AVISO and PODAAC User Handbook

IGDR and GDR Jason Products

CENTRE NATIONAL D'ETUDES SPATIALES

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http://www-aviso.cnes.fr http://podaac.jpl.nasa.gov

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1. INTRODUCTION

JASON-1 is a follow-on mission to the highly successful TOPEX/POSEIDON (T/P) mission. The satellite is named after the leader of the Argonauts' famous quest to recover the Golden Fleece. The JASON-1 mission is jointly conducted by the French Space Agency, "*Centre National d'Etudes Spatiales"* (CNES) and the United States National Aeronautics and Space Administration (NASA).

1.1. Handbook Purpose

The purpose of this document is to assist users of the CNES/NASA JASON-1 Geophysical Data Record (GDR) and Interim Geophysical Data Record (IGDR) products by providing a comprehensive description of GDR content and format. Both products have the same format. We will so refer to (I)GDR in this document when the information is relevant for both products. Let us recall that the GDR is identical to the IGDR except for the following points:

- a more precise orbit is used (impacts on altitude field, Doppler, …)
- improved pole location data are used (Pole Tide update)
- DORIS ionospheric correction is included
- it is a fully validated product

Section 5 provides a list of all fields from the IGDR that could be updated in the GDR.

The document also provides an overview of the JASON-1 mission and a description of the measurements and corrections. More information on data algorithms and sensors can be found in JASON-1 project documents (see Reference list in appendix B for the " Algorithms Definition, Accuracy and Specification" documents).

The geographical arrangement for distributing the JASON-1 data products to the international scientific community is covered by a CNES-NASA agreement. Both centers will disseminate all (I)GDR data. JASON-1 data are distributed through two agencies:

- AVISO : http://www-aviso.cnes.fr
  "***A**rchivage, **V**alidation et **I**nterprétation des données des **S**atellites **O**céanographiques*" is the French multi-satellite databank dedicated to space oceanography, developed by CNES.
- PO.DAAC : http://podaac.jpl.nasa.gov
  The **P**hysical **O**ceanography **D**istributed **A**ctive **A**rchive **C**enter is one element of the Earth Observing System Data and Information System (EOSDIS), developed by NASA.

1.2. Handbook Overview

This is a combination of a guide to data usage and a reference handbook, so not all sections will be needed by all readers.

Section 1 provides background information about the (I)GDR and this document.

Section 2 is an overview of the JASON-1 mission.

Section 3 is an introduction to using the JASON-1 data.

Section 4 is an introduction to the JASON-1 altimeter algorithms.

Section 5 provides a description of the content and format of the JASON-1 (I)GDRs.

Section 6 provides a detailed description of each field of the (I)GDR header records.

Section 7 provides a detailed description of each field of the (I)GDR science records.

Appendix A contains acronyms.

Appendix B contains references.

Appendix C describes how to order information or data from AVISO and PO.DAAC and lists related Web sites.

1.3. Document reference and contributors

When referencing this document, please use the following citation :

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1.4. Conventions

1.4.1. Vocabulary

In order to reduce confusion in discussing altimeter measurements and corrections, the following terms are used in this document as defined below.

DISTANCE and LENGTH are general terms with no special meaning in this document.

RANGE is the distance from the satellite to the surface of the Earth, as measured by the altimeter. Thus, the altimeter measurement is referred to as "range" or "altimeter range," not height.

ALTITUDE is the distance of the satellite or altimeter above a reference point. The reference point used is the reference ellipsoid. This distance is computed from the satellite ephemeris data.

HEIGHT is the distance of the sea surface above the reference ellipsoid. The sea surface height is the difference of the altimeter range from the satellite altitude above the reference ellipsoid.

1.4.2. Orbits, Revs and Passes

An ORBIT is one circuit of the earth by the satellite as measured from one ascending node crossing to the next. An ascending node occurs when the subsatellite point crosses the earth's equator going from south to north. A REVOLUTION or REV is synonymous with orbit.

The (I)GDR data is organized into pass files in order to avoid having data boundaries in the middle of the oceans, as would happen if the data were organized by orbit. A PASS is half a revolution of the earth by the satellite from extreme latitude to the opposite extreme latitude. For JASON-1, an ASCENDING PASS begins at the latitude -66.15 deg and ends at +66.15 deg. A DESCENDING PASS is the opposite (+66.15 deg to -66.15 deg). The passes are numbered from 1 to 254 representing a full repeat cycle of the JASON-1 ground track. Ascending passes are odd numbered and descending passes are even numbered.

1.4.3. Reference Ellipsoid

The "reference ellipsoid" is the first-order definition of the non-spherical shape of the Earth as an ellipsoid of revolution with equatorial radius of 6378.1363 kilometers and a flattening coefficient of 1/298.257 (same reference ellipsoid as used by the T/P mission.)

1.4.4. Correction Conventions

All environmental and instrument corrections are computed so that they should be added to the quantity which they correct. That is, a correction is applied to a measured value by

$$\text{Corrected Quantity} = \text{Measured Value} + \text{Correction}$$

This means that a correction to the altimeter range for an effect that lengthens the apparent signal path (e.g., wet troposphere correction) will be computed as a negative number. Adding this negative number to the uncorrected (measured) range will reduce the range from its original value toward the correct value.

Example:

Corrected Range = Measured Range + Range Correction

1.4.5. Time Convention

Times are UTC and referenced to January 1, 1958 00:00:00.00, sometimes abbreviated UTC58.

A UTC leap second can occur on June 30 or December 31 of any year. The leap second is a sixty-first second introduced in the last minute of the day. Thus, the UTC values (minutes:seconds) appear as: 59:58 ; 59:59 ; 59:60 ; 00:00 ; 00:01

In Section 5 reference will be made to UTC1 and UTC2. These are ASCII expressions of UTC times expressed using the following format:

- UTC1 format gives time in seconds and is recorded with 19 characters. The format is:

  YYYY-MM-DDTHH:MM:SS

- UTC2 format gives time in seconds and is recorded with 26 characters. The format is:

  YYYY-MM-DDTHH:MM:SS.XXXXXX

where

YYYY = year

MM = month (01 to 12)

DD = day of month (01 to 31)

HH = hours (00 to 23)

MM = minutes (00 to 59)

SS = seconds (00 to 59 or 60 for UTC leap second)

XXXXXX = microseconds

1.4.6. Unit Convention

All distances and distance corrections are reported in tenths of millimeters (10^{-1} mm).

1.4.7. Flagging and Editing

In general, flagging consists of three parts: instrument flags (on/off), telemetry flags (preliminary flagging and editing) and data quality flags (geophysical processing flags).

Instrument flags provide information about the state of the various instruments on the satellite.

Telemetry flags are first based on instrument modes and checking of telemetry data quality. Only severely corrupted data are not processed. Flag setting is designed to get a maximum amount of data into the Sensor Data Records (part of the SGDR products). Science data are processed only when the altimeter is in tracking mode.

Quality flags are determined from various statistical checks on the residuals after smoothing or fitting through the data themselves. These flags are set if gaps in the data are detected, or residuals have exceeded predetermined thresholds, or if the gradients of the data exceed predetermined thresholds.

1.4.8. Default Values

Data elements are recorded as 1, 2, or 4 byte (signed or unsigned) integers. When a parameter is unavailable (e.g. missing data) then the parameter value is set to a default value. Default values are defined to be the maximum possible value for the storage type. For example, a signed 2-byte integer has a default value of 32 767, and an unsigned integer has a default value of 65535. Furthermore, if a parameter value was determined to be out of range of the possible values of the storage type, then the sign of the parameter value is retained. This is accomplished by setting the parameter value to the maximum (minimum) value available to the storage type if the original value was found to be larger (smaller) than this maximum (minimum).

The following are the maximum (default) and minimum values for the various storage types and sizes:

Data Storage Type	Size	Minimum Value	Maximum (Default) Value
signed integer	1 byte	-128	2^7-1 = 127
unsigned integer	1 byte	0	2^8-1 = 255
bitfield	1 byte	0	2^8-1 = 255
signed integer	2 bytes	-32768	2^{15}-1 = 32 767
unsigned integer	2 bytes	0	2^{16}-1 = 65535
bitfield	2 bytes	0	2^{16}-1 = 65535
signed integer	4 bytes	-2147483648	2^{31}-1 = 2147483647
unsigned integer	4 bytes	0	2^{32}-1 = 4294967295

1.4.9. Bit Fields Order

Regarding the bitfield notation, the convention is to number the bits from right to left :

- the least significant bit (LSB) at location 0 and the most significant bit (MSB) at location 7, for a one byte bitfield
- the least significant bit (LSB) at location 0 and the most significant bit (MSB) at location 15, for a two byte bitfield
- the least significant bit (LSB) at location 0 and the most significant bit (MSB) at location 31, for a four byte bitfield

This convention is represented below for one and two bytes bitfield.

One Byte

7	6	5	4	3	2	1	0
MSB							LSB

Two bytes

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

1.4.10. Byte Order

All data files are generated according to the big endian byte-ordering convention, which stores the most significant byte in the lowest memory address (the word is stored `big-end-first').

Most Unix systems are big endian. Motorola 680x0 microprocessors (and therefore Macintoshes), Hewlett-Packard PA-RISC, and Sun SuperSPARC processors are big endian. The Silicon Graphics MIPS and IBM/Motorola PowerPC processors are both little and big endian (bi-endian). The Intel 80X86 and Pentium and DEC Alpha RISC processors are little endian. Windows NT and OSF/1 are little endian.

Warning : depending upon your computer, you may need to swap bytes.

Note that both the AVISO and PO.DAAC ftp servers provide sample data products in binary and ascii format to allow users to verify correct usage of read software. These servers also provide read software in various programming languages.

2. JASON-1 MISSION OVERVIEW

JASON-1 is jointly conducted by the French Space Agency, "*Centre National d'Etudes Spatiales"* (CNES), and the United States' National Aeronautics and Space Administration (NASA) for studying the global circulation from space. The mission uses the technique of satellite altimetry to make precise and accurate observations of sea level for several years. JASON-1 was launched on 7 December 2001.

2.1. JASON-1 Mission

JASON-1 is a follow-on mission to the highly successful TOPEX/POSEIDON (T/P) mission. The main goal of this mission is to measure the sea surface topography at least at the same performance level of T/P. This provides an extended continuous time series of high-accuracy measurements of the ocean topography from which scientists can determine the general circulation of the ocean and understand its role in the Earth's climate. In addition to the primary JASON-1 IGDR and GDR data products provided with a 2-3 and 30 day latency, respectively, JASON-1 also supports the preparation of operational ocean services by providing a non-validated near-real-time (3 hour latency) JASON-1 data product, the Operational Sensor Data Record (OSDR). JASON-1 is the first in a twenty-year series of satellites to take over from T/P, marking the start of operational satellite altimetry.

The JASON-1 mission supports new research programs such as the Climate Variability and Predictability program (CLIVAR) and the Global Ocean Data Assimilation Experiment (GODAE).

2.2. JASON-1 Requirements

The major elements of the mission include a satellite carrying an altimetric system for measuring the height of the satellite above the sea surface; a precision orbit determination system for referring the altimetric measurements to geodetic coordinates; a data analysis and distribution system for processing the satellite data, verifying their accuracy, and making them available to the scientific community; and a Principal Investigator program for scientific studies based on the satellite observations.

The JASON-1 mission shall be designed in a way that allows an optimum continuation of the T/P scientific mission. This means that the error budget and orbit characteristics (repeat period, inclination, altitude) of JASON-1 shall be identical to those of T/P. To ensure that science and mission goals are accomplished by the JASON-1 mission, the following requirements were established.

2.2.1. Accuracy of Sea-level Measurements

Requirements for the JASON-1 (I)GDR are derived directly from the post-launch T/P error budget, with the JASON-1 system required to be at least as good as the T/P system. Each measurement of sea level shall have an accuracy of ±4.2 cm for the GDR products and 5.2 cm for the IGDR (1 standard deviation) over 1 second averages for typical oceanic conditions of 2 m significant wave height and 11dB sigma-naught. This error budget includes the altimeter noise, uncertainties in corrections of atmospheric path delays, sea-state related biases, and orbit error.

The following table provides a summary of error budget at the end of the verification phase.

	IGDR (3 days)		**GDR (30 days)**	
	Spec	**Performance**	**Spec**	**Performance**
Altimeter noise (cm) (H1/3=2m, s=11dB) 1Hz	*1.7*	**1.6**	*1.7*	**1.6**
Sea State Bias (%H1/3)	*1.2%*	**1% ***	*1.2%*	**1% ***
Ionosphere (cm)	*0.5***	**0.5****	*0.5***	**0.5****
Dry Tropo (cm)	*0.7*	**0.7**	*0.7*	**0.7**
Wet Tropo (cm)	*1.2*	**1.2**	*1.2*	**1.2**
Corrected Range (RSS, cm) (H1/3=2m, s=11dB) 1Hz	*3.3*	**3**	*3.3*	**3**
Orbit (radial component) (cm)	*4*	**2.5**	*2.5*	**1.5**
Corrected Sea Surface Height (RSS,cm) (H1/3=2m, s=11dB) 1 Hz	*5.2*	**3.9**	*4.2*	**3.3**
Wave Height H1/3 (m or %H1/3, whichever is greater)	*0.5 or 10%*	**0.4 *** or 10%**	*0.5 or 10%*	**0.4 *** or 10%**
Wind Speed (m/s)	*1.7*	**1.5 *****	*1.7*	**1.5 *****

* improvement studies in progress

** after filtering over 100 km

*** after bias calibration

2.2.2. Sampling Strategy

Sea level shall be measured along a fixed grid of subsatellite tracks such that it will be possible to investigate and minimize the spatial and temporal aliases of surface geostrophic currents and to minimize the influence of the geoid on measurements of the time-varying topography.

2.2.3. Tidal Aliases

Sea level shall be measured such that tidal signals will not be aliased into semiannual, annual, or zero frequencies (which influences the calculation of the permanent circulation) or frequencies close to these.

2.2.4. Duration and coverage

Sea level shall be measured for a minimum of three years, with the potential to extend this period for an additional two years.

The JASON-1 satellite shall overfly the reference T/P ground tracks. The grid of subsatellite tracks shall extend in latitude at least as far south as the southern limit of the Drake Passage (62 deg) and the subsatellite tracks that comprise the grid will cross at sufficiently large angles that the two orthogonal components of surface slope can be determined with comparable accuracy.

2.2.5. Data Reduction and Distribution

A system to process and distribute data to the Principal Investigators shall be tested, documented, and in operation at the time of launch. A minimum of 95% of the oceanic data that could be acquired by the spacecraft shall be acquired with no systematic gaps, processed and made available for scientific investigations. The intent is to collect and process all data continuously. Small amounts of data could be lost during adjustments of the satellite's orbit, during tests of the altimeter's performance, and during various other such events.

2.3. Satellite Description

The 500 kg satellite consists of a multi-mission PROTEUS (***P**late Forme **R**econfigurable pour l'**O**bservation de la **TE**rre, les telecommuncations et les **U**tilisations **S**cientifiques*) platform and a JASON-1 specific payload module. The platform provides all housekeeping functions including propulsion, electrical power, command and data handling, telecommunications, and attitude control. The payload module provides mechanical, electrical, thermal, and dynamical support to the JASON-1 instruments.

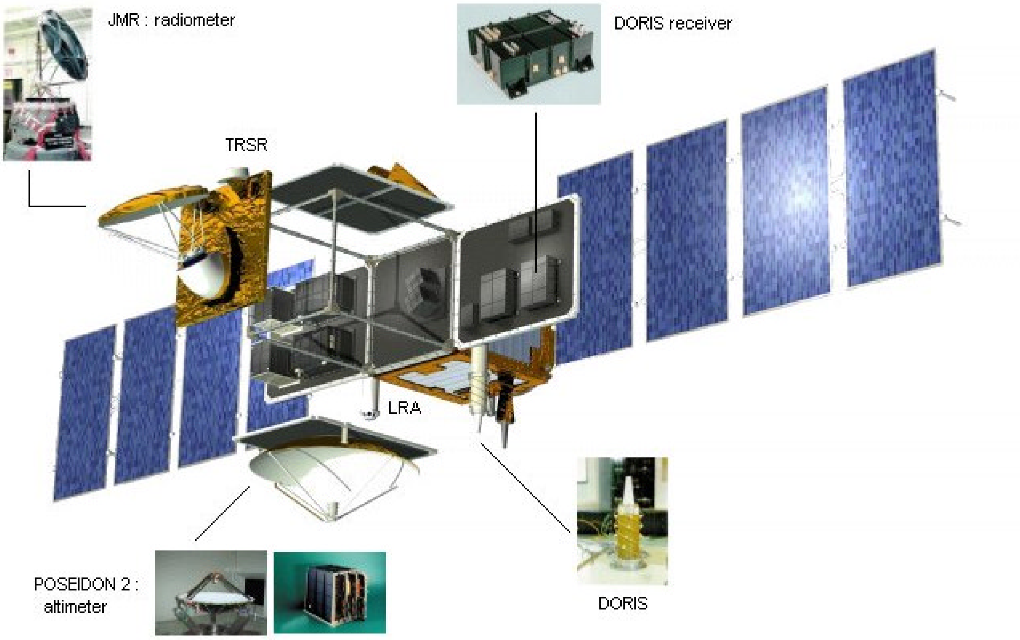


Figure 1 JASON-1 satellite

JASON-1 Characteristics

Satellite mass	500 kg
Satellite power	450 w
Platform mass	270 kg
Platform power	300 W
Payload mass	120 kg
Payload power	147 W
Altimeter mass	55 kg
Altimeter power	78 W
Launch Vehicle	Dual Delta II
Launch Site	Vandenberg Air Force Base

2.3.1. Sensors

The science and mission goals are carried out with a satellite carrying five science instruments, three from CNES and two from NASA.

- Dual-frequency Ku/C band Solid State Radar Altimeter (POSEIDON-2) (CNES)

  The Poseidon-2 altimeter, operating at 13.575 GHz (Ku band) and 5.3 GHz (C band), is the primary sensor for the JASON-1 mission. The measurements made at the two frequencies are combined to obtain measurements of the altimeter range, wind speed, significant wave height, and the ionospheric correction. The Poseidon-2 package consists of dual redundant altimeter units each of which has low mass and low power consumption.

- Dual-frequency Doppler Orbitography and Radiopositioning by Satellite (DORIS) tracking system receiver (CNES)

  The DORIS Precise Orbit Determination (POD) system uses a two-channel, two-frequency (401.25 MHz and 2036.25 MHz) Doppler receiver on the satellite to observe the tracking signals from a network of approximately 50 ground transmitting beacons. It provides all-weather global tracking of the satellite for POD and a correction for the influence of the ionosphere on both the Doppler signal and altimeter signals. The DORIS on-board package includes the receiver itself, the ultra-stable oscillator, and an omni-directional antenna located on the nadir face of the satellite. It includes a dual beacon receiving capability and an on-board real time function (***D**étermination **I**mmédiate d'**O**rbite par **D**oris **E**mbarque*, or DIODE) to compute the orbit ephemeris with an accuracy of 30 cm (1 standard deviation).

- Three-frequency JASON-1 Microwave Radiometer (JMR) (NASA)

  The JMR measures the sea surface microwave brightness temperatures at three frequencies (18.7 GHz, 23.8 GHz and 34.0 GHz) to provide the total water vapor content in the troposphere along the altimeter beam. The 23.8 GHz channel is the primary channel for water-vapor measurement and is a redundant channel on the JMR. The 18.7 GHz channel provides a correction for wind-induced effects in the sea surface background emissions, and the 34.0 GHz channel provides a correction for cloud liquid water. The measurements are combined to obtain the error in the satellite range measurements caused by pulse delay due to the water vapor.

