THE ADVANCED SCATTEROMETER PROCESSING SYSTEM FOR ERS DATA: DESIGN, PRODUCTS AND PERFORMANCES

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ABSTRACT

Since the launch of ERS-1 in 1991 and ERS-2 in 1995, carrying a C-band Scatterometer, a data set of more than thirteen years of backscattered signal from the Earth surface is available for exploitation. With its global coverage, day or night and all-weather operation, ERS Scatterometer data offer unique opportunity for long-term studies and research. Beyond the original mission of ERS Scatterometer, intended to provide measurements of the wind vector over the Oceans, a large number of new unforeseen applications have emerged during the last years. Originally developed to measure winds over the ocean from space, Scatterometer data has proved to be very useful in a variety of studies. These new applications cover the wind, but also land, continental or sea ice, soil moisture, and vegetation and require high quality and long-term backscatter information. To fulfil the needs of such large scientific community, the European Space Agency (ESA) has developed the project: Advanced Scatterometer Processing System (ASPS). Main scope of the project is to provide with state of the art algorithm, high quality and homogenous Scatterometer measurements (sigma nought) of the Earth surface and high quality wind field over the Oceans by re-processing the entire ERS mission. Additional scope is to provide on experimental basis scientific products in high resolution tailored for the emerging Scatterometer application.

The ASPS project is now in a pre-operational phase and the scope of the paper is to give to the scientific community an overview of the ASPS architectural design, to report on the ASPS product format and performances. Those new data, available in the next years, hopefully will help the scientific community to better understand and monitor the Earth's climate changes and to protect our environment.

1. INTRODUCTION

The ERS Scatterometer mission initiated in 1991 with the launch of the first satellite and continued in 1995 with the launch of a second satellite is still into operation phase despite some harm occurred on the flight segment. The most challenging event occurred on January 17th 2001 when 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). The reason of that reconfiguration was to increase the mission safety, after the lost of 5 of the 6 on-board gyroscopes and therefore to preserve the one remaining only for the orbital manoeuvres. With that new AOCS configuration the satellite attitude was slightly degraded in particular for the yaw angle. The impact in the received signal of the satellite mispointing cannot be corrected in the existing ground processor mainly based on pre-computed Look Up Table derived with the assumption of a very high stability of the spacecraft [1]. As consequence the backscattering coefficients derived from the returned echoes were not calibrated anymore and the distribution of the Scatterometer data to the users was discontinued. At the mid of 2001, a series of internal (ESA) studies had demonstrated that the processing of Scatterometer data acquired in ZGM was possible and with good results [2]. For that reason a complete review of the Scatterometer processor has been carried out to guarantee the continuity of the ERS Scatterometer mission with the nominal high data quality. ESA engineers, research department and industries had been involved to re-design and re-implement the Scatterometer ground processing chain and in about two years a new ground processor called ESACA (ERS Scatterometer Attitude Corrected Algorithm) has been put into operation on August 21st 2003. From that day onward Scatterometer data are available for the end users and meteorological centre via the GTS network. Since March 2004 the ECMWF assimilates ERS Scatterometer winds in the meteorological forecast model.

The basic idea for the Advanced Scatterometer Processing System (ASPS) was born from the initial phase of the ESACA project at the end of 2001. The re-design of the Scatterometer ground processor was a unique opportunity to have from one side a processor able to handle with data acquired in ZGM to continue the mission and on the other side to have a state-of-the-art facility to re-process the entire ERS Scatterometer date set.

2. THE ASPS ACHIEVEMENTS

Beyond the original mission of the ERS Scatterometer, intended to provide measurements of the wind vector over the Oceans, a large number of new unforeseen application have emerged. Originally developed to measure winds over the ocean from space, Scatterometer data has proved to be very useful in a variety of studies. These new applications cover the wind, but also land, continental or sea ice, soil moisture, and vegetation and require high quality and long-term backscatter information.

For those reasons, the first achievement of the ASPS is the ERS mission re-processing. The ASPS will provide for conventional and emerging application a homogenous set of measurements of the Earth surface (Land and Ocean) at C-band throughout the different phases of the ERS mission. ASPS will also provide high quality wind fields over the Oceans. This is an important achievement in particular for all applications that need a long and consistent data set of observations like oceanography and climatologic studies. Moreover the quality of the re-processed products will take an advantage from an accurate repetition of the calibration exercise that will be performed before the mission re-processing activity with a new state-of-the-art calibration facility (TOSCA) [3]. The scope is to compute the best calibration constant and the best characterization of the in flight instrument parameters such as the antenna pattern profile and the calibration sub-system gain.

The second achievement is the re-processing of the data acquired during the “Regional Mission”. In that case, one orbit is acquired in several ground station with small data segment that must be merged at the beginning of the processing chain to obtain the full data segment.

The third achievement is to provide for new applications “scientific” products with an enhancement spatial resolution and Sea Ice detection algorithm.
The fourth achievement is the production of a Data Quality report delivered with the ASPS product to the user.

