Incorporating NOAA-derived VIIRS AOD into the Navy Aerosol Model to Monitor SAL Events over the North Tropical Atlantic Basin

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Focus:

Assist Puerto Rico NWS/Fire Weather Agency in forecasting SAL events beyond 3 days

effort adaptable to downwind regions:
South/Southeast US, Gulf of Mexico, Bahamas, Central America, North and South America

photo courtesy: NOAA

Background & Motivation

NOAA-JPSS Sponsored Project

1. NRL-MMD supporting NWS-Puerto Rico and CIMH (Barbados)

- NexSat and SAL satellite websites
  - near real time state-of-the-art GEO and LEO products
  - Model overlays
- Navy Aerosol Analysis Prediction System (NAAPS)
  - global operational dust model with R&D versatility
- Overall objective for greater Caribbean region
  - supporting general weather, fires, TC's, dust events

2. Current focus related to African dust/Saharan Air Layer (SAL) Events

- Improving dust model output via NAAPS – *applying NOAA VIIRS AOD*
- Host additional S.A.L. products through multi-agency/academia collaborations
- Publications, BAMS

3. Integrate SAL monitoring with human health aspects

- Gain better understanding of African dust impacts over greater Caribbean
  - Scientific aspects
  - Human health aspects
- Seeking further partnerships with various local & national agencies

courtesy: Dr. Jeff Masters – Weather Underground

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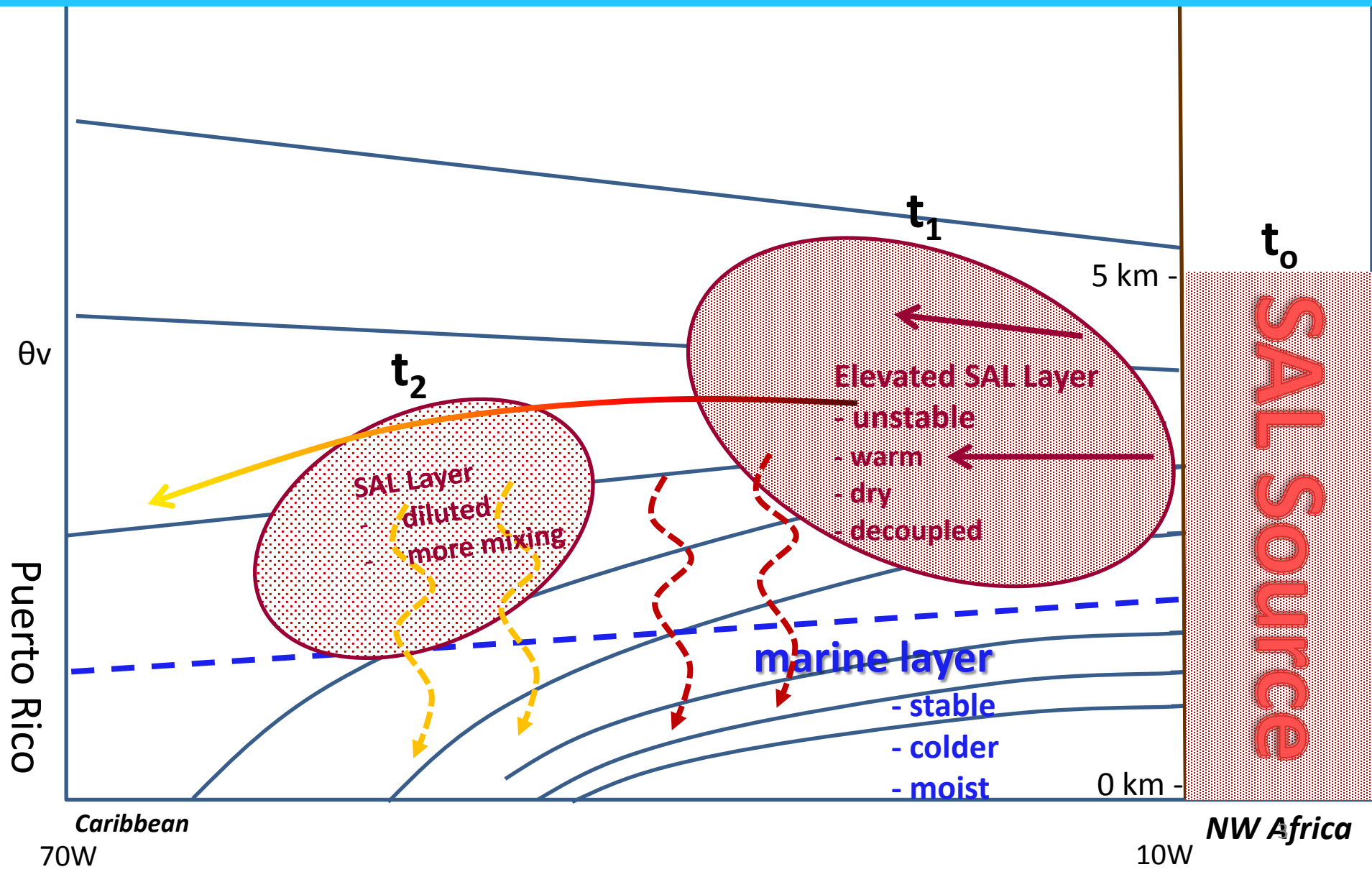
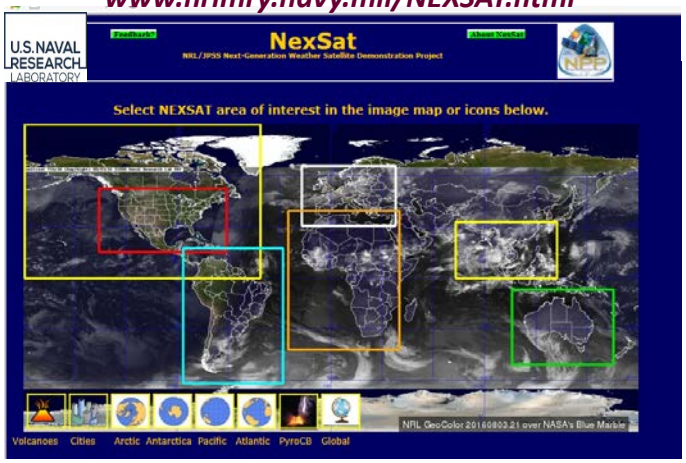
Environment Depicting SAL Propagation Across Tropical Atlantic Basin

