EUMETSAT ITT 14/209556

Jason-CS SAR Mode Sea State Bias Study

Keypoint 1 by webex

4th December 2015

Approach

- Extend preliminary analyses by Gommenginger et al. (2013)
  - Swell conditions characterised by swell wavelength, swell height and swell direction from Envisat ASAR data
- Collocations of Cryosat-2 and Envisat ASAR
  - L1B waveforms split into different subsets according to ASAR swell wavelength, swell height and swell direction.
  - examine the shape of L1B SAR waveforms in different swell conditions and to detect the nature and the frequency of waveform distortions.
- Other data to be used to characterise swell conditions at the time of Cryosat-2 SAR acquisitions:
  - Directional wave spectra from buoys (in North-East Atlantic)
  - Numerical wave model output (WaveWatch3 from Ifremer).
    - comparison of WW3 output with ASAR and buoy data to determine accuracy of models to provide necessary swell information

Datasets and time span

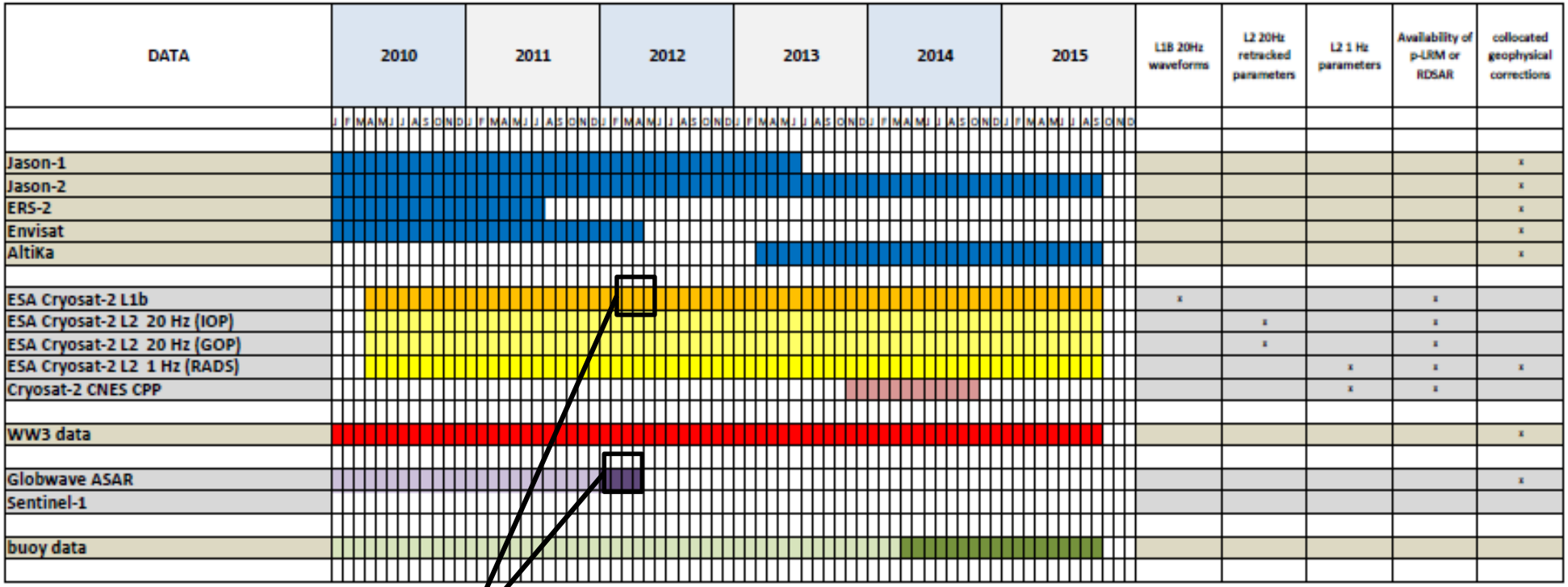
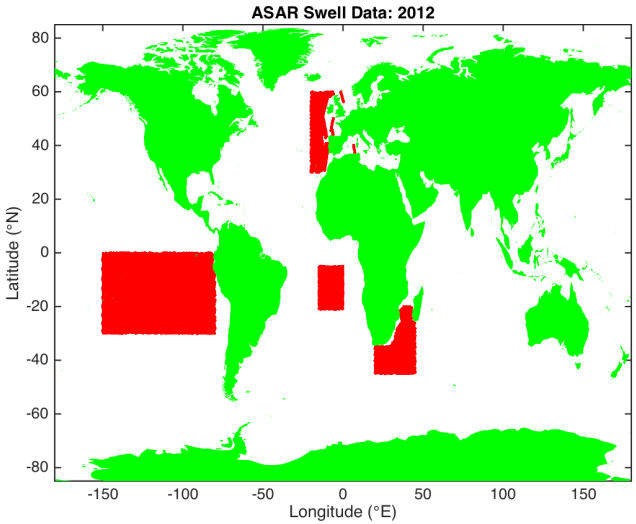


