Navy Global Aerosol and Data Assimilation Systems

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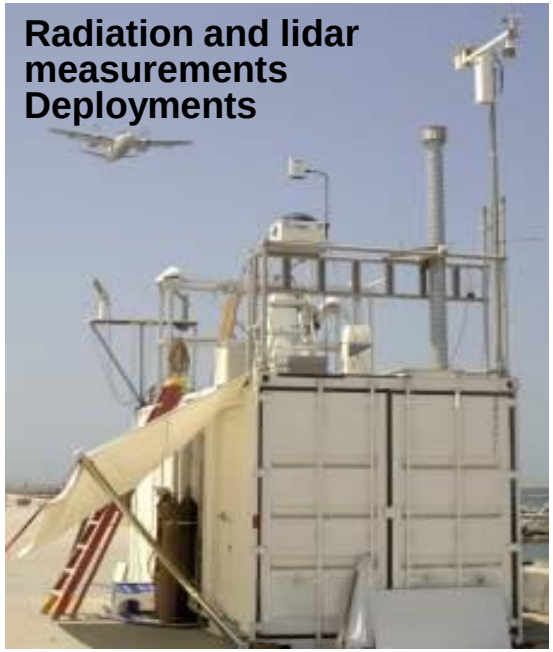
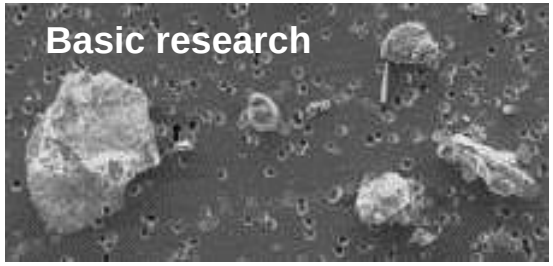
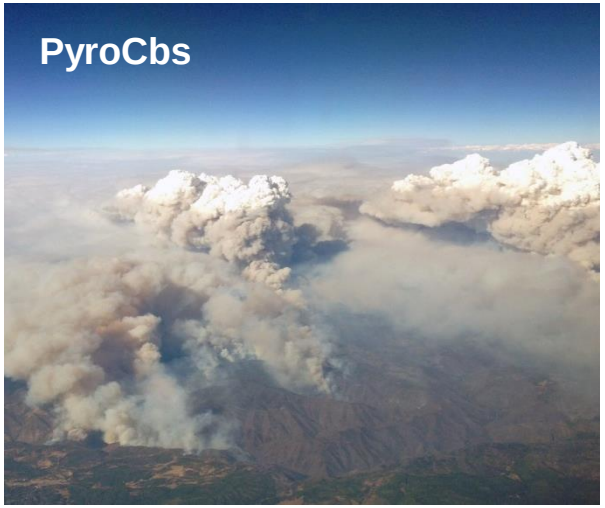
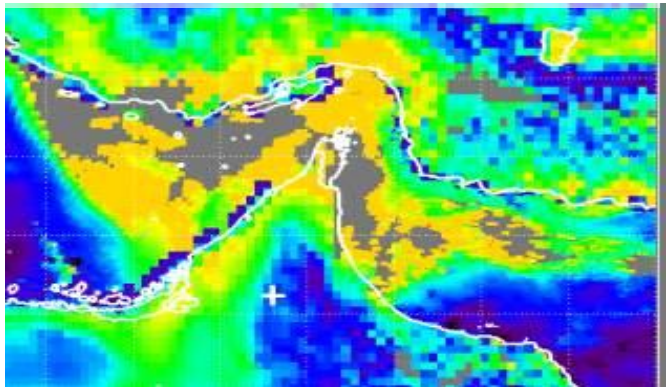
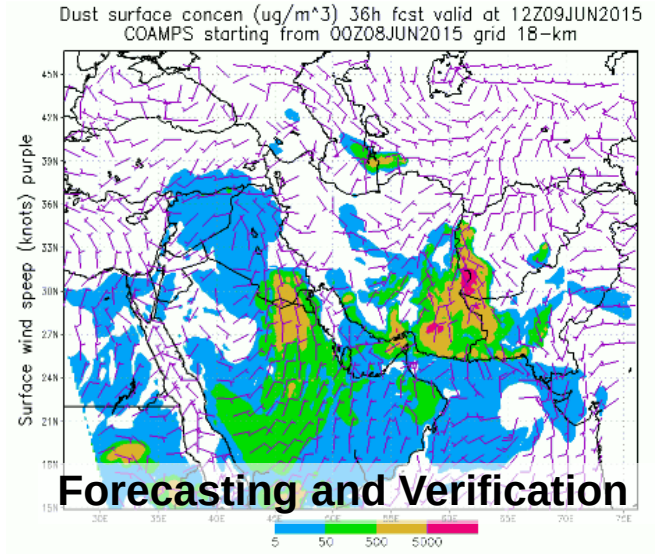






Data assimilation
QA/QC of Operational satellites
Study of Aerosol interactions

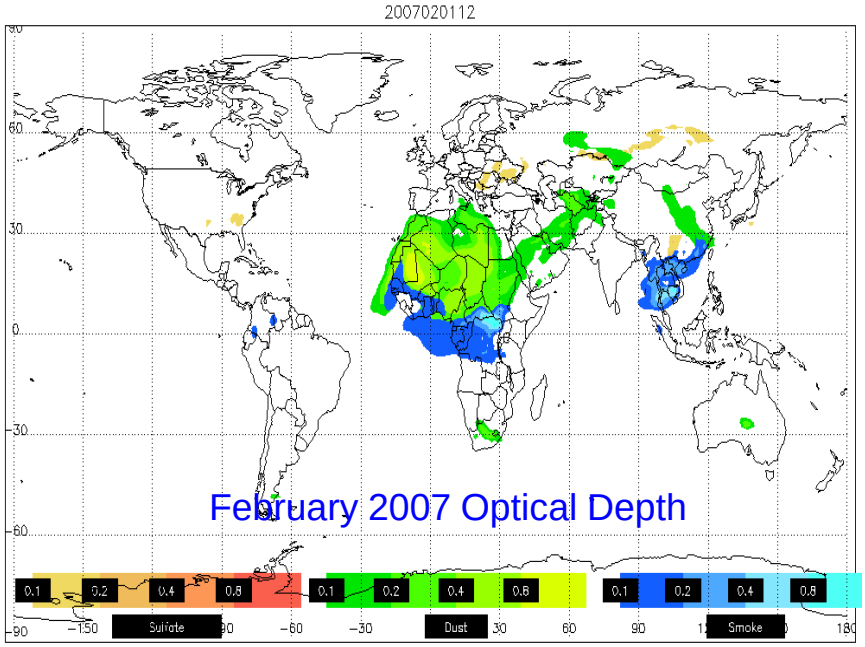




NAAPS and COAMPS

Global Modeling: Navy Aerosol Analysis and Predication System (NAAPS)

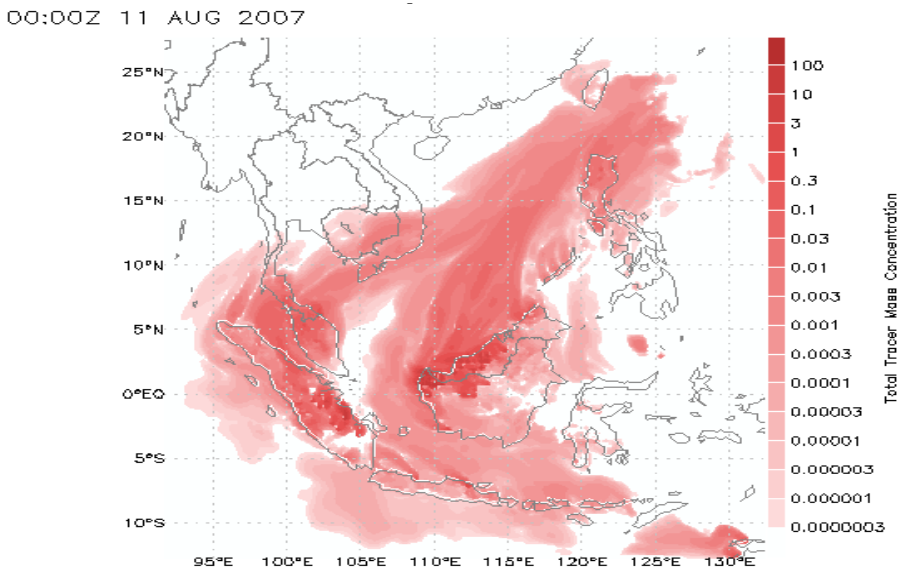
- **World's first operational global aerosol model and is now at 1/3 degree based on NAVGEM fields.**
- **Utilizes world's first operational aerosol data assimilation & fire data streams.**
- **Forecast dust, smoke, pollution, and sea salt**



