Presenters and acknowledgement

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☐ John Halley Gotway
☐ Randy Bullock
☐ Lacey Holland
☐ Eric Gilleland
☐ Dave Ahijevych

With thanks to the Air Force Weather Agency (AFWA) for their support
Outline

- MET Overview (Barb)
- Technical Information (John)
- MODE Tool (Randy and John)
- Grid Stat Tool (Lacey and John)
- Point Stat Tool (Lacey and John)
- Analysis Examples (Eric and Dave)
- Future Plans (Barb)
Outline

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MET – Who?

☐ Project lead
  ■ Barbara Brown: bgb@ucar.edu

☐ MET science and statistics
  ■ David Ahijevych: ahijevyc@ucar.edu
  ■ Barbara Brown: bgb@ucar.edu
  ■ Chris Davis: cdavis@ucar.edu
  ■ Eric Gilleland: ericg@ucar.edu
  ■ Lacey Holland: lholland@ucar.edu

☐ Software development
  ■ Randy Bullock: bullock@ucar.edu
  ■ John Halley Gotway: johnhg@ucar.edu
MET background and status

- Developmental Testbed Center (DTC) and WRF communities were in need of verification tools with new capabilities, for use by
  - Model developers
    - Model evaluation
    - Model development and improvement
  - Operational model users
  - DTC
    - Model intercomparisons
    - Testing and evaluating model formulations
- In response, AFWA provided support for this activity starting in late summer 2006
- Beta version to be released at end of June 2007
Objectives of MET

- Verification of high-resolution forecasting systems (e.g., WRF); also applicable to other modeling systems
- Modular and flexible
- Include state-of-the-art verification methodologies – including new methods from the modeling, verification, and user communities
- Freely available to the WRF user community
- Future: Tools incorporated into a more formal “system”
  - Database
  - GUI
  - Etc.
Requirements

- The tools must include:
  - Standard verification approaches
  - Confidence intervals
  - Initial capability for spatial verification techniques

- Replicate existing NCEP operational verification capabilities (e.g., I/O, methods, statistics)

- Documentation

- Code maintenance

- Ability to implement additional capabilities (including contributed code)

- Freely available to the modeling, verification, and operational communities, including universities, private sector, NCEP, etc.
Community Input

- WRF User’s meeting on the system at AMS in San Antonio (Jan 2007)
  - Less than half respondents were currently using any sort of verification method/tool
  - More than half of respondents said they expected to use verification capabilities on a daily basis!
  - Many interested in object-based/features-based approaches

- WRF Verification Workshop (Feb 2007)
  - Verification and modeling experts
  - Discussion of future capabilities: Ensemble verification, spatial verification methods, extremes, confidence intervals
MET Overview
Spatial verification method: MODE

- **MODE**: Method for Object-based Diagnostic Evaluation

- Other spatial methods to be included in the future

Image: John Halley Gotway
Grid-to-grid verification (grid_stat)

- Verification with two gridded datasets (grid-to-grid verification)

- Produces “standard” statistics
  - Contingency tables
  - Continuous variables
Grid-to-point verification (*point_stat*)

- Several methods for interpolation available to match point-based data
- Matched pair data

- Option to provide forecast data from surrounding grid points
- Datasets selected by the user
WVT Beta Version

- Available June 30, 2007
- “Toolkit” structure
- Traditional verification approaches for standard surface and upper air variables (e.g., ETS, MAE)
- Confidence intervals
- Initial spatial verification capability (MODE)
- Data input/output, matching – covered in next presentation
Confidence intervals

- Confidence intervals take into account various sources of error (e.g., sampling, observational)
- Computation of confidence intervals for verification stats is not always straightforward
  - Parametric vs. non-parametric methods
  - Taking into account spatial and temporal correlations
- MET will include both parametric methods (e.g., assuming Gaussian distribution) and re-sampling methods (e.g., bootstrapping)
Spatial verification methods

- Traditional methods are inadequate for verification of high-resolution spatial fields
  - Smooth forecasts generally achieve better scores, even if they are not realistic
  - Don’t reward “good” forecasts
  - Non-diagnostic

- A variety of types of methods are possible
  - Entity-based (Ebert CRA method); object-based; scale methods; neighborhood methods; composite methods
  - Each answers different kinds of questions

- MODE will be included in the first release of MET
- Future versions will include additional approaches
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MET Overview

INPUT → RFMT → INTERMED → STATS → OUTPUT

Gridded Grib Input:
- Observation Stage II/IV
- Forecast Model Data From Post

PCP Combine → Gridded NetCDF Fcst/Obs → MODE

Gridded NetCDF Fcst/Obs → Grid Stat

Point PrepBufr Input Obs

PB2NC → NetCDF Point Obs → Point Stat

MODE → PS Ascii NetCDF

Ascii VSDB NetCDF

[ ] = optional
Technical Information

- MET distributed as a tarball to be downloaded and compiled locally
- Platform and Compilers:
  - Developed and tested using Debian/GNU Linux 3.1 and GNU g++/f77
- Language:
  - Written in C and C++ with calls to a Fortran 77 library
- Portability:
  - Future support for additional WRF supported architectures and compilers
Technical Information: Why C++?

- Object-based method heavily employs object-oriented aspects of C++
- Leverage existing internal verification library code base written in C and C++ while working with a limited schedule and budget
- Tools controlled by ascii configuration files to limit the number of code changes necessary for most users
- Ability to modify existing tools written in C++ by calling newly developed Fortran subroutines
- Ability to add new tools written entirely in Fortran
Technical Information

- Dependencies:
  - **WRF Post-Processor**
    - Put model output onto a regular grid
  - **COPYGB** (included with Post)
    - Re-grid observations to match model output
  - **BUFRLIB**
    - [http://www.nco.ncep.noaa.gov/sib/decoders/BUFRLIB](http://www.nco.ncep.noaa.gov/sib/decoders/BUFRLIB)
    - Fortran library for reading PrepBufr point observations
  - **CWORDSH**
    - Fortran blocking utility
Technical Information

- Dependencies (cont):
  - **NetCDF**
    - [http://www.unidata.ucar.edu/software/netcdf](http://www.unidata.ucar.edu/software/netcdf)
  - **GSL** (Developer’s GNU Scientific Library)
    - [http://www.gnu.org/software/gsl](http://www.gnu.org/software/gsl)
    - Used in computing confidence intervals
  - **C++ and Fortran compilers**
    - Developed using GNU g++ and f77
Technical Information

- Configuration files:
  - Tools controlled by config files
  - Formatted ascii config files passed via the command line
  - One each for:
    - pb2nc
    - mode
    - grid_stat
    - point_stat
  - To be discussed during detailed sessions on components
Directory Structure

- MET/
  - README Makefile
    - src/
      - pcp_combine/ grid_stat/ mode/
      - pb2nc/ point_stat/
    - lib/ Several Libraries
    - bin/ Built Executables
    - data/
      - colortables/ config/ map/ poly/ ps/
      - sample_fcst/ sample_obs/
    - scripts/ Sample Scripts
    - doc/ Documentation
    - out/ Sample Output
Observation Data Availability

