Global aerosol forecasting and data assimilation in GFS/GSI

Overview, Work Plan and Progress Update

Sarah Lu, Ho-Chun Huang, Jeff McQueen, Yu-Tai Hou (NCEP)
Mian Chin and Arlindo da Silva (GSFC)

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Contributions from..

- **NOAA**
  - NCEP:
    - Steve Lord, Mark Iredell, Shrinivas Moorthi, John Derber, Russ Treadon
  - NESDIS:
    - Shobha Kondragunta
  - NWS:
    - Paula Davidson
  - OAR:
    - Steve Fine
- **JCSDA**
  - Paul van Delst, Quanhua Liu, Yong Han, Xu Li
- **OAR/EPA**
  - Rohit Mathur, Ken Schere

NCEP global aerosol forecasting and data assimilation

- **OVERVIEW**
  - Create an integrated operational system for forecasting and improved assimilation of atmospheric chemistry
- **GOAL**
  - Generate an optimal (accurate and affordable) description of the global distribution of atmospheric aerosols
  - Provide improved air-chemistry forecasts, through improved use of satellite data
- **APPROACH**
  - Incorporate prognostic aerosols (NASA GOCART) in NCEP GFS/CFS
    - Off-line non-interactive (**EMC AQ project**)
    - In-line interactive (**JSDI project**)
  - Assimilate aerosol measurements (radiance) in JCSDA Gridpoint Statistical Interpolation system (GSI)
  - Leverage common modeling framework and shared software development
    - Earth Systems Modeling Framework **(ESMF)**
    - Joint Center for Satellite Data Assimilation **(JCSDA)**

Aerosol products and applications

Products	Usage
4D distribution of aerosol concentrations	Initial and boundary conditions for regional air quality models
4D distribution of aerosol optical properties	Atmospheric corrections for remote sensing of land surfaces and ocean
Surface distribution of particulate matter PM	Regional air quality
Improved surface, atmospheric, and top-of-atmosphere radiative budget	Climate research

An end-to-end work plan

- **Adoption of GOCART modeling components**
    - Modified GFS/CFS radiation module to include aerosol impacts
    - Expanded the number of GFS tracer to include aerosols
   - Develop ESMF interface for coupling GFS and GOCART

- **Utilization of satellite aerosols measurements**
    - Provided Model-Predicted aerosol field to develop and implement aerosol module in the CRTM (by the JCSDA/CRTM group, Quanhua Liu et al.)
    - Develop aerosol assimilation capability in GSI

- **Integration of global aerosol products in NOAA modeling systems**
    - Couple global aerosol products with GFS/GSI, CMAQ-NAM and SST analysis system
    - Optimize configuration to fit operational requirements

GOCART Grid Component

Sources

Chemistry/ Transformation

Sinks

Dust	**Depends on surface winds**		

Topographic Source
4 size classes 0.1 – 6 μm radius

Improved representation of sub-micron particles
5 size classes 0.03 – 10 μm dry radius

Sea salt

Swelling by RH

Sedimentation
Dry deposition
Wet removal

DMS

Based on measured sea surface concentration

Chemistry

Oxidation to SO_2

SO_2

Anthropogenic
Biomass burning
Oxidation of DMS w/ OH and NO_3

Chemistry
Dry deposition
Wet removal

Oxidation to SO_4

SO_4

Anthropogenic
Biomass burning
Oxidation of SO_2 w/ OH and
Aqueous reaction with H_2O_2

Dry deposition
Wet removal

Fractionation of Hydrophobic & Hydrophilic Components

BC/OC

Biomass burning
Biofuel
Anthropogenic, other
Biogenic OC

Dry deposition
Wet removal
(hydrophilic only)

Arlindo da Silva (GMAO)