February 2007 Optical Depth

Mesoscale Modeling: Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS®)

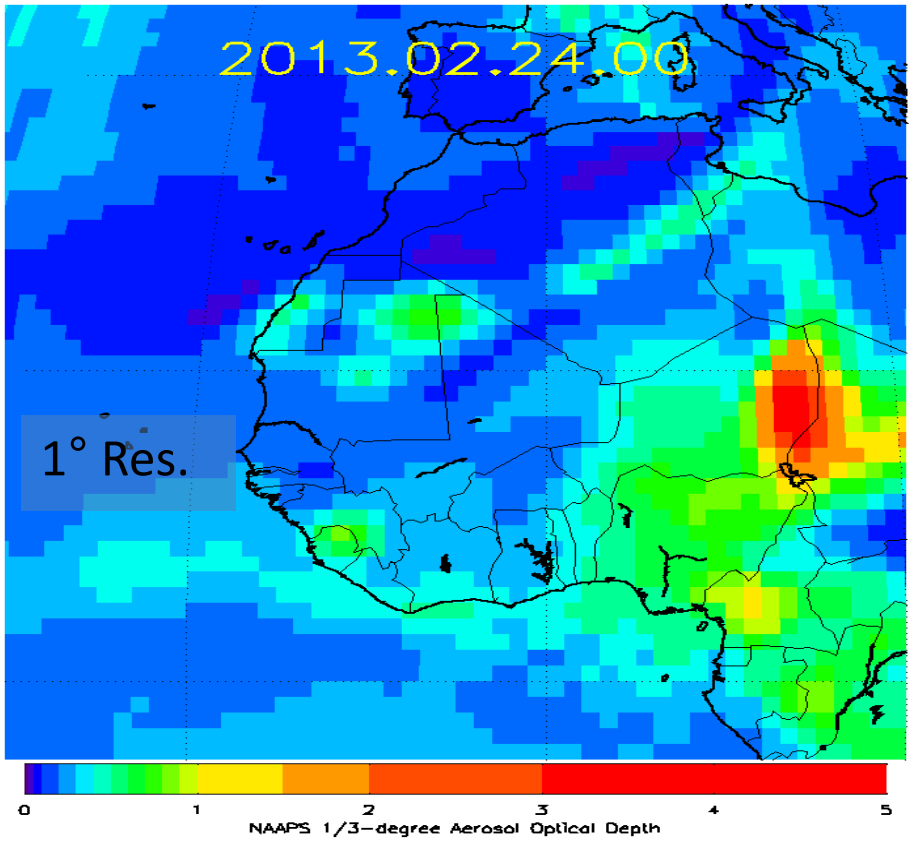
- **COAMPS® is mesoscale model fully coupled with the ocean.**
- **Dust forecasts operational at FNMOC since 2001 Currently adding aerosol species fully coupled with the model.**
- **Can be used to study complicated coastal flows where aerosol particles, winds, and water vapor covary.**

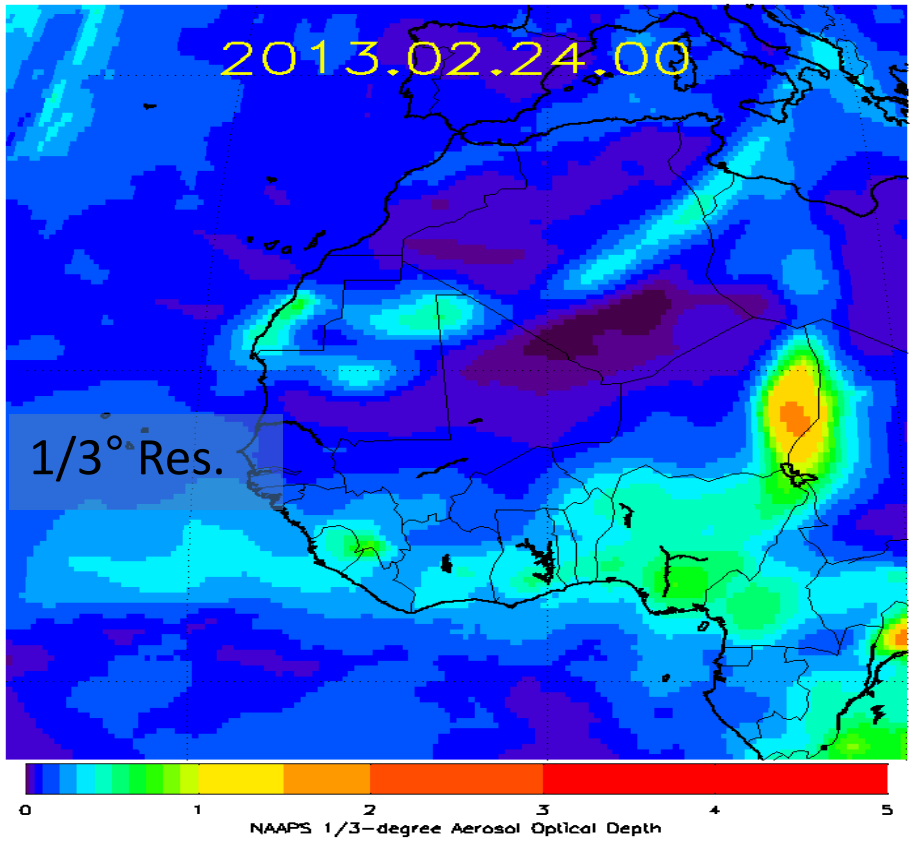


1/3° QA/QC and NAVDAS-AOD Progress

NAVDAS-AOD

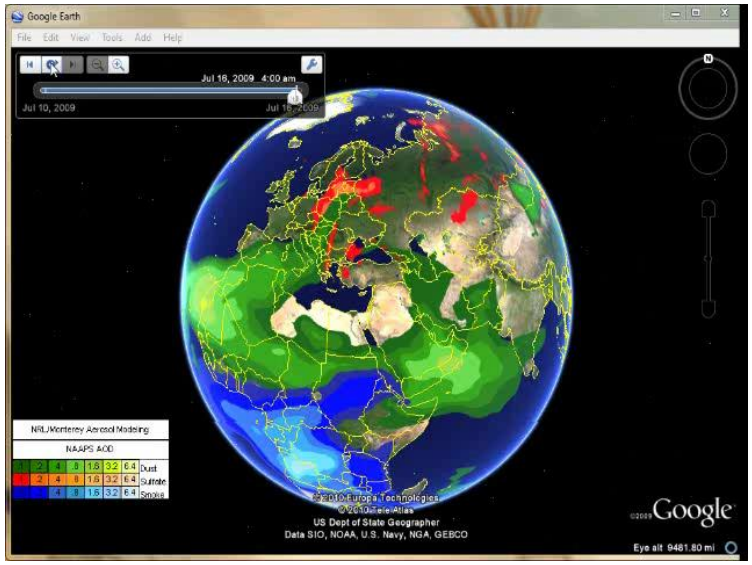
- Added capability for the system to use variable spatial resolution satellite data (e.g. 1°, ½°, 1/3° or 1/n resolution). Completed.
- Successful cycling of 1/3° NAAPS with NAVDAS-AOD on NRL machines.



