Overview of Satellite Radiance Data Assimilation in FV3 Regional System

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Introduction

NOAA's new generation Numerical Weather Prediction systems are based on the concept of unifying around the Finite Volume Cubed-Sphere (FV3) dynamical core. The FV3 is used for global NWP and will be for convective-scale applications as well. For convective-scale NWP a limited area version of the FV3 dynamic core is used and is known as the Stand Alone Regional (FV3-SAR). This limited area configuration is poised to underpin the rapidly updated, convection allowing ensemble system in the NCEP production suite as the Rapid Refresh Forecast System (RRFS) in the 2022-2023 timeframe.

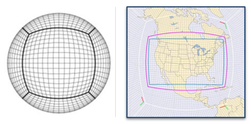
The early phase of testing and development with the 3 km FV3-SAR leverages a configuration similar to the current operational 3 km NAM CONUS nest which features a 6-hour long assimilation cycle, with hourly forecast/analysis components, ending with a free forecast. The assimilation is conducted using a hybrid 3DEnVar method within GSI. The current developmental system assimilates the same satellite radiances as is done with the operational NAM, which features radiances from the following instruments onboard polar orbiting satellites: AMSUA, MHS, IASI, AIRS, ATMS and CrIS. However, observations that feature continuous, low-latency coverage over a high-resolution limited area CONUS domain are of particular importance in the emerging RRFS framework. GOES-16 carries the Advanced Baseline Imager (ABI) which observes Earth with 16 different spectral bands, including two visible channels, four near-infrared channels, and ten infrared channels. ABI Clear Sky Radiance (CSR) data produced from GOES-16 radiance observation have been distributed to the Numerical Weather Prediction (NWP) community by NOAA/NESDIS. In this study, the impact of GOES-16 CSR data assimilation in NOAA's developmental, 3km FV3-SAR system will be investigated.

FV3 Regional System & Assimilate Satellite Data

FV3 Regional Daily Runs

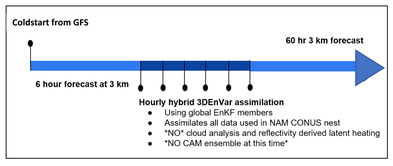
- EMC currently tests FV3-SAR with 3-km grid-spacing and 64L. ICs and lateral boundary conditions are from the GFS. The system is run twice a day at 00Z and 12Z with hourly data assimilation.
- The system currently assimilates both conventional data and satellite radiance data.

FV3 Regional Domains



Domain grid: 1402 x 1194
Model top: 55 km (same as in global FV3)
Vertical levels: 64 (same as in global FV3)

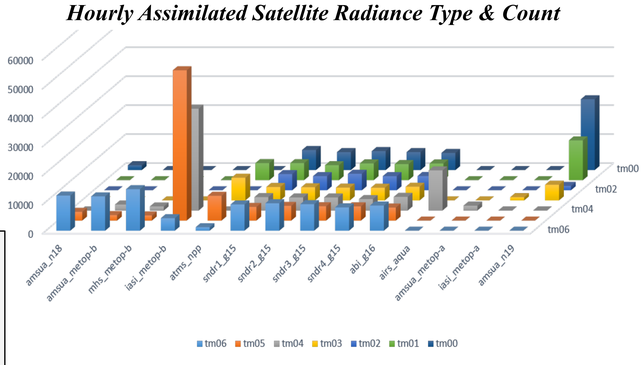
Current DA Testing in FV3-SAR



Radiance Obs Assimilated in FV3-SAR

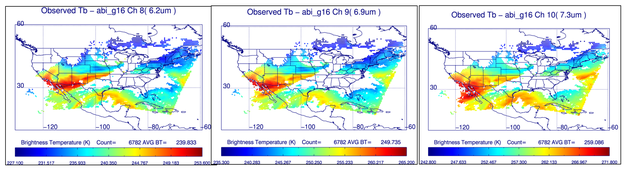
AMSU-A		**MHS**		**Hyperspectral**	
NOAA-15	Channels 1-5,7-10, 12-13, 15	NOAA-18	Channels 1-5	AIRS AQUA	148 Channels
NOAA-18	Channels 1-4,6-7, 10-13, 15	NOAA-19	Channels 1-2,4-5	IASI METOP-A	165 Channels
NOAA-19	Channels 1-6, 9-13, 15	METOP-A	Channels 1-5	IASI METOP-B	165 Channels
METOP-A	Channels 1-6, 9-13, 15	METOP-B	Channels 1-5	NPP CrIS	84 Channels
METOP-B	Channels 8-13	**Geo Sounder &Imager**		NOAA-20 CrIS	84 Channels
AQUA	Channels 6, 8-13	GOES-15	Channels 1-15	**AVHRR**	
ATMS		GOES-16	Channels 8-10	METOP-A	Channels 3-5
NPP	Channels 1-14,16-22	**SSMIS**		NOAA-18	Channels 3-5
NOAA-20	Channels 1-14, 16-22	F17	Channels 1,5-7,24		

