REPORT

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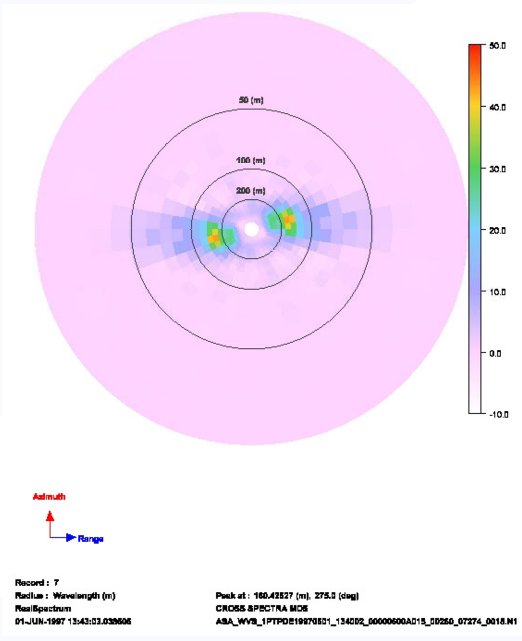
ERS WAVE MISSION REPROCESSING- QC SUPPORT ENVISAT MISSION EXTENSION SUPPORT

- Annual Report
1st April 2012 - 31st March 2013



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Summary:

This report summarizes the activities and achievements within the project "ERS Wave mission reprocessing-QC support Envisat Mission extension support" for the period 1st April 2012 until 31st March 2013.

Keywords: ASAR WM, Sentinel-1, Level 2, WVW, WSS, ASAR Cal/Val

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Content

1. Introduction

This is the annual report for the ESRIN/contract No.21334 as described in [R-1], [R-3] related to the work packages:

- **WP 1000: ASAR Wave Product Quality Control & CAL/VAL Monitoring**
  - Wp 1100: Routine WV L1 calibration and L2 product quality control
  - Wp 1200: L2 product validation

- **WP 2000: ASAR Wave Algorithm Processing Baseline Maintenance**
  - Wp 2100: Algorithm Upgrade and Impact Assessment
  - Wp 2200: Verification Using Prototype

- **WP 4000: Definition of Calibration Method Using Wind Model**
  - Wp 4100: Description of Calibration Method and Expected Performance
  - Wp 4200: Validation of Calibration Results Against Transponders

- **WP 5000: New Algorithm Development**
  - Wp 5100: Development of New Methodology Tailored to S-1 WV
  - Wp 5200: Prototype Algorithm Development and Testing

- **WP 6000: QWG Participation**
  - Wp 6100: Participation in QWG meetings

For WP100 and WP2000 there has been no activity since the loss of Envisat in April 2012. The resources were allocated to the other work packages.

Summaries of achievements were presented at SeaSAR2012, and detail descriptions can be found in the corresponding proceeding papers [R-6], [R-7].

2. Reference and applicable documents

2.1. Reference documents

[R-1] Technical Support the Global Validation and long term quality controld of ASAR Wave Mode products – Statement of Work, ENVI-CLVL-EOPG-SW-11-000X, Issue 0, Rev.9, 08/03/2011, Draft

[R-2] Request for CCN work Quotation – ESRIN/Contract No.21334/08/I-NB, CCN.2, ESA/ESRIN, 26.08.2011

[R-3] Johnsen H., Collard F., "Global Validation and Long-Term Quality Assessment of ASAR Wave Mode Products - Description of Work", Norut, 10.08.2011

[R-4] Johnsen H., Collard F., "SAR wave processing – improvements towards Sentinel-1 mission", Proc. of SeaSAR2012, 18-23 June 2012, Tromsø, ESA Special Publication SP-709, ESA/ESTEC, Noordwijk, NL

[R-5] Engen G., H. Johnsen, "High-precision Doppler estimation for ocean applications", Proc. of SeaSAR2012, 18-23 Juni 2012, Tromsø, ESA Special Publication SP-709, ESA/ESTEC, Noordwijk, NL