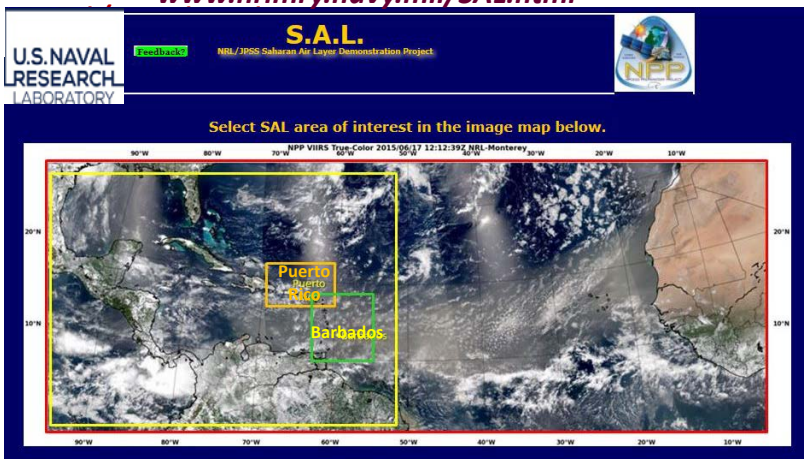


NRL-MMD Websites for SAL Support

www.nrlmry.navy.mil/NEXSAT.html



www.nrlmry.navy.mil/SAL.html



Standard Products
Visible (daytime)
Visible (night time)
Infrared
Water Vapor
True Color
Pseudo/GEO True Color
Rain Rates
Lidar CALIPSO/CALIOP MPLNET
Rain Totals • 3, 6, 12, 24 hours • 2, 3, 4, 5, 6, 7, 10, 12, 14 days
*Winds • Scatterometer (sfc) • GEO o low level o middle level o upper level

Cloud Products
Cloud layers (snow, low-middle, high)
Cirrus cloud detection
Contrail detection
Nocturnal Low CLouds
Convective cloud top height
Cloud properties • effective radius • optical depth • cloud top temperature • cloud top height • cloud type

Environmental Products
Aerosol amounts (optical depth)
Biomass (vegetation type)
Dust detection · MODIS · VIIRS · MSG (DEBRA)
Fire detection (hot spots)
Lightning detection

Models	
Navy global (NAVGEM)	NAAPS dust model
Sea Level Pressure	Total AOD
500 mb Heights	Coarse AOD
sfc, 700 500 300 mb Winds	Fine AOD
1000-500 mb Thickness	Concentration [dust]
Surface Temperature	
Jet Stream	

