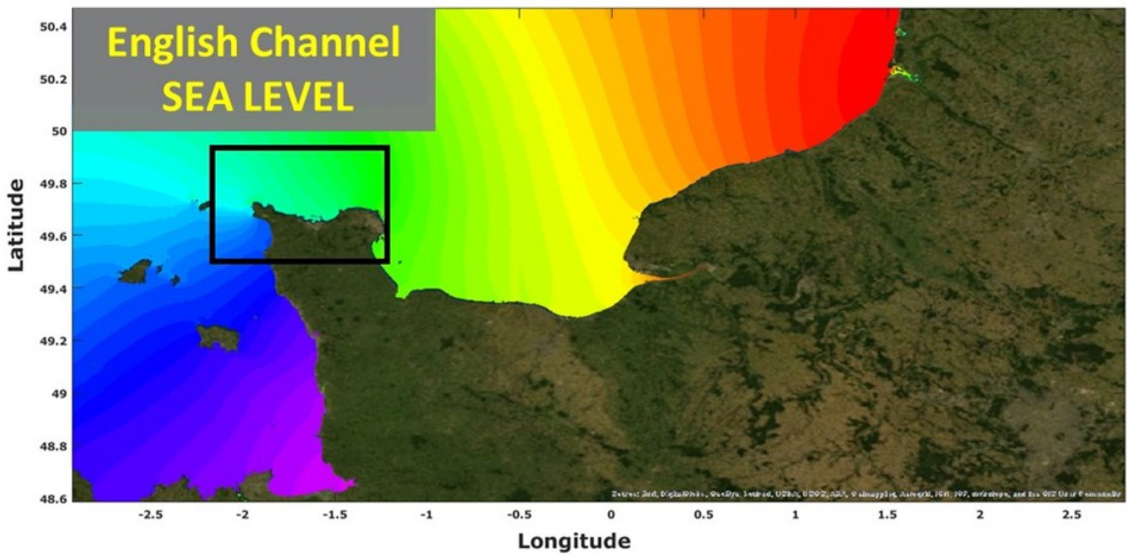
Physical Processes in Coastal Zones

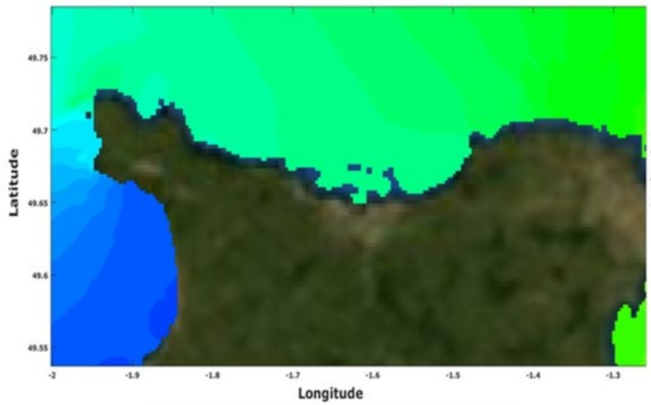
Vertical: 20 cm 60-80% of hydrodynamic variability *(Carter et al., 1993)*

Horizontal: < 1 Km ??