As last achievement, the ASPS shall be able to process ASCAT data (foreseen for launch on Metop on 2005 with 15 years of operations). In that way the ASPS products have the opportunity to cover a three decades of Scatterometer measurements.

3. ASPS ARCHITECTURAL DESIGN

The ASPS architectural design is presented in Figure 2.

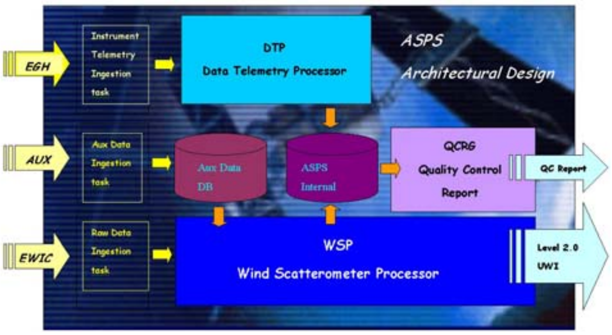

Figure 2 ASPS Design overview

The ingestion modules are responsible for the acquisition of the Instrument raw data packets (echoes, calibration pulse, noise measurements and instrument auxiliary data), the acquisition of the instrument telemetry data (instrument working modes, temperatures, currents and voltages of the transmitter and calibration chain, the antenna temperatures) and the acquisition of the auxiliary data (the state vectors to derive the satellite position and velocity, the correlation time to relate the on-board time with the universal time, the background wind information used to perform the ambiguity removal in the wind retrieval module).
The raw data ingestion task is also responsible to perform a quality analysis of the ingested packets. It is able to patch up corrupted packet or reject low quality packet. In the case that the same packet is available from different acquisition data streams (this is the nominal case for the “Regional Mission Scenario”) the ingestion task is able to select the one with the best quality.
The auxiliary data ingestion task is responsible to store inside an internal database the state vector and the time correlation data. It is also responsible to extract from the meteorological forecast the background winds used in the ambiguity removal algorithm and to store that data set in the internal database.
The Telemetry ingestion task is responsible to collect and prepare the instrument telemetry data for the Data Telemetry Processor.

The ASPS main processing modules are:

- The Wind Scatterometer Processor (WSP)
- The Data Telemetry Processor (DTP)
- The Quality Control Report Generator (QCRG)

The WSP is responsible to process the Scatterometer raw data in order to obtain calibrated sigma nought measurements and, over the Ocean, wind speed and direction estimation. It is basically the ESACA processor put into the real time operation since August 2003 with some upgrades concerning the ingestion of the raw data and the detection of the arcing event in the transmission tube. The detail description of the ESACA processing chain is reported in [4], here are described the main advantages of this new processor with reference to the old processing chain named LRDPF.

The LRDPF processor was based on a large number of pre-computed off-line parameters (Look Up Table) interpolated throughout the processing while the ESACA computes exactly all the data on the fly. ESACA contains the yaw estimation module to process data acquired in ZGM. The computation of the radiometric resolution (Kp) has been refined with a more accurate algorithm to estimate the real variance present in the echo samples. The wind retrieval is performed with the CMOD-5 geophysical model function developed by KNMI and ECMWF [5]. The ambiguity removal scheme has been upgraded with the MSC algorithm [6].

In addition to the UWI product, the WSP is able to generate an intermediate product for QC and instrument long loop assessment (ASPS Level 1.5), a new user product the ASPS Level 2.0 that is the baseline product of the system and a scientific Level 2.0 product with high-resolution sigma nought (25 Km) and Sea Ice detection flag based on neural network output [7].

The processing of ASCAT data will be also possible with the WSP.

The DTP is responsible for the extraction of the instrument working modes timelines and the computation of the averaging values (per orbit) of the following instrument parameters:

- Input and output calibration sub-system power
- TWT Currents and Voltages
- TWT and Antenna Temperatures

Those parameters are stored in the ASPS internal database for further processing.

The QCRG is responsible for the generation of a report containing data quality and long-loop instrument performances information. The report is an output product of the ASPS and its content is mainly based on the parameter monitoring during the ERS mission lifetime [8], [9]. The scope of the report is to give to the user a good level of confidence on the data. The report contains the following information derived from the ASPS internal database and from the ASPS Level 1.5 and Level 2.0 products: a time-series with the evolution (averaged over one orbit) of the CoG of the received signal spectrum, the CoG of the Doppler compensated received signal and its standard deviation, the yaw error angle, the internal calibration level, the noise power, the number of nodes affected by arc, the number of 3 valid sigma noughts, statistics on the various PCDs contained in the Level 1.5 and Level 2.0, the distance from the C-Band model, the antenna profiles computed over the Brazilian rain forest, the histograms of the gamma nought over the rain forest, the evolution of the peak position of the gamma nought histograms, the evolution of all the instrument telemetry parameters as extracted by the DTP module, the log of the Out Of Limit values (Yaw, Doppler, Calibration power, Noise) that affects the data quality, the log list of the missing data.

