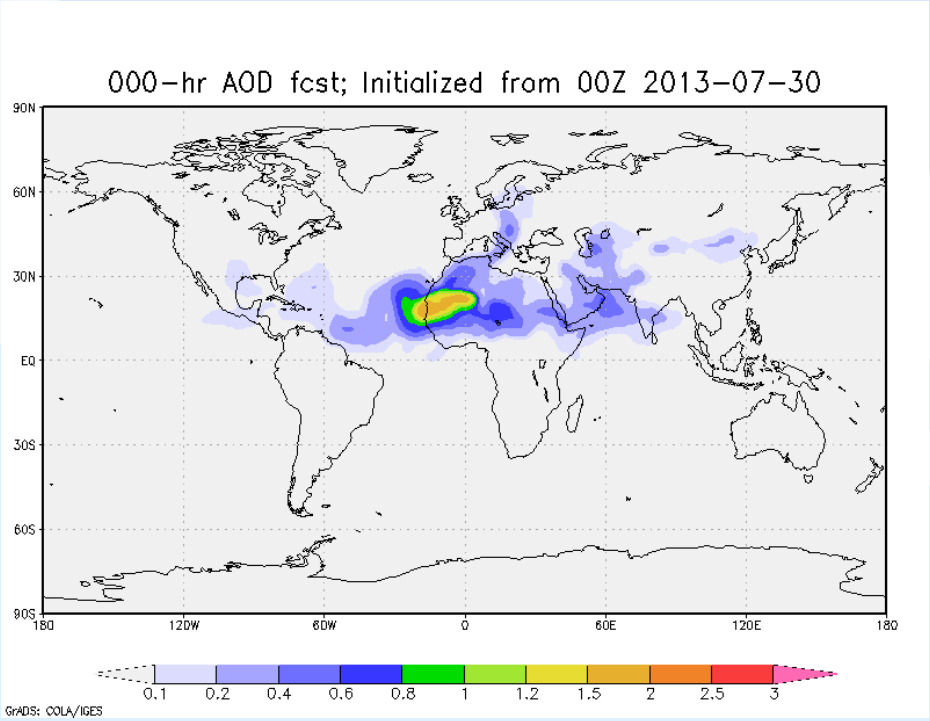
Toward Improving NCEP Global Aerosol Forecasting System using VIIRS Aerosol Observations



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2014 JPSS Science Teams Annual Meeting

Why Include Aerosols in the Predictive Systems?

- Improve weather forecasts and climate predictions by taking into account of aerosol effects on radiation and clouds
- Improve the handling of satellite observations by properly accounting for aerosol effects during the assimilation procedure
- Provide aerosol (lateral and upper) boundary conditions for regional air quality predictions
- Account for the aerosol impact on climate, human health, ecosystem, and visibility.
- Meet NWS and WMO global dust forecasting goals

Presentation Outline

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

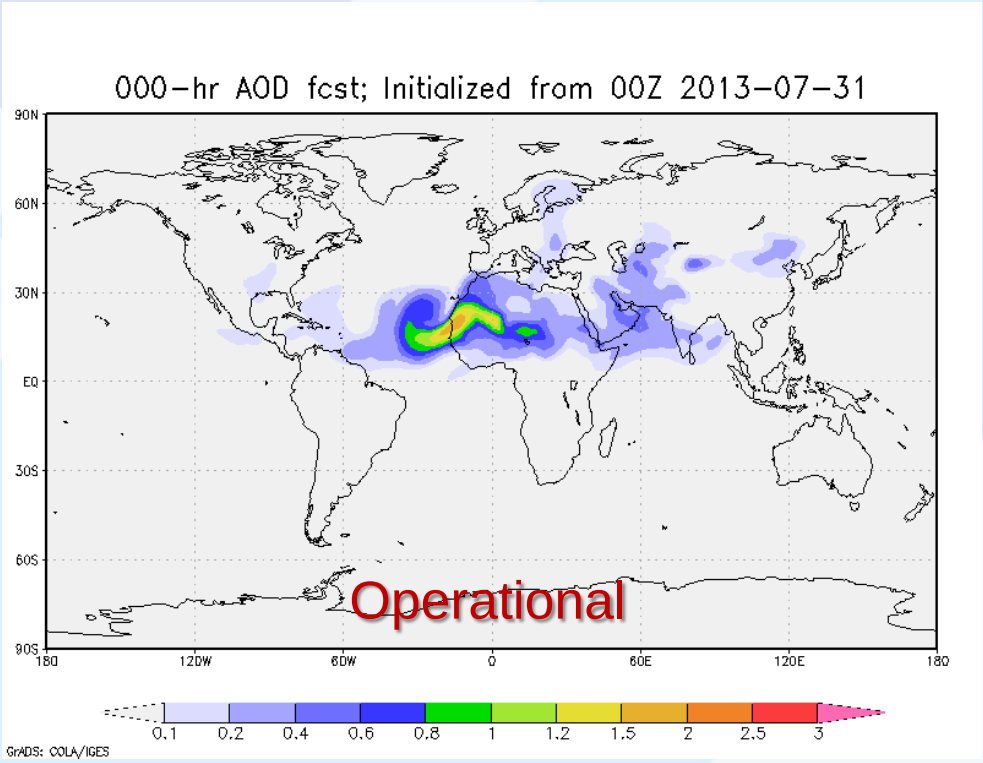
Near-Real-Time Global Aerosol Forecasting

