



UFS Webinar Series: METplus Verification and Diagnostics Framework - Updates, Plans and Challenges

Tara Jensen on behalf of the METplus Team

NCAR/RAL
NOAA/GSL

and

Developmental Testbed Center

UFS Seminar Series

9 June 2022



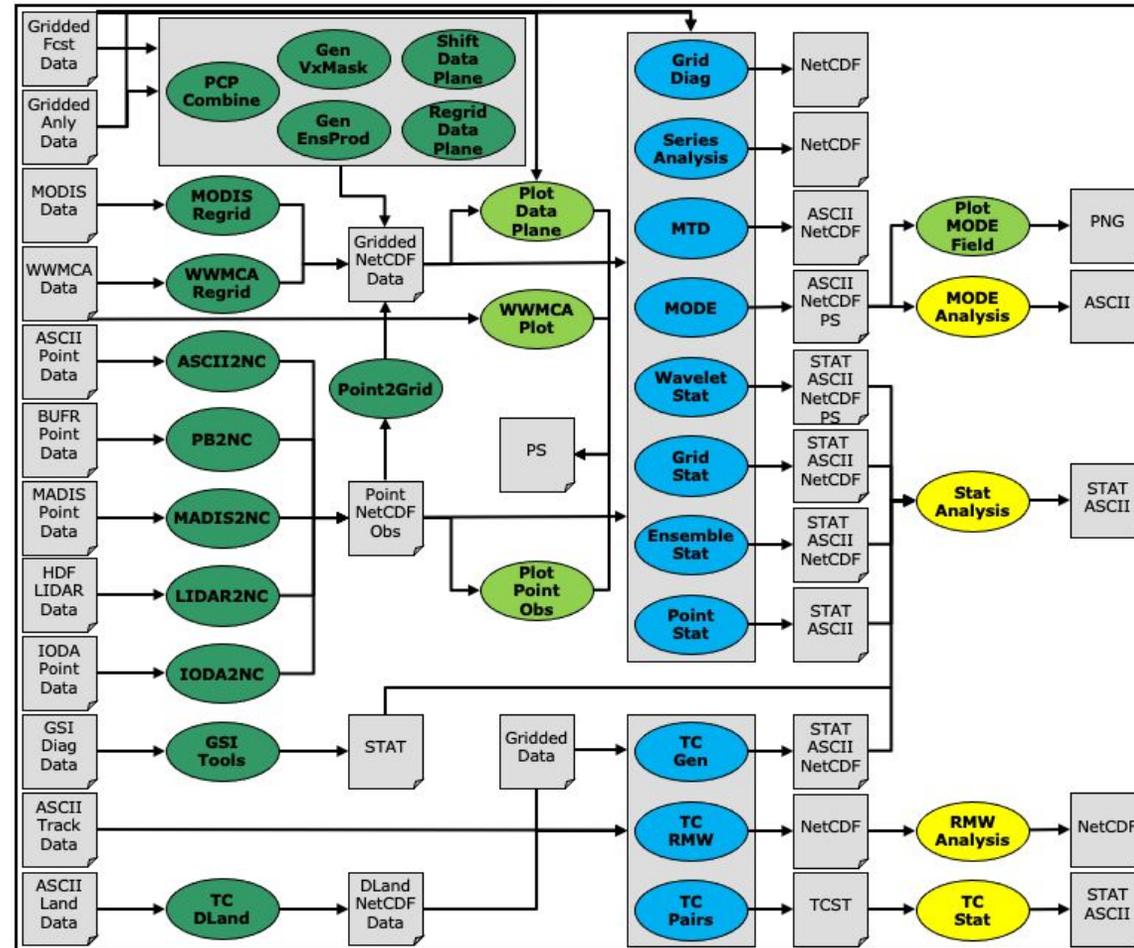
What is METplus

At its core is the
Model
Evaluation Tools

Also includes:

- Configuration files for sharing of settings and demonstration
- Use of environment variables for integration with scripts
- Calling of python scripts for extended flexibility