☐ Stage II/IV
  - Current day: 
    ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/hourly/prod/
  - Daily tar file archive for a few months: 

☐ PrepBufr
  - Current day for NAM: 
    ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/nam/prod/ndas.YYYYMMDD/ndas.tIIz.prepbufr.tmHH.nr
  - Archived data is under investigation
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MODE
Method for Object-Based Diagnostic Evaluation
Outline

- Object Detection
- Use of Fuzzy Logic in Merging & Matching
- A Simple Application
- Future Directions
Step # 1: Raw Data

In this case,
Precipitation Data over the
Continental United States
Step # 2: Convolution

This is Essentially
a Smoothing Operation
Step # 3: Thresholding

This Produces an
On/Off Mask Field
Step # 4: Restoration

Original (Raw) Data is Restored to Object Interiors
Fuzzy Logic

- Attributes
- Interest Maps
- Confidence Maps
- Weights
# Object Attributes

*Simple or Composite*

<table>
<thead>
<tr>
<th>Single</th>
<th>Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td><strong>Intersection</strong></td>
</tr>
<tr>
<td><strong>Centroid</strong></td>
<td><strong>Union</strong></td>
</tr>
<tr>
<td><strong>Axis Angle</strong></td>
<td><strong>Centroid Distance</strong></td>
</tr>
<tr>
<td><strong>Angle Confidence</strong></td>
<td><strong>Angle Difference</strong></td>
</tr>
<tr>
<td><strong>Median Intensity</strong></td>
<td><strong>Area Ratio</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Intensity Ratio</strong></td>
</tr>
</tbody>
</table>
Centroid

Axis

Convex Hull
Forecast Object

Observed Object

Union

Intersection

Symmetric Difference
Fuzzy Logic

- Attributes
- Interest Maps
- Confidence Maps
- Weights
Fuzzy Logic

- Attributes
- Interest Maps
- Confidence Maps
- Weights
Fuzzy Logic

- Attributes
- Interest Maps
- Confidence Maps
- Weights
Total Interest

\[ T(\alpha) = \frac{\sum_{i} w_i C_i(\alpha) I_i(\alpha_i)}{\sum_{i} w_i C_i(\alpha)} \]
Alternative Merging Method

Double Thresholding
Composite Object Centroid Differences 
over the Appalachian Mountains
Space ... the Final Frontier

3D Objects
Centroid & Axis
PCP Combine and MODE Tools

**INPUT** → RFMT → INTERMED → STATS → OUTPUT

**Gridded Grib Input:**
- Observation Stage II/IV
- Forecast Model Data From Post

**PCP Combine**
- PCP Combine
- NetCDF Fcst/Obs

**MODE**
- PS Ascii NetCDF

**Grid Stat**
- Ascii VSDB NetCDF

**Point Stat**
- VSDB

**Point PrepBufr Input Obs**
- PB2NC
- NetCDF Point Obs
Outline for Practicals

- Overview of tool
- Usage statement
- Example(s)
- Configuration file (if applicable)
- Output files

- Goal: Familiarity with look and feel
PCP Combine Tool Practical

- Optional tool for use in combining precipitation accumulations

**Input:**
- Grib model or observation data containing accumulated precipitation already on the same grid
- Use “copygb” tool to re-grid grib files

**Output (1 file):**
- NetCDF file containing desired accumulation interval
PCP Combine: Usage

Usage: `pcp_combine`

```
  pcp_init_time pcp_accum_time vx_time vx_accum_time out_file
  <<-pcpdir precip_dir> <<-pcprx precip_reg_exp> <<-v level>
```

- "pcp_init_time" indicates the model initialization time of the precipitation files in YYYY-MM-DD_HH:MM:SS format (required).
- "pcp_accum_time" indicates the accumulation time of the precipitation files in HH format. The accumulation time must be in whole hours (required).
- "vx_time" indicates the desired verification time in YYYY-MM-DD_HH:MM:SS format (required).
- "vx_accum_time" indicates the desired accumulation time interval to be used for verification in HH format. The verification accumulation time must be in whole hours (required).
- "out_file" indicates the name of the output NetCDF file to be written consisting of the sum of the accumulation intervals (required).
- `-pcpdir` overrides the default WRF precipitation directory (VX_BASEDIR/data/sample_obs/ST2ml) with "precip_dir" (optional).
- `-pcprx` overrides the default regular expression for WRF precipitation file naming convention (.* with "precip_reg_exp" (optional).
- `-v` overrides the default level of verbosity (1) with "level" (optional).

**Note:** Set pcp_init_time to 0000-00-00_00:00:00 for combining observation files.
PCP Combine: Example

- Combine 3-hourly model accumulations into a single 24 hour accumulation forecast:
  
  ```
  pcp_combine
  2005-08-07_00:00:00:00 3 2005-08-08_00:00:00:00 24
  sample_fcst_2005080700I_24L_24A.nc
  -pcpdir ./data/sample_fcst/2005080700
  ```

- Combine 1-hourly observation accumulations into a single 24 hour accumulation observation:
  
  ```
  pcp_combine
  0000-00-00_00:00:00:00 1 2005-08-08_24:00:00:00 24
  sample_obs_2005080800V_24A.nc
  -pcpdir ../data/sample_obs/ST2ml
  ```
PCP Combine: NetCDF Output (ncview)

WRF Model Forecast

Stage II Observation

24 hour accumulations valid at 20050808 00Z
MODE Tool Practical

- Tool for features-based verification by comparing objects defined in the forecast and observation fields

- Input:
  - NetCDF output of pcp_combine
  - Grib fcst and obs data on a common grid
  - Use “copygb” tool to re-grid grib files
  - Configuration file(s)

- Output (4 files):
  - PostScript summary plots
  - NetCDF simple and composite object fields
  - Ascii contingency table statistics
  - Ascii object statistics
MODE Tool: Usage

Usage: `mode` [options]

- `fcst_file` obs_file
- `config config_file`
- `config_merge merge_config_file`
- `outdir output_dir`
- `v level`
- `plot` `obj_plot` `obj_stat` `ct_stat`

- `fcst_file` is a forecast file in either Grib or netCDF format (output of `pcp_combine`) containing the field to be verified (required).
- `obs_file` is an observation file in either Grib or netCDF format (output of `pcp_combine`) containing the verifying field (required).
- `config` overrides the default fuzzy engine settings with the contents of "config_file" (optional).
- `config_merge` overrides the default fuzzy engine settings for merging within the fcst/obs fields with the contents of "merge_config_file" (optional).
- `outdir` overrides the default output directory ("VX_BASEDIR/out/mode") with "output_dir" (optional).
- `v` overrides the default level of verbosity (1) with "level" (optional).
- `plot` disables plotting (optional).
- `obj_plot` disables the output of the object split and composite fields to a NetCDF file (optional).
- `obj_stat` disables the output of the object statistics file (optional).
- `ct_stat` disables the output of the contingency table standard statistics file (optional).
MODE Tool: Example

- Run MODE on 24 hour accumulation NetCDF files (output of pcp_combine):
  ```
  mode
  sample_fcst_2005080700I_24L_24A.nc
  sample_obs_2005080800V_24A.nc
  -config WrfModeConfig_APB_24
  -outdir .
  ```
MODE Tool: Config File

