Poster 133

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TMI Cross-track Bias Correction

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Abstract

Observations from the Tropical Rainfall Measurement Mission Microwave Imager (TMI) must be properly calibrated before they may be used for geophysical retrievals. This process includes converting measured counts to antenna temperatures and antenna temperatures to main beam brightness temperatures [Colton and Poe, 1995]. At the antenna temperature level, amongst other corrections, the data are corrected for biases that are a function of cross-track position. These biases result from a variety of sources that contaminate the desired on-Earth brightness temperature measurements, including emission and reflection from elements on-board the TMI spacecraft that intercept the TMI feedhorn and main antenna fields of view in the near-field (see Figures 1,2) as well as on-board sources of RF interference. The current version of TMI data (Version 7) use the cross-track bias corrections of Wentz et al. [Wentz et al., 2001]. These are based on over-ocean measurements and assume the correction is not a function of scene antenna/brightness temperature.

The results here use both over-ocean observations from the vicarious cold calibration technique of Kroodsma et al. [2016] as well the over-land observations from the vicarious warm calibration technique of Yang et al. [2016]. Using both cold and warm observations allows for the development of a scene brightness dependent bias correction. TMI Version 8 data will include this updated correction.

Sources of Cross-Track Biases

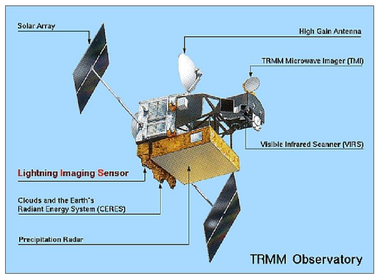

Figure 1. TMI depiction on-board TRMM spacecraft [image from UCB]. Note the TMI main reflector in relation to rest of spacecraft structure (TMI deck, High Gain Antenna, solar arrays, etc.). This structure can intercept the TMI field of view, and also appear in the TMI backlobe. In addition, on-board RF and magnetic sources can create interference at intermediate scan positions [Draper, 2014].

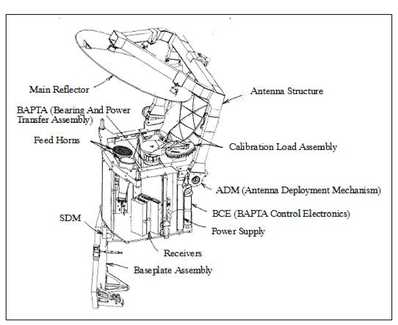

Figure 2. TMI line drawing [image from NASA]. At each edge of the TMI scan, the TMI feedhorns move under the cold sky reflector and warm load for calibration, respectively. As they move close to these calibration sources, the feedhorn fields-of-view intercept the edges of the calibration sources, spoiling the beam for on-Earth measurements at these positions.

TMI Design: Cross-Track Bias Assessment

At a given scan position, the observed antenna temperature T_A can be decomposed into the desired on-Earth interference-free main-beam brightness temperature $T_{b,mb}$, and the contribution from interference/obstruction given the effective brightness of the source of interference $T_{b,inter}$ and the effective beam fraction of the interference f_{inter} as [McKague et al., 2011]:

$$T_A = T_{b,mb} * (1 - f_{inter}) + T_{b,inter} * f_{inter}$$

Estimating $T_{b,inter}$ and f_{inter} at each scan position requires measurements known $T_{b,mb}$. These can be obtained from the vicarious cold and the vicarious warm calibration techniques. Since beam patterns as well as sources of interference vary from channel to channel, this must be done independently for each channel. The resulting corrections can be depicted as a bias from the expected T_A as a function of scan position at both cold (Figure 3) and warm (Figure 4) T_As. These biases can be linearly interpolated to compute the bias at arbitrary TA [McKague et al., 2011; Draper, 2014].

