The ENVISAT Radar Altimeter System

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Abstract. The Altimetry mission on ENVISAT will extend the time series of observations started by ERS-1 and ERS-2. The new features of the RA2 mission will improve the quality of the measurements in many aspects. The new on-board algorithms for tracking the surface, the larger range window and the extra low resolution mode will all improve data acquisition over the important ice sheet margins and over most land and wetland surfaces. New, in-situ ionospheric corrections from the dual frequency radar will be a significant improvement on the model-based corrections used in previous missions. The more precise DORIS orbit will improve the precision of all measurements, particularly in near real-time. The near real-time products are built with the same algorithms than the off-line final precision products, only some auxiliary input data may differ, thus providing already in 3 hours near-high quality Geophysical Data Record Products to support near real-time oceanography.

Keywords. ENVISAT, Radar Altimetry, Microwave Radiometer, DORIS, Data processing Algorithms, Data products, Geophysical Data Records, Near real-time.

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1 Introduction

The Radar Altimetry Mission encompasses four out of the ten instruments on board the European Earth Observation Satellite: ENVISAT (Environmental Satellite). The main objective of the ENVISAT Altimetry Mission is to ensure the continuity of the altimetric observations started with the ERS-1 satellite in 1991 and continued by ERS-2, launched in 1995. The science mission objectives are similar to that of ERS but the length of the altimeter record will exceed 15 years and will permit to examine changes on inter-annual to decadal time scales of:

- global and regional sea level
- dynamic ocean circulation patterns
- significant waveheight and wind speed climatology
- ice sheet elevation, sea-ice thickness

Another objective is to provide for the enhancement of the ERS mission, notably in ocean and ice missions, by improving the quality of the measurements and monitoring capabilities for:

- Ocean mesoscale, significant wave height and wind speed in near real-time
- Marine geophysics – Polar oceans
- Ice sheet margins – sea ice
- Lakes, wetlands and river levels
- Land
- Ionosphere, water vapor

The ENVISAT Mission is part of a coherent European Earth Observation Programme ensuring the long-term provision of continuous data sets, essential for addressing environmental and climatological issues. As such, the ENVISAT Altimetry Mission is a contribution to international Earth Observation programmes such as International Geosphere Biosphere Programme and World Climate Research Programme. ENVISAT also aims at the promotion of applications and commercial use of Earth Observation data, namely, for Altimetry, the operational sea-state and ocean circulation forecasting.

2 Oceanographic Applications

The Ocean covers 70% of the Planet and plays a key role in regulating the global climate. The ocean

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is the main reservoir for heat as well as a powerful vehicle to transport warm water masses poleward. It has the capacity to intake (but also reject) significant amounts of carbon dioxide, one of the greenhouse gases. It also supports a cost-effective type of transportation of goods, is a milieu where to discover new oil fields, is a feeding ground for fish and sea-food to nourish the ever-growing human population. The oceanographic mission objectives of ENVISAT are derived from the ERS results. To resolve low frequency signals in the ocean spectrum and to further understand oceanic processes a longer time series is however needed. The Oceanographic mission objectives of ENVISAT Altimetry are dynamic topography monitoring, mesoscale variability, seasonal and interannual variability, mean global and regional sea level trends, marine geophysics – especially in polar oceans even covered with sea-ice -, sea-state monitoring. The objectives are to be met with data products available either in near real-time (3 hours), in quasi near real-time (2-3 days) or with the highest precision off-line products.

Seasonal and interannual variability has an important impact on climate. Planetary waves propagate from months to seasons across basins to adjust the ocean in response to wind forcing. Interannual variations of the seasonal or annual cycles have a direct and sometimes dramatic impact of the global climate, well illustrated by the El Niño-Southern Oscillation (ENSO) (Fig. 1). The data serve mainly to tune and evolve global ocean and atmosphere models, to better understand the ocean-atmosphere interaction and the underlying processes.

