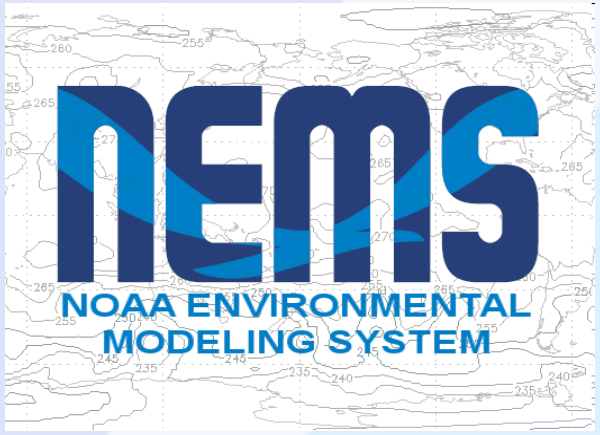
Status Update on NCEP operational Global Aerosol Forecasting System

Jun Wang, Partha Bhattacharjee (NOAA/NWS/NCEP/EMC)

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

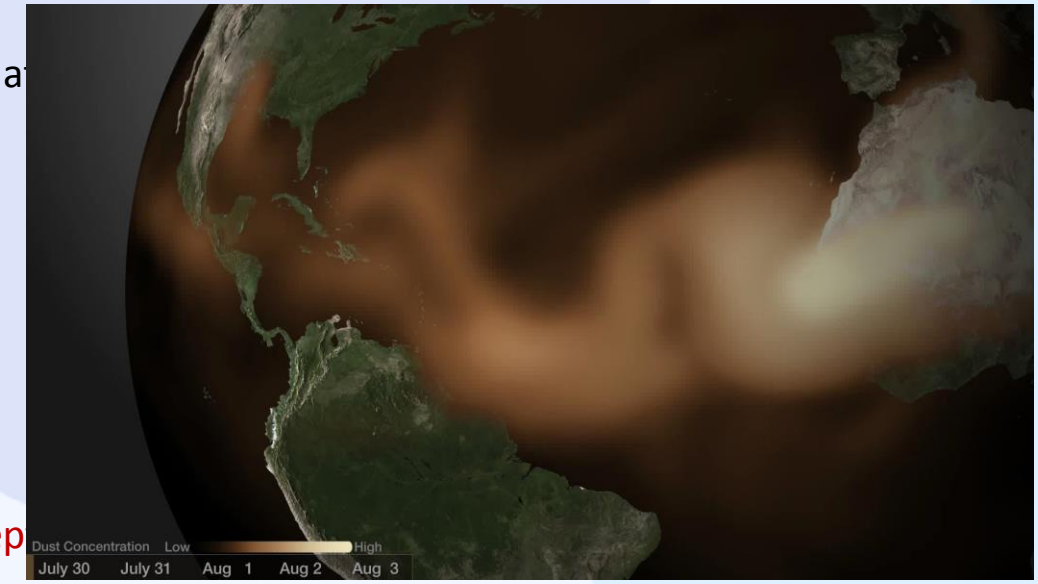
SUNY Collaborators (Sarah Lu, Sheng-Po Chen, Qilong, Min)
GSFC collaborators (Arlindo da Silva, Mian Chin, Peter Colarco, Anton Darmenov, Donifan Barahona, Atanas Trayanov)
EMC AQ group (Jeff McQueen, Jianping Huang, Ho-chun Huang, Jerry Gorline)
NESDIS collaborators (Shobha Kondragunta, Hanjun Ding)
ARL (Pius Lee)
South Dakota State Univ (Xiaoyang Zhang)
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 **FY17**
- Refine the prototype volcanic ash capability (collaborating with ECMWF)
- 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 Q1FY2016**
- **Future operational requirements and applications**

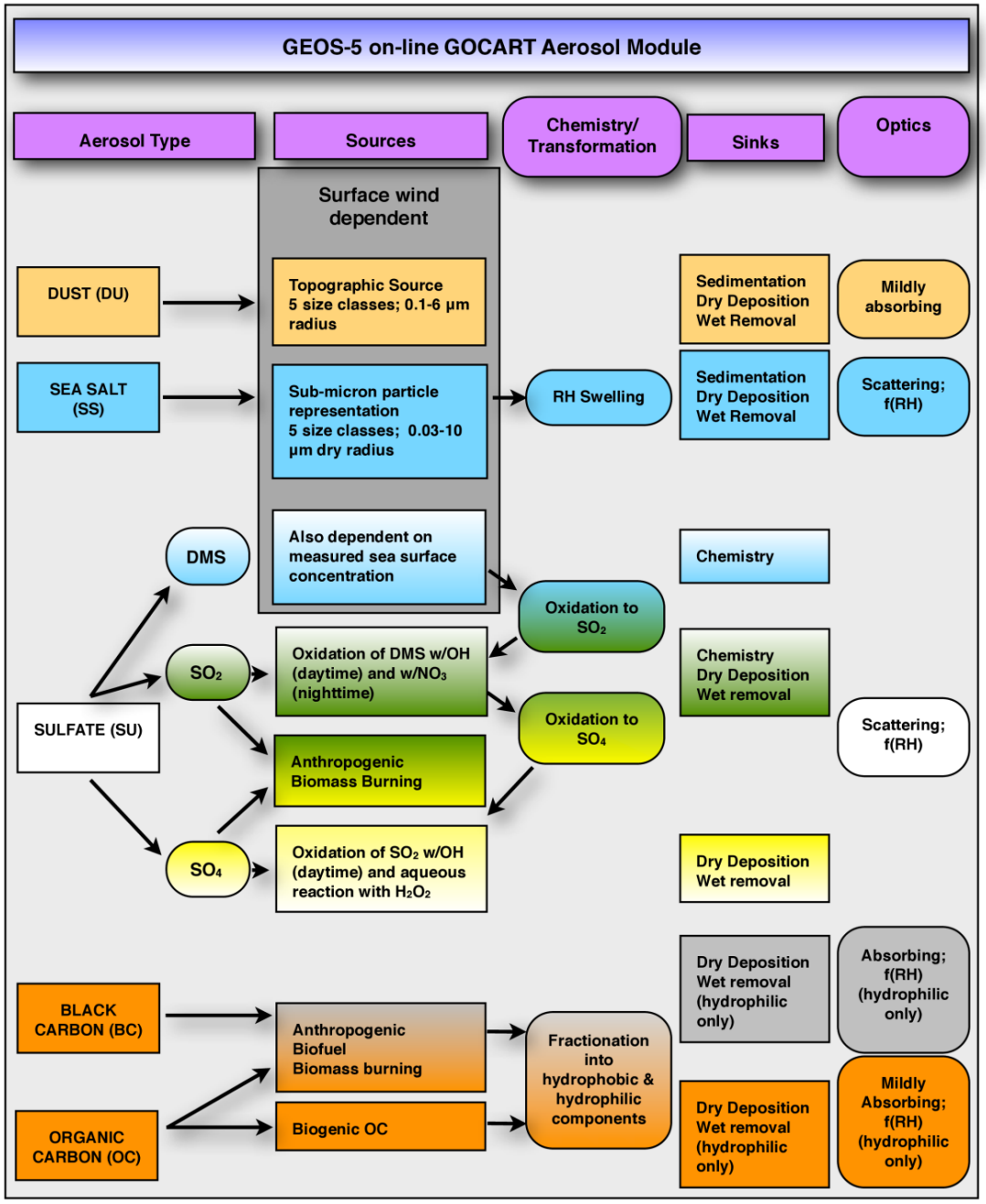
Q1FY16 Planned Implementation

- 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
  - Aerosol model was updated to new GOCART version
  - 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

