Inter-Satellite Microwave Radiometer Calibration for the GPM Constellation (X-CAL)

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Motivation

- GPM comprises a constellation of passive microwave radiometers
  - Satellites of opportunity (mostly polar sun-sync)
  - GPM observatory in non-sun-sync LEO
- Inter-calibration (X-CAL) is required in order to obtain self-consistent rainfall retrievals from all the radiometers in the constellation
  - Fundamental to this concept is the existence of the GPM Microwave Imager (GMI) in non-sun-synchronous orbit, which serves as a radiometric transfer standard for the other passive microwave sensors

CFRSL

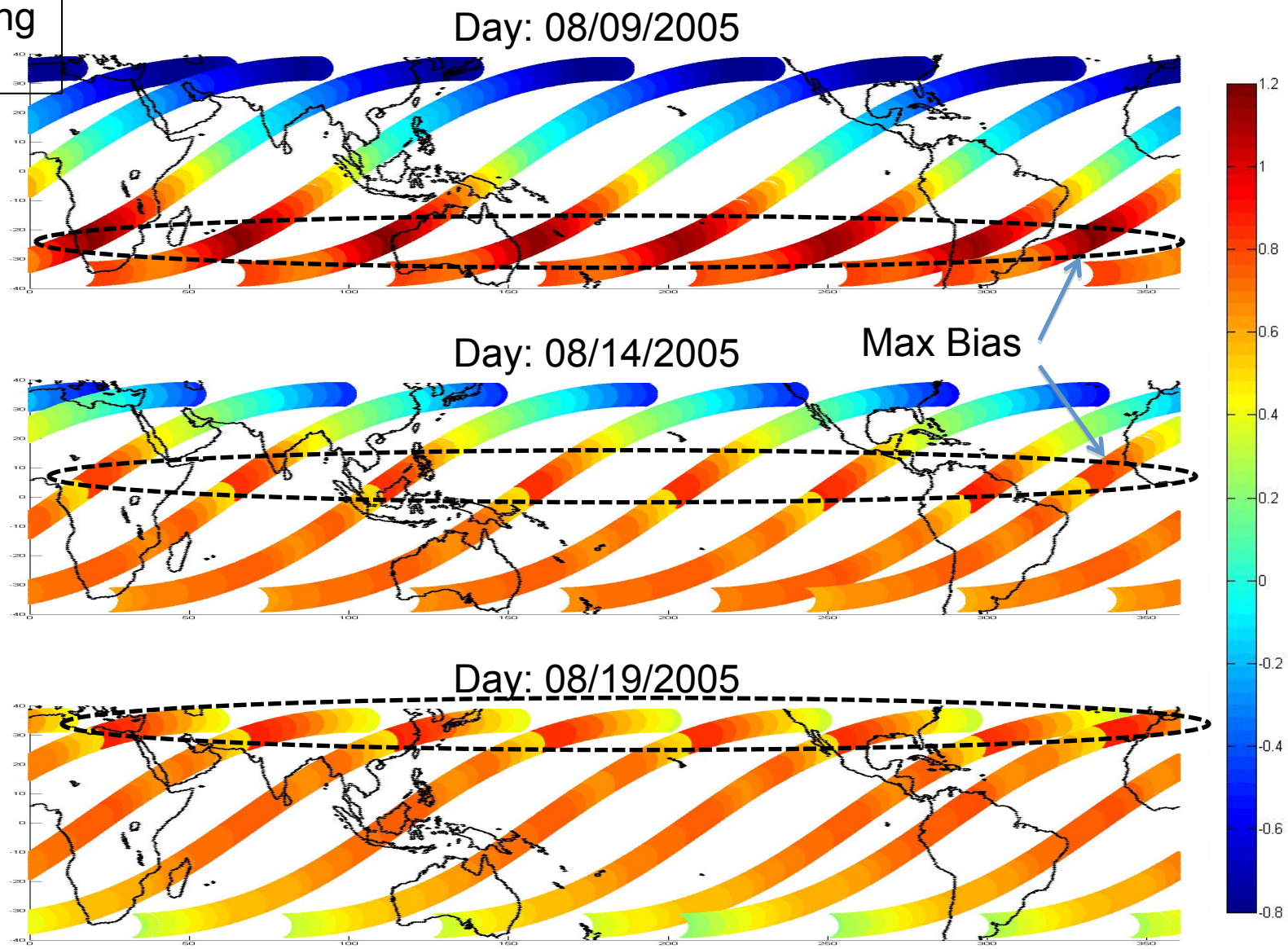
CFRSL X-CAL Research Objective

- To develop methodologies for the inter-calibration of brightness temperature (Tb) measurements from similar, but not identical, passive microwave radiometers on cooperative satellites within GPM constellation
  - Achieving rainfall measurement consistency is a multi-step process, wherein the first step is **to assure radiometric consistency among the various passive microwave sensors**
  - Our goal is to achieve relative brightness calibration consistency between constellation members (at ± 0.1 K level) relative to the GPM consensus calibration