4. THE WSP ARCHITECTURAL DESIGN OVERVIEW

The WSP is the core element of the ASPS and for that reason an overview of the architectural design is presented in Figure 3. Here the scope is to give only a functionality description of the modules used to process the Scatterometer echoes up to winds.

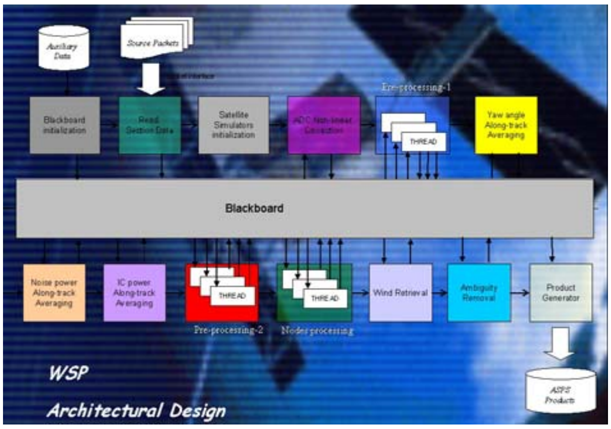

Figure 3 WSP Architectural Design overview

The **Blackboard** is a passive object where initial data and intermediate results are stored. It provides to other active processors the services to access the memorised data. The **Blackboard Initialization** is responsible to load all the WSP configuration parameters and the auxiliary data into the blackboard. The **ADCNL_correction** (ADC non-linearity correction) is responsible to perform the ADC non-linearity correction of all the data received. It is performed at the beginning of the processing chain since the ADC converter is the last block influencing the signal on-board. This includes the echo samples but also the calibration pulse and the noise power. The I/Q imbalance monitoring is also performed inside this module. The **Pre-Processing-1** has the responsibility to execute the first part of the pre-processing based on the raw data read from the blackboard. The main scope of that module is to estimate the yaw angle of the spacecraft. The yaw angle is estimated from the raw data by measuring the residual Doppler frequency shift of the received echo. Fitting the received spectrum with a target function, configurable in the initialization phase, performs that estimation. The functions available are: a Gaussian, a Sinc or a simple estimator of a CoG. The **Along Track average modules**. These three modules compute the along-track averaging of respectively the yaw angle, the noise power and internal calibration energy. The filters used for this along track averaging are configurable in the initialization phase. The **Pre-Processing-2** is responsible to execute the second part of the pre-processing (i.e. from along-track averaged Yaw angle up to obtain a backscattering coefficient values, the required geometrical information as well as the internal calibration coefficients, including computation of normalisation factors) this involves the following main tasks: the geometrical characterization of the samples (position, incidence angle, elevation angle, range, Doppler frequency, residual Doppler frequency); the compensation for the on-board filter; the up-sampling of the data to avoid spectral leakage in the next step of the processing; the computation of the phasor used to compensate the residual Doppler frequency shift and the application of this phasor to the data; the application of the low pass filter to optimize the signal-to-noise ratio of the data; the envelope detection; the block averaging; the normalization of the noise power; the computation of the normalization factors using the antenna gain pattern configured during the initializations phase. Further more the arcing flag is also computed. The **Node_Processor.** This module performs the node characterization tasks and the spatial averaging. These are in detail: the rough pre-selection of the samples belonging to each node; the precise selection of the samples; the computation of the weight associated with each selected samples; the computation of the sigma nought and Kp (radiometric resolution); the computation of the incidence and look angle at the node centre; the computation of the Land/Sea flag at the node centre and the generation of the various flags used for the QC. The **wind retrieval** is responsible to retrieve the wind solutions (up to four) from the sigma nought triplet by applying the CMOD-5 geophysical function. The **Amb_Rem_Processor** is selecting from the generated wind solutions, the more coherent one according to the wind forecast. The **product_generator** is responsible to extract from the blackboard the data required to generate products (UWI, HEY, ASPS1.5 and ASPS2.0) and to compute the parameters required for the product headers. The pre-processing-1, pre-processing-2 and the node generation tasks are organised in such a way that it allows many threads working in parallel independently. Each thread processes a given block of data. The number of concurrent threads has been tuned in such a way that the overall performance of the processing is the best.

5. THE ASPS PRODUCTS

The Table 1 reports an overview of the products generated by ASPS. The standard ASPS product available for the users is the Level 2.0. The Level 2.0 scientific will be available on request and only for specific orbits. The UWI product will be also generated on request. The Level 1.5 is an engineering product and is not available for the end users. A detailed description of the Level 2.0 product is given in Table 3 (Specific Product Header) and Table 4 (Data Set Record). The "historical" UWI product is described in [9].

