Status Update on NCEP operational Global Aerosol Forecasting System

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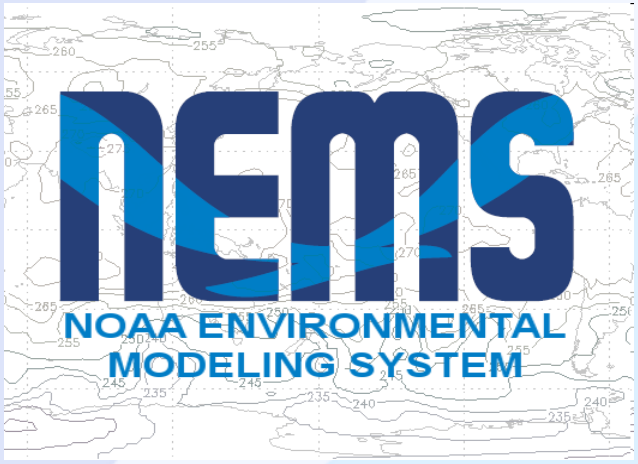
Sarah Lu, Sheng-Po Chen (SUNY at Albany)

Joint efforts in NGAC research and development



NEMS team in EMC:
Atmospheric dynamics and physics
Infrastructure, I/O and post processing
Verification
Documentation

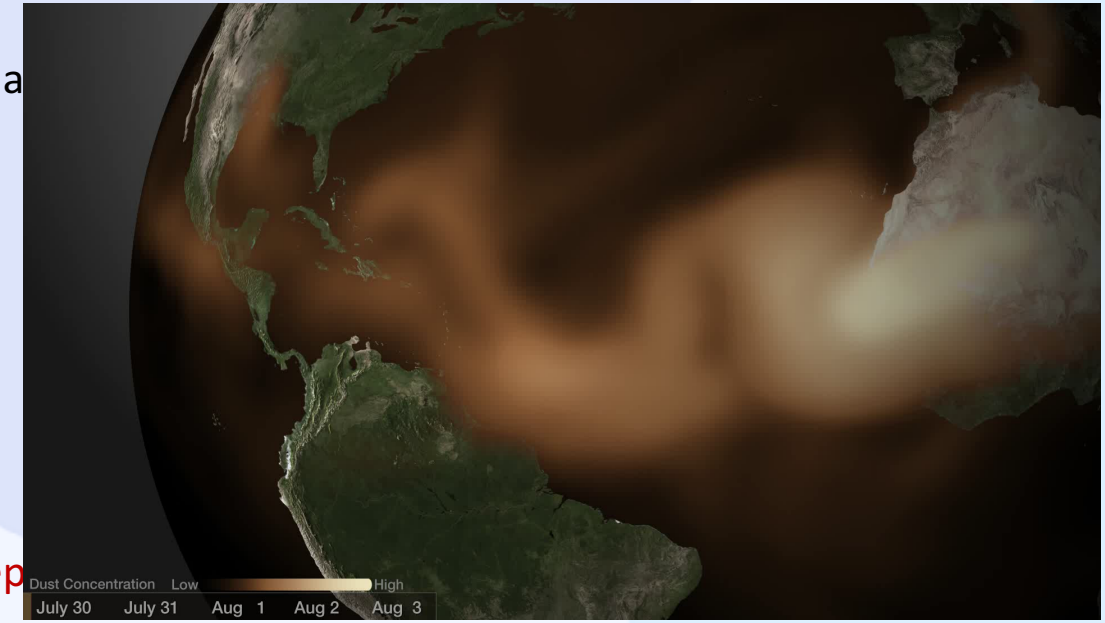
SUNY Collaborators (Sarah Lu, Sheng-Po Chen, Shih-wei Wei)
GSFC collaborators (Arlindo da Silva, Peter Colarco, Anton Darmenov, Donifan Barahona, Atanas Trayanov, Mian Chin)
NESDIS collaborators (Shobha Kondragunta, Hanjun Ding, Prabhat Koner, Andy Harris)
South Dakota State Univ (Xiaoyang Zhang)
EMC AQ group (Jeff McQueen, Jianping Huang, Ho-chun Huang, Jerry Gorline)
ARL (Pius Lee, Li Pan)
CPC (Craig Long)
ICAP working group
WMO SDS-WAS experts

Acknowledge:
NGAC is sponsored by NASA Applied Science Program, JCSDA, and NWS. This project leverages the expertise in GSFC, NESDIS, the ICAP working group, and the WMO SDS-WAS program

Current Operational NEMS GFS Aerosol Component

Current State

- Near-real-time operational system
- The first global in-line aerosol forecast system at NCEP
- AGCM : NCEP's NEMS GFS
- Aerosol: GSFC's GOCART
- 120-hr dust-only forecast once per day (00Z), output every 3-hr
- ICs: Aerosols from previous day forecast and meteorology from operational GDAS
- Implemented into NCEP Production Suite in Sep 2012
- Use near-real-time smoke emissions from satellites (collaborating with NESDIS /GSFC) FY14



Ongoing Activities and Future Plans

- Full package implementation (dust, sea salt, sulfate, and carbonaceous aerosols) **FY16**
- Aerosol analysis using VIIRS AOD **FY18**
- Provide aerosol information for potential downstream users (e.g., NESDIS's SST retrievals, CPC-EPA UV index forecasts; aerosol lateral boundary conditions for regional models)

Status update at ICAP-Recent Progress in Aerosol Observability for Global Modeling

Presentation Outline

- **Next NGAC implementation in Q4FY2016**
- **Future operational requirements and applications**

Q4FY16 Planned Implementation

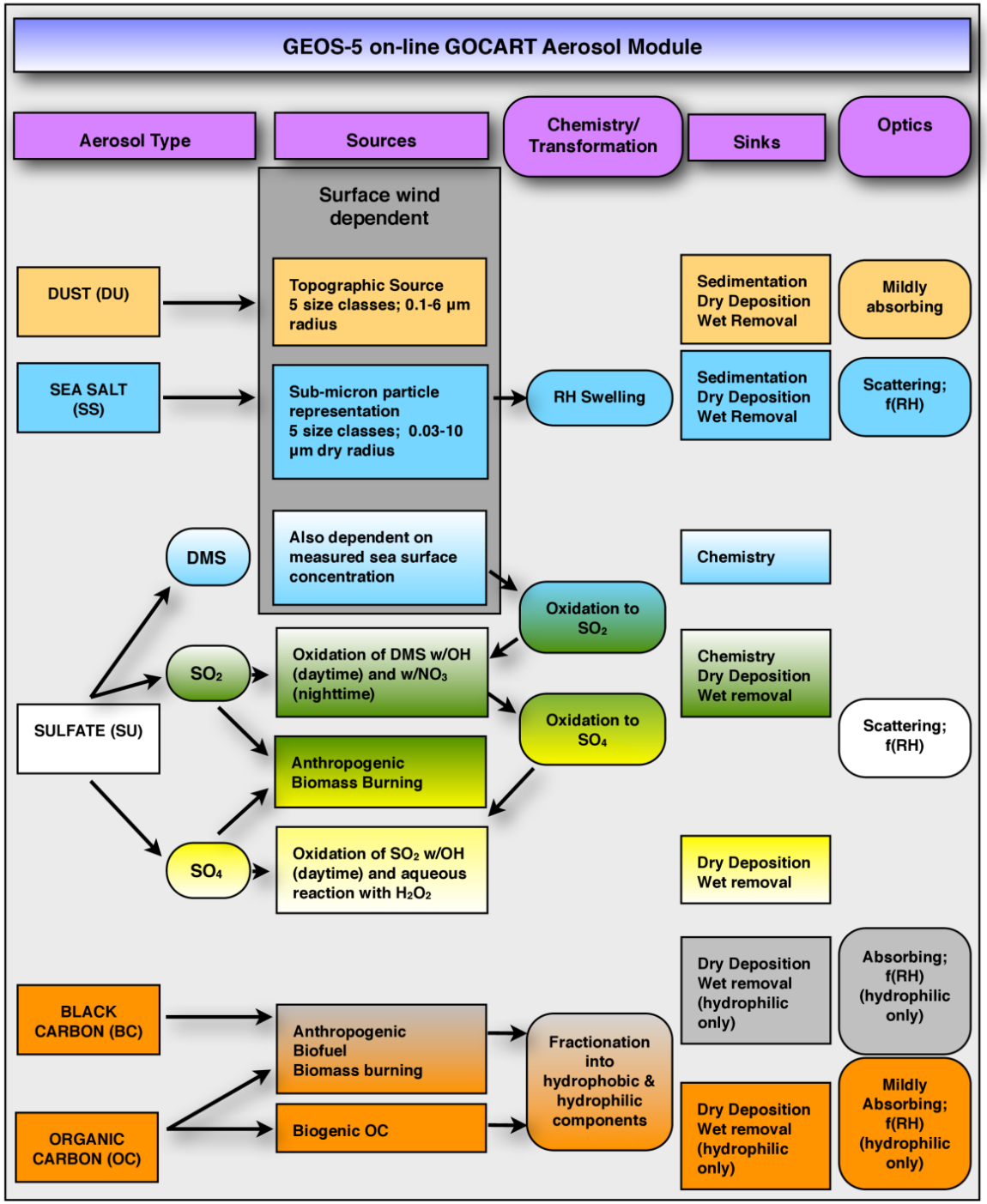
- Extend the dust-only system to include sulfate, sea salt, and carbonaceous aerosols
  - NESDIS - GSFC - NCEP collaborate to develop near-real-time biomass burning emissions GBBEPx
  - Aerosol model was updated to new GOCART version
    - Issues in sulfate chemistry have been identified, prescribed radical/gas distributions and emission inventories have been updated
    - Regional scale factors for OC, BC and SU have been derived from the comparison of GBBEPx and QFED2
  - Atmosphere physics is upgraded to the latest operational GFS physics package:
    - RRTM with McICA radiation package
    - Eddy-Diffusivity Mass-Flux(EDMF) PBL scheme,
    - Land Surface updates: canopy height scheme, soil moisture nudge, roughness length
  - New products to support down stream applications
  - Verification package for monitoring aerosol forecasts

