Evaluation of GOES-16 CSR Data and Preliminary Assimilation Results at NCEP

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1. Introduction

GOES-16 is the first of the GOES-R series of geostationary weather satellites. It became operational on 18 December 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). Table 1 lists the wavelengths of all the 16 spectral bands serving as a quick reference.

chn	Wavelength (μm)	comments
1	0.47	Visible: blue
2	0.64	Visible: red
3	0.86	Near-IR: veggie
4	1.37	Near-IR: cirrus
5	1.6	Near-IR: snow/ice
6	2.2	Near-IR: cloud particle size
7	3.9	IR: short-wave window
8	6.2	IR: upper-level tropospheric water vapor
9	6.9	IR: mid-level tropospheric water vapor
10	7.3	IR: lower-level tropospheric water vapor
11	8.4	IR: cloud-top phase
12	9.6	IR: ozone
13	10.3	IR: clean longwave window
14	11.2	IR: longwave window
15	12.3	IR: longwave window
16	13.3	IR: CO2 longwave infrared

2. ABI_G16 CSR Data

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 the clear pixels (rclrsky) and the standard deviation (stdev) 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. Fig. 1 shows the impact of using these two parameters during the thinning process.

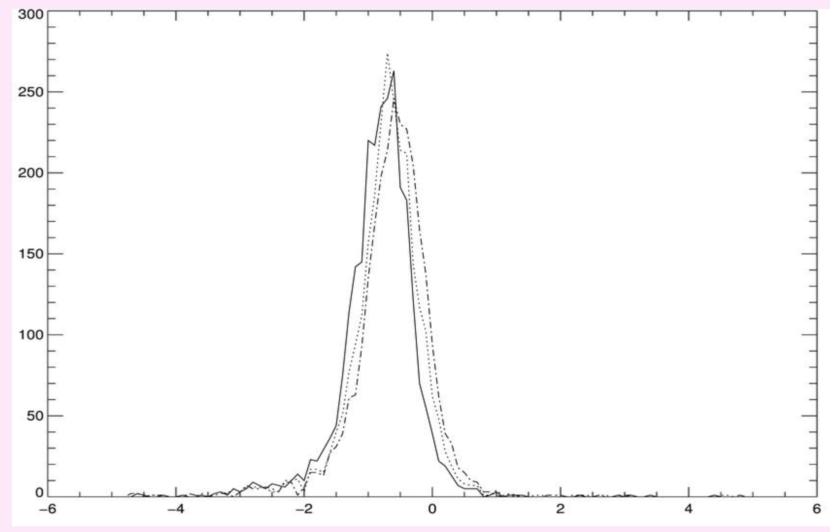


Fig. 1 OmF histogram plot for the channel 13. The solid line is for all the data over water after thinning and the dotted line uses the rclrsky during the thinning while the dot dashed line uses both rclrsky and stdev during the thinning.

3. Evaluation of the CSR Data and Quality Control

The ABI_G16 CSR data quality has been evaluated 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. 2 for the window channel, which clearly demonstrates that the Enterprise CSR removes more cloudy pixels than does the Baseline CSR. Thus, both the OmF bias and standard deviation decrease significantly for the window channel as shown in the histogram plot of the OmF (Fig. 3d). For the water vapor channels, the OmF biases from the Enterprise CSRs move to the positive side compared to those from the Baseline CSRs (Fig. 3a-c).