Table 1 ASPS Products Overview

Type	Description	Size [Mb]
ASPS Level 1.5	The Product is structured as: MPH, SPH, DSR The SPH contains averaged values for instrument long loop monitoring (Doppler frequency, Calibration energy, Noise power, Yaw error angle) and processing monitoring. The DSR contains Intermediate-processing parameters. Each DSR contains information from one Fore-Mid-Aft (FMA) sequence therefore the sampling is about one DSR per second. The product covers one orbit from ascending node crossing. The total number of DSR is, for a full orbit, about 6000	Full Orbit 0.5 MB
ASPS Level 2.0	The Product is structured as: MPH, SPH, DSR The SPH contains averaged values for data QC (statistics on the PCD flags at node level, mean wind speed and direction biases, mean distance to the CMOD model) and processing information. The DSR contains one row of across track node (19 nodes). The main parameters of the node are the following : 3 beam sigma nought, Rank 1-4 Wind Vector, Ambiguity removed Wind Vector, Sea/Land Flag, Yaw angle flag, The geometrical resolution of the node is about 50x50 Km^2 the distance between two adjacent nodes is constant and equal to about 25 Km. The sampling of the DSR (along track) is about 25 Km. The product covers one orbit from ascending node crossing. The total number of DSR is, for a full orbit, about 1500	Full Orbit 2.7 MB
ASPS Level 2.0 *Scientific*	As the Level 2.0 but 41 nodes across track. Node resolution about 25 Km distance between two adjacent nodes about 12.5 Km DSR sampling along track about 12.5 Km, Sea Ice flag.	Full orbit 11.5 MB
UWI	The Product is structured as: MPH, SPH, DSR The SPH processing information. The DSR contains one square of 361 nodes (19x19). 3 beam sigma nought, Ambiguity removed Wind Vector, Sea/Land Flag The geometrical resolution of the node is about 50x50 Km^2 the distance between two adjacent nodes is constant and equal to about 25 Km (along track and across track). One UWI covers an	Full orbit 1.5 MB

	area of about 500x500 Km^2 One full orbit correspond to about 83 UWI products	

6. THE ASPS LEVEL 2.0 PRODUCT

The Main Product Header is valid for all ASPS products and it is as the one used in the fast delivery data (UWI). It contains information regarding the quality of the acquisition chain, the data acquisition time, the processing time, the auxiliary data (state vector and correlation time) and the software version used. A detailed description is given in [9].

The Specific Product Header (SPH) contains information regarding the processing performed: nominal or high resolution, the type of window applied for the spatial filter, the distance to the CMOD used to retrieve the wind, the algorithm used for the wind retrieval: fast or precise. In the first case a table is used to describe the CMOD geophysical function, in the second case the analytical formula of the CMOD is used. The SPH stores statistics on the various flags associated with the nodes as an indicator of the product quality. In the SPH are also stored: the mean wind speed and direction biases (Scatterometer winds vs Meteorological background winds) and the mean distance to the CBAND model. Additional information reported in the SPH is the WSP version number, the WSP configuration file version used in the processing and the version of the background winds table used in the ambiguity removal module.

The Data Set Record contains one row of across track nodes. The number of nodes is 19 for the nominal resolution and 41 for the high-resolution product. Each data set record has a small header with the following information: record number (starting with 1 at the equator ascending crossing node), acquisition time (UTCT) of the Mid beam relative to the mid swath (node 10 for nominal resolution, node 21 for high resolution product), the sub satellite track heading relative to the North for node 10 or 21 (high resolution).

