NOAA/NWS/NCEP Atmospheric Constituent Prediction Capability – Aerosol Forecast Verification

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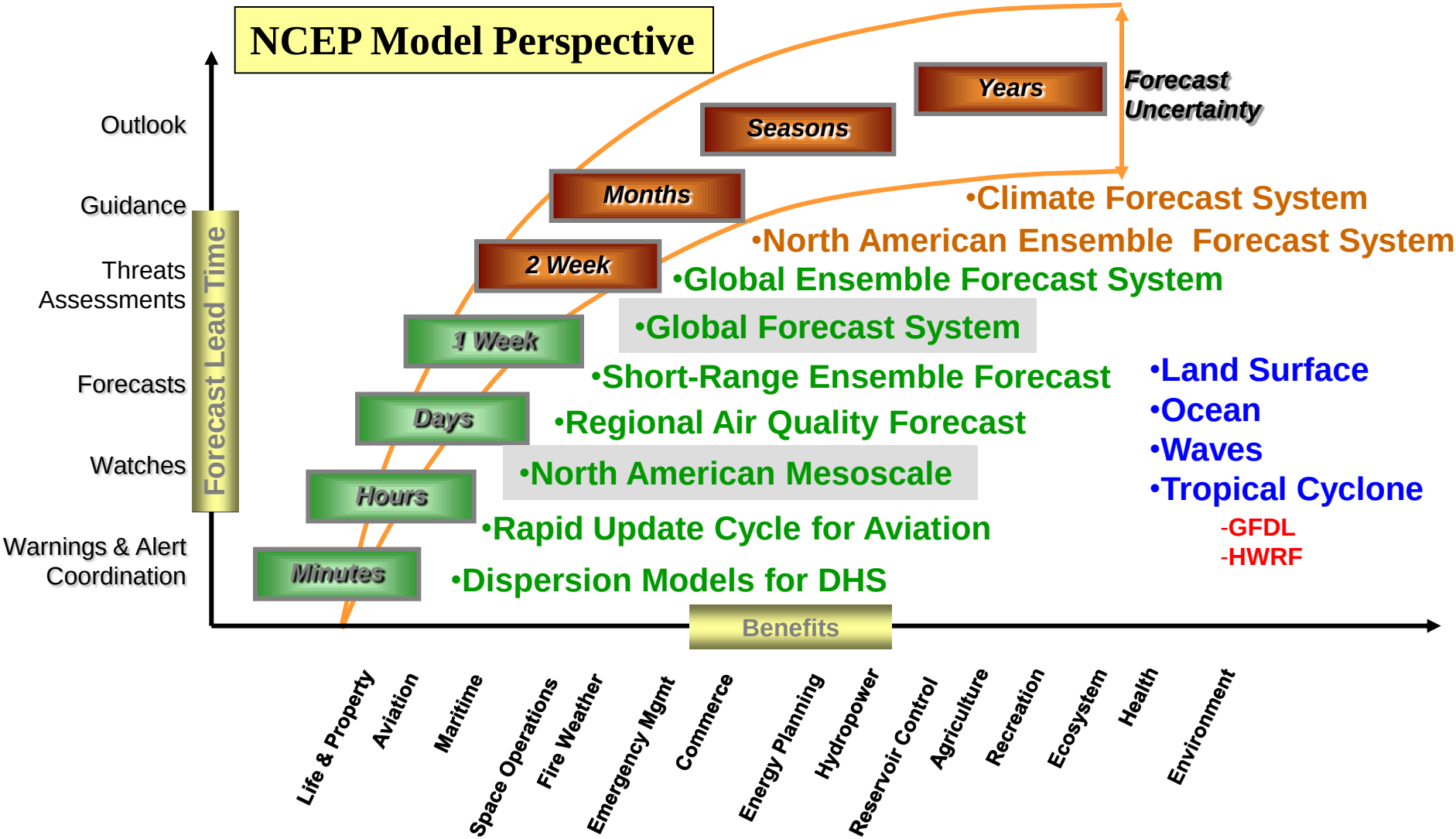
International Cooperative for Aerosol Prediction: Aerosol Verification
Sept 30 – Oct 1, 2010

Outline

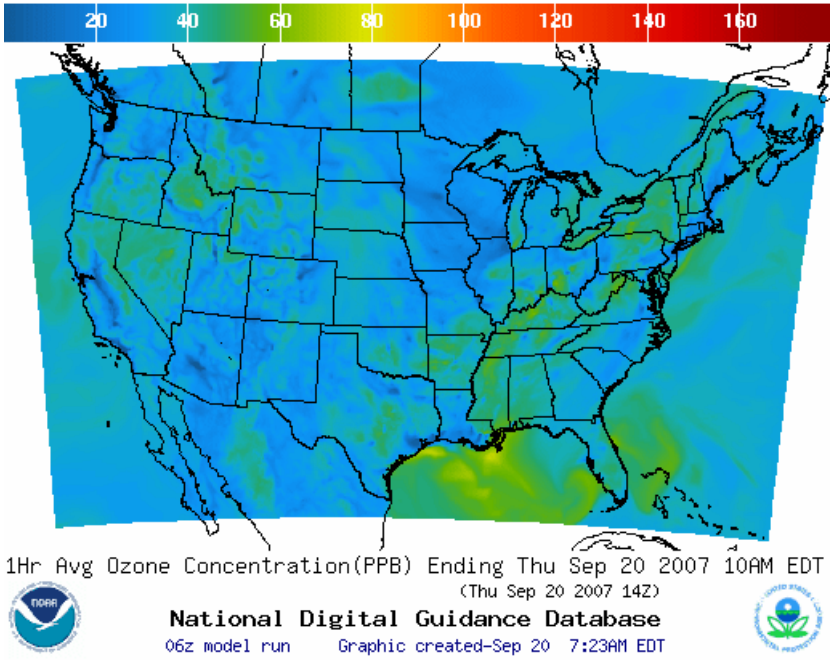
- NCEP global and regional prediction systems
- Atmospheric constituent prediction systems
- Model verification
  - Meteorology forecast verification
  - Aerosol verification activities
- Summary

