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Outline:

1. Military requirements
2. Overview of model suite
3. Verification and Validation
4. Distribution
5. Lessons learned and issues
Why does DoD care about aerosol particles?

- Impacts on satellite retrievals, intelligence gathering
- Impacts on visibility, operations and equipment
- Impacts on the atmospheric radiative budget (direct, semi-direct, indirect)
- Impacts on EO systems, slant-range vis., lock-on range

⇒ Mostly concerned with direct effects (vis and IR) and mechanical effects
### Operational Forecast System Components

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<th>System</th>
<th>Function</th>
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<td>NOGAPS</td>
<td>Forecasts dynamics</td>
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<td>NAVDAS-AOD</td>
<td>Data assimilation for aerosols</td>
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<td>FLAMBE*</td>
<td>Detects fires, determines smoke flux</td>
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<td>DSD</td>
<td>Dust source locations</td>
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<td>NAAPS, COAMPS</td>
<td>Forecast aerosol concentrations</td>
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<td>FAROP**</td>
<td>Calculates aerosol optical properties</td>
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<td>MCSST†, TAWS‡</td>
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<td>NPOESS</td>
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† NRL Atmospheric Variational Data Assimilation System – Aerosol Optical Depth
*Fire Locating and Modeling of Burning Emissions
**Forecast of Atmospheric and Optical Radiative Properties
† Multi-channel Sea Surface Temperature
‡ Target Acquisition Weapons Software
Operational Status of Models

- NAVDAS-AOD operational, four times a day
- FLAMBE (fire detection) operational, four times a day
- NAAPS operational at FNMOC, 6-day forecast, four times a day
- COAMPS operational for SW Asia, Afghanistan, 3-day forecast, twice a day.
- FAROP operational, four times a day
  - Derived optical properties in TEDS
  - Available for TAWS, NPOESS
- Products available on SIPR/NIPR on NRL Web sites:
  - www.nrlmry.navy.mil/aerosol/
  - www.nrl-mry.navy.smil.mil/aerosol/

⇒ Progress due to operationally focused R&D
Off-line Aerosol Modeling Flow Diagram

Yellow = in Beta  Green = FNMOC Operational
**FLAMBE: Fire Locating and Modeling of Burning Emissions**

**Purpose:** Determine real-time smoke fluxes

**Input:** GOES, MODIS

**Output:**
- Location (lat, lon)
- Smoke flux, g m\(^{-2}\) s\(^{-1}\)

**Horizontal res.:**
- GOES: 4 km; MODIS: 1 km

**Temporal res.:**
- GOES: 30 min., MODIS: 2X Day

**Next step:** use global geostationary satellites

Data latency (4h) not suitable for in-line simulations
NAVDAS-AOD: NRL Atmospheric Variational Data Assimilation System – Aerosol Optical Depth

<table>
<thead>
<tr>
<th><strong>Purpose:</strong></th>
<th>Data assimilation for aerosol optical depth (3-d Var)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status:</strong></td>
<td>Operational, 4x daily</td>
</tr>
<tr>
<td><strong>Input:</strong></td>
<td>NRL Level 3 MODIS Over-Ocean AOD (6-h data window)</td>
</tr>
<tr>
<td></td>
<td><strong>Next step:</strong> Over-land MODIS, MISR and CALIPSO</td>
</tr>
<tr>
<td><strong>Future input:</strong></td>
<td>NPP, NPOESS, AVHRR, MetOp, MSG, MTSAT, AATSR, GOES-R</td>
</tr>
<tr>
<td><strong>Output:</strong></td>
<td>Aerosol analysis and: 3-d distribution of four species error statistics</td>
</tr>
<tr>
<td></td>
<td>Temporal resolution: 3 hourly</td>
</tr>
<tr>
<td></td>
<td>Distribution: NAAPS and FAROP; web</td>
</tr>
</tbody>
</table>

⇒ Data latency (4h) not suitable for in-line simulations
Other Issues:
• MODIS near end of life
• NPP and JPSS VIIRS data quality is uncertain
• SDR vs. EDR
  • Dependence on EDRs (produced by others)
  • Burden of processing SDR
  • Latency, data volume, control
  • Need to transition QC/QA to upstream centers
• Modeler’s needs differ from conventional imagery
  • Sparse but accurate vs. pretty pictures
• Need to transition QC/QA to upstream centers
• Near-real-time availability of community datasets to FNMOC
**Purpose:** Forecasts aerosol concentrations

