Global and Regional Modeling

Pius Lee – NOAA Air Resources Lab (ARL)

with contributions from:

NOAA ARL: Daniel Tong, Li Pan, Youhua Tang, Barry Baker
NOAA National Centers for Environmental Prediction: Jeff McQueen, Jianping Huang, Ho-Chun Huang
NOAA National Weather Service: Ivanka Stajner, Sikchya Upadhayay
N.Y. State University, Albany: Sarah Lu, Shengpo Chen
Leverage NAQFC daily understanding of the big picture and meteorology
Leverage NAQFC long term record and day-by-day understanding

**O$_3$ MDA8 bias** [n = 875]

**Reduction of O$_3$ summer time high bias**

**MDA8 O$_3$ performance**

**PM$_{2.5}$ daily mean bias** [n = 467]

**PM$_{2.5}$ performance**
Impact of forest fires in testing of PM2.5 predictions

Difference between two PM2.5 predictions: with-minus-without fire emissions
Impact of fugitive dust on PM2.5 forecast

PM$_{2.5}$ ($\mu$g m$^{-3}$)
NWS Next Generation Global Forecasting System

- Chemical Analysis: homogeneously generated fields over multiple years
- NAQFC in finer resolutions: Chemically, spatially and temporally
- Incorporation of air-surface exchange processes in air chemistry
- Air chemistry as one of NWS Earth Modeling System Framework components
NOAA’s Southern Oxidant and Aerosol Study (SOAS) - June-July 2013

4 km domain nested within the 12 km NAQFC

Relevance: Campaign Collaboration AQ Forecasting
FY 2013 – 2015: AQAST Tiger Team: Air Quality Reanalysis

(Translating Research to Services)

- AQ Assessments
- State Implementation Plan Modeling
- Rapid deployment of on-demand rapid-response forecasting; e.g., new fuel type, etc.
- Health Impacts assessments
- Demonstration of the impact of observations on AQ distributions
- Ingestion of new AQAST products into operations

http://acmg.seas.harvard.edu/aqast/projects.html

NCAR_Colloquium July 25 – August 5, 2016
Regional Chemical Reanalysis:

National correlation map between AIRNow measurement and MODIS AOD

Typically good correlation between surface PM$_{2.5}$ and AOD retrieved by MODIS

MODIS (Moderate Resolution Imaging Spectroradiometer) AOD

- **Orbit:** 705 km, **10:30 a.m.** descending node (Terra) or **1:30 p.m.** ascending node (Aqua)
- **Swath** Dimensions: 2330 km (cross track) by 10 km (along track at nadir)
- **Spatial Resolution:** 250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36)

http://terra.nasa.gov/About/

NCAR_Colloquium July25 – August 5 2016
Optimal Interpolation (OI)


\[ X^a = X^b + BH^T (HBH^T + O)^{-1} (Y - HX) \]

• Obs far away (beyond background error correlation length scale) have no effect in the analysis.

• Injection of Obs through OI takes place at 1700 UTC daily.
Horizontal Error Statistics

AOD error statistics results w/ NMC

AOD error statistics results through Hollingsworth-Lönnberg approach

NCAR_Colloquium July 25 – August 5 2016
a) 12z July 2 2011 forecast valid for 18z on same day: NAQFC setup.

Color-shading for Surface PM$_{2.5}$ ($\mu$g m$^{-3}$)

Color bar for bias w.r.t. AIRNow ($\mu$g m$^{-3}$)

b) Same as a) but with data assimilation adjusted Initialization.

Large reduction in underestimation of PM2.5 w.r.t. a)

Tang et al., 2015: Using optimal interpolation to assimilate surface measurements and satellite AOD for ozone and PM2.5: A case study for July 2011, JAWMA, 65, 1206-1216
Chemical Reanalyses Product: Friendly downloadable

As reanalysis Meteorological fields For NWP community

Chemical reanalysis Fields for atmospheric Modelers and epidemiologist

<table>
<thead>
<tr>
<th>NWP</th>
<th>Ensembles</th>
<th>Reanalysis</th>
<th>Climate</th>
<th>Programmatic</th>
<th>Servers</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM</td>
<td>Lo-Res</td>
<td>CFS</td>
<td>CM2.X</td>
<td>SRRS</td>
<td>LAS</td>
</tr>
<tr>
<td>GFS</td>
<td>Hi-Res</td>
<td>NARR</td>
<td>CFS</td>
<td>NDFD</td>
<td>GDS</td>
</tr>
<tr>
<td>RUC</td>
<td>Probability Tool</td>
<td>Global R1/R2</td>
<td>SST</td>
<td>RTMA</td>
<td>TDS</td>
</tr>
</tbody>
</table>
Collaborations and data sharing

- Global and Regional AQ modeling National Centers and Institutions:
  - NCEP, and NESDIS
  - EPA, and NASA
  - Other national centers around the world

- Measurement intensive campaigns provide insights:
  - AQ Modeling involves in OSSE
  - AQ Modeling involves in Campaign support

- NGGPS and NUOPC will be the two deafening buzz words:
  - Next Generation Global Forecasting System
  - National Unified Operational Prediction Capability

NCAR_Colloquium July 25 – August 5 2016