Workshop:
Application of HEC-HMS using Gridded Precipitation in Watersheds Outside of the United States

Overview

This workshop is designed to help users applying HEC-GeoHMS and HEC-HMS in watersheds outside of the United States. In particular, this workshop will demonstrate the application of gridded precipitation within HEC-HMS outside of the regions covered by the HRAP and SHG grid systems. Prior to HEC-HMS version 4.2, it was not possible to utilize the gridded precipitation option in HEC-HMS for areas outside of the U.S. due to limitations in how gridded data was stored in HEC-DSS. The HEC-DSS grid data libraries have been modified to include storage of gridded data in the **Universal Transverse Mercator** (**UTM**) spatial reference system.

Gridded precipitation can come from different sources and this workshop demonstrates the application of precipitation grids developed using precipitation gage information and from satellite derived precipitation estimates. In addition to setting up a gridded model, the workshop shows how to prepare an HMS model to run with a variety of sources of precipitation data – point rainfall, grid-based interpolation, and satellite precipitation.

Although the workshop uses the PERSIANN gridded precipitation product as one example, the workshop does not promote the use of PERSIANN for watershed model, the use of PERSIANN data was meant to show a possible data source and how it could be utilized for an HEC-HMS model. PERSIANN data, which makes use of many different satellite-based estimate of precipitation, can be downloaded from the Center for Hydrometeorology and Remote Sensing (CHRS), which is part of the University of California at Irvine (http://chrs.web.uci.edu/). The workshop does discuss model calibration. The workshop also introduces a number of software applications, including

GageInterp, Data Storage System (DSS), ESRI Model Builder, and utility software like DSS2ASCII and ASCII2DSS.

Please Note: ***This Workshop is intended for Watersheds located outside of the United States. The data in the workshop is intended for informational use only.***

In this workshop, the user will:

- Develop an HEC-HMS Basin Model using HEC-GeoHMS.
  - Generate a UTM ModClark Grid Cell Parameter File (necessary step in order to apply gridded precipitation).
- Develop Grid Based Precipitation with GageInterp.
  - Learn how to prepare a GageInterp Control File.
  - Learn how to run GageInterp and then transfer Gridded Precipitation to an HEC-HMS Model.
- Develop gridded DSS records from the satellite based PERSIANN-CDR data set.
- Calibrate an HEC-HMS model to Multiple Precipitation Boundary Conditions.
  - Modelling method 1) Point Rainfall with the Clark Unit Hydrograph method.
  - Modelling method 2) Gridded Precipitation from GageInterp with the Clark Unit Hydrograph method.
  - Modelling method 3) Gridded Precipitation from GageInterp with the ModClark Unit Hydrograph method.
  - Modelling method 4) Satellite Data using the PERSIANN-CDR data set with the ModClark unit Hydrograph method.

The project files for this workshop are available as well. There is a directory that includes all project files for starting the workshop and then the solution files. As show below, the "Before" directory includes the workshop files you would start with if you wanted to follow along with the workshop instructions. The "After" directory contains the project files that you should get when completing all the steps in the workshop. The computer programs required to generate UTM grids in DSS are provided in the "hecexe" directory and documentation for those programs is provided in the docs directory.

Folder \...\Mongolia_UTM\Before\ contains data sets before the workshop
Folder \...\Mongolia_UTM\After\ contains data sets after the workshop
Folder \...\Mongolia_UTM\hecexe\ contains grid processing programs
Folder \...\Mongolia_UTM\docs\ contains documentation for grid programs

Before proceeding, please read the accompanying "Program Setup" document and follow the instructions it contains to install the utility programs required by this workshop.

The Watershed

The study area for this workshop is 2,820 square kilometers of the approximately 6750 square kilometer Tuul River watershed. The Tuul River watershed is located in the central and northern region of Mongolia. There are two streamflow gages in the study area that contain daily flow measurements for June, July, and August 1993. The most downstream streamflow gage is located near the City of Ulaanbataar, approximately 15 km upstream of the Chinggis Khan International Airport. The other upstream streamflow gage is located near the City of Terelz. The Tuul River has a highly braided floodplain with several bridge crossings. The watershed is located in UTM Zone 48 North. A map of the watershed is shown in (Figure 1).
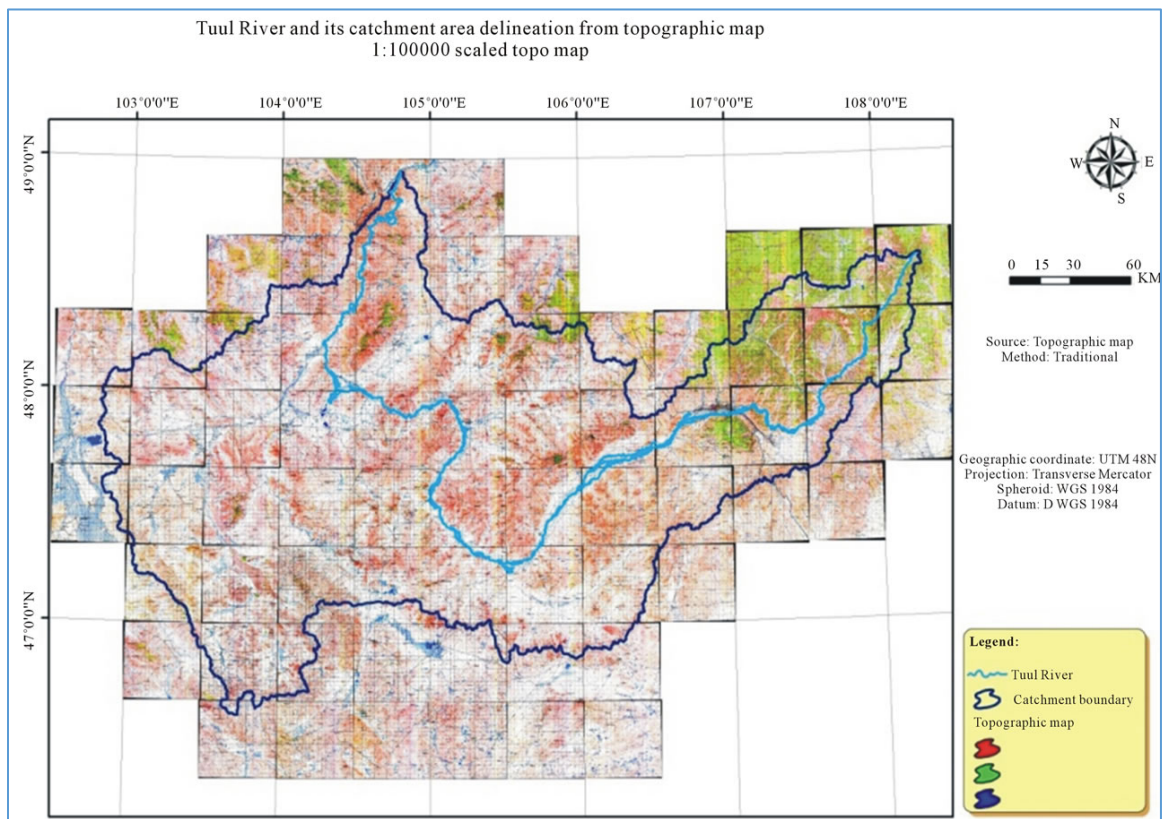
Figure 1: Tuul River Watershed

