OVERVIEW of NRL/FNMOC AEROSOL VALIDATION METHODS

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Radiative transfer in the atmosphere at UV, Vis, and IR wavelengths is a major concern.
Operational Status of Models

- **NAAPS** global aerosol forecast, operational at FNMOC, 6-day forecast, four times a day
- **COAMPS** regional aerosol forecast, operational for SW Asia, 3-day forecast, twice a day
  - 18-km SW Asia, 6-km PG, 6-km Afghanistan
- **FLAMBE** fire detection, operational, four times a day
- **NAVDAS-AOD** 2D-VAR Aerosol DA, operational, four times a day
- **FAROP** operational, four times a day, derives optical properties

COAMPS forecast of dust plumes
12Z 29 October, 2009
NAAPS COMPARISON TO AVHRR AOD

Use for monitoring of model behavior regionally

- NE Pacific/W. Amer.: 653, 0.472
- West Tropical Atlantic: 539, 0.117
- Sahara: 908, 0.741
- Central Asia: 76, 0.781
- NW Pacific/E Asia: 395, 0.534
- S. Amer.: 1251, 0.627
- Africa: 1016, 0.750
- Indian O./Austr.: 1697, 0.341
- Other: 3662, 0.383
- Entire Globe: 10890, 0.605
NAAPS Station Monitoring: 14 days at Sede Boker

NAAPS/Aeronet data 2010091600 - 2010100318 - SEDEBOKER

Optical Depth

Last 14 days

Forecast
Natural run

+ Land/Ocean MODIS
+ Land/Ocean MISR

AERONET Used to Monitor Impact of Data Assimilation

Information available regionally and over different time periods
COAMPS:
Forecasting Individual Dust Plumes

Qualitative validation

Dust Enhancement Product (DEP; FNMOC) for 1330 GMT 9 Nov, 2009

COAMPS 6-km Dust 24-h Forecast (FNMOC) for 1200 GMT 9 Nov, 2009
48-hour Dust Model Comparison Side-By-Side: Requested by forecasters

Qualitative comparison
144-h Dust Model Comparison

Forecasters also request quantitative comparison.
Quantitative verification can be done using prediction rates taken from quantitative precipitation forecasting:

1. **dust storm prediction rate**: number of correctly predicted dust incidents/number observed dust incidents,

2. **dust storm false alarm rate**: ratio of number of falsely predicted dust incidents to number of observed clear-sky, incidents

3. **dust storm threat score**: \((\text{number of predicted dust incidents})/(\text{predicted dust} + \text{missed dust} + \text{false alarm dust incidents})\)

4. **total prediction rate**: \((\text{number of correctly predicted dust incidents} + \text{correctly predicted clear-sky incidents})/\text{(total observations)}\).

‘Dust Storm’ is defined as visibility less than 3.5 km
Quantitative Validation Required to Evaluate High-Resolution Dust Source Database in COAMPS

Erodible Fraction on 9-km COAMPS grid derived from DSD

Forecasted Mass Load (mg m⁻²)
Figure 9. Time series of observed (a) visibility, weather type, and winds at Zabol, Iran from 00Z October 8-14, 2001. For explanation of weather symbols see Table 3. (b) COAMPS forecasted visibility on the 9-km grid at Zabol, Iran from 00Z October 8-14, 2001 using NRL, (c) TOMS, and (d) USGS dust sources databases. Note the inverted visibility (y) axis.

Visibility reports adequate for V&V
Quantitative Measure of Impact of the Use of DSD in COAMPS

Forecast Skill Scores:

- All improved with implementation of DSD
• On multi-day time-scales, AQ is dominated by sources, mixing, transport, and removal, all with strong dynamical dependence

• Validation is required for relevant dynamical properties:
  • $T_g$,
  • surface winds, 925 mb winds,
  • TKE, $H_{pbl}$,
  • precipitation, cloud fraction, CWV
  • $F_{TOA}$,
  • potential temperature, stability

• Leverage the NWP community
  • Use their case studies and results
  • Do enough validation to convince them they have a problem that needs to be solved

Dynamics are Largely Forgotten
### Table 2. Required Model Output for Dust Model Intercomparison

<table>
<thead>
<tr>
<th>Variable</th>
<th>Contents</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFLX</td>
<td>dust emission flux ((d &lt; 20 \ \mu m))</td>
<td>mg/m²/h</td>
</tr>
<tr>
<td>DC1B</td>
<td>dust concentration at first model level ((d &lt; 20 \ \mu m))</td>
<td>µg/m³</td>
</tr>
<tr>
<td>DC7H</td>
<td>dust concentration at 700 hPa ((d &lt; 20 \ \mu m))</td>
<td>µg/m³</td>
</tr>
<tr>
<td>DCLN</td>
<td>dust column loading (height (z &lt; 10 \ \text{km})) ((d &lt; 20 \ \mu m))</td>
<td>mg/m²</td>
</tr>
<tr>
<td>WS10</td>
<td>wind speed at 10 m level</td>
<td>m/s</td>
</tr>
<tr>
<td>USTR</td>
<td>surface friction velocity</td>
<td>m/s</td>
</tr>
<tr>
<td>USTH</td>
<td>threshold surface friction for dust lift up</td>
<td>m/s</td>
</tr>
<tr>
<td>PREP</td>
<td>precipitation rate</td>
<td>mm/h</td>
</tr>
<tr>
<td>DDRY</td>
<td>dust dry deposition ((d &lt; 20 \ \mu m))</td>
<td>mg/m²/3 h</td>
</tr>
<tr>
<td>DWET</td>
<td>dust wet deposition ((d &lt; 20 \ \mu m))</td>
<td>mg/m²/3 h</td>
</tr>
</tbody>
</table>