GOCART Module

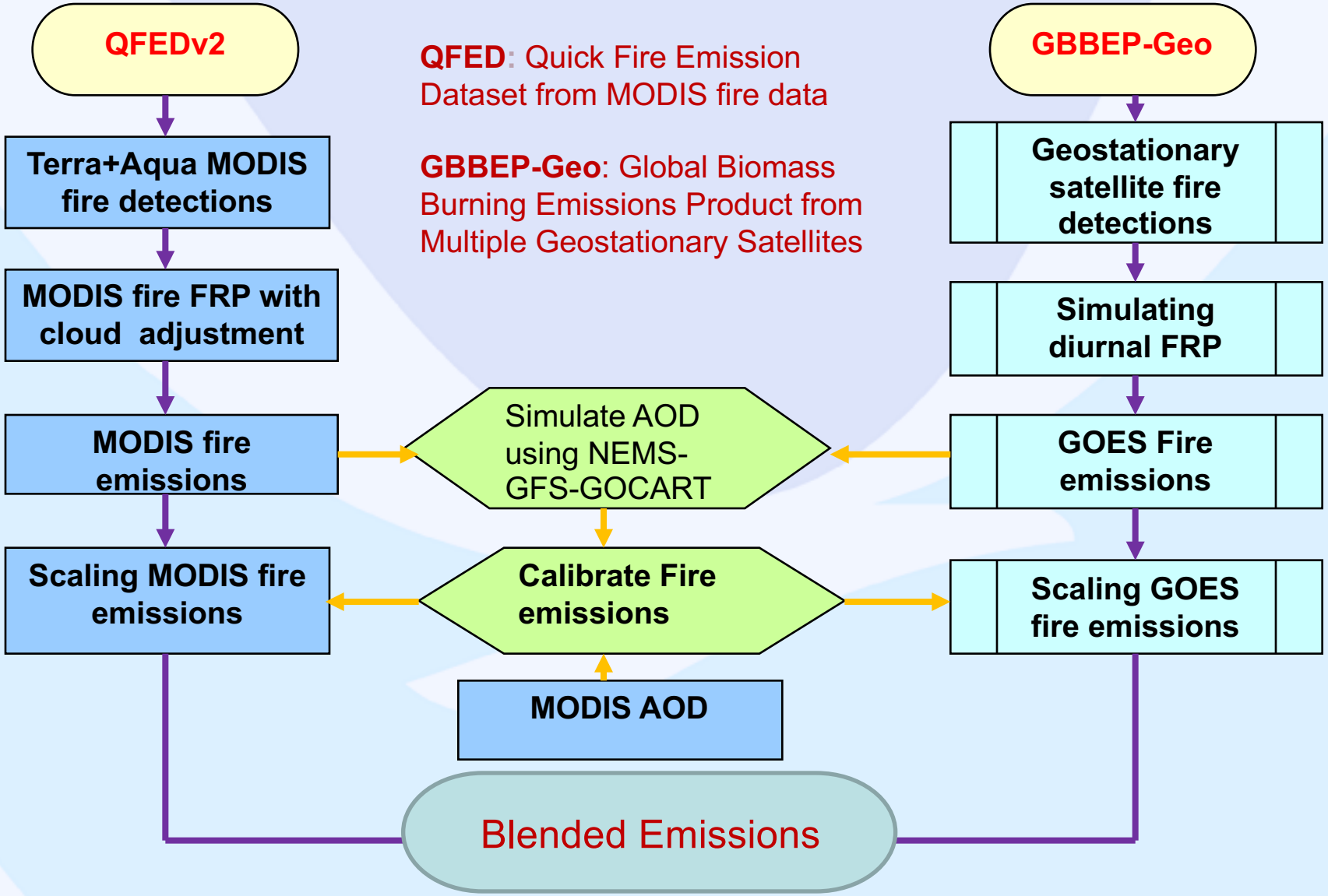
In-line chemistry advantage

- Consistency: no spatial-temporal interpolation, same physics parameterization
- Efficiency: lower overall CPU costs and easier data management
- Interaction: Allows for feedback to meteorology

GOCART diagram provided by Peter Colarco (GSFC)



Flowchart for blended Polar and Geo biomass burning emissions

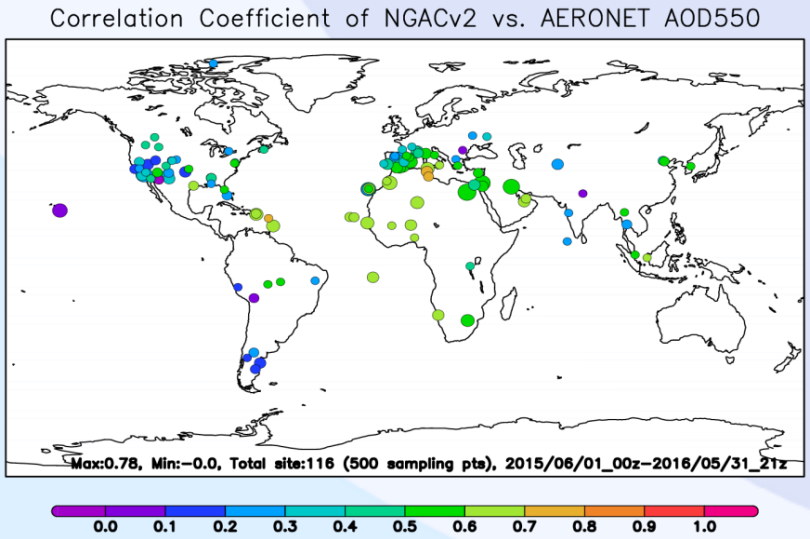


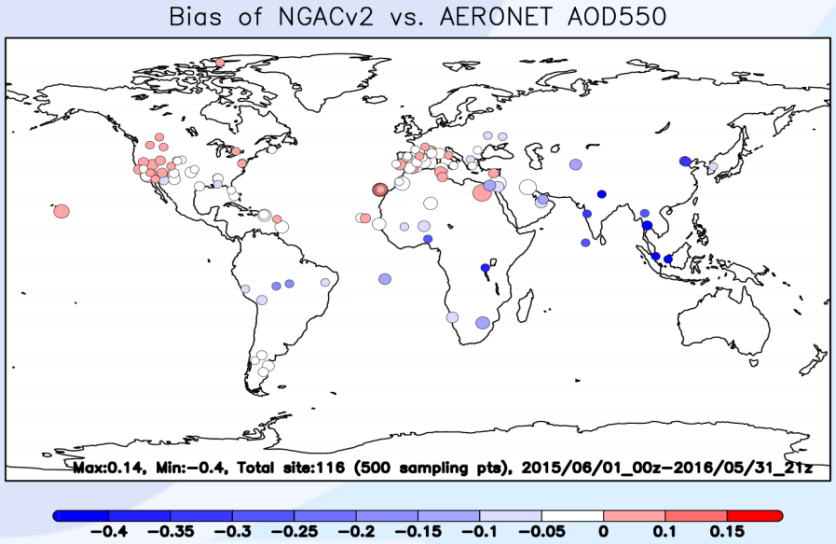
- Scaling factors are region and biome dependent but static.
- Blended emissions will be generated daily at NESDIS/OSPO for NGAC.
- Scaling factors need to be re-generated only if there is a new satellite replacing an old satellite.

