METplus

METplus: Model Diagnostics Science Spotlight

Tara Jensen on behalf of the METplus Team

NCAR/RAL
NOAA/GSL
and
Developmental Testbed Center

Unifying Innovations in Forecast Capabilities Workshop
18-22 July 2022
College Park, MD

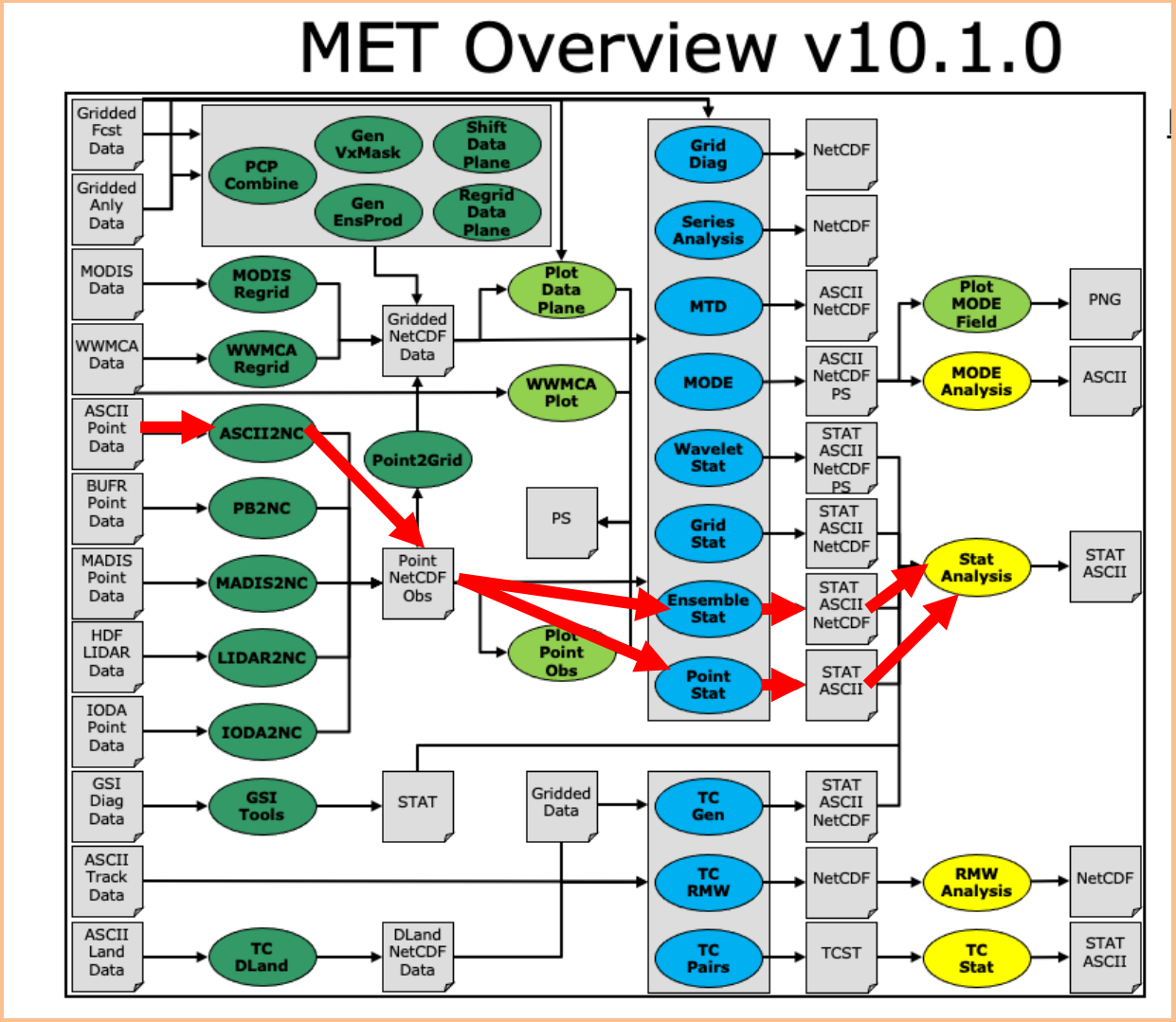
What is Meant by Diagnostics

- Investigation or analysis of the cause or nature of a condition, situation, or problem – **Merriam Webster Dictionary**
- Used for discovering the characteristics or cause of a problem in a system or machine – **Cambridge Dictionary**
- A distinguishing sign or symptom; characteristic – **Collins Dictionary**

- Model diagnostics including process-level testing and evaluation, which is focused on critical processes or phenomena, is indispensable to identify and understand the model error or bias sources and pinpoint areas for model improvements.
  – UIFCW description of this session

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

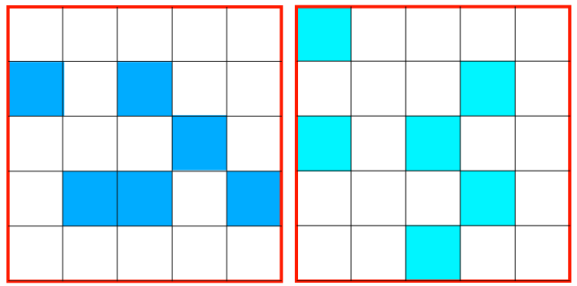
Basically the arrows between tools

Also includes:

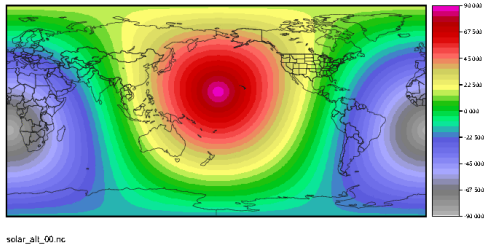
- Configuration files driving data between tools
- Use of environment variables for integration with workflows

Tools That Support Diagnostics

Neighborhood Methods

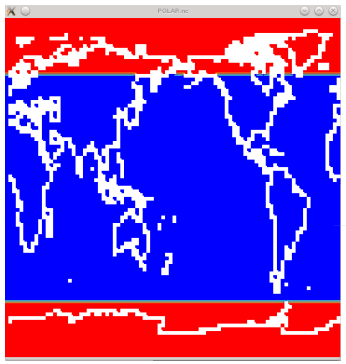


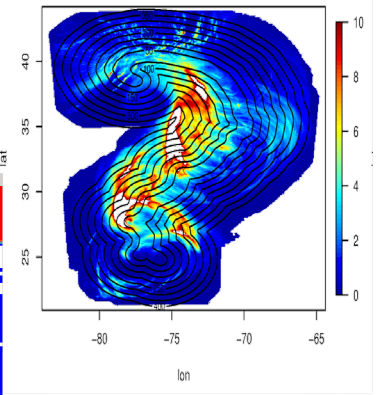
Fraction = 6/25 = 0.24 Fraction = 6/25 = 0.24



solar_alt_00.nc

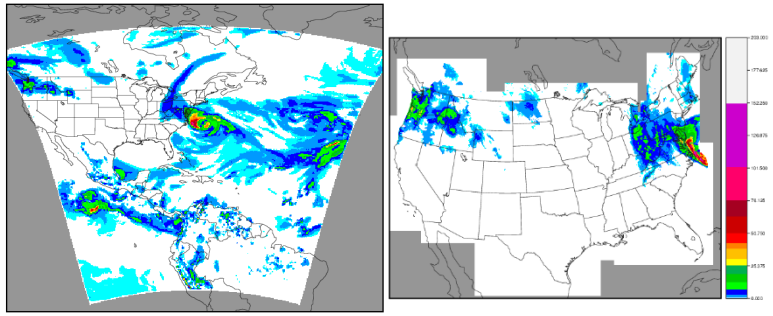
Masking



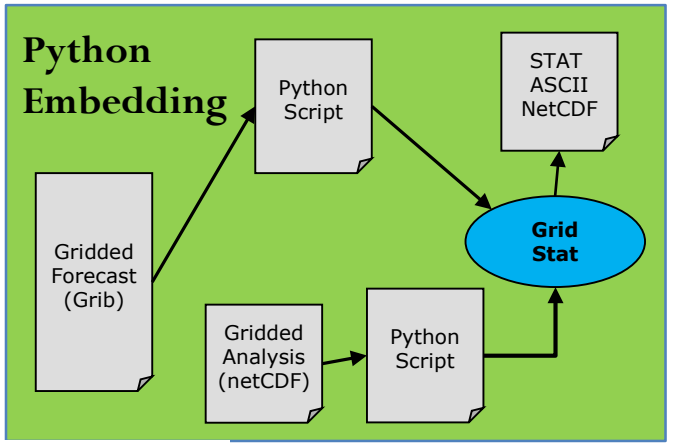


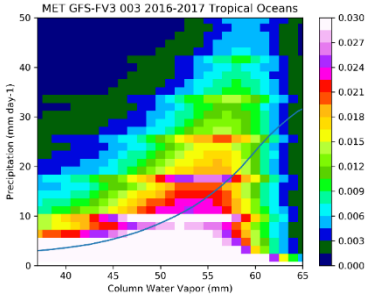
Traditional	
Grid-Stat, Point-Stat, Series-Analysis *Contingency table statistics (CTS)* *Continuous statistics* *Probability forecast statistics* *Confidence intervals*	**Ensemble-Stat** *CRPS, CRPSS* *Rank prob., Prob. Integral Transform (PIT), and Relative Position histograms* *Spread/Skill* *Ignorance* *Confidence intervals*
Spatial	
MODE *Location differences* *Geometric attribute differences* *Intersection area* *Intensity distributions & differences* *CTS measures*	**MODE-TD** *Time and location differences* *Volume differences* *Velocity differences* *Intersection volume* *Intensity distributions & differences*
Wavelet-Stat *MSE by scale* *Energy by scale* *Intensity-scale skill score*	**Grid-Stat and Point-Stat** *FSS, HiRA* *Distance Measures: MED, Baddeley, Hausdorff, Zhu, etc.*
Tropical Cyclones and Diagnostics	
MET-TC *Track error (along, cross, total)* *Intensity errors (pressure, wind)* *Rapid intensification/weakening errors* *CTS measures of TC genesis* **TC-GEN** *CTS measures of TC genesis*	**Grid-Diag** *Distributions of fields for use in contour plots* **TC-RMW** *Radius of maximum wind errors and metrics*

Auto Regridding

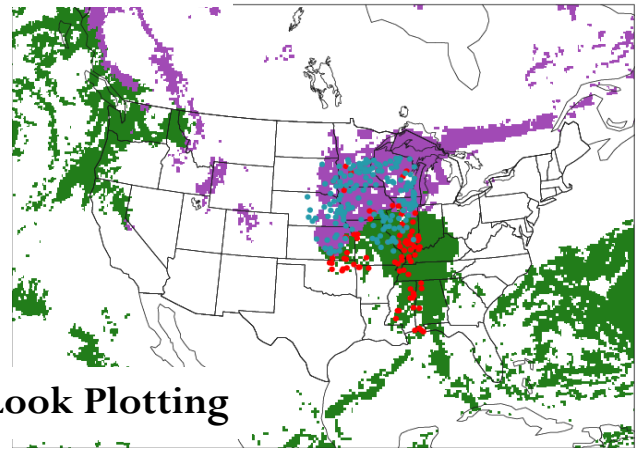


Python Embedding





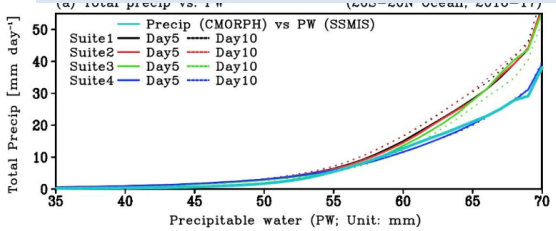
Multivariate PDFs For Climo and Percentiles

