Development of Aerosol Data Assimilation System at NOAA

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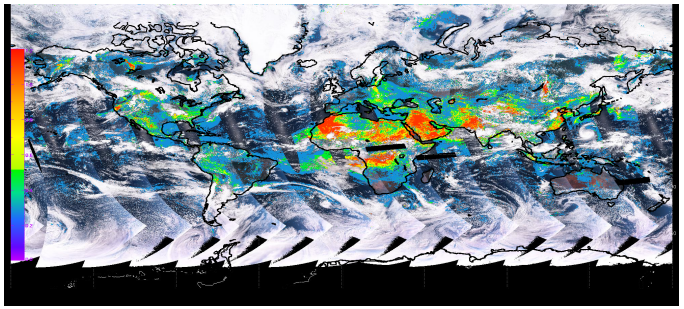
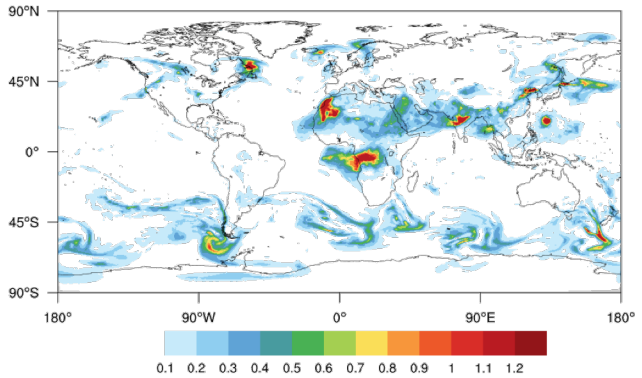
[9]South Dakota State University

- Model:
  - Operational cube-sphere GFS-GOCART aerosols (dust, sea-salt, carbonaceous species, sulphate),
  - Resolution ~100km (C96).

- Data Assimilation:
  - 550 nm Aerosol Optical Depth retrievals from VIIRS,
  - Hybrid Ensemble-Variational approach (20 members),
  - JEDI framework.

AOD 550 nm 20150805



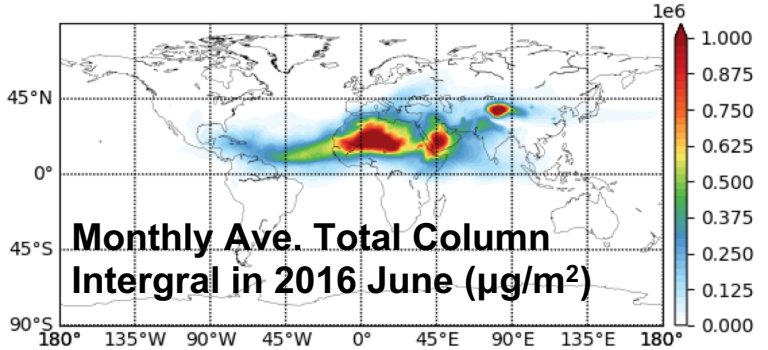


"Development of the National Global Data Assimilation Ensemble-based System for Forecasting of Aerosols"
by Pagowski and Kleist, grant from Weather Program Office, 2019-2022

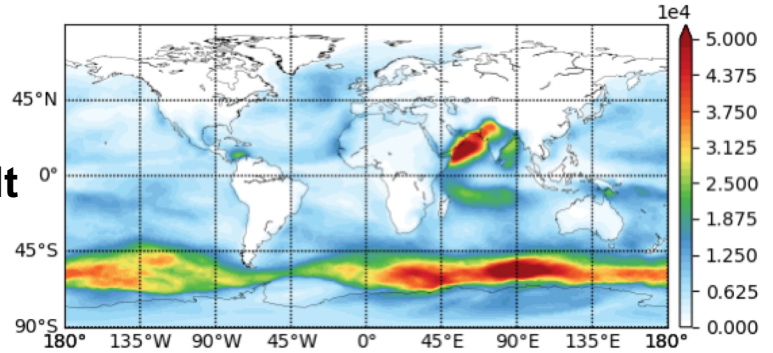
FV3-GFS GOCART Model

- FV3-based GFS coupled with the Goddard Chemistry Aerosol Radiance and Transport (GOCART) aerosol scheme at C96 (~100 km)
  - Dust with five size bins
  - Sea salt with five size bins
  - Hydrophobic and hydrophilic organic and black carbon
  - Sulfate
- Blended Global Biomass Burning Emissions Products (GBBEPx) and Fire Radiative Product (FRP)
- Chemistry coupled with the core meteorological model via NUOPC interface

