Verification of Air Quality Models at NCEP's Environmental Modeling Center
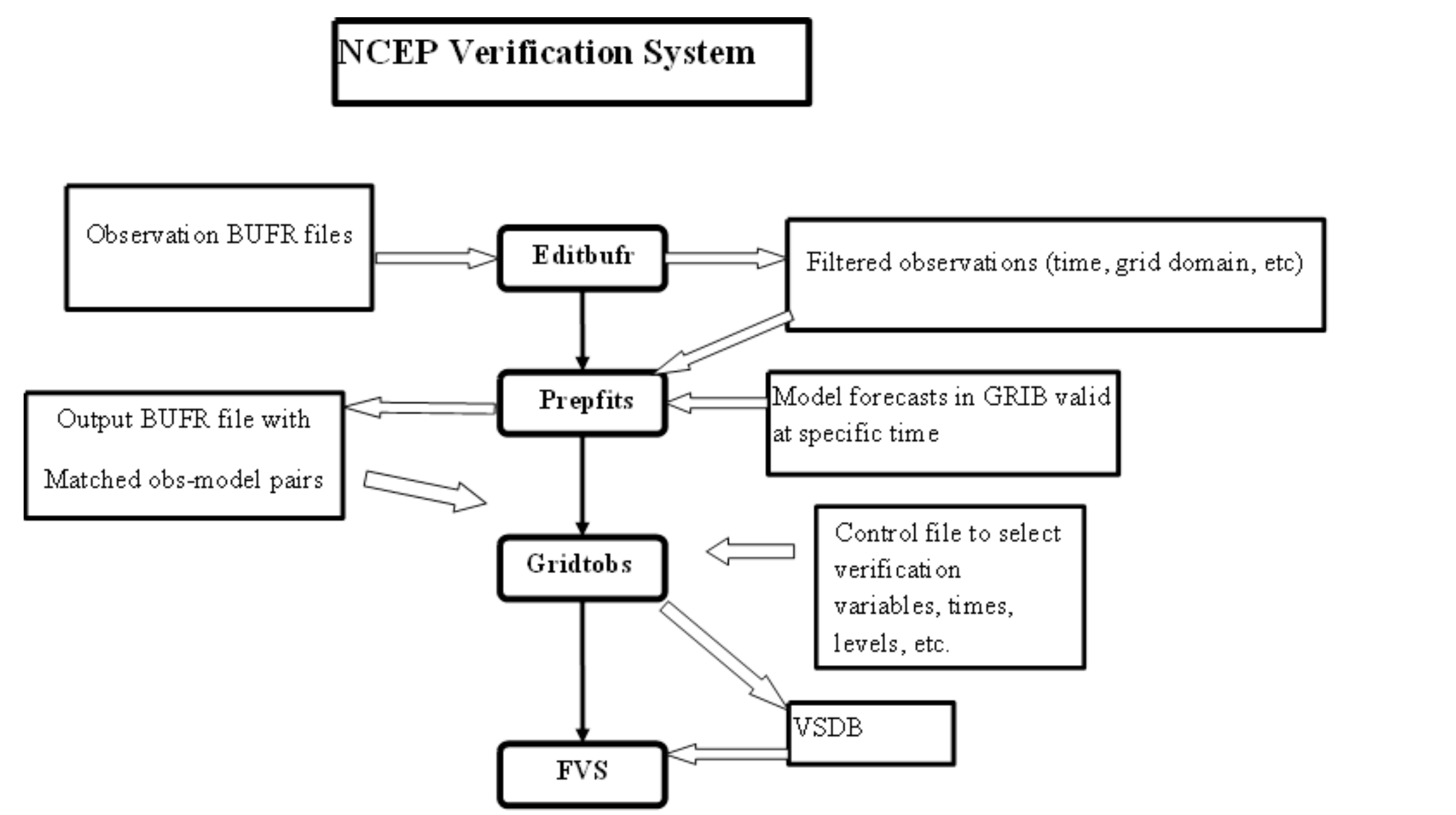
Perry Shafran[1,2], Jeffery McQueen[1], Jianping Huang[1,2], Binbin Zhou[1,2], Ho-Chun Huang[1,2]