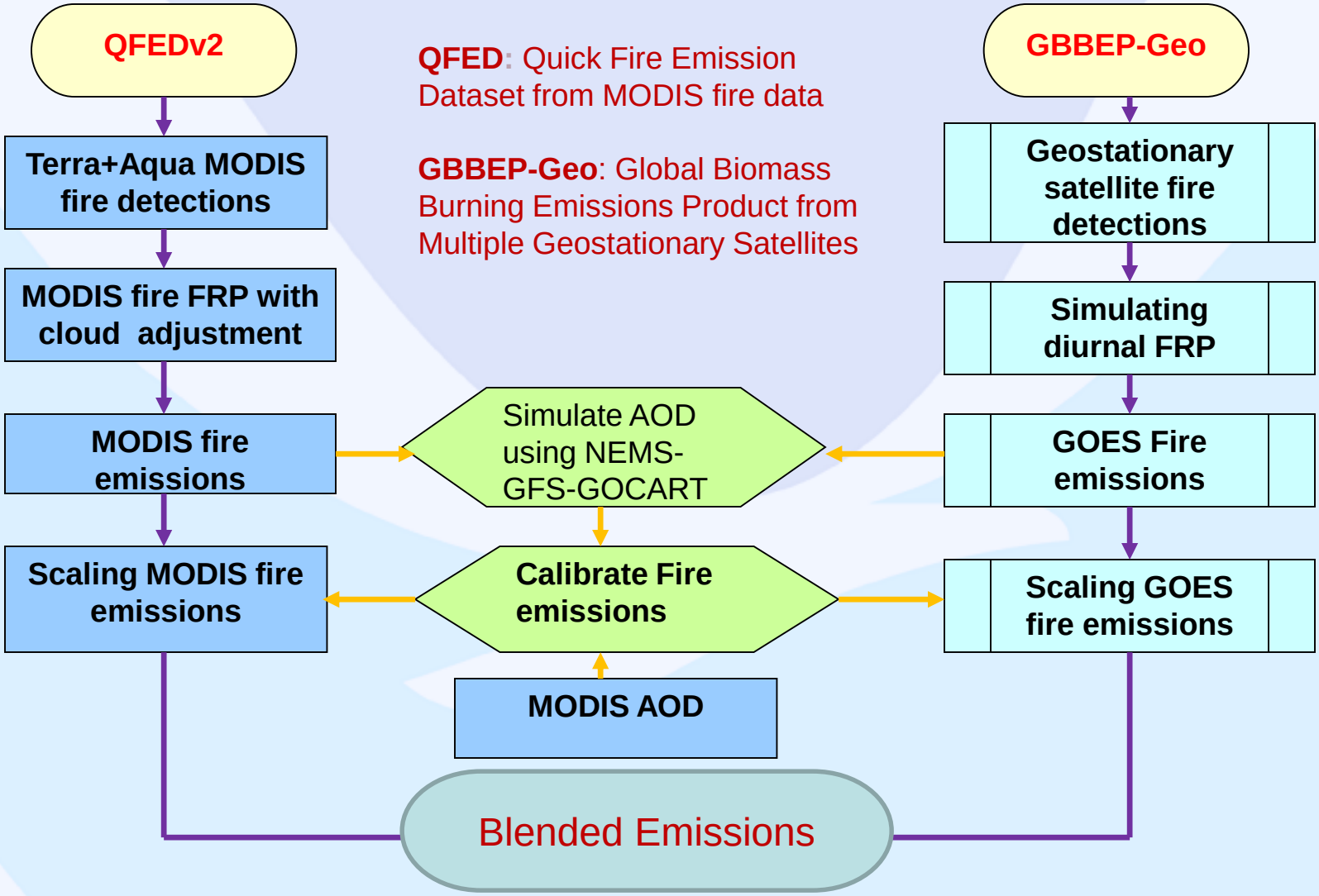
In-line chemistry advantage

- 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



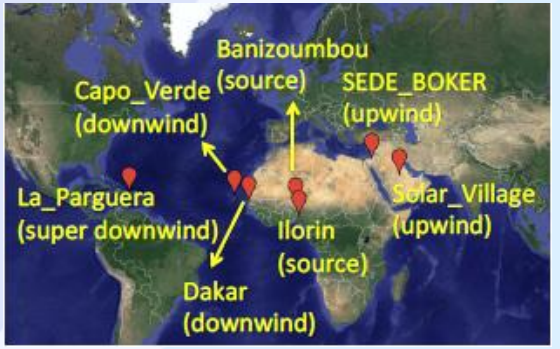
- Scaling factors are region and biome dependent but static.
- Blended emissions will be generated daily at NESDIS/OSPO for NGAC.
- Scaling factors need to be re-generated only if there is a new satellite replacing an old satellite.

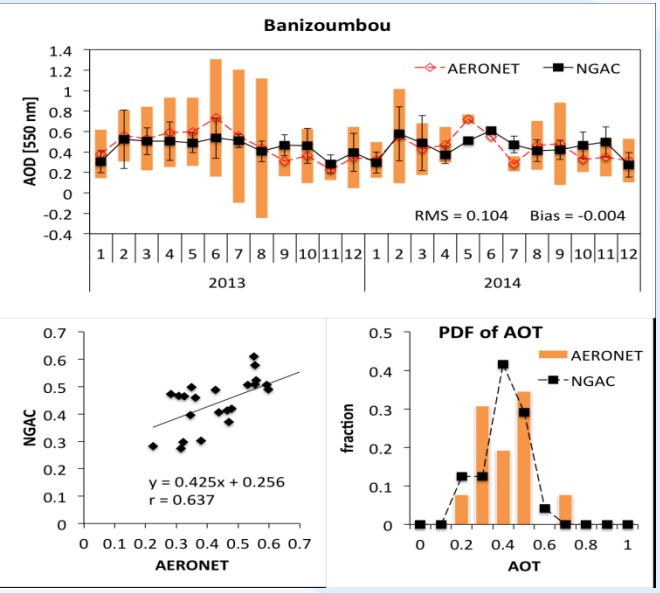
Shobha Kondragunta (NESDIS/STAR)