Handling Raw Data:
- grid_res = 13;
- vx_grib_code = "APCP/A24";
- mask_missing_flag = 3;
- mask_grid = "";
- mask_grid_flag = 0;
- mask_poly = "";
- mask_poly_flag = 0;
- fcst_raw_threshold = 0.0;
- obs_raw_threshold = 0.0;

Object Definition:
- fcst_conv_radius = 3;
- obs_conv_radius = 3;
- bad_data_threshold = 0.5;
- fcst_conv_threshold = 5.0;
- obs_conv_threshold = 5.0;
- fcst_area_threshold = 0;
- obs_area_threshold = 0;
- fcst_inten_threshold = 0.0;
- obs_inten_threshold = 0.0;

Merging and Matching Options:
- fcst_merge_threshold = 2.5;
- obs_merge_threshold = 2.5;
- fcst_merge_flag = 0;
- obs_merge_flag = 0;
- match_flag = 1;
- max_centroid_dist = 800/grid_res;

Fuzzy Engine Weights:
- centroid_dist_weight = 2.0;
- boundary_dist_weight = 4.0;
- convex_hull_dist_weight = 0.0;
- angle_diff_weight = 1.0;
- area_ratio_weight = 1.0;
- int_area_ratio_weight = 2.0;
- complexity_ratio_weight = 0.0;
- intensity_percentile = 50;
- intensity_ratio_weight = 0.0;

Fuzzy Engine Interest/Conf Functions:
- centroid_dist_if = ...
- boundary_dist_if = ...
- convex_hull_dist_if = ...
- angle_diff_if = ...
- area_ratio_if(x) = ...
- int_area_ratio_if = ...
- complexity_ratio_if(x) = ...
- intensity_ratio_if(x) = ...
- aspect_ratio_conf(t) = ...
- area_ratio_conf(t) = ...

Fuzzy Engine Thresholds:
- total_interest_threshold = 0.7;
- print_interest_threshold = 0.0;

Misc:
- zero_border_size = 4;
- raw_color_table = ...
- mode_color_table = 62
- ncep_defaults = 1;
MODE Tool: PS Output

(1) mode_APCP_24_SFC_2005080700I_24L_24A.ps

Includes 4+ pages of Plots:
1. Overview (shown)
2. Fcst detail
3. Obs detail
4. Object overlap
   ... Fcst merging
   ... Obs merging

- Conv Radius of 3
- Conv Thresh of 5
- 8 simple fcst objects
- 10 simple obs objects
- 5 matched composites

<table>
<thead>
<tr>
<th>Forecast</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
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<tr>
<td>5</td>
<td>9</td>
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<tr>
<td>5</td>
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<td>8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

|            |   |              |   |
|------------|---|--------------|
| 8          | 6 | 0.6902       |
| 1          | 2 | 0.6896       |
| 6          | 8 | 0.6812       |
| 7          | 8 | 0.6628       |
| 7          | 6 | 0.6469       |
| 3          | 8 | 0.6421       |
| 8          | 4 | 0.6351       |
| 2          | 8 | 0.6321       |
| 2          | 6 | 0.6279       |
| 4          | 2 | 0.6278       |
| 1          | 3 | 0.6234       |
| 6          | 4 | 0.6174       |
| 4          | 1 | 0.6128       |
| 5          | 2 | 0.6095       |
| 5          | 4 | 0.6013       |
| 5          | 3 | 0.6013       |
| 5          | 6 | 0.5884       |
| 8          | 10| 0.5877       |
| 5          | 7 | 0.5746       |
| 5          | 5 | 0.5738       |
| 4          | 9 | 0.5624       |
| 5          | 10| 0.5533       |
| 3          | 6 | 0.5503       |
| 1          | 5 | 0.5414       |
| 4          | 5 | 0.5314       |
| 1          | 9 | 0.5126       |
| 5          | 8 | 0.5094       |
| 6          | 7 | 0.4962       |
| 4          | 10| 0.4852       |
| 8          | 7 | 0.4788       |
| 7          | 4 | 0.4713       |
| 2          | 4 | 0.4674       |
| 6          | 9 | 0.4487       |
| 4          | 7 | 0.4328       |
| 1          | 10| 0.4325       |
| 8          | 9 | 0.4312       |
| 1          | 4 | 0.4318       |
| 4          | 4 | 0.4310       |
| 3          | 4 | 0.4308       |

- Fcst merging
- Obs merging

Fuzzy Engine Weights
- Centroid Distance: 2.00
- Boundary Distance: 4.00
- Convex Hull Distance: 0.00
- Angle Difference: 1.00
- Area Ratio: 1.00
- Intersection/Area: 2.00
- Complexity Ratio: 0.00
- Intensity Ratio: 0.00
- Total Interest Threshold: 0.70

Mark Missing: on
Mark Grid: off
Mark Polygon: off
Raw Threshold: 0.00 mm
Conv Radius: 3 gs
Conv Thres: 3.00 mm
Area Thres: 0 gs
Inter Thres: 0.00 mm
Merge Thres: 1.25 mm
Matching: match/merge
Simple: 8
Unmatched: 3
Composites: 5
MODE Tool: NetCDF Output (ncview)

(2) mode_APCP_24_SFC_objects_2005080700I_24L_24A.nc

Forecast Simple Objects

Observation Simple Objects

Forecast Composite Objects

Observation Composite Objects
### MODE Tool: Cont. Table Statistics

(3) mode_APCP_24_SFC_fcst_obs_2005080700I_24L_24A_cts.txt

<table>
<thead>
<tr>
<th>valid_ymd</th>
<th>valid_hms</th>
<th>lead_hr</th>
<th>accum_hr</th>
<th>fcst_rad</th>
<th>fcst_thresh</th>
<th>obs_rad</th>
<th>obs_thresh</th>
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<td>24</td>
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<td>5.0</td>
<td>3</td>
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<tr>
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<td>000000</td>
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<td>24</td>
<td>3</td>
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<td>3</td>
<td>5.0</td>
<td>filter</td>
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<tr>
<td>20050808</td>
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<td>24</td>
<td>3</td>
<td>5.0</td>
<td>3</td>
<td>5.0</td>
<td>object</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
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<th>fy_on</th>
<th>fn_oy</th>
<th>fn_on</th>
</tr>
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<tbody>
<tr>
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<td>2516</td>
<td>1396</td>
<td>527</td>
<td>1973</td>
</tr>
<tr>
<td>6412</td>
<td>2516</td>
<td>1396</td>
<td>527</td>
<td>1973</td>
</tr>
<tr>
<td>6412</td>
<td>315</td>
<td>420</td>
<td>494</td>
<td>5183</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Bias</th>
<th>PODY</th>
<th>PODN</th>
<th>FAR</th>
<th>CSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7001</td>
<td>1.2856</td>
<td>0.8268</td>
<td>0.5856</td>
<td>0.3569</td>
<td>0.5668</td>
</tr>
<tr>
<td>0.7001</td>
<td>1.2856</td>
<td>0.8268</td>
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<td>0.9085</td>
<td>0.3894</td>
<td>0.9250</td>
<td>0.5714</td>
<td>0.2563</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GSS</th>
<th>HK</th>
<th>HSS</th>
<th>Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2555</td>
<td>0.4124</td>
<td>0.4068</td>
<td>3.3780</td>
</tr>
<tr>
<td>0.2555</td>
<td>0.4124</td>
<td>0.4068</td>
<td>3.3780</td>
</tr>
<tr>
<td>0.1961</td>
<td>0.3144</td>
<td>0.3272</td>
<td>0.0517</td>
</tr>
</tbody>
</table>
MODE Tool: Object Statistics

