METplus Practical Session Guide (Version 3.0)

METplus Practical Session Guide (Version 3.0)

Welcome to the METplus Practical Session Guide

The METplus practical consists of five sessions. Each session contains instructions for running individual MET tools directly on the command line followed by instructions for running the same tools as part of a METplus use case.

Please follow the link to the appropriate session:

admin Wed, 02/12/2020 - 18:37

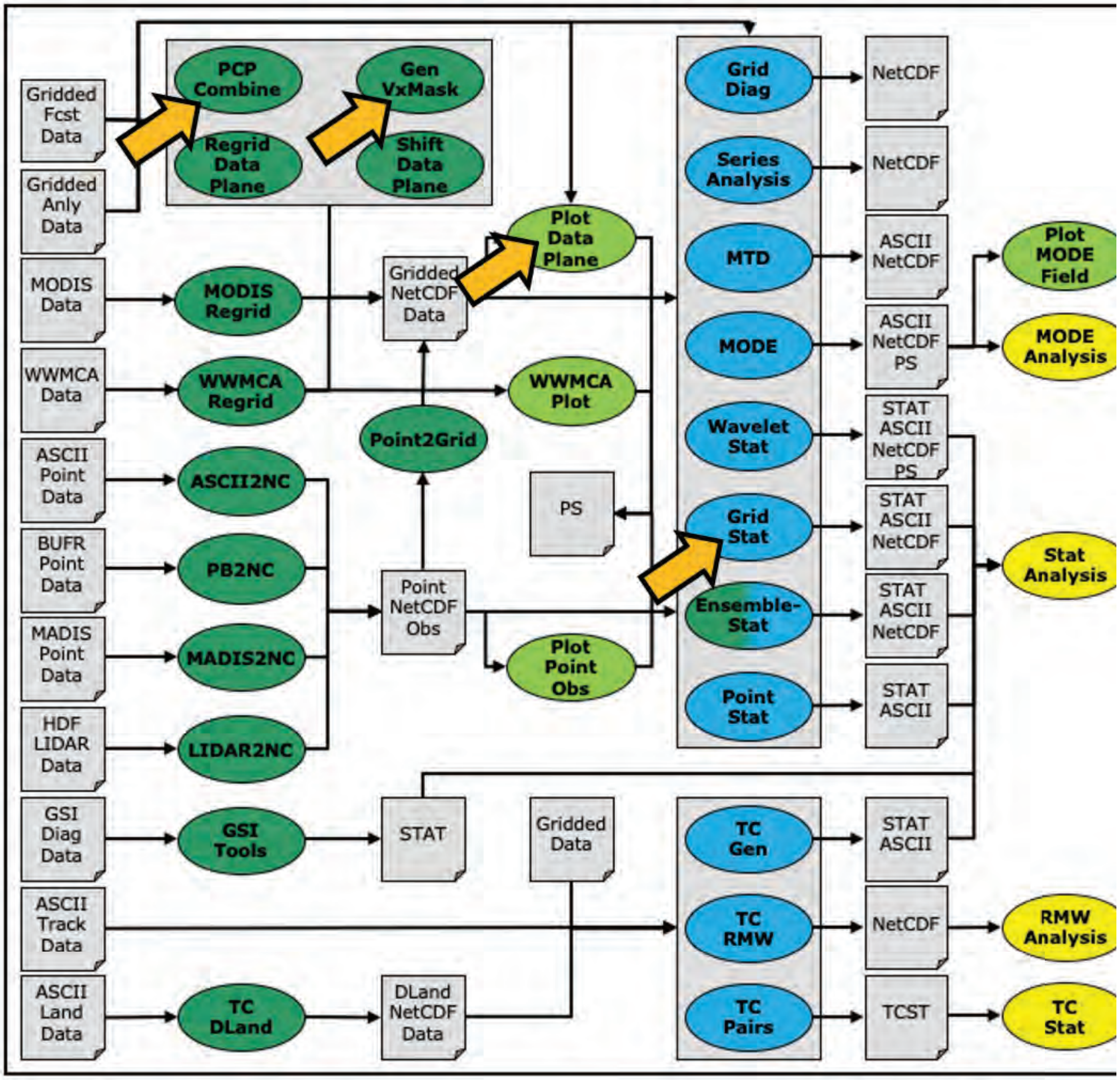
Session 1: METplus Setup/Grid-to-Grid

Session 1: METplus Setup/Grid-to-Grid

METplus Practical Session 1

During the first METplus practical session, you will run the tools indicated below:

Practical Session 1 Tools



During this practical session, please work on the **Session 1** exercises. Proceed through the tutorial exercises by following the navigation links at the bottom of each page.

Each practical session builds on the output of previous practical sessions. So please work on them **in the order listed**.

Throughout this tutorial, code blocks in **BOLD** white text with a black background should be copied from your browser and pasted on the command line. You can copy-and-paste the text using one of two methods:

1. Use the mouse:

- Hold down the left mouse button to select the text
- Place the mouse in the desired location and click the middle mouse button once to paste the selected text

2. Use the **Copy** and **Paste** options:

- Hold down the left mouse button to select the text
- Click the right mouse button and select the option for **Copy**
- Place the mouse in the desired location, click the right mouse button, and select the option for **Paste**

Note: Instructions in this tutorial use **vi** to open and edit files. If you prefer to use a different file editor, feel free to substitute it whenever you see **vi**.

Note: Instructions in this tutorial use **okular** to view pdf, ps, and png files. If you prefer to use a different file viewer, feel free to substitute it whenever you see **okular**.

Click the 'METplus Setup >' on the bottom right to get started!

admin Wed, 06/12/2019 - 16:55

METplus Setup

METplus Setup

METplus Overview

METplus is a set of python modules that have been developed with the flexibility to run MET for various use cases or scenarios. The goal is to simplify the running of MET for scientists. Currently, the primary means of achieving this is through the use of METplus configuration files, aka. "conf files". It is designed to provide a framework in which additional MET use cases can be added. The conf file implementation utilizes a Python package called produtil that was developed by NOAA/NCEP/EMC for the HWRF system.

The METplus Python application is designed to be run as stand alone module files - calling one MET process; through a user defined process list - as in this tutorial; or within a workflow management system on an HPC cluster - which is TBD.

Please be sure to follow the instructions in order.

METplus Useful Links

The following links are just for reference, and not required for this practical session. A METplus release is available on GitHub, and provides sample data and instructions.

GitHub METplus links

METplus User's Guide on GitHub
METplus Releases on GitHub

The METplus-related code repositories are available in GitHub in the following locations:

- **https://github.com/NCAR/METplus** - Python wrappers and use cases
- **https://github.com/NCAR/MET** - Core MET codebase
- **https://github.com/NCAR/METviewer** - Display system for MET output
- **https://github.com/NCAR/METdb** - Database system for MET output (currently private)
- **https://github.com/NCAR/METplotpy** - Python plotting scripts (currently private)
- **https://github.com/NCAR/METcalcpy** - Python calculation functions (currently private)
- **METexpress** - Streamlined display system (currently lives in NOAA's VLab)

New features are developed and bugs are tracked using GitHub issues in each repository.

admin Mon, 06/24/2019 - 15:58

METplus: Initial setup

METplus: Initial setup

Prerequisites: Software

The following is a full list of software that is required to utilize all the functionality in METplus.
NOTE: We will not by running the cyclone plotter or grid plotting scripts in this tutorial. So the additional libraries mentioned below are not installed.

- ***Python 3.6.3 or higher***
- Additional Python libraries (not included in most base installations):
  - Required to run all wrappers except the plotters
    - ***dateutil***
    - *all dependencies of above packages*
  - Required by the cyclone plotter and grid plotting scripts.
    - ***numpy***
    - ***cartopy***
    - *all dependencies of above packages*
- ***MET 9.0*** - already installed locally on the tutorial machines (NOAA hera).
- ***R*** - used by TCMPRPlotter wrapper, Wraps the MET plot_tcmpr.R script
- ***ncap2*** - NCO netCDF Operators
- ***wgrib2*** - only needed for series analysis wrappers (SeriesByLead and SeriesByInit)
- ***ncdump*** - NetCDF binaries
- ***convert*** - Utilitity from ImageMagick software suite

Prerequisites: Environment

For this tutorial, the MET software is available on Dakota (NCAR) or via a module file on Hera (NOAA). In both cases, builds of MET9.0 and METplus3.0 have been installed globally, so the MET software is available when you login and source the tutorial environment file.

The **MET*** environment variables are set to allow the METplus scripts to be run from any directory.

1. Create a directory called 'METplus_Tutorial' to hold all of the files you will create during the tutorial. This can be any directory that you have write permission. **In the following instructions, change "/path/to" to the directory you chose:**

EDIT AFTER COPYING and BEFORE HITTING RETURN!

```
cd /path/to
```

Then create a directory called METplus_Tutorial. This is the location of all of your tutorial work, including configuration files, output data, and any other notes you'd like to keep.

```
mkdir METplus_Tutorial
```

Go into the tutorial directory and run 'pwd' to get the full path to this directory. Set this path in an environment variable.

```
cd METplus_Tutorial
```

bash:

```
export METPLUS_TUTORIAL_DIR=`pwd`
```

csh:

```
setenv METPLUS_TUTORIAL_DIR `pwd`
```

2. Now copy the tutorial setup shell script to configure your runtime environment for use with METplus. You will also copy over a METplus .conf file that you will use to run:

If tutorial setup scripts have been provided to you, then copy them into your tutorial directory and modify them. If you running these instructions on your own machine, you will need to obtain the generic tutorial setup scripts and modify them to include the correct paths on your machine.

If tutorial scripts have been provided (bash):

(NOTE: replace /path/to with where the primary METplus tutorial files are located)

```
cp /path/to/TutorialSetup.linux-bash.sh ${METPLUS_TUTORIAL_DIR}
cp /path/to/tutorial.conf ${METPLUS_TUTORIAL_DIR}
```

If tutorial scripts have been provided (csh):

(NOTE: replace /path/to with where the primary METplus tutorial files are located)

```
cp /path/to/TutorialSetup.linux-csh.sh ${METPLUS_TUTORIAL_DIR}
cp /path/to/tutorial.conf ${METPLUS_TUTORIAL_DIR}
```

On hera:

```
cp /scratch1/BMC/dtc/Julie.Prestopnik/METplus/METplus_Tutorial/TutorialSetup.hera.sh ${METPLUS_TUTORIAL_DIR}
cp /scratch1/BMC/dtc/Julie.Prestopnik/METplus/METplus_Tutorial/tutorial.conf ${METPLUS_TUTORIAL_DIR}
```

On your machine (bash):

```
cd ${METPLUS_TUTORIAL_DIR}
wget https://dtcenter.org/sites/default/files/community-code/metplus/tutorial-data/TutorialSetup.linux-bash.sh.txt
mv TutorialSetup.linux-bash.sh.txt TutorialSetup.linux-bash.sh
wget https://dtcenter.org/sites/default/files/community-code/metplus/tutorial-data/tutorial.conf
```

On your machine (csh):

```
cd ${METPLUS_TUTORIAL_DIR}
wget https://dtcenter.org/sites/default/files/community-code/metplus/tutorial-data/TutorialSetup.linux-csh.sh.txt
mv TutorialSetup.linux-csh.sh.txt TutorialSetup.linux-csh.sh
wget https://dtcenter.org/sites/default/files/community-code/metplus/tutorial-data/tutorial.conf
```

The tutorial setup script sets the paths for **METPLUS_TUTORIAL_DIR**, **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA**. On hera, it loads several modules needed for the **MET** and **METplus** software to run correctly. Finally, it appends the **$PATH** environment variable to include the directory where the **METplus** python scripts are located.

3. Open up the TutorialSetup script with your favorite editor and set the environment variable values. If the tutorial setup script was provided to you, you will only need to change the value for **METPLUS_TUTORIAL_DIR**. If not, you will need to set each environment variable to the appropriate value. If you are unsure what to set for any of the variables, please refer to the descriptions below. Be sure to save the file before you close it.

Note that the following echo and ls commands may not work correctly until the script is sourced in Step 4.

```
vi ${METPLUS_TUTORIAL_DIR}/TutorialSetup.*
```

The following describes what each environment variable should be set to and an example of the contents of these directories to help you determine where they are on your machine.

METPLUS_TUTORIAL_DIR

The directory you created to store all of your tutorial files

Example contents:

```
ls ${METPLUS_TUTORIAL_DIR} -1
```

```
tutorial.conf
TutorialSetup.linux-bash.sh
```

Example value:

```
/home/metplus_user/METplus_Tutorial
```

MET_BUILD_BASE

The directory where MET is installed

Example contents:

```
ls ${MET_BUILD_BASE} -1
```

```
bin
share
```

```
ls ${MET_BUILD_BASE}/bin -1
```

```
ascii2nc
gis_dump_shp
gsid2mpr
mode
pb2nc
plot_point_obs
rmw_analysis
tc_dland
tc_stat
ensemble_stat
gis_dump_shx
gsidens2orank
mode_analysis
pcp_combine
point2grid
series_analysis
tc_gen
wavelet_stat
gen_vx_mask
grid_diag
lidar2nc
modis_regrid
plot_data_plane
point_stat
shift_data_plane
tc_pairs
wwmca_plot
gis_dump_dbf
grid_stat
madis2nc
mtd
plot_mode_field
regrid_data_plane
stat_analysis
tc_rmw
wwmca_regrid
```

Example value:

```
echo ${MET_BUILD_BASE}
```

```
/home/metplus_user/met-9.0
```

NOTE: If MET has not been installed on your machine, you can obtain it here: https://dtcenter.org/community-code/model-evaluation-tools-met/download

METPLUS_BUILD_BASE

The directory where METplus is installed

Example contents:

```
ls ${METPLUS_BUILD_BASE} -1
```

```
build_components
check_python.py
docs
environment.yml
internal_tests
manage_externals
parm
README.md
requirements.txt
sorc
ush
```

Example value:

```
/home/metplus_user/METplus-3.0
```

NOTE: If the METplus wrappers have not been installed on your machine, you can follow the instructions here: https://ncar.github.io/METplus/Users_Guide/installation.html

METPLUS_DATA

The directory containing sample input data to use for the tutorial

Example contents:

```
ls ${METPLUS_DATA} -1
```

```
met_test
model_applications
```

Example value:

```
echo ${METPLUS_DATA}
```

```
/d1/metplus_user/METplus_Data
```

NOTE: If you have not downloaded the sample data tarballs, you can obtain them here (Refer to the "Sample Input Data" section for the version of METplus you are going to use): https://github.com/ncar/metplus/releases

4. Source the environment file to apply the settings to the current shell. Each time you log in, you will have to source this file again.

On **hera**:

```
source ${METPLUS_TUTORIAL_DIR}/TutorialSetup.hera.sh
```

On **linux server (bash)**:

```
source ${METPLUS_TUTORIAL_DIR}/TutorialSetup.linux-bash.sh
```

On **linux server (csh)**:

```
source ${METPLUS_TUTORIAL_DIR}/TutorialSetup.linux-csh.sh
```

To avoid needing to source this file every time you log in, you can add a few lines to your shell settings file. For example for bash on hera, you can add these lines to the end of ~/.bashrc:

```
METPLUS_TUTORIAL_DIR=$HOME/METplus_Tutorial
source $METPLUS_TUTORIAL_DIR/TutorialSetup.hera.sh
```

5. Check to make sure the environment variables are set successfully by typing 'env'. If you did everything correctly, running 'which master_metplus.py' should show you the path to the script in the shared location, ${METPLUS_BUILD_BASE}:

```
env
which master_metplus.py
```

And typing 'point_stat' will give you usage information for the MET command.

```
point_stat
```

You should see the usage statement for Point-Stat. The version number listed should correspond to the version listed in **MET_BUILD_BASE**. If it does not, you will need to either reload the met module, or add **${MET_BUILD_BASE}/bin** to your PATH.

Check that you have **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA** set correctly:

```
echo ${METPLUS_BUILD_BASE}
echo ${MET_BUILD_BASE}
echo ${METPLUS_DATA}
```

METPLUS_BUILD_BASE is the full path to the METplus installation (/path/to/METplus-X.Y)
MET_BUILD_BASE is the full path to the MET installation (/path/to/met-X.Y)
METPLUS_DATA is the location of the sample test data directory

Using The Software

For this tutorial we'll use the **METplus v3.0** release, which has been installed in a common location. We will configure METplus to run the **met-9.0** software, which has also been installed in a common location. Fo each exercise, we will copy the relevant parameter files from the shared METplus location to your own directory so you can modify them without changing the shared installation settings.

Please use the following instructions to setup METplus on your tutorial machine:

1. Create a user_config and output directories to store METplus configuration files you will create:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/user_config ${METPLUS_TUTORIAL_DIR}/output
```

2. List the contents of the metplus_tutorial directory:

```
ls -1 ${METPLUS_TUTORIAL_DIR}
```

```
output/
tutorial.conf
TutorialSetup.hera.sh
user_config/
```

Sample Data Input and Location of Output

The **Sample Input Data** used to run the examples in this tutorial already exist in a shared location, which is specified in TutorialSetup.[machine].sh.

When running METplus wrapper use cases, all **output** is placed in the **${METPLUS_TUTORIAL_DIR}/output** directory. User-modified METplus config files may further specify subdirectories in the ***output*** directory.

When running MET tools on the command line, all output will be written to **${METPLUS_TUTORIAL_DIR}/output/met_output**

Information: MET and METplus Source Code

While installing your own copy of MET and METplus is beyond the scope of this tutorial, you can find the code tarballs and release notes here. A list of Existing builds covering several NCAR and NOAA machines is here.

If you find the Existing Build entries for dakota (NCAR machines) and hera (NOAA machines), those correspond to the TutorialSetup.hera.sh and TutorialSetup.dakota.sh scripts.

admin Mon, 06/24/2019 - 15:59

METplus: Directories and Configuration Files - Overview

METplus: Directories and Configuration Files - Overview

METplus directory structure

Brief description and overview of the ***METplus/*** directory structure.

```
ls ${METPLUS_BUILD_BASE}
```

- ***build_components/*** - files for downloading and building MET (not used here)
- ***docs/*** - Sphinx RST files used to generate the User's Guide.
- ***internal_tests/*** - for engineering tests
- ***manage_externals/*** - downloading additional software to run METplus (not used here)
- ***parm/*** - where **METplus** default config files and use case config files live
- ***sorc/*** - executables and doxygen documentation build system
- ***ush/*** - **METplus** python scripts

METplus default configuration files

Look inside the directory ${METPLUS_BUILD_BASE}/parm

```
ls ${METPLUS_BUILD_BASE}/parm
```

Look at the METplus default configuration files:

```
ls ${METPLUS_BUILD_BASE}/parm/metplus_config
```

The METplus default configuration files **metplus_system.conf**, **metplus_data.conf**, **metplus_runtime.conf**, and **metplus_logging.conf** are always read by default and in the order shown. Any additional configuration files passed in on the command line are then processed in the order in which they are specified. This allows for each successive conf file the ability to override variables defined in any previously processed conf files. It also allows for defining and setting up conf files from a general (settings used by all use cases, ie. MET install dir) to more specific (Plot type when running track and intensity plotter) structure. The idea is to created a hiearchy of conf files that is easier to maintain, read, and manage. It is important to note, running METplus creates a single configuration file, which can be viewed to understand the result of all the conf file processing.

When METplus is run, the final metplus conf file is generated here:
metplus_runtime.conf:METPLUS_CONF=**{OUTPUT_BASE}/metplus_final.conf**
Use this file to see the result of all the conf file processing, this can be very helpful when troubleshooting,

NOTE: The syntax for METplus configuration files MUST include a "[section]" header with the variable names and values on subsequent lines.

The **metplus_config** directory - there are four config files:

1. ***metplus_system.conf***
    - contains "[dir]" and "[exe]" to set directory and executable paths
    - any information specific to host machine
2. ***metplus_data.conf***
    - Sample data or Model input location
    - filename templates and regex for filenames
3. ***metplus_runtime.conf***
    - contains "[config]" section
    - var lists, stat lists, configurations, process list
    - anything else needed at runtime
4. ***metplus_logging.conf***

    - contains [config] section for setting various logging configuration options.

The **met_config** directory (in ${METPLUS_BUILD_BASE}/parm) - this contains "wrapped" MET configuration files that are used by calls to MET via the METplus wrappers. The wrappers set environment variables that control settings in the MET configuration files through these environment variables. See https://ncar.github.io/METplus/Users_Guide/met_tool_wrapper/GridStat/GridStat.html#met-configuration for more information.

METplus Use Cases

The **use_cases** directory - this is where the use cases you will be running exist. Under the **use_cases** directory are two subdirectories: **met_tool_wrapper** and **model_applications**. The **met_tool_wrapper** directory contains use cases that run a single METplus wrapper. They are a good starting point to see how the wrapper scripts generate commands that run the MET tools. The **model_applications** directory contains more complex use cases that often run multiple wrappers and demonstrate real evaluations from users.

MET Tool Wrapper Use Cases

Look at the MET Tool Wrapper Use Cases

```
cd ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper
```

The **met_tool_wrapper** use case files are organized into subdirectories by wrapper, e.g. **Example** or **GridStat**. They contain METplus configuration files (ending with .conf) and Sphinx documentation files (ending with .py). If a MET tool that is called by a use case uses a MET configuration file, the file used for the **met_tool_wrapper** use cases is found in **parm/met_config**.

- **met_tool_wrapper/Example** - directory
- **met_tool_wrapper/Example/Example.conf** - use case configuration file
- **met_tool_wrapper/Example/Example.py** - Sphinx documentation file
- **met_tool_wrapper/GridStat** - directory
- **met_tool_wrapper/GridStat/GridStat.conf** - use case configuration file
- **met_tool_wrapper/GridStat/GridStat.py** - Sphinx documentation file
- **parm/met_config/GridStatConfig_wrapped** - MET configuration file used in the GridStat.conf use case

Model Application Use Cases

Look at the Model Application use cases

```
cd ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications
```

The **model_applications** use case files are organized in subdirectories by category, e.g. **precipitation** or **convection_allowing_models**. They contain METplus configuration files (ending with .conf) and Sphinx documentation files (ending with .py). If a MET tool that is called by a use case uses a MET configuration file, the file used for the **model_applications** use cases are also found in this directory. The follow the naming format <MET-tool-name>Config_<description>, i.e. GridStatConfig_PROB.

- **model_applications/precipitation** - directory
- **model_applications/precipitation/GridStat_fcstGFS_obs_CCPA_GRIB.conf** - use case configuration file
- **model_applications/precipitation/GridStat_fcstGFS_obs_CCPA_GRIB.py** - Sphinx documentation file
- **model_applications/precipitation/GridStatConfig_precip** - MET configuration file

Example Use Case

Let's look at the Example use case, ***Example.conf***, under **met_tool_wrapper/Example**

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/Example/Example.conf
```

Notice that there are dictionary sections, denoted by, e.g., [config], [dir], and [filename_template]. Contained in each section are variables, denoted in ALL_CAPS. These can be modified as needed. In the METplus system, unmodified config files remain in the subdirectories of **${MET_BUILD_BASE}**, while user-modified files are stored in ${**METPLUS_TUTORIAL_DIR}/user_config**.

No changes are needed in Example.conf. Close it and continue to the next page.

Unless otherwise indicated, all directories are relative to your **${METPLUS_TUTORIAL_DIR}** directory.

admin Mon, 06/24/2019 - 15:59

METplus: User Configuration Settings

METplus: User Configuration Settings

Modify your Tutorial/User conf files

In this section you will modify the configuration files that will be read for each call to METplus.

The paths in this practical session guide assume:

- You have created a user_config directory in your **${METPLUS_TUTORIAL_DIR}** directory
- You have added the shared METplus **ush** directory to your PATH (done in TutorialSetup.hera.sh)
- You are using the shared installation of MET.

If not, then you need to adjust accordingly.

1. Change to the ${METPLUS_TUTORIAL_DIR} directory. Try running master_metplus.py. You should see the usage statement output to the screen.

```
master_metplus.py
```

The METplus python script **master_metplus.py** can be run from anywhere, but for consistency, we will change to ${METPLUS_TUTORIAL_DIR} so that all the subdirectories including user_config and output are below the working directory.

2. Now try to pass in the example.conf configuration file found in your parm directory under use_cases/met_too_wrapper/Examples

```
master_metplus.py \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/Example/Example.conf
```

You should see output like this:

```
04/02 15:40:18.305 METplus (met_util.py:79) INFO: Starting METplus v3.0
04/02 15:40:18.306 metplus (config_metplus.py:77) INFO: Starting METplus configuration setup.
04/02 15:40:18.310 metplus (config_launcher.py:200) INFO: /contrib/METplus/METplus-3.0/parm/metplus_config/metplus_system.conf: Parsed this file
04/02 15:40:18.312 metplus (config_launcher.py:200) INFO: /contrib/METplus/METplus-3.0/parm/metplus_config/metplus_data.conf: Parsed this file
04/02 15:40:18.313 metplus (config_launcher.py:200) INFO: /contrib/METplus/METplus-3.0/parm/metplus_config/metplus_runtime.conf: Parsed this file
04/02 15:40:18.315 metplus (config_launcher.py:200) INFO: /contrib/METplus/METplus-3.0/parm/metplus_config/metplus_logging.conf: Parsed this file
04/02 15:40:18.315 metplus (config_launcher.py:200) INFO: /contrib/METplus/METplus-3.0/parm/use_cases/met_tool_wrapper/Example/Example.conf: Parsed this file
04/02 15:40:18.315 metplus (config_launcher.py:567) ERROR: Directory OUTPUT_BASE is set to or contains /path/to. Please set this to a valid location
04/02 15:40:18Z run-METplus-metplus: ERROR:  Directory OUTPUT_BASE is set to or contains /path/to. Please set this to a valid location
```

Note it ends with an error message stating that **OUTPUT_BASE** was not set correctly. You will need to configure the METplus wrappers to be able to run a use case.

The values in the default **metplus_system.conf**, **metplus_data.conf**, **metplus_runtime.conf**, and **metplus_logging.conf** configuration files are read in first when you run master_metplus.py. The settings in these files can be overridden in the use case conf files and/or a user's custom configuration file.

Some variables in the system conf are set to '/path/to' and must be overridden to run METplus, such as **OUTPUT_BASE** in **metplus_system.conf**.

3. View the **metplus_system.conf** file and notice how **OUTPUT_BASE = /path/to** . This implies it is REQUIRED to be overridden to a valid path.

```
less ${METPLUS_BUILD_BASE}/parm/metplus_config/metplus_system.conf
```

Note: The default installation of METplus has **/path/to** values for **MET_INSTALL_DIR** and **INPUT_BASE**. These values were set in the shared METplus configuration when it was installed. This was done because these settings will likely be set to the same values for all users.

4. View the tutorial configuration files in your ***${METPLUS_TUTORIAL_DIR}*** directory.

```
less ${METPLUS_TUTORIAL_DIR}/tutorial.conf
```

The **[dir] INPUT_BASE, OUTPUT_BASE, and MET_INSTALL_DIR** variables must all be set to run METplus**.**

Note: A METplus conf file is not a shell script. You CAN NOT refer to environment variables as you would in a shell script or command prompt, i.e. ${HOME}. Instead, you must reference the environment variable $HOME as ***{ENV[HOME]}***

Reminder: Make certain to maintain the KEY = VALUE pairs under their respective current [sections] in the conf file.

NOTE: When installing METplus, you will need to set the full path to the non-MET executables in the metplus_system.conf file if they are not found in the user's path. This step was completed when METplus was installed in the shared location.

Creating user conf files

You can create additional configuration files to be read by the METplus wrappers to override variables.

Reminder: When adding variables to be overridden, make sure to place the variable under the appropriate section.
For example, [config], [dir], [exe]. If necessary, refer to the default appropriate **${METPLUS_BUILD_BASE}/parm/metplus_config** conf files to determine the [section] that corresponds to the variable you are overriding. **The value set will be the last one in the sequence of configuration files.** See **output/metplus_final.con**f to see what values were used for a given METplus run.

1. Create a new configuration file in your user_config directory and override the [dir] OUTPUT_BASE variable to point to a different location.

```
cd ${METPLUS_TUTORIAL_DIR}/user_config
vi change_output_base.conf
```

Copy and paste the following text into the file and save it.

```
[dir]
OUTPUT_BASE = {ENV[METPLUS_TUTORIAL_DIR]}/output_changed
```

We will test out using these configurations on the next page.

admin Mon, 06/24/2019 - 16:00

METplus: How to Run

METplus: How to Run

Running METplus

Running METplus involves invoking the python script **master_metplus.py** followed by a list of configuration files using the -c option for each additional conf file.

Reminder: The default set of conf files are always read in and processed in the following order;
metplus_system.conf, **metplus_data.conf**, **metplus_runtime.conf**, **metplus_logging.conf**.

files are required to perform a useful task. It will generate an error statement if something is amiss.

1. Review the example.conf configuration file

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/Example/Example.conf
```

2. Call the master_metplus.py script again, this time passing in the Example.conf configuration file and the tutorial.conf configuration file with the -c command line option. You should see logs output to the screen.

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/Example/Example.conf
```

Note: The environment variable **METPLUS_BUILD_BASE** determines where to look for paths to use_case files. The **METPLUS_TUTORIAL_DIR** environment variable determines where to look for user-modified config files.

