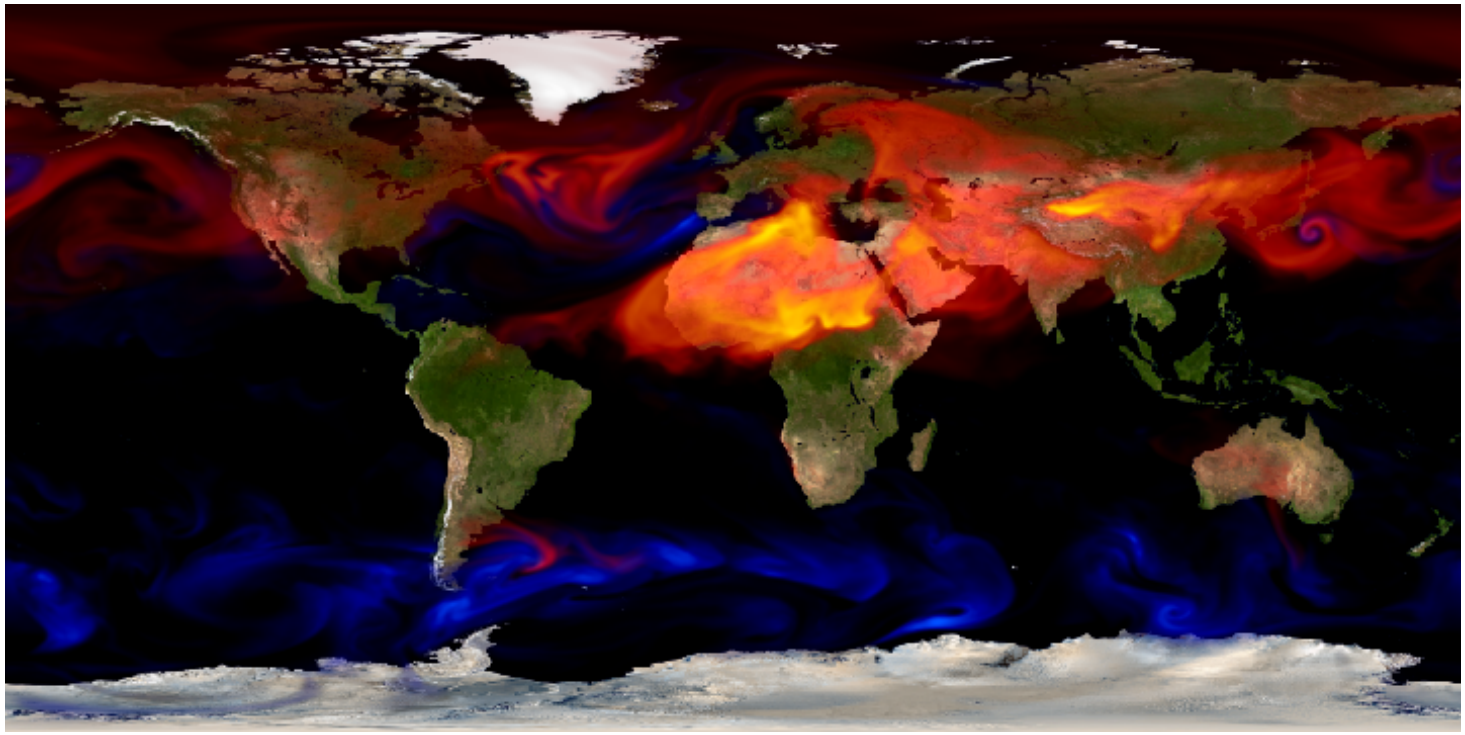
Status update on NCEP Global Aerosol Forecasting and Analysis System



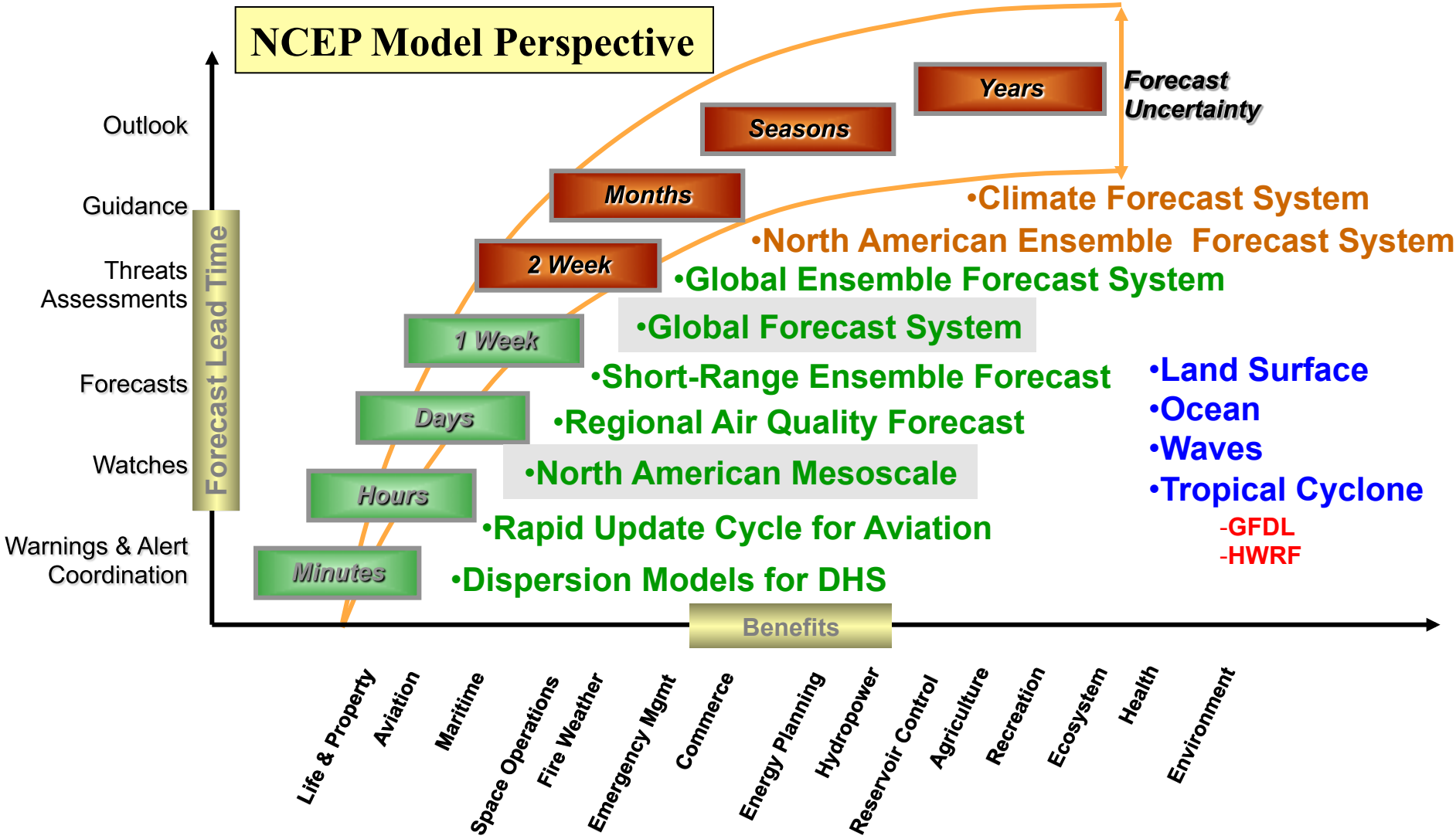
Sarah Lu
NOAA/NWS/NCEP Environmental Modeling Center
Also at I.M. System Groups, Inc

Outline

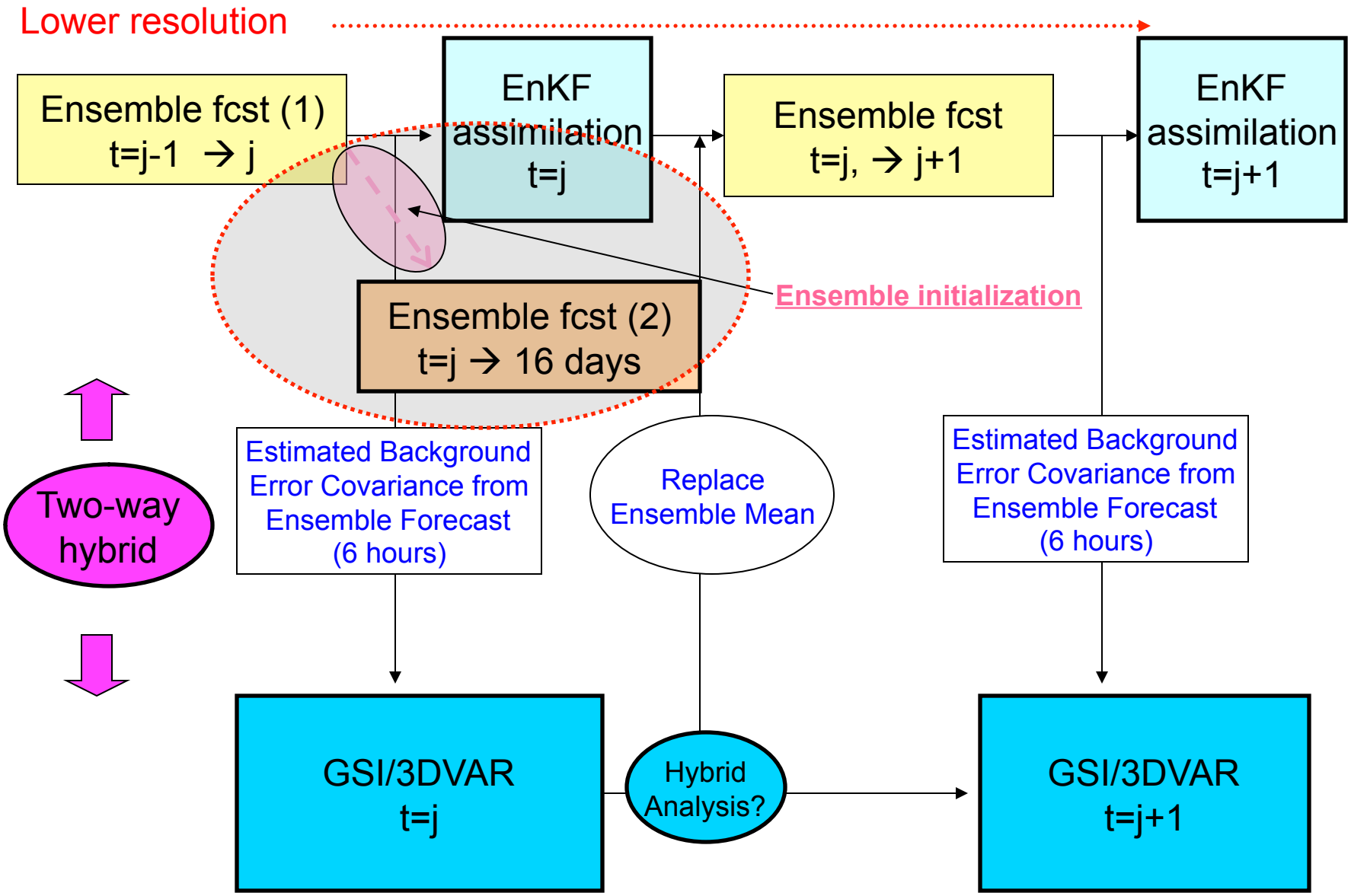
1. Introduction
2. Model development:
   NOAA Environmental Modeling System
3. Preliminary Results
4. Next steps

