

# SSM/I(S) Ocean Products Suite, Version-7 Background Documentation

## Data Product Team:

Key Science Team Lead: Frank J Wentz, Remote Sensing Systems

Product Team Members: Kyle Hilburn, Deborah K Smith, Marty Brewer

## Roles of Data Product Team Members:

Years are listed for team members no longer at RSS. Those without years listed are still current RSS employees.

Development of Algorithm: Frank Wentz

Testing of Algorithm: Frank Wentz and Kyle Hilburn (2005 - 2016)

Product Validation: Frank Wentz, Thomas Meissner, Carl Mears

Product Production: Frank Wentz and Deborah Smith (1996 - 2016)

Product Distribution: Sharon Tremble (1996 - 2010)

Deborah Smith (1996 - 2016)

Marty Brewer

Help Desk: Sharon Tremble (1996 - 2004)

Deborah Smith (2004 - 2015)

Marty Brewer

## Contact Information for Data Team:

Remote Sensing Systems, [www.remss.com](http://www.remss.com), [support@remss.com](mailto:support@remss.com)

707-545-2904

**Sponsor:** NASA

## Production Overview:

Raw level TDR data used for Ocean Suite data production are obtained from the NOAA CLASS Data Archive at ([www.class.noaa.gov](http://www.class.noaa.gov)). TDR files for each SSM/I or SSMIS instrument are downloaded directly to RSS and processed to L1 and L2 files from which these Ocean Products Suite data are made. A radiative transfer model (RTM) is used to derive brightness temperatures from instrument antenna counts. Satellite microwave brightness temperatures over the ocean are used to derive wind speed, integrated column water vapor, total cloud liquid water and rain rates.

## Product Design:

V7 Ocean Products Suite binary data from RSS are described on the RSS web page ([www.remss.com/missions/SSM/I](http://www.remss.com/missions/SSM/I)). GHRC creates V7 netCDF files from the RSS V7 Ocean Product data.

The binary format SSM/I Ocean Product Suite was originally designed by Frank Wentz and Deborah Smith in 1996 to meet the needs of scientific users from many countries with limited internet speed, varying operating systems, and low hard drive space. Each binary file contains two single byte arrays containing ascending orbits and descending orbits for each of the 5 variables (time, wind speed, water vapor, cloud liquid water, and rain rate). Upon bringing the data to GHRC, the design was repeated within the netCDF data files. The netCDF files contain CF compliant metadata. The binary files continue to be available from RSS. The RSS binary files are identical to the GHRC netCDF data files except for file format and metadata content.

### **RSS Product Processing and Algorithm Version History:**

V7 produced (2012 - ) improved calibration (described in V7 Calibration Document)  
V6 produced (2006 - 2012) improved calibration and algorithm changes to bring uniformity to all microwave instrument data  
V5 produced (2002 - 2006) improved radiative transfer model  
V4 produced (1996 - 2002)  
Early NASA Pathfinder version: (pre-1996 and not publicly available).

### **Description of SSM/I Instrument:**

None available

### **Description of SSM/I/S Instrument:**

Kunkee, D.B., G.A. Poe, D.J. Boucher, S.D. Swadley, Y. Hong, J.E. Wessel, and E.A. Uliana, 2008, Design and Evaluation of the First Special Sensor Microwave Imager/Sounder, IEEE Transactions on Geoscience and Remote Sensing, 46(4), doi: 10.1109/TGRS.2008.917980.

### **Calibration of the SSM/I and SSMIS Instruments:**

No publication describing the pre-orbit instrument calibration could be located.

### **Description of current SSM/I and SSMIS Data Calibration Process:**

Wentz, F. J., (2013), [SSM/I Version-7 Calibration Report](#), report number 011012, Remote Sensing Systems, Santa Rosa, CA, 46pp.

### **Description of the Algorithm Approach:**

#### Data required:

4 data sets are used in the RSS algorithm to derive ocean products from microwave radiometer brightness temperatures:

- 1) NCEP GDAS wind fields routinely downloaded from nomads.ncep.noaa.gov, an archive of the same data is at <http://rda.ucar.edu/datasets/ds083.2>
- 2) CCMP winds located at <ftp://podaac-ftp.jpl.nasa.gov/allData/ccmp/L3.0/flk>,
- 3) Reynolds SST Climatology from NOAA (1981 to 2000) obtained from <http://www.cpc.ncep.noaa.gov/> and Reynolds SST OISST V2 data from <ftp.emc.ncep.noaa.gov>

### Overview:

Instrument TDR data obtained from NOAA CLASS are transitioned backwards to raw instrument antenna counts and then forward processed using the RSS RTM into L1A, L2A and then binary ocean data product files that are publicly provided on the RSS web and ftp servers. GHRC converts these binary data files to netCDF format and adds CF-compliant metadata.