3. Check the directory specified by the **OUTPUT_BASE** configuration variable. You should see that files and sub-directories have been created

```
ls ${METPLUS_TUTORIAL_DIR}/output
```

4. Review the master log file to see what was run. Compare the log output to the example.conf configuration file to see how they correspond to each other. The log file will have today's date in the filename. Since METplus was configured to list today's timestamp in YYYYMMDDHHMMSS format, each run of METplus will generate a separate log file. List all of the log files and view the latest master_metplus log file:

```
cat < `ls -1 ${METPLUS_TUTORIAL_DIR}/output/logs/master_metplus.log.*`
```

You will notice that METplus ran for 5 valid times, processing 4 forecast hours for each valid time. For each run time, it ran twice using two different input templates to find files.

```
metplus INFO: ****************************************
metplus INFO: * Running METplus
metplus INFO: * at valid time: 201702010000
metplus INFO: ****************************************
metplus.Example INFO: Running ExampleWrapper at valid time 20170201000000
metplus.Example INFO: Input directory is /dir/containing/example/data
metplus.Example INFO: Input template is {init?fmt=%Y%m%d}/file_{init?fmt=%Y%m%d}_{init?fmt=%2H}_F{lead?fmt=%3H}.{custom?fmt=%s}
metplus.Example INFO: Processing custom string: ext
metplus.Example INFO: Processing forecast lead 3 hours initialized at 2017-01-31 21Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_21_F003.ext
metplus.Example INFO: Processing custom string: nc
metplus.Example INFO: Processing forecast lead 3 hours initialized at 2017-01-31 21Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_21_F003.nc
metplus.Example INFO: Processing custom string: ext
metplus.Example INFO: Processing forecast lead 6 hours initialized at 2017-01-31 18Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_18_F006.ext
metplus.Example INFO: Processing custom string: nc
metplus.Example INFO: Processing forecast lead 6 hours initialized at 2017-01-31 18Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_18_F006.nc
metplus.Example INFO: Processing custom string: ext
metplus.Example INFO: Processing forecast lead 9 hours initialized at 2017-01-31 15Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_15_F009.ext
metplus.Example INFO: Processing custom string: nc
metplus.Example INFO: Processing forecast lead 9 hours initialized at 2017-01-31 15Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_15_F009.nc
metplus.Example INFO: Processing custom string: ext
metplus.Example INFO: Processing forecast lead 12 hours initialized at 2017-01-31 12Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_12_F012.ext
metplus.Example INFO: Processing custom string: nc
metplus.Example INFO: Processing forecast lead 12 hours initialized at 2017-01-31 12Z and valid at 2017-02-01 00Z
metplus.Example INFO: Looking in input directory for file: 20170131/file_20170131_12_F012.nc
metplus INFO: ****************************************
metplus INFO: * Running METplus
metplus INFO: * at valid time: 201702010600
metplus INFO: ****************************************
...
```

5. Now run METplus passing in the Example.conf from the previous run AND your newly created configuration file that changes the value of OUTPUT_BASE.

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/Example/Example.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/change_output_base.conf
```

6. Check the directory specified by the **OUTPUT_BASE** configuration variable that you set in the change_output_base.conf configuration file. You should see that files and sub-directories have been created in the new location.

```
ls ${METPLUS_TUTORIAL_DIR}/output_changed
```

Remember: Additional conf files are processed after the metplus_config files in the order specified on the command line. OUTPUT_BASE was set in tutorial.conf and then overridden in user_config/change_output_base.conf
Order matters, since each successive conf file will override any variable defined in a previous conf file.

Note: The processing order allows for structuring your conf files from general (variables shared-by-all) to specific (variables shared-by-few).

Always call tutorial.conf first.

admin Mon, 06/24/2019 - 16:04

MET Tool: PCP-Combine

We now shift to a discussion of the MET PCP-Combine tool and will practice running it directly on the command line. Later in this session, we will run PCP-Combine as part of a METplus use case.

PCP-Combine Functionality

The PCP-Combine tool is used (if needed) to **add**, **subtract**, or **sum** accumulated precipitation from several gridded data files into a single NetCDF file containing the desired accumulation period. Its NetCDF output may be used as input to the MET statistics tools. PCP-Combine may be configured to combine any gridded data field you'd like. However, all gridded data files being combined must have already been placed on a common grid. The copygb utility is recommended for re-gridding GRIB files. In addition, the PCP-Combine tool will only sum model files with the same initialization time unless it is configured to ignore the initialization time.

PCP-Combine Usage

View the usage statement for PCP-Combine by simply typing the following:

```
pcp_combine
```

Usage:
pcp_combine

[[-sum] sum_args] | [-add input_files] | [-subtract input_files] | [-derive stat_list input_files]
(Note: "|" means "or")

[-sum] sum_args	***Precipitation from multiple files containing the same accumulation interval should be summed up using the arguments provided.***
-add input_files	***Data from one or more files should be added together where the accumulation interval is specified separately for each input file.***
-subtract input_files	***Data from exactly two files should be subtracted.***
-derive stat_list input_files	***The comma-separated list of statistics in "stat_list" (sum, min, max, range, mean, stdev, vld_count) should be derived using data from one or more files.***
out_file	Output NetCDF file to be written.
[-field string]	Overrides the default use of accumulated precipitation (optional).
[-name list]	Overrides the default NetCDF variable name(s) to be written (optional).
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging
[-compress level]	NetCDF file compression

Use the **-sum**, **-add**, **-subtract,** or **-derive** command line option to indicate the operation to be performed. Each operation has its own set of required arguments.

admin Mon, 06/24/2019 - 16:05

PCP-Combine Tool: Run Sum Command

PCP-Combine Tool: Run Sum Command

Since PCP-Combine performs a simple operation and reformatting step, no configuration file is needed.

1. Start by making an output directory for PCP-Combine and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/pcp_combine
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/pcp_combine
```

2. Now let's run PCP-Combine twice using some sample data that's included with the MET tarball:

```
pcp_combine \
-sum 20050807_000000 3 20050807_120000 12 \
sample_fcst_12L_2005080712V_12A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_fcst/2005080700
```

```
pcp_combine \
-sum 00000000_000000 1 20050807_120000 12 \
sample_obs_12L_2005080712V_12A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

The "****" symbols in the commands above are used for ease of reading. They are line continuation markers enabling us to spread a long command line across multiple lines. They should be followed immediately by "Enter". You may copy and paste the command line OR type in the entire line with or without the "\".

Both commands run the **sum** command which searches the contents of the **-pcpdir** directory for the data required to create the requested accmululation interval.

In the first command, PCP-Combine summed up 4 3-hourly accumulation forecast files into a single 12-hour accumulation forecast. In the second command, PCP-Combine summed up 12 1-hourly accumulation observation files into a single 12-hour accumulation observation. PCP-Combine performs these tasks very quickly.

We'll use these PCP-Combine output files as input for Grid-Stat. So make sure that these commands have run successfully!

admin Mon, 06/24/2019 - 16:13

PCP-Combine Tool: Output

When PCP-Combine is finished, you may view the output NetCDF files it wrote using the ***ncdump*** and ***ncview*** utilities. Run the following commands to view contents of the NetCDF files:

```
ncview sample_fcst_12L_2005080712V_12A.nc &
ncview sample_obs_12L_2005080712V_12A.nc &
ncdump -h sample_fcst_12L_2005080712V_12A.nc
ncdump -h sample_obs_12L_2005080712V_12A.nc
```

The ncview windows display plots of the precipitation data in these files. The output of ncdump indicates that the gridded fields are named **APCP_12**, the GRIB code abbreviation for accumulated precipitation. The accumulation interval is 12 hours for both the forecast (3-hourly * 4 files = 12 hours) and the observation (1-hourly * 12 files = 12 hours).

Note, if ncview is not found when you run it on your system, you may need to load it first. For example, on hera, you can use this command:

```
 module load ncview
```

Plot-Data-Plane Tool

The Plot-Data-Plane tool can be run to visualize any gridded data that the MET tools can read. It is a very helpful utility for making sure that MET can read data from your file, orient it correctly, and plot it at the correct spot on the earth. When using new gridded data in MET, it's a great idea to run it through Plot-Data-Plane first:

```
plot_data_plane \
sample_fcst_12L_2005080712V_12A.nc \
sample_fcst_12L_2005080712V_12A.ps \
'name="APCP_12"; level="(*,*)";'
```

```
gv sample_fcst_12L_2005080712V_12A.ps &
```

Ghostview (gv) can take a little while before it displays. If you don't have gv on your computer, try using display, or any tool that can visualize PostScript files, e.g.:

```
display sample_fcst_12L_2005080712V_12A.ps &
```

Another option is to create a PNG file from the PS file, also rotating it to appear the right way:

```
convert -rotate 90 sample_fcst_12L_2005080712V_12A.ps \
sample_fcst_12L_2005080712V_12A.png display sample_fcst_12L_2005080712V_12A.png
```

Next try re-running the command list above, but add the **convert(x)=x/25.4;** function to the config string (*Hint: after the level setting and ; but before the last closing tick*) to change units from millimeters to inches. What happened to the values in the colorbar?

Now, try re-running again, but add the **censor_thresh=lt1.0; censor_val=0.0;** options to the config string to reset any data values less 1.0 to a value of 0.0. How has your plot changed?

The **convert(x)** and **censor_thresh/censor_val** options can be used in config strings and MET config files to transform your data in simple ways.

admin Mon, 06/24/2019 - 16:13

PCP-Combine Tool: Add and Subtract Commands

PCP-Combine Tool: Add and Subtract Commands

We have run examples of the PCP-Combine **-sum** command, but the tool also supports the **-add**, **-subtract**, and **-derive** commands. While the **-sum** command defines a directory to be searched, for **-add**, **-subtract**, and **-derive** we tell PCP-Combine exactly which files to read and what data to process. The following command adds together 3-hourly precipitation from 4 forecast files, just like we did in the previous step with the **-sum** command:

```
pcp_combine -add \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 03 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_06.tm00_G212 03 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_09.tm00_G212 03 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_12.tm00_G212 03 \
add_APCP_12.nc
```

By default, PCP-Combine looks for accumulated precipitation, and the **03** tells it to look for 3-hourly accumulations. However, that **03** string can be replaced with a configuration string describing the data to be processed, which doesn't have to be accumulated precipation. The configuration string should be enclosed in single quotes. Below, we add together the U and V components of 10-meter wind from the same input file. You would not typically want to do this, but this demonstrates the functionality. We also use the **-name** command line option to define a descriptive output NetCDF variable name:

```
pcp_combine -add \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 'name="UGRD"; level="Z10";' \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 'name="VGRD"; level="Z10";' \
add_WINDS.nc \
-name UGRD_PLUS_VGRD
```

While the **-add** command can be run on one or more input files, the **-subtract** command requires *exactly two*. Let's rerun the wind example from above but do a subtraction instead:

```
pcp_combine -subtract \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 'name="UGRD"; level="Z10";' \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 'name="VGRD"; level="Z10";' \
subtract_WINDS.nc \
-name UGRD_MINUS_VGRD
```

Now run Plot-Data-Plane to visualize this output. Use the **-plot_range** option to specify a the desired plotting range, the **-title** option to add a title, and the **-color_table** option to switch from the default color table to one that's good for positive and negative values:

```
subtract_WINDS.nc \
subtract_WINDS.ps \
'name="UGRD_MINUS_VGRD"; level="(*,*)";' \
-plot_range -15 15 \
-title "10-meter UGRD minus VGRD" \
-color_table ${MET_BUILD_BASE}/share/met/colortables/NCL_colortables/posneg_2.ctable
```

Now view the results:

```
gv subtract_WINDS.ps &
```

admin Mon, 06/24/2019 - 16:14

PCP-Combine Tool: Derive Command

PCP-Combine Tool: Derive Command

While the PCP-Combine **-add** and **-subtract** commands compute exactly one output field of data, the **-derive** command can compute multiple output fields in a single run. This command reads data from one or more input files and derives the output fields requested on the command line (sum, min, max, range, mean, stdev, vld_count).

Run the following command to derive several summary metrics for both the 10-meter U and V wind components:

```
pcp_combine -derive min,max,mean,stdev \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_*.tm00_G212 \
-field 'name="UGRD"; level="Z10";' \
-field 'name="VGRD"; level="Z10";' \
derive_min_max_mean_stdev_WINDS.nc
```

In the above example, we used a wildcard to list multiple input file names. And we used the **-field** command line option twice to specify two input fields. For each input field, PCP-Combine loops over the input files, derives the requested metrics, and writes them to the output NetCDF file. Run ncview to visualize this output:

```
ncview derive_min_max_mean_stdev_WINDS.nc &
```

This output file contains 8 variables: 2 input fields * 4 metrics. Note the output variable names the tool chose. You can still override those names using the **-name** command line argument, but you would have to specify a comma-separated list of 8 names, one for each output variable.

johnhg Tue, 07/23/2019 - 17:13

MET Tool: Gen-Vx-Mask

MET Tool: Gen-Vx-Mask

Gen-Vx-Mask Functionality

The Gen-Vx-Mask tool may be run to speed up the execution time of the other MET tools. Gen-Vx-Mask defines a bitmap masking region for your domain. It takes as input a gridded data file defining your domain and a second argument to define the area of interest (varies by masking type). It writes out a NetCDF file containing a bitmap for that masking region. You can run Gen-Vx-Mask iteratively, passing its output back in as input, to define more complex masking regions.

You can then use the output of Gen-Vx-Mask to define masking regions in the MET statistics tools. While those tools can read ASCII lat/lon polyline files directly, they are able to process the output of Gen-Vx-Mask much more quickly than the original polyline. The idea is to define your masking region once for your domain with Gen-Vx-Mask and apply the output many times in the MET statistics tools.

Gen-Vx-Mask Usage

View the usage statement for Gen-Vx-Mask by simply typing the following:

```
gen_vx_mask
```

Usage: gen_vx_mask		
	input_file	**Gridded data file defining the domain**
	mask_file	**Defines the masking region and varies by -type**
	out_file	**Output NetCDF mask file to be written**
	[-type string]	Masking type: poly, box, circle, track, grid, data, solar_alt, solar_azi, lat, lon, shape
	[-input_field string]	Define field from input_file for grid point initialization values, rather than 0.
	[-mask_field string]	Define field from mask_file for data masking.
	[-complement, -union, -intersection, -symdiff]	Set logic for combining input_field initialization values with the current mask values.
	[-thresh string]	Define threshold for circle, track, data, solar_alt, solar_azi, lat, and lon masking types.
	[-height n, -width n]	Define dimensions for box masking.
	[-shapeno n]	Define the index of the shape for shapefile masking.
	[-value n]	Output mask value to be written, rather than 1.
	[-name str]	Specifies the name to be used for the mask.
	[-log file]	Outputs log messages to the specified file
	[-v level]	Level of logging
	[-compress level]	NetCDF compression level

admin Mon, 06/24/2019 - 16:06

Gen-Vx-Mask Tool: Run

Gen-Vx-Mask Tool: Run

Start by making an output directory for Gen-Vx-Mask and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/gen_vx_mask
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/gen_vx_mask
```

Since Gen-Vx-Mask performs a simple masking step, no configuration file is needed.

We'll run the Gen-Vx-Mask tool to apply a polyline for the CONUS (Contiguous United States) to our model domain. Run Gen-Vx-Mask on the command line using the following command:

```
gen_vx_mask \
${METPLUS_DATA}/met_test/data/sample_obs/ST2ml/ST2ml2005080712.Grb_G212 \
${MET_BUILD_BASE}/share/met/poly/CONUS.poly \
CONUS_mask.nc \
-v 2
```

Re-run using verbosity level 3 and look closely at the log messages. How many grid points were included in this mask?

Gen-Vx-Mask should run very quickly since the grid is coarse (185x129 points) and there are 244 lat/lon points in the CONUS polyline. The more you increase the grid resolution and number of polyline points, the longer it will take to run. View the NetCDF bitmap file generated by executing the following command:

```
ncview CONUS_mask.nc &
```

Notice that the bitmap has a value of 1 inside the CONUS polyline and 0 everywhere else. We'll use the CONUS mask we just defined in the next step.

You could try running **plot_data_plane** to create a PostScript image of this masking region. Can you remember how?

Notice that there are several ways that **gen_vx_mask** can be run to define regions of interest, including the use of Shapefiles!

admin Mon, 06/24/2019 - 16:16

MET Tool: Grid-Stat

MET Tool: Grid-Stat

Grid-Stat Functionality

The Grid-Stat tool provides verification statistics for a matched forecast and observation grid. If the forecast and observation grids do not match, the **regrid** section of the configuration file controls how the data can be interpolated to a common grid. All of the forecast gridpoints in each spatial verification region of interest are matched to observation gridpoints. The matched gridpoints within each verification region are used to compute the verification statistics.

The output statistics generated by Grid-Stat include continuous partial sums and statistics, vector partial sums and statistics, categorical tables and statistics, probabilistic tables and statistics, neighborhood statistics, and gradient statistics. The computation and output of these various statistics types is controlled by the **output_flag** in the configuration file.

Grid-Stat Usage

View the usage statement for Grid-Stat by simply typing the following:

```
grid_stat
```

Usage: grid_stat

fcst_file	**Input gridded forecast file containing the field(s) to be verified.**
obs_file	**Input gridded observation file containing the verifying field(s).**
config_file	**GridStatConfig file containing the desired configuration settings.**
[-outdir path]	Overrides the default output directory (optional).
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging (optional).
[-compress level]	NetCDF compression level (optional).

The forecast and observation fields must be on the same grid. You can use **copygb** to regrid GRIB1 files, **wgrib2** to regrid GRIB2 files, or the automated regridding within the **regrid** section of the MET config files.

At a minimum, the input gridded **fcst_file**, the input gridded **obs_file**, and the configuration **config_file** must be passed in on the command line.

admin Mon, 06/24/2019 - 16:06

Grid-Stat Tool: Configure

Grid-Stat Tool: Configure

Start by making an output directory for Grid-Stat and changing directories:

```
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/grid_stat
```

The behavior of Grid-Stat is controlled by the contents of the configuration file passed to it on the command line. The default Grid-Stat configuration file may be found in the **data/config/GridStatConfig_default** file. Prior to modifying the configuration file, users are advised to make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/GridStatConfig_default GridStatConfig_tutorial
```

Open up the **GridStatConfig_tutorial** file for editing with your preferred text editor.

```
vi GridStatConfig_tutorial
```

The configurable items for Grid-Stat are used to specify how the verification is to be performed. The configurable items include specifications for the following:

- The forecast fields to be verified at the specified vertical level or accumulation interval
- The threshold values to be applied
- The areas over which to aggregate statistics - as predefined grids, configurable lat/lon polylines, or gridded data fields
- The confidence interval methods to be used
- The smoothing methods to be applied (as opposed to interpolation methods)
- The types of verification methods to be used

You may find a complete description of the configurable items in section 8.3.2 of the MET User's Guide. Please take some time to review them.

For this tutorial, we'll configure Grid-Stat to verify the 12-hour accumulated precipitation output of PCP-Combine. We'll be using Grid-Stat to verify a single field using NetCDF input for both the forecast and observation files. However, Grid-Stat may in general be used to verify an arbitrary number of fields. Edit the **GridStatConfig_tutorial** file as follows:

- Set:

  ```
  fcst = {
    field = [
      {
        name       = "APCP_12";
        level      = [ "(*,*)" ];
        cat_thresh = [ >0.0, >=5.0, >=10.0 ];
      }
    ];
  }
  obs = fcst;
  ```

  To verify the field of precipitation accumulated over 12 hours using the 3 thresholds specified.

- Set:

  ```
  mask = {
    grid = [];
    poly = [ "../gen_vx_mask/CONUS_mask.nc",
             "MET_BASE/poly/NWC.poly",
             "MET_BASE/poly/SWC.poly",
             "MET_BASE/poly/GRB.poly",
             "MET_BASE/poly/SWD.poly",
             "MET_BASE/poly/NMT.poly",
             "MET_BASE/poly/SMT.poly",
             "MET_BASE/poly/NPL.poly",
             "MET_BASE/poly/SPL.poly",
             "MET_BASE/poly/MDW.poly",
             "MET_BASE/poly/LMV.poly",
             "MET_BASE/poly/GMC.poly",
             "MET_BASE/poly/APL.poly",
             "MET_BASE/poly/NEC.poly",
             "MET_BASE/poly/SEC.poly" ];
  }
  ```

  To accumulate statistics over the Continental United States (CONUS) and the 14 NCEP verification regions in the United States defined by the polylines specified. To see a plot of these regions, execute the following command:

  ```
  gv ${MET_BUILD_BASE}/share/met/poly/ncep_vx_regions.pdf &
  ```

- In the boot dictionary, set:

  ```
  n_rep = 500;
  ```

  To turn on the computation of bootstrap confidence intervals using 500 replicates.

- In the nbrhd dictionary, set:

  ```
  width      = [ 3, 5 ];
  cov_thresh = [ >=0.5, >=0.75 ];
  ```

  To define two neighborhood sizes and two fractional coverage field thresholds.

- Set:

  ```
  output_flag = {
    fho    = NONE;
    ctc    = BOTH;
  ```

```
   mcts   = NONE;
   cnt     = BOTH;
   sl1l2   = BOTH;
   sal1l2 = NONE;
   vl1l2   = NONE;
   val1l2 = NONE;
   pct     = NONE;
   pstd   = NONE;
   pjc     = NONE;
   prc     = NONE;
   eclv    = NONE;
   nbrctc = BOTH;
   nbrcts = BOTH;
   nbrcnt = BOTH;
   grad    = BOTH;
   dmap  = NONE;
}
```

To compute contingency table counts (CTC), contingency table statistics (CTS), continuous statistics (CNT), scalar partial sums (SL1L2), neighborhood contingency table counts (NBRCTC), neighborhood contingency table statistics (NBRCTS), and neighborhood continuous statistics (NBRCNT).

admin Mon, 06/24/2019 - 16:17

Grid-Stat Tool: Run

Grid-Stat Tool: Run

Next, run Grid-Stat on the command line using the following command:

```
grid_stat \
../pcp_combine/sample_fcst_12L_2005080712V_12A.nc \
../pcp_combine/sample_obs_12L_2005080712V_12A.nc \
GridStatConfig_tutorial \
-outdir . \
-v 2
```

Grid-Stat is now performing the verification tasks we requested in the configuration file. It should take a minute or two to run. The status messages written to the screen indicate progress.

In this example, Grid-Stat performs several verification tasks in evaluating the 12-hour accumulated precipiation field:

- For continuous statistics and partial sums (CNT and SL1L2), 15 output lines each:
  (1 field * 15 masking regions)
- For contingency table counts and statistics (CTC and CTS), 45 output lines each:
  (1 field * 3 raw thresholds * 15 masking regions)
- For neighborhood methods (NBRCNT, NBRCTC, and NBRCTS), 90 output lines each:
  (1 field * 3 raw thresholds * 2 neighborhood sizes * 15 masking regions)

To greatly increase the runtime performance of Grid-Stat, you could disable the computation of bootstrap confidence intervals in the configuration file. Edit the **GridStatConfig_tutorial** file as follows:

```
vi GridStatConfig_tutorial
```

- In the **boot** dictionary, set:

  ```
  n_rep = 0;
  ```

  To disable the computation of bootstrap confidence intervals.

Now, try rerunning the Grid-Stat command listed above and notice how much faster it runs. While bootstrap confidence intervals are nice to have, they take a long time to compute, especially for gridded data.

admin Mon, 06/24/2019 - 16:17

Grid-Stat Tool: Output

Grid-Stat Tool: Output

The output of Grid-Stat is one or more ASCII files containing statistics summarizing the verification performed and a NetCDF file containing difference fields. In this example, the output is written to the current directory, as we requested on the command line. It should now contain 10 Grid-Stat output files beginning with the **grid_stat_** prefix, one each for the CTC, CTS, CNT, SL1L2, GRAD, NBRCTC, NBRCTS, and NBRCNT ASCII files, a STAT file, and a NetCDF matched pairs file.

The format of the CTC, CTS, CNT, and SL1L2 ASCII files will be covered for the Point-Stat tool. The neighborhood method and gradient output are unique to the Grid-Stat tool.

- Rather than comparing forecast/observation values at individual grid points, the **neighborhood** method compares areas of forecast values to areas of observation values. At each grid box, a fractional coverage value is computed for each field as the number of grid points within the neighborhood (centered on the current grid point) that exceed the specified raw threshold value. The forecast/observation fractional coverage values are then compared rather than the raw values themselves.
- **Gradient** statistics are computed on the forecast and observation gradients in the X and Y directions.

Since the lines of data in these ASCII files are so long, we strongly recommend configuring your text editor to **NOT** use dynamic word wrapping. The files will be much easier to read that way.

```
ncview grid_stat_120000L_20050807_120000V_pairs.nc &
```

Click through the **2d vars** variable names in the ncview window to see plots of the forecast, observation, and difference fields for each masking region. If you see a warning message about the min/max values being zero, just click **OK**.

Now dump the NetCDF header:

```
ncdump -h grid_stat_120000L_20050807_120000V_pairs.nc
```

View the NetCDF header to see how the variable names are defined.

Notice how ***MANY*** variables there are, separate output for each of the masking regions defined. Try editing the config file again by setting **apply_mask = FALSE;** and **gradient = TRUE;** in the **nc_pairs_flag** dictionary. Re-run Grid-Stat and inspect the output NetCDF file. What affect did these changes have?

admin Mon, 06/24/2019 - 16:18

METplus Motivation

METplus Motivation

We have now successfully run the PCP-Combine and Grid-Stat tools to verify 12-hourly accumulated preciptation for a single output time. We did the following steps:

- Identified our forecast and observation datasets.
- Constructed PCP-Combine commands to put them into a common accumulation interval.
- Configured and ran Grid-Stat to compute our desired verification statistics.

Now that we've defined the logic for a single run, the next step would be writing a script to automate these steps for many model initializations and forecast lead times. Rather than every MET user rewriting the same type of scripts, use **METplus** to automate these steps in a use case!

admin Mon, 06/24/2019 - 16:19

METplus Use Case: GridStat

METplus Use Case: GridStat

The GridStat use case utilizes the MET *Grid-Stat* tool.

Optional: Refer to the **MET Users Guide** for a description of the MET tools used in this use case.
Optional: Refer to the **METplus Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

Change to the ${METPLUS_TUTORIAL_DIR}

```
cd ${METPLUS_TUTORIAL_DIR}
```

1. **Review the use case configuration file: GridStat.conf**

Open the file and look at all of the configuration variables that are defined. This use-case shows a simple example of running Grid-Stat on 3-hour accumulated precipitation forecasts from WRF to Stage II quantitative precipitation estimates.

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/GridStat/GridStat.conf
```

Note: Forecast and observation variables are referred to individually including reference to both the NAMES and LEVELS, which relate to .

```
# Name of forecast variable 1
FCST_VAR1_NAME = APCP
# List of levels to evaluate for forecast variable 1
# A03 = 3 hour accumulation in GRIB file
FCST_VAR1_LEVELS = A03
# Name of observation variable 1
OBS_VAR1_NAME = APCP_03
# List of levels to evaluate for observation variable 1
# (*,*) is NetCDF notation - must include quotes around these values!
# must be the same length as FCST_VAR1_LEVELS
OBS_VAR1_LEVELS = "(*,*)"
```

Which relates to the following fields in the MET configuration file

```
fcst = {
  field = [
    {
     name = "APCP";
     level = [ "A03" ];
    }
  ];
}
obs = {
  field = [
    {
     name = "APCP_03";
     level = [ "(*,*)" ];
    }
}
```

Also note: Paths in GridStat.conf may reference other config options defined in a different configuration files. For example:

```
FCST_GRID_STAT_INPUT_DIR = {INPUT_BASE}/met_test/data/sample_fcst
```

where **INPUT_BASE** which is set in the tutorial.conf configuration file. METplus config variables can reference other config variables even if they are defined in a config file that is read afterwards.

2. **Run the use case:**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/GridStat/GridStat.conf
```

METplus is finished running when control returns to your terminal console and you see the following text:

```
INFO: METplus has successfully finished running.
```

3. **Review the output files:**

You should have output files in the following directories:

```
ls ${METPLUS_TUTORIAL_DIR}/output/met_tool_wrapper/GridStat/GridStat/2005080700
```

- grid_stat_WRF_APCP_vs_MC_PCP_APCP_03_120000L_20050807_120000V_eclv.txt
- grid_stat_WRF_APCP_vs_MC_PCP_APCP_03_120000L_20050807_120000V.stat
- grid_stat_WRF_APCP_vs_MC_PCP_APCP_03_120000L_20050807_120000V_grad.txt

Take a look at some of the files to see what was generated. Beyond the .stat file, the Economic Cost/Loss Value (eclv) and Gradient (grad) line types were also written to separate .txt files. If you inspect **${METPLUS_BUILD_BASE}/parm/met_config/GridStatConfig_wrapped**, you will notice that the **ctc** and **cts** line type settings are "STAT" while **eclv** and **grad** line types are set to "BOTH".

```
less
${METPLUS_TUTORIAL_DIR}/output/met_tool_wrapper/GridStat/GridStat/2005080700/grid_stat_WRF_APCP_vs_MC_PCP_APCP_03_120000L_20050807_1
20000V.stat
```

4. **Review the log output:**

Log files for this run are found in **${METPLUS_TUTORIAL_DIR}/logs**. The filename contains a timestamp of the current day.

```
ls -1 ${METPLUS_TUTORIAL_DIR}/output/logs/master_metplus.log.*
```

5. **Review the Final Configuration File**

The final configuration file is called **metplus_final.conf**. This contains all of the configuration variables used in the run. It is found in the top level of **[dir] OUTPUT_BASE**.

