ERS-1/2 Scatterometer new products: mission reprocessing and data quality improvement

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ABSTRACT

Since the beginning of the ERS-1 Scatterometer mission in 1991 a long dataset of backscattering signal from the Earth surface is available for studies and researches. The Scatterometer has been originally designed for wind retrieval over the ocean but now it is proved that Scatterometer data may be also useful for other applications over land such as soil moisture, vegetation and ice cover which require high spatial resolution products.
The need of high quality products and of a long homogeneous set of measurements has leaded ESA to develop the project Advanced Scatterometer Processing System (ASPS). The aim of the ASPS is to reprocess the entire ERS1/2 Scatterometer mission data set as well as to provide new scientific products with an enhanced resolution (25km).
The scope of this paper is to present to the users community the description of the new ASPS product, an overview of the ASPS system, the current state of the ERS-2 Scatterometer instrument and the quality of the measurements.

INTRODUCTION

The ERS Scatterometer is a radar working at 5.3 GHz (C-band) designed to acquire the backscattered signal from the Earth surface. The measurements at C band are independent of the cloud coverage and illumination. The Scatterometer has three antennae looking 45° forward, sideways and 45° backward, with respect to the satellite's flight, that illuminate a 500km wide swath as the satellite moves along the orbit (see Figure 1). The incidence angle across the swath varies from a minimum of about 18° to a maximum of about 56°.

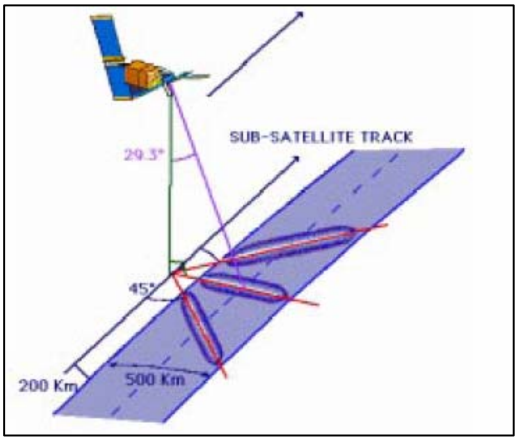

Figure 1: ERS satellite Scatterometer Geometry

Since the beginning of the mission the Scatterometer measurements has been processed with a spatial resolution of 50 km with a grid spacing of 25 Km. New products data of all the ERS Scatterometer missions with a higher spatial resolution of 25 km (with a grid spacing of 12.5 km) and an improved accuracy (see Table 1) generated within the mission reprocessing project will be available to the users in the next months.

Swath width	500 km
Spatial resolution	Nominal 50 km High resolution 25 km
Grid Spacing	Nominal 25 km High resolution 12.5 km
Temporal Resolution	~3 days
Radiometric stability	< 0.5 dB
Radiometric Accuracy (Kp)	3% Nominal resolution 6% High resolution

Table 1: Scatterometer Specification

The Scatterometer mission started in 1991 with the launch of ERS-1 satellite that was in operation until 1996. In 1995 a second satellite ERS-2 was launched that is still in operation.
From 1991 to 2003 the Scatterometer mission was exploited with a global coverage of the Earth (Figure 2).

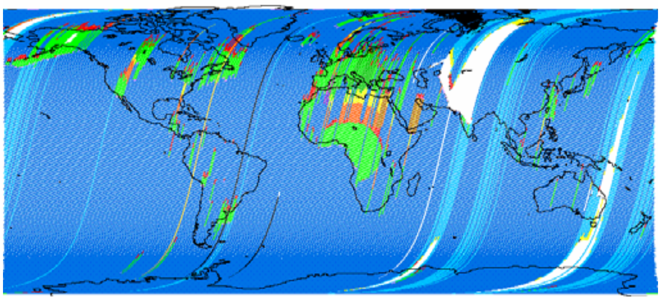

Fig.2: ERS-1/2 Global Mission 1991 - 2003

Since 2003, due to the on-board tape recorder failure, the mission continues within the Regional Mission Scenario: data is available only in the visibility of the Ground Stations (Figure 3). For this reason the only way to improve the data coverage is add new ground stations or increasing the number of acquisitions on the existing ones.

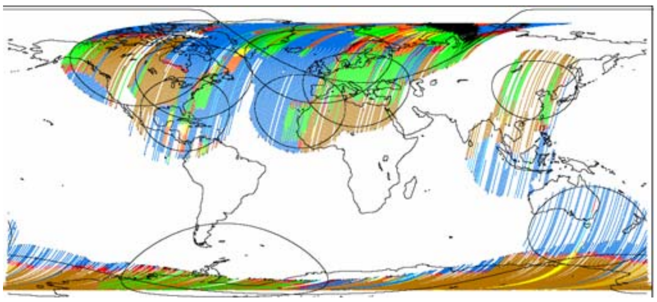

Fig. 3: ERS-2 Regional Mission 2003 - 2007

In Table 2 the ground stations currently into operation are listed with the date in which they were put into operation.

