Using SURFRAD Aerosol Optical Depth Measurements for Model Evaluation.
A Study with FV3-GOCART and WRF-Chem and their Assimilation Systems

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1. AEROSOLS and AOD ASSIMILATION in FV3

- GOCART scheme: 15 species,
- simplified gas to aerosol and aerosol to aerosol conversions,
- emissions from anthropogenic sources,
- wind-driven dust, and seas-salt emissions,
- forest fire emissions from MODIS retrievals with plume rise
- observations are de-biased MODIS AODs at 550 nm from Neural Network Retrieval (NNR) processing,
- Community Radiative Transfer Model (CRTM) calculates AOD,
- 20 ensemble members with perturbed meteorology only,
- Ensemble Kalman Filter (EnKF) calculates increments based on differences between observations and forecasts.
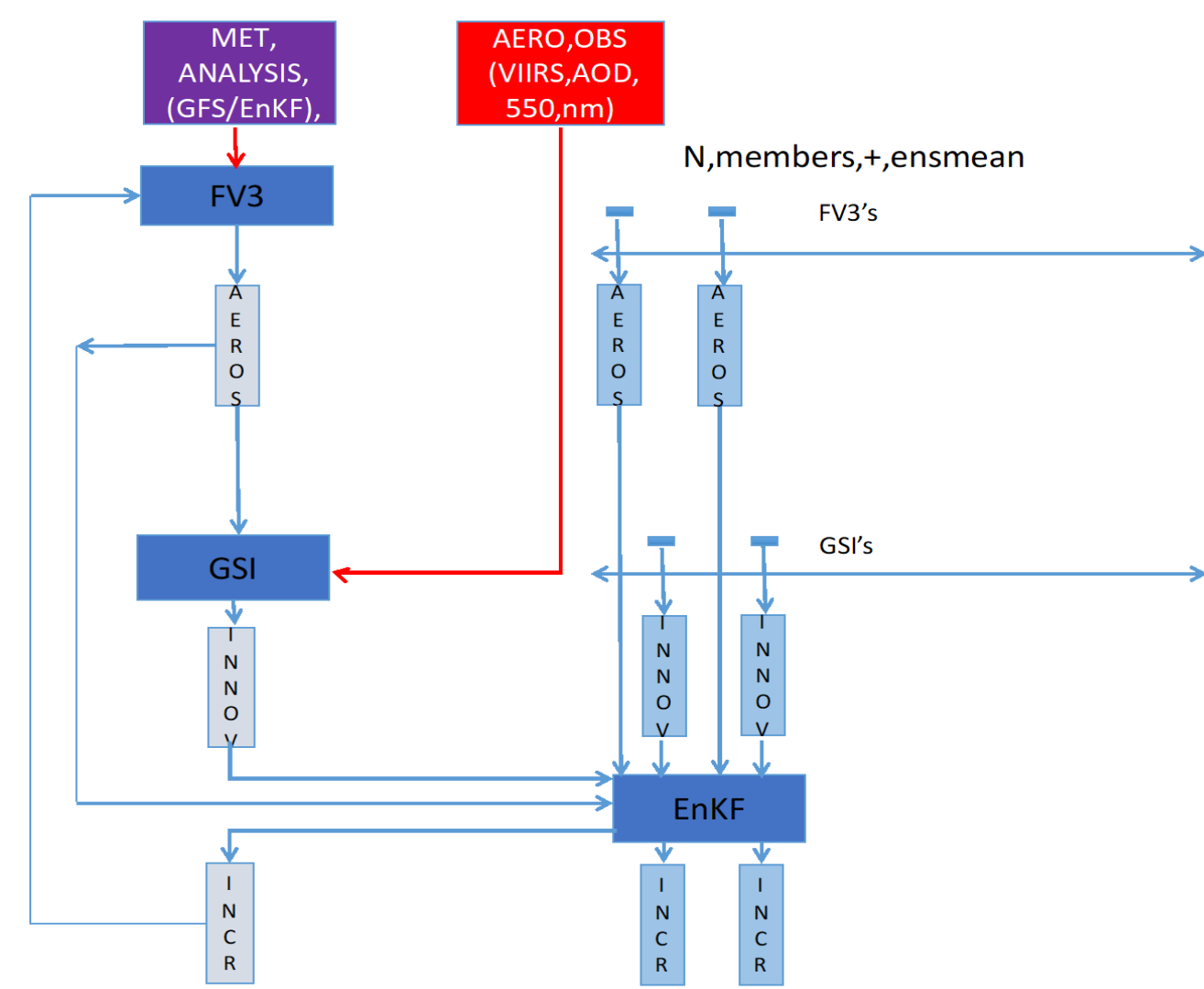

Fig. 1. A simplified schematic of data assimilation procedure: GSI is Gridpoint Statistical Interpolation, EnKF is ensemble Kalman filter. Meteorology is not assimilated but updated from the analyses. AEROS stands for aerosol forecast, INNOV for innovation, INCR for increment.

