Validation of Re-processed NRCS Data from ASCAT-A

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1 - Abstract

The Advanced Scatterometer (ASCAT) on the METOP series of satellites is a six beam, real aperture, vertical polarised, C-band radar designed primarily to provide global ocean winds for assimilation into numerical weather prediction models. Its dense coverage also makes it useful for near real time use by operational weather forecasters.

The basic measurement provided by the ASCAT is the normalised radar cross section (NRCS) for which other important applications have emerged in recent years over land and sea ice areas, where it provides information on parameters such as soil moisture and ice concentration.

Seven years after the start of the ASCAT mission, a reprocessing of the full mission has taken place and an analysis of instrument behaviour, calibration accuracy and stability has been carried out.

This analysis demonstrates that the data satisfies the science data quality requirements recommended by the ASCAT Science Advisory Group, namely a maximum error of 0.1 dB in the absolute and relative calibration, less than 0.1 dB peak to peak variation in the relative calibration across the swath and a calibration stability of better than 0.1 dB over 5 years.

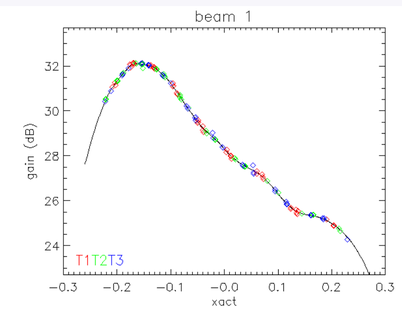
2 - Calibration

The ASCAT is calibrated by means of three transponders based in Turkey. The measurements recorded during a calibration campaign allow the antenna gain patterns to be determined. These are then used during the processing along with the viewing geometry to calculate normalisation factors for transforming the ASCAT measurements into calibrated backscatter.

Calibration campaigns took place in 2007, 2010 & 2012. With the exception of the left mid beam, the gain patterns in each beam showed only minor differences and a single averaged gain pattern was used for the reprocessing.

The left mid beam was observed to undergo a small and sudden change in 2011 which affected the backscatter in the operational products by around 0.1 dB. This was taken in to account for the reprocessing by using two gain patterns, one for the data prior to Sep 2011 and one for data afterwards. This removes the effect of the sudden change ensuring the level 1b data has a uniform and consistent calibration.

Transponder on site in Turkey



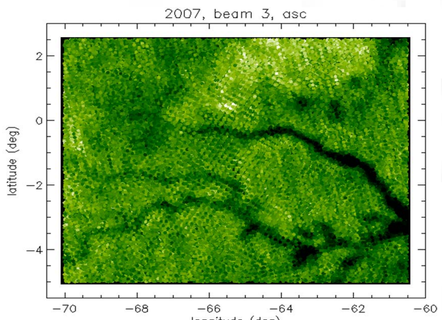
Set of transponder data with fitted gain model

3 - Absolute & Relative Calibration Accuracy

Several methods were used to examine the absolute and relative accuracy of the calibration. These included:

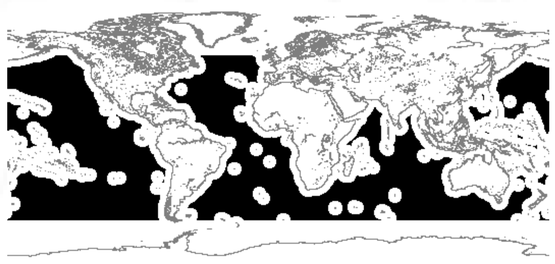
- Using the backscatter from an area of Amazon rainforest to calculate the mean γ_0 which was then compared to known values from the ERS-2 scatterometer.
- Comparing the backscatter measured over areas of open ocean (for incidence angles less than 55°) to the value given by the ocean backscatter model CMOD5.

The results from these techniques are summarised in the tables below and show that the absolute and relative calibration accuracies are better than the target of 0.1 dB.



beam	ASCAT γ_0 (dB)	Rel Cal Acc (dB)	ERS γ_0 (dB)	Abs Cal Acc (dB)
0	-6.61	-0.02	-6.54	-0.07
1	-6.63	-0.04	-6.63	0.00
2	-6.58	+0.01	-6.50	-0.08
3	-6.64	-0.05	-6.54	-0.10
4	-6.64	-0.05	-6.63	-0.01
5	-6.59	0.00	-6.50	-0.09

Rainforest area and ASCAT absolute and relative calibration accuracy by comparison to ERS2



beam	Ocean σ_0 – CMOD5 (dB)	Rel.Cal.Acc (dB)
0	0.03	-0.05
1	0.04	-0.04
2	0.04	-0.04
3	0.09	+0.01
4	0.02	-0.06
5	0.08	0.00

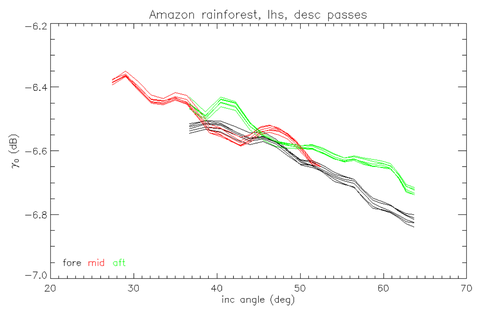
Open ocean area and absolute and relative calibration accuracy by comparison to CMOD5

4 - Relative Calibration Across the Swath

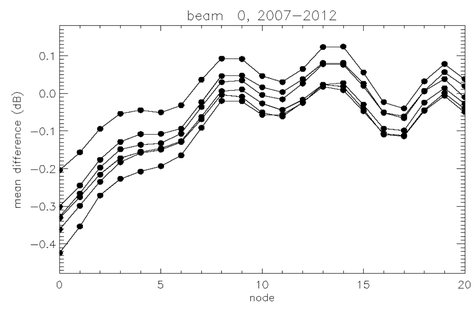
The behaviour of the calibration across the swath has been investigated using a variety of techniques:

- Examination of the mean rainforest γ_0 in each beam as a function of incidence angle
- Analysis of the difference between the ocean backscatter in each beam and CMOD5 as a function of incidence angle.
- Examination of the difference between the backscatter from Antarctic sea ice and the ice line model.

