# MET 6.1 Enhancements

MET 6.0 Bugfixes

- https://dtcenter.org/met/users/support/known_issues/METv6.0/index.php
- **09/20/2017:** Fix madis2nc segfault, Add support for GRIB2 decimal level values, Add support for GRIB2_stat_type filtering option.
- **07/31/2017:** Add support for Polar Stereographic CF-Compliant NetCDF files.
- **07/25/2017:** Fix GRIB1 file support for fixed level types.
- **07/21/2017:** Fix support for reorienting NetCDF lat/lon grids, Fix Mercator grid support, Fix GRIB2 file support for fixed level types.
- **06/23/2017:** Fix Grid-Stat's handling of missing climatology data, Fix PCP-Combine to handle accumulation hours up to 5 digits in length.
- **06/16/2017:** Fix MET NetCDF file support for more than 2 dimensions, Fix GRIB2 file support for probabilities.
- **04/19/2017:** Print status message after running make test, Remove duplicate GRIB2 table entry for APCP, Change warnings for mutiple GRIB table matches to debug messages, Refine bilinear interpolation logic at the grid boundary, Fix buffer overflow bug in PB2NC, Fix dimension indexing bug in MET NetCDF library.

MET 6.1 Beta on WCOSS

- **tide**:
  - module use /global/noscrub/Julie.Prestopnik/modulefiles
  - module load met/6.1_beta4
- **luna**:
  - module use /gpfs/hps3/emc/global/noscrub/Julie.Prestopnik/modulefiles
    module load met/6.1_beta4
- **gyre**:
  - module use /global/noscrub/Julie.Prestopnik/modulefiles
    module load met/6.1_beta4
- **surge**:
  - module use /gpfs/hps3/emc/global/noscrub/Julie.Prestopnik/modulefiles
  - module load met/6.1_beta4
- **theia**:
  - module use /contrib/modulefiles/
 - module load met/6.1_beta4

NCEP Regions as Polylines

- Lat/Lon Polyline version of these files in data/poly directory.
- Comparing VSDB to MET, Mallory Row found some issues.

