Aquarius L3 Gridded 1-Degree Seasonal Soil Moisture, Version 4

USER GUIDE

How to Cite These Data

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


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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AQ3_SNSM

NSIDC 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

The data files are in Hierarchical Data Format 5 (HDF5). The values are stored as bytes, 2-byte integers, or 4-byte floats. Data are 32-bit float. The palette object is 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 on the HTTPS site in the https://n5eil01u.ecs.nsidc.org/AQUARIUS/ directory. Data files are organized into directories by time period: Monthly and Seasonal:

/AQ3_ANSM.004/
/AQ3_DYSM.004/
/AQ3_MOSM.004/
/AQ3_SNSM.004/
/AQ3_WKSM.004/

Within each directory, folders are organized by date, for example:

/2013.09.03/
/2013.09.10/
/2013.09.17/
/2013.09.24/

Folders contain HDF5 and XML (.xml) files.

1.3 File Naming Convention

File names correspond to those of their parent Aquarius binned data products, indicating the binning periods as part of the names.

Files are named according to the following conventions and as described in Table 1:

Q20112442014273.L3m_MO_SOILM_V4.0_rad_sm_1deg
QYYYYDDyyyyddd.L3m_ttt_SOILM_vvvv_rad_sm_1deg

Where:

Table 1. File Naming Convention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>Indicates Aquarius instrument</td>
</tr>
<tr>
<td>YYYY</td>
<td>Year climatology start</td>
</tr>
<tr>
<td>DDD</td>
<td>Day climatology start</td>
</tr>
<tr>
<td>yyyy</td>
<td>Year climatology end</td>
</tr>
<tr>
<td>ddd</td>
<td>Day climatology end</td>
</tr>
<tr>
<td>L3m</td>
<td>Processing level</td>
</tr>
<tr>
<td>ttt</td>
<td>Binning period length, where: DAY = daily 7D = weekly MO = monthly SNSP = seasonal spring SNSU = seasonal summer SNAU = seasonal autumn SNWI = seasonal winter YR = yearly (annual)</td>
</tr>
<tr>
<td>SOILM</td>
<td>Geophysical parameter: SOILM = soil moisture</td>
</tr>
<tr>
<td>vvvv</td>
<td>Data version, example: V4.0</td>
</tr>
<tr>
<td>rad_sm_1deg</td>
<td>1-degree radiometer soil moisture</td>
</tr>
</tbody>
</table>

Each data file is paired with an XML file of the same name with .xml extension. The XML file contains metadata associated with the data file.

1.4 File Size

Data files are approximately 262 KB each.

XML files are approximately 3 KB each.

1.5 Volume

Data Volume for Aquarius L3 Daily Soil Moisture is approximately 476 MB.

Data Volume for Aquarius L3 Weekly Soil Moisture is approximately 70 MB.

Data Volume for Aquarius L3 Monthly Soil Moisture is approximately 17 MB.
Data Volume for Aquarius L3 Seasonal Soil Moisture is approximately 5.6 MB.

Data Volume for Aquarius L3 Annual Soil Moisture is approximately 1.8 MB.

1.6 Spatial Coverage

Spatial coverage is global.

1.6.1 Spatial Resolution

Spatial resolution of the L3 data is 1 degree.

1.6.2 Projection and Grid Description

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

1.7 Temporal Coverage

25 August 2011 to 07 June 2015.

Due to a power failure on the Satélite de Aplicaciones Científicas (SAC)-D spacecraft on 08 June 2015, data from NASA's Aquarius instrument are no longer being produced. For more information on this event, please refer to the official NASA announcement. 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 to 07 June 2015.

The weekly data start from August 20, 2011 in 7 day intervals until the present, yeilding a weekly data file every 7 days. The first weekly data have a time period of August 20 to August 26, 2011. The file name specifies the start date and end dates for Aquarius coverage. For example, the weekly file named: Q20142392014245.L3m_7D_SOILM_V4.0_rad_sm_1deg contains data from Day Of Year (DOY) 239, 2014 to DOY 245, 2014.

The month data for August 2011 is a partial coverage only, comprised of observations from August 25 to August 31, 2011.

Similarly, the yearly data for 2011 has observations after August 25, 2011 only.

The seasons are defined between equinox and solstice. The file names contain the exact DOY for each season (Autumn: March 21 to June 21; Summer: June 22 to September 22; Fall: September
23 to December 21; and Winter: December 21 to March 20). For example: the file Q20141722014263.L3m_SNSU_SOILM_V4.0_rad_sm_1deg contains the data for summer 2014 ranging from DOY 172 (June 21, 2014) to DOY 263 (September 20, 2014).

1.7.1 Temporal Resolution

Daily, Weekly, Monthly, Seasonal, and Annual

1.8 Parameter or Variable

The L3 products are representations of binned data products generated from Aquarius data. The data object, l3m_data, represents a mean Soil Moisture value of all composites for the mission at each grid point. The grid resolution is 1 degree.