Task 1: Developing an HEC-HMS Basin Model using HEC-GeoHMS

In this task, we will utilize the Terrain Preprocessing tools to develop an initial subbasin and stream network within HEC-GeoHMS. The workshop will finalize subbasin and river delineations and then create initial model files for an HEC-HMS model. This task is divided into two sections. Part 1a sets up an ArcMap project that includes GeoHMS and loads a terrain model. Part 1b creates the HMS model elements—subbasins, routing reaches, junctions—that will represent the Tuul basin in HEC-HMS and exports them from ArcGIS into model files that can be imported into the HEC-HMS program.

Users who are already familiar with GeoHMS may want to skip ahead to Steps 21-25 of part 1b, which shows how the UTM grid and the corresponding gridcell file are created. Users who are not familiar with GeoHMS should refer to the GeoHMS User's Manual for more in-depth discussion of the steps below.

1a. Starting an ArcMap Project and configuring for GeoHMS.

1. Open **ArcMap** with the **Blank Map** template selected. Click **OK**.
2. Make sure the **GeoHMS Tools** toolbox is added to ArcToolbox. **Click the ArcToolbox Window** button to open ArcToolbox. If you do not see GeoHMS toolbox, then place the mouse pointer on top of ArcToolbox and **click the right mouse button**. Select the **Add Toolbox** option in the list. By default, these toolboxes are located at *C:\ProgramFiles(x86)\ArcGIS\Desktop10.2\ArcToolbox\Toolboxes.*
3. Load the Spatial Analyst Extension by selecting the **Customize** menu => **Extensions**. Make sure Spatial Analyst is turned **on.**
4. Make sure **Background Processing** is turned **off**. Select the **Geoprocessing** menu => **Geoprocessing Options**. Make sure the **Enable** box is **Not checked** for Background Processing.
5. Load the **HEC-GeoHMS** toolbar. Select **Customize** => **Toolbars**… and check the **HEC-GeoHMS** toolbar.
6. Load the terrain data. Click the **Add Data** button and navigate to **Before\GeoHMS_UTM\fil_clip** and click the **Add** button. The terrain data should have already been projected into the appropriate UTM zone. Usually, the first data layer added to an ArcMap project is used to set the projection for the data frame. All data layers created by GeoHMS will be set to the same projection as the data frame.

7. Prepare to save the ArcMap document with relative path names by selecting *File* => *Map Document Properties*. Check the box to *"Store relative pathnames to data sources"* and click *OK*. Using relative pathnames makes it easier to pass an ArcMap project from one computer to another, as long as all data layers and ArcMap document are saved in the same directory **(**Figure 2**)**.
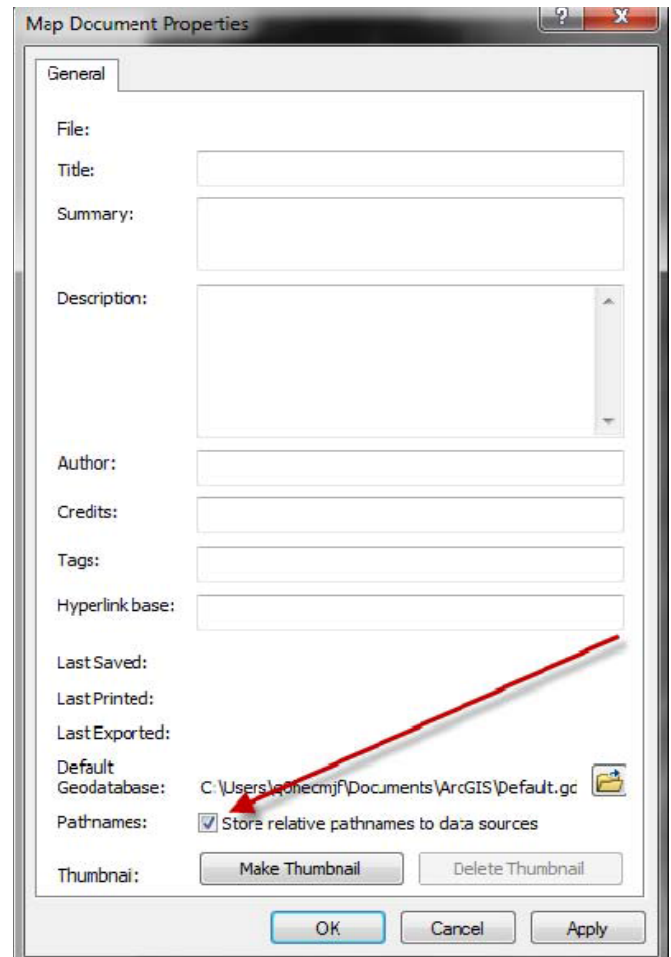

Figure 2: Map Document Properties

1b. Completing the GeoHMS project and generate files for and HEC-HMS project. Steps 1 through 9 show how to develop the initial subbasin and river network by using GeoHMS and the terrain data to delineate subbasins and reaches. The GeoHMS Terrain Preprocessing menu contains menu options for each of the steps below.