- Polyline is a closed area with no holes.
  - **SAK**: Southern Alaska split into two pieces.
  - **NPO**: Should have hole for portion of SAK.
  - **SPO**: Should have hole for HWI region.
  - SAK.poly, NPO.poly, and SPO.poly are excluded from met-6.1.
- Missing rows and columns along edge of domain.
- No good solution yet.
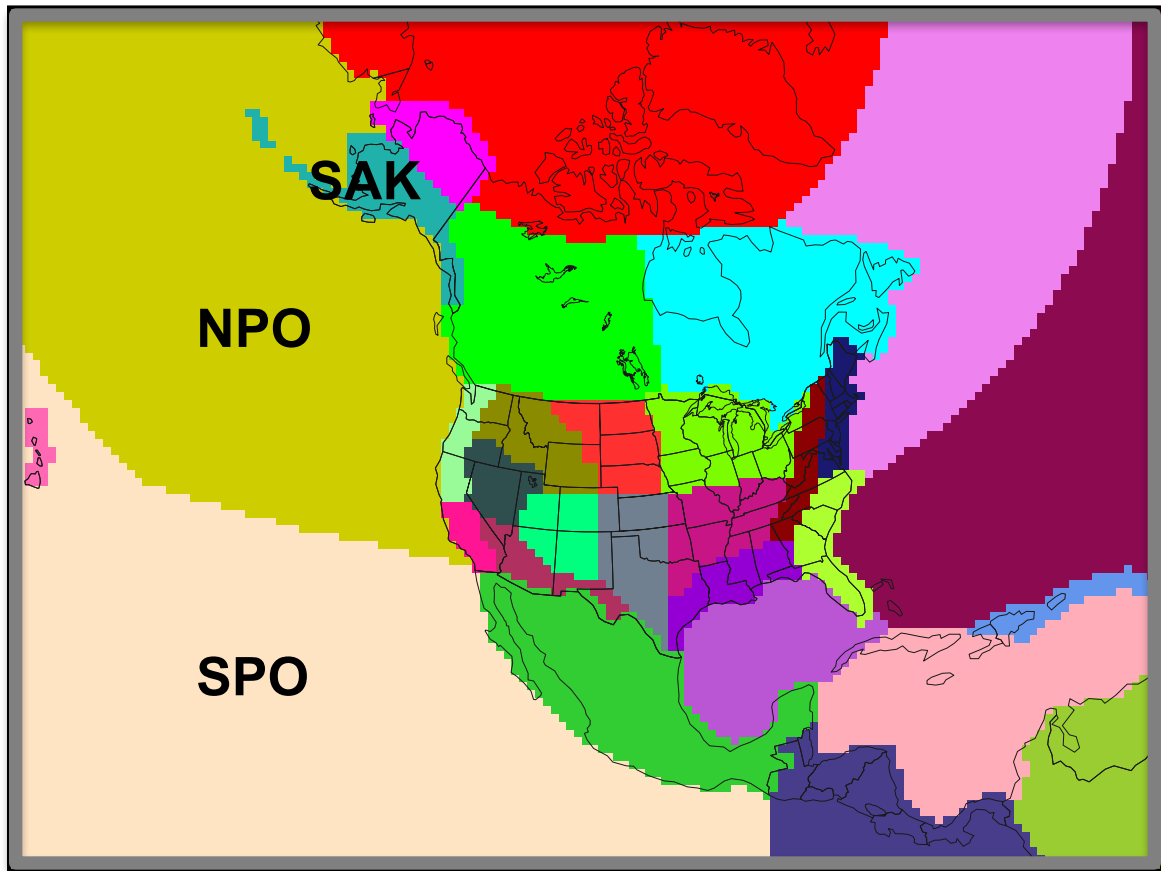
Auto-Regridding of Masks

- 31 NCEP Verification Regions are defined for Grid 104.

  - CONUS, EAST, and WEST are groups of sub-regions.

- Added 34 NetCDF files to data/poly/NCEP_masks.

- **met-6.0:** Mask must be defined on verification domain:

  - ERROR : parse_poly_mask() -> The masking and verification grids do not match:

- **met-6.1:** Regrid mask (NEAREST neighbor) to verification domain:

  - DEBUG 2: Regridding mask grid to the verification grid using nearest neighbor interpolation:

- Most similar to VSDB logic.

GRID 104

GRID 223
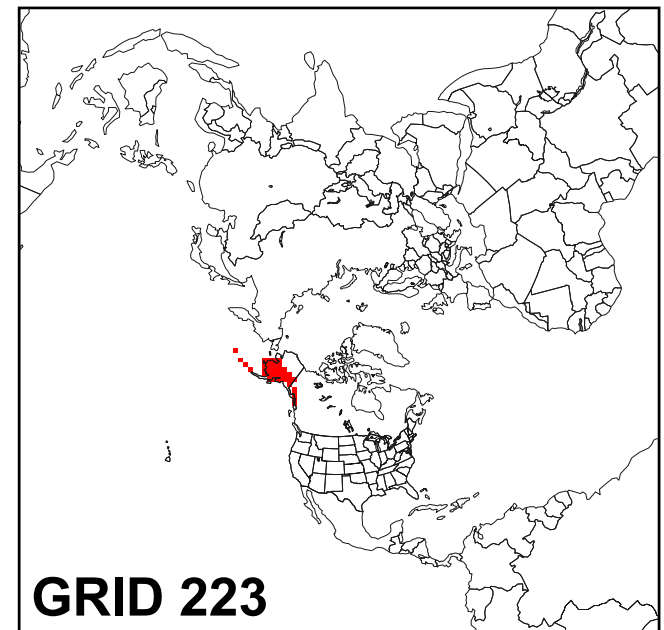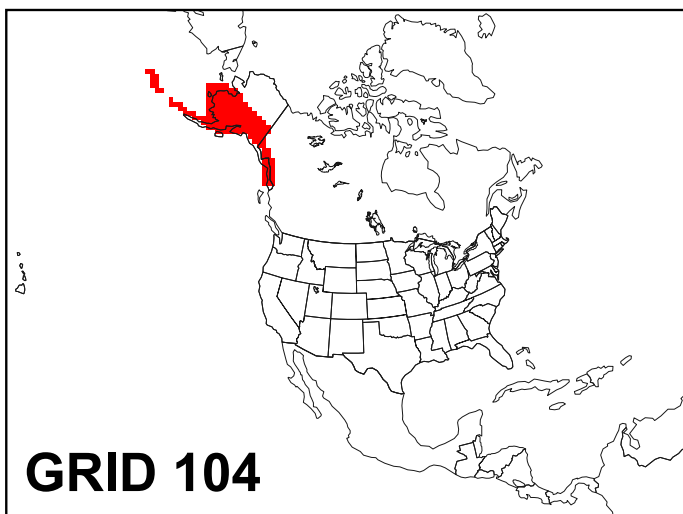
PB2NC: Configuration

