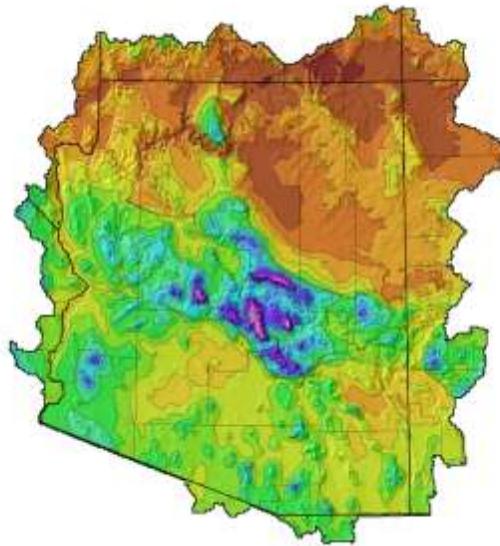




Probable Maximum Precipitation Study for Arizona

PMP Evaluation Tool Description and Usage



Prepared for
Arizona Department of Water Resources
3550 North Central Avenue
Phoenix, AZ 85012
www.azwater.gov

Prepared by
Applied Weather Associates, LLC
PO Box 680
Monument, Co 80132
(719) 488-9117
www.appliedweatherassociates.com

Ed Tomlinson, PhD, Project Manager
Bill Kappel, Senior Meteorologist
Geoff Muhlestein, GIS/Staff Scientist
Douglas Hultstrand, Hydrometeorologist
Tye Parzybok, Senior Meteorologist

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PMP Evaluation Tool Description and Usage

The PMP Evaluation Tool was developed under contract for the Arizona Department of Water Resources (ADWR). The tool is a Python-based script designed to run within the ArcGIS environment. The tool provides gridded PMP values at a spatial resolution of 90 arc-seconds for a user-designated drainage basin or area. PMP values are calculated for local storm types at the 1-, 2-, 3-, 4-, 5-, and 6-hour durations and for tropical and general winter storm types at the 6-, 12-, 18-, 24-, 48-, and 72-hour durations. These gridded PMP values are used to compute a basin average PMP depth for each duration. Each of the gridded values and the basin average are then temporally distributed and exported as GIS files.

As an ArcGIS based tool, much of the terminology used to describe and discuss the PMP Evaluation Tool is unique to the ArcGIS environment. The following definitions are applicable in reference to the PMP Evaluation Tool:

1. **Folder** – A container element designed to group files or other folders (also called a directory).
2. **Datasets**– A collection of data often stored as a raster (GRID), vector (Shapefile or Feature Class), or Table. May or may not have a spatial component.
3. **Geodatabase** – An ArcGIS specific spatial database. The geodatabase is a container used to hold a collection of datasets. Similar to a folder, but specific to the ArcGIS environment. The PMP Evaluation Tool uses File Geodatabases.
4. **GRID** – A raster dataset format (can be either integer or floating point)
5. **Shapefile** – A common vector geospatial dataset format. Contains a collection of shapes, or features. Can be stored within a folder.
6. **Feature Class** - A single collection of geographic features. Similar to a shapefile but specific to the ArcGIS environment. Feature classes must be stored within a Geodatabase or Feature Dataset.
7. **Feature Dataset** – An ArcGIS specific folder used to store a collection of feature classes with the same spatial reference and extent. Must be stored within a geodatabase.
8. **Metadata** – Information describing a dataset. The databases use the FGDC metadata format. Stored in an .xml file sharing the name of the target dataset.
9. **ArcMap** – A visual GIS mapping application included within the ArcGIS environment.
10. **ArcCatalog** – A GIS file browser included within the ArcGIS environment.
11. **ArcToolbox** – A user interface in ArcGIS used for accessing, organizing, and managing a collection of geoprocessing tools, models, and scripts.
12. **Python** – A high-level scripting language commonly used for geoprocessing automation within the ArcGIS environment.

A fundamental level of experience with the ArcGIS Desktop software suite is recommended for implementation and usage of the PMP Evaluation Tool.

