Increased momentum toward unified verification and diagnostic evaluation of NCAR and NOAA community models

Tara L. Jensen[1,4], J. Halley Gotway[1,4], M. Ek[1,4], C. Davis[2], J. Dudhia[2], A. Gettelman[3],

[1]NCAR/RAL, Boulder, CO [2]NCAR/MMM, Boulder, CO [3]NCAR/CGD, Boulder, CO [4]Developmental Testbed Center, Boulder, CO

dtcenter.org/community-code/model-evaluation-tools-met jensen@ucar.edu met_help@ucar.edu

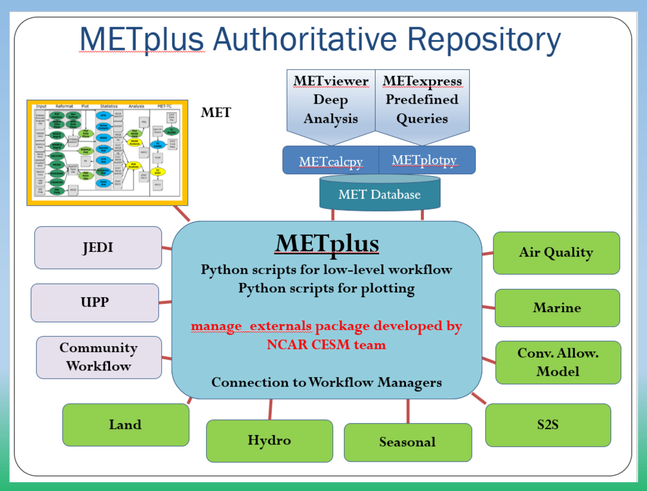
github.org/NCAR/MET github.org/NCAR/METplus github.org/NCAR/METviewer

The Model Evaluation Tools (MET) is a comprehensive numerical weather prediction (NWP) verification package supported to the community by the Developmental Testbed Center (DTC). It provides traditional verification statistics (e.g. RMSE, bias, skill scores), advanced spatial verification methods, and methods for ensemble and probabilistic forecasts. MET also includes pre-processing and aggregation tools, interpolation methods, and confidence intervals. **METplus** is an umbrella package that includes a suite of Python wrappers to streamline the set-up process and make it easier to facilitate reproducible evaluation and diagnostics across the community. METplus has been selected as the foundation of the NOAA unified evaluation capability and is being assessed for a similar purpose for NCARs community modeling suites.

What is METplus

Suite of tools extending MET bundled together with Python wrappers:

- MET (core)
- METviewer database and display (core)
- Analysis and Plotting
  - METviewer and METexpress User Interface
  - METviewer Batch Engine
  - Python plotting scripts
- Communication between MET & python algorithms
- Running in parallel with current EMC operational verification package



Why Unify?

Unified evaluation has three goals: (1) to create and apply approaches to evaluation that are compatible and interoperable to the extent possible; (2) to help unify modeling approaches across time and space scales; and (3) to integrate different communities so that their collective knowledge can be shared through collaborative interpretation of diagnostic results.

Unified evaluation is part of unified modeling, and further, can guide advances in model components, physics and chemistry that function well across the widest possible space and time domains. Using METplus as a foundation for unified evaluation may be a good starting point.

Regridding

Automotated Regridding within Statistical Tools

Regridding options:

- To Forecast Grid
- To Observation Grid
- To Pre-defined Grid (e.g. NCEP G212, MRMS grid, or user generated)
- To a Grid specification (similar concept to UPP copygb)
- *Stand-alone tool available for regridding outside statistical tools*

Interpolation options:

- Unweighted Mean
- Distance-weighted mean
- Min, Max, Median
- Least Squares
- Bilinear
- Budget

