
AQUARIUS/SAC-D

AQUARIUS LEVEL-2 DATA PRODUCT


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Version 5



Aquarius Level-2 Data Product

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DOCUMENT CHANGE LOG

Change Number	Change Date	Pages Affected	Changes/ Notes	General Comments
-	12 February 2013	All	Version 2.0	
	7 March 2014	11,12,16,18	Updates to radiometer quality flags; added new radiometer fields and ancillary SWH.	
	20 March 2014	5,6,12,13,15,17	Corrections based on comments.	
	4 April 2014	11,12	Final changes to wind, roughness and Tb_cons flags.	
	20 May 2014	16	Added SST-corrected SSS as a radiometer parameter.	
	25 June 2015	16	Removed SST-corrected SSS, added SSS uncertainty, density and emissivity correction fields and ATBD references.	V4.0 update
	21 September 2017	5-8,10-12,14-21,25	Added SSS uncertainty analysis parameters, spiciness, RIM products; updated land surface temp and soil moisture data source; updated rad flags, ancillary SSS and rad polarization rotation angles; added list of temperatures for radiometer calibration	V5.0 update

1.0 Introduction

This document describes the specifications of the Aquarius Level-2 archive products, which are produced and distributed by the NASA Goddard Space Flight Center's Aquarius Data Processing System (ADPS). The products are implemented in the Hierarchical Data Format 5 (HDF5), and HDF terminology is used in this document.

These specifications are given in terms of the logical implementation of the products in HDF and are not a physical description of file contents. Therefore, HDF software must be used to create or read these products.

An Aquarius Level-2 product is generated from one Aquarius Level-1A data file. It contains physical measurements as computed from the Level-1A raw data, either at the instrument or the observed surface locations along with coordinates of viewed locations and navigation data. This product is stored as one physical HDF file.

Each product contains data from one orbit of Aquarius data. An orbit is defined as starting when the SAC-D spacecraft passes the South Pole. An orbit may be downlinked multiple times (either to the CONAE ground stations at Cordoba or other stations supported by CONAE). The best quality data are selected for each orbit during the Level 0 to 1A data processing and used to create the input Level 1A file.

2.0 Naming Convention

The form of a Level-2 file name is Qyyyydddhhmmss.L2_ttt_vvvv, where Q is for Aquarius, yyyydddhhmmss are the concatenated digits for the UTC year, day of the year, hours, minutes, and seconds of the first sample (block) in the product, ttt is the type of data in the product, and vvvv is the processing version. Examples of file names are:

Q2013007015300.L2_SCI_V4.0 for standard science data product version 4.0.

3.0 Global Attributes

For global attributes that have constant values specific to this product type, the value is given.

3.1 Mission and Documentation

creator_email, publisher_email : " data@oceancolor.gsfc.nasa.gov"

creator_url, publisher_url: <http://oceandata.sci.gsfc.nasa.gov>

institution, creator name, publisher name (character): "NASA/GSFC OBPG"

instrument: "Aquarius radiometer, Aquarius Scatterometer"

keywords: "SURFACE SALINITY, SALINITY, AQUARIUS, Jet Propulsion Laboratory, NASA, <http://aquarius.nasa.gov/>, AQUARIUS SAC-D, Aquarius Scatterometer, Aquarius Radiometer"

keywords_vocabulary: "NASA Global Change Master Directory (GCMD) Science Keywords"

license: "http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/"

mission_characteristics (character): "Nominal orbit: inclination = 98.0 (Sun-synchronous); node = 6 PM (ascending); eccentricity = <0.002; altitude = 657 km; ground speed = 6.825 km/sec".

platform: "Aquarius/SAC-D"

project: "SAC-D Aquarius".

sensor_characteristics (character): "Number of beams = 3; channels per receiver = 4; radiometer frequency = 1.413 GHz; scatterometer frequency = 1.26 GHz; bits per sample = 16; instantaneous radiometer field-of-view = 6.5 degrees; instantaneous scatterometer field-of-view = 4.9 degrees; science data block period = 1.44 sec."

source: "Aquarius Mission Data Processing System (ADPS)"

title (character): "Aquarius Level-2 Data".

3.2 Processing Information

cdm_data_type: "swath"

conventions (character): "CF-1.6"; Climate and Forecast (CF) metadata conventions used.

date_created (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYY-MM-DDTHH:MM:SS.FFFZ.

delta_TND_H_coefficient (4-byte float, array size **Number of Beams**): calibration coefficients applied to the Radiometer Ta H polarization for this orbit, computed from the exponential fits. The calculation and application of these coefficients is described in "Aquarius Calibration for V3.0", D. M. Levine, L. Hong and T. Meissner. It is in L2_QL and L2_SCI data and not in L2_CAL data files.

delta_TND_V_coefficient (4-byte float, array size **Number of Beams**): calibration coefficient applied to the Radiometer Ta V polarization for this orbit, computed from the exponential fits (see above) . It is in L2_QL and L2_SCI data and not in L2_CAL data files.

history (character): the name of the Level-1A file (without path) from which the current product was created, input and processing control parameters to generate current L2 radiometer science data

id: level 2 data file id, "QYYYYDOYHHMMSS.L2_XXX_VYYY", where "XXX" is the data type, e.g. "SCI", and "YYY" is the version number

mean_solar_1415_MHzf_flux (float): The noon-time value of solar flux. This is the average value of the stations of the Air Force Radio Solar Telescope Network (RSTN) reporting at 1.4 GHz (Learmonth, San Vito, Sagmore Hill, Palehua). The data are available at: <http://www.swpc.noaa.gov/ftpdir/lists/radio/rad.txt>. These data are used to compute the contribution of the Sun (direct, reflected and glint) and associated flags.

rad_ancillary_filen (character): the names of the ancillary data files (without path) used to process the radiometer data, where **n** = 1, 2, or 3. Depending on the timing of

the Aquarius granule with respect to the ancillary data times, there may be either 2 or 3 sets of data with corresponding instances of this attribute.

processing_level: 2

product_version, Processing_version (character): identifies the version of the products, e.g. V1.0.

radiometer_calibration_files (character): the names of the radiometer calibration coefficient files (without path) used to process the radiometer data.

radiometer_data_tables (character): the names of the radiometer look-up table files (without path) used to process the radiometer data.

radiometer_flag_limits (character): brief listing of limits used to set the radiometer quality flags specified in section 4.2.

radiometer_offset_correction (4-byte float, array size **2*Number of Beams**): offset corrections applied to the radiometer Ta values. These are the estimated residual instrumental errors in the antenna temperatures after the “**Delta TND X coefficient**” gain corrections are applied. The calculation and application of these coefficients is described in “Aquarius Calibration for V3.0”, D. M. Levine, L. Hong and T. Meissner. The order is (1V, 1H, 2V, 2H, 3V, 3H). Set to 0.0 if not used.

scatterometer_ancillary_files (character): the names of the ancillary files (without path) used to process the scatterometer data.

scatterometer_coefficient_files (character): the names of the scatterometer coefficient files (without path) used to process the scatterometer data.

scatterometer_history (character): additional scatterometer input and processing control parameters used to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters.

software_id (character): identifies version of the software used to create this product.

standard_name_vocabulary CF Standard Name Table v27

supplementary_matchup_data: additional parameters of Aquarius footprint match-up Argo data, including ARGO temperature, pressure and etc. See match-up data in “SSS_matchup”. Ref. Doc_____

3.3 Data Time

node_crossing_time (character): UTC of ascending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYY-MM-DDTHH:MM:SS.FFFZ.

time_coverage_start (character): start UTC of the first block of the orbit; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYY-MM-DDTHH:MM:SS.FFFZ.

time_coverage_end (character): start UTC of the last block of the orbit; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYY-MM-DDTHH:MM:SS.FFFZ.