- Laser Retroreflector Array (LRA) (NASA)

  The LRA is placed on the nadir face of the satellite and reflects signals from a network of 10 to 15 satellite laser tracking stations. It supports the JASON-1 Calibration and Validation function for POD.

- Turbo Rogue Space Receiver (TRSR) (NASA)

  The TRSR is an advanced codeless sixteen-channel Global Positioning System (GPS) receiver developed by the Jet Propulsion Laboratory (JPL). The on-board package is comprised of dual redundant TRSR units and choke ring antennae. The GPS data are intended to provide supplementary positioning data in support of the POD function and/or to improve gravity field models.

2.3.2. Orbit

The JASON-1 satellite will fly the same ground-track as the original T/P with a 254 pass, 10-day exact repeat cycle. The JASON-1 and T/P satellites were phased approximately 70 seconds apart during the calibration phase. On August 15, 2002 (cycle 365 pass 111) the T/P satellite began its “drift phase” by moving to a new orbit in preparation for the Tandem Mission. The drift phase lasted until September 16, 2002 ending with cycle 368, pass 171. Data for cycle 368, pass 172 and later are on the final fixed tandem mission ground track, which is interleaved with the JASON-1 ground track, providing improved temporal and spatial coverage. Orbital characteristics and the equator crossing longitudes for JASON-1 are given below. Figure 2 is a plot of the ground track on a world map.

Mean classical orbit elements

Semi-major axis	7,714.43 km
Eccentricity	0.000095
Inclination	66.04 deg
Argument of periapsis	90.0 deg
Inertial longitude of the ascending node	116.56 deg
Mean anomaly	253.13 deg

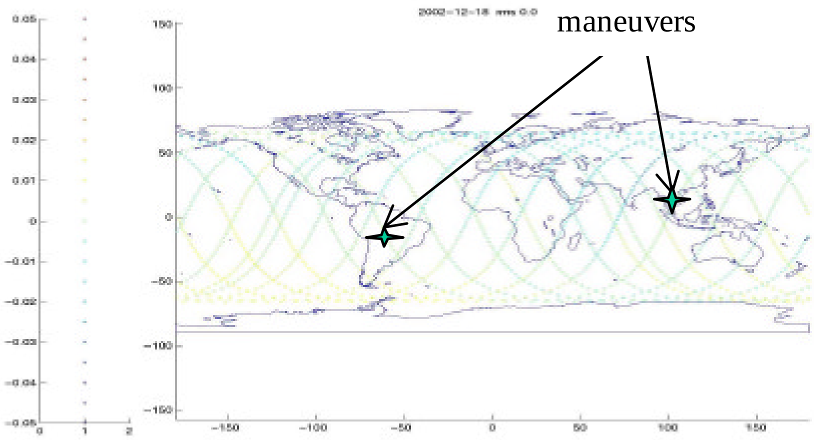
Auxiliary data

Reference (Equatorial) altitude	1,336 km
Nodal period	6,745.72 sec
Repeat period	9.9156 days
Number of revolutions within a cycle	127
Equatorial cross-track separation	315 km
Ground track control band	$\pm$ 1 km
Acute angle at Equator crossings	39.5 deg
Longitude of Equator crossing of pass 1	99.9249 deg
Inertial nodal rate	-2.08 deg/day
Orbital speed	7.2 km/s
Ground track speed	5.8 km/s

This orbit overflies two verifications sites. The prime CNES verification site is located at Cape Senetosa on the island of Corsica (8^{o} 48' E, 41^{o} 34' N (ascending pass 85). The prime NASA verification site is located on the Harvest oil platform near Pt. Conception, California (239^{o} 19' E, 34^{o} 28' N) (ascending pass 43).

A satellite orbit slowly decays due to air drag, and has long-period variability because of the inhomogeneous gravity field of Earth, solar radiation pressure, and smaller forces. Periodic maneuvers are required to keep the satellite in its orbit. The frequency of maneuvers depends primarily on the solar flux as it affects the Earth's atmosphere, and there are expected to be one maneuver (or series of maneuvers) every 40 to 200 days.

Each orbit maintenance maneuver is performed as two thrusts on pass 254 cycle N and 1 cycle N+1 (see plot below). Orbit computation is optimised to minimize the orbit error during such periods. Science data are taken during orbit maintenance maneuvers and will be distributed (see orb_state_flag, in section 7.2).



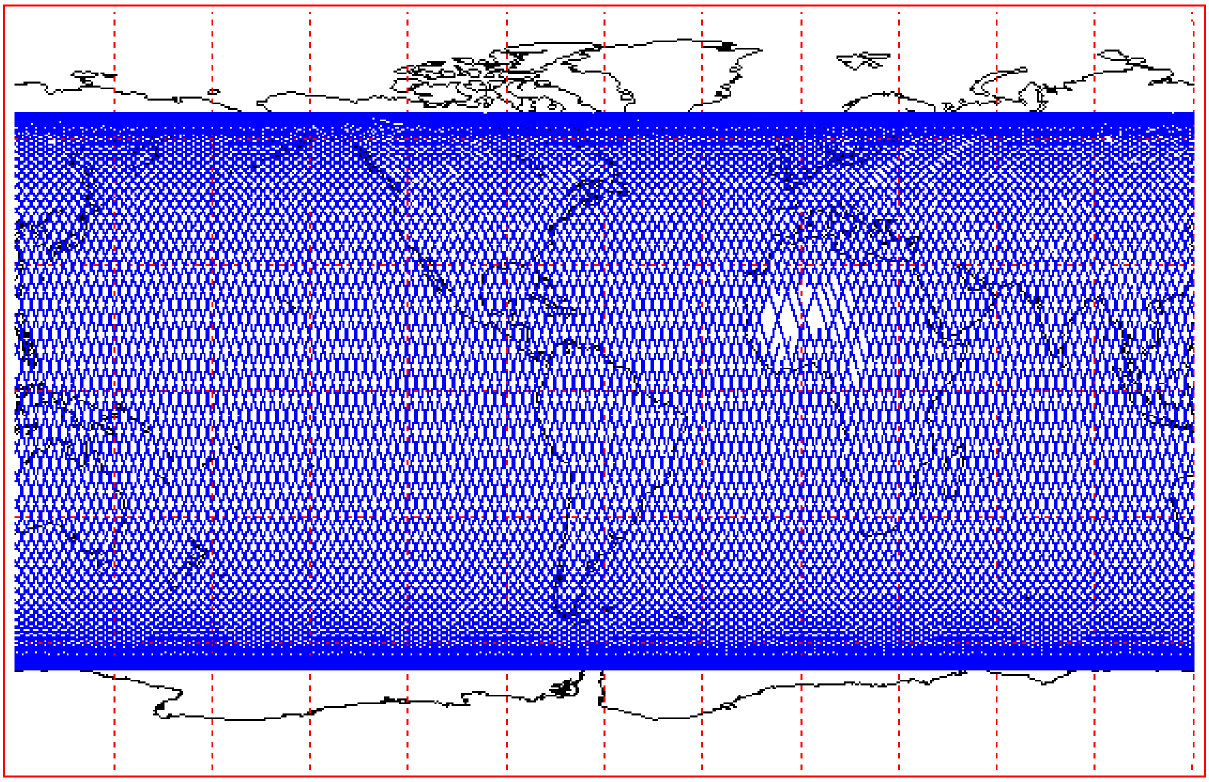


Figure 2 Plot of the ground track on a world map
(example given for cycle 142 of the T/P mission.)

EQUATOR CROSSING LONGITUDES (IN ORDER OF PASS NUMBER)

Pass	Longitude	Pass	Longitude	Pass	Longitude	Pass	Longitude
1	99.9249	65	272.8379	129	85.7515	193	258.6642
2	265.7517	66	78.6647	130	251.5783	194	64.4909
3	71.5776	67	244.4904	131	57.4042	195	230.3169
4	237.4044	68	50.3172	132	223.2310	196	36.1437
5	43.2305	69	216.1435	133	29.0576	197	201.9704
6	209.0573	70	21.9702	134	194.8843	198	7.7971
7	14.8844	71	187.7974	135	0.7117	199	173.6248
8	180.7112	72	353.6242	136	166.5385	200	339.4515
9	346.5387	73	159.4520	137	332.3659	201	145.2793
10	152.3655	74	325.2788	138	138.1927	202	311.1061
11	318.1928	75	131.1062	139	304.0198	203	116.9330
12	124.0196	76	296.9330	140	109.8466	204	282.7598
13	289.8463	77	102.7596	141	275.6727	205	88.5862
14	95.6731	78	268.5864	142	81.4995	206	254.4130
15	261.4989	79	74.4124	143	247.3252	207	60.2389
16	67.3256	80	240.2392	144	53.1520	208	226.0657
17	233.1515	81	46.0652	145	218.9782	209	31.8922
18	38.9783	82	211.8920	146	24.8050	210	197.7189
19	204.8049	83	17.7190	147	190.6320	211	3.5463
20	10.6317	84	183.5458	148	356.4588	212	169.3731
21	176.4592	85	349.3733	149	162.2866	213	335.2005
22	342.2860	86	155.2000	150	328.1133	214	141.0273
23	148.1139	87	321.0274	151	133.9409	215	306.8545
24	313.9406	88	126.8541	152	299.7676	216	112.6813
25	119.7676	89	292.6810	153	105.5943	217	278.5075
26	285.5944	90	98.5078	154	271.4211	218	84.3343
27	91.4209	91	264.3336	155	77.2471	219	250.1600
28	257.2477	92	70.1603	156	243.0739	220	55.9867
29	63.0736	93	235.9862	157	48.8999	221	221.8129
30	228.9004	94	41.8130	158	214.7267	222	27.6397
31	34.7268	95	207.6395	159	20.5536	223	193.4666
32	200.5535	96	13.4663	160	186.3804	224	359.2934
33	6.3809	97	179.2937	161	352.2079	225	165.1212
34	172.2076	98	345.1205	162	158.0346	226	330.9479
35	338.0351	99	150.9484	163	323.8620	227	136.7755
36	143.8619	100	316.7751	164	129.6887	228	302.6023

Pass	Longitude	Pass	Longitude	Pass	Longitude	Pass	Longitude
37	309.6891	101	122.6022	165	295.5157	229	108.4290
38	115.5159	102	288.4290	166	101.3425	230	274.2558
39	281.3423	103	94.2556	167	267.1683	231	80.0819
40	87.1690	104	260.0823	168	72.9951	232	245.9087
41	252.9947	105	65.9083	169	238.8209	233	51.7347
42	58.8215	106	231.7351	170	44.6477	234	217.5614
43	224.6476	107	37.5614	171	210.4741	235	23.3883
44	30.4744	108	203.3881	172	16.3009	236	189.2150
45	196.3012	109	9.2154	173	182.1282	237	355.0425
46	2.1280	110	175.0422	174	347.9550	238	160.8693
47	167.9557	111	340.8697	175	153.7829	239	326.6966
48	333.7825	112	146.6964	176	319.6096	240	132.5234
49	139.6102	113	312.5237	177	125.4369	241	298.3504
50	305.4370	114	118.3505	178	291.2636	242	104.1772
51	111.2637	115	284.1770	179	97.0902	243	270.0031
52	277.0905	116	90.0038	180	262.9170	244	75.8299
53	82.9167	117	255.8295	181	68.7430	245	241.6556
54	248.7435	118	61.6562	182	234.5697	246	47.4824
55	54.5694	119	227.4823	183	40.3959	247	213.3088
56	220.3962	120	33.3090	184	206.2227	248	19.1355
57	26.2229	121	199.1358	185	12.0499	249	184.9628
58	192.0497	122	4.9626	186	177.8767	250	350.7896
59	357.8771	123	170.7903	187	343.7042	251	156.6174
60	163.7039	124	336.6170	188	149.5309	252	322.4442
61	329.5313	125	142.4448	189	315.3582	253	128.2715
62	135.3580	126	308.2716	190	121.1850	254	294.0983
63	301.1851	127	114.0984	191	287.0117		
64	107.0119	128	279.9252	192	92.8384		

EQUATOR CROSSING LONGITUDES (IN ORDER OF LONGITUDE)

Pass	Longitude	Pass	Longitude	Pass	Longitude	Pass	Longitude
135	0.7117	27	91.4209	173	182.1282	154	271.4211
46	2.1280	192	92.8384	84	183.5458	65	272.8379
211	3.5463	103	94.2556	249	184.9628	230	274.2558
122	4.9626	14	95.6731	160	186.3804	141	275.6727
33	6.3809	179	97.0902	71	187.7974	52	277.0905
198	7.7971	90	98.5078	236	189.2150	217	278.5075
109	9.2154	1	99.9249	147	190.6320	128	279.9252
20	10.6317	166	101.3425	58	192.0497	39	281.3423
185	12.0499	77	102.7596	223	193.4666	204	282.7598
96	13.4663	242	104.1772	134	194.8843	115	284.1770
7	14.8844	153	105.5943	45	196.3012	26	285.5944
172	16.3009	64	107.0119	210	197.7189	191	287.0117
83	17.7190	229	108.4290	121	199.1358	102	288.4290
248	19.1355	140	109.8466	32	200.5535	13	289.8463
159	20.5536	51	111.2637	197	201.9704	178	291.2636
70	21.9702	216	112.6813	108	203.3881	89	292.6810
235	23.3883	127	114.0984	19	204.8049	254	294.0983
146	24.8050	38	115.5159	184	206.2227	165	295.5157
57	26.2229	203	116.9330	95	207.6395	76	296.9330
222	27.6397	114	118.3505	6	209.0573	241	298.3504
133	29.0576	25	119.7676	171	210.4741	152	299.7676
44	30.4744	190	121.1850	82	211.8920	63	301.1851
209	31.8922	101	122.6022	247	213.3088	228	302.6023
120	33.3090	12	124.0196	158	214.7267	139	304.0198
31	34.7268	177	125.4369	69	216.1435	50	305.4370
196	36.1437	88	126.8541	234	217.5614	215	306.8545
107	37.5614	253	128.2715	145	218.9782	126	308.2716
18	38.9783	164	129.6887	56	220.3962	37	309.6891
183	40.3959	75	131.1062	221	221.8129	202	311.1061
94	41.8130	240	132.5234	132	223.2310	113	312.5237
5	43.2305	151	133.9409	43	224.6476	24	313.9406
170	44.6477	62	135.3580	208	226.0657	189	315.3582
81	46.0652	227	136.7755	119	227.4823	100	316.7751
246	47.4824	138	138.1927	30	228.9004	11	318.1928
157	48.9999	49	139.6102	195	230.3196	176	319.6096
68	50.3172	214	141.0273	106	231.7351	87	321.0274

Pass	Longitude	Pass	Longitude	Pass	Longitude	Pass	Longitude
233	51.7347	125	142.4448	17	233.1515	252	322.4442
144	53.1520	36	143.8619	182	234.5697	163	323.8620
55	54.5694	201	145.2793	93	235.9862	74	325.2788
220	55.9867	112	146.6964	4	237.4044	239	326.6966
131	57.4042	23	148.1139	169	238.8209	150	328.1133
42	58.8215	188	149.5309	80	240.2392	61	329.5313
207	60.2389	99	150.9484	245	241.6556	226	330.9479
118	61.6562	10	152.3655	156	243.0739	137	332.3659
29	63.0736	175	153.7829	67	244.4904	48	333.7825
194	64.4909	86	155.2000	232	245.9087	213	335.2005
105	65.9083	251	156.6174	143	247.3252	124	336.6170
16	67.3256	162	158.0346	54	248.7435	35	338.0351
181	68.7430	73	159.4520	219	250.1600	200	339.4515
92	70.1603	238	160.8693	130	251.5783	111	340.8697
3	71.5776	149	162.2866	41	252.9947	22	342.2860
168	72.9951	60	163.7039	206	254.4130	187	343.7042
79	74.4124	225	165.1212	117	255.8295	98	345.1205
244	75.8299	136	166.5385	28	257.2477	9	346.5387
155	77.2471	47	167.9557	193	258.6642	174	347.9550
66	78.6647	212	169.3731	104	260.0823	85	349.3733
231	80.0819	123	170.7903	15	261.4989	250	350.7896
142	81.4995	34	172.2076	180	262.9170	161	352.2079
53	82.9167	199	173.6248	91	264.3336	72	353.6242
218	84.3343	110	175.0422	2	265.7517	237	355.0425
129	85.7515	21	176.4592	167	267.1683	148	356.4588
40	87.1690	186	177.8767	78	268.5864	59	357.8771
205	88.5862	97	179.2937	243	270.0031	224	359.2934
116	90.0038	8	180.7112				

2.3.3. The JASON-1 Project Phases

The satellite mission has two phases:

The first phase, the calibration/validation phase, began when the satellite reached the operational orbit and the satellite and sensor systems were functioning normally. This phase continued until the data received from the sensors were satisfactorily calibrated and verified. The phase began shortly after launch. A preliminary calibration/validation workshop was held June 2002. A second calibration/validation workshop was held October 2002, where Jason-1 to TOPEX/POSEIDON cross validation was extensively discussed : recommendations were issued both on TOPEX/POSEIDON and Jason-1 science processing algorithms.

The second phase, the operational phase, began April 2003 when all necessary algorithm and processing changes were implemented to have Jason-1 performances at the same level as TOPEX/POSEIDON.

2.4. Data Processing and Distribution

Processing centers, called respectively CNES SSALTO and NASA JPL POCC, include functions such as science data processing, data verification and precision orbit determination.

Processed data are placed in National archives for further distribution to the scientific community. There are three levels of processed data:

1. Telemetry data (raw data),
2. Sensor Data Records (engineering units),
3. Geophysical Data Records (geophysical units).

Geophysical data records are sent as they become available to AVISO and PO.DAAC for processing, archiving, managing, and distribution to PIs and the wider scientific community.

The operational sensor data record (OSDR), which is a non-validated product that uses orbits computed by the on-board DORIS Navigator (DIODE) and does not perform ground retracking of the altimeter waveforms, are available with a latency of 3-5 hours. The interim geophysical data record (IGDR), which is also a non-validated product but that uses a preliminary orbit and applies ground retracking, are available by pass with a latency of 2-3 days. The geophysical data record (GDR), which is a fully validated product that uses a precise orbit and applies ground retracking, are available by repeat cycle with a latency of 30 days.

3. USING THE (I)GDR DATA

3.1. Overview

This section will give the reader a guide to the use of the JASON-1 (I)GDR data. Remember that this is research data. While this handbook tries to be correct and complete, nothing can replace the information to be gained at conferences and other meetings of those using these data. Information is also available on the PODAAC and AVISO web servers. The reader must proceed with caution and at his or her own risk. Please direct questions and comments to the contacts given on the last page of this handbook.

The instruments on JASON-1 make direct observations of the following quantities: altimeter range, ocean significant wave height, ocean radar backscatter cross-section (a measure of wind speed), ionospheric electron content in the nadir direction, tropospheric water content, and position relative to the GPS satellite constellation. Ground based laser station and DORIS station measurements of the satellite location and speeds are used in precision orbit determination (POD). The DORIS stations also measure the ionospheric electron content along the line of sight to the satellite. All of these measurements are useful in themselves, but they are made primarily to derive the sea surface height with the highest possible accuracy. Such a computation also needs external data (not collected aboard JASON-1), e.g., atmospheric pressure, etc. In addition, instrument health and calibration data are collected onboard and used to make corrections to the main measurements and to monitor the instrument stability on the long term.