Current State

- Near-real-time operational system. implemented into NCEP Production Suite in Sept 2012
- The first global in-line aerosol forecast system at NWS
- Model Configuration:
  - Resolution: T126 (~ 1°x1°) L64
  - 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
- Leverages the expertise in GSFC, NESDIS, the ICAP working group (NRL, ECMWF, JMA, UKMO, GMAO, BSC), and WMO SDS-WAS program.

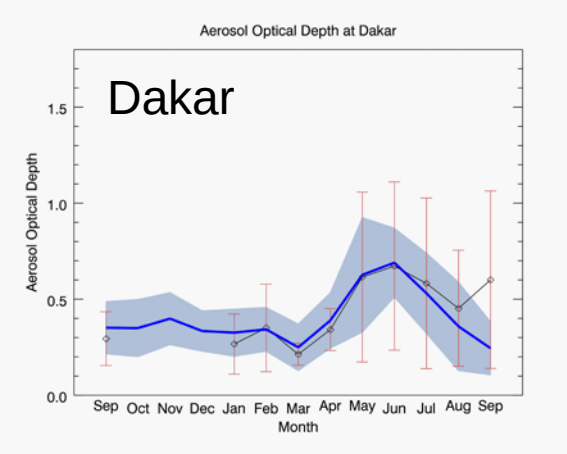
In-line chemistry advantage

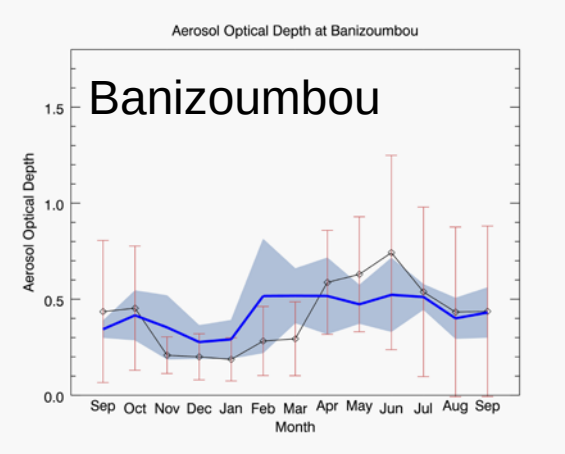
- Consistency: no spatial-temporal interpolation, same physics parameterization
- Efficiency: lower overall CPU costs and easier data management
- Interaction: Allows for feedback to meteorology

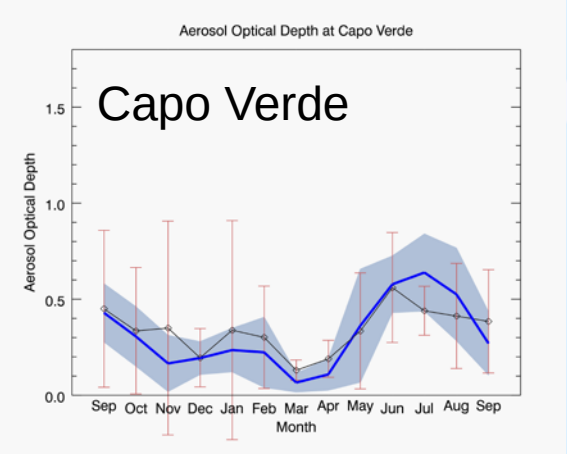


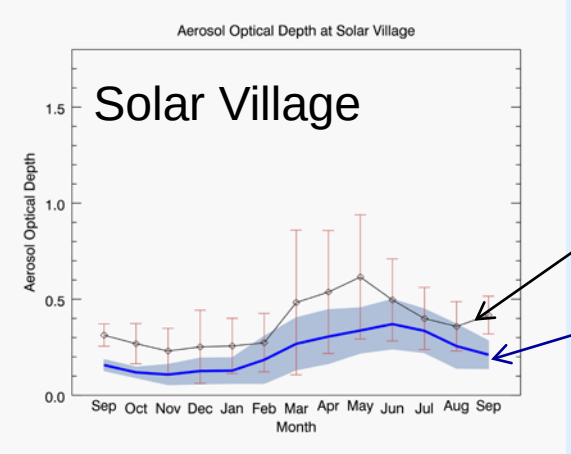
Near-Real-Time Global Aerosol Forecasting

- NGAC forecasts are routinely evaluated using AOD observations from AERONET and MODIS as well as aerosol analysis from other models
- Results of 1-year operational NGAC forecast (09/2012-09/2013) are shown here
- NCEP is yet to extend forecast verification system to include VIIRS aerosol products