```
less ${METPLUS_TUTORIAL_DIR}/output/metplus_final.conf
```

admin Mon, 06/24/2019 - 16:07

End of Practical Session 1: Additional Exercises

End of Practical Session 1: Additional Exercises

Congratulations! You have completed Session 1!

If you have extra time, you may want to try these additional MET exercises:

- Run Gen-Vx-Mask to create a mask for Eastern or Western United States using the polyline files in the **data/poly** directory. Re-run Grid-Stat using the output of Gen-Vx-Mask.
- Run Gen-Vx-Mask to exercise all the other masking types available.
- Reconfigure and re-run Grid-Stat with the distance-map **(dmap)** dictionary defined, the **dmap** output line type enabled, and the **distance_map** flag is "TRUE" in the **nc_pairs_flag** dictionary.

If you have extra time, you may want to try these additional METplus exercises. The answers are found on the next page.

EXERCISE 1.1: Run a Model_Application Use-Case

Instructions:

1. **Explore the types of model_applications available**

```
ls ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/*
```

an example to start from. The convention includes the [MET-Statistical-Tools]_fcstType_obsType_climatologyType_GeneralDescriptors_FileFormats.

```
e.g. ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/GridStat_fcstGFS_obsGFS_climoNCEP_MultiField.conf
is running Grid-Stat on GFS forecasts and GFS analysis files and using NCEP climatology to compute statistics for multiple fields.
```

2. **Review the configuration file.**

Note how the use of BOTH to specify the forecast field and observation/analysis field are configured the same. Also note how there are 4 fields specified at varying levels, which will result in evaluation of 10 unique fields.

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/GridStat_fcstGFS_obsGFS_climoNCEP_MultiField.conf
```

```
BOTH_VAR1_NAME = TMP
BOTH_VAR1_LEVELS = P850, P500, P250
BOTH_VAR2_NAME = UGRD
BOTH_VAR2_LEVELS = P850, P500, P250
BOTH_VAR3_NAME = VGRD
BOTH_VAR3_LEVELS = P850, P500, P250
BOTH_VAR4_NAME = PRMSL
BOTH_VAR4_LEVELS = Z0
```

3. **Run master_metplus.py on this use-case**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/GridStat_fcstGFS_obsGFS_climoNCEP_MultiField.conf
```

4. **Inspect the output. Note metplus_final.conf indicates the subdirectories under ${METPLUS_TUTORIAL_DIR} where the data were written out.**

EXERCISE 1.2: Add_RH - Add another field to grid_stat

Instructions: Modify the METplus configuration files to add relative humidity (RH) at pressure levels 500 and 250 (P500 and P250) to the output.

1. **Copy the GridStat.conf configuration file and rename it to GridStat_add_rh.conf for this exercise.**

```
cp ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/GridStat_fcstGFS_obsGFS_climoNCEP_MultiField.conf
${METPLUS_TUTORIAL_DIR}/user_config/GridStat_add_rh.conf
```

2. **Open GridStat_add_rh.conf with an editor and add the extra information.**

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/GridStat_add_rh.conf
```

Hint: The variables that you need to add must go under the **[config]** section.

You should also change **OUTPUT_BASE** to a new location so you can keep it separate from the other runs.

```
[dir]
OUTPUT_BASE = {ENV[METPLUS_TUTORIAL_DIR]}/output/exercises/add_rh
```

3. **Rerun master_metplus passing in your new custom config file for this exercise**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/GridStat_add_rh.conf
```

Recall that tutorial.conf sets the base directories while GridStat_add_rh.conf changes the output directory. tutorial.conf should always be called first.

You should see the relative humidity field appear in the log output from grid_stat.

```
ls -1 ${METPLUS_TUTORIAL_DIR}/output/exercises/add_rh/logs/master_metplus.log.*
```

Look for:

```
DEBUG 2: Processing RH/P500 versus RH/P500, for smoothing method NEAREST(1), over region FULL, using 10512 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P500 versus RH/P500, for smoothing method NEAREST(1), over region NHX, using 3600 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P500 versus RH/P500, for smoothing method NEAREST(1), over region SHX, using 3600 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P500 versus RH/P500, for smoothing method NEAREST(1), over region TRO, using 2448 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P500 versus RH/P500, for smoothing method NEAREST(1), over region PNA, using 1311 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 1: Regridding field RH/P250 to the verification grid.
DEBUG 1: Regridding field RH/P250 to the verification grid.
DEBUG 2:
DEBUG 2: --------------------------------------------------------------------------------
DEBUG 2:
DEBUG 2: Processing RH/P250 versus RH/P250, for smoothing method NEAREST(1), over region FULL, using 10512 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P250 versus RH/P250, for smoothing method NEAREST(1), over region NHX, using 3600 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P250 versus RH/P250, for smoothing method NEAREST(1), over region TRO, using 2448 pairs.
DEBUG 2: Computing Scalar Partial Sums.
DEBUG 2: Processing RH/P250 versus RH/P250, for smoothing method NEAREST(1), over region PNA, using 1311 pairs.
DEBUG 2: Computing Scalar Partial Sums.
```

Go to the next page for the solution to see if you were right!

EXERCISE 1.3: log_boost - Change the Logging Settings

Instructions: Modify the METplus configuration files to change the logging settings to see what is available.

1. **Create a new custom configuration file and name it log_boost.conf for this exercise.**

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/log_boost.conf
```

Set OUTPUT_BASE to a new location so you can keep it separate from the other runs.

```
[dir]
OUTPUT_BASE = {ENV[METPLUS_TUTORIAL_DIR]}/output/exercises/log_boost
```

The sections at the bottom of this page describe different logging configurations you can change. Play around with changing these settings and see how it affects the log output. You can refer to ${METPLUS_BUILD_BASE}/parm/metplus_config/metplus_logging.conf to see all possible configurations that affect logging.

2. **Rerun the GridStat.conf use case passing in your new custom config file**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/GridStat/GridStat.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/log_boost.conf
```

3. **Review the log output to see how things have changed from these settings**

```
e.g. less ${METPLUS_TUTORIAL_DIR}/output/exercises/log_boost/logs/master_metplus.log.YYYYMMDDHHMMSS
```

For example, override LOG_METPLUS and add more text to the filename (or even use another METplus config variable).

Log Configurations

Separate METplus Logs from MET Logs

Setting [config] LOG_MET_OUTPUT_TO_METPLUS to no will create a separate log file for each MET application.

```
[config]
LOG_MET_OUTPUT_TO_METPLUS = no
```

For this use case, two log files will be created: master_metplus.log.YYYYMMDDHHMMSS and grid_stat.log.YYYYMMDDHHMMSS. If you don't see two files, make sure you put the **LOG_MET_OUTPUT_TO_METPLUS** setting ***AFTER*** a line with **[config]** on it.

Increase Log Output Level for MET Applications

Setting [config] LOG_MET_VERBOSITY to a number between 1 and 10 will change the logging level for the MET applications logs. Increasing the number results in more log output. The default value is 2.

```
[config]
LOG_MET_VERBOSITY = 3
```

You can also set [config] LOG_GRID_STAT_VERBOSITY to change the logging level for the GridStat log only. If set, the wrapper-specific value takes precedence over the generic LOG_MET_VERBOSITY value.

```
[config]
LOG_GRID_STAT_VERBOSITY = 5
```

Increase Log Output Level for METplus Wrappers

Setting [config] LOG_LEVEL will change the logging level for the METplus logs. Valid values are NOTSET, DEBUG, INFO, WARNING, ERROR, CRITICAL. Logs will contain all information of the desired logging level and higher. The default value is INFO.

```
[config]
LOG_LEVEL = DEBUG
```

When an error occurs, boosting the log level to DEBUG will provide you with more information to help resolve the issue.

Change Format of Time in Logfile Names

Setting LOG_TIMESTAMP_TEMPLATE to %Y%m%d will remove hours, minutes, and seconds from the log file time. The default value is %Y%m%d%H%M%S which results in the format YYYYMMDDHHMMSS.

```
LOG_TIMESTAMP_TEMPLATE = %Y%m%d
```

For this use case, the log files will have the format: master_metplus.log.YYYYMMDD

Use Time of Data Instead of Current Time

Setting LOG_TIMESTAMP_USE_DATATIME to yes will use the first time of your data instead of the current time.

```
[config]
LOG_TIMESTAMP_USE_DATATIME = yes
```

For this use case, INIT_BEG = 2005080700, so the log files will have the format: master_metplus.log.20050807 instead of using today's date (if LOG_TIMESTAMP_TEMPLATE = %Y%m%d)

admin Mon, 06/24/2019 - 16:08

Answers to Exercises from Session 1

Answers to Exercises from Session 1

Answers to Exercises from Session 1

These are the answers to the exercises from the previous page. Feel free to ask a MET representative if you have any questions!

ANSWER 1.1: add_rh - Add another field to grid_stat

Instructions: Modify the METplus configuration files to add relative humidity (RH) at pressure levels 500 and 250 (P500 and P250) to the output.

Answer: In the GridStat_add_rh.conf param file, add the following variables to the **[config]** section.

```
BOTH_VAR5_NAME = RH
BOTH_VAR5_LEVELS = P500, P250
```

cindyhg Tue, 06/25/2019 - 11:44

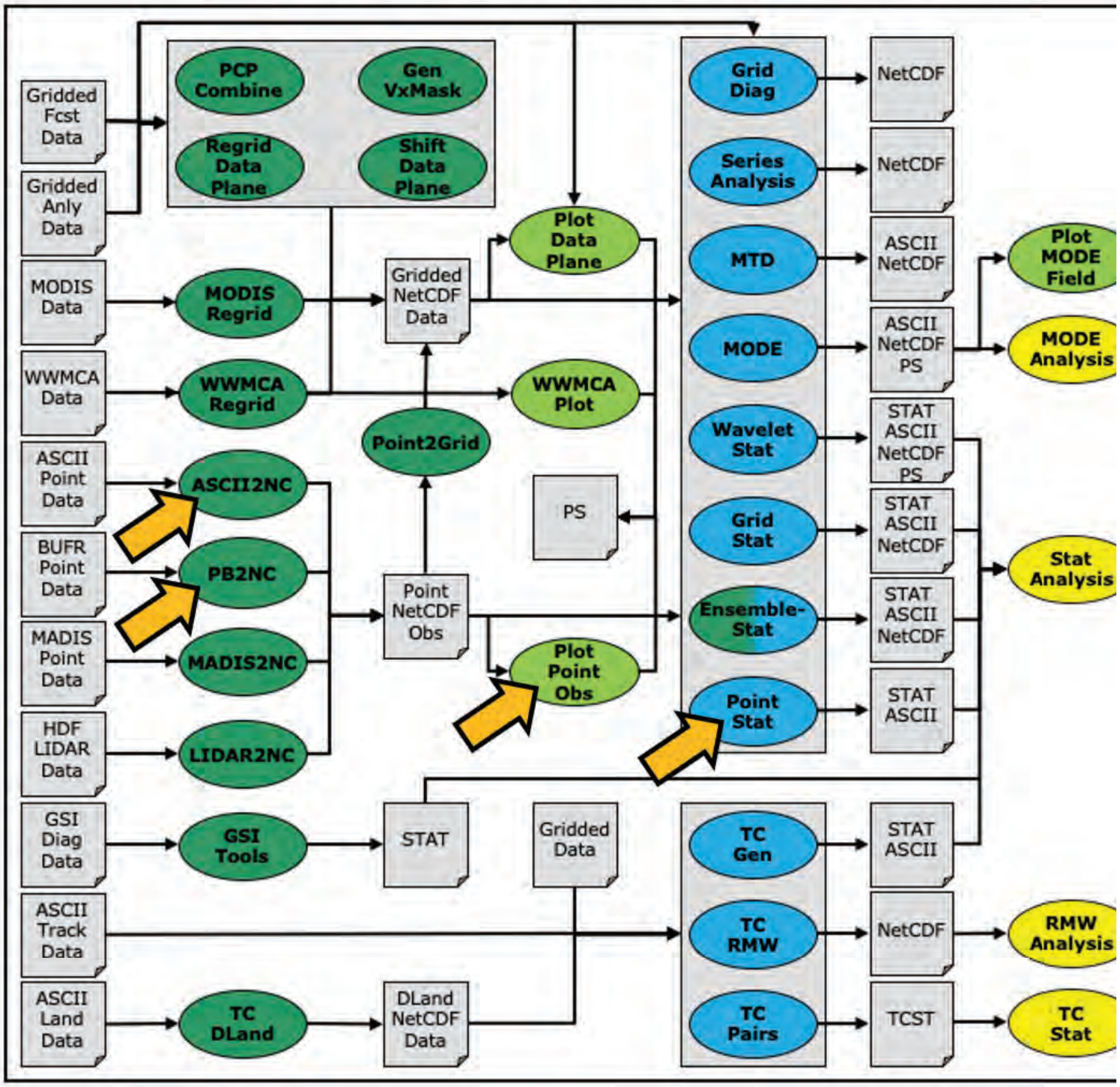
Session 2: Grid-to-Obs

Session 2: Grid-to-Obs

METplus Practical Session 2

During this practical session, you will run the tools indicated below:

Practical Session 2 Tools



You may navigate through this tutorial by following the links at the bottom of each page or by using the menu navigation.

Since you already set up your runtime enviroment in **Session 1**, you **should** be ready to go! To be sure, run through the following instructions to check that your environment is set correctly.

Prerequisites: Verify Environment is Set Correctly

Before running these instructions, you will need to ensure that you have a few environment variables set up correctly. If they are not set correctly, these instructions will not work properly.

1. Check that you have **METPLUS_TUTORIAL_DIR** set correctly:

```
echo ${METPLUS_TUTORIAL_DIR}
ls ${METPLUS_TUTORIAL_DIR}
```

If you don't see a path in your user directory output to the screen, set this environment variable in your user profile before continuing.

2. Check that you have **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA** set correctly:

```
echo ${METPLUS_BUILD_BASE}
echo ${MET_BUILD_BASE}
echo ${METPLUS_DATA}
ls ${METPLUS_BUILD_BASE}
ls ${MET_BUILD_BASE}
ls ${METPLUS_DATA}
```

If any of these variables are not set, please set them. They will be referenced throughout the tutorial. You can do this by sourcing the appropriate TutorialSetup.[hera/bash/cshrc].sh file, that is:

On **hera**:

```
source /path/to/METplus_Tutorial/TutorialSetup.hera.sh
```

On **linux server (bash)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-bash.sh
```

On **linux server (csh)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-csh.sh
```

where /path/to is the path to your METplus_Tutorial directory.

METPLUS_BUILD_BASE is the full path to the METplus installation (/path/to/METplus-X.Y)
MET_BUILD_BASE is the full path to the MET installation (/path/to/met-X.Y)
METPLUS_DATA is the location of the sample test data directory

3. Check that you have loaded the MET module correctly:

```
which point_stat
```

You should see the usage statement for Point-Stat. The version number listed should correspond to the version listed in **MET_BUILD_BASE**. If it does not, you will need to either reload the met module, or add **${MET_BUILD_BASE}/bin** to your PATH.

4. Check that the correct version of **master_metplus.py** is in your **PATH**:

```
which master_metplus.py
```

If you don't see the full path to script from the shared installation, please set it. It should look the same as the output from this command:

```
echo ${METPLUS_BUILD_BASE}/ush/master_metplus.py
ls ${METPLUS_BUILD_BASE}/ush/master_metplus.py
```

See the instructions in Session 1 for more information.

You are now ready to move on to the next section.

admin Wed, 06/12/2019 - 16:57

MET Tool: PB2NC

MET Tool: PB2NC

PB2NC Tool: General

PB2NC Functionality

The PB2NC tool is used to stratify (i.e. subset) the contents of an input PrepBufr point observation file and reformat it into NetCDF format for use by the Point-Stat or Ensemble-Stat tool. In this session, we will run PB2NC on a PrepBufr point observation file prior to running Point-Stat. Observations may be stratified by variable type, PrepBufr message type, station identifier, a masking region, elevation, report type, vertical level category, quality mark threshold, and level of PrepBufr processing. Stratification is controlled by a configuration file and discussed on the next page.

The PB2NC tool may be run on both PrepBufr and Bufr observation files. As of met-6.1, support for Bufr is limited to files containing embedded tables. Support for Bufr files using external tables will be added in a future release.

For more information about the PrepBufr format, visit:

https://emc.ncep.noaa.gov/emc/pages/infrastructure/bufrlib.php

For information on where to download PrepBufr files, visit:

https://dtcenter.org/community-code/model-evaluation-tools-met/input-data

PB2NC Usage

View the usage statement for PB2NC by simply typing the following:

```
pb2nc
```

Usage: pb2nc

netcdf_file	**output netcdf path/filename**
config_file	**configuration path/filename**
[-pbfile prepbufr_file]	additional input files
[-valid_beg time]	Beginning of valid time window [YYYYMMDD_[HH[MMSS]]]
[-valid_end time]	End of valid time window [YYYYMMDD_[HH[MMSS]]]
[-nmsg n]	Number of PrepBufr messages to process
[-index]	List available observation variables by message type (no output file)
[-dump path]	Dump entire contents of PrepBufr file to directory
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging
[-compression level]	NetCDF file compression

At a minimum, the input **prepbufr_file**, the output **netcdf_file**, and the configuration **config_file** must be passed in on the command line. Also, you may use the **-pbfile** command line argument to run PB2NC using multiple input PrepBufr files, likely adjacent in time.

When running PB2NC on a new dataset, users are advised to run with the **-index** option to list the observation variables that are present in that file.

cindyhg Tue, 06/25/2019 - 09:25

PB2NC Tool: Configure

PB2NC Tool: Configure

PB2NC Tool: Configure

Start by making an output directory for PB2NC and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/pb2nc
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/pb2nc
```

The behavior of PB2NC is controlled by the contents of the configuration file passed to it on the command line. The default PB2NC configuration may be found in the **data/config/PB2NCConfig_default** file. Prior to modifying the configuration file, users are advised to make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/PB2NCConfig_default PB2NCConfig_tutorial_run1
```

Open up the **PB2NCConfig_tutorial_run1** file for editing with your preferred text editor.

```
vi PB2NCConfig_tutorial_run1
```

The configurable items for PB2NC are used to filter out the PrepBufr observations that should be retained or derived. You may find a complete description of the configurable items in section 4.1.2 of the MET User's Guide or in the configuration **README** file.

For this tutorial, edit the **PB2NCConfig_tutorial_run1** file as follows:

- Set:

  ```
  message_type = [ "ADPUPA", "ADPSFC" ];
  ```

  To retain only those 2 message types. Message types are described in: http://www.emc.ncep.noaa.gov/mmb/data_processing/prepbufr.doc/table_1.htm

- Set:

  ```
  obs_window = {
    beg = -1800;
    end =  1800;
  }
  ```

  So that only observations within 1800 second (30 minutes) of the file time will be retained.

- Set:

  ```
  mask = {
    grid = "G212";
    poly = "";
  }
  ```

  To retain only those observations residing within NCEP Grid 212, on which the forecast data resides.

- Set:

  ```
  obs_bufr_var = [ "QOB", "TOB", "UOB", "VOB", "D_WIND", "D_RH" ];
  ```

  To retain observations for specific humidity, temperature, the u-component of wind, and the v-component of wind and to derive observation values for wind speed and relative humidity.

  While we are request these observation variable names from the input file, the following corresponding strings will be written to the output file: SPFH, TMP, UGRD, VGRD, WIND, RH. This mapping of input PrepBufr variable names to output variable names is specified by the **obs_prepbufr_map** config file entry. This enables the new features in the current version of MET to be backward compatible with earlier versions.

Next, save the **PB2NCConfig_tutorial_run1** file and exit the text editor.

PB2NC Tool: Run

PB2NC Tool: Run

PB2NC Tool: Run

Next, run PB2NC on the command line using the following command:

```
pb2nc \
${METPLUS_DATA}/met_test/data/sample_obs/prepbufr/ndas.t00z.prepbufr.tm12.20070401.nr \
tutorial_pb_run1.nc \
PB2NCConfig_tutorial_run1 \
-v 2
```

If this run fails due to runtime issues, please download a copy of the output file here and manually save it as **tutorial_pb_run1.nc**.

PB2NC is now filtering the observations from the PrepBufr file using the configuration settings we specified and writing the output to the NetCDF file name we chose. This should take a few minutes to run. As it runs, you should see several status messages printed to the screen to indicate progress. You may use the **-v** command line option to turn off (**-v 0**) or change the amount of log information printed to the screen.

Inspect the PB2NC status messages and note that **69833** PrepBufr messages were filtered down to **8394** messages which produced **52491** actual and derived observations. If you'd like to filter down the observations further, you may want to narrow the time window or modify other filtering criteria. We will do that after inspecting the resultant NetCDF file.

cindyhg Tue, 06/25/2019 - 09:27

PB2NC Tool: Output

PB2NC Tool: Output

PB2NC Tool: Output

When PB2NC is finished, you may view the output NetCDF file it wrote using the ***ncdump*** utility. Run the following command to view the header of the NetCDF output file:

```
ncdump -h tutorial_pb_run1.nc
```

In the NetCDF header, you'll see that the file contains nine dimensions and nine variables. The **obs_arr** variable contains the actual observation values. The **obs_qty** variable contains the corresponding quality flags. The four header variables (**hdr_typ, hdr_sid, hdr_vld, hdr_arr**) contain information about the observing locations.

The **obs_var**, **obs_unit**, and **obs_desc** variables describe the observation variables contained in the output. The second entry of the **obs_arr** variable (i.e. **var_id**) lists the index into these array for each observation. For example, for observations of temperature, you'd see **TMP** in **obs_var**, **KELVIN** in **obs_unit**, and **TEMPERATURE OBSERVATION** in **obs_desc**. For observations of temperature in **obs_arr**, the second entry (**var_id**) would list the index of that temperature information.

Inspect the output of **ncdump** before continuing.

Plot-Point-Obs

The **plot_point_obs** tool plots the location of these NetCDF point observations. Just like **plot_data_plane** is useful to visualize gridded data, run **plot_point_obs** to make sure you have point observations where you expect. Run the following command:

```
plot_point_obs \
tutorial_pb_run1.nc \
tutorial_pb_run1.ps
```

Display the output PostScript file by running the following command:

```
gv tutorial_pb_run1.ps &
```

Each red dot in the plot represents the location of at least one observation value. The **plot_point_obs** tool has additional command line options for filtering which observations get plotted and the area to be plotted. View its usage statement by running the following command:

```
plot_point_obs
```

By default, the points are plotted on the full globe. Next, try rerunning **plot_point_obs** using the **-data_file** option to specify the grid over which the points should be plotted:

```
plot_point_obs \
tutorial_pb_run1.nc \
tutorial_pb_run1_zoom.ps \
-data_file ${METPLUS_DATA}/met_test/data/sample_fcst/2007033000/nam.t00z.awip1236.tm00.20070330.grb
```

MET extracts the grid information from the first record of that GRIB file and plots the points on that domain. Display the output PostScript file by running the following command:

```
gv tutorial_pb_run1_zoom.ps &
```

The **plot_data_plane** tool can be run on the NetCDF output of any of the MET point observation pre-processing tools (**pb2nc**, **ascii2nc**, **madis2nc**, and **lidar2nc**).

cindyhg Tue, 06/25/2019 - 09:29

PB2NC Tool: Reconfigure and Rerun

PB2NC Tool: Reconfigure and Rerun

Now we'll rerun PB2NC, but this time we'll tighten the observation acceptance criteria. Start by making a copy of the configuration file we just used:

```
cp PB2NCConfig_tutorial_run1 PB2NCConfig_tutorial_run2
```

Open up the **PB2NCConfig_tutorial_run2** file and edit it as follows:

```
vi PB2NCConfig_tutorial_run2
```

- Set:

  ```
  message_type = [];
  ```

  To retain all message types.

- Set:

  ```
  obs_window = {
    beg = -25*30;
    end =  25*30;
  }
  ```

  So that only observations 25 minutes before and 25 minutes after the top of the hour are retained.

- Set:

  ```
  quality_mark_thresh = 1;
  ```

  To retain only the observations marked "Good" by the NCEP quality control system.

Next, run PB2NC again but change the output name using the following command:

```
pb2nc \
${METPLUS_DATA}/met_test/data/sample_obs/prepbufr/ndas.t00z.prepbufr.tm12.20070401.nr \
tutorial_pb_run2.nc \
PB2NCConfig_tutorial_run2 \
-v 2
```

If this run fails due to runtime issues, please download a copy of the output file here and manually save it as **tutorial_pb_run2.nc**.

Inspect the PB2NC status messages and note that **4000** observations were retained rather than **52491** in the previous example. The majority of the observations were rejected because their **valid time** no longer fell inside the tighter **obs_window** setting.

When configuring PB2NC for your own projects, you should err on the side of keeping more data rather than less. As you'll see, the grid-to-point verification tools (Point-Stat and Ensemble-Stat) allow you to further refine which point observations are actually used in the verification. However, keeping a lot of point observations that you'll never actually use will make the data files larger and slightly slow down the verification. For example, if you're using a Global Data Assimilation (GDAS) PREPBUFR file to verify a model over Europe, it would make sense to only keep those point observations that fall within your model domain.

cindyhg Tue, 06/25/2019 - 09:31

METplus Use Case: PB2NC

METplus Use Case: PB2NC

METplus Use Case: PB2NC

This use case utilizes the MET *PB2NC* tool.

The default statistics created by this use case only dump the partial sums, so we will be also modifying the MET configuration file to add the continuous statistics to the output.

There is a little more setup in this use case, which will be instructive and demonstrate the basic structure, flexibility and setup of METplus configuration.

Optional: Refer to the **MET Users Guide** for a description of the MET tools used in this use case.
Optional: Refer to the **METplus Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

1. **Review the settings in the PB2NC.conf file:**

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/PB2NC/PB2NC.conf
```

Note that the input and output directories are specified in the [dir] section, while CONFIG_DIR points to a directory of met_config files:

```
[dir]
# location of configuration files used by MET applications
CONFIG_DIR = {PARM_BASE}/met_config

# directory containing input to PB2NC
PB2NC_INPUT_DIR = {INPUT_BASE}/met_test/data/sample_obs/prepbufr

# directory to write output from PB2NC
PB2NC_OUTPUT_DIR = {OUTPUT_BASE}/pb2nc
```

```
# Location of MET config file to pass to PB2NC
# References CONFIG_DIR from the [dir] section
PB2NC_CONFIG_FILE = {CONFIG_DIR}/PB2NCConfig_wrapped
```

Let's look at the PB2Nc_CONFIG_FILE

```
cd ${METPLUS_BUILD_BASE}/parm/met_config
```

Values for the MET tool PB2NC are passed in from METplus config files, including PB2NC.conf

```
less PB2NCConfig_wrapped
```

```
////////////////////////////////////////////////////////////////////////////////
//
// PB2NC configuration file.
//
// For additional information, see the MET_BASE/config/README file.
// ////////////////////////////////////////////////////////////////////////////////

//
// PrepBufr message type
//
message_type =  ${PB2NC_MESSAGE_TYPE} ;

//
// Mapping of message type group name to comma-separated list of values
// Derive PRMSL only for SURFACE message types
//
message_type_group_map = [
{ key = "SURFACE"; val = "ADPSFC,SFCSHP,MSONET"; },
{ key = "ANYAIR";  val = "AIRCAR,AIRCFT"; },
{ key = "ANYSFC";  val = "ADPSFC,SFCSHP,ADPUPA,PROFLR,MSONET"; },
{ key = "ONLYSF";  val = "ADPSFC,SFCSHP" }
];
```

No modifications are needed to run the PB2NC METplus tool. Go back to the Tutorial directory

```
cd ${METPLUS_TUTORIAL_DIR}
```

2. **Run the PB2NC use case:**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/PB2NC/PB2NC.conf
```

3. **Review the output files:**

The following is the statistical ouput and files are generated from the command:

```
ls ${METPLUS_TUTORIAL_DIR}/output/pb2nc
```

- sample_pb.nc

cindyhg Tue, 06/25/2019 - 09:48

MET Tool: ASCII2NC

MET Tool: ASCII2NC

ASCII2NC Tool: General

ASCII2NC Functionality

The ASCII2NC tool reformats ASCII point observations into the intermediate NetCDF format that Point-Stat and Ensemble-Stat read. ASCII2NC simply reformats the data and does much less filtering of the observations than PB2NC does. ASCII2NC supports a simple 11-column format, described below, the Little-R format often used in data assimilation, surface radiation (SURFRAD) data, Western Wind and Solar Integration Studay (WWSIS) data, and AErosol RObotic NEtwork (Aeronet) data. Future version of MET may be enhanced to support additional commonly used ASCII point observation formats based on community input.

MET Point Observation Format

The MET point observation format consists of one observation value per line. Each input observation line should consist of the following 11 columns of data:

1. **Message_Type**
2. **Station_ID**

4. **Lat** in degrees North
5. **Lon** in degrees East
6. **Elevation** in meters above sea level
7. **Variable_Name** for this observation (or **GRIB_Code** for backward compatibility)
8. **Level** as the pressure level in hPa or accumulation interval in hours
9. **Height** in meters above sea level or above ground level
10. **QC_String** quality control string
11. **Observation_Value**

It is the user's responsibility to get their ASCII point observations into this format.

ASCII2NC Usage

View the usage statement for ASCII2NC by simply typing the following:

```
ascii2nc
```

Usage: ascii2nc

ascii_file1 [...]	**One or more input ASCII path/filename**
netcdf_file	**Output NetCDF path/filename**
[-format ASCII_format]	Set to **met_point**, **little_r**, **surfrad**, **wwsis**, or **aeronet**
[-config file]	Configuration file to specify how observation data should be summarized
[-mask_grid string]	Named grid or a gridded data file for filtering point observations spatially
[-mask_poly file]	Polyline masking file for filtering point observations spatially
[-mask_sid file|list]	Specific station ID's to be used in an ASCII file or comma-separted list
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging
[-compress level]	NetCDF compression level

At a minimum, the input **ascii_file** and the output **netcdf_file** must be passed on the command line. ASCII2NC interrogates the data to determine it's format, but the user may explicitly set it using the **-format** command line option. The **-mask_grid**, **-mask_poly**, and **-mask_sid** options can be used to filter observations spatially.

cindyhg Tue, 06/25/2019 - 09:32

ASCII2NC Tool: Run

ASCII2NC Tool: Run

ASCII2NC Tool: Run

Start by making an output directory for ASCII2NC and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/ascii2nc
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/ascii2nc
```

Since ASCII2NC performs a simple reformatting step, typically no configuration file is needed. However, when processing high-frequency (1 or 3-minute) SURFRAD data, a configuration file may be used to define a time window and summary metric for each station. For example, you might compute the average observation value +/- 15 minutes at the top of each hour for each station. In this example, we will not use a configuration file.

