S2S Verification Topics at the NOAA Environmental Modeling Center

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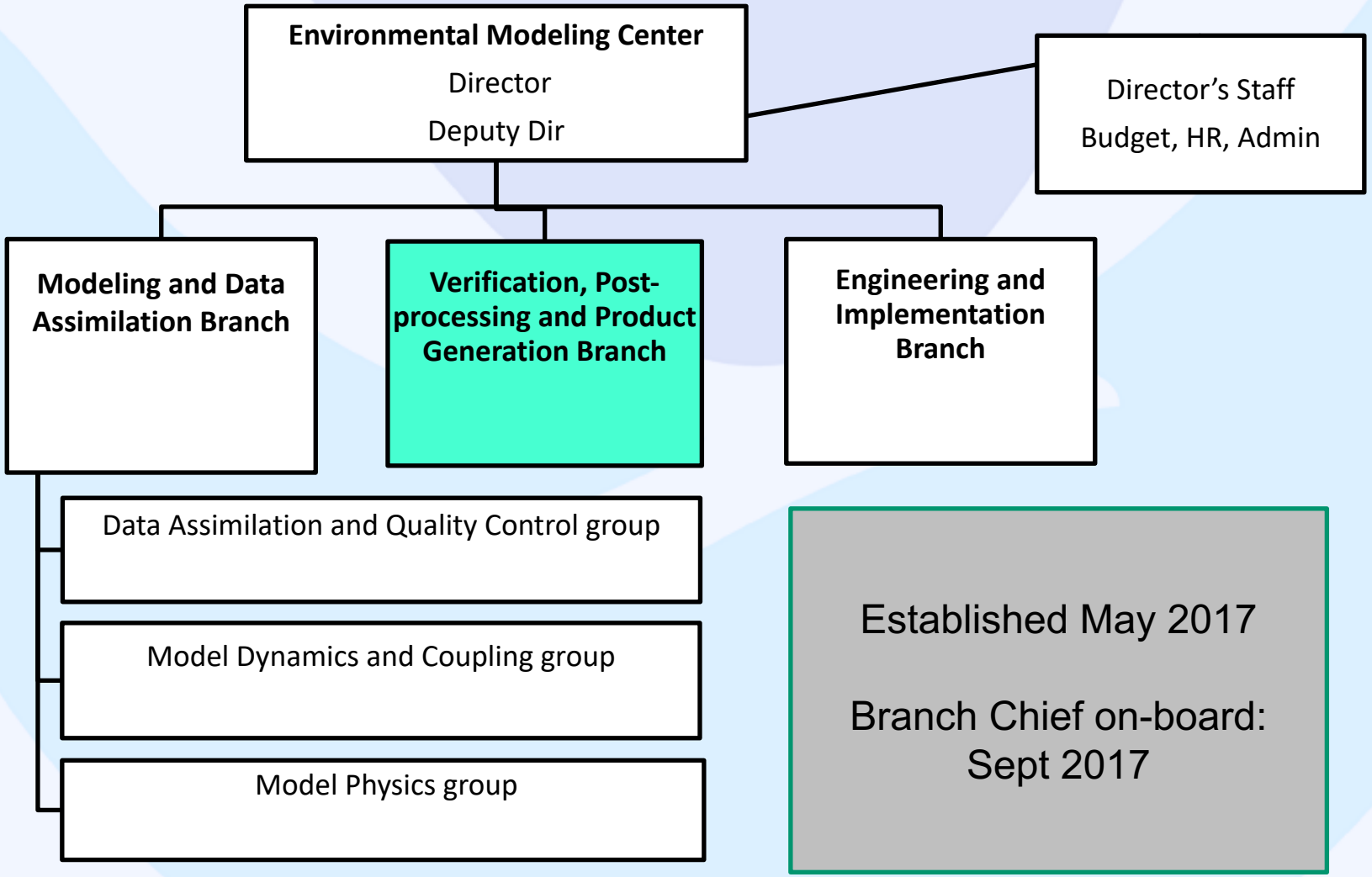
New EMC Branch - VPPPG

Verification, Post-Processing, Product Generation



Established May 2017

Branch Chief on-board: Sept 2017

VPPPG Branch Purpose

- Consolidates verification and evaluation functions to more efficiently and consistently support all modeling groups.
- Also removes evaluation functions from model science chain of command, ensuring ***independent*** evaluations

Functions (from new functional statement) include:

- Conduct **diagnostic verification studies** of model performance on weather and climate time and space scales;
- Processing and quality control of **observations**;
- **Evaluation of new observing systems** for the atmosphere, ocean, land surface and cryosphere;
- Data impact studies to evaluate potential improvements in forecast skill with new or improved observing systems;
- **Ensemble products** using models from EMC and external partners;
- **Post-processing of model output** and **generation of products** for use by internal and external users and partners.

