NOAA/NWS/NCEP Atmospheric Constituent Prediction Capability – Status, Progress, and Observational Requirements

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Atmospheric Composition Forecasting Working Group: Aerosol Observability
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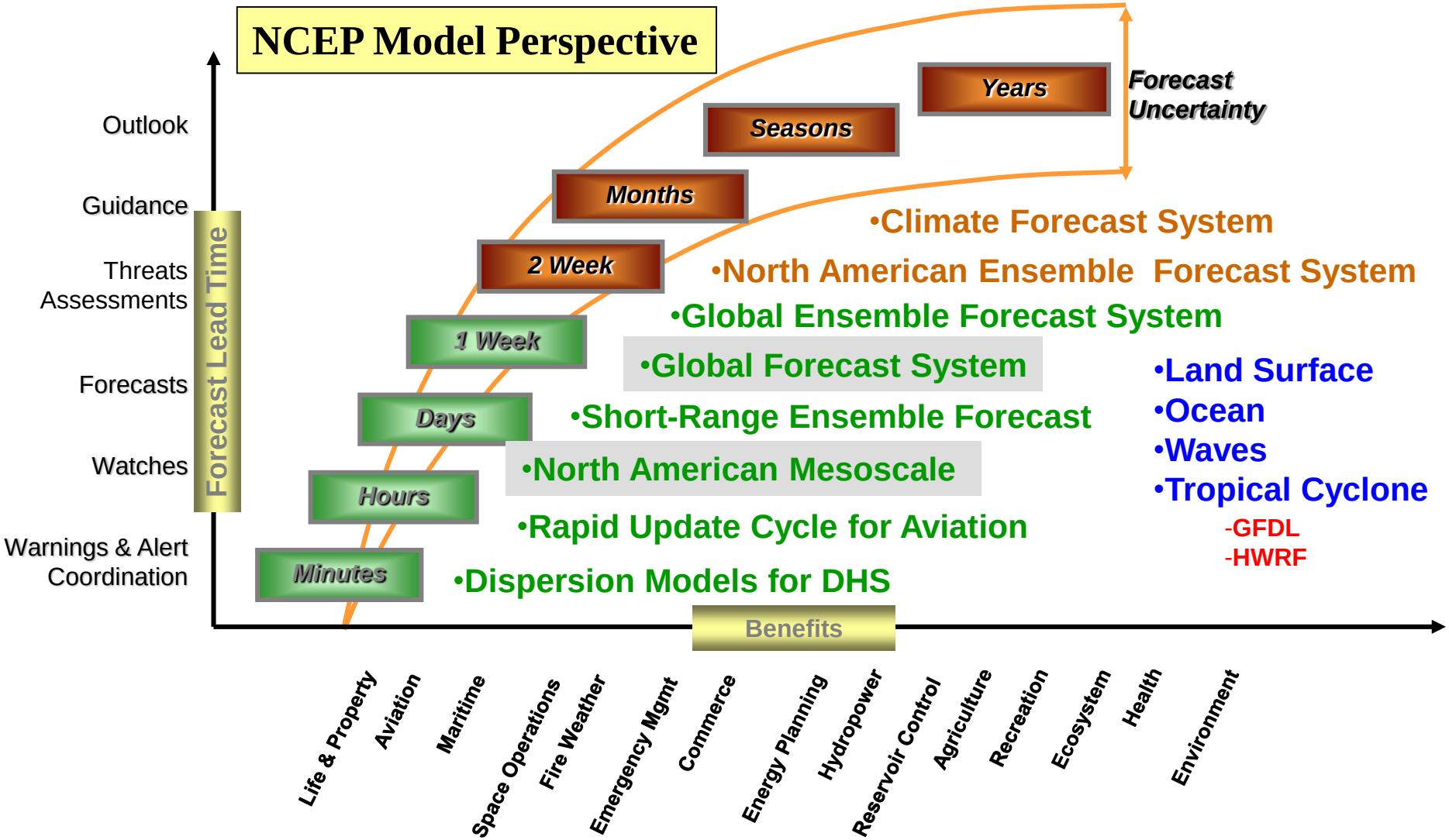
Outline

- NCEP global and regional prediction systems
- Air quality prediction systems
- Data assimilation plans and requirements
- Summary

NWS Seamless Suite of Forecast Products Spanning Weather and Climate



Global Forecast System (GFS)