Fig. 2. Top: composite VIIRS AOD retrieval on 20150805. Bottom: AOD FV3-GOCART free run (left) and EnKF analysis (right) at 2015080512.

2. AEROSOLS and AOD ASSIMILATION in WRF-Chem

- similar to FV3 GOCART chemistry scheme,
- similar emissions except for anthropogenic,
- 3D-Var assimilation of de-biased MODIS AOD with the Gridpoint Statistical Interpolation (GSI).

3. SURFRAD and AERONET

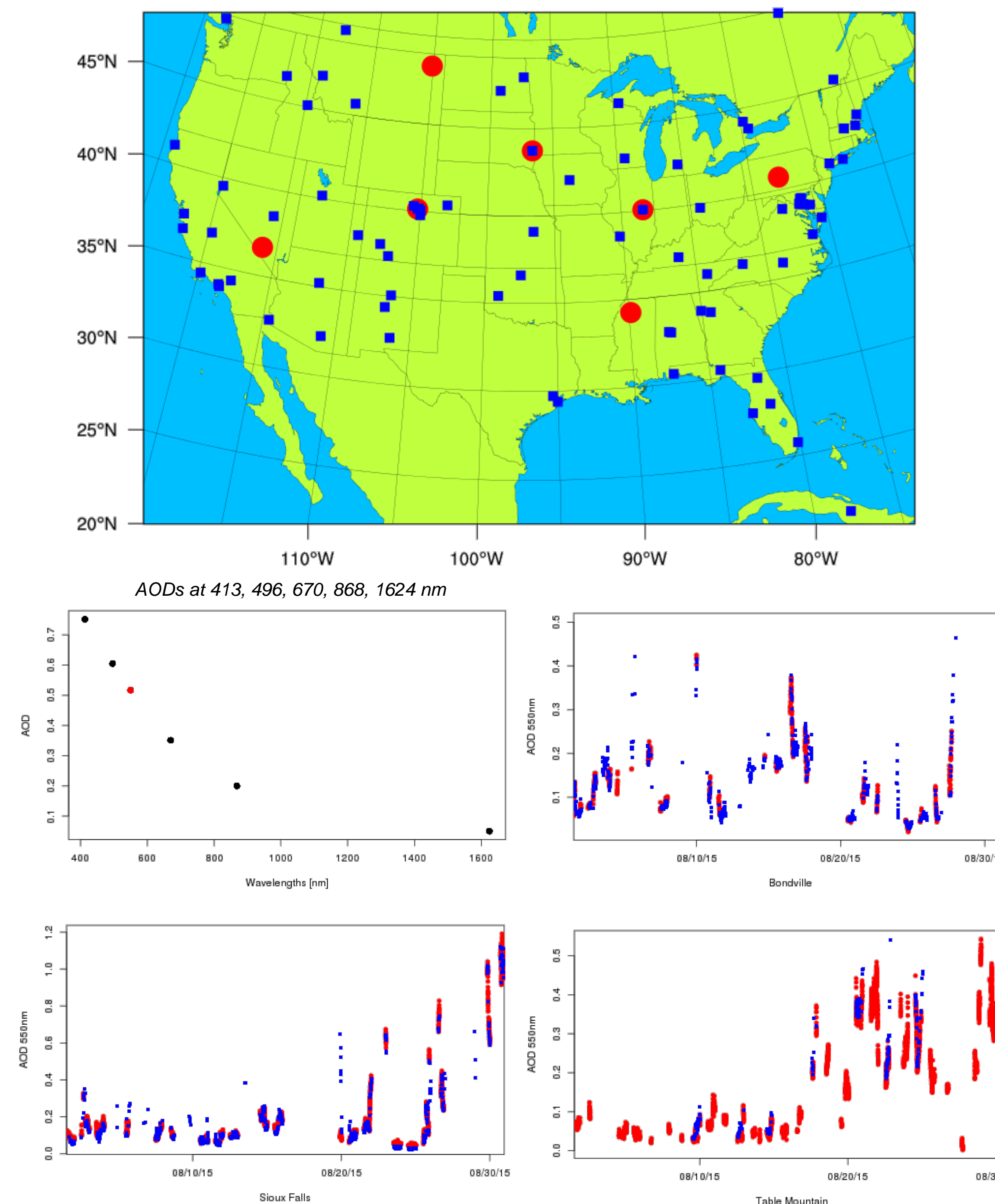AODs at 413, 496, 670, 868, 1624 nm

Fig. 3. Top: SURFRAD and AERONET over North America. Bottom: Tension spline interpolation AOD to 550nm and coincident SURFRAD and AERONET AOD 550nm at Bonville, IL, Sioux Falls, SD, and Table Mountain, CO in August 2015.

NOAA's SURFRAD surface radiation budget (SRB) network consists of seven stations that represent a wide range of climate types across the continental U.S. The network began on 1 Jan. 1995 and continues operation today. Its primary measurements are climate-quality upward and downward shortwave and longwave irradiance. Several ancillary measurements and calculations are made to help interpret the SRB observations, including atmospheric state variables, multispectral aerosol optical depth, spectral albedo, 1-min. hemispheric sky images, interpolated NWS soundings to each station location, and RadFlux products (empirically derived equivalent clear-sky irradiance and other quantities). Soon ceilometers will be installed at all stations.

