Aquarius L3 Weekly Polar-Gridded Normalized Radar Cross Section, Version 5

USER GUIDE

How to Cite These Data

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

Brucker, L., E. Dinnat, and L. Koenig. 2015. *Aquarius L3 Weekly Polar-Gridded Normalized Radar Cross Section, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/Aquarius/AQ3_NRCS.005. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AQ3_NRCS

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

The data set consists of weekly gridded products of L–band Normalized Radar Cross Section (NRCS) from the Aquarius/SAC-D mission scatterometer operating at 1.26 GHz. This product is composed of six files per seven-day cycle: one per each of three scatterometer beams, and one per hemisphere. Each file contains the weekly mean NRCS at three polarizations: Vertical Transmit Vertical Receive (NRCS_VV), Vertical Transmit Horizontal Receive (NRCS_VH), and Horizontal Transmit Horizontal Receive (NRCS_HH), along with the scatterometer ice fraction and all associated standard deviations.

Observations are provided in each file for ascending and descending orbits. NRCS observations from ascending and descending orbits were not combined together due to the anisotropy of the ice covered surfaces. NRCS at the two cross-polarizations are assumed identical at the top of the atmosphere, and thus only one cross-polarization is provided in this product.

The term ice fraction refers to estimated sea ice concentration integrated over the sensor field of view and weighted by the antenna gain patterns. Similarly, land fraction data is integrated over the sensor field of view and weighted by the antenna gain patterns. The land fraction, distributed as an ancillary file, was obtained averaging all values per grid cell for the entire Aquarius period (August 2011 â€“ June 2015), and keeping only the results when more than 35 values existed per grid cell.

This data set is designed for the monitoring of the Earth polar regions. Due to the lack of polar-gridded products from the Aquarius/SAC-D mission, applications over the cryosphere have been limited. This data set provides weekly polar-gridded products of Aquarius data to improve understanding of L–band observations of ice sheets, sea ice, frozen soil/permafrost, and the polar oceans (Brucker et al. 2014b, and Brucker et al, 2014c). Additionally, this product is intended to facilitate access to L–band data, and can be used to assist in algorithm developments.

1.1 Format

The data files are distributed in HDF5 format.

1.2 File and Directory Structure

Data are available on the HTTPS site in the `https://n5eil01u.ecs.nsidc.org/AQUARIUS/AQ3_NRCS.005/` directory. Within this directory, the folders are organized by date, for example `/2011.08.25/` to `/2015.05.28/`.

The two highest level directories in the HDF5 files contain the weekly-gridded data for ascending orbits and descending orbits as shown in Figure 1.

