Aquarius L3 Weekly Polar-Gridded Brightness Temperature and Sea Surface Salinity, 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. A*quarius L3 Weekly Polar-Gridded Brightness Temperature and Sea Surface Salinity, 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_TB.005. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AQ3_TB

National Snow and Ice Data Center

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1 DATA DESCRIPTION

The data set consists of weekly gridded products of L-band (frequency ~1.4 GHz) brightness temperature (TB) from the Aquarius/SAC-D radiometer. This product is composed of six files per seven-day cycle: one per radiometer beam, and one per hemisphere. Each file contains the weekly gridded Brightness Temperature at Vertical polarization (TBV), Brightness Temperature at Horizontal polarization (TBH), as well as Sea Surface Salinity (SSS), ice fraction (ICEF), and all associated standard deviations. The number of footprint observations considered in the calculation of the weekly means and standard deviations is also available. Observations are provided for ascending orbits, descending orbits, and both orbit types combined.

SSS fields available in this product are separated per beam, since a slight bias might exist between the three different radiometer beams. Another Level-3 product (Aquarius L3 Weekly Polar-Gridded Sea Surface Salinity) consists of the SSS retrieved using all three radiometer beams combined.

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—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 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, permafrost, and the polar oceans. Additionally, this product is intended to facilitate access to L-band data, and can be used to assist in algorithm developments (Brucker et al. 2014b and Brucker et al. 2014c)

1.1 File Information

1.1.1 Format

The data files are distributed in HDF5 format.