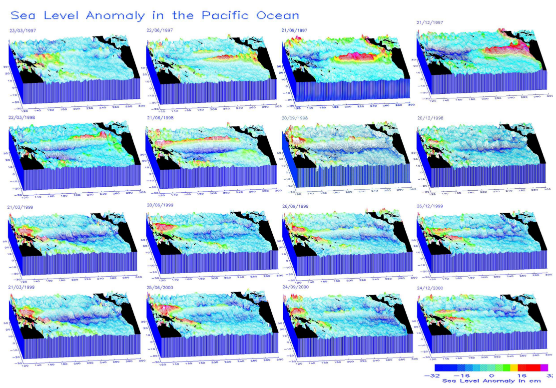

Fig. 1 Series of Sea Level Anomaly (cm) in the Tropical Pacific. Each row is one year –'97, '98, '99, '00– with one sample of the sea level anomaly field at each season, by column: March, June, September and December. The strong El Niño Event of late '97 followed by a La Niña event is clearly visible. A film of such 3D vignettes helps the researcher "visualize" the wave propagation involved in such events. Each weekly field can be assimilated in an ocean model. (SLA data processed by R. Scharroo, DEOS, NL, graphics processed at ESA/ESRIN.)

The ocean is vast and hosts a full spectrum of signals. One orbiting satellite alone cannot pretend to cover that spectrum. There are significant advantages in merging the data from two or more Altimetry missions sampling the Earth with different orbital patterns. A good illustration is the enrichment in space resolution of the mesoscale variability field computed with merged data from ERS and TOPEX/POSEIDON (Fig. 2), which are in the same orbital configuration as ENVISAT and Jason [1].

3 Ice and Sea-Ice Applications

Polar ice sheets and sea ice play a vital role in the global climate system due to both their effectiveness in reflecting incoming solar radiation, and as a huge store of freshwater. Sea Ice acts as a barrier between the ocean and the atmosphere, cutting off exchanges of heat, moisture and momentum. Brine expulsion during seasonal sea ice formation and intense cooling of the sea surface through polynyas drive the thermohaline circulation of the oceans. This process creates the dense bottom water in the Pacific, Indian and Atlantic Oceans. It is responsible for the poleward transport of heat in the North Atlantic, which ensures mild winters for Western Europe.

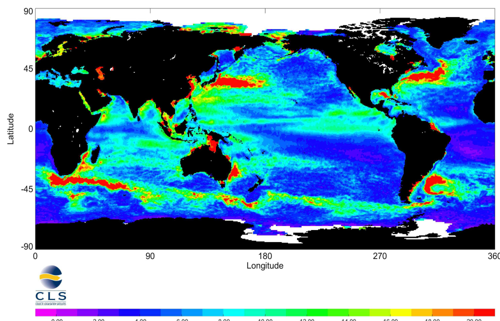

Fig. 2 Root mean square of sea level anomaly (in cm) obtained from merged ERS and T/P data from 0ctober '92 to October '97. Note the high resolution of the map brought by the denser ground track mesh of ERS. (Courtesy of PY LeTraon, CLS.)

This critical component of the climate system is not well represented in current climate models but is clearly important if accurate predictions of the consequences of global warming are to be made. Global warming is predicted to be greatest in the Arctic region. If Arctic sea-ice is lost, it could change the circulation pattern of the North Atlantic resulting in severe winters for Western Europe. Melting of the Greenland and Antarctic ice sheets would contribute to global sea level rise.

The vast, remote and inhospiTable polar regions can only be effectively monitored through a global remote sensing system. Polar regions experience between 50 and 90% cloud cover and spend long periods in darkness, which limits the observations of optical and thermal infrared instrument. However, this task is particularly well served by satellite-borne active Radar instruments.

