REFINEMENT OF VICARIOUS COLD CALIBRATION DOUBLE DIFFERENCE FOR GPM RADIOMETER INTER-CALIBRATION

Rachael Kroodsma, Darren McKague, Christopher Ruf

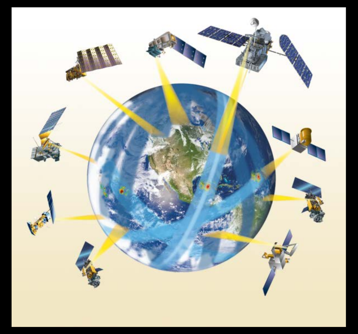
University of Michigan – Department of Atmospheric, Oceanic and Space Sciences

Introduction

The Global Precipitation Measurement (GPM) mission will utilize several different microwave radiometers on individual satellites to provide global coverage of precipitation measurements. Inter-calibration of the radiometers is necessary, since the individual instrument characteristics of each radiometer must be accounted for. The University of Michigan is using a vicarious calibration technique for inter-calibration that uses both cold [1] and warm [2] reference points. Refinement of the method at the cold end will be presented here.

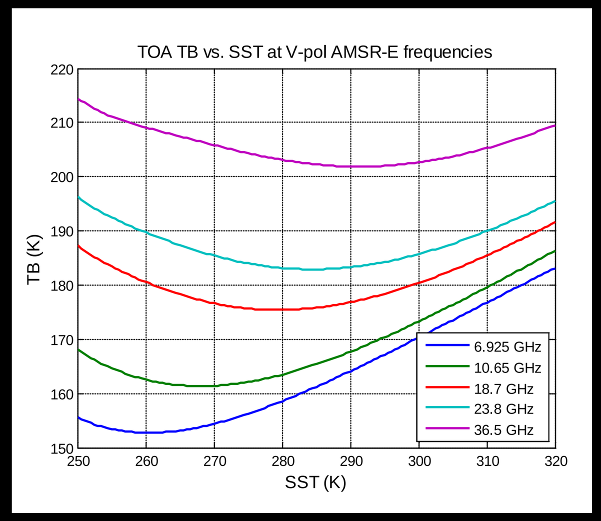
Radiometer	Frequency (GHz)					Nominal EIA (degrees)	Orbital Altitude (km)	Orbital Inclination (degrees)
WindSat	6.8V 6.8H	10.7V 10.7H	18.7V 18.7H	23.8V 23.8H	37.0V 37.0H	49.9-55.3	840	98.7
TMI		10.65V 10.65H	19.35V 19.35H	21.3V	37.0V 37.0H	53.3 (post-boost)	402.5 (post-boost)	35
AMSR-E	6.925V 6.925H	10.65V 10.65H	18.7V 18.7H	23.8V 23.8H	36.5V 36.5H	55	705	98
SSM/I			19.35V 19.35H	22.235V	37.0V 37.0H	53.1	833	98.8

Table shows radiometers that are currently being used for inter-calibration algorithm development [3]. AMSR-E and TMI are used as examples here.

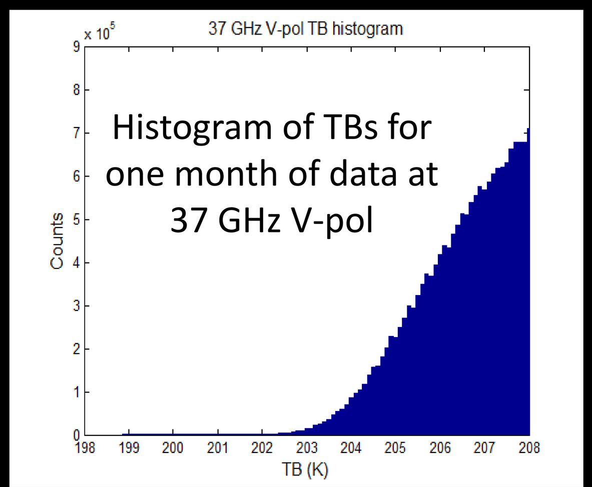


Vicarious Cold Calibration

For every frequency, polarization, and earth incidence angle (EIA), there is a sea surface temperature (SST) where the brightness temperature (TB) is at a minimum. To calculate the vicarious cold cal TB point, a polynomial is fit to an inverse cumulative distribution function of the TB population histogram. The CDF is fit in a region near but higher than the expected cold cal TB (e.g. 3%-10%) and extrapolated down to 0%.

