NOAA ROSES Semi-Annual Report

Reporting Period: September 2020 – February 2021 (1st report)

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Project Title: Assimilation of radiance tendency of water vapor bands from geostationary satellites using FV3GFS

Executive Summary (1 paragraph max)

The objective of this project is to investigate a new approach for Assimilating Radiance Tendency (ART) water vapor (WV) observations. These observations are available from the advanced imagers onboard domestic and international Geostationary (GEO) satellites, such as Advanced Baseline Imager (ABI) on the GOES-R series, Advanced Himawari Imager (AHI) on Himiwari-8/9, and Advanced Meteorological Imager (AMI) on Geostationary - Korea Multi-Purpose Satellite-2 (GK-2). The advantage for using ART is that it does not require a bias correction, because the radiance tendencies from both observations and background can be considered bias free within a short period of time (i.e. 1 hour). The bias correction, used to remove biases between observations and background for traditional assimilation technique, may reduce or compromise the useful information in the observations. The proposed work will develop the technical methodology, test and assess the impact of ART from domestic and international GEO satellites on global weather forecast skill using a recent version of the FV3GFS that has a 4-D hybrid EnVar data assimilation system.

Progress toward FY20 Milestones and Relevant Findings (with any Figs)

1. Methodology has been developed to calculate the dtb from the ABI/G16 CSR BUFR data. The lat/lon of each radiance observation is used to calculate the east/west (EW) and south/north (SN) viewing angles. From those, the i/j indices can be accurately calculated based on the fact that ABI pixel-to-pixel viewing angle change is 56 μradians in both EW and SN directions. This allows fast dtb calculation. Figure 1 shows an example of the dtb imagery of the three ABI WV bands. Overall the temporal change within an hour is small for the full disk. However, some areas see significant increase/decrease in the brightness temperature. These are likely due to the different air mass moving in/out of the area. Assimilating these information should help better simulate the boundaries of different air mass in NWP models. It is found that some time steps may have data missing in the CSR BUFR files. In situations like that, dtb from 10 minutes earlier or later will be used instead. Figure 2 shows that the dtb has little temporal variations within 10 minutes.

2. FV3GFS v15.2 does not have the capability to assimilate ABI. The relevant code segment in V16 was ported into v15.2. A two-week spin-up of the bias correction for all three ABI water vapor channels was conducted starting from 0 using smaller observational weights for the time period 00z 15 May – 18z 31 May 2020. A second run was conducted for 6 weeks for the time period 00z 15 May – 18z 30 June 2020 using observational weights obtained from the V16 parallel run. The first two weeks were for fine tuning of the bias correction coefficients. The control run spanned 4 weeks from 00z 1 June -18z 30 June 2020.

3. A machine learning based quality control scheme is developed to screen out surface contamination. Simulation studies show that the QC retains more than 99% of surface

uncontaminated WV radiances from bands 8 and 9, and more than 95% from band 10. And more than 94%, 86%, and 42% of the surface contaminated WV radiances with surface contamination smaller than noise are retained for band 8, 9, and 10. Only 0.08%, 0.25%, and 0.18% of those passed the QC have surface contaminations larger than noise. Besides, of all the WV radiances passed the QC but with surface contaminations, band 8 has 96.2% of the samples with surface contributions less than 10% of the noise, band 9 has 95.8%, and band 10 has 98.2%. These results indicate that the ABI WV radiances passed the QC, even with surface contamination, have small chance of substantial or large surface contamination. The QC is applied to the real ABI/GOES-16 data. It is found that the QC is effective in removing the cloud contaminated radiances as well. That is likely because the QC was developed with clear sky radiances only.

