SWOT Science Team Meeting

September 13-15, 2021

Monitoring the Intertidal Topography Using the Future SWOT Mission

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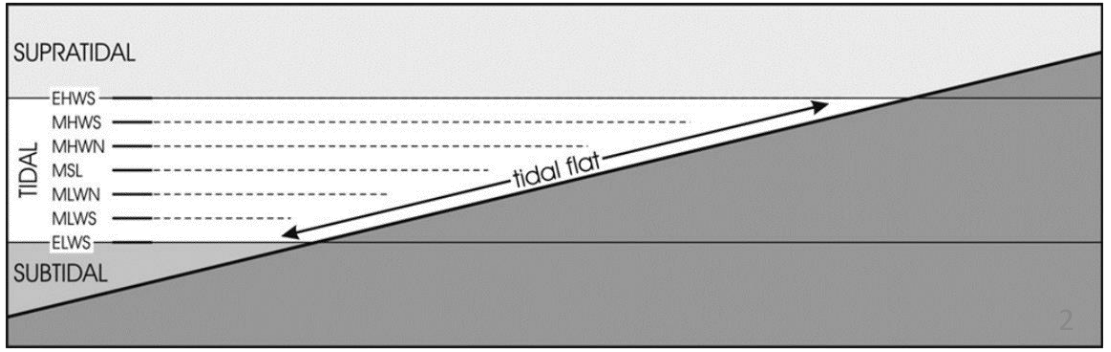
Intertidal Flats

- Gently sloped areas located between the high and low water spring tide marks (Gao 2019)
- Widely spread coastal systems (Murray et al. 2019)
- Provide habitat for a large variety of biota
- They are currently under high pressure
- Since 1980s, they have declined globally by 16% (Murray et al. 2019)

↓

Monitoring intertidal topography is fundamental for environmental protection, coastal flood forecasting, navigation, and fishing, etc.



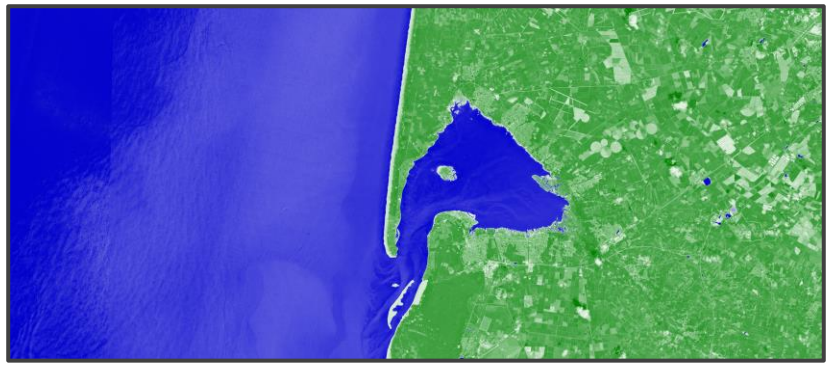
Intertidal areas and the waterline method

Intertidal Areas

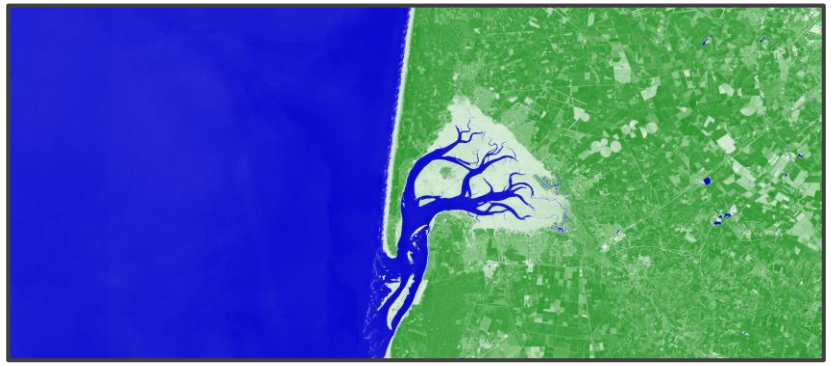
Gently sloped areas located between the high and low water spring tide marks [Gao 2019]

