Aquarius L3 Gridded 1-Degree Annual Soil Moisture, Version 5

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Bindlish, R. and T. Jackson. 2018. *Aquarius L3 Gridded 1-Degree Annual Soil Moisture, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/CDNI7NG92EHP. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AQ3_ANSM

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

The Aquarius L3 Gridded 1-Degree Soil Moisture Data are produced by NASA Goddard Space Flight Center's Aquarius Data Processing Segment (ADPS).

1.1 Format

Data are provided in Hierarchical Data Format 5 (HDF5) files. Data values are stored as bytes, 2-byte integers, and 4-byte floats. Soil moisture data are 32-bit float and color palette values are 8-bit unsigned integer. Each data file is paired with an associated XML file. XML files contain file level metadata and location, platform, and campaign information.

1.2 File and Directory Structure

Data are available at:

`https://n5eil01u.ecs.nsidc.org/AQUARIUS/AQ3_ANSM.005/`

Data files are organized in directories by date in YYYY.MM.DD format, for example:

```
/2011.08.25/*
/2012.01.01/
/2013.01.01/
/2014.01.01/
```

* **Note:** The annual file for 2011 coincides with the beginning of the Aquarius mission and therefore only contains data from 25 August 2011 onward. Similarly, the annual file for 2015 coincides with the end of the Aquarius mission and therefore only contains data through 07 June 2015.

1.3 File Naming Convention

All files are named according to the convention shown in the following example. File name variables are defined in Table 1.

Example

`Q20142442014273.L3m_YR_SOILM_V5.0_rad_sm_1deg`

Naming Convention

`QYYYYDDDyyyyddd.L3m_TT_SOILM_V5.0_rad_sm_1deg`

Table 1. File Naming Convention

Variable	Description
Q	Indicates Aquarius instrument
YYYYDDD	Start date (4-digit year, 3-digit day)
yyyyddd	End date (4-digit year, 3-digit day)
L3m	Processing level (Level-3 mapped)
TT	Observation period: YR: Yearly (annual mean)
SOILM	Parameter (SOILM: soil moisture)
V5.0	Data version number (V5.0)
rad_sm_1deg	1-degree radiometer soil moisture

1.4 Volume

The total volume for all Aquarius L3 annual soil moisture files is approximately 476 MB.

1.5 Spatial Coverage

The spatial coverage for this data set is global.

1.5.1 Spatial Resolution

Data are 1-degree spatial resolution.

1.5.2 Projection and Grid Description

The main HDF5 data group, called `l3m_data`, is a two-dimensional array (180 rows, 360 columns) of an Equidistant Cylindrical projection (also known as Plate Carrée) of the globe.

1.6 Temporal Coverage

The temporal coverage for this data set spans from 25 August 2011 through 07 June 2015.

Due to a power failure on the Satélite de Aplicaciones Científicas (SAC)-D spacecraft on 08 June 2015, data from the NASA Aquarius instrument are no longer being produced. For more information on this event, refer to the official NASA announcement, International Spacecraft Carrying NASA's Aquarius Instrument Ends Operations. The NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC) will continue to distribute Aquarius soil moisture and polar-gridded data sets for the full duration of the mission, 25 August 2011 through 07 June 2015.

1.6.1 Temporal Resolution

The temporal resolution for this data set is annual.

1.7 Parameter or Variable

This Level-3 product is a representation of a binned data product generated from Aquarius data. The HDF5 data group called `l3m_data` represents mean soil moisture at each grid point.

1.7.1 Parameter Description

Each Level-3 soil moisture product contains the `l3m_data` object, with attributes described in Table 2.

Table 2. Level-3 Soil Moisture `l3m_data` Object Attributes

Name	Value
Scaling	linear
Scaling Equation1	(Slope*l3m_data) + Intercept = Parameter value
Slope	1.0
Intercept	0
_FillValue	-32767.0
add_offset	0.0
scale_factor	1.0
[1] Scaling equations are typically provided to rescale the data for plotting purposes; however, in this case the scaling equation results in no change to the data values, and therefore can be disregarded.	

The group called `palette` in each data file is the color palette used in the graphics generated from the mapped files. This, or any other palette, can be used with these data.