- met-6.0 was limited to P, Q, T, Z, U, V, and derived variables.
- met-6.1 reads many more observation types from PREPBUFR *and* BUFR.
- Switch from identifying obs as GRIB1 strings to BUFR mnemonics:
  - **met-6.0**: `obs_grib_code = [ "SPFH", "TMP", "HGT", "UGRD", "VGRD" ];`
  - **met-6.1**: `obs_bufr_var  = [ "QOB", "TOB", "ZOB", "UOB", "VOB" ];`
- Define obs_bufr_map and obs_prepbufr_map for backward compatibility:

```
obs_bufr_map = [];
obs_prefbufr_map = [
    { key = "POB";     val = "PRES";  },
    { key = "QOB";     val = "SPFH";  },
    { key = "TOB";     val = "TMP";   },
    { key = "ZOB";     val = "HGT";   },
    { key = "UOB";     val = "UGRD";  },
    { key = "VOB";     val = "VGRD";  },
    { key = "D_DPT";   val = "DPT";   },
    { key = "D_WDIR";  val = "WDIR";  },
    { key = "D_WIND";  val = "WIND";  },
    { key = "D_RH";    val = "RH";    },
    { key = "D_MIXR";  val = "MIXR";  },
    { key = "D_PRMSL"; val = "PRMSL"; }
];
```

Mapping BUFR mnemoics to GRIB1 usage.

"D_" prefix for derived observation types.

PB2NC: Output

- Self-describing output NetCDF file format.
- Replace **gc** GRIB code with **var_id** index into the **obs_var** variable.
- **met-6.0:**
  ```
  float obs_arr(nobs, obs_arr_len) ;
      obs_arr:columns = "hdr_id gc lvl hgt ob" ;
  ```
- **met-6.1:**
  ```
  float obs_arr(nobs, obs_arr_len) ;
      obs_arr:columns = "hdr_id var_id lvl hgt ob" ;
  char obs_var(obs_var_num, mxstr) ;
      obs_var:long_name = "BUFR variable names from Table B" ;
  obs_var =
      "SPFH", "TMP", "HGT", "UGRD", "VGRD", "DPT", "WIND", "RH", "MIXR" ;
  ```
- Run with **–index** option to list available observations, along with message types:
  ```
  DEBUG 1: HOCB: HEIGHT OF BASE OF CLOUD types: ADPUPA AIRCFT ADPSFC SFCSHP
  DEBUG 1: TP06: TOTAL PRECIPITATION PAST 6 HOURS types: ADPSFC
  DEBUG 1: TP24: TOTAL PRECIPITATION PAST 24 HOURS types: ADPSFC
  DEBUG 1: MITM: MINIMUM TEMPERATURE types: ADPSFC
  DEBUG 1: MXTM: MAXIMUM TEMPERATURE types: ADPSFC
  ```
- Add **message_type_map** config file option for renaming input message types.
- Add **–obs_var** command line option for plot_point_obs utility.

