Intercalibration of high frequency radiometer channels

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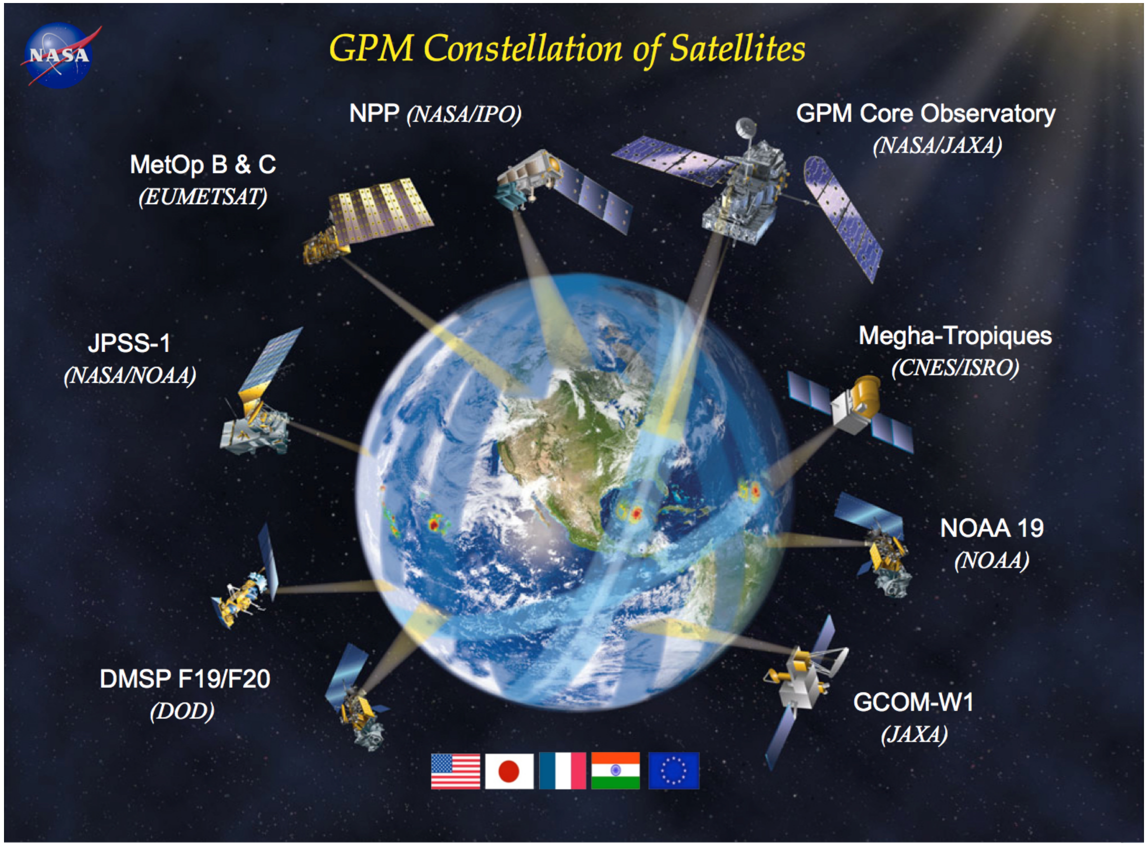
With thanks to the GPM XCAL team.

