ASCAT Calibration & Validation

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Introduction

- The ASCAT calibration and validation plan covers
  - calibration and monitoring using three active transponders
  - validation and monitoring of level 1b backscatter at EUMETSAT using natural targets (e.g. rainforest and ocean)
  - validation and monitoring of level 2 winds at the OSI SAF using NWP results and ocean buoy measurements

- Results are documented in EUMETSAT reports, OSI-SAF reports and peer reviewed papers

ASCAT transponders

- Three transponders located in Turkey
  - EUMETSAT member state
  - Distant from open ocean so that operation of ASCAT in calibration mode minimises interruption to ocean data
  - Positioned to give optimum sampling of each antenna beam during the 29 day repeat cycle
  - Located on top of hills and away from built up regions in order to minimise multipath effects

ASCAT transponders

Transponder tower at western site

View from transponder tower at central site

ASCAT calibration principle

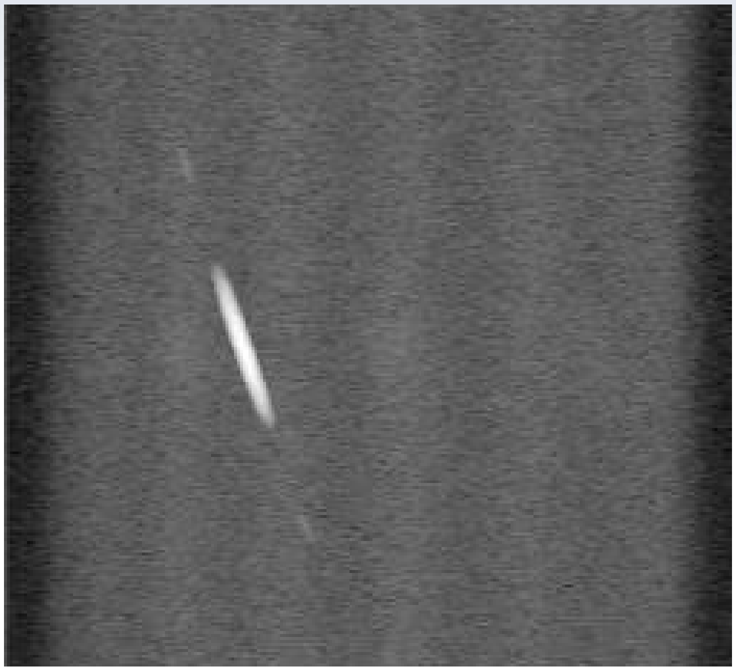
- As ASCAT passes overhead the transponder cuts through the beam. With a sufficient number of cuts, the gain pattern can adequately sampled and a model fitted to the data.
- Assuming the Earths backscatter is unity then the gain model allows the signal detected by ASCAT to be estimated.
- Differences between estimated and actual signal are caused by the Earths backscatter not being unity. Dividing the measured signal by the estimated signal gives the actual backscatter.
- Hence, the estimated signal is effectively a normalisation factor than can be used to convert ASCAT measurements into absolutely calibrated backscatter.

ASCAT calibration campaigns

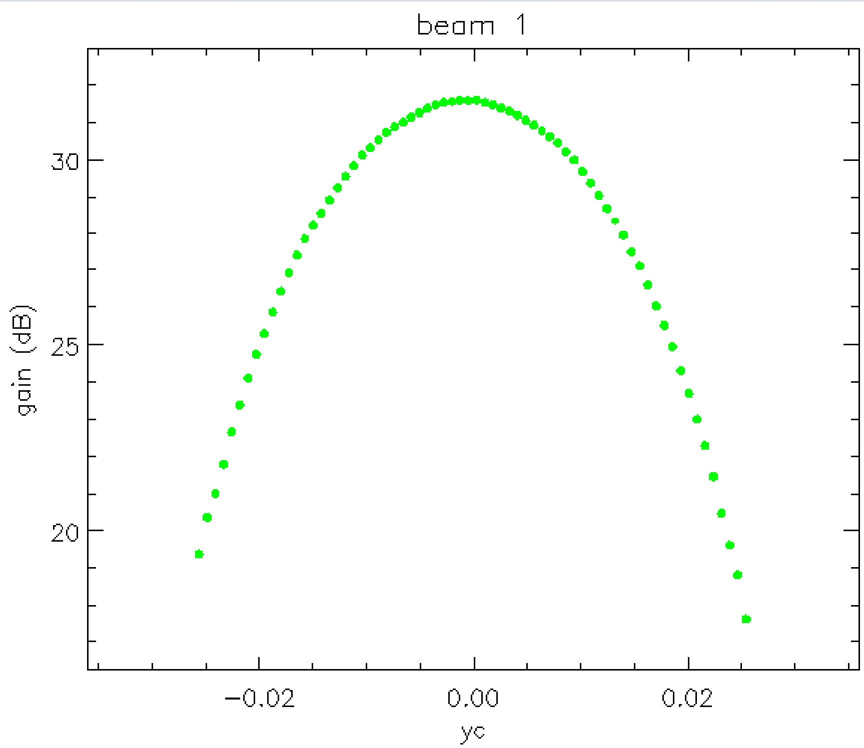
- First calibration campaign took place in Nov/Dec 2006 using one transponder. This gave a preliminary calibration for the commissioning phase.
- Second campaign took place in Nov 2007 to Feb 2008 and used all three transponders. These results are currently being used for operational data and for reprocessed data covering 2007-2008.
- Third transponder campaign started in March 2010 and will finish May 2010. If the results are significantly different from the last campaign then the calibration will be updated.