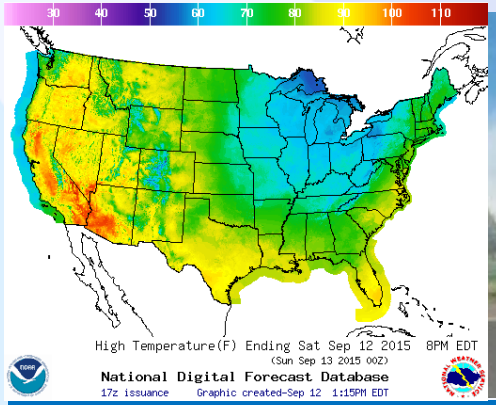
Employee alignment: 9 federal positions, ~35 contractors supporting projects

S2S Verification Software Systems at EMC

- As part of the Next Generation Global Prediction System (NGGPS), the community is moving towards a *unified verification system*
- The Model Evaluation Tools (MET+) software system (NCAR) will eventually be the *exclusive* verification software package used at EMC
- Current EMC S2S verification software at EMC developed in-house
- Essentially the same as CPC's verification software
- If funded, EMC S2S verification software will move to MET+
- EMC is testing the development of ensemble forecasts to 35 days, with varying strategies (Zhu talk at this workshop)
- EMC Verification web page organization coming soon

Model Evaluation Tools

Forecasters



Government Centers

University and National Lab Researchers

Comprehensive and unified verification tool - Make R2O more efficient - Provide a consistent set of metrics

Allows Researchers and Operational Scientists to speak a "common verification" language

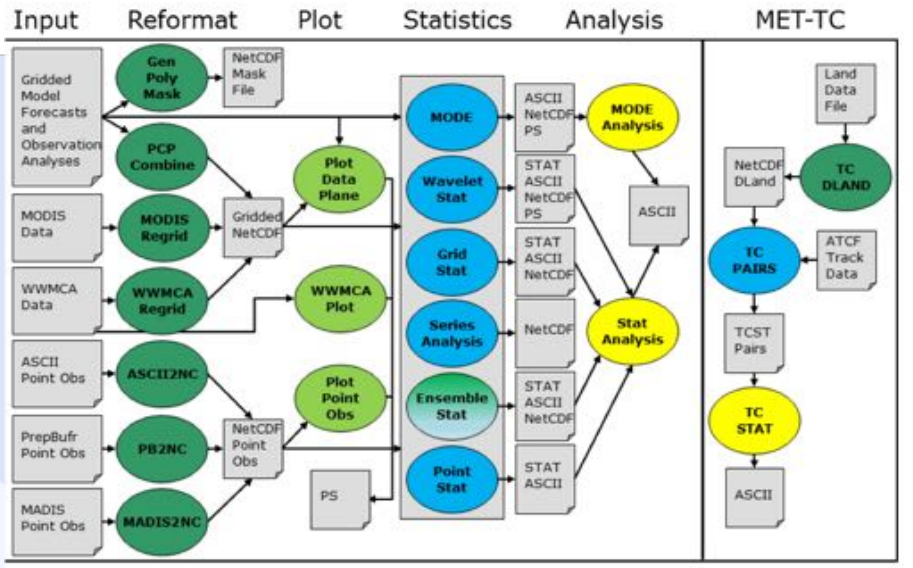
MET
Model Evaluation Tools

User Support of unified package provides greater opportunity to train all on verification best practices

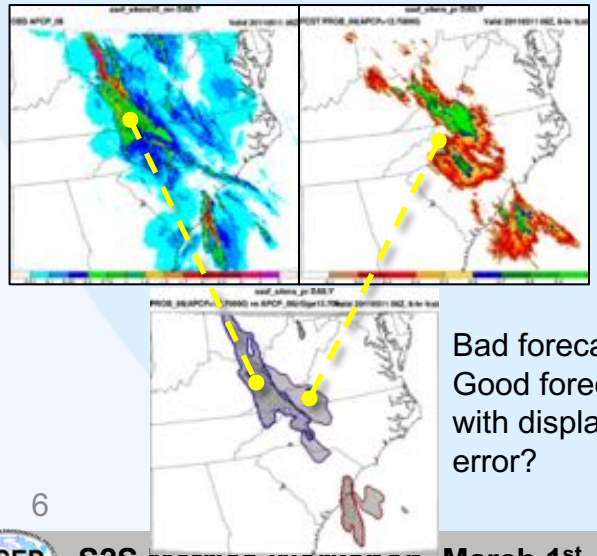
MET
Model Evaluation Tools

A verification toolkit designed for flexible yet systematic evaluation
(supported to the community via the DTC)