Hourly Assimilated Satellite Radiance Type & Count

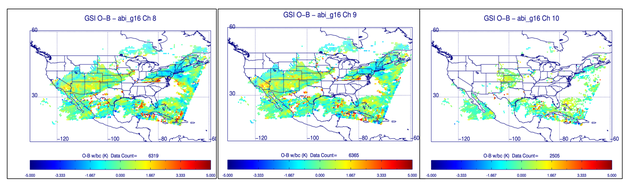


- The regional FV3 test system assimilates the same radiance data as global FV3, but the assimilation frequency is hourly
- Use the radiance data through Regional ATOVS Retransmission Service (RARS) to reduce the data latency
- The bias correction for all satellite instrument are estimated in regional model

Obs of GOES-16 ABI CSR



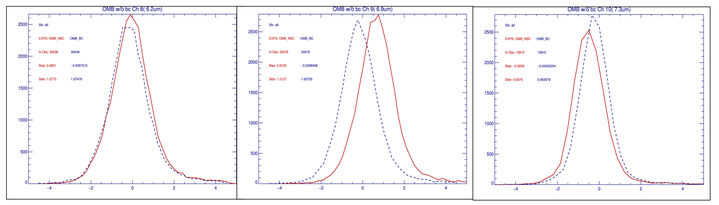
O-B of QC-Passed GOES-16 ABI CSR



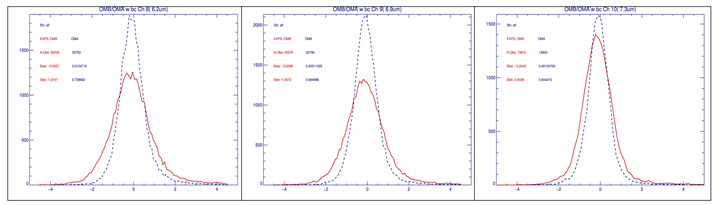
- The GOES-16 ABI CSR product contains averaged brightness temperatures (BT), standard deviations (SDs) of BT and a clear-sky pixel ratio at 10 individual infrared bands. Three water vapor channels cover the wavelength of 6.2-, 6.9-, 7.3-μm .
- Quality control applied to GOES-16 radiance same as in global FV3 includes: data were tossed when
  (1) WV Channels BT SDs >1.3K
  (2) The ratio of clear sky pixels < 70%
  (3) |O-B| > 3.0 x Obs_Error
- Observation error set to 3.0 K as in global system;
- Data thinning box is 30km.
- Bias correction coefficients estimated from regional FV3.
- More details refer to the presentation #4.01 (*Assimilation of infrared Radiance from Geostationary Satellite at NCEP*).