RESOLUTION

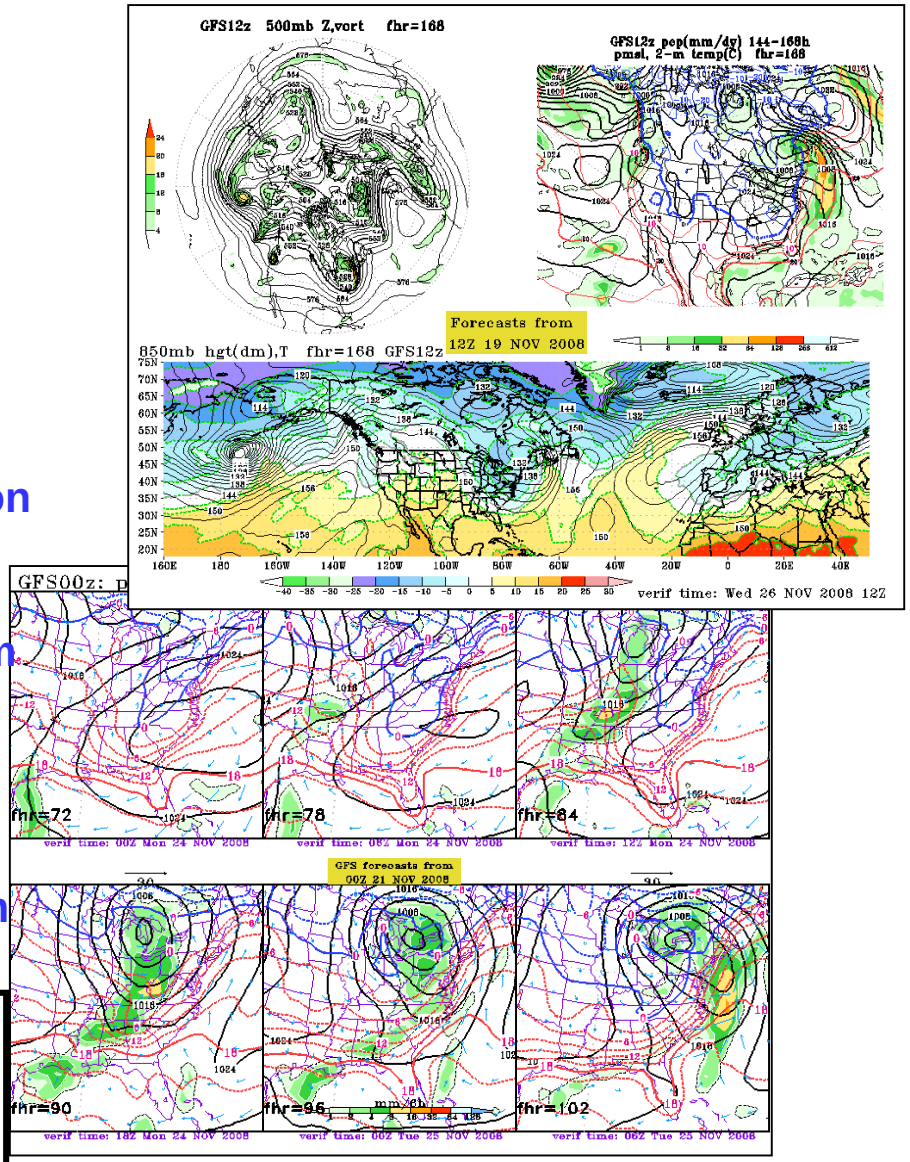
- T382 horizontal resolution (~ 37 km)
- 64 vertical levels (from surface to 0.2 mb)

MODEL PHYSICS AND DYNAMICS

- Vertical coordinate changed from sigma to hybrid sigma-pressure
- Non-local vertical diffusion
- Simplified Arakawa-Schubert convection scheme
- RRTM longwave radiation
- NCEP shortwave radiation scheme based on MD Chou's scheme
- Explicit cloud microphysics
- Noah LSM (4 soil layers: 10, 40, 100, 200 cm depth)

INITIAL CONDITIONS (both atmosphere and land states)

- NCEP Global Data Assimilation System



- 4 Cycles per day
- T382(~35km) to 7.5 days
- T190(~70km) to 16 days

GSI 3D-VAR/GFS Plans for FY10

- **Data Assimilation (Implemented 17 December 2009)**
  - **Assimilate:**
    - **NOAA-19 AMSU-A/B, HIRS**
    - **RARS 1b data**
    - **NOAA-18 SBUV/2 and OMI**
  - **Improved use of GPS RO observations**
    - **Refractivity forward operator**
    - **Allow more observations, in particular in the tropical latitudes, due to better QC checks for COSMIC data**
    - **Better QC procedures Metop/GRAS, GRACE-A and CHAMP**
- **Modify GFS shallow/deep convection and PBL (17 June 2010)**
  - **Detrainment from all levels (deep convection)**
  - **Testing at low resolution shows reduction in high precipitation bias**
  - **PBL diffusion in inversion layers reduced (decrease erosion of marine stratus)**
- **GSI/GFS Resolution (17 June 2010)**
  - **Working towards T574 (~28km) & 64 L (Operational Parallel Running)**
  - **T190 (~70km) from 7.5 to 16 days**