4. MODEL COMPARISON and STATISTICS
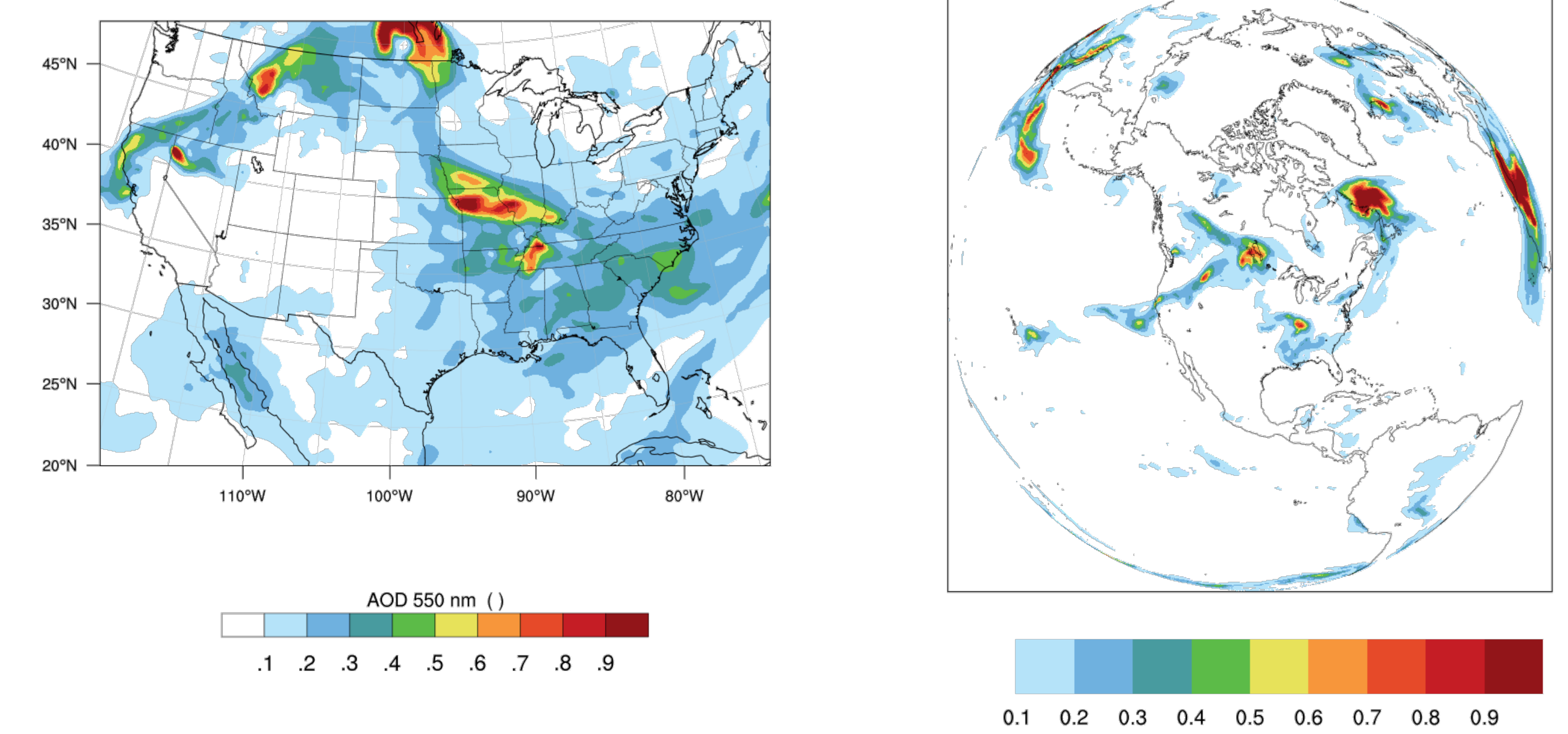