All of these show the presence of small oscillations in the calibration across the swath. However these are small, typically less than 0.1 dB peak to peak which meets the recommended accuracy.



Oscillations in the rainforest γ_0 in the left fore mid & aft beams 2007-2013

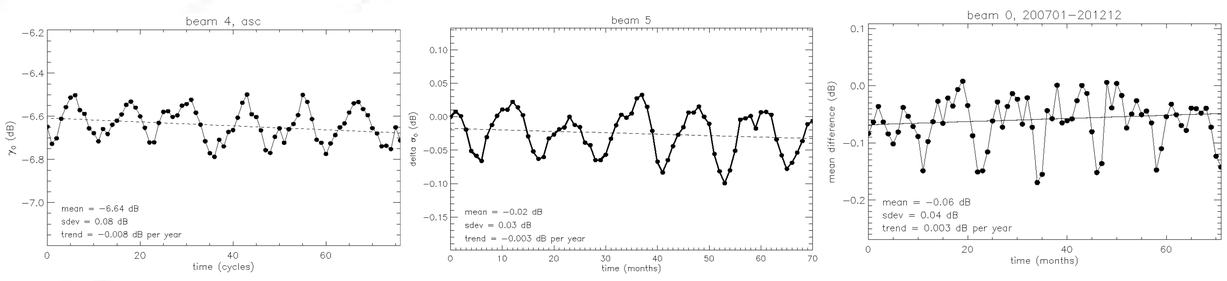


Oscillations in the difference between sea ice backscatter and ice line model in the left fore beam, 2007-2013

5 - Calibration Stability

The stability of the calibration was investigated using backscatter from rainforest, sea ice and ocean and the results were very consistent, indicating a very stable instrument:

- Examination of the mean γ_0 from the rainforest shows a worst case change (from the set of all beams) of 0.008 dB per year (lower left plot).
- The changing position of the ocean cone in ocean backscatter indicates a worst case calibration change of 0.003 dB per year, (middle plot).
- The mean difference between backscatter from sea ice and the ice line model shows a worst case change of 0.003 dB per year (right hand plot).



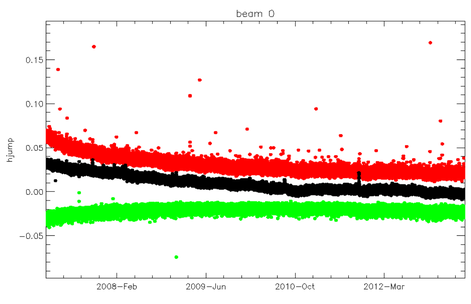
Trends in ASCAT calibration using rainforest, ocean and sea ice backscatter

6 - Behaviour of key level 1a and level 1b parameters

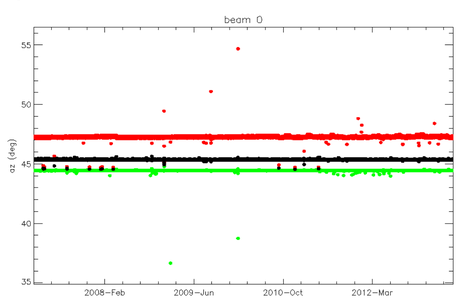
Monitoring of key calibration, geometrical and measurement parameters from the level 1a and 1b data showed that the instrument performance was of high quality. A few minor issues were noted:

The left hand plot shows the min, max and mean of the across swath ASCAT filter shape estimated from noise measurements . A small number of outliers are observed and are found to be caused by interference from ground based radars. The impact on the backscatter quality is small.

The right hand plot shows the min max and mean of the difference in azimuth angle between the left fore and mid beam. This is usually close to 45 ° but occasional small gaps in the ASCAT data near the poles have a strong effect on the calculation of spatial averages and a few outliers can be seen. These data can be identified through quality control.



Time series of the estimated filter shape



Time series of the azimuth angle

Summary and conclusions

The entire mission data from ASCAT-A (2007-2013) has been reprocessed using a single consistent calibration based on data from three calibration campaigns and a consistent processor version configuration, given in [1].

An analysis of the data set is given in [2] and demonstrates a very stable instrument and that the backscatter data satisfies the data quality requirements recommended by the ASCAT Science Advisory Group, namely a maximum error of 0.1 dB in the absolute and relative calibration, less than 0.1 dB peak to peak variation in the relative calibration across the swath and a calibration stability of better than 0.1 dB over 5 years. A description of the reprocessing and the data set, including quality control recommendations and other usage guidelines, is given in [3].

These data can be now further used for the generation of wind, soil moisture and sea ice Climate Data Records. The data set and associated documentation will now enter a formal review, pre-requisite to its release to the EUMETSAT Data Centre and to the wide User Community.

Further information

The reprocessed ASCAT-A data was produced by EUMETSAT as part of the European reanalysis of global climate observations (ERA-CLIM) project and is freely available.

For further information (including the documents below) please contact Julia.Figa@eumetsat.int, Craig.Anderson@eumetsat.int or the EUMETSAT help desk (www.eumetsat.int).

[1] ASCAT NRCS Processing Algorithm Theoretical Basis Document
[2] ASCAT/Metop-A Reprocessed L1 Data Set Validation Report
[3] ASCAT /METOP-A Reprocessed Level 1 Data Record User Guide

International Ocean Vector Wind Science Team, Brest (France) 2014