METplus Tutorial

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with contributions from Jim Frimel, George McCabe, Howard Soh, Tatiana Burek, Randy Bullock , Tina Kalb, Hank Fisher, and Jonathan Vigh

Oct 1-5, 2018

National Center for Weather and Climate Prediction

College Park, MD

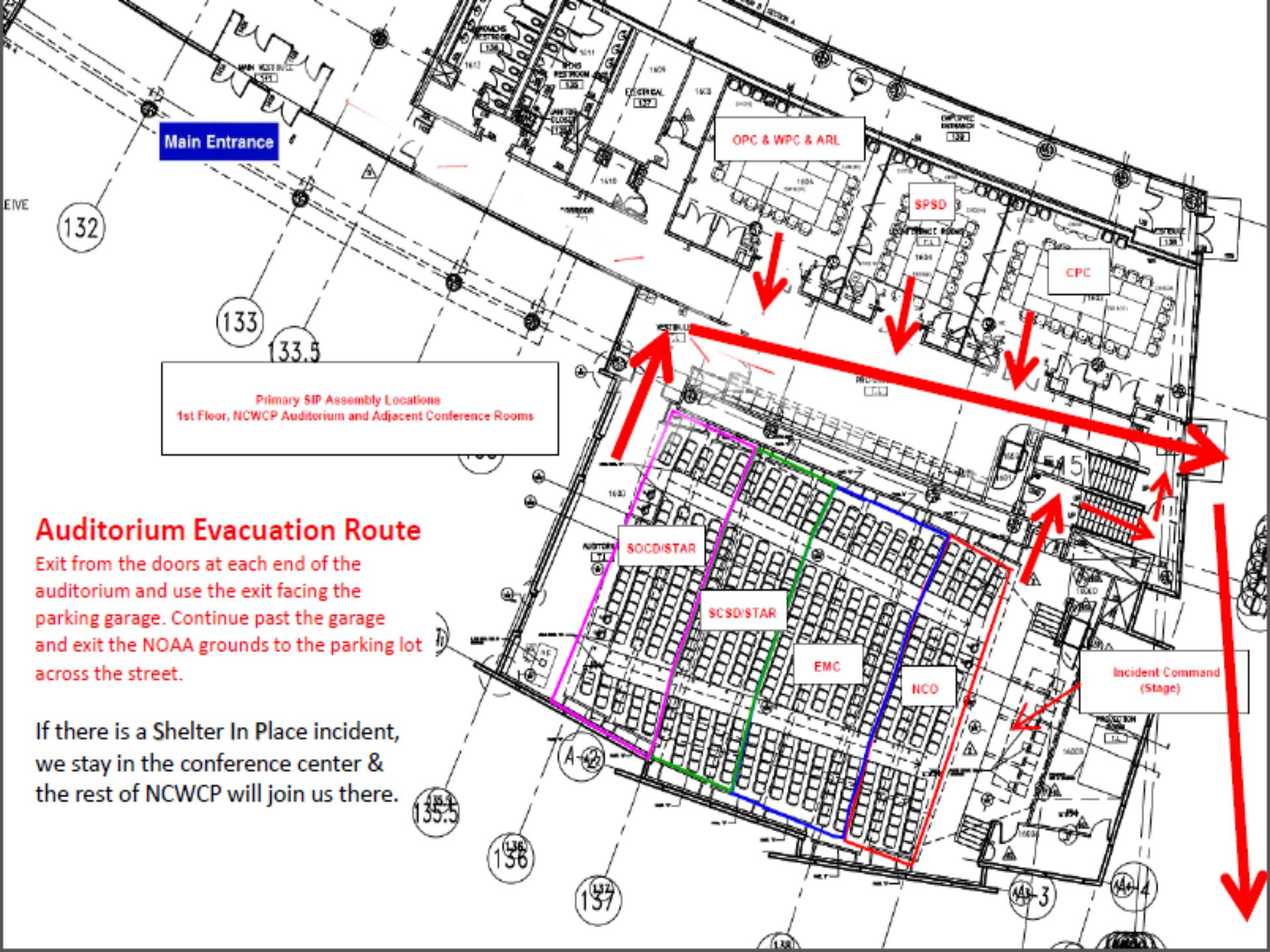
Welcome

Tutorial sponsored by Next Generation Global Prediction System (NGGPS) Program Office

On the phone: Mute your phones until you want to ask a question
In the audience: Silence your phones; Use microphones for questions
Meals and coffee breaks:

Breaks and Lunches are on your own

Wifi (NOAAGuest): Type your email into browser
Safety and evacuation: See next slides



Auditorium Evacuation Route

Exit from the doors at each end of the auditorium and use the exit facing the parking garage. Continue past the garage and exit the NOAA grounds to the parking lot across the street.

If there is a Shelter In Place incident, we stay in the conference center & the rest of NCWCP will join us there.


Auditorium Evacuation Route
NCWCP
Earth System Science Interdisciplinary Center
Joint Global Change Research Institute
Ronald reagan center washdc
Evacuation Assembly Area
Construction Zone
River Road
Google
Imagery ©2017

Goals of Tutorial

- Train users on how to install METplus and the MET component
- Familiarize users with MET and METviewer components
- Train users on how to use METplus use-cases out of the box and then customize them
- Encourage users to contribute to development
- Update users on new and upcoming features
- Obtain input from users about how to enhance the system

General Schedule

Detailed Schedule				Color Key	
REMOTE ACCESS INFO - ReadyTalk		*Please share ReadyTalk resources when possible*		Fundamental/Overview	
Audio: 866-740-1260 meeting_id: 4978479				Advanced Topic	
Web: www.readytalk.com; join meeting_id: 4978479				Updates and User Input	
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
8:30	**Tutorial starts at 10:30 AM ET**	MET Tools Overview - pre-processing; masking; regridding	MODE and MODE-TD; Assistance with setting up METplus	MET-TC and METplus Track and Intensity use-case	Review of 1-3 METplus use-cases selected by group on Thursday
10:00	--	BREAK		BREAK	BREAK
10:30	Introductions, Basic METplus overview	MET Tools Overview - Grid-Stat; Point-Stat; Ensemble Stat	Whats New in MET and METviewer	METplus in use at NCEP; Assistance with METplus	Coming Enhancements and User Input
12:00	LUNCH	LUNCH	LUNCH	LUNCH	ADJOURN
1:00	Compiling MET - Fundamental instructions and nuances of Theia, WCOSS, Jet and Gaea; METviewer in a container	METviewer Overview - loading data and user interface	METplus repo and developers best practices;METplus use-cases; Global grid-to-grid	METplus use-cases; Feature Relative; Meso grid-to-point	
2:30	BREAK	BREAK	BREAK	BREAK	
3:00	Installing METplus - Fundamental Instructions, configuring for common install location; how to run and troubleshooting	METviewer Overview - running in batch; modify XML; scorecards	METplus use-cases; Global grid-to-point; Accumulated Precip	General METplus Q&A including MET and METviewer components	
4:30	ADJOURN	ADJOURN	ADJOURN	ADJOURN	

Show of Hands… Who's here from

Who's here from:

- EMC
- WPC
- CPC
- JCSDA
- Other?

Who has used:

- MET
- METviewer
- METplus

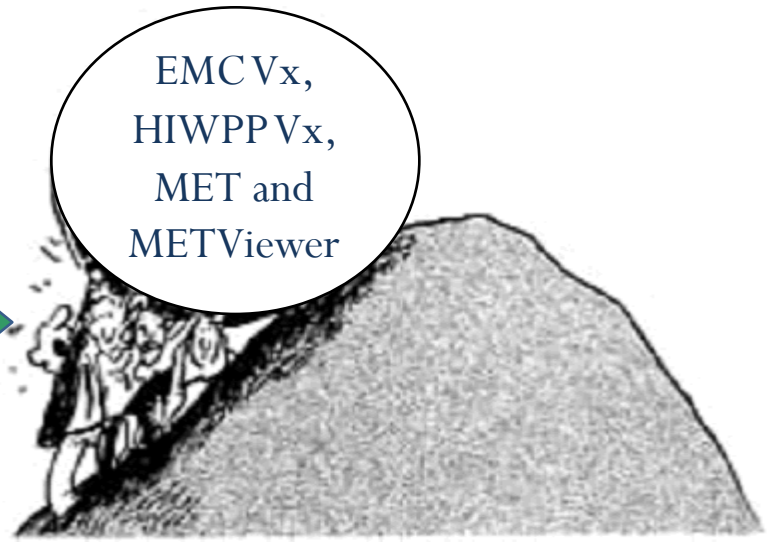
History

Status in 2016

Recommendations to unify on MET/METViewer (MET+):

- UMAC committee
- NGGPS Verification and Validation Team
- 2nd CAM Ensemble Design Workshop *(*where possible)*
- NUOPC is tracking unification progress

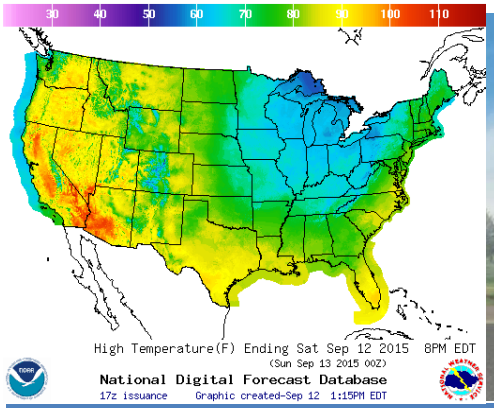
Unification
Let's all work together to build a unified package



- ***3400+ users in 130 countries***
- ***Increased use at NOAA and Air Force***
- ***MET is maintained publicly on NCAR and NOAA HPCs***

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

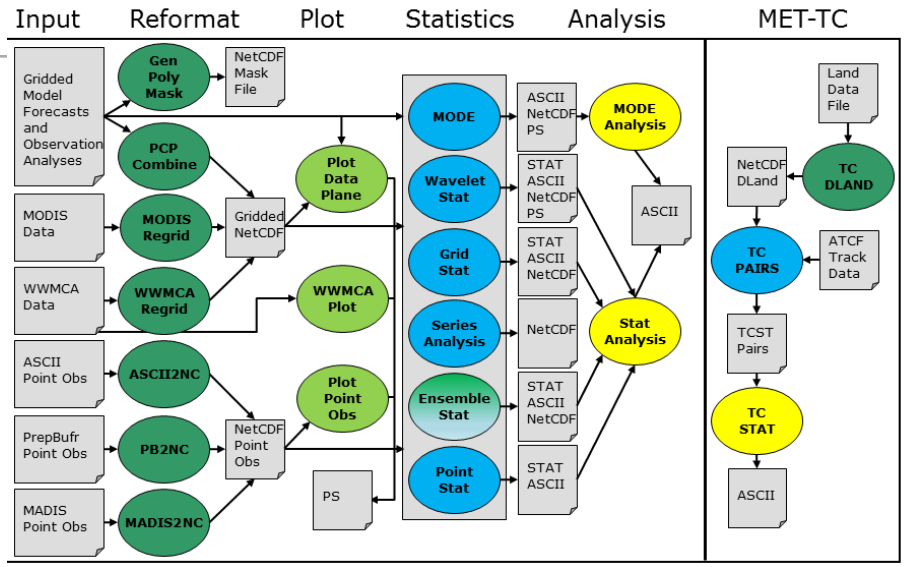
MET
Model Evaluation Tools

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

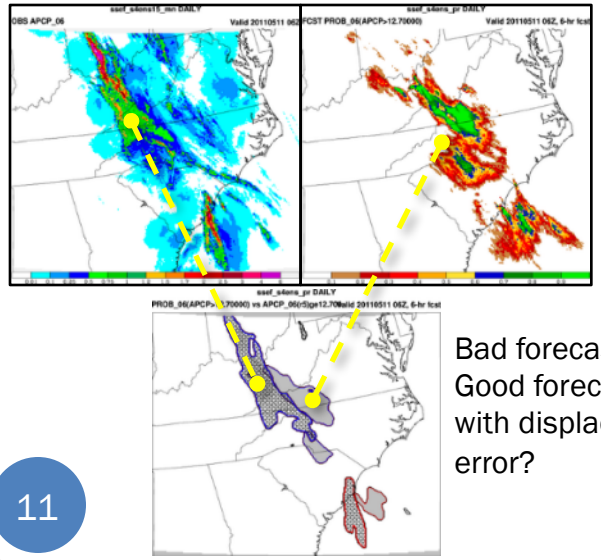
MET Model Evaluation Tools

A Verification Toolkit Designed for Flexible Yet Systematic Evaluation (supported to the community via the DTC)

- Originally developed to replicated the EMC mesoscale verification system
- **Over 85 traditional statistics** using both point and gridded datasets
- 15 interpolation methods
- Computation of confidence intervals
- Able to read in GRIB1, GRIB2 and CF-compliant NetCDF
- **Applied to many spatial and temporal scales**
- 3500+ users, both US & Int'l

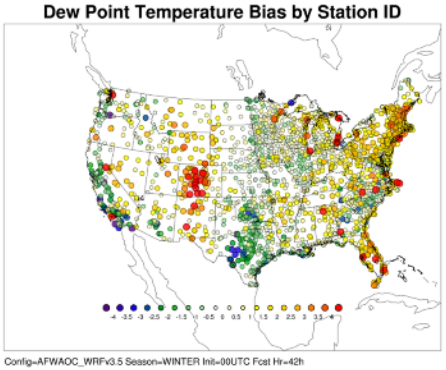


Object Based and Spatial Methods

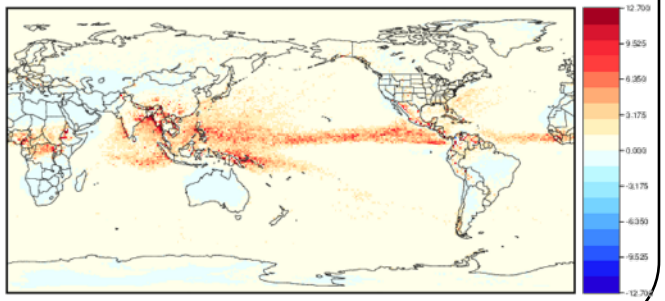


Bad forecast or Good forecast with displacement error?

