Assimilation of VIIRS aerosol products to improve NCEP global aerosol predictions

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Outline

1. Scope of global aerosol prediction at NCEP
2. The need for aerosol data assimilation
3. Status update in aerosol data assimilation
4. Conclusions

NCEP global aerosol modeling and assimilation

Long-term goal

- Allow aerosol impacts on weather forecasts and climate predictions to be considered
- Enable NCEP to provide quality atmospheric constituent products serving the stakeholders, e.g., health professionals, policy makers, climate scientists, and solar energy plant managers

Phased implementation for NEMS GFS Aerosol Component (NGAC)

- Phase 1: Dust-only forecasts (operational)
- Phase 2: Multi-species forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS's NRT GBBEPx smoke emissions (planned FY16 implementation)
- Phase 3: Multi-species forecasts initialized from aerosol analysis

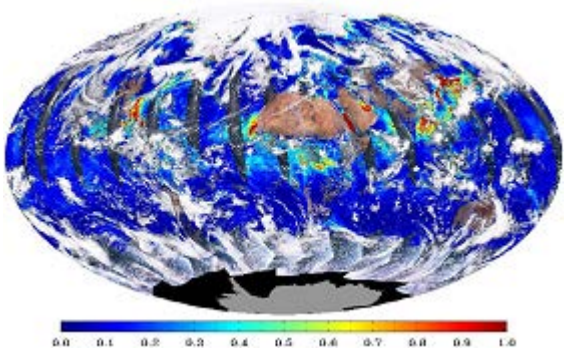
Incremental updates for aerosol data assimilation

- The first phase is based on the GSI framework using VIIRS AOD as input observations and the NGAC output as first guess
- The system will be extended to use multi-sensor and multi-platform aerosol observations and evolve to an ensemble-based system

Using satellite data to improve aerosol forecasting

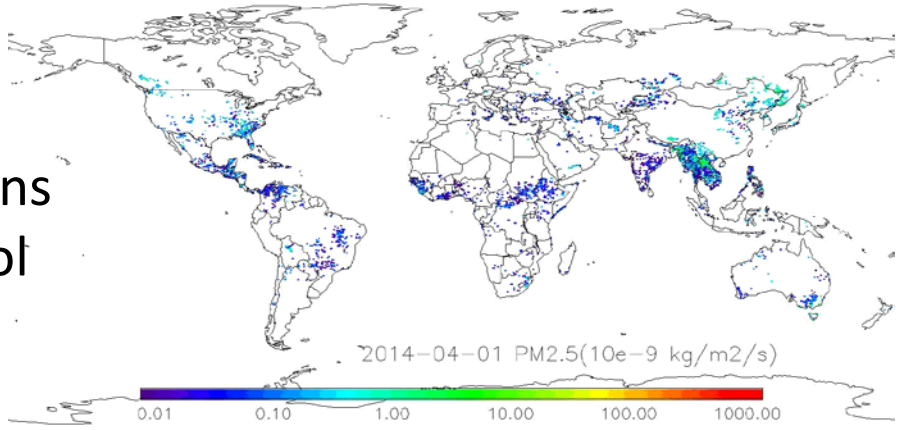
- NCEP's global aerosol forecasting capability has been build upon multi-institute collaboration (NCEP, GSFC, STAR, SUNYA) and leverage the expertise in other modeling centers (ICAP)
- Satellite observations have been used to improve aerosol products
  - Routine monitoring of model performance
  - Near-real-time biomass burning emissions from satellite observations
  - Data assimilation of satellite aerosol observations (in development)