The information at the node level is an upgrade of the one contained in the UWI product. The philosophy behind was on one side to keep as much as possible a "well known and historical" format in order to make possible an easy use of the product and on the other side the ZGM operation phase adds some specific parameters that have been taken into account. In the ZGM phase, the yaw angle is evolving (up to some degrees) along the orbit. For that reason the acquisition geometry is not fixed as for the nominal Yaw Steering Mode (YSM). This fact is causing the lost of a constant relationship between the acquisition time of the echo and the position of the samples on the Earth surface. In order to keep the position of the nodes on a fixed grid (independently from the yaw angle) the ground processor assigns a position on the Earth surface to all the samples and then collects the ones that contribute to the node. As consequence the T_0 acquisition time for the Mid beam samples cannot be solely used to derive the corresponding acquisition time of the Fore and Aft antenna samples that are contributing to the node. For that reason the fields 6, 7 and 8 have been added. In those fields is stored the node acquisition time since the ascending node for the three beams. The absolute time can easily be derived by adding the ascending node time stored in the field 19 of the MPH. The time reported is the time of the echo related to the sample belonging at the centre of the node. Those fields allow a direct correlation of the node with the instrument raw data (the echoes) and instrument telemetry as well as the correlation with the Level 1.5 product. In the fields 10, 15 and 20 is reported the incidence angle of the backscattering measurements respectively for the Fore, Mid and Aft antenna. Due to the yaw variation, the incidence angle cannot be assumed constant inside the node. For that reason it is reported in the product the incidence angle of the sample closer to the centre of the node. It should be noted, that the Fore and Aft sample closer to the node centre could have different incidence angles due to the modification of the acquisition geometry caused by a no zero yaw angle. In the fields 13, 18 and 23 is reported the number of valid samples belonging to the node. Those fields replace the "counter of missing/corrupted source packets" in the UWI node definition. The reason is because with a fix geometry (as the case in YSM) the number of expected source packets that are contributing to a node is a constant and make sense to counter the missing ones. In ZGM the assumption of a constant number of source packets for each node is not correct. The real number depends on the yaw angle and for that reason a straightforward choice was to record the number of samples that have contributed to the node measurements. As for the UWI this number has a sign: positive to indicate the wind only operation, negative to indicate wind/wave operation. The fields from 24 to 35 report, for each Sea node, the 4 wind solutions as derived by the wind retrieval algorithm. The wind solution (speed and direction) is ranked with reference to the Euclidian distance between the measured triplets and the CMOD. The value of the maximum likelihood distance is also reported for each sea node. In field 36 and field 38 is reported the wind speed and direction bias. It is the difference between the Scatterometer wind (the one selected by the ambiguity removal) and the meteorological wind used as background in the ambiguity removal. For the Level 2.0, the Product Confidence Data (PCD) has been extended. The PCD section-1 (field 39) contains new information regarding the "Spectral properties" of the sample used to build the node. The aim of those PCD is to monitor the signal spectrum as received from the instrument (bits 12-14) and at the end (bits 6-11) of the ground processing. The effect of a yaw error angle in the received signal is a shift of the spectrum. Taking into account that the on-board receiver has a limited bandwidth (about 30 KHz) the signal shift cannot exceed a fraction of that value without the lost of the energy. The bits 12-14 are set if the frequency shift is above a configurable threshold. Once the yaw angle is estimated by the Doppler shift, it is possible to compensate the spectrum for that value. The bits 6–11 summaries the quality of the received spectrum after the on-ground Doppler compensation. An effective compensation provides a spectrum with a relative narrow bandwidth centred on the low pass filter shape. In that case the best signal to noise ratio is achieved with an accurate measurement of the backscattered energy. The PCD section-2 aims on one side (bits 3-8) to monitor the instrument parameters (noise power, calibration energy, Kp and arc) and on the other side (bits 9-14) to monitor the performances of the wind retrieval. Bits 15-16 are used to select the ambiguity removed wind solution. The geophysical PCD flags the node as Land/Sea or Sea Ice (only for scientific products).

Table 2 ASPS Level 2.0 Specific Product Header description

Field	Description
1	Bit 1 : 0 ASPS : 1 ASPS scientific upgrade Bit 2 : 0 Nominal resolution (50Km) : 1 High resolution Bit 3 : 0 No ambiguity removal : 1 ambiguity removal applied Bit 4-5 : 0 Hamming window : 1 Spare (for Scientific upgrades) : 2 Spare (for Scientific upgrades) : 3 Spare (for Scientific upgrades) Bit 6 C-band Model Distance used : 0 Euclidian : 1 Maximum Likelihood Distance Bit 7 : 0 Fast wind retrieval : 1 Precise wind retrieval Bit 8 Spare
2	Absolute Orbit Number
3	Number of nodes with 3 valid sigma noughts
4	Number of nodes with 2 valid sigma noughts
5	Number of nodes with 1 valid sigma nought
6	Total number of nodes with Land Flag
7	Total number of nodes with Ice Flag (Valid only for scientific upgrades)
8	Number of nodes with arcing flag set
9	Number of nodes with Kp flag set
10	Number of nodes with frame checksum error flag set
11	Number of nodes with Noise Power flag set
12	Number of nodes with Internal Calibration flag set
13	Number of nodes with Doppler Compensation CoG flag set
14	Number of nodes with Doppler Compensation "standard deviation" flag set
15	Number of nodes with Doppler Shift flag set
16	Number of nodes with Yaw angle flag set
17	Number of wind nodes
18	Number of low wind nodes
19	Number of high wind nodes
20	Number of nodes with distance from C-BAND MODEL flag set
21	Number of nodes with wind speed bias flag set
22	Number of nodes with wind direction bias flag set
23	Mean Wind Speed Bias
24	Wind speed standard deviation
25	Mean Wind Direction Bias
26	Mean Distance from C-BAND MODEL node1
27-66	Mean Distance from C-BAND MODEL node 2 to node 19 (Valid only for nominal resolution Field 5-66 are blank) Mean Distance from C-BAND MODEL node 2 to node 41 (Valid only for high resolution)
67	WSP version and WSP Configuration file version number
68	Meteo Table ID (table type 83 forecast F 18)
69	Meteo Table ID (table type 84 forecast F 24)
70	Meteo Table ID (table type 85 forecast F 30)
71	Meteo Table ID (table type 86 forecast F 36)
72	Spare
73	Spare
74	Spare