NOTE: ECMWF at T1279 (~16km) with 91 levels

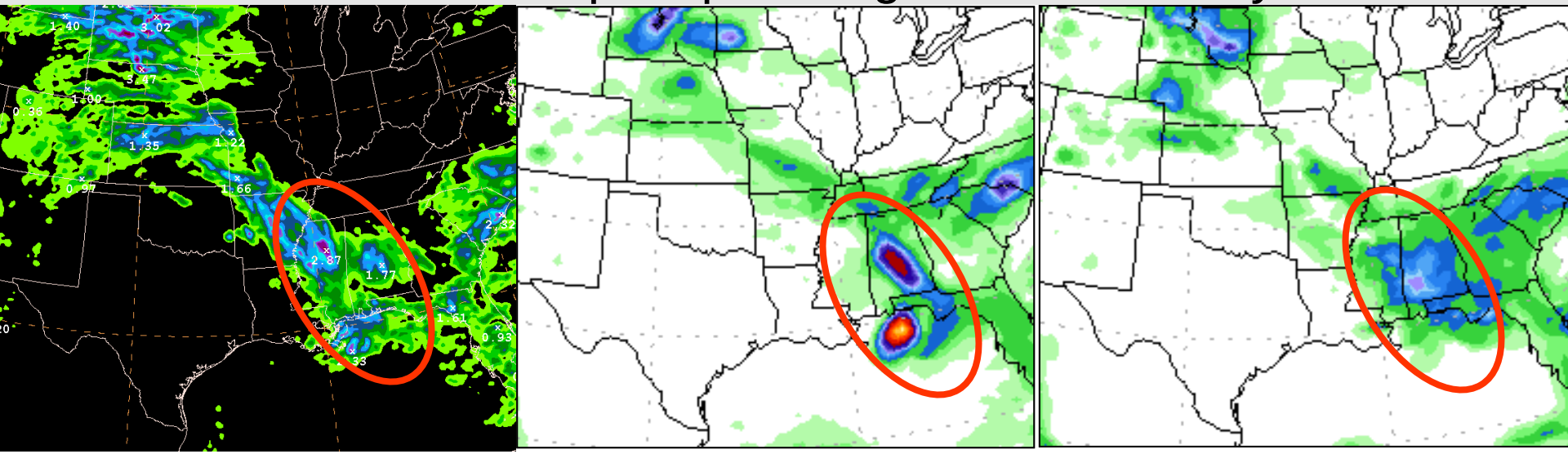
GFS Plans for FY10

Scheduled June 2010

- **Modify GFS shallow/deep convection and PBL**
  - Detrainment from all levels (deep convection)
  - PBL diffusion in inversion layers reduced (decrease erosion of marine stratus)

- **GSI/GFS Resolution**
  - T382 (~35km) to T574 (~28km) & 64L

24 h accumulated precip ending 12 UTC 14 July 2009



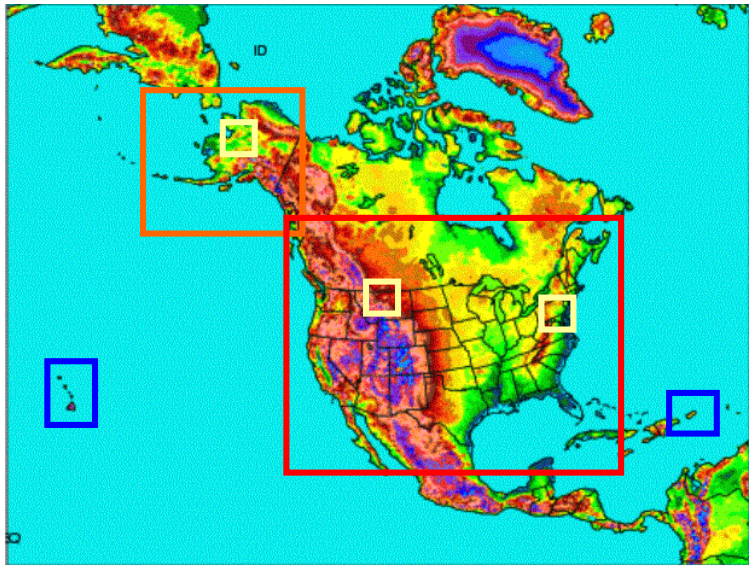
Observed | Operational GFS | Upgraded Physics GFS

Updated GFS physics package eliminates grid-point precipitation “bombs”

NCEP Mesoscale Modeling for CONUS: Planned FY11

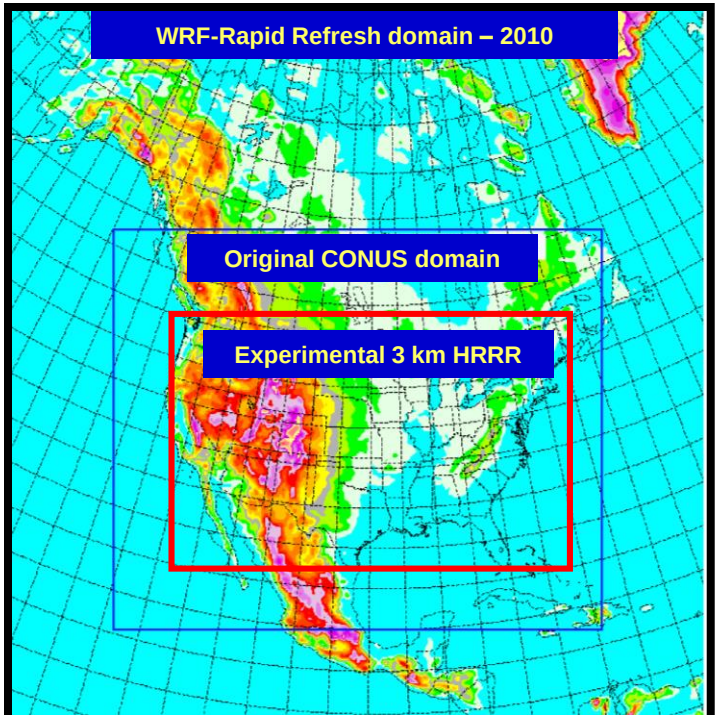
NAM

- NEMS based NMM
- Bgrid replaces Egrid
- Parent remains at 12 km
- Multiple Nests Run to ~48hr
  - ~4 km CONUS nest
  - ~6 km Alaska nest
  - ~3 km HI & PR nests
  - ~1.5-2km DHS/FireWeather/IMET possible