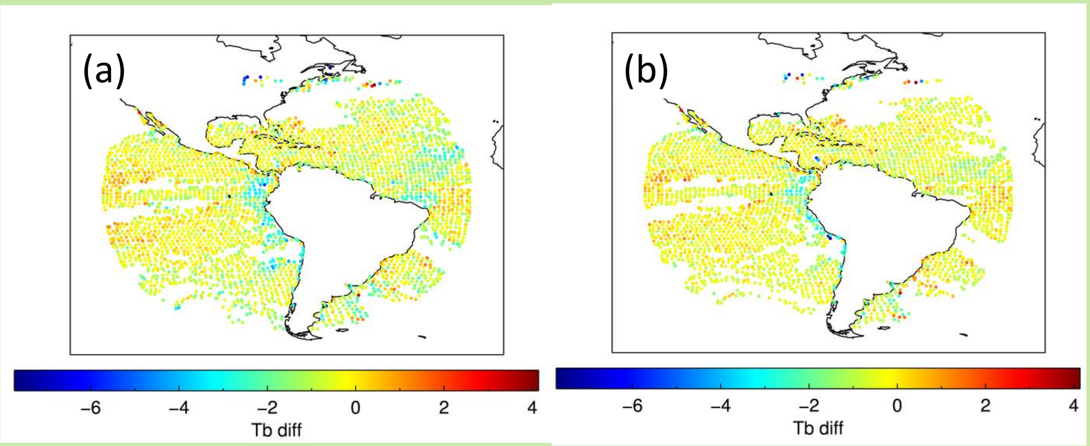
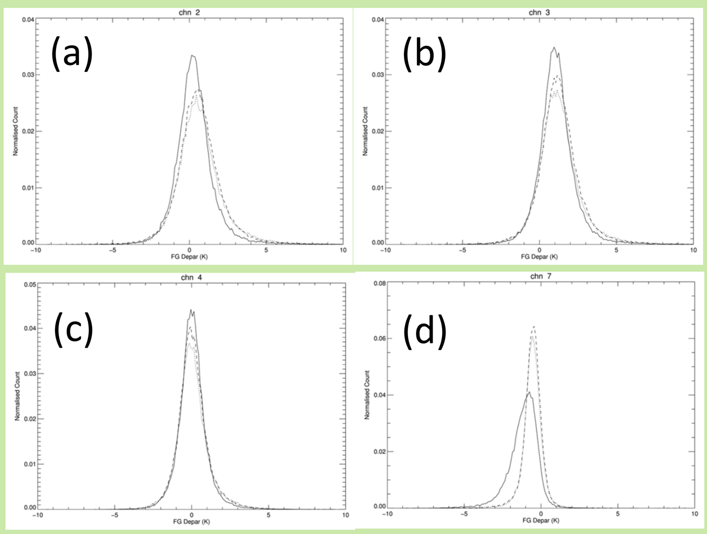


Fig2. (a) is the BT differences between the baseline CSR data and the simulated model equivalences (OmF) for the window channel. (b) is the same as (a) but for the enterprise CSR data.

Fig. 3 shows the normalized histogram plots of the OmF from the baseline CSR in solid , the enterprise CSR in dashed and the updated Enterprise CSR in dotted line for the three water vapor channels (a), (b), (c) and the window channel (d).



However, due to the Enterprise version of the CSR still not being 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 (Fig. 4b). 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. 5). These additional cloud tests remove cloud contaminated data efficiently.

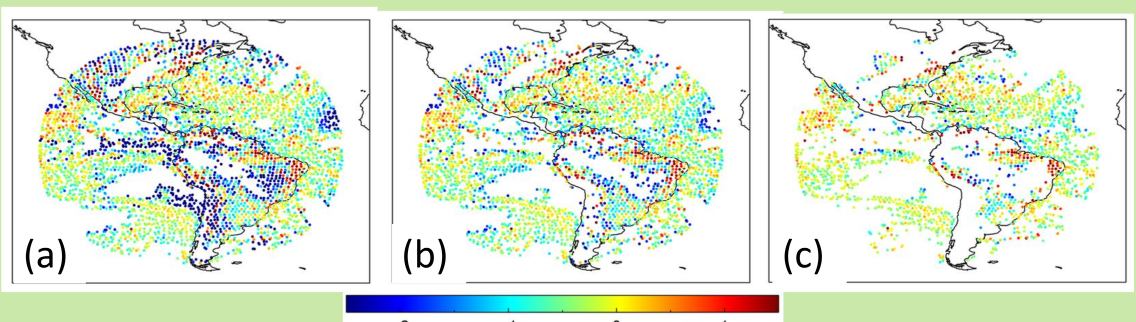


***Fig. 4.** shows the baseline CSR OmF for the window channel. (a) no additional cloud tests, (b) the first cloud test is applied and (c) two additional cloud tests are applied (see text).*

