模式評估工具（MET）校驗軟體之應用介紹

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Sep 19 2018

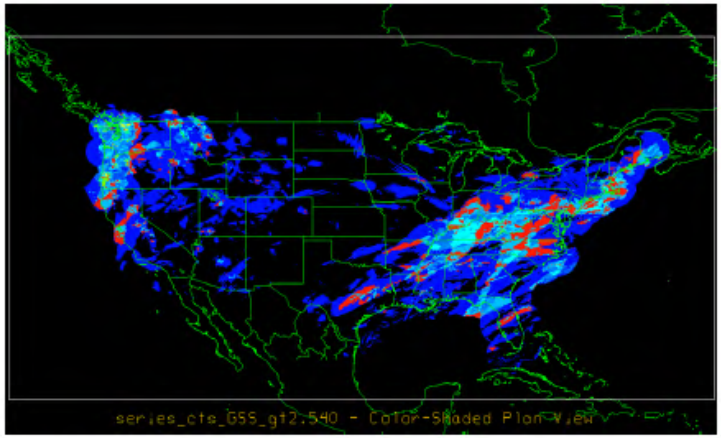
Source from *MET Tutorial Presentations: Winter 2018*, [online]
Available at:
https://dtcenter.org/met/users/docs/presentations/MET_Tutorial_20180131/index.php
[Accessed 07 Sep 2018]

Community Tools for Forecast Evaluation

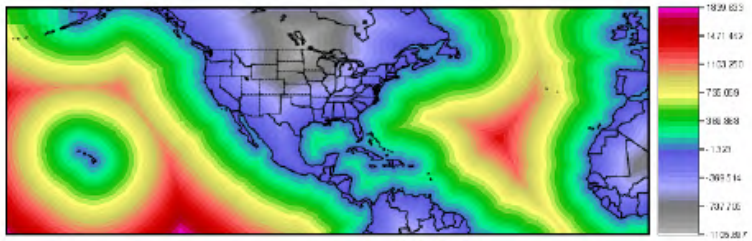
- Traditional and new tools
- Initial version released in 2008
- Includes
  - Traditional approaches
  - Spatial methods (MODE, Scale, Neighborhood)
  - Confidence Intervals
  - Ensemble methods
- Supported to the community
  - More than 2,400 users (50% university)
  - Regular tutorials
  - Email help

MET

Model Evaluation Tools



Spatial distribution of Gilbert Skill Score



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

MET Users

- METv6.1: Released December 04, 2017
  - Pre-installed on tutorial machines
- 3500+ registered MET users from 132 countries
  - 48/27/14/11%: University/Gov't/Nonprofit/Private
  - 30/16/6/3%: USA/China/India/Brazil
- On-line and hands-on tutorials

www.dtcenter.org/met/users

ABOUT TESTING & EVALUATION COMMUNITY CODES VISITOR PROGRAM EVENTS

MET USERS PAGE

Home
Terms of Use
Overview
Download▶
Documentation
User Support▶
Related Links

MODEL EVALUATION TOOLS

Welcome

Welcome to the users page for the Model Evaluation Tools (MET) verification package. MET was developed by the National Center for Atmospheric Research (NCAR) Developmental Testbed Center (DTC) through the generous support of the U.S. Air Force Weather Agency (AFWA) and the National Oceanic and Atmospheric Administration (NOAA).

Description

MET is designed to be a highly-configurable, state-of-the-art suite of verification tools. It was developed using output from the Weather Research and Forecasting (WRF) modeling system but may be applied to the output of other modeling systems as well.

MET provides a variety of verification techniques, including:

- Standard verification scores comparing gridded model data to point-based observations
- Standard verification scores comparing gridded model data to gridded observations
- Spatial verification methods comparing gridded model data to gridded observations using neighborhood, object-based, and intensity-scale decomposition approaches
- Ensemble and probabilistic verification methods comparing gridded model data to point-based or gridded observations
- Aggregating the output of these verification methods through time and space

EVENTS

AMS 2018 NWP using Docker Containers
01.06.2018 to 01.06.2018
Location: AMS Annual Meeting in Austin, TX

2018 Hurricane WRF Tutorial
01.23.2018 to 01.25.2018
Location: College Park, MD

ANNOUNCEMENTS

MET Version 6.1 Release
12.04.2017

Release v3.9a of the HWRF system
10.16.2017

MET NEWS

MET Online Tutorial
New for METv6.1 on 2017.12.04

METv6.0 Running within a Docker container
New for Mac and Windows 10 users who wish to skip building and installing METv6.0

MET SPONSORS

National Center for Atmospheric Research (NCAR)

Dependencies

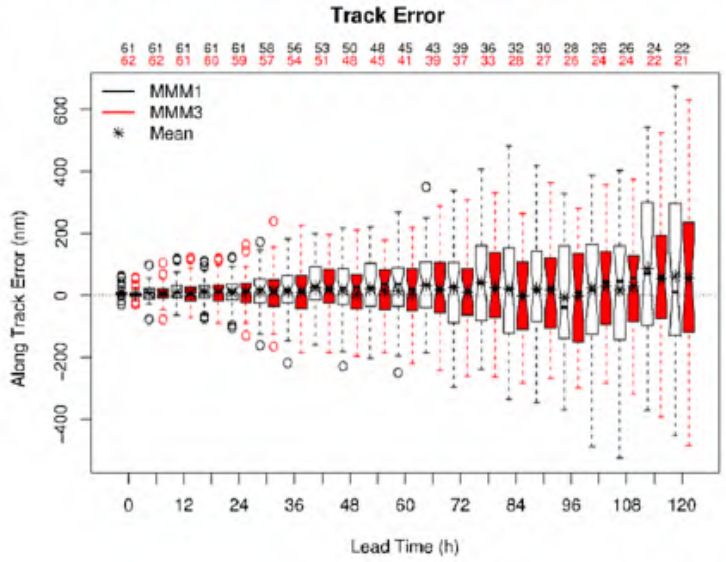
- REQUIRED:
  - C++/Fortran Compilers (GNU, PGI, Intel)
  - GNU Make Utility
  - Unidata's NetCDF4 library (both NetCDF-C and NetCDF-CXX)
  - HDF5 library (required to support NetCDF4)
  - NCEP's BUFRLIB Library v10.2.3
  - GNU Scientific Library (GSL)
  - Z Library (zlib)
- OPTIONAL:
  - GRIB2 C-Library with JASPER and PNG libraries
  - HDF4 and HDF-EOS2 libraries for MODIS-Regrid tool
  - Cairo and FreeType libraries for MODE-Graphics tool
- RECOMMENDED:
  - Unified Post-Processor
  - COPYGB (included with Unified Post-Processor)
  - wgrib and wgrib2
  - R statistics and graphics package

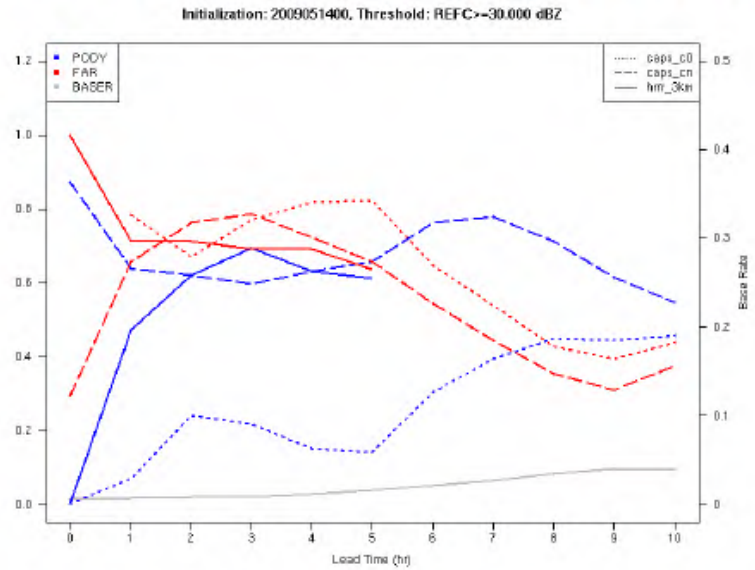
Building MET

- Steps for building MET:
  1. Build required/optional libraries.
     - Same family of compilers for MET
  2. Download and unpack latest MET patches.
  3. autoconf determines available compilers, but can be explicitly set by the user
  4. Set environment variables in .cshrc or equivalent file
     - Paths for HDF5, NetCDF, BUFRLIB, and GSL libraries
     - The compilation of various tools can be turned on/off
  5. Configure the installation for your system and run configure
     - The compilation of various tools can be turned on/off
  6. Run make install and make test and check for runtime errors.
     - Test scripts run each of the MET tools at least once.
     - Uses sample data distributed with the tarball.

Graphics

- Limited graphics incorporated into MET
- Options for plotting MET statistical output
  - R, NCL, IDL, GNUPlot, and many others
- Sample plotting scripts on MET website
- Future METViewer database/display system

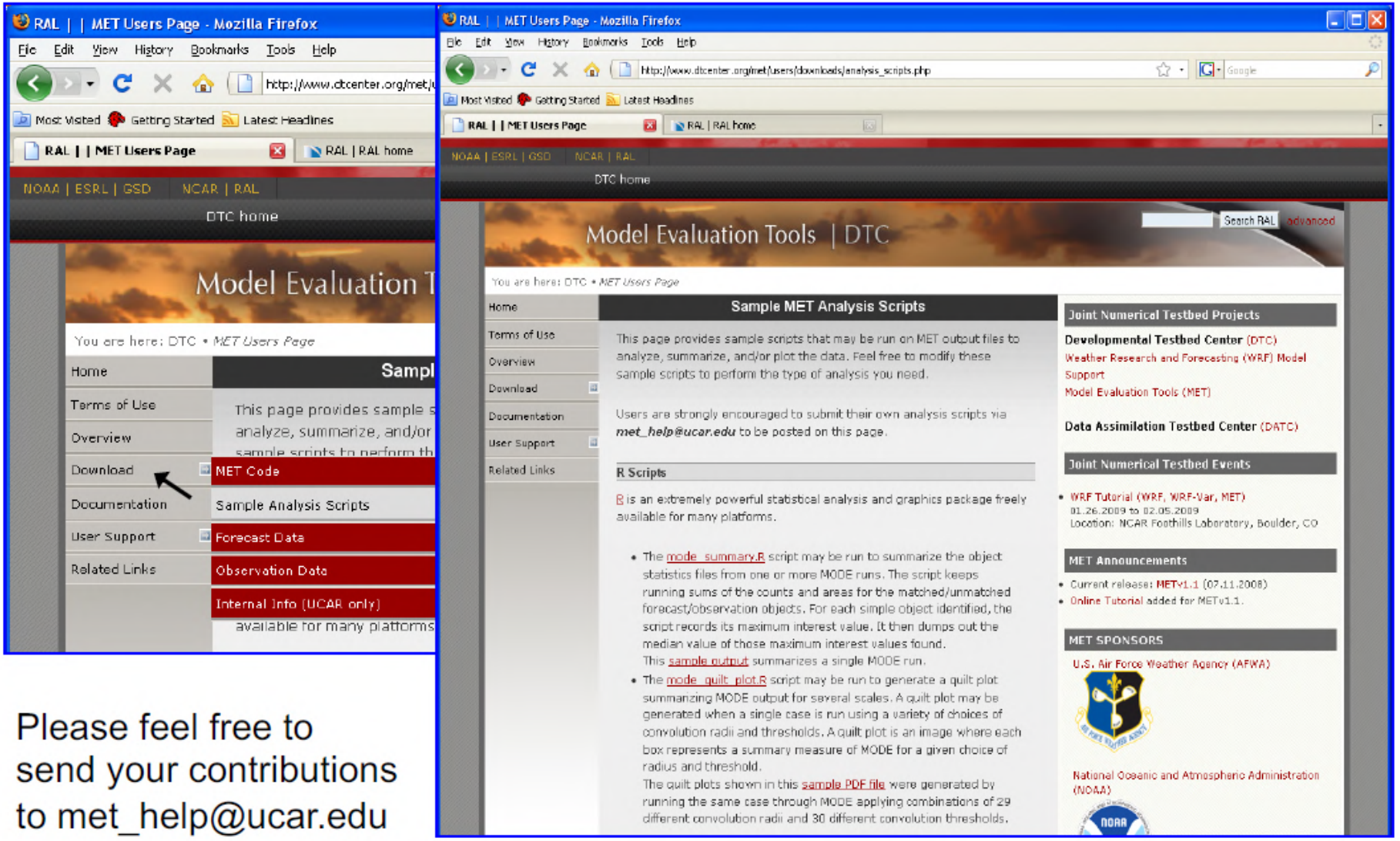




R Statistics and Graphics

- The R Project for Statistical Computing (www.r-project.org)
  - Powerful statistical analysis and plotting tools
  - Large and growing user community
  - Freely available and well supported for Linux/Windows/Mac
- Sample R plotting and analysis scripts posted on the MET website
- Use R to plot data in the practical sessions

User Contributed Plotting Scripts

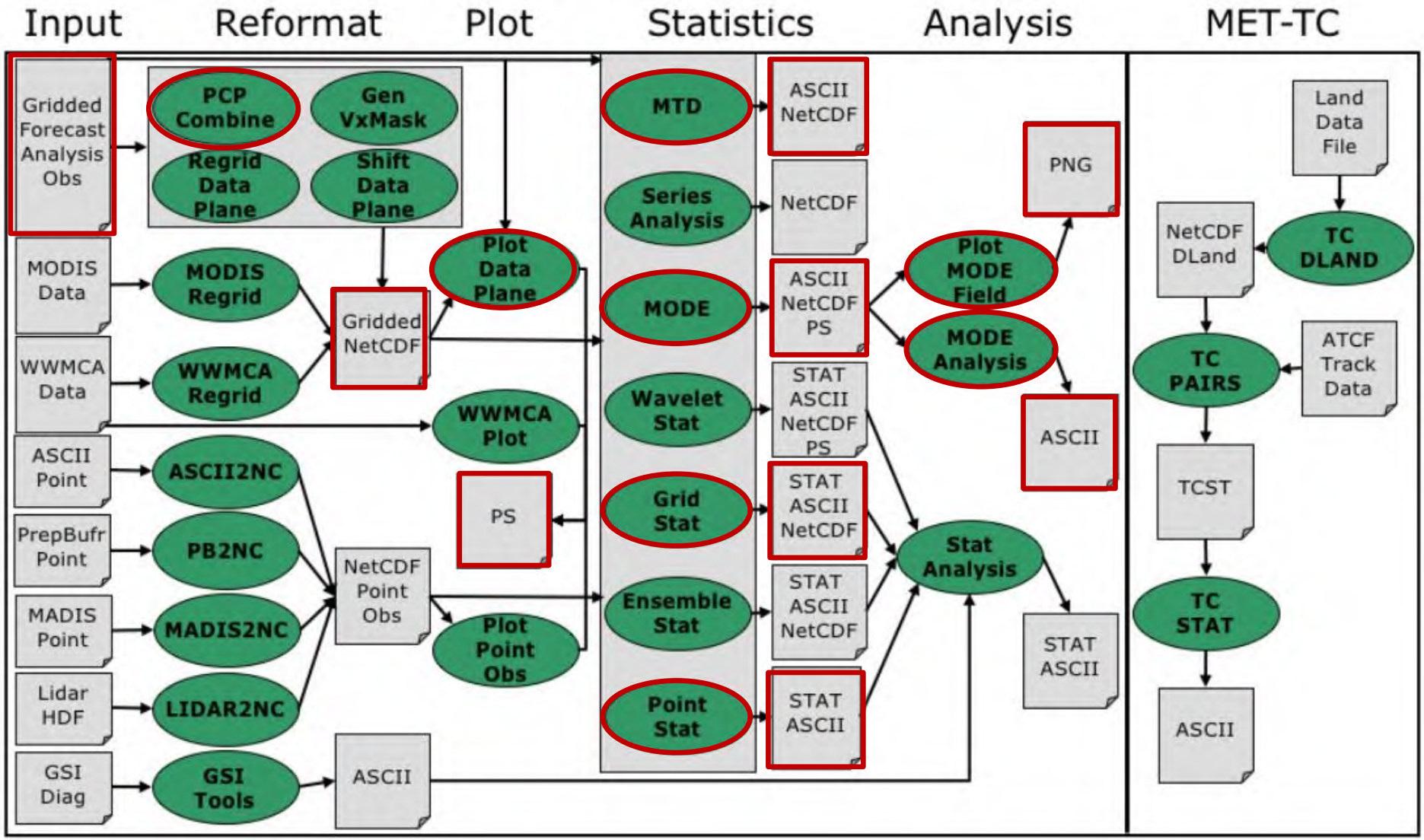


Please feel free to send your contributions to met_help@ucar.edu

Supported File Formats

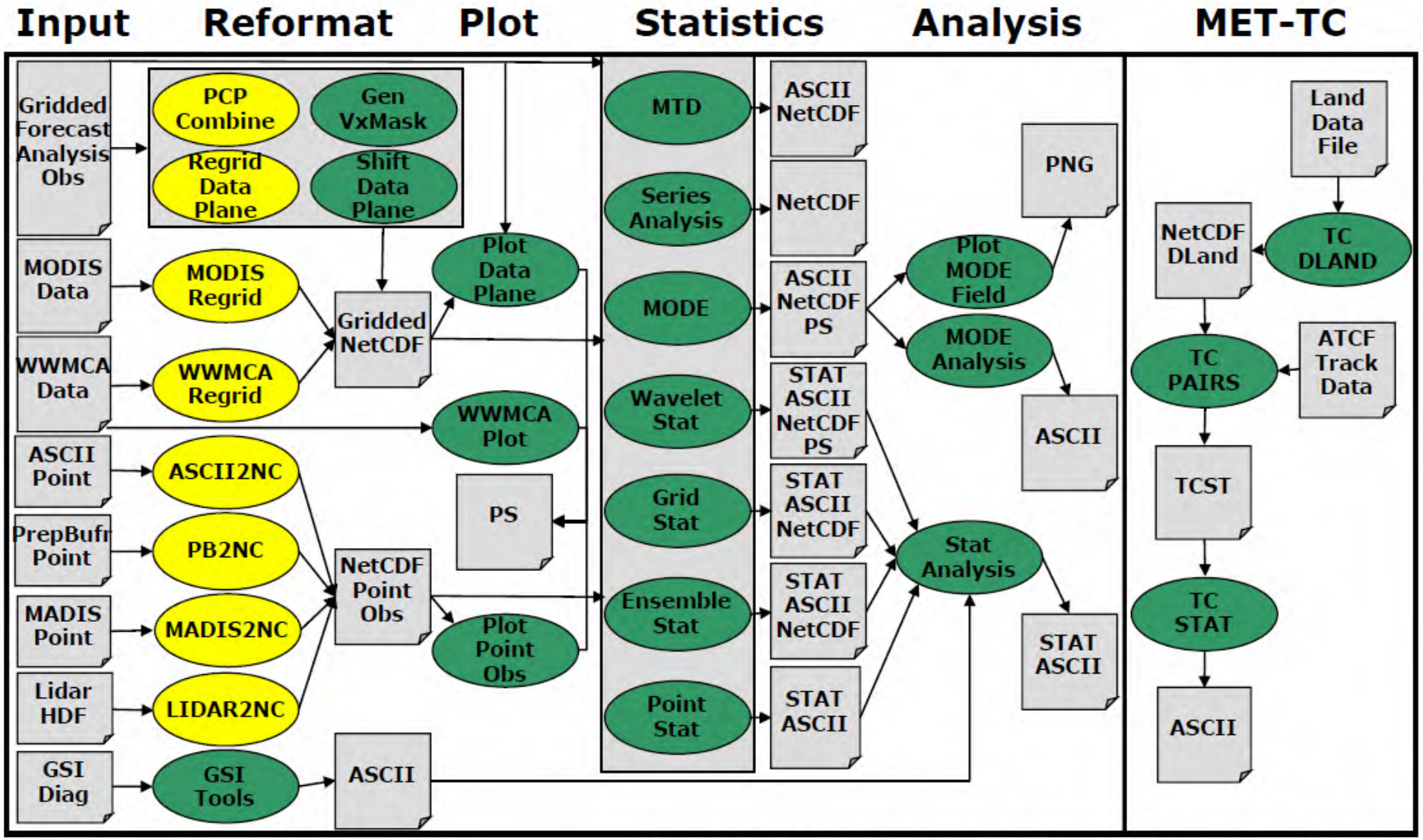
- **Forecasts**
  - **GRIB1** – GRIdded Binary file
  - **GRIB2** – GRIB version 2 disabled by default (***--enable-grib2***)
  - **NetCDF** – Output from wrf_interp WRF-ARW utility, CF-Compliant versions 3 and 4, and internal MET NetCDF format
- **Gridded Analyses**
  - Same as Forecast file formats
  - GRIB Stage II/IV, MRMS, URMA, Model Analyses
  - **WWMCA** – World Wide Merged Cloud Analysis
  - **TRMM** – Tropical Rainfall Measuring Mission
  - **MODIS** – Moderate-Resolution Imaging Spectroradiometer
- **Point Observations**
  - **PREPBUFR** – binary data assimilation product (NDAS or GDAS)
  - **ASCII** – "MET specific" 11-column, little-r, SURFRAD, WWSIS, Aeronet
  - **MADIS** – Metar, Raob, Profiler, Maritime, Mesonet, or acarsProfiles
  - **LIDAR** - CALIPSO

MET Overview v6.1



Data	MET Tool
Gridded Forecasts Gridded Observations	Grid stat (traditional or neighborhood) Series Analysis Wavelet Stat MODE Ensemble Tool
Gridded Forecasts Point Observations	Point Stat Ensemble Tool
Tropical Cyclone A decks and B decks (both point observations)	MET - TC

Pre-Processing / Reformatting

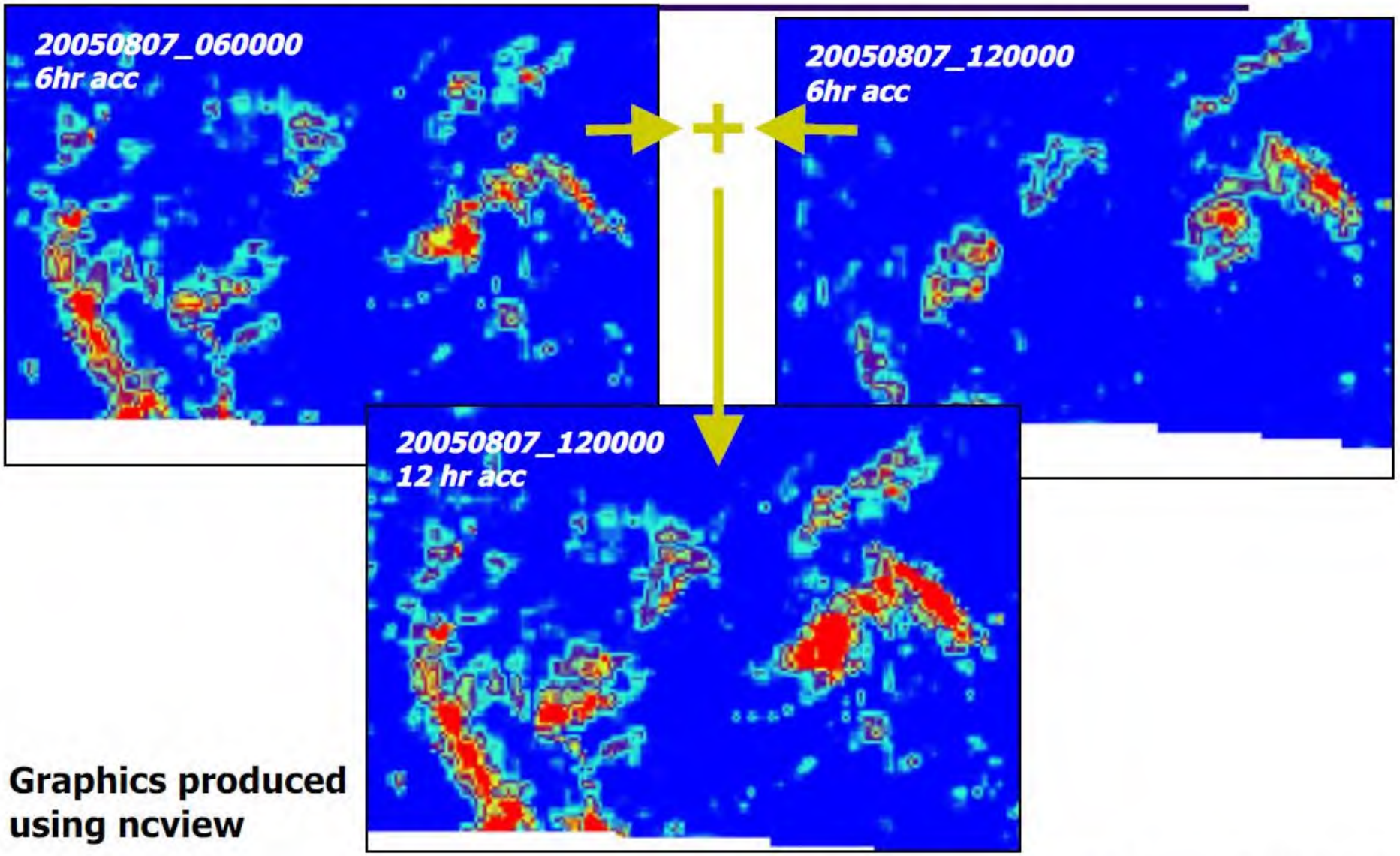


Data Reformating Tools

- **PB2NC, ASCII2NC, MADIS2NC, LIDAR2NC**
  - Reformat point observations to the NetCDF format expected by Point-Stat and Ensemble-Stat.
- **MODIS_Regrid, WWMCA_Regrid**
  - Regrid HDF MODIS or binary WWMCA observations to the gridded NetCDF format expected by the MET statistics tools.
- **Regrid_Data_Plane**
  - Regrid one or more gridded data fields to user-specified grid.
- **PCP_Combine**
  - Add, subtract, or sum precipitation values across multiple gridded data files and write to the gridded NetCDF format expected by the MET statistics tools.