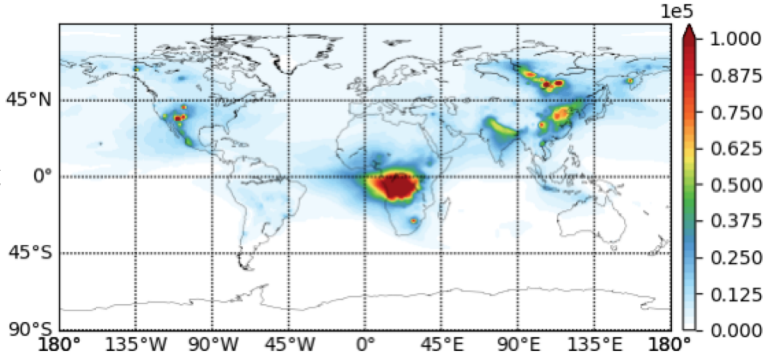
Dust



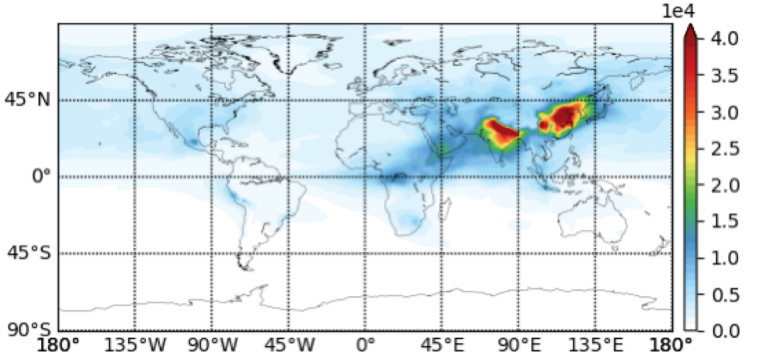
Sea salt



OC+BC

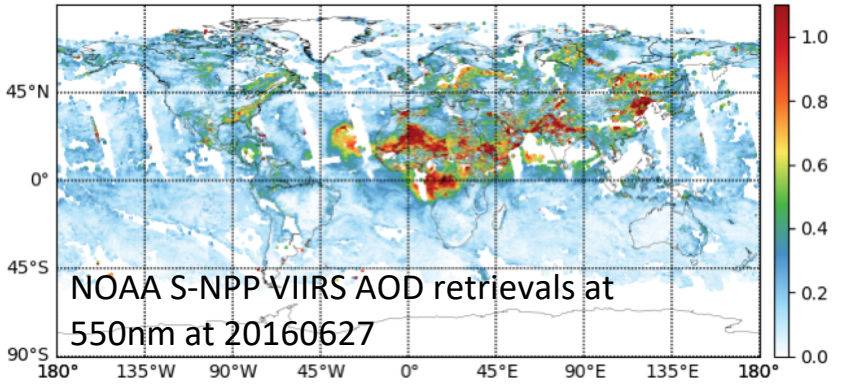


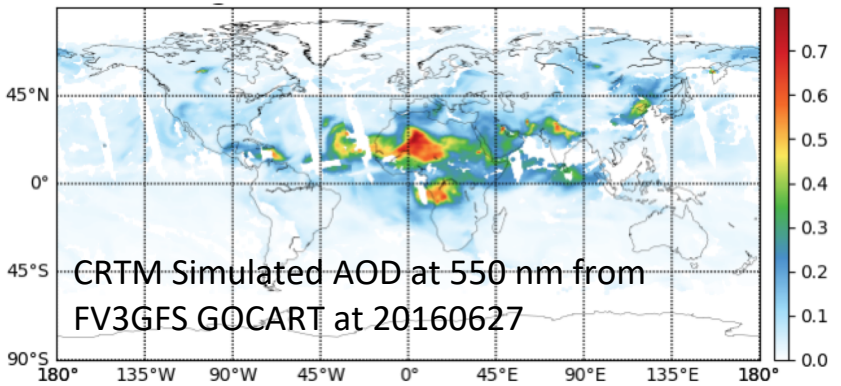
SO_4

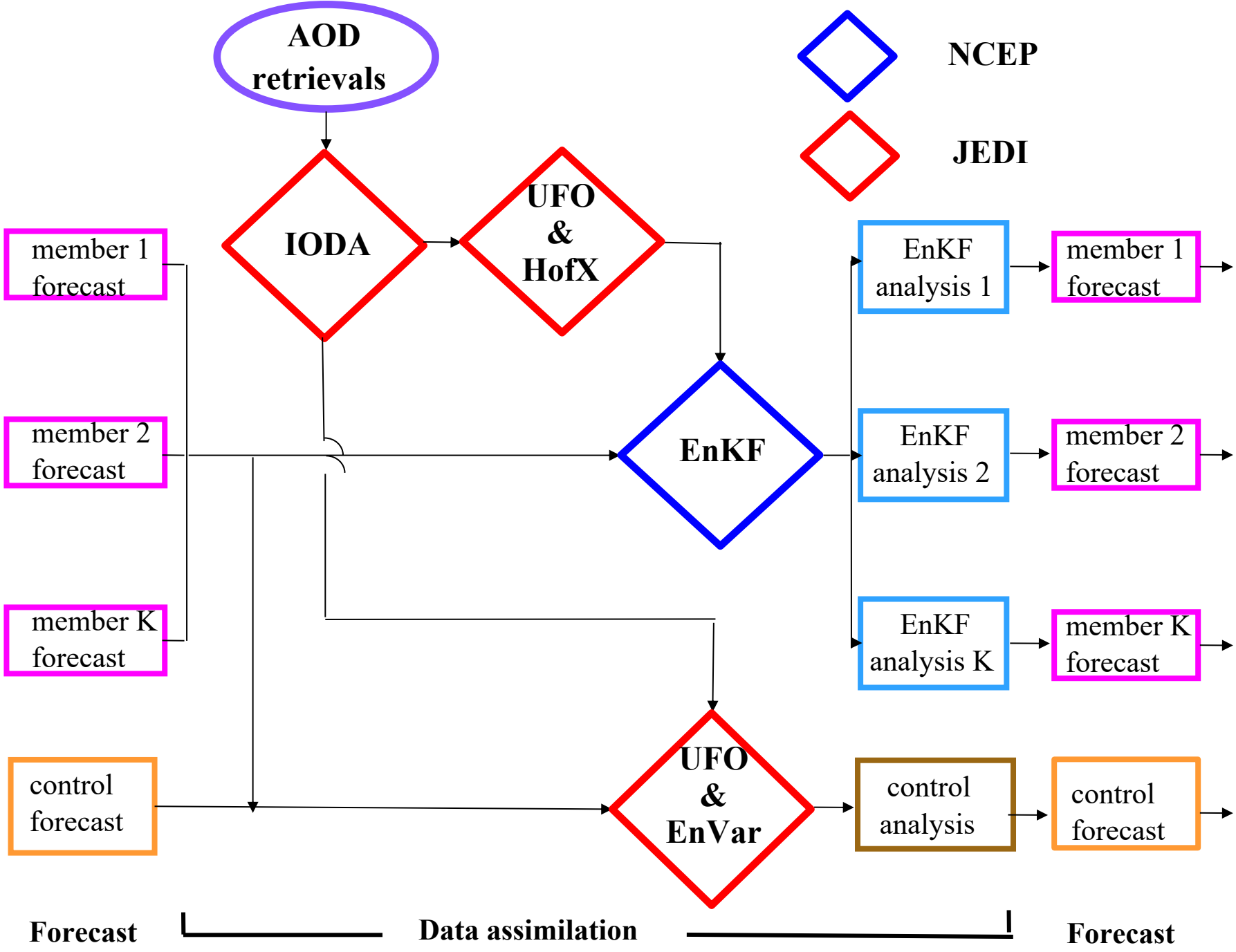


Hybrid Ensemble-Variational Aerosol Data Assimilation System

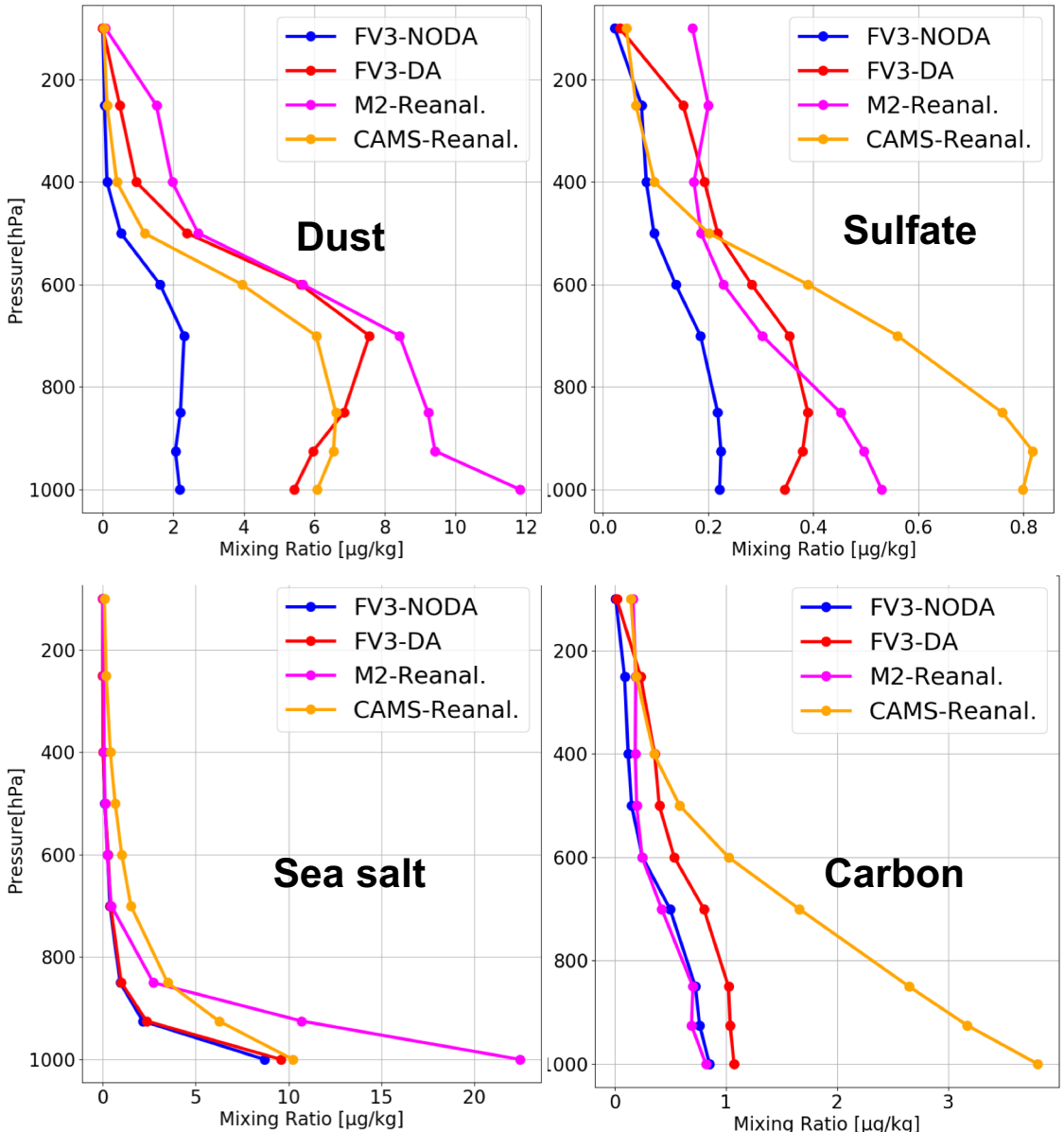
- Data assimilation (DA) combines model forecasts (background) with information from observations to obtain the best estimate of the true state.
- Joint Effort for Data assimilation Integration (JEDI) - the next-generation unified DA system is being developed at JCSDA.
- Developed 3DEnVar ensemble-based DA capability within JEDI for assimilating AOD retrievals to improve global aerosol analyses and forecasts:
  - Thinning of MODIS and VIIRS 550 nm AOD retrievals and formatting in IODA;
  - AOD observation operator using aerosol optical properties in the Community Radiative Transfer Model (CRTM) and included in UFO;
  - FV3-JEDI interface for GOCART aerosols for variational minimization;
  - Modified NCEP's EnKF to operate on native FV3 grid (using until KF's available in JEDI);
  - HofX Forward operator for EnKF;
  - All integrated within NCEP's operational global DA workflow for the future operational application.