Arcachon Bay – Sentinel-2 - NDWI

High Tides

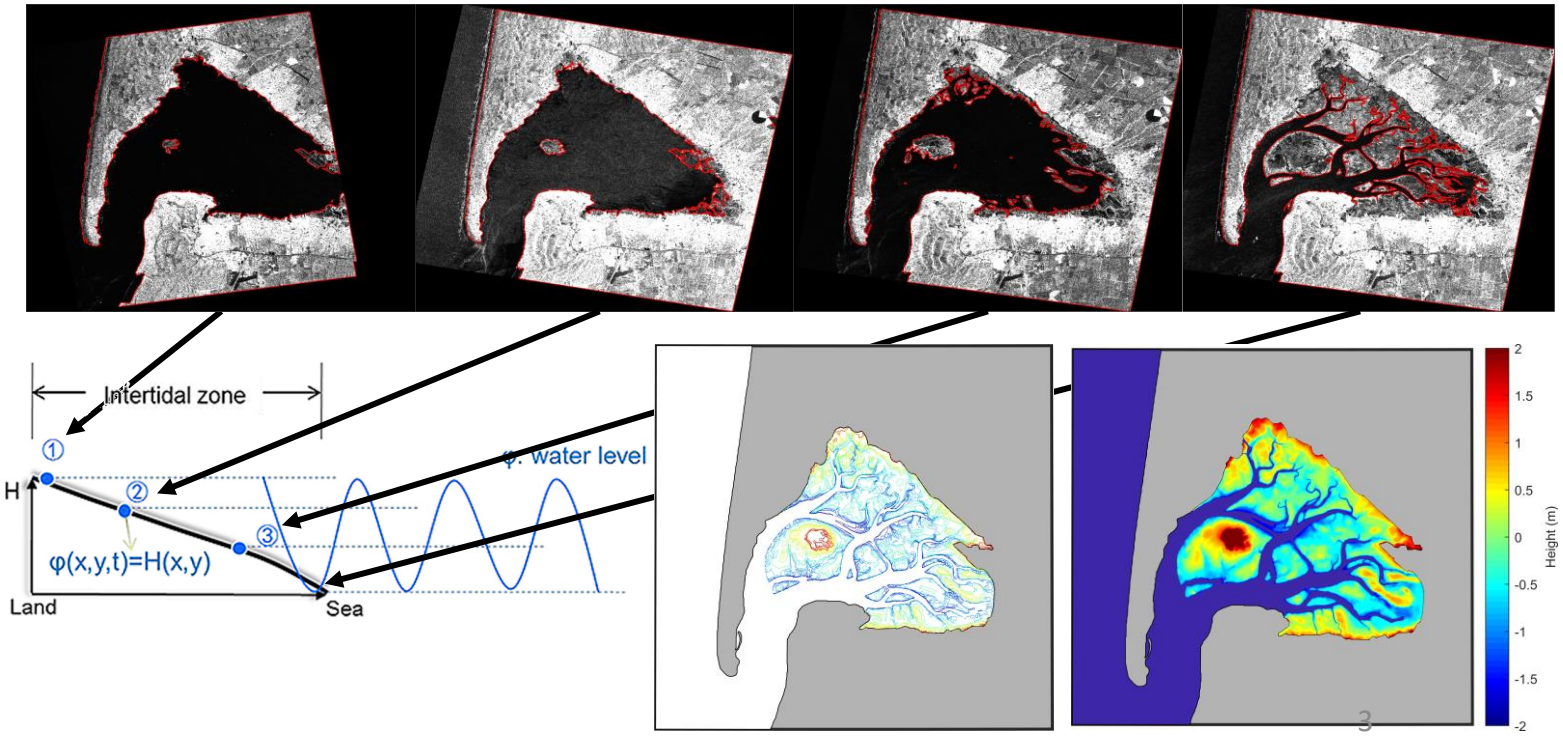


Low Tides



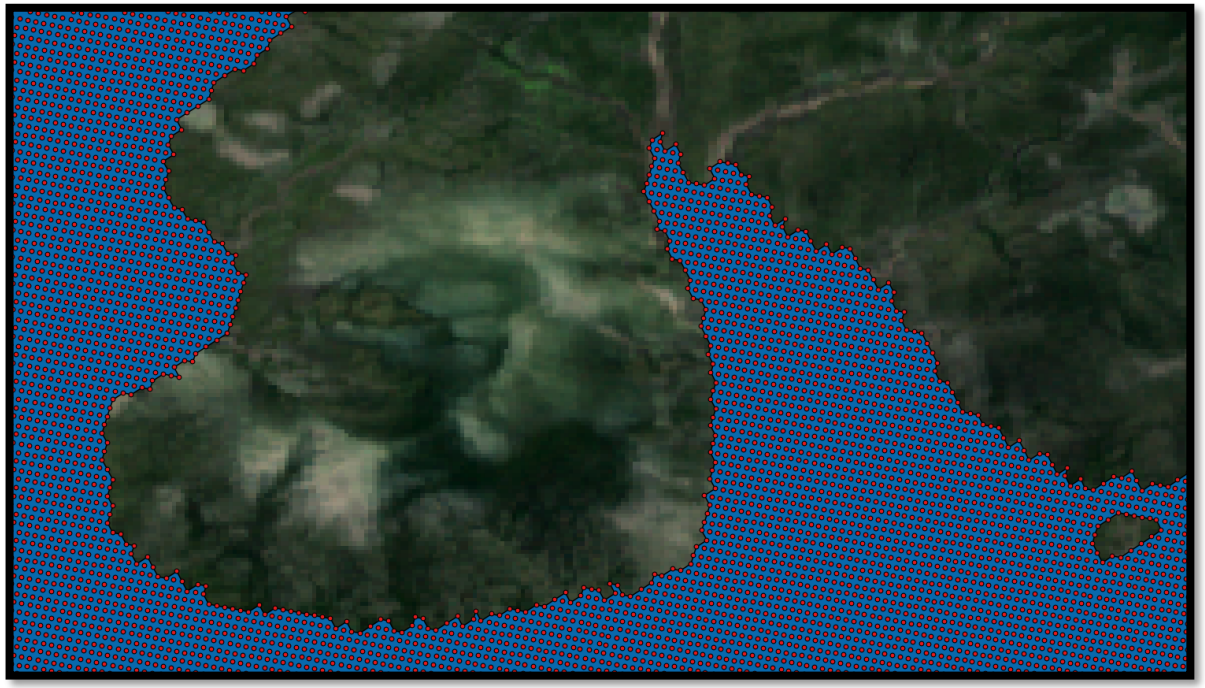
The waterline method [Mason et al. (1995)]

- Extracting waterlines from a series of images
- Assigning heights to waterlines using sea level information
- Assembling and interpolating the waterlines to form a gridded-DEM