PCP Combine

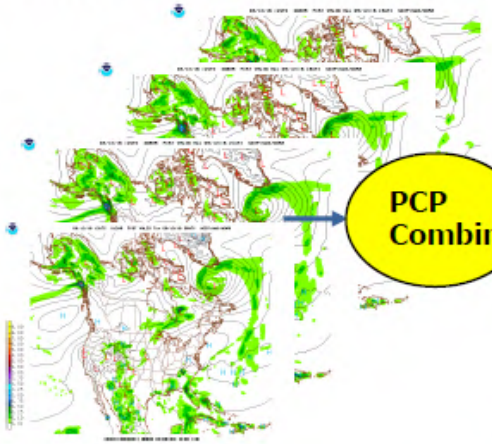
PCP-Combine: Example #1



Graphics produced using ncview

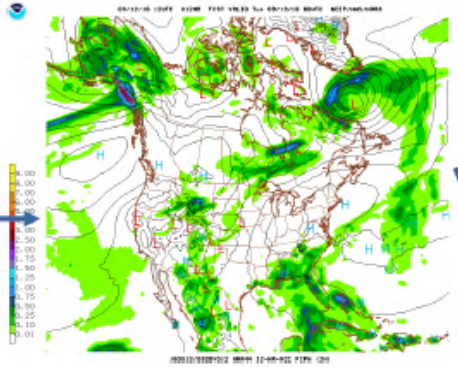
Example: Accumulated precipitation

3-h accumulation QPE

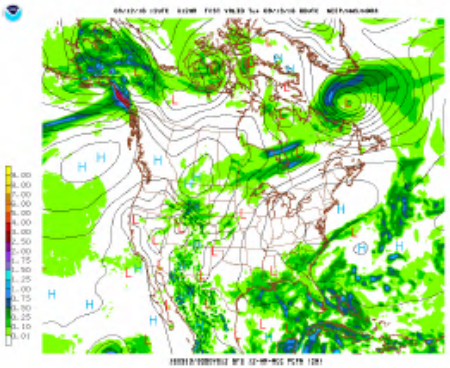


PCP Combine

12-h accumulation QPE



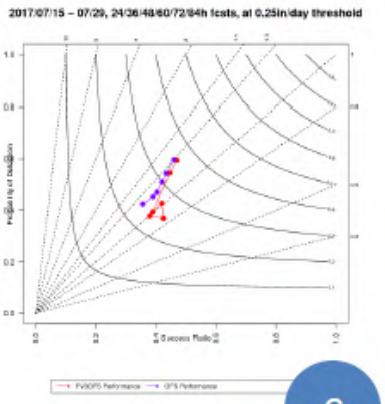
12-h accumulation QPF



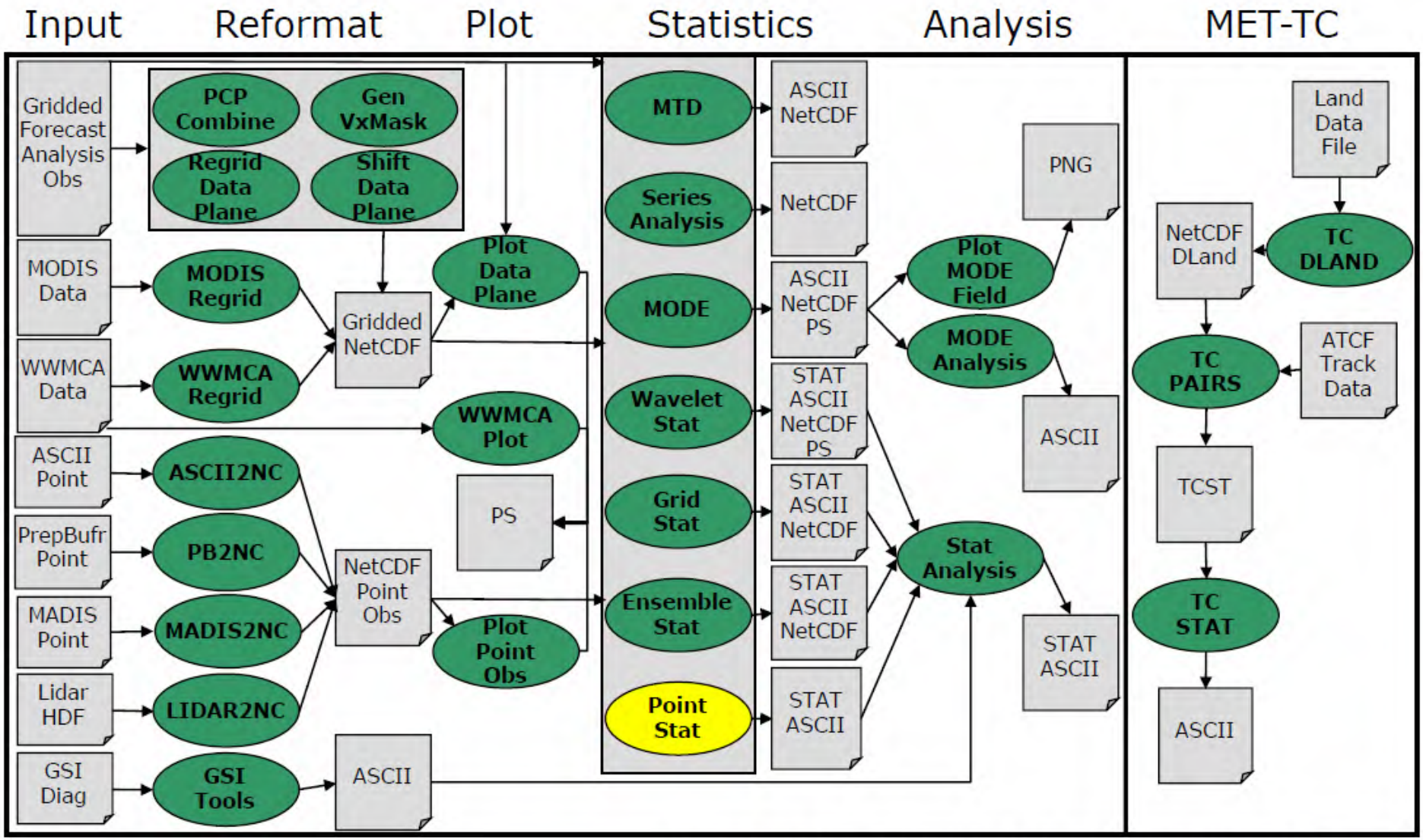
- MODE
- MODE-TD
- Wavelet Stat
- Grid Stat
- Series Analysis
- Ensemble Stat
- Point Stat

METViewer Database and Display

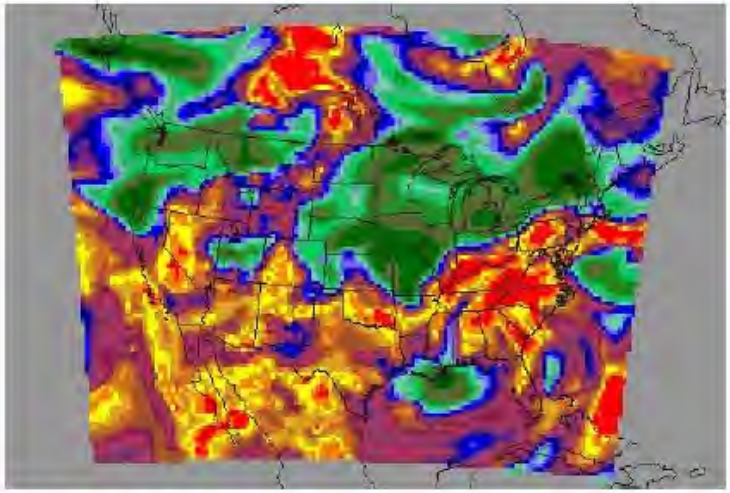
Multiple runs over time



Point-Stat Tool



Point-Stat: Overview



- Compare **gridded forecasts** to **point observations.**
- Accumulate matched pairs over a defined area at a single point in time.
- Verify one or more variables/levels.
- Analysis tool provided to aggregate through time.

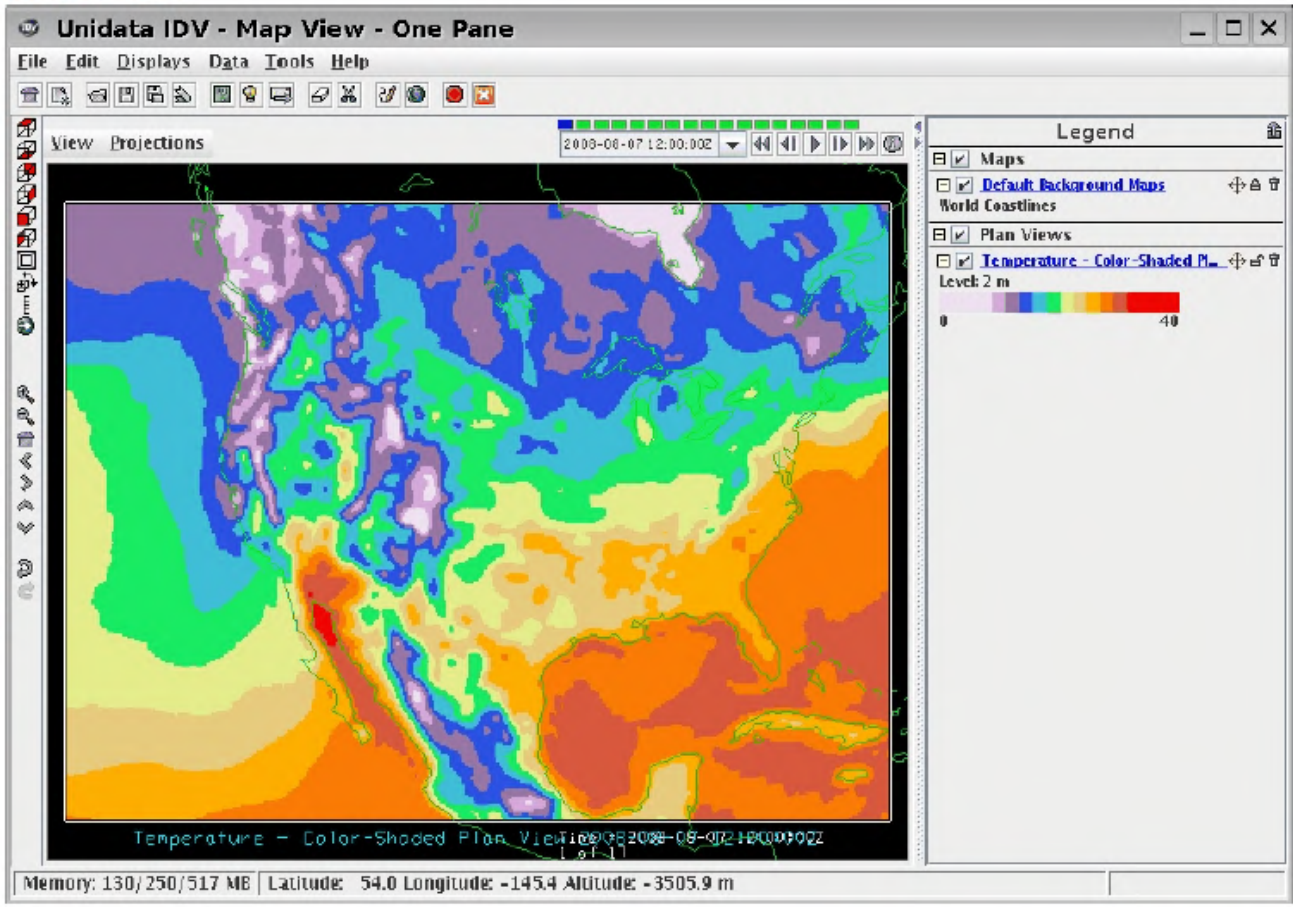
- Verification methods:
  - Continuous statistics for raw fields.
  - Single and Multi-Category counts and statistics for thresholded fields.
  - Parametric and non-parametric confidence intervals for statistics.
  - Compute partial sums for raw fields and/or the raw matched pair values.
  - Methods for probabilistic forecasts.
  - HiRA spatial verification method.

Point-Stat: Input/Output

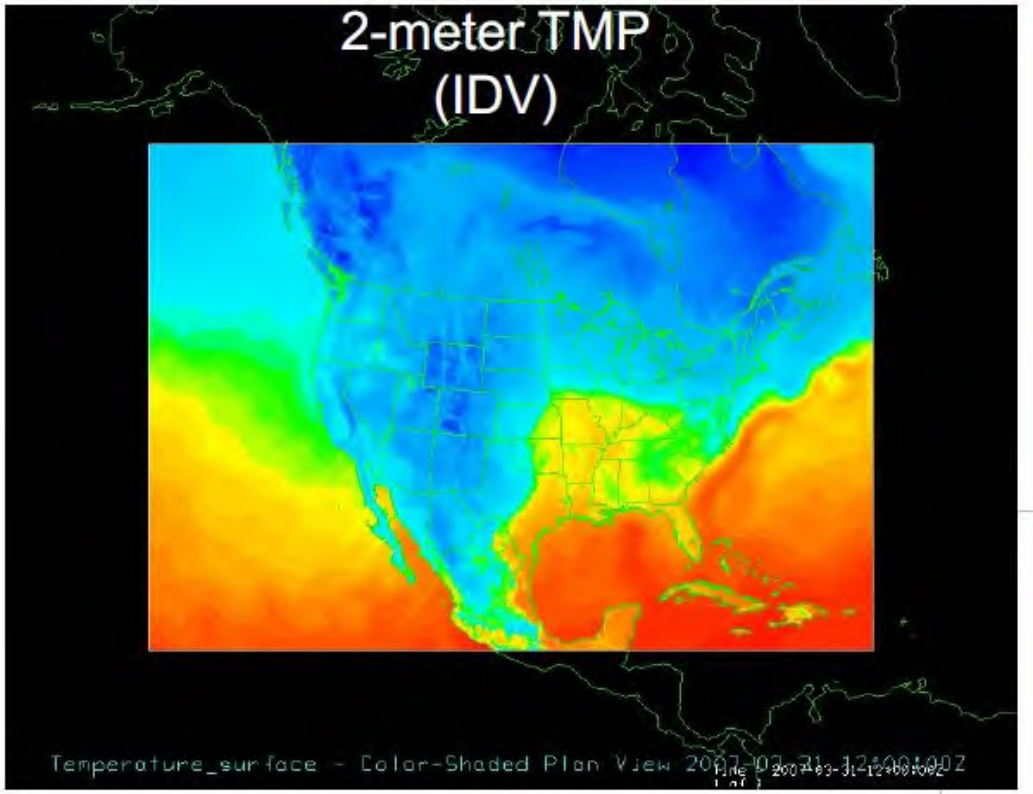
- Input Files
  - Gridded forecast file
    - GRIB1 output of Unified Post-Processor (or other)
    - GRIB2 from NCEP (or other)
    - NetCDF from PCP-Combine, wrf_interp, or CF-compliant
  - Point observation file
    - NetCDF output of PB2NC, ASCII2NC, MADIS2NC, or LIDAR2NC
  - ASCII configuration file
- Output Files
  - ASCII statistics file with all output lines (end with ".stat")
  - Optional ASCII files sorted by line type with a header row (ends with "_TYPE.txt")

Use Case: 2-m Temperature

- Verify 2-m temperature versus PREPBUFR point observations.
  - Initialized 2008080712 with 3-hourly output to 48h
  - Run WRFOUT through UPP to create GRIB
  - Unidata's IDV for display

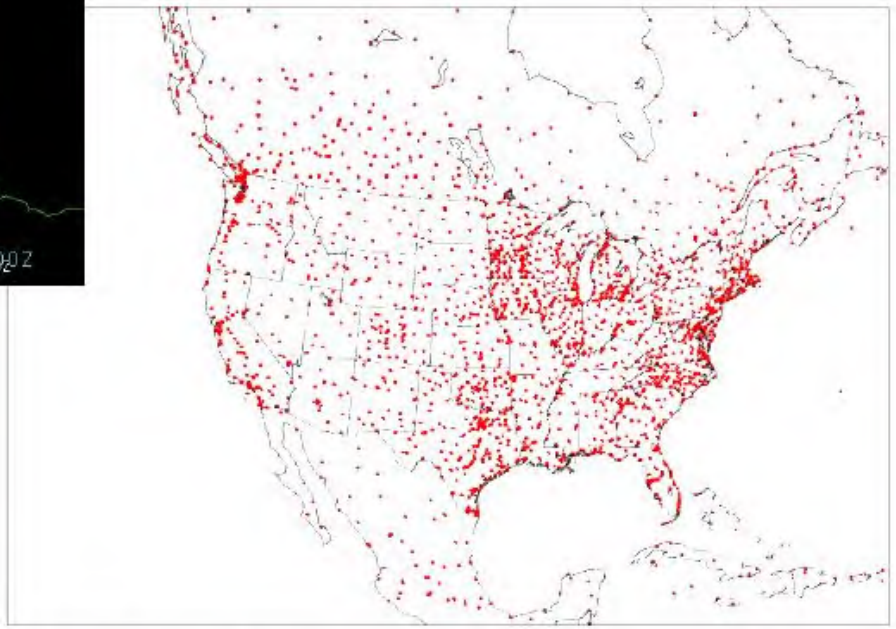


Point-Stat: Input



4003 TMP ADPSFC Obs
(plot_point_obs)

sample_pb.nc

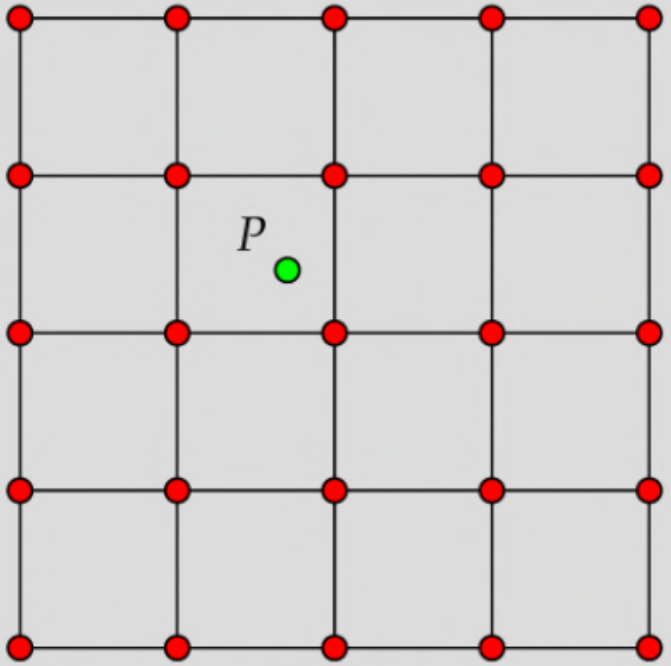


Interpolation

Need to Choose:

(1) Method

(2) Width



Point-Stat: Horizontal Interpolation

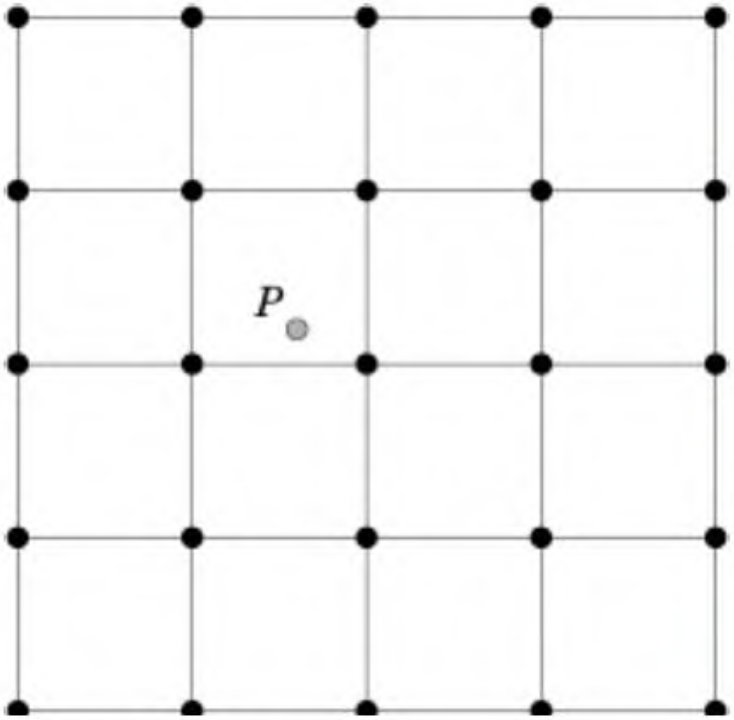


Figure 4-1: *Diagram illustrating matching and interpolation methods used in MET. See text for explanation.*

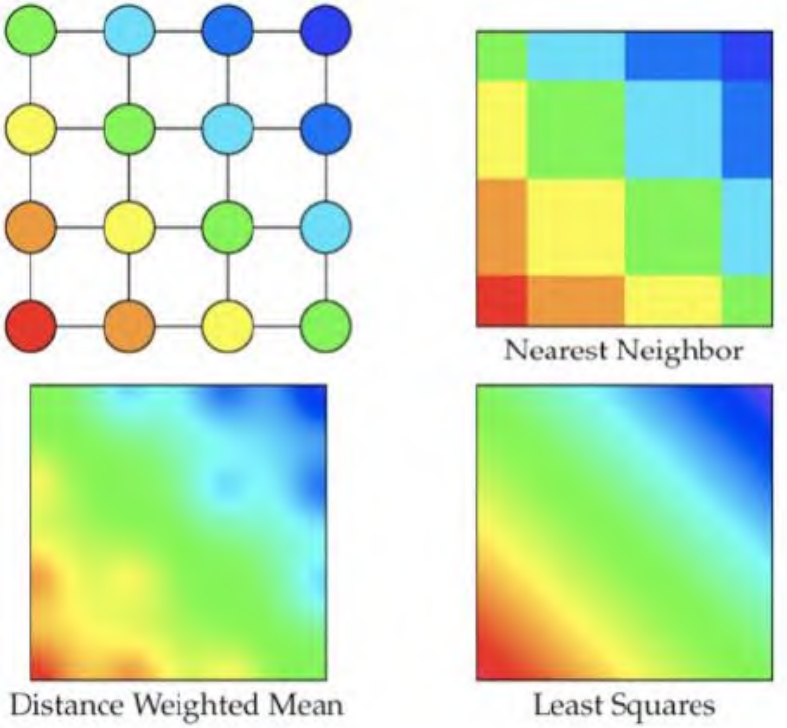


Figure 4-2: *Illustration of some matching and interpolation methods used in MET. See text for explanation.*

Interpolation Methods

	Min	Max	Median	UW Mean	DW Mean	Nearest Nbr	Least Squares
Point Stat	✓	✓	✓	✓	✓	✓	✓
Grid Stat	✓	✓	✓	✓	N/A	N/A	N/A

For Grid Stat, these are smoothing methods.

Point-Stat: Categorical (Dichotomous)

- Base Rate
- Mean Forecast
- Accuracy (ACC)
- FBI
- POD
- PODn
- POFD
- False Alarm Ratio (FAR)
- CSI (TS)
- GSS (ETS)
- Hanssen-Kuipers Discriminant (H-K)
- HSS
- Odds Ratio (OR)
- Logarithm of the Odds Ratio (LODDS)
- Odds Ratio Skill Score (ORSS)
- EDS/ SEDS
- EDI/ SEDI
- Bias Adjusted GSS

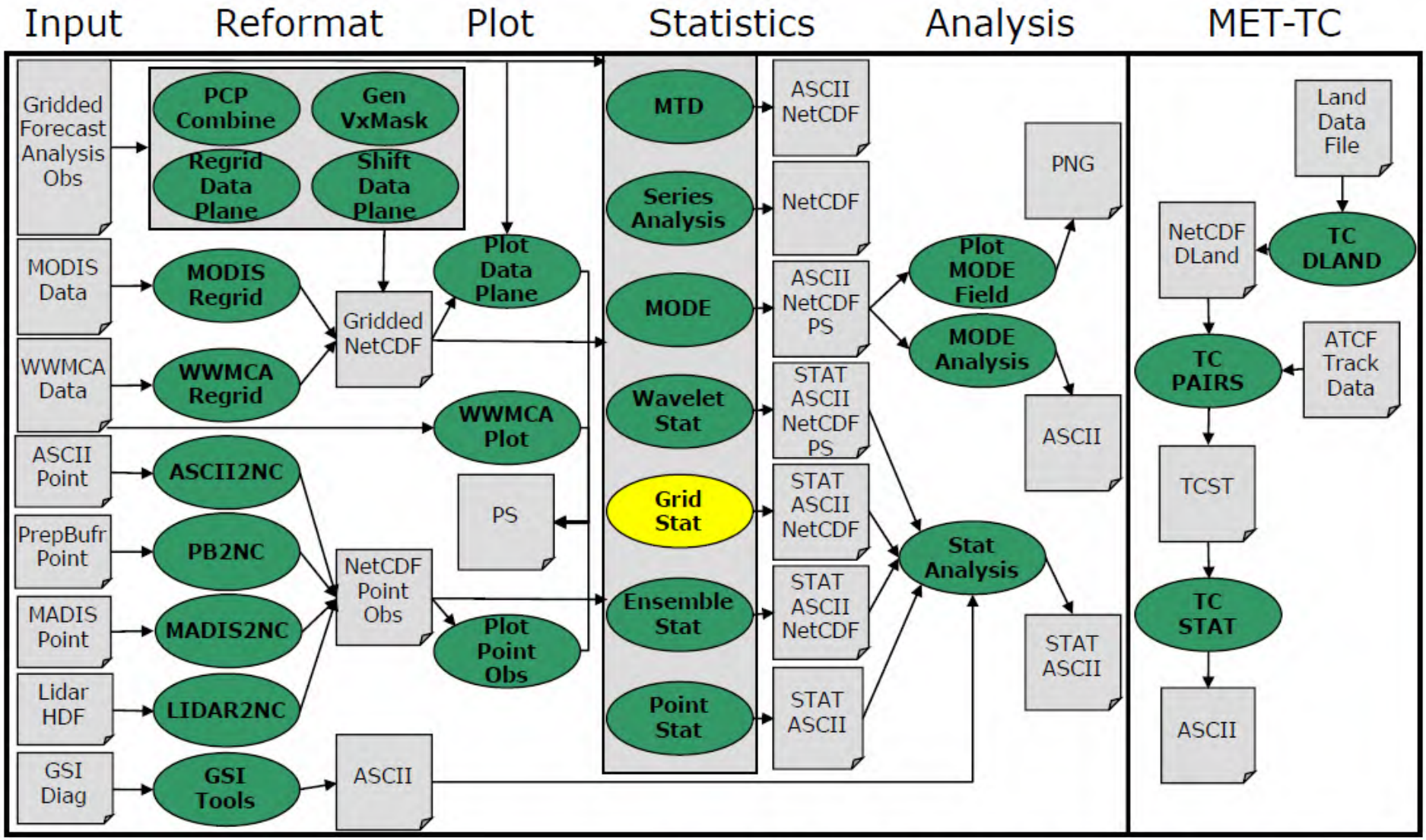
Point-Stat: Continuous

- Mean/ SD F
- Mean/ SD O
- Pearson Correlation Coefficient
- Spearman rank Correlation Coefficient
- Kendall's tau statistic
- ME/ Bias/ MSE/ RMSE/ SD/ MAE
- Interquartile Range (IQR)
- Median Absolute Deviation (MAD)
- Percentiles of the errors (10, 25, 50, 75, 90)
- Anomaly Correlation
- MSE Skill Score
- RMS F anomaly (f-c)
- RMS O anomaly (o-c)

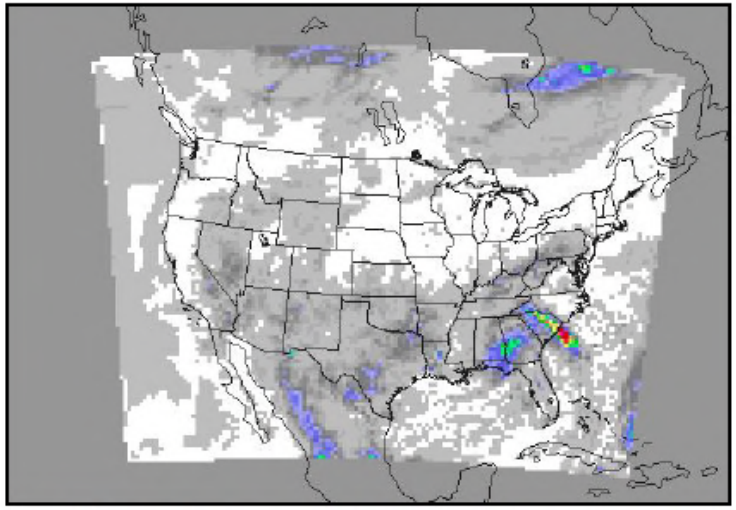
Point-Stat: Probabilistic

- Reliability
- Resolution
- Uncertainty
- Base Rate
- ROC area
- Brier Score
- Observed Yes Total Proportion
- Observed No Total Proportion
- Calibration
- Refinement
- Likelihood

Grid-Stat Tool

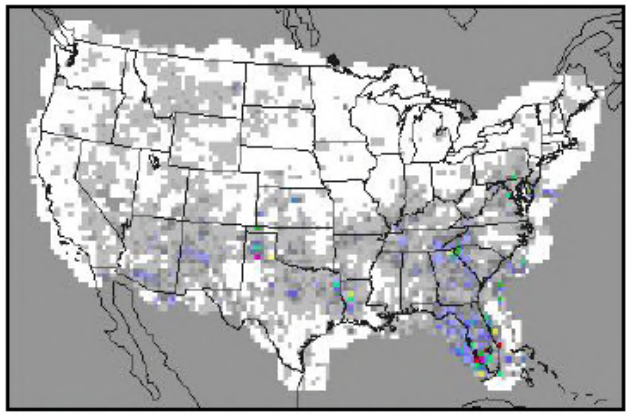


Grid-Stat: Overview



- Compare **gridded forecasts** to **gridded observations** on the same grid.
- Accumulate matched pairs over a defined area at a single point in time.
- Verify one or more variables/levels.
- Analysis tool provided to aggregate through time.