PB2NC: Time Summary

- Port the logic for time summary derivations from ASCII2NC to PB2NC.

- For example, compute the hourly maximum of 5 minutes winds or compute the daily maximum concentration.

ASCII2NC Column 7

- **met-6.0:**

  ```
  The "met_point" ASCII format consists of 11 columns:
      Message_Type Station_ID Valid_Time(YYYYMMDD_HHMMSS)
      Lat(Deg North) Lon(Deg East) Elevation(msl)
      Grib_Code Level Height(msl or agl) QC_String
      Observation_Value
  ```

- In **met-6.1**, the **Grib_Code** column may either contain an integer or a strings.

  - Integers are interpreted as GRIB1 codes (backward compatibility).
  - Strings are stored in the **obs_var** output variable.

obs Dictionary for Point Data

- The point observation files generated by PB2NC, LIDAR2NC, MADIS2NC, and ASCII2NC are read by Point-Stat, Ensemble-Stat, and Plot-Point-Obs.
- These tools can process both **OLD** (met-6.0 and prior) and **NEW** (met-6.1) NetCDF point observation files.
- Use GRIB1 conventions for old files:

```
fcst = {
    field = [ { name = "APCP"; level = "A24"; } ];
}
obs = fcst; // APCP is GRIB code 61
```

- Use BUFR variable names for new files:

```
fcst = {
    field = [ { name = "APCP"; level = "A24"; } ];
}
obs = {
    field = [ { name = "TP24"; level = "Z0"; } ];
}
```

Interpolation Shape

- Add support for circular interpolation, regridding, and data smoothing areas rather than just squares.

- Smooth data by computing the **MAX** of **WIDTH** of 30.

shape = SQUARE

shape = CIRCLE
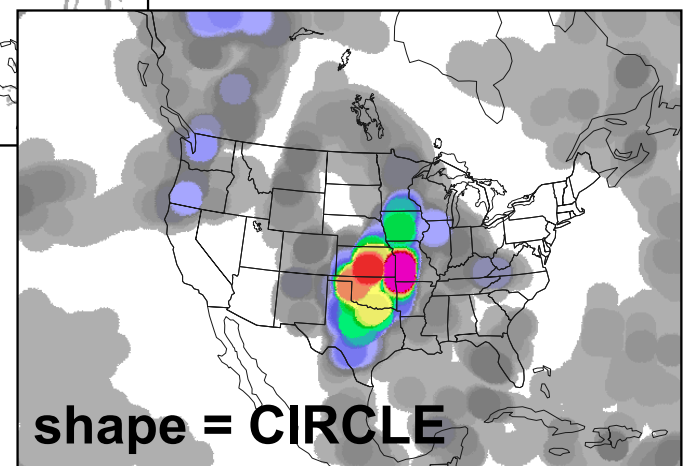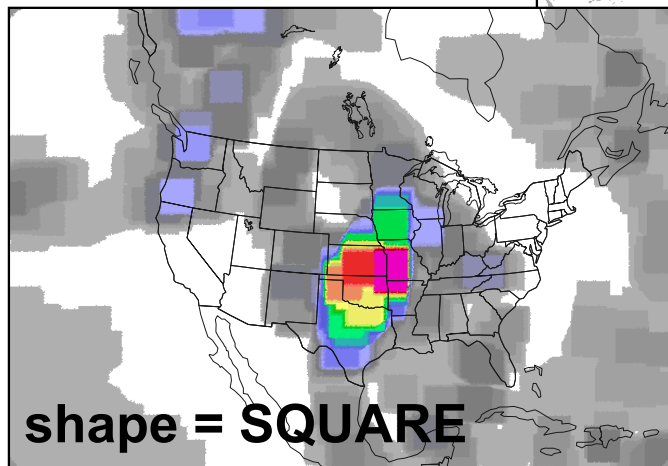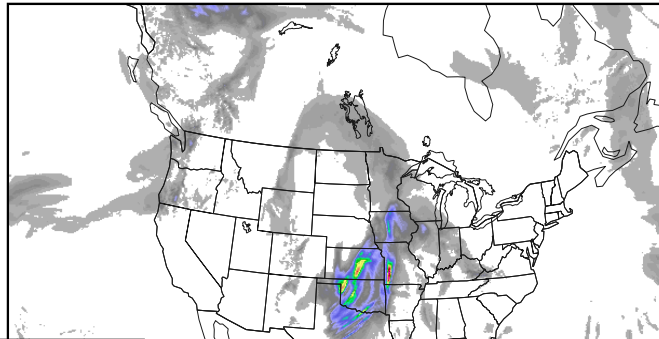
Gen-Vx-Mask Updates