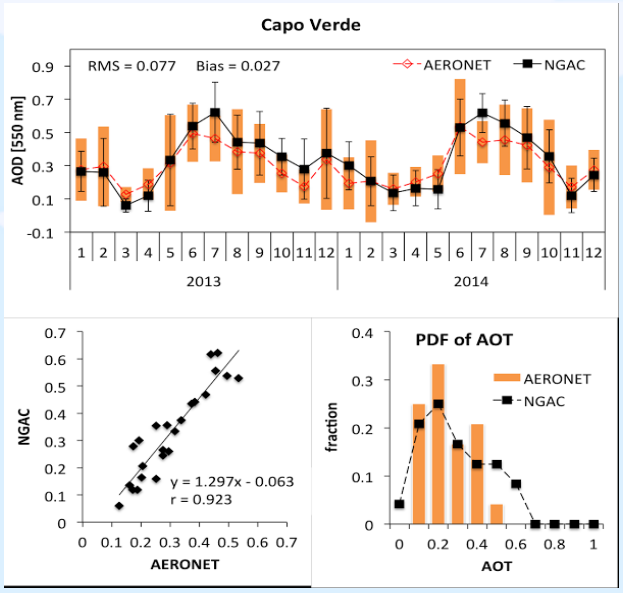
NGAC verification

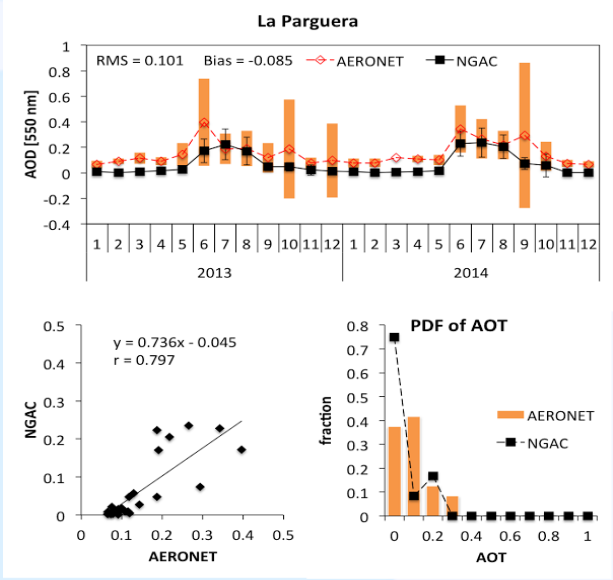
- Statistics of 2013-2014 NGAC vs. AERONET

Site	Type	# of monthly mean compared	Correlation coefficient	Bias
SEDE_BOKER	upwind	24	0.78	-0.04
Solar_Village	upwind	15	0.83	-0.11
Banizoumbou	Saharan source	24	0.64	-0.00
Ilorin	Saharan source	16	0.56	-0.31
Capo_Verde	downwind	24	0.92	0.03
Dakar	downwind	24	0.91	0.02
La_Parguera	super downwind	24	0.80	-0.08



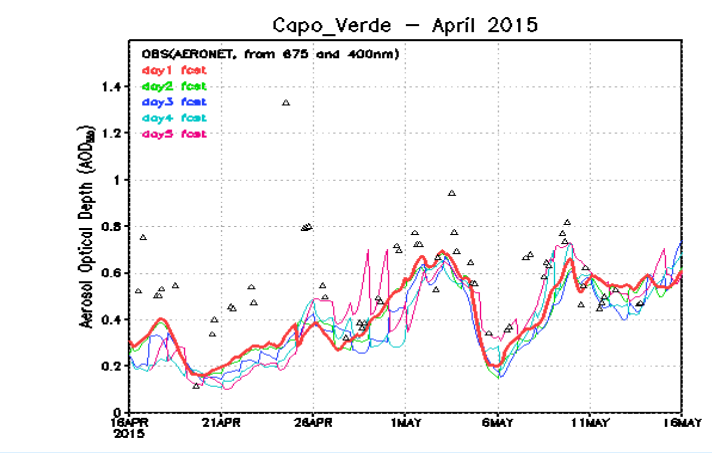




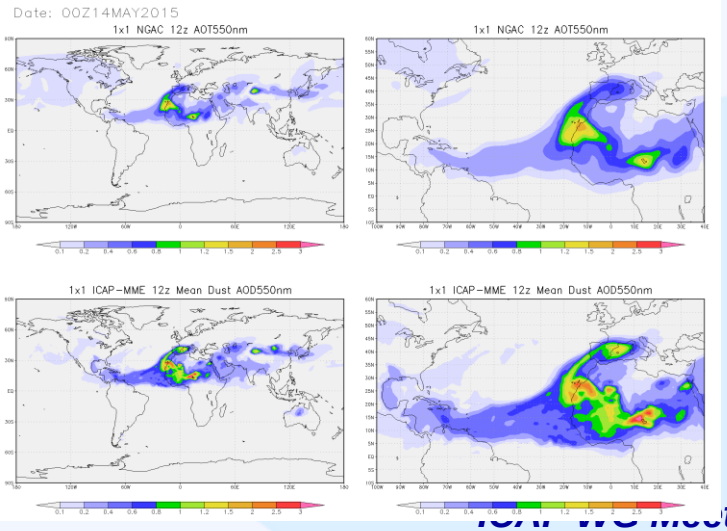


NGAC verification (cont.)

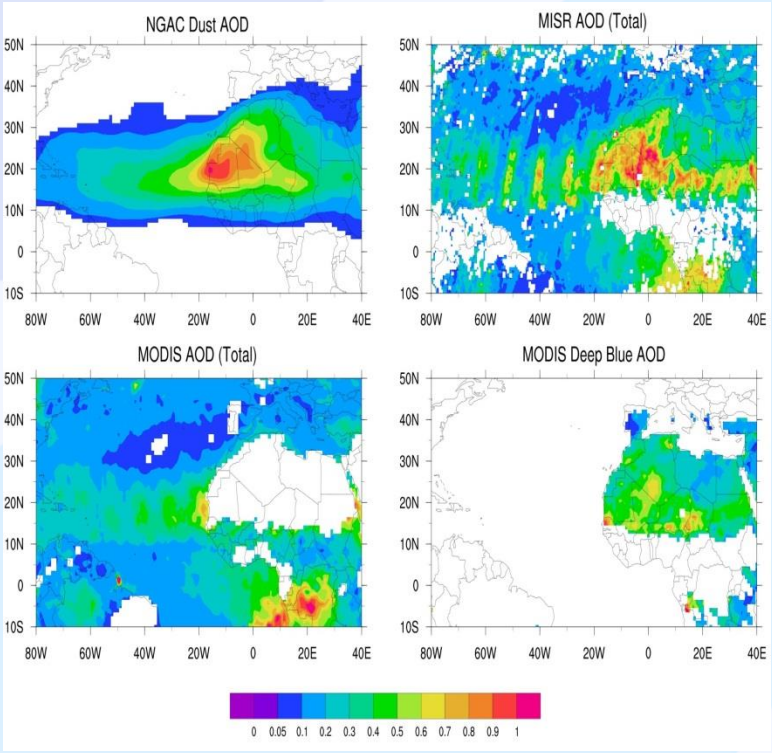
- Daily verification:
  - NGAC vs AERONET