- Verification methods:
  - Continuous statistics for raw fields.
  - Single and Multi-Category counts and statistics for thresholded fields.
  - Parametric and non-parametric confidence intervals for statistics.
  - Compute partial sums for raw fields.
  - Methods for probabilistic forecasts.
  - Economic Cost/Loss Value.
  - Neighborhood verification methods.
  - Fourier decomposition.

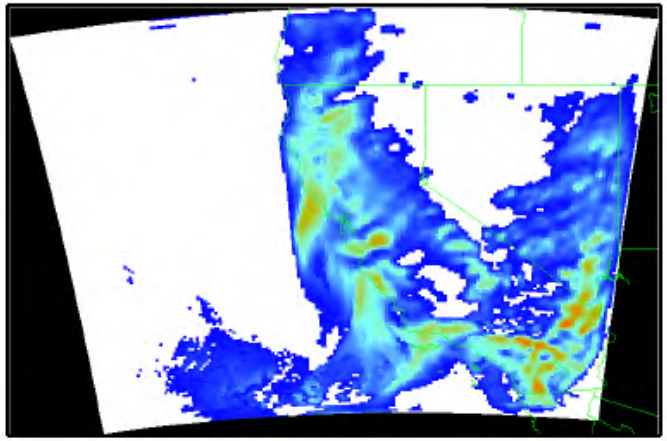


Grid-Stat: Input/Output

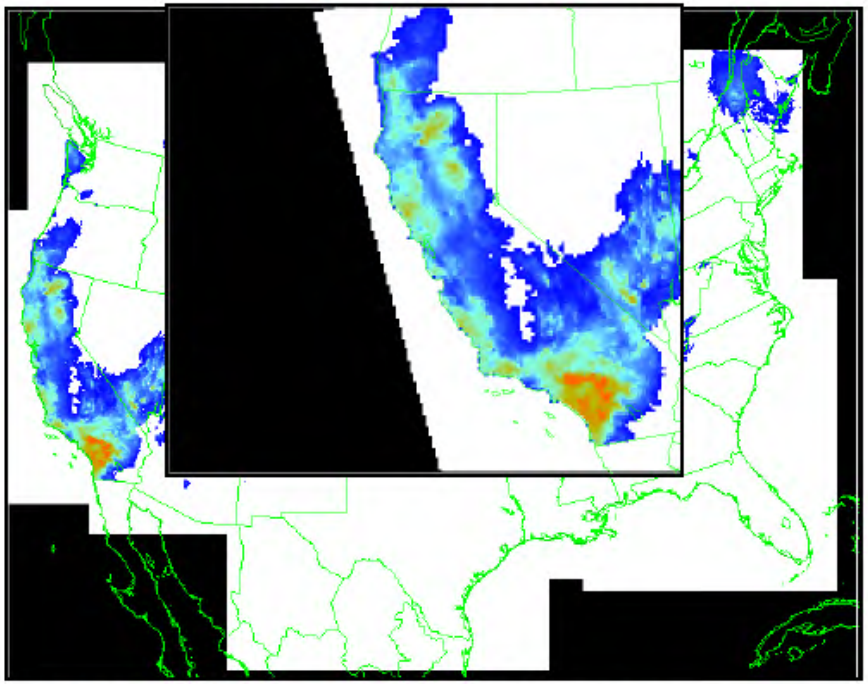
- Input Files
  - Gridded forecast and observation files
    - GRIB1 output of Unified Post-Processor (or other)
    - GRIB2 from NCEP (or other)
    - NetCDF from PCP-Combine, wrf_interp, or CF-compliant
  - ASCII configuration file
- Output Files
  - ASCII statistics file with all output lines (end with ".stat")
  - Optional ASCII files sorted by line type with a header row (ends with "_TYPE.txt")
  - Optional NetCDF matched pairs file

Grid-Stat: Common Grid

Model Forecast



StageIV Analysis

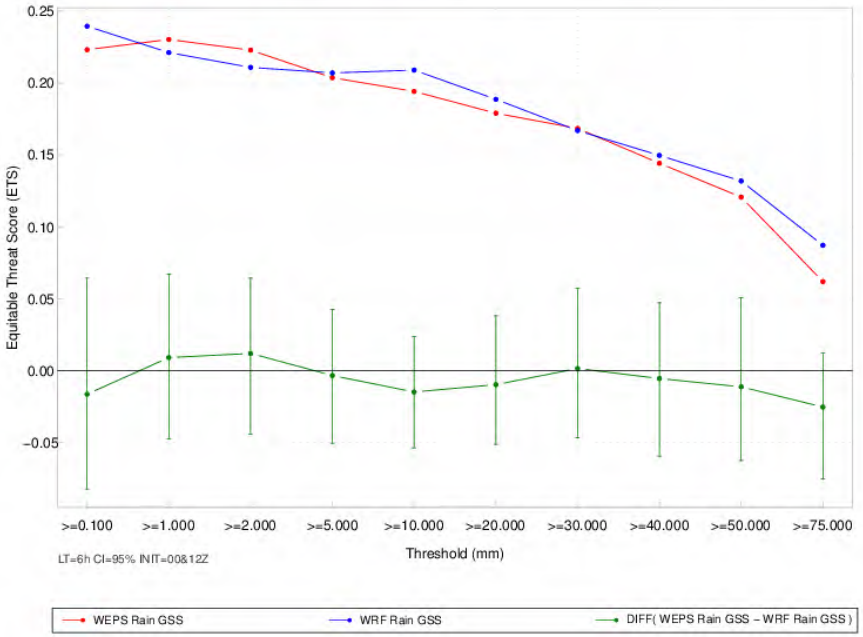


- Forecast and observations must be placed on a common grid.
- Regrid the StageIV Analysis (GRIB) to the model domain:

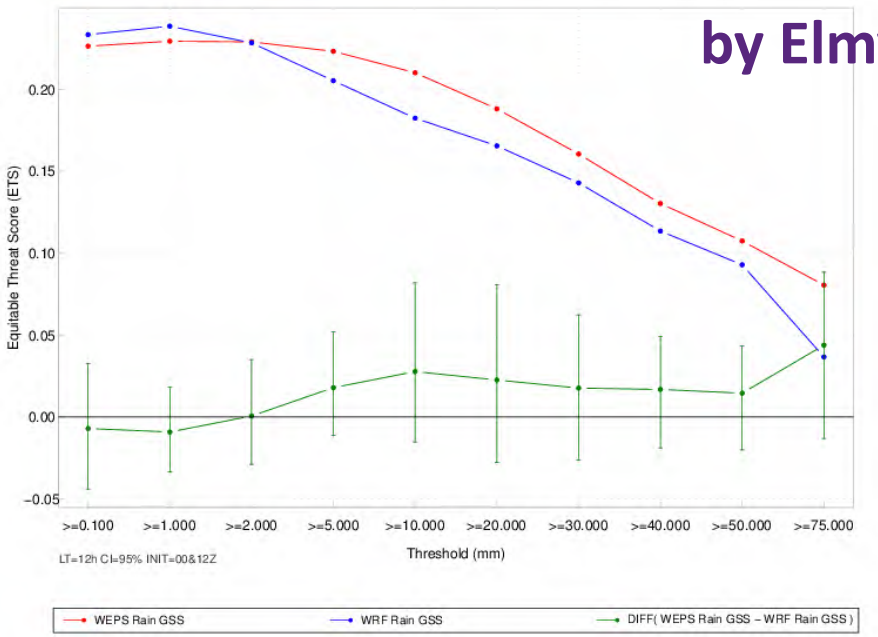
```
copygb –xg"255 5 169 154 31357 -129770 8 -120500 10395 10395 0 64" \
        ST4.2010122212.06h ST4.2010122212.06h_regrid
```

  - Practice running copygb in the practical session.
- Automated regridding in configuration file or use regrid_data_plane.

Equitable Threat Score (ETS) for 6h Forecast Lead Time

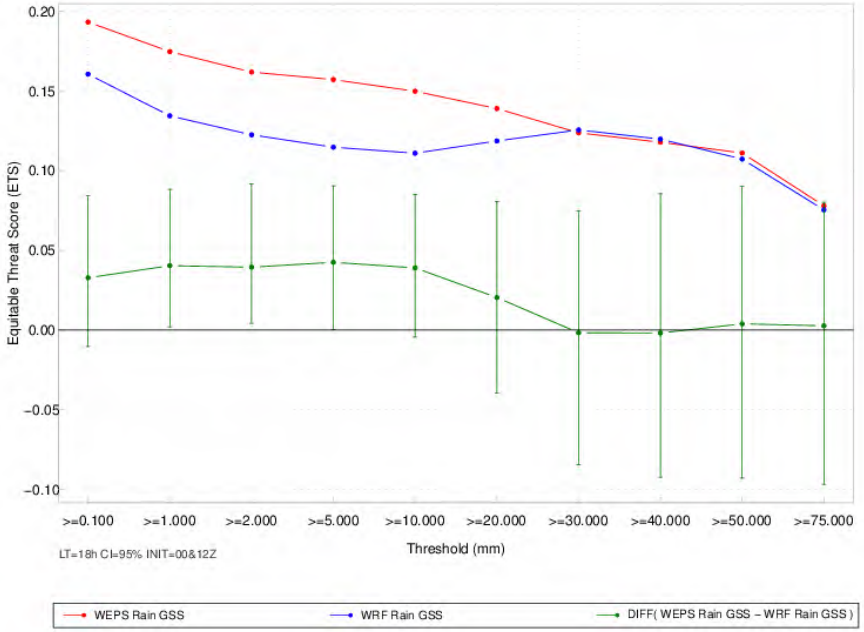


Equitable Threat Score (ETS) for 12h Forecast Lead Time

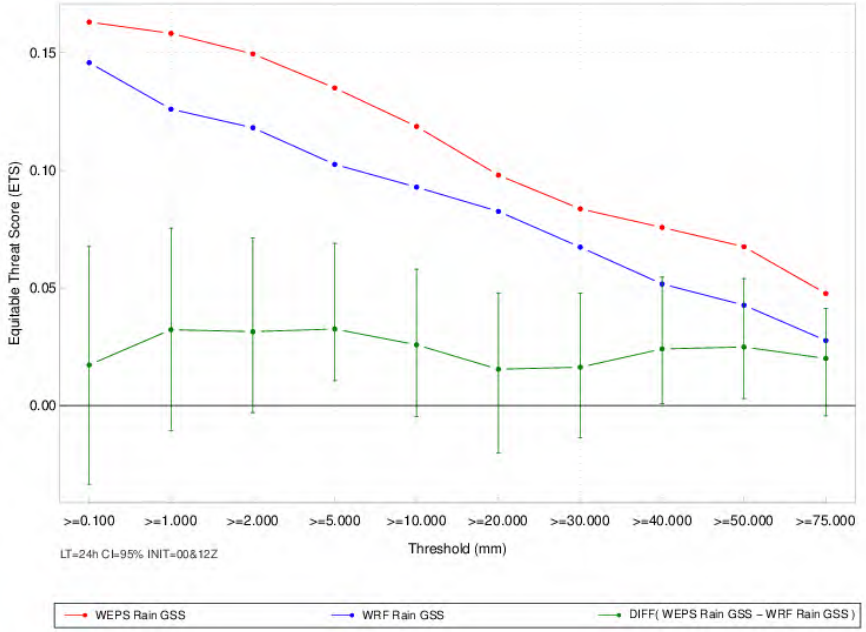


by Elmy

Equitable Threat Score (ETS) for 18h Forecast Lead Time

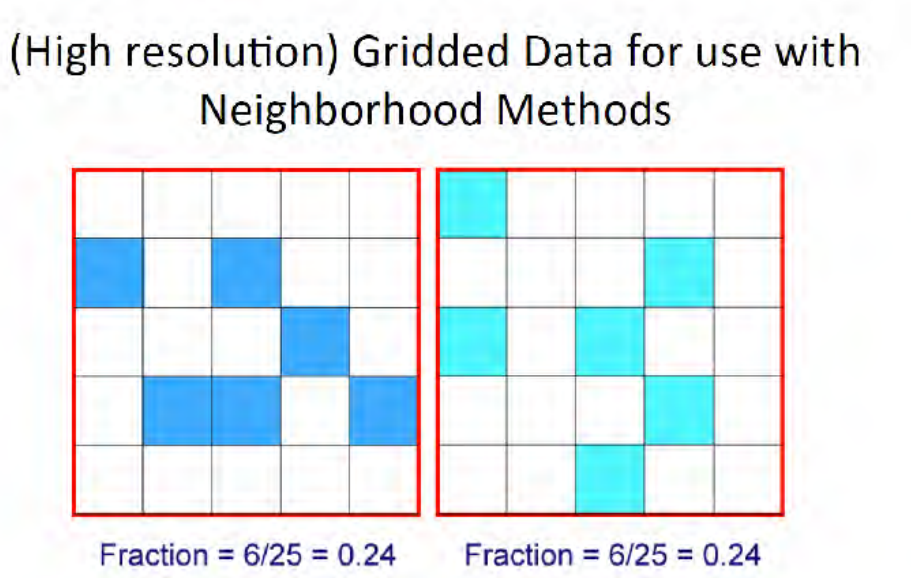


Equitable Threat Score (ETS) for 24h Forecast Lead Time



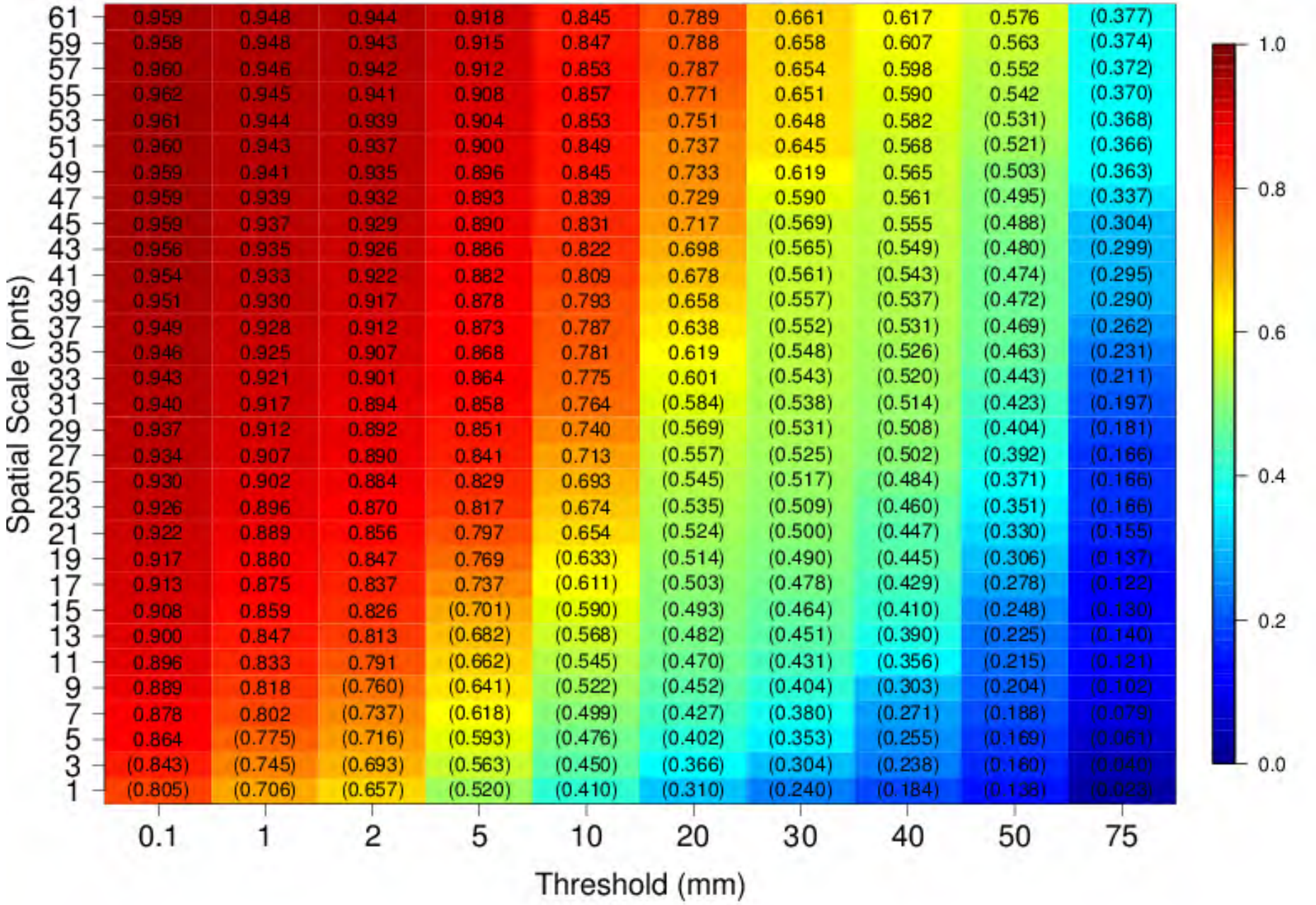
Grid-Stat: Neighborhood Continuous Statistics

- FBS
- FSS
- Asymptotic FSS
- Uniform FSS
- Forecast Rate
- Observation Rate



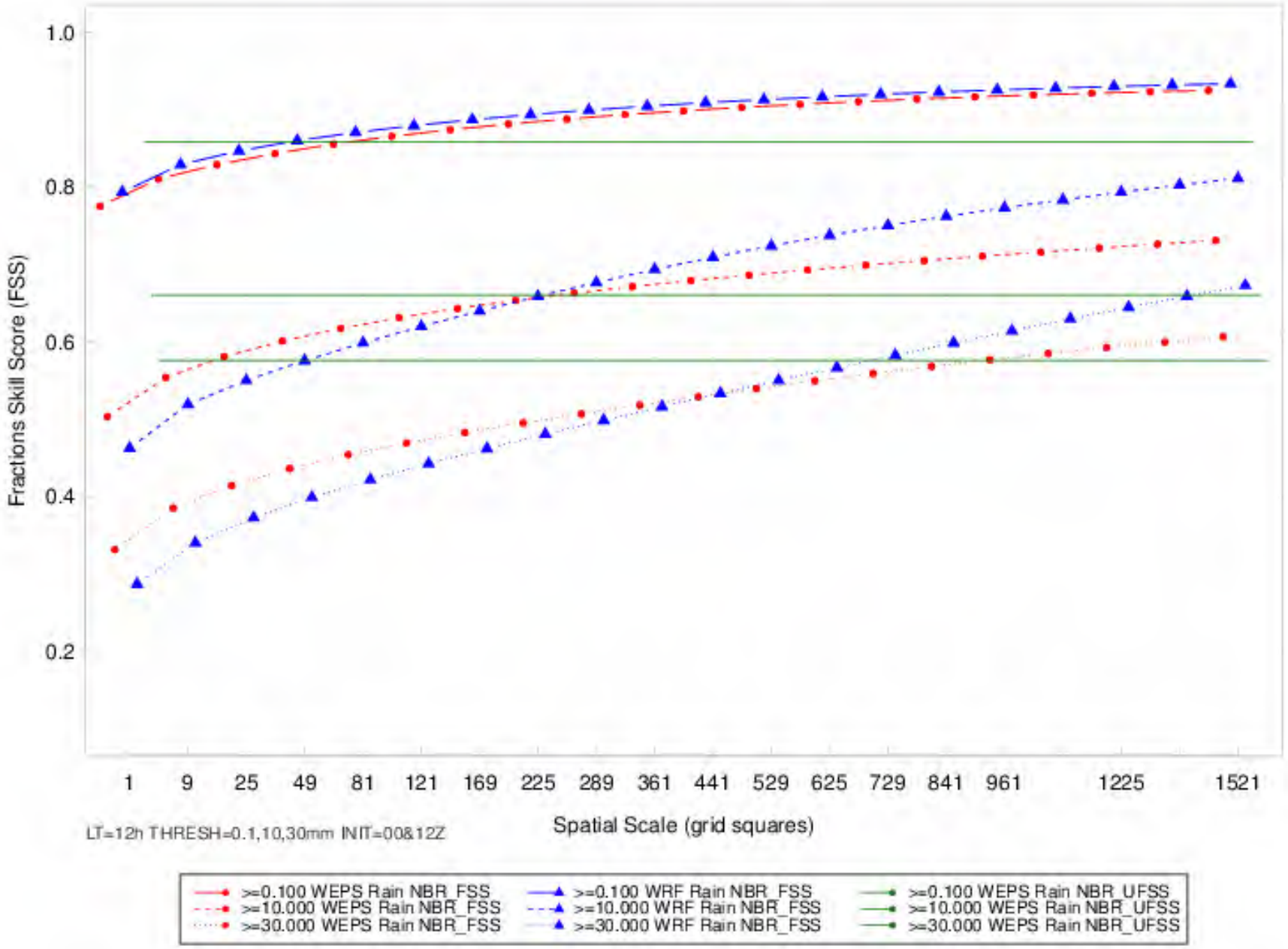
FSS for WRF, 12–hour

by Elmy



Fractions Skill Score (FSS) for 12h Forecast Lead Time

by Elmy

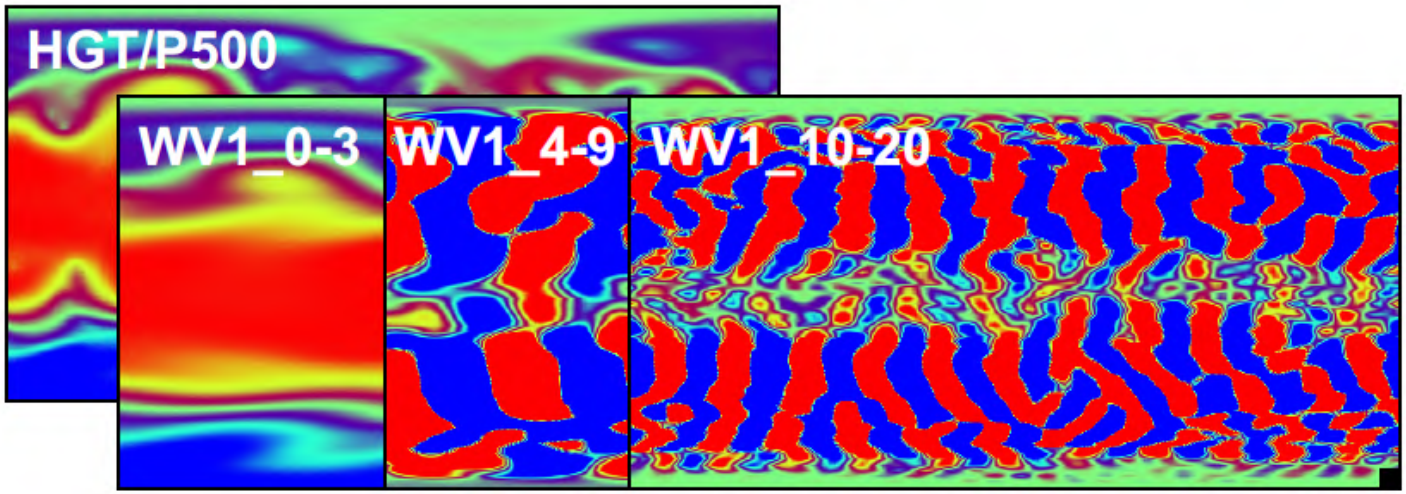


Grid-Stat: Fourier Decomposition

- Added support to Grid-Stat for 1-Dimensional Fourier decompositions.
- Affects output for CNT, SL1L2, SAL1L2, VL1L2, and VAL1L2 line types.
- Configuration file option to specify the waves:

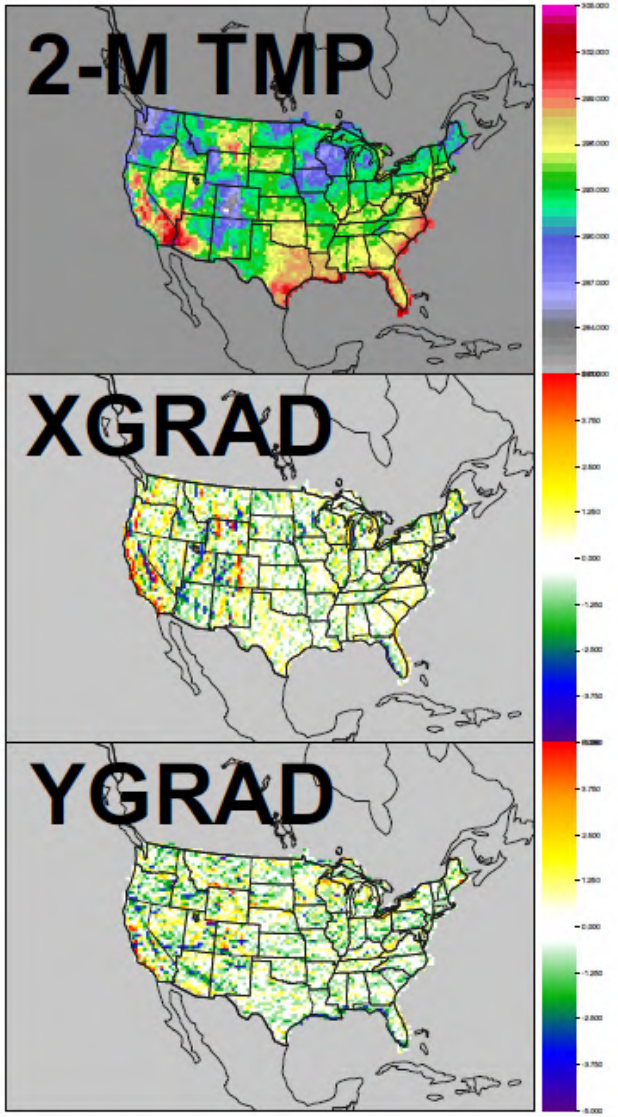
```
fourier = {
  wave_1d_beg = [  0, 0, 4, 10 ];
  wave_1d_end = [ 72, 3, 9, 20 ];
}
```

- Wave numbers indicated in the **INTERP_MTHD** column:
  - **WV1_0-72**
  - **WV1_0-3**
  - **WV1_4-9**
  - **WV1_10-20**



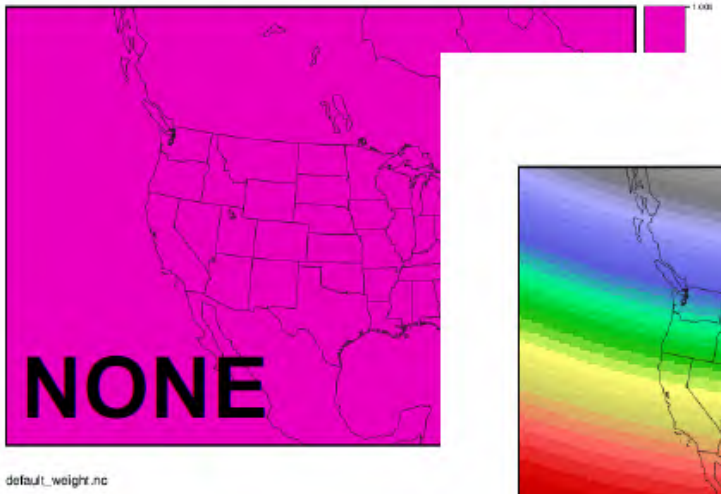
Grid-Stat: Gradients

- **GRAD** line type contains the S1 score and its components.
  - WMO-mandated statistic from 1954.
  - Computed over the gradients of forecast and observation fields computed in the X and Y grid direction.
  - Adapted from VSDB code:
    - FGBAR: mean forecast gradient
    - OGBAR: observed gradient
    - MGBAR: mean of maximum gradient
    - EGBAR: mean of gradient differences
    - S1 = 100 * EGBAR / MGBAR
    - S1_OG = 100 * EGBAR / OGBAR
    - FGOG_RATIO = FGBAR / OGBAR

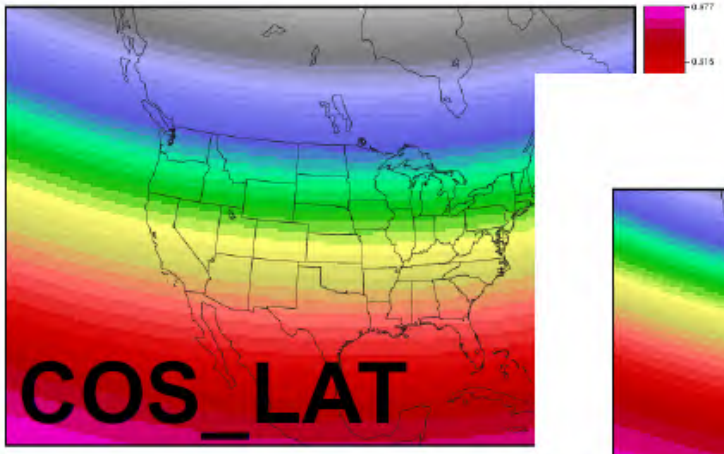


Grid-Stat: Grid Weighting

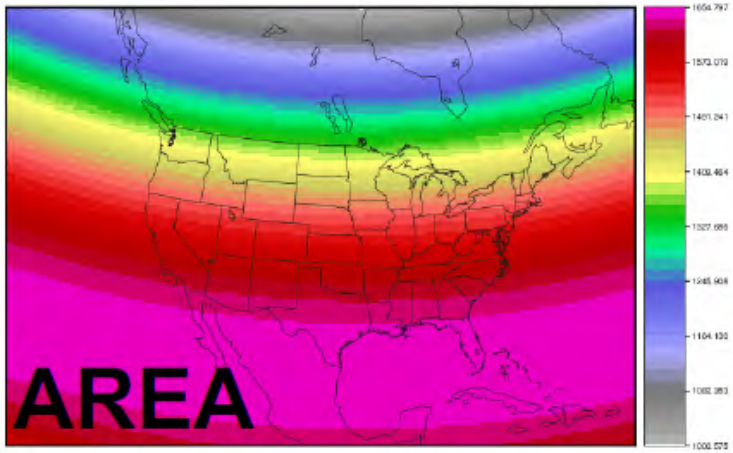
```
// The "grid_weight_flag" specifies how grid weighting should be applied…
//    - "NONE" to disable grid weighting using a constant weight (default).
//    - "COS_LAT" to define the weight as the cosine of the grid point latitude.
//      This an approximation for grid box area used by NCEP and WMO.
//    - "AREA" to define the weight as the true area of the grid box (km^2).
grid_weight_flag = NONE;
```



default_weight.nc



cos_lat_weight.nc

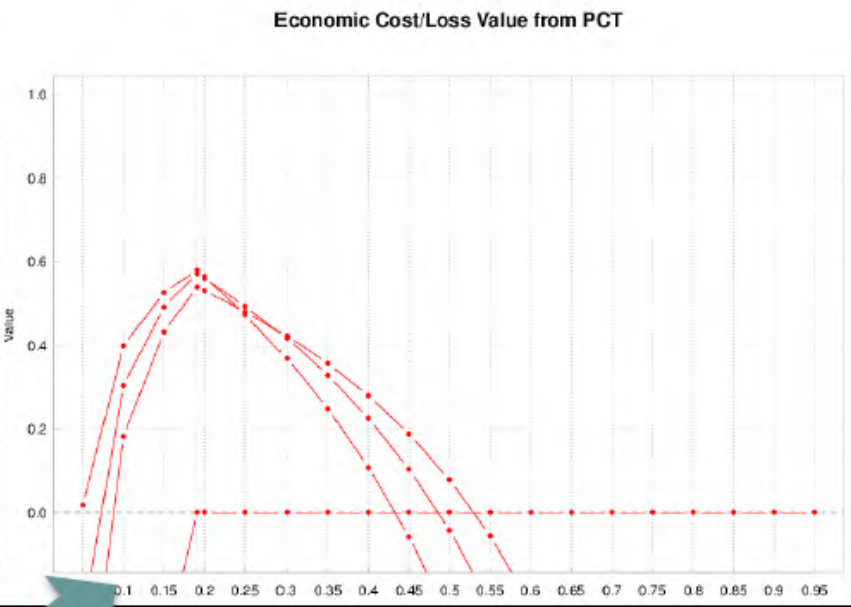


true_area_weight.nc

Economic Cost/Loss Value

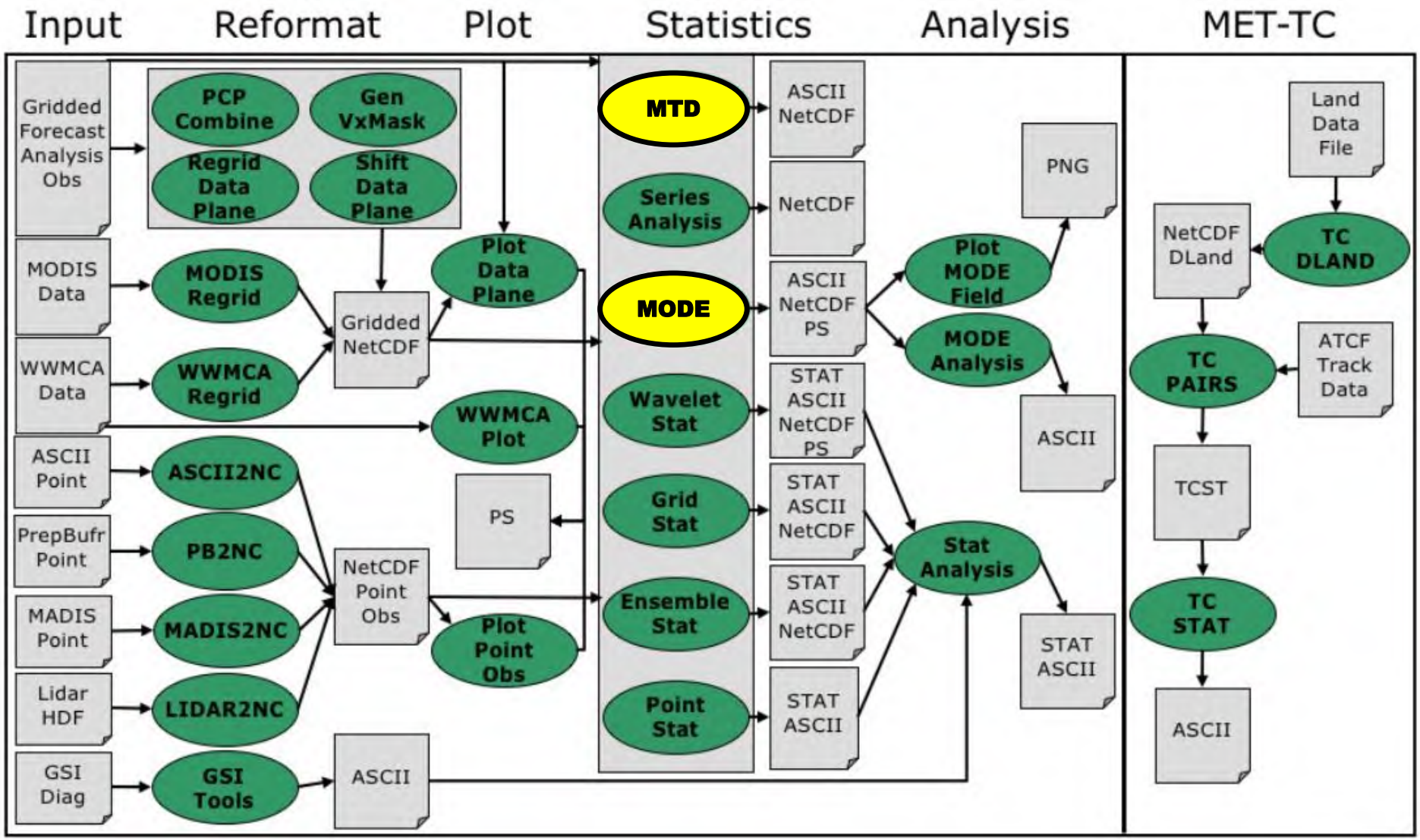
- Grid-Stat, Point-Stat, and Stat-Analysis can output the ECLV line type.
- Equivalent to the VSDB ECON line type, except…
  - ECON is only generated when evaluating ensemble probabilities.
  - ECLV from 2x2 CTC contingency table yields a single curve.
  - ECLV from Nx2 PCT probabilistic contingency table yields N curves.
- One ECLV line equals one curve on the plot.
  - Undefined at 0 and 1.
  - Maximized for the base rate.

Forecast	Observation		Total
	o = 1 (e.g., "Yes")	o = 0 (e.g., "No")	
p_1 = midpoint of (0 and threshold1)	n_{11}	n_{10}	$n_{1\cdot} = n_{11} + n_{10}$
p_2 = midpoint of (threshold1 and threshold2)	n_{21}	n_{20}	$n_{2\cdot} = n_{21} + n_{20}$
⋮	⋮	⋮	⋮
p_i = midpoint of (threshold$i$ and 1)	n_{i1}	n_{i0}	$n_{i\cdot} = n_{i1} + n_{i0}$
Total	$n_{\cdot 1} = \Sigma n_{i1}$	$n_{\cdot 0} = \Sigma n_{i0}$	$T = \Sigma n_i$

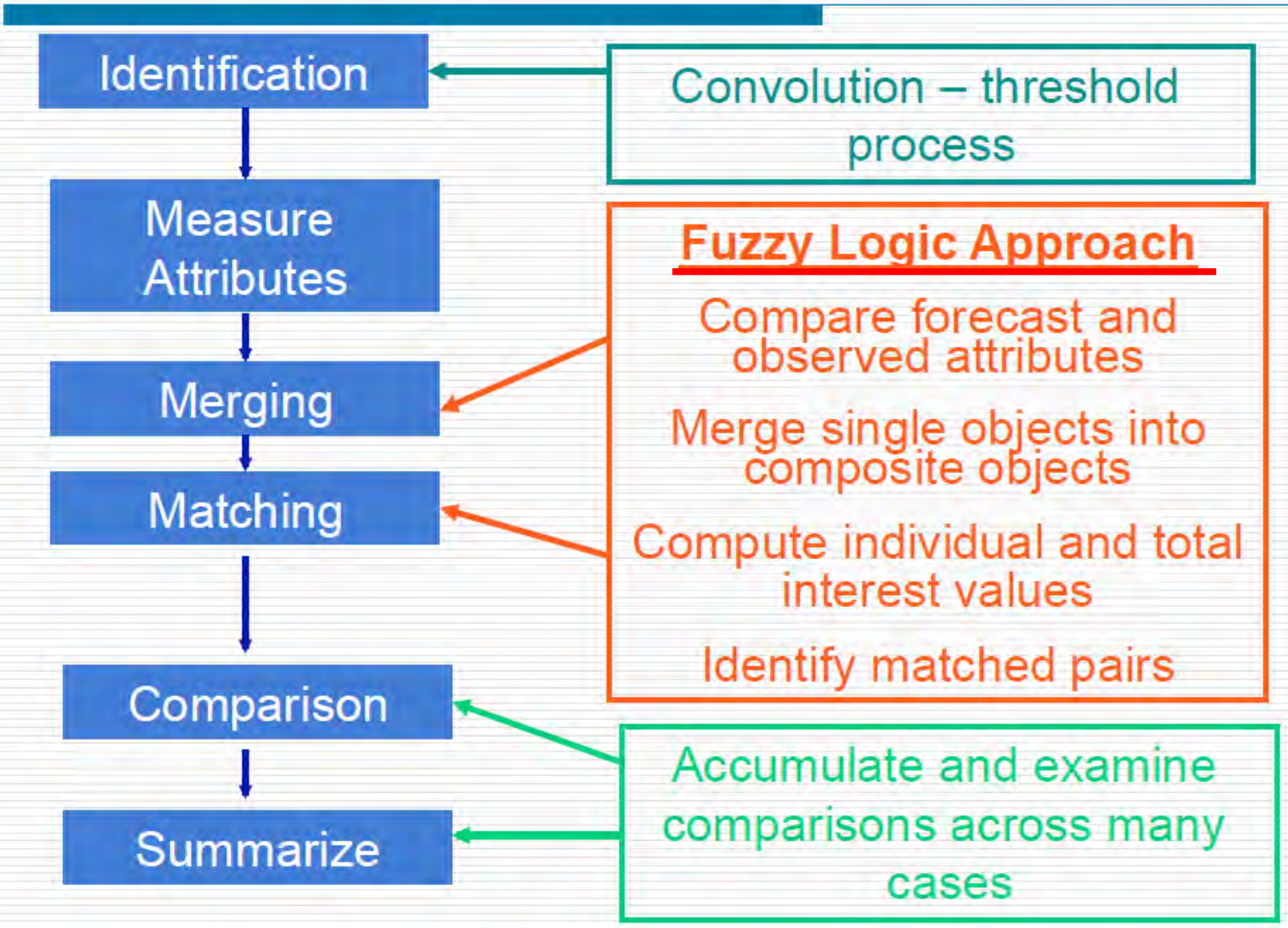



```
eclv_points = 0.05; // 0 to 1 every 0.05
eclv_points = [ 0.1, 0.2, 0.3, 0.4, 0.5, 0.65, 0.8, 0.95 ]; // non-equal
```

MODE

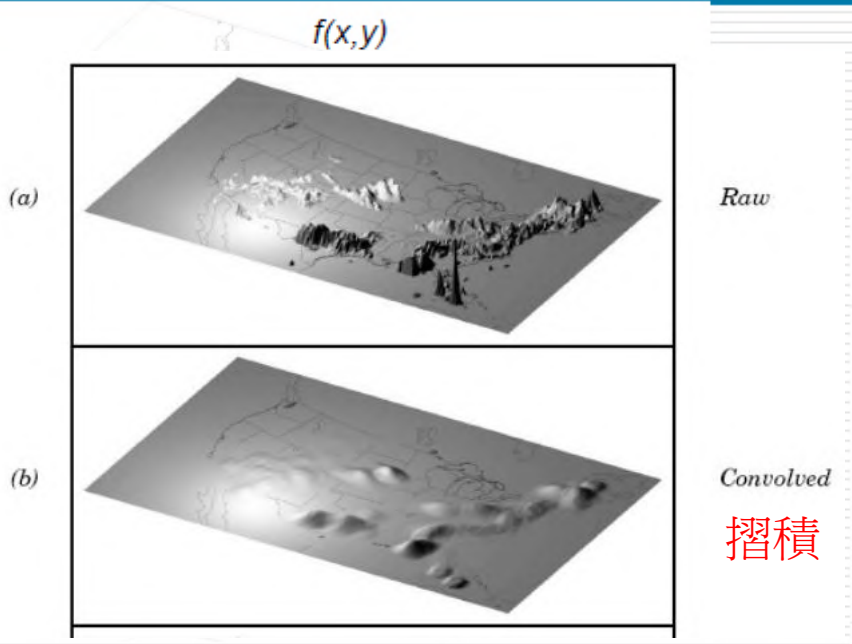

Input
Reformat
Plot
Statistics
Analysis
MET-TC
Gridded Forecast Analysis Obs
MODIS Data
WWMCA Data
ASCII Point
PrepBufr Point
MADIS Point
Lidar HDF
GSI Diag
PCP Combine
Gen VxMask
Regrid Data Plane
Shift Data Plane
MODIS Regrid
WWMCA Regrid
ASCII2NC
PB2NC
MADIS2NC
LIDAR2NC
GSI Tools
Gridded NetCDF
NetCDF Point Obs
ASCII
Plot Data Plane
WWMCA Plot
PS
Plot Point Obs
MTD
Series Analysis
MODE
Wavelet Stat
Grid Stat
Ensemble Stat
Point Stat
ASCII NetCDF
NetCDF
ASCII NetCDF PS
STAT ASCII NetCDF PS
STAT ASCII NetCDF
STAT ASCII NetCDF
STAT ASCII
Plot MODE Field
MODE Analysis
Stat Analysis
PNG
ASCII
STAT ASCII
Land Data File
NetCDF DLand
TC DLAND
TC PAIRS
ATCF Track Data
TCST
TC STAT
ASCII

MODE: Object-based approach



(E. Gilleland et al. 2007)

Object identification



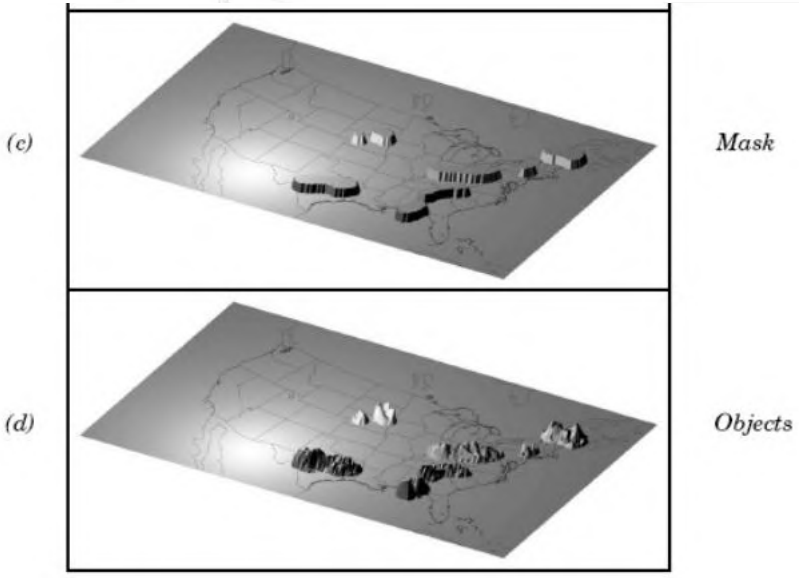
摺積

$$g(x,y) = \sum_{(u,v)\in G} \phi(u,v)\, f(x-u, y-v)$$

$$\phi(x,y) = \begin{cases} H & \text{if } x^2 + y^2 \le R^2 \\ 0 & \text{otherwise} \end{cases}$$

$$\pi R^2 H = 1.$$

$$h(x,y) = \begin{cases} 1 & \text{if } g(x,y) \ge T \\ 0 & \text{otherwise} \end{cases}$$

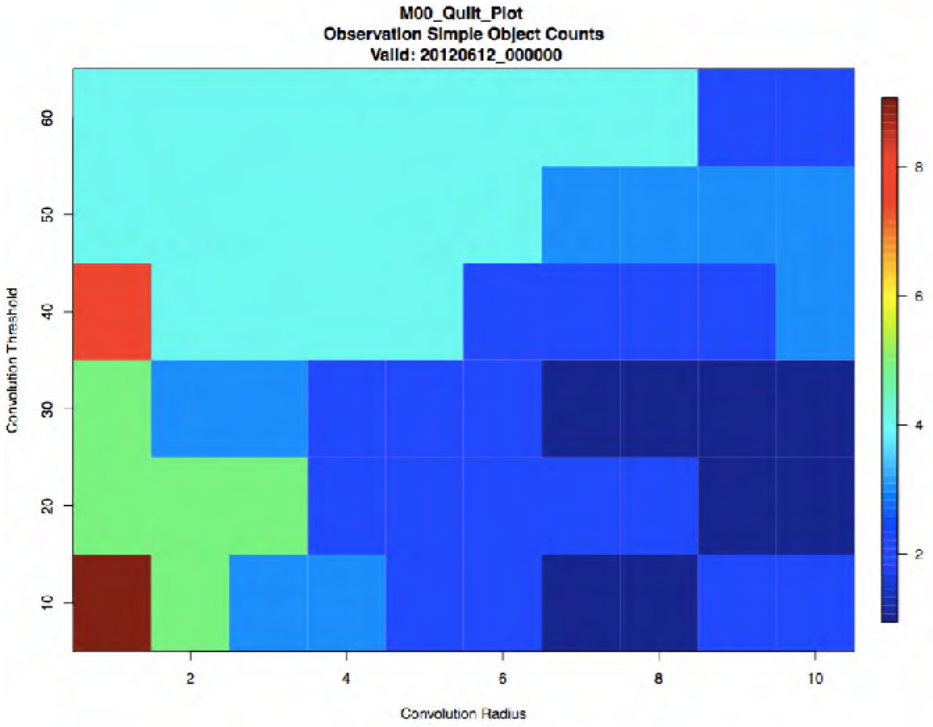


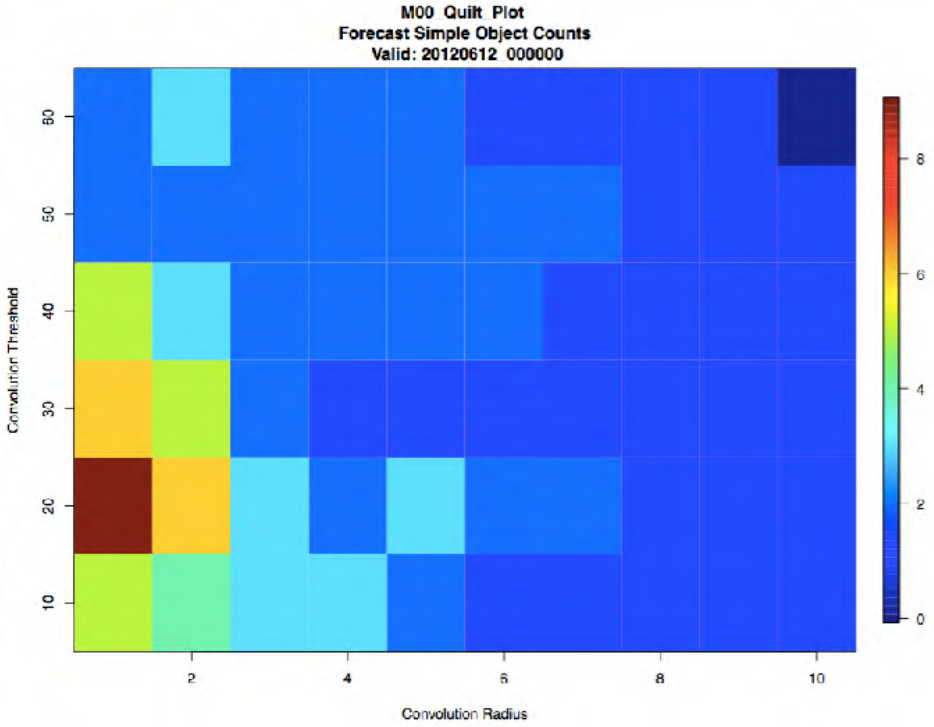
Restore original field where h(x,y) =1

2 parameters:

1. Convolution radius (R)
2. Threshold (T)

WRF Quilt Plot Example





by Elmy

Object Attributes

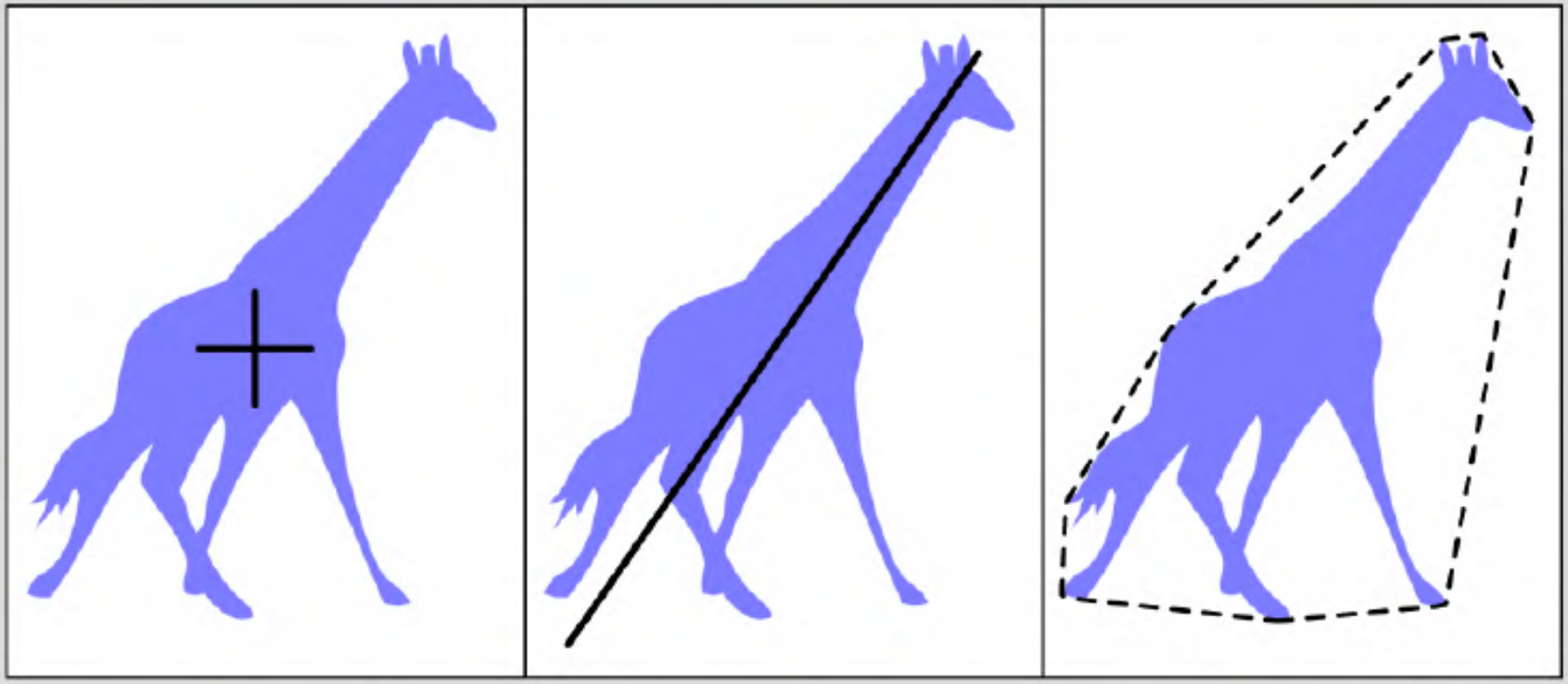
Single:

- Area
- Centroid
- Axis Angle
- Median Intensity
- Complexity
- Aspect Ratio
- Curvature

Pair:

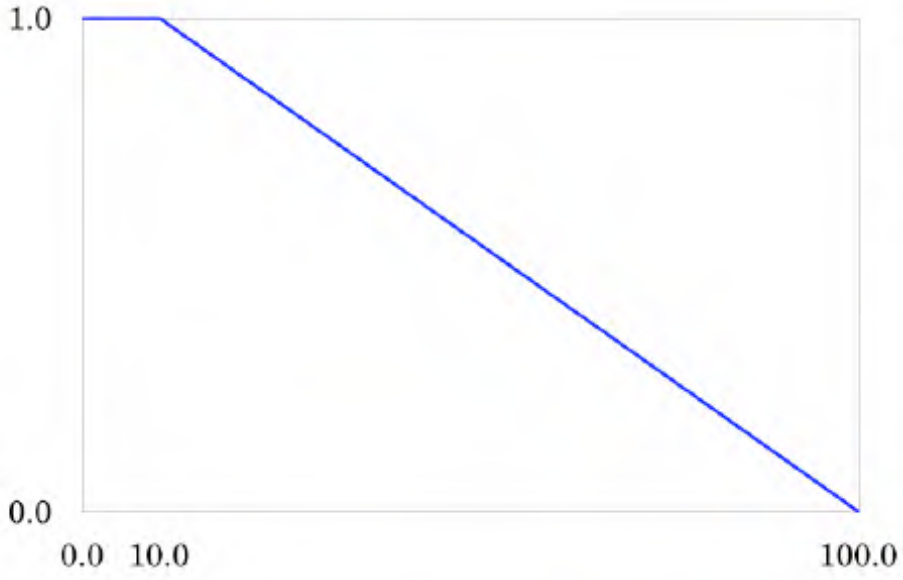
- Centroid Distance
- Angle Difference
- Median Intensity Ratio
- Intersection Area
- Convex Hull Distance
- Boundary Distance
- Area Ratio

Example Single Attributes



Centroid Axis Convex Hull

Fuzzy Logic: Interest Maps



X	Y
0.0	1.0
10.0	1.0
100.0	0.0

Total Interest

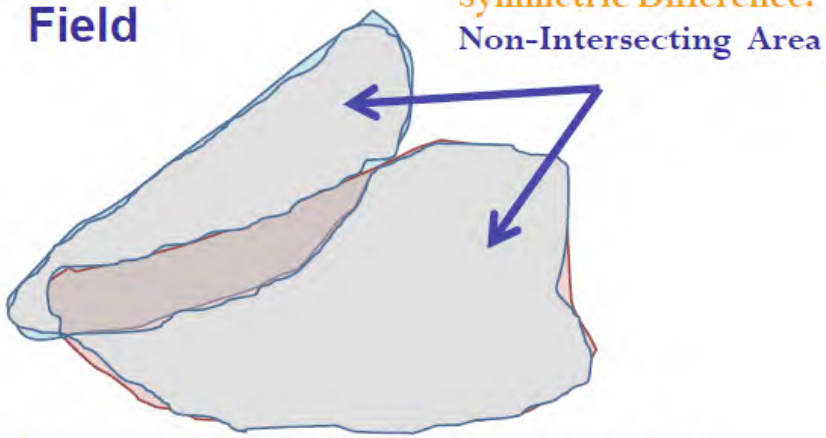
Calculated from weights, attributes, and interest maps.

$$T(\alpha) = \frac{\sum_i w_i \, C_i(\alpha) \, I_i(\alpha_i)}{\sum_i w_i \, C_i(\alpha)}$$

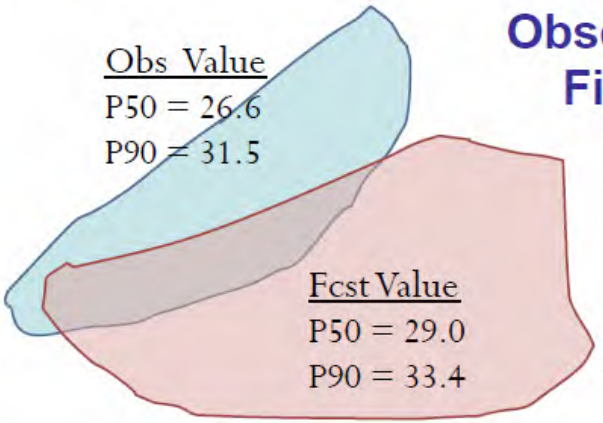
Use of Pair Attributes defined by MODE

Forecast Field

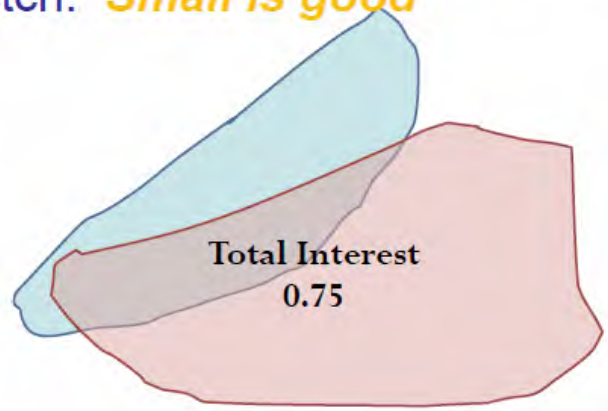
Observed Field



Symmetric Diff: May be a good summary statistic for how well Forecast and Observed objects match. ***Small is good***



P50 | P90 Int: Provides objective measures of Median (50th percentile) and near-Peak (90th percentile) intensities found in objects. ***Ratio close To 1 is good***

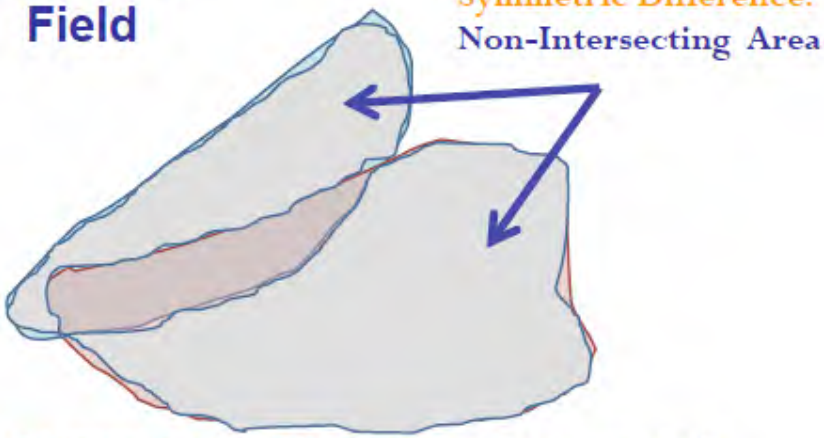


Total Interest: Summary statistic derived from fuzzy logic engine with user-defined Interest Maps for all these attributes plus some others. ***Close to 1 is good***

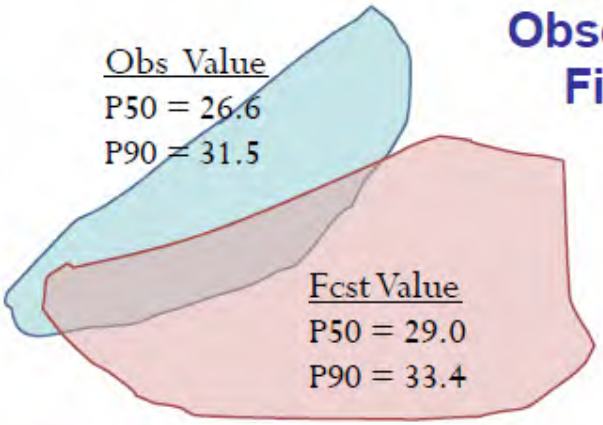
Use of Pair Attributes defined by MODE

Forecast Field

Observed Field

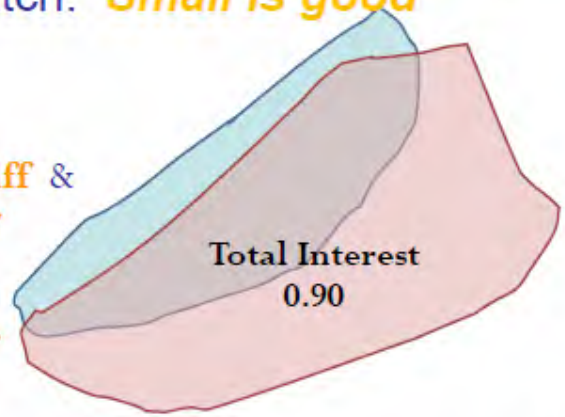


Symmetric Diff: May be a good summary statistic for how well Forecast and Observed objects match. ***Small is good***



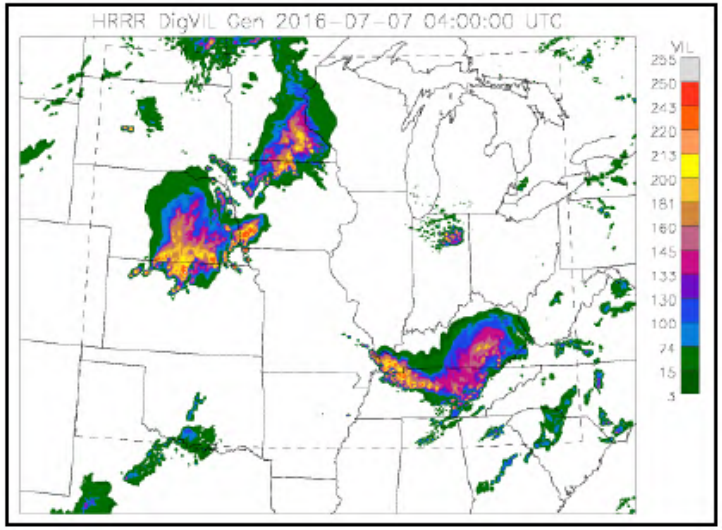
P50 | P90 Int: Provides objective measures of Median (50th percentile) and near-Peak (90th percentile) intensities found in objects. ***Ratio close To 1 is good***

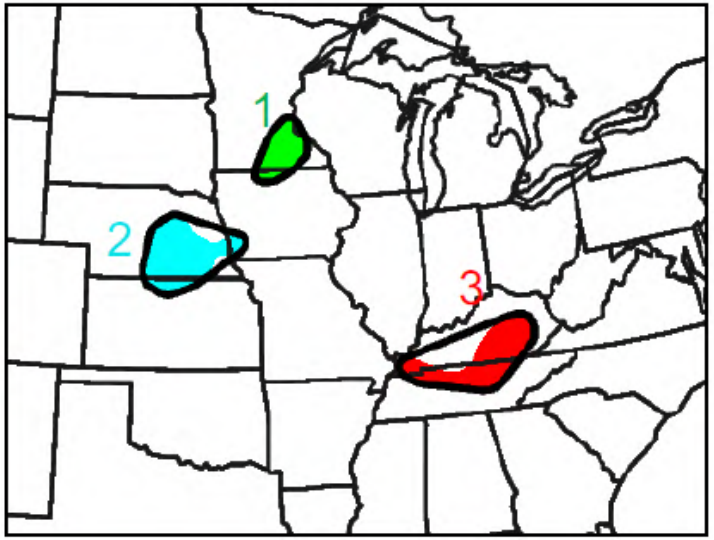
Angle_diff & Sym_diff less so Total Int. higher



Total Interest: Summary statistic derived from fuzzy logic engine with user-defined Interest Maps for all these attributes plus some others. ***Close to 1 is good***

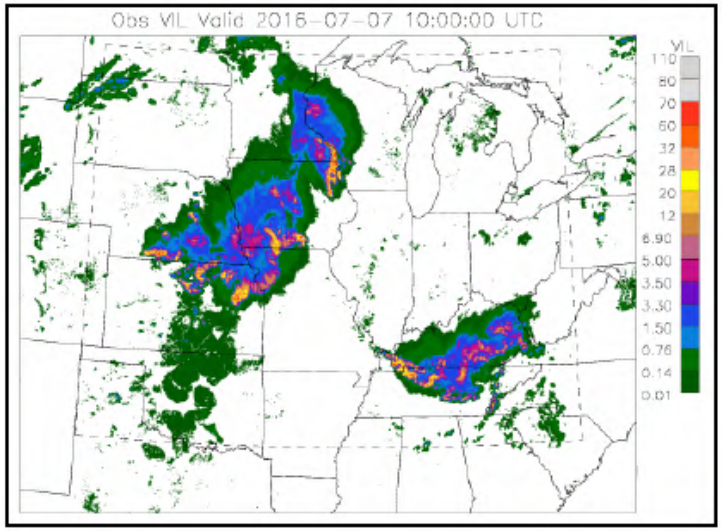
MODE Example: Traditional

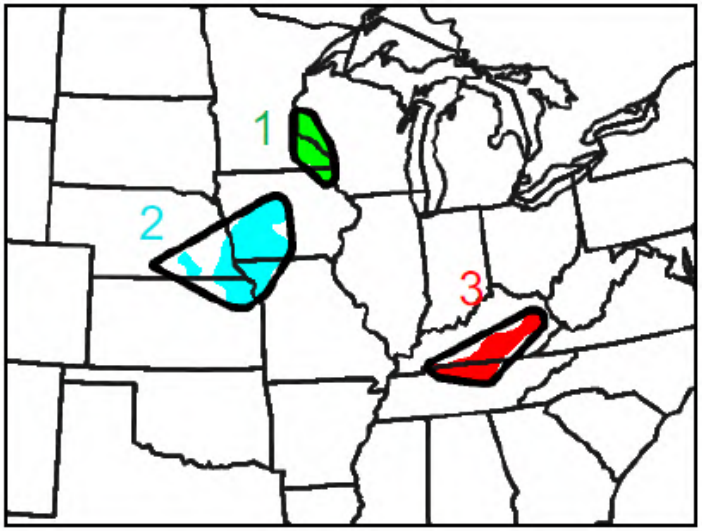




Object #3

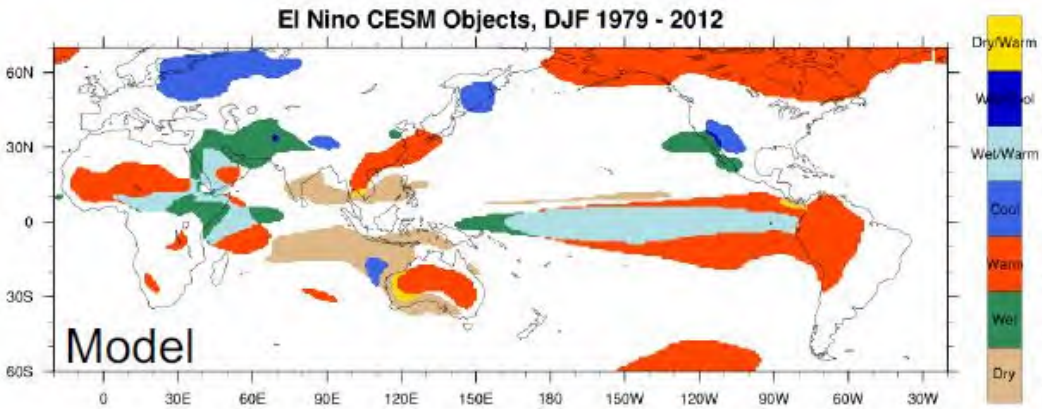
Fcst Area: 6302
Obs Area: 4020
Centroid Dist: 12.4
Int Area: 3189
Interest: 0.98

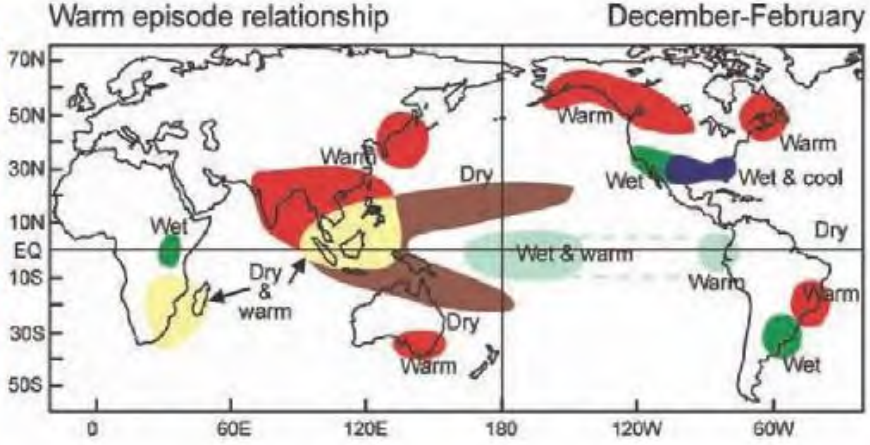


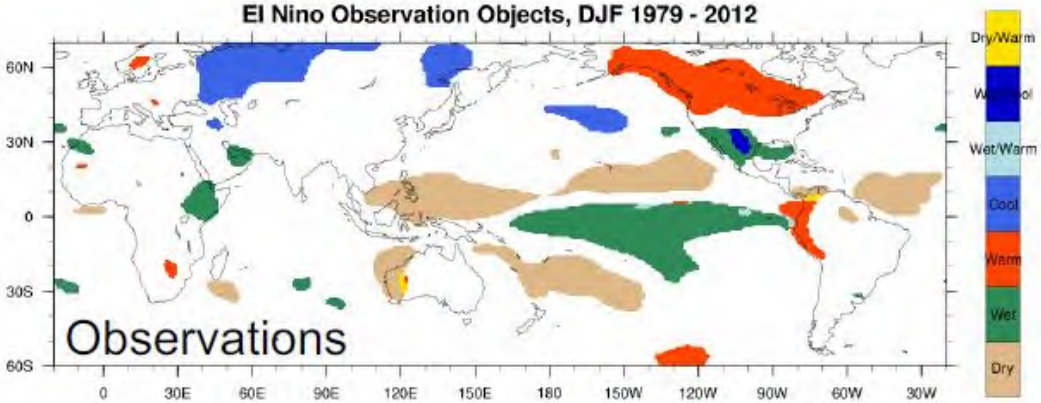


No False alarms or misses

MODE Example: El Nino Climate

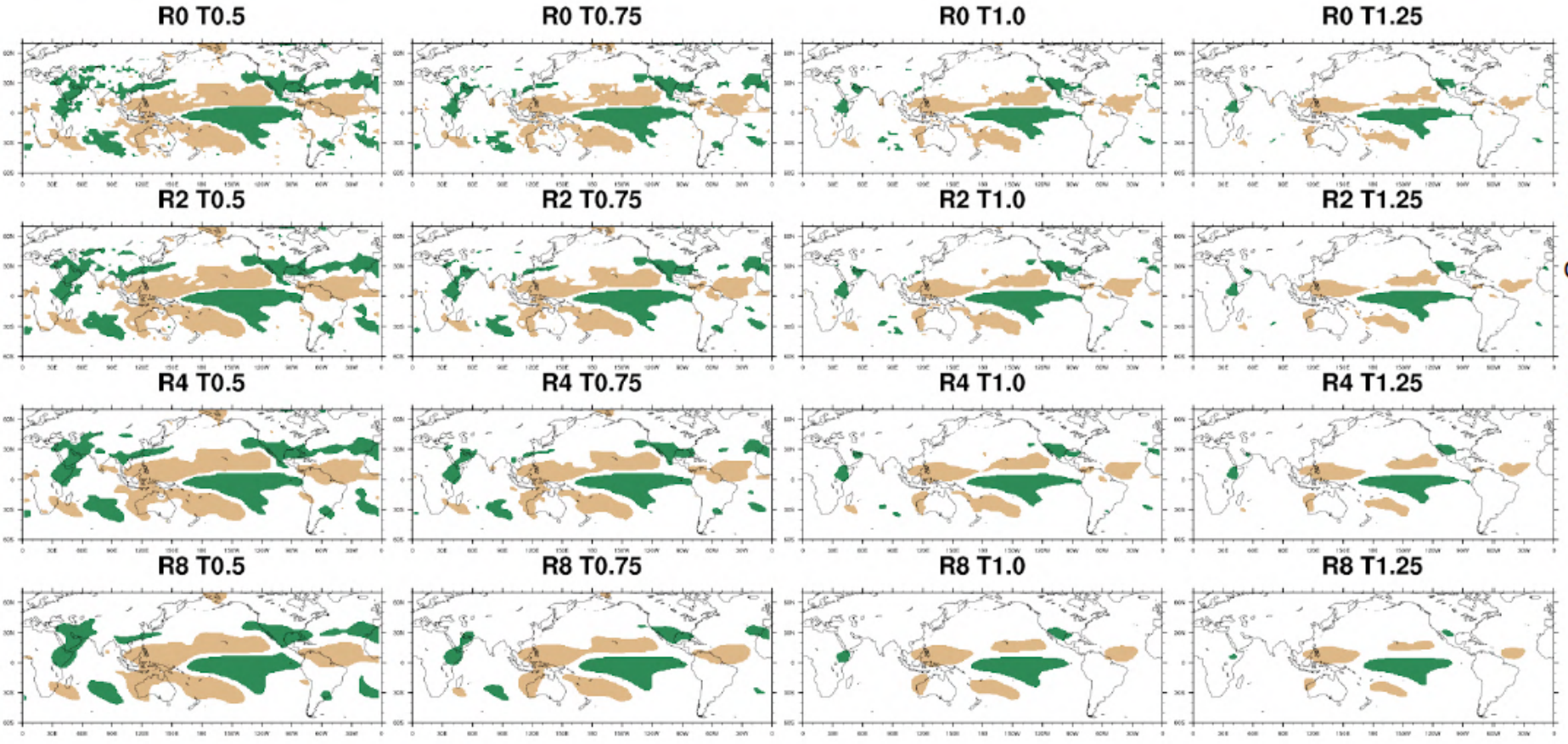






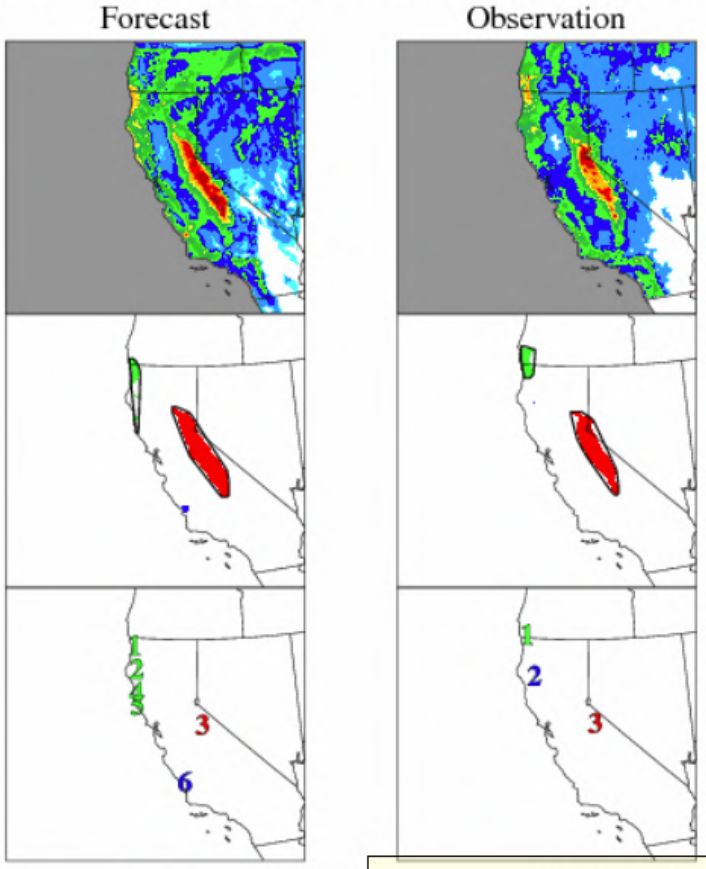
- Not individual forecasts
- Quantify differences in each anomaly type separately