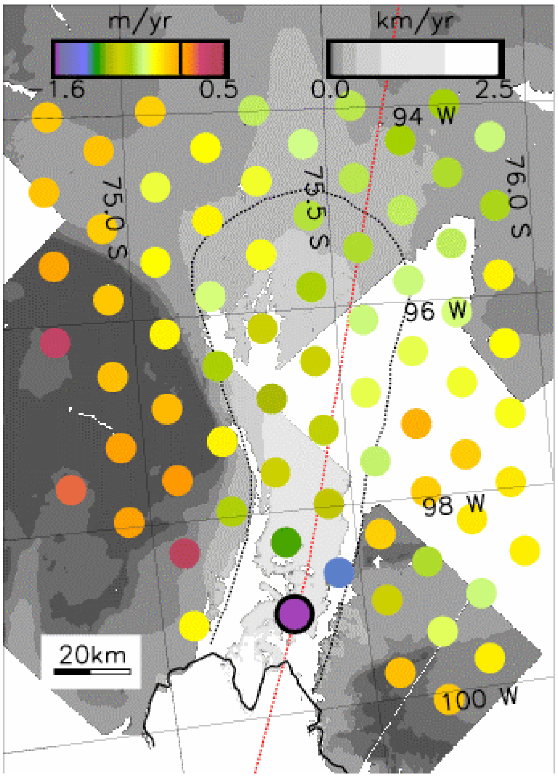

Fig. 3 Rate of elevation change of the lower 200km of the Pine Island Glacier. The coloured dots are located at crossover points and have an area equal to the RA footprint. The grey shading is the velocity field derived from ERS SAR data. (Produced at MSSL/UCL.)

Techniques developed using the ERS Radar Altimeters have allowed the monitoring of ice sheet mass balance and the derivation of sea ice thickness through the measurement of freeboard. Continuous Altimetric measurement of the Antarctic ice sheet since 1992 has revealed for the first time a significant thinning of a West Antarctic glacier (Fig. 3).The Pine Island Glacier has retreated and thinned inland by as much as 10 metres. It is important to continue this monitoring with the ENVISAT RA–2 to establish if this retreat will accelerate the mass discharge from the West Antarctic Ice Sheet.

Balance velocities, i.e., depth-averaged velocity required to maintain the ice sheet in a state of balance at a given point for a given surface mass flux, have been estimated over the Antarctic grounded ice sheet using ERS altimeter data (Fig. 4). Balance velocities depend mainly on the surface slope and is modulated by surface mass balance and ice thickness. Their study contributes to the understanding of ice sheet dynamics and their response to climatic forcing.

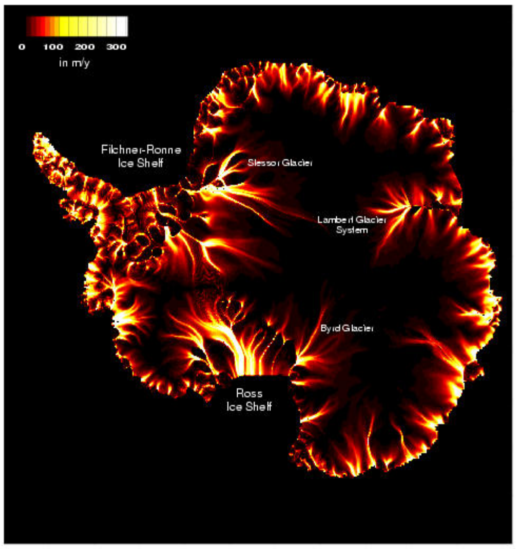

Fig. 4 Balance velocities estimated from ERS Altimeter. (Produced by F. Remy, LEGOS)

Sea-ice thickness can be sampled using moored or submarine mounted Upward Looking Sonar (ULS). Moored ULS are only sampling a fixed location and Submarines tend to sample limited areas for only a few weeks each year. This is not sufficient to deduce full regional and seasonal variations. Freeboard measurement by satellite is the only technique which can measure sea ice thickness at the time and length scales that climate investigation demands. The technique has been developed using ERS Altimeter data, verified using the ULS measurements and implemented in the ENVISAT RA-2 ground processing. Results from ERS suggest that the recently reported thinning of Arctic sea ice may be localised (Fig. 5). Continued monitoring by the ENVISAT RA–2 is critical to establish long term trends.The ENVISAT Altimetry mission will extend and improve the monitoring of

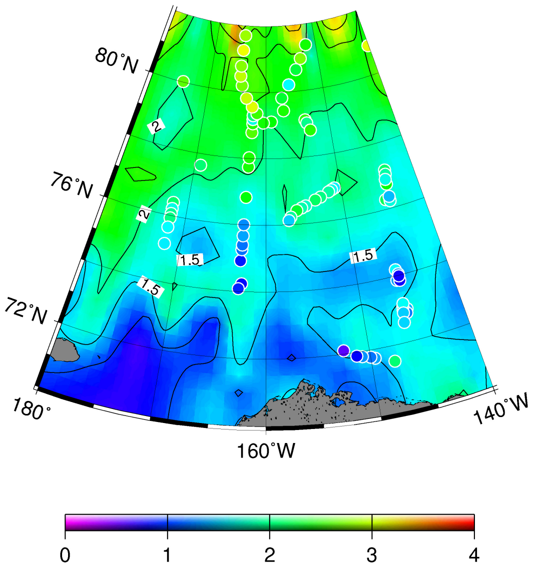

Fig. 5 A comparison between RA derived sea ice thickness (m) and sparse measurements from Upward Looking Sonar on submarines (dots). Both sets of measurements are from October 1996. (Produced at MSSL/UCL.)

the cryosphere in the climatically important polar regions.