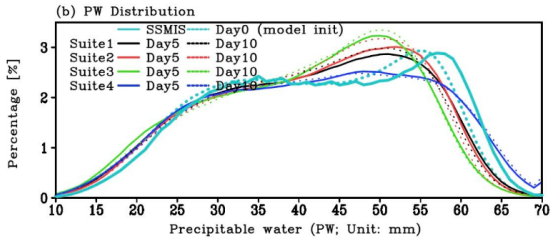


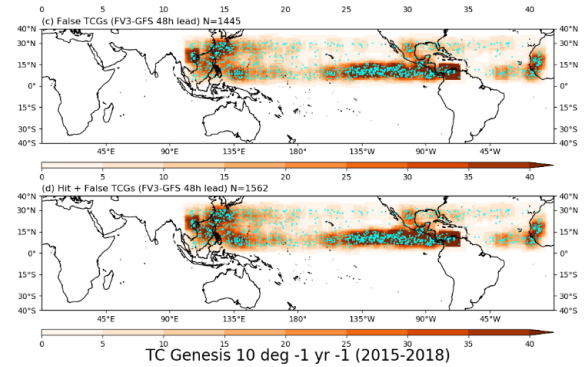
Quick-Look Plotting

Example of Diagnostics

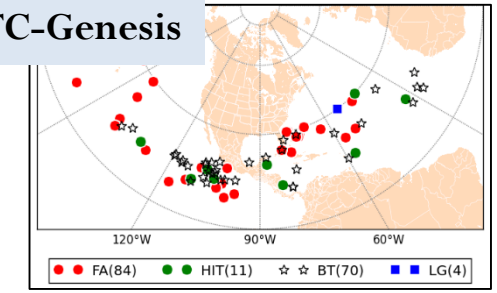
S2S Multivariate distributions

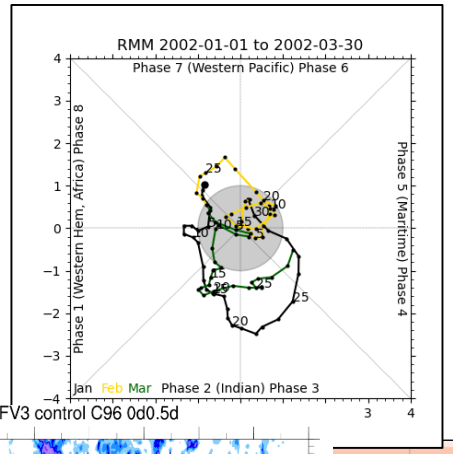


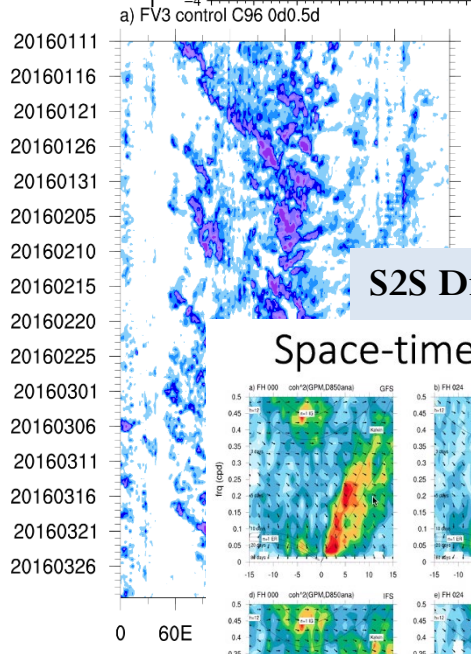


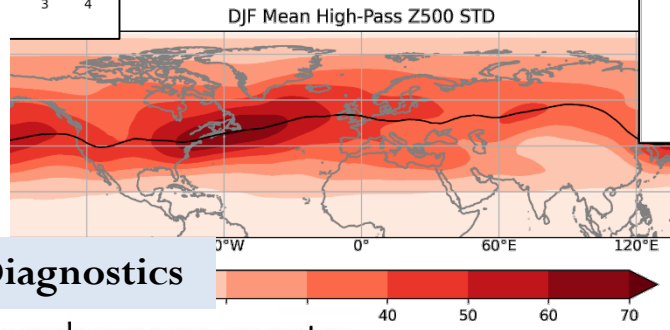


S2S TC-Genesis



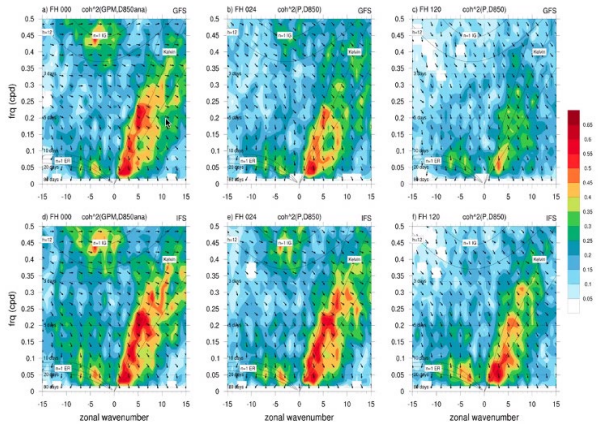




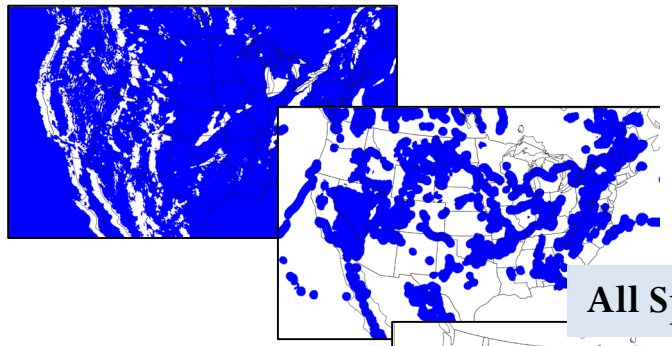


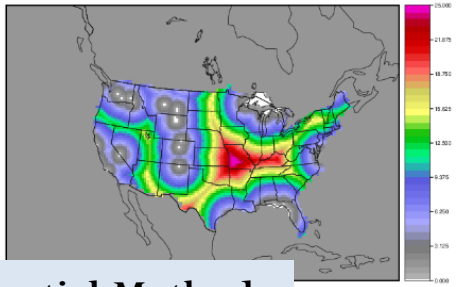
S2S Diagnostics

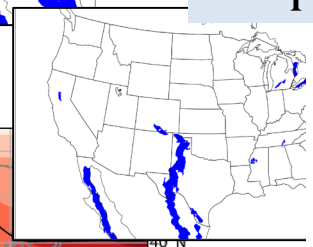
Space-time coherence spectra

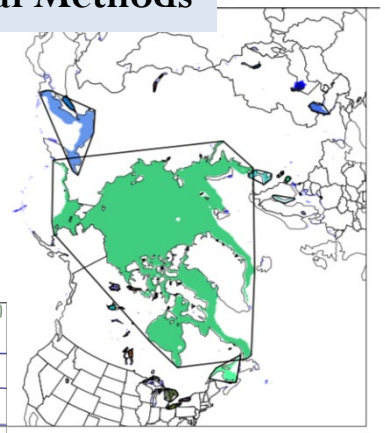


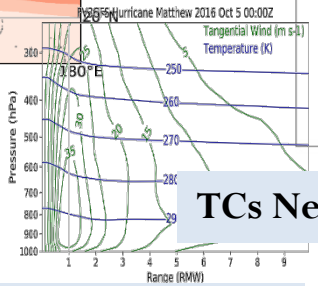
All Spatial Methods





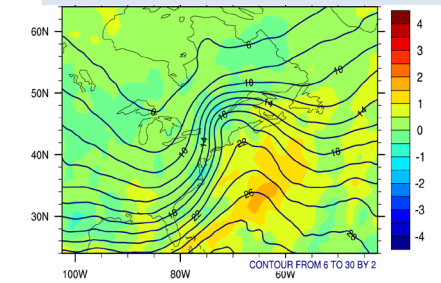


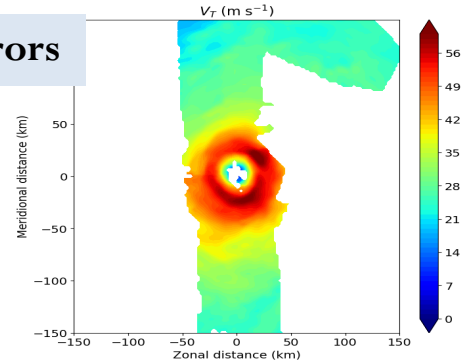




TCs New Projections and Obs

SRW/MRW Systematic Errors

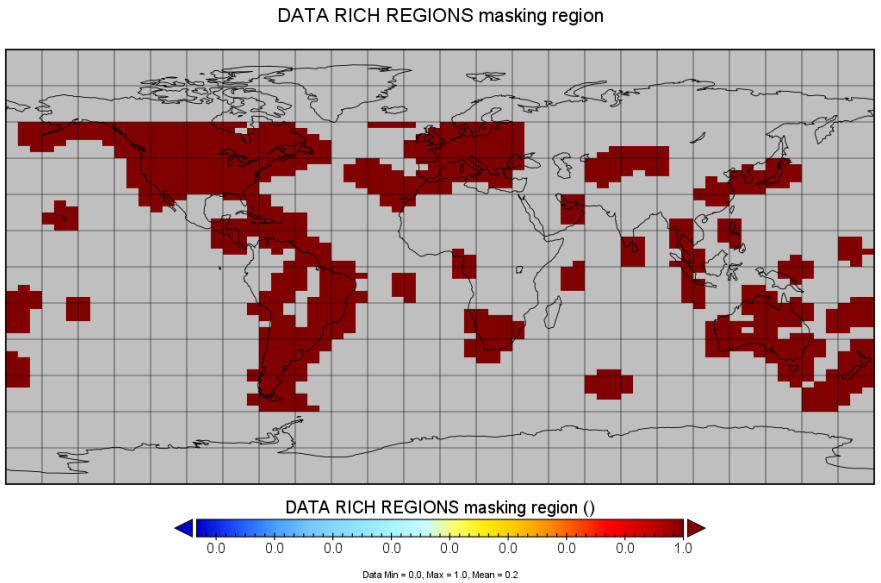




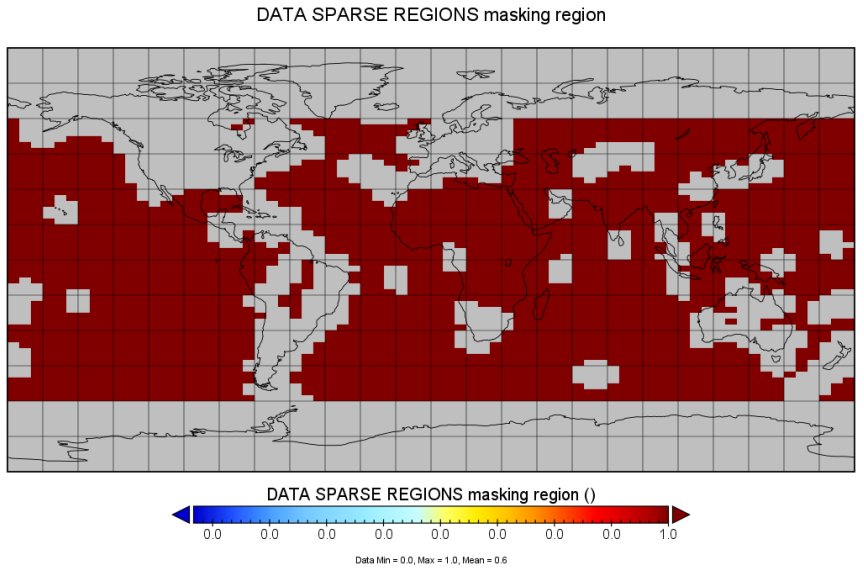
Examples from the Community

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

2. **Data Rich vs. Data Sparse Regions**



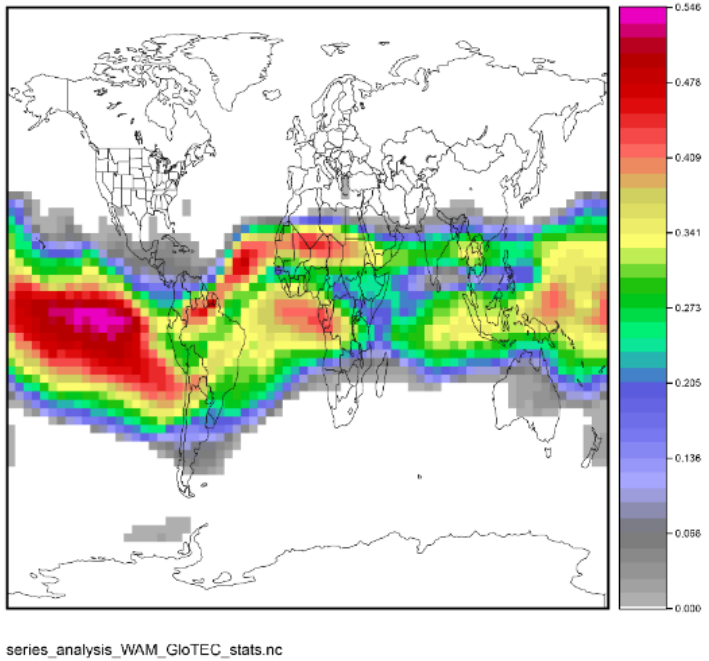
Near Observing Stations



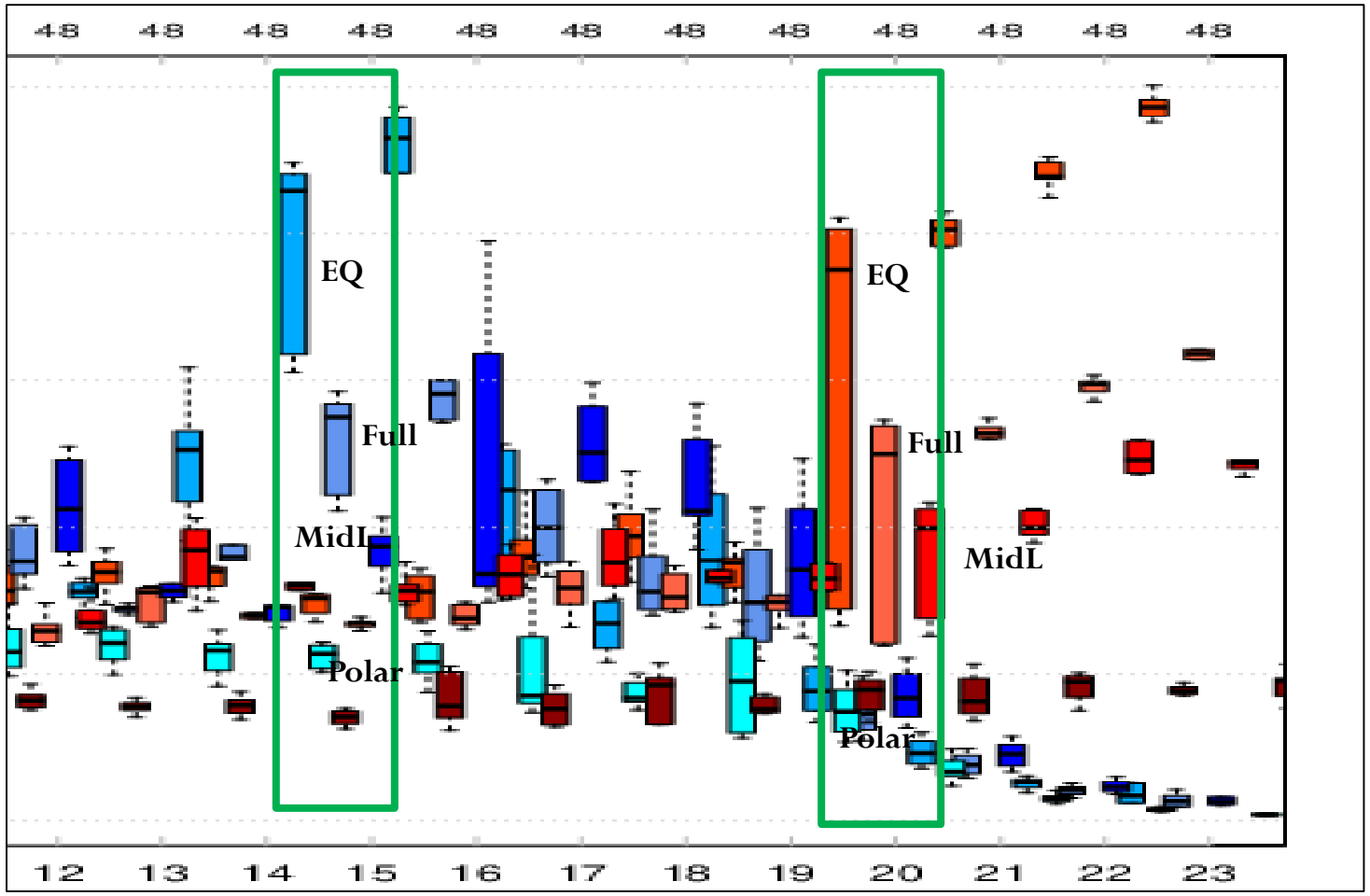
Not Near Observing Stations

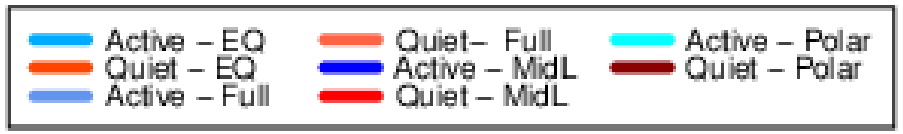
Example: Masking by Latitude Bands and Activity