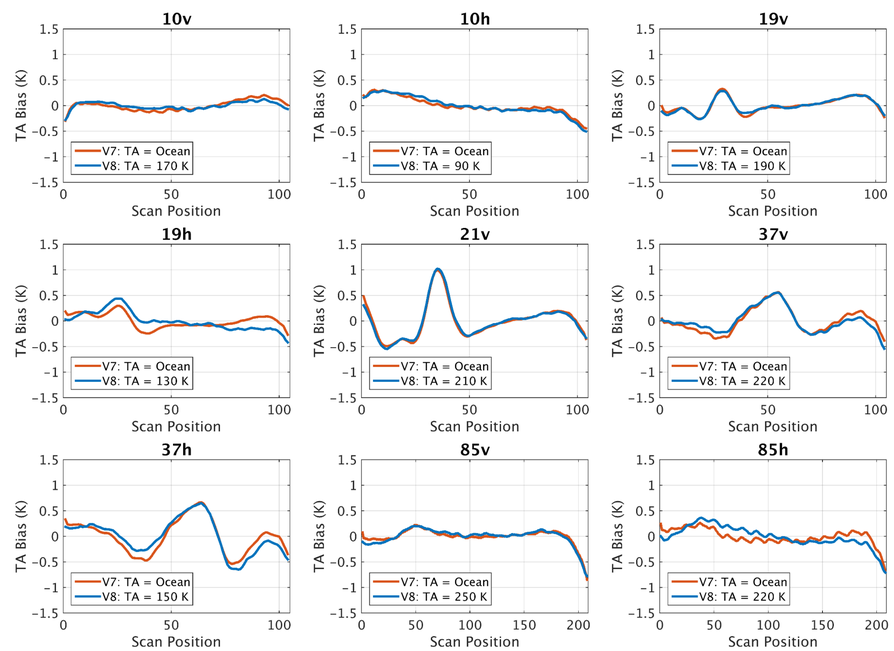

Figure 3. Comparison of old (orange) and new (blue) estimates of TMI scan biases for "cold" scenes. Since both were calculated using over-ocean observations, the results are very similar.

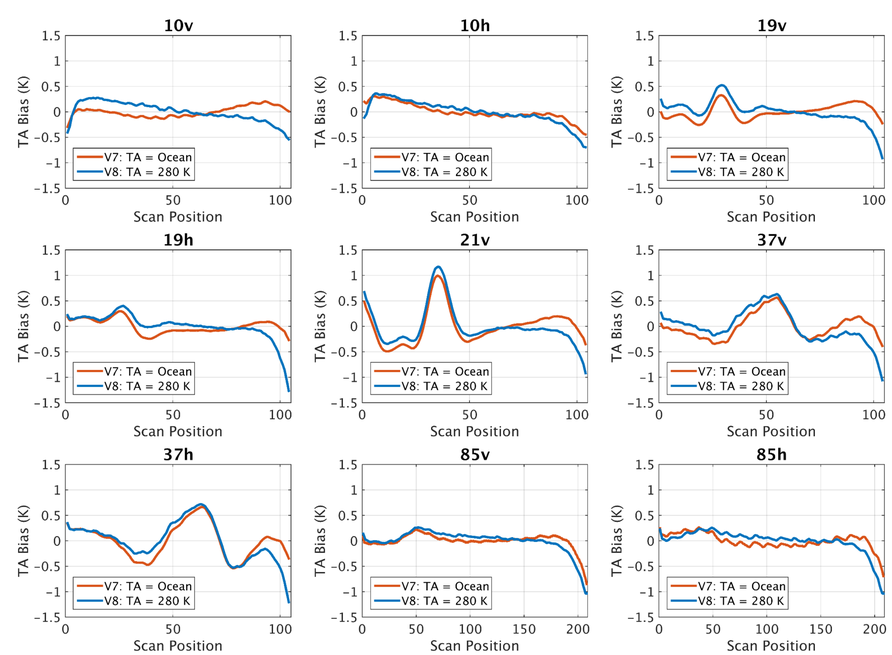

Figure 4. Comparison of old (orange) and new (blue) estimates of TMI scan biases for "warm" scenes. The old method assumed these biases are constant as a function of scene T_A, so the new biases differ significantly (by as much as ~ 1K for, e.g., right side of 19h scan).

Reference T_As

Table 1. Reference T_As by channel for the cold observations (left) and warm observations (right) used in Figures 3 and 4, respectively. Cold observations are ocean scenes. Warm observations are from globally distributed, densely vegetated forests.

Channel	Cold T_A (K)	Warm T_A (K)
10v	170	280
10h	90	280
19v	190	280
19h	130	280
21v	210	280
37v	220	280
37h	150	280
85v	250	280
85h	220	280

Conclusions

The current version of the TMI brightness temperatures provided by PMM uses a cross-track bias correction derived from over-ocean scenes that assumes these biases are constant as a function of scene brightness temperature. The analysis depicted in Figure 4 shows that scan biases over warm scenes can differ from those over cold scenes by as much as 1 K. The next version of PMM TMI observations will therefore use a linear interpolation of the results shown here in Figures 3 and 4 to compute a scene T_A dependent cross-track bias correction. This will result in more accurate warm to moderate T_A TMI observations.

References

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