STATUS OF THE UNIVERSITY OF MICHIGAN CONTRIBUTIONS TO PMM RADIOMETER INTER-CALIBRATION

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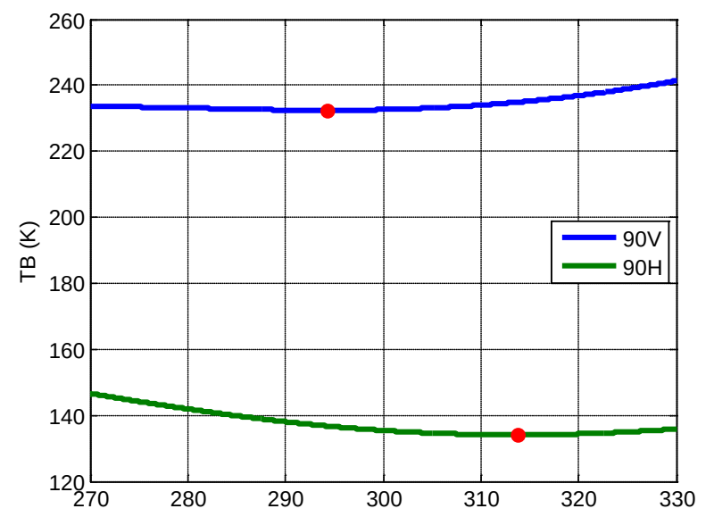
Vicarious Cold Extension to 85-92 GHz

High frequency raises concerns that were not present at the lower frequencies [4]. These include increased sensitivity to water vapor, unphysical sea surface temperature (SST) where the H-pol cold cal TB occurs, and cloud top ice scattering causing colder TBs than what are observed from the surface.

TB vs. SST for 90 GHz V- and H-pol at 55° EIA with calm surface winds and no atmospheric water vapor.



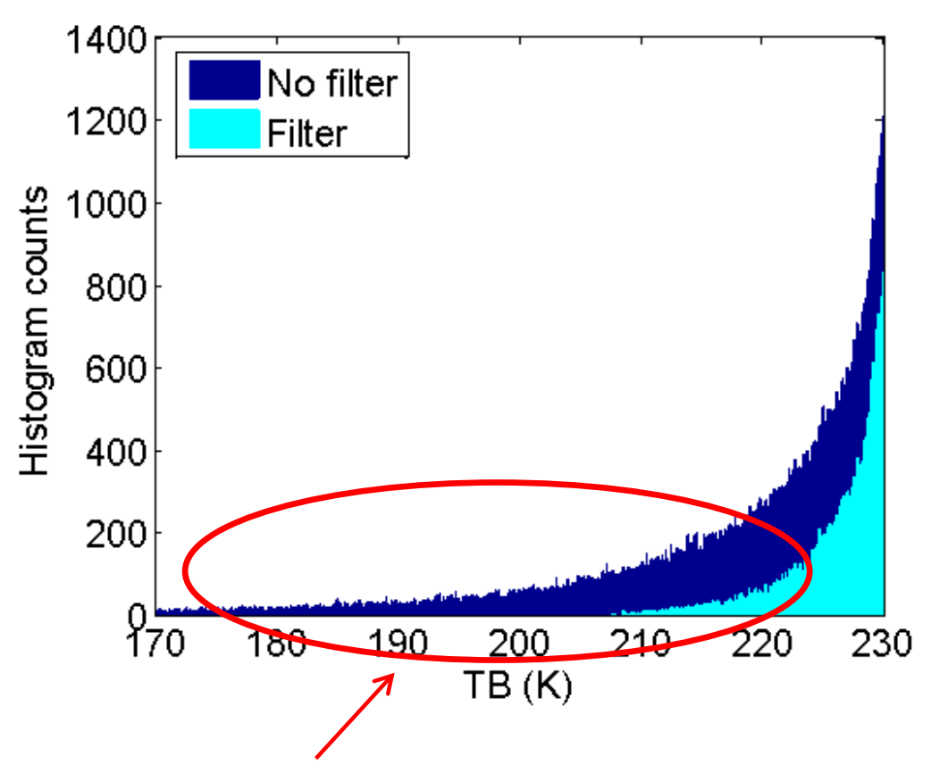
90 GHz V-pol coldest TBs occur at SST = 295 K. 90 GHz H-pol coldest TBs occur at SST=314 K.