AERONET

NGAC

Near-Real-Time Global Aerosol Forecasting

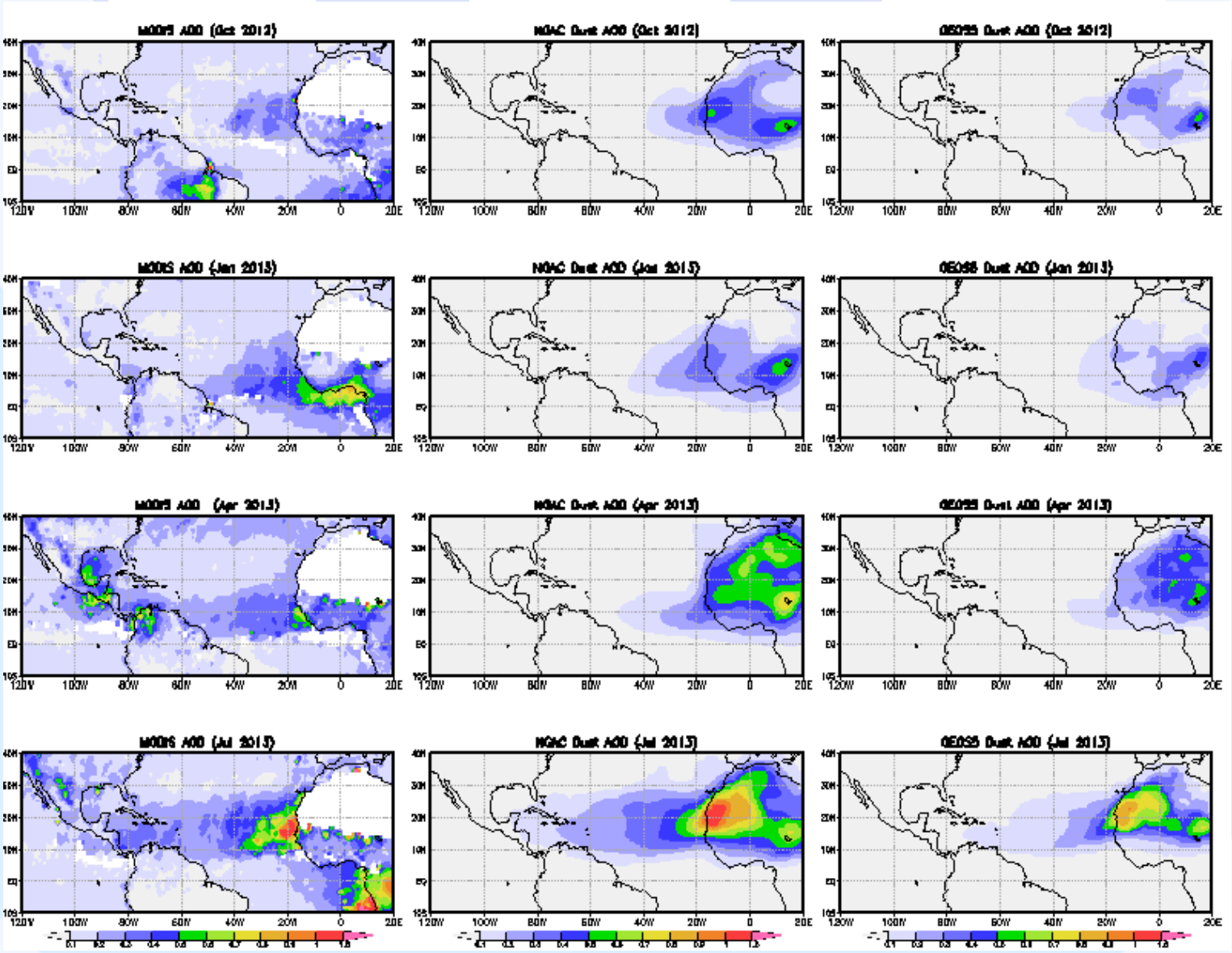
MODIS AOD | NGAC dust AOD | GEOS-5 dust AOD