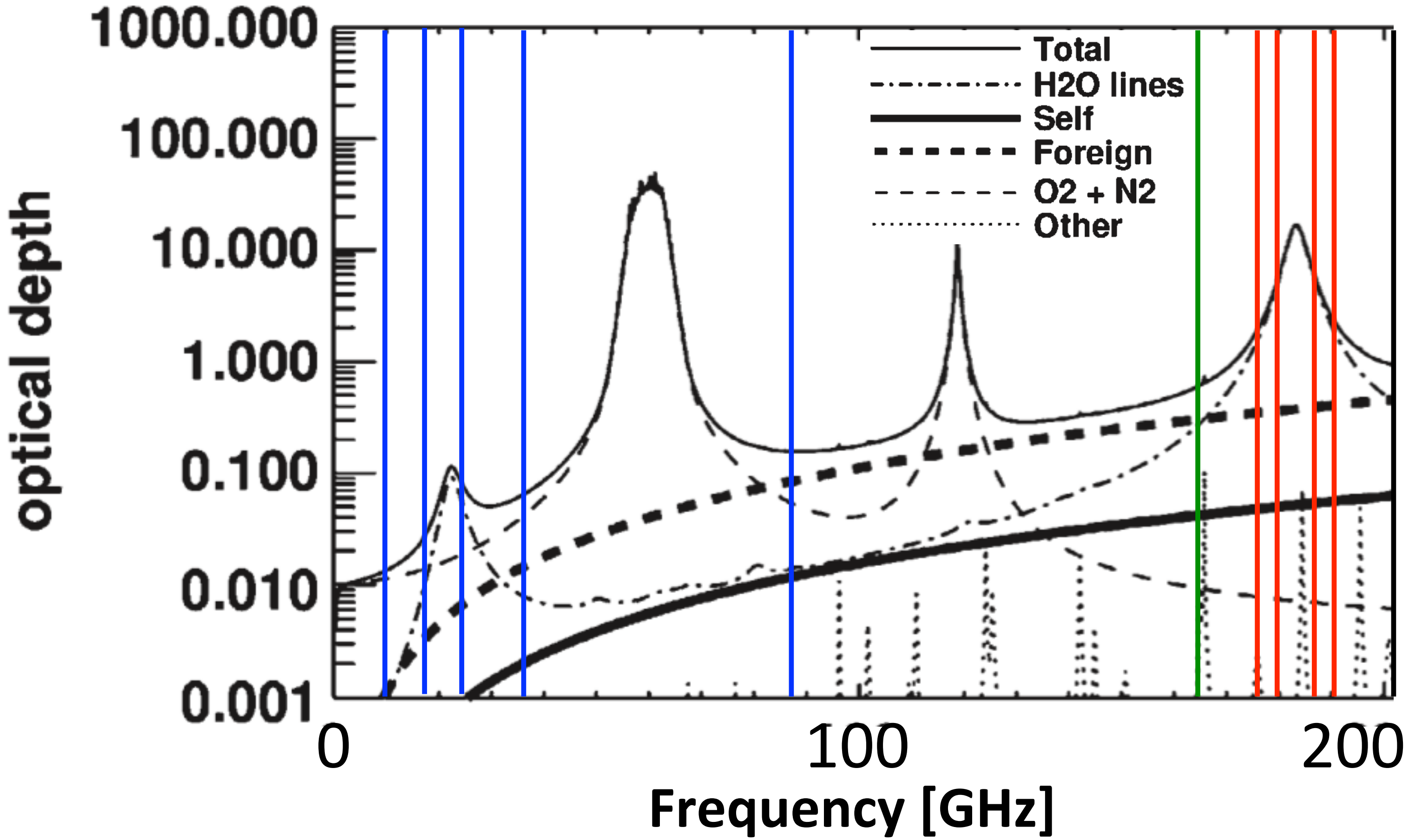
Motivation

- The Global Precipitation Measurement (GPM) mission will achieve global coverage with high sampling frequency by using a constellation of satellites.
- Radiometer inter-calibration is critical for obtaining accurate precipitation retrievals from satellite constellations.



http://pmm.nasa.gov/GPM/constellation-partners

GMI radiometer channels



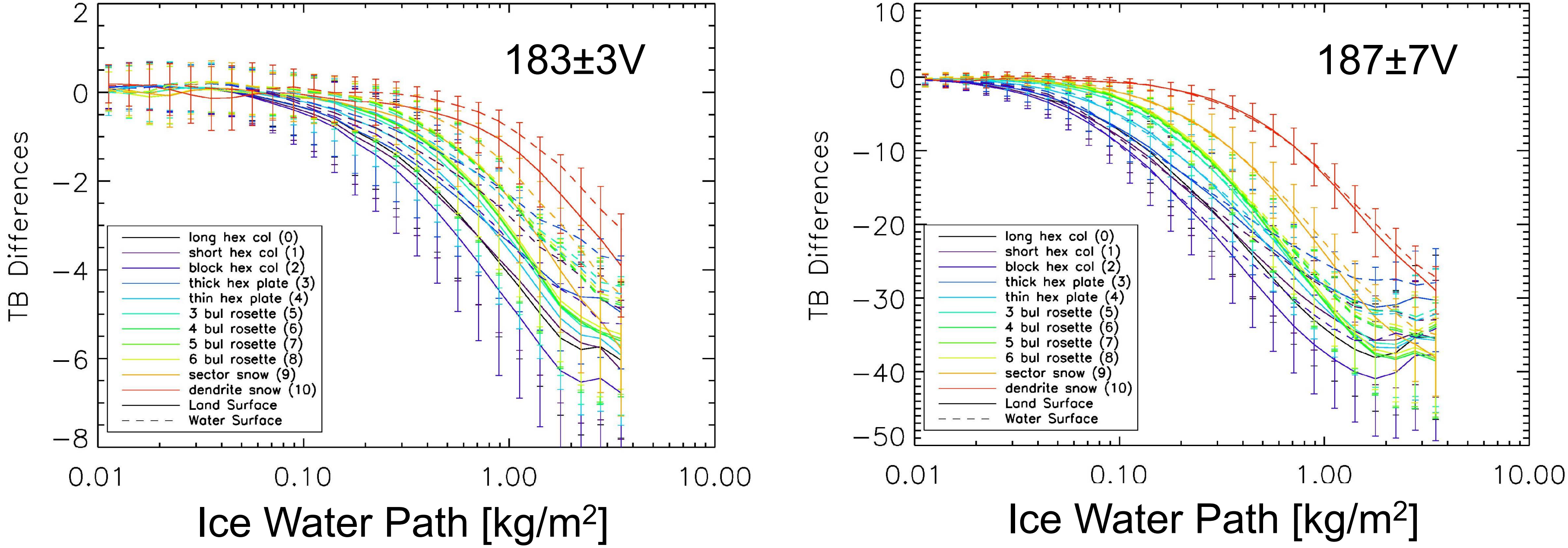
Clear-sky optical depths for a US standard atmosphere