Table 3 ASPS Level 2.0 Data Set Record description

Field	Description
1	Data Record number, starting with 1
2	Mid beam acquisition time (UTC) node 10 (or node 21 for high resolution)
3	Subsatellite Track Heading w.r.t. North, turning clockwise at time of node 10 (or node 21 for high resolution)
4	Geodetic latitude of Node 1.
5	East Longitude of Node 1
6 7 8	Fore, Mid, Aft beam acquisition time Node 1 since ascending node crossing.
9	Sigma nought Node 1 Fore beam
10	Incidence angle Node 1 Fore beam
11	Look angle Node 1 Fore beam
12	Kp Node 1 Fore beam
13	Number of samples used for Node 1 Fore beam
14 - 18	As 9-13 Mid beam
19 - 23	As 9-13 Aft beam
24	Wind Speed Node 1 - Rank1
25	Wind Direction Node 1 - Rank1
26	Distance from the C-BAND MODEL Node 1 Rank1
27 - 29	As 24 – 26 Rank-2
30 - 32	As 24 – 26 Rank-3
33 - 35	As 24 – 26 Rank-4
36	Wind Speed bias (ambiguity removed solution)
37	Spare

38	Wind Direction bias (Ambiguity removed solution)
39	Node Confidence Data -1 Bit 1 Summary PCD factor 0: processing according to full specification 1: result to be viewed with limitation. Summary PCD-1 set OR Summary PCD-2 set (see field 39). Bit 2 Summary PCD-1 0: processing according to full specification 1: result to be viewed with limitation. One of the PCD listed below is not zero. Bit 3 Fore beam flag Bit 4 Mid beam flag Bit 5 Aft beam flag Bit 6 Doppler Compensation CoG flag (Fore) Bit 7 Doppler Compensation StDev flag (Fore) Bit 8 Doppler Compensation CoG flag (Mid) Bit 9 Doppler Compensation StDev flag (Mid) Bit 10 Doppler Compensation CoG flag (Aft) Bit 11 Doppler Compensation StDev flag (Aft) Bit 12 Doppler frequency Shift (Fore) Bit 13 Doppler frequency Shift (Mid) Bit 14 Doppler frequency Shift (Aft) Bit 15 Yaw error angle flag Bit 16 Frame checksum flag
40	Node Confidence Data -2 Bit 1 Summary PCD-2 factor 0: processing according to full specification 1: result to be viewed with limitation. One of the PCD listed below is not set to zero. (valid only for bit 2 -14) Bit 2 Spare Bit 3 Internal Calibration flag Bit 4 Arcing flag Fore beam Bit 5 Arcing flag Mid beam Bit 6 Arcing flag Aft beam Bit 7 Noise Power flag Bit 8 Limit of Kp value Bit 9 Distance from C-Band Model Flag Bit 10 Wind Speed bias (selected solution) flag Bit 11 Wind direction bias (selected solution) flag Bit 12 Low wind flag Bit 13 High wind flag Bit 14 Spare Bit 15-16 Ambiguity removal flag
41	Geophysical PCD Bit 1 Land-Sea Flag 0: Sea 1: Land Bit 2 Ice flag (only for scientific upgrades) 0: No ice 1: Ice Bit 3 - 8 Spare
42 - 725 OR 42 - 1561	From node 2 to node 19 (as Fields 4 - 41) OR From node 2 to node 41 (as Fields 4 - 41) only high resolution product

7. PRODUCT PERFORMANCES

The first objective of the pre-operational version of the ASPS is to achieve the same calibration performances of the "old" LRDPF processor. In that way, the homogeneity of the sigma nought measurements is assured throughout the entire ERS mission. For that reason the gamma nought measurement over the Brazilian rain forest was compared. The Figure 3 shows the comparison of the peak position of the Gamma nought histograms for the LRDPF (blue) and ESACA/ASPS (red) data. The histograms are relative to one cycle of data (35 days) and have been computed for ascending and descending passes.

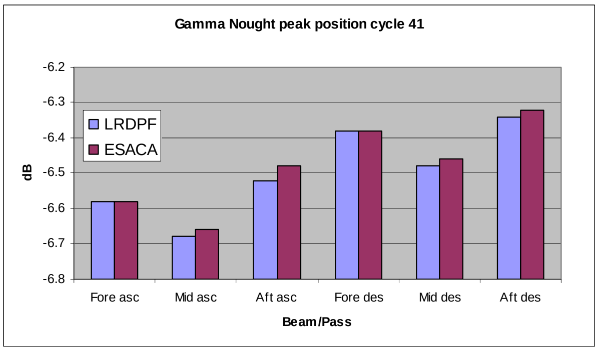

Figure 3 Gamma Nought comparison

As reported the ESACA/ASPS gamma nought values are very close to LRDPF. It is foreseen to refine that calibration to attenuate the small difference among the three antennae by using the new calibration tool (TOSCA). The calibration performances across the swath are similar to the LRDPF, the antenna patterns are flat within 0.3 dB (see Figure 4) and a further improvement is expected after the repetition of the calibration exercise.