File Structure

The tool, source script, all input data, and output data locations are all 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 three subfolders: Input, Output, and Script. The ‘Input’ folder contains all input GIS files (Figure 9.1). 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 91 SPAS analyzed storm DAD zones. The Storm_Adj_Factors.gdb contains a feature class for each analyzed event 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. Finally, the Non_Storm_Data.gdb contains spatial data not directly relating to the input storms. There is only a single feature dataset within this GDB titled ‘Vector_Grid’. Within ‘Vector_Grid’ are two feature classes: Grid_Points_AZ, a point feature class, and Vector_Grid_AZ, a polygon feature class representing the grid cells for each of 64,103 grid points.

The ‘Output’ folder is designed to store the model output after it is created and contains a subfolder for each storm type (General_Winter, Local, and Tropical). Within each storm type subfolder, there are two file geodatabases; GRIDs.gdb and PMP.gdb. There are also two subfolders; Metadata_Templates and Text_Output. The GRID.gdb stores the basin raster output in GRID raster format. The PMP.gdb stores a feature class PMP_Points in vector (point) format. PMP_Points has a separate feature for each basin grid point, located at the grid cell centroids. There is also a PMP_Points_Mean geodatabase table produced in the PMP.gdb which stores the average basin PMP values for each duration. The ‘Metadata_Templates’ folder contains the .xml metadata templates that are applied to the output GIS files when they are created. The ‘Text_Output’ folder holds a single space-delimited PMP_Distribution.txt file which stores the basin PMP and temporally distributed PMP values.

The ‘Script’ folder contains an ArcToolbox called PMP_Tools.tbx and the Python script PMP_Calc.py. The toolbox contains a tool called ‘AZ Basin PMP Tool’ that is used by ArcGIS to call the script. The ArcToolbox was created with ArcGIS v. 10.1 but has been exported to a version 10.0 toolbox for version compatibility.

ArcCatalog 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.

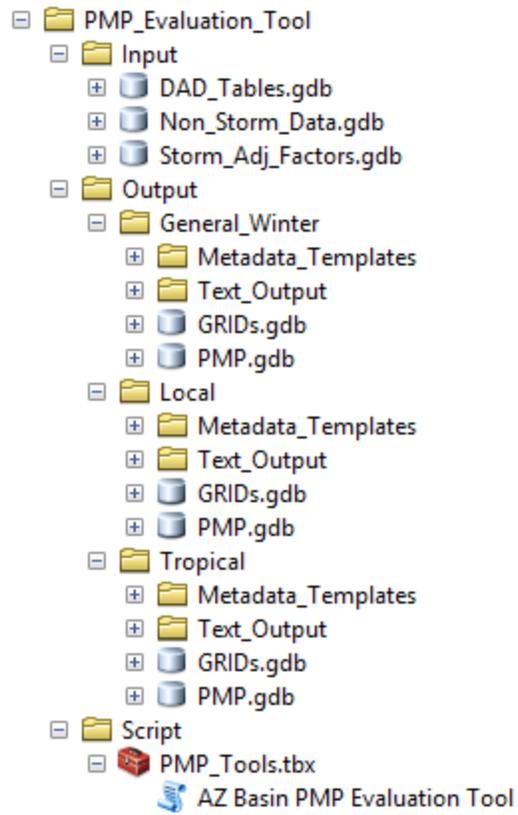


Figure 1 GIS file structure for the Arizona PMP Evaluation Tool as viewed from ArcCatalog

Python Script

Due to the large number of storm datasets and grid points within the project domain, a scripted process is necessary to compare each value efficiently and accurately for a given area of interest and make the necessary calculations. ArcGIS has adopted the Python scripting language as the viable option for compiling powerful geoprocessing operations as clearly and concisely as possible.

The script is stored within the PMP Evaluation Tool project folder at `\Script\PMP_Calc.py`. A hardcopy version of the code is given in Appendix H. The `PMP_Calc.py` code can be opened and edited within any text editor. The python script uses the `arcpy`, `arcpy.management`, and `arcpy.conversion` modules. After the input parameters are provided, the script runs the `pmpAnalysis()` three times, once for each storm type. To shorten and simplify the code, repeatable functions are designed and called within the code when needed. Within the broader `pmpAnalysis()` function, several smaller functions are called to perform various tasks:

| | |
|------------------------------|---|
| createPMPfc() | Creates the <code>PMP_Points</code> 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 |
| updatePMP() | Writes the largest adjusted rainfall value (PMP) to the <code>PMP_Points</code> feature class |
| temporalDistSixHour() | Temporally distributes the 6-hour General and Tropical PMP values |
| temporalDistTenMin() | Temporally distributes the 10-min Local storm PMP values |
| outputPMP() | Creates raster PMP output, basin-average table output, text file output, and applies metadata to output GIS files |