1.1.2 File Structure

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

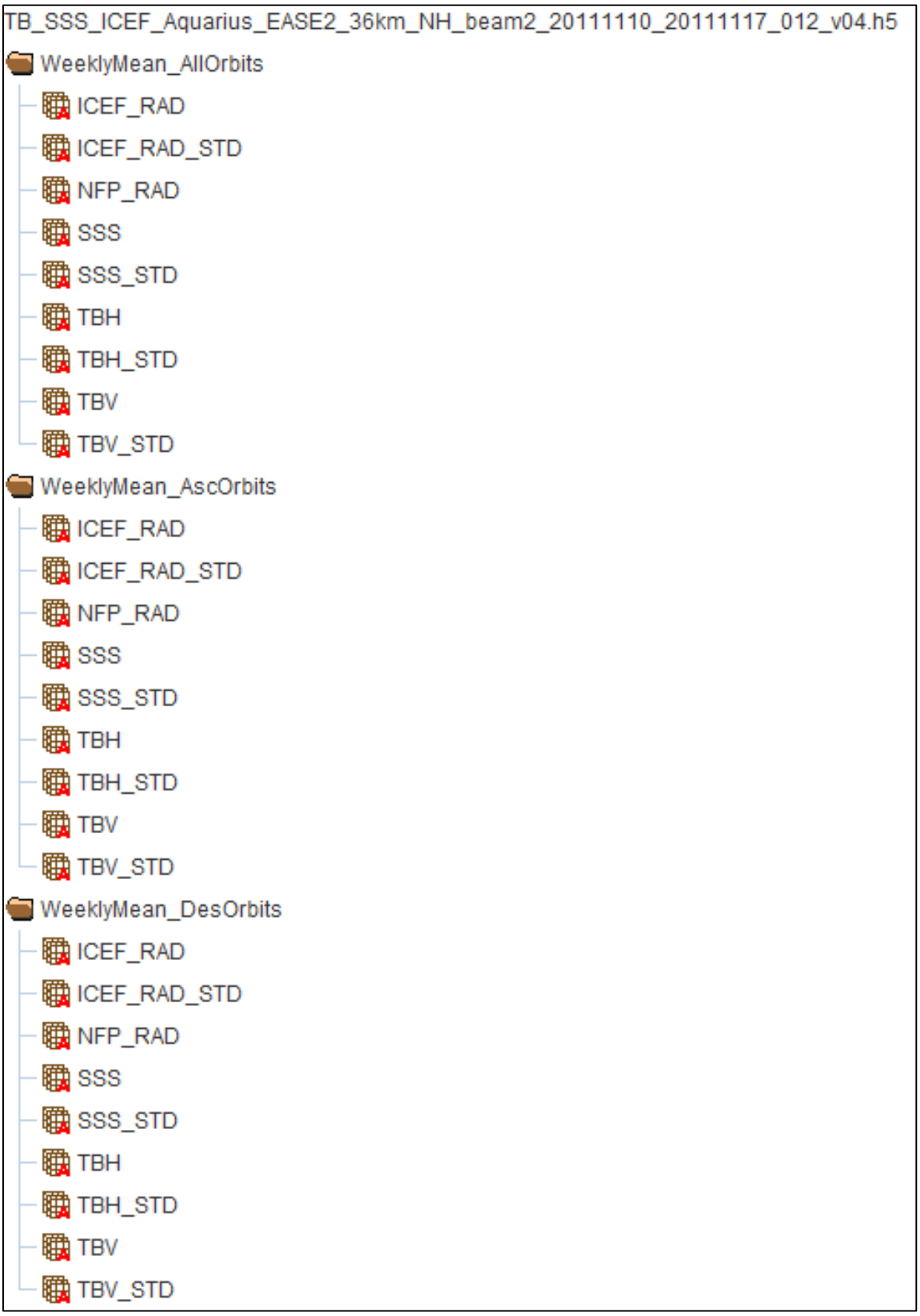

Figure 1. File Structure.

1.1.3 Ancillary Data Files

The following ancillary files are also provided:

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.

1.1.4 File Naming Convention

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

Example file name:

```
TB_SSS_ICEF_Aquarius_EASE2_36km_NH_beam1_20110825_20110901_001_v05.h5
```

```
TB_SSS_ICEF_Aquarius_EASE2_36km_xH_beamB_YYYYMMDD_YYYYMMDD_CCL_vXX.h5
```

Where:

Table 1. File Naming Convention

Variable	Description
SSS3b_ICEF_Aquarius	Sea Surface Salinity 3 beam, 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
YYYY	Four-digit year of the first/last measurements in the given cycle
MM	Two-digit 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

1.1.5 File Size

HDF files range from approximately 790 KB to 953 KB.

1.2 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

1.2.1 Spatial Resolution

The native spatial resolution of the radiometer 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.

1.2.2 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.

1.3 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.

1.3.1 Temporal Resolution

Weekly averages

1.4 Parameters

Aquarius Level-3 Weekly Polar-Gridded Sea Surface Salinity all orbit, ascending orbit, and descending orbit data parameters are described in Table 2.

Table 2. Parameters

Name	Description	Units
TBV	Weekly mean brightness temperature at vertical polarization	Kelvin
TBV_STD	Weekly standard deviation of brightness temperature at vertical polarization	Kelvin
TBH	Weekly mean brightness temperature at horizontal polarization	Kelvin
TBH_STD	Weekly standard deviation of brightness temperature at horizontal polarization	Kelvin
NFP_RAD	Number of foot print measurements for radiometric retrievals	n/a
SSS	Weekly mean sea surface salinity	Practical Salinity Unit (psu)
SSS_STD	Weekly standard deviation of sea surface salinity	Practical Salinity Unit (psu)
ICEF_RAD	Weekly mean radiometer ice fraction	n/a
ICEF_RAD_STD	Weekly standard deviation of sea ice fraction in the radiometer field of view	n/a

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

1.4.1 Sample Data Record

Figure 2 shows an image of Aquarius weekly polar-gridded TB at vertical polarization during September 26 to October 3, 2013 over the Northern Hemisphere latitudes north of 50° N.

