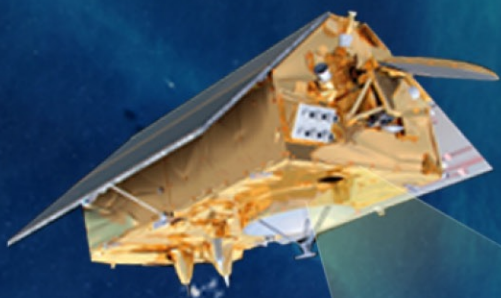




# 13<sup>th</sup> COASTAL ALTIMETRY WORKSHOP & COASTAL ALTIMETRY TRAINING

6–10 February 2023 | Universidad de Cádiz, Spain



## Fully Focused SAR Altimetry and Innovative River Level Gauges for Coastal Monitoring – the FFSAR-Coastal Project

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## FFSAR – Coastal

The FFSAR-Coastal Project is applying the SMAP Fully Focused SAR (FFSAR) altimetry processor on Sentinel-3A and Sentinel 3B data in order to evaluate the potential of FFSAR altimeter data to contribute to coastal and estuarine monitoring.

Two different environments :

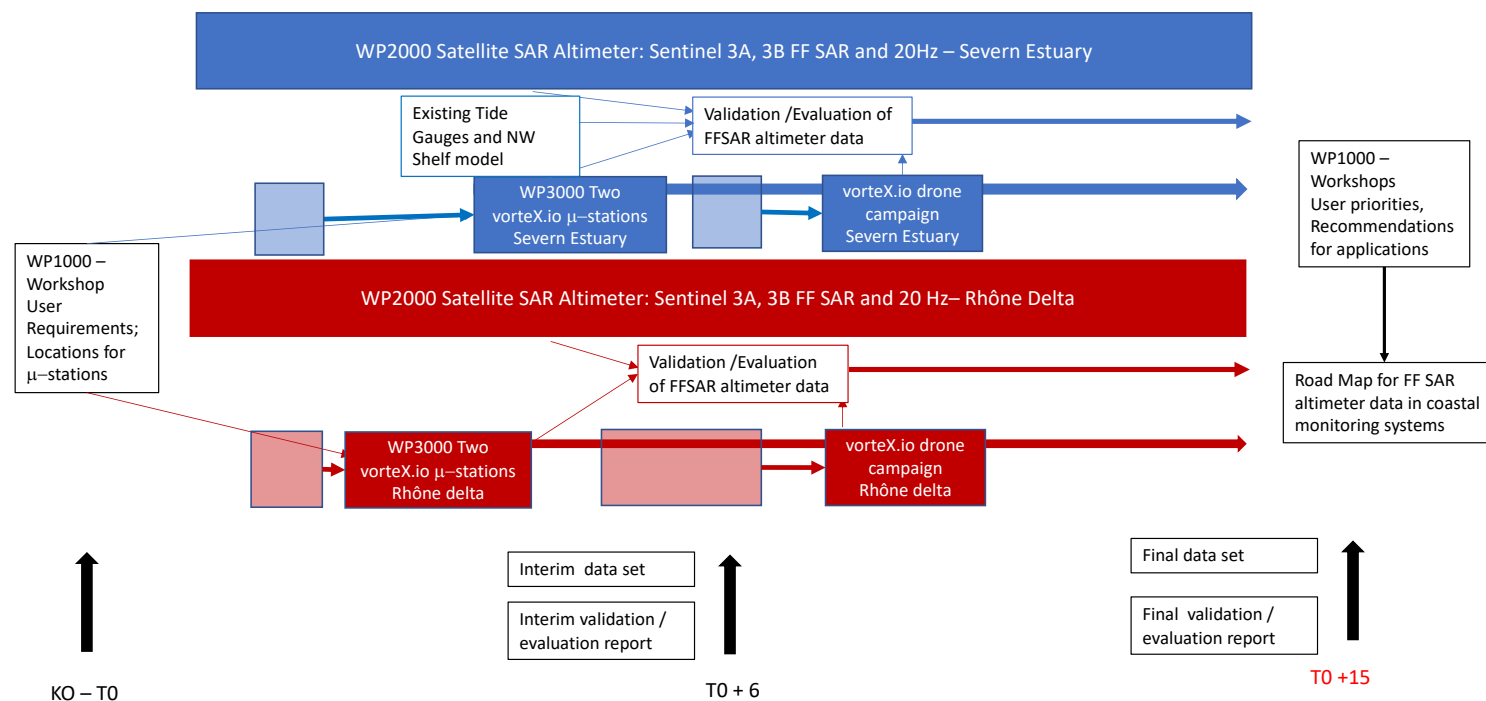
- The Severn Estuary : Highly dynamic mixed tidal estuary environment, confluence between a river and its estuary experiencing large tidal range and strong tidal currents.
- The lower Rhone Delta and Camargue: A low lying, flat river delta and wetland environment, susceptible to inundation and rising water levels.