Metadata are included as global attributes within each data file and have been adapted for Version 5 to more closely align with Climate and Forecast (CF) metadata conventions. A total of 68 metadata fields are provided, such as minimum and maximum data values, units, and platform and projection information. Values for some data fields may vary from granule to granule.

Figure 1 shows the average soil moisture estimates for the year 2012.

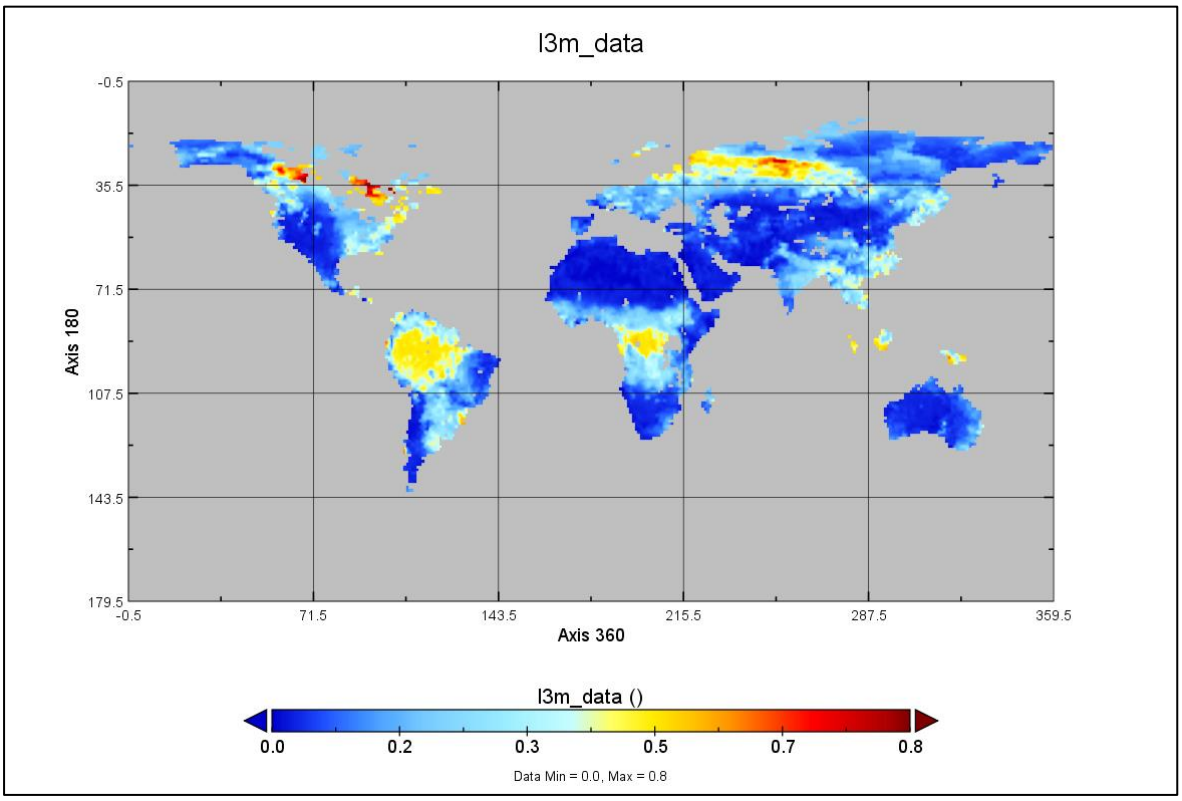

Figure 1. This plot shows Aquarius soil moisture estimates acquired using all three beams for the year 2012.

2 SOFTWARE AND TOOLS

HDF-aware software must be used to read the Aquarius soil moisture files. The following external links provide access to software for reading and viewing HDF5 data files. Please be sure to review instructions on installing and running the programs.

HDFView: Visual tool for browsing and editing HDF4 and HDF5 files. For additional tools, see the HDF5 Tools and Software Web site.

