Technical Note Describing the Differences between Version 8 Calibration and Version 7 Calibration of the SSMI(S) Brightness Temperature - RSS CDR (01B-05)

Version 7 calibration began with the first SSM/I (F08) and carried the calibration forward to more recent satellites (see version 7 ATBD and Wentz, [2013]). Version 8 takes the opposite approach. The calibration originates with the recent GPM Microwave Imager (GMI) instrument on the Global Precipitation Mission (GPM) satellite, and then proceeds backwards to earlier instruments, including SSMIS F18. The reason for this change is that the calibration of the GMI instrument is better understood than any previous instrument. This is in part because in addition to cold space and warm target calibration points, GMI includes an on-board noise source that injects ~100K of noise into the radiometer system, allowing for 2 additional calibration points, cold space + 100K, and the warm target + 100K. These additional points allow the non-linearity of the radiometer to be precisely measured for the first time. This, in turn, allows us to more precisely tie the absolute calibration of the GMI instrument to our radiative transfer model over a wide range of scene brightness temperatures, including both ocean (intermediate TB) and land (high TB). The GMI calibration procedure is described in detail in Wentz and Draper [2016].

The precise calibration of the GMI instrument allows us to develop a detailed model of the seasonal and diurnal variation of the brightness temperature of the surface emission from the Amazon rain forest for each channel. This in turn allows the use of the Amazon as a third calibration point to assess the absolute calibration and non-linearity of other satellites, including F18. Note that without the third point, it is impossible to determine whether observed intersatellite differences are due to absolute calibration offsets, or to differences in radiometer non-linearity. In version 7, we assumed that the radiometer response for each instrument is linear. In version 8, the non-linearity is determined as part of the calibration procedure by comparing collocated observations from different satellites.

Between Version-7 and Version-8, the atmospheric part of the radiative transfer model we use for calibration underwent a major upgrade. Version-7 was based on the atmospheric RTM described in Wentz and Meissner (2000). In 2016, we published an upgrade atmospheric model in Wentz and Meissner (2016). After this publication, we found a problem related to the shape of the water vapor line derived in Wentz and Meissner (2016) when comparing ocean TBs from different satellites after a correction for non-linearity is applied. The ocean T_Bs are very sensitive to this shape. We found the above problem can be resolved if the width of the line shape is reduced by 4%. This increases the absorption at 22.235 GHz by 4%. The 23.8 GHz absorption also increases, but by less (around 1 %). Using the new line shape, the F18 SSMIS was recalibrated over the ocean. Since the 22.235 GHz absorption is now higher, the recalibrated SSMIS T_Bs are also higher. This adjustment to RTM made it possible to match the brightness temperatures over the amazon to the degree reported above. These results are important in that they confirm the need to reduce the water vapor line width: a result found by other investigators as well. The shape of the water vapor line is a critical element in doing satellite inter-calibration and directly impacts the calibration of F18 over the spectral range from 19-37 GHz. The revised RTM is now being used for all subsequent Version 8 calibration work and is incorporated into Version 8 for F18.

All calibration is now based on comparisons between the satellite in question, and either GMI or TMI. This is important because the rapidly precessing nature of the TMI and GMI low-inclination angle orbits makes it possible to create a satellite-satellite collocation dataset that is close in time, and the difference in local time between the satellite in question (in this case F18) and GMI are roughly equally populated on the + and – sides of exactly collocated in time. This minimizes the contribution of errors associated with the diurnal variability of geophysical parameters.

Table 1. Major Differences between Version 7 and Version 8 Calibration

	Version 7	**Version 8**
Satellites	F08-F17	F18
Absolute Calibration	RTM is absolute reference, with large uncertainties over land	RTM is absolute reference. Land uncertainties reduced by 3-point calibration
Absolute Inter-Satellite Biases	Removed by APC adjustments	Removed by APC adjustments
Relative Inter-Satellite Biases	Hot target adjusted using $\Delta T_h(\alpha, \beta)$	Hot target adjusted using $\Delta T_h(\alpha, \beta)$
PM versus AM T_A Differences	Hot target adjusted using $\Delta T_h(\psi, t)$	Hot target adjusted using $\Delta T_h(\psi, t)$
Ocean Surface RTM Version	Meissner and Wentz (2010)	Meissner and Wentz (2010)
Atmospheric RTM Version	Wentz and Meissner (2000)	Wentz and Meissner (2016) + Vapor Line Adjustment
Intersatellite collocations	DT < 6 hours, possibly asymmetric in time	DT < 1 hour, symmetric in time

The main difference that will be apparent to users is that the calibration for warm scenes, such as mid-latitude and tropical land scenes, will be much more consistent. For warm scenes, the calibration changes are as large as several tenths of a degree K. For cooler ocean scenes, the differences between V7 and V8 are much smaller, on the order of several hundredths of a degree K.

As time goes on, we plan to upgrade other SSMIS and SSMI satellites to the Version 8 standard. These upgrades will happen at irregular intervals as the calibration process becomes complete.

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