3.4 Data Characteristics

- number_of_beams** (4-byte integer): 3; number of antenna beams; order is inner, middle, outer.
- number_of_blocks** (4-byte integer): number of Aquarius science blocks in the orbit at 1.44-second intervals.
- radiometer_polarizations** (4-byte integer): 4; number of polarizations in raw radiometer data; order is V, +45, -45, H.
- radiometer_signals_per_subcycle** (4-byte integer): 5, number of radiometer antenna signal measurements in a 120 msec subcycle; first 2 are 20 msec, last 3 are 10 msec.
- radiometer_subcycles** (4-byte integer): 12; the number of 120 msec subcycles in a 1.44 second science block.
- scatterometer_polarizations** (4-byte integer): 2; number of scatterometer receive polarizations; order is V, H; last dimension of the **scat_rfi_flags** array (Section 4.2)
- scatterometer_subcycles** (4-byte integer): 8; the number of 180 msec subcycles in a 1.44 second science block.

3.5 File Metrics

- nominal_navigation** (character): "TRUE" or "FALSE"; indicates nominal pointing during the orbit; set to FALSE during maneuvers or anomalies.
- percent_rfi** (4-byte float): percent of radiometer data with the RFI flag set, computed as the number of RFI-flagged 10-ms samples divided by the total samples; if SA1 exclusion is enabled, these samples are not counted as either RFI-flagged or total.
- percent_water** (4-byte float): percent of data in this product not contaminated by land.

3.6 Orbit Coordinates

- cycle_number** (4-byte integer): number of the weekly cycle from the start of the mission. Cycle 1 started with the first orbit on 25 August 2011. Each cycle will contain 103 orbits.
- geospatial_lat_units** (character): "degrees North"; units used for all latitude values in this product.
- geospatial_lon_units** (character): "degrees East"; units used for all longitude values in this product.
- orbit_node_longitude** (4-byte float): longitude of scene's orbit ascending node (longitude at equatorial crossing of PM-side node).
- orbit_number** (4-byte integer): orbit number from the start of the mission.
- pass_number** (4-byte integer): pass (orbit) number within the weekly cycle (1 to 103).

4.0 Data Objects

The following groups of data objects -- Block Attributes, Aquarius Flags, Aquarius Data, Navigation, and Converted Telemetry -- contain data that are functions of blocks. That is, each data object within these groups has data for each block and is therefore dimensioned by the value of the global attribute, **Number of Blocks**. For objects that are dimensioned by beam and polarization, the order is specified in **3.4 Data Characteristics**.

4.1 Block Attributes

The following data objects belong to the group "Block Attributes". Attributes of the objects are shown in **bold**.

sec (8-byte float, array size **Number of Blocks**): **long_name** = "Block time, seconds of day"; **valid_range** = (0.d0,86399.999999d0); **units** = "seconds"; mid-block times of Aquarius physical parameter values in seconds of day.

secGPS (8-byte float, array size **Number of Blocks**): **long_name** = "Block time, GPS time"; **units** = "seconds"; block times of Aquarius physical parameter values in seconds since the GPS epoch (0 hours UTC on 6 January 1980).

rad_samples (2-byte integer array size **Number of Blocks** x **Number of Beams** x **Radiometer Polarizations**): **long_name** = "Number of radiometer samples per average"; number of radiometer samples used per block, beam and polarization in the radiometer parameter averages in the **Aquarius Data** group (section 4.3). Samples that are flagged for RFI interference (see **rad_rfi_flags** below) are not used in the averages. Note that the 20-msec DPU averages are counted as 2 samples. The maximum is 84 with all samples and 60 with SA1 excluded.

scat_samples (2-byte integer array size **Number of Blocks** x **Number of Beams**): **long_name** = "Number of scatterometer samples per average"; number of scatterometer samples used per block and beam in the scatterometer parameter averages in the **Aquarius Data** group (section 4.3). Samples that are flagged for RFI interference in either polarization (see **scat_rfi_flags** below) are not used in the averages, so this value is not polarization-dependent. This is done to ensure that RFI detected on one polarization does not corrupt the corresponding sample of the other polarization.

solar xray flux (4-byte float, array size **Number of Blocks**): The peak value of X-ray flux during a solar flare. This is used to generate a flag to identify occurrence of a solar flare. It is a surrogate for the associated L-band flux which is not as readily available. This long wavelength (1-8 A^o) from the GOES satellite is used and is available at: <http://www.swpc.noaa.gov/ftplib/lists/xray>.

4.2 Aquarius Flags

The following data objects belong to the group "Aquarius Flags". These represent the non-nominal data conditions that are detected for the radiometer and scatterometer measurements for each block and beam. The bit convention is 0-base, with the LSB as bit 0. Attributes of the objects are shown in **bold**. Beam and polarization order is specified in **3.4 Data Characteristics**.

rad_rfi_flags (byte, array size **Number of Blocks x Number of Beams x Radiometer Polarizations x Radiometer Subcycles**): **long_name** = "Radiometer RFI flags"; Radio frequency interference flags for each radiometer measurement in the block. Bit 2 represents the CND RFI flag. Bits 3 - 7 represent the individual radiometer short accumulations (SA1 - SA5) during each subcycle in a block. Each bit is set to 1 if RFI was detected for that measurement. The MSB and LSB are zero fill. If SA1 is excluded, bit 3 is also zero fill.

scat_rfi_flags (byte, array size **Number of Blocks x Number of Beams x Scatterometer Polarizations**): **long_name** = "Scatterometer RFI flags"; Radio frequency interference flags for each scatterometer measurement in the block, as identified by either the RFI algorithm on board the Aquarius instrument or the ground-processing RFI detection algorithm. The 8 bits of each entry represent the RFI flags for the individual scatterometer subcycle sequences in each block. There is one bit per sequence per receive polarization, in the sequence order (LSB) sequence 1, sequence 2, ..., sequence 8 (MSB), where sequence 1 comes first in time and sequence 8 comes last in the block. The RX polarization order is V-pol, H-pol.

radiometer_flags (4-byte integer, array size **Number of Blocks x Number of Beams x Max Radiometer Flags**): **long_name** = "Radiometer data quality flags"; each bit represents a data quality condition that was detected for that beam and block. For each flag condition, up to **Max Radiometer Flags** (last array dimension) individual flags are set per beam. Table 1 presents the condition associated with each flag, including the thresholds used; the meaning of the last dimension; the use as a flag or mask at Level-2, and the associated radiometer science data fields. Moderate and severe flags are mutually exclusive (e.g., the moderate flag is 0 if the severe flag is set). Any unused array elements are set to 0. This array has attributes that provide the names of the algorithms used in determining the setting of the flags. The algorithms associated with these names are described in "Flag Documentation", D. M. Le Vine, and "Proposal for Flags and Masks Version 3.0", D. M. Le Vine and T. Meissner. The use of the flags to exclude data from calibration analysis and Level-3 products is described in the notes.

