Project:	**Scatterometer Engineering Support Laboratory**
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Issue	Revision	Date	Sheet	Description of Change
Draft	0	02.06.2008	All	1st Issue
	01			Added description of sea-ice probability field in ASPS2.0 product.
				Added ASPS 1.0
	02	30.11.2011		Added UPG and ASCAT products Added references + citations

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1 Introduction

The wind scatterometer uses three antennas (Fore, Mid and Aft beams) to measure the energy backscattered by the ground in order to calculate the backscattering coefficients in three directions (σ^0_{Fore}, σ^0_{Mid}, σ^0_{Aft}). One of the main applications is wind (speed and direction) retrieval over the ocean.

The ground processing operations are aimed at converting the raw measurements (samples of the echoes) into calibrated sigma-nought measurements as a first step and into wind vectors (wind speed is represented by the vector magnitude and the direction by it's orientation), this is achieved through many processing operations, the main blocks are re-sampling, Doppler compensation, low pass filtering, normalization and spatial filtering [AD 8],[AD 7] and [RD 13] This is carried out for the three beams.

At the end of the process, a grid of points (nodes) on earth is obtained, the grid of nodes are separated by 25 Km (nominal resolution) or 50 km (high resolution) in both directions (along-track and across-track) and for every node the sigma-nought measurements are derived [AD 4].

Since wind speed/direction retrieval can only be performed over sea, a global land map is used as a mask to identify the land nodes and sea nodes (see Section 6.3.2.6.1 Land-sea flag). A specific algorithm is used to identify the ice nodes (see Section 6.3.2.6.2 Ice flag). Identification errors are possible, particularly over mixed nodes (containing land and sea or ice and sea).

The conversion of the backscattering coefficients (sigma-nought) measurements to a wind vector is based on a C-band theoretical model. The wind solutions closest to the measurements are pre-selected. As the theoretical analysis shows that up to four solutions can exist, an ambiguity removal algorithm is required to select the most appropriate solution.

1.1 Scope of the document

This document is the ASPS products handbook. The ASPS products (ASPS 1.0, ASPS 1.5, ASPS 2.0 and ASPS UWI) are generated by the scatterometer Advanced Processing System. The format of the ASPS products will be presented through the document to provide information to provide insight in the content of the products and the meaning and consequences of the different fields..

All the fields and flags of the products are described in detail; examples and numerical values are provided for more clarity.

1.2 References

1.2.1 Applicable Documents

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[AD 3] ERS-2 satellite to ground segment interface specification, Technical Report ER-IS-ESA-GS-0002, Dec 2, 1993. ERS-2 Programme

[AD 4] Dr.H. Munz and S. Schutz, Wind scatterometer ground processing requirements up to σ^0 -triplets.Technical Report ER-RP-DSF-SY-0006, Dornier , December 1987.

[AD 5] P. Lecompte, Wind scatterometer processing requirements from σ^0 triplets to dealiased Wind, Technical Report ER-SA-ESA-SY-1121, ESRIN ESA, February 1993.

[AD 6] P. Lecompte, CMOD4 Model Description, Technical Report ER-SA-ESA-SY-1120, ESRIN ESA, February 1993.

[AD 7] X. Neyt, P. Pettiaux, M. De Smet, E. Cuvelier and M. Acheroy, Scatterometer Algorithm Review, Technical Report RMA-SIC-011109, Royal Military Academy, Mar 02, 2012.

[AD 8] X. Neyt, P. Pettiaux, M. De Smet and M. Acheroy, Scatterometer Algorithm Review, Architectural Design Document, Technical Report RMA-SIC-020220, Royal Military Academy, Mar 02, 2012.

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[AD 10] X. Neyt, N. Manise and M. Acheroy, Tool For Scatterometer Calibration, State of the Art Report, RMA-SIC-050729, Royal Military Academy, December 4, 2006

[AD 11] A. Elyouncha, X. Neyt, User-provided grid scatterometer product, RMA-SIC-081102, Royal Military Academy, November 29, 2011

[AD 12] ASCAT Level 1 product format specification, EPS.MIS.SPE.97233, EUMETSAT, September 8, 2008

[AD 13] EPS programme generic product format specification, EPS.GGS.SPE.96167, EUMETSAT, February 16, 2005

[AD 14] ASCAT measurement data interface specification, MO-TN-DOR-SC-0015, Astrium GmbH, July 21, 2003

1.2.2 Reference Documents

[RD 11] P. Lecomte, The ERS scatterometer instrument and the on-ground Processing of its Data, in Proceeedings of a Joint ESA-Eumetsat Workshop on Emerging Scatterometer Application – From Research to Operation, pp. 241-260, ESTEC, (The Netherlands), Nov. 1998.

[RD 12] R. Crapolicchio and P. Lecompte, The ERS wind scatterometer mission: routine monitoring activities and results, in Proceeedings of a Joint ESA-Eumetsat Workshop on Emerging Scatterometer Application – From Research to Operation, pp. 285-298, ESTEC, (The Netherlands), Nov. 1998.

[RD 13] X. Neyt, P. Pettiaux and M. Acheroy, Scatterometer Ground Processing review for gyro-less operations, In Proceedings of SPIE Remote Sensing of the Ocean, Sea Ice and Large Water Regions 2002, volume 4880, Crete, Greece, September 2002.

[RD 14] P. Pettiaux, X. Neyt, and M. Acheroy, Validation of the ERS-2 Scatterometer Ground Processor Upgrade, In Proceedings of SPIE Remote Sensing of the Ocean, Sea Ice and Large Water Regions 2002, volume 4880, Crete, Greece, September 2002.

[RD 15] R. Crapolicchio, P. Lecomte, and X. Neyt. The advanced scatterometer processing system for ERS data: Design, products and performances. In Proceedings of the Envisat Symposium, Salzburg, Austria, September 2004.

[RD 16] R. Crapolicchio, P. Lecomte, The ERS wind product specification, Proceeding of Emerging Scatterometer Application workshop, ESTEC, Noordwijk, The Netherlands, 5 – 7 October 1998, ESA-SP-424, pp 271 – 284.

[RD 17] X. Neyt, N. Manise, and M. Acheroy. Enhanced neural-network based sea/ice discrimination using ERS scatterometer data. In Proceedings of SPIE Remote Sensing of the Ocean, Sea Ice and Large Water Regions 2005, volume 5977, Brugge, Belgium, September 2005.

1.3 Abbreviations

AD	Applicable Document
ADC	Analogue Digital Converter
ADCU	ADC Unit
AMI	Advanced Microwave Instrument
ASCAT	Advanced Scatterometer
ASPS	Advanced Satterometer Processing System
BER	Bit Error RateCMS Control and Monitor Subsystem
CoG	Center of Gravity
DPMC	Data Processing, Monitoring and Control Facility
DPS	Data Path Switcher
DSR	Data Set Record
EECF	Earthnet ERS Central Facility

1 Introduction

ERS	European Remote Sensing
ESA	European Space Agency
ESRIN	European Space Research Institute
EWIC	Extracted Wind Calibration Data
FDP	Fast Delevery Processor
FMA	Fore – Mid – Aft
FS	Frame Synchronizer
HDDT	High Density Digital Tape
HR	High Rate
IC	Internal calibration
Kp	normalized standard deviation of σ0
LBR	Low Bit Rate
LR	Low Rate
LRDPF	Low Rate Data Processing Facility
MMCC	Mission Management and Control Center
MPH	Main Product Header
OBRC	On Board Range Compression
OGRC	On Ground Range Compression
PCD	Product Confidence Data
QC	Quality Control
RD	Reference Document
SAR	Synthetic Aperture Radar
SARFDP	Synthetic Aperture Radar Fast Delivery Processor
StDev	Standard Deviation
SV	State Vector
SPH	Specific Product Header
UPG	User Provided Grid
UWI	User Wind Data
WSP	Wind Scatterometer Processor
YSM	Yaw Steering Mode
ZGM	Zero Gyro Mode
σ0 (or sigma0)	Sigma-nought (absolute normalized radar cross-section)

2 Ground segment

2.1 Technical infrastructure

The ground segment consists of an ensemble of facilities for the acquisition, processing, distribution and archiving of the satellite data and of the derived products.

A network of ground stations implemented around the world assures the ERS-2 telemetry once per orbit. The ERS telemetry consists of two parts: High Rate data (105 Mbit/s) and Low Rate data (1093.75 Kbit/s) [AD 2].

The main functions of the ground stations are: real time data acquisition, acquisition of the LBR data from the on-board tape recorder and data processing and generation of fast delivery products.

The end user interface and the exploitation of the payload data has been implemented within the ESRIN EECF (Earthnet ERS Central Facility) in Frascati, Italy, while the satellite planning and control functions, including the control of the Kiruna station are the responsibility of the MMCC in Darmstad, Germany. The processing parameters and commands will be processed by the Control and Monitor Subsystem, CMS [AD 2].

In the old processing system, the products were generated by the SARFDP and LRDPF fast delivery processors. The SARFDP produce AMI Image and AMI Wave products. The AMI Wind product is produced by the LRDPF (Low Rate Data Processing Facility) [AD 2]. For compatibility, some fields related to the old processors remain in the MPH, but they are obsolete for the products described in this document (ASPS 1.0, ASPS 1.5, ASPS 2.0 and ASPS UWI) which are generated by the new ASPS processing chain.

The low bit rate data from ERS-2 were transcribed from HDDT to Exabyte tapes directly at the receiving station [AD 2]. In 2003 the on–board tape recorders failed and since then the LBR data are acquired in real time when the satellite enters the visibility area of the available ground stations. Possibly, the coverage of several ground stations overlap and in that case, the same data (at source-packet level) is acquired by different ground stations. For source-packets acquired by several stations, the source-packet with the highest quality is retained for further processing (merging operation). The fields related to HDDT are obsolete for the ASPS products and are only kept for compatibility.

2.2 Review of the processor

The ASPS processor is a chain of signal processing modules, the input of the chain is the echo signal power and the output are sigma triplets for each node. The main modules are: ADC non linearity correction, yaw estimation, amplitude correction, Doppler compensation, low pass filtering, envelope detection, normalization/calibration and spatial averaging.

