



FNMOCC/NRL Operational Aerosol Analysis and Forecasting



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Outline:

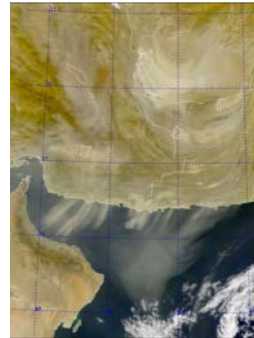
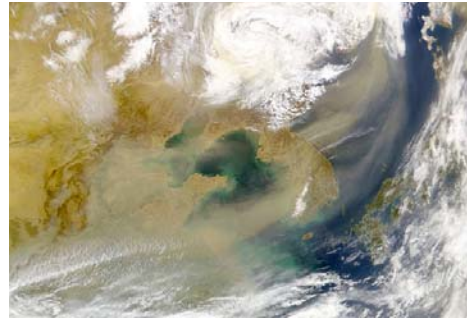
1. Military requirements
2. Overview of model suite
3. Verification and Validation
4. Distribution
5. Lessons learned and issues



Why does DoD care about aerosol particles?



- Impacts on satellite retrievals, intelligence gathering



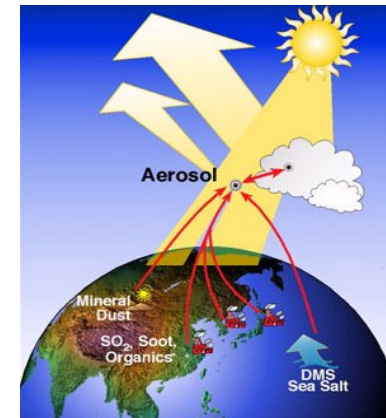
- Impacts on EO systems, slant-range vis., lock-on range



- Impacts on visibility, operations and equipment



- Impacts on the atmospheric radiative budget (direct, semi-direct, indirect)