AOD retrievals
NCEP
JEDI
IODA
UFO & HofX
member 1 forecast
member 2 forecast
member K forecast
EnKF
EnKF analysis 1
EnKF analysis 2
EnKF analysis K
member 1 forecast
member 2 forecast
member K forecast
control forecast
UFO & EnVar
control analysis
control forecast
Forecast
Data assimilation
Forecast

Monthly and Globally Averaged Mixing Ratio Profiles of Aerosol Species 6-hour Forecasts Comparison with/without AOD DA



FV3-NODA: FV3-GFS GOCART model 6-hour forecasts without AOD DA

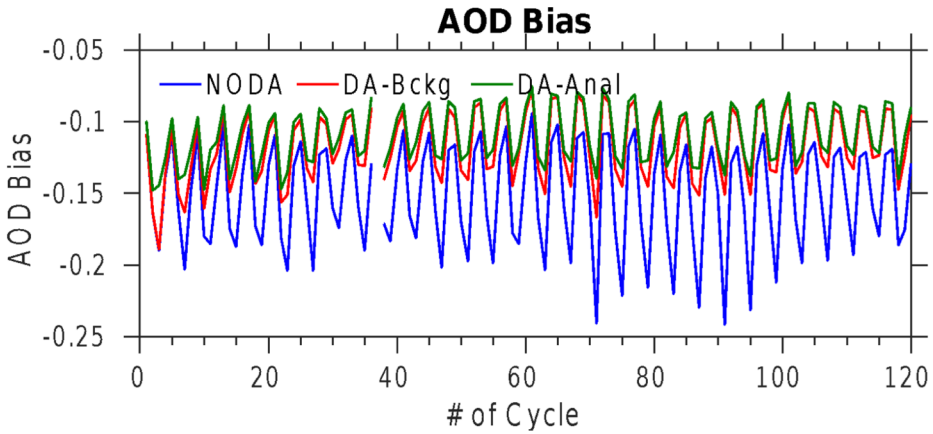
FV3-DA: FV3-GFS GOCART model 6-hour forecasts with AOD DA

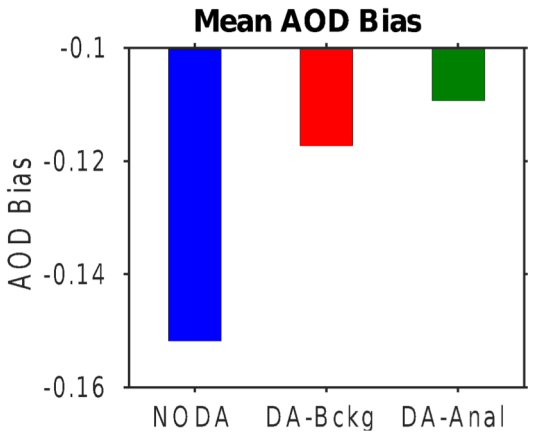
M2/CAMS-Reanal: NASA MERRA-2/ ECMWF CAMSiRA reanalysis

- After AOD assimilation, FV3-DA-Bckg better matchs NASA/EC reanalyses than FV3-NODA for dust and SO4.
- Due to insufficient spread for sea salt, difference between FV3-NODA and FV3-DA-Bckg is relatively small.
- Largely different mixing ratio profiles between NASA and EC reanalyses suggest large uncertainty of aerosol forecasts and DA.