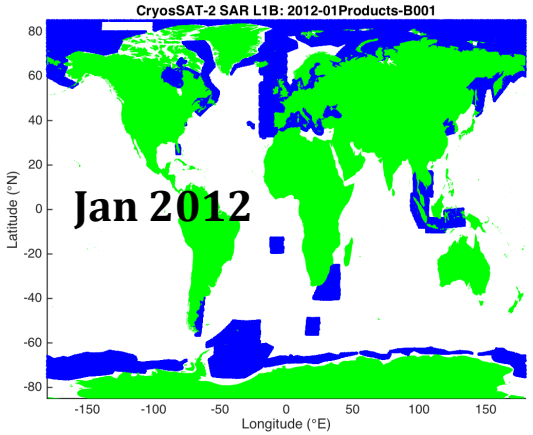
Figure 1

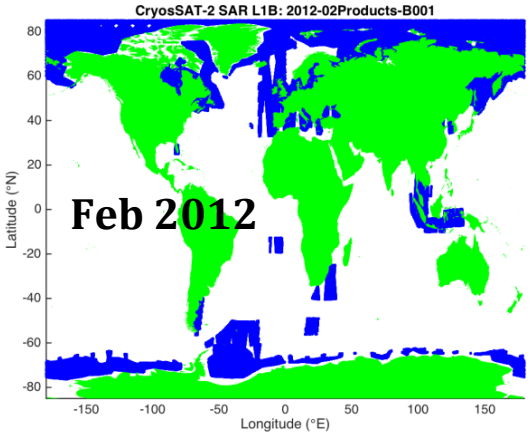
- Overlap between **Cryosat-2 L1B and L2** products and **Envisat ASAR** mission is **July 2010 to April 2012.**
- Other ocean wave data: **WaveWatch3** (global, full period); **Sentinel-1 L2 swell** (no/little data so far).
- ESA Cryosat-2 L1B SAR waveforms available for Baseline A, B and C over different periods.
- **CNES Cryosat Pilot Products (CPP)** available through collaboration with the ESA SCOOP project, limited to Nov 2013 to Oct 2014 (no overlap with Envisat ASAR).

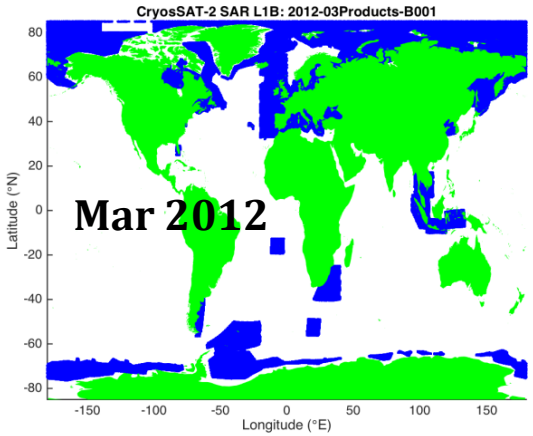
Cryosat-2 mode mask 2012 and extracted Envisat ASAR

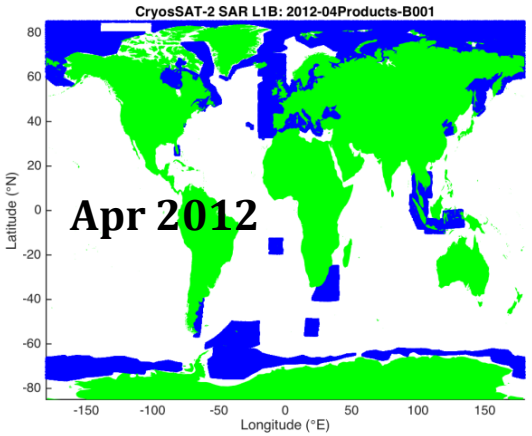
Location of extracted Envisat ASAR in 2012