[R-6] Faozi S., H. Johnsen, "Sea surface wind retrieval using both normalized radar cross-section and polarization residual Doppler frequency from TerraSAR-X data", Proc. of IGARSS-2012, 22-27 July 2012, München, IEEE Catalog Number: CFP12IGA-ART, ISBN: 978-1-4673-1159-5, ISSN: 2153-7003

[R-7] Collard F., Aouf L., Johnsen H., “Wave mode processing algorithms, product validation and assimilation. Wave retrievals and applications - White Paper”, Proc. of SeaSAR2012, 18-23 June 2012, Tromsø, ESA Special Publication SP-709, ESA/ESTEC, Noordwijk, NL

[R-8] Mouche A., “Toward a strategy for calibration and validation of the Image modes over the Ocean. Application to ENVISAT Wide Swath mode”. A Technical Note for CalVal Rider 3 project.

[R-9] R. Husson, Thesis manuscript, Development and validation of a global observation-based swell model using Synthetic Aperture Radar operating in wave mode, 2012

3. Results

3.1. ASAR Wave Product Quality Control & CAL/VAL Monitoring

With the loss of Envisat in April 2012, the activity of routine calibration and validation of ASAR WM Level1b and Level 2 products ended as well.

However, reanalysis of the time evolution of the calibration constant derived from the ASAR WM Level 2 product revealed an interesting seasonal oscillation (Figure 1). These oscillations are also observed by using other calibration methods like PS. The hypothesis is that these oscillations come from an unknown seasonal variation in the noise level. A special paper on this topic is scheduled from EUSAR 2014.

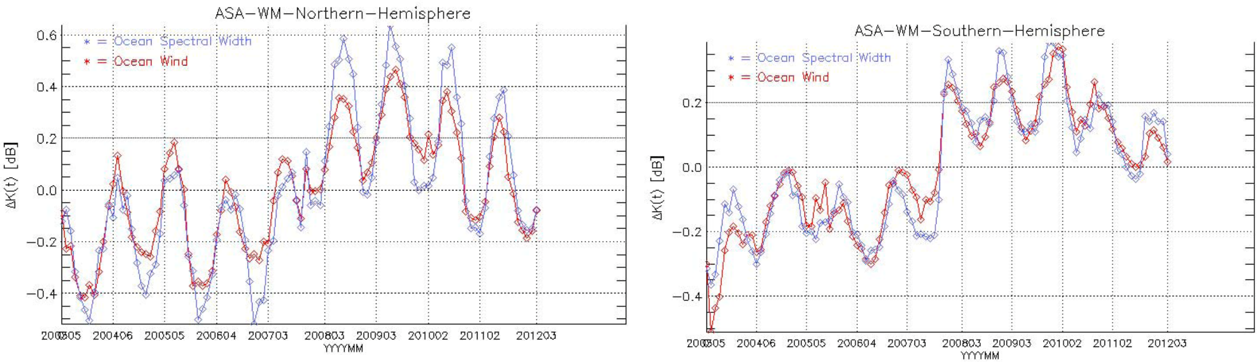

Figure 1 : Relative change in calibration constant as function of time, derived from ASAR WM data using ocean wind data (red curve) and the ocean spectral width (blue curve). The left plot is from Northern Hemisphere and the right plot is from Southern Hemisphere.

3.2. ASAR Wave Algorithm Processing Baseline Maintenance

As a consequence of the loss of Envisat, there has been no ASAR WM algorithm upgrade within this reporting period.

3.3. Test Data Set For MTF Upgrade & Swell Tracking

3.3.1. Test Data Set For MTF from WSS Data

The test data set (about 500 WSS scenes, Figure 2, left) gathered over the Atlantic were processed into Level 1b products and collocated with WW3 data. A MTF analysis has been done, but the data suffers from much noise. However, we can from Figure 2 (right plot) see that the wind dependency in the MTF reveals some dependency on incidence angle. Example of WSS wave field derived with updated MTF is shown in Figure 3