A quality control is performed at each stage of the processing chain. Depending on the result of this control, different actions are performed and flags are set to indicate the QC result. The main quality controls and the flags resulting from each QC are detailed further in this chapter.

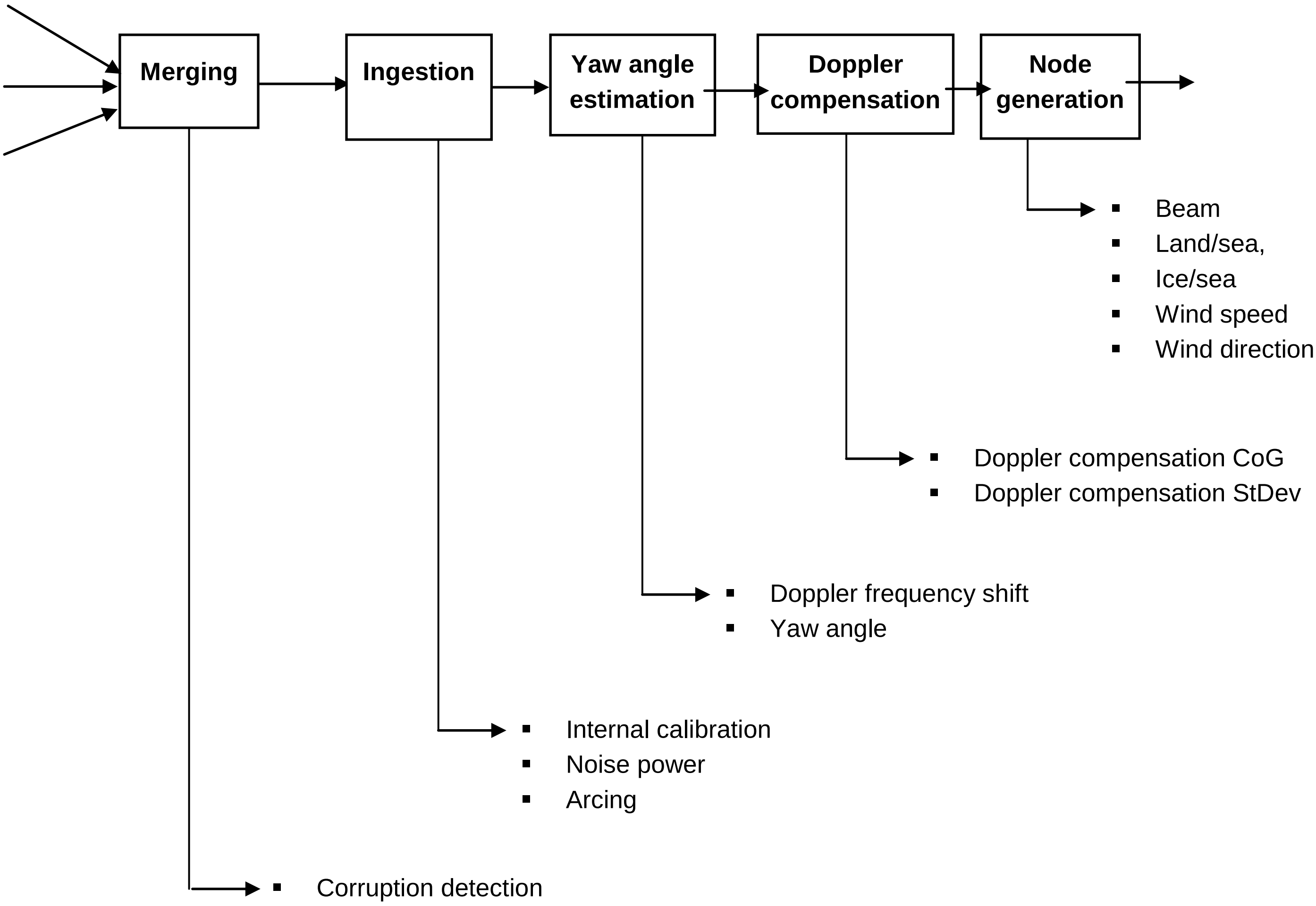

Figure 1:Simplified block diagram of the processor

2.2.1 Corruption detection

Corruption of the source packets can be detected by CRC or by monitoring the value of slowly-varying quantities (noise power, internal calibration level). Whenever this occurs, the corrupted values are replaced by default values. However, corruption of the measured data cannot be detected as such and if another quantity was detected as corrupted, the corresponding measured data and hence the sigma nought should be interpreted with care, for more detailed information see [AD 7] chapter 13.

2.2.1.1 Frame checksum

A frame Checksum flag is set when either bits 8-9 (Frame Synchronizer) of the MPH are equal to 1 and bits 10-11 (FS processor to I/F) of the MPH are greater than 0, in this case noise power and calibration pulse are replaced with default values (see below) [AD 7] section 13.2.4.3

2.2.1.2 Corrupted noise power

An additional check of the noise power level is performed in the quality control applied to source packets during the ingestion. Corrupted noise power is detected if the measured noise power is out of a defined interval. In this case, the noise power is replaced by default values and the noise power flag is set [AD 7] section 13.3.3.

Maximum Corrupted Noise Power Threshold = 100 (Fore), 100 (Mid), 100 (Aft) [ADCU]

Noise Power Default = 1.0 (Fore), 0.0 (Mid), 1.0 (Aft) [ADCU]

2.2.1.3 Corrupted calibration pulses

Corrupted calibration pulse is assumed when the maximum of the calibration energy is above a configured threshold. In this case, the calibration pulse energy is replaced by a linearly extrapolated default value [AD 7] section 13.3.4.

Calibration Corrupted Threshold = 4000 (Fore), 3000 (Mid), 4000 (Aft) [ADCU]

2.2.2 Internal calibration

Internal calibration consists in injecting a fraction of the transmitted pulse directly into the receiver low noise amplifier in order to correct the gain, to monitor instrument ageing and to detect anomalies.

The energies of the 4 calibration pulses corresponding to one measurement block are averaged together. The resulting energy is monitored against a threshold and whenever this threshold is exceeded, the internal calibration flag is set [AD 7] section 13.3.1.

2.2.2.1 Calibration subsystem failure

Failure of the calibration subsystem is detected when the echo signal power is larger than a configurable threshold (thus actually assessing some power was transmitted by the instrument) and the calibration pulse energy is smaller than a configurable threshold. In this case the calibration pulse is replaced using a linearly extrapolated default value [AD 7] section 13.3.5.

Echo threshold = 5.0 (Fore), 5.0 (Mid), 5.0 (Aft) [ADCU]

Calibration pulse threshold = 350 (Fore), 100 (Mid), 350 (Aft) [ADCU]Noise power

The signal power measured by the scatterometer is the echo signal power plus the receiver noise power. To improve the instrument accuracy, the receiver noise is measured separately and then subtracted from the sum of both.

The noise measurements are taken after each transmitted pulse except the 1st, 11th, 21st and 31st before the signal returns. During each sequence of 32 pulses, 28 noise signals are measured. The corresponding in-phase and quadrate noise measurements intensities are averaged together on-board and the corresponding averages are transmitted to the ground [AD 7][RD 11].

The noise power is compared to a predefined threshold and the noise power flag is set when it exceeds this threshold.

2.2.3 Arcing

Arcing is an electrical anomaly affecting the transmitting tube. When this occurs, the power amplifier, which is the last stage of the transmitting system, is switched off during 15 seconds, which leads to missing transmit pulses. The averaged energy of four calibration pulses (1st, 11th, 21st and 31st) of each measurement block (32 pulses) is used to detect missing transmit pulses due to arcing of the power amplifier.

Arcing events are detected when the echo signal is lower than configured threshold and the calibration energy is smaller than another threshold; in this case the arcing flag is set and the calibration pulses are replaced using a linear extrapolation [AD 7] section 13.3.8.

2.2.4 Doppler compensation and Yaw angle estimation

2.2.4.1 Doppler frequency shift

Due to the relative motion between the satellite and the ground, the echo signal spectrum is shifted. In order to have the spectrum fit in the on-board filter pass band on-board Doppler compensation is required [AD 7].

If the Doppler frequency shift is out of a configured interval, the corresponding flags are set. In that case, echo energy is lost due to on-board filtering and the sigma naught will be under-estimated.

2.2.4.2 Yaw angle estimation

The yaw angle is estimated from the raw data by measuring the residual Doppler frequency shift, the yaw angle that caused the measured frequency shift is then taken as estimate for the spacecraft’s yaw angle [AD 7] chapter 9[RD 13].

If the estimated yaw angle is outside the configured intervals, the corresponding flag is set. In that case, the on-ground Doppler compensation will possibly not be able to recover the whole signal, which will cause an under-estimation of the sigma naught.

2.2.4.3 On-ground Doppler compensation

The efficiency of the on-ground residual Doppler compensation is checked by measuring the Center of gravity and the Standard deviation of the resulting spectrum. If their values are outside the defined intervals, the Doppler compensation CoG and/or standard deviation flags are set. This means that the on-ground Doppler compensation was not successful and that the sigma nought are possibly under-estimated.

2.2.5 Node dependent flags

2.2.5.1 Beam flag

This flag indicates the validity of the measurements performed by the three antennas Fore/Mid/Aft. The measurements are valid if the flag is not set. The flag is set if the sigma naught is lower than zero or if the number of samples is smaller than a threshold (minimum number of source packets needed per node, per beam), in this case the sigma and Kp are assigned default (sentinel) values.

2.2.5.2 Land/sea

A node is assigned land status according to the percentage of land-samples within the surrounding area contributing to the considered node. A node is flagged “land”, hence the flag is set, if more than 15% of the samples that contribute to it are over land. In this case no wind extraction is attempted for the given node. The ENVISAT map is used as land mask [AD 9], page36, 37.

2.2.5.3 Ice/sea

The method used for discrimination between sea-ice and open water is described in details in [RD 17]. In this case no wind extraction is attempted for the considered node. Ambiguities are possible when discriminating between ice and sea due to the presence of mixed nodes (where both sea and ice is present). The determination algorithm only uses the current measurements and does not exploit temporal coherence of the ice field [RD 17].

