AQUARIUS USER GUIDE

Aquarius Dataset Version 2.0

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Summary

On June 10, 2011 the Aquarius/SAC-D mission was launched. The mission is a joint effort between NASA and the Argentinian Space Agency, CONAE (Comisión Nacional de Actividades Espaciales), and is the first mission with the primary goal of measuring salinity from space. The Aquarius/SAC-D observatory carries the Aquarius microwave radiometer. Given the challenge of remotely sensed salinity observation for intended oceanographic and climate science-related applications, this instrument was built to be an order of magnitude more accurate than any previous earth science radiometers previously launched. Other instrumentation onboard includes a scatterometer providing coincident measurements used in sea surface roughness corrections critical for obtaining more accurate salinity retrievals.

The flow of evaluation data products from Aquarius began on 8/27/2012, and February 2013 sees a milestone in calibration/evaluation efforts by the Aquarius Science Team with the release of the validated (v2.0) Aquarius dataset. The Aquarius data are processed and provided by the Ocean Biological Processing Group (OBPG, NASA/GSFC), and the Physical Oceanography Distributed Active Archive Center (PO.DAAC, NASA/JPL) is the designated NASA data archive of the Aquarius project. PO.DAAC hosts all Aquarius datasets identified by the Science Team for long-term archival. This document is a guide to understanding, reading, accessing and using the Aquarius data products available from PO.DAAC. Pointers to detailed documentation on specific technical matters pertaining to Aquarius and other key external information resources are also provided.

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1 Introduction

This document is the Physical Oceanography Distributed Active Archive Center's (PO.DAAC) Aquarius data user's guide. The Guide is current to v2.0 of the Aquarius dataset, released and publicly available via PO.DAAC February 2013. Version 2.0 is an important milestone for Aquarius; it represents the first operational/science data release for Aquarius and is the culmination of a year's worth of calibration/evaluation efforts by the project.

1.1 Purpose

The purpose of this user guide document is to provide a comprehensive description of the content, format, and usage of the Aquarius data products, and the supported Level-2 swath and Level-3 mapped image data in particular. Information on how to access all Aquarius data products hosted at PO.DAAC is provided. Information resource and pointers to specific, detailed technical documentation of potential importance to Aquarius users are also given. We begin with a brief, general overview of the Aquarius mission.

1.2 Overview of the Aquarius/SAC-D Mission

Aquarius is a mission of original discovery and exploration that aims to measure sea surface salinity from space in order to provide a global view of salinity variability needed for climate studies. The mission is a collaboration between NASA and CONAE (Comisión Nacional de Actividades Espaciales), the Space Agency of Argentina.

Three decades of scientific and technological development have made it possible to accurately measure sea surface salinity (SSS) from 657 kilometers above the earth's surface. The Aquarius/SAC-D satellite orbits the earth approximately every 98 minutes, and with a swath width of 390 km across-track, completely surveys the earth every 7 days (Figure 1). Given target applications, the mission specification is for monthly averaged SSS at 150 km spatial resolution to an accuracy of 2 parts per thousand (PSU). With over 86% of global evaporation and 78% of global precipitation processes occurring over the ocean, the unprecedented frequency, broad-scale coverage, and accuracy of remotely sensed salinity data from Aquarius will provide important new insights on the hydrological cycle, oceanographic processes, and climate, greatly expanding upon extremely limited past measurements.

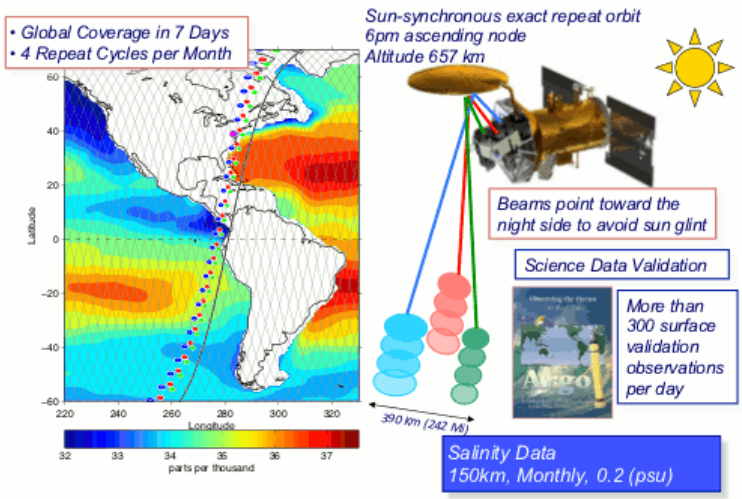


Figure 1. Aquarius Mission Design and Measurement Approach.

1.2.1 Sea Surface Salinity Definition

Sea surface salinity, or SSS, is the salinity of seawater near the surface of the ocean that is expressed in practical salinity units (PSU) or grams of salt/1000 grams of seawater. Aquarius uses a microwave radiometer with a 1.414 GHz range that penetrates to approximately 1mm below the ocean surface. Brightness temperatures are derived from three radiometers and are used to determine the salinity. Corrections for the roughness of the ocean surface, based on an onboard scatterometer, as well as sea surface temperature, must be applied to determine an accurate SSS. Thus the resultant salinity may be considered a measurement characteristic of the top 1mm of the ocean surface.

1.2.2 Aquarius Orbit

- Sun-synchronous exact repeat orbit
- Global coverage in 7 days
- Altitude of 657 km
- Orbit period ~97 minutes 52 seconds -- 14 to 15 orbits per day – 103 orbits per week
- An orbit is defined as starting when the SAC-D spacecraft passes the South Pole.
- Ascending node of 6pm (crosses equator while traveling north at 6pm local time and while traveling south at 6am local time). This ascending node allows it to straddle the boundary between dawn and dusk at all but the highest latitudes.

1.2.3 Aquarius Instruments

- 3 radiometers in push broom alignment
- Beams are at incidence angles of 28.7, 37.8, and 45.6^{o} incident to the ocean surface. The beams point away from the sun to mitigate glint.
- Footprints for the beams are: 74 km along track x 94 km cross track, 84x120 km and 96x156 km yielding a total cross track of 370 km.
- Radiometers measure brightness temperature at 1.414 GHz in the horizontal and vertical polarizations (T_H and T_V).
- Includes a scatterometer to measure ocean backscatter in each footprint. The scatterometer will alternately get data from each of the radiometer feed horns at 1.26 GHz. This instrument is used for surface roughness corrections to the salinity data, and has an approximate 390km swath.
- Additional instruments aboard the Aquarius/SAC-D observatory currently not directly involved in salinity measurement include: MWR, NIRST, HSC, DCS, ROSA, CARMEN I, TDP.

1.2.4 Aquarius Salinity Retrieval Overview

The Aquarius remotely sensed salinity measurement is accomplished by measuring microwave emission from the sea surface in terms of brightness temperature, and correcting for other natural emission sources and sinks. Ocean brightness temperatures (Tb) are related to the dielectric properties of seawater as described by the “Klein and Swift” dielectric model function, and at lower microwave frequencies, these properties are modulated by salinity. The frequency 1.413 GHz (L-band) used by Aquarius radiometers is sufficiently sensitive to salinity to be viable and is legally protected for scientific purposes (radio astronomy and Earth remote sensing) from radio interference. The three Aquarius microwave radiometers measure microwave brightness temperature (in units of Kelvins, K) in the vertical and horizontal polarizations (TbH and TbV, respectively). The radiometers also measure polarimetric channels to correct for the Faraday rotation of the signal as it passes through the ionosphere. However, the largest single error source is ocean surface roughness effects due to wind and waves; therefore, the

Aquarius instrument includes an integrated L-band (1.26 GHz) radar scatterometer to measure simultaneous oceanic backscatter in the footprint and undertake the correction based on coincident roughness measurements. The smallest errors appear in the tropical and mid-latitudes, and the largest in the sub-polar regions. Over the open ocean, salinity ranges only from about 32 to 37 PSU. An accuracy of about 0.2 PSU (or 0.1 K) global RMS when data are averaged monthly on 150-km scales is, therefore, needed to achieve the mission's science goals. Full technical details on the Aquarius algorithms are given in the Aquarius Algorithm Theoretical Basis Document (ATBD) and related addenda and in the Scatterometer ATBD.

1.2.5 Aquarius Processing and Data Flows

The basic flow of data between components involved in the acquisition and processing of data for Aquarius/SAC-D are summarized in figures 2 and 3 below.

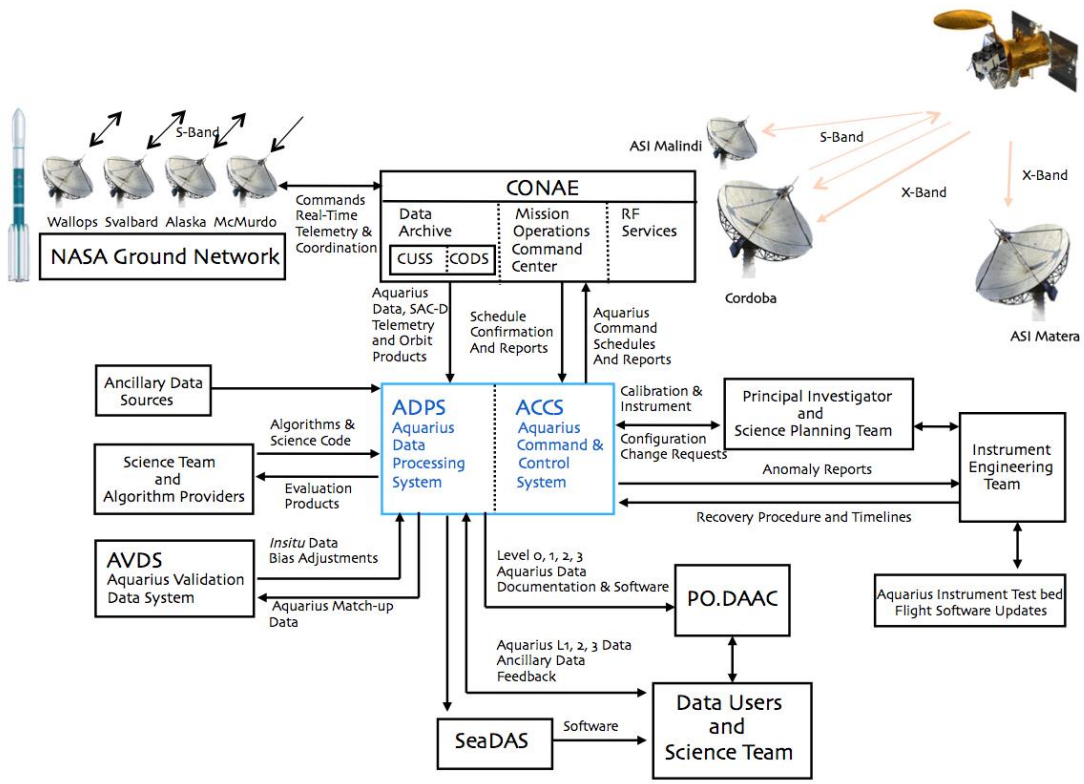


Figure 2. Aquarius Project Interfaces.

Processing Overview

Raw Aquarius HRD data files and HRT telemetry files are downlinked and archived at CONAE via a network of ground receiving stations (figure 2). An orbit may be downlinked multiple times to the CONAE ground station at Cordoba and the Matera ground station operated by the Agenzia Spaziale Italiana (ASI). Science data processing (Level-0 through Level-3 products) is undertaken by the Ocean Biological Processing Group (OBPG) at NASA/GSFC. The best quality source Aquarius data are selected for each orbit during the Level-0 to 1A data processing.

Summarized in figure 3, the key stages of Aquarius science data processing via the ADPS (Aquarius Data Processing System) include:

- Level-0 Preprocessor: process each HRD downlink file to produce a single time-ordered set of Aquarius science blocks and removes duplicates.
- Level-0-to-1A: separate Level-0 files into orbits, unpack science data, incorporate overlapping ephemeris and SAC-D HKT and convert Aquarius HKT.
- Level-1A Merge: consolidate Level-1A files from overlapping downlinks into a single, best-quality full orbit product.
- Level-1A-to-2: perform calibration, atmospheric correction and salinity retrieval for Aquarius science data – radiometer and scatterometer code delivered by RSS (Remote Sensing Systems) and JPL (NASA Jet Propulsion Laboratory).
- Level-2-to-3 Binning: Level-2 salinity and wind speed retrievals for one day geographically projected and collected into equal-area bins.
- Level-3 Binning and Mapping: Level-3 binned files aggregated to longer time periods (weekly, monthly, etc.) and projected onto map grid.

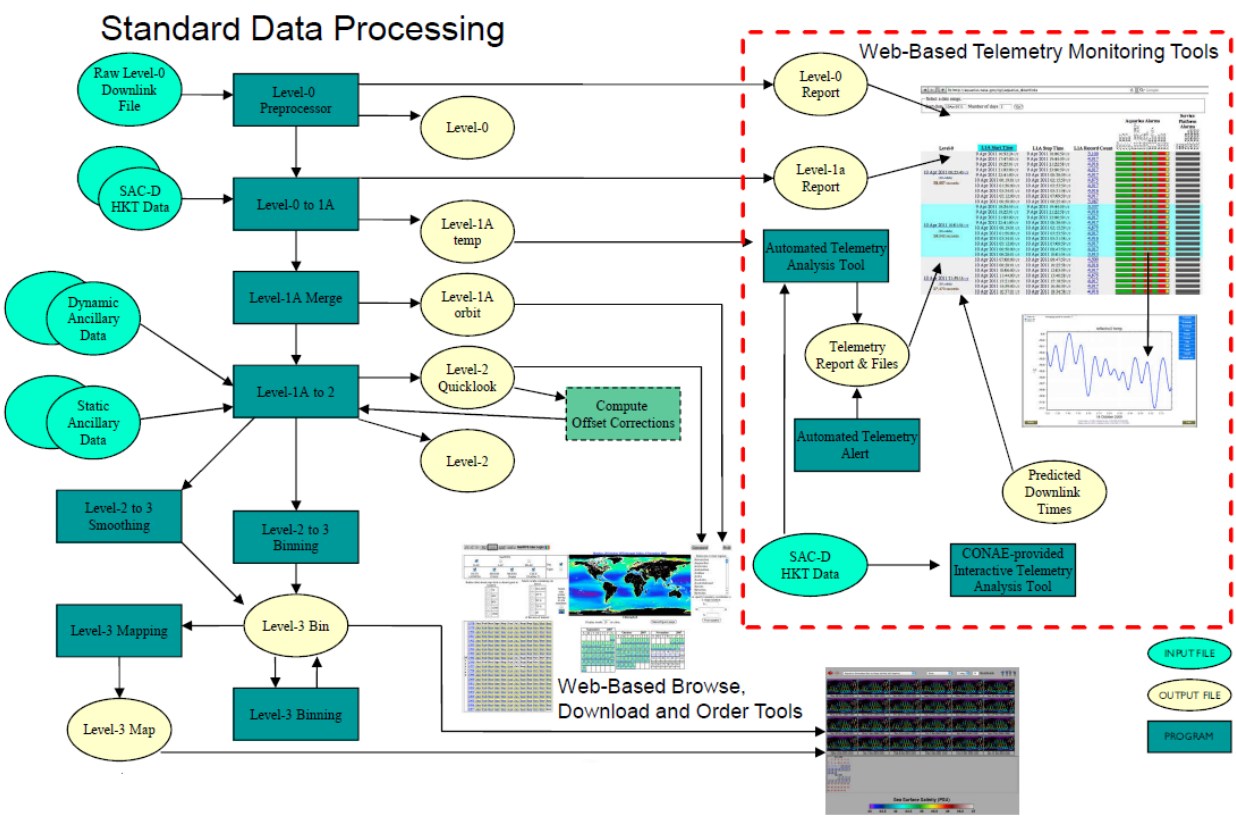


Figure 3. Overview of Aquarius Data Processing via ADPS at OBPG/GSFC

Processing additionally involves the usage of ancillary model data fields from the operational HYCOM and NCEP models (see Appendix 1 for further details on source inputs, and Aquarius Level-2 ancillary field descriptions in section 4.3.2).

Processing Frequency

At the time of writing of this Guide, Aquarius V2.0 data are processed through the end of January 2013, and will be augmented on monthly intervals for the next few months. The lag is due to the delays required to have the new data necessary to recalculate the sensor calibrations.

Data Access

Archival of and access to all Aquarius datasets is via the PO.DAAC , the NASA Physical Oceanography Distributed Active Archive Center located at JPL (figure 2). PO.DAAC is the designated archive of record for Aquarius/SAC-D, responsible for the long-term archival and stewardship of Aquarius datasets (L0 through L3), key technical documents, and other related mission artifacts. PO.DAAC also provides active user support for Aquarius data users.

PO.DAAC routinely crawls OBPG in automated fashion for recently published Aquarius granules via well-defined data interfaces, and ingests these data files into the archive. Up until now, PO.DAAC has been acquiring Aquarius granules published by the data provider (OBPG) with daily frequency and with a latency (time from measurement to through to delivery for archival) of 72 hours. Note though that due to some changes in processing for v2.0 of the Aquarius dataset, OBPG will, at least in the near-term, be processing and publishing granules in batches for archival and distribution by PO.DAAC every 30 days.

Once in the archive, datasets can be searched via PO.DAAC's online data catalog and data can be accessed via a range of available services and tools. Details of how users can discover and access Aquarius data products are given in section 2 below.

