METplus Introduction

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July 30 – August 1, 2019

Tutorial

Monterey, CA

MET Package

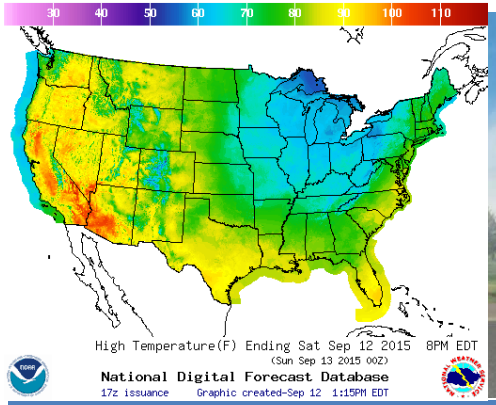
- MET is community code supported by DTC that is free to download (registration required)
  - Approximately 3800+ registered users
  - 124 countries
  - Universities, Government, Private Companies, Non-Profits

- Free Download MET release and compile locally.
  - Register and download: **www.dtcenter.org/met/users**
- Language:
  - Primarily in C++ with calls to some Fortran libraries
- Supported Platforms and Compilers:
  - Linux with GNU compilers
  - Linux with Portland Group (PGI) compilers
  - Linux with Intel compilers
- On-line tutorial available
- In-person tutorials generally given yearly

- Being Adopted by NOAA, NRL, AF
- In operation in South Africa, Under Consideration by the Met Office, and ECMWF

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

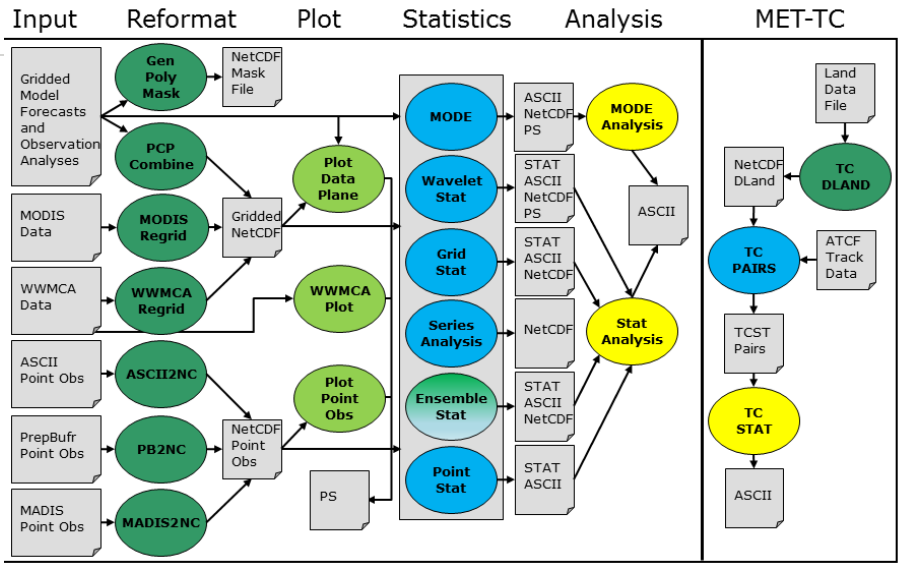
MET
Model Evaluation Tools

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

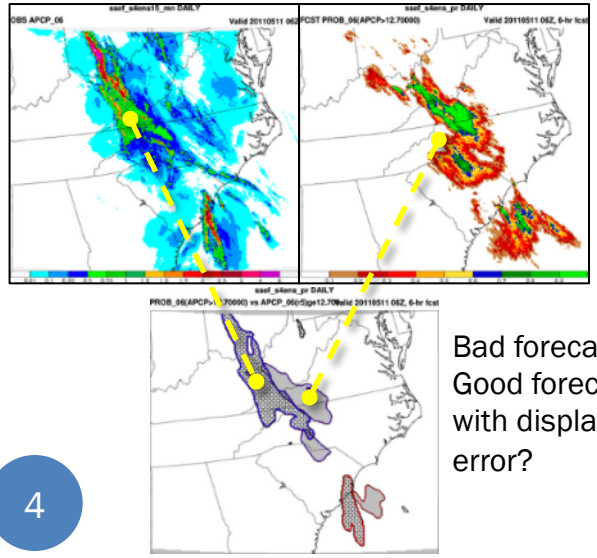
MET
Model Evaluation Tools

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

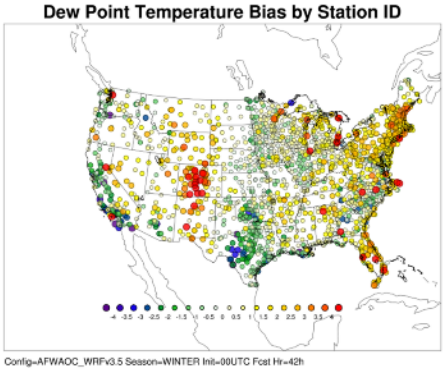


Object Based and Spatial Methods

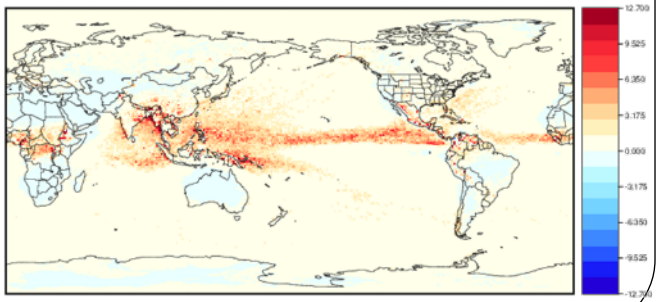


Bad forecast or Good forecast with displacement error?