STATION	SINCE	STATION	SINCE
KIRUNA (S)*	7 September 2003	MIAMI (USA)	February 2005
MASPALOMAS (E)*	7 September 2003	BEIJING (CHI)	25 June 2005
GATINEAU (CAN)*	7 September 2003	MCMURDO (ANTARTICA)	5 July 2005
PRINCE ALBERT (CAN)*	7 September 2003	HOBART (AUS)	5 December 2005
WEST FREUGH (UK)	12 December 2003	SINGAPORE	19 October 2006
MATERA (I)	3 March 2004	CHETUMAL (MEX)	18 October 2007

Table 2: Ground Stations into operation (*Date from which the number of acquired orbits has been improved)

In order to constantly improve the data coverage new ground stations will be operative in the next months.

ERS-1/2 SCATT MISSION REPROCESSING: ASPS OBJECTIVES

The Scatterometer has been originally designed for wind retrieval over the ocean but now it is proved that the Scatterometer data may be also useful for other applications over land such as soil moisture, vegetation and ice cover which requires high spatial resolution products and long term backscatter information.
The need to improve of high quality products and of a long homogeneous set of measurements had leaded ESA to develop the project Advanced Scatterometer Processing System (ASPS).

The main aims of the ASPS project is the reprocessing of the entire global ERS-1/2 Scatterometer mission (1991 – 2003) in order to provide a homogeneous data set of the measurements of the Earth surface at C-band through the different phases of the ERS missions.
On January 2001 the Attitude and Orbit Control system (AOCS), used to pilot the ERS-2 satellite, has been switched in the so-called Gyro-less mode (ZGM) due to the lost of two gyroscopes. With this new AOCS configuration the satellite attitude was slightly degraded in particular for the yaw angle. As consequence the backscattering coefficients derived were not calibrated anymore. After some studies a complete review of the Scatterometer processor was performed to guarantee the continuity of the ERS Scatterometer mission. Since august 2003 a new ground processor called ESACA (ERS Scatterometer Attitude Corrected Algorithm) containing the yaw estimation module to process data acquired in ZGM has been put into operation.
An upgraded version of ESACA is a module of ASPS. Therefore ASPS is capable to process data acquired in ZGM from 2001 to 2003 and provides yaw correction information. This information is currently used to apply a geolocation correction in the ATSR images.

The second aim is the reprocessing of the “Regional Mission”. In that scenario data is available only for a small segment in the visibility of each ground stations and different ground stations can acquire data over the same area simultaneously. Due to the Scatterometer acquisition geometry a set of sigma nought triplets is only available in the central part of the segment with a loss at the beginning and the end of the acquisition. ASPS reprocesses all the data segment available from the different ground stations in one segment, by selecting the best row data quality from the different stations in case of overlaps.

Another aim is to provide new “scientific” products with an enhanced spatial resolution (25km) and Sea Ice detection algorithm. High resolution data will be further processed to retrieve soil wet index from 0 (dry soil) to 1 (satured soil). This is an on-going project between ESA and the Vienna University of Technology (TU Wien).

Within ASPS the wind retrieval is performed with the CMOD-5 geophysical model function developed by KNMI and ECMWF.

Furthermore ASPS system provides a very detailed QC report to monitor the instrument performances and the data quality.

CALIBRATION IMPROVEMENT

In order to improve the quality of the Scatterometer data, a calibration activity over the ERS-2 data has been performed to compute the best calibration constant and the best characterization of the in flight instrument parameters such as the antenna pattern profile to be used for the Scatterometer mission reprocessing. For this activity, the TOSCA (Tools for Scatterometer Calibration) calibration facility has been used.
The calibration activity has been performed using the ERS-2 data over the rain forest. Figure 4 shows the Gamma nought ($\gamma0$) across the swath for the current data (left) and for the ASPS re-processed one (right).
It can be noted that re-processed data, on the right, has a better radiometric accuracy, flatter profile, and a better interbeam calibration.

