Intercalibration of 183 GHz channels

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Summary

• 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. Here we present comparisons between the 183 GHz channels of the MetOp MHS, NOAA-18 MHS, NOAA-17 AMSU-B, NOAA-16 AMSU-B and NOAA-15 AMSU-B instruments for one year of data (2008). The approach adopted here was to compare measurements from each of these instruments with radiative transfer model simulations using the radiosonde-based "Merged Sounding" product for the specification of the atmospheric state over DoE ARM sites located in the Southern Great Plains (SGP), Oklahoma, and the Tropical Western Pacific (TWP1). An important feature of our approach is the use of well-validated radiative transfer modeling tools, using consistent physics across spectral regions and up-to-date water vapor spectroscopy to accurately model the water vapor absorption.

• Comparisons of absolute model/measurement differences for each instrument show systematic effects that are likely associated with biases in the upper tropospheric humidity from the radiosonde-based specification of the atmospheric state. Future versions of the ARM Merged Sounding product will likely include improved radiosonde corrections.

• **Relative differences between satellite instruments indicate that all instruments examined here are within +/-1 K of MetOp MHS brightness temperatures in the 240 to 270 K range**, with larger differences at the extreme warm and cold ends of the measured range.

Approach

- Coincidence criteria: Center of satellite footprint within 8km of ARM site
- Use ARM Merged Sounding profiles as input to the radiative transfer model
- Apply channel-dependent column water vapor thresholds to ensure no sensitivity to surface
- Screen for "clear-sky" cases using ground-based microwave radiometer
- Compare modeled vs measured brightness temperatures for different satellite instruments

Merged Sounding product

– Best available estimate of atmospheric state
– Profiles of temperature and humidity over ARM sites
– 266 vertical levels between 0 and 20 km
– 1 minute temporal resolution
  • Temporal coincidence is not an issue
– Sophisticated scaling/interpolation/smoothing scheme combines information from a number of sources:
  • Radiosonde soundings
    – Primary basis for temperature/humidity profile information
  • Ground-based microwave radiometer (MWR)
    – Constrains total column atmospheric water vapor
  • Surface meteorological instruments
    – Boundary conditions for lowest atmospheric level
  • ECMWF model output

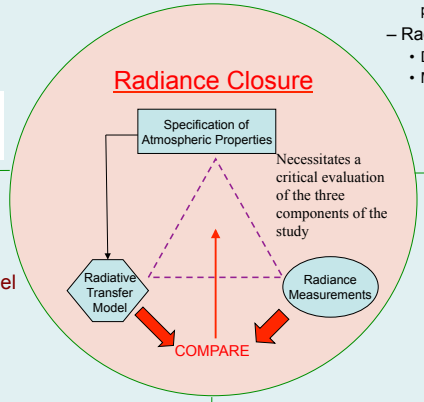
Use of Merged Sounding product allows greater number of match-ups than the use of individual radiosonde launches.

ARM Climate Research Facilities

The "true" atmospheric state?

- Merged Sounding profiles represent our best estimate of the atmospheric state, but are not perfect….
- Known issues with radiosondes:
  – Humidity and pressure-dependent 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
    • Depends on SZA (e.g. Cady-Pereira et al., 2008)
    • MWR scaling corrects for overall bias in column
      – Does not correct for shape, issues in upper troposphere

Radiance Closure



MonoRTM

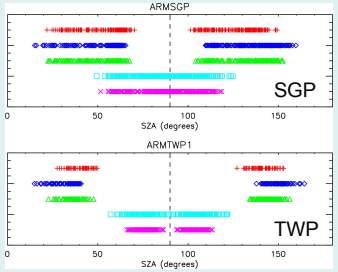
• Monochromatic Radiative Transfer Model
• Developed at AER Inc
• Publicly available: http://rtweb.aer.com

•Spectroscopic input:
  • Line parameters, line mixing, continuum absorption
  • Carefully validated
    • Comparisons with high-quality, ground-based measurements
      •Cadeddu et al., 2007
      •Payne et al., 2008
      •Payne et al., 2011

Satellite Measurements

Brightness temperatures from NOAA CLASS (http://www.class.noaa.gov)