Precipitation flag derived from combinations of low/high frequencies used to remove cold TBs due to hydrometeor scattering.

$$TB_{37V} - TB_{37H} > 50K \qquad TB_{89V} > TB_{22V}$$
$$TB_{89V} > TB_{19V} + 10K \qquad TB_{89V} > TB_{37V}$$
$$TB_{89H} > TB_{19H} + 30K \qquad TB_{89H} > TB_{37H} + 10K$$

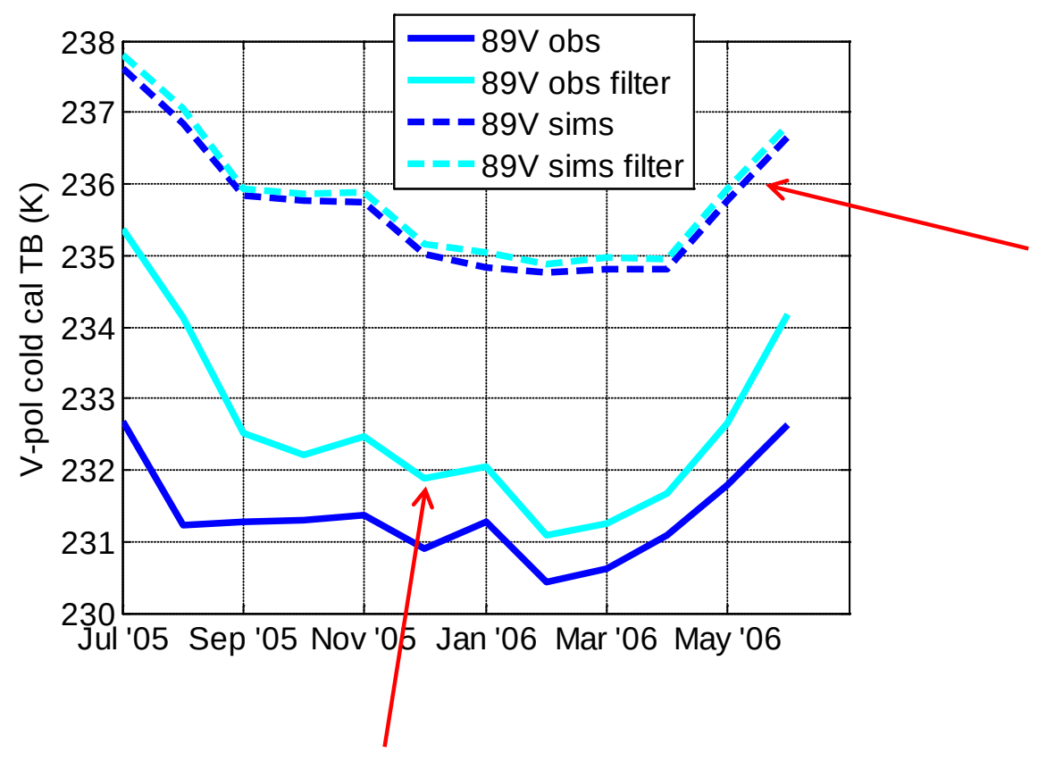
If these are not true, data is flagged

Filtered high freq TB data using combinations of the low freqs/pols



TBs due to hydrometeor scattering removed with filter

Observed and simulated cold cal TB for 89V showing the effect of the filter.



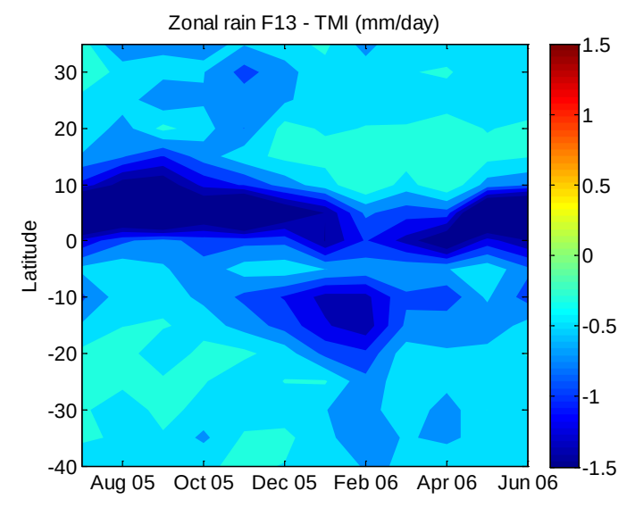
Filtered obs cold cal TB warmer than unfiltered obs cold cal TB.