SWOT Products over coastal areas

Pixel cloud product



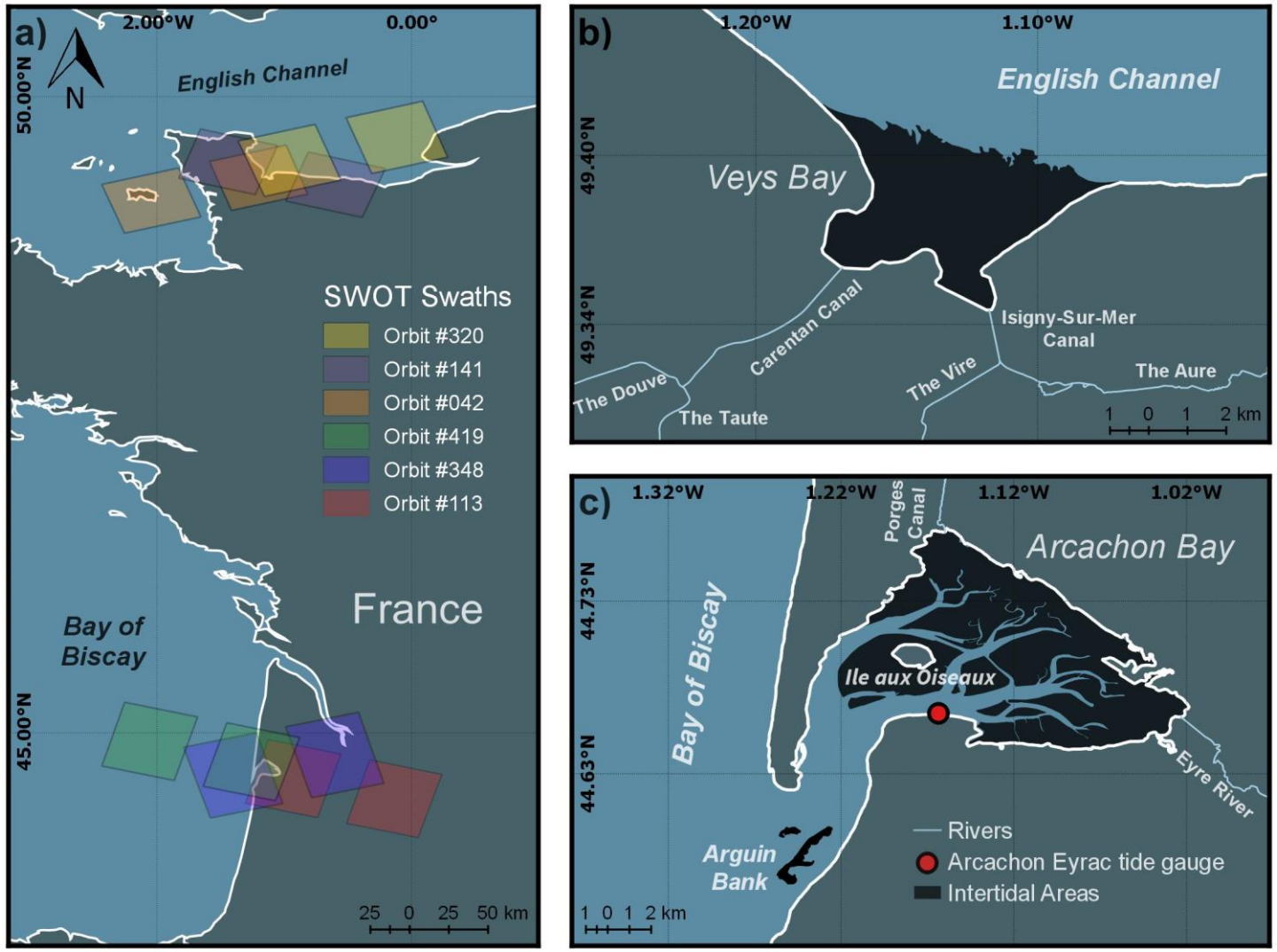
The product provides for each point classified as water:

- Longitude
- Latitude
- Water level
- Pixel size

+ Water mask

SWOT will render the waterline method completely independent of in situ measurements

Study Sites and objectives



Objectives:

- Assess the potential of SWOT to generate intertidal DEMs
- Examine the impact of the SWOT sampling scheme
- Examine the impact of the acquisition period
- Examine the ability of SWOT to track topographic changes

Generating SWOT intertidal DEMs

- SWOT-type observables simulated by the SWOT Hydrology Toolbox (SWOT HR Simulator) available on Github

Input

-Mission start time: 01/01/2016
-Simulation start time 01/06/2016
-Simulation end time: 01/10/2016