1.3 Aquarius Information Resources & Documentation

The present document focuses on format, access and usage aspects of the Aquarius data products for the current validated, v2.0 release of the dataset. In this section, key information resources pertaining to Aquarius are provided together with a list of other important documentation on specific technical issues. Items listed are also referenced in related sections of this Guide as necessary.

1.3.1 User Support

PO.DAAC provides user support services for Aquarius. Any questions regarding Aquarius data holdings, from how to access the data through questions on data format and usage, can be submitted via email to our user services team at: podaac@podaac.jpl.nasa.gov or salinity@podaac.jpl.nasa.gov.

1.3.2 On-line Information Resources

General information on the Aquarius mission and its current status is available from the project website: http://aquarius.nasa.gov/. A comprehensive list of Aquarius/SAC-D online data access and telemetry monitoring resources are available on this site. The mission site also hosts the Aquarius Event Log page, which dynamically returns information on all maneuvers, anomalies, and other critical events while also providing graphical summaries of these data. Additional information on Aquarius is available via the PO.DAAC salinity and Aquarius portal pages, and at OBPG/GSFC web-site, the data provider for Aquarius. Their Aquarius Ground System WIKI provides links to a range of useful information resources, including the Major Events and Software Change Log.

1.3.3 Aquarius Technical Documentation

All key technical documents relating to Aquarius are available from the PO.DAAC public FTP-site and listed below by category with links. The document producer is also specified. Items without hyperlinks and not on the FTP-site are in preparation.

Data Description Documents

- Aquarius Data Users Guide (PO.DAAC) – this document
- L1A Data format description (OBPG)
- L2 Data format description (OBPG)

Algorithm Description Documents

- L2-ATBD (Algorithm Theoretical Basis Document) including radar/radiometer wind geophysical model function (RSS/GSFC) with ATBD Addendum 1 and 2 documents
- Radar ATBD and Radar RFI algorithm (JPL)

Instrument Calibration (post-launch) Documents

- Radiometer calibration methodology with RFI algorithm description (GSFC/ESR)
- Pointing correction analysis (JPL)
- Radar calibration report (JPL)

Level-2 Salinity Validation Documents

- Aquarius Salinity data validation analysis (ESR)

Level-3 Dataset Documents

- Flags applied and methods used in the production of L3 products (ESR)
- L3 smoothing algorithm description (implemented for L3 monthly smoothed products)

Technical documentation providers:

ESR	Earth and Space Research
GSFC	NASA Goddard Space Flight Center
JPL	NASA Jet Propulsion Laboratory
PO.DAAC	Physical Oceanography DAAC, NASA/JPL
RSS	Remote Sensing Systems

2 Aquarius Data Discovery & Access

This section describes how users can search for Aquarius data products via the PO.DAAC website portal and then access the data via available tools and services. Aquarius data archived at PO.DAAC include Level-0, Level-1A, Level-2, and Level-3 products (see section 3 for details). Please note though that only L2 and L3 Aquarius data are supported.

2.1 Search

The PO.DAAC portal supports interactive, drill-down searches and exposure of our data product catalogues by measurement parameter, sensor, satellite platform, collection or keyword. Simply entering the keyword "Aquarius" in the dataset search bar on the main portal page returns a list of all Aquarius datasets maintained within the PO.DAAC archive with associated metadata descriptions. Similar results can be obtained by drill-down selection via the "Browse Dataset" toolbar on the home page. Listed datasets can be further filtered by processing level, spatial and temporal resolutions, latency and other attributes and criteria via the faceted search panel on the left of the page. Clicking on individual dataset items listed returns a page with complete dataset-level metadata descriptions for the selected product. The associated "Data Access" and "Granule (File) Listing" tabs are pages that respectively provide:

- A list of particular data access services (FTP, OPeNDAP, THREDDS) available for the particular dataset, together with an indication of file format and compression information.
- A complete listing of available data files for that product, organized by Year/Month/Day levels that can be expanded and drilled down into.

Details of catalogued dataset level metadata captured by the PO.DAAC DMAS system (Data Management & Archive System) are provided in Appendix 2.

2.2 Data Access via FTP and Site Organization

All Aquarius validated data (version 2.0 and above) and related resources are accessible via the public PO.DAAC FTP-site (ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/). The contents and organization of the Aquarius portion of this site is described below. *

2.2.1 ReadMe Files

The root level Aquarius folder contains three ReadMe files that summarise some information provided here and in other sections of this User's Guide. *README.TXT* describes the site layout. Information documenting current known issues with the Aquarius dataset is available in the text file *README.KnownIssues. README.EventLog* describes the source, location and contents of available Aquarius Event log information. While much of this information is also captured in this Guide, users should periodically consult the READMEs for the most up to date information on these aspects. Information in the README files are dataset version independent.

2.2.2 Data Directories

Aquarius data on the FTP-site range from Level 0 through 3 products and are organized according to the pattern summarized in table 1.

Table 1. PO.DAAC FTP-site Organization for Aquarius by Product Level

Aquarius Data Type	Access URL prepend with ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/
Level-0	L0/SSS_0/<*YYYY*>/<*DDD*>
Level-1A	L1/SSS_1a/<*YYYY*>/<*DDD*>
Level-2	L2/<version>/<YYYY>/<*DDD*>
Level-3	L3/mapped/<version>/<freq>/<category> <*YYYY*>

Where:

<YYYY> is the Year e.g. 2013 (applies to all product levels)
<DDD> is the Julian Day of year e.g. 312 (applies to product levels 0-2)
<version> is the version of the Aquarius dataset e.g. v2.0 (applies to all product levels 2-3)
<freq> is the L3 product time interval: daily, 7day, monthly, seasonal, annual (applies only to level 3)
<category> is the L3 product category as follows: (applies only to level 3)

SCIA – maps based on data from *ascending* phases of orbits only
SCID – maps based on data from de*scending* phases of orbits only
SCI – maps based on all/combined data (no filtering on orbit ascending/descending phase)
SCISM – monthly smoothed salinity maps produced from combined data

Highest level sub-directories contain Aquarius data at different processing levels, from the raw binary L0 data through to the L3 mapped (gridded) products available for sea surface salinity and wind speed on daily, weekly, monthly, seasonal and annual intervals. For Level-2 data and above, files are then arranged in subdirectories by dataset version (eg. /V2). Then files are organized in lower level subdirectories by time period (eg. /*Year, /DayOfYear*), and in the case of L3 additionally by product time interval (daily|7day|monthly|3month) and product category (SCIA|SCID|SCI|SCISM). Please note that a smoothed product is only available for salinity on a monthly interval. All other L3 mapped products are available for both salinity and wind speed parameters for all 5 time intervals (daily, 7day, monthly, seasonal, annual) and category (ascending, descending, combined) combinations.

Information on Aquarius data products of all levels available from PO.DAAC is given in section 3 below with complete characterizations of L1A, L2 and L3 file format and metadata attribute and variable descriptions in section 4. Other than the L0 data that is binary, all data other files are in HDF5 format (http://www.hdfgroup.org/HDF5/) and bz2 compressed. Each data file has a corresponding, similarly named .md5 file that contains checksum information used internally to validate file transfers from the data provider and assure the integrity of the data.

2.2.3 Documentation Directory

The FTP-site Aquarius root level subdirectory /***docs*** contains the User's Guide to the Aquarius data together with other key documents on specific technical aspects provided by the Aquarius Science Team. A listing of available items was given in section 1.3.3 above. Since this documentation is data version dependent, users should consult available documents and associated version directory corresponding to the dataset version they are using (e.g. /***docs/V2*** *).*

2.2.4 Reader Software Directory

The FTP-site Aquarius root level subdirectory ***/sw*** contains software written in MATLAB and IDL that can be used to read the HDF5 level-2 and level-3 data. A later section (2.4.5) describes the usage of these routines. Reader software provided will work for all versions of the Aquarius data.

2.3 Data Access via Web-services

All Aquarius datasets are additional available via OPenDAP and THREDDS Web-services from PO.DAAC.

2.3.1 OPeNDAP

OPenDAP is a data transport architecture and HTTP-based protocol widely used by the earth science community and supported by PO.DAAC. It allows both interactive person-to-machine and automated machine-to-machine access to data, with optional additional data sub-setting options specified by an extended URL. The structure of the basic URL for accessing Aquarius L2 and L3 datasets is as follows and analogous to that previously described for FTP:

http://opendap.jpl.nasa.gov/opendap/SalinityDensity/aquarius/

2.3.2 THREDDS

Aquarius data are also accessible from PO.DAAC via THREDDS (Thematic Realtime Environmental Distributed Data Services), a framework for dynamic distributed aggregation, cataloging and publication of datasets, metadata and associated resources via the Internet. The THREDDS catalogue at PO.DAAC for Aquarius can be accessed by users via the following URL:

http://thredds.jpl.nasa.gov/thredds/podaac_catalogs/AQUARIUS_L3_SMI_V20_catalog.html

Complete L3 daily, 7day, monthly, and seasonal time series for both salinity and wind speed respectively are aggregated and accessible via THREDDS. For each THREDDS aggregation, access is available via a range of protocols including OPeNDAP, WCS, WMS, some of which permit interactive subsetting by parameters such as time. Dynamic plotting options are also available for selected data series and subsets via THREDDS.

2.4 Data Access via Tools

Aquarius datasets are also accessible via a suite of Aquarius and PO.DAAC Web-based tools. These are summarized briefly here and access links are provided.

2.4.1 Aquarius/SAC-D Event Log

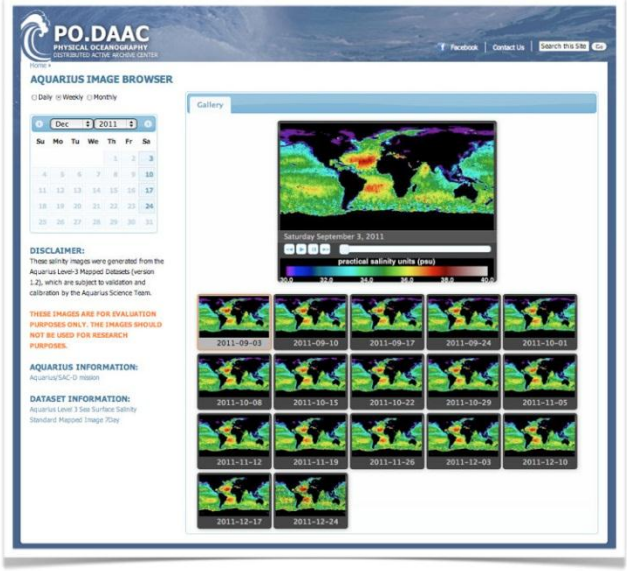
The Aquarius mission website hosts the Aquarius Event Log page. This tool dynamically returns information on all maneuvers, anomalies, and other critical events together with a listing of impacted data files. A useful option also exists there allowing users to download the log information on this page in CSV format. Graphical summaries of Aquarius/SAC-D maneuver and anomaly event statistics are also provided.

Spacecraft Maneuver and Anomaly Tracking

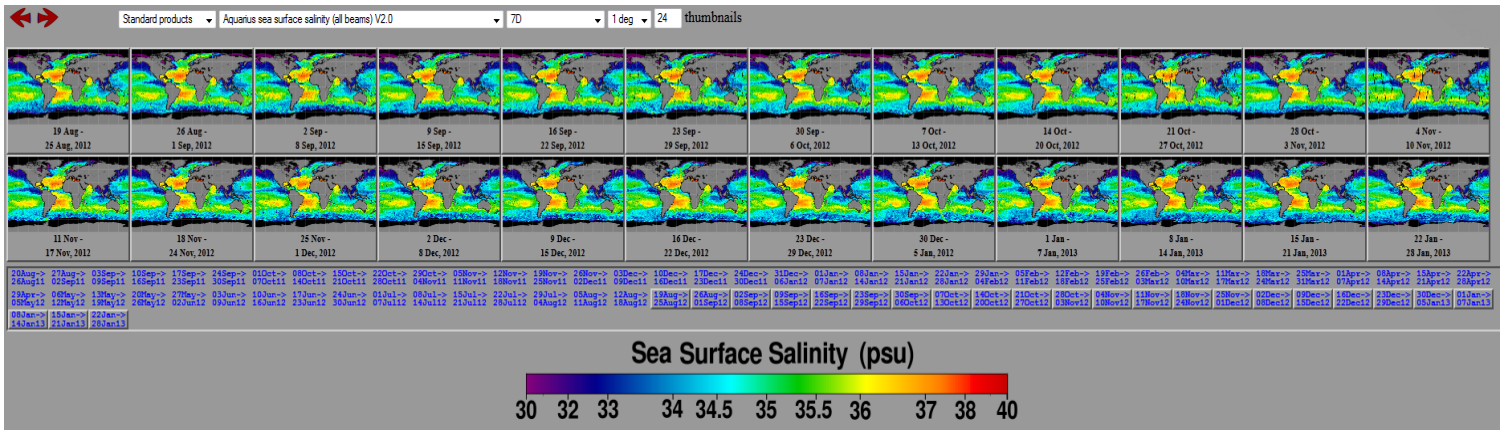
Month	Time Spent in Maneuvers days	hh:mm:ss	%	Time Spent in Anomalies days	hh:mm:ss	%
Dec 2011		00: 11:00	0.025		00: 00:00	0
Jan 2012		00: 00:00	0		00: 18:50	0.042
Feb 2012		00: 00:00	0		00: 00:32	0.001
Mar 2012		04: 47:32	0.644		07: 07:36	0.964
Apr 2012		00: 52:08	0.121		05: 57:42	0.829
May 2012		00: 23:00	0.052		00: 36:00	0.081
Jun 2012		00: 52:10	0.121		00: 10:46	0.025
Jul 2012		00: 39:40	0.089	1	21: 31:29	6.124
Aug 2012		00: 22:03	0.049		04: 52:00	0.654
Sep 2012		00: 21:35	0.05	1	11: 46:27	4.971
Oct 2012		00: 22:09	0.05	1	03: 41:45	3.724
Nov 2012		00: 52:10	0.121	1	23: 55:00	6.663
Dec 2012		00: 21:59	0.049		03: 10:48	0.428
Jan 2013		00: 52:10	0.117		02: 46:28	0.373
Feb 2013		00: 00:00	0		00: 00:00	0
Mission to Date 448 days 20:50:11		10: 57:36	0.102	7	13: 55:23	1.69

2.4.2 Aquarius Level-3 Browsers

The Aquarius Level-3 Browser tool is available at http://podaac.jpl.nasa.gov/aquarius/gallery. Illustrated adjacent and intuitive to use, the browser allows effortless navigation and viewing of PO.DAAC Aquarius imagery data holdings by time period as individual global sea surface salinity (SSS) maps and animation sequences. Simply pick the image type (Daily, Weekly or Monthly composite) and use the calendar selector tool to choose a period of interest. Selectable thumbnails of all available data for the chosen period appear sequentially in the image Galley portion of the page. Click on a particular item in the gallery listing or a specific date in the calendar tool to see the full image with associated salinity color scale. Use the interactive controls to step forward or back through the sequence or view as an animation. Double click on the image in focus to see an enlarged rendering within a popup window, and use mouse controls to zoom into particular areas of interest.

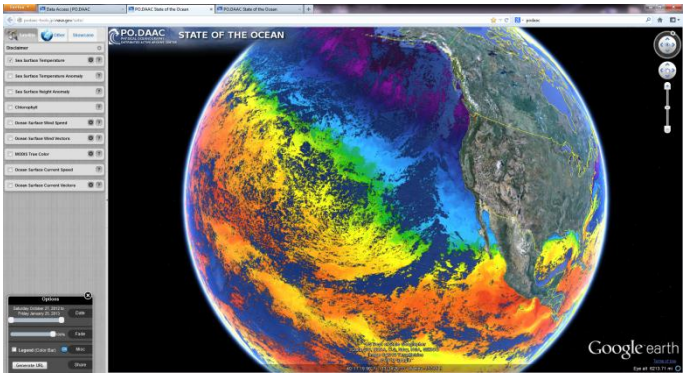


A similar useful tool for browsing Aquarius Level-3 products is available from the data provider (OBPG) at http://oceancolor.gsfc.nasa.gov/cgi/l3. This tool allows users to view both Aquarius salinity (SSS) and wind speed products for all available time intervals (daily, 7day, monthly, seasonal, annual) including the monthly smoothed SSS product, with the option also of examining data outputs per beam.



2.4.3 SOTO

The SOTO (State of the Ocean) tool is a browser-based Google Earth application allowing visualization of a range of key environmental imagery data layers, including Aquarius, either directly exposing Level-3 data or derived from Level-2 datasets all archived at PO.DAAC. SOTO's focus is primarily present time frame, and as such provides access to imagery that spans the most current 30 days. For Aquarius, the 7 day running means of L3 daily data that provide global coverage are exposed. SOTO can be accessed from http://podaac-tools.jpl.nasa.gov/soto/. If not already installed, users will be prompted to install the Google Earth browser plugin.



2.4.4 Reader Software

Users simply wanting to browse the structure, metadata and data contents of Aquarius data files interactively via a GUI tool should consider the following free and easy to use software packages: Panoply (NASA/GISS) and HDFview (HDFgroup). For users wanting to access Aquarius data for analysis, PO.DAAC provides routines in MATLAB and IDL in the \SW directory of the FTP-site to read the Aquarius L2 and L3 HDF5 data files. This section briefly describes the usage of these routines. Basic familiarity with the MATLAB and IDL scientific programming environments is assumed.