ERS-2 CURRENT ANTENNA PATTERN　　　ERS-2 ASPS ANTENNA PATTERN

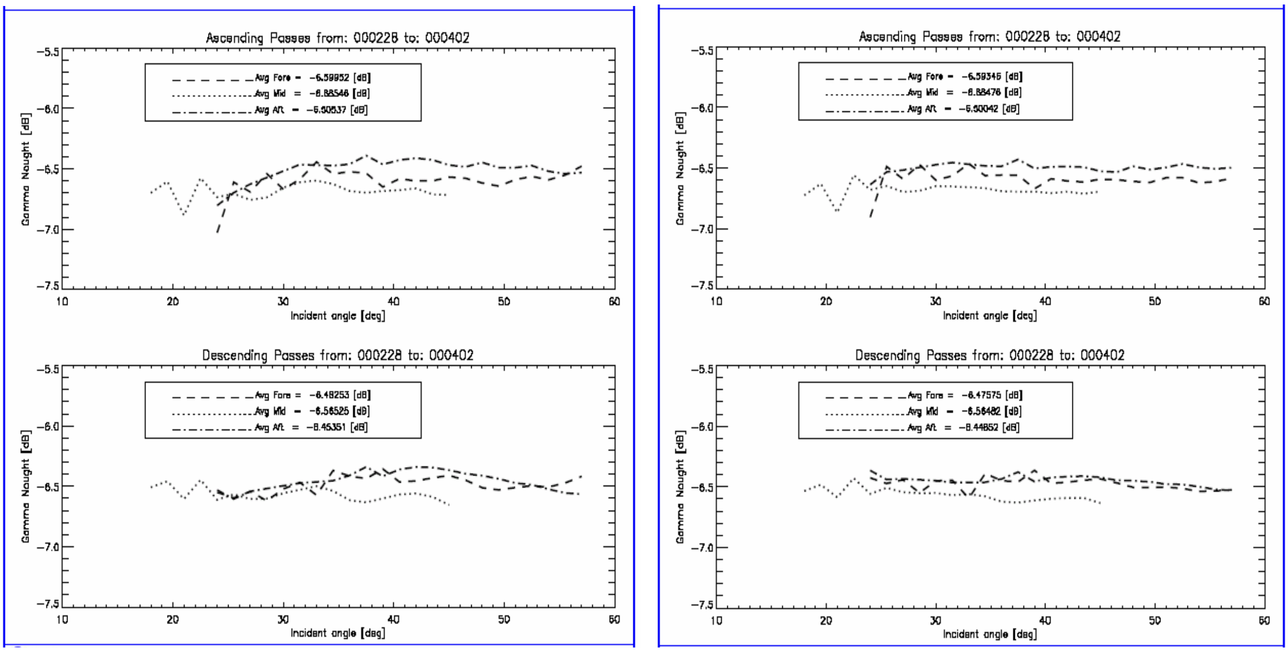

Fig 4: Gamma Nought across the swath (over the rain forest). On the left the current data; on the right ASPS re-processed data.

ASPS LEVEL 2 PRODUCTS

The standard ASPS product available for the users is the Level 2.0 product. ASPS generates also an intermediate product for Quality control (QC) and instrument assessment called ASPS level 1.5. To maintain the compatibility with the actual ERS ground segment one additional output from ASPS is the UWI product.

The Level 2.0 product is structured as follow:

- MPH (Main Product Header)
- SPH (Specific Product Header)
- DSR (Data Set Record)

The MPH contains the information regarding the quality of the acquisition chain, the data acquisition time, the processing time, the auxiliary data and the version software used.

The SPH contains information regarding the processing performed (nominal or high resolution), the type of the window applied for the spatial filtering, the distance to the CMOD used to retrieve the wind, the algorithm used for the wind retrieval. The SPH stores also averaged values for QC: statistics on the PCD flags at node level, mean wind speed and direction biases (Scatterometer winds vs Meteorological background winds), mean distance to the CMOD model.

The DSR contains one row of across track node (19 in nominal resolution, 41 in high resolution). Each data set record has a small header with the record number (starting with 1 at the equator ascending crossing node), acquisition time of the Mid beam relative to the mid swath, the sub-satellite track heading relative to the North for the node 10 or 21 (high resolution). At node level, the main parameters of the node are the following:

- 3 beam sigma nought
- The incidence angle for each beam
- Rank 1-4 Wind Vector
- Ambiguity removed Wind Vector
- Sea/Land Flag
- Ice flag and Ice probability
- Yaw angle flag.

The geometrical resolution of the node is about 50x50 Km^2 in nominal resolution, 25x25 Km^2 in high resolution. The distance between two adjacent nodes is constant and equal to about 25 Km in nominal resolution (12.5 km in High resolution). The product covers one orbit from ascending node crossing. The total number of DSR is, for a full orbit, about 1500 in nominal resolution (about 3000 in high resolution).