MET Overview v10.1.0

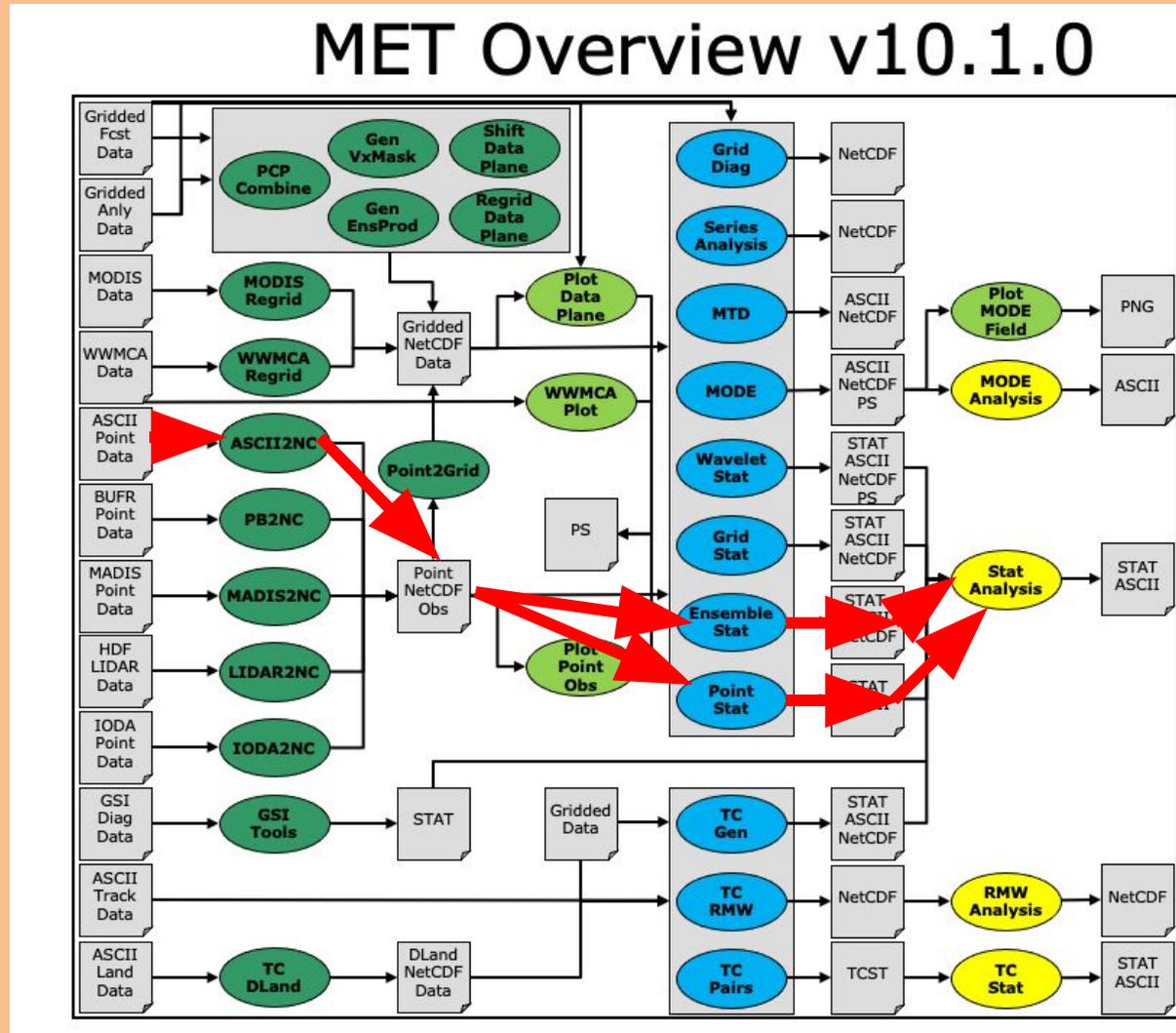


Includes tools for:

- Reformatting
- Quick look plotting
- Statistics computation
- Analysis

What is METplus

A framework that provides low-level workflow to accomplish verification and diagnostic activities



Legend

File I/O

Reformat Tool

Plot Tool

Statistic Tool

Analysis Tool

Basically the arrows between tools

Also includes:

- Configuration files driving data between tools
- Use of environ-ment variables for integration with workflows

It's All in the Branding

- MET is at the core – everything else is extra, including the METplus framework

METplus

MET
Model Evaluation Tools

* Not METPlus, MetPlus,
MetPLUS, Metplus,
MET/METplus, MET/METPlus,
etc

METplus Analysis
Suite

METviewer

METexpress

METdatadb

METcalcpy

METplotpy

Great Expectations

- NWS plans include METplus in the Stages and Gates for Research to Operations activities for the Global (Ensemble) Forecast System (GFS/GEFS), Rapid Refresh Forecast System (RRFS), Hurricane Analysis and Forecast System (HAFS), and other EMC supported model applications.
- To achieve this, DTC and the UFS conducted a Metrics Workshop in February 2021 to identify community vetted metrics for use at the Gates. The resulted in the following set of metrics

Operational Application	# of Metrics Identified	# of Metrics to Add
SRW	32	6-10
MRW	36	~15 Land/Marine/Cryo Obs
S2S	27	3 plus ~15 Land/Marine/Cryo Obs
Seasonal	29	8 plus ~15 Land/Marine/Cryo Obs
AQ/Atm Comp		3 Observation sources

Recent Contributions from:

DTC AF \$

DTC NCAR Base \$

DTC NOAA Base \$\$

DTC UFS-R2O
\$\$\$\$\$

Naval Research Lab
\$\$

JTTI projects \$\$\$

OSTI projects \$\$\$

CPO projects \$\$

Met Office \$\$

United Arab Emirates \$

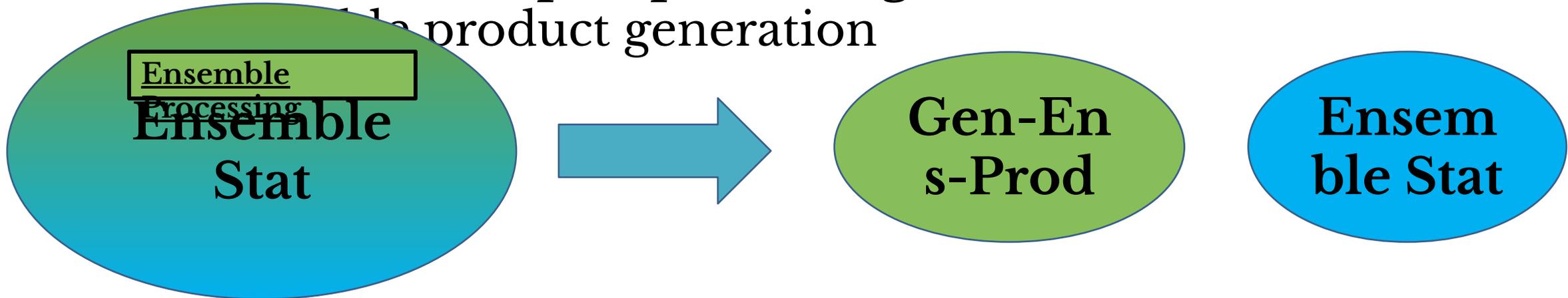
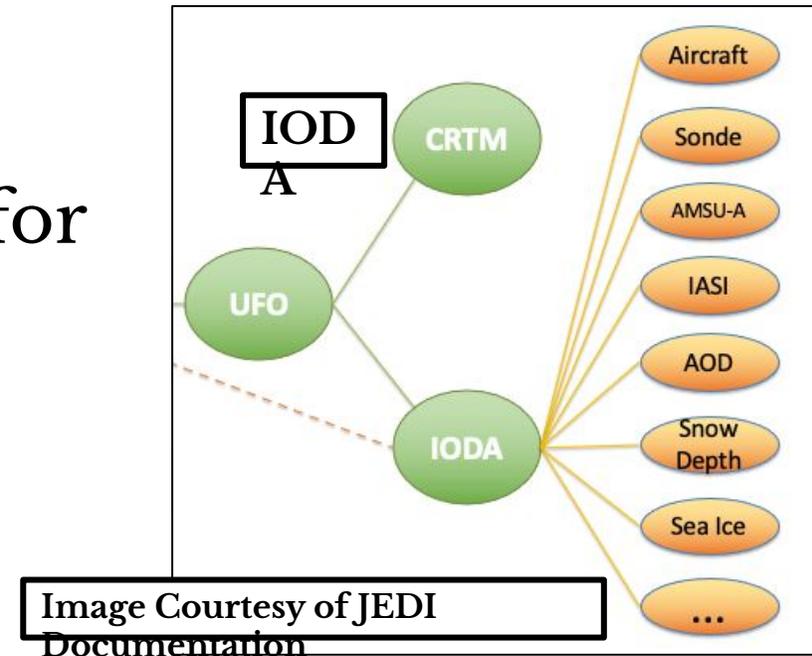
Key:

\$ \geq \$100K/yr;

