Assimilation of FY-3 MWTS radiance data into Chinese NWP systems

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1. Introduction

Chinese Fengyun-3A (FY-3A) satellite was successfully launched on 27 May, 2008. The Microwave Temperature Sounder (MWTS) onboard FY-3A is the first microwave sounding unit in China. The second in the FY-3 series, FY-3B, was successfully launched on November 5, 2010, carrying the same instruments as those on board FY-3A. On September, 23, 2013, the satellite FY-3C was launched. The MWTS onboard FY-3A/B has four channels that are similar to AMSU-A channels 3, 5, 7, and 9 and provide atmospheric temperature sounding. The microwave sounding unit onboard FY-3C has thirteen channels that are similar to SNPP ATMS temperature sounding channels. This report details the quality control (QC) scheme and the impacts on Numerical Weather Prediction (NWP) system.

2. Quality Control scheme

To assimilate these MWTS radiances into NWP system, a cloud detection scheme is needed. Currently, there are several cloud detection methods developed for microwave satellite measurements (eg: AMSU-A). However, the two surface-sensitive channels (23.8 GHz and 31.4 GHz) used in the existing cloud detection schemes are not available from the MWTS onboard FY-3A/B/C satellite. These algorithms developed for the AMSU-A data cannot be directly applied to the MWTS observations.

A new cloud detection algorithm is proposed for the MWTS (Li and Zou, 2013). The method is based on the cloud fraction product provided by the Visible and InfrarRed Radiometer (VIRR) onboard FY-3 satellites. A MWTS field-of-view (FOV) with a cloud fraction greater than a threshold f_{VIRR} will be identified as a cloudy radiance. The threshold f_{VIRR} is determined by the AMSU-A cloud liquid water path products, obtained from the Microwave Surface and Precipitation Products System (MSPPS). Analysis of the test results indicates that most clouds are identifiable by applying a VIRR cloud fraction threshold of 76%.

Other QC steps for FY-3A/B/C MWTS include the following: (i) two (for FY-3A/B) or eight (for FY-3C) outmost FOVs; (ii) measurements from low level channels over sea ice and land; (iii) coastal FOVs; and (v) outliers with large differences between model simulations and observations. In addition, another step is needed for FY-3C MWTS. The differences between brightness temperature observations and simulated observations based on numerical weather predictions, i.e., O-B, exhibit a clear striping pattern. We use the PCA+EEMD method to remove the striping noise. Firstly, the principal component analysis is applied to isolate scan-dependent features such as the cross-track striping from the atmospheric signal. Secondly, an Ensemble Empirical Mode Decomposition (EEMD) is used to extract the striping noise. When the noise is removed from the data, the striping noise is imperceptible in the global distribution of O-B for FY-3C MWTS sounding channels.

3. Impacts on the global NWP system

The impact of MWTS radiances on the prediction of Chinese NWP system GRAPES (Global and Regional Assimilation and Prediction System) was researched. Both typhoon case study and cycle experiments were conducted. The typhoon case study shows that the assimilation of MWTS data can improve the typhoon track prediction by changing the model-predicted steering flow. The impact cycle experiments conducted for 30-day periods show that the QC scheme removed the outliers efficiently. Verifications indicate that forecast skill is improved after assimilating MWTS data.

4. Plans

The FY series is becoming an increasingly important component of the global observing system. The applications of these measurements have also been researched in ECMWF and UKMO. Currently, a telecommunication conference on the improved assimilation of FY satellite data among CMA/NSMC (National Satellite Meteorological Centre), CMA/NWPC (Numerical Weather Prediction Center), UKMO and ECMWF, was held regularly. The conference is proved to be a very efficient and economical means of communicating the findings between the four centers.

In the near future, plans are made to assimilate Microwave Humidity and Temperature Sounder (MWHTS) and FY-3D microwave sounder data in a new version of the operational GRAPES. More details on the MWTS impact evaluation can be found in Li, et al., 2015.

References:

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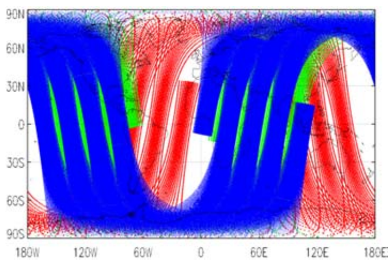

Fig.1: Data coverage of MWTS from FY-3A (green) on 0300 UTC-0900 UTC July 1, 2012, FY-3B (red) on 0300 UTC-0900 UTC July 1, 2013 and FY-3C (blue) on 0300 UTC-0900 UTC July 1, 2014.

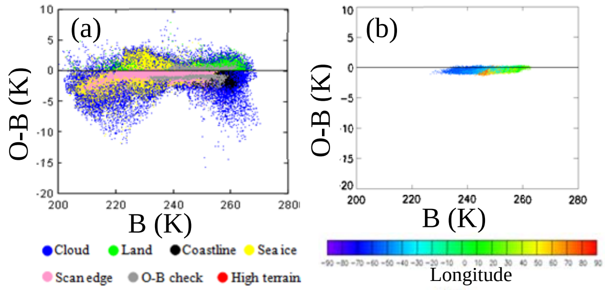

Fig.2: Scatter plots of the differences of brightness temperature between observations and model simulations for FY-3A MWTS channel 2 (a) outliers and (b) data that pass quality control during 1-5 July 2011.