



The Naval Research Laboratory's Marine Meteorology Division Dust Forecasting Capabilities

Annette Walker

Arizona Dust Storm Workshop
March 5, 2019



Navy Aerosol and Visibility Forecast Needs:

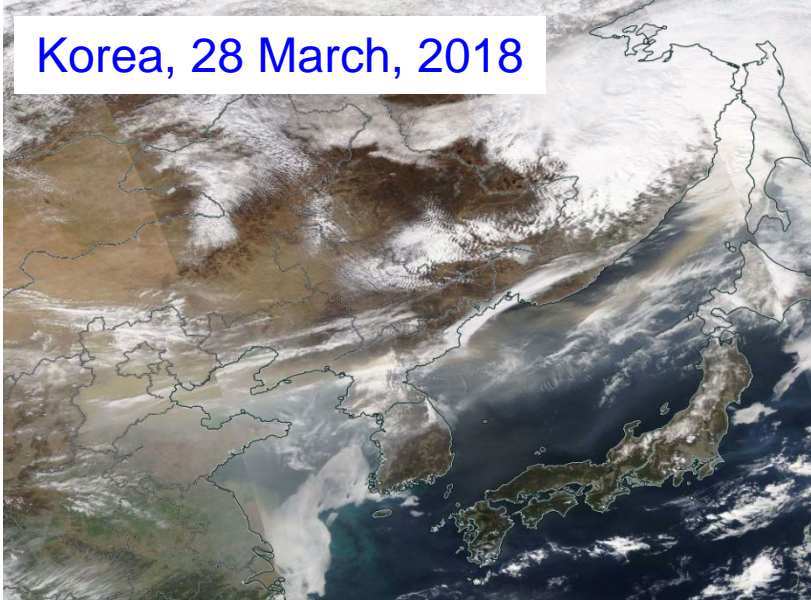
- Tactical and strategic planning
- Target Acquisition
- Port Navigation
- Carrier landings
- Ship defense



Impact of Dust Aerosols on DoD Activities



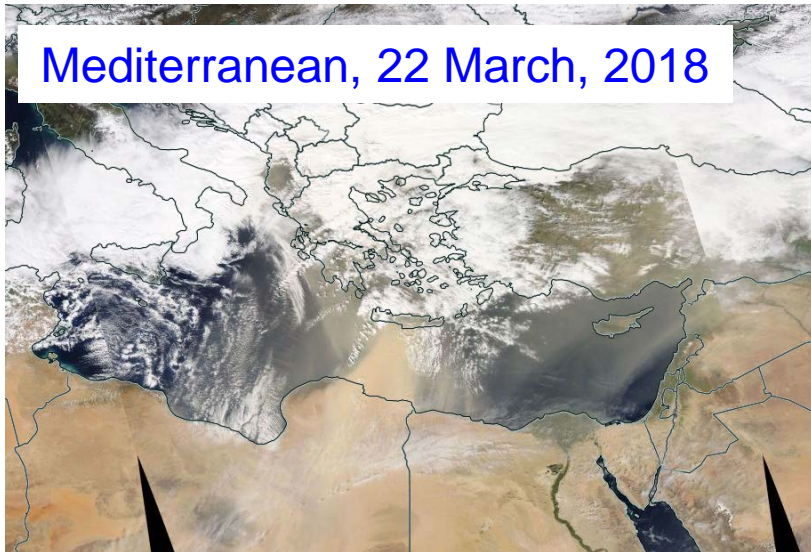
Korea, 28 March, 2018



Southwest Asia, 04 December, 2017



Mediterranean, 22 March, 2018

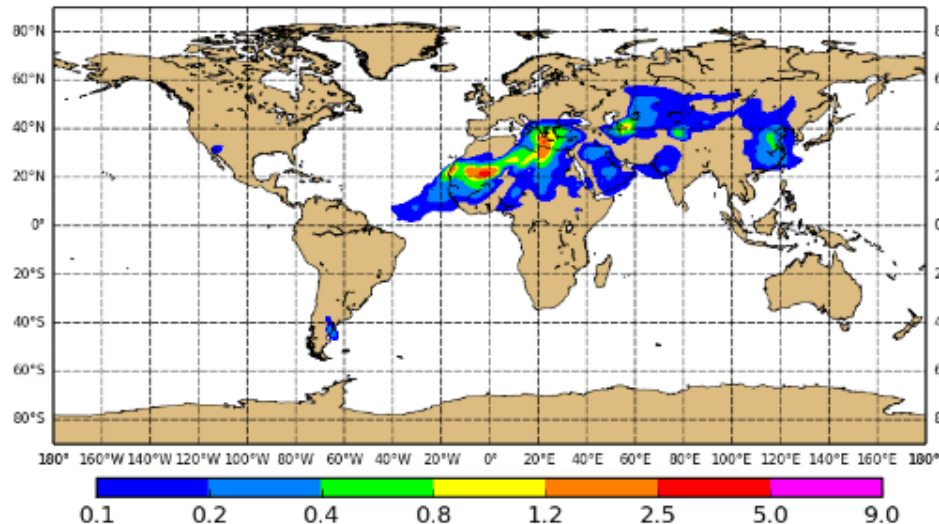


Global and Mesoscale Aerosol Models

Navy Aerosol Analysis and Prediction System (NAAPS)

- World's first operational global aerosol model (at 1/3 degree resolution)
- 6-day forecasts dust, smoke, pollution, and sea salt aerosols (run 4x/day)
- Utilizes world's first operational aerosol data assimilation & fire data streams