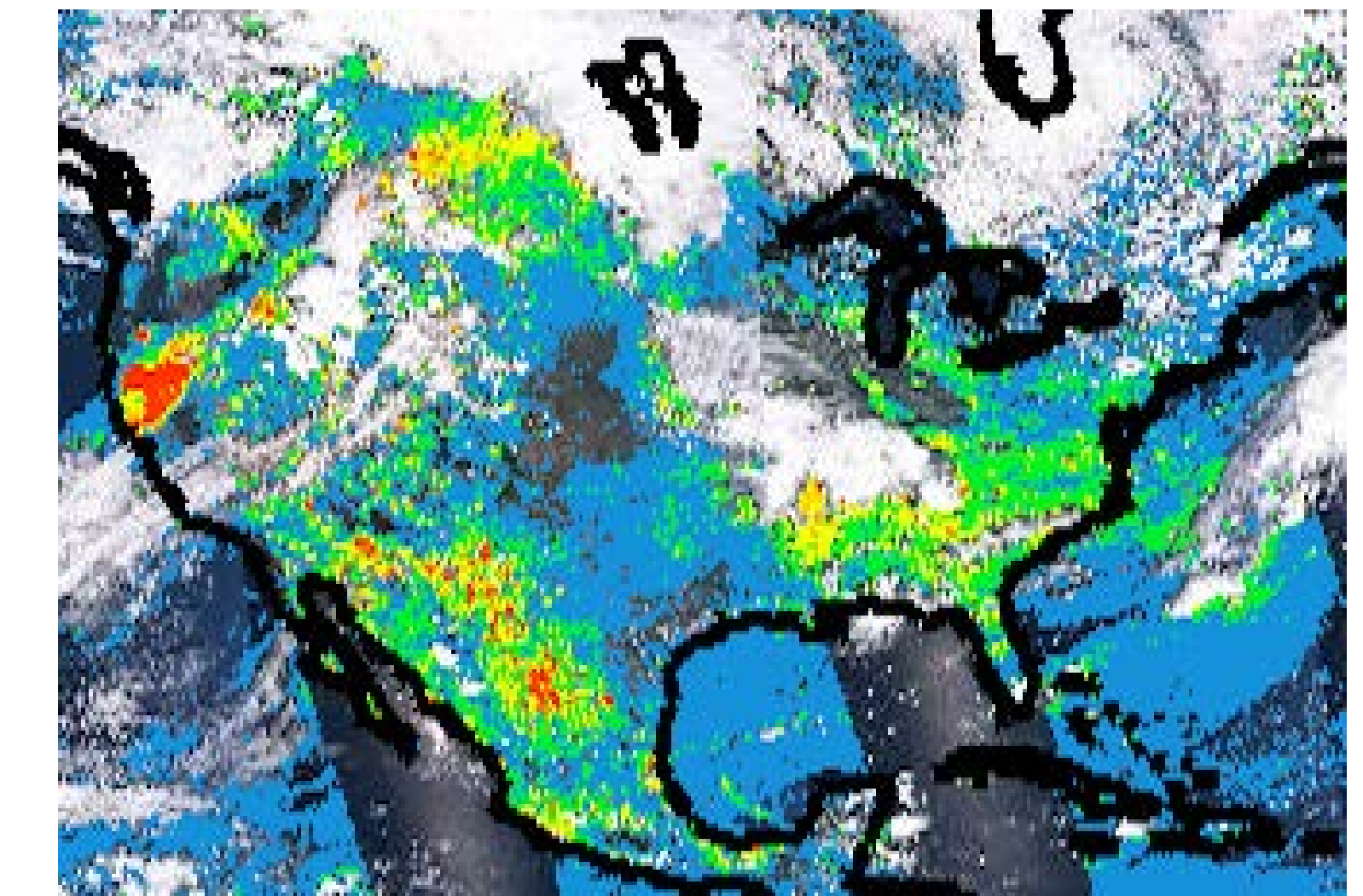

AOD 550 nm ( )