scatterometer_flags (4-byte integer, array size **Number of Blocks x Number of Beams**): **long_name** = "Scatterometer data quality flags"; each bit represents a data quality condition that was detected for that beam and block. The algorithms associated with these flags, and the use of the corresponding bits as masks or as flags, are fully described in the Scatterometer Science Processing Software User Manual, AQ-485-0541, JPL D-51444.

rim_status_flag (4-byte integer, array size **Number of Blocks x Number of Beams**): **long_name** = "RIM processing status"; 2 bits flag for RIM computation. First bit in 1 indicates NOAA Climate Prediction Center Morphing Technique (CMORPH) is not available, second bit in 1 indicates CMORPH for IRR has been removed for low quality.

Table 1. Conditions indicated for the pixel associated with the setting of individual bits in **radiometer_flags**, along with the flag dimension and related data fields

Bit Set = 1	Condition Indicated	Last Flag Dimension	Flag/Mask	Data Fields
0 (LSB)	RFI moderate contamination $7 \leq \text{samples} < 15$	Polarization (V, P, M, H)	F	rad_samples
1	RFI severe contamination $\text{samples} < 7$	V, P, M, H	F	rad_samples
2	Rain in main beam rain: rate > 0.25 mm/hr missing data	Rain missing data	F/M F	rim_irr
3	Land contamination moderate: $0.001 < \text{land frac} \leq 0.01$ severe: $\text{land frac} > 0.01$ mask: $\text{land frac} > 0.5$	moderate severe mask	F F M	rad_land_frac
4	Sea ice contamination moderate: $0.001 < \text{ice frac} \leq 0.01$ severe: $\text{ice frac} > 0.01$ mask: $\text{ice frac} > 0.5$	moderate severe mask	F F M	rad_ice_frac
5	Wind/foam contamination moderate: $15 < \text{wind speed} \leq 20$ severe: $\text{wind speed} > 20$ wind speed non-convergence scatterometer flags 29 or 31 (severe RFI) set	moderate severe converge scat RFI	F M M M	anc_wind_speed rad_hh_wind_speed rad_hhh_wind_speed scatterometer_flags
6	Unusual brightness temperature moderate: $1.0 < \text{abs}(T_f - T_{a_exp}) \leq 3.0$ severe: $\text{abs}(T_f - T_{a_exp}) > 3.0$	V moderate V severe H moderate H severe	F	rad_TfV rad_exp_TaV rad_TfH rad_exp_TaH
7	Direct solar flux contamination moderate: $0.02 < \text{solar direct} \leq 0.05$ severe: $\text{solar direct} > 0.05$	V moderate V severe H moderate H severe	F	rad_solar_Ta_dir_V rad_solar_Ta_dir_H
8	Reflected solar flux contamination moderate: $0.02 < \text{solar reflect} \leq 0.05$ severe: $\text{solar reflect} > 0.05$	V moderate V severe H moderate H severe	F	rad_solar_Ta_ref_V rad_solar_Ta_ref_H
9	Sun glint moderate: $0.02 < \text{solar glint} \leq 0.05$ severe: $\text{solar glint} > 0.05$	V moderate V severe H moderate H severe	F	rad_solar_Ta_bak_V rad_solar_Ta_bak_H
10	Moon contamination ² moderate: $0.02 < \text{moon refl} \leq 0.05$ severe: $\text{moon refl} > 0.05$	V moderate V severe H moderate H severe	F	rad_moon_Ta_ref_V rad_moon_Ta_ref_H
11	Galactic contamination ² moderate: $0.02 < \text{galactic} \leq 0.05$ severe: $\text{galactic} > 0.05$	V moderate V severe H moderate H severe	F	rad_galact_Ta_ref_V rad_galact_Ta_ref_H
12	Non-nominal navigation $\text{abs}(\text{roll}) > 1.0$ $\text{abs}(\text{pitch}) > 1.0$ $\text{abs}(\text{yaw}) > 5.0$	roll pitch yaw	M M M	att_ang beam_clat beam_clon

	clat, clon = -999	OOB	M	
13	SA overflow Overflow bit set in NRT telemetry	overflow	M	radiom_nrt_tlm (L1A)
14	Roughness Correction roughness correction failure no SWH ³	roughness SWH	F F	anc_swh
15	Solar flare contamination moderate: 5.e-5 < flux ≤ 1.e-4 severe: flux > 1.e-4	moderate severe	F	solar xray flux
16	Pointing Anomaly AOCS anomaly from database ACS mode ≠ 5	anomaly acs_mode	M M	acs_mode
17	Rad Tb consistency rad_Tb_consistency > 0.4 emissivity = NaN	Tb_cons emissivity	F M	rad_Tb_consistency
18	Surface Temperature moderate: 0C ≤ SST < 5C severe: SST < 0C	moderate severe	F M	anc_surface_temp
19	RFI Level Moderate: TF – TA > 0.30 or -1.0 ≤ TF – TA < -0.30 Severe: TF-TA < -1.0 or > 0.30	moderate severe	F M	rad_TaX rad_TfX
20	Non-nominal commanded state OpLUT ≠ 0		M	L1A:dpu_status_tlm ¹
21	Moon Reflected Radiation Moon moderate: 0.25<Ta_ref≤0.5 Moon severe: Ta_ref > 0.5 Galaxy Reflected Radiation Ta_ref > 5.6 or (Ta_ref > 3.6 and HH wind < 3.0)	moderate severe severe severe	F M M M	rad_moon_Ta_ref_H rad_moon_Ta_ref_V rad_galact_Ta_ref_H rad_galact_Ta_ref_V rad_hh_wind_speed
22	Land RFI (Thresholds are, 1-3V 339 K; 344 K; 350 K and 1-3H 327 K; 321 K; 315 K)	V H Spare Spare	F	rad_TfV rad_TfH
23	Excessive Asc/Desc difference due to contamination from undetected RFI; geographic zones specified as external file		M	RFI region map ⁴
24 - 31 (MSB)	Spares			

Footnotes:

⁽¹⁾ dpu_status_tlm is a field in the Level-1A product.

⁽²⁾ These flags have been superseded by flag 21, but are retained for consistency with earlier versions.

⁽³⁾ SWH is not used in V5.0 roughness correction any more

⁽⁴⁾ not a field in L2

Data Masking Notes:

1. Masks for Calibration: The following flags (identified by bit number) are used as masks to isolate a subset of the Aquarius L2 data to be used for calibration: 2, 3, 4, 5, 6, 12, 13, 14, 16, 17, 18, 19, 21, 23. In the case of flags 3, 4, 5, 6 and 18, 19, 21 data are masked whenever the flag level is moderate or severe. For additional information see AQ-014-PS-0006.