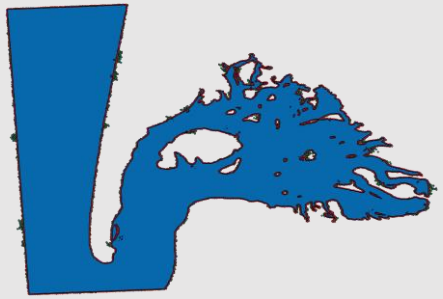
-Region of Interest

-Input-DEM + Water level to generate water masks at each SWOT passage

SWOT Hydrology Toolbox

Output

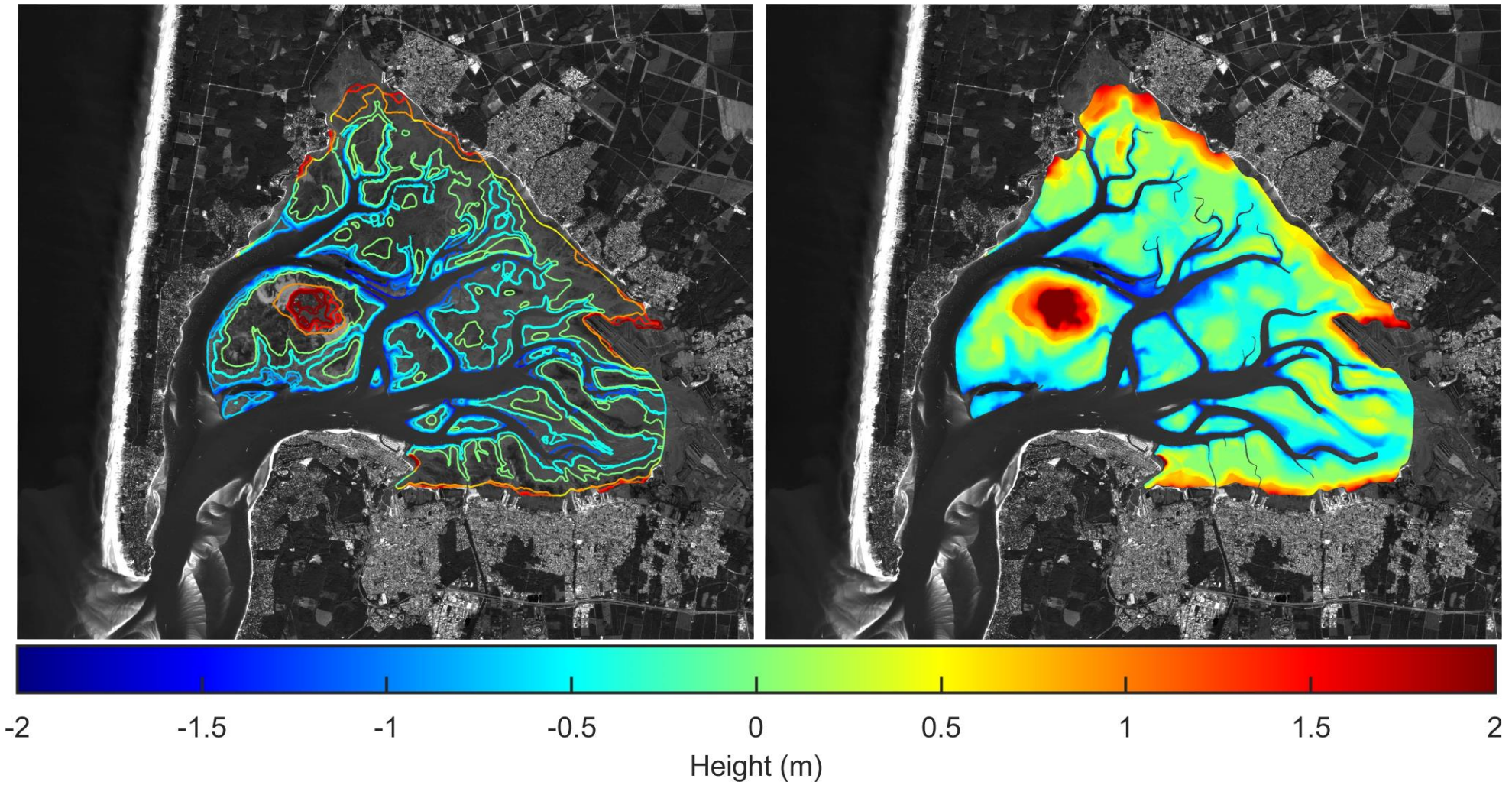
Series of water masks and their corresponding water level simulated according to SWOT technical performance



