Impact of aerosol direct effects in the coupled WRF-CMAQv5.0 modeling system

K. Wyat Appel, David C. Wong, Jonathan E. Pleim, Shawn J. Roselle, Chao Wei and Rohit Mathur

U.S. EPA, Research Triangle Park, Durham NC, 27711

Motivation

Conventional CMAQ air quality simulations utilize meteorological inputs that are run independently of the Chemical Transport Model (CTM)

The coupled WRF-CMAQ system runs the meteorological model and CTM together, which allows for communication (feedback) between the two models

Feedback is important for including the effects that aerosols have on the meteorological fields (e.g. solar radiation) providing a more realistic representation of the atmosphere

In this work, the coupled WRF-CMAQ modeling system is used to examine the impact of aerosol direct effects on model estimates (performing simulations with and without aerosol direct effects)

Model Configuration

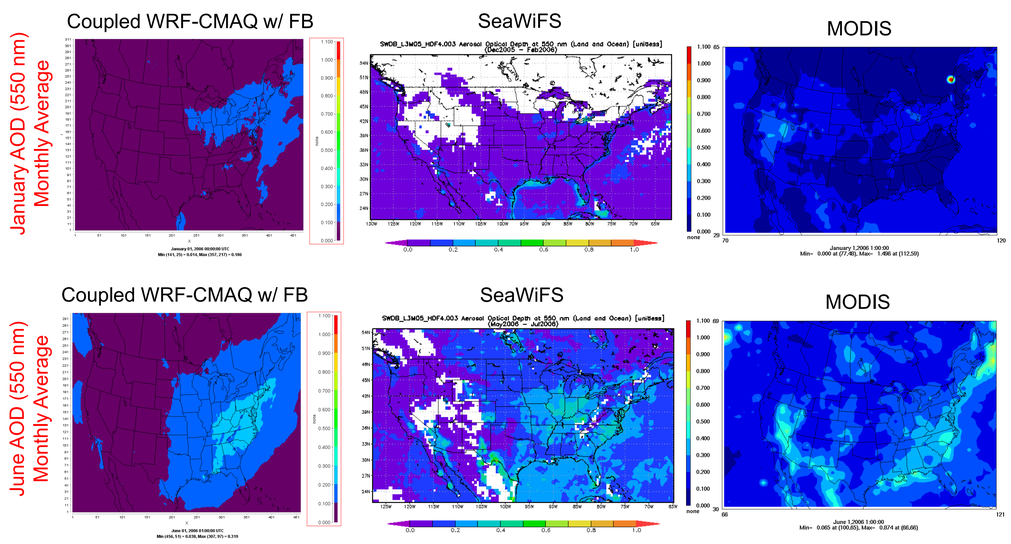
WRFv3.3 Configuration
- 12km horizontal grid spacing
- 35 Vertical Layers
  - top at 50 hPa
  - top of lowest layer ~ 20 m
- RRTMG long- and short-wave radiation
  - feedback applies to short-wave only
- KF2 CP scheme
- Pleim-Xiu LSM
- Morrison microphysics
- ACM2 PBL scheme

CMAQv5.0 Configuration
- 12km CONUS domain (extending into Canada)
- CB05TUCL chemistry
- GEOS-Chem boundary conditions
- lightning NO emissions included
- wind-blown dust emissions included

January and June 2006
- coupled w/ aerosol direct effects (F)
- coupled w/o aerosol direct effects (NF)

Coupled model simulations (w/ feedback) require approximately 4.5 hours/day (128 procs) or 5.5 hours/day (96 procs)

Satellite Aerosol Optical Depth



The modeling system tends to slightly overestimate AOD in January and underestimate AOD in June compared to satellite AOD estimates.