Shobha Kondragunta (NESDIS/STAR)

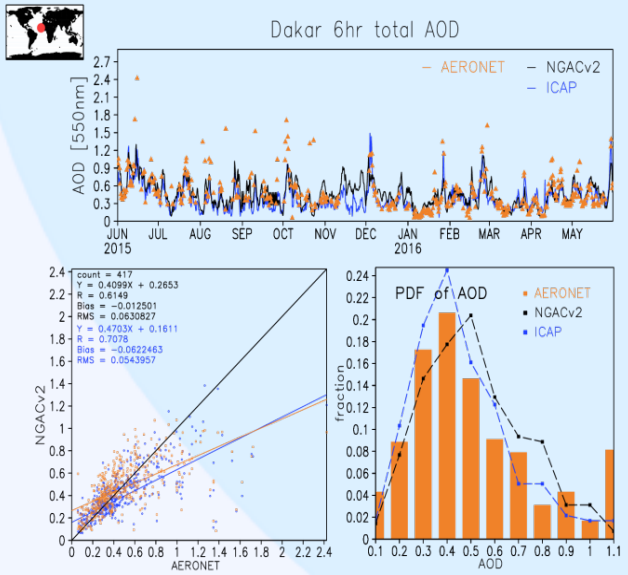
NGAC verification

- Statistics of 2015-2016 NGAC vs. AERONET

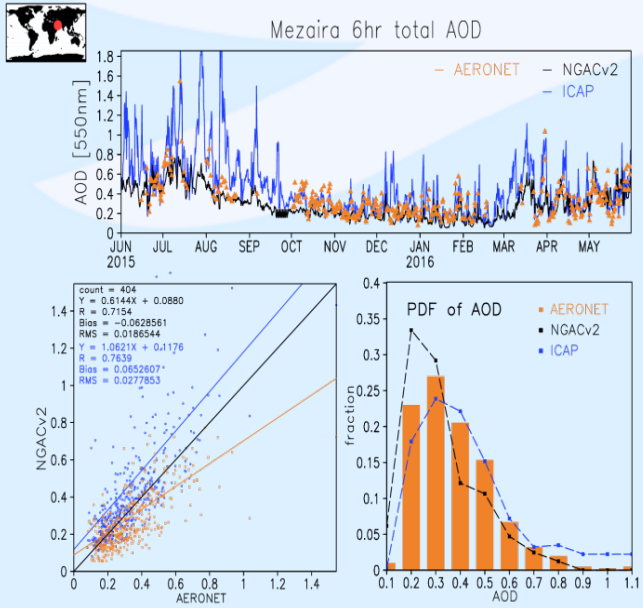




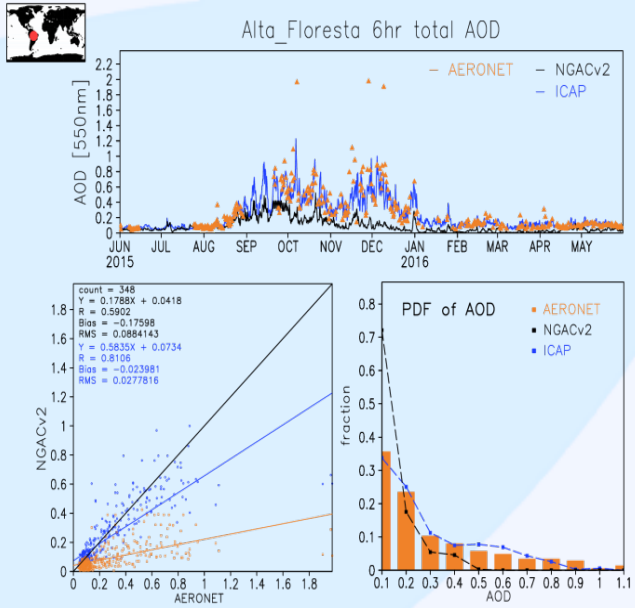
Mineral dust



Arabian dust

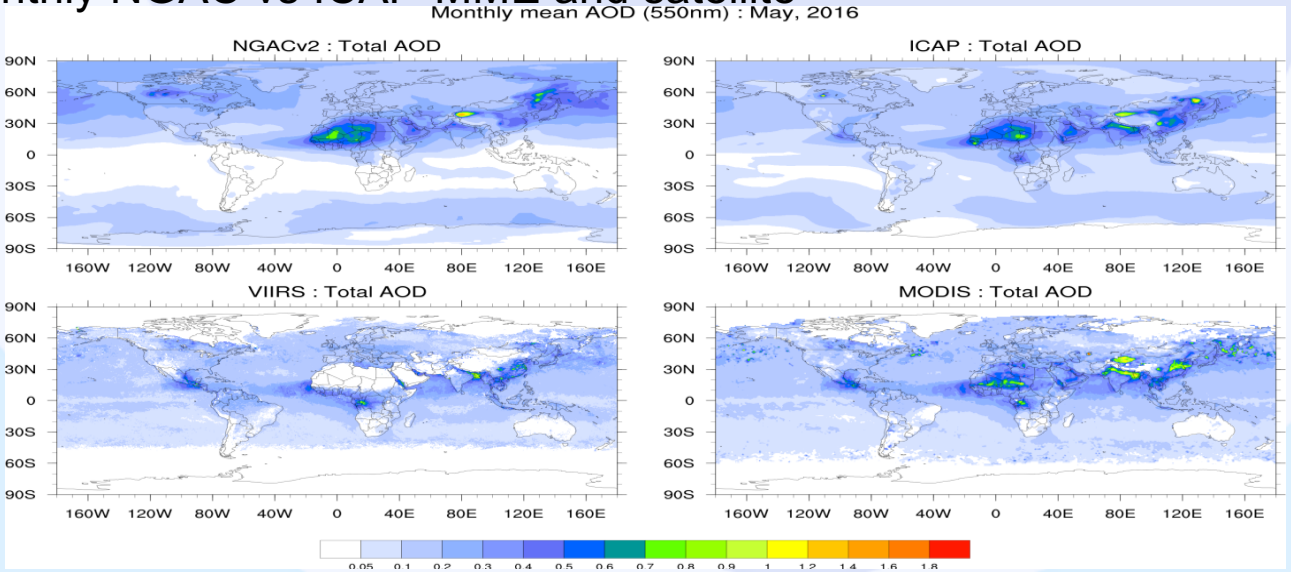


Biomass burning

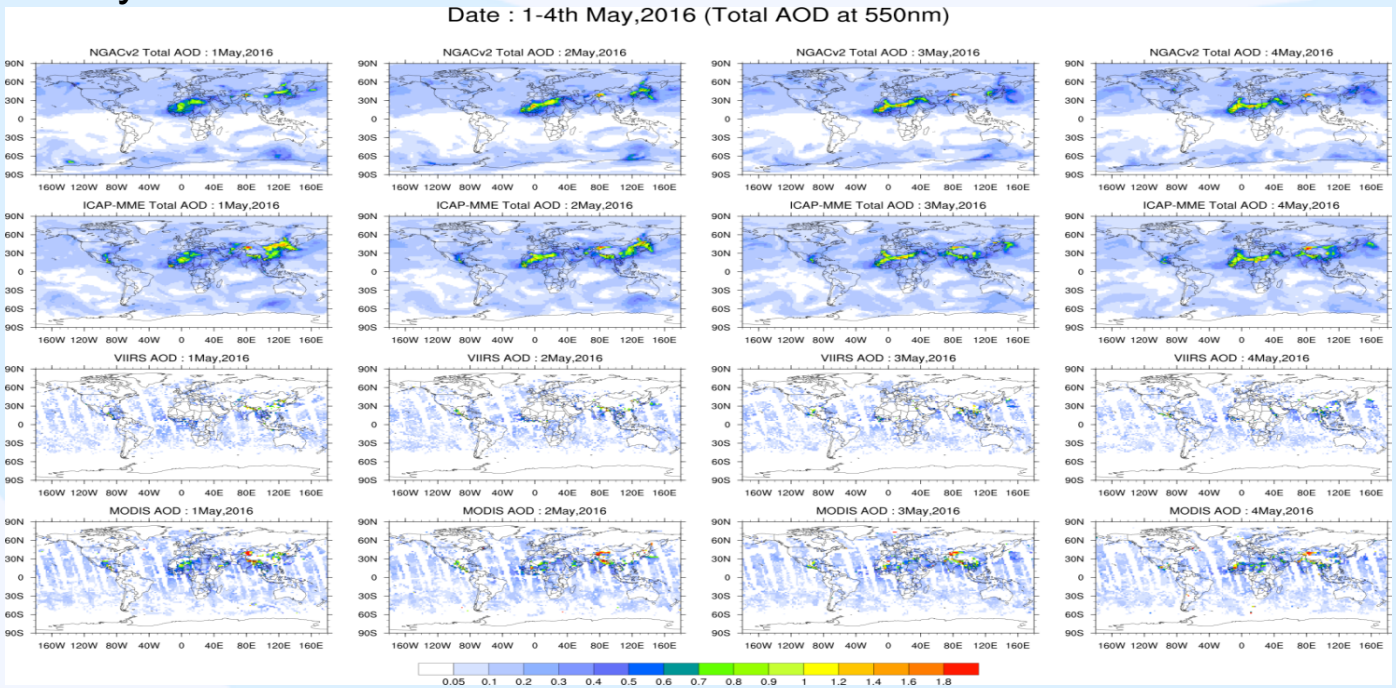


NGAC verification (cont.)