NWS Seamless Suite of Forecast Products Spanning Weather and Climate



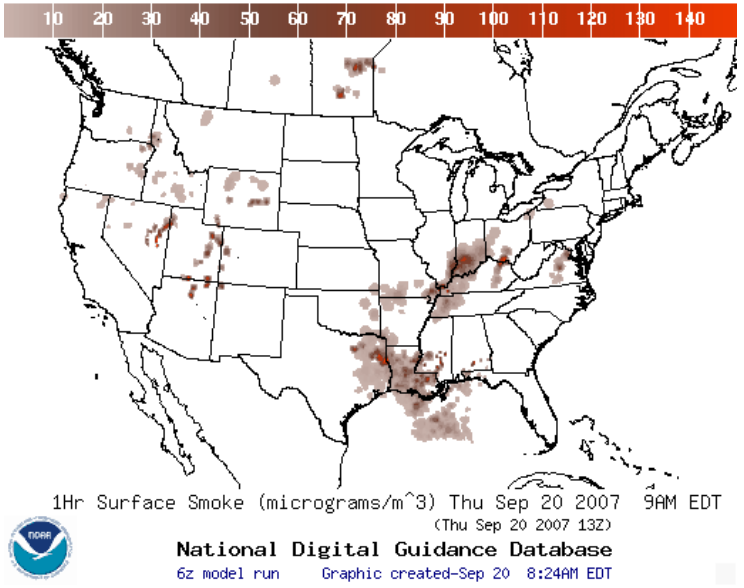
Operational AQ forecast guidance

www.weather.gov/aq



CONUS Ozone

Expansion Implemented September, 2007



Smoke Products

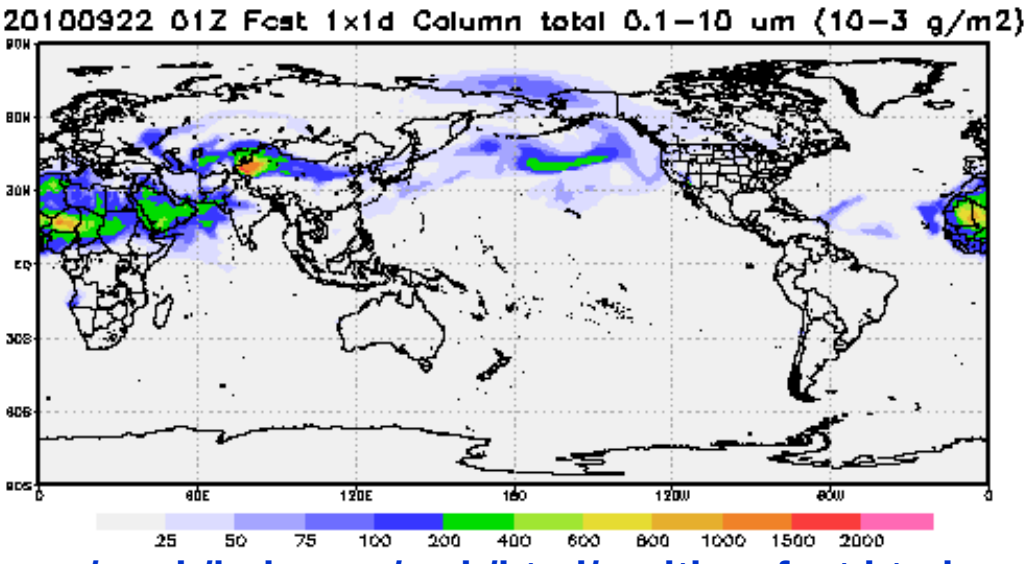
Implemented March, 2007

Further information: www.nws.noaa.gov/ost/air_quality

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

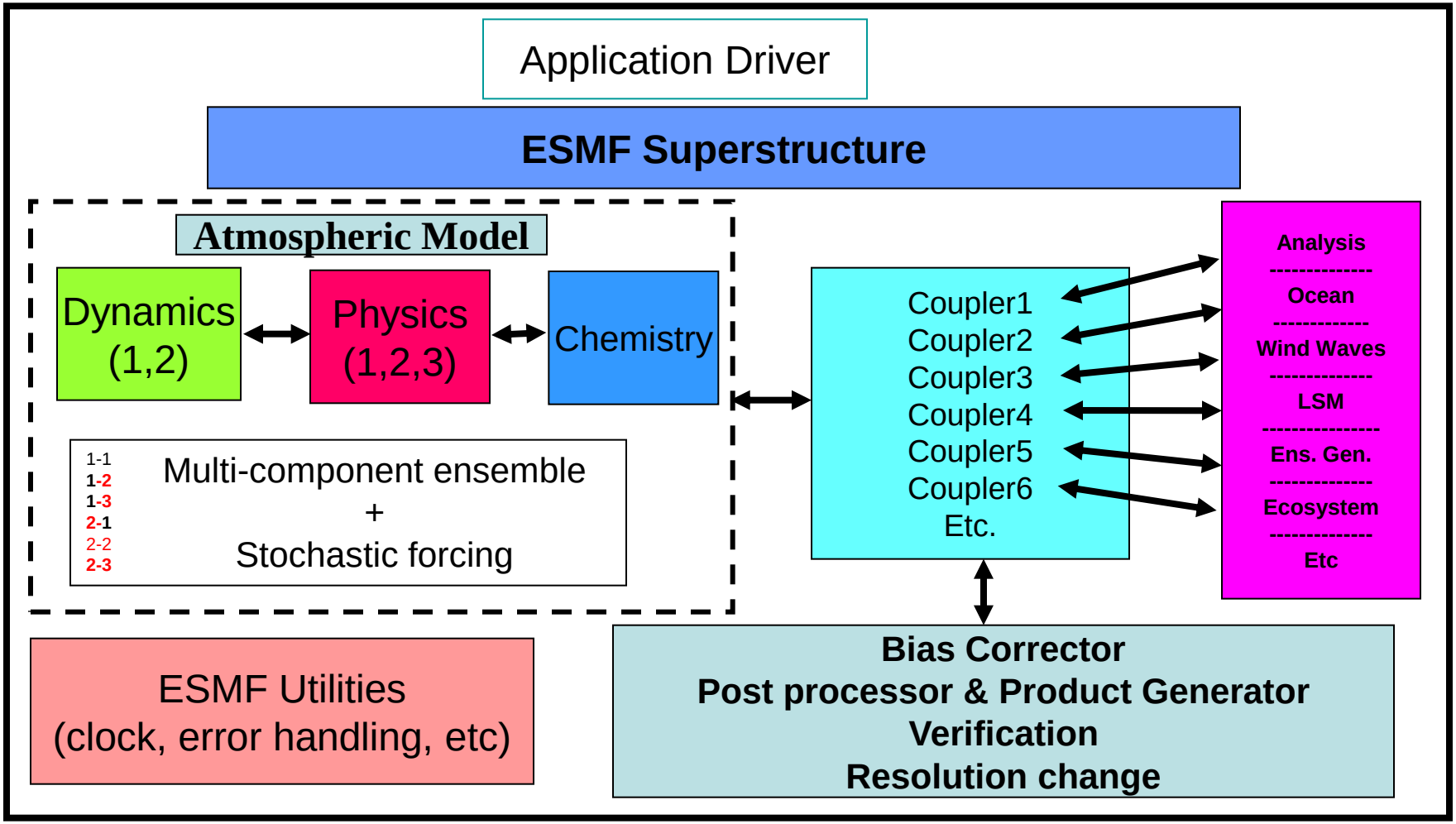
- **NASA GOCART aerosol module**
  - Off-line dust-only GOCART CTM, driven by operational GFS (real-time testing since December 2009)
  - On-line implementation of GOCART in NEMS GFS (prototype development and testing)