(4) mode_APCP_24_SFC_fcst_obs_2005080700I_24L_24A.txt

Line types:
1. Simple forecast objects (8 lines)
2. Simple observation objects (10 lines)
3. Pairs of simple objects (up to 80 lines)
4. Composite forecast objects (5 lines)
5. Composite observation objects (5 lines)
6. Pairs of matched composite objects (5 lines)

Columns (42 of them!):
(1) valid_ymd, valid_hms, lead_hr, accum_hr
(1) fcst_rad, fcst_thresh, obs_rad, obs_thresh
(2) object_id, object_cat, centroid_x, centroid_y, centroid_lat, centroid_lon
(2) axis_ang, length, width, area, area_filter
(2) curvature, curvature_x, curvature_y, complexity
(2) intensity_10, intensity_25, intensity_50, intensity_75, intensity_90
(2) intensity_50, intensity_sum
(3) centroid_dist, boundary_dist, convex_hull_dist, angle_diff
(3) area_ratio, intersection_area, union_area, symmetric_diff
(3) intersection_over_area, complexity_ratio,
(3) percentile_intensity_ratio, interest

(1) = header columns for all rows
(2) = columns apply only to fcst or obs object line types
(3) = columns apply only to pair line types
MODE Tool: Threshold Merging

Apply lower merging threshold of 2.5 mm
MODE Tool: Run on RH At 500 mb

- Compare 12 hour forecast to analysis field
- Conv Radius of 5
- Conv Thresh of 80%
- 8 simple fcst objects
- 9 simple obs objects
- 5 matched composites

**MODE: RH at ISBL_500**

**Init Time:** Aug 7, 2005 00:00:00
**Valid Time:** Aug 7, 2005 12:00:00
**Lead Time:** 12 hours
**Accum Time:** 0 hours

**Fuzzy Engine Weights**
- Centroid Distance: 2.00
- Boundary Distance: 4.00
- Convex Hull Distance: 0.00
- Angle Difference: 1.00
- Area Ratio: 1.00
- Intersection/Area: 2.00
- Complexity Ratio: 0.00
- Intensity Ratio: 0.00
- Total Interest Thresh: 0.70

**Forecast**
- Mask Missing: on
- Mask Grid: off
- Mask Polygon: off
- Raw Thresh: 0.00 %
- Conv Radius: 5 ga
- Conv Thresh: 8.00 %
- Area Thresh: 0 ga
- Inten Thresh: 0.00 %
- Merge Thresh: 75.00 %
- Matching: none
- Simple: 8
- Unmatched: 3
- Composites: 5

**Observation**
- Mask Missing: on
- Mask Grid: off
- Mask Polygon: off
- Raw Thresh: 0.00 %
- Conv Radius: 5 ga
- Conv Thresh: 8.00 %
- Area Thresh: 0 ga
- Inten Thresh: 0.00 %
- Merge Thresh: 75.00 %
- Matching: match/merge
- Simple: 8
- Unmatched: 3
- Composites: 5

**Forecast/Interest**
- 4
- 7
- 6
- 9
- 1
- 1
- 1
- 0.9066
- 0.8779
- 0.8273

**Observation/Interest**
- 2
- 8
- 7
- 6
- 9
- 3
- 0.6369
- 0.6518
- 0.6305
- 0.6156
- 0.6060
- 0.5996
- 0.5931
- 0.5824
- 0.5474
- 0.5413
- 0.5391
- 0.5257
- 0.4786
- 0.4701
- 0.4536
- 0.4532
- 0.4386
- 0.4315
- 0.4326
- 0.4077
- 0.3408
- 0.3321
- 0.3263
- 0.3241
- 0.3053
- 0.2908
- 0.1918

**Forecast/Interest**
- 1
- 5
- 9
- 4
- 2
- 9
- 7
- 2
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
Outline

- MET Overview (Barb)
- Technical Information (John)
- MODE Tool (Randy and John)
- Grid Stat Tool (Lacey and John)
- Point Stat Tool (Lacey and John)
- Analysis Examples (Eric and Dave)
- Future Plans (Barb)
Grid Stat Tool

INPUT → RFMT → INTERMED → STATS → OUTPUT

Gridded Grib Input:
Observation Stage II/IV
Forecast Model Data From Post

PCP Combine
Gridded NetCDF Fcst/Obs

MODE
Grid Stat

Point PrepBufr Input Obs
PB2NC
NetCDF Point Obs

Point Stat
VSDB

PS Ascii NetCDF
Ascii VSDB NetCDF

VSDB

[ ] = optional
Grid Stat Tool Science

- What does `grid_stat` do?
- When do I use it?
- What can I tweak?
- What comes out?
What does `grid_stat` do?

It’s not *THAT* complicated!

From:
http://www.rubegoldberg.com
What does *grid_stat* do?

- Verification with two gridded datasets (grid-to-grid verification)
- Produces verification statistics
  - FHO statistics (Forecast rate, hit rate, observed rate)
  - Contingency table counts
  - Contingency table statistics
  - Statistics for continuous variables
- Allows accumulation of statistics across regions for gridded datasets
When do I use *grid_stat*?

Examples:

- Stage II/IV accum. precip.
- Model analyses (not recommended when forecast/analysis are from same model)

*Grid_*stat can be used for any model field output as long as both fcst and obs use same grib codes.
What can I tweak?

- Model field to verify
- Area to verify over
- Apply thresholds
- Alpha levels for confidence intervals
- Output type
What comes out?

- Output in VSDB format
  - For more about VSDB see: [http://www.emc.ncep.noaa.gov/mmb/papers/brill/VSDBformat.txt](http://www.emc.ncep.noaa.gov/mmb/papers/brill/VSDBformat.txt)
  - Interface with other systems, databases
  - Need initially to replicate existing capabilities in other verif. systems

- Other ASCII output
  - CTC (Contingency Table Counts)
  - CTS (Contingency Table Statistics)
  - FHO (Forecast rate, Hit rate, Observed rate)
  - Statistics for Continuous Variables
Statistics for discrete fields

- Total observations
- FHO statistics
- Contingency table counts
- Contingency table proportions
- Accuracy
- Bias
- Probability of Detecting Yes
- Probability of Detecting No
- False Alarm Ratio
- Critical Success Index
- Gilbert Skill Score
- Hanssen and Kuipers Discriminant
- Heidke Skill Score
- Odds Ratio
Statistics for continuous fields

- forecast/observation mean*
- forecast/observation standard deviation*
- Pearson correlation coefficient*
- Spearman rank correlation coefficient*
- Kendall tau rank correlation coefficient*
- mean error*
- standard deviation of the error*
- frequency bias
- mean absolute error
- mean squared error
- bias-corrected mean squared error
- root-mean squared error
- percentiles of the error
- partial sums