red products: *deemed important by NWS-PR*

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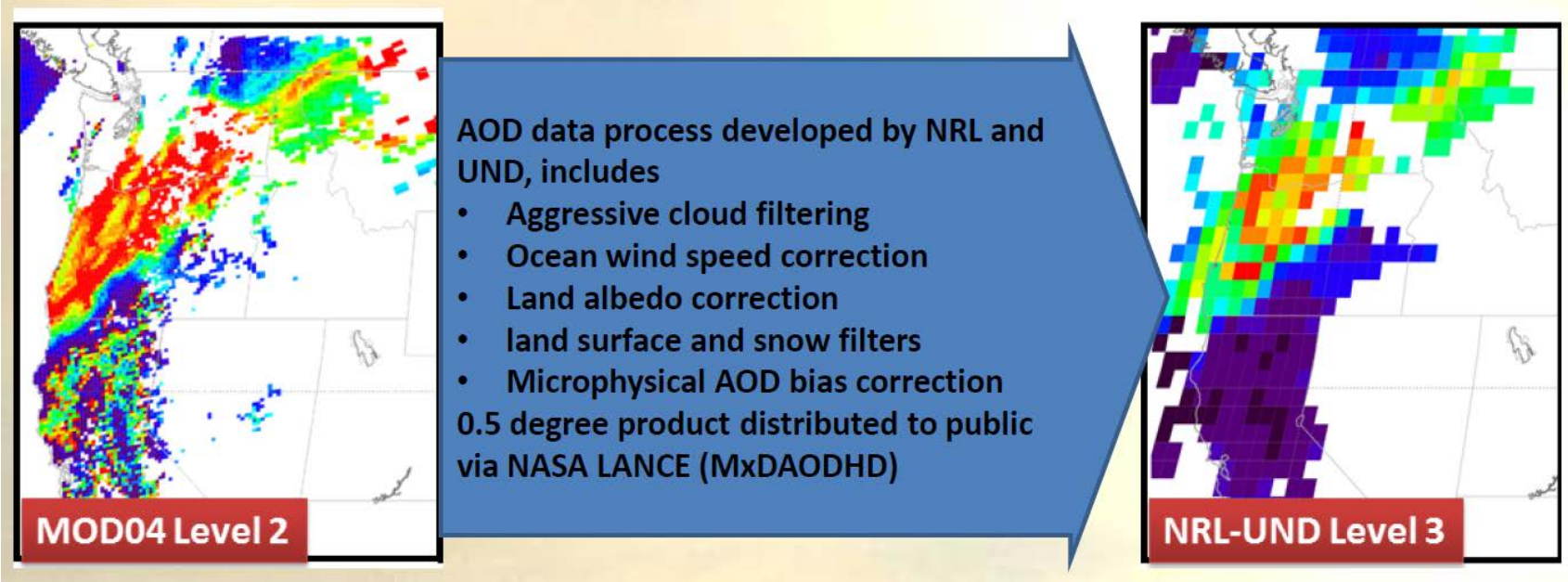
Navy Aerosol Analysis and Prediction System NAAPS

- Produces 6-day forecasts, 4 times daily, 0.3 X 0.3 degree res, 42 vertical levels of:
  - Mass concentrations of sulfate + organic aerosols , biomass burning smoke, dust, sea salt and column total aerosol optical depth (AOD)
- Utilizes Meteorological analysis and forecast fields from the Navy Global Environmental Model (NAVGEM)
- Can be initialized with assimilation of MODIS, VIIRS, AVHRR, MISR, and CALIOP data (current operational model uses MODIS only)
- Dust emission triggered when NAVGEM friction velocity exceeds thresholds (0.6 m/s) & sfc moisture < 0.4
- Valuable resource for air quality & fire hazard prediction throughout Western Atlantic regions
- For this experiment, a research version of the model used identical configurations, initializing using either VIIRS+MODIS or MODIS-only data
- Model validation results use AERONET Level 2.0 data

Ref: http://www.nrlmry.navy.mil/aerosol/

Preparing aerosol data for assimilation in NAAPS: filtering, correction, aggregation



- Pre-processing of VIIRS IDPS EDR data for NAAPS assimilation → Transition to NOAA Enterprise
- "fullQA" uses information packaged with EDR granules to filter data:
  - QA = 'Good' (highest EDR QA value)
  - Cloud mask, cloud proximity, snow flags, glint flags
- Observations aggregated to 1-degree, 6-hour
  - Operational NAAPS now 1/3°, 1° used for testing
- Two tests run
  - Short test: qualitative: 1-30 June 2014 (dust event 23-28 June)
  - Long test: quantitative: 2013.01.24.00 to 2014.01.12.00

Courtesy: Edward Hyer, NRL

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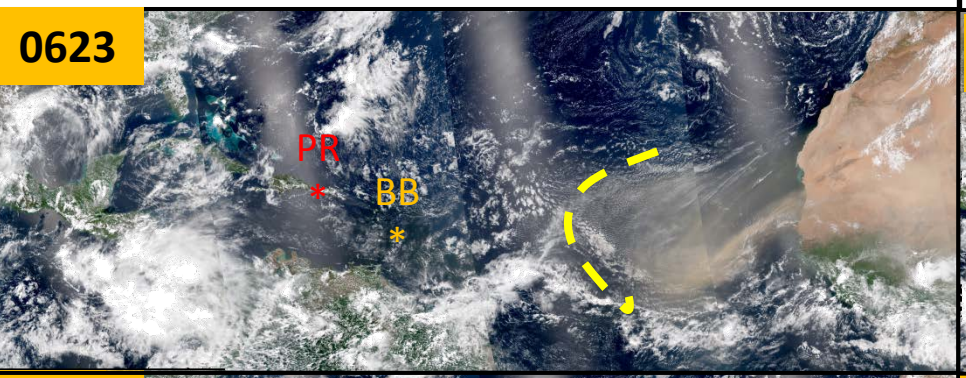
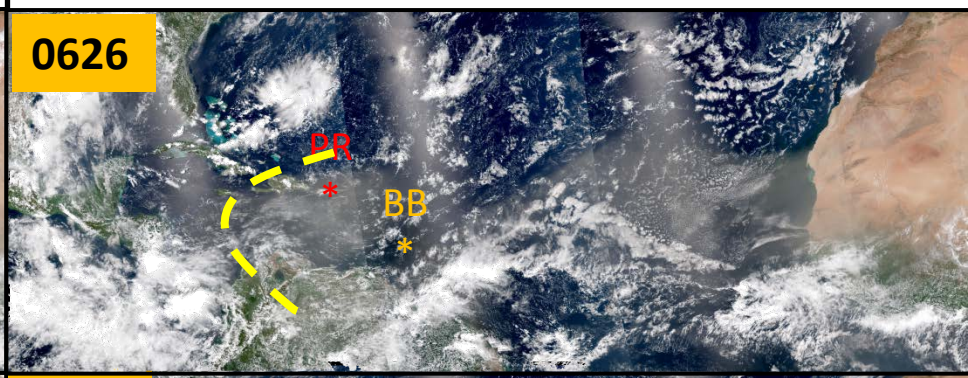
Tracking a *dusty* SAL Event