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

NEMS

NOAA Environmental Modeling System



- **Earth Science Modeling Framework (ESMF) infrastructure**
- **Community-based development: on-going efforts to integrate new ESMF-based components into NEMS, including GOCART (from GSFC), FIM (from ESRL), and MOM4 (from GFDL)**
- **One unified atmospheric component that can invoke multiple dynamics (spectral, NMM-B) and physics (GFS, NAM). FY11 implementation for regional NMM-B.**

NCEP global aerosol forecasting system

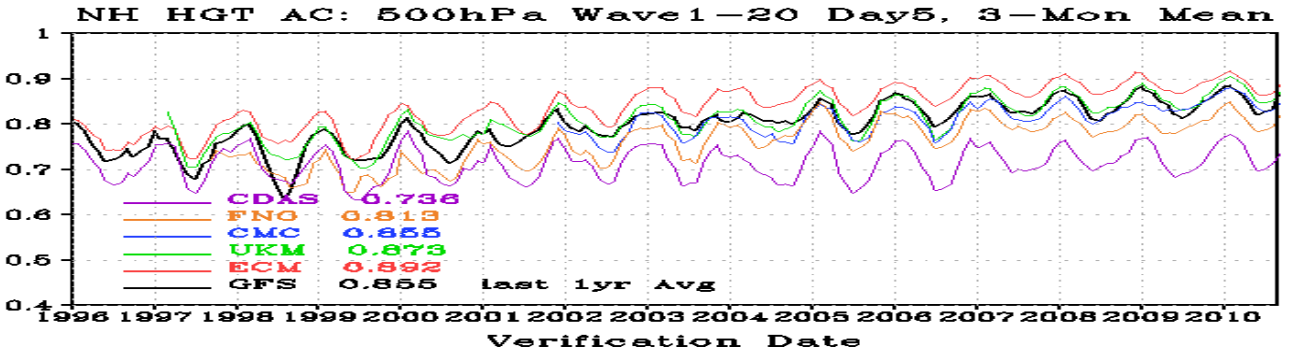
- **GOALS**
  - Generate an optimal (accurate and affordable) description of global aerosol distributions
  - Provide improved forecasts, through exploitation of satellite data

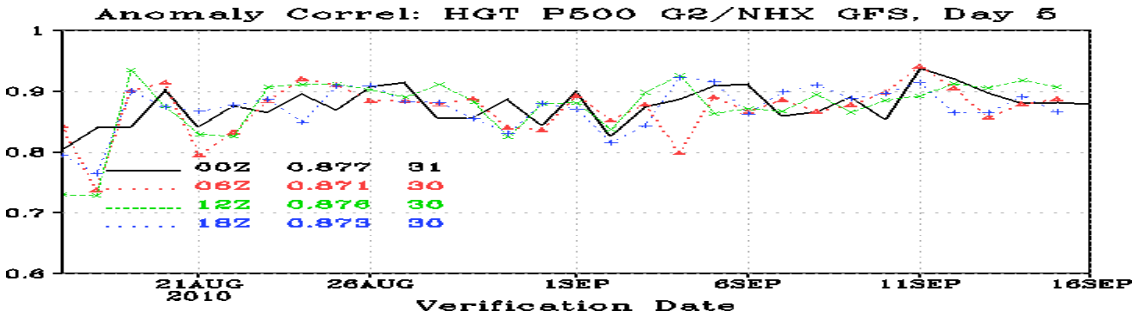
- **STATUS & OUTCOMES**
  - NASA aerosol module (GOCART) has been implemented into NOAA Environmental Modeling System (NEMS)
  - The new on-line aerosol forecast system is currently being evaluated
  - Outcomes of the new aerosol element include the following aspects:
    - Enable NCEP to produce global short-range chemical weather forecasts
    - Provide a first step toward an aerosol data assimilation capability at NCEP
    - Provide lateral aerosol boundary conditions for regional air quality forecast system
    - Create aerosol information needed for atmospheric correction in satellite retrievals
    - Allow NCEP to explore aerosol-chemistry-climate interaction in the climate system (GFS is the AGCM of NCEP climate forecast system)