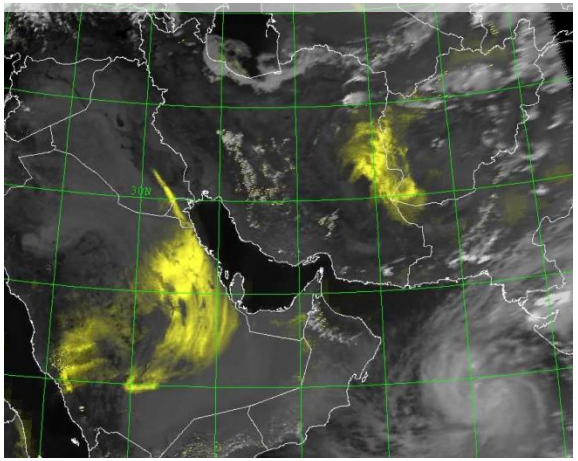


Operational Status of Models

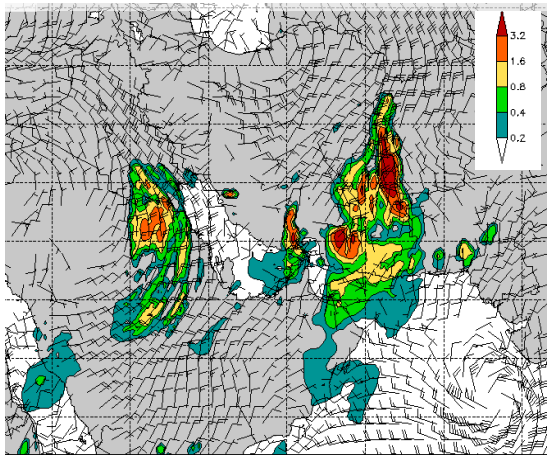
- NAAPS operational at FNMOC, 6-day forecast, four times a day
- COAMPS operational for SW Asia, 3-day forecast, twice a day
  - 18-km SW Asia, 6-km PG, 6-km Afghanistan
- FLAMBE fire detection, operational, four times a day
- NAVDAS-AOD 2D-VAR Aerosol DA, operational, four times a day
- FAROP operational,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



NRL DEBRA 20150608 12Z

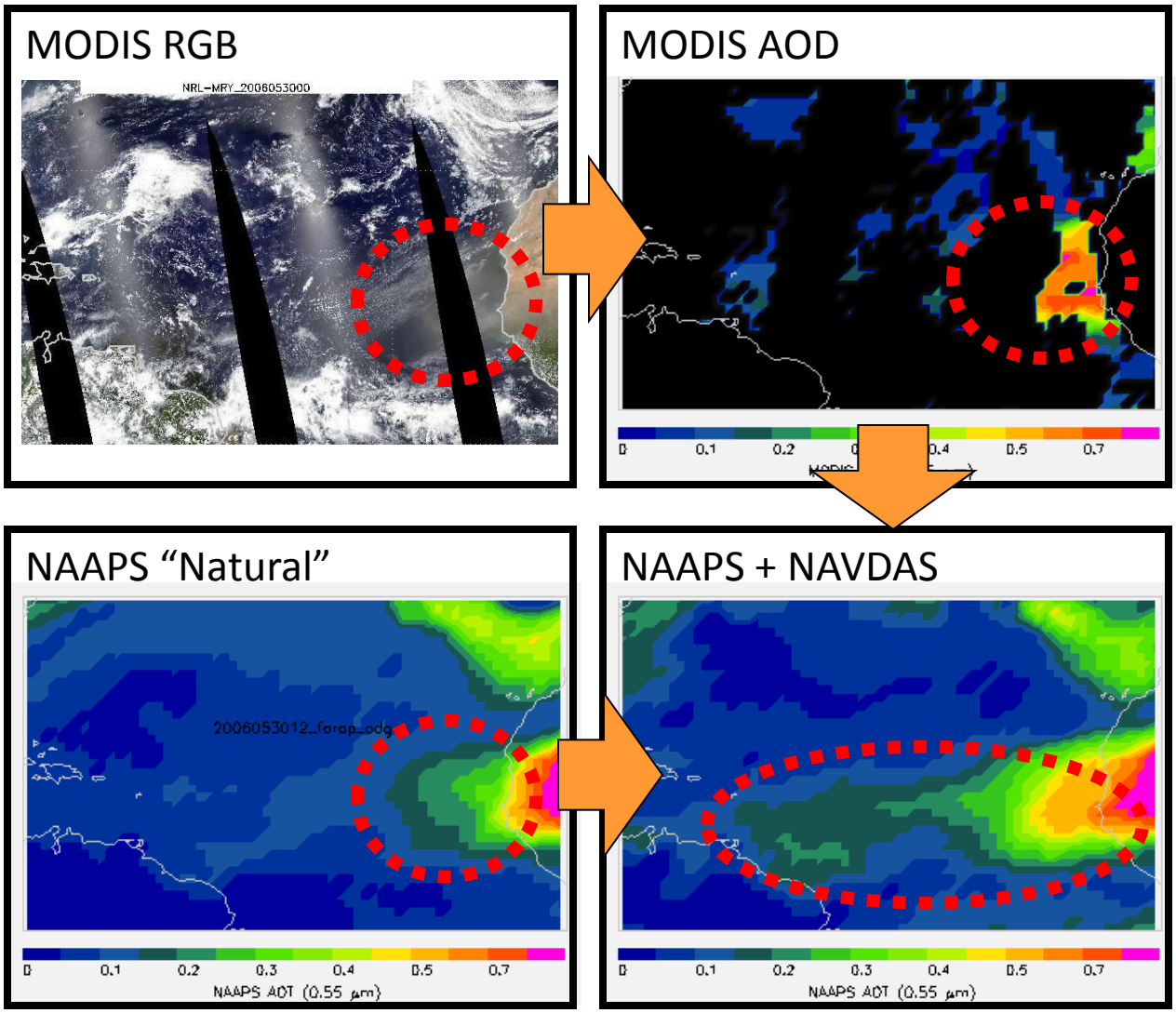


COAMPS 24 hr forecast VT 20150608 12Z



AOD and sfc winds

NAVDAS-AOD Data Assimilation



Produces 6-hourly, global 3-d distributions of aerosol species (sulfate, smoke, dust, salt), in real-time (and back to 2000)