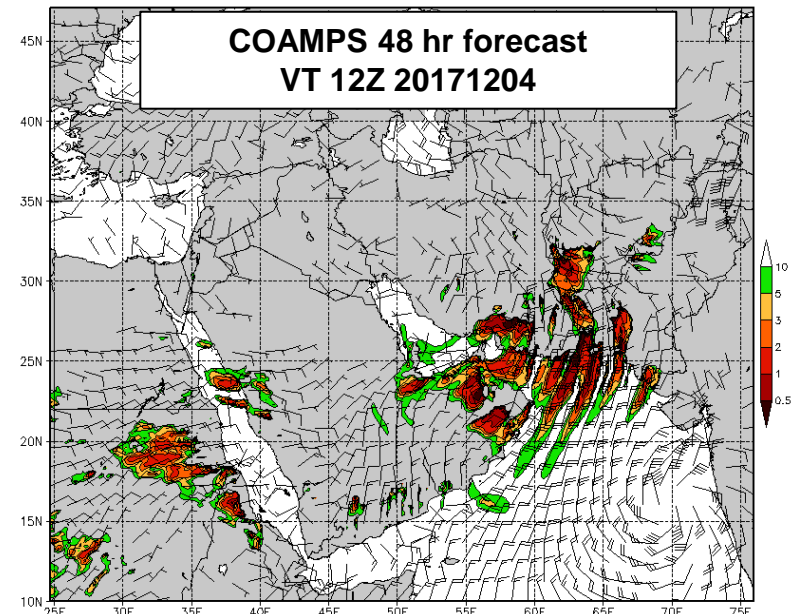
NAAPS Analysis 00Z 20180322
Dust Aerosol Optical Depth



Plots Generated Friday 23 March 2018 11UTC NRL/Monterey Aerosol Modeling

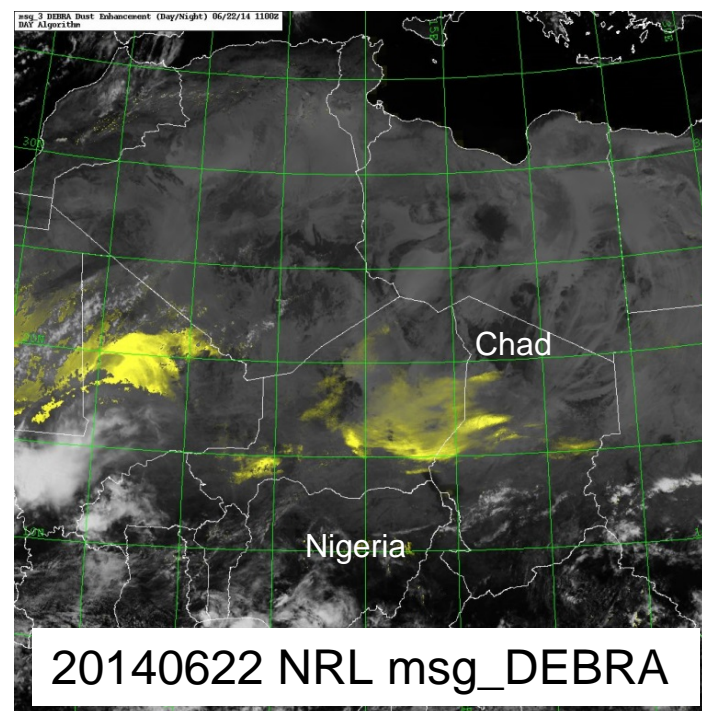
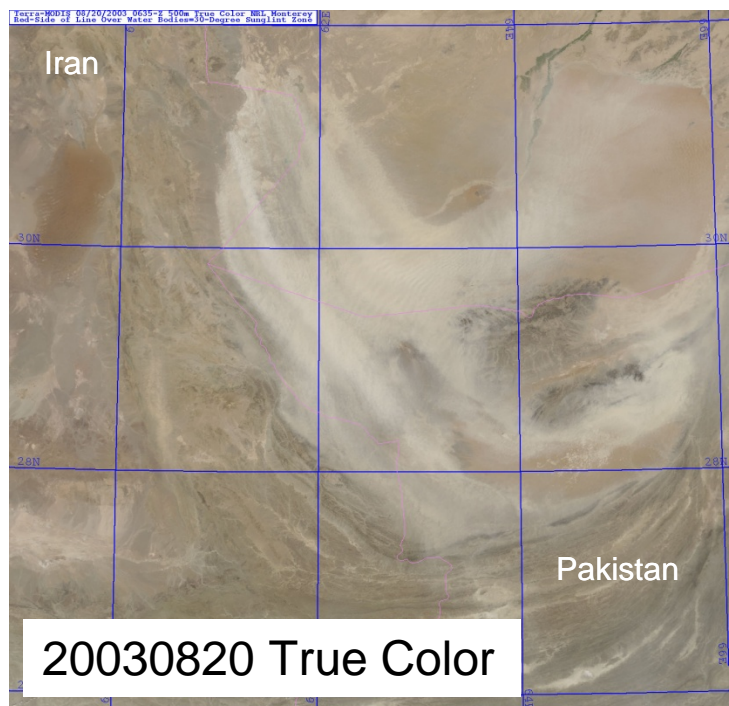
Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS)

- Operational dust forecasts at FNMOG since 2001 (currently 1.6 and 15 km resolution, run 2x/day; 72 hr forecasts)
- Accurately forecasts the onset/cessation of low visibility conditions, and individual dust plumes
- Uses the NRL high-resolution dust source database