\$\$\$\$\$ \geq \$500K/year

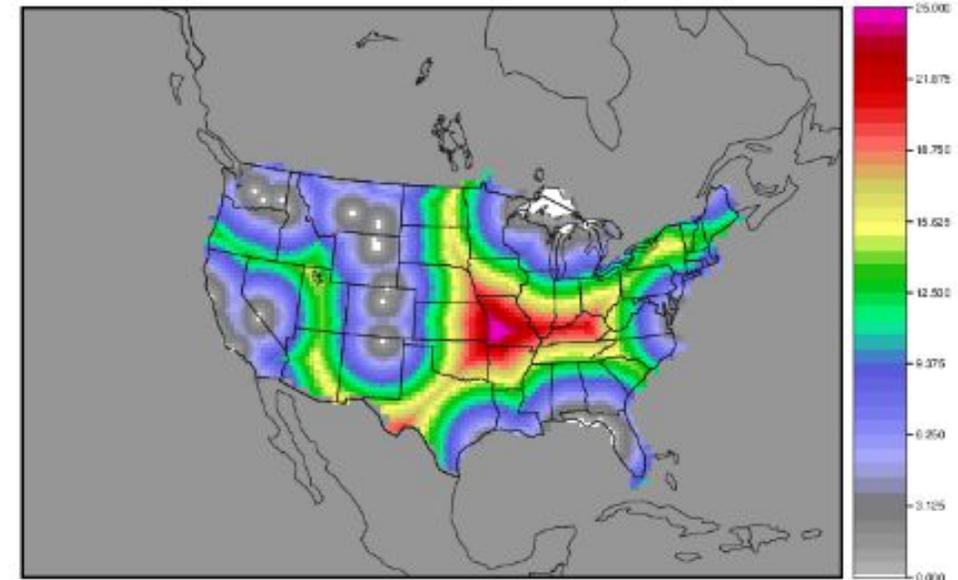
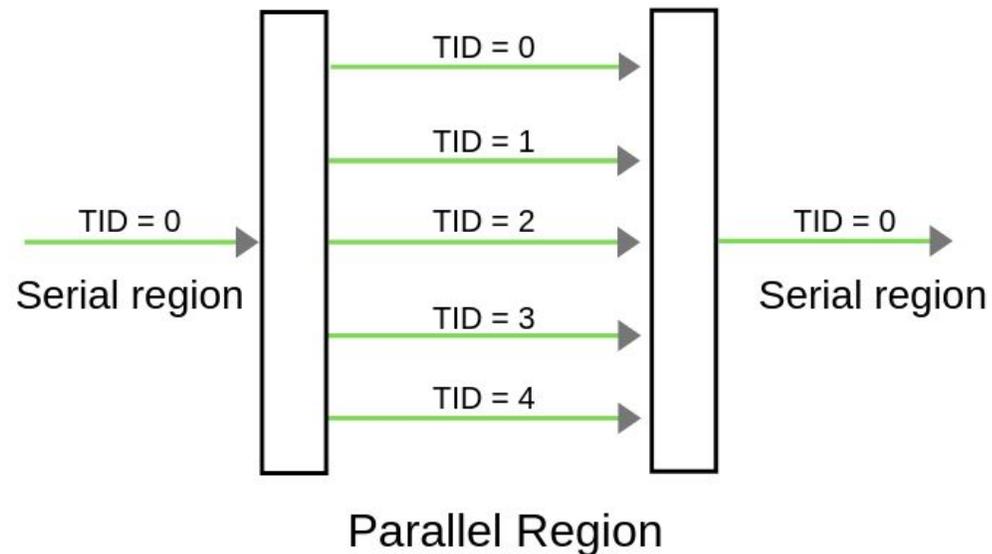
MET Enhancements: New Tools

- IODA2NC tool – extracts observations from IODA output for use with point-base verification tools
- Gen-Ens-Prod tool for *non-statistical post processing* of the product generation



MET Enhancements: Grid-Stat

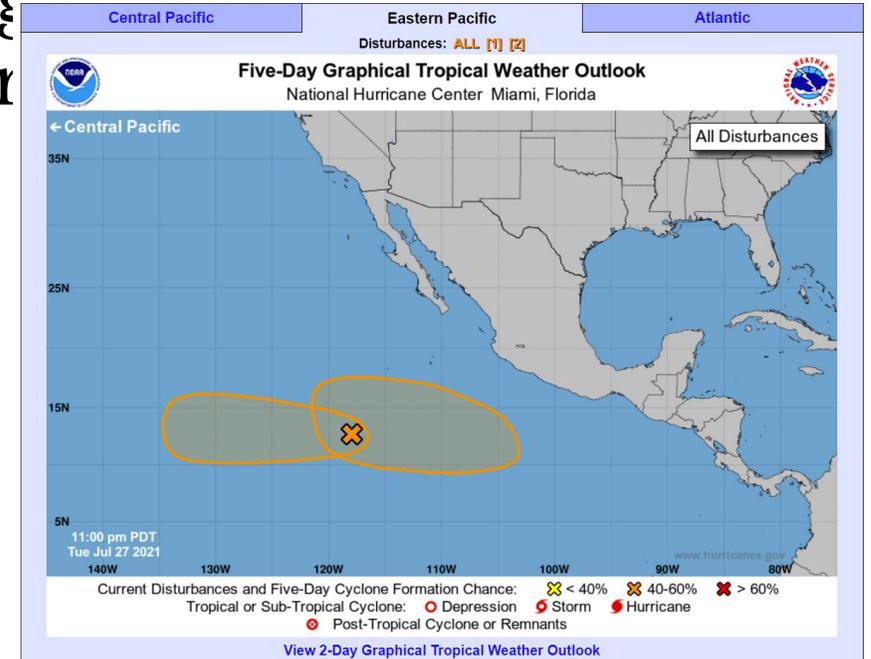
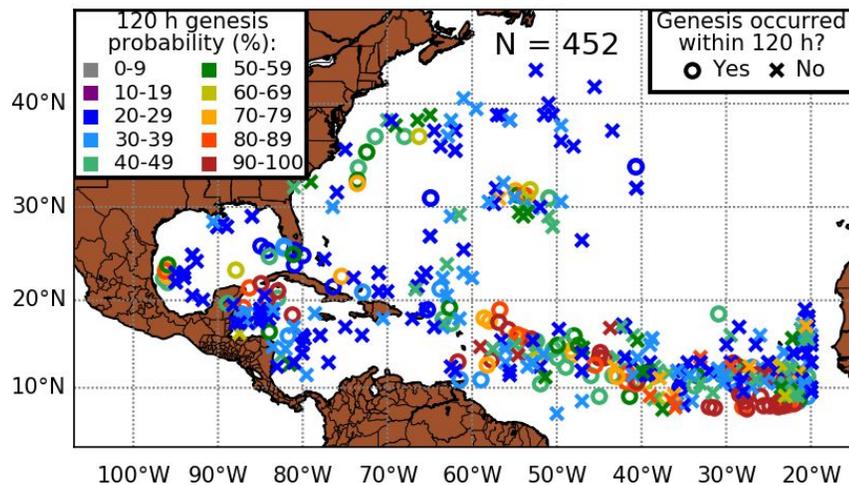
- Enhance GridStat to use OpenMP for efficient computation of neighborhood statistics by setting `$OMP_NUM_THREADS`
- Add G and G-Beta to the DMAP line type from Grid-Stat