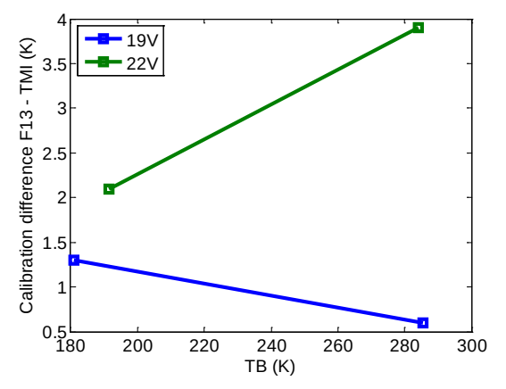
Filtered sims cold cal TB very similar to unfiltered. This means that the precipitation flag is removing warm TBs (simulations do not include scattering).

Effect on Derived Products

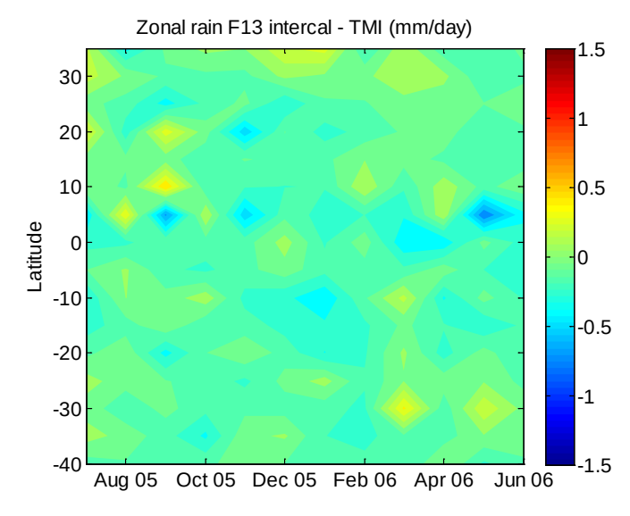
We want to know how inter-calibration affects the derived rain products for GPM. We have started by looking at the Level 3 algorithm used to derive the TRMM 3A11 product [5]. A comparison between SSM/I derived rain and TMI derived rain is shown with and without inter-calibration applied.

