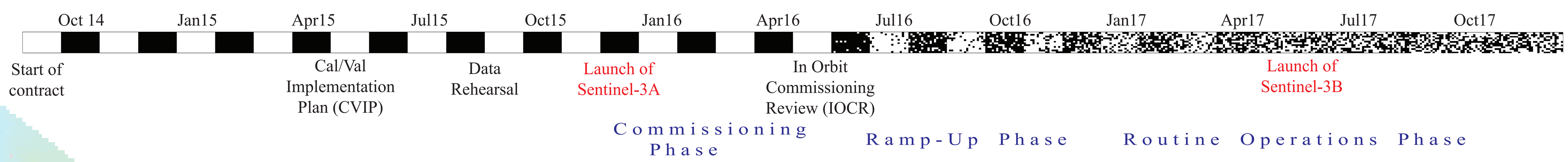
The role of the Sentinel-3 Mission Performance Centre in Maintaining High Standards within Operational Altimetry

Graham Quartly, Sylvie Labroue, Marie-Laure Frery, Andrew Shepherd, Steve Baker, Alan Muir, Monica Roca, Jean-François Cretaux, Frédérique Remy, Benoit Meyssignac, Salch Abdalla, Stéphane Calmant, Mathilde Cancet, Guillaume Valladeau, Pierre Féménias



Introduction

Sentinel-3 will be the first satellite to provide near-global coverage of Delay Doppler Altimetry, but achieving the high-quality high-resolution data expected requires attention to details for all aspects of the measurements, both of the altimeter (SRAL) and the microwave radiometer (MWR). To examine and maintain the quality of all Sentinel-3 data, ESA has sponsored the Sentinel-3 Mission Performance Centre (S3MPC), which is jointly run with EUMETSAT and co-ordinated by ACRI. For the Surface Topography Mission (STM), the S3MPC has been charged with ensuring the usefulness of SRAL and MWR data by performing quality control checks (near real-time and offline products) and assessing the long-term performance through a series of ongoing validation experiments.

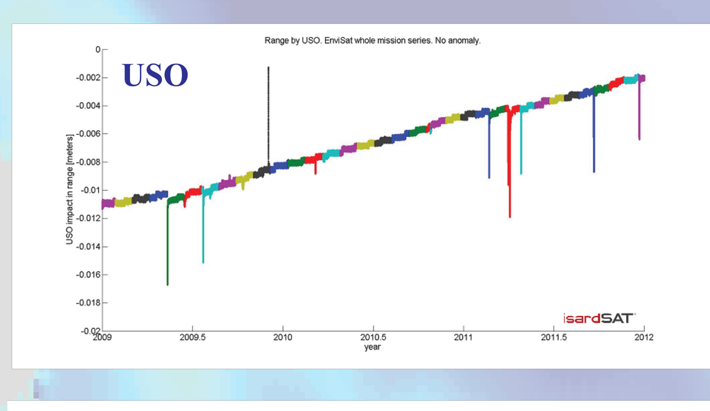
The project commenced in autumn 2014, and its remit covers all surfaces (ocean, cryosphere and inland waters), and it will be responsible for:

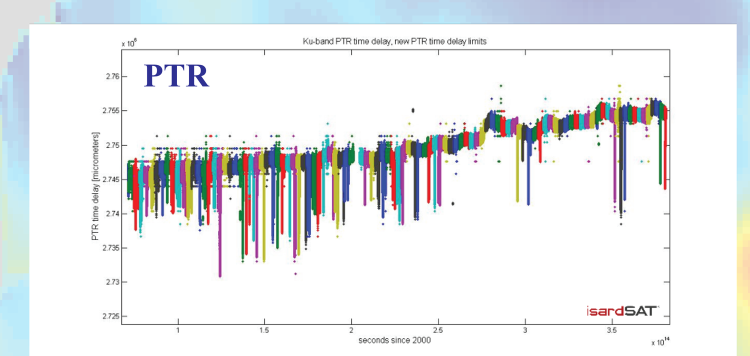
- SRAL & MWR Calibration & Monitoring
- Tuning of Ground processing for L1 & L2 Products
- Validation of L2 Products
- Altimeter Calibration via Transponders

Of course, many of the illustrations are for work performed with Envisat and Cryosat-2, as the project partners were heavily involved in the validation of those altimeters.