Meteorology Forecast Verification

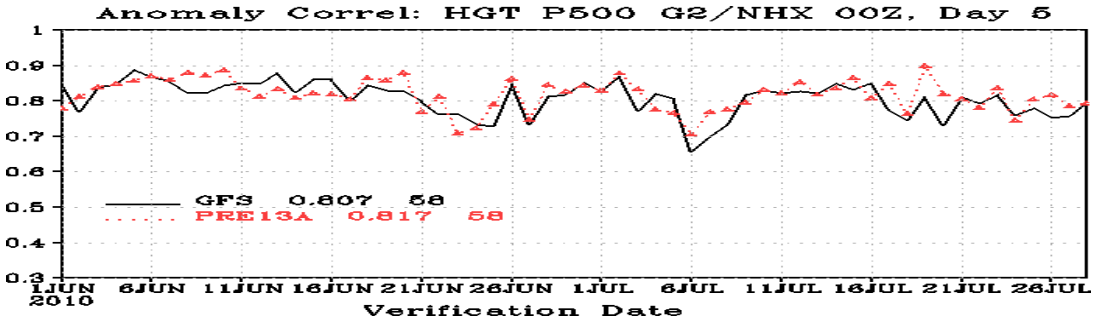
- As an operational NWP center, NCEP routinely verifies the forecast products to assess and enable improvement of the quality of forecasts.
- Specific performance measures are used in forecast verification, e.g.,
  - Environmental Modeling Center (EMC) uses mean anomaly correlations for 5-day forecasts of 500-hPa to evaluate medium range weather forecasts
  - Climate Prediction Center (CPC) uses Heidke skill scores to evaluate seasonal forecasts (i.e., 90-day outlooks)
  - Hydrometeorological Prediction Center (HPC) uses threat scores to verify quantitative precipitation forecasts

NCEP tracks long-term performance statistics (TOP: forecasts from multiple NWP models), monitor the operational model (MIDDLE: forecasts among 4 cycles), and evaluate the parallel system (BOTTOM: forecasts from operational and parallel systems)





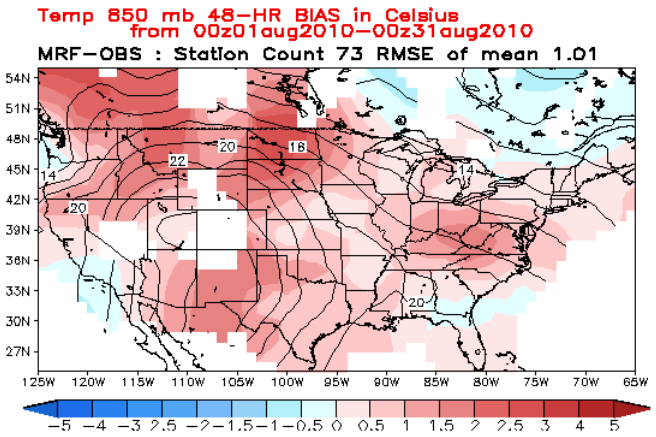
http://www.emc.ncep.noaa.gov/gmb/STATS_vsdb



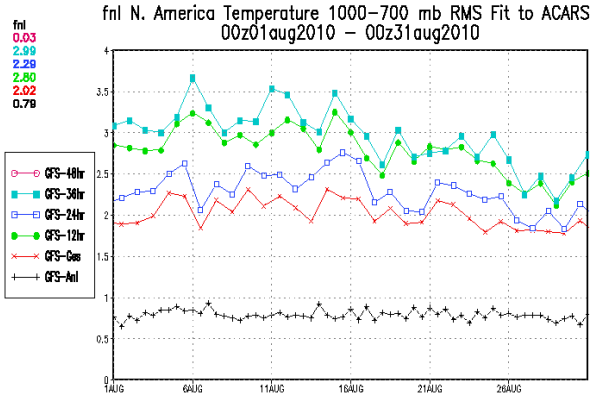
http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb_glopara/Q3FY10_2010JJA/

Since no single verification measure provides complete information about the quality of the product, NCEP models are verified against analysis and independent observation data set extensively.

