Operational use of surface-sensitive clear-sky radiance data in JMA's global NWP system

Izumi Okabe
Numerical Prediction Division, Japan Meteorological Agency
E-mail: i-okabe@met.kishou.go.jp

1. Introduction

Clear-sky radiance (CSR) data from geostationary satellites contain information on water vapor (WV) amounts in the upper troposphere. The usage of surface-sensitive (WV band; 6.9 and 7.3 μm) CSR data from Himawari-8 was previously limited over ocean areas in the Japan Meteorological Agency's (JMA's) global NWP system (Kazumori 2018) because accurate land surface temperature and emissivity information is required for assimilation. Against this background, JMA developed a new methodology for radiative transfer (RT) calculation using retrieved land surface temperature data. Assimilation experiments performed with this methodology indicated that surface-sensitive CSRs from Himawari-8 and Meteosat Second Generation (MSG) data for areas over land had positive impacts on WV field accuracy in first-guess (FG) and forecasting scores from JMA's global spectral model (GSM). The results of these experiments are reported here.

2. Methodology

To improve RT calculation accuracy, JMA now uses the atlas of Wisconsin University (Borbas and Ruston 2010) for land surface emissivity data rather than a constant value (0.90) and land surface temperatures from Himawari-8's band-13 window channel (10.8 μm) CSRs rather than FG surface temperature data from the GSM. These CSR observation data and FG atmospheric profiles are leveraged in RT calculation to determine land surface temperatures, which are in turn used in RT calculation to derive FG brightness temperatures for WV-band CSRs. Quality control (QC) is modified to rejected CSR data for altitudes exceeding 4,000 m in GSM topography, thereby eliminating the use of CSR data over the Tibet Plateau, where extremes of geographical relief cause gaps between actual altitudes and those used in the GSM. These gaps affect the accuracy of RT calculation, and CSR data for areas over high mountains contain less WV information than those for areas over low plains and oceans, since there is less WV at such high altitudes. The time interval for assimilation of Meteosat and GOES CSR data was also changed from two hours to an hour in addition to the adoption of Himawari-8 CSR data usage.

3. Assimilation experiment

The control experiment (referred to here as CNTL) had the same configuration as the operational JMA global NWP system as of June 2018. Surface-sensitive CSRs from Himawari-8 and MSGs were assimilated, and QC for CSR data at high altitudes and the periodicity change were added to the test experiment (referred to as TEST). The experiments covered periods of around four months from June 10 to October 11 2017 and from November 10 2017 to March 11 2018.

4. Impacts on the NWP system

Figure 1 shows normalized changes in the standard deviation (STD) of FG departure for microwave humidity sounder (MHS) data and radiosonde observation data on relative humidity. The reduced values indicate an improvement in correspondence between FG and other observations. Figure 2 shows differences in the FG departure's STD for MHS data between TEST and CNTL. Decreases (plotted in blue) in STD were observed over land areas (e.g., Australia and Africa). As these observations contain information on WV in the troposphere, the results suggest a positive impact from surface-sensitive CSR assimilation over land on WV field accuracy for FGs in the troposphere. Forecasting scores in the short range were improved in the fields of humidity, temperature and wind speed (Figures 3 and 4). The altitude of forecasting improvement was that in which correspondence between FG and radiosonde observations was enhanced, as shown in Figure 1.

5. Summary

JMA began assimilating surface-sensitive CSR data from Himawari-8 for areas over land and MSG data for areas over land and oceans on October 18 2018. A new RT calculation method involving the use of data from the Wisconsin University land surface emissivity atlas and land surface temperatures retrieved from window-channel CSR observation data was developed for assimilation of surface-sensitive CSRs. At the same time, the quality control was modified to remove CSR data from high-altitude areas. The time interval for the assimilation of Meteosat and GOES CSRs was changed from two hours to an hour, and positive impacts from surface-sensitive CSR assimilation on the WV field of the FG were found. Improved short-range forecast scores were also observed for specific humidity, temperature, wind speed and geopotential height fields in the assimilation experiment.

References

Borbas, E. E. and Ruston, B. C. (2010). The RTTOV UWiremis IR land surface emissivity module, AS Mission Report NWPSAF-MO-VS-042, EUMETSAT Numerical Weather Prediction Satellite Applications Facility, 24pp.

Kazumori, M., 2018: Assimilation of Himawari-8 Clear Sky Radiance data in JMA's global and mesoscale NWP systems. J. Meteor. Soc. Japan, 96B, 173-192.