Python Embedding

Call Python Scripts from MET

- User writes a script to read gridded data into a 2-dimensional array of data.
- The 2D NumPy array must be named **met_data**.
- The script should define a dictionary named **attr** which defines:
  - ***valid*** *and initialization (****init****) times as strings in YYYYMMDD[_HH[MMSS]] format.*
  - ***lead*** *and accumulation (****accum****) times as strings in HH[MMSS] format.*
  - ***name***, ***long_name***, *level, and* ***units*** *as strings.*
  - ***grid*** *dictionary defining the projection and grid information in the same way as the gridded NetCDF files produced by MET.*

```
########################################
   ##
   ##  create the metadata dictionary
   ##

attrs = {

   'valid': valid_time.strftime("%Y%m%d_%H%M%S"),
   'init':  valid_time.strftime("%Y%m%d_%H%M%S"),
   'lead':  '00',
   'accum': '06',

   'name':      var_name,
   'long_name': var_name,
   'level':     'Surface',
   'units':     'mm',

   'grid': {
      'name': 'ECMWF-Global',
      'type' :   'LatLon',
      'lat_ll' :   -90.0,
      'lon_ll' :     0.0,
      'delta_lat' :   1.0,
      'delta_lon' :   1.0,
      'Nlat' :      181,
      'Nlon' :      360,
   }

}

print("Attributes: " + repr(attrs))
```

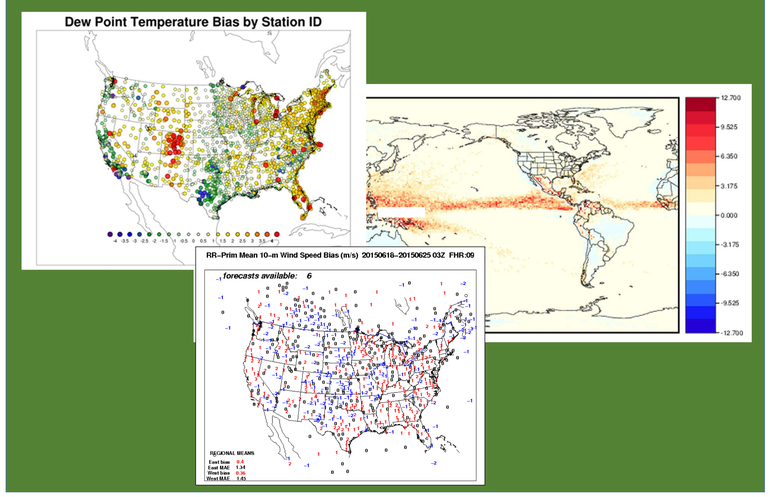
Command Line

python scripts/python/read_ascii_numpy.py data/python/fcst.txt FCST

MET config file setting

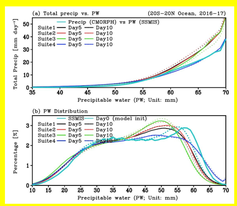
plot_data_plane PYTHON_NUMPY python.ps 'name="scripts/python/read_ascii_numpy.py data/python/fcst.txt FCST";'

Spatial Representation of Errors



Design Philosophy: One Tool – Many Applications

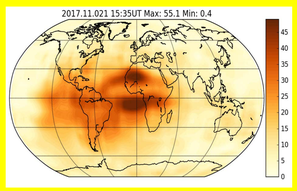
S2S



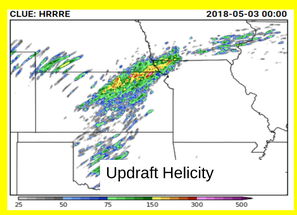
New Tool in Development

- Inventories the data
- Develops the PDF
- User configurable bins for PDF and Percentiles
- Writes out – or holds in memory – bins or percentiles for use by other tools to compute diagnostics or statistics using Grid-Stat, Point-Stat, MODE, MODE Time Domain

Space Weather

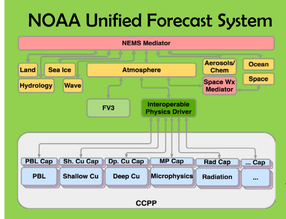


CAM



Coming Soon – Additional Support for Coupled Models

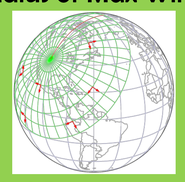
NOAA Unified Forecast System



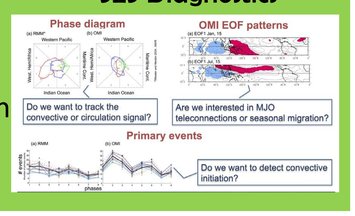
NCAR SIMA

Climate/S2S
Oceans/Waves
Sea Ice
Aerosols/Chem
Tropical Cyclones
LSM/Hydro
Renewables
Space Wx
High Resolution