2.2.5.4 Wind speed-direction-distance

The wind retrieval algorithm generates up to four solutions (wind speed and direction) for each node. To each of these solutions the distance between the σ^0 triplets measurements and the solution computed using an analytical model is attached. The solutions are ranked by increasing Euclidean distance. The Rank 1 solution has the smallest distance. The ambiguity removal algorithm re-sorts the first two solutions in order to increase the spatial homogeneity of the wind field.

The value of wind speed resulting from the process described above is compared to a predefined threshold, if it exceeds this threshold the high wind flag is set and if it is under the threshold, the low wind flag is set.

The wind speed/direction bias is the difference between the wind vector obtained from the scatterometer measurements (the one selected by the ambiguity removal algorithm) and the meteorological wind used as background in the ambiguity removal. If this bias exceeds configured thresholds the wind speed/direction bias flags are set.

2.3 Output products

The ASPS processor generates 3 types of products: ASPS 1.5, ASPS 2.0 and ASPS UWI. Moreover experimental products can be generated, namely ASPS 1.0, ASPS UPG and ASPS ASCAT.

All the ASPS products have the same structure: a Main Product Header (MPH), followed by a Specific Product Header (SPH) and several Data Set Records (DSR). The MPH is the same for all products, SPH and DSR format is product-dependent.

As a general rule, acquisition and downlink information is stored in the MPH, quality control and processing information covering the entire product is given in the SPH, and information related to the quality of individual nodes or node rows is stored in the DSR.

In ASPS 1.5 products, a DSR contains information from one FMA sequence, i.e., one DSR every second, and one product covers one orbit between ascending node crossings. The total number of DSR, for a full orbit is about 6000. ASPS 1.0 products have a similar structure.

In ASPS 2.0 products, a DSR contains one row of 19 (nominal resolution) or 41 (high resolution) nodes, one DSR (row) every 4 seconds, and one product covers one orbit between ascending node crossings. The total number of DSR for a full orbit is about 1500.

In ASPS-UWI products, a DSR contains one square of 19 nodes x 19 nodes (361 nodes), one product covers one area of about 500x500 km², and one full orbit corresponds to about 85 products.

ASPS UPG products, contain the same information as ASPS 2.0, but the geographical positions of the nodes are arbitrary (user-provided).

ASCAT products are generated from ASCAT level 0, level 1A or level 1B full resolution data. The output format can be either ASCAT level 1B or ASPS2.0, taking into account the two swaths (left and right).

Further technical details on the scatterometer processing chain are given in [AD 7]. The products format are described in more details in [AD1].

3 Main Product Header

The Main Product Header (MPH) description applies to the ASPS1.5, ASPS 2.0 and UWI products.

3.1 Product size

The size of the MPH is 176 bytes, The MPH contains information about the SPH and DSR size, the field 8 contains the size of the SPH in Bytes which is 100 bytes (ASPS 1.5), the field 9 contains the number of product data set records and the field 10 contains the size of each product data set record in bytes.

3.2 Product generation

A product can be generated by several processors (subsystems). The products described in this document are generated by the ASPS processor. The 11th field indicates the subsystem that generated the product, and the 16th field indicates the processor software version used to generate the product.

3.2.1 Product Identifier (field 1)

(For ESA internal operational only): set of characters and integers which form a unique identifier.

3.2.2 Product Type (field 2)

(See [AD 1] Appendix A, table B)

UWI is type 8, ASPS 1.5 is type 41 and ASPS 2.0 is type 42. ASPS 1.0 type is not defined.

3.2.3 Spacecraft

The Spacecraft field (field 3) indicates the satellite type, 1 for ERS-1 and 2 for ERS-2.

3.3 Time and clocking

UTCT (field 4): represents the UTC time of sub-satellite point at beginning of product or the time of the first line of nodes. It has the following format in ASCII: dd-MMM-yyyy hh:mm:ss.ttt (for example: 30-JAN-1987 14:30:27.123).

UTCG (field 7): represents the UTC time at which the MPH was generated.

REFT (field 13): represents the reference time. Time relation used to convert from satellite time to UTC, used together with the next two fields.

CLOCK (field 14): Reference binary time of the satellite clock

ASCN (field 19): UTC time of ascending node state vector

3.4 Station ID

ID of the station where the data was processed

1. Kiruna station (KS)
2. Fucino station (FS)
3. Gatineau station (GS)
4. Maspalomas station (MS)
5. EECF station (ES)
6. Prince Abert station (PS)
7. West Freugh (WF)
8. Hobart (HL)

3.5 Product Confidence Data

All ASPS products contain information on the quality of the content. This information is contained in the Product Confidence Data (PCD) field of each product's Main Product Header (MPH), 16 bits provide a summary of checks performed before product dissemination. For the ASPS 1.0, ASPS 1.5 and 2.0, an other PCD field is present in the SPH.

3.5.1 PCD Summary flag (bit 1)

Qualifies the success of product generation, the flag is set to 0 when the product is correctly generated and set to 1 when at least one of the remaining 15 bits of the PCD in the MPH is set.

3.5.2 Downlink performance and X-Band acquisition chain (bit 4-5)

The scatterometer performs the backscatter related measurements at a frequency of 5.3Ghz (C-band) but it performs the telemetry operations using S-band and/or X-band links depending on the ground station capabilities.

During the acquisition, the following PCD is collected:

- Bit error rate (BER) estimate
- Downlink channel signal strength
- I and Q bit synch lock status
- Demodulator lock status

The DPMC collects the PCD and checks it against configured limits and passes the result as a PCD flags. The flag is set to 0 if the performance is better than minimum threshold, set to 1 if the performance is equal to or worse than threshold and set to 2 if the performance is unknown [AD 2].

3.5.3 Performance and status of processing chain (bit 7-8-9-10-11)

During product generation the following equipments are monitored:

- HDDTs (High Density Digital Tapes)
- FS (Frame Synchronizer)
- Frame Synchronizer to product processor interfaces
- SARFDP and LRDPF processor status
- HDDT Summary (bit-7)

The HDDTs are monitored by the DPMC/CMS, which collects status information generated by the tape search units (TSUs). The DPMC/CMS also collects “synch lock” status via the tape search unit every 2.5 seconds, checks the parameters against predefined limits, and passes the resulting flag to the processor. The flag is set to 0 if the performance is better than supplied minimum threshold, set to 1 if the performance is equal to or worse than threshold and set to 2 if the performance is unknown [AD 2].

As mentioned above, the fields related to SARFDP, LRDPF, and HDDT are obsolete for the ASPS products.

3.5.3.1 Frame Synchronizer (bit 8-9)

The ground telemetry system require a Frame synchronizer to isolate the first synchronization word (synchronization pattern). During the replay of the tapes, the frame synchronizer monitors the BER and the lock status of the down-linked data. The DPMC/CMS samples the frame synchronizer status every 2.5 second, checks the parameters against predefined limits and passes the resulting flag on to the processor. The flag is set to 0 if the performance is better than supplied minimum threshold, set to 1 if the performance is equal to or worse than threshold and set to 2 if the performance is unknown.

3.5.3.2 FS to processor I/F LRDPF and SARFDP (bit 10-11)

The frame synchronizer to processor interfaces are monitored in the SARFDP and the LRDPF. The processors check the parity bit in the incoming data from the frame synchronizer. The flag is set if at least one parity error is detected.

3.5.4 Checksum Analysis on Low Rate Frames (bit 12-13)

The LR transfer frame checksums are analyzed by the Frame synchronizer. The LRDPF takes action by replacing the noise and calibration pulse data with defaults, and by flagging the event in the MPH. A count of checksum errors is maintained and a flag in the MPH set if the ratio of erroneous frames to total frames exceeds a threshold.

3.5.5 Quality of down-linked formats and source packets (bit 14-15)

The performance of instrument formats and source packets is monitored by the SARFDPs and the LRDPF through analysis of the data from the frame synchronizer. If a source packet (LR) or format (HR) cannot be reassembled, that is, it is too short or too long, all data are totally disregarded. In addition, a flag is set accordingly in the MPH and in the PCD of the cell.

The threshold is defined in a configuration file (table), the version number of this table is indicated by the field 17 of the MPH.

3.5.6 Quality of auxiliary data (bit 16)

In addition to the measurement and calibration, data information termed “auxiliary data” is provided to the ground. The auxiliary data shall contain all AMI related information necessary for interpretation and processing of the measurement data including calibration data that was measured on-board but are not part of the main measurement of the instrument; external calibration files from sources other than the satellite; processor configuration files; and any other files needed by instrument processor.

Auxiliary data in the header of the down-linked source packets are checked by the processors against predefined limits. If a processor is unable to extract all the auxiliary data needed for the product generation, a flag is set accordingly in the MPH.

3.6 Range compression (bit 1-2)

This flag is used for SAR products only.

3.7 State vector (fields 19-25)

A state vector (SV) is a set of data describing exactly where the satellite is located in space and how it is moving, from the SV the object’s current and future position can be determined. The SV contains 7 elements, 3 position coordinates (m), 3 velocity components (m/s), and the time at which these values were valid. The reference system is North (latitude), East (longitude) and altitude as showed in the following figure (the figure is not a representation of an ERS orbit).

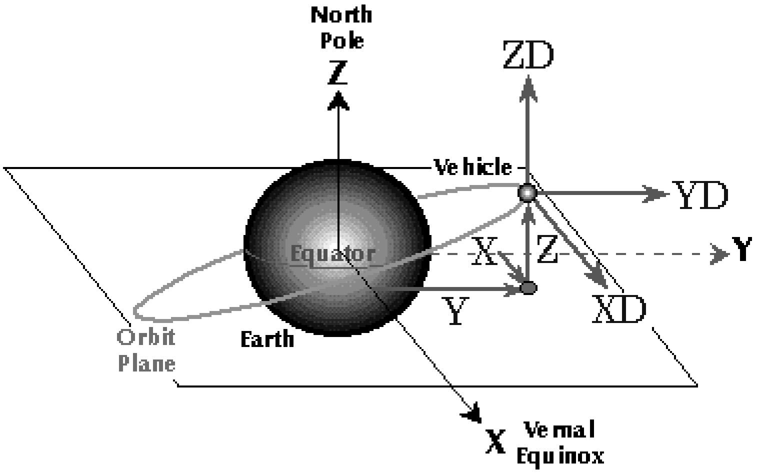

Figure 2: State vector

4 ASPS Level 1.0 Product

4.1 Introduction

This product aims at providing the sigma naught values at the raw spatial resolution of the instrument, i.e., without spatial averaging nor resampling.

