Clear-Sky Radiance (CSR) Assimilation from Geostationary Infrared Imagers at NCEP

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1. CSR Products from Geostationary Infrared Imagers

Clear-Sky Radiance (CSR) is a product that has been generated by averaging brightness temperatures (BTs) from the clear pixels identified by a cloud mask within a processing segment. Only the CSR from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on Meteosat-11 (M11) is currently assimilated in operations at the National Centers for Environmental Prediction (NCEP). Several additional CSR products have recently become available in BUFR format, including the Advanced Baseline Imager (ABI) on GOES-16 (G16), the Advanced Himawari Imager (AHI) and the SEVIRI on Meteosat-08 (M08). These CSR products are similar with a few minor differences, such as ABI CSR having higher temporal resolution and its clear-pixel percentage within a processing segment not being channel dependent. Investigations have been performed on the impact of these additional CSR products on global analysis and forecast skill using NCEP's Finite-Volume on a Cubed-Sphere Global Forecast System (FV3GFS) system. This work will be briefly discussed in this paper and will be included in the next implementation of the FV3GFS. Figure 1 shows the global coverage of all four CSR products. The CSR data in the figure are already thinned to 145km.

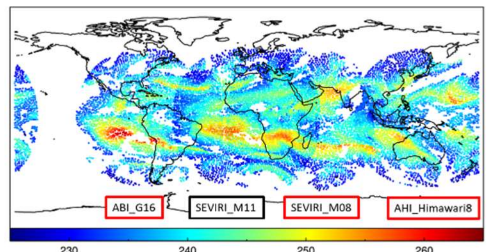

Figure 1. Observed BT for upper peaking water vapor channel from ABI_G16, SEVIRI_M11, SEVIRI_M08 and AHI_Himawari8.

2. Evaluations of CSR products

The geostationary CSR data assimilation focuses on the water vapor (WV) channels only. The weighting functions of these WV channels from all four instruments are plotted in Fig.2. All four instruments have similar weighting functions for the upper-level WV channel. Only ABI and AHI have the mid-level channel and show similar features. ABI and AHI are more similar to each other than to SEVIRI for the lower-level channel. The SEVIRI instruments are more sensitive to the lower troposphere.

The CSR data quality for each instrument has been evaluated through studying the statistical characteristics of the CSR products compared with their simulated model equivalences using the operational FV3GFS model forecast and Community Radiative Transfer Model (CRTM) as the forward operator, so-called first guess (FG) departures. Figure 3 shows normalized FG departure histograms for all of the four instruments on the same plot for easy comparison. The three panels (a), (b), and (c), respectively, represent the upper-, mid- and lower-level WV channels. The data samples span the whole month of May 2019 over both sea and land surfaces after quality control has been applied. Solid lines represent the FG departures before bias correction is conducted. It is clear that these instruments have different biases, but their FG departures all have a Gaussian distribution of very similar shape, except for the lower-level WV channel. The standard deviations are larger for SEVIRI, especially for SEVIRI_M08, possibly because the SEVIRI lower-level WV channels are more sensitive to the lower part of the atmosphere according to the weighting function plot in Fig. 2. In addition, the SEVIRI_M08 covers more of the land than the SEVIRI_M11 shown in Fig. 1. The FG departures after bias correction are shown in dashed lines in these plots where all the biases become nearly zero. For the lower-level channel, SEVIRI_M08 (in magenta) has a lower peak. The variational bias correction performs reasonably well in correcting the biases for these four different instruments.

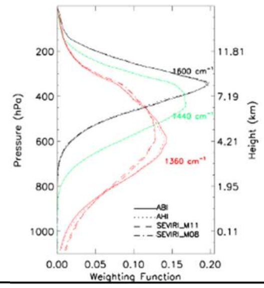

Figure 2. Weighting functions of the WV channels from the instruments ABI_G16, AHI, SEVIRI_M11 and SEVIRI_M08.