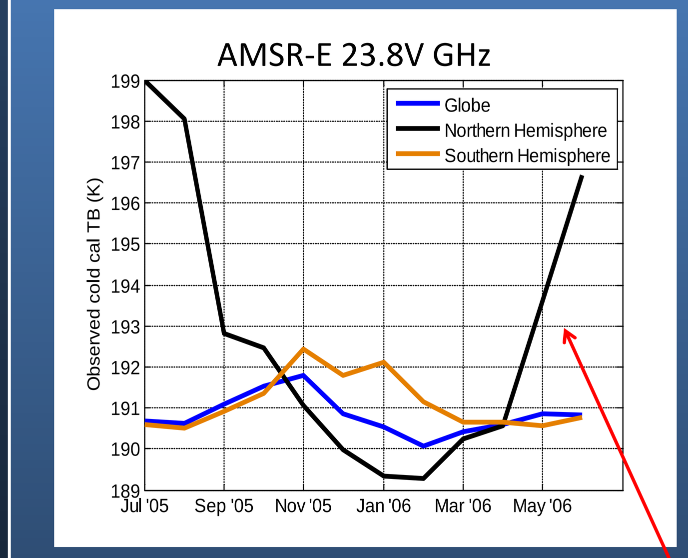


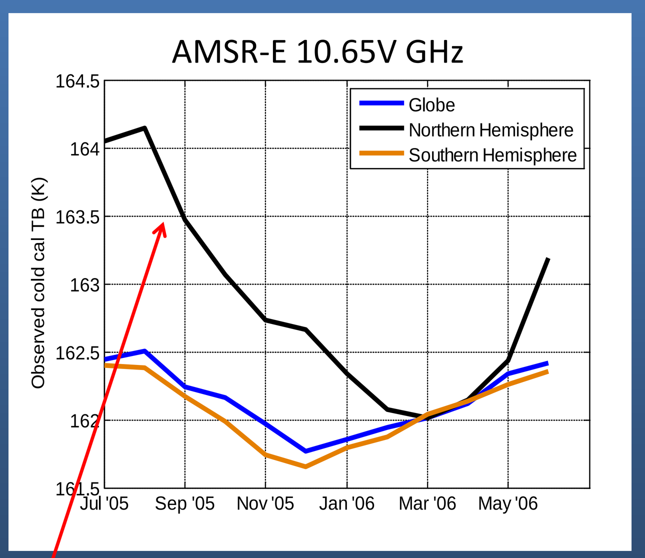
TOA TB vs. SST for no atmospheric water vapor.