4 Land Applications

Over land the Radar Altimeter echoes have a non-predicTable shape. This is why this field of applications has slowly and painstakingly matured. A remarkable result from the ERS-1 Geodetic phase is the Altimeter Corrected Elevation Model ACE [2] which replaces more than 28 % of the most precise Global Digital Elevation Model (GDEM), GLOBE [3], with an altimeter derived height dataset and corrects another 17 % (Fig. 6). The ENVISAT Altimeter, even if it will not fly an orbit as dense as the ERS-1 Geodetic mission, will enhance this result in terms of accuracy and new areas never measured before. The ACE newly generated product, released end February 2001, is part of the Market Development Programme within the ESA Earth Observation Envelope Programme.

Another Land application that has been painstakingly attempted since SeaSat is river and lake levels monitoring. Radar Altimetry is a powerful tool for this application as it unifies all the worldwide river and lake level measurements, even the ones most remote or inaccessible, with a unique gauge. Being able to measure the global river levels, be it only once or twice a month would be a significant contribution to Hydrology.

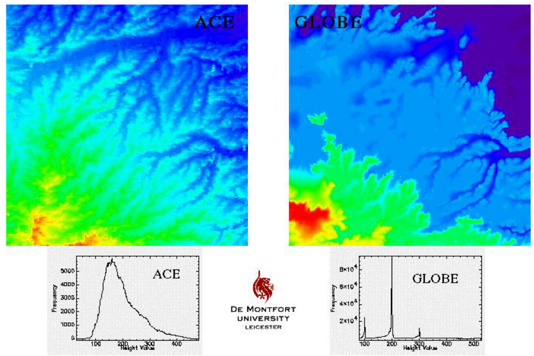

Fig. 6 This figure compares the ERS altimeter derived map (ACE) of part of the Amazon basin together with the GLOBE map of the same area (73-68W, 11-6S). Note the 100m contours in the GLOBE histogram and the fine detail –rich histogram– in ACE. (Produced by Prof. Ph. Berry, De Montfort University, UK)

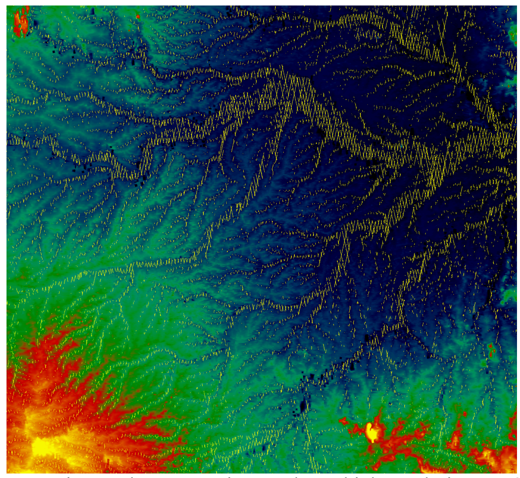

Fig. 7 River echoes superimposed on high-resolution ERS-1 Altimeter derived topography and river network. The plot shows a 11x12 degree square of South America containing part of the Amazon basin (15-4S, 75-63W) with the ACE GDEM heights (high: yellow through red low: green to dark blue) overlaid with ERS-1 Geodetic Mission “water type” returns in sulphur yellow. Note that this part of the ACE GDEM is totally derived from Altimetry, which has provided a huge increase in spatial and vertical resolution over previous GDEM models for this region rich in river networks. (Produced by Prof. Ph. Berry, De Montfort University, UK)

Its has been demonstrated with ERS Altimeter that echoes from an inland water surface are clearly discernible and convertible to river or lake levels. The inclusion of an Ice mode on ERS 1 and ERS 2 has led to a huge increase in the percentage of the Earth's land surfaces from which valid altimeter echoes have been obtained. This has also resulted in coverage of the majority of the world's river systems, raising the exciting possibility of a ten-year time series of river height data. The inclusion of a third tracking mode on ENVISAT should further increase the land hydrology potential of Altimetry with even greater river coverage, as well as continuing the hydrology time series. To illustrate the ERS/ENVISAT contribution, Fig. 7 shows part of the Amazon river system, with 35-day river crossings from ERS-2 superimposed on an altimeter derived rivers map.