Geographical Representation of Errors



90th Percentile of difference between two models



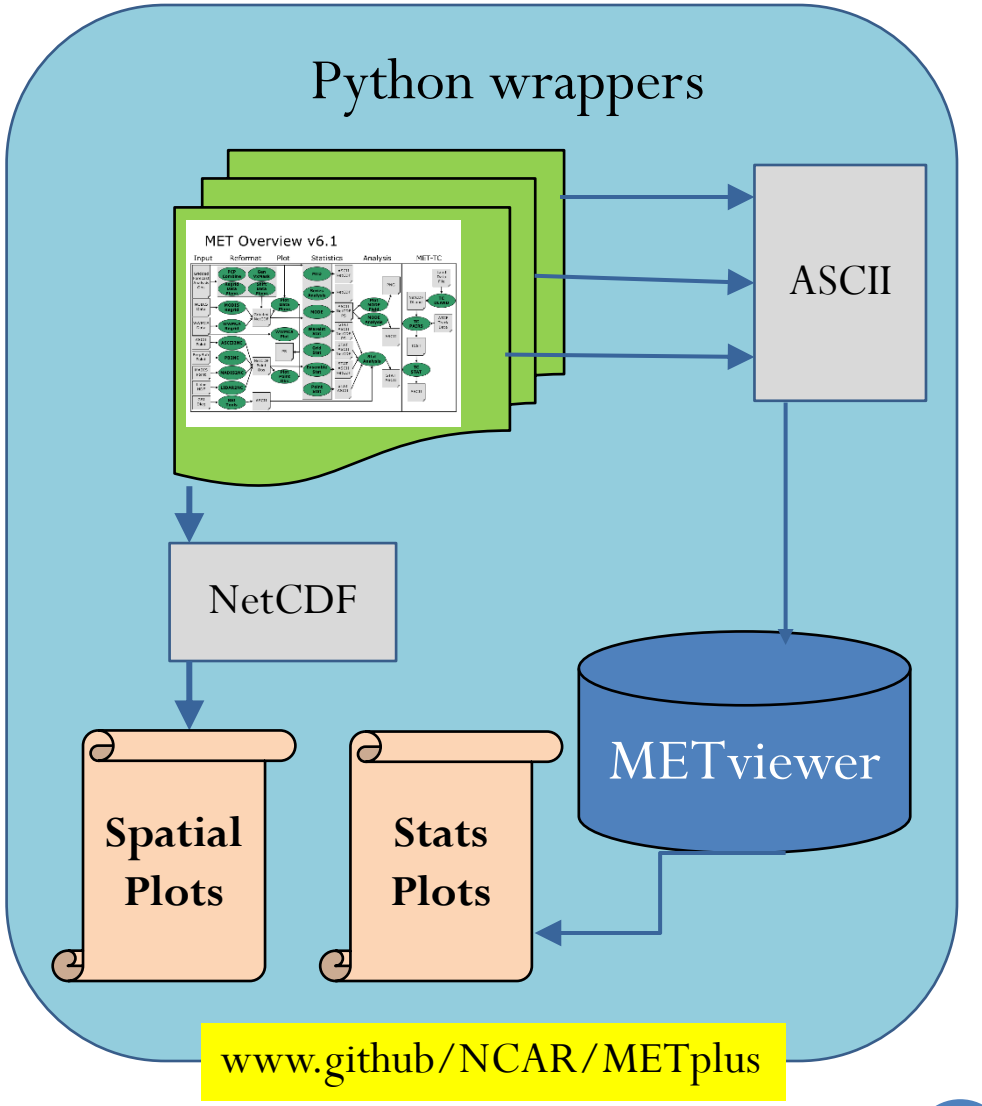
METplus Overview

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

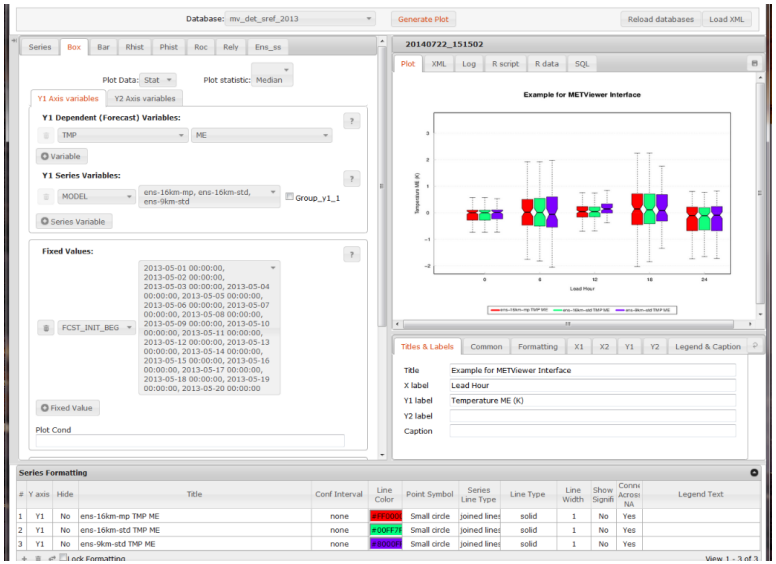
Python scripting infrastructure for MET tools.

1,527 commits | 14 branches | 15 releas

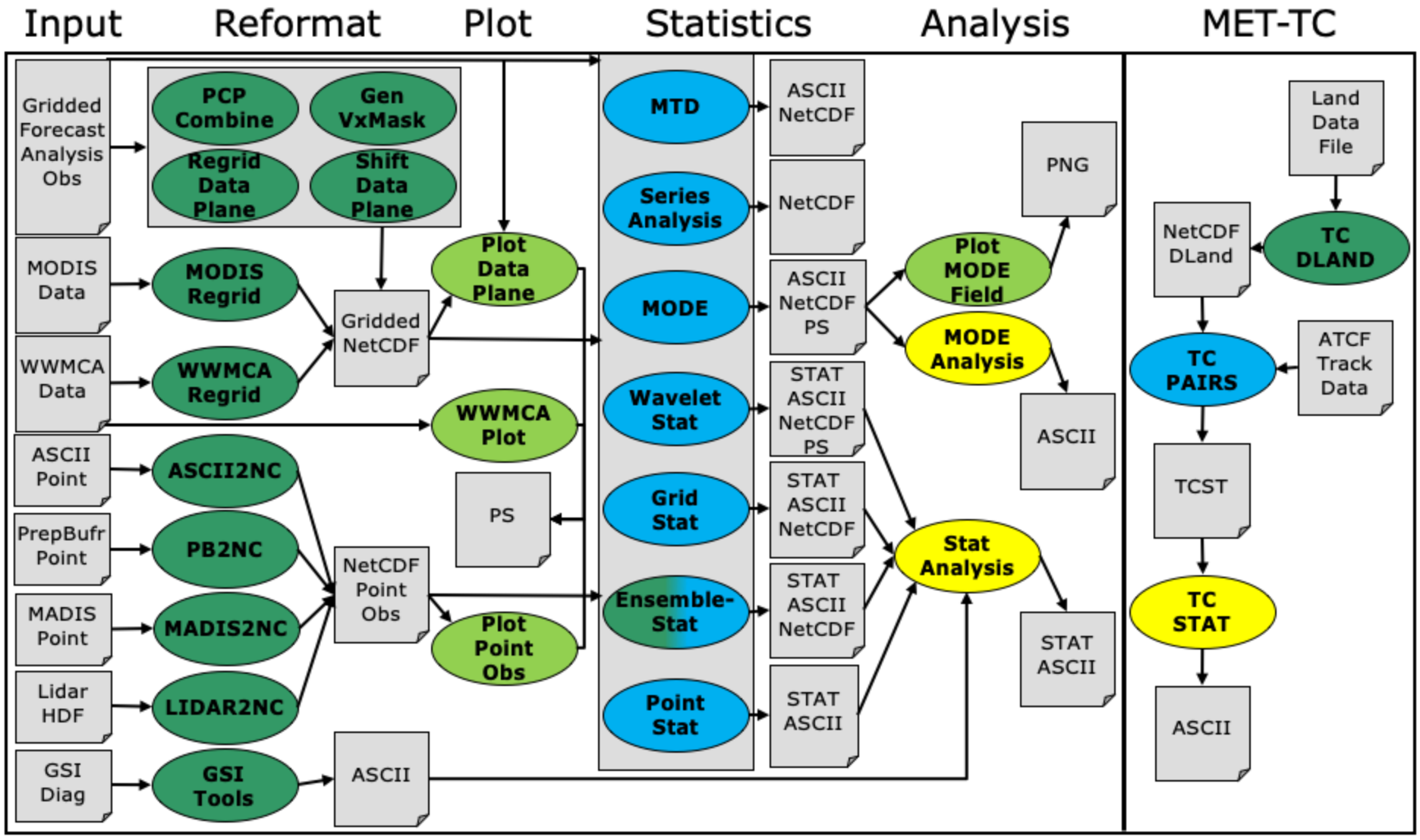
Branch: master | New pull request | Create

