Development of Radar Altimetry Data Processing in the Oceanic Coastal Zone

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EWP1 – Deliverable D1.2a. Processor Improvements: Technical Note

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Revision History

Issue	Date	Change
1	25 July 2011	Draft release

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1 Introduction

The aim of this document is to describe the changes to the COASTALT processor introduced since the release of revision 1.0.1 [RD 8]. At this time, the processor was placed under version control (subversion), and versions of the software will be referenced by tagged release number and, where necessary, the full subversion information.
In the next section, we will provide a summary of the main changes, and then provide details of how these changes have been implemented.

2 Summary of Processor revisions

There have been 4 tagged releases of the COASTALT processor since it was placed under version control, as summarised in Table 2-1. The main changes to the structure of the processor have been introduced to create a more modular structure that will be simpler to maintain. Other changes have been introduced to increase usability of the final products and address accuracy of the retracked parameters.

Table 2-1 Tagged releases of the COASTALT Processor and main changes

Release	Base svn revision	Main Changes
1.0.1	r7	Initial release Compliant with Product Specification 1.0.1r2
1.1	r45	Compliant with Product Specification 1.1 Corrected scale factors and units for some variables (incorrectly set in v1.0.1) Corrected values of _FillValue attributes to match the standard definitions for the appropriate variables type Processing of auxiliary files (CST, CHD) and initial attempt to process USO files (incorrect file versions used) Added basic User Module function capability Corrected interpolation of time to 18 Hz time Reconfigured main processor to: pre-process data to restrict processing and output to coastal mask calculate 18 Hz corrections in new function Determination of Range and ionospheric corrections from COASTALT retracker parameters (new functions added) Redesigned NetCDF generation code added functions to initialise a variable and to generate a new product removed generation of redundant (unused) attributes Added distance to coast tool to release Added coastal mask tool to release
2.0	r75	Compliant with Product Specification 2.0 Added new variables (18 Hz interpolations) Changed data type of interpolated variables from double or float to integer or short, adding appropriate scale factors Unpacked map flags from one byte per sample to 2D flags for ease of application Added more information in variable attributes (comment, standard_name, source and flag_meanings) from Netcdf_info.txt file Renaming of Processor to COASTALT_Processor Changed structure of main processor to: correctly processes 18 hz interpolations at 'ends' of sections minimise unnecessary io (read waveforms when used) Improved processing of auxiliary files: generation of sigma0 scale factor for correction of sigma-0 generated USO correction using correct auxiliary files more efficient IO (one read per file) Improved error checking on reading input strings Improved User Module function
2.0r3	r91	Compliant with Product Specification 2.0r3

		hs changed to swh in long name specification Added new global attributes for processing information Corrected Q parameter in implementation of Specular retracker Re: Typo in Deng and Featherstone 2006 Added check for invalid hz18_diff_1hz_lat / hz18_diff_1hz_lon values when calculating 18 hz locations Updated fitting parameters (centre bin ku and centre bin s) to recover Ku & S band range bias and corrected nominal satellite height

3 Additional Variables and Global Attributes

For the initial release of the v1.0 processor and products, only corrections required during calculation of new variables (sea state bias corrections, and dry tropospheric correction and a geocentric tidal height solution) were interpolated to 18 Hz. There was a request for providing all the necessary geophysical corrections at 18 Hz to allow simple computation of corrected sea surface height and hence additional variables were included in the products.

The use of some of the flags was complicated by packing of flags in the SGDR products, requiring determination of the byte values within a single integer. For ease of use, these were unpacked to 2 dimensions.

Additional global attributes were also requested to supply additional information on the processing and product version.

3.1 Method of interpolation for 18 Hz variables

The COASTALT processor uses data from the level 2 SGDR products to generate the output product. Where 18Hz values have been generated from the source 1 Hz data, a simple linear interpolation method has been used.

For any given 1 Hz variable from the record at time t ($Var1Hz_{(t)}$), the 18 Hz values ($Var18Hz_{(t,i)}$) are determined using the values at this record, the preceding record (t-1) and the following record (t+1) using:

$$Var18Hz_{(t,i)} = (Var1Hz_{(t)} - Var1Hz_{(t-1)}) \times (i + 11.5)/20 \quad \text{for } i=1\ldots10$$
$$Var18Hz_{(t,i)} = (Var1Hz_{(t+1)} - Var1Hz_{(t)}) \times (i + 0.5)/20 \quad \text{for } i=11\ldots20$$

3.2 New Variables

The new variables introduced in v2.0 of the product are given in Table 3-1.