183 GHz channels

Magnitude of signal

- GPM radiometer will have channels positioned around the 183 GHz H_2O line
  - Sensitive to frozen hydrometeors

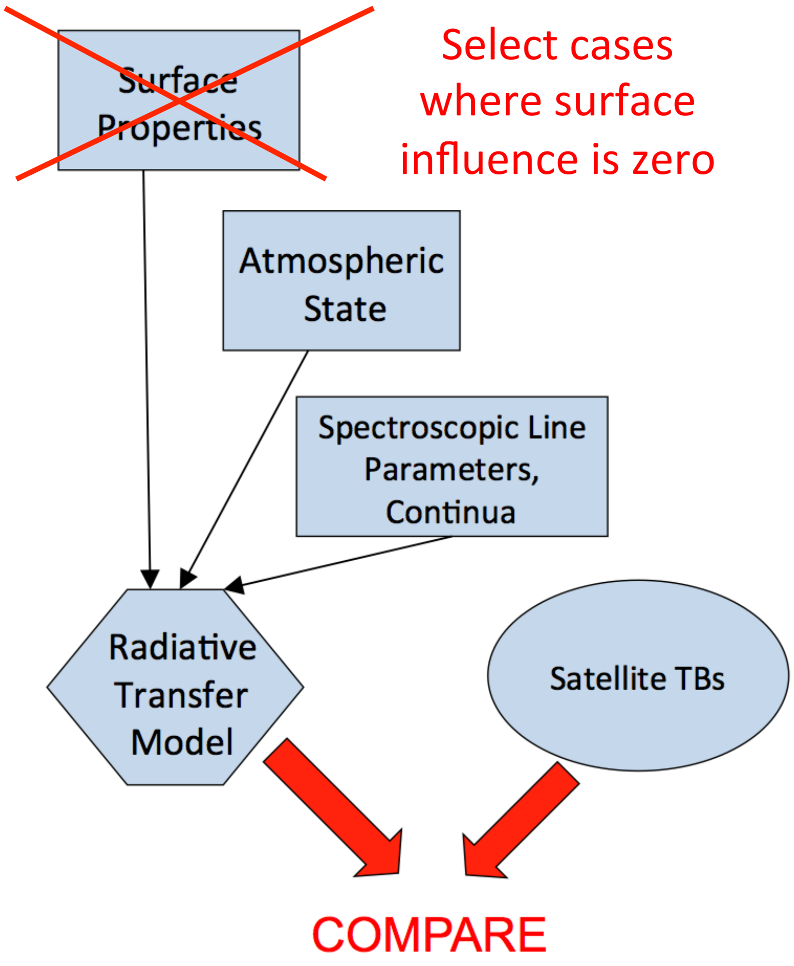
Simulations of (Tb with hydrometeors) minus (Tb for clear air)



- G. Skofronick-Jackson, Benjamin Johnson, and Joe Munchak, "Detection Thresholds of Falling Snow from Satellite-borne Active and Passive Sensors," Accepted by IEEE TGRS, October 2012

Approach: Double differences

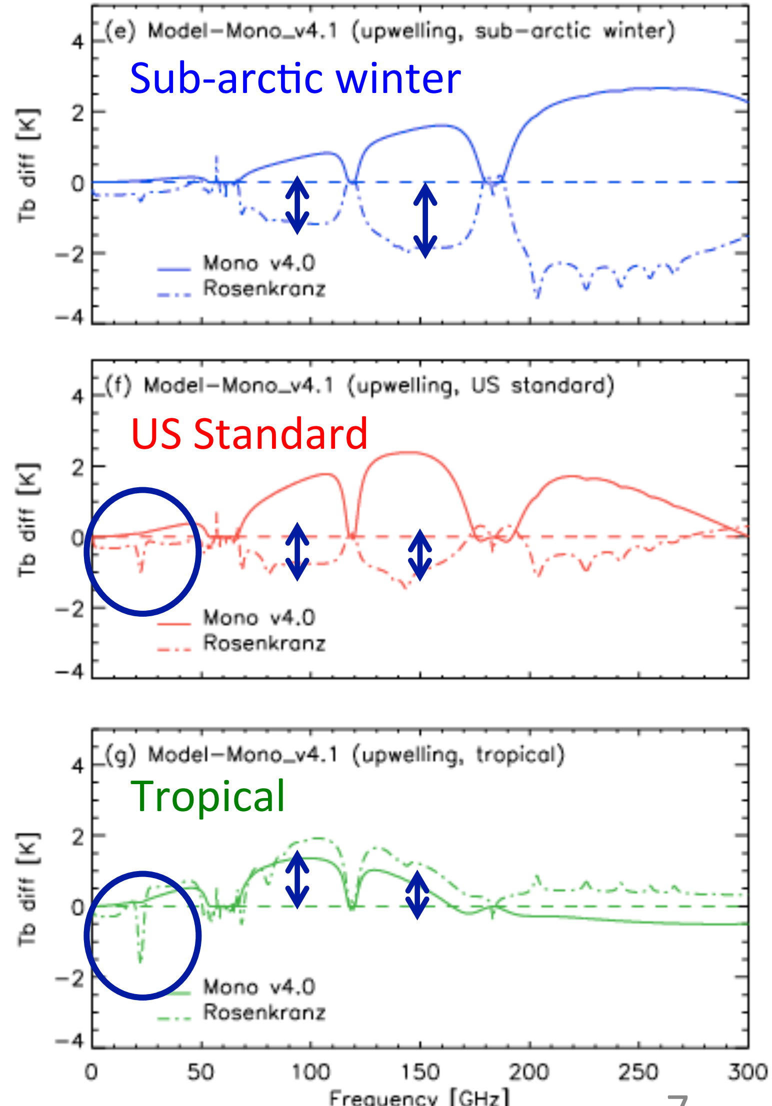
- GPM concept:
  - **Constellation members referenced to core satellite**
  - Goal for 183 GHz channels:
    - Inter-instrument differences < **~1 K**
- **Double differences**
  - D_A = Measurement$_A$ – Calculation$_A$
  - D_B = Measurement$_B$ – Calculation$_B$
  - **Double difference = $D_B - D_A$**