- Monthly NGAC vs ICAP-MME and satellite



- Daily NGAC vs ICAP-MME and satellite

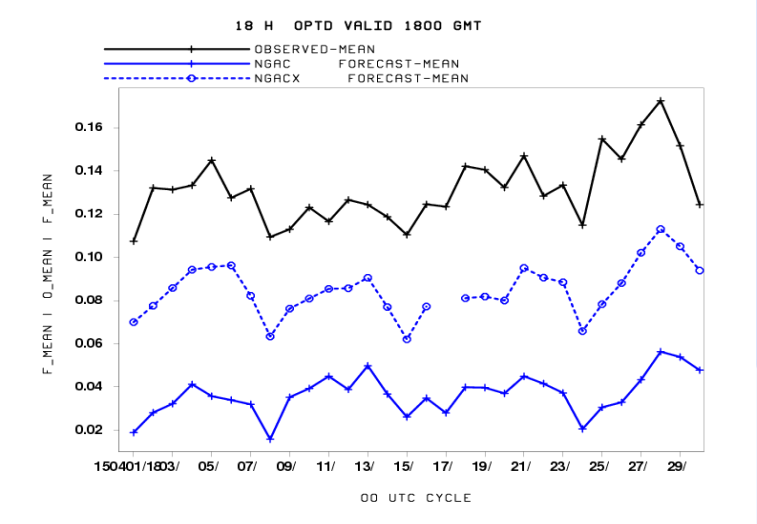


NGAC Evaluation and Verification

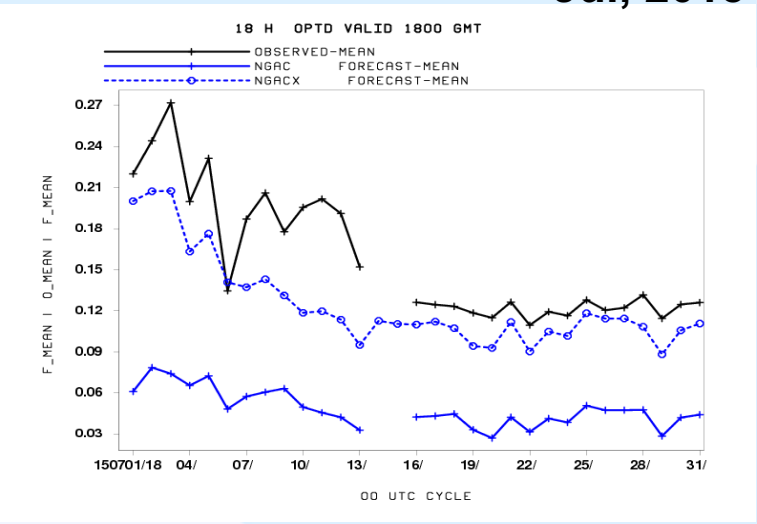
NGAC production vs V2 parallel total AOD against observations at fh18

GLOBE

Apr, 2015

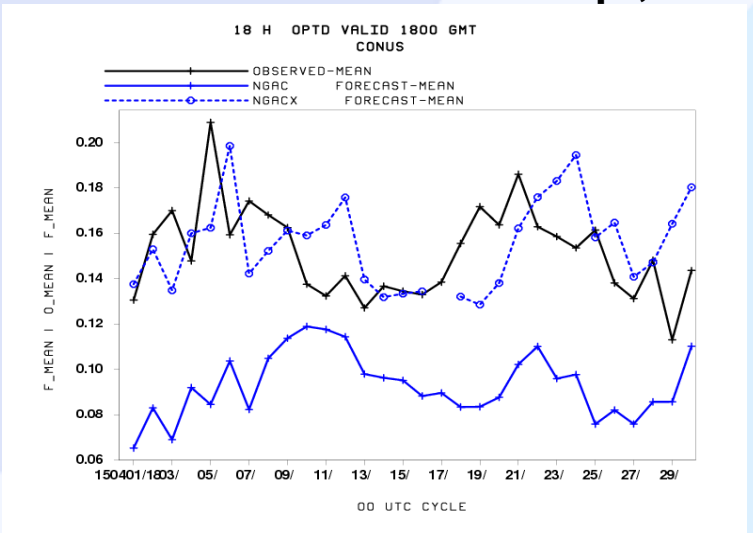


Jul, 2015



CONUS

Apr, 2015



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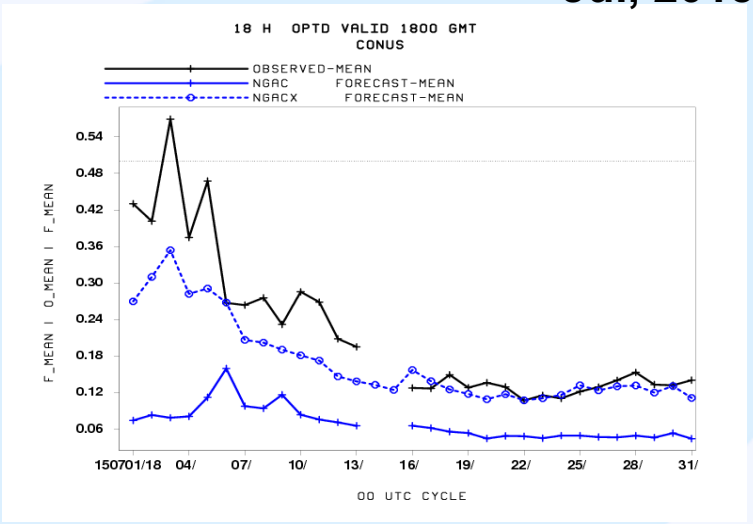
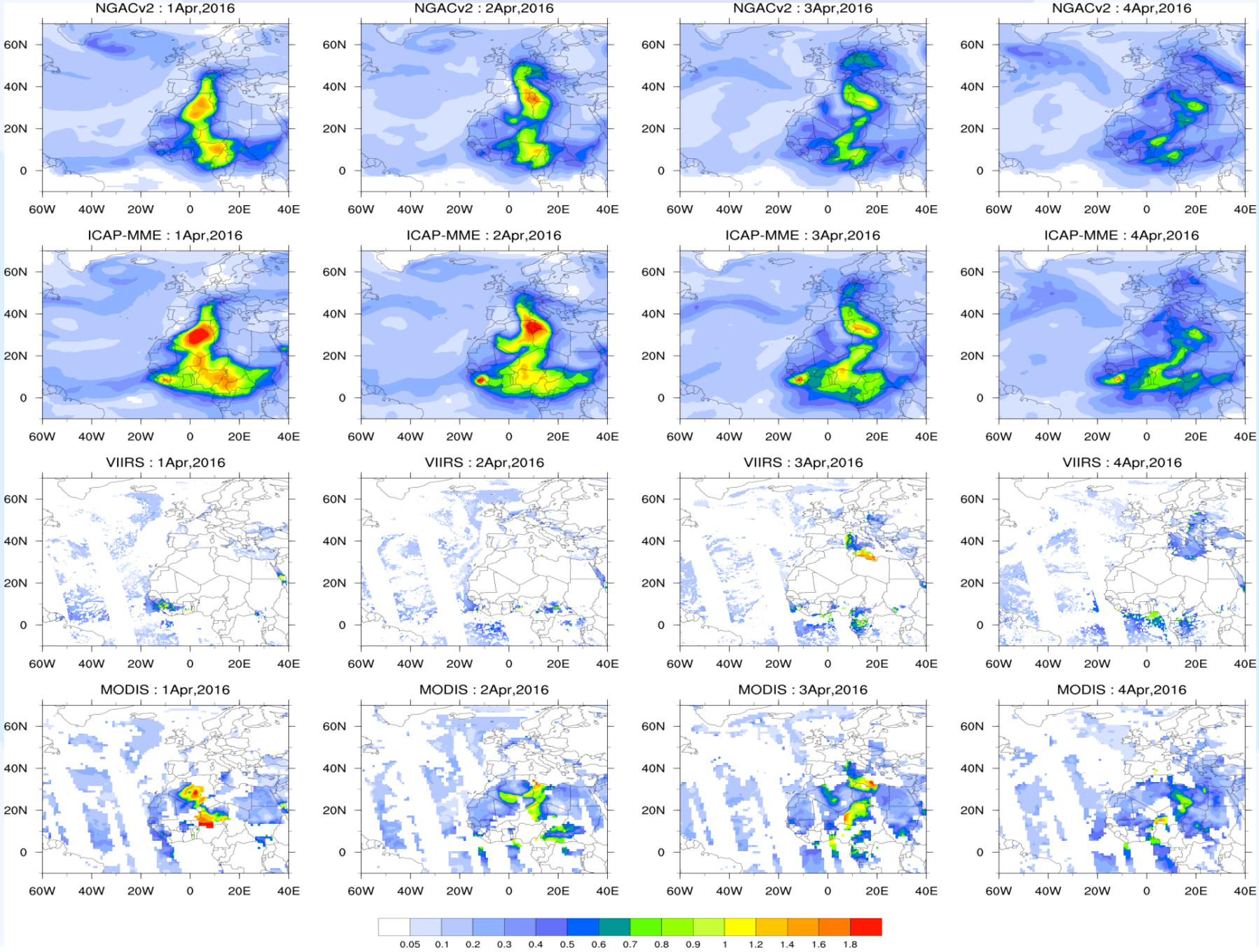
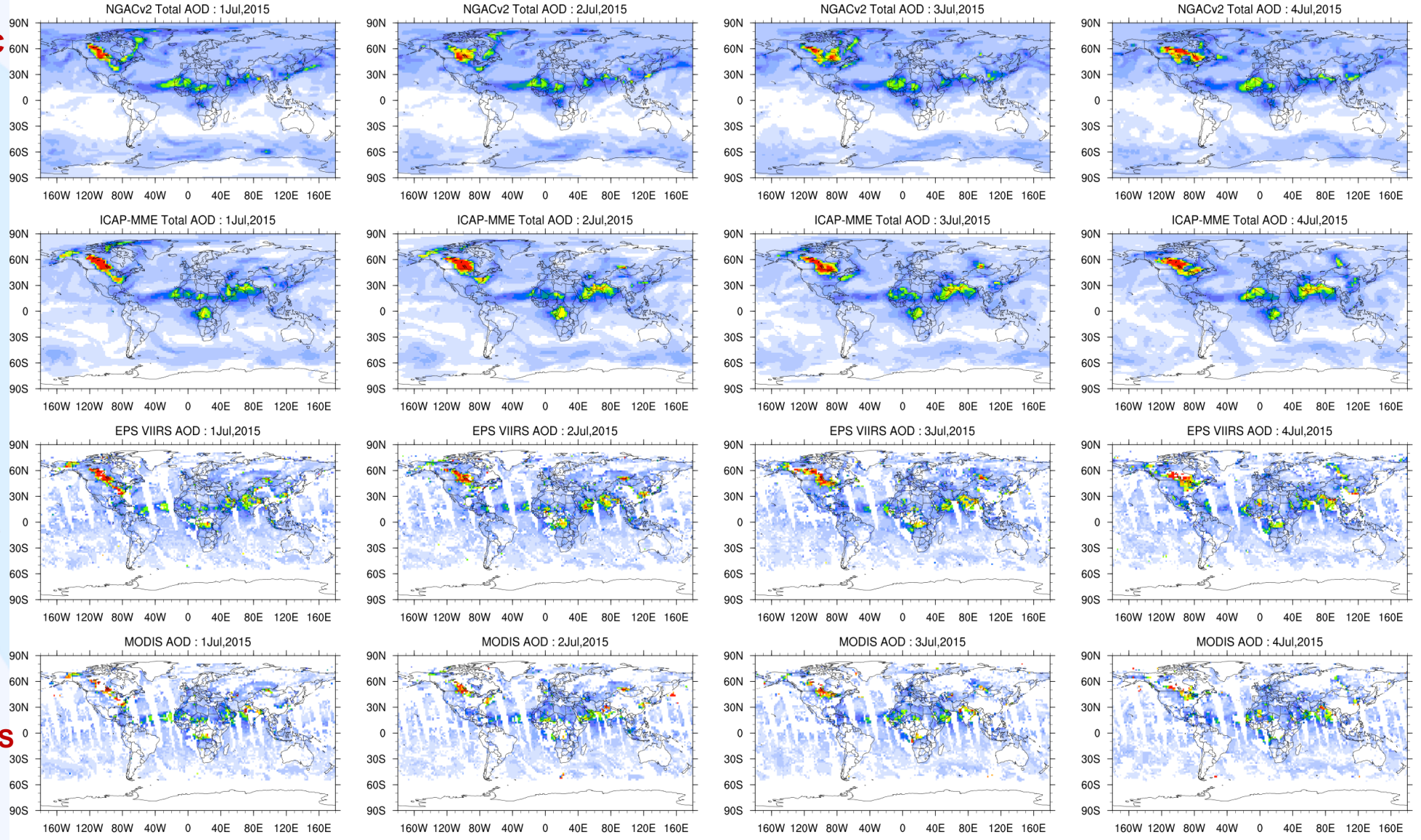