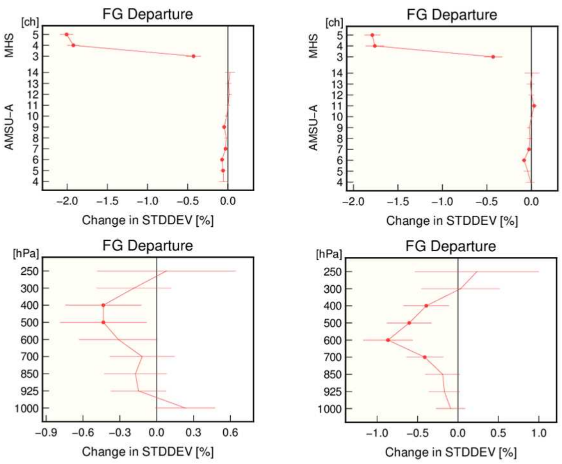

Figure 1. Normalized changes in the standard deviation (STDDEV) of first-guess departures for microwave sounding data for each channel number [ch] (top) and radiosonde observation data for relative humidity for each pressure height (bottom). The validation periods are from June 21 to October 11 2017 (right) and from November 21 2017 to March 11 2018 (left).

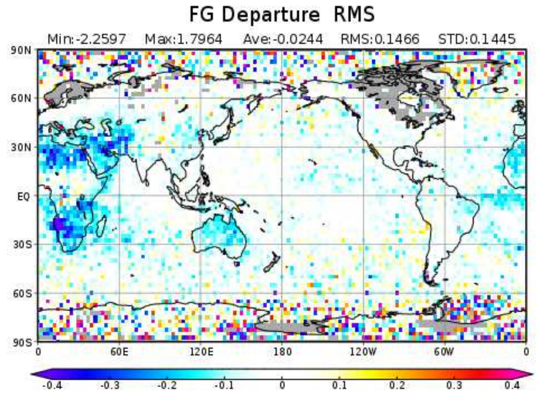

Figure 2. Normalized changes in the standard deviation of first-guess departures for MHS (channel 4). The validation period is from June 21 to October 11 2017.

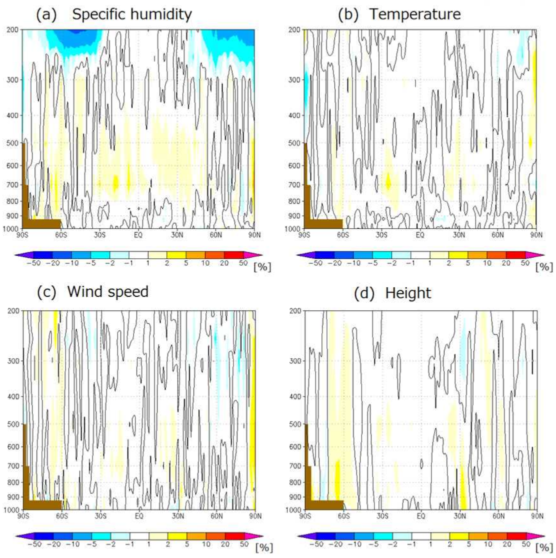

Figure 3. Relative improvement of root mean square error of 24-hour forecasts for (a) specific humidity, (b) temperature, (c) wind speed and (d) height. Forecasts of only 12 UTC initials were counted, and ECMWF analysis was used in validation. The validation period is from July 1 to September 30 2017.

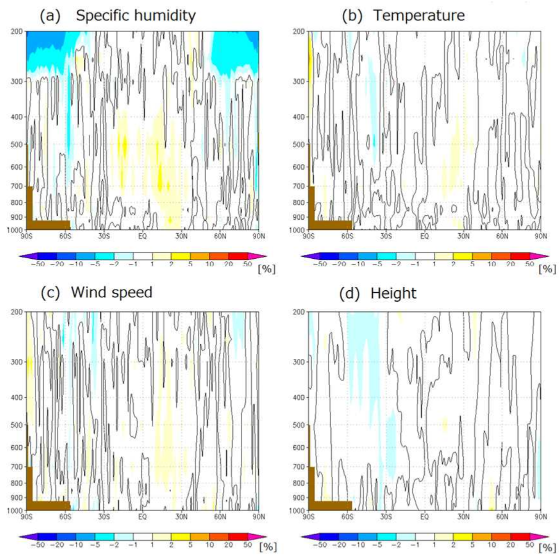

Figure 4. As per Fig. 3, but with a validation period from December 1 2017 to February 28 2018.