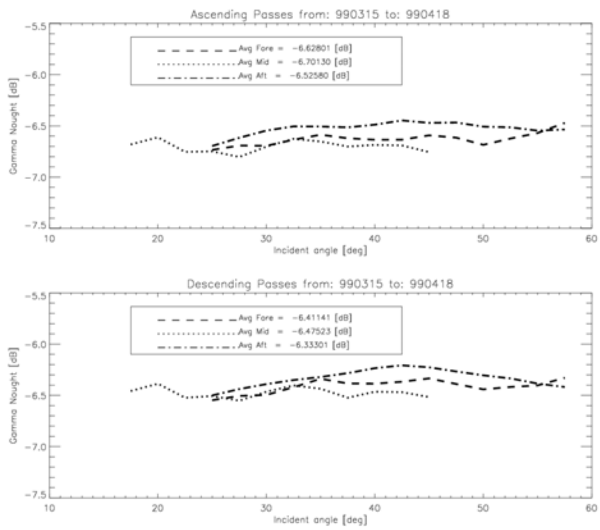

Figure 4 ASPS across swath calibration

The accuracy of the Yaw error angle estimation has been evaluated by comparing the Yaw error retrieved by the Scatterometer and the one retrieved by the SAR wave processor. The result is a very good agreement as shown in Figure 5 (upper plot blue line wave data, black line Scatterometer). The lower plot shows the evolution of the Doppler frequency shift. That is the main information used to derive the yaw error angle in the upper plot of Figure 5.

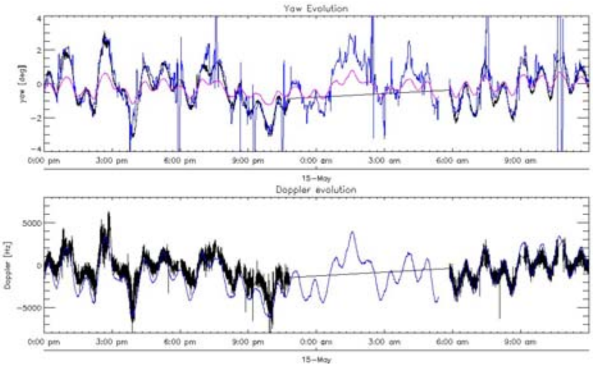

Figure 5 ASPS Yaw error angle validation

For the pre-operational user products, the wind retrieval schema is based on the CMOD-4 and the ambiguity removal on the MSC [6]. Those algorithms are similar to the ones implemented in the real time processing (ESACA) and the performances are routinely monitored by ECMWF. The quality of the wind speed is nominal and the quality of the wind direction is higher than ever. More details are given in [11]. For the scientific products (high resolution) some results are presented in Figure 6. The upper panel (Fig. 6-a) shows the wind field over the English Channel for the nominal resolution product and the lower panel (Fig 6-b) shows the same for the High-resolution product. The improvement of the wind coverage is clear, in particular along the coast.

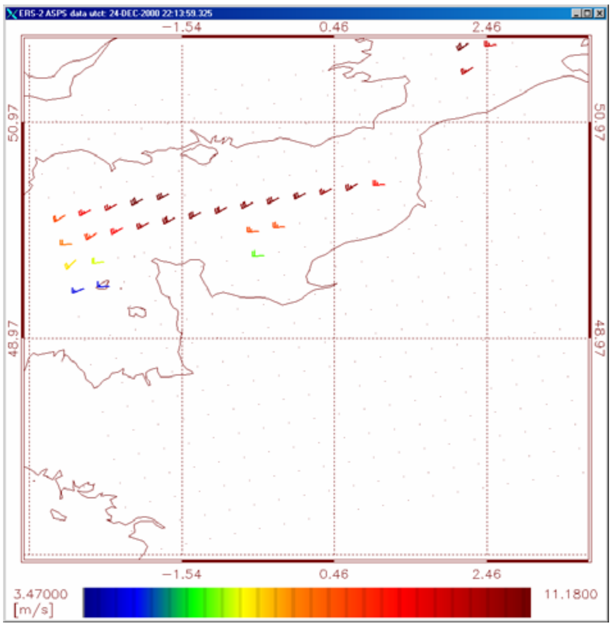

Figure 6-a ASPS Nominal resolution winds over the English Channel

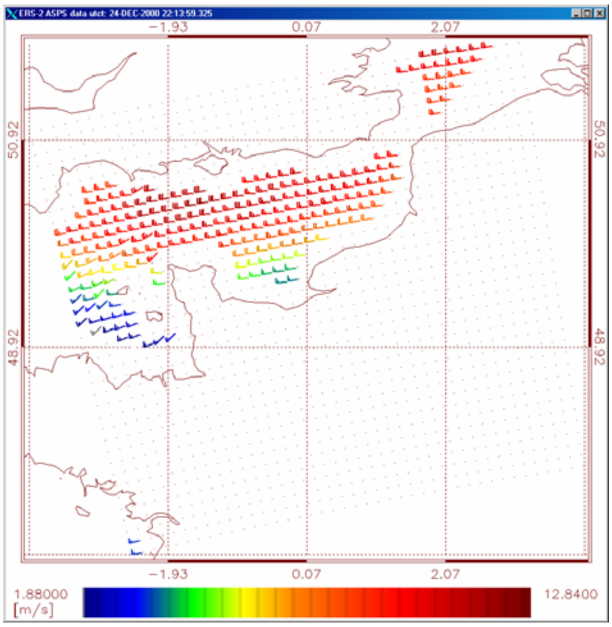

Figure 6-b ASPS High-resolution winds over the English Channel

The high-resolution product allows to detect the Sea / Land limit with more accuracy (see Figure 7) as well as structures in the wind field (see Figure 8).