Panoply NetCDF, HDF and GRIB Data Viewer: Cross-platform application that plots geo-gridded arrays from NetCDF, HDF and GRIB datasets.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

The Aquarius Single Channel Algorithm (SCA) uses the L-band horizontally polarized (h-pol) brightness temperature observations due to the higher sensitivity of this channel to soil moisture. The Aquarius SCA approach is based on the simplified radiative transfer model developed under the assumption that the canopy and soil temperatures are the same (Jackson 1993). The SCA is

applied to the individual Aquarius footprint Level-2 brightness temperature observations to produce a swath-based time-ordered product. (Bindlish and Jackson 2013; Bindlish et al. 2013).

3.2 Data Acquisition Methods

The Version 5 Aquarius Level-3 Soil Moisture product is generated from brightness temperature measurements included in the NASA Aquarius Level-2 Sea Surface Salinity & Wind Speed Data V5.0 product. The best quality data are selected for each orbit during Level-0 (L0) to Level-1A (L1A) data processing and are then used to create the Level-2 (L2) file that is input to the L3 science file.

3.3 Derivation Techniques and Algorithms

The Aquarius Level-3 gridding algorithm uses local polynomial fitting to grid the Level-2 soil moisture retrievals on a 1 degree grid (Fan and Gijbels, 1996; Lilly and Lagerloef, 2008). The Level-3 processing of Aquarius satellite data takes measurements at the boresight locations of the three radiometer beams, which have been already converted into physical units of soil moisture, and maps these onto a 1 degree grid.

This method fits a Pth-order polynomial at each grid point x_m. For data values g_n observed at locations x_n, n = 1, 2, … N, this corresponds to minimizing

$$\sum_{n=1}^{N} \left| g_n - \sum_{p=0}^{P} \widehat{\beta_p}(x)[x_n - x]^2 \right|^2 K_h(x_n - x)$$

(Equation 1)

at every grid point x = x_m, where

$$K_h(x) = K\left(\frac{x}{h}\right)/h$$

(Equation 2)

is a decaying weighting function which depends upon the bandwidth h, with K(x) being a probability distribution function.

The regression coefficients

$$\widehat{\beta_p(x)}$$

(Equation 3)

P = 1, 2, … P vary with spatial location, and are estimated at all grid point locations.

The function g(x) is estimated by the lowest order coefficient,

$$\hat{g}(x) = \hat{\beta}_o(x)$$ **(Equation 4)**

while higher-order regression coefficients estimate the derivatives of the field through

$$g^{(p)}(x) = p!\,\hat{\beta}_{po}(x)$$ **(Equation 5)**

The above discussion focuses on a 1-dimensional application, but can be extended to a 2-dimensional application. A complete description for the 2-dimensional problem is available in Fan and Gijbels (1996) and Lilly and Lagerloef (2008).

3.3.1 Processing Steps

Each product represents data binned over the period covered by the original Aquarius product. The mean for the observation period is used to obtain the values for the grid points from the binned data products. Each product contains one soil moisture image and is stored in one physical HDF file. The data are not filtered during the gridding process. The user is advised to refer to the flags in the Aquarius L2 Swath Single Orbit Soil Moisture Data.

3.3.2 Version History

The following table outlines the version history for this product.

Table 3. Version History Details

Version	Description
V5	Changes to this version include: • Updated Version 5 Aquarius brightness temperature data were used as input • File-level metadata were modified to more closely align with Climate and Forecast (CF) metadata conventions
V4	For Version 4 Aquarius L3 Gridded 1-Degree Soil Moisture Data, the data set was updated to use the most recent version (Version 4) of Aquarius Brightness Temperatures as input.

Version	Description
V3	The Aquarius L3 Gridded 1-Degree Soil Moisture Data, Version 3 were processed from the Aquarius L2 Swath Single Orbit Soil Moisture Data, Version 3. Changes to this version include: • Use of the most recent version (Version 3) of Aquarius Brightness Temperatures as input • Aquarius Brightness Temperatures are no longer re-calibrated before soil moisture retrievals as was done for Version 2 data • Soil moisture observations are valid over a wider range of brightness temperatures compared to Version 2 data • Updates were made to the soil moisture model parameters (b and ω)
V2	First public data release

3.4 Sensor or Instrument Description

Aquarius/SAC-D is a collaboration between NASA and Argentina's space agency, Comisión Nacional de Actividades Espaciales (CONAE), with participation from Brazil, Canada, France and Italy. The Aquarius instrument was built jointly by NASA's Jet Propulsion Laboratory and NASA's Goddard Space Flight Center.