Aerosol observations from VIIRS



From NOAA/NESDIS/STAR website

Near-real-time biomass burning emissions from multiple satellites



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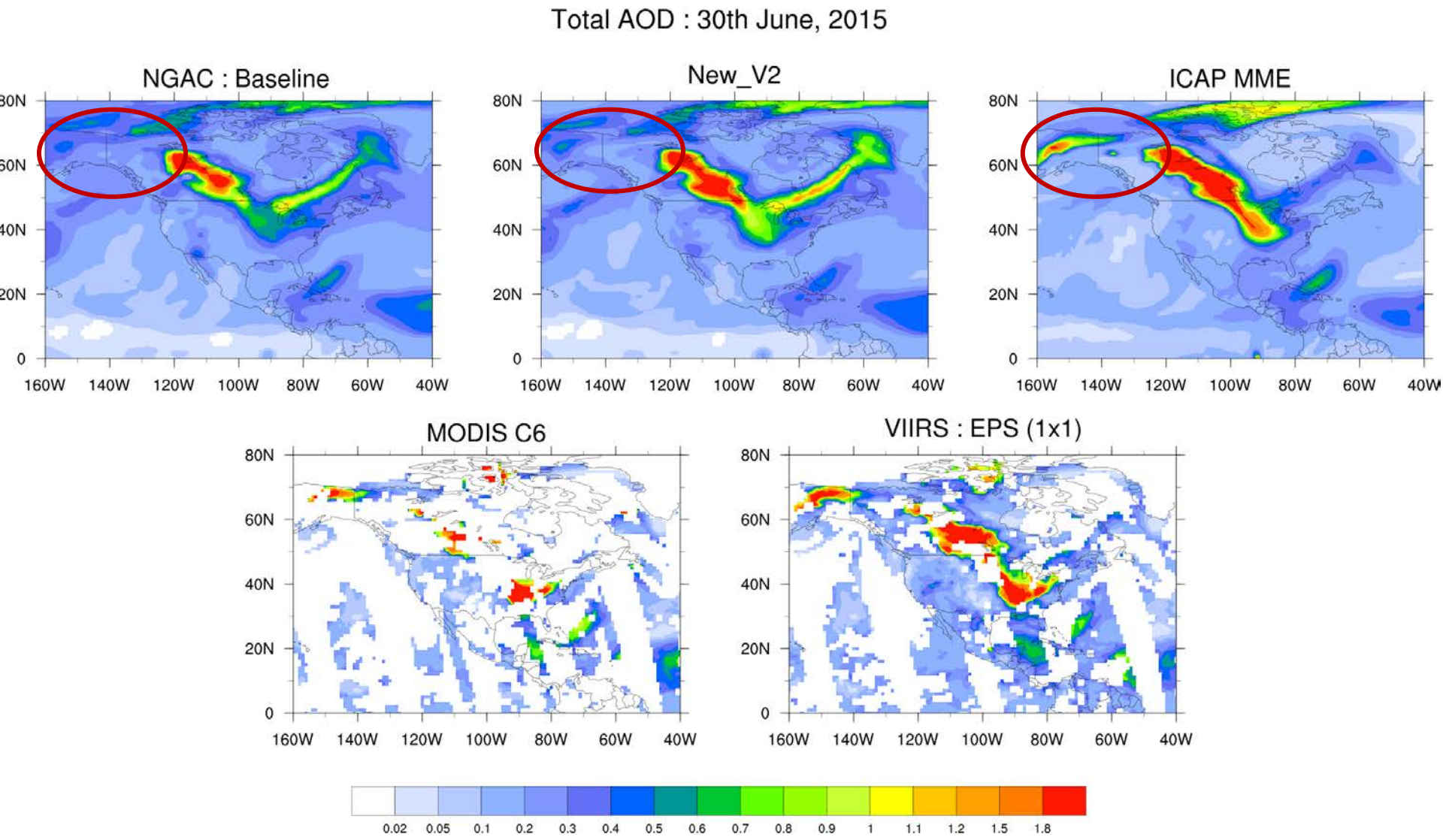
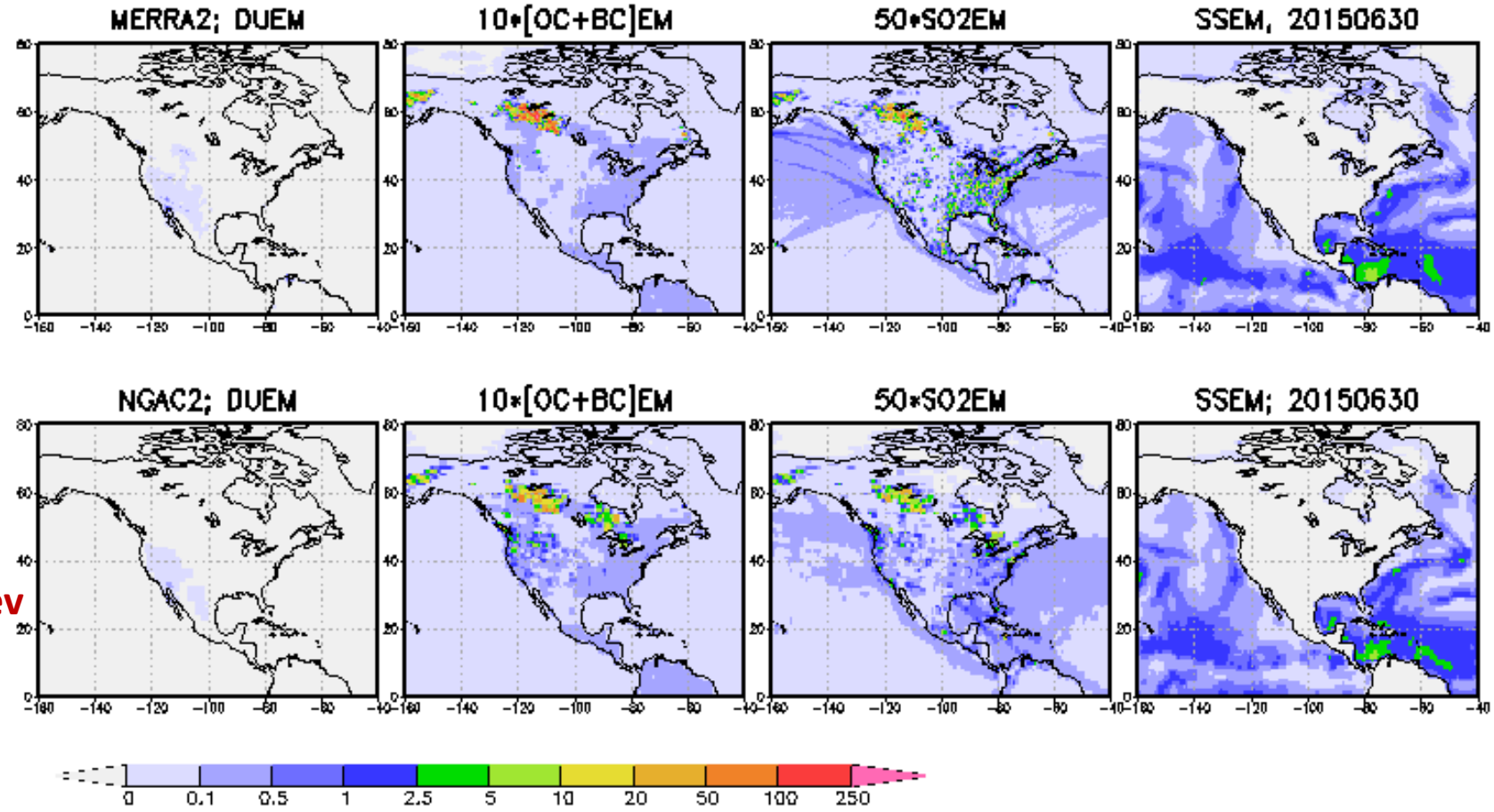
July 2015 case: Lower AOD in NGACv2 than ICAP-MME for the areas affected by Alaska and Africa smoke