Dust event on April 1-4, 2016



Smoke event on Jul 1-4, 2015

Date : 1-4th July,2015 (Total AOD at 550nm)



NGAC Product Suite and Applications

NGAC provides 1x1 degree products in GRIB2 format twice per day

Product files and their contents include:

UV index forecasts **AOD assimilation** **AVHRR SST** **AIRS retrievals**

- **ngac.t00z.aod_$CH.grib2, CH=340nm, 440nm, 550nm, 660nm, 860nm, 1p63um, 11p1um**
  - Aerosol Optical Depth (AOD) at specified wavelength from 0 to 120 hour

- **ngac.t00z.a2df$FH.grib2, FH=00, 03, 06, ….120**
  - Total AOD at 0.55 micron
  - Fields from all species: dust, sea salt, carbonaceous aerosols, and sulfate
    - AOD
    - emission, sedimentation, dry deposition, and wet deposition fluxes
  - Single scatter albedo and asymmetric factor for total aerosols at 0.34 micron
  - *Ångström* Exponent for total aerosols from 0.44 and 0.66 micron

Budget, ocean productivity

UV index forecasts

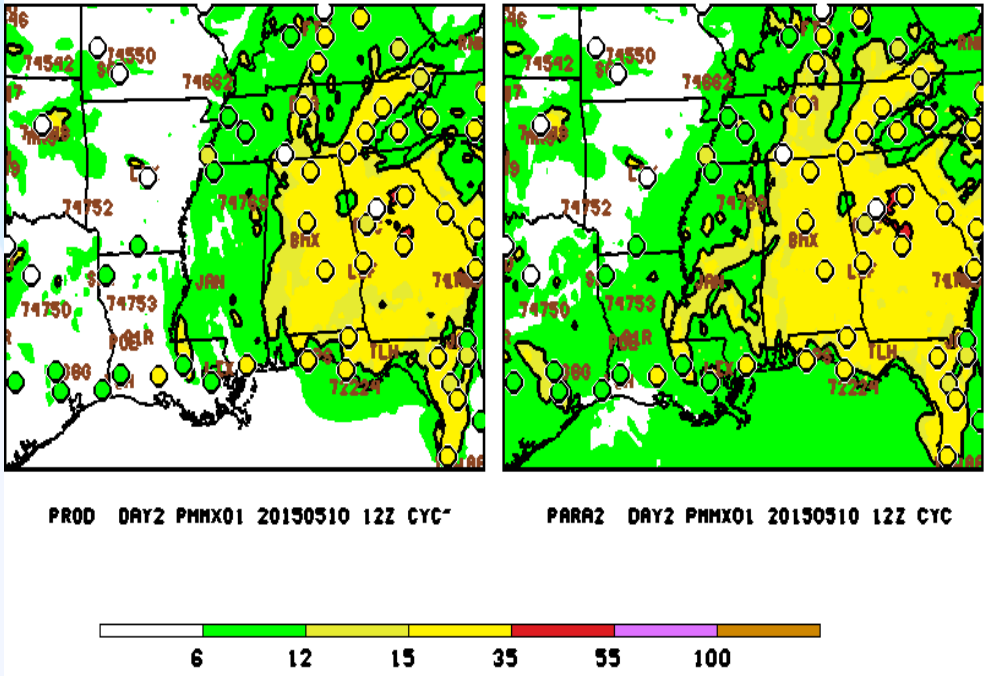
- **ngac.t00z.a3df$FH.grib2, FH=00, 03, 06, ….120** ← **Atmospheric correction**
  - Pressure, temperature, relative humidity at model levels
  - Mixing ratios for aerosol species at model levels

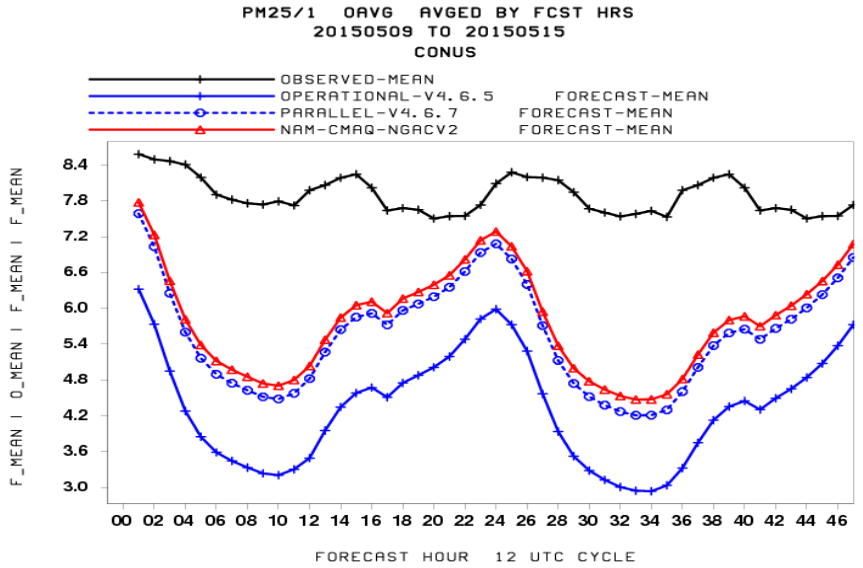
Potential applications for NGAC products are highlighted in red.
New products are in pink.