### Documentation:

Wentz, F. J. and T. Meissner, (2007), [AMSR-E Ocean Algorithms: Supplement 1](#), report number 051707, Remote Sensing Systems, Santa Rosa, CA, 6 pp.

Wentz, Frank J. and Thomas Meissner, (2000), [AMSR Ocean Algorithm, Version 2](#), report number 121599A-1, Remote Sensing Systems, Santa Rosa, CA, 66 pp.

The SSM/I and SSMIS algorithm approach is very similar to the above two documents for AMSR-E. There are no formal ATBDs for the V7 RSS SSM/I or the SSMIS ocean products. An algorithm description for a much earlier version (pathfinder) of the SSM/I algorithm is available: Wentz F. J., (1997), [A Well-calibrated Ocean Algorithm for SSM/I](#), *Journal of Geophysical Research*, 102 (C4), pg. 8703-8718.

### **Product Quality:**

Ocean data quality for an earlier product version is given in the following publications:

Hilburn, KA, FJ Wentz, 2008, [Intercalibrated passive microwave rain products from the unified microwave ocean retrieval algorithm \(UMORA\)](#), *Journal of Applied Meteorology and Climatology*, 47, 778-794.

Mears, CA, DK Smith, FJ Wentz, 2001, [Comparison of Special Sensor Microwave Imager and buoy-measured wind speeds from 1987 - 1997](#), *Journal of Geophysical Research*, 106, 11719-11729.

Meissner, T, DK Smith, FJ Wentz, 2001, [A 10-year intercomparison between collocated Special Sensor Microwave Imager oceanic surface wind speed retrievals and global analyses](#), *Journal of Geophysical Research*, 106, 11731-11742.

Wentz, FJ, L Ricciardulli, KA Hilburn and others, 2007, [How much more rain will global warming bring?](#), *Science*, 317, 233-235.

Wentz, F.J., 2015, [A 17-Yr Climate Record of Environmental Parameters Derived from the Tropical Rainfall Measuring Mission \(TRMM\) Microwave Imager](#), *J Climate*, 28, 6882-6902.

The validation procedure described in Section 12 of the Wentz 2015 paper has also been applied to all SSM/I and SSMIS data but the results have not been published in any peer-reviewed literature. The TMI analysis in the above paper shows comparisons of TMI to SSM/I and SSMIS instruments and is a reasonable analysis for determining data quality.

Many other scientists have independently validated the SSM/I data - see the list of publications at <http://www.remss.com/support/publications>

**Data Limitations:**

The SSM/I and SSMIS data products contain ocean variables stored as single bytes, therefore the data have been scaled to convert from real numbers to integers between 0 and 256. This process results in rounding and therefore limits the resolution of the data. The RSS binary data used contain the following data resolutions: Wind speed: 0.2 m/s, Water Vapor: 0.3 mm, Cloud Liquid Water: 0.01 mm, Rain Rate: 0.1 mm/hr.

**RSS V7 Data Product Description:**

The following content is from [www.remss.com/missions/ssmi](http://www.remss.com/missions/ssmi) web page. This web page changes over time and has been included here to hold the RSS V7 description documentation for preservation (downloaded May 2016). Only the most relevant information to the GHRC data products has been included.

**Introduction**

The Special Sensor Microwave Imager (SSM/I) and the Special Sensor Microwave Imager Sounder (SSMIS) are satellite passive microwave radiometers. This series of instruments has been carried onboard Defense Meteorological Satellite Program (DMSP) satellites since 1987. These are near-polar orbiting satellites. The instruments are referred to by satellite number starting with F08 and are listed in the table below. Currently operating instruments are: F15, F16, F17 and F18. Ocean measurements we derive from the radiometer observations include Surface Wind Speed, Atmospheric Water Vapor, Cloud Liquid Water, and Rain Rate.

