ASCAT BACKSCATTER: VALIDATION AND CURRENT DEVELOPMENTS

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Abstract

The Advanced SCATterometer (ASCAT) on METOP-A satellites is a real aperture, vertical polarisation, C-band radar designed primarily to provide global ocean winds operationally. The main application of these data is the assimilation into numerical weather prediction models. Its dense coverage makes the data also extremely useful for direct use by operational weather forecasters in near real time. The main measurement provided by the ASCAT is the normalised radar backscatter, for which other important applications have emerged in the recent years over land and sea ice areas, where it provides information on other parameters such as soil moisture and ice concentration and age. Four years after the start of the ASCAT mission, a preliminary long-term evaluation of the normalised radar backscatter calibration, accuracy and stability has been carried out. The consistency of the radar backscatter data record is summarised and current and planned developments in the processing are introduced.

INTRODUCTION

The ASCAT, on board METOP-A since 2006, is a real aperture radar operating at 5.255 GHz (C-band) and using vertically polarised antennae. The instrument accurately measures the radar backscatter from the surface of the Earth. Over the ocean surface, the backscatter is primarily influenced by the wind speed and direction and hence ocean wind vector information can be retrieved. Over land, it corresponds to a mixture of surface and volume scattering associated with the radar penetration depth, which provides information on surface type, vegetation cover and soil moisture content. Furthermore, the strongly isotropic backscatter response characteristic from sea ice surfaces makes it possible to use scatterometer data in combination with other microwave data, to retrieve sea ice cover, concentration and age [RD1].

The accuracy of the retrieved geophysical information depends on the accuracy of the underlying radar backscatter measurements. The calibration/validation approach for ASCAT backscatter can be summarised as follows:

- Absolute calibration of the antenna gain patterns and pointing, based on specifically designed and calibrated ground transponders
- Correction of raw echoes for instrument variations and antenna thermal noise.
- Normalisation of corrected power into backscatter for a given orbit geometry.
- Validation of the backscatter over a variety of natural targets, namely ocean and rainforest.

RECENT AND PLANNED PRODUCT PROCESSING AND FORMAT CHANGES

The last upgrade of the ASCAT Level 1 operational processor took place in August 18th 2011. This is version 7.4. A number of important improvements were introduced:

- Revised Kp algorithm: Improved calculation of on-board correlation coefficients and better use of those during the backscatter variance estimation. The Kp values from the new algorithm are slightly higher than those given by the current algorithm
**Hamming window filter correction for 12.5 km product:** The variable width function across the swath was until now applied with reverse across-track node order from far to near swath, affecting particularly the mid beams.

**New backscatter calibration (EC_2010 campaign):** Oscillations of the antenna gain pattern in elevation are diminished and the observed calibration change for the MID LEFT beam in September 2009 is compensated for. More details on the analysis of the EC_2010 results are given in the next section.

One month of test data, processed with the old and new configurations, were generated for the purpose of validating all the changes, as well as to assess their impact on the Level 2 parameters retrieval, such as wind vectors, soil moisture and sea ice [RD2, RD3, RD4]. Below are several examples of the various backscatter validation aspects.

Figure 1 shows that, as expected from the results of the EC_2010 analysis (described in next section), the mean backscatter values along the full range of incidence angles decrease about 0.1 dB for all beams, and an additional 0.1 dB is observed in the case of the MID LEFT beam, which successfully compensates a permanent instrument beam calibration change observed to have happened in September 2009. With respect to Kp, the change is as expected a slight increase for all beams and along the full incidence angle range.

![Figure 1: Mean differences between the backscatter (above) and the Kp (below) in the ASCAT Level 1b 25 km products generated with processor versions 7.4 and 7.3.](image)

With respect to the standard deviation of the differences, we can observe in Figure 2 for the 25 km product the effect of the implementation of the EC_2010 calibration (oscillations across node number), while in the 12.5 km product plot, the additional effect of the hamming window width function correction across the swath is particularly visible, as was expected, for the MID beams.
Figure 2: Standard deviation of the backscatter differences between processor versions 7.4 and 7.3 for the 25 km (left) and 12.5 km (right) products (courtesy of OSI SAF).

Figure 3 shows in more detail how the implementation of the EC_2010 calibration in the version 7.4 of the processor configuration decreases the along beam oscillations, particularly for the worst case of oscillations observed to now, which was the FORE RIGHT beam.