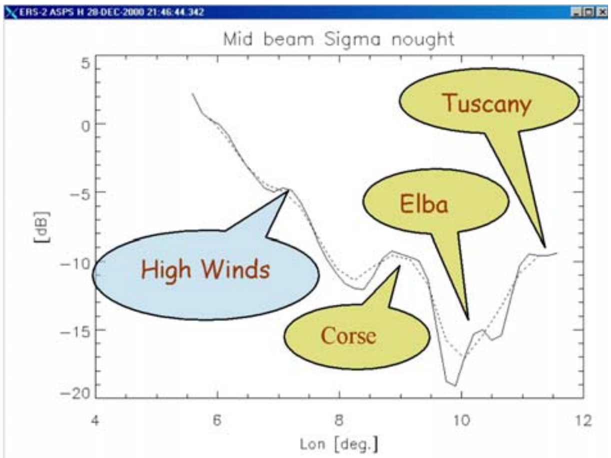

Figure 7 ASPS High-resolution and Nominal (dashed) sigma nought across the Tyrrhenian Sea.

8. CONCLUSIONS

The purpose of this paper is to introduce the ASPS system to the scientific and application users and to give some figures on products performances. As baseline, the pre-operational version of ASPS data reaches the same performances as the nominal products (fast delivery data) in terms of sigma nought calibration and winds. Further improvements in the data quality are expected during the re-processing phase with the usage of more accurate antenna pattern profiles and gain constants computed by TOSCA and with the implementation of the CMOD-5 scheme for the wind retrieval and the Ice detection algorithm. The capability to process also ASCAT data will set the ASPS as a state-of-the-art and powerful facility to catch a three decades of C-band backscatter measurements from Space. The high-resolution product is really a 25 Km product; allows detecting interesting features over Land and Sea for some selected case study. Some ASPS beta products are available for the scientific community from the authors for evaluation. Technical details on the Scatterometer processor are given in the References, most of them available on the ESRIN-PCS web site: http://earth.esa.int/pcs/ers/scatt/articles/

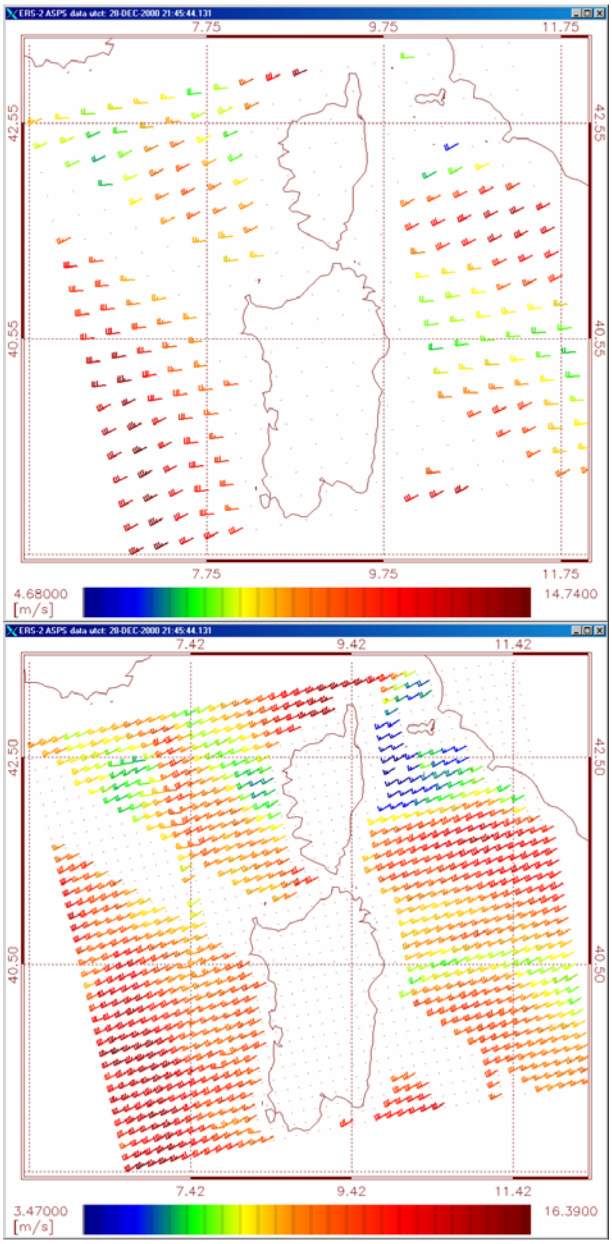

Figure 8 ASPS Nominal (upper panel) and High-resolution (lower panel) winds across the Tyrrhenian Sea

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