The sample ASCII observations in the MET tarball are still identified by GRIB code rather than the newer variable name option. Dump that file and notice that the GRIB codes in the seventh column could be replaced by corresponding variable names. For example, 52 corresponds to **RH**:

```
cat ${METPLUS_DATA}/met_test/data/sample_obs/ascii/sample_ascii_obs.txt
```

Run ASCII2NC on the command line using the following command:

```
ascii2nc \
${METPLUS_DATA}/met_test/data/sample_obs/ascii/sample_ascii_obs.txt \
tutorial_ascii.nc \
-v 2
```

ASCII2NC should perform this reformatting step very quickly since the sample file only contains data for 5 stations.

cindyhg Tue, 06/25/2019 - 09:33

ASCII2NC Tool: Output

ASCII2NC Tool: Output

ASCII2NC Tool: Output

When ASCII2NC is finished, you may view the output NetCDF file it wrote using the ***ncdump*** utility. Run the following command to view the header of the NetCDF output file:

```
ncdump -h tutorial_ascii.nc
```

The NetCDF header should look nearly identical to the output of the NetCDF output of PB2NC. You can see the list of stations for which we have data by inspecting the **hdr_sid_table** variable:

```
ncdump -v hdr_sid_table tutorial_ascii.nc
```

This ASCII data only contains observations at a few locations. Use the **plot_point_obs** to plot the locations, increasing the level of verbosity to 3 to see more detail:

```
plot_point_obs \
tutorial_ascii.nc \
tutorial_ascii.ps \
-data_file ${METPLUS_DATA}/met_test/data/sample_fcst/2007033000/nam.t00z.awip1236.tm00.20070330.grb \
-v 3
```

```
gv tutorial_ascii.ps &
```

Next, we'll use the NetCDF output of PB2NC and ASCII2NC to perform Grid-to-Point verification using the Point-Stat tool.

cindyhg Tue, 06/25/2019 - 09:37

MET Tool: Point-Stat

MET Tool: Point-Stat

Point-Stat Tool: General

Point-Stat Functionality

The Point-Stat tool provides verification statistics for comparing gridded forecasts to observation points, as opposed to gridded analyses like Grid-Stat. The Point-Stat tool matches gridded forecasts to point observation locations using one or more configurable interpolation methods. The tool then computes a configurable set of verification statistics for these matched pairs. Continuous statistics are computed over the raw matched pair values. Categorical statistics are generally calculated by applying a threshold to the forecast and observation values. Confidence intervals, which represent a measure of uncertainty, are computed for all of the verification statistics.

Point-Stat Usage

View the usage statement for Point-Stat by simply typing the following:

```
point_stat
```

Usage: point_stat

fcst_file	**Input gridded file path/name**
obs_file	**Input NetCDF observation file path/name**
config_file	**Configuration file**
[-point_obs file]	Additional NetCDF observation files to be used (optional)
[-obs_valid_beg time]	Sets the beginning of the matching time window in YYYYMMDD[_HH[MMSS]] format (optional)
[-obs_valid_end time]	Sets the end of the matching time window in YYYYMMDD[_HH[MMSS]] format (optional)
[-outdir path]	Overrides the default output directory (optional)
[-log file]	Outputs log messages to the specified file (optional)
[-v level]	Level of logging (optional)

At a minimum, the input gridded **fcst_file**, the input NetCDF **obs_file** (output of PB2NC, ASCII2NC, MADIS2NC, and LIDAR2NC, *last two not covered in these exercises*), and the configuration **config_file** must be passed in on the command line. You may use the **-point_obs** command line argument to specify additional NetCDF observation files to be used.

cindyhg Tue, 06/25/2019 - 09:38

Point-Stat Tool: Configure

Point-Stat Tool: Configure

Point-Stat Tool: Configure

Start by making an output directory for Point-Stat and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/point_stat
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/point_stat
```

The behavior of Point-Stat is controlled by the contents of the configuration file passed to it on the command line. The default Point-Stat configuration file may be found in the **data/config/PointStatConfig_default** file.

The configurable items for Point-Stat are used to specify how the verification is to be performed. The configurable items include specifications for the following:

- The forecast fields to be verified at the specified vertical levels.
- The type of point observations to be matched to the forecasts.
- The threshold values to be applied.
- The areas over which to aggregate statistics - as predefined grids, lat/lon polylines, or individual stations.
- The confidence interval methods to be used.
- The interpolation methods to be used.
- The types of verification methods to be used.

Let's customize the configuration file. First, make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/PointStatConfig_default PointStatConfig_tutorial_run1
```

Next, open up the **PointStatConfig_tutorial_run1** file for editing and modify it as follows:

- Set:

  ```
  fcst = {
    message_type = [ "ADPUPA" ];
    field = [
      {
        name     = "TMP";
        level      = [ "P850-1050", "P500-850" ];
        cat_thresh = [ <=273, >273 ];
      }
    ];
  }
  obs = fcst;
  ```

- To verify temperature over two different pressure ranges against ADPUPA observations using the thresholds specified.
- Set:

  ```
  ci_alpha = [ 0.05, 0.10 ];
  ```

  To compute confidence intervals using both a 5% and a 10% level of certainty.

- Set:

  ```
  output_flag = {
     fho    = BOTH;
     ctc    = BOTH;
     cts    = STAT;
     mctc   = NONE;
     mcts   = NONE;
     cnt    = BOTH;
     sl1l2  = STAT;
     sal1l2 = NONE;
     vl1l2  = NONE;
     val1l2 = NONE;
     pct    = NONE;
     pstd   = NONE;
     pjc    = NONE;
     prc    = NONE;
     ecnt   = NONE;
     eclv   = BOTH;
     mpr    = BOTH;
  }
  ```

  To indicate that the forecast-hit-observation (FHO) counts, contingency table counts (CTC), contingency table statistics (CTS), continuous statistics (CNT), partial sums (SL1L2), economic cost/loss value (ECLV), and the matched pair data (MPR) line types should be output. Setting SL1L2 and CTS to **STAT** causes those lines to only be written to the output **.stat** file, while setting others to **BOTH** causes them to be written to both the **.stat** file and the optional **LINE_TYPE.txt** file.

- Set:

  ```
  output_prefix = "run1";
  ```

  To customize the output file names for this run.

Note that in the **mask** dictionary, the **grid** entry is set to **FULL**. This instructs Point-Stat to compute statistics over the entire input model domain. Setting **grid** to **FULL** has this special meaning.

Next, save the **PointStatConfig_tutorial_run1** file and exit the text editor.

cindyhg Tue, 06/25/2019 - 09:40

Point-Stat Tool: Run

Point-Stat Tool: Run

Point-Stat Tool: Run

Next, run Point-Stat to compare a GRIB forecast to the NetCDF point observation output of the ASCII2NC tool. Run the following command line:

```
point_stat \
${METPLUS_DATA}/met_test/data/sample_fcst/2007033000/nam.t00z.awip1236.tm00.20070330.grb \
../ascii2nc/tutorial_ascii.nc \
PointStatConfig_tutorial_run1 \
-outdir . \
-v 2
```

Point-Stat is now performing the verification tasks we requested in the configuration file. It should take less than a minute to run. You should see several status messages printed to the screen to indicate progress.

If you receive a syntax error such as the one listed below, review PointStatConfig_tutorial_run1 for an extra comma after the "}" on line number 59

```
      cat_thresh = [ >273.0 ];
      }, <---Remove the comma
```

```
DEBUG 1: Default Config File: /usr/local/met-9.0/share/met/config/PointStatConfig_default
DEBUG 1: User Config File: PointStatConfig_tutorial_run1
ERROR  :
ERROR  : yyerror() -> syntax error in file "/tmp/met_config_26760_0"
ERROR  :
ERROR  :    line   = 59
ERROR  :
ERROR  :    column = 0
ERROR  :
ERROR  :    text   = "]"
ERROR  :
ERROR  :
ERROR  :    ];
ERROR  : _____
ERROR  :
```

Now try rerunning the command listed above, but increase the verbosity level to 3 (**-v 3**). Notice the more detailed information about which observations were used for each verification task. If you run Point-Stat and get fewer matched pairs than you expected, try using the **-v 3** option to see why the observations were rejected.

Users often write MET-Help to ask why they got zero matched pairs from Point-Stat. The first step is always rerunning Point-Stat using verbosity level 3 or higher to list the counts of reasons for why observations were not used!

cindyhg Tue, 06/25/2019 - 09:41

Point-Stat Tool: Output

Point-Stat Tool: Output

Point-Stat Tool: Output

The output of Point-Stat is one or more ASCII files containing statistics summarizing the verification performed. Since we wrote output to the current directory, it should now contain 6 ASCII files that begin with the **point_stat_** prefix, one each for the FHO, CTC, CNT, ECLV, and MPR types, and a sixth for the STAT file. The STAT file contains all of the output statistics while the other ASCII files contain the exact same data organized by line type.

Since the lines of data in these ASCII files are so long, we strongly recommend configuring your text editor to **NOT** use dynamic word wrapping. The files will be much easier to read that way:

- In the **kwrite** editor, select **Settings->Configure Editor**, de-select **Dynamic Word Wrap** and click **OK**.
- In the **vi** editor, type the command **:set nowrap**. To set this as the default behavior, run the following command:
  ```
  echo "set nowrap" >> ~/.exrc
  ```

Open up the **point_stat_run1_360000L_20070331_120000V_ctc.txt** CTC file using the text editor of your choice and note the following:

```
vi point_stat_run1_360000L_20070331_120000V_ctc.txt
```

- This is a simple ASCII file consisting of several rows of data.
- Each row contains data for a single verification task.
- The **FCST_LEAD, FCST_VALID_BEG, and FCST_VALID_END** columns indicate the timing information of the forecast field.
- The **OBS_LEAD, OBS_VALID_BEG, and OBS_VALID_END** columns indicate the timing information of the observation field.
- The **FCST_VAR, FCST_LEV, OBS_VAR,** and **OBS_LEV** columns indicate the two parts of the forecast and observation fields set in the configure file.
- The **OBTYPE** column indicates the PrepBufr message type used for this verification task.
- The **VX_MASK** column indicates the masking region over which the statistics were accumulated.
- The **INTERP_MTHD** and **INTERP_PNTS** columns indicate the method used to interpolate the forecast data to the observation location.
- The **FCST_THRESH** and **OBS_THRESH** columns indicate the thresholds applied to FCST_VAR and OBS_VAR.
- The **COV_THRESH** column is not applicable here and will always have NA when using point_stat.
- The **ALPHA** column indicates the alpha used for confidence intervals.
- The **LINE_TYPE** column indicates that these are **CTC** contingency table count lines.
- The remaining columns contain the counts for the contingency table computed by applying the threshold to the forecast/observation matched pairs. The **FY_OY** (forecast: yes, observation: yes), **FY_ON** (forecast: yes, observation: no), **FN_OY** (forecast: no, observation: yes), and **FN_ON** (forecast: no, observation: no) columns indicate those counts.

Next, answer the following questions about this contingency table output:

1. What do you notice about the structure of the contingency table counts with respect to the two thresholds used? Does this make sense?
2. Does the model appear to resolve relatively cold surface temperatures?
3. Based on these observations, are temperatures >273 relatively rare or common in the P850-500 range? How can this affect the ability to get a good score using contingency table statistics? What about temperatures <=273 at the surface?

Close that file, open up the **point_stat_run1_360000L_20070331_120000V_cnt.txt** CNT file, and note the following:

```
vi point_stat_run1_360000L_20070331_120000V_cnt.txt
```

- The columns prior to **LINE_TYPE** contain the same data as the previous file we viewed.
- The **LINE_TYPE** column indicates that these are **CNT** continuous lines.
- The remaining columns contain continuous statistics derived from the raw forecast/observation pairs. See section 4.3.3 of the **MET User's Guide** for a thorough description of the output.
- Again, confidence intervals are given for each of these statistics as described above.

Next, answer the following questions about these continuous statistics:

evaluation? Why or why not?
2. Comparing the first line with an alpha value of 0.05 to the second line with an alpha value of 0.10, how does the level of confidence change the upper and lower bounds of the confidence intervals (CIs)?
3. Similarily, comparing the first line with few numbers of matched pairs in the TOTAL column to the third line with more, how does the sample size affect how you interpret your results?

Close that file, open up the **point_stat_run1_360000L_20070331_120000V_fho.txt** FHO file, and note the following:

```
vi point_stat_run1_360000L_20070331_120000V_fho.txt
```

- The columns prior to **LINE_TYPE** contain the same data as the previous file we viewed.
- The **LINE_TYPE** column indicates that these are **FHO** forecast-hit-observation rate lines.
- The remaining columns are similar to the contingency table output and contain the total number of matched pairs, the forecast rate, the hit rate, and observation rate.
- The forecast, hit, and observation rates should back up your answer to the third question about the contingency table output.

Close that file, open up the **point_stat_run1_360000L_20070331_120000V_mpr.txt** MPR file, and note the following:

```
vi point_stat_run1_360000L_20070331_120000V_mpr.txt
```

- The columns prior to **LINE_TYPE** contain the same data as the previous file we viewed.
- The **LINE_TYPE** column indicates that these are **MPR** matched pair lines.
- The remaining columns are similar to the contingency table output and contain the total number of matched pairs, the matched pair index, the latitude, longitude, and elevation of the observation, the forecasted value, the observed value, and the climatologic value (if applicable).
- There is a lot of data here and it is recommended that the **MPR** line_type is used only to verify the tool is working properly.

cindyhg Tue, 06/25/2019 - 09:42

Point-Stat Tool: Reconfigure

Point-Stat Tool: Reconfigure

Point-Stat Tool: Reconfigure

Now we'll reconfigure and rerun Point-Stat. Start by making a copy of the configuration file we just used:

```
cp PointStatConfig_tutorial_run1 PointStatConfig_tutorial_run2
```

This time, we'll use two dictionary entries to specify the forecast field in order to set different thresholds for each vertical level. Point-Stat may be configured to verify as many or as few model variables and vertical levels as you desire. Edit the **PointStatConfig_tutorial_run2** file as follows:

```
vi PointStatConfig_tutorial_run2
```

- Set:

```
fcst = {
  field = [
   {
     name       = "TMP";
     level      = [ "Z2" ];
     cat_thresh = [ >273, >278, >283, >288 ];
   },
   {
     name       = "TMP";
     level      = [ "P750-850" ];
     cat_thresh = [ >278 ];
   }
  ];
}
obs = fcst;
```

To verify 2-meter temperature and temperature fields between 750hPa and 850hPa, using the thresholds specified.

- Set:

```
message_type = ["ADPUPA","ADPSFC"]
sid_inc = [];
sid_exc = [];
obs_quality = [];
duplicate_flag = NONE;
obs_summary = NONE;
obs_perc_value = 50;
```

To include the Upper Air (UPA) and Surface (SFC) observations in the evaluation

- Set:

```
mask = {
  grid  = [ "G212" ];
  poly  = [ "MET_BASE/poly/EAST.poly",
            "MET_BASE/poly/WEST.poly" ];
  sid   = [];
  llpnt = [];
}
```

- Set:

  ```
  interp = {
    vld_thresh = 1.0;
    shape      = SQUARE;
    type = [
      {
        method = NEAREST;
        width  = 1;
      },
      {
        method = DW_MEAN;
        width  = 5;
      }
    ];
  }
  ```

  To indicate that the forecast values should be interpolated to the observation locations using the nearest neighbor method and by computing a distance-weighted average of the forecast values over the 5 by 5 box surrounding the observation location.

- Set:

  ```
  output_flag = {
    fho    = BOTH;
    ctc    = BOTH;
    cts    = BOTH;
    mctc   = NONE;
    mcts   = NONE;
    cnt    = BOTH;
    sl1l2  = BOTH;
    sal1l2 = NONE;
    vl1l2  = NONE;
    val1l2 = NONE;
    pct    = NONE;
    pstd   = NONE;
    pjc    = NONE;
    prc    = NONE;
    ecnt   = NONE;
    eclv   = BOTH;
    mpr    = BOTH;
  }
  ```

  To switch the SL1L2 and CTS output to **BOTH** and generate the optional ASCII output files for them.

- Set:

  ```
  output_prefix = "run2";
  ```

  To customize the output file names for this run.

Let's look at our configuration selections and figure out the number of verification tasks Point-Stat will perform:

- **2 fields:** TMP/Z2 and TMP/P750-850
- **2 observing message types:** ADPUPA and ADPSFC
- **3 masking regions:** G212, EAST.poly, and WEST.poly
- **2 interpolations:** UW_MEAN width 1 (nearest-neighbor) and DW_MEAN width 5

Multiplying **2 * 2 * 3 * 2 = 24**. So in this example, Point-Stat will accumulate matched forecast/observation pairs into 24 groups. However, some of these groups will result in 0 matched pairs being found. To each non-zero group, the specified threshold(s) will be applied to compute contingency tables.

Can you diagnose **why** some of these verification tasks resulted in zero matched pairs? (*Hint: Reread the tip two pages back!*)

cindyhg Tue, 06/25/2019 - 09:44

Point-Stat Tool: Rerun

Point-Stat Tool: Rerun

Point-Stat Tool: Rerun

Next, run Point-Stat to compare a GRIB forecast to the NetCDF point observation output of the PB2NC tool, *as opposed to the much smaller ASCII2NC output we used in the first run*. Run the following command line:

```
point_stat \
${METPLUS_DATA}/met_test/data/sample_fcst/2007033000/nam.t00z.awip1236.tm00.20070330.grb \
../pb2nc/tutorial_pb_run1.nc \
PointStatConfig_tutorial_run2 \
-outdir . \
-v 2
```

Point-Stat is now performing the verification tasks we requested in the configuration file. It should take a minute or two to run. You should see several status messages printed to the screen to indicate progress. Note the number of matched pairs found for each verification task, some of which are 0.

In this step, we have verified 2-meter temperature. The Plot-Data-Plane tool within MET provides a way to visualize the gridded data fields that MET can read. Run this utility to plot the 2-meter temperature field:

```
plot_data_plane \
${METPLUS_DATA}/met_test/data/sample_fcst/2007033000/nam.t00z.awip1236.tm00.20070330.grb \
nam.t00z.awip1236.tm00.20070330_TMPZ2.ps \
'name="TMP"; level="Z2";'
```

Plot-Data-Plane requires an input gridded data file, an output postscript image file name, and a configuration string defining which 2-D field is to be plotted. View the output by running:

```
display nam.t00z.awip1236.tm00.20070330_TMPZ2.ps &
```

View the usage for Plot-Data-Plane by running it with no arguments or using the --help option:

```
plot_data_plane --help
```

Now rerun this Plot-Data-Plane command but...

1. Set the title to **2-m Temperature**.
2. Set the plotting range as **250** to **305**.
3. Use the color table named **${MET_BUILD_BASE}/share/met/colortables/NCL_colortables/wgne15.ctable**

Next, we'll take a look at the Point-Stat output we just generated.

See the usage statement for all MET tools using the **--help** command line option or with no options at all.

cindyhg Tue, 06/25/2019 - 09:45

Point-Stat Tool: Output

Point-Stat Tool: Output

Point-Stat Tool: Output

The format for the CTC, CTS, and CNT line types are the same. However, the numbers will be different as we used a different set of observations for the verification.

Open up the **point_stat_run2_360000L_20070331_120000V_cts.txt** CTS file, and note the following:

```
vi point_stat_run2_360000L_20070331_120000V_cts.txt
```

- The columns prior to **LINE_TYPE** contain header information.
- The **LINE_TYPE** column indicates that these are **CTS** lines.
- The remaining columns contain statistics derived from the threshold contingency table counts. See section 7.3.3 of the MET User's Guide for a thorough description of the output.
- Confidence intervals are given for each of these statistics, computed using either one or two methods. The columns ending in **_NCL**(normal confidence lower) and **_NCU** (normal confidence upper) give lower and upper confidence limits computed using assumptions of normality. The columns ending in **_BCL** (bootstrap confidence lower) and **_BCU** (bootstrap confidence upper) give lower and upper confidence limits computed using bootstrapping.

Close that file, open up the **point_stat_run2_360000L_20070331_120000V_sl1l2.txt** SL1L2 partial sums file, and note the following:

```
vi point_stat_run2_360000L_20070331_120000V_sl1l2.txt
```

- The columns prior to **LINE_TYPE** contain header information.
- The **LINE_TYPE** column indicates these are **SL1L2** partial sums lines.

Lastly, the **point_stat_run2_360000L_20070331_120000V.stat** file contains all of the same data we just viewed but in a single file. The Stat-Analysis tool, which we'll use later in this tutorial, searches for the **.stat** output files by default but can also read the **.txt** output files.

```
vi point_stat_run2_360000L_20070331_120000V.stat
```

cindyhg Tue, 06/25/2019 - 09:46

METplus Use Case: PointStat

METplus Use Case: PointStat

METplus Use Case: PointStat

This use case utilizes the MET *Point-Stat* tool.

Optional: Refer to the **MET Users Guide** for a description of the MET tools used in this use case.
Optional: Refer to the **METplus Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

1. **View Configuration File**

Change to the ${METPLUS_TUTORIAL_DIR} directory:

```
cd ${METPLUS_TUTORIAL_DIR}
```

Define a unique directory under output that you will use for this use case. Create a configuration file to override **OUTPUT_BASE** to that directory.

In the [dir] section the forecast and observations directories are specified in relation to INPUT_BASE (${METPLUS_DATA}, while the output directory is given in relation to {OUTPUT_BASE} (${METPLUS_TUTORIAL_DATA}/output

```
FCST_POINT_STAT_INPUT_DIR = {INPUT_BASE}/met_test/data/sample_fcst
OBS_POINT_STAT_INPUT_DIR = {INPUT_BASE}/met_test/out/pb2nc
...
POINT_STAT_OUTPUT_DIR = {OUTPUT_BASE}/point_stat
```

Using the PointStat configuration file, you should be able to run the use case using the sample input data set without any other changes.

2. **Run the PointStat use case:**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/PointStat/PointStat.conf
```

3. **Review the output files:**

The following is the statistical output and files are generated from the command:

```
ls ${METPLUS_TUTORIAL_DIR}/output/point_stat
```

- point_stat_360000L_20070331_120000V.stat

4. **Update configuration file and re-run**

Copy the configuration file to the user_config directory and open for editing:

```
cp ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/PointStat/PointStat.conf
${METPLUS_TUTORIAL_DIR}/user_config/PointStat_tutorial.conf
vi ${METPLUS_TUTORIAL_DIR}/user_config/PointStat_tutorial.conf
```

Update the POINT_STAT_OUTPUT_PREFIX and consolidate the FCST_VAR and OBS_VAR settings into BOTH_VAR being they are identical.

```
POINT_STAT_OUTPUT_PREFIX = run2
...
BOTH_VAR1_NAME = TMP
BOTH_VAR1_LEVELS = P750-900
BOTH_VAR1_THRESH = <=273, >273

BOTH_VAR2_NAME = UGRD
BOTH_VAR2_LEVELS = Z10
BOTH_VAR2_THRESH = >=5

BOTH_VAR3_NAME = VGRD
BOTH_VAR3_LEVELS = Z10
BOTH_VAR3_THRESH = >=5
```

5. **Rerun the use-case and compare the output**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/PointStat_tutorial.conf
```

Diff the original output file with run2. They should be identical.

```
diff \
${METPLUS_TUTORIAL_DIR}/output/point_stat/point_stat_360000L_20070331_120000V.stat \
${METPLUS_TUTORIAL_DIR}/output/point_stat/point_stat_run2_360000L_20070331_120000V.stat
```

cindyhg Tue, 06/25/2019 - 09:53

Additional Exercises

Additional Exercises

End of Practical Session 2

Congratulations! You have completed Session 2!

If you have extra time, you may want to try this additional METplus exercise.

The default statistics created by this use case only dump the partial sums, so we will be also modifying the MET configuration file to add the continuous statistics to the output. There is a little more setup in this use case, which will be instructive and demonstrate the basic structure, flexibility and setup of METplus configuration.

EXERCISE 2.1: Rerun Point-Stat to produce additional continuous statistics file types.

Instructions: Modify the METplus MET configuration file for Upper Air to write Continuous statistics (cnt) and the Vector Continuous Statistics (vcnt) line types to both the stat file and its own file.

METplus to call MET tools directly by passing values from METplus into MET.

```
cp ${METPLUS_BUILD_BASE}/parm/met_config/PointStatConfig_wrapped \
${METPLUS_TUTORIAL_DIR}/user_config/PointStatConfig_add_linetype
vi ${METPLUS_TUTORIAL_DIR}/user_config/PointStatConfig_add_linetype
```

Change the values for cnt and vcnt, in output flag, from NONE to BOTH

```
output_flag = {

... other entries ...

cnt = BOTH;

... other entries ...
vcnt = BOTH;
```

Also copy and modify the PointStat.conf file to point to the modified met_config file (PointStatConfig_add_linetype)

```
cp ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/PointStat/PointStat.conf \
${METPLUS_TUTORIAL_DIR}/user_config/PointStat_add_linetype.conf
vi ${METPLUS_TUTORIAL_DIR}/user_config/PointStat_add_linetype.conf
```

Change the line
POINT_STAT_CONFIG_FILE ={PARM_BASE}/met_config/PointStatConfig_wrapped
to
POINT_STAT_CONFIG_FILE = {ENV[METPLUS_TUTORIAL_DIR]}/user_config/PointStatConfig_add_linetype

Rerun master_metplus. Use -c dir.OUTPUT_BASE to change the output directory from the command line:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/PointStat_add_linetype.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/PointStatAddLinetype
```

Review the additional output files generated under ${METPLUS_TUTORIAL_DIR}/output/PointStatAddLinetype/point_stat

```
point_stat_360000L_20070331_120000V.stat
point_stat_360000L_20070331_120000V_cnt.txt
point_stat_360000L_20070331_120000V_vcnt.txt
```

Open the stat file and notice there are two more linetypes, cnt and vcnt

cindyhg Tue, 06/25/2019 - 09:55

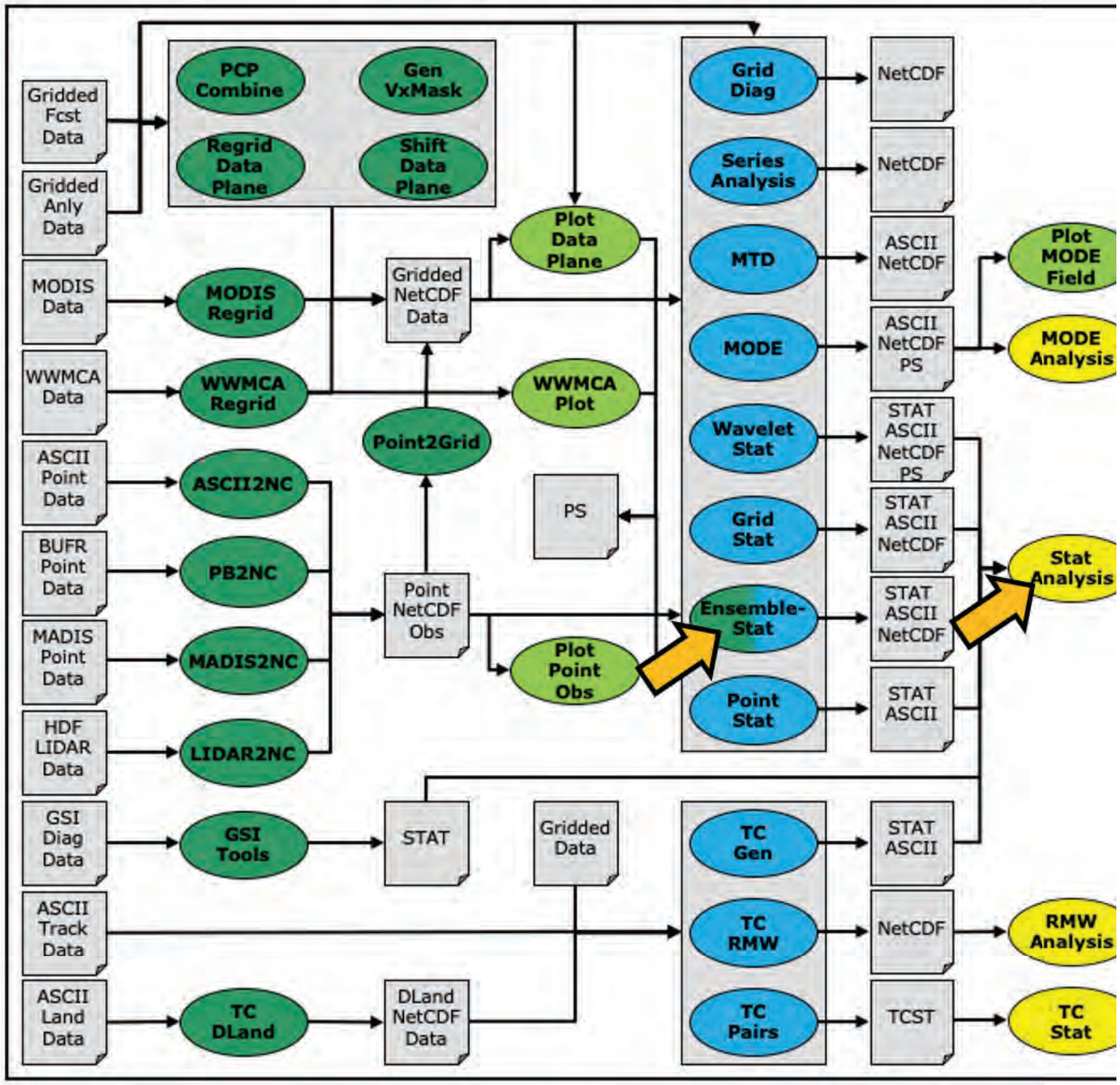
Session 3: Ensemble and PQPF

Session 3: Ensemble and PQPF

METplus Practical Session 3

During this practical session, you will run the tools indicated below:

Practical Session 3 Tools



You may navigate through this tutorial by following the links at the bottom of each page or by using the menu navigation.

Since you already set up your runtime enviroment in **Session 1**, you **should** be ready to go! To be sure, run through the following instructions to check that your environment is set correctly.

Prerequisites: Verify Environment is Set Correctly

Before running these instructions, you will need to ensure that you have a few environment variables set up correctly. If they are not set correctly, these instructions will not work properly.

1. Check that you have **METPLUS_TUTORIAL_DIR** set correctly:

```
echo ${METPLUS_TUTORIAL_DIR}
ls ${METPLUS_TUTORIAL_DIR}
```

If you don't see a path in your user directory output to the screen, set this environment variable in your user profile before continuing.

2. Check that you have **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA** set correctly:

```
echo ${METPLUS_BUILD_BASE}
echo ${MET_BUILD_BASE}
echo ${METPLUS_DATA}
ls ${METPLUS_BUILD_BASE}
ls ${MET_BUILD_BASE}
ls ${METPLUS_DATA}
```

If any of these variables are not set, please set them. They will be referenced throughout the tutorial. You can do this by sourcing the appropriate TutorialSetup.[hera/bash/cshrc].sh file, that is:

On **hera**:

```
source /path/to/METplus_Tutorial/TutorialSetup.hera.sh
```

On **linux server (bash)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-bash.sh
```

On **linux server (csh)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-csh.sh
```

where /path/to is the path to your METplus_Tutorial directory.

METPLUS_BUILD_BASE is the full path to the METplus installation (/path/to/METplus-X.Y)
MET_BUILD_BASE is the full path to the MET installation (/path/to/met-X.Y)
METPLUS_DATA is the location of the sample test data directory

3. Check that you have loaded the MET module correctly:

```
which point_stat
```

You should see the usage statement for Point-Stat. The version number listed should correspond to the version listed in **MET_BUILD_BASE**. If it does not, you will need to either reload the met module, or add **${MET_BUILD_BASE}/bin** to your PATH.

4. Check that **METPLUS_PARM_BASE** was set correctly.