MET Enhancements: MET-TC tools

- Enhance TC Gen to verify NHC tropical weather outlook shapefiles
- Fix to read supported RI edeck input lines and ignore unsupported edeck probability line types
- Overhaul the genesis matching logic, add the development and operational scoring

Season-to-date TC genesis forecast verification
2021 CON based 120 hour genesis forecasts through 12/26 22Z



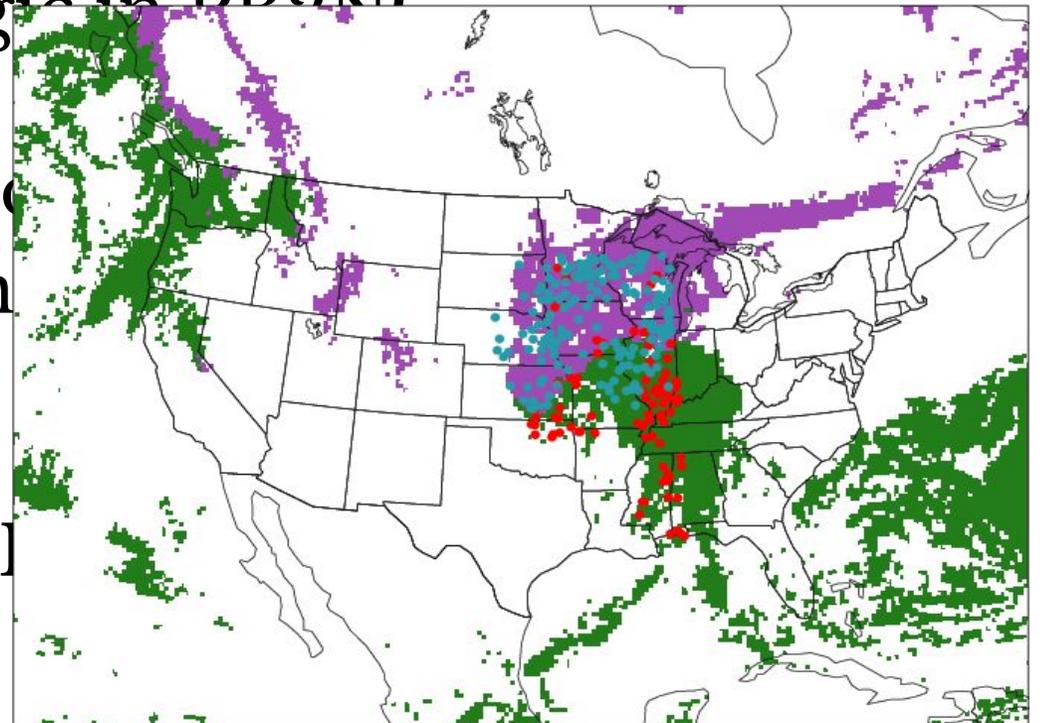
Images
courtesy
of Dan
Halperin

MET Enhancements: Ensembles

- Enhance EnsembleStat and GenEnsProd to read all ensemble members from a single input file
- Enhance Gen-Ens-Prod to standardize ensemble members relative to climatology
- Enhance Ensemble-Stat to compute probabilistic statistics for user-defined or climatology-based thresholds
- Enhance Ensemble-Stat to apply the HiRA method to ensembles
- Add logic to Ensemble-Stat to handle an ensemble control member
- Add support for the Hersbach CRPS algorithm by adding new columns to the ECNT line type and derive the Hersbach CRPSCI, FMP and CRPSS, FMP statistics from

MET Enhancements: Pre-processing Tools

- Enhance PB2NC to derive Mixed-Layer CAPE (MLCAPE)
- Enhance TC-Gen to verify genesis probabilities from ATCF e-deck files
- Enhance the PBL derivation logic in PB2NC
- Change -type for Gen-Vx-Mask optional argument to a required
- Improve the Point2Grid runtime performance
- Process point observations by variable name instead of GRID
- Overhaul Plot-Point-Obs to be highly configurable



MET Enhancements: Python Embedding

- netCDF4 Python package is now required in place of the pickle package!
- Replace the pickle format for temporary python files with NetCDF
- Complete support for Python Xarray embedding
- Treat gridded fields of entirely missing data as missing files
- Clarify error messages for Xarray python embedding
- Add support for Gaussian grids with python embedding
- Enhance to support the “grid” being defined as a named grid or specification string
- Enhance to parse python long variables as integers to simplify scripting
- Fix the read_ascii_mpr.py python embedding script to pass all 37 columns of MPR data to Stat-Analysis

MET Enhancements: New Statistics

- Modify the climatological Brier Score computation to match the NOAA/EMC VSDB method
- Modify the climatological CRPS computation to match the NOAA/EMC VSDB method
- Add support for the Hersbach CRPS algorithm by add new columns to the ECNT line type
- Enhance MET to derive the Hersbach CRPSCL_EMP and CRPSS_EMP statistics from a single deterministic reference model

MET Enhancements: New Output

- Enhance MET to compute the CBS Index and write to new SSIDX STAT line type
- Enhance Stat-Analysis to write the GO Index to new SSIDX STAT line type
- Add Scatter Index to the CNT line type
- Add ORANK line type to the ULiPA output from Point Stat
- Add G and G-Beta to the output from Grid-Stat
- Add the genesis matched (GENMPR) output line

Table 15.2 Variables, levels, and weights used to compute the CBS Index for 24, 48, 72, 96 and 120 hour lead times.

Variable	Level	Weights by Region		
		North Hem	Tropics	South Hem
Pressure	Mean sea level	6.4	x	3.2
Height	500 hPa	2.4	x	1.2
Wind speed	250 hPa	2.4	1.2	1.2
	850 hPa	x	2.0	x