Calibration step 1

Convert transponder signal to gain in antenna coordinates

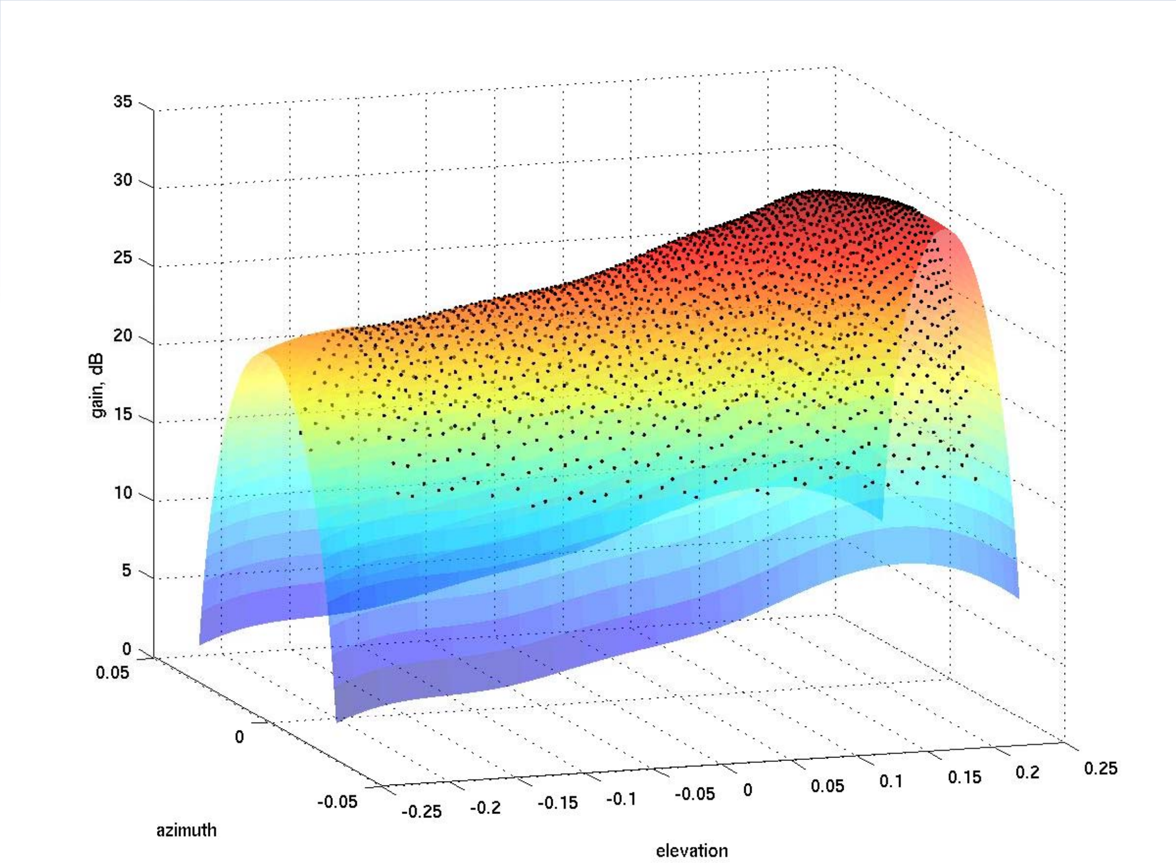


Typical transponder signal seen by ASCAT



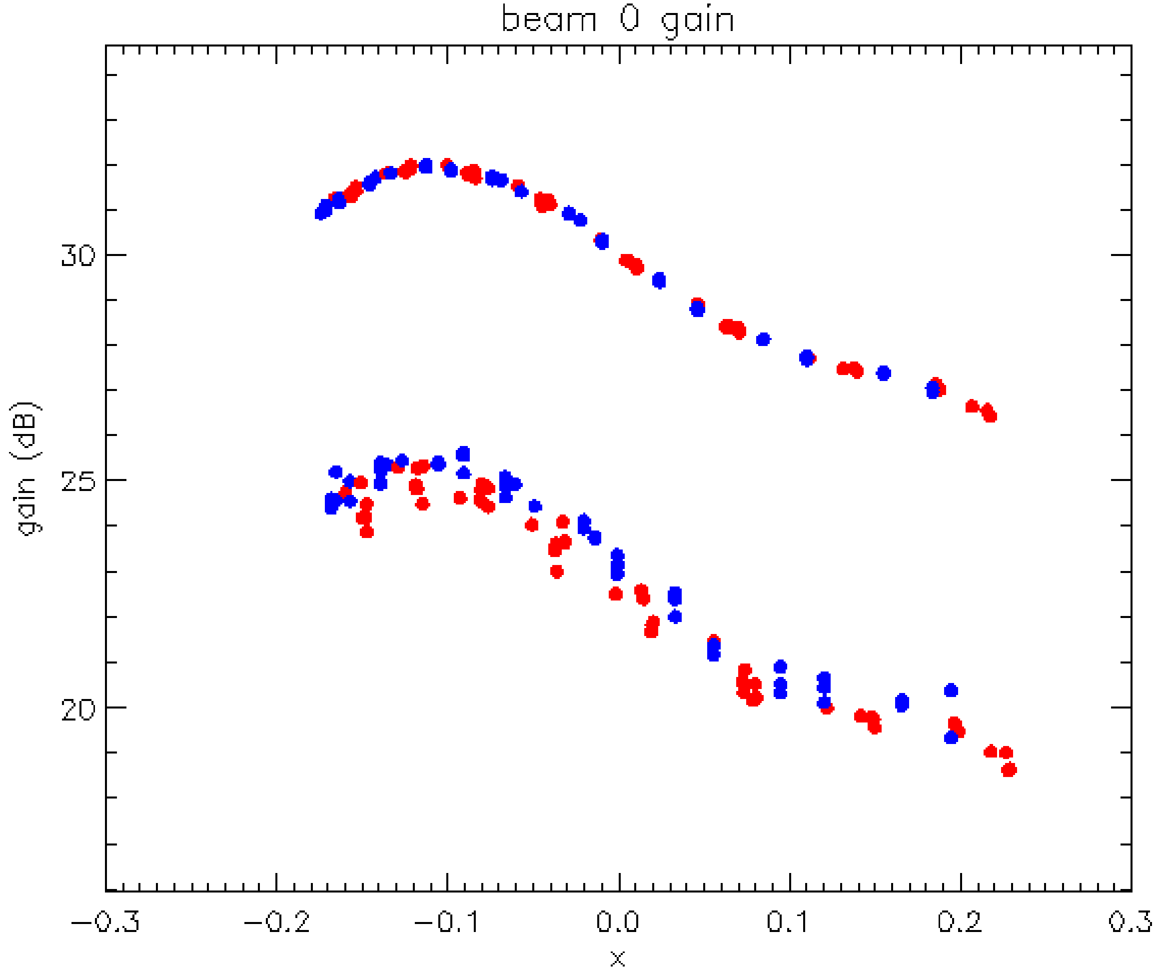
Antenna gain as a function of azimuth angle

Calibration step 1



Multiple passes over the transponder allow the entire gain pattern to be sampled.