[1]NOAA/NCEP/EMC; [2]I. M. Systems Group

CMAS Conference, Oct 27-29, 2014, Chapel Hill, NC
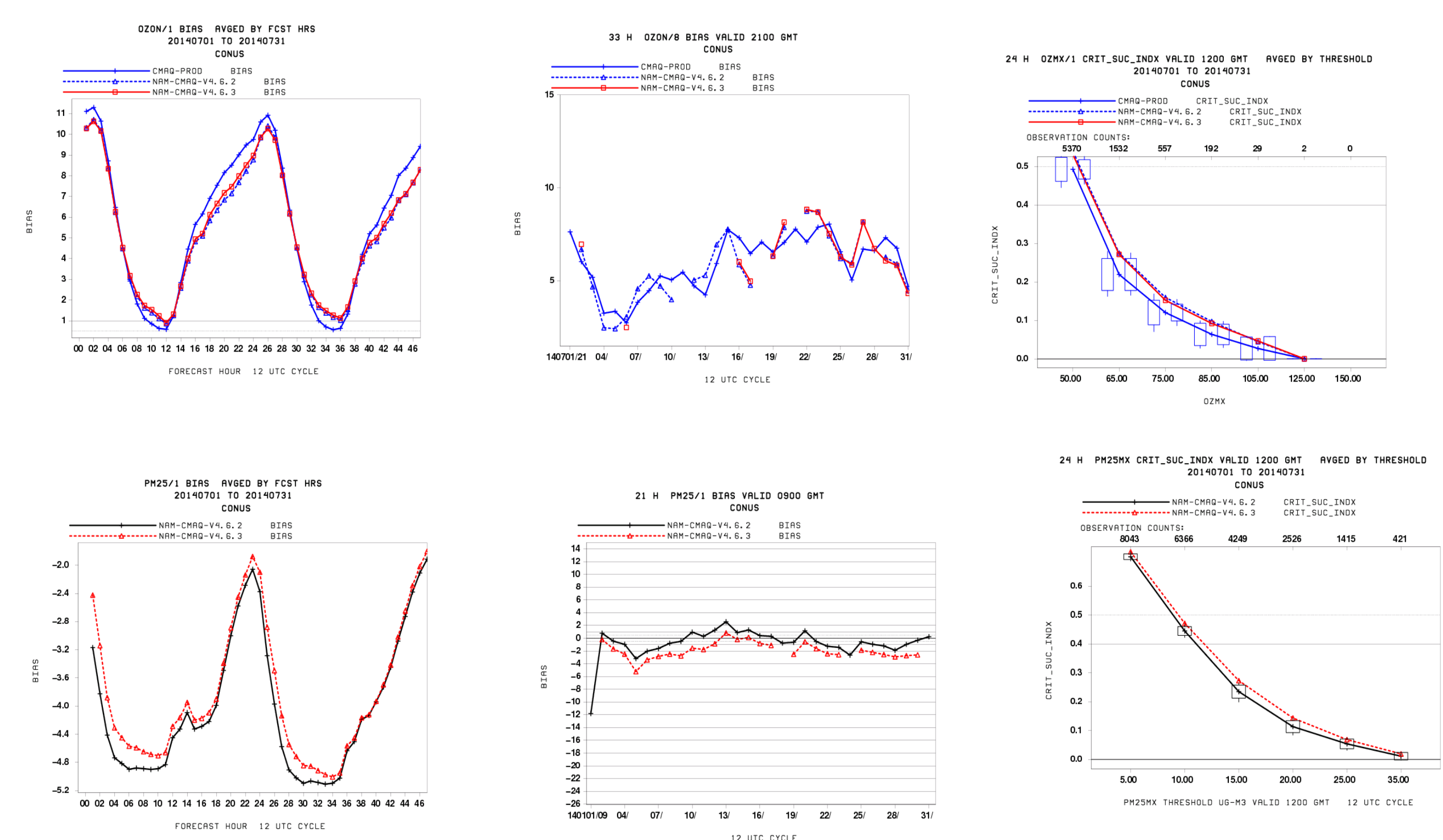Author correspondence: Perry.Shafran@noaa.gov