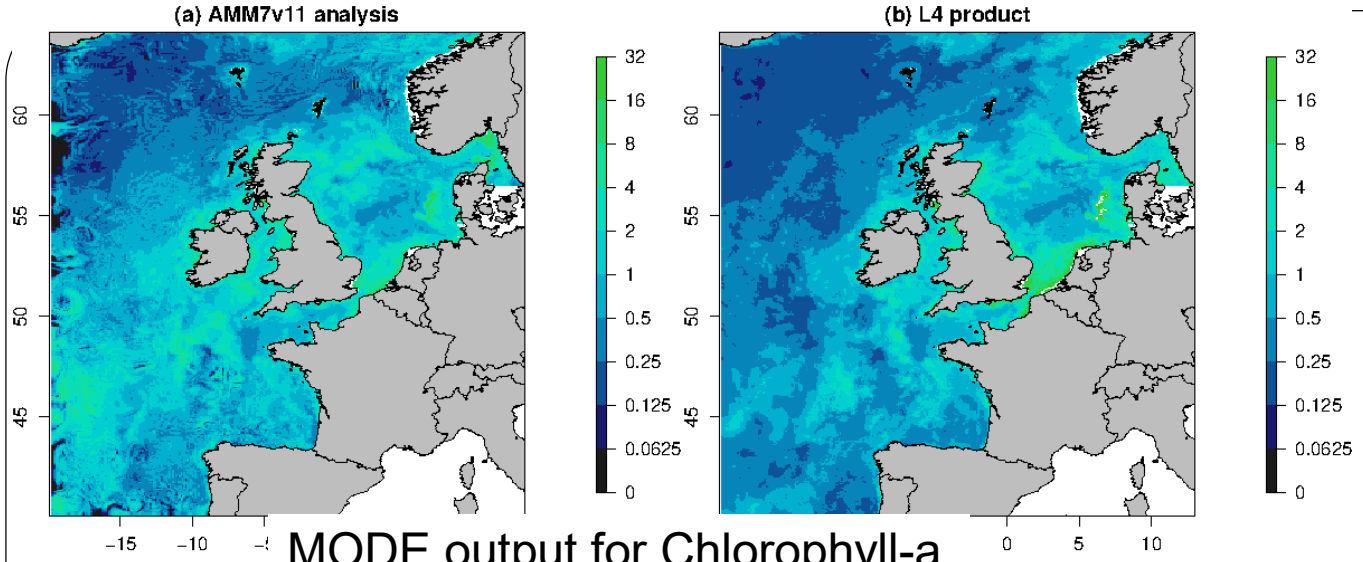
Base Rate >25 TEC



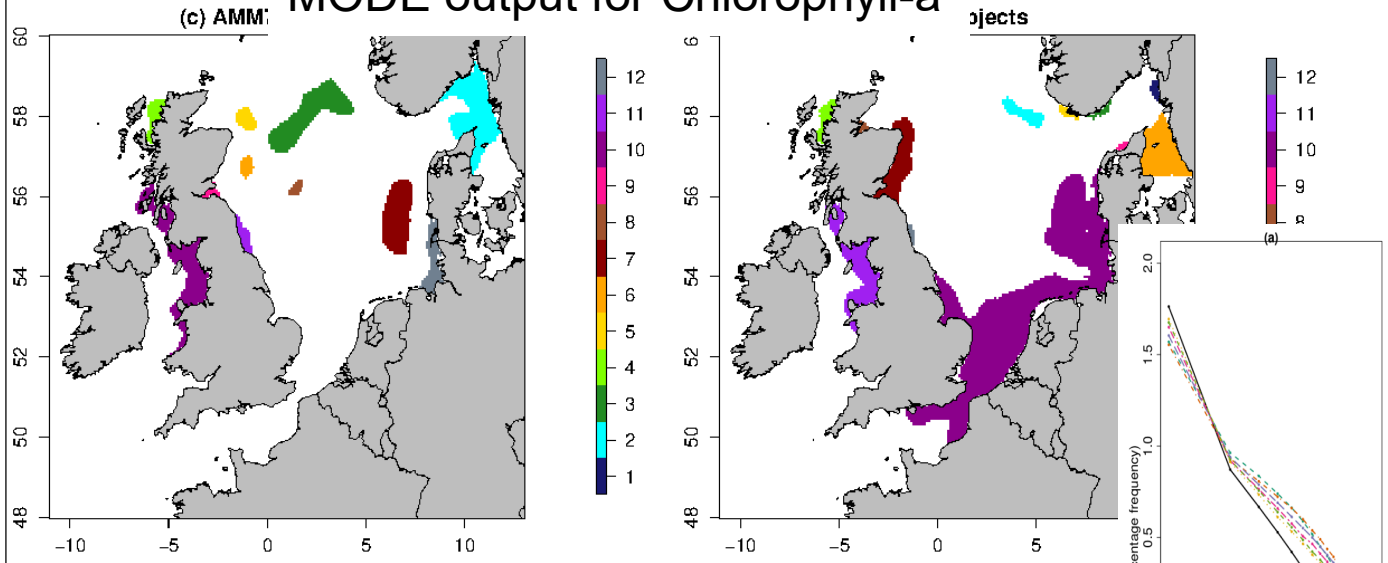
series_analysis_WAM_GloTEC_stats.nc



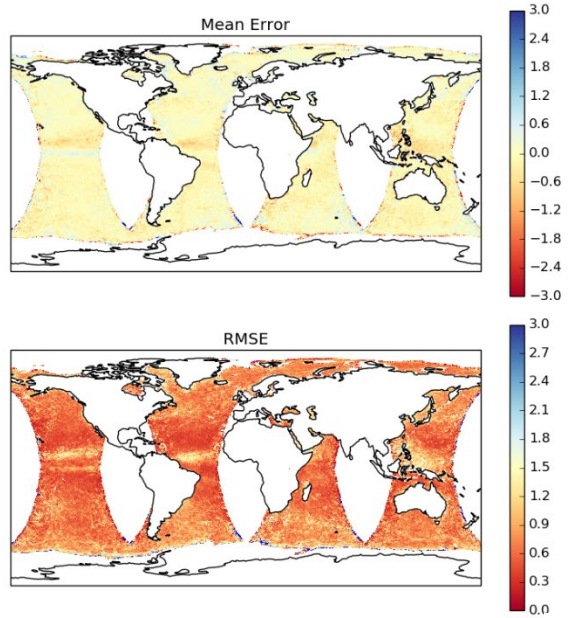




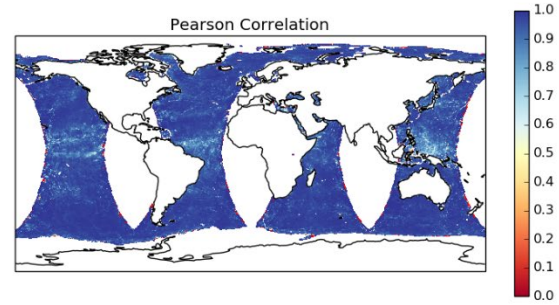
MODE output for Chlorophyll-a



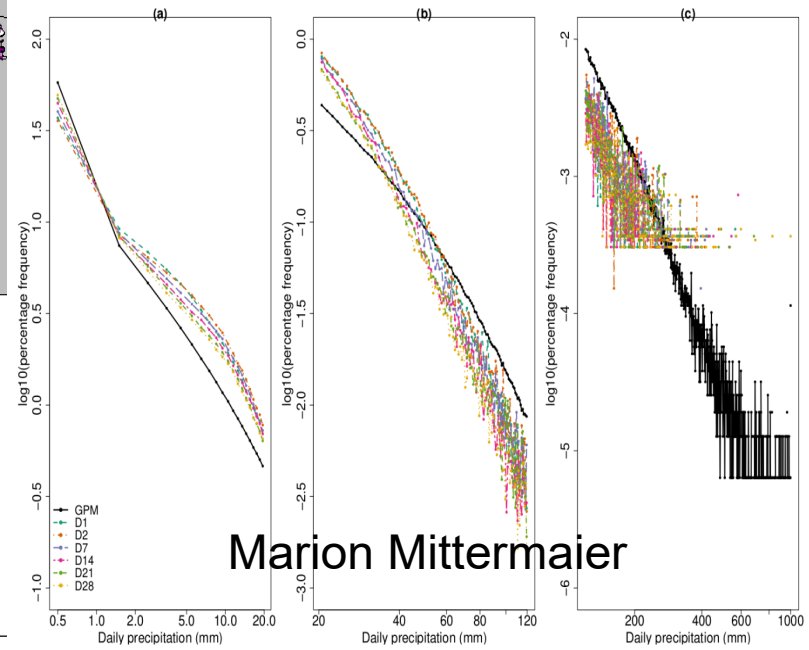
Mittermaier et al. 2021, Ocean Science



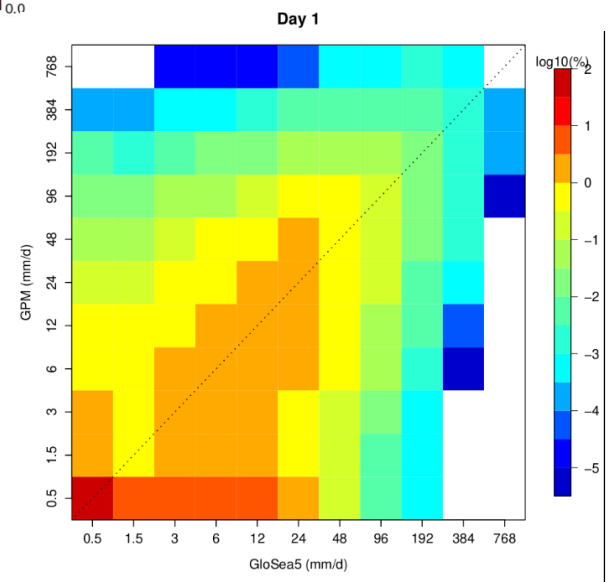
Ric Crocker



Series-Analysis output of scatterometer winds



Marion Mittermaier

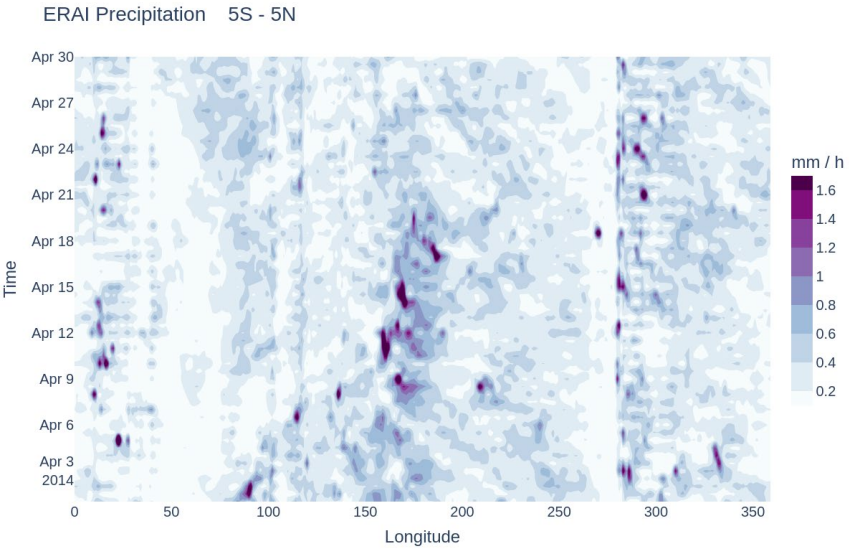