Oct 2012

Jan 2013

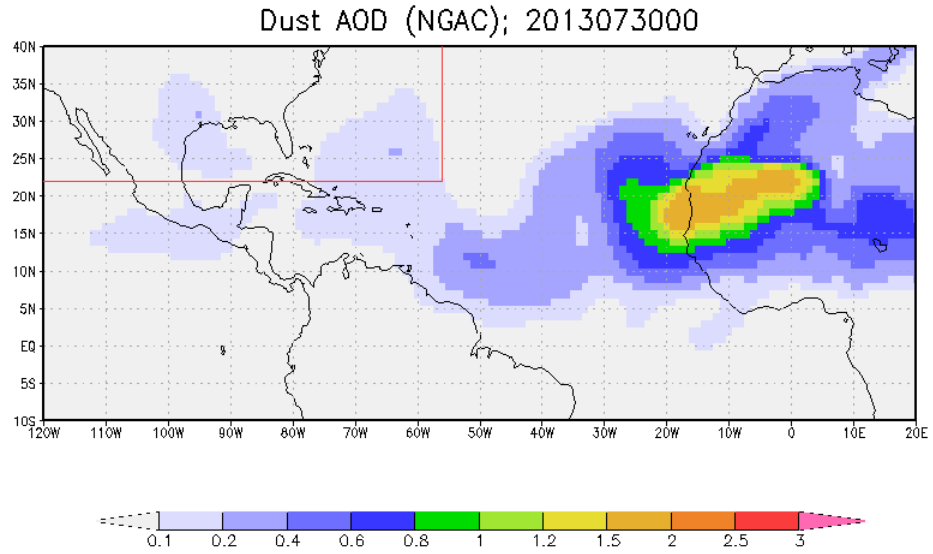
Apr 2013

Jul 2013

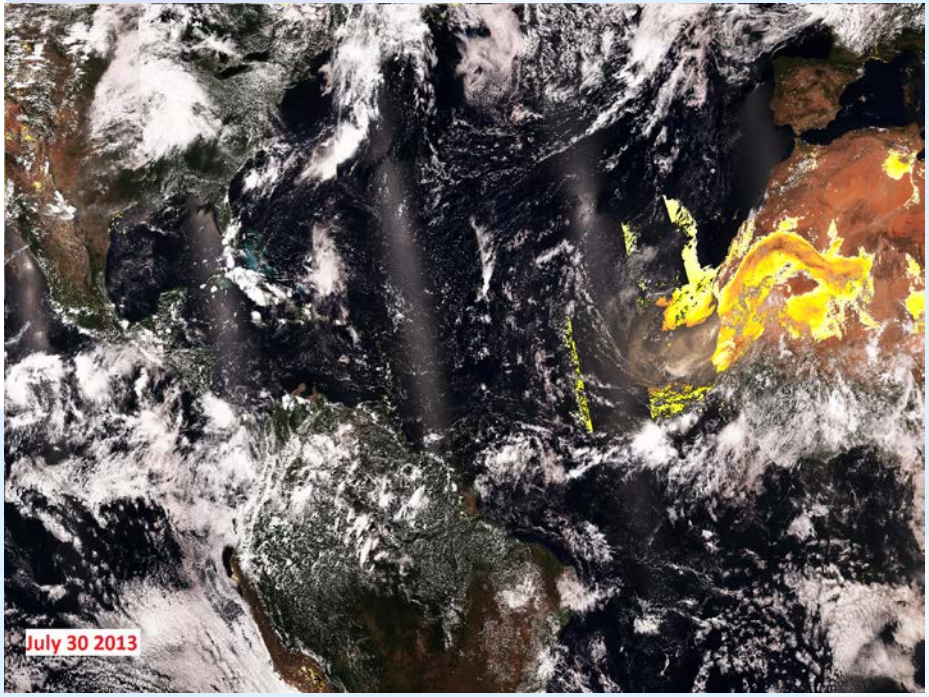


Near-Real-Time Global Aerosol Forecasting

Saharan Dust Transport by NGAC forecasts



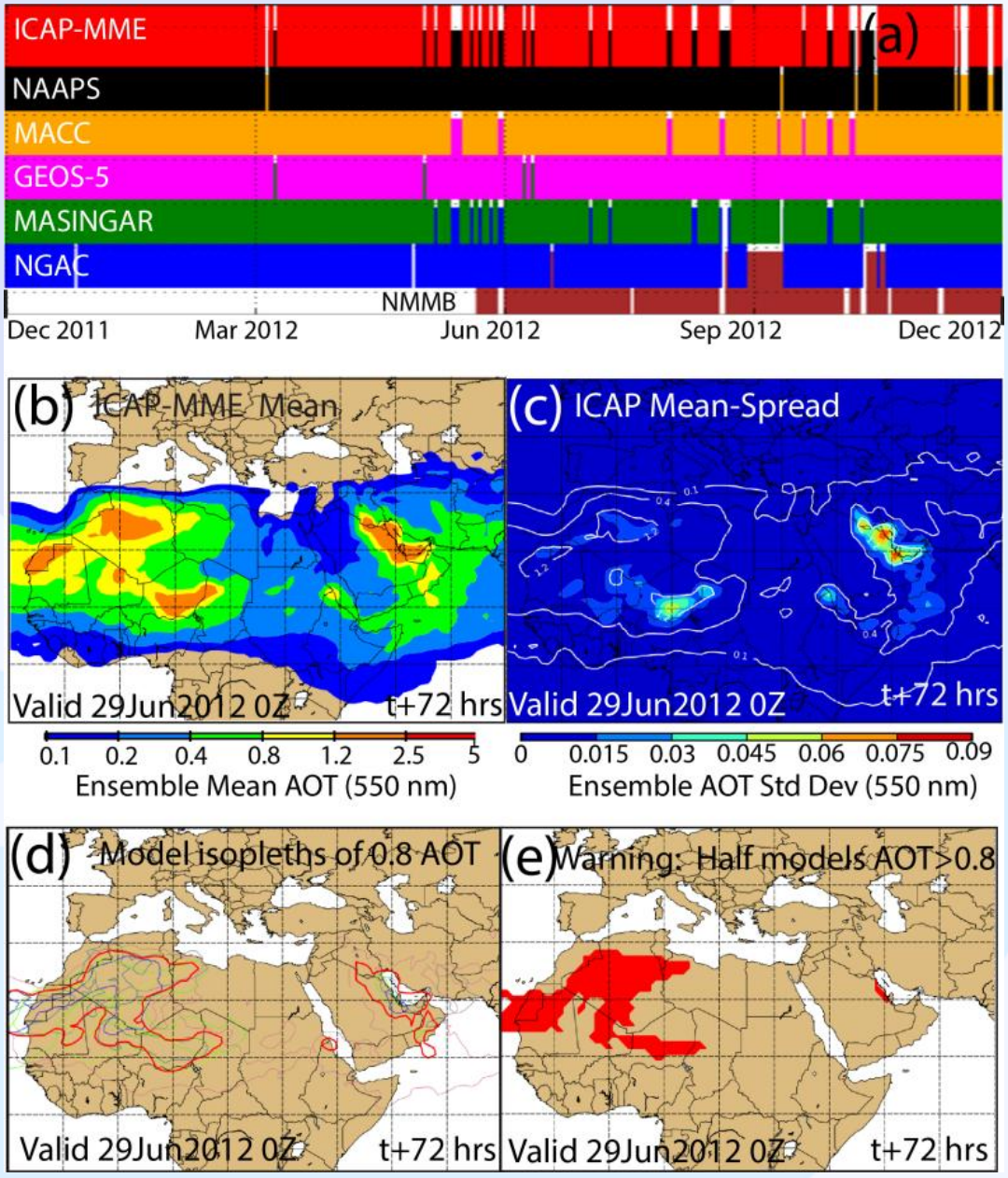
VIIRS Dust Aerosol Index: MODIS dust mask algorithm applied to VIIRS globally



Pubu Ciren and Shobha Kondragunta (NESDIS/STAR)

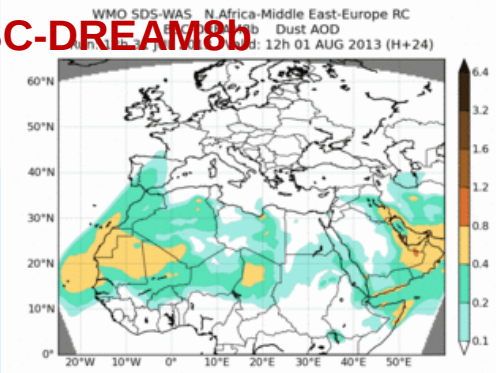
Near-Real-Time Global Aerosol Forecasting

- NGAC dust products contribute global multi-model ensemble (by International Cooperative for Aerosol Prediction, ICAP) and regional multi-model ensemble (by WMO Sand and Dust Storm Warning Advisory and Assessment System, SDS-WAS)
- NGAC forecasts are independently evaluated by the ICAP and SDS-WAS programs