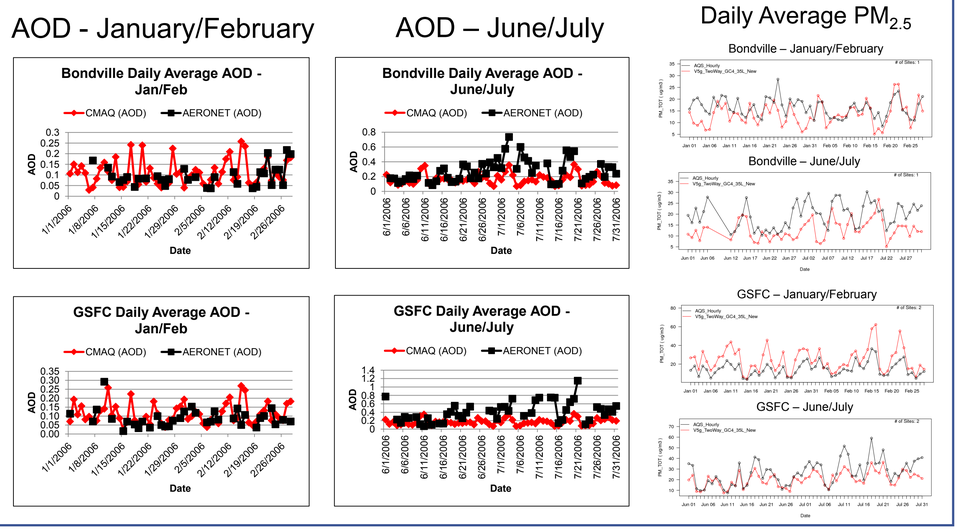
AERONET AOD

AEerosol RObotic NETwork
Provides measurements of Aerosol Optical Depth (among other measurements)

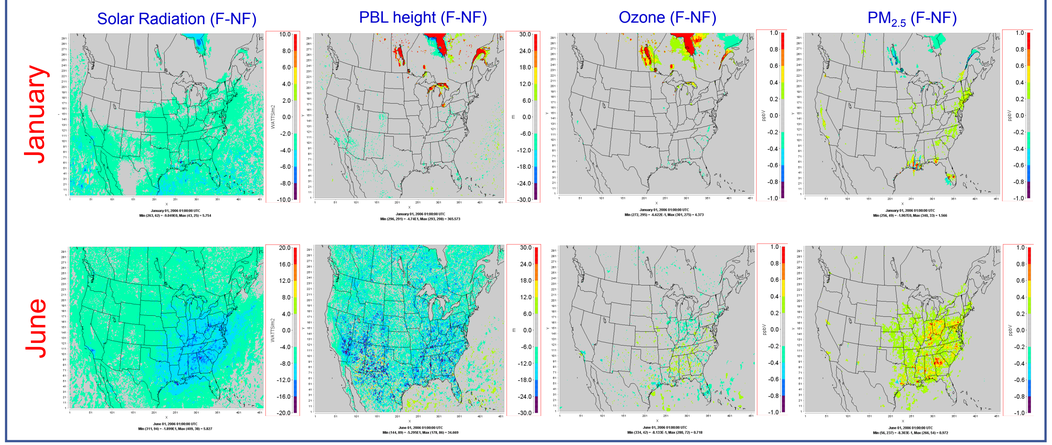
Basic AOD instrument is a sun photometer measuring direct solar radiation

Two U.S. sites used here
- Bondville, IL (40.05N, 88.37W)
- Goddard Space Flight Center, Greenbelt, MD (38.99N, 76.84W)

Level 2.0 data used with pre- and post- field calibration applied, cloud screened and quality assured
http://aeronet.gsfc.nasa.gov/new_web/index.html

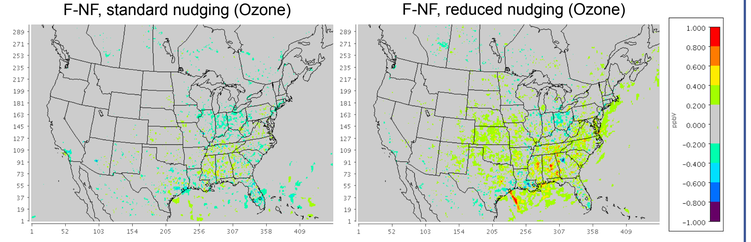


Impact of Aerosol Direct Effects on Met and AQ Fields



Re-ran feedback and no-feedback simulations for June 2006 using smaller soil and air nudging coefficients

Reduced Nudging Strength



Reducing the nudging strength increases the impact that aerosol feedbacks have on the model estimates.

Summary and Conclusions

- ❑ Impact of aerosol direct effects apparent in the coupled WRF-CMAQ modeling system
- ❑ Comparisons of modeled and satellite observed AOD indicate the model tends to underestimate AOD on average in June
- ❑ Comparisons with ground based AOD measurements suggest that the model overestimates AOD in the winter and underestimates AOD in the summer
- ❑ The feedback effects appear to mostly improve the CMAQ model estimates in the summertime based on comparisons with observed data (not shown here)
- ❑ The feedback effect in the wintertime (January) is relatively small
- ❑ Reducing the nudging strength in WRF allows for greater feedback effect from aerosols