ESMF Component Framework

Mark Iredell (NCEP)
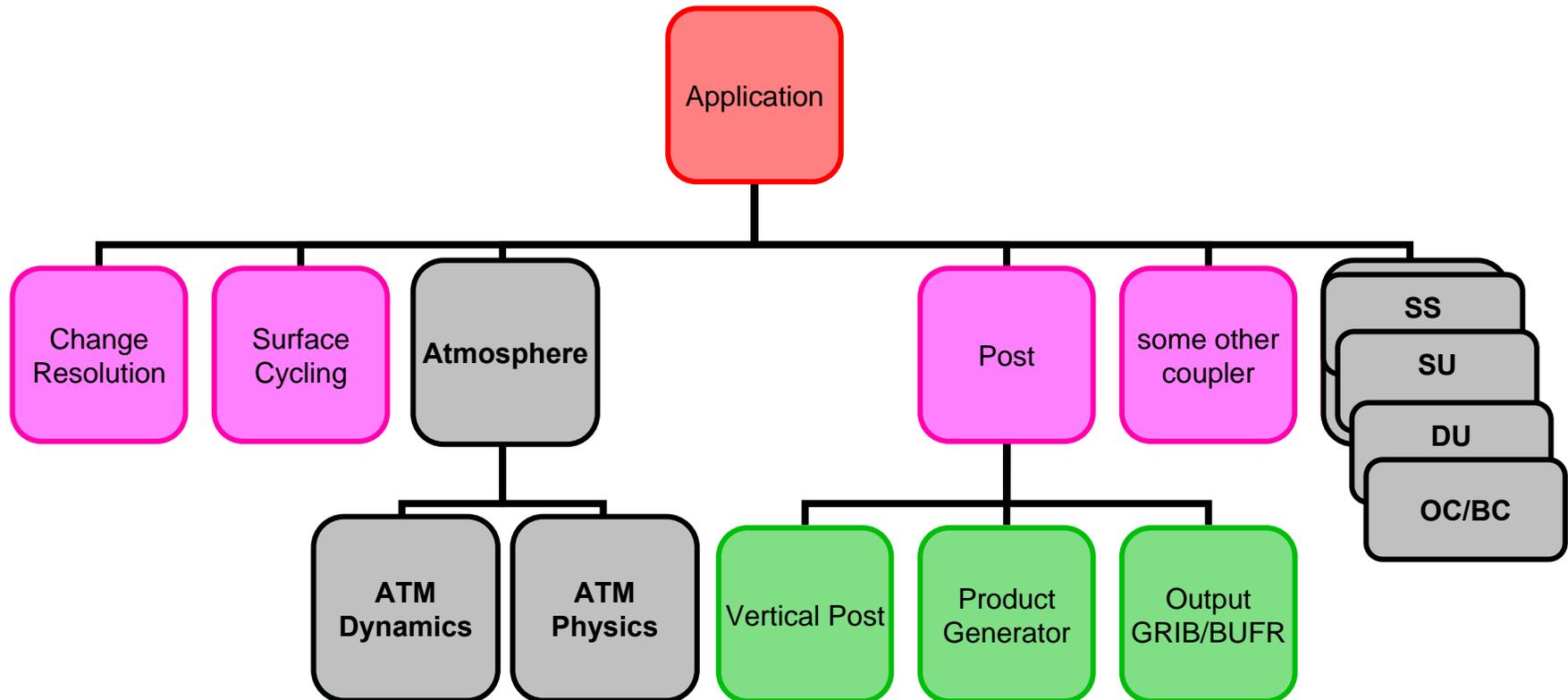
Initial aerosol forecasting system