Radiative Transfer Model

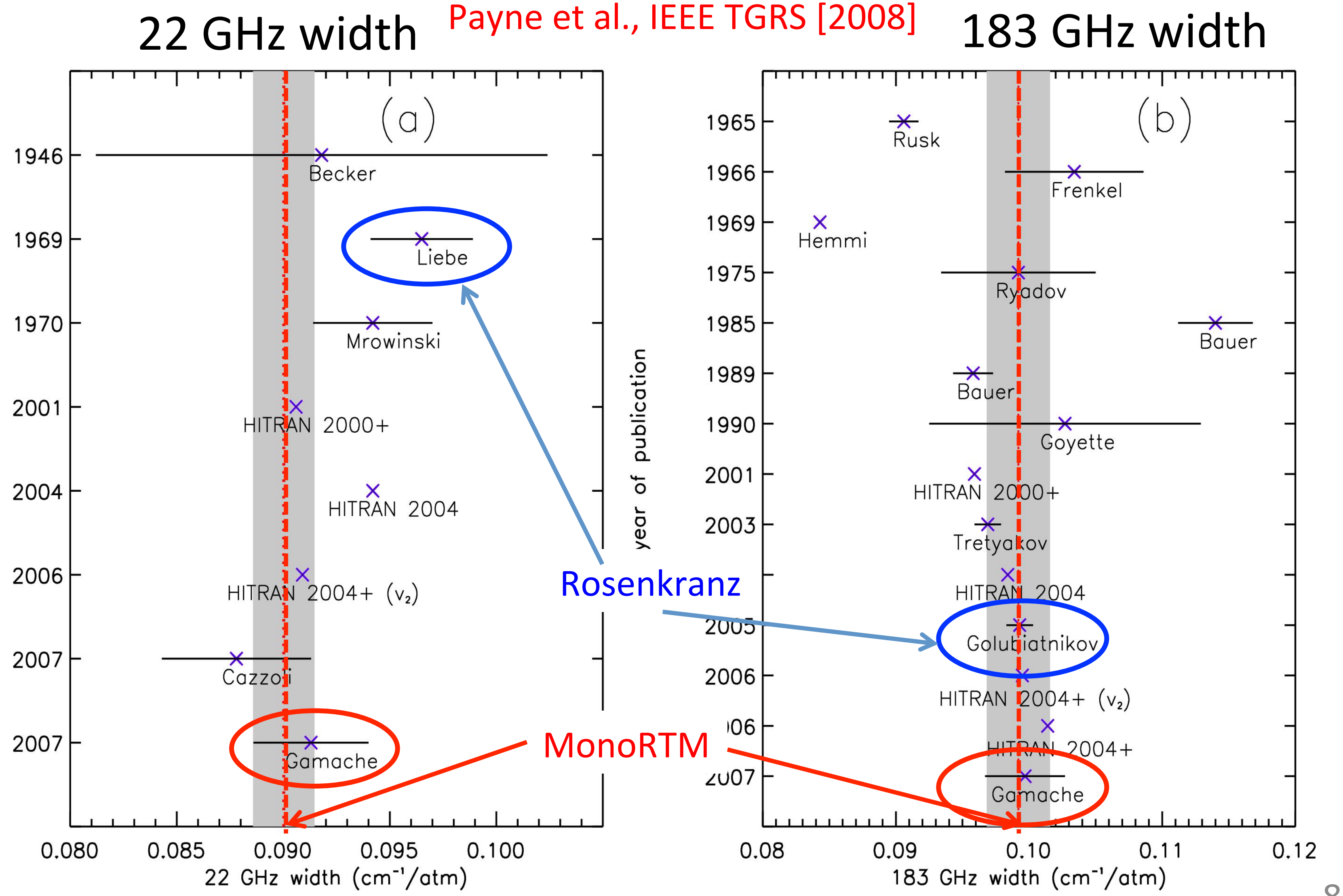
- **MonoRTM**
  - Monochromatic Radiative Transfer Model
  - **Developed at AER**
    - Clough et al. [2005]
  - Molecular absorption for all spectral regions
  - Absorption from liquid water in the microwave region
  - Extensively validated against high-quality ground-based measurements