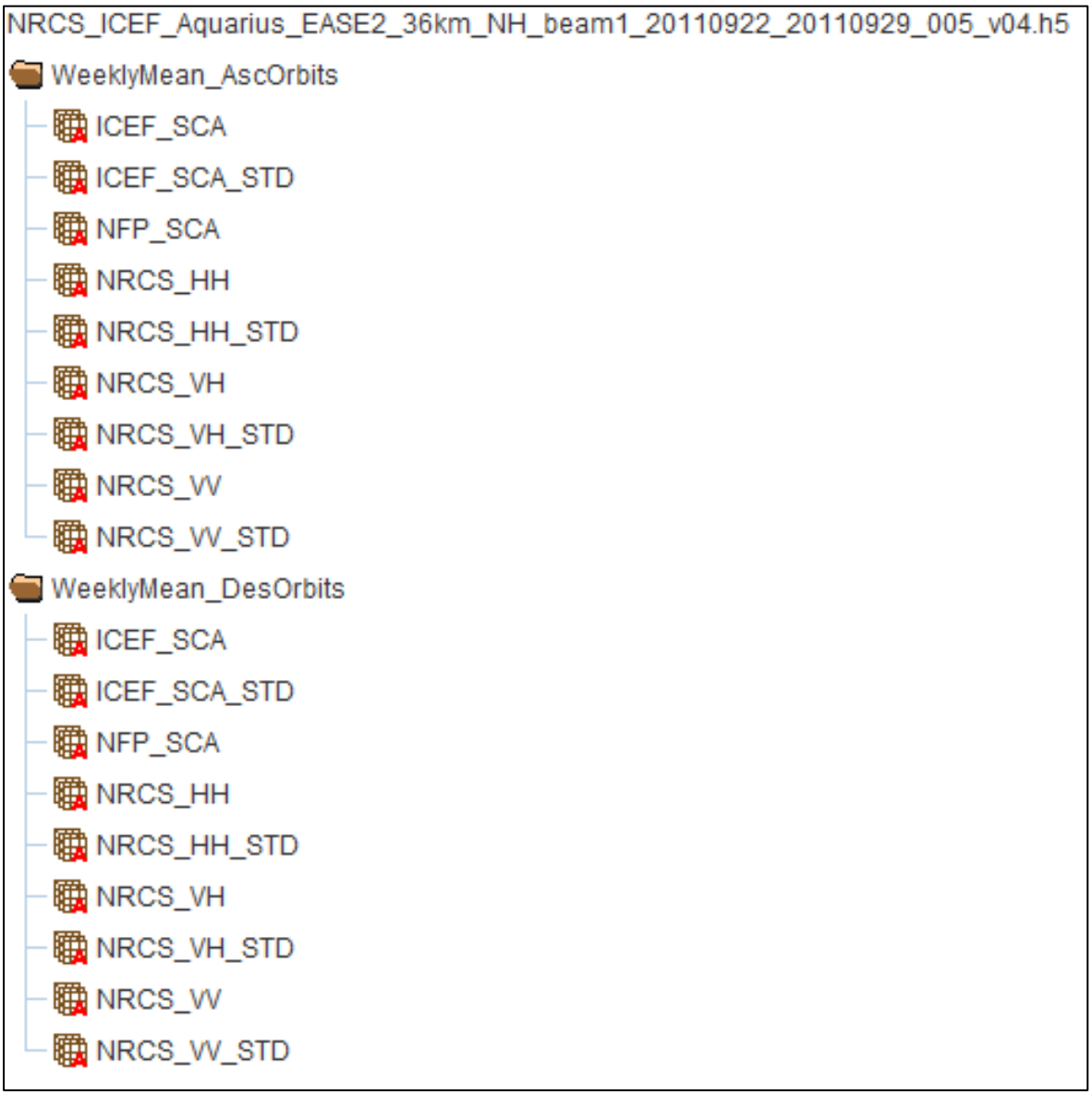

Figure 1. File Structure.

Ancillary data files include:

Northern hemisphere coordinates and land fraction of the Aquarius weekly polar-gridded product on the EASE-Grid 2.0 grid at 36 km resolution:
Coordinates_LandFraction_EASE2_36km_NH_v05.h5

Southern hemisphere coordinates and land fraction of the Aquarius weekly polar-gridded product on the EASE-Grid 2.0 grid at 36 km resolution:
Coordinates_LandFraction_EASE2_36km_SH_v05.h5

List of Aquarius orbit cycle numbers with the corresponding dates of cycle start and end:
Cycle_Date.dat

1.3 File Naming Convention

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

Example file name:

```
NRCS_ICEF_Aquarius_EASE2_36km_NH_beam2_20110825_20110901_001_v05.h5
```

```
NRCS_ICEF_Aquarius_EASE2_36km_xH_beamB_YYYYMMDD_YYYYMMDD_CCL_vXX.h5
```

Where:

Table 1. File Naming Convention

Variable	Description
NRCS_ICEF_Aquarius	Normalized Radar Cross Section and Ice Fraction Aquarius data
EASE2_36km	Version 2.0 Equal-Area Scalable Earth Grid cells at 36 km x 36 km
xH	Hemisphere. NH = Northern Hemisphere; SH = Southern Hemisphere
beamB	Aquarius radiometer beam used by the scatterometer, B = 1, 2, or 3
YYYY	Four-digit year of the first/last measurements in the given cycle
MM	Two-digit of the month of the first/last measurements in the given cycle
DD	Two-digit day of the first/last measurements in the given cycle
CCL	Aquarius orbit cycle number, 3 digits
vXX	Polar-gridded product version number.
.h5	Indicates HDF5 file format

1.4 File Size

HDF files range from approximately 294 KB to 482 KB.