SRAL Internal Calibration

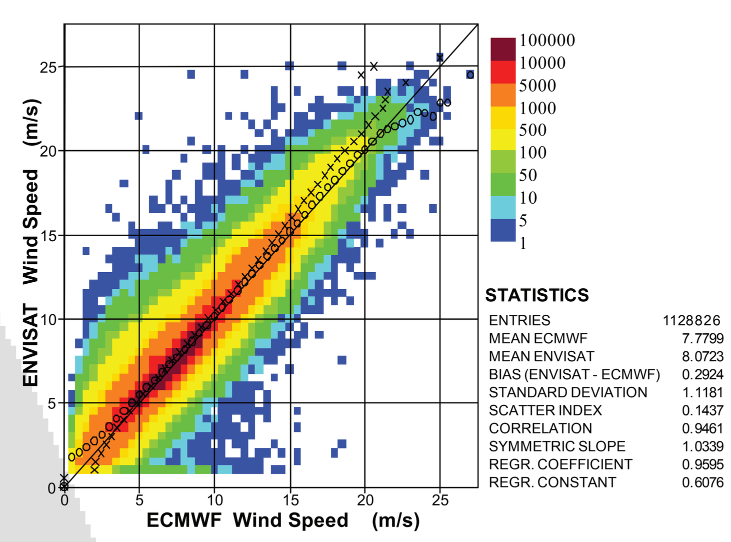
The internal calibration modes of the SRAL will be monitored frequently to check for any change in instrument performance. This is similar to work previously performed for Envisat (see illustrations below).





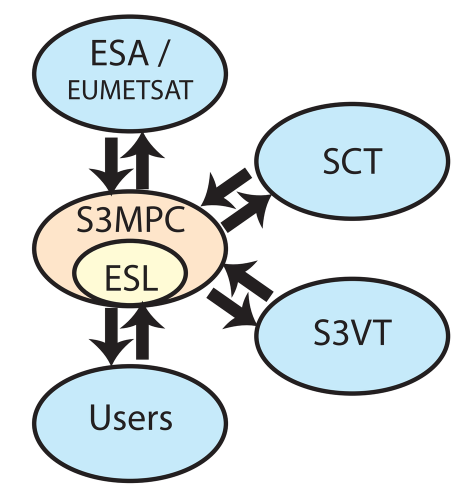
Metocean Monitoring

Sentinel-3 metocean products — significant wave height (SWH), wind speed, wet tropospheric correction and water vapour correction — will be compared with the output of ECMWF's Integrated Forecasting System, by averaging the satellite products along track to the resolution of the analysis. These "super observations" will be directly compared via histograms, scatter plots, maps and time series (see example for Envisat). This will be performed on a daily, weekly and monthly basis. Comparisons with *in situ* data will be done in delayed mode, due to the scarcer *in situ* observations, and triple collocation analysis will be used to estimate the errors.



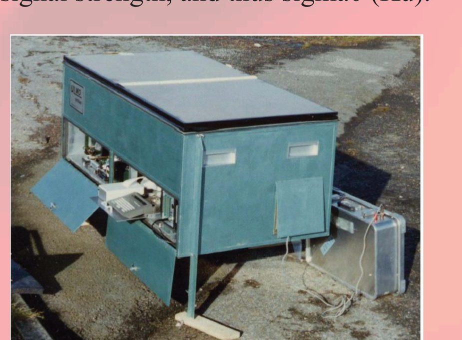
Communication Structure

The initial funding for the S3MPC is through ESA (Tech. Off.: P. Femenias), and there will also be significant communications with ESA's Sentinel-3 Commissioning Team, the Sentinel-3 Validation Team and, of course, end users. The Expert Support Laboratories are an integral part of the long-term validation effort within the S3MPC, and the S3MPC will be working within the Quality Working Group for the Surface Topography Mission.