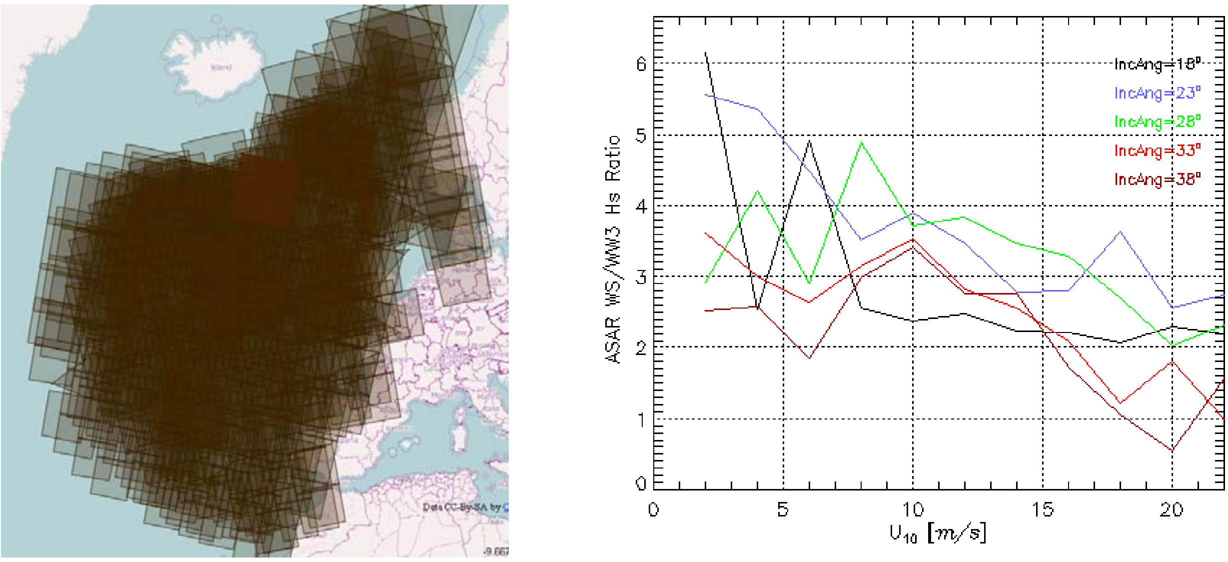

Figure 2 : Left: Coverage of ASAR WSS dataset acquired and processed in March 2012 at VIGISAT ground station in Brest. Right: Ratio of Level 1b spectral energy and WW3 Hs as function of wind speed for different swaths. The spectral energy (or Hs) is taken from the dominant partition.