⇒ Mostly concerned with direct effects (vis and IR) and mechanical effects



Operational Forecast System Components



System

NOGAPS

NAVDAS-AOD

FLAMBE*

DSD

NAAPS, COAMPS

FAROP**

TEDS, Metcast

MCSST†, TAWS‡

NPOESS

Function

Forecasts dynamics

Data assimilation for aerosols

Detects fires, determines smoke flux

Dust source locations

Forecast aerosol concentrations

Calculates aerosol optical properties

Database and Distribution

Applications

† 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

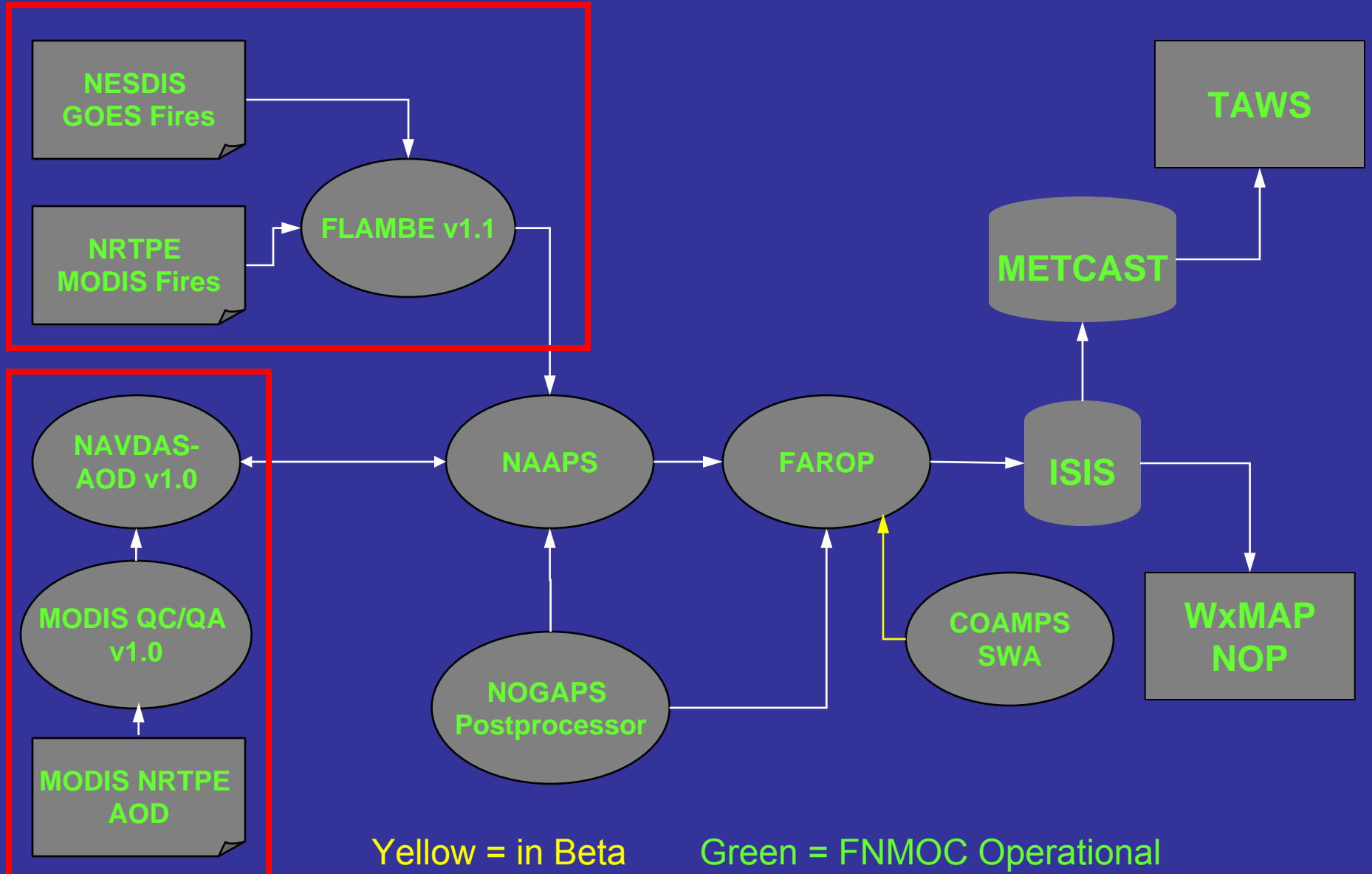


- **NAVDAS-AOD** operational, four times a day
- **FLAMBE** (fire detection) operational, four times a day
- **NAAPS** operational at FNMOC, 6-day forecast, four times a day
- **COAMPS** operational for SW Asia, Afghanistan, 3-day forecast, twice a day.
- **FAROP** operational, four times a day
 - Derived 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

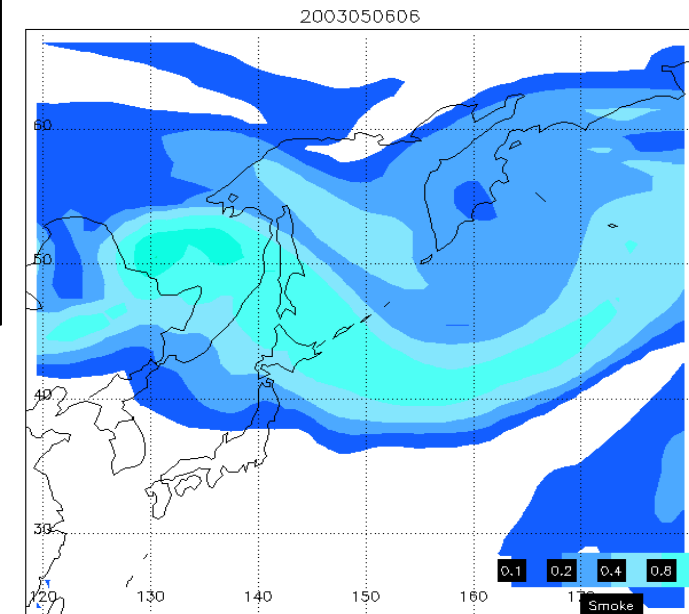
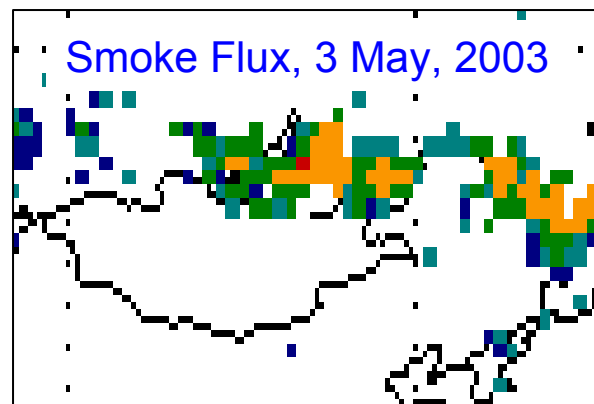
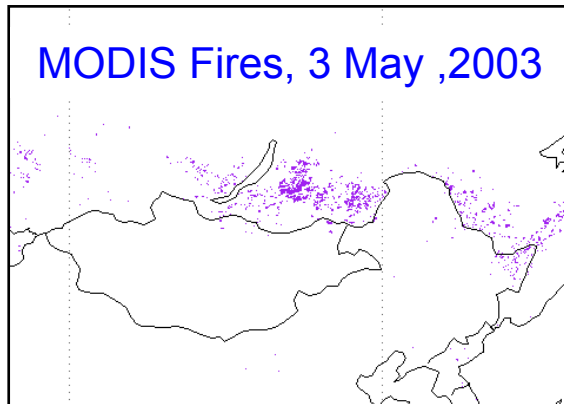
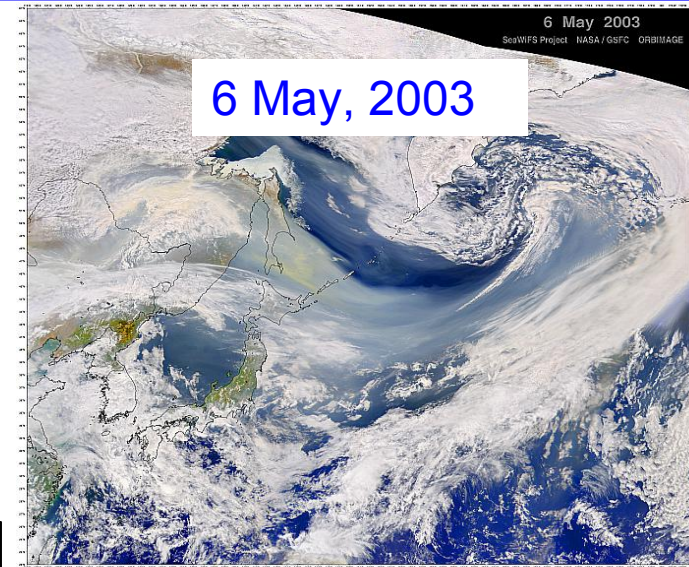