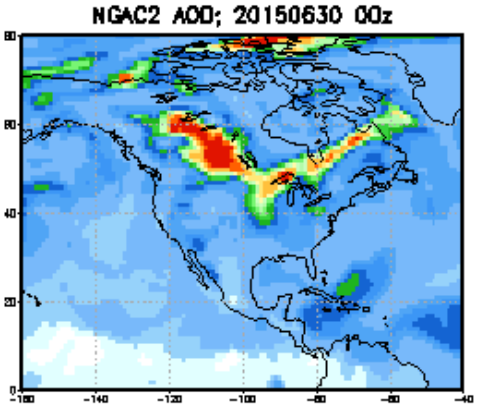
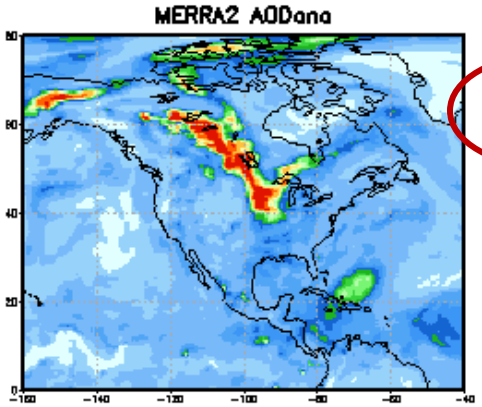
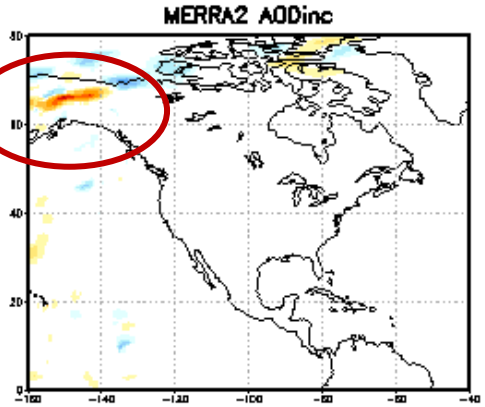
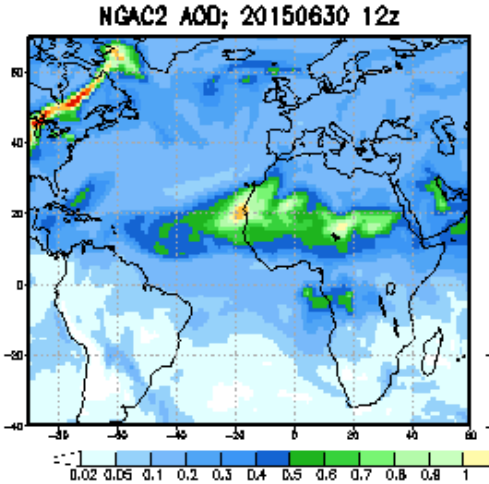
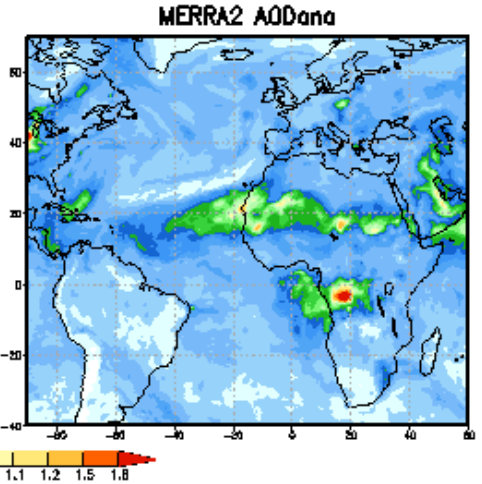
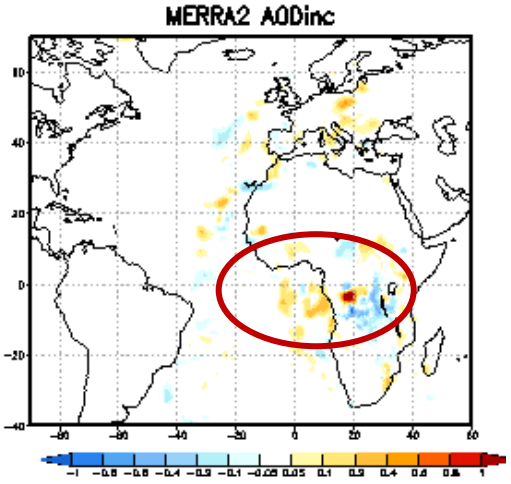
Emissions for DU, OC+BC, SO2, SS for 2015-06-30 12Z

MERRA2

NGACV2_rev



Comparable Alaska smoke emissions in QFED2 (for MERRA2) and GBBEPx (for NGAC v2)

	NGAC AOD	MERRA2 AOD	MERRA2 analysis increment
00Z			
12Z			

Comparable smoke emissions between QFED2 and GBBEPx

The AODs differences between MERRA2 and NGACv2 are attributed to analysis increment

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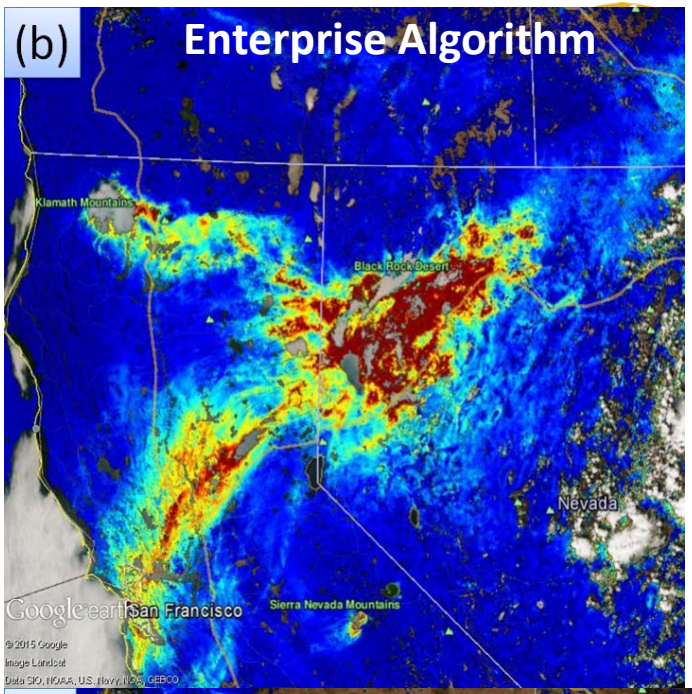
Project Milestones Overview