First Result

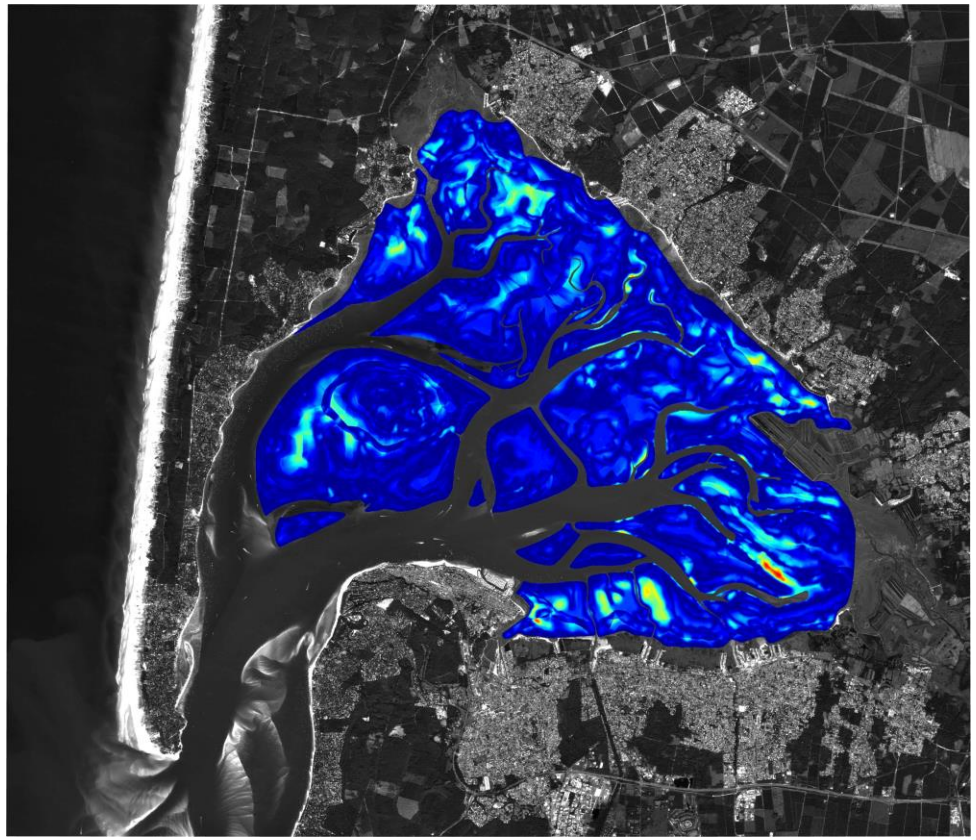
SWOT Waterline

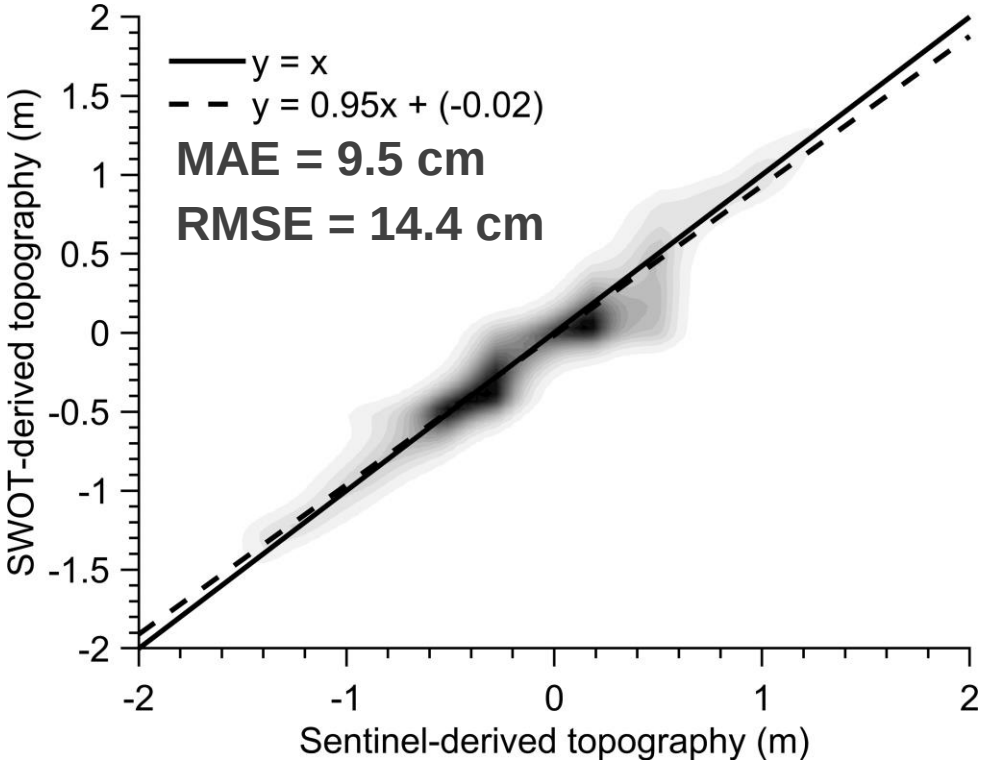
SWOT intertidal DEM

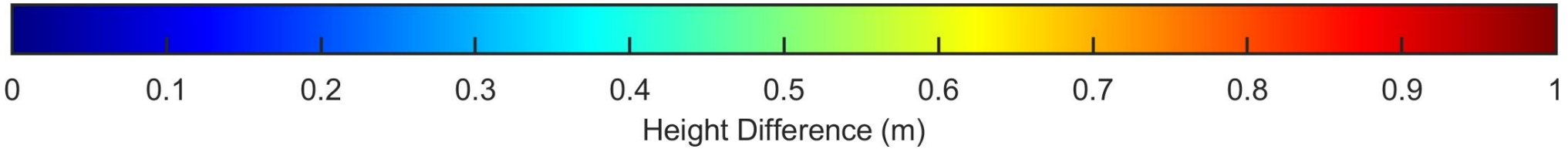


DEMs comparison

Abs(input DEM – SWOT DEM)





