Assimilation of VIIRS AOT EDR for Air Quality Analyses and Forecasts: A Comparison with the Assimilation of MODIS AOT

Zhiquan Liu (liuz@ucar.edu), Junmei Ban, Hui-Chuan Lin

National Center for Atmospheric Research, Boulder, CO, USA

WRF/Chem and GSI Aerosol Data Assimilation

- WRF/Chem is an online-coupled meteorology-chemistry model
  - allow aerosol/chemistry feedback to meteorological fields.

- 3D mass concentrations of 15 aerosol variables from the GOCART aerosol module within the WRF/Chem model are analysis variables in GSI
  - Hydrophobic and hydrophilic organic carbon (OC_1, OC_2)
  - Hydrophobic and hydrophilic black carbon (BC_1, BC_2)
  - Sulfate, Dust in 5 particle-size bins, Sea salt in 4 particle-size bins
  - $P25$: unspeciated aerosols contributing to $PM_{2.5}$

- Aerosol background error covariance statistics
  - "NMC" method, univariate correlation, no cross-correlation b.w. variables

- Allow the assimilation of MODIS/VIIRS AOT/Radiance and surface PM2.5/PM10

- Observation operator: CRTM for MODIS/VIIRS AOT and visible-band radiances

- Multiple data assimilation methods can be used: 3DVAR, EnKF and Hybrid

- Also allow simultaneous assimilation of aerosol and meteorological observations

Experiment design

Domain   : East Asia
Resolution   : horizontal 20km; vertical 57L
grid points   : 240x200
Study Period   : 2013-11-06 ~ 2013-12-06; 06 UTC analyses with 24h cycle
Spin up   : 10 days from 2013-11-01
Background error : (48hfc-24hfc) from control experiment

WRF/Chem Emission : Global EDGAR + Streets (monthly variation)

Satellites overpass : around 06 UTC
Thinning   : 40km
Time window   : ±1.5h

3 cycling experiments:
(1) Control: No AOT DA, continued aerosol forecasts
(2) VIIRS AOT DA: assimilate VIIRS Ch 4 AOT @555nm
(3) Aqua MODIS AOT DA: assimilate MODIS Ch 4 AOT @550nm