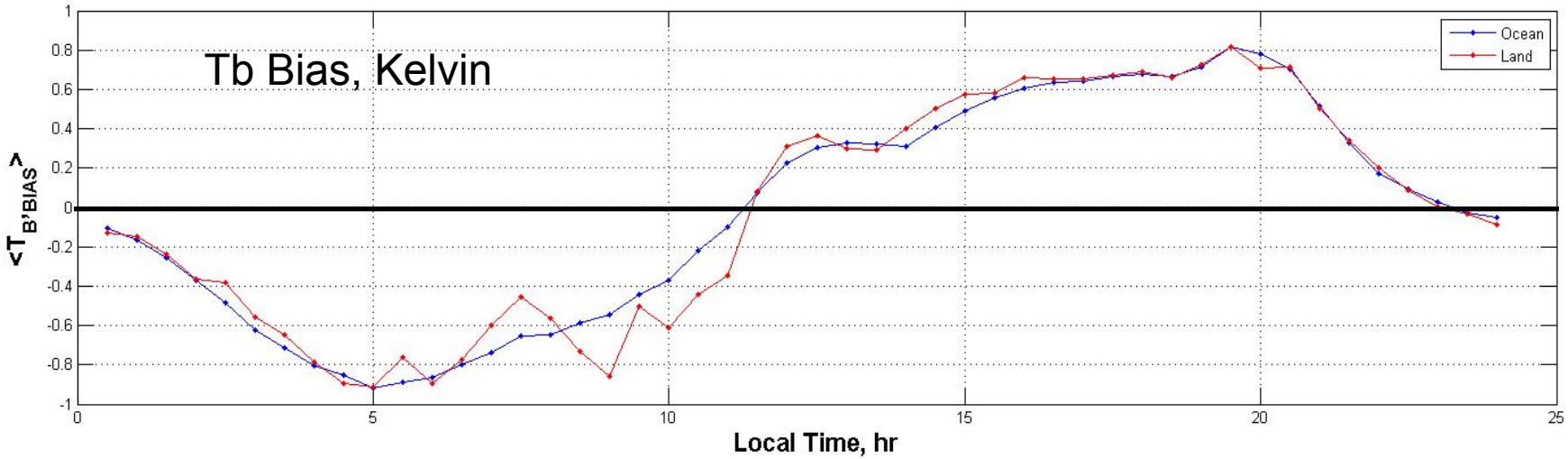
What are the consequences of NOT performing X-CAL?

Example: TMI Emissive Antenna resulted in a time-varying T_B Bias

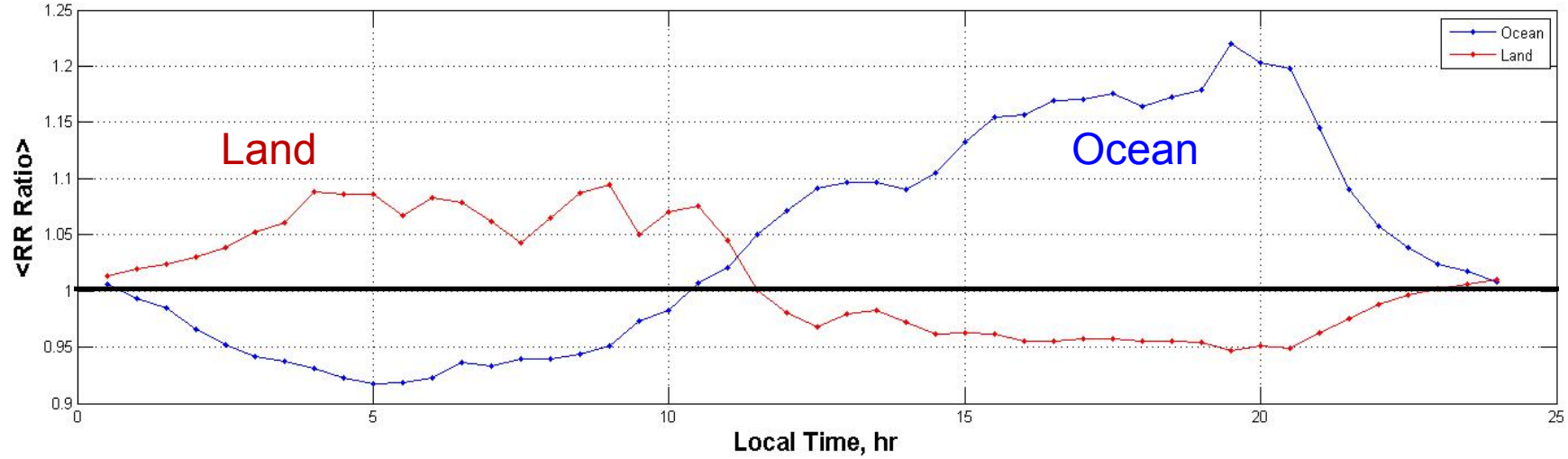
Ascending Pass



Produced Temporal/Spatial Rainfall Errors in Monthly Diurnal Rainfall Cycle for Ocean & Land