- Add support for **lat** and **lon** masking types:

```
"-type string" overrides the default masking type (poly):
    "poly", "box", "circle", "track", "grid", "data",
    "solar_alt", "solar_azi", "lat", or "lon"
```
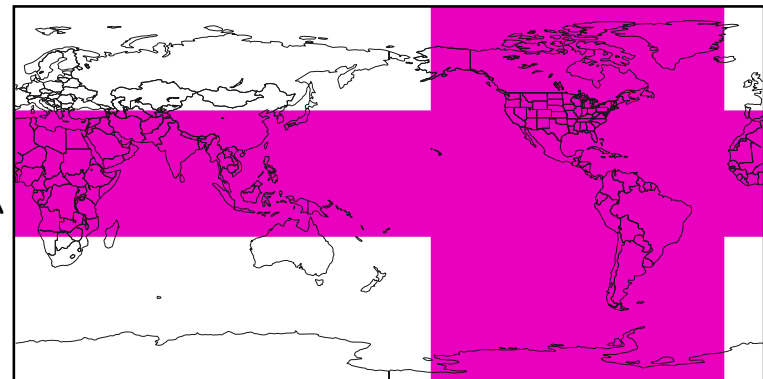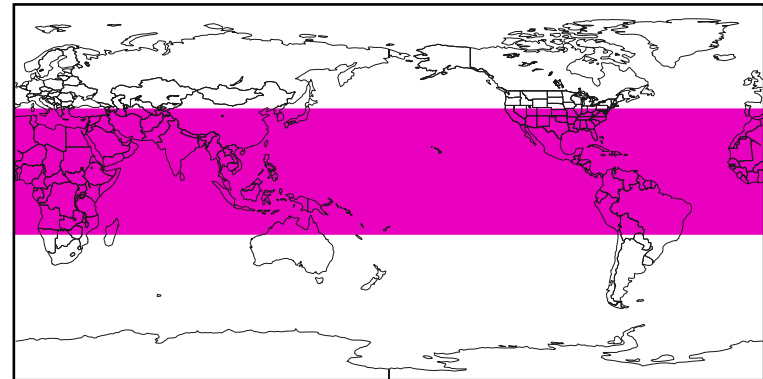
```
gen_vx_mask \
GFS.grb GFS.grb LAT_BAND.nc \
-type lat -thresh '>=-20&&<=40' \
-name LAT_BAND
```

(1) Define domain. (2) Define mask.

```
gen_vx_mask \
LAT_BAND.nc LAT_BAND.nc CROSS.nc \
-type lon -thresh '>=-160&&<=-20' \
-union -name CROSS
```

Unit Conversion Functions

- Enhance config file language to support functions of 1 variables.