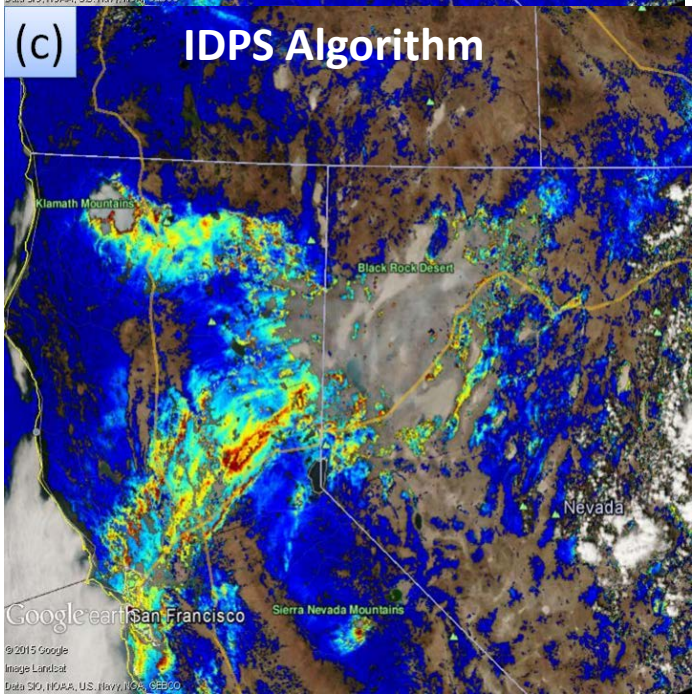
Task	Description	Milestones/ Deliverables
1. VIIRS quality assurance and bias correction	Conduct VIIRS AOD error analysis and establish VIIRS data screening procedure	DA grade VIIRS AOD products
2. Global aerosol analysis	Develop GSI-based AOD data assimilation system using NCEP's NGAC as first guess and VIIRS AOD as observation input	GSI AOD DA system
3.Benchmark study	Demonstrate the anticipated improvement resulted from AOD DA	Benchmark report

Task 1 VIIRS AOD Quality Assurance and Bias Correction

- VIIRS operational AOD (IDPS version) is well validated and documented. However, the following issues have been documented:
  - Smoke plumes are identified as cirrus cloud
  - Data gaps over bright surfaces
  - Measurement range extends only from 0 to 2 optical depth units

- Enterprise algorithm has been developed to circumvent the deficiencies. This algorithm to be operational in NDE in 2016
  - Testing and evaluation ongoing





Task 1 VIIRS AOD Quality Assurance and Bias Correction –cont'd

- Obtain AOD and dust/smoke mask products from Enterprise algorithms for select case studies and do model comparison studies

- Identify VIIRS AOD data artifacts and sources of errors and develop data screening procedures if needed

Task 2 Technical/Scientific Progress

- With an older version of GSI/CRTM, NCAR and ESRL assimilates MODIS AOD using WRF-CHEM as first guess
- AOD DA code has been committed to the GSI code repository
- We are extending the new GSI option to use NGAC as first guess and VIIRS AOD as observation input.

Task 2 Technical/Scientific Progress –cont'd

- GOCART interface in GSI:
  - GSI code modified to read in NGAC first guess
- Observation reading interface in GSI:
  - GSI code modified to read VIIRS AOD
  - Observation thinning for VIIRS AOD will be done in reading step.
- Specification of background error
  - Calculated using the NMC method
  - Spatial correlation for GOCART aerosol species
- Specification of observation errors
  - Determined from VIIRS versus AERONET comparisons (VIIRS Cal/Val)
- Observation operator
  - Use JCSDA Community Radiative Transfer Model (CRTM V2.2.3) as observation operator for VIIRS AOD
  - Forward and Jacobian models
- Synergistic activities:
  - VIIRS AOD from Enterprise algorithm has been encoded in BUFR format and dumped to a development database at EMC

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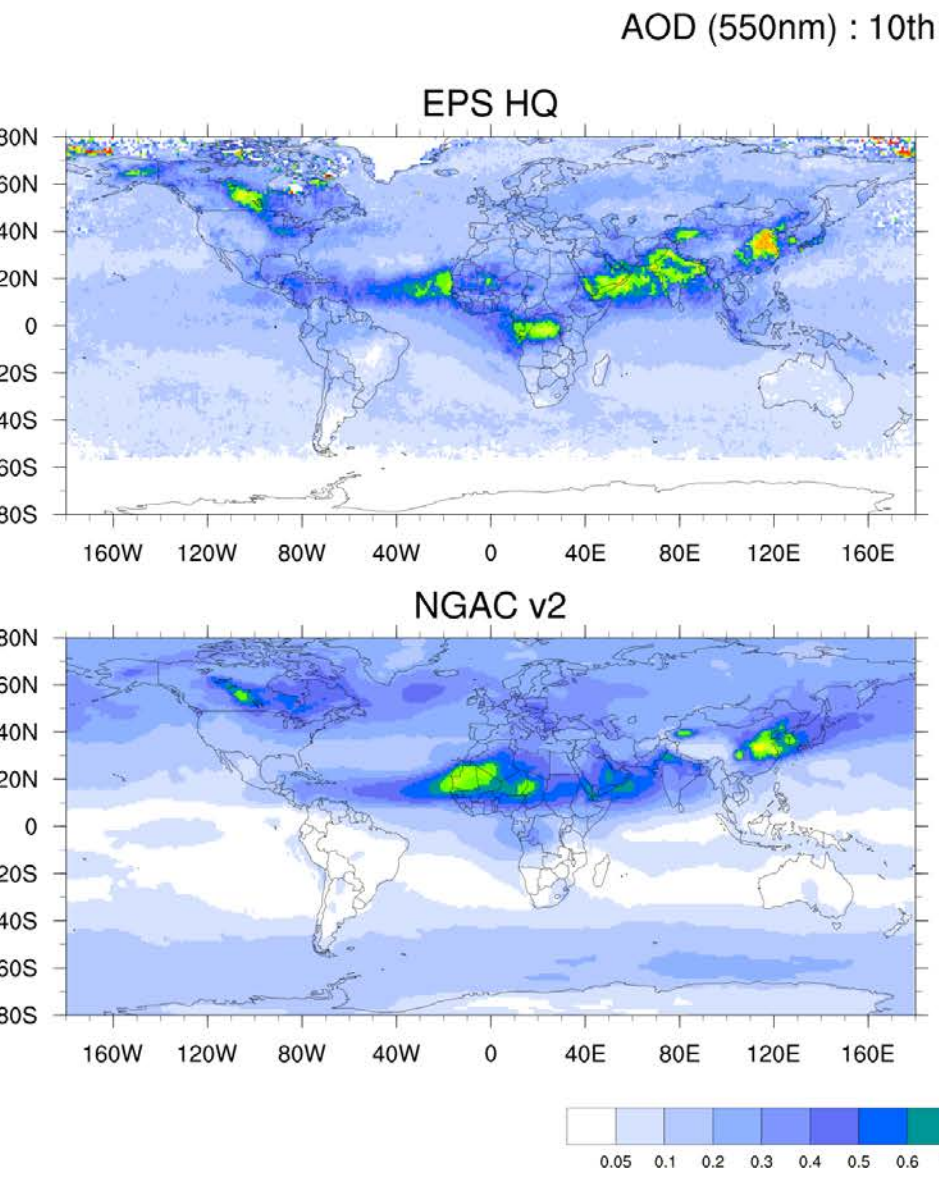
Concluding Remarks