1. **Fill the Sinks**
   - ***Preprocessing => Fill Sinks*** (This step has already been completed).
   - The Output **DEM** is **fil_clip** (Figure 3).
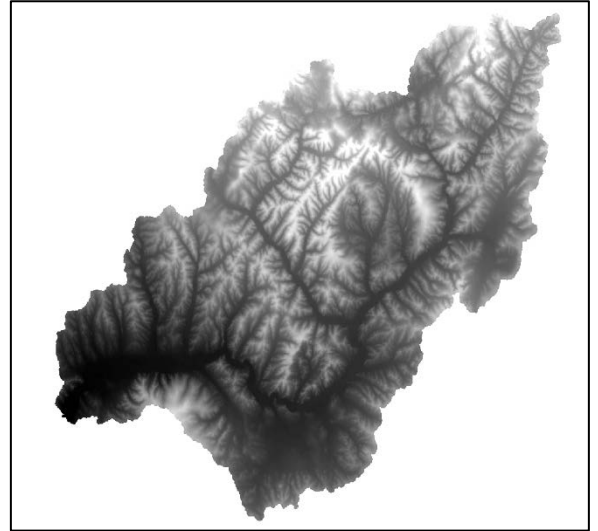
Figure 3: Digital Elevation Model

2. **Flow Direction**
   - ***Preprocessing => Flow Direction.***
   - Confirm that the Input Hydro DEM is **fil_clip.**
   - Use the default name **Fdr** for the **Output Flow Direction Grid** *(*Figure 4*)***.**
   - Click **OK.**
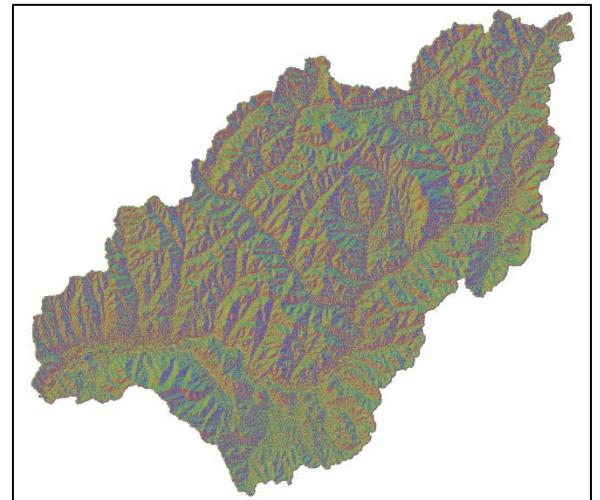
3. **Flow Accumulation**
   - ***Preprocessing => Flow Accumulation***.
   - Confirm Input Flow Direction Grid is **Fdr.**
   - Use the default name **Fac** for the **Output Flow Accumulation Grid.**
   - Click **OK.**

Figure 4: Flow Direction

4. **Stream Definition**
   - **Preprocessing => Stream Definition.**
   - Confirm that the **Input Flow Accumulation Grid** is **Fac.**
   - Enter a stream threshold of **300000** cells (Number of cells to define stream) (Figure 5).
   - Use the default name **Str** for the **Output Stream Grid.**
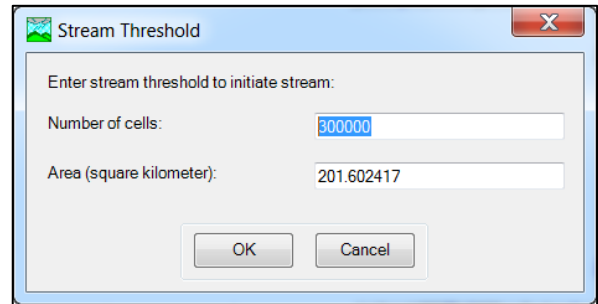   - Click **OK.**

Figure 5: Stream Definition

5. **Stream Segmentation**
   - **Preprocessing => Stream Segmentation.**
   - Confirm that **the Input Stream Grid** is **Str** and Input Flow Direction Grid is **Fdr.**
   - Use the default name **StrLnk** for **the Output Stream Link Grid.**
   - Click **OK.**

6. **Catchment Grid Delineation**
   - **Preprocessing => Catchment Grid Delineation** (Figure 6)**.**
   - Confirm that the Input Flow Direction Grid is **Fdr** and Input Link Grid is **StrLnk.**
   - Use the default name **Cat** for the **Output Catchment Grid.**
   - Click **OK.**
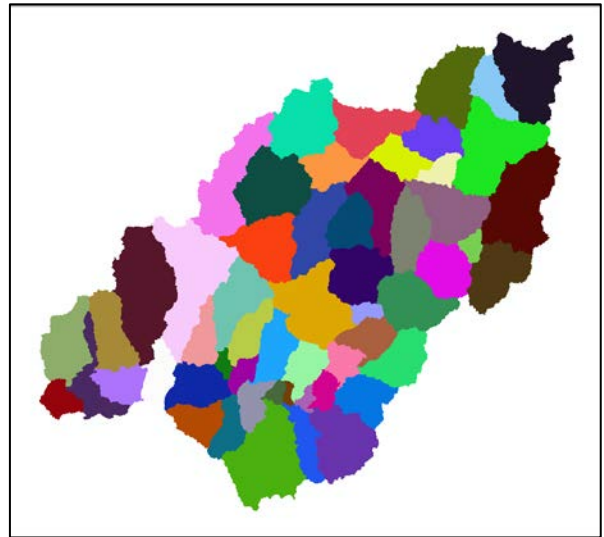
Figure 6: Catchment Grid Delineation

7. **Watershgon Polygon Processing**
   - **Preprocessing => Catchment Polygon Processing** (Figure 7).
   - Confirm that the Input **Catchment** Grid is **Cat.**
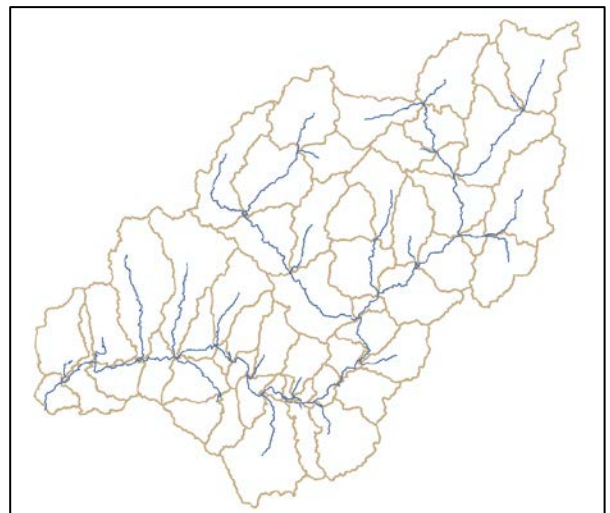   - Use the default name **Catchment** for the Output Catchment.
   - Click **OK.**

8. **Drainage Line Processing**
   - **Preprocessing => Drainage Line Processing** (Figure 7)**.**
   - Confirm that the Input Stream Link Grid is **StrLnk** and Flow Direction Grid is **Fdr.**

Figure 7: Catchment and Drainage Line Processing

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- Use the default name **DrainageLine** for the **Output Drainage Line** layer.
- Click **OK.**

9. **Adjoint Catchment Processing**
    - **Preprocessing** => **Adjoint Catchment Processing.**
    - Confirm **Input Drainage Line** is **DrainageLine** and **Input Catchment** is **Catchment.**
    - Use the default name **AdjointCatchment** for the **Output Adjoint Catchment** layer.
    - Click **OK.**

Step 10 is required to create a study area specific data frame. The study data frame will allow the user to customize the subbasin and river delineation and compute properties for each subbasin and river reach.