  - NGAC vs ICAP-MME



- Monthly scale comparison between NGAC and satellites

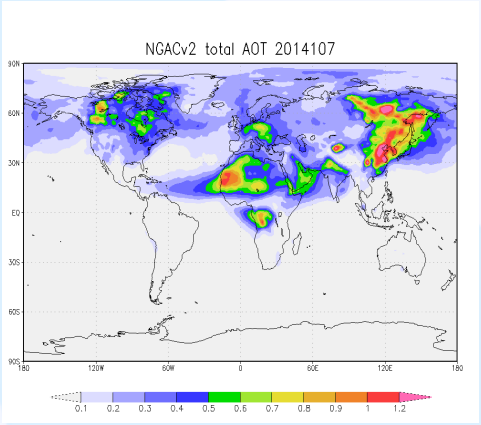


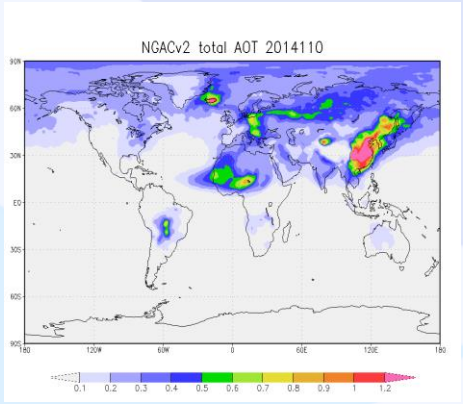
NGAC full aerosol forecasts

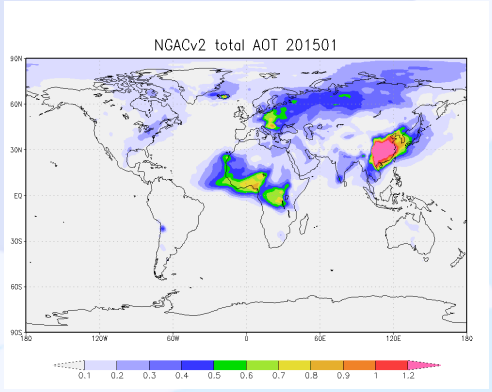
- NGAC has the capability to simulate dust, sulfate, sea salt, and carbonaceous aerosols.
- Near real time GBBEP-Geo biomass burning emission is fed into NGAC
- Results of 1 year NGACv2 forecast parallel run from Jul 2014-Jun 2015 compared with MERRAero