2.4.4.1 MATLAB Reader

The script file "aq_H5_reader_podaac.m" contains MATLAB code for the function ***aq_H5_reader_podaac()*** that reads variables and metadata into memory and optionally plots the data prints to file attributes of the granule for either Aquarius L2 and L3 HDF5 files. For the L3 file, the routine returns longitude and latitude vectors (360 and 180 elements respectively) and a 2-dimensional [360x180] Sea Surface Salinity array variable corresponding to the 1 degree spatial resolution, global coverage Aquarius L3 product. For the L2 product, the routine returns three 2-D array variables for latitude, longitude, and sea surface salinity data (each consistently dimensioned by the Number of Data Blocks=4083 x Number of Radiometer Beams= 3). The routine automatically detects whether it is dealing with a L2 or L3 files on the basis of the standard Aquarius filename pattern. This read software was created using MATLAB version 7.4.0.287 with HDF5 libraries. Further comments are available inline in the code.

Usage

Calling the function: ***aq_H5_reader_podaac(fn)*** where **fn** = path/filename
eg: aq_H5_reader_podaac('c:/v/ Q2013001004300.L2_EVSCI_V1.3.9.hdf')

The filename and path is the only information than needs to be passed when the function is called. Call the function from either the MATLAB command line or within a script using a suitable argument value.

Optional Settings: Toggling the following specific Boolean flags in the code allows the user to alter the behaviour of the routine with respect to optional data plotting, metadata display, and scroll pausing.

attr_disp = true; - write attributes to screen or set to *False* (code line 74)
make_fig = true; - plot data or set to *False* (code line 75)
examine_params = false; - *True* pauses function to examine all parameters (code line 76)

2.4.4.2 IDL Reader

For users of IDL, the "*h5_browser*" is a GUI-based tool part of the IDL software suite that is easy to use and particularly helpful for inspecting Aquarius data products. For users wanting to read the Aquarius data particularly for analysis purposes in the IDL environment, PO.DAAC provides two IDL readers: one for the Level-2 data (*read_aquarius_hdf_L2.pro*), and one for the Level-3 data (*read_aquarius_hdf_L3_mapped.pro*). Both can be run interactively from the IDL command line.

read_aquarius_hdf_L2.pro

Usage: *rdhdf5_aq, file, data1, prt=PRT*

Input: is simply the Aquarius Level-2 file name and path.

Outputs: - IDL structure "*data1*" contains the full array of the different parameters in the level 2 data.
- Output file "*finfo.tags*" contains a full listing of all the attributes & variables contained in different groups of
the Level-2 file.

read_aquarius_hdf_L3_mapped.pro

Usage: *rdhdf5_aq, file, data1, prt=PRT*

Input: is simply the Aquarius Level-2 file name and path.

Outputs: - IDL structure "*data1*" contains the fully mapped 1 degree sea surface salinity data contained in the L3 file.
- Output file "*finfo.tags*" contains a full listing of all the attributes & variables of the Level-3 file.

3 Aquarius Data Products

Aquarius data archived at PO.DAAC include Level-0, Level-1A, Level-2, and Level-3 products. All files are in HDF5 format with the exception of the binary Level-0. Aquarius products supported and accessible via and supported by PO.DAAC include both L2 swath data and L3 gridded. Archived but unsupported products at PO.DAAC include L0, and L1A data. An overview of Aquarius dataset types is provided below, and a complete listing of archived products by level is given in table 2. A total of 33 L0 through L3 products are provided as part of the Aquarius v2.0 release.

3.1 Level-0 Product

Level-0 files are raw binary data downloaded from the satellite. Typically 4 files per day are sent. These data are delivered to the Aquarius Ground Segment (AGS) at Goddard from the Argentinian Space Agency, CONAE. Processing is undertaken at OBPG/GSFC via the ADPS.

3.2 Level-1A Product

Level-1A data products are produced from the L0 products. The ADPS sorts the raw data by time and places the data into 1 orbit (~98 minute) files with 10 minutes before and after the orbit appended to it resulting in ~118 minutes of data. The files include block attributes, converted telemetry, navigation, and raw Aquarius data. The file structure, including granular metadata and variables, can be found in section 4.2. Each file contains data for 1 orbit of Aquarius (~98 minutes) yielding 14 or 15 files per day. 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 L0 to 1A data processing and used to create the input L1A file.

3.3 Level-2 Product

An Aquarius Level-2 product is generated by the ADPS from the corresponding source L1A product and is stored as one physical HDF file. Thus as for the L1A, each L2 file contains data for 1 orbit of Aquarius (~98 minutes) yielding 14 or 15 files per day. The L2 product contains physical measurements as computed from the L1A data, either at the instrument or the observed surface locations along with coordinates of viewed locations and navigation data. The instrument data includes the radiometer observed brightness temperatures and scatterometer normalized radar cross-section (NRCS) data, with calculated sea surface temperature and wind speeds derived from these. L2 files also contain some variables with ancillary data from select sources. L2 orbital/swath files additionally contain quality flags, block data and navigation data. As the Aquarius instrument gets data through 3 feed horns/beams on the instrument, flag and navigation have dimensions of n by 3, where n = the number of data points for each feed horn. The data point frequency is on observation every 1.44s. Detailed descriptions of the file structure including granular metadata and variables can be found in section 4.3. A summary of associated L2 flags is given in section 4.3.4.

3.4 Level-3 mapped Products

Level-3 standard mapped image (SMI) products depict sea surface salinity or wind speed. L3 mapped salinity and wind products are generated for the same spatial and temporal resolutions. Each file has a spatial resolution of 1 degree, and values represent averages for grid cells over predefined temporal intervals. Daily, 7 day, monthly, seasonal (3 months) and annual products are available. In addition, L3 Ascending (A), Descending (D) products are provided for all time periods for both salinity and wind speed. These employ retrieved values for ascending and descending portions of orbits respectively. These disaggregated datasets are provided given known subtle differences between ascending and descending orbit values. A monthly, smoothed L3 salinity product is also provided. Thus a total of 31 level 3 mapped products are provided as part of the Aquarius v2.0 release. Sea surface salinity mapped products are computed as averages across all 3 radiometers as well as individual instrument files. Daily files have sparse spatial coverage as it takes 7 days for Aquarius to completely cover the earth. The file structure including granular metadata and variables can be found in section 4.4.

Table 2. Aquarius Dataset V2.0 Products by Level/Type with Associated Dataset Metadata.

Level	Product Short Name (PO.DAAC DMAS System)	Product Long Name & Description	Temporal Resolution	Ellipsoid Type	Projection Type
0	AQUARIUS_L0_SSS	Aquarius Level-0 Sea Surface Salinity	1 observation every 1.44 seconds. Repeats orbit track every 7 days.	N/A	Swath
1A	AQUARIUS_L1A_SSS	Aquarius Level-1A Sea Surface Salinity Aquarius L1A data contains raw Aquarius, navigation and telemetry data. Each granule covers 118 minutes, a 98 minute orbit plus 10 minutes of overlap with the following and previous orbits.	1 observation every 1.44 seconds. Repeats orbit track every 7 days.	N/A	Swath
2	AQUARIUS_L2_SSS	Aquarius Level-2 Sea Surface Salinity Aquarius L2 data contains sea surface salinity, radiometer, scatterometer, ancillary, flags, converted telemetry and navigation data. Each granule covers a single 98 minute orbit.	1 observation every 1.44 seconds. Repeats orbit track every 7 days.	N/A	Swath
3	AQUARIUS_L3_SSS_SMI_DAILY	Aquarius Level-3 Sea Surface Salinity Standard Mapped Image Daily Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged daily.	Daily	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMI_7DAY	Aquarius Level-3 Sea Surface Salinity Standard Mapped Image 7Day Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by week.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMI_MONTHLY	Aquarius Level 3 Sea Surface Salinity Standard Mapped Image Monthly Aquarius Level 3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged monthly.	Monthly	WGS 84	Gridded Smoothed
3	AQUARIUS_L3_SSS_SMI_MONTHLY_SM	Aquarius Level 3 Sea Surface Salinity Standard Mapped Image Monthly Smoothed Aquarius Level 3 sea surface salinity (SSS) standard mapped images data contains gridded and smoothed SSS averaged monthly (see Lillie & Lagerloef, 2008)	Monthly	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMI_3MONTH	Aquarius Level-3 Sea Surface Salinity Standard Mapped Image 3 Month - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by season.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMI_ANNUAL	Aquarius Level-3 Sea Surface Salinity Standard Mapped Image Annual - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by year.	Annual	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMI_DAILY	Aquarius Level-3 Wind Speed Standard Mapped Image Daily - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged daily.	Daily	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMI_7DAY	Aquarius Level-3 Wind Speed Standard Mapped Image 7 Day - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by week.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMI_MONTHLY	Aquarius Level-3 Wind Speed Standard Mapped Image Monthly - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged monthly.	Monthly	WGS 84	Gridded

Level	Product Short Name (PO.DAAC DMAS System)	Product Long Name & Description	Temporal Resolution	Ellipsoid Type	Projection Type
3	AQUARIUS_L3_WIND_SPEED_SMI_3MONTH	Aquarius Level-3 Wind Speed Standard Mapped Image 3 Month - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by season.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMI_ANNUAL	Aquarius Level-3 Wind Speed Standard Mapped Image Annual - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by Year.	Annual	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMIA_DAILY	Aquarius Level-3 Sea Surface Salinity Ascending Standard Mapped Image Daily Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged daily using values for ascending portions of orbits only.	Daily	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMIA_7DAY	Aquarius Level-3 Sea Surface Salinity Ascending Standard Mapped Image 7Day Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by week using values for ascending portions of orbits only.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMIA_MONTHLY	Aquarius Level 3 Sea Surface Salinity Ascending Standard Mapped Image Monthly Aquarius Level 3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged monthly using values for ascending portions of orbits only.	Monthly	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMIA_3MONTH	Aquarius Level-3 Sea Surface Salinity Ascending Standard Mapped Image 3 Month - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by season using values for ascending portions of orbits only.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMIA_ANNUAL	Aquarius Level-3 Sea Surface Salinity Ascending Standard Mapped Image Annual - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by year using values for ascending portions of orbits only.	Annual	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMID_DAILY	Aquarius Level-3 Sea Surface Salinity Descending Standard Mapped Image Daily Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged daily using values for descending portions of orbits only.	Daily	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMID_7DAY	Aquarius Level-3 Sea Surface Salinity Descending Standard Mapped Image 7Day Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by week using values for descending portions of orbits only.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMID_MONTHLY	Aquarius Level 3 Sea Surface Salinity Descending Standard Mapped Image Monthly Aquarius Level 3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged monthly using values for descending portions of orbits only.	Monthly	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMID_3MONTH	Aquarius Level-3 Sea Surface Salinity Descending Standard Mapped Image 3 Month - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by season using values for descending portions of orbits only.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_SSS_SMID_ANNUAL	Aquarius Level-3 Sea Surface Salinity Descending Standard Mapped Image Annual - Aquarius L3 sea surface salinity (SSS) standard mapped images data contains gridded SSS averaged by year using values for descending portions of orbits only.	Annual	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMIA_DAILY	Aquarius Level-3 Wind Speed Ascending Standard Mapped Image Daily - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged daily using values for ascending portions of orbits only.	Daily	WGS 84	Gridded

Level	Product Short Name (PO.DAAC DMAS System)	Product Long Name & Description	Temporal Resolution	Ellipsoid Type	Projection Type
3	AQUARIUS_L3_WIND_SPEED_SMIA_7DAY	Aquarius Level-3 Wind Speed Ascending Standard Mapped Image 7 Day - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by week using values for ascending portions of orbits only.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMIA_MONTHLY	Aquarius Level-3 Wind Speed Ascending Standard Mapped Image Monthly - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged monthly using values for ascending portions of orbits only.	Monthly	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMIA_3MONTH	Aquarius Level-3 Wind Speed Ascending Standard Mapped Image 3 Month - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by season using values for ascending portions of orbits only.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMIA_ANNUAL	Aquarius Level-3 Wind Speed Ascending Standard Mapped Image Annual - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by Year using values for ascending portions of orbits only.	Annual	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMID_DAILY	Aquarius Level-3 Wind Speed Descending Standard Mapped Image Daily - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged daily using values for descending portions of orbits only.	Daily	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMID_7DAY	Aquarius Level-3 Wind Speed Descending Standard Mapped Image 7 Day - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by week using values for descending portions of orbits only.	7 Day	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMID_MONTHLY	Aquarius Level-3 Wind Speed Descending Standard Mapped Image Monthly - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged monthly using values for descending portions of orbits only.	Monthly	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMID_3MONTH	Aquarius Level-3 Wind Speed Descending Standard Mapped Image 3 Month - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by season using values for descending portions of orbits only.	3 Months	WGS 84	Gridded
3	AQUARIUS_L3_WIND_SPEED_SMID_ANNUAL	Aquarius Level-3 Wind Speed Descending Standard Mapped Image Annual - Aquarius L3 wind speed standard mapped images data contains gridded wind speed averaged by Year using values for descending portions of orbits only.	Annual	WGS 84	Gridded

3.5 File Naming Conventions

All times and dates are to be in Coordinated Universal Time (UTC).

Level-0 data files have a unique file naming convention that is beyond the scope of this document. The following conventions apply to all of the Level-1A, 2, and 3 data files:

- The initial "Q" in the file name indicates that the file contains Aquarius data.
- The remaining part of the file name before the first period (".") indicates the time the data in the file covers:
    - [yyyy] is the year and [ddd] is the day of year of the data. For 7 day, monthly, seasonal, or annual Level-3 data, there are two pairs of [yyyy][ddd] representing the year/day-of-year of the start of the data, and the year/day-of-year of the end of the data. Level-3 daily files require only one set of [yyyy][ddd] to represent year/day-of-year of the data.
    - Level-1A and Level-2 data files indicate a more precise time for the start of the data by adding [hh][mm][ss], representing hours, minutes and seconds, after the [yyyy][ddd].
- The section of the file name between the first and second period indicates several different characteristics of the data file, with the complexity increasing with the level.
    - The initial "L" precedes the indicator for the data level: 1A – Level 1A; 2 – Level 2; 3b – Level-3 binned; 3m – Level-3 mapped image files.
    - The [period] field in Level-3 data file names indicates the time length of data contained in the file: DAY – daily data; 7D – seven days; MO – monthly; SNSP – seasonal (3 months); YR – annual.
    - The "SCI" in the file name indicates the data has been processed to scientific parameters.
    - [Bn] appended to the "SCI" in a L3 data file name indicates the data are from a single beam (B1, B2, or B3 indicate the beam number). Otherwise, the data are from all 3 beams.
    - [SM] appended to the "SCI" in a L3 data file name indicates the data are from all 3 beams but are smoothed. Smoothing is undertaken for the monthly salinity product only.
    - [A] or [D] appended to the "SCI" in a L3 data file name indicates the data employed in computing grid cell averages are from Ascending and Descending portions of orbits respectively.
    - Level-2 and 3 data also include a version indicator [Vn.n] to indicate the version and subversion number of the data (e.g. V2.0).

- Additional filename parameters exist depending on the specific product level. These are summarized in table 3 below.

- All L1A through L3 product files are in HDF5 format. Files will normally be stored and delivered with BZip2 compression, and this will be indicated with .bz2 appended to the file name.

The Aquarius file naming convention as applied to specific product levels is shown in the following table.

Table 3. Aquarius Data File Naming Conventions.

Aquarius Data Level	File Naming Convention
Level-3 Standard Mapped Image	**Q[yyyy][ddd][yyyy][ddd].L3m_[period]_SCI[Bn][SM]_V[n.n]_[dtype]_1deg** dtype will either be SSS or scat_wind_speed indicating whether it contains salinity or wind data. _1deg indicates that the SMI files have a 1 degree resolution. Examples: Q2010340.L3m_DAY_SCIB2_V1.0_scat_wind_speed_1deg Q20103372010343.L3m_7D_SCI_V1.0_SSS_1deg
Level-2	**Q[yyyy][ddd][hh][mm]][ss].L2_SCI_V[n.n]** Level-2 files are for one orbit with an end time approximately 98 minutes after the start time. Example: Q2010340005700.L2_SCI_V1.0
Level-1A	**Q[yyyy][ddd][hh][mm]][ss].L1A_SCI** Level-1A files are for one orbit with 10 minute buffers before and after the orbit. They have an end time approximately 118 minutes after the start time. Example: Q2007196201700.L1A_SCI
Level-0	**[yyyy][mm][dd]_[hh][mm]][ss].AQ_L0** yyyy, mm, dd, hh, mm, and ss are year, month, day, hour, minute and second of the start of the data. AQ stands for Aquarius _L0 indicates a level 0 file. Level-0 files have an end time approximately 14 hours after the start time. As 4 or 5 are produced per day there is built in overlap to achieve data redundancy. Example: 20070104_084659.AQ_L0

4 Aquarius Data Product Structure

All Aquarius data files above L0 are in HDF5 format. The structure of these files is described here. While the details may vary between product levels and type, internally all have a consistent hierarchical organization with name of the file at the top level, a set of global metadata attributes within, and a series of dataset variable groups beneath. Groups function as both logical and physical data structure containers within files that can be hierarchically related in the HDF5 data model. Each group contains one or more variables each associated with a specific parameter, which themselves have attributes.