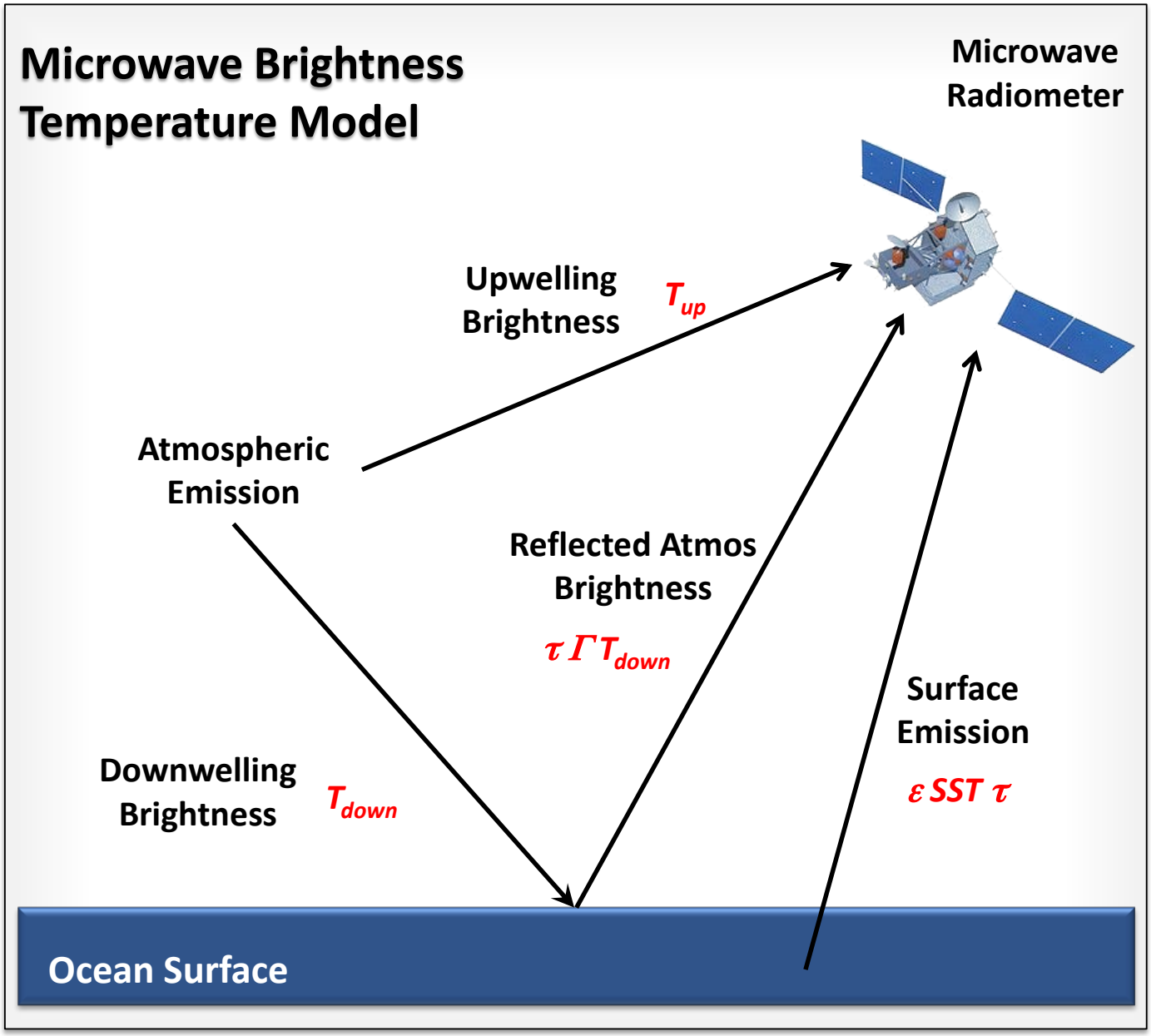
RR Ratio = (RR V6)/(RR V7)



How is X-CAL Performed?