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 v8.1



Laundry List of Statistics

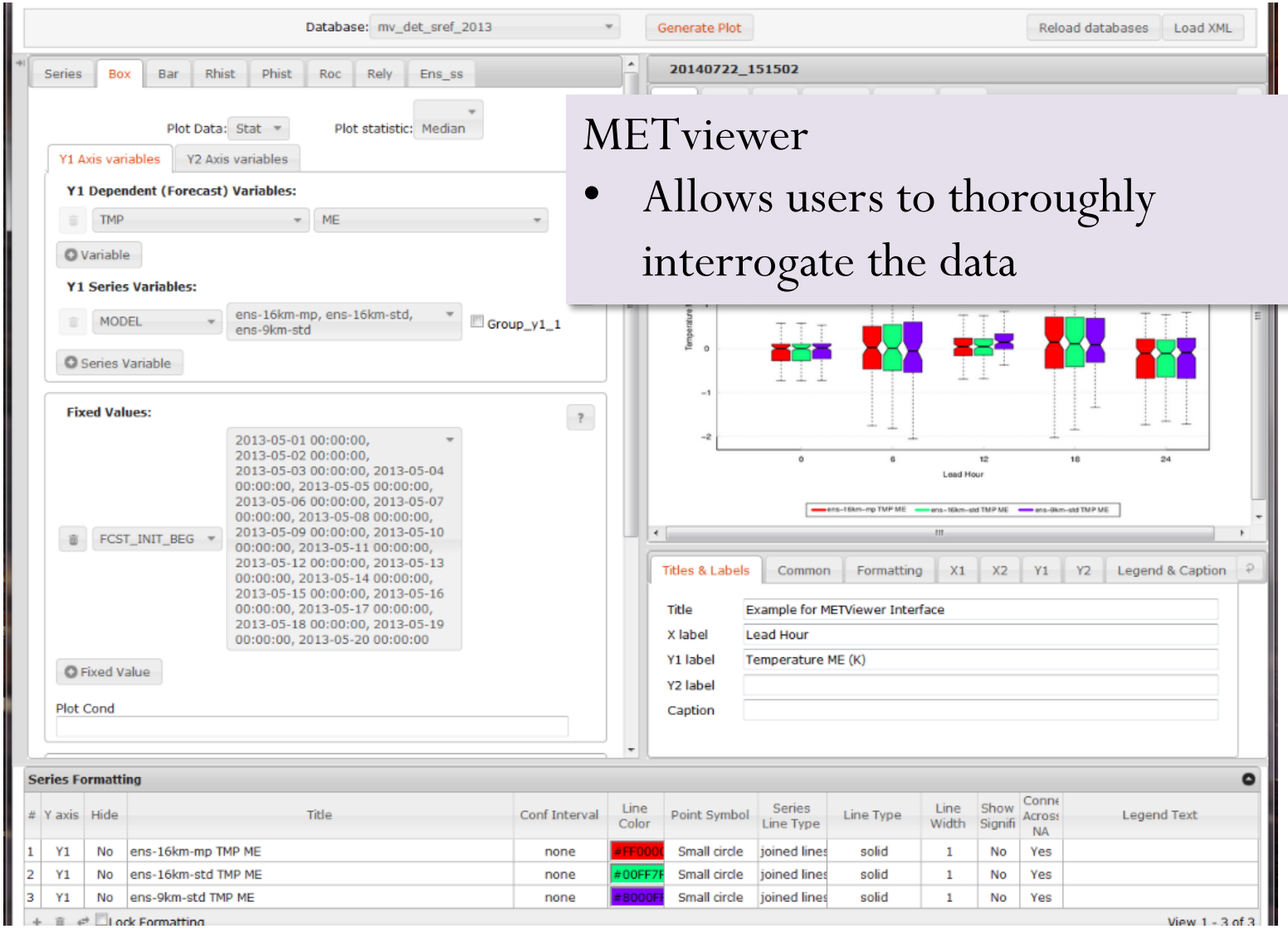
Type	Statistics
Continuous	Forecast and Observation mean, Standard deviation of the forecast and observations, Mean error (F-O), Standard deviation of the error, Anomaly Correlation, Pearson correlation coefficient, Spearman's rank correlation coefficient, Kendall's tau statistic, Multiplicative bias, 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 Score and Skill Score, Ignorance Score, Rank Histogram, Probability Integral Transform, Relative Position, Spread, Skill, Spread and Skill of members perturbed to represent observation error, Spread+obs error
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 Score, HiRA methods for neighborhoods around point observations
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