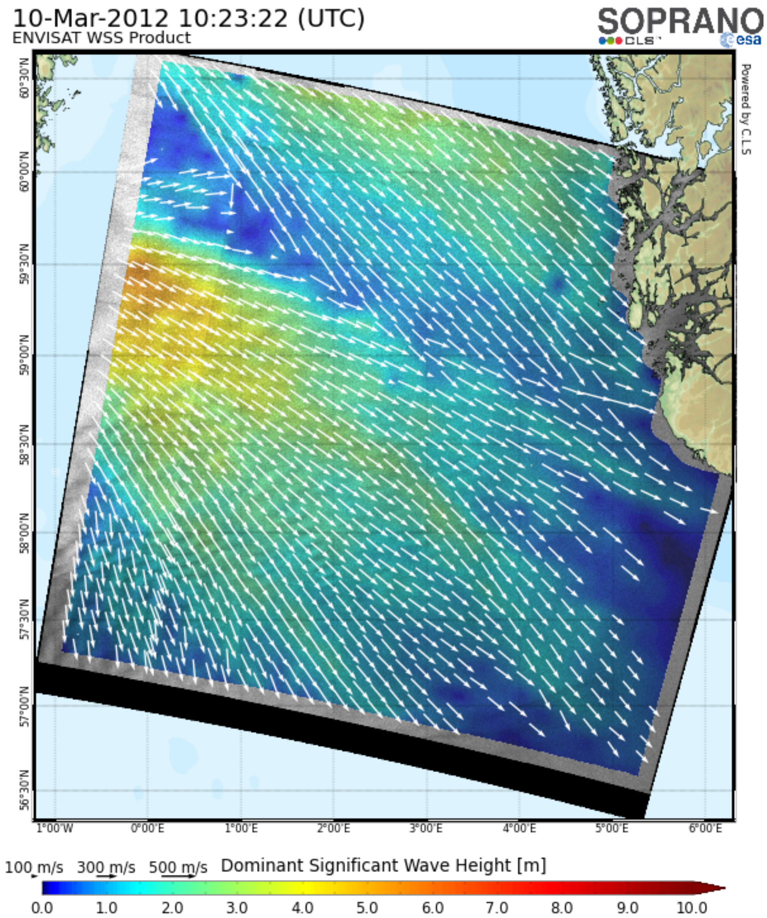

Figure 3 : WSS wave field retrieved using updated MTF from colocation between WSS and WW3 datasets.

3.3.2. Wave Product and Swell Tracking from WSS Data

The same dynamic validation scheme used for ASAR wave mode has been applied to ASAR wide swath mode. It is shown that synthetic swell field technique (method described in [R-9]) provides interesting properties suitable for Wave Mode products validation. Firstly it provides much more collocated points with in-situ buoy data (more collocation over 1 buoy in one year than 10 years over whole buoy network when only Wave Mode observation and buoys are collocated). Secondly, by filtering out measurement noise and outliers, it provides both a way to identify outliers for subsequent detailed analysis but it also allow much more precise characterization of systematic errors such as bias and trends in the bias as function of the value itself.

In Figure 4, the bias with large significant swell height (over 2 m) is much stronger constrained with the synthetic swell field. Similarly on Figure 5, the bias with long wavelength (over 14sec) is much better characterized using the synthetic swell field.

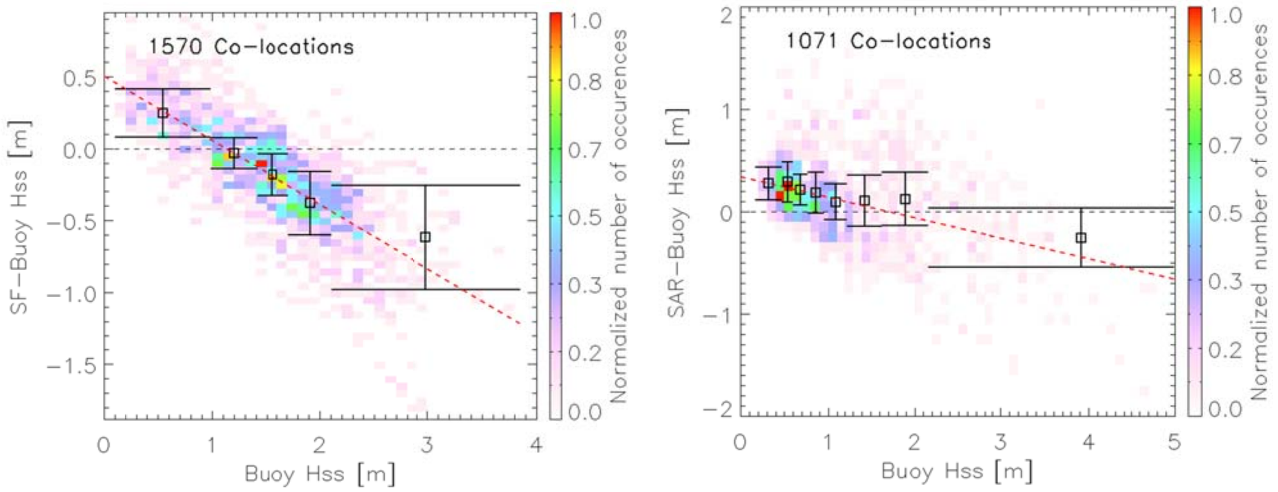

Figure 4 : Difference of significant swell height retrieved using updated MTF from colocation between WSS and WW3 datasets. Left is the difference between SAR Synthetic Swell field and stratus wave buoy in 2008. Right is the difference between SAR L2 wave mode and whole wave buoy network for 10 years.