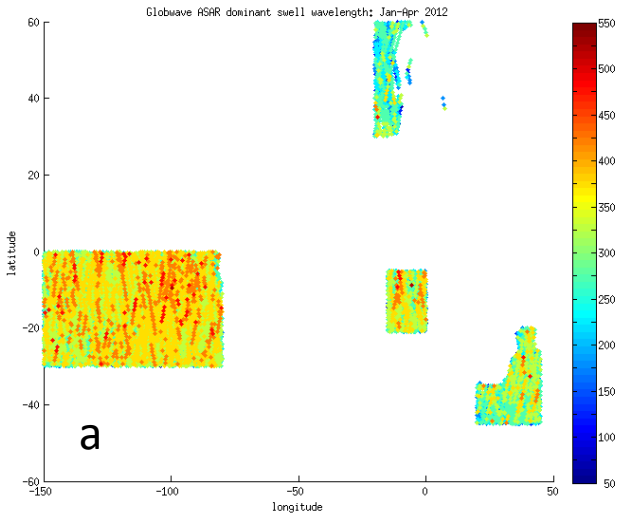




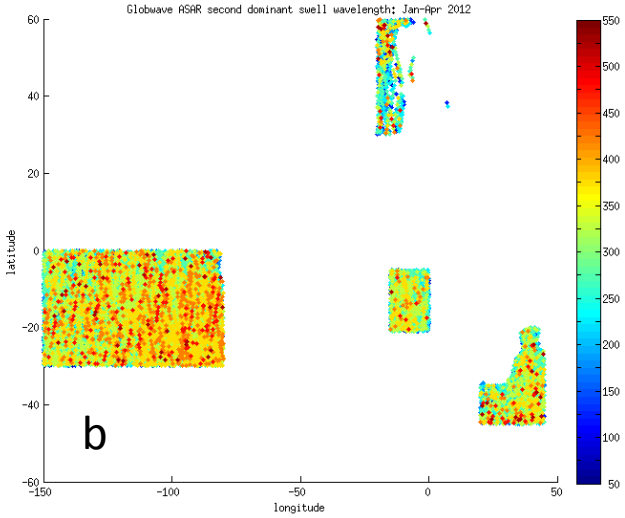
Location of Cryosat-2 L1B SAR mode data from January to April 2012.

ASAR swell wavelength (Jan-Apr 2012)

Dominant swell



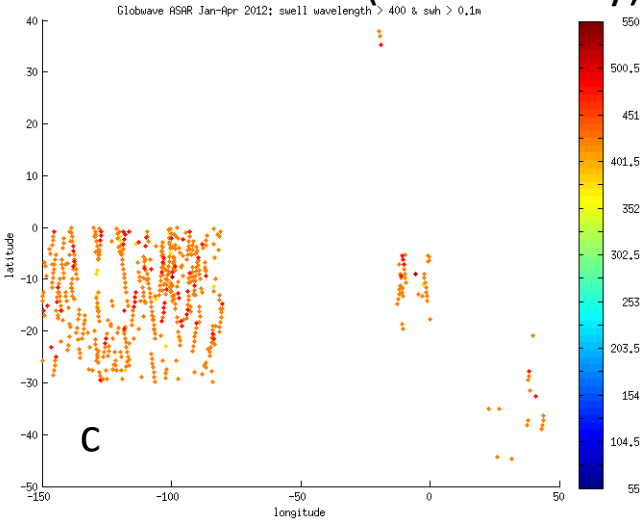
2nd dominant swell



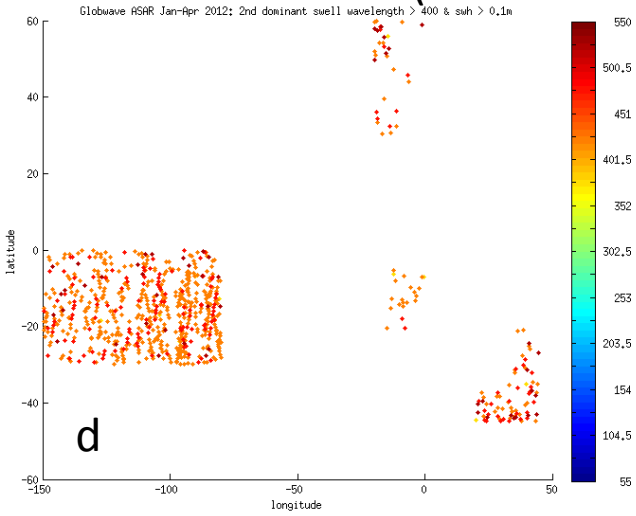
Maps of dominant (a,c) and second dominant (b,d) swell, for all significant wave heights over 0.1m

Colour denotes swell wavelength (m)

Dominant swell (> 400m only)



2nd dominant swell (> 400m only)