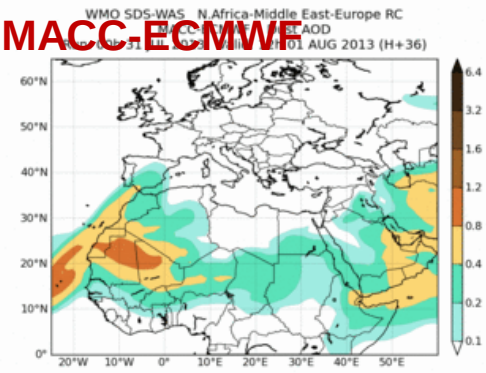


Near-Real-Time Global Aerosol Forecasting

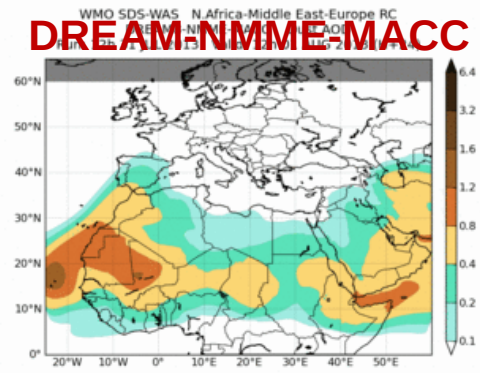
BSC-DREAM8b



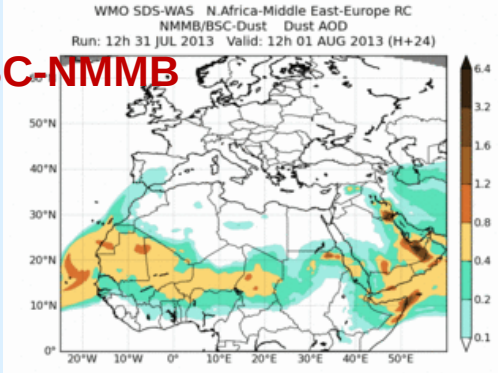
MACC-ECMWF



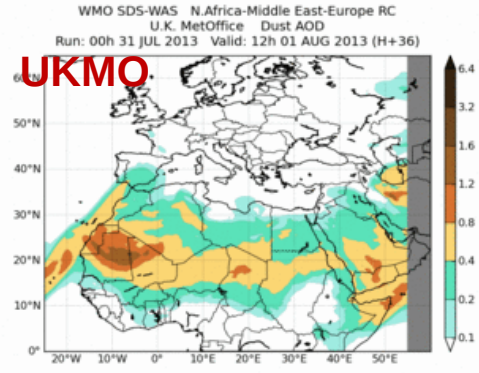
DREAM-NMME-MACC



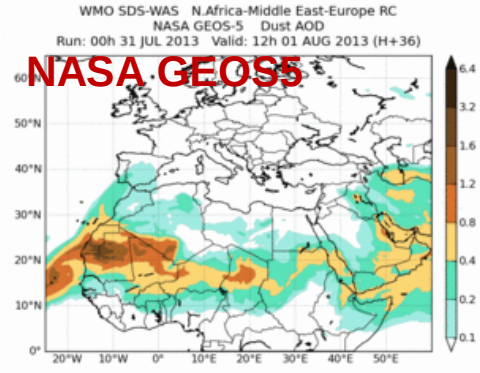
BSC-NMMB



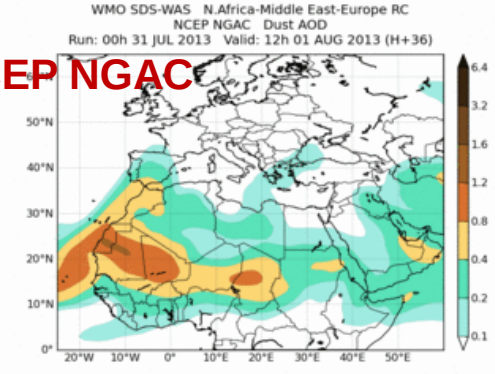
UKMO



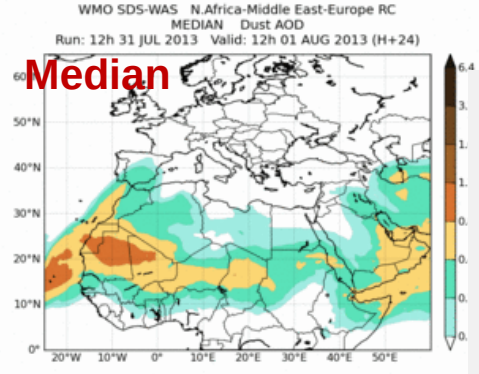
NASA GEOS5



NCEP NGAC



Median



- SDS-WAS Africa node, conducts daily inter comparison for dust AOD and dust surface concentration
- Regional multi-model ensemble, including 5 global models (NCEP, ECMWF, GMAO, UKMO, BSC)