2. Masks for L3: The masks used for calibration are also used for transferring data from L2 to L3. However, for L3 data are masked only if the level for flags 3, 4, 5, 18, 19, or 21 is severe, and flag 2 produces a separate L3 product.

Table 2. Conditions indicated for the pixel associated with the setting of individual bits in **scatterometer_flags**.

Bit Set = 1	Condition Indicated
(LSB) 0 – 10	Spares
11	Overall quality (1 = poor)
12	Negative power computed for TOI (antenna) HH sigma-0
13	Negative power computed for TOI (antenna) VH sigma-0
14	Negative power computed for TOI (antenna) VV sigma-0
15	Negative power computed for TOI (antenna) HV sigma-0
16	Unsuccessful Faraday rotation removal HH
17	Unsuccessful Faraday rotation removal VH
18	Unsuccessful Faraday rotation removal VV
19	Unsuccessful Faraday rotation removal HV
20	Non-nominal attitude (e.g., roll, pitch or yaw out of range)
21	Scatterometer beams off Earth
22	Negative power computed for TOA HH sigma-0
23	Negative power computed for TOA VH sigma-0
24	Negative power computed for TOA VV sigma-0
25	Negative power computed for TOA HV sigma-0
26	Rain in main beam (moderate)*
27	Rain in main beam (severe)*
28	RFI corruption of H-pol signal (moderate)
29	RFI corruption of H-pol signal (severe)
30	RFI corruption of V-pol signal (moderate)
31 (MSB)	RFI corruption of V-pol signal (severe)

(*) Not currently implemented

4.3 Aquarius Data

The Aquarius computed physical parameters in the Level-2 product are stored in data objects belong to the group "Aquarius Data". The complete list of available parameters is given in Sections 4.3.1 (Radiometer), 4.3.2 (Scatterometer), and 4.3.3 (Ancillary data). Each data object has a data type of 4-byte float and dimensions **Number of Blocks** x **Number of Beams**. All objects have standard attributes **long_name**, **valid_min**, **valid_max**, and **_FillValue**.

4.3.1 Radiometer Data

This section describes the Aquarius radiometer science data parameters, including references to the appropriate sections of the radiometer ATBD. Where the same parameter is provided at multiple polarizations, a single description is provided with the polarizations listed (e.g., {V, H}). Each data object has dimensions **Number of Blocks** x **Number of Beams**.

EIA_err: Estimated random error in boresight Earth Incidence Angle.

EIA_SSS_sens: Estimated SSS retrieval sensitivity to boresight Earth Incidence Angle random error.

NEDT_X_err, X = {V, H, 3}: Estimated radiometer Noise Equivalent Delta Temperature random error at polarization X.

NEDT_X_SSS_sens, X = {V, H, 3}: Estimated SSS retrieval sensitivity to radiometer Noise Equivalent Delta Temperature input at polarization X.

IU_coupling_err: Estimated systematic error in computing first (I) and third (U) stokes coupling.

IU_coupling_SSS_sens: Estimated SSS retrieval sensitivity to IU coupling correction.

rad_TaX0, X = {V, H, 3}: Radiometer antenna temperature at polarization X. This is the radiometer output (TOI), calibrated (counts to TA) and averaged to 1.44 sec blocks with no other processing.

rad_TaX, X = {V, H, 3}: Radiometer antenna temperature at polarization X corrected for instrumental errors. This is the radiometer output (TOI), calibrated (counts to TA) and averaged to 1.44 sec blocks (same as **rad_TaX0**), with a gain adjustment (specified by **Delta TND X coefficient**) and offset correction (**Radiometer Offset Correction**) applied (see description of these corrections in Section 3.2).

rad_TfX0, X = {V, H, 3}: Radiometer antenna temperature at polarization X after RFI removal. This is the radiometer output (TOI), calibrated (counts to TA) and averaged to 1.44 sec blocks (same as **rad_TaX0**) after RFI has been removed.

rad_TfX, X = {V, H, 3}: Radiometer antenna temperature at polarization X corrected for instrumental errors and RFI removal. This is the radiometer output (TOI), calibrated and averaged to 1.44 sec blocks (same as **rad_TaX**) but with RFI removed

rad_toi_X, X = {V, H, 3}: Brightness temperature from the surface at the radiometer (i.e. top of the ionosphere, TOI) at polarization X. This is obtained from the radiometer antenna temperature after RFI removal, **rad_TfX**, by removing all non-surface

- sources (except the atmosphere) and then applying the antenna pattern correction, APC. (ATBD, Section 3.3, Equation 46.)
- rad_toa_X_nolc**, $X = \{V, H\}$: Brightness temperature at the top of the atmosphere (TOA) at polarization X . This is obtained from the radiometer brightness temperature, **rad_toi_X**, by applying a correction for Faraday rotation. The Faraday rotation angle is obtained from **rad_toi_X**, using the ratio of the third and second Stokes parameters. (ATBD, Section 3.4, Equations 47-48).
- rad_toa_X**, $X = \{V, H\}$: Brightness temperature at the top of the atmosphere (TOA) at polarization X with a correction for land contamination. This is obtained from the radiometer brightness temperature, **rad_toa_X_nolc**, by applying an additional correction for contamination due to land appearing in the antenna sidelobes. This is not a correction for land in the main beam. (ATBD, Section 3.8, Equation 55)
- rad_far_rot_ang**: Faraday rotation angle determined from the ratio of the third and second Stokes parameters using data in **rad_toi_X**. This is the angle used in converting from **rad_toi_X** to **rad_toa_X_nolc** (ATBD, Section 3.4, Equations 47-48).
- rad_galact_Ta_dir_X**, $X = \{V, H, 3\}$: Celestial background radiation at L-band impinging directly on the radiometer antenna. In nominal operation it enters via the antenna sidelobes (ATBD Section 2.2.1).
- rad_galact_Ta_err**: Estimated systematic error in galactic effects. This value is derived for I/2.
- rad_galact_Ta_SSS_sens**: Estimated SSS retrieval sensitivity to galactic effects. This value is derived for I/2.
- rad_galact_Ta_ref_X**, $X = \{V, H, 3\}$: Celestial background radiation at L-band after reflection from the Earth surface. In nominal operation (i.e. pointing toward the surface) it enters primarily via the antenna mainbeam. A constant value of 3.0 K is removed and treated separately (ATBD Section 2.2.1).
- rad_galact_Ta_ref_GO_X**, $X = \{V, H\}$: Celestial background radiation at L-band after reflection from the Earth surface, derived from geometric optics with no empirical adjustment. (ATBD Addendum III, Section 5).
- rad_geo_rot_ang**: Geometric rotation angle.
- rad_galact_dTa_X**, $X = \{V, H\}$: Empirical adjustment to the correction for reflected celestial background radiation at L-band. (ATBD Addendum III, Section 5).
- rad_pol_rot_ang**: Radiometer polarization rotation angle.
- rad_solar_Ta_dir_X**, $X = \{V, H, 3\}$: Direct radiation from the Sun. Radiation from the Sun, arriving via line-of-sight from the Sun. This enters via the radiometer antenna sidelobes. The radiation is proportional to the mean solar flux (no flares). (ATBD Section 2.2.3)
- rad_solar_Ta_ref_X**, $X = \{V, H, 3\}$: Reflected radiation from the Sun. The radiation arrives after reflection from the Earth surface and enters through the antenna side lobes. The radiation is proportional to the mean solar flux (no flares). (ATBD Section 2.2.4)

rad_solar_Ta_bak_X, $X = \{V, H, 3\}$: Sun glint. Radiation from the Sun which is scattered from the rough ocean surface toward the radiometer. This is only significant when the footprint of the main antenna beam is illuminated by the Sun. (ATBD Section 2.2.5)

rad_moon_Ta_ref_X, $X = \{V, H, 3\}$: Radiation from the Moon at polarization X after reflection from the Earth. This is important several times each month when the reflection occurs close to the footprint of the antenna main beam (ATBD Section 2.2.6).

