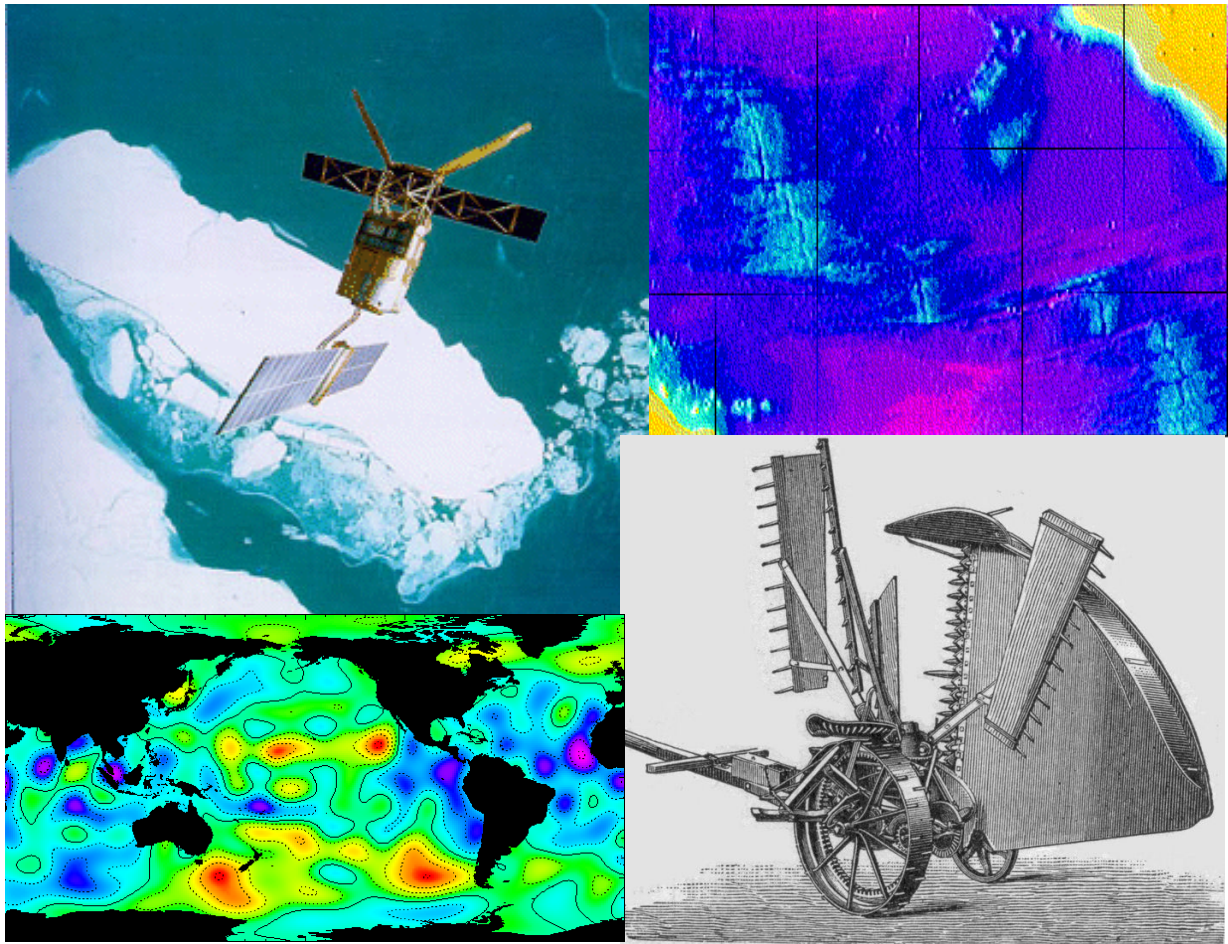


REAPER

Product Handbook for ERS Altimetry Reprocessed Products



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Releases listed in italics are unofficial and are provided for information and comments only.

Detailed History of Changes in Officially Released Versions

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1 Introduction

1.1 Purpose and scope of this user guide

This document is intended to give REAPER data users a concise overview of the contents of the REAPER Level 2 (L2) products, and to provide an introduction to how to use them for scientific work.

Familiarity with how to read a netCDF formatted product is assumed.

This revision of the document is released to accompany version RP01 of the REAPER products. For details of the product versioning, see section 2.1.

1.2 The REAPER project

The REAPER project comprises the **Re**processing of **Al**timeter **P**roducts for **ERS**. The European Space Agency's two European Remote Sensing (ERS) satellites, ERS-1 and -2, were launched into the same orbit in 1991 and 1995 respectively. Their payloads included a synthetic aperture imaging radar, radar altimeter, microwave radiometer and instruments to measure ocean surface temperature and wind fields. The two satellites acquired a combined data set extending over two decades. The ERS-1 mission ended on 10th March 2000 and ERS-2 was retired on 5th September 2011.

The purpose of the project is to reprocess consistently all the radar altimeter and microwave radiometer data from August 1991 to July 2003 to generate an improved, homogeneous long-term data series. All radar altimeter, microwave radiometer and orbit products from both satellites must be reprocessed to achieve this. Another goal is to align both the ERS datasets and the Envisat dataset.

1.3 Improvements on previous products

The REAPER project allows the best algorithms, correction models and auxiliary data available now to be used. The list of improvements can be split into several areas.

1.3.1 Orbit

Precise orbit solutions have been generated using an improved gravity model and including satellite laser ranging data. Four possible solutions were computed over the entire mission period and independently evaluated. The best solution was selected. This reduces geographically correlated errors and improves accuracy during high solar activity periods, in this case 1991-2 and 2000-2. See [R1].

1.3.2 Time calibration

The ultra-stable oscillator (USO) clock drift in both satellites has been corrected. This leads to more accurate time measurement, instrument path-delay correction values, echo power correction and echo shape correction.

The time-tag bias present in the REAPER data will be estimated as part of the QA activity performed upon the data before release. See Annexe 1 for details and a link to the results. The estimated time-tag bias is not corrected for in the REAPER processing, but is stated so that the user can correct the altitude via the altitude rate.

1.3.3 Microwave radiometer

The microwave radiometer reprocessing uses a new, neural network approach to estimating the wet tropospheric correction, atmospheric attenuation, and atmospheric liquid and water vapour contents. Also new is the correction of potential drift on ERS-1 and an added correction for Earth side-lobe brightness temperatures based on global seasonal maps. Thus these improvements impact on some geophysical corrections.

1.3.4 Geophysical corrections

As well as those listed in section 1.3.3 above, other geophysical corrections have been improved. Again, relating to the wet tropospheric correction, the European Centre for Medium Range Weather Forecasting (ECMWF) have re-analysed their own data and issued improvements. Their basic model also changed in 2002, causing a step change in values. Further, there were errors in the processing of ERS data from 1992 and 1994. All of these issues have now been fixed and a single, homogeneous dataset released. The data used by REAPER is ERA-Interim.

Ionospheric corrections have also been consolidated into a homogeneous dataset, using the New Ionospheric Climatology 2009 (NIC09) model until 1998 and the GPS Ionosphere Maps (GIM) after that.

Tidal corrections have been merged using the same algorithms and models used by Envisat.

The high latitudes of the geoid have been modified as for CryoSat-2, for details see [R2].

Full details of the models used are in section 6.

1.3.5 Instrument corrections and centre of gravity

As well as the improvements available due to better time calibration (see section 1.3.2), the centre of gravity offset has been reviewed and improved using data from previous processing runs.

The values used in the REAPER processing (applied to reference the range to CoG) are:

ERS1 CoG = 852.3 mm

ERS2 CoG = 840.1 mm

1.3.6 Intercalibration

Intercalibration between ERS-1, ERS-2 and Envisat, between all three radar altimeters and all three microwave radiometers, has led to several improvements, including the incorporation of inter-mission bias corrections. Envisat style retrackerers are used in the REAPER processing, allowing easier comparison. REAPER ERS-2 data is cross-calibrated to the released ENVISAT v2.1 product and the REAPER ERS-1 data to REAPER ERS-2.

Intercalibration is performed on range and backscatter values (only) by the application of an external bias value. These bias values were derived during the commissioning phase of the REAPER project via crossover analysis. Each retracker, in each mode (ice/ocean), has an individual bias for both range and backscatter. The elevation values in the product were computed using the ranges with the biases applied. Parameters derived from backscatter are likewise computed using the biased value.

The biases, already applied, are (for the RP01 version of the REAPER products):

Table 1: Backscatter bias in dB (including system constant)

Retracker	Mode	E1 bias	E2 bias
ICE1	OCEAN	-108.3351	-103.9212
ICE2	OCEAN	-108.3459	-103.9334
SIRT	OCEAN	-108.3441	-103.93
OCEAN	OCEAN	-108.3319	-103.9172
ICE1	ICE	-108.731	-104.005
ICE2	ICE	-108.656	-104.014
SIRT	ICE	-108.731	-104.005
OCEAN	ICE	-108.729	-104.006

Table 2: Range bias in m

Retracker	Mode	E1 bias	E2 bias
ICE1	OCEAN	-0.1523	-0.545
ICE2	OCEAN	-0.081	-0.481
SIRT	OCEAN	0.32	-0.075

OCEAN	OCEAN	-0.065	-0.474
ICE1	ICE	0.59	-0.051
ICE2	ICE	-0.218	-0.412
SIRT	ICE	0.135	-0.503
OCEAN	ICE	-0.173	-0.537

Note that the backscatter 'bias' also contains a constant term from the radar equation. Also note that significant wave height is not inter-calibrated.

1.3.7 Output

Outputs have been brought into line with modern altimetry products. The output format is netCDF.

1.4 The radar altimeters

On each satellite, the radar altimeter (RA) is a Ku-band (13.8 GHz) pulse-limited nadir-pointing active microwave sensor designed to measure the timing of return echoes from ocean and ice surfaces. ERS-1 carried the first radar altimeter that included two separate operating modes to optimise performance over both ocean and non-ocean surfaces.

Return echoes must be captured by the altimeter in a range window comprising a number of discrete samples known as range gates. A tracking algorithm is used to predict the where to position the range window to capture an echo, based on information from the previous echo. If the leading edge of the waveform falls outside the window, the altimeter 'loses track' of the surface and must re-acquire it by moving the position of the range window. Data obtained in this acquisition mode is not useful for altimetry.

The ERS RA tracking modes have different range gate resolutions, defining different effective range window sizes, and each has different tracking algorithms. Ocean mode uses the 3ns range gates and has a narrow range window, while ice mode uses the 12ns range gates, giving it a wider range window and therefore the ability to maintain tracking over surfaces too variable for ocean mode, such as the continental ice sheets.

1.5 The orbits

Both satellites have the same orbit characteristics:

Type	Near-circular, polar, Sun-synchronous
Altitude	782 to 785 km
Inclination	98.52 deg.
Period	About 100 minutes
Orbits per day	14.3
Repeat cycle	3-day, 35-day and 176-day

1.6 The mission phases

Each mission phase is a part of the mission with a ground track pattern that is distinct from the previous and following periods. ERS-1 has mission phases A to G (plus R), while ERS-2 has phases A and B. Within any given phase there is a repeating pattern of ground tracks. One full completion of the repeat period is known as a cycle. Note that at the start of the tandem phase both satellites followed the same ground tracks, ERS-1 leading ERS-2 by 35 minutes. Also note that ERS-2 phase B repeats the ground tracks of ERS-1 phase C, after a period of almost 20 years, affording a good opportunity to see changes over time. The following table details the mission phases:

Satellite	Mission Phase	Phase Name	Cycle in days	Start Date	End Date
ERS-1	A	Commissioning	3	25 th July 1991	10 th December 1991
	B	Ice Phase	3	28 th December 1991	30 th March 1992
	R	Roll Tilt Mode Campaign	35	4 th April 1992	13 th April 1992

	C	Multidisciplinary Phase	35	14 th April 1992	21 st December 1993
	D	Second Ice Phase	3	23 rd December 1993	10 th April 1994
	E	Geodetic Phase	168	10 th April 1994	28 th September 1994
	F	Shifted Geodetic Phase	168	28 th September 1994	21 st March 1995
	G	Tandem Phase	35	21 st March 1995	5 th Jun 1996
ERS-2	A	Tandem Phase	35	29 th April 1996	21 st February 2011
	B	Multidisciplinary Phase	3	10 th March 2011	6 th July 2011

More detailed information is available from <http://www.deos.tudelft.nl/ers/phases>

1.7 Data access and data processing tools

For commissioning and CAL/VAL purposes, Level 2 netCDF format data may be accessed via file transfer protocol (FTP) to a server hosted at IFREMER. Access details are available from UCL and have been disseminated to the commissioning teams.

Final dissemination of the data to users is under the authority of ESA and the IDEAS team. The data will be freely accessible via the Fast Registration ESA Web page:

<https://earth.esa.int/web/guest/pi-community/apply-for-data/fast-registration>

As the data is presented in a simple netCDF v3 format, any tool capable of ingesting netCDF data can be used for processing.

The L2 data conforms to the CF-1.6 conventions for netCDF data and is aligned in contents and variable naming (where possible and appropriate) with the Sentinel-3 L2 products.

1.8 Altimetry texts and further reading

A good overview is provided at <http://www.altimetry.info/>, and another at http://earth.eo.esa.int/brat/documents/Radar_Altimetry_Tutorial_20090406.pdf

A good basic textbook is Satellite Altimetry and Earth Sciences, edited by Lee-Leung Fu and Anny Cazenave, published by Academic Press, ISBN 0-12-269545-3.

The two references above explain the basic concepts and terms used in radar altimetry, such as the relationship between altitude, range and height, and the process of retracking.

There are also tutorial sections in the CryoSat-2 Product Handbook, see [R2], and the Sentinel-3 Product Handbook, see [R24].

The CF conventions for netCDF data are available here: <http://cf-convention.github.io>

Coastal Altimetry, edited by S. Vignudelli, A. Kostianoy, P. Cipollini and J. Benveniste, published by Springer, ISBN 978-3-642-12795-3, is useful for further reading.

2 Overview of data quality

2.1 Product History

The current revision of the REAPER L2 products is RP01. The product version is indicated by this string of four characters in the filename. The file naming convention is fully specified in section 3.3. If, or when, the REAPER products are updated, the old revisions will be listed here.

2.2 Known issues in RP01

2.2.1 Microwave radiometer auxiliary data was sub-optimal

During the inter-calibration activity for the ERS MWR data, configuration parameters derived during the creation of v2.1 of the ENVISAT dataset were used. Later analysis of the ENVISAT products showed these parameters to be incorrect. The result is that the MWR wet tropospheric correction in the REAPER product (`rad_wet_tropo_corr`) is of poor quality.

Magnitude — the commissioning analysis showed the MWR wet tropospheric correction to be too large, by approximately 2cm.

Resolution — none at the time of writing. A new inter-calibration activity of the ERS MWR data against the fixed v2.1b ENVISAT dataset is required.

2.2.2 Time tags

Time tags are not guaranteed to be monotonic and increasing i.e. there may be overlapping ranges of time between files, outliers and forwards and backwards time jumps. The overlap is generally between a few seconds and half a minute.

Within files there are regular outliers in the time tags. Several times during one cycle a file contains a few 1-Hz records in which an isolated time tag is off from the others in the sequence by a few tens of seconds to hours. The 20-Hz time tags are likewise off. Time tags not only reverse but can also jump forward and then back to normal.

Particularly affected is ERS-1 cycle 150, where nearly every pass has a few time tags out of sync. The cause of this issue is corruption in the on-board binary counter. Measurements affected should be rejected.

Resolution — none at present. Future resolution of this issue requires patching of the ERAC L0 data to reverse the bit flips that corrupt the onboard clock.

2.2.3 Degraded orbit flagging

There is no flag in the L2 product to denote times at which the orbit solution is degraded (following manoeuvres for example).

Resolution — A table of orbits affected can be found in Annex 2

2.2.4 Platform commissioning activities

For both ERS-1 and ERS-2, in-orbit commissioning activities resulted in data being received that is sub-optimal for science uses. Data that is degraded in this way needs to be carefully assessed before use. There is no flag in the L2 product to indicate data that is affected.

Resolution — A table of orbits affected can be found in Annex 2

2.2.5 Out of range PTR corrections

Filtering has been applied to the PTR correction to range derived at L1 to remove bad values. In this case, the value of `inst_range_corr_20hz` is zero. This results in the range and elevation values being significantly displaced. The elevation/range values are not set to `_FillValue` as the user may wish to correct them with an averaged PTR correction derived from good data, and they are so significantly displaced that it is obvious that they are bad.

Resolution — None. Not an error, but something for the user to be aware of.

2.2.6 Wind Speed

The wind speed model as implemented on the REAPER product is exactly the model by S. Abdallah, derived for Envisat. However, it is clipped at 5.0 dB on the low end and 19.6 dB on the high end. That means particularly that higher wind speeds may not be accurately represented: they are limited to 28.5 m/s. Though these winds are rare, they are very important to monitor.

Note that, because of the bias of the backscatter with respect to Envisat (low by about 0.5 to 0.8 dB) the wind speed will also be biased.

Resolution — None at the time of writing.

2.2.7 SWH

The significant wave height (SWH) values have changed significantly between OPR and REAPER. Note that the means have increased both for ERS-1 and ERS-2 between OPR and REAPER. Also the average SWH is not the same for ERS-1 and ERS-2, neither in the OPR data nor in the REAPER data. Hence there is some system-dependent bias.

Resolution — None at the time of writing.

2.2.8 Radiometer Data

A significant number of the ERS-2 MWR data (radiometer wet tropospheric correction, brightness temperatures) are missing, particularly for all of the period between 30 Dec 1995 to 16 Jan 1996 and from 1 to 6 January 2003.

2.2.9 Incorrect Attributes

Product users should note that there are some errata concerning parameter attributes in the netCDF files.

2.2.9.1 *atmos_corr_sig0*

The variable **atmos_corr_sig0** has the wrong long_name: instead of "square of the off nadir angle computed from Ku waveforms" it should be "atmospheric attenuation correction to backscatter coefficient".

For clarity the comment attribute should contain: "This correction is already applied to ocean_sig0".

In addition to the above, the scale_factor is wrong: 0.0001 should be 0.01. The values are correct, just the attribute is wrong.

2.2.9.2 *hf_fluctuations_corr*

The variable name, the long_name, and the standard_name of **hf_fluctuations_corr** wrongly suggests that this is only the high-frequency part, where it is in fact the total inverse barometer correction. However this nomenclature is required for consistency with other missions.

2.2.9.3 *ocean_tide_non_equil*

ocean_tide_non_equil is part of (i.e. included within) **ocean_tide_sol1** and **ocean_tide_sol2**. This is not clear in the comment attribute.

2.2.9.4 *mission (global attribute)*

The global attribute mission is not always set to "E1" or "E2". It is only once in error on ERS-1 data, but many times in error from ERS-2 cycle 36 onwards. For example, in file

```
E2_REAP_ERS_ALT_2M_19980924T160448_19980924T160804_RP01.nc
    :mission = "0 " ;
```

The mission is correctly indicated by the characters in the filename.

3 Product descriptions and conventions

To derive scientifically valid data from the L2 products, the user should select the data and corrections relevant to them, and take error flags or fill values into account. The products are fully described in section 5. This section gives a broader overview of the products and introduces necessary conventions.

3.1 Product types

There are three L2 data products. The basic dataset is contained in the geophysical data record (GDR) product. The extended sensor geophysical data record (SGDR) product contains all of the parameters found in the GDR with the addition of the echo waveforms and selected parameters from the level 1b data. There is also a reduced 1Hz meteorological (Meteo) product.

3.2 File format

The L2 data is stored in netCDF files as defined by the netCDF library v3.6. Documentation on the standard is available from <http://www.unidata.ucar.edu/downloads/netcdf/netcdf-3.6.0/index.jsp>

The files are readable by any application with netCDF support. As netCDF v3.6 does not support unsigned variables, all product contents that are generated as unsigned integers are saved as signed integers. Conversion back to unsigned format is the responsibility of the data user.

3.3 File naming conventions

REAPER produces L2 files that correspond to the original L0 file processed — the processing is based on the dump orbit at the acquisition station.

The file naming convention is this:

MM_AAAA_BBBBBBBBBB_nnnnnnnnTnnnnnn_nnnnnnnnTnnnnnn_YYYY.ZZZ

The fields are defined as:

MM	Mission ID
AAAA	File Class
BBBBBBBBBB	File Type
nnnTnn	Start and end times
YYYY	Version
ZZZ	Further file type information

The mission ID is E1 or E2 for ERS1 and ERS2 respectively.

The file class for REAPER data is always REAP .

The file type is ERS_ALT_2_ for GDR, ERS_ALT_2S for SGDR and ERS_ALT_2M for Meteo.

The times are in UTC and are date in year-month-day followed by hours-minutes-seconds. The version number starts at RP01 and it increments as appropriate (so if the data is reprocessed, it will become RP02).

The three letter extension is .nc by convention for netCDF files, the third character being unused.

3.4 Data rates

There are two data rates in the L2 product, a low rate of 1Hz and a high rate of 20Hz. These rates are not exact; they are rounded numbers. Each low rate data value is usually an average of 20 high rate values. High rate data is stored in the netCDF files in multidimensional arrays with one dimension set to 20. This format emphasises the association between averaged 1Hz data and the twenty 20Hz records that produced it. Each set of twenty related records is known as a High Rate Block (HRB).

Most 1Hz data is also represented at 20Hz, microwave radiometer (MWR) data and the atmospheric and geophysical corrections are only given at 1Hz. Each 1Hz value is then applied to the corresponding twenty 20Hz measurements.

3.5 Distinguishing science and calibration data

The L2 products contain data from calibration periods and other processes which should not be used for scientific work. Periods fit for use are those where the RA is tracking, which can be determined from the `alt_state_flag_20hz` variable. If this variable is set to 2 (tracking ocean) or 3 (tracking ice) then the data can be used. At 1 Hz, the averaged values exclude non-tracking data and the type of tracking is given in `alt_state_flag`.

It is important to recall that while the mode was usually switched between ice and ocean mode depending on surface type, in some instances the instrument was commanded into ice mode over the ocean as well. Therefore, for oceanographic purposes, reject any file for which the global attribute `ra0_tracking_ice_percent` is larger than expected.

3.6 Default values convention

In the REAPER dataset, bad values are indicated by setting the value within the dataset to the specified `_FillValue` setting for that value. This is only done when the value is known to be useless. Where data is thought to be degraded, but still potentially useful, it is included. The user should check the appropriate source of QA information in the product. For example, the quality of the parameter `ice2_range_20hz` can be determined by inspecting `ice2_mqe_20hz`.

3.7 Retracker validity

There are four retrackerers; ocean, ice1 - also called offset centre of gravity (OCOG), ice2 and sea-ice. The set of variables `*_qual_flag_20hz` can be used to determine if the retracking was successful.

The `qual_wf_*` set of variables can be used to determine the quality of the retracked waveform.

As a general rule, data is usable for scientific work if the corresponding range value is not set to `_FillValue` and the `qual_wf_reject_20hz` flag is good.

3.8 Time

Measurement time is stored as a double-precision floating-point number, counting in seconds from 00:00:00 1st January 1990. The 1Hz time is the average of the twenty 20Hz times it was derived from.

3.9 Range corrections

There are six variables named 'range' in the L2 GDR product:

- The `tracker_range_20hz` is the range measured by the onboard tracker as the window delay, corrected for instrumental effects and CoG offset.
- The `ocean_range_20hz` is the `tracker_range` retracked using the ocean retracker and corrected for instrumental effects and CoG offset.
 - `ocean_range` is a 1Hz average of this value
- The `ice1_range_20hz` is the `tracker_range` retracked using the ice1 retracker and corrected for instrumental effects and CoG offset.
- The `ice2_range_20hz` is the `tracker_range` retracked using the ice2 retracker and corrected for instrumental effects and CoG offset.
- The `sitrack_range_20hz` is the `tracker_range` retracked using the sea-ice retracker and corrected for instrumental effects and CoG offset.

Thus the range in the L2 product for each retracker is fully corrected for CoG and instrumental effects, including Doppler.