The NCEP Verification System

❑ Verification – comparison between models and either point observation datasets (gridtobs) or gridded analyses (grid2grid)

❑ Allows model developers to determine how well the model is performing, shows biases, detects errors

❑ Air quality models developed at ARL and run at NCEP
- Community Mesoscale Air Quality (CMAQ model) – gridtobs verification of ozone and 2.5-micron Particulate Matter (PM2.5, or simply PM)
- HYSPLIT – grid2grid verification of smoke and dust

❑ CMAQ – Modeling system that includes a meteorology-chemistry processor along with a chemistry transport module to forecast ground-level ozone and PM and other atmosphere pollutants

❑ HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model – used to show how hazardous materials are transported, dispersed, and deposited

❑ Verification also performed on the AQ models' inputs, the 12-km NMMB-based North American Model (NAM). Variables verified that are important to air quality
- Planetary boundary layer (PBL) height
- 2-m temperatures
- 10-m winds (speed and direction)
- Total cloud cover
- Relative humidity

❑ Statistics calculated: Root Mean Square Error and bias (both AQ and met models. We also calculate skill scores like the Critical Success Index (CSI), equitable threat scores (ETS), and hit rates.
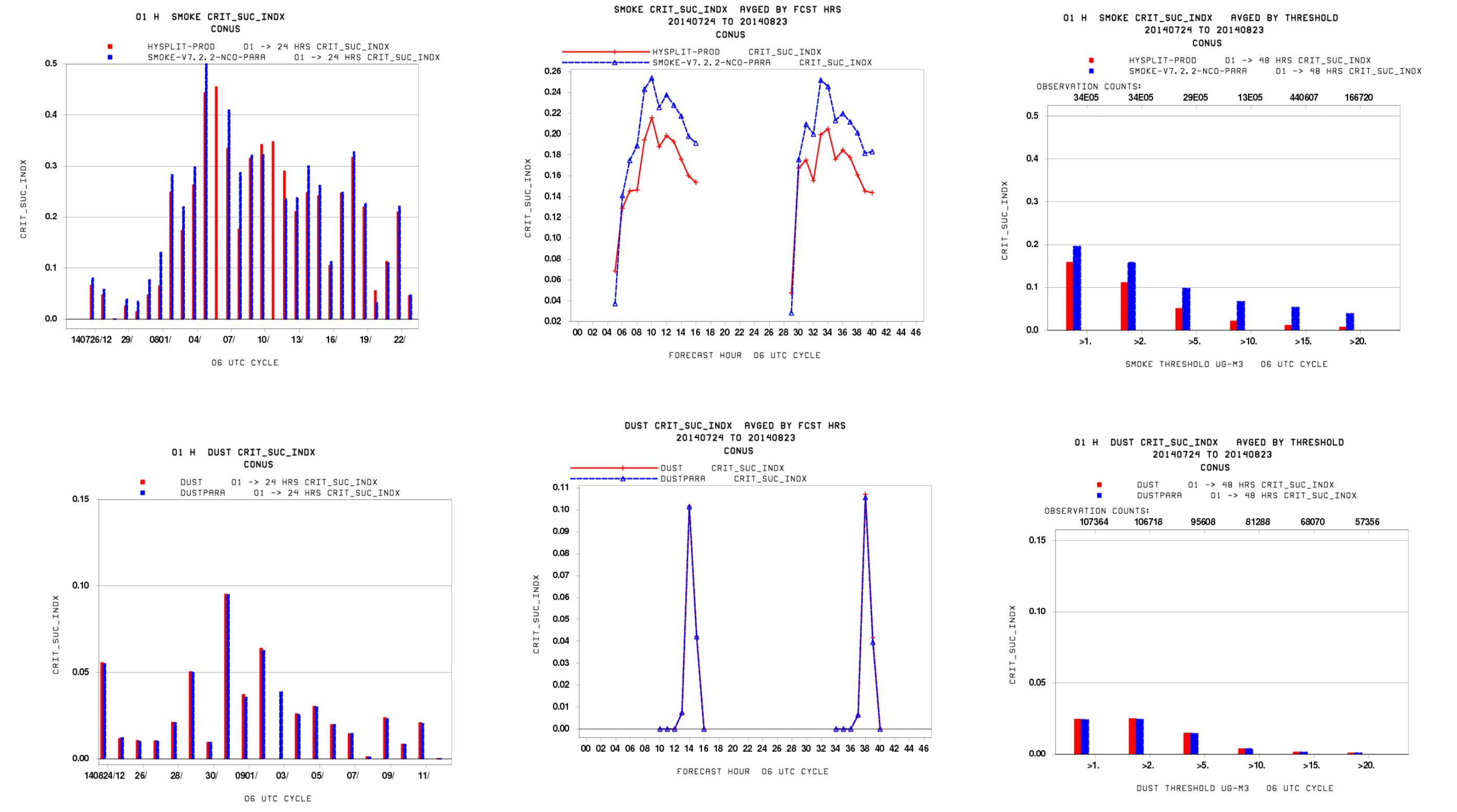
Grid2obs Flowchart