10. **Setup and Extract the Dataset for a Hydrologic Model**
    - **Project Setup** => **Start New Project.**
    - Specify outlet location with **Add Project Points** tool (see blue push pin) (Figure 8).
    - **Project Setup** => **Generate Project.**
    - On the **Generate Project** form, specify layers in your terrain preprocessing data frame.
    - Click **OK.**
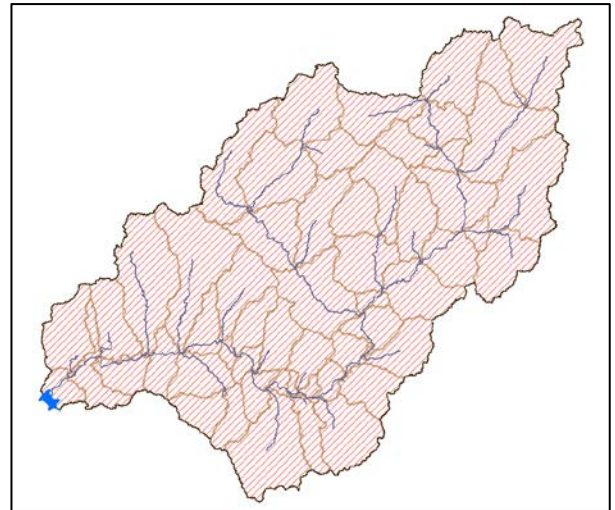
Figure 8: Add Project Point

Steps 11 and 12 show how to customize the subbasin and river delineation. Determining how many subbasin and river reach segments is one of the most important decisions made in a modeling study and impact model calibration and performance. The number of subbasins for the Tuul River watershed was kept small due to the limited number of observed streamflow gages. Only five subbasins were used to model the area upstream of the Ulaanbataar stream gage; however, many more subbasins could have been specified.

11. Basin Subdivision

- Use the GeoHMS **Subbasin Divide** tool to subdivide the subbasins at stream flow gage locations. In the HEC-HMS model, these gage locations would later be useful for comparing simulated vs. observed hydrographs during calibration steps.

12. Basin Merge

- Use the ArcMap **Select Features tool** and select the subbasins you want to merge together.
- The GeoHMS toolbar has a menu option for merging subbasins, **Basin Processing** => **Basin Merge.**
- After subbasin merge and river merge, final subbasin and stream delineation is shown in Figure 9**.**

Stream flow gage
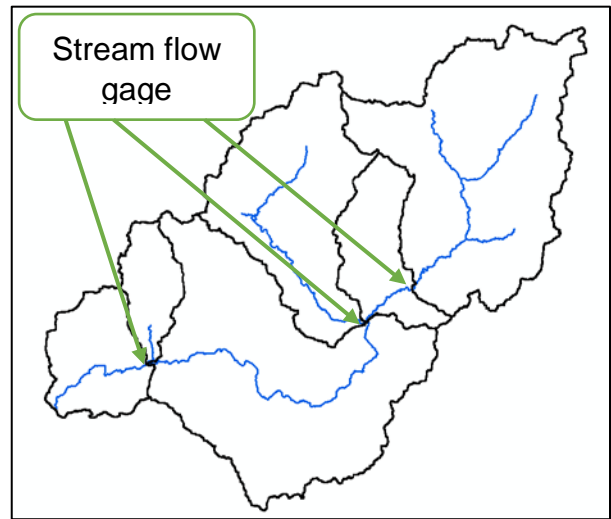
Figure 9: Basin Merge

Steps 13 through 17 are required to compute subbasin and reach characteristics. Tools on the Characteristics menu are used in these steps.

13. River Length

- **Characteristics** => **River Length.**
- Click **OK.**

14. River Slope

- **Characteristics** => **River Slope.**
- Specify the **Raw DEM** as the Input **Raw DEM.**
- Specify **River** for Input River layer.
- Click **OK.**

15. Longest Flow Path

- **Characteristics** => **Longest Flowpath** (see Figure 10).
- Verify the Input **Raw DEM**, **Flow Direction Grid** and **Subbasin** layers are selected.
- Accept the default name for the **Output Longest Flow Path** layer.
- Click **OK.**

16. **Basin Centroid**
    - **Characteristics** => **Basin Centroid.** (see Figure 10)
    - **Choose the Subbasin layer.**
    - Use the default name for the **Output Centroidal Layer.**
    - Click **OK.**

17. **Centroidal Flow Path**
    - **Characteristics** => **Centroidal Longest Flowpath.** (see Figure 10)
    - The program prompts the user to verify the Subbasin, Centroid, and Longest Flow Path layers.
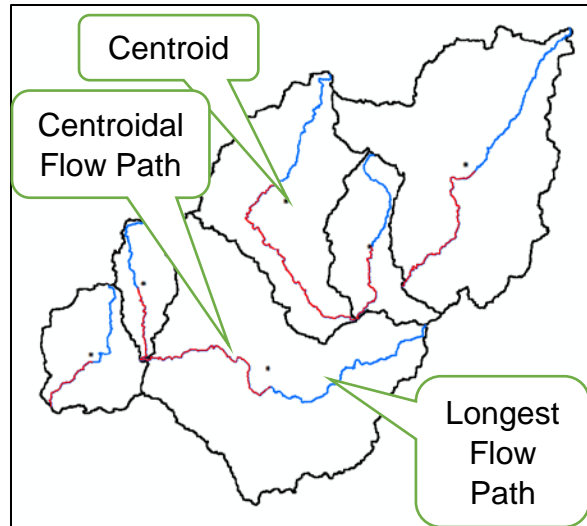   - Use the default name for the **Output Centroidal Flow Path** layer.
    - Click **OK.**

Figure 10: Longest Flow-path

Steps 18 through 21 are required to define the modeling processes and the naming convention used throughout the model. GeoHMS will assign default names to subbasins, reaches, and junctions. These names should be modified to include project specific names. The GeoHMS Parameters menu contains the tools discussed in the following steps.