Calibration step 1



Red and blue show ascending and descending passes

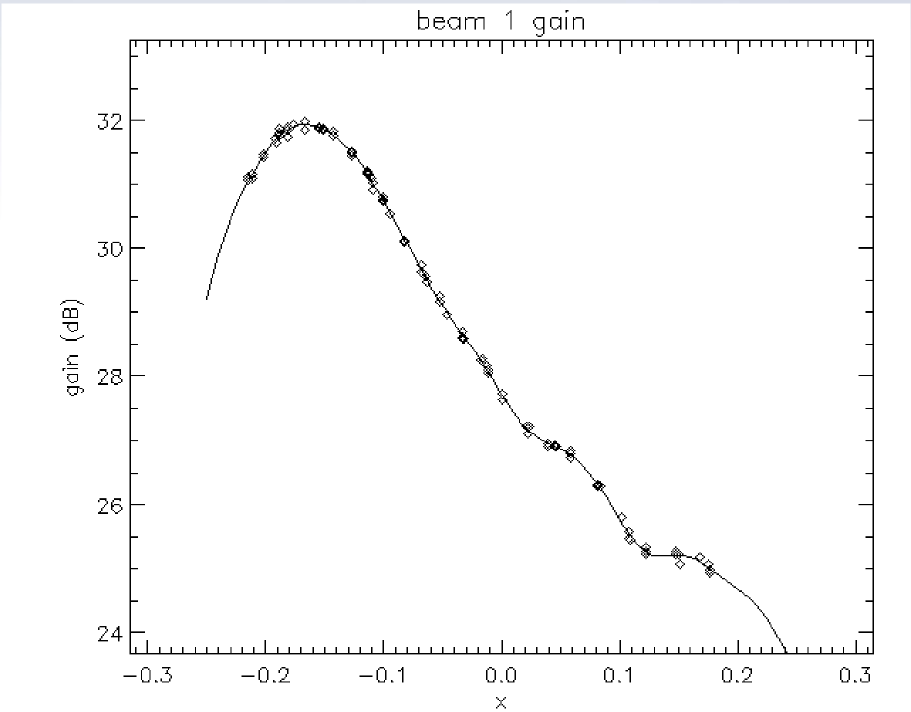
Upper line is a section through centre of gain pattern

Lower line is a section through edge of gain pattern

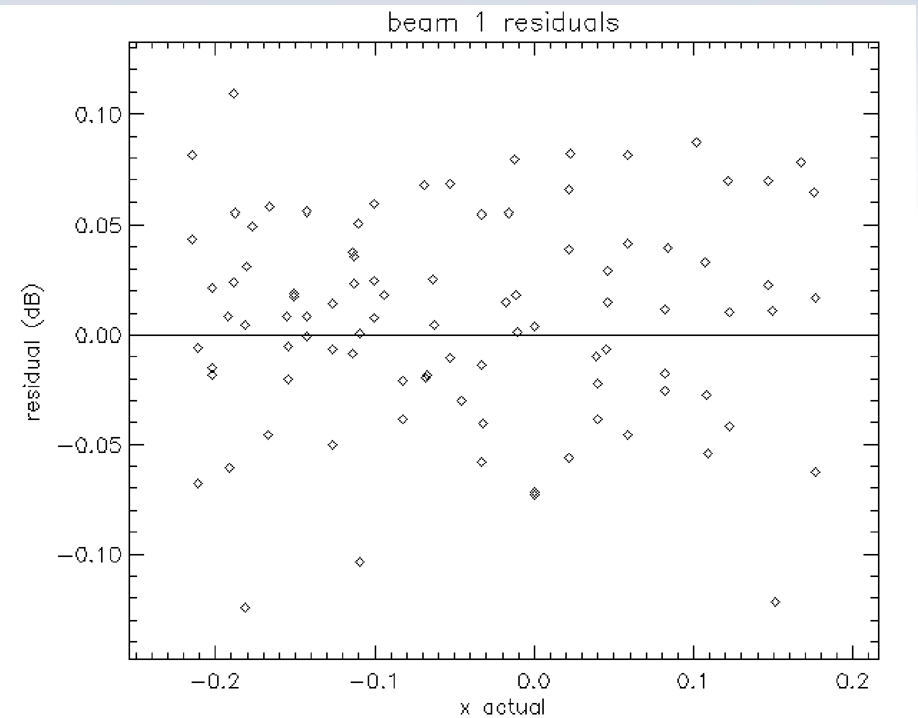
Differences between ascending and descending possibly due to thermal effects causing the antenna azimuthal pointing to alter slightly