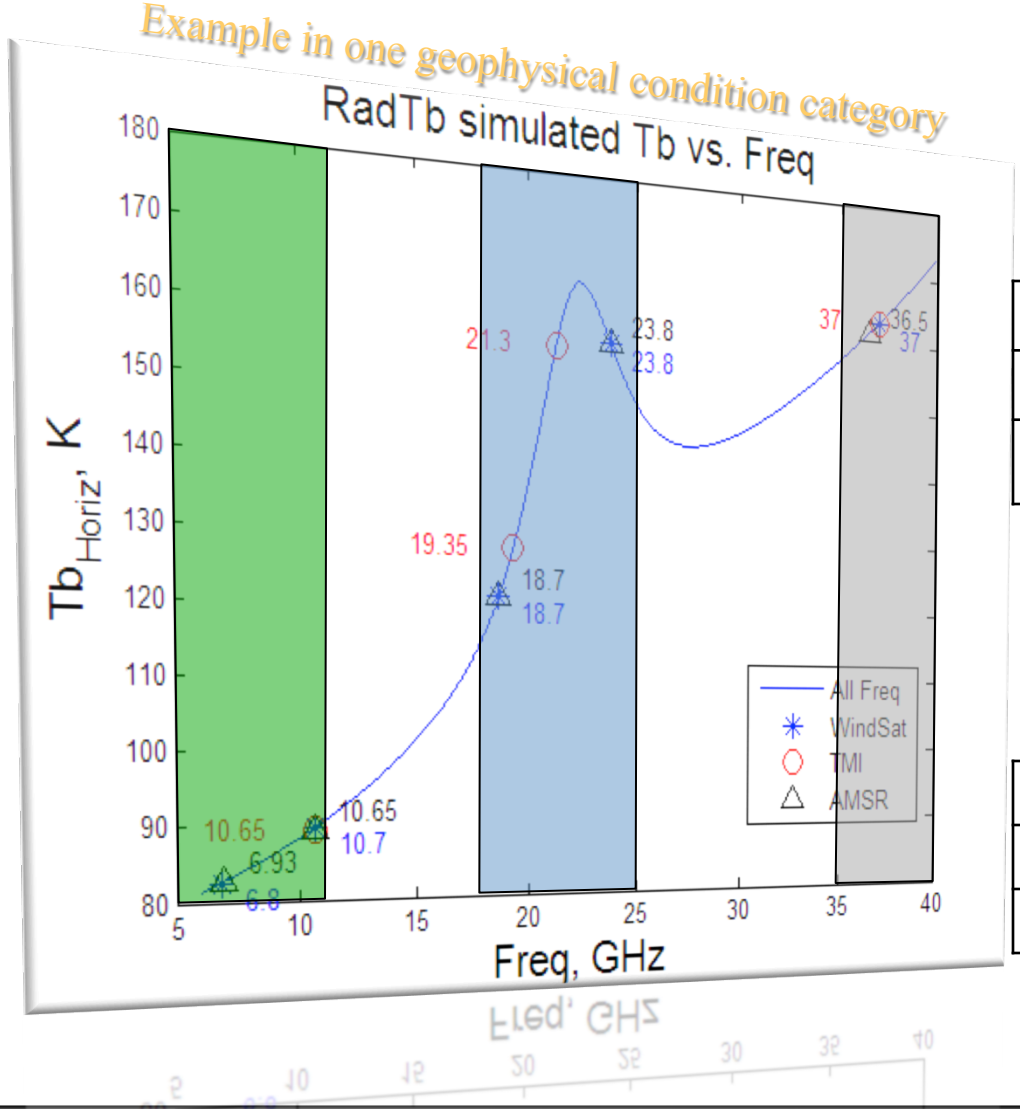
- In the simplest case, two radiometers simultaneously view a homogeneous clear-sky ocean scene and compare the observation difference ΔTb_{obs}
- However most radiometers are similar BUT NOT identical; therefore the observed brightness temperature differences are not necessarily calibration biases
- Thus, we use Radiative Transfer Tb Models (RTM) to calculate the theoretical expected ΔTb_{RTM}