* Confidence intervals can be produced for these variables
Grid Stat Tool

INPUT → RFMT → INTERMED → STATS → OUTPUT

Gridded Grib Input: Observation Stage II/IV
Forecast Model Data From Post

PCP Combine
Gridded NetCDF Fcst/Obs

MODE
Grid Stat

Point Stat
VSDB

PS Ascii NetCDF
Ascii VSDB NetCDF

Point PrepBufr Input Obs
PB2NC
NetCDF Point Obs

[ ] = optional
Grid Stat Tool Practical

- Tool for comparing two gridded fields using standard verification methods for discrete and continuous statistics

- Input:
  - NetCDF output of pcp_combine
  - Grib fcst and obs data on a common grid
    - Use “copygb” tool to re-grid grib files
  - Configuration file

- Output (2+ files):
  - NetCDF difference fields
  - VSDB statistics file
  - Ascii statistics files
Grid Stat Tool: Usage

Usage: `grid_stat`

`fcst_file obs_file model`

`<-config config_file> <-outdir output_dir> <-v level>`

- "fcst_file" is a forecast file in either Grib or netCDF format (output of `pcp_combine`) containing the field(s) to be verified (required).

- "obs_file" is an observation file in either Grib or netCDF format (output of `pcp_combine`) containing the verifying field(s) (required).

- "model" is the name of the model being verified (required).

- `-config` overrides the default GridStat configuration settings with the contents of "config_file" (optional).

- `-outdir` overrides the default output directory (VX_BASEDIR/out/grid_stat) with "output_dir" (optional).

- `-v` overrides the default level of verbosity (1) with "level" (optional).

NOTE: The forecast and observation fields must be on the same grid.
Grid Stat Tool: Example

Run grid_stat on 24 hour accumulation NetCDF files (output of pcp_combine)

```
grid_stat
  sample_fcast_2005080700I_24L_24A.nc
  sample_obs_2005080800V_24A.nc
  WRF
  -config GridStatConfig_APCP_24
  -outdir .
```
Grid Stat Tool: Config File

- `vx_grib_code = "APCP/A24";`
- `mask_grids = "G212 G165 G166";`
- `mask_polys = "/pd6/score/verif_se/data/poly/MDW.poly  
/pd6/score/verif_se/data/poly/LMV.poly";`
- `thresholds = "gt0.0 ge5.00";`
- `ci_alpha = "0.10 0.05";`
- `output_flag[] = [ 2, 2, 2, 2, 2, 2, 2, 2, 1 ];`
  
  **Output types:**
  - FHO, CTC, CTP, CFP, COP (contingency table contents)
  - CTS (contingency table statistics)
  - CNT (continuous statistics)
  - SL1L2 (partial sums)
  - NetCDF (difference fields)

  0 -> do not write line type
  1 -> write to VSDB
  2 -> write to both VSDB and Ascii

- `ncep_defaults = 1;`
Grid Stat Tool: Masking Regions

- **NCEP Grids**
  - 75 of NCEP Grids are defined (GNNN)
  - Need to add support for Mercator
  - [http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html](http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html)
  - Implementing new grids requires minor code changes

- **Lat/Lon Polyline Regions**
  - 33 NCEP verification sub-domains are defined
  - [http://www.emc.ncep.noaa.gov/mmb/research/nearsfc/nearsfc.verf.html](http://www.emc.ncep.noaa.gov/mmb/research/nearsfc/nearsfc.verf.html)
  - Users may define their own with no code change required
Grid Stat Tool: NetCDF Output (ncview)

(1) grid_stat_2005080700I_24L_diff.nc
Contains 1 difference field of APCP for each of 5 verification regions

G212  G165  G166
MDW  LMV
Grid Stat Tool: VSDB Output

(2) grid_stat_2005080700I_24L.vsdb

- **Line Header Columns (9 of them):**
  - VRS, MODEL, F-HR, INIT_TIME, OBTYPE, VX_MASK, **LINE_TYPE**, VAR, LEVEL =

- **Line types:**
  1. *FHO* Forecast, Hit, Observation Rates (as used by NCEP)
  2. *CTC* Contingency Table Counts (as used by NCAR-RAL)
  3. *CTP* Contingency Table Proportions of the Total Count
  4. *CFP* Contingency Table Proportions of the Forecast Count
  5. *COP* Contingency Table Proportions of the Observation Count
  6. **CTS** Contingency Table Statistics (13 columns)
     - TOTAL, BASER, FMEAN, ACC, BIAS, PODY, PODN, FAR, CSI, GSS, HK, HSS, ODDS
  7. **CNT** Continuous Statistics (33 columns)
     - TOTAL, FBAR, FBAR_CL, FBAR_CU, FSTDEV, FSTDEV_CL, FSTDEV_CU, OBAR, OBAR_CL, OBAR_CU, OSTDEV, OSTDEV_CL, OSTDEV_CU, CORR, CORR_CL, CORR_CU, ME, ME_CL, ME_CU, ESTDEV, ESTDEV_CL, ESTDEV_CU, FBIAS, MAE, MSE, BCMSE, RMSE, E10, E25, E50, E75, E90
  8. **SL1L2** Scalar L1L2 Partial Sums (6 columns)
     - TOTAL, FBAR, OBAR, FOBAR, FFBAR, OOBAR

(*) = easily derived from each other
Duplicate of the data in the VSDB file organized by line type and including a header row

<table>
<thead>
<tr>
<th>VRS MODEL</th>
<th>F-HR</th>
<th>INIT_TIME</th>
<th>OTYPE</th>
<th>VX_MASK</th>
<th>FHO_T</th>
<th>VAR</th>
<th>LEVEL</th>
<th>TOTAL</th>
<th>F_RATE</th>
<th>H_RATE</th>
<th>O_RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G212</td>
<td>FHO&gt;0.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>6412</td>
<td>0.61011</td>
<td>0.39239</td>
<td>0.47458</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G165</td>
<td>FHO&gt;0.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>2645</td>
<td>0.69452</td>
<td>0.39433</td>
<td>0.46238</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G166</td>
<td>FHO&gt;0.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>3764</td>
<td>0.55048</td>
<td>0.39107</td>
<td>0.48326</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>MDW</td>
<td>FHO&gt;0.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>887</td>
<td>0.20631</td>
<td>0.03382</td>
<td>0.09921</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>LMV</td>
<td>FHO&gt;0.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>526</td>
<td>0.84791</td>
<td>0.70722</td>
<td>0.74905</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G212</td>
<td>FHO&gt;=5.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>6412</td>
<td>0.11167</td>
<td>0.03587</td>
<td>0.11650</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G165</td>
<td>FHO&gt;=5.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>2645</td>
<td>0.05822</td>
<td>0.00983</td>
<td>0.06616</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>G166</td>
<td>FHO&gt;=5.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>3764</td>
<td>0.14931</td>
<td>0.05420</td>
<td>0.15197</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>MDW</td>
<td>FHO&gt;=5.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>887</td>
<td>0.02255</td>
<td>0.00338</td>
<td>0.00564</td>
</tr>
<tr>
<td>V01 WRF</td>
<td>24</td>
<td>2005080700</td>
<td>MC_PCP</td>
<td>LMV</td>
<td>FHO&gt;=5.000</td>
<td>APCP/24</td>
<td>SFC</td>
<td>526</td>
<td>0.22814</td>
<td>0.03232</td>
<td>0.17681</td>
</tr>
</tbody>
</table>
Outline