18. **Select HMS Process**
    - **Parameters** => **Select HMS Processes.**
    - Verify that the Subbasin and River layers are selected from the dropdown menus, select Parameters Applicable to your project.
    - Click **OK.**

19. **River Auto Name**
    - **Parameters** => **River Auto Name.**
    - Verify that the River layer is selected.
    - Click **OK.**

20. **Basin Auto Name**
    - **Parameters** => **Basin Auto Name.**
    - Verify that the Subbasin layer is selected.
    - Click **OK.**

Step 21 overlays the precipitation grid over the watershed and assigns cells in that grid to the subbasins in the model. This step creates the numbering system for the cells as it will be applied in the HMS model. It is essential that the coordinate system and cell size chosen at this step must be the same as those that will be used for georeferencing the precipitation data and loading it into DSS grid records.

21. **Grid Cell Processing**
- **Parameters** => **Grid Cell Processing** (Figure 11)
- **Select the grid cell method: SHG**
- **Select SHG grid cell: 2000** (meters implied)
- **Select the projection** => **Change** => **Projected Coordinate System** => **UTM** => **WGS 1984** => **Northern Hemisphere** => **WGS 1984 UTM Zone 48N** (Figure 12). Click **OK.**
- Verify that the appropriate layers and default name for the new layer are selected in Figure 13 and Figure 14.
- Click **OK.**
- The resulting gridded subbasin is shown in (Figure 15).
- Click **OK.**
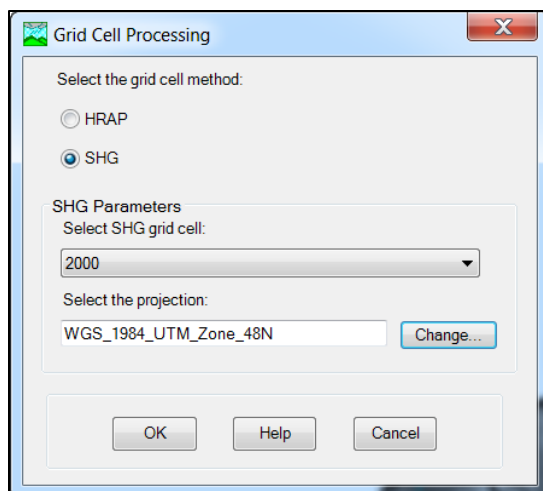
Figure 11: Grid Cell Processing
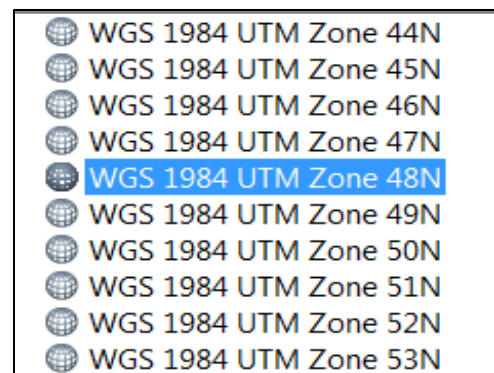
Figure 12: WGS 1984 UTM Zone 48N
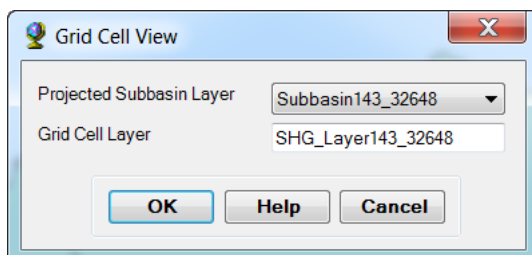
Figure 13: Grid Cell View
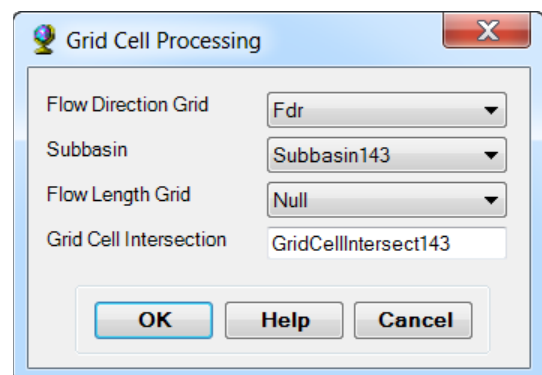
Figure 14: Grid Cell Processing

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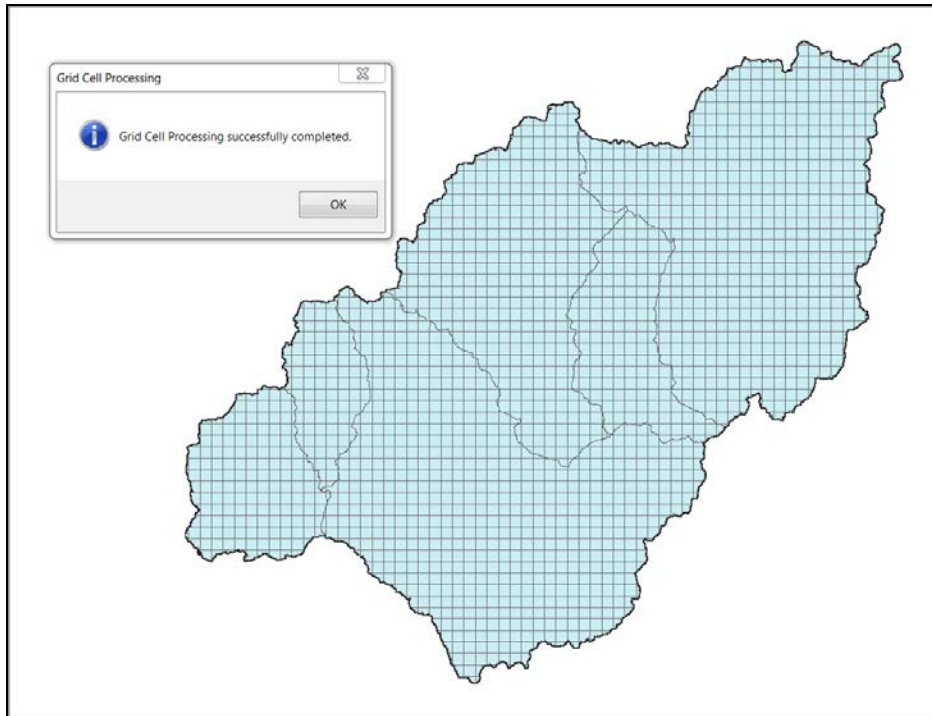
Figure 15: Resulting Gridded Subbasins

Steps 22 through 24 are required to create the HEC-HMS project specific files. Tools on the GeoHMS HMS menu are included below.