- Finally, we calculate the double difference between the observed and expected ΔTb's, which we call the radiometric bias

Microwave Radiative Transfer Model



RTM T_b Spectrum

The ocean scene Tb varies with channel freq, incidence angle, and oceanic and atmospheric geophysical parameters



Calib. TMI with WindSat

* 37GHz is a common freq.

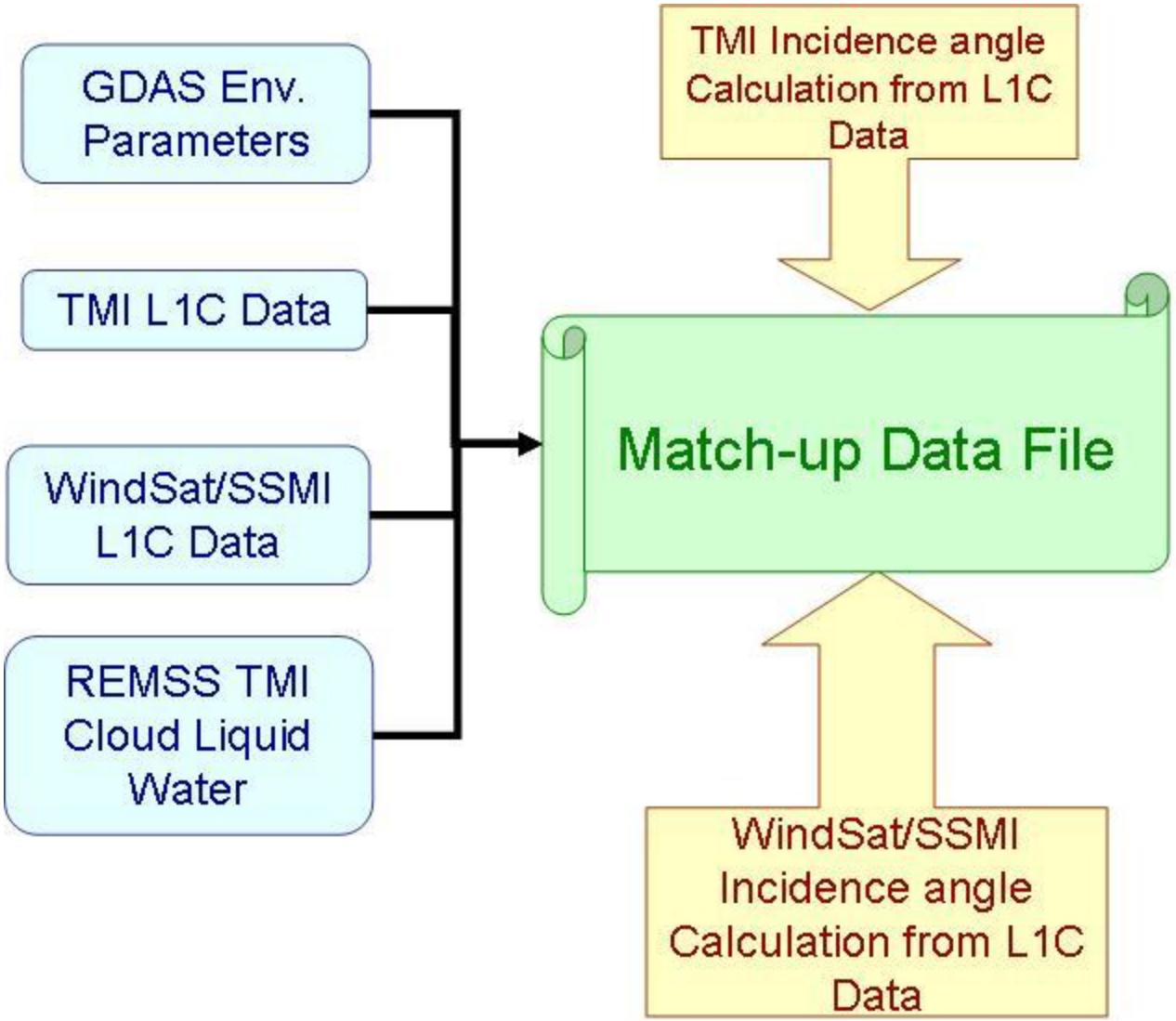
f_1:TMI (GHz)		10.65	19.35	21.3
H	f_0: WindSat (GHz)	10.7	18.7	N/A
V		10.7	18.7	18.7