3.10 Geophysical range corrections

Different corrections are applied over ocean (as indicated by `surface_type` equal to zero) and other surfaces **when computing elevation**. The same calculations apply to all four retrackerers, and have been applied to compute the height measurements given in the GDR.

The convention for correction is that to *apply* them, they should be *added* to range (or *subtracted* from elevation, if not already applied).

Over ocean the calculation was:

corrected retracked range = range + dry + wet + dac + iono + ot + olt + lpt + lptne + set + pt

Otherwise the calculation was:

corrected retracked range = initial range + dry + wet + iono + olt + set + pt

Where:

range = tracker range (corrected to CoG) + effect of retracker
 dry = dry tropospheric correction, `model_dry_tropo_corr`
 wet = wet tropospheric correction, `model_wet_tropo_corr` or `rad_wet_tropo_corr`
 dac = dynamic atmospheric correction, `hf_fluctuations_corr`
 iono = ionospheric correction, `iono_corr_model` or `iono_corr_gps`
 ot = ocean tide, `ocean_tide_sol1` or `ocean_tide_sol2`
 olt = ocean loading tide, `load_tide_sol1` or `load_tide_sol2`
 lpt = long period ocean tide, `ocean_tide_equil`
 lptne = long period non-equilibrium ocean tide, `ocean_tide_non_equil`
 set = solid earth tide, `solid_earth_tide`
 pt = polar tide, `pole_tide`

For the ocean tides, solution 1 was applied. For the wet tropospheric correction, the model correction was applied unless over ocean where the MWR derived correction was applied if valid.

If any of the corrections that need to be applied are flagged bad, then no corrections are applied and the elevation is flagged bad.

The electromagnetic bias, also known as sea state bias, `sea_state_bias` is *never* applied by the L2 processing that computes elevation. This is left for the user to apply to the elevation measurement if appropriate.

A traditional inverse barometric correction is also present in the product (`inv_bar_corr`) for the user to apply instead of `hf_fluctuations_corr` if their specific use-case requires it.

If the RA is tracking over ocean then the `alt_state_flag_20hz` variable value will be 2. If it is tracking over any other surface the value will be 3. Any other values indicate that the RA is not tracking, and data from that measurement should not be used.

The models used are listed in Section 6.

3.11 Doppler correction

The `dop_c` variable contains the Doppler correction that has been added to the onboard range. It is thus already incorporated into the retracked ranges.

The `delta_dop_c` variable contains the delta Doppler correction, which is applied when the echo returning from the surface does not originate at nadir - this happens over sloping terrain. It is *only* applied during the computation of the `offset_elevation_20hz` height measurement.

3.12 Instrument correction

The `inst_range_corr_20hz` variable contains the instrument correction that has been added to the onboard range. It is thus already incorporated into the retracked ranges. If zero, the PTR measurement derived in the L1

processing was thought to be incorrect and was not applied. The user may either reject the data or apply their own correction in this situation.

3.13 Centre of gravity correction

The `cog_corr_20hz` variable contains the centre of gravity offset, the vertical distance from the satellite's centre of mass to the RA antenna. It has been applied to the ranges in the product.

3.14 Range correction errors

It is possible that some corrections to range cannot be provided, due to lack of data with which to calculate the correction value. In that case, the correction is set to `_FillValue`.

3.15 Slope correction

If the RA is passing over sloping terrain then the return echo it detects may not be from nadir. If a slope model has been used to calculate corrected values of latitude, longitude, elevation, azimuth and attitude, then the `interp_flag_slope_model_20hz` variable will be set to 0. The corrected values are then contained in the `offset_latitude`, `offset_longitude`, `offset_elevation` variables, and the output of the slope computation is given in the `offset_azimuth` and `offset_attitude` variables.

3.16 Determining terrain type

The `surface_type` variable gives the nadir surface type according to the TERRAINBASE model, see section 6.

- 0 indicates open ocean or semi-enclosed seas.
- 1 indicates enclosed seas or lakes.
- 2 indicates continental ice.
- 3 indicates land.

The `ice_flag` variable indicates the presence of sea-ice in the altimeter footprint.

- 0 indicates ocean.
- 1 indicates sea ice.
- 2 indicates that no evaluation has been made.

4 Examples of data usage

Here follow some examples of how to select data from the product to use for scientific work. Depending on the tool used to read the data, it may automatically apply the scaling values given in the variable attributes and remove data that is flagged as bad.

4.1 Height profile of Antarctica - high data rate

Choose the relevant file(s) on the basis of the date/locations you want. Date is part of the filename (see section 3.3).

Decide whether to use the ice1 or the ice2 retracker, as these are likely to be the most relevant. In this example ice1 is selected.

Using any netCDF tool or reading code, read in:

```
latitude_20hz
longitude_20hz
ice1_elevation_20hz
alt_state_flag_20hz
surface_type
```

All of these variables except the ones with names ending in `_1hz` will be arranged in a 20 by `n` array, as this reflects how the high data rate relates to the low data rate. Reorder each variable into time order.

Define `time_ordered_var` as an array with `20 * n` elements.

Populate it, e.g. like this:

```
FOR i = 0 to n-1 DO
  FOR j=0, 19 DO
    time_ordered_var( ( i * 20 ) + j ) = var( i, j )
```

The last two variables are given at the 1hz data rate, as an array of `n` elements. To get them into sync with the others, expand them.

Define `time_ordered_var` as an array with `20 * n` elements.

Populate it, e.g. like this:

```
FOR i = 0 to n-1 DO
  FOR j=0, 19 DO
    time_ordered_var( ( i * 20 ) + j ) = var( i)
```

Select tracking data in the required mode. In this case choose where:

- `alt_state_flag_20hz = 2` i.e. the RA is tracking and in ice mode

Further select data within the latitude / longitude range required. For Antarctica, first select latitudes below 60° south, and then select where:

`surface_type = 3` i.e. continental ice

4.2 Significant wave height - low data rate

Choose the relevant file(s) on the basis of the date you want, which is part of the filename (see section 3.3).

SWH is available at the 1Hz data rate. It is accompanied by its own measures of quality.

Using any netCDF tool or reading code, read in:

```
swh  
swh_rms  
swh_numval  
surface_type
```

Since all these variables are given at the low data rate, they can be used with no further rearrangement. Select where:

- `surface_type = 0` i.e. ocean
- `swh_numval` contains an acceptable number of data points e.g. > 15
- `swh_rms` is acceptably low e.g. < 1m

The selected `swh` will give the required values.

4.3 Slope-corrected elevation - high data rate

Choose the relevant file(s) on the basis of the date you want, which is part of the filename (see section 3.3).

Slope corrected data (also known as 'offset' data in the product) is given at the 20Hz data rate. It is accompanied by its own flags.

Using any netCDF tool or reading code, read in:

```
offset_latitude_20hz  
offset_longitude_20hz  
offset_elevation_20hz
```

The selected offset latitude and longitude now give the echoing point rather than nadir. The height estimate is slope corrected.

5 L2 Product Contents

5.1 Product Attributes

At L1, the L1 product is written out with ASCII headers in the ENVISAT format – see [R6] for the contents of the REAPER MPH and SPH. The MPH and SPH of the L1b product is then duplicated in the L2 product(s) in the form of netCDF global attributes. A number of new attributes are then added to capture features of the L2 processing. The attributes used are listed below.

Table 3: L2 netCDF attributes derived from L1b MPH

Attribute Name	Description	Type	Unit
proc_stage	Processing stage flag	char	set to 'R'
product	Product ID	text	n/a
proc_centre	ID of the centre performing the processing	text	n/a
proc_time	UTC time of processing (L1 product generation time)	text	n/a
software_ver	Software version number of processing software (used at L1)	text	n/a
sensing_start	UTC time of start of sensing	text	n/a
sensing_stop	UTC time of end of sending	text	n/a
phase	Mission phase	char	n/a
cycle	Cycle number	int	n/a
rel_orbit ¹	Start relative orbit number (actually pass number)	int	n/a
abs_orbit	Start absolute orbit number	int	n/a
state_vector_time	UTC of state vector	text	n/a
delta_ut1	UT1-UTC	double	seconds
x_position	X position in Earth- fixed reference	double	metres
y_position	Y position in Earth- fixed reference	double	metres
z_position	Z position in Earth- fixed reference	double	metres
x_velocity	X velocity in Earth- fixed reference	double	metres/second
y_velocity	Y velocity in Earth- fixed reference	double	metres/second
z_velocity	Z velocity in Earth- fixed reference	double	metres/second
vector_source	Set to 'RP' for POD orbit	text	set to 'RP'
utc_sbt_time	UTC time corresponding to sat_binary_time	text	n/a
sat_binary_time	Satellite Binary Time (SBT), the integer time reported by the satellite clock	double	binary count
clock_step	Clock step size	double	picoseconds
leap_utc	UTC time of the occurrence of the leap second (if any)	text	n/a
leap_err	Has value 1 if a leap second occurs within the product, otherwise 0	byte	1 or 0
leap_sign	Leap second sign	text	+1 or 0 or -1
product_err	Has value 1 if errors have been detected in the product, otherwise 0	byte	1 or 0

Table 4: L2 netCDF attributes derived from L1b SPH

Attribute Name	Description	netCDF Data Type	Units
ra0_first_record_time	UTC of the first record in the Main MDS of this product	double	MJD2000
ra0_last_record_time	UTC of the last record in in the Main MDS of this product	double	MJD2000
ra0_first_lat	WGS84 latitude of the first record in the Main MDS	double	degrees north
ra0_first_long	WGS84 longitude of the first record in the Main MDS	double	degrees east
ra0_last_lat	WGS84 latitude of the last record in the Main MDS	double	degrees north

¹ Note that this field increments twice per orbit and would be more properly called a pass number.

ra0_last_long	WGS84 longitude of the last record in the Main MDS	double	degrees east
ra0_proc_flag	Processing errors significance flag. 1 if the percentage of DSRs containing processing errors during SP data block processing is more than the acceptable threshold	byte	1 or 0
ra0_header_flag	Header errors significance flag. 1 if the percentage of DSRs containing processing errors during SP header processing is more than the acceptable threshold	byte	1 or 0
ra0_processing_quality	Percentage of quality checks successfully passed during the SP data blocks processing	double	percent
ra0_header_quality	Percentage of quality checks successfully passed during the SP Headers processing	double	percent
ra0_acquisition_percent	Percentage of acquisition mode	double	percent
ra0_tracking_ocean_percent	Percentage of tracking on ocean	double	percent
ra0_tracking_ice_percent	Percentage of tracking on ice	double	percent
ra0_if_cal_percent	Percentage of IF calibration	double	percent
ra0_olc_ptr_percent	Percentage of OLC-PTR calibration	double	percent
uso_applied_1	First used value of 15 MHz USO applied during processing	text	frequency and start time ²
uso_applied_2	Second used value of 15 MHz USO applied during processing (if any)	text	frequency and start time
uso_applied_3	Third used value of 15 MHz USO applied during processing (if any)	text	frequency and start time

Table 5: L2 netCDF attributes derived at L2

Attribute Name	Description	netCDF Data Type	Units
l2_ref_doc	Reference document (the product specification)	text	N/A
ocean_retracker_version_for_ocean	The version of the ocean retracker used during the creation of this product (ocean mode records). Current options are "MLE3" and "MLE4"	text	N/A
ocean_retracker_version_for_ice	The version of the ocean retracker used during the creation of this product (ice mode records). Current options are "MLE3" and "MLE4"	text	N/A
sptr_missing	Flag indicating whether the MCD bit indicating missing SPTR was set for any record in the L1b dataset.	byte	0/1
mission	Mission identifier	text	'E1' 'E2'
l2_proc_time	UTC time of processing (L2 product generation time)	text	n/a
l2_software_ver	Software version number of processing software (used at L2)	text	n/a
l2_range_bias_applied_ocean_mode_ice1_retracker	Range bias added to ocean mode ICE1 retracker ranges	double	m
l2_range_bias_applied_ocean_mode_ice2_retracker	Range bias added to ocean mode ICE2 retracker ranges	double	m
l2_range_bias_applied_ocean_mode_ocean_retracker	Range bias added to ocean mode ocean retracker ranges	double	m
l2_range_bias_applied_ocean_mode_sitrack_retracker	Range bias added to ocean mode sea-ice retracker ranges	double	m

² The USO frequency and time are encoded into a string formatted like this "15000000.0323675@19960301T140012". This indicates that the specified frequency (in Hz) was applied to the data starting at the given date-stamp (in this example 14:00:12 UTC on 1st March 1996).

l2_range_bias_applied_ice_mode_ice1_retracker	Range bias added to ice mode ICE1 retracker ranges	double	m
l2_range_bias_applied_ice_mode_ice2_retracker	Range bias added to ice mode ICE2 retracker ranges	double	m
l2_range_bias_applied_ice_mode_ocean_retracker	Range bias added to ice mode ocean retracker ranges	double	m
l2_range_bias_applied_ice_mode_sitrack_retracker	Range bias added to ice mode sea-ice retracker ranges	double	m
l2_sig0_bias_applied_ocean_mode_ice1_retracker	Bias added to backscatter for ocean mode ICE1 retracker	double	dB
l2_sig0_bias_applied_ocean_mode_ice2_retracker	Bias added to backscatter for ocean mode ICE2 retracker	double	dB
l2_sig0_bias_applied_ocean_mode_ocean_retracker	Bias added to backscatter for ocean mode ocean retracker	double	dB
l2_sig0_bias_applied_ocean_mode_sitrack_retracker	Bias added to backscatter for ocean mode sea-ice retracker	double	dB
l2_sig0_bias_applied_ice_mode_ice1_retracker	Bias added to backscatter for ice mode ICE1 retracker	double	dB
l2_sig0_bias_applied_ice_mode_ice2_retracker	Bias added to backscatter for ice mode ICE2 retracker	double	dB
l2_sig0_bias_applied_ice_mode_ocean_retracker	Bias added to backscatter for ice mode ocean retracker	double	dB
l2_sig0_bias_applied_ice_mode_sitrack_retracker	Bias added to backscatter for ice mode sea-ice retracker	double	dB
potential_orbit_degradation	Set to 1 in the case of potential degradation of the orbit solution.	byte	boolean
potential_range_degradation	Set to 1 in the case of potential degradation of the range measurement due to platform effects.	byte	boolean

The last two flags are not output by the L2 processing, but may be added to the products by the post-processing step that cuts the products at the poles and removes the overlapping data.

At L1, a standard set of DSDs is generated in the ENVISAT ASCII format. All of the DSDs present in the L1 product are preserved in the netCDF attributes at L2 and are added to, to record the additional auxiliary files used in processing at L2. The format used for the DSDs is as shown in Table 6. The number increases from 1 to the number of DSDs and the total number of DSDs is recorded in the attribute `reference_DSD_count`.

Table 6: netCDF attributes for DSDs

Attribute Name	Description	netCDF Data Type	Units
reference_DSD_1_DS_name	The file type (as used in the Job Order) of this reference file.	text	N/A
reference_DSD_1_filename	The filename (without path) of this file.	text	N/A
reference_DSD_count	The total number of DSDs	int	count

5.2 Product Parameters Overview

5.2.1 Available L2 parameters

The following table shows which parameters are present in each of the three L2 filetypes:

Table 7: Contents of L2 filetypes

Field	Meteo	GDR	SGDR
time	✓	✓	✓
meas_ind	x	✓	✓
time_20hz	x	✓	✓
lat	✓	✓	✓
lon	✓	✓	✓
lat_20hz	x	✓	✓
lon_20hz	x	✓	✓
surface_type	✓	✓	✓
rad_surf_type	✓	✓	✓
qual_alt_1hz_range_ocean	✓	✓	✓
qual_alt_1hz_swh_ocean	✓	✓	✓
qual_alt_1hz_sig0_ocean	✓	✓	✓
rad_state_flag_l2_proc_error	✓	✓	✓
rad_state_flag_orb	✓	✓	✓
rad_state_flag_orb_prop	✓	✓	✓
rad_state_flag_orb_init	✓	✓	✓
rad_state_validity	✓	✓	✓
rad_state_flag	✓	✓	✓
rad_state_flag_land_ocean	✓	✓	✓
rad_state_bt_check	✓	✓	✓
alt_state_flag	✓	✓	✓
alt_state_flag_20hz	x	✓	✓
alt_state_flag_tracking_surface_20hz	x	✓	✓
alt_state_flag_tracking_type_20hz	x	✓	✓
alt_state_flag_lost_track_assert_20hz	x	✓	✓
alt_state_flag_lost_track_alarm_20hz	x	✓	✓
alt_state_flag_chirp_type_20hz	x	✓	✓
ice_flag	✓	✓	✓
ice_class_1	✓	✓	✓
ice_class_2	✓	✓	✓
ice_class_3	✓	✓	✓
ice_class_4	✓	✓	✓
interp_flag_tb	✓	✓	✓
alt	✓	✓	✓
alt_20hz	x	✓	✓
orb_alt_rate	✓	✓	✓
orb_alt_rate_20hz	x	✓	✓
ocean_range	✓	✓	✓
ocean_range_20hz	x	✓	✓
ocean_range_used_20hz	x	✓	✓
ocean_range_rms	✓	✓	✓
ocean_range_numval	✓	✓	✓
ocean_qual_flag_20hz	x	✓	✓
off_nadir_angle_wf	✓	✓	✓
off_nadir_angle_wf_20hz	x	✓	✓
tracker_range_20hz	x	✓	✓
swh_20hz	x	✓	✓

<u>swh_used_20hz</u>	X	✓	✓
<u>ice1_range_20hz</u>	X	✓	✓
<u>thermal_noise_20hz</u>	X	✓	✓
<u>ice2_range_20hz</u>	X	✓	✓
<u>ice2_le_width_20hz</u>	X	✓	✓
<u>ice2_1st_te_slope_20hz</u>	X	✓	✓
<u>ice2_2nd_te_slope_20hz</u>	X	✓	✓
<u>sitrack_range_20hz</u>	X	✓	✓
<u>ice2_mqe_20hz</u>	X	✓	✓
<u>ocean_mqe_20hz</u>	X	✓	✓
<u>amplitude_20hz</u>	X	✓	✓
<u>peakiness_20hz</u>	X	✓	✓
<u>peakiness</u>	✓	✓	✓
<u>width_20hz</u>	X	✓	✓
<u>cog_corr_20hz</u>	X	✓	✓
<u>inst_range_corr_20hz</u>	X	✓	✓
<u>doppler_corr_20hz</u>	X	✓	✓
<u>delta_doppler_corr_20hz</u>	X	✓	✓
<u>wind_speed_alt</u>	✓	✓	✓
<u>ocean_sig0_used_20hz</u>	X	✓	✓
<u>ocean_sig0_20hz</u>	X	✓	✓
<u>ice1_sig0_20hz</u>	X	✓	✓
<u>ice2_sig0_20hz</u>	X	✓	✓
<u>sitrack_sig0_20hz</u>	X	✓	✓
<u>ocean_sig0</u>	✓	✓	✓
<u>ocean_sig0_rms</u>	✓	✓	✓
<u>ocean_sig0_numval</u>	✓	✓	✓
<u>swh_squared</u>	✓	✓	✓
<u>swh_signed</u>	✓	✓	✓
<u>swh</u>	✓	✓	✓
<u>swh_rms</u>	✓	✓	✓
<u>swh_numval</u>	✓	✓	✓
<u>sea_state_bias</u>	✓	✓	✓
<u>offset_lat_20hz</u>	X	✓	✓
<u>offset_lon_20hz</u>	X	✓	✓
<u>offset_elevation_20hz</u>	X	✓	✓
<u>offset_azimuth_20hz</u>	X	✓	✓
<u>offset_attitude_20hz</u>	X	✓	✓
<u>ice1_elevation_20hz</u>	X	✓	✓
<u>sitrack_elevation_20hz</u>	X	✓	✓
<u>tb_238</u>	✓	✓	✓
<u>tb_365</u>	✓	✓	✓
<u>tb_238_rms</u>	✓	✓	✓
<u>tb_365_rms</u>	✓	✓	✓
<u>qual_wf_low_power_20hz</u>	X	✓	✓
<u>qual_wf_low_peakiness_20hz</u>	X	✓	✓
<u>qual_wf_high_peakiness_20hz</u>	X	✓	✓
<u>qual_wf_noisy_20hz</u>	X	✓	✓
<u>qual_wf_bad_le_20hz</u>	X	✓	✓
<u>qual_wf_low_var_20hz</u>	X	✓	✓
<u>qual_wf_not_tracking_20hz</u>	X	✓	✓
<u>qual_wf_reject_20hz</u>	X	✓	✓
<u>ice1_qual_flag_20hz</u>	X	✓	✓
<u>ice2_qual_flag_20hz</u>	X	✓	✓
<u>sitrack_qual_flag_20hz</u>	X	✓	✓

<u>model_dry_tropo_corr</u>	✓	✓	✓
<u>inv_bar_corr</u>	✓	✓	✓
<u>hf_fluctuations_corr</u>	✓	✓	✓
<u>surface_pressure</u>	✓	✓	✓
<u>model_wet_tropo_corr</u>	✓	✓	✓
<u>rad_wet_tropo_corr</u>	✓	✓	✓
<u>rad_water_vapor</u>	✓	✓	✓
<u>rad_liquid_water</u>	✓	✓	✓
<u>wind_speed_model_u</u>	✓	✓	✓
<u>wind_speed_model_v</u>	✓	✓	✓
<u>iono_corr_model</u>	✓	✓	✓
<u>iono_corr_gps</u>	✓	✓	✓
<u>mean_sea_surface_1</u>	✓	✓	✓
<u>mean_sea_surface_2</u>	✓	✓	✓
<u>geoid</u>	✓	✓	✓
<u>ocean_tide_sol1</u>	✓	✓	✓
<u>ocean_tide_sol2</u>	✓	✓	✓
<u>load_tide_sol1</u>	✓	✓	✓
<u>load_tide_sol2</u>	✓	✓	✓
<u>ocean_tide_equil</u>	✓	✓	✓
<u>ocean_tide_non_equil</u>	✓	✓	✓
<u>solid_earth_tide</u>	✓	✓	✓
<u>pole_tide</u>	✓	✓	✓
<u>bathymetry</u>	✓	✓	✓
<u>atmos_corr_sig0</u>	✓	✓	✓
<u>interp_flag_slope_model_20hz</u>	x	✓	✓
<u>agc_20hz</u>	x	✓	✓
<u>scaling_factor_20hz</u>	x	✓	✓
<u>inst_time_corr_20hz</u>	x	✓	✓
<u>inst_agc_corr_20hz</u>	x	✓	✓
<u>agc_cal_factor_20hz</u>	x	✓	✓
<u>p_ref_20hz</u>	x	✓	✓
<u>sptr_jumps_corr_20hz</u>	x	✓	✓
<u>mcd_20hz</u>	x	✓	✓
<u>sc_bin_count</u>	x	x	✓
<u>ku_wf</u>	x	x	✓
<u>window_delay</u>	x	x	✓
<u>rx_dist_coarse</u>	x	x	✓
<u>rx_dist_fine</u>	x	x	✓
<u>num_flight_cal_meas</u>	x	x	✓
<u>dop_time_c</u>	x	x	✓
<u>noise_floor</u>	x	x	✓
<u>stl_disc_out</u>	x	x	✓
<u>htl_disc_out</u>	x	x	✓
<u>agc_disc_out</u>	x	x	✓
<u>htl_beta_branch</u>	x	x	✓
<u>rx_offset</u>	x	x	✓
<u>a_htl_coeff</u>	x	x	✓
<u>b_htl_coeff</u>	x	x	✓
<u>a_agc_coeff</u>	x	x	✓
<u>b_agc_coeff</u>	x	x	✓
<u>a_stl_coeff</u>	x	x	✓
<u>b_stl_coeff</u>	x	x	✓
<u>slope</u>	x	x	✓
<u>wvf_ind</u>	x	x	✓

5.2.2 L2 parameters units and types

The following table gives a quick reference to the units and type of each parameter.