1.8.1 Parameter Description

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaling</td>
<td>linear</td>
</tr>
<tr>
<td>Scaling Equation</td>
<td>(Slope*l3m_data) + Intercept = Parameter value</td>
</tr>
<tr>
<td>Slope</td>
<td>1.0</td>
</tr>
<tr>
<td>Intercept</td>
<td>0</td>
</tr>
<tr>
<td>_FillValue</td>
<td>-32767.0</td>
</tr>
<tr>
<td>add_offset</td>
<td>0.0</td>
</tr>
<tr>
<td>scale_factor</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The palette object included in the data file is the color palette used in graphics generated from the mapped files. The user can either use this palette or any palette of their choice.

Metadata are included as global attributes. Table 3 lists the global attribute names and the values from data file Q20112442014273.L3m_MO_SOILM_V4.0_rad_sm_1deg. Values that vary from granule to granule are noted.
<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Name</td>
<td>Q20112442011273.L3m_MO_SOILM_V4.0_rad_sm_1deg</td>
</tr>
<tr>
<td>Sensor Name</td>
<td>Aquarius</td>
</tr>
<tr>
<td>Sensor</td>
<td>Aquarius Level-3 Standard Mapped Image</td>
</tr>
<tr>
<td>Data Center</td>
<td>NASA/GSFC OBPG</td>
</tr>
<tr>
<td>Mission</td>
<td>SAC-D Aquarius</td>
</tr>
<tr>
<td>Mission Characteristics</td>
<td>Nominal orbit: inclination=98.0 (Sun-synchronous); node=6PM (ascending); eccentricity=&lt;0.002; altitude=657 km; ground speed=6.825 km/sec</td>
</tr>
<tr>
<td>Sensor Characteristics</td>
<td>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</td>
</tr>
<tr>
<td>Product Type</td>
<td>MO</td>
</tr>
<tr>
<td>Processing Version</td>
<td>V4.0</td>
</tr>
<tr>
<td>Software Name</td>
<td>smigen</td>
</tr>
<tr>
<td>Software Version</td>
<td>5.04</td>
</tr>
<tr>
<td>Processing Time</td>
<td>2015166163059000 (varies)</td>
</tr>
<tr>
<td>Input Files</td>
<td>Q20112442011273.L3b_MO_SOILM_V4.0.main (varies)</td>
</tr>
<tr>
<td>Processing Control</td>
<td>smigen par=Q20112442011273.L3m_MO_SOILM_V4.0_rad_sm_1deg.param (varies)</td>
</tr>
<tr>
<td>Input Parameters</td>
<td>ifile = Q20112442011273.L3b_MO_SOILM_V4.0.main</td>
</tr>
<tr>
<td>L2 Flag Names</td>
<td>POINTING,NAV,LANDRED,ICERED,REFL_1STOKESMOONRED,REFL_1STOKESGALTFTADIFFRED,RFI_REGION,SAOVERFLOW,COLDWATERRED,WINDRED,TBCONS</td>
</tr>
<tr>
<td>Name</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Period Start Year</td>
<td>2011</td>
</tr>
<tr>
<td>Period Start Day</td>
<td>244 (varies)</td>
</tr>
<tr>
<td>Period End Year</td>
<td>2011 (varies)</td>
</tr>
<tr>
<td>Period End Day</td>
<td>274 (varies)</td>
</tr>
<tr>
<td>Start Time</td>
<td>2011244021854088 (varies)</td>
</tr>
<tr>
<td>End Time</td>
<td>2011274002912490 (varies)</td>
</tr>
<tr>
<td>Start Year</td>
<td>2011 (varies)</td>
</tr>
<tr>
<td>Start Day</td>
<td>244 (varies)</td>
</tr>
<tr>
<td>Start Millisec</td>
<td>1752490 (varies)</td>
</tr>
<tr>
<td>End Year</td>
<td>2011 (varies)</td>
</tr>
<tr>
<td>End Day</td>
<td>274 (varies)</td>
</tr>
<tr>
<td>End Millisec</td>
<td>1752490 (varies)</td>
</tr>
<tr>
<td>Start Orbit</td>
<td>1214</td>
</tr>
<tr>
<td>End Orbit</td>
<td>1654</td>
</tr>
<tr>
<td>Map Projection</td>
<td>Equidistant Cylindrical</td>
</tr>
<tr>
<td>Latitude Units</td>
<td>degrees North</td>
</tr>
<tr>
<td>Longitude Units</td>
<td>degrees East</td>
</tr>
<tr>
<td>Northernmost Latitude</td>
<td>90.0</td>
</tr>
<tr>
<td>Southernmost Latitude</td>
<td>-90.0</td>
</tr>
<tr>
<td>Westernmost Longitude</td>
<td>-180.0</td>
</tr>
<tr>
<td>Easternmost Longitude</td>
<td>180.0</td>
</tr>
<tr>
<td>Latitude Step</td>
<td>1.0</td>
</tr>
<tr>
<td>Longitude Step</td>
<td>1.0</td>
</tr>
<tr>
<td>SW Point Latitude</td>
<td>-89.5</td>
</tr>
<tr>
<td>SW Point Longitude</td>
<td>-179.5</td>
</tr>
<tr>
<td>Data Bins</td>
<td>10875</td>
</tr>
<tr>
<td>Number of Lines</td>
<td>180</td>
</tr>
<tr>
<td>Number of Columns</td>
<td>360</td>
</tr>
<tr>
<td>Parameter</td>
<td>Soil Moisture</td>
</tr>
<tr>
<td>Measure</td>
<td>Mean</td>
</tr>
<tr>
<td>Units</td>
<td>m³/m³</td>
</tr>
<tr>
<td>Scaling</td>
<td>linear</td>
</tr>
<tr>
<td>Scaling Equation</td>
<td>(Slope*l3m_data) + Intercept = Parameter value</td>
</tr>
<tr>
<td>Slope</td>
<td>1.0</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0</td>
</tr>
<tr>
<td>Name</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Data Minimum</td>
<td>0.02</td>
</tr>
<tr>
<td>Data Maximum</td>
<td>0.85605</td>
</tr>
<tr>
<td>Suggested Image Scaling</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.4</td>
</tr>
<tr>
<td>Suggested Image Scaling Type</td>
<td>LINEAR</td>
</tr>
<tr>
<td>Suggested Image Scaling Applied</td>
<td>No</td>
</tr>
</tbody>
</table>