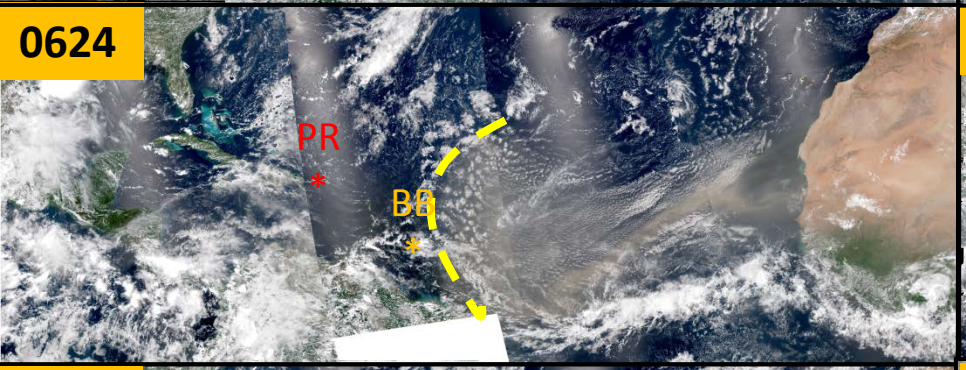
23 – 28 June, 2014

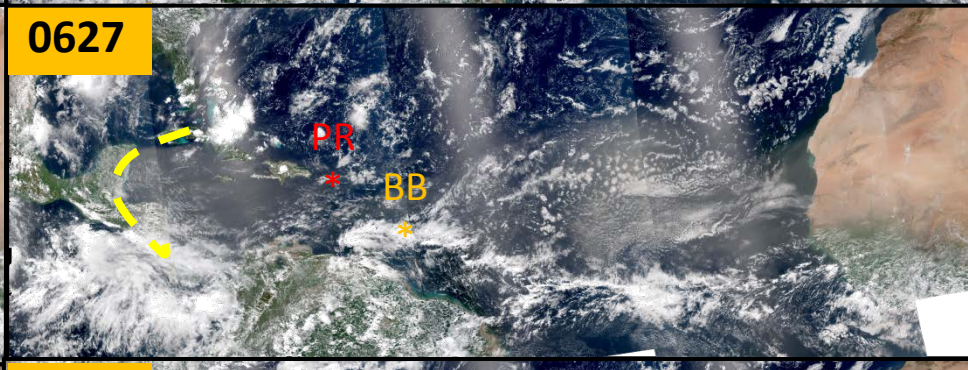
VIIRS True Color imagery

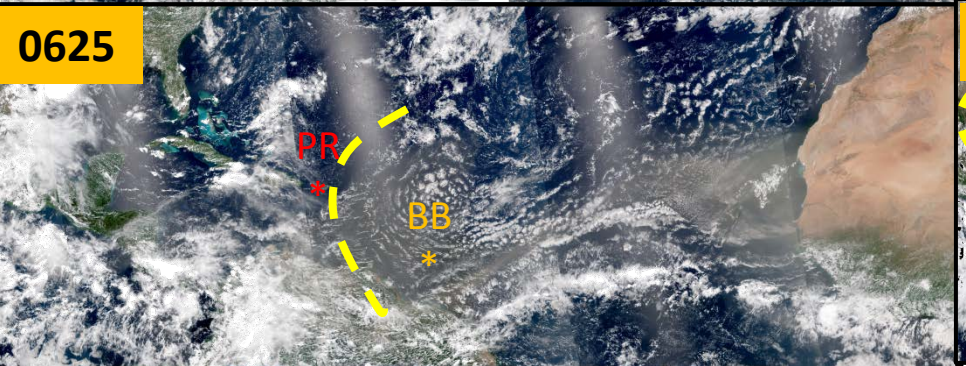
Targeted areas: Puerto Rico (PR) and Barbados (BB)

