Intercalibration of 183 GHz radiometer channels

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Overview

Radiometer intercalibration is a critical component of obtaining accurate precipitation retrievals from satellite constellations, and removing intersatellite differences will be of vital importance for the success of the GPM mission.

Many of the activities of the GPM cross-calibration (XCAL) working group have so far focused on "double difference" (DD) approaches to cross-calibration [e.g. Wilheit et al., 2013].

Double differences for channels in the vicinity of water vapor lines (both 183 and 22 GHz) are sensitive to the water vapor profile used as input to the radiative transfer model [Payne et al., 2012; Datta et al., 2014; Kroodsma et al., 2014].

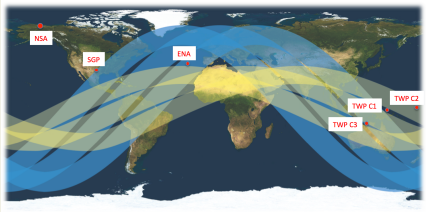
Radiosonde-based profiles (and NWP models) are subject to altitude- and time-of-day- dependent biases. GPS-RO profiles extend over large horizontal distances.

Time-of-day-dependent biases in water vapor profiles can introduce spurious latitude and seasonal dependence in radiometer double differences.

Improvement in "reference" profile datasets would enable further improvements in radiometer intercalbration.

1. Water vapor profiles

Merged Sounding profiles at DoE ARM sites



Yellow: TRMM orbit tracks. **Blue**: GPM orbit tracks. **Red:** ARM sites
Visualization of TRMM and GPM tracks courtesy of J. Turk (JPL)

- "Best estimate" of atmospheric state (Troyan, 2012)
- Profiles of temperature and humidity over DoE ARM sites
- 1 minute temporal resolution (temporal coincidence not an issue)
- Sophisticated scaling/interpolation/smoothing scheme combines information from a number of sources:
  - Radiosonde soundings
  - **Ground-based microwave radiometer (MWR) constrains PWV**
  - Surface meteorological instruments, ECMWF model output

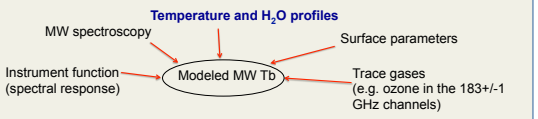
- Merged Sounding profiles are not perfect!
  - Humidity and pressure-dependent sonde humidity biases
    - e.g. Miloshevich et al. (2009)
    - Strong dry bias in upper tropospheric humidity
    - Plans for future versions of the Merged Sounding product involve inclusion of the Miloshevich correction
  - Radiation dry bias (SZA-dependent)
    - MWR scaling corrects for overall bias in column
    - But not for SZA-dependent biases in upper troposphere!

2. Radiative transfer model calculations

- MonoRTM
- Monochromatic Radiative Transfer Model
- Publicly available at http://rtweb.aer.com

- **Main differences between MonoRTM & Rosenkranz models:**
- Width of 22 GHz water vapor line
- Water vapor continuum (MonoRTM uses MT_CKD)
- Number of lines and input format

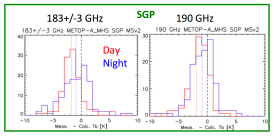
- **Ground-based validation supports MonoRTM 22 GHz line width**
- Payne et al. (2008)
- **Ground-based validation led to update of MT_CKD continuum**
- Payne et al. (2011)
- Similar conclusions on relative contributions of self/foreign continua arrived at by Remote Sensing Systems in satellite-derived empirical modification to Rosenkranz model

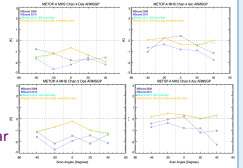


3. Example single differences

✧ These comparisons: PWV high enough to block surface contributions

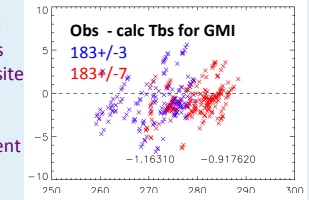
- MetOp MHS instruments: "Well-behaved"
- Clean design, extensive efforts on pre-flight characterization

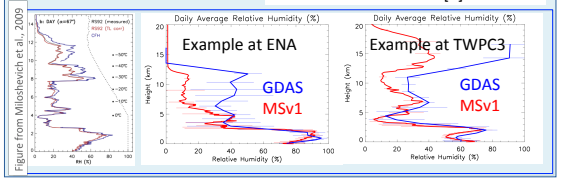




- MetOp-A MHS single differences: one year of match-ups over the ARM SGP site
- Day/night differences are apparent

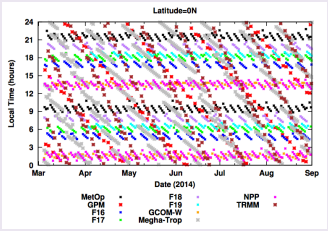
- GMI single differences:
- 3 months of match-ups over the ARM TWPC3 site
- **Jul/Aug/Sept 2014**
- Scatter on GMI comparisons ~consistent with that on MHS comparisons





4. Implications of profile biases for DDs

- DD = $(obs_{TGT}\text{-}calc_{TGT}) - (obs_{SRC}\text{-}calc_{SRC})$



Constellation local sampling time: Equator.
Figure courtesy of J. Turk (JPL)

- Time-of-day-dependent biases in water vapor profiles can introduce spurious latitude and seasonal dependence in radiometer double differences
- This issue does not only affect double differences calculated at specific sites.
- **"Better" estimates of "true" atmospheric state?**
- Retrieval from microwave radiometer in pair
  - Radiometers can have different channel coverage
  - T info not always available
- Retrieval of T, q from co-located infrared sounder
  - Not all MW radiometers colocated with IR meas.
- Future improvements to radiosonde/MS corrections?

5. Conclusions/Future work

- **Latest GMI calibration (ITE030): 183 GHz single differences comparable to those from other well-characterized 183 GHz radiometers**
- Altitude and time-of-day dependent biases present in radiosonde-based (and NWP!) datasets
- These affect single (obs-calc) and double differences
- Implications for intercalibration of 22 **AND** 183 GHz channels
- **Future work:**
- **Double differences based on nighttime only Merged Sounding comparisons should be relatively robust**
- Investigation of improved radiosonde corrections

Acknowledgements

PMM STM funding, GPM XCAL team, DoE ARM program

References

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