- MET Overview (Barb)
- Technical Information (John)
- MODE Tool (Randy and John)
- Grid Stat Tool (Lacey and John)
- Point Stat Tool (Lacey and John)
- Analysis Examples (Eric and Dave)
- Future Plans (Barb)
Point Stat Tool

INPUT → RFMT → INTERMED → STATS → OUTPUT

Gridded Grib Input:
Observation Stage II/IV
Forecast Model Data From Post

PCP Combine

Grid Stat

MODE

PS Ascii NetCDF

Ascii VSDB NetCDF

Point Stat

VSDB

Gridded NetCDF Fcst/Obs

Point PrepBufr Input Obs

PB2NC

NetCDF Point Obs

= optional
Point Stat Tool Science

- What does `point_stat` do?
- When do I use it?
- What can I tweak?
- What comes out?
What does \textit{point\_stat} do?

- Verification using point-based observations (i.e., ungridded obs)
- Produces verification statistics
  - FHO statistics (forecast rate, hit rate, observed rate)
  - Contingency table counts
  - Contingency table scores
  - Statistics for continuous variables
- Allows accumulation of statistics across regions
When do I use `point_stat`?

- When you have ungridded obs (prepbufr)
- Why is prepbufr used?
  - Available in real-time
  - Initial need to replicate capabilities of other systems
- What may be contained in prepbufr?
  - Upper air observations (rawinsondes, pibals, dropsondes, etc.)
  - Surface Synoptic & METAR reports
  - ACARS, AIREPs/PIREPs, AMDAR
  - Satellite, Nexrad Winds
  - Ship & buoy reports
  - Many others, see: [http://www.emc.ncep.noaa.gov/mmb/data_processing/prepbufr.doc/table_1.htm](http://www.emc.ncep.noaa.gov/mmb/data_processing/prepbufr.doc/table_1.htm)
  - Depending on source, some types restricted from public
What can I tweak?

- Model field to verify
- Area to verify over
- Thresholds
- Alpha levels for confidence intervals
- Interpolation scheme
- Observation types
- Output type
What comes out of `point_stat`?

- Output in NCEP’s VSDB format
- Other ASCII output
  - CTC (Contingency Table Counts)
  - CTS (Contingency Table Statistics)
  - FHO (Forecast rate, Hit rate, Observed rate)
  - Statistics for Continuous Variables
Statistics for discrete fields

- Total observations
- FHO statistics (forecast rate, hit rate, observation rate)
- Contingency table counts
- Contingency table proportions
- Accuracy
- Bias
- Probability of Detecting Yes
- Probability of Detecting No
- False Alarm Ratio
- Critical Success Index
- Gilbert Skill Score
- Hanssen and Kuipers Discriminant
- Heidke Skill Score
- Odds Ratio
Statistics for continuous fields

- forecast/observation mean*
- forecast/observation standard deviation*
- Pearson correlation coefficient*
- Spearman rank correlation coefficient*
- Kendall tau rank correlation coefficient*
- mean error*
- standard deviation of the error*
- frequency bias
- mean absolute error
- mean squared error
- bias-corrected mean squared error
- root-mean squared error
- percentiles of the error
- scalar and vector partial sums

* Confidence intervals can be produced for these variables
PB2NC Tool Practical

- Tool for reading PrepBufr observation files, parsing out desired observations, deriving additional quantities, and converting to a NetCDF format
- Modeled after NCEP’s editbufr
- PrepBufr file must first be fortran blocked

Input:
- PrepBufr observation file
- Configuration file

Output (1 file):
- Stratified NetCDF observation file

(*) = under development
PB2NC Tool: cwordsh

- Perform fortran blocking on input PrepBufr file to allow for an unformatted fortran read of the binary PrepBufr data
- Input: Unblock PrepBufr file
- Output: Fortran blocked PrepBufr file
- Example:

  ```cwordsh
  block
  ndas.t00z.prepbufr.tm12.20070401.nr
  ndas.t00z.prepbufr.tm12.20070401.nr.blk```
PB2NC Tool: Usage

Usage:  

```
pb2nc
  prepbufr_file netcdf_file
  <-config config_file> <-v level>
  <-nmsg num_messages> <-dump dump_dir>
```

- "prepbufr_file" is the input PrepBufr observation file to be converted to netCDF format (required).
- "netcdf_file" indicates the name of the output netCDF file to be written (required).
- "-config" overrides the default pb2nc settings with the contents of "config_file" (optional).
- "-v" overrides the default level of verbosity (10) with "level" (optional).
- "-nmsg" indicates that the number of PrepBufr message to process is "num_messages" (optional).
- "-dump" indicates that the entire contents of "prepbufr_file" should also be dumped to text files in the directory specified by "dump_dir" (optional).
PB2NC Tool: Stratification

- Ability to stratify by:
  - PrepBufr message type
    - ADPUPA  AIRCAR AIRCFT  ADPSFC  ERS1DA  GOESND  GPSIPW
    - MSONET  PROFLR  QKSWND  RASSDA  SATEMP  SATWND  SFCBOG
    - SFCSHP  SPSSMI  SYNDAT  VADWND
  - Station ID
  - Valid time window
    - Seconds +/- observation time
  - Location (NCEP Grid or Lat/Lon Polyline)
  - Elevation window
  - PrepBufr Report Type
  - Input Report Type
  - Instrument Type
  - Vertical Level
  - Observation Variable Type
  - Quality Mark
  - Data Level Category
PB2NC Tool: Example

- Run pb2nc on PrepBufr file with observations around 2007033112

```
  pb2nc
  ndas.t00z.prepbufr.tm12.20070401.nr.blk
  ndas.t00z.prepbufr.tm12.20070401.nr.nc
  -config PB2NCConfig -v 2
```
PB2NC Tool: Config File

- message_type "";
- station_id = "";
- beg_ds = -1800;
- end_ds = 1800;
- mask_grid = "G212";
- mask_poly = "";
- beg_elev = -1000;
- end_elev = 100000;
- pb_report_type = "";
- in_report_type = "";
- instrument_type = "";
- beg_level = 1;
- end_level = 255;
- obs_grib_code = "SPFH TMP HGT UGRD VGRD";
- quality_mark_threshold = 2;
- multiple_quality_marks_flag = 0;
- level_category = "";

PrepBufr2NC config file: PB2NCConfig
Opening PrepBufr file: ndas.t00z.prepbufr.tm12.20070401.nr.blk
Creating netCDF file: ndas.t00z.prepbufr.tm12.20070401.nr.nc
Processing 69833 PrepBufr messages... 0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95%
Total PrepBufr Messages processed = 69833
Rejected based on message type = 0
Rejected based on station id = 0
Rejected based on valid time = 42784
Rejected based on masking grid = 14617
Rejected based on masking polygon = 0
Rejected based on elevation = 0
Rejected based on pb report type = 0
Rejected based on input report type = 0
Rejected based on instrument type = 0
Rejected based on zero observations = 2716
Total PrepBufr Messages retained = 9716
Total observation records retained = 56630
PB2NC Tool: NetCDF Output (ncdump)