Calib. AMSR with TMI

* 10.65GHz is a common freq.

f_1:AMSR (GHz)		6.925	18.7	23.8	36.5
H	f_0: TMI (GHz)	10.65	19.35	37	37
V		10.65	19.35	21.3	37

X-CAL Match-up Data Sets (1°Lat/Lng Boxes)



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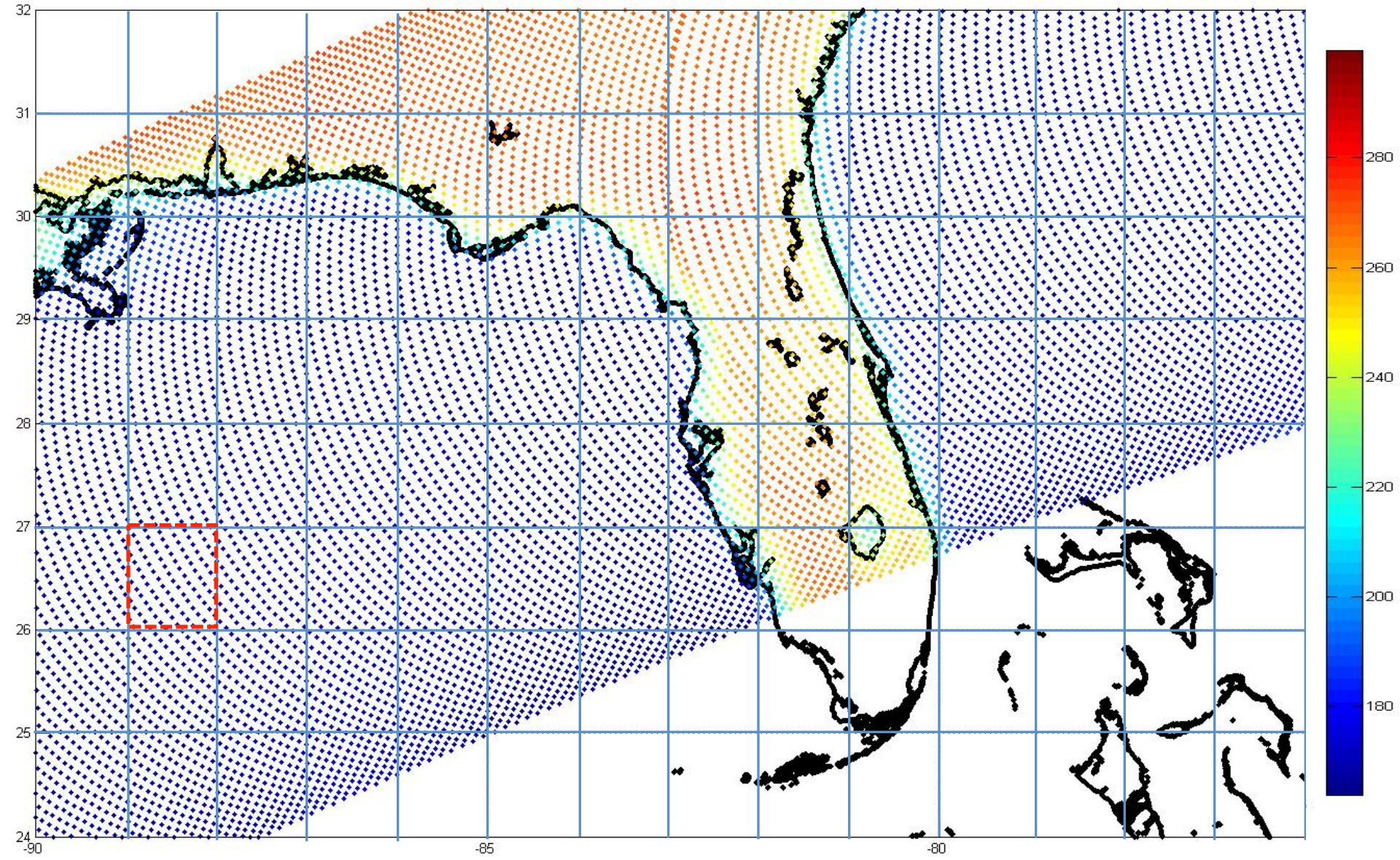
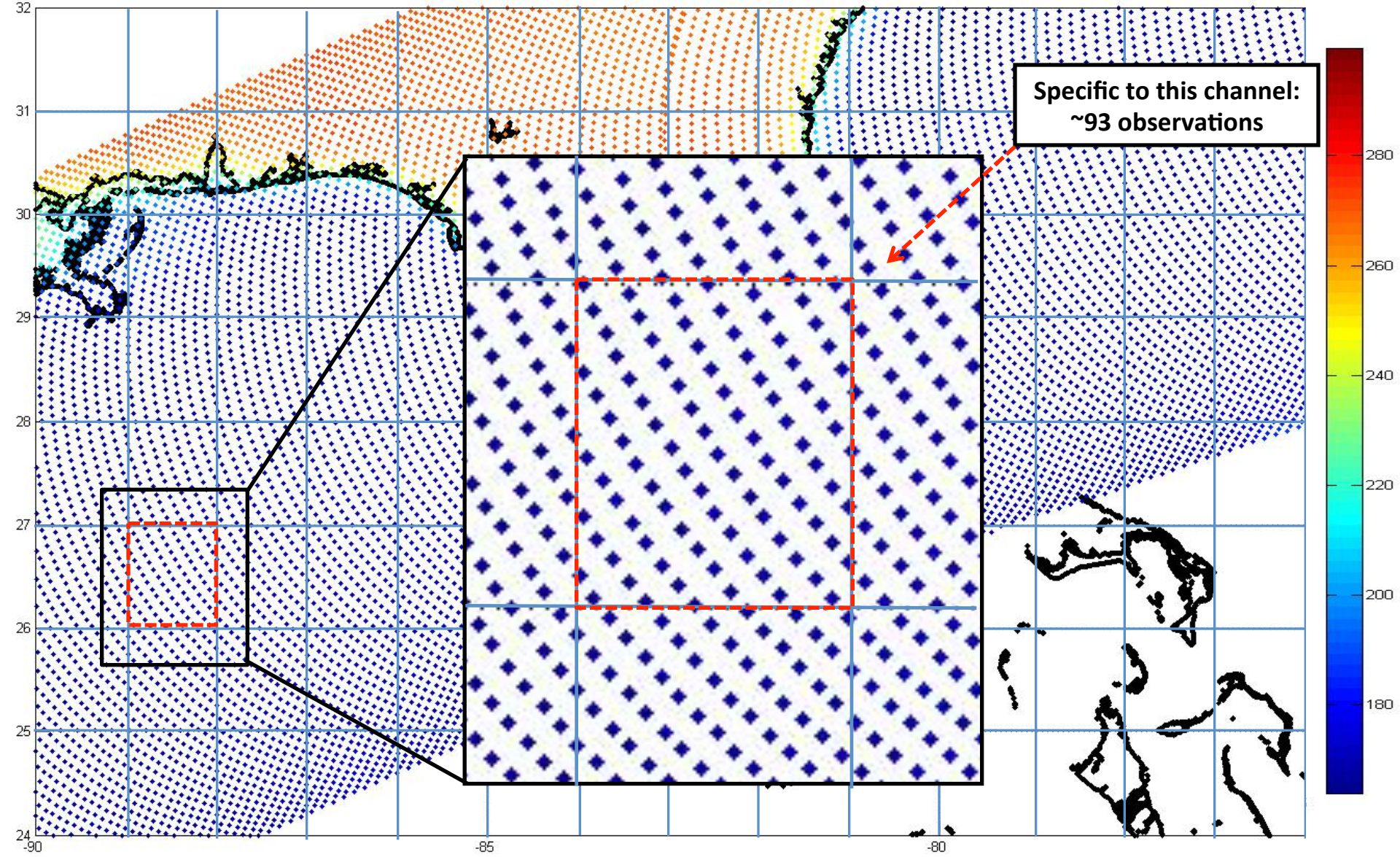
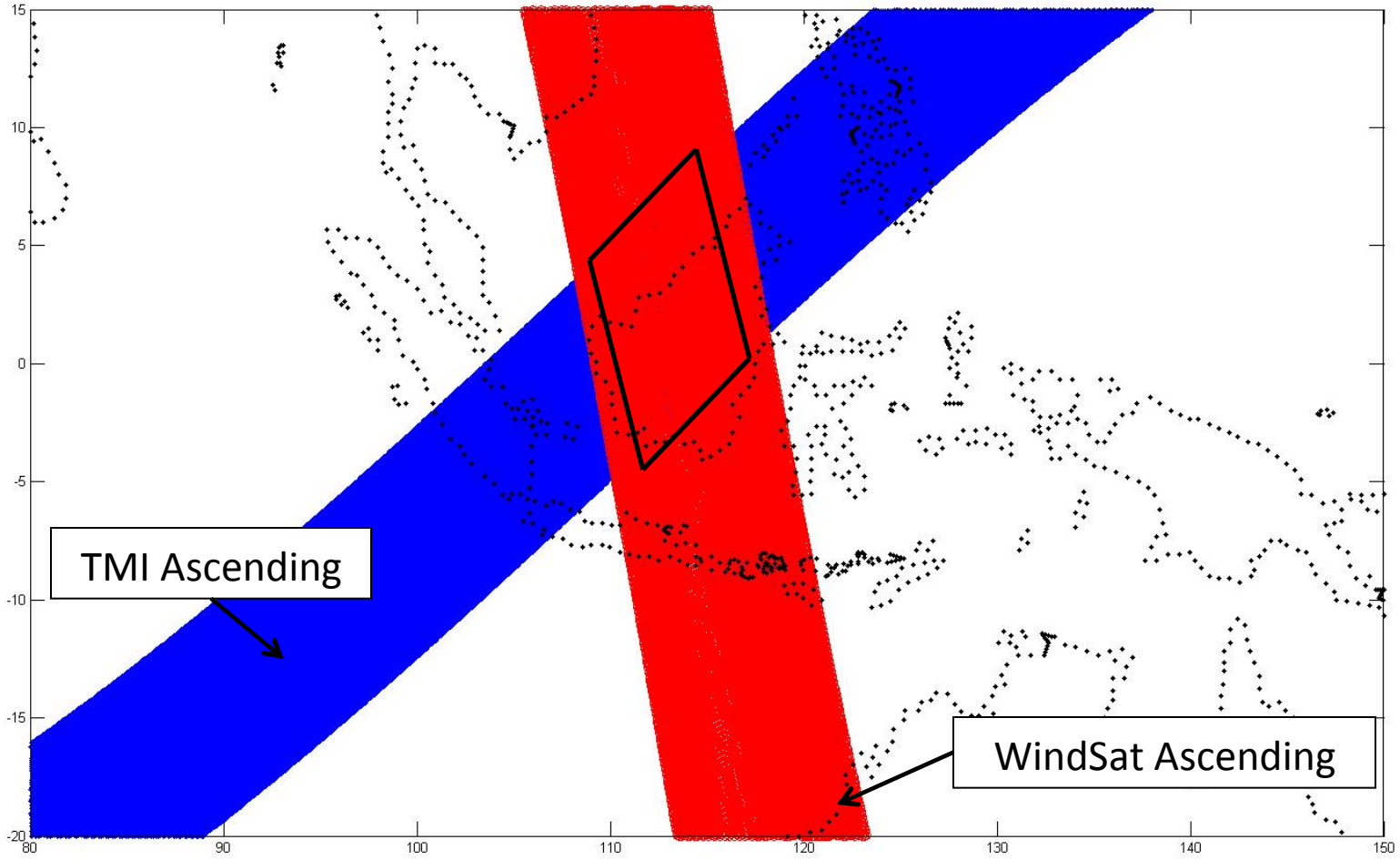
Example: TMI 10 GHz V-Pol Earth Gridding