<u>Assimilated Data:</u>

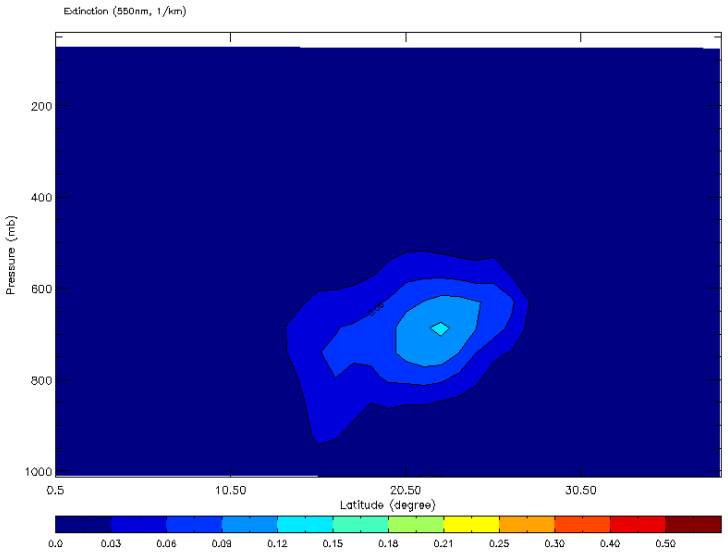
NRL Level 3 version of MODIS AOD

AERONET and CALIPSO climatology used for speciation

Operational at Navy

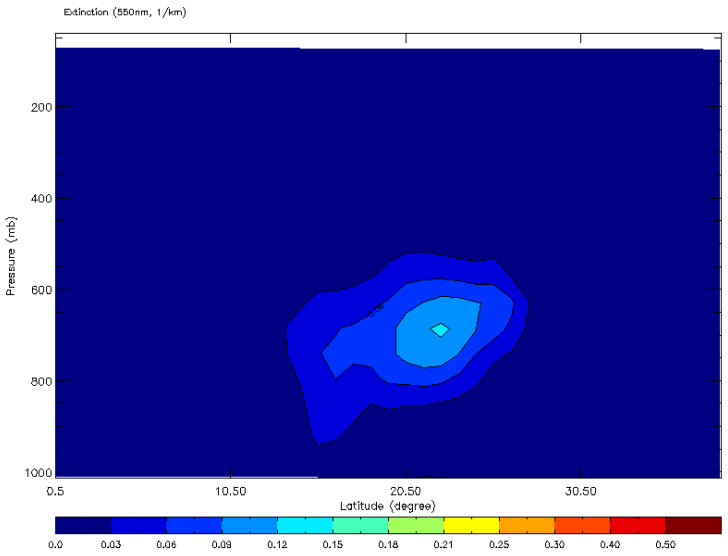
- **Coming soon: over-land AOD**
- **CALIPSO used for 3-d var data assimilation and validation**

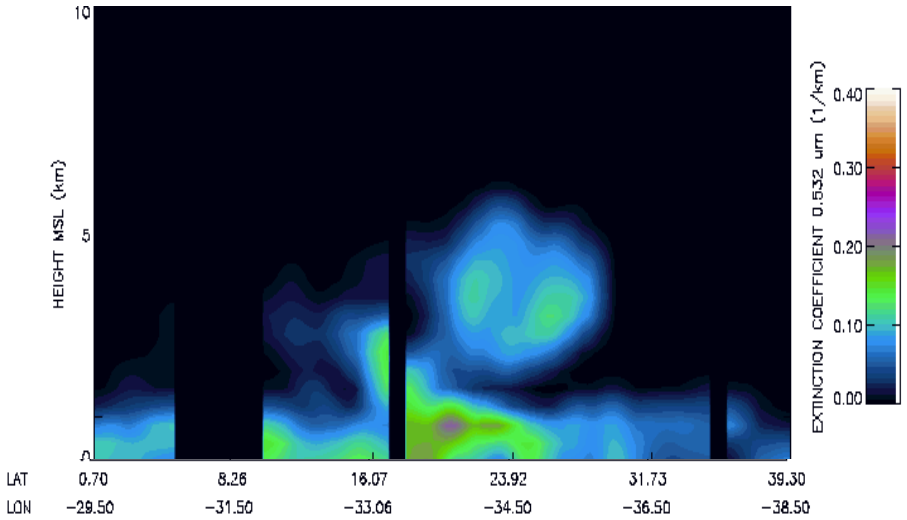
CALIPSO Assimilation



- NAAPS 0.532 μm extinction profile (before assimilation, above) depicts elevated aerosol (dust) in SAL, only diffuse aerosol is noted elsewhere in profile

CALIPSO Assimilation





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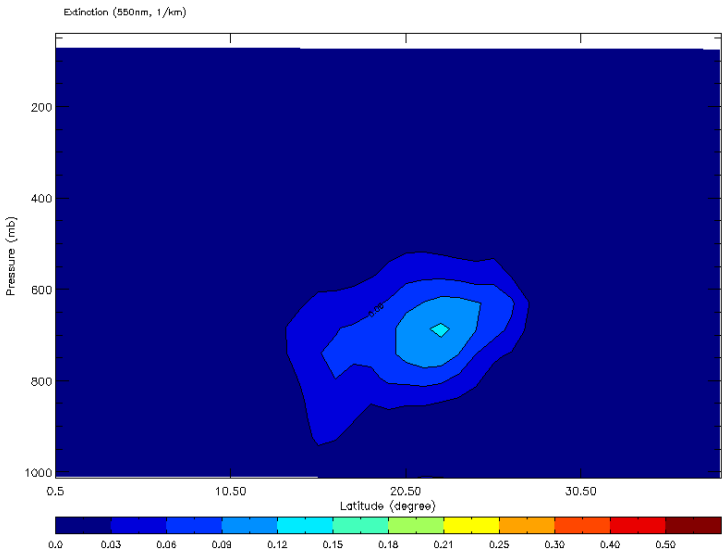
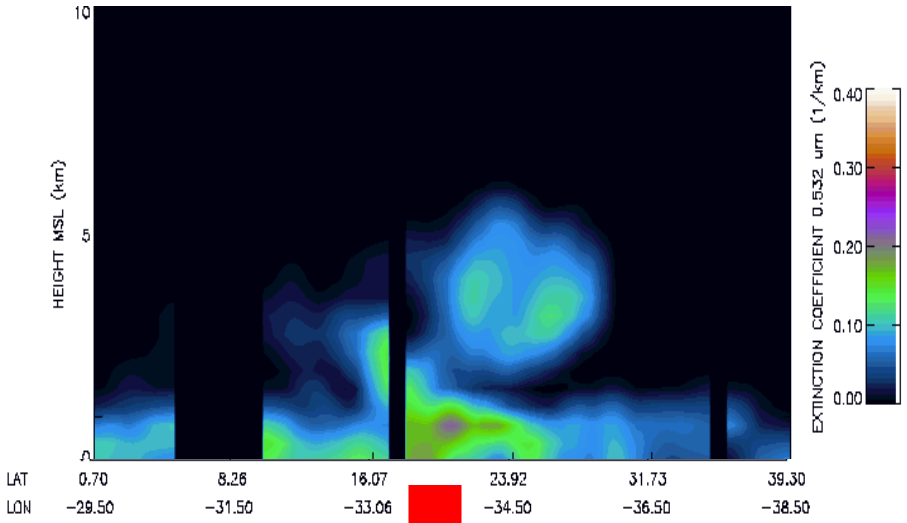
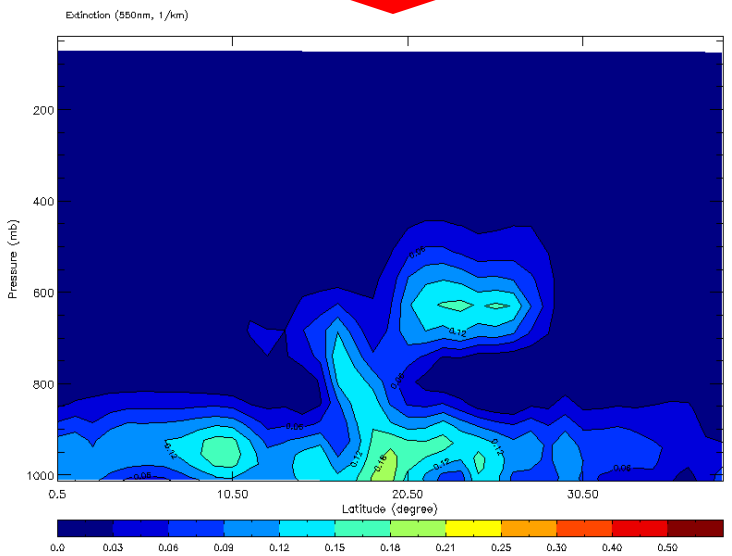
- Processed CALIPSO data (top right) indicate substantial near-surface layer