This (I)GDR contains all relevant corrections needed to calculate the sea surface height. For the other "geophysical variables" in the (I)GDR: ocean significant wave height, tropospheric water content, ionospheric electron content (derived by a simple formula), and wind speed, the needed instrument and atmospheric corrections have already been applied.

The following sections explain the rationale for how the corrections should be applied.

3.2. Conventions

In this section references are made to specific (I)GDR parameters by name. For example, surface_type is a flag parameter indicating, among other things, whether or not the data point is over open ocean. All parameters are described in alphabetical order in Section 7.

WARNING: Default values are given to data when computed values are not available (See Section 1.3.8) so you must screen parameters to avoid using those with default values. Also you must check flag values. The related flags are given with the parameter in Section 7 although some discussion of flags appears in this section.

3.3. Altimeter Range

The main data of the (I)GDR are the altimeter ranges. The (I)GDR provides ranges measured at Ku band (range_ku) and C band (range_c). The Ku band range is used for most applications. The reported ranges are corrected for instrument effects. These corrections are separately reported for each of the Ku and C band ranges (net_instr_corr_ku and net_instr_corr_c). The reported ranges must be corrected for path delay in the atmosphere through which the radar pulse passes and the nature of the reflecting sea surface. Recall all range corrections are defined so they should be ADDED to the range. The corrected range is given by

```
Corrected Range = range + wet troposphere correction
                      + dry troposphere correction
                      + ionosphere correction
                      + sea state bias
```

Wet troposphere correction Use JMR correction (rad_wet_tropo_corr).

Dry troposphere correction Use model correction (model_dry_tropo_corr).

Ionosphere correction Use altimeter ionosphere correction (iono_corr_alt_ku to correct range_ku). (IMPORTANT: See Section 3.8 "Smoothing the Ionosphere Correction").

Sea State Bias Use sea state bias correction (sea_state_bias_ku to correct range_ku).

NOTE: The ionosphere and sea state bias corrections are both frequency dependent. Therefore Ku band corrections should only be applied to Ku band ranges, and C band corrections should only be applied to C band ranges. Section 3.9 explains how the C band ionosphere correction can be derived from the Ku band ionosphere correction (iono_corr_alt_ku), while the C band sea state bias correction is provided as sea_state_bias_c.

3.4. Sea Surface Height

Sea surface height (SSH) is the height of the sea surface above the reference ellipsoid. It is calculated by subtracting the corrected range (see above) from the Altitude:

```
Sea Surface Height = Altitude - Corrected Range
```

Corrected Range is defined above.

Altitude - Orbit altitude (see parameter altitude)

3.5. Sea Level Anomaly

The sea level anomaly (SLA), also referred to as Residual Sea Surface, is defined here as the sea surface height minus the mean sea surface and minus known geophysical effects, namely tidal and inverse barometer. It is given by:

```
Sea Level Anomaly = Sea Surface Height - Mean Sea Surface
                                      - Tide Effects
                                      - Inverse Barometer
                                      - High Frequency Wind Response
```

Sea Surface Height is defined above.

Mean Sea Surface See discussion below in this section and in Section 4.

Tide Effects See discussion below in this section and in Section 4.

Inverse Barometer Use inv_bar_corr (also see Section 4.)

High Frequency Wind Response Use hf_fluctuations_corr (also see Section 4.)

The SLA then contains information about

1. real changes in ocean topography related to ocean currents
2. dynamic response to atmospheric pressure
3. differences between tides and the tide models
4. differences between the mean sea surface model and the true mean sea surface at the JASON-1 location
5. unmodeled or mismodeled measurement effects (skewness, sea state bias, altimeter errors, tropospheric corrections, ionosperhic correction, etc.)
6. orbit errors

Of course, there is also random measurement noise. Understanding the first four items as a function of space and time is the purpose of JASON-1.

3.5.1. Geophysical Surface - Mean Sea Surface or Geoid

The geophysical fields Geoid (geoid) (actually geoid undulation, but called simply geoid) and Mean Sea Surface (mss) are distances above the reference ellipsoid, as is the Sea Surface Height. These values are for the location indicated by latitude and longitude. If the values of these fields are needed at a different location within the current frame, along-track interpolation may be done using the high rate (20/second) range and altitude values.

As the geoid is derived from the mean sea surface, the latter is the better-known quantity. The residual surface with respect to the geoid is sometimes called the "dynamic topography" of the ocean surface.

The (I)GDR provides a choice of two models for the mean sea surface: a global model (see parameter mss) that is derived globally using various sources of data; and a model derived exclusively along the T/P ground track from T/P sea surface height data (see parameter mss_tp_along_trk).

See also discussions of mean sea surface and geoid in Section 4.

3.5.2. Tide Effects

The total tide effect on the sea surface height is the sum of three values from the (I)GDR:

```
Tide Effect = Geocentric Ocean Tide + Solid Earth Tide + Pole Tide
```

(See also section 4.8 and subsections)

Geocentric Ocean Tide The geocentric ocean tide provided on the (I)GDR is actually the sum total of the ocean tide with respect to the ocean bottom, and the loading tide height of the ocean bottom.

```
Geocentric Ocean Tide (on (I)GDR) = Ocean Tide + Load Tide
```

The (I)GDR provides a choice of two geocentric ocean tide values, ocean_tide_sol1 and ocean_tide_sol2. Each uses a different model for the sum total of the ocean tide and loading tide heights from the diurnal and semidiurnal tides, but both include an equilibrium representation of the long-period ocean tides at all periods except for the zero frequency (permanent tide) term. Note that the (I)GDR also explicitly provides the loading tide height from each of the two models that are used to determine the two geocentric ocean tide values, load_tide_sol1, load_tide_sol2. Of course, the geocentric ocean tide values and loading tide values should not be used simultaneously, since the loading tide height would be modeled twice.

Solid Earth Tide Use solid_earth_tide (NOTE: Zero frequency (permanent tide) term also not included in this parameter.)

Pole Tide Use pole_tide

The tide values all have the same sign/sense in that positive numbers indicate that the surface is farther from the center of the Earth.

3.6. Data Editing Criteria

The following editing criteria are a recommended guideline for finding good records from the (I)GDR to calculate the sea level anomaly from the Ku band range. The user should review these criteria before using them and may wish to modify them!

First, check the following conditions to retain only ocean data and remove any bad, missing, or flagged data (note that the parameters are listed in order as they appear in the data record):

surface_type = 0	**/* open oceans or semi-enclosed seas */**
alt_echo_type = 0	**/* ocean-like */**
rad_surf_type = 0	**/* ocean */**
qual_1hz_alt_data = 0 (all bits)	**/* Ku band range is good */**
qual_1hz_alt_instr_corr = 0 (all bits)	**/* Ku band range instrument correction is good */**
qual_1hz_rad_data = 0 (all bits)	**/* brightness temperatures (all channels) are good */**
orb_state_flag = 3	**/* adjusted (preliminary/precise) orbit */**
altitude	**not equal default value**
range_ku	**not equal default value**
model_dry_tropo_corr	**not equal default value**
rad_wet_tropo_corr	**not equal default value**
iono_corr_alt_ku	**not equal default value**
sea_state_bias_ku	**not equal default value**
mss	**not equal default value**
inv_bar_corr	**not equal default value**
ocean_tide_sol1	**not equal default value**
solid_earth_tide	**not equal default value**
pole_tide	**not equal default value**
ecmwf_meteo_map_avail = 0	**/* ECMWF meteorological map available */**
tb_interp_flag = 0 or 1	**/* radiometer interpolation flag is good */**
rain_flag = 0	**/* no rain */**
ice_flag = 0	**/* no ice */**
interp_flag bit 0 = 0	**/* mss interpolation flag is good */**
interp_flag bit 1 = 0	**/* ocean_tide_sol1 interpolation flag is good */**
interp_flag bit 3 = 0	**/* meteorological data interpolation flag is good */**

In addition to checking the above conditions, it is also recommended to filter the data as follows to retain only the most valid data :

Number of valid points (range_numval_ku) ≥ 10

0 mm ≤ RMS of 1/sec range (range_rms_ku) ≤ 200 mm

-130 000 mm ≤ (altitude – range_ku) ≤ 100 000 mm

-2500 mm < dry tropospheric correction (model_dry_tropo_corr) < -1900 mm

-500 mm ≤ wet tropospheric correction (rad_wet_tropo_corr) ≤ -1 mm

-400 mm ≤ ionospheric correction (iono_corr_alt_k) ≤ 40 mm

-500 mm ≤ sea state bias correction (sea_state_bias_ku) ≤ 0 mm

-5000 mm ≤ ocean tide correction (ocean_tide_sol1) ≤ +5000 mm

-1000 mm ≤ solid earth tide correction (solid_earth_tide) ≤ +1000 mm

-150 mm ≤ pole tide correction (pole_tide) ≤ +150 mm

0 mm ≤ significant waveheight (swh_ku) ≤ 11 000 mm

7 dB ≤ sigma naught (sig0_ku) ≤ 30 dB

0 m/s ≤ altimeter wind speed ≤ 30 m/s

-0.2 deg^2 ≤ square of off nadir angle from waveforms (off_nadir_angle_ku_wvf) ≤ 0.16 deg^2

To restrict study to deep water, apply a limit, e.g., water depth of 1000m or greater, using the bathymetry parameter (ocean depth in meters.)

Additional empirical tests may be used to refine data editing and remove spurious data :

-2 m ≤ Difference of significant waveheight (swh_c - swh_ku) ≤ 2 m

swh_rms_ku / $(MAX(swh\_ku, 1))^{1/3}$ < 18

swh_rms_c / $(MAX(swh\_ku, 1))^{1/3}$ < 44

range_rms_ku / $(MAX(swh\_ku, 1))^{1/3}$ < 100

range_rms_c / $(MAX(swh\_ku, 1))^{1/3}$ < 170

sigma0_rms_ku < 0.22 dB

sigma0_rms_c < 0.26 dB

3.7. Mean Sea Surface and Adjustment of the Cross Track Gradient

To study sea level changes between two dates, it is necessary to difference sea surface heights from different cycles at the exact same latitude-longitude, so that the not well-known time-invariant geoid cancels out. However, the (I)GDR samples are not given at the same latitude-longitude on different cycles. They are given approximately every 1 sec along the pass (about 6 km, the time difference and distance vary slightly with satellite height above the surface), and the satellite ground track is allowed to drift by ± 1 km. This introduces a problem: on different cycles the satellite will sample a different geoid profile. This effect is the so-called cross-track geoid gradient, and *Brenner and Koblinsky* [1990] estimated it at about 2 cm/km over most of the ocean, larger over continental slopes, reaching 20 cm/km at trenches. Even if the passes repeated exactly, one would have to interpolate along the pass (say, to a fixed set of latitudes) because a 3 km mismatch in along pass position would cause approximately a 6 cm difference in the geoid, which would mistakenly be interpreted as a change in oceanographic conditions.

Both problems are simultaneously solved if the quantity one interpolates along a given pass is the difference

`residual_height - mean_sea_surface`

Then the real geoid changes across the track are automatically accounted for (to the extent the MSS model is close to the true geoid) because the MSS is spatially interpolated to the actual satellite lat-lon in the (I)GDR. The residual_height term above is the residual sea surface height after applying all the tidal, atmospheric and ionospheric corrections, etc. Otherwise, those need to be interpolated separately.

One possible approach is to interpolate along track to a set of common points, a "reference" track. The reference could be

(1) an actual pass with maximum data and/or minimum gaps or

(2) a specially constructed fixed track (see below).

The procedure is

(1) For each common point, find neighboring points in the pass of interest (POI).

(2) In the POI, interpolate along track to the common point, using longitude as the independent variable, for each quantity of interest - sea surface height (see above), mean sea surface, geoid, tides, etc.

(3) As stated above, the quantity to compare at each common point is

dSSH = interpolated POI SSH - interpolated POI MSS

(4) Other geophysical corrections must be applied to dSSH, depending on the type of investigation.

The geoid model in the (I)GDR could be substituted for MSS model, but its use will result in reduced accuracy in the interpolation because the resolution of the geoid undulation is lower than that of the MSS (limited by the 360 x 360 geoid model).

Desirable features of a fixed reference track include

(1) equal spacing of points (good for FFT)

(2) independent variable = (point longitude - pass equator crossing longitude)

(3) equator is a point (simplifies calculation of item 2)

(4) point density similar to original data density.

With these specifications, it is possible to make only two fixed tracks, one ascending and one descending, which will serve for all passes. The template pass is then shifted by the equator crossing longitude found in the header (Equator_Longitude) of each pass. Recall that Equator_Longitude is from a predicted orbit (not updated during GDR processing). Improved accuracy can be obtained by interpolating in the latitude, longitude values. When one interpolates to the reference track, it is good practice to check that the interpolated latitude from the data records used is close to the latitude on the reference track.

3.8. Smoothing Ionosphere Correction

The ionospheric (range) correction is expected to be negative, but positive values are allowed up to +40 mm to accommodate instrument noise effects. To reduce the noise, it is recommended to average over 100 km or more [*Imel*, 1994], which usually results in negative numbers.

Ionospheric averaging is not being done to data provided on the (I)GDR in order to provide a reversible correction, which the users may smooth as desired. In order to use a smoothed ionospheric correction, do the following:

1. Smooth iono_corr_alt_ku as desired. Care should be taken regarding flagged data, editing criteria, and in the case of data (land) gaps. Typical/maximum smoothing scales are 100-150 km (20-25 frames) for local times between 06 and 24 hours and 150-200 km (25-35 frames) for local times between 00 and 06 hours. The shorter (longer) smoothing time is also more appropriate during times of high (low) solar activity.

2. Apply the smoothed ionospheric correction to sea surface height as shown earlier.

It is not recommended that this approach be applied to iono_corr_doris_ku, which is smoothed as a result of the model used.

3.9. Total Electron Content from Ionosphere Correction

To calculate Ionospheric Total Electron Content, TEC, use the following formula:

Ionospheric Total Electron Content = $-(dR*f^2)/40.3$

where

Ionospheric Total Electron Content is in electrons/m^2.

dR = Ku band ionospheric range correction from the (I)GDR in meters (iono_corr_alt_ku or iono_corr_doris_ku)

f = frequency in Hz (for the Ku band this is 13.575 GHz)

Note that the TEC could then be converted to a C band ionosphere range correction using the same formula above, but with the C band frequency of 5.3 GHz.

3.10. Range Compression

Each 1Hz frame of the Poseidon-2 Ku and C band range measurements (range_ku and range_c) are derived from the linear regression of the respective valid 20 Hz range measurements (range_hi_rate_ku and range_hi_rate_c). An iterative outlier detection scheme is adopted in this linear regression and the resulting 20 Hz measurements are identified by setting the corresponding bit in the parameters (range_mapvalpts_ku/ range_mapvalpts_c) to 1. Measurements not considered as outliers have the corresponding bit in parameters (range_mapvalpts_ku/range_mapvalpts_c) set to 0. The number of valid 20 Hz measurements that are used to derive each of the 1 Hz measurements is provided on the (I)GDRs (range_numval_ku and range_numval_c), as are the root-mean-square of the differences between the valid 20 Hz measurements and the derived 1 Hz measurement (range_rms_ku and range_rms_c). Specialized applications, such as over land, ice, lakes or rivers, may require that the users perform their own compression algorithm on the 20 Hz measurements.

3.11. Timetags for Twenty per Frame Ranges

The Poseidon-2 20Hz measurements are equally spaced in each frame. The time tag of the first 20 Hz measurement in the frame is determined by adding an offset, Time_Shift_Mid_Frame (found in the (I)GDR header) to the 1 Hz time tag (defined by time_day, time_sec, time_microsec). The time tag of each subsequent 20 Hz measurement in the frame is determined by adding the time interval between two consecutive 20 Hz measurements, Time_Shift_Interval (found in the (I)GDR header).

```
Time tag of nth 20 Hz measurement =
```

```
1 Hz Time Tag (from time_day, time_sec, time_microsec)
- Time_Shift_Mid_Frame
+ (n-1) * Time_Shift_Interval
```

where n = 1 to 20.

4. ALTIMETRIC DATA

This section presents a short discussion of the main quantities on the (I)GDR.

An excellent overview of the theoretical and practical effects of radar altimetry is the "Satellite Altimetry" Chapter by *Chelton et al* [2001]. Copies can be obtained from PO.DAAC (see contact points at the end of this document.)

4.1. Precision Orbits

CNES has the responsibility for producing the orbit ephemerides for the JASON-1 data products. The JASON-1 IGDRs provide a preliminary orbit that has radial accuracies better than 4 cm (RMS), while the GDRs provide a precise orbit that has radial accuracies better than 2.5 cm (RMS). Both of these orbits are computed with the JGM-3 gravity model and take advantage of DORIS and satellite laser (only for the GDR) ranging tracking data. At present, GPS tracking data are not used to determine the preliminary or precise orbits.

4.2. Altimeter Range

An altimeter operates by sending out a short pulse of radiation and measuring the time required for the pulse to return from the sea surface. This measurement, called the altimeter range, gives the distance between the instrument and the sea surface, provided that the velocity of the propagation of the pulse and the precise arrival time are known. The dual frequency altimeter on JASON-1 performs range measurements at the Ku and C band frequencies (see range_ku and range_c), enabling measurements of the range and the total electron content (see discussion below on ionosphere). While both range measurements are provided on the (I)GDR (see range_ku and range_c), the Ku band range measurement has much higher accuracy than the C band measurement.

The range reported on the JASON-1 (I)GDR has already been corrected for a variety of calibration and instrument effects, including calibration errors, pointing angle errors, center of gravity motion, and terms related to the altimeter acceleration such as Doppler shift and oscillator drift. The sum total of these corrections also appears on the (I)GDR for each of the Ku and C band ranges (see net_instr_corr_ku and net_instr_corr_c).

4.3. Geoid

The geoid is an equipotential surface of the Earth's gravity field that is closely associated with the location of the mean sea surface. The reference ellipsoid is a bi-axial ellipsoid of revolution. The center of the ellipsoid is ideally at the center of mass of the Earth although the center is usually placed at the origin of the reference frame in which a satellite orbit is calculated and tracking station positions given. The separation between the geoid and the reference ellipsoid is the geoid undulation (see geoid parameter).

The geoid undulation, over the entire Earth, has a root mean square value of 30.6m with extreme values of approximately 83m and -106m. Although the geoid undulations are primarily long wavelength phenomena, short wavelength changes in the geoid undulation are seen over seamounts, trenches, ridges, etc., in the oceans. The calculation of a high resolution geoid requires high resolution surface gravity data in the region of interest as well as a potential coefficient model that can be used to define the long and medium wavelengths of the Earth's gravitational field. Surface gravity data are generally only available in certain regions of the Earth and spherical harmonic expansions of the Earth's gravitational potential are usually used to define the geoid globally. Currently, such expansions are available to degree 360 and in some cases higher.

For ocean circulation studies, it is important that the long wavelength part of the geoid be accurately determined. New geopotential models have become available that are an improvement over the JGM3 and OSU91A models (JGM3 is described in *Tapley et al.*, 1994; OSU91A is described in *Rapp et al.*, 1991.) In particular, the JASON-1 (I)GDR adopts the EGM96 geopotential to compute the geoid [*Lemoine et al.*, 1998]. The EGM96 geopotential model has been used to calculate point values of geoid undulation on a 0.25 x 0.25 degree grid that spans the latitude range +85.0 deg. to -85.0 deg. The EGM96 model is complete to spherical harmonic degree and order 360, and has been corrected appropriately so as to refer to the mean tide system as far as the permanent tide is concerned [*Rapp et al.*, 1991]. The k_2 Love number used in this conversion was 0.3. The geoid undulations are given with respect to an ideal geocentric mean Earth ellipsoid, whose semi-major axis remains undefined (i.e., there is no zero-degree term in the spherical harmonic series of these geoid undulations). The flattening of this reference ellipsoid is f=1/298.257 so that values are consistent with constants adopted for T/P.

