NOAA ROSES Semi-Annual 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 water vapor observations. These observations are available from the advanced imagers onboard domestic and international geostationary satellites, such as Advanced Baseline Imager (ABI) on the GOES-R series, Advanced Himawari Imager on Himiwari-8/9, and Advanced Meteorological Imager on Geostationary - Korea Multi-Purpose Satellite-2. The advantage assimilating radiance tendency 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 techniques, may reduce or compromise the useful information in the observations. The proposed work will develop the water tendency assimilation methodology and assess its effectiveness using a recent version of the Finite-Volume Cubed-Sphere dynamical core Global Forecast System (FV3GFS).

Progress toward FY21 Milestones and Relevant Findings (with any Figs)

1. Table 1 summarizes the setup used for the assimilation experiments that are analyzed in this report. The control (CTRL) used the setup adopted from NCEP and assimilates the ABI clear sky radiances (CSR) from bands 8 and 10. The observational errors used to weight the observations are 3, 2.5 and 2.2K for band 8, 9 and 10 respectively. Various tendency assimilation experiments were conducted. The observational errors used in the tendency experiments are scaled from those used in the CTRL. The scaling factors are 1, 0.5, 0.25 and 0.125 for EXP1 - EXP4 respectively. Figure 1a shows the change in root mean square error (rms) and standard deviation of observation – first guess (O-B) and observation – analysis (O-A) for ABI band 8. The absolute values of O-B from each experiment are binned and rms and standard deviation are calculated for each bin. Change in rms or standard deviation of O-B and O-A for each bin is then determined. A negative rms or standard deviation change indicates an improvement. For the CTRL, improvement comes from absolute O-B larger than 0.65K. For EXP1 - EXP4, this lower bound value is between 0.6 and 0.9K. The upper limit of O-B that resulted in improved O-A is greatly reduced when the observational errors become smaller. This is related to the threshold used to reject observations with large departures from the first guess, also known as the gross check. The current threshold used in the gross check is 3 times the ABI observational errors. In EXP5, we removed the dependency of the gross check threshold from the observational errors. The new thresholds are determined based on the histograms of water vapor tendencies

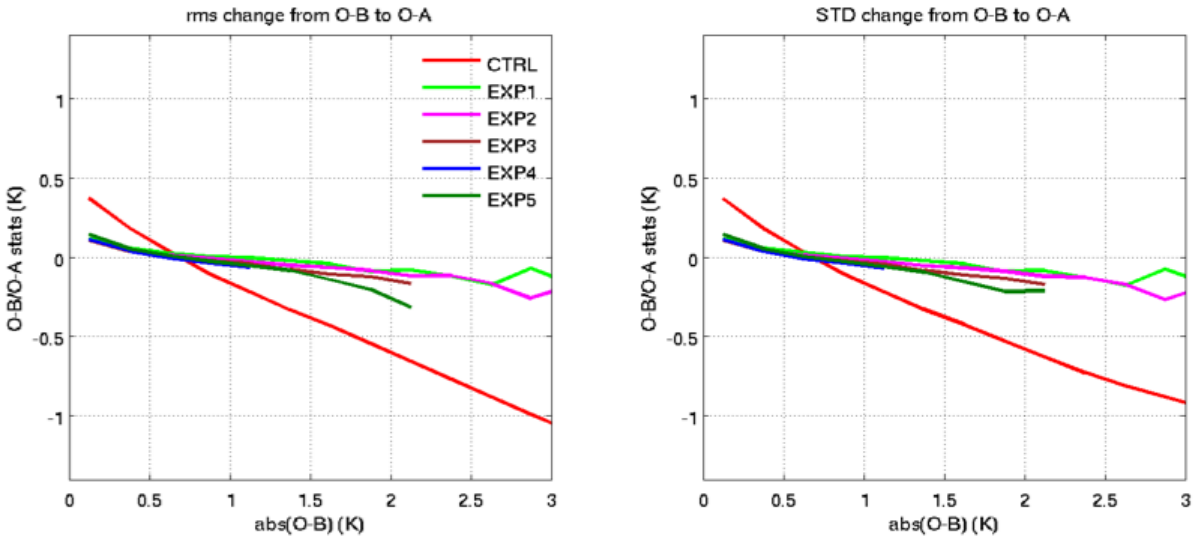
calculated and they are 2.08K, 2.02K and 1.60K for band 8, 9 and 10 respectively. The change in the threshold used by the gross check has enabled the inclusion of larger O-Bs. These O-Bs have improved O-As. Band 10 (Figure 1b) shows a similar pattern.

2. Forecast verification was conducted for EXP1 - EXP4 and compared against the CTRL. Figure 2 shows the global 500hPa geopotential height anomaly correlation. Compared with the CTRL, EXP1 and EXP2 show improved anomaly correlation but are not statistically different. EXP3 and EXP4 do not show similar improvements as EXP1 and EXP2. The rms and STD changes from O-B to O-A is larger for these experiments as shown in Figure 1. This poor performance is probably due to a smaller range of O-B being assimilated due to the gross error check.