Vicarious cold cal TB

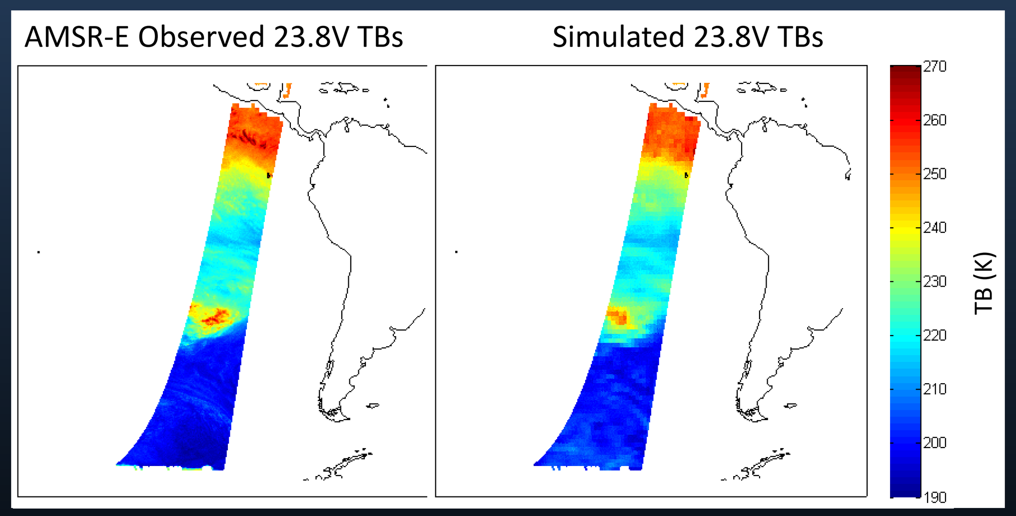
The vicarious cold cal algorithm is used to find an observed cold cal TB from radiometer observed TBs. The vicarious cold calibration minimizes the impact of water vapor but does not completely eliminate it.