Funded by **ESA** through the EO4Society Open Call

<https://www.satoc.eu/projects/ffsar/>

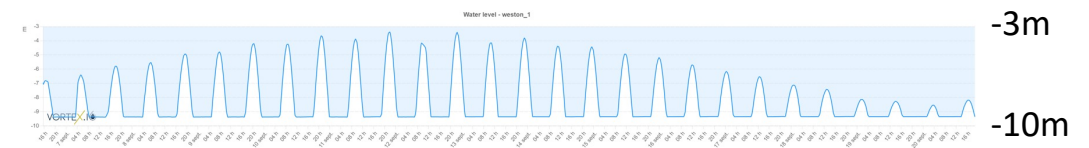
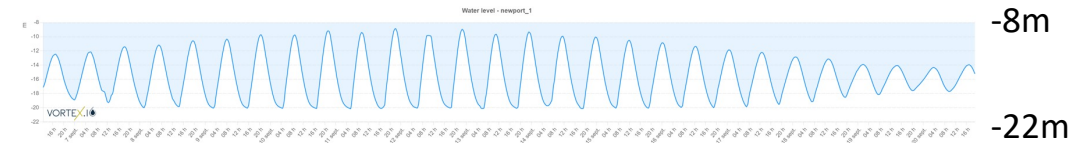


- Fully Focussed SAR processing (DTU)
  - Apply SMAP FFSAR processor for S3A, S3B data in Severn and Rhône areas
  - Validate against in-situ data, evaluate ability to map key features
  - Identify optimum processing choices
- vortex.io micro-gauges
  - Install 4  $\mu$ gauges (2 per region) for in situ validation
  - Drone campaigns to map water level from in situ sites to satellite track
- User Engagement / Application Road Map (NOC, CCO)
  - Workshops > Roadmap for FFSAR processing in Coastal Monitoring Systems



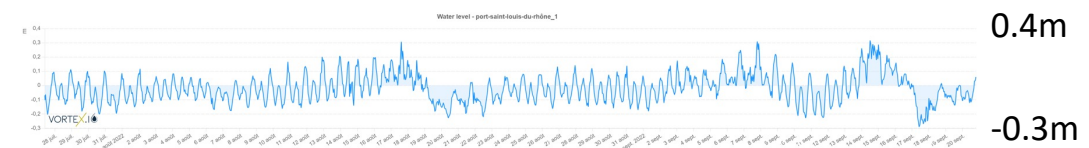
### Vortex.io “micro” Gauges

- LiDAR, 8Mpx camera
- Real Time data
- Remote management
- Lightweight, small and easy to install



### FFSAR Coastal Installations

- Severn Estuary: Newport & Weston Super Mare (06/09/22)
- Rhône delta: Port St Louis du Rhône & Fos sur Mer (27/07/22)
- To be deployed until June 2023



Connect water level at gauge to satellite track at the time of overpass.

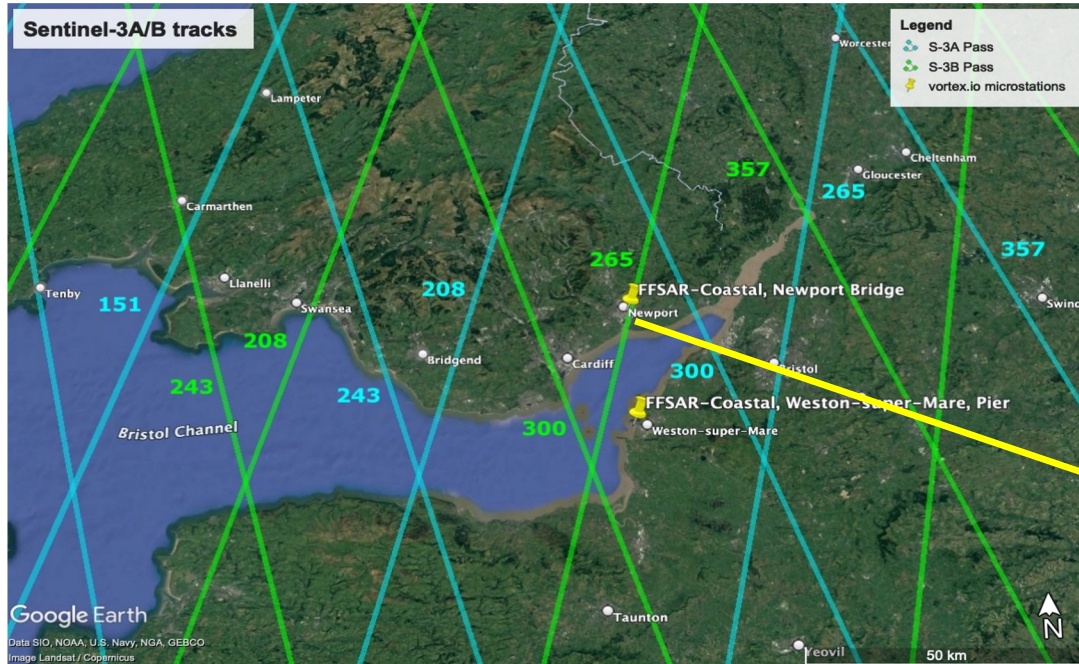
- LiDAR: cm level accuracy, 50cm to 90m range
- 8Mpx camera: water mask, orthophotos
- 900g

### Flight planning

- Deployment from river banks or boat, depends on respective locations of gauges and satellite tracks
- Regulations for flying near airports
- Feb – March 2023