CALIPSO Assimilation







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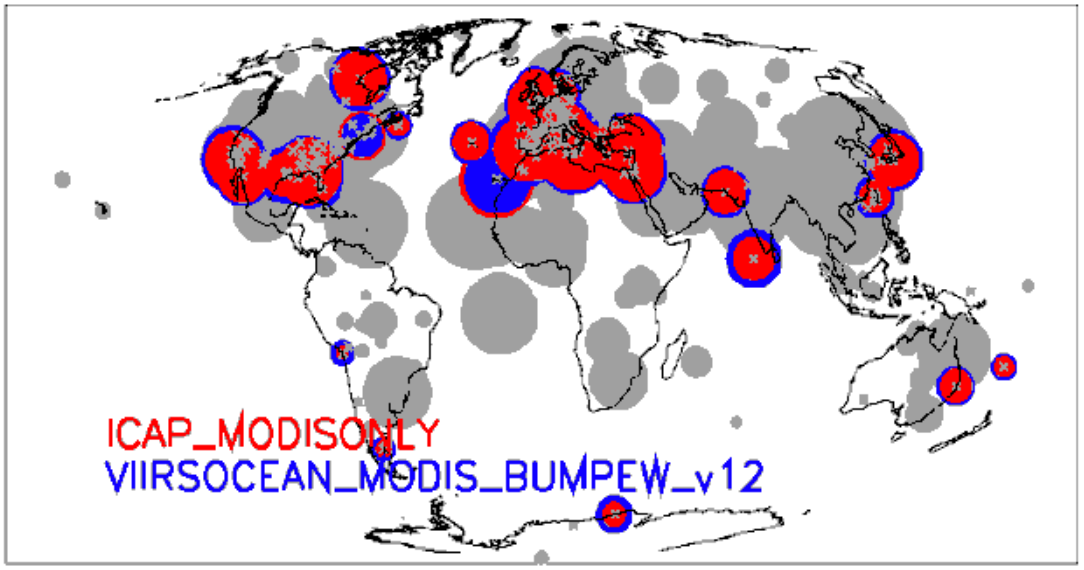
- Processed CALIPSO data (top right) indicate substantial near-surface layer
- After assimilation (right) NAAPS shows all features seen in CALIPSO

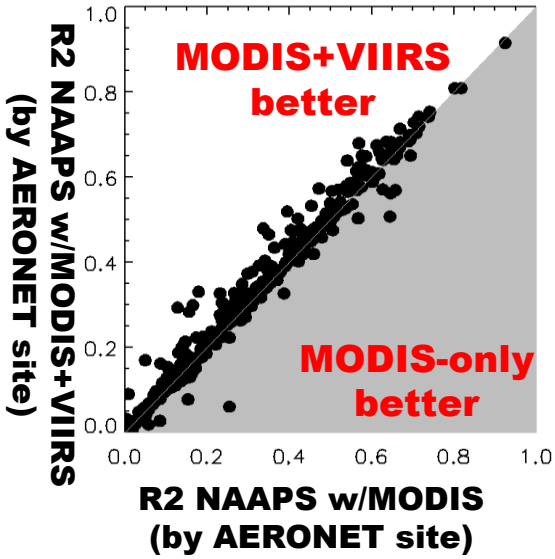
Comparison of NAAPS analyzed AOD to AERONET

- EXAMPLE: Verification of VIIRS impact on NAAPS assimilation done using AERONET L1.5

LEFT: Correlation coefficient r^2 for each AERONET station for **VIIRS+MODIS** and **MODIS-only**. Larger = better. (gray = small/no difference).
RIGHT: scatter plot of per-station r2 of analyzed AOD.

- VIIRS+MODIS has better r^2 at 272 of 399 stations
- RMSE also tested: VIIRS+MODIS has lower RMSE at 234 of 399 stations





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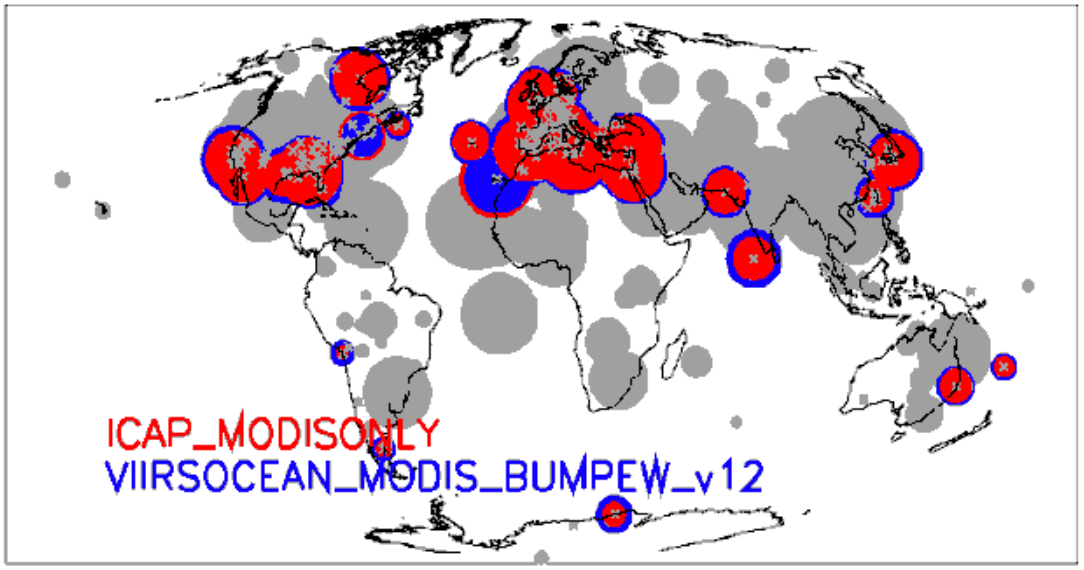