Meteor. initial conditions are the same for 3 exps (from GFS at 06 UTC).
Ran 48-h forecasts from 06 UTC, 24-h forecast serve as the background for next cycle's analysis. Hourly forecast output for verification.
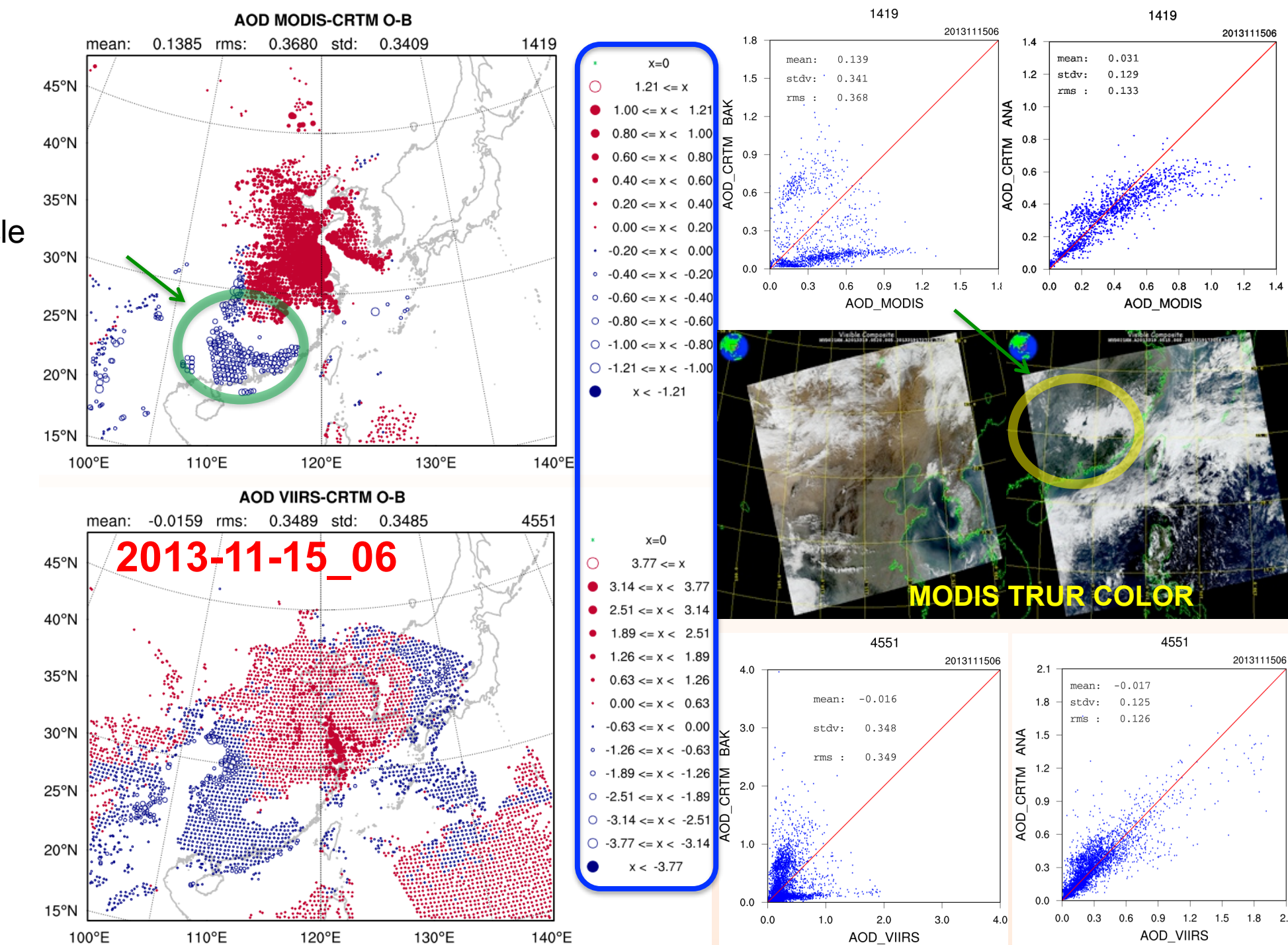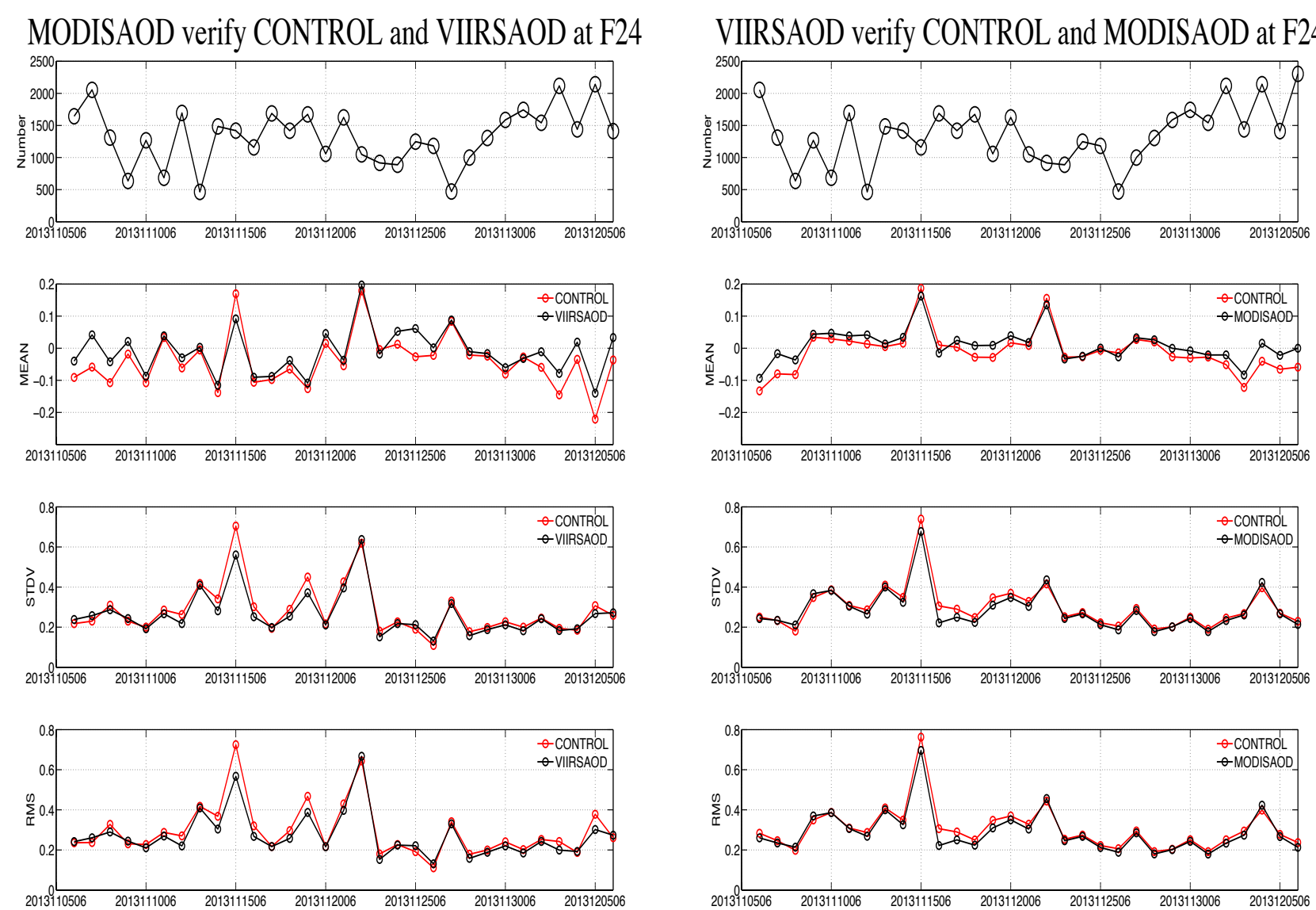
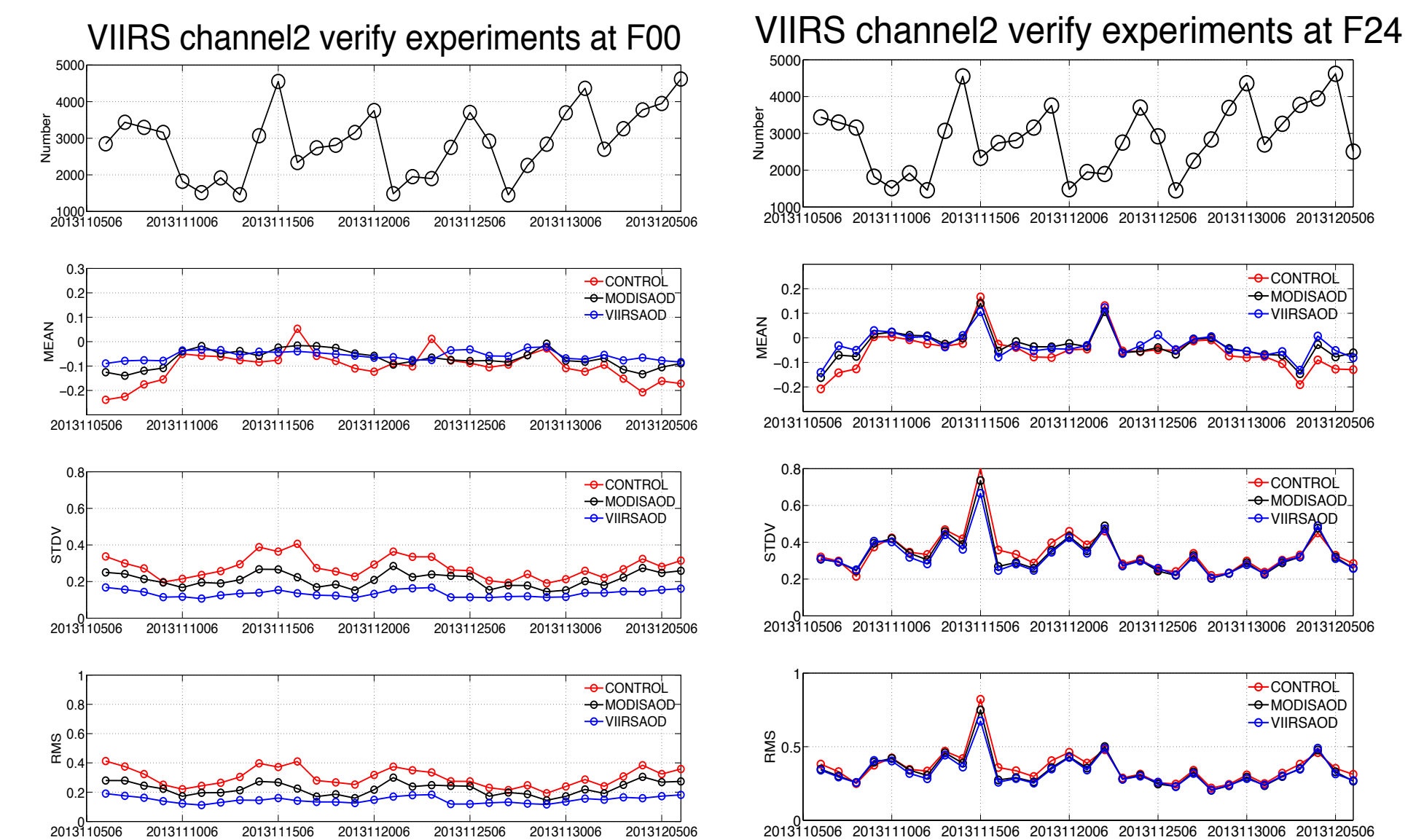