Table 8: L2 parameters units and type

Field	Unit	Scale	Type
<u>time</u>	seconds	-	double
<u>meas_ind</u>	count	-	short
<u>time_20hz</u>	seconds	-	double
<u>lat</u>	degrees_north	1.e-06	int
<u>lon</u>	degrees_east	1.e-06	int
<u>lat_20hz</u>	degrees_north	1.e-06	int
<u>lon_20hz</u>	degrees_east	1.e-06	int
<u>surface_type</u>	-	-	byte
<u>rad_surf_type</u>	-	-	byte
<u>qual_alt_1hz_range_ocean</u>	-	-	byte
<u>qual_alt_1hz_swh_ocean</u>	-	-	byte
<u>qual_alt_1hz_sig0_ocean</u>	-	-	byte
<u>rad_state_flag_l2_proc_error</u>	-	-	byte
<u>rad_state_flag_orb</u>	-	-	byte
<u>rad_state_flag_orb_prop</u>	-	-	byte
<u>rad_state_flag_orb_init</u>	-	-	byte
<u>rad_state_validity</u>	-	-	byte
<u>rad_state_flag</u>	-	-	byte
<u>rad_state_flag_land_ocean</u>	-	-	byte
<u>rad_state_bt_check</u>	-	-	byte
<u>alt_state_flag</u>	-	-	byte
<u>alt_state_flag_20hz</u>	-	-	byte
<u>alt_state_flag_tracking_surface_20hz</u>	-	-	byte
<u>alt_state_flag_tracking_type_20hz</u>	-	-	byte
<u>alt_state_flag_lost_track_assert_20hz</u>	-	-	byte
<u>alt_state_flag_lost_track_alarm_20hz</u>	-	-	byte
<u>alt_state_flag_chirp_type_20hz</u>	-	-	byte
<u>ice_flag</u>	-	-	byte
<u>ice_class_1</u>	-	0.01	short
<u>ice_class_2</u>	-	0.01	short
<u>ice_class_3</u>	-	0.01	short
<u>ice_class_4</u>	-	0.01	short
<u>interp_flag_tb</u>	-	-	byte
<u>alt</u>	m	0.001	int
<u>alt_20hz</u>	m	0.001	int
<u>orb_alt_rate</u>	m/s	0.001	int
<u>orb_alt_rate_20hz</u>	m/s	0.001	int
<u>ocean_range</u>	m	0.001	int
<u>ocean_range_20hz</u>	m	0.001	int
<u>ocean_range_used_20hz</u>	-	-	byte
<u>ocean_range_rms</u>	m	0.001	short
<u>ocean_range_numval</u>	count	-	byte
<u>ocean_qual_flag_20hz</u>	-	-	byte
<u>off_nadir_angle_wf</u>	degrees^2	0.0001	short
<u>off_nadir_angle_wf_20hz</u>	degrees^2	0.0001	short
<u>tracker_range_20hz</u>	m	0.001	int
<u>swh_20hz</u>	m	0.001	short
<u>swh_used_20hz</u>	-	-	byte

<u>ice1_range_20hz</u>	m	0.001	int
<u>thermal noise_20hz</u>	count	0.01	short
<u>ice2_range_20hz</u>	m	0.001	int
<u>ice2_le_width_20hz</u>	m	0.001	int
<u>ice2 1st te slope_20hz</u>	-	1.	int
<u>ice2 2nd te slope_20hz</u>	-	1.	int
<u>sitrack_range_20hz</u>	m	0.001	int
<u>ice2_mqe_20hz</u>	count	0.0001	int
<u>ocean_mqe_20hz</u>	count	0.0001	int
<u>amplitude_20hz</u>	count	0.001	int
<u>peakiness_20hz</u>	count	0.001	int
<u>peakiness</u>	count	0.001	int
<u>width_20hz</u>	count	0.001	short
<u>cog_corr_20hz</u>	m	0.001	short
<u>inst_range_corr_20hz</u>	m	0.001	int
<u>doppler_corr_20hz</u>	m	0.001	short
<u>delta_doppler_corr_20hz</u>	m	0.001	short
<u>wind speed_alt</u>	m/s	0.01	short
<u>ocean_sig0_used_20hz</u>	-	-	byte
<u>ocean_sig0_20hz</u>	dB	0.01	short
<u>ice1_sig0_20hz</u>	dB	0.01	short
<u>ice2_sig0_20hz</u>	dB	0.01	short
<u>sitrack_sig0_20hz</u>	dB	0.01	short
<u>ocean_sig0</u>	dB	0.01	short
<u>ocean_sig0_rms</u>	dB	0.01	short
<u>ocean_sig0_numval</u>	count	-	byte
<u>swh_squared</u>	m ²	1.e-06	int
<u>swh_signed</u>	m	0.001	short
<u>swh</u>	m	0.001	short
<u>swh_rms</u>	m	0.001	short
<u>swh_numval</u>	count	-	byte
<u>sea_state_bias</u>	m	0.001	short
<u>offset_lat_20hz</u>	degrees_north	1.e-06	int
<u>offset_lon_20hz</u>	degrees_east	1.e-06	int
<u>offset_elevation_20hz</u>	m	0.001	int
<u>offset_azimuth_20hz</u>	radian	1.e-06	int
<u>offset_attitude_20hz</u>	radian	1.e-06	int
<u>ice1_elevation_20hz</u>	m	0.001	int
<u>sitrack_elevation_20hz</u>	m	0.001	int
<u>tb_238</u>	K	0.01	short
<u>tb_365</u>	K	0.01	short
<u>tb_238_rms</u>	K	0.01	short
<u>tb_365_rms</u>	K	0.01	short
<u>qual_wf_low_power_20hz</u>	-	-	byte
<u>qual_wf_low_peakiness_20hz</u>	-	-	byte
<u>qual_wf_high_peakiness_20hz</u>	-	-	byte
<u>qual_wf_noisy_20hz</u>	-	-	byte
<u>qual_wf_bad_le_20hz</u>	-	-	byte
<u>qual_wf_low_var_20hz</u>	-	-	byte
<u>qual_wf_not_tracking_20hz</u>	-	-	byte
<u>qual_wf_reject_20hz</u>	-	-	byte
<u>ice1_qual_flag_20hz</u>	-	-	byte
<u>ice2_qual_flag_20hz</u>	-	-	byte
<u>sitrack_qual_flag_20hz</u>	-	-	byte
<u>model_dry_tropo_corr</u>	m	0.001	short

<u>inv_bar_corr</u>	m	0.001	short
<u>hf_fluctuations_corr</u>	m	0.001	short
<u>surface_pressure</u>	Pa	10.	short
<u>model_wet_tropo_corr</u>	m	0.001	short
<u>rad_wet_tropo_corr</u>	m	0.001	short
<u>rad_water_vapor</u>	kg/m ²	0.1	short
<u>rad_liquid_water</u>	kg/m ²	0.01	short
<u>wind_speed_model_u</u>	m/s	0.001	short
<u>wind_speed_model_v</u>	m/s	0.001	short
<u>iono_corr_model</u>	m	0.001	short
<u>iono_corr_gps</u>	m	0.001	short
<u>mean_sea_surface_1</u>	m	0.001	int
<u>mean_sea_surface_2</u>	m	0.001	int
<u>geoid</u>	m	0.001	int
<u>ocean_tide_sol1</u>	m	0.001	short
<u>ocean_tide_sol2</u>	m	0.001	short
<u>load_tide_sol1</u>	m	0.001	short
<u>load_tide_sol2</u>	m	0.001	short
<u>ocean_tide_equil</u>	m	0.001	short
<u>ocean_tide_non_equil</u>	m	0.001	short
<u>solid_earth_tide</u>	m	0.001	short
<u>pole_tide</u>	m	0.001	short
<u>bathymetry</u>	m	0.001	int
<u>atmos_corr_sig0</u>	dB	0.01	short
<u>interp_flag_slope_model_20hz</u>	-	-	byte
<u>agc_20hz</u>	dB	0.01	int
<u>scaling_factor_20hz</u>	dB	0.01	int
<u>inst_time_corr_20hz</u>	s	1.e-12	int
<u>inst_agc_corr_20hz</u>	dB	0.01	short
<u>agc_cal_factor_20hz</u>	dB	0.01	short
<u>p_ref_20hz</u>	counts	0.01	int
<u>sptr_jumps_corr_20hz</u>	s	1.e-12	int
<u>mcd_20hz</u>	-	-	int
<u>sc_bin_count</u>	-	-	byte
<u>ku_wf</u>	count	-	short
<u>window_delay</u>	s	1.e-12	double
<u>rx_dist_coarse</u>	s	1.25e-08	short
<u>rx_dist_fine</u>	s	1.25e-08	short
<u>num_flight_cal_meas</u>	count	1.	short
<u>dop_time_c</u>	s	1.e-12	int
<u>noise_floor</u>	count	0.01	int
<u>stl_disc_out</u>	-	0.01	int
<u>htl_disc_out</u>	s	1.25e-12	int
<u>agc_disc_out</u>	count	0.1	int
<u>htl_beta_branch</u>	-	1.25e-14	int
<u>rx_offset</u>	s	1.25e-11	int
<u>a_htl_coeff</u>	-	0.001	int
<u>b_htl_coeff</u>	-	1.e-05	int
<u>a_agc_coeff</u>	-	0.01	int
<u>b_agc_coeff</u>	-	0.0001	int
<u>a_stl_coeff</u>	-	0.1	int
<u>b_stl_coeff</u>	-	0.001	int
<u>slope</u>	-	0.01	int
<u>wvf_ind</u>	count	-	byte

5.3 Detailed description of L2 parameters

5.3.1 time

The CDL definition of the variable `time` is:

```
double time(time) ;
    time:units = "seconds since 1990-01-01 00:00:00.0" ;
    time:long_name = "time (sec. since 1990-01-01)" ;
    time:standard_name = "time" ;
    time:calendar = "gregorian" ;
    time:comment = "Time counted in seconds since 1990-01-01 00:00:00." ;
```

This is derived from a direct conversion of the 20 Hz time to a count of seconds past the datum point. The 1 Hz time is interpolated from the 20 Hz values. Before product cutting, this value will reflect overlaps and single-bit errors present in the original ERAC data.

5.3.2 meas_ind

The CDL definition of the variable `meas_ind` is:

```
short meas_ind(meas_ind) ;
    meas_ind:units = "count" ;
    meas_ind:long_name = "elementary measurement index" ;
    meas_ind:comment = "Set to be compliant with the CF-1.1 convention. Counts 0..19." ;
```

This parameter provides the necessary dimension information for compliance with CF.

5.3.3 time_20hz

The CDL definition of the variable `time_20hz` is:

```
double time_20hz(time, meas_ind) ;
    time_20hz:units = "seconds since 1990-01-01 00:00:00.0" ;
    time_20hz:long_name = "time (sec. since 1990-01-01)" ;
    time_20hz:standard_name = "time" ;
    time_20hz:calendar = "gregorian" ;
    time_20hz:comment = "Time counted in seconds since 1990-01-01 00:00:00." ;
```

This is a direct conversion of the time to a count of seconds past the datum point. Before product cutting, this value will reflect overlaps and single-bit errors present in the original ERAC data.

5.3.4 lat

The CDL definition of the variable `lat` is:

```
int lat(time) ;
    lat:units = "degrees_north" ;
    lat:_FillValue = 2147483647 ;
    lat:long_name = "latitude" ;
    lat:standard_name = "latitude" ;
    lat:scale_factor = 1.e-06 ;
    lat:comment = "Positive latitude is North latitude, negative latitude is South latitude." ;
```

The latitude of the 1 Hz record on the range [-90,+90] (positive North) on the WGS84 ellipsoid.

5.3.5 lon

The CDL definition of the variable lon is:

```
int lon(time) ;
  lon:units = "degrees_east" ;
  lon:_FillValue = 2147483647 ;
  lon:long_name = "longitude" ;
  lon:standard_name = "longitude" ;
  lon:scale_factor = 1.e-06 ;
  lon:comment = "East longitude relative to Greenwich meridian." ;
```

The longitude of the 1 Hz record on the range [-180,+180] (positive East) on the WGS84 ellipsoid.

5.3.6 lat_20hz

The CDL definition of the variable lat_20hz is:

```
int lat_20hz(time, meas_ind) ;
  lat_20hz:units = "degrees_north" ;
  lat_20hz:_FillValue = 2147483647 ;
  lat_20hz:long_name = "20 Hz latitude" ;
  lat_20hz:standard_name = "latitude" ;
  lat_20hz:scale_factor = 1.e-06 ;
  lat_20hz:comment = "Positive latitude is North latitude, negative latitude
is South latitude." ;
```

The latitude of the 20 Hz record on the range [-90,+90] (positive North) on the WGS84 ellipsoid.

5.3.7 lon_20hz

The CDL definition of the variable lon_20hz is:

```
int lon_20hz(time, meas_ind) ;
  lon_20hz:units = "degrees_east" ;
  lon_20hz:_FillValue = 2147483647 ;
  lon_20hz:long_name = "20 Hz longitude" ;
  lon_20hz:standard_name = "longitude" ;
  lon_20hz:scale_factor = 1.e-06 ;
  lon_20hz:comment = "East longitude relative to Greenwich meridian." ;
```

The longitude of the 20 Hz record on the range [-180,+180] (positive East) on the WGS84 ellipsoid.

5.3.8 surface_type

The CDL definition of the variable surface_type is:

```
byte surface_type(time) ;
  surface_type:_FillValue = 127b ;
  surface_type:long_name = "surface type" ;
  surface_type:flag_values = "0b, 1b, 2b, 3b" ;
  surface_type:flag_meanings = "ocean lake_enclosed_sea ice land" ;
  surface_type:coordinates = "lon lat" ;
  surface_type:comment = "Computed using the TERRAINBASE model: 0= open ocean
s or semi-enclosed seas; 1= enclosed seas or lakes; 2= continental ice; 3= land
." ;
```

The surface type is derived at the 1 Hz location from the surface type mask file.

5.3.9 rad_surf_type

The CDL definition of the variable `rad_surf_type` is:

```
byte rad_surf_type(time) ;
  rad_surf_type:_FillValue = 127b ;
  rad_surf_type:long_name = "radiometer surface type" ;
  rad_surf_type:flag_values = "0b, 1b" ;
  rad_surf_type:flag_meanings = "ocean land" ;
  rad_surf_type:coordinates = "lon lat" ;
```

This surface type is derived at the 1 Hz location from the radiometer data.

5.3.10 qual_alt_1hz_range_ocean

The CDL definition of the variable `qual_alt_1hz_range_ocean` is:

```
byte qual_alt_1hz_range_ocean(time) ;
  qual_alt_1hz_range_ocean:_FillValue = 127b ;
  qual_alt_1hz_range_ocean:long_name = "quality flag for 1 Hz altimeter data:
range from ocean retracker" ;
  qual_alt_1hz_range_ocean:flag_values = "0b, 1b" ;
  qual_alt_1hz_range_ocean:flag_meanings = "good bad" ;
  qual_alt_1hz_range_ocean:coordinates = "lon lat" ;
```

This flag indicates whether the 1 Hz ocean retracker range data is good.

5.3.11 qual_alt_1hz_swh_ocean

The CDL definition of the variable `qual_alt_1hz_swh_ocean` is:

```
byte qual_alt_1hz_swh_ocean(time) ;
  qual_alt_1hz_swh_ocean:_FillValue = 127b ;
  qual_alt_1hz_swh_ocean:long_name = "quality flag for 1 Hz altimeter data: S
WH from the ocean retracker" ;
  qual_alt_1hz_swh_ocean:flag_values = "0b, 1b" ;
  qual_alt_1hz_swh_ocean:flag_meanings = "good bad" ;
  qual_alt_1hz_swh_ocean:coordinates = "lon lat" ;
```

This flag indicates whether the 1 Hz significant wave height data is good.

5.3.12 qual_alt_1hz_sig0_ocean

The CDL definition of the variable `qual_alt_1hz_sig0_ocean` is:

```
byte qual_alt_1hz_sig0_ocean(time) ;
  qual_alt_1hz_sig0_ocean:_FillValue = 127b ;
  qual_alt_1hz_sig0_ocean:long_name = "quality flag for 1 Hz altimeter data:
backscatter coefficient from the ocean retracker" ;
  qual_alt_1hz_sig0_ocean:flag_values = "0b, 1b" ;
  qual_alt_1hz_sig0_ocean:flag_meanings = "good bad" ;
  qual_alt_1hz_sig0_ocean:coordinates = "lon lat" ;
```

This flag indicates whether the 1 Hz backscatter value derived from the ocean retracking is good.

5.3.13 rad_state_flag_l2_proc_error

The CDL definition of the variable `rad_state_flag_l2_proc_error` is:

```
byte rad_state_flag_l2_proc_error(time) ;
    rad_state_flag_l2_proc_error:_FillValge = "127b" ;
    rad_state_flag_l2_proc_error:long_name = "radiometer state flag: 12 process
ing error" ;
    rad_state_flag_l2_proc_error:flag_values = "0b, 1b" ;
    rad_state_flag_l2_proc_error:flag_meanings = "no_error error" ;
    rad_state_flag_l2_proc_error:coordinates = "lon lat" ;
    rad_state_flag_l2_proc_error:comment = "Set if an error occurred in the L2
radiometer processing. From REAPER MWR Chain MCD field." ;
```

5.3.14 rad_state_flag_orb

The CDL definition of the variable rad_state_flag_orb is:

```
byte rad_state_flag_orb(time) ;
    rad_state_flag_orb:_FillValue = 127b ;
    rad_state_flag_orb:long_name = "radiometer state flag: orbit accuracy" ;
    rad_state_flag_orb:flag_values = "0b, 1b" ;
    rad_state_flag_orb:flag_meanings = "propagator_used interpolator_used" ;
    rad_state_flag_orb:coordinates = "lon lat" ;
    rad_state_flag_orb:comment = "Method used for orbit determination. From REA
PER MWR Chain MCD field." ;
```

5.3.15 rad_state_flag_orb_prop

The CDL definition of the variable rad_state_flag_orb_prop is:

```
byte rad_state_flag_orb_prop(time) ;
    rad_state_flag_orb_prop:_FillValue = 127b ;
    rad_state_flag_orb_prop:long_name = "radiometer state flag: propagation mod
e status" ;
    rad_state_flag_orb_prop:flag_values = "0b, 1b, 2b, 3b" ;
    rad_state_flag_orb_prop:flag_meanings = "no_error warning_detected several_
errors_and_no_results incoherent_flag" ;
    rad_state_flag_orb_prop:coordinates = "lon lat" ;
    rad_state_flag_orb_prop:comment = "Orbit propagator status flag for propaga
tion mode at L1b/L2. From REAPER MWR Chain MCD field, but reordered to make zer
o the no error state." ;
```

5.3.16 rad_state_flag_orb_init

The CDL definition of the variable rad_state_flag_orb_init is:

```
byte rad_state_flag_orb_init(time) ;
    rad_state_flag_orb_init:_FillValue = 127b ;
    rad_state_flag_orb_init:long_name = "radiometer state flag: initialisation
mode status" ;
    rad_state_flag_orb_init:flag_values = "0b, 1b, 2b, 3b" ;
    rad_state_flag_orb_init:flag_meanings = "no_error warning_detected several_
errors_and_no_results incoherent_flag" ;
    rad_state_flag_orb_init:coordinates = "lon lat" ;
    rad_state_flag_orb_init:comment = "Orbit proagator status flag for propaga
tion mode at L1b/L. From REAPER MWR Chain MCD field, but reordered to make zero
the no error state." ;
```

5.3.17 rad_state_validity

The CDL definition of the variable rad_state_validity is:

```
byte rad_state_validity(time) ;
  rad_state_validity:_FillValue = 127b ;
  rad_state_validity:long_name = "radiometer dataset validity" ;
  rad_state_validity:valid_range = "0b, 7b" ;
  rad_state_validity:flag_mask = "1b, 2b, 4b" ;
  rad_state_validity:flag_meanings = "temp_flag obdh_flag bp_flag" ;
  rad_state_validity:coordinates = "lon lat" ;
  rad_state_validity:comment = "Validity: Indicates dataset record validity (
result of the weighted sequence of Temp_flg, OBDH_flg and BP_flg. From REAPER M
WR Chain MCD field." ;
```

5.3.18 rad_state_flag

The CDL definition of the variable rad_state_flag is:

```
byte rad_state_flag(time) ;
  rad_state_flag:_FillValue = 127b ;
  rad_state_flag:long_name = "radiometer state flags" ;
  rad_state_flag:valid_range = "0b, 15b" ;
  rad_state_flag:flag_mask = "1b, 2b, 4b, 8b" ;
  rad_state_flag:flag_meanings = "header_flag telemetry_flag processing_flag
crc_flag" ;
  rad_state_flag:coordinates = "lon lat" ;
  rad_state_flag:comment = "Combination of four radiometer status flags. Erro
rs are indicated by individual bits set. From REAPER MWR Chain MCD field." ;
```

5.3.19 rad_state_flag_land_ocean

The CDL definition of the variable rad_state_flag_land_ocean is:

```
byte rad_state_flag_land_ocean(time) ;
  rad_state_flag_land_ocean:_FillValue = 127b ;
  rad_state_flag_land_ocean:long_name = "radiometer state flag: land/ocean" ;
  rad_state_flag_land_ocean:flag_values = "0b, 1b" ;
  rad_state_flag_land_ocean:flag_meanings = "ocean land" ;
  rad_state_flag_land_ocean:coordinates = "lon lat" ;
  rad_state_flag_land_ocean:comment = "Land/Ocean detection flag. From REAPER
MWR Chain MCD field." ;
```

5.3.20 rad_state_bt_check

The CDL definition of the variable rad_state_bt_check is:

```
byte rad_state_bt_check(time) ;
  rad_state_bt_check:_FillValue = 127b ;
  rad_state_bt_check:long_name = "radiometer BT range check" ;
  rad_state_bt_check:valid_range = "0b, 3b" ;
  rad_state_bt_check:flag_mask = "1b, 2b" ;
  rad_state_bt_check:flag_meanings = "ch2_out_of_range ch1_out_of_range" ;
  rad_state_bt_check:coordinates = "lon lat" ;
  rad_state_bt_check:comment = "Individual bits are set if the brightness tem
perature of channel 2 or 1 is out of range. From REAPER MWR Chain MCD field." ;
```

5.3.21 alt_state_flag

The CDL definition of the variable `alt_state_flag` is:

```
byte alt_state_flag(time) ;
    alt_state_flag:FillValue = 127b ;
    alt_state_flag:long_name = "altimeter status flag: altimeter" ;
    alt_state_flag:flag_values = "0b, 1b, 2b, 3b " ;
    alt_state_flag:flag_meanings = "other unknown tracking_ocean tracking_ice"
;
    alt_state_flag:coordinates = "lon lat" ;
    alt_state_flag:comment = "Status appropriate for 1hz records. " ;
```

If a block of 20 records contains any useful data that is tracking the surface, then that tracking will be in either ocean or ice mode. This flag records that information at 1Hz. If there are no tracking records, then the type will be 'other'. If there are records present with an unknown type at 20Hz, then the type will be 'unknown'.

5.3.22 alt_state_flag_20hz

The CDL definition of the variable `alt_state_flag_20hz` is:

```
byte alt_state_flag_20hz(time, meas_ind) ;
    alt_state_flag_20hz:FillValue = 127b ;
    alt_state_flag_20hz:long_name = "altimeter status flag: altimeter" ;
    alt_state_flag_20hz:flag_values = "0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b " ;
    alt_state_flag_20hz:flag_meanings = "aquisition dummy_ptr tracking_ocean tracking_ice ptr if other_status incoherent_status time_jump" ;
    alt_state_flag_20hz:coordinates = "lon_20hz lat_20hz" ;
    alt_state_flag_20hz:comment = "Status for the current record, derived by the L1b processing. Time_Jump is corruption of the SBC sufficient to put the time stamp outside the current file start/stop times." ;
```

Type 0, 'acquisition', is where the altimeter is attempting to begin tracking the surface. This data can not be used for science purposes.

Type 7, 'incoherent status', states that the flagging of the record in the ERAC data was internally inconsistent – it is not possible to determine what the actual type of this record is.

Type 8 results when a single bit error in the spacecraft binary counter produces a jump in time large enough to be certain that it is not part of the orbit currently being processed. Smaller jumps are ambiguous (due to small jumps and overlaps in the ERAC data) and are not flagged in this way.