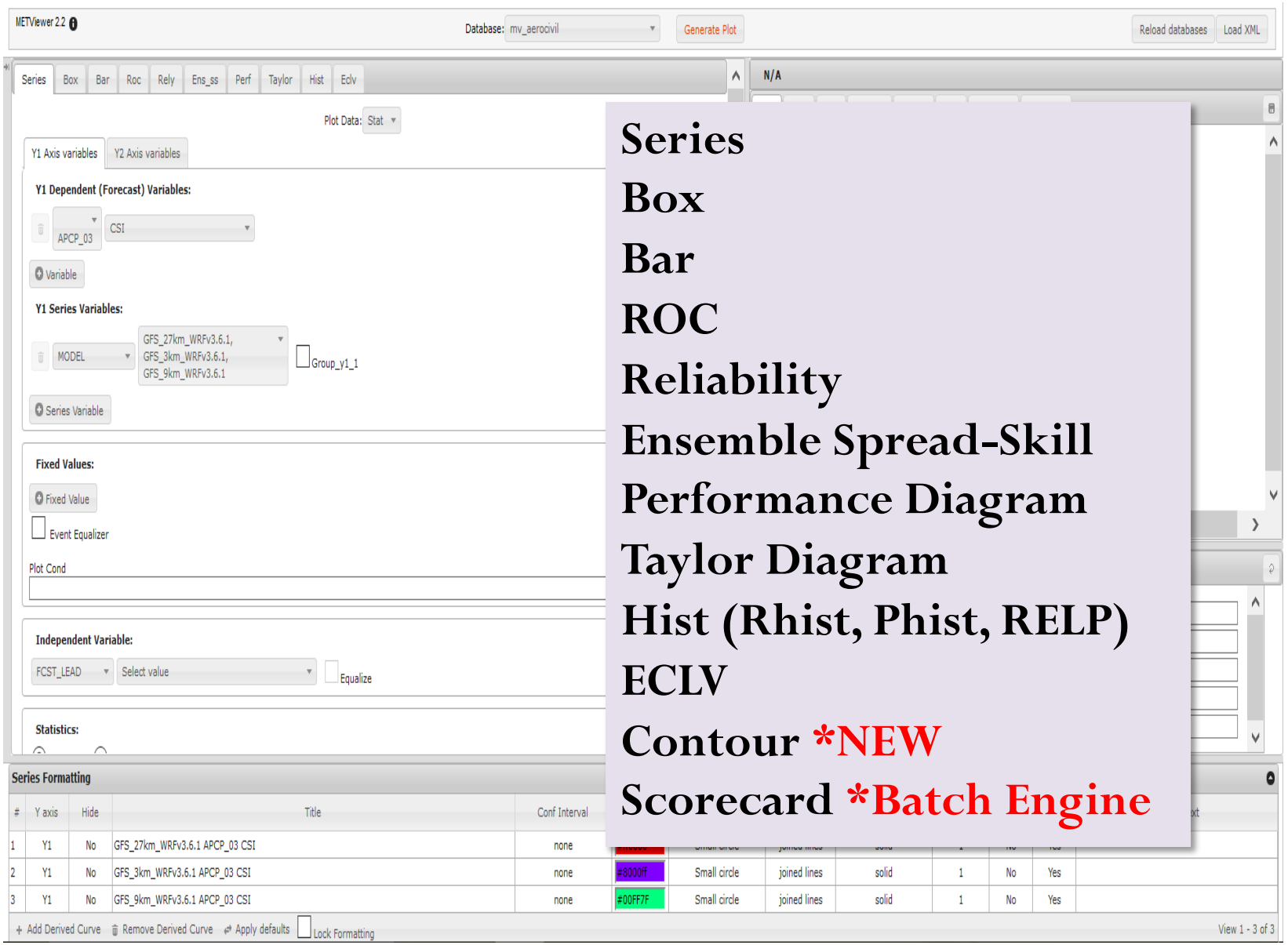
METviewer Database and Display



METviewer

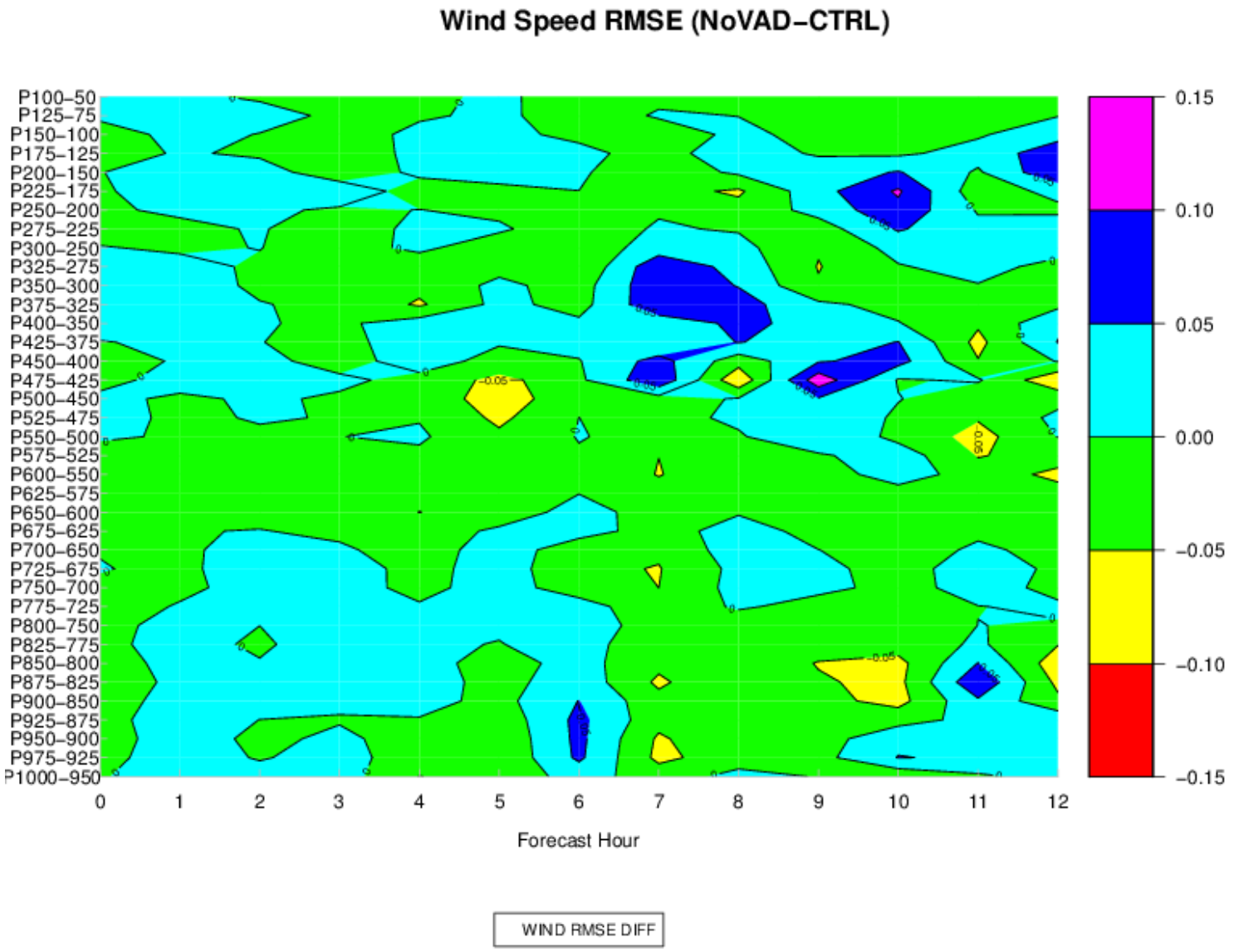
- Allows users to thoroughly interrogate the data

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

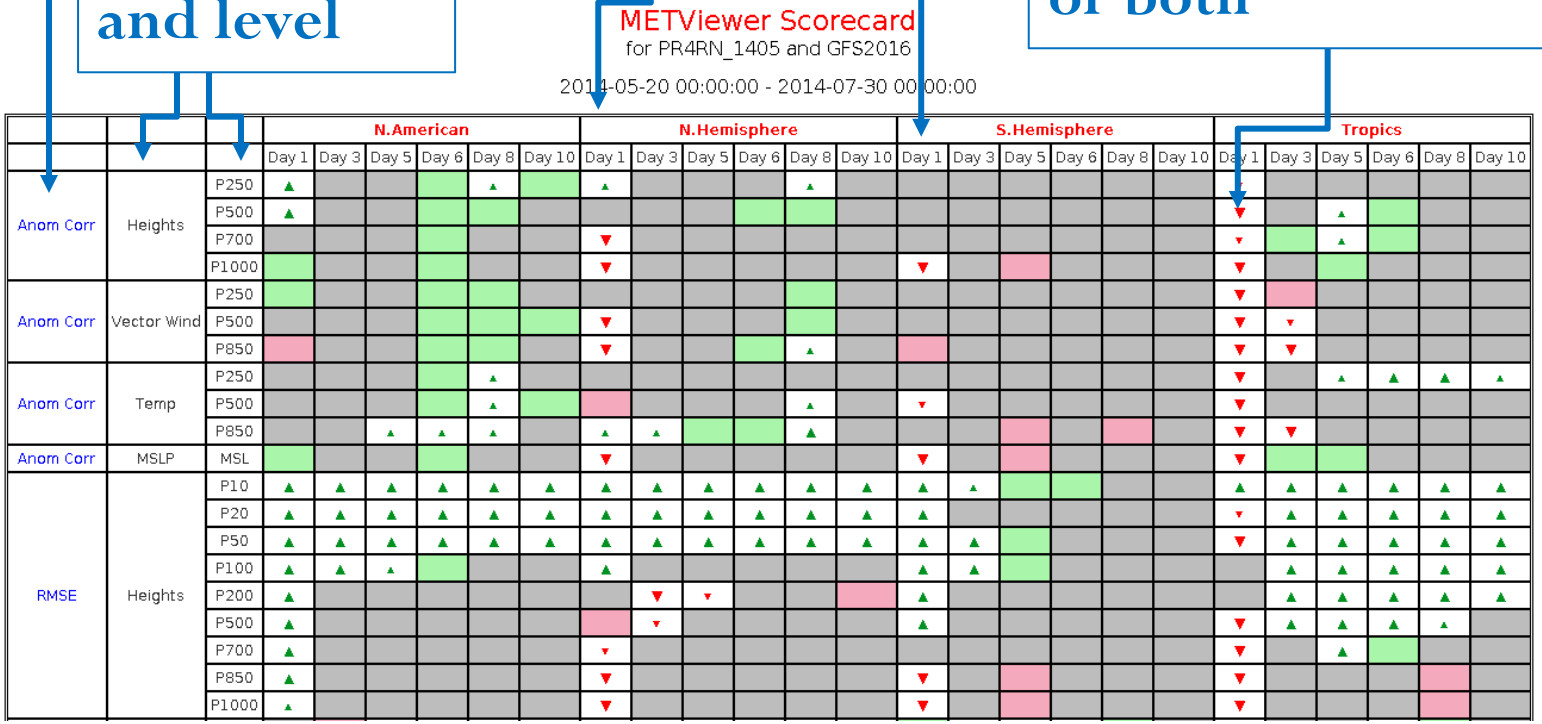
Specify statistic

Specify field and level

Specify regions

Specify aggregations

Specify whether you have symbol, values or both



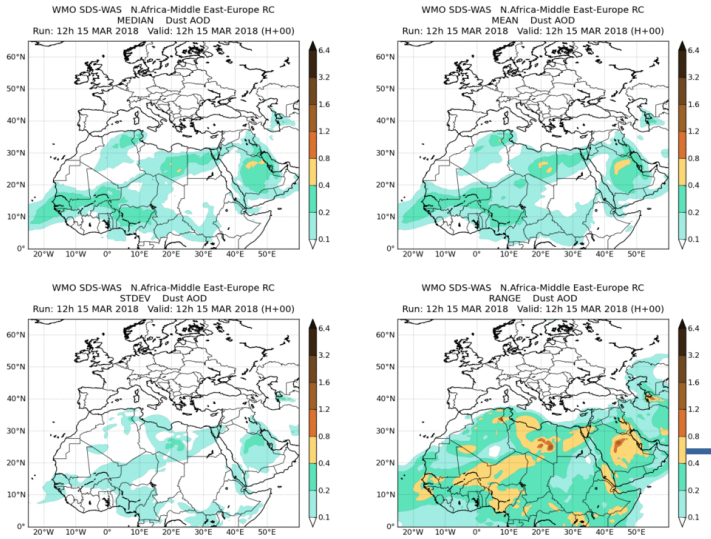
Working Towards Easy Usability: METplus Use Case Example