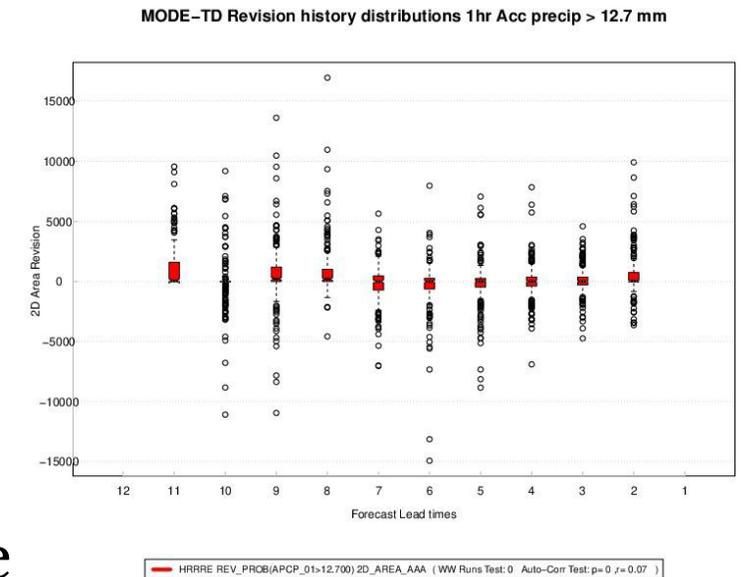
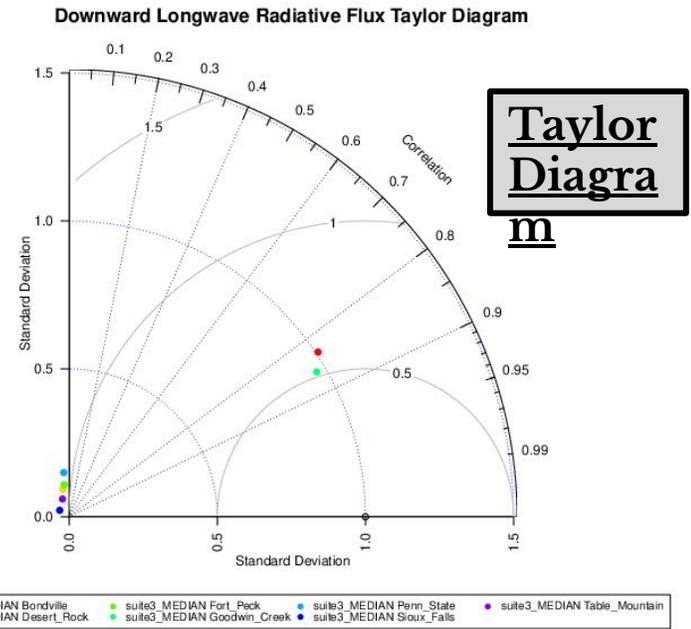
MET Enhancements: Misc

- Support percentile thresholds for frequency bias not equal to 1 (e.g. ==FBIAS0.9)
- Enhance the matching logic and update several config options to support its S2S application
- Enhance support for rotated lat-lon grids and update related documentation

- Update GRIB1/2 table entries for the MXUPHL, MAXREF, MAXUVV, and MAXDVV variables
- Update the Air Force GRIB tables to reflect current AF usage

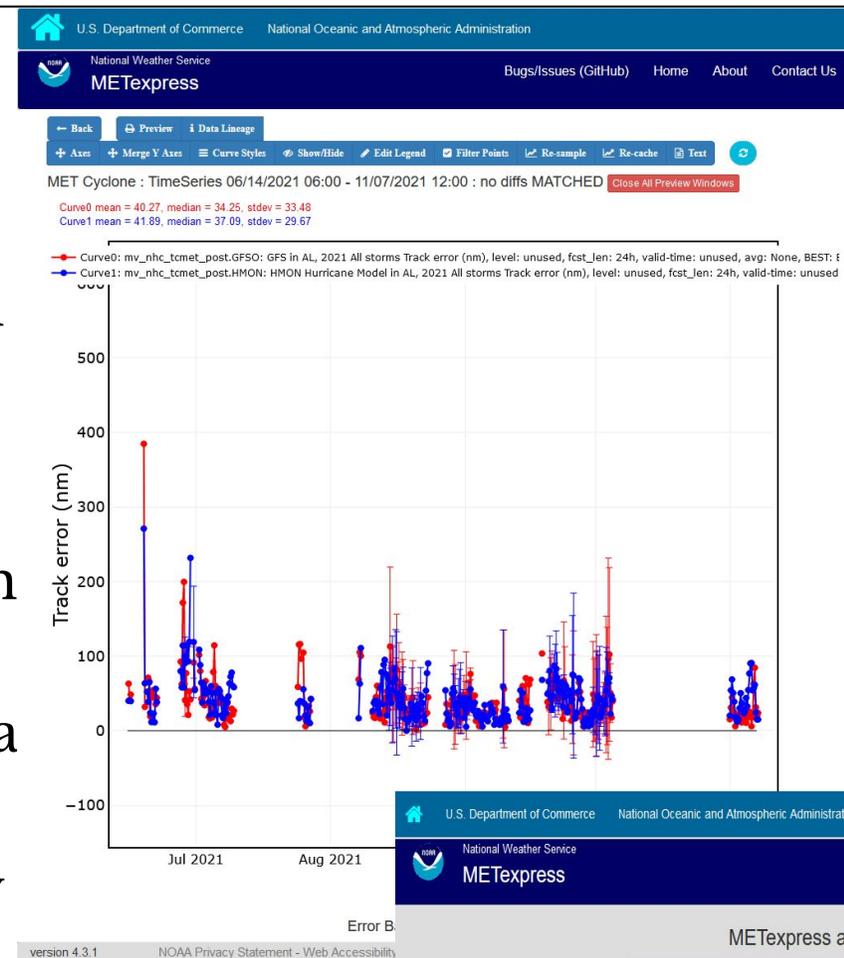
METviewer

- Transition of existing templates from R-statistics to Python for computation (METcalcpy) and plotting (METplotpy) completed – Python is now the default plotting method with R-statistics still available for testing purposes
- Python implementation of:
 - Taylor diagram, Contour plot
 - ECLV plot, Ensemble Spread-Skill plot (ens_ss),
 - Bar plot, Box plot, and Histograms - Probability, Relative, Rank,
 - Revision series for MODE-TD
- Add custom lines (horizontal and/or vertical) to plots
- New SSIDX STAT line type and statistic SS_INDEX\
 Bo
X
Pl
t
- Aggregate and plot the HSS_EC statistic from the MCTS line type



METexpress

- Apps
 - MET Cyclone – display verification for extratropical cyclones
 - MET MODE – new app
 - MET Ensemble – generate perform diagrams
- Statistics – added fractional error as a scalar stat
- Plotting – various selection & display enhancements
- Amazon Web Services (AWS) – NOAA EMC instance replaced
- Engineering
 - Updated Meteor UI toolkit to latest v2.6.1



This screenshot shows the "METexpress apps:" menu. It features a list of application buttons: MET Upper Air, MET Anomaly Correlation, MET Surface, MET Air Quality, MET Ensemble, MET Precipitation, and MET Cyclone. The interface includes the NOAA logo and the text "U.S. Department of Commerce National Oceanic and Atmospheric Administration". At the bottom, there are links for "NOAA Privacy Statement", "Web Accessibility Statement", "Disclaimer for External Links", "NOAA", and "U.S. Department of Commerce".