Table 3-1 New Variables (all provided at 18 Hz)

Variable	Long Name	Source
uso_clock_correction	USO Clock Correction	Linear interpolation from 1 Hz values generated from auxiliary USO correction files
hz18_inv_barom_corr	18Hz interpolated Inverted barometer correction	Linear interpolation from 1 Hz SGDR field 40 values
hz18_mod_wet_tropo_corr	18Hz interpolated Model wet tropospheric correction	Linear interpolation from 1 Hz SGDR field 41 values
hz18_ra2_ion_corr_ku	18Hz interpolated RA2 Ionospheric correction on Ku-band	Linear interpolation from 1 Hz SGDR field 43 values
hz18_ra2_ion_corr_s	18Hz interpolated RA2 Ionospheric correction on S-band	Linear interpolation from 1 Hz SGDR field 44 values
hz18_ion_corr_doris_ku	18Hz interpolated Ionospheric correction from DORIS on Ku-band	Linear interpolation from 1 Hz SGDR field 45 values
hz18_ion_corr_doris_s	18Hz interpolated Ionospheric correction from DORIS on S-band	Linear interpolation from 1 Hz SGDR field 46 values
hz18_ion_corr_mod_ku	18Hz interpolated Ionospheric correction from model on Ku-band	Linear interpolation from 1 Hz SGDR field 47 values
hz18_ion_corr_mod_s	18Hz interpolated Ionospheric correction from model on S-band	Linear interpolation from 1 Hz SGDR field 48 values
hz18_dib_hf	18Hz interpolated MOG2D HF	Linear interpolation from 1 Hz SGDR field 51

	contribution	values
hz18_m_sea_surf_ht	18Hz interpolated Mean sea-surface height	Linear interpolation from 1 Hz SGDR field 98 values
hz18_geoid_ht	18Hz interpolated Geoid height	Linear interpolation from 1 Hz SGDR field 99 values
hz18_ocean_depland_elev	18Hz interpolated Ocean depth/land elevation	Linear interpolation from 1 Hz SGDR field 100 values
hz18_tot_geocen_ocn_tide_ht_sol2	18Hz interpolated Total geocentric ocean tide height (sol. 2)	Linear interpolation from 1 Hz SGDR field 102 values
hz18_long_period_ocn_tide_ht	18Hz interpolated Long period Tide height	Linear interpolation from 1 Hz SGDR field 103 values
hz18_tidal_load_ht_sol1	18Hz interpolated Tidal loading height (sol. 1)	Linear interpolation from 1 Hz SGDR field 114 values
hz18_tidal_load_ht_sol2	18Hz interpolated Tidal loading height (solution 2)	Linear interpolation from 1 Hz SGDR field 104 values
hz18_solid_earth_tide_ht	18Hz interpolated Solid earth tide height	Linear interpolation from 1 Hz SGDR field 105 values
hz18_geocen_pole_tide_ht	18Hz interpolated Geocentric pole tide height	Linear interpolation from 1 Hz SGDR field 106 values
distance_from_coast	Distance to coast	Generated using distance from coast tool and added to product using add_corr tool
mwr_wet_trop_interp_flag	MWR wet tropospheric correction interpolation flag	Generated at 18Hz during generation of DLM wet tropospheric correction

3.3 Unpacking of flags

The flags in Table 3-2 are calculated by 'unpacking' the original integer flags, where each of the first 20 bytes within each integer word corresponds to the flag for an 18 Hz sample. The flags were converted to 2 dimensional short integers, with the flag value set to match the byte value (0 or 1) of the corresponding bit in the source variable.

Table 3-2 Unpacked 18 Hz Flags

Variable	Long Name
ku_ocean_retrk_qua_flags	Ku-band ocean retracking quality flags
s_ocean_retrk_qua_flags	S-band ocean retracking quality flags
map_18hz_ku_trk`	Map of valid points for 18Hz Ku-band tracker range
map_18hz_ku_ocean_flags	Map of 18Hz valid points for Ku-band ocean range
map_18hz_s_ocean_flags	Map of 18Hz valid points for S-band ocean range
slp_mod_flags	Slope model present flags
map_18hz_k_cal_ku_flags	Map of valid points for 18Hz K-cal ku

3.4 New Global Attributes

The new global attributes introduced in v2.0 of the product are given in Table 3-3

Table 3-3 Global Attributes added to products

Attribute Name	Description
Product_spec	Version of CGDR Product Specification applicable to product
Product_revision	Version of COASTALT processor used to generate product
RA2_CONFIGURATION_DATA	RA-2 Level1B Configuration File
RA2_CHARACTERISATION_DATA	RA-2 Level1B Characterisation Data File
USO_CORRECTION_DATA	USO Correction Data File

4 Use of Auxiliary Files

4.1 Calculation of USO Correction

The calculation of the Ultra Stable Oscillator (USO) correction is determined differently for three separate time periods:

1) For cycles up to and including cycle 045, the USO was not exhibiting anomalous behaviour, and the value of the USO correction will been set to 0.
2) From 2 Feb 2010 (cycle 087) the USO clock period correction is included in the RA-2 product and has already been applied, hence the USO Correction in the products will be set to 0.
3) From 13 March 2006 to 2 Feb 2010 (cycles 046 – 87), all data should have a USO correction applied, determined using auxiliary files available from the F-PAC at the same location as the SGDR data, in the directory gdr_ous_corr (ftp://ra2_data@diss-nas-fp.eo.esa.int/gdr_ous_corr).