4.1 Global Metadata Attributes

Table 4 lists alphabetically and compares the global metadata attributes found in Aquarius data files by product level and type. Representative sample attribute values are also given. Full descriptions of file global metadata attributes for Level-1A, L2 and L3 products are provided in later sections in tables 5, 7 and 16-17 respectively.

Table 4. Aquarius Data file Global Attributes by Data Product Level/Type.

Attribute	Data Type	L1A	L2	L3m SSS	L3m Wind
Anomaly Status String	String		Included only if anomaly occurs during orbit		
Cycle Number	Integer	2	2		
Conventions			"CF-1.6"; Climate and Forecast (CF) metadata conventions used.	"CF-1.6"	"CF-1.6"
Data Bins	Integer			0	0
Data Center	String	NASA/GSFC Aquarius Data Processing Center		0	0
Data Maximum	Float			38.3064	19.6107
Data Minimum	Float			27.7696	-999
Data Type	String	SCI	SCI		
Delta TND H coefficient	Float		0.004769839, 0.0060151783, 0.0054100547		
Delta TND V coefficient	Float		0.0057764184, 0.00512049, 0.0062645986		
Easternmost Longitude	Float			180	180
End Day	Unsigned Integer	249	249	146	146
End Millisec	Integer	56038647	67198650	1758840	1758840
End Orbit	Integer			0	0
End Time	String	2011249153358640	2011249183958650	2011146002918840	2011146002918840
End Year	Integer	2011	2011	2011	2011
Input Files	String	Q20110906_160229_T20110906_115900_20110906_135559.AQ_L1A,Q20110906_160229_T20110906_133601_20110906_1	Q2011249170200.L1A_SCI	Q2011145.L3b_DAY_SCI_V1.0.main	Q2011145.L3b_DAY_SCI_V1.0.main

Attribute	Data Type	L1A	L2	L3m SSS	L3m Wind
		53358.AQ_L1A,…			
Input Parameters	String	IFILE = /data2/sdpsoper/vdc/vpu5/workbuf/Q2011145.L3b_DAY_SCI_V1.0.main|OFILE = Q2011145.L3m_DAY_SCI_V1.0_SSS_1deg|PFILE = |PROD = SSS|PALFILE			
institution			NASA/GSFC OBPG		
Intercept	Float			0.0	0.0
L2 Flag Names	Byte			0	0
_lastModified	String		2011263153256000	2013044144518000	2013044144518000
Latitude Step	Float			1	1
Latitude Units	String		degrees North	degrees North	degrees North
Longitude Step	Float			1	1
Longitude Units	String		degrees East	degrees East	degrees East
Map Projection	String			Equidistant Cylindrical	Equidistant Cylindrical
Mean Solar 1415 MHz Flux	Float		91.56463		
Measure	String			Mean	Mean
Mission	String	SAC-D Aquarius	SAC-D Aquarius	SAC-D Aquarius	SAC-D Aquarius
Mission Characteristics	String	Nominal orbit: inclination=98.0 (Sun-synchronous); node=6PM (ascending); eccentricity=<0.002; altitude=657 km; ground speed=6.825 km/sec			
Node Crossing Time	String	2011249141030000	2011249172630000		
Nominal Navigation	String		True		
Northernmost Latitude	Float			90	90
Number of ATC Frames	Integer	1228			
Number of Attitude Samples	Integer	887			
Number of Beams	Integer	3	3		
Number of Blocks	Integer	4916	4083		
Number of Columns	Integer			360	360
Number of Lines	Integer			180	180
Number of Orbit Vectors	Integer	120			
Number of RAD Frames	Integer	1229			
Orbit	Integer			0	0
Orbit Node Longitude	Float	58.6853	9.54973		
Orbit Number	Integer	1294	1296		
Orbit Start Time	String	2011249134600000			
Orbit Stop Time	String	2011249152400000			
Parameter	String			Sea Surface Salinity	Scatterometer Wind Speed
Pass Number	Integer	82	84		
Percent Data Bins	Float				
Percent Non-default Radiometer LUTs	Float	0			
Percent RFI	Float	0.0	0		
Percent Water	Float		0.629815		
Period End Day	Integer			0	0

Attribute	Data Type	L1A	L2	L3m SSS	L3m Wind
Period End Year	Integer			0	0
Period Start Day	Integer			0	0
Period Start Year	Integer			0	0
Processing Control	String	l1amerge_aquarius l1amerge.inputs /data1/sdpsoper/vdc/vpu0/workbuf	ifile=/data4/sdpsoper/vdc/vpu3/workbuf/Q2011249170200.L1A_SCI ofile=/data4/sdpsoper/vdc/vpu3/workbuf/Q2011249170200.L2_SCI_V1.1 yancfile1=y2011090612.h5 pversion=V1.1	smigen par=Q2011145.L3m_DAY_SCI_V1.0_SSS_1deg.param	smigen par=Q2011145.L3m_DAY_SCI_V1.0_scat_wind_speed_1deg.param
Processing Time	String	2011252145942000	2011263153256000	2011156065845000	2011156065849000
Processing Version	String		V1.1	V1.0	V1.0
Product Center Time	String	2011249143459840			
Product Name	String	Q2011249134600.L1A_SCI	Q2011249170200.L2_SCI_V1.1	Q2011145.L3m_DAY_SCI_V1.0_SSS_1deg	Q2011145.L3m_DAY_SCI_V1.0_scat_wind_speed_1deg
Product Type	Byte			0	0
RAD_ANCILLARY_FILE1	String		y2011090612.h5:N2011249_SST_OIV2AVAM_24h.nc,N2011250_SST_OIV2AVAM_24h.nc,N201124912_QATM_NCEP_6h.h5,N201124912_QMET_NCEP_6h…		
RAD_ANCILLARY_FILE2	String		y2011090618.h5:N2011249_SST_OIV2AVAM_24h.nc,N2011250_SST_OIV2AVAM_24h.nc,N201124918_QATM_NCEP_6h.h5,N201124918_QMET_NCEP_6h,…		
RAD_ANCILLARY_FILE3	String		y2011090700.h5:N2011249_SST_OIV2AVAM_24h.nc,N2011250_SST_OIV2AVAM_24h.nc,N201125000_QATM_NCEP_6h.h5,N201125000_QMET_NCEP_6h,…		
Radiometer Calibration Files	String		coeff_loss_v3.txt,coeff_nl.txt		
Radiometer Data Tables	String		land_tables.h5,gain_ice.h5,tausq.h5,ocean_reflectance.h5,mk_sss_algo_tables.h5,sun_tables.h5,sun_bak_tables.h5,galaxy_wind_tables_080111.h5,apc_matrix_090711.h5,dtb_dwin_090711.h5		
Radiometer Flag Limits	String		RFI: 15 7 Land: 0.005 0.02 Ice: 0.005 0.02 Wind: 7 15 Temp: 1 3 FluxD: 0.02 0.05 FluxR: 0.02 0.05 Glint: 0.02 0.05 Moon: 0.02 0.05 Gal: 0.02 0.05 RPY: 1 5 4		

Attribute	Data Type	L1A	L2	L3m SSS	L3m Wind
			Flare: 5e-05 0.0001		
Radiometer LUTs Block Count	Integer	4917, 0, 0, 0, 0, 0, 0, 0			
Radiometer Long Accumulations	Integer	8			
Radiometer Offset Correction	Float		-0.051605914, 0.069516964, -0.05597063, -0.029664312, -0.10964265, -0.04576162		
Radiometer Polarizations	Integer	4	4		
Radiometer Signals per Subcycle	Integer	5	5		
Radiometer Subcycles	Integer	12	12		
SW Point Latitude	Float			-89.5	-89.5
SW Point Longitude	Float			-179.5	-179.5
Scaling	String			linear	linear
Scaling Equation	String			(Slope*l3m_data) + Intercept = Parameter value	
Scatterometer Ancillary Files	String		SEAICEFILE1=N201124900_SEAICE_NCEP_24h.hdf,TECFILE1=N201124900_TEC_IGS_24h.h5,QMETFILE1=N201124912_QMET_NCEP_6h,QMETFILE2=N201124918_QMET_NCEP_6h,…		
Scatterometer Coefficient Files	String		atc_prt_convert_v3.txt, ext_temps_constants_convert_v3.txt,scat_temps_convert_v1.txt,radiometer_constants_convert_v2.txt,cmd_gn.dat		
Scatterometer Polarizations	Integer	6	6		
Scatterometer Processing Control	String		limits L1B_limits_10-16-2009.txt -debug -1 -param_file params_10-5-2009.txt -dir_dat -apc_file		
Scatterometer Subcycles	Integer	8	8		
Sensor	String	Aquarius	Aquarius	Aquarius	Aquarius
Sensor Characteristics	String		Number of beams=3; channels per receiver=4; frequency 1.413 GHz; bits per sample=16; instantaneous field of view=6.5 degrees; science data block period=1.44 sec.	0	0
Sensor Name	Byte			0	0
Slope	Float			1	1

Attribute	Data Type	L1A	L2	L3m SSS	L3m Wind
Software ID	String	0.01	1.12		
Software Name	String			smigen	smigen
Software Version	String			4.17	4.17
Southernmost Latitude	Float			-90	-90
Start Day	Integer	249	249	145	145
Start Millisec	Integer	48961045	61320568	1431960	1431960
Start Orbit	Integer			0	0
Start Time	String	2011249133601040	2011249170200560	2011145002351960	2011145002351960
Start Year	Integer	2011	2011	2011	2011
Station Latitude	Float			0	0
Station Longitude	Float			0	0
Station Name	Byte			0	0
Suggested Image Scaling Applied	String			No	No
Suggested Image Scaling Maximum	Float			38	20
Suggested Image Scaling Minimum	Float			32	0
Suggested Image Scaling Type	String			LINEAR	LINEAR
Title	String	Aquarius Level 1A Data	Aquarius Level 2 Data	Level-3 Standard Mapped Image	Level-3 Standard Mapped Image
Units	String			PSU	m s-1
Westernmost Latitude	Float			-180	-180
Westernmost Longitude	Float			-180	-180

4.2 Level-1A Product Description

The filename for the Level-1A Aquarius product conforms to standards previously described and illustrated by the following example: **Q2013001004300.L1A_SCI**. In addition to global file metadata, Level-1A files contain data for a range of measured variables organized in five groups: *Block Attributes*, *Converted Telemetry*, *Navigation*, *Raw Aquarius Data*, *SAC-D Telemetry*. Tables 5 and 6 respectively list and describe attributes associated both with Aquarius L1A global file metadata and group variables. The source documentation on which this information is based is:

Patt, F. et al. (2013). Aquarius Level-1A Data Product, September 2012. NASA/GSFC.

Table 5. Aquarius L1A Global Attributes and Values Listed by Category.

Attribute Name	Description/Value	Type	Array Size
	MISSON and DOCUMENTION ATTRIBUTES		
Product Name	The name of the product file (without path). E.g. Q2012070005700.L1A_SCI.hdf	String(31)	Scalar
Title	Aquarius Level 2 Data	String(22)	Scalar
Data Center	NASA/GSFC Aquarius Data Processing Center	String(42)	Scalar
Mission	SAC-D Aquarius	String(15)	Scalar
Mission Characteristics	Nominal orbit: inclination = 98.0 (Sun-synchronous); node = 6 PM (ascending); eccentricity = <0.002; altitude = 657 km; ground speed = 6.825 km/sec	String(137)	Scalar
Sensor	Aquarius	String(9)	Scalar
Data Type	SCI	String(4)	Scalar
Software ID	Identifies version of the software used to create this product. (e.g. 1.05)	String(5)	Scalar
Processing Time	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 YYYYDDDHHMMSSFFF. (e.g. 2012076162214000)	String(17)	Scalar
Input Files	The name of the Level-1A file (without path) from which the current product was created; stored in the product as part of its processing history. (e.g. Q2012001012500.L1A_SCI)	String(23)	Scalar
Processing Control	Input and processing control parameters used to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters; stored in the product as part of its processing history. e.g. l1amerge_aquarius l1amerge.inputs /data1/sdpsoper/vdc/vpu0/workbuf	String(2158)	Scalar
	DATE/TIME ATTRIBUTES		
Orbit Start Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070005700740	String(17)	Scalar
Orbit Stop Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070023458820	String(17)	Scalar
Start Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070005700740	String(17)	Scalar
End Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070023458820	String(17)	Scalar
Node Crossing Time	UTC of acscending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF. e.g. 2012001014930000	String(17)	Scalar
Product Center Time	UTC of the mid-block of the orbit; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF. e.g. 2012070023458820	String(17)	Scalar

Attribute Name	Description/Value	Type	Array Size
Start Year	UTC year of first block of the orbit. e.g. 2012	Integer (32-bit)	Scalar
Start Day	UTC day-of-year of first block of the orbit. e.g. 70	Integer (32-bit)	Scalar
Start Millisec	UTC milliseconds-of-day of the first block of the orbit. e.g. 3420747	Integer (32-bit)	Scalar
End Year	UTC year of last block of the orbit. e.g. 2012	Integer (32-bit)	Scalar
End Day	UTC day-of-year of last block of the orbit. e.g. 70	Integer (32-bit)	Scalar
End Millisec	UTC milliseconds-of-day of the last block of the orbit. e.g. 9298828	Integer (32-bit)	Scalar
	DATA CHARACTERISTICS		
Number of Blocks	Number of Aquarius science blocks in the orbit. (= 4917)	Integer (32-bit)	Scalar
Number of Beams	Number of antenna beams; order is inner, middle, outer. (= 3)	Integer (32-bit)	Scalar
Number of Orbit Vectors	Number of Orbit Vectors. (= 120)	Integer (32-bit)	Scalar
Number of RAD Frames	Number of RAD Frames. (= 1229)	Integer (32-bit)	Scalar
Radiometer Long Accumulations	Number of radiometer long accumulations (=8)	Integer (32-bit)	Scalar
Radiometer Polarizations	Number of polarizations in raw radiometer data; order is V, +45, -45, H. (= 4)	Integer (32-bit)	Scalar
Radiometer Subcycles	The number of 120 msec subcycles in a 1.44 second science block. (= 12)	Integer (32-bit)	Scalar
Radiometer Signals per Subcycle	Number of radiometer antenna signal measurements in a 120 msec subcycle; first 2 are 20 msec, last 3 are 10 msec. (= 5)	Integer (32-bit)	Scalar
Scatterometer Polarizations	Number of scatterometer receive polarizations; order is V, H; last dimension of the **scat_rfi_flags** array (= 2)	Integer (32-bit)	Scalar
Scatterometer Subcycles	The number of 180 msec subcycles in a 1.44 second science block. (= 8)	Integer (32-bit)	Scalar
	FILE METRICS		
Missing Blocks	Number of missing data blocks (e.g. 0)	Integer (32-bit)	Scalar
Number of ATC Frames	Number of ATC Frames (e.g. 1229)	Integer (32-bit)	Scalar
Number of Altitude Samples	Number of Altitude Samples (e.g. 887)	Integer (32-bit)	Scalar
Radiometer LUTs Block Count	Number of blocks of Radiometer LUTs (e.g. 4917, 0, 0, 0, 0, 0, 0, 0)	Integer (32-bit)	8
Percent Non-default Radiometer LUTs	Percent of data in this product with non-default LUTs . e.g. 0.0	Float (32-bit)	Scalar
	ORBIT COORDINATES		
Orbit Number	Orbit number from the start of the mission. e.g. 4024	Integer (32-bit)	Scalar
Orbit Node Longitude	Longitude of scene's orbit ascending node (longitude at equatorial crossing of PM-side node). e.g -109.2135	Float (32-bit)	Scalar
Cycle Number	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. e.g. 29	Integer (32-bit)	Scalar
Pass Number	Pass (orbit) number within the weekly cycle (1 to 103). e.g. 31	Integer (32-bit)	Scalar

Table 6. Aquarius L1A Data Variables and Associated Attribute Values by Group.