5 ENVISAT Radar Altimetry Mission Characteristics

ENVISAT will cover high latitude ocean, ice sheet and land surface areas not covered by TOPEX/POSEIDON, GFO or Jason. The 35-day repeat cycle, on same ground track as ERS-2, allows for dense cross-track spacing and optimum synergistic combinations with the simultaneous operating Jason/GFO altimetric missions for a wide range of applications. This advantage has clearly been demonstrated from the current ERS missions, together with data from TOPEX/POSEIDON [4]. The ENVISAT orbit characteristics are reported in Table 1.

Table 1.

ENVISAT Orbit Characteristics	
orbit type:	sun synchronous
ascending node:	22:00 MLST
inclination:	98.5°
altitude:	~ 800 km
orbits per day:	14 11/35
repeat period:	35days (501 orbits)
ground-track spacing:	~80km at Equator
ground-track repeat: ±1 km	

6 The Radar Altimetry Payload

The Altimetry set of instruments is composed of:

RA-2: multi-resolution, self-adaptive, dual-frequency radar altimeter;
MWR: dual frequency nadir viewing microwave radiometer;
DORIS: dual frequency Doppler tracking system for orbit estimation.
LRR: Laser retro-reflector for tracking.

7 The ENVISAT Radar Altimeter

RA-2 belongs to a new generation of radar altimeters. One of the major improvements of the RA-2 with respect to ERS RA is its second frequency (3.2 GHz, S-Band) for compensation of delay due to ionospheric electron density. It is designed for low height noise (Pulse repetition frequency of 1795 Hz) and improved waveheight accuracy with two additional bins on the echo leading edge. Its tracking follows a novel strategy allowing for a robust on-board collection of accurately quantified radar echoes over all surfaces: a new feature is the Model Free Tracker, robust at handling non-ocean like echoes, sampled over 128 bins. RA-2 has three different range resolutions adapted to different scenarios (ocean, ice sheets, sea ice, wetlands, ice edge, land) and thus to avoid losing track. Whereas previous altimeters had data dropouts in difficult terrain areas, RA-2 will remain longer in tracking, providing valuable data for applications involving ice edges, land, lakes, wetlands, coastal zones. The switching is controlled autonomously. RA-2 has the capability to preserve a small amount of individual echoes (unaveraged echoes, at 1795 Hz). These echoes will allow engineering and scientific studies.

Table 2. RA-2 has three different resolution modes

bandwidth (MHz)	resolution (m)	range window (m)
320	0.5	64
80	2	256
20	8	1024

No geophysical parameter estimation is performed on-board where computer resources are limited and fully dedicated to collecting high quality echoes, so retracking is applied on-ground to create each product, including the ones delivered in near real-time. To optimise retrieval for each kind of surface the waveforms are processed in different complementary manners: four retrackers – ocean, sea-ice, ice1, ice2 – are run in parallel all the time (over all surfaces). Their outputs are delivered in the Geophysical Data Record product (GDR) and in the waveform product (SGDR). Land echoes are so complex, diverse and unpredicTable that they cannot be handled by a single retracker: the land applications users will access the waveforms. For more details in instrument operation and performance see [5].

8 The ENVISAT Microwave Radiometer

The primary mission of ENVISAT MWR is the determination of tropospheric water vapour path delay correction for RA-2. Additional applications of MWR data include surface emissivity, ice sheet dynamics, sea-ice mapping, land surface temperature, but imaging radiometers are most likely used for these applications. The ENVISAT MWR has the same concept and specification as the two ERS MWRs, but it has a new design and shares the Instrument Control Unit with DORIS, (was ATSR on ERS). It is a Dual frequency, Dicke radiometer (1 kHz switch frequency), near-nadir viewing using offset parabola antenna and two feeds. The parabola is fixed, whereas it needed deployment on ERS. The MWR characteristics are given in Table 3.