rad_moon_Ta_err: Estimated systematic error in lunar effects. This value is derived for 1/2.

rad_moon_Ta_SSS_sens: Estimated SSS retrieval sensitivity to lunar effects. This value is derived for 1/2.

rad_TbV_land_contam_err: Estimated systematic error in ocean surface Tb land contamination calculation.

rad_TbV_land_contam_SSS_sens: Estimated SSS retrieval sensitivity to ocean surface Tb land contamination correction.

rad_TbV_ice_contam_err: Estimated systematic error in ocean surface Tb sea-ice contamination calculation.

rad_TbV_ice_contam_SSS_sens: Estimated SSS retrieval sensitivity to ocean surface Tb sea-ice contamination correction.

rad_TbX, $X = \{V, H\}$: Brightness temperature at the surface prior to making a correction for roughness. This is obtained from **rad_toa_X** after correction for attenuation and emission from the atmosphere (ATBD Section 3.5).

rad_TbX_nolc, $X = \{V, H\}$: Brightness temperature at the surface prior to making a correction for roughness but without the correction for land in the antenna sidelobes. This is obtained from **rad_toa_X_nolc** after correction for attenuation and emission from the atmosphere (ATBD Section 3.5).

rad_TbX_rc, $X = \{V, H\}$: Brightness temperature at the surface after making a correction for roughness. This is obtained from **rad_TbX** after correction for roughness (ATBD Section 3.6; Addendum, Section III).

rad_TbX_rc_nolc, $X = \{V, H\}$: Brightness temperature at the surface after making a roughness correction but without making a correction for land in the sidelobes. This is obtained from **rad_TbX_nolc** after correction for roughness (ATBD Section 3.6; Addendum Section III).

rad_Tb_consistency: Magnitude of the difference between the measured brightness temperature at the surface after all corrections (**rad_TBX_rc**) and the predicted values obtained using the derived SSS (not HYCOM) and a flat surface. The difference is squared, summed over both polarizations and the square root taken.

rad_Tb_consistency_nolc: Same as **rad_Tb_consistency** but using the measured values before land correction (i.e. using **rad_TbX_nolc_rc**).

RFI_level_err: Estimated systematic error in RFI level calculation.

RFI_level_SSS_sens: Estimated SSS retrieval sensitivity to RFI level.

- SSS:** Retrieved sea surface salinity. Obtained from **rad_TbX_rc** (ATBD Section 3.6; Addendum Section IV).
- SSS_matchup:** the Argo salinity that collocated with Aquarius footprints. It is for validation purposes and not used in calibration. Ref. Doc_____
- SSS_nolc:** Retrieved sea surface salinity with no land sidelobe correction. Obtained from **rad_TbX_nolc_rc** (ATBD Section 3.6; Addendum Section IV).
- SSS_unc:** Estimated total uncertainty in **SSS** including random and systematic components.
- SSS_unc_EIA:** Estimated SSS retrieval uncertainty due to boresight Earth Incidence Angle random error.
- SSS_unc_galact_Ta:** Estimated SSS retrieval uncertainty due to galactic effect systematic error.
- SSS_unc_IU_coupling:** Estimated SSS retrieval uncertainty due to IU coupling systematic error.
- SSS_unc_moon_Ta:** Estimated SSS retrieval uncertainty due to moon effect systematic error.
- SSS_unc_NEDT_X,** $X = \{V, H, 3\}$: Estimated SSS retrieval uncertainty due to radiometer Noise Equivalent Delta Temperature random error at polarization X.
- SSS_unc_RFI_level:** Estimated SSS retrieval uncertainty due to RFI level systematic error.
- SSS_unc_ran:** Estimated random component of uncertainty in **SSS**.
- SSS_unc_surface_temp:** Estimated SSS retrieval uncertainty due to sea surface temperature systematic error.
- SSS_unc_sys:** Estimated systematic component of uncertainty in **SSS**.
- SSS_unc_TbV_land_contam:** Estimated SSS retrieval uncertainty due to ocean surface Tb land contamination systematic error.
- SSS_unc_TbV_ice_contam:** Estimated SSS retrieval uncertainty due to ocean surface Tb sea-ice contamination systematic error.
- SSS_unc_wind_speed_rand:** Estimated SSS retrieval uncertainty due to wind speed random error.
- SSS_unc_wind_dir_rand:** Estimated SSS retrieval uncertainty due to wind direction random error.
- SSS_unc_wind_speed_syst:** Estimated SSS retrieval uncertainty due to wind speed systematic error.
- density:** Sea surface density derived from Aquarius SSS and ancillary SST using TEOS-10 equation of state (McDougall & Barker, 2011).
- Spiciness:** Sea surface spiciness (McDougall & Krzysik, 2015) derived from Aquarius SSS and ancillary SST using TEOS-10 equation of state (McDougall & Barker, 2011). As of GSW 3.05, it's now officially implemented in the GSW toolbox/TEOS-10 as `gsw_spiciness0`: http://www.teos-10.org/pubs/gsw/html/gsw_spiciness0.html

- rad_exp_TaX**, $X = \{V, H, 3\}$: Model derived radiometer antenna temperature. The antenna temperature is obtained using the salinity field from the HYCOM model and working the retrieval algorithm in reverse (ATBD Section 3.7).
- rad_exp_TaX_hhh**, $X = \{V, H, 3\}$: Model derived radiometer antenna temperature using the derived wind speed (**rad_hhh_wind_speed**). The antenna temperature is obtained using the salinity field from the HYCOM model and working the retrieval algorithm in reverse (ATBD Section 3.7).
- rad_exp_TbX**, $X = \{V, H\}$: Predicted brightness at the surface using the HYCOM salinity field. The brightness temperature (ATBD, Equation 43-44) is computed for a smooth surface to which the roughness correction (ATBD, Addendum, Section III) is added.
- rad_exp_TbX0**, $X = \{V, H\}$: Brightness temperature of an ideal surface (i.e. flat, with no waves) and with the salinity of the HYCOM reference ocean and Reynolds SST, but modified as described in Equations 43-44 of the ATBD.
- rad_hh_wind_speed**: Wind speed derived using the measured scatterometer sigma-0 and sigma-0 wind model function at HH-pol (ATBD Addendum III, Section 2). This is used as the wind during calibration (drift correction). It is also used as the wind in the correction for reflected galactic and solar radiation.
- rad_hhh_wind_speed**: Wind speed derived using the scatterometer sigma-0 at HH-pol and the radiometer Tb at H-pol (ATBD Addendum III, Section 2). This is used for the wind in the surface roughness correction for the final science product (ATBD Addendum III, Section 3).
- rad_dtb_sst_wspd_X**, $X = \{V, H\}$: Radiometer SST bias emissivity correction (Addendum IV to ATBD, RSS Technical Report #061515).
- rad_wind_dir_rand_err**: Estimated random error in radiometer derived wind direction.
- rad_wind_dir_rand_SSS_sens**: Estimated SSS retrieval sensitivity to random error in wind direction.
- rad_wind_speed_rand_err**: Estimated random error in radiometer derived wind speed.
- rad_wind_speed_rand_SSS_sens**: Estimated SSS retrieval sensitivity to random error in wind speed.
- rad_wind_speed_syst_err**: Estimated systematic error in radiometer derived wind speed.
- rad_wind_speed_syst_SSS_sens**: Estimated SSS retrieval sensitivity to systematic error in wind speed.