GFS/CFS forecast from T_0 ————————————→

            ↓ **Communication of dynamics info**

GOCART forecast from T_0 – – – – – – – – →

              ↓ **Communication of chemical info**

GFS/CFS forecast from T+ ————————————→

                 ↓

GOCART forecast from T+ – – – – – – – – – – →

                   ↓
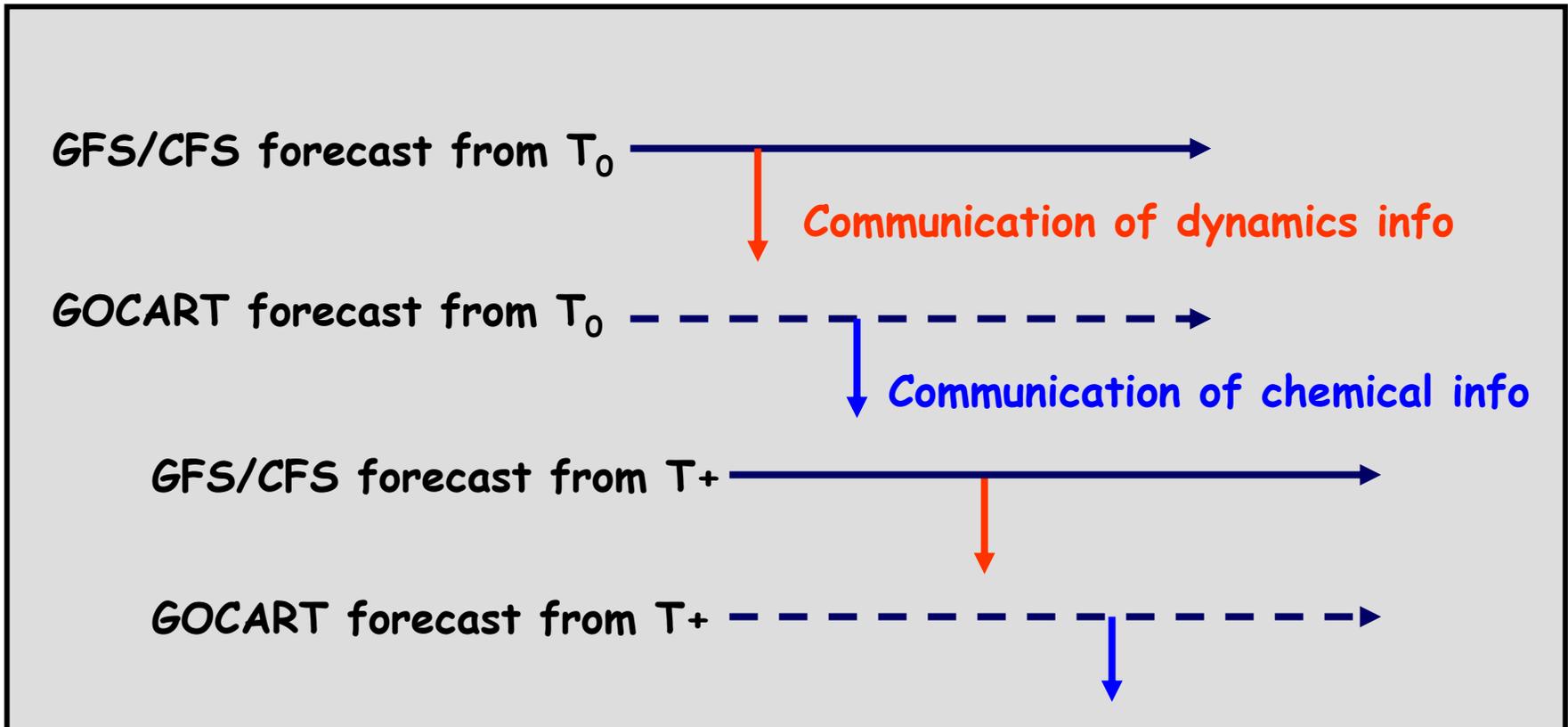
- Initially chemistry will not interact with meteorology
- 3D couplers not yet built for ESMF (awaiting gridded GFS)

Developments and Applications

Provide GFS/GSI aerosol fields

GFS

GOCART

3-D global Aerosols particles distribution

Verification - AOD & vertical Profile from satellite and in-situ measurements

Chemical and PM BCs for regional AQF (CMAQ-NMM)