```
echo ${METPLUS_PARM_BASE}
ls ${METPLUS_PARM_BASE}
```

If you don't see the full path to your METplus/parm directory under the tutorial directory, please set it. See the instructions in Session 1 for more information.

METPLUS_PARM_BASE is the full path to the user's configuration file directory (${METPLUS_TUTORIAL_DIR}/METplus/parm)

5. Check that the correct version of **master_metplus.py** is in your **PATH**:

```
which master_metplus.py
```

If you don't see the full path to script from the shared installation, please set it. It should look the same as the output from this command:

```
echo ${METPLUS_BUILD_BASE}/ush/master_metplus.py
ls ${METPLUS_BUILD_BASE}/ush/master_metplus.py
```

See the instructions in Session 1 for more information.

You are now ready to move on to the next section.

admin Wed, 06/12/2019 - 16:58

MET Tool: Ensemble-Stat

MET Tool: Ensemble-Stat

Ensemble-Stat Tool: General

Ensemble-Stat Functionality

The Ensemble-Stat tool may be used to derive several summary fields, such as the ensemble mean, spread, and relative frequencies of events (i.e. similar to a probability). The summary fields produced by Ensemble-Stat may then be verified using the other MET statistics tools. Ensemble-Stat may also be used to verify the ensemble directly by comparing it to gridded and/or point observations. Statistics are then derived using those observations, such as rank histograms and the continuous ranked probability score.

Ensemble-Stat Usage

View the usage statement for Ensemble-Stat by simply typing the following:

```
ensemble_stat
```

At a minimum, the input gridded ensemble files and the configuration **config_file** must be passed in on the command line. You can specify the list of ensemble files to be used either as a count of the number of ensemble members followed by the file name for each (**n_ens ens_fil e_1 ... ens_file_n**) or as an ASCII file containing the names of the specify gridded and/or point observations to be used for computing rank histograms and other ensemble statistics.

As with the other MET statistics tools, all ensemble data and gridded verifying observations must be interpolated to a common grid prior to processing. This may be done using the automated **regrid** feature in the Ensemble-Stat configuration file or by running **copygb** and/or **wgrib2** first.

cindyhg Tue, 06/25/2019 - 08:31

Ensemble-Stat Tool: Configure

Ensemble-Stat Tool: Configure

Start by making an output directory for Ensemble-Stat and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/ensemble_stat
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/ensemble_stat
```

The behavior of Ensemble-Stat is controlled by the contents of the configuration file passed to it on the command line. The default Ensemble-Stat configuration file may be found in the **data/config/EnsembleStatConfig_default** file. The configurations used by the test script may be found in the **scripts/config/EnsembleStatConfig*** files. Prior to modifying the configuration file, users are advised to make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/EnsembleStatConfig_default EnsembleStatConfig_tutorial
```

Open up the **EnsembleStatConfig_tutorial** file for editing with your preferred text editor.

```
vi EnsembleStatConfig_tutorial
```

The configurable items for Ensemble-Stat are broken out into two sections. The first section specifies how the ensemble should be processed to derive summary fields, such as the ensemble mean and spread. The second section specifies how the ensemble should be verified directly, such as the computation of rank histograms and spread/skill. The configurable items include specifications for the following:

- **Section 1: Ensemble Processing (ens dictionary)**
  - The ensemble fields to be summarized at the specified vertical level or accumulation interval.
  - The threshold values to be applied in computing ensemble relative frequencies (e.g. the percent of ensemble members exceeding some threshold at each point).
  - Thresholds to specify how many of the ensemble members must actually be present with valid data.
- **Section 2: Verification (fcst and obs dictionaries)**
  - The forecast and observation fields to be verified at the specified vertical level or accumulation interval.
  - The matching time window for point observations.
  - The type of point observations to be matched to the forecasts.
  - The areas over which to aggregate statistics - as predefined grids or configurable lat/lon polylines.
  - The interpolation or smoothing methods to be used.

You may find a complete description of the configurable items in section 9.3.2 of the MET User's Guide. Please take some time to review them.

For this tutorial, we'll configure Ensemble-Stat to summarize and verify 24-hour accumulated precipitation. While we'll run Ensemble-Stat on a single field, please note that it may be configured to operate on multiple fields. The ensemble we're verifying consists of 6 members defined over the west coast of the United States. Edit the ***EnsembleStatConfig_tutorial*** file as follows:

- In the **ens** dictionary, set

  ```
  field = [
    {
      name       = "APCP";
      level      = [ "A24" ];
      cat_thresh = [ >0, >=5.0, >=10.0 ];
    }
  ];
  ```

  To read 24-hour accumulated precipitation from the input GRIB files and compute ensemble relative frequencies for the thresolds listed.

- In the **fcst** dictionary, set

  ```
  field = [
    {
      name     = "APCP";
      level    = [ "A24" ];
    }
  ];
  ```

  To also verify the 24-hour accumulated precipitation fields.

- In the **fcst** dictionary, set:

  ```
  message_type = [ "ADPSFC" ];
  ```

  To verify against surface observations.

- In the **point observation filtering** section, set:

  ```
  prob_cat_thresh= [ >=0, >=5.0, >=10.0 ];
  ```

  To specify thresholds to use for computation of the Ranked Probability Score (RPS).

- In the **mask** dictionary, set

```
            "MET_BASE/poly/SWC.poly" ];
```

  To also verify over the northwest coast (NWC) and southwest coast (SWC) subregions.

- Set:

  ```
  output_flag = {
     ecnt  = BOTH;
     rhist = BOTH;
     phist = BOTH;
     orank = BOTH;
     ssvar = BOTH;
     relp  = BOTH;
  }
  ```

  To compute continuous ensemble statistics (ECNT), ranked histogram (RHIST), probability integral transform histogram (PHIST), observation ranks (ORANK), spread-skill variance (SSVAR), and relative position (RELP).

Save and close this file.

johnhg Thu, 07/25/2019 - 16:07

Ensemble-Stat Tool: Run

Ensemble-Stat Tool: Run

Next, run Ensemble-Stat on the command line using the following command, using wildcards to list the 6 input ensemble member files:

```
ensemble_stat \
6 ${METPLUS_DATA}/met_test/data/sample_fcst/2009123112/*gep*/d01_2009123112_02400.grib \
EnsembleStatConfig_tutorial \
-grid_obs ${METPLUS_DATA}/met_test/data/sample_obs/ST4/ST4.2010010112.24h \
-point_obs ${METPLUS_DATA}/met_test/out/ascii2nc/precip24_2010010112.nc \
-outdir . \
-v 2
```

Ensemble-Stat is now performing the tasks we requested in the configuration file. Note that we've passed the input ensemble data directly on the command line by specifying the number of ensemble members (6) followed by their names using wildcards. We've also specified one gridded StageIV analysis field (**-grid_obs**) and one file containing point rain gauge observations (**-point_obs**) to be used in computing rank histograms. This tool should run pretty quickly.

When Ensemble-Stat is finished, it will have created 9 output files in the current directory: 7 ASCII statistics files (**.stat**, **_ecnt.txt**, **_rhist.txt**, **_phist.txt**, **_orank.txt**, **_ssvar.txt** , and **_relp.txt**) , a NetCDF ensemble file (**_ens.nc**), and a NetCDF matched pairs file (**_orank.nc**).

johnhg Thu, 07/25/2019 - 16:09

Ensemble-Stat Tool: Output

Ensemble-Stat Tool: Output

The **_ens.nc** output from Ensemble-Stat is a NetCDF file containing the derived ensemble fields, one or more ASCII files containing statistics summarizing the verification performed, and a NetCDF file containing the gridded matched pairs.

All of the line types are written to the file ending in **.stat**. The Ensemble-Stat tool currently writes six output line types, **ECNT**, **RHIST**, **PHIST**, **RELP**, **SSVAR**, and **ORANK**.

1. The **ECNT** line type contains contains continuous ensemble statistics such as spread and skill. Ensemble-Stat uses assumed observation errors to compute both perturbed and unperturbed versions of these statistics. Statistics to which observation error have been applied can be found in columns which include the **_OERR** (for observation error) suffix.
2. The **RHIST** line type contains counts for a ranked histogram. This ranks each observation value relative to ensemble member values. Ideally, observation values would fall equally across all available ranks, yielding a flat rank histogram. In practice, ensembles are often under-(U shape) or over-(inverted U shape) dispersive. In the event of ties, ranks are randomly assigned.
3. The **PHIST** line type contains counts for a probability integral transform histogram. This scales the observation ranks to a range of values between 0 and 1 and allows ensembles of different size to be compared. Similarly, when ensemble members drop out, RHIST lines cannot be aggregated together but PHIST lines can.
4. The **RELP** line is the relative position, which indicates how often each ensemble member's value was closest to the observation's value. In the event of ties, credit is divided equally among the tied members.
5. The **ORANK** line type is similar to the matched pair (**MPR**) output of Point-Stat. For each *point* observation value, one ORANK line is written out containing the observation value, its rank, and the corresponding ensemble values for that point. When verifying against a *gridded*analysis, the ranks can be written to the NetCDF output file.
6. The **SSVAR** line contains binned spread/skill information. For each observation location, the ensemble variance is computed at that point. Those variance values are binned based on the **ens_ssvar_bin_size** configuration setting. The skill is determined by comparing the ensemble mean value to the observation value. One **SSVAR** line is written for each bin summarizing the all the observation/ensemble mean pairs that it contains.

The STAT file contains all the ASCII output while the **_ecnt.txt**, **_rhist.txt**, **_phist.txt**, **_orank.txt**, **_ssvar.txt**, and **_relp.txt** files contain the same data but sorted by line type. Since so much data can be written for the ORANK line type, we recommend disabling the output of the optional text file using the **output_flag** parameter in the configuration file.

Since the lines of data in these ASCII file are so long, we strongly recommend configuring your text editor to **NOT** use dynamic word wrapping. The files will be much easier to read that way.

Open up the **ensemble_stat_20100101_120000V_rhist.txt** RHIST file using the text editor of your choice and note the following:

```
vi ensemble_stat_20100101_120000V_rhist.txt
```

- There are 6 lines in this output file resulting from using 3 verification regions in the **VX_MASK** column (**FULL**, **NWC**, and **SWC**) and two observations datasets in the **OBTYPE** column (ADPSFC point observations and gridded observations).

- There is output for 7 ranks - since we verified a 6-member ensemble, there are 7 possible ranks the observation values could attain.

Close this file, and open up the **ensemble_stat_20100101_120000V_phist.txt** PHIST file, and note the following:

```
vi ensemble_stat_20100101_120000V_phist.txt
```

- There are 5 lines in this output file resulting from using 3 verification regions (**FULL**, **NWC**, and **SWC**) and two observations datasets (ADPSFC point observations and gridded observations), where the ADPSFC point observations for the SWC region were all zeros for which the probability integral transform is not defined.
- Each line contains columns for the **BIN_SIZE** and counts for each bin. The bin size is set in the configuration file using the **ens_phist_bin_size** field. In this case, it was set to .05, therefore creating 20 bins (1/ens_phist_bin_size).

Close this file, and open up the **ensemble_stat_20100101_120000V_orank.txt** ORANK file, and note the following:

```
vi ensemble_stat_20100101_120000V_orank.txt
```

- This file contains 1866 lines, 1 line for each observation value falling inside each verification region (**VX_MASK**).
- Each line contains 44 columns, including header information, the observation location and value, its rank, and the 6 values for the ensemble members at that point.
- When there are *ties*, Ensemble-Stat randomly assigns a rank from all the possible choices. This can be seen in the **SWC** masking region where all of the observed values are 0 and the ensemble forecasts are 0 as well. Ensemble-Stat randomly assigns a rank between 1 and 7.

Close this file, and use the **ncview** utility to view the NetCDF ensemble fields file:

```
ncview ensemble_stat_20100101_120000V_ens.nc &
```

This file contains variables for the following:

1. Ensemble Mean
2. Ensemble Standard Deviation
3. Ensemble Mean minus 1 Standard Deviation
4. Ensemble Mean plus 1 Standard Deviation
5. Ensemble Minimum
6. Ensemble Maximum
7. Ensemble Range
8. Ensemble Valid Data Count
9. Ensemble Relative Frequency (for 3 thresholds)

The output of any of these summary fields may be disabled using the **output_flag** parameter in the configuration file.

Use the **ncview** utility to view the NetCDF gridded observation rank file:

```
ncview ensemble_stat_20100101_120000V_orank.nc &
```

This file is only created when you've verified using gridded observations and have requested its output using the **output_flag** parameter in the configuration file. Click through the variables in this file. Note that for each of the three verification areas (**FULL**, **NWC**, and **SWC**) this file contains 4 variables:

1. The gridded observation value
2. The observation rank
3. The probability integral transform
4. The ensemble valid data count

In **ncview**, the random assignment of tied ranks is evident in areas of zero precipitation.

Close this file.

Feel free to explore using this dataset. Some options to try are:

- Try setting **skip_const = TRUE;** in the config file to discard points where all ensemble members and the observation are tied (i.e. zero precip). If you want to save it to a different file, make sure you set output_prefix to something meaningful, such as "run2", or "skip-constant".
- Try setting **obs_thresh = [>0.01];** in the config file to only consider points where the observation meets this threshold. How does this differ from the using skip_const?
- Use **wgrib** to inventory the input files and add additional entries to the **ens.field** list. Can you process 10-meter U and V wind?

johnhg Thu, 07/25/2019 - 16:11

MET Tool: Stat-Analysis

MET Tool: Stat-Analysis

Stat-Analysis Tool: General

Stat-Analysis Functionality

The Stat-Analysis tool reads the ASCII output files from the Point-Stat, Grid-Stat, Wavelet-Stat, and Ensemble-Stat tools. It provides a way to filter their STAT data and summarize the statistical information they contain. If you pass it the name of a directory, Stat-Analysis searches that directory recursively and reads any **.stat** files it finds. Alternatively, if you pass it an explicit file name, it'll read the contents of the file regardless of the suffix, enabling it to the optional **_LINE_TYPE.txt** files. Stat-Analysis runs one or more analysis jobs on the input data. It can be run by specifying a single analysis job on the command line or multiple analysis jobs using a configuration file. The analysis job types are summarized below:

- The **filter** job simply filters out lines from one or more STAT files that meet the filtering options specified.
- The **summary** job operates on one column of data from a single STAT line type. It produces summary information for that column of data: mean, standard deviation, min, max, and the 10th, 25th, 50th, 75th, and 90th percentiles.
- The **aggregate** job aggregates STAT data across multiple time steps or masking regions. For example, it can be used to sum contingency table data or partial sums across multiple lines of data. The **-line_type** argument specifies the line type to be summed.
- The **aggregate_stat** job also aggregates STAT data, like the **aggregate** job above, but then derives statistics from that aggregated STAT data. For example, it can be used to sum contingency table data and then write out a line of the corresponding contingency table statistics. The **-line_type** and **-out_line_type** arguments are used to specify the conversion type.
- The **ss_index** job computes a skill-score index, of which the GO Index (**go_index**) is a special case. The GO Index is a performance metric used primarily by the United States Air Force.

populate a 2x2 contingency table from which categorical statistics are derived.

Stat-Analysis Usage

View the usage statement for Stat-Analysis by simply typing the following:

```
stat_analysis
```

Usage:
stat_analysis

-lookin path	**Space-separated list of input paths where each is a _TYPE.txt file, STAT file, or directory which should be searched recursively for STAT files. Allows the use of wildcards (required).**
[-out filename]	Output path or specific filename to which output should be written rather than the screen (optional).
[-tmp_dir path]	Override the default temporary directory to be used (optional).
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging
[-config config_file] | [JOB COMMAND LINE] (Note: "|" means "or")	
[-config config_file]	**STATAnalysis config file containing Stat-Analysis jobs to be run.**
[JOB COMMAND LINE]	**All the arguments necessary to perform a single Stat-Analysis job. See the MET Users Guide for complete description of options.**

At a minimum, you must specify at least one directory or file in which to find STAT data (using the **-lookin path** command line option) and either a configuration file (using the **-config config_file** command line option) or a job command on the command line.

cindyhg Tue, 06/25/2019 - 08:36

Stat-Analysis Tool: Configure

Stat-Analysis Tool: Configure

Stat-Analysis Tool: Configure

Start by making an output directory for Stat-Analysis and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/stat_analysis
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/stat_analysis
```

The behavior of Stat-Analysis is controlled by the contents of the configuration file or the job command passed to it on the command line. The default Stat-Analysis configuration may be found in the **data/config/StatAnalysisConfig_default** file. Let's start with a configuration file that's packaged with the met-8.0 test scripts:

```
cp ${MET_BUILD_BASE}/share/met/config/STATAnalysisConfig_default STATAnalysisConfig_tutorial
```

Open up the **STATAnalysisConfig_tutorial** file for editing with your preferred text editor.

```
vi STATAnalysisConfig_tutorial
```

You will see that most options are left blank, so the tool will use whatever it finds or whatever is specified in the command or job line. If you go down to the **jobs[]**section you will see a list of the jobs run for the test scripts. Remove those existing jobs and add the following 2 analysis jobs:

```
jobs = [
"-job aggregate -line_type CTC -fcst_thresh >273.0 -vx_mask FULL -interp_mthd NEAREST",
"-job aggregate_stat -line_type CTC -out_line_type CTS -fcst_thresh >273.0 -vx_mask FULL -interp_mthd NEAREST"
];
```

The first job listed above will select out only the contingency table count lines (CTC) where the threshold applied is >273.0 over the FULL masking region. This should result in 2 lines, one for pressure levels P850-500 and one for pressure P1050-850. So this job will be aggregating contingency table counts across vertical levels.

The second job listed above will perform the same aggregation as the first. However, it'll dump out the corresponding contingency table statistics derived from the aggregated counts.

Close the file and run it on the next page.

cindyhg Tue, 06/25/2019 - 08:38

Stat-Analysis Tool: Run on Point-Stat output

Stat-Analysis Tool: Run on Point-Stat output

Stat-Analysis Tool: Run on Point-Stat output

Now, run Stat-Analysis on the command line using the following command:

```
stat_analysis \
-config STATAnalysisConfig_tutorial \
-lookin ../point_stat \
-v 2
```

The output for these two jobs are printed to the screen. Try redirecting their output to a file by adding the **-out** command line argument:

```
-config STATAnalysisConfig_tutorial \
-lookin ../point_stat \
-v 2 \
-out aggr_ctc_lines.out
```

The output was written to **aggr_ctc_lines.out**. We'll look at this file in the next section.

Next, try running the first job again, but entirely on the command line without a configuration file:

```
stat_analysis \
-lookin ../point_stat \
-v 2 \
-job aggregate \
-line_type CTC \
-fcst_thresh ">273.0" \
-vx_mask FULL \
-interp_mthd NEAREST
```

Note that we had to put double quotes (") around the forecast theshold string for this to work.

Next, run the same command but add the **-dump_row** command line option. This will redirect all of the STAT lines used by the job to a file. Also, add the ***-out_stat*** command line option. This will write a full STAT output file, including the 22 header columns:

```
stat_analysis \
-lookin ../point_stat \
-v 2 \
-job aggregate \
-line_type CTC \
-fcst_thresh ">273.0" \
-vx_mask FULL \
-interp_mthd NEAREST \
-dump_row aggr_ctc_job.stat \
-out_stat aggr_ctc_job_out.stat
```

Open up the file **aggr_ctc_job.stat** to see the 2 STAT lines used by this job.

```
vi aggr_ctc_job.stat
```

Open up the file **aggr_ctc_job_out.stat** to see the 1 output STAT line. Notice that the **FCST_LEV** and **OBS_LEV** columns contain the input strings concatenated together.

```
vi aggr_ctc_job_out.stat
```

Try re-running this job using **-set_hdr FCST_LEV P1050-500** and **-set_hdr OBS_LEV P1050-500**. How does that affect the output?

The use of the **-dump_row** option is **highly recommended** to ensure that your analysis jobs run on the exact set of data that you intended. It's easy to make mistakes here!

cindyhg Tue, 06/25/2019 - 08:39

Stat-Analysis Tool: Output

Stat-Analysis Tool: Output

Stat-Analysis Tool: Output

On the previous page, we generated the output file **aggr_ctc_lines.out** by using the **-out** command line argument. Open that file using the text editor of your choice, and be sure to turn word-wrapping off.

This file contains the output for the two jobs we ran through the configuration file. The output for each job consists of 3 lines as follows:

1. The **JOB_LIST** line contains the job filtering parameters applied for this job.
2. The **COL_NAME** line contains the column names for the data to follow in the next line.
3. The third line consists of the line type generated (**CTC** and **CTS** in this case) followed by the values computed for that line type.

Next, try running the Stat-Analysis tool on the output file **../point_stat/point_stat_run2_360000L_20070331_120000V.stat**. Start by running the following job:

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat \
-v 2 \
-job aggregate \
-fcst_var TMP \
-fcst_lev Z2 \
-vx_mask EAST -vx_mask WEST \
-interp_pnts 1 \
-line_type CTC \
-fcst_thresh ">278.0"
```

This job should aggregate 2 CTC lines for 2-meter temperature across the EAST and WEST regions. Next, try creating your own Stat-Analysis command line jobs to do the following:

1. Do the same aggregation as above but for the 5x5 interpolation output (i.e. 25 points instead of 1 point).
2. Do the aggregation listed in (1) but compute the corresponding contingency table statistics (CTS) line. Hint: you will need to change the job type to **aggregate_stat** and specify the desired **-out_line_type**.
   How do the scores change when you increase the number of interpolation points? Did you expect this?
3. Aggregate the scalar partial sums lines (SL1L2) for 2-meter temperature across the EAST and WEST masking regions.
   How does aggregating the East and West domains affect the output?

5. Run an **aggregate_stat** job directly on the matched pair data (MPR lines), and use the **-out_line_type** command line argument to select the type of output to be generated. You'll likely have to supply additional command line arguments depending on what computation you request.

Now answer this question about this Stat-Analysis output:

1. How do the scores compare to the original (separated by level) scores? What information is gained by aggregating the statistics?

When doing the exercises above, don't forget to use the **-dump_row** command line option to verify that you're running the job over the STAT lines you intended.

If you get stuck on any of these exercises, you may refer to the exercise answers on the next page. We will return to the Stat-Analysis tool in the future practical sessions.

cindyhg Tue, 06/25/2019 - 09:13

Stat-Analysis Tool: Exercise Answers

Stat-Analysis Tool: Exercise Answers

1. Job Number 1:

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat -v 2 \
-job aggregate -fcst_var TMP -fcst_lev Z2 -vx_mask EAST -vx_mask WEST -interp_pnts 25 -fcst_thresh ">278.0" \
-line_type CTC \
-dump_row job1_ps.stat
```

2. Job Number 2:

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat -v 2 \
-job aggregate_stat -fcst_var TMP -fcst_lev Z2 -vx_mask EAST -vx_mask WEST -interp_pnts 25 -fcst_thresh ">278.0" \
-line_type CTC -out_line_type CTS \
-dump_row job2_ps.stat
```

3. Job Number 3:

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat -v 2 \
-job aggregate -fcst_var TMP -fcst_lev Z2 -vx_mask EAST -vx_mask WEST -interp_pnts 25 \
-line_type SL1L2 \
-dump_row job3_ps.stat
```

4. Job Number 4:

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat -v 2 \
-job aggregate_stat -fcst_var TMP -fcst_lev Z2 -vx_mask EAST -vx_mask WEST -interp_pnts 25 \
-line_type SL1L2 -out_line_type CNT \
-dump_row job4_ps.stat
```

5. This MPR job recomputes contingency table statistics for 2-meter temperature over G212 using a new threshold of ">=285":

```
stat_analysis \
-lookin ../point_stat/point_stat_run2_360000L_20070331_120000V.stat -v 2 \
-job aggregate_stat -fcst_var TMP -fcst_lev Z2 -vx_mask G212 -interp_pnts 25 \
-line_type MPR -out_line_type CTS \
-out_fcst_thresh ge285 -out_obs_thresh ge285 \
-dump_row job5_ps.stat
```

johnhg Thu, 07/25/2019 - 22:07

Use Case: Ensemble

Use Case: Ensemble

The EnsembleStat MET Tool Wrapper use case utilizes the MET *Ensemble-Stat* tool.

Optional: Refer to the MET Users Guide for a description of the MET tools used in this use case.
Optional: Refer to the **METplus Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

Change to the ${METPLUS_TUTORIAL_DIR} directory:

```
cd ${METPLUS_TUTORIAL_DIR}
```

1. **Review the use case configuration file: EnsembleStat.conf**

Open the file and look at all of the configuration variables that are defined.

Note that variables in EnsembleStat.conf reference other config variables that have been defined in other configuration files. For example:

```
FCST_ENSEMBLE_STAT_INPUT_DIR = {INPUT_BASE}/met_test/data/sample_fcst
```

This references **INPUT_BASE** which is set in the tutorial.conf configuration file. METplus config variables can reference other config variables even if they are defined in a config file that is read afterwards.

2. **Run the use case:**

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/EnsembleStat/EnsembleStat.conf
```

METplus is finished running when control returns to your terminal console and you see the following text:

```
INFO: METplus has successfully finished running.
```

3. **Review the output files:**

You should have output files in the following directories:

```
ls ${METPLUS_TUTORIAL_DIR}/output/ensemble/200912311200/ensemble_stat
```

- ensemble_stat_20100101_120000V_ecnt.txt
- ensemble_stat_20100101_120000V_ens.nc
- ensemble_stat_20100101_120000V_orank.nc
- ensemble_stat_20100101_120000V_orank.txt
- ensemble_stat_20100101_120000V_phist.txt
- ensemble_stat_20100101_120000V_relp.txt
- ensemble_stat_20100101_120000V_rhist.txt
- ensemble_stat_20100101_120000V_ssvar.txt
- ensemble_stat_20100101_120000V.stat

Take a look at some of the files to see what was generated.

```
less ${METPLUS_TUTORIAL_DIR}/output/ensemble/200912311200/ensemble_stat/ensemble_stat_20100101_120000V.stat
```

4. **Review the log output:**

Log files for this run are found in **${METPLUS_TUTORIAL_DIR}/logs**. The filename contains a timestamp of the current day.

```
ls -1 ${METPLUS_TUTORIAL_DIR}/output/logs/master_metplus.log.*
```

View the log file with the latest timestamp.

5. **Review the Final Configuration File**

The final configuration file is called **metplus_final.conf**. This contains all of the configuration variables used in the run. It is found in the top level of **[dir] OUTPUT_BASE**.

```
less ${METPLUS_TUTORIAL_DIR}/output/metplus_final.conf
```

Note: metplus_final.conf is overwritten with every call to master_metplus.py

cindyhg Tue, 06/25/2019 - 09:15

Use Case: PQPF

Use Case: PQPF

METplus Use Case: QPF Probabilistic

The QPF Probabilistic use case utilizes the MET *Pcp-Combine*, R*egrid-Data-Plane*, and *Grid-Stat* tools.