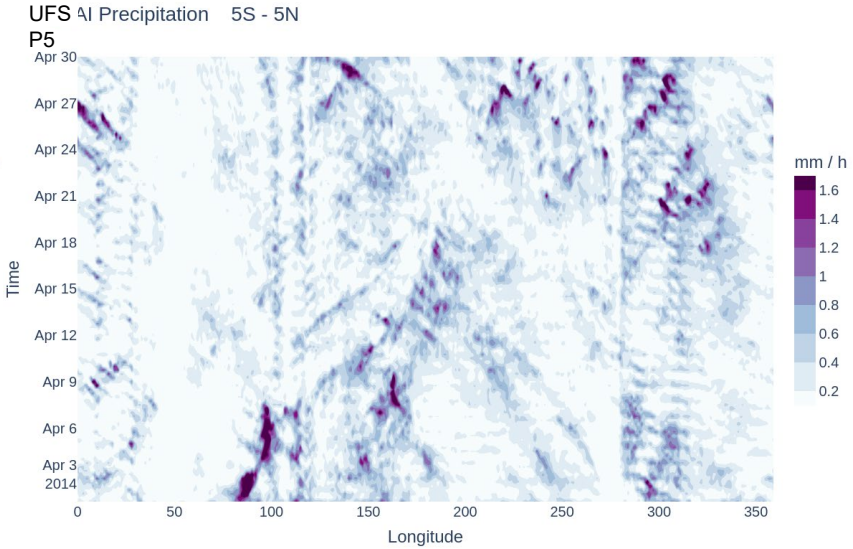
Joint and marginal distributions

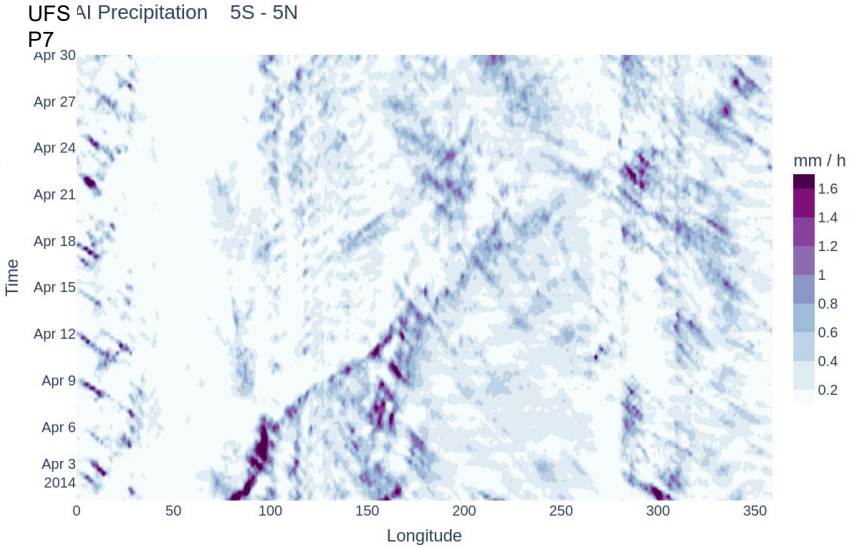
Grid-Diag

Slide Courtesy of Marion Mittermaier, Met Office

Hovmoeller







Ran metplus 3 times with different input and yaml files.

Each run outputs one figure for the given input file.

At the moment the aspect ratio settings and title are not read by the python script.

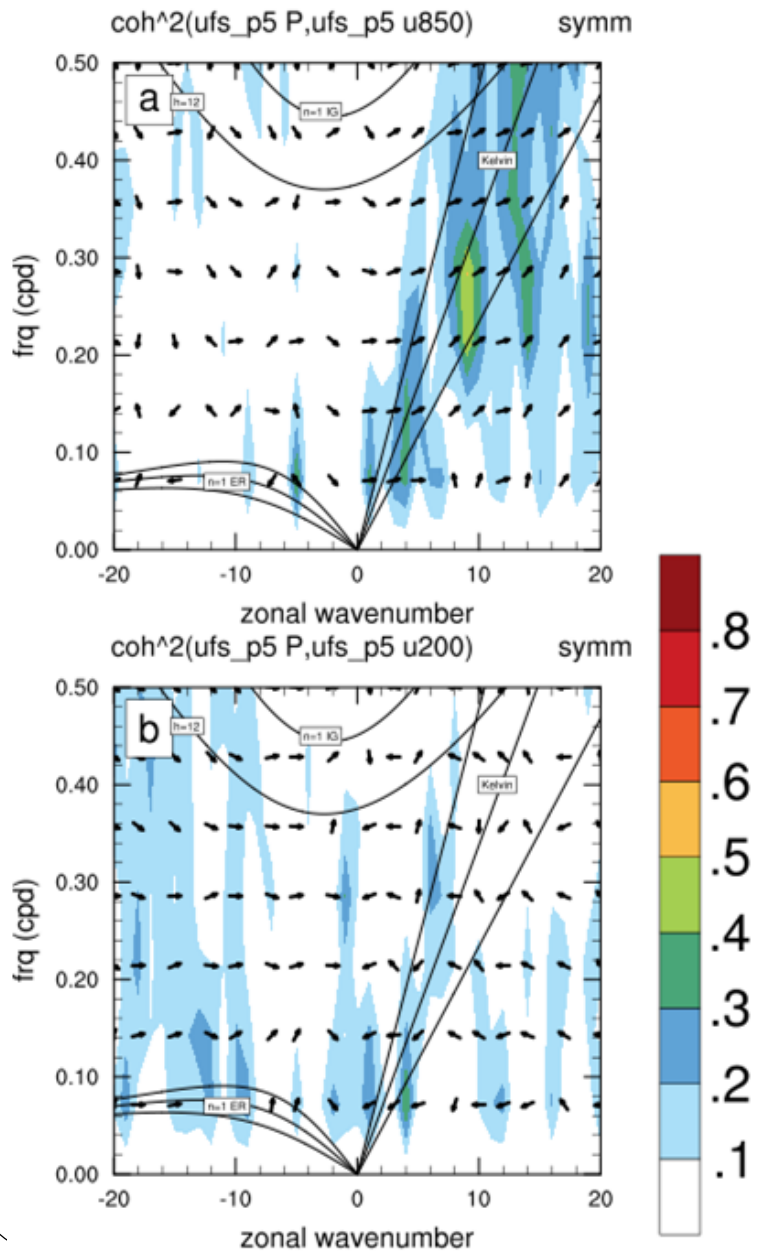
Differences between verification, P5 and P7 are apparent.