VT: Mon 12Z 04 DEC 17
FNMOG 15km COAMPS (U): Dust Surface Visibility [nm] Winds [kts] 048 HR FCST
Run: 2017120212Z Tau: 48

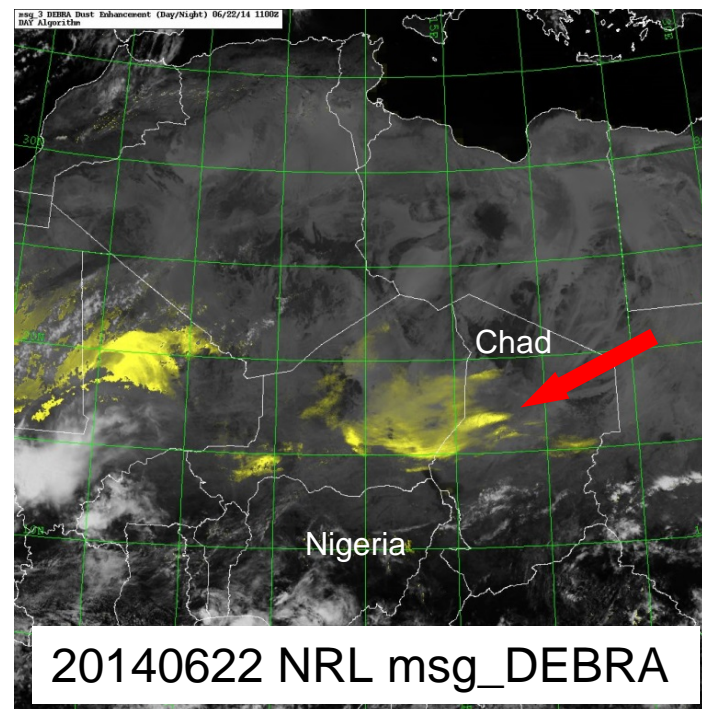
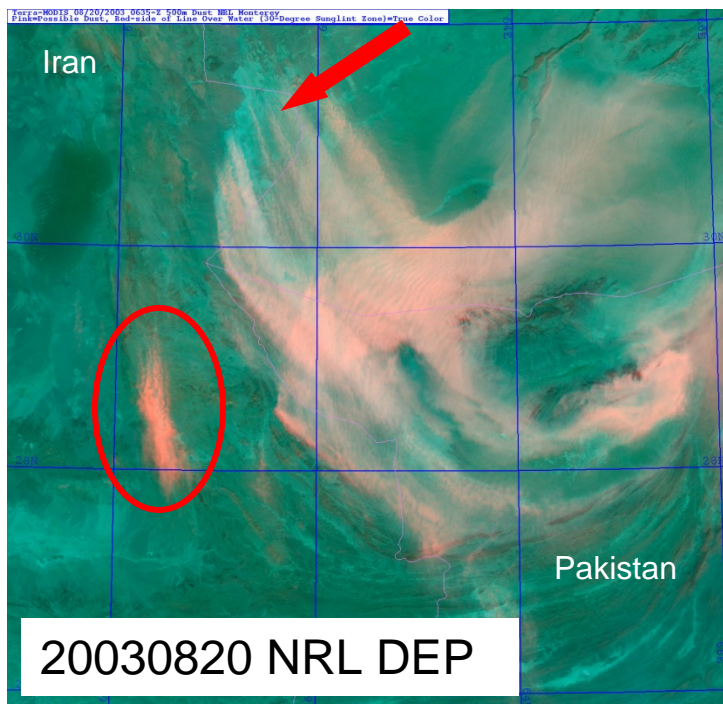
High-resolution Dust Source Database



Approach and Methodology

- **NRL Dust Enhancement Products**
- Used 17 years of NRL DEP + 8 years of DEBRA msg_RGB to locate/update dust plume sources
- 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)

High-resolution Dust Source Database



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High-resolution Dust Source Database