Zonal rain without inter-cal

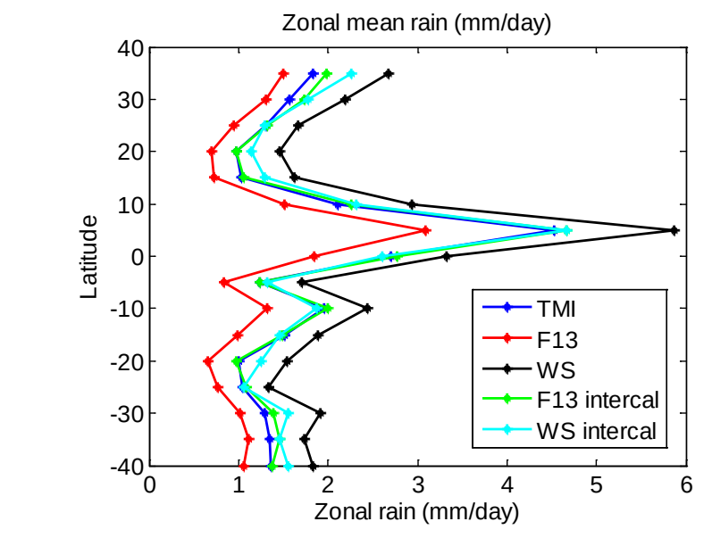


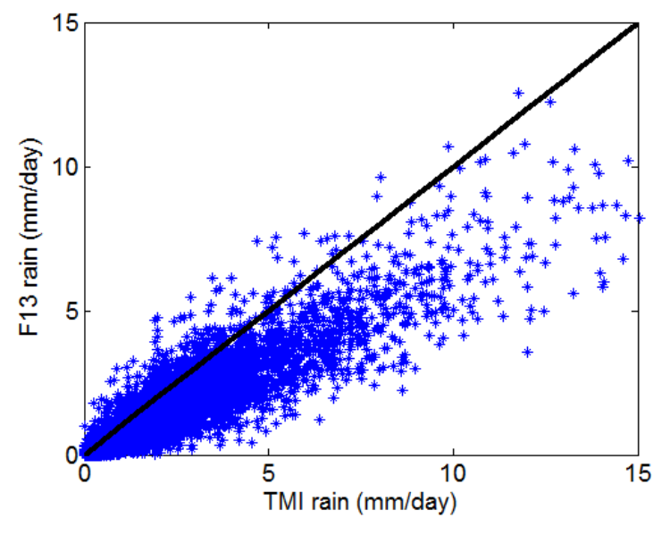


Zonal rain with inter-cal



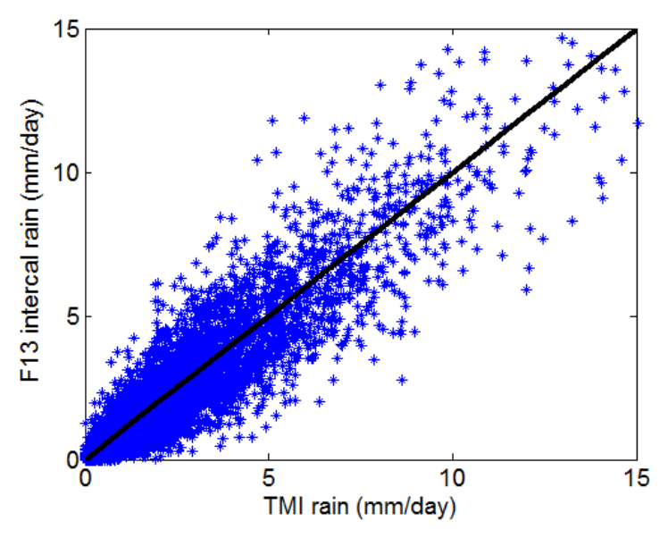
Zonal mean rain TMI, SSM/I, and WindSat





Inter-cal applied to F13 TBs to shift to TMI TBs

Inter-calibration greatly improves the derived rain consistency



We will expand this analysis in the future to the Level 2 GPROF derived rain product.