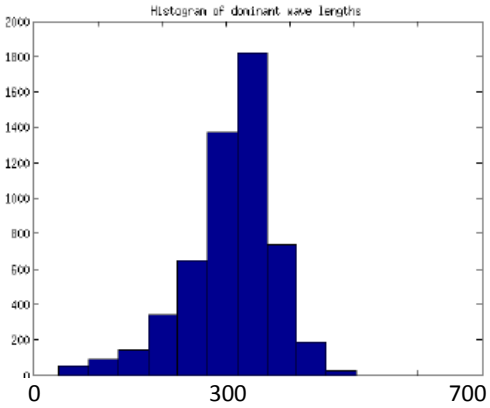


Figures c and d show only swell with wavelength over 400m. Colour axis limits range from 55m and 550m

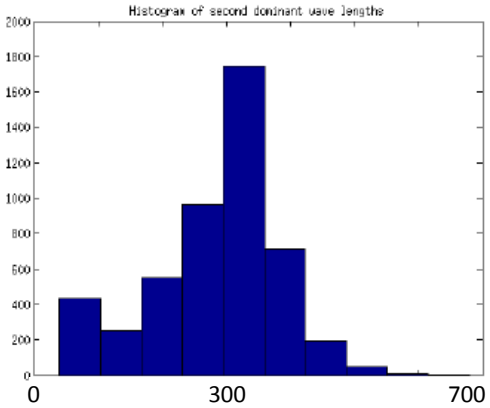
Collocating Cryosat-2 SAR & Envisat ASAR

Preliminary results: Jan-April 2012

Dominant swell length



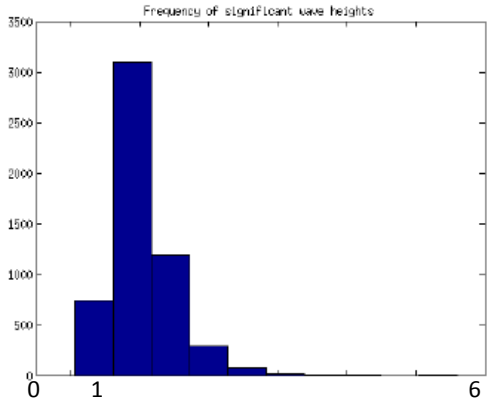
2nd dominant swell length



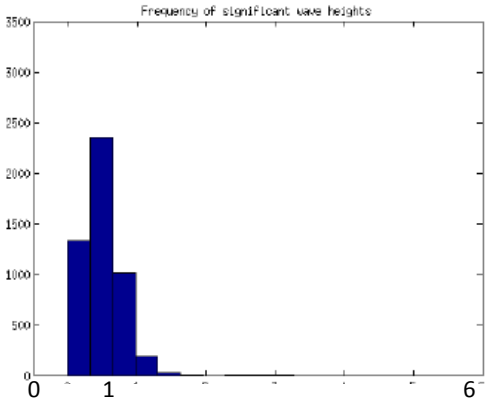
Histogram of Envisat ASAR dominant and second dominant swell wavelength

Initially, looking at extreme categories: 100-200 m and 400+ m)