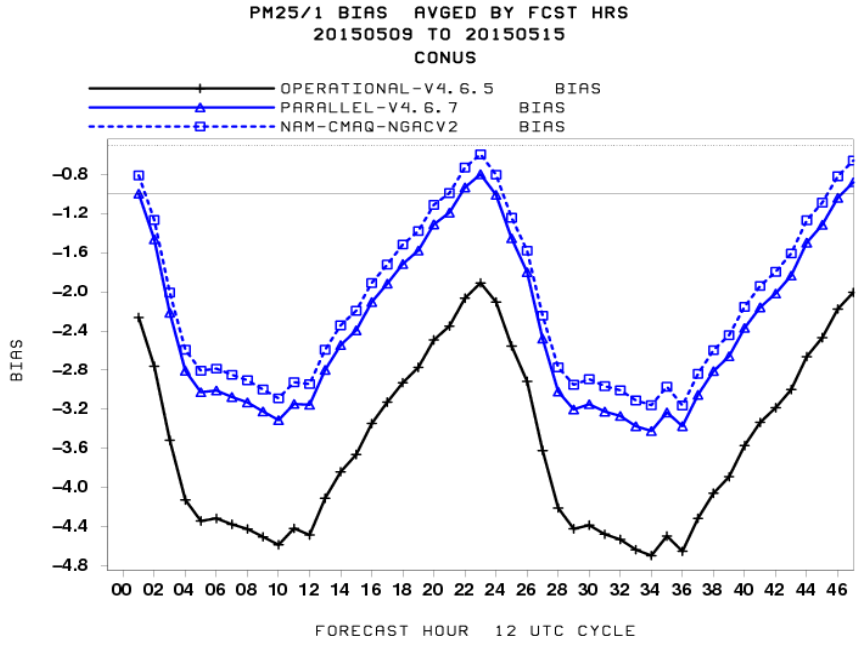
Dynamic LBCs for regional model CMAQ

- Recently implemented operational NAM-CMAQ using dynamic LBCs from NGACv1 versus experimental NAM-CMAQ with dynamic LBCs from NGACv2.
- The inclusion of LBCs from operational NGAC forecast is found to improve PM forecasts, and it is in CMAQ Q12016 implementation. Initial tests show that using NGACv2 forecast as LBC further improves CMAQ PM forecast.

Dust event on 201505100-20150515

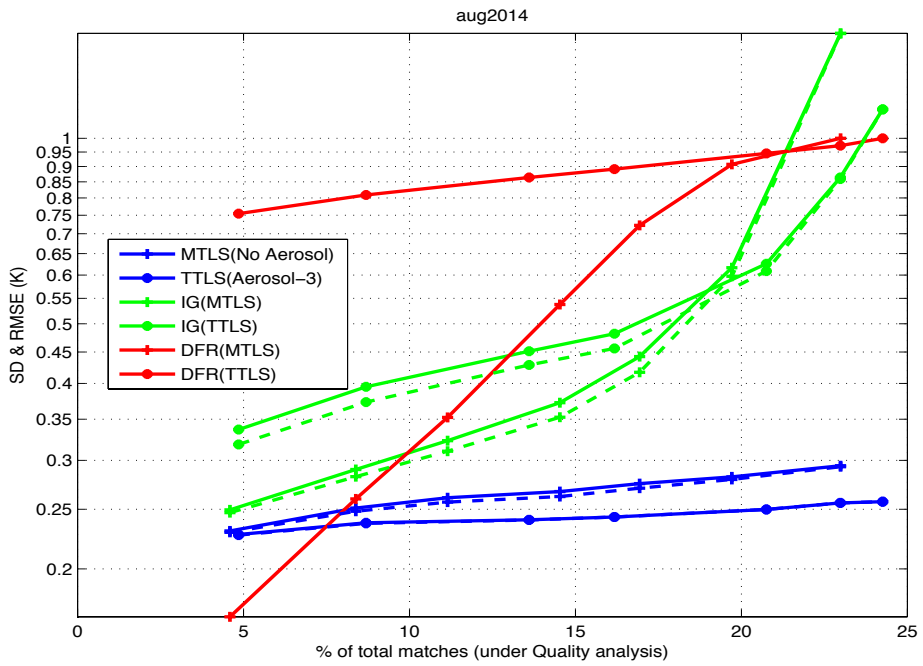




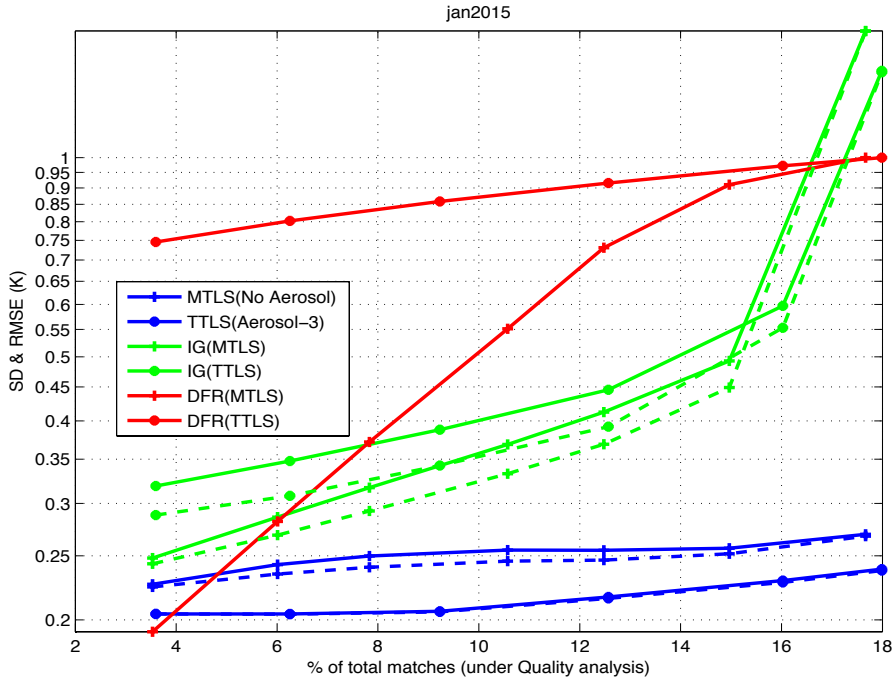


Jeff Mcqueen and Jianping Huang

Improving Satellite SST retrieval using NGAC multiple species aerosol forecast



- Retrieval results (night only) for sea surface temperature (SST) are using physical deterministic methods (MTLS and TTLS) from MODIS-AQUA measurement
- **TTLS cannot be implemented without representative aerosol data**



- **There are improvements in SST retrieval on whole data sets using aerosol data, the information content improves drastically.**

Prabhat Koner and Andy Harris

Planned future implementation

NCEP is developing global aerosol forecasting/assimilation capability

- The aerosol project builds upon extensive collaboration with NOAA labs/centers (NESDIS) and external research community (SUNY, GSFC, the ICAP working group, WMO SDS-WAS program)

- Phased implementation
  - Phase 1: Dust-only forecasts (operational) **(Implemented in Q4FY2012)**
  - Phase 2: Forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS's GBBPEx smoke emissions (planned FY16 implementation) **(Ongoing, Q4FY2016)**
  - Phase 3: Aerosol analysis using VIIRS AOD (Planned FY18 implementation) **(Funded by JCSDA)**

Presentation Outline

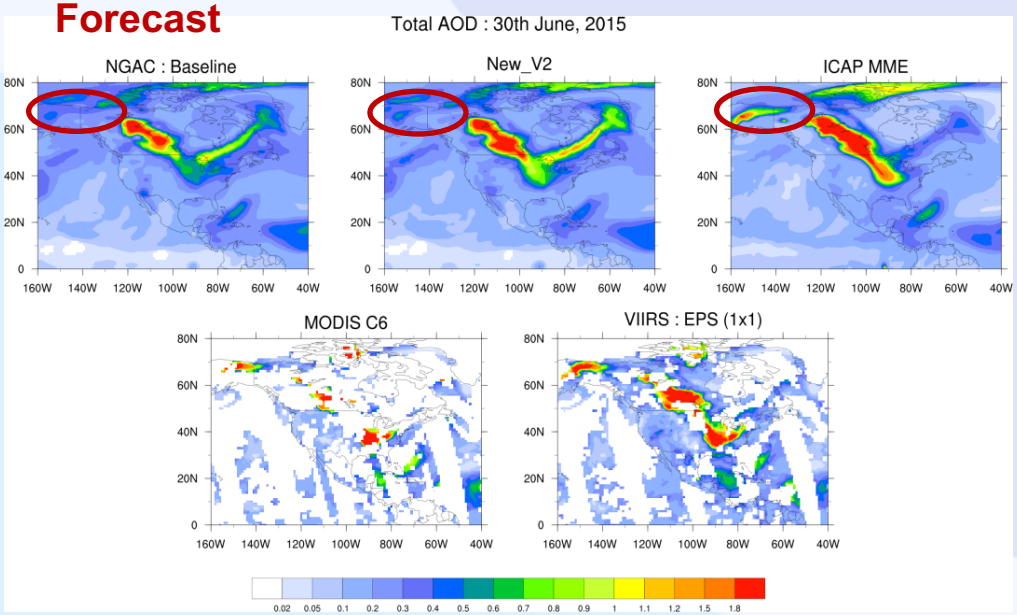
- Current Operational Configuration
- **Future operational requirements and applications**

