A Unified Approach to Verification

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7th WMO Verification Workshop

How this started

MET Released in 2007; Now has 3300 registered users internationally – until recently not within the national centers/labs
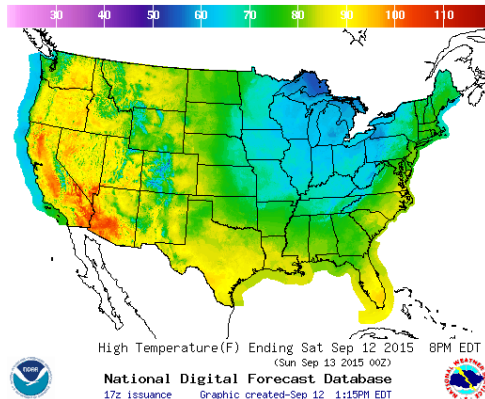
2015-2016 Recommendations to Unify on MET/METViewer:

- UCAR Model Advisory Committee (UMAC) to NCEP
- Next Generation Global Prediction System (NGGPS) Verification and Validation Team
- 2nd Convection Allowing Model (CAM) Ensemble Design Workshop

Unification
Let's all work together to build a unified package

EMC Vx, HIWPP Vx, MET and METViewer
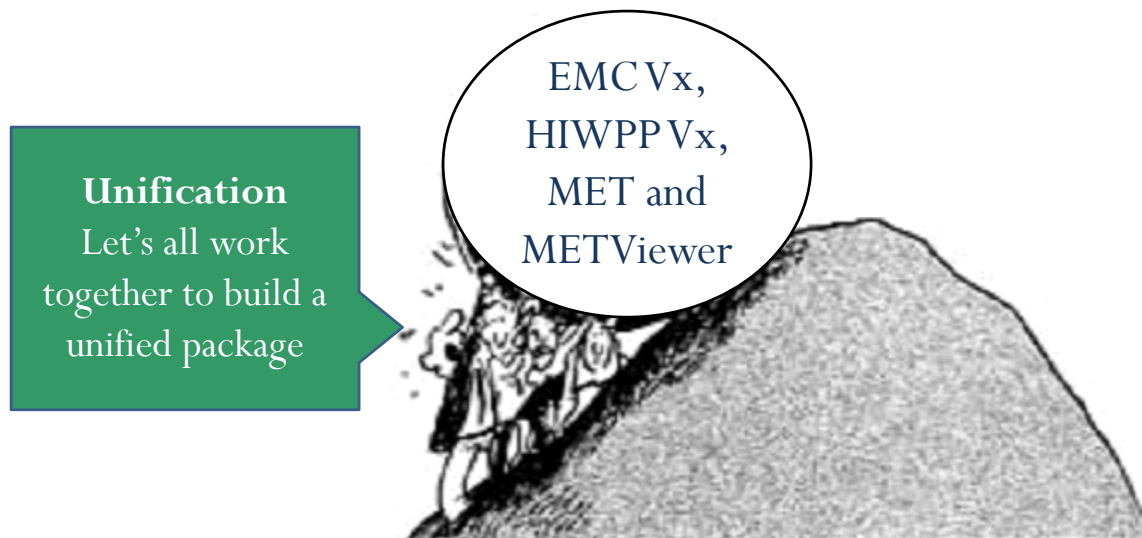
Why Unification

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

DTC
Developmental Testbed Center

MET

Model Evaluation Tools

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

- **Over 70 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
- Applied to many spatial and temporal scales
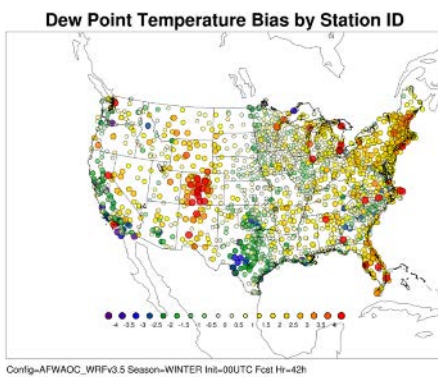- 3200+ users, both US (30%) and internationally (70%)
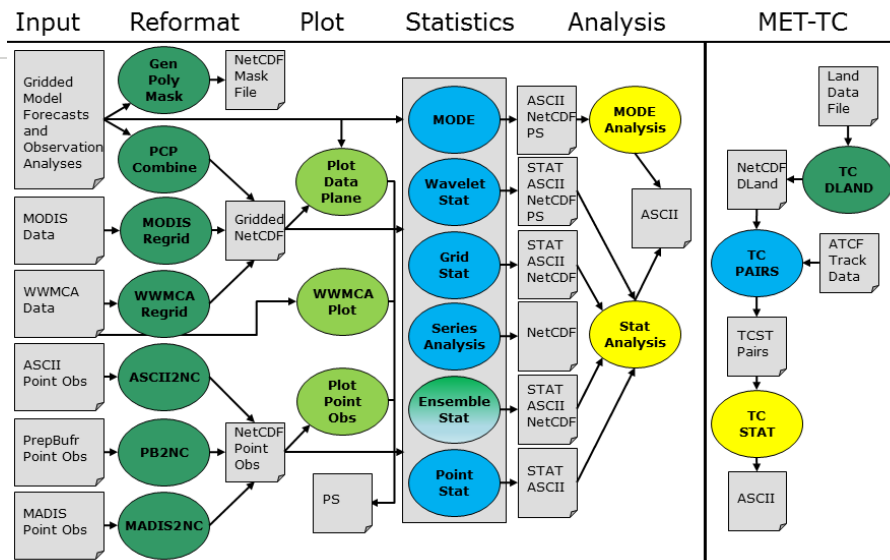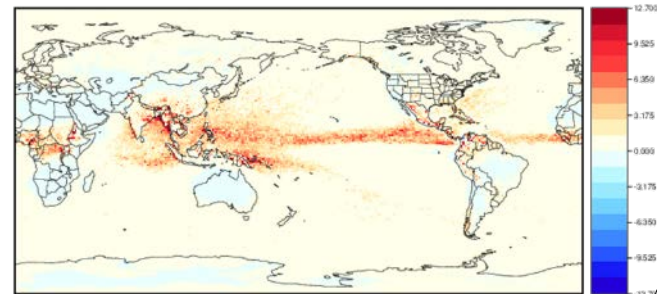
Object Based and Spatial Methods
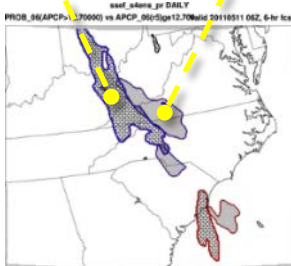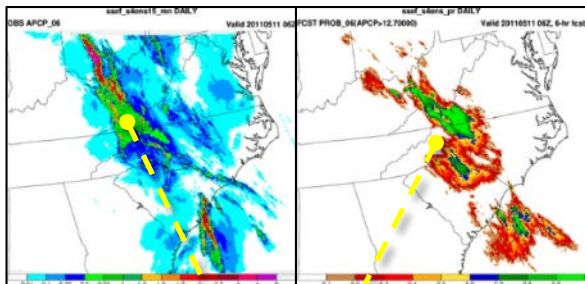
Bad forecast or Good forecast with displacement error?