The Aquarius instrument includes three radiometers and one scatterometer. The soil moisture data are collected by the radiometers. The radiometers measure brightness temperature at 1.414 GHz in the horizontal and vertical polarizations (T_H and T_V). The scatterometer is a microwave radar sensor that measures backscatter for surface roughness corrections. Table 4 summarizes instrument characteristics.

Table 4. Aquarius Instrument Characteristics

Instrument	Characteristics
3 radiometers in push-broom alignment	Frequency: 1.413 GHz Band width: less than or equal to 26 MHz Swath Width: 390 km Science data block period: 1.44 sec Footprints for the beams are: 74 km along track x 94 km cross track, 84 x 120 km, and 96 x 156 km, yielding a total cross track of 390 km. Beam incidence angles of 29.36, 38.49, and 46.29 degrees incident to the surface. Beams point away from the sun.
Scatterometer	Frequency: 1.26 GHz Band Width: 4 MHz Swath Width: 390 km Science data block period: 1.44 sec

SAC-D spacecraft Orbit Parameters:

- 98 minute sun-synchronous
- 6 PM ascending orbit, 6 AM descending orbit
- 657 km equatorial altitude (655 km minimum, 685 km maximum over the orbit)
- Ground-track repeat interval: Weekly, 103 orbits

4 REFERENCES AND RELATED PUBLICATIONS

Bindlish, Rajat, and Thomas J. Jackson. 2013. Aquarius Soil Moisture ATBD Users Guide, Version 2.0. Beltsville, Maryland USA: USDA Hydrology and Remote Sensing Lab. (https://nsidc.org/sites/nsidc.org/files/files/data/aquarius/Aquarius-VSM-ATBD-UsersGuide.pdf, 315 KB)

Bindlish, Rajat, Thomas Jackson, Michael Cosh, Tianjie Zhao and Peggy O'Neill. 2015. Global Soil Moisture from the Aquarius Satellite: Description and Initial Assessment. *IEEE Geosciences and Remote Sensing Letters* 12(5):923-927.

Fan, J. and I. Gijbels. 1996. *Local Polynomial Modelling and its Applications*, Chapman and Hall, 1996.

Jackson, T. J. 1993. Measuring Surface Soil Moisture Using Passive Microwave Remote Sensing. *Hydrological Processes* 7:139–152.

Lilly, Jonathan and Gary Lagerloef. 2008. *Aquarius Level 3 Processing Algorithm Theoretical Basis Document*. ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/docs/v2/AquariusLevel3_GriddingSmoothingPaper_Lilly&Lagerloef2008.pdf

Piepmeier, Jeffrey, Shannon Brown, Joel Gales, Liang Hong, Gary Lagerloef, David Le Vine, Paolo de Matthaeis, Thomas Meissner, Rajat Bindlish, and Thomas Jackson. 2013. *Aquarius Radiometer Post-Launch Calibration for Product Version 2.0*, Aquarius Project Document: AQ-014-PS-0015. ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/docs/v2/AQ-014-PS-0015_AquariusInstrumentCalibratrionDescriptionDocument.pdf.

4.1 Related Data Collections

AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Parms, & QC EASE-Grids, Version 2

SMAP Data Sets at NSIDC

AMSR-E/Aqua Daily L3 Surface Soil Moisture, Interpretive Parameters, & QC EASE-Grids, Version 2

AMSR-E Validation Soil Moisture Data

Aquarius Level-1 and Level-2 Sea Surface Salinity Data

Aquarius Level-2 Swath Single Orbit Soil Moisture Data

ESA Soil Moisture and Ocean Salinity (SMOS)

Soil Moisture Product Using Aquarius/SAC-D Observations

4.2 Related Websites

Aquarius L2 Soil Moisture Documentation

Aquarius Web site at NASA Goddard Space Flight Center

Aquarius Data Web Site at NSIDC

Aquarius Web Site at PODAAC

SMAP Web Site at NSIDC

SMOS Website at ESA

NASA Aquarius Gallery: Soil Moisture - monthly soil moisture map images

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Publication Date

02 December 2013

6.2 Date Last Updated

September 2018