Transponder Calibration

Transponders are an essential part of the altimeter calibration, providing estimates of range bias and time tag bias. The instrument at Svalbard (pictured) will be complemented by one at Crete that will also provide an absolute calibration of signal strength, and thus sigma0 (Ku).



S3MPC Duties

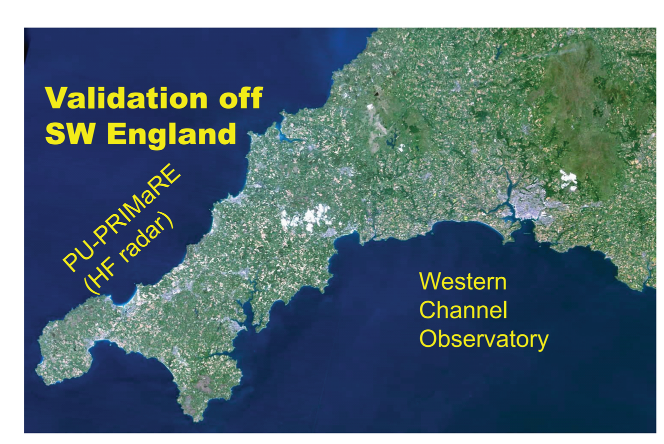
In the Commissioning Phase, the assessment of data quality will be performed by the ESA/CNES teams for the sensor calibrations, and by S3MPC for Level 2 activities. After the IOCR, the S3MPC will be responsible for monitoring data availability and product validity by:

- Analysing quality of physical parameters
- Estimating system performance
- Detecting anomalies and investigating their causes

Coastal and Inland

Some aspects of the Sentinel-3 validation are scheduled for later in the project, once the Routine Operational Phase has started and more than a year's data are available. Validation of geostrophic currents will be carried out at two sites off the southwest coast of the UK, making use of the PU-PRIMaRE HF radar system and the long-term monitoring at the Western Channel Observatory.

Provided that lakes are large enough for clear water-only radar echoes, they provide an opportunity for accurate absolute calibration, since waves, tides, SSB and inverse barometer effect are negligible. Large lakes also provide multi-satellite calibrations using a single site. However care is needed to minimise the effects of seiches, GPS errors and wet tropospheric correction.



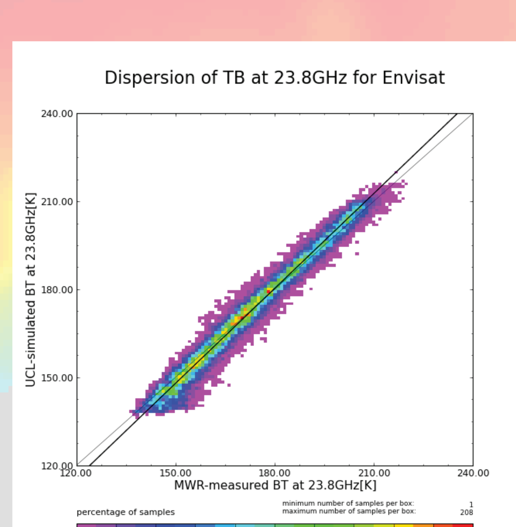
MWR Calibration

The MWR will measure brightness temperatures at 23.8 & 36.5 GHz, which will be used in combination with the altimeter's sigma0 record to infer the wet tropospheric correction (WTC) and the atmospheric attenuation, via a neural net. The S3MPC has three tasks in this regard:

- Monitor the health of the instrument
- Validate the brightness temperatures
- Tune the coefficients of the neural net, using a Radiative Transfer Model applied to the latest version of the ECMWF analysis.