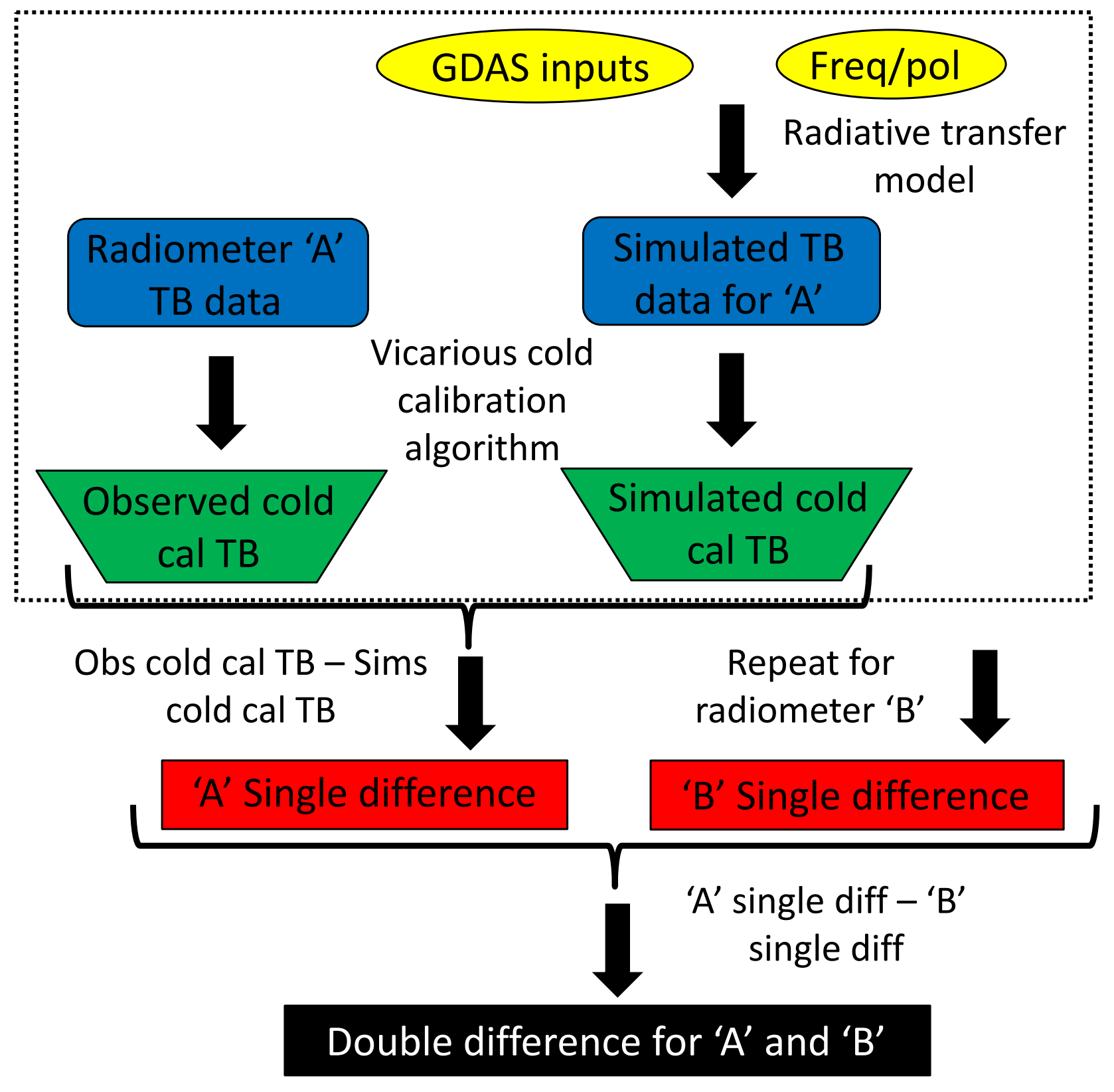
References

[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. T. and C. S. 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] Kroodsma, R. A., D. S. McKague, and C. S. Ruf, "Inter-calibration of microwave radiometers using the vicarious cold calibration double difference method," *J. Selected Topics Remote Sens.*, 5(3), 1006-1013, 2012.
[4] Kroodsma, R. A., D. S. McKague, and C. S. Ruf, "Extension of vicarious cold calibration to 85-92 GHz for spaceborne microwave radiometers," *IEEE Trans. Geosci. Remote Sens.*, accepted.
[5] Wilheit, T. T., A. T. C. Chang, and L. S. Chiu, "Retrieval of monthly rainfall indices from microwave radiometric measurements using probability distribution functions," *J. Atmos. Oceanic Technol.*, 8(1), 118-136, 1991.

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 taken into account. The University of Michigan as part of the X-Cal team is using a vicarious calibration technique for inter-calibration that uses both cold [1] and warm [2] reference points. Recent contributions to the inter-calibration algorithm by the University of Michigan are presented here.

Flow chart shows the method of inter-calibration at the cold end using vicarious cold calibration [3].



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

Summary

- Vicarious cold calibration has been extended to the 85-92 GHz range
- SSMIS and AMSR2 instruments added to the GPM constellation
  - Similar results to the rest of the X-Cal team
- Inter-calibrating radiometers shown to significantly improve consistency in Level 3 derived rain
  - Will expand to Level 2
- Differences in simulations shown to affect inter-calibration
  - Further analysis to be done

SSMIS and AMSR2

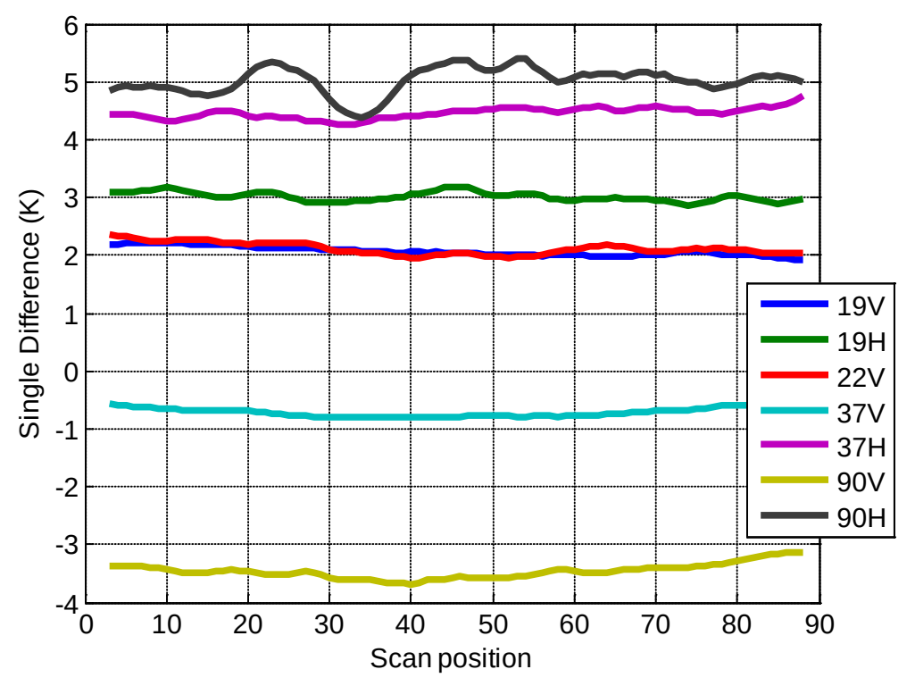
The two most recent radiometers added to the GPM constellation are the Special Sensor Microwave Imager/Sounder (SSMIS) (F16, F17, F18) and the Advanced Microwave Scanning Radiometer 2 (AMSR2).

