DEVELOPMENT OF A MICROWAVE RADIOMETER INTER-CALIBRATION TRANSFER FUNCTION FOR THE GPM CONSTELLATION

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1. INTRODUCTION

To improve our understanding of the distribution and temporal variability of precipitation, the joint NASA/JAXA Global Precipitation Mission (GPM) will use a constellation of satellites that will include microwave radiometers. These radiometers will need to be well calibrated as well as well inter-calibrated in order to make use of the data; inter-calibration is the process of quantifying the relationship between the measured brightness temperatures (Tbs) of one radiometer relative to another. It is the role of the GPM Intersatellite Calibration Working Group (ICWG) to define the process by which this inter-calibration is performed.

The method of inter-calibration developed by the ICWG team at the University of Michigan is based upon combining the cold and warm vicarious calibration techniques of Ruf [1] and Brown and Ruf [2]. These results have been summarized in previous IGARSS presentations [3, 4]. Using stable, on Earth targets as references for a two point calibration, the vicarious calibration technique provides a means for transferring main beam brightness temperature calibration standards between space-borne radiometers that operate at different frequencies, incidence angles, polarizations and orbit geometries. Prior to inter-calibration, each radiometer is pre-screened to remove known Tb issues using the vicarious calibration technique to derive more accurate absolute calibration [5, 6], diagnose attitude offsets in the instrument [5], and determine and adjust for calibration stability [1].

As a test case, the ICWG is analyzing data from July 2005 through June 2006 for four radiometers: the Defense Meteorological Satellite Program Special Sensor Microwave/Imager (SSM/I) on the F13 and F14 satellites, the Naval Research Lab WindSat radiometer, and NASA's Tropical Rainfall Measurement Mission Microwave Imager (TMI). Previous work [1-6] has shown the ability of the vicarious calibration technique to calibrate individual radiometers and has shown initial results for radiometer inter-calibration. This paper will present a method for radiometer inter-calibration using recent updates to the technique and will demonstrate the application of the method to the ICWG test constellation. In addition, the stability of the TMI radiometer will be assessed.

2. RADIOMETER INTER-CALIBRATION

GPM constellation inter-calibration will be quantified via an inter-calibration transfer function. For this transfer function, a reference will be chosen to which the radiometers will be calibrated to create consistent radiometer-to-radiometer Tbs. The most convenient choice for a reference is one of the radiometers in the constellation. Once chosen, the Tbs from any constellation radiometer can be related to the reference radiometer via the expression:

$$T_b' = a * T_b + b \tag{1}$$

Where T_b' is the Tb of the constellation radiometer relative to the reference radiometer, T_b is the original observed Tb (with pre-screening), *a* is the transfer function gain, and *b* is the transfer function offset. Since the vicarious inter-calibration method makes independent measurements at two points, both the transfer function gain and offset can be computed.

Amongst the test case set, three of the four radiometers - WindSat, SSM/I F13, and SSM/I F14 - are in sun-synchronous orbits with fixed, but differing equatorial crossing times, while one - TMI - is in a non-sun-synchronous orbit, with an equatorial crossing time that varies over the range covered by the other three. While not critical for the vicarious calibration method, matching the local time of observations between the radiometers reduces uncertainty in corrections for diurnal variability that are used in the vicarious warm calibration process. This makes TMI a logical choice as the reference radiometer. Details of the pre-screening of all four radiometers plus the transfer function for WindSat, SSM/I F13, and SSM/I F14 relative to TMI will be presented. The transfer function of each channel of WindSat relative to TMI for the given data is shown in Table 1. Details concerning the residual differences in radiometer calibration, both before and after the inter-calibration procedure is performed, will also be presented.

Table 1. Inter-calibration transfer function parameters for WindSat relative to TMI derived from test data set (July 2005 through June 2006).

Inter-calibration Transfer Function Parameter	**Channel**						
	10V	**10H**	**19V**	**19H**	**22V**	**37V**	**37H**
Gain, a	1.008	1.005	1.014	1.009	1.011	1.027	1.004
Offset, b	2.9	1.9	4.6	3.5	5.7	10.3	3.6

In addition to presenting the ICWG test set inter-calibrations, the stability of the reference radiometer TMI will be analyzed for the time period from 1999 through 2009.

References

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