Temp 850mb, RAOBS

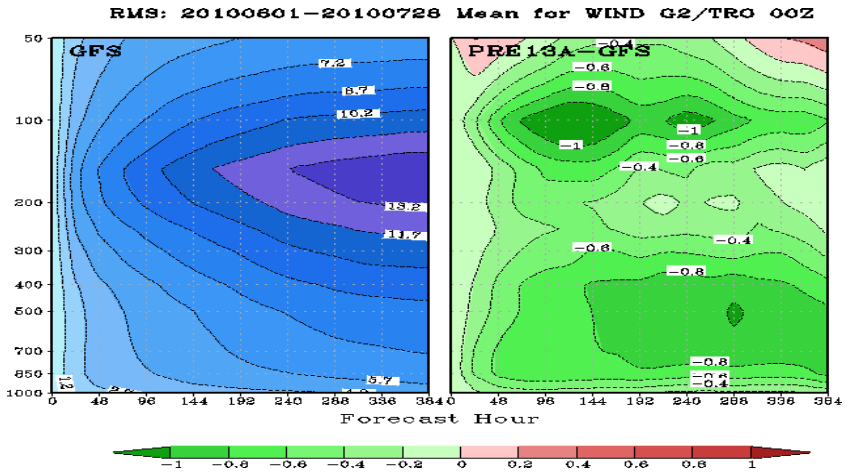


Temp 1000-700mb, ACARS

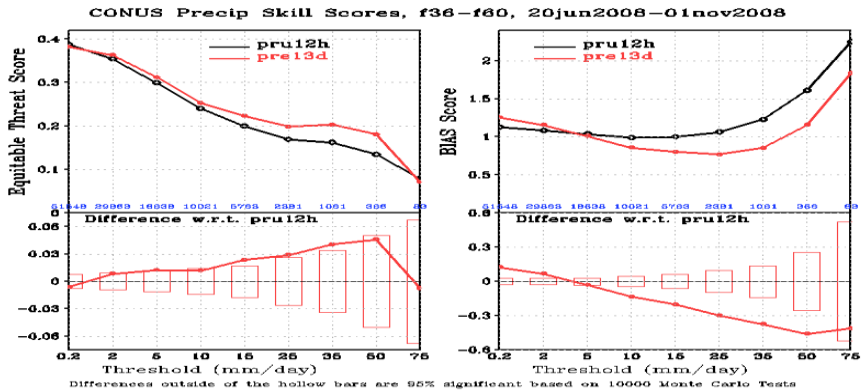


www.emc.ncep.noaa.gov/gmb/wx24fy/ssaha

Tropical Wind, Analysis



Precip, Sfc rain gauge



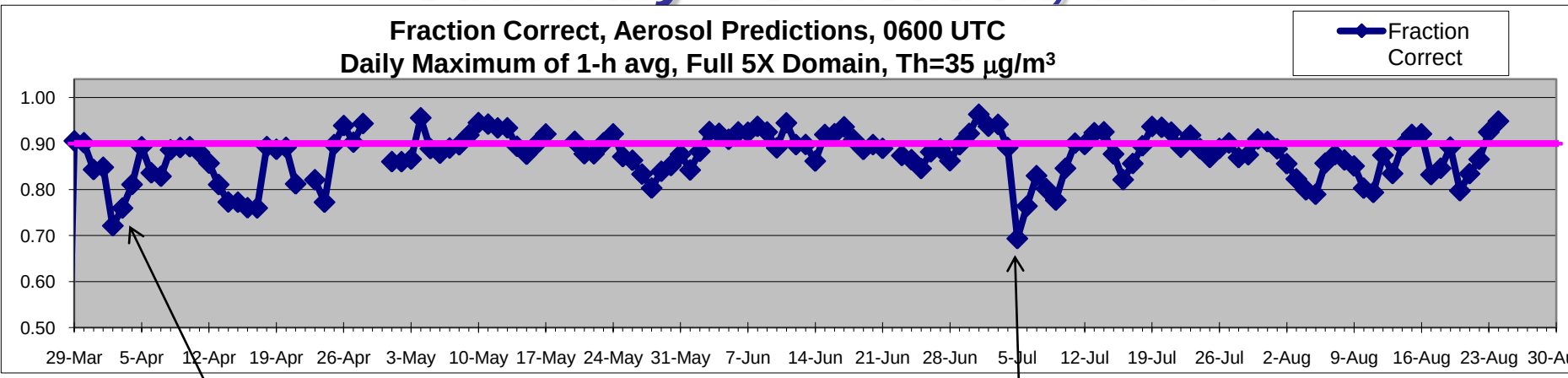
www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb_glopara/Q3FY10_2008/

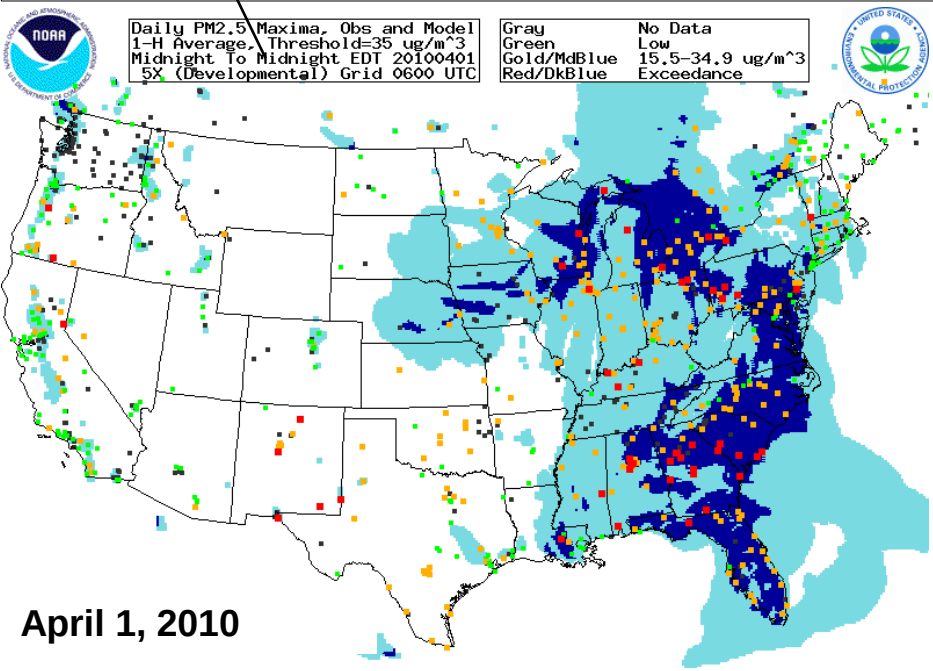
Regional AQ Forecast Verification

- NCEP has the expertise and experiences to verify the meteorology products, and is developing the capability to verify ozone and aerosol forecasts.
- NOAA National AQ forecast capability (NAQFC)
  - Use standard measures (e.g., Bias, RMSE), categorical statistics (e.g., FC, TS, CSI), and probabilistic verification statistics (e.g., Reliability diagrams, Relative Operational Characteristics)
  - Real-time verification: AIRNOW surface PM observations are used to verify AQ prediction of PM and GOES Aerosol Smoke Product is used to verify smoke predictions
  - Retro verification: aerosol composition observations from STN and IMPROVE networks have been used.

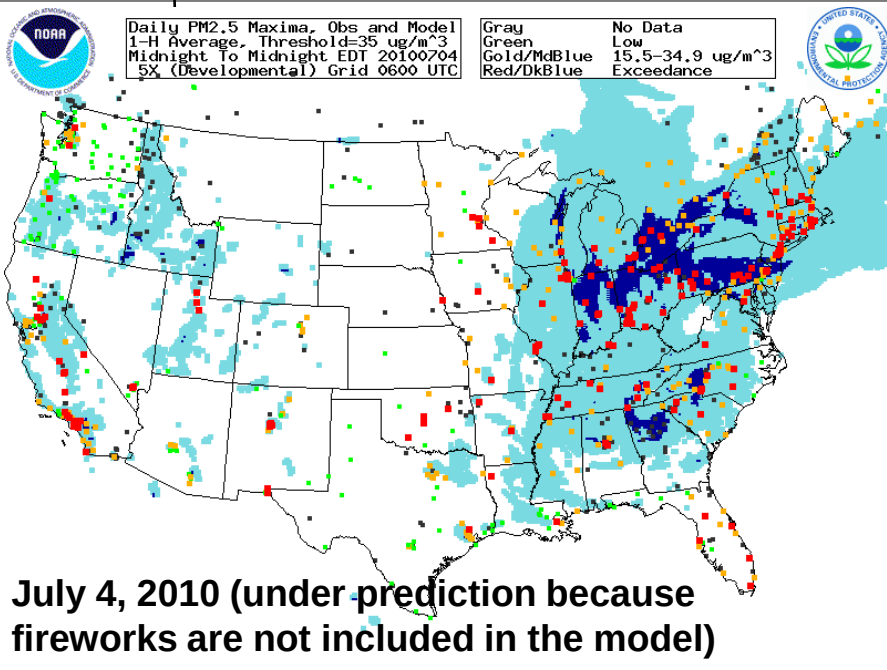
Developmental Aerosol Predictions:

Summary Verification, 2010





April 1, 2010



July 4, 2010 (under prediction because fireworks are not included in the model)

FC with respect to the alert threshold of 35 µg/m3 (the standard for daily max of the 24-hr averaged PM2.5) is most relevant to AQ forecasters.