To extract only records where the altimeter is (or believes it is) tracking the surface, test this field and look for values of 2 or 3.

5.3.23 alt_state_flag_tracking_surface_20hz

The CDL definition of the variable `alt_state_flag_tracking_surface_20hz` is:

```
byte alt_state_flag_tracking_surface_20hz(time, meas_ind) ;
    alt_state_flag_tracking_surface_20hz:FillValue = 127b ;
    alt_state_flag_tracking_surface_20hz:long_name = "altimeter status flag: tracking surface" ;
    alt_state_flag_tracking_surface_20hz:flag_values = "0b, 1b " ;
    alt_state_flag_tracking_surface_20hz:flag_meanings = "ocean ice" ;
    alt_state_flag_tracking_surface_20hz:coordinates = "lon_20hz lat_20hz" ;
    alt_state_flag_tracking_surface_20hz:comment = "The tracking mode." ;
```


5.3.24 alt_state_flag_tracking_type_20hz

The CDL definition of the variable alt_state_flag_tracking_type_20hz is:

```
byte alt_state_flag_tracking_type_20hz(time, meas_ind) ;
  alt_state_flag_tracking_type_20hz:_FillValue = 127b ;
  alt_state_flag_tracking_type_20hz:long_name = "altimeter status flag: tracking type" ;
  alt_state_flag_tracking_type_20hz:flag_values = "0b, 1b, 2b " ;
  alt_state_flag_tracking_type_20hz:flag_meanings = "tracking_from_acquisition tracking_preset tracking_from_tracking" ;
  alt_state_flag_tracking_type_20hz:coordinates = "lon_20hz lat_20hz" ;
  alt_state_flag_tracking_type_20hz:comment = "The tracking method." ;
```

5.3.25 alt_state_flag_lost_track_assert_20hz

The CDL definition of the variable alt_state_flag_lost_track_assert_20hz is:

```
byte alt_state_flag_lost_track_assert_20hz(time, meas_ind) ;
  alt_state_flag_lost_track_assert_20hz:_FillValue = 127b ;
  alt_state_flag_lost_track_assert_20hz:long_name = "altimeter status flag: lost track assert" ;
  alt_state_flag_lost_track_assert_20hz:flag_values = "0b, 1b " ;
  alt_state_flag_lost_track_assert_20hz:flag_meanings = "No Yes" ;
  alt_state_flag_lost_track_assert_20hz:coordinates = "lon_20hz lat_20hz" ;
  alt_state_flag_lost_track_assert_20hz:comment = "Indicates if the counter for the number of non-tracked waveforms non-zero." ;
```

5.3.26 alt_state_flag_lost_track_alarm_20hz

The CDL definition of the variable alt_state_flag_lost_track_alarm_20hz is:

```
byte alt_state_flag_lost_track_alarm_20hz(time, meas_ind) ;
  alt_state_flag_lost_track_alarm_20hz:_FillValue = 127b ;
  alt_state_flag_lost_track_alarm_20hz:long_name = "altimeter status flag: lost track alarm" ;
  alt_state_flag_lost_track_alarm_20hz:flag_values = "0b, 1b " ;
  alt_state_flag_lost_track_alarm_20hz:flag_meanings = "no yes" ;
  alt_state_flag_lost_track_alarm_20hz:coordinates = "lon_20hz lat_20hz" ;
  alt_state_flag_lost_track_alarm_20hz:comment = "Indicates if the threshold for non-tracking waveforms been reached, triggering a return to acquisition." ;
```

5.3.27 alt_state_flag_chirp_type_20hz

The CDL definition of the variable alt_state_flag_chirp_type_20hz is:

```
byte alt_state_flag_chirp_type_20hz(time, meas_ind) ;
  alt_state_flag_chirp_type_20hz:_FillValue = 127b ;
  alt_state_flag_chirp_type_20hz:long_name = "altimeter status flag: transmitted chirp type" ;
  alt_state_flag_chirp_type_20hz:flag_values = "0b, 1b" ;
  alt_state_flag_chirp_type_20hz:flag_meanings = "ocean_chirp ice_chirp" ;
  alt_state_flag_chirp_type_20hz:coordinates = "lon_20hz lat_20hz" ;
  alt_state_flag_chirp_type_20hz:comment = "Defines the type of chirp transmitted for the current record." ;
```

5.3.28 ice_flag

The CDL definition of the variable `ice_flag` is:

```
byte ice_flag(time) ;
  ice_flag:_FillValue = 127b ;
  ice_flag:long_name = "ice flag" ;
  ice_flag:flag_values = "0b, 1b, 2b" ;
  ice_flag:flag_meanings = "no_ice ice not_evaluated" ;
  ice_flag:coordinates = "lon lat" ;
  ice_flag:comment = "" ;
```

This flag value is determined by the percentage membership values in the fields that follow. The `ice_flag` variable indicates the presence of sea-ice in the altimeter footprint.

0 indicates ocean.

1 indicates sea ice.

2 indicates that no evaluation has been made.

5.3.29 ice_class_1

The CDL definition of the variable `ice_class_1` is:

```
short ice_class_1(time) ;
  ice_class_1:_FillValue = 32767s ;
  ice_class_1:long_name = "sea ice class 1 membership" ;
  ice_class_1:scale_factor = 0.01 ;
  ice_class_1:coordinates = "lon lat" ;
  ice_class_1:comment = "Percentage membership of sea-ice class 1, open water
." ;
```

Percentage membership of the class 'open water' after classification.

5.3.30 ice_class_2

The CDL definition of the variable `ice_class_2` is:

```
short ice_class_2(time) ;
  ice_class_2:_FillValue = 32767s ;
  ice_class_2:long_name = "sea ice class 2 membership" ;
  ice_class_2:scale_factor = 0.01 ;
  ice_class_2:coordinates = "lon lat" ;
  ice_class_2:comment = "Percentage membership of sea-ice class 2, first-year
ice." ;
```

Percentage membership of the class 'first-year ice' after classification..

5.3.31 ice_class_3

The CDL definition of the variable `ice_class_3` is:

```
short ice_class_3(time) ;
  ice_class_3:_FillValue = 32767s ;
  ice_class_3:long_name = "sea ice class 3 membership" ;
  ice_class_3:scale_factor = 0.01 ;
  ice_class_3:coordinates = "lon lat" ;
  ice_class_3:comment = "Percentage membership of sea-ice class 3, multi-year
ice." ;
```

Percentage membership of the class 'multi-year ice' after classification..

5.3.32 ice_class_4

The CDL definition of the variable `ice_class_4` is:

```
short ice_class_4(time) ;
    ice_class_4:_FillValue = 32767s ;
    ice_class_4:long_name = "sea ice class 4 membership" ;
    ice_class_4:scale_factor = 0.01 ;
    ice_class_4:coordinates = "lon lat" ;
    ice_class_4:comment = "Percentage membership of sea-ice class 4, wet ice."
;
```

Percentage membership of the class 'wet ice' after classification..

5.3.33 interp_flag_tb

The CDL definition of the variable `interp_flag_tb` is:

```
byte interp_flag_tb(time) ;
    interp_flag_tb:_FillValue = 127b ;
    interp_flag_tb:long_name = "radiometer brightness temperatures interpolation" ;
    interp_flag_tb:flag_values = "0b, 1b, 2b, 3b" ;
    interp_flag_tb:flag_meanings = "good interpolation_with_gap extrapolation failure" ;
    interp_flag_tb:coordinates = "lon lat" ;
    interp_flag_tb:comment = "Possible values are: 0 = interpolation without gap between MWR data, 1 = interpolation with gap between MWR data, 2 = extrapolation of MWR data, 3 = failure of extrapolation and interpolation." ;
```

5.3.34 alt

The CDL definition of the variable `alt` is:

```
int alt(time) ;
    alt:units = "m" ;
    alt:_FillValue = 2147483647 ;
    alt:long_name = "1 Hz altitude of satellite" ;
    alt:standard_name = "height_above_reference_ellipsoid" ;
    alt:scale_factor = 0.001 ;
    alt:coordinates = "lon lat" ;
    alt:comment = "Altitude of satellite above the reference ellipsoid." ;
```

The instantaneous altitude rate of the satellite at the time of the 1Hz timestamp above. Created by Lagrangian interpolation of the 20Hz values.

5.3.35 alt_20hz

The CDL definition of the variable `alt_20hz` is:

```
int alt_20hz(time, meas_ind) ;
    alt_20hz:units = "m" ;
    alt_20hz:_FillValue = 2147483647 ;
    alt_20hz:long_name = "20 Hz altitude of satellite" ;
    alt_20hz:standard_name = "height_above_reference_ellipsoid" ;
    alt_20hz:scale_factor = 0.001 ;
```

```
alt_20hz:coordinates = "lon_20hz lat_20hz" ;
alt_20hz:comment = "Altitude of satellite above reference ellipsoid." ;
```

The altitude of the CoG of the satellite above the WGS84 ellipsoid at the time of the 20Hz timestamp above.

5.3.36 orb_alt_rate

The CDL definition of the variable `orb_alt_rate` is:

```
int orb_alt_rate(time) ;
orb_alt_rate:units = "m/s" ;
orb_alt_rate:_FillValue = 2147483647 ;
orb_alt_rate:long_name = "1 Hz orbital altitude rate" ;
orb_alt_rate:scale_factor = 0.001 ;
orb_alt_rate:coordinates = "lon lat" ;
orb_alt_rate:comment = "Altitude rate of satellite with respect to the reference ellipsoid." ;
```

The instantaneous altitude rate of the satellite at the time of the 1Hz timestamp above. Created by Lagrangian interpolation of the 20Hz values.

5.3.37 orb_alt_rate_20hz

The CDL definition of the variable `orb_alt_rate_20hz` is:

```
int orb_alt_rate_20hz(time, meas_ind) ;
orb_alt_rate_20hz:units = "m/s" ;
orb_alt_rate_20hz:_FillValue = 2147483647 ;
orb_alt_rate_20hz:long_name = "20 Hz orbital altitude rate" ;
orb_alt_rate_20hz:scale_factor = 0.001 ;
orb_alt_rate_20hz:coordinates = "lon_20hz lat_20hz" ;
orb_alt_rate_20hz:comment = "Altitude rate of satellite with respect to the reference ellipsoid." ;
```

The instantaneous altitude rate of the satellite at the time of the 20Hz timestamp above.

5.3.38 ocean_range

The CDL definition of the variable `ocean_range` is:

```
int ocean_range(time) ;
ocean_range:units = "m" ;
ocean_range:_FillValue = 2147483647 ;
ocean_range:long_name = "1 Hz Ku band corrected altimeter range from ocean retracker" ;
ocean_range:standard_name = "altimeter_range" ;
ocean_range:quality_flag = "qual_alt_1hz_range_ocean" ;
ocean_range:scale_factor = 0.001 ;
ocean_range:coordinates = "lon lat" ;
ocean_range:comment = "All instrumental corrections included, and system bias." ;
```

1Hz averaged range from the ocean retracker. Corrected for instrumental effects and referenced to the spacecraft CoG. Includes the static bias correction given in the netCDF attributes.

5.3.39 ocean_range_20hz

The CDL definition of the variable `ocean_range_20hz` is:

```

int ocean_range_20hz(time, meas_ind) ;
  ocean_range_20hz:units = "m" ;
  ocean_range_20hz:_FillValue = 2147483647 ;
  ocean_range_20hz:long_name = "20 Hz Ku band corrected altimeter range from
ocean retracker" ;
  ocean_range_20hz:standard_name = "altimeter_range" ;
  ocean_range_20hz:scale_factor = 0.001 ;
  ocean_range_20hz:coordinates = "lon_20hz lat_20hz" ;
  ocean_range_20hz:comment = "All instrumental corrections included, and syst
em bias." ;

```

20Hz range from the ocean retracker. Corrected for instrumental effects and referenced to the spacecraft CoG. Includes the static bias correction given in the netCDF attributes.

5.3.40 `ocean_range_used_20hz`

The CDL definition of the variable `ocean_range_used_20hz` is:

```

byte ocean_range_used_20hz(time, meas_ind) ;
  ocean_range_used_20hz:_FillValue = 127b ;
  ocean_range_used_20hz:long_name = "20 Hz flag for utilization in the comput
ation of 1 Hz Ku band range" ;
  ocean_range_used_20hz:flag_values = "0b, 1b" ;
  ocean_range_used_20hz:flag_meanings = "yes no" ;
  ocean_range_used_20hz:coordinates = "lon_20hz lat_20hz" ;
  ocean_range_used_20hz:comment = "Map of rejected points not used to compute
the 1-Hz Ku band altimeter range." ;

```

Indicates whether this measurement was used in the formation of the 1Hz averaged measurement.

5.3.41 `ocean_range_rms`

The CDL definition of the variable `ocean_range_rms` is:

```

short ocean_range_rms(time) ;
  ocean_range_rms:units = "m" ;
  ocean_range_rms:_FillValue = 32767s ;
  ocean_range_rms:long_name = "RMS of the Ku band range" ;
  ocean_range_rms:scale_factor = 0.001 ;
  ocean_range_rms:coordinates = "lon lat" ;
  ocean_range_rms:comment = "Compression of Ku-band high rate elements is pre
ceded by a detection of outliers. Only valid high rate values are used to compu
te this element." ;

```

Standard deviation of the measurements used to form the 1Hz measurement.

5.3.42 `ocean_range_numval`

The CDL definition of the variable `ocean_range_numval` is:

```

byte ocean_range_numval(time) ;
  ocean_range_numval:units = "count" ;
  ocean_range_numval:_FillValue = 127b ;
  ocean_range_numval:long_name = "number of valid points for Ku band range" ;
  ocean_range_numval:valid_min = 0b ;
  ocean_range_numval:valid_max = 20b ;
  ocean_range_numval:coordinates = "lon lat" ;

```

Number of points used to form the 1Hz measurement.

5.3.43 ocean_qual_flag_20hz

The CDL definition of the variable `ocean_qual_flag_20hz` is:

```
byte ocean_qual_flag_20hz(time, meas_ind) ;
    ocean_qual_flag_20hz:FillValue = 127b ;
    ocean_qual_flag_20hz:long_name = "20 Hz Ku band ocean retracking quality flag" ;
    ocean_qual_flag_20hz:flag_values = "0b, 1b" ;
    ocean_qual_flag_20hz:flag_meanings = "good bad" ;
    ocean_qual_flag_20hz:coordinates = "lon_20hz lat_20hz" ;
    ocean_qual_flag_20hz:comment = "ocean retracking quality flag." ;
```

5.3.44 off_nadir_angle_wf

The CDL definition of the variable `off_nadir_angle_wf` is:

```
short off_nadir_angle_wf(time) ;
    off_nadir_angle_wf:units = "degrees^2" ;
    off_nadir_angle_wf:FillValue = 32767s ;
    off_nadir_angle_wf:long_name = "square of the off nadir angle computed from Ku waveforms" ;
    off_nadir_angle_wf:scale_factor = 0.0001 ;
    off_nadir_angle_wf:coordinates = "lon_20hz lat_20hz" ;
    off_nadir_angle_wf:comment = "Only computed if the ocean retracker is run in MLE4 mode." ;
```

The 1Hz average of the attitude (mispointing) of the satellite derived from the waveform. It is possible for this to be a negative value due to the effect of noise on the shape of the trailing edge of the waveform.

5.3.45 off_nadir_angle_wf_20hz

The CDL definition of the variable `off_nadir_angle_wf_20hz` is:

```
short off_nadir_angle_wf_20hz(time, meas_ind) ;
    off_nadir_angle_wf_20hz:units = "degrees^2" ;
    off_nadir_angle_wf_20hz:FillValue = 32767s ;
    off_nadir_angle_wf_20hz:long_name = "20 Hz square of the off nadir angle computed from Ku waveforms" ;
    off_nadir_angle_wf_20hz:scale_factor = 0.0001 ;
    off_nadir_angle_wf_20hz:coordinates = "lon_20hz lat_20hz" ;
    off_nadir_angle_wf_20hz:comment = "Only computed if the ocean retracker is run in MLE4 mode." ;
```

The attitude (mispointing) of the satellite derived from the waveform. It is possible for this to be a negative value due to the effect of noise on the shape of the trailing edge of the waveform.

5.3.46 tracker_range_20hz

The CDL definition of the variable `tracker_range_20hz` is:

```
int tracker_range_20hz(time, meas_ind) ;
    tracker_range_20hz:units = "m" ;
    tracker_range_20hz:FillValue = 2147483647 ;
    tracker_range_20hz:long_name = "20 Hz Ku band altimeter range (no retracking)" ;
```

```
g)" ;
tracker_range_20hz:standard_name = "altimeter_range" ;
tracker_range_20hz:scale_factor = 0.001 ;
tracker_range_20hz:coordinates = "lon_20hz lat_20hz" ;
tracker_range_20hz:comment = "All instrumental corrections included." ;
```

20Hz range from the onboard tracking (the window delay converted to range). Corrected for instrumental effects and referenced to the spacecraft CoG.

5.3.47 swh_20hz

The CDL definition of the variable swh_20hz is:

```
short swh_20hz(time, meas_ind) ;
swh_20hz:units = "m" ;
swh_20hz:_FillValue = 32767s ;
swh_20hz:long_name = "20 Hz Ku band corrected significant waveheight" ;
swh_20hz:standard_name = "sea_surface_wave_significant_height" ;
swh_20hz:scale_factor = 0.001 ;
swh_20hz:coordinates = "lon_20hz lat_20hz" ;
swh_20hz:comment = "Computed directly from sigma c. No bias correction." ;
```

The square-root of the absolute value of significant wave height squared with the sign of the original value applied.

5.3.48 swh_used_20hz

The CDL definition of the variable swh_used_20hz is:

```
byte swh_used_20hz(time, meas_ind) ;
swh_used_20hz:_FillValue = 127b ;
swh_used_20hz:long_name = "20 Hz flag for utilization in the computation of
1 Hz Ku band significant waveheight" ;
swh_used_20hz:flag_values = "0b, 1b" ;
swh_used_20hz:flag_meanings = "yes no" ;
swh_used_20hz:coordinates = "lon_20hz lat_20hz" ;
swh_used_20hz:comment = "Map of rejected points not used to compute the 1-H
z Ku-band significant waveheight." ;
```

Indicates whether this record was used in the formation of the 1 Hz average value.

5.3.49 ice1_range_20hz

The CDL definition of the variable ice1_range_20hz is:

```
int ice1_range_20hz(time, meas_ind) ;
ice1_range_20hz:units = "m" ;
ice1_range_20hz:_FillValue = 2147483647 ;
ice1_range_20hz:long_name = "20 Hz Ku band altimeter range (ice1 retracking
)" ;
ice1_range_20hz:standard_name = "altimeter_range" ;
ice1_range_20hz:scale_factor = 0.001 ;
ice1_range_20hz:coordinates = "lon_20hz lat_20hz" ;
ice1_range_20hz:comment = "All instrumental corrections included, and syste
m bias." ;
```

20Hz range from the ICE1 retracker. Corrected for instrumental effects and referenced to the spacecraft CoG. Includes the static bias correction given in the netCDF attributes.

5.3.50 thermal_noise_20hz

The CDL definition of the variable `thermal_noise_20hz` is:

```
short thermal_noise_20hz(time, meas_ind) ;
    thermal_noise_20hz:units = "count" ;
    thermal_noise_20hz:FillValue = -1s ;
    thermal_noise_20hz:long_name = "Thermal noise estimate" ;
    thermal_noise_20hz:scale_factor = 0.01 ;
    thermal_noise_20hz:coordinates = "lon_20hz lat_20hz" ;
    thermal_noise_20hz:comment = "Taken as an average over a gate in the range
window." ;
```

5.3.51 ice2_range_20hz

The CDL definition of the variable `ice2_range_20hz` is:

```
int ice2_range_20hz(time, meas_ind) ;
    ice2_range_20hz:units = "m" ;
    ice2_range_20hz:FillValue = 2147483647 ;
    ice2_range_20hz:long_name = "20 Hz Ku band altimeter range (ice2 retracking
)" ;
    ice2_range_20hz:standard_name = "altimeter_range" ;
    ice2_range_20hz:scale_factor = 0.001 ;
    ice2_range_20hz:coordinates = "lon_20hz lat_20hz" ;
    ice2_range_20hz:comment = "All instrumental corrections included, and syste
m bias." ;
```

20Hz range from the ICE2 retracker. Corrected for instrumental effects and referenced to the spacecraft CoG. Includes the static bias correction given in the netCDF attributes.

5.3.52 ice2_le_width_20hz

The CDL definition of the variable `ice2_le_width_20hz` is:

```
int ice2_le_width_20hz(time, meas_ind) ;
    ice2_le_width_20hz:units = "m" ;
    ice2_le_width_20hz:FillValue = 2147483647 ;
    ice2_le_width_20hz:long_name = "Width of the leading edge of the waveform (
ice2 retracking)" ;
    ice2_le_width_20hz:scale_factor = 0.001 ;
    ice2_le_width_20hz:coordinates = "lon_20hz lat_20hz" ;
    ice2_le_width_20hz:comment = "The width of the leading edge of the waveform
, as estimated by the ice2 retracker." ;
```

5.3.53 ice2_1st_te_slope_20hz

The CDL definition of the variable `ice2_1st_te_slope_20hz` is:

```
int ice2_1st_te_slope_20hz(time, meas_ind) ;
    ice2_1st_te_slope_20hz:units = "s^-1" ;
    ice2_1st_te_slope_20hz:FillValue = 2147483647 ;
    ice2_1st_te_slope_20hz:long_name = "Slope of the first part of the trailing
edge of the waveform (ice2 retracking)" ;
```



```
ice2_1st_te_slope_20hz:scale_factor = 1. ;
ice2_1st_te_slope_20hz:coordinates = "lon_20hz lat_20hz" ;
ice2_1st_te_slope_20hz:comment = "The slope of the first part of the trailing edge of the waveform as estimated by the ice2 retracker." ;
```

5.3.54 ice2_2nd_te_slope_20hz

The CDL definition of the variable `ice2_2nd_te_slope_20hz` is:

```
int ice2_2nd_te_slope_20hz(time, meas_ind) ;
ice2_2nd_te_slope_20hz:units = "s^-1" ;
ice2_2nd_te_slope_20hz:FillValue = 2147483647 ;
ice2_2nd_te_slope_20hz:long_name = "Slope of the second part of the trailing edge of the waveform (ice2 retracking)" ;
ice2_2nd_te_slope_20hz:scale_factor = 1. ;
ice2_2nd_te_slope_20hz:coordinates = "lon_20hz lat_20hz" ;
ice2_2nd_te_slope_20hz:comment = "The slope of the second part of the trailing edge of the waveform as estimated by the ice2 retracker." ;
```

5.3.55 sitrack_range_20hz

The CDL definition of the variable `sitrack_range_20hz` is:

```
int sitrack_range_20hz(time, meas_ind) ;
sitrack_range_20hz:units = "m" ;
sitrack_range_20hz:FillValue = 2147483647 ;
sitrack_range_20hz:long_name = "20 Hz Ku band altimeter range (sea-ice retracking)" ;
sitrack_range_20hz:standard_name = "altimeter_range" ;
sitrack_range_20hz:scale_factor = 0.001 ;
sitrack_range_20hz:coordinates = "lon_20hz lat_20hz" ;
sitrack_range_20hz:comment = "All instrumental corrections included, and system bias." ;
```

20Hz range from the sea-ice retracker. Corrected for instrumental effects and referenced to the spacecraft CoG. Includes the static bias correction given in the netCDF attributes.

5.3.56 ice2_mqe_20hz

The CDL definition of the variable `ice2_mqe_20hz` is:

```
int ice2_mqe_20hz(time, meas_ind) ;
ice2_mqe_20hz:units = "count" ;
ice2_mqe_20hz:FillValue = 2147483647 ;
ice2_mqe_20hz:long_name = "20 Hz Ku band MQE (ice2 retracking)" ;
ice2_mqe_20hz:scale_factor = 0.0001 ;
ice2_mqe_20hz:coordinates = "lon_20hz lat_20hz" ;
ice2_mqe_20hz:comment = "Mean Quadratic Error between the waveforms samples and the corresponding model samples built from the ice2 retracking outputs." ;
```

Mean quadratic error between the waveform samples and the corresponding model built by the ICE2 retracker.