FLAMBE: Fire Locating and Modeling of Burning Emissions



Purpose: Determine real-time smoke fluxes
Input: GOES, MODIS
Output:
Fire parameters: Location (lat, lon)
Smoke flux, $\text{g m}^{-2} \text{s}^{-1}$
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



Purpose: Data assimilation for aerosol optical depth (3-d Var)

Status: Operational, 4x daily

Input: NRL Level 3 MODIS Over-Ocean AOD (6-h data window)

Next step: Over-land MODIS, MISR and CALIPSO

Future input: NPP, NPOESS, AVHRR, MetOp, MSG, MTSAT, AATSR, GOES-R

Output:

Aerosol analysis and error statistics: 3-d distribution of four species

Temporal resolution: 3 hourly

Distribution: NAAPS and FAROP; web

⇒ **Data latency (4h) not suitable for in-line simulations**



Satellite Aerosol Data Assimilation



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



NAAPS: Navy Aerosol Analysis and Prediction System



Purpose:

Forecasts aerosol concentrations

Status:

Operational, 4X day

Input:

NOGAPS, NAAPS,
FLAMBE

Output:

Species:

Dust, Smoke,
Sulfate, SO₂,
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:

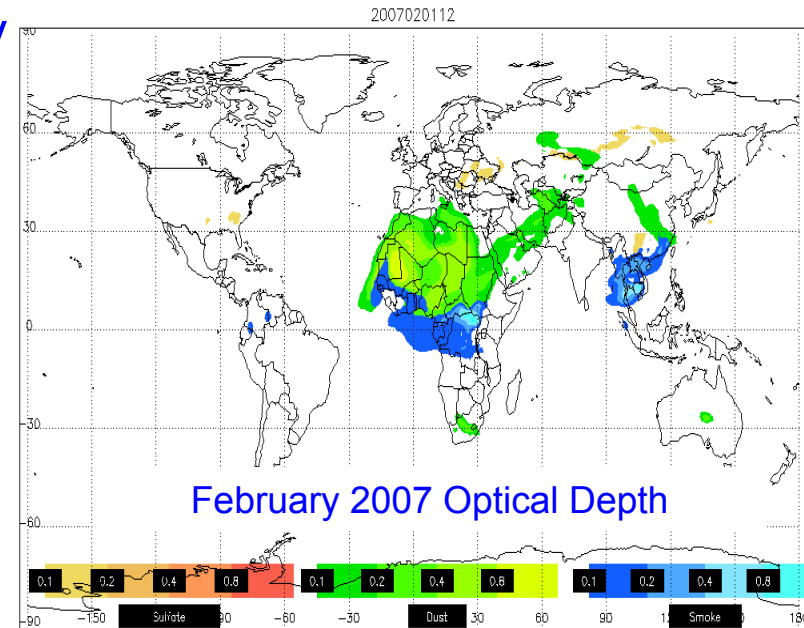
3-hourly first 24 hours, 6-hourly for next
3 days, 12 hourly last two days

Data volume:

1.8 Gb per forecast cycle

Distribution:

Internal, plots on web





FAROP: Forecast of Aerosol Radiative and Optical Properties



- ⇒ 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

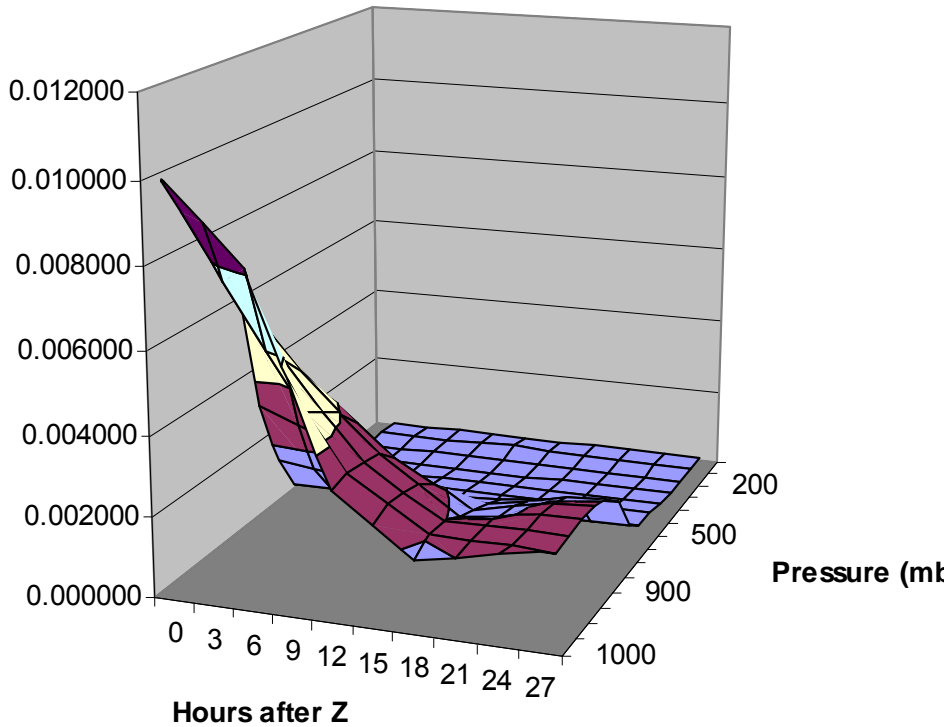


FAROP: Forecast of Aerosol Radiative and Optical Properties

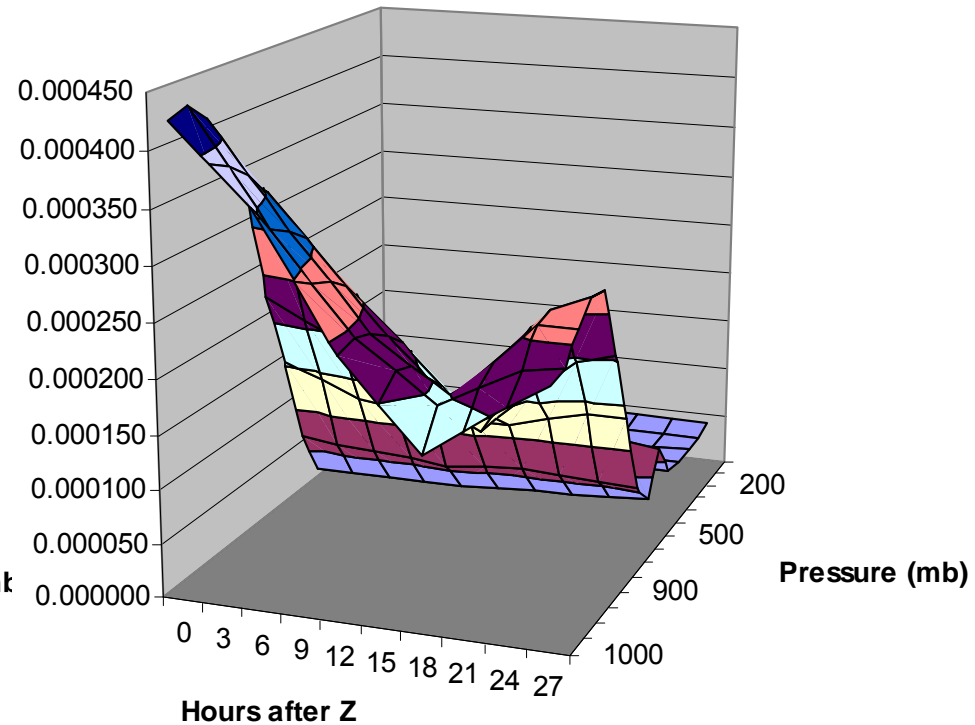


Sample extinction (km^{-1}) output for
12:00 GMT 10/04/2005 at 1 48 19 S, 114 45 23 E

1.06 μm Extinction



3-5 μm Extinction





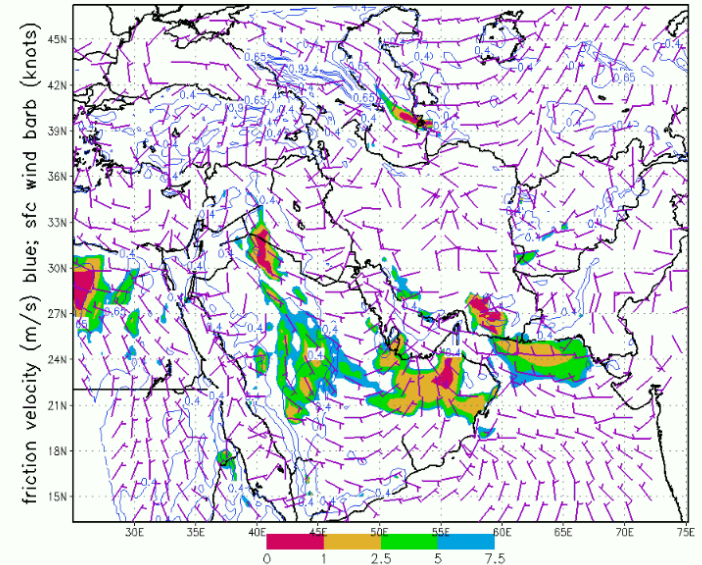
COAMPS: Coupled Ocean/Atmosphere Prediction System



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, $\mu\text{g m}^{-3}$
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

Surface dust visibility (nm) 03h fcst valid at 15Z28FEB2007
COAMPS starting from 12Z28FEB2007 grid 18-km