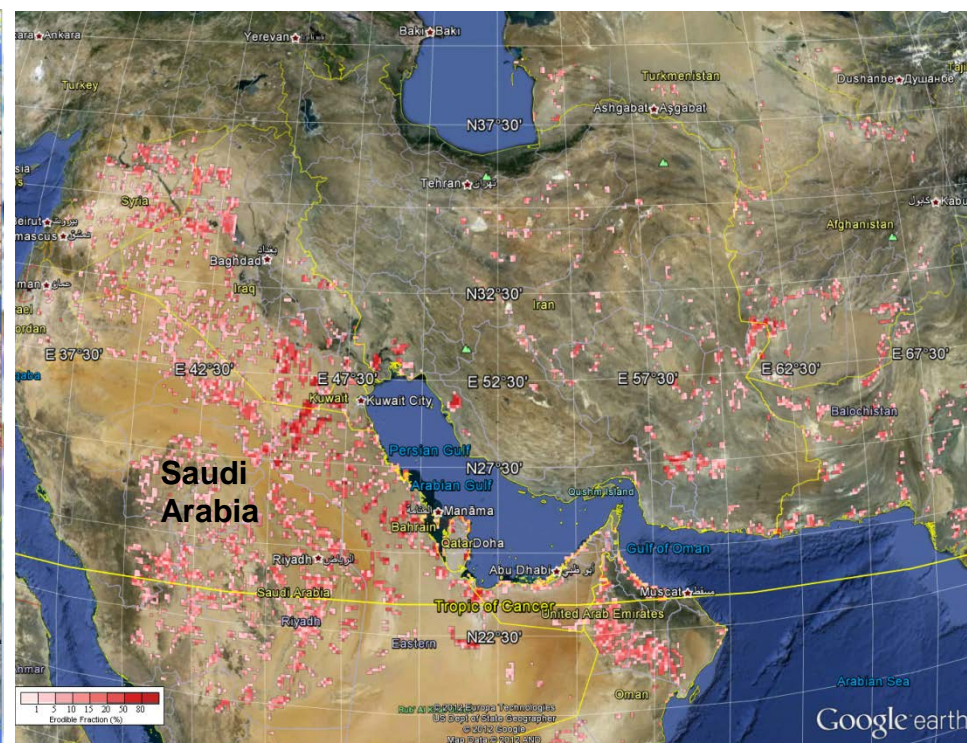
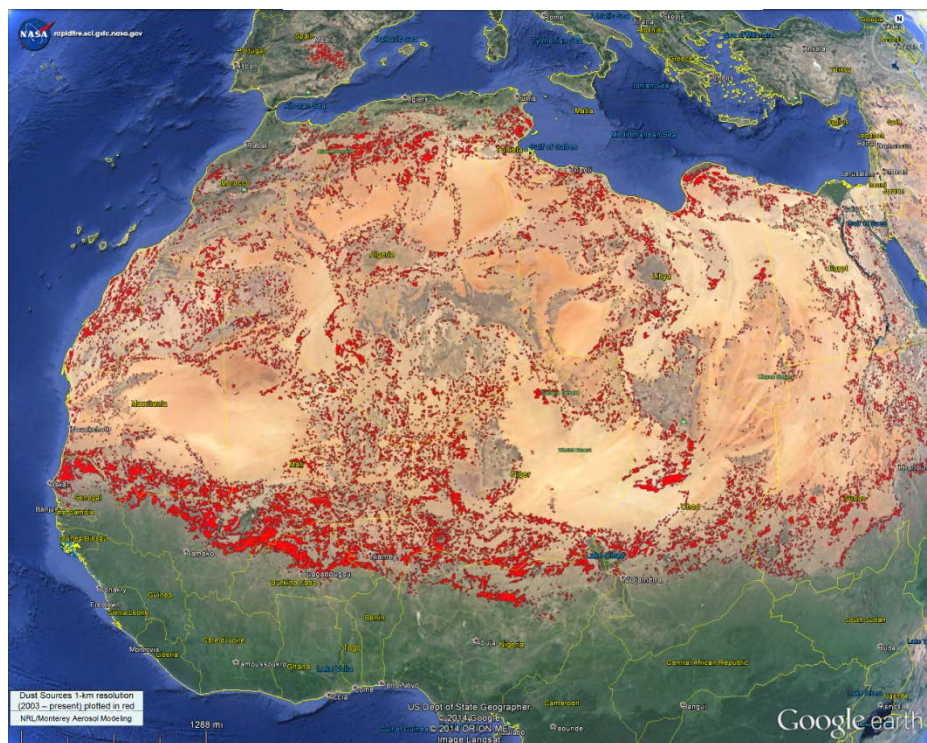
- Solid red shapes identify dust source areas located using DEP and msg_DEBRA
- DSD used in COAMPS (1 km sources gridded to 1.6, 5, 15, and 45 km resolution)

$$\text{Flux}_{\text{dust}} \propto \text{Erodible Fraction} * u_*^4$$

- GE kml used on the watch floors at the FWC and OWS