**Figure 6.** Time variation of wind speed at 10 m height (WS10). Sites are Tazhong, Ejin Qi, Hohhot, Taiyuan, and Beijing. WS$_{10}$ from each model are shown by min, 25%, 50% (mode), 75%, and max values. Quartile values between the 25% and 75% percentiles are shaded. Triangles show the observed wind speed from SYNOP observation at 6-hour intervals.
Figure 7. Time variation of the surface dust concentration (μg/m³). (a) Tazhong, (b) Ejin Qi, (c) Lanzhou and (d) Hohhot. The surface dust concentration from each model is shown by min, 25%, 50% (mode), 75%, and max value. Quartile value between 25% and 75% percentile are shaded. Triangles are observed VC_{TSP} converted from SYNOP visibility. The circles with horizontal bar are daily averaged PM_{10} measurements from the Chinese SEPA sites.
Use of Surface Obs. for Validation

NRL Station Model

- Used to highlight visibility reducing weather related to aerosol events (as cyan)

- Differentiates these events from precipitation events (in green)
Use of Surface Obs. for Validation:
Density is sufficient in many regions
Use of Surface Obs. for Validation: High quality stations have consistent reports
BASE CRITERIA (strict)

- At least 18 months of data
- Reports every 3 hours
- Less than one week of missing values (RH, vis, T) per year
- Correlation between current weather and visibility (i.e., heavy fog and clear skies should have different vis)
- No hard visibility maximum at 4 km (India filter)
- Visibility values must have spread
  - Automated stations reporting constant vis not useful

<table>
<thead>
<tr>
<th>FILTER TYPE</th>
<th>FAILING STATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY</td>
<td>2018</td>
</tr>
<tr>
<td>MISSING FIELD</td>
<td>2180</td>
</tr>
<tr>
<td>HISTORY</td>
<td>873</td>
</tr>
<tr>
<td>SPREAD</td>
<td>2482</td>
</tr>
<tr>
<td>TOTAL REMOVED</td>
<td>6159</td>
</tr>
</tbody>
</table>
Surface Station Filtering

BASE CRITERIA
Only successful in China and Europe

RELAXED FREQUENCY
Africa, Americas, Russia, SE Asia, Southern Pacific
Six hourly reports
Australia
Many report only at 05 and 23 UTC
Hinterlands not reporting visibility
Surface Station Filtering

ACCEPTED

- Regular reporting
- Aerosol obs influencing vis
Surface Station Filtering

REJECTED

- Visibility and current weather reporting sporadic
Surface Station Filtering

REJECTED

- Dust/Weather and Vis not correlated
Surface Station Filtering

REJECTED

- 4 km Maximum
**WMO METEOROLOGICAL WARNINGS STUDY GROUP (METWSG) considering change in definitions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Code</th>
<th>Description of present or past weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂</td>
<td>4</td>
<td>Visibility reduced by smoke</td>
</tr>
<tr>
<td>5</td>
<td>Haze</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Widespread dust in suspension in the air, NOT raised by wind at time of observation</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Dust or sand raised by wind, at time of observation</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Light fog</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Slight or moderate duststorm or sandstorm, has decreased during past hour</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Slight or moderate duststorm or sandstorm, no appreciable change during past hour</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Slight or moderate duststorm or sandstorm, has increased during past hour</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Severe dust storm or sandstorm, has decreased during past hour</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Severe dust storm or sandstorm, no appreciable change during past hour</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Severe dust storm or sandstorm, has increased during past hour</td>
<td></td>
</tr>
</tbody>
</table>

Plan – Add Vis and wind speed criteria to discriminate from LRT.

But Vis and wind speed are already reported and available to user.

Real problem – sand storm (dune-related) and dust storm are reported together even though defined differently:
- sandstorm – 10-50 ft altitude, large particles
- dust storm – up to several km altitude, small particles

Decision to be made in Nov.
Summary and Recommendations

Goals
- Specific validation over region for our customers (vis, PM2.5)
- Common validation for our peers (AOD, fluxes)

Situation
- Model intercomparison and V&V are different approaches
- Customers are quite different from center to center:
  - Navy interest is 0-72 hr forecasts of visibility
  - AQ interest is forecasts for health, ozone, PM2.5
- Customers and program managers are interested in model intercomparison
- Underfunded and understaffed
- Each center chooses specific variables, domain, approach
- Select some sites of common interest to different centers
- Select a few variables of common interest for intercomparison
- Real-time easier than retrospective (?)