```c
netcdf ndas.t00z.prepbufr.tm03.20070401.nr {

dimensions:
    mxstr = 20;
    hdr_arr_len = 7;
    obs_arr_len = 11;
    nobs = UNLIMITED; // (56630 currently)
    nmsg = 9716;

variables:
    float obs_arr(nobs, obs_arr_len);
    obs_arr:long_name = "array of observation values";
    obs_arr:_fill_value = -9999.f;
    obs_arr:columns = "hdr_id level p_level gc ob qm pc rc fc an cat";
    obs_arr:hdr_id_long_name = "index of matching header data";
    obs_arr:level_long_name = "vertical level";
    obs_arr:p_level_long_name = "pressure level (hPa or mb)";
    obs_arr:gc_long_name = "grib code corresponding to the observation type";
    obs_arr:ob_long_name = "observation value";
    obs_arr:qm_long_name = "quality mark";
    obs_arr:pc_long_name = "program code";
    obs_arr:rc_long_name = "reason code";
    obs_arr:fc_long_name = "forecast value";
    obs_arr:an_long_name = "analyzed value";
    obs_arr:cat_long_name = "data level category";
}
```
PB2NC Tool: NetCDF Output (cont’d)

```c
char hdr_typ(nmsg, mxstr);
   hdr_typ:long_name = "message type";
char hdr_sid(nmsg, mxstr);
   hdr_sid:long_name = "station identification";
char hdr_vld(nmsg, mxstr);
   hdr_vld:long_name = "valid time (observation time plus dhr)";
   hdr_vld:units = "YYYY-MM-DD_HH:MM:SS UTC";
float hdr_arr(nmsg, hdr_arr_len);
   hdr_arr:long_name = "array of observation station header values";
   hdr_arr:_fill_value = -9999.f;
   hdr_arr:columns = "lon lat dhr elv typ t29 itp"
   hdr_arr:lon_long_name = "longitude";
   hdr_arr:lon_units = "degrees_east";
   hdr_arr:lat_long_name = "latitude";
   hdr_arr:lat_units = "degrees_north";
   hdr_arr:dhr_long_name = "observation time minus cycle time";
   hdr_arr:dhr_units = "hours";
   hdr_arr:elv_long_name = "elevation";
   hdr_arr:elv_units = "meters";
   hdr_arr:typ_long_name = "prepbufr report type";
   hdr_arr:t29_long_name = "input report type";
   hdr_arr:itp_long_name = "instrument type";

// global attributes:
   :FileOrigins = "File ndas.t00z.prepbufr.tm12.20070401.nr.nc generated 2007-06-13_18:14:16 UTC on host cardinal";
   :obs_time = "2007-03-31_12:00:00";
...}
```
Tool for comparing a gridded forecast field to point observations using standard verification methods for discrete and continuous statistics

Input:
- Grib forecast data
- NetCDF point observations (output of pb2nc)
- Grib climatological data (optional)
- Configuration file

Output (1+ files):
- VSDB statistics file
- Ascii statistics files
Point Stat Tool: Usage

**Usage:**  *point_stat*

```
fcst_file obs_file model
<config config_file> <climo climo_file>
<outdir output_dir> <-v level>
```

- "**fcst_file**" is a forecast file in Grib format containing the field(s) to be verified (required).
- "**obs_file**" is an observation file in netCDF format (output of pb2nc) containing the verifying observation data points (required).
- "**model**" is the name of the model being verified (required).
- `-config` overrides the default PointStat configuration settings with the contents of "config_file" (optional).
- `-climo` provides a Grib file containing climatological values on the same grid as the forecast file to be used when computing scalar and vector anomaly measures using the contents of "climo_file". If not provided, scalar and vector anomaly values will not be computed (optional).
- `-outdir` overrides the default output directory (/pd6/score/verif_se/out/point_stat) with "output_dir" (optional).
- `-v` overrides the default level of verbosity (1) with "level" (optional).
Point Stat Tool: Example

- Run `point_stat` on a 36 hour NAM forecast initialized at 2007033000 and valid at 2007033112