1. Introduction

NWS Seamless Suite of Forecast Products Spanning Weather and Climate



Flow Chart for Hybrid Variation and Ensemble Data Assimilation System (HVEDAS) - concept

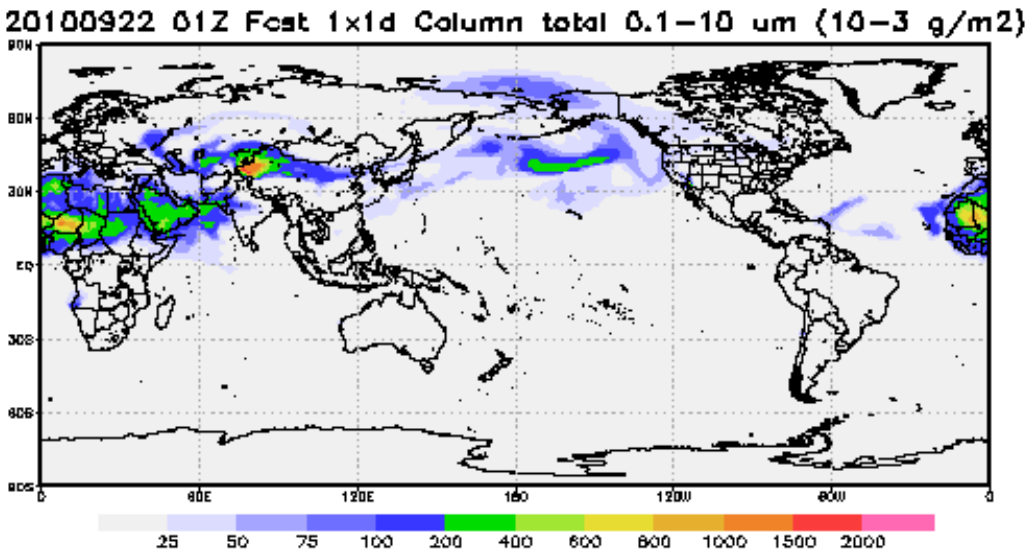


Yuejian Zhu

Global System: Gas and Aerosol Representation

- **Parameterized ozone physics**
  - Ozone production and destruction in GFS are parameterized from monthly/zonal mean dataset derived from NRL 2D ozone chemistry model

- **NASA GOCART aerosol module**
  - Off-line dust-only GOCART CTM, driven by GFS (real-time testing since December 2009)
  - On-line implementation of GOCART in NEMS GFS (prototype development and testing)



This slide was presented at the 2nd ICAP Workshop last Oct.

http://www.emc.ncep.noaa.gov/mmb/hchuang/web/html/realtime.fcst.html

- We re-visited the "off-line then in-line" approach last Dec

- The off-line system is frozen and plan underway to implement the in-line system operationally (target: Q1 FY12 for parallel, subject to potential issues)

- The initial implementation will be a low-resolution dust-only system that provides LBCs for regional AQ system

Why in-line system?

Timeline			Off-line System	In-line System
Q2FY12	dust/smoke	Provide dynamic dust/smoke LBCs for regional AQ forecasts	YES	YES
FY12+	volcanic ash	Provide global volcanic particulates transport tracking capability and LBCs for regional AQ	YES	YES
	full package	Radiation feedback in GFS	NO	YES
		Atmospheric correction in SST retrievals	NO	YES
		Aerosol effects in GSI/CRTM	NO	YES
		Aerosol data assimilation	NO	YES
		Aerosol-cloud interaction in GFS/ CFS	NO	YES

2. NOAA Environmental Modeling System (NEMS) Aerosol Component

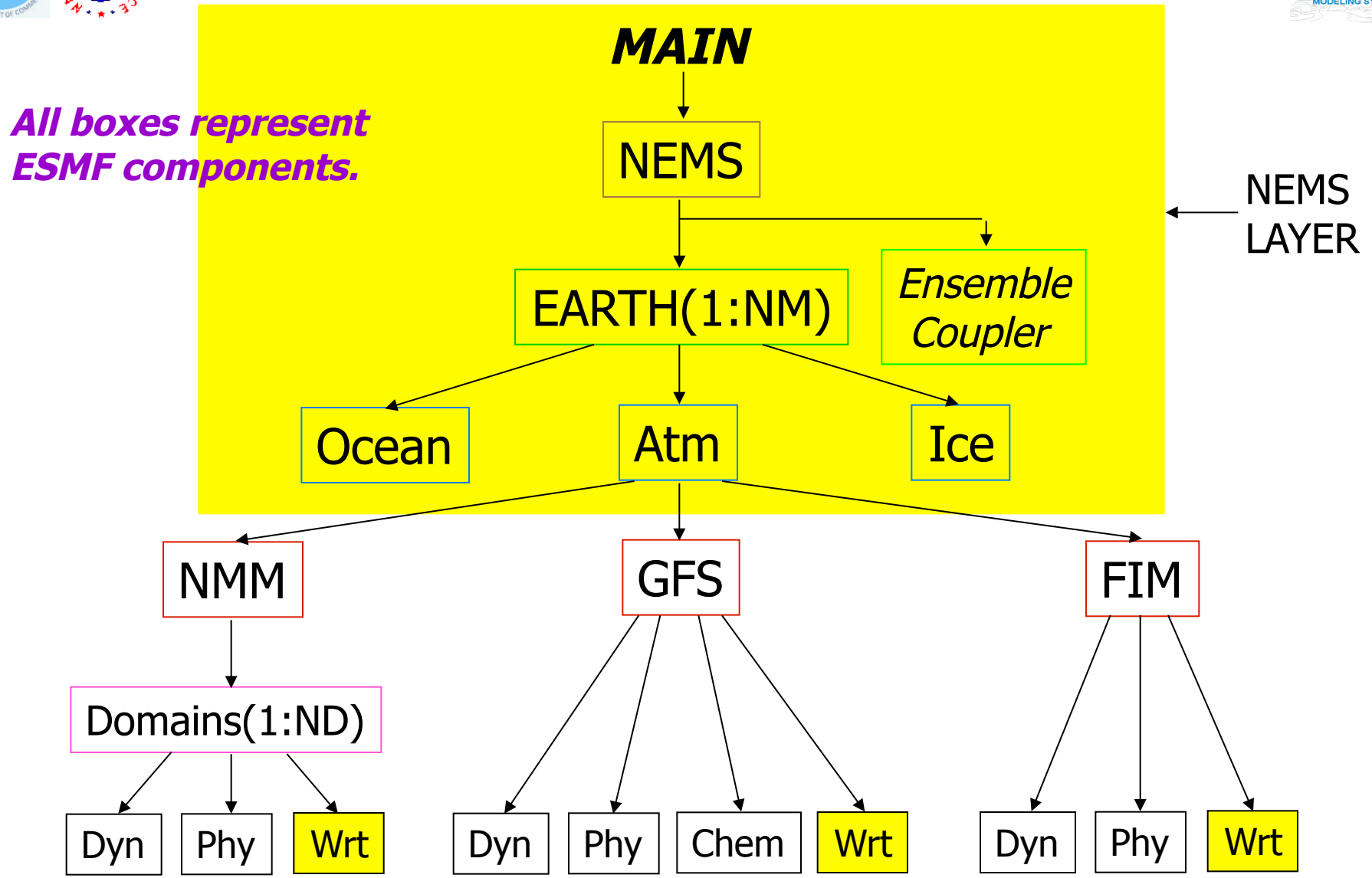
3rd ICAP workshop, 11-13 May 2011

What is NEMS?

- NEMS stands for
  NOAA Environmental Modeling System
- A shared, portable, high performance software superstructure and infrastructure
- For use in operational prediction models at National Centers for Environmental Prediction (NCEP)
- National Unified Operational Prediction Capability (NUOPC) with Navy and Air Force
- Eventual support to community through Developmental Test Center (DTC)
- http://www.emc.ncep.noaa.gov/NEMS/
- NEMS implementation Plans
  - 2011 implementation: NMMB with nests
  - 2012 implementation: NEMS GFS Aerosol Component (NGAC)

From Mark Iredell & Tom Black presentation (2010 AMS/NWP conference)

NEMS Component Structure



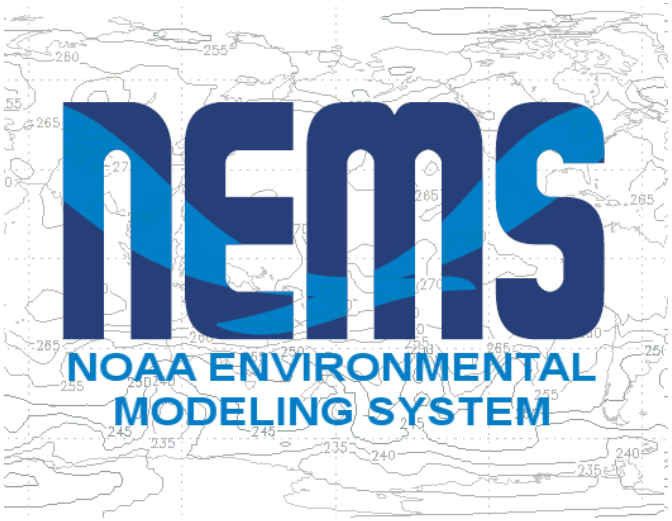
All boxes represent ESMF components.

Below the dashed line the source codes are organized by the model developers.