5.3.57 ocean_mqe_20hz

The CDL definition of the variable `ocean_mqe_20hz` is:

```
int ocean_mqe_20hz(time, meas_ind) ;
ocean_mqe_20hz:units = "count" ;
```

```

ocean_mqe_20hz:_FillValue = 2147483647 ;
ocean_mqe_20hz:long_name = "20 Hz Ku band MQE (ocean retracking)" ;
ocean_mqe_20hz:scale_factor = 0.0001 ;
ocean_mqe_20hz:coordinates = "lon_20hz lat_20hz" ;
ocean_mqe_20hz:comment = "Mean Quadratic Error between the waveforms samples and the corresponding model samples built from the ocean retracking outputs." ;

```

Mean quadratic error between the waveform samples and the corresponding model built by the ocean retracker.

5.3.58 amplitude_20hz

The CDL definition of the variable `amplitude_20hz` is:

```

int amplitude_20hz(time, meas_ind) ;
  amplitude_20hz:units = "count" ;
  amplitude_20hz:_FillValue = 2147483647 ;
  amplitude_20hz:long_name = "OCOG fitted waveform amplitude" ;
  amplitude_20hz:scale_factor = 0.001 ;
  amplitude_20hz:coordinates = "lon_20hz lat_20hz" ;

```

5.3.59 peakiness_20hz

The CDL definition of the variable `peakiness_20hz` is:

```

int peakiness_20hz(time, meas_ind) ;
  peakiness_20hz:units = "count" ;
  peakiness_20hz:_FillValue = 2147483647 ;
  peakiness_20hz:long_name = "1 Hz peakiness on Ku waveforms" ;
  peakiness_20hz:scale_factor = 0.001 ;
  peakiness_20hz:coordinates = "lon lat" ;
  peakiness_20hz:comment = "Simple average of 20Hz values." ;

```

Peakiness of the 20Hz waveform.

5.3.60 peakiness

The CDL definition of the variable `peakiness` is:

```

int peakiness(time) ;
  peakiness:units = "count" ;
  peakiness:_FillValue = 2147483647 ;
  peakiness:long_name = "1 Hz peakiness on Ku waveforms" ;
  peakiness:scale_factor = 0.001 ;
  peakiness:coordinates = "lon lat" ;
  peakiness:comment = "Simple average of 20Hz values." ;

```

Average of the peakiness derived for the 20Hz valid waveforms.

5.3.61 width_20hz

The CDL definition of the variable `width_20hz` is:

```

short width_20hz(time, meas_ind) ;
  width_20hz:units = "count" ;
  width_20hz:_FillValue = 32767s ;
  width_20hz:long_name = "OCOG fitted waveform width" ;

```

```
width_20hz:scale_factor = 0.001 ;
width_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.62 cog_corr_20hz

The CDL definition of the variable `cog_corr_20hz` is:

```
short cog_corr_20hz(time, meas_ind) ;
  cog_corr_20hz:units = "m" ;
  cog_corr_20hz:_FillValue = 32767s ;
  cog_corr_20hz:long_name = "center of gravity correction to altimeter range"
;
  cog_corr_20hz:scale_factor = 0.001 ;
  cog_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
  cog_corr_20hz:comment = "This value has been applied to the range estimates
in the product to reference them to the antenna." ;
```

This value is a constant in the current release of the REAPER data. Variation of the CoG was found to be negligible when working to a precision of 1 mm.

5.3.63 inst_range_corr_20hz

The CDL definition of the variable `inst_range_corr_20hz` is:

```
int inst_range_corr_20hz(time, meas_ind) ;
  inst_range_corr_20hz:units = "m" ;
  inst_range_corr_20hz:_FillValue = 2147483647 ;
  inst_range_corr_20hz:long_name = "instrument correction to range" ;
  inst_range_corr_20hz:scale_factor = 0.001 ;
  inst_range_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
  inst_range_corr_20hz:comment = "This instrument correction to range was app
lied to the onboard tracker value at L1." ;
```

Instrument correction to range. This was applied at L1 and is contained within the onboard range estimate.

Note : With the method of filtering out bad PTR measurements currently employed by REAPER, this value may occasionally be set to zero. When this occurs, a large error in range can be observed. Therefore this value should be used to filter the data before use.

5.3.64 doppler_corr_20hz

The CDL definition of the variable `doppler_corr_20hz` is:

```
short doppler_corr_20hz(time, meas_ind) ;
  doppler_corr_20hz:units = "m" ;
  doppler_corr_20hz:_FillValue = 32767s ;
  doppler_corr_20hz:long_name = "Doppler correction to altimeter range" ;
  doppler_corr_20hz:scale_factor = 0.001 ;
  doppler_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
  doppler_corr_20hz:comment = "The Doppler correction to range is applied at
L1 and included in the onboard tracker value." ;
```

Doppler correction to range. This was applied at L1 and is contained within the onboard range estimate.

5.3.65 delta_doppler_corr_20hz

The CDL definition of the variable `delta_doppler_corr_20hz` is:

```

short delta_doppler_corr_20hz(time, meas_ind) ;
  delta_doppler_corr_20hz:units = "m" ;
  delta_doppler_corr_20hz:_FillValue = 32767s ;
  delta_doppler_corr_20hz:long_name = "delta Doppler correction to altimeter
range" ;
  delta_doppler_corr_20hz:scale_factor = 0.001 ;
  delta_doppler_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
  delta_doppler_corr_20hz:comment = "This value has been added to the range u
sed to compute the offset_elevation_20hz value to correct for the effect of slo
ping terrain." ;

```

Delta-doppler correction to range. This corrects the above Doppler correction when the point of the echo return from the surface is not coincident with the nadir point. This arises over sloping terrain. Applied during the computation of the elevation of the offset echoing point.

5.3.66 wind_speed_alt

The CDL definition of the variable `wind_speed_alt` is:

```

short wind_speed_alt(time) ;
  wind_speed_alt:units = "m/s" ;
  wind_speed_alt:_FillValue = 32767s ;
  wind_speed_alt:long_name = "altimeter wind speed" ;
  wind_speed_alt:standard_name = "wind_speed" ;
  wind_speed_alt:scale_factor = 0.01 ;
  wind_speed_alt:coordinates = "lon lat" ;
  wind_speed_alt:comment = "Should not be used over land. " ;

```

The estimate of wind speed, calculated from the `ocean_sig0` by reference to a wind speed look up table. The table to be used for reprocessing is the output of a REAPER validation phase activity and will be supplied by CLS. For initial testing, the table by S. Abdalla used for reprocessing ENVISAT (IPF 6.04) was used.

5.3.67 ocean_sig0_used_20hz

The CDL definition of the variable `ocean_sig0_used_20hz` is:

```

byte ocean_sig0_used_20hz(time, meas_ind) ;
  ocean_sig0_used_20hz:_FillValue = 127b ;
  ocean_sig0_used_20hz:long_name = "20 Hz flag for utilization in the computa
tion of 1 Hz Ku band backscatter coefficient" ;
  ocean_sig0_used_20hz:flag_values = "0b, 1b" ;
  ocean_sig0_used_20hz:flag_meanings = "yes no" ;
  ocean_sig0_used_20hz:coordinates = "lon_20hz lat_20hz" ;
  ocean_sig0_used_20hz:comment = "Map of rejected points not used to compute
the 1-Hz Ku-band backscatter coefficient." ;

```

Indicates whether this record was used in the formation of the 1 Hz averaged backscatter.

5.3.68 ocean_sig0_20hz

The CDL definition of the variable `ocean_sig0_20hz` is:

```

short ocean_sig0_20hz(time, meas_ind) ;
  ocean_sig0_20hz:units = "dB" ;
  ocean_sig0_20hz:_FillValue = 32767s ;
  ocean_sig0_20hz:long_name = "20 Hz Ku band corrected backscatter coefficien
t" ;

```

```
ocean_sig0_20hz:standard_name = "surface_backwards_scattering_coefficient_o
f_radar_wave" ;
ocean_sig0_20hz:scale_factor = 0.01 ;
ocean_sig0_20hz:coordinates = "lon_20hz lat_20hz" ;
ocean_sig0_20hz:comment = "All instrumental corrections included, including
the system bias and atmospheric attenuation (atmos_corr_sig0). " ;
```

The 20Hz backscatter values derived by the ocean retracker. The bias value given in the netCDF attributes has been applied.

5.3.69 ice1_sig0_20hz

The CDL definition of the variable `ice1_sig0_20hz` is:

```
short ice1_sig0_20hz(time, meas_ind) ;
ice1_sig0_20hz:units = "dB" ;
ice1_sig0_20hz:_FillValue = 32767s ;
ice1_sig0_20hz:long_name = "20 Hz Ku band backscatter coefficient (ice1 ret
racking)" ;
ice1_sig0_20hz:standard_name = "surface_backwards_scattering_coefficient_of
_radar_wave" ;
ice1_sig0_20hz:scale_factor = 0.01 ;
ice1_sig0_20hz:coordinates = "lon_20hz lat_20hz" ;
ice1_sig0_20hz:comment = "All instrumental corrections included, including
the system bias and atmospheric attenuation (atmos_corr_sig0). " ;
```

The 20Hz backscatter values derived by the ICE1 retracker. The bias value given in the netCDF attributes has been applied.

5.3.70 ice2_sig0_20hz

The CDL definition of the variable `ice2_sig0_20hz` is:

```
short ice2_sig0_20hz(time, meas_ind) ;
ice2_sig0_20hz:units = "dB" ;
ice2_sig0_20hz:_FillValue = 32767s ;
ice2_sig0_20hz:long_name = "20 Hz Ku band backscatter coefficient (ice2 ret
racking)" ;
ice2_sig0_20hz:standard_name = "surface_backwards_scattering_coefficient_of
_radar_wave" ;
ice2_sig0_20hz:scale_factor = 0.01 ;
ice2_sig0_20hz:coordinates = "lon_20hz lat_20hz" ;
ice2_sig0_20hz:comment = "All instrumental corrections included, including
the system bias and atmospheric attenuation (atmos_corr_sig0). " ;
```

The 20Hz backscatter values derived by the ICE2 retracker. The bias value given in the netCDF attributes has been applied.

5.3.71 sitrack_sig0_20hz

The CDL definition of the variable `sitrack_sig0_20hz` is:

```
short sitrack_sig0_20hz(time, meas_ind) ;
sitrack_sig0_20hz:units = "dB" ;
sitrack_sig0_20hz:_FillValue = 32767s ;
sitrack_sig0_20hz:long_name = "20 Hz Ku band backscatter coefficient (sea-i
ce retracking)" ;
```

```
sitrack_sig0_20hz:standard_name = "surface_backwards_scattering_coefficient_of_radar_wave" ;
sitrack_sig0_20hz:scale_factor = 0.01 ;
sitrack_sig0_20hz:coordinates = "lon_20hz lat_20hz" ;
sitrack_sig0_20hz:comment = "All instrumental corrections included, including the system bias and atmospheric attenuation (atmos_corr_sig0). " ;
```

The 20Hz backscatter values derived by the sea-ice retracker. The bias value given in the netCDF attributes has been applied.

5.3.72 ocean_sig0

The CDL definition of the variable `ocean_sig0` is:

```
short ocean_sig0(time) ;
ocean_sig0:units = "dB" ;
ocean_sig0:_FillValue = 32767s ;
ocean_sig0:long_name = "Ku band corrected backscatter coefficient from ocean retracker" ;
ocean_sig0:standard_name = "surface_backwards_scattering_coefficient_of_radar_wave" ;
ocean_sig0:quality_flag = "qual_alt_1hz_sig0" ;
ocean_sig0:scale_factor = 0.01 ;
ocean_sig0:coordinates = "lon lat" ;
ocean_sig0:comment = "All instrumental corrections included, including the system bias and atmospheric attenuation (atmos_corr_sig0). " ;
```

A 1Hz average of the backscatter values derived by the ocean retracker. The bias value given in the netCDF attributes has been applied.

5.3.73 ocean_sig0_rms

The CDL definition of the variable `ocean_sig0_rms` is:

```
short ocean_sig0_rms(time) ;
ocean_sig0_rms:units = "dB" ;
ocean_sig0_rms:_FillValue = 32767s ;
ocean_sig0_rms:long_name = "RMS of the Ku band backscatter coefficient" ;
ocean_sig0_rms:scale_factor = 0.01 ;
ocean_sig0_rms:coordinates = "lon lat" ;
ocean_sig0_rms:comment = "Compression of Ku-band high rate elements is preceded by a detection of outliers. Only valid high-rate values are used to compute this element." ;
```

The standard deviation of the measurements used to form the 1Hz average.

5.3.74 ocean_sig0_numval

The CDL definition of the variable `ocean_sig0_numval` is:

```
byte ocean_sig0_numval(time) ;
ocean_sig0_numval:units = "count" ;
ocean_sig0_numval:_FillValue = 127b ;
ocean_sig0_numval:long_name = "number of valid points used to compute Ku backscatter coefficient" ;
ocean_sig0_numval:valid_min = 0b ;
```

```
ocean_sig0_numval:valid_max = 20b ;
ocean_sig0_numval:coordinates = "lon lat" ;
```

The number of measurements used to form the 1Hz average.

5.3.75 `swh_squared`

The CDL definition of the variable `swh_squared` is:

```
int swh_squared(time) ;
    swh_squared:units = "m^2" ;
    swh_squared:_FillValue = 2147483647 ;
    swh_squared:long_name = "Ku band corrected significant waveheight squared"
;
    swh_squared:scale_factor = 1.e-06 ;
    swh_squared:coordinates = "lon lat" ;
    swh_squared:comment = "Computed directly from sigma c. No bias correction."
;
```

1Hz averaged value of significant waveheight squared. This can be a negative value for waveforms with a very steep leading edge.

5.3.76 `swh_signed`

The CDL definition of the variable `swh_signed` is:

```
short swh_signed(time) ;
    swh_signed:units = "m" ;
    swh_signed:_FillValue = 32767s ;
    swh_signed:long_name = "Ku band corrected significant waveheight" ;
    swh_signed:standard_name = "sea_surface_wave_significant_height" ;
    swh_signed:quality_flag = "qual_alt_1hz_swh" ;
    swh_signed:scale_factor = 0.001 ;
    swh_signed:coordinates = "lon lat" ;
    swh_signed:comment = "Computed directly from sigma c. No bias correction. N
egative values not replaced by fill value." ;
```

The square-root of the absolute value of the 1Hz averaged value of significant wave height squared (`swh_sq`, which can be negative) with the sign of the original value applied.

5.3.77 `swh`

The CDL definition of the variable `swh` is:

```
short swh(time) ;
    swh:units = "m" ;
    swh:_FillValue = 32767s ;
    swh:long_name = "Ku band corrected significant waveheight" ;
    swh:standard_name = "sea_surface_wave_significant_height" ;
    swh:quality_flag = "qual_alt_1hz_swh" ;
    swh:scale_factor = 0.001 ;
    swh:coordinates = "lon lat" ;
    swh:comment = "Computed directly from sigma c. No bias correction." ;
```

The 1Hz averaged significant waveheight. This quantity is clipped to positive values only.

5.3.78 `swh_rms`

The CDL definition of the variable `swh_rms` is:

```
short swh_rms(time) ;
    swh_rms:units = "m" ;
    swh_rms:_FillValue = 32767s ;
    swh_rms:long_name = "RMS of the Ku band significant waveheight" ;
    swh_rms:scale_factor = 0.001 ;
    swh_rms:coordinates = "lon lat" ;
    swh_rms:comment = "Compression of Ku-band high rate elements is preceded by
a detection of outliers. Only valid high rate values are used to compute this e
lement." ;
```

The standard deviation of the measurements used to form the 1Hz average.

5.3.79 `swh_numval`

The CDL definition of the variable `swh_numval` is:

```
byte swh_numval(time) ;
    swh_numval:units = "count" ;
    swh_numval:_FillValue = 127b ;
    swh_numval:long_name = "number of valid points used to compute Ku significa
nt waveheight" ;
    swh_numval:valid_min = 0b ;
    swh_numval:valid_max = 20b ;
    swh_numval:coordinates = "lon lat" ;
```

The number of measurements used to form the 1Hz average.

5.3.80 `sea_state_bias`

The CDL definition of the variable `sea_state_bias` is:

```
short sea_state_bias(time) ;
    sea_state_bias:units = "m" ;
    sea_state_bias:_FillValue = 32767s ;
    sea_state_bias:long_name = "sea state bias correction in Ku band" ;
    sea_state_bias:standard_name = "sea_surface_height_bias_due_to_sea_surface_
roughness" ;
    sea_state_bias:source = "Empirical solution fitted on REAPER commissioning
data" ;
    sea_state_bias:institution = "Altimetrics" ;
    sea_state_bias:scale_factor = 0.001 ;
    sea_state_bias:coordinates = "lon lat" ;
    sea_state_bias:comment = "A sea state bias correction must be added (negati
ve value) to the instrument range to correct this range measurement for sea sta
te delays of the radar pulse. " ;
```

The Electromagnetic (or Sea-state) Bias correction to range. Computed from a table derived for the REAPER project by Altimetrics.

5.3.81 `offset_lat_20hz`

The CDL definition of the variable `offset_lat_20hz` is:


```
int offset_lat_20hz(time, meas_ind) ;
    offset_lat_20hz:units = "degrees_north" ;
    offset_lat_20hz:_FillValue = 2147483647 ;
    offset_lat_20hz:long_name = "latitude of echoing point derived by slope correction" ;
    offset_lat_20hz:standard_name = "latitude" ;
    offset_lat_20hz:scale_factor = 1.e-06 ;
    offset_lat_20hz:comment = "Positive latitude is North latitude, negative latitude is South latitude. Corrected from nadir to estimated echo point by slope model." ;
```

The latitude of the actual echoing point as derived by slope correction on the range [-90,+90] (positive North) on the WGS84 ellipsoid. For records over a flat surface, this will equal the 20 Hz latitude.

5.3.82 offset_lon_20hz

The CDL definition of the variable `offset_lon_20hz` is:

```
int offset_lon_20hz(time, meas_ind) ;
    offset_lon_20hz:units = "degrees_east" ;
    offset_lon_20hz:_FillValue = 2147483647 ;
    offset_lon_20hz:long_name = "longitude of echoing point derived by slope correction" ;
    offset_lon_20hz:standard_name = "longitude" ;
    offset_lon_20hz:scale_factor = 1.e-06 ;
    offset_lon_20hz:comment = "East longitude relative to Greenwich meridian. Corrected from nadir to estimated echo point by slope model." ;
```

The longitude of the actual echoing point as derived by slope correction on the range [-180,+180] (positive East) on the WGS84 ellipsoid. For records over a flat surface (or for which there is no slope model), this will equal the 20 Hz longitude.

5.3.83 offset_elevation_20hz

The CDL definition of the variable `offset_elevation_20hz` is:

```
int offset_elevation_20hz(time, meas_ind) ;
    offset_elevation_20hz:units = "m" ;
    offset_elevation_20hz:_FillValue = 2147483647 ;
    offset_elevation_20hz:long_name = "20 Hz Ku band altimeter height (ice1 retracking, slope correction)" ;
    offset_elevation_20hz:standard_name = "height_above_reference_ellipsoid" ;
    offset_elevation_20hz:scale_factor = 0.001 ;
    offset_elevation_20hz:coordinates = "offset_lon_20hz offset_lat_20hz" ;
    offset_elevation_20hz:comment = "All instrumental and geophysical corrections included, and system bias. Corrected for surface slope via slope model." ;
```

The elevation of the echoing point above the WGS84 ellipsoid, derived by slope correction.

5.3.84 offset_azimuth_20hz

The CDL definition of the variable `offset_azimuth_20hz` is:

```
int offset_azimuth_20hz(time, meas_ind) ;
    offset_azimuth_20hz:units = "radian" ;
    offset_azimuth_20hz:_FillValue = 2147483647 ;
    offset_azimuth_20hz:long_name = "20 Hz Ku band echo azimuth" ;
```

```

offset_azimuth_20hz:scale_factor = 1.e-06 ;
offset_azimuth_20hz:coordinates = "lon_20hz lat_20hz" ;
offset_azimuth_20hz:comment = "The azimuth angle between the north vector a
nd the echo point vector." ;

```

The elevation of the echoing point above the WGS84 ellipsoid, derived by slope correction.

5.3.85 offset_attitude_20hz

The CDL definition of the variable `offset_attitude_20hz` is:

```

int offset_attitude_20hz(time, meas_ind) ;
offset_attitude_20hz:units = "radian" ;
offset_attitude_20hz:_FillValue = 2147483647 ;
offset_attitude_20hz:long_name = "20 Hz Ku band echo attitude" ;
offset_attitude_20hz:scale_factor = 1.e-06 ;
offset_attitude_20hz:coordinates = "lon_20hz lat_20hz" ;
offset_attitude_20hz:comment = "The attitude angle between the nadir vector
and the echo point vector." ;

```

The attitude from which the echo was returned over a sloping surface.

5.3.86 ice1_elevation_20hz

The CDL definition of the variable `ice1_elevation_20hz` is:

```

int ice1_elevation_20hz(time, meas_ind) ;
ice1_elevation_20hz:units = "m" ;
ice1_elevation_20hz:_FillValue = 2147483647 ;
ice1_elevation_20hz:long_name = "20 Hz Ku band altimeter height (ice1 retra
cking)" ;
ice1_elevation_20hz:standard_name = "height_above_reference_ellipsoid" ;
ice1_elevation_20hz:scale_factor = 0.001 ;
ice1_elevation_20hz:coordinates = "lon_20hz lat_20hz" ;
ice1_elevation_20hz:comment = "All instrumental and geophysical corrections
included, and system bias." ;

```

The elevation of the echoing point above the WGS84 ellipsoid geoid derived by the ICE1 retracker. This is altitude of the CoG minus fully corrected range. See section 3.10 for the list of geophysical corrections applied.

5.3.87 sitrack_elevation_20hz

The CDL definition of the variable `sitrack_elevation_20hz` is:

```

int sitrack_elevation_20hz(time, meas_ind) ;
sitrack_elevation_20hz:units = "m" ;
sitrack_elevation_20hz:_FillValue = 2147483647 ;
sitrack_elevation_20hz:long_name = "20 Hz Ku band altimeter height (sea-ice
retracking)" ;
sitrack_elevation_20hz:standard_name = "height_above_reference_ellipsoid" ;
sitrack_elevation_20hz:scale_factor = 0.001 ;
sitrack_elevation_20hz:coordinates = "lon_20hz lat_20hz" ;
sitrack_elevation_20hz:comment = "All instrumental and geophysical correcti
ons included, and system bias." ;

```

The elevation of the echoing point above the WGS84 ellipsoid geoid derived by the sea-ice retracker. This is altitude of the CoG minus fully corrected range. See section 3.10 for the list of geophysical corrections applied.

5.3.88 `tb_238`

The CDL definition of the variable `tb_238` is:

```
short tb_238(time) ;
  tb_238:units = "K" ;
  tb_238:_FillValue = 32767s ;
  tb_238:long_name = "23.8 GHz main beam brightness temperature" ;
  tb_238:standard_name = "surface_brightness_temperature" ;
  tb_238:quality_flag = "interp_flag_tb rad_state_" ;
  tb_238:scale_factor = 0.01 ;
  tb_238:coordinates = "lon lat" ;
  tb_238:comment = "Brightness temperature measured by the microwave radiometer at 23.8 GHz and cross-calibrated with ENVISAT. This is an averaged, 1 Hz value computed from the valid 20 Hz measurements." ;
```

Brightness temperature measured by the microwave radiometer at 23.8 GHz. This is an averaged, 1 Hz value computed from the valid 20 Hz measurements.

Note: The intercalibration adjustment (linear function of BT) between ERS-1/2 and Envisat is covered by the REAPER L1B MWR chain. Therefore, the value in this field is already intercalibrated.

5.3.89 `tb_365`

The CDL definition of the variable `tb_365` is:

```
short tb_365(time) ;
  tb_365:units = "K" ;
  tb_365:_FillValue = 32767s ;
  tb_365:long_name = "36.5 GHz main beam brightness temperature" ;
  tb_365:standard_name = "surface_brightness_temperature" ;
  tb_365:quality_flag = "interp_flag_tb rad_state_" ;
  tb_365:scale_factor = 0.01 ;
  tb_365:coordinates = "lon lat" ;
  tb_365:comment = "Brightness temperature measured by the microwave radiometer at 36.5 GHz and cross-calibrated with ENVISAT. This is an averaged, 1 Hz value computed from the valid 20 Hz measurements." ;
```

Brightness temperature measured by the microwave radiometer at 36.5 GHz. This is an averaged, 1 Hz value computed from the valid 20 Hz measurements.

Note: The intercalibration adjustment (linear function of BT) between ERS-1/2 and Envisat is covered by the REAPER L1B MWR chain. Therefore, the value in this field is already intercalibrated.

5.3.90 `tb_238_rms`

The CDL definition of the variable `tb_238_rms` is:

```
short tb_238_rms(time) ;
  tb_238_rms:units = "K" ;
  tb_238_rms:_FillValue = 32767s ;
  tb_238_rms:long_name = "RMS of 23.8 GHz main beam brightness temperature" ;
  tb_238_rms:standard_name = "surface_brightness_temperature" ;
  tb_238_rms:quality_flag = "interp_flag_tb rad_state_" ;
  tb_238_rms:scale_factor = 0.01 ;
  tb_238_rms:coordinates = "lon lat" ;
  tb_238_rms:comment = "The standard deviation of the 20 Hz measurements of t
```

he 23.8 GHz brightness temperature that were used to compute the 1 Hz averaged value.)" ;

5.3.91 `tb_365_rms`

The CDL definition of the variable `tb_365_rms` is:

```
short tb_365_rms(time) ;
  tb_365_rms:units = "K" ;
  tb_365_rms:_FillValue = 32767s ;
  tb_365_rms:long_name = "RMS of 36.5 GHz main beam brightness temperature" ;
  tb_365_rms:standard_name = "surface_brightness_temperature" ;
  tb_365_rms:quality_flag = "interp_flag_tb rad_state_" ;
  tb_365_rms:scale_factor = 0.01 ;
  tb_365_rms:coordinates = "lon lat" ;
  tb_365_rms:comment = "The standard deviation of the 20 Hz measurements of the 36.5 GHz brightness temperature that were used to compute the 1 Hz averaged value.)" ;
```

5.3.92 `qual_wf_low_power_20hz`

The CDL definition of the variable `qual_wf_low_power_20hz` is:

```
byte qual_wf_low_power_20hz(time, meas_ind) ;
  qual_wf_low_power_20hz:_FillValue = 127b ;
  qual_wf_low_power_20hz:long_name = "quality flag for 20 Hz waveform data: average waveform power lower than configurable multiple of noise" ;
  qual_wf_low_power_20hz:flag_values = "0b, 1b" ;
  qual_wf_low_power_20hz:flag_meanings = "good bad" ;
  qual_wf_low_power_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.93 `qual_wf_low_peakiness_20hz`

The CDL definition of the variable `qual_wf_low_peakiness_20hz` is:

```
byte qual_wf_low_peakiness_20hz(time, meas_ind) ;
  qual_wf_low_peakiness_20hz:_FillValue = 127b ;
  qual_wf_low_peakiness_20hz:long_name = "quality flag for 20 Hz waveform data: waveform peakiness lower than threshold" ;
  qual_wf_low_peakiness_20hz:flag_values = "0b, 1b" ;
  qual_wf_low_peakiness_20hz:flag_meanings = "good bad" ;
  qual_wf_low_peakiness_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.94 `qual_wf_high_peakiness_20hz`

The CDL definition of the variable `qual_wf_high_peakiness_20hz` is:

```
byte qual_wf_high_peakiness_20hz(time, meas_ind) ;
  qual_wf_high_peakiness_20hz:_FillValue = 127b ;
  qual_wf_high_peakiness_20hz:long_name = "quality flag for 20 Hz waveform data: waveform peakiness higher than threshold" ;
  qual_wf_high_peakiness_20hz:flag_values = "0b, 1b" ;
  qual_wf_high_peakiness_20hz:flag_meanings = "good bad" ;
  qual_wf_high_peakiness_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.95 `qual_wf_noisy_20hz`

The CDL definition of the variable `qual_wf_noisy_20hz` is:

```
byte qual_wf_noisy_20hz(time, meas_ind) ;
    qual_wf_noisy_20hz:_FillValue = 127b ;
    qual_wf_noisy_20hz:long_name = "quality flag for 20 Hz waveform data: power
in noise gate is above threshold" ;
    qual_wf_noisy_20hz:flag_values = "0b, 1b" ;
    qual_wf_noisy_20hz:flag_meanings = "good bad" ;
    qual_wf_noisy_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.96 qual_wf_bad_le_20hz

The CDL definition of the variable `qual_wf_bad_le_20hz` is:

```
byte qual_wf_bad_le_20hz(time, meas_ind) ;
    qual_wf_bad_le_20hz:_FillValue = 127b ;
    qual_wf_bad_le_20hz:long_name = "quality flag for 20 Hz waveform data: no s
ignificant leading edge detected by comparison of weighted sums of two range wi
ndow gates" ;
    qual_wf_bad_le_20hz:flag_values = "0b, 1b" ;
    qual_wf_bad_le_20hz:flag_meanings = "good bad" ;
    qual_wf_bad_le_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.97 qual_wf_low_var_20hz

The CDL definition of the variable `qual_wf_low_var_20hz` is:

```
byte qual_wf_low_var_20hz(time, meas_ind) ;
    qual_wf_low_var_20hz:_FillValue = 127b ;
    qual_wf_low_var_20hz:long_name = "quality flag for 20 Hz waveform data: var
iance of waveform is below threshold" ;
    qual_wf_low_var_20hz:flag_values = "0b, 1b" ;
    qual_wf_low_var_20hz:flag_meanings = "good bad" ;
    qual_wf_low_var_20hz:coordinates = "lon_20hz lat_20hz" ;
```

5.3.98 qual_wf_not_tracking_20hz

The CDL definition of the variable `qual_wf_not_tracking_20hz` is:

```
byte qual_wf_not_tracking_20hz(time, meas_ind) ;
    qual_wf_not_tracking_20hz:_FillValue = 127b ;
    qual_wf_not_tracking_20hz:long_name = "quality flag for 20 Hz waveform data
: waveform is not a tracking waveform" ;
    qual_wf_not_tracking_20hz:flag_values = "0b, 1b" ;
    qual_wf_not_tracking_20hz:flag_meanings = "good bad" ;
    qual_wf_not_tracking_20hz:coordinates = "lon_20hz lat_20hz" ;
    qual_wf_not_tracking_20hz:comment = "This flag being clear does not guarant
ee that the altimeter is tracking the surface correctly." ;
```

5.3.99 qual_wf_reject_20hz

The CDL definition of the variable `qual_wf_reject_20hz` is:

```
byte qual_wf_reject_20hz(time, meas_ind) ;
    qual_wf_reject_20hz:_FillValue = 127b ;
    qual_wf_reject_20hz:long_name = "quality flag for 20 Hz waveform data: mast
er waveform QA rejection flag" ;
    qual_wf_reject_20hz:flag_values = "0b, 1b" ;
    qual_wf_reject_20hz:flag_meanings = "good bad" ;
```

```
qual_wf_reject_20hz:coordinates = "lon_20hz lat_20hz" ;
qual_wf_reject_20hz:comment = "Set if any other flag rejects the waveform.
This can be used as a master flag to filter on." ;
```

5.3.100 ice1_qual_flag_20hz

The CDL definition of the variable ice1_qual_flag_20hz is:

```
byte ice1_qual_flag_20hz(time, meas_ind) ;
    ice1_qual_flag_20hz:_FillValue = 127b ;
    ice1_qual_flag_20hz:long_name = "20 Hz Ku band ice1 retracking quality flag
" ;
    ice1_qual_flag_20hz:flag_values = "0b, 1b" ;
    ice1_qual_flag_20hz:flag_meanings = "good bad" ;
    ice1_qual_flag_20hz:coordinates = "lon_20hz lat_20hz" ;
    ice1_qual_flag_20hz:comment = "ice1 retracking quality flag." ;
```

5.3.101 ice2_qual_flag_20hz

The CDL definition of the variable ice2_qual_flag_20hz is:

```
byte ice2_qual_flag_20hz(time, meas_ind) ;
    ice2_qual_flag_20hz:_FillValue = 127b ;
    ice2_qual_flag_20hz:long_name = "20 Hz Ku band ice2 retracking quality flag
" ;
    ice2_qual_flag_20hz:flag_values = "0b, 1b" ;
    ice2_qual_flag_20hz:flag_meanings = "good bad" ;
    ice2_qual_flag_20hz:coordinates = "lon_20hz lat_20hz" ;
    ice2_qual_flag_20hz:comment = "ice2 retracking quality flag." ;
```

5.3.102 sitrack_qual_flag_20hz

The CDL definition of the variable sitrack_qual_flag_20hz is:

```
byte sitrack_qual_flag_20hz(time, meas_ind) ;
    sitrack_qual_flag_20hz:_FillValue = 127b ;
    sitrack_qual_flag_20hz:long_name = "20 Hz Ku band sitrack retracking qualit
y flag" ;
    sitrack_qual_flag_20hz:flag_values = "0b, 1b" ;
    sitrack_qual_flag_20hz:flag_meanings = "good bad" ;
    sitrack_qual_flag_20hz:coordinates = "lon_20hz lat_20hz" ;
    sitrack_qual_flag_20hz:comment = "Sea-ice retracking quality flag." ;
```

5.3.103 model_dry_tropo_corr

The CDL definition of the variable model_dry_tropo_corr is:

```
short model_dry_tropo_corr(time) ;
    model_dry_tropo_corr:units = "m" ;
    model_dry_tropo_corr:_FillValue = 32767s ;
    model_dry_tropo_corr:long_name = "model dry tropospheric correction" ;
    model_dry_tropo_corr:standard_name = "altimeter_range_correction_due_to_dry
_troposphere" ;
    model_dry_tropo_corr:source = "European Center for Medium Range Weather For
ecasting" ;
    model_dry_tropo_corr:institution = "ECMWF" ;
    model_dry_tropo_corr:scale_factor = 0.001 ;
```

```

    model_dry_tropo_corr:coordinates = "lon lat" ;
    model_dry_tropo_corr:comment = "Computed at the altimeter time-tag from the
interpolation of 2 meteorological fields that surround the altimeter time-tag.
A dry tropospheric correction must be added (negative value) to the instrument
range to correct this range measurement for dry tropospheric range delays of th
e radar pulse. " ;

```

Dry Tropospheric Correction - to be added to range measurement to correct for the propagation delay to the radar pulse, caused by the dry-gas component of the Earth's atmosphere. From the ERA-Interim ECMWF model.

5.3.104 inv_bar_corr

The CDL definition of the variable `inv_bar_corr` is:

```

short inv_bar_corr(time) ;
    inv_bar_corr:units = "m" ;
    inv_bar_corr:_FillValue = 32767s ;
    inv_bar_corr:long_name = "inverted barometer height correction" ;
    inv_bar_corr:standard_name =
"altimeter_range_correction_due_to_air_pressure_at_low_frequency" ;
    inv_bar_corr:source = "European Center for Medium Range Weather
Forecasting" ;
    inv_bar_corr:institution = "ECMWF" ;
    inv_bar_corr:scale_factor = 0.001 ;
    inv_bar_corr:coordinates = "lon lat" ;

```

```

    inv_bar_corr:comment = "Computed at the altimeter time-tag from the interpo
lation of 2 meteorological fields that surround the altimeter time-tag. An inve
rse barometric correction must be added (negative value) to the instrument rang
e to correct this range measurement delays to the radar pulse due to air pressu
re. This field is a component of hf_fluctuations_corr so do not apply both. " ;

```

Inverse Barometric Correction - to be added to range measurement to correct for the depression of the ocean surface caused by the local barometric pressure. From the ECMWF model.

5.3.105 hf_fluctuations_corr

The CDL definition of the variable `hf_fluctuations_corr` is:

```

short hf_fluctuations_corr(time) ;
    hf_fluctuations_corr:units = "m" ;
    hf_fluctuations_corr:_FillValue = 32767s ;
    hf_fluctuations_corr:long_name = "high frequency fluctuations of the sea su
rface topography" ;
    hf_fluctuations_corr:standard_name = "sea_surface_height_correction_due_to_
air_pressure_and_wind_at_high_frequency" ;
    hf_fluctuations_corr:source = "MOG2d" ;
    hf_fluctuations_corr:institution = "CLS" ;
    hf_fluctuations_corr:scale_factor = 0.001 ;
    hf_fluctuations_corr:coordinates = "lon lat" ;
    hf_fluctuations_corr:comment = "This is provided including the low frequenc
y inverse barometric effect. Do not apply both." ;

```

High Frequency Variability Correction - to be added to range measurement to correct for the depression of the ocean surface caused by the high-frequency components of the local barometric pressure. From the MOG2d model.

This includes the inverse barometric effect, so only one of the two corrections should be applied. By default, the MOG2d is applied and the IB is not.

5.3.106 `surface_pressure`

The CDL definition of the variable `surface_pressure` is:

```
short surface_pressure(time) ;
  surface_pressure:units = "Pa" ;
  surface_pressure:_FillValue = 32767s ;
  surface_pressure:long_name = "air pressure" ;
  surface_pressure:standard_name = "air_pressure" ;
  surface_pressure:source = "European Center for Medium Range Weather Forecasting" ;
  surface_pressure:institution = "ECMWF" ;
  surface_pressure:scale_factor = 10. ;
  surface_pressure:coordinates = "lon lat" ;
  surface_pressure:comment = "Atmospheric pressure at the surface." ;
```

Atmospheric pressure at the surface provided by the ECMWF model.

5.3.107 `model_wet_tropo_corr`

The CDL definition of the variable `model_wet_tropo_corr` is:

```
short model_wet_tropo_corr(time) ;
  model_wet_tropo_corr:units = "m" ;
  model_wet_tropo_corr:_FillValue = 32767s ;
  model_wet_tropo_corr:long_name = "model wet tropospheric correction" ;
  model_wet_tropo_corr:standard_name = "altimeter_range_correction_due_to_wet_troposphere" ;
  model_wet_tropo_corr:source = "European Center for Medium Range Weather Forecasting" ;
  model_wet_tropo_corr:institution = "ECMWF" ;
  model_wet_tropo_corr:scale_factor = 0.001 ;
  model_wet_tropo_corr:coordinates = "lon lat" ;
  model_wet_tropo_corr:comment = "Computed at the altimeter time-tag from the interpolation of 2 meteorological fields that surround the altimeter time-tag. A wet tropospheric correction must be added (negative value) to the instrument range to correct this range measurement for wet tropospheric range delays of the radar pulse. " ;
```

Wet Tropospheric Correction, derived from a model - to be added to range measurement to correct for the propagation delay to the radar pulse, caused by the H₂O component of the Earth's atmosphere. From the ERA-Interim ECMWF model.

5.3.108 `rad_wet_tropo_corr`

The CDL definition of the variable `rad_wet_tropo_corr` is:

```
short rad_wet_tropo_corr(time) ;
  rad_wet_tropo_corr:units = "m" ;
  rad_wet_tropo_corr:_FillValue = 32767s ;
  rad_wet_tropo_corr:long_name = "radiometer wet tropospheric correction" ;
  rad_wet_tropo_corr:standard_name = "altimeter_range_correction_due_to_wet_troposphere" ;
  rad_wet_tropo_corr:source = "MWR" ;
```



```
rad_wet_tropo_corr:institution = "CLS" ;
rad_wet_tropo_corr:quality_flag = "qual_rad_1hz interp_flag_tb" ;
rad_wet_tropo_corr:scale_factor = 0.001 ;
rad_wet_tropo_corr:coordinates = "lon lat" ;
rad_wet_tropo_corr:comment = "A wet tropospheric correction must be added (
negative value) to the instrument range to correct this range measurement for w
et tropospheric range delays of the radar pulse. " ;
```

Wet Tropospheric Correction, as derived by the microwave radiometer - to be added to range measurement to correct for the propagation delay to the radar pulse, caused by the H₂O component of the Earth's atmosphere.

5.3.109 rad_water_vapor

The CDL definition of the variable `rad_water_vapor` is:

```
short rad_water_vapor(time) ;
rad_water_vapor:units = "kg/m^2" ;
rad_water_vapor:_FillValue = 32767s ;
rad_water_vapor:long_name = "radiometer water vapor content" ;
rad_water_vapor:standard_name = "atmosphere_water_vapor_content" ;
rad_water_vapor:source = "MWR" ;
rad_water_vapor:institution = "CLS" ;
rad_water_vapor:quality_flag = "interp_flag_tb" ;
rad_water_vapor:scale_factor = 0.1 ;
rad_water_vapor:coordinates = "lon lat" ;
rad_water_vapor:comment = "Should not be used over land." ;
```

Water vapour content (column integrated).

5.3.110 rad_liquid_water

The CDL definition of the variable `rad_liquid_water` is:

```
short rad_liquid_water(time) ;
rad_liquid_water:units = "kg/m^2" ;
rad_liquid_water:_FillValue = 32767s ;
rad_liquid_water:long_name = "radiometer liquid water content" ;
rad_liquid_water:standard_name = "atmosphere_cloud_liquid_water_content" ;
rad_liquid_water:source = "MWR" ;
rad_liquid_water:institution = "CLS" ;
rad_liquid_water:quality_flag = "interp_flag_tb" ;
rad_liquid_water:scale_factor = 0.01 ;
rad_liquid_water:coordinates = "lon lat" ;
rad_liquid_water:comment = "Should not be used over land." ;
```

Liquid water content (column integrated).

5.3.111 wind_speed_model_u

The CDL definition of the variable `wind_speed_model_u` is:

```
short wind_speed_model_u(time) ;
wind_speed_model_u:units = "m/s" ;
wind_speed_model_u:_FillValue = 32767s ;
wind_speed_model_u:long_name = "U component of the model wind vector" ;
wind_speed_model_u:standard_name = "wind_speed" ;
wind_speed_model_u:source = "European Center for Medium Range Weather Forec
```

```
asting" ;
  wind_speed_model_u:institution = "ECMWF" ;
  wind_speed_model_u:scale_factor = 0.001 ;
  wind_speed_model_u:coordinates = "lon lat" ;
  wind_speed_model_u:comment = "Computed at the altimeter time-tag from the interpolation of 2 meteorological fields that surround the altimeter time-tag. " ;
```

U component of the surface windspeed from the ERA-Interim ECMWF model.

5.3.112 wind_speed_model_v

The CDL definition of the variable `wind_speed_model_v` is:

```
short wind_speed_model_v(time) ;
  wind_speed_model_v:units = "m/s" ;
  wind_speed_model_v:_FillValue = 32767s ;
  wind_speed_model_v:long_name = "V component of the model wind vector" ;
  wind_speed_model_v:standard_name = "wind_speed" ;
  wind_speed_model_v:source = "European Center for Medium Range Weather Forecasting" ;
  wind_speed_model_v:institution = "ECMWF" ;
  wind_speed_model_v:scale_factor = 0.001 ;
  wind_speed_model_v:coordinates = "lon lat" ;
  wind_speed_model_v:comment = "Computed at the altimeter time-tag from the interpolation of 2 meteorological fields that surround the altimeter time-tag. " ;
```

V component of the surface windspeed from the ERA-Interim ECMWF model.

5.3.113 iono_corr_model

The CDL definition of the variable `iono_corr_model` is:

```
short iono_corr_model(time) ;
  iono_corr_model:units = "m" ;
  iono_corr_model:_FillValue = 32767s ;
  iono_corr_model:long_name = "Modelled ionospheric correction on Ku band" ;
  iono_corr_model:standard_name = "altimeter_range_correction_due_to_ionosphere" ;
  iono_corr_model:source = "NIC09" ;
  iono_corr_model:institution = "Altimetrics" ;
  iono_corr_model:scale_factor = 0.001 ;
  iono_corr_model:coordinates = "lon lat" ;
  iono_corr_model:comment = "An ionospheric correction must be added (negative value) to the instrument range to correct this range measurement for ionospheric range delays of the radar pulse. " ;
```

Model Ionospheric Correction - to be added to range measurement to correct for the delay to the Radar pulse caused by free electrons in the ionosphere. Computed from an Ionospheric model supplied by Altimetrics.

5.3.114 iono_corr_gps

The CDL definition of the variable `iono_corr_gps` is:

```
short iono_corr_gps(time) ;
  iono_corr_gps:units = "m" ;
```

```
iono_corr_gps:_FillValue = 32767s ;
iono_corr_gps:long_name = "GIM ionospheric correction on Ku band" ;
iono_corr_gps:standard_name = "altimeter_range_correction_due_to_ionosphere
" ;
iono_corr_gps:source = "Altimetrics" ;
iono_corr_gps:institution = "Altimetrics" ;
iono_corr_gps:scale_factor = 0.001 ;
iono_corr_gps:coordinates = "lon lat" ;
iono_corr_gps:comment = "An ionospheric correction must be added (negative
value) to the instrument range to correct this range measurement for ionospheric
range delays of the radar pulse. " ;
```

GIM Ionospheric Correction - to be added to range measurement to correct for the delay to the Radar pulse caused by free electrons in the ionosphere. Computed from the concurrent GIM data and supplied by Altimetrics.

5.3.115 mean_sea_surface_1

The CDL definition of the variable `mean_sea_surface_1` is:

```
int mean_sea_surface_1(time) ;
mean_sea_surface_1:units = "m" ;
mean_sea_surface_1:_FillValue = 2147483647 ;
mean_sea_surface_1:long_name = "mean sea surface height above reference ellipsoid" ;
mean_sea_surface_1:source = "CLS01" ;
mean_sea_surface_1:institution = "CLS" ;
mean_sea_surface_1:scale_factor = 0.001 ;
mean_sea_surface_1:coordinates = "lon lat" ;
mean_sea_surface_1:comment = "" ;
```

MSS from the model CLS01.

5.3.116 mean_sea_surface_2

The CDL definition of the variable `mean_sea_surface_2` is:

```
int mean_sea_surface_2(time) ;
mean_sea_surface_2:units = "m" ;
mean_sea_surface_2:_FillValue = 2147483647 ;
mean_sea_surface_2:long_name = "mean sea surface height above reference ellipsoid" ;
mean_sea_surface_2:source = "UCL04" ;
mean_sea_surface_2:institution = "UCL" ;
mean_sea_surface_2:scale_factor = 0.001 ;
mean_sea_surface_2:coordinates = "lon lat" ;
mean_sea_surface_2:comment = "" ;
```

MSS from the model UCL04. This model, developed for Cryosat, is more accurate at extreme latitudes.

5.3.117 geoid

The CDL definition of the variable `geoid` is:

```
int geoid(time) ;
geoid:units = "m" ;
geoid:_FillValue = 2147483647 ;
geoid:long_name = "geoid height" ;
```

```

geoid:standard_name = "geoid_height_above_reference_ellipsoid" ;
geoid:source = "EGM2008" ;
geoid:institution = "CLS" ;
geoid:scale_factor = 0.001 ;
geoid:coordinates = "lon lat" ;
geoid:comment = "Computed from the geoid model with a correction to refer t
he value to the mean tide system i.e. includes the permanent tide (zero frequen
cy). " ;

```

Geoid from the model EGM2008.

5.3.118 ocean_tide_sol1

The CDL definition of the variable `ocean_tide_sol1` is:

```

short ocean_tide_sol1(time) ;
  ocean_tide_sol1:units = "m" ;
  ocean_tide_sol1:_FillValue = 32767s ;
  ocean_tide_sol1:long_name = "ocean tide height (solution 1)" ;
  ocean_tide_sol1:source = "GOT4.7" ;
  ocean_tide_sol1:institution = "CLS" ;
  ocean_tide_sol1:scale_factor = 0.001 ;
  ocean_tide_sol1:coordinates = "lon lat" ;
  ocean_tide_sol1:comment = "Solution 1 corresponds to GOT4.7 model. This is
the pure ocean tide, not including the corresponding loading tide (load_tide_so
l1) and equilibrium long-period ocean tide height (ocean_tide_equil). The perma
nent tide (zero frequency) is not included in this parameter because it is incl
uded in the geoid and mean sea surface (geoid, mean_sea_surface). " ;

```

Ocean Tide - (component of total ocean tide) to be added to the range to remove the effect of local tide and adjust the measurement to the mean sea surface. This is solution 1 for the tide computed from the GOT 4.7 model.