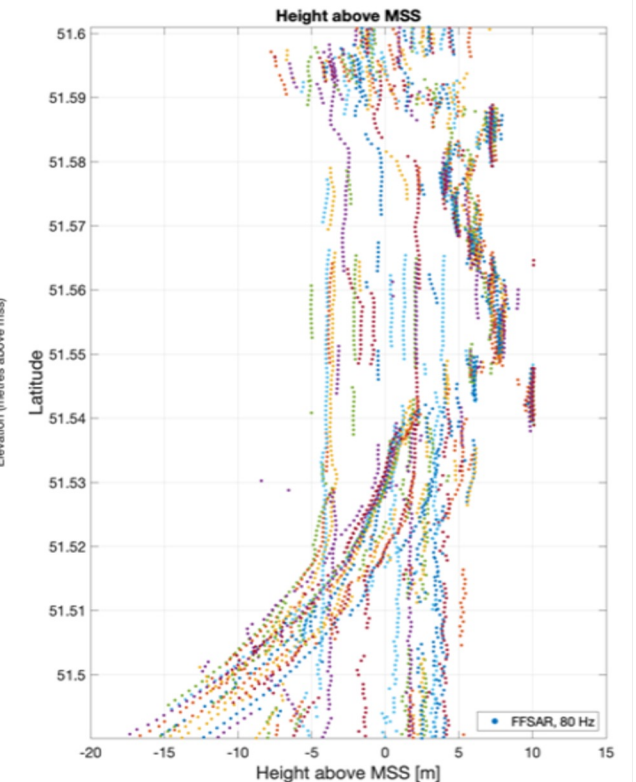
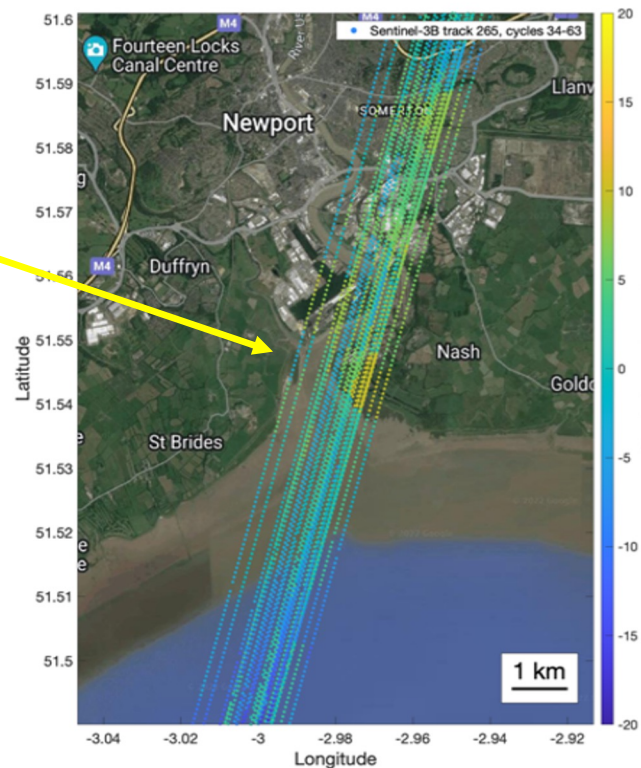


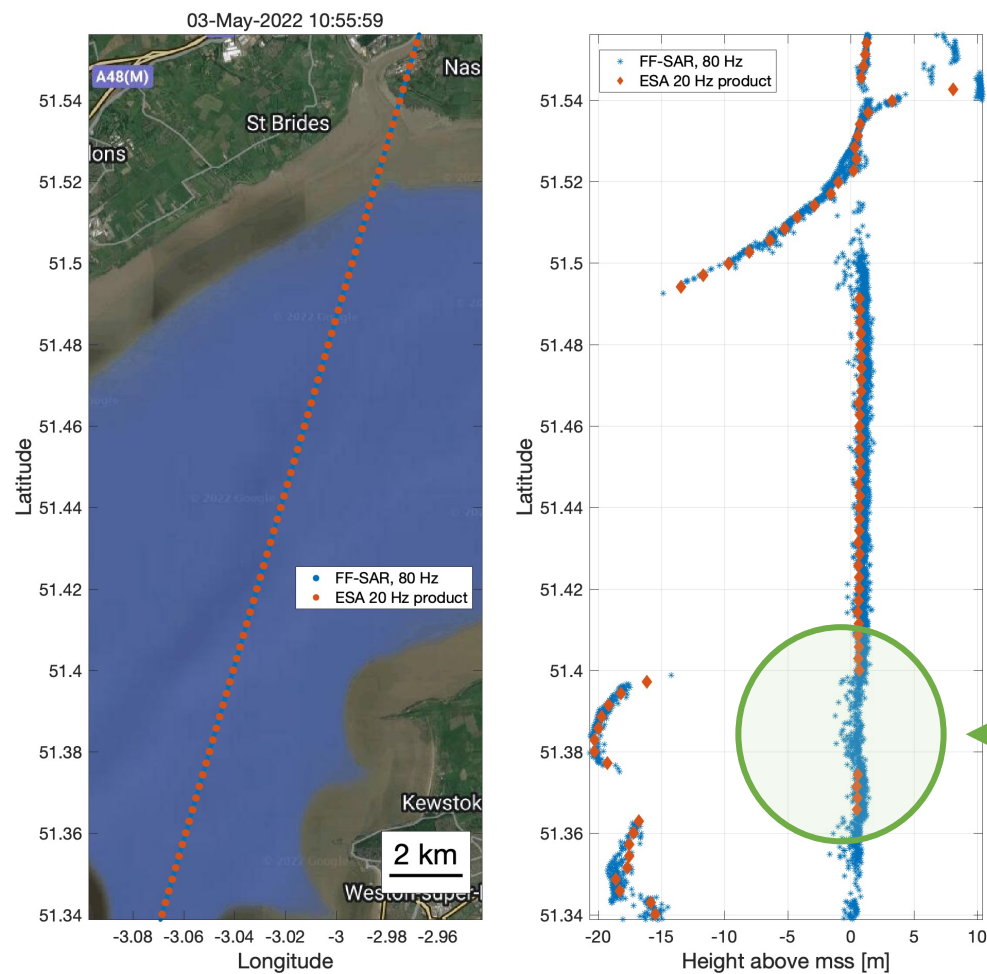
- Apply SMAP (Standalone Multi-Mission Altimetry Processor) to Sentinel 3A and 3B data
- Initial results to identify the optimum processing choices, then applied to generate time series of data for selected tracks.
- Validation against in-situ data and models.
- Evaluate how well FFSAR altimeter data can resolve fine scale features in two different environments.
- Severn Estuary: Ability to capture small scale physical signals (surface gradients, currents, roughness signatures) in highly tidal regions and to detect and measure tidal asymmetry/gradients
- Rhône delta: Ability of FFSAR data to accurately map different low lying channels and filaments.