A global PM forecasting system for operational AQ forecasters
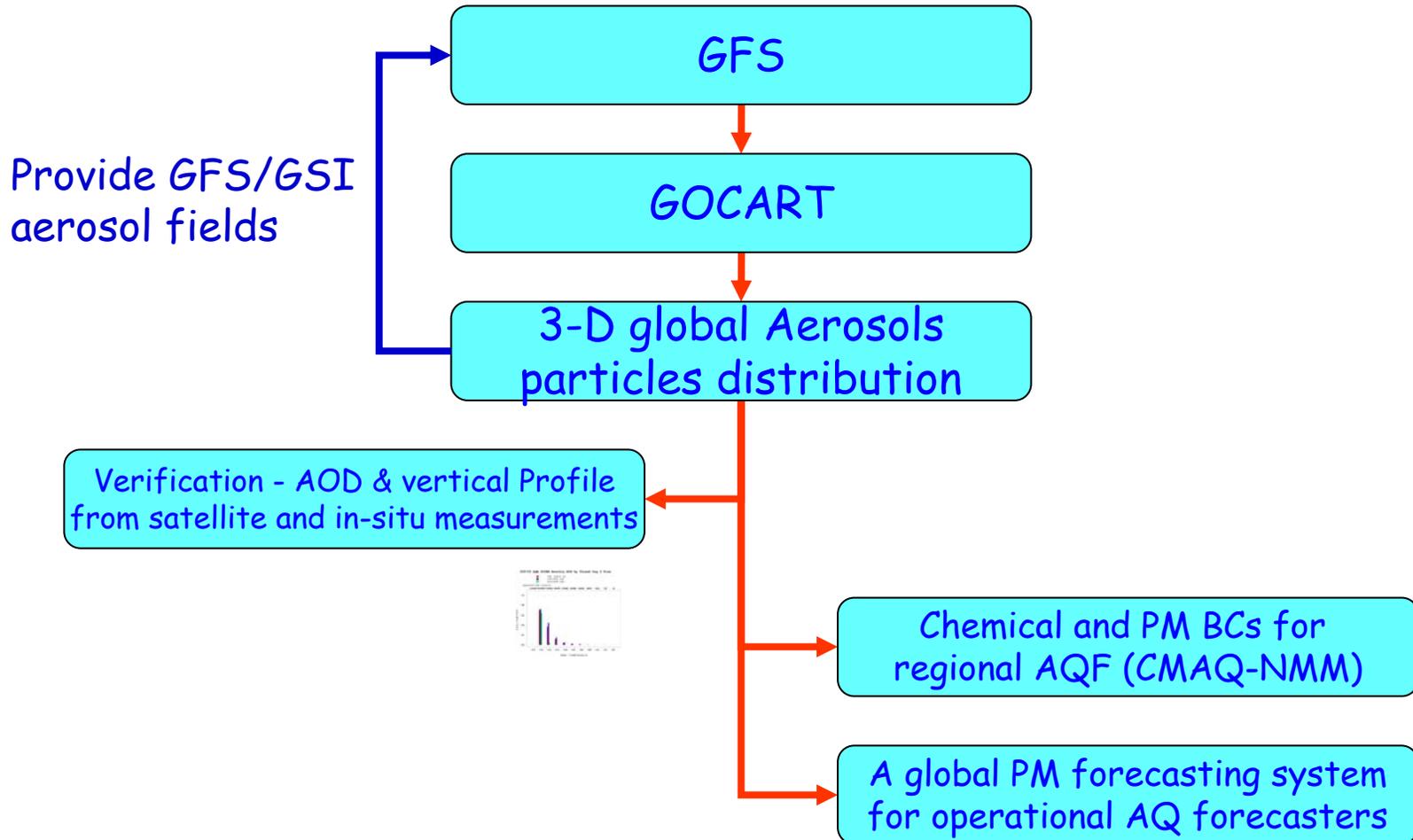
Aerosol effect on HIRS brightness temperature retrieval

