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Natural and vicarious calibration targets for satellite based microwave sensors

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1. Motivation

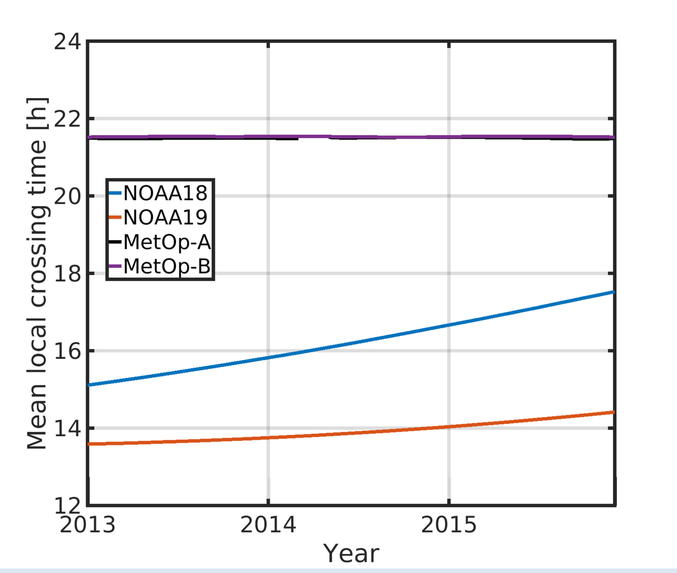

Fig. 1. Mean local crossing times of the ascending node of MHS-satellites for a 3 year testperiod.

- Two decades of microwave (MW) humidity sounding around 183.31 GHz from multiple instruments across many polar orbiting satellites.
  → Here MW Humidity Sounder (MHS) is analyzed.
- Need of traceable uncertainty estimates for the individual datasets by applying robust intercalibration methods.
- A robust intercalibration method needs to account for systematic deviations between the datasets:

→ Equator crossing times constrain each dataset to specific phase of diurnal cycle.

2. Intercalibration Methods

following John et al., 2013

	Main flaw of each method:
1. Simultaneous Nadir Overpasses: Compare datasets using only space- and time-collocated measurements.	1. Mainly measurements from latitudes > 70° N/S.
2. Zonal Averages: Compare datasets as function of latitude, representing different climates and sampling.	2. Does not account for different equator crossing times.
3. Natural Targets: Compare datasets of certain geographical regions, where diurnal cycle in humidity is assumed to be small.	3. Tough to quantify diurnal cycle in the MW Measurements.

3. Approach to refine Natural Targets

- Hypothesis: Humidity diurnal cycle is weak over oceanic regions of subsidence.
- Analysis by using Upper Tropospheric Humidity (UTH) retrieved from Brightness Temperatures (T_b) at 183.31 ± 1.1 GHz from SAPHIR onboard Megha-Tropiques.