Since the geoid undulations have been computed from an expansion to degree 360, the resolution of the undulations will be on the order of 50km. Data used to derived the EGM96 model include surface gravity data from different regions of the globe, altimeter derived gravity anomalies from the GEOSAT Geodetic Mission, altimeter derived anomalies from ERS-1, direct satellite altimetry from T/P, ERS-1 and GEOSAT, and satellite tracking to over 20 satellites using satellite laser ranging, GPS, DORIS, the Tracking and Data Relay Satellite System (TDRSS), and TRANET.

More information on EGM96 can be found at http://cddisa.gsfc.nasa.gov/926/egm96/egm96.html

4.4. Mean Sea Surface

A Mean Sea Surface (mss) represents the position of the ocean surface averaged over an appropriate time period to remove annual, semi-annual, seasonal, and spurious sea surface height signals. A MSS is given as a grid with spacing consistent with the altimeter and other data used in the generation of the grid values. The MSS grid can be useful for data editing purposes; for the calculation of along track and cross track geoid gradients; for the calculation of gridded gravity anomalies, for geophysical studies; for a reference surface to which sea surface height data from different altimeter missions can be reduced, etc. The JASON-1 (I)GDR provides for two models of the MSS (see parameters mss and mss_tp_along_trk). The first is a global MSS model that is generated from multiple satellite altimetry missions, and the second is a model specifically generated along the T/P ground track.

Longer time spans of data that become available in the future, along with improved data handling techniques could improve the current MSS models. Care must be given to the retention of high frequency signal and the reduction of high frequency noise.

4.4.1. GSFC00.1

The GSFC00.1 MSS model is computed from satellite altimetry data from a variety of missions. These include, 6 years of T/P data (Cycles 11 to 232), multi-years of ERS-1/2 35 day repeat cycle data (ERS-1 Phase C: Cycles 1 to 18, Phase G: Cycles 1 to 13; ERS-2: Cycles 1 to 29)], GEOSAT GM and ERM data, and ERS-1 168 day data. The model is computed on a 2' grid oceanwide between the latitudes of ±80 degrees. The 2' grid of the GSFC00.1 model is interpolated to provide the mean sea surface (see parameter mss) at the location of each altimeter measurement, and an interpolation quality flag (see parameter interp_flag) indicates the quality of this interpolation. Note that a static inverse barometer correction reference to a constant mean pressure of 1013.3 mbar was applied to the sea surface height data that contributed to the original GSFC00.1 MSS model. However, a global mean pressure of 1010.9 mbar is more consistent with the inverse barometer correction that is provided on the JASON-1 (I)GDR. For this reason the JASON-1 (I)GDR provide values from a modified GSFC00.1 model that has a bias of 23.9 mm added to it (see section 4.9). The model provides the mean sea surface height reference to the reference ellipsoid. Refer to http://magus.stx.com/mssh/mssh.html for more details on the original GSFC00.1 model.

4.4.2. Along-Track MSS Model

The JASON-1 (I)GDR provide a parameter for a MSS model that is specifically generated along the T/P ground track (see parameter mss_tp_along_trk). At present, no specific model has been chosen for this parameter and it is therefore set to a default value.

4.5. Geophysical Corrections

The atmosphere and ionosphere slow the velocity of radio pulses at a rate proportional to the total mass of the atmosphere, the mass of water vapor in the atmosphere, and the number of free electrons in the ionosphere. In addition, radio pulses do not reflect from the mean sea level but from a level that depends on wave height and wind speed. The errors due to these processes cannot be ignored and must be removed. Discussions of these effects are given in *Chelton et al.* [2001].

4.5.1. Troposphere (dry and wet)

The propagation velocity of a radio pulse is slowed by the "dry" gasses and the quantity of water vapor in the Earth's troposphere. The "dry" gas contribution is nearly constant and produces height errors of approximately -2.3 m. The water vapor in the troposphere is quite variable and unpredictable and produces a height calculation error of -6cm to -40cm. However, these effects can be measured or modeled as discussed below.

The gases in the troposphere contribute to the index of refraction. In detail, the refractive index depends on pressure and temperature. When hydrostatic equilibrium and the ideal gas law are assumed, the vertically integrated range delay is a function only of the surface pressure, see *Chelton et al.* [2001]. The dry meteorological tropospheric range correction is principally equal to the surface pressure multiplied by -2.277mm/mbar, with a small adjustment also necessary to reflect a small latitude dependence (see model_dry_tropo_corr parameter).

model_dry_tropo_corr = -2.277*P_{atm}*(1 + 0.0026 * cos(2*phi))

where P_{atm} is surface atmospheric pressure in mbar, phi is latitude, and model_dry_tropo_corr is the dry troposphere correction in mm. There is no straightforward way of measuring the nadir surface pressure from a satellite, so it is determined from model assimilated weather data from the European Center for Medium Range Weather Forecasting (ECMWF). The uncertainty of the ECMWF atmospheric pressure products is somewhat dependent on location. Typical errors vary from 1 mbar in the northern Atlantic Ocean to a few mbars in the southern Pacific Ocean. A 1-mbar error in pressure translates into a 2.3 mm error in the dry tropospheric correction.

The amount of water vapor present along the path length contributes to the index of refraction of the Earth's atmosphere. Its contribution to the delay of the radio pulse, the wet tropospheric delay, can be estimated by measuring the atmospheric brightness near the water vapor line at 22.2356 GHz and providing suitable removal of the background. The Jason-1 Microwave Radiometer (JMR) measures the brightness temperatures in the nadir path at 18.7, 23.8 and 34.0 GHz: the water vapor signal is sensed by the 23.8 GHz channel, while the 18.7 GHz channel removes the surface emission (wind speed influence), and the 34 GHz channel removes other atmospheric contributions (cloud cover influence) [*Keihm et al.*, 1995]. Measurements are combined to obtain the error in the satellite range measurement due to the water vapor effect (see rad_wet_tropo_corr parameter). The uncertainty is less than 1.2 cm RMS [e.g. *Cruz Pol et al.*, 1998 and *Ruf et al.*, 1994].

The ECMWF meteorological model also calculates a value of the wet tropospheric delay, and an interpolated value from this model is also provided on the (I)GDR as a backup to the measurement from the JMR (see model_wet_tropo_corr). This backup will prove useful when sun glint, land contamination, or anomalous sensor behavior makes the JMR measurement of the wet tropospheric delay unusable.

The ECMWF meteorological fields are interpolated to provide the model dry and wet tropospheric corrections at the time and location of the altimeter measurement (see model_dry_tropo_corr and model_wet_tropo_corr) and an interpolation quality flag is provided on the (I)GDR to indicate the quality of this interpolation (see interp_flag).

4.5.2. Ionosphere

At the frequencies used by the POSEIDON-2 altimeter, the propagation velocity of a radio pulse is slowed by an amount proportional to the density of free electrons of the Earth's ionosphere, also known as the total electron content (TEC). The retardation of velocity is inversely proportional to frequency squared. For instance, it causes the altimeter to slightly over-estimate the range to the sea surface by typically 0.2 to 20 cm at 13.6 GHz. The amount varies from day to night (very few free electrons at night), from summer to winter, and as a function of the solar cycle (fewer during solar minimum.) (For treatments of this correction, see *Chelton et al.* [2001], *Imel* [1994], and *Callahan* [1984]. Also, see Sec 3.8 on smoothing the ionospheric correction.)

Because this effect is dispersive, measurement of the range at two frequencies allows it to be estimated. Under typical ocean conditions of 2-meter significant wave height the Ku band ionospheric range correction that is determined from the dual frequency measurements from the altimeter is expected to have an accuracy of ±0.5 cm (see iono_corr_alt_ku parameter).

The ionospheric path delay can also be inferred from dual-frequency DORIS measurements but with much less accuracy owing to the time-space interpolation required of the DORIS observations to obtain a nadir measurement. The DORIS ionospheric path delay correction provided on the JASON-1 GDR (see iono_corr_doris_ku) is considered to be a backup to the nominal dual frequency altimeter measurement, and has an accuracy of 2 cm (see iono_corr_doris_ku parameter). The average of the difference between the ionospheric path delays from the TOPEX altimeter and DORIS is nearly 1 to 2 cm with an rms of 1 to 3 cm (depending on the local time of the cycle.) While this rms difference is small viewed globally, there are large differences in some regions. The main areas are the western Pacific due to lack of DORIS coverage and the equatorial Atlantic due to insufficient geomagnetic modeling. The subsolar point is another area of discrepancy due to the peak of the electron content.

Note that the DORIS ionospheric path delay is set to default value on the IGDR (not available in near real time processing).

4.5.3. Ocean Waves (sea state bias)

Unlike the preceding effects, sea-state effects are an intrinsic property of the large footprint radar measurements. The surface scattering elements do not contribute equally to the radar return; troughs of waves tend to reflect altimeter pulses better than do crests. Thus the centroid of the mean reflecting surface is shifted away from mean sea level towards the troughs of the waves. The shift, referred to as the electromagnetic (EM) bias, causes the altimeter to overestimate the range (see *Rodriguez et al.*, [1992]). In addition, a skewness bias also exists from the assumption in the onboard algorithms that the probability density function of heights is symmetric, while in reality it is skewed. Finally, there is a tracker bias, which is a purely instrumental effect. The sum of EM bias, skewness bias, and tracker bias is called 'sea state bias' (see sea_state_bias_ku and sea_state_bias_c parameters.)

The accuracy of sea state bias models remains limited and continues to be a topic of research. The current most accurate estimates are obtained using empirical models derived from analyses of the altimeter data. Based on the results of *Gaspar et al.* [1994 and 1996] and others, the initial algorithms for JASON-1 compute the sea state bias from a bilinear interpolation of a table of sea state biases versus significant wave height and wind speed, based on new parametric fits by Labroue [2002]. This version of the sea state bias model was empirically derived using data from cycles 19 to 30 of the Jason-1 mission. For a typical significant wave height (SWH) of 2 meters, the error in the sea state bias correction is approximately 1-2 cm, i.e., 0.5 to 1.0% of the effect. Because of the general paucity of data, the empirical model is not defined in some SWH-wind speed regimes, and the sea state biases in these regimes are returned as default values..

In addition to the Ku and C band sea state bias corrections [sea_state_bias_ku and sea_state_bias_c], the JASON-1 (I)GDRs also provide a composite sea state bias correction parameter. The use of a composite sea state bias introduces a formulation for the sea surface height that is independent of the ionospheric correction. The classical equation for retrieving altimetric sea surface heights (ignoring frequency independent effects) is:

SSH = H - [R_Ku + SSB_Ku + Iono_Alt_Ku] (1)

where H, R_Ku, SSB_Ku, and Iono_Alt_Ku, are the satellite orbit, the Ku-band range measurement, sea state bias correction and ionospheric correction, respectively. However, the ionospheric correction is computed from the differences between the Ku and C band ranges after being corrected for sea state bias effects:

Iono_Alt_Ku = Delta_f_Ku*[(R_Ku + SSB_Ku) - (R_C + SSB_C)] (2)

where

Delta_f_Ku = (f_C*f_C)/((f_Ku*f_Ku) - (f_C*f_C)) (3)

Inserting (2) into (1) provides for an alternative formulation of the sea surface height that is independent of the ionospheric correction (again, ignoring frequency independent effects):

SSH = H - [(1 + Delta_f_Ku)*R_Ku + Delta_f_Ku*R_C + SSB_comp] (4)

where

SSB_Comp = [(1 + Delta_f_Ku)*SSB_Ku - Delta_f_Ku*SSB_C] (5)

Equation (4) then provides an alternative formulation of the sea surface height that is independent of the ionospheric correction, but dependent on a composite sea state bias, SSB_Comp. Equation (1) makes use of an ionospheric correction, and the computation of the ionospheric correction implies knowledge of the Ku and C band sea state biases. However, the Ku and C band sea state biases are usually determined from sea surface height crossover techniques and therefore themselves dependent on the ionospheric correction. The advantage of using equation (4) is that it makes use of a single sea state bias, the composite sea state bias, that can also be determined from classical crossover minimization techniques but without any dependence on the ionospheric correction. Both equations (2) (and therefore equation (1)) and (4) make use of noisy C-band measurements.

4.6. Rain Flag

Liquid water along the pulse's path reduces the energy returned to the altimeter, mainly at Ku band. In heavy rain, there are competing effects from attenuation and surface changes. The small-scale nature of rain cells tends to produce rapid changes in the strength of the echo as the altimeter crosses rain cells. Both effects degrade the performance of the altimeter. Data contaminated by rain should be rare (most are located in the west equatorial pacific) and are consequently tagged and ignored (see rain_flag parameter).

The rain flag on the JASON-1 (I)GDR is set if integrated liquid water content measured by the JMR is larger than a specified threshold, AND if the difference between the measured Ku backscatter coefficient and an expected Ku backscatter coefficient, estimated from the C-band backscatter which is much less affected by rain, is larger than either a specified threshold or a specified multiple of the uncertainty in the expected backscatter coefficient [*Tournadre and Morland*, 1998].

4.7. Ice Flag

The range measurement from the altimeter is likely to have larger errors when the pulse is reflected off ice surfaces. Of course, the ice surface is not at sea level, but some unknown distance above it. For this reason the JASON-1 (I)GDR provides an ice flag (see ice_flag parameter) to indicate when the data point is likely to be over ice. The ice flag is set if a climatological map predicts ice at the given location, and if the wind speed derived from the altimeter measurement is less than 1 m/s, i.e., the backscatter is larger than normally expected from the ocean.

4.8. Tides

Tides are obviously a significant contributor to the observed sea surface height [*LeProvost*, 2001]. While they are of interest in themselves, they have more variation than all other time-varying ocean signals. Since they are highly predictable, they are removed from the data in order to study ocean circulation. The T/P orbit was specifically selected (inclination and altitude) so that diurnal and semidiurnal tides would not be aliased to low frequencies.

There are several contributions to the tidal effect: the ocean tide, the load tide, the solid earth tide and the pole tide. The ocean tide, load tide and solid earth tide are all related to luni-solar forcing of the earth, either directly as is the case of the ocean and solid earth tide, or indirectly as is the case with the load tide since it is forced by the ocean tide. The pole tide is due to variations in the earth's rotation and is unrelated to luni-solar forcing.

JASON-1 (I)GDRs do not explicitly provide values for the pure ocean tide, but instead provide values for a quantity referred to as the geocentric ocean tide, which is the sum total of the ocean tide and the load tide. Values of the load tide that were used to compute the geocentric ocean tide are also explicitly provided, so the pure ocean tide can be determined by subtracting the load tide value from the geocentric ocean tide value. Note that the permanent tide is not included in either the geocentric ocean tide or solid earth tide corrections that are provided on the JASON-1 (I)GDR.

4.8.1. Geocentric Ocean Tide

As mentioned above, the geocentric ocean tide is a quantity sometimes used to refer to the sum total of the ocean tide and the load tide. The JASON-1 (I)GDR provides two choices for the geocentric ocean tide, each of which is computed as the sum total of the diurnal and semidiurnal ocean and load tides as predicted by a particular model, and an equilibrium representation of the long-period ocean tides at all periods except for the zero frequency (constant) term. The two geocentric tide values provided on the JASON-1 (I)GDR, ocean_tide_sol1 and ocean_tide_sol2, are computed with diurnal and semidiurnal ocean and load tide values predicted by the GOT99.2 and FES99 models, respectively. Similarly, the two load tide values provided on the JASON-1 (I)GDR, load_tide_sol1 and load_tide_sol2, provide the load tide values predicted by the GOT99.2 and FES99 models, respectively.

Both models are interpolated to provide the geocentric ocean and load tides at the location of the altimeter measurement, and an interpolation quality flag is provided on the (I)GDRs to indicate the quality of this interpolation (see interp_flag.)

GOT99.2 Ocean Tide Model

The GOT99.2 model is an empirical model of the diurnal and semidiurnal ocean tides (see ocean_tide_sol1). This model was developed by R.D. Ray at the Goddard Space Flight Center, [*Ray*, 1999]. The model is based on over six years (232 repeat cycles) of sea surface height measurements by the T/P satellite altimeter. The model benefits from the use of prior hydrodynamic models, several in shallow and inland seas, as well as the global finite-element model FES94.1 [*Le Provost et al.*, 1994]. The GOT99.2 model is based on the least squares harmonic analysis of the T/P sea surface height data that estimates coefficients for the Q1, O1, P1, K1, N2, M2, S2, and K2 tidal constituents (among others), and accounts for nodal modulations of all lunar tides. The GOT99.2 model coefficients have been estimated from sea surface heights that have applied an inverse barometer correction that is based on daily means of the atmospheric pressure, rather than the 6 hourly fields that are typically used to determine the dry troposphere correction on the T/P data products. Daily means of the atmospheric pressure eliminate atmospheric loading effects on the ocean at the S1 and S2 frequencies from the applied inverse barometer correction. In doing so, the S1 and S2 tides predicted by the GOT99.2 model actually include this atmospheric loading effect on the oceans.

FES99 Ocean Tide Model

The FES99 model is a finite-element hydrodynamic model, constrained with tide gage and past altimeter data [*Le Provost*, 2001] (see ocean_tide_sol2.)

It is based on the resolution of the tidal barotropic equations on a global finite element grid without any open boundary condition, which leads to solutions independent of in situ data (no open boundary conditions and no data assimilation). The accuracy of the 'free' solutions was improved by assimilating tide gauge and TOPEX/Poseidon (T/P) altimeter information through a revised representer assimilation method. A careful selection of in situ tide gauge data from different data banks allowed to build a collection of about 700 data values for each of the eight computed waves (M2, S2, N2, K2, 2N2, K1, O1 and Q1). These data were assimilated to produce the FES98 version, which is independent of altimetry. To improve FES98 in deep ocean, T/P data were also assimilated. For the eight main constituents of the tidal spectrum (M2, S2, N2, K2, 2N2, K1, O1, and Q1), approximately 700 tide gauges and 687 T/P altimetric crossover data sets harmonically analysed, were assimilated. An original algorithm was developed to calculate the tidal harmonic constituents at crossover points of the T/P altimeter database. Additional work was performed for the S2 wave by reconsidering the inverted barometer correction. 19 minor constituents have also been added by admittance as well as 3 long period constituents to complete the spectrum. They are both distributed on a 0.25ƒx0.25ƒ grid interpolated from the full finite element solutions.

4.8.2. Long period Ocean Tide

The long-period ocean tides are a subject of continuing investigation. To first order, they can be approximated by an equilibrium representation. However, the true long-period ocean tide response is thought to have departures from an equilibrium response that increase with decreasing period. The two principal long-period ocean tide components Mf and Mm, with fortnightly and monthly periods respectively, are known to have departures from an equilibrium response with magnitudes less than 1-2 cm.

The JASON-1 (I)GDR explicitly provides a value for an equilibrium representation of the long-period ocean tide that includes all long-period tidal components excluding the permanent tide (zero frequency) component (see parameter ocean_tide_equil). Note that both geocentric ocean tide values on the (I)GDR (ocean_tide_sol1 and ocean_tide_sol2) already include the equilibrium long-period ocean tide and should therefore not be used simultaneously.