From Mark Iredell & Tom Black presentation (2010 AMS/NWP conference)

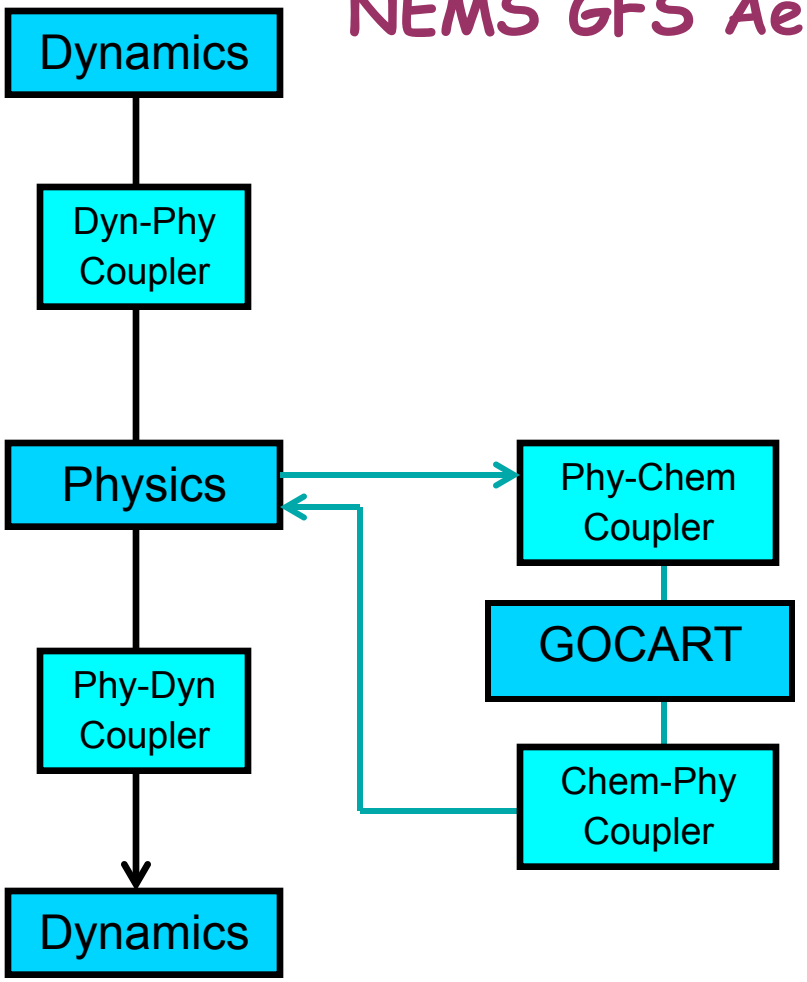
Team efforts toward building global aerosol forecast capability at NCEP

Mark Iredell (NEMS framework)
Sarah Lu (aerosol modeling)
Shrinivas Moorthi (physics)
Yu-Tai Hou (radiation-aerosol)
Henry Juang (dynamics)
Jun Wang (I/O)
Hui-Ya Chuang (post)
Weiyu Yang (replay capability)
Ho-Chun Huang (GSI, verification)
Downstream application (Xu Li, Jeff McQueen, Youhua Tang)



GSFC collaborators (Arlindo da Silva and Mian Chin)
NESDIS collaborators (Quanhua Liu, Shobha Kondragunta)

Primary integration runstream of NEMS GFS Aerosol Component (NGAC)



PHY2CHEM coupler component transfers data from phy export state to chem import state

- Convert units (e.g., precip rate, surface roughness)
- Calculations (e.g., soil wetness, tropopause pressure, relative humidity, air density, geopotential height)
- Flip the vertical index for 3D fields from bottom-up to top-down

GOCART grid component computes source, sink, and transformation for aerosols

CHEM2PHY coupler component transfers data from chem export state to phy export state

- Flip vertical index back to bottom-up
- Update 2d aerosol diagnosis fields

- Dynamics, physics and chemistry run on the same grid in the same decomposition
- Concurrent code development: The coupler componentss can be revised to incorporate the on-going and future changes in GFS and/or GOCART

3.Preliminary Results

Preliminary results of dust-only NGAC simulations

MODEL CONGIFURATION:

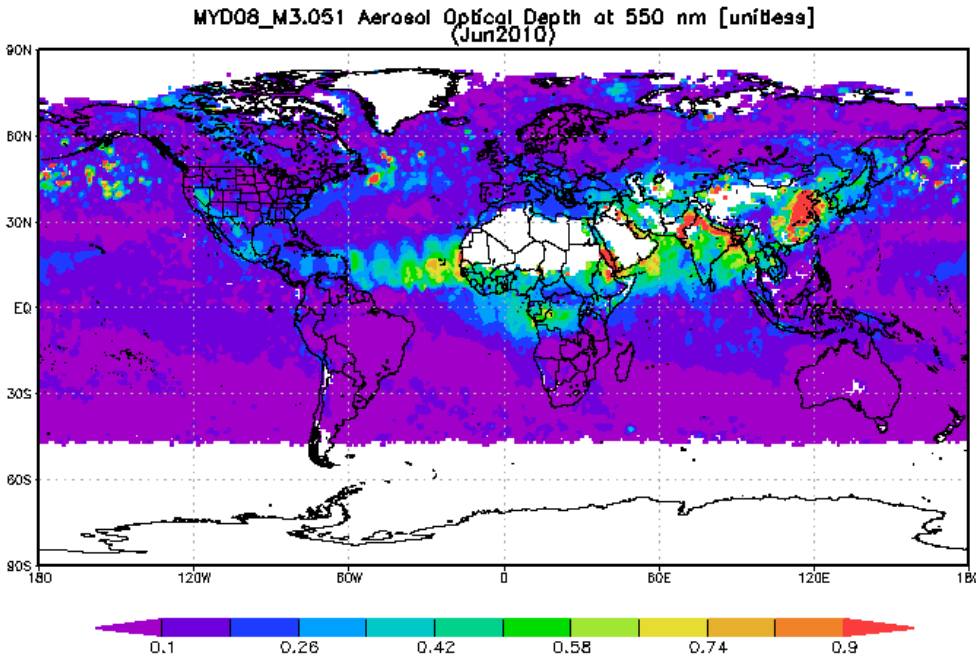
- Resolution: T126 L64
- Output every 3 hour
- Sigma-Pressure hybrid coordinate
- Physics package same as the operational GFS except for
  - Relaxed Arakawa-Schubert (RAS) convection scheme with the capability of tracer scavenging and convective transport
  - Pre-July 2010 version of boundary layer and shallow convection scheme

INITIAL CONDITIONS

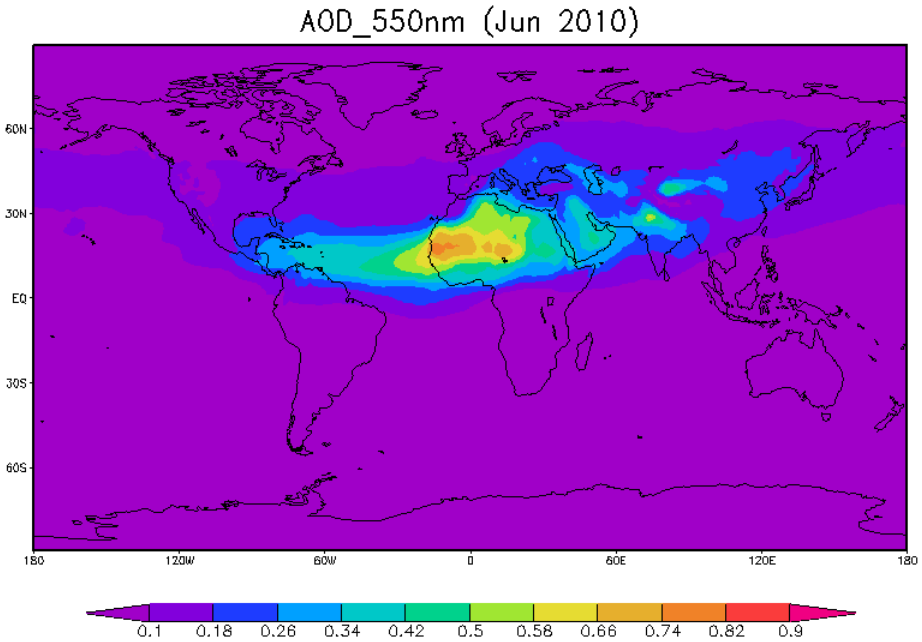
- NCEP Global Data Assimilation System (GDAS) analysis for meteorology
- Cold-start for aerosols (set to a fixed value: 1.e-12 in kg/kg)

REPLAY MODE

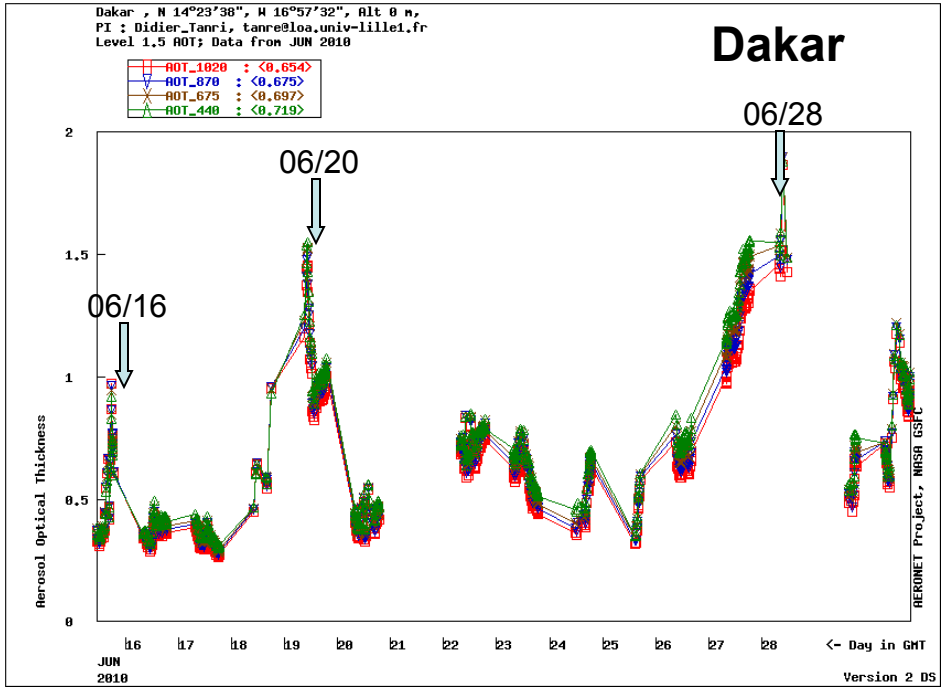
- Meteorological fields are replaced by operational T574 GDAS every 24 hour