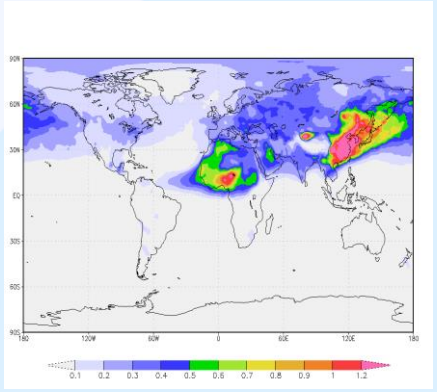
Total AOD at 550 nm

NGACv2 PARA

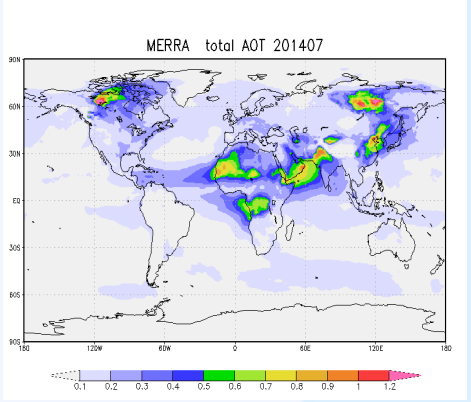


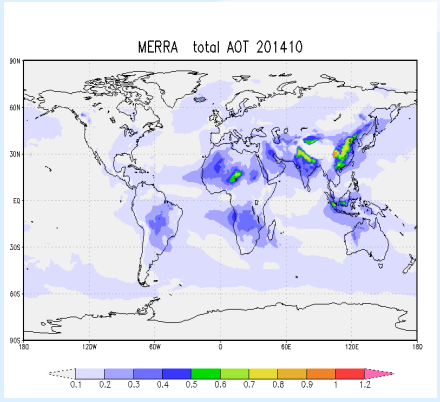


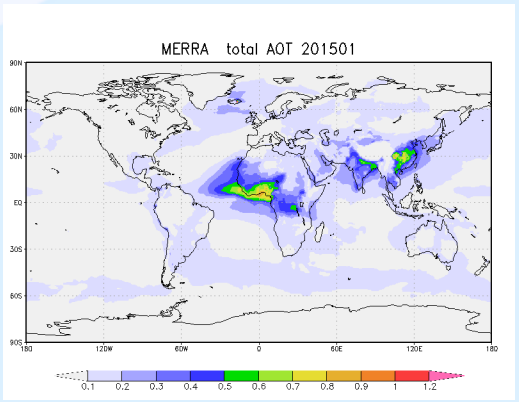


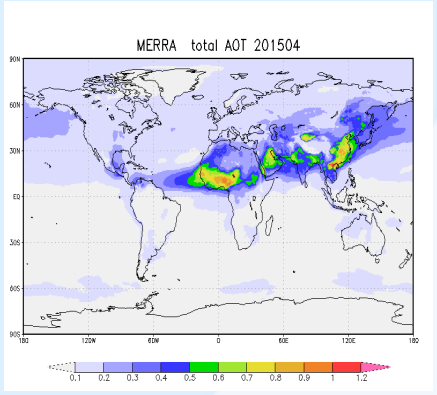


MERRAero

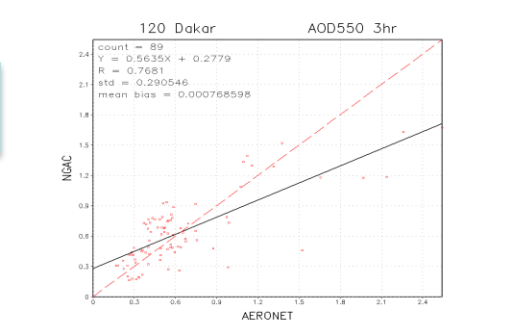
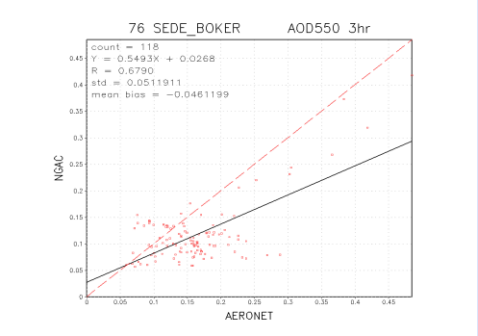
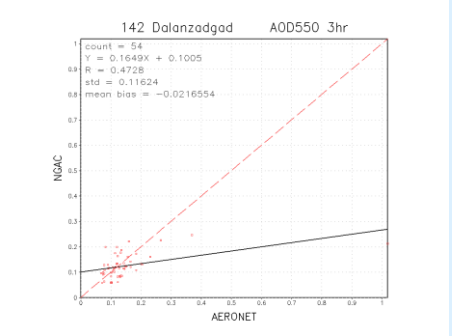
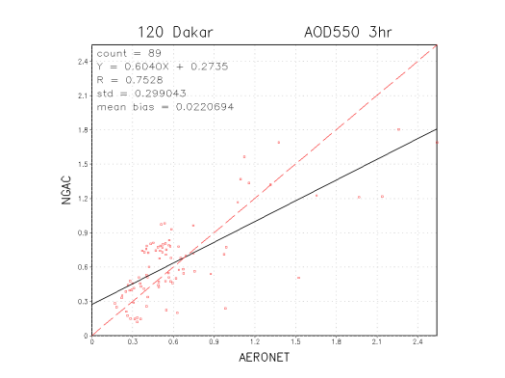
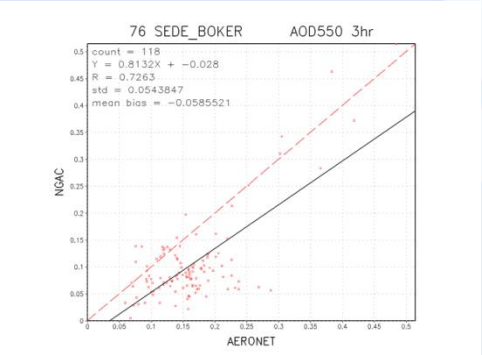
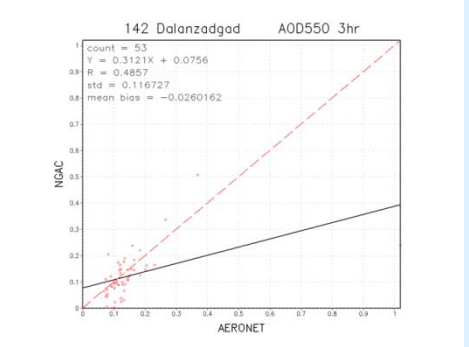
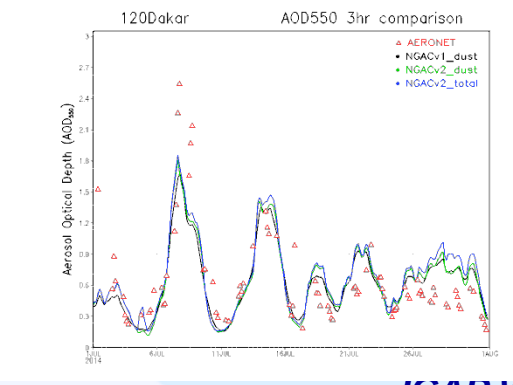
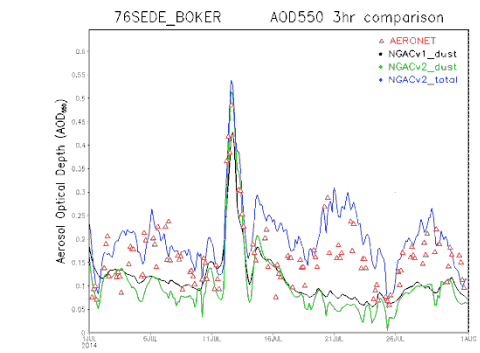
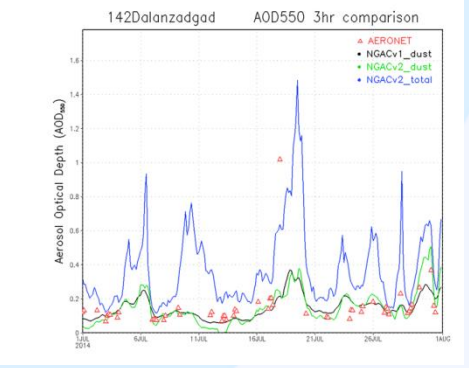






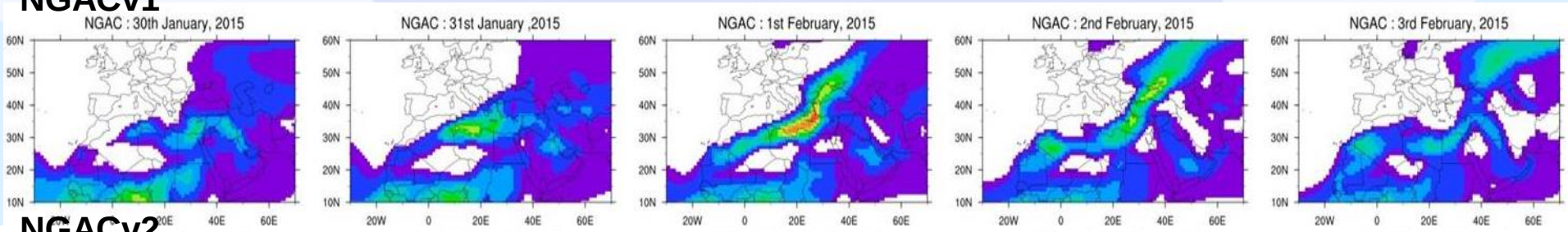


NGAC dust AOD para vs prod

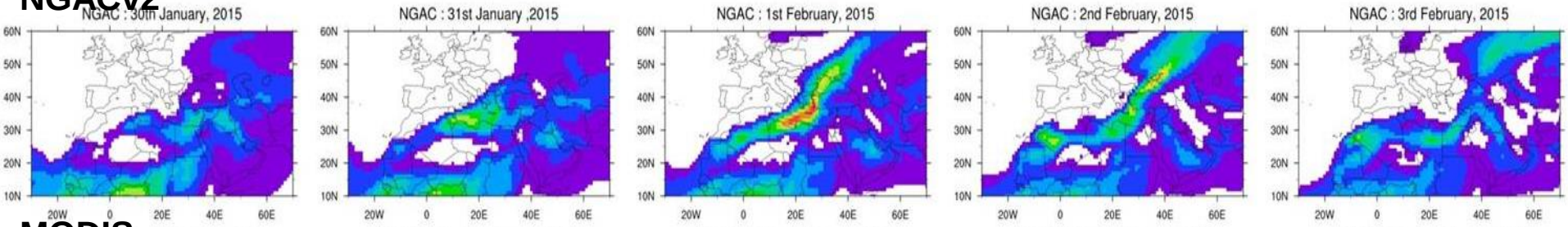
	Dakar	Sede Boker	Dalanzadgod
NGAC prod			
NGAC para			
VS AERONET			