The JASON-1 (I)GDR provide a parameter for a non-equilibrium representation of the long-period ocean tides (see parameter ocean_tide_neq_lp). At present, no specific model has been chosen for this parameter and it is therefore set to a default value. Solid Earth Tide

The solid Earth responds to external gravitational forces similarly to the oceans. The response of the Earth is fast enough that it can be considered to be in equilibrium with the tide generating forces. Then, the surface is parallel with the equipotential surface, and the tide height is proportional to the potential. The two proportionality constants are the so-called Love numbers. It should be noted that the Love numbers are largely frequency independent, an exception occurs near a frequency corresponding to the K1 tide constituents due to a resonance in the liquid core [*Wahr*, 1985 and *Stacey*, 1977].

The JASON-1 (I)GDR computes the solid earth tide, or body tide, as a purely radial elastic response of the solid Earth to the tidal potential (see parameter solid_earth_tide.) The adopted tidal potential is the *Cartwright and Tayler* [1971] and *Cartwright and Edden* [1973] tidal potential extrapolated to the 2000 era, and includes degree 2 and 3 coefficients of the tidal potential. The permanent tide (zero frequency) term is excluded from the tidal potential that is used to compute the solid earth tide parameter for the JASON-1 (I)GDR. The elastic response is modeled using frequency independent Love numbers. The effects of the resonance in the core is accounted for by scaling the tide potential amplitude of the K1 tidal coefficient and some neighboring nodal terms by an appropriate scale factor.

4.8.3. Pole Tide

The pole tide is a tide-like motion of the ocean surface that is a response of both the solid Earth and the oceans to the centrifugal potential that is generated by small perturbations to the Earth's rotation axis. These perturbations primarily occur at periods of 433 days (called the Chandler wobble) and annual. These periods are long enough for the pole tide displacement to be considered to be in equilibrium with the forcing centrifugal potential. The JASON-1 (I)GDR provides a single field for the radial geocentric pole tide displacement of the ocean surface (see pole_tide parameter), and includes the radial pole tide displacement of the solid Earth and the oceans.

The pole tide is easily computed as described in *Wahr* [1985]. Modeling the pole tide requires knowledge of proportionality constants, the so-called Love numbers, and a time series of perturbations to the Earth's rotation axis, a quantity that is now measured routinely with space techniques. Note that the pole tide on the IGDR and GDR may differ, since the pole tide on the GDR is computed with a more accurate time series of the Earth's rotation axis.

4.9. Inverse Barometer Effect

As atmospheric pressure increases and decreases, the sea surface tends to respond hydrostatically, falling or rising respectively. Generally, a 1-mbar increase in atmospheric pressure depresses the sea surface by about 1 cm. This effect is referred to as the inverse barometer (IB) effect.

The instantaneous IB effect on sea surface height in millimeters (see parameter inv_bar_corr) is computed from the surface atmospheric pressure, P_{atm} in mbar:

$$inv\_bar\_corr = -9.948 * (P_{atm} - P)$$

where *P* is the time varying mean of the global surface atmospheric pressure over the oceans.

The scale factor 9.948 is based on the empirical value [*Wunsch*, 1972] of the IB at mid latitudes. Some researchers use other values. Note that surface atmospheric pressure is also proportional to the dry tropospheric correction, and so the parameter inv_bar_corr approximately changes by 4 to 5 mm as model_dry_tropo_corr changes by 1 mm (assuming a constant mean global surface pressure). The uncertainty of the ECMWF atmospheric pressure products is somewhat dependent on location. Typical errors vary from 1 mbar in the northern Atlantic Ocean to a few mbars in the southern Pacific Ocean. A 1-mbar error in pressure translates into a 10 mm error in the computation of the IB effect.

Note that the time varying mean global pressure over the oceans, P, during the first eight years of the T/P mission had a mean value of approximately 1010.9 mbar, with an annual variation about this mean of approximately 0.6 mbar. However, the T/P data products provided a static inverse barometer correction referenced to a constant mean pressure of 1013.3 mbar.

IB(T/P) = -9.948*(P_atm - 1013.3)

Sea surface heights that are generated after applying an inverse barometer correction referenced to a mean pressure of 1013.3 mbar are therefore approximately -9.948*(1010.9-1013.3) = 23.9 mm lower than those that are generated after applying an inverse barometer correction referenced to a time varying global mean pressure, and the difference between the two sea surface heights has an annual variation of approximately 9.948*0.6 = 6 mm.

4.9.1. Barotropic/Baroclinic Response to Atmospheric Forcing

The High Frequency Wind and Pressure Response correction complements the Inverted Barometer (IB) correction. Like both tides and IB, the ocean response to wind and pressure (after removing the IB part) has energy at periods shorter than the 20 day implied by the ~10 day repeat cycle of JASON-1. This correction can be thought of as a departure from the IB response to pressure, although strictly it is the difference between the response to wind and pressure minus the IB. "*Ali and Zlotnicki* [2000] compute this response with a barotropic model that is forced by NCEP operational wind and pressure. The model output is filtered in time to pass frequencies shorter than 20 days. See also *Stammer et al.* [1999] and *Tierney et al.* [2000]."

At present, no specific model has been chosen for this parameter and it is set to a default value.

4.10. Sigma 0

The backscatter coefficients, sigma0 Ku and C values (see parameters sig0_ku and sig0_c), reported on the (I)GDR are corrected for atmospheric attenuation using atmos_sig0_corr_ku and atmos_sig0_corr_c (see Sec 7). Note that "unbiased" sigma0 values are recorded on the Jason-1 data products. A bias of approximately -2.26 dB in the Ku band and –0.28 dB in the C band has been applied to the provided sigma0 for any geophysical algorithms that require use of sigma0. These biases have been determined from comparisons to sigma0 from the Topex altimeter.

4.11. Wind Speed

The model functions developed to date for altimeter wind speed have all been purely empirical. The model function establishes a relation between the wind speed, and the sea surface backscatter coefficient and significant wave height. A wind speed is calculated through a mathematical relationship with the Ku-band backscatter coefficient and the significant wave height (see wind_speed_alt) using the Vandemark and Chapron algorithm. The wind speed model function is evaluated for 10 meter above the sea surface, and is considered to be accurate to 2 m/s.

A wind speed is also computed through an empirical relationship to brightness temperatures measured by the JMR [*Keihm et al.*, 1995] (see wind_speed_rad). The coefficients of this relationship have been determined from the regression of island radiosonde data computations combined with seasonal and latitude dependent wind speed statistics.

Finally, a 10-meter (above surface) wind vector (in east-west and north-south directions) is also provided on the JASON-1 (I)GDR (see parameters wind_speed_model_u and wind_speed_model_v). This wind speed vector is determined from an interpolation of the

ECMWF meteorological model. The best accuracy for the wind vector varies from about 2 m/s in magnitude and 20 degrees in direction in the northern Atlantic Ocean, to more then 5 m/s and 40 degrees in the southern Pacific Ocean.

NOTE: The QuikSCAT and NSCAT scatterometer winds are calculated at 10 m. ERS-1/2 scatterometer winds are reported at 19.5 m.

4.12. Bathymetry Information

The JASON-1 (I)GDR provides a parameter bathymetry that gives the ocean depth or land elevation of the data point. Ocean depths have negative values, and land elevations have positive values. This parameter is given to allow users to make their own "cut" for ocean depth. The value of the parameter is determined from the DTM2000.1 model from N. Pavlis and J. Saleh [personal communication, 2000] of the Raytheon ITSS/Goddard Space Flight Center. The model is provided globally with a 2' resolution. The heritage of DTM2000.1 goes back to the OSUJAN98 database [*Pavlis and Rapp*, 1990] and the JGP95E database [Chapter 2 of *Lemoine et al.*, 1998]. The bathymetric information in DTM2000.1 (originating from *Smith and Sandwell's* [1994] global sea floor topography) has significant differences with the ETOPO5 bathymetric model. The mean and standard deviation of these differences is 10 m and 270 m, respectively.

4.13. Sea Surface Height Bias Recommendation

The current estimate for the absolute bias in the Jason-1 sea-surface height measurements (SSH) is +131 ± 5 mm (formal error). This estimate is based on 50 overflights of three principal calibration sites: 1) Corsica Island [*Bonnefond et al.*, 2002], 2) Harvest oil platform off the coast of central California [*Haines et al.*, 2002], and 3) Bass Strait, Australia [*Watson et al.*, 2002]. The sense of this bias is such that SSH measurements formed from the Jason (I)GDR data are spuriously high. Users electing to correct for the bias, e.g., to better align Jason-1 and T/P data, should subtract 131 mm from the SSH measurements.

It should be noted that the bias reflects the combination of the mean errors from all of the corrections that are used to compute sea surface height. The bias provided above is intended for sea surface height measurements that are computed with the standard (I)GDR corrections.

5. (I)GDR general description

The (I)GDR is an offline geophysical product generated from operational and science telemetry from Poseidon-2, processed DORIS, GPS and laser data for the orbit, and telemetry from the JASON-1 Microwave Radiometer (JMR). Unlike the OSDR, the (I)GDR contains all environmental and geophysical corrections. Instrumental corrections have been applied to (I)GDR data. Furthermore dedicated ground retracking is performed on the waveforms to improve the accuracy of the product. The IGDR is a non-fully validated product which contains data for both bands (Ku and C) at a rate of 1 Hz and 20 Hz. It is structured in pass files (pole to pole structure).

The GDR is identical to the IGDR except for the following points :

- a more precise orbit is used
- improved pole location data are used
- DORIS ionospheric correction is included
- it is a fully validated product

We have so the following fields that are recomputed for the GDR :

- latitude (`latitude`)
- longitude (`longitude`)
- altitude (`altitude`, `orb_state_flag` and `alt_hi_rate`)
- orbital altitude rate (`orb_alt_rate`)
- net sum of the instrumental corrections (update of the Doppler correction) (`net_instr_corr_ku` and `net_instr_corr_c`)
- corrected ground retracked altimeter ranges (`range_ku` and `range_c`)
- altimeter ionospheric correction (`iono_corr_alt_ku`)
- DORIS ionospheric correction (`iono_corr_doris_ku`)
- pole tide height (`pole_tide`)

5.1. Fields presently not available on (I)GDR

Be aware that presently the following 3 fields are not calculated :

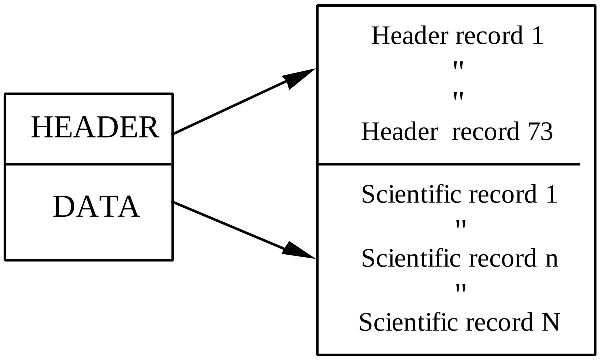
- High frequency fluctuations of the sea surface topography (`hf_fluctuations_corr`)
- Along-track mean sea surface (`mss_tp_along_trk`)

- Non-equilibrium ocean tide (`ocean_tide_neq_lp`)

The corresponding fields (number 71,75 and 80) are set to the default value.

5.2. Content

A pass-file contains a header (73 records) and 3360 scientific data records maximum. Whereas the header is recorded in ASCII type, the data part is recorded in a UNIX binary integer type. A scientific data record contains 96 fields, each stored as one, two or four bytes, or spare (1 byte).



5.3. Header description

The information included in the header are encoded in ASCII and follow the SFDU CCSDS rules. They cover the followings areas :

- generation of the product
- sensors
- processing information
- data flow of the product
- product confidence data
- reference of the auxiliary data used to generate the product

5.4. Data description

The information included in the data record cover the following areas :

- time tag
- location and surface type
- quality information and sensors status
- orbit
- altimeter range
- altimeter range corrections
- significant waveheight
- significant waveheight corrections
- backscatter coefficient
- backscatter coefficient corrections
- off nadir angle
- brightness temperatures
- geophysical parameters
- environmental parameters
- flags

Most of this information is provided at 1 Hz rates, while some parameters like orbit and altimeter range are also provided at 20 Hz rates.

6. HEADER ELEMENTS

Section 6.1 describes the format of the header elements and section 6.2 defines each element of the header in alphabetical order by the following characteristics :

Definition	Element definition
Element type	An element type can be bitfield, integer, real or a string.
Byte length	Size of elements in 8-bit bytes.
Storage type	A storage type can be signed (signed integer), unsigned (unsigned integer), bit (contiguous sequence of bits) or character (contiguous sequence of ASCII characters).
Unit	Unit of measure including scale factor, UTC[1] or none (/)
Field number	field number in the header part
Comment	Other comment if any.

When an item can not be filled, there is N/A which stands for not applicable.

[1] Any time variable recorded in CCSDS headers has UTC2 format as defined in section 1.3.5.

6.1. Header overview

The header is composed of 73 records which are described in the table below. Generally, each record is constituted by :

- one keyword followed by a Separator (if any)
- the value of the fields (if any)
- followed by a semicolon and a newline (if any)

In the table below :

- **“offset”** is the offset in bytes to access directly to the record
- **“total bytes**” is the total length of the record expressed in bytes
- **“Keyword_format”** is the format of the keyword (string) including the separator
- **“Keyword_content”** is the value of the keyword set on the GDR
- **“Keyword_separator”** is the value of the separator (set to “none” if not used)
- **Value_format** is the format of the field (string, set to “none” if not used)
- **Semicolon** is a semicolon character (if set to “y” in the table otherwise set to "n")
- **Newline** is a newline character (if set to “y” in the table otherwise set to "n")

Below is an example of the first 18 lines of the header:

CCSD3ZF0000100000001CCSD3VS00006PRODUCER
Product_File_Name = JA1_GDR_2PDP001_070.CNES;
Producer_Agency_Name = CNES;
Processing_Center = SSALTO;
File_Data_Type = GDR ;
Reference_Document = SMM-ST-M-EA-10879-CN Issue 3.1;
Reference_Software = cma V3.0;
Operating_System = SunOS 5.7;
Product_Creation_Time = 2000-05-11T13:33:57.000000;
CCSD$$MARKERPRODUCERCCSD3KS00006PASSFILE
Mission_Name = Jason-1;
Altimeter_Sensor_Name = POSEIDON-2;
Radiometer_Sensor_Name = JMR;
DORIS_Sensor_Name = DORIS-2 GM;
Acquisition_Station_Name = Kiruna;
Cycle_Number = 1;
Absolute_Revolution_Number = 35;
Pass_Number = 70;

Field number	Offset	Total bytes	Keyword Format	Keyword Content	Keyword Separator	Value Format	Units	Semicolon	NewLine
1	0	20	Char*20	CCSD3ZF0000100000001	"none"	"none"	Char*0 : /	n	n
2	20	21	Char*20	CCSD3VS00006PRODUCER	"none"	"none"	Char*0 : /	n	y
3	41	62	Char*20	Product_File_Name	" = "	Char*40	Char*0 : /	y	y
4	103	29	Char*23	Producer_Agency_Name	" = "	Char*4	Char*0 : /	y	y
5	132	28	Char*20	Processing_Center	" = "	Char*6	Char*0 : /	y	y
6	160	23	Char*17	File_Data_Type	" = "	Char*4	Char*0 : /	y	y
7	183	73	Char*21	Reference_Document	" = "	Char*50	Char*0 : /	y	y
8	256	43	Char*21	Reference_Software	" = "	Char*20	Char*0 : /	y	y
9	299	41	Char*19	Operating_System	" = "	Char*20	Char*0 : /	y	y
10	340	52	Char*24	Product_Creation_Time	" = "	Char*26	Char*0 : /	y	y
11	392	20	Char*20	CCSD$$MARKERPRODUCER	"none"	"none"	Char*0 : /	n	n
12	412	21	Char*20	CCSD3KS00006PASSFILE	"none"	"none"	Char*0 : /	n	y
13	433	24	Char*15	Mission_Name	" = "	Char*7	Char*0 : /	y	y
14	457	36	Char*24	Altimeter_Sensor_Name	" = "	Char*10	Char*0 : /	y	y
15	493	30	Char*25	Radiometer_Sensor_Name	" = "	Char*3	Char*0 : /	y	y
16	523	32	Char*20	DORIS_Sensor_Name	" = "	Char*10	Char*0 : /	y	y
17	555	49	Char*27	Acquisition_Station_Name	" = "	Char*20	Char*0 : /	y	y
18	604	22	Char*15	Cycle_Number	" = "	Char*5	Char*0 : /	y	y
19	626	36	Char*29	Absolute_Revolution_Number	" = "	Char*5	Char*0 : /	y	y
20	662	19	Char*14	Pass_Number	" = "	Char*3	Char*0 : /	y	y
21	681	30	Char*23	Absolute_Pass_Number	" = "	Char*5	Char*0 : /	y	y
22	711	43	Char*15	Equator_Time	" = "	Char*26	Char*0 : /	y	y
23	754	34	Char*20	Equator_Longitude	" = "	Char*7	Char*5 : <deg>	y	y
24	788	53	Char*25	First_Measurement_Time	" = "	Char*26	Char*0 : /	y	y
25	841	52	Char*24	Last_Measurement_Time	" = "	Char*26	Char*0 : /	y	y
26	893	42	Char*29	First_Measurement_Latitude	" = "	Char*6	Char*5 : <deg>	y	y
27	935	41	Char*28	Last_Measurement_Latitude	" = "	Char*6	Char*5 : <deg>	y	y
28	976	44	Char*30	First_Measurement_Longitude	" = "	Char*7	Char*5 : <deg>	y	y
29	1020	43	Char*29	Last_Measurement_Longitude	" = "	Char*7	Char*5 : <deg>	y	y
30	1063	25	Char*18	Pass_Data_Count	" = "	Char*5	Char*0 : /	y	y
31	1088	31	Char*24	Ocean_Pass_Data_Count	" = "	Char*5	Char*0 : /	y	y
32	1119	20	Char*12	Ocean_PCD	" = "	Char*3	Char*3 : <%>	y	y
33	1139	41	Char*13	Time_Epoch	" = "	Char*26	Char*0 : /	y	y
34	1180	27	Char*21	TAI_UTC_Difference	" = "	Char*4	Char*0 : /	y	y
35	1207	50	Char*22	Time_Of_Leap_Second	" = "	Char*26	Char*0 : /	y	y
36	1257	39	Char*23	Time_Shift_Mid_Frame	" = "	Char*10	Char*4 : <us>	y	y
37	1296	38	Char*22	Time_Shift_Interval	" = "	Char*10	Char*4 : <us>	y	y
38	1334	25	Char*15	Range_Offset	" = "	Char*4	Char*4 : <km>	y	y
39	1359	32	Char*19	Average_Pressure	" = "	Char*5	Char*6 : <daPa>	y	y