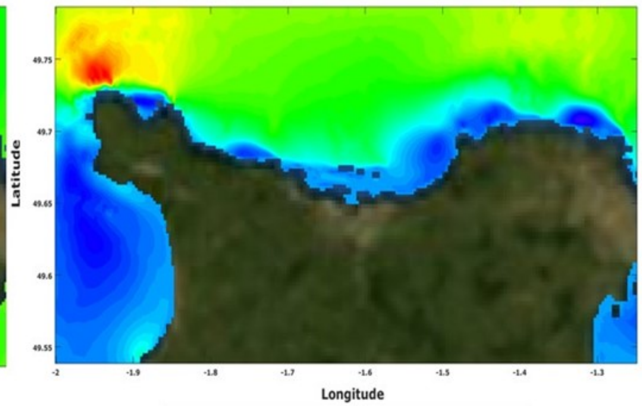


SPATIAL RESOLUTION OF SWOT MEASUREMENTS

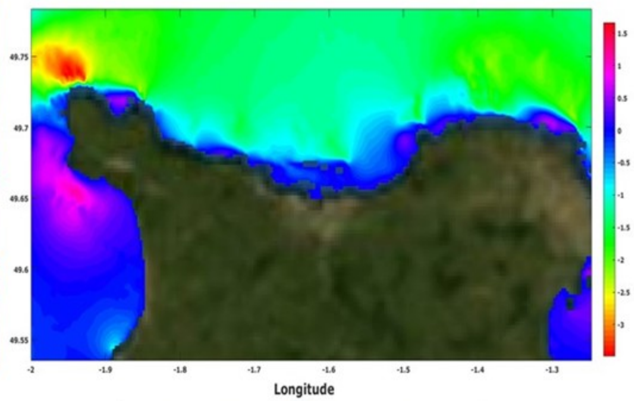




MESH GRID 1 Km



MESH GRID 500m

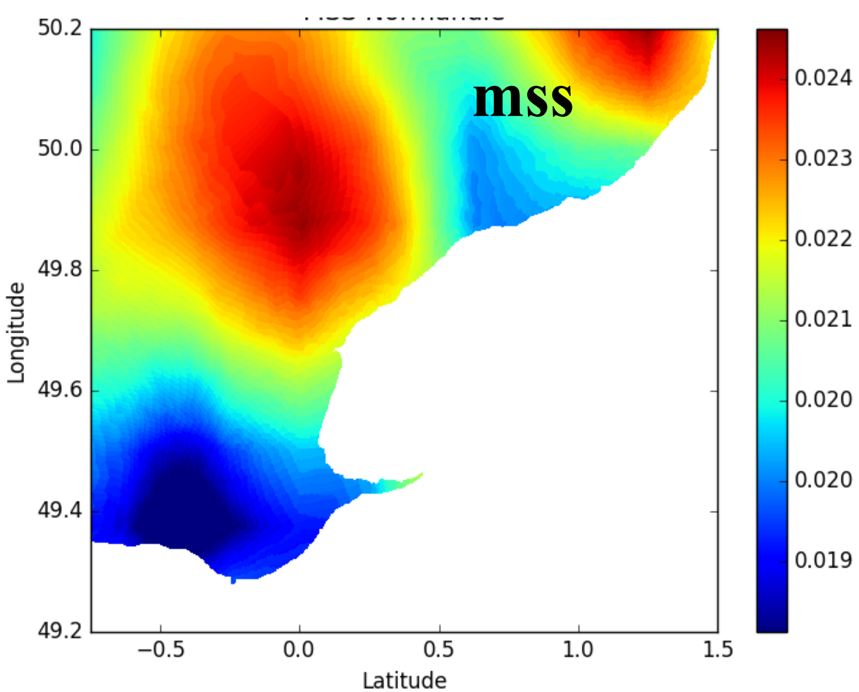


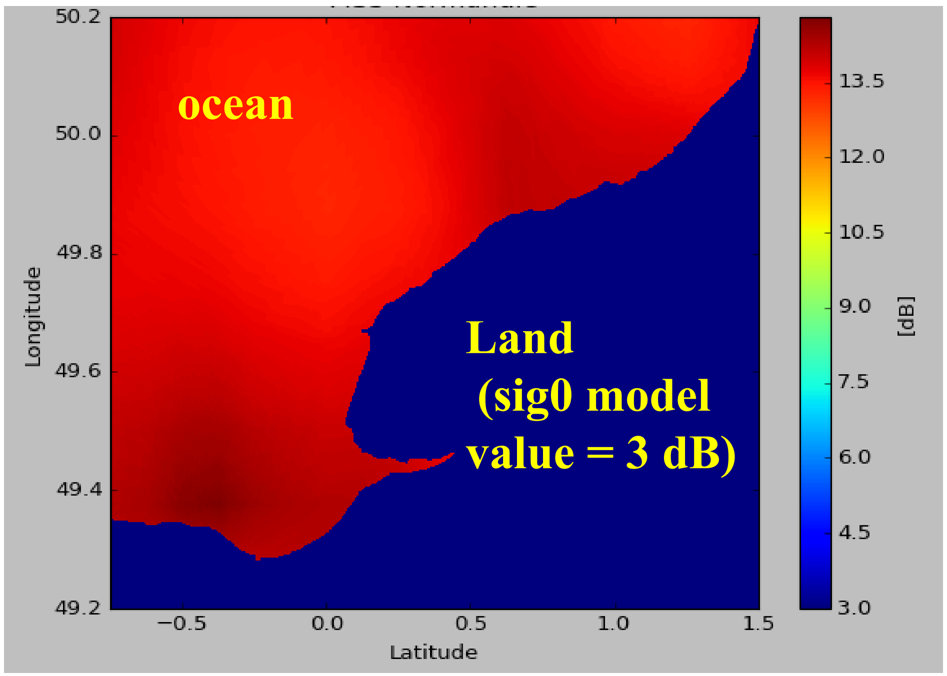
MESH GRID 250m

USE OF CNES/CLS SWOT SIMULATOR FOR COASTAL ZONES

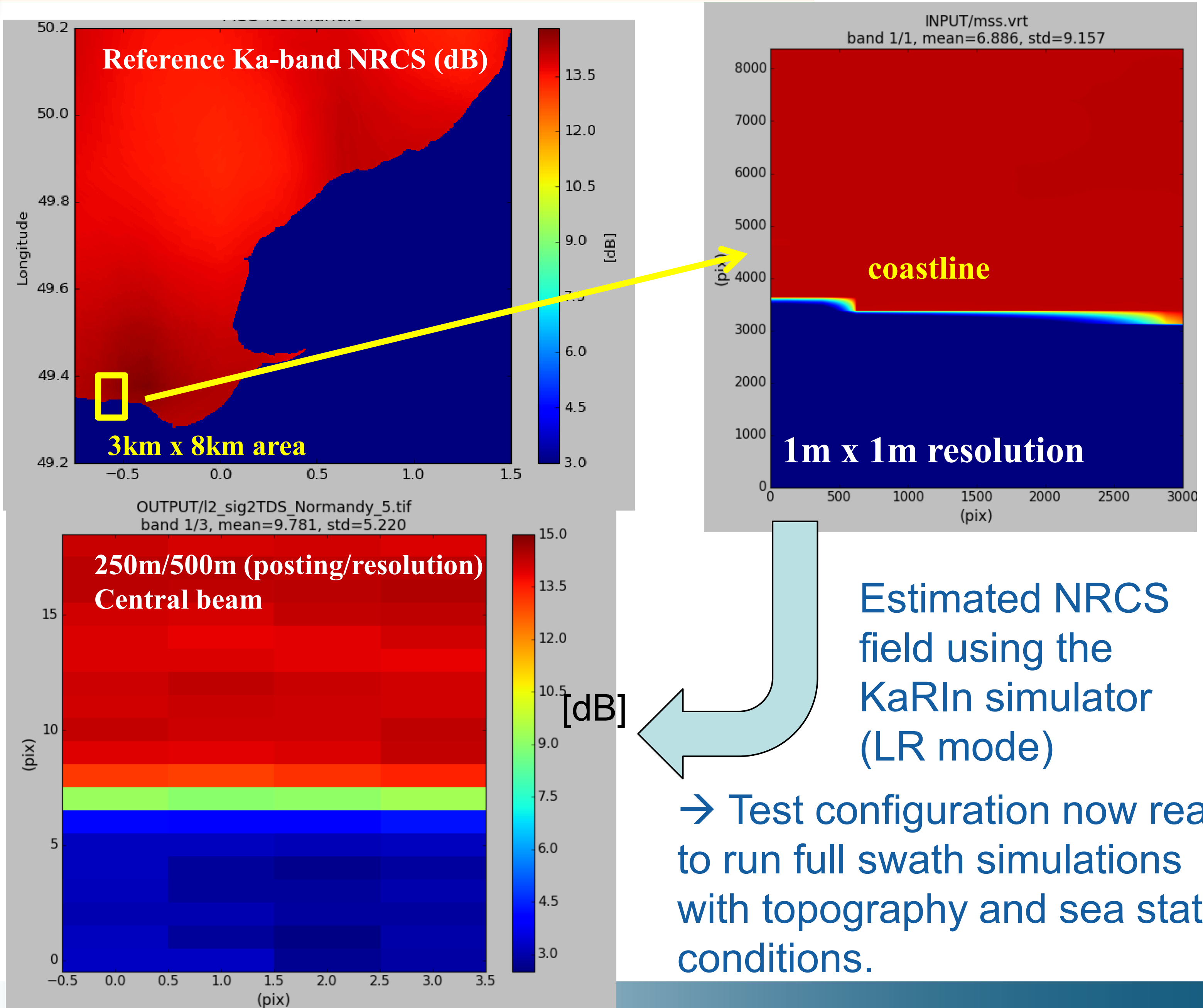
- Set-up of a coastal simulation case (Normandie):
  - ➢ Adaptation of the software interfaces (DEM, mask, radiometry)
  - ➢ Validation test with sea surface roughness model (no topography for now).
  - ➢ LR mode tested, then HR mode

Input sea surface roughness ⇨ **Reference Ka-band NRCS (dB)**





SOME ASPECTS OF HYDRODYNAMIC SWOT MEASUREMENTS IN COASTAL ZONES



Estimated NRCS field using the KaRIn simulator (LR mode)

→ Test configuration now ready to run full swath simulations with topography and sea state conditions.

FURTHER SUGGESTIONS

Combining LR/HR is important since the vertical precision needed depends on the physical phenomena in coastal and estuarine zones.

Considering the Layover in different contexts: presence of vegetation, shoreline with cliff, wet sandy beaches.

Considering other wave spectra for SWOT simulator

Investigating the impact of IG waves in SWOT measurements

Comparison between modelled results, HR simulator, & in-situ data (tide gauges) in particular these provided by the Seine estuary Cal/val campaign produced the last week => Pascal Bonnefond presentation (29/06/2017)