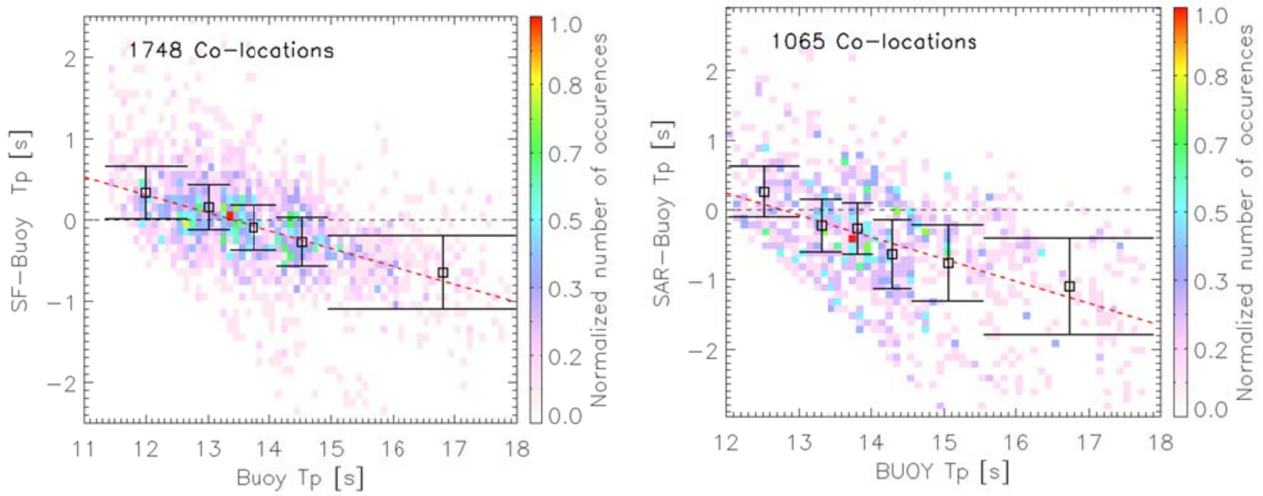

Figure 5 : Difference of dominant wave period retrieved using updated MTF from colocation between WSS and WW3 datasets. Left is the difference between SAR Synthetic Swell field and stratus wave buoy in 2008. Right is the difference between SAR L2 wave mode and whole wave buoy network for 10 years.

3.3.3. Test Data Set from ASAR WM

In parallel to the WSS test data set generation, the historical WM data set at VV-S2-S4 and HH-S2-S4 were previously processed to similar form as the WSS test data set, using the collocated WAM model instead of WW3 for assessment of MTF. The data set was in this period used to update of the baseline look-up tables for the Sentinel-1 WM Level 2 processor. The main findings and adjustments made to the baseline MTF were the wind dependency on the MTF, as shown Figure 6. Figure 6 shows the correction profiles applied to the MTF amplitude of the baseline look-up tables. The incidence angle dependency in the MTF observed from WSS data (Figure 2) is here confirmed using the WM data. However, the polarization dependency is rather week, except for low winds.

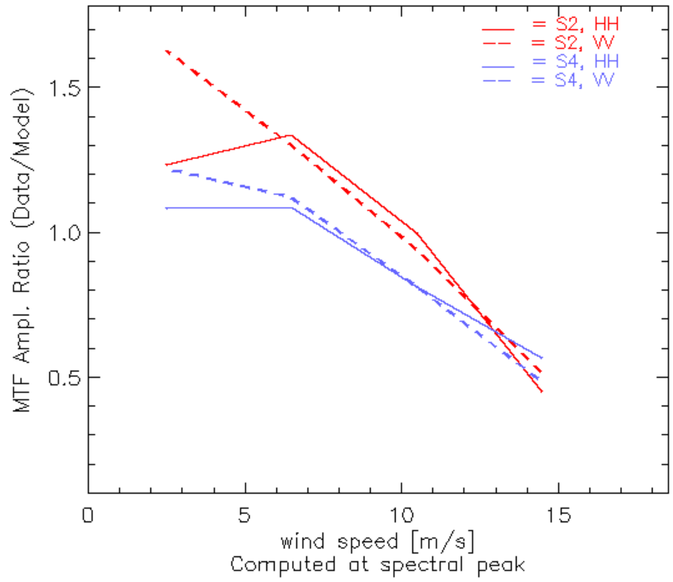

Figure 6 : MTF amplitude correction profile as function of wind speed for S2 and S4 in both VV and HH polarization. These correction profiles are implemented in the baseline Level 2 look-up tables.