We have analyzed data from Jan 2011 – Dec 2011 for SSMIS and Sep 2012 – Jan 2013 for AMSR2.

	Frequency (GHz)				
AMSR2	10.65V 10.65H	18.7V 18.7H	23.8V 23.8H	36.5V 36.5H	89.0V A/B 89.0H A/B
SSMIS		19.35V 19.35H	22.235V	37.0V 37.0H	91.655V 91.655H

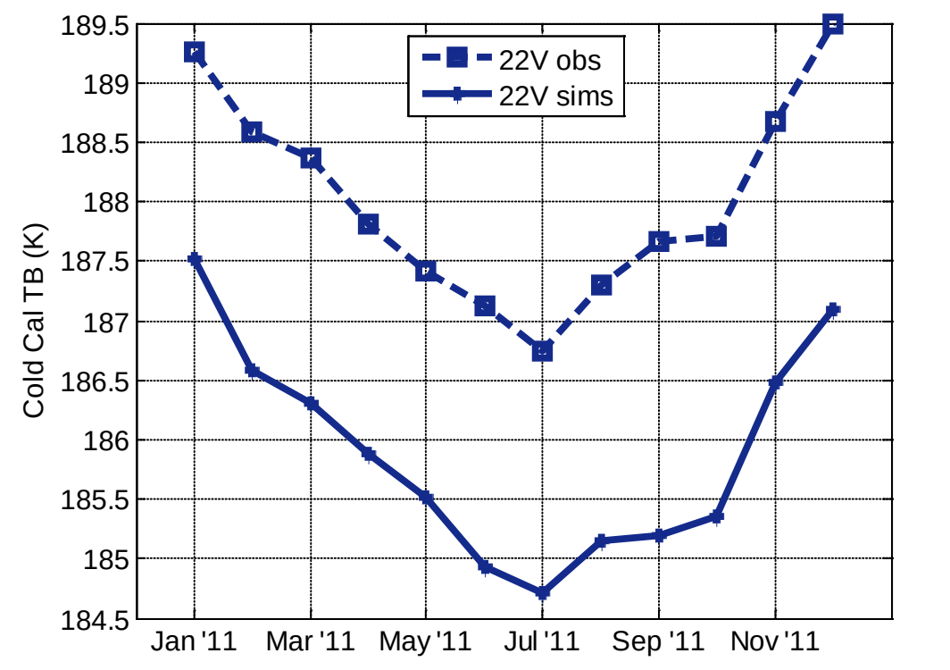
SSMIS F17 scan position and seasonal cold cal TB analysis. Sims are able to model EIA variation across scan, producing a single difference that is relatively flat across the scan. Sims are also able to model seasonal cycle in the obs cold cal TB.

F17 scan dependent single difference



Relatively flat single difference across scan.

F17 22V monthly obs and sims cold cal TB



Sims cold cal TB follows obs cold cal TB. Single difference does not include seasonal variability.