- **Main differences between MonoRTM and the Rosenkranz model:**
  - 22 GHz H_2O line width
  - Self and foreign-broadened H_2O continua
  - **Differences up to ~2K in modeled Tbs**

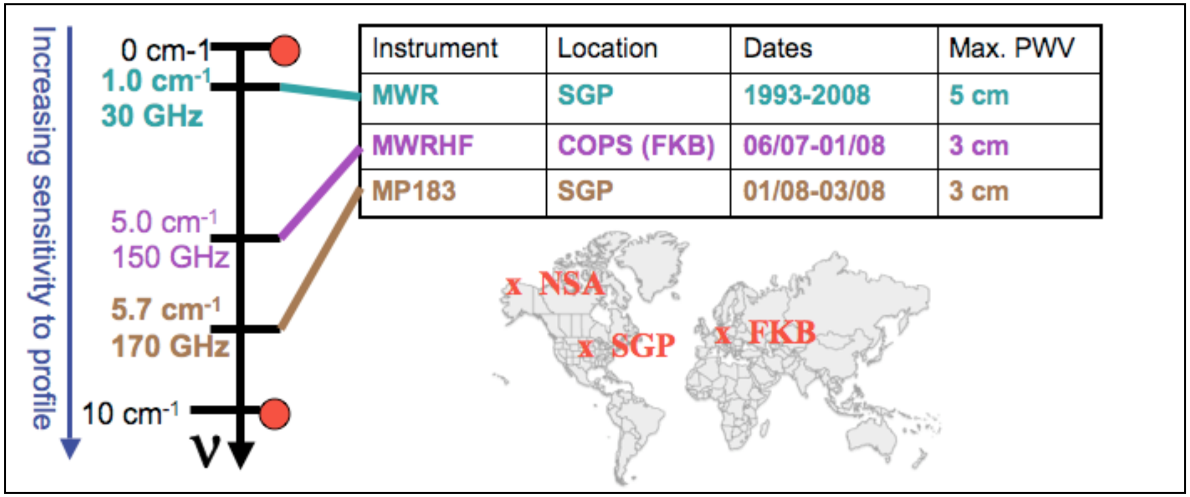


Spectroscopic input: Line parameters

Payne et al., IEEE TGRS [2008]



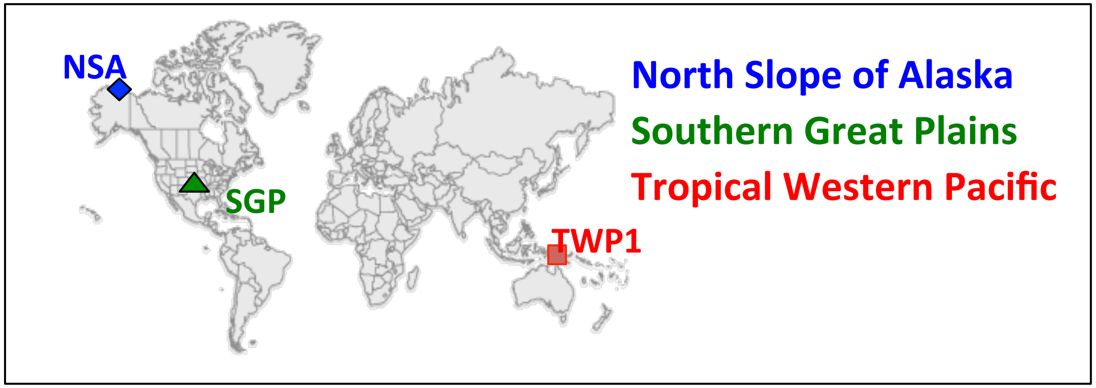
Spectroscopic input: H_2O continuum



Instrument	Location	Dates	Max. PWV
MWR	SGP	1993-2008	5 cm
MWRHF	COPS (FKB)	06/07-01/08	3 cm
MP183	SGP	01/08-03/08	3 cm

Inputs to RTM: Atmospheric state

- **Temperature, H_2O profiles**
- **Merged Sounding** product (MS)
  - From Department of Energy (DoE) Atmospheric Radiation Measurement (**ARM**) sites
    - NSA, SGP, TWP1
  - Sophisticated interpolation of radiosonde profiles
    - 1 minute temporal resolution
  - Attempts to correct for **known radiosonde biases**
  - Assume MS are our **best estimate of "truth"**