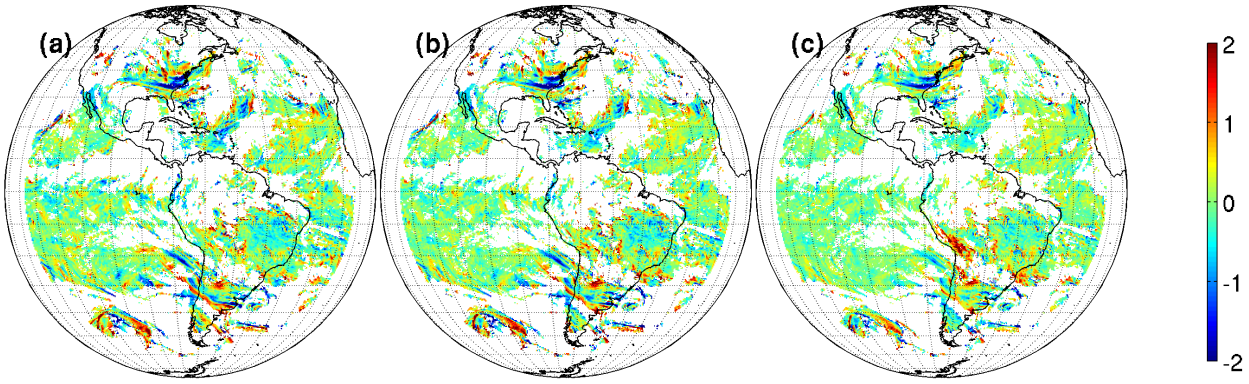

Figure 1. The dtb imagery of (a) band 8, (b) band 9, and (c) band 10. The dtb is calculated as the brightness temperature difference between 22 and 21 UTC (former minus the latter) on May 31, 2020. Only clear percentages of both times greater than 10% is retained. The dtb has a slightly reduced spatial coverage when compared with both time steps, about 89 % remained.

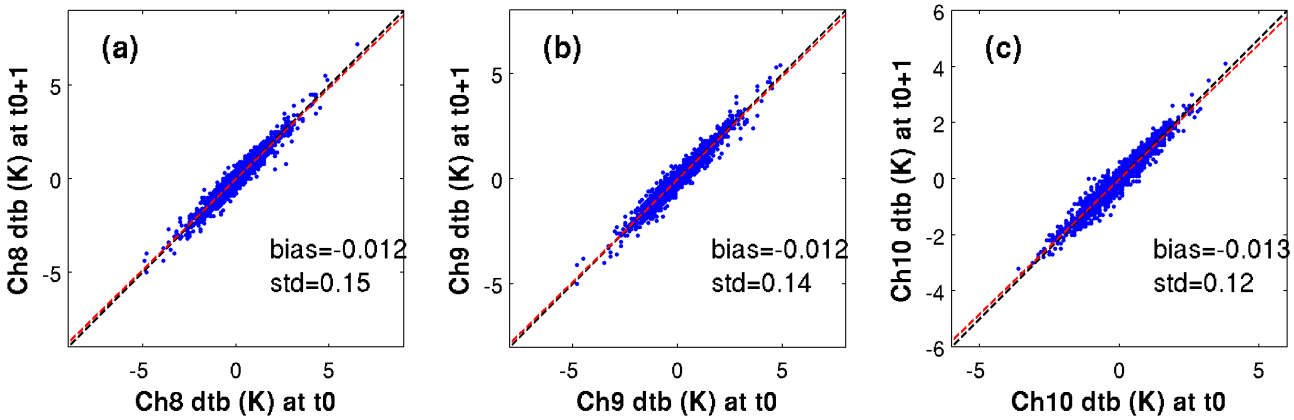

Figure 2. The scatter plot of dtb for (a) band 8, (b) band 9, and (c) band 10 between (x-axis) 21:00/22:00 and (y-axis) 21:10/22:10 UTC. Note that dtb has little temporal variation (close-to-zero bias and small STD) within 10 minutes.

Plans for Next Reporting Period

1. Implement the ART in to FV3GFS
2. Impact study of the machine learning based QC