Group	Variable	Type	Data Space Array Dimensions	Long Name	Units	Range
Block Attributes	atc_frmnum	Integer (32-bit)	5200 x 1	ATC Frame Number		
	atc_subframe	Char (8-bit)	5200 x 1	ATC Sub-Frame Number		
	blk_sec	Float (64-bit)	5200 x 1	Block time, seconds of day	seconds	
	rad_frmnum	Integer (32-bit)	5200 x 1	Radiometer Frame Number		
	rad_subframe	Char (8-bit)	5200 x 1	Radiometer Sub-Frame Number		
Converted Telemetry	apdu_analog_tlm	Float (32-bit)	5200 x 5	Aquarius Power Distribution Unit analog telemetry		
	atc_omt1_analog_tlm	Float (32-bit)	1300 x 17	ATC OMT1 analog telemetry		
	atc_omt1_discrete_tlm	Unsigned Char (8-bit)	1300 x 17	ATC OMT1 discrete telemetry		
	atc_omt2_analog_tlm	Float (32-bit)	1300 x 17	ATC OMT2 analog telemetry		
	atc_omt2_discrete_tlm	Unsigned Char (8-bit)	1300 x 17	ATC OMT2 discrete telemetry		
	atc_omt3_analog_tlm	Float (32-bit)	1300 x 17	ATC OMT3 analog telemetry		
	atc_omt3_discrete_tlm	Unsigned Char (8-bit)	1300 x 17	ATC OMT3 discrete telemetry		
	atc_rbe_analog_tlm	Float (32-bit)	1300 x 17	ATC RBE analog telemetry		
	atc_rbe_discrete_tlm	Unsigned Char (8-bit)	1300 x 17	ATC RBE discrete telemetry		
	deploy_analog_tlm	Float (32-bit)	5200 x 4	Antenna deployment analog telemetry		
	deploy_discrete_tlm	Integer (32-bit)	5200 x 7	Antenna deployment discrete telemetry		
	dpu_analog_tlm	Float (32-bit)	1300 x 12	DPU analog telemetry		
	dpu_status_tlm	Unsigned Char (8-bit)	1300 x 4 x 13	DPU discrete telemetry		
	ext_temp_analog_tlm	Float (32-bit)	5200 x 38	External Temperature Sensor analog telemetry		
	icds_analog_tlm	Float (32-bit)	5200 x 14	ICDS analog telemetry		
	icds_discrete_tlm	Integer (32-bit)	5200 x 8	ICDS discrete telemetry		
	radiom_nrt_tlm	Unsigned Integer (16-bit)	1300 x 4 x 17	Radiometer discrete non-real-time telemetry		
	rbe1_analog_tlm	Float (32-bit)	1300 x 21	RBE1 analog telemetry		
	rbe2_analog_tlm	Float (32-bit)	1300 x 21	RBE2 analog telemetry		
	rbe3_analog_tlm	Float (32-bit)	1300 x 21	RBE3 analog telemetry		
	rfe1_analog_tlm	Float (32-bit)	1300 x 23	RFE1 analog telemetry		
	rfe2_analog_tlm	Float (32-bit)	1300 x 23	RFE2 analog telemetry		
	rfe3_analog_tlm	Float (32-bit)	1300 x 23	RFE3 analog telemetry		

Group	Variable	Type	Data Space Array Dimensions	Long Name	Units	Range
	scatter_analog_tlm	Float (32-bit)	5200 x 30	Scatterometer analog telemetry		
	scatter_discrete_tlm	Unsigned Char (8-bit)	5200 x 8	Scatterometer discrete telemetry		
Navigation	att_ang	Float (64-bit)	937 x 3	Spacecraft roll, pitch, yaw	degrees	-180, 180
	att_flags	Integer (32-bit)	937	Attitude flags		
	att_time	Float (64-bit)	937	Time tag of attitude data	seconds	
	orb_pos	Float (64-bit)	125 x 3	Orbital position vector	meters	-7.1e+06, 7.1e+06
	orb_time	Float (64-bit)	125	Time tag of orbit vectors	seconds	
	orb_vel	Float (64-bit)	125 x 3	Orbital velocity vector	meters/sec	-7600, 7600
	quaternion	Float (64-bit)	937 x 4	ECI-to-spacecraft quaternion		-1, 1
Raw Aquarius Data	apdu_tlm	Unsigned Char (8-bit)	5200 x 5	Aquarius Power Distribution Unit telemetry		
	atc_tlm	Unsigned Char (8-bit)	5200 x 36	Active Thermal Control Unit telemetry		
	checksum	Unsigned Integer (16-bit)	5200	Checksum		
	deploy_tlm	Unsigned Char (8-bit)	5200 x 5	Antenna deployment telemetry		
	gps_time_tag	Integer (32-bit)	5200	Block GPS time tag	seconds	
	icds_status	Unsigned Char (8-bit)	5200 x 12	ICDS processing status		
	icds_tlm	Unsigned Char (8-bit)	5200 x 24	ICDS engineering telemetry		
	pad	Unsigned Char (8-bit)	5200 x 35	Pad		
	radiom_cnd	Unsigned Integer (16-bit)	1300 x 4 x 12 x 3 x 4	Radiometer CND Looks		
	radiom_header	Unsigned Integer (16-bit)	1300 x 4	Radiometer block header		
	radiom_lavg	Unsigned Integer (16-bit)	1300 x 4 x 8 x 3 x 4	Radiometer Long Accumulations		
	radiom_nrt_tlm	Unsigned Char (8-bit)	1300 x 4 x 10	Radiometer non-real-time telemetry		
	radiom_rt_tlm	Unsigned Char (8-bit)	1300 x 4 x 50	Radiometer real-time telemetry		
	radiom_signals	Unsigned Integer (16-bit)	1300 x 4 x 12 x 5 x 3 x 4	Radiometer Antenna Looks		
	scatter_dc	Unsigned Integer (16-bit)	5200 x 2	Scatterometer DC data		
	scatter_headers	Unsigned Char (8-bit)	5200 x 8	Scatterometer subcycle headers		
	scatter_loop	Unsigned Integer (16-bit)	5200 x 3 x 6	Scatterometer Loopback Measurements		
	scatter_pwr	Unsigned Integer (16-bit)	5200 x 8 x 3 x 6	Scatterometer Power		
	scatter_rfi	Unsigned Char (8-bit)	5200 x 4	Scatterometer RFI flags for H-pol		
	scatter_tlm	Unsigned Char (8-bit)	5200 x 37	Scatterometer telemetry		
	start_synch	Integer (32-bit)	5200	Start-synch word	dummy	

Group	Variable	Type	Data Space Array Dimensions	Long Name	Units	Range
	temp_tlm	Unsigned Char (8-bit)	5200 x 70	External Temperature Sensors telemetry		
	time_tag_offset	Integer (32-bit)	5200	Block time offset from GPS	62.5 nanosec units	
SAC-D Telemetry	sacd_hkt	Unsigned Char (8-bit)	1040 x 4000	SAC-D raw housekeeping telemetry blocks		

4.3 Level-2 File Organization & Description

The filename for the Level-2 Aquarius product conforms to standards previously described and illustrated by: **Q2012001012500.L2_SCI_V1.3**. In addition to global file metadata, Level-2 files contain data for a range of measured variables organized in five categorical groups: *Aquarius Data, Aquarius Flags, Block Attributes, Converted Telemetry,* and *Navigation*. These are described in detail in the sections below. Group data objects hold data for each block (1.44 second Aquarius instrument sampling interval) and Aquarius beam; these arrays are therefore typically dimensioned by the value of the global attributes *Number of Blocks* (e.g. 4083) and *Number of Beams* (3), in addition potentially to further dimensional variables in select cases. Tables 7-15 list and describe attributes associated both with global file metadata and each of the L2 Aquarius variable datasets by group. The source documentation on which this information is based is:

Patt, F. et al. (2013). Aquarius Level-2 Data Product Version 2.0, January, 2013. NASA/GSFC.

4.3.1 Global Metadata

A complete listing and definition of global metadata fields associated with Aquarius Level-2 files is given in table 7 below. Attributes are presented by categorical groups. Representative attribute values are provided for illustration of content together with detailed descriptions of fields.

Table 7. Aquarius L2 Data File Global Metadata Attributes by Category.

Attribute Name	Description/Value	Type	Array Size
	MISSON and DOCUMENTION ATTRIBUTES		
Product Name	The name of the product file (without path). E.g. Q2012070005700.L2_SCI_V1.3	String(31)	Scalar
Title	Aquarius Level 2 Data	String(22)	Scalar
Data Center	NASA/GSFC Aquarius Data Processing Center	String(42)	Scalar
institution	NASA/GSFC OBPG	String(15)	Scalar
Mission	SAC-D Aquarius	String(15)	Scalar
Mission Characteristics	Nominal orbit: inclination = 98.0 (Sun-synchronous); node = 6 PM (ascending); eccentricity = <0.002; altitude = 657 km; ground speed = 6.825 km/sec	String(137)	Scalar
Sensor	Aquarius	String(9)	Scalar
Sensor Characteristics	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-	String(163)	Scalar

Attribute Name	Description/Value	Type	Array Size
	view = 6.5 degrees; instantaneous scatterometer field-of-view = 4.9 degrees; science data block period = 1.44 sec		
Data Type	SCI	String(4)	Scalar
	MISSON and DOCUMENTION ATTRIBUTES		
Software ID	Identifies version of the software used to create this product. (e.g. 2.00)	String(5)	Scalar
Processing Version	Identifies the version of the products (e.g. V2.0)	String(7)	Scalar
Processing Time	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 YYYYDDDHHMMSSFFF. (e.g. 2012076162214000)	String(17)	Scalar
Conventions	"CF-1.6"; Climate and Forecast (CF) metadata conventions used.	String(7)	Scalar
_lastModified	Same as "Processing Time" attribute above. (e.g. 2012076162214000)	String(17)	Scalar
Input Files	The name of the Level-1A file (without path) from which the current product was created; stored in the product as part of its processing history. (e.g. Q2012001012500.L1A_SCI)	String(23)	Scalar
RAD_ANCILLARY_FILEn *RAD_ANCILLARY_FILE1*	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. This information is stored in the product as part of its processing history. e.g. y2012031000.h5:N2012069_SST_OIV2AV_24h.nc,N2012070_SST_OIV2AV_24h.nc,N201207000_QATM_NCEP_6h.h5,N201207000_QMET_NCEP_6h,N201207000_SEAICE_NCEP_24h.hdf,N201207100_SEAICE_NCEP_24h.hdf,N201206900_SALINITY_HYCOM_24h.h5,N201207000_SALINITY_HYCOM_24h.h5	String(248)	Scalar
RAD_ANCILLARY_FILE2	y2012031006.h5:N2012069_SST_OIV2AV_24h.nc,N2012070_SST_OIV2AV_24h.nc,N201207006_QATM_NCEP_6h.h5,N201207006_QMET_NCEP_6h,N201207000_SEAICE_NCEP_24h.hdf,N201207100_SEAICE_NCEP_24h.hdf,N201206900_SALINITY_HYCOM_24h.h5,N201207000_SALINITY_HYCOM_24h.h5	String(248)	Scalar
RAD_ANCILLARY_FILE3	y2012031000.h5:N2012069_SST_OIV2AV_24h.nc,N2012070_SST_OIV2AV_24h.nc,N201207000_QATM_NCEP_6h.h5,N201207000_QMET_NCEP_6h,N201207000_SEAICE_NCEP_24h.hdf,N201207100_SEAICE_NCEP_24h.hdf,N201206900_SALINITY_HYCOM_24h.h5,N201207000_SALINITY_HYCOM_24h.h5	String(248)	Scalar
Scatterometer Ancillary Files	The names of the ancillary files (without path) used to process the scatterometer data; stored in the product as part of its processing history. e.g. SEAICEFILE1=N201207000_SEAICE_NCEP_24h.hdf,TECFILE1=N201207000_TEC_IGR_24h.h5,QMETFILE1=N201207000_QMET_NCEP_6h,QMETFILE2=N201207006_QMET_NCEP_6h	String(146)	Scalar
Radiometer Calibration Files	The names of the radiometer calibration coefficient files (without path) used to process the radiometer data; stored in the product as part of its processing history. e.g. coeff_loss_v3.txt,coeff_nl.txt	String(31)	Scalar
Radiometer Data Tables	The names of the radiometer look-up table files (without path) used to process the radiometer data; stored in the product as part of its processing history. e.g. land_tables.h5,gain_ice.h5,tausq.h5,ocean_reflectance.h5,mk_sss_algo_tables.h5,sun_tables.h5,sun_bak_tables.h5,galaxy_wind_tables_080111.h5,apc_matrix_090711.h5,.,.	String(174)	Scalar
Scatterometer Coefficient Files	The names of the scatterometer coefficient files (without path) used to process the scatterometer data; stored in the product as part of its processing history. e.g. atc_prt_convert_v3.txt,ext_temps_constants_convert_v3.txt,scat_temps_convert_v1.txt,radiometer_constants_convert_v2.txt,cmd_gn.dat	String(131)	Scalar
Processing Control	Input and processing control parameters used to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters; stored in the product as part of its processing history. e.g. ifile=/data4/sdpsoper/vdc/vpu3/workbuf/Q2012070005700.L1A_SCI ofile=/data4/sdpsoper/vdc/vpu3/workbuf/Q2012070005700.L2_SCI_V1.3 yancfile1=y2012031000.h5 yancfile2=y2012031006.h5 rad_apc_file=$OCDATAROOT/aquarius/radiometer/apc_matrix_090711.h5 rad_sssalgo_file=$OCDATAROOT/aquarius/radiometer/mk_sss_algo_tables.h5 rad_galwind_file=$OCDATAROOT/aquarius/radiometer/galaxy_wind_tables_080111.h5 rad_sun_file=$OCDATAROOT/aquarius/radiometer/sun_tables.h5 rad_sunbak_file=$OCDATAROOT/aquarius/radiometer/sun_bak_tables.h5 rad_oceanrefl_file=$OCDATAROOT/aquarius/radiometer/ocean_reflectance.h5 rad_dtbdwin_file= coeff_loss_file=$OCDATAROOT/aquarius/radiometer/coeff_loss_v3.txt coeff_nl_file=$OCDATAROOT/aquarius/radiometer/coeff_nl.txt sss_algorithm=SIGMA0	String(2158)	Scalar

Attribute Name	Description/Value	Type	Array Size
	emiss_coeff_harm_file=$OCDATAROOT/aquarius/radiometer/wind_emiss_harm_coeffs_v3.h5 scat_coeff_harm_file=$OCDATAROOT/aquarius/radiometer/sigma0_harm_coeffs_v3.h5 dtbw_win_sigma_file=$OCDATAROOT/aquarius/radiometer/dtbw_win_sigma.h5 iopt_drift=false deflection_ratio_coeff_file=$OCDATAROOT/aquarius/radiometer/deflection_ratio_coeff_file.txt l2prod=default:rad_TbV_rc_nolc,rad_TbH_rc_nolc,rad_TbV_rc,rad_TbH_rc,rad_Tb_error_nolc,rad_Tb_error pversion=V1.3 incalfilelist=l2calinputs.txt rad_landtables_file=$OCDATAROOT/aquarius/radiometer/land_tables.h5 rad_landcorr_file=$OCDATAROOT/aquarius/radiometer/land_corr_tables.h5 rad_gainice_file=$OCDATAROOT/aquarius/radiometer/gain_ice.h5 rad_tausq_file=$OCDATAROOT/aquarius/radiometer/tausq.h5 radantGa4_file=$OCDATAROOT/aquarius/radiometer/radantGa4.h5 radantGa16_file=$OCDATAROOT/aquarius/radiometer/radantGa16.h5 radantGm16_file=$OCDATAROOT/aquarius/radiometer/radantGm16.h5 matchup_lat=-999 matchup_lon=-999 matchup_delta_lat=1.0 matchup_delta_lon=1.0 matchup_min_distance=35.0 browse=false iopt_rfi=true matchup_limits_file= yancfile3=		
Scatterometer Processing Control	Additional scatterometer input and processing control parameters used to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. Stored in the product as part of its processing history. e.g. -limits /sdps/sdpsoper/Science/OCSSW/trunk/data/aquarius/scatterometer/L1B_limits_flA_09-14-2011.txt -debug -1 -L2_filter_rfi -param_file /sdps/sdpsoper/Science/OCSSW/trunk/data/aquarius/scatterometer/params_10-10-2011.txt -dir_dat /sdps/sdpsoper/Science/OCSSW/trunk/data/aquarius/scatterometer -dir_out /data4/sdpsoper/vdc/vpu3/workbuf -dir_scratch /dev/shm/tmp_34996892 -apc_file /sdps/sdpsoper/Science/OCSSW/trunk/data/aquarius/scatterometer/L2_APC_matrix_theory_10-04-2011.txt -cal_level 3 -suppress_tlm_warnings -i /data4/sdpsoper/vdc/vpu3/workbuf/Q2012070005700.L1A_SCI	String(590)	Scalar
Delta TND H coefficient	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 "Instrument calibration (post-launch): Radiometer calibration methodology", J. Piepmeier et al. e.g. 0.004769839, 0.0060151783, 0.0054100547	Float (32-bit)	3 (# of Beams)
Delta TND V coefficient	calibration coefficient applied to the Radiometer Ta V polarization for this orbit, computed from the exponential fits (see above). e.g. 0.0057764184, 0.00512049, 0.0062645986	Float (32-bit)	3 (# of Beams)
Radiometer Offset Correction	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 "Instrument calibration (post-launch): Radiometer calibration methodology", J. Piepmeier et al. The order is (1V, 1H, 2V, 2H, 3V, 3H). Set to -9999.0 if not used.	Float (32-bit)	6 (2 x # Beams)
Radiometer Flag Limits	Brief listing of limits used to set the radiometer quality flags (see Table 12). e.g. FI: 15 7 Land: 0.005 0.02 Ice: 0.005 0.02 Wind: 7 15 Temp: 1 3 FluxD: 0.02 0.05 FluxR: 0.02 0.05 Glint: 0.02 0.05 Moon: 0.02 0.05 Gal: 0.02 0.05 RPY: 1 5 4 Flare: 5e-05 0.0001	String(178)	Scalar
Mean Solar 1415 MHz Flux	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. E.g. 91.56463	Float (32-bit)	Scalar
	DATE/TIME ATTRIBUTES		
Start Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070005700740	String(17)	Scalar
End Time	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 YYYYDDDHHMMSSFFF. e.g. 2012070023458820	String(17)	Scalar
Node Crossing Time	UTC of acscending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF. e.g. 2012001014930000	String(17)	Scalar
Start Year	UTC year of first block of the orbit. e.g. 2012	Integer (32-bit)	Scalar
Start Day	UTC day-of-year of first block of the orbit. e.g. 70	Integer (32-bit)	Scalar
Start Millisec	UTC milliseconds-of-day of the first block of the orbit. e.g. 3420747	Integer (32-bit)	Scalar