Effect of Radius and Threshold



Page 1 of PostScript

MODE: APCP_24_A24_ENS_MEAN at A24 vs APCP_24 at A2



object pictures

Fcst	Obs	Interest
3	3	1.0000
1	1	0.9360
2	2	0.6436
5	2	0.6372
4	2	0.5085
2	1	0.4060
1	2	0.3871
4	1	0.3545
3	1	0.3422
6	3	0.3265
1	3	0.3141
4	3	0.2813
3	2	0.2719
2	3	0.2704
5	1	0.2406
5	3	0.2266
6	1	0.2203
6	2	0.1936

Total Interest of object pairs

Pairs above dashed line have high enough Interest to be processed further

Field names model description

	Forecast	Observation
Model:	hmt-ens-d01	
Field:	APCP_24_A24_ENS_MEAN	
Level:	A24	A24
Units:	kg/m^2	kg/m^2
Initial:	20110216 12:00:00	20110216 12:00:00
Valid:	20110217 12:00:00	20110217 12:00:00
Accum:	24:00:00	24:00:00

	Forecast	Observation
Mask M/G/P:	on/off/off	on/off/off
Raw Thresh:	>=0.00	>=0.00
Conv Radius:	2 gs	2 gs
Conv Thresh:	>=25.40	>=25.40
Area Thresh:	>=0 gs	>=0 gs
Inten Thresh:	p100>=0.00	p100>=0.00
Merge Thresh:	>=20.00	>=20.00
Merging:	thresh	thresh
Matching:	match/merge	
Simple/M/U:	6/5/1	3/2/1
Area:	696 gs	589 gs
Area M/U:	674/22	585/4
Cluster:	2	2
MMI:	0.6404	0.9360
MMI (F+O):	0.6436	

Weight of object attributes

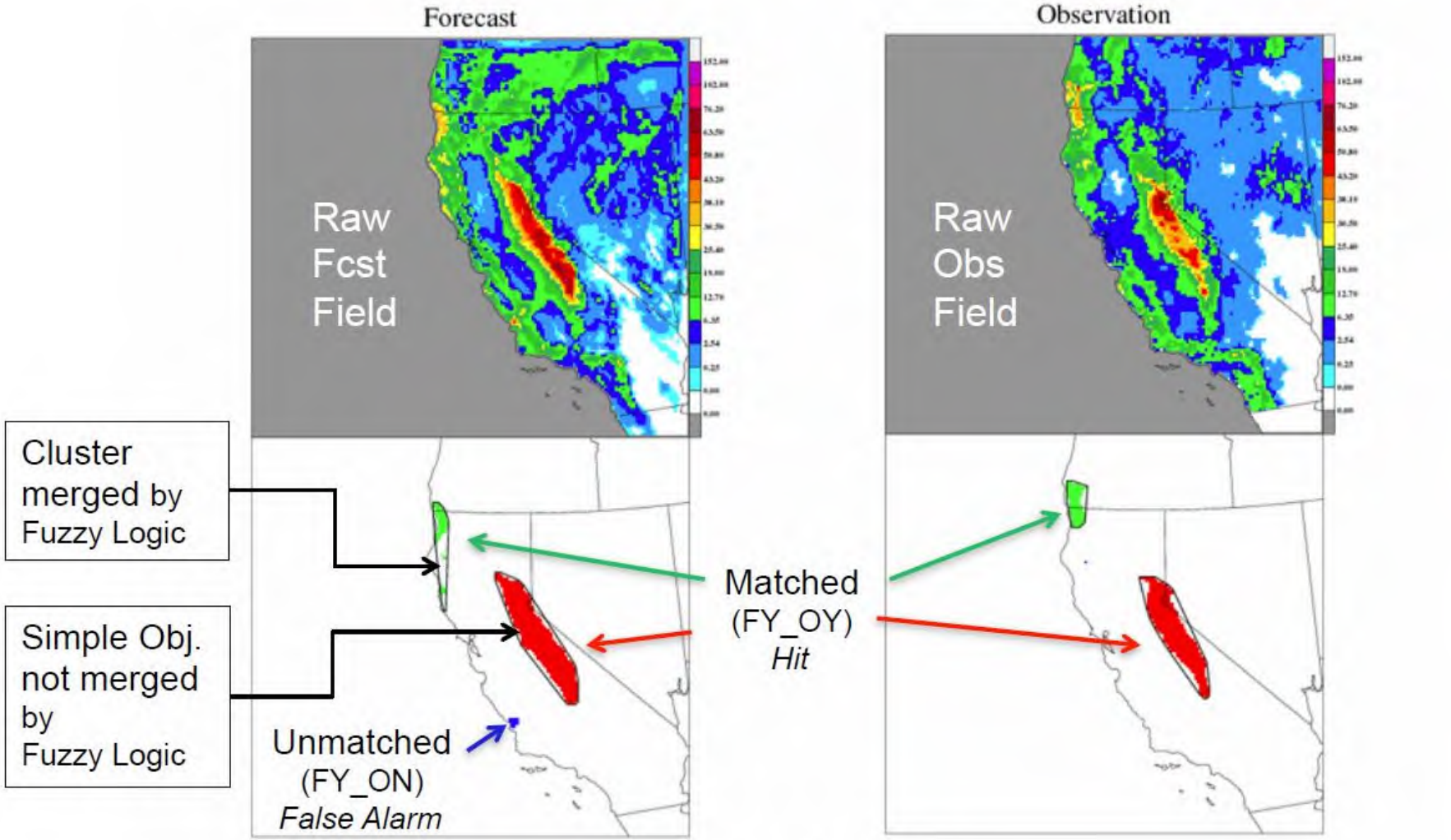
Centroid/Boundary:	2.00	4.00
Convex Hull/Angle:	0.00	1.00
Area/Intersection Area:	4.00	4.00
Complexity/Intensity:	0.00	2.00
Total Interest Thresh:	0.70	

Definition of objects

- smoothing radius
- intensity threshold
- area threshold
- matching and/or merging
- # and area of objects
- **M**edian **M**ax. **I**nterest (**MMI**)

Page 2 and 3 of PostScript:

- Band shows which Simple Objects are merged (aka Cluster)
- Colors show matching between Fcst and Obs.

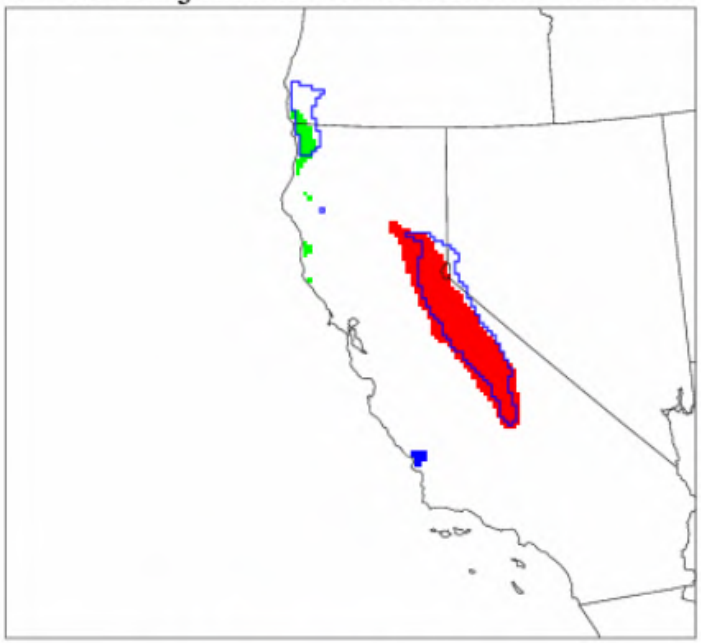


Page 4 of PostScript

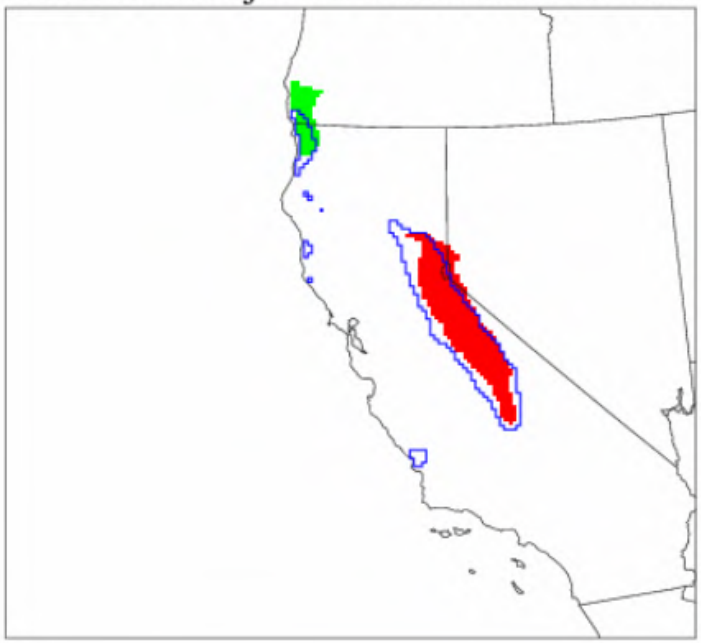
Objects overlapped
In two different views…

Which do you prefer?

Forecast Objects with Observation Outlines

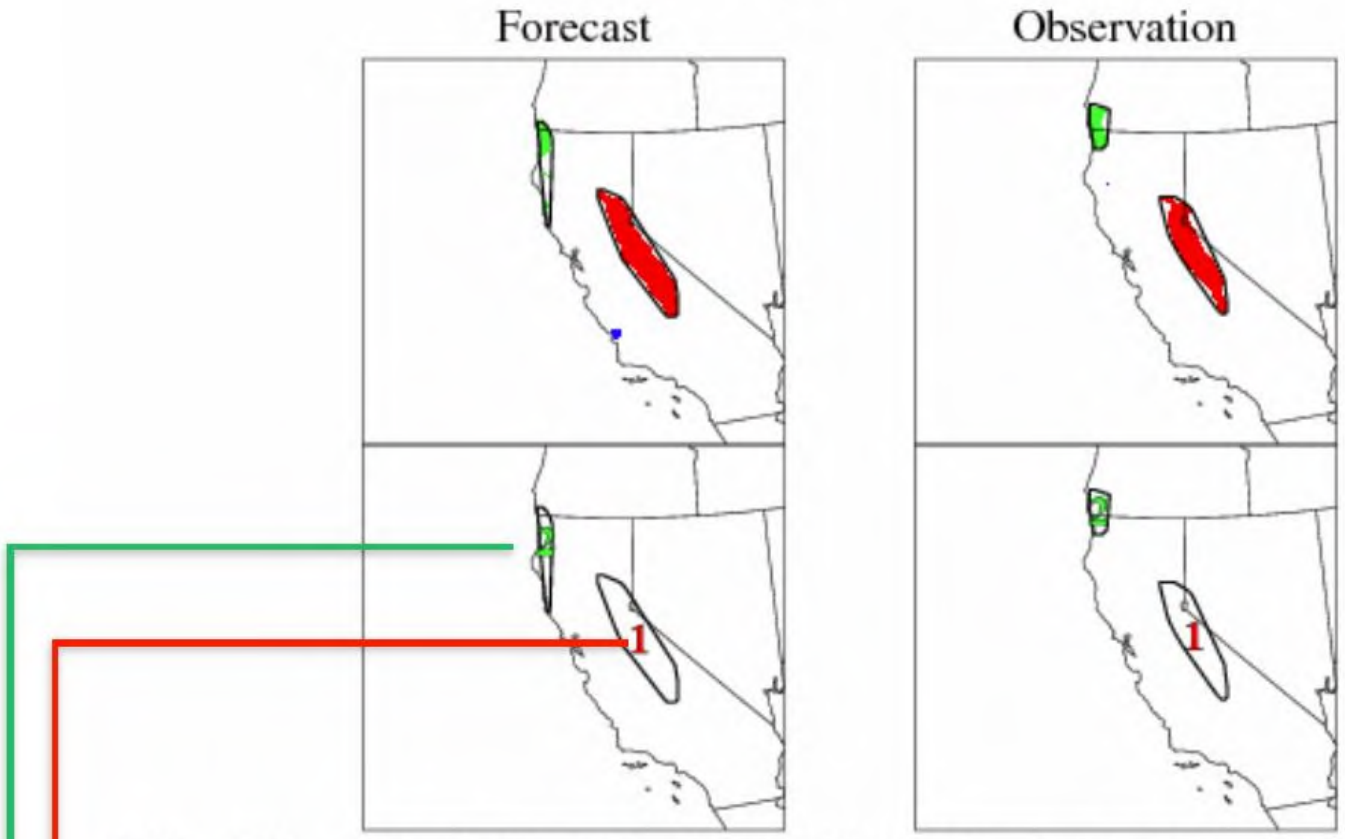


Observation Objects with Forecast Outlines



Page 5 of PostScript - Summary information for clusters in the domain

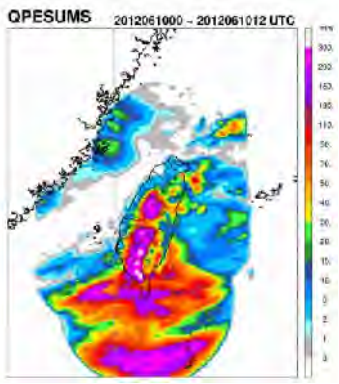
Cluster Object Information



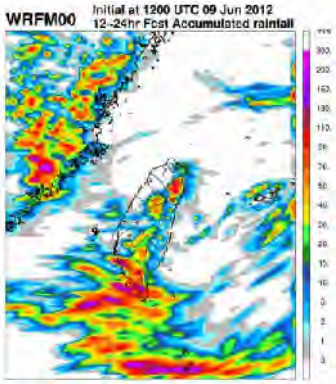
CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYM DIFF	FCST INT50	OBS INT50	FCST INT90	OBS INT90	TOT INTR
1	1.51	3.65	579	466	418	627	209	39.89	34.95	56.20	49.70	1.0000
2	11.94	2.59	95	119	53	161	108	27.56	27.40	34.28	36.42	0.9909

MODE applied to TW Rain Example

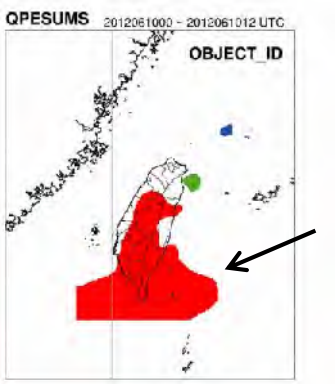
OBS



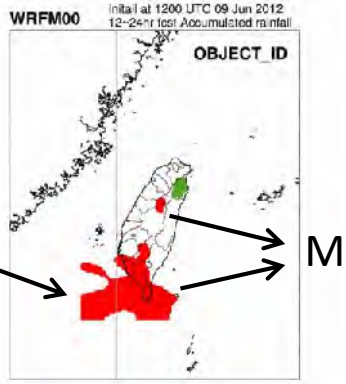
FCST



Matched Object 1
Matched Object 2
Unmatched Object

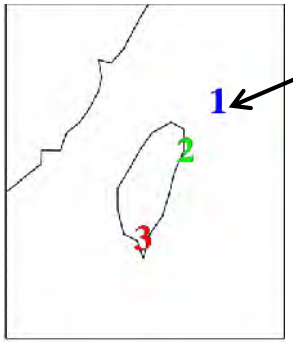


Matching

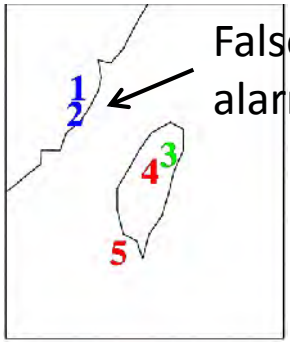


Merging

Fcst	Obs	Interest
5	3	0.9273
4	3	0.8662
3	2	0.7979



Misses



False alarms

by Elmy

FCST matched object

by Elmy

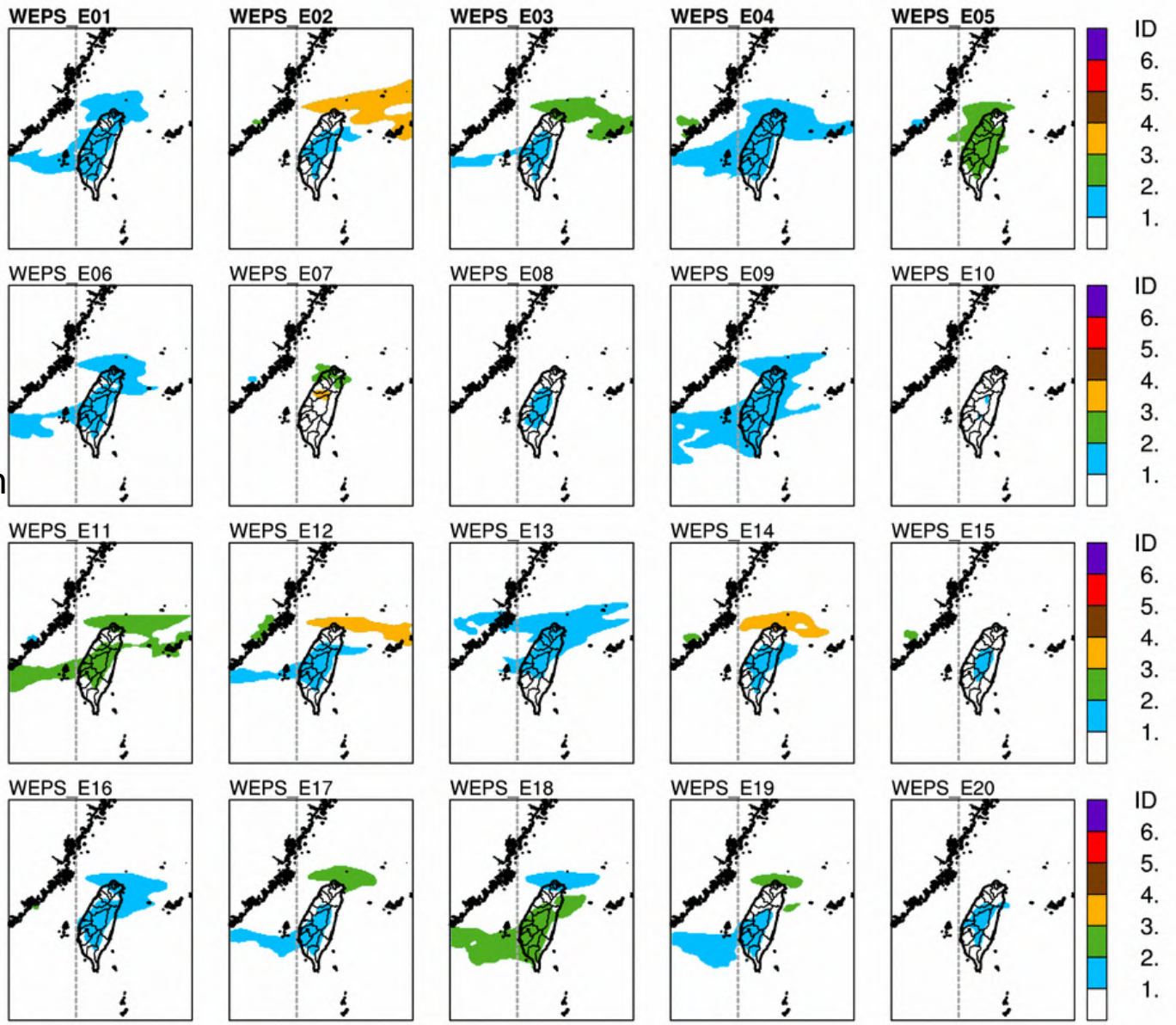
Objects:

conv_radius (R) = 20km
(4-gridpoint)

conv_thresh (T) ≧ 30 mm

max_cent_dist (MCD)

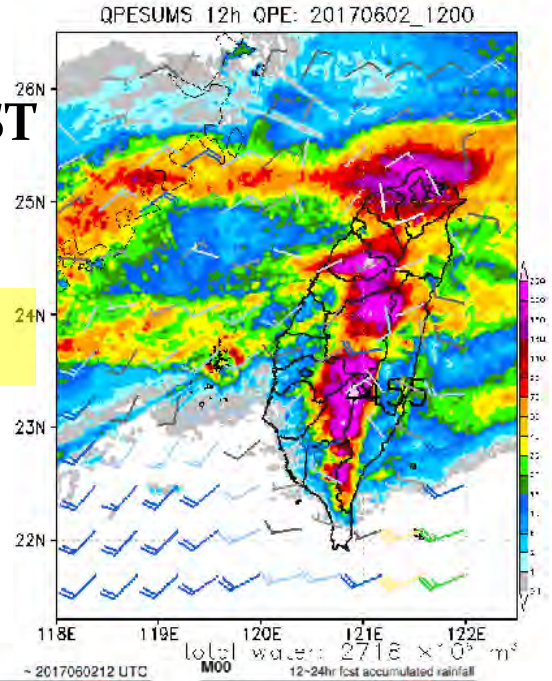
= 200 km



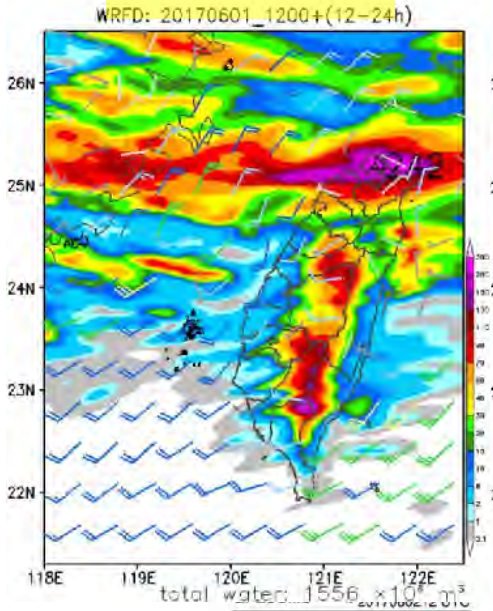
Valid time：

2017.6.2 20 LST

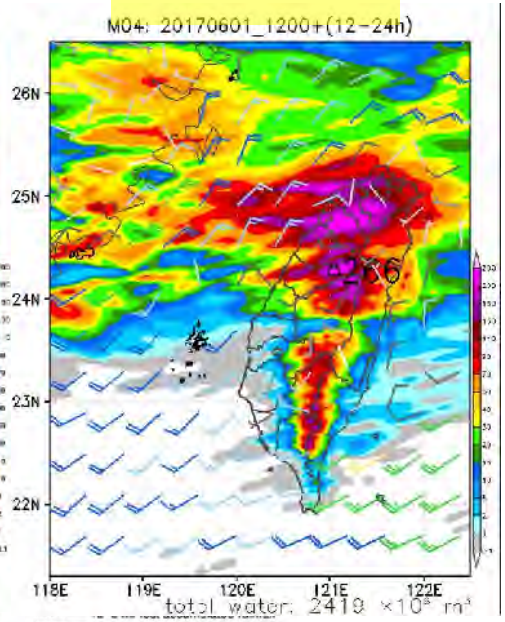
OBS



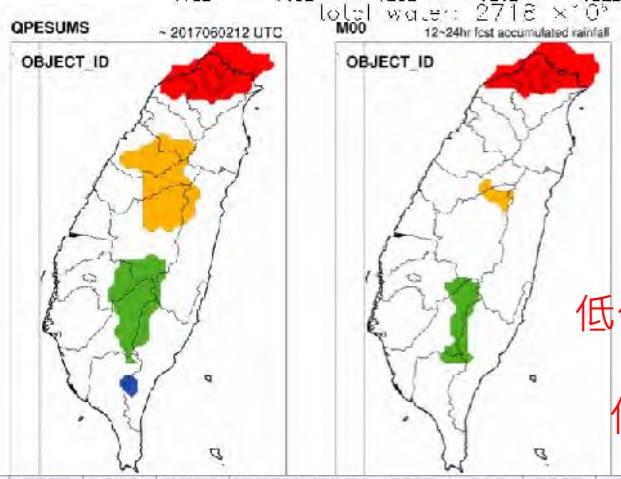
5 km



3 km



5 km

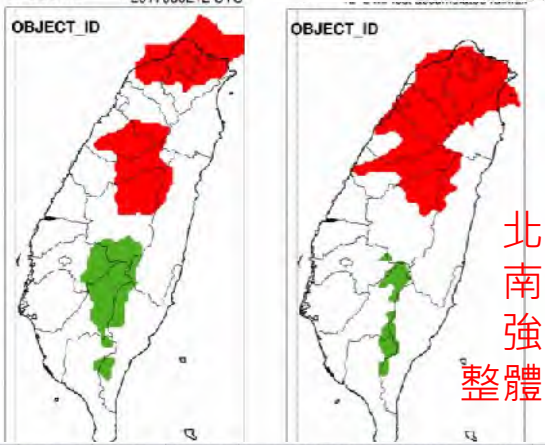


低估(尤其中部)
強度不足
位置掌握佳

CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	0.54	8.57	122	131	112	141	29	158.52	167.47	215.54	241.74	1.0000
2	4.59	2.64	49	120	34	135	101	126.14	171.27	170.71	247.72	0.9419
3	3.71	58.39	3	135	3	135	132	126.98	177.73	132.66	247.50	0.8451

- Area ratio: 0.93 0.41 0.02
- Median intensity ratio: 0.95 0.74 0.71
- Centroid distance: 0.54 4.59 3.71
- **Total interest: 0.929**