AOT Cross-Verification: analysis
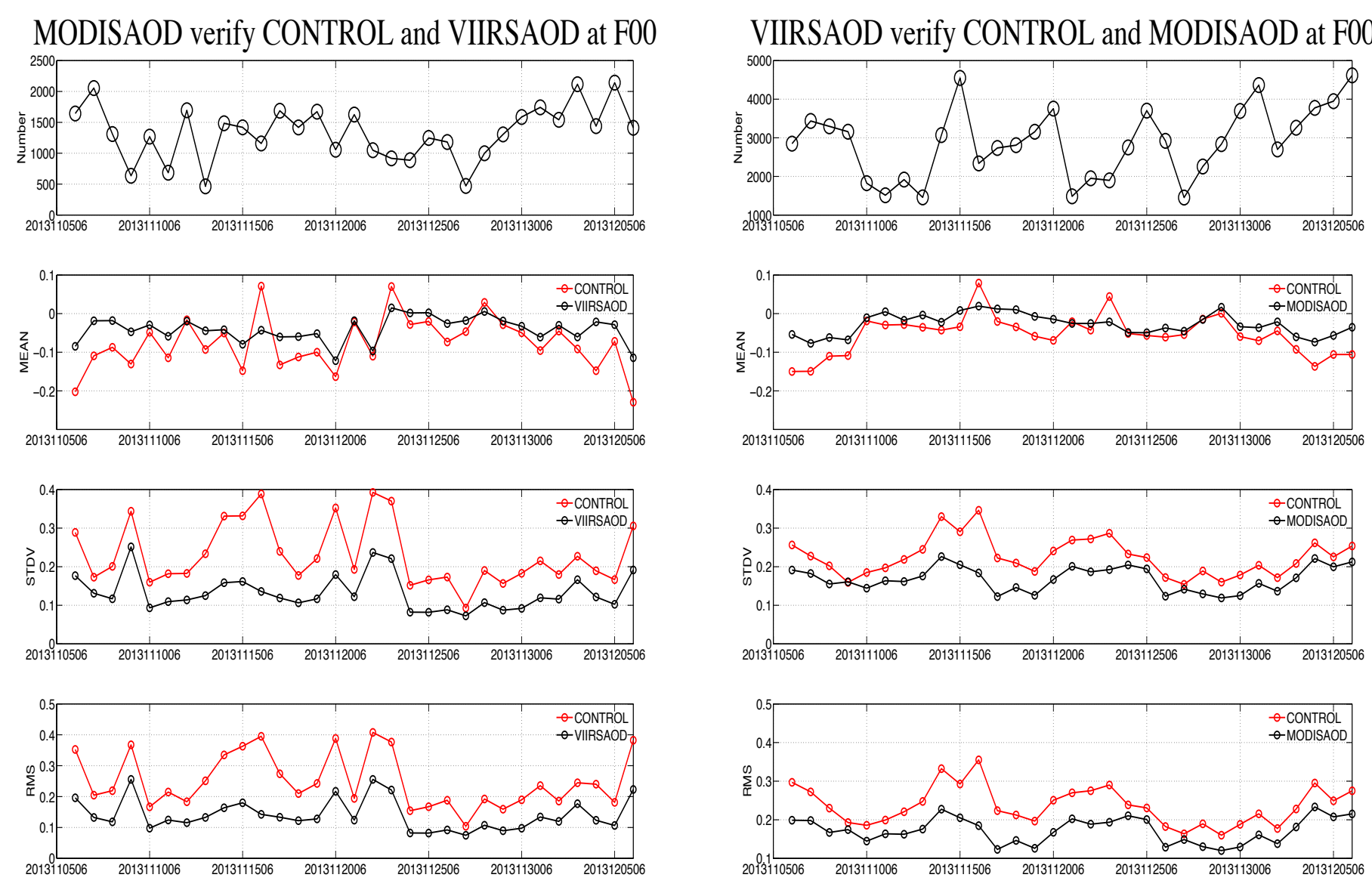