Attribute Name	Description/Value	Type	Array Size
End Year	UTC year of last block of the orbit. e.g. 2012	Integer (32-bit)	Scalar
End Day	UTC day-of-year of last block of the orbit. e.g. 70	Integer (32-bit)	Scalar
End Millisec	UTC milliseconds-of-day of the last block of the orbit. e.g. 9298828	Integer (32-bit)	Scalar
	DATA CHARACTERISTICS		
Number of Blocks	Number of Aquarius science blocks in the orbit at 1.44-second intervals. (= 4083)	Integer (32-bit)	Scalar
Number of Beams	Number of antenna beams; order is inner, middle, outer. (= 3)	Integer (32-bit)	Scalar
Radiometer Polarizations	Number of polarizations in raw radiometer data; order is V, +45, -45, H. (= 4)	Integer (32-bit)	Scalar
Radiometer Subcycles	The number of 120 msec subcycles in a 1.44 second science block. (= 12)	Integer (32-bit)	Scalar
Radiometer Signals per Subcycle	Number of radiometer antenna signal measurements in a 120 msec subcycle; first 2 are 20 msec, last 3 are 10 msec. (= 5)	Integer (32-bit)	Scalar
Scatterometer Polarizations	Number of scatterometer receive polarizations; order is V, H; last dimension of the **scat_rfi_flags** array (= 2)	Integer (32-bit)	Scalar
Scatterometer Subcycles	The number of 180 msec subcycles in a 1.44 second science block. (= 8)	Integer (32-bit)	Scalar
	FILE METRICS		
Percent Water	Percent of data in this product not contaminated by land. e.g. 0.68622816	Float (32-bit)	Scalar
Percent RFI	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. e.g. 0	Float (32-bit)	Scalar
Nominal Navigation	Indicates nominal pointing during the orbit; set to FALSE during maneuvers or anomalies. (="TRUE" or "FALSE")	String(6)	Scalar
Anomaly Status String	Indicates type of anomaly (if any) that occurred in this orbit; included only for orbits with anomalies.	String	Scalar
	ORBIT COORDINATES		
Latitude Units	Units used for all latitude values in this product. (= degrees North)	String(14)	Scalar
Longitude Units	Units used for all longitude values in this product. (= degrees East)	String(13)	Scalar
Orbit Number	Orbit number from the start of the mission. e.g. 4024	Integer (32-bit)	Scalar
Orbit Node Longitude	Longitude of scene's orbit ascending node (longitude at equatorial crossing of PM-side node). e.g -109.2135	Float (32-bit)	Scalar
Cycle Number	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. e.g. 29	Integer (32-bit)	Scalar
Pass Number	Pass (orbit) number within the weekly cycle (1 to 103). e.g. 31	Integer (32-bit)	Scalar

4.3.2 "Aquarius Data" Group Variables

Aquarius observational and ancillary data are stored in the ***Aquarius Data*** group object of the Aquarius Level-2, HDF5 product file. Table 8 lists L2 data variables belonging to this data group. The table provides a complete description of available parameters by category: Radiometer, Scatterometer, Ancillary Data, and SAC-D Microwave Radiometer MWR. For each parameter, the values of the attribute **Long Name, Description** and **Units** are given together with a summary of associated data structure attributes. Each data object has dimensions **Number of Blocks** x **Number of Beams**. (Blocks are defined in section 4.3.2)

Please note that the values of ancillary variables are interpolated in space and time to the Aquarius beam footprints. Sources of ancillary datasets employed are cited in the associated variable descriptions below, and fully documented in Appendix 1.

Table 8. Description of Variables Associated with the "*Aquarius Data*" Group of Aquarius Level-2 Files. Variable listings are organized in blocks by the instrument type with which the parameter is associated (Radiometer, Scatterometer, MWR). Note that for compactness here, radiometer parameters having multiple polarizations are represented in the table within a single row as **X** = {V, H, 3} or {V, H} polarizations as may apply. Similarly for scatterometer parameters, but with **X** = {VV, HH, HV VH} or {V, H} polarizations as may apply. In contrast, in the data files themselves each parameter polarization is represented as a distinct dataset variable. Variables not yet fully implemented but present in the current version of the L2 data files are indicated by ***;** such variables are assigned default Null values (-9999).

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
			RADIOMETER PARAMETERS	
rad_Ta**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Ta **X** polarization: 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.	Kelvin
rad_Ta**X**0 where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Ta **X** polarization (no exp drift): 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.	Kelvin
rad_Tf**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Ta **X** polarization (rfi filtered): 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.	Kelvin

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
rad_Tf**X**0 where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Ta **X** polarization (rfi filtered/no exp drift): 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.	Kelvin
rad_toi_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer TOI Tb **X** polarization: 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 comments (except the atmosphere) and then applying the antenna pattern correction, APC. (ATBD, Section 3.3, Equation 46.)	Kelvin
rad_toa_**X** where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Radiometer TOA Tb **X** polarization: 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 mainbeam. (ATBD, Section 3.8, Equation 55)	Kelvin
rad_toa_**X**_nolc where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Radiometer TOA Tb **X** polarization (no land correction): 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).	Kelvin
rad_far_TaH	Float (32-bit)	4083 x 3	Radiometer Faraday Angle: Faraday rotation angle determined from the ratio of the third and second Stokes parameters using data in rad_TfX. This is the angle used in converting from rad_toi_X to rad_toa_X_nolc (ATBD Section 3.4, Equations 47-48).	degrees
rad_galact_Ta_dir_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Galactic Direct Corr **X** polar: Celestial background radiation at L-band impinging directly on the radiometer antenna. In nominal operation it enters via the antenna side lobes (ATBD Section 2.2.1).	Kelvin
rad_galact_Ta_ref_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Galactic Reflect Corr **X** polar: 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).	Kelvin

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
rad_solar_Ta_dir_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Solar Direct Corr **X** polar: 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)	Kelvin
rad_solar_Ta_ref_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Solar Reflect Corr **X** polar: 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)	Kelvin
rad_solar_Ta_bak_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Solar Back Scattered **X** polar: 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)	Kelvin
rad_Tb**X** where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Tb **X** polarization (no rough correction): 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).	Kelvin
rad_Tb**X**_nolc where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Earth surface Tb **X** polarization (no land correction): 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).	Kelvin
rad_Tb**X**_rc where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Tb **X** polarization (roughness correction): 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).	Kelvin
rad_Tb**X**_rc_nolc where **X** = {V, H} polarizations	Float (32-bit)	4083 x 3	Tb **X** polarization (roughness correction, no land correction): 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).	Kelvin
rad_Tb_consistency	Float (32-bit)	4083 x 3	Tb consistency check: 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. However, the difference at V-pol is zero because rad_TbV_rc is used to derive the SSS. Hence, this is the magnitude of the difference at H-pol.	Kelvin

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
rad_Tb_consistency_nolc	Float (32-bit)	4083 x 3	Tb consistency check (no land correction): Same as rad_Tb_consistency but using the measured values before land correction (i.e. using rad_TbX_nolc_rc).	Kelvin
SSS	Float (32-bit)	4083 x 3	Sea Surface Salinity: Retrieved sea surface salinity. Uses only vertical polarization. Obtained from rad_TbV_rc (ATBD Section 3.6; Addendum Section IV).	PSU
SSS_error *	Float (32-bit)	4083 x 3	Sea Surface Salinity error: Estimated uncertainty in SSS; *not currently implemented. All values = -9999.*	PSU
SSS_nolc	Float (32-bit)	4083 x 3	Sea Surface Salinity (no land correction): Retrieved sea surface salinity with no land sidelobe correction. Uses only vertical polarization. Obtained from rad_TbV_nolc_rc (ATBD Section 3.6; Addendum Section IV).	PSU
SSS_error_nolc *	Float (32-bit)	4083 x 3	Sea Surface Salinity error (no land correction): Estimated uncertainty in SSS_nolc; *not currently implemented. All values = -9999.*	PSU
rad_moon_Ta_ref_**X** where **X** = {V, H, 3} polarizations	Float (32-bit)	4083 x 3	Radiometer Lunar Reflect Corr **X** polar: 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).	Kelvin
rad_exp_Ta**X** where **X** = {V, H, 3} polarization	Float (32-bit)	4083 x 3	Radiometer Ta **X** (expected): 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).	Kelvin
rad_exp_Tb**X**	Float (32-bit)	4083 x 3	Radiometer Tb **X** (expected) : 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.	Kelvin
rad_exp_Tb**X**0	Float (32-bit)	4083 x 3	Radiometer Tb **X** (expected smooth): 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.	Kelvin
			SCATTEROMETER PARAMETERS	
scat_**X**_ant where X = {VV, HH, HV VH}	Float (32-bit)	4083 x 3	TOI Scatterometer NRCS for **X** polarization: Estimated normalized radar cross-section (NRCS, or sigma-0) at the antenna (i.e., TOI, top of ionosphere) for each polarization. (Defaults to -999 if the value cannot be computed)	db

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
scat_**X**_toa where X = {VV, HH, HV VH}	Float (32-bit)	4083 x 3	TOA Scatterometer NRCS for **X** polarization: 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. (Defaults to -999 if the value cannot be computed)	db
scat_tot_toa	Float (32-bit)	4083 x 3	TOA Scatterometer (Total): 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). (Defaults to -999 if the value cannot be computed)	db
scat_wind_speed	Float (32-bit)	4083 x 3	Scatterometer Wind Speed: Estimated wind speed at the ocean surface. (Defaults to -999 if the value cannot be computed)	m/s
wind_uncertainty	Float (32-bit)	4083 x 3	Estimated wind speed error: 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. (Defaults to -999 if the value cannot be computed)	m/s
scat_esurf_**X** where X = {V, H}	Float (32-bit)	4083 x 3	Excess surface scatterometer emissivity (**X** pol): Excess surface emissivity due to wind for V and H polarizations derived from scatterometer data and the radiometer model function. (Defaults to -999 if the value cannot be computed)	
scat_esurf_**X**_uncertainty where X = {V, H}	Float (32-bit)	4083 x 3	Uncertainty in surface emissivity (**X**-pol): 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. (Defaults to -999 if the value cannot be computed)	
Kpc_**X**_ant where X = {VV, HH, HV VH}	Float (32-bit)	4083 x 3	Kpc statistical uncertainty for ANT **X** NRCS: Statistical uncertainty for the antenna sigma-0 (Kpc = sqrt(var(sig-0))/sig-0)). (Defaults to -999 if the value cannot be computed)	
Kpc_**X**_toa	Float (32-bit)	4083 x 3	Kpc statistical uncertainty for TOA **X** NRCS: Statistical uncertainty for the top-of-atmosphere sigma-0 (Kpc = sqrt(var(sig-0))/sig-0). Algorithm still TBD; current KPC_TOA output is preliminary. (Defaults to -999 if the value cannot be computed)	
Kpc_total	Float (32-bit)	4083 x 3	Statistical uncertainty for total power NRCS: Statistical uncertainty for the total power sigma-0. (Defaults to -999 if the value cannot be computed)	
scat_**X**_exp where X = {VV, HH, HV VH}	Float (32-bit)	4083 x 3	Expected Sigma0 for **X** polarization: Estimated normalized radar cross-section (NRCS, or sigma-0) at the surface for each polarization, predicted using a geophysical model based on the wind dataset over ocean only. Over land, this value defaults to -999. (Also defaults to -999 if the value cannot be computed)	db

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
			ANCILLARY PARAMETERS	
anc_wind_speed	Float (32-bit)	4083 x 3	Ancillary Wind Speed 10m above surface: 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).	m/s
anc_wind_dir	Float (32-bit)	4083 x 3	Ancillary Wind Direction 10m above surface: 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)	degrees
anc_cwat	Float (32-bit)	4083 x 3	Cloud Water: 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 14). 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/.	kg m-2
anc_subsurf_temp	Float (32-bit)	4083 x 3	Sub-surface Temperature: The subsurface temperature over the land is the NCEP GFS GDAS product for the layer (0-10 cm) because emission from this layer is most closely correlated with soil moisture. This field is not valid over the ocean. Data is obtained from: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.	Kelvin
anc_surface_temp	Float (32-bit)	4083 x 3	Surface Temperature: The surface temperature over the ocean is the NOAA OISST (Reynolds) product. Over land, the NCEP GFS GDAS product for the surface layer (0-10 cm) is used because emission from this layer is most closely correlated with soil moisture. Data is available from: ftp.emc.ncep.noaa/gov/cmb/sst/oisst_v2/YEARLY_FILES	Kelvin
anc_surface_pressure	Float (32-bit)	4083 x 3	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/.	Pascals

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
anc_SSS	Float (32-bit)	4083 x 3	Sea surface salinity (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).	PSU
anc_swe	Float (32-bit)	4083 x 3	Snow water equivalent: The snow water equivalent from NCEP GFS GDAS. Data is obtained from ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.	Kg/m2
anc_trans	Float (32-bit)	4083 x 3	Atmospheric Transmittance: A measure of attenuation through the atmosphere. It is the parameter, τ(0,S), defined in equation 28-29 in the section 2.3.1 of the Level-2 ATBD. When τ(0,S) = 0 the path is completely opaque.	
anc_Tb_up	Float (32-bit)	4083 x 3	Upwelling atmospheric brightness temperature: 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.	Kelvin
anc_Tb_dw	Float (32-bit)	4083 x 3	Downwelling atmospheric brightness temperature: 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.	Kelvin
anc_sm	Float (32-bit)	4083 x 3	Soil Moisture: The soil moisture content when over land. This is obtained from the NCEP GFS GDAS operational data product at 1 degree resolution: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.	
rad_land_frac	Float (32-bit)	4083 x 3	Fraction of land contamination (radiometer): 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	Float (32-bit)	4083 x 3	Fraction of ice contamination (radiometer): 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/.	

Parameter/Variable	Data Type	Data Space (Array Size)	Variable Long Name & Description	Units
scat_land_frac	Float (32-bit)	4083 x 3	Fraction of land contamination (scatterometer): 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. (Defaults to -999 if the value cannot be computed)	
scat_ice_frac	Float (32-bit)	4083 x 3	Fraction of ice contamination (scatterometer): The fraction of sea ice in the block-integrated footprint, ranging from 0.0 for no ice to 1.0 for complete ice coverage. (Defaults to -999 if the value cannot be computed)	

4.3.3 "Block Attributes" Group Variables

The following table lists and defines Level-2 data objects belonging to the group ***Block Attributes***. A block is essentially the fundamental unit of data representation for the Aquarius L2 swath data. Each block represents a constant 1.44 second instrument sample interval along the Aquarius orbit. Since the orbit period is 97.86 minutes, the files can be either 97 or 98 minutes long. Since files are set to an integer number of minutes in length, the "Number of Blocks" can vary between files. There are 4083 blocks per 98 minute duration orbit and L2 file. Every block is associated with geolocation extent and time range parameters, and Aquarius geophysical data. Both within and between Groups, all data variable arrays are indexed consistently by block number, beam, and in select cases also by additional dimensional parameters (e.g. polarizations).

Table 9. Variables associated with the "*Block Attributes*" Group of Aquarius Level-2 files.

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description	Units
rad_samples	Unsigned Integer (16-bit)	4083 x 3 x 4 (Blocks x Beams x Radiometer Polarizations)	Number of radiometer samples per average: The number of radiometer samples used per block, beam and polarization in the radiometer parameter averages in the Aquarius Data group. Samples that are flagged for RFI interference (see: rad_rfi_flags) 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	Unsigned Integer (16-bit)	4083 x 3 (Blocks x Beams)	Number of scatterometer samples per average: The number of scatterometer samples used per block and beam in the scatterometer parameter averages in the ***Aquarius Data*** group. Samples flagged for RFI interference (see: rad_rfi_flags) in either polarization 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.	
sec	Float (64-bit)	4083 (Blocks)	Block time, seconds of day: Mid-block times of Aquarius physical parameter values in seconds of day. valid_range = (0.d0,86399.999999d0)	seconds
secGPS	Float (64-bit)	4083 (Blocks)	Block time, GPS time: Block times of Aquarius physical parameter values in seconds since the GPS epoch (0 hours UTC on 6 January 1980).	seconds
solar xray flux	Float (32-bit)	4083 (Blocks)	Solar xray flux (0.1 - 0.8 nanometers): 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 Ao) from the GOES satellite is used and is available at: http://www.swpc.noaa.gov/ftpdir/lists/xray.	watts/m2

4.3.4 "Aquarius Flags" Group Variables

This section summarizes the organization of Aquarius quality flag data within Level-2 product files and describes the flag values that have been assigned. These quality flags represent the non-nominal data conditions that are detected for radiometer and scatterometer measurements for each block and beam. The bit convention is 0-base, with the LSB as bit 0. Beam and polarization order is specified in the set of "Data Characteristics" global file attributes (Table 7). Table 10 describes data objects belonging to the group "***Aquarius Flags"***. Table 11 summarizes metadata attributes associated with these data objects where present, and more specifically with the radiometer_flags and scatterometer_flags objects within the *Aquarius Flags* data group.