Good agreement at the beginning of the forecast (April 1) with rapid decorrelation of forecast and verification.

P7 appears to have more light precipitation than P5 and less well-defined diurnal cycle over South America.

Slide Courtesy of Maria Gehne, NOAA/PSL

Space-time Coherence Spectra

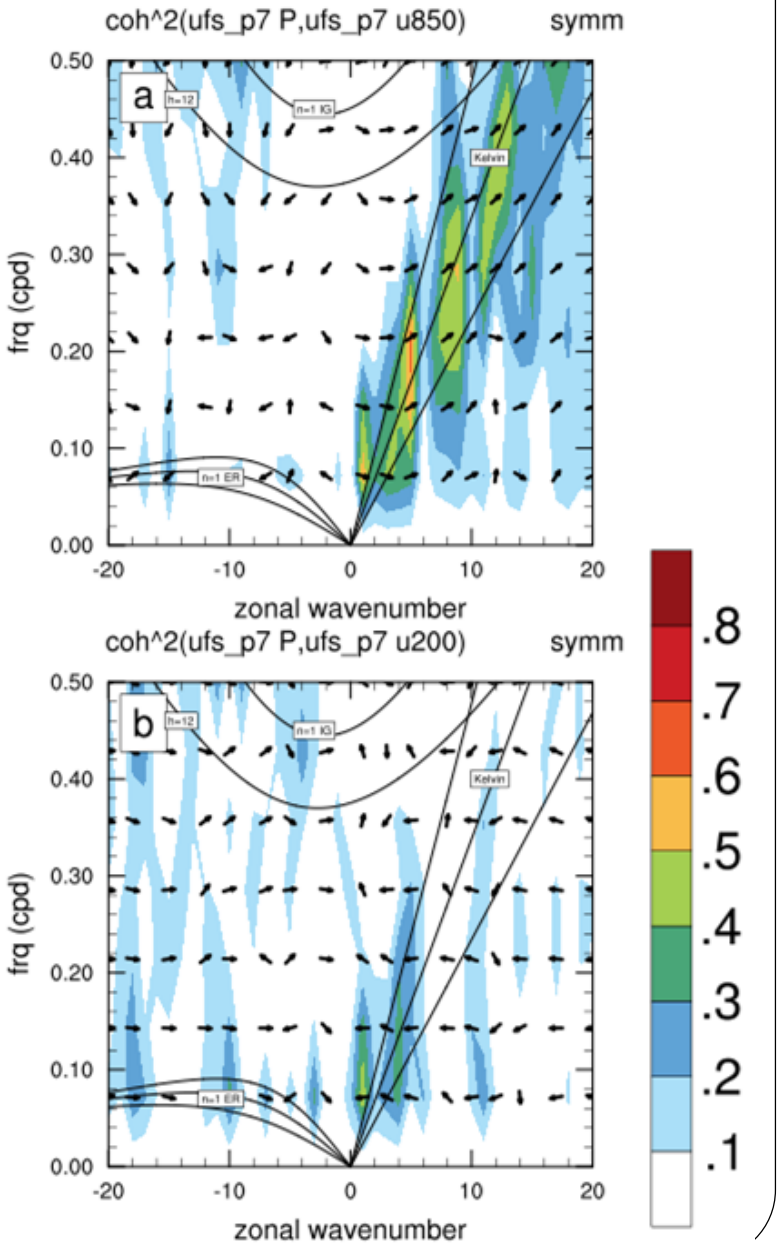


Coherence-squared spectra show regions in wavenumber-frequency space where precipitation and zonal winds are coupled.

Shows that UFS P7 has stronger convection-dynamics coupling than UFS P5. And P7 is more consistent with observations.

Need to add more flexibility to these plotting tools.

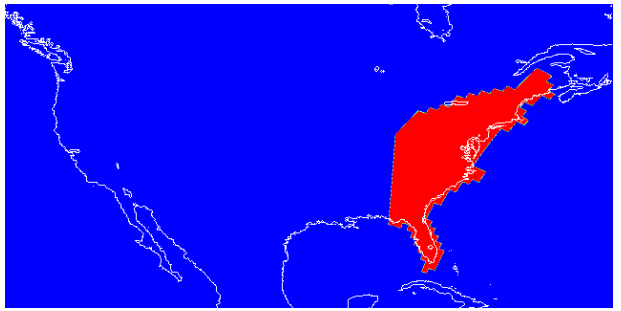
Slide Courtesy of Maria Gehne, NOAA/PSL



Snowband Events

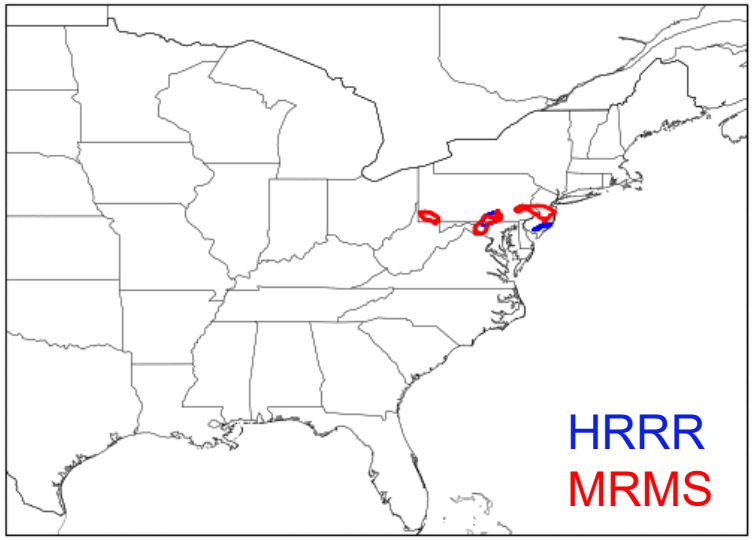
Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

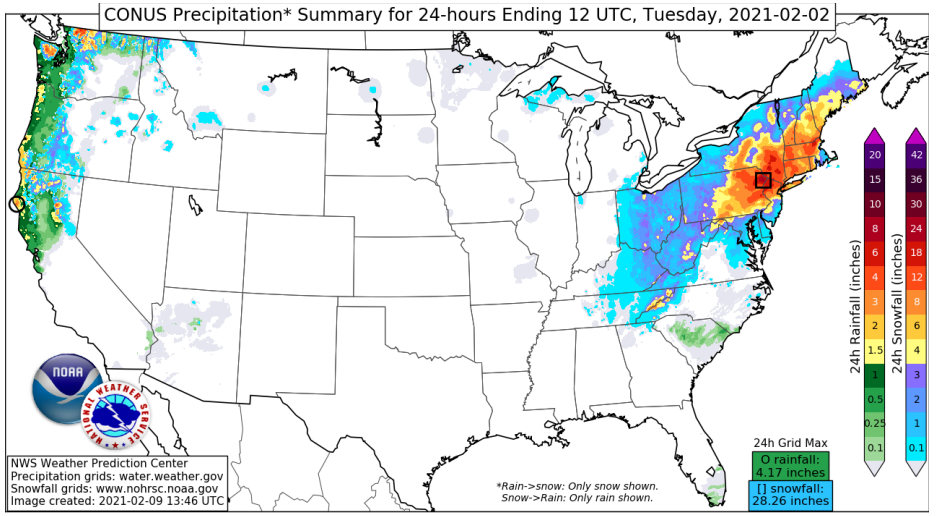
- Snowband cases of interest
  - 2020121600, 2020122400, 2021013100, 2021020100, 2022010300, 2022010600, 2022011600
- HRRR forecast vs MRMS/HRRR Analysis
- Modified CONUS East (quarter) mask applied



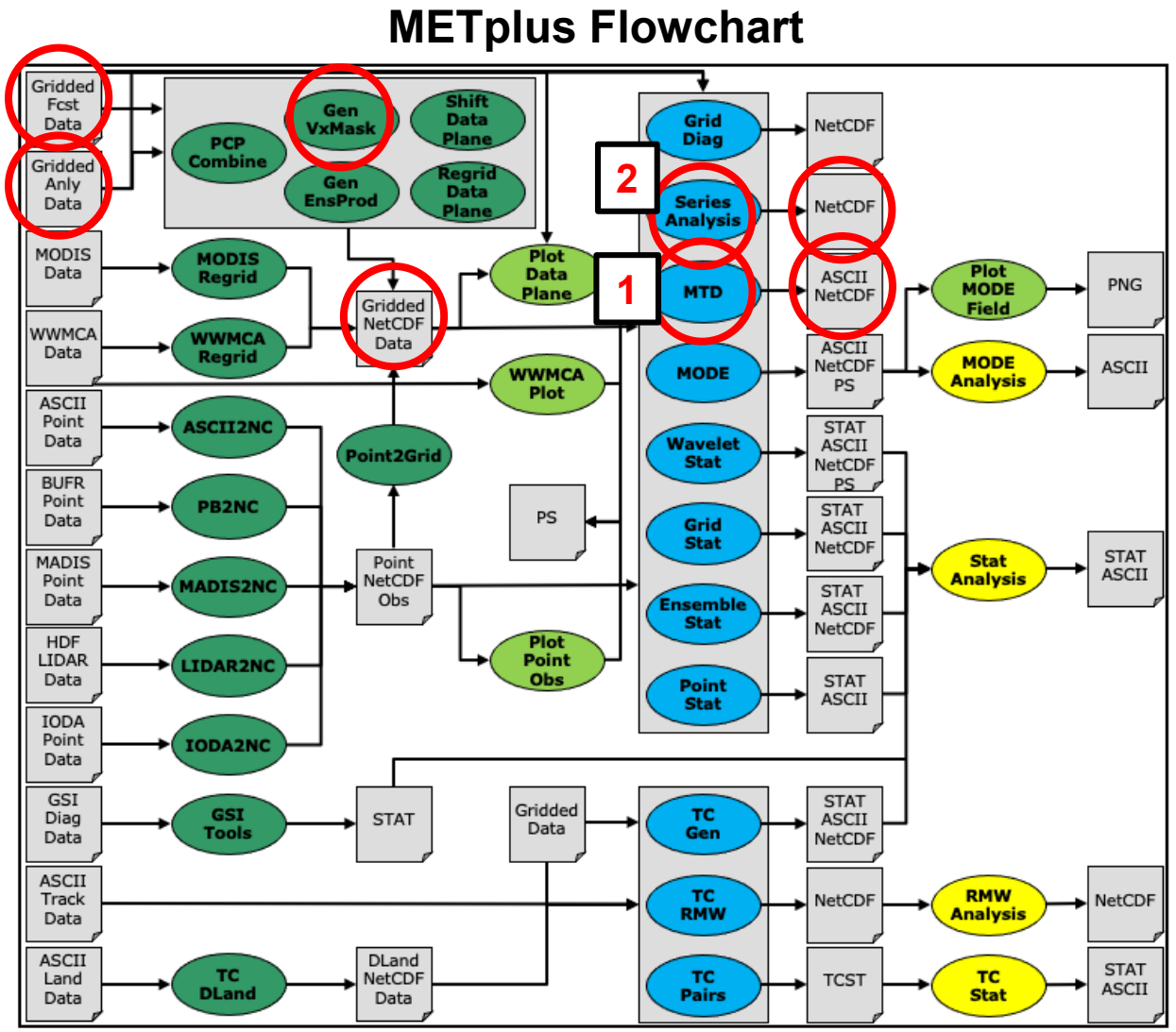
Mask

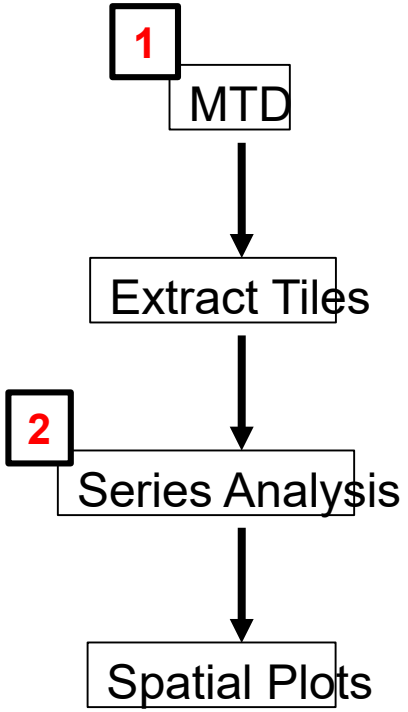
HRRR vs MRMS 2021020100 F01





Feature Relative Use Case





MTD Configs
- Conv thresh ≥ 1.27 mm
- Conv rad: 5 grid points
- Min vol: 1000 grid points

