Navy Aerosol System Science and Development for Operations
http://www.nrlmry.navy.mil/aerosol/

10th ICAP Working Group
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Send comments
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Overview

• Overview of peoples and systems
• Systems update
• Major projects: MURI, C-FOG, CAMP$^2$Ex, & PISTON
• Recent results in the literature from the last year
Navy Sponsored Aerosol Development for Operations Community

NRL Monterey (Marine Meteorology)
Anthony Bucholtz: Radiation, tactical decision aids
Chris Camacho: Software engineering
James Campbell: Cirrus, lidar studies
Josh Cossuth: Remote sensing systems
Edward Hyer: Satellite data, biomass burning, transitions
Kathleen Kaku (CSRA): Air quality, chemistry
Arunas Kuciauskas: Dust systems
Ming Liu: Inline NAVGEM aerosol
Mayra Oyola (ASEE) Dust radiation
David Peterson: Fire meteorology, biomass burning
Elizabeth Reid: Deployments and analysis
Jeffrey Reid: Applied meteorology & aerosol
Benjamin Ruston: Dust Infrared impacts on DA
Mindy Surratt: Remote sensing
Annette Walker: Mesoscale aerosol & dust sources
Doug Westphal: Emeritus
Peng Xian: ICAP-MEE, NAAPS reanalysis

NRL Washington DC (Remote Sensing)
Maggie Anguelova: Microwave retrievals
Juli Rubin: Ensemble systems
Ivan Savelyev: Sea Salt production

Key ONR Programs
HAALE: Littoral zone aerosol prediction S. Miller (CSU, PI), S. Albers (CIRA), R. Holz (SSEC), S. Kreidenweis (CSU), S. van den Heever (CSU), J. Wang (UI), J. Zhang (UND), and M. Zupansky (CIRA)
C-FOG: Fog prediction: J. Fernando (U. NotreDame) et al.
PISTON: Maritime Continent intraseasonal oscillations
Plus Joint with NASA CAMP²Ex
### Current Research & Development areas

#### Basic Research
- Aerosol clim., lifecycle, & meteorology
- Aerosol microphys/chem/optics
- Aerosol observability/predictability
- Aerosol Radiation
- Arctic radiation & cloud
- Biomass burning emissions
- Cirrus radiation
- Fire meteorology
- Marine Boundary Layer/Wave Physics

#### Aerosol Product Lines
- DA grade satellite products
- Dust source database
- FAROP
- FLAMBE
- Lidar aerosol climatology
- Performance Surfaces

#### Global Modeling
- NAAPS Operational
- NAAPS Reanalysis
- NAAPS Ensemble
- ICAP MME
- Fused Products
  + NAVDAS-AOD
  + DART

#### Interdisciplinary
- Applied meteorology
- NWP
- Oceanography, ocean color, SST
- Tactical decision aids

#### Mesoscale
- COAMPS Dust
- COAMPS Scaler
NAAPS:  
- Global aerosol forecasts  
- Deterministic  
- Offline  
- NOGAPS driven  
- 1x1 deg

NAAPS-Operational:  
- Run @ FNMOC

NAAPS-Operational:  
- NAVGEM driven  
- 1/3x1/3 deg  
- Plan: Follow NAVGEM resolution

NAAPS-Operational:  
- NAVGEM In-Line Aerosol:  
  - ESPC  
  - Aerosol => NAVDAS QC

NAAPS-Operational:  
- NAVGEM In-Line Aerosol:  
  - Fully-coupled  
  - Initialized with NAVGEM DA  
  - Science opportunities to explore NWP-aerosol interactions

NAAPS-Research:  
- NAVGEM driven  
- 1/3x1/3 deg  
- Plan: Follow NAVGEM resolution

NAAPS-Research:  
- Run @ NRL  
- Scientific research  
- Model improvement  
- 2DVar Satellite DA

NAVGEM In-Line Aerosol:  
- ENAAPS:  
  - Probabilistic aerosol forecasts

NAAPS-Research:  
- Run @ NRL  
- NAVGEM driven  
- 1/3x1/3 deg  
- Plan: Follow NAVGEM resolution