MetOp-A MHS
NOAA-18 MHS
NOAA-17 AMSU-B
NOAA-16 AMSU-B
NOAA-15 AMSU-B



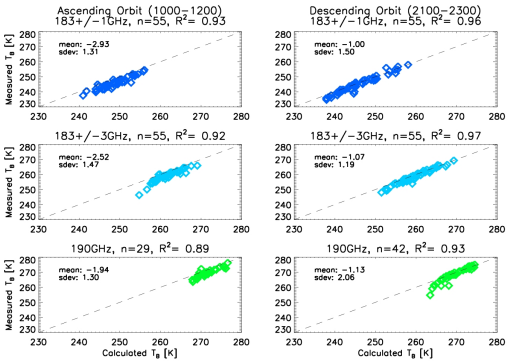
Solar zenith angles at satellite overpass times

Results

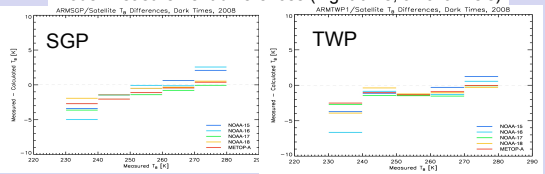
All instruments/sites show better measurement/model agreement for night-time overpasses.

Common variation of model/measurement differences with scan position is likely indicative of biases in the upper tropospheric humidity in the ARM Merged Sounding product.

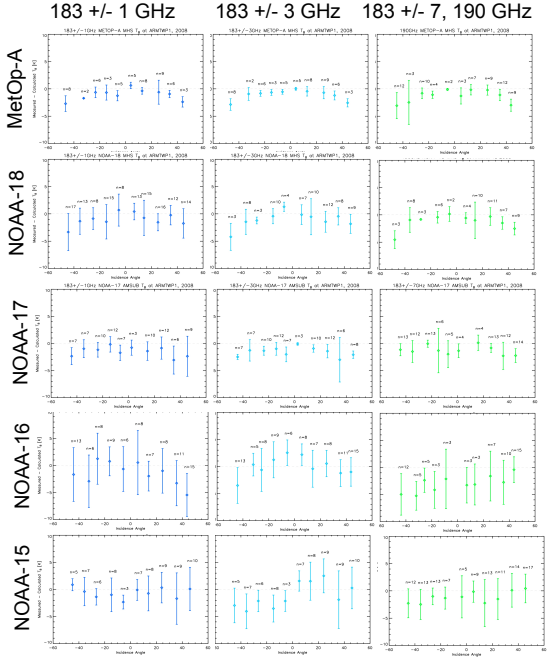
Example of day/night differences: MetOp-A MHS over TWP site



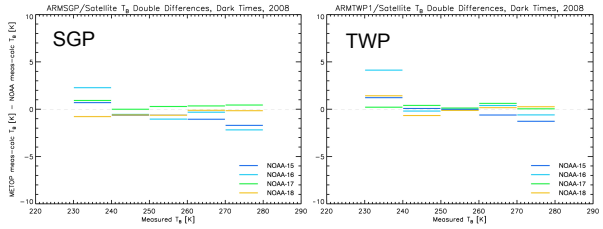
Model/measurement differences (night-time, all channels)



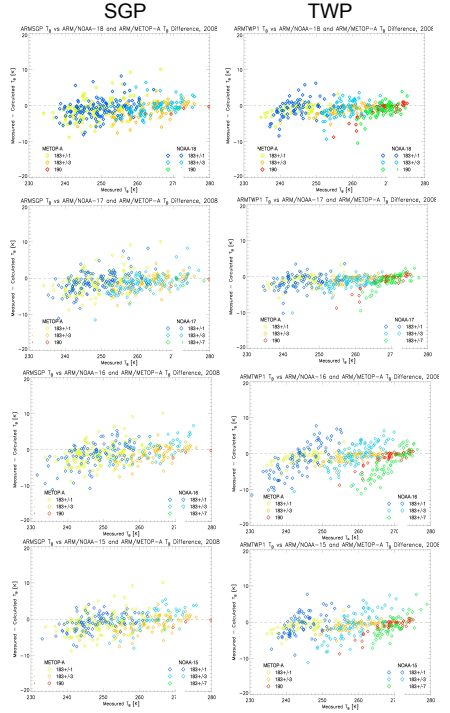
Variation of model/measurement differences with scan position
TWP site, night-time only



Double differences (night-time, all channels, relative to Metop-A)



All **night-time** model/measurement comparisons



- Double difference results: consistent picture for both ARM sites.
- All five instruments: good agreement in 240 to 270 K range.
- ARM Merged Sounding product can provide a useful transfer standard for intercalibration of 183 GHz satellite channels.
- Future plans for the Merged Sounding product involve inclusion of improved radiosonde corrections, which could improve the utility of this product as an absolute reference.