Fig. 4. Top: composite VIIRS AOD retrieval on 20150805. Bottom: AOD WRF-Chem (right) and FV3_GOCART analysis at 2015080518 (MODIS misses fires or VIIRS wrongly "detects" fires ?)
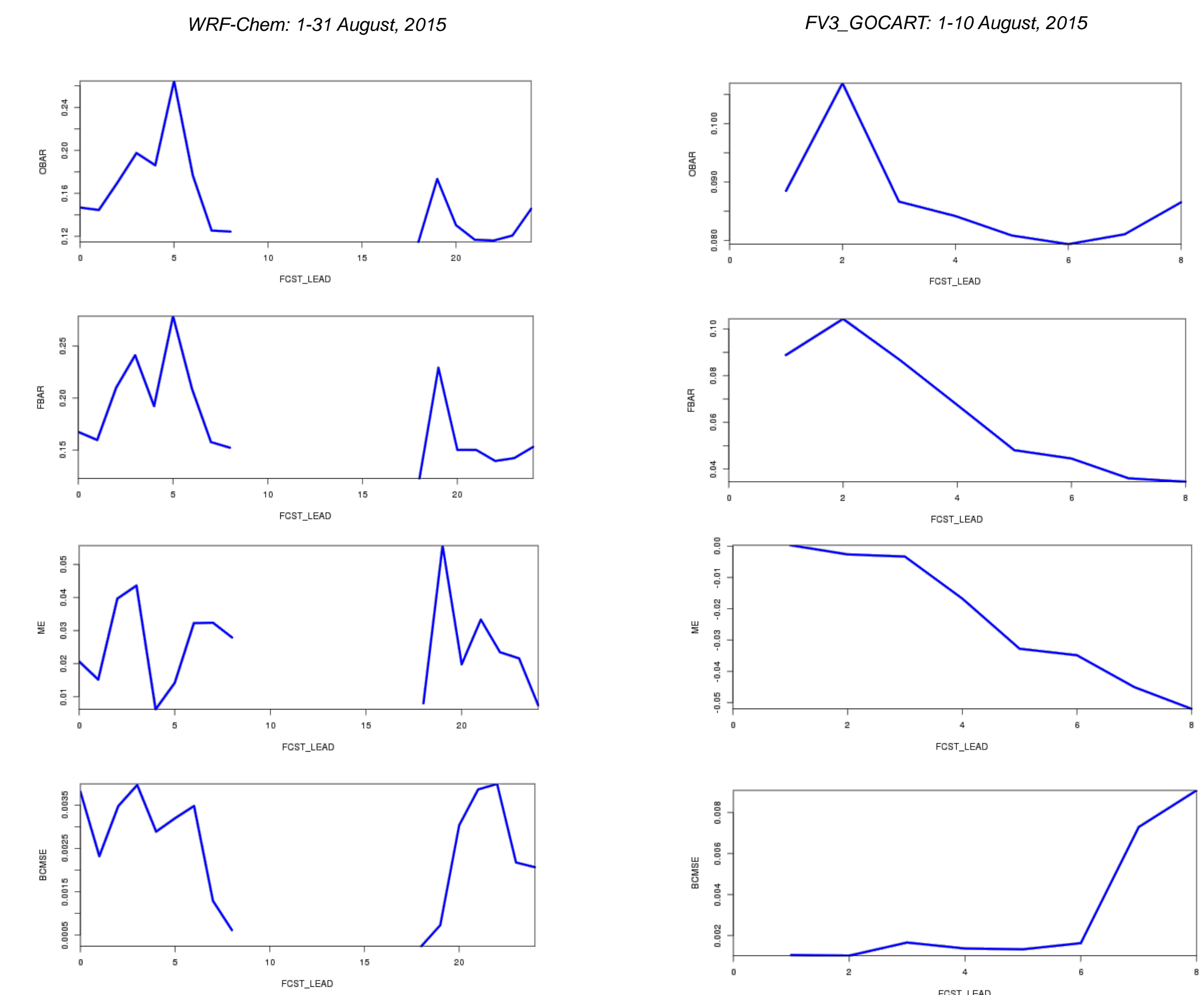