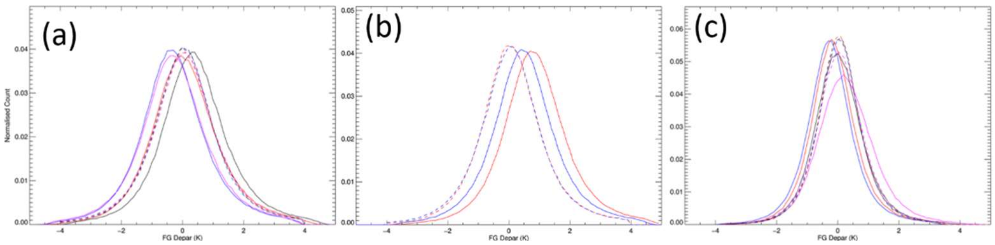

Figure 3. (a) Normalized histogram plot of the FG departure for channel 8 from the ABI_G16 in red, AHI_Himawari8 in blue, and channel 5 from the SEVIRI_M08 in magenta and SEVIRI_M11 in black. The solid and dashed curves are before and after the bias correction. (b) the same for channel 9 from ABI_G16 and AHI_Himawari8. (c) the same for channel 10 from ABI_G16 and AHI_Himawari8 and channel 5 from the SEVIRI_M08 and SEVIRI_M11.

3. Assimilation Experiment Configuration and Results

A set of parallel experiments were performed utilizing the Gridpoint Statistical Interpolation's hybrid 4DEnVar in NCEP's Global FV3GFS Data Assimilation System (GDAS), with the operational configuration at a reduced resolution of C384 for the deterministic component and at the C192 for the 80 ensemble members, covering the period of April 23 to June 30, 2019. The first week of the experiments was used to spin up the bias correction coefficients which are initialized from zero. The months of May and June were used for verification to evaluate the additional CSR data impact on the global analysis and forecast skill. The CSR data from the WV channels on the ABI_G16, AHI_H08 and SEVIRI_M08 were assimilated in the experiment while they were passively monitored in the control run. The assigned observation errors were estimated from the globally averaged Observation minus Forecast statistics. Figure 4(a) shows the relative humidity (RH) analysis increment root-mean-square (RMS) error is reduced by assimilating additional CSR data, which implies improvement in the first guess relative humidity fields. This is consistent with more Microwave Humidity Sensor (MHS) data on Metop-A being assimilated for most of the cycles, as shown in Fig. 4(b).

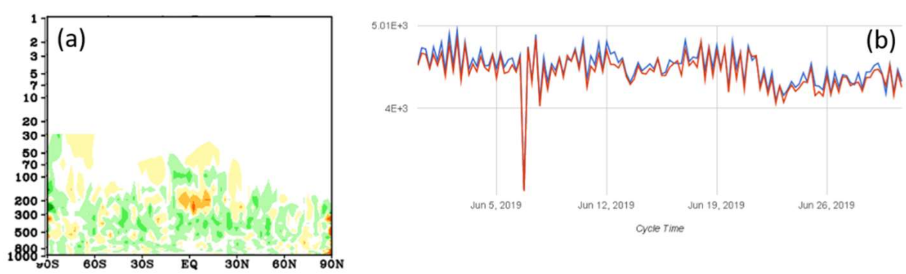

Figure 4. (a) Differences of the RH analysis increment RMS error between the experiment and the control. Green color represents RMS is reduced in the experiment. (b) Time series plot of the assimilated MHS-Metop-A data counts. Blue line is the experiment with additional CSRs assimilated and red is the control.

Acknowledgments

Thanks to Steve Stegall, Sudhir Nadiga and Kate Friedman at NCEP/EMC and Qiang Zhao, Peter Keehn and Tom King at NESDIS for supporting the geostationary CSR real-time BUFR data. Thanks to Yong Chen for providing the weighting function plot. Fanglin Yang and Mary Hart are thanked for proofreading the draft.