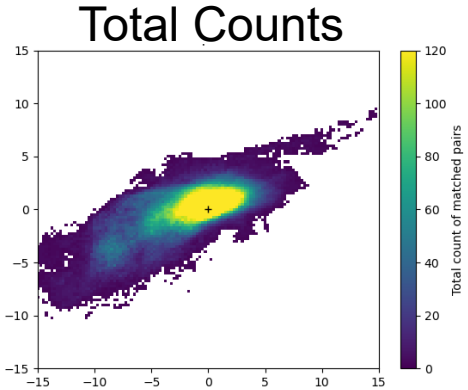
Extract Tiles Configs
- 30° x 30° tile
- 0.25° grid spacing

Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

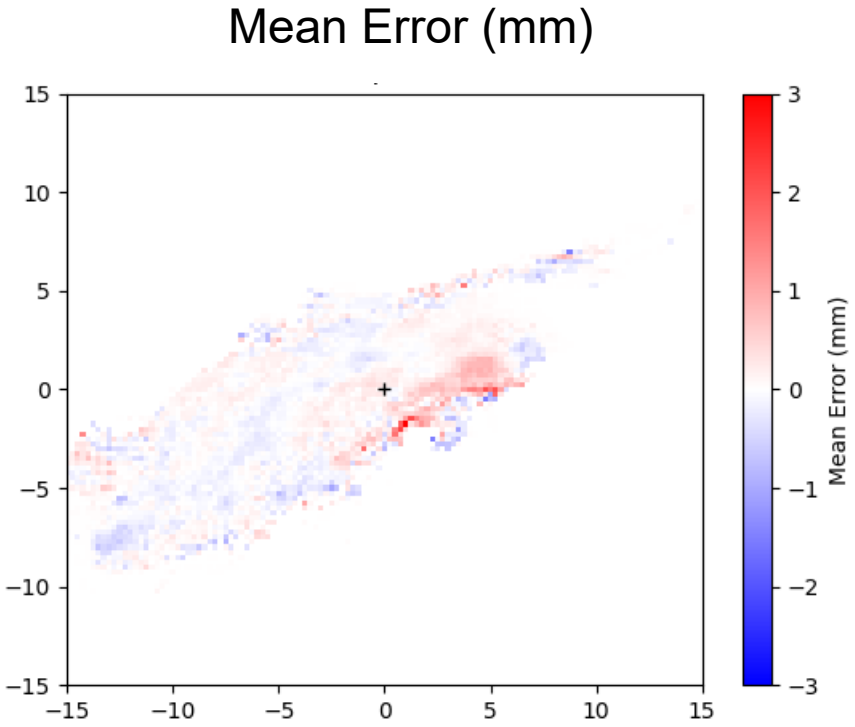
Series Analysis

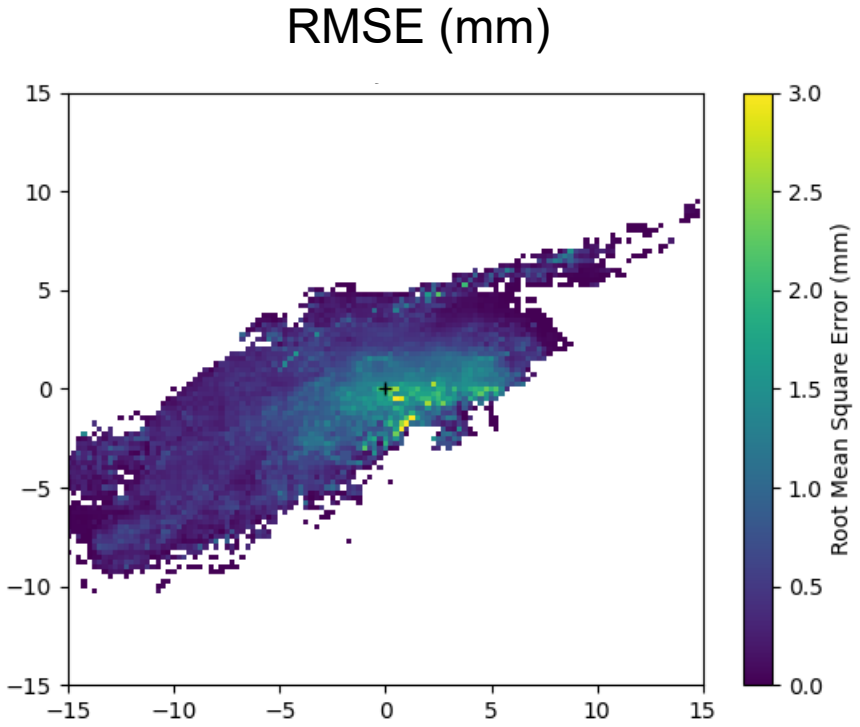
Accumulated Precipitation ≥ 0.05 inches

Masked with categorical snow



HRRR vs MRMS

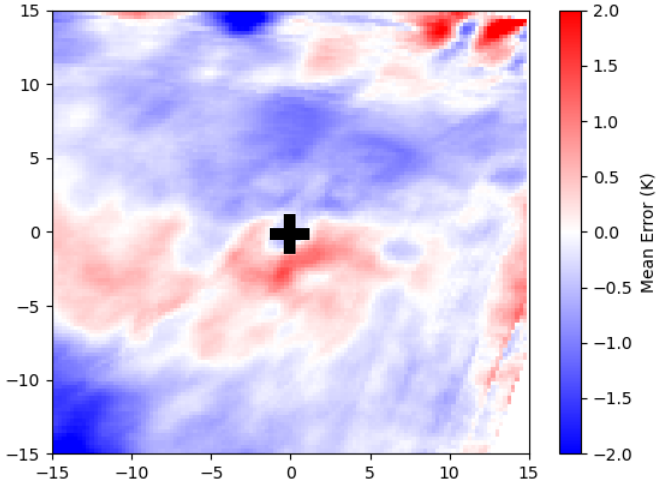




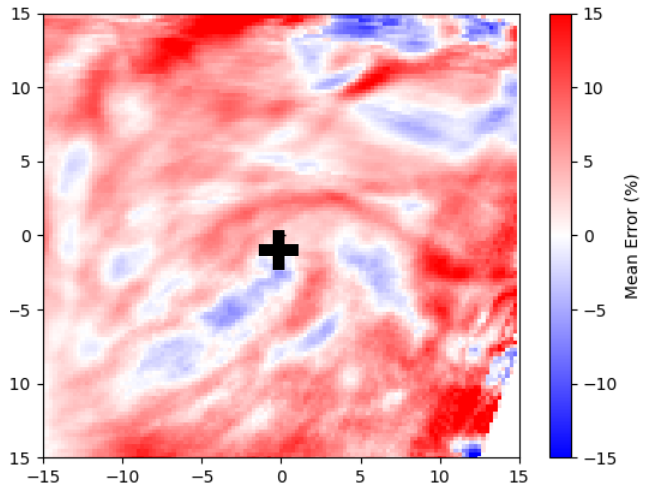
Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