METplus: S2S Enhancements

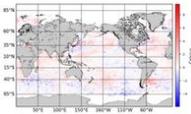
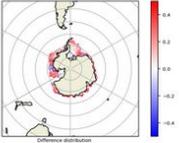
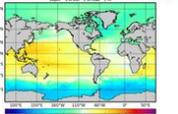
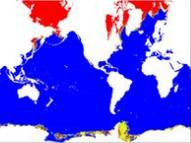
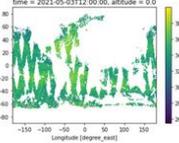
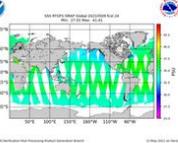
- Add harmonic pre-processing to the RMM use case
- Add Grid-Stat configuration options for distance_map dictionary
- Add stat_analysis to the Blocking and Weather Regime processing
- Enhance TC-Pairs wrapper to make valid_inc, valid_exc, and write_valid configurable options
- Add support for using filename templates for defining input level in PCPCombine
- Modify wrappers that use wrapped MET config files to default to parm/met_config versions if unset
- Modify user diagnostic feature relative use case to use MetPy Python package
- Updated logic for handling _CLIMO_MEAN_FIELD variables for specifying climatology fields

METplus: New Use Case (24)

- **MET_tool_wrapper:** IODA2NC, GenEnsProd, GFDLTracker_TC, Extract_Tiles using MTD tracks, Python Embedding of Point-Obs into Point-Stat
- **Precipitation:** Precipitation-type comparison
- **TC:** TC Verification Compare ADECK vs GFDL tracker for TC, TC Genesis, and Extra-TC tracking
- **Medium Range Weather:** Feature Relative to MTD output for feature centroid latitude
- **Marine and Cryosphere:** RTOFS vs GHR, RTOFS vs SMOS SSS 1 day composite and RTOFS vs. OSTIA Ice Cover
- **Seasonal to Subseasonal:** RMM 1& 2, OMI PhaseDiagram, Weather Regime Calculation, OMI plot for MJO indices, RMM plot from Compute Zonal and Meridional Means

5.2.5. Marine and Cryosphere

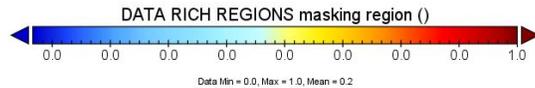
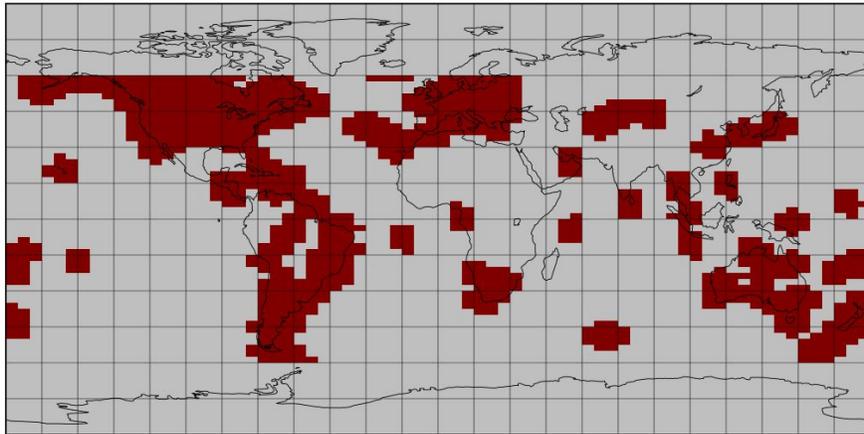
Data related to verification involving marine and cryosphere systems, which includes sea-ice

 <p>GridStat: Python Embedding to read and process SST</p>	 <p>GridStat: Python Embedding to read and process ice cover</p>	 <p>Grid-Stat and MODE: Sea Ice Validation</p>	 <p>GridStat: Python Embedding to read and process sea surface heights</p>
 <p>PlotDataPlane: Python Embedding of tripolar coordinate file</p>	 <p>GridStat: Python Embedding for sea surface salinity using level 3, 1 day</p>	 <p>GridStat: Python Embedding for sea surface salinity using level 3, 8 day mean</p>	

Example of Defining Verification Regions using Quality Control Flag for Space Weather

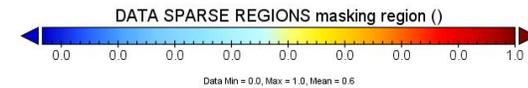
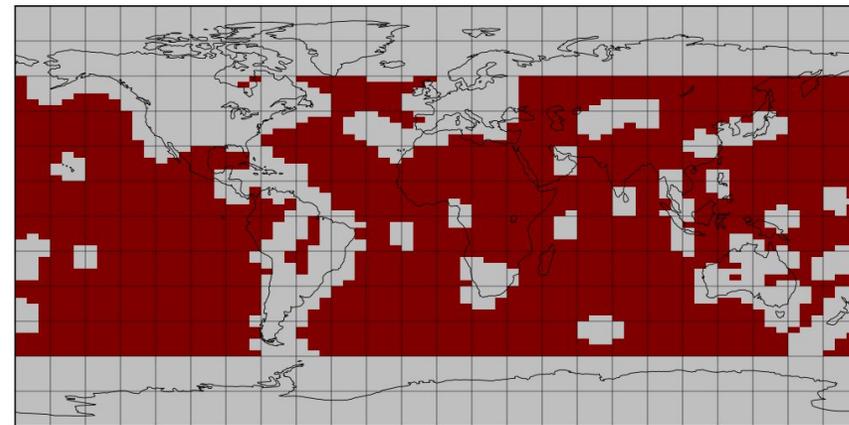
2. Data Rich vs. Data Sparse Regions