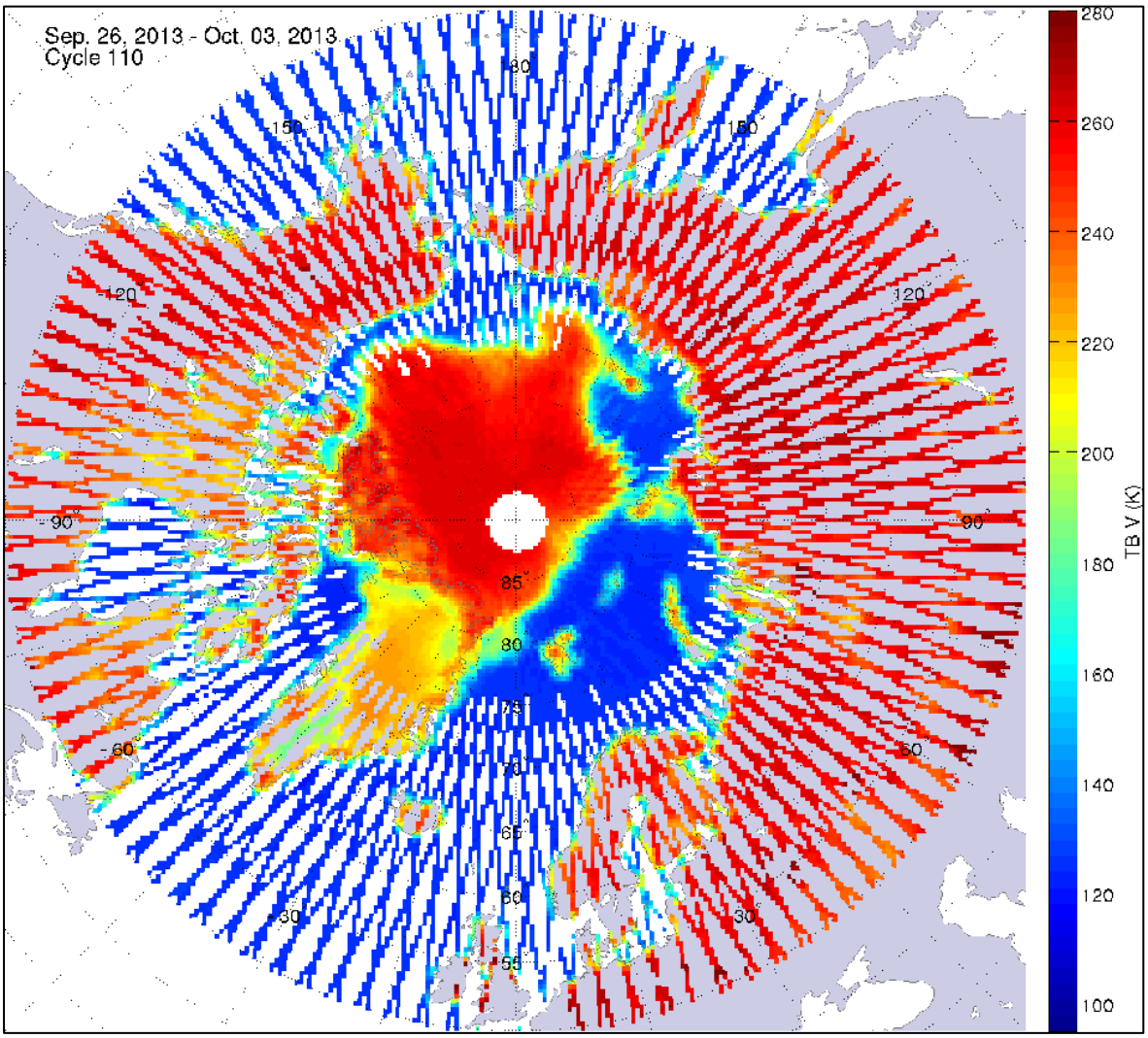

Figure 2. Sample image of Version 4 TB Northern Hemisphere data

Figure 3 shows an image of Aquarius weekly polar-gridded TB at vertical polarization observed during September 26, to October 3, 2013 over the Southern Hemisphere, latitudes south of 50° S.