- NESDIS new Enterprise Processing System (EPS) VIIRS High Quality (HQ) AOD product provides coverage over bright surfaces
- Aerosol features seen in EPS mean AOD map are present in ICAP but not in NGAC v2 (experimental)

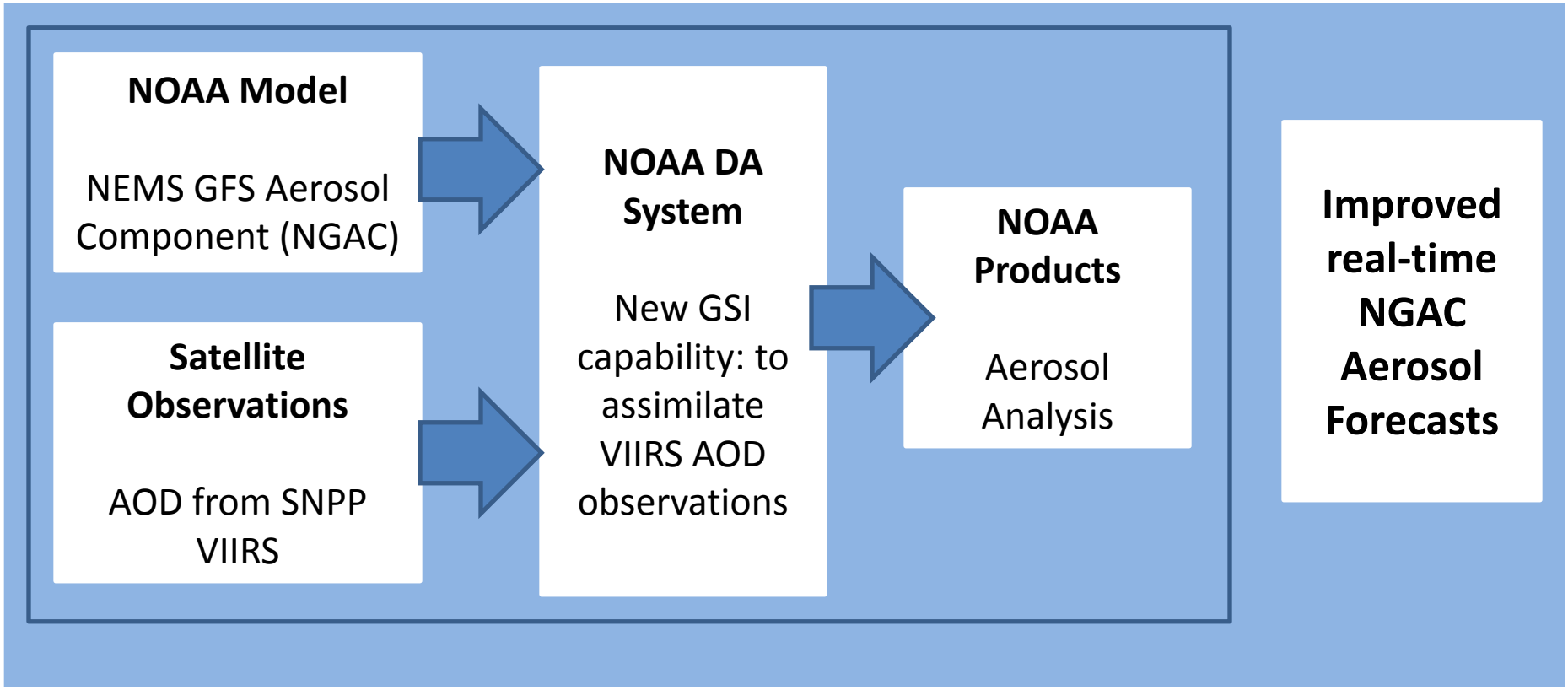
Concluding Remarks

- Ongoing efforts:
  - VIIRS AOD data assimilation using GSI and NGAC
  - The prototype system is being testing and evaluated

- Planned activities
  - Ensemble-based DA (Unified Global Coupled System)
  - Assimilate aerosol observations from multiple platforms

BackUp Slides

Improving NCEP global aerosol forecasts using SNPP VIIRS aerosol products



Major Milestones:

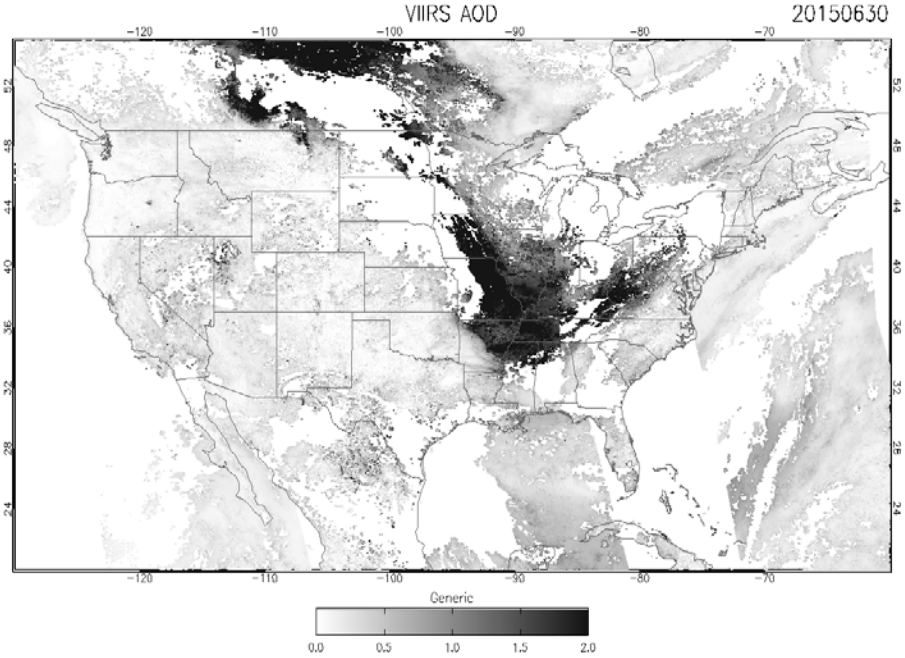
- Data assimilation grade VIIRS aerosol products
- Prototype GSI VIIRS AOD assimilation system

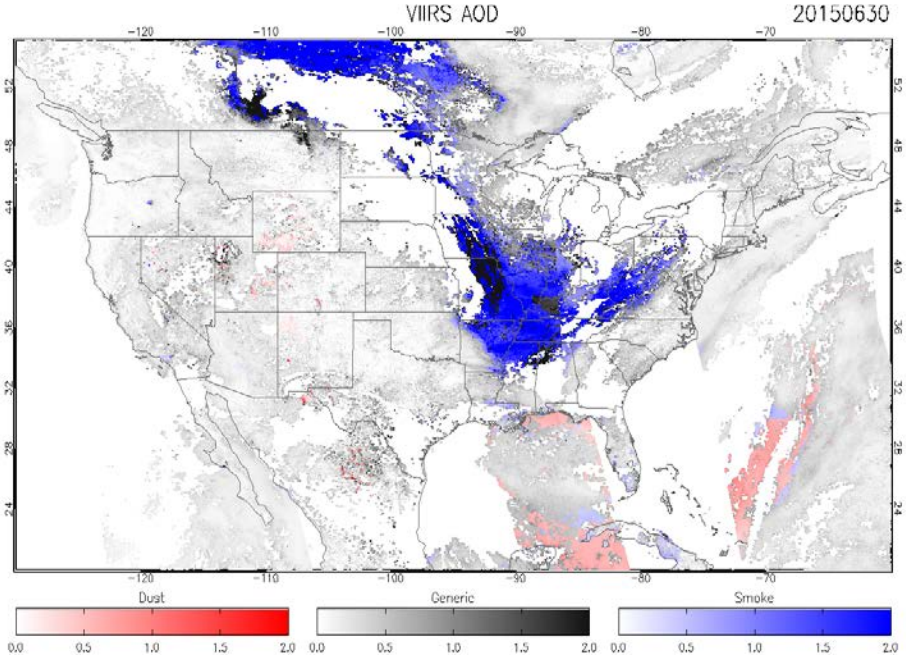
Quick Checkup of VIIRS Aerosol Products

- VIIRS Enterprise Algorithm AOD Product
  - Moderate channel resolution ~750m
  - Daily global coverage with 14-15 orbits

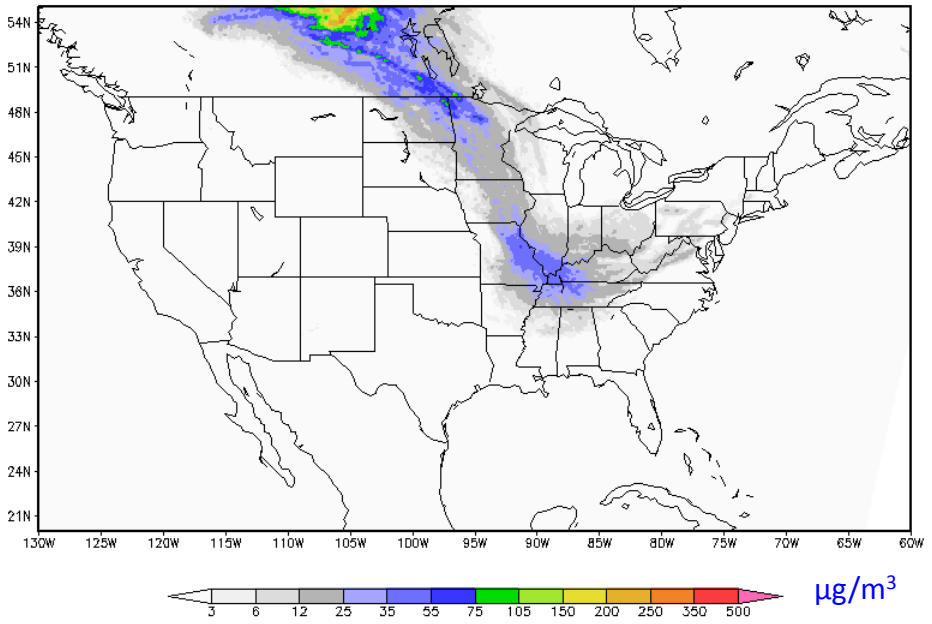
- VIIRS Smoke/Dust Detection Product
  - DAI based algorithm with deep-blue channels
  - Detects dust and smoke plumes

- A few wildfire episodes were selected based on operational HYSPLIT model smoke forecasts
- HYSPLIT smoke forecasts were taken as reference and compared against