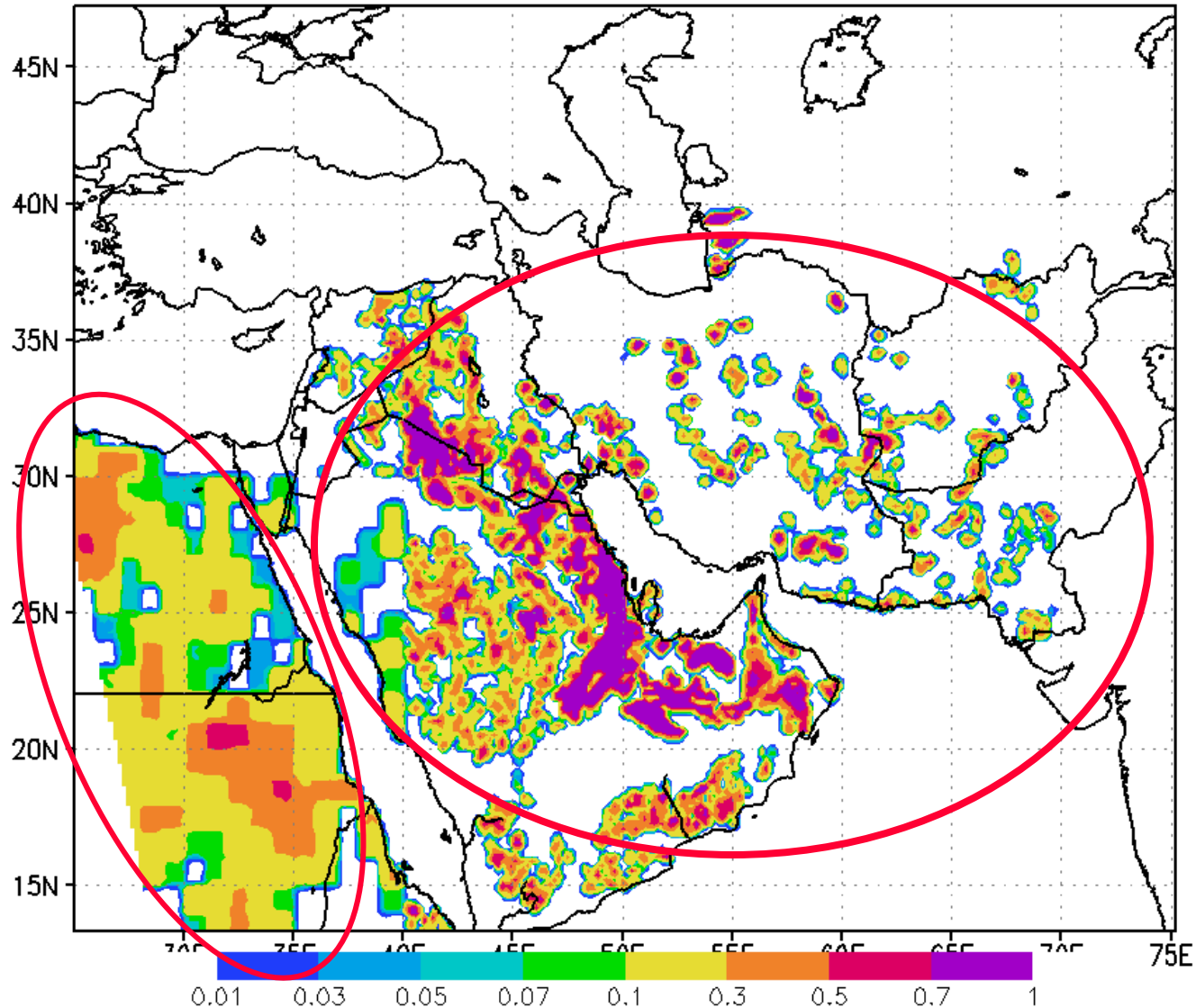




Dust Source Database (DSD)

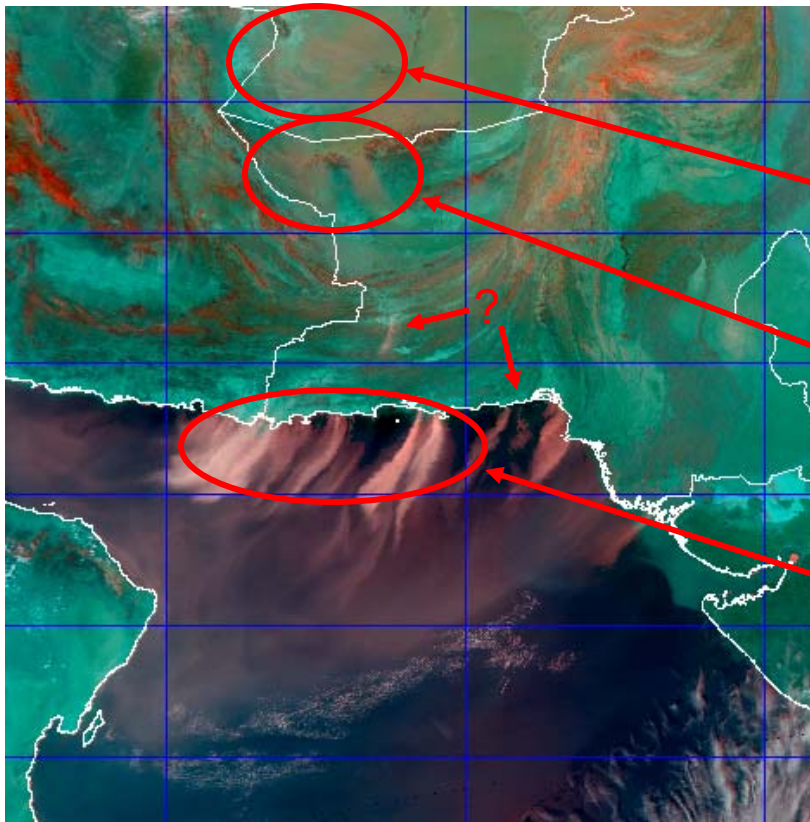


- Conventional source inventories not relevant at mesoscales
- Detailed dust inventory developed from satellite data, weather reports, etc., pragmatic approach