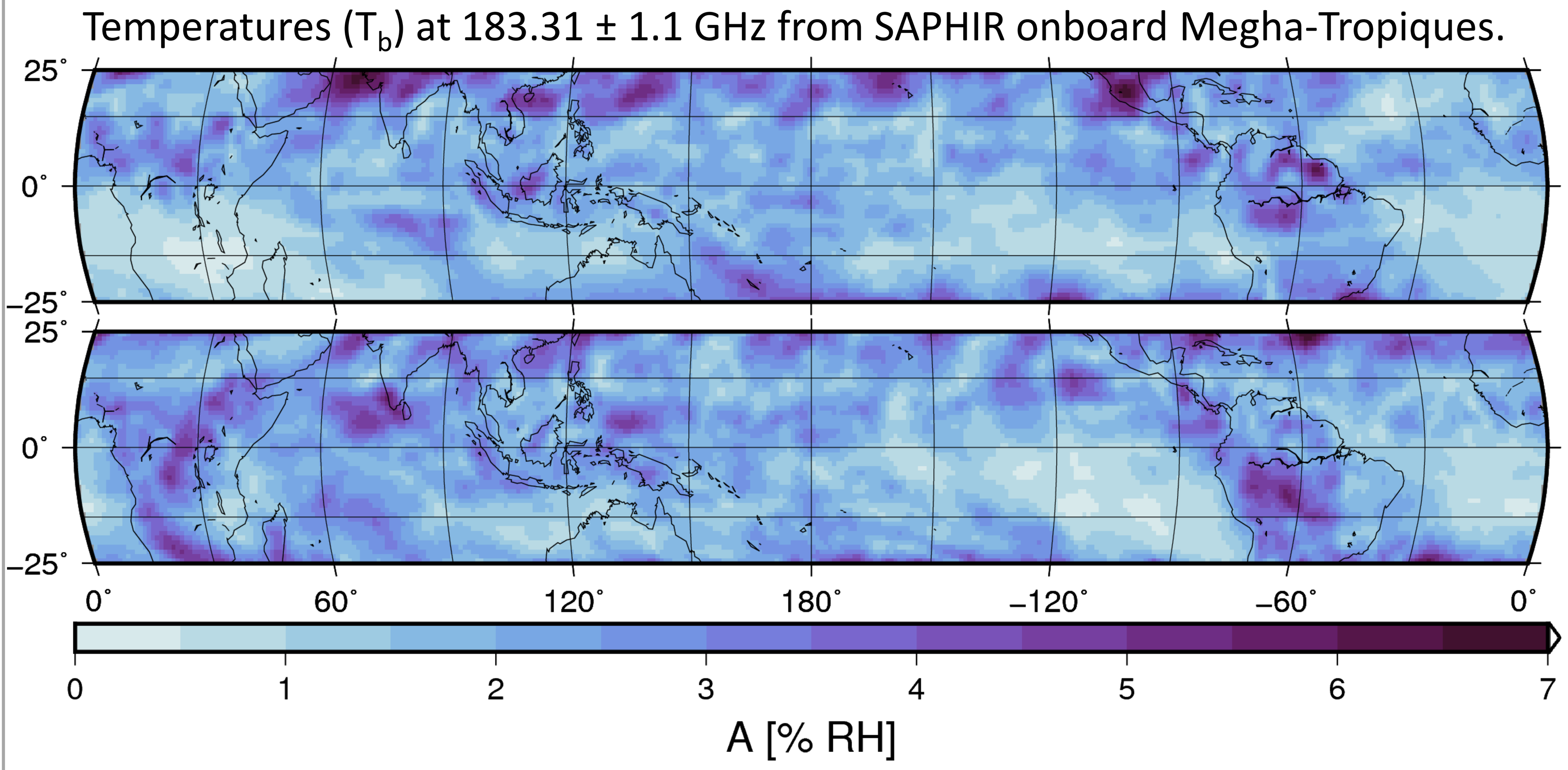

Fig. 2. Map of UTH diurnal cycle amplitude A from SAPHIR measurements for JJA (top) and SON (bottom).

- Relation between T_b and UTH:

$$UTH = \exp(a \cdot T_b + b)\,, a < 0$$

→ Problem of the method: Natural target locations show annual cycle and are not very distinct.

4. 90th T_b-percentile as a vicarious calibration target?

- Consider same Hypothesis as for Natural Targets, that in regions of low UTH (high T_b) there is a weak diurnal cycle.
- Look at difference of 90th T_b-percentile of one polar orbiting MW sounder (MHS, NOAA18) between ascending and descending node datasets.