Observed 1-min AOD Data

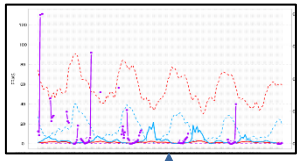
ASCII 2NC

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

Stat Analysis

STAT ASCII

Working Towards Easy Usability: METplus Use Case Example

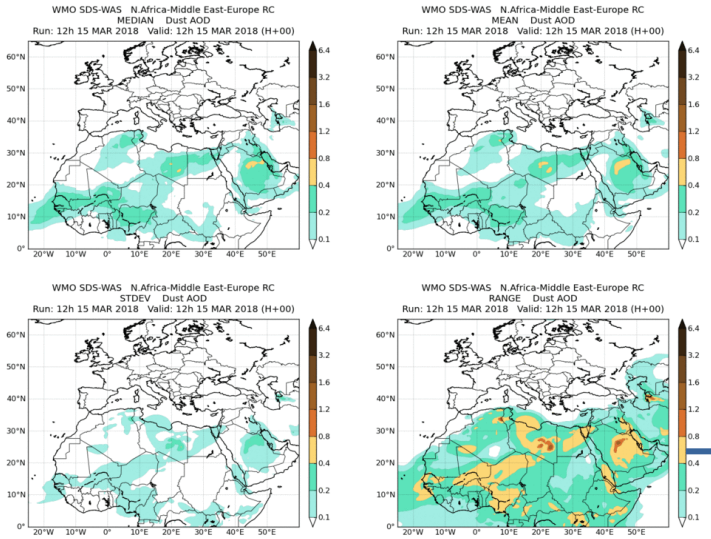
Observed 1-min AOD Data

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

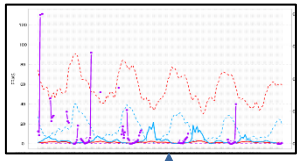
MODE

Grid Stat

Series Analysis

Ensemble Stat

Point Stat



Plotting Script

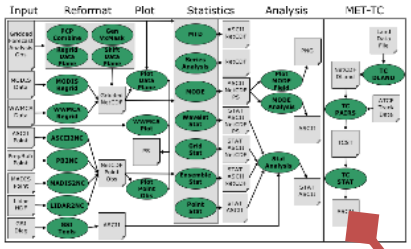
STAT ASCII

Series Analysis

STAT ASCII

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

Atmos Comp and Chem

Marine

CAM

S2S

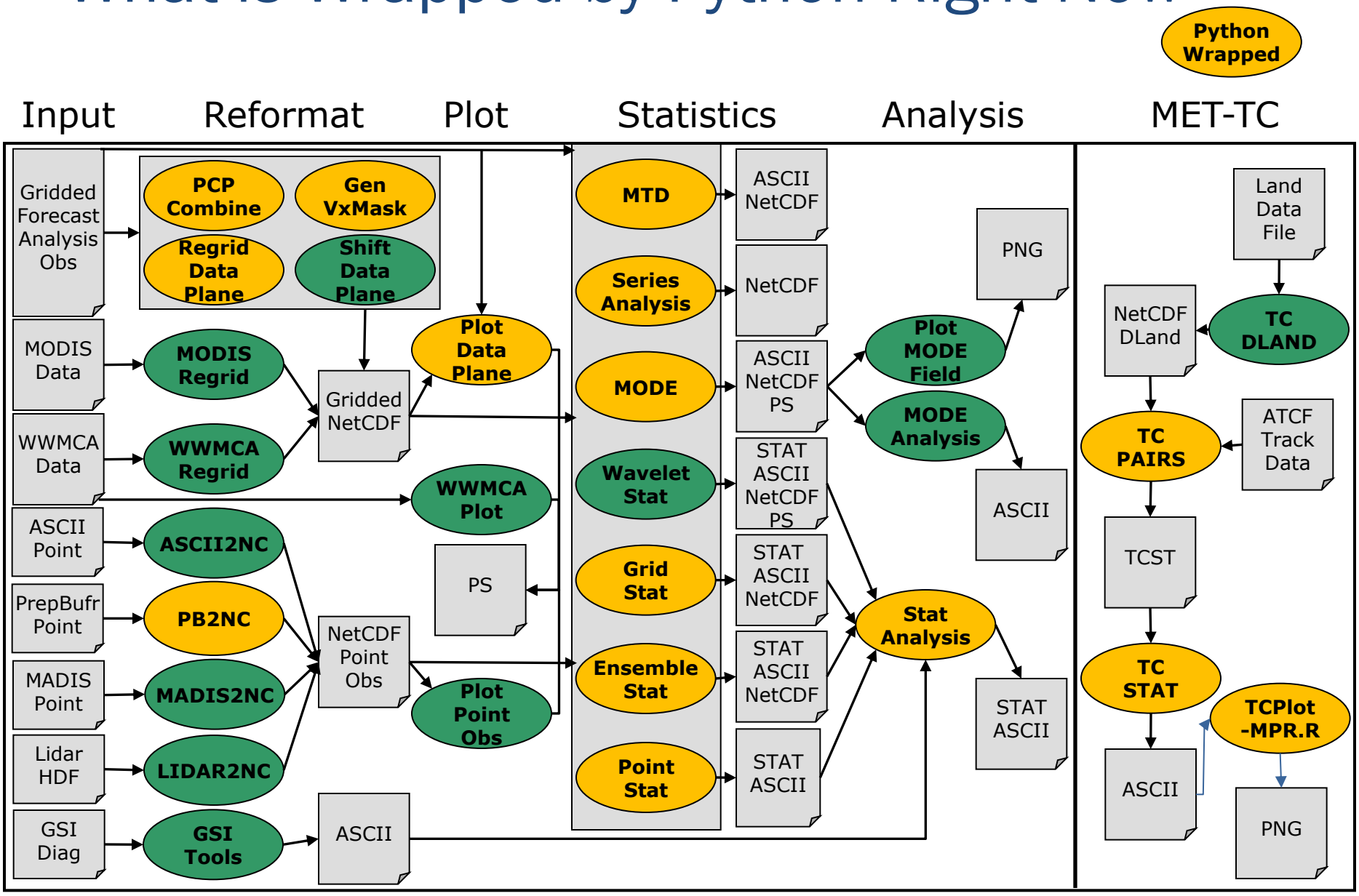
Space Weather

Hydro

Land

What Does Wrapped by Python Mean?

What is Wrapped by Python Right Now

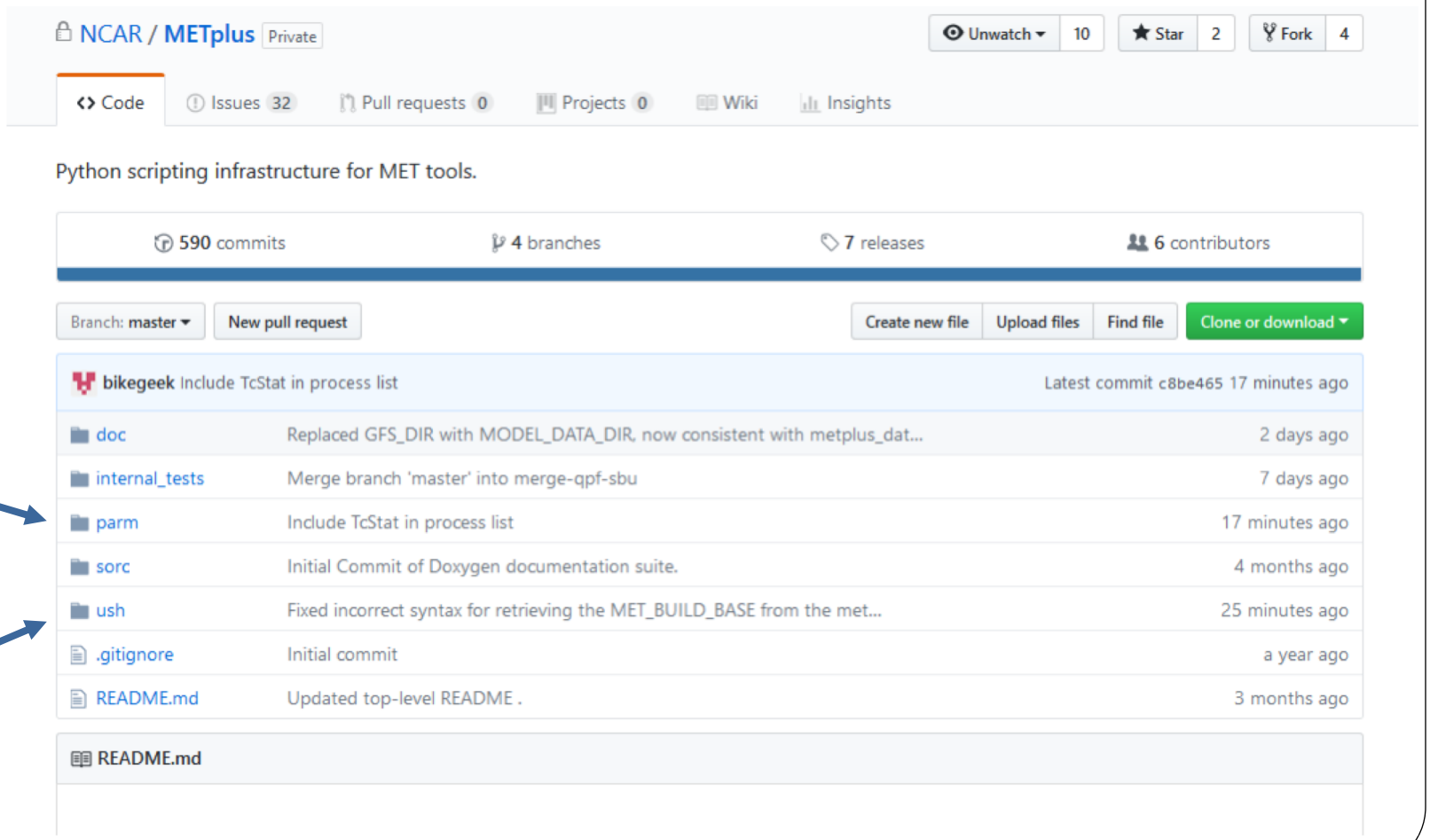


What does wrapped by Python mean?

