Why and how does the actual spectral response matter for microwave radiance assimilation ?

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Abstract

Based on Global/Regional Assimilation and PrEdiction System-Global Forecast System (GRAPES-GFS) and actual Spectral Response Functions (SRFs) of three selected single-passband channels (Channel 5, 6 and 7) of FengYun-3D MicroWave Temperature Sounders-2 (FY-3D MWTS-2), impacts of actual SRFs on Brightness Temperature (TB) simulation were analyzed. Compared with simulation by ideal SRFs, averaged STandard DeViation (STDV) and bias of Observation minus Background (OMB) by actual SRFs decreases about -5.0% and 37.3%. The reductions on equatorial regions are more obvious than middle and high latitudes. Five types of deformations were put forward to analyze their impacts on TB simulation. Attenuation, shifting and extending of passband have more impacts on simulated TB compared with trap on passband. The differences between TBs simulated using ideal and actual SRFs don't depend on the magnitude of the difference between ideal and actual SRFs, but on the balances of different types of deformations of actual SRF.

1 Introduction

Traditionally, SRF for microwave instrument used in RTTOV and CRTM is the ideal boxcar shape. According to the following results, the more different SRFs don't necessarily induce more different simulated TBs, the differences depend on the balance of several deformations on the passband. The more accurate TB simulation, the less bias correction accounting for the observation operator, and hence the bias correction could be constrained mainly by the calibration uncertainties. The accuracies of RTM and instrument characteristics are all important for precise TB simulation. Actual SRF can reflect instrument characteristics more accurate than ideal SRF. This study analyzed the impact of actual SRF of FY-3D MWTS-2 (referred to as MWTS-2) and discussed the reason by simulating different types of deformed SRFs.

2 Results and Discussions

2.1 Impact of actual and ideal SRFs

In this study, the ideal SRF was set as boxcar. The actual SRF of MWTS-2 was provided by National Satellite Meteorological Center (NSMC) of CMA (Figure 1(a)). The spectral resolutions of the three SSPCs are 0.1 MHz. This resolution can reduce computation time while preserving a high sampling accuracy.
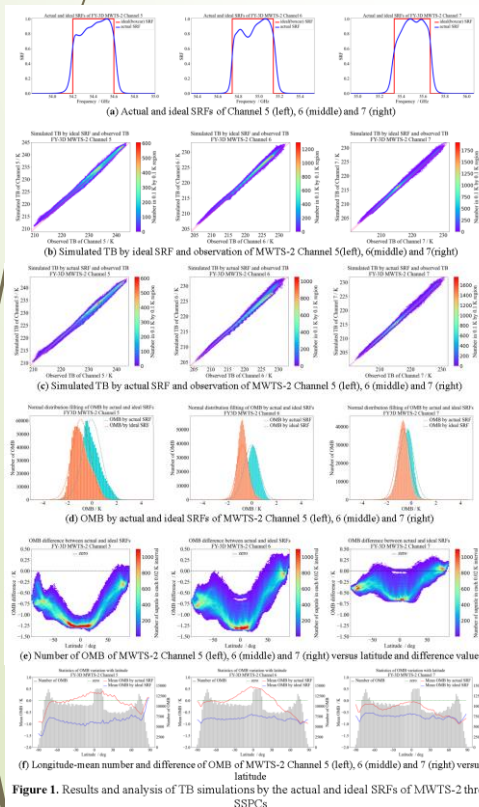

Figure 1. Results and analysis of TB simulations by the actual and ideal SRFs of MWTS-2 three SSPCs

TBs were simulated by RTTOV and compared with the MWTS-2 observations (Figure 1(b) and (c)). Histograms of OMB by ideal and actual SRFs were also calculated and listed (Figure 1(d)). OMB differences of actual and ideal SRFs change with latitude (Figure 1(e) and (f)). The OMB differences appear a valley near the equator and a peak near poles. OMB differences of Arctic regions are closer to zero than Antarctic. In this region, lower atmospheric temperature decreases atmospheric contribution to TB, contribution from surface became larger. The high the latitude, the small the contribution of atmosphere to TB, the small the effects of actual SRF. This phenomenon is worthy of further study. Differences of Channel 5 are similar to Channel 6, are larger than those of Channel 7.
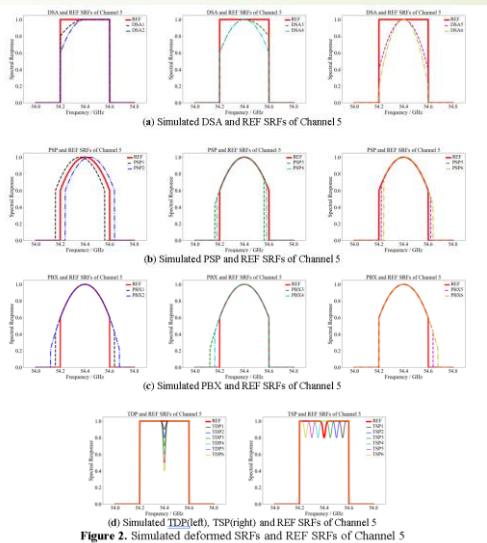

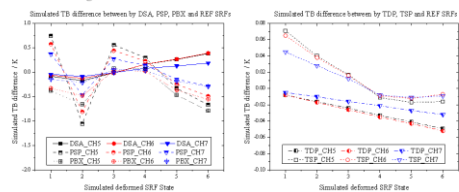**Figure 2.** Simulated deformed SRFs and REF SRFs of Channel 5

Figure 3. Simulated deformed SRFs and their impacts compared with REF SRFs

2.2 Impacts of typical SRF deformations on TB simulation

Five typical SRF deformations, Double Side Attenuation (DSA), Peak shifted on Passband (PSP), PassBand eXtending (PBX), Trap Deepened on Passband (TDP) and Trap shifted on Passband (TSP) were defined in this study. Figure 2 shows the deformed SRFs and REF SRF of Channel 5. For Channel 6 and 7, similar deformed SRFs were simulated with different central frequency and bandwidth. Among the five typical deformations appearing on actual SRF, DSA, PSP and PBX affect the simulated TB about 0.1–1 K (left of Figure 3(f)). TDP and TSP have little impacts with values of about 0.01-0.1 K (right of Figure 3(f)). The simulating results also show that the more different SRFs don't necessarily induce more different simulated TBs, the differences between simulated TBs under ideal and actual SRFs, don't ultimately depend on the magnitude of the difference between ideal and actual SRFs, but on the complicated balances of different types of deformations on the actual SRFs.

3 Conclusion

our results provide interesting and valuable information. Suppressing attenuation and keeping attenuation balance at low-frequency and high-frequency ends of passband are more important and useful than inhibiting trap appearing on the center of the passband. Sidelobe on high-frequency side of passband has larger impact than on low-frequency side for MWTS-2 selected channels. The design process doesn't have to pursue the absolutely flat boxcar response, by sacrificing other important performance. Instrumental design will benefit from the above information.

Reference:

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