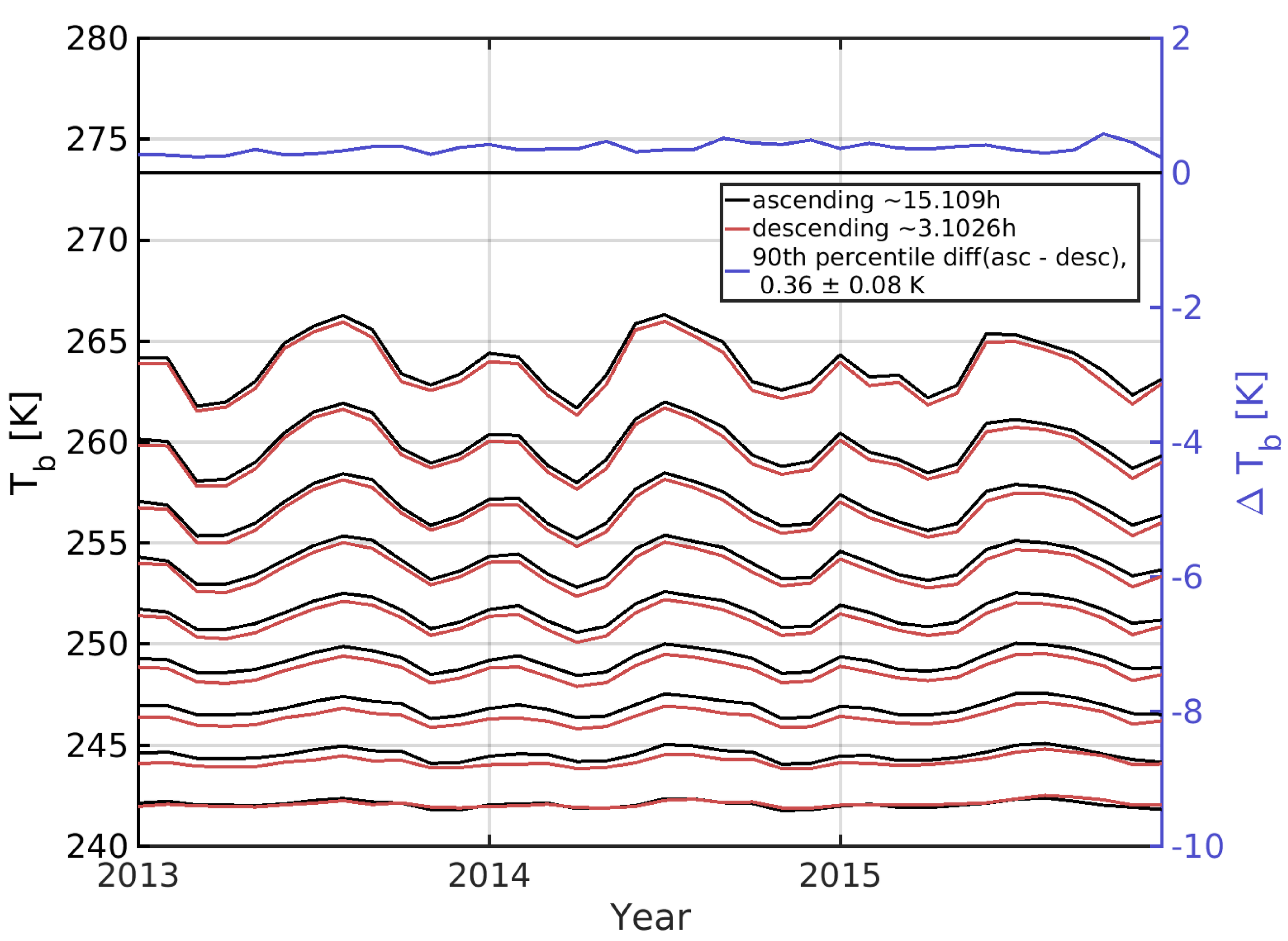

Fig. 3. Monthly decadal percentiles (10th to 90th) of T_b's from MHS onboard of NOAA18 at 183.31 ± 1.0 GHz, separated into ascending node and descending node. Used data between 45° N/S, full swath with applied Limb-correction and orographical filter.

→ Diurnal influence minimal for 10th percentile, hypothesis for Natural Targets does not hold true for T_b-space, because of exponential relation to UTH.

5. Estimation of intersatellite Biases

Attempt to disentangle instrumental intersatellite Biases from diurnal cycle effect for the four currently operating MHS instruments:

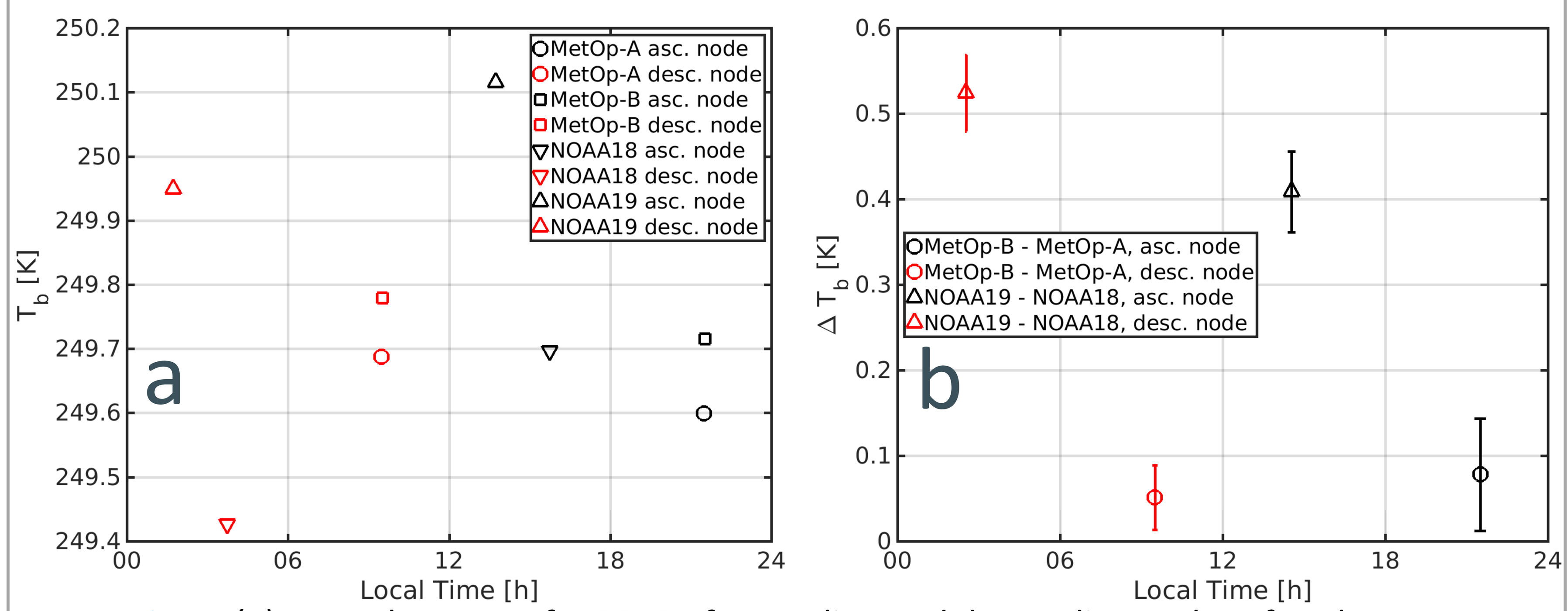

Fig. 4. (a) Annual mean T_b for 2013 of ascending and descending nodes of each instrument against their characteristic local crossing times. (b) Intersatellite Biases from (a) with standard deviation over monthly Biases of 2013.

→ NOAA18 with NOAA19 and MetOp-A with MetOp-B constitute two pairs of comparable instruments, since they are close in their crossing time.

→ Instrumental intersatellite Biases should be independent of local time, whereas diurnal effects yield variational Biases in local time.

6. Multipoint intercalibration of MW instruments using percentiles

- Use decadal percentiles of monthly ascending and descending node data from individual satellites as the measure of intersatellite comparison.
- MHS onboard of NOAA18 is chosen as reference, since it has the longest lifetime.