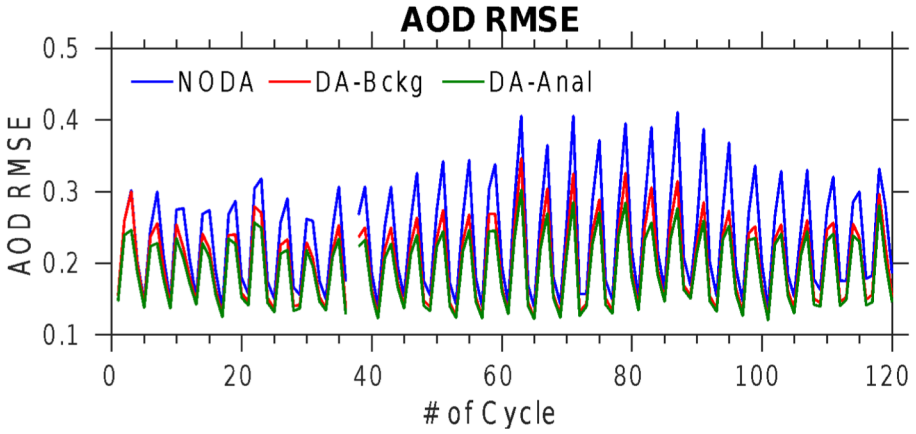
Innovation Statistics of VIIRS AOD at 550nm

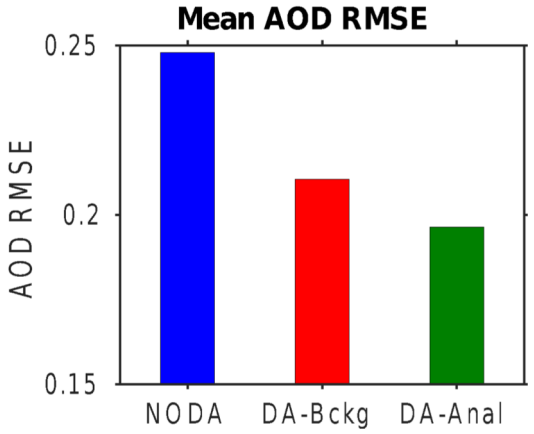
Bias





RMSE

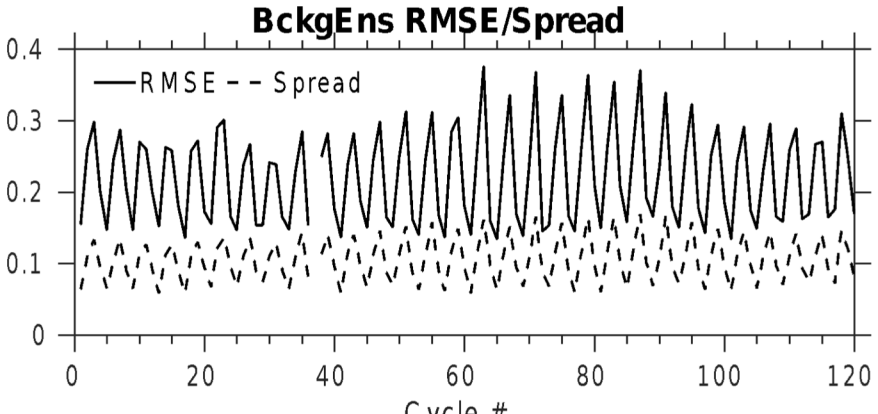




NODA: 6-hour forecasts in exp. without AOD DA.

DA-Bckg /DA-Anal: 6-hour background/Analysis in exp. with AOD DA.

Ens. Bckg. Err /Spread



- Assimilation of AOD at 550nm reduces negative bias and error of simulated AOD at 550nm.
- Insufficient spread in background ensemble.