Toward Improving NCEP Global Aerosol Forecasting System using VIIRS Aerosol Observations

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Why Include Aerosols in the Predictive Systems?

- Improve weather forecasts and climate predictions by taking into account of aerosol effects on radiation and clouds
- Improve the handling of satellite observations by properly accounting for aerosol effects during the assimilation procedure
- Provide aerosol (lateral and upper) boundary conditions for regional air quality predictions
- Account for the aerosol impact on climate, human health, ecosystem, and visibility.
- Meet NWS and WMO global dust forecasting goals
Presentation Outline

- Current Operational Configuration
- Future operational requirements and applications
Current State

- Near-real-time operational system. implemented into NCEP Production Suite in Sept 2012
- The first global in-line aerosol forecast system at NWS
- Model Configuration:
  - Resolution: T126 (~ 1°x1°) L64
  - AGCM: NCEP’s NEMS GFS
  - Aerosol: GSFC’s GOCART
- 120-hr dust-only forecast once per day (00Z), output every 3-hr
- ICs: Aerosols from previous day forecast and meteorology from operational GDAS
- Leverages the expertise in GSFC, NESDIS, the ICAP working group (NRL, ECMWF, JMA, UKMO, GMAO, BSC), and WMO SDS-WAS program.

In-line chemistry advantage

- Consistency: no spatial-temporal interpolation, same physics parameterization
- Efficiency: lower overall CPU costs and easier data management
- Interaction: Allows for feedback to meteorology

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- NGAC forecasts are routinely evaluated using AOD observations from AERONET and MODIS as well as aerosol analysis from other models.
- Results of 1-year operational NGAC forecast (09/2012-09/2013) are shown here.
- NCEP is yet to extend forecast verification system to include VIIRS aerosol products.
Near-Real-Time Global Aerosol Forecasting

Oct 2012

Jan 2013

Apr 2013

Jul 2013
Near-Real-Time Global Aerosol Forecasting

Saharan Dust Transport by NGAC forecasts

Dust AOD (NGAC); 2013073000

VIIRS Dust Aerosol Index: MODIS dust mask algorithm applied to VIIRS globally

Pubu Ciren and Shobha Kondragunta (NESDIS/STAR)

5th ICAP WG Meeting, 5-8 Nov 2013
• NGAC dust products contribute global multi-model ensemble (by International Cooperative for Aerosol Prediction, ICAP) and regional multi-model ensemble (by WMO Sand and Dust Storm Warning Advisory and Assessment System, SDS-WAS)

• NGAC forecasts are independently evaluated by the ICAP and SDS-WAS programs
Near-Real-Time Global Aerosol Forecasting

- SDS-WAS Africa node, conducts daily inter comparison for dust AOD and dust surface concentration
- Regional multi-model ensemble, including 5 global models (NCEP, ECMWF, GMAO, UKMO, BSC)

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Presentation Outline

- Current Operational Configuration
- Future operational requirements and applications
NGAC aerosol forecasts

- NGAC has the capability to simulate dust, sulfate, sea salt, and carbonaceous aerosols.
- NGAC using NESDIS’s NRT smoke emissions is slated for operation implementation in FY15.
- An example is given here where NGAC experiments for 2011 are conducted.

Dust aerosols

Carbonaceous aerosols
Flowchart of Blending QFED and GBBEP-Geo

**QFEDv2**
- Terra+Aqua MODIS fire detections
- MODIS fire FRP with cloud adjustment
- MODIS fire emissions calibrated with GFEDv2 and MODIS AOD

**QFED**: Quick Fire Emission Dataset from MODIS fire data

**GBBEP-Geo**: Global Biomass Burning Emissions Product from Multiple Geostationary Satellites
- Geostationary satellite fire detections
- Simulating diurnal FRP
- Fire emissions
- Adjusting Fire emissions to QFEDv2
- Tuning blended fire emissions
- NEMS-GFS-GOCART forecast

**Blended global biomass burning emission**
- Simulating AOD using NEMS-GFS
- Scaling fire emissions
- MODIS AOD

Xiaoyang Zhang (SDSU)

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FY15 Planned Implementation

- Extend the dust-only system to include sulfate, sea salt, and carbonaceous aerosols
  - NESDIS - GSFC - NCEP collaboration to develop and test near-real-time biomass burning emissions (GBBEPx)