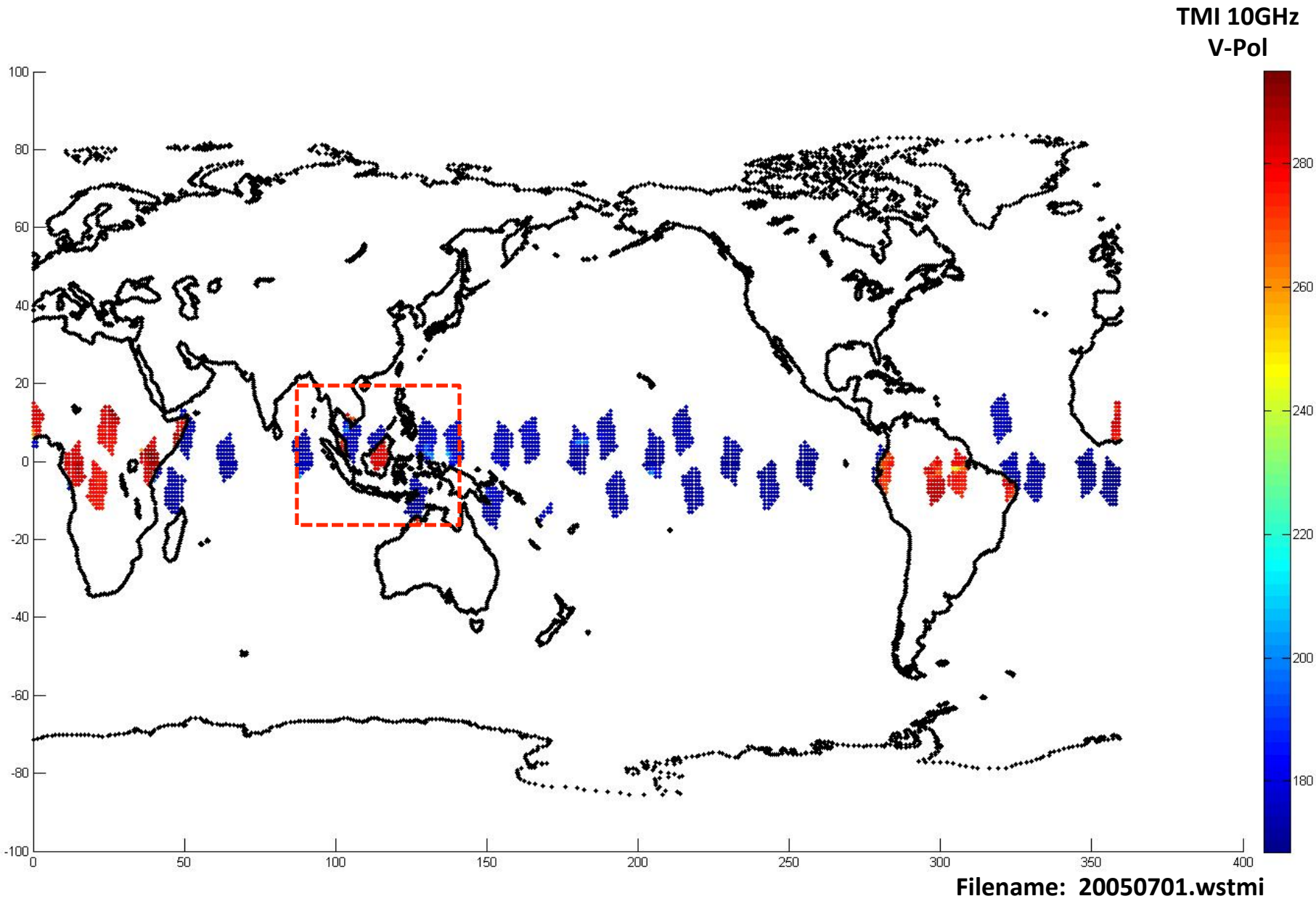
Average over 1 Degree Box



Orbit Swath Crossings between TMI and WindSat

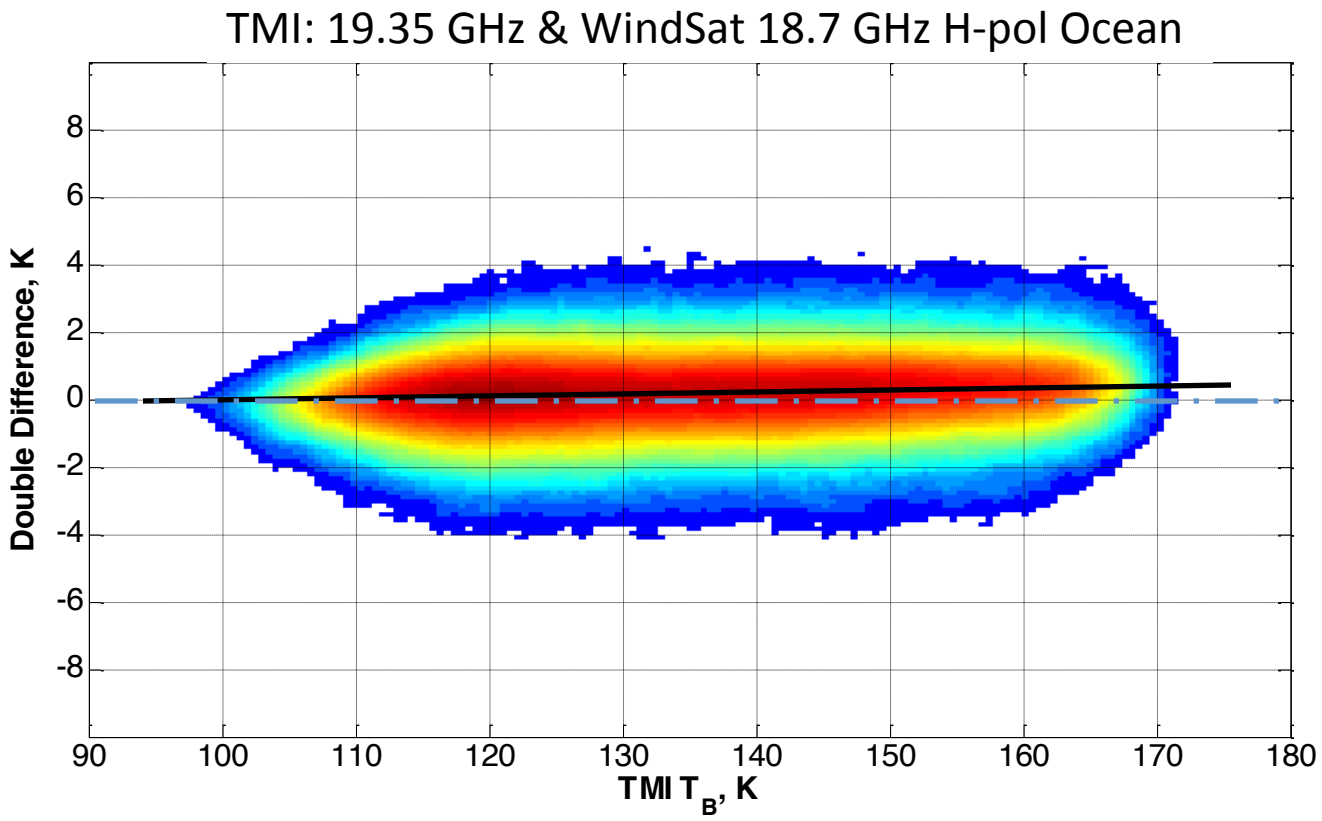


Collocation Between WindSat & TMI (1 Day) (± 1 Hour)



Example: Double Difference Tb Biases – Ocean
X-Cal year: July 2005 – June 2006

$$DD\_Bias = \Delta \mathrm{Tb}_{\mathrm{obs}} - \Delta \mathrm{Tb}_{RTM}$$



Summary

- The PMM X-CAL working group has been collaborating on Inter-satellite radiometric calibration since 2007
  - Our procedures are well established and are ready to support the GMI launch in 2014
  - New GPM constellation satellite X-CAL's are in progress For:
    - AMSR-2, SSMIS, and Megha Tropiques (MT)
    - For both SSMIS and MT, this includes both Imager and Sounder channels X-CAL