- Use convert(x) function to define unit conversions:

```
convert(x) = log10(x);
convert(x) = sqrt(x);
```

- Common conversion functions pre-defined in share/met/config/ConfigConstants:
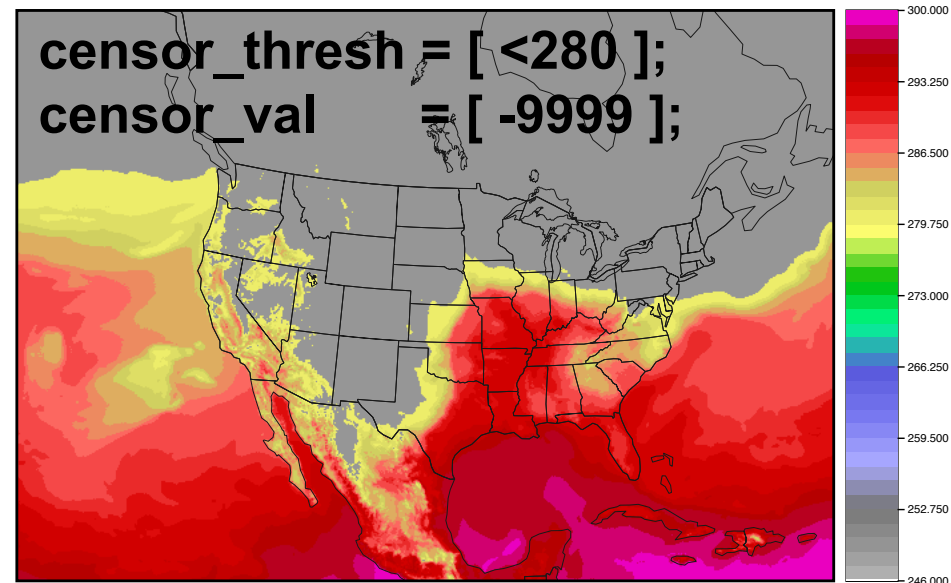
```
K_to_C(t) = t - 273.15;
C_to_K(t) = t + 273.15;
C_to_F(t) = 1.8 * t + 32.0;
```

Censoring Data

- Applying MET to wider range of data types reveals need for pre-processing.
- Censor logic is applied to raw data before any regridding is done.
- May be specified separately for each forecast and/or observation field:
  - The **censor_thresh** entry is an array of thresholds.
  - The **censor_val** entry is an array of replacement values.
- Reflectivity Example:
  - Forecast reflectivity values are 0 or >= 35 dBZ.
  - Observed reflectivity values are continuous less than 35 dBZ.
  - Define observation censor:
    ```
    censor_thresh = [ <35 ];
    censor_val    = [ 0 ];
    ```

- Used to make the forecast and observation data more comparable.
- Can be used for range checking data.

censor_thresh = [<280];
censor_val   = [-9999];

300.000
293.250
286.500
279.750
273.000
266.250
259.500
252.750
246.000

MODE Updates

- Censor logic replaces existing **raw_thresh** logic for MODE.
  - The raw_thresh is just censoring with a replacement value of 0.
  - Remove raw_thresh config file option.
  - Remove AREA_FILTER column from MODE **_obj.txt** files.
  - Remove FILTER line from MODE **_cts.txt** files.
- MODE Enhancements
  - Add new output columns for N_VALID, GRID_RES, and OBTYPE.
  - Speed up convex hull detection algorithm.
  - Remove **zero_boder_size** config file option and enhance logic to detect objects which touch the edge of the domain.
- Fix bug to generate PostScript output when no matching is requested.

Grid-Stat and Point-Stat Updates

- WMO Manual on the Global Data-processing and Forecasting System, 2010
  - Enhance MET to produce required statistics.
    - Added Root-Mean-Squared Forecast Anomaly (**RMSFA**) and Root-Mean-Square-Observation Anomaly (**RMSOA**) to the CNT line type.
    - Added S1 score (described later)
    - Cosine latitude weighting (met-6.0)
    - Support 1.5 degree ERA climatology.
    - NCEP providing feedback on required statistics, methods, and data formats.