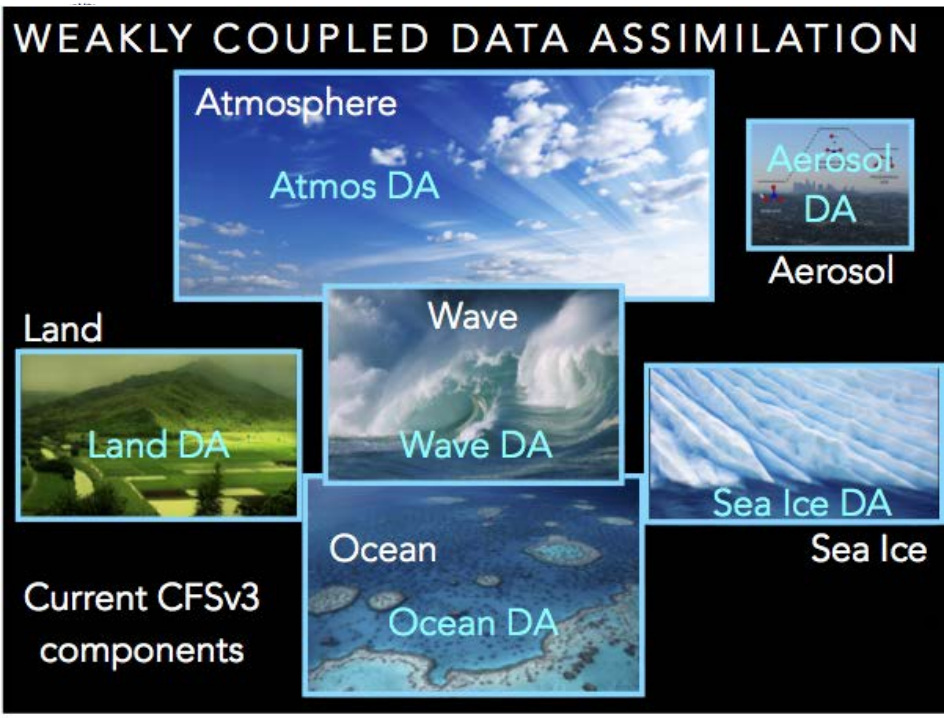
HYSPLIT Column Average Smoke Concentration 2015063018

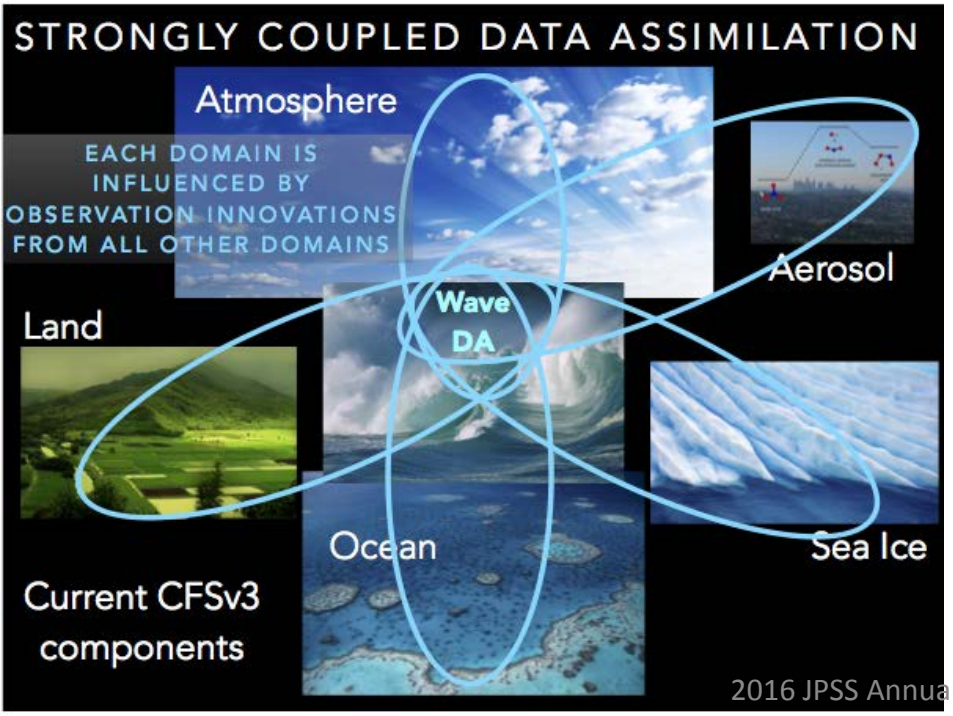


Unified Global Coupled System (UGCS)

- Efforts are underway at NCEP/EMC to develop a fully-coupled ensemble-based DA system for earth system components, including atmosphere, ocean, land, sea ice, wave, and aerosols.

- The UGCS-aerosol infrastructure will leverage the variational GSI efforts project (e.g., quality assurance and bias-correction of the VIIRS AOD observations; specification of the observation errors; observation operator implemented in the GSI)