<b>Instrument</b>	<b>Start Date</b>	<b>Stop Date</b>
F08 SSM/I	Jul 1987	Dec 1991
F10 SSM/I	Dec 1990	Nov 1997
F11 SSM/I	Dec 1991	May 2000
F13 SSM/I	May 1995	Nov 2009
F14 SSM/I	May 1997	Aug 2008
F15 SSM/I	Dec 1999	present (do not use after Aug 2006 for climate study)
F16 SSMIS	Oct 2003	present
F17 SSMIS	Dec 2006	present
F18 SSMIS	Oct 2009	present (data are NOT currently available at RSS)
F19 SSMIS	Apr 2014	Feb 2016 (data are NOT currently available at RSS)

## Instrument Description

These Special Sensor Microwave/Imager (SSM/I) and Special Sensor Microwave Imager Sounder (SSMIS) data products are produced as part of the NASA's MEaSUREs Program. Remote Sensing Systems generates SSM/I and SSMIS data products using a unified, physically-based algorithm to simultaneously retrieve the products. This algorithm is a product of 20 years of refinements, improvements, and verifications. While the algorithm has evolved over time, a substantial background to the radiative transfer function used to derive the ocean measurements is described in several publications.

Band [GHz]	Polarization	Spatial Resolution (3-dB footprint size) [km x km]
19.35	V,H	69 x 43
23.235	V	50 x 40
37.0	V,H	37 x 28
85.5	V,H	15 x 13

Remote Sensing Systems performs a detailed processing of SSM/I & SSMIS instrument data in two stages. The first stage produces an interim product (identified by "rt" within the file name) which is made available as soon as possible, generally within hours of when the data are recorded. This product can be incomplete or contain geolocation errors and erroneous brightness temperatures inherent in the data supplied to RSS. These errors are removed with final processing which is usually completed within a few days of the initial product. The final product replaces the interim product automatically, with the "rt" designation in the file name changing to "v7".

## RSS Ocean Products

The SSM/I & SSMIS ocean data products include daily files consisting of ascending and descending swaths, and time-averaged data as follows:

daily    orbital data mapped to 0.25 degree grid, data overwritten by later data

3-day    average of 3 days ending on file date

weekly    average of 7 days ending on the Saturday file date

monthly    average of all data within month

Geophysical graphic images can be viewed on our web page and binary data files can be downloaded from our ftp server: <ftp.ssmi.com/ssmi>

## Gridded Binary Files

Daily binary data files and Time-Averaged (3-day, weekly and monthly) data files are produced. The daily files consist of SSM/I or SSMIS geophysical products mapped to a regular grid complete with data gaps between orbits. Two maps exist for each ocean measurement, one of ascending orbit segments and the other of descending orbit segments. Data on each of the segment maps are overwritten at both the high latitudes where successive orbits cross and at the "seam" or region where the last orbit of the day overlaps the first orbit of the day. Daily data files contain time values representing the time (in minutes UTC) of the data for that cell. Time-Averaged data files do not contain any time values.

Each binary data file available from the RSS ftp site consists of ten (daily) or four (averaged) 0.25 x 0.25 degree grid (1440,720) byte maps. For daily files, five local morning (descending, except F08) maps in the following order, Time (T), 10 meter Surface Wind Speed (W), Atmospheric Water Vapor (V), Cloud Liquid Water (L), and Rain Rate (R), are followed by five local evening (ascending, except F08) maps in the same order. Time-Averaged files contain just the geophysical layers in the same order [W,V,L,R].

### RSS SSM/I and SSMIS ocean measurement product details. Measurements are provided in the order contained in the data files.

Acronym	Product Name	Product Description	Scale	Offset	Valid Data Range	Reason for no data
TIME	Time	Minutes since midnight GMT Fractional hour of day GMT	6.0 0.1	0. 0.	0 to 1440. 0.0 to 24.0	no data
WSPD_MF	10-m surface wind speed	Wind speed using 18.7 GHz channel and above	0.2	0.	0. to 50.0 m/s	sun glint, rain, RFI, near sea ice or land (~50 km)
VAPOR	Columnar atmospheric water vapor	Total gaseous water contained in a vertical column of the atmosphere	0.3	0.	0. to 75.0 mm 1gm/cm <sup>2</sup> =10mm	heavy rain or near land (~25 km)
CLOUD	Columnar cloud liquid water	Total cloud liquid water contained in a vertical column of the atmosphere	0.01	-0.05	-0.05 to 2.45 mm	near land (~25 km)
RAIN	Rain rate	Rate of liquid water precipitation	0.1	0.	0. to 25.0 mm/hr	near land (~25 km)

