

GIS PMP Tool Documentation

Regional Probable Maximum Precipitation Study for Oklahoma-Arkansas-Louisiana-Mississippi

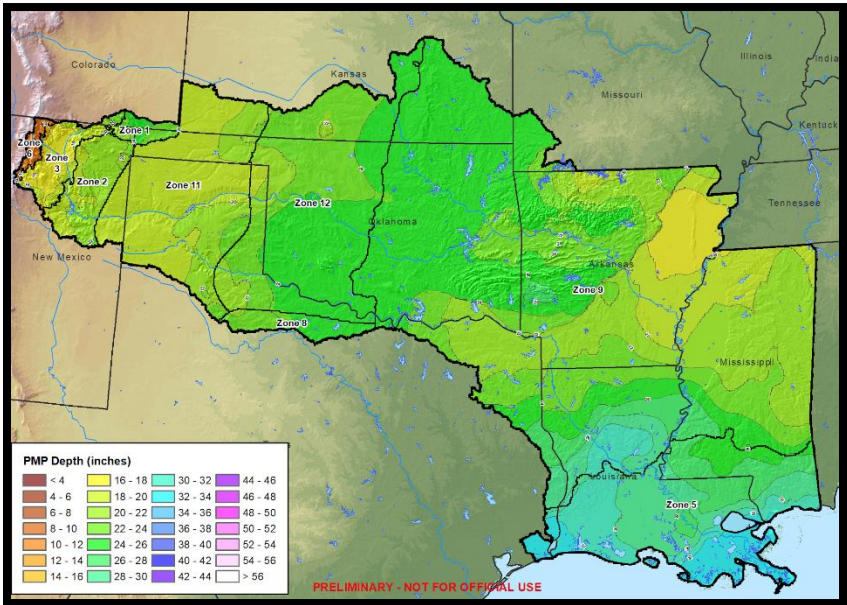


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1. PMP Tool Description and Usage

The PMP Evaluation Tool employed in this study uses a Python-based script designed to run within the ArcGIS environment. ESRI's ArcGIS Desktop Basic software, version 1.4 or later, is required to run the tool, and it is recommended that the user have a basic familiarity with the operation of this software. The tool provides gridded PMP values at a spatial resolution of 90 arc-seconds (equivalent to .025 x .025 decimal degrees) for a user-designated drainage basin or area at user-specified durations, in addition to basin average PMP depths and temporally distributed accumulations.

1.1 File Structure

The tool, source script, and the storm databases are stored within the 'PMP_Evaluation_Tool' project folder. The file and directory structure within the 'PMP_Evaluation_Tool' folder should be maintained as it is provided, as the script will locate various data based on its relative location within the project folder. If the subfolders or geodatabases within are relocated or renamed, then the script must be updated to account for these changes.

The file structure consists of only two subfolders: Input and Script. The 'Input' folder contains all input GIS files (Figure 1.1). There are three ArcGIS file geodatabase containers within the 'Input' folder: DAD_Tables.gdb, Storm_Adj_Factors.gdb, and Non_Storm_Data.gdb. The DAD_Tables.gdb contains the DAD tables (in file geodatabase table format) for each of the SPAS-analyzed storm DAD zones included in the storm database. The Storm_Adj_Factors.gdb contains a feature class for each storm center and stores the adjustment factors for each grid point as a separate feature. These feature classes are organized into feature datasets, according to storm type (General, Local, and Tropical). The storm adjustment factor feature classes share their name with their DAD Table counterpart. The naming convention is SPAS_XXXX_Y, where XXXX is the SPAS storm ID number and Y is the DAD zone number. In the case of a hybrid storm (i.e., a storm that is run as both a general and local storm type), there will be a suffix "_gen" or "_loc" to differentiate the storm type specific to the adjustment factors in the feature class. Finally, the Non_Storm_Data.gdb contains spatial data not directly relating to the input rainfall depth or adjustment factors such as the grid network vector files. The geodatabase also contains the temporal distribution pattern tables and a table and a feature class of the storm center locations.