Cold End Double Differences ('Radiometer' – TMI)*

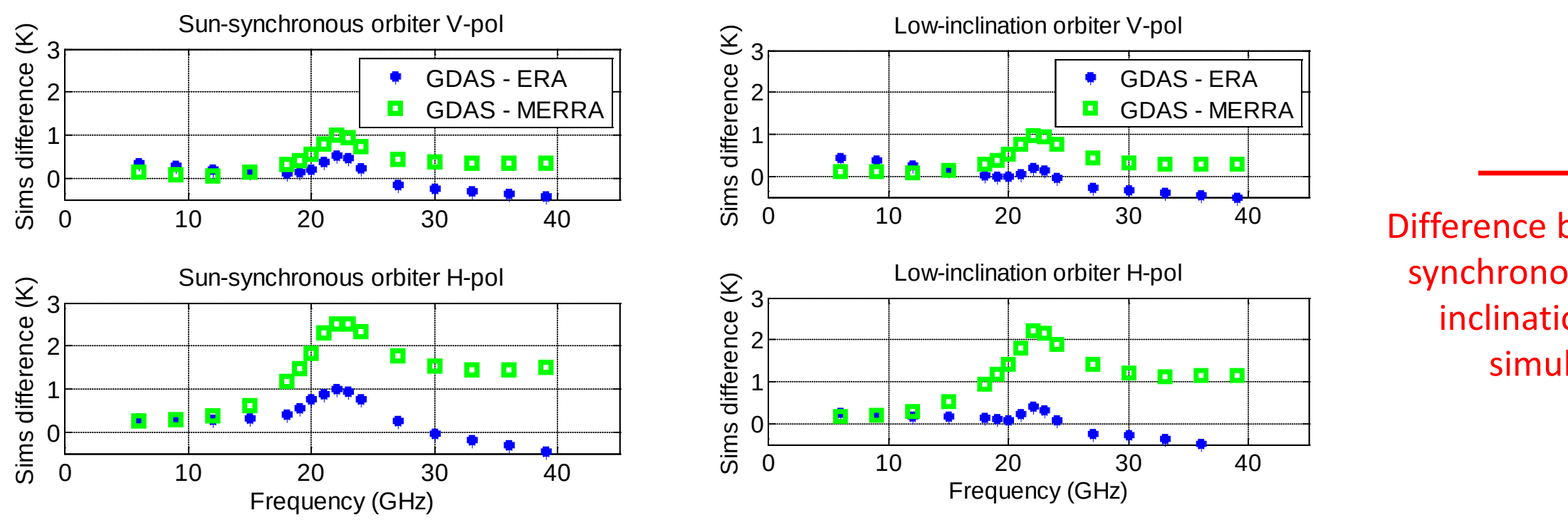
	10V	10H	19V	19H	22V	37V	37H	85V	85H	85V	85H
AMSR2	3.97	5.03	4.50	3.85	4.32	4.44	5.24	2.23	3.50	2.40	3.04
SSMIS F16			1.36	2.43	2.44	1.13	2.14	0.78	1.05		
SSMIS F17			1.41	2.45	2.53	1.30	2.18	0.08	1.02		
SSMIS F18			1.45	2.29	2.43	1.19	2.16	0.44	0.64		

*Our numbers show good agreement with the rest of the X-Cal team.

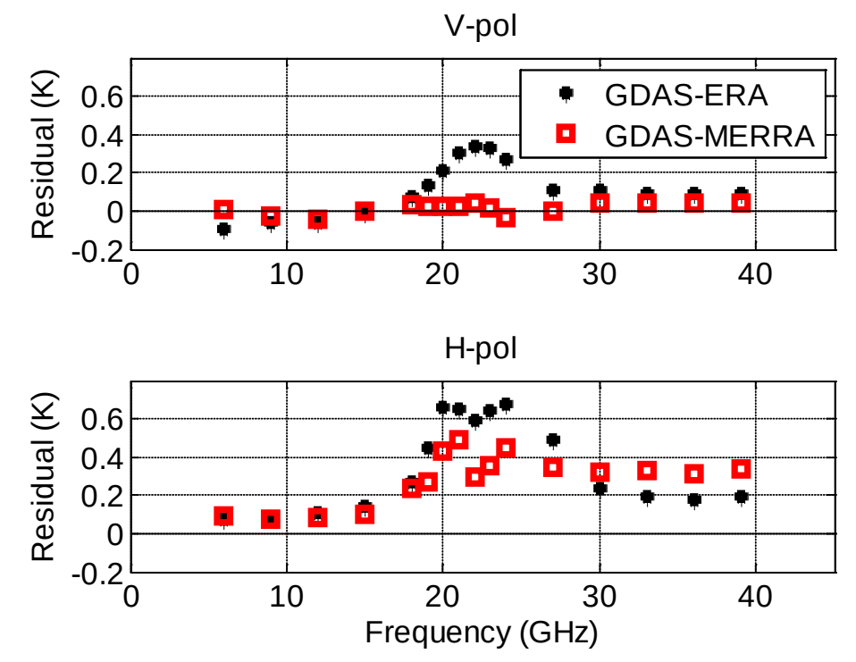
Inter-Calibration Error due to RTM Input Field