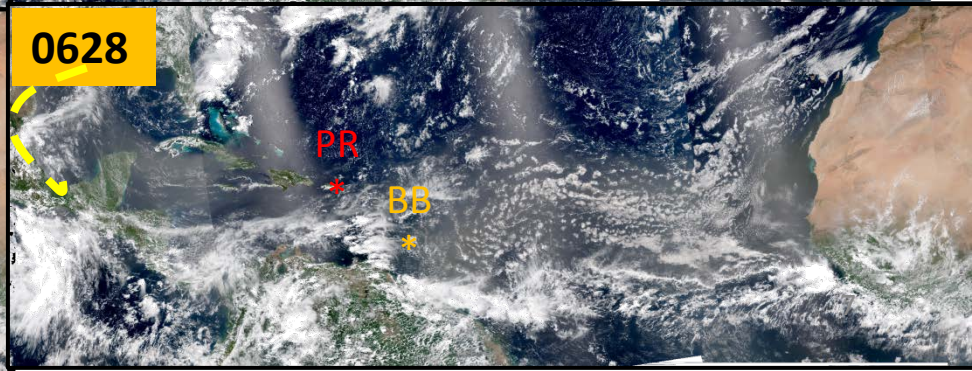










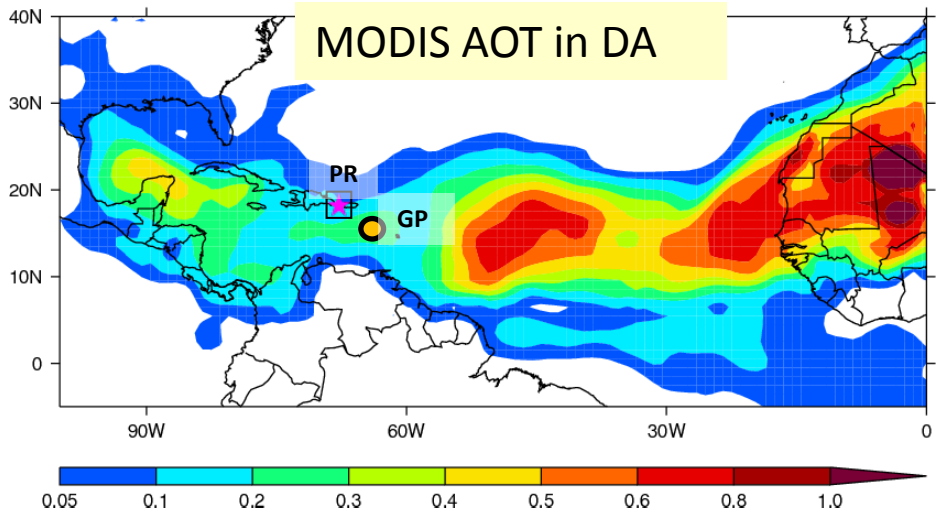


Comparing NAAPS: with MODIS vs VIIRS AOD in DA

pink star = La Paguera, orange dot = Guadaloupe

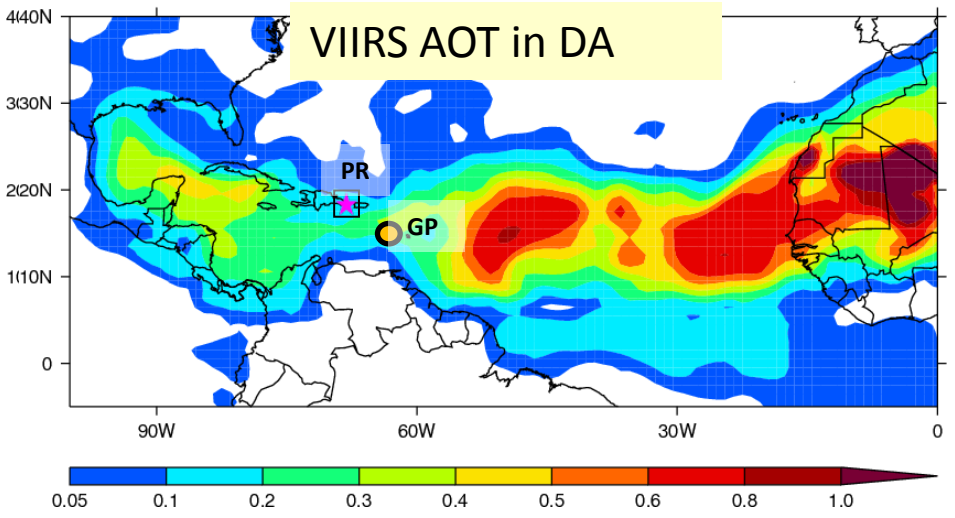
NAAPS dust AOD 2014062818

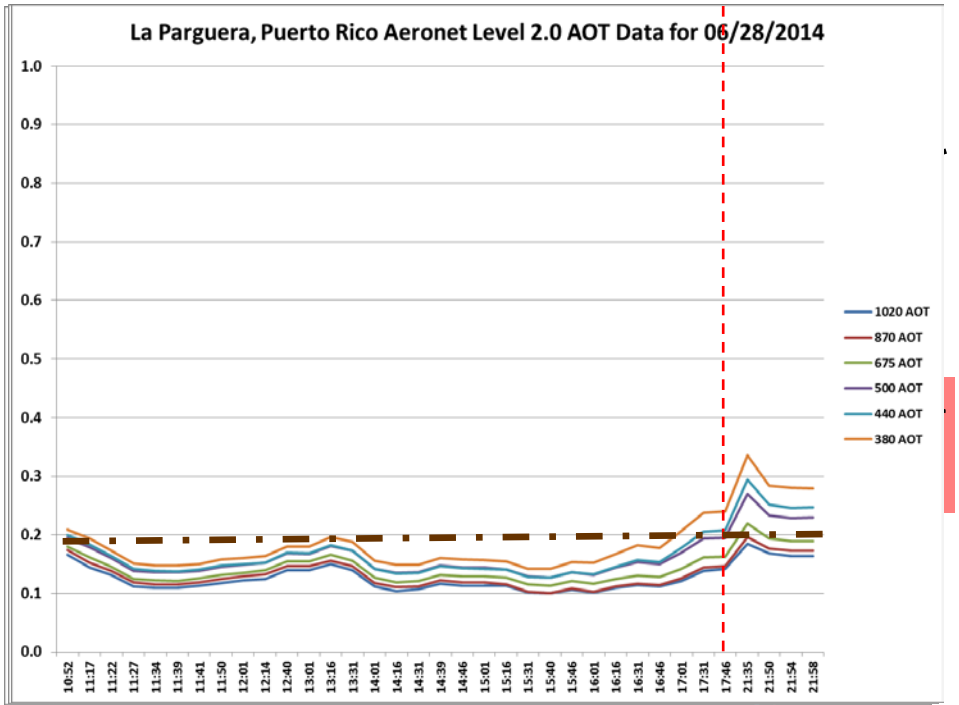
MODIS AOT in DA



