Soil Moisture Active Passive (SMAP) Project
Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Validated Version 2 Data Products

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DOCUMENT CHANGE LOG

Revision	Date	Sections Changed	Reason for Change

TBD, TBR, TBS LOG

Section/Page	Description	Due Date

Executive Summary

This report serves as an addendum to "Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Beta-Level Data Products" providing analysis and assessment of calibration quality of SMAP radiometer brightness temperatures available in the L1B_TB and L1C_TB validated data products. Like the beta-level products, the calibration uses cold sky and vicarious ocean sources. Geolocation remains the same as before. Statistical analyses were updated to assess the impact of radio-frequency interference (RFI) and improvements provided by algorithm filtering . The calibration error budget is assessed using the global ocean target and comparison to Soil Moisture and Ocean Salinity (SMOS) radiometer data provides additional validation.

Results show a major improvement in the 6-month temporal stability of the data with calibration extending back to March 31, 2015 power-on. The calibration meets the mission requirement error budget of <1.8 K rms and drift <0.4 K/month. Geolocation performance continues to meet requirements with ample margin. RFI filtering performs similar to the beta-level release with the improvement of reduced false alarms at coastlines.

The report finds that the radiometer calibration compares favorably with SMOS over land and ocean with differences < 1 K. The report notes several limitations and unaddressed areas in the current calibration. These include antenna pattern correction, polarimetric channel calibration, and reflector emissivity correction.. Despite these remaining areas, this first validated product is of sufficient quality that it should be distributed to and used by the larger science and application communities.

1 Introduction

This document summarizes the changes from the beta-level data present in this validated data release. The team is delivering Level 1B (time-ordered) and 1C (gridded) brightness temperature data with a validated calibration for use by the larger science and application communities. These data are distributed through the National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC). Both reprocessed data covering the period starting March 31, 2015 and operational forward stream are available.

The primary validation assessment is performed comparing the calibrated data to the ocean emissivity model. Favorable comparison to SMOS over land and ocean provide additional validation. The instrument continues to perform as expected. Both geolocation accuracy and NEDT meet the project requirements. Comparison with SMOS indicates the calibration is of sufficient quality to enable reasonable soil moisture retrieval performance. A concise summary of the current performance is listed in Table 1.1.

Table 1.1: Performance of SMAP Radiometer Level 1 Data.

Parameter	Beta-level	Requirement
NEDT (over land)	1.1 K	< 1.6 K
Geolocation accuracy	2.7 km	< 4 km
Ocean Model RMSD	1.3 K	< 1.4 K
Land SMAP/SMOS comparison (H pol)	–0.48 K	n/a
Land SMAP/SMOS comparison (V pol)	–0.87 K	n/a

This document is an addendum to the beta-level release document, which needs to be consulted for complete understanding of the calibration quality.

Reference:

"Soil Moisture Active Passive (SMAP) Project Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Beta-Level Data Products". Tech. Rep. JPL D-93978, [online] http://nsidc.org/data/docs/daac/smap/sp_l1b_tb/pdfs/L1B-L1C-Beta-Report.pdf

2 Geolocation Assessment

No change from beta-level release.

Geolocation is better than 3 km absolute error.

3 Bias Removal in T_{ND}

No change from beta release.

4 Drift Removal in T_{ND}

The calibration was updated to handle changes in the SAR transmit state, front-end temperatures (see Section 5), and changing reflector & radome temperatures during eclipse season. The calibration bias with respect to the ocean model is shown in Fig. 4.1.