1.5 Spatial Coverage

Northern Hemisphere:
Southernmost Latitude: 50° N
Northernmost Latitude: 87.4° N
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

Southern Hemisphere:
Southernmost Latitude: 79° S

Northernmost Latitude: 50° S
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

1.5.1 Spatial Resolution

The native spatial resolution of the scatterometer footprint is 390 km (total crosstrack of three beams of 74 km along track x 94 km cross track, 84 x 120 km, and 96 x 156 km). Data are then gridded using the 36 km EASE-Grid 2.0 global projection.

1.5.2 Projection and Grid Description

The data are gridded to the Equal-Area Scalable Earth version 2.0 grid (Brodzik et al. 2012), with a grid cell resolution of 36 km. See also EASE-Grid 2.0 Format Description.

1.6 Temporal Coverage

25 August 2011 to 28 May 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.

1.6.1 Temporal Resolution

Weekly averages

1.7 Parameter or Variable

Aquarius L3 Polar-Gridded Weekly NRCS ascending orbit and descending orbit data parameters are described in Table 2.

Table 2. Parameters

Name	Description	Units
NRCS_VV	Weekly mean normalized radar cross section at VV polarization	Decibels
NRCS_VV_STD	Weekly mean standard deviation of the normalized radar cross section at VV polarization	Decibels

Name	Description	Units
NRCS_VH	Weekly mean normalized radar cross section at VH polarization	Decibels
NRCS_VH_STD	Weekly mean standard deviation of the normalized radar cross section at VH polarization	Decibels
NRCS_HH	Weekly mean normalized radar cross section at HH polarization	Decibels
NRCS_HH_STD	Weekly mean standard deviation of the normalized radar cross section at HH polarization	Decibels
ICEF_SCA	Weekly mean scatterometer ice fraction	n/a
ICEF_SCA_STD	Weekly mean standard deviation of the scatterometer Ice fraction	n/a
NFP_SCA	Number of foot print measurements for scatterometer retrievals	n/a

The statistical significance of the standard deviation should be evaluated against the Number of Foot Print for the SCAtterometer (NFP_SCA) measurements in the grid cell.

1.7.1 Sample Data Record

An image of Aquarius weekly polar-gridded NRCS at VV polarization observed during ascending orbits over the Antarctic ice sheet during September 26 to October 3, 2013 is provided in Figure 2.