The need for Aerosol DA

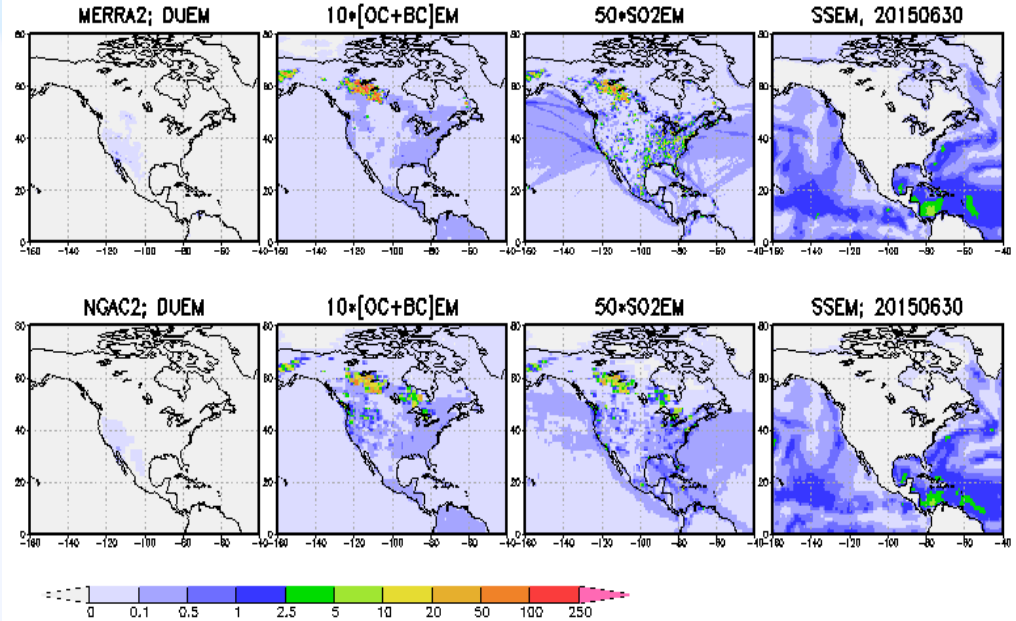
- Significant differences between NGACv2 and MERRA2 are observed
- These differences between NGAC V2 and MERRA2 can be attributed to aerosol DA in MERRA2
- Our efforts on tuning NGAC V2 and refining scaling factor in GBBEPx may have limited impact on reducing NGAC2 vs MERRA2 differences.
- All four ICAP-MME members assimilate MODIS AOD. Without DA capability in NGAC V2, the differences between NGAC V2 versus ICAP-MME can not be resolved by improving the NGAC model alone

June 30 2015 case: Lower AOD in NGACv2 than ICAP-MME for the areas affected by Alaska and Africa smoke

Forecast

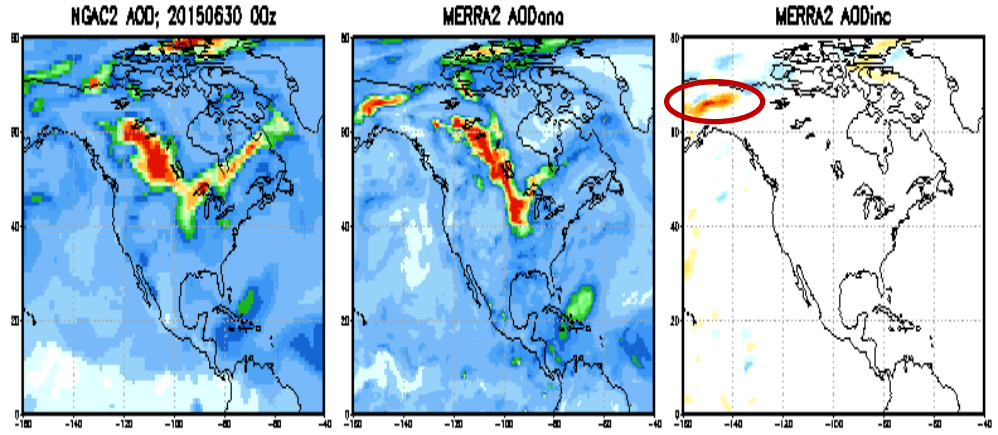


Emissions

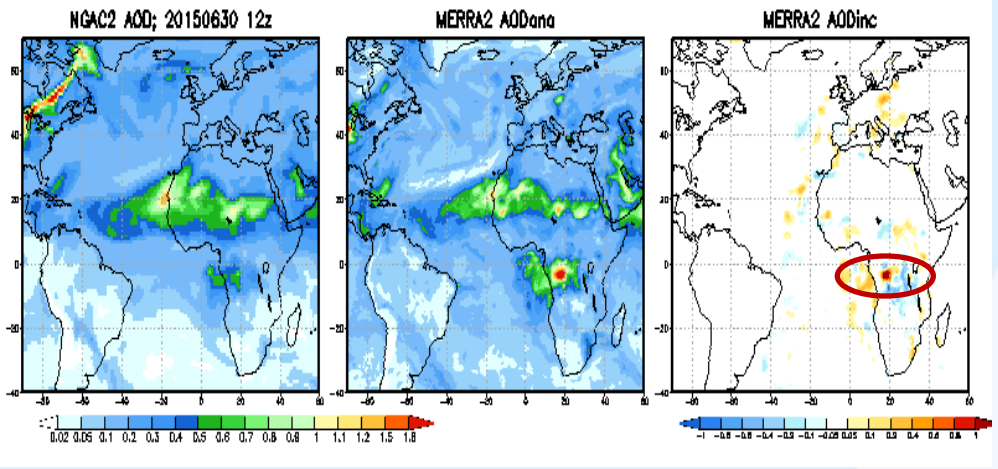


NGAC AOD **MERRA2 AOD** **MERRA2 analysis increment**

00Z



12Z

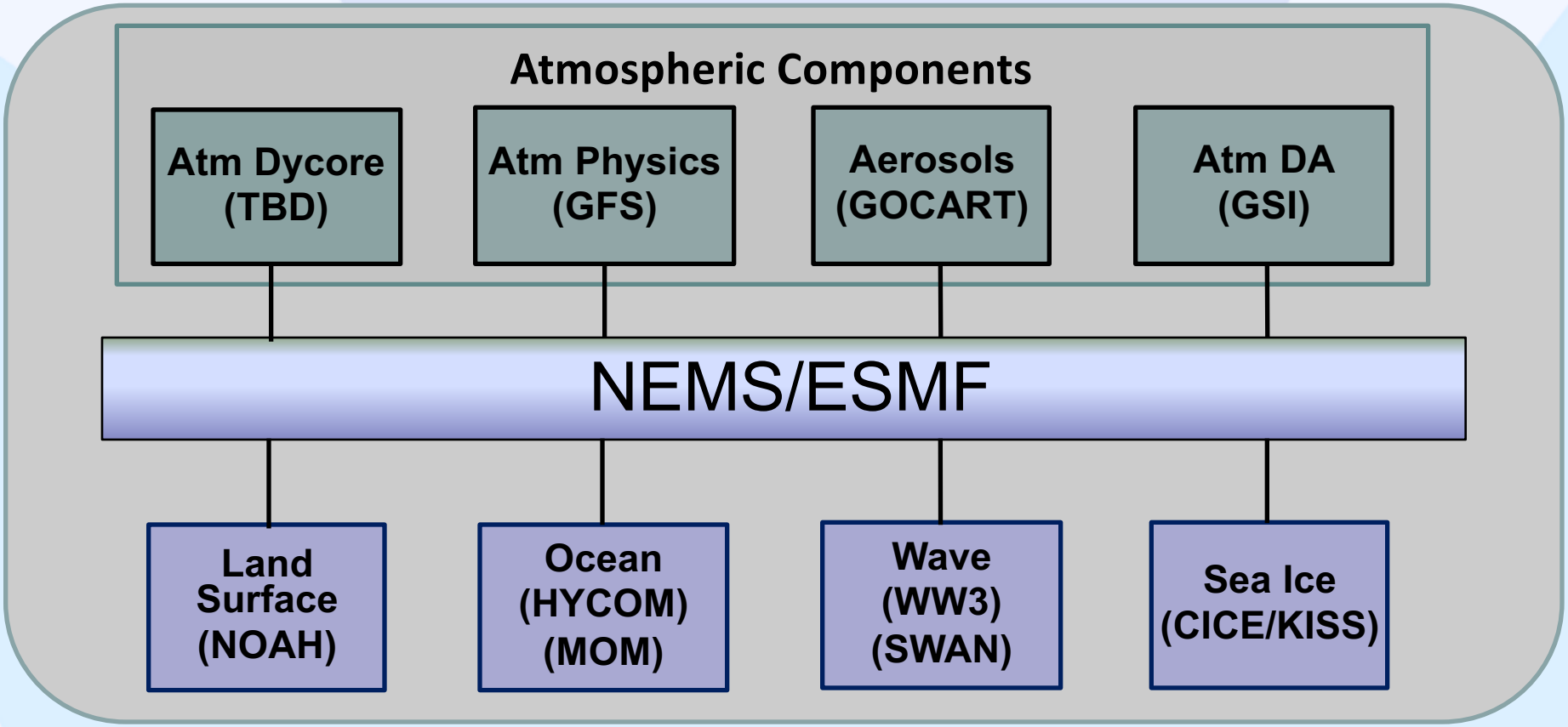


Priority System Enhancements

- **Ongoing activities**
  - Enable aerosol impacts on medium range high resolution weather forecasts (GFS/GDAS)
  - Build aerosol-chemistry-climate interaction in the next generation of Climate Forecast System (CFS)
  - Evaluate the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) schemes on Rainfall Forecast in the NGGPS
  - Provide lateral aerosol boundary conditions for regional aerosol forecast system
  - Provides global aerosol information for various applications (e.g., satellite radiance data assimilation, satellite retrievals, SST analysis, UV-index forecasts, solar electricity production)

- **Long-term goal**
  - Enable global atmospheric constituents forecasting capability to improve weather and climate forecast with aerosol impacts on various time scales fully accounted
  - Provide quality atmospheric constituents forecast products to serve a wide-range stakeholders, such as health professionals, aviation authorities, policy makers, and climate scientists