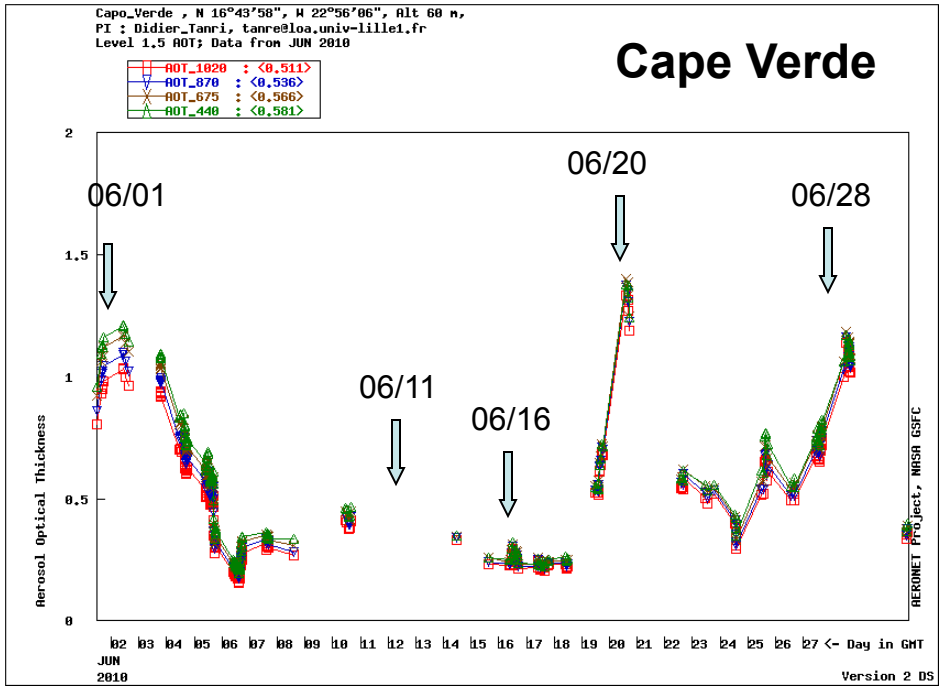


Monthly average of 550nm AOD for June 2010 from MODIS onboard Aqua (top) and dust-only NGAC simulations (bottom)

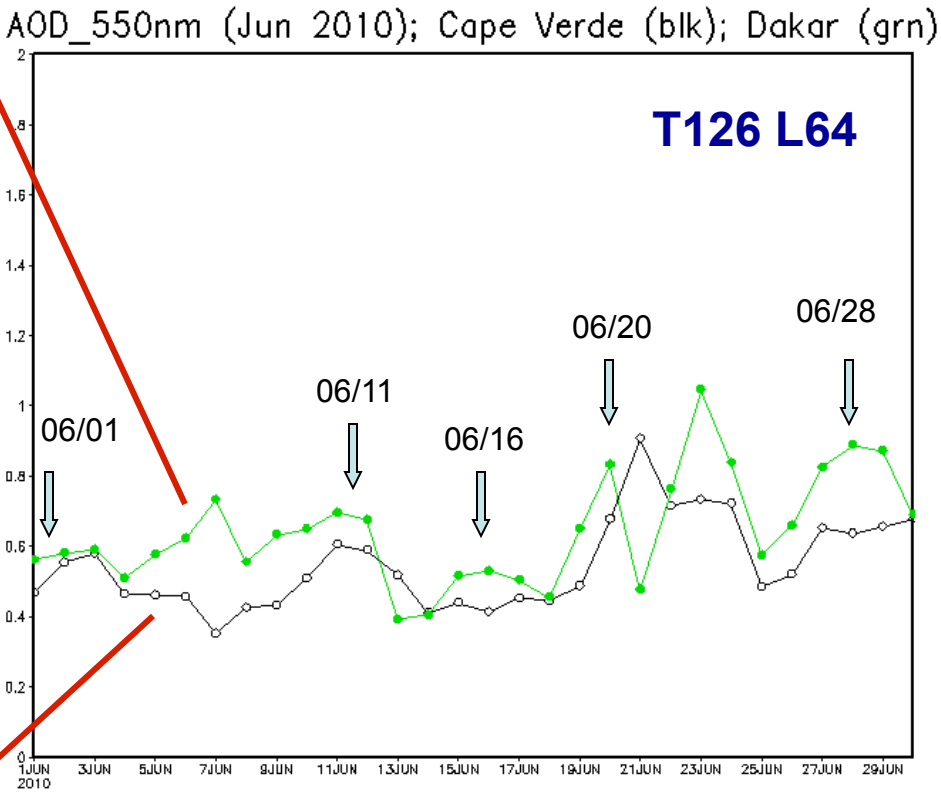


DATA: Giovanni online data system, developed and maintained by the NASA DISC

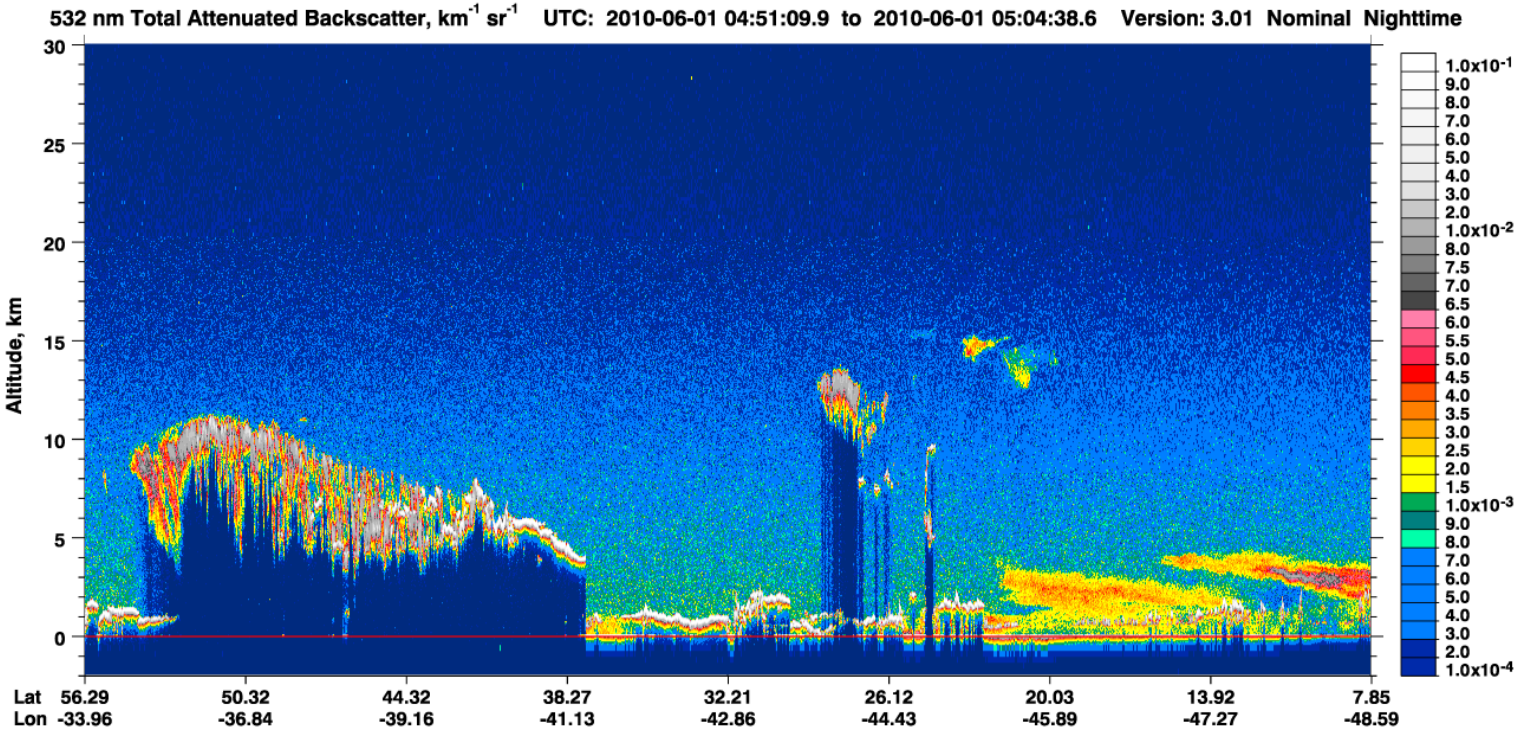


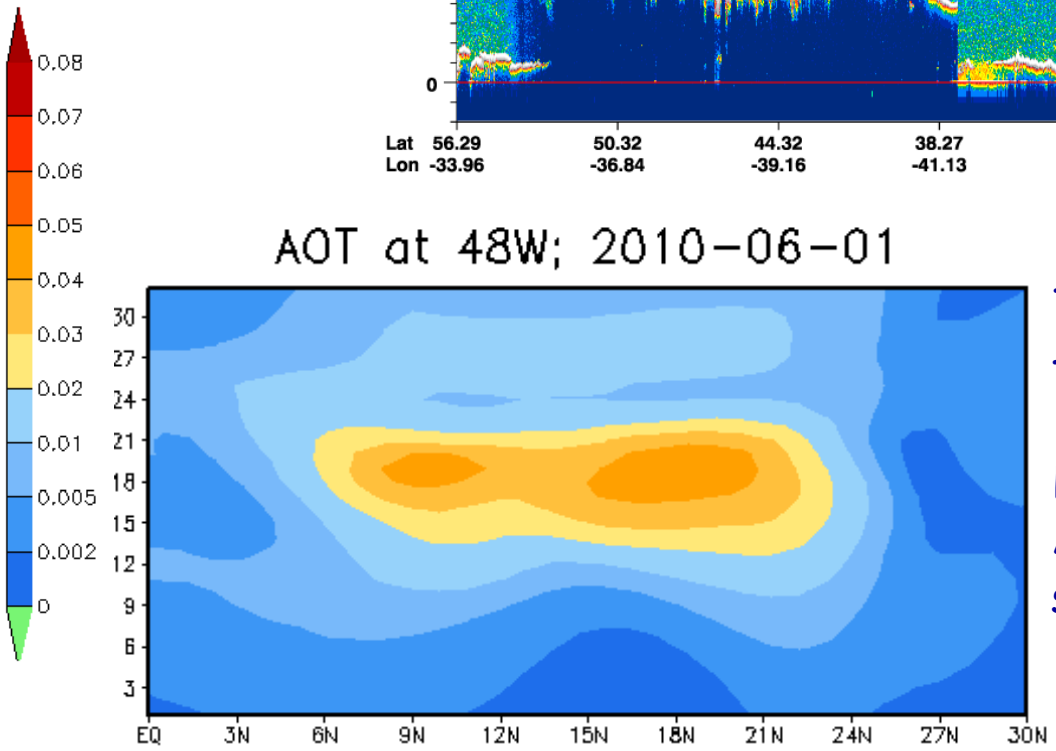


Time series of 550 nm AOD for June 2010 from AERONET sites (left) and dust-only NGAC (right)



We thank PI Didier Tanri for his effort in establishing and maintaining Dakar and Cape Verde sites.