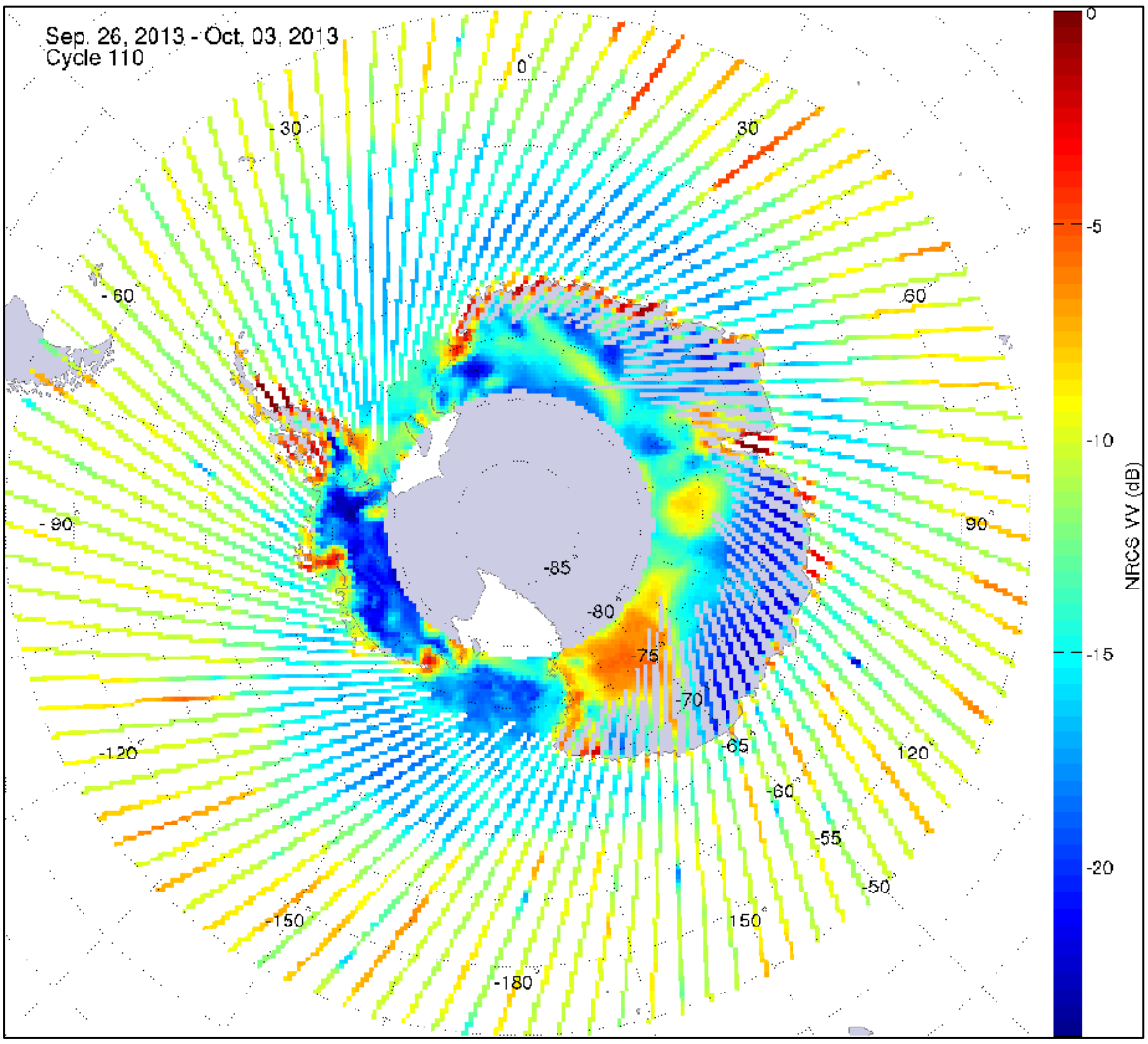

Figure 2. Sample image of NRCS Verison 4 data.

2 SOFTWARE AND TOOLS

MATLAB readers: For loading and mapping Aquarius Level-3 polar-gridded weekly radiometer and scatterometer data. Note: this tool was provided by the Principal Investigator "as-is" as a service to the user community in the hope that it will be useful. Please note that support for the program is limited. Bug reports, comments, and suggestions for improvement are welcome; please send to nsidc@nsidc.org.

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 HDF-EOS Tools and Information Center.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Acquisition Methods

The following information is extracted from Brucker et al. 2014a, and Brucker et al. 2014b.

Aquarius Level-2 data used are distributed by NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC). The PO.DAAC Aquarius Level-2 product consists of the observations, retrievals, and ancillary data along the swath, including Brightness Temperature (TB), NRCS, Sea Surface Salinity (SSS), and ICEF. Neither new algorithms nor new observation processing were done. For further information on the Aquarius Level-2 data, see the Aquarius User Guide.

3.2 Derivation Techniques and Algorithms

The Level-3 weekly polar-gridded NRCS data are derived from the Aquarius Level-2 data and repackaged as polar-gridded weekly Level-3 products of NRCS. Derivation occurs only in that Radio Frequency Interference (RFI) contaminated observations are excluded and a weekly average is calculated per EASE-Grid 2.0 cell.

Gridded data were produced using all the Aquarius observations flagged as RFI free, and recorded during nominal operation of the spacecraft.

NRCS observations at latitudes greater than 50 degrees in both hemispheres are averaged and gridded into a weekly product.

According to the orbit and sensor characteristics, the temporal resolution of the product was set to one week, corresponding to the time of revisit. Since the Aquarius sensors are in a push-broom alignment, a weekly-gridded product provides the largest spatial coverage.