The format of this product is very similar to the ASPS Level 1.5 product, they share the same SPH and a major part of DSR. The main difference (advantage) is that ASPS Level1.0 contains the sigma measurement block and the geometry parameters (latitude, longitude, incidence angle, elevation angle and look angle) related to each source packet.

4.2 Specific Product Header

Is the same as the ASPS Level 1.5 product (See section 5.2)

4.3 Data Set Record

The same format as the ASPS Level 1.5 product with the following additional fields. These fields provide the concerned value (sigma, latitude, …) for each measurement sample of the current data block.

4.3.1 Sigmap (fields 30,31,32)

The fields 30, 31 and 32 of the DSR contain three sigma-nought per pulse arrays corresponding respectively to the Fore, Mid and Aft beams. These sigma-nought are calibrated and averaged over the 32 pulses transmitted by the instrument. However, no spatial averaging is performed as this is precisely the main aim of this product.

4.3.2 Latitudes (fields 33,34,35)

See section 6.3.2.1.1

The fields 33, 34 and 35 of the DSR contain respectively three Latitude arrays corresponding respectively to the samples of the Fore, Mid and Aft beams.

4.3.3 Longitudes (fields 36,37,38)

See section 6.3.2.1.1

The fields 36, 37 and 38 of the DSR contain respectively three Longitude arrays corresponding respectively to the samples of the Fore, Mid and Aft beams.

4.3.4 Incidence angles (fields 39,40,41)

See section 6.3.2.2.2

The fields 39, 40 and 41 of the DSR contain respectively three incidence angle arrays corresponding respectively to the samples of the Fore, Mid and Aft beams.

4.3.5 Elevation angles (fields 42,43,44)

The antenna elevation angle with respect to the nadir.

The fields 42, 43 and 44 of the DSR contain respectively three elevation angle arrays corresponding respectively to the samples of the Fore, Mid and Aft beams.

4.3.6 Look angles (fields 45,46,47)

See section 6.3.2.2.3

The fields 45, 46 and 47 of the DSR contain respectively three look angle arrays corresponding respectively to the samples of the Fore, Mid and Aft beams.

This field is only computed when sigma is not equal to 0, when it’s not the case it takes the default value -999.99.

4.3.7 Kp (fields 48,49,50)

See section 6.3.2.2.4

The fields 48, 49 and 50 of the DSR contain respectively three Kp arrays corresponding respectively to Fore, Mid and Aft beams.

This field is only computed when sigma is not equal to 0, when it’s not the case it takes the default value -999.99.

5 ASPS Level 1.5 Product

5.1 Introduction

The ASPS level 1.5 product has the same format structure (MPH, SPH and DSR) as the other ASPS products, one DSR corresponds to one FMA sequence.

5.2 Specific Product Header

The specific product header contains information pertaining to the whole data set records, either as is or averaged quantities over the whole data set records. It can be used to obtain quality information about the product without having to actually read the entire ASPS product.

5.2.1 Product Confidence Data

This groups processing and quality information at the product level.

5.2.1.1 Summary PCD factor (bit 1)

All PCD collected during acquisition and product generation, are summarized in this flag.

The summary PCD factor is set to 0 when the processing is performed according to full specification. It is set to 1 if at least one of the flags (bit 2-10) of the PCD is set.

5.2.1.2 Doppler compensation flags (bit 2-3)

Due to the relative motion between the satellite and the target, the radar echo on the earth's surface does not have the same frequency as the transmitted signal because of Doppler frequency shift the range of this shift is 50-150 KHz for the fore antenna and 0-10Khz for the mid antenna. Hence a frequency tuning of the scatterometer receiver (on-board Doppler compensation) is performed to keep the echo signal within the 25Khz on-board bandwidth. Since the on-board compensation is pre-defined, it cannot take into account residual Doppler frequency shift due to non-zero yaw angles and an additional compensation is necessary on ground [AD 7].

The adequacy of the on-board compensation is assessed by measuring the offset and the standard deviation of the received signal spectrum with respect to zero. The adequacy of the on-ground compensation is also assessed by analyzing the spectrum of the signal after on-ground Doppler compensation.

5.2.1.2.1 Center of Gravity flag (bit 2)

This flag is set if the value of CoG of the received power spectrum after on-ground compensation of any beam is out of the interval defined in configuration file.

Interval: [-1000 1000] Hz (Fore-Mid-Aft).

If this bit is set, on-ground Doppler compensation failed and the deduced sigma-nought are probably under-estimated.

5.2.1.2.2 Standard Deviation flag (bit 3)

The flag is set if the standard deviation of the received power spectrum of any beam after on ground compensation is out of the interval defined in the configuration file.

Interval: [1000 2500] Hz (fore-Aft)

Interval: [2000 2500] Hz (Mid)

5.2.1.2.3 Frequency shift flag (bit 4)

This flag is set if the Doppler frequency shift of any beam before on ground compensation is out of the interval defined in the configuration file.

Interval: [-6000Hz 6000Hz] (Fore-Mid-Aft).

If this bit is set, a significant part of the pre-compensation pulse energy was shifted outside the on-board anti-aliasing filter. As a consequence, the sigma-nought will be under-estimated.

5.2.1.3 Yaw angle flag (bit 5)

The yaw angle is to be understood as the deviation with respect to the nominal yaw angle in yaw steering mode (YSM).

This flag is set if the Yaw angle of any beam is out of the interval defined in the configuration file.

Interval: [-2° +2°].

The Doppler shift resulting from a yaw angle deviations (from the YSM) of up to 2° can be corrected for. Larger Doppler frequency shifts, due to a larger yaw angle, lead to a degradation of the sigma nought measurement.

5.2.1.4 Noise power flag (bit 6)

This flag is set if any Noise power level measured by any beam is above or equal the threshold defined in the configuration file.

Threshold: 1.5 ADCU (Fore-Mid-Aft).

The noise level measured is typically very low (~1 ADCU). When this flag is set, sigma-nought measurements are strongly affected by external noise (interference from an external source).

5.2.1.5 Internal Calibration flag (bit 7)

The flag is set whenever the internal calibration level is outside the pre-defined interval. A low calibration level is typically an indication of an arcing event, but can also be the symptom of a degradation of the high power amplifier. A too high calibration level typically indicates a corruption of the source packet ([AD 7] p18 and [RD 11]). In this case, the calibration pulse energy value is replaced by a default value.

The sigma-nought data should not be used when the flag is set.

Fore/Aft beam thresholds: [500, 3000] 10^{-3} ADCU

Mid beam thresholds: [150, 1500] 10^{-3} ADCU

5.2.1.6 Arcing flag (bit 8)

The flag is set if the internal calibration level is below a configurable threshold for at least one beam. In this case, the calibration pulse energy is replaced by a default value.

The sigma-nought data should not be used when the flag is set. During the arcing, no power or a strongly reduced power level is transmitted, the data will contain only the noise measurement.

5.2.1.7 Frame checksum flag (bit 9)

For every source packet contributing to a node a frame checksum flag is set (or not) by the frame synchronizer (see 3.5.3.1). The frame Checksum flag is set when either bits 8-9 (Frame Synchronizer) of the MPH are equal to 1 and bits 10-11 (FS processor to I/F) of the MPH are greater than 0

This flag is set whether at least one of the input flags has been set by the frame synchronizer. If checksum error happens.

Frame synchronizer error: 0 if no error, 1 if parity error, 2 if checksum error (3 if both)

Whenever the flag is set, calibration and noise data are replaced with default values (see above). This happens when the frame synchronizer error is greater or equal than 2 for any of the three beams..

5.2.1.8 Spectrum fit method flag (bit 10-11)

The spectrum of the returned echo is shifted due to the Doppler effect. I In order to measure the Doppler frequency shift, hence the Yaw angle, several methods to estimate the spectral shift can be used.

This flag indicates the estimation method used, it’s set respectively to 0, 1 and 2, when the method used is Center of Gravity, Gaussian-fit or Sinc-fit method. Currently, only the Gaussian-fit method is used.

5.2.2 Doppler Compensation

See description (section 5.2.1.2 above)

The fields 3-11 contain Doppler compensation-related information.

5.2.2.1 Averaged CoG

The fields 3-5-7 contain the averaged (over all the Data set Records) Center of Gravity of the power spectrum of the received signal *after* on-ground Doppler compensation for respectively the Fore, Mid and Aft beam.

Unit: 1 Hz

5.2.2.2 Averaged standard Deviation

The fields 4-6-8 contain the average of the standard deviation of received spectrum after on ground

Doppler compensation for respectively the Fore, Mid and Aft beams.

Unit: 1 Hz

5.2.2.3 Averaged Doppler Frequency Shift

The fields 9-10-11 contain the averaged (over all the Data set Records) the Doppler Frequency Shift of received spectrum for respectively the Fore, Mid and After beams, *before* the on ground Doppler compensation.

Unit: 1Hz

5.2.3 Averaged Yaw error angle

The Yaw angle error is the difference between the estimated value and the nominal value in Yaw Steering Mode (theoretically 0 deg). [AD 7] p61-62-63 and [RD 14]

The value of the Yaw error angle averaged over all the data set records and for all the beams, is given in the field 12. The fields 13-14-15 give respectively the average of the Yaw error angle for each beam (Fore-Mid-Aft).

Unit: 10^{-3} deg

5.2.4 Averaged Noise power

The values of noise power averaged over all Data Set Records for the both components in-phase and in-quadrature (separately) and for each beam (Fore-Mid-Aft) are given respectively in the fields 16-21.