Geographical Representation of Errors



90th Percentile of difference between two models



The Goal: Have Capability to Evaluate All Aspects of the Coupled UFS

Already have pre-existing packages which we will link in

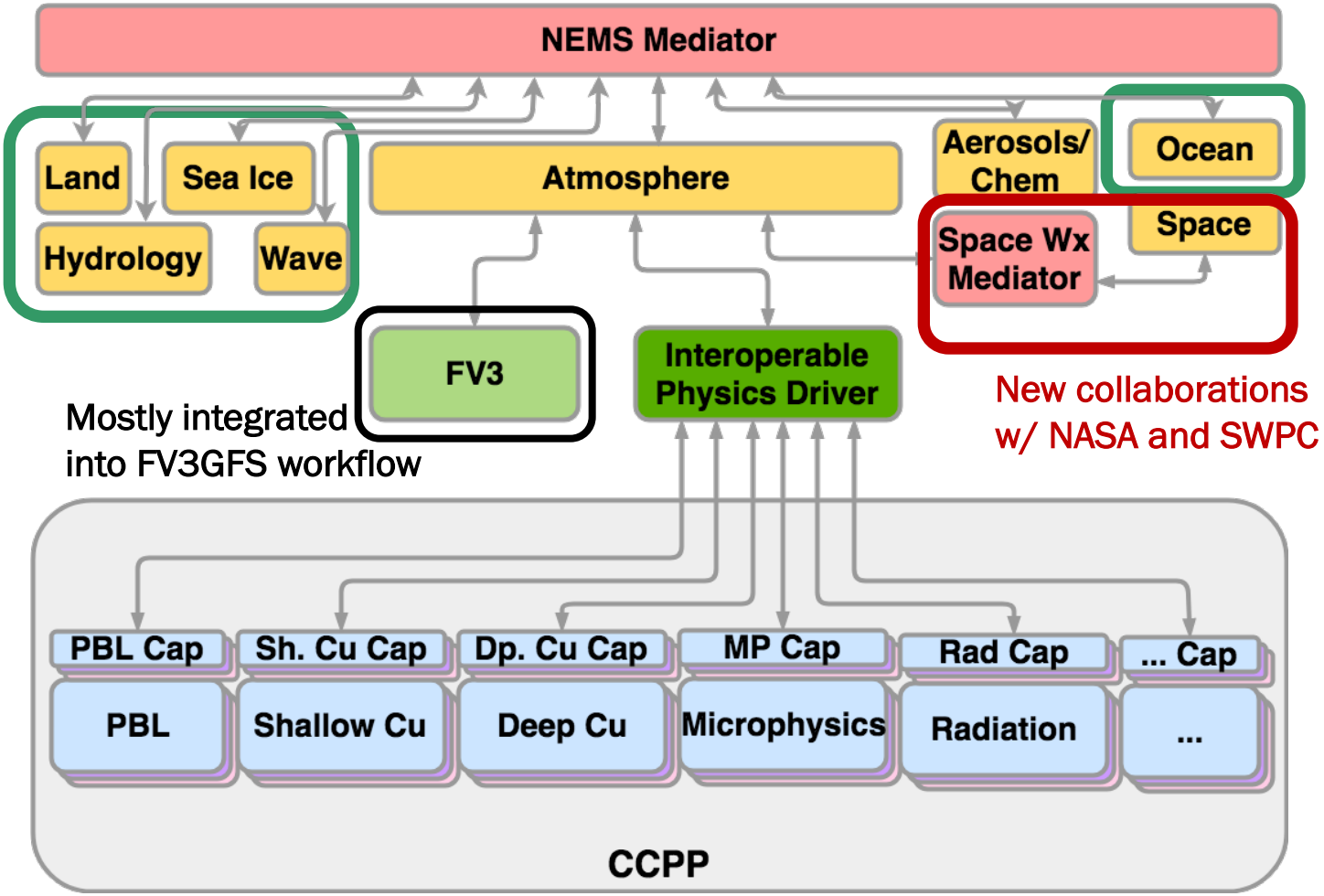
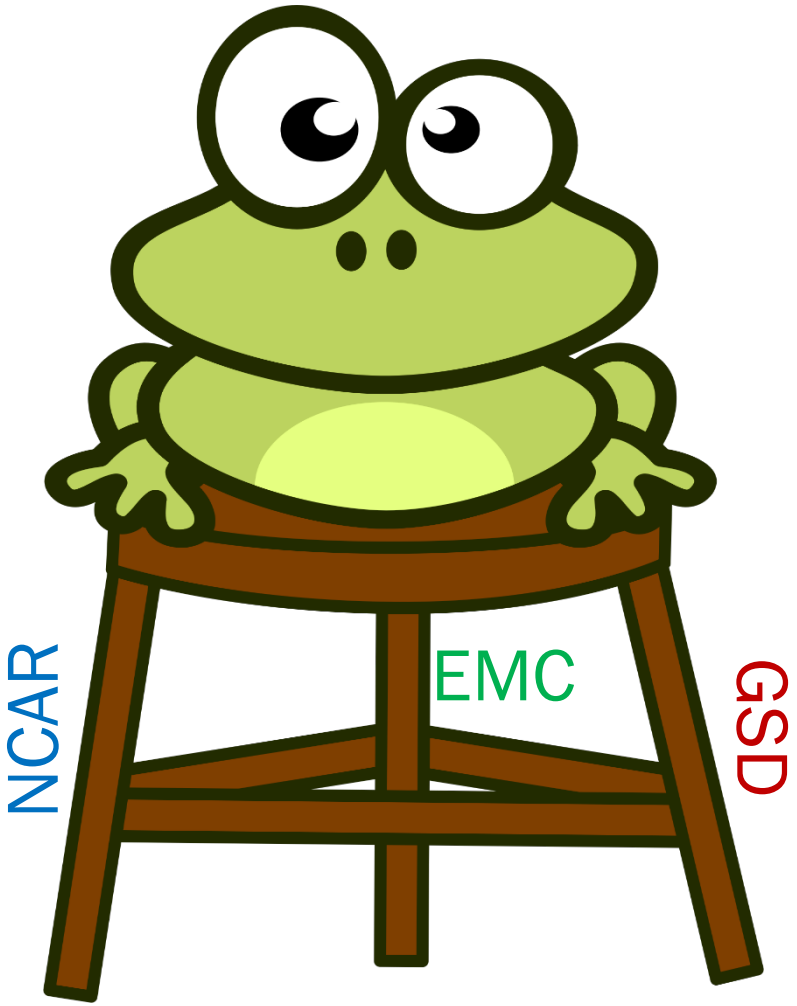


Image courtesy of GMTB

Unification Roadmap

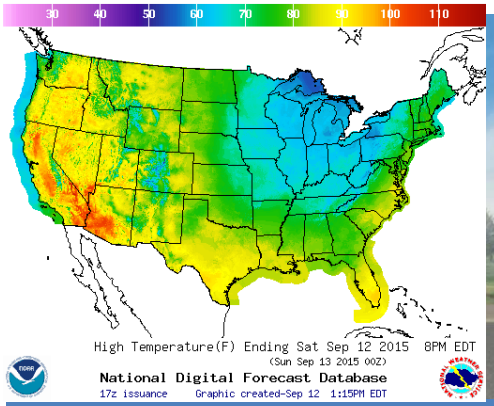
https://github.com/NCAR/METplus/wiki/NGGPS-Verification-Unification-Requirements---Status-Reports

- 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



Unifying Through Blending: Contributions from Multiple Projects

Forecasters



Operational Centers

Researchers

DTC Community Support

Long-term Projects

DTC T&E | NGGPS | HFIP | USWRP | JTTI | Hurricane Supplemental

Projects of Opportunity

DTC Visitor | NOAA, NASA, DOE | Other NCAR Labs | International Capacity Building | Community Contribution

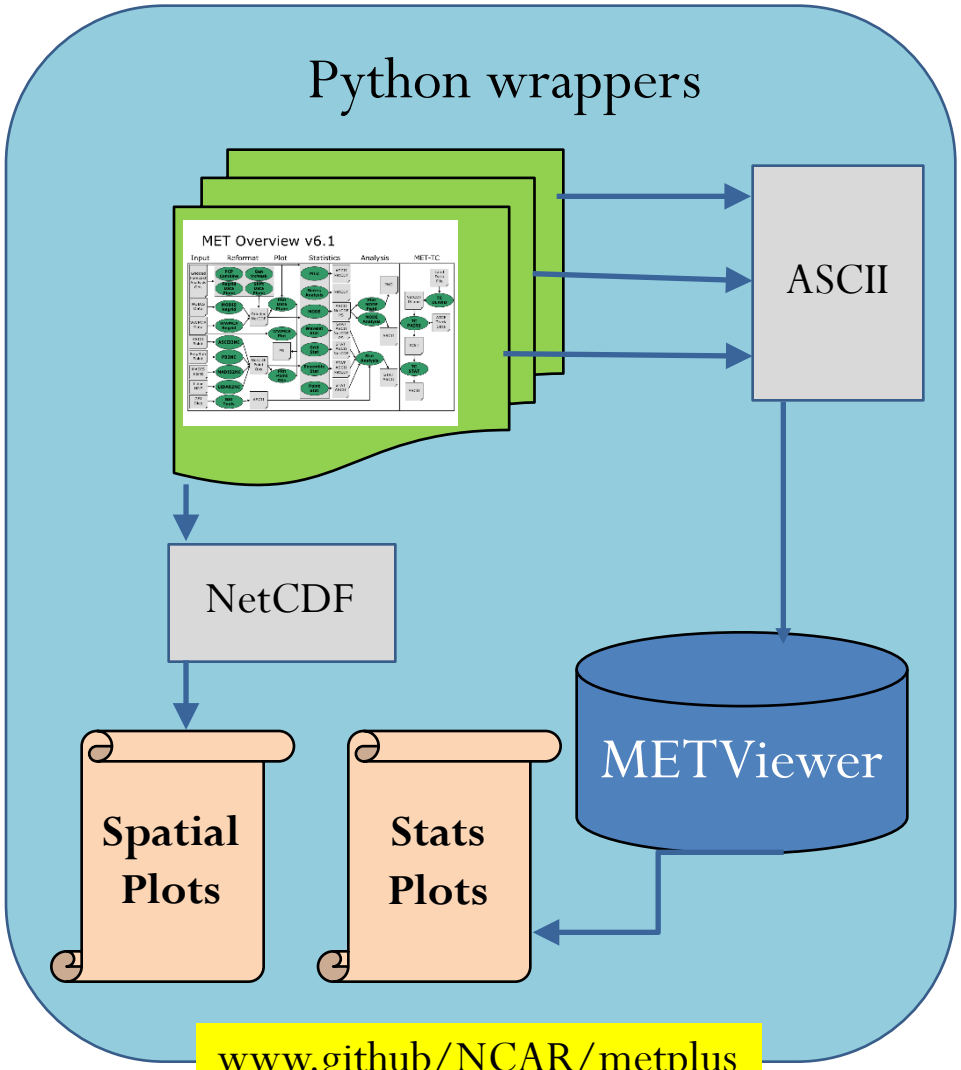
METplus Overview

General Concept of METplus

Python wrappers around:

- MET (core)
- METViewer (core)
- Plotting
  - METViewer User Interface
  - METViewer Batch Engine
  - Python plotting scripts
- Communication between MET & python algorithms

***Near Term:** After Global - CAM, Ensembles and Aerosols / Air Qual*
***Longer Term:** Earth System "Components"*



Components

NCAR / METplus

Code | Issues 55 | Pull requests 0 | Projects 0 | Wiki | Insights

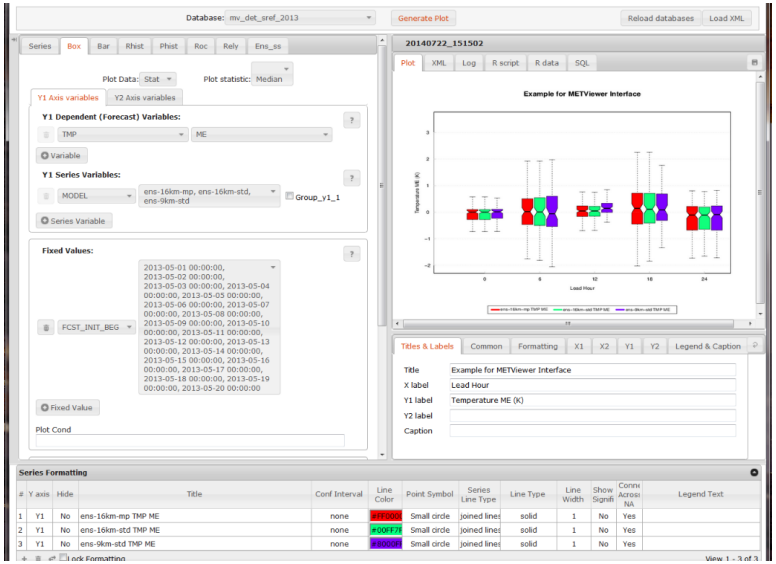
Python scripting infrastructure for MET tools.