- **Over 85 traditional statistics** using both point and gridded datasets
- Multiple interpolation methods
- Computation of confidence intervals
- Able to read in GRIB1, GRIB2 and CF-compliant NetCDF 4, HDF5
- Applied to many spatial and temporal scales (multi-decadal climate to 15-min storm-scale)
- Regridding within the tools and ability to apply complex masking
- 3400+ users, both US & Int'l

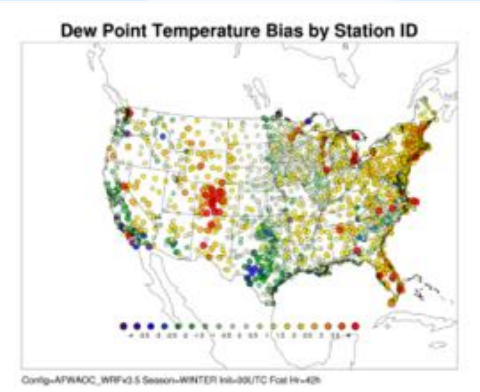


Object Based and Spatial Methods

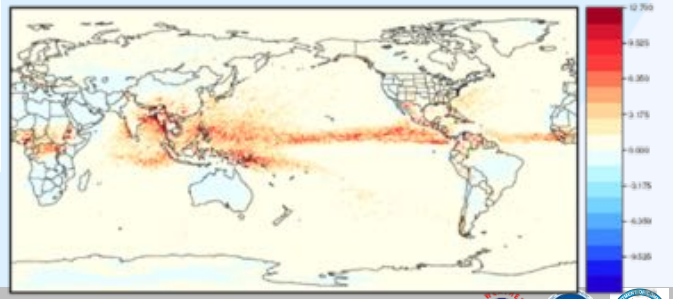


Bad forecast or Good forecast with displacement error?

Geographical Representation of Errors



90th Percentile of difference between two models



S2S Verification Needs at EMC

- Current software and strategy verifies standard metrics, such as these values (for the CFSv2):
  - 2m temperature
  - Surface precipitation
  - MJO
  - SSTs
  - Various Anomaly Correlation (500mb, etc.)

- EMC uses verification tools for two main purposes:
  - Internal model verification during testing and refinement
  - Operational verification of real-time models
  - EMC is an *implementation* Center of R&D from the community
  - Operational verification at EMC needs to be community-vetted and peer-reviewed