- S3B from track 265 processed using SMAP.
- Water levels by combining SMAP output with L2 files from ESA/scihub.

Results from OCOG re-tracker  
Are we seeing bathymetry at low tide?



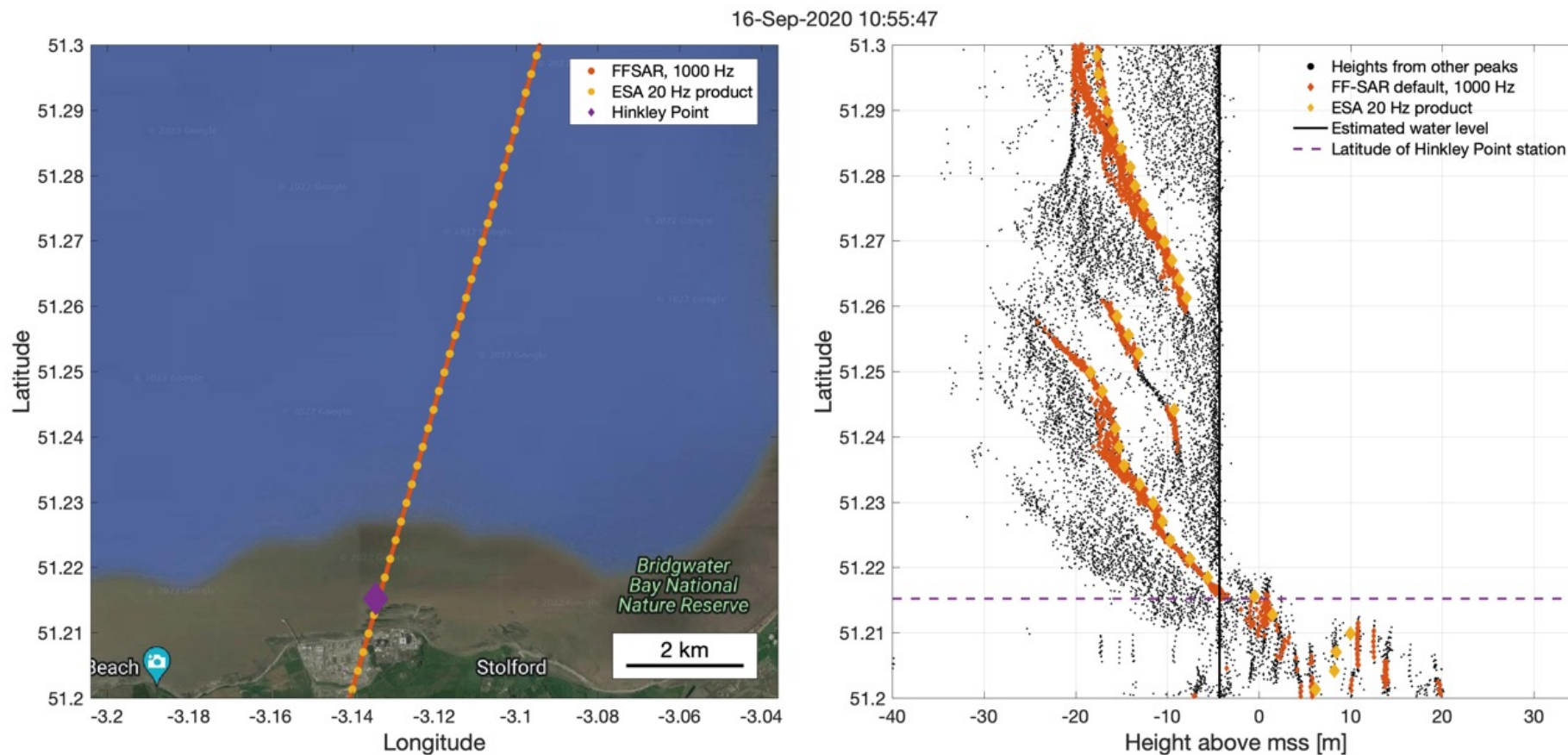


In fact, it is snagging to off-nadir reflections

In some places, the water level is present in FFSAR where it is not available in standard processing