The data values between 0 and 250 need to be scaled to obtain meaningful geophysical data. To scale the data, multiply by the scale factors listed in the table above (and add the offset to cloud). Values above 250 have been reserved for the following:

- 0 to 250 = valid geophysical data
- 251 = missing wind speed due to rain,  
missing water vapor due to heavy rain
- 252 = sea ice
- 253 = observations exist, but are bad  
(not used in composite maps)
- 254 = no observations
- 255 = land mass

The daily, 3-day and monthly maps are stored by instrument in appropriate year and month subdirectories. The weekly data files are stored by instrument in the /weeks directory. The file names have the following naming conventions:

Daily fs\_yyyymmddvv.gz

3-Day fs\_yyyymmddvv\_d3d.gz

Weekly fs\_yyyymmddv7.gz

Monthly fs\_yyyymm7.gz

Where ss, yyyy, mm, dd, and vv stand for:

fs file specifier F08, F10, F11, F13, F14, F15, F16, F17, F18

yyyy year 1998, 1999, 2000, etc.

mm month 01 (Jan), 02 (Feb), etc.

dd day 01, 02,...31

vv version  
rt = real time  
v7 = version 7 (final product)

The center of the first cell of the 1440 column and 720 row map is at 0.125 E longitude and -89.875 latitude. The center of the second cell is 0.375 E longitude, -89.875 latitude.

## Data Access

SSM/I and SSMIS data products are available for each instrument for the time periods listed in Table 1 above. Due to successive satellite launches, there is often more than one instrument in operation at a time. As with all the other RSS satellite products, the data are provided in a gridded, binary format file. Binary data files can be downloaded from the RSS ftp server: <ftp.remss.com/ssmi>. SSM/I and SSMIS data are available in netCDF data format from the NASA GHRC.

## References

- Wentz, F. J., (2013), [SSM/I Version-7 Calibration Report](#), report number 011012, Remote Sensing Systems, Santa Rosa, CA, 46pp.
- Meissner, T., and F. J. Wentz, (2012), [The emissivity of the ocean surface between 6 - 90 GHz over a large range of wind speeds and Earth incidence angles](#), IEEE TGRS, 50(8), 3004-3026.
- Hilburn, K. A., and F. J. Wentz, (2008), [Intercalibrated passive microwave rain products from the unified microwave ocean retrieval algorithm](#), Journal of Applied Meteorology and Climatology, 47, 778-795.
- Wentz, F. J. and T. Meissner, (2007), [AMSR-E Ocean Algorithms; Supplement 1](#), report number 051707, Remote Sensing Systems, Santa Rosa, CA, 6 pp.
- Wentz, Frank J. and Thomas Meissner, (2000), [AMSR Ocean Algorithm, Version 2](#), report number 121599A-1, Remote Sensing Systems, Santa Rosa, CA, 66 pp.
- Wentz, Frank J. and Roy W. Spencer, (1998), [SSM/I Rain Retrievals within a Unified All-Weather Ocean Algorithm](#), Journal of the Atmospheric Sciences, 55, 1613-1627.
- Wentz F. J., (1997), [A Well-calibrated Ocean Algorithm for SSM/I](#), Journal of Geophysical Research, 102 (C4), pg. 8703-8718.

## Acknowledgements

These SSM/I and SSMIS data are produced by Remote Sensing Systems with support NASA. Data are available at [www.remss.com](http://www.remss.com). We are grateful to NOAA for access to SSM/I and SSMIS TDR data.

## How to Cite the GHRC netCDF Data:

An example citation is listed below for the Daily data grids from F17 DMSP instrument.

Wentz, F.J., K. Hilburn and D.K. Smith. 2012. RSS V7 SSMIS Ocean Product Grids Daily from DMSP F17 netCDF [indicate subset used]. Data set available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. [<http://ghrc.nsstc.nasa.gov/pub/ssmis/f17/daily/>], doi:<http://dx.doi.org/10.5067/MEASURES/DMSP-F17/SSMIS/DATA301>