Dominant swell height



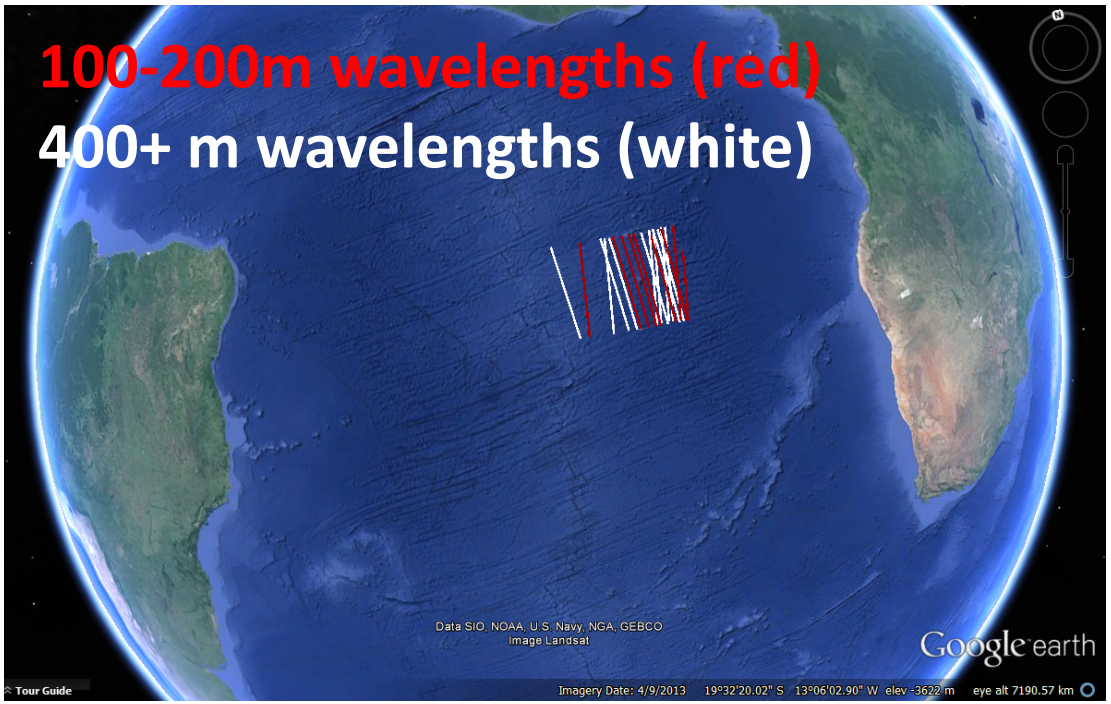
2nd dominant swell height



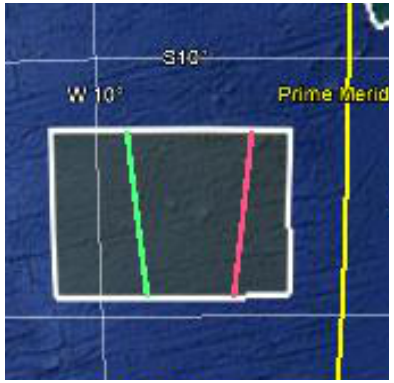
Histogram of swell wave heights

Co-location validation

Cryosat-2 SAR data in South Atlantic collocated with Envisat ASAR for 100-200m and 400+m swell conditions



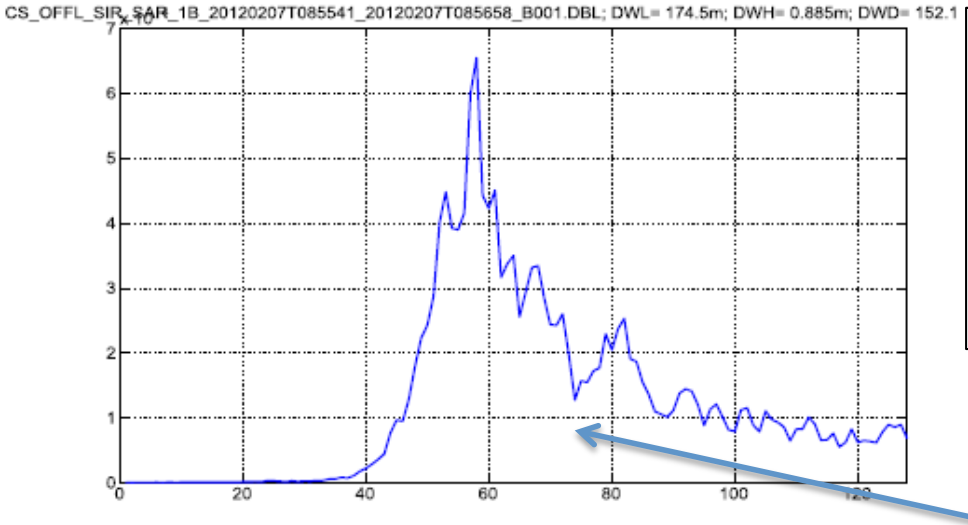
The direction with regards to north of Cryosat-2 ascending (green) and descending (pink) tracks.



The Cryosat-2 orbit has an inclination of 92°

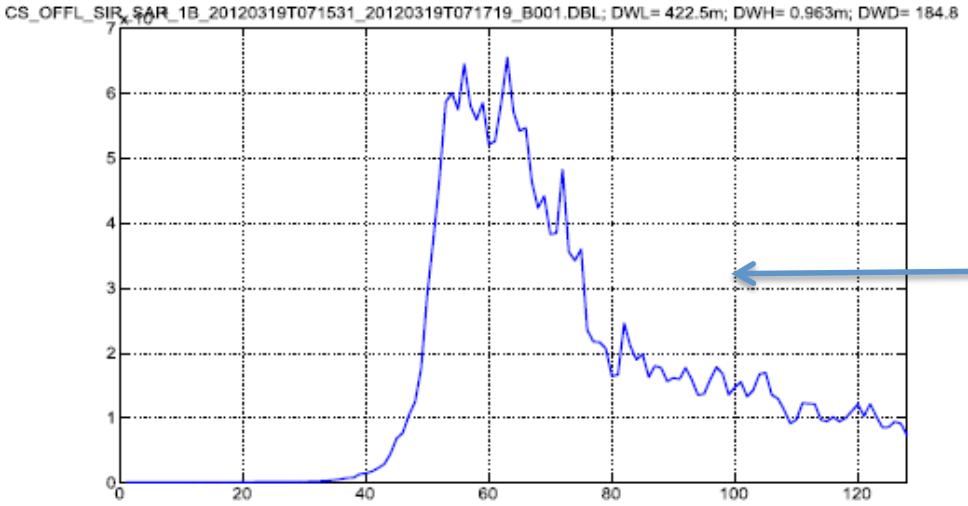
This is used to ascertain whether swell is parallel of perpendicular to tracks