ECLV Line Type

- Added support to Grid-Stat and Point-Stat for computation of the Economic Cost-Loss Value (**ECLV**) line type.
- Equivalent to the VSDB ECON line type, except…
  - ECON is only generated when evaluating ensemble probabilities.
  - ECLV from 2x2 contingency table yield a single curve.
  - ECLV from Nx2 probabilistic contingency table yields N curves.
- Configuration file option to specify the cost/loss ratios to be evaluated:
  - eclv_points = 0.05; // equal spacing
  - eclv_points = [0.05, 0.10, 0.15, 0.20, 0.25, 0.50, 0.75]; // non-equal

```
//   – The "eclv_points" entry specifies the economic cost/loss ratio points
//   to be evaluated. For each cost/loss ratio specified, the relative value
//   will be computed and written to the ECLV output line. This entry may
//   either be specified as an array of numbers between 0 and 1 or as a single
//   number. For an array, each array entry will be evaluated. For a single
//   number, all evenly spaced points between 0 and 1 will be evaluated, where
//   eclv_points defines the spacing. Cost/loss values are omitted for
//   ratios of 0.0 and 1.0 since they are undefined.
```

GRAD Line Type

- Added support to Grid-Stat for new GRAD line type with the S1 score and its components.

  - WMO-mandated statistic published in 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
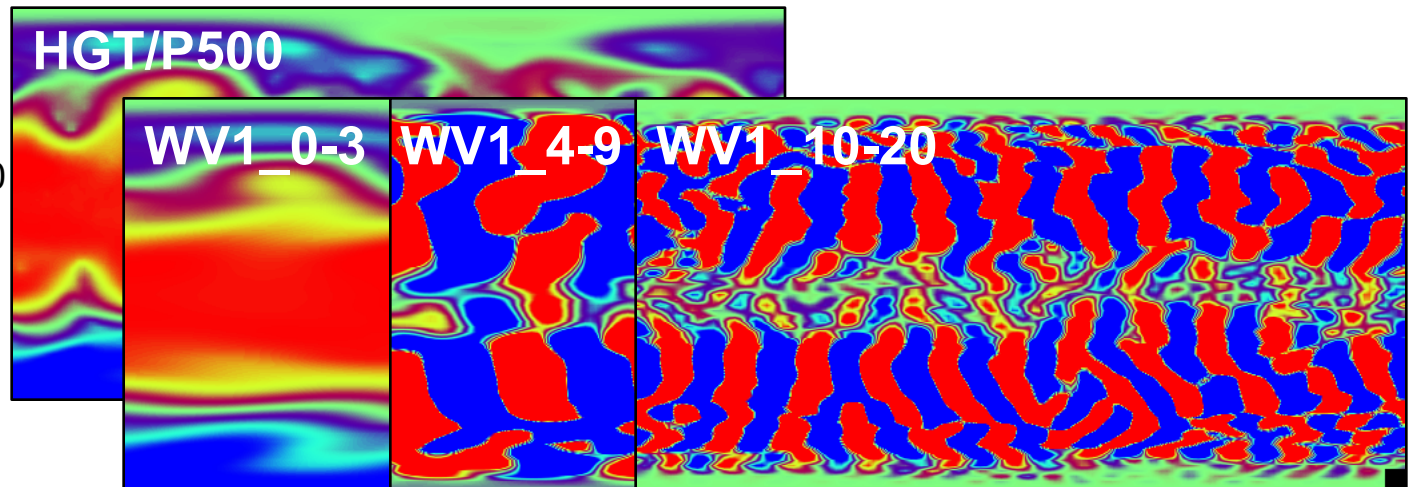   - FGOG_RATIO = FGBAR / OGBAR

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 nc_pairs

```
nc_pairs_flag   = {
    latlon      = TRUE;
    raw         = TRUE;
    diff        = TRUE;
    climo       = TRUE;
    weight      = FALSE;
    nbrhd       = FALSE;
    fourier     = FALSE;
    gradient    = FALSE;
    apply_mask  = TRUE;
}
```

- Enable the **fourier** and **gradient** output flags to include the 1-Dimensional Fourier Decomposition and Gradient fields in the NetCDF matched pairs output file.