4.3.2 Scatterometer Data

This section describes the Aquarius scatterometer science data parameters. Where the same parameter is provided at multiple polarizations, a single description is provided with the polarizations listed (e.g., {V, H}). Each data object has dimensions **Number of Blocks** x **Number of Beams**.

scat_X_ant, X = {VV, HH, HV VH}: Estimated normalized radar cross-section (NRCS, or sigma-0) at the antenna (i.e., TOI, top of ionosphere) for each polarization.

scat_X_toa, X = {VV, HH, HV VH}: Estimated normalized radar cross-section (NRCS, or sigma-0) at the top of the atmosphere (TOA), after Faraday rotation and cross-pol leakage corrections, for each polarization.

scat_tot_toa: Estimated normalized radar cross-section (NRCS, or sigma-0) for the total power received by the radar for each beam (the sum of the power in all four channels, which is independent of Faraday rotation).

scat_wind_speed: Estimated wind speed at the ocean surface.

wind_uncertainty (4-byte real, array size **Number of Blocks** x **Number of Beams**):
long_name = "Estimated wind speed error"; **units** = m/s; Estimated uncertainty in wind speed at the ocean surface. This is currently a lower bound for the error, derived from the Kpc variance propagated through wind retrieval.

scat_esurf_X, X = {V, H}: Excess surface emissivity due to wind for V and H polarizations derived from scatterometer data and the radiometer model function.

scat_esurf_X_uncertainty, X = {V, H}: Estimated uncertainty in excess surface emissivity for V and H pol. This is currently a lower bound for the error, derived from the Kpc variance propagated through wind retrieval.

Kpc_X_ant, X = {VV, HH, HV VH}: Statistical uncertainty for the antenna sigma-0 (Kpc = $\sqrt{\text{var}(\text{sig-0})}/\text{sig-0}$)

Kpc_X_toa, X = {VV, HH, HV VH}: Statistical uncertainty for the top-of-atmosphere sigma-0 (Kpc = $\sqrt{\text{var}(\text{sig-0})}/\text{sig-0}$). Algorithm still TBD; current KPC_TOA output is preliminary.

Kpc_total: Statistical uncertainty for the total power sigma-0.

scat_X_exp, X = {VV, HH, HV VH}: Estimated normalized radar cross-section (NRCS, or sigma-0) at the surface for each polarization, predicted using a geophysical model based on the wind data set over ocean only. Over land, this value defaults to -999.

4.3.3 Ancillary Data

The ancillary data parameters used for the Aquarius science data processing are described in this section. All parameters are interpolated in space and time to the Aquarius beam footprints unless otherwise specified. Each data object has dimensions **Number of Blocks x Number of Beams** unless specified.

anc_wind_speed: The wind speed from NCEP GFS GDAS at 10 m. Data is available from: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>. In the L2 algorithm this NCEP GDAS wind speed is multiplied by a factor of 1.03 in order to make it consistent with observations from buoys and microwave satellites (SSM/I, WindSat).

anc_wind_dir: The wind direction over the ocean is obtained from the NCEP GFS GDAS 10 meter level. The direction conforms to the meteorological convention (i.e. the wind direction is the direction from which the wind is blowing). In the current algorithm for the roughness correction, the direction dependence is determined using this value (expressed as azimuthal angle relative to the look direction, **celphi**). Both radiometer and scatterometer observations are corrected for wind direction. (ATBD, Addendum I). Data is available from: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

anc_cwat: The total columnar liquid water above the viewed location. In the processing, it is used to calculate the integral along the slant path of the radiometer boresight. Approximately, this is the value obtained by dividing by cosine (**celtht**, see Table 3). The actual calculation is done slightly differently (see ATBD). The data are obtained from the NCEP GFS GDAS at: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

anc_swe: The snow water equivalent from NCEP GFS GDAS. Data is obtained from: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

anc_surface_temp: The surface temperature over the ocean is the Canadian Meteorological Center product. Over land, the GEOS-5 product for the surface layer is used. Data is ordered from, http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl?LOOKUPID_List=MST1NXMLD, select `tavg1_2d_mld_Nx` from the Data Product pull down tab and select TSURF.

anc_surface_temp_err: Estimated systematic error in ancillary sea surface temperature input.

anc_surface_temp_SSS_sens: Estimated SSS retrieval sensitivity to ancillary sea surface temperature input.

anc_surface_pressure: Atmospheric pressure is obtained from the NCEP GFS GDAS. The value at the surface at radiometer boresight is listed in this field (the vertical profile is used in the algorithm; ATBD, Section 2.3.2). Data is obtained from: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

anc_subsurf_temp: The subsurface temperature over the land is for the layer (0-5 cm) because emission from this layer is most closely correlated with soil moisture. This field is not valid over the ocean. Data is ordered from GEOS-5, http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl?LOOKUPID_List=MST1NXMLD, select `tavg1_2d_mld_Nx` from the Data Product pull down tab and select TSOIL1.

anc_SSS_hycom: The reference sea surface salinity used for computing **rad_exp_TbX**. It is obtained from the hybrid coordinate ocean model (HYCOM: <http://hycom.org>) with data assimilation, operated in support of US Navy operations and provided by the Florida State University Center for Ocean-Atmosphere Prediction Studies (FSU/COAPS).

anc_SSS_argo: interpolated monthly Scripps Institution of Oceanography Argo salinity data (http://sio-argo.ucsd.edu/RG_Climatology.html). It is used whenever valid values are present in the calibration loop.

anc_trans: A measure of attenuation through the atmosphere. It is the parameter, $\tau(0,S)$, defined in equation 28-29 in the section 2.3.1 of the Level-2 ATBD. When $\tau(0,S) = 0$ the path is completely opaque.

anc_Tb_up: A measure of the upwelling radiation from the atmosphere at L-band. It is expressed as the effective brightness temperature at the top of the atmosphere and defined by Equation 30 in Section 2.3.1 of the Level-2 ATBD.

anc_Tb_dw: A measure of the downwelling radiation from the atmosphere at L-band. It is expressed as the effective brightness temperature at the bottom of the atmosphere and defined by Equation 31 in Section 2.3.1 of the Level-2 ATBD.