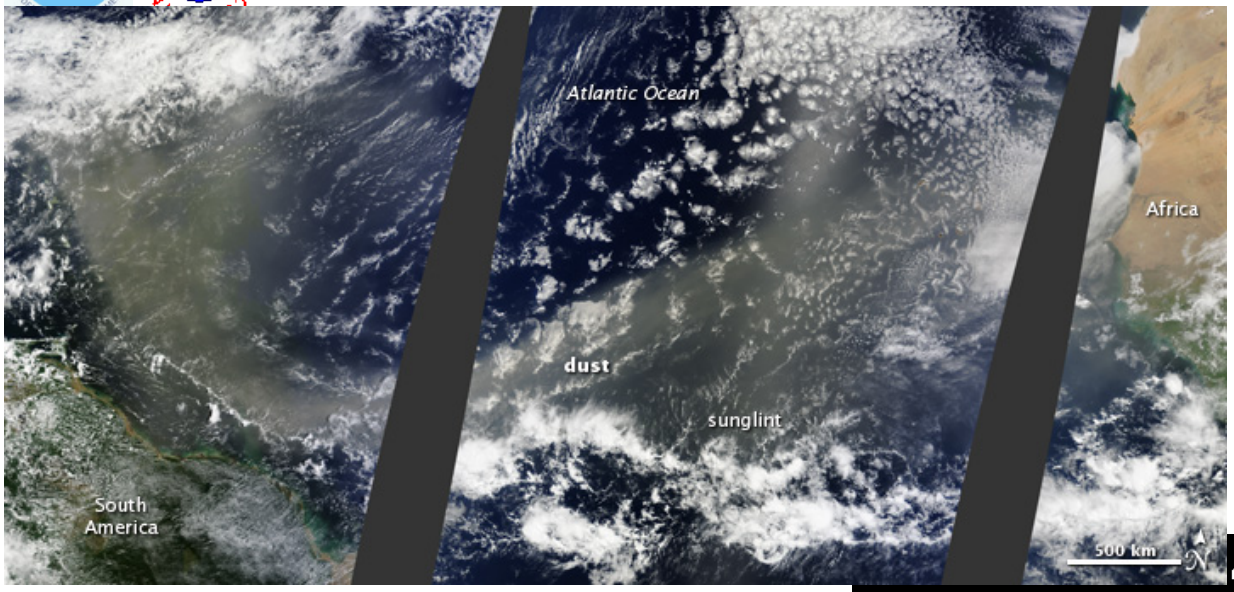


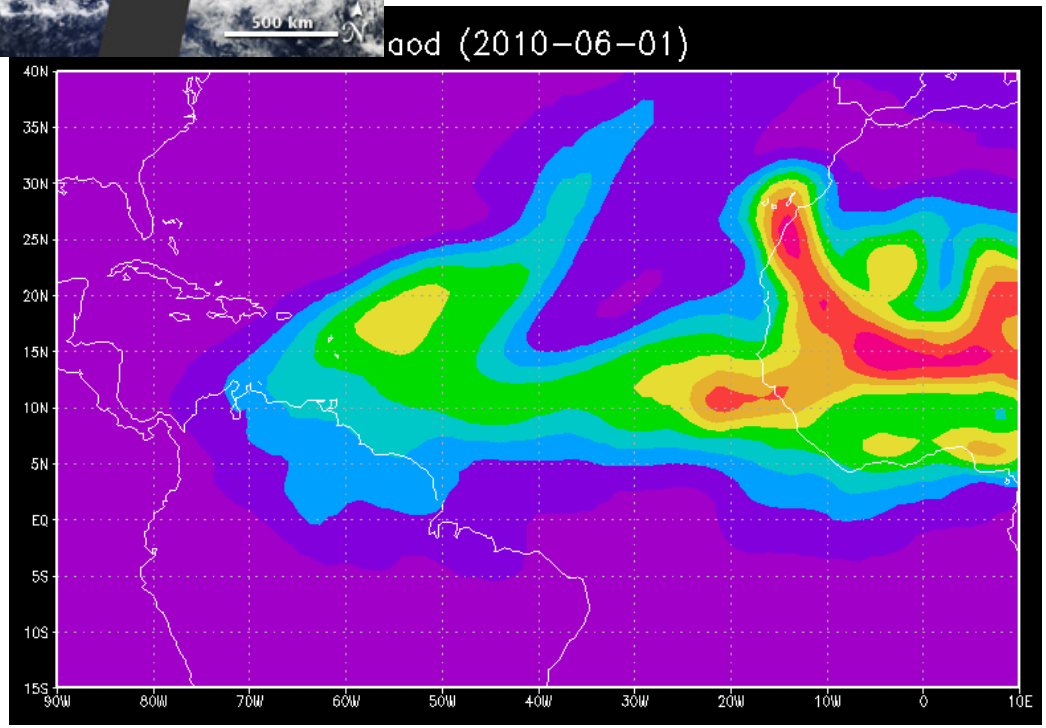


Top: Profile of 532 nm backscatter from CALIOP onboard CALIPSO

Bottom: Cross section of 550nm AOT at 48W from dust-only NGAC simulations

Saharan Dust Crosses the Atlantic





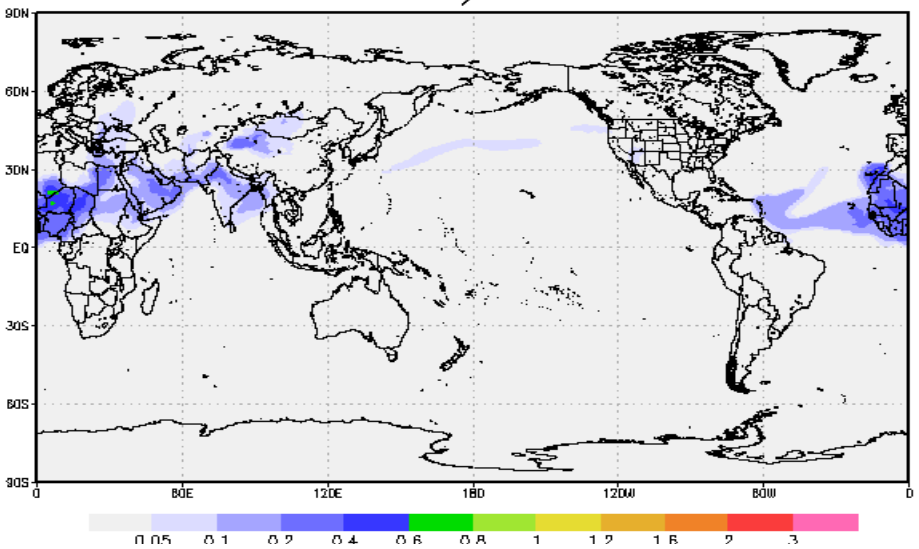
Left: MODIS on Terra

http://earthobservatory.nasa.gov

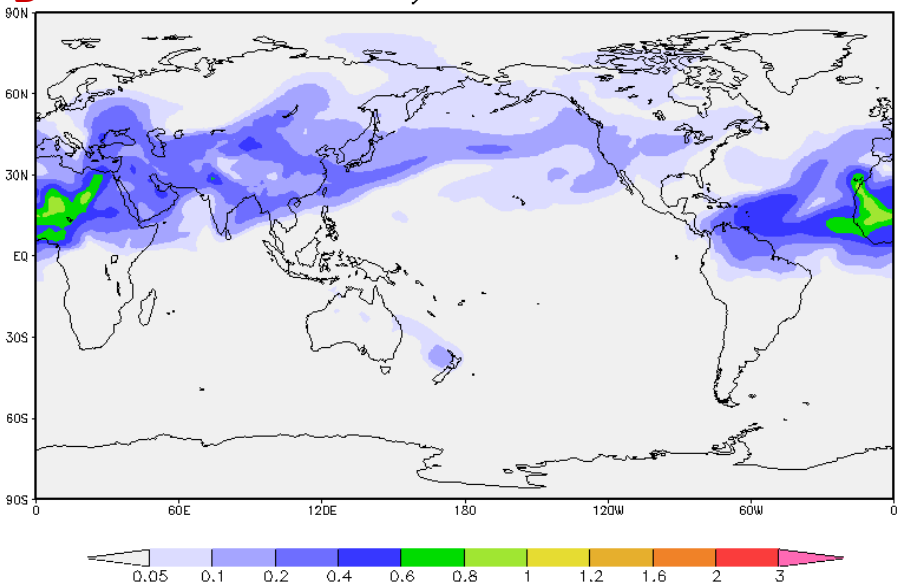
Right: AOD from NGAC

GFS-GOCART: In-line vs off-line

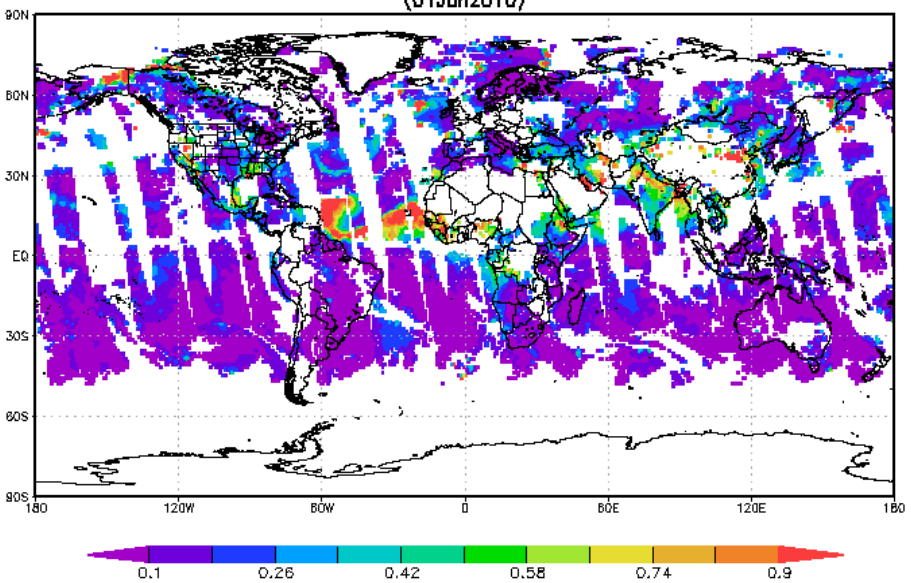
A



B



C



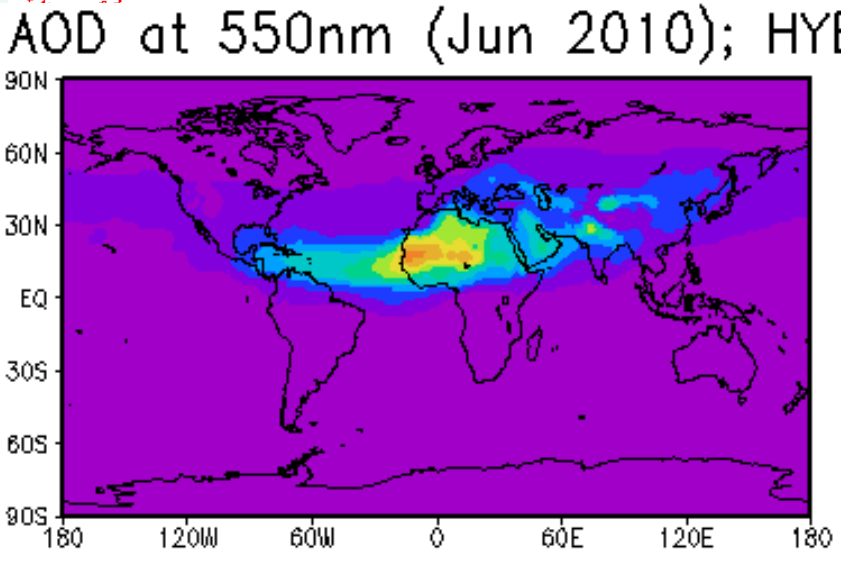
A. AOD at 500nm from off-line system
B. AOD at 550nm from in-line system
C. AOD at 550nm from MODIS

For the 2010-06-01 dust outbreak case, the in-line system agrees better with observations