For NRCS, each beam and each orbit type was treated independently. The distinction for each beam is needed due to the different incidence angles. The distinction between each orbit type is necessary because of the anisotropy of the ice covered surfaces (Brucker et al. 2014b). For each week and hemisphere, eighteen NRCS maps are produced and distributed (one for each of the three beams, each of the three polarizations, and each of the two orbit types).

A Delaunay triangulation with linear interpolation was applied to the weekly-gridded values to spatially interpolate NRCS in grid cells without observations during the cycle. To avoid interpolating over too large a region in case of significant data loss, the interpolation was not applied and a NaN element is provided where six or more contiguous grid cells had no data.

The ICEF results from a combination of two elements: estimated sea ice concentration and antenna characteristics. Sea ice concentration estimates are obtained from the analysis by NOAA's Marine Modeling and Analysis Branch (http://polar.ncep.noaa.gov/seaice/Analyses.shtml), available daily at a spatial resolution of 1/12 degree, and distributed by the U.S. National Centers for Environmental Prediction (NCEP) as the Global Forecast System (GFS) Global Data Assimilation System (GDAS) sea ice product.

3.2.1 Processing Steps

Using the latest Aquarius Level-2 data version 4.0:

- Select data at latitudes greater than 50 degrees.
- Reject data contaminated by RFI.
- Reject data collected during spacecraft maneuvers or anomaly periods as reported on the Aquarius status Web page.
- Grid and average data per seven-day cycle corresponding to the spacecraft time of revisit.
- Where less than six contiguous grid cells do not have data, apply a Delaunay triangulation with linear interpolation to the weekly-gridded values to spatially interpolate them in grid cells without observations/retrievals during the cycle.
- For a given one-week orbit cycle, all measurements within a same grid cell were averaged together, and the standard deviation calculated.

3.2.2 Version History

Version 5 of Aquarius L3 Weekly Polar-Gridded Normalized Radar Cross Section utilizes Version 4 of the Aquarius Level-2 NRCS as input data.

3.2.3 Errors Sources

Scatterometer sensitivity varies with incidence angle, and is better than 0.1 dB. The calibration stability is within 0.1 dB (Yueh et al. 2012).

The ICEF results from a combination of two elements: estimated sea ice concentration, and antenna characteristics. Sea ice concentration estimates are obtained from the analysis by NOAA's Marine Modeling and Analysis Branch (http://polar.ncep.noaa.gov/seaice/Analyses.shtml), available daily at a spatial resolution of 1/12 degrees, and distributed by the U.S. National Centers for Environmental Prediction (NCEP) as the Global Forecast System (GFS) Global Data Assimilation System (GDAS) sea ice product.

Both passive and active L–band observations are impacted by Radio Frequency Interference (RFI). In the weekly-gridded products, data associated with an RFI flag in the Level–2 products is eliminated (Brucker et al. 2014a). The detection and mitigation of RFI in the Aquarius scatterometer observation are based on two methods described in section 8 of Yueh et al. 2012. One method is based on a sensitive on–board RFI flagging technique, and the other is a ground–based, outlier flagging method.

3.3 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 radiometers measure brightness temperature at 1.414 GHz in the horizontal and vertical polarizations (TBH and TBV). The scatterometer is a microwave radar sensor that measures backscatter for surface roughness corrections. The NRCS data are collected by the scatterometer.

The Aquarius scatterometer does not operate at the same frequency as the three radiometers because the frequency band 1.400 – 1.427 GHz is protected for passive sensors on Earth exploration satellites and radio astronomy space research according to the International Telecommunication Union, 2012. The scatterometer observes NRCS at 1.26 GHz. Operating the scatterometer at a slightly lower frequency protects the radiometer from direct contaminations. The scatterometer uses the same three feed horns as the radiometers, providing NRCS observations at the same incidence angles as the TB observations. The footprint sizes are slightly smaller due to the two-way path from the spacecraft to the surface and back, despite the lower frequency. Scatterometer sensitivity varies with incidence angle, and the calibration stability is within 0.1 dB (Yueh et al. 2012). For all practical purposes the radiometer and scatterometer measurements are considered coincident (Brucker et al. 2014a).