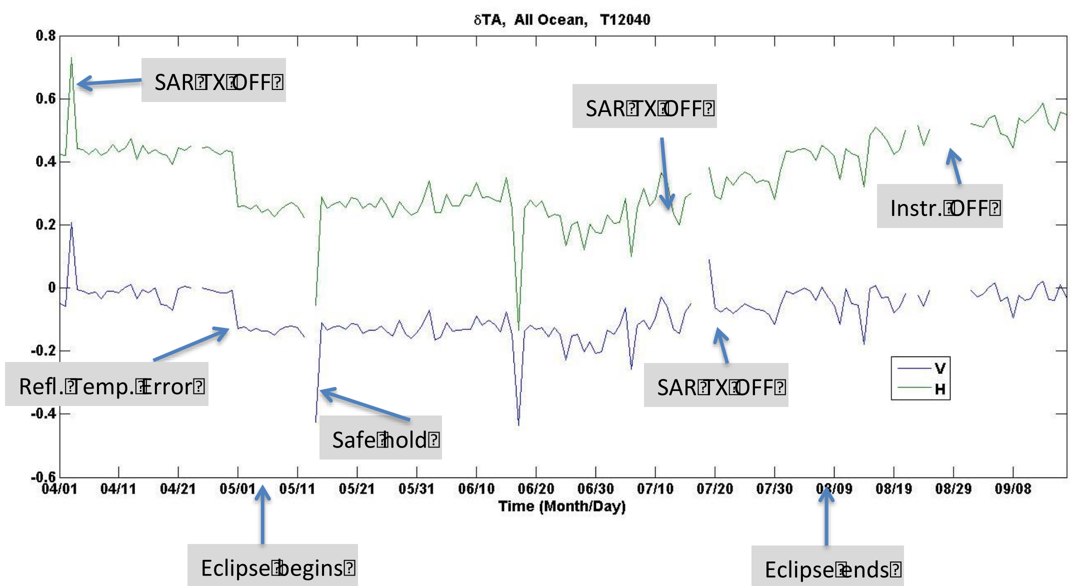
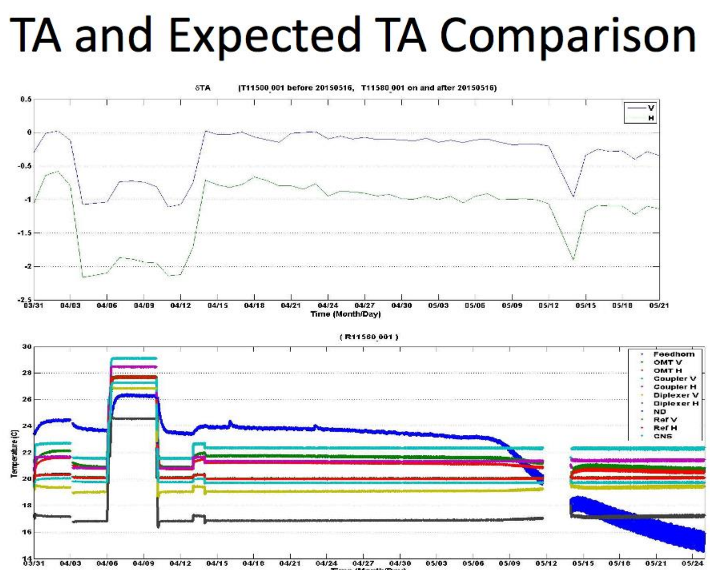


Figure 4.1 Radiometer T_A calibration bias and drift.

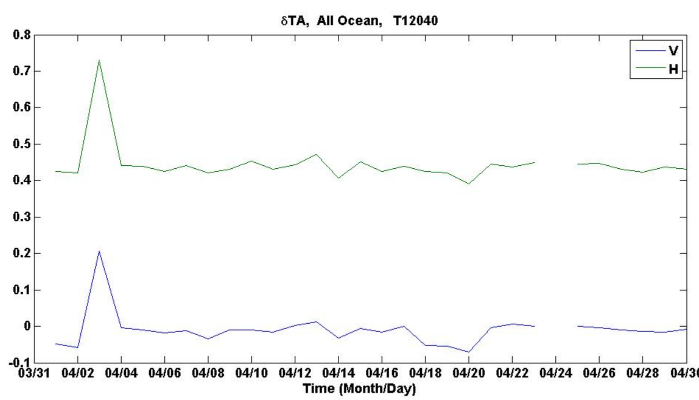
5 Front-End Loss Effects

5.1 Thermal Stability: Front-end RF Components and SAR Transmitter

Figure 5.1(b) below shows the RF element temperatures during a planned bake-out. The front-end loss temperature coefficients were adjusted to remove the dependence on changes due to SAR transmit status and heater set points. Before bake-out the SAR transmitter was also turned off. The global δT_A (Fig. 5.1(a)) over the ocean shows two separate impacts due to these events. Figure 5.1(c) shows the improved calibration with these steps removed.



(a,b)



(c)

Figure 5.1: (a) Daily averaged global ocean δT_A indicating T_A biases due to SAR transmitter being turned off (Apr 3) and on (Apr 13) and radiometer bake-out (Apr 6 to Apr 10). (b) Front-end temperature of the RF components over the same period. (c) Corrected calibration.

