Recent Updates on the Usage of GNSS RO Data in JMA's Operational Global Data Assimilation System

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1. Introduction

The Japan Meteorological Agency (JMA) began assimilating Global Navigation Satellite System (GNSS) Radio Occultation (RO) refractivity data into its operational global NWP system on March 22, 2007, and revisions to this process were implemented in the system on December 18, 2012. The major updates are as follows:

- Additional use of refractivity data from TerraSAR-X and C/NOFS and resumption of GRACE-A refractivity data assimilation
- Updates of observation operators and elimination of the bias correction procedure

A bias correction procedure had been implemented in the pre-processing of RO data due to the presence of systematic biases in the tropical and polar regions. As the biases were reduced via updates of the observation operators, the correction procedure was eliminated. The updates are described in detail in the next section.

Observation system experiments for the new assimilation configuration incorporating these updates showed improved analysis and forecasting of temperature and sea surface pressure, especially in the Southern Hemisphere. Most of the improvements were brought about by the observation operator updates.

2. Updates and related impacts

JMA began assimilating RO refractivity data from GRACE-A, TerraSAR-X and C/NOFS in addition to data from Metop-A and COSMIC with the implementation of new observation operators. The number of assimilated RO data increased threefold relative to the previous operation.

Two major changes were applied to the observation operators. One was an improvement of the interpolation algorithm used for the conversion of height information. In previous operation, vertical interpolation for the computation of background refractivity values was designed on a geometric height scale. Accordingly, calculation for the conversion of geopotential height to geometric height was required for each model grid point to seek two levels between which the observation was located. The previous algorithm lacked accuracy because latitude dependence was not considered in the calculation of gravitational acceleration. Against this background, a revised method incorporating consideration of latitude dependence was introduced into the updated operators. This approach also has the advantage of reducing computational cost because height conversion is unnecessary for model grid points. The other major change was a modification of tangent linear and adjoint operators for the computation of pressure perturbation. The previous operators produced increments of only temperature and water vapor for the levels surrounding the observation. As consideration of pressure perturbation results in increments to sea surface pressure as well as temperature and water vapor, it plays an important role in the improvement of sea surface pressure analysis.

Observation system experiments for the new assimilation configuration were performed for the two months of August 2011 and January 2012. The control experiment (CNTL) had the same configuration as the previous operational global system, and the test experiment (TEST) included the above-mentioned updates, which were newly introduced into the operational system.

Figure 1 shows the mean and standard deviation of fractional normalized Metop-A refractivity differences between observations (without bias correction) and model simulations as a function of geometric height in three latitudinal bands for August 2011. Observations above 30 km (shown in grey) were not used in either experiment due to the presence of biases between observations and model simulations. In the CNTL experiment, there was a positive bias in the tropics and negative biases in the Arctic and Antarctic. In the TEST experiment, the biases were clearly reduced compared to those of the CNTL experiment. Figure 2 shows the monthly average of analyzed sea surface pressure differences between TEST and CNTL. Large differences were seen especially around the Antarctic. The effect of RO data assimilation is noticeable in this region, where surface weather observation stations are sparse. The increments in the TEST experiment were brought about by the new operators incorporating perturbation of pressure.

Acknowledgements

The authors would like to thank GFZ for providing GRACE-A and TerraSAR-X data, EUMETSAT for providing Metop-A data, USAF for providing C/NOFS data and NSPO and UCAR for providing COSMIC data.

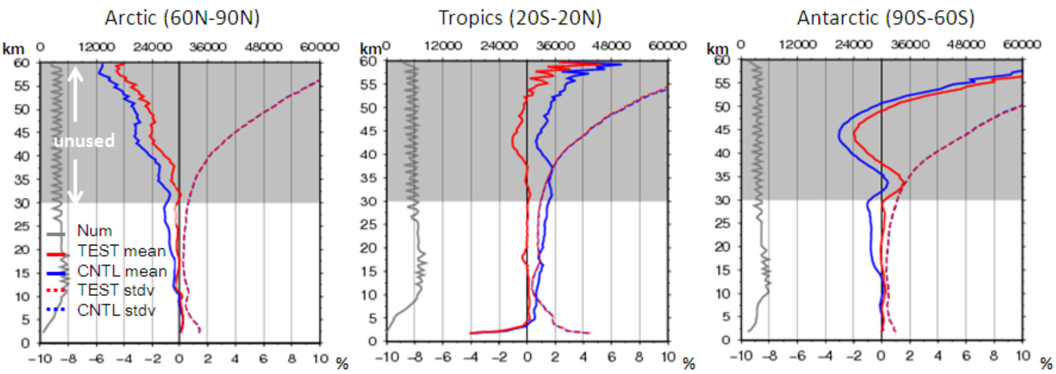

Figure 1: Mean and standard deviation of fractional refractivity differences ((O − B) / B * 100) between Metop-A observations (O) and model simulations (B) as a function of geometric height in the TEST and CNTL experiments for August 2011

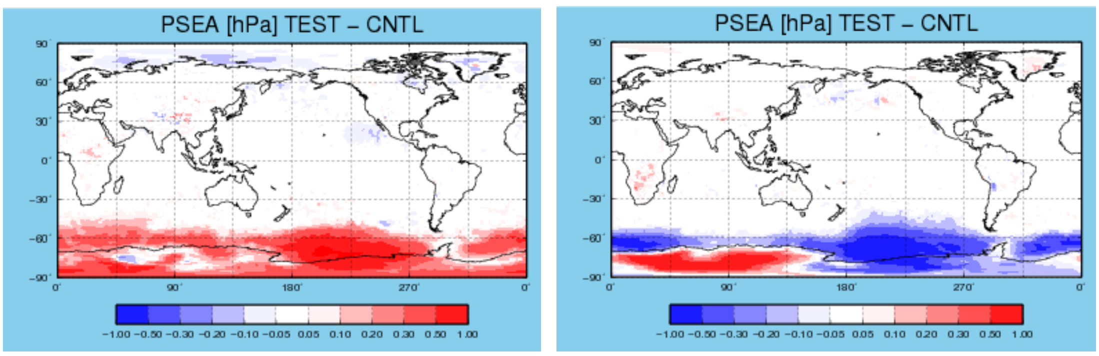

Figure 2: Monthly average of analyzed sea surface pressure differences between TEST and CNTL for August 2011 (left) and January 2012 (right)