anc_sm: The soil moisture content when over land. This is obtained from the GEOS-5 data, http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl?LOOKUPID_List=MST1NXMLD, select `tavg1_2d_mld_Nx` from the Data Product pull down tab and select SFMC.

anc_swh: The significant wave height data from NCEP, used for the radiometer Tb surface roughness correction. Data is obtained from: <ftp.ncep.noaa.gov/pub/data/nccf/com/wave/prod/>.

rad_land_frac: The gain weighted land fraction: Integration over the radiometer footprint with 1 = land and 0 = non-land (water and sea ice) weighted by the antenna pattern. Computation is made using the GSFC ODPS (SeaWiFS) 1 km resolution land mask. "Land" includes ice/snow covered land.

rad_ice_frac: The gain weighted fraction of sea ice in the radiometer footprint. The Integration is over the radiometer footprint with 0 = water and 0 = land and 1 = sea ice weighted by the antenna pattern. Computation is made using the NCEP GFS GDAS ice product: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>.

rim_anom[1,3,5]: Sea surface salinity anomalies for different depths (surface, 1m, 3m and 5m) due to rain impact.

rim_bf_irr: Rain Beam Fill fraction for the Instantaneous Rain Rate, computed from rain impact model (RIM). Represents area weighted percentage of the beam that exceeds an IRR threshold (0.25 mm/hour). Units = "%"

rim_irr: Instantaneous Rain Rate computed from RIM. Units = "millimeter/hour"

rim_pss: Probability of Salinity Stratification computed from RIM.

rim_sss: The sea surface salinity estimation based on HYCOM and RIM. Units = PSU.

scat_land_frac: The gain weighted fraction of land in the scatterometer footprint. The computation is made using the 2-way beam pattern and GSFC ODPS 1 km land mask. Land fractions should be less than 0.005, and preferably less than 0.001.

See the "Scatterometer Science Processing Software (L1A_to_L2) User Manual" for additional information.

scat_ice_frac: The gain weighted fraction of sea ice in the scatterometer footprint. The computation is made using the 2-way beam pattern and the NCEP sea-ice map: <ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/>. The values range from 0.0 (no sea ice) to 1.0 (totally ice). Sea ice errors should be less than 0.02. See the "Scatterometer Science Processing Software (L1A_to_L2) User Manual" for additional information.

4.4 Navigation

The group "Navigation" includes the spacecraft orbit and attitude information, celestial object locations and the geolocation fields. For the last, there are separate fields for the radiometer, the scatterometer, and the MWR (TBA). The spacecraft and celestial object fields are described below, and the geolocation fields are given in Table 3. All of the fields in Table 3 have a data type of 4-byte float and dimensions **Number of Blocks** x **Number of Beams**; the fields cellatfoot, cellonfoot, scat_latfoot and scat_lonfoot have an additional dimension of 4 corresponding to the four beam ellipse points. All geolocation fields are computed at the mid-block times represented by the data field **sec** in the **Block Attributes** group.

orb_pos (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Orbital position vector"; **valid_range** = (-7100000.,7100000.); **units** = "meters"; orbit position vector at mid-block times; used to determine spacecraft position for geolocation.

orb_vel (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Orbital velocity vector"; **valid_range** = (-7600.,7600.); **units** = "meters per second"; orbit velocity vector at mid-block times; used to determine spacecraft position for geolocation.

sclon (8-byte float, array size **Number of Blocks**): **long_name** = "Spacecraft nadir point longitude"; **valid_range** = (-180., 180.); **units** = "degrees"; longitude of the spacecraft orbit nadir point.

sclat (8-byte float, array size **Number of Blocks**): **long_name** = "Spacecraft nadir point latitude"; **valid_range** = (-90., 90.); **units** = "degrees"; latitude of the spacecraft orbit nadir point.

scalt (8-byte float, array size **Number of Blocks**): **long_name** = "Spacecraft altitude"; **valid_range** = (650,000., 690,000.); **units** = "meters"; spacecraft orbit altitude.

zang (8-byte float, array size **Number of Blocks**): **long_name** = "Intra-Orbit Angle"; **valid_range** = (0., 360.); **units** = "degrees"; angle within orbit from South pole passage at mid-block times.

att_ang (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Spacecraft roll, pitch, yaw"; **valid_range** = (-180.,180.); spacecraft attitude Euler angles at mid-block times; relates spacecraft orientation to orbit reference frame.

acs_mode (1-byte integer, array size **Number of Blocks**): **long_name** = "ACS control mode"; spacecraft attitude control system (ACS) mode for each block (5 = science, 6 = propulsion, 3 = safehold, 12 = survival).

sund (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Earth-to-Sun unit vector (eci)"; **valid_range** = (-1,1); **units** = "unitless"; direct Sun vector in ECI coordinates at mid-block times.

sunr (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Sun reflection unit vector (eci)"; **valid_range** = (-1,1); **units** = "unitless"; reflected Sun vector in ECI coordinates at mid-block time.

moond (8-byte float, array size **Number of Blocks** x 3): **long_name** = "Earth-to-Moon unit vector (eci)"; **valid_range** = (-1,1); **units** = "unitless"; Moon vector in ECI coordinates at mid-block time.

Table 3. Available Geolocation Parameters for Aquarius Level-2 Products

Name	Long Name	Valid Range	Units
beam_clat	Beam Center Latitude	-90 – 90	Degrees
beam_clon	Beam Center Longitude	-180 – 180	Degrees
cellatfoot	Geodetic Latitudes (3 db)	-90 – 90	Degrees
cellonfoot	Geodetic Longitudes (3db)	-180 – 180	Degrees
celtht*	Boresight Earth Incidence Angle	0 – 90	Degrees
celphi	Boresight Earth Azimuth Angle	0 – 360	Degrees
sunglt	Sun Glint Angle	-180 – 180	Degrees
suntht	Sun Vector Earth Incidence Angle	-180 – 180	Degrees
sunphi	Sun Vector Earth Azimuth Angle	0 – 360	Degrees
moonglt	Moon Glint Angle	0 – 180	Degrees
glxlat	Galaxy Declination (J2000)	-90 – 90	Degrees
glxlon	Galaxy Right Ascension (J2000)	0 - 360	Degrees
scat_beam_clat	Scatterometer Beam Center Latitude	-90 – 90	Degrees
scat_beam_clon	Scatterometer Beam Center Longitude	-180 - 180	Degrees
scat_latfoot	Scatterometer Latitude Footprint	-90 – 90	Degrees
scat_lonfoot	Scatterometer Longitude Footprint	-180 - 180	Degrees
scat_polarization_roll	Scatterometer Polarization Roll Angle	-180 - 180	Degrees

* Parameters related to uncertainty in SSS retrieval

4.5 Converted Telemetry

The following data objects belong to the group "Converted Telemetry". Attributes of the objects are shown in **bold**. This group contains Aquarius temperatures in the **rad_caltemps** object, unpacked from raw telemetry and converted to physical units; and the computed radiometer gain and offset values used to calibrate the antenna brightness temperatures, shown in Table 4. The data objects in the table each have dimensions **Number of Blocks x Number of Beams**.