North Africa DSD

SW Asia DSD



North America High-resolution DSD



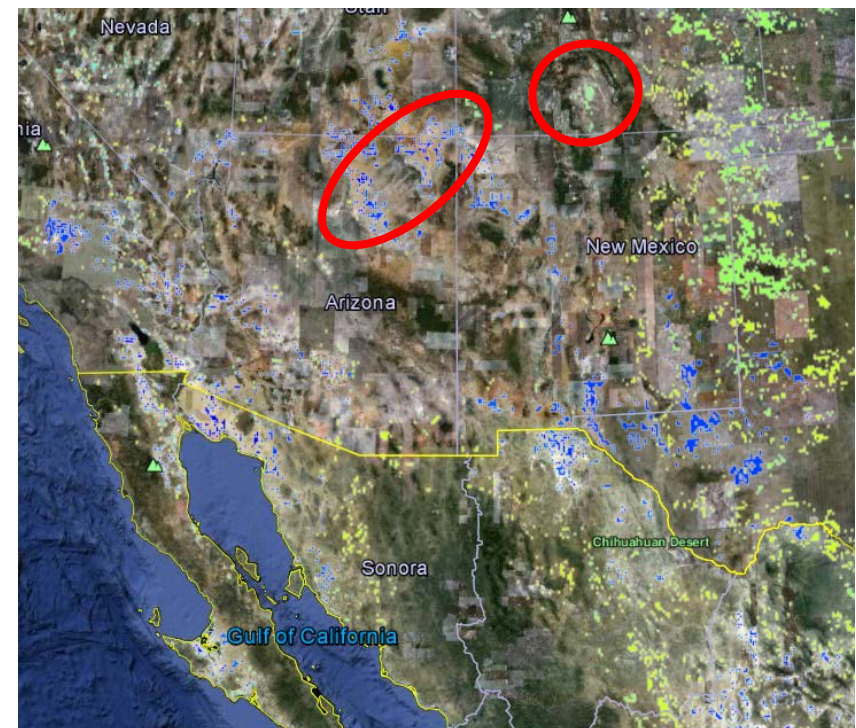
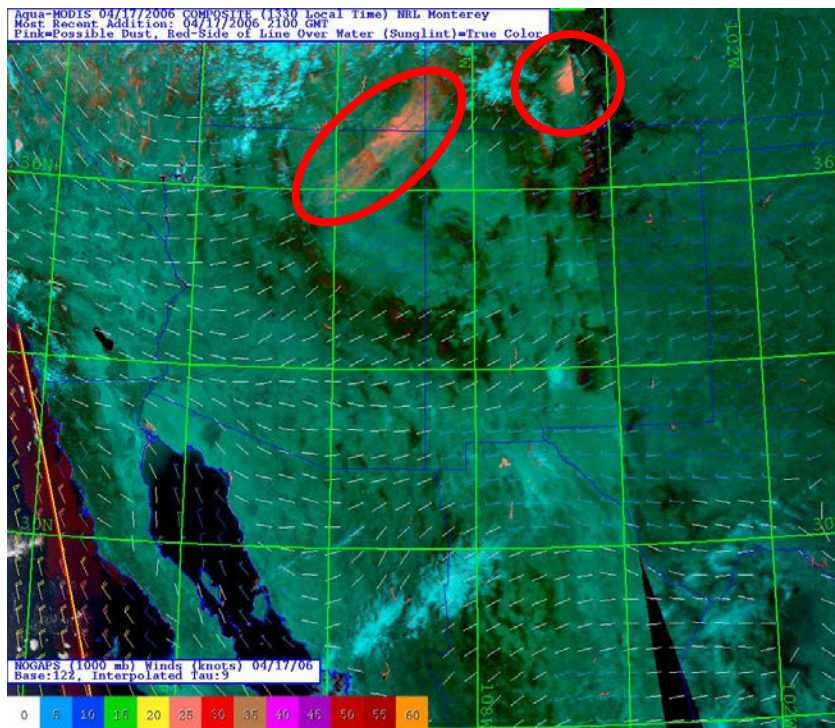
- Same approach taken with North America (added machine learning component)
- Used NASA/USGS MODIS global land surface and albedo datasets
- Formed self-organizing map (SOM) containing 1,000 classes