5.3.119 ocean_tide_sol2

The CDL definition of the variable `ocean_tide_sol2` is:

```

short ocean_tide_sol2(time) ;
  ocean_tide_sol2:units = "m" ;
  ocean_tide_sol2:_FillValue = 32767s ;
  ocean_tide_sol2:long_name = "ocean tide height (solution 2)" ;
  ocean_tide_sol2:source = "FES2004" ;
  ocean_tide_sol2:institution = "CLS" ;
  ocean_tide_sol2:scale_factor = 0.001 ;
  ocean_tide_sol2:coordinates = "lon lat" ;
  ocean_tide_sol2:comment = "Solution 2 corresponds to FES2004 model. This is
the pure ocean tide, not including the corresponding loading tide (load_tide_so
l2) and equilibrium long-period ocean tide height (ocean_tide_equil). The perma
nent tide (zero frequency) is not included in this parameter because it is incl
uded in the geoid and mean sea surface (geoid, mean_sea_surface). " ;

```

Ocean Tide - (component of total ocean tide) to be added to the range to remove the effect of local tide and adjust the measurement to the mean sea surface. This is solution 2 for the tide computed from the FES 2004 model.

5.3.120 load_tide_sol1

The CDL definition of the variable `load_tide_sol1` is:

```

short load_tide_sol1(time) ;
  load_tide_sol1:units = "m" ;
  load_tide_sol1:_FillValue = 32767s ;
  load_tide_sol1:long_name = "load tide height for geocentric ocean tide (solution 1)" ;
  load_tide_sol1:source = "GOT4.7" ;
  load_tide_sol1:institution = "CLS" ;
  load_tide_sol1:scale_factor = 0.001 ;
  load_tide_sol1:coordinates = "lon lat" ;
  load_tide_sol1:comment = "This value can be added to the corresponding ocean tide height value recorded in the product (ocean_tide_sol1). " ;

```

Ocean Loading Tide - to be added to the range to remove the effect of local tidal distortion to the Earth's crust. This is solution 1 for the tide computed from the GOT 4.7 model.

5.3.121 load_tide_sol2

The CDL definition of the variable `load_tide_sol2` is:

```

short load_tide_sol2(time) ;
  load_tide_sol2:units = "m" ;
  load_tide_sol2:_FillValue = 32767s ;
  load_tide_sol2:long_name = "load tide height for geocentric ocean tide (solution 2)" ;
  load_tide_sol2:source = "FES2004" ;
  load_tide_sol2:institution = "CLS" ;
  load_tide_sol2:scale_factor = 0.001 ;
  load_tide_sol2:coordinates = "lon lat" ;
  load_tide_sol2:comment = "This value can be added to the corresponding ocean tide height value recorded in the product (ocean_tide_sol2). " ;

```

Ocean Loading Tide - to be added to the range to remove the effect of local tidal distortion to the Earth's crust. This is solution 2 for the tide computed from the FES 2004 model.

5.3.122 ocean_tide_equil

The CDL definition of the variable `ocean_tide_equil` is:

```

short ocean_tide_equil(time) ;
  ocean_tide_equil:units = "m" ;
  ocean_tide_equil:_FillValue = 32767s ;
  ocean_tide_equil:long_name = "equilibrium long-period ocean tide height" ;
  ocean_tide_equil:standard_name = "sea_surface_height_amplitude_due_to_equilibrium_ocean_tide" ;
  ocean_tide_equil:source = "Cartwright tidal potential" ;
  ocean_tide_equil:institution = "CLS" ;
  ocean_tide_equil:scale_factor = 0.001 ;
  ocean_tide_equil:coordinates = "lon lat" ;
  ocean_tide_equil:comment = "This value can be added to the two geocentric ocean tide height values recorded in the product (ocean_tide_sol1 and ocean_tide_sol2)." ;

```

Long-Period equilibrium Ocean Tide (component of total ocean tide) to be added to the range to remove the effect of local tide and adjust the measurement to the mean sea surface.

5.3.123 ocean_tide_non_equil

The CDL definition of the variable `ocean_tide_non_equil` is:

```
short ocean_tide_non_equil(time) ;
  ocean_tide_non_equil:units = "m" ;
  ocean_tide_non_equil:_FillValue = 32767s ;
  ocean_tide_non_equil:long_name = "non-equilibrium long-period ocean tide height" ;
  ocean_tide_non_equil:standard_name = "sea_surface_height_amplitude_due_to_non_equilibrium_ocean_tide" ;
  ocean_tide_non_equil:source = "FES2004" ;
  ocean_tide_non_equil:institution = "CLS" ;
  ocean_tide_non_equil:scale_factor = 0.001 ;
  ocean_tide_non_equil:coordinates = "lon lat" ;
  ocean_tide_non_equil:comment = "This parameter is computed as a correction to the parameter ocean_tide_equil. This value can be added to ocean_tide_equil (or ocean_tide_sol1, ocean_tide_sol2) so that the resulting value models the total non equilibrium ocean tide height. " ;
```

Long-Period non-equilibrium Ocean Tide (component of total ocean tide) to be added to the range to remove the effect of local tide and adjust the measurement to the mean sea surface.

5.3.124 solid_earth_tide

The CDL definition of the variable `solid_earth_tide` is:

```
short solid_earth_tide(time) ;
  solid_earth_tide:units = "m" ;
  solid_earth_tide:_FillValue = 32767s ;
  solid_earth_tide:long_name = "solid earth tide height" ;
  solid_earth_tide:standard_name = "sea_surface_height_amplitude_due_to_earth_tide" ;
  solid_earth_tide:source = "Cartwright tidal potential" ;
  solid_earth_tide:institution = "CLS" ;
  solid_earth_tide:scale_factor = 0.001 ;
  solid_earth_tide:coordinates = "lon lat" ;
  solid_earth_tide:comment = "The permanent tide (zero frequency) is not included. " ;
```

Solid Earth Tide - added to the range to remove the effect of local tidal distortion in the Earth's crust. From the Cartwright model.

5.3.125 pole_tide

The CDL definition of the variable `pole_tide` is:

```
short pole_tide(time) ;
  pole_tide:units = "m" ;
  pole_tide:_FillValue = 32767s ;
  pole_tide:long_name = "geocentric pole tide height" ;
  pole_tide:standard_name = "sea_surface_height_amplitude_due_to_pole_tide" ;
  pole_tide:source = "Wahr [1985]" ;
  pole_tide:institution = "CLS" ;
  pole_tide:scale_factor = 0.001 ;
```

```
pole_tide:coordinates = "lon lat" ;
pole_tide:comment = "" ;
```

Geocentric Polar Tide - to be added to the range to remove a long-period distortion of the Earth's crust. Although called a 'tide' this is in fact caused by variations in centrifugal force as the Earth's rotational axis moves its geographic location. From the Wahr model.

5.3.126 bathymetry

The CDL definition of the variable `bathymetry` is:

```
int bathymetry(time) ;
  bathymetry:units = "m" ;
  bathymetry:_FillValue = 2147483647 ;
  bathymetry:long_name = "ocean depth/land elevation" ;
  bathymetry:source = "MACCESS" ;
  bathymetry:institution = "CLS" ;
  bathymetry:scale_factor = 0.001 ;
  bathymetry:coordinates = "lon lat" ;
```

Ocean Depth / Land Elevation from the model MACCESS.

5.3.127 atmos_corr_sig0

The CDL definition of the variable `atmos_corr_sig0` is:

```
short atmos_corr_sig0(time) ;
  atmos_corr_sig0:units = "dB" ;
  atmos_corr_sig0:_FillValue = 32767s ;
  atmos_corr_sig0:long_name = "atmospheric attenuation correction to backscatter coefficient" ;
  atmos_corr_sig0:scale_factor = 0.01 ;
  atmos_corr_sig0:coordinates = "lon lat" ;
  atmos_corr_sig0:comment = "This correction is already applied to ocean_sig0." ;
```

The correction to backscatter due to the attenuation of the atmosphere. This is derived from the MWR data and is set to a constant default (non-zero) if the MWR data is not available.

5.3.128 interp_flag_slope_model_20hz

The CDL definition of the variable `interp_flag_slope_model_20hz` is:

```
byte interp_flag_slope_model_20hz(time, meas_ind) ;
  interp_flag_slope_model_20hz:_FillValue = 127b ;
  interp_flag_slope_model_20hz:long_name = "20 Hz slope model interpolation flag" ;
  interp_flag_slope_model_20hz:flag_values = "0b, 1b" ;
  interp_flag_slope_model_20hz:flag_meanings = "good bad" ;
  interp_flag_slope_model_20hz:coordinates = "lon_20hz lat_20hz" ;
  interp_flag_slope_model_20hz:comment = "This flag indicates if the slope model has been successfully interpolated, and the resulting correction applied to offset_elevation_20hz." ;
```

5.4 L1b parameters included at L2

A number of engineering level parameters are included in the L2 products for reference. The majority of users should not need to make use of them.

5.4.1 agc_20hz

The CDL definition of the variable `agc_20hz` is:

```
int agc_20hz(time, meas_ind) ;
    agc_20hz:units = "dB" ;
    agc_20hz:_FillValue = 2147483647 ;
    agc_20hz:long_name = "Ku band corrected AGC" ;
    agc_20hz:scale_factor = 0.01 ;
    agc_20hz:coordinates = "lon lat" ;
    agc_20hz:comment = "AGC is corrected for instrumental errors due to the imperfections of the on-board attenuators." ;
```

The AGC, copied from the L1b product.

5.4.2 scaling_factor_20hz

The CDL definition of the variable `scaling_factor_20hz` is:

```
int scaling_factor_20hz(time, meas_ind) ;
    scaling_factor_20hz:units = "dB" ;
    scaling_factor_20hz:long_name = "scaling factor for backscatter coefficient" ;
    scaling_factor_20hz:_FillValue = 2147483647 ;
    scaling_factor_20hz:scale_factor = 0.01 ;
    scaling_factor_20hz:coordinates = "lon_20Hz lat_20Hz" ;
    scaling_factor_20hz:comment = "This scaling factor represents the backscatter coefficient for a retracked waveform amplitude equal to 1." ;
```

5.4.3 inst_time_corr_20hz

The CDL definition of the variable `inst_time_corr_20hz` is:

```
int inst_time_corr_20hz(time, meas_ind) ;
    inst_time_corr_20hz:units = "s" ;
    inst_time_corr_20hz:_FillValue = 2147483647 ;
    inst_time_corr_20hz:long_name = "instrument correction to window delay" ;
    inst_time_corr_20hz:scale_factor = 1.e-12 ;
    inst_time_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
    inst_time_corr_20hz:comment = "This instrument correction to time was applied to the window delay value at L1. It is the same as inst_range_c_20hz but expressed in units of time." ;
```

5.4.4 inst_agc_corr_20hz

The CDL definition of the variable `inst_agc_corr_20hz` is:

```
short inst_agc_corr_20hz(time, meas_ind) ;
    inst_agc_corr_20hz:units = "dB" ;
    inst_agc_corr_20hz:_FillValue = 32767s ;
    inst_agc_corr_20hz:long_name = "sigma 0 flight calibration factor" ;
    inst_agc_corr_20hz:scale_factor = 0.01 ;
    inst_agc_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
    inst_agc_corr_20hz:comment = "The Sigma 0 Flight Calibration Factor, copied from the L1b product." ;
```


5.4.5 `agc_cal_factor_20hz`

The CDL definition of the variable `agc_cal_factor_20hz` is:

```
short agc_cal_factor_20hz(time, meas_ind) ;
    agc_cal_factor_20hz:units = "dB" ;
    agc_cal_factor_20hz:_FillValue = 32767s ;
    agc_cal_factor_20hz:long_name = "AGC calibration factor" ;
    agc_cal_factor_20hz:scale_factor = 0.01 ;
    agc_cal_factor_20hz:coordinates = "lon_20hz lat_20hz" ;
    agc_cal_factor_20hz:comment = "The AGC calibration factor, copied from the
L1b product." ;
```

5.4.6 `p_ref_20hz`

The CDL definition of the variable `p_ref_20hz` is:

```
int p_ref_20hz(time, meas_ind) ;
    p_ref_20hz:units = "counts" ;
    p_ref_20hz:_FillValue = 2147483647 ;
    p_ref_20hz:long_name = "power reference value" ;
    p_ref_20hz:scale_factor = 0.01 ;
    p_ref_20hz:coordinates = "lon_20hz lat_20hz" ;
    p_ref_20hz:comment = "The Power Reference Value, copied from the L1b produc
t." ;
```

5.4.7 `sptr_jumps_corr_20hz`

The CDL definition of the variable `sptr_jumps_corr_20hz` is:

```
int sptr_jumps_corr_20hz(time, meas_ind) ;
    sptr_jumps_corr_20hz:units = "s" ;
    sptr_jumps_corr_20hz:_FillValue = 2147483647 ;
    sptr_jumps_corr_20hz:long_name = "SPTR jumps correction to range." ;
    sptr_jumps_corr_20hz:scale_factor = 1.e-12 ;
    sptr_jumps_corr_20hz:coordinates = "lon_20hz lat_20hz" ;
    sptr_jumps_corr_20hz:comment = "The SPTR jumps correction, copied from the
L1b product." ;
```

The SPTR jumps correction has already been applied in the L1 processing.

5.4.8 `mcd_20hz`

The CDL definition of the variable `mcd_20hz` is:

```
int mcd_20hz(time, meas_ind) ;
    mcd_20hz:long_name = "L1b MCD bitfield" ;
    mcd_20hz:coordinates = "lon_20hz lat_20hz" ;
    mcd_20hz:valid_min = 0 ;
    mcd_20hz:valid_max = 2147483647 ;
    mcd_20hz:_Unsigned = "true" ;
    mcd_20hz:comment = "The MCD bitmask taken from the L1b product." ;
```

The L1b MCD flag word is defined as follows:

Bit number	Description
31	Warning flag for decoded resolution identifier.
30-28	Not used.

27	Warning flag on packet length.
26	Warning flag on ICU datation. Timestamp is potentially corrupted.
25	Not used.
24	On board tracking processing error.
23	Warning flag for computed AGC. Value out of expected range.
22	Warning flag for computed Rx delay. Value out of expected range.
21-20	Warning flag for waveform samples. Empty waveform indicated by 01.
19	SPTR jumps correction invalid
18-0	Not used.

5.4.9 `sc_bin_count`

The CDL definition of the variable `sc_bin_count` is:

```
byte sc_bin_count(time, meas_ind, sbc_ind) ;
  sc_bin_count:long_name = "spacecraft binary counter" ;
  sc_bin_count:coordinates = "lon_20hz lat_20hz" ;
  sc_bin_count:valid_min = 0b ;
  sc_bin_count:valid_max = -1b ;
  sc_bin_count:_Unsigned = "true" ;
  sc_bin_count:comment = "The 6-byte binary spacecraft clock." ;
```

5.4.10 `ku_wf`

The CDL definition of the variable `ku_wf` is:

```
short ku_wf(time, meas_ind, wvf_ind) ;
  ku_wf:units = "count" ;
  ku_wf:long_name = "waveform samples" ;
  ku_wf:coordinates = "lon_20hz lat_20hz" ;
  ku_wf:valid_min = 0s ;
  ku_wf:valid_max = -1s ;
  ku_wf:_Unsigned = "true" ;
  ku_wf:comment = "The Ku-band waveform." ;
```

5.4.11 `window_delay`

The CDL definition of the variable `window_delay` is:

```
double window_delay(time, meas_ind) ;
  window_delay:units = "s" ;
  window_delay:_FillValue = -1. ;
  window_delay:long_name = "Window delay" ;
  window_delay:scale_factor = 1.e-12 ;
  window_delay:coordinates = "lon_20hz lat_20hz" ;
  window_delay:comment = "The window delay, copied from the L1b product." ;
```

5.4.12 `rx_dist_coarse`

The CDL definition of the variable `rx_dist_coarse` is:

```
short rx_dist_coarse(time, meas_ind) ;
  rx_dist_coarse:units = "s" ;
  rx_dist_coarse:long_name = "coarse time delay" ;
  rx_dist_coarse:scale_factor = 1.25e-08 ;
  rx_dist_coarse:valid_min = 0s ;
```

```
rx_dist_coarse:valid_max = -1s ;
rx_dist_coarse:_Unsigned = "true" ;
rx_dist_coarse:coordinates = "lon_20hz lat_20hz" ;
rx_dist_coarse:comment = "The coarse time delay, copied from the L1b product." ;
```

5.4.13 rx_dist_fine

The CDL definition of the variable `rx_dist_fine` is:

```
short rx_dist_fine(time, meas_ind) ;
  rx_dist_fine:units = "s" ;
  rx_dist_fine:long_name = "fine time delay" ;
  rx_dist_fine:scale_factor = 1.25e-08 ;
  rx_dist_fine:valid_min = 0s ;
  rx_dist_fine:valid_max = -1s ;
  rx_dist_fine:_Unsigned = "true" ;
  rx_dist_fine:coordinates = "lon_20hz lat_20hz" ;
  rx_dist_fine:comment = "The fine time delay, copied from the L1b product." ;
```

5.4.14 num_flight_cal_meas

The CDL definition of the variable `num_flight_cal_meas` is:

```
short num_flight_cal_meas(time, meas_ind) ;
  num_flight_cal_meas:units = "count" ;
  num_flight_cal_meas:_FillValue = 32767s ;
  num_flight_cal_meas:long_name = "number of flight calibration measurements" ;
  num_flight_cal_meas:scale_factor = 1. ;
  num_flight_cal_meas:coordinates = "lon_20hz lat_20hz" ;
  num_flight_cal_meas:comment = "The number of flight calibration measurements, copied from the L1b product." ;
```

5.4.15 dop_time_c

The CDL definition of the variable `dop_time_c` is:

```
int dop_time_c(time, meas_ind) ;
  dop_time_c:units = "s" ;
  dop_time_c:_FillValue = 2147483647 ;
  dop_time_c:long_name = "Doppler range correction expressed as time" ;
  dop_time_c:scale_factor = 1.e-12 ;
  dop_time_c:coordinates = "lon_20hz lat_20hz" ;
  dop_time_c:comment = "The Doppler range correction, copied from the L1b product." ;
```

The Doppler correction has already been applied in the L1 processing.

5.4.16 noise_floor

The CDL definition of the variable `noise_floor` is:

```
int noise_floor(time, meas_ind) ;
  noise_floor:units = "count" ;
  noise_floor:_FillValue = 2147483647 ;
```

```
noise_floor:long_name = "noise floor estimate" ;
noise_floor:scale_factor = 0.01 ;
noise_floor:coordinates = "lon_20hz lat_20hz" ;
noise_floor:comment = "The noise floor estimate, copied from the L1b product." ;
```

5.4.17 stl_disc_out

The CDL definition of the variable `stl_disc_out` is:

```
int stl_disc_out(time, meas_ind) ;
stl_disc_out:units = "1" ;
stl_disc_out:_FillValue = 2147483647 ;
stl_disc_out:long_name = "STL discriminator output" ;
stl_disc_out:scale_factor = 0.01 ;
stl_disc_out:coordinates = "lon_20hz lat_20hz" ;
stl_disc_out:comment = "The STL discriminator output in slope units, copied from the L1b product." ;
```

5.4.18 htl_disc_out

The CDL definition of the variable `htl_disc_out` is:

```
int htl_disc_out(time, meas_ind) ;
htl_disc_out:units = "s" ;
htl_disc_out:_FillValue = 2147483647 ;
htl_disc_out:long_name = "HTL discriminator output" ;
htl_disc_out:scale_factor = 1.25e-12 ;
htl_disc_out:coordinates = "lon_20hz lat_20hz" ;
htl_disc_out:comment = "The HTL discriminator output, copied from the L1b product." ;
```

5.4.19 agc_disc_out

The CDL definition of the variable `agc_disc_out` is:

```
int agc_disc_out(time, meas_ind) ;
agc_disc_out:units = "count" ;
agc_disc_out:_FillValue = 2147483647 ;
agc_disc_out:long_name = "AGC discriminator output" ;
agc_disc_out:scale_factor = 0.1 ;
agc_disc_out:coordinates = "lon_20hz lat_20hz" ;
agc_disc_out:comment = "The AGC discriminator output, copied from the L1b product." ;
```

5.4.20 htl_beta_branch

The CDL definition of the variable `htl_beta_branch` is:

```
int htl_beta_branch(time, meas_ind) ;
htl_beta_branch:units = "1" ;
htl_beta_branch:_FillValue = 2147483647 ;
htl_beta_branch:long_name = "HTL beta branch output" ;
htl_beta_branch:scale_factor = 1.25e-14 ;
htl_beta_branch:coordinates = "lon_20hz lat_20hz" ;
htl_beta_branch:comment = "The HTL beta branch output, per PRI, copied from the L1b product." ;
```

5.4.21 rx_offset

The CDL definition of the variable `rx_offset` is:

```
int rx_offset(time, meas_ind) ;
  rx_offset:units = "s" ;
  rx_offset:_FillValue = 2147483647 ;
  rx_offset:long_name = "Receiver time offset" ;
  rx_offset:scale_factor = 1.25e-11 ;
  rx_offset:coordinates = "lon_20hz lat_20hz" ;
  rx_offset:comment = "The receiver time offset, copied from the L1b product." ;
```

5.4.22 a_htl_coeff

The CDL definition of the variable `a_htl_coeff` is:

```
int a_htl_coeff(time, meas_ind) ;
  a_htl_coeff:units = "1" ;
  a_htl_coeff:_FillValue = 2147483647 ;
  a_htl_coeff:long_name = "HTL filter alpha coefficient" ;
  a_htl_coeff:scale_factor = 0.001 ;
  a_htl_coeff:coordinates = "lon_20hz lat_20hz" ;
  a_htl_coeff:comment = "The HTL filter alpha coefficient, copied from the L1 b product." ;
```

5.4.23 b_htl_coeff

The CDL definition of the variable `b_htl_coeff` is:

```
int b_htl_coeff(time, meas_ind) ;
  b_htl_coeff:units = "1" ;
  b_htl_coeff:_FillValue = 2147483647 ;
  b_htl_coeff:long_name = "HTL filter beta coefficient" ;
  b_htl_coeff:scale_factor = 1.e-05 ;
  b_htl_coeff:coordinates = "lon_20hz lat_20hz" ;
  b_htl_coeff:comment = "The HTL filter beta coefficient, copied from the L1b product." ;
```

5.4.24 a_agc_coeff

The CDL definition of the variable `a_agc_coeff` is:

```
int a_agc_coeff(time, meas_ind) ;
  a_agc_coeff:units = "1" ;
  a_agc_coeff:_FillValue = 2147483647 ;
  a_agc_coeff:long_name = "AGC filter alpha coefficient" ;
  a_agc_coeff:scale_factor = 0.01 ;
  a_agc_coeff:coordinates = "lon_20hz lat_20hz" ;
  a_agc_coeff:comment = "The AGC filter alpha coefficient, copied from the L1 b product." ;
```

5.4.25 b_agc_coeff

The CDL definition of the variable `b_agc_coeff` is:

```
int b_agc_coeff(time, meas_ind) ;
  b_agc_coeff:units = "1" ;
```

```
b_agc_coeff:_FillValue = 2147483647 ;
b_agc_coeff:long_name = "AGC filter beta coefficient" ;
b_agc_coeff:scale_factor = 0.0001 ;
b_agc_coeff:coordinates = "lon_20hz lat_20hz" ;
b_agc_coeff:comment = "The AGC filter beta coefficient, copied from the L1b
product." ;
```

5.4.26 a_stl_coeff

The CDL definition of the variable `a_stl_coeff` is:

```
int a_stl_coeff(time, meas_ind) ;
a_stl_coeff:units = "1" ;
a_stl_coeff:_FillValue = 2147483647 ;
a_stl_coeff:long_name = "STL filter alpha coefficient" ;
a_stl_coeff:scale_factor = 0.1 ;
a_stl_coeff:coordinates = "lon_20hz lat_20hz" ;
a_stl_coeff:comment = "The STL filter alpha coefficient, copied from the L1
b product." ;
```

5.4.27 b_stl_coeff

The CDL definition of the variable `b_stl_coeff` is:

```
int b_stl_coeff(time, meas_ind) ;
b_stl_coeff:units = "1" ;
b_stl_coeff:_FillValue = 2147483647 ;
b_stl_coeff:long_name = "STL filter beta coefficient" ;
b_stl_coeff:scale_factor = 0.001 ;
b_stl_coeff:coordinates = "lon_20hz lat_20hz" ;
b_stl_coeff:comment = "The STL filter beta coefficient, copied from the L1b
product." ;
```

5.4.28 slope

The CDL definition of the variable `slope` is:

```
int slope(time, meas_ind) ;
slope:units = "1" ;
slope:_FillValue = 2147483647 ;
slope:long_name = "slope parameter" ;
slope:scale_factor = 0.01 ;
slope:coordinates = "lon_20hz lat_20hz" ;
slope:comment = "The slope parameter, in slope units, copied from the L1b p
roduct." ;
```

5.4.29 wvf_ind

The CDL definition of the variable `wvf_ind` is:

```
byte wvf_ind(wvf_ind) ;
wvf_ind:units = "count" ;
wvf_ind:long_name = "waveform measurement index" ;
wvf_ind:comment = "Set to be compliant with the CF-1.1 convention. Counts 0
..63." ;
```

6 Auxiliary data

This is a list of models used and data sources. Please consult the acronym list (section 8) where necessary.