3.4. Definition of Calibration Method Using Wind Model

The basic principle is to use a well-known and calibrated (C-band scatterometers) backscatter model for sea surface that provides expected NRCS to incidence angle and external model surface wind speed and direction. Comparison between expected and observed backscatter yields a calibration constant that is shown to be unbiased and highly accurate (less than 0.1dB) providing a sufficient number of data are used and a even selection of wind direction and wind speed is considered. A technical note was written as output from this task [R-8].

3.5. New Algorithm Development

3.5.1. Development of New Methodology Tailored to S-1 WV

Detection of extreme long wavelengths is hampered by the existing WM Level 2 algorithm due to the low frequency removal procedure applied to the data in combination with an imperfect MTF at low wavenumbers. Some improvements of the baseline processing has been done, mainly in terms of processing flexibility, while issues related to the MTF at low wavenumbers still are unsolved (see Figure 7).

Concerning the very long swell extraction, besides the loss of some swell partitions due to the low pass filtering operation, additional bias low on the dominant wavelength or peak period is observed on the inverted swell spectra (Figure 7) when compared to corresponding buoy observations. Note that equivalent peak period estimated directly from cross spectra do not seem to have quite such a bias low and further investigation is needed to understand what caused this bias in the inversion process.

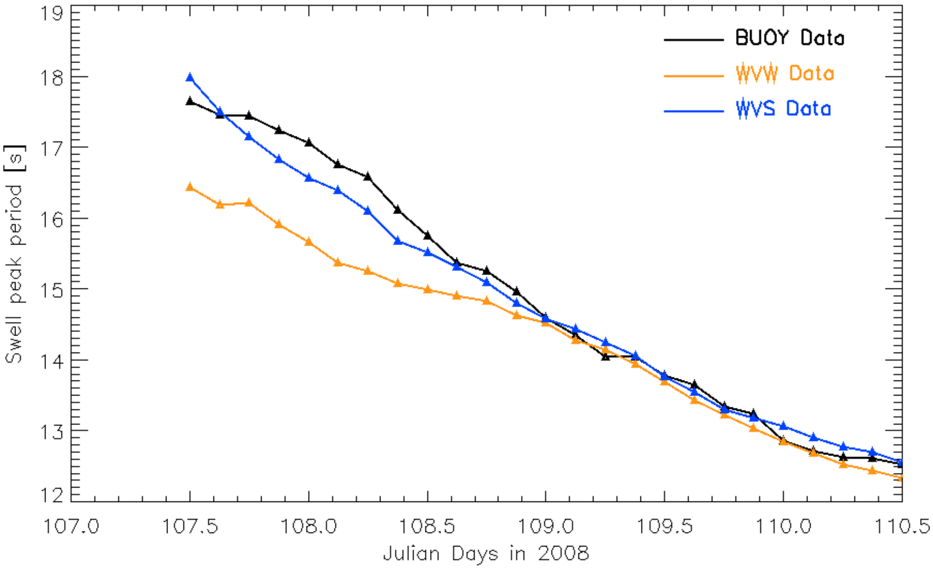

Figure 7 : Evolution system is passing by a wave buoy location. Dominant swell peak period extracted from both SAR WVS cross spectra (blue) is superimposed to dominant wave period extracted from the SAR L2 WVW wave spectra (red) and to buoy time/frequency map.

Although the MTF problem is still not solved for low wavenumbers, the Sentinel-1 L2 processor is designed flexible in terms of changing the wavenumber domain, the detrending and the low pass filtering operations.

3.5.2. Prototype Algorithm Development and Testing

The baseline look-up tables derived in Section 0 were adapted to the Sentinel-1 WM Level 2 processor. These look-up tables were integrated into the baseline IPF Level 2 OSW processor and tested extensively using ASAR WM data, and also on ASAR IM data for limited cases.