Example 1: two Cryosat-2 SAR waveforms
Similar conditions except swell length



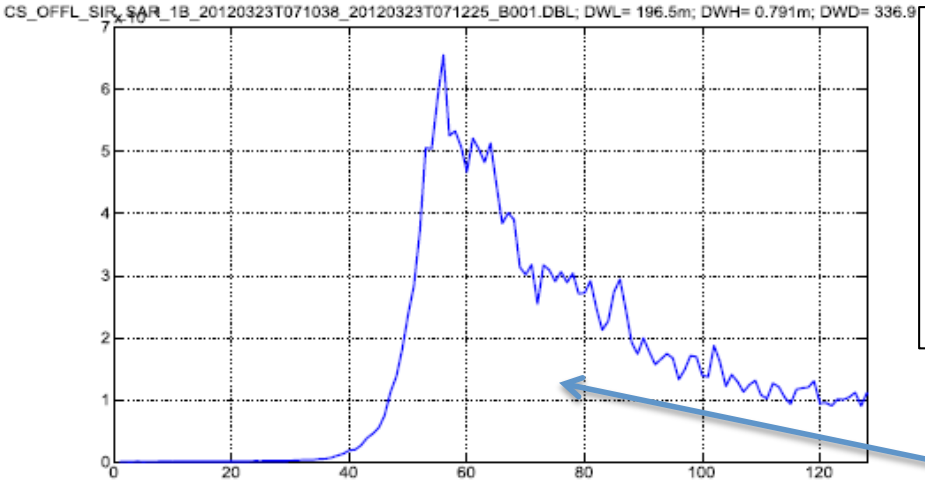
Same region, same ground-track orientation, same swell height, same swell direction but ≠ swell wavelength

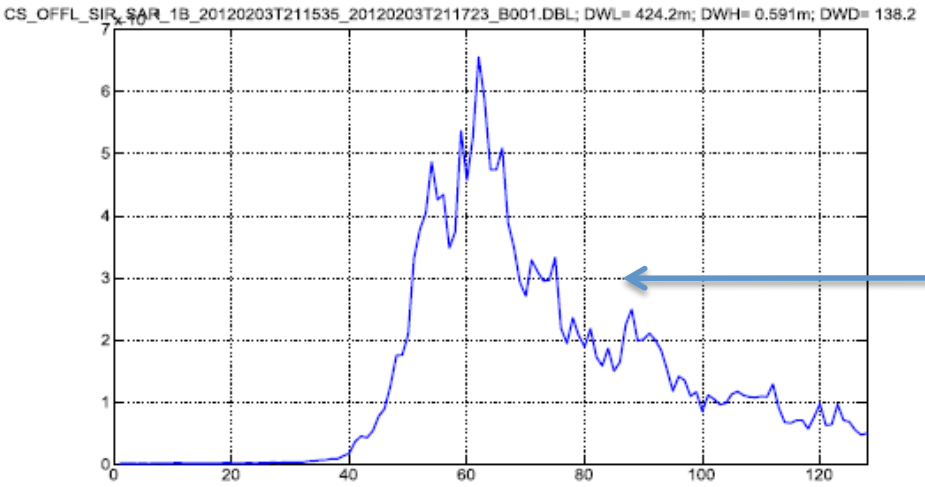
Short swell wavelength (100 – 200m)
Wave height < 1m
Wave direction parallel to altimeter



Long swell wavelength (400+ m)
Wave height < 1m
Wave direction parallel to altimeter