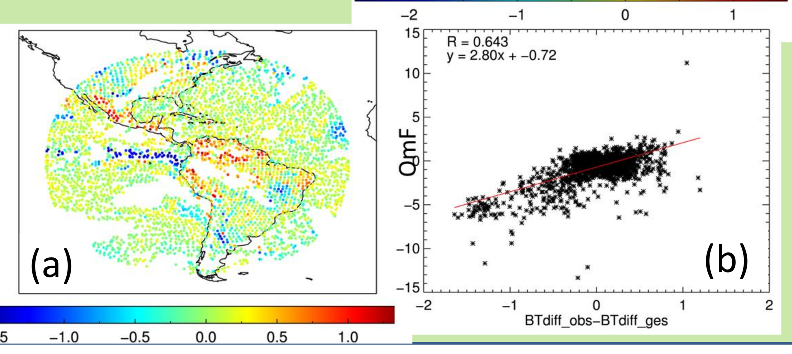


***Fig. 5.** (a) the observation brightness temperature differences (BTdiff_obs) between the channels 14 and 15 minus the model simulated brightness temperature differences between the channels 14 and 15 (BTdiff_ges). (b) scatter plot of BTdiff_obs minus BTdiff_ges (x axis) versus the OmF (y axis).*

4. CSR Assimilation Experiments and Preliminary 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 three water vapor channels (Channels 8-10) are used over both water and land. Observation errors assigned are 2.4K, 2.2K and 2.0K, respectively. Adaptive bias correction is initiated with zero values (Fig. 6). Fig. 7 shows the normalized OmF histograms of the three water vapor channels and the channel 13 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). The first 10 days of the experiments are used as the bias correction spin-up period and excluded from the verification. These preliminary assimilation experiments show neutral impact from the ABI_G16 CSR data when verified against their own analyses (Fig.8). However, there are some increase on the data count of the MHS_Metop-a observations being assimilated when the ABI_G16 CSR is used (Fig.9).

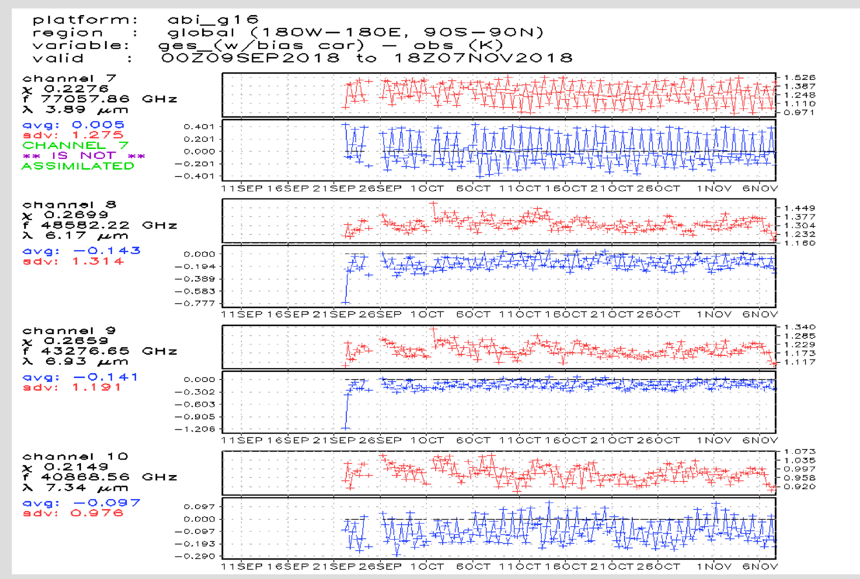


***Fig. 6** shows the time series of the global OmF after the bias correction for the channels 7-10 over the experiment period from Sep. 22 to Nov. 7, 2018.*