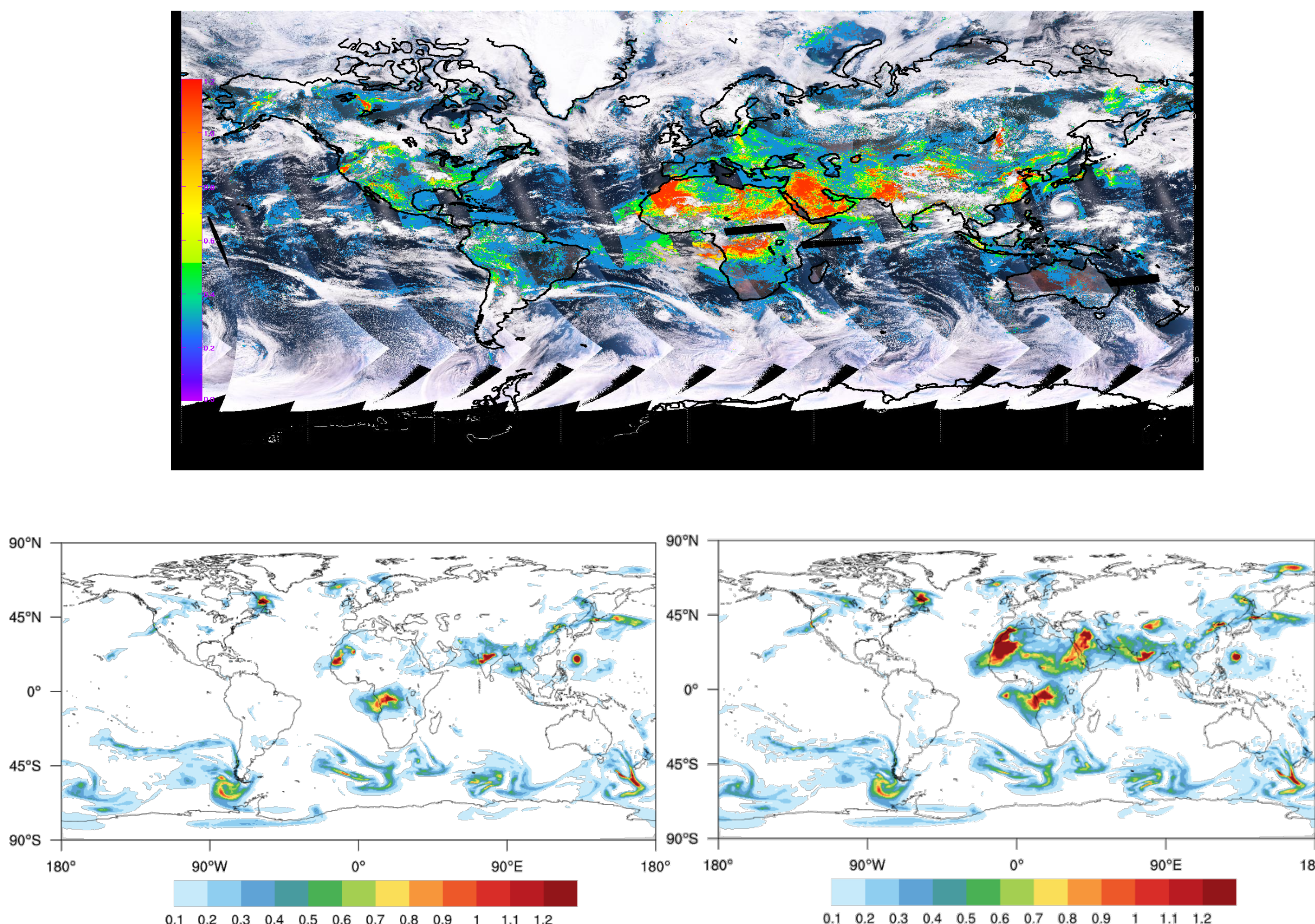
WRF-Chem: 1-31 August, 2015   FV3_GOCART: 1-10 August, 2015

Fig. 5. Summary statistics: from top average AOD observations, Average AOD forecast, bias, de-biased RMSE