Example 2: two Cryosat-2 SAR waveforms
Similar conditions except swell length



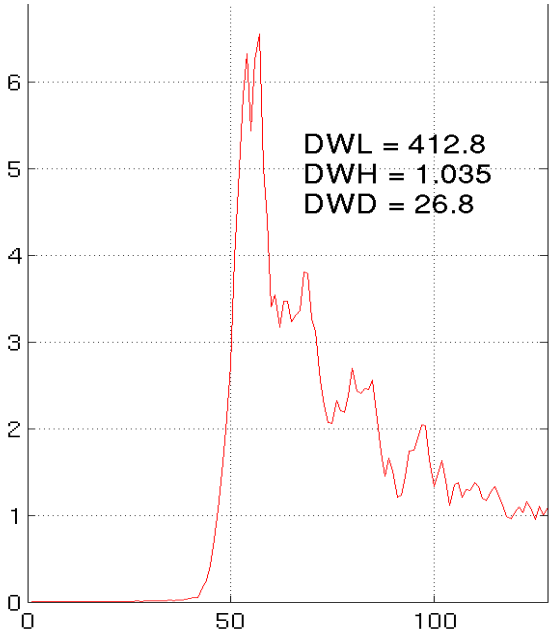


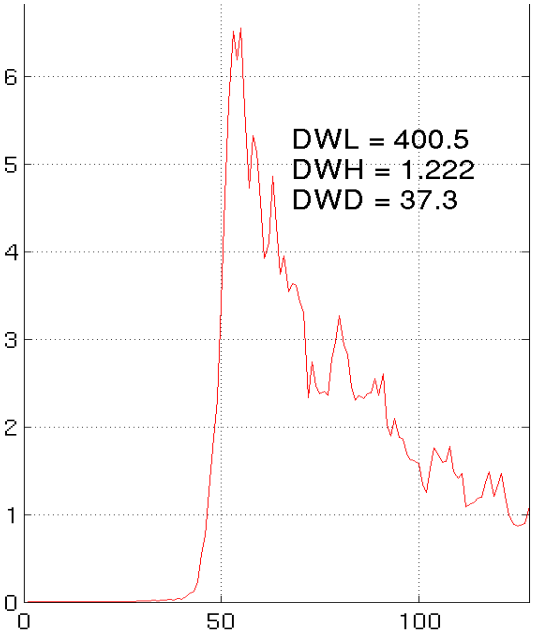
Same region, same ground-track orientation, same swell height, same swell direction but ≠ swell wavelength

Short swell wavelength (100 – 200m)
Wave height < 1m
Wave direction perpendicular to altimeter

Long swell wavelength (400+ m)
Wave height < 1m
Wave direction perpendicular to altimeter

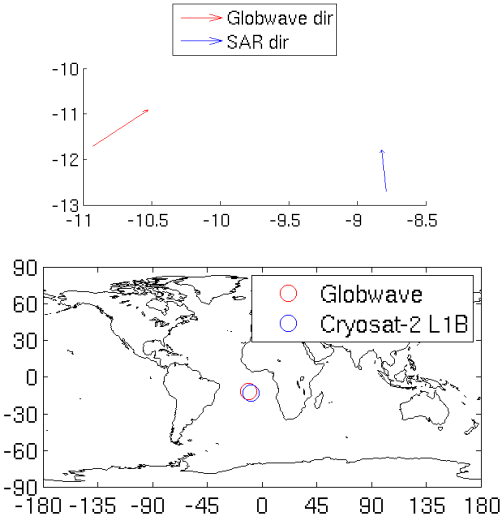
Example 3: two Cryosat-2 SAR waveforms Similar conditions

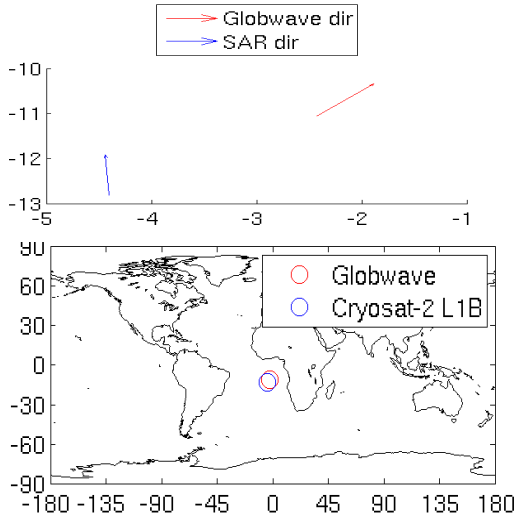




Two waveforms from similar ground track & ocean swell conditions

- Swell wavelength > 400 m
- Swell wave height 1 - 1.3 m
- Swell direction perpendicular to ground track





- Anomalies in both waveforms
- Anomalies have different characteristics, even though the conditions are a priori the same.
- Further investigations needed to ascertain the robustness and possible cause of these features

