Evaluation of GOES-16 Clear-sky Radiance Data and Preliminary Assimilation Results at NCEP

Haixia Liu[1,2], Andrew Collard[1,2], John Derber[3], Sharon Nebuda[4] and James Jung[4]
1. IMSG, Rockville, MD, U.S.A. 2. NCEP/EMC, College Park, MD, U.S.A.
3. NCEP/EMC Retired, U.S.A, 4. CIMSS, University of Wisconsin
Email: Haixia.Liu@noaa.gov

1. ABI_G16 CSR Data

GOES-16 is the first of the GOES-R series of geostationary weather satellites. It became operational on December 18, 2017 – replacing GOES-13 in the GOES-East position centered on the Americas. It provides high temporal and spatial resolution imagery of the Earth through 16 spectral bands at visible and infrared wavelengths, using its Advanced Baseline Imager (ABI). The numerical weather prediction (NWP) community has an interest in using radiances from the water vapor infrared channels. Due to the extremely large data volume at its original pixel level, the Clear-Sky Radiance (CSR) product has been developed at the University of Wisconsin from the 2 km pixels for the infrared channels 7-16. The baseline cloud mask is used to identify clear and cloudy pixels in a 15x15 processing box, then the brightness temperatures (BTs) from the clear pixels are averaged within the processing box. Meanwhile, the percentage of clear pixels and the standard deviation of the BTs from the clear pixels within the processing box are reported as well. These two parameters can be very helpful during the thinning process.

2. Evaluation of the CSR Data and Additional Cloud Detection

The ABI_G16 CSR data quality has been evaluated at the National Centers for Environmental Prediction (NCEP) through studying the statistical characteristics of the CSR data, compared with the simulated model equivalence (OmF) using the operational Global Forecast System (GFS) model. Results have been fed back to the CSR algorithm developers. Several versions of the CSR data have been tested at NCEP/EMC. The most important change during this CSR algorithm development is the cloud mask update from the baseline cloud mask to the so-called enterprise channel dependent cloud mask. A comparison of the OmF statistics from both the baseline and enterprise cloud mask CSRs is shown in Fig. 1 for the window channel. The OmF horizontal maps in Figs. 1 (a) and (b) clearly demonstrate that the enterprise CSR removes more cloudy pixels than does the baseline CSR. Thus, both the OmF bias and standard deviation decrease significantly as shown in the histogram plot of the OmF (Fig. 1c). However, since to the enterprise version of the CSR will not be available in real time for use anytime soon, in order to operationally assimilate the CSR data in real time we have to stay with the baseline CSR. Additional cloud detections need to be performed to remove cloud contaminated data before the assimilation is done. Data from the low peaking water vapor and surface channels are excluded if the clear-sky percentage is smaller than 0.98 or the BT standard deviation from the clear pixels within the processing box is larger than 0.5k. Second, since Channel 14 is more transparent than Channel 15 under clear-sky conditions, opaque clouds can generate smaller BT differences between these two channels than the BT differences from the simulated model equivalences. Fig. 2 shows the OmF from the baseline CSR before and after the above-mentioned additional cloud tests are applied to the window channel. These additional tests remove cloud contaminated data efficiently.

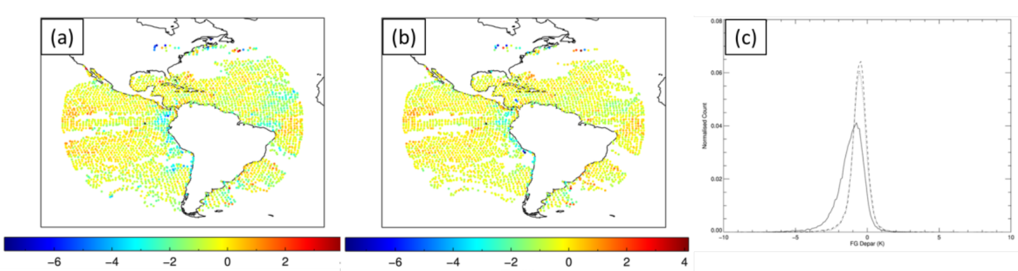

Figure 1. (a) is the BT differences between the baseline CSR data and the simulated model equivalences (OmF) for the window channel. (b) is the same as (a) but for the enterprise CSR data. (c) is the normalized histogram plot of the OmF from the baseline CSR in solid and the enterprise CSR in dashed and dotted lines.