Presentation Outline

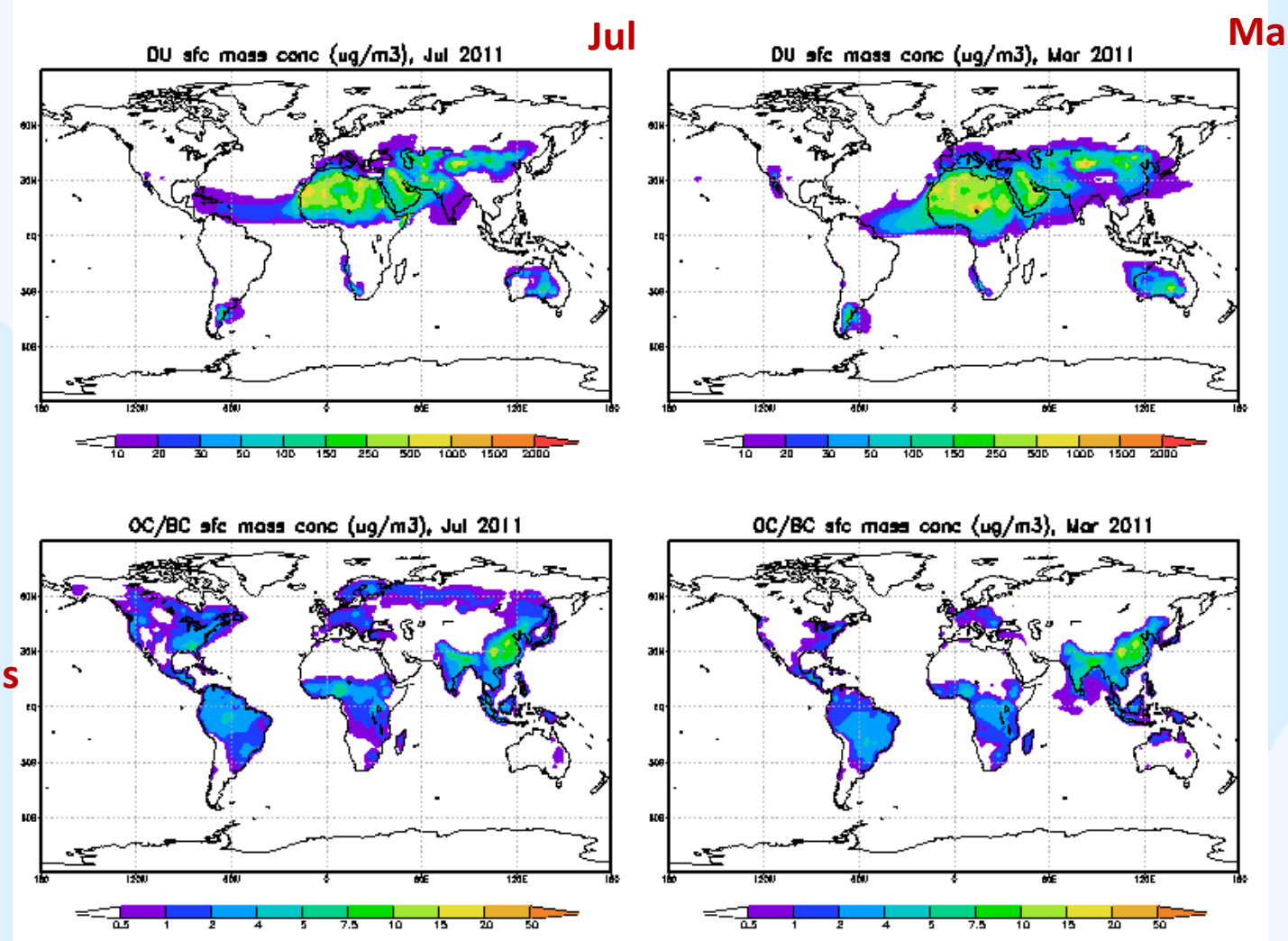
- Current Operational Configuration
- **Future operational requirements and applications**

NGAC aerosol forecasts

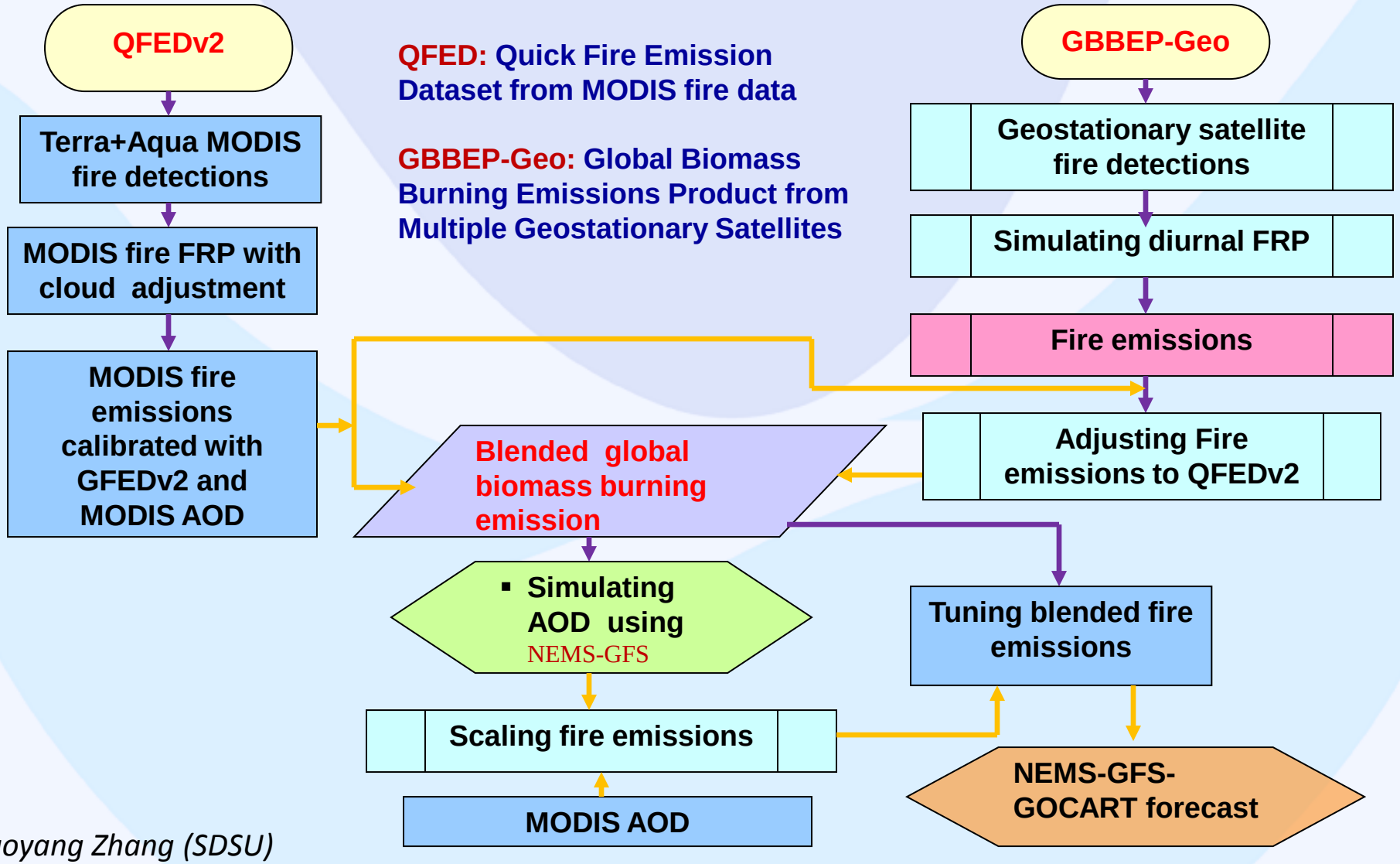
- NGAC has the capability to simulate dust, sulfate, sea salt, and carbonaceous aerosols.
- NGAC using NESDIS's NRT smoke emissions is slated for operation implementation in FY15
- An example is given here where NGAC experiments for 2011 are conducted