Rapid Refresh

- WRF-based ARW
- Use of GSI analysis
- Expanded 13 km Domain to include Alaska
- Experimental 3 km HRRR



Air Quality Prediction Systems

	Model	Region	Products
Operational	Smoke NAM-HYSPLIT	CONUS- 12 km Alaska Hawaii	Daily smoke forecasts (06 UTC, 48 h)
	NAM-CMAQ	CONUS 12 km Hawaii (Sept 2010) Alaska (Sept 2010)	ozone forecasts 2x/day (06 & 12 UTC to 48h) from anthropogenic sources
Under Development	NAM-HYSPLIT-CMAQ	CONUS 12 km	dust & total fine particulate matter, under development
	GFS-GOCART Dev Para Sept 2010	Off-line Global dust (1x1°) *Smoke under development*	1x/day global dust (72h) for WMO & regional CMAQ LBC
	NEMS/GFS GOCART Dev Para Sept 2011	In-line interactive global aerosols	global with interactive aerosols
	NEMS/NMMB-CMAQ	In-line interactive global/regional aerosols	regional AQ w/ aerosol impacts on radiation

Why Include Aerosols in the Predictive Systems?

- Provide improve weather and air quality guidance for forecasters and researchers
- Fine particulate matter (PM2.5) is the leading contributor to premature deaths from poor air quality
- Improved satellite radiance assimilation in the Community Radiative Transfer Model (CRTM) allowing realistic atmospheric constituents loading
- Improve SST retrievals
- Provide aerosol lateral boundary conditions for regional air quality forecasting systems, e.g., NAQFC.
- Meet NWS and WMO global dust forecasting goals

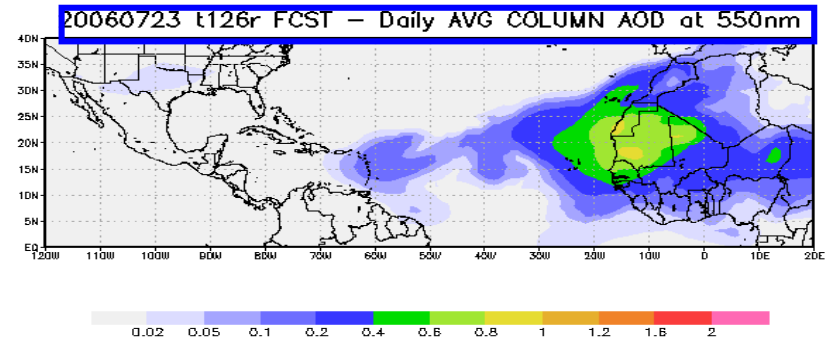
Global System:
Gas and Aerosol Representation and Data Assimilation

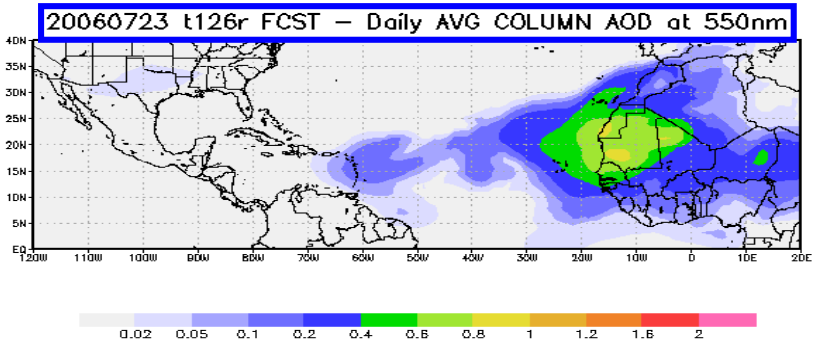
- **Ozone**
  - GFS ozone climatology w/ monthly production and loss
  - GSI with SBUV2 profile ozone (noaa-17, noaa-18) and OMI total column ozone (aura)
  - Future observations for GSI includes:
    - SBUV2 (noaa-19)
    - GOME-2 (METTOP)

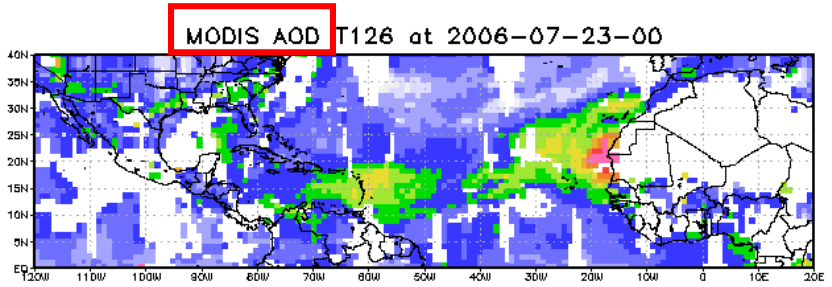
- **Aerosol**
  - GFS with NASA/GOCART aerosol modules (in progress)
  - GSI with MODIS AOD (aqua, terra; in progress)
  - Future observations for GSI includes:
    - OMI AI
    - Geostationary AOD (GOES-11, GOES-12)
    - MetoSAT-9, and MTSAT
    - GOME-2 OMI-like aerosol retrievals, AIRS, MLS, ABI (GOES-R), VIIRS (NPOESS)