Table 10. Variables belonging to the Level-2 file group "*Aquarius Flags".*

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description
rad_rfi_flags	Unsigned Char (8-bit)	4083 x 3 x 4 x 12 (Blocks x Beams x Radiometer Polarizations x Radiometer Subcycles)	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.
radiometer_flags	Unsigned Integer (32-bit)	4083 x 3 x 4 (Blocks x Beams x Max. Radiometer Flags)	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 12 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 (17 July 2012 draft).
scat_rfi_flags	Unsigned Char (8-bit)	4083 x 3 x 2 (Blocks x Beams x RX polarizations)	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.
scatterometer_flags	Unsigned Integer (32-bit)	4083 x 3 (Blocks x Beams)	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.

Table 11. Variables associated with members of "*Aquarius Flags*" L2 data group. In addition to long_name attributes shared by all group variables, the radiometer_flags and scatterometer_flags variables also possess a range of other attributes documented here.

Parameter/ Variable	Attribute	Value / Algorithm Name	Data Type	Array Size
radiometer_flags	long_name	Radiometer data quality flags	String(30)	Scalar
	Direct solar flux contamination	FLUXD	String(6)	Scalar
	Galactic contamination	GALACTIC	String(9)	Scalar
	Land contamination	LAND	String(5)	Scalar
	Moon contamination	MOON	String(5)	Scalar
	Non-nominal navigation	NAV	String(4)	Scalar
	RFI contamination	RFI	String(4)	Scalar
	Rain in main beam	RAIN	String(5)	Scalar
	Reflected solar flux contamination	FLUXR	String(6)	Scalar
	Roughness correction failure	ROUGH	String(6)	Scalar
	SA overflow	SAOVERFLOW	String(11)	Scalar
	Sea ice contamination	ICE	String(4)	Scalar
	Sun glint	SUNGLINT	String(9)	Scalar
	Unusual brighness temperature	TEMP	String(5)	Scalar
	Wind/foam contamination	WIND	String(5)	Scalar
scatterometer_flags	long_name	Scatterometer data quality flags	String(33)	Scalar
	Faraday rotation removal	FARADAY	String(8)	Scalar
	Negative TOA sigma0	NEGSIG	String(7)	Scalar
	Non-nominal attitude	BADATT	String(7)	Scalar
	RFI corruption of signal	RFI	String(4)	Scalar
	Rain in main beam	RAIN	String(5)	Scalar
	Non-nominal attitude	BADATT	String(7)	Scalar
rad_rfi_flags	long_name	Radiometer RFI flags	String(21)	Scalar
scat_rfi_flags	long_name	Scatterometer RFI flags	String(24)	Scalar

Radiometer quality flag definitions for each bit associated with the ***radiometer_flags*** parameter of the ***Aquarius Flags*** group within Level-2 files are given in table 12.

Table 12. Conditions indicated for the pixel associated with the setting of individual bits in *radiometer_flags* variable of the Level-2 "*Aquarius Flags*" group, along with the flag dimension and related radiometer data fields.

Bits Set =1	Condition Indicated	Last Flag Dimension	Flag/Mask	Radiometer Fields
0 (LSB)	RFI moderate contamination 7 < samples < 15	Polarization (V, P, M, H)	F	rad_samples
1	RFI severe contamination samples <7	V, P, M, H	F	rad_samples
2	Rain in main beam *(not yet implemented)*	V moderate, V severe H moderate, H severe	F	N/A
3	Land contamination Moderate: 0.005 < land frac < 0.02 Severe: land frac > 0.02	moderate, severe	F	rad_land_frac
4	Sea ice contamination Moderate: 0.005 < ice frac < 0.02 Severe: ice frac > 0.02	moderate, severe	F	rad_ice_frac
5	Wind/foam contamination Moderate: 7 < wind speed < 15 Severe: wind speed > 15	moderate, severe	F	anc_wind_speed
6	Unusual brightness temperature Moderate: 1.0 < abs(Tf-exp_Ta) < 3.0 Severe: abs(Tf-exp_Ta) > 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 < solar direct <0.05 severe: 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 < solar reflect < 0.05 severe: 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 < solar glint < 0.05 severe: 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 moderate: 0.02 < moon direct < 0.05 severe: moon direct > 0.05	V moderate, V severe H moderate, H severe	F	rad_moon_Ta_ref_V rad_moon_Ta_ref_H
11	Galactic contamination moderate: 0.02<galactic<0.05 severe: 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 abs(roll) > 1.0 abs(pitch) > 5.0	roll, pitch, yaw OOB	F M	att_ang beam_clat beam_clon

	abs(yaw) > 4.0 clat, clon = -999			
13	SA overflow Overflow bit set in NRT telemetry	Overflow	M	radiom_nrt_tlm (L1A)
14	Full roughness correction not performed (1 = partial correction)	Partial correction	F	N/A
15	Solar flare contamination	moderate severe	F	
16 – 31 (MSB)	Spares			

The scatterometer flagging scheme for each bit currently associated with the ***scatterometer_flags*** variable is summarized in table 13 and defined in more detail below.

Table 13. Conditions indicated for the pixel associated with the setting of individual bits in scatterometer_flags variable of the Level-2 "*Aquarius Flags*" group. These correspond to the algorithm names given by the attributes.
* indicates flag not currently implemented.

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)

4.3.5 "Navigation" Group Variables

The Level-2 data group "***Navigation"*** includes the spacecraft orbit and attitude information, celestial object locations and the geolocation fields. Note that for the latter, there are separate variables for the radiometer, the scattermeter, and the MWR. Geolocation, spacecraft and celestial object attributes within the Navigation group are listed and defined in Table 14 below. These are grouped as "Geolocation Parameters" and "Non-Geolocation parameters" respectively. Most of the variable arrays are of dimension (**Number of Blocks** x **Number of Beams**). Arrays for "scat_latfoot" and "scat_latfoot" variables are additionally dimensioned by the number of associated ellipsoid points per beam (=4). All geolocation fields are computed at the mid-block times represented by the **sec** variable of the ***Block Attributes*** group.

Table 14. Data variables belonging to the Level-2 file group "*Navigation".*

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description	Units	Valid Range
			Geolocation Parameters		
beam_clat	Float (32-bit)	4083 x 3	Beam Center Latitude	degrees	-90, 90
beam_clon	Float (32-bit)	4083 x 3	Beam Center Longitude	degrees	-180, 180
cellatfoot	Float (32-bit)	4083 x 3 x 4	Geodectic Latitudes (3 dB)	degrees	-90, 90
cellonfoot	Float (32-bit)	4083 x 3 x 4	East Longitudes (3 dB)	degrees	-180, 180
celtht	Float (32-bit)	4083 x 3	Boresight Earth Incidence Angle	degrees	-180, 180
celphi	Float (32-bit)	4083 x 3	Boresight Earth Azimuth Angle	degrees	-180, 180
sunglt	Float (32-bit)	4083 x 3	Sun Glint Angle	degrees	-180, 180
suntht	Float (32-bit)	4083 x 3	Sun Vector Earth Incidence Angle	degrees	-180, 180
sunphi	Float (32-bit)	4083 x 3	Sun Vector Earth Azimuth Angle	degrees	-180, 180
moonglt	Float (32-bit)	4083 x 3	Moon Glint Angle	degrees	-180, 180
glxlat	Float (32-bit)	4083 x 3	Galaxy Declination (J2000)	degrees	-90, 90
glxlon	Float (32-bit)	4083 x 3	Galaxy Right Ascension (J2000)	degrees	-180, 180
scat_beam_clat	Float (32-bit)	4083 x 3	Scatterometer Beam Center Latitude: Center latitude of the beam footprints on the Earth's surface for each beam and block. (Defaults to -999 if the value cannot be computed)	degrees	-90, 90

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description	Units	Valid Range
scat_beam_clon	Float (32-bit)	4083 x 3	Scatterometer Beam Center Longitude: Center longitude of the beam footprints on the Earth's surface for each beam and block. (Defaults to -999 if the value cannot be computed.)	degrees	-180, 180
scat_latfoot	Float (32-bit)	4083 x 3 x 4	Scatterometer Latitude Footprint: Latitudes of the –3dB points of the beam footprints on the Earth's surface, along and across the beam direction. (Defaults to -999 if the value cannot be computed)	degrees	-90, 90
scat_lonfoot	Float (32-bit)	4083 x 3 x 4	Scatterometer Longitude Footprint: Longitudes of the –3dB points of the beam footprints on the Earth's surface, along and across the beam direction. (Defaults to -999 if the value cannot be computed)	degrees	-180, 180
scat_polarization_roll	Float (32-bit)	4083 x 3	Polarization roll angle: Polarization roll angle for each beam, at start of the block. A positive roll angle represents a counterclockwise rotation of the instrument V/H vectors relative to the ellipsoidally-defined geometric beam vectors when looking down the boresite from the instrument to the ground. (Defaults to -999 if the value cannot be computed)	degrees	-180, 180
			Non-Geolocation Parameters		
acs_mode	Integer (8-bit)	4083	ACS control mode: Spacecraft attitude control system (ACS) mode for each block (5 = science, 6 = propulsion, 3 = safehold, 12 = survival).	unitless	3, 5, 6, 12
att_ang	Float (64-bit)	4083 x 3	Spacecraft roll, pitch, yaw: Spacecraft attitude Euler angles at mid-block times; relates spacecraft orientation to orbit reference frame.	degrees	-180, 180
moond	Float (64-bit)	4083 x 3	Earth-to-Moon unit vector (eci): Moon vector in ECI coordinates at mid-block time.	unitless	-1, 1
orb_pos	Float (64-bit)	4083 x 3	Orbital position vector: Orbit position vector at mid-block times; used to determine spacecraft position for geolocation.	m	-7.1e+06, 7.1e+06
orb_vel	Float (64-bit)	4083 x 3	Orbital velocity vector: Orbit velocity vector at mid-block times; used to determine spacecraft position for geolocation.	m/s	-7600, 7600
scalt	Float (64-bit)	4083	Spacecraft altitude. Spacecraft orbit altitude.	m	650,000, 690,000

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description	Units	Valid Range
sclat	Float (64-bit)	4083	Spacecraft nadir point latitude: Latitude of the spacecraft orbit nadir point.	degrees	-90, 90
sclon	Float (64-bit)	4083	Spacecraft nadir point longitude: Longitude of the spacecraft orbit nadir point.	degrees	-180, 180
sund	Float (64-bit)	4083 x 3	Earth-to-Sun unit vector (eci): Direct Sun vector in ECI coordinates at mid-block times.	unitless	-1, 1
sunr	Float (64-bit)	4083 x 3	Sun reflection unit vector (eci): Reflected Sun vector in ECI coordinates at mid-block time.	unitless	-1, 1
Zang	Float (64-bit)	4083 x 3	Intra-Orbit Angle: Angle within orbit from South pole passage at mid-block times.	degrees	0, 360

4.3.6 "Converted Telemetry" Group Variables

Data objects belong to the group ***Converted Telemetry*** are listed and defined below. This group contains Aquarius temperatures in the **rad_caltemps** object, unpacked from raw telemetry and converted to physical units. This parameter holds the computed radiometer gain and offset values used to calibrate the antenna brightness temperatures (Table 15). All data objects in this table each have dimensions **Number of Blocks** x **Number of Beams**.

Table 15. Data variables belonging to the Level-2 file group "*Converted Telemetry*".

Parameter/ Variable	Data Type	Data Space (Array Size)	Long Name & Description
rad_caltemps	Float (32-bit)	4083 x 85	Radiometer calibration temperatures: Aquarius temperatures used to calibrate the instrument brightness temperatures.
rad_ghh	Float (32-bit)	4083 x 3	Radiometer HH gain
rad_gmm	Float (32-bit)	4083 x 3	Radiometer MM gain
rad_gpp	Float (32-bit)	4083 x 3	Radiometer PP gain
rad_gvv	Float (32-bit)	4083 x 3	Radiometer VV gain
rad_oh	Float (32-bit)	4083 x 3	Radiometer H offset
rad_om	Float (32-bit)	4083 x 3	Radiometer M offset
rad_op	Float (32-bit)	4083 x 3	Radiometer P offset
rad_ov	Float (32-bit)	4083 x 3	Radiometer V offset

4.4 Level-3 File Organization & Description

Level-3 Aquarius mapped (L3m) data products are also provided in HDF5 file format. For any given day and time period (daily, weekly, monthly, seasonal), global, 1degree spatial resolution, mean sea surface salinity (SSS) and wind speed products are provided as distinct data files. As mentioned in section 3.4, there are additionally Ascending and Descending products for both salinity and wind speed for all time intervals. Plus there is 1 smoothed monthly SSS product giving 31 Level 3m products total as part of the Aquarius v2.0 release.

All L3m products are identical in structure. Each file contains a global level metadata portion, a 180x360 data array of type 32-bit Float (***l3m_data***) containing the geo-referenced measurement values in units of PSU or m/s for SSS and wind speed respectively. (Note that all ***l3m_data*** values are modulated by the defined scaling relationship with type, slope and offset parameters declared in the ***l3m_data*** metadata attributes of similar name). Additionally, a data structure with color palette information (***palette***: 3x256 of type Byte) is also present in the L3 files. Null SSS and Wind Speed data values in ***l3m_data*** are designated by the *_FillValue* attribute = -32767.0. The positional index for a given cell value within the 2-dimensional data array corresponds to the Longitude and Latitude of the Aquarius sea surface salinity or wind speed observation. Both the SSS and Wind Speed L3m product files have identical data and metadata structures. The filenames for these products conforms to standards previously described and illustrated by the following examples:

Q2012001.L3m_DAY_SCI_V2.0_SSS_1deg (Daily salinity)
Q20130082013014.L3m_7D_SCID_V2.0_scat_wind_speed_1deg (7 day wind speed, Descending)
Q20112132011243.L3m_MO_SCISM_V2.0_SSS_1deg (Monthly salinity, Smoothed)

4.4.1 Level-3 Sea Surface Salinity Standard Mapped Image File Structure

This section describes the L3m standard mapped image (SMI) SSS product line and the attributes of the file-level metadata in particular since otherwise the organization of the data variables themselves is identical. Table 16 lists global metadata attributes with representative values for L3m SSS products.

Table 16. Aquarius Level-3 Mapped SSS Product Global Metadata Attributes.

Parameter Attribute Name	Value	Type	Array Size
Data Bins	0	Integer (32-bit)	Scalar
Data Center	0	Char (8-bit)	Scalar
Data Maximum	46.87865	Float (32-bit)	Scalar
Data Minimum	0.0	Float (32-bit)	Scalar
Easternmost Longitude	180.0	Float (32-bit)	Scalar
End Day	71	Integer (16-bit)	Scalar
End Millisec	4755529	Integer (32-bit)	Scalar
End Orbit	0	Integer (32-bit)	Scalar
End Time	2.01207E+15	String(17)	Scalar
End Year	2012	Integer (16-bit)	Scalar
Input Files	Q2012070.L3b_DAY_SCI_V1.3.main	String(35)	Scalar

Parameter Attribute Name	Value	Type	Array Size
Input Parameters	IFILE = /data2/sdpsoper/vdc/vpu1/workbuf/Q2012070.L3b_DAY_SCI_V1.3.main|OFILE = Q2012070.L3m_DAY_SCI_V1.3_SSS_1deg|PFILE = |PROD = SSS|PALFILE = DEFAULT|PROCESSING VERSION = V1.3|MEAS = 1|STYPE = 0|DATAMIN = 0.000000|DATAMAX = 0.000000|LONWEST = -180.000000|LONEAST = 180.000000|LATSOUTH = -90.000000|LATNORTH = 90.000000|RESOLUTION = 1deg|PROJECTION = RECT|GAP_FILL = 0|SEAM_LON = -180.000000|PRECISION=F	String(416)	Scalar
Intercept	0.0	Float (32-bit)	Scalar
L2 Flag Names	0	Char (8-bit)	Scalar
Latitude Step	1.0	Float (32-bit)	Scalar
Latitude Units	degrees North	String(14)	Scalar
Longitude Step	1.0	Float (32-bit)	Scalar
Longitude Units	degrees East	String(13)	Scalar
Map Projection	Equidistant Cylindrical	String(24)	Scalar
Measure	Mean	String(5)	Scalar
Mission	SAC-D Aquarius	String(15)	Scalar
Mission Characteristics	Nominal orbit: inclination=98.0 (Sun-synchronous)	String(137)	Scalar
Northernmost Latitude	90.0	Float (32-bit)	Scalar
Number of Columns	360	Integer (32-bit)	Scalar
Number of Lines	180	Integer (32-bit)	Scalar
Orbit	0	Integer (32-bit)	Scalar
Parameter	Sea Surface Salinity	String(21)	Scalar
Period End Day	0	Integer (16-bit)	Scalar
Period End Year	0	Integer (16-bit)	Scalar
Period Start Day	0	Integer (16-bit)	Scalar
Period Start Year	0	Integer (16-bit)	Scalar
Processing Control	smigen par=Q2012070.L3m_DAY_SCI_V1.3_SSS_1deg.param	String(56)	Scalar
Processing Time	2012079130959000	String(17)	Scalar
Processing Version	V1.3	String(7)	Scalar
Product Name	Q2012070.L3m_DAY_SCI_V1.3_SSS_1deg	String(39)	Scalar
Product Type	0	Char (8-bit)	Scalar
SW Point Latitude	-89.5	Float (32-bit)	Scalar
SW Point Longitude	-179.5	Float (32-bit)	Scalar
Scaling	linear	String(8)	Scalar
Scaling Equation	(Slope*l3m_data) + Intercept = Parameter value	String(47)	Scalar
Sensor	Aquarius	String(9)	Scalar
Sensor Characteristics	0	Char (8-bit)	Scalar
Sensor Name	0	Char (8-bit)	Scalar
Slope	1.0	Float (32-bit)	Scalar
Software Name	smigen	String(7)	Scalar
Software Version	4.27	String(5)	Scalar
Southernmost Latitude	-90.0	Float (32-bit)	Scalar
Start Day	70	Integer (16-bit)	Scalar
Start Millisec	3748947	Integer (32-bit)	Scalar
Start Orbit	0	Integer (32-bit)	Scalar
Start Time	2012070010228940	String(17)	Scalar

Parameter Attribute Name	Value	Type	Array Size
Start Year	2012	Integer (16-bit)	Scalar
Station Latitude	0.0	Float (32-bit)	Scalar
Station Longitude	0.0	Float (32-bit)	Scalar
Station Name	0	Char (8-bit)	Scalar
Suggested Image Scaling Applied	No	String(3)	Scalar
Suggested Image Scaling Maximum	70.0	Float (32-bit)	Scalar
Suggested Image Scaling Minimum	0.0	Float (32-bit)	Scalar
Suggested Image Scaling Type	ATAN	String(5)	Scalar
SW Point Latitude	-89.5	Float (32-bit)	Scalar
SW Point Longitude	-179.5	Float (32-bit)	Scalar
Title	Level-3 Standard Mapped Image	String(31)	Scalar
Units	PSU	String(4)	Scalar
Westernmost Longitude	-180.0	Float (32-bit)	Scalar

4.4.2 Level-3 Wind Speed Standard Mapped Image File Structure

Aquarius Level-3 mapped data also include wind speed products at 1degree spatial resolution for daily, weekly, monthly and seasonal time intervals. The structure of these files, described previously (section 4.4), is identical to those of the SSS product. Here the attributes of the file-level metadata in particular are described. Table 17 lists global metadata attributes with representative values for L3m wind speed products.