Unit: 10^{-3} ADCU.

5.2.5 Averaged Internal calibration

The values of Internal calibration level averaged over all Data Set Records for each beam (Fore-Mid-Aft) are given respectively in the fields 22,23 and 24 [AD 7].

Unit: 10^{-3} ADCU.

5.2.6 DSR counters

A Data Set Record is flagged (bit set to 1) when the value of it's corresponding field is above/bellow a configured threshold or out of defined interval. The SPH contain 8 DSR counters counting the number of flagged DSR's.

The total number of DSR's with arcing, noise power, internal calibration, Doppler compensation CoG, Doppler compensation standard deviation, Doppler frequency shift and yaw angle flags set are given respectively in the fields 28-34.

5.2.7 Other fields

In addition to all the fields listed above the SPH contains:

- The Absolute Orbit Number (field n°2) which is the number of the orbit corresponding to the data.
- Wind Scatterometer Processor (WSP) configuration file version number (field n°35)

5.3 Data Set Record

Each ASPS 1.5 product contains a variable number of Data Set Records depending on the availability of AMI data in wind or wind/wave mode throughout an orbit. The wind/wave mode consists of interrupting the scatterometer every 200 or 300 km for 2 FMA sequences (approximately 2 seconds) in order to collect a small SAR images of the waves.

Every product corresponds to measurements collected during one orbit, hence the maximum (without interruption) number of DSR's in one product is 6000 (one orbit lasts about 100 min).

Each data set record contains information related to one FMA sequence (32 measurement pulses for each beam).

The total number of DSR is stored in the field 9 of the MPH, and the size of one DSR is stored in the field 10 of the MPH.

The first field of the DSR contains the Record number, starting with 1.

5.3.1 DSR Confidence Data – 1

5.3.1.1 Summary PCD bits (bit 1-2)

This section contains two flags summarizing the status of the other flags of the PCD:

The summary PCD factor flag (bit 1) is set to 0 when the processing has been performed according to full specification, and is set to 1 when the summary PCD-1 is set or when the summary PCD-2 is set.

The summary PCD-1 flag (bit 2) is set to 0 when the processing has been performed according to full specification, and is set to 1 when one of the PCD flags listed below is set.

5.3.1.2 Doppler Compensation flags

The quality of the achieved Doppler compensation is characterized by two values: the Center of gravity and the standard deviation of the power spectrum after compensation, these values are compared to predefined limits and the results set the flags [AD 7] chapter 9.

5.3.1.2.1 Center of Gravity flag (bits 3-5-7)

Qualify the validity of the Center of gravity of the spectrum after on-ground Doppler compensation. If the CoG is within the configured interval, the flag is set to 0. The flag is calculated for each beam Fore-Mid-Aft. If the flag is not set, this means that the on-ground Doppler compensation was successful. If the flag is set, the computed sigma nought might be invalid (typically, they will be underestimated).

Defined interval: [-1000 1000] Hz (Fore-Mid-Aft)

5.3.1.2.2 Standard Deviation flag (bits 4-6-8)

Qualify the validity of the standard deviation of the spectrum after on-ground Doppler compensation. If the flag is not set, the compensation has succeeded. The flag is calculated for every beam.

Defined interval: Fore and Aft beams: [1000, 2500] Hz
Mid beam: [2000, 3500] Hz

5.3.1.2.3 Frequency Shift flag (bits 9-10-11)

The Doppler frequency shift measures the frequency shift of the received echo before on-ground compensation. The flag is set if the value is outside pre-defined interval. The flag is calculated for each beam.

Values outside the pre-defined interval mean part of the echoed signal was filtered out by the on-board anti-aliasing filter and, hence, the on-ground compensation will not be able to recover the lost signal. This causes an under-estimation of the sigma-nought.

Defined interval: Fore-Mid-Aft beams: [-6000, 6000] Hz

5.3.1.3 Yaw error angle flag (bit 12)

The Yaw error angle is the difference between the estimated value and the theoretical YSM value. The flag is set when the Yaw error angle is out of a pre-defined interval.

Defined interval: [-2°, +2°]

A large yaw error can imply a large Doppler frequency shift of the received signal. When a large Doppler frequency shift is experienced, the sigma nought is typically under-estimated, even if the on-board Doppler frequency compensation was successful.

References: for more details see [AD 7] section 9.4 and [RD 14]

5.3.1.4 Internal Calibration flag (bit 13)

See flag description ASPS1.5 (section 5.2.1.5).

The flag is set if any Internal Calibration level measured by any beam is out of the interval defined in the configuration file.

5.3.1.5 Arcing flag (bit 13-14-15)

See flag description ASPS 1.5 (section 5.2.1.6)

The bits 13, 14 or 15 are set when arcing is detected respectively on Fore, Mid or Aft beam. When arcing is present, the sigma naught will be under-estimated.

5.3.2 DSR Confidence Data – 2

5.3.2.1 Summary PCD – 2 (bit 1)

This flag summarizes the status of all the flags of the PCD-2, the flag is set to 1 if one of the flags listed below is set.

5.3.2.2 Frame Checksum flag (bit 2)

See Frame Checksum flag in the SPH (section 5.2.1.7)

5.3.2.3 Noise Power flags (bit 3-8)

See Noise Power flag in the SPH (section 5.2.1.4)

The bits 3,5 and 7 corresponds to the I component and the bits 4,6 and 8 corresponds to the Q components for the Fore, Mid and Aft beam respectively. If any of these flags is set, the sigma nought might have been contaminated by noise and/or the noise measurement was corrupted.

5.3.3 Time and position

This section gives information related to the satellite position and time of data acquisition in four fields, the quantities are given at the acquisition time of the mid-beam source packet.

ASCN: acquisition time since ascending node crossing. The time is given in 200 ms unit.

HEAD: gives the angle measured on the ground between the North and the satellite Track Heading, turning clockwise.

LAT: Geodetic Latitude of sub-satellite point at acquisition time. Negative values denote south Latitude and positive values denote north Latitude.

LON: East Longitude of sub-satellite point at acquisition time (0-360 deg from Greenwich to East)

5.3.4 Yaw angle

Due to the malfunction of the gyroscopes, a new piloting mode (ZGM) has been developed to control the spacecraft in order to minimize the Doppler frequency shift on the received echo. The yaw angle is measured with respect to the theoretical angle, which minimizes the Doppler frequency shift in the middle of the Mid beam. Ideally, the yaw angle should be zero. Non-zero values will induce a Doppler frequency shift on the received signal.

Fields 7, 8 and 9 contain the estimated Yaw angle respectively for the Fore, Mid and After beam. The field 10 contains the estimated Yaw angle averaged along track [AD 7] chapter 9 and [RD 14].

Unit: 10^{-3} deg.

5.3.5 Doppler Compensation

5.3.5.1 Center of Gravity

Fields 11-13-15 give respectively the CoG of the power spectrum of the signal after on-ground Doppler compensation, for the Fore, Mid and Aft beam.

Unit: 1 Hz.

5.3.5.2 Standard Deviation

Fields 12-14-16 give respectively the Standard deviation of the power spectrum of the signal after on-ground Doppler compensation, for the Fore-Mid and Aft beam.

Unit: 1 Hz.

5.3.5.3 Frequency Shift

Fields 17-18-19 give respectively the frequency shift of received echo (before on-ground Doppler Compensation) for the Fore-Mid and Aft beam. Unit: 1 Hz.

5.3.6 Noise power

The fields from 20 to 25 give respectively the Mean Noise power for the Fore, Mid and Aft beam and for the in-phase and in-quadrature component. Typically, the noise power measured by all the beams is very low (<1 ADCU), the lowest level is measured by the Mid antenna (~0 ADCU) compared to the side antennas (~0.9 ADCU).

Unit: 10^{-3} ADCU

5.3.7 Internal Calibration

The fields 26-27-28 give respectively the Internal Calibration (IC) Level for the Fore, Mid and Aft beam. In general the IC level is very high compared to the noise power, The IC level of the Mid antenna is lower than that of the Fore/Aft antennas.

Unit: 10^{-3} ADCU.

6 ASPS Level 2.0 Product

6.1 Introduction

The ASPS level 2.0 product has the same format structure (MPH, SPH and DSR) as the other ASPS products, one DSR is equivalent to one line of 19 nodes in nominal resolution and 41 nodes in high resolution.

6.2 Specific Product Header

The SPH gives an overview of the quality of the source packets thus the performance of the product.

6.2.1 Product Description

6.2.1.1 Product Type (bit 1)

This flag indicates the type of the product, is set to 0 when the product is ASPS.

6.2.1.2 Product Resolution (bit 2)

The processor can operate in two resolution levels. The nominal resolution corresponds to 50 km spatial resolution (25 km grid spacing), and in this mode each line contains 19 nodes. High resolution corresponds to 25 km spatial resolution (12.5 km grid spacing) and each line contains 41 nodes, the flag is set when the high resolution mode is used.

6.2.1.3 Wind Field Ambiguity removal (bit 3)

The Wind Field ambiguity removal selects the most likely solution from the solutions provided at each node by the retrieval algorithm. This flag is set to 0 when the wind field removal is *not* applied. In that case, the wind solutions are ranked by increasing Euclidean distance (smallest Euclidean distance first) [AD 5].

6.2.1.4 Spatial filtering methods (bit 4-5)

The scatterometer product consists of a grid of points (nodes) separated by (approximately) 25 km along-track and 25 km across-track (nominal resolution, 12.5km in high resolution), in order to increase the measurements accuracy, samples taken within a certain area (area of integration) around each node are spatially averaged using a separable Hamming-weighting [AD 7][AD 11][RD 11].

The flag is set to 0 when a separable Hamming window is used, set to 1 when a radial Hamming window is used and set to 2 when a radial Blackman window is used.

6.2.1.5 Wind Retrieval settings (bit 6-7)

6.2.1.5.1 C-Band model Distance used (bit 6)

This flag indicates which distance has been applied to initially rank the wind solutions. It is set to 0 when the Euclidean distance is used and set to 1 when maximum likelihood distance is used for the initial ranking.