Calibration step 2

Fit gain pattern model to data set



Transponder data and fitted gain pattern in left mid beam



Residuals between data and model

Calibration step 2

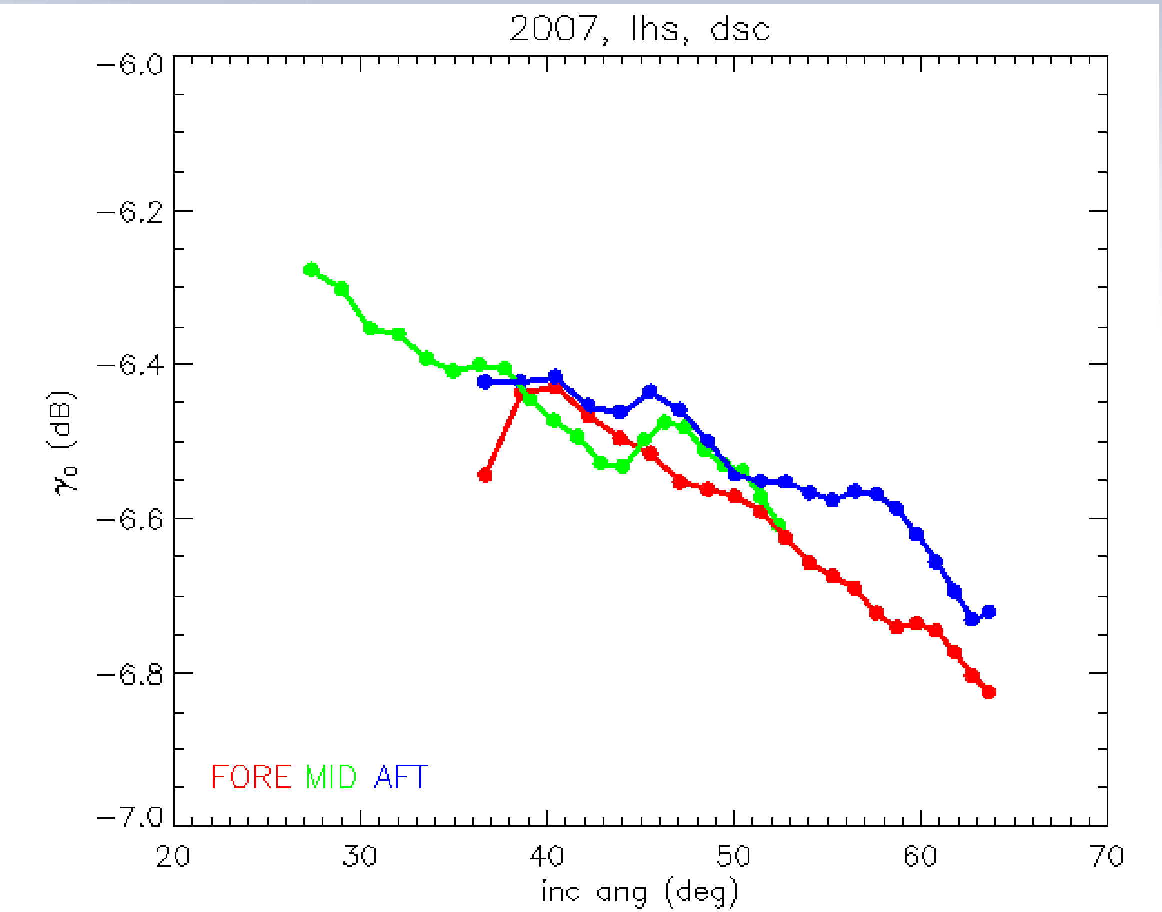
- Simple analysis: RMS residual approx 0.06 dB so considering a 2 sigma error gives a 95% probability that ASCAT calibration accuracy over the transponder test site is better than 0.12 dB.
- More detailed analysis taking into account other types of error gives the calibration accuracy to be

Beam	2σ (95.4%)	3σ (99.7%)
LF	0.25 dB	0.33 dB
LM	0.27	0.35
LA	0.31	0.39
RF	0.22	0.30
RM	0.21	0.29
RA	0.23	0.31

Validation using rainforest

- Rainforest areas have been extensively studied and monitored with the ERS-1 and ERS-2 scatterometers
- The parameter $\gamma_0 = \sigma_0/\cos\theta$ is found to be approximately constant with respect to incidence angle, geographical location and time with a value of about -6.6 dB.
- Hence rainforest data can be used to validate ASCAT data in a simple and direct manner

Validation using rainforest



With ASCAT data we find that the mean Amazon rainforest γ_0 is as expected but is not constant with incidence angle.

This suggest there will be problems when constructing long term time series of ERS and ASCAT data.

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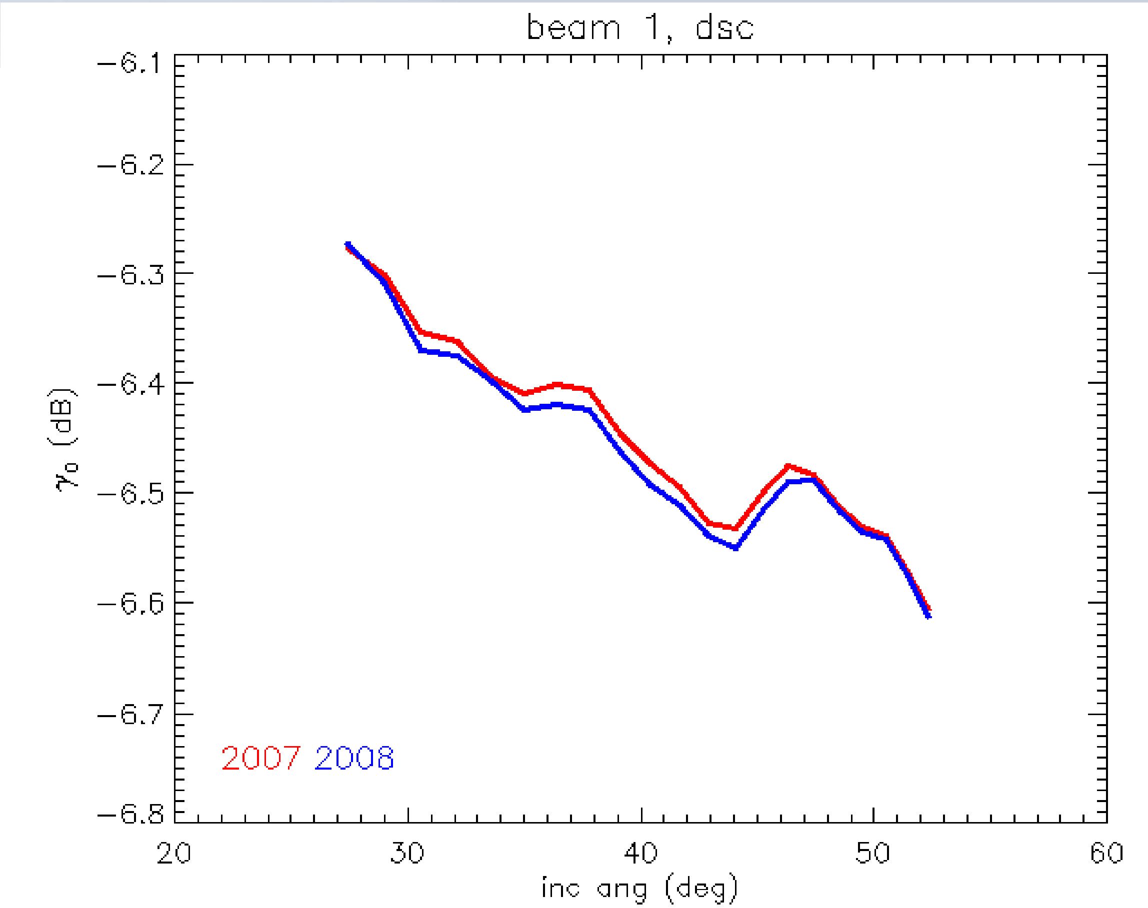
Monitoring using rainforest