Dust event on Feb, 1 2015

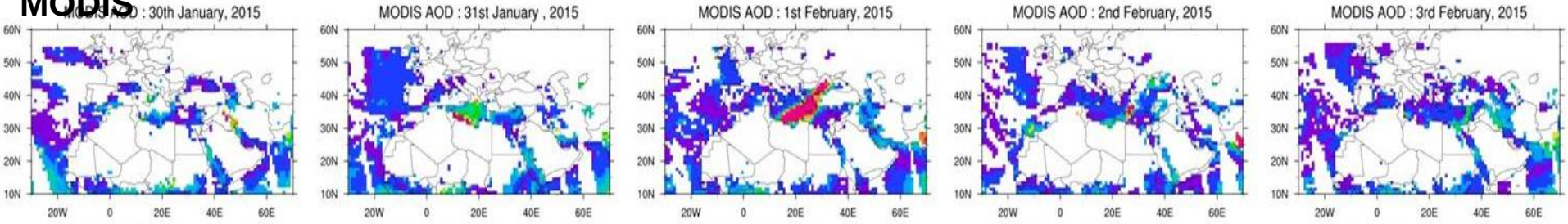
NGACv1



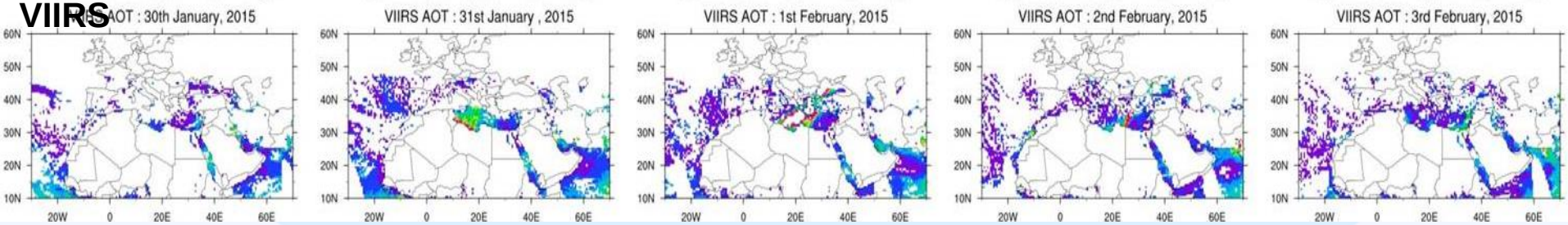
NGACv2



MODIS



VIIRS



Smoke event on Apr 17, 2015

NGAC para

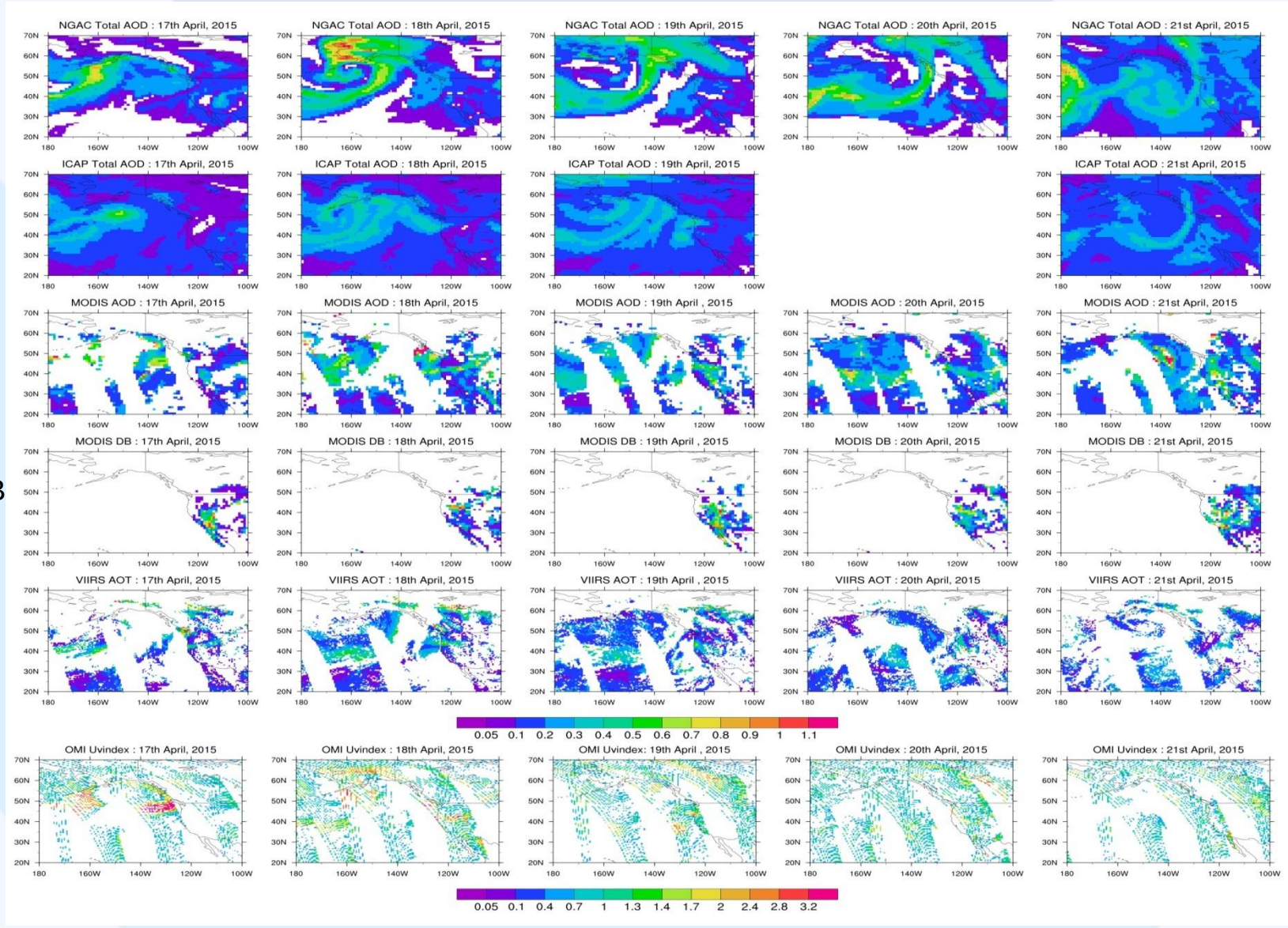
ICAP

MODIS

MODIS DB

VIIRS

OMI



NGAC Product Suite and Applications

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

Product files and their contents include:

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

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

- **ngac.t00z.a2df$FH, 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, 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.

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 (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, Q1FY2016)**
  - Phase 3: Aerosol analysis using VIIRS AOD (Planned FY17 implementation) **(Funded by JCSDA)**