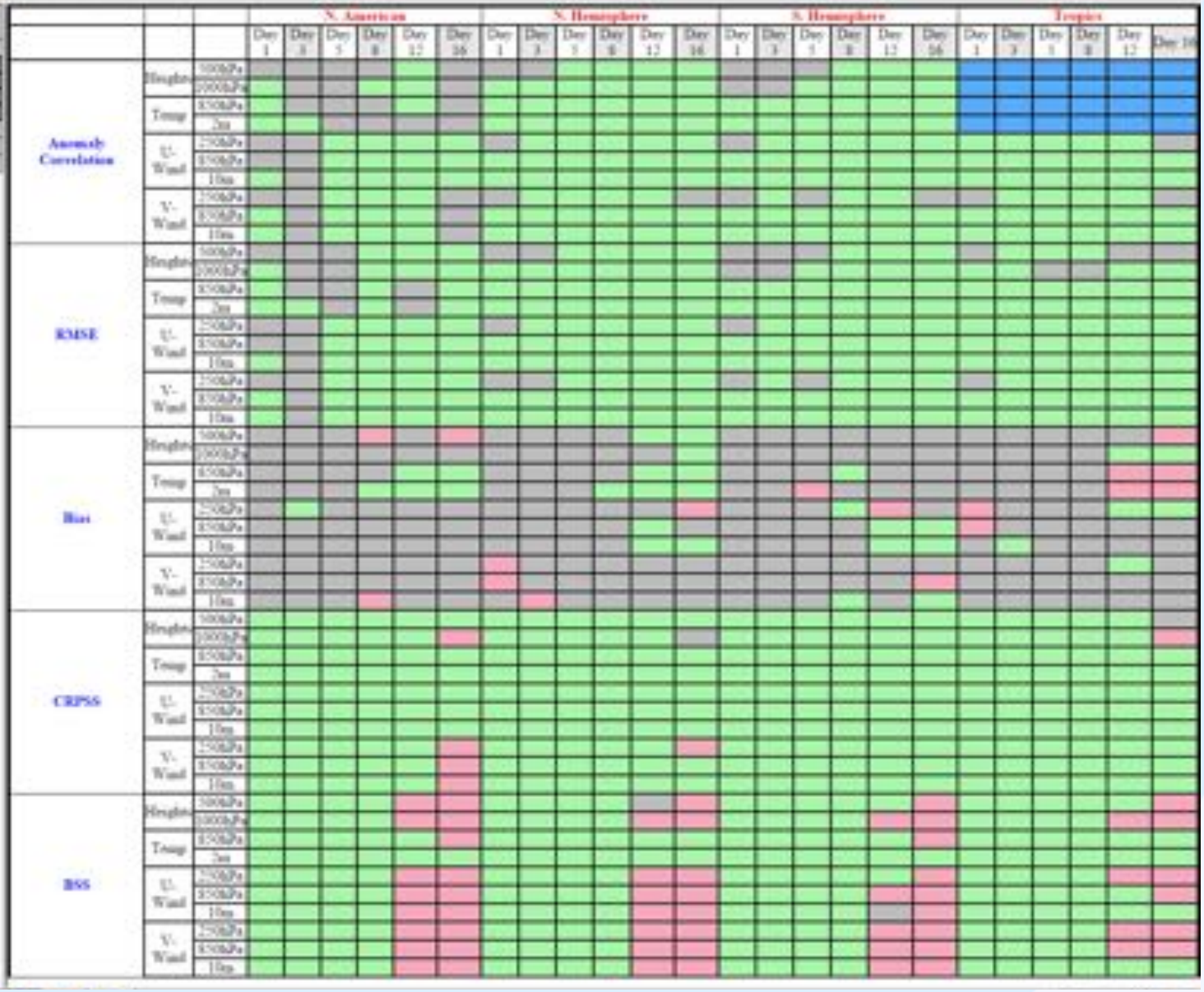
Scores Card: GEFSv11 21m .vs 41m (August 1 – October 1 2013)

Against NCEP analysis

Green: significant better (95%)

Pink: significant worse (95%)

Grey: In-significant or neutral



S2S Verification Examples at EMC

- Prototype Unified Forecast System: Coupled Subseasonal System
  - GSM: Spectral T574L64 semi-Lagrangian grid
  - MOM5.1: GFDL Ocean Model. Z-coordinates, Tripolar CFSv2 grid 0.25^{o} in the tropics and 0.5^{o} global.
  - CICE5: Los Alamos Sealce Model. Same grid as MOM5.1 ocean model.
  - April 2011 to March 2017
  - 144 forecasts, two weeks apart

- Calibration Climatologies
  - Fit six year time series to a sine wave of period 365.24 days
  - Plus three harmonics
  - Done for each grid point and variable separately
  - Need systematic error correction (SEC) to produce a smooth climo

CONUS 2-meter temperature AC (CPC daily*)

	UFSbench	UFSbench	CFSv2ops	CFSv2ops
	Raw	**Sec**	**Raw**	**Sec**
week1	78.0	**87.5**	79.3	85.9
week2	40.1	**46.7**	41.7	46.4
week3	19.4	**23.3**	17.6	19.9
week4	11.0	**12.6**	0.3	1.8
week3&4	20.8	**26.1**	11.6	14.7

UFSbench equal or better than the CFSv2ops for all lead times.

*CPC Global 0.5 degree Daily 2-m TMIN/TMAX from:
ftp://ftp.cpc.ncep.noaa.gov/precip/wd52ws/global_temp/
e.g., CPC_GLOBAL_T_V0.x_0.5deg.lnx.YYYY

S2S Verification Needs at EMC

- WWRP/WGNE Joint Working Group on Forecast Verification Research (JWGFVR)
  - Wiki page: S2S sub-project on verification and products
    - http://s2sprediction.net/xwiki/bin/view/Main/Verification
- WMO Standardized Verification System (SVS) for Long Range Forecasts (LRF)
- WMO's Commission for Climatology (CCI) – probabilistic forecasts
- Deterministic vs Probabilistic
- Limited sample sizes and low levels of predictability

Questions and Research

- Asking the right verification questions for a S2S system:
  - What is S2S forecast “skill”? Needs to be defined for S2S
  - Difficult due to poor predictability
  - Complicated to design a verification system that works well

- Research needs for verification
  - What’s beyond the standard skill scores?
  - Designing the right kind of hindcasts
  - Object-oriented verification
  - Revisiting the WMO standards
  - Probabilistic verification