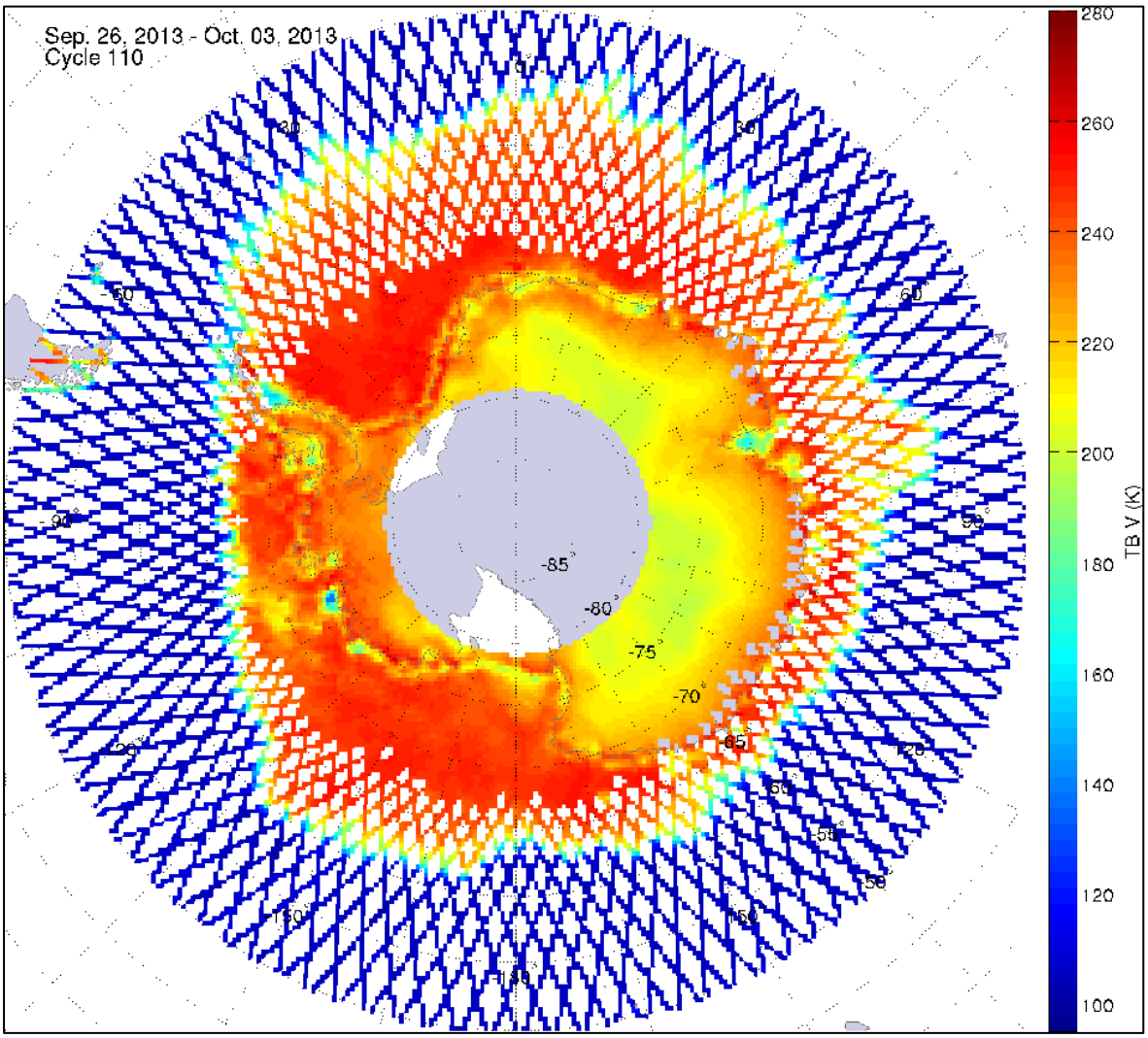

Figure 3. Sample image of Version 4 TB Southern Hemisphere data

2 SOFTWARE AND TOOLS

MATLAB readers: For loading and mapping Aquarius Level-3 weekly polar-gridded 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), Normalized Radar Cross Section (NRCS), 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 TB (at V and H polarizations) and SSS data are derived from the Aquarius Level-2 TB and SSS data distributed by NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) and repackaged as weekly polar-gridded Level-3 products of TB and SSS. Derivation occurs only when Radio Frequency Interference (RFI) contaminated observations are excluded and a weekly average is calculated per EASE-Grid 2.0 cell.

The PO.DAAC Level-2 TB product is computed after empirical calibration of the measured antenna temperatures against a forward radiative transfer model over ocean surfaces (Le Vine et al. 2011a). More details about the Level-2 processing can be found in Wentz and Le Vine (2012), Le Vine et al. (2012), and Piepmeier et al. 2013.