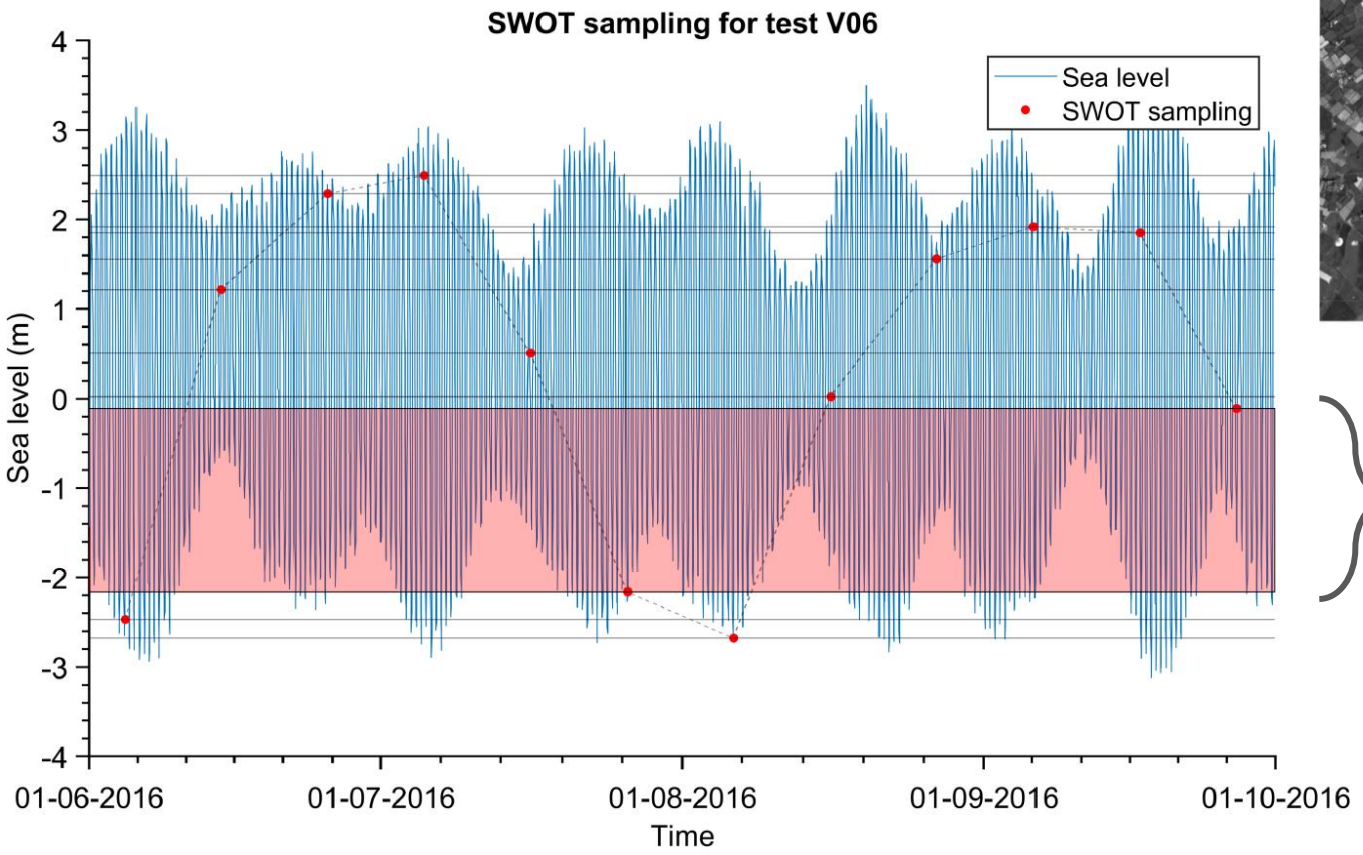


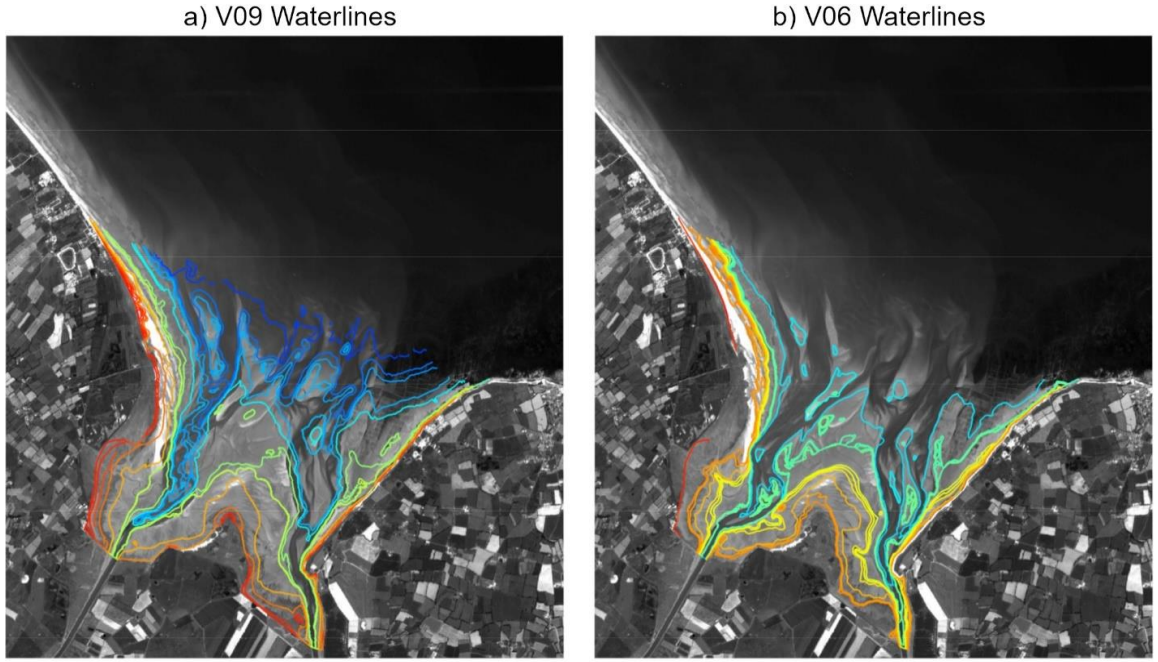
Impact of SWOT sampling scheme

Study site	Test name	Mission start time	Simulation start time	Simulation end time	Number of passes	Acquisition period (month)	MAE (cm)	RMSE (cm)
Arcachon	A01	01-01-2016	01-06-2016	01-10-2016	16	4	9.5	14.4
	A02	06-01-2016	01-06-2016	01-10-2016	16	4	5.2	8.4
	A03	12-01-2016	01-06-2016	01-10-2016	17	4	8.5	14.0
	A04	18-01-2016	01-06-2016	01-10-2016	15	4	19.5	30.6
	A05	24-01-2016	01-06-2016	01-10-2016	14	4	7.3	12.5
	A06	30-01-2016	01-06-2016	01-10-2016	16	4	9.0	13.9
	A07	05-02-2016	01-06-2016	01-10-2016	13	4	10.2	15.6
	A08	11-02-2016	01-06-2016	01-10-2016	16	4	8.7	12.9
	A09	17-02-2016	01-06-2016	01-10-2016	14	4	12.3	19.6
	A10	23-02-2016	01-06-2016	01-10-2016	15	4	6.9	12.0
	A11	29-02-2016	01-06-2016	01-10-2016	15	4	7.6	12.9
Veys	V01	01-01-2016	01-06-2016	01-10-2016	12	4	11.6	18.4
	V02	06-01-2016	01-06-2016	01-10-2016	12	4	17.6	24.7
	V03	12-01-2016	01-06-2016	01-10-2016	12	4	18.3	30.4
	V04	18-01-2016	01-06-2016	01-10-2016	12	4	15.1	24.0
	V05	24-01-2016	01-06-2016	01-10-2016	11	4	21.1	37.0
	V06	30-01-2016	01-06-2016	01-10-2016	12	4	28.4	50.1
	V07	05-02-2016	01-06-2016	01-10-2016	11	4	13.9	20.8
	V08	11-02-2016	01-06-2016	01-10-2016	12	4	15.0	24.3
	V09	17-02-2016	01-06-2016	01-10-2016	12	4	10.2	17.3
	V10	23-02-2016	01-06-2016	01-10-2016	12	4	22.6	38.0
	V11	29-02-2016	01-06-2016	01-10-2016	12	4	12.8	19.5