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

Control File and Config

Python Scripts



What does wrapped by Python mean?

METplus/parm/use_cases/grid_to_grid/examples/precip.conf

 # Grid to Grid Precipitation Example

[config]
# time looping - options are INIT, VALID, RETRO, and REALTIME
LOOP_BY = VALID

# Format of VALID_BEG and VALID_END
VALID_TIME_FMT = %Y%m%d%H

# Start time for METplus run
VALID_BEG = 2017061300

# End time for METplus run
VALID_END = 2017061300

Increment between METplus runs
May be in seconds-hours
VALID_INCREMENT = 86400 or 24H

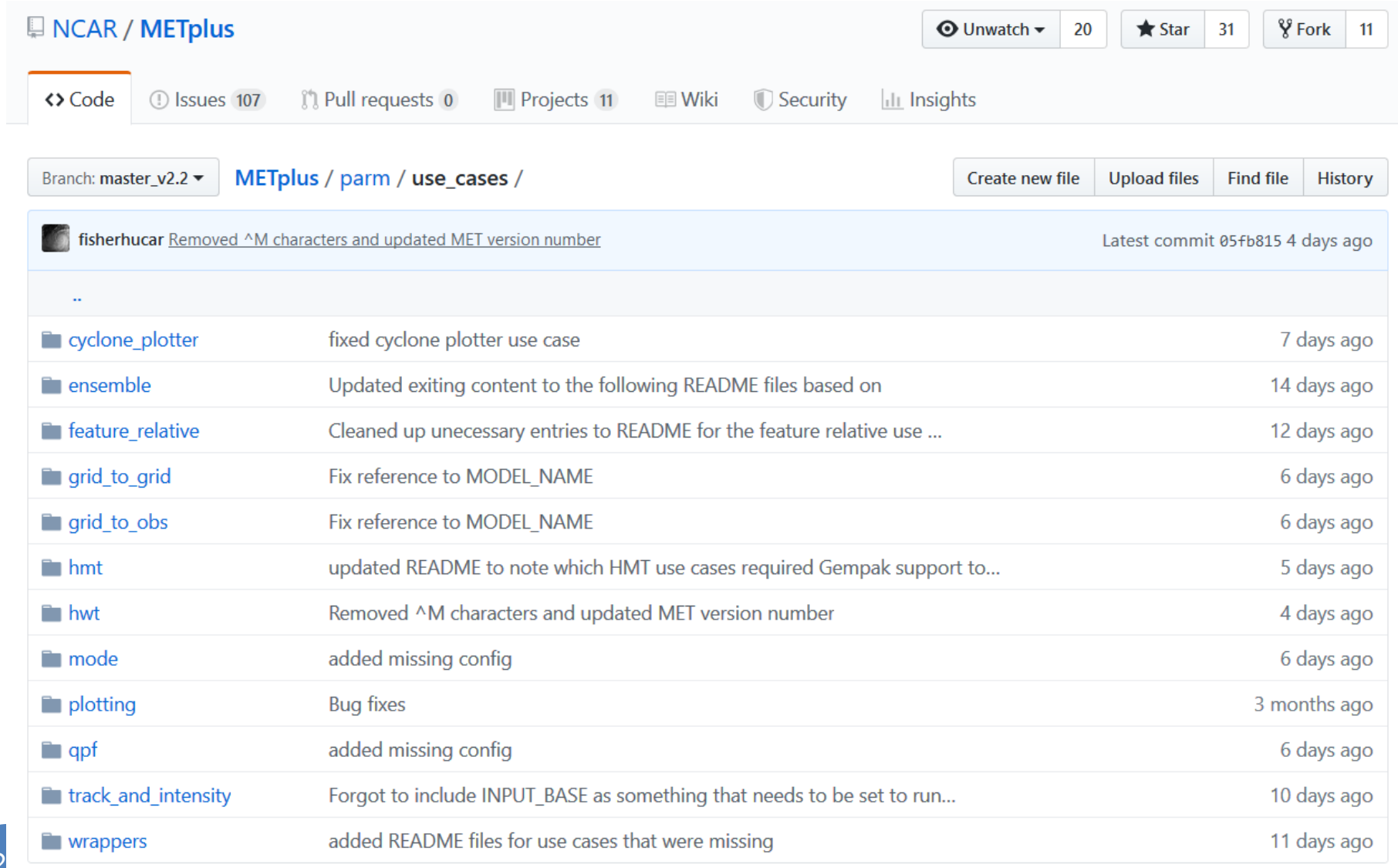
# List of applications to run
PROCESS_LIST = PcpCombine, GridStat

# run pcp_combine on forecast data
FCST_PCP_COMBINE_RUN = True

# mode of pcp_combine to use (SUM, ADD, SUBTRACT)
FCST_PCP_COMBINE_METHOD = SUM

# list of variables to compare
FCST_VAR1_NAME = APCP
FCST_VAR1_LEVELS = A24

METplus Use-Cases



NCAR / METplus

Unwatch 20 | Star 31 | Fork 11

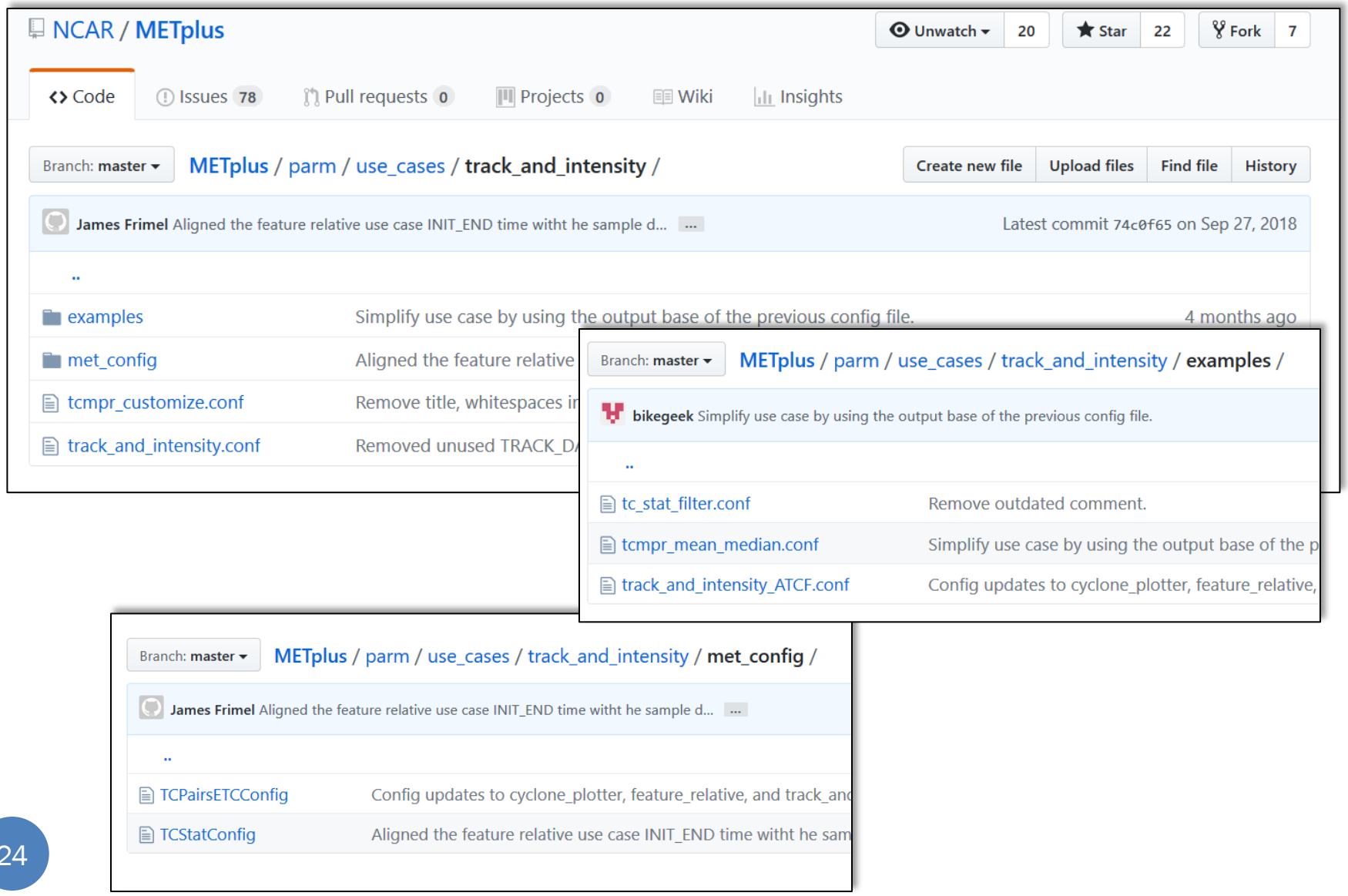
Code | Issues 107 | Pull requests 0 | Projects 11 | Wiki | Security | Insights