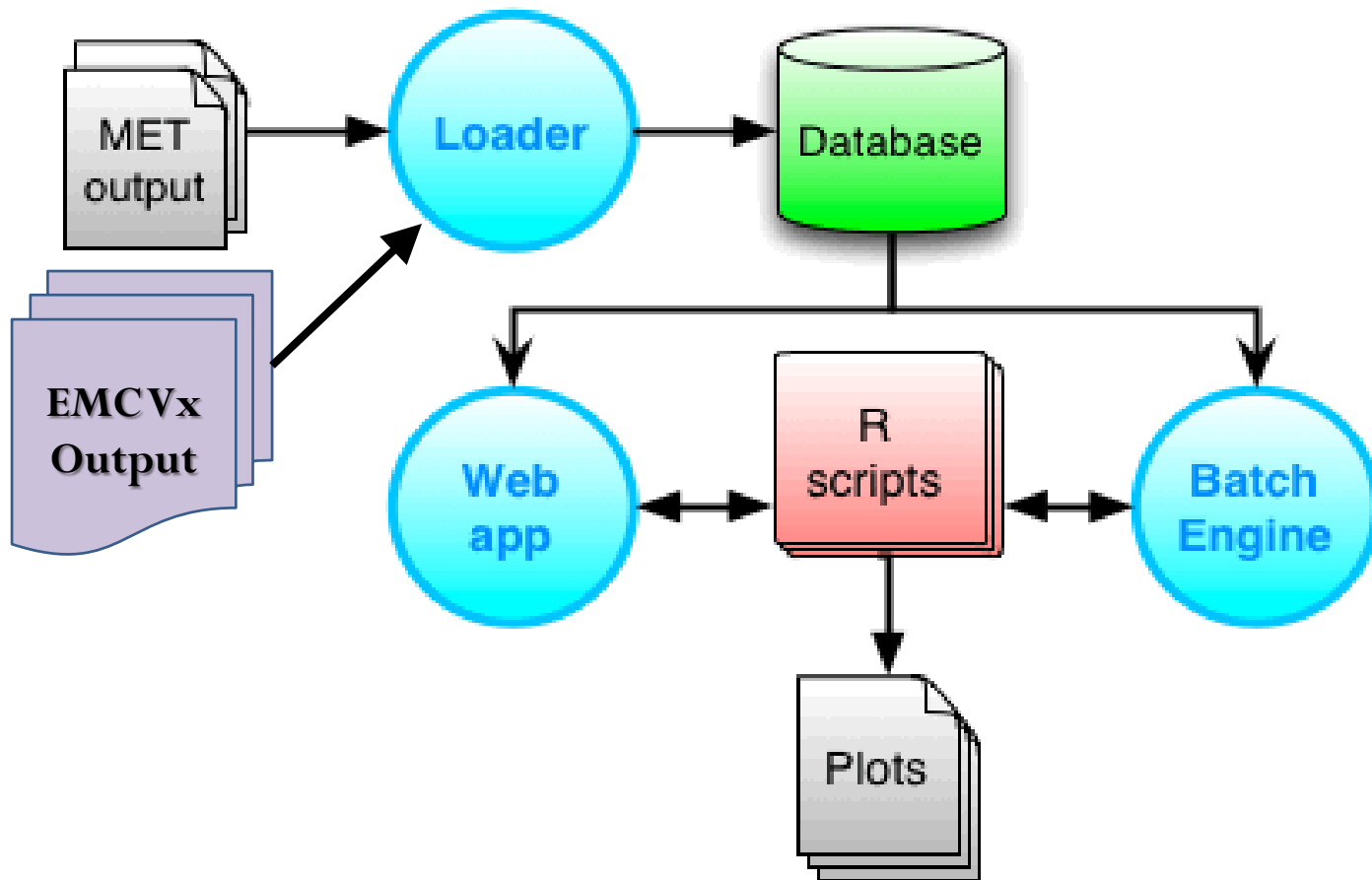### Geographical Representation of Errors
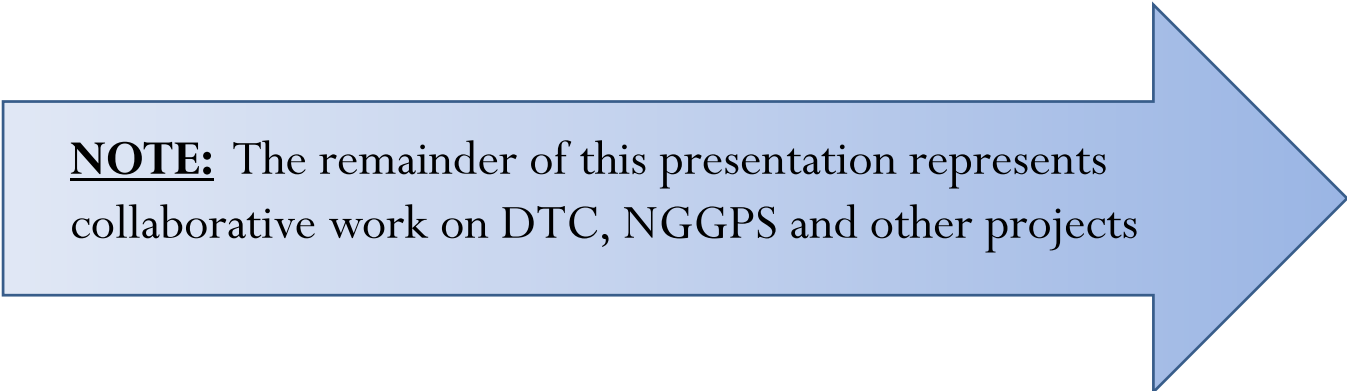