- The launch date of SWOT impacts the sampling regime for the same acquisition period
- The sampling (orbit) of SWOT influences the quality of DEMs
- The aliasing is at the origin of this influence

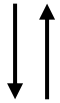
Tidal Aliasing





No waterlines for this water level range

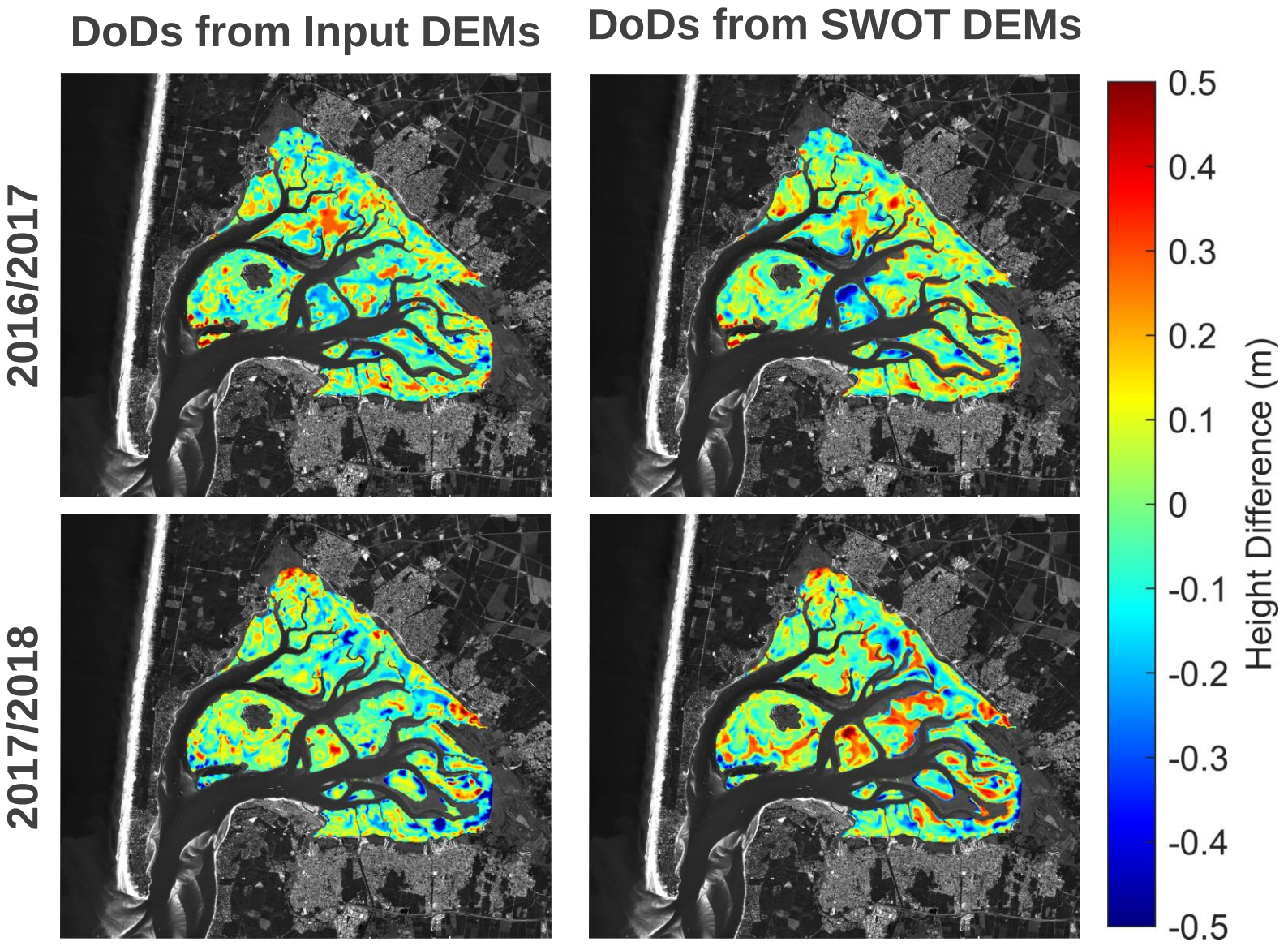
Impact of the Acquisition period



Study site	Test name	Mission start time	Simulation start time	Simulation end time	Number of passes	Acquisition period (month)	MAE (cm)	RMSE (cm)
Arcachon	A02	06-01-2016	01-06-2016	01-10-2016	16	4	5.2	8.4
	A12	06-01-2016	01-08-2016	01-10-2016	9	2	16.2	25.3
	A13	06-01-2016	01-07-2016	01-10-2016	13	3	6.2	9.5
	A14	06-01-2016	01-05-2016	01-10-2016	21	5	4.9	8.1
	A15	06-01-2016	01-04-2016	01-10-2016	25	6	4.6	7.9
	A16	06-01-2016	01-03-2016	01-10-2016	28	7	4.4	7.9
Veys	V09	17-02-2016	01-06-2016	01-10-2016	12	4	10.2	17.3
	V12	17-02-2016	01-08-2016	01-10-2016	6	2	19.4	30.9
	V13	17-02-2016	01-07-2016	01-10-2016	9	3	12.4	18.9
	V14	17-02-2016	01-05-2016	01-10-2016	14	5	9.4	16.3
	V15	17-02-2016	01-04-2016	01-10-2016	17	6	6.7	11.4
	V16	17-02-2016	01-03-2016	01-10-2016	20	7	6.7	11.5