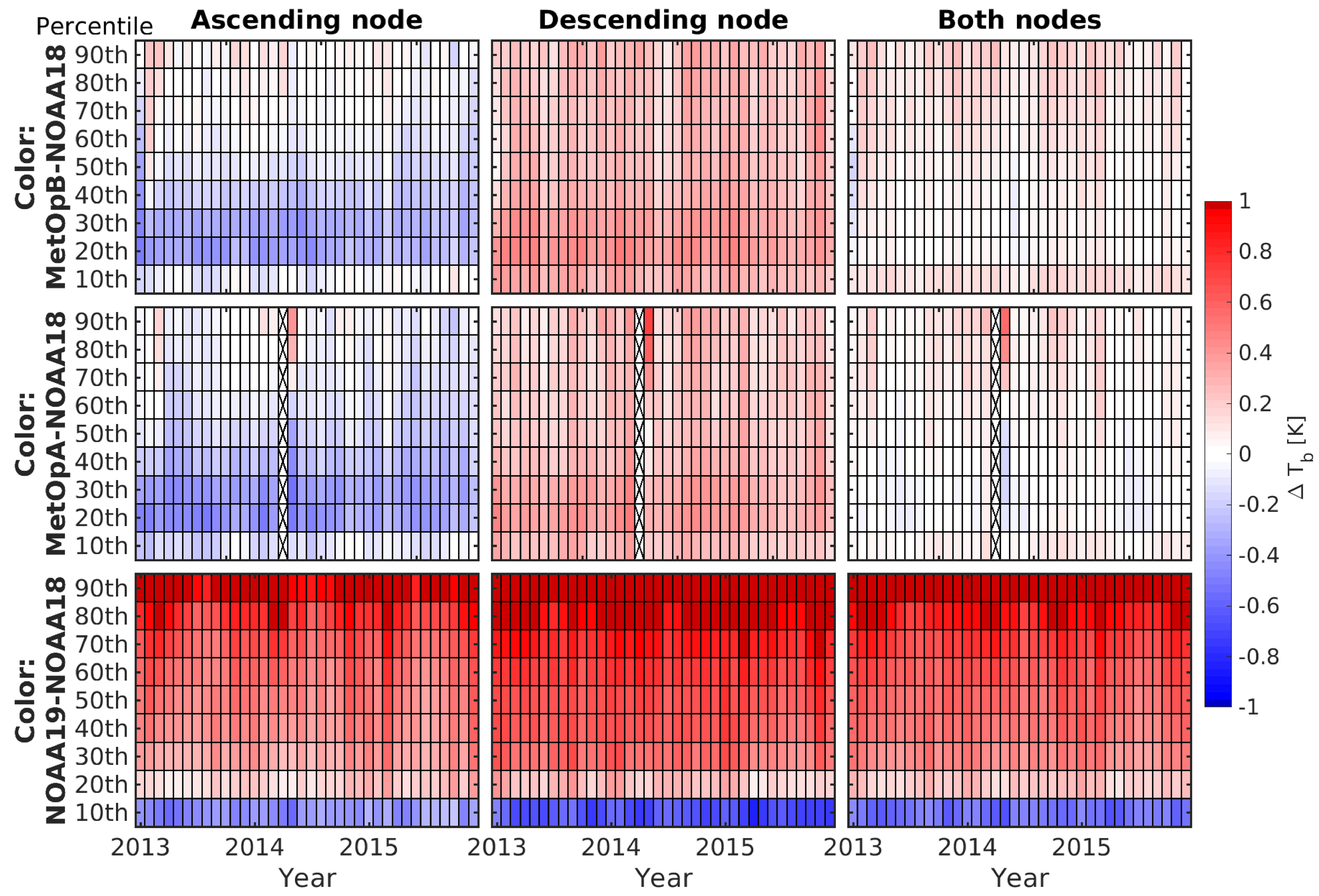

Fig. 5. Timeseries of monthly intersatellite decadal percentile differences (10th to 90th) for MHS instruments at 181.31 ± 1.0 GHz. Rows depict instrument comparisons with respect to NOAA18. Columns depict data used for the comparison, e.g. the ascending/descending/both node data. The color depicts the intersatellite difference for a given percentile and month.

→ Qualitative disentangling of intersatellite instrumental offsets from diurnal cycle offsets possible by considering the different sets of compared data.

→ Intersatellite offsets can be considered as a function of T_b.
Clear instrumental offset visible for NOAA19, which depends on T_b.

7. Conclusions

- Oceanic subsidence regions of low UTH are not suited as calibration targets due to exponential relationship between UTH and T_b.
- In contrast to the Bias, Percentiles allow the intercomparison of instruments on different satellites as a function of T_b.
- Dividing the dataset of individual satellites into ascending and descending node yields a diurnal cycle effect of below 1 K for all percentiles at 183.31 ± 1.0 GHz.
- Intersatellite differences that are significantly greater than the satellite internal node differences indicate an instrumental problem.
- By using only the ascending or descending node data for the instrument intercomparison, diurnal cycle offsets can be qualitatively disentangled from instrumental offsets, as was seen for NOAA19.

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References:

John, Viju & Allan, Richard & Bell, William & Buehler, Stefan & Kottayil, A. (2013). Assessment of calibration methods for satellite microwave humidity sounders. Journal of Geophysical Research: Atmospheres. 118. . 10.1002/jgrd.50358.