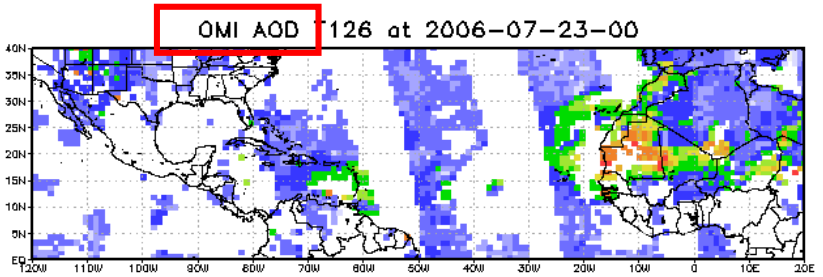
Spatial Evaluation of Experimental Global Dust Forecasts

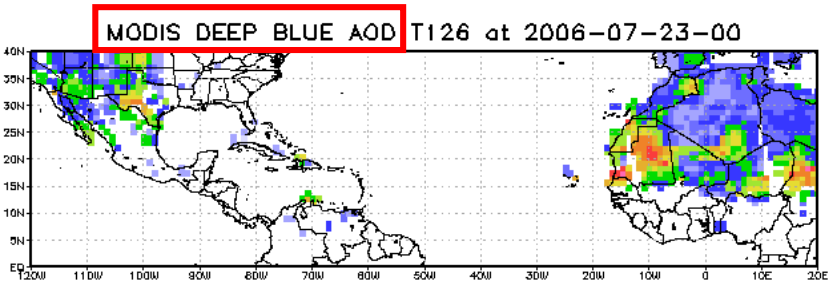
Observations (MODIS, OMI and MISR) used to evaluate offline GFS-GOCART Sahara Dust Trans-Atlantic simulation With NCEP T126 resolution