6.2.1.5.2 Wind retrieval method (bit 7)

Two versions of the wind retrieval algorithm are implemented, a so-called “fast” wind retrieval and a so-called “precision” wind retrieval. The precision algorithm uses an analytical description of the model function and uses a Nelder-Mead method to find the minimum distance between the measurement and the model. The fast method uses a pre-computed table containing the σ^0 value for each wind speed, direction and incidence angle, the precision is limited by the table’s size [AD 5][AD 6].

The flag is set to 0 if the fast wind retrieval method was used and set to 1 if precision wind retrieval method was used.

6.2.2 Number of nodes with valid sigma

A sigma nought measurement validity is indicated by the beam flags in the Node Confidence data –1 field (see below). For a given beam a sigma is valid if the corresponding beam flag is not set. The product provides three fields counting the number of nodes with 3, 2 and 1 valid sigma-nought (fields 3-4-5).

6.2.3 Total number of flagged nodes

The ASPS 2.0 specific product header contains 17 fields reserved to count the total number of nodes flagged with different flags listed hereafter: land, Ice, arcing, Kp, frame checksum error, Noise power, Internal calibration, Doppler compensation CoG, Doppler compensation StDev, Doppler shift, Yaw angle, wind (at least one wind speed/direction/distance solution calculated), low wind, high wind, distance from C-band model, wind speed bias and wind direction bias. The description of each flag is given below.

6.2.4 Wind bias and wind distance

The mean wind speed and direction biases are stored in field 23 and field 25. The bias is the difference between the wind vector obtained from the scatterometer measurements (the one selected by the ambiguity removal algorithm) and the meteorological wind used as background in the ambiguity removal. The wind speed standard deviation is stored in field 24. The fields 26-66 contain the mean distance from the C-Band model, represented as an array of 41 cells (high resolution) where each cell contain the mean distance of the corresponding node; in case of nominal resolution only the first 19 cells should be considered [AD 5][AD 6].

The mean wind speed/direction bias and the wind speed standard deviation are set to the default value 32767 if no meteorological background wind has been used in the wind ambiguity removal.

Units: 10^{-3} m/s (speed bias), 10^{-2} deg (direction bias), 10^{-3} m/s (speed standard deviation), 10^{-3} (mean distance)

6.2.5 Meteo table ID

In the ambiguity removal process (see wind processing [AD 5]) meteorological wind forecasts in form of meteo tables are used as a priori information for the selection of a coherent wind field. These tables are updated every six hours. The fields 69-72 indicate the version of the background winds table used in the ambiguity removal, and the field 72 reports the type of the meteo table used in the processing, which could be an Operational Forecast (PALU), ERA-40 analysis or Operational analysis (OPAN).

6.2.6 Other fields

In addition of the fields listed above the SPH contains the following fields:

- Absolute orbit number: The number of the orbit corresponding to data.
- WSP version
- WSP configuration file version number

6.3 Product Data Set Records

The length and the number of records in the DSR is determined by the product type and is given in the Main Product Header. Each Data record contains information related to one line of nodes.

6.3.1 Header

The Header applies to the whole line, that is to say the 19 (or 41 for high resolution) nodes of the same row have the same header.

6.3.1.1 Data Record number

The index of the line, starting with 1.

6.3.1.2 Mid beam acquisition time (UTC)

The Mid beam acquisition time measured of node 10 (at mid swath). In practice, the reported time is the acquisition time of the sample closest to the node centre. The acquisition time has the following format: dd-MMM-yy hh:mm:ss.ttt (i.e. 22-AUG-2007 04:37:02.519)

6.3.1.3 Sub-satellite track Heading

Indicates the orientation of the satellite for the considered line of nodes. The angle is measured w.r. to North, turning clockwise at time of node 10 (or node 21 for high resolution).

Unit: 10^{-3} deg

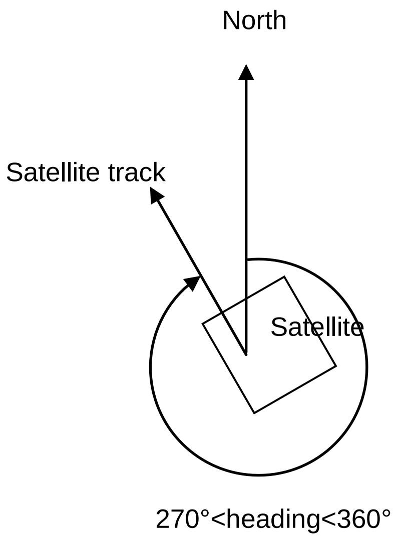

Figure 3: Satellite heading (Ascending pass)

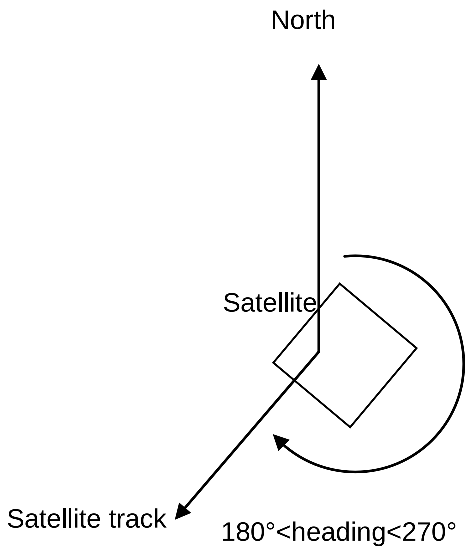

Figure 4: Satellite heading (Descending pass)

6.3.2 Node

The following fields apply to each node of the current line. That is to say every DSR contains as many successive Node fields as the number of nodes on one line. [AD 7] chapter 11 gives a detailed description of the node geometry.

6.3.2.1 Node Time and Position

6.3.2.1.1 Geodetic Latitude/ East Longitude

A negative value denotes South latitude and a positive value denotes North latitude. The longitude is calculated between 0-360 from Greenwich to the East. For example a node situated on the American continent will have approximately a longitude between 240 and 290 deg.

Unit: 10^{-3} deg

6.3.2.1.2 Beam acquisition time

Time since the first node after passing the equator in the ascending direction.

Unit: 200 ms

6.3.2.2 Measurements block

6.3.2.2.1 Sigma nought

The normalized backscattering coefficient σ0 based on the Fore/Mid/Aft beam measurements. The measurement validity is indicated by the beam flag (the 3^{rd}-4^{th}-5^{th} Bit in NCD 1 see below).

A (raw) value of –999999999 indicates an invalid sigma nought. This can occur

- Because the actual measured energy was smaller than the noise power.
- If no sample contributed to the node (empty node).
- For some reason, the measurement is not valid.

In that case, the beam-ok flag is set to zero and the other values (Kp, …) are also invalid.

Unit: 10^{-7} dB

6.3.2.2.2 Incidence angle

The incidence angle is measured at the node, between the Fore/Mid/Aft beam and the vertical to the tangential plane at the concerned node [AD 7] section 11.5 and [RD 11], fig 23 (definition of the node localization).

Unit: 0.1 deg

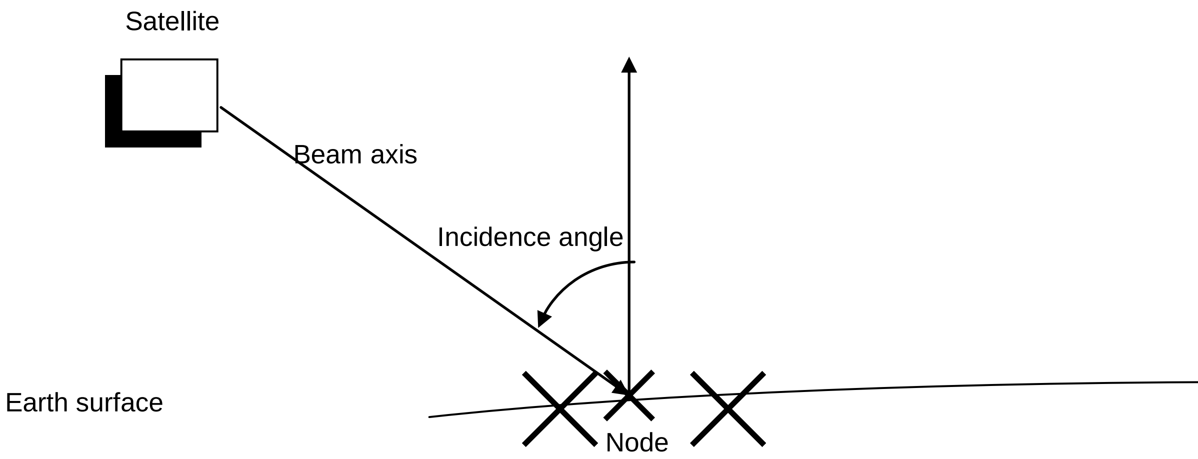

Figure 5: Incidence angle

6.3.2.2.3 Look angle

The antenna look angle is measured clockwise at each node. It is the angle between the North and the Fore/Mid/Aft antenna's beam axis [AD 7] section 11.5 and [RD 11], fig 23: definition of the node localization.

Unit: 0.1 deg

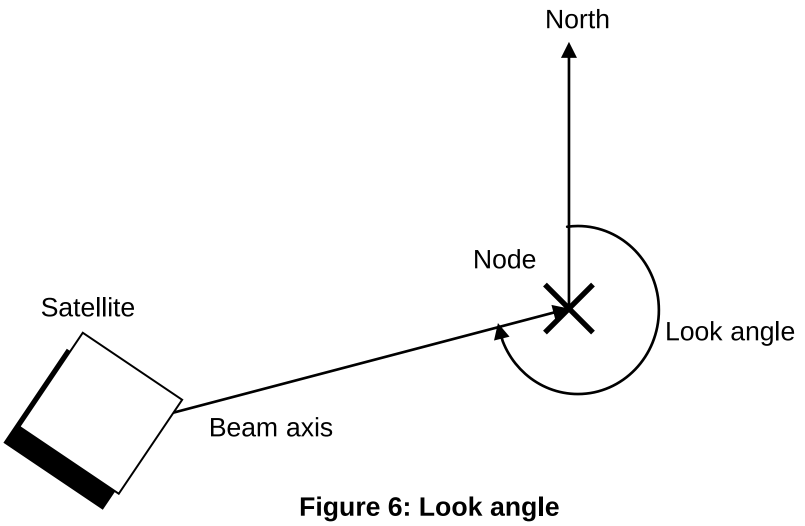

Figure 6: Look angle

6.3.2.2.4 Kp calculation

Kp is the normalized standard deviation of the σ0. Kp can be used to evaluate the accuracy of the measurements [AD 7] chapter 12.