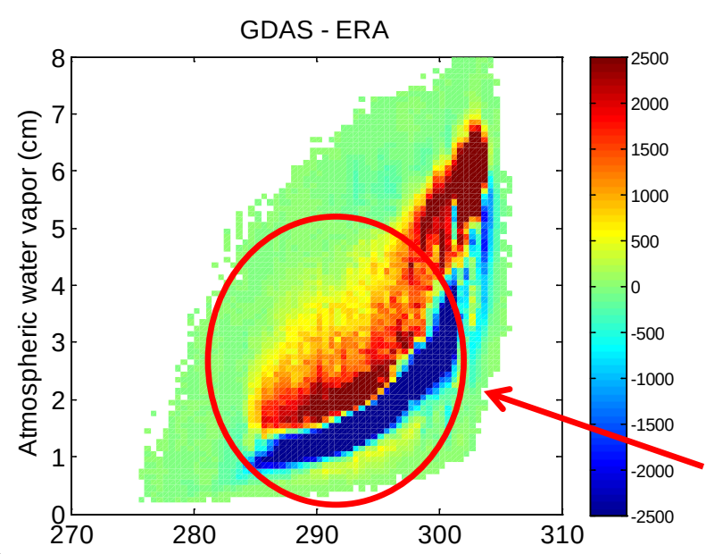
It is yet unknown to what extent errors in the simulation input fields (e.g. SST, water vapor profile) affect the double difference. Sensitivity to the input fields is expected to be removed through the double difference, however, recent analysis has shown that is not always the case.

Comparison of the cold cal TB derived from three simulation fields: GDAS, ERA, and MERRA. Simulations are run at a range of frequencies 6-40 GHz and a constant EIA of 53° for a hypothetical radiometer on a sun-synchronous orbiter and a non-sun-synchronous orbiter at 40° inclination.



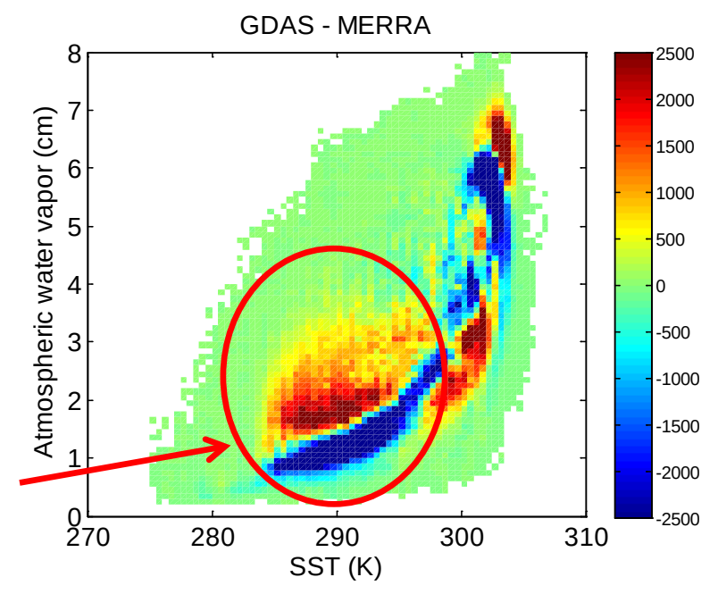
Difference between sun-synchronous and low-inclination orbiter simulations

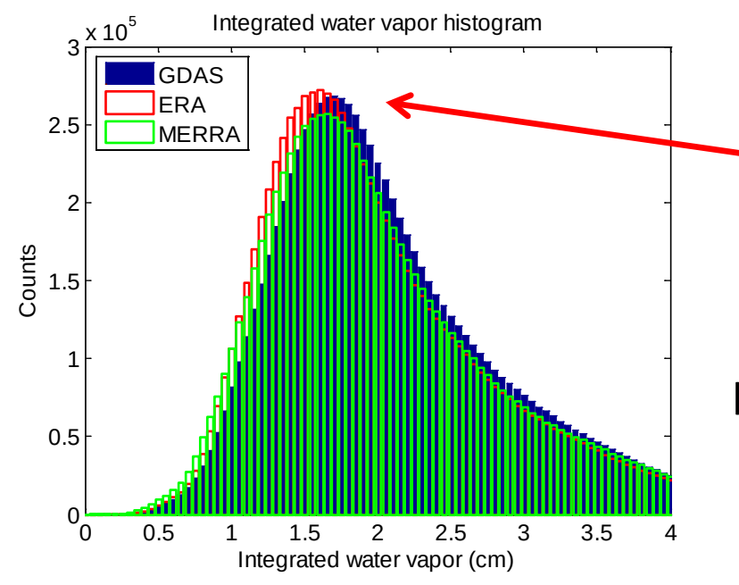




2D histogram plots of GDAS, ERA, and MERRA integrated water vapor and SST.

GDAS has more water vapor than ERA and MERRA at low SSTs





GDAS water vapor peaks higher than ERA

Water vapor histogram for SST range 280-295 K.