Optional: Refer to the **MET Users Guide** for a description of the MET tools used in this use case.
Optional: Refer to the **METplus Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

Review Use Case Configuration File

The configuration file is located in use_cases/model_applications/precipitation and is called **GridStat_fcstHRRR-TLE_obsStgIV_GRIB.conf**

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/precipitation/GridStat_fcstHRRR-TLE_obsStgIV_GRIB.conf
```

Note that several processes are called in this use-case and that there is a specific setting to tell METplus that the forecast field is probabilistic. For example:

```
PROCESS_LIST = PcpCombine, RegridDataPlane, GridStat
FCST_IS_PROB = true
```

Also note that variables in **GridStat_fcstHRRR-TLE_obsStgIV_GRIB.conf** reference other config variables that have been defined in configuration files. For example:

```
REGRID_DATA_PLANE_VERIF_GRID = {INPUT_BASE}/model_applications/precipitation/mask/CONUS_HRRRTLE.nc
OBS_PCP_COMBINE_INPUT_DIR = {INPUT_BASE}/model_applications/precipitation/StageIV
```

This references **INPUT_BASE** which is set in the METplus tutorial.conf file (${METPLUS_TUTORIAL_DIR}**/tutorial.conf**). METplus config variables can reference other config variables even if they are defined in a config file that is read afterwards.

Run METplus

Run the following command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/precipitation/GridStat_fcstHRRR-TLE_obsStgIV_GRIB.conf
```

METplus is finished running when control returns to your terminal console and you see the following text:

```
INFO: METplus has successfully finished running.
```

Review the Output Files

You should have output files in the following directories:

```
ls ${METPLUS_TUTORIAL_DIR}/output/model_applications/precipitation/GridStat_fcstHRRR-TLE_obsStgIV_GRIB/GridStat/201609041200
```

- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V_pct.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V_pjc.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V_prc.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V_pstd.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V.stat
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_070000L_20160904_190000V_pct.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_070000L_20160904_190000V_pjc.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_070000L_20160904_190000V_prc.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_070000L_20160904_190000V_pstd.txt
- grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_070000L_20160904_190000V.stat

Take a look at some of the files to see what was generated.

```
less ${METPLUS_TUTORIAL_DIR}/output/model_applications/precipitation/GridStat_fcstHRRR-
TLE_obsStgIV_GRIB/GridStat/201609041200/grid_stat_PROB_PHPT_APCP_vs_STAGE4_GRIB_APCP_A06_060000L_20160904_180000V.stat
```

Review the Log Files

Log files for this run are found in **${METPLUS_TUTORIAL_DIR}/output/logs**. The filename contains a timestamp of the year, month, day, hour, minute, second that the METplus command was run. The log file for this command will be the most recent one.

```
ls ${METPLUS_TUTORIAL_DIR}/output/logs
```

Note: the time zone of your computer may not be the same as the time zone you are in. For example, hera uses UTC which is 6 hours ahead of Mountain Daylight Time and 7 hours ahead of Mountain Standard Time (the time zone in Boulder, Colorado).

Review the Final Configuration File

The final configuration file is **metplus_final.conf**. This contains all of the configuration variables used in the run.

```
less ${METPLUS_TUTORIAL_DIR}/output/metplus_final.conf
```

cindyhg Tue, 06/25/2019 - 09:17

Additional Exercises

Additional Exercises

End of Practical Session 3

Congratulations! You have completed Session 3!

If you have extra time, you may want to try these additional METplus exercises. The answers are found on the next page.

EXERCISE 3.1: accum_3hr - Build a 3 Hour Accumulation Instead of 6

vs. MRMS QPE example. Then compare 3 hour accumulations in the forecast and observation data with grid_stat.

Copy your custom configuration file and rename it to **GridStat-ensemble.accum_3hr.conf** for this exercise.

```
cp ${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/precipitation/GridStat_fcstHRRR-TLE_obsStgIV_GRIB.conf \
${METPLUS_TUTORIAL_DIR}/user_config/GridStat-ensemble.accum_3hr.conf
```

Open **GridStat-ensemble.accum_3hr.conf** with an editor and change values.

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/GridStat-ensemble.accum_3hr.conf
```

HINT: There is a variable in the observation data named **BOTH_VAR_LEVELS** that currently contains a 6 hour accumulation.

You can also set the **OUTPUT_BASE** entry under the **[dir]** section on the command line to define a new location so you can keep it separate from the other runs.

Rerun master_metplus passing in your new custom config file, **tutorial.conf**, and setting the new **OUTPUT_BASE** for this exercise.

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/GridStat-ensemble.accum_3hr.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/exercises/accum_3hr
```

Review the log file. You should see Pcp-Combine read 3 files and run Grid-Stat comparing both 3 hour accumulations.

```
ls ${METPLUS_TUTORIAL_DIR}/output/exercises/accum_3hr/logs/master_metplus.log.*
```

```
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090418.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090417.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090416.01h
DEBUG 2: Skipping 480079 of 987601 grid points which do not meet the valid data threshold (1).
DEBUG 1: Creating output file: /path/to/tutorial/output/exercises/accum_3hr/model_applications/precipitation/GridStat_fcstHRRR-
TLE_obsStgIV_GRIB/uswrp/StageIV_grib/bucket/20160904/ST4.2016090418_A03h
DEBUG 2: Writing output variable "APCP_03" for the "sum" of "APCP/A01".
```

Go to the next page for the solution to see if you were right!

EXERCISE 3.2: input_1hr - Force Pcp-Combine to only use 1 hour accumulation files

Instructions: Modify the METplus configuration files to force Pcp-Combine to use **six 1 hour accumulation files instead of one 6 hour accumulation file** of observation data in the PHPT vs. StageIV GRIB example.

Tip: Recall from the original QPF exercise that METplus used a 6 hour observation accumulation file as input to Pcp-Combine to build a 6 hour accumulation file for the example where forecast lead = 6.

From the log output found in **${METPLUS_TUTORIAL_DIR}/output/logs**:

```
DEBUG 2: Performing derivation command (sum) for 1 files.
DEBUG 1: Reading data (name="APCP"; level="A6";) from input file: /path/to/METplus_Data/qpf/uswrp/StageIV/20160904/ST4.2016090418.06h
DEBUG 2: Skipping 399779 of 987601 grid points which do not meet the valid data threshold (1).
DEBUG 1: Creating output file: /path/to/tutorial/output/qpf-prob/uswrp/StageIV_grib/bucket/20160904/ST4.2016090418_A06h
DEBUG 2: Writing output variable "APCP_06" for the "sum" of "APCP/A6".
```

Copy your custom configuration file and rename it to **GridStat-ensemble.input_1hr.conf** for this exercise.

```
cd ${METPLUS_TUTORIAL_DIR}/user_config
cp GridStat-ensemble.accum_3hr.conf GridStat-ensemble.input_1hr.conf
```

Open **GridStat-ensemble.input_1hr.conf** with an editor and add the extra information.

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/GridStat-ensemble.input_1hr.conf
```

HINT 1: The variables that you need to add must go under the **[config]** section.

HINT 2: The **FCST_PCP_COMBINE_INPUT_LEVEL** and **OBS_PCP_COMBINE_INPUT_LEVEL** variables set the accumulation interval that is found in grib2 input data for forecast and observation data respectively.

You should also change **OUTPUT_BASE** to a new location so you can keep it separate from the other runs.

```
[dir]
OUTPUT_BASE = {ENV[METPLUS_TUTORIAL_DIR]}/output/exercises/input_1hr
```

Rerun master_metplus passing in your new custom config file for this exercise keeping in mind to order of configuration files matters and the **OUTPUT_BASE** in **GridStat-ensemble.input_1hr.conf** will override what is in the tutorial.conf file

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/GridStat-ensemble.input_1hr.conf
```

```
DEBUG 2: Performing derivation command (sum) for 6 files.
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
```

```
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090417.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090416.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090415.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090414.01h
DEBUG 1: Reading data (name="APCP"; level="A01";) from input file:
/d1/projects/METplus/METplus_Data/model_applications/precipitation/StageIV/20160904/ST4.2016090413.01h
DEBUG 2: Skipping 480079 of 987601 grid points which do not meet the valid data threshold (1).
DEBUG 1: Creating output file: /path/to/tutorial/output/exercises/input_1hr/model_applications/precipitation/GridStat_fcstHRRR-
TLE_obsStgIV_GRIB/uswrp/StageIV_grib/bucket/20160904/ST4.2016090418_A06h
DEBUG 2: Writing output variable "APCP_06" for the "sum" of "APCP/A01".
```

Go to the next page for the solution to see if you were right!

cindyhg Tue, 06/25/2019 - 09:21

Answers to Exercises from Session 3

Answers to Exercises from Session 3

Answers to Exercises from Session 3

These are the answers to the exercises from the previous page. Feel free to ask a MET representative if you have any questions!

ANSWER 3.1: accum_3hr - Build a 3 Hour Accumulation Instead of 6

Instructions: Modify the METplus configuration files to build a 3 hour accumulation instead of a 6 hour accumulation from forecast data using Pcp-Combine in the HREF MEAN vs. MRMS QPE example. Then compare 3 hour accumulations in the forecast and observation data with grid_stat.

Answer: In the **user_config/GridStat-ensemble.accum_3hr.conf** file, change the following variables in the **[config]** section:

Change:

```
BOTH_VAR1_LEVELS = A06
```

To:

```
BOTH_VAR1_LEVELS = A03
```

ANSWER 3.2: input_1hr - Force Pcp-Combine to only use 1 hour accumulation files

Instructions: Modify the METplus configuration files to force Pcp-Combine to use six 1 hour accumulation files instead of one 6 hour accumulation file of observation data in the PHPT vs. StageIV GRIB example.

Answer: In the **user_config/GridStat-ensemble.input_1hr.conf** file, change the following variable to the **[config]** section:

Change:

```
BOTH_VAR1_LEVELS = A03
```

Back to:

```
BOTH_VAR1_LEVELS = A06
```

Also change:

```
OBS_PCP_COMBINE_INPUT_ACCUMS = 6,1
```

To:

```
OBS_PCP_COMBINE_INPUT_ACCUMS = 1
```

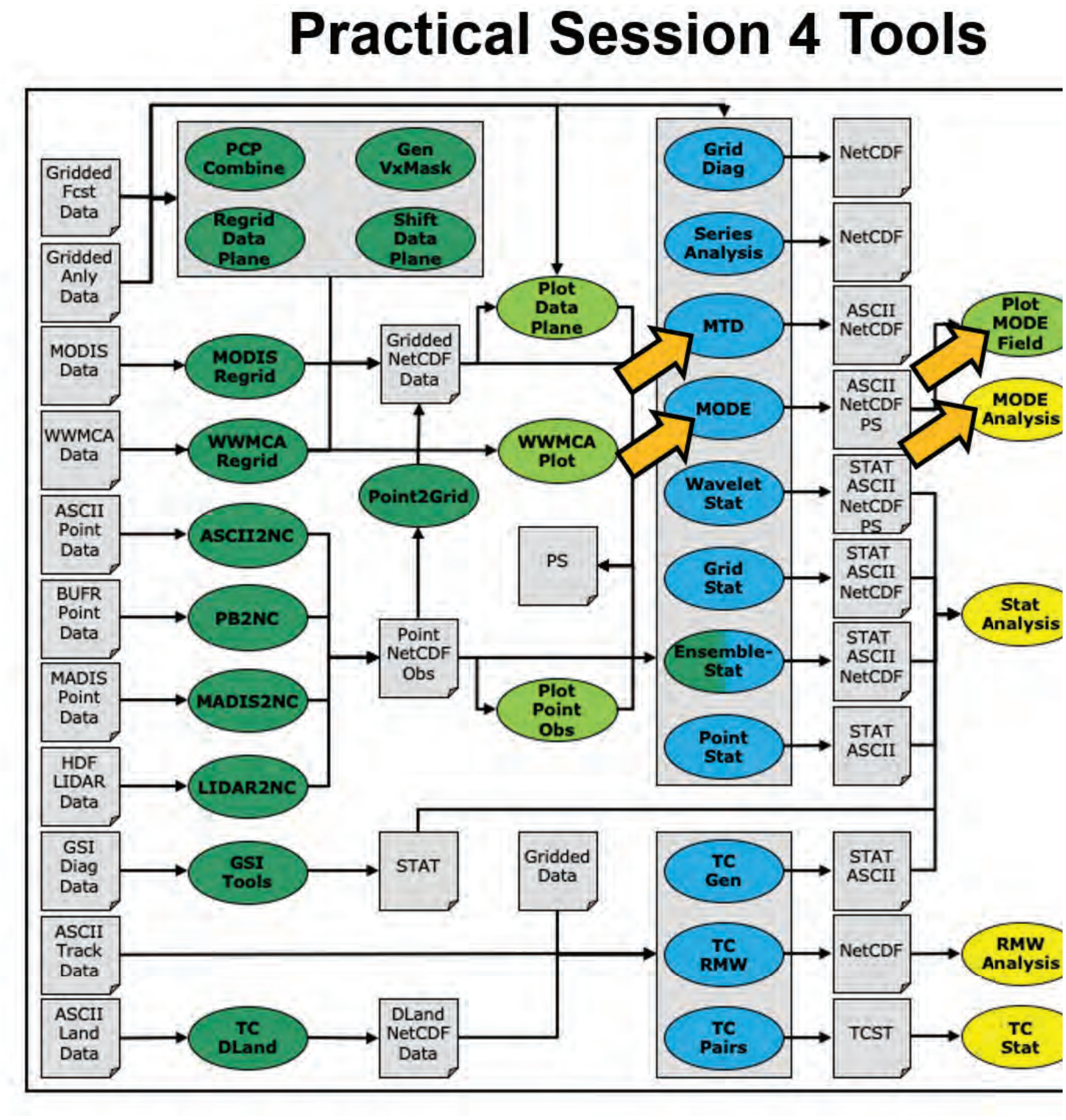
cindyhg Tue, 06/25/2019 - 09:23

Session 4: MODE and MTD

Session 4: MODE and MTD

METplus Practical Session 4

During this practical session, you will run the tools indicated below:



You may navigate through this tutorial by following the links at the bottom of each page or by using the menu navigation.

Since you already set up your runtime environment in **Session 1**, you **should** be ready to go! To be sure, run through the following instructions to check that your environment is set correctly.

Prerequisites: Verify Environment is Set Correctly

Before running these instructions, you will need to ensure that you have a few environment variables set up correctly. If they are not set correctly, these instructions will not work properly.

1. Check that you have **METPLUS_TUTORIAL_DIR** set correctly:

```
echo ${METPLUS_TUTORIAL_DIR}
```

If you don't see a path in your user directory output to the screen, set this environment variable in your user profile before continuing.

2. Use the **"env"** command to check that you have **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA** set correctly:

```
> env | grep MET
```

If any of these variables are not set, please set them. They will be referenced throughout the tutorial. You can do this by sourcing the appropriate TutorialSetup.[hera/bash/cshrc].sh file, that is:

On **hera**:

```
source /path/to/METplus_Tutorial/TutorialSetup.hera.sh
```

On **linux server (bash)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-bash.sh
```

On **linux server (csh)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-csh.sh
```

where /path/to is the path to your METplus_Tutorial directory.

METPLUS_BUILD_BASE is the full path to the METplus installation (/path/to/METplus-X.Y)
MET_BUILD_BASE is the full path to the MET installation (/path/to/met-X.Y)
METPLUS_DATA is the location of the sample test data directory

3. Check that you have loaded the MET module correctly:

```
point_stat
```

You should see the usage statement for Point-Stat. The version number listed should correspond to the version listed in **MET_BUILD_BASE**. If it does not, you will need to either reload the met module, or add **${MET_BUILD_BASE}/bin** to your PATH.

4. Check that the correct version of **master_metplus.py** is in your **PATH**:

```
which master_metplus.py
```

If you don't see the full path to script from the shared installation, please set it. It should look the same as the output from this command:

```
echo ${METPLUS_BUILD_BASE}/ush/master_metplus.py
```

See the instructions in Session 1 for more information.

You are now ready to move on to the next section.

admin Wed, 06/12/2019 - 16:58

MET Tool: MODE

MET Tool: MODE

MODE Tool: General

MODE Functionality

MODE, the Method for Object-Based Diagnostic Evaluation, provides an object-based verification for comparing gridded forecasts to gridded observations. MODE may be used in a generalized way to compare any two fields containing data from which objects may be well defined. It has most commonly been applied to precipitation fields and radar reflectivity. The steps performed in MODE consist of:

- Define objects in the forecast and observation fields based on user-defined parameters.
- Compute attributes for each of those objects: such as area, centroid, axis angle, and intensity.
- For each forecast/observation object pair, compute differences between their attributes: such as area ratio, centroid distance, angle difference, and intensity ratio.
- Use fuzzy logic to compute a total interest value for each forecast/observation object pair based on user-defined weights.
- Based on the computed interest values, match objects across fields and merge objects within the same field.
- Write output statistics summarizing the characteristics of the single objects, the pairs of objects, and the matched/merged objects.

MODE may be configured to use a few different sets of logic with which to perform matching and merging. In this tutorial, we'll use the most simple approach, but users are encouraged to read Chapter 14 of the MET User's Guide for a more thorough description of MODE's capabilities.

MODE Usage

View the usage statement for MODE by simply typing the following:

```
mode
```

Usage: mode

fcst_file	**Input gridded forecast file containing the field to be verified**
obs_file	**Input gridded observation file containing the verifying field**
config_file	**MODEConfig file containing the desired configuration settings**
[-config_merge merge_config_file]	Overrides the default fuzzy engine settings for merging within the fcst/obs fields (optional).
[-outdir path]	Overrides the default output directory (optional).
[-log file]	Outputs log messages to the specified file

[-compress level]   NetCDF compression level

The forecast and observation fields must be on the same grid. You can use **copygb** to regrid GRIB1 files, **wgrib2** to regrid GRIB2 files, or use the automated regridding functionality within the MET config files.

At a minimum, the input gridded **fcst_file**, the input gridded **obs_file**, and the configuration **config_file** must be passed in on the command line.

cindyhg Tue, 06/25/2019 - 07:58

MODE Tool: Configure

MODE Tool: Configure

MODE Tool: Configure

Start by making an output directory for MODE and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/mode
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/mode
```

The behavior of MODE is controlled by the contents of the configuration file passed to it on the command line. The default MODE configuration file may be found in the **data/config/MODEConfig_default** file. Prior to modifying the configuration file, users are advised to make copies of existing configuration files:

```
cp ${METPLUS_DATA}/met_test/scripts/config/MODEConfig_APCP_12 MODEConfig_APCP_12
cp ${METPLUS_DATA}/met_test/scripts/config/MODEConfig_APCP_24 MODEConfig_APCP_24
cp ${METPLUS_DATA}/met_test/scripts/config/MODEConfig_RH MODEConfig_RH
```

We'll be using these three configuration files during this session. Open up the **MODEConfig_APCP_12** file to view it.

```
vi MODEConfig_APCP_12
```

The configuration items for MODE are used to specify how the object-based verification approach is to be performed. In MODE, as in the other MET statistics tools, you can compare any two fields. When necessary, the items in the configuration file are specified separately for the forecast and observation fields. In most cases though, users will be comparing the same forecast and observation fields. The configurable items include parameters for the following:

- The forecast and observation fields and vertical levels or accumulation intervals to be compared
- Options to mask out a portion of or threshold the raw fields
- The forecast and observation object definition parameters
- Options to filter out objects that don't meet a size or intensity criteria
- Flags to control the logic for matching/merging
- Weights to be applied for the fuzzy engine matching/merging algorithm
- Interest functions to be used for the fuzzy engine matching/merging algorithm
- Total interest threshold for matching/merging
- Various plotting options

While the MODE configuration file contains many options, beginning users will typically only need to modify a few of them. You may find a complete description of the configurable items in section 14.3.2 of the MET User's Guide. Please take some time to review them.

At the bottom of MODE_Config_APCP_12, change "version" to "9.0"

```
////////////////////////////////////////////////////////////////////////////////

output_prefix = "";
version = "V9.0";

////////////////////////////////////////////////////////////////////////////////
```

Close MODEConfig_APCP_12. Also change the version number in MODEConfig_APCP_24 and MODEConfig_RH. We'll start here using by running the configuration files we copied over, as-is.

cindyhg Tue, 06/25/2019 - 08:01

MODE Tool: Run

MODE Tool: Run

MODE Tool: Run

Next, run MODE three times on the command line using those three configuration files with the following commands:

```
mode \
${METPLUS_DATA}/met_test/out/pcp_combine/sample_fcst_12L_2005080712V_12A.nc \
${METPLUS_DATA}/met_test/out/pcp_combine/sample_obs_2005080712V_12A.nc \
MODEConfig_APCP_12 \
-outdir . \
-v 2
```

```
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_24.tm00_G212 \
${METPLUS_DATA}/met_test/out/pcp_combine/sample_obs_2005080800V_24A.nc \
MODEConfig_APCP_24 \
-outdir . \
-v 2
```

It is very possible you will receive and error message after running the APCP_24 case that includes this:

```
ERROR :
ERROR : check_met_version() -> The version number listed in the config file (V8.1) is not compatible with the current
version of the code (V9.0).
ERROR :
HDF5-DIAG: Error detected in HDF5 (1.10.4) thread 0:
```

This is not an HDF5 error. Instead, follow the instructions and make sure you updated the version to be V9.0 in both the MODEConfig_APCP_24 and MODEConfig_RH prior to re-running the above command and then the RH command below.

```
mode \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_12.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080712/wrfprs_ruc13_00.tm00_G212 \
MODEConfig_RH \
-outdir . \
-v 2
```

These commands make use of sample data that's distributed with the MET tarball. They run MODE on 12-hour accumulated precipitation, 24-hour accumulated precipitation, and on a field of relative humidity.

cindyhg Tue, 06/25/2019 - 08:02

MODE Tool: Output

MODE Tool: Output

MODE Tool: Output

The output of MODE typically consists of 4 files: 2 ASCII statistics files, 1 NetCDF object file, and 1 PostScript summary plot. The output of any of these files may be disabled using the appropriate MODE command line argument. In this example, the output is written to the current **mode** directory, as we requested on the command line.

The MODE output file naming convention is similar to that of the other MET tools. It contains timing information about the forecast being evaluated (forecast valid, lead, and accumulation times). If you rerun MODE on the same fields but with a slightly different configuration, the new output will override the old output, unless you redirect it to a different directory using the ***-outdir*** command line argument. You can also edit the **output_prefix** in the MODE configuration file to customize the output file names. The 4 MODE output files are described briefly below:

- The PostScript file ends in **.ps** and is described below.
- The NetCDF object file ends in **_obj.nc** and contains the object indices.
- The ASCII contingency table statistics file and ends in **_cts.txt**.
- The ASCII object statistics file ends in **_obj.txt** and contains all of the object and object comparison data.

You can use ghostview (gv) to look at the postscript file output from each of these three forecasts.

```
gv mode_240000L_20050808_000000V_240000A.ps &
```

If ghostview is not available, use **display** to view the files. Click on the image to get a command box, then use **File -> Next** to move to the next page of the image.

There are multiple pages of output. Take a moment to look them over:

1. Page 1 summarizes the entire MODE run. Thumbnail images show the input data, resolved objects, and numbers identifying each object for both the forecast and observation fields. The color indicates object matching between the forecast and observation fields. Royal blue indicates an unmatched object. The object definition information is listed at the bottom of the page, and a sorted list of total object interest is listed on the right side.

2. Page 2 is an expanded view of the forecast thumbnail images.
3. Page 3 is an expanded view of the observation thumbnail images.
4. Page 4 has images showing the forecast objects with observation object outlines overlaid, and vice-versa.
5. Page 5 shows images and statistics for matching object clusters (i.e. one or more forecast objects matching one or more observation objects). These statistics also appear in the ASCII output from MODE.
6. When double-thresholding or fuzzy engine merging is enabled, additional PostScript pages are added to illustrate those methods.

You may view the output NetCDF file using **ncview**. Execute the following command to view the NetCDF object output of MODE:

```
ncview mode_120000L_20050807_120000V_120000A_obj.nc &
```

Click through the 2D variable names in the ncview window to see plots of the four object fields in the file (NOTE: if a window pops up informing you "the min and max are both...", just Click "OK" and then the field will render). The **fcst_obj_id** and **obs_obj_id** contain the indices for the forecast and observation objects defined by MODE. The **fcst_clus_id** and **obs_clus_id** contain indices for the matched cluster objects.

What are the benefits of spatial methods over traditional statistics? The weaknesses? What are some examples where an object-based verification would be inappropriate?

To accumulate the output of the object based verification, you use the MODE-Analysis Tool. We will use this next.

cindyhg Tue, 06/25/2019 - 08:04

Use Case: MODE

METplus Use Case: MODE

The MODE use case utilizes the MET *Mode* tools.

Optional: Refer to the MET Users Guide for a description of the MET tools used in this use case.
Optional: Refer to **A-Z Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

Review Use Case Configuration File: MODE.conf

Open the file and look at all of the configuration variables that are defined.

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MODE/MODE.conf
```

Note that variables in **MODE.conf** reference other config variables that have been defined in other configuration files. For example:

```
OBS_MODE_INPUT_DIR = {INPUT_BASE}/met_test/data/sample_fcst
```

This references **INPUT_BASE** which is the METplus tutorial configuration file **${METPLUS_TUTORIAL_DIR}/tutorial.conf**. METplus config variables can reference other config variables even if they are defined in a config file that is read afterwards.

Run METplus

Change to ${METPLUS_TUTORIAL_DIR}

```
cd ${METPLUS_TUTORIAL_DIR}
```

Run the following command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MODE/MODE.conf
```

METplus is finished running when control returns to your terminal console and you see the following text:

```
INFO: METplus has successfully finished running.
```

Review the Output Files

You should have output files in the following directories:

```
ls ${METPLUS_TUTORIAL_DIR}/output/mode/2005080712
```

- mode_WRF_RH_vs_WRF_RH_P500_120000L_20050807_120000V_000000A_cts.txt
- mode_WRF_RH_vs_WRF_RH_P500_120000L_20050807_120000V_000000A_obj.nc
- mode_WRF_RH_vs_WRF_RH_P500_120000L_20050807_120000V_000000A_obj.txt
- mode_WRF_RH_vs_WRF_RH_P500_120000L_20050807_120000V_000000A.ps

Take a look at some of the files to see what was generated.

```
less ${METPLUS_TUTORIAL_DIR}/output/mode/2005080712/mode_WRF_RH_vs_WRF_RH_P500_120000L_20050807_120000V_000000A_obj.txt
```

Review the Log Files

Log files for this run are found in **${METPLUS_TUTORIAL_DIR}/output/mode/logs/**.

The filename contains a timestamp of when it was run, in format YYYYMMDDhhmmss. The most recent timestamp will be from running the MODE use case.

```
ls ${METPLUS_TUTORIAL_DIR}/output/logs/master_metplus.log.*
```

NOTE: If you ran METplus on a different day than today, the log file will correspond to the day you ran. Note that some computers, such as NOAA's hera are set to UTC.

Review the Final Configuration File

The final configuration file is **output/metplus_final.conf**. This contains all of the configuration variables used in the run.

```
less ${METPLUS_TUTORIAL_DIR}/output/metplus_final.conf
```

cindyhg Tue, 06/25/2019 - 08:07

MET Tool: MTD

MET Tool: MTD

MODE-Time-Domain: General

MODE-Time-Domain Functionality

The MODE-Time-Domain (MTD) tool was added in MET version 6.0. It applies an object-based verification technique in comparing a gridded forecast to a gridded analysis. It defines 3-dimensional space/time objects, tracking 2-dimensional objects through time. It writes summary object information to ASCII statistics files and writes object fields to NetCDF format. The MTD tool can be used to quantify the duration of events and timing errors.

View the usage statement for MODE-Time-Domain by simply typing the following:

```
mtd
```

The forecast and observation fields must be on the same grid. You can use **copygb** to regrid GRIB1 files, **wgrib2** to regrid GRIB2 files, or use the automated regridding functionality within the MET config files.

At a minimum, the **-fcst** and **-obs** options must be used to specify the data to be processed. Alternatively, the **-single** option specifies that MTD should be run on a single dataset. The **-config** option specifies the name of the configuration file.

cindyhg Tue, 06/25/2019 - 08:13

MTD: Configure

MTD: Configure

MTD: Configure

Start by making an output directory for MTD and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/mtd
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/mtd
```

The behavior of MTD is controlled by the contents of the configuration file passed to it on the command line. The default MTD configuration file may be found in the **data/config/MTDConfig_default** file. Prior to modifying the configuration file, make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/MTDConfig_default MTDConfig_tutorial
```

The configuration items for MTD are used to specify how the space-time-object-based verification approach is to be performed. Just as MODE may be used to compare any two fields, the same is true of MTD. When necessary, the items in the configuration file are specified separately for the forecast and observation fields. In most cases though, users will be comparing the same forecast and observation fields. The configurable items include specifications for the following:

- The verification domain.
- The forecast and observation fields and vertical levels or accumulation intervals to be compared.
- The forecast and observation object definition parameters.
- Options to filter out objects that don't meet a minimum volume.
- Matching/merging weights and interest functions.
- Total interest threshold for matching/merging.
- Flags to control output files.

For this tutorial, we'll configure MTD to process the same series of data we ran through the Series-Analysis tool. Just like MODE, MTD compares a single forecast field to a single observation field in each run.

Open up the **MTDConfig_tutorial** file for editing with the text editor of your choice and edit it as follows:

```
vi MTDConfig_tutorial
```

Set the **fcst** dictionary as follows:

```
fcst = {
  field = {
    name  = "APCP";
    level = "A03";
  }
  conv_radius = 2;
  conv_thresh = >=2.54;
}
```

Set the **obs** dictionary as follows:

```
obs = {
  field = {
    name  = "APCP_03";
    level = "(*,*)";
  }
  conv_radius = 2;
  conv_thresh = >=2.54;
}
```

Set:

```
min_volume = 0;
```

To retain all objects regardless of their volume.

Save and close this file.

cindyhg Tue, 06/25/2019 - 08:15

MTD: Run

MTD: Run

First, we need to prepare our observations by putting 1-hourly StageII precipitation forecasts into 3-hourly buckets. Create an output directory:

```
mkdir -p sample_obs/ST2ml_3h
```

Run the following PCP-Combine commands to prepare the observations:

```
pcp_combine -sum 00000000_000000 01 20050807_030000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080703V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_060000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080706V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_090000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080709V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_120000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080712V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_150000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080715V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_180000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080718V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050807_210000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080721V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

```
pcp_combine -sum 00000000_000000 01 20050808_000000 03 \
sample_obs/ST2ml_3h/sample_obs_2005080800V_03A.nc \
-pcpdir ${METPLUS_DATA}/met_test/data/sample_obs/ST2ml
```

Rather than listing 8 input forecast and observation files on the command line, we will write them to a file list first. Since the 0-hour forecast does not contain 3-hourly accumulated precip, we will exclude that from the list. We will use the 3-hourly APCP output from PCP-Combine that we prepared above:

```
ls -1 ${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs* | egrep -v "_00.tm00" > fcst_file_list
ls -1 sample_obs/ST2ml_3h/sample_obs* > obs_file_list
```

Next, run the following MTD command:

```
mtd \
-fcst fcst_file_list \
-obs obs_file_list \
-config MTDConfig_tutorial \
-outdir . \
-v 2
```

Just as with MODE, MTD applies a convolution operation to smooth the data. However, there are two important differences. In MODE, the convolution shape is a circle (radius = conv_radius). In MTD, the convolution shape is a square (width = 2*conv_radius+1) and for time t, the values in that square are averaged for times t-1, t, and t+1. Convolving in space plus time enables MTD to identify more continuous space-time objects.