rad_caltemps (4-byte float, array size **Number of Blocks** x 85): **long_name** = "Radiometer calibration temperatures"; Aquarius temperatures used to calibrated the instrument brightness temperatures. List in order is, ET_FD1_TMP, ET_FD2_TMP, ET_FD3_TMP, ET_OMT1_H_PROBE_TMP, ET_OMT1_V_PROBE_TMP, ET_OMT2_H_PROBE_TMP, ET_OMT2_V_PROBE_TMP, ET_OMT3_H_PROBE_TMP, ET_OMT3_V_PROBE_TMP, ET_CPLR_1H_TMP, ET_CPLR_1V_TMP, ET_CPLR_2H_TMP, ET_CPLR_2V_TMP, ET_CPLR_3H_TMP, ET_CPLR_3V_TMP, ET_DPLX_1H_TMP, ET_DPLX_1V_TMP, ET_DPLX_2H_TMP, ET_DPLX_2V_TMP, ET_DPLX_3H_TMP, ET_DPLX_3V_TMP, RD_RFE1_HDL1TN, RD_RFE1_HDL1TP, RD_RFE1_VDL1TN, RD_RFE1_VDL1TP, RD_RFE2_HDL1TN, RD_RFE2_HDL1TP, RD_RFE2_VDL1TN, RD_RFE2_VDL1TP, RD_RFE3_HDL1TN, RD_RFE3_HDL1TP, RD_RFE3_VDL1TN, RD_RFE3_VDL1TP, ET_RFL1_TMP, ET_RFL2_TMP, ET_RFL3_TMP, ET_RFL4_TMP, ET_RFL5_TMP, ET_RFL6_TMP, ET_RFL7_TMP, ET_RFL8_TMP, RD_RBE1_D_VT, RD_RBE1_D_PT, RD_RBE1_D_MT, RD_RBE1_D_HT, RD_RBE2_D_VT, RD_RBE2_D_PT, RD_RBE2_D_MT, RD_RBE2_D_HT, RD_RBE3_D_VT, RD_RBE3_D_PT, RD_RBE3_D_MT, RD_RBE3_D_HT, SC_LVPS_BOX_TEMP, SC_SSPA_RF_DCK_TMP, SC_SCG_TMP, SC_SBE_LNA_TMP, SC_SBE_TX_CHN_TMP, SC_SBE_RX_CHN_TMP, SC_SFE_TX_LOAD_TMP, SC_SBE_STP_ATTEN_TMP, SC_SFE_LBK_ATTEN_TMP, SC_SFE_LBK_SW_TMP, SC_SFE_BM_SW_TMP, ET_SFE_H1_COAX_TMP, ET_SFE_H2_COAX_TMP, ET_SFE_H3_COAX_TMP, ET_SFE_V1_COAX_TMP, ET_SFE_V2_COAX_TMP, ET_SFE_V3_COAX_TMP, RD_RFE1_CNDNDT, RD_RFE1_VNDTP, RD_RFE1_HNDTP, RD_RFE1_VNDTN, RD_RFE1_HNDTN, RD_RFE2_CNDNDT, RD_RFE2_VNDTP, RD_RFE2_HNDTP, RD_RFE2_VNDTN, RD_RFE2_HNDTN, RD_RFE3_CNDNDT, RD_RFE3_VNDTP, RD_RFE3_HNDTP, RD_RFE3_VNDTN, RD_RFE3_HNDTN. In the mnemonics, "ET" means external, "FD" means feed horn, "TMP" means temperature reading, "OMT" means orthomode transducer, "H" or "V" is the polarization, "CPLR" means coupler, "DPLX" means diplexer, "RFE" means radiometer front end, "HDL1TN" means H-pol dicke load 1 temperature negative, "VDL1TP" means V-pol dick oad 1 temperature positive, "RFL" means reflector, "RBE" means radiometer back end, "D_V[P,M,H]" means detector temperature for V, P, M and H channels, "SC" means space craft, "SC_SCG_TMP" is the scatterometer chirp generator temperature, "SBE" means scatterometer backend, "T[R]X_CHN" means transmitter/receiver channel, "SC_SBE_STP_ATTEN_TMP" is the SBE step attenuator temperature, "LBK" means loopback, "SW" means switch, "SFE" means scatterometer front end, "ND" means noise diode, "VNDTN" means V-pol ND temperature negative. See reference document "AQU-REF-001505_comprehensive_ATBD_TAA.pdf" for application of these temperatures in radiometer counts to Ta calibration.

Table 4. Radiometer Calibration Gains and Offsets

Name	Long Name	Units
rad_ghh	Radiometer HH gain	counts/Kelvin
rad_gmm	Radiometer MM gain	counts/Kelvin
rad_gpp	Radiometer PP gain	counts/Kelvin
rad_gvv	Radiometer VV gain	counts/Kelvin
rad_oh	Radiometer H offset	counts
rad_om	Radiometer M offset	counts
rad_op	Radiometer P offset	counts
rad_ov	Radiometer V offset	counts

5.0 Change History

Date	Description	By
3/6/2012	Added fields and metadata to the product format to reflect the ND-based radiometer calibration correction and the scatterometer-based roughness correction; removed SSS_land; added new radiometer flags.	Fred Patt
3/8/2012	Removed unneeded calibration fields from Converted Telemetry group.	Fred Patt
3/20/2012	Added uncorrected Tb back; added DR fit coefficients as metadata	Fred Patt
4/9/2012	Revised radiometer flag structure; changed rad_Tb_error to rad_Tb_consistency.	Fred Patt
7/31/2012	Revised radiometer flags and improve description according to recommendations by D. Le Vine; updated scatterometer fields based on software user's guide update, and field/flag descriptions based on input from A. Freedman.	Fred Patt
8/23/2012	Added new radiometer fields for V1.3.4; corrected and clarified multiple items based on comments from D. Le Vine.	Fred Patt
9/17/2012	Added new radiometer fields for V1.3.5.	Fred Patt
12/13/2012	Added new metadata and ancillary fields for V1.3.7.	Fred Patt
1/30/2013	Revamped the description of the Aquarius science data fields; updated the global and object-level attributes to be CF compliant.	Fred Patt

2/12/2013	Mean solar L-band flux made a global attribute; X-ray flux moved to Block Attributes .	Fred Patt
3/07/2014	Incorporated updates to radiometer quality flags and data fields based on D. Levine flag document and information from algorithm team.	Fred Patt
3/20/2014	Minor corrections and revisions based on comments.	Fred Patt
4/4/2014	Updated radiometer flags.	Fred Patt
5/13/2014	Added SSS_bias_adj field.	Fred Patt
6/25/2015	Updated SSS fields and added density for V4.0.	Fred Patt
11/5/2015	Addition of SSS uncertainty analysis parameters	Liang Hong
1/28/2016	Added spiciness and 5 RIM products	Liang Hong
6/23/2016	Added 3 RIM_SSS products	Liang Hong
10/4/2016	Updated land surface temp and soil moisture data source	Liang Hong
7/18/2017	Updated mission and documentation section to reflect latest changes in L2 metadata	Liang Hong
9/21/2017	Added complete list of temperatures for radiometer calibration	Liang Hong