Arizona and Colorado: April 17, 2006 21Z

Plumes originate in Painted Desert and San Luis Valley

Corresponding SOM-Classes: 218, 228, 229, 249, 258, 260 (blue)

513, 521, 525, 526 (yellow green)



North America High-resolution DSD



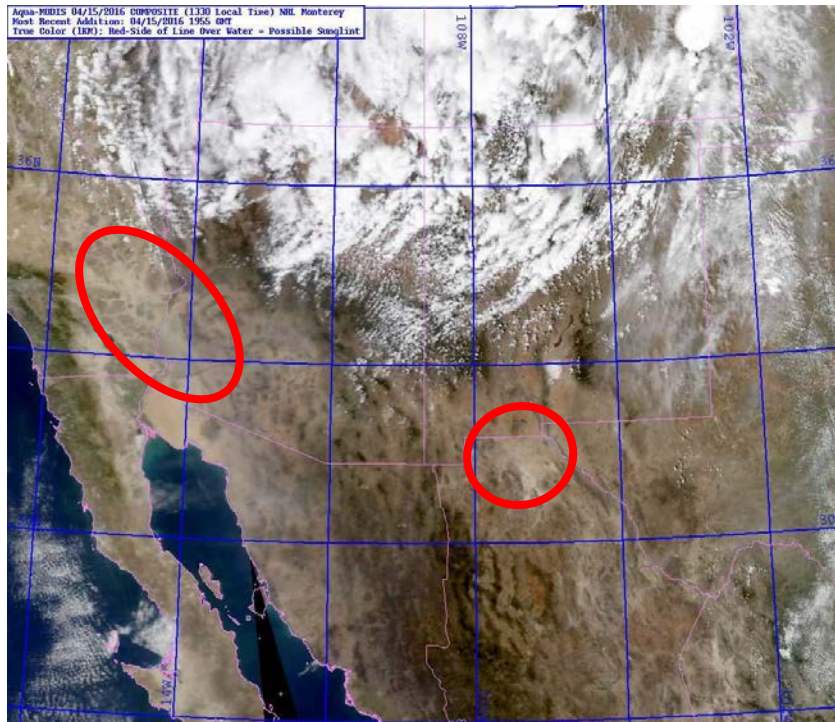
April 15, 2016 1955Z

Two Active Regions: California/Arizona and northern Mexico

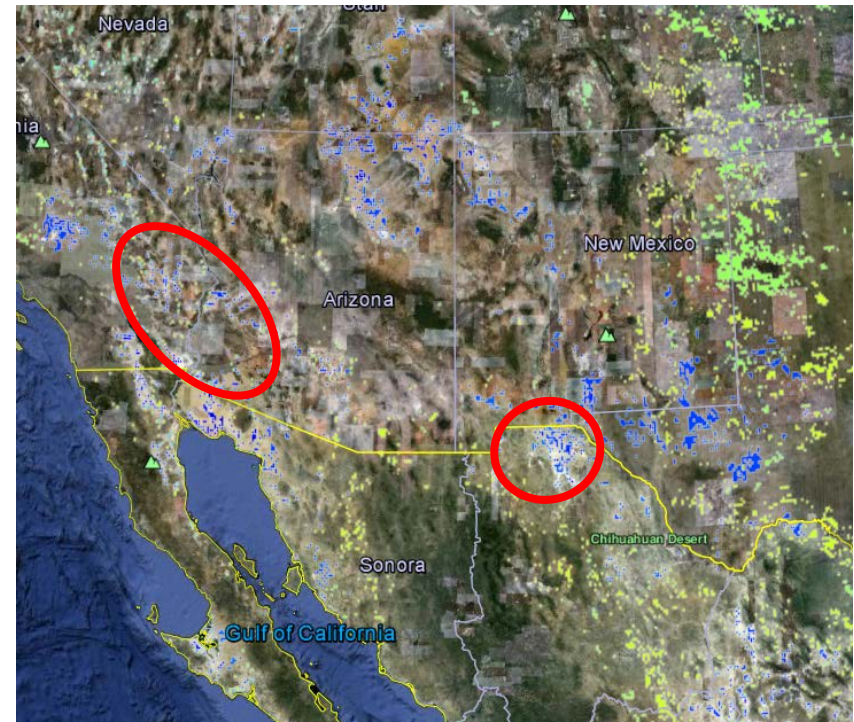
Point Sources

- Danby (dry) Lake, Mojave Desert
- Agricultural sources along CA/AZ border
- Hydrologic sources (seasonal streams/Casas Grandes) by Los Trios

MODIS Aqua True Color



NRL DSD



North America High-resolution DSD



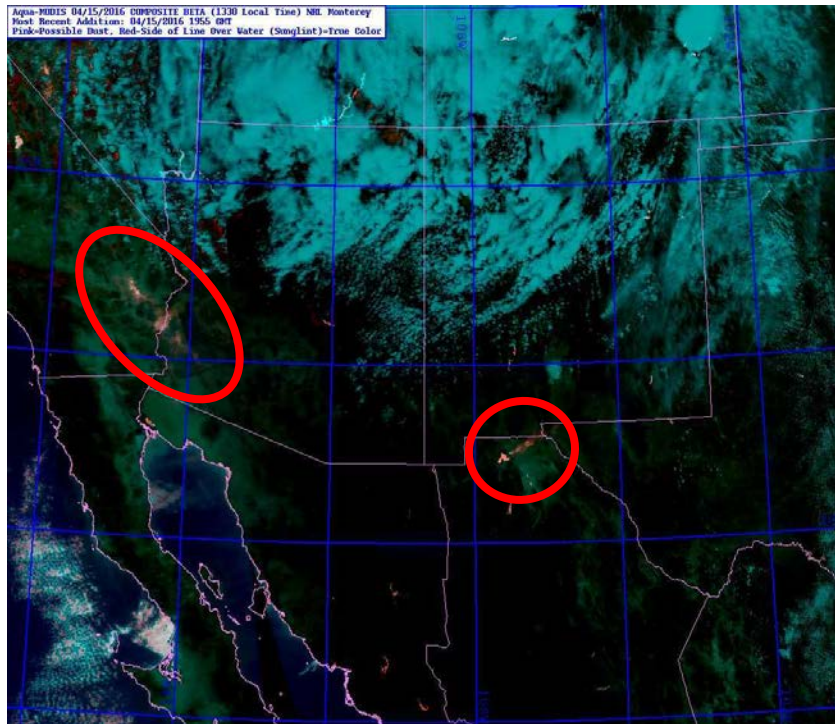
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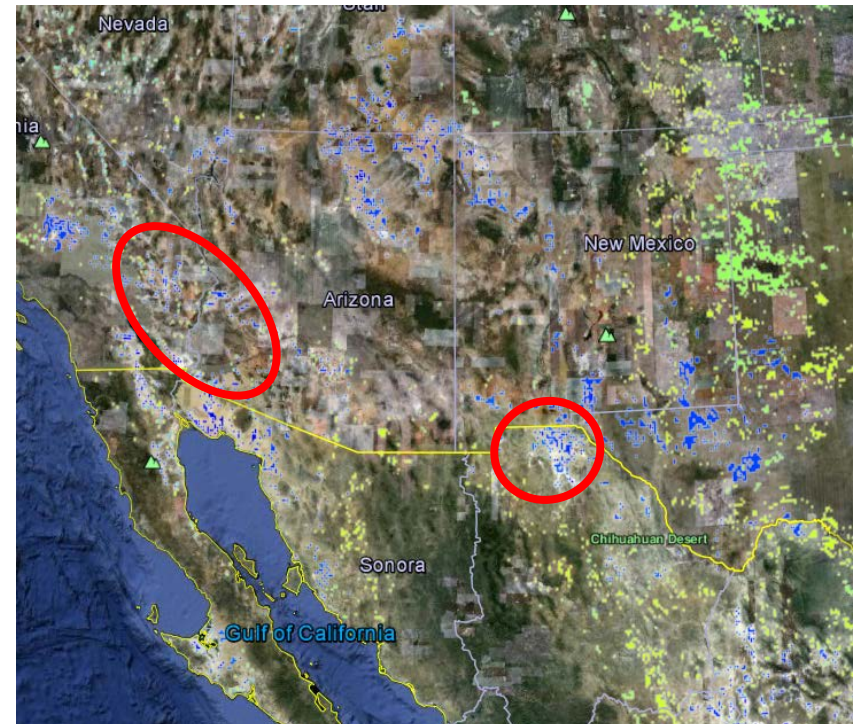
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MODIS Aqua NRL DEP