Radius of Max Wind



S2S Diagnostics



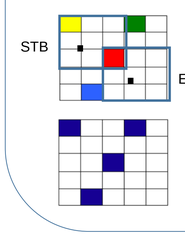
Neighborhoods

Gridded Neighborhood Methods

Allows for some spatial / temporal uncertainty in either model or observation by giving credit for being 'close'.

Gridded - Fraction of events computed for both fields. Fraction skill score is then computed

Point Obs - HiRA Mittermaier, 2014



Fraction of "events" in neighborhood converted to fraction and treated as a probability

Ob is either "0" or "1" based on event threshold

Brier Score typically used to quantify skill

MODE & MTD

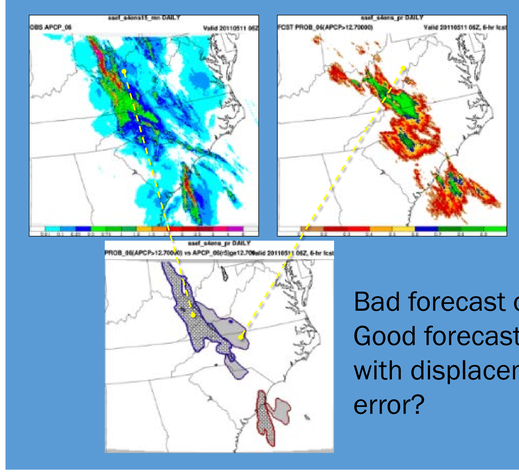
Method for Object Diagnostic Evaluation and MODE Time Domain

- Convolution (smoothing) and thresholding performed analogous to traditional 2D MODE then the raw values are re-established within the object..
- 3D objects are then formed by connecting to objects immediately adjacent in space +/-1 time step.
- Forecasts must have high enough temporal resolution so 2D objects overlap
- This method has been applied to many spatial and temporal scales: Convection Allowing Models (CAMs) *(Clark et. al, 2014)* as well as Climate Models

Reference:

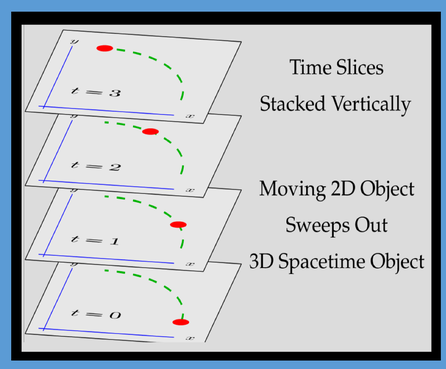
Clark, A. J., R. G. Bullock, T. L. Jensen, M. Xue, and F. Kong, 2014: Application of object-based time-domain diagnostics for tracking precipitation systems in convection-allowing models. *Wea. Forecasting*, **29**, 517-542.

MODE



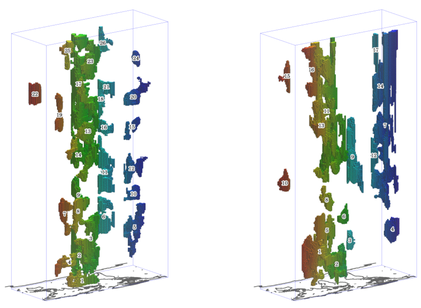
Bad forecast or Good forecast with displacement error?

MTD



Errors to be detected: Timing, Velocity, Duration, Build-up & Decay

Drought Index from Climate Model



Development of METplus is supported by the sponsors of the Developmental Testbed Center (DTC), the National Oceanic and Atmospheric Organization (NOAA), the National Aeronautics and Space Administration (NASA). DTC sponsors include NOAA, NCAR, U.S. Air Force (USAF), and National Science Foundation (NSF). NCAR is sponsored by NSF.