Improved results using 10 peak re-tracker – can extract true water level

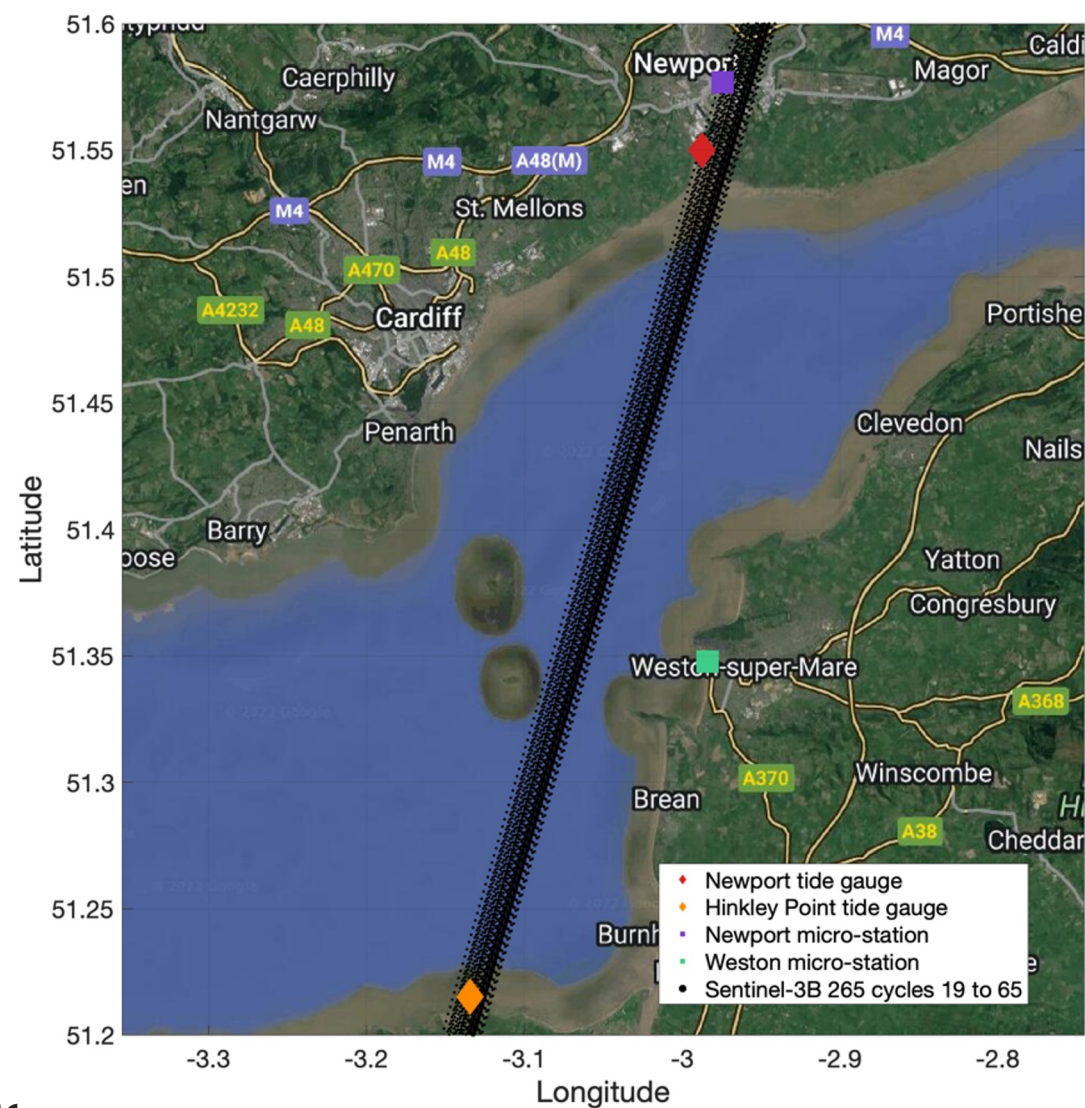


RON 265 from Sentinel-3B is close to several tide gauges and to the micro-stations