There is extensive documentation with 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 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
 - Set all PMP values to 0
 - For each storm in database
 - Lookup storm's depth-area-duration (DAD) value for basin 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
 - Temporally distribute PMP values
 - Create raster GRID files for each duration
 - Create .txt output file for PMP values
 - Create Average PMP geodatabase table
 - Attach metadata to each output file

The 'PMP_Evaluation_Tool' script tool within the PMP_Tools.tbx ArcToolbox opens and runs the script within the ArcGIS environment. The 'PMP_Evaluation_Tool' script tool was set up with two parameters, as described in Section 9.3.1: the basin shapefile with a data type of "Feature Layer"; and the PMP Evaluation Tool folder location, with a data type of "Folder". In addition to running as a standalone tool, the script tool can be incorporated into Model Builder or be called as a sub-function of another script.

Usage

The 'PMP_Evaluation_Tool' project folder should be stored locally at a location that can be accessed (both read/write) by ArcGIS desktop. The 'AZ Basin PMP Evaluation Tool' is located in the PMP_Tools.tbx toolbox, within the 'Script' folder. The 'AZ Basin PMP Evaluation Tool' ArcToolbox is an ArcGIS Desktop version 10.0 toolbox and can be opened and run from either ArcCatalog or ArcMap. The tool is forward compatible with ArcGIS desktop versions.

Model Input Parameters

The tool requires only two parameters as input. The first parameter is feature layer, such as a basin shapefile or feature class, designed to outline the area of interest for the PMP analysis. The basin shapefile must have a map surface projection spatial reference, with units of either feet or meters (e.g. Universal Transverse Mercator or State Plane). 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 basin shapefile extends beyond the project analysis domain, only the grid cells within the domain will be analyzed, although the PMP depths will be calculated for the area of the entire basin..

The second input parameter is the file path location of the 'PMP_Evaluation_Tool' project folder. This parameter points the script to the location if the input datasets and tells the script where to place the output.

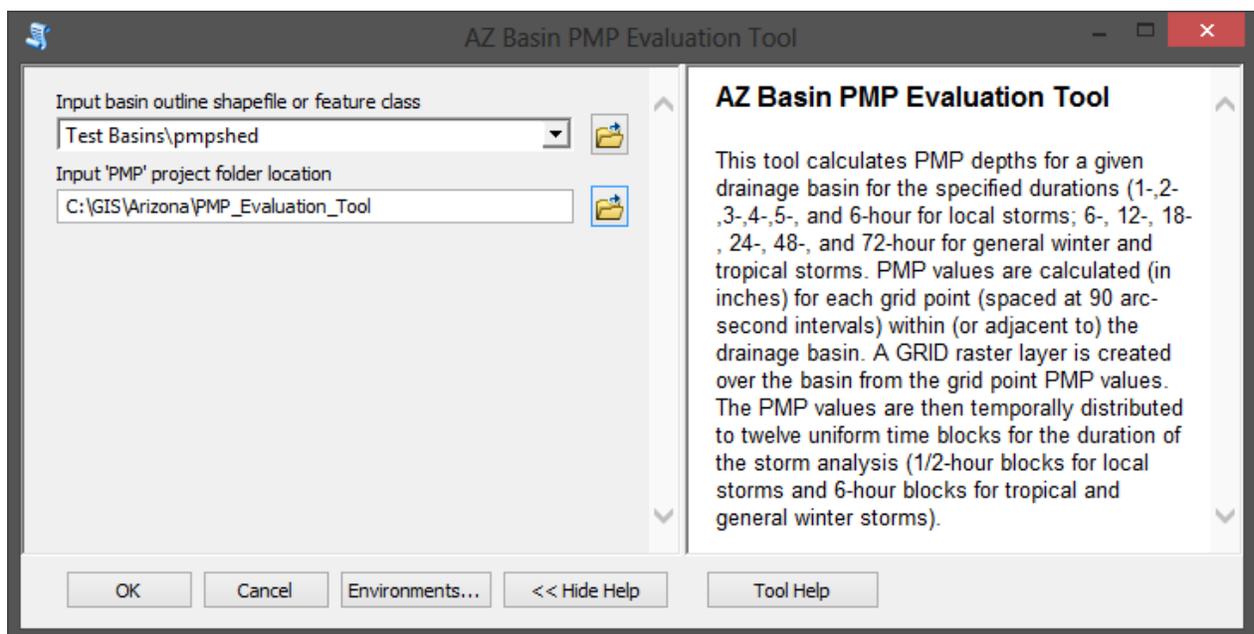


Figure 2 Example of PMP Evaluation Tool parameter input dialogue window as run from ArcGIS Desktop