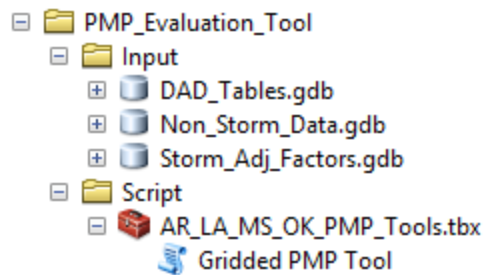


Figure 1.1 - PMP tool file structure.

The 'Script' folder contains an ArcToolbox called PMP_Tools.tbx. The toolbox contains a script tool called 'Gridded PMP Tool' that is used to calculate basin PMP. ArcGIS Desktop should be used for viewing the GIS tool file structure and interacting with the input and output geospatial data and metadata. A typical operating system's file browser does not allow access to the geodatabase containers and cannot be used to directly run the tool.

1.2 Usage

The 'Gridded PMP Tool' tool stored within the PMP_Tools.tbx. ArcToolbox opens and runs the script within the ArcGIS environment and can be run from ArcCatalog an ArcMap map session. In addition to running as a standalone tool, the tool can be incorporated into Model Builder or be called as a sub-function of another script.

To run the tool, the user navigates to the PMP_Tools.tbx toolbox, expands it, and opens the PMP tool. The dialogue window opens and the user populates input parameters (see Figure 1.2) and clicks the 'OK' button. The tool will run in the foreground and display text output in the Messages window. Processing time can vary greatly depending on AOI size, the number of durations selected, and computer hardware. Most basins generally take 5 to 10 minutes to analyze all three storm types. The tool produces PMP output described in Section 1.4.

1.3 Input Parameters

The tool requires twelve parameters as input to define the area and durations to be analyzed (

Table 1.1).

Table 1.1 - Parameters for the PMP calculation tool.

Parameter # (in script)	Display Name	Data Type	Type	Direction	MultiValue
0	Input basin outline shapefile or feature class	Feature Layer	Required	Input	No
1	Location of "PMP_Evaluation_Tool" Folder	Folder	Required	Input	No
2	Output Folder	Folder	Required	Input	No
3	Local storm durations	String	Optional	Input	Yes
4	General storm durations	String	Optional	Input	Yes
5	Tropical storm durations	String	Optional	Input	Yes
6	Use basin area size for areal average	Boolean	Required	Input	No
7	Area-size to use (sqmi)	Double	Optional	Input	No
8	Apply weighted average to border grid cells	Boolean	Required	Input	No
9	Include sub-basin averages	Boolean	Optional	Input	No
10	Sub-basin field	Field	Optional	Input	No
11	Include depth-duration chart in output	Boolean	Optional	Input	No
12	Apply temporal distributions	Boolean	Optional	Input	No

Figure 1.2 shows the tool dialogue window with each of the input parameters. The first parameter required by the tool dialogue is a feature layer, such as a basin shapefile or feature class, designed to outline the area of interest (AOI) for the PMP analysis. If the AOI dataset does not have a surface projection, the tool will apply the Albers Equal Area projection for the purpose of calculating the AOI area size. If the feature layer has multiple features (or polygons), the tool will use the combined area as the analysis region. Only the selected polygons will be used if the tool is run from the ArcMap environment with selected features highlighted. If the AOI shapefile extends beyond the project analysis domain PMP will only be calculated for grid cells inside the project domain. The AOI shapefile or feature class should not have any spaces or symbol characters in the filename.