Sea State Bias Formulation

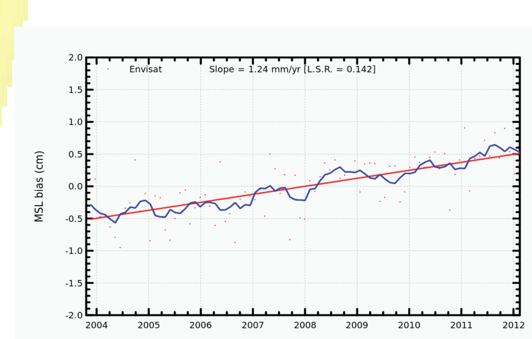
A new model for sea state bias (SSB) will be developed during the Ramp-Up Phase. As such models are specific to the retracker, such analysis using the CLS suite of programmes will be undertaken with the final parameterization of the SAMOSA retracker, and with a validated algorithm for surface wind speed.

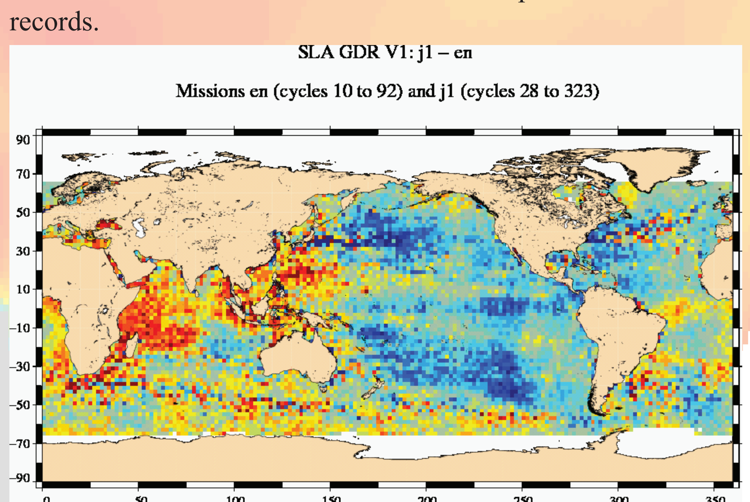


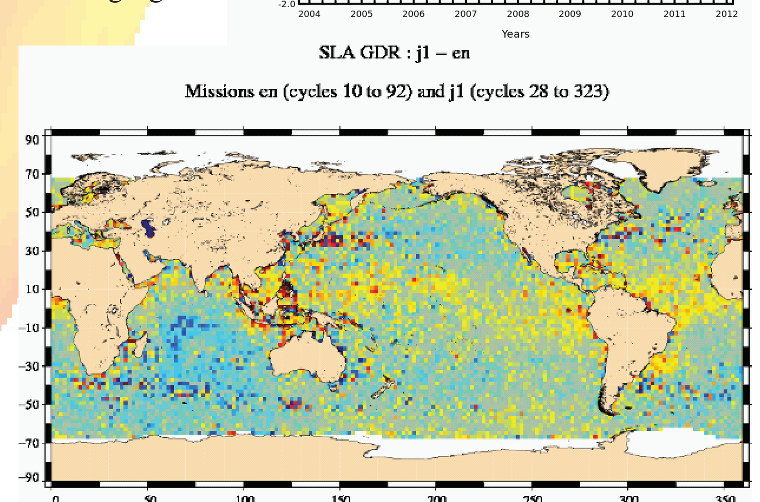
Validation of 23.8 GHz Brightness Temperature for Envisat MWR using simulated values from the UCL (Université Catholique de Louvain) radiative transfer model.

Inter-Mission Comparisons

Sentinel-3 altimetric data will also be compared with those from other missions – Jason-2, Jason-3, AltiKa & Cryosat-2 are expected to be flying at the same time. Differences in derived sea surface elevation can point to errors in orbits or corrections, with such comparisons not only categorizing any problem with the Sentinel-3 data, but also enabling it to help improve the uncertainty in the others' corrections. There will also be routine comparisons to the available tide gauge records.