22. Map to HMS Units
- **HMS** => **Map to HMS Units.**
- Select the "**SI**" unit system.
- Click **OK.**

23. Check and Create HMS Schematic
- **HMS** => **Check Data.**
- Click **Yes.**
- **HMS** => **HMS Schematic.**
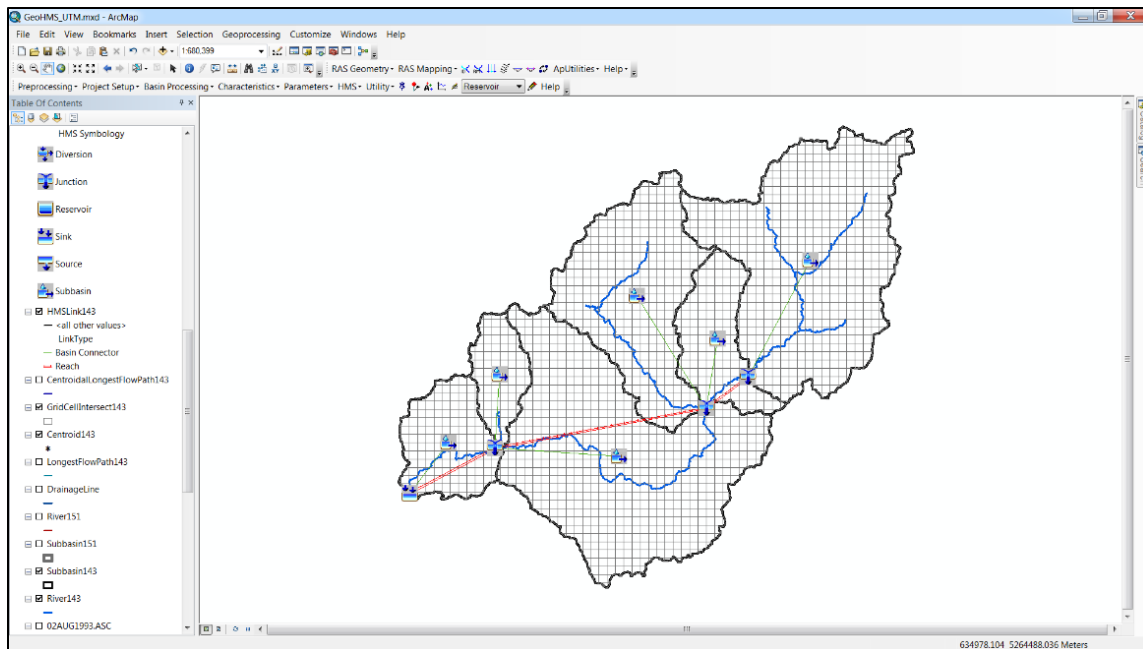- Click **Ok.**
- **HMS** =>**Toggle Legend** => **HMS Legend** (Figure 16).

Figure 16: HMS Legend

24. Export HMS Model Files
- **HMS** => **Add Coordinates** and make sure the correct layers are selected.
- Click **OK.**
- **HMS** => **Prepare Data for Model Export.**
- **Click OK.**
- **HMS** => **Background Shape File.**
- **Click OK.**
- **HMS** => **Basin Model File.**
- **Click OK.**

The last step is to create the grid cell parameter file. The grid cell parameter file contains a list of each grid cell located within a subbasin and is required for HEC-HMS to apply gridded precipitation within a DSS record to the subbasin element. Each GridCell within the subbasin contains the X coordinate (Xcoord), Y coordinate (Ycoord), travel length to the subbasin outlet, and area.

25. Export ModClark Grid Cell File
- **HMS** => **Grid Cell File (**Figure 17**)**
- Click **OK.**

13
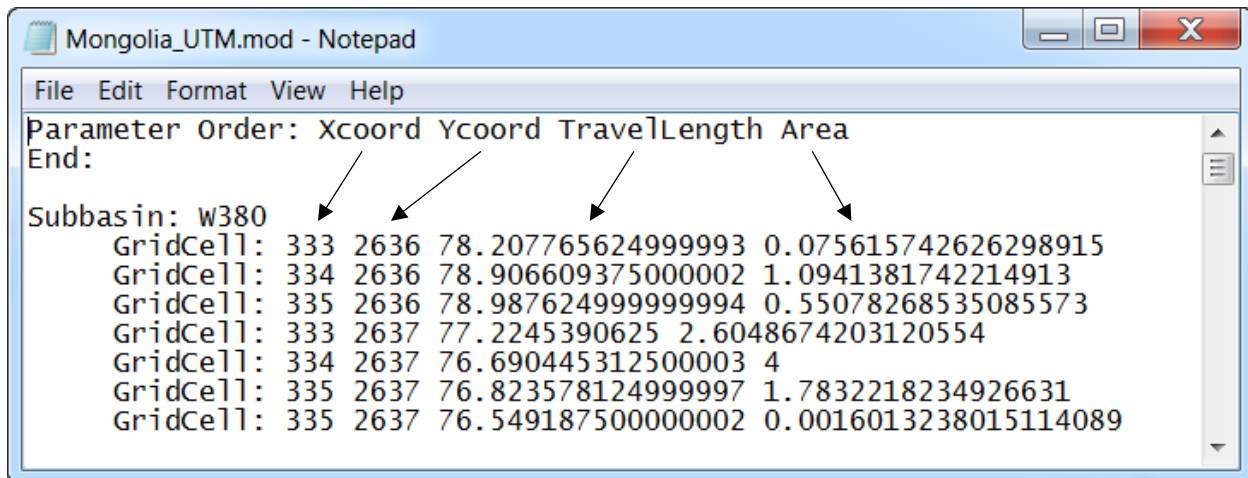
Figure 17: ModClark Grid Cell File

Once the files have been created by GeoHMS, then they can be imported into an HEC-HMS project. The required files include the Basin Model file and the Grid Cell Parameter file. The subbasin and reach shapefiles are not required but can be used for adding background layers to the HEC-HMS basin model.

Task 1 Summary

We have used GeoHMS to create a basin model and a gridcell file for the Tuul watershed. The gricell file assigns grid cells to subbasins in the basin model using X and Y cell index values based on coordinates in UTM zone 48. To use this model to simulate a runoff event in the basin, we need to provide precipitation grids that are georeferenced and indexed using the same coordinate system and the same row and column positioning and indexing. Task 2 uses the gageInterp program to construct these precipitation grids, and Task 3 imports precipitation grids from an online archive and re-projects them to align with the cells in our basin model.