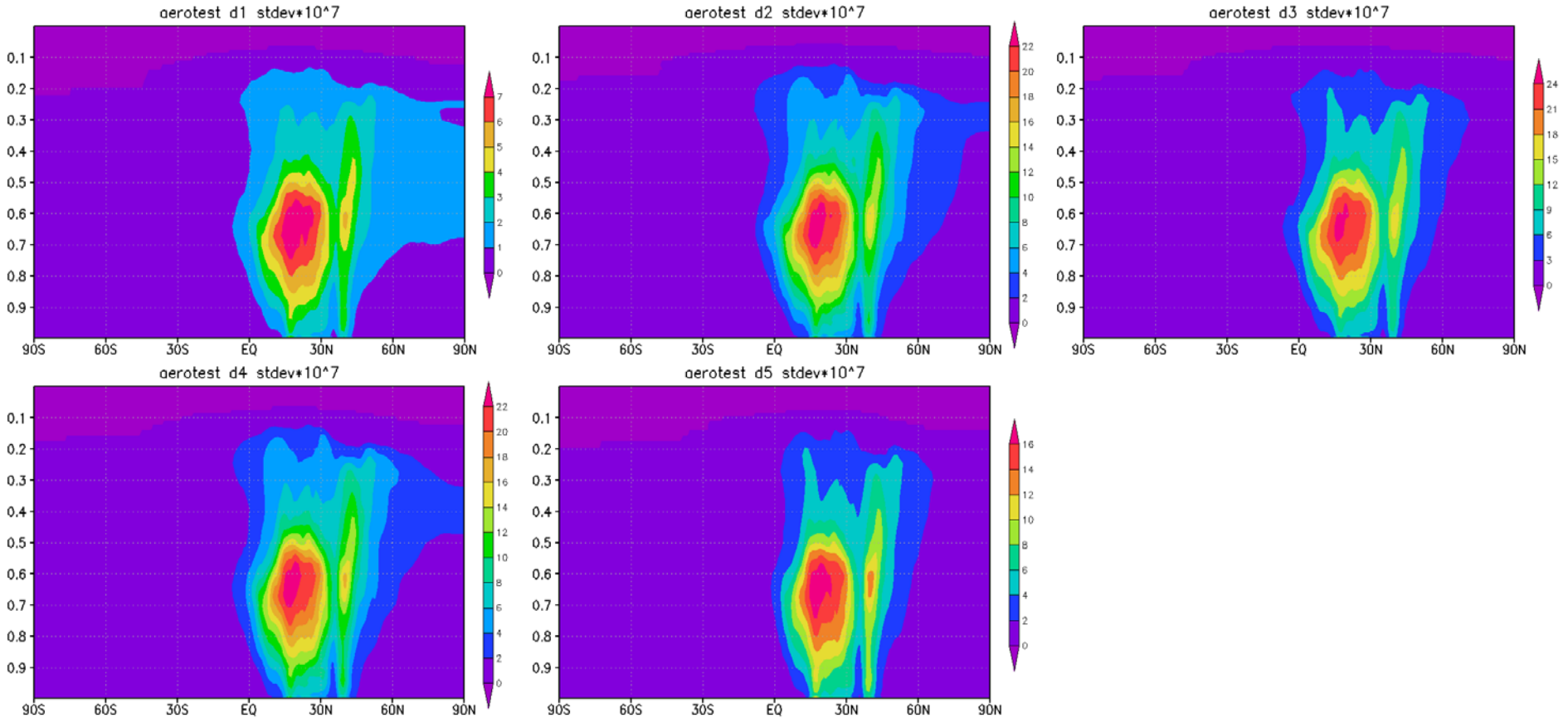
Weak coupling

- Aerosol analysis is combined with the independent analyses from the other system components to produce a coupled forecast.

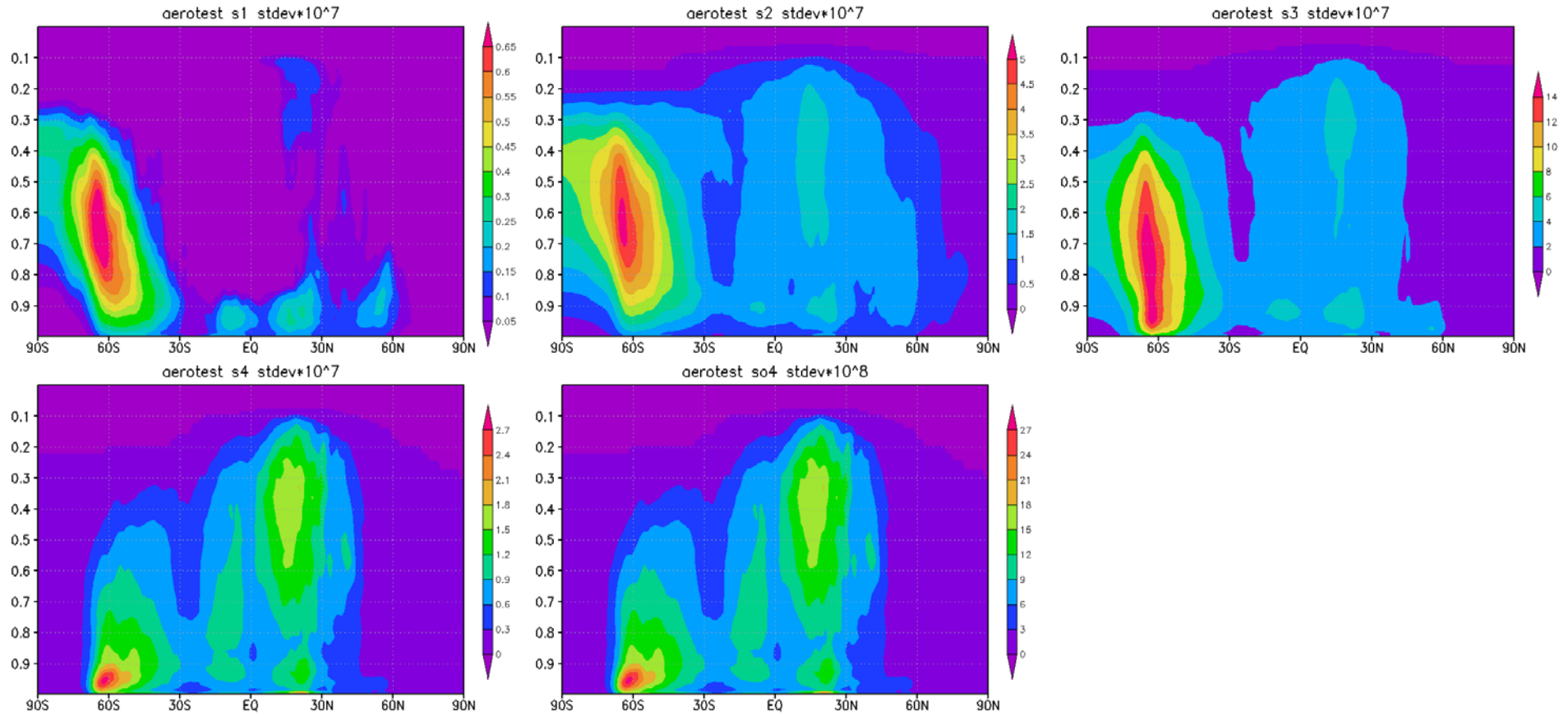
Strong coupling

- Incorporate innovations from other system components
- Iterative testing of the addition of innovations, e.g., sea surface temperature from the ocean component, soil moisture from the land component, and winds from the atmosphere component.)

Dust bin 1 to bin 5 standard deviation



Sea salt bin 1 to bin 4 and sulfate standard deviation



OC and BC standard deviation