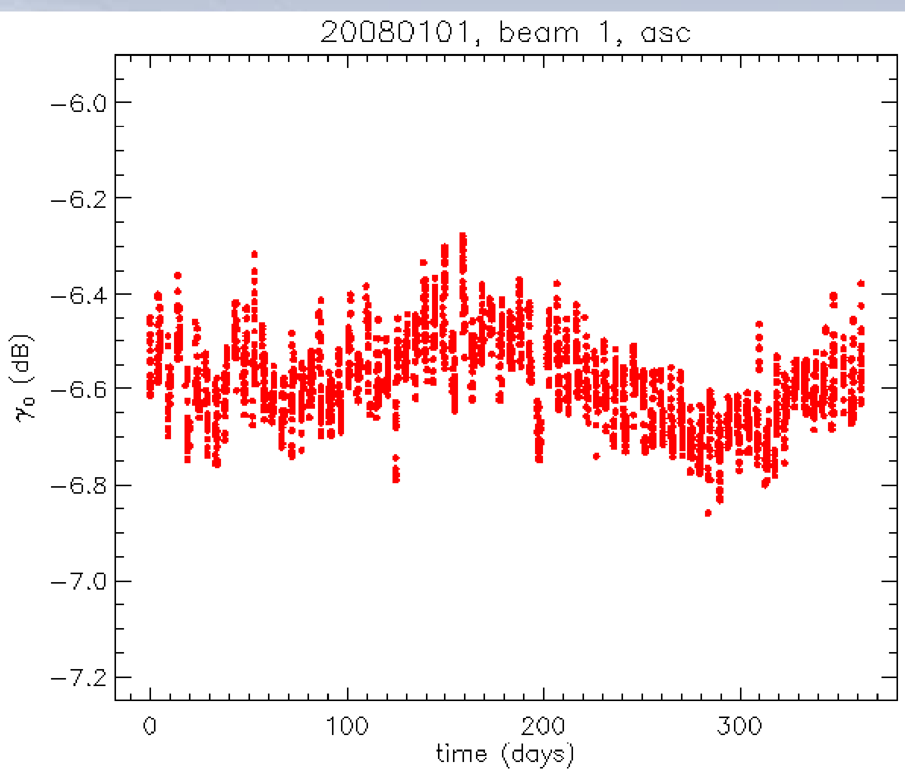


Mean rainforest γ_0 in 2007 and 2008

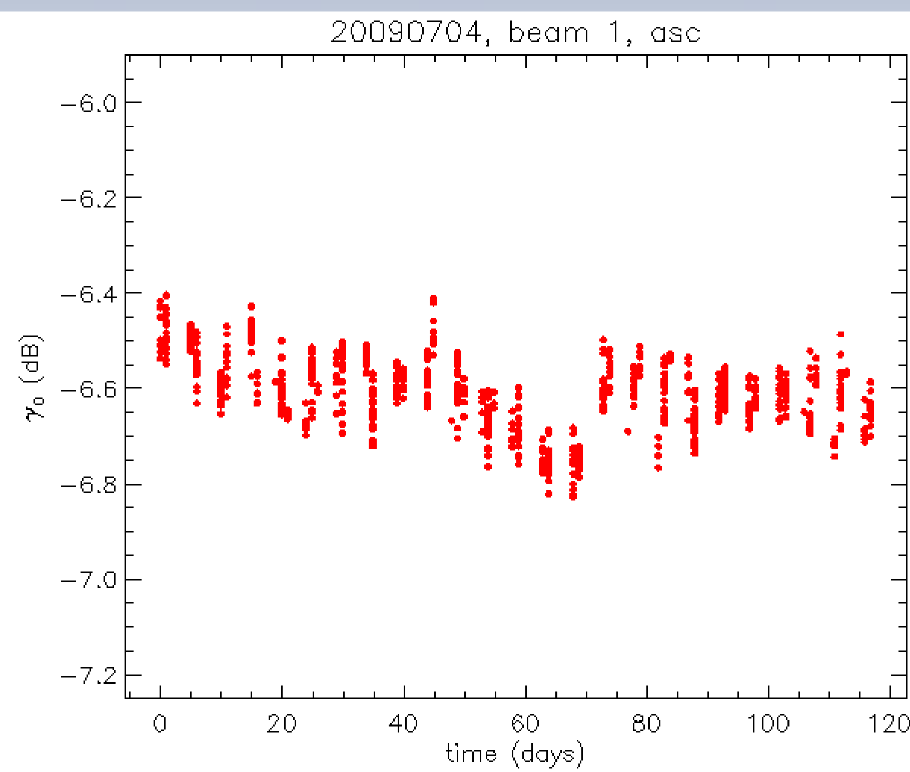
Average difference less than 0.01 dB

Indicates the stability of ASCAT and rainforest.