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Task 2: Develop Grid Based Precipitation with GageInterp

There are two precipitation gages within the study area that recorded cumulative precipitation in 12-hour increments. In Task 2, we will work with the GageInterp program to create gridded precipitation records for use in HEC-HMS by interpolating point rainfall from time-series reports at these two rain gages. The products of GageInterp for this task are precipitation grids in UTM coordinates saved in a DSS file. The origin, extent and cell size of these grids must align with the gridcell file created in Task 1, so that the precipitation reported on these grids can be applied to the subbsins in the HMS model.

GageInterp is a command line program that is controlled by parameters in an input control file or entered on the command line at run time. The type of information required in a GageInterp control file includes start and end time of precipitation, time interval, precipitation grid type and cell size, extent of the grid, filename of the observed precipitation, point rainfall gage locations and data, and output filename of the interpolated precipitation grids. These parameters are described more fully in the gageInterp manual that is included with this workshop data set.

A. GageInterp Parameters

Much of the information that gageInterp needs to generate the grids correctly can be entered into the control file without reference to the HMS or GeoHMS projects. That information is provided in the file "Mongolia_UTM_starter.ctl" shown in Figure 18.

The first block of text includes the start and end time of the period (the year 1993) for which grids will be created, and the time step, expressed in minutes, that each grid represents. In this case, the time step matches the 12-hour reporting interval of the two precipitation gages. In this workshop, the grids are created every 720 minutes from 01 January 1993 to 31 December 1993.

The second block of text includes information about the grid type. We're using a UTM grid system, since it is the only grid system that gageInterp supports for locations outside of the U.S. The watershed is located in UTM zone 48N and the cell size if 2000 meters—matching the coordinate system and cell size we chose for the gridcell file we created in GeoHMS.

The third block of text includes information about the grid, the location of the lower left grid cell (cell origin) and the number of rows and columns. The values for the row and column numbers are blank, and will be filled by examining our GeoHMS project.

The fourth block of text includes the name of the output DSS file, used to save the gridded precipitation grids, as well as the pathname parts.

Finally, the last two text blocks contain information about the rain gages, the location of the DSS file storing the rain gage data and then a block of text for each gage that includes the name, DSS pathname, geographic location of the precipitation gage, and then the time zone and datum of the precipitation gage.
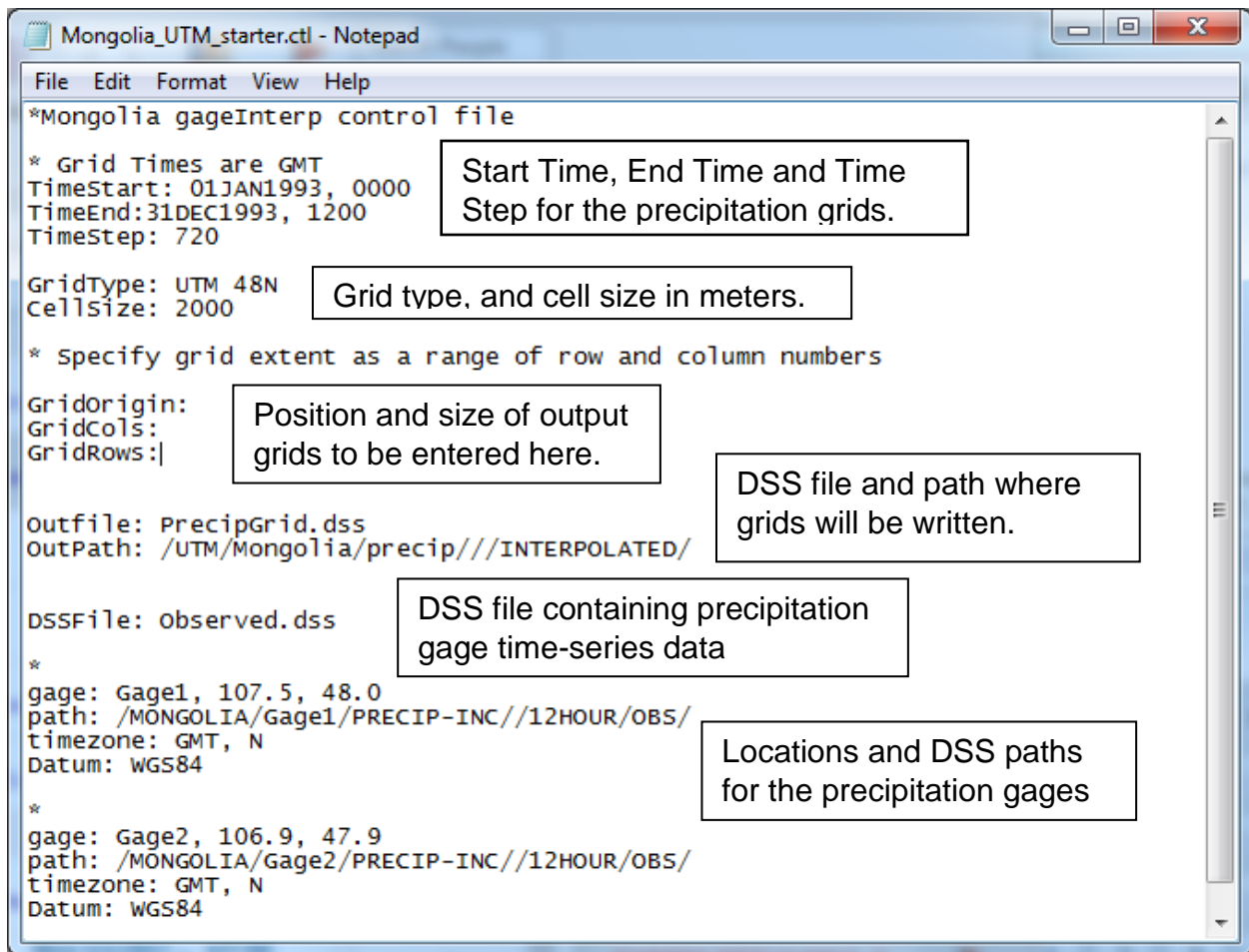
Figure 18 Partially Completed GageInterp Control File

The location of the precipitation grid that gageInterp writes must match or extend beyond the range of cells in the basin model and gridcell file we created with GeoHMS in Task 1. Steps 1 through 8 below demonstrate one approach for determining the origin of the UTM grid as cell index numbers for the lower left corner of the grid and the extent of the grid as numbers of rows and columns.