Global Aerosol Model Development
Navy Mesoscale Aerosol Modeling Family Tree

COAMPS-Dust:
- Dust only
- In-line
- tracer

COAMPS-Aerosol:
- Dust, smoke, sea salt, sulfate
- tracers

COAMPS-Aerosol:
- NAAPS Initialized boundary conditions

COAMPS-Aerosol:
- NWP-aerosol coupled
- Radiative Transfer
- DA – Littoral zone

COAMPS-DE:
- Coupled with operational DE TDA for on-scene performance prediction

Regional Aerosol Model Development

Operational

Application
ENAAPS Semi-operational at Navy DSRC

- ENAAPS was tested and converted to a NRT system at DSRC (Conrad) in FY17.
- New scripts developed to break system into smaller tasks for Cylc implementation.
1. NAAPS/ENAAPS performance ~ the same out to 48 hours.
2. ENAAPS performance better after 48 hours.
3. ENAAPS has positive bias issues at background aerosol levels ($AOD<0.1$).
4. Additional bias issues at some sites impacted by high AOD aerosol events ($AOD>0.5$).
Method is based on 6.4 National Unified Operational Prediction Capability (NUOPC)) (J. Peak, D. Hodyss)

Observations are from MODIS or any gridded AOD product (U. Wisc, Holz).

Forecast bins are defined so that they are equally populated and the bias is calculated in each.

The regression line is used to map AOD forecast to bias correction.

Method uses archived ENAAPS forecasts (1 week shown).
ENAAPS: Bias Correction
Correction applied by region and as a function of forecast lead time.

Western United States:
Smoke from Extensive Fires

Using bias correction, smoke transport is better captured in ENAAPS forecast.

24hr Forecast Correction
August 23-August 30, 2013
• Time for a Sea Salt Tune up In NAAPS.
• NAAPS tend to over predict AOD in the mid latitudes
• Replacing Monahan Whitecap fraction with Microwave derived whitecap fraction from Anguelova et al. NRL DC
• Significant improvement if we account for a microwave noise floor.
• Ongoing work on vertical distribution & deposition
What are the fundamental environmental factors that govern the spatial distribution and optical properties of littoral zone aerosols at the sub-km scale?

How can we best leverage emergent satellite observing systems and derived products via advanced D/A techniques to optimally inform a high-resolution forecast model’s initial aerosol field?
Toward Improving Coastal Fog Prediction C-FOG

Interested? Contact Joe Fernando (hfernand@nd.edu)

Science Questions

- How does warmer moist air advecting over colder ocean lead to (cold) marine fog of via competing factors of shear instabilities, turbulent mixing, and stable stratification?
- What mechanisms (convective instabilities, stratus/cumulus clouds, entrainment etc.) trigger (warm) marine fog when colder air advects over warmer ocean surface?

Approach

- A comprehensive atmosphere-ocean field campaign (September-November 2018) in eastern Canada.
- Studies on coastal fog physics/governing parameters
- Analytical studies on fog physics/governing parameters
- Cascading simulations: Mesoscale (NWP), Large eddy & direct numerical simulations

Principal Investigators

- Clive Dornan (Scripts)
- Joseph Fernando (U Notre Dame, PI)
- Ismail Gultepe (Environment Canada)
- Eric Pardyjak (U. Utah)
- Qing Wang (NPS)

Principal Collaborators

- Chris Hocut (ARL)
- Andrew Heymsfield (NCAR)
Cloud, Aerosol, Monsoon Processes Philippines (CAMP³Ex)
Aircraft maintenance pushed us to summer 2019. Interested? jeffrey.reid@nrlmry.navy.mil

• NASA, Manila Observatory, NRL will conduct an airborne P3 and Lear 35 campaign out of Subic Bay Philippines September, 2019.

• Research will focus on these questions
  • Do aerosol particles influence warm/mixed phase precipitation in tropical environments?
  • Do aerosol induced changes in clouds and precipitation feedback into aerosol lifecycle?
  • How does the aerosol and cloud influence on radiation co-vary and interact?

• Manila Observatory is taking a lead on how land use change effects clouds and if this change is a confounder for perceived aerosol impacts.

• ~100 scientist, including ~20 Philippine scientist will conduct ~16 8-hour P3 and 8 5-hour Lear 35 flights to measure the cloud and pollution environment around the Philippines.
Selected Instruments

NASA P-3B
- Aerosol in-situ microphysics:
  - Black carbon
  - Cloud condensation nuclei
  - Composition
  - Light scattering
  - Size distribution
- Aerosol profiles (lidar)
- Cloud cover/properties
  - Cloud cameras
  - Cloud in-situ microphysics
  - Droplet/ice particle size
  - Polarimeter
  - Precipitation
- Cloud/precip remote sensing
  - 94 GHz radar
  - 18-27 GHz radar
  - Microwave radiometer
- Tracer Gases (CO₂, CO, SO₂, NOx)
- Radiative balance: Hyperspec., Solar, & IR flux
- State variables (temperature, wind humidity):
  - In-situ & profile
  - Sea surface temperature

SPEC Lear Jet 35
Aerosol Size
Cloud in-situ microphysics
droplet/ice particle size precipitation
Making lemonade: Mission push gives us some time to exercise the latest data streams—Models, Terra/Aqua/SNPP, CALIPSO/CloudSat and GPM.