Figure 5 show the backscattering coefficient (σ0) for the Aft beam over England and Northern France. On the right the nominal resolution data is displayed, on the left the high resolution one. As can be noted, the high resolution data allows to better recognize image details like large cities, coastline and structures on the sea backscattering.

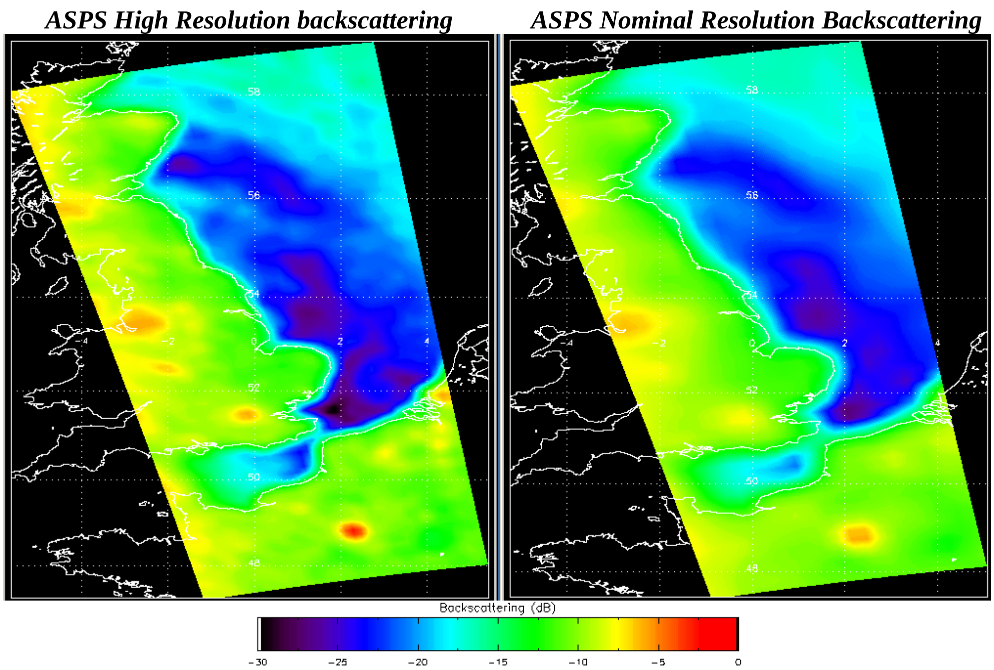

Fig.5: Backscattering coefficient for the aft beam: ASPS nominal resolution (on the right) and high resolution (on the left) data.

CONCLUSION

The purpose of this paper is to present the new ERS Scatterometer products generated with the Advanced Scatterometer Processing System (ASPS) to the users. The need to harmonize more that sixteen years of ERS Scatterometer measurements of backscattering signal from the Earth surface and to improve the products quality has bring to develop the ASPS system with the main aim to reprocess the entire ERS Scatterometer mission and to provide new scientific products with an enhanced resolution (25km). The data quality has been improved by computing a more define antenna pattern. This new products can be very useful also for the emerging Scatterometer applications such as soil moisture, vegetation and ice cover that requires high spatial resolution and good accuracy.

REFERENCE

[1] R. Crapolicchio, P. Lecomte, X. Neyt, “The advanced Scatterometer Processing System for ERS data: design, products and performances”, *Proceedings of 2004 Envisat & ERS Symposium, 6-10 September 2004, Salzburg, Austria.*
[2] P. Lecomte, “The ERS Scatterometer instrument and the On-Ground processing of its Data”, *Proceedings of Emerging Scatterometer Applications: from research to Operations, ESTEC, Noordwijk, The Netherlands 5 – 7 October 1998, ESA-SP-424*
[3] X. Neyt. P. Pettiaux, M. Acheroy, “Scatterometer Ground Processing Review for Gyro-Less Operations”, *Proceeding of 9th International Symposium on Remote Sensing, Crete, Greece 22 - 27 September 2002*
[4] P. Pettiaux, X. Neyt., M. Validation of the ERS-2 Scatterometer Ground Processor Upgrade, *Proceeding of 9th International Symposium on Remote Sensing, Crete, Greece 22 - 27 September 2002.*
[5] R. Crapolicchio, P. Lecomte, On the Stability of Amazon rain forest backscattering during the ERS-2 Scatterometer mission lifetime, *Proceeding of ASAR Workshop 2003, Canada.*
[6] H. Hersbach, A. Stoffelen, S. de Haan, “The improved C-band Geophysical Model Function CMOD5”, *Proceedings of 2004 Envisat & ERS Symposium, 6-10 September 2004, Salzburg, Austria.*
[7] ESA PCS WEB: http://earth.esa.int/pcs/ers/scatt/