6.1 Dynamic auxiliary data

The slope model is derived from the same set of DEMs used to create the slope model for the EnviSat mission, however the processing has been updated to take account of the ERS orbits, see [R3].

Meteorological data – ERA-Interim model (see [R4]) comprising:

- U wind component
- V Wind component
- Dry tropospheric correction
- Wet tropospheric correction
- Surface pressure
- Mean sea surface pressure

Altitude of ECMWF grid points, see [R4].

Pole location position - IERS data, see [R5].

Ionospheric correction - NIC09, see [R6], and JPL's GIM, see [R7] and [R8].

High frequency variability (as used in the dynamic atmospheric correction) - MOG2D see [R9] and [R10].

6.2 Static auxiliary data

RA instrument characterisation - provided by the project.

Physical constants - provided by the project.

SOI processing parameters, i.e. the algorithm characterisation - provided by the project.

Orbit - see [R1].

Sea state bias table – a new model, derived from REAPER commissioning data, by Altimetrics. Not yet published.

Solid Earth tide - Cartwright's model, see [R12].

Geocentric polar tide – Wahr model, see [R23].

Ocean tide and ocean loading tide - GOT4.7 (solution 1), see [R13], and FES2008 (solution 2), see [R14].

Long period tide - Cartwright and Taylor's model, see [R15].

Long period non-equilibrium tide - FES2004, see [R16].

Geoid height - EGM2008, see [R17].

Mean sea surface - CLS01, see [R17], and UCL04 (as used in the CryoSat-2 mission), see [R2].

Ocean depth / land elevation map - MACESS, see [R19].

Land / sea mask - TERRAINBASE, see [R20].

Windspeed table - Abdalla algorithm, see [R21].

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8 Acronym List

This section contains acronyms found in this document, and also acronyms that will more generally be found in background documentation regarding ERS or altimetry in general.

ACQ	Acquisition
AGC	Automatic Gain Control
BT	Brightness Temperature
CDF	Common Data Format
CLC	Closed Loop Calibration
CLS	Collecte Localisation Satellites
CLS01	CLS mean sea surface model 01
COG	Centre of Gravity
CRC	Cyclic Redundancy Code (or Check)
DAC	Dynamic Atmospheric Correction
DEM	Digital Elevation Model
ECMWF	European Centre for Medium-Range Weather Forecasting
EGM2008	Earth Gravitational Model 2008
EM Bias	Electromagnetic Bias
ERA	ECMWF Re-Analysis
ERAC	ERS Radar Altimeter Calibration Data
ERS	European Remote Sensing [satellite]
ESA	European Space Agency
ESRIN	European Space Research Institute
FDPU	FFT Data Power Unit
FES2008	Finite Elements Hydrodynamic [model] 2008
FTP	File Transfer Protocol
GCAL	Ground Calibration Loop
GDR	Geophysical Data Record
GIM	GPS Ionosphere Maps
GOT4.7	Global Ocean Tide [model] 4.7
GPS	Global Positioning System
HRB	High Rate Block
HTL	Height Tracking Loop
IB	Inverse Barometric [Effect]
IERS	International Earth Rotation Service
IF	Intermediate Frequency
JPL	Jet Propulsion Laboratory (NASA institute)
L0/1/1b/2	Level 0/1/1b/2
LE	Leading Edge
LPT	Long Period [Ocean] Tide
LPTNE	Long Period [Ocean] Tide (Non-Equilibrium)
LSB	Least Significant Bit
MCD	Measurement Confidence Data
MOG2D	Modèle d'Onde de Gravité à 2 Dimensions
MSB	Most Significant Bit
MSS	Mean Sea Surface
MSSL	Mullard Space Science Laboratory
MWR	Microwave Radiometer
N/A	not applicable
NASA	North American Space Agency
NIC09	New Ionospheric Climatology 2009
OCOG	Offset Centre of Gravity
ODLE	Ocean Depth / Land Elevation
OET	Ocean Elastic Tide
OLC	Open Loop Calibration
OLT	Ocean Loading Tide

OT	Ocean Tide
PRI	Pulse Repetition Interval
PT	[Geocentric] Polar Tide
PTR	Point Target Response
RA	Radar Altimeter
RMS	Root Mean Square
RSS	Return Signal Simulator
QA	Quality Analysis (or Assurance)
SC	Spacecraft
SET	Solid Earth Tide
SGDR	Sensor Geophysical Data Record
SOI	System Ocean and Ice [file]
SP	Source Packet
SPTR	Scanning Point Target Response
SSB	Sea State Bias
STL	Slope Tracking Loop
SWH	Significant Wave Height
TB	Température de Brilliance (Brightness Temperature)
TE	Trailing Edge
UCL	University College London
UCL04	UCL mean sea surface model 04
USO	Ultra-Stable Oscillator
UTC	Universal Time (Coordinated)
WF	WaveForm
WGS84	World Geodetic System 1984

Annexe 1: Calibration and Validation Report

During the routine processing of the full 12-year time span, systematic QA was performed on each cycle of data to verify the long-term stability of the Reaper products.

The QA service is designed to

- Validate the product format
- Establish validity of product parameters
- Show long term trends to establish stability of measurements and detect drift in change of performance over time
- Detect anomalies

The results of analyses performed by the QA service are displayed on a dedicated public access web site. The site URL is :

<http://reaper.mssl.ucl.ac.uk/qa>

It is recommended that users browse the QA website where results of detailed analyses can be viewed by ERS phase, cycle, geographical area etc.

All Reaper data has been processed through the MSSL QA system with good results.

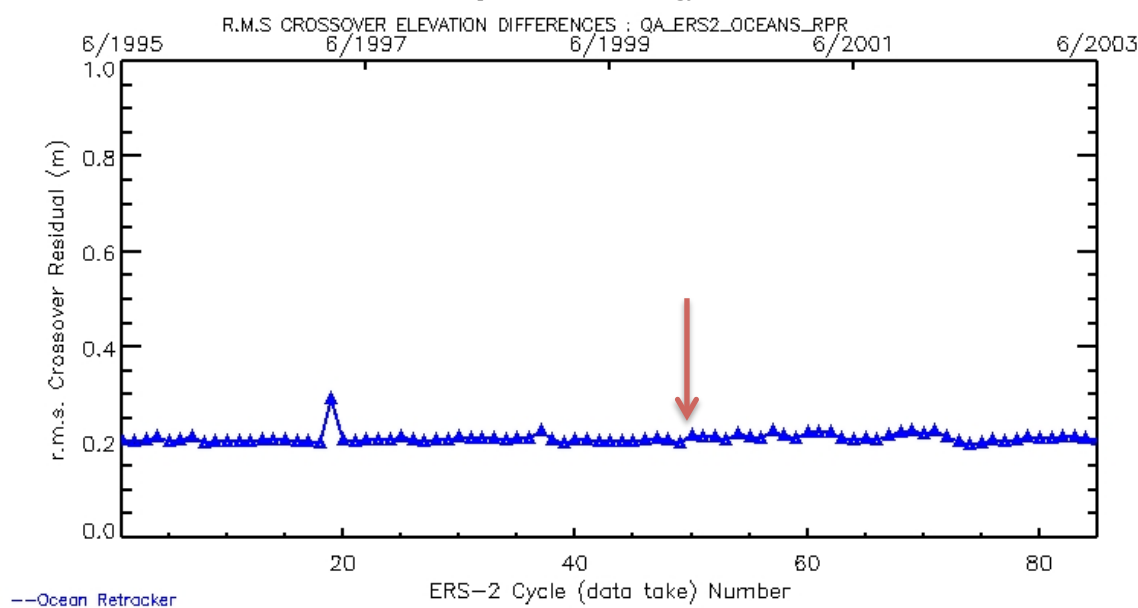
Crossovers

The QA website provides results of analysis of crossover processing for the 35-day repeat cycles of Reaper Level-2 GDR data.

<http://reaper.mssl.ucl.ac.uk/qa/crossovers.php>

Over time intervals where there is no expected change in the surface elevation, height difference at a crossover point provides a measure of altimeter and chain performance, height error and antenna polarity issues. Crossover data is also used to derive the Time Tag Bias.

As can be seen from the ERS-2 phase A (35-day cycles) plot of RMS crossover elevation differences over oceans, the general trend shows a slight increase in RMS from cycle 50 onwards (red arrow in the plot below). This is consistent with the date from which ERS-2 operated in mono-gyro mode.



In the example shown above, the peak at cycle 19 is coincident with a number of known degraded orbits.

In the case of ERS-1, crossovers are calculated for the 3-day cycle phases as well as the 35-day and 168-day phases but results will be more variable due to the smaller number of crossover points.

Crossovers cannot be processed when there are too few tracks in a cycle. In the case of ERS-1 3-day cycles, there are often too few crossover points for processing. The number of crossover points processed, or absence of crossover points is noted in the Cycle Statistics table below each plot on the website.

Mean X-over RMS of global oceans (~20cm) is much improved as compared to WAP (~29cm).

Results from Crossover Correction Tests are shown at:

http://reaper.mssl.ucl.ac.uk/qa/crossovers_correction_checks.php

The effectiveness of geophysical and atmospheric corrections over global oceans are tested by sequentially adding in each correction to the uncorrected height and calculating the resulting RMS crossover residual for each cycle. The fully corrected data are used to compute an RMS and then each correction is subtracted in turn from this. As a double check the corrections are added back in with their sign reversed. Thus, when a correction is subtracted, the RMS should increase, and it should greatly increase when the sign-reversed quantity is added in.

L2 Parameters

Essential Level 2 parameters are monitored and the outputs shown in histograms and geographical plots on a per-cycle basis that allows assessment of individual parameters and overall end-to-end measurement performance. The per-cycle metrics are plotted over time to reveal long term drifts and seasonal cyclic signals. Statistics are also derived separately to characterise the performance over particular areas: global, global oceans, north polar, south polar.

It is recommended that users browse the QA results of the L2 parameters that are relevant to their particular use case.

For example the L2 Height maps at <http://reaper.mssl.ucl.ac.uk/qa/height.php> serve to highlight any anomalous orbits in each cycle.

Retracker Validity Maps at http://reaper.mssl.ucl.ac.uk/qa/retracker_validity.php show the validity flags of each of the retrackerers (see section 3.7) on a per-cycle basis and per-phase.

Reaper Calibration Monitoring

Quality Assessment on the two main calibration chains (IF Mask and PTR) has been carried out by isardSAT. The results are presented in the Reaper Calibration Monitoring QA Results document at

http://reaper.mssl.ucl.ac.uk/qa/docs/isardSAT_REAPER_CAL_Monitoring.pdf

Orbit and Range Quality

Altimetrics, as part of their L2 Validation, have identified degraded orbits for ERS-1 and ERS-2.

Degraded orbits are listed in Annex 2: e1_flags.dat and e2_flags.dat. Both of these files are ASCII and their meaning is explained in the headers to the files, starting with a hash (#).

Annexe 2: Degraded Orbits

These files are provided for the convenience of users who wish to filter out data that may be of poor quality due to orbital manoeuvres or anomalous PTR correction behaviour. As the product is not split by pass, the user should inspect the `rel_orbit` attribute of the file and compare against the pass range below, remembering that a file will usually contain data at least one pass beyond the number given in the `rel_orbit` attribute.

File `e1_flags.dat`

```
# e1_flags.dat
#
# This file contains information about raising flags in the RADS
# data files. Each line holds the instruction for the setting
# of one flag.
#
# The meaning of each of the columns is as follows:
# (1) Flag to be set or cleared (11 = quality of range, 15 = quality of orbital altitude)
# (2) Set (1) or clear (0)
# (3) Cycle
# (4)-(5) Pass range
# (6) Selection code for additional editing (-1=none, 2=latitude)
# (7)-(8) Limits for additional editing on field specified in (6)
# (9) Remark
#
# Original records used with OPR v6 data
11 1 34 77 77 -1 0 0 'Degradation of range'
15 1 35 2 14 -1 0 0 'Set degraded orbit flag'
15 1 61 1 86 -1 0 0 'Set degraded orbit flag'
15 1 62 1 86 -1 0 0 'Set degraded orbit flag'
15 1 63 1 57 -1 0 0 'Set degraded orbit flag'
11 1 65 49 50 -1 0 0 'Degradation of range'
11 1 65 61 61 -1 0 0 'Degradation of range'
11 1 65 79 79 -1 0 0 'Degradation of range'
11 1 83 672 672 2 40 60 'Degradation of range after switch-on'
15 1 86 375 376 -1 0 0 'Set degraded orbit flag'
11 1 86 995 995 2 0 20 'Degradation of range after switch-on'
11 1 87 192 192 2 -90 -70 'Degradation of range'
11 1 92 995 995 2 0 20 'Degradation of range after switch-on'
15 1 100 356 365 -1 0 0 'Set degraded orbit flag'
11 1 100 414 414 -1 0 0 'Degradation of range'
11 1 104 2 86 -1 0 0 'Degradation of range'
11 1 122 39 57 -1 0 0 'Degradation of range'
11 1 137 76 77 -1 0 0 'Degradation of range'
15 1 151 268 283 -1 0 0 'Set degraded orbit flag'
11 1 155 995 995 2 0 20 'Degradation of range after switch-on'
#
# Added as part of REAPER project, 2014-04-01
# Orbit flags
15 1 152 986 1001 -1 0 0 'Set degraded orbit flag'
11 1 154 898 903 -1 0 0 'Set degraded orbit flag'
#
# Added as part of REAPER project, 2014-06-15
# Orbit flags
15 1 16 22 42 -1 0 0 'Set degraded orbit flag'
15 1 48 48 57 -1 0 0 'Set degraded orbit flag'
```

```

15 1 55 18 19 -1 0 0 'Set degraded orbit flag'
15 1 63 82 86 -1 0 0 'Set degraded orbit flag'
15 1 64 1 7 -1 0 0 'Set degraded orbit flag'
15 1 65 52 53 -1 0 0 'Set degraded orbit flag'
15 1 65 60 63 -1 0 0 'Set degraded orbit flag'
15 1 71 6 8 -1 0 0 'Set degraded orbit flag'
15 1 71 50 74 -1 0 0 'Set degraded orbit flag'
15 1 83 201 244 -1 0 0 'Set degraded orbit flag'
15 1 83 273 293 -1 0 0 'Set degraded orbit flag'
15 1 83 364 379 -1 0 0 'Set degraded orbit flag'
15 1 83 453 487 -1 0 0 'Set degraded orbit flag'
15 1 87 566 567 -1 0 0 'Set degraded orbit flag'
15 1 90 389 389 -1 0 0 'Set degraded orbit flag'
15 1 90 178 224 -1 0 0 'Set degraded orbit flag'
15 1 90 533 549 -1 0 0 'Set degraded orbit flag'
15 1 94 513 523 -1 0 0 'Set degraded orbit flag'
15 1 101 108 168 -1 0 0 'Set degraded orbit flag'
15 1 102 55 77 -1 0 0 'Set degraded orbit flag'
15 1 138 52 52 -1 0 0 'Set degraded orbit flag'
15 1 140 1093 1098 -1 0 0 'Set degraded orbit flag'
15 1 142 2156 2166 -1 0 0 'Set degraded orbit flag'
15 1 142 2184 2185 -1 0 0 'Set degraded orbit flag'
15 1 143 15 17 -1 0 0 'Set degraded orbit flag'
15 1 144 520 520 -1 0 0 'Set degraded orbit flag'
# Range flag (probably OLC PTR)
11 1 46 44 44 -1 0 0 'Degradation of range, probably OLC'
11 1 35 61 61 -1 0 0 'Degradation of range, probably OLC'
11 1 54 54 54 -1 0 0 'Degradation of range, probably OLC'
11 1 57 20 20 -1 0 0 'Degradation of range, probably OLC'
11 1 79 5 5 -1 0 0 'Degradation of range, probably OLC'
11 1 82 1 86 -1 0 0 'Degradation of range, probably OLC'
11 1 87 566 566 2 -90 -30 'Degradation of range'
11 1 140 3620 3620 2 -90 -30 'Degradation of range, probably OLC'
11 1 142 3567 3567 -1 0 0 'Degradation of range, probably OLC'
11 1 142 4580 4580 -1 0 0 'Degradation of range, probably OLC'
11 1 149 241 241 -1 0 0 'Degradation of range, probably OLC'

```

File e2_flags.dat

```

# e2_flags.dat
#
# This file contains information about raising flags in the RADS
# data files. Each line holds the instruction for the setting
# of one flag.
#
# The meaning of each of the columns is as follows:
# (1) Flag to be set or cleared (11 = quality of range, 15 = quality of orbital altitude)
# (2) Set (1) or clear (0)
# (3) Cycle
# (4)-(5) Pass range
# (6) Selection code for additional editing (-1=none, 2=latitude)
# (7)-(8) Limits for additional editing on field specified in (6)
# (9) Remark
#
11 1 19 904 1002 -1 0 0 'Eliminate data ERS-2 Cycle 19 pass 904 - Cycle 20 pass 51,
reason unknown'

```

```

11 1 20 1 51 -1 0 0 'Eliminate data ERS-2 Cycle 19 pass 904 - Cycle 20 pass 51,
reason unknown'
11 1 23 203 203 2 25 24 'Eliminate data between 25N and 45N, UTC jump'
11 1 27 612 612 2 -60 -45 'Eliminate data between 45S and 60S, anomaly in internal
calibration'
11 1 31 396 396 2 -7 1 'Eliminate data between 7S and 1N, anomaly in internal
calibration'
11 1 31 402 402 2 20 60 'Eliminate data between 20N and 60N, anomaly in internal
calibration'
11 1 32 402 402 2 -55 -20 'Eliminate data between 55S and 20S, anomaly in internal
calibration'
11 1 35 276 276 2 45 65 'Eliminate data between 45N and 65N, anomaly in internal
calibration'
11 1 36 246 246 2 35 40 'Eliminate data between 35N and 40N, telemetry problems'
11 1 36 555 555 2 -70 -40 'Eliminate data between 70S and 40S, telemetry problems'
11 1 36 973 973 2 50 60 'Eliminate data between 50N and 60N, telemetry problems'
11 1 37 660 660 2 -5 40 'Eliminate data between 5S and 40N, slope of unknown
reason'
11 1 39 682 682 2 -21 -15 'Eliminate data between 15S and 21S, telemetry problems'
11 1 48 78 78 2 25 40 'Eliminate data between 25N and 40N, payload restart'
11 1 52 920 920 2 20 30 'Eliminate data between 20N and 30N, telemetry problem'
11 1 54 202 202 2 50 90 'Eliminate data above 50N, telemetry problem'
#
# Added as part of REAPER project, 30-03-2014
# Orbit flags
15 1 4 260 260 -1 0 0 'Set degraded orbit flag'
15 1 7 575 583 -1 0 0 'Set degraded orbit flag'
15 1 7 986 999 -1 0 0 'Set degraded orbit flag'
15 1 8 312 346 -1 0 0 'Set degraded orbit flag'
15 1 79 424 461 -1 0 0 'Set degraded orbit flag'
15 1 83 212 227 -1 0 0 'Set degraded orbit flag'
# Range flag (probably OLC PTR)
11 1 9 898 898 -1 0 0 'Degradation of range, probably OLC'
11 1 9 992 992 2 10 90 'Degradation of range, probably OLC'
#
# Added as part of REAPER project, 15-06-2014
# Orbit flags
15 1 14 5 7 -1 0 0 'Set degraded orbit flag'
15 1 17 210 227 -1 0 0 'Set degraded orbit flag'
15 1 19 333 432 -1 0 0 'Set degraded orbit flag'
15 1 23 202 211 -1 0 0 'Set degraded orbit flag'
15 1 25 411 413 -1 0 0 'Set degraded orbit flag'
15 1 30 925 939 -1 0 0 'Set degraded orbit flag'
15 1 32 934 949 -1 0 0 'Set degraded orbit flag'
15 1 36 43 43 -1 0 0 'Set degraded orbit flag'
15 1 37 754 769 -1 0 0 'Set degraded orbit flag'
15 1 50 477 483 -1 0 0 'Set degraded orbit flag'
15 1 52 90 92 -1 0 0 'Set degraded orbit flag'
15 1 53 328 328 -1 0 0 'Set degraded orbit flag'
15 1 53 612 614 -1 0 0 'Set degraded orbit flag'
15 1 54 493 495 -1 0 0 'Set degraded orbit flag'
15 1 54 942 945 -1 0 0 'Set degraded orbit flag'
15 1 54 949 959 -1 0 0 'Set degraded orbit flag'
15 1 57 404 445 -1 0 0 'Set degraded orbit flag'
15 1 59 30 30 -1 0 0 'Set degraded orbit flag'
15 1 59 32 32 -1 0 0 'Set degraded orbit flag'

```

15	1	60	788	930	-1	0	0	'Set degraded orbit flag'
15	1	60	988	1002	-1	0	0	'Set degraded orbit flag'
15	1	61	10	20	-1	0	0	'Set degraded orbit flag'
15	1	62	321	339	-1	0	0	'Set degraded orbit flag'
15	1	68	166	170	-1	0	0	'Set degraded orbit flag'
15	1	68	605	607	-1	0	0	'Set degraded orbit flag'
15	1	69	120	131	-1	0	0	'Set degraded orbit flag'
15	1	69	214	333	-1	0	0	'Set degraded orbit flag'
15	1	72	454	461	-1	0	0	'Set degraded orbit flag'
#	Range	flag	(probably	OLC	PTR)			
11	1	14	906	906	2	-5	20	'Degradation of range, probably OLC'
11	1	15	622	622	2	30	90	'Degradation of range, probably OLC'
11	1	27	811	811	2	-15	90	'Degradation of range, probably OLC'
11	1	35	291	291	-1	0	0	'Degradation of range, probably OLC'
11	1	40	639	639	-1	0	0	'Degradation of range, probably OLC'
11	1	45	639	639	-1	0	0	'Degradation of range, probably OLC'
11	1	48	78	78	2	0	90	'Degradation of range, probably OLC'
11	1	56	777	777	-1	0	0	'Degradation of range, probably OLC'
11	1	58	832	832	-1	0	0	'Degradation of range, probably OLC'
11	1	59	527	527	-1	0	0	'Degradation of range, probably OLC'
11	1	60	222	222	2	-30	0	'Degradation of range, probably OLC'
11	1	68	298	298	-1	0	0	'Degradation of range, probably OLC'
11	1	68	328	328	-1	0	0	'Degradation of range, probably OLC'
11	1	68	611	611	-1	0	0	'Degradation of range, probably OLC'
11	1	70	177	177	2	0	90	'Degradation of range, probably OLC'
11	1	71	162	162	2	0	90	'Degradation of range, probably OLC'