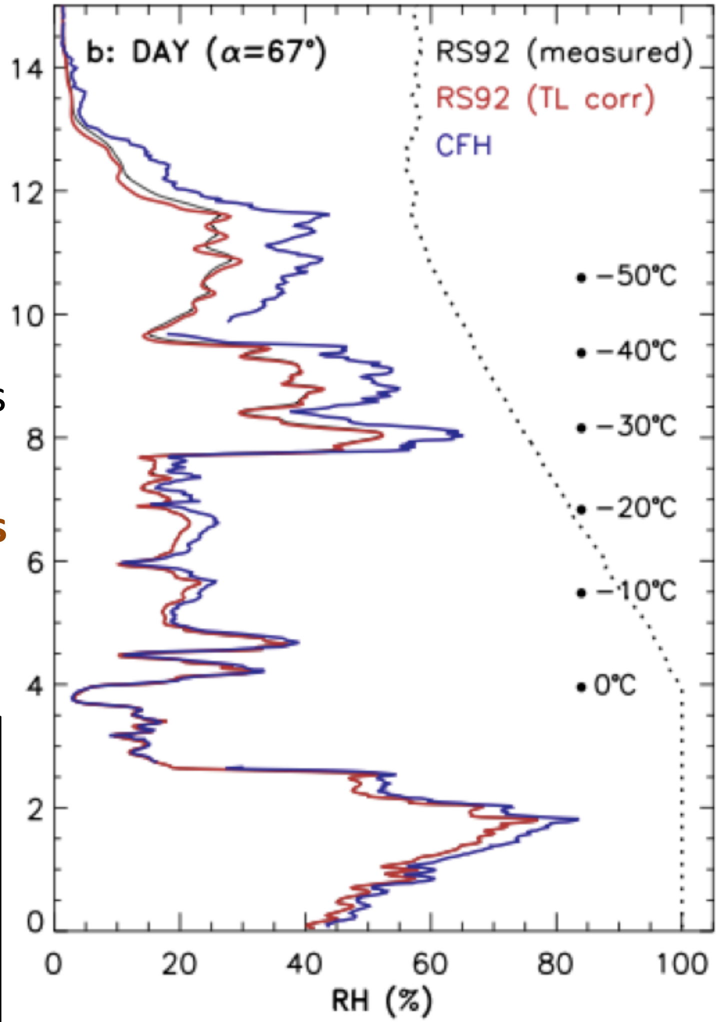


Figure from Miloshevich et al. (2009)

Input to RTM: Global Forecast System

- ARM Merged Sounding profiles
  - Provides best(?) available estimate of "truth"
  - Dataset is independent from the satellite Tbs
  - **Coverage extremely sparse**

- **NOAA Global Forecast System (GFS)**
  - **Excellent coverage**: Provides profiles for all locations, times
  - Assimilates info from satellite radiometers (not independent)
  - Finite temporal, spatial resolution

- **Perform GFS comparisons over ARM sites**
  - Do we see consistent behavior in relative terms?
  - **Are the double differences the same as those calculated using the Merged Sounding profiles?**