Field number	Offset	Total bytes	Keyword Format	Keyword Content	Keyword Separator	Value Format	Units	Semicolon	NewLine
40	1391	205	Char*17	Header_Padding	" = "	Char*186	Char*0 : /	y	y
41	1596	20	Char*20	CCSD$$MARKERPASSFILE	"none"	"none"	Char*0 : /	n	n
42	1616	21	Char*20	CCSD3SS00006MEASFILE	"none"	"none"	Char*0 : /	n	y
43	1637	61	Char*19	Altimeter_Level1	" = "	Char*40	Char*0 : /	y	y
44	1698	62	Char*20	Radiometer_Level1	" = "	Char*40	Char*0 : /	y	y
45	1760	20	Char*20	CCSD$$MARKERMEASFILE	"none"	"none"	Char*0 : /	n	n
46	1780	21	Char*20	CCSD3SS00006AUXFILES	"none"	"none"	Char*0 : /	n	y
47	1801	93	Char*30	POSEIDON-2_Characterization	" = "	Char*61	Char*0 : /	y	y
48	1894	80	Char*17	POSEIDON-2_LTM	" = "	Char*61	Char*0 : /	y	y
49	1974	79	Char*16	JMR_Main_Beam	" = "	Char*61	Char*0 : /	y	y
50	2053	82	Char*19	JMR_BT_Averaging	" = "	Char*61	Char*0 : /	y	y
51	2135	79	Char*16	DORIS_TEC_Map	" = "	Char*61	Char*0 : /	y	y
52	2214	75	Char*12	DORIS_USO	" = "	Char*61	Char*0 : /	y	y
53	2289	76	Char*13	Orbit_Data	" = "	Char*61	Char*0 : /	y	y
54	2365	80	Char*17	PF_Corrections	" = "	Char*61	Char*0 : /	y	y
55	2445	79	Char*16	Pole_Location	" = "	Char*61	Char*0 : /	y	y
56	2524	35	Char*13	MTO_Fields	" = "	Char*20	Char*0 : /	y	y
57	2559	74	Char*11	ORF_Data	" = "	Char*61	Char*0 : /	y	y
58	2633	101	Char*38	POSEIDON-2_OB_RET_Correction_Tables	" = "	Char*61	Char*0 : /	y	y
59	2734	80	Char*17	POSEIDON-2_SSB	" = "	Char*61	Char*0 : /	y	y
60	2814	90	Char*27	POSEIDON-2_Composite_SSB	" = "	Char*61	Char*0 : /	y	y
61	2904	92	Char*29	JMR_Retrieval_Coefficients	" = "	Char*61	Char*0 : /	y	y
62	2996	83	Char*20	LAND_SEA_Mask_Map	" = "	Char*61	Char*0 : /	y	y
63	3079	41	Char*19	Ocean_Tide_Sol_1	" = "	Char*20	Char*0 : /	y	y
64	3120	41	Char*19	Ocean_Tide_Sol_2	" = "	Char*20	Char*0 : /	y	y
65	3161	44	Char*22	Tidal_loading_Sol_1	" = "	Char*20	Char*0 : /	y	y
66	3205	44	Char*22	Tidal_loading_Sol_2	" = "	Char*20	Char*0 : /	y	y
67	3249	82	Char*19	Solid_Earth_Tide	" = "	Char*61	Char*0 : /	y	y
68	3331	33	Char*11	NEQ_Tide	" = "	Char*20	Char*0 : /	y	y
69	3364	34	Char*12	Geoid_Map	" = "	Char*20	Char*0 : /	y	y
70	3398	32	Char*10	MSS_Map	" = "	Char*20	Char*0 : /	y	y
71	3430	50	Char*17	Bathymetry_Topography_Map	" = "	Char*28	Char*0 : /	y	y
72	3480	20	Char*20	CCSD$$MARKERAUXFILES	"none"	"none"	Char*0 : /	n	n
73	3500	20	char*20	FCST3IF0011400000001	"none"	"none"	Char*0 : /	n	n
	Total	**3520**	*						

6.2. Header content (alphabetical order)

Absolute_Pass_Number

Definition :	Absolute pass number i.e., pass number computed since beginning of cycle 1
Element type :	String
Byte length :	5
Storage type :	Character
Unit :	/
Field number :	21
Comment :	/

Absolute_Revolution_Number

Definition :	Absolute orbit number i.e., orbit number computed since beginning of cycle 1
Element type :	String
Byte length :	5
Storage type :	Character
Unit :	/
Field number :	19
Comment :	/

Acquisition_Station_Name

Definition :	Name of the station where the raw data have been acquired (directly derived from Level 1.0 product)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	17
Comment :	/

Altimeter_Level1

Definition :	Name of the altimeter Level 1.0 input file
Element type :	String
Byte length :	40
Storage type :	Character
Unit :	/
Field number :	43
Comment :	/

Altimeter_Sensor_Name

Definition :	POSEIDON-2
Element type :	String
Byte length :	10
Storage type :	Character
Unit :	/
Field number :	14
Comment :	/

Average_Pressure

Definition :	Average global pressure from meteorological fields over oceans (unit : 10 Pa) The nearest meteorological field to the first measurement of the pass is used to compute this average pressure
Element type :	String
Byte length :	5
Storage type :	Character
Unit :	<daPa>
Field number :	39
Comment :	/

Bathymetry_Topography_Map

Definition :	Name of the bathymetry/topography model (Currently DTM2000.1)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	71
Comment :	/

CCSD$$MARKERAUXFILES

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	72
Comment :	/

CCSD$$MARKERMEASFILE

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	45
Comment :	/

CCSD$$MARKERPASSFILE

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	41
Comment :	/

CCSD$$MARKERPRODUCER

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	11
Comment :	/

CCSD3KS00006PASSFILE

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	12
Comment :	/

CCSD3SS00006AUXFILES

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	46
Comment :	/

CCSD3SS00006MEASFILE

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	42
Comment :	/

CCSD3VS00006PRODUCER

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	2
Comment :	/

CCSD3ZF0000100000001

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	1
Comment :	**/**

Cycle_Number

Definition :	Cycle number. First Jason-1 cycle was on January, 15th 2002. Tools to convert from cycle and pass number to UTC date are available on PODAAC and AVISO web servers
Element type :	String
Byte length :	5
Storage type :	Character
Unit :	/
Field number :	18
Comment :	**/**

DORIS_Sensor_Name

Definition :	DORIS-2 GM
Element type :	String
Byte length :	10
Storage type :	Character
Unit :	/
Field number :	16
Comment :	**/**

DORIS_TEC_Map

Definition :	Name of the file containing the Total Electronic Content calculated from DORIS measurements.(Set to 61 blank characters if the file was not available or not used (e.g., for the IGDR) for the product generation)
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	51
Comment :	**/**

DORIS_USO

Definition :	Name of the file containing the on-board Doris frequency shift
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	52
Comment :	**/**

Equator_Longitude

Definition :	Longitude in degrees of equator crossing (format xxx.xx)
Element type :	String
Byte length :	7
Storage type :	Character
Unit :	<deg>
Field number :	23
Comment :	/

Equator_Time

Definition :	UTC date & time of equator crossing (CCSDS UTC2 format defined in paragraph 1.4.5)
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	22
Comment :	/

FCST3IF0011400000001

Definition :	/
Element type :	String
Byte length :	0
Storage type :	Character
Unit :	/
Field number :	73
Comment :	/

File_Data_Type

Definition :	Type of data (IGDR or GDR or SGDR)
Element type :	String
Byte length :	4
Storage type :	Character
Unit :	/
Field number :	6
Comment :	/

First_Measurement_Latitude

Definition :	Latitude in degrees of first measurement in the product (format +xx.xx or -xx.xx)
Element type :	String
Byte length :	6
Storage type :	Character
Unit :	<deg>
Field number :	26
Comment :	/

First_Measurement_Longitude

Definition :	Longitude in degrees of first measurement in the product (format xxx.xx)
Element type :	String
Byte length :	7
Storage type :	Character
Unit :	<deg>
Field number :	28
Comment :	/

First_Measurement_Time

Definition :	UTC date & time of first measurement in the product (CCSDS UTC2 format defined in paragraph 1.4.5)
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	24
Comment :	/

Geoid_Map

Definition :	Name of the geoid model (currently EGM96)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	69
Comment :	/

Header_Padding

Definition :	Blank characters added to force header size to be a multiple of data record length
Element type :	String
Byte length :	186
Storage type :	Character
Unit :	/
Field number :	40
Comment :	/

JMR_BT_Averaging

Definition :	Name of the file containing the characterization data for the JMR radiometer used to compute the along track average brightness temperatures
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	50
Comment :	/

JMR_Main_Beam

Definition : Name of the file containing the characterization data for the JMR radiometer, used to compute the brightness temperatures from the antenna temperatures

Element type : String
Byte length : 61
Storage type : Character
Unit : /
Field number : 49
Comment : /

JMR_Retrieval_Coefficients

Definition : Name of the file containing the geophysical coefficient for the JMR used to compute the geophysical parameters from the brightness temperatures
Element type : String
Byte length : 61
Storage type : Character
Unit : /
Field number : 61
Comment : /

LAND_SEA_Mask_Map

Definition : Name of the file containing the Land/Sea mask map
Element type : String
Byte length : 61
Storage type : Character
Unit : /
Field number : 62
Comment : /

Last_Measurement_Latitude

Definition : Latitude in degrees of last measurement in the product (format +xx.xx or -xx.xx)
Element type : String
Byte length : 6
Storage type : Character
Unit : <deg>
Field number : 27
Comment : /

Last_Measurement_Longitude

Definition : Longitude in degrees of last measurement in the product (format xxx.xx)
Element type : String
Byte length : 7
Storage type : Character
Unit : <deg>
Field number : 29
Comment : /

Last_Measurement_Time

Definition :	UTC date & time of last measurement in the product (CCSDS UTC2 format defined in paragraph 1.4.5)
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	25
Comment :	/

Mission_Name

Definition :	Jason-1
Element type :	String
Byte length :	7
Storage type :	Character
Unit :	/
Field number :	13
Comment :	/

MSS_Map

Definition :	Name of the Mean Sea Surface model (currently GSFC00.1)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	70
Comment :	/

MTO_Fields

Definition :	Name of the MTO model from which meteorological parameters have been derived (Currently ECMWF_T511)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	56
Comment :	/

NEQ_Tide

Definition :	Name of the dynamic model for long period tides (currently NONE)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	68
Comment :	/

Ocean_Pass_Data_Count

Definition : Number of 1 Hz measurements over ocean in the product
Element type : String
Byte length : 5
Storage type : Character
Unit : /
Field number : 31
Comment : /

Ocean_PCD

Definition : Product confidence data in percentage (ratio of the altimeter data declared OK to the total number of ocean measurements where data integrity is determined using the quality flag for the 1 Hz altimeter data (altimeter + radiometer + environmental parameters)
Element type : String
Byte length : 3
Storage type : Character
Unit : <%>
Field number : 32
Comment : /

Ocean_Tide_Sol_1

Definition : Name of the ocean tide model #1 (currently GOT99)
Element type : String
Byte length : 20
Storage type : Character
Unit : /
Field number : 63
Comment : /

Ocean_Tide_Sol_2

Definition : Name of the ocean tide model #2 (currently FES99)
Element type : String
Byte length : 20
Storage type : Character
Unit : /
Field number : 64
Comment : /

Operating_System

Definition : ID of the operating system (i.e., SunOS 5.8)
Element type : String
Byte length : 20
Storage type : Character
Unit : /
Field number : 9
Comment : /

Orbit_Data

Definition :	Name of the file containing the orbit ephemeris (MOE for IGDR, POE for GDR)
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	53
Comment :	/

ORF_Data

Definition :	Orbit Revolution File used to create the pass file products
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	57
Comment :	/

Pass_Data_Count

Definition :	Number of 1 Hz measurements in the product
Element type :	String
Byte length :	5
Storage type :	Character
Unit :	/
Field number :	30
Comment :	/

Pass_Number

Definition :	Pass number within the cycle
Element type :	String
Byte length :	3
Storage type :	Character
Unit :	/
Field number :	20
Comment :	/

PF_Corrections

Definition :	Name of the file containing the platform corrections (mispointing relative to the subsatellite point distance between antenna center of phase and center of gravity)
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	54
Comment :	/

Pole_Location

Definition :	Name of the file containing the pole location data
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	55
Comment :	/

POSEIDON-2_Characterization

Definition :	Name of the file containing the characterization data for the POSEIDON-2 altimeter
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	47
Comment :	/

POSEIDON-2_Composite_SSB

Definition :	Name of the file containing the composite Sea state bias coefficients for Poseidon-2
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	60
Comment :	/

POSEIDON-2_LTM

Definition :	Name of the file containing the Long Term Monitoring values for the POSEIDON-2 altimeter
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	48
Comment :	/

POSEIDON-2_OB_RET_Correction_Tables

Definition :	Name of the file containing the on-board retracking coefficient corrections (for level1B and level2 processing)
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	58
Comment :	/

POSEIDON-2_SSB

Definition :	Name of the file containing the Sea state bias coefficients for Poseidon-2
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	59
Comment :	/

Processing_Center

Definition :	Center (SSALTO or JSDS)
Element type :	String
Byte length :	6
Storage type :	Character
Unit :	/
Field number :	5
Comment :	/

Producer_Agency_Name

Definition :	Name (CNES or NASA)
Element type :	String
Byte length :	4
Storage type :	Character
Unit :	/
Field number :	4
Comment :	/

Product_Creation_Time

Definition :	UTC date & time of product generation (CCSDS UTC2 format defined in paragraph 1.4.5) i.e., 2000-06-21T04:20:00.000000
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	10
Comment :	/

Product_File_Name

Definition :	Name of the product (i.e., JA1_IGD_2PvPccc_ppp.CNES or JA1_IGD_2PvPccc_ppp.NASA)
Element type :	String
Byte length :	40
Storage type :	Character
Unit :	/
Field number :	3
Comment :	/

Radiometer_Level1

Definition :	Name of the radiometer Level 1.0 input file
Element type :	String
Byte length :	40
Storage type :	Character
Unit :	/
Field number :	44
Comment :	/

Radiometer_Sensor_Name

Definition :	JMR
Element type :	String
Byte length :	3
Storage type :	Character
Unit :	/
Field number :	15
Comment :	/

Range_Offset

Definition :	Offset to be added to the altitude and to the range to retrieve the absolute values of these parameters (i.e., 1300 km)
Element type :	String
Byte length :	4
Storage type :	Character
Unit :	<km>
Field number :	38
Comment :	/

Reference_Document

Definition :	ID of the document describing the product (i.e., SMM-ST-M-EA-10879-CN)
Element type :	String
Byte length :	50
Storage type :	Character
Unit :	/
Field number :	7
Comment :	/

Reference_Software

Definition :	ID of the software used to create the product (i.e., CMA Vx.x)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	8
Comment :	/

Solid_Earth_Tide

Definition :	Name of the file containing the Cartwright and Edden tide potential amplitudes for the solid earth tide and the Equilibrium long period ocean tide height calculation
Element type :	String
Byte length :	61
Storage type :	Character
Unit :	/
Field number :	67
Comment :	/

TAI_UTC_Difference

Definition :	Increment to be applied to UTC to give TAI (dt=TAI-UTC)
Element type :	String
Byte length :	4
Storage type :	Character
Unit :	/
Field number :	34
Comment :	the increment is given in seconds.

Tidal_loading_Sol_1

Definition :	Name of the loading tide model #1 (currently GOT99)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	65
Comment :	/

Tidal_loading_Sol_2

Definition :	Name of the loading tide model #2 (currently FES99)
Element type :	String
Byte length :	20
Storage type :	Character
Unit :	/
Field number :	66
Comment :	/

Time_Epoch

Definition :	Reference used for measurement datation in the product (value=1958-01-01T00:00:00.00000)
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	33
Comment :	/

Time_Of_Leap_Second

Definition :	UTC Time at which a leap second occurred in the product. (CCSDS UTC2 format defined in paragraph 1.4.5) Set to 0000-00-00T00:00:00.000000 if not useful
Element type :	String
Byte length :	26
Storage type :	Character
Unit :	/
Field number :	35
Comment :	/

Time_Shift_Interval

Definition :	Time interval (microseconds) between two 20 Hz waveforms
Element type :	String
Byte length :	10
Storage type :	Character
Unit :	<us>
Field number :	37
Comment :	/

Time_Shift_Mid_Frame

Definition :	Offset to apply to time to derive the time tag of the first 20 Hz waveform (unit: microsecond)
Element type :	String
Byte length :	10
Storage type :	Character
Unit :	<us>
Field number :	36
Comment :	/

7. (I)GDR ELEMENTS

Section 7.1 describes the format of the data elements of the (I)GDR and section 7.2 defines each element of the data records in alphabetical order by the following characteristics :

Definition	Element definition.
Element type	An element type can be bitfield or integer.
Byte length	Size of element in 8-bit bytes.
Storage type	A storage type can be signed (signed integer), unsigned (unsigned integer), bit (contiguous sequence of bits) or character (contiguous sequence of ASCII characters).
Dimension	Dimension (1 or 20 for the high rate fields).
Unit	Unit of measure including scale factor, or none (/).
Minimum value	Typical or approximate minimum element value.
Maximum value	Typical or approximate maximum element value.
Default value	Element value when the measurement is not available or when the element has not been computed ("flag value").
Quality flags	Flags indicating the quality of this element, or none (/). This item exists if the element is not a flag itself.
Comment	Other comment.

When an item cannot be filled, there is N/A which stands for not applicable.

7.1. Data record format

The data part is composed of n records, where n is the number of measurements acquired by the satellite. All of the measurements acquired on board will be included in the level 2 products

The table below describes briefly one data record. The following convention is used :

I = Unsigned integer

SI = Signed integer

BF = Bit flag

PASSFILE : SCIENTIFIC DATA RECORD n

Field Number	*Record Location*	*Mnemonic*	*Content*	*Type*	*Dim.*	*Size*	*Units*
		Time Tag					
1	**1**	time_day	time stamp 1 (number of days from reference date)	I	1	4	Day
2	**5**	time_sec	time stamp 2 (seconds within the day)	I	1	4	s
3	**9**	time_microsec	time stamp 3 (microseconds)	I	1	4	µs
		Location and Surface Type					
4	**13**	latitude	Latitude	SI	1	4	µdeg
5	**17**	longitude	Longitude	I	1	4	µdeg
6	**21**	surface_type	surface type	I	1	1	/
7	**22**	alt_echo_type	altimeter echo type (0 = ocean-like , 1 = non ocean-like)	BF	1	1	/
8	**23**	rad_surf_type	radiometer surface type (0 = ocean , 1 = land)	BF	1	1	/
		Quality information and sensors status					
9	**24**	qual_1hz_alt_data	quality flag for 1 Hz altimeter data	BF	1	1	/
10	**25**	qual_1hz_alt_instr_corr	quality flag for 1 Hz altimeter instrumental corrections	BF	1	1	/
11	**26**	qual_1hz_rad_data	quality flag for 1 Hz radiometer data	BF	1	1	/
12	**27**	alt_state_flag	Altimeter state flag	BF	1	1	/
13	**28**	rad_state_flag	Radiometer state flag	BF	1	1	/
14	**29**	orb_state_flag	orbit state flag	I	1	1	/
15	**30**	qual_spare	spare (to be aligned)	BF	3	1	/
		Orbit					
16	**33**	altitude	1 Hz altitude of satellite	I	1	4	10^{-4} m
17	**37**	alt_hi_rate	Differences between altitudes corresponding to the elementary measurements to that of the averaged measurements	SI	20	4	10^{-4} m
18	**117**	orb_alt_rate	orbital altitude rate	SI	1	2	cm/s
19	**119**	orb_spare	spare (to be aligned)	I	2	1	/
		Altimeter Range					
20	**121**	range_ku	1 Hz Ku band range	I	1	4	10^{-4} m
21	**125**	range_hi_rate_ku	Differences between elementary Ku range and averaged Ku band range	SI	20	4	10^{-4} m
22	**205**	range_c	1 Hz C band range	I	1	4	10^{-4} m
23	**209**	range_hi_rate_c	differences between elementary C range and averaged C band range	SI	20	4	10^{-4} m
24	**289**	range_rms_ku	RMS of the Ku band range	I	1	2	10^{-4} m
25	**291**	range_rms_c	RMS of the C band range	I	1	2	10^{-4} m
26	**293**	range_numval_ku	number of valid points for Ku band range	I	1	1	/
27	**294**	range_numval_c	number of valid points for C band range	I	1	1	/
28	**295**	range_spare	spare (to be aligned)	I	2	1	/
29	**297**	range_mapvalpts_ku	map of valid points used to compute Ku band range	BF	1	4	/
30	**301**	range_mapvalpts_c	map of valid points used to compute C band range	BF	1	4	/
		Altimeter Range corrections					