Table 17. Aquarius Level-3 Mapped Wind Speed Product Global Attributes.

Parameter Attribute Name	Value	Type	Array Size
Data Bins	0	Integer (32-bit)	Scalar
Data Center	0	Char (8-bit)	Scalar
Data Maximum	46.87865	Float (32-bit)	Scalar
Data Minimum	0.0	Float (32-bit)	Scalar
Easternmost Longitude	180.0	Float (32-bit)	Scalar
End Day	71	Integer (16-bit)	Scalar
End Millisec	4755529	Integer (32-bit)	Scalar
End Orbit	0	Integer (32-bit)	Scalar
End Time	2.01207E+15	String(17)	Scalar
End Year	2012	Integer (16-bit)	Scalar
Input Files	Q2012070.L3b_DAY_SCI_V1.3.main	String(35)	Scalar
Input Parameters	IFILE = /data2/sdpsoper/vdc/vpu1/workbuf/Q2012070.L3b_DAY_SCI_V1.3.main|OFILE = Q2012070.L3m_DAY_SCI_V1.3_SSS_1deg|PFILE = |PROD = SSS|PALFILE = DEFAULT|PROCESSING VERSION = V1.3|MEAS = 1|STYPE = 0|DATAMIN = 0.000000|DATAMAX = 0.000000|LONWEST = -180.000000|LONEAST = 180.000000|LATSOUTH = -90.000000|LATNORTH = 90.000000|RESOLUTION = 1deg|PROJECTION = RECT|GAP_FILL	String(416)	Scalar

Parameter Attribute Name	Value	Type	Array Size
	= 0|SEAM_LON = -180.000000|PRECISION=F		
Intercept	0.0	Float (32-bit)	Scalar
L2 Flag Names	0	Char (8-bit)	Scalar
Latitude Step	1.0	Float (32-bit)	Scalar
Latitude Units	degrees North	String(14)	Scalar
Longitude Step	1.0	Float (32-bit)	Scalar
Longitude Units	degrees East	String(13)	Scalar
Map Projection	Equidistant Cylindrical	String(24)	Scalar
Measure	Mean	String(5)	Scalar
Mission	SAC-D Aquarius	String(15)	Scalar
Mission Characteristics	Nominal orbit: inclination=98.0 (Sun-synchronous)	String(137)	Scalar
Northernmost Latitude	90.0	Float (32-bit)	Scalar
Number of Columns	360	Integer (32-bit)	Scalar
Number of Lines	180	Integer (32-bit)	Scalar
Orbit	0	Integer (32-bit)	Scalar
Parameter	Scatterometer Wind Speed	String(21)	Scalar
Period End Day	0	Integer (16-bit)	Scalar
Period End Year	0	Integer (16-bit)	Scalar
Period Start Day	0	Integer (16-bit)	Scalar
Period Start Year	0	Integer (16-bit)	Scalar
Processing Control	smigen par=Q2012070.L3m_DAY_SCI_V1.3_SSS_1deg.param	String(56)	Scalar
Processing Time	2012079130959000	String(17)	Scalar
Processing Version	V1.3	String(7)	Scalar
Product Name	Q2012070.L3m_DAY_SCI_V1.3_scat_wind_speed_1deg	String(39)	Scalar
Product Type	0	Char (8-bit)	Scalar
SW Point Latitude	-89.5	Float (32-bit)	Scalar
SW Point Longitude	-179.5	Float (32-bit)	Scalar
Scaling	linear	String(8)	Scalar
Scaling Equation	(Slope*l3m_data) + Intercept = Parameter value	String(47)	Scalar
Sensor	Aquarius	String(9)	Scalar
Sensor Characteristics	0	Char (8-bit)	Scalar
Sensor Name	0	Char (8-bit)	Scalar
Slope	1.0	Float (32-bit)	Scalar
Software Name	smigen	String(7)	Scalar
Software Version	4.27	String(5)	Scalar
Southernmost Latitude	-90.0	Float (32-bit)	Scalar
Start Day	70	Integer (16-bit)	Scalar
Start Millisec	3748947	Integer (32-bit)	Scalar
Start Orbit	0	Integer (32-bit)	Scalar
Start Time	2012070010228940	String(17)	Scalar
Start Year	2012	Integer (16-bit)	Scalar
Station Latitude	0.0	Float (32-bit)	Scalar
Station Longitude	0.0	Float (32-bit)	Scalar

Parameter Attribute Name	Value	Type	Array Size
Station Name	0	Char (8-bit)	Scalar
Suggested Image Scaling Applied	No	String(3)	Scalar
Suggested Image Scaling Maximum	20.0	Float (32-bit)	Scalar
Suggested Image Scaling Minimum	0.0	Float (32-bit)	Scalar
Suggested Image Scaling Type	LINEAR	String(5)	Scalar
SW Point Latitude	-89.5	Float (32-bit)	Scalar
SW Point Longitude	-179.5	Float (32-bit)	Scalar
Title	Level-3 Standard Mapped Image	String(31)	Scalar
Units	m s-1	String(4)	Scalar
Westernmost Longitude	-180.0	Float (32-bit)	Scalar

5 Aquarius Data Accuracy and Validation

The Aquarius mission requirement is that the global salinity residual mean square (RMS) error is no more than 0.2 PSU on 150x150 km and monthly average. As yet, v2.0 of the Aquarius dataset partially meets this standard, and can be considered “validated” in the sense also that data accuracy and errors have been carefully documented. The "quasi-monthly" calibration errors have been isolated and corrected. However, there remain some spurious signals that vary seasonally, and are likely due to residual errors in the corrections for galactic reflection, radio frequency interference (RFI) and other sources. These will be the subject of further investigation by the Aquarius Science Team and future Aquarius algorithm improvement and dataset releases. Users are urged to read the Aquarius data validation analysis document carefully to understand the accuracy limits and warnings about when and where residual errors could be misinterpreted as oceanographic signals, particularly in certain regions and on certain time scales.

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Additional links

- **Official NASA Aquarius Page**
- **Comision Nacional de Actividades Espaciales (CONAE)**
- **PO.DAAC Aquarius Page**
- **OBPG/GSFC http://oceancolor.gsfc.nasa.gov/Page**
- **Earth & Space Research (ESR) Aquarius page**
- **Jet Propulsion Laboratory (JPL) Aquarius Page**
- **European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) Mission**
- **The Salinity Sea Ice Working Group (SSIWG)**
- **ARGO**

7 Acronyms & Abbreviations

Table 18. List of Abbreviations and Definitions Employed in the Aquarius User Guide Document.

Abbreviation	Definitions
AGS	Aquarius Ground Segment
BZIP	Basic Leucine Zipper
CONAE	Comision Nacional de Actividades Espaciales - Argentinian National Commission of Space Activities
db	Unit: Decibel
DMAS	PO.DAAC Data Management & Archive System
ESR	Earth and Space Research
GSFC	NASA Goddard Space Flight Center
GHz	Unit: gigahertz
HDF	Hierarchical Data Format
JPL	NASA Jet Propulsion Laboratory (California Institute of Technology)
Kpc	Random component of scatterometer error ratio
LSB	Least significant bit
m	Unit: Meters
m/s	Unit: meters per second
MSB	Most significant bit
NASA	National Aeronautics and Space Administration
NRCS	Normalized radar cross-section
OBPG	Ocean Biological Processing Group at NASA/GSFC
PALS	Passive/Active L-/S-band microwave instrument developed at JPL
RMS	Residual mean square error statistic
RSS	Remote Sensing Systems
PO.DAAC	Physical Oceanography Distributed Active Archive Center at JPL
RFI	Radio Frequency Interference
SAC	Satelite de Aplicaciones Cientificas - Scientific Application Satellite
SSS	Sea Surface Salinity
Tb	Brightness temperature
TO:	Top of the Atmosphere
TOI	Top of the Ionosphere
T_h	Horizontal Polarization
T_v	Vertical Polarization
VV	Polarization channel: Vertical transmit, vertical receive
VH	Polarization channel: Vertical transmit, horizontal receive
HV	Polarization channel: Horizontal transmit, vertical receive
HH	Polarization channel: Horizontal transmit, horizontal receive

8 Appendix 1: Aquarius Ancillary Data

Ancillary data from the operational HYCOM model (http://hycom.org/) and NCEP (http://www.ncep.noaa.gov/) are employed in Aquarius processing and also included as outputs in the Aquarius Level-2 product that is produced. This section briefly summarizes ancillary data inputs used by ADPS.

HYCOM

HYCOM Source:
The version of HYCOM used by Aquarius is the GOFS 3.0 (http://hycom.org/dataserver/glb-analysis/expt-90pt9). This operational, now-cast model run by the Naval research Lab (NRL) and Florida State University (FSU) assimilates available along track satellite altimeter observations, satellite and in situ sea surface temperature as well as in situ vertical temperature and salinity profiles from XBTs, ARGO floats, and moored buoys. For more details on GOFS 3.0, the reader is referred to Metzger et al. (2008, 2010) and Chassignet et al. (2009). The specific dataset being used for Aquarius is: "GLBa0.08/Expt 90.9"

HYCOM Data Access:
HYCOM GOFS 3.0 data is accessed by OBPG/GSFC via FTP from
ftp://ftp.hycom.org/datasets/GLBa0.08/expt_90.9.

FSU also serve this dataset via OpenDAP:
http://tds.hycom.org/thredds/GLBa0.08/expt_90.9.html?dataset=GLBa0.08/expt_90.9.

The data on both their ftp and OpenDAP sites are the same. However, there may be differences depending on when the data are downloaded because near-real time files are supplanted by reanalysis products daily with a rolling 10 day window.

Processing of HYCOM Data:
The native resolution of the HYCOM GOFS 3.0 GLBa0.08/Expt 90.9 product has a grid spatial resolution of 1/12 degree. ADPS uses the near-surface fields from HYCOM and re-grids these to a 0.25x0.25 degree longitude-latitude grid for Aquarius processing. Re-gridding is based on bilinear interpolation of values from the 4 adjacent nearest neighbor cells. HYCOM has a hybrid densith-depth vertical coordinate with 32 density layers and depth-level minimum thickness that ranges from 1 m to about 430 m (as described by the HYCOM input parameter name-list file ftp://ftp.hycom.org/datasets/GLBa0.08/expt_90.9/config/blkdat.input_90.9).
In the HYCOM server, the output has also been mapped to the 33 standard Levitus depth levels.

Additionally, the Aquarius Level-2 product contains the ancillary data variable field "**anc_SSS"** based on the HYCOM inputs described above. HYCOM data this time are re-gridded to collocate with swath data blocks of the Aquarius L2 dataset.

NCEP

All NOAA NCEP ancillary data fields used in Aquarius are obtained from the NOAA National Operational Model Archive & Distribution System (NCEP GFS GDAS) at:
ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/ .
Source details for each L2 ancillary variables based on NCEP (*anc_wind_speed, anc_wind_dir, anc_cwat, anc_subsurf_temp, anc_surface_temp, anc_surface_pressure, anc_swe, anc_trans, anc_Tb_up, anc_Tb_dw, anc_sm*) are given in Table 8 above.

9 Appendix 2: PO.DAAC Dataset Level Metadata

PO.DAAC maintains a searchable online catalog of datasets archived and accessible via the data portal at http://podaac.jpl.nasa.gov/. The following table summarizes the dataset-level metadata captured for Aquarius datasets at PO.DAAC that underlies this online catalog. Table describes metadata common to all archived datasets at PO.DAAC, including Aquarius products across dataset levels. The table 3 lists the various Aquarius data products maintained at PO.DAAC with dataset level metadata that are unique to each dataset.

Table 19. Dataset-level Metadata Captured for Each Archived Dataset and Discoverable via PO.DAAC's On-line Catalogue. Listed attributes are grouped categorically. Values are intended for illustration purposes and are not necessarily Aquarius dataset related.

Metadata Field	Value(s)
PROJECT RELATED	
short name	EOS
long name	Earth Observing System
	Provider Related
short name	JPL PODAAC
long name	Jet Propulsion Laboratory, Physical Oceanography Distributed Active Archive Center
resource	http://podaac.jpl.nasa.gov
	Source Related
short name	AQUARIUS_SAC-D
long name	Aquarius SAC-D
type	SPACECRAFT (currently null)
orbit period	98
inclination angle	98
description	Aquarius SAC-D is a joint venture between NASA and Argentina's Space Agency CONAE. In addition to NASA's Aquarius instrument CONAE instruments include MWR (Microwave Radiometer), NIRST (New Infrared Sensor Technology), HSC (High Sensitivity Camera), TDP (Technological Demonstration Package) and DCS (Data Collection System). Italy's ASI is providing ROSA (Radio Occultation Sounder for Atmosphere) and France's CNES Carmen 1 which consists of ICARE (Cosmic radiation effects) and SODAD (micro particles and space debris).
CITATION RELATED	
title	Aquarius Sea Surface Salinity Products
creator	Frank Wentz, Simon Yueh, Gary Lagerloef
version	
publisher	Goddard Ocean Color Group, Gene Feldman, Joel Gales
series name	Aquarius Sea Surface Salinity Products
release place	Goddard Space Flight Center, 8800 Greenbelt Rd.; Greeenbelt, Md., 20771
citation detail	Aquarius Sea Surface Salinity Products
online resource	http://podaac.jpl.nasa.gov/salinity/data.html

Metadata Field	Value(s)	
CONTACT RELATED		
Role	Technical Contact	
Name	User Services	
email	podaac@podaac.jpl.nasa.gov	
phone	(null)	
fax	(null)	
address	(null)	
COVERAGE RELATED		
north latitude	90	
south latitude	-90	
west longitude	-180	
east longitude	180	
DATA POLICY RELATED		
data class	ARCHIVE-DIST	
data format	HDF5	
compress type	BZIP2	
checksum type	MD5	
spatial type	NONE	
access constraint	NONE	
use constraint	NONE	
REGION RELATED		
region	Global	
ONLINE RESOURCE RELATED		
Resource	**Thumbnail Image**	**Guide Document (x below is 1, 2 or 3)**
path	/data/export/web/thumbnails	ftp://podaac-ftp.jpl.nasa.gov/ allData/aquarius/Lx/docs/Aquarius_Lx.html ftp://saltmarsh.jpl.nasa.gov/docs/
type	Thumbnail	dataset guide
SENSOR RELATED	Thumbnail image for Website	describes the level x Aquarius data
Sensor Related		
short name	AQUARIUS_RADIOMETER	AQUARIUS_SCATTEROMETER
long name	Aquarius Radiometer	Aquarius Scatterometer
swath width	390	373

10 Appendix 3: Archival of Aquarius Evaluation Datasets

Prior to release of the first validated Aquarius dataset version (v2.0, Feb. 2013) all Aquarius datasets were considered **evaluation** products and were thus subject to a registration/disclaimer acknowledgement process. **Users are strongly encouraged to use the current validated Aquarius data** rather than prior evaluation versions. However, PO.DAAC still maintains all Aquarius datasets produced by the data provider and designated for PO.DAAC archival. All evaluation, public Aquarius versions are still accessible via the legacy registration ftp site (ftp://saltmarsh.jpl.nasa.gov/) and the access page http://podaac.jpl.nasa.gov/AquariusDataAccess (Login simply involves users specifying the email address that they used previously during registration). PO.DAAC also maintains a separate access controlled site for the Aquarius Science Team, where all Aquarius Cal/Val datasets and interim evaluation versions not for public distribution are maintained.