1,527 commits | 14 branches | 15 releas

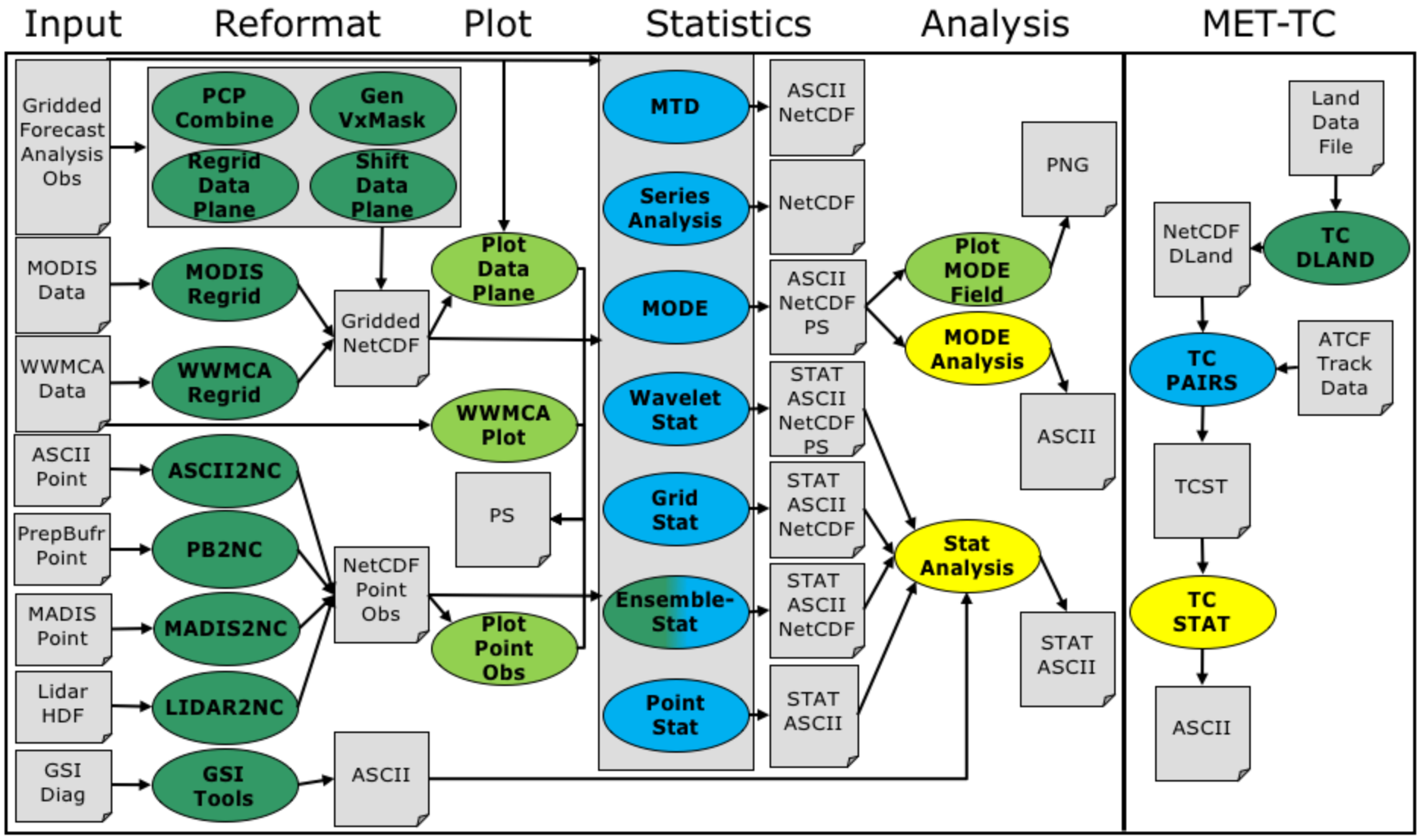
Branch: master | New pull request | Create

jimfrimel Updated notes in the logging conf file.

doc	One more minor change to affiliation list
internal_tests	Replaced all instances of INIT_INC with INIT_INCREMENT
parm	Updated notes in the logging conf file.
sorc	Change name from Alpha-produtil to Beta-METplus.
ush	Aligned the feature relative use case INIT_END time witht he sample d...



MET Overview v8.0



Laundry List of Statistics

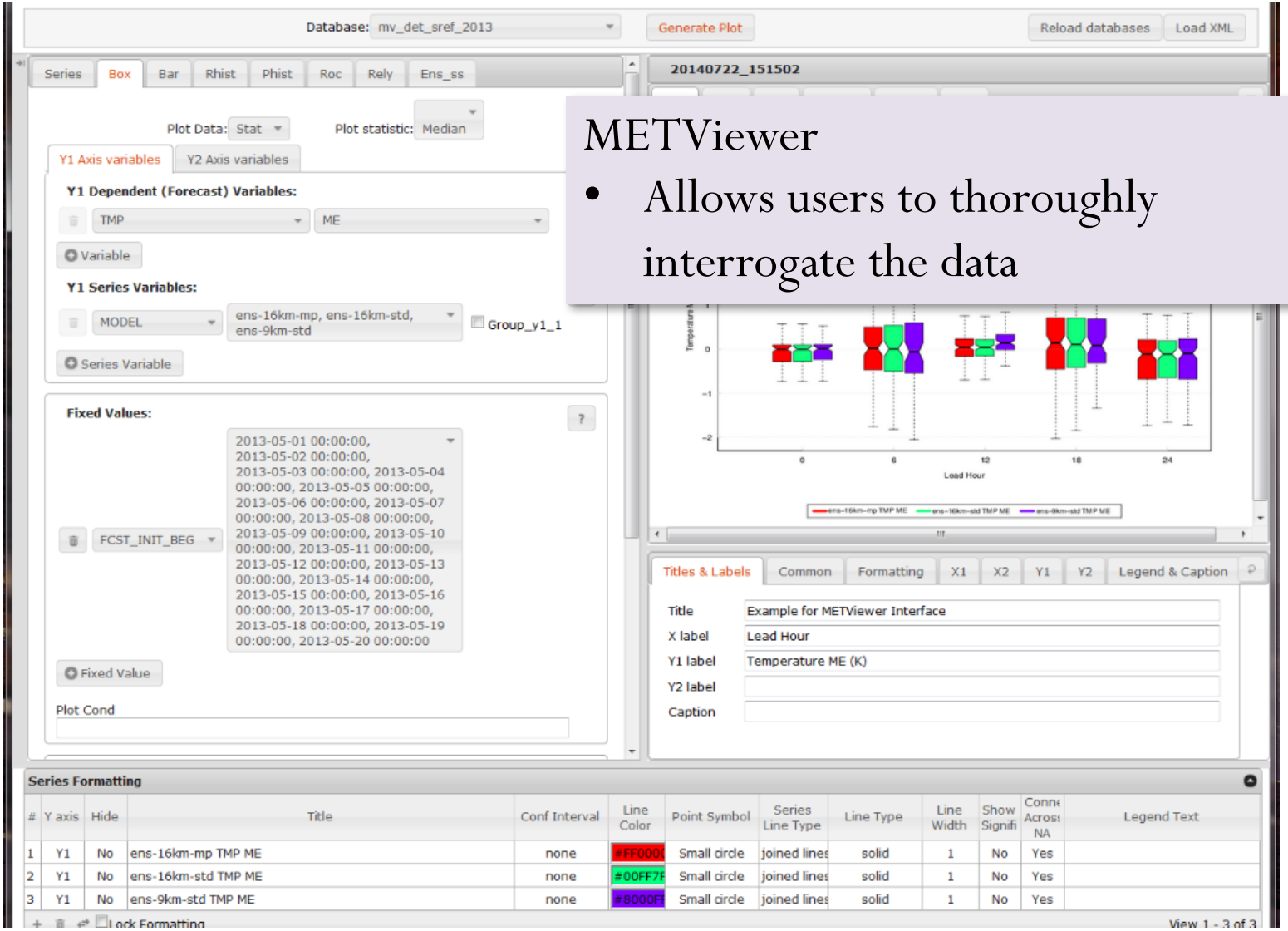
Type	Statistics
Continuous	Forecast and Observation mean, Standard deviation of the forecast and observations, Mean error (F-O), Standard deviation of the error, Anomaly Correlation, Pearson correlation coefficient, Spearman's rank correlation coefficient, Kendall's tau statistic, Multiplicative bias, Mean absolute error, Mean squared error, Bias-corrected mean squared error, Root mean squared error, 10th, 25th, 50th, 75th, and 90th percentiles of the error, Interquartile Range, Median Absolute Deviation, Square of the mean error, Mean squared error skill score, Root mean squared forecast anomaly, Root mean squared observation anomaly, Mean of absolute value of forecast and observed gradients, Mean of maximum of absolute values of forecast and observed gradients, Mean of absolute value of forecast minus observed gradients, S1 score, S1 score with respect to observed gradient, Ratio of forecast and observed gradients, Scalar Partial Sums, Vector Partial Sums, Anomaly Partial Sums
Categorical	Base rate, Forecast mean, Accuracy, Frequency Bias, Probability of detecting yes, Probability of detecting no, Probability of false detection, False alarm ratio, Critical Success Index, Gilbert Skill Score, Hanssen-Kuipers Discriminant, Heidke Skill Score, Odds Ratio, Logarithm of the Odds Ratio, Odds Ratio Skill Score, Extreme Dependency Score, Symmetric Extreme Dependency Score, Extreme Dependency Index, Symmetric Extremal Dependency Index, Bias Adjusted Gilbert Skill Score, Gerrity Score for multi-categorical statistics

Laundry List of Statistics

Type	Statistics
Probability	Base Rate, Reliability, Brier Score, Resolution, Uncertainty, Climatological Brier Score, Brier Skill Score, Receiver Operating Characteristic (ROC) Curve, Area under the ROC curve, Reliability Diagram points, Economic Cost/Loss Relative Value Diagram points), Calibration, Refinement, Likelihood
Ensemble	Continuous Ranked Probability Skill Score, Ignorance Score, Rank Histogram, Probability Integral Transform, Relative Position
Skill by Spatial Scale	Fourier Decomposition of fields prior to computation of scores or use Wavelet_Stat tool which computes for each scale: Mean squared error, Intensity scale skill score, Forecast energy squared, Observed energy squared, Frequency Bias. Not scale dependent: Base rate
Neighborhood	Same as categorical statistics plus Fractions Brier Score, Fractions Skill Score, Asymptotic Fractions Skill Score, Uniform Fractions Skill ScorTCe
Tropical Cyclones	Mean, Standard deviation, Minimum Value, Percentiles, Maximum Value, Interquartile Range, Range, Sum, Independence time, Frequency of superior performance, contingency tables counts for Rapid Intensification and Rapid Weakening, contingency tables counts for Probability of Rapid Intensification and Rapid Weakening