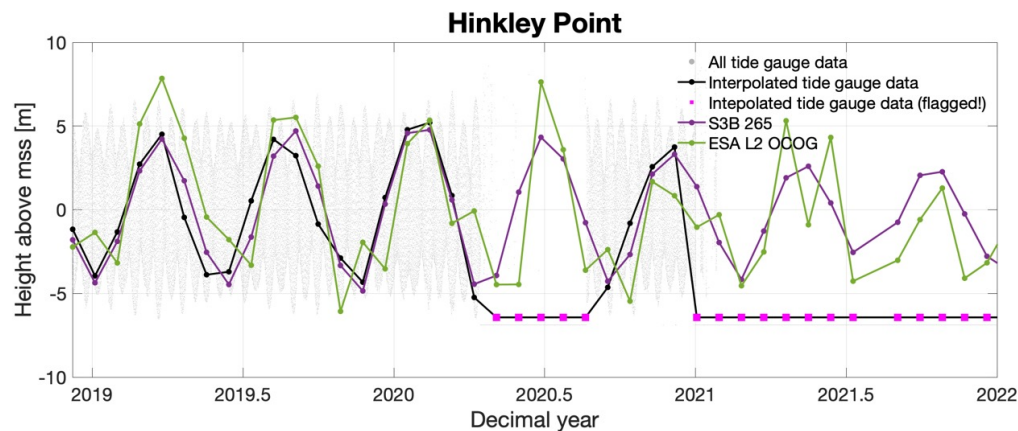
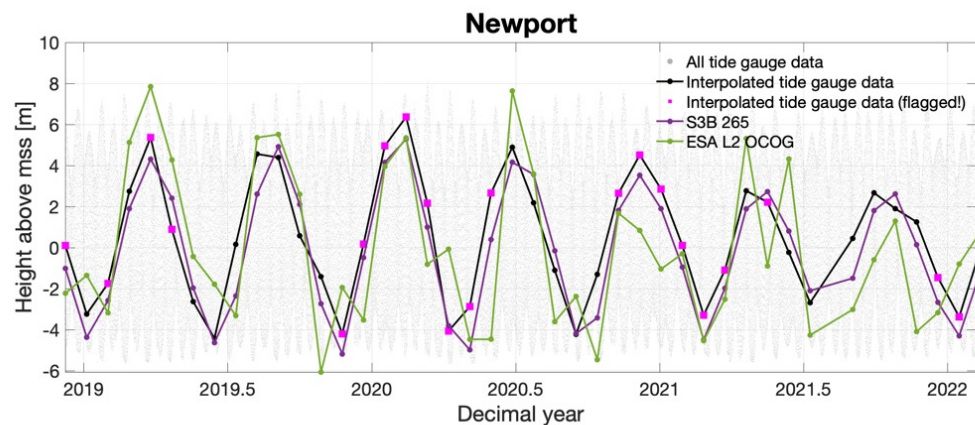
**Tide gauges used for validation of FFSAR data:**

**Newport**

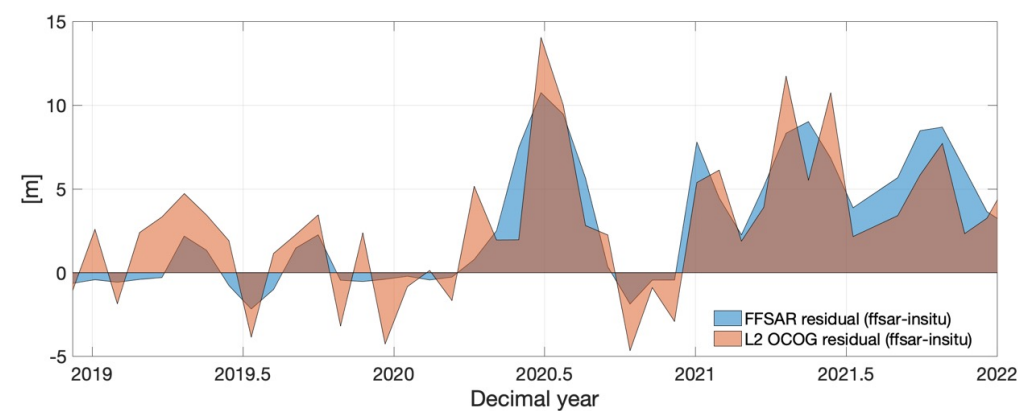
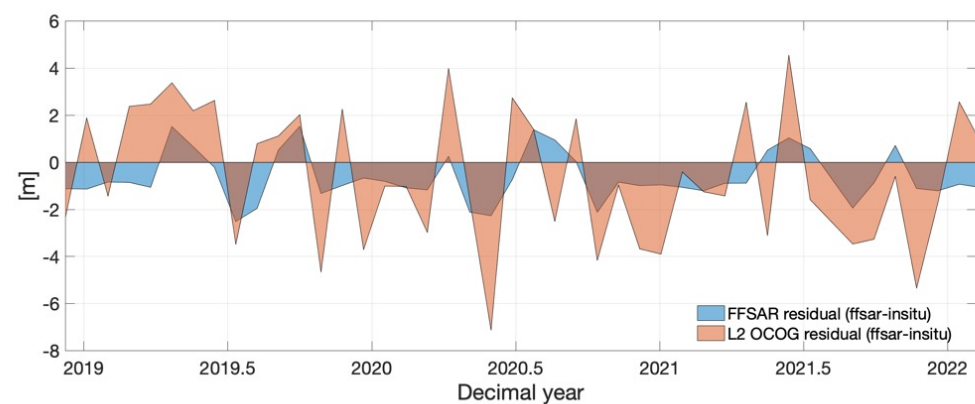
**Hinkley Point**