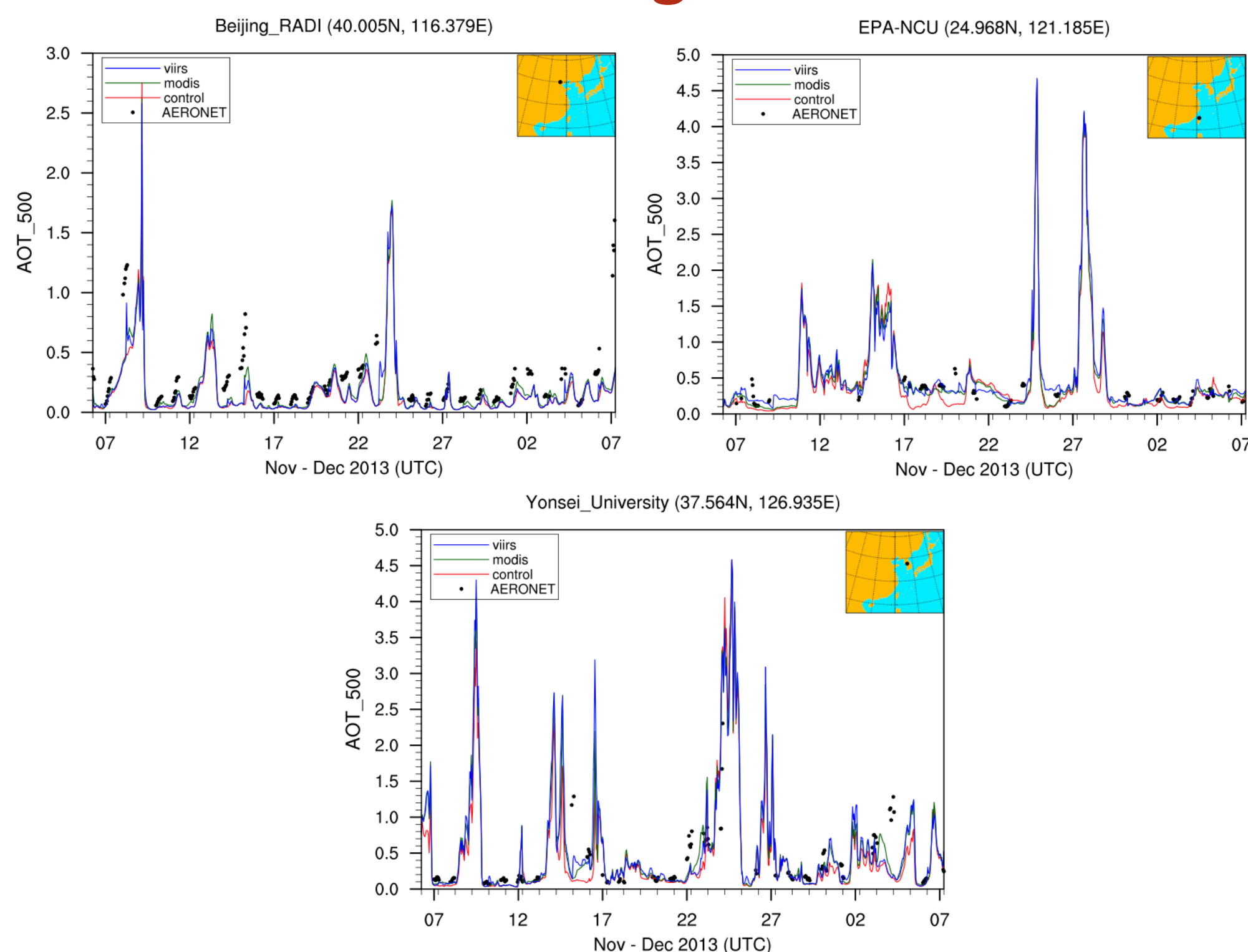**VIIRS AOT DA slightly better than MODIS AOT DA**