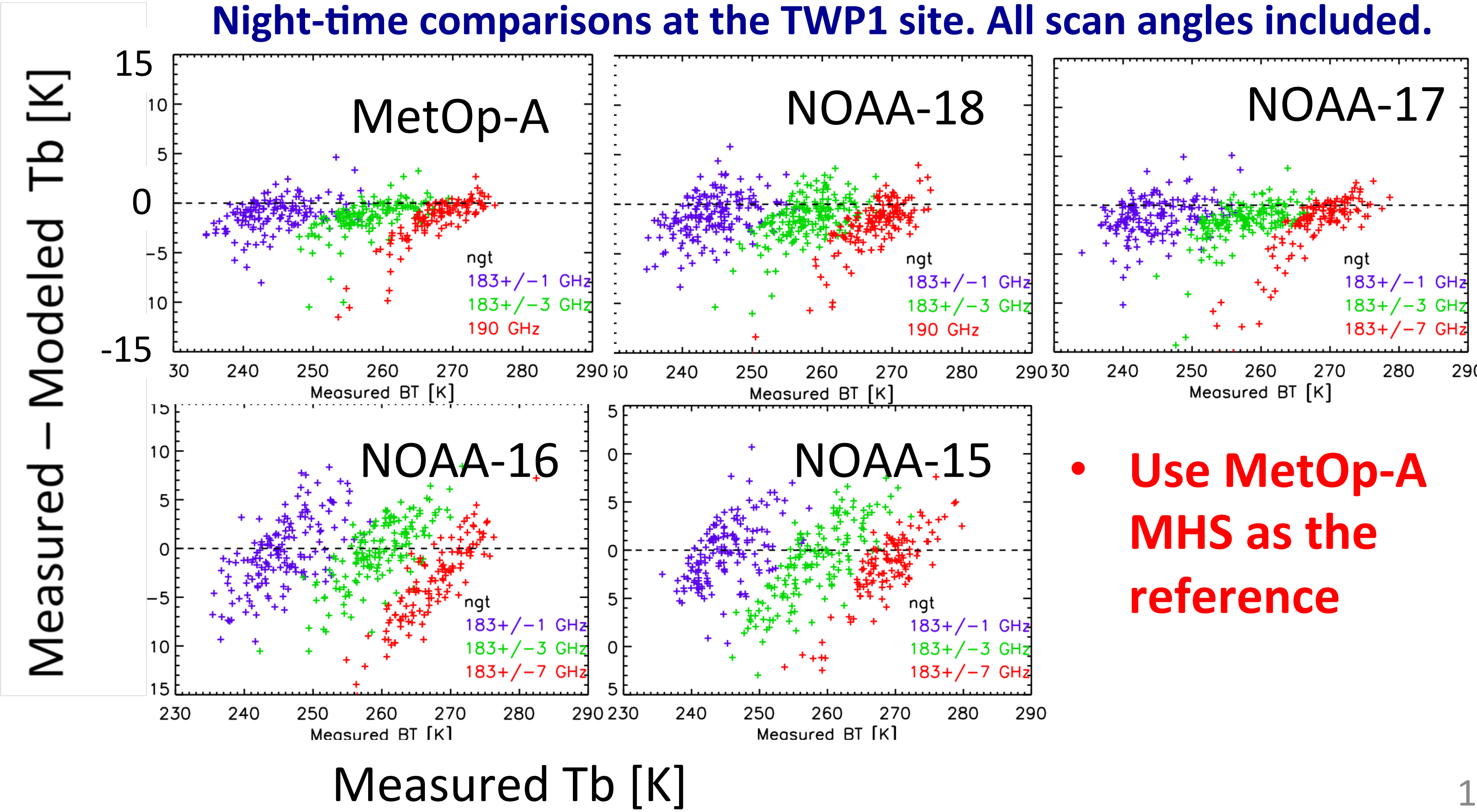
Satellite Measurements

- **One year of measurements: 2008**
- Instruments: Cross-track radiometers
  - **MetOp-A MHS**
  - **NOAA-18 MHS**
  - **NOAA-17 AMSU B**
  - **NOAA-16 AMSU B**
  - **NOAA-15 AMSU B**
- Satellite Tb data obtained via NOAA CLASS site
  - Data supplied **without antenna pattern correction**
- Measurements where footprint center within 8 km of an ARM site
- **"Clear-sky"** measurements
  - determined using approach of Buehler et al. (2007)
- **Avoid surface influence** using channel-dependent total precipitable water vapor thresholds

Example comparisons

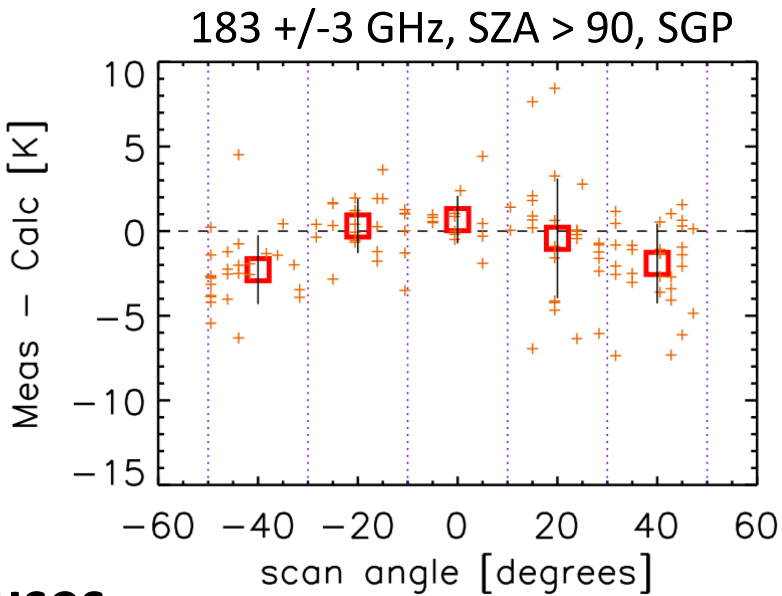
- All instruments/channels show some scan angle dependence

Night-time comparisons at the TWP1 site. All scan angles included.