Monitoring using rainforest



Time series shows annual variation in rainforest of 0.2 dB

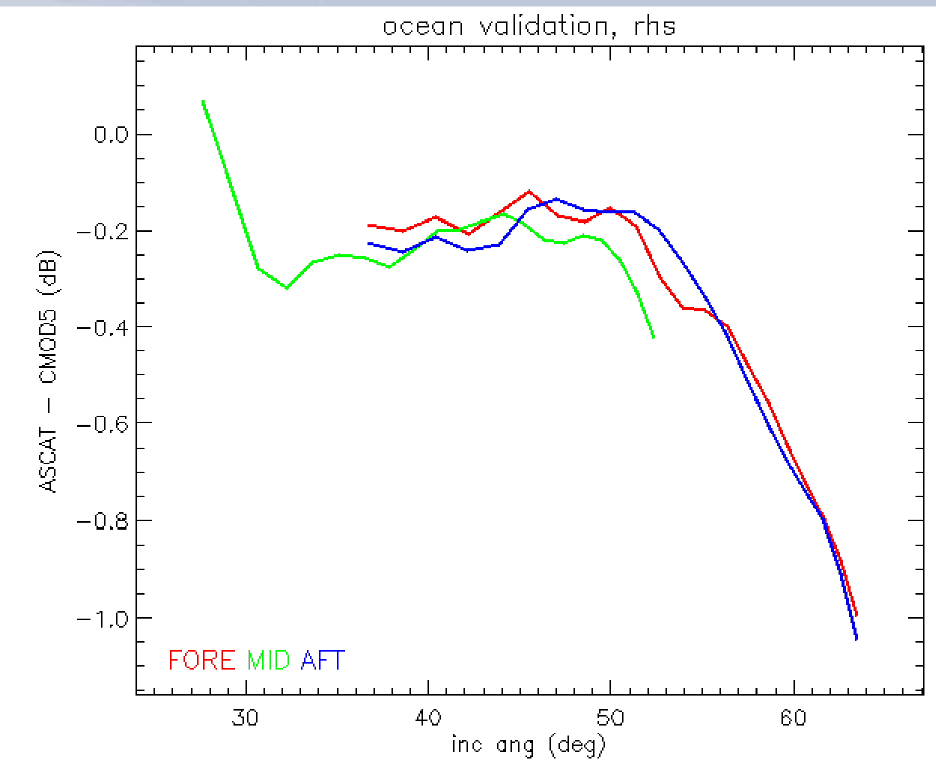


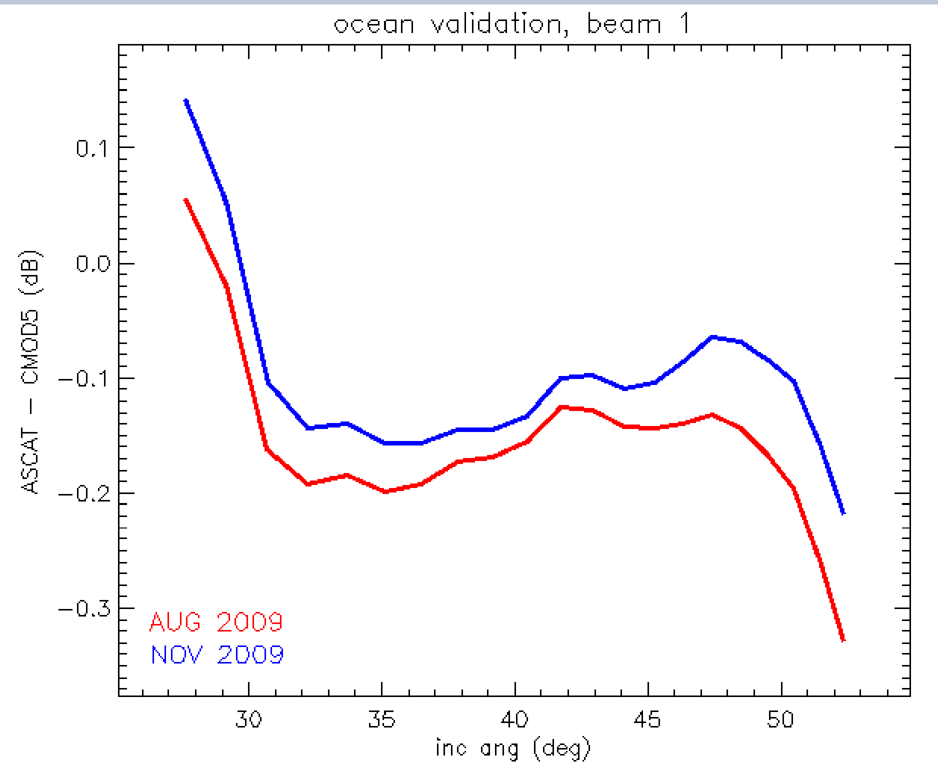
0.1 dB jump in LM beam during Sep 2009 (processor upgrade, satellite manoeuvre)

Validation using ocean

- Several generations of ocean backscatter models have been developed using ERS scatterometer data.
- These can be used with NWP wind fields to produce model backscatter estimates which can then be used to validate ASCAT data.
- At the OSI-SAF mean difference between data and model backscatter is removed from ASCAT data before retrieving wind vectors for the level 2 product. This effectively recalibrates ASCAT data to the model and allows wind retrieval to be independent of changes to ASCAT calibration.