Aerosol Effect on hirs3_n17

Quanhua Liu, JCSDA workshop 2007
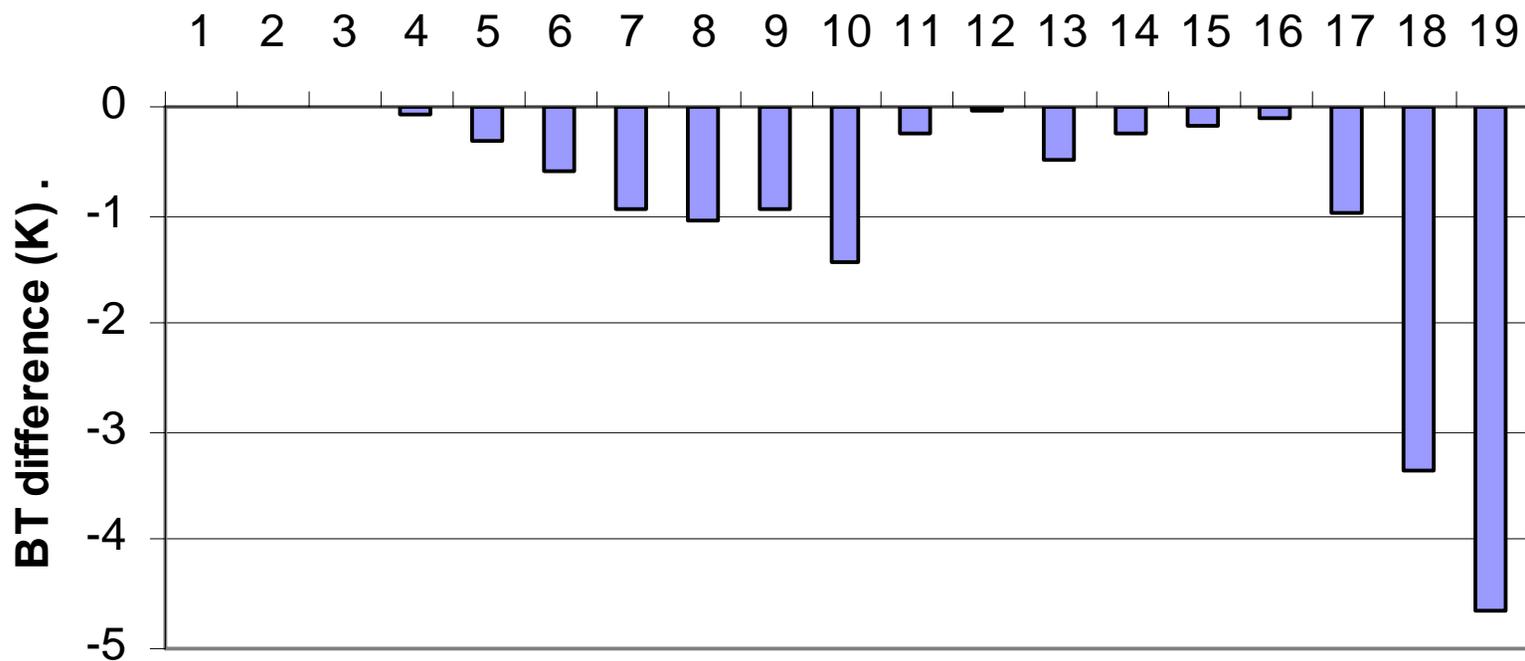
Preliminary CFS results