Verification for CMAQ is a grid2obs system as shown in the flowchart above, verification for HYSPLIT is grid2grid, which simply is a direct comparison of gridpoints on model and analysis grids (on the same grid).
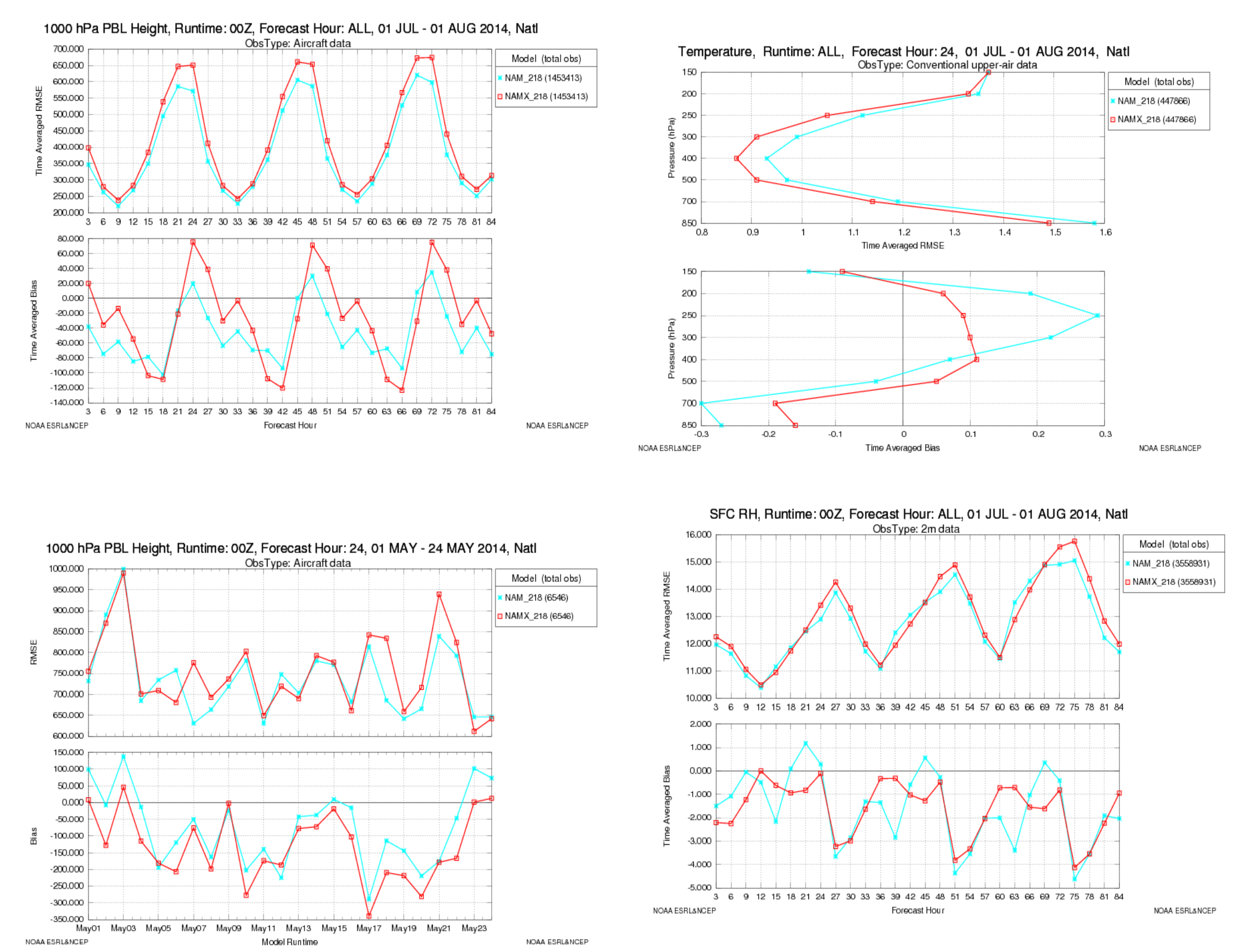
CMAQ Verification