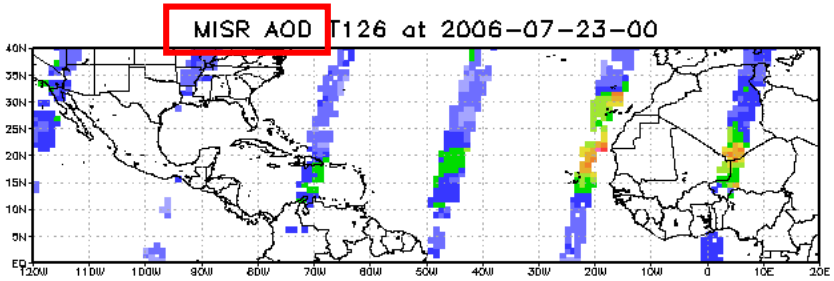




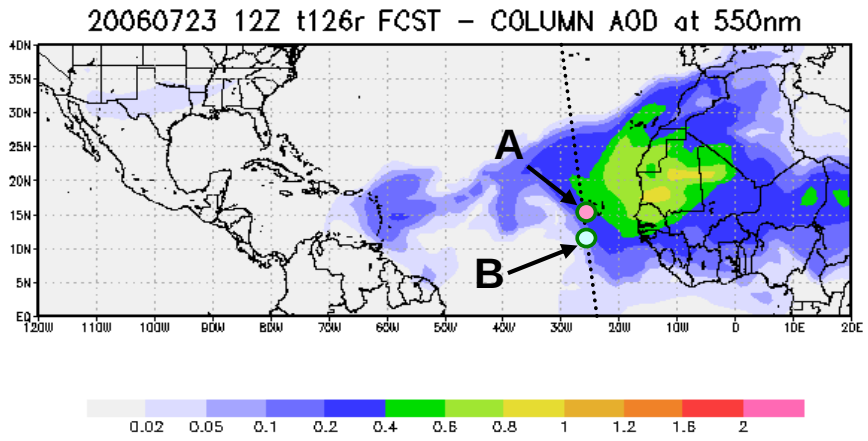


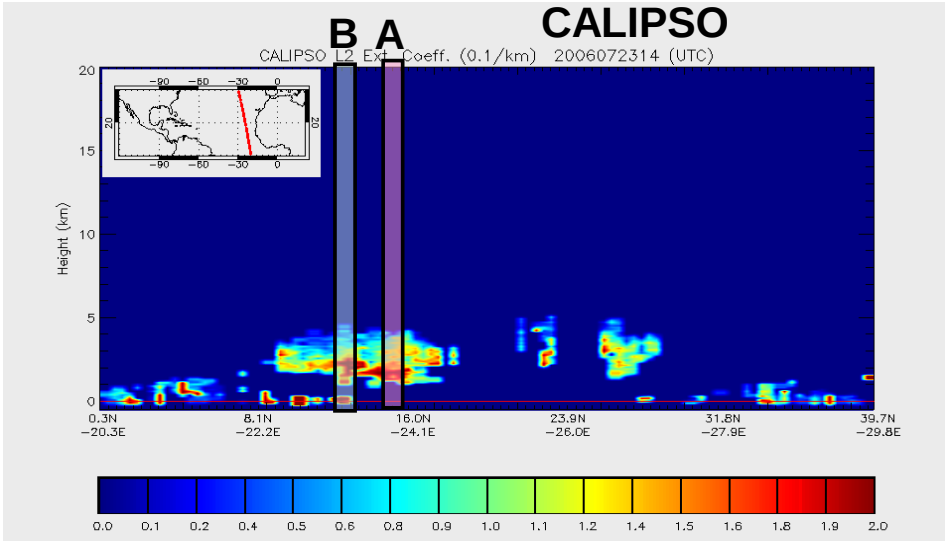




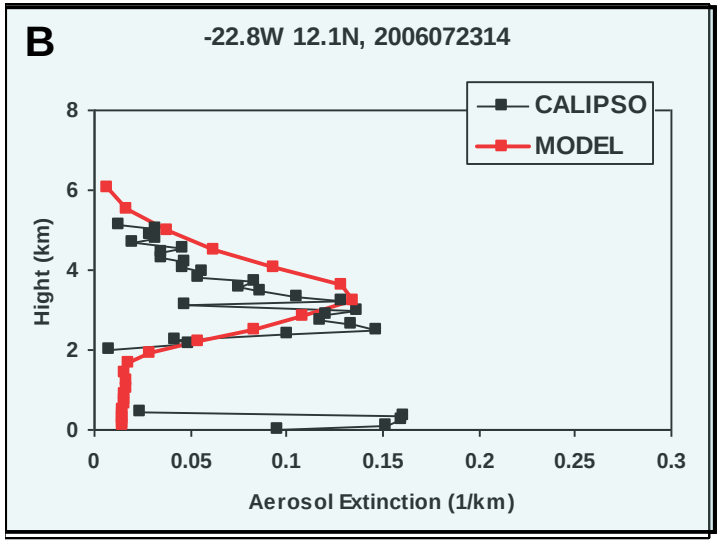


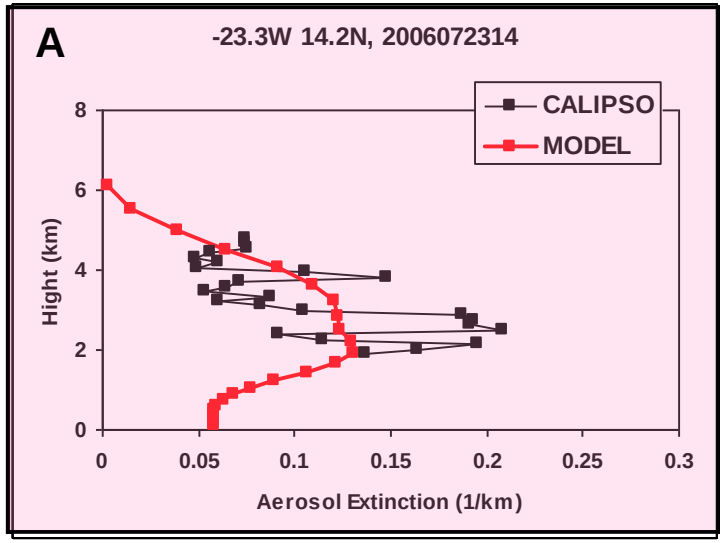
Evaluation of Vertical Distribution of Experimental Global Dust Forecasts