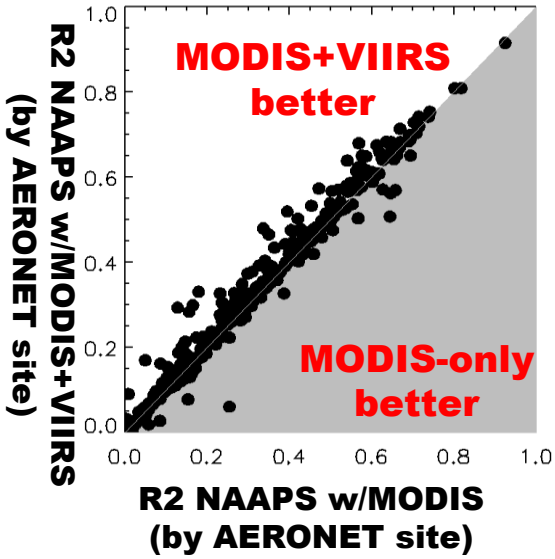

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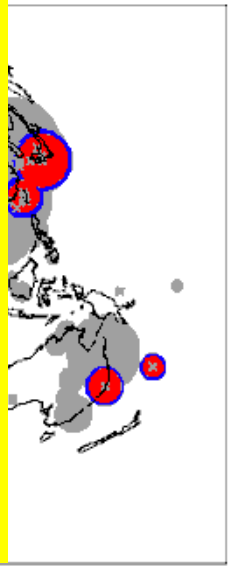
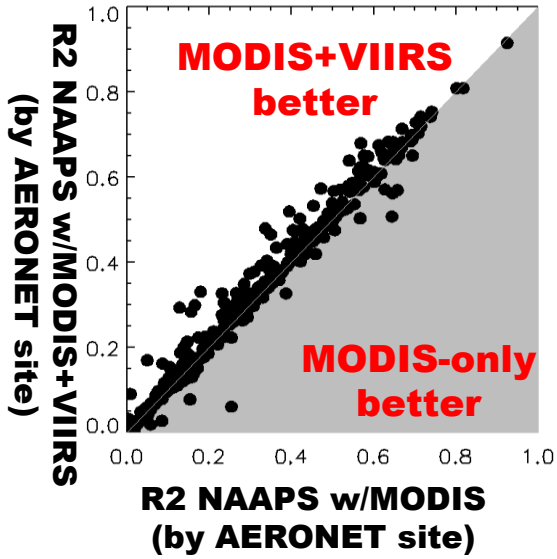
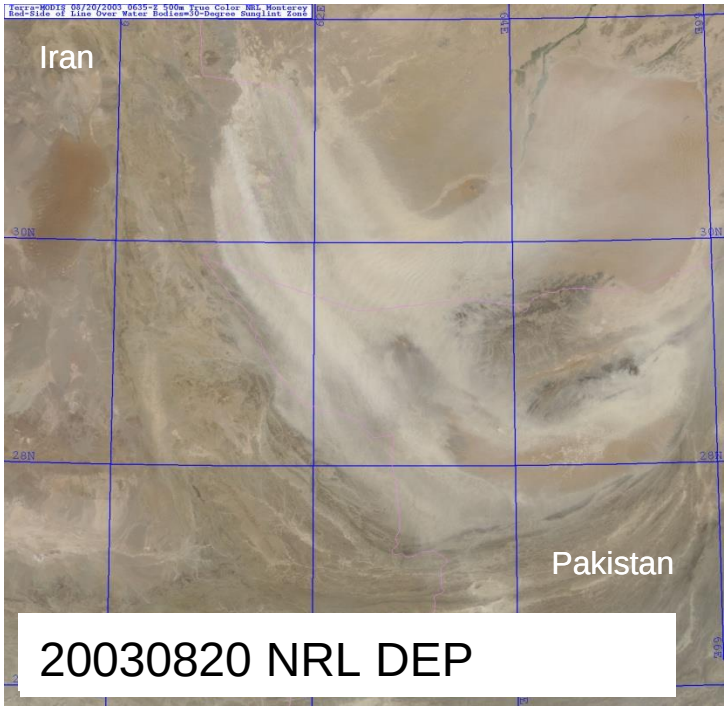
Take Away:
NPP VIIRS works
JPSS VIIRS will also work

Transition of MODIS+VIIRS to operations is pending

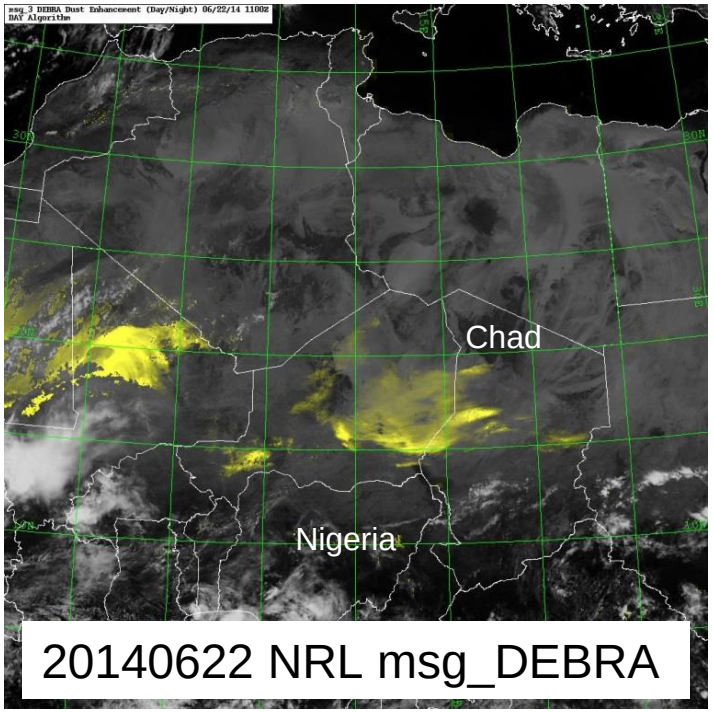




Regional Dust Source Database High-resolution



20030820 NRL DEP



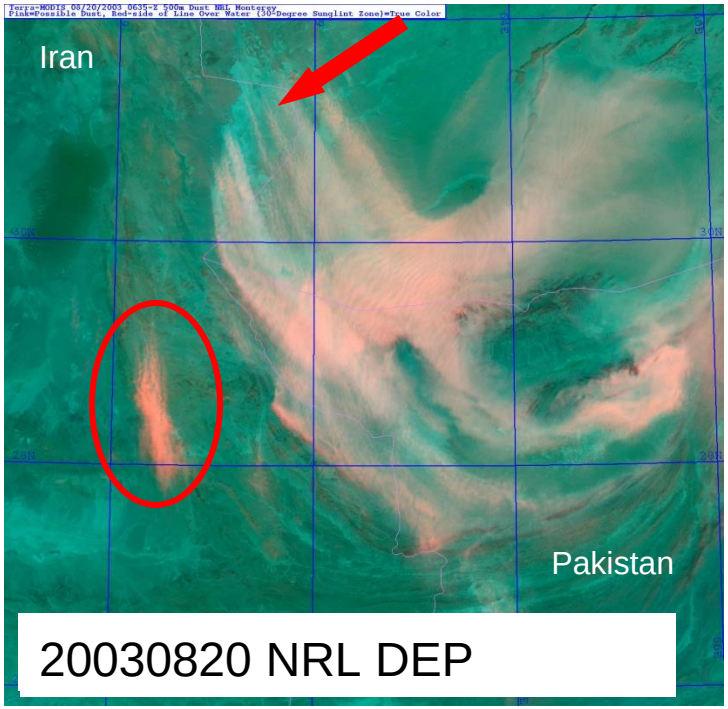
20140622 NRL msg_DEBRA

Approach and Methodology

- Used 14 yrs of NRL Dust Enhancement Product (DEP) imagery (250m - 1km)
  - + 5 years of NRL DEBRA Meteosat RGB product (higher temporal res. 15 min)
- Dust source area entered into database
  - (cursor location tool = 1km precision)

- COAMPS 10 m wind overlays (plume head vs tail)
- Surface weather maps (showing dust storms, reduced visibility)
- Cross-correlate land and water features using maps, atlases, GE)

Regional Dust Source Database High-resolution



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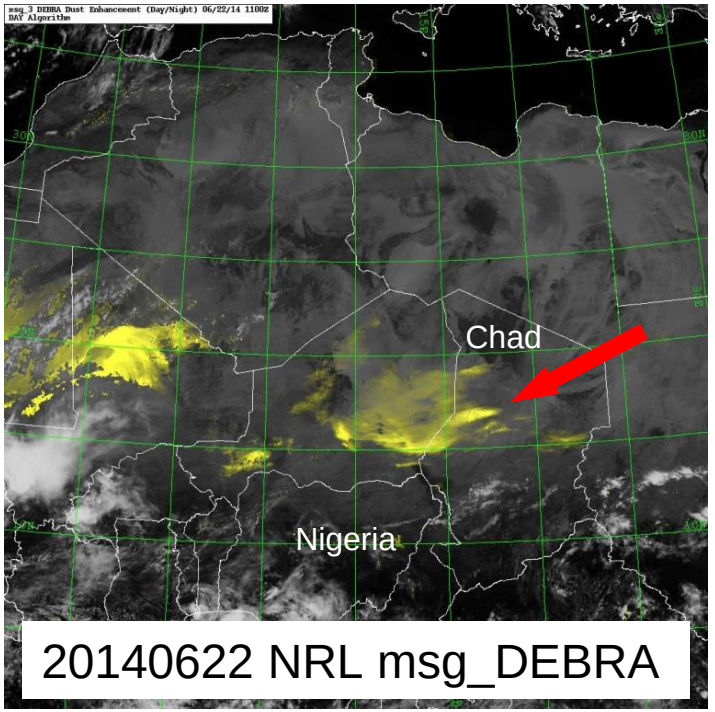