Branch: master_v2.2 — METplus / parm / use_cases / — Create new file | Upload files | Find file | History

fisherhucar Removed ^M characters and updated MET version number — Latest commit 05fb815 4 days ago

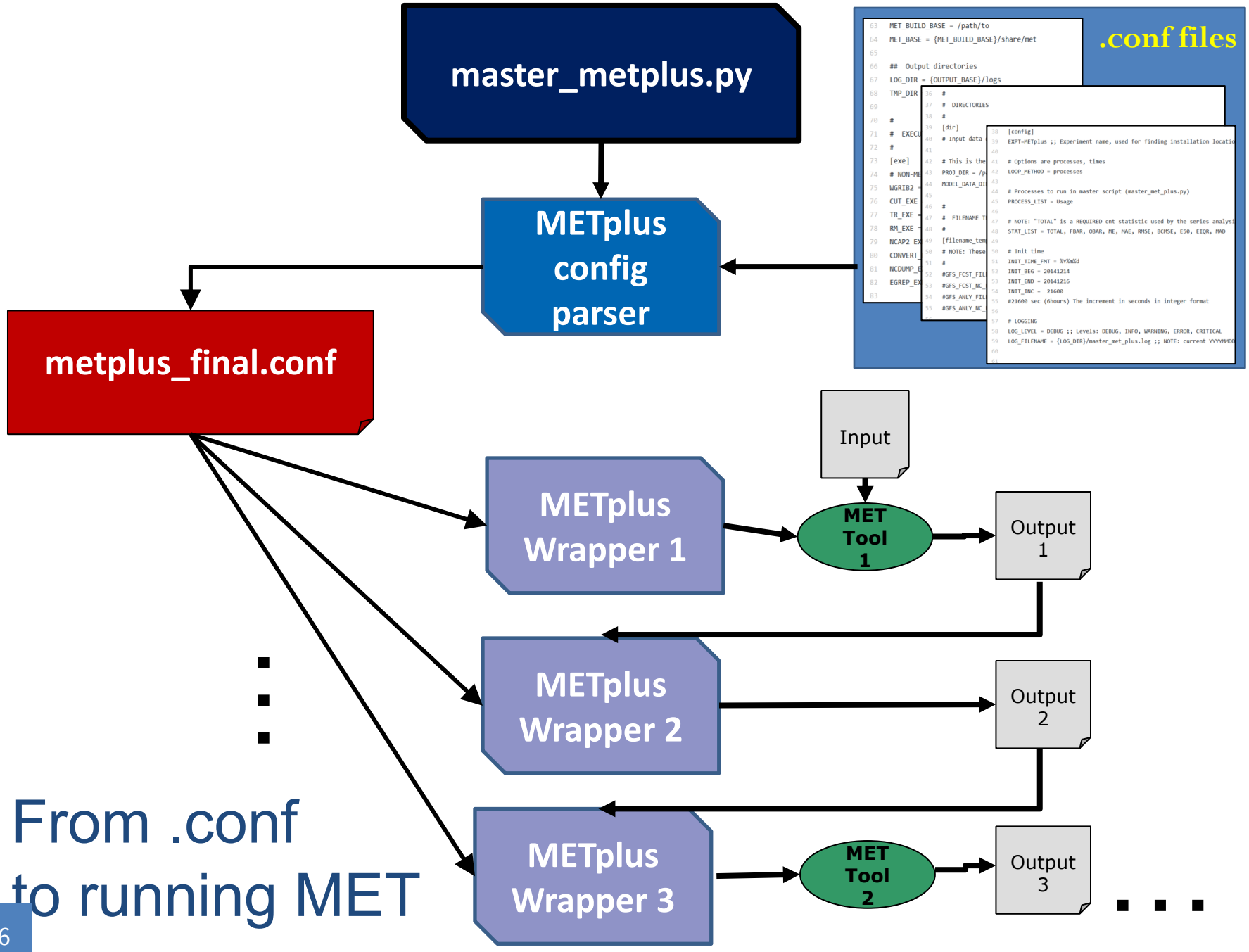
..		
cyclone_plotter	fixed cyclone plotter use case	7 days ago
ensemble	Updated exiting content to the following README files based on	14 days ago
feature_relative	Cleaned up unecessary entries to README for the feature relative use ...	12 days ago
grid_to_grid	Fix reference to MODEL_NAME	6 days ago
grid_to_obs	Fix reference to MODEL_NAME	6 days ago
hmt	updated README to note which HMT use cases required Gempak support to...	5 days ago
hwt	Removed ^M characters and updated MET version number	4 days ago
mode	added missing config	6 days ago
plotting	Bug fixes	3 months ago
qpf	added missing config	6 days ago
track_and_intensity	Forgot to include INPUT_BASE as something that needs to be set to run...	10 days ago
wrappers	added README files for use cases that were missing	11 days ago

METplus Use-Cases



```
19   // Stratify by the AMODEL o
20   //
21   //amodel = [];
22   //bmodel = [];
23   amodel = ${AMODEL};
24   bmodel = ${BMODEL};
25
26   //
27   // Stratify by the DESC col
28   //
29   //desc = [];
30   desc = ${DESC};
31
32   //
33   // Stratify by the STORM_ID
34   //
35   //storm_id = [];
36   storm_id = ${STORM_ID};
37
38   //
39   // Stratify by the BASIN co
40   // May add using the "-basi
41   //
42   //basin = [];
43   basin = ${BASIN};
```

```
60   // Stratify by the INIT times.
61   // Model initialization time windows to include or exclude
62   // May modify using the "-init_beg", "-init_end", "-init_inc",
63   // and "-init_exc" job command options.
64   //
65   //init_beg = "";
66   //init_end = "";
67   //init_inc = [];
68   //init_exc = [];
69   init_beg = "${INIT_BEG}";
70   init_end = "${INIT_END}";
71   init_inc = ${INIT_INCLUDE};
72   init_exc = ${INIT_EXCLUDE};
73
74   //
75   // Stratify by the VALID times.
76   //
77   //valid_beg = "";
78   //valid_end = "";
79   //valid_inc = [];
80   //valid_exc = [];
81   valid_beg = "${VALID_BEG}";
82   valid_end = "${VALID_END}";
83   valid_inc = ${VALID_INCLUDE};
84   valid_exc = ${VALID_EXCLUDE};
```



