RSS SMAP Salinity BETA (Version 1.0) Release Notes

1. Release Date

12/07/2015

2. Data Access

ftp://ftp.remss.com/smap/L3/v1.0/

www.remss.com/missions/smap

Contact: Thomas Meissner, meissner@remss.com.

3. Citing These Data

As a condition of using these data, we ask you to use the following citation:

Meissner, T., Wentz, F.J., J. Scott, 2015: Remote Sensing Systems SMAP Level 3 Ocean Surface Salinities [Running 8-day, Monthly] on 0.25 deg grid, Version 1.0. (BETA). Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/missions/smap.

Continued production of this data set requires support from NASA. We need you to be sure to cite these data when used in your publications so that we can demonstrate the value of this data set to the scientific community. Please include the following statement in the acknowledgement section of your paper:

"SMAP data are produced by Remote Sensing Systems and sponsored by the NASA Ocean Salinity Science Team. They are available at www.remss.com. "

4. Level 3 Data Files

1. 8-day running averages centered on each day starting with day of the year 95 (04/05/2015). The 8-day running window was chosen as it is the SMAP orbit repeat cycle.
   Filename: /8day_running/*YYYY*/sss_smap_8day_running_*YYYY_DOY*_v1.0.dat.gz
2. Monthly averages starting with 04/2015.
   Filename: /monthly/*YYYY*/sss_smap_monthly_*YYYY_MM*_v1.0.dat.gz

YYYY = long year, *MM*= month of the year, *DOY* = day of the year.

5. File Format and Reader

The data files are gridded binary and contain 2 arrays mapped on a 0.25 deg grid

1. integer(4), dimension(1440,720) :: *map_num*
   Long integer array containing the number of Level 2C observations in each ¼ deg grid cell that went into the Level 3 average.
2. real(4), dimension(1440,720) :: *map_sss*
   Single precision floating point array containing the Level 3 SMAP sea surface salinity.

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. Invalid or missing values in the salinity maps have been set to -9999.0.

To read the arrays:

read(...) map_num

read(...) map_sss

6. Spatial Resolution

The **spatial resolution** of the SMAP salinity observations is the same as the SMAP L1A antenna temperature data [Piepmeier et al., 2015], which is **approximately 40 km**.

7. Processing Schedule and Latency

RSS plans to batch process the V1.0 Level 3 SMAP salinities retroactively about once every month. Newly processed files (both 8-day running and monthly) will be placed into the corresponding directories on the RSS FTP server once every month.

A validated data release (V 2.0) containing both OI Level 2 (including the essential intermediate products of the retrieval algorithm) and Level 3 data is planned for early 2016.

8. Known Issues

1. We observe significant fresh biases in the SMAP V1.0 BETA salinities at high Northern latitudes (> 40°N) peaking during summer solstice. We suspect that they are related to the inaccuracies of the thermal model for the physical reflector temperature that is used in the correction for the emissive reflector (section 7). We advise to use SMAP V1.0 BETA salinity data above 40°N with caution.
2. Likely intrusion of undetected RFI is observed in the Western Pacific near China, Korea and Japan.

9. Level 2 Processing Algorithm

The RSS SMAP salinity retrieval algorithm ingests RFI filtered antenna temperatures (TA) from the SMAP L1B data files [Piepmeier et al., 2015] together with basic spacecraft ephemeris information (S/C location, velocity, and attitude) and time of observation. Until 10/23/2015 we have used TA data from the SMAP L1B BETA release. After that date we are using TA data from the validated SMAP Version 2.0 L1B release.

As a first step we perform an optimum interpolation (OI) and resample the L1B TA onto a fixed 0.25 deg Earth grid, which are called Level 2A files. The resampling is done separately for the forward (for) and the backward (aft) look. The OI keeps approximately the noise and the spatial resolution (47 km x 36 km). The auxiliary fields that are needed in the salinity retrieval algorithm get resampled onto the same grid (Level 2B files).

The SMAP salinity retrieval algorithm is then run on these Level 2B files and produces calibrated SMAP Level 2C surface ocean brightness temperatures (TB) and sea surface salinity (SSS) values.

The SMAP Level 2C SSS themselves have an estimated accuracy of about 1 psu due to the noise figures of the L1B TA, which it get ingested into the L2 processing. The L2C SSS data are thus of limited use for common ocean applications and therefore we do not provide them in the BETA (V1.0) salinity data release.