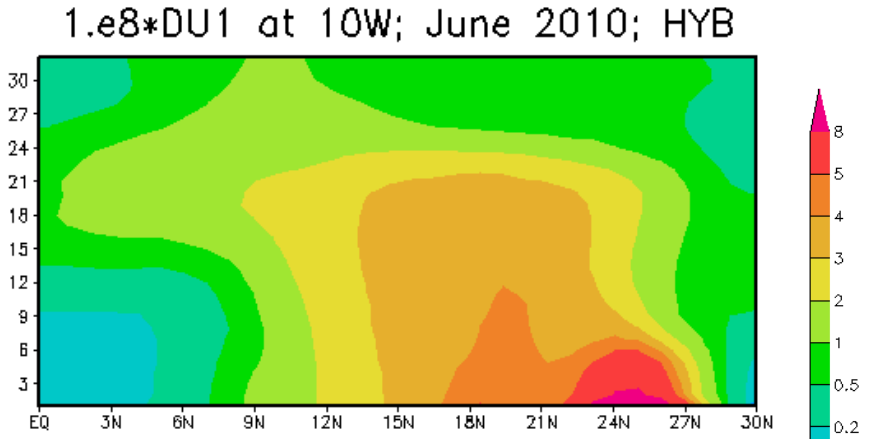
Next Steps

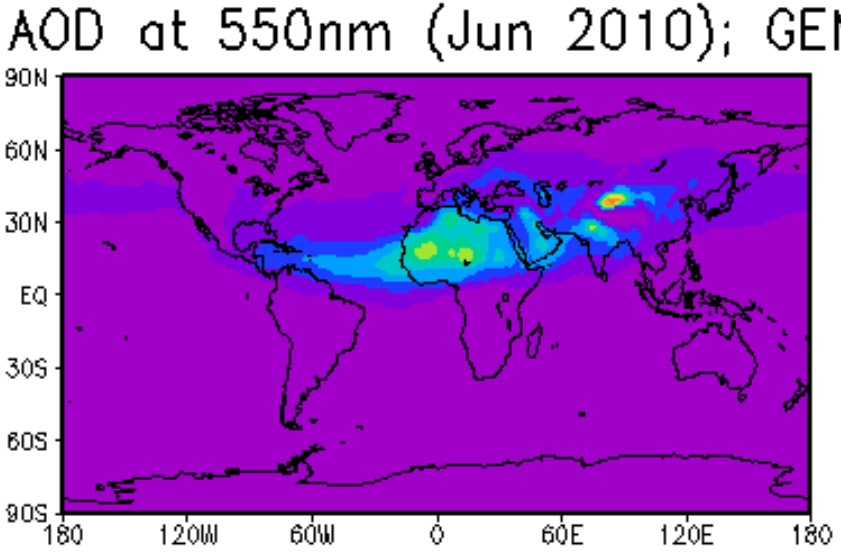
- Model evaluation to determine the model configuration
- Code optimization
- Set up NRT system for the operational implementation
- Set up aerosol verification system
- Adapt the non-iterating dimensional-splitting semi-Lagrangian (NDSL) advection scheme
- Adapt the NRT biomass burning emissions tested in the off-line system

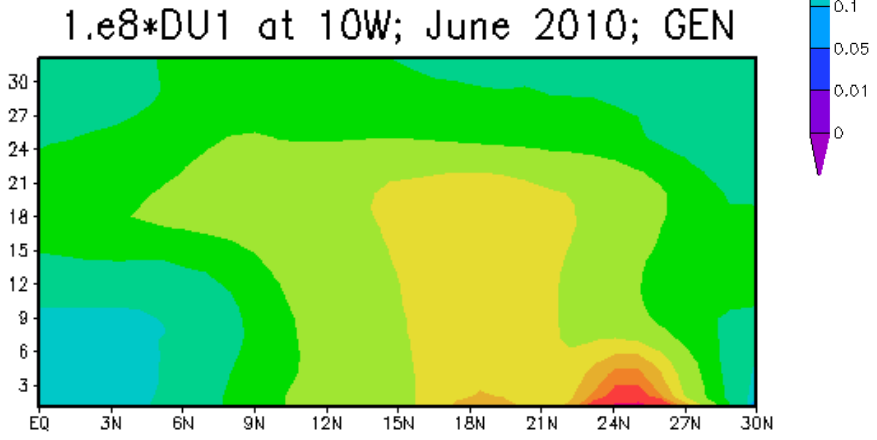
Sensitivity to dynamics (hybrid/σ vs general/θ)



Left: Monthly mean AOD distribution
Right: Cross section of dust mixing ration (bin 1) at 10W

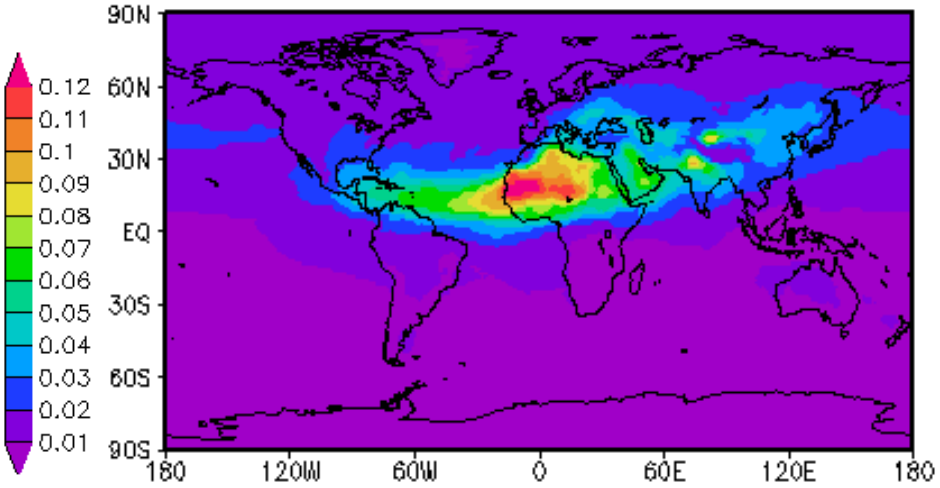






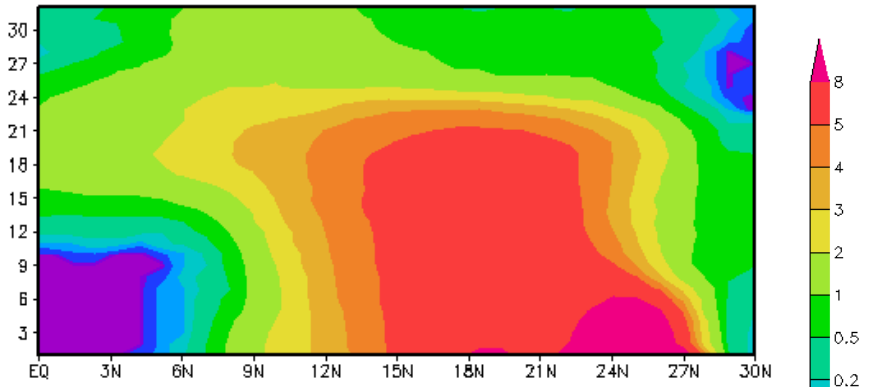
Sensitivity to physics (RAS vs SAS)