If your data has high enough time frequency that the features at one timestep overlap those at the next timestep, it may be well-suited for MTD.

cindyhg Tue, 06/25/2019 - 08:16

MTD: Output

MTD: Output

MTD: Output

The MTD output typically consists of 6 files: 5 ASCII statistics files and 1 NetCDF object file. MTD does not create any graphical output. In this example, the output is written to the current **mtd** directory as we requested on the command line.

- mtd_20050807_030000V_2d.txt
- mtd_20050807_030000V_3d_pair_cluster.txt
- mtd_20050807_030000V_3d_pair_simple.txt
- mtd_20050807_030000V_3d_single_cluster.txt
- mtd_20050807_030000V_3d_single_simple.txt
- mtd_20050807_030000V_obj.nc

in the configuration file, which should be used to prevent the output of one run from over-writing the output of a previous run. The 6 MTD output files are described briefly below:

- The NetCDF object file ends in **.nc** and contains gridded fields of the raw data, simple object indices, and cluster object indices for each forecast and observed timestep.
- The ASCII file ending with **_2D.txt** contains many columns similar to the output of MODE. This data summarizes the 2-dimensional object attributes for each individual time slice of the 3D forecast and observation objects.
- The ASCII files ending with **_single_simple.txt** and **_single_cluster.txt** contain 3D space-time attributes for simple and cluster objects, respectively.
- The ASCII files ending with **_pair_simple.txt** and **_pair_cluster.txt** contain 3D space-time attributes for pairs of simple and cluster objects, respectively.

Use the ***ncview*** utility to view the NetCDF object output of MTD:

```
ncview mtd_20050807_030000V_obj.nc &
```

Select the variable named **fcst_raw** and click the **time** index to advance through the timesteps. Now, do the same for the **fcst_object_id** variable. Notice that the objects are defined in the active areas in the raw fields. Also notice some features merging (i.e. combining) as time passes while other features split (i.e. break apart). While they may be disconnected at a particular timestep, they remain part of the same space-time object.

Next, explore the ASCII output files and pay close attention to the header columns. Notice the generalization of the 2D MODE object attributes to 3 dimensions. Area measure becomes volume. MTD measures the object speed. Each object has a beginning and ending time.

cindyhg Tue, 06/25/2019 - 08:17

Use Case: MTD

Use Case: MTD

METplus Use Case: MTD

Reference Material

The MTD (Mode Time Domain) use case utilizes the MET *MTD* tools.

Optional: Refer to the MET Users Guide for a description of the MET tools used in this use case.
Optional: Refer to the **A-Z Config Glossary** section of the METplus Users Guide for a reference to METplus variables used in this use case.

Review Use Case Configuration File: MTD.conf

Open the file and look at all of the configuration variables that are defined.

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MTD/MTD.conf
```

Note that there are options to specify to run the tool with one file or two, depending on the science question being answered, as well configuration options for the settings regularly adjusted by users. For example:

```
MTD_SINGLE_RUN = False
MTD_SINGLE_DATA_SRC = OBS
FCST_MTD_CONV_RADIUS = 0
FCST_MTD_CONV_THRESH = >=10
OBS_MTD_CONV_RADIUS = 15
OBS_MTD_CONV_THRESH = >=1.0
```

Also note that there is a configuration option to run MTD variables in MTD.conf reference other config variables that have been defined in other configuration files. For example:

```
OBS_MTD_INPUT_DIR = {INPUT_BASE}/met_test/new
```

This references **INPUT_BASE** which is set in the METplus data configuration file (**metplus_config/metplus_data.conf**). METplus config variables can reference other config variables even if they are defined in a config file that is read afterwards.

Run METplus

Change to the $METPLUS_TUTORIAL_DIR directory

```
cd ${METPLUS_TUTORIAL_DIR}
```

Run the following command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MTD/MTD.conf
```

METplus is finished running when control returns to your terminal console and you see the following text:

INFO: METplus has successfully finished running.

Review the Output Files

You should have output files including the following:

```
ls ${METPLUS_TUTORIAL_DIR}/output/mtd/2005080712
```

- mtd_WRF_APCP_vs_MC_PCP_APCP_03_A03_20050807_060000V_2d.txt
- mtd_WRF_APCP_vs_MC_PCP_APCP_03_A03_20050807_060000V_3d_single_simple.txt
- mtd_WRF_APCP_vs_MC_PCP_APCP_03_A03_20050807_060000V_obj.nc

Take a look at some of the files to see what was generated.

Open the output NetCDF file with ncview to look at the data:

```
ncview ${METPLUS_TUTORIAL_DIR}/output/mtd/2005080712/mtd_WRF_APCP_vs_MC_PCP_APCP_03_A03_20050807_060000V_obj.nc
```

Click on the buttons in the Var: section (i.e. fcst_raw) to view the fields.

Open an output text file to view the contents:

```
less ${METPLUS_TUTORIAL_DIR}/output/mtd/2005080712/mtd_WRF_APCP_vs_MC_PCP_APCP_03_A03_20050807_060000V_3d_single_simple.txt
```

Review the Log Files

Log files for this run are found in **${METPLUS_TUTORIAL_DIR}/output/mtd/logs**. The filename contains a timestamp of the current year, month, day, hour, minute, and second.

```
ls ${METPLUS_TUTORIAL_DIR}/output/logs/master_metplus.log.*
```

NOTE: If you ran METplus on a different day than today, the log file will correspond to the day you ran.

Review the Final Configuration File

The final configuration file is **metplus_final.conf**. This contains all of the configuration variables used in the run.

```
less ${METPLUS_TUTORIAL_DIR}/output/metplus_final.conf
```

cindyhg Tue, 06/25/2019 - 08:20

Additional Exercises

Additional Exercises

End of Practical Session 4

Congratulations! You have completed Session 4!

If you have extra time, you may want to try these additional METplus exercises.

EXERCISE 4.1: Change Forecast Lead List to Using Intervals

Instructions: Modify the METplus configuration files to change the forecast leads that are processed by MTD. Following these instructions will give you more insight on how METplus configures MTD.

To do this, copy your MTD configuration file and rename it to mtd.skip.conf for this exercise.

```
cp \
${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MTD/MTD.conf \
$METPLUS_TUTORIAL_DIR/user_config/mtd.skip.conf
```

Open mtd.skip.conf with an editor to change forecast lead values and add an additional lead time.

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/mtd.skip.conf
```

Change LEAD_SEQ to process the same forecasts but using an increment rather than listing the explicit values

```
LEAD_SEQ = begin_end_incr(6, 15, 3)
```

Close the file and rerun master_metplus passing in your new custom config file for this exercise and changing **OUTPUT_BASE** to a new location so you can keep it separate from the other runs.

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/mtd.skip.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/exercises/mtd_skip
```

Did you see the WARNING message?

```
WARNING: Could not find OBS file /d1/projects/METplus/METplus_Data/met_test/new/ST2ml2005080715_A03h.nc using template ST2ml{valid?fmt=%Y%m%d%H}_A03h.nc
```

If you look in the data directories for this run, you will see that while the forecast for the 15 hour lead exists, the observation file does not. METplus will only add items to the MTD lists if both corresponding files are available.

```
ls -1 ${METPLUS_DATA}/met_test/data/sample_fcst/2005080700
ls -1 ${METPLUS_DATA}/met_test/new/ST2*
```

Now look at the file lists that were generated by METplus for MTD

```
less ${METPLUS_TUTORIAL_DIR}/output/exercises/mtd_skip/stage/file_lists/20050807000000_mtd_fcst_APCP.txt
```

```
less ${METPLUS_TUTORIAL_DIR}/output/exercises/mtd_skip/stage/file_lists/20050807000000_mtd_obs_APCP_03.txt
```

Check the log file for any differences from the last run that processed forecast leads 6, 9, and 12 hour.

```
ls ${METPLUS_TUTORIAL_DIR}/output/exercises/mtd_skip/logs/master_metplus.log.*
```

Instructions: Modify the METplus configuration files to change the forecast leads that are processed by MTD. Following these instructions will give you more insight on how METplus configures MTD.

To do this, copy your MTD configuration file and rename it to mtd.unzip.conf for this exercise.

```
cp ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/MTD/MTD.conf ${METPLUS_TUTORIAL_DIR}/user_config/mtd.unzip.conf
```

Open mtd.unzip.conf with an editor and change the LEAD_SEQ to process forecast leads 3 and 6 hours.

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/mtd.unzip.conf
```

```
LEAD_SEQ = 3H, 6H
```

Close the file and rerun master_metplus passing in your new custom config file and **OUTPUT_BASE** for this exercise

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/mtd.unzip.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/exercises/unzip
```

Now look at the file list that were generated by METplus for MTD observation files

```
less ${METPLUS_TUTORIAL_DIR}/output/exercises/unzip/stage/file_lists/20050807000000_mtd_obs_APCP_03.txt
```

Notice that the path of the 3 hour file is under your ${METPLUS_TUTORIAL_DIR}, while the 6 hour file is under ${METPLUS_DATA}. If you look in the data directories for this run, you will see that the 3 hour observation file is gzipped in ${METPLUS_DATA}.

```
ls -1 ${METPLUS_DATA}/met_test/new/ST2*
```

METplus can recognize that files with gz, bzip2, or zip extensions are compressed and will do so automatically, placing the uncompressed file in the staging directory so that METplus doesn't modify any data in the input directory. METplus can be configured to scrub the staging directory after the run completes to save space, or leave the files so that they may be used by subsequent METplus runs without having to uncompress again (See **SCRUB_STAGING_DIR** and **STAGING_DIR** in the METplus User's Guide).

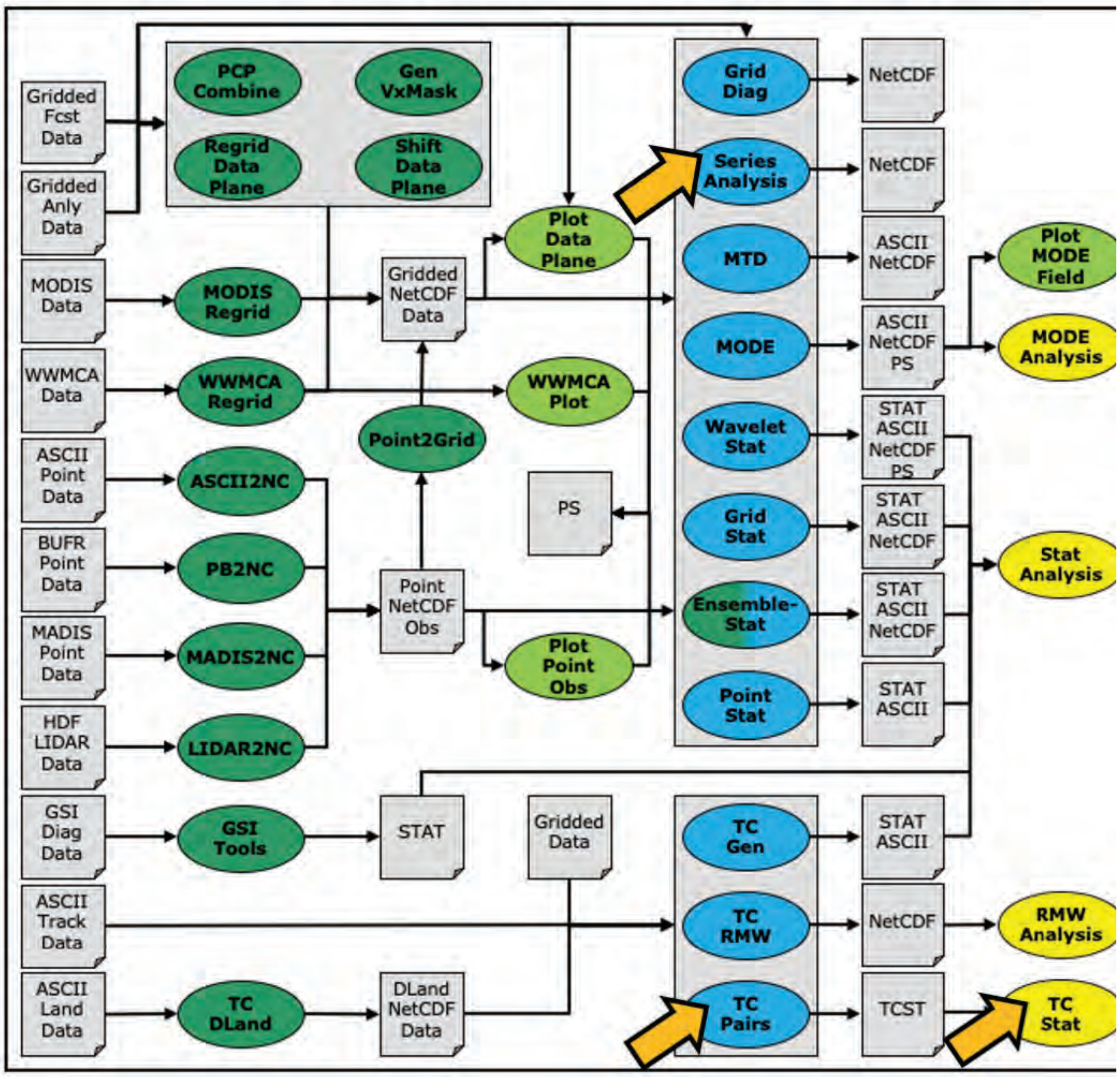
cindyhg Tue, 06/25/2019 - 08:25

Session 5: Trk&Int/Feature Relative

Session 5: Trk&Int/Feature Relative

During this practical session, you will run the tools indicated below:

Practical Session 5 Tools



You may navigate through this tutorial by following the links at the bottom of each page or by using the menu navigation.

Since you already set up your runtime environment in **Session 1**, you **should** be ready to go! To be sure, run through the following instructions to check that your environment is set correctly.

Prerequisites: Verify Environment is Set Correctly

Before running these instructions, you will need to ensure that you have a few environment variables set up correctly. If they are not set correctly, these instructions will not work properly.

1. Check that you have **METPLUS_TUTORIAL_DIR** set correctly:

```
echo ${METPLUS_TUTORIAL_DIR}
```

If you don't see a path in your user directory output to the screen, set this environment variable in your user profile before continuing.

2. Check that you have **METPLUS_BUILD_BASE**, **MET_BUILD_BASE**, and **METPLUS_DATA** set correctly using another option, "printenv":

```
printenv | grep MET
```

If any of these variables are not set, please set them. They will be referenced throughout the tutorial. You can do this by sourcing the appropriate TutorialSetup.[hera/bash/cshrc].sh file, that is:

On **hera**:

```
source /path/to/METplus_Tutorial/TutorialSetup.hera.sh
```

On **linux server (bash)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-bash.sh
```

On **linux server (csh)**:

```
source /path/to/METplus_Tutorial/TutorialSetup.linux-csh.sh
```

where /path/to is the path to your METplus_Tutorial directory.

METPLUS_BUILD_BASE is the full path to the METplus installation (/path/to/METplus-X.Y)
MET_BUILD_BASE is the full path to the MET installation (/path/to/met-X.Y)
METPLUS_DATA is the location of the sample test data directory

3. Check that you have loaded the MET module correctly:

```
which point_stat
```

You should see the usage statement for Point-Stat. The version number listed should correspond to the version listed in **MET_BUILD_BASE**. If it does not, you will need to either reload the met module, or add **${MET_BUILD_BASE}/bin** to your PATH.

4. Check that the correct version of **master_metplus.py** is in your **PATH**:

```
which master_metplus.py
```

If you don't see the full path to script from the shared installation, please set it. It should look the same as the output from this command:

```
echo ${METPLUS_BUILD_BASE}/ush/master_metplus.py
```

See the instructions in Session 1 for more information.

You are now ready to move on to the next section.

admin Wed, 06/12/2019 - 16:59

MET Tool: TC-Pairs

MET Tool: TC-Pairs

TC-Pairs Tool: General

TC-Pairs Functionality

The TC-Pairs tool provides position and intensity information for tropical cyclone forecasts in Automated Tropical Cyclone Forecast System (ATCF) format. Much like the Point-Stat tool, TC-Pairs produces matched pairs of forecast model output and an observation dataset. In the case of TC-Pairs, both the model output and observational dataset (or reference forecast) must be in ATCF format. TC-Pairs produces matched pairs for position errors, as well as wind, sea level pressure, and distance to land values for each input dataset.

TC-Pairs input data format

As mentioned above, the input to TC-Pairs is two ATCF format files, in addition to the **distance_to_land.nc** file generated with the TC-Dland tool. The ATCF file format is a comma-separated ASCII file containing the following fields:

Basin	basin
CY	annual cyclone number (1-99)
YYYYMMDDHH	Date - Time - Group
TECHNUM/MIN	Objective sorting technique number, minutes in Best Track
TECH	acronym for each objective technique
TAU	forecast period
LatN/S	Latitude for the date time group
LonE/W	Longitude for date time group
VMAX	Maximum sustained wind speed
MSLP	Minimum sea level pressure
TY	Highest level of tropical cyclone development
RAD	wind intensity for the radii at 34, 50, 64 kts
WINDCODE	radius code
RAD1	full circle radius of wind intensity, 1st quadrant wind intensity
RAD2	radius of 2nd quadrant wind intensity

RAD4	radius of 4th quadrant wind intensity
...	

These are the first 17 columns in the ATCF file format. MET-TC requires the input file has all 17 comma-separated columns present (although valid data is not required). For a full list of the columns as well as greater detail on the file format, see: http://www.nrlmry.navy.mil/atcf_web/docs/database/new/abdeck.txt

Model data must be run through a vortex tracking algorithm prior to becoming input for MET-TC. Running a vortex tracker is outside the scope of this tutorial, however a freely available and supported vortex tracking software is available at: http://www.dtcenter.org/HurrWRF/users/downloads/index.php

If users choose to use operational model data for input to MET-TC, all U.S. operational model output in ATCF format can be found at: ftp://ftp.nhc.noaa.gov/atcf/archive. Finally, the most common use of MET-TC is to use the best track analysis (used as observations) to generate pairs between the model forecast and the observations. Best track analyses can be found at the same link as the operational model output.

Open files aal112017.dat (model data) and bal112017.dat (BEST track). Take a look at the columns and gain familiarity with ATCF format. These files are input ATCF files for TC-Pairs.

```
vi ${METPLUS_DATA}/met_test/atcf_data/aal182012.dat
```

```
vi ${METPLUS_DATA}/met_test/atcf_data/bal182012.dat
```

In addition to the files above, data from five total storms over hurricane seasons 2011-2012 in the AL basin will be used to run TC-Pairs. Rather than running a single storm, these storms were chosen to provide a larger sample size to provide more robust statistics.

- aal092011: Irene
- aal182011: Rina
- aal052012: Ernesto
- aal092012: Isaac
- aal182012: Sandy

cindyhg Mon, 06/24/2019 - 11:18

TC-Pairs Tool: General

TC-Pairs Tool: General

TC-Pairs Tool: General

TC-Pairs Usage

View the usage statement for TC-Pairs by simply typing the following:

```
tc_pairs
```

Usage: tc_pairs

-adeck source	**Input ATCF format track files**
-edeck source	**Input ATCF format ensemble probability files**
-bdeck source	**Input ATCF format observation (or reference forecast) file path/name**
-config file	**Configuration file**
[-out_base]	path of output file base
[-log_file]	name of log associated with tc_pairs output
[-v level]	Level of logging (optional)

At a minimum, the input ATCF format **-adeck (or -edeck) source**, the input ATCF format **-bdeck source**, and the configuration **-config file** must be passed in on the command line.

The -adeck, -edeck, and -edeck options can be set to either a specific file name or a top-level directory which will be searched for files ending in ".dat".

cindyhg Mon, 06/24/2019 - 11:56

TC-Pairs Tool: Configure

TC-Pairs Tool: Configure

TC-Pairs Tool: Configure

Start by making an output directory for TC-Pairs and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/tc_pairs
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/tc_pairs
```

Like the Point-Stat tool, the TC-Pairs tool is controlled by the contents of the configuration file passed to it on the command line. The default TC-Pairs configuration file may be found in the **data/config/TCPairsConfig_default** file.

The configurable items for TC-Pairs are used to specify which data are ingested and how the input data are filtered. The configurable items include specifications for the following:

- All model names to include in matched pairs
- Storms to include in verification: parsed by storm_id, basin, storm_name, cyclone
- Date/Time/Space restrictions: initialization time, valid time, lead time, masking
- User defined consensus forecasts

The first step is to set-up the configuration file. Keep in mind, TC-Pairs should be run with the largest desired sample in mind to minimize re-running this tool! First, make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/TCPairsConfig_default TCPairsConfig_tutorial_run
```

Next, open up the **TCPairsConfig_tutorial_run** file for editing and modify it as follows:

```
vi TCPairsConfig_tutorial_run
```

Set:

```
model = [ "HWRF", "AVNO", "GFDL" ];
basin = [ "AL" ];
```

To identify the models that we want to verify, as well as the basin. The three models identified are all U.S. operational models: HWRF, GFS (AVNO), and GFDL. Any field left blank will assume no restictions.

Set:

```
consensus = [
  {
    name     = "CONS";
    members  = [ "HWRF", "AVNO", "GFDL" ];
    required = [ false, false, false ];
    min_req  = 2;
  }
];
```

To compute a user defined consensus named "CONS". The membership of the consensus are the three listed models, none are required, but 2 must be present to calculate the consensus.

Set:

```
match_points = TRUE;
```

To only keep pairs that are the intersection of the model forecast and observation.

Next, save the **TCPairsConfig_tutorial_run** file and exit the text editor.

This run uses the default distance to land output file. Run ncview to see it:

```
ncview ${MET_BUILD_BASE}/share/met/tc_data/dland_global_tenth_degree.nc &
```

Water points have distance to land values greater than 0 while land points have distances <= 0.

cindyhg Mon, 06/24/2019 - 11:57

TC-Pairs Tool: Run

TC-Pairs Tool: Run

TC-Pairs Tool: Run

Next, run TC-Pairs to compare all three ATCF forecast models specified in configuration file to the ATCF format best track analysis. Run the following command line:

```
tc_pairs \
-adeck ${METPLUS_DATA}/met_test/atcf_data/aal*dat \
-bdeck ${METPLUS_DATA}/met_test/atcf_data/bal*dat \
-config TCPairsConfig_tutorial_run \
-out tc_pairs \
-v 2
```

TC-Pairs is now grabbing the model data we requested in the configuration file, generating the consensus, and performing the additional filtering criteria. It should take approximate 20 seconds to run. You should see several status messages printed to the screen to indicate progress.

There should be an output file "tc_pairs.tcst" in the directory, where .tcst stands for TC statistics. The next page will describe what is in the file.

If you are running many models over many storms/seasons, it is best to run TC-Pairs using a script to call TC-Pairs for each storm. This avoids potential memory issues when parsing very large datasets.

cindyhg Mon, 06/24/2019 - 11:58

TC-Pairs Tool: Output

TC-Pairs Tool: Output

TC-Pairs Tool: Output

The output of TC-Pairs is an ASCII file containing matched pairs for each of the models requested. In this example, the output is written to the **tc_pairs.tcst** file as we requested on the command line. This output file is in TCST format, which is similar to the STAT output from the Point-Stat and Grid-Stat tools. For more header information on the TCST

Remember to configure your text editor to **NOT** use dynamic word wrapping. The files will be much easier to read that way:

- In the **kwrite** editor, select **Settings->Configure Editor**, de-select **Dynamic Word Wrap** and click **OK**.
- In the **vi** editor, type the command **:set nowrap**. To set this as the default behavior, run the following command:

```
echo "set nowrap" >> ~/.exrc
```

Open **tc_pairs.tcst**

```
vi tc_pairs.tcst
```

- Notice this is a simple ASCII file with rows for each matched pair for a single valid time and similar to the MPR line type written by other tools.
- Any field that has **A** in the column name (such as AMAX_WIND, ALAT) indicate the model forecast.
- Any field that has **B** in the column name (such as BMAX_WIND, BLAT) indicate the observation field (Best Track).
- The **TK_ERR, X_ERR, Y_ERR, ALTK_ERR, CRTK_ERR** columns are calculated track error, X component position error, Y component postion error, along track error, and cross track error, respectively.
- Columns 34-63 are the 34-, 50-, and 64-kt wind radii for each quadrant.

cindyhg Mon, 06/24/2019 - 11:59

MET Tool: TC-Stat

MET Tool: TC-Stat

TC-Stat Tool: General

TC-Stat Functionality

The TC-Stat tool reads the **.tcst** output file(s) of the TC-Pairs tool. This tools provides the ability to further filter the TCST output files as well as summarize the statistical information. The TC-Stat tool reads **.tcst** files and runs one or more analysis jobs on the data. TC-Stat can be run by specifying a single job on the command line or multiple jobs using a configuration file. The TC-Stat tool is very similar to the Stat-Analysis tool. The two analysis job types are summarized below:

- The **filter** job simply filters out lines from one or more TCST files that meet the filtering options specified.
- The **summary** job operates on one column of data from TCST file. It produces summary information for that column of data: mean, standard deviation, min, max, and the 10th, 25th, 50th, 75th, and 90th percentiles, independence time, and frequency of superior performance.
- The **rirw** job identifies rapid intensification or weakening events in the forecast and analysis tracks and applies categorical verification methods.
- The **probrirw** job applies probabilistic verification methods to evaluate probability of rapid inensification forecasts found in edeck's.

TC-Stat Usage

View the usage statement for TC-Stat by simply typing the following:

```
tc_stat
```

Usage:
tc_stat

-lookin path	**TCST file or top-level directory containing TCST files (where TC-Pairs output resides). It allows the use of wildcards (at least one tcst file is required).**
[-out file]	Output path or specific filename to which output should be written rather than the screen (optional).
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging
[-config config_file] | [*JOB COMMAND LINE*] (Note: "|" means "or")	
[-config config_file]	***TCStat config file containing TC-Stat jobs to be run.***
[JOB COMMAND LINE]	***Arguments necessary to perform a TC-Stat job.***

At a minimum, you must specify at least one directory or file in which to find TCST data (using the **-lookin path** command line option) and either a configuration file (using the **-config config_file** command line option) or a job command on the command line.

cindyhg Mon, 06/24/2019 - 12:01

TC-Stat Tool: Configure

TC-Stat Tool: Configure

TC-Stat Tool: Configure

Start by making an output directory for TC-Stat and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/tc_stat
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/tc_stat
```

The behavior of TC-Stat is controlled by the contents of the configuration file or the job command passed to it on the command line. The default TC-Stat configuration may be found in the **data/config/TCStatConfig_default** file. Make a copy of the default configuration file and make following modifications:

```
cp ${MET_BUILD_BASE}/share/met/config/TCStatConfig_default TCStatConfig_tutorial
```

Open up the **TCStatConfig_tutorial** file for editing with your preferred text editor.

```
vi TCStatConfig_tutorial
```

```
amodel = [ "HWRF", "GFDL" ];
bmodel = [ "BEST" ];
event_equal = TRUE;
```

To only parse over two of the three model names in the **tc_pairs.tcst** file. The **event_equal=TRUE** flag will keep pairs for specified forecast valid and lead times that are only in both HWRF and GFDL pairs.

Many of the filter options are left blank, indicating TC-Stat should parse over all available fields. You will notice many more available filter options beyond what was available with the TCPairsConfig.