NAAPS dust AOD 2014062818

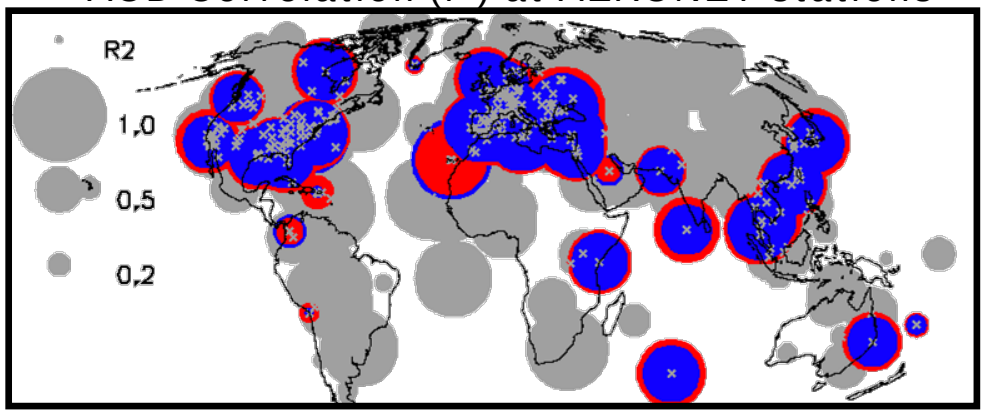
VIIRS AOT in DA



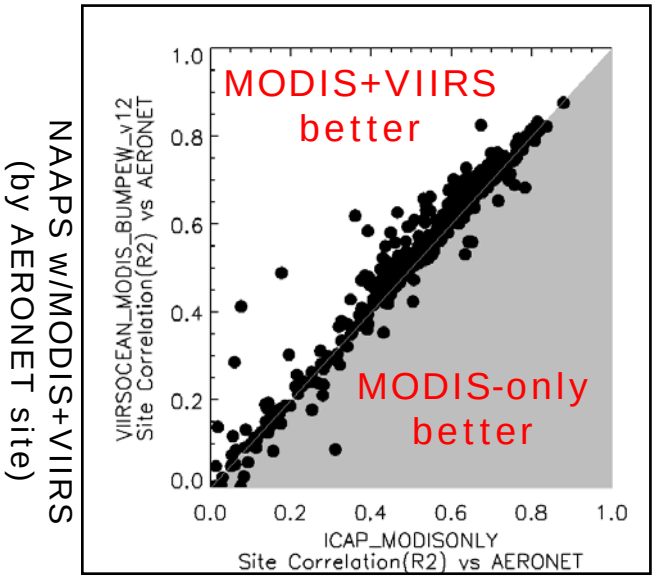


12-month quantitative test: NAAPS runs using MODIS-only (OPS) vs VIIRS+MODIS

AOD Correlation (r^2) at AERONET stations



MODIS+VIIRS MODIS only



NAAPS w/MODIS+VIIRS (by AERONET site)