Table 3. MWR Characteristics

Frequency:	23.8 GHz	36.5 GHz
Bandwidth:	400 MHz	400 MHz
Polarisation:	Linear	Linear
Integration	150 ms	150 ms
Dynamic Range:	3 – 313 K	3 – 313 K
Footprint Size:	20.5 km	19.2 km
Footprint Centre:	25km behind	35 km ahead
Sensitivity:	0.6 K	0.6 K
Accuracy:	< 3 K	< 3 K
Data Rate:	0.427 kbps	

The calibration is based on a sky-horn (cold load) and an internal hot load. It is performed about twice a minute, or less on demand. All MWR measurements are delivered in the RA-2 products; hence they are called RA-2/MWR data products. For more details bout the RA-2/MWR data products see Benveniste et al. [6].

9 DORIS on ENVISAT

The DORIS system (Doppler Orbitography and Radiopositioning Integrated by Satellite) was developed by CNES (Centre National d'Etudes Spatiales), IGN (Institut Géographique National) and GRGS (Groupe de Recherche en Géodésie Spatiale) to meet science and operational user requirements in very precise orbit determination. DORIS is an uplink radio system based on the Doppler principle. It measures relative velocity between the orbiting satellite and a dense, permanent network of ground based beacons. The basic principle of the DORIS system is explained in [7]. A discussion of the role of DORIS to realize the full potential of Altimetry may be found in [8].

For ENVISAT, the accuracy of the real-time orbit provided by the DORIS/DIODE ("Détermination Immédiate d'Orbite par Doris Embarqué") onboard software has been estimated at the level of 40 cm from various simulations of the radial component. It is expected that the 30 cm level will be reached using an upgraded version of the software. The altimeter near-real-time products will benefit from such a high quality real-time orbit.

The accuracy of the radial component of the offline precise orbit has been specified at the level of 10 cm. Even more challenging, a figure of 3 cm has often been quoted as a goal. Experience gained with TOPEX/POSEIDON and the SPOT satellites concerning precise orbit determination as well as simulations indicate that the 10 cm specification will be reached with no major difficulty, whereas the 3 cm goal is a challenge that the ENVISAT Precise Orbit Determination (POD) team will actively participate in. Interactions with the Jason-1 POD group as well as with teams of other geodetic missions (e.g. CHAMP, GOCE, GRACE) will help optimising the performances of the orbit computation using DORIS and laser tracking measurements.

10 The ENVISAT Laser Retro-Reflector

A Laser Retro-Reflector is mounted on the Earth facing panel close to the RA-2 antenna to support satellite ranging for precise orbit determination and RA-2 range measurement calibration. Laser tracking provides the distance between the spacecraft and the station and is assimilated in precise orbit determination. It will be extensively used during the commissioning phase and regularly during the mission to verify the stability of the positioning system.

The LRR is a passive device that will be used as a reflector by ground-based laser ranging stations using high power pulsed lasers. The operating principle is to measure on ground the round-trip time of laser pulses reflected from the LRR. LRR is composed of corner-cubes which are designed to reflect the incident laser beam back directly, making the reflected beam parallel to the incident beam within a few arcseconds. The corner-cubes, made of the highest quality fused silica, work in the visible spectrum at two specified wavelengths (l=694 nm and l=532 nm). The corner-cubes are symmetrically mounted on a hemispherical housing with one nadir-looking corner-cube in the centre, surrounded by an angled ring of eight corner-cubes. This will allow laser ranging in the field of view angles of 360° in azimuth and 60° elevation around satellite's nadir. The mass of the LRR is 2 kg. The LRR was developed by Aerospatiale.