3 km

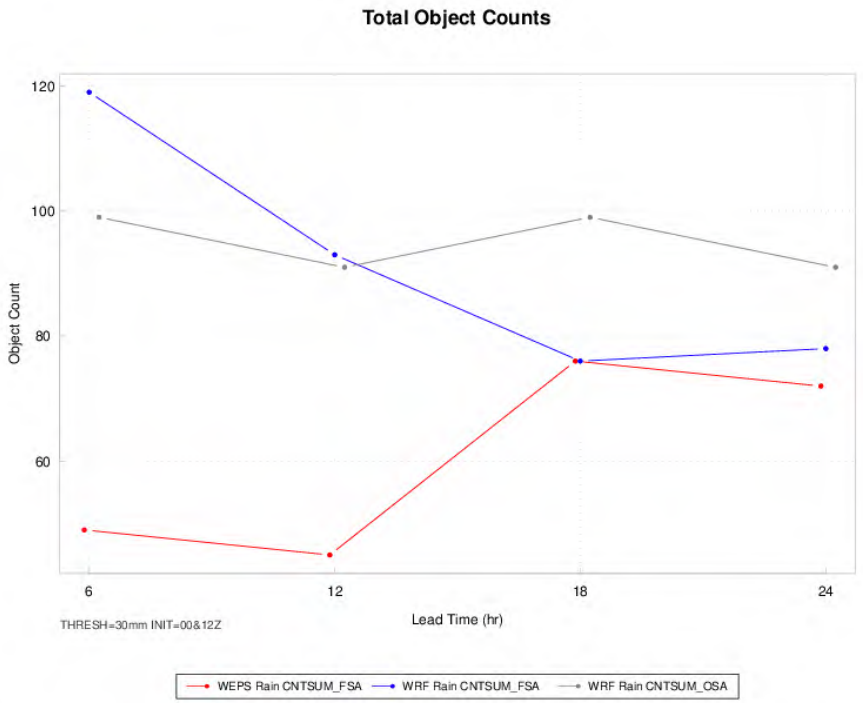


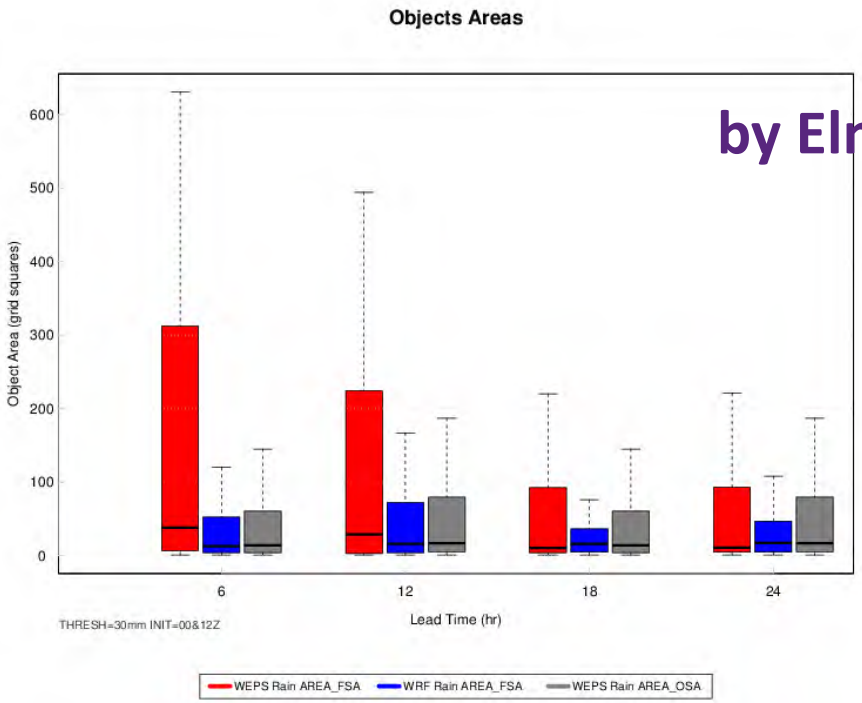
北部高估
南部低估
強度不足
整體表現梢佳

CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	6.11	0.85	890	758	460	1188	728	142.73	173.04	212.71	248.90	1.0000
2	7.24	0.71	75	360	53	382	329	126.12	173.77	151.70	247.98	0.9096

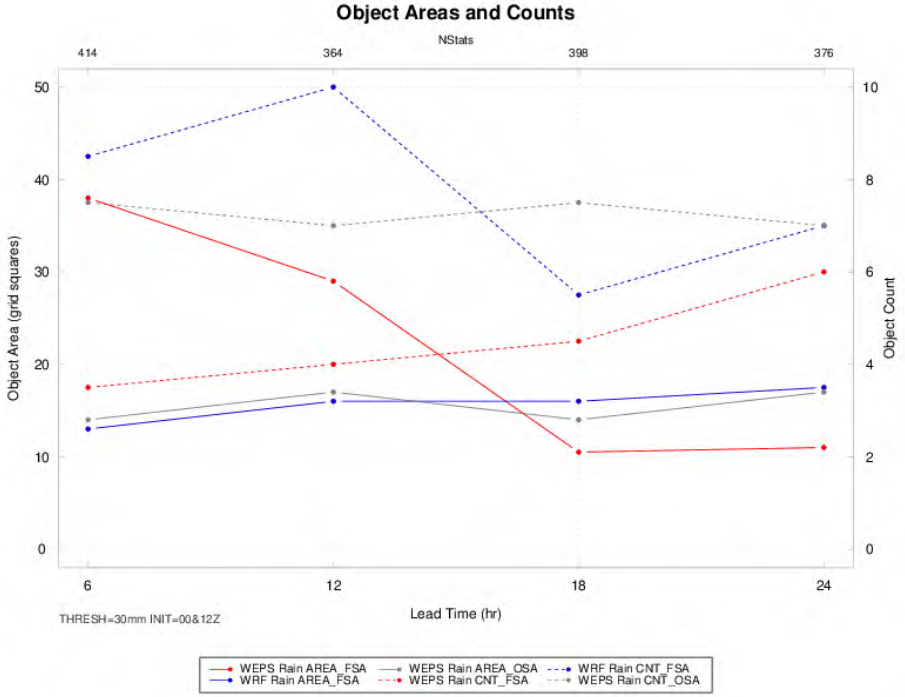
- Area ratio: 1.17 0.21
- Median intensity ratio: 0.82 0.73
- Centroid distance: 6.11 7.24
- **Total interest: 0.955**

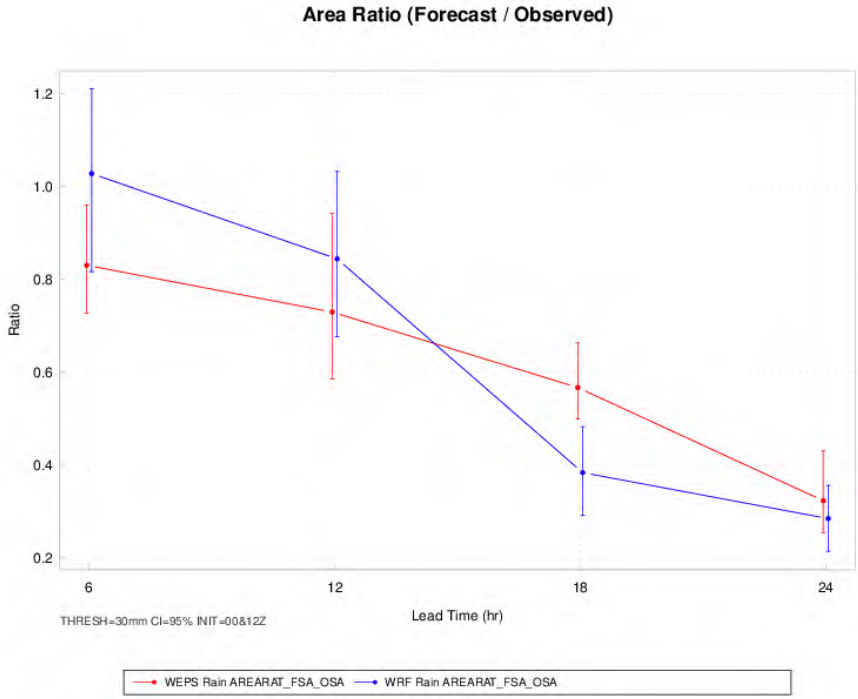
by Elmy


Total Object Counts
Object Count
Lead Time (hr)
THRESH=30mm INIT=00&12Z
WEPS Rain CNTSUM_FSA
WRF Rain CNTSUM_FSA
WRF Rain CNTSUM_OSA

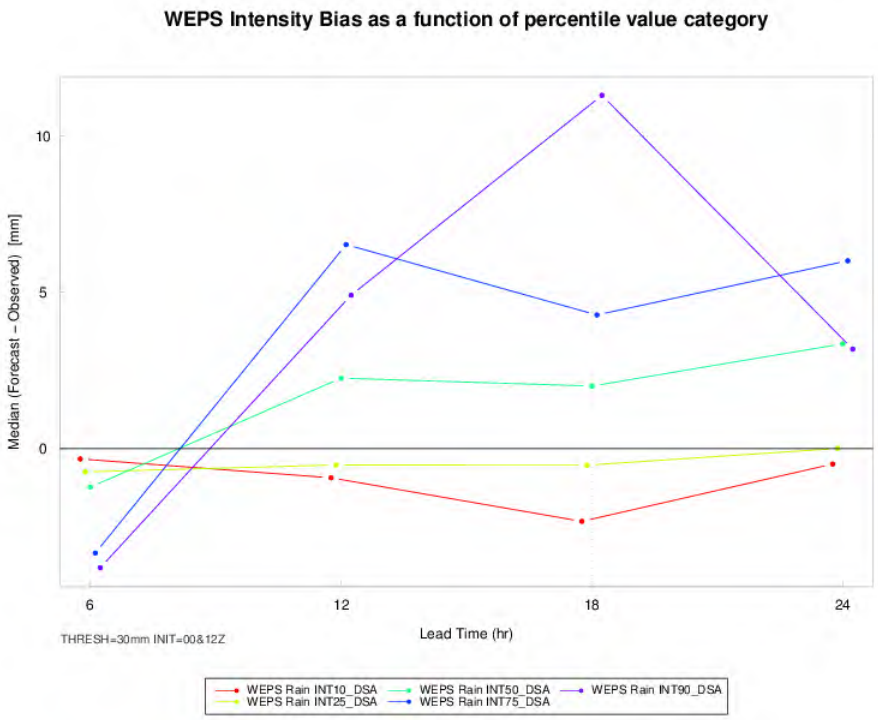

Objects Areas
Object Area (grid squares)
Lead Time (hr)
THRESH=30mm INIT=00&12Z
WEPS Rain AREA_FSA
WRF Rain AREA_FSA
WEPS Rain AREA_OSA

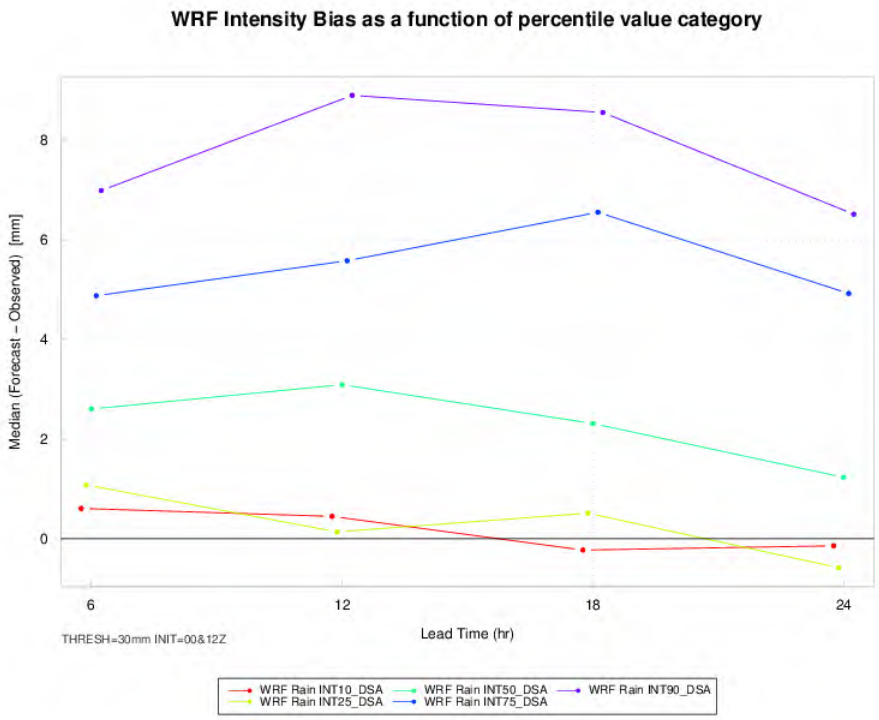
by Elmy


Object Areas and Counts
NStats
414
364
398
376
Object Area (grid squares)
Object Count
Lead Time (hr)
THRESH=30mm INIT=00&12Z
WEPS Rain AREA_FSA
WRF Rain AREA_FSA
WEPS Rain AREA_OSA
WEPS Rain CNT_FSA
WRF Rain CNT_FSA
WEPS Rain CNT_OSA


Area Ratio (Forecast / Observed)
Ratio
Lead Time (hr)
THRESH=30mm CI=95% INIT=00&12Z
WEPS Rain AREARAT_FSA_OSA
WRF Rain AREARAT_FSA_OSA

by Elmy


WEPS Intensity Bias as a function of percentile value category
Median (Forecast – Observed) [mm]
10
5
0
6
12
18
24
Lead Time (hr)
THRESH=30mm INIT=00&12Z
WEPS Rain INT10_DSA
WEPS Rain INT25_DSA
WEPS Rain INT50_DSA
WEPS Rain INT75_DSA
WEPS Rain INT90_DSA


WRF Intensity Bias as a function of percentile value category
Median (Forecast – Observed) [mm]
8
6
4
2
0
6
12
18
24
Lead Time (hr)
THRESH=30mm INIT=00&12Z
WRF Rain INT10_DSA
WRF Rain INT25_DSA
WRF Rain INT50_DSA
WRF Rain INT75_DSA
WRF Rain INT90_DSA

by Elmy

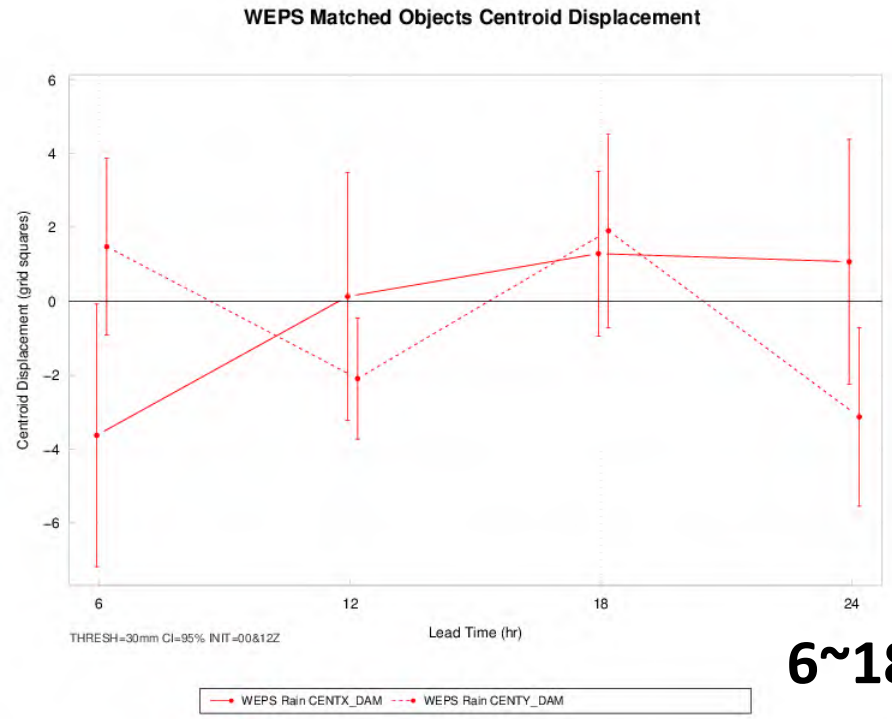
Matched Objects Centroid Displacement

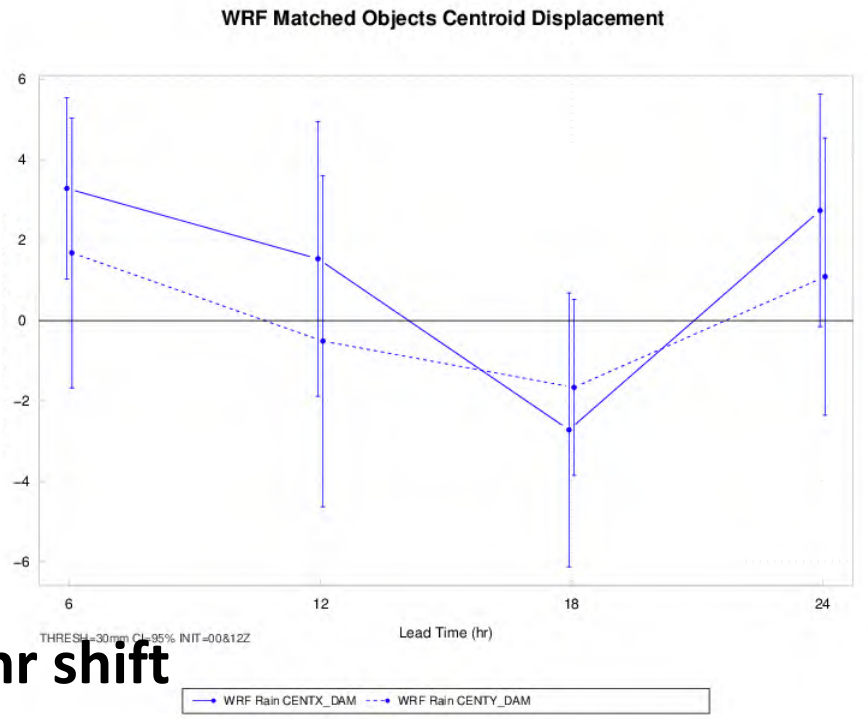
WEPS (CENTX)

WEPS (CENTY)

WRF (CENTX)

WRF (CENTY)





6~18 hr shift

X: westerly -> neutral -> easterly

X: easterly -> westerly

Y: northerly -> southerly

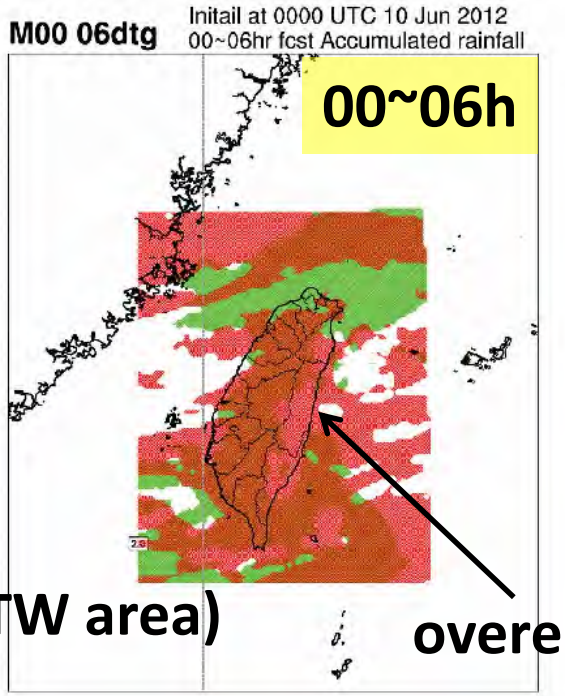
by Elmy

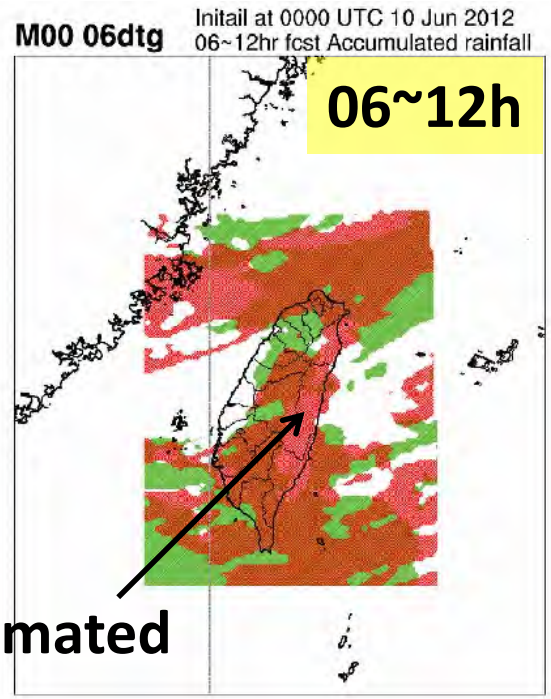
3day WRF Objs

3day OBS Objs

08~20 LST

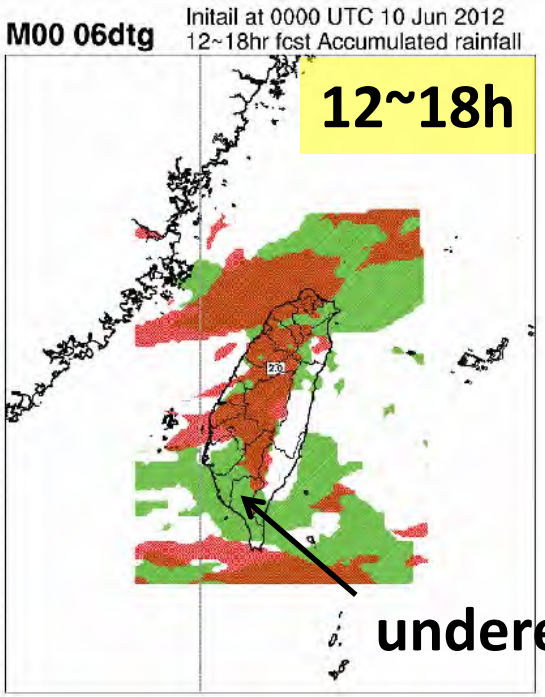
easterly bias (TW area)

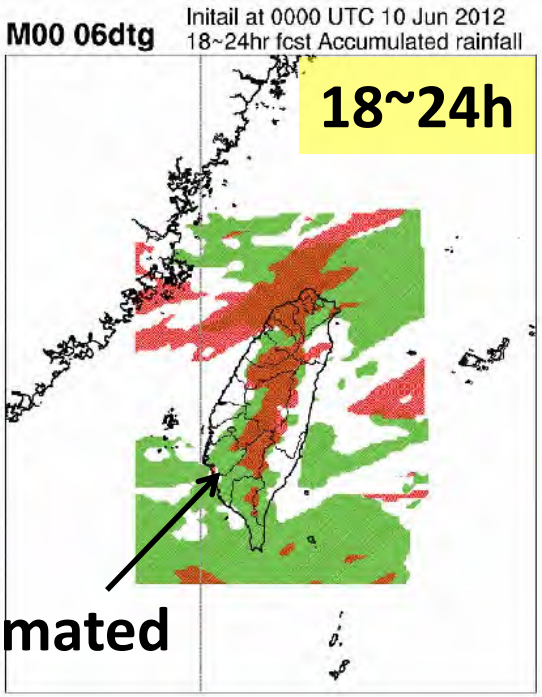




overestimated

20~08 LST



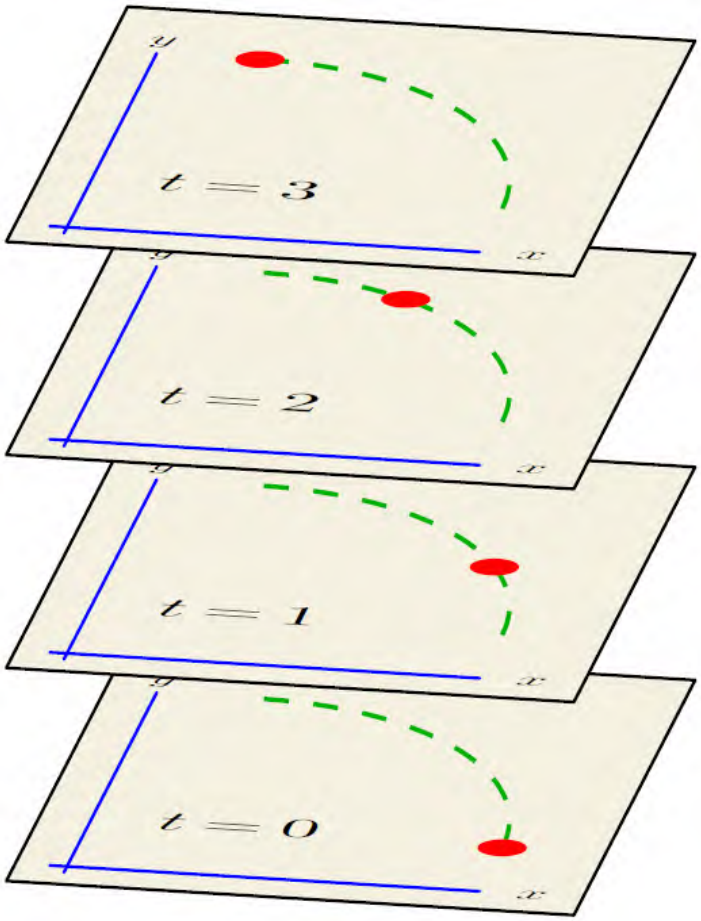


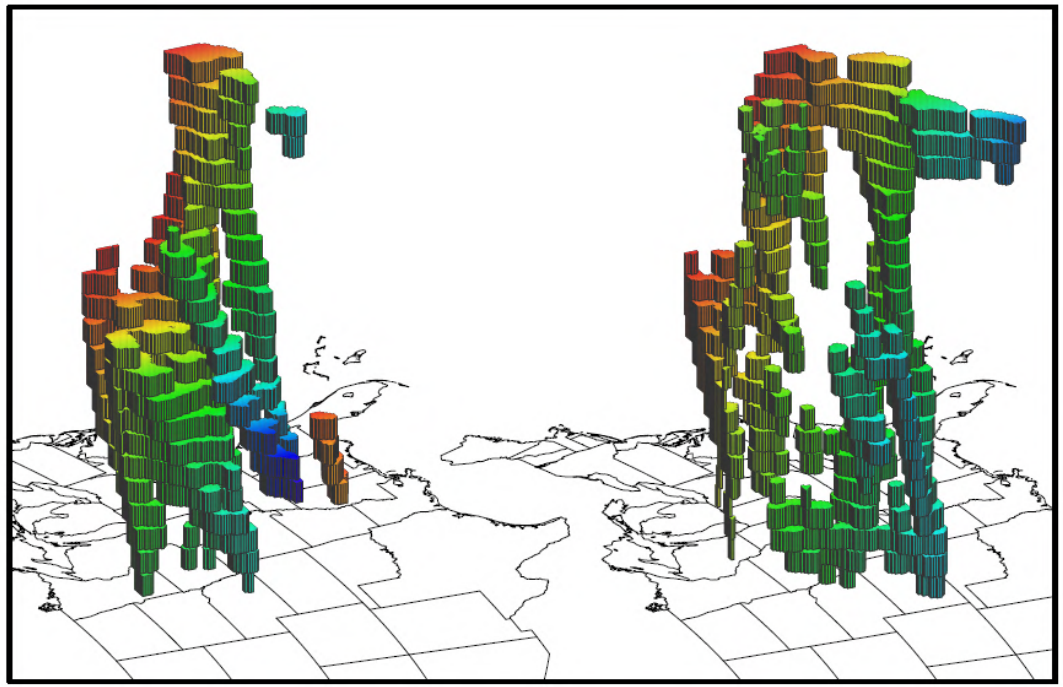
underestimated

Applications of MODE

- Climatological summaries of object characteristics
- Evaluation of individual forecasting systems
  - Systematic errors
  - Matching capabilities (overall skill measure)
  - Model diagnostics
  - User-relevant information
  - Performance as a function of scale
- Comparison of forecasting systems
  - As above