Field Number	*Record Location*	*Mnemonic*	*Content*	*Type*	*Dim.*	*Size*	*Units*
31	**305**	net_instr_corr_ku	net instrumental correction on Ku band range	SI	1	4	10^{-4} m
32	**309**	net_instr_corr_c	net instrumental correction on C band range	SI	1	4	10^{-4} m
33	**313**	model_dry_tropo_corr	model dry tropospheric correction	SI	1	2	10^{-4} m
34	**315**	model_wet_tropo_corr	model wet tropospheric correction	SI	1	2	10^{-4} m
35	**317**	rad_wet_tropo_corr	radiometer wet tropospheric correction	SI	1	2	10^{-4} m
36	**319**	iono_corr_alt_ku	altimeter ionospheric correction on Ku band	SI	1	2	10^{-4} m
37	**321**	iono_corr_doris_ku	Doris iono correction on Ku band	SI	1	2	10^{-4} m
38	**323**	sea_state_bias_ku	sea state bias correction in Ku-band	SI	1	2	10^{-4} m
39	**325**	sea_state_bias_c	sea state bias correction in C-band	SI	1	2	10^{-4} m
40	**327**	sea_state_bias_comp	composite sea state bias correction	SI	1	2	10^{-4} m
		Significant Waveheight					
41	**329**	swh_ku	Ku band significant waveheight	I	1	2	10^{-3} m
42	**331**	swh_c	C band significant waveheight	I	1	2	10^{-3} m
43	**333**	swh_rms_ku	RMS of the Ku band significant waveheight	I	1	2	10^{-3} m
44	**335**	swh_rms_c	RMS of the C band significant waveheight	I	1	2	10^{-3} m
45	**337**	swh_numval_ku	number of valid points used to compute Ku significant waveheight	I	1	1	/
46	**338**	swh_numval_c	number of valid points used to compute C significant waveheight	I	1	1	/
		Significant Waveheight corrections					
47	**339**	net_instr_corr_swh_ku	net instrumental correction on Ku band significant waveheight	SI	1	2	10^{-3} m
48	**341**	net_instr_corr_swh_c	net instrumental correction on C band significant waveheight	SI	1	2	10^{-3} m
		Backscatter coefficient					
49	**343**	sig0_ku	Ku band backscatter coefficient	I	1	2	10^{-2} dB
50	**345**	sig0_c	C band backscatter coefficient	I	1	2	10^{-2} dB
51	**347**	sig0_rms_ku	RMS of the Ku band backscatter coefficient	I	1	2	10^{-2} dB
52	**349**	sig0_rms_c	RMS of the C band backscatter coefficient	I	1	2	10^{-2} dB
53	**351**	sig0_numval_ku	number of valid points used to compute Ku backscatter coefficient	I	1	1	/
54	**352**	sig0_numval_c	number of valid points used to compute C backscatter coefficient	I	1	1	/
55	**353**	agc_ku	Ku band AGC	I	1	2	10^{-2} dB
56	**355**	agc_c	C band AGC	I	1	2	10^{-2} dB
57	**357**	agc_rms_ku	RMS of the Ku band AGC	I	1	2	10^{-2} dB
58	**359**	agc_rms_c	RMS of the C band AGC	I	1	2	10^{-2} dB
59	**361**	agc_numval_ku	number of valid points used to compute Ku band AGC	I	1	1	/
60	**362**	agc_numval_c	number of valid points used to compute C band AGC	I	1	1	/
		Backscatter coefficient corrections					
61	**363**	net_instr_sig0_corr_ku	net instrumental correction on Ku band backscatter coefficient	SI	1	2	10^{-2} dB

Field Number	*Record Location*	*Mnemonic*	*Content*	*Type*	*Dim.*	*Size*	*Units*
62	**365**	net_instr_sig0_corr_c	net instrumental correction on C band backscatter coefficient	SI	1	2	10^{-2} dB
63	**367**	atmos_sig0_corr_ku	Atmospheric attenuation correction on Ku band backscatter coefficient	SI	1	2	10^{-2} dB
64	**369**	atmos_sig0_corr_c	Atmospheric attenuation correction on C band backscatter coefficient	SI	1	2	10^{-2} dB
		Off nadir angle					
65	**371**	off_nadir_angle_ku_wvf	Square of the off nadir angle computed from Ku waveforms	SI	1	2	10^{-4} deg^2
66	**373**	off_nadir_angle_ptf	Square of the off nadir angle computed from platform data	SI	1	2	10^{-4} deg^2
		Brightness Temperatures					
67	**375**	tb_187	18,7 GHz brightness temperature	I	1	2	10^{-2} K
68	**377**	tb_238	23,8 Ghz brightness temperature	I	1	2	10^{-2} K
69	**379**	tb_340	34 GHz brightness temperature	I	1	2	10^{-2} K
		Geophysical parameters					
70	**381**	mss	mean sea surface height	SI	1	4	10^{-4} m
71	**385**	mss_tp_along_trk	TP along-track mean sea surface	SI	1	4	10^{-4} m
72	**389**	geoid	geoid height	SI	1	4	10^{-4} m
73	**393**	bathymetry	ocean depth/land elevation	SI	1	2	m
74	**395**	inv_bar_corr	inverted barometer height correction	SI	1	2	10^{-4} m
75	**397**	hf_fluctuations_corr	High frequency fluctuations of the sea surface topography	SI	1	2	10^{-4} m
76	**399**	geo_spare	spare (to be aligned)	BF	2	1	/
77	**401**	ocean_tide_sol1	geocentric ocean tide height (solution 1)	SI	1	4	10^{-4} m
78	**405**	ocean_tide_sol2	geocentric ocean tide height (solution 2)	SI	1	4	10^{-4} m
79	**409**	ocean_tide_eq_lp	equilibrium long-period ocean tide height	SI	1	2	10^{-4} m
80	**411**	ocean_tide_neq_lp	non-equilibrium long-period ocean tide height	SI	1	2	10^{-4} m
81	**413**	load_tide_sol1	loading tide height for geocentric ocean tide solution 1	SI	1	2	10^{-4} m
82	**415**	load_tide_sol2	loading tide height for geocentric ocean tide solution 2	SI	1	2	10^{-4} m
83	**417**	solid_earth_tide	solid earth tide height	SI	1	2	10^{-4} m
84	**419**	pole_tide	geocentric pole tide height	SI	1	2	10^{-4} m
		Environmental parameters					
85	**421**	wind_speed_model_u	U component of the model wind vector	SI	1	2	cm/s
86	**423**	wind_speed_model_v	V component of the model wind vector	SI	1	2	cm/s
87	**425**	wind_speed_alt	altimeter wind speed	I	1	2	cm/s
88	**427**	wind_speed_rad	radiometer wind speed	I	1	2	cm/s
89	**429**	rad_water_vapor	radiometer water vapour content	SI	1	2	10^{-2} g/cm2
90	**431**	rad_liquid_water	radiometer liquid water	SI	1	2	10^{-2} kg/cm2
		Flags					
91	**433**	ecmwf_meteo_map_avail	ECMWF meteorological map availability	BF	1	1	/
92	**434**	tb_interp_flag	radiometer brightness temperatures interpolation flag	I	1	1	/

Field Number	*Record Location*	*Mnemonic*	*Content*	*Type*	*Dim.*	*Size*	*Units*
93	**435**	rain_flag	rain flag (0 : OK, 1 : rain)	BF	1	1	/
94	**436**	ice_flag	ice flag (0 : OK, 1 : ice)	BF	1	1	/
95	**437**	interp_flag	interpolation flag	BF	1	1	/
96	**438**	flag_spare	spare (to be aligned)	BF	3	1	/

7.2. ELEMENTS content (alphabetical order)

agc_c

Definition :	C band AGC
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	5 500
Default Value :	65 535
Quality flag :	/
Comment :	/

agc_ku

Definition :	Ku band AGC
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	5 000
Default Value :	65 535
Quality flag :	/
Comment :	/

agc_numval_c

Definition :	number of valid points used to compute C band AGC
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

agc_numval_ku

Definition :	number of valid points used to compute Ku band AGC
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

agc_rms_c

Definition :	RMS of the C band AGC
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	250
Default Value :	65 535
Quality flag :	/
Comment :	Compression of C band high rate elements is preceded by a detection of outliers. Only valid high-rate values are used to compute this element.

agc_rms_ku

Definition :	RMS of the Ku band AGC
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	250
Default Value :	65 535
Quality flag :	/
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.

altitude

Definition :	1 Hz altitude of satellite with respect to reference altitude
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	300 000 000
Maximum Value :	700 000 000
Default Value :	4 294 967 295
Quality flag :	orb_state_flag
Comment :	A reference offset is subtracted from the 1Hz altitudes and ranges. The reference offset can be found in the header part

alt_echo_type

Definition : altimeter echo type (0 = ocean-like , 1 = non ocean-like)
Element type : Bitfield
Byte length : 1
Storage type : Unsigned
Dimension : 1
Unit : /
Minimum Value : 0
Maximum Value : 1
Default Value : 255
Quality flag : /
Comment : This element is determined by testing the rms of the high rate range measurements against a threshold as well as the number of valid high rate range measurements against a minimum value.

alt_hi_rate

Definition : Differences between the altitudes corresponding to the 20 Hz measurements with the altitude corresponding to the 1Hz measurement (altitude)
Element type : Integer
Byte length : 4
Storage type : Signed
Dimension : 20
Unit : 10^{-4} m
Minimum Value : -80 000
Maximum Value : 80 000
Default Value : 2 147 483 6472 147 483 647
Quality flag : /
Comment : These values are required to derive 20 Hz sea surface heights from the 20 Hz range measurements.

alt_state_flag

Definition : altimeter state flag
Element type : Bitfield
Byte length : 1
Storage type : Unsigned
Dimension : 1
Unit : /
Minimum Value : /
Maximum Value : /
Default Value : 255
Quality flag : /
Comment : this field is defined by :

Bits	Indicator
0	Spare
1	Altimeter operating (0 = side A (nominal POSEIDON-2 altimeter), 1 = side B (redundancy))
2	Reception bandwidth inversion (0 = Not reversed, 1 = reversed)
3	Spectrum coding (0 = I and Q, 1 = $I^2 + Q^2$)
4	C bandwidth (0 = 320 Mhz; 1 = 100 MHz)
5	Ku/C band sequencing (0 = 3Ku-1C-3Ku , 1 = 2Ku-1C-2Ku)
6	Ku band status (0 = on , 1 = off)
7	C band status (0 = on , 1 = off)

atmos_sig0_corr_c

Definition :	atmospheric attenuation correction on C band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	50
Default Value :	32 767
Quality flag :	/
Comment :	This value is added to the backscatter coefficient derived from the Automatic Gain Control data (agc_c) to produce sig0_C.

atmos_sig0_corr_ku

Definition :	atmospheric attenuation correction on Ku band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	50
Default Value :	32 767
Quality flag :	/
Comment :	This value is added to the backscatter coefficient derived from the Automatic Gain Control data (agc_ku) to produce sig0_ku.

bathymetry

Definition :	ocean depth/land elevation
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	m
Minimum Value :	-10 000
Maximum Value :	10 000
Default Value :	32 767
Quality flag :	/
Comment :	This element is computed from DTM2000.1 database.

ecmwf_meteo_map_avail

Definition :	ECMWF meteorological map availability
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	0
Default Value :	255
Quality flag :	/
Comment :	It is defined on one byte. Possible values are: 0 meaning "2 maps, nominal" (six hours apart) 1 meaning "2 maps, degraded" (more than six hours apart) 2 meaning "1 map, extrapolation used" 3 meaning "no map" Given the latest definition of the meteorological field processing algorithms, this flag will always be set to 0.

flag_spare

Definition :	spare (to be aligned)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	3
Unit :	/
Minimum Value :	255
Maximum Value :	255
Default Value :	255
Quality flag :	/
Comment :	/

geo_spare

Definition :	spare (to be aligned)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	2
Unit :	/
Minimum Value :	255
Maximum Value :	255
Default Value :	255
Quality flag :	/
Comment :	/

geoid

Definition :	geoid height
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-1 500 000
Maximum Value :	1 500 000
Default Value :	2 147 483 647
Quality flag :	/
Comment :	It is computed from the EGM96 model with a correction to refer the value to the mean tide system i.e. includes the permanent tide (zero frequency). [See section 4.3 for more details].

hf_fluctuations_corr

Definition :	High frequency fluctuations of the sea surface topography
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-3 000
Maximum Value :	3 000
Default Value :	32 767
Quality flag :	/
Comment :	See section 4.4 for more details

ice_flag

Definition :	ice flag (0 : no ice, 1 : ice)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	The ice flag is set if a climatological map predicts ice at the given location, and if the wind speed derived from the altimeter measurement is less than 1 m/s [See section 4.7 for more details].

interp_flag

Definition :	interpolation flag
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	this field is defined by :

Bits	**Indicator** (0 = Good and 1 = Bad)
0	MSS interpolation flag
1	ocean tide solution 1 interpolation flag (0=4 points over ocean, 1=less than 4 points)
2	ocean tide solution 2 interpolation flag (0=4 points over ocean, 1=less than 4 points)
3	Meteorological data interpolation flag (0=4 points over ocean, 1=less than 4 points)
4	Spare
5	Spare
6	Spare
7	Spare

inv_bar_corr

Definition :	inverted barometer height correction
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-3 000
Maximum Value :	3 000
Default Value :	32 767
Quality flag :	interp_flag (bit #3)
Comment :	It is computed at the altimeter measurement epoch from the interpolation of 2 meteorological fields that surround the altimeter measurement epoch [See section 4.9 for more details].

iono_corr_alt_ku

Definition :	altimeter ionospheric correction on ku band
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-5 000
Maximum Value :	40
Default Value :	32 767
Quality flag :	/
Comment :	An ionospheric correction must be added (negative value) to the instrument range (range_ku) to correct this range measurement for ionospheric range delays of the radar pulse [See section 3.8 for more details].

iono_corr_doris_ku

Definition :	Doris iono correction on ku band
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-5 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	/
Comment :	An ionospheric correction must be added (negative value) to the instrument range (range_ku) to correct this range measurement for ionospheric range delays of the radar pulse [See section 3.8 for more details].

latitude

Definition :	latitude
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	µdeg
Minimum Value :	-70 000 000
Maximum Value :	70 000 000
Default Value :	2 147 483 647
Quality flag :	orb_state_flag
Comment :	Positive latitude is North latitude, whereas negative latitude is South latitude [See section 4.1 for more details].

load_tide_sol1

Definition :	loading tide height for geocentric ocean tide solution 1
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-2 000
Maximum Value :	2 000
Default Value :	32 767
Quality flag :	/
Comment :	This value has already been added to the corresponding ocean tide height value recorded in the product (ocean_tide_sol1) [See section 4.8 for more details].

load_tide_sol2

Definition :	loading tide height for geocentric ocean tide solution 2
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-2 000
Maximum Value :	2 000
Default Value :	32 767
Quality flag :	/
Comment :	This value has already been added to the corresponding ocean tide height value recorded in the product (ocean_tide_sol2) [See section 4.8 for more details].

longitude

Definition :	longitude
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	µdeg
Minimum Value :	0
Maximum Value :	359 999 999
Default Value :	4 294 967 295
Quality flag :	orb_state_flag
Comment :	The longitude corresponds to the East longitude relative to Greenwich meridian [See section 4.1 for more details].

model_dry_tropo_corr

Definition :	model dry tropospheric correction
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-25 000
Maximum Value :	-22 000
Default Value :	32 767
Quality flag :	interp_flag (bit #3)
Comment :	It is computed at the altimeter measurement epoch from the interpolation of 2 meteorological fields that surround the altimeter measurement epoch. A dry tropospheric correction must be added (negative value) to the instrument range to correct this range measurement for dry tropospheric range delays of the radar pulse [See section 4.5.1 for more details].

model_wet_tropo_corr

Definition :	model wet tropospheric correction
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-5 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	interp_flag (bit #3)
Comment :	It is computed at the altimeter measurement epoch from the interpolation of 2 meteorological fields that surround the altimeter measurement epoch. 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 [See section 4.5.1 for more details].

mss

Definition :	mean sea surface height
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-1 500 000
Maximum Value :	1 500 000
Default Value :	2 147 483 647
Quality flag :	interp_flag (bit #0)
Comment :	This value is computed from the GSFC00.1 mean sea surface model; a bias of 23.9 mm is added to the GSFC00.1 MSS model to give this parameter [See section 4.4 for more details].

mss_tp_along_trk

Definition :	TP along-track mean sea surface
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-1 500 000
Maximum Value :	1 500 000
Default Value :	2 147 483 647
Quality flag :	/
Comment :	This value is computed from a mean sea surface model that has been specifically derived along the TOPEX/POSEIDON ground track using only T/P data [See section 4.4 for more details]

net_instr_corr_c

Definition :	net instrumental correction on C band range
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-120 000
Maximum Value :	120 000
Default Value :	2 147 483 647
Quality flag :	qual_1hz_alt_instr_corr (bit #1)
Comment :	This value has already been added to the 1 Hz C band range recorded in the product (range_c)

net_instr_corr_ku

Definition :	net instrumental correction on Ku band range
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-120 000
Maximum Value :	120 000
Default Value :	2 147 483 647
Quality flag :	qual_1hz_alt_instr_corr (bit #0)
Comment :	This value has already been added to the 1 Hz Ku band range recorded in the product (range_ku)

net_instr_corr_swh_c

Definition :	net instrumental correction on C band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	-1 000
Maximum Value :	1 000
Default Value :	32 767
Quality flag :	qual_1hz_alt_instr_corr (bit #3)
Comment :	This value has already been added to the 1 Hz C band SWH recorded in the product (swh_c)

net_instr_corr_swh_ku

Definition :	net instrumental correction on Ku band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	-1 000
Maximum Value :	1 000
Default Value :	32 767
Quality flag :	qual_1hz_alt_instr_corr (bit #2)
Comment :	This value has already been added to the 1 Hz Ku band SWH recorded in the product (swh_ku)

net_instr_sig0_corr_c

Definition :	net instrumental correction on C band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	-1 000
Maximum Value :	1 000
Default Value :	32 767
Quality flag :	qual_1hz_alt_instr_corr (bit #5)
Comment :	This value has already been added to the 1 Hz C band backscatter coefficient (sig0_c). The AGC (agc_c) recorded in the product has also been corrected for this instrumental correction.

net_instr_sig0_corr_ku

Definition :	net instrumental correction on Ku band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	-1 000
Maximum Value :	1 000
Default Value :	32 767
Quality flag :	qual_1hz_alt_instr_Corr (bit #4)
Comment :	This value has already been added to the 1 Hz Ku band backscatter coefficient (sig0_ku). The AGC (agc_ku) recorded in the product has also been corrected for this instrumental correction.

ocean_tide_eq_lp

Definition :	equilibrium long-period ocean tide height
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-2 000
Maximum Value :	2 000
Default Value :	32 767
Quality flag :	/
Comment :	This value has already been added to the two geocentric ocean tide height values recorded in the product (ocean_tide_sol1 and ocean_tide_sol2). The permanent tide (zero frequency) is not included in this parameter because it is included in the geoid and mean sea surface (geoid, mss) [See section 4.8 for more details].