11 RA-2/MWR Data Products

Based on the experience drawn from the ERS missions, significant improvements are built into this new generation of altimetric products, particularly for the enhanced quality of the near real-time observations, which becomes nearly as precise as the final precise product. The product specification process has included a large consultation of users of ERS and TOPEX/POSEIDON altimetric data. Further product refinement and state-of-the-art algorithm specification were done in the framework of three European Expert Support Laboratories (ESL), Alenia Aerospazio (I), Collecte Localisation Satellite (F) and Mullard Space Science Laboratory (UK). The algorithm specifications have been validated by prototyping within the ESL. Once verified, ESL prototypes became reference processors to produce test data sets designed to validate the ground segment instrument data processing facility (IPF). Moreover, the RA-2 and MWR products and algorithms were peer-reviewed by dedicated experts and were the subject of an open review at the ENVISAT Altimetry Products and Algorithms Review Workshop held in ESA/ESRIN in June 1999.

The ENVISAT RA-2 and MWR Data Products - already available in near real-time - will have a global coverage, the wet tropospheric correction from the microwave radiometer and the ionospheric correction from the two frequencies, as well as many other improvements coming from the novel design of second generation Radar Altimeter. The near real-time processing is comprehensive and runs the same algorithms as for off-line products, only the availability and quality of auxiliary data differ.

The suite of products is based on one main Geophysical Data Record product (GDR). The ENVISAT general product format is exploited to add sub-structure inside the product to hold additional data such as the averaged waveforms (at 18 Hz), the individual waveforms (at 1800 Hz) and the Microwave Radiometer data set. Thus, the waveform data product (SGDR) is a superset containing the same geophysical data records than the GDR with waveform data sets appended. Moreover, these products are global, independent of the sub-satellite terrain and of the radar altimeter measurement resolution mode, thus avoiding artificial boundaries between geographic features like land-sea, land-ice or land-lake transitions and ensuring that ocean, land, ice, lake or wetlands data always ends up in the same (unique, global) data product.

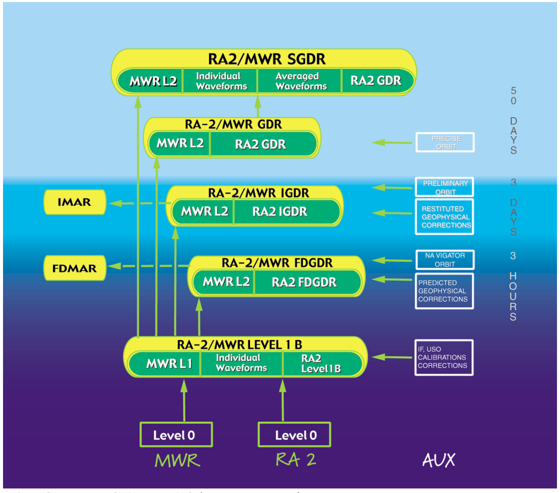

Fig. 8 ENVISAT RA2/MWR Product Tree

Another product called Fast Delivery GDR (FDGDR) is delivered once in less than three hours, for weather forecasting, sea-state and real time ocean circulation applications. An ocean-related parameters subset of the FDGDR, called FDMAR (for Marine Abridged Record) is extracted to reduce the volume of on-line data transfers. FDMAR is converted in the so-called BUFR format commonly used by meteorological offices. Then the GDR product is delivered again in less than 3 days, called Interim GDR (IGDR), for ocean circulation monitoring and forecasting applications, substituting the meteo predictions for the more precise analyses and the preliminary orbit for an improved orbit solution. The final GDR and SGDR products containing the most precise instrument calibrations and orbit solution are delivered after 30 days (not more than 50 days). The schematic in fig. 8 summarises the organisation, the relationship and latency of the products generation. The terminology used to name products is based on the nomenclature traditionally used in Altimetry. The product names are stored in the first field of the specific product header. ENVISAT products are also identified in the ground segment by product IDs.

The ENVISAT products are categorised in three distinct levels:

- Level 0 (raw): unprocessed data as it comes from the instrument.
- Level 1b (engineering): data converted to engineering units, with instrumental calibration applied (IF filter -corrects power distortions of echo waveforms-, internal range calibrations,

corrections for possible drift of reference timing source, no retracking); the product segmented in half-orbit (pole-to-pole) mainly contains datation (conversion of satellite time to UTC) geolocation, time delay, orbit (<50 cm near-real-time to ~3 cm off-line), sigma-zero, averaged waveform samples at 18 Hz data rate, individual waveform at full pulse repetition frequency and MWR brightness temperatures.