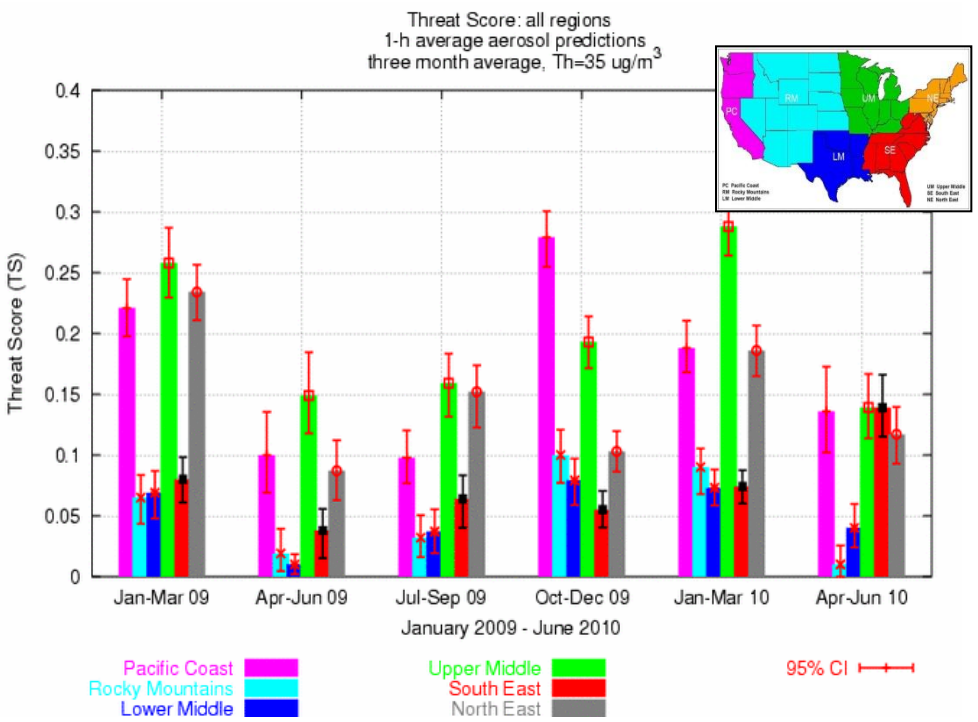
2x2 contingency table

Forecast \ Observed	yes	no
yes	a	b
no	c	d

FC = (a + d)/(a + b + c + d)
TS = a /(a + b + c) (2)
POD = a/(a + c) (3)
FAR = b/(a + b)

Verification for CONUS PM using EPA AIRNOW PM observations

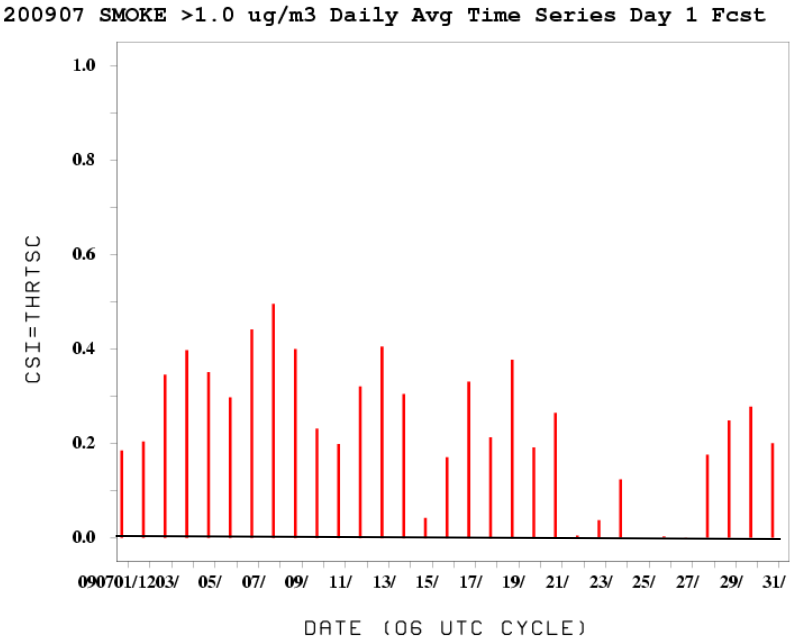
Threat Score (TS), 1-h aerosols
Jan 2009 - Jun 2010, Th = 35 ug/m^3



http://slosh.nws.noaa.gov/aqverif/

Verification for Alaska smoke using NESDIS GOES-W GOES GASP

Critical Success Index (CSI), daily avg smoke
July 2009, Th = 1 ug/m^3



http://www.emc.ncep.noaa.gov/mmb/jhuang/web/html/score_mon.html

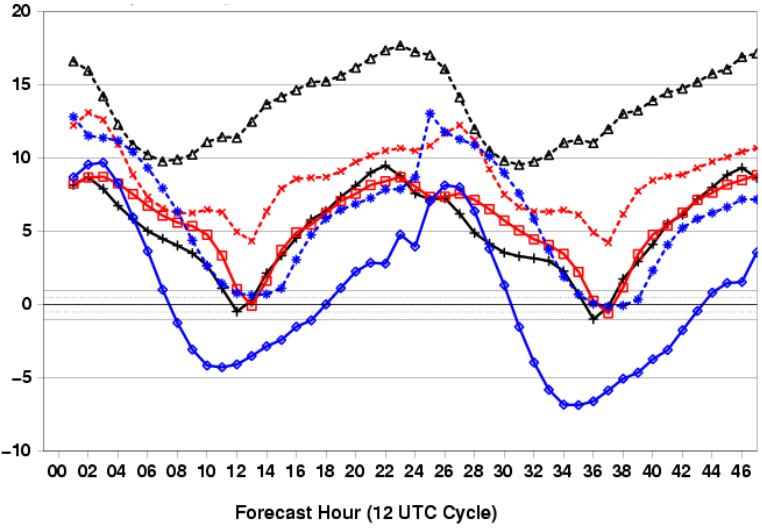
GASP: GOES Aerosol Smoke Product (Shobha Kondragunta, NESDIS)