MODE Time Domain





(Bullock 2011)

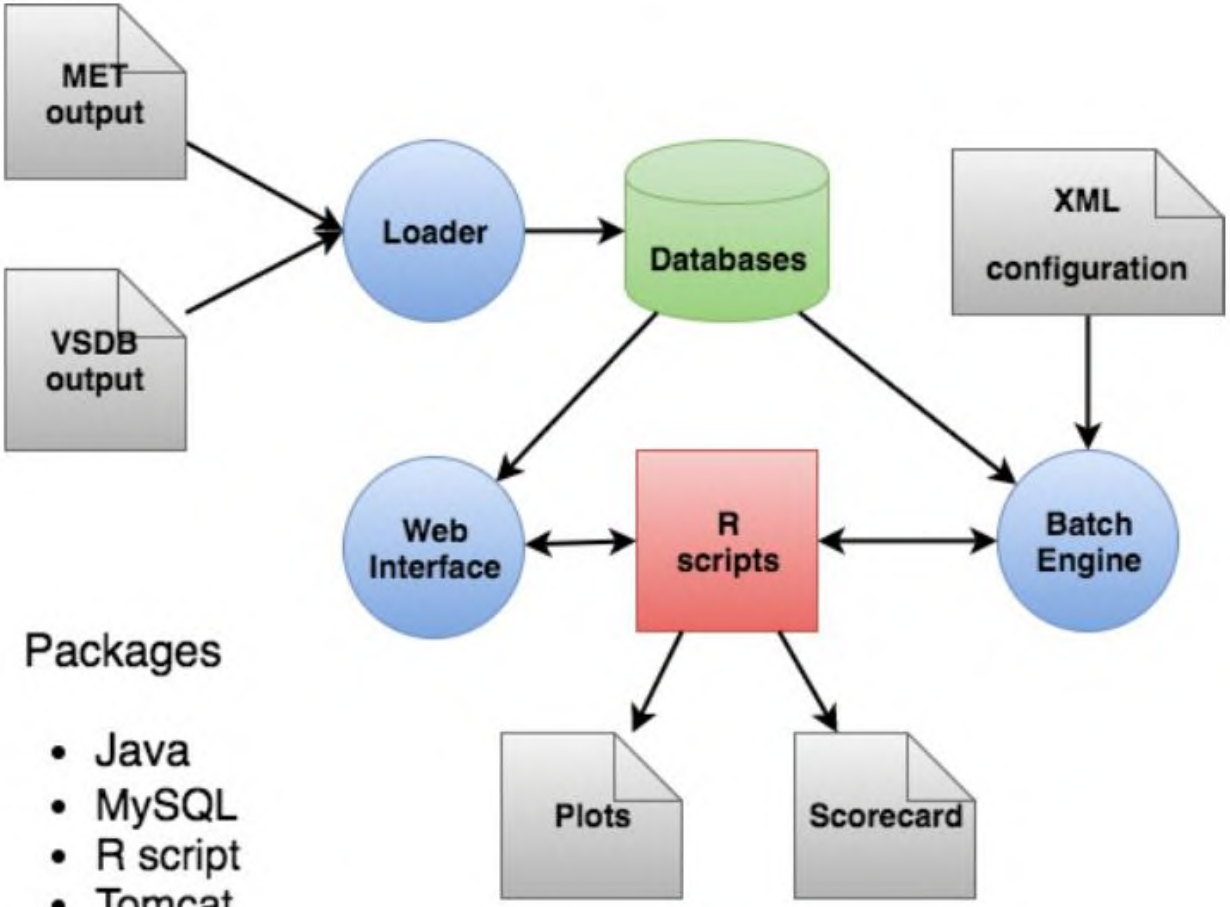
Forecast Errors

2D MODE	MTD
Location Errors	Timing Errors
Intensity Errors	Velocity Errors
Shape Errors	Duration Errors
Size Errors	Buildup & Decay
Orientation Errors	

What is METViewer

- A software package designed to help MET users visualize MET output.
- Flexible, can be use as a stand-alone or web application.
- Written in Java and relies on:
  - database for data storage and retrieval
  - R language for plotting

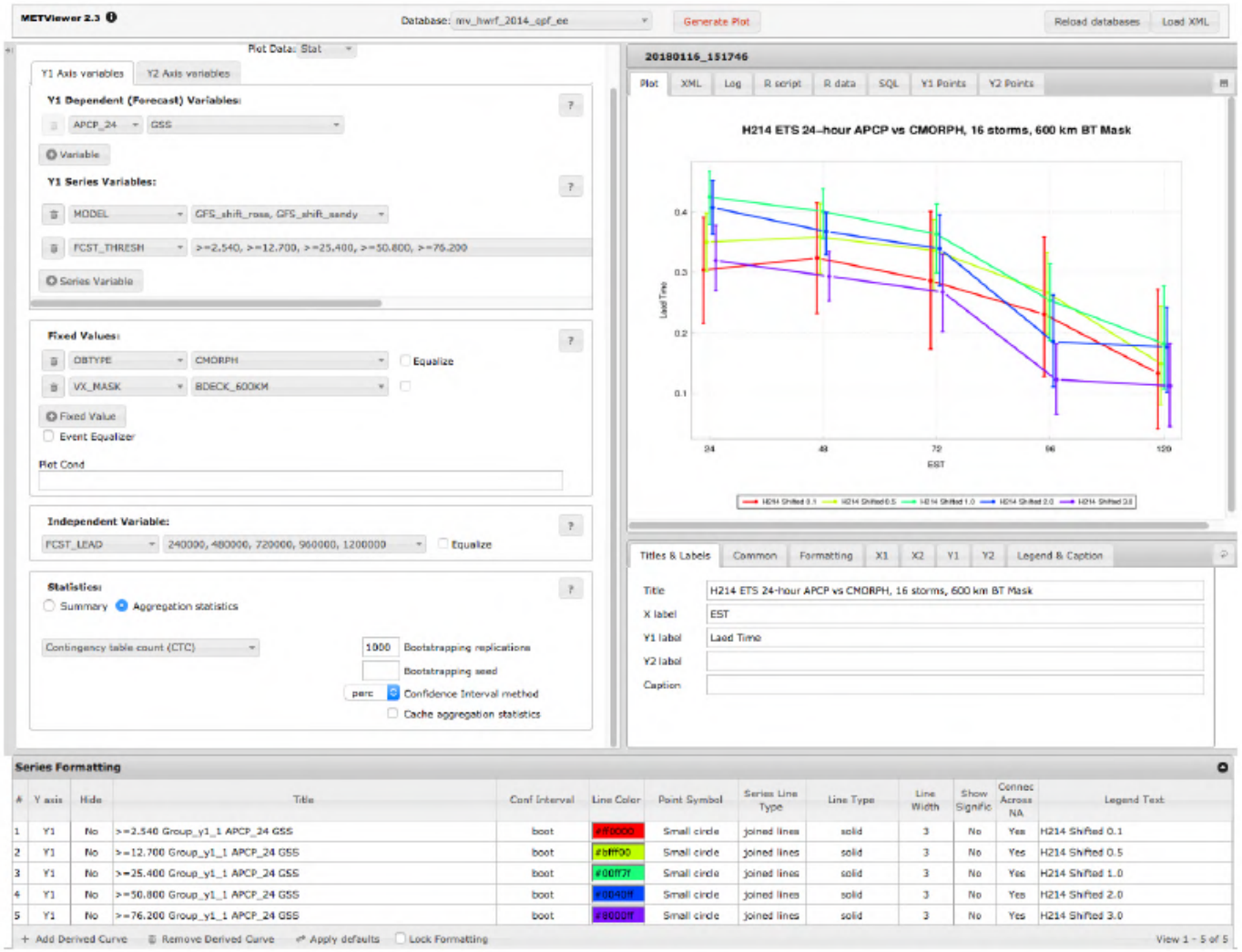
METViewer components



Packages

- Java
- MySQL
- R script
- Tomcat

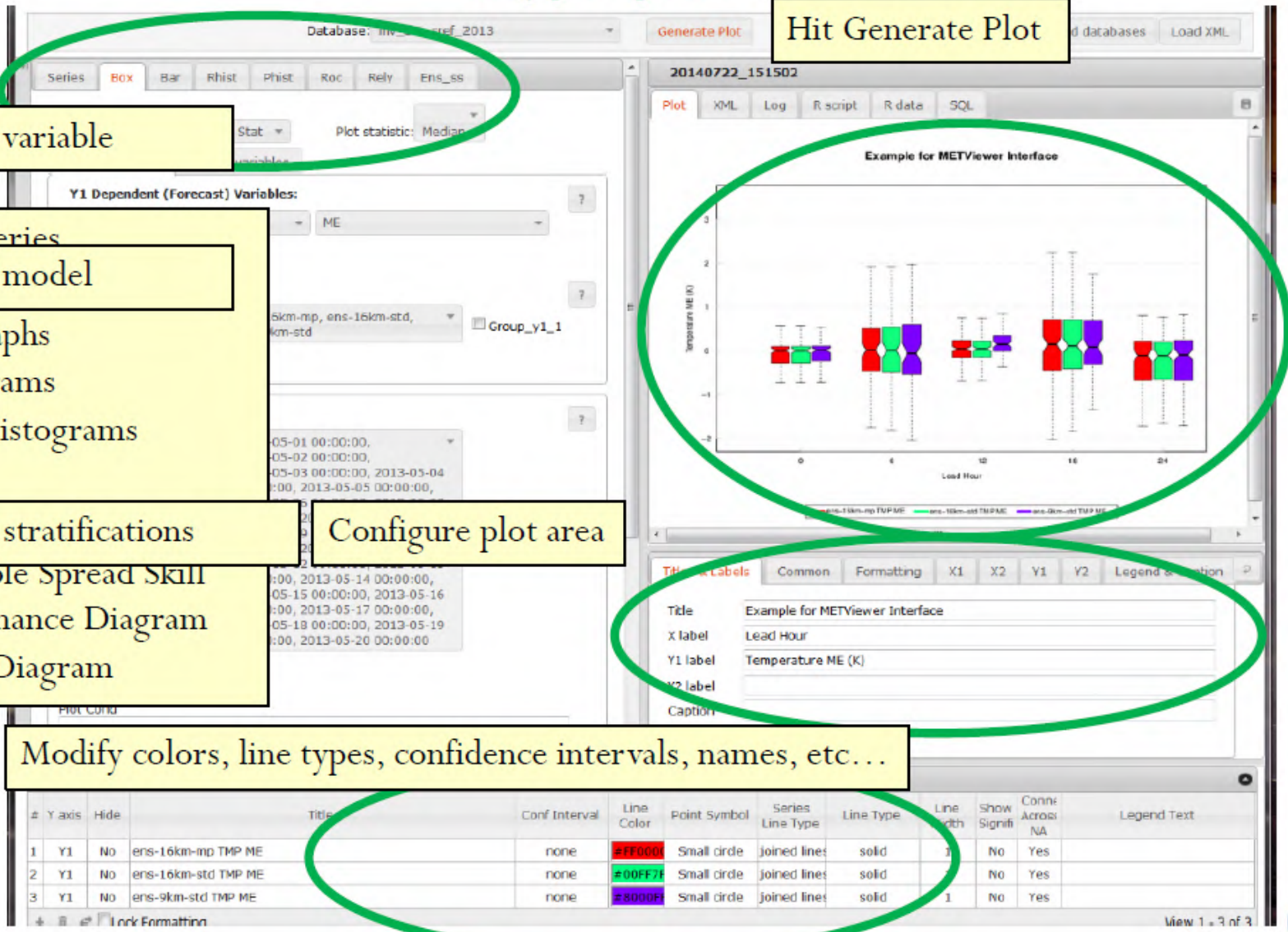
http://www.dtcenter.org/met/metviewer



#	Y axis	Hide	Title	Conf Interval	Line Color	Point Symbol	Series Line Type	Line Type	Line Width	Show Signific	Connec Across NA	Legend Text
1	Y1	No	>=2.540 Group_y1_1 APCP_24 GSS	boot	#ff0000	Small circle	joined lines	solid	3	No	Yes	H214 Shifted 0.1
2	Y1	No	>=12.700 Group_y1_1 APCP_24 GSS	boot	#bfff00	Small circle	joined lines	solid	3	No	Yes	H214 Shifted 0.5
3	Y1	No	>=25.400 Group_y1_1 APCP_24 GSS	boot	#00ff7f	Small circle	joined lines	solid	3	No	Yes	H214 Shifted 1.0
4	Y1	No	>=50.800 Group_y1_1 APCP_24 GSS	boot	#0040ff	Small circle	joined lines	solid	3	No	Yes	H214 Shifted 2.0
5	Y1	No	>=76.200 Group_y1_1 APCP_24 GSS	boot	#8000ff	Small circle	joined lines	solid	3	No	Yes	H214 Shifted 3.0

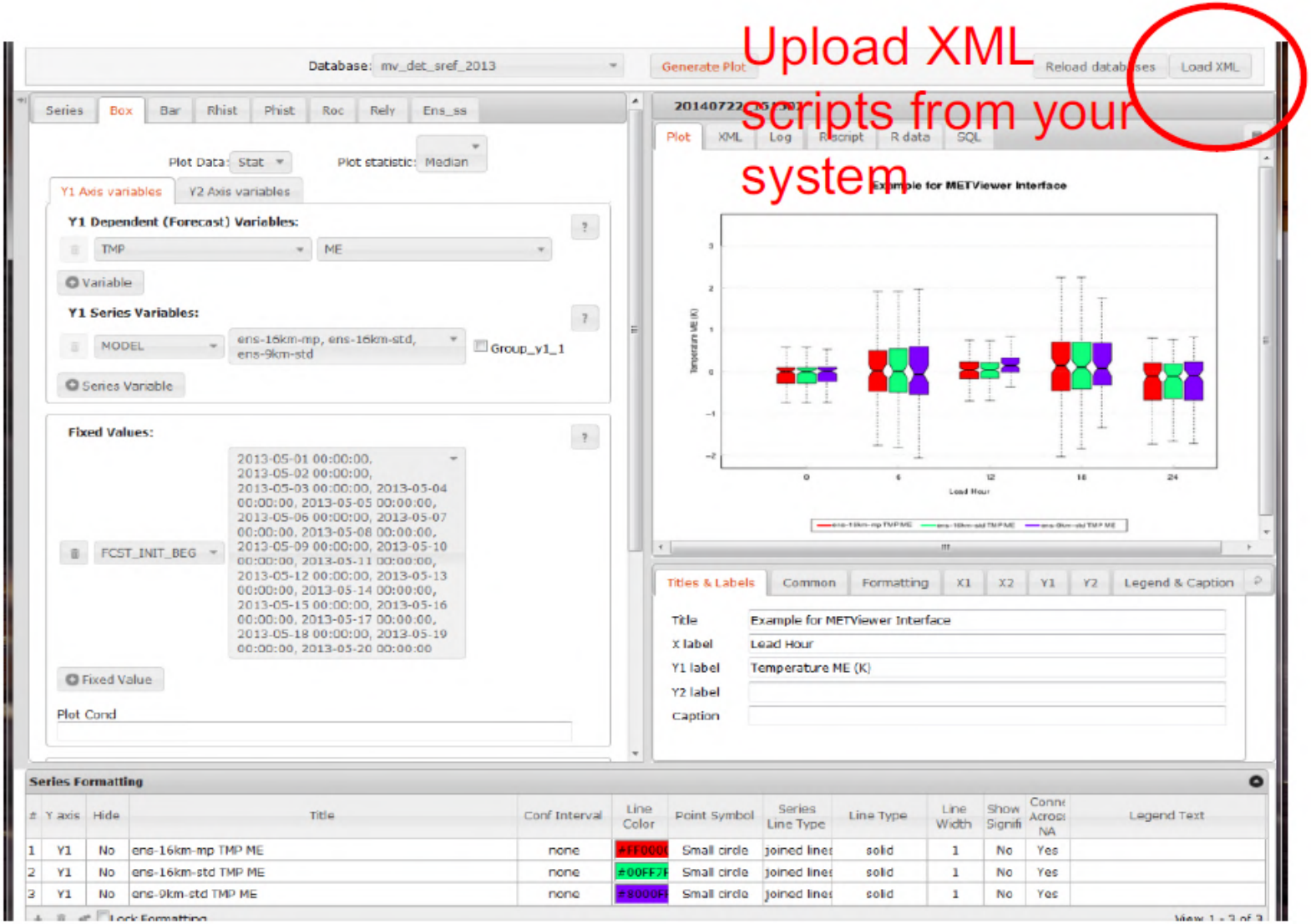
METViewer

Many plot options

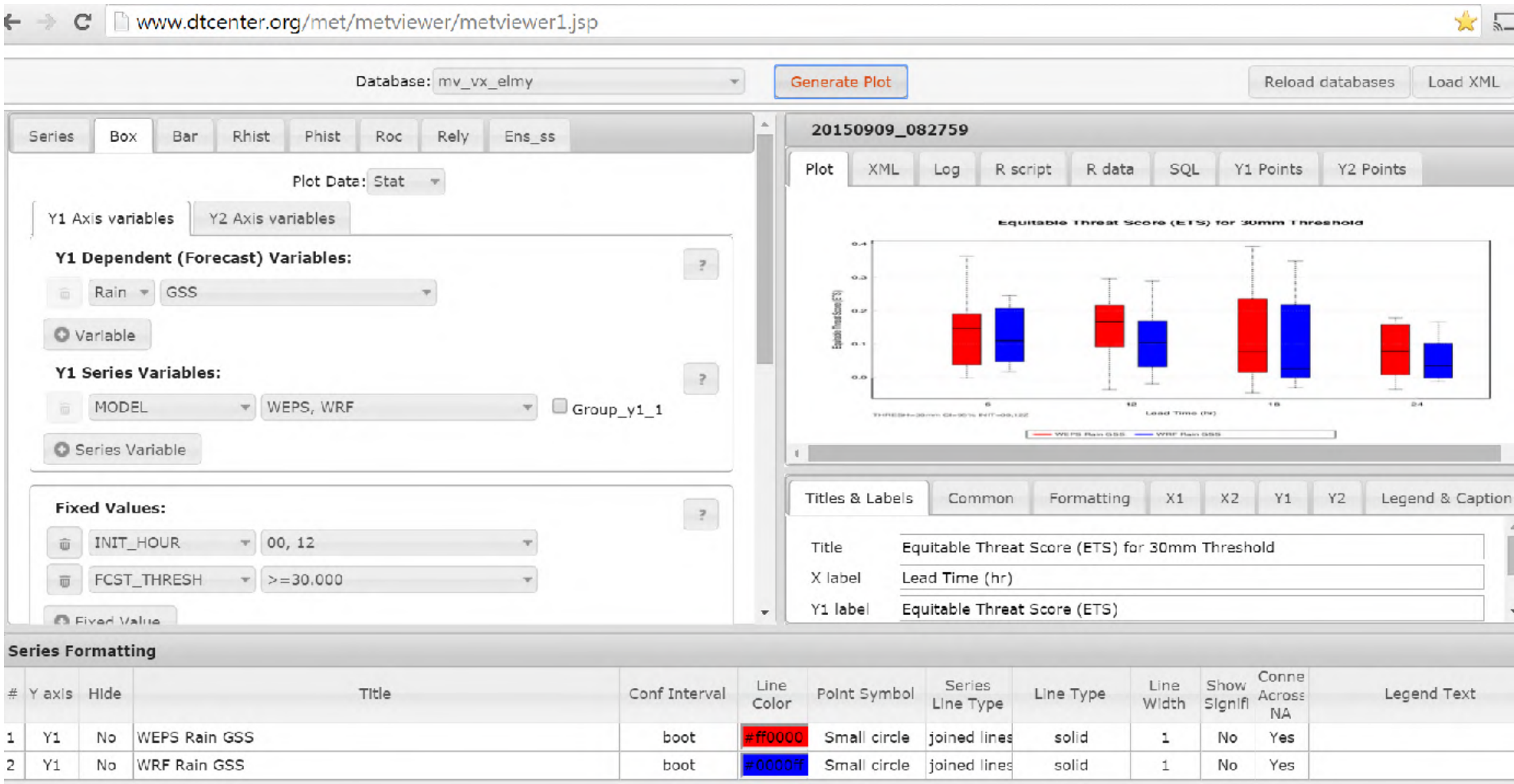


#	Y axis	Hide	Title	Conf Interval	Line Color	Point Symbol	Series Line Type	Line Type	Line Width	Show Signifi	Conne Across NA	Legend Text
1	Y1	No	ens-16km-mp TMP ME	none	#FF0000	Small circle	joined lines	solid	1	No	Yes	
2	Y1	No	ens-16km-std TMP ME	none	#00FF7F	Small circle	joined lines	solid	1	No	Yes	
3	Y1	No	ens-9km-std TMP ME	none	#8000FF	Small circle	joined lines	solid	1	No	Yes	

Upload XML configuration



METViewer Example #1

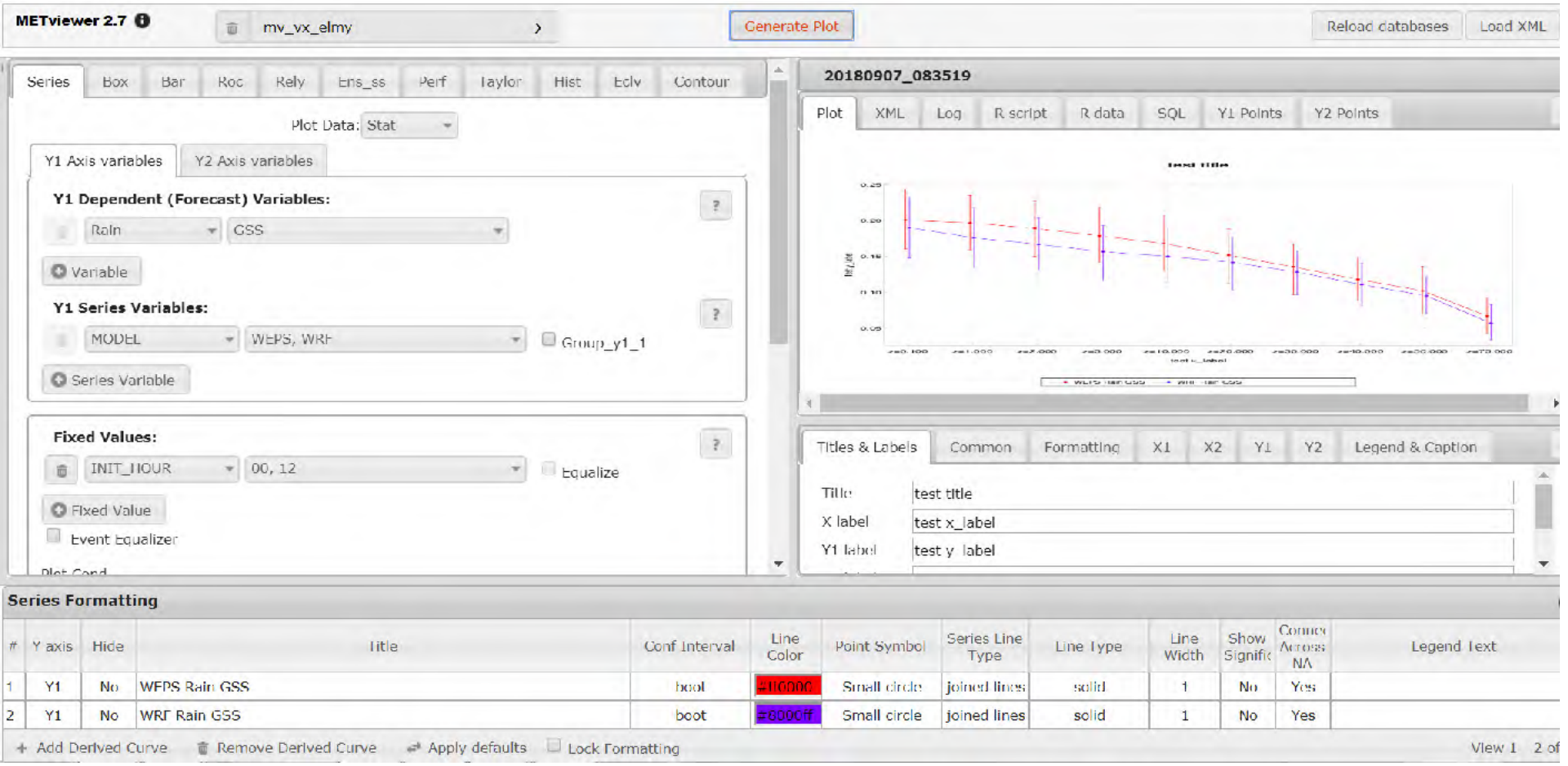


Series Formatting

#	Y axis	Hide	Title	Conf Interval	Line Color	Point Symbol	Series Line Type	Line Type	Line Width	Show Signif	Conne Across NA	Legend Text
1	Y1	No	WEPS Rain GSS	boot	#ff0000	Small circle	joined lines	solid	1	No	Yes	
2	Y1	No	WRF Rain GSS	boot	#0000ff	Small circle	joined lines	solid	1	No	Yes	

by Elmy

METViewer Example #2



by Elmy

Where to get help

https://dtcenter.org/met/users/