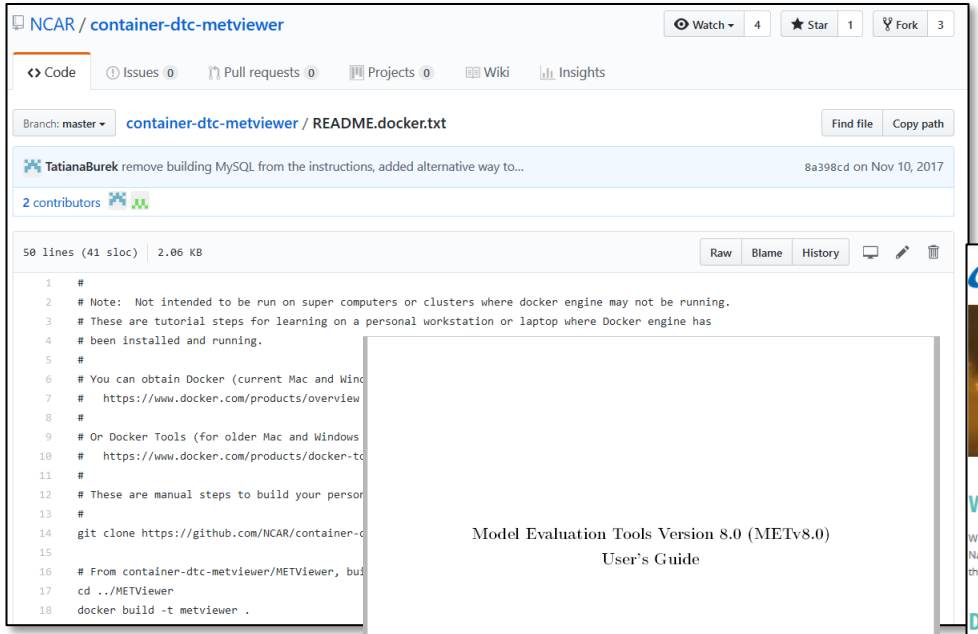
From .conf to running MET

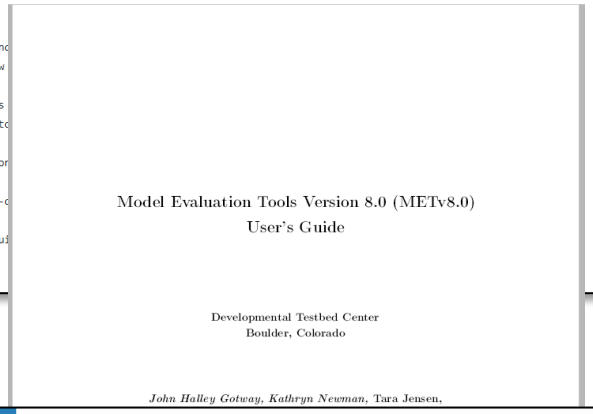
Support

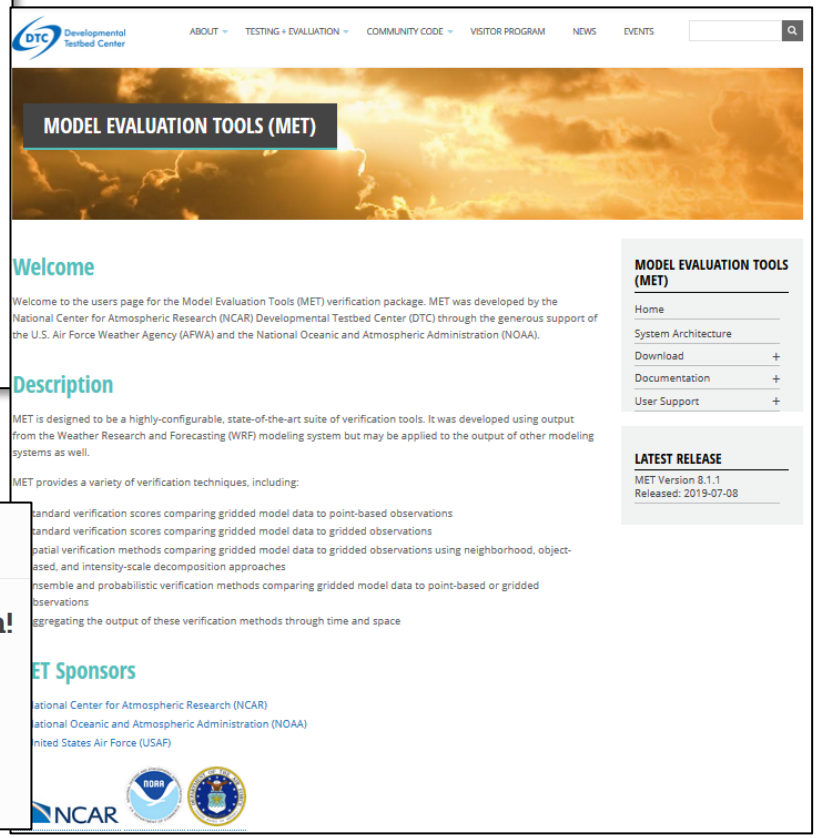
Repositories and Support

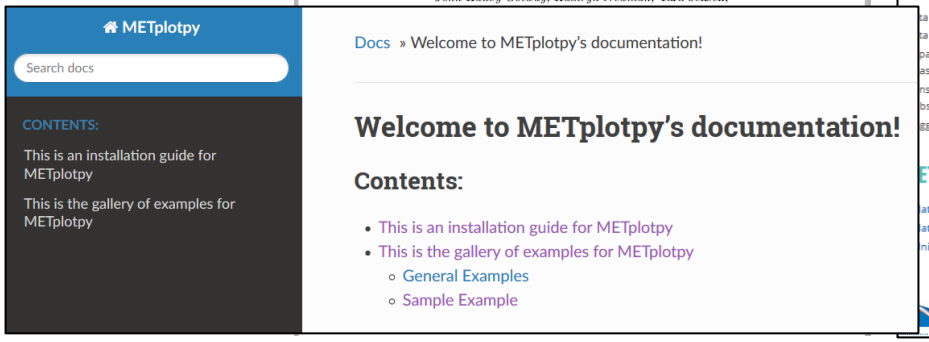
GitHub

docker









Supporting the Community: Current Releases and Resources

METv8.1.1

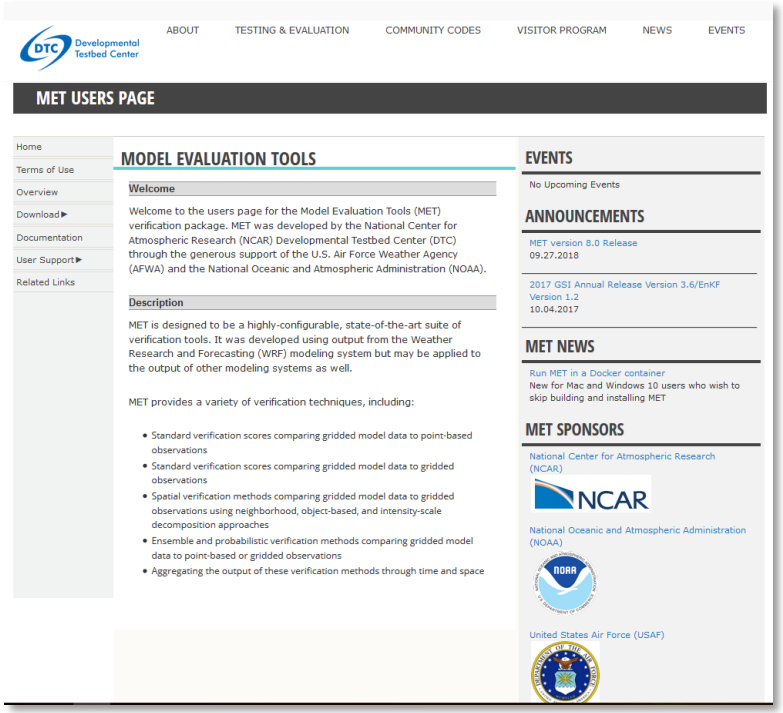
- Downloadable Tarballs on DTC website
- Support for NCAR and NOAA HPC platforms
- In Container
  - *User's Guide available*
  - *Online Tutorial*
  - *Will move to GitHub by end of year*

METviewer 2.11

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

METplus 2.2

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



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

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

METplus GitHub: github.com/NCAR/METplus

MET GitHub: github.com/NCAR/MET

METviewer GitHub: github.com/NCAR/METviewer

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

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

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

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