AOD at 550nm (Jun 2010); HYB_RAS

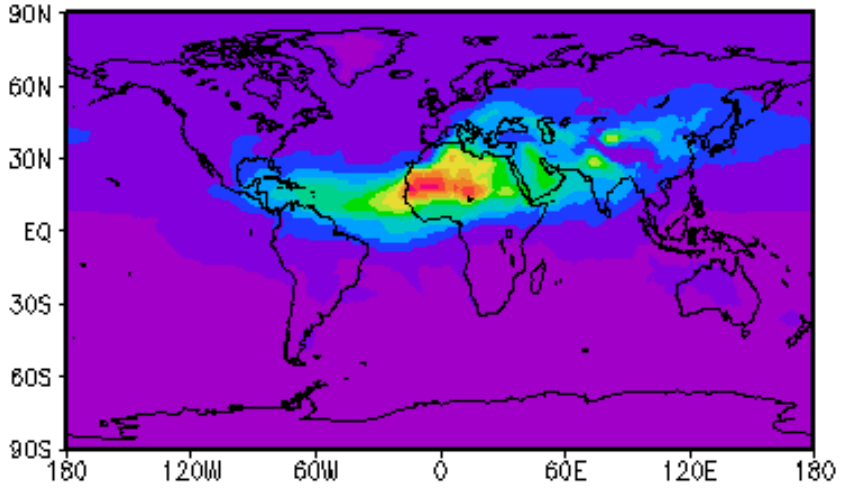


Left: Monthly mean AOD distribution
Right: Cross section of dust mixing ration (bin 1) at 10W

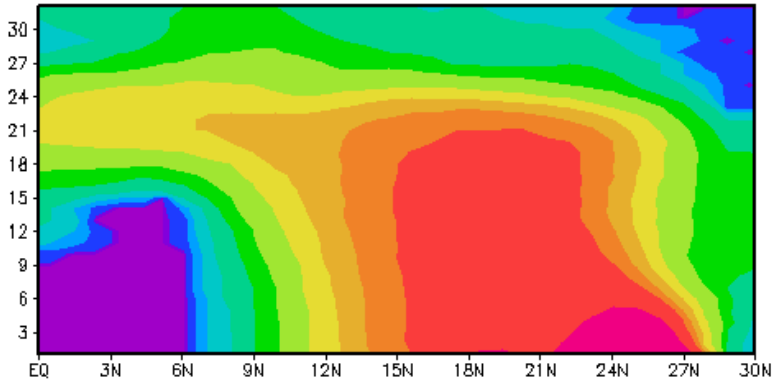
1.e9*DU1 at 10W; June 2010; HYB/RAS



AOD at 550nm (Jun 2010); HYB_SAS



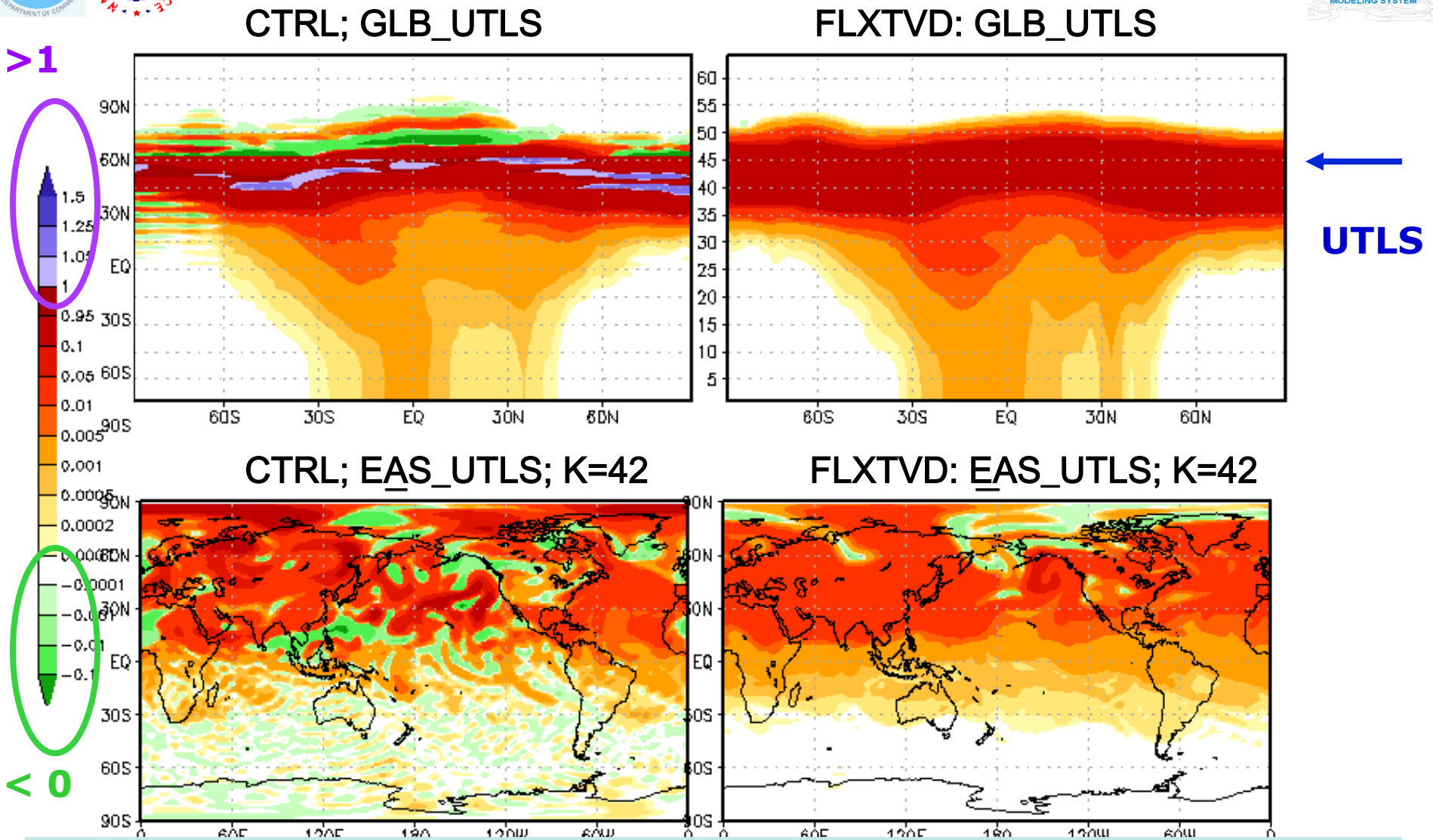
1.e9*DU1 at 10W; June 2010; HYB/SAS



Next Steps

- Model evaluation to determine the model configuration
- Code optimization
- Set up NRT system for the operational implementation
- Set up aerosol verification system
- Adapt the non-iterating dimensional-splitting semi-Lagrangian (NDSL) advection scheme
- Adapt the NRT biomass burning emissions tested in the off-line system

NEMS GFS tracer experiment



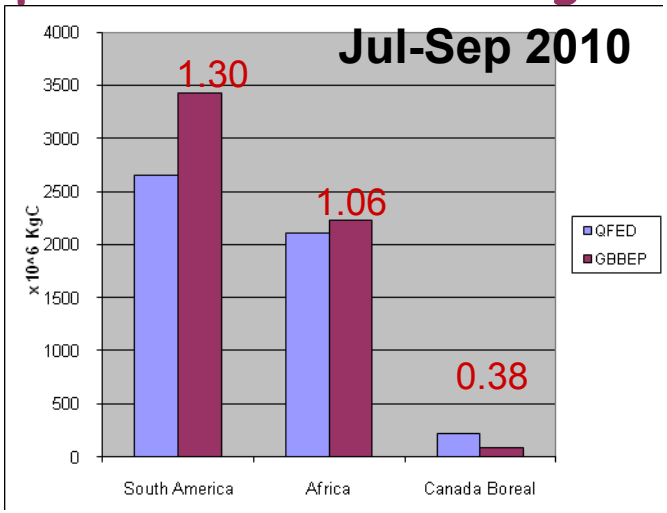
- Flux-limited vertical advection reduces (but does not eliminate) negative tracer values caused by spectral transform.
- Semi-Lagrangian schemes (positive definite advection with mass conserving) are under the development

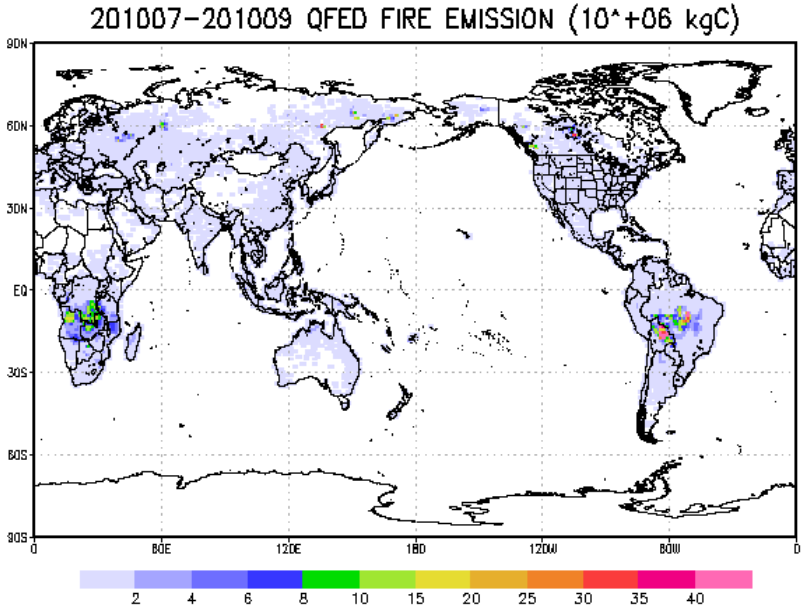
Next Steps

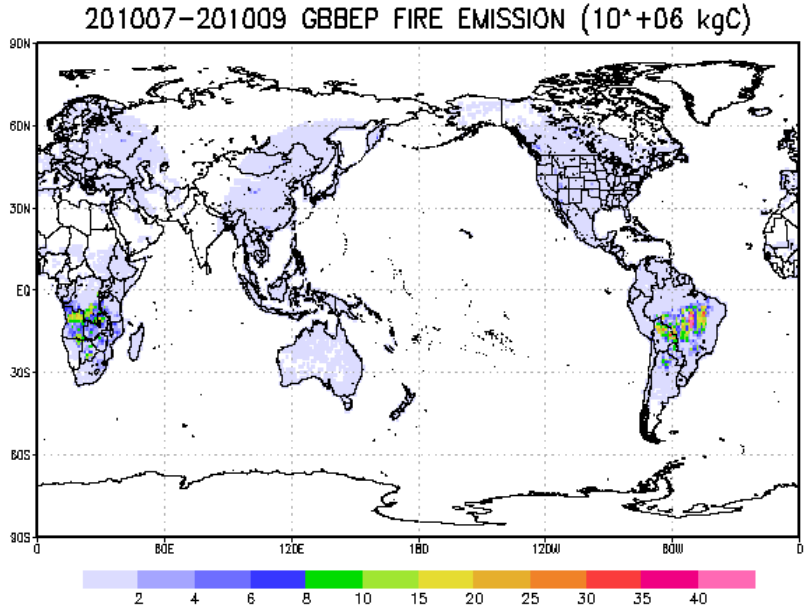
- Model evaluation to determine the model configuration
- Code optimization
- Set up NRT system for the operational implementation
- Set up aerosol verfication system
- Adapt the non-iterating dimensional-splitting semi-Lagrangian (NDSL) advection scheme
- Adapt the NRT biomass burning emissions tested in the off-line system

Satellite observations provide a choice of near-real time and global fire emissions dataset for operational forecasting

- **NASA Quick Fire Emission Dataset version 1 (QFED)** using MODIS fire counts onboard Aqua and Terra.
- **NOAA/NESDIS Global Biomass Burning Emissions Product (GBBEP)** using Fire Radiative Power observed from a constellation of geostationary satellites (GOES, MetoSAT, and MTSAT)
- QFED has smaller area of detected fires but with stronger carbon emissions.
- There is a limited coverage for geostationary satellites at high latitudes.