90th Percentile of difference between two models

4

METViewer components

Current Verification Priorities

☑ Document requirements

☑ Transition MET to run at EMC

☑ Extend it to reproduce all current EMC global metrics

☑ Enhance METViewer to handle large amounts data

☑ Begin including metrics for ocean, ice, land, aerosols, space weather and system coupling

☑ Identify and begin including process oriented methods

NOTE: The remainder of this presentation represents collaborative work on DTC, NGGPS and other projects

Unification Roadmap

- Met with 50+ NCEP staff (EMC, WPC, CPC, NCO)
- Included discussions with coupled system "components"
- 99 functional requirements and 19 non-functional broken down by priorities
  - Statistics
  - Plot types
  - Data types
  - Preprocessing
  - Database and display
  - Documentation and help desk

22	GlobalDet	4	Must be able to verify forecasts against NCEP/CPC gauge analysis.		✔
23	GlobalDet, MMDet	1	Must be able to compute 3-, 6- and 24 -hour accumulated QPF and QPE values		✔
24	AllEMC	1	Must produce 2-D maps of forecasted values. This is implied from Requirement 1. This requirement may initially be met with links to maps generated elsewhere.	Some capability by 06/17; rest in NGGPS YR2	✔
25	GlobalDet, GlobalEns, MMDet, MMEns, MEG	1	Must have ability to produce standardized, pre-generated graphical images		✔
26	AllEMC	1	Must have ability to compare against multiple analyses and obs sets		✔
27	GlobalEns	1	Must have ability to verify against CCPA for precipitation		✔
28	GlobalDet, GlobalEns, MMDet, Fit2Obs	1	Must be able to read data in PrepBUFR format.	Prototype TBD 04/17	✔
29	AllEMC, WPC	1	Must be able to read all standard NCEP grids		✔
30	AllEMC	1	Must have flexible masking to define regions; should be able to at a minimum define 1) regions that are over land or over ocean, and 2) regions defined by lat, long corner points		✔
31	GlobalEns, MMEns	1	Must be able to read GRIB variants from NCEP, UKM, ECM, CMC, FNO, JMA, NCMRWF and German models	Can read first 3. Need sample files to determine if complete	✔
32	GlobalEns	1	Must produce output that can be used by a plotting package to create plan-view for model data.		✔
21	MMDet	1	Must be able to run neighborhood method to compute FSS for multiple neighborhoods. Implicit in Requirement 19		✔

Phase I TBD 01/17
Phase II TBD 05/17
Weighting done
Climo TBD 03/17
NGGPS-YR2-3 if still required
Prototype TBD 02/17
Prototype TBD 02/17
Prototype TBD 02/17
Prototype TBD 04/17
Prototype TBD 04/17

Funding for completion
TBD 06/17

...ved, and the full list ...he highest, or most ...goals of the NGGPS ...time and resources

...further refined and

...aluation. To list the ...g abbreviations are

elsewhere in this document.

Areas of Focus

- Treatment of uncertainty
- Scorecard and weighted performance indices
- Ensemble and probability verification metrics
- Diagnostic tools (scales at which errors occur, energy spectra)
- Physics-oriented metrics (radiation, fluxes, cloud verification)
- Forecast consistency and extreme weather
- Object-oriented metrics
- Coupled model component performance
- Validation – during development process
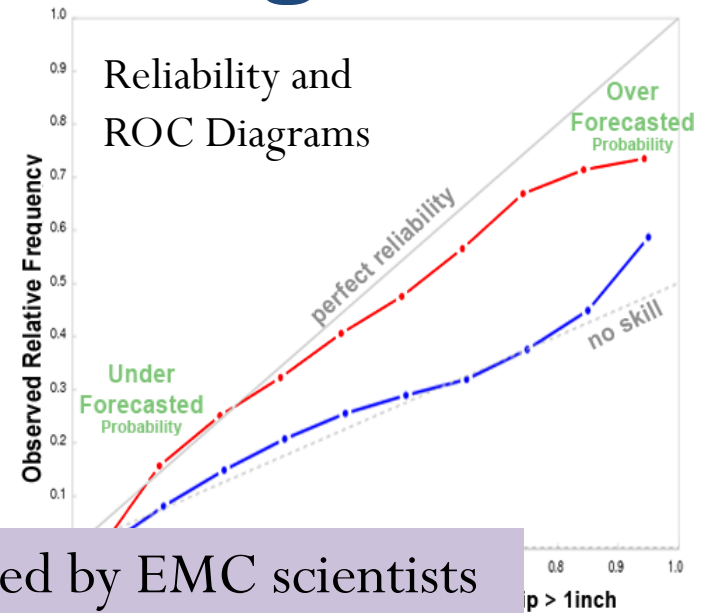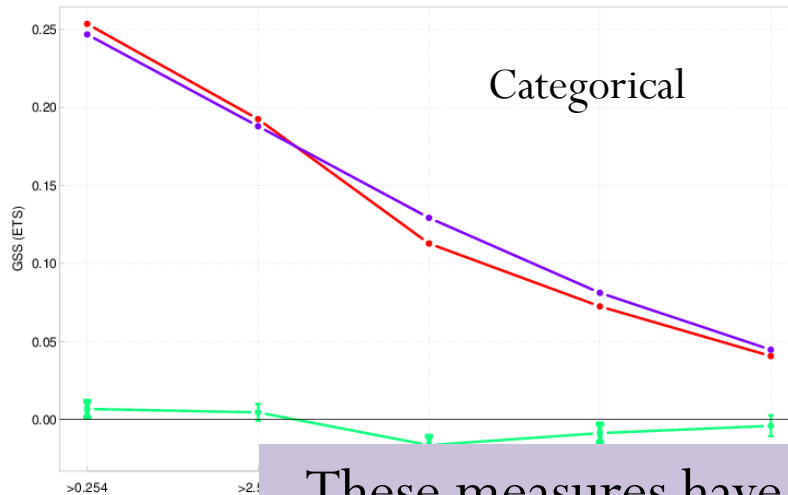
MET+ Unified Package