An example using ASAR IM data is shown below (Figure 8), and further results were presented at SeaSAR 2012 and can be found in the proceedings [R-4].

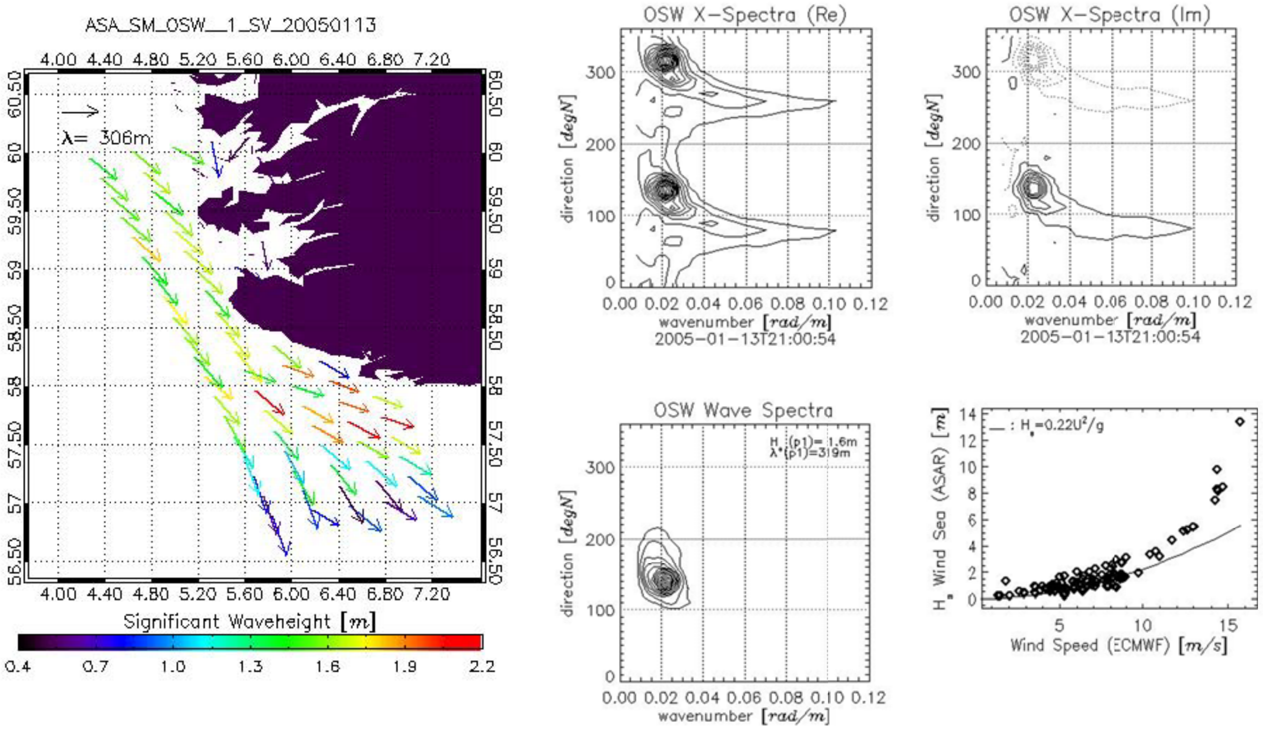

Figure 8 : Example of updated WM Level 2 processing of ASAR IM data.

The prototype Level 2 wave processor has also been extended to process:

- Level 0 data as input data, by adding a Level 0 reader and a SAR focusing algorithm in the L2 pipe
- Other data sources such as TerraSAR-X Level 1 data, by adding a TerraSAR-X reader in the L2 pipe

A limited number of TerraSAR-X data has been processed to Level 1b format (see example in Figure 9), and an initial analysis has been undertaken. This analysis will continue in the next project phase. Of particular interest is to use the dual-pol data to better assess the modulation transfer function.