GrADS: COLA/IGES



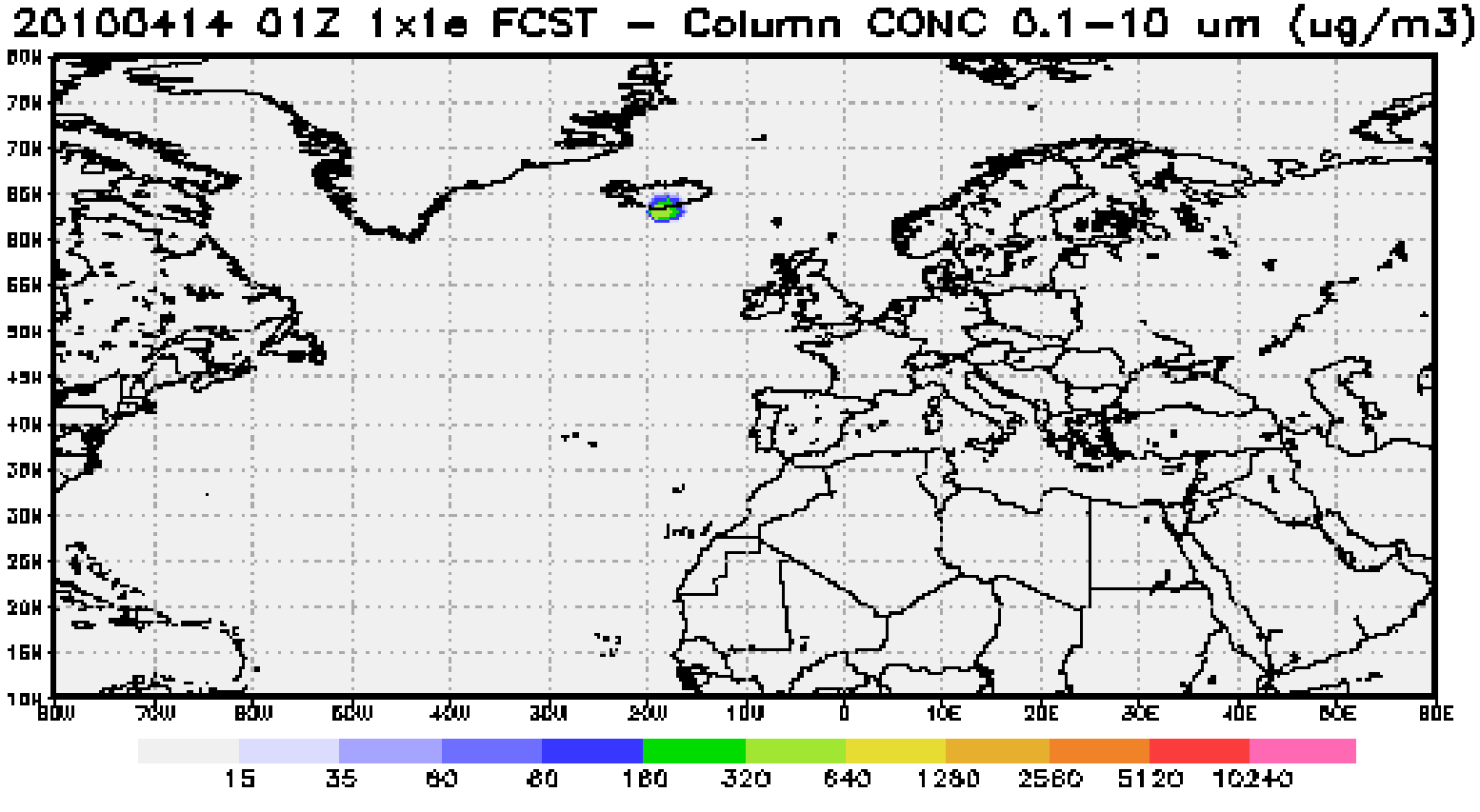


Experimental Volcanic Ash Simulation From Eyjafjallajökull Volcano, Iceland

- Analysis made 14 April to 20 April 2010
- GFS-GOCART offline system (in development)
  - Driven by operational GFS meteorology (T382 scaled to 1˚x1˚)
  - Dust (5 size bins; in radius)
    - DU1 : 0.1 – 1.0 µm
    - DU2 : 1.0 - 1.8 µm
    - DU3 : 1.8 – 3.0 µm
    - DU4 : 3.0 – 6.0 µm
    - DU5 : 6.0 – 10.0 µm
  - Emissions:
    - $1x10^6$ kg/hr in a 1˚x1˚ grid box at layer 24 (~ 5 km) for each dust bib size
    - total emission is $5x10^6$ kg/hr (continuous release)

Experimental Volcanic Ash Simulation From Eyjafjallajökull Volcano, Iceland

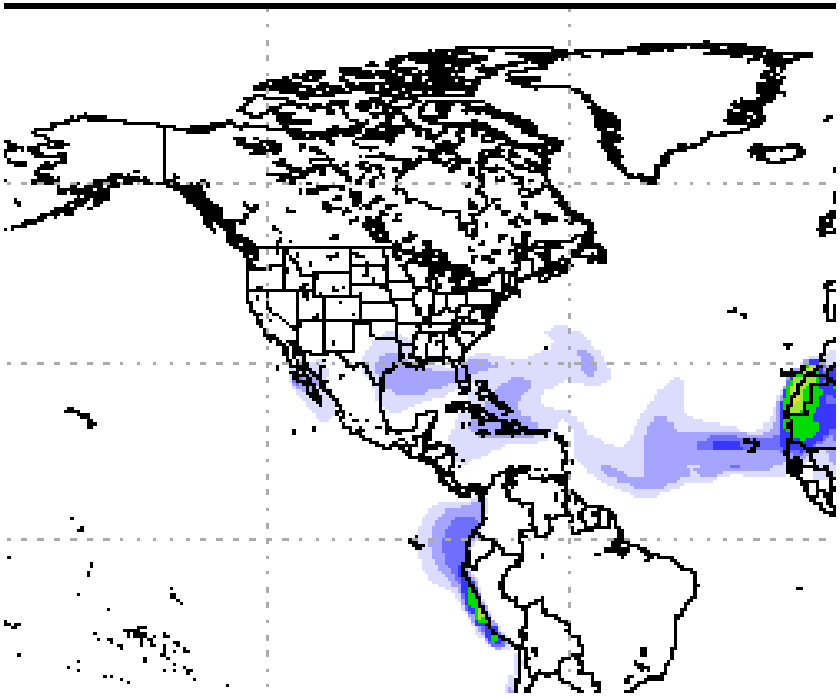
- Forecasts initialized 00 UTC April 14 to April 21
- Total column concentration
- Hourly average



