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

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FFSAR-Coastal

The objective of the FFSAR-Coastal Project is to apply the SMAP Fully Focused SAR (FFSAR) altimetry processor on Sentinel-3A and Sentinel 3B data and evaluate the potential of FFSAR altimeter data to make a significant new contribution to coastal and estuarine monitoring systems.

Two different environments are being considered: The Severn estuary (Fig 1): A highly dynamic mixed tidal estuary environment, the confluence between a river and its estuary experiencing large tidal range and strong tidal currents; The lower Rhône delta and Camargue (Fig 2): A low lying, flat river delta and wetland environment, susceptible to inundation and rising water levels.

By studying these two very different environments, the potential applicability and benefits offered by FF SAR altimeter data in other coastal, estuarine and delta locations will be demonstrated. FFSAR-Coastal is funded by ESA under the EO Science for Society Programme – Open Call
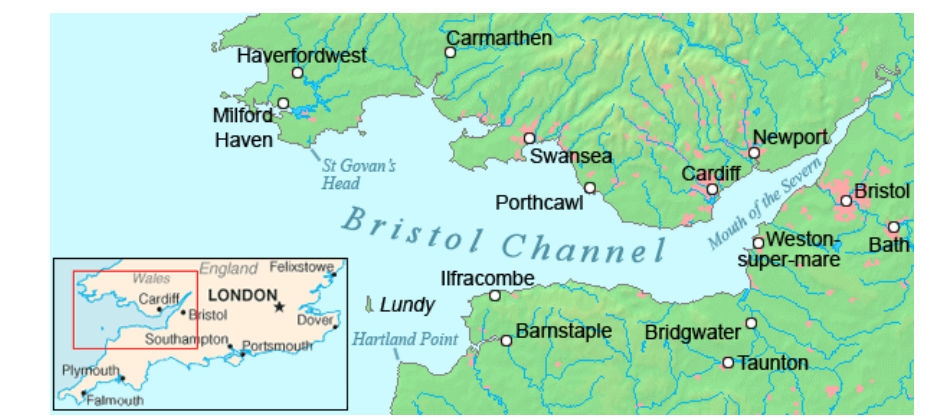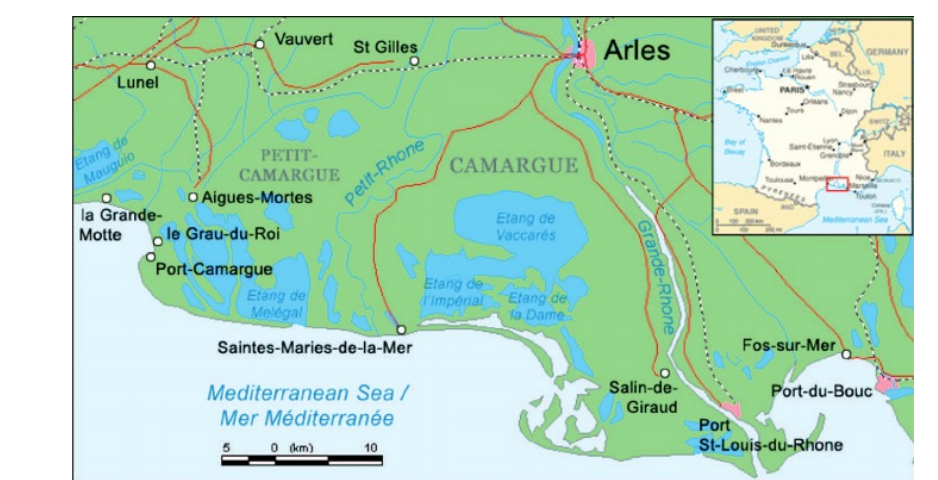

Figure 1 The Severn Estuary area

Figure 2 The Rhône delta area

Implementation Plan

There are three aspects to the Implementation Plan (Fig 3):

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 (vortex.io)

- Install four micro gauges (two per region) for in situ validation
- Drone campaigns to reference water level from in situ sites to satellite track

User Engagement / Application Road Map (NOC, CCO)

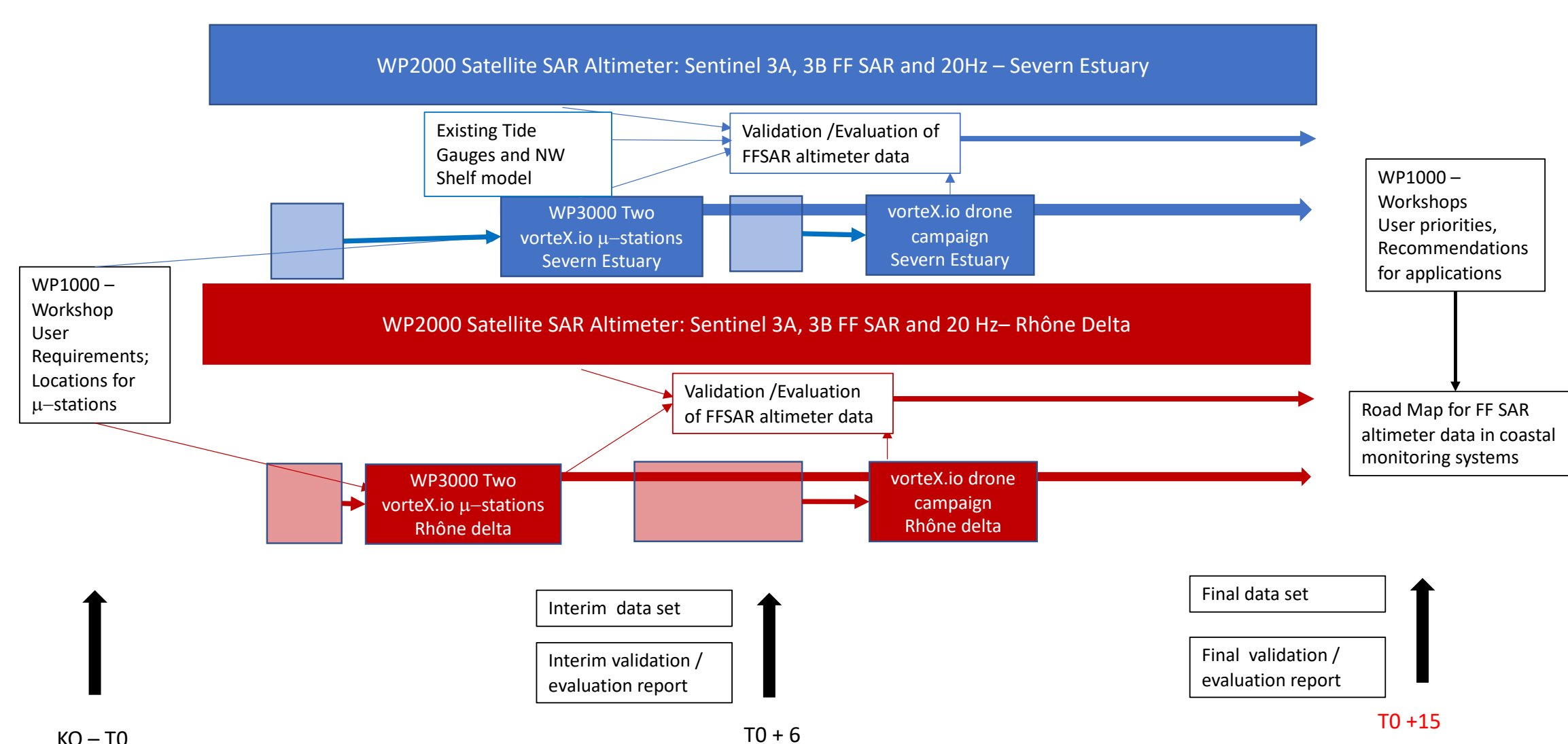- Workshops > Roadmap for use of FFSAR processing in Coastal Monitoring Systems

Figure 3 FFSAR-Coastal Implementation Plan

Initial Results for the Severn Estuary

Input files have been downloaded for RONs 265, 299, and 208 for both S3A and S3B, and all cycles from 265B have been processed using the SMAP with different settings to find the most appropriate setup. Water levels are found by combining SMAP output with L2 files from ESA/scihub.

Focusing on data over Newport, initial analysis with output from the ocog retracker showed a retrieval of multiple levels (Fig 7, left), further analysis of output from the multi-peak retracker (Fig 7 right) suggested that echoes were being received from off-nadir locations, but careful selection could identify the nadir echo and hence enable the true along track water level to be retrieved.
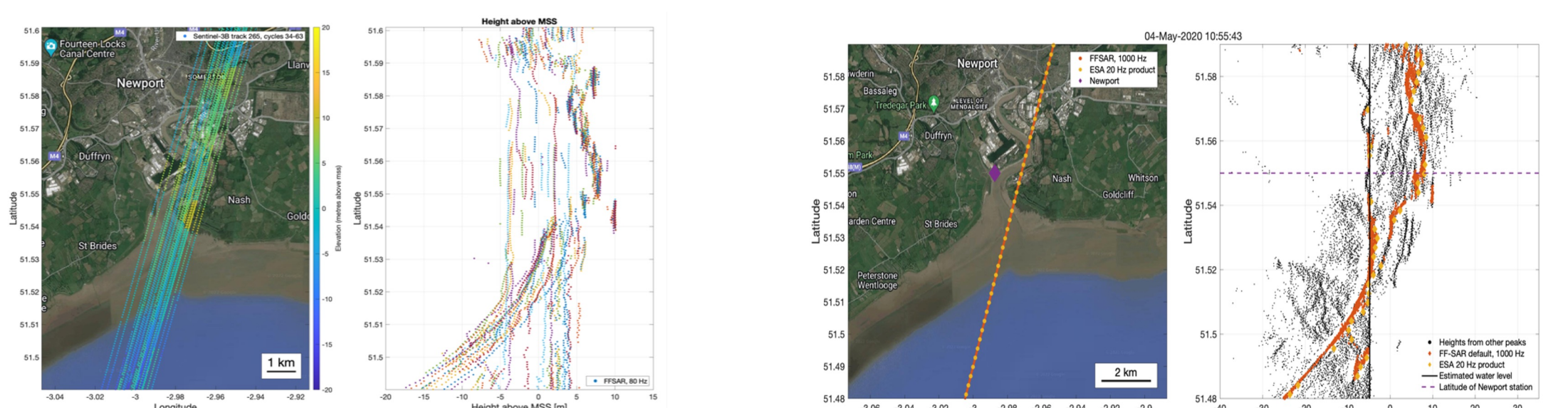
Figure 7 Analysis of data from Sentinel 3B track 265. Left panel, output from the ocog retracker, right panel, output from the multipeak retracker

Sea levels retrieved from the multi-peak retracker were then validated against the Newport and Hinkley Point tide gauges (Fig 8). Generally good agreement was found, but with a high rmse of 1.2m (Newport), or 1.1m (Hinkley Point). This compares to an rmse of 3m for data from the ocog retracker.
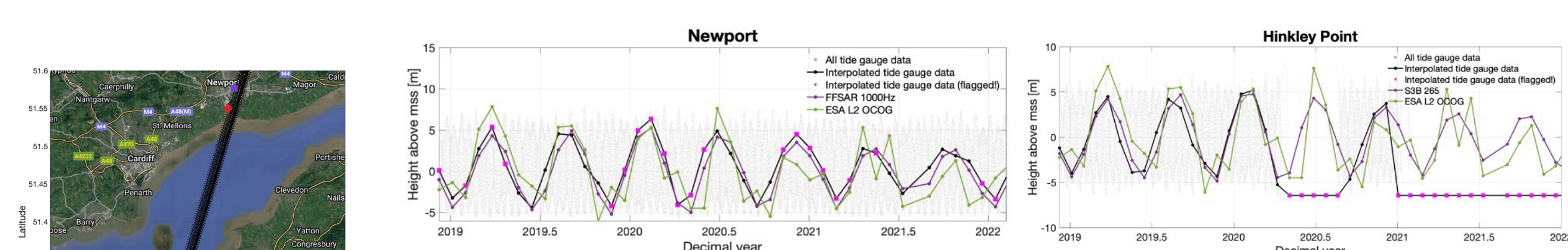
Figure 8 Validation of FFSAR processed data from Sentinel 3B track 265. Left panel: track 265 and the location of the Newport and Hinkley Point tide gauges. Centre and right: Time series of water height above mean sea surface for Newport and Hinkley Point from altimeter and tide gauge data

In –situ validation - Vortex.io in-situ gauges

Four innovative "micro-gauges" have been supplied by vortex.io and installed. Two in the Severn Estuary at Newport & Weston Super Mare (06/09/22), and two on locations on the Rhône delta: Port St Louis du Rhône & Fos sur Mer (27/07/22) (Fig 4). They will remain deployed until June 2023.

The Vortex.io "micro" Gauges are lightweight and easy to install. They host a liDAR and 8Mpx camera, are run remotely and provide data in real time via G4 mobile network (Fig 5).
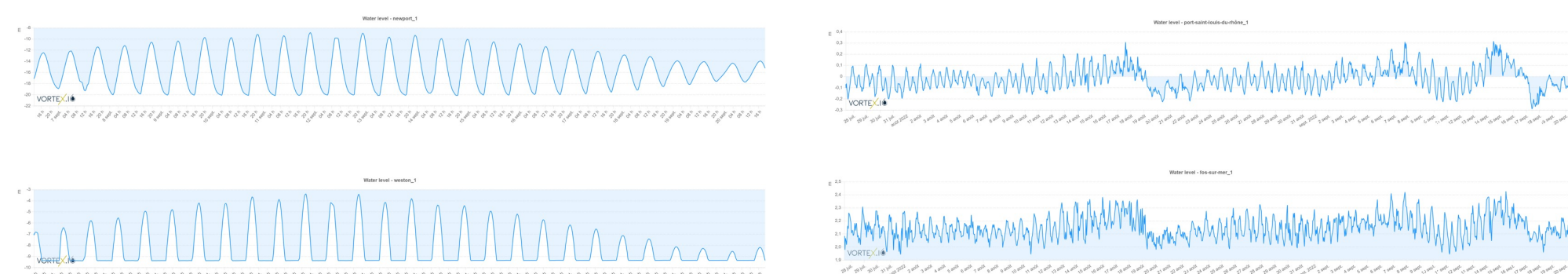

Figure 4 Locations of the vortex.io microgauages

Figure 6 Illustration of a vorteX.io µVTX-1 installed in the south of France

Figure 5 Water level records from the vortex microgauges at Newport, Weston Super Mare, Port St Louis du Rhône, and Fos Sur Mer
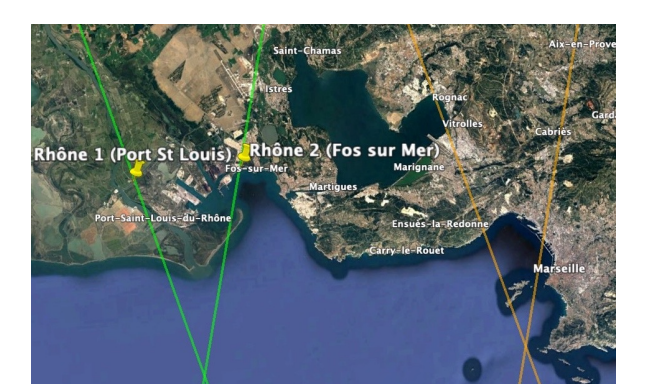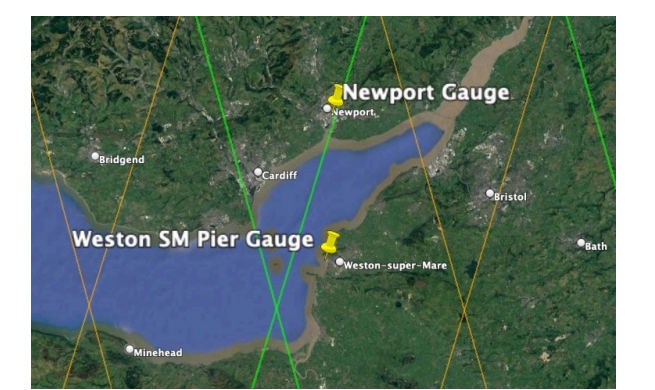
Fully Focused SAR Altimeter Processing

DTU is applying the SMAP Apply SMAP (Standalone Multi-Mission Altimetry Processor) to Sentinel 3A and 3B data for tracks from the two regions. Initial results are being assessed to identify the optimum processing choices, which will then be applied to generate time series of data for selected tracks.

These data are also being validated against in-situ data and models, and further analysis will aim to evaluate how well FFSAR altimeter data can resolve fine scale features in the two different environments.

For the Severn Estuary this analysis will assess the ability of FFSAR processed data to capture small scale physical signals (surface gradients, currents, roughness signatures) in highly tidal regions and to detect and measure tidal asymmetry/gradients, and for the Rhône delta the assessment will consider how well the data can be used to accurately map different low-lying channels and filaments.

Next Steps

Rhône Delta

Data for the Rhône delta have been downloaded and processed. Further analysis and validation against in situ data will be used to establish the best processing set up. A drone campaign in late 2022 will enable the water level at the locations of the vortex.io microgauges to be referenced to that under the satellite tracks,

Severn Estuary

There will be further analysis to establish the best re-tracker options, which may be different for each track. A drone campaign is planned for Q1 2023 to link the water levels at the gauge locations to the satellite tracks.

Project Outputs

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
- Will be available at: www.coastalmonitoring.org

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 a coastal monitoring system

www.satoc.eu/projects/ffsar   -   https://eo4society.esa.int/projects/ffsar-coastal