NGGPS Prediction Model Components



- NGGPS implementation plan development includes an aerosol team
- Development of dust/aerosol capabilities is underway by universities and federal labs

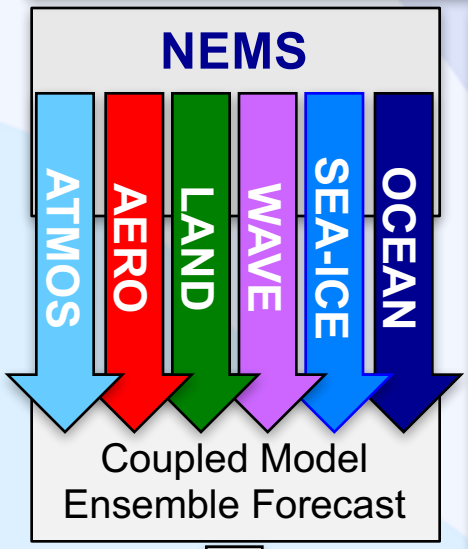
Ivanka Stajner

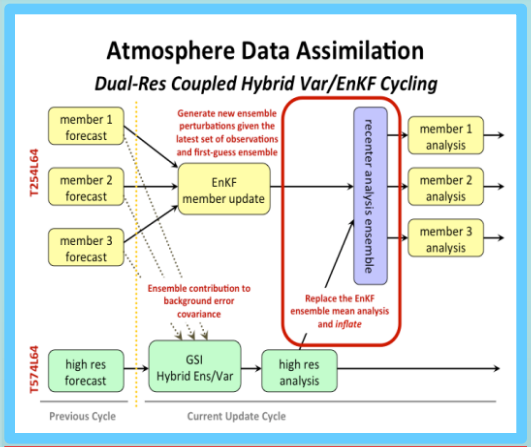
NGGPS Dust/Aerosol Development in Progress

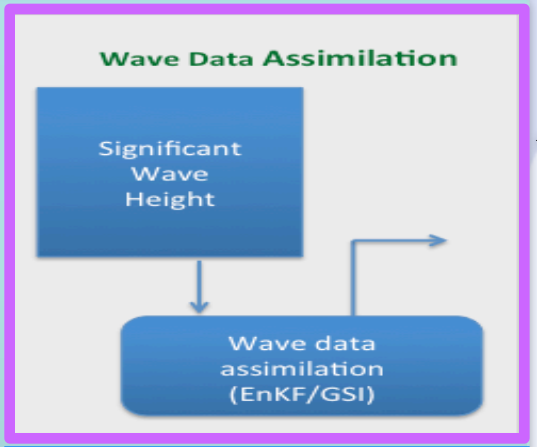
- Paul Ginoux (NOAA GFDL)
  - Implementation and Testing of Regional and Global Dust Forecasting
- Sarah Lu (SUNY Albany)
  - Investigation of Aerosol Effects on Weather Forecast using NCEP Global Forecast System – radiative effects
  - Improving Cloud Microphysics and Their Interactions with Aerosols in the NCEP Global Models
- Georg Grell (NOAA/ESRL/GSD)
  - Using Advanced Photochemical and Aerosol Modules to Verify the Applicability of GOCART Aerosol Modules within Global Weather Prediction Models
- Zhanqing Li (Univ. of MD)
  - Evaluating the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) Schemes on Rainfall Forecast in the NGGPS

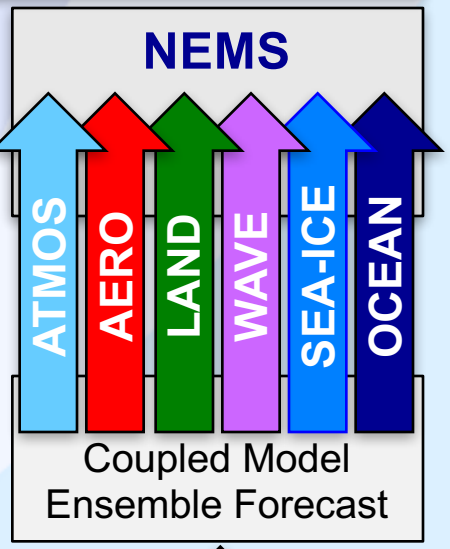
Ivanka Stajner

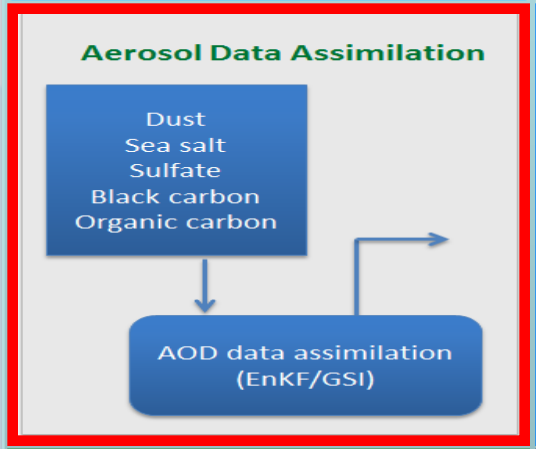
NCEP Coupled Hybrid-EnKF Data Assimilation System

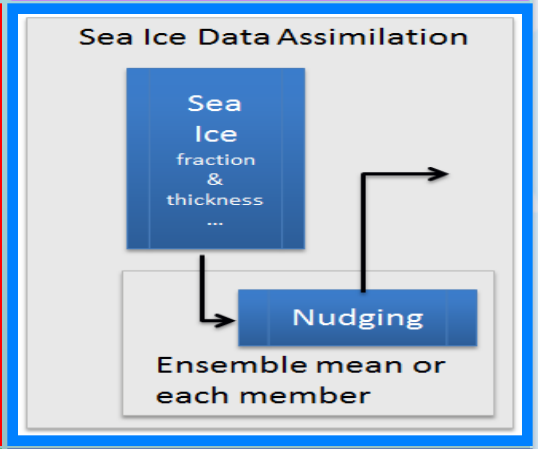


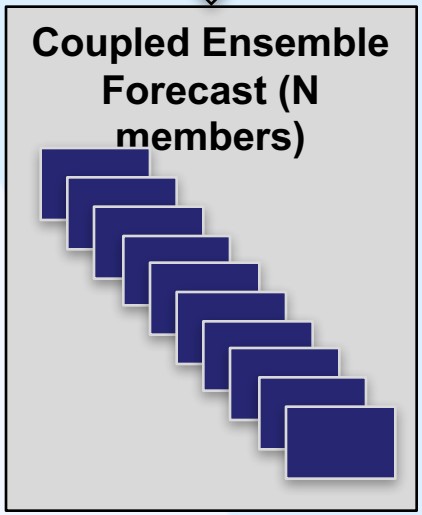


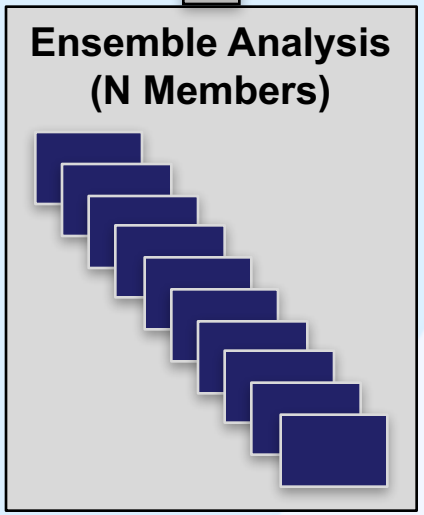


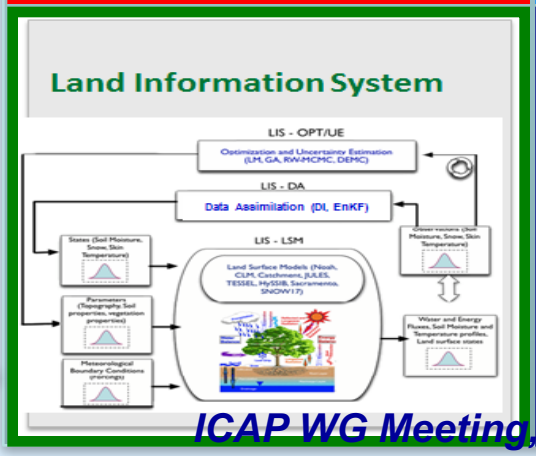


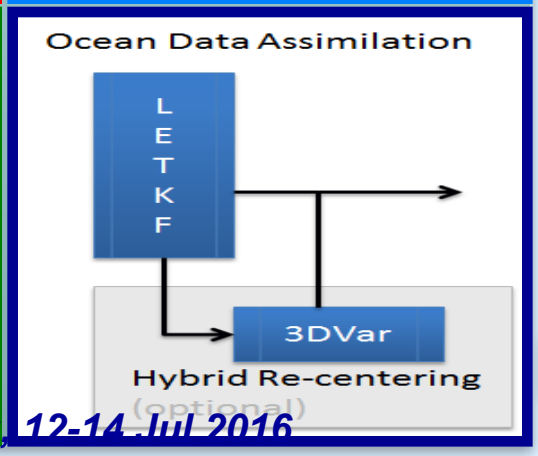












INPUT

OUTPUT

Thank You