**Status:** Operational, 4X day

**Input:** NOGAPS, NAAPS, FLAMBE

**Output:**
- **Species:** Dust, Smoke, Sulfate, SO$_2$, Sea salt
- **Units:** Mass concentration

**Horizontal resolution:** 1 degree, 360 X 180 grid

**Vertical resolution:** 20 m, 200 m inc. to 2 km, 1 km inc. to 16 km

**Temporal resolution:** 3-hourly first 24 hours, 6-hourly for next 3 days, 12 hourly last two days

**Data volume:** 1.8 Gb per forecast cycle

**Distribution:** Internal, plots on web

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Optical depth and concentration not directly useful

- Post processor calculates optical properties and estimate slant path visibility from NAAPS and NOGAPS data.
- Derives extinction, absorption, and asymmetry parameter at all levels and optical depth at 19 wavelengths and 3 bands (340 nm-10.6 μm)
- Forecast fields distributed via Navy database
- Operational at FNMOC; fields used daily by NAVO in SST algorithm
Sample extinction (km\(^{-1}\)) output for
12:00 GMT 10/04/2005 at 1 48 19 S, 114 45 23 E

1.06µm Extinction

3-5µm Extinction
**COAMPS: Coupled Ocean/Atmosphere Prediction System**

**Purpose:** Forecasts aerosol concentrations

**Status:** Operational, 2X day

**Input:** NOGAPS

**Output:**

- **Species:** Dust, cloud elements (ice, snow, rain, etc.), Smoke, sulfate, sea salt, drizzle
- **Units:** Mass concentration, $\mu g \, m^{-3}$
- **Horizontal resolution:** Variable, nominally 6-, 18- and 54-km grids
- **Vertical resolution:** 20 m at sfc., ~200 m inc. to 2 km, ~1 km inc. to 20 km
- **Temporal resolution:** 1-hourly
- **Data volume:** 0.5 Gb per forecast
- **Distribution:** Internal, web
Conventional source inventories not relevant at mesoscales

Detailed dust inventory developed from satellite data, weather reports, etc., pragmatic approach

Application of DSD in COAMPS

DSD enables capability to forecast individual dust plumes.

Potential for real-time source detection?
Dust Model Validation Using Horizontal Visibility

- 8-14, 2001, Zabol, Iran

- Observed vs. three dust source databases

⇒ High-Res required for accurate onset and cessation
⇒ Visibility reports adequate for V&V (and DA?)
⇒ Avoids the pitfalls of the AOD-to-Vis conversion
DoD Customers

- CENTCOM: dust forecasting in Iraq and Afghanistan
- TAWS: ingests extinction coefficients
- NAVO and EUMETSAT: dust screening of SST retrievals
  - Issue: removal of NAAPS output fields from GODAE server at FNMOC request
  - Impact: Severely limits our ability to collaborate with national labs and academia
- NDWC: fleet synthetic training
- NRO, NGA: scene correction, situational awareness
- NPOESS: algorithm development

⇒ Widely varying customer base
Product Distribution
Issue: One size fits none

Operational Centers want all products, domains, etc. all in one place. Leads to deep layering of products.
⇒ More than 2 or 3 mouse-clicks unacceptable; slow response.
⇒ Center web sites slow to adapt to new products or respond to new requests.
Smaller, locally owned, agile web sites are optimal. E.g. 28th OWS. They own their plotting and web shop.

Sample NRL site: one click per product. Sits on top of Center sites.
Product Distribution:
AQ is a Weather Phenomena

COAMPS dust products presented with dynamical vars.
GE Display of NAAPS and FLAMBE

March 30, 2008

⇒ GE is only qualitative; but demanded by customer
1. Define Domains
2. Choose Products: Parameters, Levels, Times
3. Schedule Downloads

Downloads occur regularly thereafter
Lessons Learned and Issues

- Fire and AOD data latency (4h) not suitable for in-line simulations
- MODIS near end of life
- NPP and JPSS VIIRS data quality is uncertain
- SDR vs EDR:
  - Dependence on EDRs (produced by others)
  - Burden of processing SDR
  - Latency, data volume, control
  - Need to transition QC/QA to upstream centers
- Modeler’s needs differ from conventional imagery
  - ‘Sparse but accurate’ vs. ‘Pretty pictures’
- Near-real-time availability of community and foreign datasets to FNMOC
END

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