Verification of CONUS ozone using EPA AIRNOW ozone observations

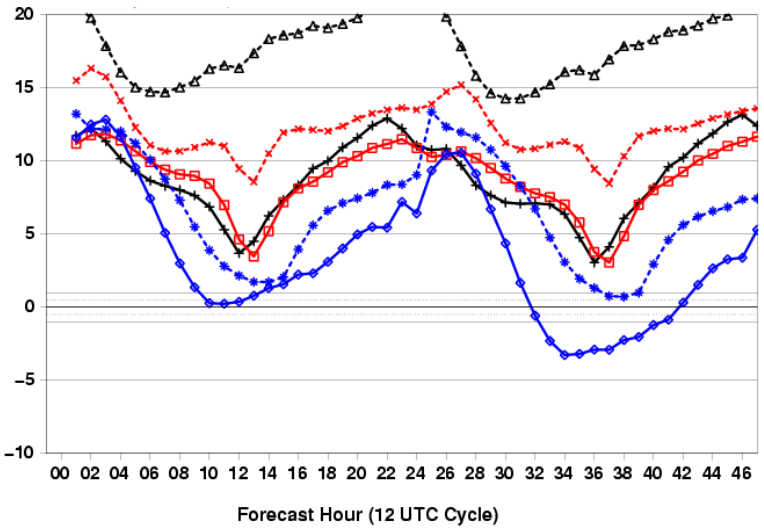
Bias, 1-hr ozone

June – Sept 2010

Production



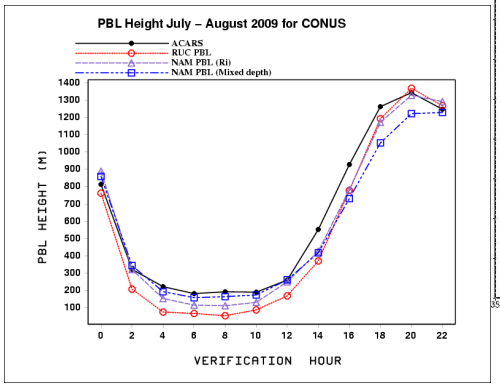
Experimental

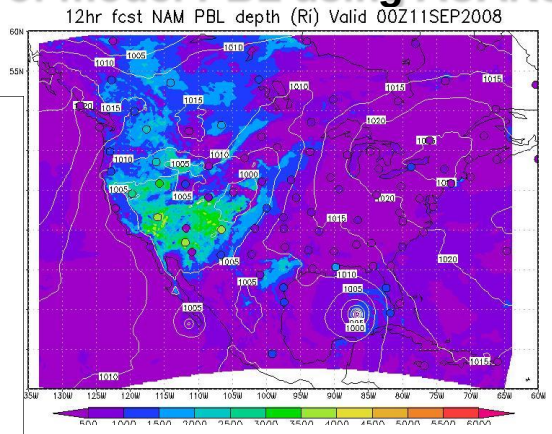


AQMPROD VARB: OZON/1 RGN: Northeast LVL: SFC STAT: bias
AQMPROD VARB: OZON/1 RGN: Southeast LVL: SFC STAT: bias
AQMPROD VARB: OZON/1 RGN: Midwest LVL: SFC STAT: bias
AQMPROD VARB: OZON/1 RGN: LMiss-Vall LVL: SFC STAT: bias
AQMPROD VARB: OZON/1 RGN: SWEST-Coast LVL: SFC STAT: bias
AQMPROD VARB: OZON/1 RGN: NWEST-Coast LVL: SFC STAT: bias

Verification statistics are used to monitor the operational model (TOP LEFT) and to evaluate the parallel system (TOP RIGHT). Sensible weather elements that impact AQ (e.g., low level temperature, moisture, wind, cloud cover, and PBL height) are also verified (RIGHT: PBL)