HRRR Forecast vs HRRR Analysis

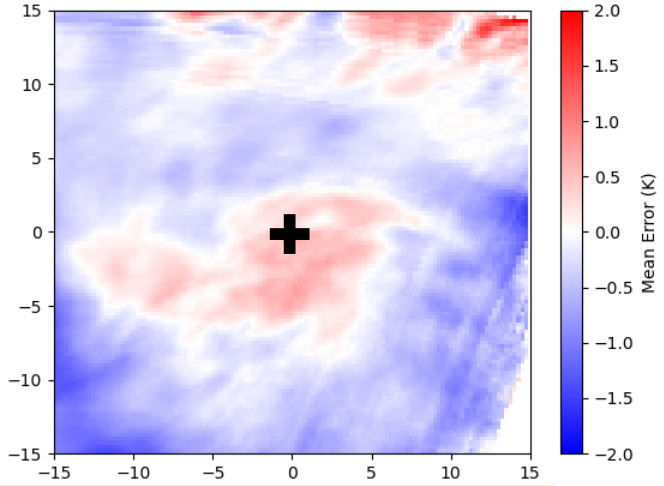
850 hPa Temperature



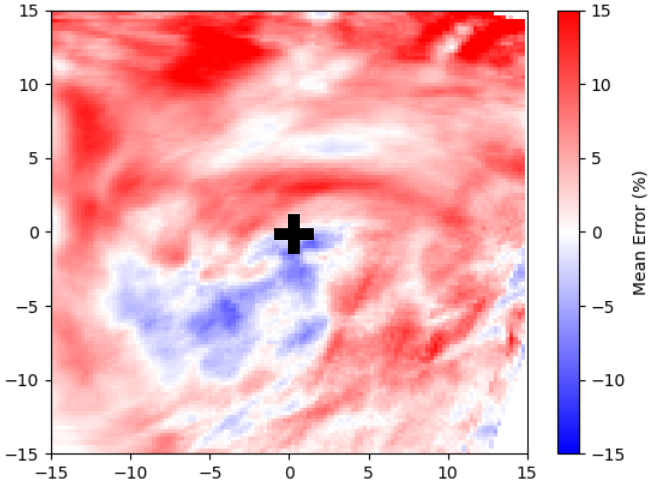
700 hPa RH



700 hPa Temperature

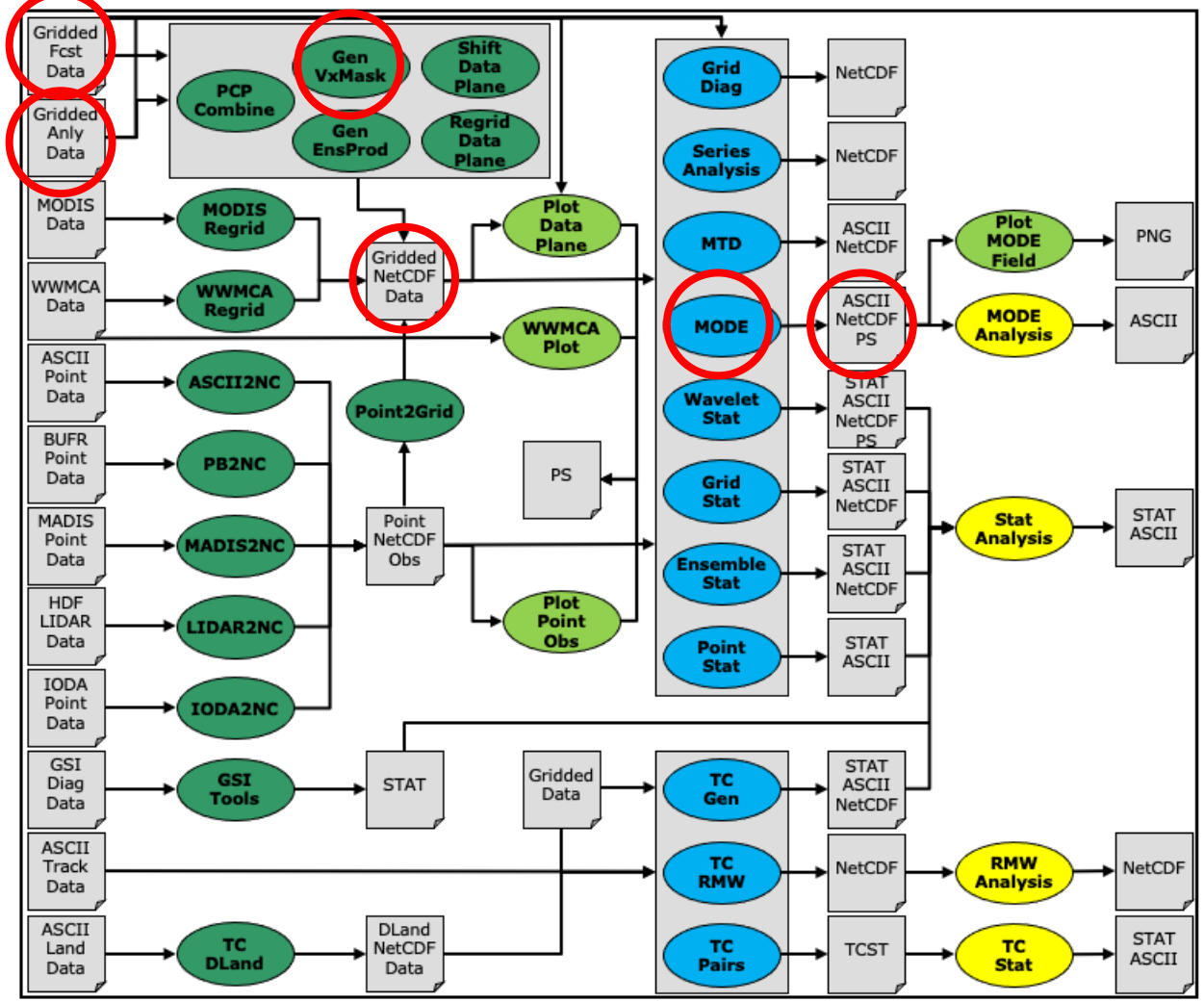


500 hPa RH



Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

Multivariate MODE Use Case



Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

Multivariate MODE Configuration

- Runs MODE on 2 or more variables to identify a super object based on a user-defined logical expression

Example (Blizzard)

*MODE_MULTIVAR_LOGIC = #1 && #2 && #3

1. Precipitation type = snow
2. Wind speed >= 35 mph
3. Visibility <= ¼ mile

* Available in METplus 5.0.0-beta1

- For each variable, an input template needs to be defined

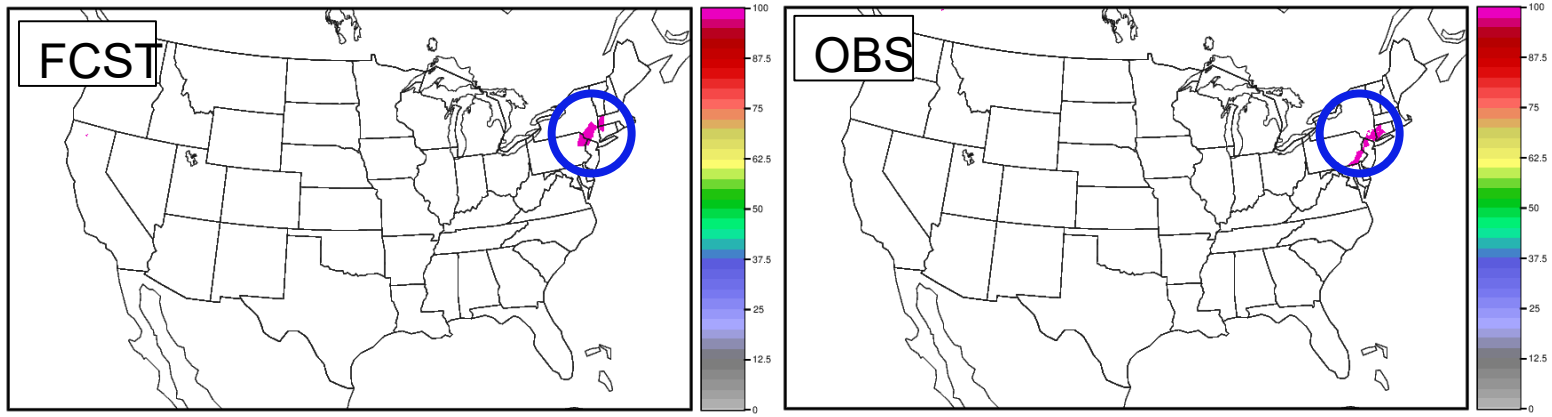
FCST_MODE_INPUT_TEMPLATE = {filename_template_1}, {filename_template_2}, {filename_template_3}

Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

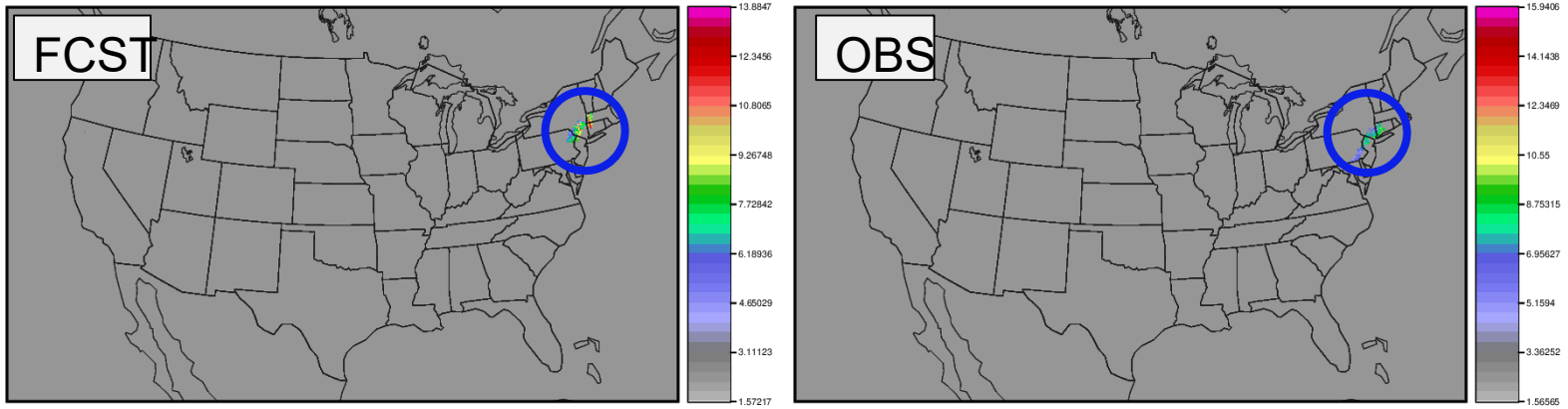
Multivariate MODE

Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

- Multivariate MODE produces NetCDF files containing the FCST and OBS super objects



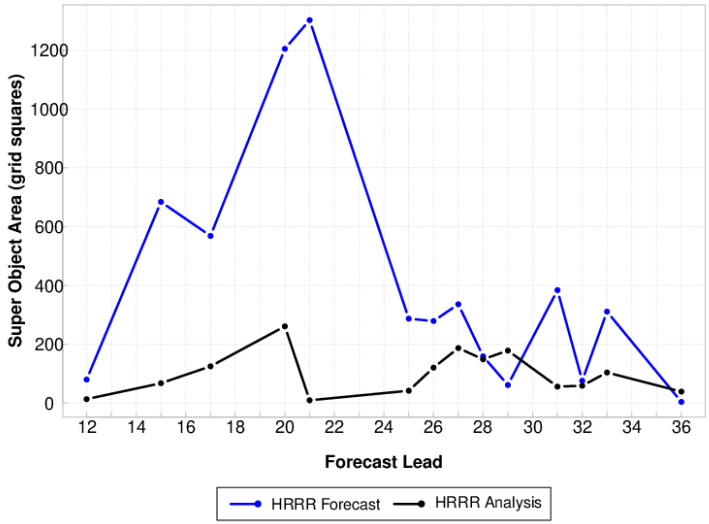
- Using GenVxMask, you can data mask a field using these super objects (e.g. 10 m wind speeds)



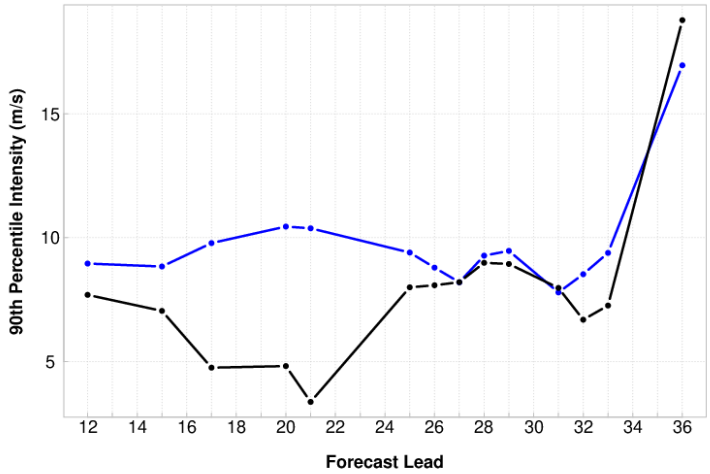
1 February 2021 Snowband with Blizzard Conditions