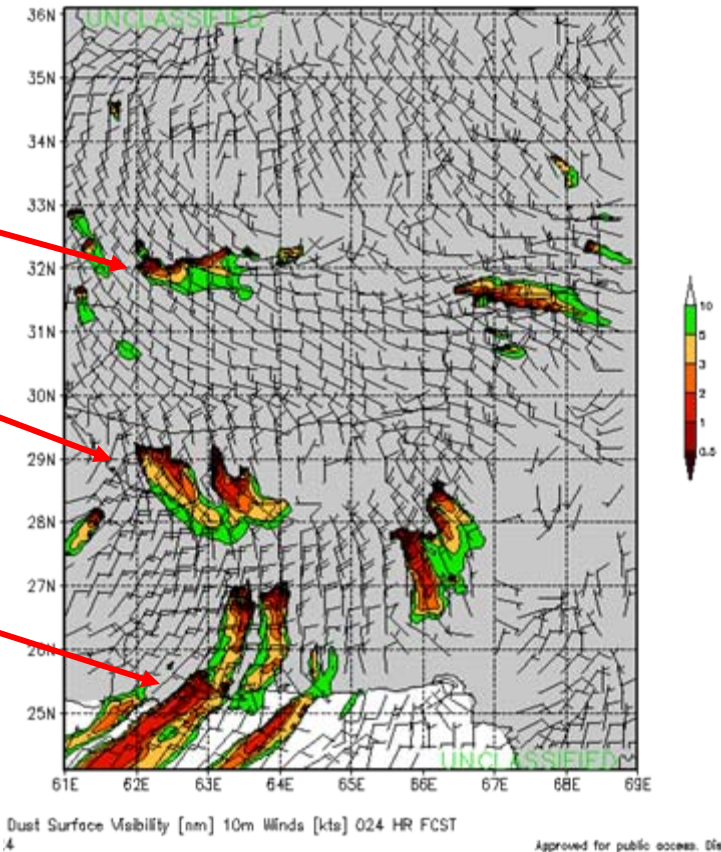


Walker, A. L., M. Liu, S. D. Miller, K. A. Richardson, and D. L. Westphal (2009), Development of a dust source database for mesoscale forecasting in southwest Asia, *J. Geophys. Res.*, 114, D18207, doi:10.1029/2008JD011541.

Application of DSD in COAMPS

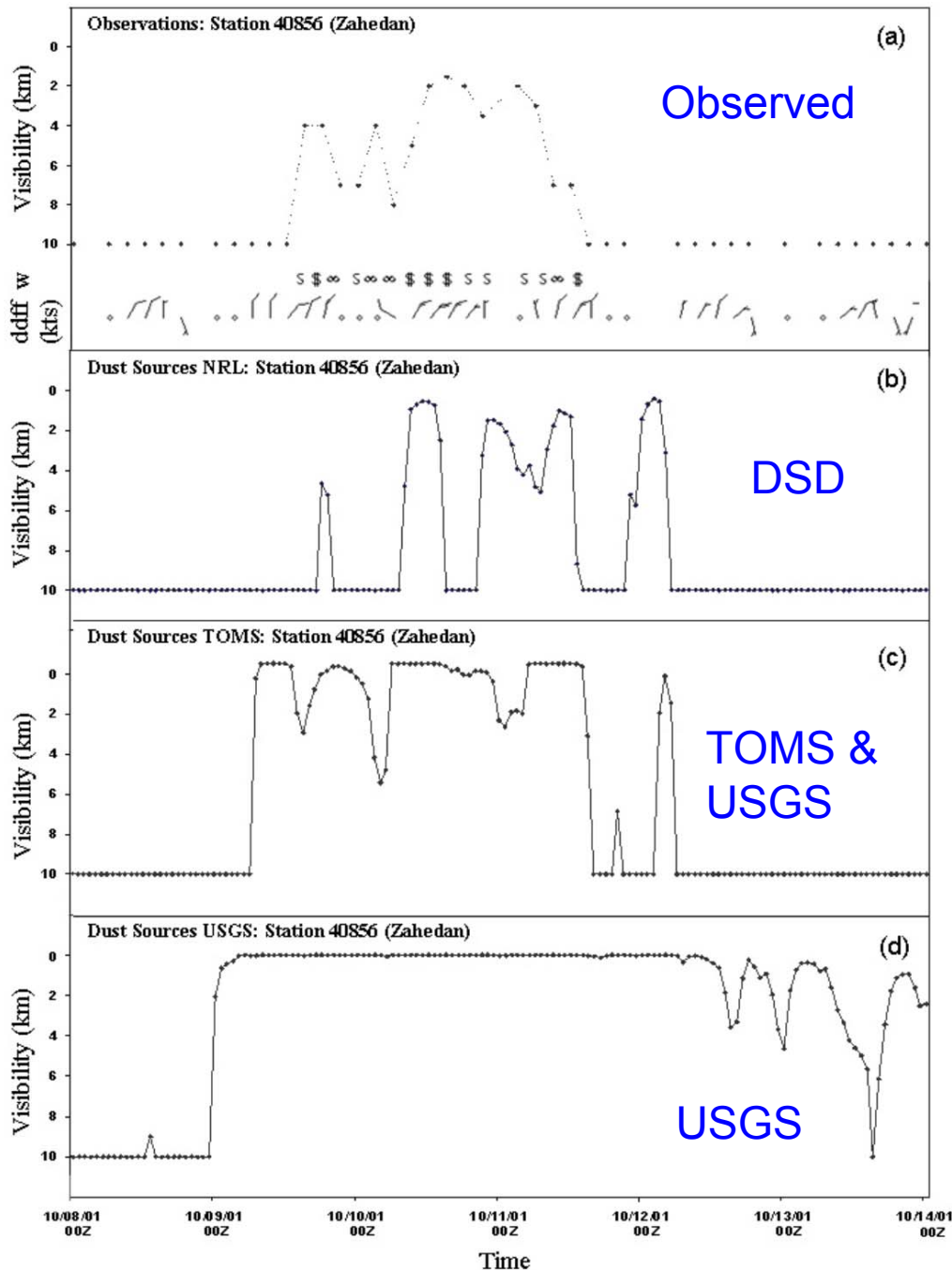


Dust Enhancement Product (DEP;
FNMOC) for 1330 GMT 9 Nov, 2009



COAMPS 6-km Dust 24-h Forecast
(FNMOC) for 1200 GMT 9 Nov, 2009

- ⇒ 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.