Verification of model PBL using ACARS

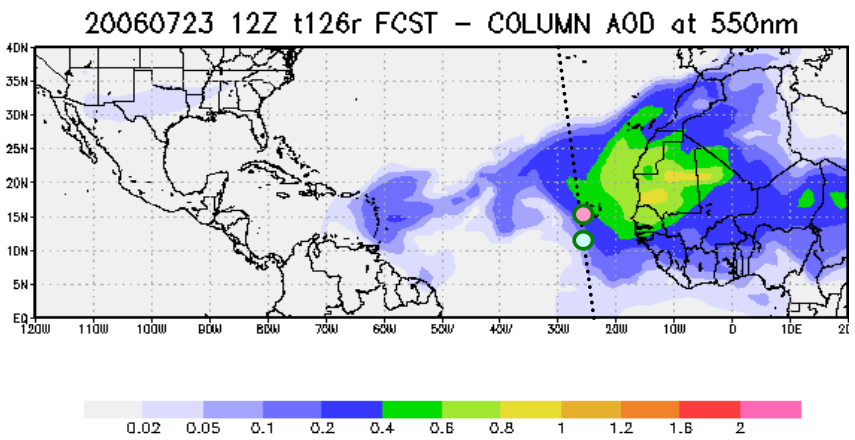


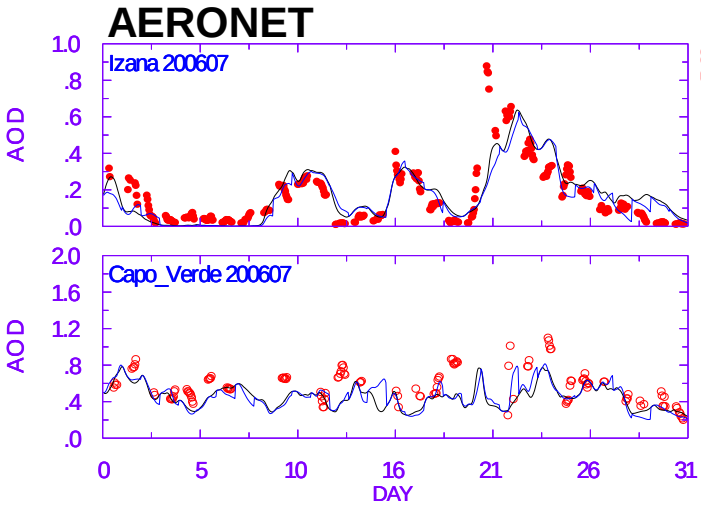


PBL analysis has been added to NOAA Real Time Mesoscale Analysis (RTMA) using derived PBL heights information from RAOBS, ACARS, CAP, COSMIC and RADAR data.

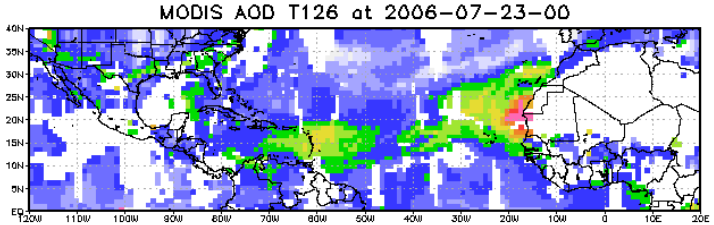
Global Aerosol Forecast Verification

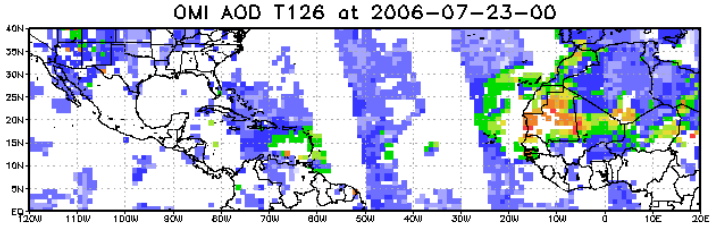
- Global aerosol forecast capability is being developed, by linking GSFC GOCART model with NCEP GFS
- Retro case studies are conducted to evaluate dust-only GOCART CTM, using column AOD from surface network (AERONET) and satellites (MODIS, OMI, and MISR) and profile observations from CALIPSO
- Real-time verification: work in progress

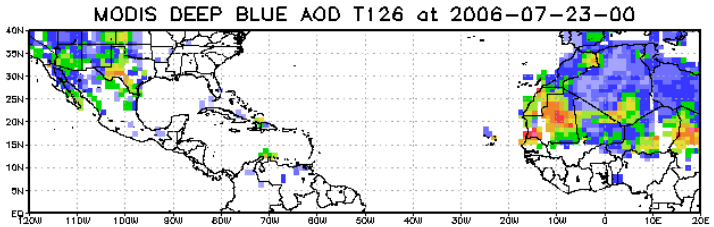


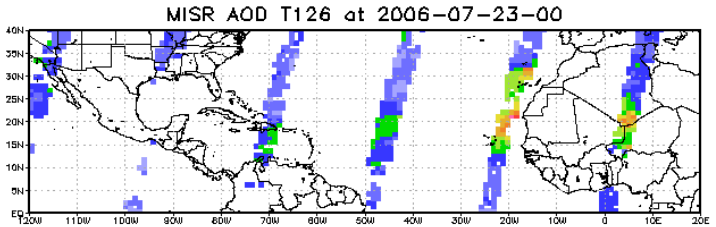


MODIS,OMI,MISR

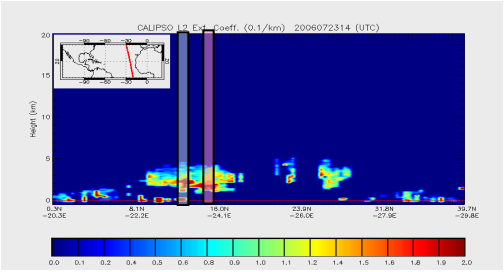


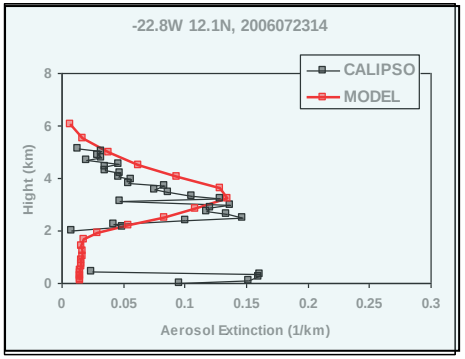


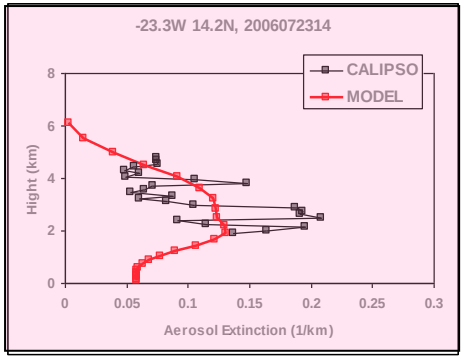




CALIPSO







Dongchul Kim (now at NASA GSFC)

Concluding Remarks

- NCEP is performing routine verification of PM predictions for the US.
- The goal is to ensure that the NAQFC meets the needs of local and state AQ forecasters and provides timely and accurate information to the general public.
  - Verification is based on the accuracy w.r.t. the PM standard (currently 35 $\mu g/m^3$)
  - Near-real-time verification relies on AIRNOW surface PM measurements
- NCEP is developing global aerosol forecasting capability and is extending the verification system to verify and evaluate global aerosol predictions.
- Issues faced by NCEP for verifying/evaluating global aerosol forecasts
  - Verification goal and performance metrics TBD
  - Data Sources
    - Analysis data (aerosol data assimilation in development)
    - Independent observations (limited observations on composition and vertical structure)

THANK YOU