Here is an overview of a few other processor updates planned for the next months:

- Level 1A improvements: Better handling of data gaps, better flagging of instrument changes in near real time, faster geolocation.
- Level 1B improvements: Overall quality flag refinement, generation of backscatter line of nodes on a fixed time-based grid, format optimisation of the ASCA_SZF product for near real time use.
- Product formats: New Level 1B format soon available for archived data in netCDF.

TRANSPONDER EXTERNAL CALIBRATION CAMPAIGN IN 2010

An independent estimation of the absolute instrument calibration accuracy and stability is provided by External Calibration campaigns, which allow for a direct estimation of the two-dimensional antenna gain patterns from measurements taken over active point targets (ground transponders) of very accurately known radar cross-section and geographical location. The following campaigns have been carried out since the beginning of the ASCAT mission:
• EC_2006: preliminary calibration with only 1 transponder, put into operations in March 2007.
• EC_2007-08: complete calibration in July 2008, with a refinement in Dec 2008 [RD5, RD6].
• EC_2010: analysis completed and calibration update in August 2011 [RD7].

In this last campaign, an important improvement is a better handling of previously observed offsets in the antenna pointing corresponding to ascending and descending passes, as the validation results in the previous section confirm. The results of EC2010 suggest also an increase in the instrument gain, with an overall impact on the mean absolute backscatter calibration given in Table 2. In summary, after the introduction in the ground processing of the new instrument calibration, the backscatter has decreased about 0.1 dB for all beams, except for the MID LEFT beam, for which the descent is of 0.2 dB.

<table>
<thead>
<tr>
<th>Beam</th>
<th>LF (0)</th>
<th>LM (1)</th>
<th>LA (2)</th>
<th>RF (3)</th>
<th>RM (4)</th>
<th>RA (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backscatter correction (dB)</td>
<td>0.081</td>
<td>0.201</td>
<td>0.113</td>
<td>0.075</td>
<td>0.070</td>
<td>0.074</td>
</tr>
</tbody>
</table>

Table 2: Average descent in mean absolute backscatter calibration, after the instrument gain corrections suggested by the analysis of the 2010 external calibration transponder campaign measurements.

As shown in Figure 4, validation over natural targets has not successfully explained to date this suggested instrument change in the 2.5 years separating the two main transponder campaigns. Investigation is ongoing, in order to be able to assess with confidence the stability of the ASCAT
measurement system over the mission life time, which is a key input to the reprocessing of the full ASCAT mission, project now planned for 2012.

THE ASCAT L1B BACKSCATTER RECORD

A consistent data record is important, in order to be able to infer real geophysical parameter changes from the analysis of long term series. For this analysis to be reliable, confidence in the stability of the measuring and processing systems is necessary.

With respect to the processing configuration stability, regular reprocessing campaigns are carried out to achieve it, where a consistent configuration is used to process long term series of data. A second reprocessing campaign is planned for the ASCAT scatterometer mission in 2012. With respect to the stability of the measurement system, a model representing the instrument calibration changes along the whole mission lifetime is still to be determined, after more confidence is gathered on the reliability of the available calibration and validation methods.

In Table 2, an overview of the measurement (including calibration) and processing configuration continuity since the beginning of the mission to date is given.

<table>
<thead>
<tr>
<th>Source</th>
<th>Sensing period</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reprocessed</td>
<td>2007-2008</td>
<td>EC_2007-08 and static backscatter normalisation</td>
</tr>
<tr>
<td>Operational</td>
<td>Jan-Aug 2009</td>
<td>EC_2007-08 and static backscatter normalisation</td>
</tr>
<tr>
<td>Operational</td>
<td>Sept 2009 – Aug 2011</td>
<td>EC_2007-08, dynamic backscatter normalisation, MID LEFT beam calibration change (0.1 dB)</td>
</tr>
<tr>
<td>Operational</td>
<td>Aug 2011 - ...</td>
<td>EC_2010 calibration, dynamic backscatter normalisation, compensation of ML beam change and calibration oscillations</td>
</tr>
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</table>

Table 2: Overview of the consistency of ASCAT L1b data record available from the EUMETSAT Data Centre.

REFERENCES AND FURTHER INFORMATION