ocean_tide_neq_lp

Definition :	non-equilibrium long-period ocean tide height
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-2 000
Maximum Value :	2 000
Default Value :	32 767
Quality flag :	/
Comment :	This parameter is computed as a correction to the parameter ocean_tide_eq_lp. This value can be added to ocean_tide_eq_lp (or ocean_tide_sol1, ocean_tide_sol2) so that the resulting value models the total non equilibrium ocean tide height. [See section 4.8 for more details].

ocean_tide_sol1

Definition :	geocentric ocean tide height (solution 1)
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-50 000
Maximum Value :	50 000
Default Value :	2 147 483 647
Quality flag :	interp_flag (bit #1)
Comment :	It is computed from the GOT99.2 model. This value includes the corresponding loading tide (load_tide_sol1) and equilibrium long-period ocean tide height (ocean_tide_eq_lp). The permanent tide (zero frequency) is not included in this parameter because it is included in the geoid and mean sea surface (geoid, mss) [See section 4.8 for more details]

ocean_tide_sol2

Definition :	geocentric ocean tide height (solution 2)
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-50 000
Maximum Value :	50 000
Default Value :	2 147 483 647
Quality flag :	interp_flag (bit #2)
Comment :	It is computed from the FES99 model. This value includes the corresponding loading tide (load_tide_sol2) and equilibrium long-period ocean tide height (ocean_tide_eq_lp). The permanent tide (zero frequency) is not included in this parameter because it is included in the geoid and mean sea surface (geoid, mss) [See section 4.8 for more details]

off_nadir_angle_ku_wvf

Definition :	square of the off nadir angle computed from Ku waveforms
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} deg^2
Minimum Value :	0
Maximum Value :	900
Default Value :	32 767
Quality flag :	qual_1hz_alt_data (bit #6)
Comment :	/

off_nadir_angle_ptf

Definition :	square of the off nadir angle computed from platform data
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} deg^2
Minimum Value :	0
Maximum Value :	900
Default Value :	32 767
Quality flag :	qual_1hz_alt_data (bit #7)
Comment :	/

orb_alt_rate

Definition :	orbital altitude rate
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	cm/s
Minimum Value :	-1 500
Maximum Value :	1 500
Default Value :	32 767
Quality flag :	/
Comment :	The reference surface for the orbital altitude rate is the combined MSS/geoid surface GSFC00.1/EGM96. It is used to compute the Doppler correction which is included in the net_instr_corr_ku and net_instr_corr_c parameters.

orb_spare

Definition :	spare (to be aligned)
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	2
Unit :	/
Minimum Value :	255
Maximum Value :	255
Default Value :	255
Quality flag :	/
Comment :	/

orb_state_flag

Definition : orbit state flag
Element type : Integer
Byte length : 1
Storage type : Unsigned
Dimension : 1
Unit : /
Minimum Value : 0
Maximum Value : 9
Default Value : 255
Quality flag : /
Comment : This flag is defined on one byte.
It may range from 0 to 9 with the following meaning:

- 0 characterizes a mission operations orbit that is computed during a maneuver period
- 1 stands for an adjusted mission operations orbit
- 2 stands for an extrapolated mission operations orbit
- 3 stands for an adjusted (preliminary/precise) orbit
- 4 indicates that the (preliminary/precise) orbit is estimated during a maneuver period
- 5 indicates that the (preliminary/precise) orbit is interpolated over a tracking data gap
- 6 means that the (preliminary/precise) orbit is extrapolated for a duration less than 1 day
- 7 means that the (preliminary/precise) orbit is extrapolated for a duration that ranges from 1 day to 2 days
- 8 means that the (preliminary/precise) orbit is extrapolated for a duration larger than 2 days, or that the orbit is extrapolated just after a maneuver
- 9 stands for the DORIS DIODE navigator orbit

The nominal value is 3.

pole_tide

Definition : geocentric pole tide height
Element type : Integer
Byte length : 2
Storage type : Signed
Dimension : 1
Unit : 10^{-4} m
Minimum Value : -1000
Maximum Value : 1000
Default Value : 32 767
Quality flag : /
Comment : [See section 4.8 for more details]

qual_1hz_alt_data

Definition :	quality flag for 1 Hz altimeter data
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	this field is defined by :

Bits	**Indicator** (0 = Good and 1 = Bad)
0	Ku band range
1	C band range
2	Ku band SWH
3	C band SWH
4	Ku band backscatter coefficient
5	C band backscatter coefficient
6	off nadir angle from Ku band waveform parameters
7	off nadir angle from platform

qual_1hz_alt_instr_corr

Definition :	quality flag for 1 Hz altimeter instrumental corrections
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	this field is defined by :

Bits	**Indicator** (0 = Good and 1 = Bad)
0	Ku band range instrumental correction
1	C band range instrumental correction
2	Ku band SWH instrumental correction
3	C band SWH instrumental correction
4	Ku band backscatter coefficient instrumental correction
5	C band backscatter coefficient instrumental correction
6	Spare
7	Spare

qual_1hz_rad_data

Definition :	quality flag for 1 Hz radiometer data
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	this field is defined by :

Bits	**Indicator** (0 = Good and 1 = Bad)
0	18,7 Ghz brightness temperature
1	23,8 Ghz brightness temperature
2	34 Ghz brightness temperature
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare

qual_spare

Definition :	spare (to be aligned)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	3
Unit :	/
Minimum Value :	255
Maximum Value :	255
Default Value :	255
Quality flag :	/
Comment :	/

rad_liquid_water

Definition :	radiometer liquid water
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2}kg/cm^2
Minimum Value :	0
Maximum Value :	200
Default Value :	32 767
Quality flag :	qual_1hz_rad_data and tb_interp_flag
Comment :	This element should not be used over land.

rad_state_flag

Definition :	radiometer state flag
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	This flag is defined as follows: Bit 0 indicates Mode (0 = Mode 2 (nominal), 1 = Mode 1) Bit 1 indicates Mode 1 Cal Sequence (0 = Normal data taking in Mode 1 or Mode 2, 1 = Mode 1 Cal Sequence) Bits 2 and 3 indicate active 23.8 GHz channel Bit 2 = Channel 2 (0 = On, 1 = Off) Bit 3 = Channel 3 (0 = On, 1 = Off) Bits 4 to 7 are set to 0. If Bit_2 = Bit_3 = 0, then the 23.8 GHz brightness temperature that is provided and used in the geophysical processing is taken from the nominal channel (Channel 3). Be aware that if the radiometer is not functioning, this flag will be set to 0. User should test the qual_1hz_rad_data flag which will be set to "bad" in such a case.

rad_surf_type

Definition :	radiometer surface type (0 = ocean , 1 = land)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	1
Default Value :	1
Quality flag :	/
Comment :	The radiometer surface type can be set to land (=1) over ocean when the JMR data are not present. The radiometer surface type is then not estimated and set to its default value (=1)

rad_water_vapor

Definition :	radiometer water vapour content
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-2}g/cm^{2}
Minimum Value :	0
Maximum Value :	700
Default Value :	32 767
Quality flag :	qual_1hz_rad_data and tb_interp_flag
Comment :	This element should not be used over land.

rad_wet_tropo_corr

Definition :	radiometer wet tropospheric correction
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-5 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	qual_1hz_rad_data and tb_interp_flag
Comment :	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.

rain_flag

Definition :	rain flag (0 : OK, 1 : rain)
Element type :	Bitfield
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	255
Quality flag :	/
Comment :	[See section 4.6 for more details].

range_c

Definition :	1 Hz C band range with respect to the reference altitude
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	300 000 000
Maximum Value :	700 000 000
Default Value :	4 294 967 295
Quality flag :	qual_1hz_alt_data (bit #1)
Comment :	The reference altitude found in the header should be added to range_c to provide the actual C band range of the satellite. This value has already been corrected for instrument effects using net_instr_corr_c

range_hi_rate_c

Definition :	Differences betwen the 20 Hz range measurements with the 1Hz range measurement (range_c)
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	20
Unit :	10^{-4} m
Minimum Value :	-150 000
Maximum Value :	150 000
Default Value :	2 147 483 647
Quality flag :	/
Comment :	/

range_hi_rate_ku

Definition :	Differences betwen the 20 Hz range measurements with the 1Hz range measurement (range_ku)
Element type :	Integer
Byte length :	4
Storage type :	Signed
Dimension :	20
Unit :	10^{-4} m
Minimum Value :	-150 000
Maximum Value :	150 000
Default Value :	2 147 483 647
Quality flag :	/
Comment :	/

range_ku

Definition :	1 Hz Ku band range with respect to the reference altitude
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	300 000 000
Maximum Value :	700 000 000
Default Value :	4 294 967 295
Quality flag :	qual_1hz_alt_data (bit #0)
Comment :	The reference altitude found in the header should be added to range_ku to provide the actual Ku band range of the satellite. This value already has already been corrected for instrument effects using net_instr_corr_ku

range_mapvalpts_c

Definition :	map of valid points used to compute C band range
Element type :	Bitfield
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	4 294 967 295
Quality flag :	/
Comment :	**/**

range_mapvalpts_ku

Definition :	map of valid points used to compute Ku band range
Element type :	Bitfield
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	/
Maximum Value :	/
Default Value :	4 294 967 295
Quality flag :	/
Comment :	Bits 0 to 19 correspond to the first to last 20 Hz measurements 1= bad, 0 = good

range_numval_c

Definition :	number of valid points for C band range
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	Bits 0 to 19 correspond to the first to last 20 Hz measurements 1= bad, 0 = good

range_numval_ku

Definition :	number of valid points for Ku band range
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

range_rms_c

Definition :	RMS of the C band range
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	0
Maximum Value :	3 000
Default Value :	65 535
Quality flag :	/
Comment :	Compression of C band high rate elements is preceded by a detection of outliers. Only valid high-rate values are used to compute this element.

range_rms_ku

Definition :	RMS of the Ku band range
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	0
Maximum Value :	2 000
Default Value :	65 535
Quality flag :	/
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.

range_spare

Definition :	spare (to be aligned)
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	2
Unit :	/
Minimum Value :	255
Maximum Value :	255
Default Value :	255
Quality flag :	/
Comment :	/

sea_state_bias_c

Definition :	sea state bias correction in C-band
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-6 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	/
Comment :	A sea state bias correction must be added (negative value) to the instrument range (range_c) to correct this range measurement for sea state delays of the radar pulse [see section 4.5.3]. This element should not be used over land.

sea_state_bias_comp

Definition :	composite sea state bias correction
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-6 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	/
Comment :	A sea state bias correction must be added (negative value) to the instrument range (combination of range_c and range_ku [see section 4.5.3]) to correct this range measurement for sea state delays of the radar pulse. This element should not be used over land.

sea_state_bias_ku

Definition :	sea state bias correction in Ku-band
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-6 000
Maximum Value :	0
Default Value :	32 767
Quality flag :	/
Comment :	A sea state bias correction must be added (negative value) to the instrument range (range_ku) to correct this range measurement for sea state delays of the radar pulse [see section 4.5.3]**.** This element should not be used over land.

sig0_c

Definition :	C band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	3 000
Default Value :	65 535
Quality flag :	qual_1hz_alt_data (bit #5)
Comment :	This value has already been corrected for atmospheric attenuations and instrumental effects using atmos_sig0_corr_c and net_instr_sig0_corr_c [See section 4.10 for more details].

sig0_ku

Definition :	Ku band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	3 000
Default Value :	65 535
Quality flag :	qual_1hz_alt_data (bit #4)
Comment :	This value has already been corrected for atmospheric attenuations and instrumental effects using atmos_sig0_corr_ku and net_instr_sig0_corr_ku [See section 4.10 for more details].

sig0_numval_c

Definition :	number of valid points used to compute ku backscatter coefficient
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

sig0_numval_ku

Definition :	number of valid points used to compute C backscatter coefficient
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

sig0_rms_c

Definition :	RMS of the C band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	250
Default Value :	65 535
Quality flag :	/
Comment :	Compression of C band high rate elements is preceded by a detection of outliers. Only valid high-rate values are used to compute this element.

sig0_rms_ku

Definition :	RMS of the ku band backscatter coefficient
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} dB
Minimum Value :	0
Maximum Value :	250
Default Value :	65 535
Quality flag :	/
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.

solid_earth_tide

Definition :	solid earth tide height
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	10^{-4} m
Minimum Value :	-10 000
Maximum Value :	10 000
Default Value :	32 767
Quality flag :	/
Comment :	It is calculated using Cartwright and Tayler tables and consists of the second and third degree constituents. The permanent tide (zero frequency) is not included. [See section 4.8 for more details]

surface_type

Definition :	surface type
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	3
Default Value :	255
Quality flag :	/
Comment :	The values of this flag are : 0 = open oceans or semi-enclosed seas; 1 = enclosed seas or lakes; 2 = continental ice; 3 = land. It is computed using a DTM2000 file [see section 4.12 for more details].

swh_c

Definition :	C band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	0
Maximum Value :	25 000
Default Value :	65 535
Quality flag :	qual_1hz_alt_data (bit #3)
Comment :	This value has already been correct for instrumental effects using net_instr_corr_swh_c.

swh_ku

Definition :	Ku band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	0
Maximum Value :	25 000
Default Value :	65 535
Quality flag :	qual_1hz_alt_data (bit #2)
Comment :	This value has already been correct for instrumental effects using net_instr_corr_swh_ku.

swh_numval_c

Definition :	number of valid points used to compute C significant waveheight
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

swh_numval_ku

Definition :	number of valid points used to compute Ku significant waveheight
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	20
Default Value :	255
Quality flag :	/
Comment :	/

swh_rms_c

Definition :	RMS of the C band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	0
Maximum Value :	2 500
Default Value :	65 535
Quality flag :	/
Comment :	Compression of C band high rate elements is preceded by a detection of outliers. Only valid high-rate values are used to compute this element.

swh_rms_ku

Definition :	RMS of the Ku band significant waveheight
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-3} m
Minimum Value :	0
Maximum Value :	2 500
Default Value :	65 535
Quality flag :	/
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.

tb_187

Definition :	18,7 GHz brightness temperature
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} K
Minimum Value :	11 000
Maximum Value :	23 000
Default Value :	65 535
Quality flag :	qual_1hz_rad_data (bit #0)
Comment :	Brightness temperatures are unsmoothed

tb_238

Definition :	23,8 Ghz brightness temperature
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} K
Minimum Value :	13 000
Maximum Value :	25 000
Default Value :	65 535
Quality flag :	qual_1hz_rad_data (bit #1)
Comment :	Brightness temperatures are unsmoothed

tb_340

Definition :	34 GHz brightness temperature
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	10^{-2} K
Minimum Value :	15 000
Maximum Value :	26 000
Default Value :	65 535
Quality flag :	qual_1hz_rad_data (bit #2)
Comment :	Brightness temperatures are unsmoothed

tb_interp_flag

Definition :	radiometer brightness temperatures interpolation flag
Element type :	Integer
Byte length :	1
Storage type :	Unsigned
Dimension :	1
Unit :	/
Minimum Value :	0
Maximum Value :	3
Default Value :	255
Quality flag :	/
Comment :	This flag is defined on one byte. Possible values are: 0 = interpolation with no gap between JMR data 1 = interpolation with gap between JMR data 2 = extrapolation of JMR data 3 = failure of extrapolation and interpolation

time_day

Definition :	time stamp 1 (number of days from reference date)
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	day
Minimum Value :	/
Maximum Value :	/
Default Value :	4 294 967 295
Quality flag :	/
Comment :	**/**

time_microsec

Definition :	time stamp 3 (microseconds within seconds)
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	µs
Minimum Value :	0
Maximum Value :	999 999
Default Value :	4 294 967 295
Quality flag :	/
Comment :	The complete one per second elapsed time (in seconds) can be obtained as follows : **S**econds since reference date = 86400 * time_day + time_sec + 10^{-6} * tim_microsec

time_sec

Definition :	time stamp 2 (seconds within the day)
Element type :	Integer
Byte length :	4
Storage type :	Unsigned
Dimension :	1
Unit :	s
Minimum Value :	0
Maximum Value :	86 400
Default Value :	4 294 967 295
Quality flag :	/
Comment :	/

wind_speed_alt

Definition :	altimeter wind speed
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	cm/s
Minimum Value :	0
Maximum Value :	2 500
Default Value :	65 535
Quality flag :	/
Comment :	This element should not be used over land. [See section 4.11 for more details].

wind_speed_model_u

Definition :	zonal component of the model wind vector (positive eastward)
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	cm/s
Minimum Value :	-2 500
Maximum Value :	2 500
Default Value :	32 767
Quality flag :	interp_flag (bit #3) and ecmwf_meteo_map_avail
Comment :	It is computed at the altimeter measurement epoch from the interpolation of 2 meteorological fields that surround the altimeter measurement epoch.. [See section 4.11 for more details].

wind_speed_model_v

Definition :	meridional component of the model wind vector (positive northward)
Element type :	Integer
Byte length :	2
Storage type :	Signed
Dimension :	1
Unit :	cm/s
Minimum Value :	-2 500
Maximum Value :	2 500
Default Value :	32 767
Quality flag :	interp_flag (bit #3) and ecmwf_meteo_map_avail
Comment :	It is computed at the altimeter measurement epoch from the interpolation of 2 meteorological fields that surround the altimeter measurement epoch. A default value is given when one of the two meteorological fieds are not available. [See section 4.11 for more details].

wind_speed_rad

Definition :	radiometer wind speed
Element type :	Integer
Byte length :	2
Storage type :	Unsigned
Dimension :	1
Unit :	cm/s
Minimum Value :	0
Maximum Value :	2 500
Default Value :	65 535
Quality flag :	/
Comment :	This element should not be used over land. [See section 4.11 for more details].

A. Acronyms

AVISO	Archivage, Validation et Interprétation des données des Satellites Océanographiques
CCSDS	Consultative Committee on Space Data System
CLIVAR	Climate Variability and Predictability program
CNES	Centre National d'Etudes Spatiales
DIODE	Détermination Immédiate d'Orbite par Doris Embarque
DORIS	Détermination d'Orbite et Radiopositionnement Intégrés par satellite
ECMWF	European Center for Medium range Weather Forecasting
EM	ElectroMagnetic
EOSDIS	Earth Observing System Data Information System
GDR	Geophysical Data Records
GODAE	Global Ocean Data Assimilation Experiment
GPS	Global Positioning System
IB	Inverse Barometer
IGDR	Interim Geophysical Data Records
JMR	Jason-1 Microwave Radiometer
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
POD	Precision Orbit Determination
PO.DAAC	Physical Oceanography Distributed Active Archive Center
POE	Precision Orbit Ephemerides
RMS	Root Mean Square
OSDR	Operational Sensor Data Records
SDFU	Standard Formatted Data Units

SSB	Sea State Bias
SSH	Sea Surface Height
SWH	Significant Wave Height
T/P	Topex/Poseidon
TRSR	Turbo Rogue Space Receiver
UTC	Universal Time Coordinated

B. References

ADAS, « Algorithm Definition Accuracy Specification Vol 1 : Jason real time processing »
SMM-ST-M2-EA-11002-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 2 : CMA altimeter level 1B processing »
SMM-ST-M2-EA-11003-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 3 : CMA radiometer level 1B processing «
SMM-ST-M2-EA-11004-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 4 : CMA altimeter level 2 processing »
SMM-ST-M2-EA-11005-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 5 : CMA radiometer level 2 processing »
SMM-ST-M2-EA-11006-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 6 : CMA altimeter / radiometer verification processing «
SMM-ST-M2-EA-11007-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 7 : Near real time control processing«
SMM-ST-M2-EA-11008-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 8 : Off line control processing «
SMM-ST-M2-EA-11009-CN

ADAS, « Algorithm Definition Accuracy Specification Vol 9 : CMA mechanisms »
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