A period of 3 months is a good compromise between the acquisition period and a relatively stable hydrodynamic period

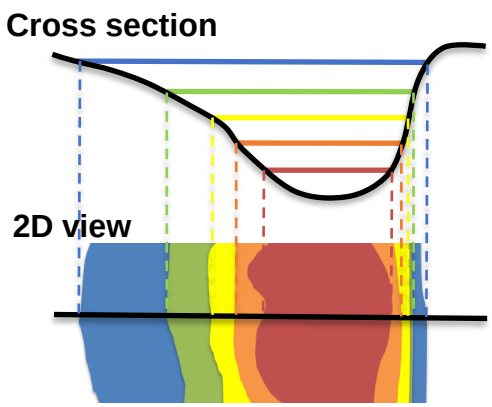
Topographic changes

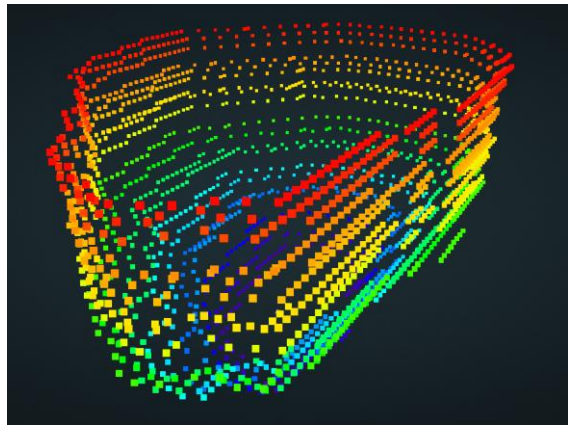


- Topographic changes were successfully detected for 2016/2017
- Inadequate sampling for 2018, due to the continuous change of phase change between SWOT's orbit and the tides
- The period during which the series of satellite images are acquired (the acquisition period) shall be chosen carefully

DoD = DEMs of Difference

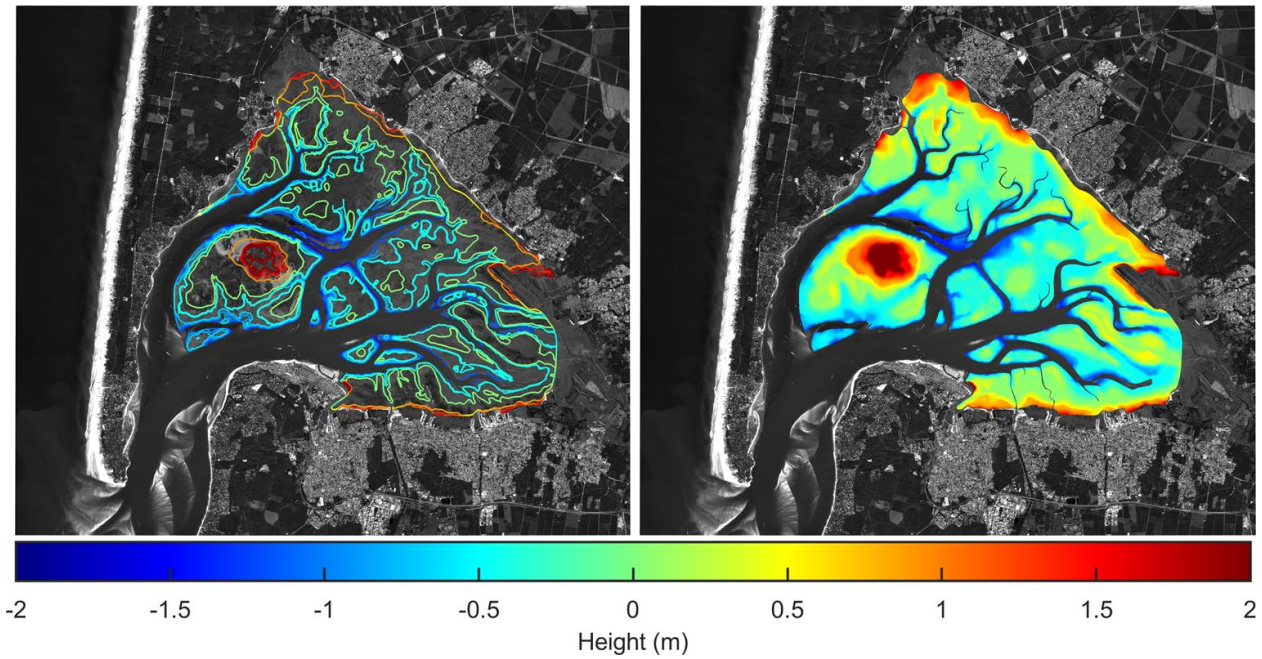
L2_HR_FPDEM Product





SWOT Waterlines

Intertidal DEM



- Floodplain DEM product
- For coastal regions it is a DEM for intertidal areas
- For now: the product will be provided as a raster DEM with 50 m resolution using PIXCVec (water/sediment boundaries from PIXCVec) data aggregated over a year
- 1 Year is a very long acquisition period for intertidal areas

Conclusions

- Using the waterline method SWOT is able to provide intertidal DEMs with an accuracy of up to 5 cm
- SWOT accuracy is dependent on the SWOT orbit and the acquisition period (duration and temporal localization)
- 3 months is a good compromise between acquisition period and a relatively stable hydrodynamic period to obtain good accuracy
- SWOT has a great potential to detect topographic changes

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Monitoring intertidal topography using the future SWOT (Surface Water and Ocean Topography) mission

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Thank you