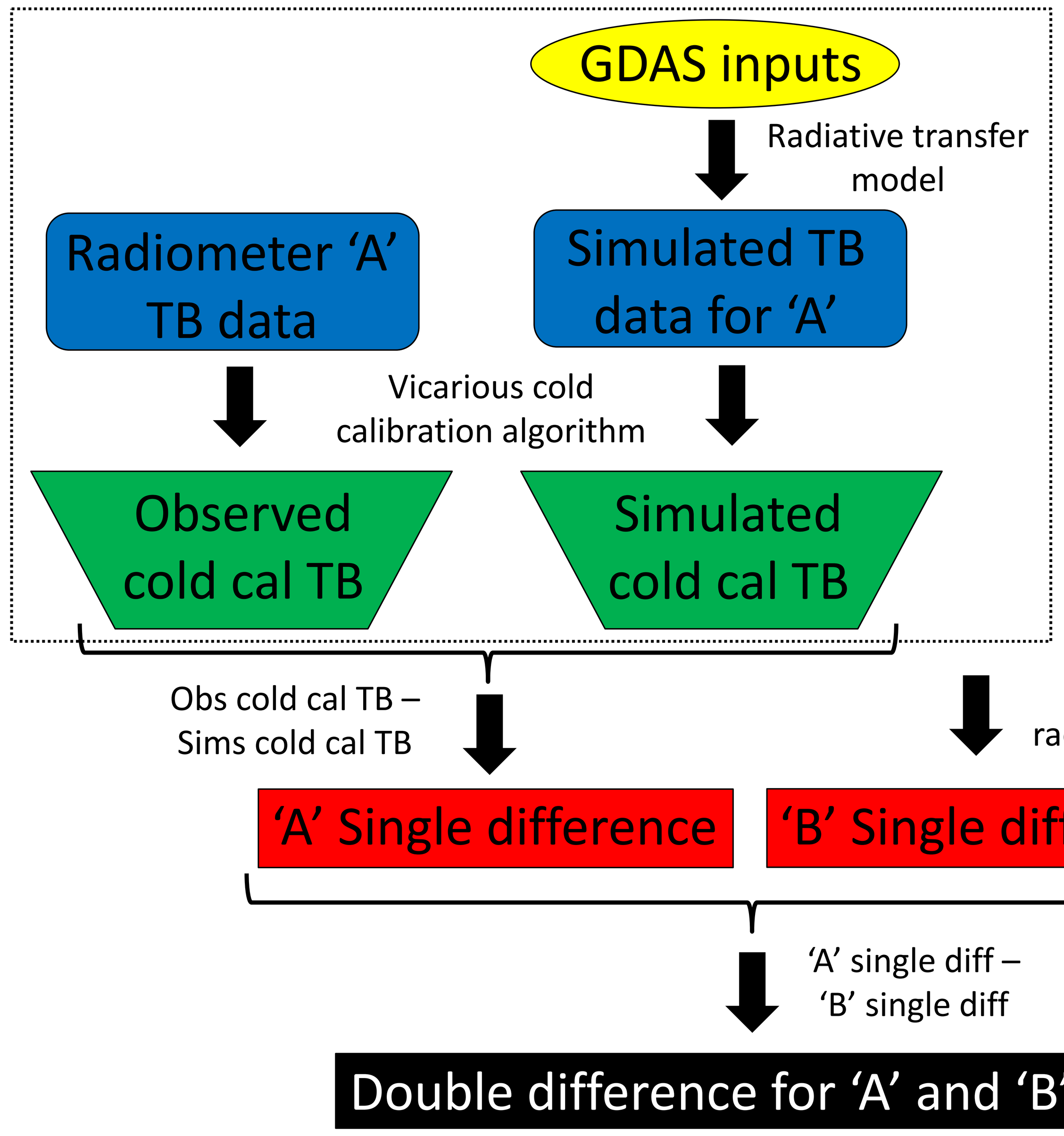
Strong seasonal signal in the NH

Simulated TBs are generated using a Radiative transfer model with inputs from the Global Data Assimilation System (GDAS) [4], from which a cold cal TB for the simulations can be computed.



Simulations match the sampling of the observations but have a coarser resolution due to the GDAS inputs only given for 1° lat/lon grid boxes.

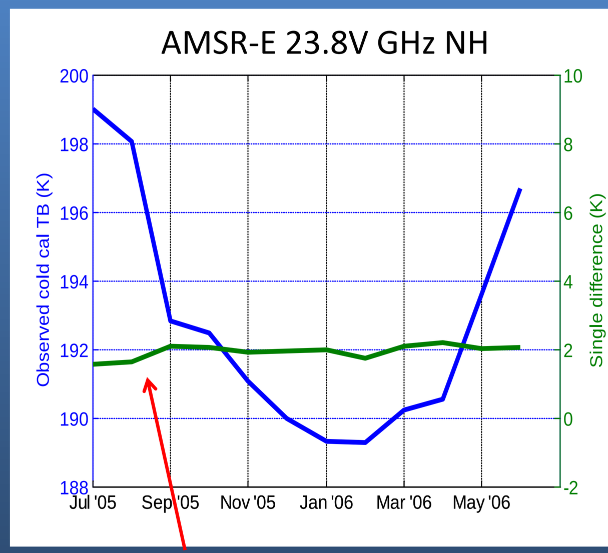
Inter-calibration Algorithm



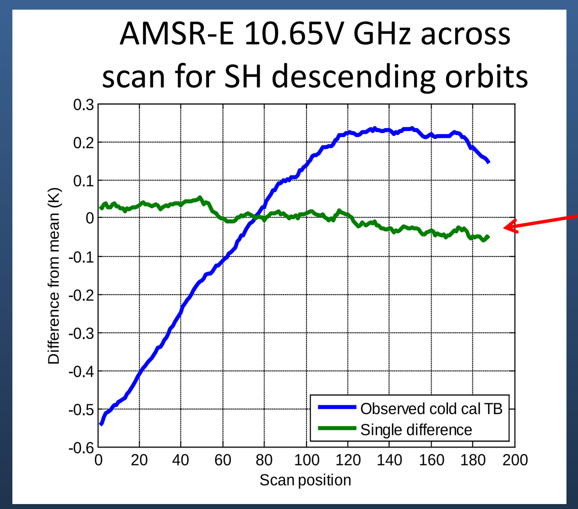
$$DD = \left(TB_{cold}^{A,obs} - TB_{cold}^{A,sims}\right) - \left(TB_{cold}^{B,obs} - TB_{cold}^{B,sims}\right)$$