Now, scroll all the way to the bottom of the TCStatConfig, and you will find the **jobs[]** section. Edit this section as follows, then save and close the editor:

```
jobs = [ "-job filter -dump_row tc_stat.tcst" ];
```

cindyhg Mon, 06/24/2019 - 12:02

TC-Stat: Run on TC-Pairs output

TC-Stat: Run on TC-Pairs output

TC-Stat: Run on TC-Pairs output

Run the TC-Stat using the following command:

```
tc_stat \
-lookin ../tc_pairs/tc_pairs.tcst \
-config TCStatConfig_tutorial -v 3
```

Open the output file **tc_stat.tcst**. We can see that this filter job simply event equalized the two models specified in **amodel**.

```
vi tc_stat.tcst
```

Let's try to filter further, this time using the command line rather than the configuration file:

```
tc_stat \
-job filter -lookin ../tc_pairs/tc_pairs.tcst \
-dump_row tc_stat2.tcst \
-water_only TRUE \
-column_str LEVEL HU,TS,TD,SS,SD \
-event_equal TRUE \
-match_points TRUE -v 3
```

Here, we ran a filter job at the command line: only keeping tracks over water (not encountering land) and with categories Hurricane (HU), Tropical Storm (TS), Tropical Depression (TD), Subtropical Storm (SS), and Subtropical Depression (SD).

Open the output file **tc_stat2.tcst**: notice fewer lines have been kept. Look at the "LEVEL" column ... note all the non-tropical and subtropical level classifications have been filtered out of the sample.

```
vi tc_stat2.tcst
```

Also, find the columns **ADLAND** and **BDLAND**. All these values are now positive, meaning the tracks over land (negative values) have been filtered.

With the filtering jobs mastered, lets give the second type of job - summary jobs - a try!

cindyhg Mon, 06/24/2019 - 12:03

TC-Stat: Run on TC-Pairs output

TC-Stat: Run on TC-Pairs output

TC-Stat: Run on TC-Pairs output

Now, we will run a summary job using TC-Stat on the command line using the following command:

```
tc_stat \
-job summary -lookin ../tc_pairs/tc_pairs.tcst \
-amodel HWRF,GFDL \
-by LEAD,AMODEL \
-column TK_ERR \
-event_equal TRUE \
-out tc_stat_summary.tcst
```

Open up the file **tc_stat_summary.tcst**. Notice this output is much different from the filter jobs.

```
vi tc_stat_summary.tcst
```

The track data is event equalized for the HWRF and GFDL models, and summary statistics are produced for the TK_ERR column for each model by lead time.

cindyhg Mon, 06/24/2019 - 12:03

TC-Stat: Plotting with R

TC-Stat: Plotting with R

In this section, you will use the R statistics software package to produce a plot of a few results. **R** was introduced in practical session 1.

The MET release includes a number of plotting tools for TC graphics. All of the Rscripts are included with the MET distribution in the **Rscripts** directory. The script for TC graphics is **plot_tcmpr.R**, which uses the TCST output files from TC-Pairs as input. At this time, there are two additional environment variables that need to be set to make this work. They are **MET_INSTALL_DIR** and **MET_BASE**. To get the usage statement, type:

For Bash:

```
export MET_INSTALL_DIR=${MET_BUILD_BASE}
export MET_BASE=${MET_INSTALL_DIR}/share/met
Rscript ${MET_BASE}/Rscripts/plot_tcmpr.R
```

For C-shell:

```
setenv MET_INSTALL_DIR ${MET_BUILD_BASE}
setenv MET_BASE ${MET_INSTALL_DIR}/share/met
Rscript ${MET_BASE}/Rscripts/plot_tcmpr.R
```

The TC-Stat tool can be called from the Rscript to do additional filter jobs on the TCST output from TC-Pairs. This can be done on the command line by calling a filter job (following tc-stat), or a configuraton file can be used to select filtering criteria. A default configuration file can be found in **Rscripts/include/plot_tcmpr_config_default.R**.

The configuration file also includes various plot types to generate: MEAN, MEDIAN, SCATTER, REFPERF, BOXPLOT, and RANK. All of the plot commands can be called on the command line as well as with the configuration file. Plots are configurable (title, colors, axis labels, etc) either by modifying the configuration file or setting options on the command line. To run from the command line:

```
Rscript ${MET_BASE}/Rscripts/plot_tcmpr.R \
-lookin ../tc_pairs/tc_pairs.tcst \
-filter "-amodel HWRF,CONS" \
-dep "TK_ERR" \
-series AMODEL HWRF,CONS \
-plot MEAN,BOXPLOT,RANK \
-outdir .
```

This plots the track error for two models: HWRF and CONS. CONS is the user defined consensus you generated in TC-Pairs.

Next, open up the output *png files:

```
display TK_ERR_boxplot.png &
display TK_ERR_mean.png &
display TK_ERR_rank.png &
```

The script produces the three plot types called in the configuration file:

1. Boxplot showing distribution of errors for a homogeneous sample of the two models (TK_ERR_boxplot.png).
2. Mean Errors with 95% CI for the same sample (TK_ERR_mean.png).
3. Rank plot indicating performance of HWRF model relative to CONS (TK_ERR_rank.png).

cindyhg Mon, 06/24/2019 - 12:03

Use Case: Track and Intensity

Use Case: Track and Intensity

METplus Use Case: Track and Intensity TCMPR (Tropical Cyclone Matched Pair) Plotter

This is a wrapper to the MET plot_tcmpr.R Rscript.

Setup

Create Custom Configuration File

Change to the METplus Tutorial Directory:

```
cd ${METPLUS_TUTORIAL_DIR}
```

Define a unique directory under output that you will use for this use case. Create a configuration file to override **OUTPUT_BASE** to that directory.

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/track_and_intensity.output.conf
```

Set **OUTPUT_BASE** to contain a subdirectory specific to the Track and Intensity use case. Make sure to put it under the **[dir]** section.

```
[dir]
OUTPUT_BASE = {ENV[METPLUS_TUTORIAL_DIR]}/output/track_and_intensity
```

Using this custom configuration file and the Track and Intensity use case configuration files that are distributed with METplus, you should be able to run the use case using the sample input data set without any other changes.

Review: Take a look at the following settings.

Rscript and changes the default and reduces the image size. It is a simple one line file, but go and take a look.

```
less ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/TCMPRPlotter/TCMPRPlotter.conf
```

The plot_tcmpr.R script knows to read this **TCMPRPlotterConfig_Customize** R config file since it is defined in the **TCMPRPlotter.conf** file.

```
TCMPR_PLOTTER_CONFIG_FILE = {PARM_BASE}/use_cases/met_tool_wrapper/TCMPRPlotter/TCMPRPlotterConfig_Customize
```

Note: If you modify the **TCMPR_PLOTTER_CONFIG_FILE** variable and leave it undefined (not set), then no configuration file will be read by the R script and the default setting of img_res=300 will be used.

These are some common settings for the track and intensity use case. These have already been defined in the **track_and_intensity.output.conf** file. If desired or needed, these can be overridden in this track and intensity use case conf files

```
TCMPR_PLOT_OUT_DIR - directory where the final plots will be stored.
TCMPR_DATA - the path to the input data, in this example, we are using the data in the TC_PAIRS_DIR directory.
MODEL_DATA_DIR - path to the METplus input data.
TRACK_DATA_DIR - path to the METplus input data.
```

Optional, Refer to the **TC-Stat tool example** section of the **MET Users Guide** for a description of plot_tcmpr.R
If you wish, refer to **Table 19.2** Format Information for TCMPR output line type, for a tabular description of the TC-Pairs output TCST format. After running this Track and Intensity example, you can view the TC-Pairs TCST output files generate by this example under your **${METPLUS_TUTORIAL_DIR}/output/track_and_intensity/tc_pairs** directory while comparing to the information in the table.

The tcmpr defaults are used for any conf settings left as, unset, For example as: XLAB =
The current settings in the conf files are ok and no changes are required. However, after running the exercise feel free to experiment with these settings.

The R script that Track and Intensity runs is located in the MET installation; **share/met/Rscripts/plot_tcmpr.R**. The usage statement with a short description of the options for **plot_tcmpr.R** can be obtained by typing: Rscript **plot_tcmpr.R** with no additional arguments. The usage statement can be helpful when setting some of the option in METplus, below is a description of these settings.

- CONFIG_FILE is a plotting configuration file
  PREFIX is the output file name prefix.
  TITLE overrides the default plot title. Bug: **CAN_NOT_HAVE_SPACES**
  SUBTITLE overrides the default plot subtitle.
  XLAB overrides the default plot x-axis label.
  YLAB overrides the default plot y-axis label.
  XLIM is the min,max bounds for plotting the X-axis.
  YLIM is the min,max bounds for plotting the Y-axis.
  FILTER is a list of filtering options for the tc_stat tool.
  FILTERED_TCST_DATA_FILE is a tcst data file to be used instead of running the tc_stat tool.
  DEP_VARS is a comma-separated list of dependent variable columns to plot.
  SCATTER_X is a comma-separated list of x-axis variable columns to plot.
  SCATTER_Y is a comma-separated list of y-axis variable columns to plot.
  SKILL_REF is the identifier for the skill score reference.
  LEGEND is a comma-separted list of strings to be used in the legend.
  LEAD is a comma-separted list of lead times (h) to be plotted.
  RP_DIFF is a comma-separated list of thresholds to specify meaningful differences for the relative performance plot.
  DEMO_YR is the demo year
  HFIP_BASELINE is a string indicating whether to add the HFIP baseline and which version (no, 0, 5, 10 year goal)
  FOOTNOTE_FLAG to disable footnote (date).
  PLOT_CONFIG_OPTS to read model-specific plotting options from a configuration file.
  SAVE_DATA to save the filtered track data to a file instead of deleting it.
  PLOT_TYPES

  - is a comma-separated list of plot types to create:
    BOXPLOT, POINT, MEAN, MEDIAN, RELPERF, RANK, SKILL_MN, SKILL_MD
    -for this example, set to MEAN,MEDIAN to generate MEAN and MEDIAN plots.

  SERIES

  - is the column whose unique values define the series on the plot,
    optionally followed by a comma-separated list of values, including:
    ALL, OTHER, and colon-separated groups.

  SERIES_CI

  - is a list of true/false for confidence intervals.
    optionally followed by a comma-separated list of values, including:
    ALL, OTHER, and colon-separated groups.

Run METplus: Run Track and Intensity use case.

Examples: **Run the track and intensity plotting script**
Generates plots using the MET **plot_tcmpr.R** Rscript.

Example 1:
In this case, the **track_and_intensity.output.conf** file PLOT_TYPES is left unset, so the default MEAN and MEDIAN will be generated.
Run the following command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/TCMPRPlotter/TCMPRPlotter.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/track_and_intensity.output.conf
```

The following directory lists the files generated from running these use cases:

```
AMAX_WIND-BMAX_WIND_boxplot.log AMAX_WIND-BMAX_WIND_boxplot.png
AMAX_WIND-BMAX_WIND_mean.png
AMAX_WIND-BMAX_WIND_median.png
AMSLP-BMSLP_mean.png
AMSLP-BMSLP_median.png
TK_ERR_mean.png
TK_ERR_median.png
```

Example 2:
In this case, add the following to your user_config track_and_intensity.output.conf file

```
vi ${METPLUS_TUTORIAL_DIR}/user_config/track_and_intensity.output.conf
```

```
[config]
TCMPR_PLOTTER_PLOT_TYPES = BOXPLOT
```

Close the file and rerun the master_metplus.py command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c ${METPLUS_BUILD_BASE}/parm/use_cases/met_tool_wrapper/TCMPRPlotter/TCMPRPlotter.conf \
-c ${METPLUS_TUTORIAL_DIR}/user_config/track_and_intensity.output.conf
```

The following directory lists the additional files generated from running this use case:

```
ls ${METPLUS_TUTORIAL_DIR}/output/track_and_intensity/tcmpr_plots
```

```
AMAX_WIND-BMAX_WIND_boxplot.log
AMAX_WIND-BMAX_WIND_boxplot.png
AMSLP-BMSLP_boxplot.log
AMSLP-BMSLP_boxplot.png
TK_ERR_boxplot.log
TK_ERR_boxplot.png
```

To view the png images generated by running these examples, use the **display** command.
cd to your OUTPUT_BASE/tcmpr_plots directory.

```
cd ${METPLUS_TUTORIAL_DIR}/output/track_and_intensity/tcmpr_plots
display AMAX_WIND-BMAX_WIND_mean.png &
display AMAX_WIND-BMAX_WIND_median.png &
display AMAX_WIND-BMAX_WIND_boxplot.png &
```

cindyhg Mon, 06/24/2019 - 14:24

MET Tool: Series-Analysis

MET Tool: Series-Analysis

Series-Analysis Tool: General

Series-Analysis Functionality

The Series-Analysis Tool accumulates statistics separately for each horizontal grid location over a series. Usually, the series is defined as a time series, however any type of series is possible, including a series of vertical levels. This differs from the Grid-Stat tool in that Grid-Stat computes statistics aggregated over a spatial masking region at a single point in time. The Series-Analysis Tool computes statistics for each individual grid point and can be used to quantify how the model performance varies over the domain.

Series-Analysis Usage

View the usage statement for Series-Analysis by simply typing the following:

```
series_analysis
```

Usage: series_analysis

-fcst file_1 ... file_n	**Gridded forecast files or ASCII file containing a list of file names.**
-obs file_1 ... file_n	**Gridded observation files or ASCII file containing a list of file names.**
[-both file_1 ... file_n]	**Sets the -fcst and -obs options to the same list of files (e.g. the NetCDF matched pairs files from Grid-Stat).**
[-paired]	**Indicates that the -fcst and -obs file lists are already matched up (i.e. the n-th forecast file matches the n-th observation file).**
-out file	**NetCDF output file name for the computed statistics.**
-config file	**SeriesAnalysisConfig file containing the desired configuration settings.**
[-log file]	Outputs log messages to the specified file
[-v level]	Level of logging (optional).
[-compress level]	NetCDF compression level (optional).

At a minimum, the **-fcst**, **-obs** (or **-both**), **-out**, and **-config** settings must be passed in on the command line. All forecast and observation fields must be interpolated to a common grid prior to running Series-Analysis.

cindyhg Mon, 06/24/2019 - 14:28

Series-Analysis Tool: Configure

Start by making an output directory for Series-Analysis and changing directories:

```
mkdir -p ${METPLUS_TUTORIAL_DIR}/output/met_output/series_analysis
cd ${METPLUS_TUTORIAL_DIR}/output/met_output/series_analysis
```

The behavior of Series-Analysis is controlled by the contents of the configuration file passed to it on the command line. The default Series-Analysis configuration file may be found in the **data/config/SeriesAnalysisConfig_default** file. Prior to modifying the configuration file, users are advised to make a copy of the default:

```
cp ${MET_BUILD_BASE}/share/met/config/SeriesAnalysisConfig_default SeriesAnalysisConfig_tutorial
```

The configurable items for Series-Analysis are used to specify how the verification is to be performed. The configurable items include specifications for the following:

- The forecast fields to be verified at the specified vertical level or accumulation interval.
- The threshold values to be applied.
- The area over which to limit the computation of statistics - as predefined grids or configurable lat/lon polylines.
- The confidence interval methods to be used.
- The smoothing methods to be applied.
- The types of statistics to be computed.

You may find a complete description of the configurable items in section 13.2.3 of the MET User's Guide. Please take some time to review them.

For this tutorial, we'll run Series-Analysis to verify a time series of 3-hour accumulated precipitation. We'll use GRIB1 for the forecast files and NetCDF for the observation files. Since the forecast and observations are different file formats, we'll specify the **name** and **level** information for them slightly differently.

Open up the **SeriesAnalysisConfig_tutorial** file for editing with your preferred text editor and edit it as follows:

```
vi SeriesAnalysisConfig_tutorial
```

- Set the **fcst** dictionary to

  ```
  fcst = {
    field = [
      {
        name  = "APCP";
        level = [ "A3" ];
      }
    ];
  }
  ```

  To request the GRIB abbreviation for precipitation (**APCP**) accumulated over 3 hours (**A3**).

- Delete **obs = fcst;** and insert

  ```
  obs = {
    field = [
      {
        name  = "APCP_03";
        level = [ "(*,*)" ];
      }
    ];
  }
  ```

  To request the NetCDF variable named **APCP_03** where its two dimensions are the gridded dimensions **(*,*)**.

- Look up a few lines above the **fcst** dictionary and set

  ```
  cat_thresh = [ >0.0, >=5.0 ];
  ```

  To define the categorical thresholds of interest. By defining this at the top level of config file context, these thresholds will be applied to both the **fcst** and **obs** settings.

- In the **mask** dictionary, set

  ```
  grid = "G212";
  ```

  To limit the computation of statistics to only those grid points falling inside the NCEP Grid 212 domain.

- Set

  ```
  block_size = 10000;
  ```

  To process 10,000 grid points in each pass through the data. Setting **block_size** larger should make the tool run faster but use more memory.

- In the **output_stats** dictionary, set

  ```
    fho    = [ "F_RATE", "O_RATE" ];
    ctc    = [ "FY_OY", "FN_ON" ];
    cts    = [ "CSI", "GSS" ];
    mctc   = [];
    mcts   = [];
  ```

```
    pct    = [];
    pstd   = [];
    pjc    = [];
    prc    = [];
```

For each line type, you can select statistics to be computed at each grid point over the series. These are the column names from those line types. Here, we select the forecast rate (FHO: F_RATE), observation rate (FHO: O_RATE), number of forecast yes and observation yes (CTC: FY_OY), number of forecast no and observation no (CTC: FN_ON), critical success index (CTS: CSI), and the Gilbert Skill Score (CTS: GSS) for each threshold, along with the root mean squared error (CNT: RMSE).

Save and close this file.

johnhg Thu, 07/25/2019 - 23:03

Series-Analysis Tool: Run

Series-Analysis Tool: Run

Series-Analysis Tool: Run

First, we need to prepare our observations by putting 1-hourly StageII precipitation forecasts into 3-hourly buckets. We already ran PCP-Combine prior to running MTD to prepare this data. Check that the 8 expected NetCDF files exist:

```
ls ../mtd/sample_obs/ST2ml_3h
```

If they do, copy that directory over to the current working directory:

```
cp -r ../mtd/sample_obs .
```

If they do not, go back and run the PCP-Combine commands listed here.

Note that the previous set of PCP-Combine commands could easily be run by looping through times in a shell script or through a METplus use case! The MET tools are often run using a scripting language rather than typing individual commands by hand. You'll learn more about automation using the METplus python scripts.

Next, we'll run Series-Analysis using the following command:

```
series_analysis \
-fcst ${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_03.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_06.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_09.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_12.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_15.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_18.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_21.tm00_G212 \
${METPLUS_DATA}/met_test/data/sample_fcst/2005080700/wrfprs_ruc13_24.tm00_G212 \
-obs sample_obs/ST2ml_3h/sample_obs_2005080703V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080706V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080709V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080712V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080715V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080718V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080721V_03A.nc \
sample_obs/ST2ml_3h/sample_obs_2005080800V_03A.nc \
-out series_analysis_2005080700_2005080800_3A.nc \
-config SeriesAnalysisConfig_tutorial \
-v 2
```

The statistics we requested in the configuration file will be computed separately for each grid location and accumulated over a time series of eight three-hour accumulations over a 24-hour period. Each grid point will have up to 8 matched pair values.

Note how long this command line is. Imagine how long it would be for a series of 100 files! Instead of listing all of the input files on the command line, you can list them in an ASCII file and pass that to Series-Analysis using the **-fcst** and **-obs** options.

johnhg Fri, 07/26/2019 - 11:44

Series-Analysis Tool: Output

Series-Analysis Tool: Output

Series-Analysis Tool: Output

The output of Series-Analysis is one NetCDF file containing the requested output statistics for each grid location on the same grid as the input files.

You may view the output NetCDF file that Series-Analysis wrote using the **ncdump** utility. Run the following command to view the header of the NetCDF output file:

```
ncdump -h series_analysis_2005080700_2005080800_3A.nc
```

In the NetCDF header, we see that the file contains many arrays of data. For each threshold (>0.0 and >=5.0), there are values for the requested statistics: F_RATE, O_RATE, FY_OY, FN_ON, CSI, and GSS. The file also contains the requested RMSE and TOTAL number of matched pairs for each grid location over the 24-hour period.

Next, run the **ncview** utility to display the contents of the NetCDF output file:

Click through the different variables to see how the performance varies over the domain. Looking at the **series_cnt_RMSE**variable, are the errors larger in the south eastern or north western regions of the United States?

Why does the extent of missing data increase for CSI for the higher threshold? Compare **series_cts_CSI_gt0.0** to **series_cts_CSI_ge5.0**. (*Hint: Find the definition of CSI in Appendix C of the* MET User's Guide *and look closely at the denominator.*)

Try running Plot-Data-Plane to visualize the observation rate variable for non-zero precipitation (i.e. **series_fho_O_RATE_gt0.0**). Since the valid range of values for this data is 0 to 1, use that to set the **-plot_range** option.

Setting **block_size** to 10000 still required 3 passes through our 185x129 grid (= 23865 grid points). What happens when you increase block_size to 24000 and re-run? Does it run slower or faster?

johnhg Fri, 07/26/2019 - 14:29

Use Case: Feature Relative

Use Case: Feature Relative

METplus Use Case: Feature Relative (Series-Analysis by init)

Setup

In this exercise, you will perform a series analysis based on the init time of your sample data. This use case focuses on using the latitude and longitude pairs for a "feature", such as a tropical cyclone or extra-tropical cyclone, to identify a user specified tile around the feature. The tiles are then used to compute statistics using Series_Analysis. Therefore, this use-case utilizes the MET Tc-Pairs, Tc-Stat, and Series-Analysis tools, and the METplus wrappers: TcPairs, ExtractTiles, TcStat, and SeriesByInit. Please refer to the **MET Users Guide** for a description of the MET tools and the **METplus Users Guide** for more details about the wrappers.

Review Use Case Configuration File: feature_relative.conf

View the file and study the configuration variables that are defined.

```
less
${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/TCStat_SeriesAnalysis_fcstGFS_obsGFS_FeatureRelative_SeriesByIn
it.conf
```

Note the configuration settings for this complex use-case. The **PROCESS_LIST** is calling three wrappers. The **SERIES_ANALYSIS_STAT_LIST** is set to four statistics, but can be set to many more. The size of the tiles are configurable using the **EXTRACT_TILES** settings. Also, note that variables in feature_relative.conf reference other variable you defined in other configuration files. For example:

```
TC_STAT_INPUT_DIR = {OUTPUT_BASE}/tc_pairs
```

This references **OUTPUT_BASE** which you set in the METplus system configuration file (**metplus_config/metplus_system.conf**). METplus config variables can reference other config variables, even if they are defined in a config file that is read afterwards.

Run METplus

Change to the METplus Tutorial Directory:

```
cd ${METPLUS_TUTORIAL_DIR}
```

Run the following command. Use -c dir.OUTPUT_BASE to change the output directory from the command line:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
-c
${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/TCStat_SeriesAnalysis_fcstGFS_obsGFS_FeatureRelative_SeriesByIn
it.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init
```

You will see output streaming to your screen. This may take up to 4 minutes to complete. METplus is finished running when control returns to your terminal console and you see the following text:

```
INFO: METplus has successfully finished running.
```

Review the Output Files

You should have output files in the following directories from the intermediate wrappers TcPairs, ExtractTiles, and TcStat, respectively:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init
```

```
tc_pairs
extract_tiles
series_init_filtered
```

and the output of interest, from the SeriesByInit wrapper:

```
series_analysis_init
```

which has a directory corresponding to the date(s) of data in the data window:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/series_analysis_init
```

and under that directory are subdirectories named by the storm:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/series_analysis_init/20141214_00
```

```
ML1201032014
ML1201042014
```

and under each of those directories lies the files of interest:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/series_analysis_init/20141214_00/ML1201042014
```

```
ANLY_ASCII_FILES_ML1201042014
FCST_ASCII_FILES_ML1201042014
series_TMP_Z2_FBAR.png
series_TMP_Z2_FBAR.ps
series_TMP_Z2_ME.png
series_TMP_Z2_ME.ps
series_TMP_Z2.nc
series_TMP_Z2_OBAR.png
series_TMP_Z2_OBAR.ps
series_TMP_Z2_TOTAL.png
series_TMP_Z2_TOTAL.ps
```

The ANLY_ASCII_FILES_ML########## (where ########## is the storm) is a text file that contains a list of the analysis data included in the series analysis. The FCST_ASCII_FILES_ML########## (where ########## is the storm) is a text file that contains a list of forecast data included in the series analysis.

The .nc files are the series analysis output generated from the MET series_analysis tool.

The .png and .ps files are graphics files that can be viewed using display or ghostview, respectively:

```
display ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/series_analysis_init/20141214_00/ML1201042014/series_TMP_Z2_FBAR.png
&
```

or

```
gv ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/series_analysis_init/20141214_00/ML1201042014/series_TMP_Z2_FBAR.ps &
```

Note: the **&** is used to run this command in the background

Review the Log File

A log file is generated in your logging directory: **${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/logs**. The filename contains the timestamp corresponding to the current day. To view the log file:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/logs/master_metplus.log.*
```

Review the Final Configuration File

The final configuration file is **metplus_final.conf**. This contains all of the configuration variables used in the run.

```
less ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_init/metplus_final.conf
```

cindyhg Mon, 06/24/2019 - 14:34

Use Case: Feature Relative

Use Case: Feature Relative

METplus Use Case: Feature Relative (Series-Analysis by lead, by forecast hour grouping)

Setup

In this exercise, you will perform a series analysis based on the lead time (forecast hour) of your sample data and organize your results by forecast hour groupings. This use case utilizes the MET Tc-Pairs, Tc-Stat, and Series-Analysis tools, and the METplus wrappers: TcPairs, ExtractTiles, TcStat, and SeriesByLead. Please refer to the MET User's Guide for a description of the MET tools and the METplus Users Guide for more details about the wrappers. Please note that the METplus User's Guide is a work-in-progress and may have missing content.

Change to the METplus Tutorial Directory:

```
cd ${METPLUS_TUTORIAL_DIR}
```

Review Use Case Configuration File: series_by_lead_by_fhr_grouping.conf

View the file and study the configuration variables that are defined.

```
less
${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/TCStat_SeriesAnalysis_fcstGFS_obsGFS_FeatureRelative_SeriesByLe
ad.conf
```

Note that the **SERIES_ANALYSIS_GROUP_FCSTS = True** and Lead time groupings are specified by the **LEAD_SEQ** config options.

```
# forecast lead sequence 1 list (0, 6, 12, 18)
LEAD_SEQ_1 = begin_end_incr(0,18,6)
# forecast lead sequence 1 label
LEAD_SEQ_1_LABEL = Day1

# forecast lead sequence 2 list (24, 30, 36, 42)
LEAD_SEQ_2 = begin_end_incr(24,42,6)
# forecast lead sequence 2 label
LEAD_SEQ_2_LABEL = Day2
```

This references **OUTPUT_BASE** which you set in the METplus system configuration file (**metplus_config/metplus_system.conf**). METplus config variables can reference other config variables, even if they are defined in a config file that is read afterwards.

Run METplus

Run the following command:

```
master_metplus.py \
-c ${METPLUS_TUTORIAL_DIR}/tutorial.conf \
${METPLUS_BUILD_BASE}/parm/use_cases/model_applications/medium_range/TCStat_SeriesAnalysis_fcstGFS_obsGFS_FeatureRelative_SeriesByLe
ad.conf \
-c dir.OUTPUT_BASE=${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_lead_fhr_groupings
```

You will see output streaming to your screen. This may take up to 3 minutes to complete. When it is complete, your prompt returns.

If you see an error that references **NCAP2**, this is correctable. **NCAP2** is a netCDF tool that can usually be found in the location where **nco** is installed. Check /usr/local/nco first or with your system administrator if you are having trouble.

```
metplus (config_launcher.py:546) ERROR: Executable NCAP2 does not exist at ncap2
run-METplus-metplus: ERROR: Executable NCAP2 does not exist at ncap2
```

This error can be overcome by adding the path to the executable in your **${METPLUS_TUTORIAL_DIR}/tutorial.conf file**. Add the following and then re-run.

```
[exe]
NCAP2 = /path/to/ncap2
# e.g. NCAP2=/usr/local/nco/bin/ncap2
```

Review the Output Files

You should have output directories including the following that result from running the wrappers TcPairs, ExtractTiles, and TcStat, respectively:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_lead_fhr_groupings
```

```
track_data_atcf
extract_tiles
series_lead_filtered
```

and the output directory of interest, from the SeriesByLead wrapper:

```
series_analysis_lead
```

That directory contains the following directories:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_lead_fhr_groupings/series_analysis_lead
```

```
Day1
Day2
series_animate
```

Day1 contain the following files:

```
ls ${METPLUS_TUTORIAL_DIR}/output/feature_relative_by_lead_fhr_groupings/series_analysis_lead/Day1
```

```
ANLY_FILES_F000_to_F018
series_F000_to_F018_TMP_Z2_ME.png
series_F000_to_F018_TMP_Z2_OBAR.ps
FCST_FILES_F000_to_F018
series_F000_to_F018_TMP_Z2_ME.ps
series_F000_to_F018_TMP_Z2_TOTAL.png
series_F000_to_F018_TMP_Z2_FBAR.png
series_F000_to_F018_TMP_Z2.nc
series_F000_to_F018_TMP_Z2_TOTAL.ps
series_F000_to_F018_TMP_Z2_FBAR.ps
series_F000_to_F018_TMP_Z2_OBAR.png
```

The ANLY_FILES_F000_to_F018 is a text file that contains a list of the data that is included in the series analysis.

Day2 contains equivalent files for forecast leads 24 to 42.

The .nc files are the series analysis output generated from the MET Series-Analysis tool.

The .png and .ps files are graphics files that can be viewed using ImageMagick: