Improvements to Sea Level measurements in the Coastal Zone through SAR mode altimetry: The ESA CP40 and SCOOP projects


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SCOOT Coastal Zone Study

The SCOOT project is running from 2015-2018. Within SCOOT there is a specific coastal zone study with the following aims:

- Characterise the expected performance of Sentinel-3 SAR SLR data in the coastal zone, including a specific regional study in the German Bight and a study of the impact of swell on the US West Coast.
- Develop, test and implement modifications to the processing of the L1B-S product (e.g. zero-padding, burst weighting window, higher pooling sizes).
- Evaluate the performance of products generated by this modified processing chain and make recommendations with regard to future implementation.
- Develop techniques to identify and discriminate against the impact of land contamination on the nadir echo ocean.
- Develop, test and implement coastal re-trackers for Sentinel-3 SAR and R2SAR data.
- Investigate how the orientation of the ground track with respect to the coastline, and the proximity of the land, affect the performance.

Wet Troposphere Modelling

Atmospheric processing has to include corrections for various geophysical factors that affect the accuracy of the retrieved products. One of the key corrections is the Wet Troposphere Correction. SCOOT will produce an enhanced wet tropospheric correction (WTC) for Sentinel-3, over the open and coastal ocean.

The algorithms are based on the GNSS-derived Path Delay Plus (PGO) methodology developed by Ui Portsmouth in the scope of previous ESA projects (COASTALT, CP40 and SL cytokine). The regional correction of the technique applied in Sentinel-3 is shown in Figure 7. The illustrations of the performance of the PGO+ WTC for Envisat. Since Sentinel-3 possesses a two-channel on-board Multi-WVR, similar to Envisat, it is expected that both radicorders and the corresponding PGO+ WTC have similar performances in the open ocean but significantly better over the coast.

SCOOP SAR Mode Altimeter Test Data Sets

The SCOOP SAR mode Altimeter Test Data Sets are based on a 2-year test data set derived from CryoSat-2 FBR data, with Sentinel-3 SAR equivalent processing, produced for 10 regions across the global oceans (Figure 8).

In phase 1, processing equivalent to that in the Sentinel-3 baseline was applied to the CryoSat-2 FBR data, summarised below:
- Delay Doppler Processing (to L1B):
  - No zero-padding, no hammering windowing. CryoSat calibration applied according to Baseline-C
  - Stack masking for Sentinel-6 applied. Equivalent to Sentinel-3 approach.
- Echo Modelling / Re-Tracking (to L2): Application of a Look-Up Table (LUT) for variable Point Target Response (PTR) width as a function of SWH.

In phase 2, modified processing schemes will be applied to the same source data. Options that will be investigated include:
- Delay Doppler Processing (to L1B): No zero-padding, (and other) windowing. Stack masking, Surface focusing. New approaches to stack processing

SCOOP Project Outcomes

The outcomes of the SCOOP project will include:

- Characterisation of the expected performance of Sentinel-3 SAR SLR mode altimeter products, in the coastal zone and open ocean.
- An evaluation & clear description of enhancements to the Sentinel-3 SAR processing, in terms of improved measurements over the open ocean.
- The provision of clear technical information of Sentinel-3 SAR SLR products and their processing, supporting correct interpretation and application by the user community.
- A Scientific Road Map including recommendations for further developments, implementations and research for Sentinel-3 SAR data

Satellite Altimetry and the Coastal Zone - The CP40 and SCOOP Projects

In the "conventional" mode of operation, satellite altimeters have difficulty in making accurate measurements close to the coast, as the footprint of the altimeter at the ground is typically ~7km, and any ground within that footprint can contour the return signal, making it difficult, if not impossible, to process. Thus at best one can hope to make sea level measurements within 7km of the coastline, and frequently this is not possible. This has obvious implications when trying to validate against tide gauge data.

We present results from two ESA studies: CP40 (CryoSat Plus for Oceans) and SCOOP (SAR Altimetry Coastal & Ocean Performance), in which the performance of SAR altimetry in the coastal zone and open ocean are assessed, and improvements to the processing schemes are developed and tested.

The philosophy of CP40 was to develop and evaluate new ocean products from CryoSat data and so maximize the scientific return of CryoSat oceans. The aim of SCOOP is to characterise the expected performance of Sentinel-3 SAR mode altimeter products, and then to develop and evaluate enhancements to the baseline processing scheme in terms of improvements to ocean measurements.

Figure 3: Top: A schematic showing the comparison of the altimeter wave at the instantaneous orbital position, showing the footprint (black) covering one cycle of three SAR tracks from CryoSat-2 SAR mode (red), and one "conventional" SAR mode (blue) altimeter footprint.

Figure 4: Top: Figure showing the coverage of the data points/ coasts. Left: Filling a smoothed model (blue) for the tracker (red). The ground is divided into coastal and open. Sentinel-3 SAR Ocean Topography (SW3) in the standard ESA processing (orange) and as processed by isardSAT (yellow). The significant reduction in noise evident in clearly evident (Credit: isardSAT)

Figure 5: Figure showing the coverage of the data points/ coasts. Left: Filling a smoothed model (blue) for the tracker (red). The ground is divided into coastal and open. Sentinel-3 SAR Ocean Topography (SW3) in the standard ESA processing (orange) and as processed by isardSAT (yellow). The significant reduction in noise evident in clearly evident (Credit: isardSAT)

Figure 6: The SCOOP coastal zone studies. Top left - the map for the W USA coast study: centre left - some early analysis of SAR mode altimeter products. Centre Right - the region for the German Bight study. Bottom Right - some of the metrics that will be used (Credit: Noveltis and U Bonn)

Figure 7: Variation of efficiency between 0900 UTC (dashed) and with the ESA Altimeter model (orange). Dots: Stations of interest (map from ocean (Credit: U Paris))

Figure 8: Regions included in the SCOOP studies. Top left: a CryoSat-2 SAR mode track. Figure 9: Data from ESA, with yellow indicating open-ocean zones and orange coastal zones (files from the Northern Atlantic and Labrador regions are assigned to both)

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