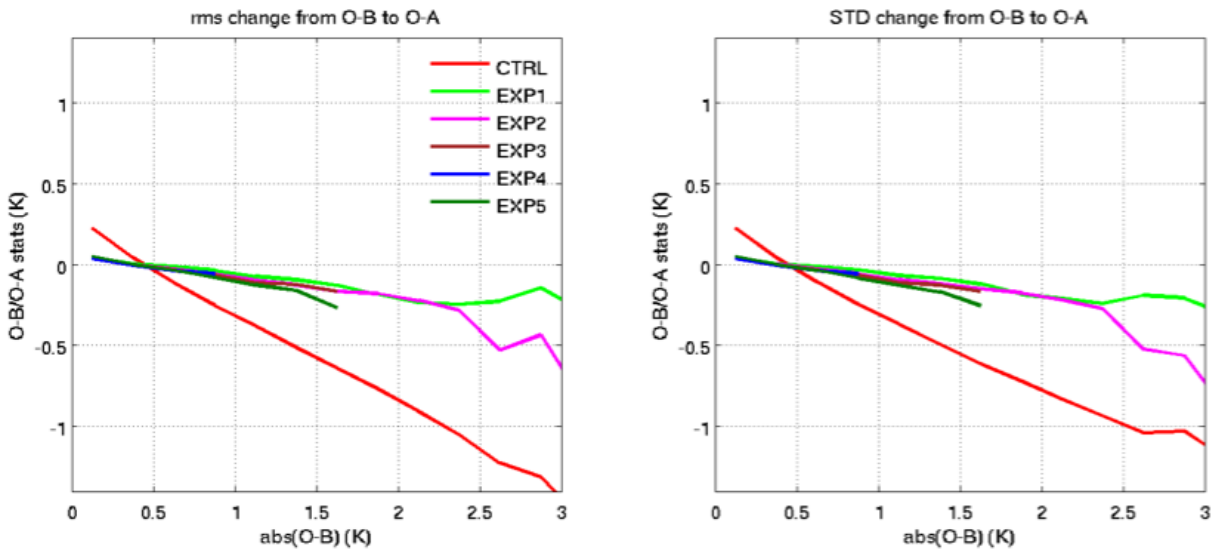
3. The methodology used in the above experiments uses the forecast fields to estimate first guess tendency. Alternatively, analysis from the previous cycle can be used in estimating the first guess tendency. Doing so has the advantage of using a more accurate background for the radiance tendency estimation. The disadvantage is a reduced number of tendency observations. The larger time difference between the two observations used to calculate tendency reduces the chances that the same observation point remains clear at both times. This alternative technique has been developed within the gridpoint statistical interpolation software.

Table 1. Experimental setup for assimilations experiments.

Experiment Name	Observations
CTRL	All existing observations + ABI CSR radiances from bands 8 and 10 (NCEP operational configuration)
EXP1	All existing observations + ABI tendency observations from band 8 to 10 using NCEP's observation weights for ABI CSR
EXP2	Same as Exp 1 but half the observation weights
EXP3	Same as Exp 1 but a quarter the observation weights
EXP4	Same as Exp 1 but one eighth the observation weights
EXP5	Same as Exp 4 but with new threshold used in gross check



(a)



(b)

Figure 1 Change in O-B/O-A (left) RMS and (right) STD for (a) ABI band 8 and (b) ABI band 10. CTRL is the operational setup. EXP1 through EXP4 assimilate ABI water vapor tendencies with observational errors scaled from the CTRL. The scaling factors for EXP1 throught EXP4 are 1, 0.5, 0.25 and 0.125 respectively. In EXP1 through EXP4, the threshold use in the gross check to reject observations with large departures from first guess is three times the ABI observational error. EXP5 has the same setup as EXP4 except the threshold use in the gross check is based on prescribed values estimated from the histograms of radiance tendency measurements.

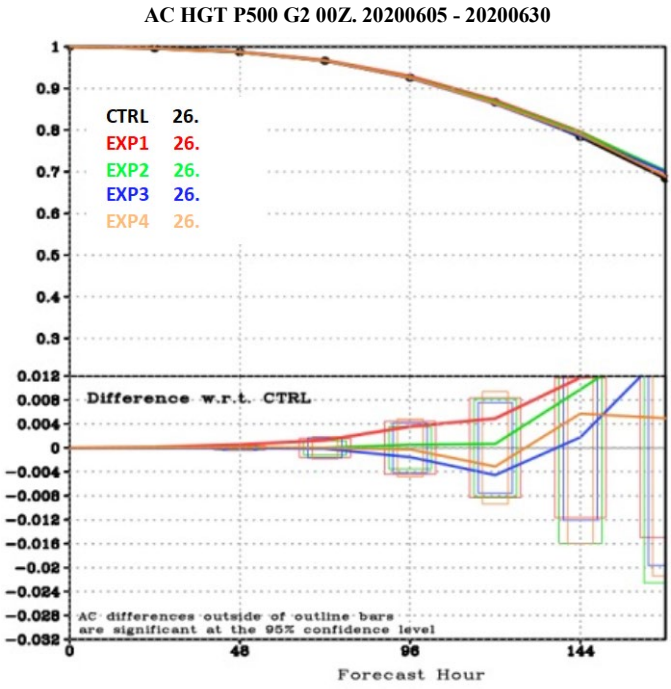


Figure 2. Global 500hPa geopotential height anomaly correlation.

Plans for Next Reporting Period

1. Forecast impact study from EXP5 with option 1. Forecast verification for EXP5 will be conducted and compared with CTRL to assess if assimilating the larger O-Bs allowed by the gross check is beneficial to forecasts.

2. Assimilation experiment using the alternative methodology described above will be performed. It will have the same setup as EXP5. A comparison between the two methodologies using assimilation statistics and forecast will be made.