Manila deployments for radiation, aerosol, chemistry and SSEC HSRL.

Strong synergy with PISTON modeling and Thompson observations.

Do all of the data streams really make sense?????
PISTON: Propagation of Intra-seasonal Oscillations
Joint sponsored CALIPSO/ONR deployment of SSEC HSRL to the Thompson

- PISTON is an ONR DRI to assess SE Asian of intraseasonal weather phenomenon across the Maritime Continent, such as the MJO.
- Included is the R/V Thompson cruise mid Aug-Mid Oct, 2018, off of Luzon to examine diurnal cycle in association with BSISO originally with some overlap with CAMP2Ex.
- Included are Air/Sea Flux, C-POL & W radar, and wind lidar.
- For the aerosol community, SSEC HSRL is slated for deployment providing the first solid lidar data in the region.
- Will exercise COAMPS aerosol.

Interested? Atmos measurements- jeffrey.reid@nrlmry.navy.mil
Meteorology Models- sue.chen@nrlmry.navy.mil
Oceanography- moum@coas.oregonstate.edu
Big news:
• China loadings and fluxes reducing since 2008.
• Steady improvement on East US Coast and Mediterranean.
• S. Asia, Persian Gulf and Red Sea flattening out.
• Slight downward trend in CERES calibration?
Examined baseline aerosol chemistry and optical properties for the SE US for SEAC4RS.

PM2.5 was better correlated between stations than AERONET AOD. For satellite it went downhill.

The mass scattering efficiency was uncorrelated to OC:SO4, but was moderately correlated with PM2.5.

But over the past decade a third of the AOD reduction in the region was due to a reduction in mass scattering efficiency.
• Used the SDA method to extract fine mode AOD in periods of moderate cloud and haze that normally are rejected in cloud screening.

• L2 AERONET and MODIS miss these events, leading to sampling bias.

• MERRA and NAAPS reanalyses under-predict in general, but especially the most severe events.
50+% population lives in the coast.

Coastal water can be very turbid as a result of runoffs from land (and coastal pollution).

Ocean color algorithm doesn’t provide any retrieval for AOD > 0.3

MODIS algorithm doesn’t do any retrieval of AOD over the turbid water.

~20% of time AOD is not retrieved simply because water is turbid. No retrieval

Retrieval is performed in the near infrared using nearest neighbor aerosol model. Yields ~18% more AOD data in the coastal water regions.

MURI: Retrieval of dust plume height from EPIC’s O2 A and B bands over ocean every hour for sunlit surfaces

The results are validated with CALIOPSO and MODIS

The higher resolution dust source database results in more fine-scale dust features in both RAMS and WRF-Chem. But there is more uncertainty in the dust forecast due to the choice of model than due to the selection of an emissions database.
MURI: Factors Impacting Coastal Aerosol Distribution within Sea-Breeze Regime

- What are the **governing environmental factors** responsible for the vertical redistribution of aerosol?
  - Factors, such as **soil saturation fraction**, that alter **surface sensible heat flux and/or vertical mixing** are responsible for vertical redistribution of tracer ahead of sea breeze front (i.e. inland region where people reside)

- This study provides **guides for potential ways to improve numerical weather prediction of sea breezes and spatio-temporal distribution of aerosol**.
  - Large-scale winds are already well simulated in forecast models
  - **Better representation of land surface properties** such as soil moisture may lead to improvements in forecast of aerosol transport

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*Park, van den Heever and Igel 2018*
Tracer (aerosol) transport is dependent on synoptic regime and island orography. Classifying the tracer behavior in idealized regimes can aid in forecasting aerosol fields near and on mountainous islands.

Kawecki and van den Heever 2018
Wrapping up.

• Motoring along on model development, inline NAAPS into NAVGEM well underway, ENAAPS cycling at DSRC.

• NRL is leveraging ONR/OSD base research programs to help guide future applied science development.

• The NASA CAMP²Ex big show got pushed to 2019, but we are making good use of the time with a virtual campaign w/ PISTON and enhanced measurements in Metro Manila.

• Lots of basic research coming out of Navy and partner programs on fundamental aerosol science, in particular on physics relative to associated regional meteorology.