Top row: Ozone concentration (1-hr averages), ops, versions 4.6.2, and 4.6.3. Bottom row: 2.5-micron Particulate Matter (PM) concentration (1-hr averages) for only versions 4.6.2 and 4.6.3. Left: Diurnal cycle plots. Center: Time Series plots at a particular forecast hour. Right: Critical Success Index (CSI) threshold scores. Verification dataset is the AIRNOW data collected through the EPA's Air Quality System (AQS). More CMAQ verification available here: http://www.emc.ncep.noaa.gov/mmb/aq/fvs/web/html/regular.html .

HYSPLIT Verification

Top row: Smoke concentration, operations and parallel. Bottom row: Dust concentration, operations and parallel. Left: Time series plots for a particular forecast hour. Center: Diurnal cycle plots. Right: Combined hours for all thresholds. All plots use the CSI (Critical Success Index) score. Verification dataset for smoke is GOES EAST Aerosol/Smoke Product (GASP), a visible satellite product available every 30 minutes with 4 km by 4 km resolution. Dust verification is MODIS-based and this available only a few hours per day. More HYSPLIT verification available here: http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html/

NAM Verification

Top left: Diurnal cycle of PBL height compared to PBL derived from aircraft soundings. Top right: Vertical profile of verification of temperature compared to radiosondes. Bottom left: Time series of 12-hr PBL height vs. PBL calculated from radiosondes. Bottom right: Diurnal cycle of relative humidity compared to surface stations. All plots compare with the NAM system (NAM) vs. the parallel NAM that was implemented on August 12, 2014 (NAMX). Met model verification is compared with radiosondes, surface, or profiles of aircraft ascents/descents.

Summary

NCEP's verification system can be used for a whole wide range of applications – from verifying data in air quality models to the inputs from meteorological models that go into it.

In the sample verification, CMAQ version 4.6.3 has improved stats over version 4.6.2.

HYSPLIT smoke/dust are improved using the particle model and input fires from Canada & Mexico.

The current ops NAM has similar PBL heights to the previous operational version and also better statistics for most variables in the PBL important to air quality

More info:
CMAQ: http://www.epa.gov/asmdnerl/Research/RIA/cmaq.html
AIRNOW: http://www.airnow.gov/
HYSPLIT: http://www.arl.noaa.gov/HYSPLIT_info.php
GASP: http://www.arl.noaa.gov/smoke.php