### 1.8.2 Sample Data Record

Below is a sample of the l3m_data soil moisture climatology data array from the file: Q20112442014273.L3m_MO_SOILM_V4.0_rad_sm_1deg.

```
0.16071  0.22976  0.22976  0.19657  0.15777  0.15777
0.1274   0.1274   0.1871   0.18483  0.16693  0.16693
0.06534  0.08972  0.15427  0.16872  0.16872  0.14687
0.05917  0.10082  0.13872  0.13872  0.13424  0.22034
0.06101  0.13039  0.15026  0.15026  0.18505  0.27296
0.04777  0.10618  0.10618  0.14647  0.17485  0.24603
0.04941  0.08218  0.08218  0.07871  0.12846  0.21371
0.03597  0.0628   0.0628   0.08638  0.12645  0.21622
0.03718  0.07301  0.07301  0.08993  0.1224   0.13274
0.03734  0.03734  0.05301  0.07994  0.10778  0.16494
0.03393  0.03393  0.04718  0.07038  0.10538  0.30449
0.02855  0.029   0.029   0.04431  0.15404  0.04838
0.03738  0.0276   0.0276   0.04746  0.08408  0.06758
0.04488  0.03459  0.04777  0.04777  0.04901  0.21728
```

Figure 1 shows the average soil moisture estimates for the month of July 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.

**Panoply netCDF, HDF and GRIB Data Viewer**: Cross-platform application. Plots geo-gridded arrays from netCDF, HDF and GRIB data sets.

For additional tools, see the **HDF5 Tools and Software Web site**.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

The Aquarius SCA algorithm 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-order product. (Bindlish and Jackson, 2013; Bindlish et al, 2013).

3.2 Data Acquisition Methods

Aquarius L3 Gridded 1-Degree Soil Moisture Climatology data are generated from measurements derived from the NASA Aquarius Level-2 Sea Surface Salinity & Wind Speed Data V4.0 product. Each climatology product contains data from one time period, monthly or seasonally. The best quality data are selected for each orbit during Level-0 to Level-1A data processing and are then used to create the Level-2 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 \(x_n\), \(n = 1, 2, \ldots, N\), this corresponds to minimizing

\[
\sum_{n=1}^{N} \left| g_n - \sum_{p=0}^{P} \hat{\beta}_p(x) [x_n - x]^2 \right|^2 K_h(x_n - x) \tag{Equation 1}
\]

at every grid point \(x = x_m\), where

\[
K_h(x) = K\left(\frac{x}{h}\right) / h \tag{Equation 2}
\]

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

The regression coefficients
\[ \beta_p(x) \]  
(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, 

\[ \hat{g}(x) = \beta_o(x) \]  
(Equation 4)

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

\[ g^{(p)}(x) = p! \beta_{po}(x) \]  
(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 Level-2 Soil Moisture product.

3.3.2 Version History

Changes in the Version 4 Aquarius L3 Gridded 1-Degree Soil Moisture Data data include: use of the most recent version (Version 4) of Aquarius Brightness Temperatures as input.

The Aquarius L3 Gridded 1-Degree Soil Moisture Data, Version 3 are processed from the Aquarius L2 Swath Single Orbit Soil Moisture Data, Version 3. Changes in the Aquarius L2 Swath Single Orbit Soil Moisture Data, Version 3 data included: 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 to the soil moisture model parameters (b and ω).
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

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| 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


### 4.1 Related Data Collections

- 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
5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Publication Date
02 December 2013

6.2 Date Last Updated
01 October 2015