AOT Cross-Verification: 24h FC

Verification using VIIRS Ch2 AOT

Verification using AERONET AOD

Verification using surface PM2.5

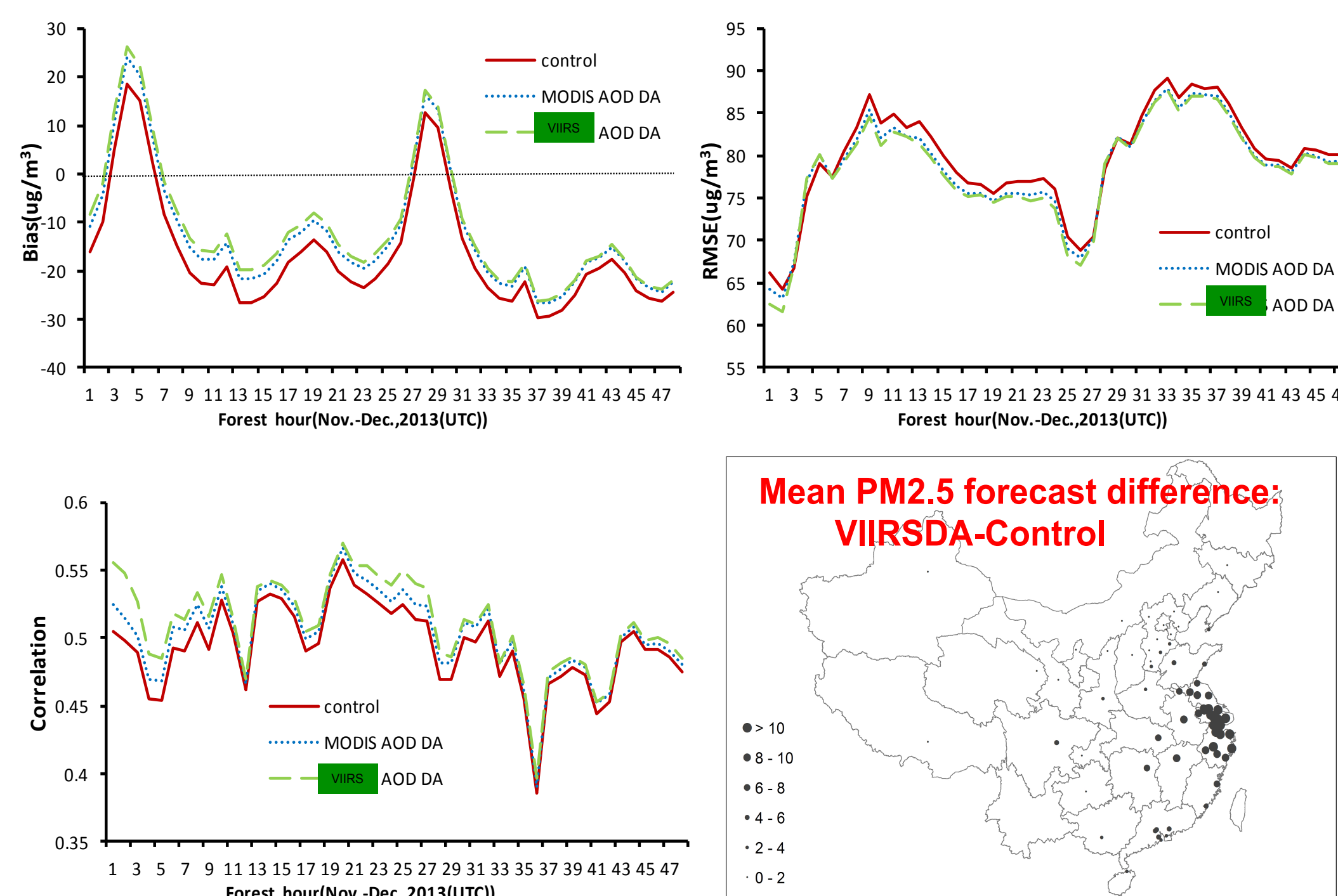**Mean PM2.5 forecast difference: VIIRSDA-Control**

Summary

- VIIRS AOT generally has better coverage than MODIS AOT from Aqua over East Asia for the data marked as the best quality

- Assimilating MODIS (Aqua only) or VIIRS AOT improved aerosol analysis and subsequent forecasts

- Assimilating VIIRS AOT resulted in slightly better results than assimilating Aqua MODIS AOT.

Future Plan

- Assimilate MODIS and VIIRS AOT together

- Assimilate multiple channels VIIRS AOT

- Improve quality control and observation error specification

- Direct assimilation of VIS/NIR radiances

- Extend from regional to global applications