Presentation Outline

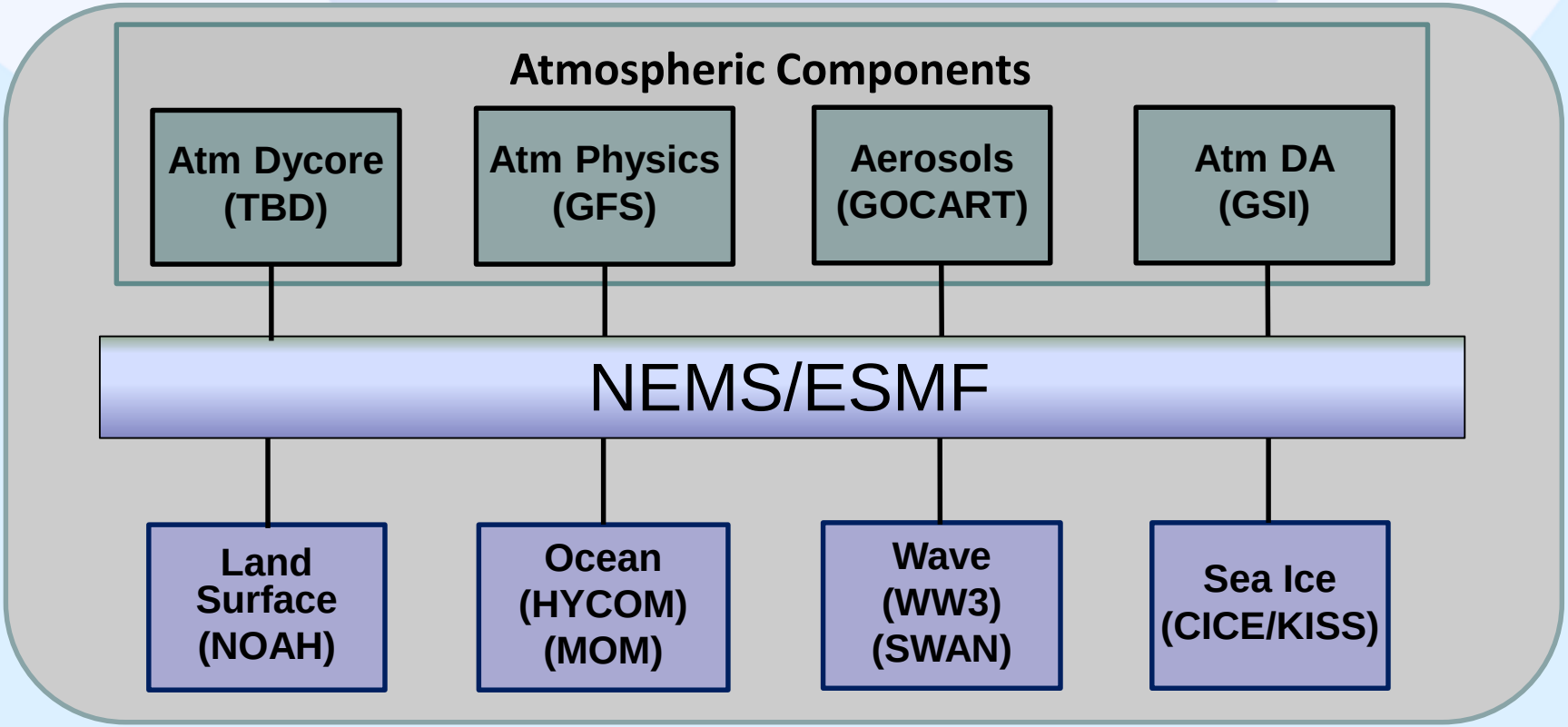
- Current Operational Configuration
- **Future operational requirements and applications**

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

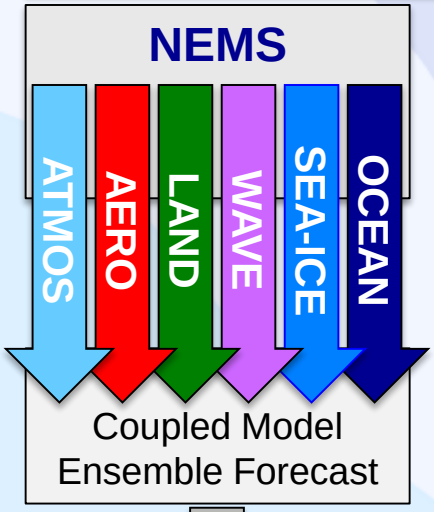
Ivanka Stajner

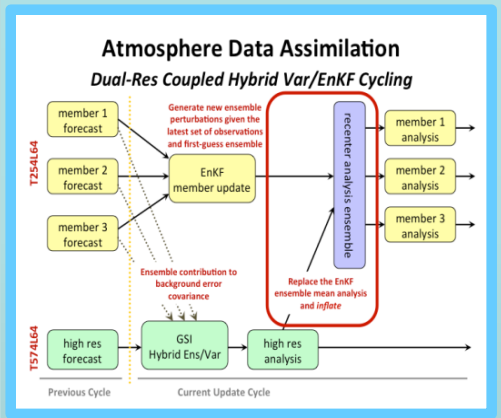
NGGPS Dust/Aerosol Development in Progress

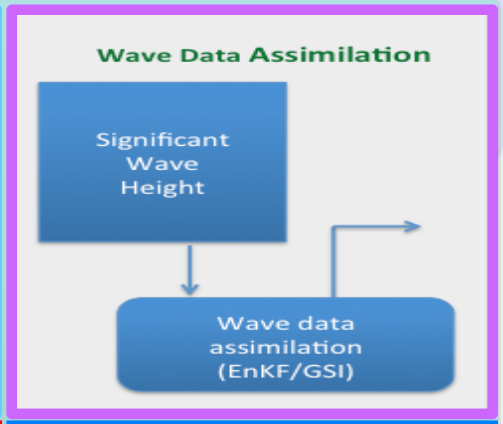
- Paul Ginoux (NOAA GFDL)
  - Implementation and Testing of Regional and Global Dust Forecasting
- Sarah Lu (SUNY Albany)
  - Investigation of Aerosol Effects on Weather Forecast using NCEP Global Forecast System – radiative effects
  - Improving Cloud Microphysics and Their Interactions with Aerosols 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

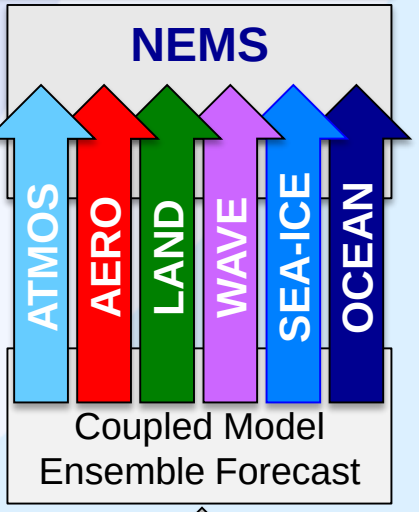
Ivanka Stajner

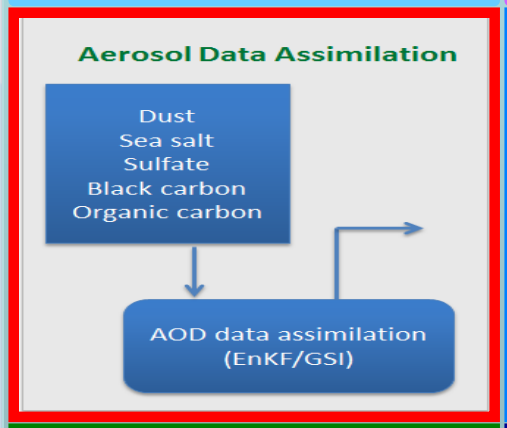
NCEP Coupled Hybrid-EnKF Data Assimilation System