Single Difference

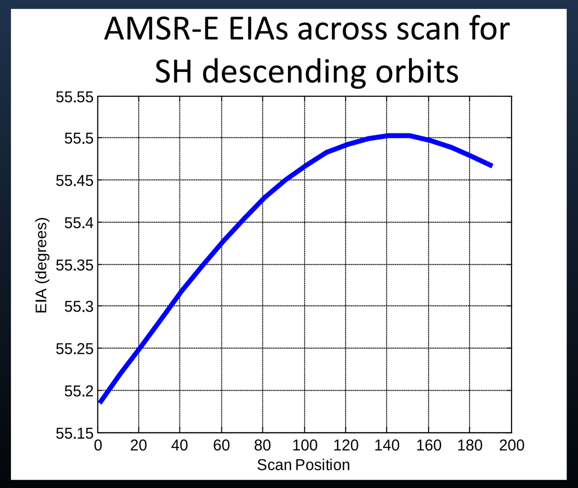
The single difference compares the vicarious cold reference points from the observations and simulations. The simulations are able to closely model the observed TBs and minimize geophysical variability or frequency/EIA differences that should not be included in the inter-calibration.



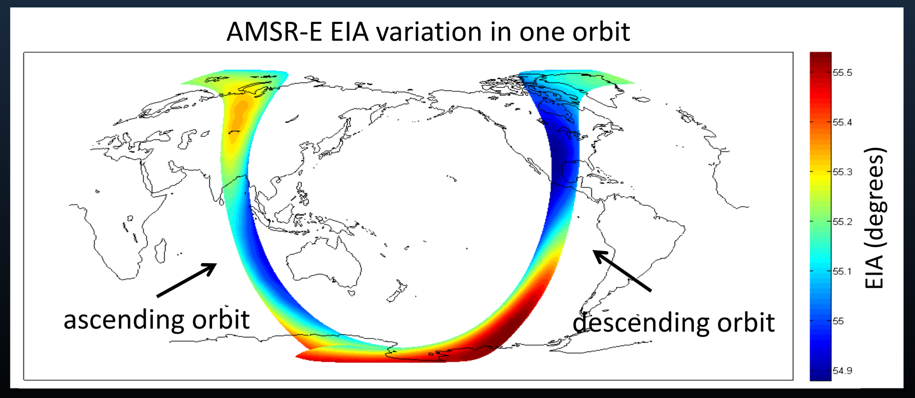
Single difference able to minimize geophysical variability



Single difference reduces EIA variation

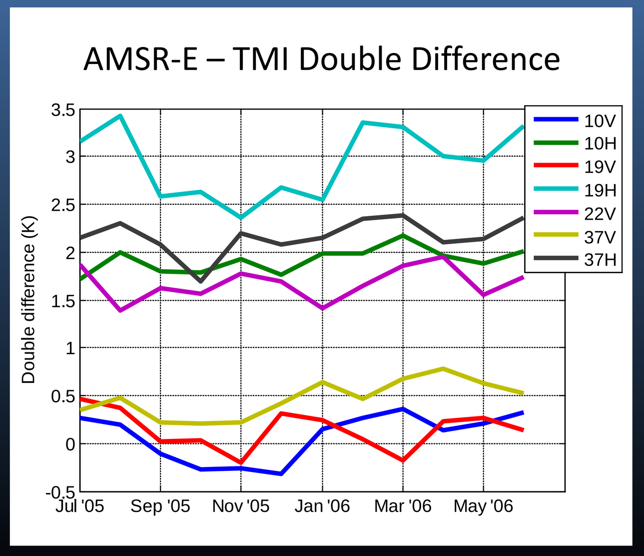


EIA variation across the scan affects the observed cold cal TB. It is modeled in the simulations and the impact is minimized.