- **Use MetOp-A MHS as the reference**

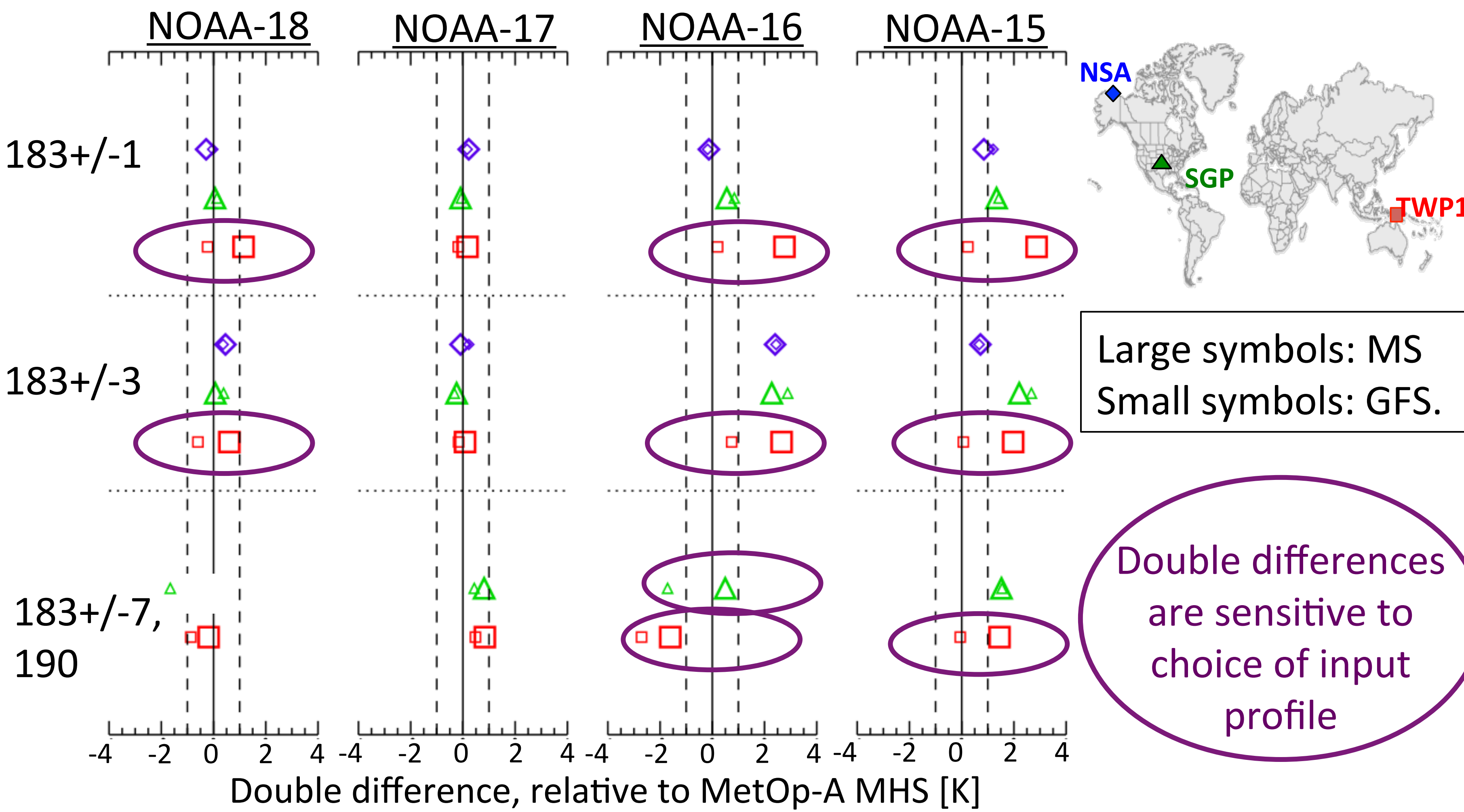
Scan angle dependence



- **Possible causes**
  - Antenna pattern correction (Not big enough)
    - E. Stocker now producing L1C files for MHS instruments that include APC
  - Antenna side lobes (Maybe?)
  - Spectroscopic uncertainties (Not big enough)
  - Uncertainties in the H_2O profile input (Maybe?)

Double differences: Different input profiles

Double differences [K] **relative to MetOp-A MHS**. All scan angles, daytime.



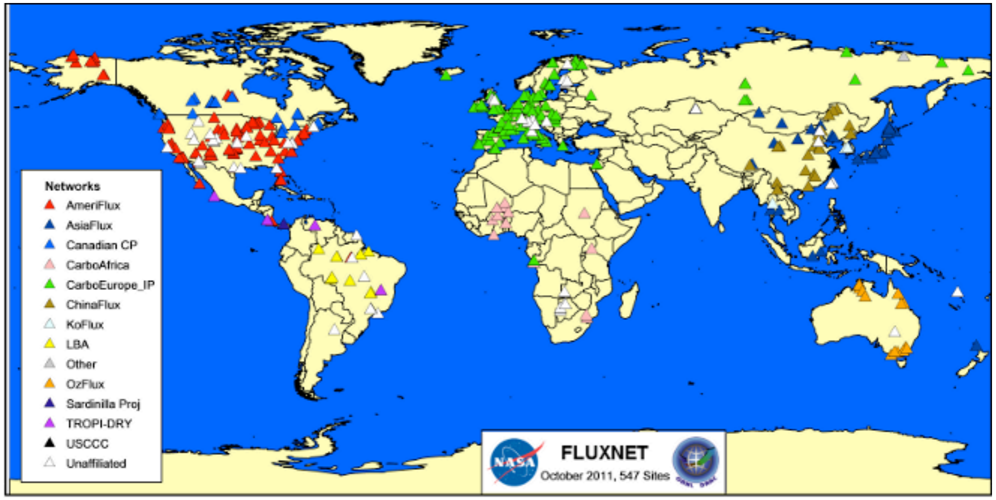
Large symbols: MS
Small symbols: GFS.

Double differences are sensitive to choice of input profile

Surface-sensitive channels

Surface-sensitive channels

- **Method to assess quality of intercalibration:**
  - Select surface stations
    - that provide reliable surface temperature estimates
    - over vegetated areas (emissivity stable in time)
  - Careful cloud screening
  - Perform surface emissivity retrievals from different sensors
  - Retrieved emissivities should agree



Summary

- **Data from instruments in the GPM constellation will be corrected to a common reference before being used in the precipitation retrieval algorithm**
- **Work to date:**
  - MetOp-A used as a reference
    - Compared with other currently-flying cross-track radiometers
  - Instrument Tbs compared using RTM output as a transfer standard
    - **Efforts to use "best estimate" input to RTM**
  - **Details of the input to the RTM can affect double difference results.**
  - Limited to locations of DoE ARM sites, sample sizes limited
- **Future work on 183 GHz channels** (surface-insensitive conditions):
  - Extend to GPM-era instruments
  - Alternative sources of input profiles
    - Infrared measurements (IASI/MHS)
    - GPS Radio Occultation profiles?
- **Future work on surface-sensitive channels**
  - Use surface emissivity retrievals from different sensors to assess quality of intercalibration

References

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