A raw value of 65501 indicates an invalid value.

Unit: 10^{-3} %

6.3.2.2.5 Number of samples

Give the number of raw data samples averaged in the computation of the sigma0 for the given Node and a given beam. Negative values indicate the instrument was in wind/wave mode. There is a minimum value below which the sigma is deemed invalid and indicated as such (beam-ok flag, see below).

6.3.2.3 Wind processing

The wind speed/direction is extracted from sigma0 measurements using a retrieval algorithm based on the C-band Geophysical model, followed by an ambiguity removal step.

The wind retrieval algorithm [AD 5][RD 11] returns up to four wind solutions (wind speed, wind direction and the distance from the solution to the C-band model). These four solutions correspond to the minimum Euclidean distances to the C-band model; the minima are ranked from the smallest to the largest distance (Rank1 to Rank4). Finally the ambiguity removal algorithm use spatial coherence of the wind field to re-rank the first two solutions. The selected Rank is indicated in NCD-2 (Bit 15-16).

The following fields description applies to each node (1-19 or 1-41) and each Rank (Rank1-Rank4).

6.3.2.3.1 Wind speed and wind direction

These fields report the wind speed and wind direction. A raw value of 32767 indicates an invalid wind solution. This occurs in the following cases [RD 11] and [AD 9] p17, 18 :

- The node is over land/ice (see section land/sea flag and Ice flag)
- Low wind (see low wind flag)
- Non-valid measurements (see beam flag)
- Invalid solution resulted from the wind extraction process (see wind speed/direction flags)

The figure below shows the wind direction for all the beams.

Unit: 0.01 m/s (speed), 0,1 deg (direction)

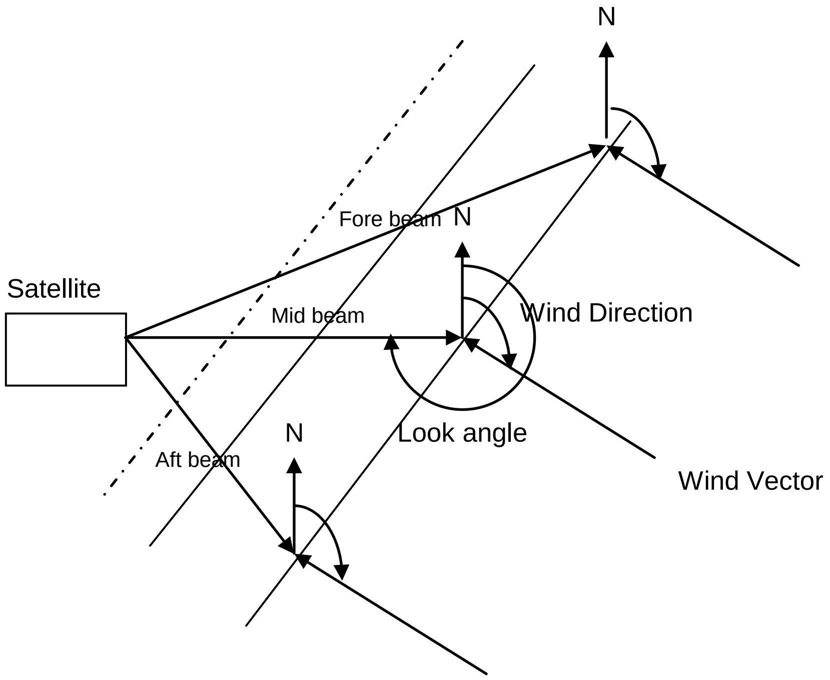

Figure 7: Wind direction

6.3.2.3.2 Distance from the C-Band Geophysical Model Function

This gives the Euclidian distance between the measured σ0 triplet and the C-band model [RD 11], [AD 9] p17, 18.

Unit: 10^{-3}

6.3.2.3.3 Wind bias

Bias of the wind solution with respect to the background wind used for ambiguity removal. The wind speed bias and the wind direction bias are stored respectively in the fileds 33 and 35 and the distance from the C-band model is indicated in the field 32.

Units: 0.01 m/s (speed bias), 0.1 deg (direction bias), 10^{-3} (distance)

6.3.2.3.4 Sea-ice probability

The probability that the node contains sea-ice is given in field 34. That probability is computed using a state-less algorithm described in [RD 17]. The probability is to be understood in a Bayesian framework, i.e. as a limiting case of the frequency of occurrence on the training set used. A probability close to 1 means that sea-ice is present and a probability close to 0 means only open water is present. Values in between means a mixed node.

Units: 0.01 %

6.3.2.4 NCD (Node Confidence Data) – 1

6.3.2.4.1 Summary bits

The summary PCD factor (bit1-Bit2) is set to 0 if all bits of the PCD (NCD-1 and NCD-2) flags are set to 0.

The Summary PCD-1 is set to 1 if one of the NCD-1 flags listed below is not zero.

6.3.2.4.2 Beam flags (bits 3-4-5)

These flags indicate the validity of the measurements performed by the three antennas Fore/Mid/Aft. The measurements are valid if the flag is not set. The flag is set if sigma nought is lower than zero or if the number of samples is smaller than a threshold MIN_NSP (minimum number of source packets needed per node, per beam). In this case sigma, Kp, incidence angle and look angle take default (invalid) values (σ^0=-999999999, Kp=32767, inc=0, look=0).

MIN_NSP (Fore-Aft) =[135 142 149 157 164 171 178 186 193 200 214 222 229 236 243 251 258 265]

MIN_NSP (Mid) = [75 80 84 89 94 99 103 108 113 118 122 127 132 136 141 146 151 155 160]

If one of the sigma triplets is missing, no wind extraction is attempted.

6.3.2.4.3 Doppler compensation flags

See ASPS 1.5 (section 5.2.1.2). The conditions described below are evaluated for each measurement. The flag at node level is set if the flag is set at any measurement contributing to that node.

6.3.2.4.3.1 Doppler Compensation CoG flag (bit 6-8-10)

If the Center of Gravity of the spectrum of the signal after on-ground Doppler compensation is outside the configured interval, the flag is set. The flag is calculated for each beam.

Defined interval: Fore-Mid-Aft beam: [-1000, 1000] Hz

6.3.2.4.3.2 Doppler Compensation StDev flag (bits 7-9-11)

If the standard deviation of the power spectrum of the signal after on-ground Doppler compensation is outside the pre-defined interval, the flag is set. The flag is calculated for every beam.

Defined interval:	Fore and Aft beams:	[1000, 2500] Hz
	Mid beam:	[2000, 2500] Hz

6.3.2.4.3.3 Doppler frequency Shift flag (bits 12-13-14)

The flag is set if the Center of Gravity of the power spectrum of the signal before on-ground Doppler compensation is outside the defined interval.

Defined interval Fore-Mid-Aft beams: [-6000, 6000] Hz

6.3.2.4.4 Yaw error angle flag (Bit 15)

See Section 5.2.3 for the yaw error angle explanation and Section 5.3.1.3 for the yaw error angle flag description. For more detailed information see [AD 7] chapter 9 and [RD 14].

This flag indicates whether the Yaw error angle is outside the pre-defined interval.

6.3.2.4.5 Frame checksum flag (Bit 16)

See ASPS 1.5 (section 5.2.1.7)

6.3.2.5 NCD (Node Confidence Data) - 2

6.3.2.5.1 Summary Bit (bit1)

This bit is zero when all other bits of the NCD-2 are set to zero.

6.3.2.5.2 Internal Calibration flag (Bit 3)

See Section 5.2.5 for Internal Calibration measurement and Section 5.2.1.5 for the flag description.

The flag is set if the internal calibration value of one of the source packets contributing to one of the sigma nought triplets of the node is outside the pre-defined interval.

6.3.2.5.3 Arcing flag (Bit 4-5-6)

See Section 5.2.1.6 for the arcing flag description.

The arcing flag is set if one of the arcing flag of one of the source packet contributing to the considered sigma-nought of the node is set.

6.3.2.5.4 Noise Power flag (Bit 7)

See Section 5.2.4 for the noise power measurements and Section 5.2.1.4 for the flag description.

The noise power flag is set if the noise power flag of one of the source packets contributing to the node is set [RD 11] and [RD 14].

6.3.2.5.5 Limit of Kp value flag (Bit 8)

The kp flag is set if one of the kp value of the triplet is outside a pre-defined interval.

Defined interval = [0.0, 200] or [0%, 20%]

6.3.2.5.6 Distance from C-Band Model Flag (Bit9)

This flag is set when the distance of the Rank 1 solution to the C-band model exceeds a defined threshold.

Maximum distance threshold = 100

6.3.2.5.7 Wind Speed /Direction bias flag (Bit 10-11)

The flag is set when the wind speed/direction bias exceeds a pre-defined threshold.

6.3.2.5.8 Low/High wind flag (Bit 12-13)

The wind speed is compared to a threshold and the flags are set from the resulting comparison.

6.3.2.5.9 Ambiguity Removal Flag (Bit 15-16)

This flag indicates which solution among the four solutions is selected by the ambiguity removal algorithm. The flag is set to 0 if Rank 1 was selected, set to 1 if Rank 2, set to 2 if Rank 3 and set to 3 if Rank 4 was selected.

6.3.2.6 Geophysical PCD

6.3.2.6.1 Land-Sea Flag (bit 1)

The flag is set if the node is over land.

6.3.2.6.2 Ice flag (bit 2)

The flag is set if the node is over Ice.

7 ASPS UWI Product

For compatibility reasons UWI product generation is maintained by the ASPS subsystem.

The UWI product is very similar to ASPS 2.0 therefore we describe only the different fields.