Forecast Super Objects with Observation Super Object Outlines

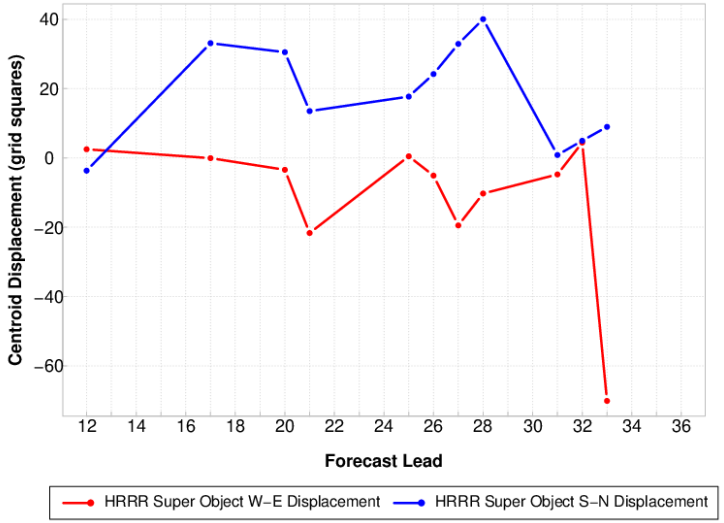
MODE Super Object Area



MODE 90th percentile Intensity



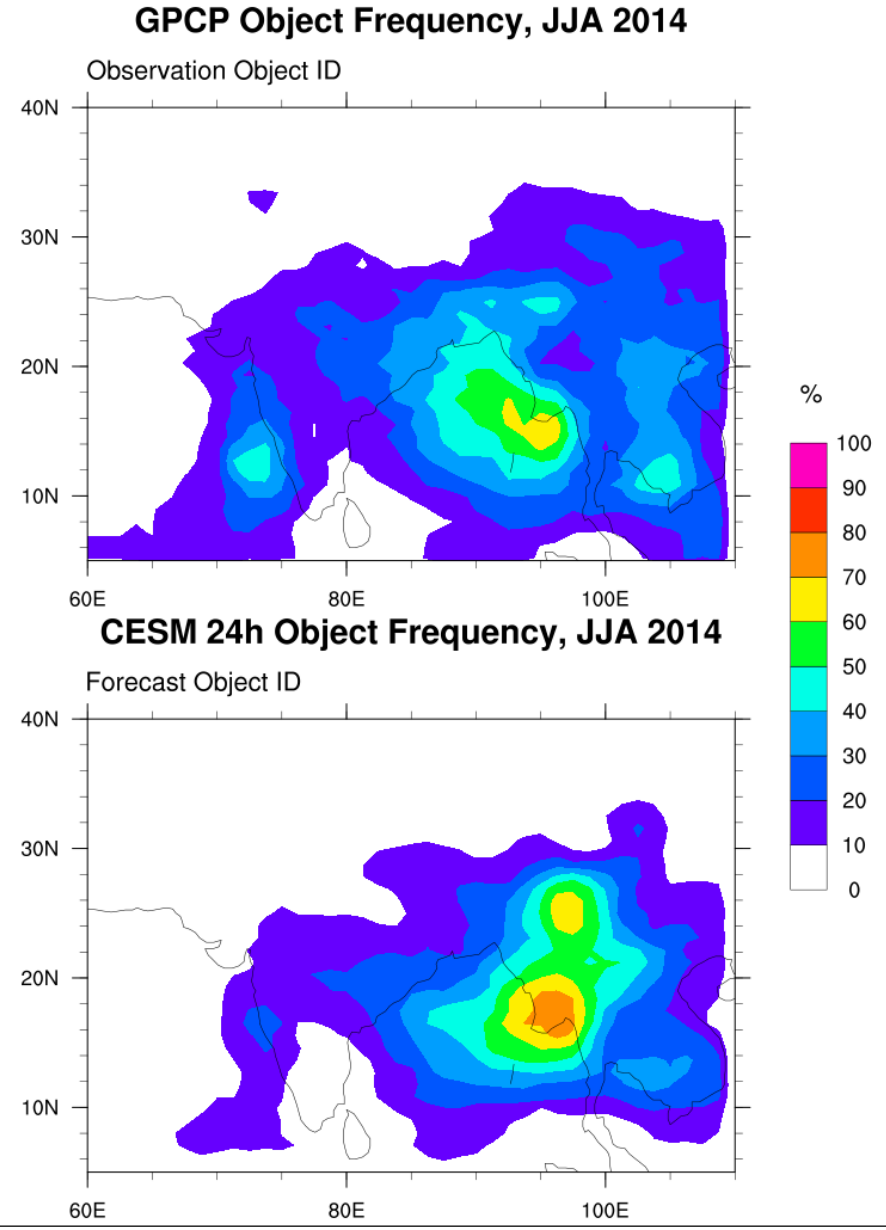
MODE Super Object Centroid Displacement



Slide Courtesy of Tracy Hertneky, NCAR/RAL and DTC

MODE Precipitation Object Frequency in Climate Models

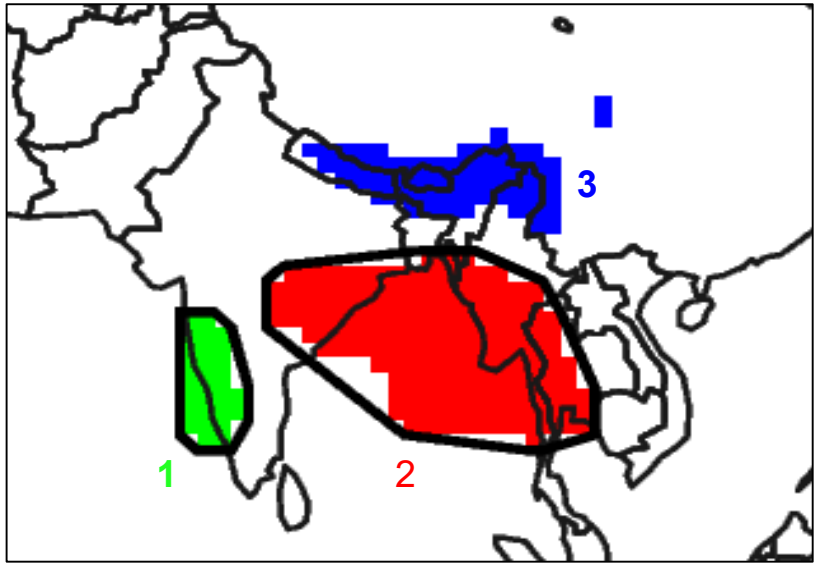
- JJA Frequency >=12 mm/day
- CESM object Frequency bi-modal
  - Southern area too frequent, too far North
- Western India: CESM too few objects (not enough precipitation), too far North
- Peak over Thailand/Cambodia region not well captured



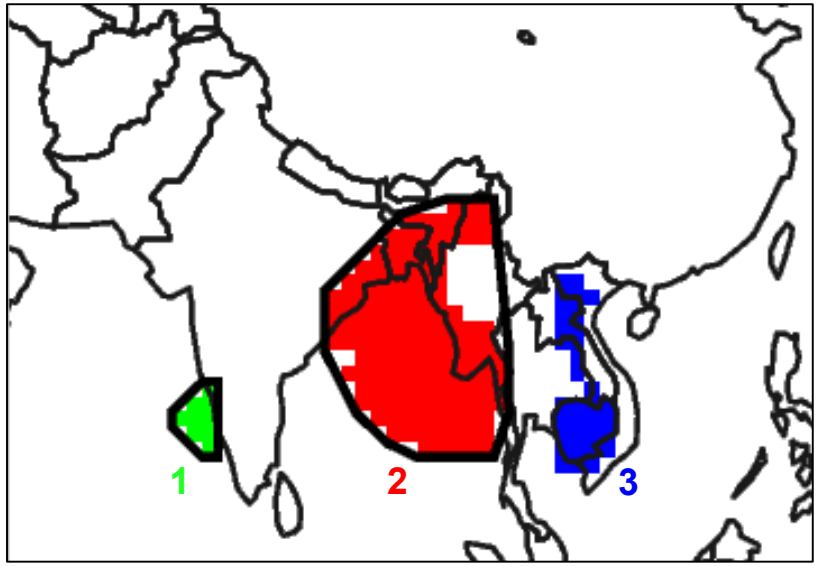
Slide Courtesy of Tina Kalb, NCAR/RAL and DTC

Monsoon MODE Frequency Statistics

Model Frequency Objects



Observation Frequency Objects



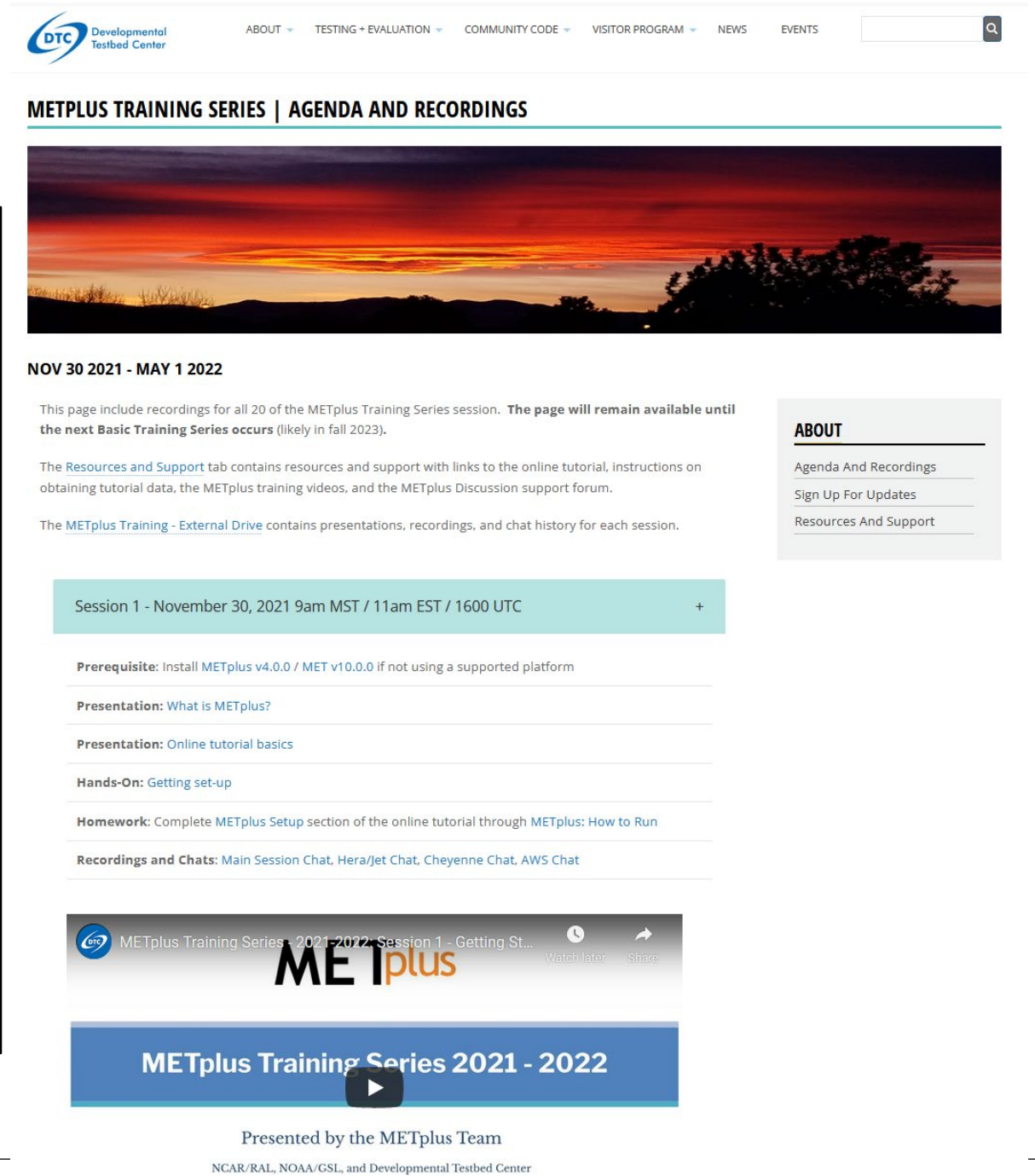
- Threshold: >=35%
- Model areas larger and farther east
- Model objects 2 and 3 oriented more E-W than observed

Object Number	Centroid Distance (grid units)	Area Ratio (grid units)	Angle Difference (degrees)	Symmetric Difference (grid units)
1	2.05	3.00	5.76	20.00
2	1.08	1.14	59.56	83.00
3	16.19	1.76	78.28	91.00

Slide Courtesy of Tina Kalb, NCAR/RAL and DTC

Training and Support Resources

- 2021 METplus Training Series recordings and presentations (https://dtcenter.org/events/2021/metplus-training-series/agenda-recordings)
- 2022 METplus Users' Workshop (https://dtcenter.org/events/2022/2022-dtc-metplus-workshop)
- METplus Training Modules (https://metplus-training.readthedocs.io/en/latest/index.html)
- METplus Online Tutorial (https://dtcenter.org/metplus-practical-session-guide-version-4-0)
- Users Guides for METplus and Components (https://dtcenter.org/community-code/metplus/documentation)
- GitHub Discussions Forum (https://github.com/dtcenter/METplus/discussions)



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

- Home
- System Architecture
- Download
  - Terms Of Use
  - Sign Up For Updates
  - Input Data
- 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
- METplus Website: https://dtcenter.org/community-code/metplus
- DTC Visitor Program: https://dtcenter.org/visitor-program

Watch for Announcements Regarding:

2022 METplus Advanced Training Series

METplus Graduate Student Hackathon