The SMAP Level 2C salinity retrieval algorithm follows the basic steps of the Aquarius Level 2 V4.0 salinity retrieval algorithm [Wentz and LeVine, 2012; Meissner et al., 2014; Meissner et al., 2015] after adapting it to the SMAP configuration. The most important differences between the Aquarius and the SMAP salinity retrieval algorithms are:

1. Due to the loss of the SMAP radar in early July 2015, there are no scatterometer wind speeds available for performing the surface roughness correction. The surface roughness correction of the SMAP salinity retrievals is based on auxiliary wind speeds from the RSS WindSat [Wentz et al., 2013] and SSMIS F17 [Wentz et al., 2012] Version 7 environmental data suite. If a rain-free march-up WindSat wind speed is available within 1 hour of the SMAP observation it is used. If not, then a rain-fee match-up SSMIS F17 observation is used if available within 1 hour of the SMAP observation. If neither a rain-free WindSat nor a rain-free SSMIS F17 wind speed match-up observation is available within 1 hour of the SMAP observation, then the NCEP GDAS wind speed is used in the surface roughness correction. It should be noted that using the NCEP GDAS wind speeds leads to a degraded surface roughness correction compared to using the microwave imager wind speeds.
2. The SMAP antenna is slightly emissive, which was not the case with Aquarius. Before processing the SMAP TA into surface TB and SSS a correction for the antenna emissivity needs to performed, which ingests the physical temperature of the reflector. There are no direct measurements of the physical reflector available but thermal model data provided by the JPL thermal team have to be used. Analysis has shown that the thermal model data in the BETA and V2.0 SMAP L1B files are inaccurate as the model has apparently been run with an incorrect value for the antenna mesh density. This inaccuracy leads to significant biases in the SMAP SSS. They become obvious when the spacecraft goes into solar eclipse, which occurs around summer solstice at higher southern latitudes. The SMAP BETA (V1.0) salinity retrieval algorithm applies an empirical correction to the thermal model data of the L1B SMAP physical antenna temperatures on order to mitigate these biases. We believe, however, that residual biases in the data still remain in some instances and will need to be dealt with in future data releases. For the emissivity of the SMAP antenna we have used a constant value of 0.011 for both v-pol and h-pol.
3. The SMAP L1B TA data, in particular the BETA release, exhibit many small calibration jumps as well as small calibration drift. An empirical offset correction for these jumps and drifts is performed in the SMAP SSS salinity retrieval algorithm. Similar as in case for the Aquarius V4.0 calibration drift correction, we use the **global salinity average from HYCOM as calibration target**.
4. Data analysis exhibits an along-scan bias of the SMAP v-pol TB as function of the azimuthal look angle in the order of 0.25 K, which is independent of time and orbit position. The cause is most likely an intrusion of parts of the S/C or instrument into the

Earth field of view. The SMAP V1.0 salinity retrieval algorithm applies an empirical correction in order to mitigate this along-scan bias.

5. The SMAP V1.0 salinity retrieval algorithm uses the following antenna pattern correction (APC) matrix transforming Earth TA into top of the ionosphere TB (I, Q, S3, S4 basis):
$$A = \begin{pmatrix} 1.0929 & -0.0001 & 0.0036 & -0.0006 \\ 0.0000 & 1.1349 & 0.0066 & -0.0001 \\ 0.0009 & 0.0042 & 1.1336 & -0.0553 \\ 0.0003 & 0.0014 & 0.0117 & 1.1297 \end{pmatrix}.$$
We have derived these APC matrix elements by integrating the pre-launch antenna patterns that were provided by JPL over the Earth field of view. We have made small post-launch adjustments for the cross-polarization matrix elements A_{Q3} and A_{43} from the 3rd Stokes parameter into the 2nd Stokes parameter Q and into the 4th Stokes parameter S4 in order to mitigate observed biases in the data.

6. The symmetrization procedure from Aquarius V3.0 for the reflected galactic radiation [Meissner et al., 2014] is **not** applied in the SMAP salinity retrievals.

10. Q/C for Level 3 Gridding

The L2C salinity values are gridded into the Level 3 data product. During the gridding for both the 8-day running averages and the monthly averages we apply Q/C checks and discard data:

1. If the sun glint angle is less than 50^o and the azimuthal look angle lies between 30^o and 50^o.
2. The moon glint angle is less than 15^o.
3. The v/h-pol average of the reflected galactic radiation exceeds 1.0 K.
4. Either the gain weighted land or sea ice fraction exceeds 0.005.

For the monthly averages we also discard data if:

5. The SST is less than 5^oC.
6. The wind speed exceeds 20 m/s.
7. There is no rain-free wind speed match-up available from either WindSat or SSMIS F17 within 1 hour from the SMAP observation. Using wind speeds from the microwave imager increases the performance of the surface roughness correction. As trade-off data coverage becomes sparse and therefore noise increases in the tropics where frequent rain occurs, because no microwave imager wind speeds are available in rain.

11. References

Piepmeier, J. R., P. Mohammed, J. Peng, E. J. Kim, G. De Amici, and C. Ruf. 2015. SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, BETA Release and Version 2. [RFI filtered antenna temperatures]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. http://dx.doi.org/10.5067/VIQYQV0AJATI.

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T. Meissner, F. Wentz, D. Le Vine and P. de Matthaeis, Addendum IV to ATBD, July 15, 2015, RSS Report #071515, ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/docs.

Wentz, F.J., K.A. Hilburn, D.K. Smith, 2012: Remote Sensing Systems DMSP [SSM/I or SSMIS] [Daily] Environmental Suite on 0.25 deg grid, Version 7, [WSPD_MF]. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/missions/ssmi.

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