Oceanography Portal : Warfighter - Windows Internet Explorer

https://portal.fnmoc.navy.mil/metoc/

File Edit View Favorites Tools Help

Oceanography Portal : Warfighter

Naval Oceanography Portal

[Manage Pages, Sign out]

Select Page: Warfighter

westphal@nrmr.navy.mil

+Customize

SERVICES CENTCOM PACOM EUCOM NORTHCOM SOUTHCOM

- Global Models (CENTCOM)
 - NOGAPS (SW Asia)
 - NOGAPS (Indian Ocean)
 - NOGAPS (Africa)
 - GFS (SW Asia)
 - GFS (Indian Ocean)
 - GFS (Africa)
 - WW3 (Global)
 - WW3 (Indian Ocean)
 - NCODA (Global)
 - WW3/Altimetry (Global)
 - Dust Models (Global)
 - NOGAPS Ensemble
 - NOGAPS Ensemble Plumes
 - Model Comparison
- Global Weather Links
 - Air Force Climatology
 - NOAA
 - Aviation Weather (NOAA)
 - JTWC
 - NAVO
 - NAVO Products
 - JAAWIN
 - Air Force Weather
 - NRL
 - USGODAE
- Regional Links (CENTCOM)
 - Forecasters Handbook (Middle East)
 - Forecasters Handbook (Arabian Sea)
 - 28th OWS
- Support Requests
 - CAAPS
 - TAWS
 - MMOS
 - AREPS
 - BALWIND
 - OPARS and METCAST
 - TDP Request Guide
 - TDP Download
- Regional Models (CENTCOM)
 - COAMPS (Indian Ocean)
 - COAMPS (SW Asia)
- Satellite Products (CENTCOM)
 - SatFocus (Indian Ocean)
 - Scatterometer (Indian Ocean)
- Meteograms
 - NORTHCOM
 - SOUTHCOM

+Add Content



Product Distribution

Issue: One size fits none



⇒ 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.

NAAPS Web Page - Windows Internet Explorer

http://www.nrlmry.navy.mil/aerosol_web/index_frame.html

File Edit View Favorites Tools Help

Google Search

NAAPS Web Page x http://krvr.com/

SATELLITE

FNMOc Sat Focus (Latest, Prev, Mosaic, Animate, GeoTiff, KMZ)

Region Res. (km)	ASea	Afghan	Cen AGulf	Cent ComAOR	Iraq	Kuwait	NCent ComAOR	Mid East	SE Iraq	Red Sea
PRODUCT										
Met7/9 IR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Met7/9 Vis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Met7/9 WVap	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Met7 Dust	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Met9 Dust	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Terra Dust	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Aqua Dust	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

FNMOc Sat Focus

[NRL Sat. Focus Page](#)

[28th OWS](#) Dust Plume Alert: [OIF](#) [OEF](#)

[JAAWIN](#) Met9 Dust Loop: [Iraq](#) [Middle East](#)

[NEMOC Satellite](#)

FORECASTS

METOC: [NOP](#) [FNMOc Portal](#) [WXMAP](#) [JAAWIN](#)

Dust, Visibility:

[NOGAPS/NAAPS Visib.](#)

DUST MODEL COMPARISON: [48 hour](#) [144 hour](#)

FNMOc Operational COAMPS: ([readme](#))

[18-km SW Asia Loop](#)

[6-km PG Loop](#)

[6-km Afghan Loop](#)

Internet | Protected Mode: On 100%



Product Distribution: AQ is a Weather Phenomena

Oceanography Portal : Regional Models (CENTCOM) - Windows Internet Explorer

https://portal.fnmoc.navy.mil/metoc/px?ospId=P-10ec43ffeb-10009&ospUfs=https://{ufsh}/wxmap_cgi/cgi-bin/wxr

File Edit View Favorites Tools Help

Oceanography Portal : Regional Models (CENTCOM)

[Go to Portal] Regional Models (CENTCOM) [Sign out]

UNCLASSIFIED
[Back](#)

FNMOX WMAP Model: COAMPS Area: SWAsia DTG: 2008033112

Available DTGs [2008032900](#) [2008032912](#)
[2008033000](#) [2008033012](#)
[2008033100](#) [2008033112](#)

	PRODUCT	all	all	all	all	all	all	all	all	all	all	all	all	all	
TAU		000	006	012	018	024	030	036	042	048	054	060	066	072	Loop
all	500 hPa Heights [m] and Rel. Vort [10-5 s-1]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	850 hPa Temperature [C], winds [kts] and Rel. Hum. [%]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	700 hPa Heights[m] ; Winds[kt] ; Temperature[degC]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	925 hPa Heights[m] ; Winds[kt] ; Temperature[degC]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Sea Level Pressure	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	1000-500 Thickness [dm] and Sea Level Pressure [mb]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Previous 6-hr Precipitation Rate [mm/6hr] and Sea Level Pressure [hPa]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	10 meter wind[kt]	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Evaporative Duct Height	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Sea Surface Temperature	●	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Dust Surface Visibility[nm] ; Winds[kt]	■	●	●	●	●	●	●	●	●	●	●	●	●	●
all	Dust Optical Depth	■	●	●	●	●	●	●	●	●	●	●	●	●	●