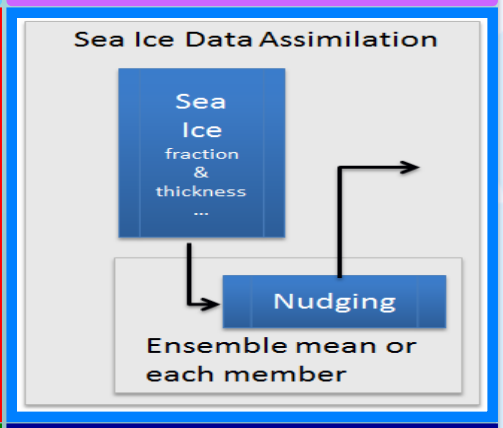


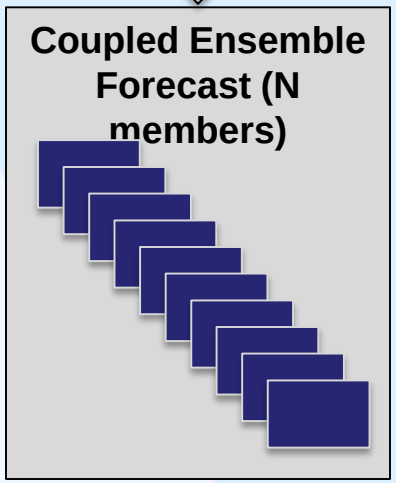


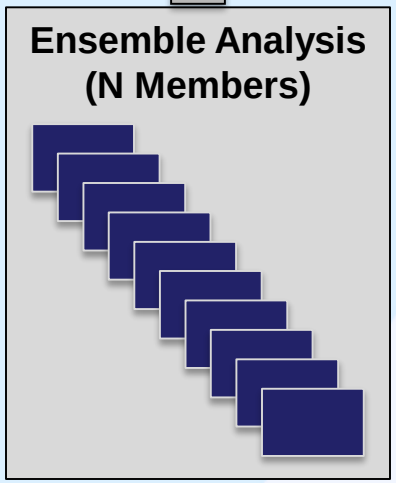


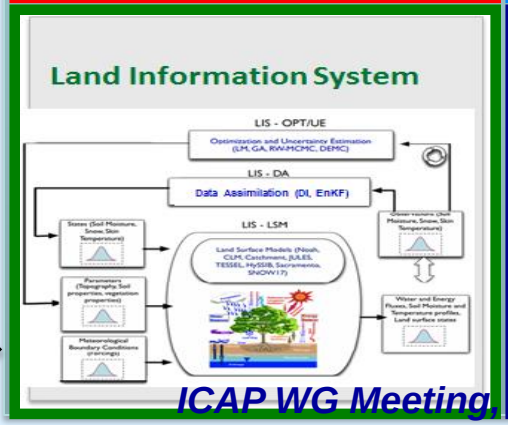


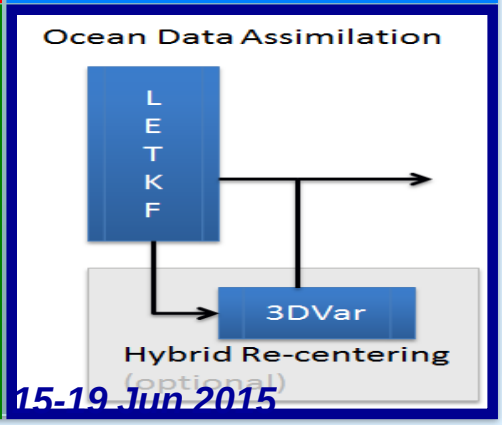












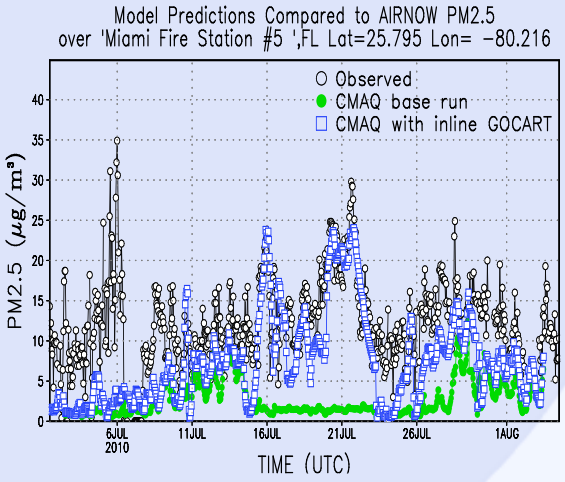
INPUT

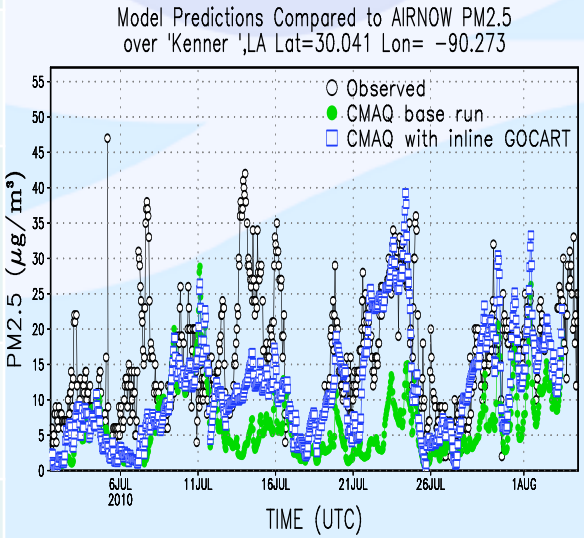
OUTPUT

Dynamic LBCs for regional models

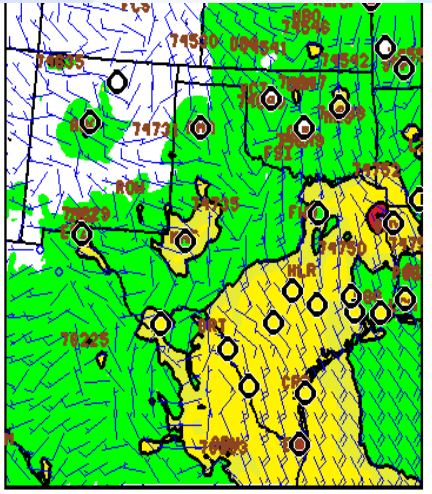
- Baseline NAM-CMAQ with static LBCs versus experimental NAM-CMAQ with dynamic LBCs from NGAC, verified against AIRNOW observations
- The inclusion of LBCs from NGAC prediction is found to improve PM forecasts, and it is in CMAQ Q42015 implementation.

	CMAQ Baseline	CMAQ Experimental
Whole domain July 1 – Aug 3	MB= -2.82 R=0.42	MB= -0.88 R=0.44
South of 38°N, East of -105°W July 1 – Aug 3	MB= -4.54 R=0.37	MB= -1.76 R=0.41
Whole domain July 18– July 30	MB= -2.79 R=0.31	MB= -0.33 R=0.37
South of 38°N, East of -105°W July 18– July 30	**MB= -4.79 R=0.27**	**MB= -0.46 R=0.41**

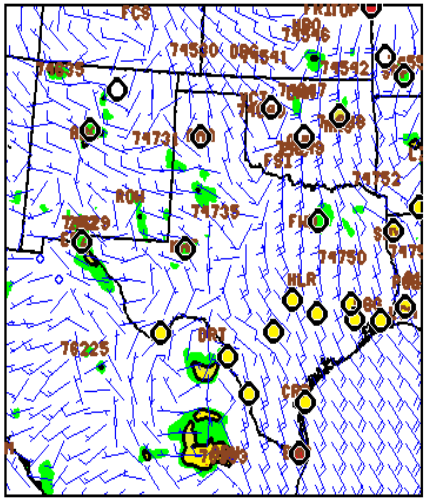




Dust event on 20150510
CMAQ PARA vs PROD



PARA1 AQM .BC SFC DAY1 PMMXO1 20150510 12Z CYCLE



PROD AQM SFC DAY1 PMMXO1 20150510 12Z CYCLE

Thank You