- Python wrappers around MET and METViewer:

- Simple to set-up and run

- Automated plotting of 2D fields and statistics

- Communication between MET & python algorithms (Cython)

Initial system – Global deterministic with plans to generalize across scales when possible to quickly spin-up Ensembles, High Resolution & Global Components

Python wrappers

ASCII

NetCDF

Spatial Plots

Stats Plots

METViewer

GitHub Repository
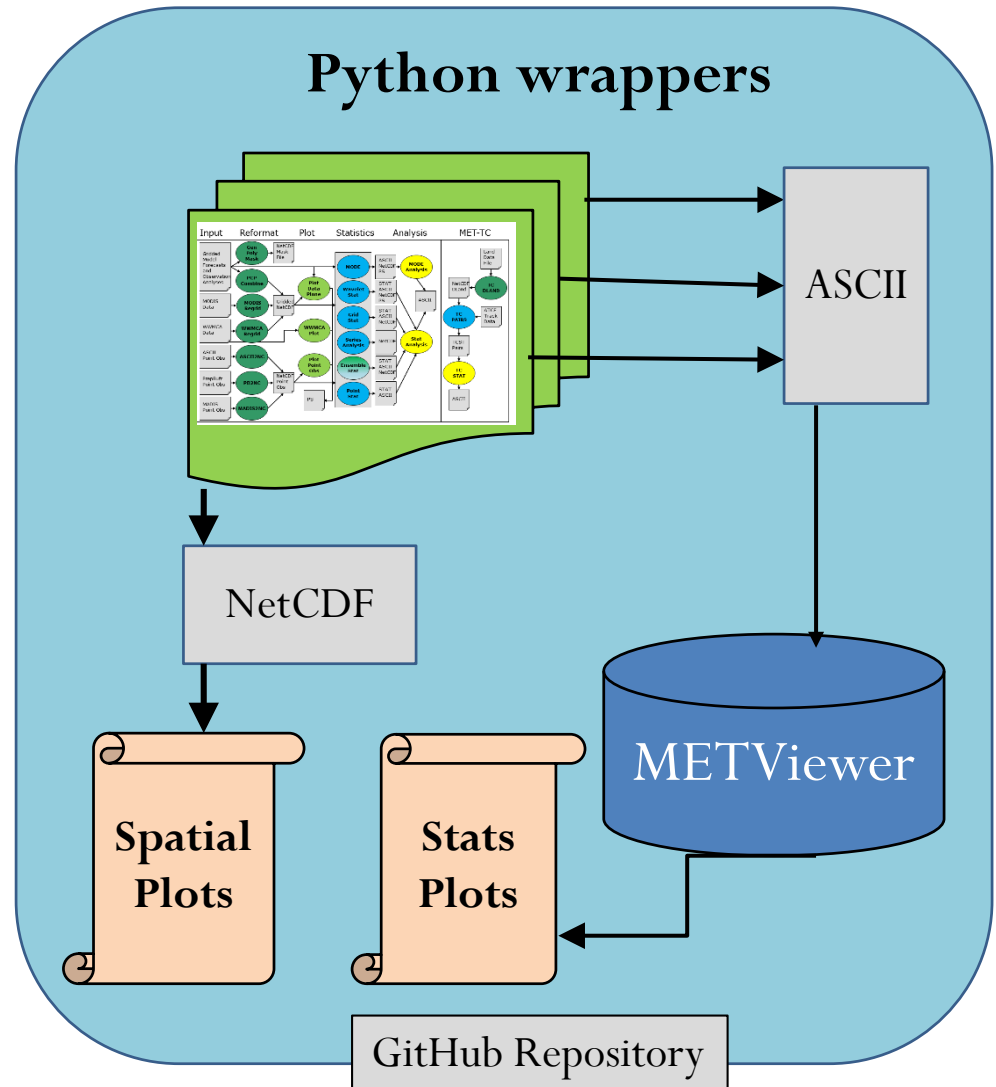
Recent Progress – Testing

Categorical Statistics – Gilbert Skill Score (Equitable Threat Score)

Categorical

Reliability and ROC Diagrams

Continuous

Rank Histograms

These measures have been vetted by EMC scientists and found to be the same as their current system
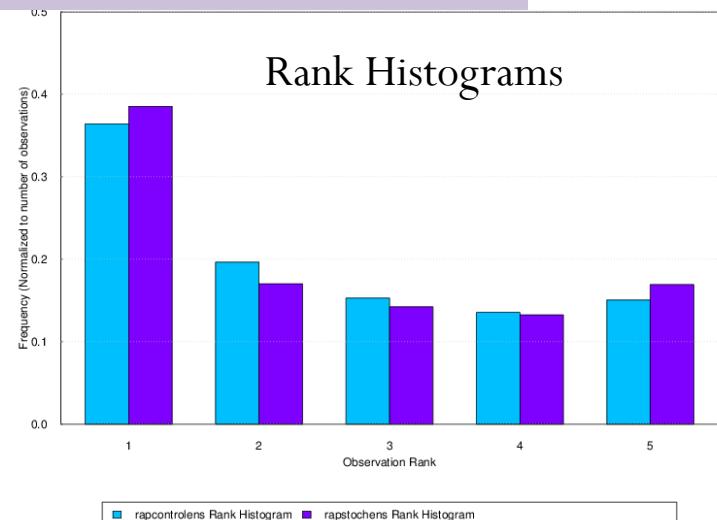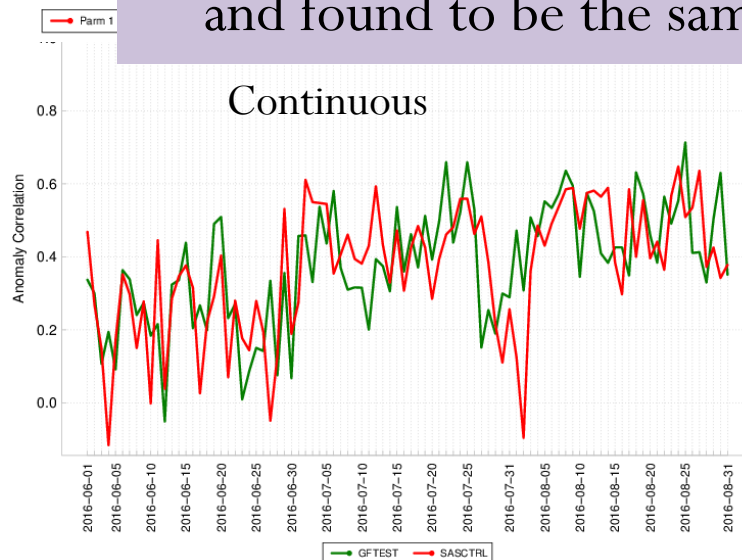
Recent Progress - METViewer

Performance and Taylor Diagram

Scripts to prune data
Speeded up boot-strapping
Updated event equalization

METViewer is our database and display system that uses MET output stored in MySQL

Recent Progress - METViewer Scorecard

Specify the Statistic

Specify the Field

Specify the regions

Specify the aggregations

Specify whether you have symbol, values or both

METViewer Scorecard
for PR4RN_1405 and GFS2016
2014-05-20 00:00:00 - 2014-07-30 00:00:00

Submit to batch engine of METViewer

Recent Progress – MET+ *alpha*
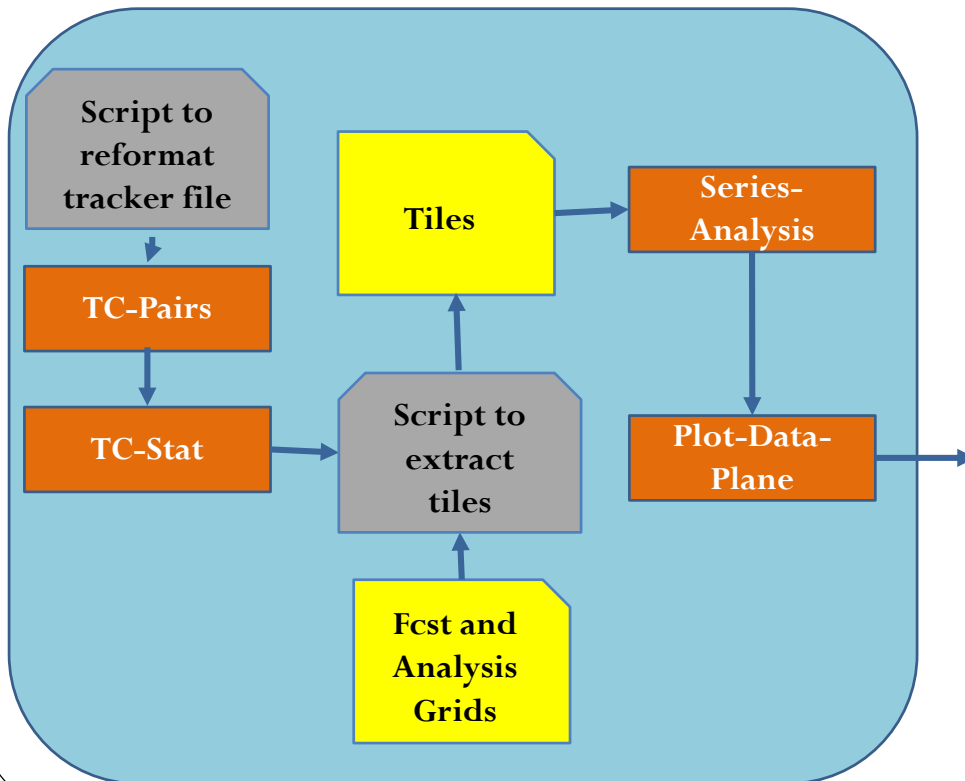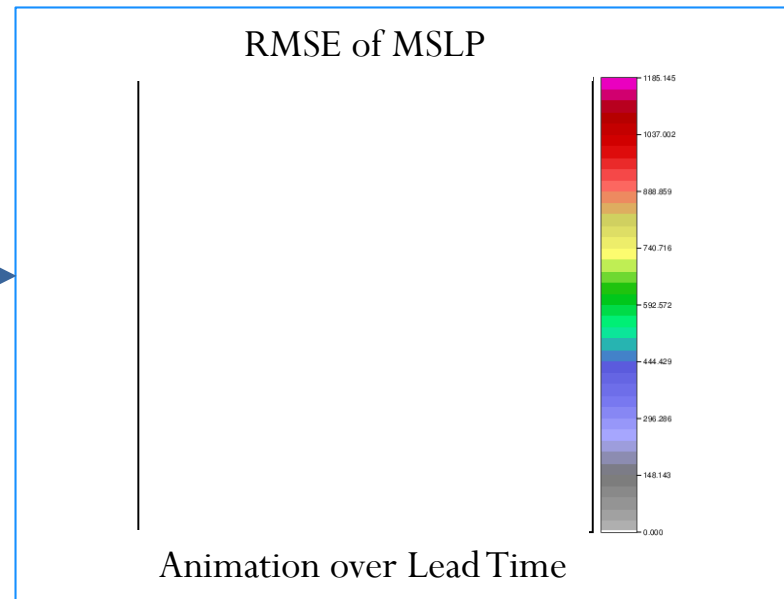
Part of NGGPS PI Project
Brian Colle – PI
Stony Brook Univ.
Released for testing on 2/6/17

- Uses TC-Pairs and TC-Stat to identify location of and extract tiles
- "Stack up" tiles by lead or init time to compute systematic errors about "feature" using Series-Analysis
- Plot results using Plot-Data-Plane (quick-look plotting)

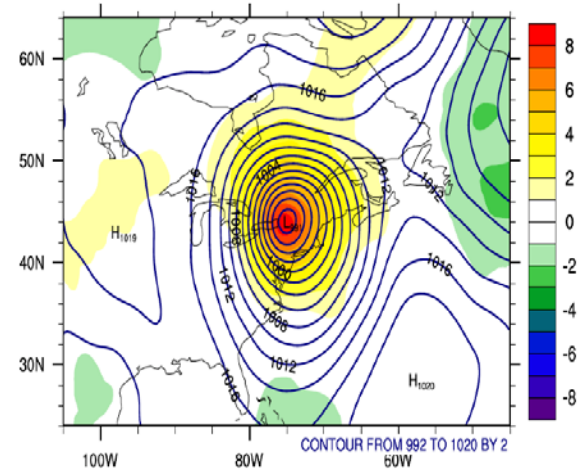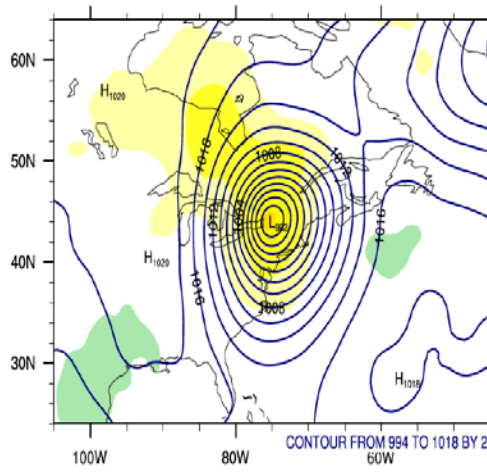## MET+ *alpha* - Python Wrappers

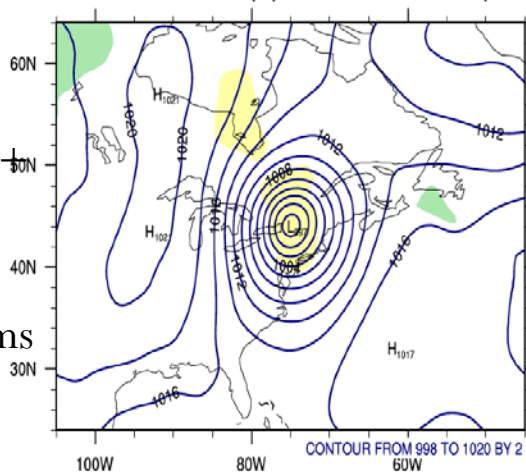RMSE of MSLP

Animation over Lead Time
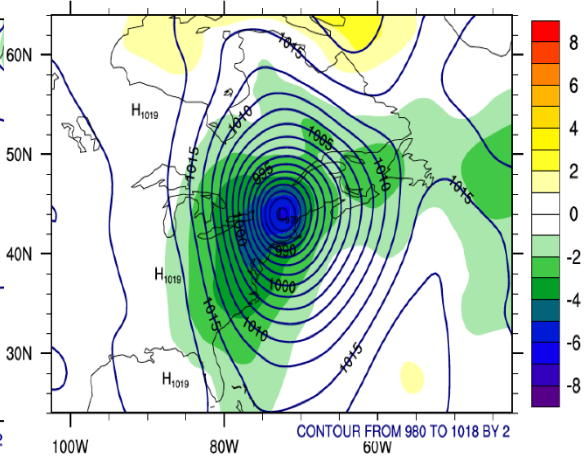
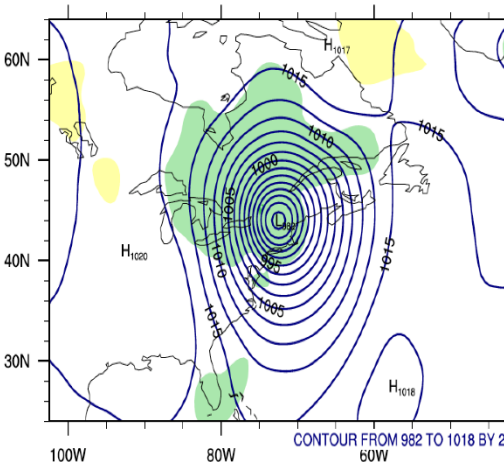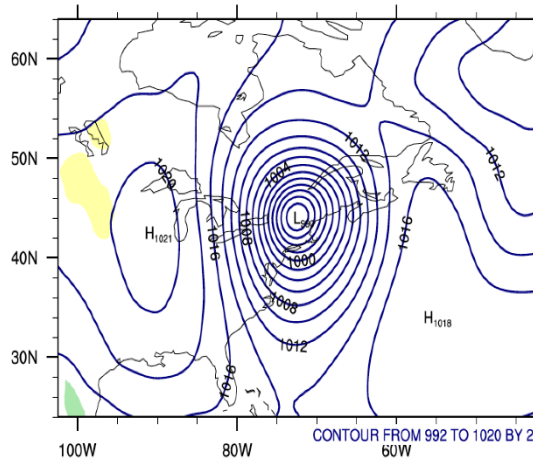# *Cyclone Relative Approach –Stony Brook Univ. Software*

Hour 54-72   Hour 78-96   Hour 102-120

GEFS
Control+
7.5 hPa
Bias
60 storms

GEFS
Control
-7.5 hPa
Bias
52
storms`

Slide Courtesy of Brian Colle, SBU

Depiction of Cyclone Relative Evaluation

Area of Interest

Forecast Track

t

t+1

t+2
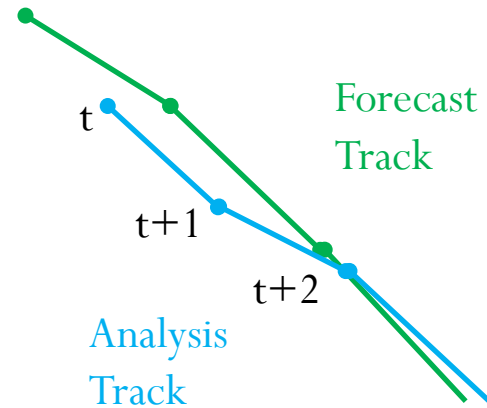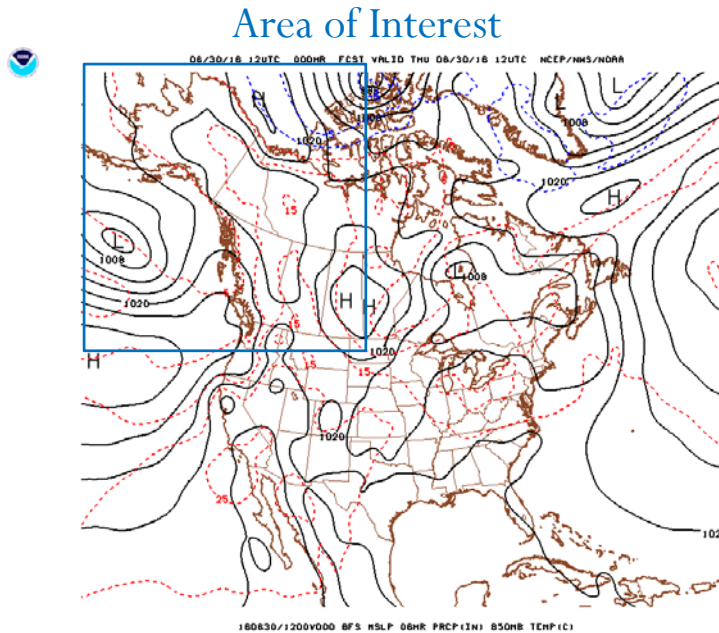
Analysis Track

Methodology

- Run tracker on forecast and analysis field
- Use MET to extract a tile centered on each lat/lon pair of track
- Use MET to compute statistics for paired fields within tile irrespective of displacement
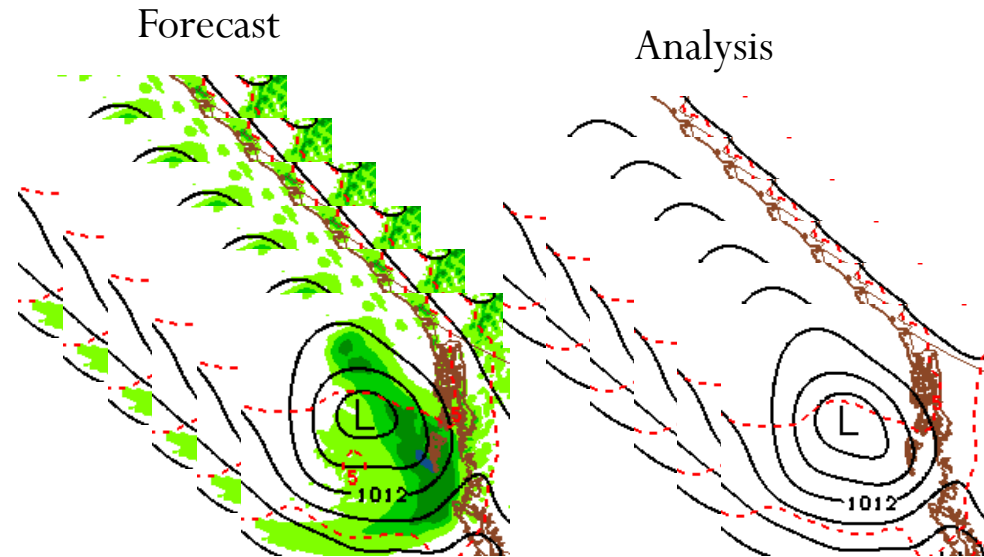
Forecast

Analysis

Recent Progress – MET+ *alpha*

Part of NGGPS PI Project
Brian Colle – PI
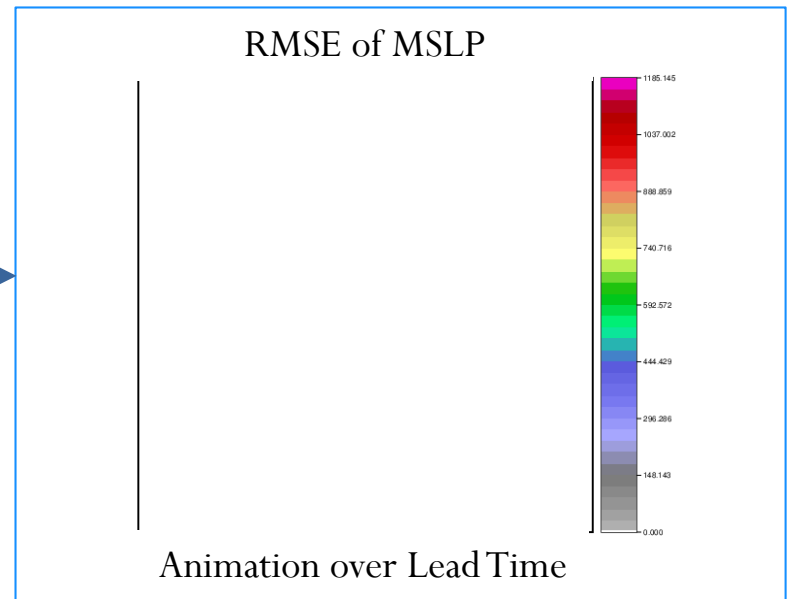*Stony Brook Univ.*
Released for testing on 2/6/17

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MET+ *alpha* - Python Wrappers

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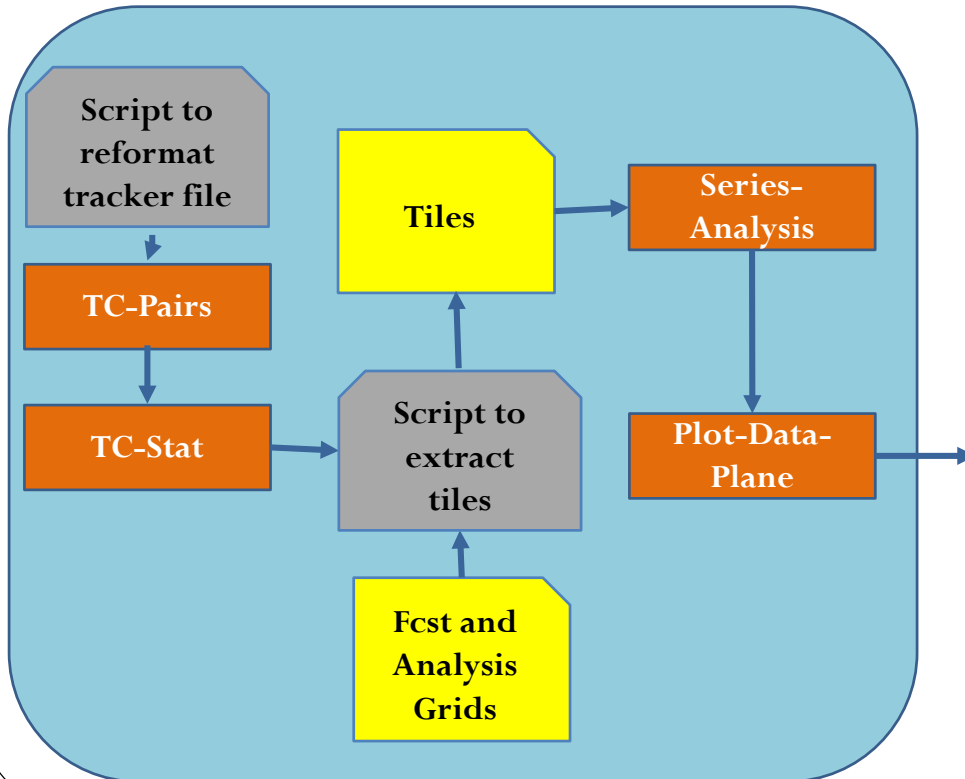
Recent Progress – Docker MET

Docker **(Amazon Web Services):**
- Open-source technology to build and deploy applications inside software containers
- Packages software containing: code, runtime, system tools, system libraries, etc
- Enables you to quickly, reliably, and consistently deploy applications
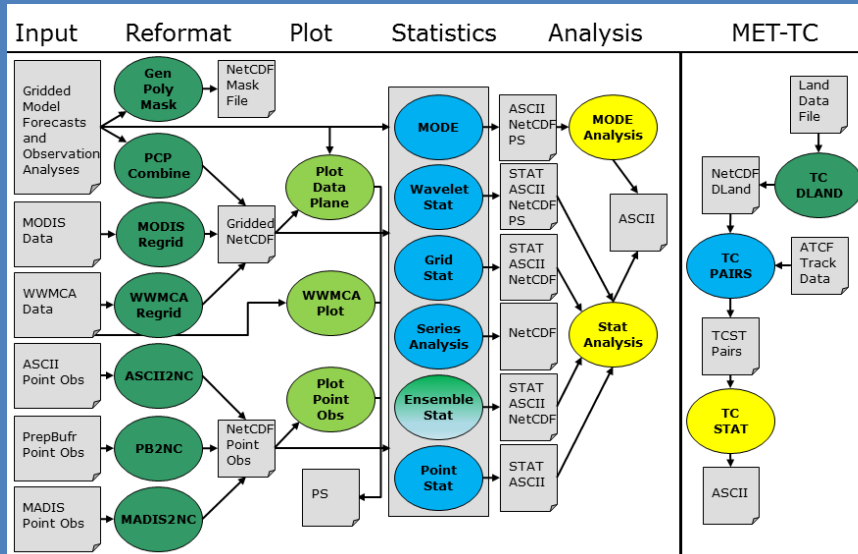
MET compiled in a Docker Container
- and –

1) Set up to work with a suite of test-cases for NWP innovation testing
2) Bundled with MET online tutorial data

Docker MET should make it easier for scientists to test out MET's capabilities

The MET+ team is working on making the container more flexible to remove the need for compilation of MET

Contact met_help@ucar.edu for more info

Summary

Unification of verification capability has begun between NOAA EMC, DTC and partner organizations using MET+

Phase I to be completed by Summer 2017
- Parallel MET+ system for global physics development at EMC and within the DTC Global Model Test Bed (GMTB)
- Many enhancements to software and training material

Phase II to be completed by Summer 2018
- MET+ available to community
- MET+ examples for multi-scale evaluation (global to storm scale) available to NGGPS and research community on DTC website

Questions?

Contact: Tara Jensen – Jensen@ucar.edu

MET Website: http://www.dtcenter.org/met/users/

MET Download:
http://www.dtcenter.org/met/users/downloads/index.php

MET Helpdesk: ***met_help@ucar.edu***

http://www.dtcenter.org/met/users/support/met_help.php