NRL DSD



North America High-resolution DSD



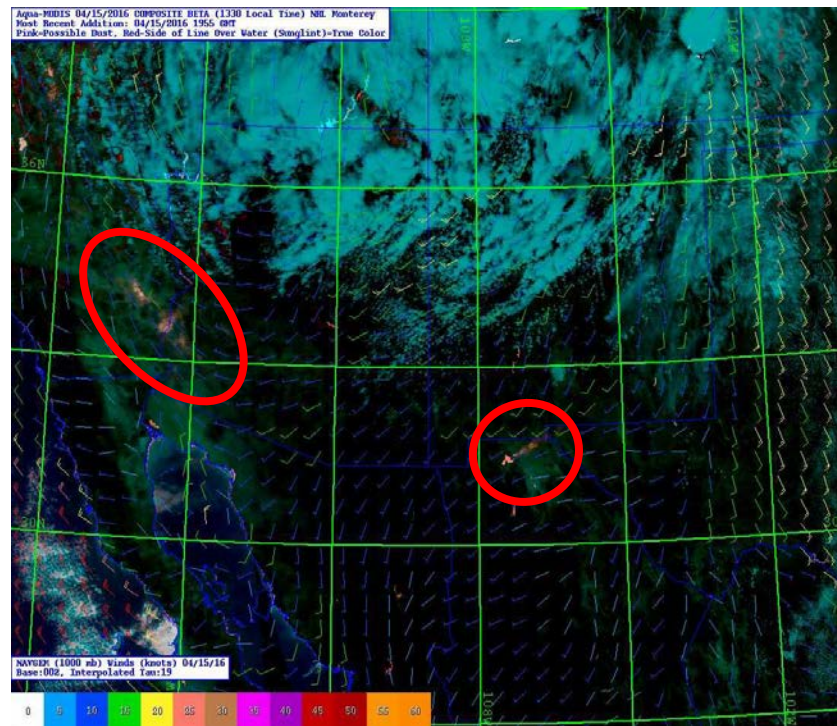
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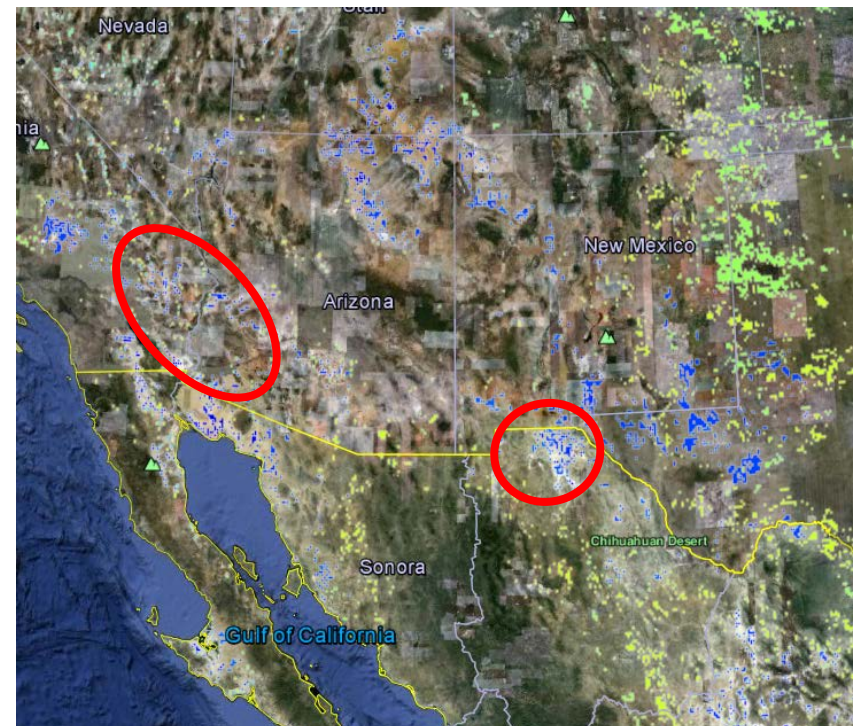
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MODIS Aqua NRL DEP



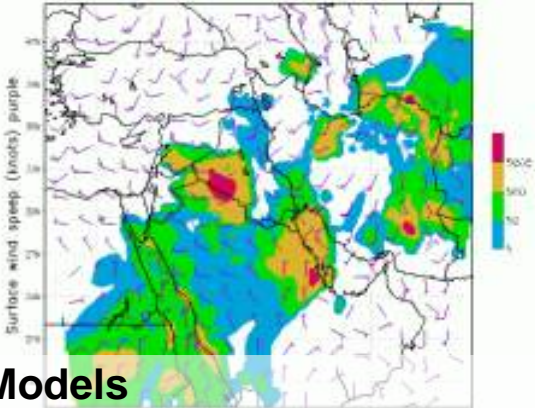
NRL DSD



Navy Aerosol Analysis Activities

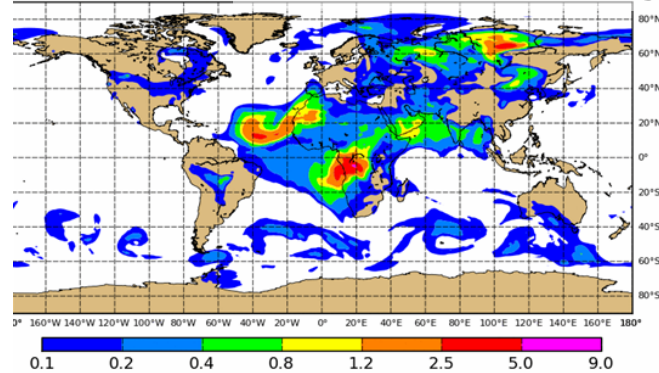


Dust surface concn ($\mu\text{g}/\text{m}^3$) 39h fcst valid at 15Z15FEB2004
COAMPS starting from 00Z14FEB2004 grid 27-km