Dust aerosols

Carbonaceous aerosols



Flowchart of Blending QFED and GBBEP-Geo



Xiaoyang Zhang (SDSU)

FY15 Planned Implementation

- Extend the dust-only system to include sulfate, sea salt, and carbonaceous aerosols
  - NESDIS - GSFC - NCEP collaboration to develop and test near-real-time biomass burning emissions (GBBEPx)

- Link low-resolution NGAC with high-resolution GDAS Hybrid EnKF and GFS

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**
  - AOD at 0.55 micron
  - Dust emission, sedimentation, dry deposition, and wet deposition fluxes
  - Dust fine mode and coarse mode surface mass concentration
  - Dust fine mode and coarse mode column mass density

Budget, ocean productivity

Air quality

Budget

- **ngac.t00z.a3df$FH, FH=00, 03, 06, ….120**
  - Pressure, temperature, relative humidity at model levels
  - Mixing ratios for 5 dust bins (0.1-1, 1-1.8, 1.8-3, 3-6, 6-10 micron) at model levels

Atmospheric correction

Potential applications for NGAC products are highlighted in red.

Priority System Enhancements

- **Long-term goal**
  - Allow aerosol impacts on weather forecasts and climate predictions to be considered
  - Enable NCEP to provide **quality atmospheric constituent products** serving wide-range of stakeholders, such as health professionals, aviation authorities, policy makers, climate scientists, and solar energy plant managers

- **Phased implementation**
  - Phase 1: Dust-only forecasts (operational)
  - Phase 2: Forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS's GBBPEx smoke emissions (planned FY15 implementation)
  - Phase 3: Aerosol analysis using VIIRS AOD (well-defined R2O building upon existing NCEP-NESDIS-GSFC collaboration)

Why VIIRS AOD Data Assimilation?

- While development work remains, ground work has been laid for building a global aerosol data assimilation capability within NGAC and Hybrid EnKF-GSI
  - Prognostic aerosol capability has been established
  - Infrastructure development (CRTM supports GOCART, GSI code development for AOD DA*)
  - Near-real-time smoke emissions have been developed, slated for operational in FY15
  - Community aerosol modeling/assimilation efforts (ICAP, GSI)

- Other centers (e.g., NRL, ECMWF, GMAO) are assimilating MODIS AOD, and are currently assessing the VIIRS aerosol products. NCEP is yet to develop the AOD data assimilation capability and will be focused on VIIRS products (instead of the "MODIS then VIIRS" approach).

* GSI AOD data assimilation: (1) Development work at NCEP is temporarily suspended due to budgetary constraint (2) Extensive development work conducted by other centers (NCAR, ESRL)

Future Operational Benefits Associated with NEMS GFS Aerosol Component	Status
Provides a first step toward an operational aerosol data assimilation capability at NOAA	VIIRS AOD data assimilation (pending support)
Allows aerosol impacts on medium range weather forecasts (GFS/GDAS) to be considered	Ongoing work at EMC
Allows NOAA to explore aerosol-chemistry-climate interaction in the Climate Forecast System (CFS) as GFS is the atmospheric model of CFS	CPO MAPP-CTB funded project
Provides global aerosol information for various applications (e.g., satellite radiance data assimilation, satellite retrievals, SST analysis, UV-index forecasts, solar electricity production)	Ongoing NCEP-NESDIS-Howard collaboration on aerosol-SST
Provides lateral aerosol boundary conditions for regional aerosol forecast system	Benchmark study completed

Conclusions

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)
  - Phase 2: Forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS's GBBPEx smoke emissions (planned FY15 implementation)
  - Phase 3: Aerosol analysis using VIIRS AOD (well-defined R2O building upon existing NCEP-NESDIS-GSFC collaboration)

Thanks.

Questions and Comments?