The processor will use information from the configuration file, at run time, to determine whether to carry out calculation of a USO correction. The configuration file may specify a single USO correction file to use (using ^B 3 option), or it may specify the directory for the processor to search for USO correction files (using ^B 4 option). If a directory is specified, the processor will search for correction files with the file naming convention:

RA2_USO_clock_C-GDR-ccc.txt

Where ccc is the cycle number.

The processor will determine whether the specified file, or any file in the specified directory, contains correction data that span the time period of the SGDR data to be processed. If a USO correction file or directory is not specified in the configuration file, or if no matching dates are found in the files specified, the USO correction values will be set to the undefined data value.

If corrections are found for the input dates, the processor will first pre-process the auxiliary file to extract the values spanning the SGDR data required, and save them to a temporary file (USO_combined_file.dat) with the time converted to the same time-base as the SGDR data.

If the data have been successfully pre-processed, the temporary file is read for each 1 Hz data record, and the provided USO corrections immediately spanning the time of this record are linearly interpolated to the time of the 1 Hz record.

The 1 Hz correction values are then interpolated to 18 Hz values using the same process as for other 1 Hz corrections.

4.2 Use of Auxiliary Constants and Characterisation File Data

The use of information from auxiliary characterisation data (CHD) and constants data (CST) files is supported by the processor.

The use of auxiliary files is specified using the configuration data file at run time. There are options to specify the CHD and CST files to use (using ^B 1 and ^B 2 options respectively), or the directory to search (using ^B 5 option) for the CHD and CST files that were used in the generation of the SGDR data. The names of CHD and CST files to search for are captured from the Specific Product Header of the SGDR data.

Auxiliary files will always be searched for, and will be used in order of:

1. CST and CHD files named in the SPH, in the directory specified in the configuration file
2. CST and CHD files named in the SPH, in the current directory
3. CST and CHD files named specifically in the configuration file

The auxiliary files are pre-processed, before processing of the SGDR data, to ensure that auxiliary data can be successfully read from these files.

If successfully read and pre-processed, then the values read from the auxiliary files are saved to a structure in the processor and used to calculate scaled SWH and Sigma-0 values from the processor retrackers. If pre-processing fails, the scaling of SWH and sigma-0 will not occur and un-scaled values will be output.

5 Plug and Play capability

The COASTALT Processor has always been intended as a tool to enable users to test and implement their own retracker options, as well as providing the standard products. To this end, a 'plug and play' capability was built into the processor software.

Use of the plug and play capability is defined in the separate user guide [RD 9].

The current implementation is limited to a fortran module, with a maximum of 7 fitted parameters.

Annexe A Glossary

Acronym	Definition
AD	Applicable Documents
CGDR	Coastal Geophysical Data Record
DLM	Digital Linear Model
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
ECMWF	European Centre for Medium-Range Weather Forecasts
F-PAC	Processing and Archiving Centre in France
FTP	File Transfer Protocol
GDR	Geophysical Data Record
MWR	Microwave Radiometer
N/A	Not Applicable
PAC	Processing and Archiving Centre
RA-2	Radar Altimeter - 2
RD	Reference Documents
SDR	Sensor Data Record
SGDR	Sensor Geophysical Data Record
SWH	Significant Wave Height
TBC	To Be Confirmed
TBD	To Be Defined
USO	Ultra Stable Oscillator
UTC	Coordinated Universal Time

Annexe B Applicable and Reference Documents

RD 1 Envisat Coastal Altimetry Product Handbook, Issue 2.0, 20 June 2011

RD 2 RA-2/MWR Product Handbook, Issue 2.2, 27 Feb 2007: http://envisat.esa.int/dataproducts/

RD 3 ENVISAT RA-2/MWR Level 2 User Manual, v1 rev.2, 20/06/2006.

RD 4 EnviSat-1 Product Specifications, ANNEX A: PRODUCT DATA CONVENTIONS PO-RS-MDA-GS-2009, Is.: 3, Rev.: D, Date: 05/05/2004

RD 5 EnviSat-1 Product Specifications, Volume 5: RA-2 Product Structure PO-RS-MDA-GS-2009, Is.: 3, Rev.: D, Date: 22/11/2007

RD 6 EnviSat-1 Product Specifications, Volume 14: RA-2 Product SpecificationsPO-RS-MDA-GS-2009, Is.: 4, Rev.: C, Date: 30/01/2009

RD 7 DEVELOPMENT OF RADAR ALTIMETRY DATA PROCESSING IN THE OCEANIC COASTAL ZONE - Statement of Work, ESA ref. ENVI-DTEX-EOPS-SW-07-0008, 2 August 2007.

RD 8 COASTALT Waveform Retracker Software Technical Specifications. COASTALT STS001 v1.2, 28 July 2009.

RD 9 COASTALT Processor: Plug and Play User Guide for COASTALT Processor – version 2.0 revision 3, Issue 1, 25 July 2011.