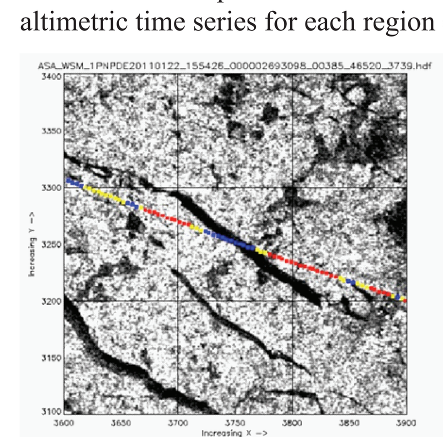


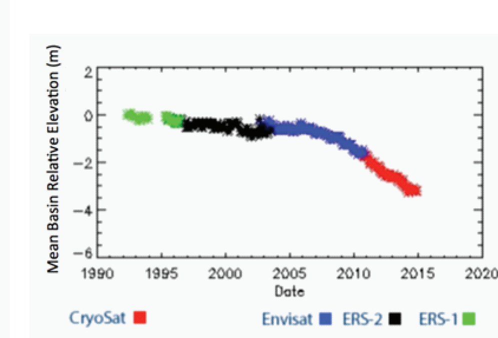
Comparison of trends within Jason-1 and Envisat v2.1 data: (left) before reprocessing, (right) after reprocessing and updates. [Ollivier et al., Mar. Geod, 2012]

Land-Ice & Sea-Ice Validation

Altimeter performance over ice is a critical part of the validation, as the returned signal has a different shape to that over the ocean, and thus requires a different retracking strategy. The different shapes allow the discrimination between floes and leads within sea-ice (see figure below) and thus the accurate estimation of both sea surface height and of the thickness of the ice (freeboard).

Over Antarctica and Greenland, each 27-day cycle will be used to generate statistics and maps of elevation and backscatter residuals. The stability of SRAL will be assessed, along with orbit and timing errors. Ultimately the Sentinel-3 data will be compared with those from Cryosat-2, and then used to extend the altimetric time series for each region (see below).

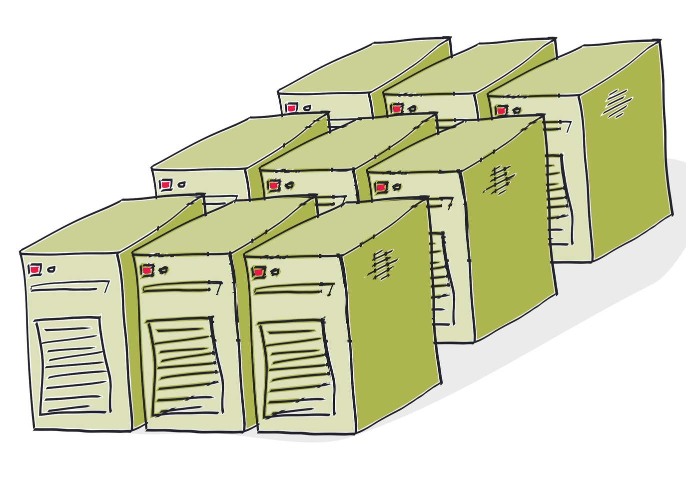




(left) Envisat wide-swath ASAR image of sea-ice (leads appear black), with near-coincident Cryosat-2 data classified by waveform (blue dots - leads; red - floes; yellow – undetermined). (right) Multi-decadal elevation change for an Antarctic basin.

Data?

In the frame of the development, of the Sentinel-3 Iinstrument Processing Facility, test datasets have been constructed for the SRAL/MWR payload, using simulated datasets and prior observations from Cryosat-2. These are currently being evaluated by the MPC ESLs prior to a wider release.



GET READY!!

Illustration of Mean Dynamic Topography from DTU Space.