## Time Series comparison with Tide Gauges

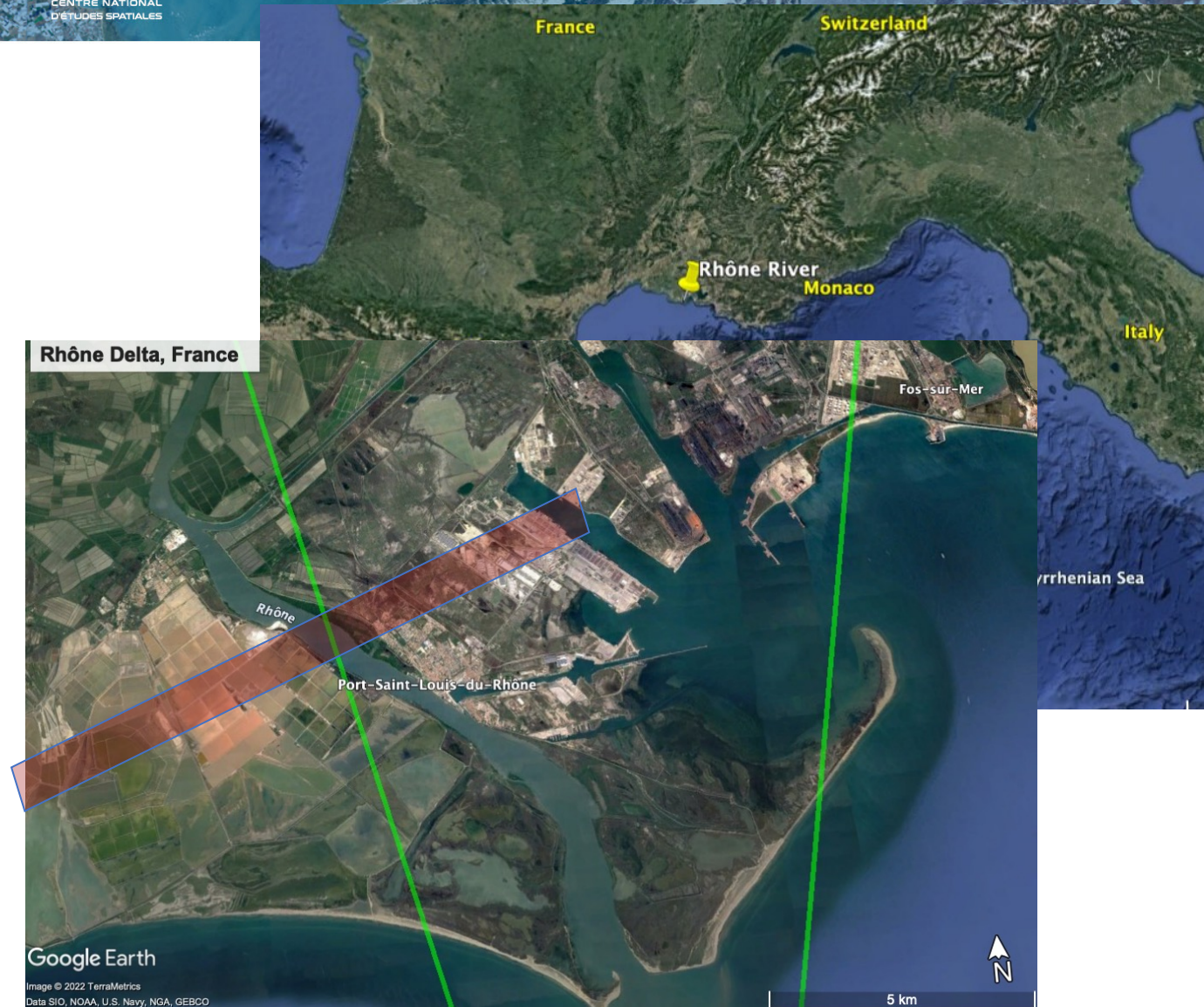


Generally good agreement but RMSE of 1.2 m.



Improvement on RMSE ~3m from ESA OCOG retracker!