```
point_stat
  nam.t00z.awip1236.tm00.20070330.grb
  ndas.t00z.prepbufr.tm12.20070401.nr.nc
  WRF
  -config PointStatConfig_NAM
  -outdir . -v 2
```
Point Stat Tool: Config File

- `vx_grib_code = "TMP/P750-900 UGRD/L10 VGRD/L10";
- `thresholds = "le0 gt0 | ge5 | ge5";
- `message_type = "ADPUPA ADPSFC";
- `mask_grids = "G212 G165 G166";
- `mask_polys = ";
- `ci_alpha = "0.05";
- `interp_flag[] = [ 0, 0, 1, 0, 1 ];
  - Interpolation Methods:
    - min, max, median, unweighted mean, distance-weighted mean
- `interp_width = "1 2";
- `interp_threshold = 1;
- `output_flag[] = [ 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2 ];
  - Output types:
    - FHO, CTC, CTP, CFP, COP (contingency table contents)
    - CTS (contingency table statistics)
    - CNT (continuous statistics)
    - SL1L2, SAL1L2, VL1L2, VAL1L2 (partial sums)
- `ncep_defaults = 1;
Forecast File: nam.t00z.awip1236.tm00.20070330.grb
Observation File: ndas.t00z.prepbufr.tm12.20070401.nr.nc
Configuration File: PointStatConfig
Climatology File: none
Creating Output VSDB file: ./point_stat_2007033000I_36L.vsdb

----------------------------------------
Reading records for Grib Field TMP at P750-900
For Grib Field TMP at P750-900 found 4 forecast levels and 0 climatology levels
----------------------------------------
Reading records for Grib Field UGRD at L10
For Grib Field UGRD at L10 found 1 forecast levels and 0 climatology levels
----------------------------------------
Reading records for Grib Field VGRD at L10
For Grib Field VGRD at L10 found 1 forecast levels and 0 climatology levels
----------------------------------------
Processing 56630 observations from 9716 PrepBufr messages...

For Grib Field TMP at P750-900 over region G212 using observation type ADPUPA, interpolation method UW_MEAN(1), found 537 pairs.
For Grib Field TMP at P750-900 over region G212 using observation type ADPUPA, interpolation method MEDIAN(2), found 537 pairs.

For Grib Field UGRD at L10 over region G212 using observation type ADPUPA, interpolation method UW_MEAN(1), found 75 pairs.
For Grib Field UGRD at L10 over region G212 using observation type ADPUPA, interpolation method MEDIAN(2), found 75 pairs.

For Grib Field VGRD at L10 over region G212 using observation type ADPUPA, interpolation method UW_MEAN(1), found 75 pairs.
For Grib Field VGRD at L10 over region G212 using observation type ADPUPA, interpolation method MEDIAN(2), found 75 pairs.

----------------------------------------
Output VSDB file: ./point_stat_2007033000I_36L.vsdb
Point Stat Tool: VSDB Output

(1) point_stat_2007033000I_36L.vsdb

- Line Header Columns (9 of them):
  - VRS, MODEL, F-HR, INIT_TIME, OBTYPE, VX_MASK, **LINE_TYPE**, VAR, LEVEL =

- Line types:
  1. FHO, CTC, CTP, CFP, COP
  6. CTS  Contingency Table Statistics (15 columns)
  7. CNT  Continuous Statistics (35 columns)
  8. SL1L2  Scalar L1L2 Partial Sums (8 columns)
    - TOTAL, FBAR, OBAR, FOBAR, FFBAR, OOBAR
    - INTERP_MTHD, INTERP_PNTS
  9. SAL1L2  Scalar Anomaly L1L2 Partial Sums (8 columns)
    - TOTAL, FABAR, OABAR, FOABAR, FFABAR, OOABAR
    - INTERP_MTHD, INTERP_PNTS
  10. VL1L2  Vector L1L2 Partial Sums (10 columns)
    - TOTAL, UFBAR, VFBAR, UOBAR, VOBAR, UVFOBAR, UVFFBAR, UVOOBAR,
    - INTERP_MTHD, INTERP_PNTS
  11. VAL1L2  Vector Anomaly L1L2 Partial Sums (10 columns)
    - TOTAL, UFABAR, VFABAR, UOABAR, VOABAR, UVFOABAR, UVFFABAR, UVOOABAR
    - INTERP_MTHD, INTERP_PNTS
Point Stat Tool: Ascii Output

(2) point_stat_2007033000I_36L_fho.txt
(3) point_stat_2007033000I_36L_ctc.txt
(4) point_stat_2007033000I_36L_ctp.txt
(5) point_stat_2007033000I_36L_cfp.txt
(6) point_stat_2007033000I_36L_cop.txt
(7) point_stat_2007033000I_36L_cts.txt
(8) point_stat_2007033000I_36L_cnt.txt
(9) point_stat_2007033000I_36L_sl1l2.txt (…_sal1l2.txt)
(11) point_stat_2007033000I_36L_vl1l2.txt (…_val1l2.txt)

Duplicate of the data in the VSDB file organized by line type and including a header row

<table>
<thead>
<tr>
<th>VRS MODEL</th>
<th>F-HR</th>
<th>INIT_TIME</th>
<th>OBTYPE</th>
<th>VX_MASK</th>
<th>FHO_T</th>
<th>VAR</th>
<th>LEVEL</th>
<th>TOTAL</th>
<th>F_RATE</th>
<th>H_RATE</th>
<th>O_RATE</th>
<th>INTERP_MTHD</th>
<th>INTERP_PNTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPUPA G212</td>
<td>FHO&lt;=0.0</td>
<td>TMP  P750-900 = 537</td>
<td>0.25512</td>
<td>0.21043</td>
<td>0.27374</td>
<td>UW_MEAN</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPUPA G212</td>
<td>FHO&gt;0.0</td>
<td>TMP  P750-900 = 537</td>
<td>0.74488</td>
<td>0.68156</td>
<td>0.72626</td>
<td>UW_MEAN</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPUPA G212</td>
<td>FHO&lt;=0.0</td>
<td>TMP  P750-900 = 537</td>
<td>0.16713</td>
<td>0.15320</td>
<td>0.45961</td>
<td>UW_MEAN</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPUPA G212</td>
<td>FHO&gt;0.0</td>
<td>TMP  P750-900 = 537</td>
<td>0.83287</td>
<td>0.52646</td>
<td>0.54039</td>
<td>UW_MEAN</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPSFC G212</td>
<td>FHO&lt;=0.0</td>
<td>TMP  P750-900 = 359</td>
<td>0.17549</td>
<td>0.15877</td>
<td>0.45961</td>
<td>MEDIAN</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPSFC G212</td>
<td>FHO&gt;0.0</td>
<td>TMP  P750-900 = 359</td>
<td>0.82451</td>
<td>0.52368</td>
<td>0.54039</td>
<td>MEDIAN</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPSFC G212</td>
<td>FHO&lt;=0.0</td>
<td>TMP  P750-900 = 359</td>
<td>0.18384</td>
<td>0.16713</td>
<td>0.45961</td>
<td>DW_MEAN</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V01 WRF</td>
<td>36</td>
<td>2007033000 ADPSFC G212</td>
<td>FHO&gt;0.0</td>
<td>TMP  P750-900 = 359</td>
<td>0.81616</td>
<td>0.52368</td>
<td>0.54039</td>
<td>DW_MEAN</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...
Outline

- MET Overview (Barb)
- Technical Information (John)
- MODE Tool (Randy and John)
- Grid Stat Tool (Lacey and John)
- Point Stat Tool (Lacey and John)
- Analysis Examples (Eric and Dave)
- Future Plans (Barb)
Analysis Examples

INPUT → RFMT → INTERMED → STATS → OUTPUT

Gridded Grib Input:
Observation Stage II/IV
Forecast Model Data From Post

PCP Combine
Gridded NetCDF Fcst/Obs

MODE
Grid Stat

Point Stat
NetCDF Point Obs

PS
Ascii NetCDF

Ascii VSDB NetCDF

VSDB

{[ ]} = optional
MET Analysis
Summary across many forecasts

- grid_stat
- point_stat
- MODE

- Stratification
- aggregation
July 15 – August 15, 2005

- 13 km
- 24 h forecasts
- Initialized 0 and 12 UTC
- 4 WRF model configurations
- 3 h accumulated precipitation
- Stage II radar-gauge estimate
- grid_stat run 1945 times
grid_stat analysis

bias

Gilbert Skill Score

![Graphs showing bias and Gilbert Skill Score with data for August 2005.]
MODE analysis

Graphs showing time series of bias, critical success index, and number of objects over UTC time periods from 00 to 21 UTC.

MAPS showing spatial distribution of analysis objects and forecast objects.
MODE rose plots

- Displacement of matched forecast objects
MODE rose plots

- Displacement of matched forecast objects
MET Analysis Tool

- Summary stats and spatial averaging
- Basic output
  - Boxplot
  - Discrimination plot
  - Reliability diagram
  - Scatter/density plot
  - Conditional quantile plot
  - Height series
  - Histogram
- R, IDL, NCL, MATLAB, GrADS examples
Outline

☐ MET Overview (Barb)
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The Future of MET

- Training, bugs, and version control
  - Successive version releases
  - Community feedback
- New capabilities to be added in next version
  - Ensemble and probability forecast verification methods
  - Methods for extremes
  - New spatial verification capabilities (e.g., Ebert CRA approach; fuzzy verification methods)
- Additional analysis capabilities
- Developing “System” concepts
  - Ex: Database interface
- Provide opportunity to demonstrate new methodologies

Gallus and Ebert 2006

Roberts 2006
How to get MET

- Beta testers are wanted!
  - Contact Lacey Holland (lholland@ucar.edu)
  - Beta release at the end of June
- Formal release in August
- Future releases will be announced through WRF-help
- Future establishment of MET user group and web site