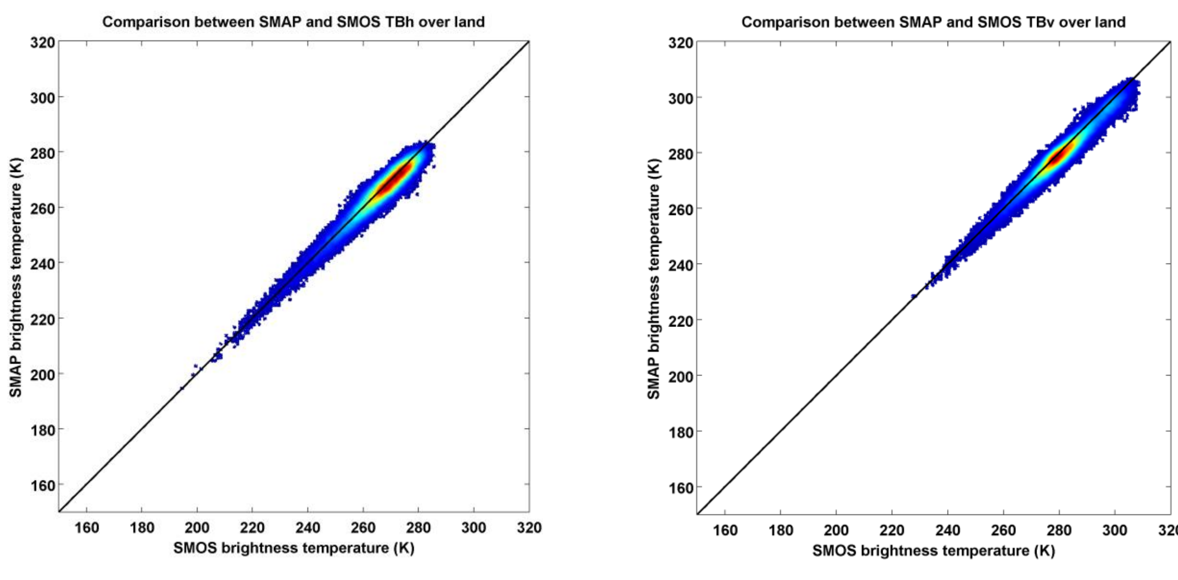
5.2 Radome and Reflector Impact on T_A Stability

In the beta-level release, the radome and reflector emissivity appeared to be underestimated. Since this determination was made, the reflector physical temperature prediction used in the algorithm was found to be cold biased and to underestimate the peak-to-peak variation over an orbit (particularly during eclipse season). The deficient physical temperature model still persists in this validated release although the emissivity was adjusted to compensate for the orbital variations. We plan to correct the models to more faithfully represent the physics prior to the Level 2 soil moisture validated data release.