Model Runtime

The tool automatically runs all three storm types at all six analysis durations. On a typical workstation the tool will take 5-15 minutes to run for most drainage basins. Several hours may be needed to complete an analysis of the entire project domain.

The GIS tool continuously outputs text to the ArcGIS geoprocessing message dialogue window while the tool is running. This text is useful for understanding where the tool is in its current iteration while the script is running, identifying errors, and recording run times and dates. After the tool has completed, the geoprocessing dialogue can be referenced and viewed with ArcGIS under the geoprocessing results window.

Model Output

Once the tool has been run, the output folders and geodatabases will be populated with the model results (Figure 9.3). The GIS files can then be brought into an ArcMap, or other compatible GIS environment, 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. Output data should be moved to an alternate permanent storage location before the tool is run again, if it is desired that the output data be preserved.

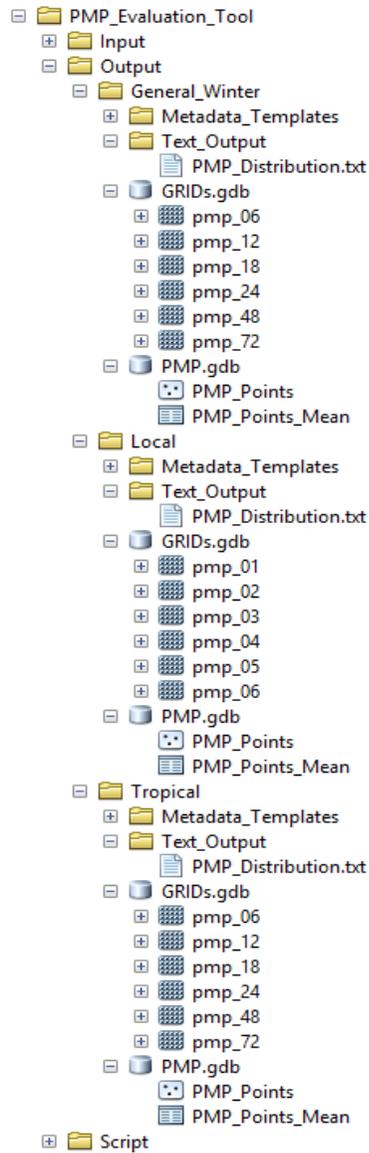


Figure 3 Example of the PMP Evaluation Tool Output folder populated after a run

The output data are organized into two geodatabase containers: GRIDs.gdb, for raster data; and PMP.gdb, for vector and tabular data. The GRIDs.gdb contains a single GRID file for each analyzed duration; six in total. The PMP.gdb contains the PMP_Points feature class which has stores each grid point centroid as a separate feature. Each feature has a field for the grid ID, latitude, longitude, analysis zone, elevation, PMP (for each duration), and temporally adjusted PMP (at each time step). The PMP.gdb also stores a separate table of the basin average PMP values. The 'Text_Output' folder contains a single space-delimited text file with the same PMP values recorded in the PMP_Points feature class. This text file can be opened with ArcGIS, Excel, or other applications capable of reading space-delimited text files.

Many of the field (column header) names are not long enough to provide adequate descriptions of the field data. This is due to the 10-digit limitation on field names. Full

GIS Dataset Metadata

Comprehensive metadata have been included for every data element within the project folder. The metadata were compiled using the Federal Geographic Data Committee (FGDC) .xml format standard and are attached to each file. The metadata can be viewed in ArcCatalog under the description tab (the FGDC metadata style may need to be enabled under ArcCatalog 'options' for proper viewing).

Metadata added primarily consist of a description of the element and a description of each attribute field (when fields are present). Metadata for all existing input data and file structure elements are present with the deliverable project folder. Metadata for each output element is applied with a function within the script during runtime. The output metadata originates from templates stored within each storm type's 'Metadata_Templates' sub-folder within the 'Output' folder.