- Link low-resolution NGAC with high-resolution GDAS Hybrid EnKF and GFS
NGAC Product Suite and Applications

NGAC provides 1x1 degree products in GRIB2 format once per day. Product files and their contents include:

- **ngac.t00z.aod_{CH}, CH=340nm, 440nm, 550nm, 660nm, 860nm, 1p63um, 11p1um**
  - Aerosol Optical Depth (AOD) at specified wavelength from 0 to 120 hour

- **ngac.t00z.a2df{FH}, FH=00, 03, 06, ....120**
  - AOD at 0.55 micron
  - Dust emission, sedimentation, dry deposition, and wet deposition fluxes
  - Dust fine mode and coarse mode surface mass concentration
  - Dust fine mode and coarse mode column mass density

- **ngac.t00z.a3df{FH}, FH=00, 03, 06, ....120**
  - Pressure, temperature, relative humidity at model levels
  - Mixing ratios for 5 dust bins (0.1-1, 1-1.8, 1.8-3, 3-6, 6-10 micron) at model levels

Potential applications for NGAC products are highlighted in red.

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Priority System Enhancements

- Long-term goal
  - Allow aerosol impacts on weather forecasts and climate predictions to be considered
  - Enable NCEP to provide *quality atmospheric constituent products* serving wide-range of stakeholders, such as health professionals, aviation authorities, policy makers, climate scientists, and solar energy plant managers

- Phased implementation
  - Phase 1: Dust-only forecasts (operational)
  - Phase 2: Forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS’s GBBPEx smoke emissions (planned FY15 implementation)
  - Phase 3: Aerosol analysis using VIIRS AOD (well-defined R2O building upon existing NCEP-NESDIS-GSFC collaboration)
Why VIIRS AOD Data Assimilation?

- While development work remains, ground work has been laid for building a global aerosol data assimilation capability within NGAC and Hybrid EnKF-GSI
- Prognostic aerosol capability has been established
- Infrastructure development (CRTM supports GOCART, GSI code development for AOD DA*)
- Near-real-time smoke emissions have been developed, slated for operational in FY15
- Community aerosol modeling/assimilation efforts (ICAP, GSI)

- Other centers (e.g., NRL, ECMWF, GMAO) are assimilating MODIS AOD, and are currently assessing the VIIRS aerosol products. NCEP is yet to develop the AOD data assimilation capability and will be focused on VIIRS products (instead of the “MODIS then VIIRS” approach).

* GSI AOD data assimilation: (1) Development work at NCEP is temporarily suspended due to budgetary constraint (2) Extensive development work conducted by other centers (NCAR, ESRL)
<table>
<thead>
<tr>
<th>Future Operational Benefits Associated with NEMS GFS Aerosol Component</th>
<th>Status</th>
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<tbody>
<tr>
<td>Provides a first step toward an operational aerosol data assimilation capability at NOAA</td>
<td>VIIRS AOD data assimilation (pending support)</td>
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<td>Allows aerosol impacts on medium range weather forecasts (GFS/GDAS) to be considered</td>
<td>Ongoing work at EMC</td>
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<td>Allows NOAA to explore aerosol-chemistry-climate interaction in the Climate Forecast System (CFS) as GFS is the atmospheric model of CFS</td>
<td>CPO MAPP-CTB funded project</td>
</tr>
<tr>
<td>Provides global aerosol information for various applications (e.g., satellite radiance data assimilation, satellite retrievals, SST analysis, UV-index forecasts, solar electricity production)</td>
<td>Ongoing NCEP-NESDIS-Howard collaboration on aerosol-SST</td>
</tr>
<tr>
<td>Provides lateral aerosol boundary conditions for regional aerosol forecast system</td>
<td>Benchmark study completed</td>
</tr>
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Conclusions

NCEP is developing global aerosol forecasting/assimilation capability

• The aerosol project builds upon extensive collaboration with NOAA labs/centers (NESDIS) and external research community (GSFC, the ICAP working group, WMO SDS-WAS program)

• Phased implementation
  • Phase 1: Dust-only forecasts (operational)
  • Phase 2: Forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS’s GBBPEX smoke emissions (planned FY15 implementation)
  • Phase 3: Aerosol analysis using VIIRS AOD (well-defined R2O building upon existing NCEP-NESDIS-GSFC collaboration)
Thanks.

Questions and Comments?