Evaluation and Correction of Observations in Atmospheric Channels of the Satellite Microwave Radiometer MTVZA-GY

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Abstract

Data in atmospheric sounding channels of the microwave radiometer MTVZA-GY on board the Russian satellite Meteor-M N2 are examined. An adaptive correction technique for MTVZA-GY antenna temperatures is motivated and developed. The technique accounts for the solar angles and sequentially assimilates observed minus simulated radiances in a perpetual 24h cycle in order to estimate up-to-date correction coefficients defined to be functions of the zenith and azimuth solar angles. The accuracy of corrected MTVZA-GY observations is compared with the accuracy of AMSU-A and MHS data.

Description

MTVZA-GY is a 29-channel microwave imaging/sounding radiometer (with conical scan geometry) somewhat similar to SSMIS or AMSU-A and MHS combined. MTVZA-GY data are available to direct readout users. Importantly, MTVZA-GY is supported by the radiative transfer model RTTOV starting from its version 11. For more, see Gayfulin et al. (2018) and the WMO OSCAR web site.

The MTVZA-GY radiometer on board Meteor-M N2 is, unfortunately, currently not working properly (since 15 August 2017). The next MTVZA-GY instrument is planned to be launched by the end of 2018. In total, 4–5 satellites of the Meteor-M type with the MTVZA-GY sensor on board are to be launched till 2025 in both the morning and the afternoon orbits.

Motivation

1. Soon after launch large biases in antenna temperatures were found. These were mitigated by a the simple linear scheme, which can be viewed as a kind of recalibration: $T_b = aT_a + b$, where T_a is the antenna temperature, T_b is the recalibrated brightness temperature, and a and b are the regression coefficients (estimated from a training sample).

   Recalibrated and bias-corrected MTVZA-GY data were assimilated by Gayfulin et al. (2017) in the meteorological data assimilation system of the HydroMetCentre of Russia. A significantly positive impact of MTVZA-GY observations in the Southern Hemisphere in the absence of AMSU-A observations was found. However, it was felt that further improvements in the data accuracy were possible.

2. It was found that after the "simple correction" $T_b = aT_a + b$, observation errors (evaluated against the background defined to be the 6h NCEP GFS forecast converted to radiances by the RTTOV model) were dependent on the *solar angles* (the zenith angle ζ and the azimuth angle α), see Fig.1 (upper panels). This led us to devise a correction scheme that exploits the solar angles dependencies in order to improve the data.

Solar-angles dependent correction (SAC) technique

To account for the dependence of the observation error on the solar angles, we let the two coefficients, a and b, of the above "simple correction" scheme be functions of the solar angles α and ζ:

$$T_b = a(\alpha, \zeta) \cdot T_a + b(\alpha, \zeta). \tag{1}$$

The gridded fields $a(\alpha, \zeta)$ and $b(\alpha, \zeta)$ required for the application of the correction model Eq.(1) are cyclically updated (i.e. sequentially estimated) every 24 hours in a variational scheme, which aims to minimize the cost function

$$J(\mathbf{a}, \mathbf{b}) = J_{\text{obs}}(\mathbf{a}, \mathbf{b}) + J_{\text{fg}}(\mathbf{a}, \mathbf{b}) + J_{\text{smo}}(\mathbf{a}, \mathbf{b}) \to \min, \tag{2}$$

where $\mathbf{a}$ and $\mathbf{b}$ are the vectors that represent the coefficient fields $a(\alpha, \zeta)$ and $b(\alpha, \zeta)$, J_{obs} penalizes deviations of observations (T_a) from the background, J_{fg} regularizes the problem and allows assimilation

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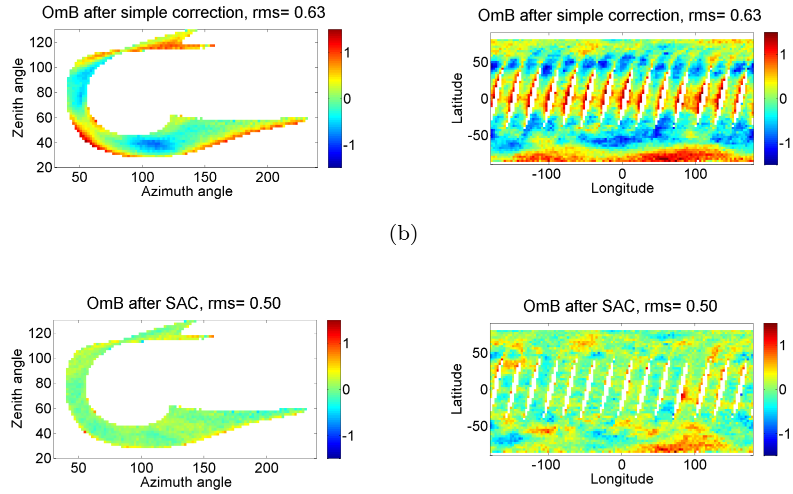

(a) (b) (c) (d)

Figure 1: Local biases for observations in channel 18 valid at times from 21h UTC, 12 June 2017 to 3h UTC, 14 June 2017 (descending orbits). *Top:* After the "simple" correction (with constant coefficients a and b). *Bottom:* After SAC. *Left:* On the α–ζ plane. *Right:* On the geographic map

of past data by controlling deviations from a *first guess* (persistence forecast of **a** and **b** from the previous cycle), and $J_{\rm smo}$ further regularizes the problem by imposing a smoothness constraint on the fields **a** and **b**. See Gayfulin et al. (2018) for more details.

Evaluation results

Three two-week periods in summer, winter, and spring/fall were selected for numerical experiments. The application of the estimated SAC correction model to independent observations was shown to significantly improve their accuracy (as compared to the above "simple correction", in which a and b are constants). The MTVZA-GY errors were compared with errors in the respective/similar channels of AMSU-A and MHS sensors for the same time periods. As compared with AMSU-A observations, corrected MTVZA-GY data in temperature sounding channels appeared to be 1–3 times less accurate. In atmospheric humidity sounding channels, the corrected MTVZA-GY observations are about 1.5–2 times less precise than the MHS data.

Local biases for SAC-corrected observations are presented in Fig.1 (lower panels). In this figure, comparing the lower panels (the SAC scheme) with the upper panels (the "simple" scheme) demonstrates how successfully the developed SAC scheme removes the local biases, leaving behind, largely, just noise.

Bibliography

D. Gayfulin, M. Tsyrulnikov, A. Uspensky, E. Kramchaninova, S. Uspensky, P. Svirenko, and M. Gorbunov. The usage of MTVZA-GYa satellite microwave radiometer observations in the data assimilation system of the Hydrometcenter of Russia. *Russian Meteorology and Hydrology*, 42(9):564–573, 2017. doi: 10.3103/S1068373917090035.

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