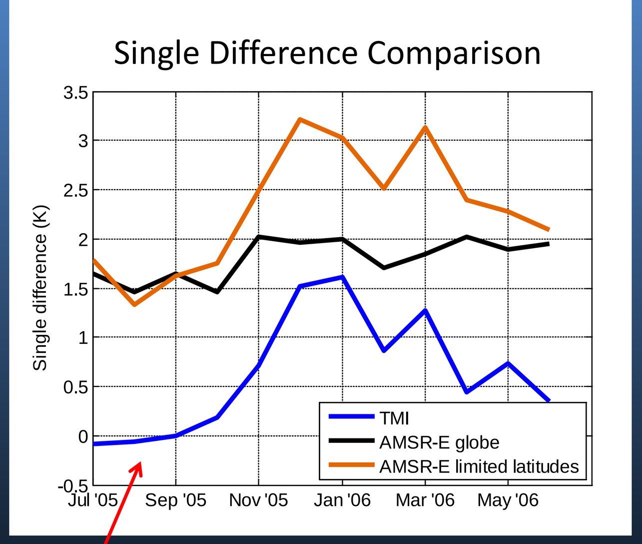


Double Difference

The double difference is used to calculate the calibration difference between two radiometers from the single differences.

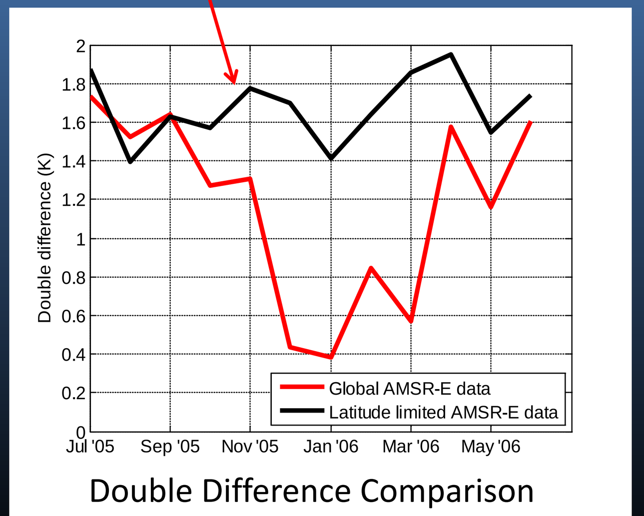


The quality of the double difference is improved when the AMSR-E data are filtered to match the same latitudes as observed by TMI as shown to the right.



Seasonal cycle in TMI single difference

Double difference with AMSR-E limited latitudes minimizes seasonal cycle



Double Difference Comparison

Key Findings

- Simulations minimize geophysical variability in the cold cal TB through the single difference
- Simulations also account for EIA variation in the cold cal TB
- Latitudes of radiometers being inter-calibrated have to be limited to the same range to improve the double difference

References

[1] Ruf, C.S. "Detection of calibration drifts in spaceborne microwave radiometers using a vicarious cold reference," *IEEE Trans. Geosci. Remote Sens*., 38(1), 44-52, 2000.
[2] Brown, S., and C. Ruf, "Determination of a Hot Blackbody Reference Target over the Amazon Rainforest for the On-orbit Calibration of Microwave Radiometers," *AMS J. Oceanic Atmos. Tech.*, 22(9), 1340-1352, 2005.
[3] McKague, D., C. Ruf and J. Puckett, "Vicarious Calibration of Global Precipitation Measurement Microwave Radiometers," Proc. 2008 IEEE International Geoscience and Remote Sensing Symposium, Boston, MA, Vol. IV, 459-462, 7-11 July 2008.
[4] U.S. National Centers for Environmental Prediction, updated daily: NCEP FNL Operational Model Global Tropospheric Analyses, continuing from July 1999. *Dataset ds083.2 published by the CISL Data Support Section at the National Center for Atmospheric Research, Boulder, CO, available online at* http://dss.ucar.edu/datasets/ds083.2/.
*Pictures courtesy of NASA