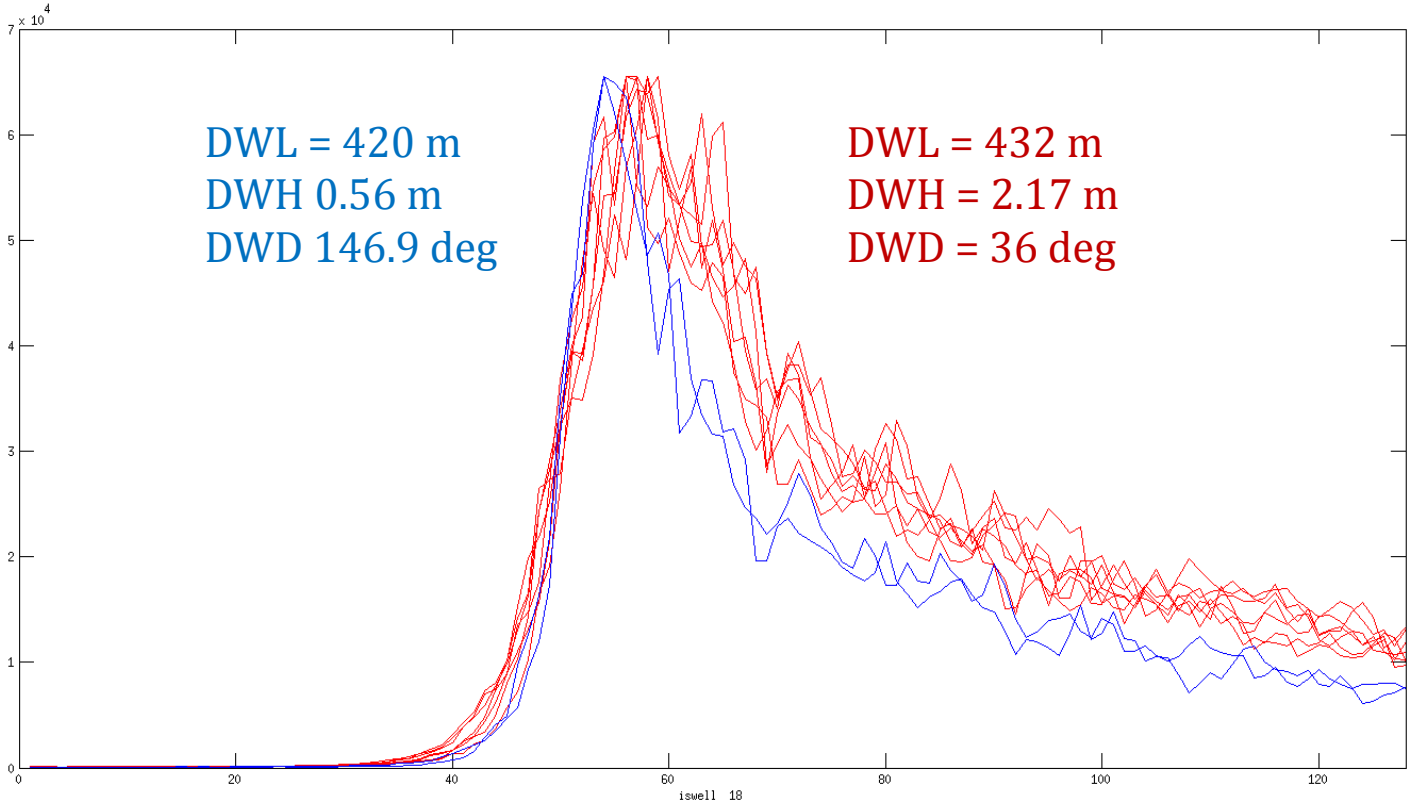
Variability in Cryosat-2 SAR waveforms: first results

Multiple Cryosat-2 acquisitions for one ASAR acquisition

Waveforms that all collocate with one specific Envisat ASAR acquisition are plotted together

Single 20Hz waveforms closest to ASAR data

Two groups for different conditions (red and blue)



- Reasonable level of consistency between waveforms in each group.
- Similar shape and features.
- To be repeated using multi-waveform averages to increase robustness to noise and provide more conclusive results.

Next steps

- Results so far validate the current approach for SAR Sea State Bias analyses
- Analyses will be extended by developing multi-waveform averages
  - statistical variability in different waveform bins
  - noise in the anomalies we observe.
  - Extended to the full 2010-2012 period
- Collect buoy and numerical wave model data for each co-location point.
  - Assess the reliability of the wave model output to characterise swell conditions.
- The activities in WP13 will build on the co-location and swell categorisation methods developed in WP12 for ASAR.
  - Methods will be applied to wave model output and CNES CPP data for the 1-year period covered by the CNES CPP dataset.
  - Response of the CPP waveforms to swell compared to observed same waveforms computed with the ESA operational processors, to determine the impact of L1 processing choices.
  - The impact of swell at L2 will be examined by comparing the Cryosat-2 SAR L2 retrieved parameters (e.g. SSH, SWH) to pLRM retrieved parameters in different swell conditions.