DATA RICH REGIONS masking region



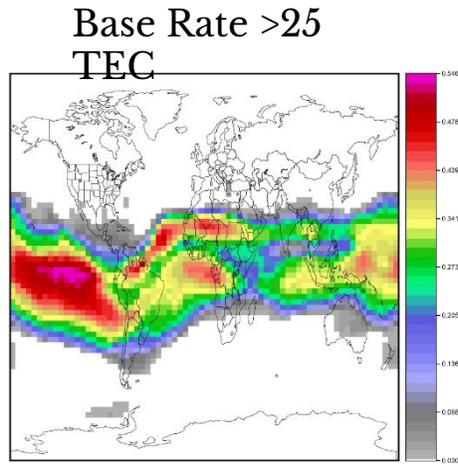
Near Observing Stations

DATA SPARSE REGIONS masking region

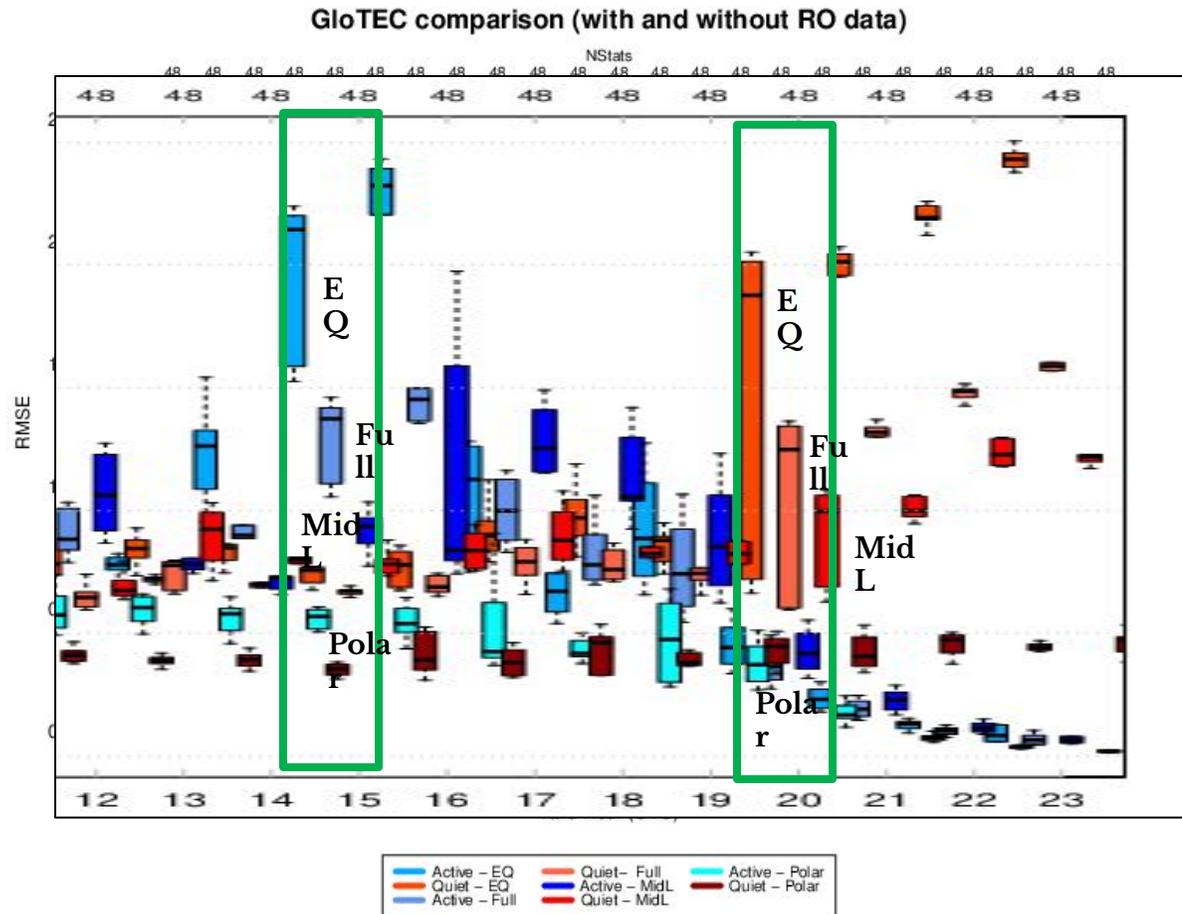


Not Near Observing Stations

Example: Masking by Latitude Bands and Activity



series_analysis_WAM_GloTEC_stats.nc



Challenges

- Small Pots of Money:

- Make it difficult to have a cohesive development strategy
- Increase project management overhead
- Makes it difficult to improve efficiency, user experience, and major code maintenance

- Community contributions:

- Many times come in hardwired and inflexible and sometimes without sufficient test data and documentation
- Can be in code-bases other than C++ and Python
- Use Python libraries that are **not**



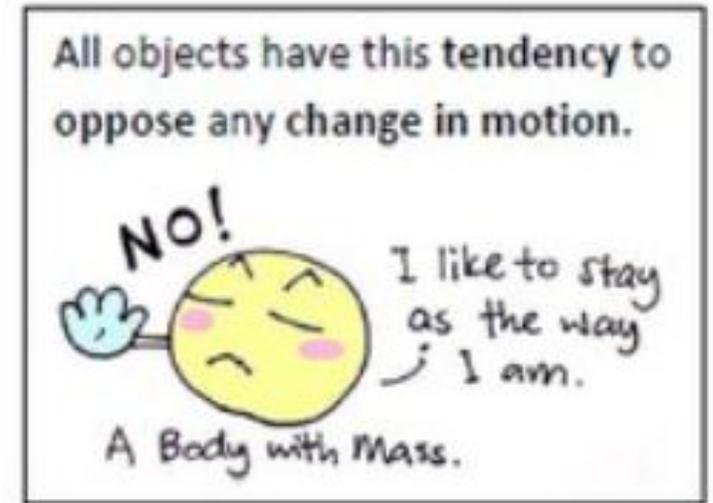
Challenges

- **Institutional and Personal Inertia:**

- Developers like using tools they are used to
- Claim there is a steep learning curve
- Wish it was all in python
- Centers need to do baselining to make sure configuration matches or they can