Validation & monitoring using ocean

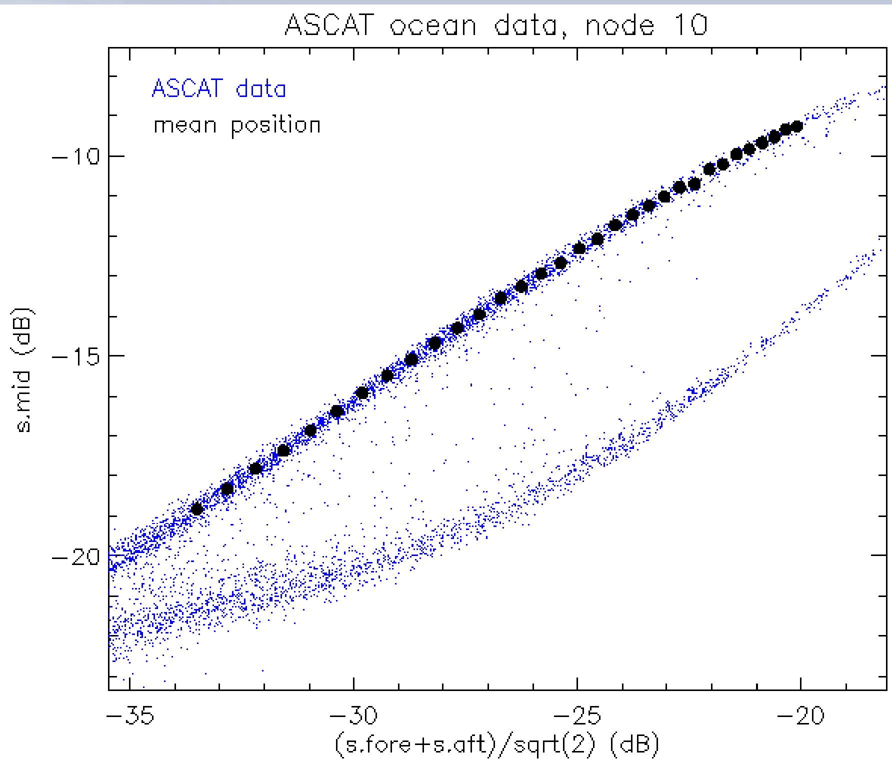


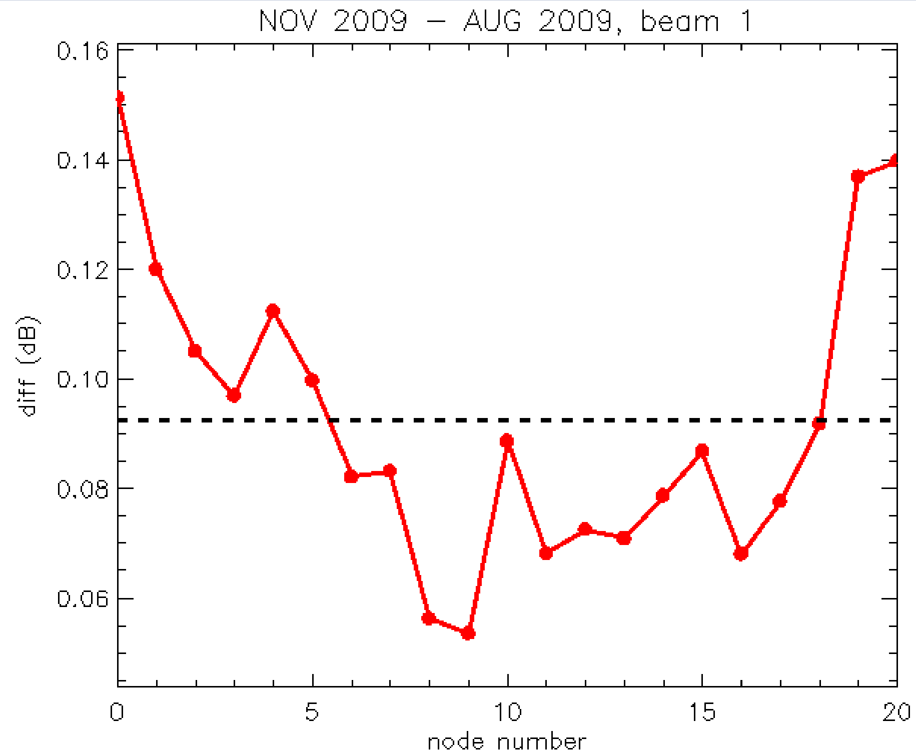


Difference between data and model is roughly constant below 55°, larger above 55°

Difference between data from LM beam and model changes by 0.1 dB around Sep 2009

Validation & monitoring using ocean





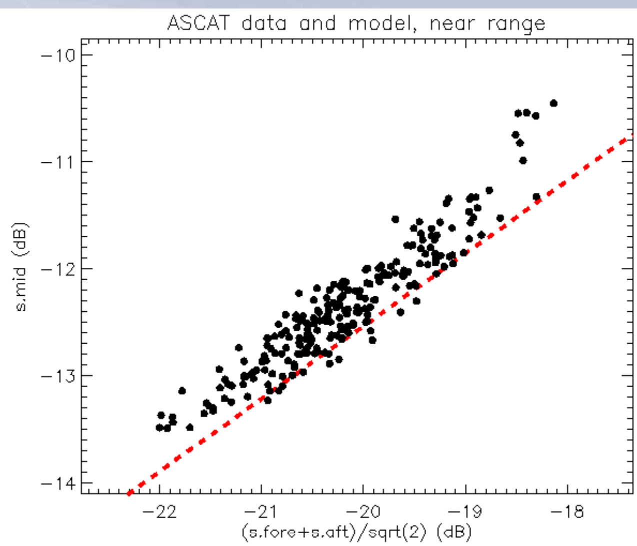
Section through ocean backscatter in LM beam and mean position.

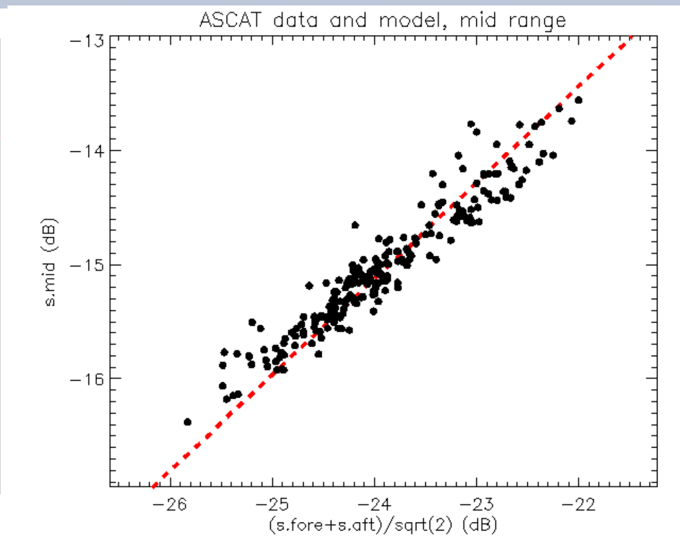
Change in mean position before and after Sep 2009 is 0.1dB

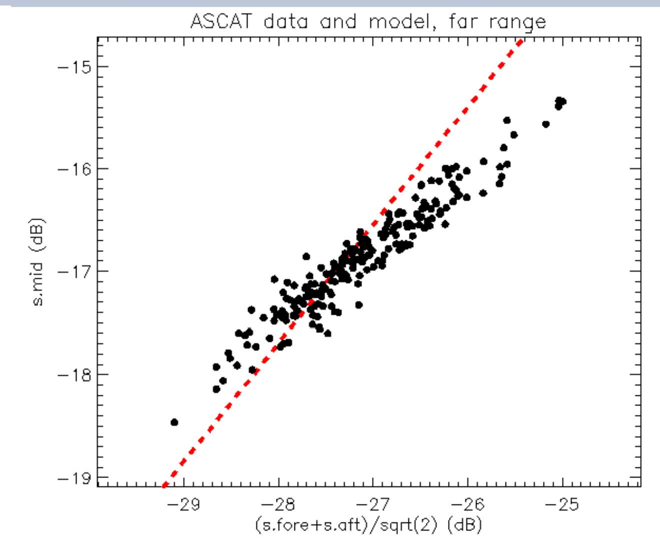
Stable sea ice

- Analysis using ERS shows that backscatter from some regions of sea ice is approximately stable and can be accurately modelled (e.g. the ice line model, de Haan & Stoffelen 2001, in which the points given by the fore mid and aft backscatter form a line in 3d space.)
- Hence we can validate ASCAT data by locating areas of stable sea ice and comparing data with the model.