6 Full Dynamic Range Calibration

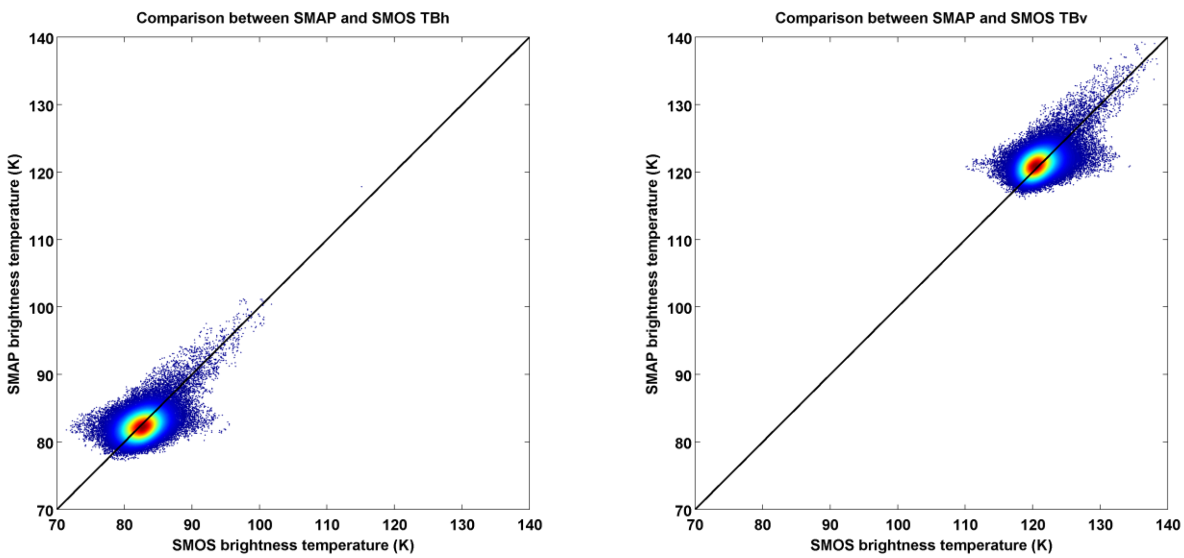
6.1 Comparison with SMOS

The inter-comparison of top-of-the-atmosphere brightness temperatures with SMOS v620 was updated using SMAP version R11850 (April-Sept 2015). Results are presented below in Figures 6.1 and 6.2. Statistical analysis results are summarized in Table 6.1.



(a) (b)

Figure 6.1: Density plot of the comparison between SMAP T_B and SMOS T_B over land for (a) H-pol, and (b) V-pol. Scale adjusted for land T_B.



(a) (b)

Figure 6.2: Density plot of the comparison between SMAP T_B and SMOS T_B over ocean for (a) H-polarization, and (b) V-polarization. Scale adjusted for ocean T_B.

Table 6.1: Statistics for SMAP and SMOS comparison.

		RMSD (K)	R	Bias [SMAP-SMOS] (K)
H pol	Land	3.35	0.9736	-0.48
	Ocean	2.30	0.3408	-0.13
	Overall	2.60	0.9995	-0.22
V pol	Land	3.22	0.9747	-0.87
	Ocean	2.20	0.4096	0.33
	Overall	2.49	0.9994	-0.03

7 Faraday Rotation Correction Assessment

No change from beta-level release.

8 Reflected Galaxy Correction Assessment

No change from beta-level release.

9 Radio-Frequency Interference Assessment

Each radio frequency interference detection algorithm has a detection threshold setting that determines its sensitivity and false alarm rate. Detection thresholds for each detector are specified in a settings file with a global spatial grid of adaptable resolution, distinct for ascending/descending passes and fore/aft looks. For the final release, all settings are uniform in space and for the ascending/descending/fore/aft cases, with the exception of the pulse detector and the T4 detector. The thresholds for the fullband pulse detector are increased at 0.1 degree spatial resolution for coastal regions, because the pulse detector may erroneously detect coastal crossings as RFI. The T4 settings were also revised for the final product release. The fullband 4th Stokes detector threshold was uniformly set (at 0.1 degree spatial resolution) to 30 K globally except along coastlines where it was set to 60 K. The subband 4th Stokes detector threshold was similarly set to 60 K globally and 120 K at the coastlines. Thresholds are doubled at the coastlines since the 4th Stokes values are higher at these locations. As with the time domain detector the ascending/descending/fore/aft cases for either the fullband or subband 4th Stokes detectors have the same global settings. Both fullband and subband 3rd Stokes detector settings remain very high (500 K and 1000 K respectively) essentially not contributing to the overall false alarm rate.

10 Fore and Aft Differences

No change from beta-level release.

11 Quality Flags

No change from beta-level release.

The quality flag “Reflected sun correction” in bit 6 does not fully flag suspect cases. The user is encouraged to add an additional filter when using the data for oceanographic purposes. This condition should be used to *ignore* data:

```
Brightness_Temperature.solar_specular_theta < 50
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12 L1C Gridded Product

No change from beta-level release.

13 Verification

The validated data meet the SMAP error budget requirement. The error budget for an L1B_TB footprint is 1.8 K rms over land. The equivalent error budget is 1.4 K over ocean (due to reduced NEDT). The error budget includes NEDT, errors in radiometric calibration, calibration drift and errors in geophysical corrections. The error budget is verified on orbit by measuring NEDT and comparing to the ocean model.

NEDT: The allocation to NEDT is 1.6 and 1.1 K rms over land and ocean, respectively. The measured NEDT is 1.1 K rms over land and 0.8 K over ocean.

Ocean RMSD: The measured difference with respect to the ocean model is 1.3 K rms.

The calibration is allowed to drift up to 0.4 K / month with respect to the ocean model. These data show changes of 0.2 K / month.

Acknowledgment

This document resulted from the many hours of diligent analyses and constructive discussion among the L1 radiometer hardware team and algorithm development team. The editors would like to express their gratitude for the contributions by the following individuals, who collectively make this document an important milestone for the SMAP project.

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