The second parameter requires the path of the 'PMP_Evaluation_Tool' folder. The default location of the folder is set within the tool parameters, but it can be changed if the user wishes to link the tool to another set of input datasets. The 'PMP_Evaluation_Tool' project folder should be stored locally at a location that can be accessed (both read/write) by ArcGIS desktop. The user will need to set the 'Output Folder' path which provides the tool with the location to create the output PMP files. The user must have read/write privileges for this folder location. The user then selects the durations to be run for each storm type. The next parameter allows the user may override the default to use the input basin feature area size for areal-average PMP calculations and enter a custom area (in square miles). A manually entered area-size will override the basin area-size in the PMP calculations. Next, the

user has the option to have the tool perform a weighted analysis on the grid cells underlying the AOI boundary. If this option is checked each boundary grid cell depth will be weighted by the portion of the cell's area inside the basin for the purposes of the basin area PMP table calculations. Finally, there is an option to include sub-basin averages. This will calculate an average PMP depth for each feature in the input basin feature class from the overall basin PMP. The average sub-basin depths will be based on the area-size of the overall basin. If the 'weighted' option was selected above it will also be applied to the sub-basin averages. If the AOI has multiple features (or sub-basins) the 'Include sub-basin averages' option can be selected to calculate the basin average PMP over each sub-basin. The user must select a field within the AOI to be used to identify each sub-basin. The field can be of numeric or text data type, but must have a unique ID for each polygon. The user can also choose to include a depth-duration chart .png image in the output folder for each storm type. Finally, the user can select the option to apply the appropriate temporal distribution patterns to the basin average PMP for each storm type. If this option is selected, the above options to select specific durations will no longer be available as the tool will need to run all the durations to properly apply temporal distributions.