Stable sea ice





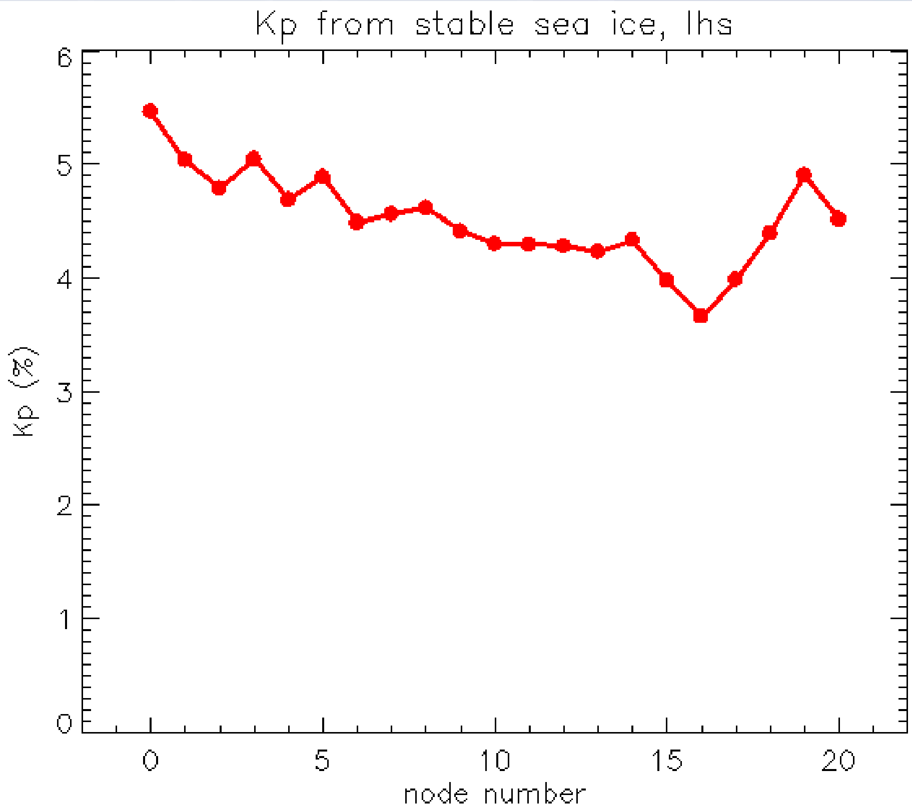


At low and mid range incidence angles ASCAT data lies close to the model

At larger incidence angles the data and ice line model start to differ

However, the model was developed from ERS data and hence only valid up to 55°

Stable sea ice



Kp derived from standard deviation of stable sea ice backscatter around best fitting straight line

Approximately 4.5 %, close to expected value of 3-4%

Summary

- Three active transponders allow the gain pattern of each beam to be determined, calibration factors to be calculated and calibration accuracy to be estimated.
- Rainforest, ocean and sea ice data have been used to validate ASCAT level 1b data and monitor the behaviour of the instrument.
- However there are discrepancies between the various validations (and also between ASCAT data and ERS data) which need to be understood.
- The third calibration campaign is underway and will allow calibration changes to be accurately investigated and, if necessary, corrected.

Further Information

Radiometric calibration of the advanced wind scatterometer ASCAT carried on board METOP-A satellite (accepted Trans. Geosci. & Rem. Sens.)

Validation and Calibration of ASCAT using CMOD5.n (Trans. Geosci. & Rem. Sens. pp386-395, vol 48, 2010)

Validation of backscatter from the advanced scatterometer (ASCAT) on Metop-A (in preparation)

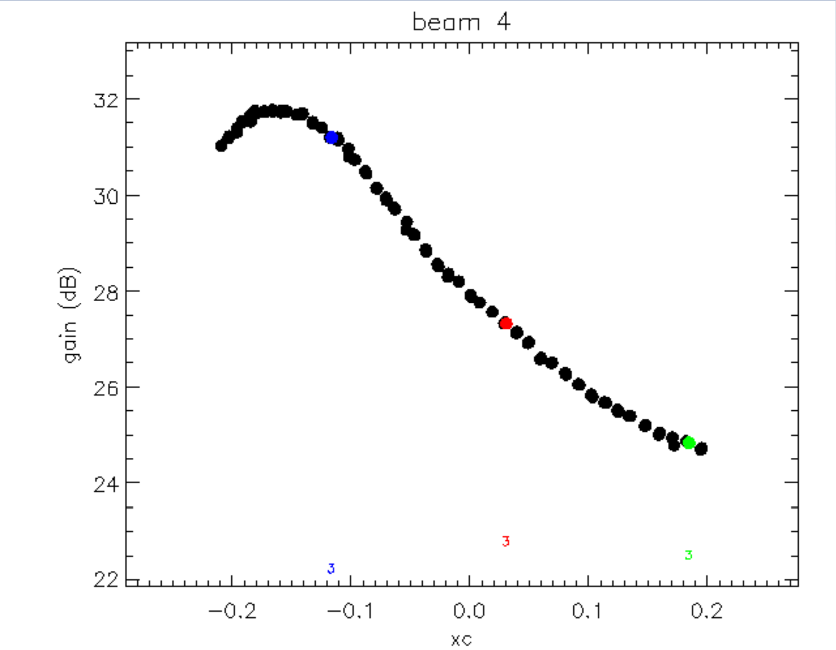
Current calibration campaign

Current calibration campaign is nearing completion.

Transponder operation (satellite tracking, monitoring, ASCAT pulse recording) has been improved.

Processing and calibration algorithms improved.

New data will reveal how the calibration has altered and allow the change in the LM beam to be investigated in detail.



Latest transponder data showing section through RM beam gain pattern