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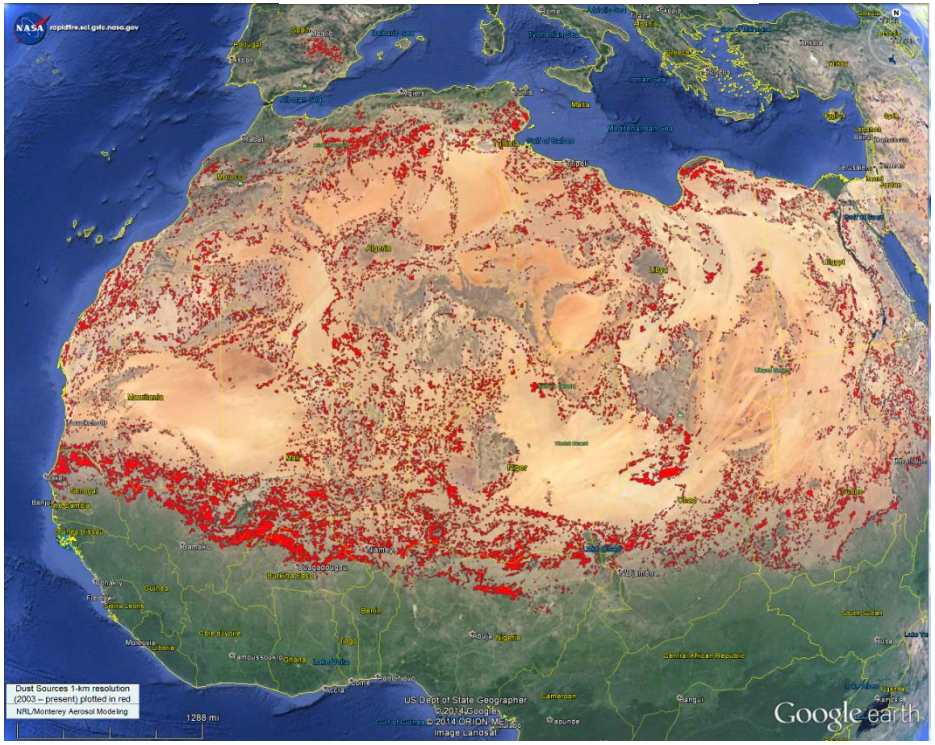
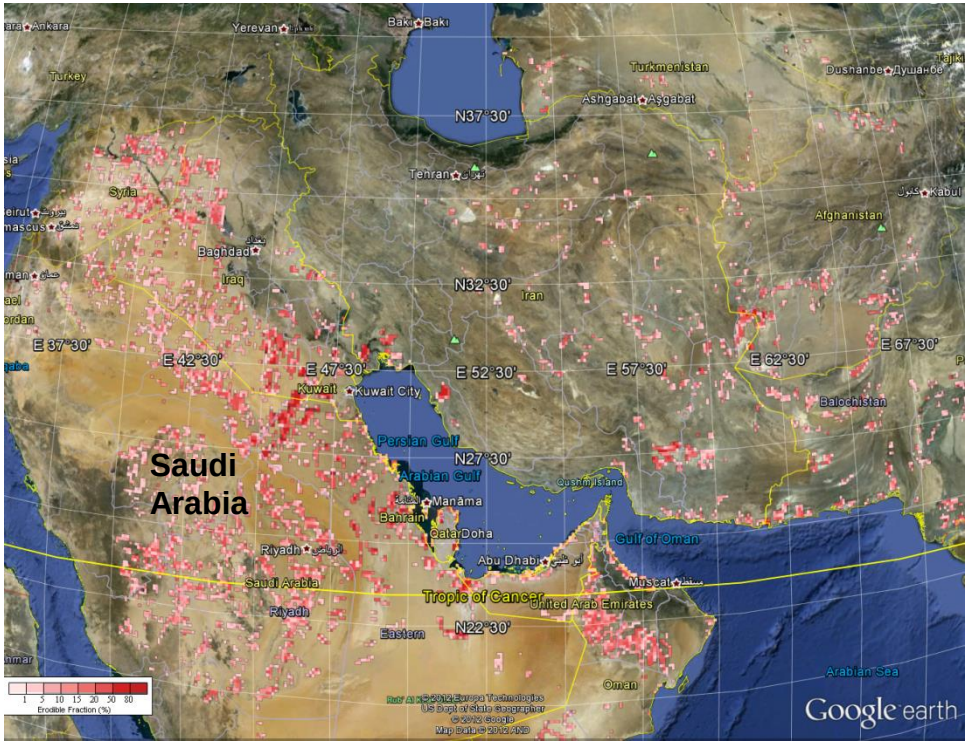
Regional Dust Source Database High-resolution

- Solid red shapes identify dust source areas located using DEP and msg_DEBRA
- DSD used in COAMPS (1 km sources gridded to 6, 9, 18, 27, 54, 81 km resolution)

North Africa DSD



SW Asia DSD

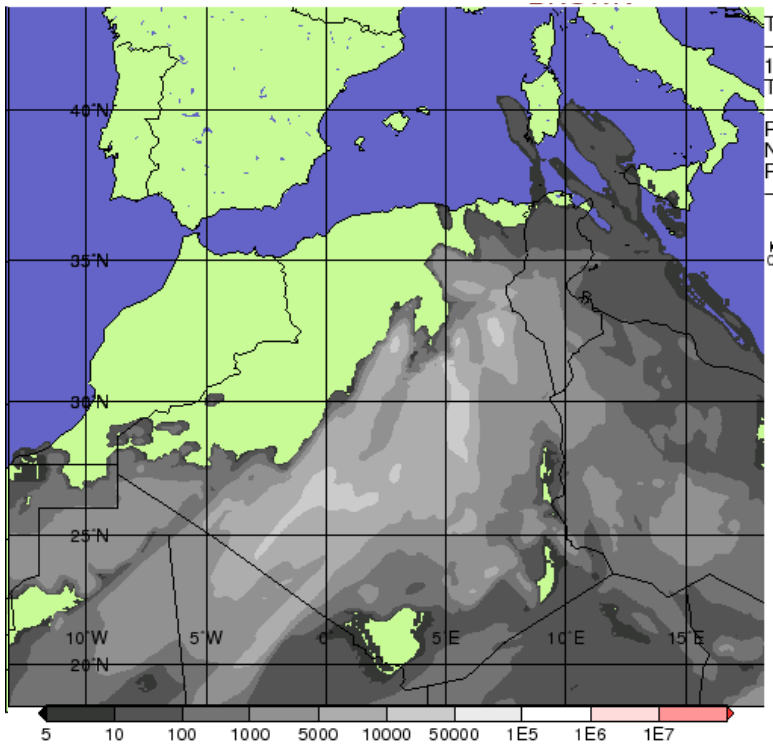


Aerosol forecasting with COAMPS

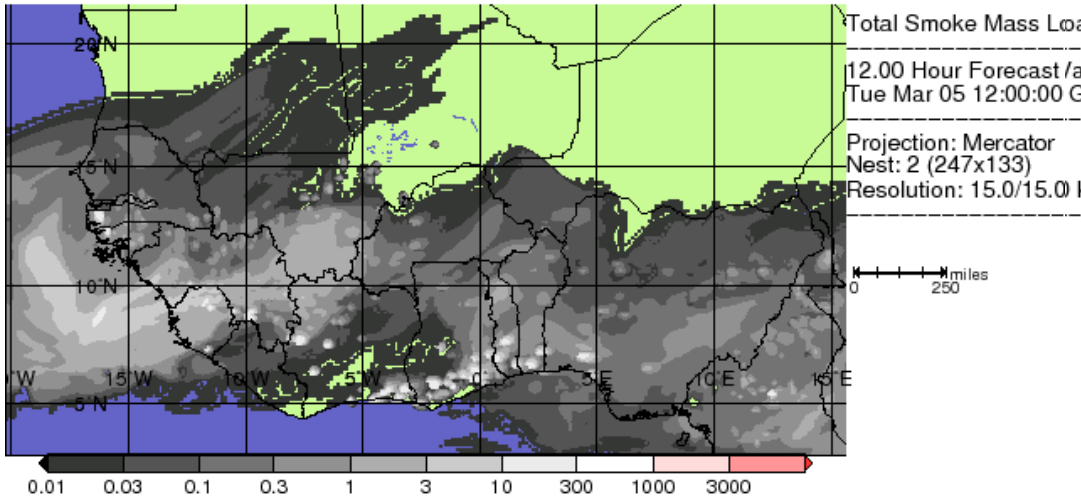
African Dust and Smoke Events

15-km COAMPS 12h forecasts of Mass Load (mg/m**2)