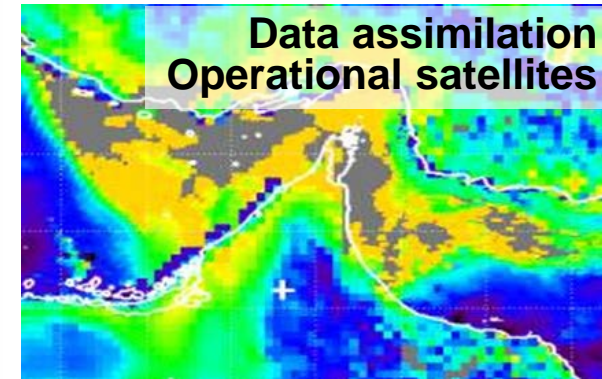


Models
Forecasting and Verification

Thursday 1 August 2013 00UTC ENAAPS-NAV Forecast t+000
Thursday 1 August 2013 00UTC Valid
TOTAL Aerosol Optical Depth at 550nm



Ensemble modeling

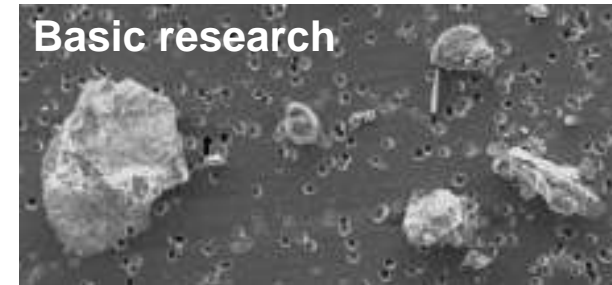


Data assimilation
Operational satellites

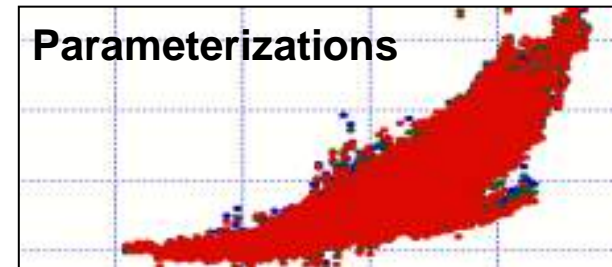


Air and ground based measurements

Field Campaigns (NASA, NCAR, NOAA)



Basic research



Parameterizations

Cold Pools



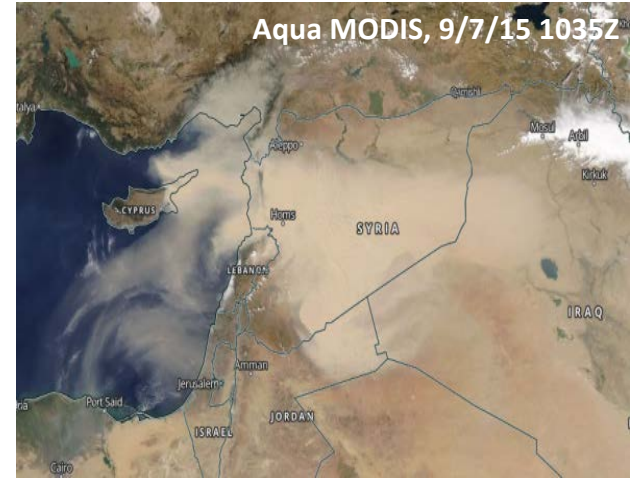
Dry Microburst



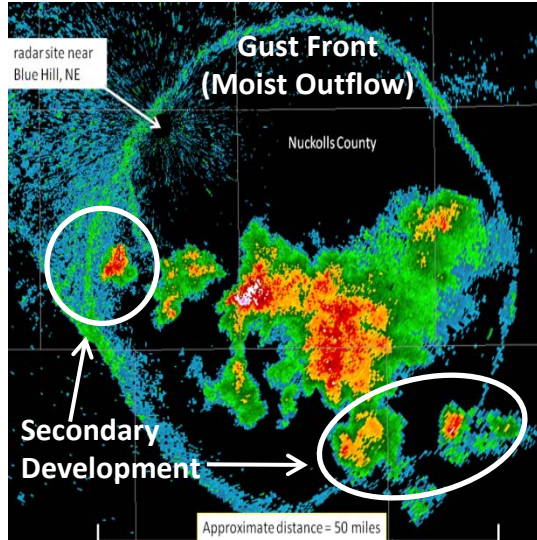
Convective Dust Storm (Haboob)



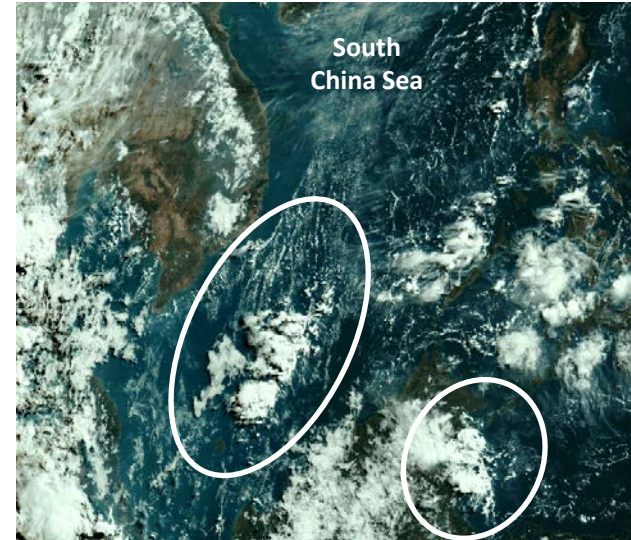
Aqua MODIS, 9/7/15 1035Z



Wet Microburst



South China Sea



Dry

Wet

NRL Dust Forecasting Capabilities



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