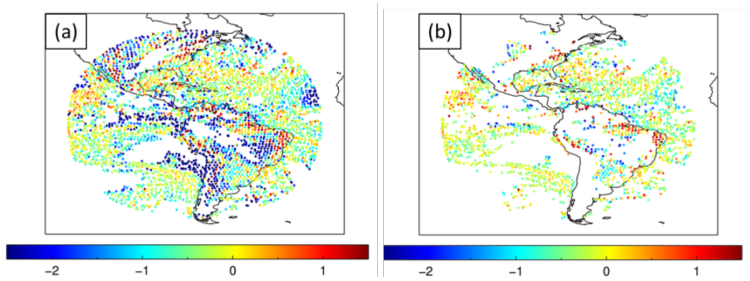

Figure 2. (a) and (b) are the baseline CSR OmF for the window channel before and after the two cloud tests are applied.

3. Preliminary CSR Assimilation Experiments and Results

The impact of the baseline CSR product has been tested in our operational GFS Data Assimilation System (GDAS) utilizing the GSI hybrid 4DEnVar. Two parallel experiments were conducted with the operational configuration at a reduced resolution of T670 for the deterministic component and at T254 resolution for the 80 ensemble members. The experiments cover the period from September 22 through November 8, 2018, with the ABI_G16 CSR data being monitored in the control and actively assimilated in the experiment. Only the three water vapor channels (Channels 8-10) are used over both water and land. Observation errors assigned are 2.4, 2.2 and 2.0 kelvin, respectively. Adaptive bias correction is initiated with zero values. The first week of the experiment is used as the bias correction spin-up period and is excluded from the verification. Fig. 3 shows the normalized OmF histograms of the three water vapor channels before and after bias correction. It appears that Channel 9 has the largest bias, and the lowest water vapor channel, 10, has little bias. The large bias for Channel 9 probably results from errors in the spectral response function or from the process of generating the CRTM coefficients (Emily Liu, personal communication). However, all three channels show good Gaussian shapes in terms of OmF after the bias correction. These preliminary assimilation experiments show neutral impact from the ABI_G16 CSR data. In the future, the ABI_G16 CSR data will be tested together with the SEVIRI CSR from both MSG08 and MSG11 and the AHI CSR from Himawari to have a better global coverage from geostationary instruments.

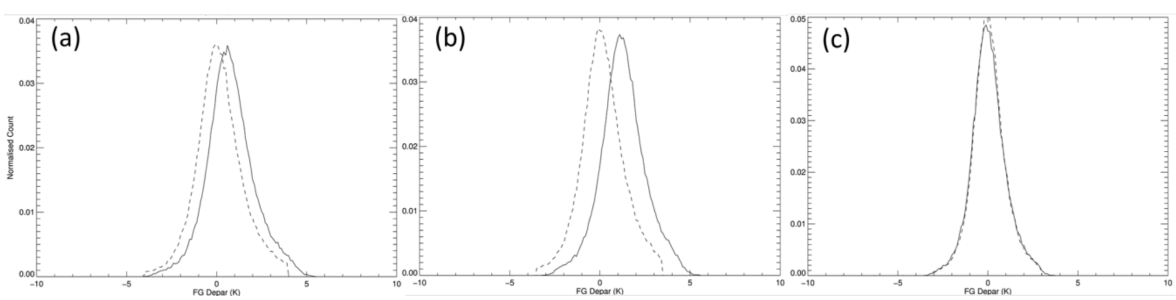

Figure 3. (a) is the normalized histogram plot of the OmF for the channel 8. The solid and dashed curves are before and after the bias correction. (b) and (c) are the same as (a) but for the channels 9 and 10, respectively.

Acknowledgments

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