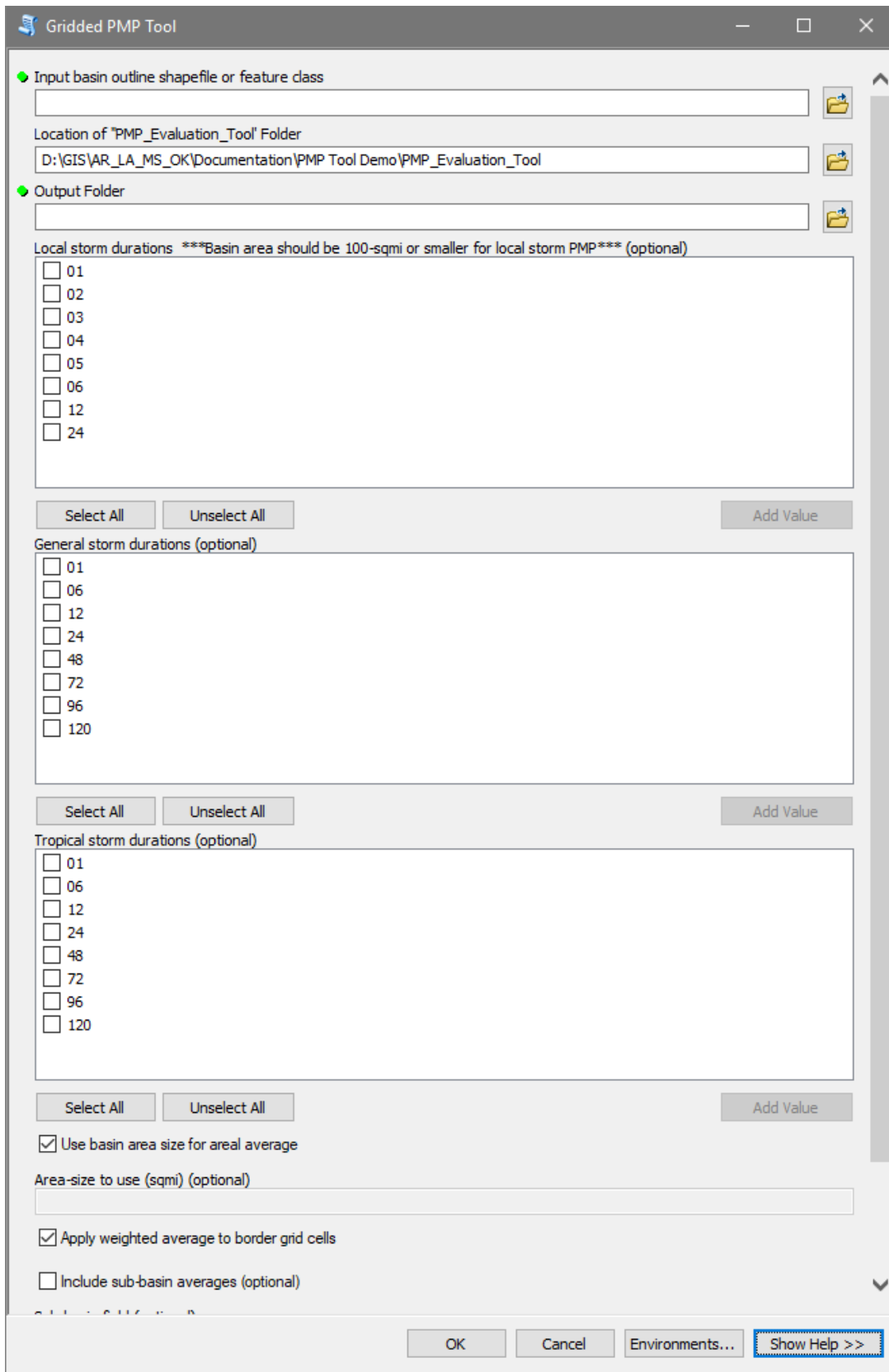


Figure 1.2: The PMP Evaluation Tool input dialogue window

The Validation tab of the tool properties contains some custom scripting to handle the input parameter formatting.

1.4 Tool Output

Once the tool has been run, the output file geodatabases will be populated with the model results. The GIS files can then be brought into an ArcMap, or other compatible GIS environments, for mapping and analysis. The tool is set to have overwrite capabilities; if output data exists, it will be overwritten the next time the tool is run, if the same output folder and same parameters are used.

A separate output folder is created for each storm type and the output is organized within file geodatabases and named according to the input basin feature name and analyzed PMP area. Each output file geodatabase contains a feature class which stores each grid point centroid within the basin as a separate feature. Each feature has a field for the grid ID, latitude, longitude, analysis zone, elevation, PMP (for each duration), and the contributing storm ID. The PMP raster files are also stored within the file geodatabase. The naming convention for the raster files is the storm type and duration (L for local/MCS, G for general, and T for tropical), followed by the input basin feature name, and ending with the basin area (in square miles). An example of the output file structure is shown in Figure 1.3.

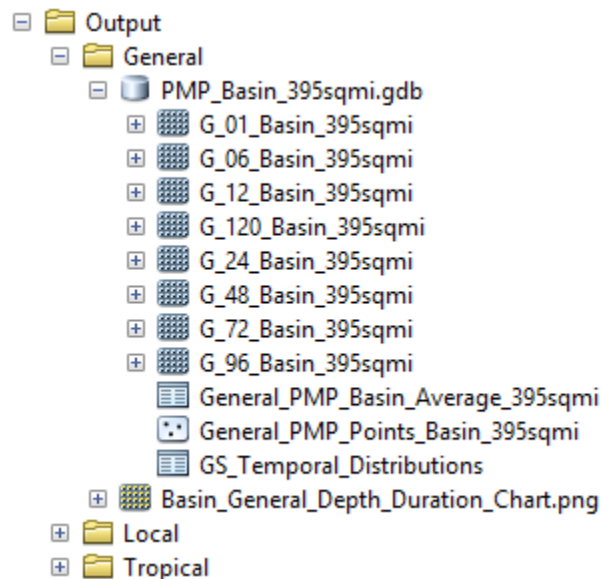


Figure 1.3: Example of the PMP tool output file structure

1.5 Python Script

Due to the large number of storm datasets and grid points within the project domain, a scripted process is well suited for comparing each value efficiently and accurately for a given area of interest and make the necessary calculations. ArcGIS has integrated the Python scripting language to allow for the custom development of geoprocessing operations and toolsets. Python can be used to access the geoprocessing, data management, and looping functionality needed to process the PMP calculations for a basin. The gridded PMP analysis script has been added to an ArcToolbox and can be run as a tool within the ArcGIS environment. The script has been imported and stored internally within the Gridded PMP Tool and all the parameters for the tool have been set. The script can be accessed by exporting it from the tool to a '.py' file. The Python code can be opened and edited within any text editor. A hardcopy version of the code is given in Appendix H.