Done Internet 100%

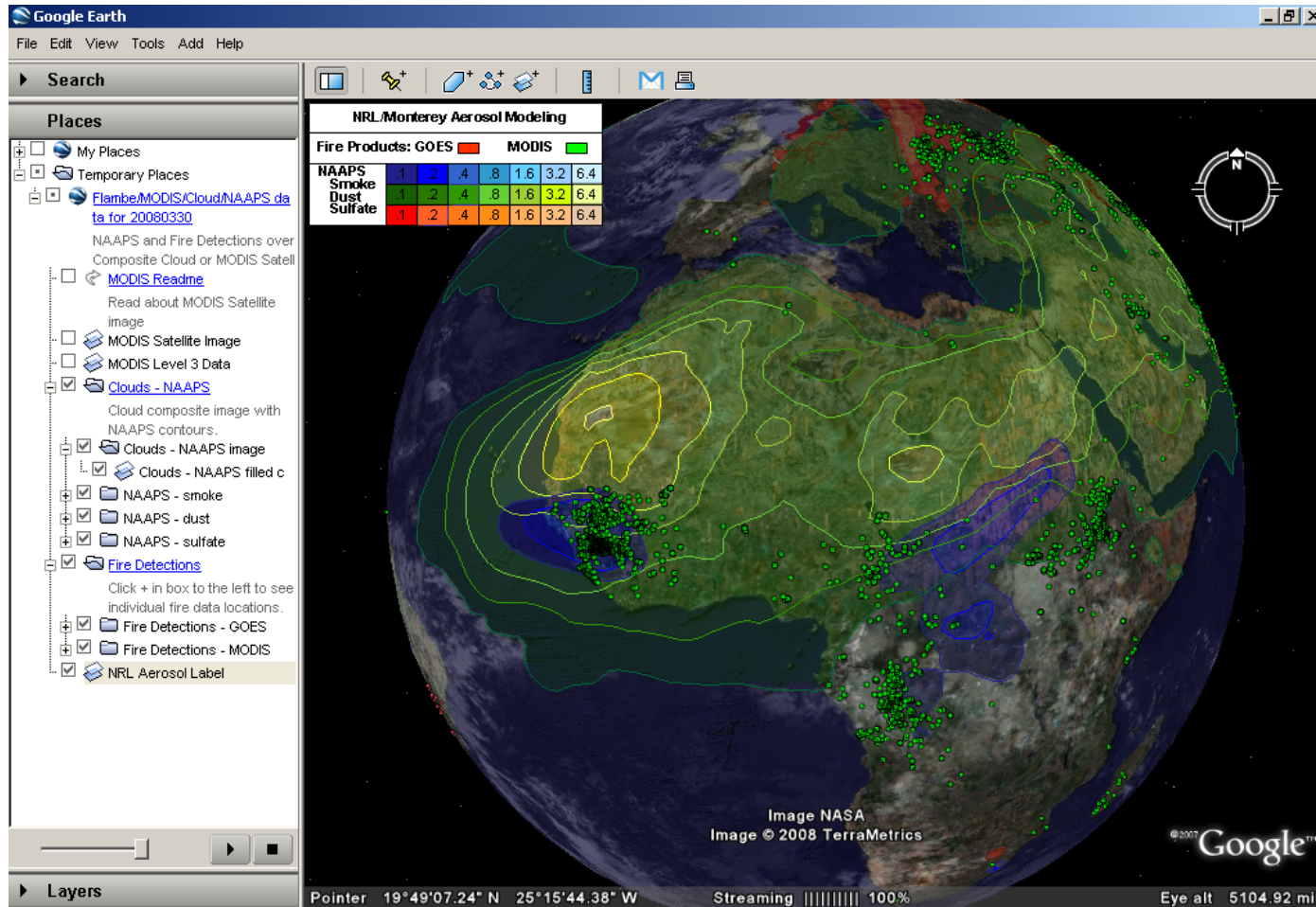
⇒ COAMPS dust products presented with dynamical vars.



GE Display of NAAPS and FLAMBE



March 30, 2008



⇒ GE is only qualitative; but demanded by customer



Automated Distribution of FAROP Data via Metcast Client (Subscription)



1. Define Domains

2. Choose Products: Parameters, Levels, Times

3. Schedule Downloads

The screenshot displays the METCAST Requestor application with several windows open:

- Product Selection - globe01**: Shows a list of product types and models. The "Parameters" list includes items like `* aero_asym_lw`, `* aero_asym_mw`, `* aero_asym_nir`, `* aero_asym_uv`, `* aero_asym_vis`, `* aero_extinct_lw`, and `* aero_extinct_mw`. A red circle highlights this list.
- Area Properties**: Shows scheduling options. The "Request Type" is set to "Scheduled". The "Local Time (24 hr)" is currently 1243. A red circle highlights the time selection area, which includes a list of times: 0000, 0600, 1200, and 1800. A "0000" value is entered in the "XXnn = every hour at nn minutes" field.
- Area Properties**: The "Request Updates Every (Minutes)" is set to 60. The "Get Data Newer Than (minutes)" is set to 720.

At the bottom of the interface, a text box states: **Downloads occur regularly thereafter**. A "Cancel" button is visible in the bottom right corner.



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



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END

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