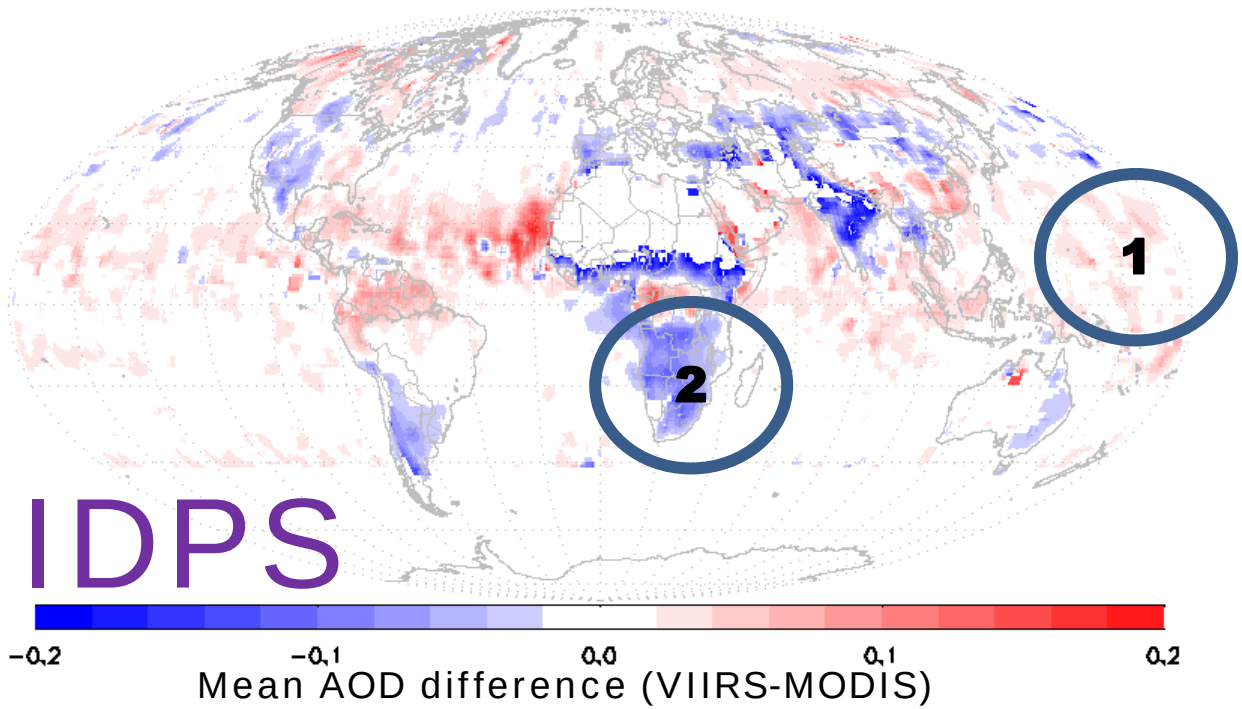
NAAPS w/MODIS (by AERONET site)

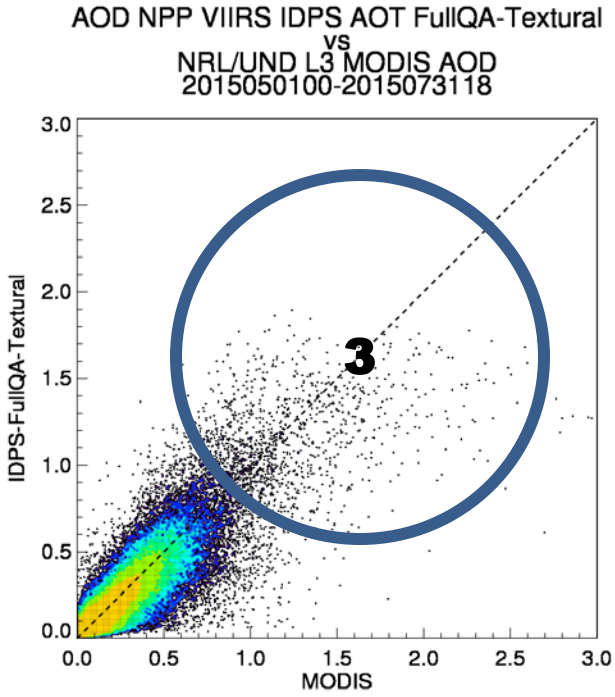
NAAPS AOD analysis results:

- **201302 – 201402 NAAPS analysis (6-hourly data) compared to AERONET L2.0 data**
- **VIIRS+MODIS better than MODIS only**
  - **correlation (r^2) vs AERONET L2.0 increased at 256 of 382 stations**
  - **Slope vs AERONET L2.0 improved at 224 of 382 stations**
  - Colored symbols on map indicate stations where r^2 differed by more than 0.05