Table 3 summarizes Aquarius instrument characteristics.

Table 3. Aquarius Instrument Characteristics

Instrument	Characteristics
3 radiometers in push-broom alignment	• Frequency: 1.413 GHz (L-band) • 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

4 REFERENCES AND RELATED PUBLICATIONS

Brodzik, M. J., B. Billingsley, T. Haran, B. Raup, and M. H. Savoie. 2012. EASE-Grid 2.0: Incremental but Significant Improvements for Earth-Gridded Data Sets, *ISPRS International Journal of Geo- Information*, 1:32–45, doi:10.3390/ijgi1010032.

Brucker, L., E. P. Dinnat, and L. S. Koenig. 2014. Weekly-gridded Aquarius L-band Radiometer/Scatterometer Observations and Salinity Retrievals Over the Polar Regions, Part 1: Product Description, *The Cryosphere*, 8:905-913. doi: 10.5194/tc-8-905-2014.

Brucker, L., E. P. Dinnat, and L. S. Koenig. 2014. Weekly-gridded Aquarius L-band Radiometer/Scatterometer Observations and Salinity Retrievals Over the Polar Regions, Part 2: Initial Product Analysis, *The Cryosphere*, 8:915-930. doi:10.5194/tc-8-915-2014.

Brucker et al. 2014. Effect of Snow Surface Metamorphism on Aquarius L-Band Radiometer Observations at Dome C, Antarctica. *IEEE TGRS* 52(11): 7408-7417, doi:10.1109/TGRS.2014.2312102.

Dinnat, E., D. Le Vine, and S. Abraham. 2013. Aquarius Cold Sky Maneuvers: Assessing Calibration Bias, Temporal Drift, and Antenna Back Lobes, *IGARSS 2013*, oral presentation.

Lagerloef, G., H.-Y Kao, O. Meln, P. Hacker, E. Hackert, Y. Chao, K. Hilburn, T. Meissner, S. Yueh, L. Hong, T. and Lee. 2013. *Aquarius Salinity Validation Analysis, Tech. Rep., NASA*, 2013.

Le Vine, D., E. Dinnat, S. Abraham, P. De Matthaeis, and F. Wentz. 2011a. The Aquarius Simulator and Cold-Sky Calibration, *Geoscience and Remote Sensing, IEEE Transactions on*, 49:3198–3210. doi:10.1109/TGRS.2011.2161481.

Le Vine, D., T. Meissner, F. Wentz, and J. Piepmeier. 2012. Aquarius Salinity Retrieval Algorithm (Version 2) Algorithm Theoretical Basis Document (ATBD), *Tech. Rep. 082912, RSS Technical Report*.

Piepmeier, Jeffrey, Shannon Brown, Emmanuel Dinnat, 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.

Wentz, F. and D. Le Vine. 2012. Aquarius Salinity Retrieval Algorithm (Version 2) Algorithm Theoretical Basis Document (ATBD), *Tech. Rep. 082912, RSS Technical Report*.

Yueh et al. 2012. Aquarius Satellite Salinity Measurements, *Aquarius/SACD Science Team Meeting, Buenos Aires, Tech. rep., NASA*.

4.1 Related Data Collections

Aquarius Level-1 and Level-2 Sea Surface Salinity Data
Aquarius L3 Polar-Gridded Weekly Brightness Temperature and Sea Surface Salinity
Aquarius L3 Polar-Gridded Weekly Sea Surface Salinity

4.2 Related Websites

Aquarius Web site at NASA Goddard Space Flight Center
Aquarius Data Web Site at NSIDC
Aquarius Web Site at PODAAC - Sea Surface Salinity Data
ESA Soil Moisture and Ocean Salinity (SMOS)

5 CONTACTS AND ACKNOWLEDGMENTS

Ludovic Brucker, Emmanuel Dinnat, and Lora Koenig
NASA Goddard Space Flight Center
Cryospheric Sciences Laboratory, Code 615
Greenbelt, MD 20771

6 DOCUMENT INFORMATION

6.1 Publication Date

21 July 2014

6.2 Date Last Updated

14 December 2015