March 2-7, 2013 Case Study



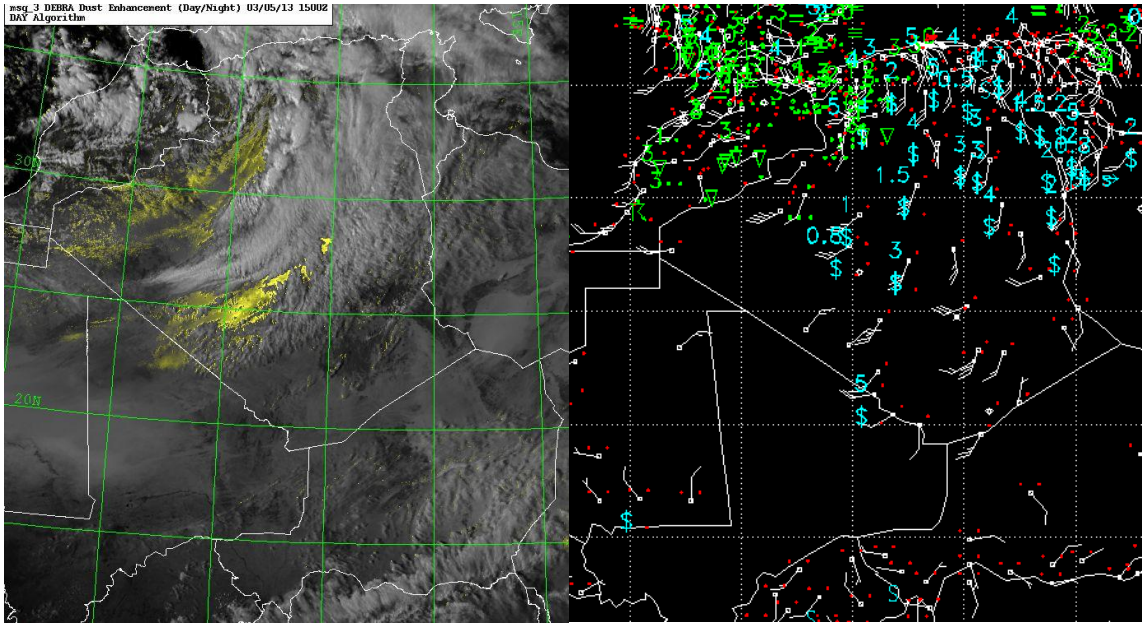
Wind-driven dust plumes



Smoke injected from FLAMBE fires

COAMPS verification of visibility

DEBRA_msg
March 5, 2013



Surface Observations
March 5, 2013

Output From Verification Package

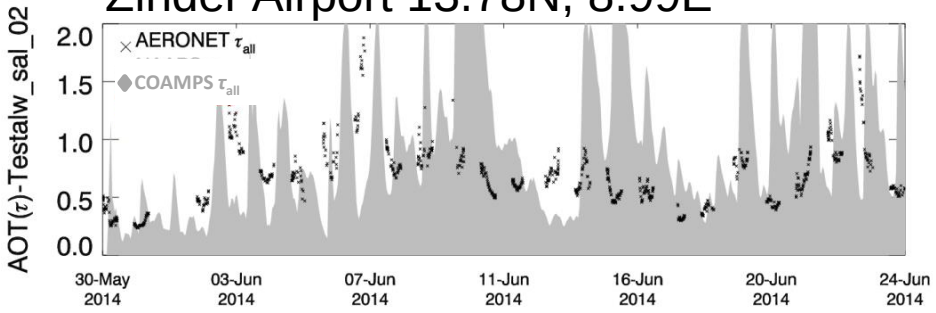
```
-----------------------------------------------
  Visibility threshold (km)     3.500000
-----------------------------------------------
total both dust obs            221    10.01359
total both clear obs          1490    67.51246
total false postive            143    6.479384
total false negative           353    15.99456
total obs                     2207
-----------------------------------------------

Total dust observations:          574
 Dust Storm Prediction Rate:     38.50174
Dust Storm False Alarm Rate:     8.756889
    Dust Storm Threat Score:     30.82287
    Dust Storm Gilbert Skill Score:    0.2029956
      Total Prediction Rate:     77.52605
```

- **Dust storm is defined as vis < 3.5 km**
- **Compare calculated COAMPS visibility with observed weather station visibility**
- **Approach enables calculation of statistics (DS, false alarm rate, total model skill)**
- **Goal is to improve Navy operational capability with a new generation of cloud and aerosol products**

COAMPS verification of AOD
Sahara summer case study
May 30- June25, 2014

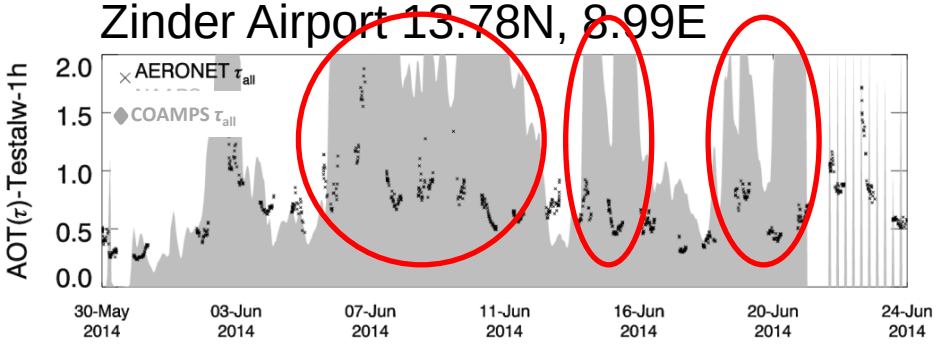
DSD

Zinder Airport 13.78N, 8.99E

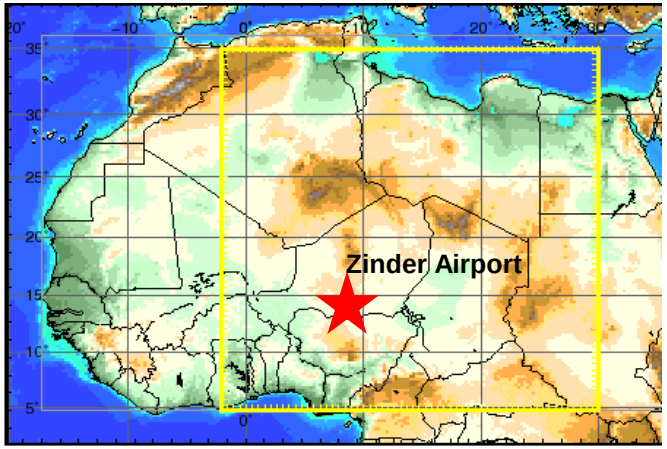


TOMS

Zinder Airport 13.78N, 8.99E



- TOMS operational one-degree dust database
- COAMPS calculated AOD is compared to observed AERONET AODs
- TOMS over predicts aerosol optical depth (AOD) by 2-4 times
- AOD prediction using the NRL DSD outperform the TOMS DSD at 6 of 12 AERONET stations



Summary

NRL Monterey uses satellite data for :

- Data assimilation
- Source functions
- Model verification and improvement

The NRL algorithms built for MODIS have been or are currently being tested for NPP-VIIRS

We have successfully run NAAPS with MODIS+VIIRS DA and have seen an improvement in modeled AODs

Since the NPP-VIIRS algorithms work the JPSS-VIIRS algorithms will also work