- **NCEP Climate Forecast System (CFS)**
  - AGCM : GFS
  - Ocean model: MOM3
- **CFS experiments**
  - 3-year runs (from 2002/01 to 2004/12)
  - Resolution: T126 L64
 - Output every 6 hr
  - Two runs:
    - Ctr: OPAC-based aerosol climatology (5° x 5°)
   - Exp: GOCART aerosol fields (2.5° x 2°; 30 lvl)
- The global impact and regional influence due to different background aerosol loading are presented.

T2m Difference
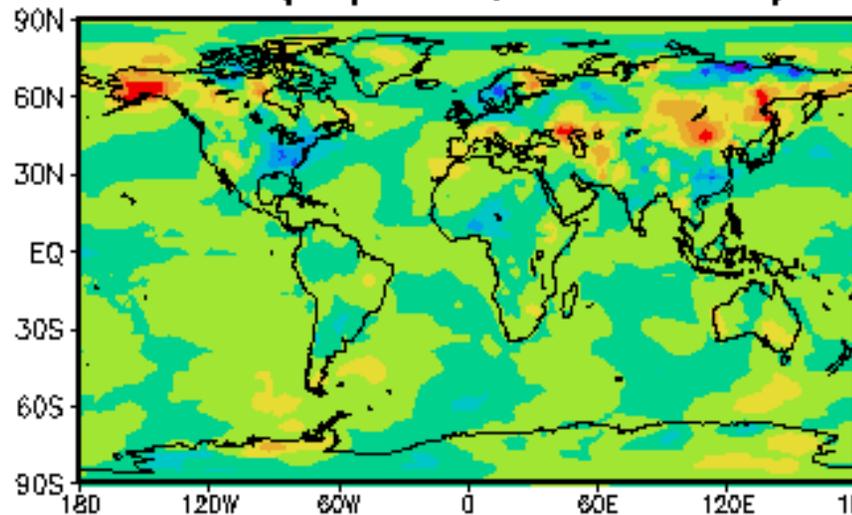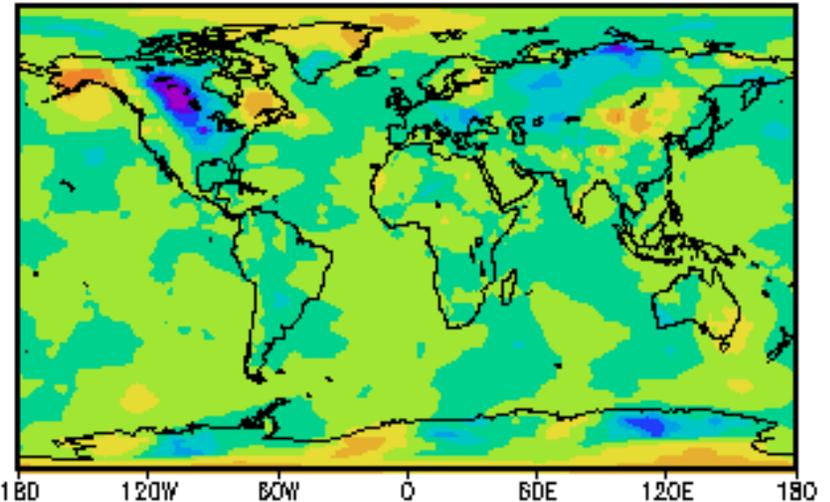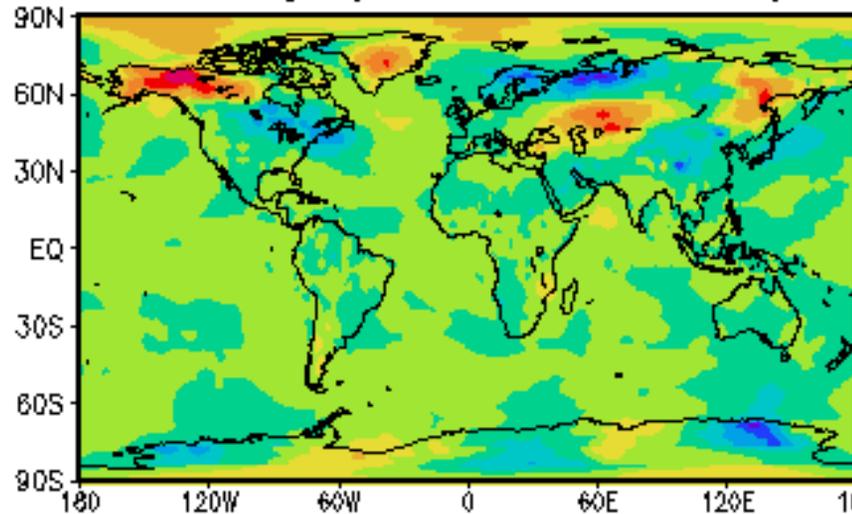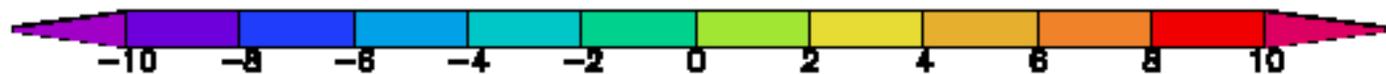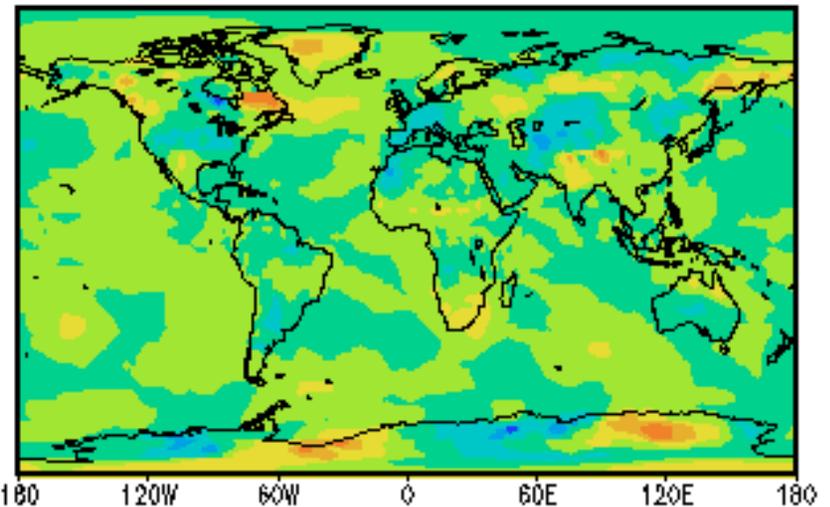
U-wind Cross Section at 10W
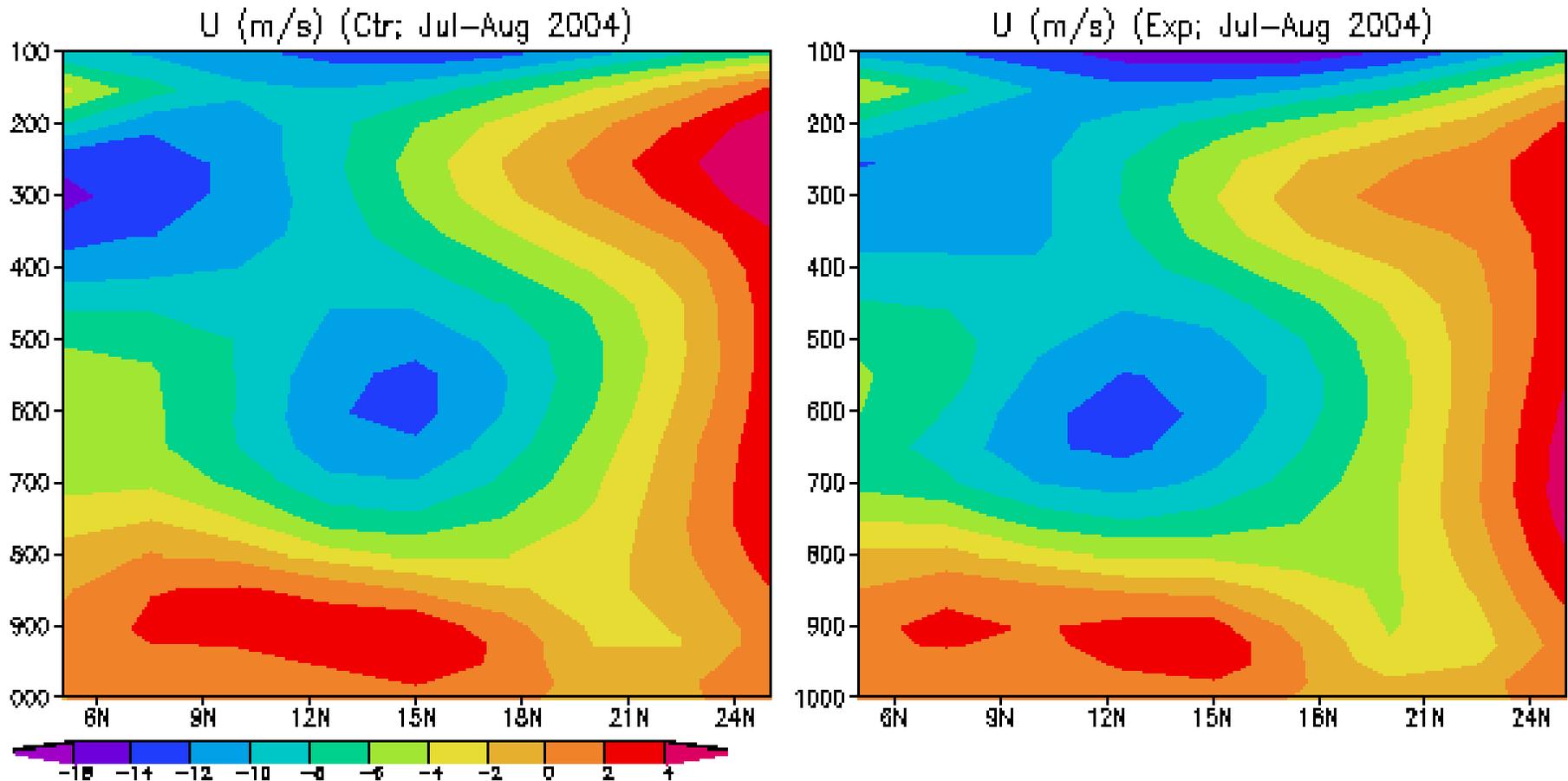
The intensity and location of African Easterly Jet are affected by background aerosol loading (via direct radiative effect)

Summary

FY06 activities

- Restructured GFS to be "GOCART-ready": modified the radiation module and expanded the tracer transport to include additional GOCART aerosol species
- Preliminary impact assessment: Conducted model sensitivity studies to evaluate the impact of different background aerosols on the GFS/CFS.
- Provided a unified approach for treatment to conform CRTM aerosol module with GFS aerosol component (ensure consistent development)
- Initial GFS-GOCART off-line linkages begun
  - Additional land-sfc, convection, radiation fields

FY07 planned activities

- Prototype GFS-GOCART system
- Benchmark studies of global aerosol simulations
- Assimilate aerosol measurements (radiance) in GSI

Thank You