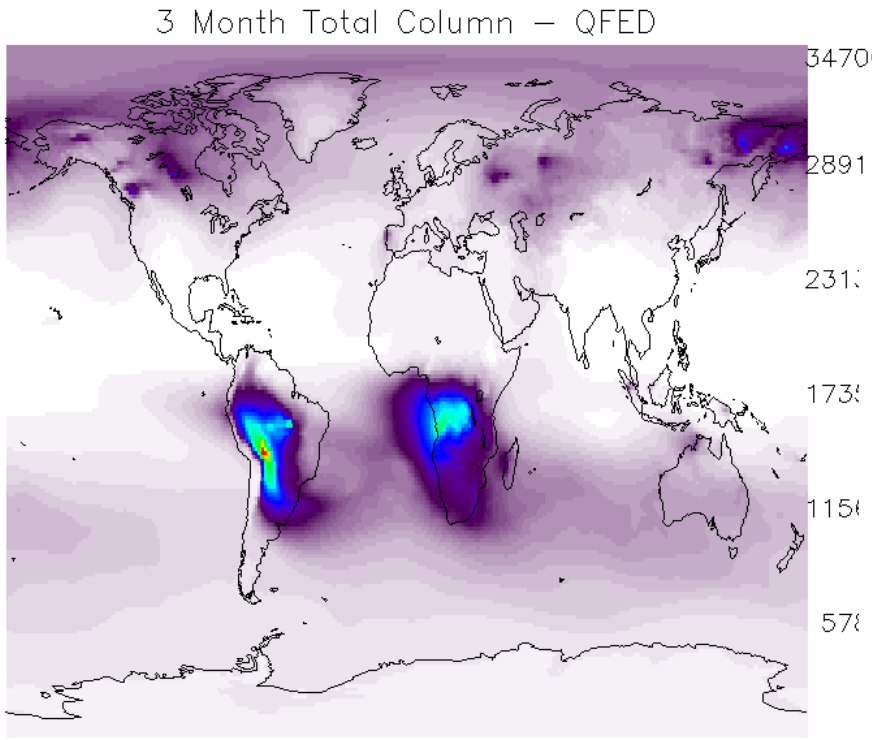


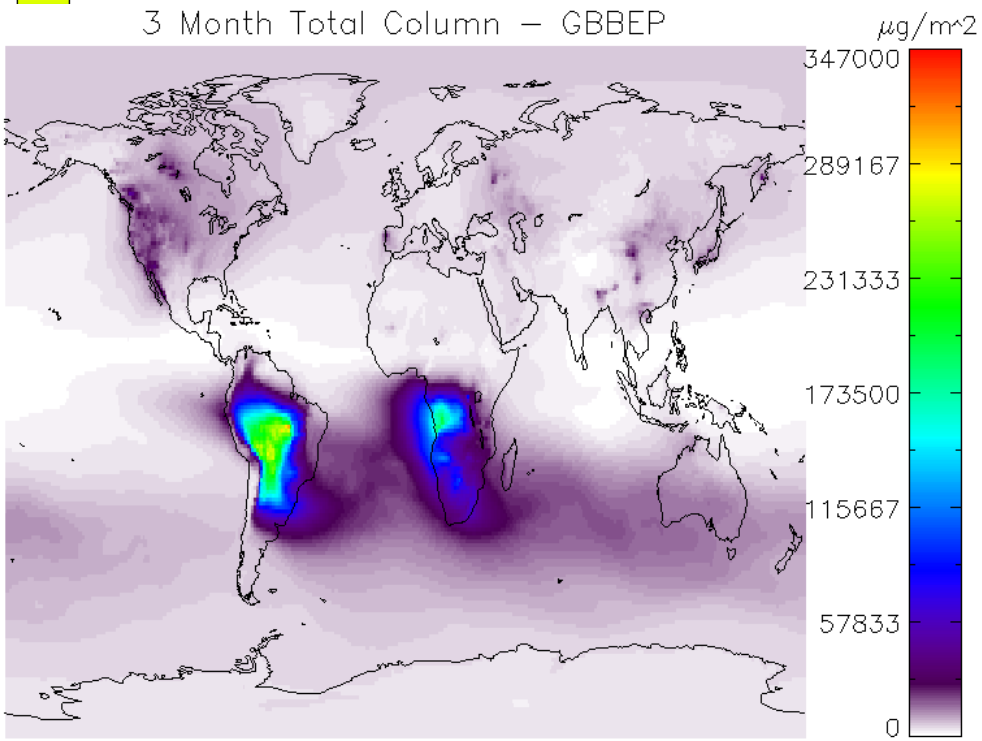




Ho-Chun Huang

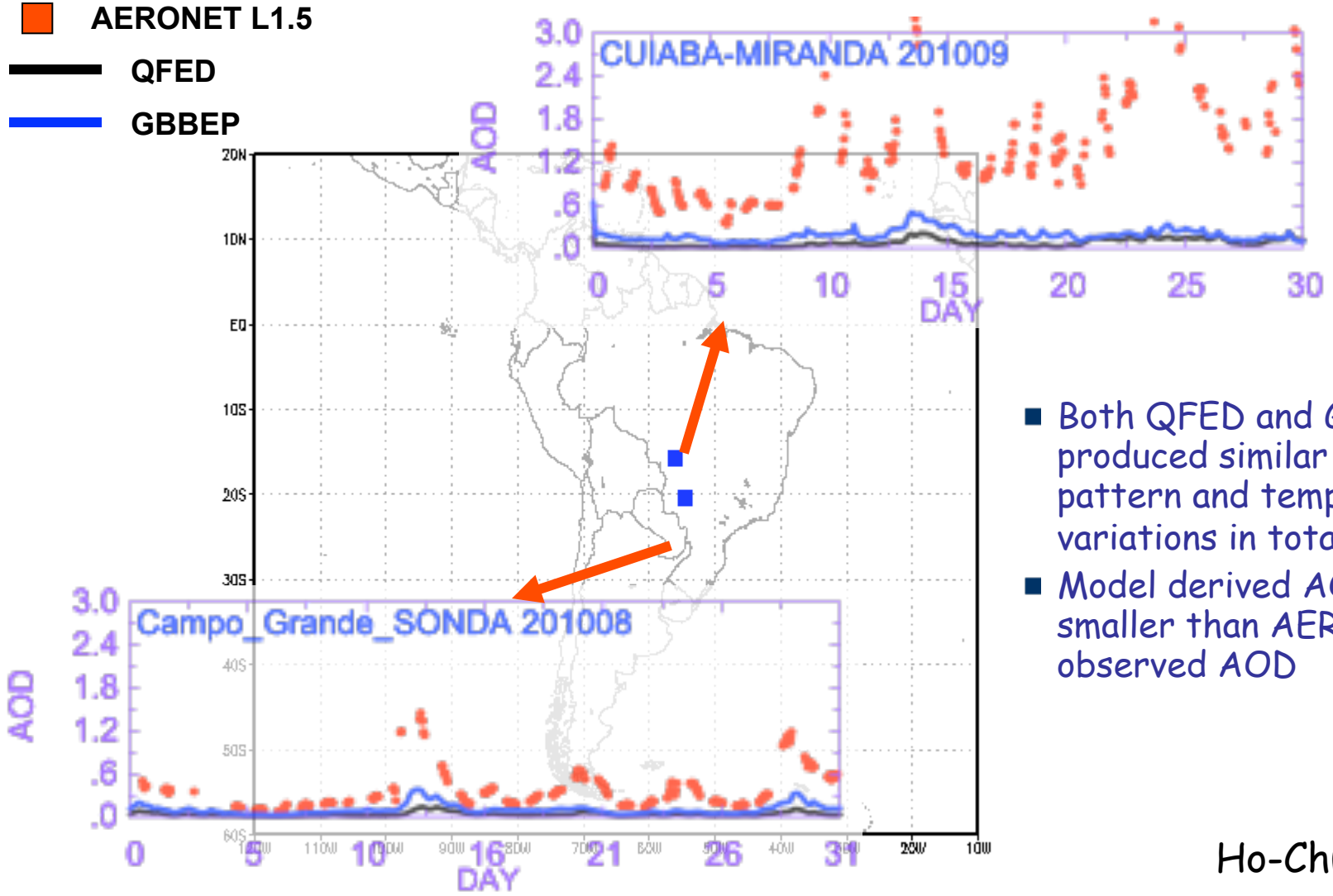
Atmospheric carbon loading from off-line GFS-GOCART simulations using QFED and GBBEP





Ho-Chun Huang

The comparison between AOD observed at AERONET sites and AOD derived from off-line GFS-GOCART simulations using QFED and GBBEP



- Both QFED and GBBEP produced similar spatial pattern and temporal variations in total carbon
- Model derived AOD are much smaller than AERONET observed AOD

Ho-Chun Huang

Outcomes of the new aerosol element include the following aspects:

- Prototype system for NEMS-CHEM
- Enable NCEP to produce global short-range chemical weather forecasts
- Provide lateral aerosol boundary conditions for regional air quality forecast system
- Create aerosol information needed for atmospheric correction in satellite retrievals
- Provide a first step toward an aerosol data assimilation capability at NCEP
- Allow NCEP to explore aerosol-chemistry-climate interaction in the climate system, noting GFS is the AGCM of NCEP coupled system


NOAA
NATIONAL WEATHER SERVICE


NCEP
NEMS
NOAA ENVIRONMENTAL MODELING SYSTEM

Thank You