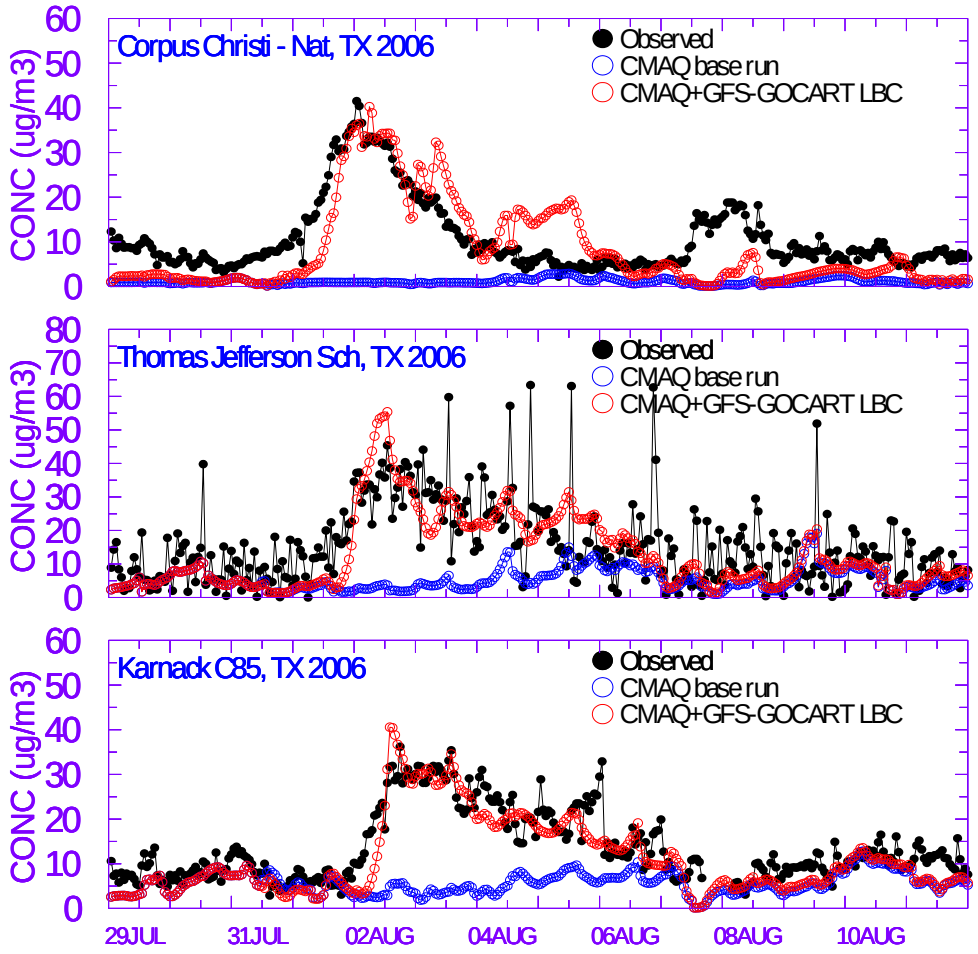
Regional System:
Gas and Aerosol Representation and Data Assimilation:

- **Ozone**
  - NCEP National Air Quality Forecasting Capability (NAQFC; offline operational with NAM Meteorology and CMAQ
  - Verification, ground-level predictions: EPA in-situ monitoring
  - NAQFC NEMS/NMMB inline (in planning)
  - GSI for regional ozone (in planning)
  - Future observations for data assimilation include
    - Total column ozone (GOES-11, GOES-12)
    - in-situ ozone concentration (USEPA/AIRNOW)
- **Aerosol**
  - NAQFC (offline in progress; NEMS/NMMB-NAQFC inline in planning)
  - Verification, developmental PM2.5 predictions: EPA in-situ monitoring
  - GSI for regional aerosol (in planning)
  - Future observations for data assimilation include:
    - in-situ particulate matter concentration (USEPA/AIRNOW)
    - MODIS AOD (aqua, terra)
    - GOES AOD

Aerosol Lateral Boundary Conditions Tests: Trans-Atlantic dust Transport



- During Texas Air Quality Study 2006, the model inter-comparison team found all 7 regional air quality models missed some high-PM events, due to trans-Atlantic Saharan dust storms.
- These events are re-visited here, using dynamic lateral aerosol boundary conditions provided from dust-only off-line GFS-GOCART.



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Satellite Data Availability

- NCEP is receiving MODIS level 1 product and OMI AI in real time
- GOES column integrated AOD product is available (regional)
- Future potential data sources
  - OMI aerosol product and radiance
  - OMI-like aerosol retrievals produced by the GOME-2
  - MODIS AOD similar products produced by the GOES-R Advanced Baseline Imager (ABI)

Challenges Associated with the Operational Use of Satellite Products

- Requirements in operational environment
  - Bring observations into operational data stream (WMO BUFR format)
  - Shorter data delivery time
- Global coverage and higher temporal resolution (mixed orbital and geostationary constellation products)
- Need profile observations for speciated aerosols as well as ozone precursor species (NO, NO_2, Hydrocarbon species).
- Forward model also needs global satellite product to improve model first guess, e.g., need near-real time global emissions derived from satellite observations (Fire emissions, Volcanic eruption)
- Critical information to improve and/or project near-real time global fire emissions in forward model simulation, e.g., injection height and fire intensity tendency

Summary

- NCEP commits to improve weather and air quality forecasts with atmospheric constituents data assimilations
- NCEP GSI is going to evolve from 3DVar to 4DVar
- Aerosol data assimilation is in development and ozone data assimilation continues to improve its DA with incorporated additional observations
- Satellite data are not only critical for data assimilation it is also important to improve forward model guess fields
- Near real-time satellite data flow is critical to operational data assimilations