The python script uses the arcpy, arcpy.analysis, arcpy.management, arcpy.conversion, numpy, pandas, and matplotlib.pyplot modules. Python and these modules are included within the ArcGIS for Desktop package. The script is designed to run as efficiently as possible with a minimal amount of code and complexity. To achieve this, the script is organized into functions that are called as needed. The primary PMP analysis calculations are calculated within the pmpAnalysis() function which is called separately for each PMP storm type analyzed. Within the broader pmpAnalysis() function, several smaller functions are called to perform various tasks:

createPMPfc()	Creates the PMP_Points feature class to store vector (point) results
getAOIarea()	Calculates the area of the input basin
dadLookup()	Gets the DAD value for the current storm based on basin area or AOI defined by the user
updatePMP()	Records the largest adjusted rainfall value (PMP)
outputPMP()	Produces output PMP GIS files and tables
basinAve()	Calculates the basin average PMP
basinZone()	Returns the transposition zone and side of Continental Divide of AOI for the temporal distribution application
temporalDistLS()	Local storm temporal distribution application
temporalDistGS()	General storm temporal distribution application
temporalDistTS()	Tropical storm temporal distribution application

temporalCritStacked() **Critically stacked temporal distribution application**
checkTemporal() **Produces a table evaluating exceedance errors in**
temporally distributed depths at intermediate
durations

There is extensive documentation within the code in the form of ‘# comments’. These comments provide guidance toward its functionality and describe the code.

While the script performs many actions, its primary purpose is to iterate through both the storm list and the grid points within the drainage basin area of interest (AOI), comparing each, and creating output based on the maximum values. To accomplish this, several layers of nested iterative “for” loops are used.

The following high-level algorithm broadly describes the script process:

- Calculate Basin Area (in mi²)
- For each Storm Type (general, tropical, and local)
 - For each duration
 - For each storm in database
 - Lookup storm’s depth-area-duration (DAD) value for AOI size
 - For each grid point in basin
 - Calculate total adjusted rainfall (TAR) by multiplying DAD value by total adjustment factor for the grid point
 - If TAR > PMP, the TAR becomes the new PMP value for that grid point
- Create PMP point feature class for the storm type
- Create PMP raster GRID files for each duration
- Create basin/sub-basin average tables
- Create a depth-duration chart
- Apply temporal distributions
- Check temporal output for exceedance errors

1.6 Known Issues and Troubleshooting

The following guidelines may prevent issues with running the GIS tool.

- Ensure your version of ArcGIS Desktop is version 1.4 (or later) and maintenance is current.
- Ensure all file and path names do not have spaces or non-alphanumeric symbols (e.g. #, \$, %). Underscores are acceptable and a good alternative to using spaces.
- Close any other applications or instances of ArcMap that may interfere with the current session, files, or file paths that will be used by the tool.
- Ensure that the tool folder, output location, and AOI files are all stored locally and not over a network location.

If the points above have been verified and issues persist, the user may try the following actions to address the issue:

- Close out ArcMap session and all open ArcGIS applications and restart session.
- Restart computer. This may be required to completely clear any locks on files or memory.
- Run the Repair Geometry tool on the AOI shapefile or feature class to correct any geometry issues within the file.
- Rename AOI file. Change tool and/or output folder paths.
- If issues persist it may be necessary to contact ESRI support or perform a clean ArcGIS installation or upgrade.