Type	Statistics
2D Objects	For each object: Location of the centroid in grid units, Location of the centroid in lat/lon degrees, Axis angle, Length of the enclosing rectangle, Width of the enclosing rectangle, Object area, Radius of curvature of the object defined in terms of third order moments, Center of curvature, Ratio of the difference between the area of an object and the area of its convex hull divided by the area of the complex hull, percentiles of intensity of the raw field within the object, Percentile of intensity chosen for use in the percentile intensity ratio, Sum of the intensities of the raw field within the object, For paired objects: Distance between two objects centroids, Minimum distance between the boundaries of two objects, Minimum distance between the convex hulls of two objects, Difference between the axis angles of two objects, Ratio of the areas of two objects, Intersection area of two objects, Union area of two objects, Symmetric difference of two objects, Ratio of intersection areas, Ratio of complexities, Ratio of the nth percentile of intensity, Total interest value computed for a pair of simple objects, NetCDF files with the objects and raw data for further processing
Objects through time	For 3D objects: x,y and t coordinates of centroid, Latitude and Longitude of centroid, x, y component of object velocity, Angle that the axis plane of an object makes with the grid x direction, Integer count of the number of 3D "cells" in an object, Object start time, Object end time, Total great circle distance travelled by the 2D spatial centroid over the lifetime of the 3D object, percentiles of intensity of the raw field within the object For 3D object pairs: Spatial distance between coordinates of object space-time centroid, Difference in index of object spacetime centroid, Difference in spatial axis plane angles, Difference in object speeds, Difference in object direction of movement, Ratio of object volumes, Difference in object start times, Difference in object end times, "Volume" of object intersection, Difference in the lifetimes of the two objects, Total interest for this object pair, NetCDF files with the objects and raw data for further processing

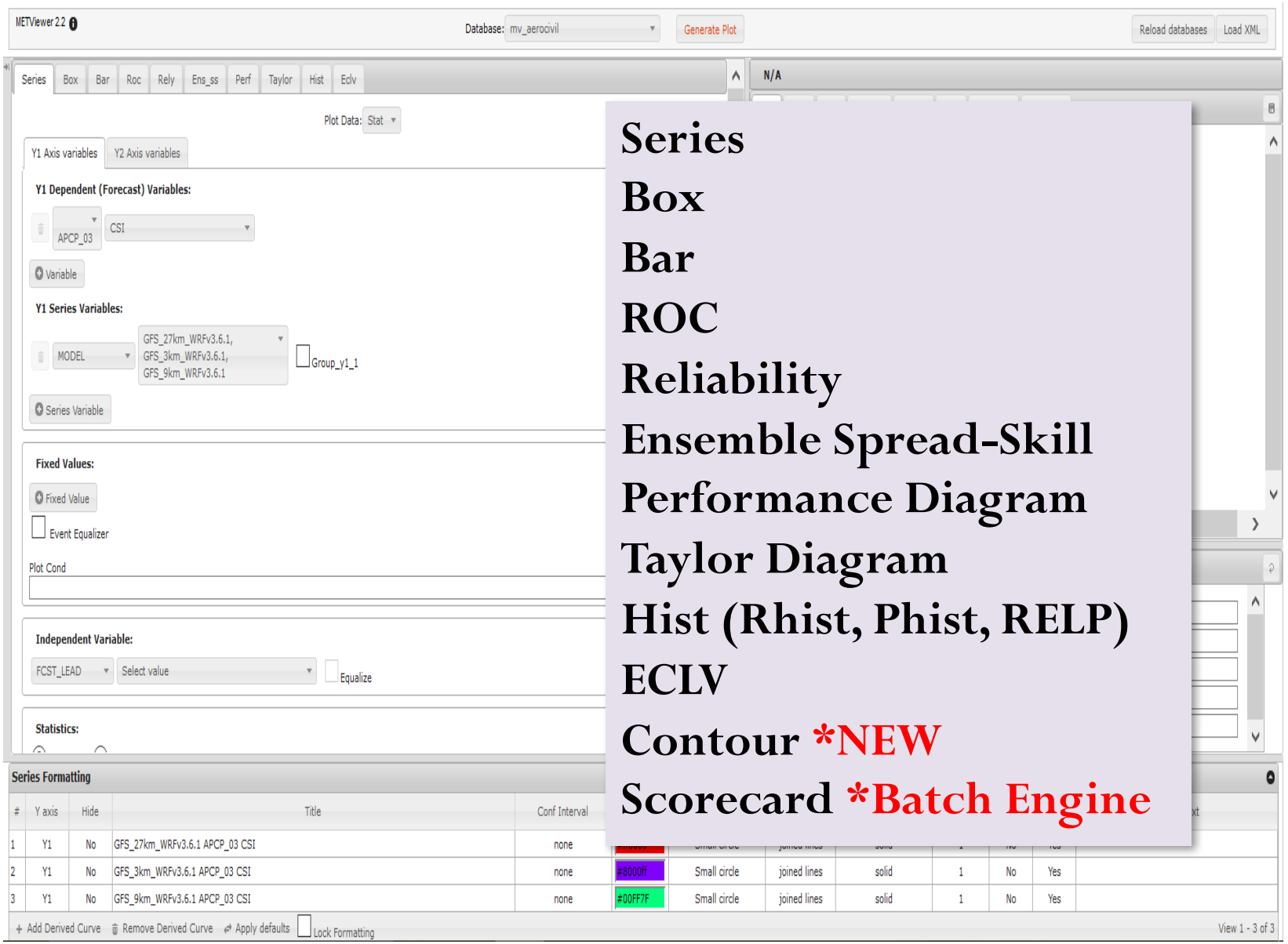
METViewer Database and Display



METViewer

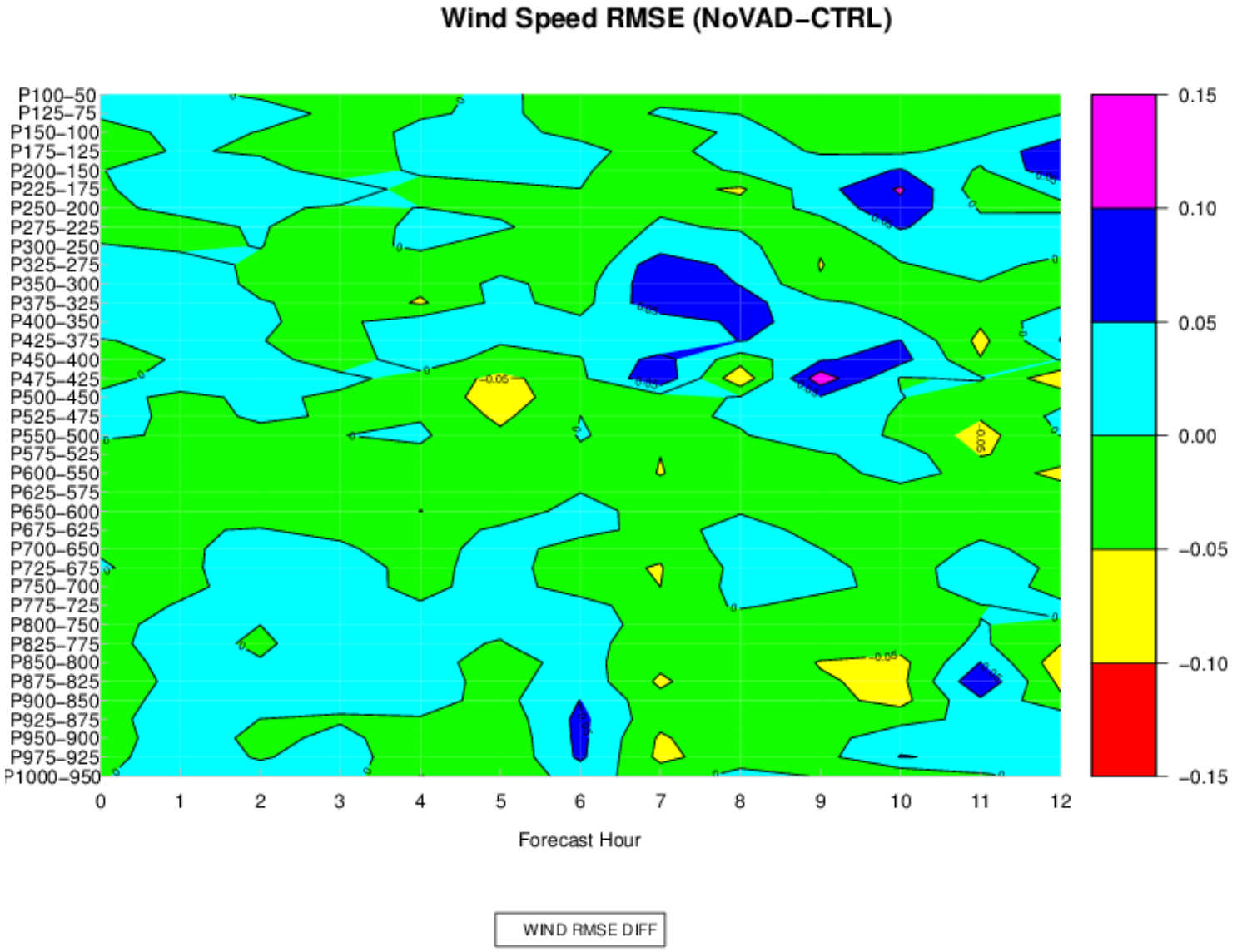
- Allows users to thoroughly interrogate the data

METViewer Plot Templates



Series
Box
Bar
ROC
Reliability
Ensemble Spread-Skill
Performance Diagram
Taylor Diagram
Hist (Rhist, Phist, RELP)
ECLV
Contour *NEW
Scorecard *Batch Engine

METViewer Contour Plots



This Year:

Scorecarding using METViewer

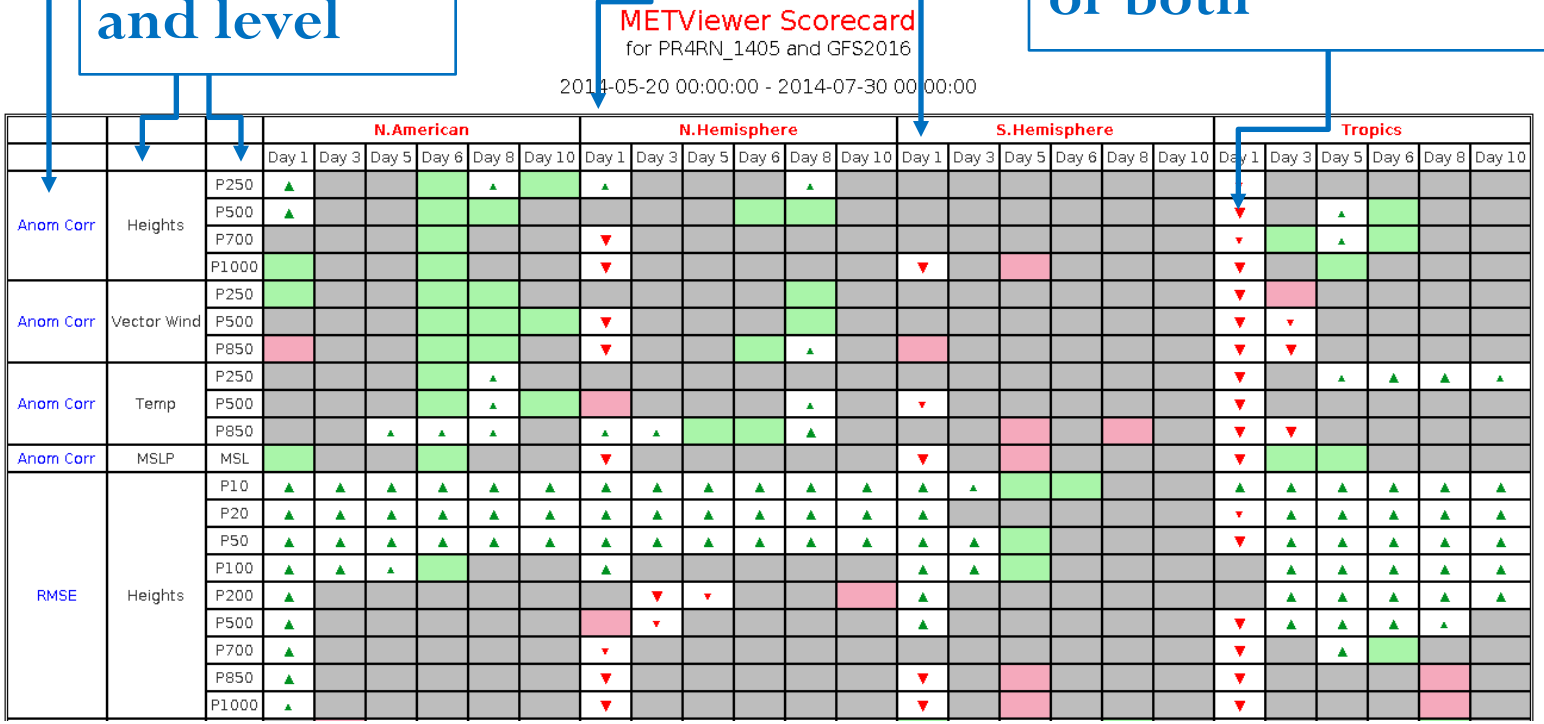
Specify statistic

Specify field and level

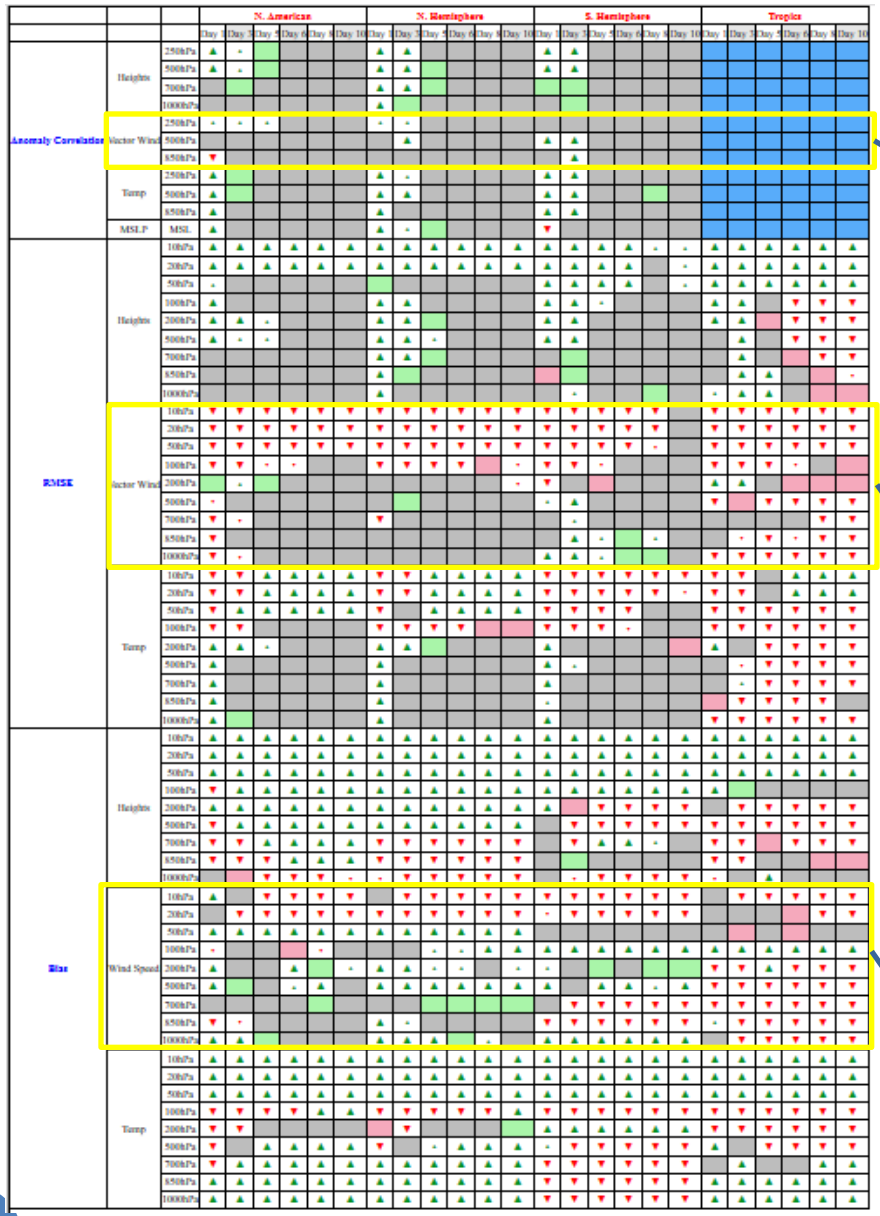
Specify regions

Specify aggregations

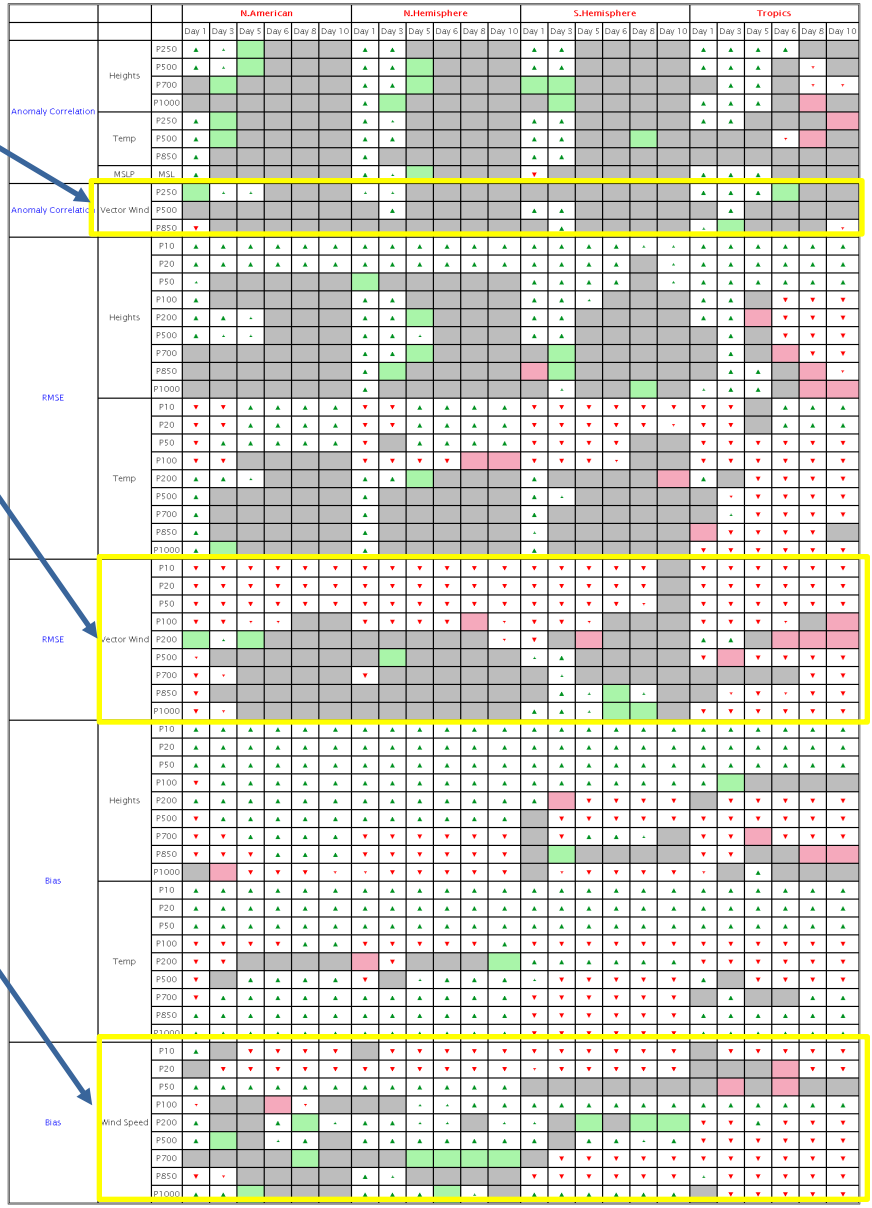
Specify whether you have symbol, values or both



VSDB Scorecard

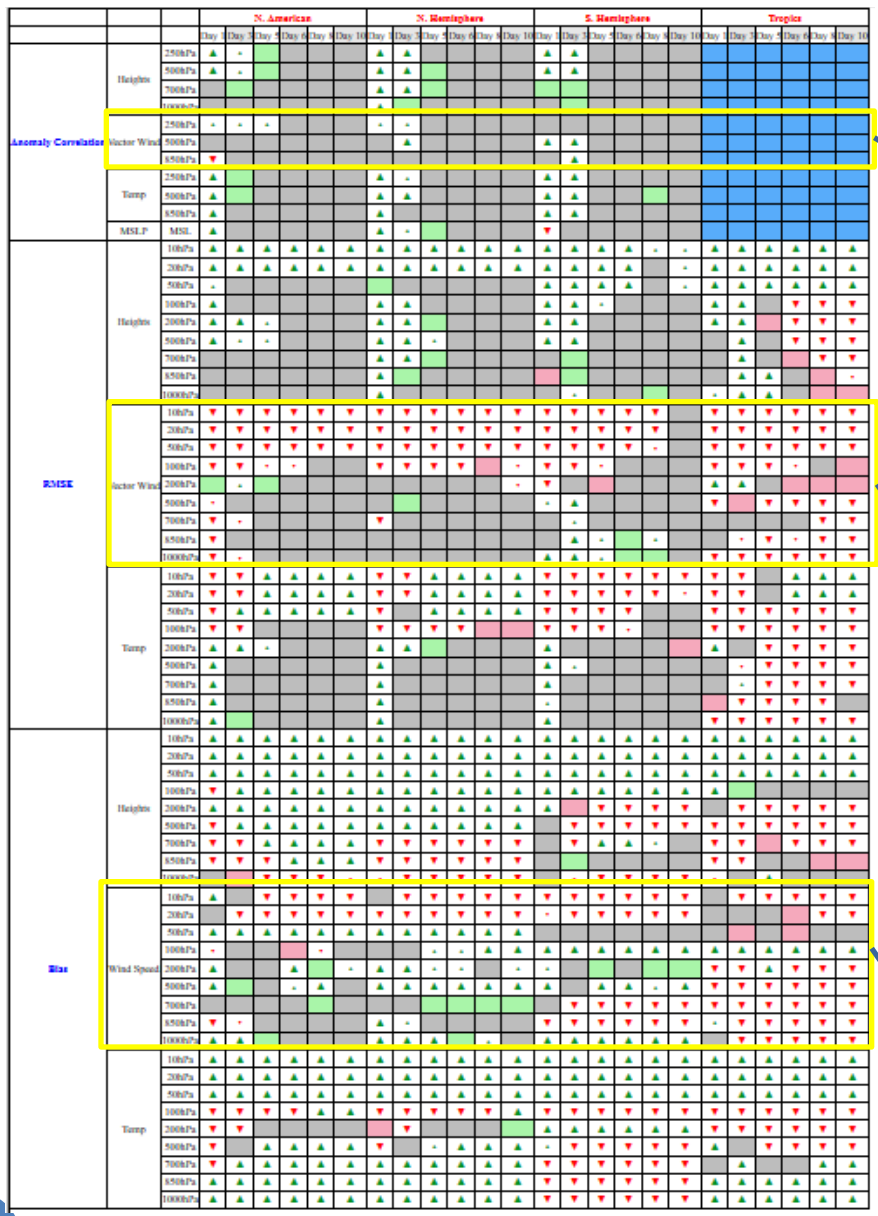


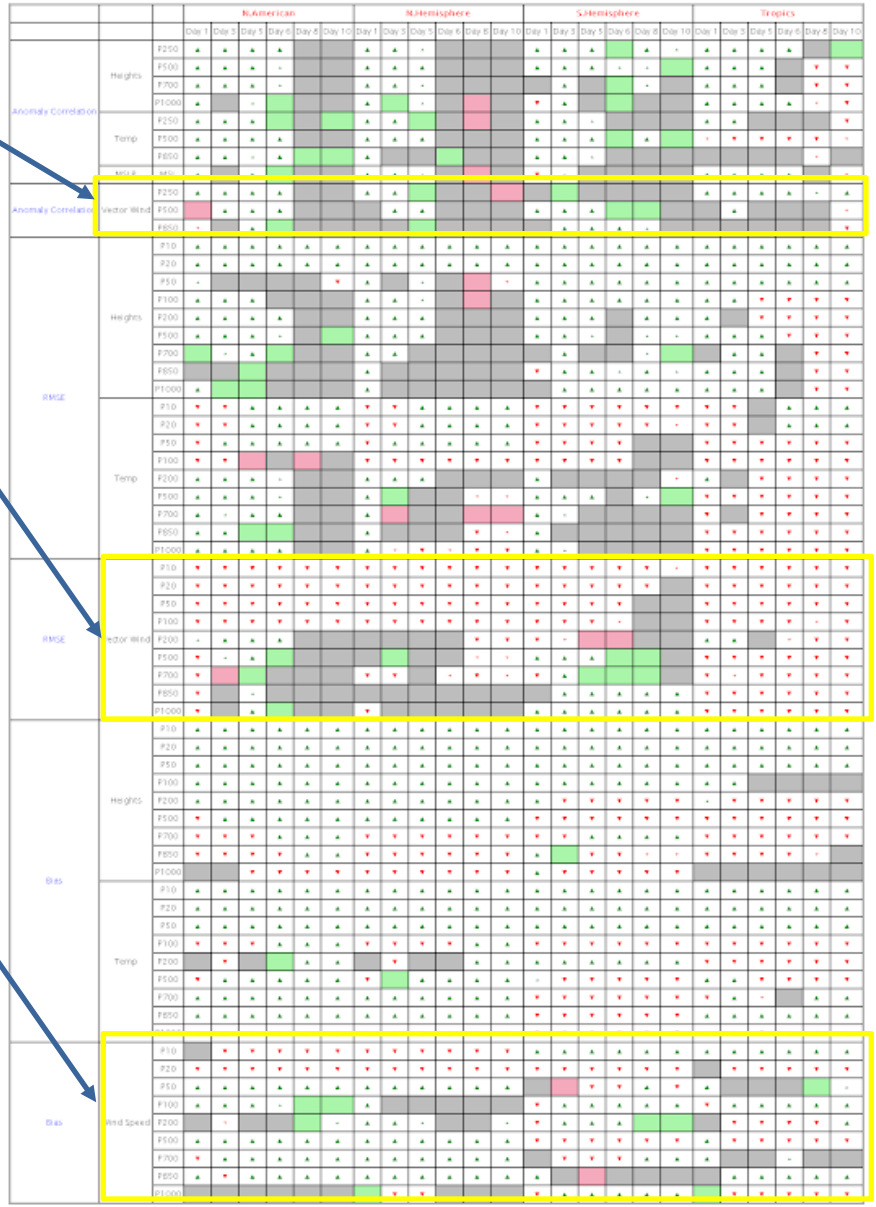
METviewer using EMC Method



VSDB Scorecard

METviewer using NCAR Method





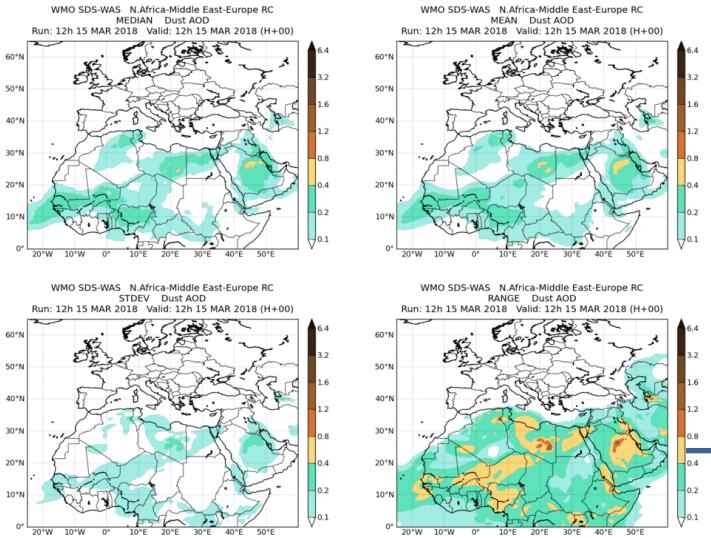
Working Towards Easy Usability: METplus Use Case Example

Observed 1-min AOD Data

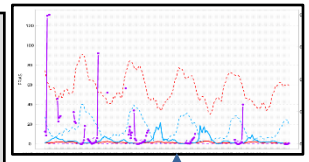
ASCII 2NC

Observed AOD 6-hr mean, max, stdev, range

Forecasted Aerosol Optical Depth (AOD): 6-hr mean, max stdev, range



- Wavelet Stat
- MODE-TD
- MODE
- Grid Stat
- Series Analysis
- Ensemble Stat
- Point Stat



Plotting Script

STAT ASCII

Series Analysis

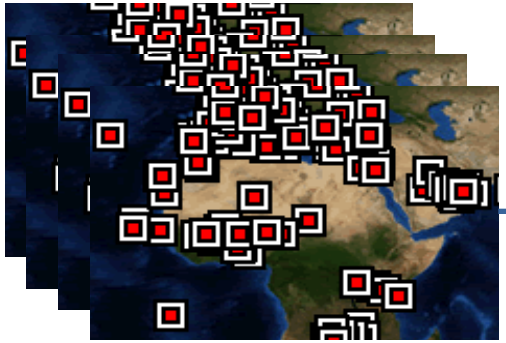
STAT ASCII

Working Towards Easy Usability: METplus Use Case Example

Observed 1-min AOD Data

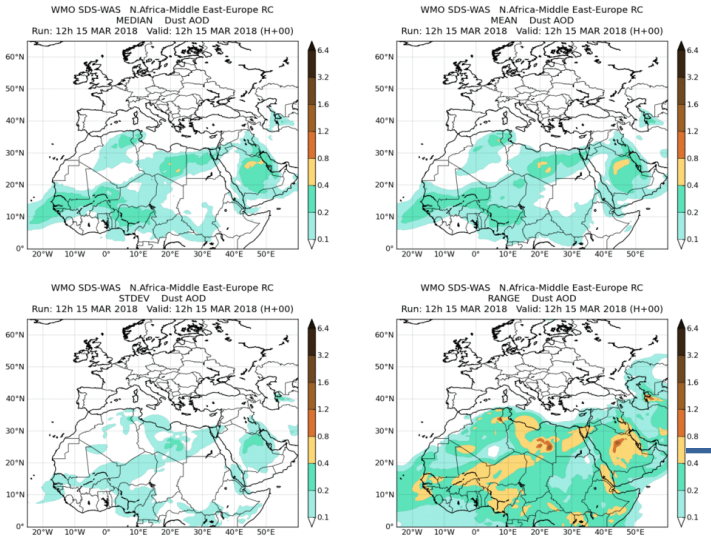
ASCII 2NC

Observed AOD 6-hr mean, max, stdev, range

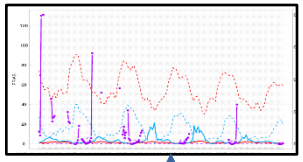


Use-case includes

- METplus .conf file
- MET config files
- Python scripts to:
  - Call Ascii2NC
  - Call Point-Stat
  - Call Stat-Analysis
  - Make statistics plot
  - Make plot of fields



Wavelet Stat
MODE-TD
MODE
Grid Stat
Series Analysis
Ensemble Stat
Point Stat



Plotting Script

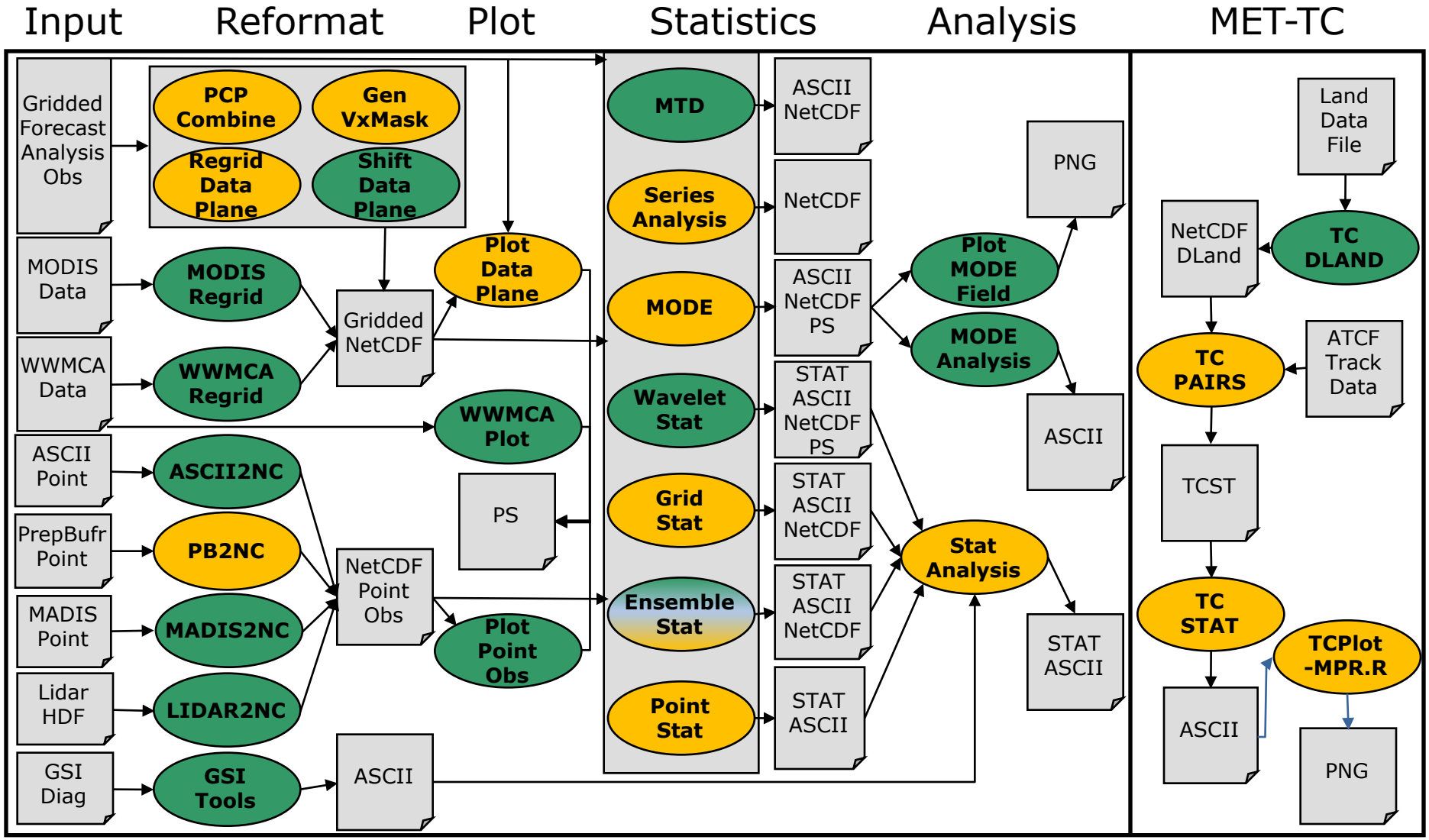
STAT ASCII

Series Analysis

STAT ASCII

What Does Wrapped by Python Mean?

What is Wrapped by Python Right Now



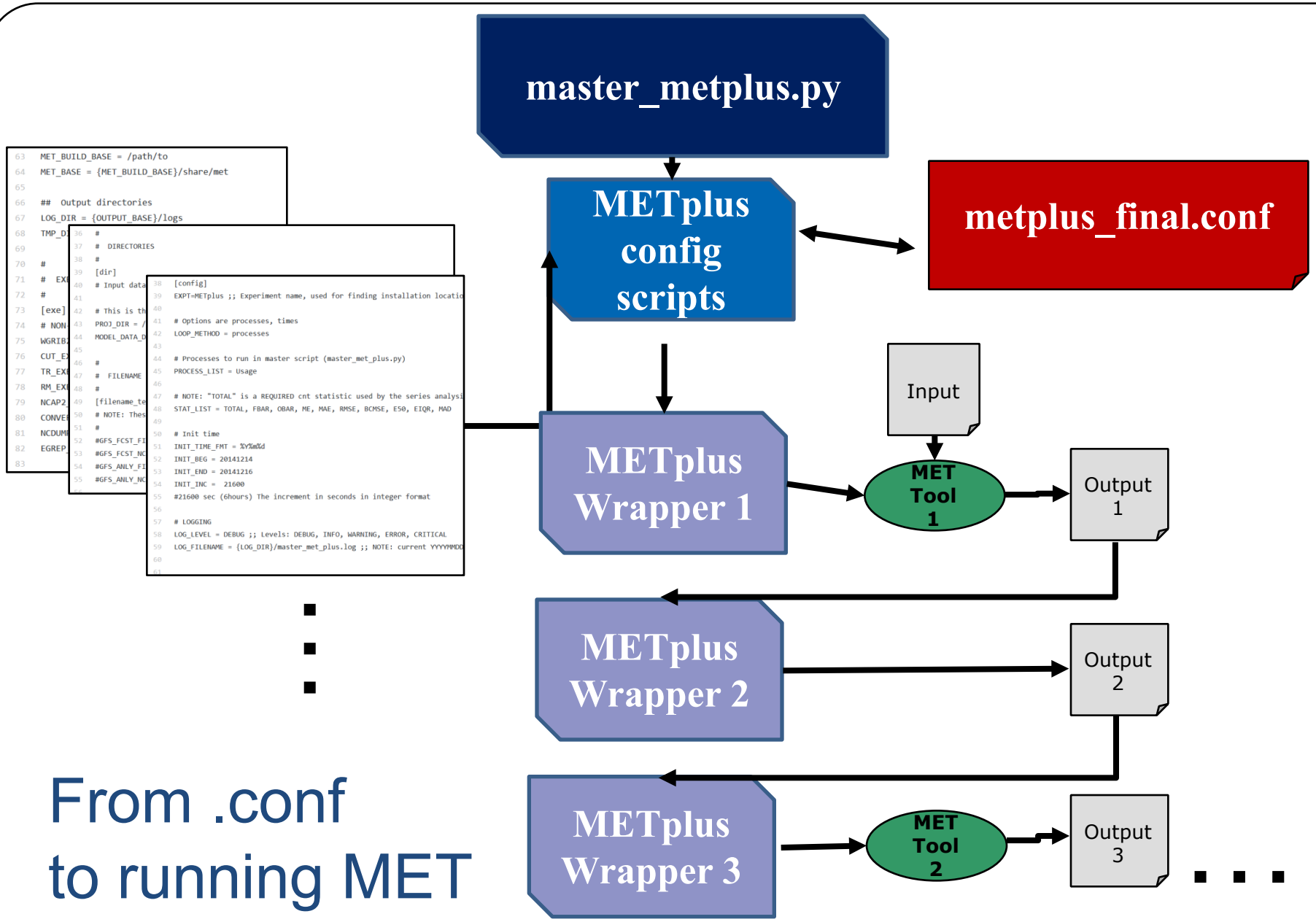
What does wrapped by Python mean?

At https://github.com/NCAR/METplus/

In MET Configs: Environment variables passed in from METplus .conf (config) file

```
30
31  ////////////////////////////////////////////////////////////////////////
32
33  cat_thresh  = [ NA ];
34  cnt_thresh  = [ NA ];
35  cnt_logic   = UNION;
36
37  //
38  // Forecast and observation fields to be verified
39  //
40  fcst = {
41
42     field = [
43        {
44           name  = "${NAME}";
45           level = [ "${LEVEL}" ];
46        }
47     ];
48
49  }
50  obs = fcst;
51
52  ////////////////////////////////////////////////////////////////////////
53
54  //
55  // Climatology mean data
```

Series_Analysis_Config



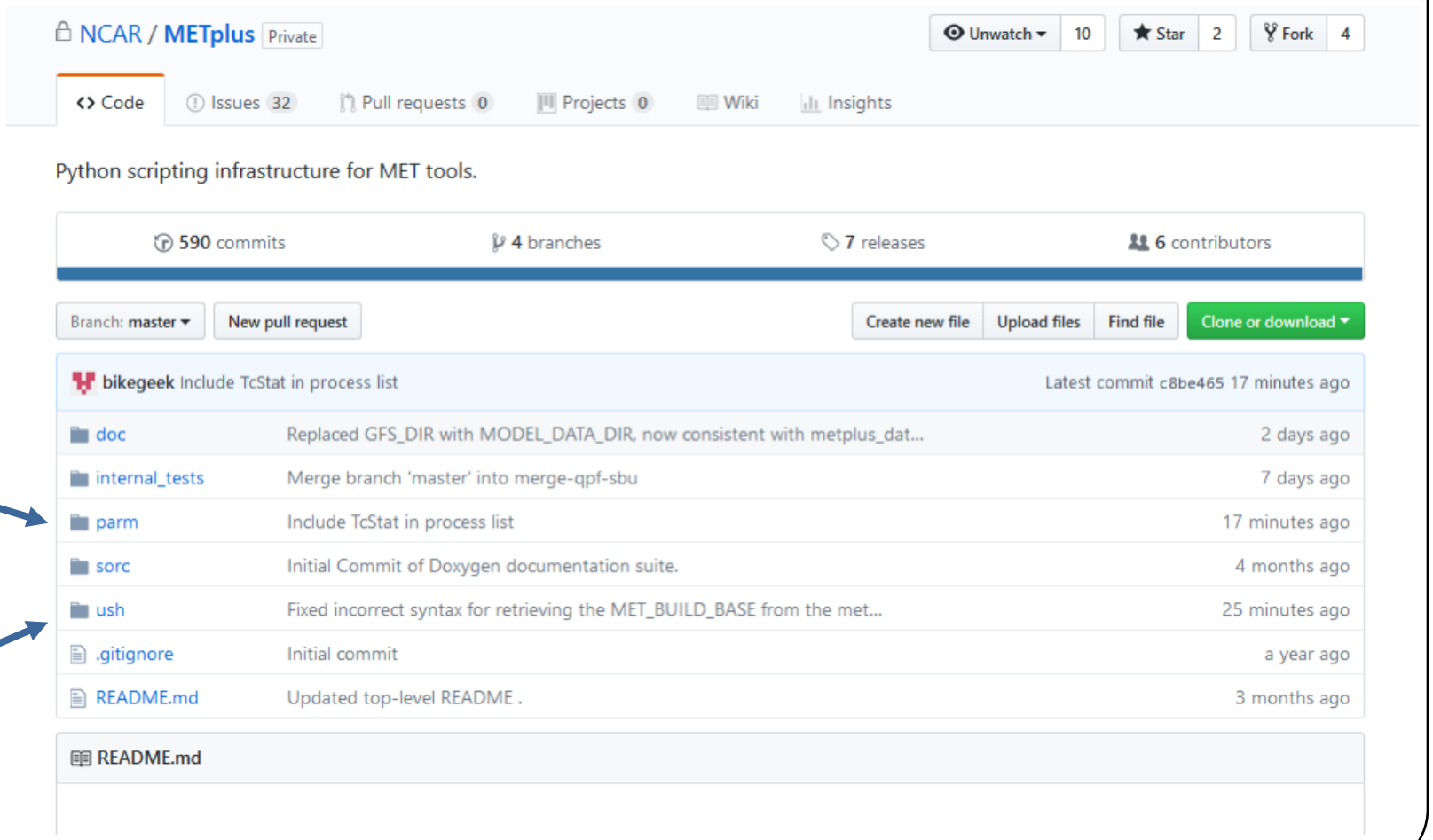
From .conf
to running MET

What does wrapped by Python mean?

At https://github.com/NCAR/METplus/

Control File and Config

Python Scripts



What does wrapped by Python mean?

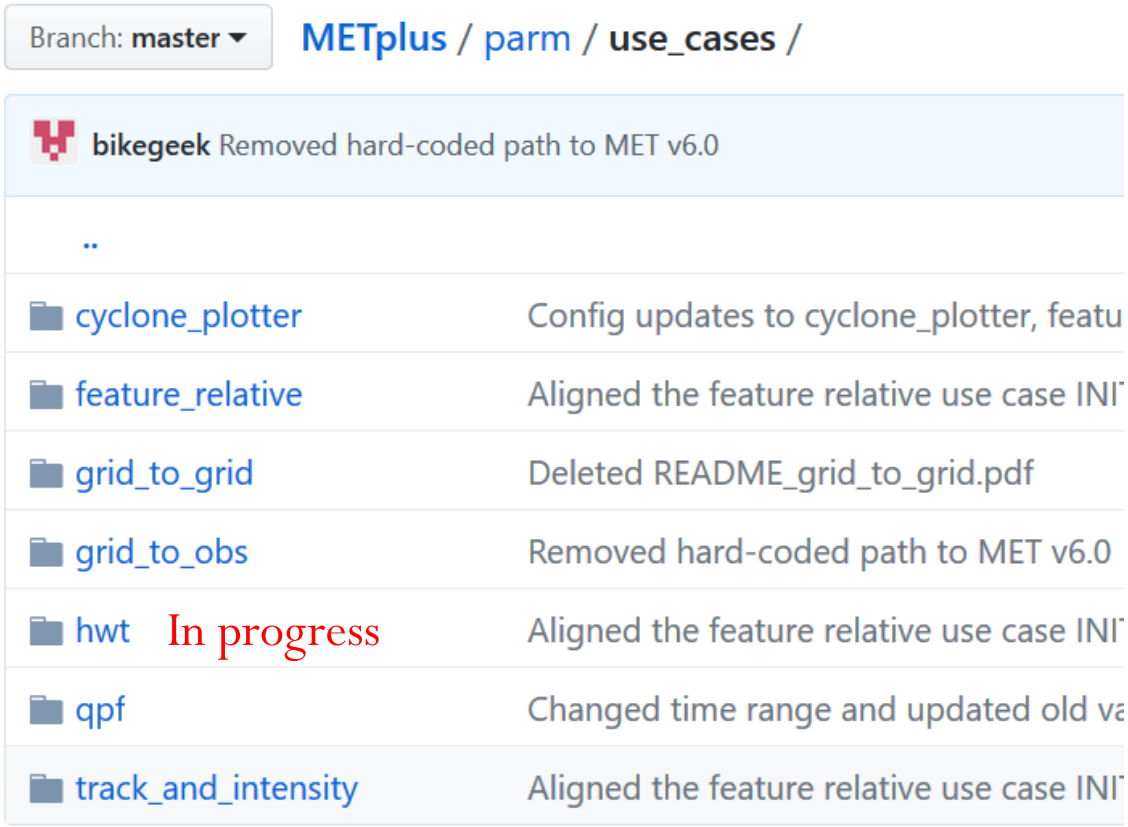
METplus/parm/use_cases/feature_relative

feature_relative.conf

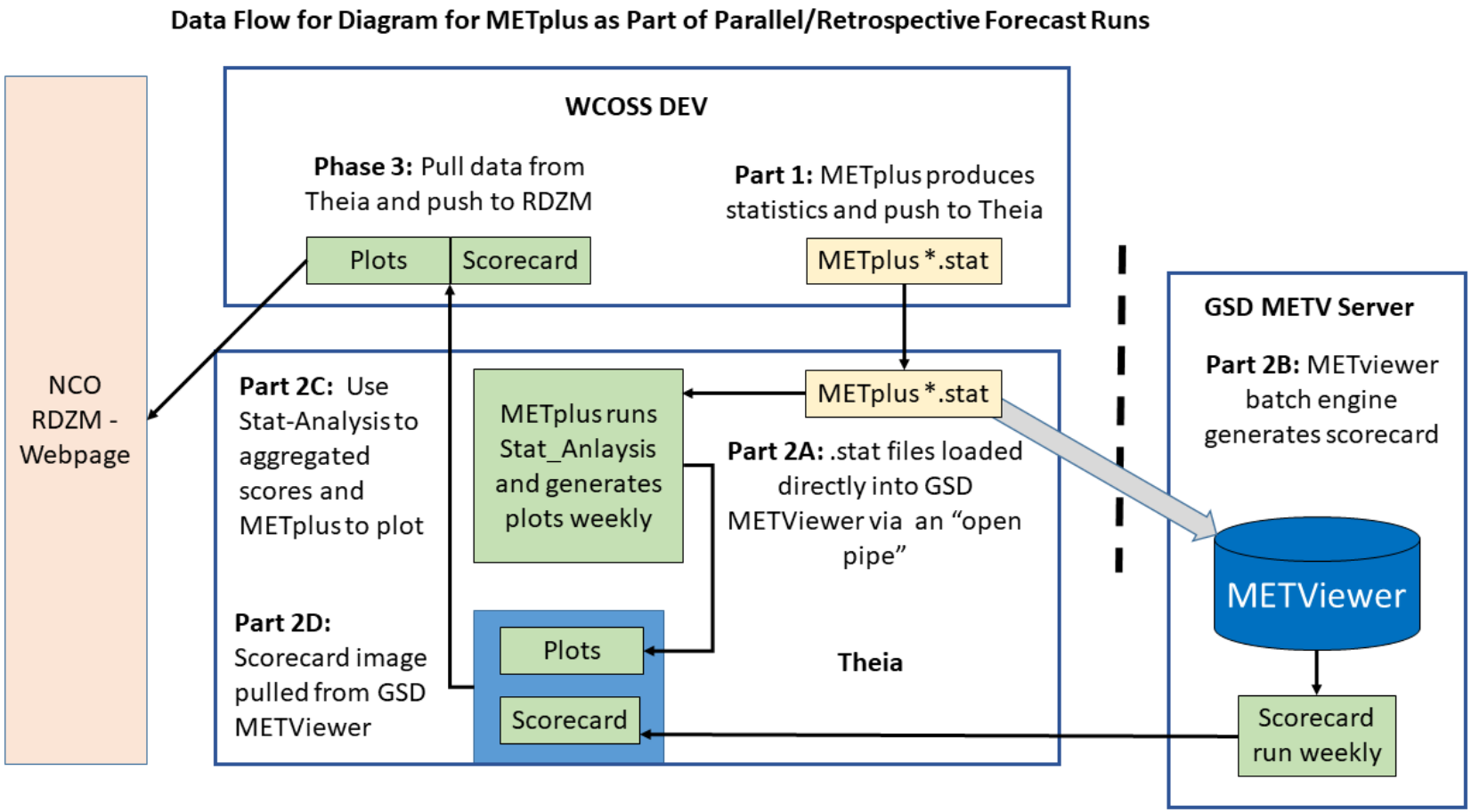
```
#
#     LISTS AND SETTINGS
#

#     Processes to run in master script (master_met_plus.py)

PROCESS_LIST = ["run_tc_pairs.py", "extract_tiles.py", "series_by_lead.py"]

#
#     NOTE: "TOTAL" is a REQUIRED cnt statistic used by the series analysis scripts
#

STAT_LIST = ["TOTAL", "FBAR", "OBAR", "ME", "MAE", "RMSE", "BCMSE", "E50", "EIQR", "MAD"]

#     Dates must be in YYYYMMDD format
#     INIT_HOUR_INC is the increment in integer format
#     INIT_HOUR_END should be a string in HH or HHH format

INIT_DATE_BEG = "20141201"
INIT_DATE_END = "20150331"
INIT_HOUR_INC =  6
INIT_HOUR_END = "18"

#     Used by extract_tiles.py to define the records of interest from the grib2 file

VAR_LIST = ["HGT/P500", "PRMSL/Z0", "TMP/Z2", "PWAT/L0", "HGT/P250", "TMP/P850", "TMP/P500", "UGRD/P250", "VGRD/P250" ]
EXTRACT_TILES_VAR_LIST = []

#     Used for performing series analysis based on lead time
```