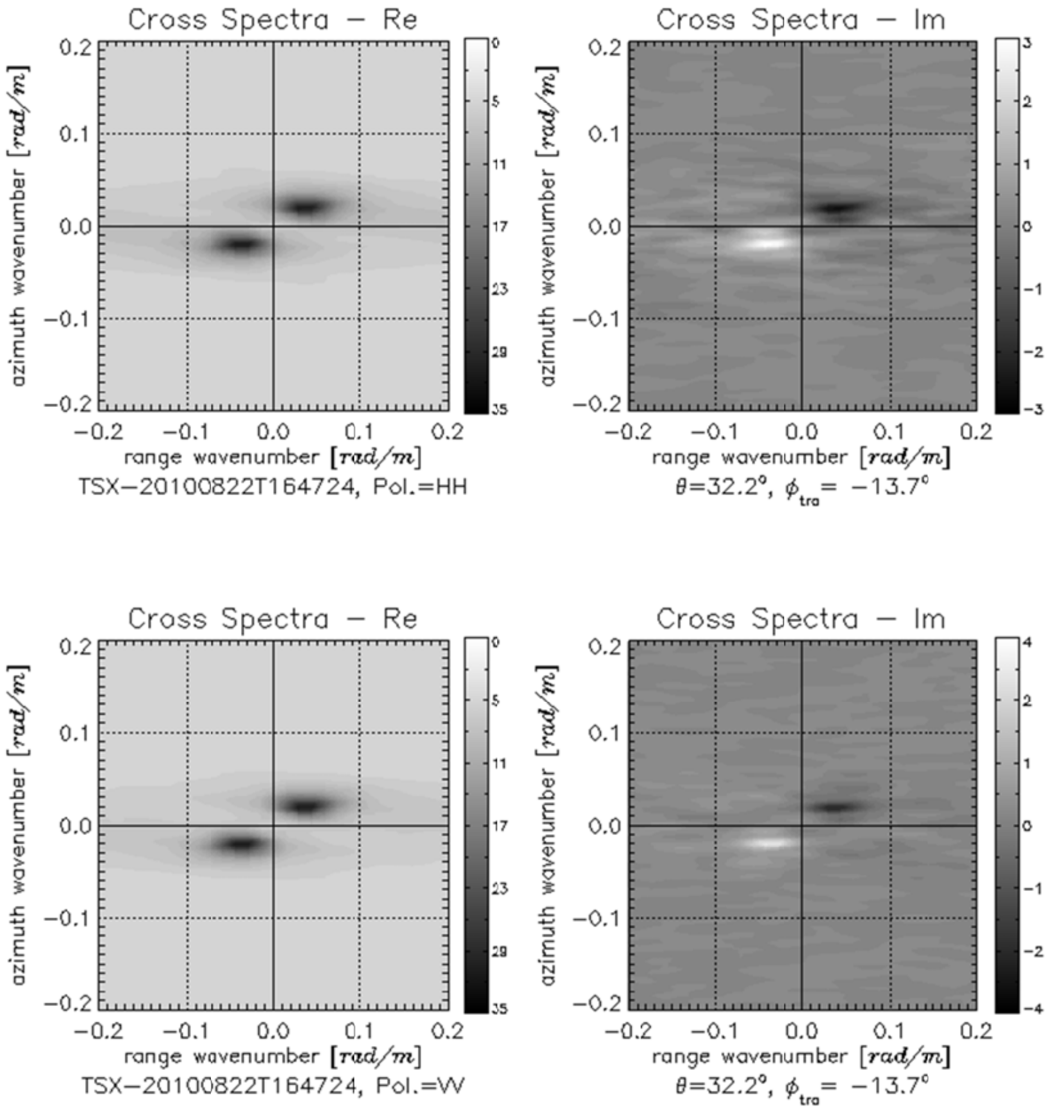

Figure 9 : Example of Dual-Pol TerraSAR-X Level 1b product processed with the prototype Level 2 processor. HH polarization upper plot, and VV polarization lower plot.

3.6. QWG Activity

3.6.1. Participation in QWG meetings

A meeting was held in December 2012 at Ifremer, were issues related to the loss of Envisat and the project progress.