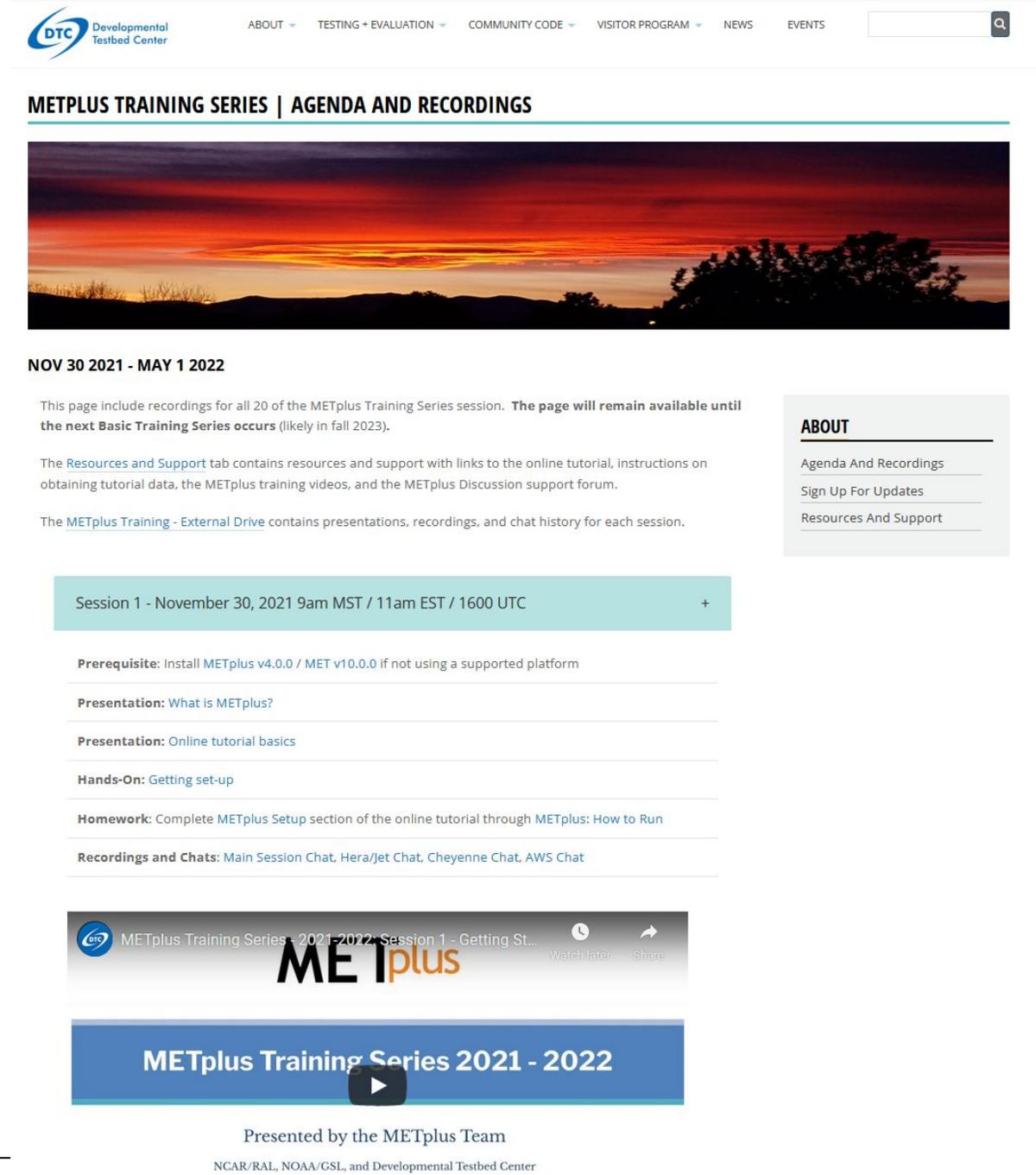
- **Some things to consider:**

- METplus users that do take the plunge find it easy once they get started
- DTC has done a lot of work to decrease the learning curve, including a recently hosted 20 hour session on the framework, but recognize more is to be done
- Many Python libraries are **not accepted** by NCO, which makes packages like MDTF and MONET less likely to make it into operations
- EMC VPPG, AF, NRL, Met Office, India's NCMRWF and others have been



Training Resources

- [METplus Training Series recordings and presentations](#)
- [METplus Online Tutorial](#)
- [Users Guides for METplus and Components](#)
- [GitHub Discussions Forum](#)



The screenshot shows the website for the METplus Training Series. At the top, there is a navigation bar with the DTC logo and links for ABOUT, TESTING + EVALUATION, COMMUNITY CODE, VISITOR PROGRAM, NEWS, and EVENTS. Below the navigation bar is a search bar. The main heading is "METPLUS TRAINING SERIES | AGENDA AND RECORDINGS". A large image of a sunset is displayed. Below the image, the date "NOV 30 2021 - MAY 1 2022" is shown. The text states: "This page include recordings for all 20 of the METplus Training Series session. The page will remain available until the next Basic Training Series occurs (likely in fall 2023)." It also mentions that the "Resources and Support" tab contains resources and support with links to the online tutorial, instructions on obtaining tutorial data, the METplus training videos, and the METplus Discussion support forum. The "METplus Training - External Drive" contains presentations, recordings, and chat history for each session. On the right side, there is an "ABOUT" section with links for "Agenda And Recordings", "Sign Up For Updates", and "Resources And Support". Below this, a session card for "Session 1 - November 30, 2021 9am MST / 11am EST / 1600 UTC" is shown with a plus sign. The session details include: "Prerequisite: Install METplus v4.0.0 / MET v10.0.0 if not using a supported platform", "Presentation: What is METplus?", "Presentation: Online tutorial basics", "Hands-On: Getting set-up", "Homework: Complete METplus Setup section of the online tutorial through METplus: How to Run", and "Recordings and Chats: Main Session Chat, Hera/Jet Chat, Cheyenne Chat, AWS Chat". At the bottom, there is a video player for "METplus Training Series - 2021-2022: Session 1 - Getting St..." with a play button and a blue banner that says "METplus Training Series 2021 - 2022". Below the video player, it says "Presented by the METplus Team" and "NCAR/RAL, NOAA/GSL, and Developmental Testbed Center".

Installations Available to UFS community

METPLUS | METPLUS-4.1 EXISTING BUILDS

Select from the list below for instructions on using existing builds of the MET and METplus software packages.

NCAR machines	+
NOAA machines	+
WCOSS	+
WCOSS2	+
HERA	+
JET	+
ORION	+
Community machines	+
Docker Hub	+
AWS	+

METPLUS | DOWNLOAD

RECOMMENDED - COORDINATED

VERSION	DOWNLOAD	DATE
Coordinated METplus 4.1	METplus 4.1.2 MET 10.1.2 METviewer 4.1.0 METexpress 4.4.3 METplotpy 1.0.0 METcalcpy 1.0.0 METdatadb 1.1.0 Documentation Existing Builds and Docker Release Notes	2022-03-15



RECOMMENDED - COMPONENTS

VERSION	DOWNLOAD	DATE
METexpress 4.4.3	METexpress-4.4.3 User's Guide Release Notes	2022-06-07
MET 10.1.2	met-10.1.2.tar.gz User's Guide Existing Builds and Docker Release Notes	2022-05-16
METplus 4.1.2	User's Guide Existing Builds and Docker Release Notes	2022-05-16
METdatadb 1.1.0	METdatadb 1.1.0 User's Guide Existing Builds and Docker Release Notes	2022-03-11
METcalcpy 1.1.0	METcalcpy 1.1.0 User's Guide Existing Builds and Docker Release Notes	2022-03-11
METplotpy 1.1.0	METplotpy 1.1.0 User's Guide Existing Builds and Docker Release Notes	2022-03-11
METviewer 4.1.0	METviewer 4.1.0 User's Guide Existing Builds and Docker Release Notes	2022-03-11

METPLUS COMPONENTS ▼

METPLUS

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System Architecture

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Documentation

User Support +

LATEST RELEASE

METexpress Version 4.4.3
Released: 2022-06-07

MET Version 10.1.2
Released: 2022-05-16

METplus Version 4.1.2
Released: 2022-05-16

Coordinated METplus Version 4.1

Thank You for Your Attention

- Tara Jensen, NCAR, jensen@ucar.edu
- <https://dtcenter.org/community-code/metplus>

2022 METplus Users' Workshop

(Free and Virtual)

27-29 June, 2022

Register on DTC Website at:

<https://dtcenter.org/events/2022/2022-dtc-metplus-workshop>