METplus Use-Cases

- MET+ integrated into FV3GFS parallel workflow
- Grid-to-Grid, Grid-to-Point, QPF/Precip, and TC Track and Intensity verification included
- Feature Relative and Extra-Tropical Cyclone examples also available

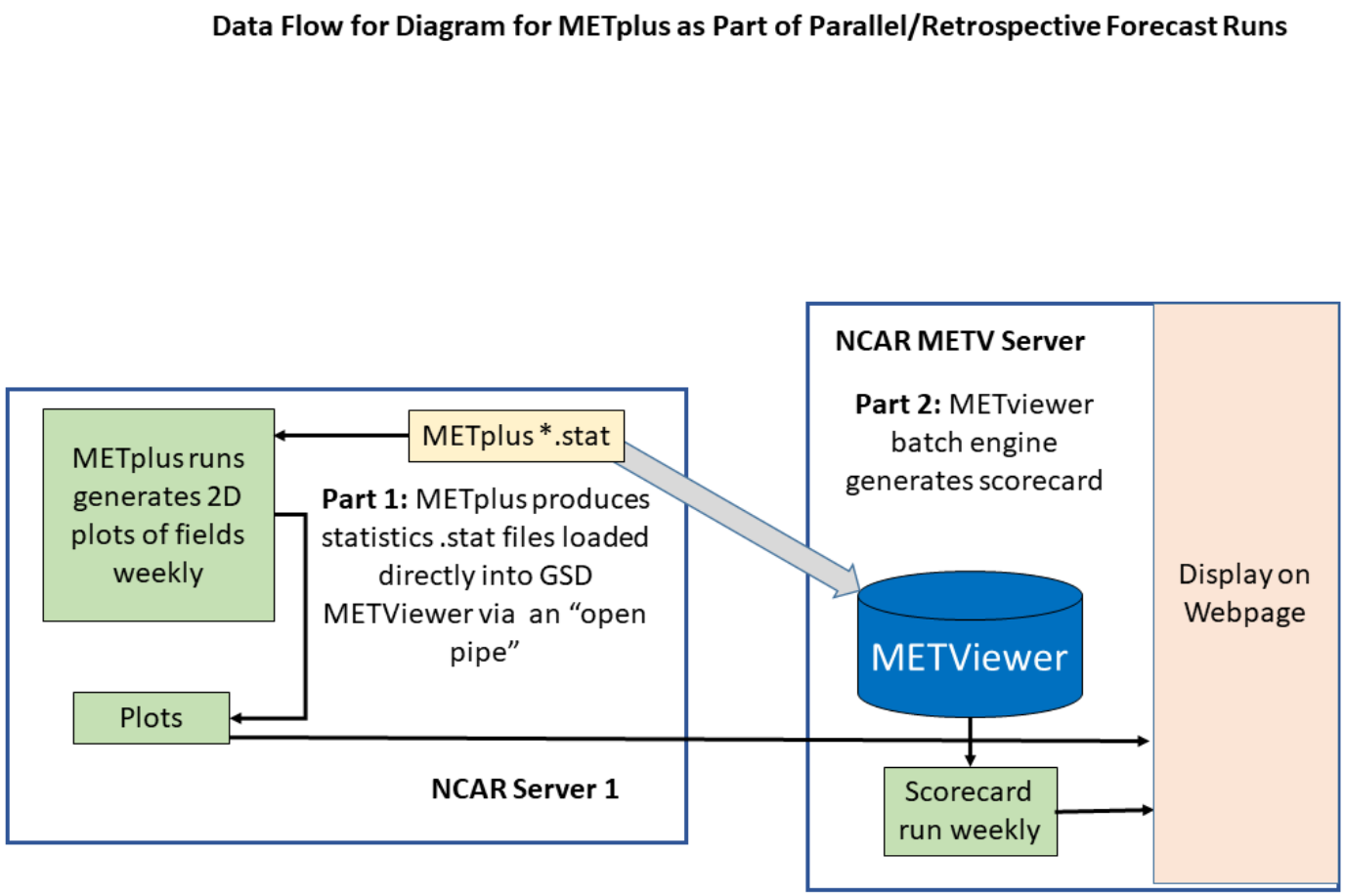


METplus at EMC



Mallory Row, NOAA/EMC, has become a METplus developer and set up this workflow

METplus at NCAR



With direct access to METviewer Server, the system is significantly less complicated

Support

Repositories and Support

NCAR / container-dtc-metviewer

Watch 4 | Star 1 | Fork 3

Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Insights

Branch: master ▾ container-dtc-metviewer / README.docker.txt

Find file | Copy path

TatianaBurek remove building MySQL from the instructions, added alternative way to... 8a398cd on Nov 10, 2017

2 contributors

50 lines (41 sloc) | 2.06 KB

Raw | Blame | History

```
#
# Note:  Not intended to be run on super computers or clusters where docker engine may not be running.
# These are tutorial steps for learning on a personal workstation or laptop where Docker engine has
# been installed and running.
#
# You can obtain Docker (current Mac and Win
#   https://www.docker.com/products/overview
#
# Or Docker Tools (for older Mac and Windows
#   https://www.docker.com/products/docker-t
#
# These are manual steps to build your perso
#
git clone https://github.com/NCAR/container-

# From container-dtc-metviewer/METViewer, bu
cd ../METViewer
docker build -t metviewer .
```

Model Evaluation Tools Version 8.0 (METv8.0)
User's Guide

Developmental Testbed Center
Boulder, Colorado

John Halley Gotway, Kathryn Newman, Tara Jensen,
Barbara Brown, Randy Bullock, and Tressa Fowler
with contributions from Julie Prestopnik, Eric Gilleland, Howard Soh,
Minna Win-Gildenmeister, George McCabe and James Frimel

September 2018

GitHub

docker

MET ONLINE TUTORIAL

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MET ONLINE TUTORIAL FOR METV6.1

Welcome to the MET Online Tutorial

- This tutorial is designed for use with METv6.1 released in December 2017.
- The exercises have been expanded to include examples for all of the MET tools.
- It describes step-by-step how to compile, configure MET, and run MET, or how to use pre-compiled versions of MET either on an HPS platform or using a docker container.
- We recommend that you work through this tutorial before you try to run MET on your own.
- A description of what's new since the previous tutorial can be found in the release notes for METv6.0 and METv6.1.
- For comments, suggestions, errors, or help concerning this online tutorial (or other MET issues) please send email to met_help@ucar.edu.

Thanks for the support!

Many thanks are owed to our sponsors for their support of MET and the development of this tutorial, including the National Oceanic and Atmospheric Administration and the United States Air Force. Thanks also go to the registered MET users and the MET workshop participants for your feedback and ideas. Thanks also go to the staff at the Developmental Testbed Center for their help, advice, and many types of support.

Using the MET Online Tutorial

Throughout this tutorial, the following conventions are used:

- **Bold font** is used for directory and filenames and occasionally to simply indicate emphasis.
- ***Bold and italic font*** is used for things to be typed on the command line, configurable items, and executable names.

Supporting the Community: Current Releases and Resources

METv8.0

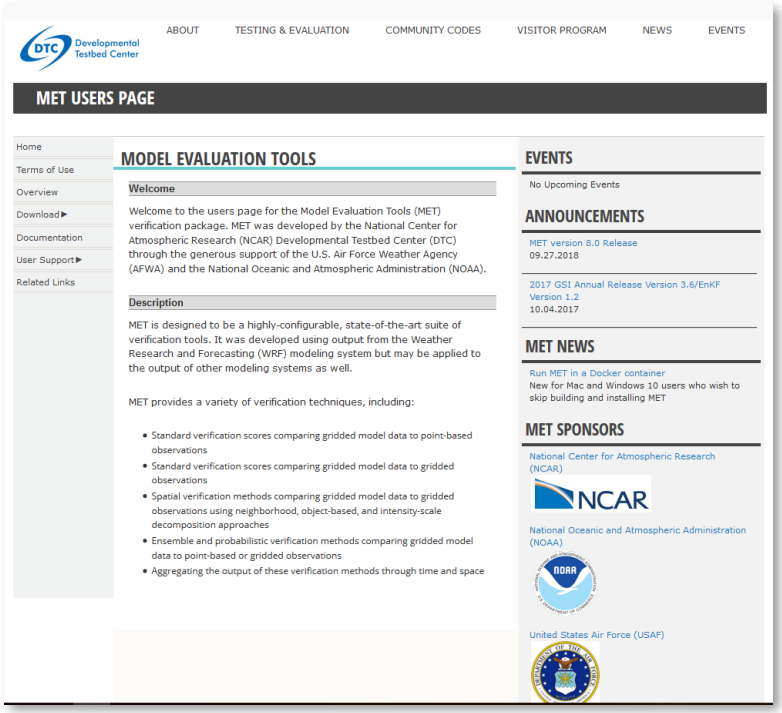
- Downloadable Tarballs on DTC website
- Support for NCAR and NOAA HPC platforms
- In Container
  - *User's Guide available*
  - *Online Tutorial*
  - *Will move to GitHub by end of year*

METviewer 2.8

- On GitHub
  - *User Guide out soon*
- In Container
  - *Limited Online Tutorial*
- Support for NOAA network

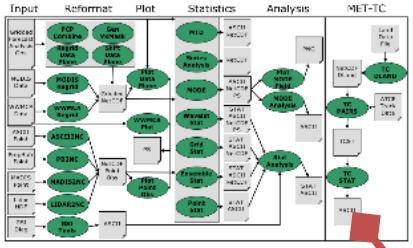
METplus 2.0

- On GitHub
  - *User Guide now available*
  - *Limited Online Tutorial*
- Support for NCAR and NOAA HPC platforms



Developing a Strategy: METplus Authoritative Repository

MET



METviewer

METexpress

In Development through NGGPS

METplus

Python scripts for low-level workflow

Python scripts for plotting

manage_externals package developed by NCAR CESM team

Connection to Workflow Managers

JEDI

UPP

CROW

Land

Hydro

Space Weather

Atmos Comp and Chem

Marine

CAM

S2S

Building a Unified Community: Tutorials, Workshops and Telecons

Tutorials and Workshops

Tutorial: Oct 1-5, 2018 (NGGPS) @NCWCP

Tutorial: Feb 4-6, 2019 (DTC) @NCAR

Bi-Weekly User Telecons

- Co-hosted by EMC and DTC
- Google Doc gathers questions
- Every other Monday METplus team answers questions on a call

Continuing to Enhance: Upcoming METplus Additions

- **Code clean-up to pass cyber-security software scans (Fortify)** and improve memory handling and speed **(DTC for AF)**
- **Ensemble and Atmospheric Composition/Air Quality Use-Cases (DTC for NOAA)**
- **Process Oriented Diagnostics (NGGPS)**
  - Moisture-Convection Coupling
  - MJO, NAO, and Teleconnection
  - TC Genesis
  - Extreme Weather related to Blocking
  - Cloud Property and Structure
- **Feature Relative Diagnostics (NGGPS)**
  - Extending the METplus Feature Relative use-case to include multi-variate fields and fluxes
- **CAM Specific Evaluation (USWRP and JTTI)**
- **Space Weather Evaluation (NOAA and NASA)**

Contacts: Tara Jensen – jensen@ucar.edu and John Halley Gotway – johnhg@ucar.edu

METplus GitHub: github.com/NCAR/METplus

MET Users Page: www.dtcenter.org/met/users/

Container MET GitHub: github.com/NCAR/container-dtc-met

METviewer GitHub: github.com/NCAR/METviewer

Container METviewer Github: github.com/NCAR/container-dtc-metviewer

All help requests go through MET Helpdesk: ***met_help@ucar.edu***

METplus work is funded by the DTC partners (NOAA, Air Force, NCAR and NSF), NGGPS program office, and USWRP R2O grants