Assimilation of GOES-16 ABI

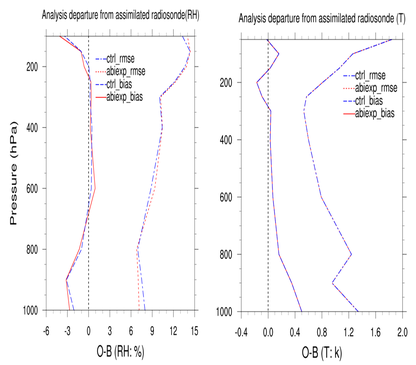
O-B with/without Bias Correction



O-B vs O-A with Bias Correction

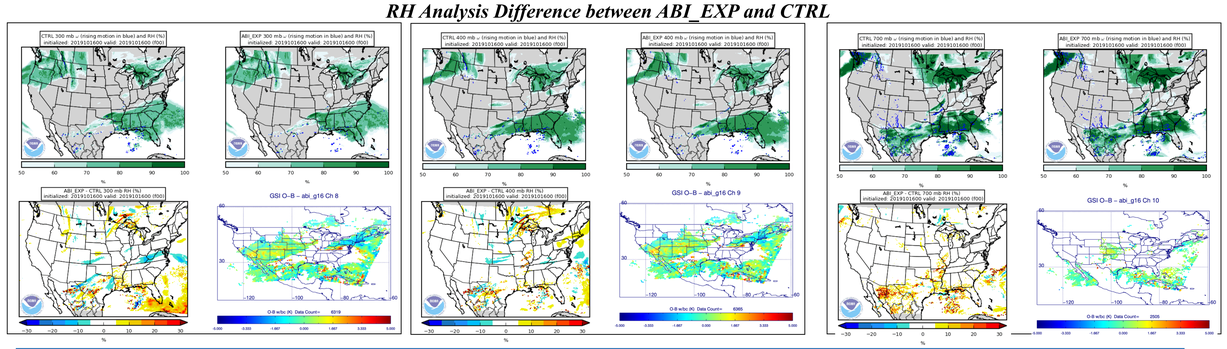


Analysis Fit to Sounding Obs



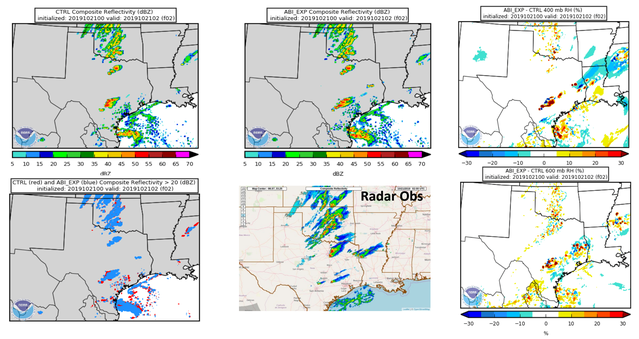
- ***CTRL: Assimilated all data except for GOES-16 ABI data***
- ***ABI_EXP: Assimilated 3 WV channels ABI on top of CTRL***

RH Analysis Difference between ABI_EXP and CTRL

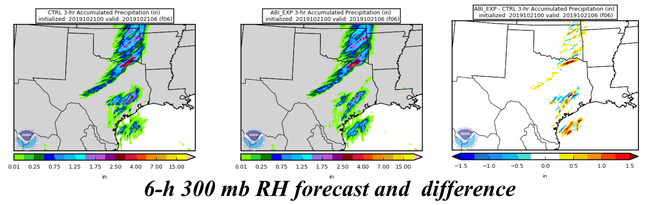


ABI impact on DFW Metro Supercells

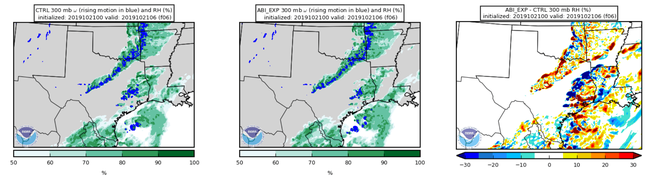
2-h Short-term forecast and difference



3-h Precipitation forecast and difference



6-h 300 mb RH forecast and difference



Summary

- Assimilation of all three water vapor channels from GOES-16 was investigated in NOAA's new generation regional mesoscale data assimilation system (FV3-SAR) with the Hybrid 3DEnVar method within an hourly Rapid Refresh framework.
- To evaluate ABI impacts in FV3-SAR, FG departures of ABI were examined. Comparable reductions of RMS errors in the FG departure were found in the mesoscale model domain, and the bias correction works properly. The 6.9 μm has a larger bias than the other two channels.
- Analysis increments in the water vapor analysis field from ABI CSR data assimilation are shown on the corresponding levels along with associated ABI CSR data coverage. But the analysis fit to radiosonde observations from seven experiments showed a mixed impact.
- The impact of ABI CSR data assimilation have been examined with the forecast of Dallas-Fort Worth Metro supercells happened on October 21, 2019. With ABI, the difference was found in the forecast of precipitation, relative humidity and radar reflectivity associated with the supercell storm. The impact of ABI on longer forecast skill score will be evaluated later.