Courtesy: Edward Hyer, NRL

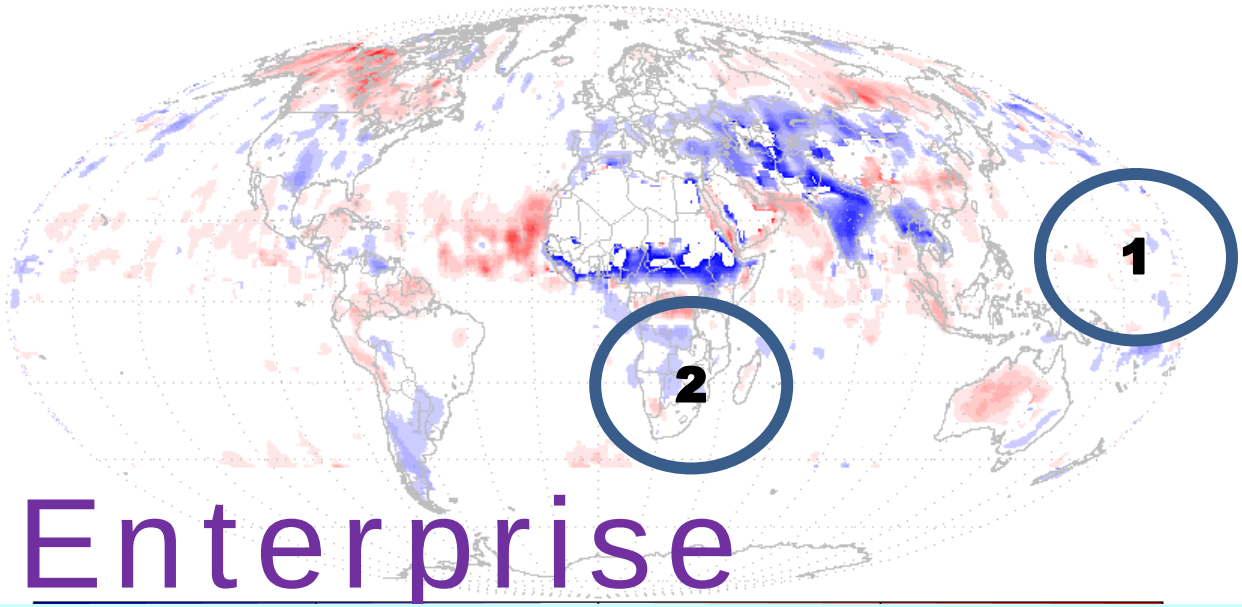
VIIRS AOD data using IDPS



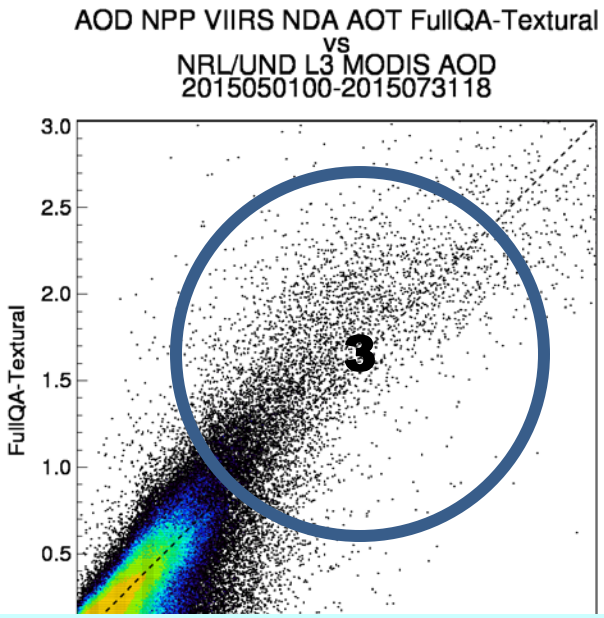


- 3-month comparison to MODIS NRL/UND L3 Data Assimilation product: 201505-201507
- VIIRS data aggregated and filtered 'FullQA' + buddy checks and neighborhood tests
- Left: map of AOD differences (paired) (smoothed for plotting)
- Right: scatter-density plot of AOD differences vs MODIS

New VIIRS AOD data using NOAA STAR Enterprise



Enterprise



Enterprise AOD from NOAA STAR

- ***Improves bias correction compared to AERONET***
- ***Allows greater number of dust-related values into NAAPS DA***
- ***DA testing of new Enterprise product is underway at NRL***

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Summary

VIIRS impact on monitoring & predicting SAL events

1. Comparisons of NAAPS DA: MODIS (OPS) vs MODIS+VIIRS AOD

a) VIIRS + MODIS outperforms MODIS-only

b) Improvements seen in case studies and statistical analyses

c) VIIRS has more spatial coverage than MODIS, particularly over the tropics, so more AOT retrievals

d) IDPS VIIRS AOT contains more bias than NOAA STAR Enterprise VIIRS AOT

e) Positive impact to forecasting SAL dust events at NWS, San Juan

   i. VIIRS DA should yield improved forecasts and characteristics of SAL propagation out to 3–6 days

2. Future Efforts

a) Will provide NAAPS with Enterprise VIIRS AOD as DA into NRL-MMD SAL webpage

b) More interaction with forecasters/scientists within greater Caribbean

Web resource: http://www.nrlmry.navy.mil/NEXSAT.html & SAL.html