7.1 Introduction

The UWI product has the same format structure (MPH, SPH and DSR) as the other ASPS products, the DSR contain 361 data set records.

7.2 Specific Product Header

7.2.1 Product Confidence Data for processing

7.2.1.1 Processing equipment status flag (bit 1 and 2)

This flag is set to 1 if there are any problems with the equipment and set to 2 if the equipment failed during the product generation.

7.2.1.2 I/Q imbalance flag (bit 4)

This flag is set when either the I or Q noise channels exceeds its thresholds. The I mean noise power and Q mean noise power for each beam are reported on the fields 12 to 17].

7.2.1.3 Internal calibration level flag (bit 5)

See Section 6.3.2.5.2.

The flag is set if the internal calibration value of one of the source packets contributing to one of the sigma nought triplets is outside the pre-defined interval.

7.2.1.4 Blank product flag (bit 6)

The flag is set if the 3 beams of all nodes of the product are invalid. [RD 16].

7.2.1.5 Doppler Compensation CoG flag (bit 7)

See Section 6.3.2.4.3

The flag is set if the Center of Gravity corresponding to any beam is out of pre-defined interval.

7.2.1.6 Doppler compensation StDev flag (bit 8)

See Section 6.3.2.4.3.

The flag is set if the standard deviation corresponding to any beam is out of pre-defined interval.

7.2.1.7 Type of meteo table used in the processing (bit 9 and 10)

This flag indicates the type of the meteo table used in the processing, which could be an Operational Forecast (PALU), ERA-40 analysis or Operational analysis (OPAN).

7.2.2 Position parameters

The fields 2, 3 and 4 give respectively the latitude, longitude and the heading orientation in degree (see Section 6.3.2.1 for an explanation of each field). The field 5 indicates the mean distance (meter) between two successive along track nodes at product center.

7.2.3 Doppler Compensation

7.2.3.1 Center of Gravity

See Section 5.3.1.2.1.

The fields 6, 8 and 10 give the center of gravity of the averaged power spectrum for the Fore, Mid and Aft beam.

Unit: 2.344 Hz

7.2.3.2 Standard Deviation

See Section 5.3.1.2.2.

The fields 7, 9 and 11 give the standard deviation of the averaged power spectrum for the Fore, Mid and Aft beam

Unit: 2.344 Hz

7.2.4 Noise power

See Section 5.2.4.

The values of noise power averaged over all Data Set Records for the both components I and Q (separately) and for each beam (Fore-Mid-Aft) are given respectively in the fields 12-17.

Unit: 10^{-3} ADCU.

7.2.5 Internal Calibration

See Section 5.2.5.

The values of Internal calibration level monitoring factor for each beam (Fore-Mid-Aft) are given respectively in the fields 18,19 and 20.

Unit: 10^{-3} ADCU.

7.2.6 Operation Mode

The mode of operation of the product is set by the first mid beam source packet contributing to spatial filtering for the first node (near swath) in the center row of a product. The mode is indicated by the bit 1 and 2 of this field, it is set to 0 when the wind mode is operating, set to 1 when the wind/wave mode is operating and set to 2 when there is no data found to identify the mode.

7.2.7 Parameter tables

The fields 22 to 71 contain a list of parameter tables ID (e.g. threshold tables…).

7.2.8 Meteo tables

See Section 6.2.5.

The meteo tables ID are stored in the fields 65 to 68, and the table type is stored in the SPH.

7.2.9 Other fields

And the fields 63 and 64 give respectively the WSP version number and the WSP configuration files identification number.

7.3 Product Data Set Records

The first field gives the Data Record Number, starting with 1

7.3.1 Node position

See Section 6.3.2.1.

7.3.2 Measurements block

See Section 6.3.2.2.

7.3.3 Wind speed and direction

See Section 6.3.2.3.

The both fields (19 and 20) take the default values (255) if the wind extraction was not possible.

Unit: 0.2 m/s (speed), 2 deg (direction)

7.3.4 Product Confidence Data

7.3.4.1 Summary PCD factor (bit 1)

See Section 6.3.2.4.1.

7.3.4.2 Beam flags (bit 2-3-4)

See Section 6.3.2.4.2.

7.3.4.3 Arcing flags (bit 5-6-7)

See Section 6.3.2.5.3.

7.3.4.4 Limit of Kp value flag (bit 8)

See Section 6.3.2.5.5.

7.3.4.5 Land-Sea flag (bit 9)

See Section 6.3.2.6.1.

7.3.4.6 Ambiguity removal flag (bit 10)

See Section 6.3.2.5.9.

7.3.4.7 Scatterometer wind flag

7.3.4.8 Meteorological background flag

7.3.4.9 Maximum likelihood distance flag

7.3.4.10 Frame checksum flag (bit 14)

See Section 6.3.2.4.5.

7.3.4.11 Yaw angle

See Section 5.2.3 for a yaw error angle explanation and Section 5.3.1.3 for a yaw error angle flag description.

7.3.4.11.1 Yaw angle computation flag (bit 15)

This flag is set when the estimation of the yaw angle failed. Estimation can fail if the spectrum of the received signal is too distorted.

7.3.4.11.2 Yaw angle error flag

This flag is set when the yaw angle is out of the pre-defined interval.

8 ASPS UPG product

8.1 Introduction

The ASPS UPG is an experimental product processed from the EWIC data and a user-provided grid. It includes the sigma naught triplets and the retrieved wind field for each node. Each data set record contains the sigma naughts and wind field corresponding to one grid node. The product sampling depends on the grid of nodes provided.

The product contains also specific fields (e.g. Ice flag, spatial filter). The quality flags have the same definitions as ASPS 2.0.

8.2 Input data

The processor needs echo source packets and associated data. For ERS measurements, EWIC products are used and for METOP measurements, ASCAT level 0 products (see section **Error! Reference source not found.**) are used. In addition a grid of nodes must be provided.

8.2.1 User-provided grid Input format

The locations of the nodes are provided via an external text file. Each line in the file corresponds to one node. And each line is composed of 4 comma-separated numbers. The first number is an integer and indexes the node, the second number is and unused integer, the third floating point number is the longitude (in decimal degrees) and the fourth field is a floating point number with the latitude (in decimal degrees). An extract of a sample user-provided grid file is shown in the table below:

1	0000000000	11.250000	58.282526
2	0100000000	-168.750000	58.282526
3	0100000001	-168.750000	58.518418
4	0100000010	-168.750000	58.754575
5	0100000011	-168.750000	58.990994

8.2.2 Spatial filter parameters

The type of the filter is configurable, the user can choose between Hamming and Blackman windows, future upgrades may add other filter types.

The across and along window length parameters are used usually to define the separable (rectangular) window widths in both directions..

8.3 Processing

The main differences between this product and the previous products are the locations of the nodes and the spatial averaging. The locations of the nodes are not anymore generated by the processor based on the satellite orbit since they are read from an external file and can thus be arbitrary.

8.4 Output product format

The output format is nearly the same as ASPS 2.0 (The node structure is exactly the same). The data set record section is organized as a sequence of N (number of nodes in the provided grid) nodes instead of rows of (19/41) nodes.

8.4.1 Specific product header

Same as ASPS2.0, see section 21

8.4.2 Data set record

Same as ASPS2.0, see section 23

Each data set record contains one node information.

9 ASCAT Level 2C product

9.1 Introduction

ASCAT level 2C is an experimental product processed from ASCAT measurement data [AD 12][AD 13][AD 14]. The level 2C product contains four wind field solutions, the ice flag and more quality flags than the level 1B product processed by EUMETSAT. The rows of nodes contain information on the two ASCAT swaths left and right. Therefore each row contains 42 or 82 nodes respectively for nominal resolution (25 km) and high resolution (12.5 km). Nodes 0-20 or 0-40 are related to the left swath and nodes 21-42 or 41-82 are related to the right swath.

9.2 Input data

The processor needs one of the following input data: Level 0, level 1A or level 1B full resolution product, a full description of these products can be found in [AD 12][AD 13][AD 14]. In addition, the processor needs the processing and instrument parameters configuration files. Examples of file names are given in the table below:

Data files	
Level	Name
Level 0	ASCA_xxx_00_M02_20081205115100Z_20081205133300Z_N_O_20081205132701Z
Level 1A	ASCA_xxx_1A_M02_20081205115059Z_20081205133258Z_N_O_20081205133651Z
Level 1B full	ASCA_SZR_1B_M02_20081205115100Z_20081205133258Z_N_O_20081205133719Z
Configuration files	
Type	Name
Instrument	ASCA_INS_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081029000204Z_xxxx_FM2xxxxTCE
Processing	ASCA_PRC_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081029000304Z_xxxx_FM2xxxxTCE

9.3 Processing

The processing of ASCAT measurement data differs from the processing of ERS measurement data. This difference is mainly due to the fact that ASCAT transmits long pulses with Linear Frequency Modulation ('chirps'), while the ERS scatterometer transmits short continuous-wave-pulses (CW-pulse). Moreover the difference in the instrument design (AMI: 3 antennas vs ASCAT: 6 antennas) and acquisition geometry (incidence angle range) imply different processor implementations.

The processing operations applied to the ASCAT data depends on the level of the input product. In case of level 1b full resolution input, which contains the geo-located sigma nought at raw resolution, the processor performs node generation, followed by a sample selection and a spatial averaging in order to provide sigma nought on 25 km or 12.5 km grid. In case of level 1A, which contains the echo source packets, geometry information and normalization factors, these echos are corrected and normalized by applying the functions provided by the product. In case of level 0, in addition to the samples geo-location, all the functions, namely, on-board receiver filter shape, power gain product and normalization factors, are computed by the processor.

For detailed description of both processors see [AD7].

9.4 Output product format

The product can be output in either level 1B or in ASPS 2.0 format. The main difference between the two formats is that only the level 2 contains wind field and more quality flags. The level 1B product format is described in [AD 12], Hence, only ASPS2.0 format is described in this document.

9.4.1 Specific product header

Same as ASPS2.0, see section 21.

9.4.2 Data set record

Same as ASPS2.0, see section 23.