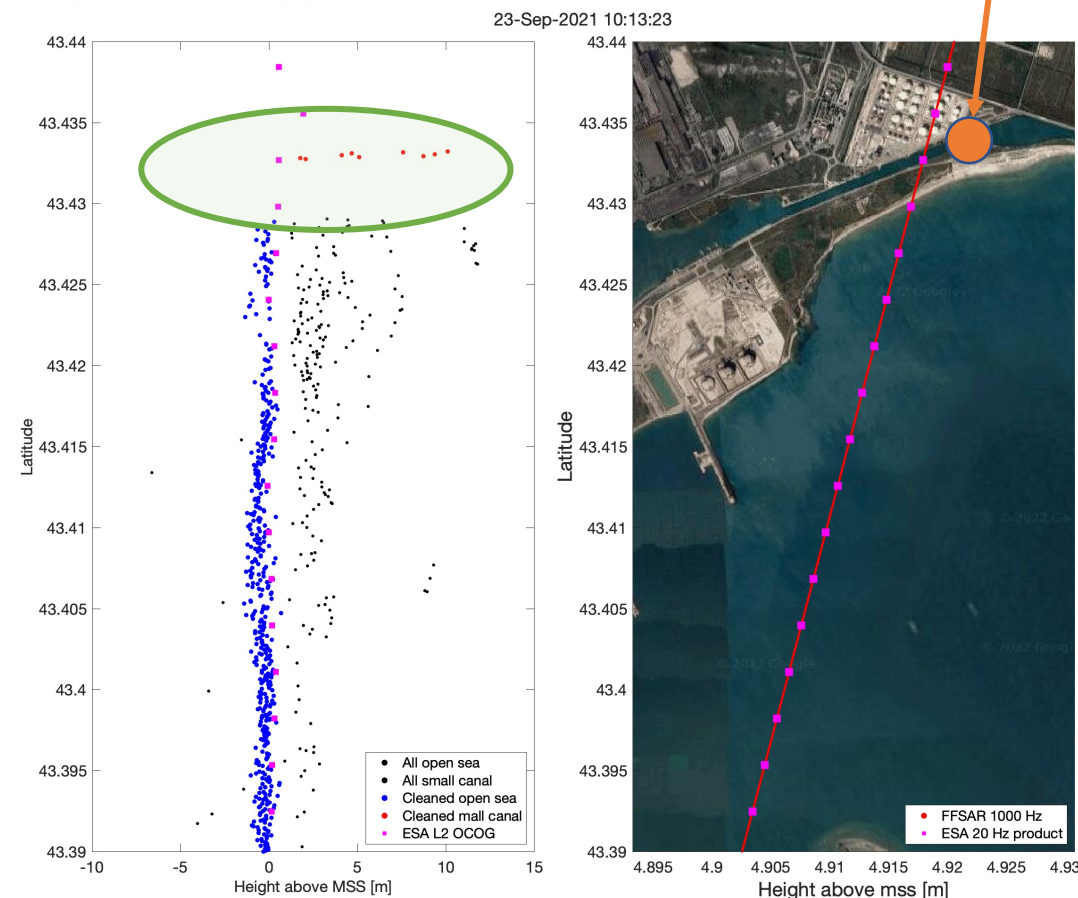
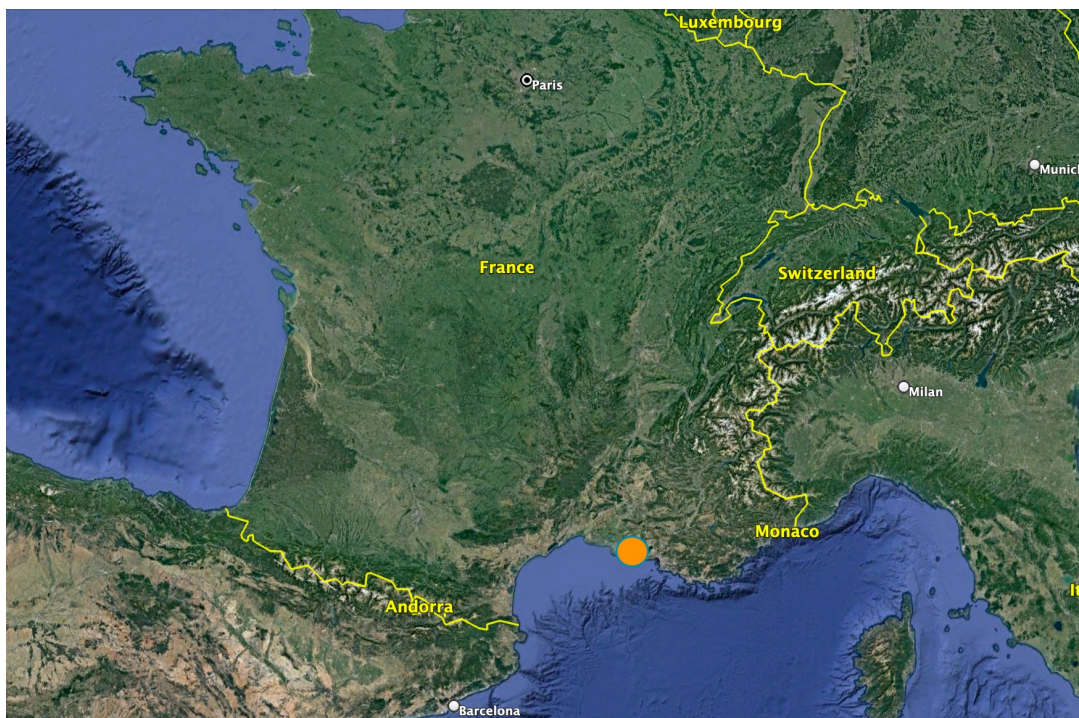
- Low-lying river delta with wetlands.
- 20 Hz resolution will provide only a single height estimate across the river.
- The high number of calm water surfaces within the altimeter footprint makes the measurements very noisy, often leading to wrong water level estimates.
- Using FF-SAR the resolution can be increased all the way up to 0.5 m.



The approach used in Severn doesn't work as well for the Rhône delta

Very scattered measurements in the Rhône River in France

Micro-station



## Data Sets

- FFSAR S3A and S3B data sets: Severn Estuary and Rhône delta
  - Along track data and time series
  - Vortex.io micro-station time series data
- Drone campaign data

<https://cco.geodata.soton.ac.uk/ccoresources/FFSAR-Coastal/>

## Product Validation and Evaluation

- Validation against in-situ and model data
- Evaluation:
  - Small scale physical signals in highly tidal regions
  - Tidal asymmetry/gradients across estuaries
  - Understanding interaction of tides and river discharge

## Application Road Map

- Key requirements from User Groups
- Recommendations for application of FFSAR in coastal monitoring systems.
- Recommendations for use of “micro” gauges as part of coastal monitoring systems

<https://eo4society.esa.int/projects/ffsar-coastal/>

## Outlook and Recommendations

- Next steps
  - Optimise FFSAR processing options for Severn and Rhône (may be different)
  - Generate along track time series
  - Evaluate capability to map small scale signals as close as possible to the coast
- Recommendations
  - User interests (UK):
    - Contribute to SWOT validation campaign in the Severn?
    - Possible contribution to UK Hydrographic Office plans to update Vertical Offshore Reference Frame (VORF)
    - Interest in ability to map difficult to access inter-tidal regions
  - User interests (FR):
    - Coastal flooding / erosion
    - River discharge, salinisation, water quality