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

TB observations and SSS retrievals 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.

Each radiometer was treated independently to produce three weekly-gridded TB products corresponding to observations from the ascending orbit, the descending orbit, and both orbit types combined. The distinction per radiometer is necessary due to the different incidence angles, which lead to different reflection intensities at the interface created by dielectric constant changes (e.g. snow/air interface). For each seven-day cycle, all valid observations from a given radiometer with footprint center within a given 36 km grid cell were averaged together, and the standard deviation was calculated. For each week and hemisphere, eighteen TB maps are produced and distributed, one for each of the three radiometers, each of the two polarizations, and each of the three orbit types (Brucker et al. 2014).

The sea ice fraction (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 PO.DAAC 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 Sea Surface Salinity utilizes Version 4 of the Level-2 Aquarius TB as input data.

3.2.3 Error Sources

The antenna temperatures are corrected for:

- the emission of extraterrestrial sources (Sun, Moon, Celestial Sky), that directly reaches the antenna through the side and back lobes

- the effect of the integration over the antenna gain patterns
- the Faraday rotation
- and atmospheric effects (upward emission, downward emission reflected at the surface, and attenuation of the signals from the surface)

These corrections provide the TBs at the Earth's surface. Over the oceans, the TB is corrected for the effects of surface roughness, including the reflected/scattered galaxy and Sun, using the scatterometer observations and a simulated wind speed. The remaining TB for a smooth surface is converted into SSS using ancillary data for the sea surface temperature, and a model for the sea water dielectric constant.

The sensitivity of TB is ~0.15 K and ~0.2 K per 1.4 s observation sample over the ocean and the dry ice sheet, respectively. Observations have shown stability within ±0.2 K over the ocean and Celestial Sky over several months (Dinnat et al., 2013; Lagerloef et al., 2013).

The requirement for the Aquarius SSS retrievals accuracy is 0.2 psu after temporal averaging over a month in global open oceans. While the algorithm used in the Aquarius Level-2 processing for retrieving SSS performs well in the tropics and mid latitudes (warmer) oceans (Lagerloef et al. 2013), L-band SSS retrieval in the polar (colder) oceans is challenging. SSS retrievals have not yet been specifically validated in cold water, and should be used with caution. L-band observations are less sensitive to salinity in cold waters. In addition, salinity retrieval is likely to be less accurate for very rough sea surfaces. For instance, in the Southern Ocean there are strong winds and the oceanic circulation is dominated by the Antarctic Circumpolar Current, which could reduce the quality of the SSS retrievals. Finally, the presence of sea ice and icebergs in the sensors field of view adds complexity to the retrieval of SSS in the high latitudes.

The weekly-gridded product contains SSS retrievals in ascending orbit and descending orbit. This distinction between the two orbit types may be required because differences have been identified (Lagerloef et al., 2013). The Aquarius Level-2 product version 3.0 has reduced the differences, though not completely eliminated them. While the origin of these differences has not been established yet, it is likely to be due in part to the reflected/scattered galaxy, and RFI contaminations. It is possible that residual RFI and sky contaminations impact the empirical calibration performed over the oceans, and therefore create biases dependent on the type of orbit. The correction for the reflected galaxy has been found insufficient, and an empirical adjustment was introduced for the source data from Level-2 version 3.0, and carried forward to the version 4.0 source data used for this current product. The galaxy contamination is very dependent on the type of orbit, because it is only significant when the contribution comes from a very limited region of the sky, for example the galactic plane.

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 SSS data are collected by the radiometers. 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. A product containing the scatterometer observations (Normalized Radar Cross Section, NRCS) is available at Aquarius Level-3 Weekly Polar-Gridded Normalized Radar Cross Section.

Table 3 summarizes 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.

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.

Dinnat, E. P. and D. M. Le Vine. 2007. Effects of the Antenna Aperture on Remote Sensing of Sea Surface Salinity at L-Band, *IEEE Transactions on Geoscience and Remote Sensing*, 45:2051–2060, doi:10.1109/TGRS.2007.890807, 2007. Dinnat, E. P. and Le Vine, D. M.: Impact of

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*.

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

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6 DOCUMENT INFORMATION

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