- Level 2 (geophysical): data converted to geophysical units (with retracking); the product mainly contains datation, geolocation, output from retrackers (range, wind speed, significant wave height, etc.), at 1 Hz plus some 18 Hz parameters (range, orbit). All geophysical products, including the near real-time products, are retracked (waveforms data are fully processed in the ground processor to extract the geophysical parameters). In order to retrieve the geophysical parameters over all types of surface (ocean, ice, sea-ice, etc.), four specialised retrackers are run in parallel all the time (over all surfaces):-
  - **Ocean** retracker: optimised for ocean surfaces, it is based on a modification of the Hayne model [9],
  - **Ice 1** retracker: optimised for general continental ice sheets, it is a model-free retracker called Offset Centre of Gravity echo model; it is used for ERS and will ensure continuity of the measurements [10],
  - **Ice 2** retracker: optimised for ocean-like echoes from continental ice sheet interior, it is a Brown-based model retracking algorithm [11],
  - **Sea-Ice** retracker: optimised for specular returns from sea-ice, it is a threshold retracking scheme for peaky waveforms [12].

The usual necessary geophysical corrections are available in the level 2 products. The ionospheric correction will come from the dual-frequency altimeter, backed-up by the measurements from DORIS and the Bent model. The wet tropospheric correction will come from the on-board microwave radiometer, backed-up by a value computed from European Center for Medium-range Weather Forecast (ECMWF) fields. Users requiring the altimeter waveforms will find them conveniently stored in the level 2 SGDR product along with the collocated geophysical corrections and the output of the four retrackers. In other words, the SGDR holds the GDR data augmented by averaged and individual waveforms. Therefore, users of ENVISAT altimetry need not access the level 1B products.

The Fast Delivery data (FDGDR) will be processed in the receiving stations and delivered in less than 3 hours. The Interim Geophysical Data Record (IGDR) and the final precision Geophysical Data Record (GDR) products will be processed off-line at the French Processing and Archiving Centre (F-PAC) in Toulouse with the same algorithms than the Fast Delivery processor. The SGDR is also built at F-PAC.

The main objective of the ENVISAT system is to provide required geophysical data products to the users. The ENVISAT User Services is the unique interface to the user community. The User Services will register data requests, both fast delivery and off-line, and organise the acquisition, processing and products delivery. It is accessible using a WWW browser via a Unified User Services Interface. This means that users will be able to access ENVISAT data services at any station or centre via an identical user interface. Following the new data policy, the use of Earth Observation data for scientific purposes is granted a special status: Category 1. Category 1 users are invited to submit a research project proposal, at any time, via the web site http://projects.esa-ao.org (the new data policy is detailed herein). All other users, called Category 2, are invited to contact the commercial distributors.
Sample data, covering the whole suite of RA-2/MWR products, have been distributed on CD-ROM, including a web-browser based displaying tools, ENVIVIEW. A batch (no graphical user interface) read-write software in C, FORTRAN and IDL, containing all the RA-2/MWR data sets structure is also available on demand.

12 Conclusion

The ENVISAT radar altimetry mission, including its support instruments, MWR, DORIS and LRR, will meet a myriad of mission objectives, ranging from oceanography to land applications. The new generation radar altimeter has in store many new capabilities to enhance the quality of the measurement - second frequency, additional echo sampling near the leading edge for a more accurate reading of waveheights - and make new measurements over difficult terrain never obtained before- three resolution modes, autonomous switching. The Geophysical Data Record (GDR) products are built from four specialised retrackers running in parallel over all surfaces. They are global with no artificial boundaries and are common to the waveform product (SGDR). The data coverage is up to 81.5°N and S in a dense ground track layout (35-day repeat cycle). The ENVISAT ground system delivers global near real-time data in less than 3 hours. These are already of near GDR quality as they are built running the same algorithms as the final precise GDRs. They contain the good quality orbit produced in real time by the DORIS Navigator and the MWR corrections and will permit accurate real-time monitoring of global oceanographic signals, contributing to major near real-time applications as the Global Ocean Data Assimilation Experiment (GODAE).

The full exploitation of the data from RA-2 demands high-quality absolute calibration at Ku and S bands for the three instrument parameters as well as a very accurate cross-calibration with previous altimeter data during overlapping flights. The objective is to provide the user community with a continuous and consistent altimetric time series.

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