Ensemble-Stat Updates

- Added config file option to exclude ties (i.e. all ensemble members and observation are identical):
  - skip_const = TRUE;
- Added config file option to filter pairs by the observation values.
  - Same as cnt_thresh in Point-Stat and Grid-Stat, but only applies to observation values.
  - obs_thresh = [>0]; // e.g. only observations of APCP > 0
- Added BSS_SMPL statistic to the PSTD line type, making MET consistent with METViewer.

RELP Line Type

- Added support to Ensemble-Stat for new relative position (**RELP**) line type.

  - Same as VSDB RELP line type.

  - Similar to the Rank Histogram line type, but no ranking is done.

  - N-th histogram bar indicates how often ensemble member N was closest (in absolute value) to the observation.

  - Ties are assigned equally to all tied members.

STAT-Analysis Updates

- Enhance –column_thresh to handle column differences with or without absolute values.
  - Filter matched pair lines where the FCST and OBS difference is >= 5:
    - -line_type MPR -column_thresh ABS(FCST-OBS) ge5
- Add RANGE and IQR output columns to summary job type.
- Allow for NA's when filtering data:
  - -column_thresh CLIMO !=NA
- Add support for init_hour and valid_hour derived columns:
  - -by INIT_HOUR or –by VALID_HOUR
- STAT-Analysis updated to aggregate and derive new line types:
  - -job aggregate ECLV
  - -job aggregate_stat -line_type CTC -out_line_type ECLV
  - -job aggregate_stat -line_type PCT -out_line_type ECLV
  - -job aggregate -line_type GRAD
  - -job aggregate -line_type RELP
  - -job aggregate_stat -line_type ORANK -out_line_type RELP

Binned Climatologies

- Enhance Grid-Stat and Point-Stat to process climatological distributions (i.e. climo mean and standard deviation).
- Binned climatologies affect only the computation of probabilistic statistics.
- Config file options:

```
climo_mean = { … };      // Climo Mean Fields
climo_stdev = { … };     // Climo Standard Deviation
climo_cdf_bins = 10;     // Number of Climo Bins
                         // Or array of bin values
```

- For each observation value, use the climo mean and standard deviation and compute a CDF value between 0 and 1.
- Place that observation into the correct climo CDF bin.
- Compute stats for all pairs within each bin.
- When climo mean and standard deviation are provided, derive the climatological probability values when computing Brier Skill Score.

Miscellaneous Changes

- Add support for Gaussian grids.
- Regrid-Data-Plane: better defaults for combinations of interp method and width.
- Support calendar = "365 days" for climate NetCDF files.
- Support southern hemisphere Lambert Conformal grids.
- Support reading NetCDF NC_STRING types instead of just NC_CHAR.
- Include form feeds as white space when parsing input ascii files.
- When writing NetCDF files, replace all instances of commas with underscores.
  - Commas cause problems for the NCO NetCDF tools, like ncatted.
- Fixed the application of the GRIB_lvl_typ filter for GRIB2.
- Added support for GRIB2_stat_type filtering option.
- Removed redundancy in GRIB2 Air Force GALWEM table.
- Fixed duplicate in NDFD GRIB table.
- Updates to MET_FAQ's on the website based on MET-Help archives:
  - **https://dtcenter.org/met/users/support/faqs/index.php**
- Updated output of –version command line option to include version information.