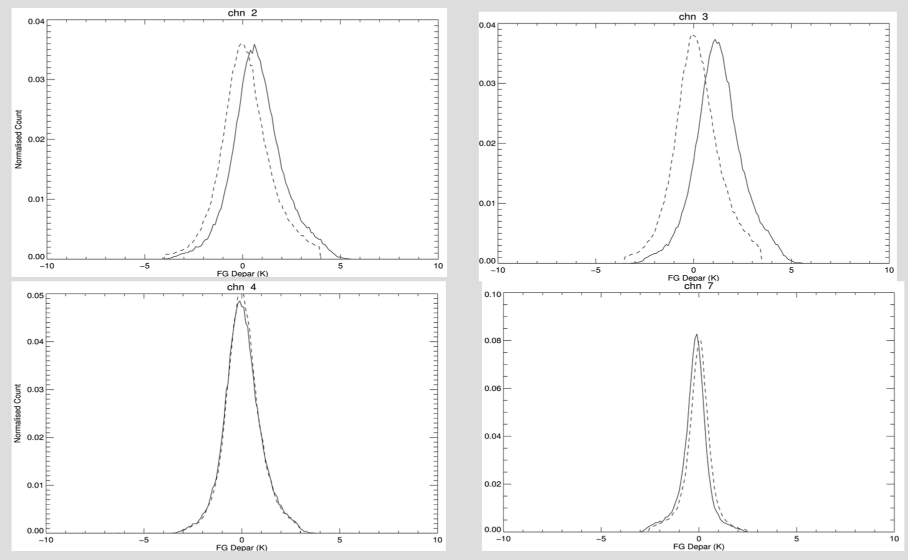


***Fig. 7** shows the normalized histogram plots of the OmF for the channels 8, 9, 10 and 13 (IR channels 2, 3, 4 and 7). The solid and dashed curves are before and after the bias correction.*

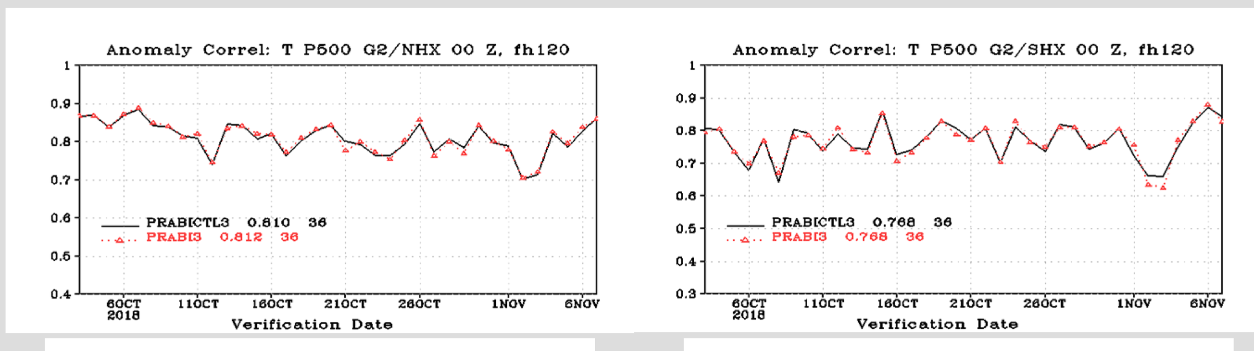


***Fig. 8** shows the time series of the temperature field anomaly correlation score at 500hpa in northern and southern hemispheres, respectively, over the period from October 3 to November 7, 2018.*

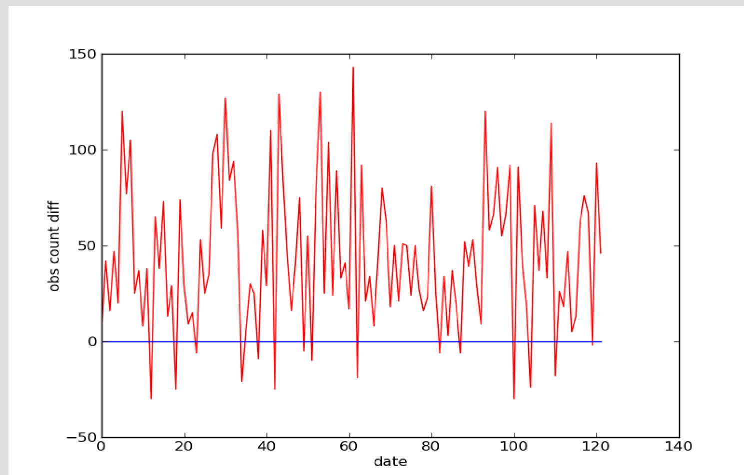


***Fig. 9** shows the time series of the observation count differences between the control and experiment for the MHS_Metop-a for the October assimilation cycles.*

5. Future Plan

The ABI_G16 CSR data will be tested with the NCEP FV3GFS configuration in the future, together with the SEVIRI CSR products from both MSG08 and MSG11 and the AHI CSR from Himawari 8 to have better global coverage from geostationary instruments. The observation errors and thinning box size can be tunable. In addition, The GOES16 All-Sky Radiance (ASR) product will be available and can be tested in the future.

6. Acknowledgements

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