1. Open the gridcell processing dataset file (**GeoHMS_UTM** in our example) in **ArcMap** (Figure 19).
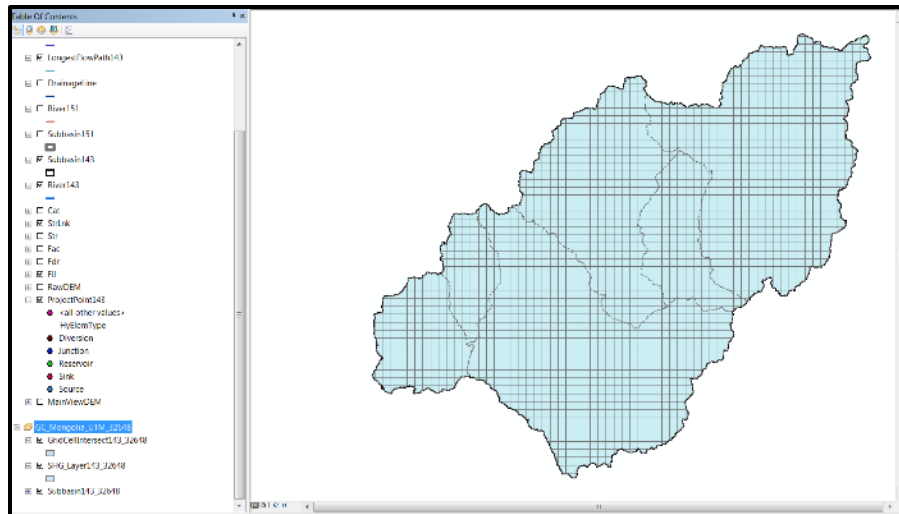
Figure 19: GeoHMS_UTM

2. Right-click on the **GC_GeoHMS_UTM** data frame and choose **Activate** (Figure 20). This data frame was used to generate the UTM grid by GeoHMS. The coordinate information can be extracted by the projection and data layers.
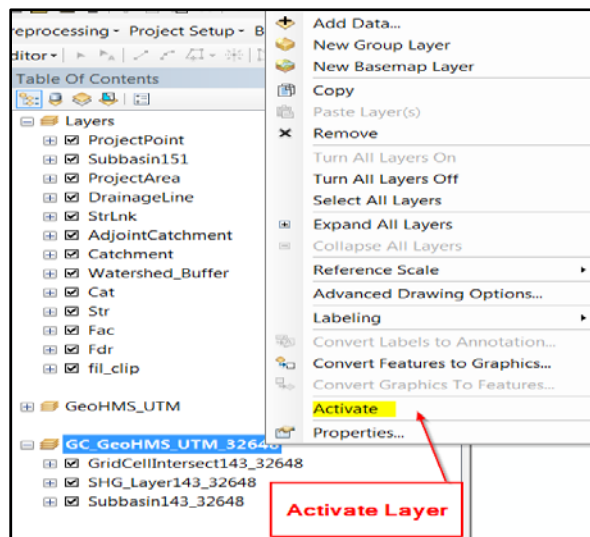
Figure 20: Activate Data Frame

3. Right Click **GC_GeoHMS_UTM** (in ArcGIS Table of Contents) => **Properties** => **General** => **Units** => **Display** => **From Dropdown Menu. Choose Degrees Minutes Seconds** in the **Display** dropdown menu (Figure 21).
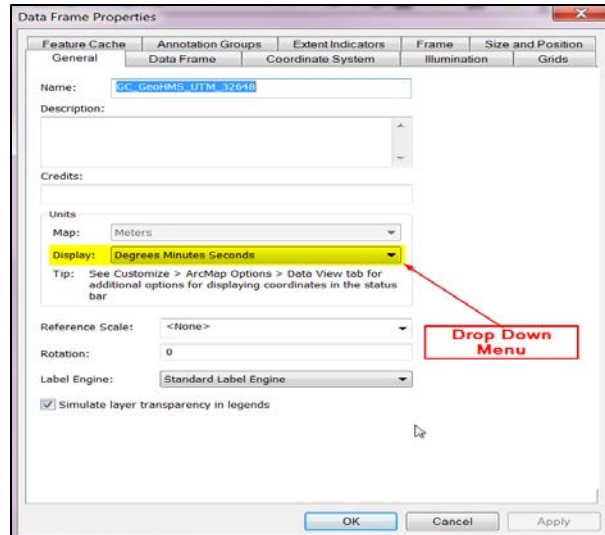
Figure 21: Dropdown Menu Choose Degrees Minutes Seconds

4. Select the **Identify** ⓘ **Tool** => **Click on Bottom Left Grid Cell.** The **Identify Screen** will open (Figure 22).
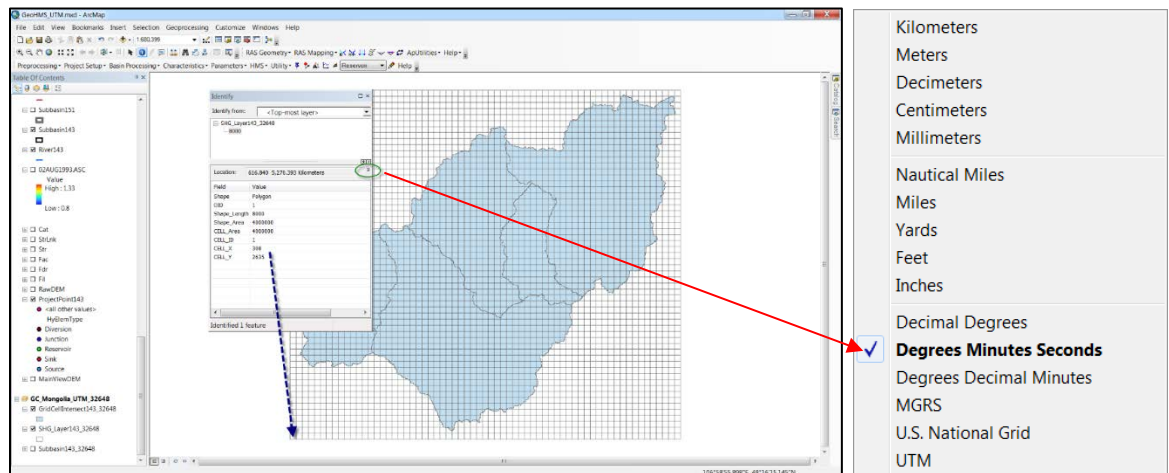
Figure 22: Identify Screen open

5. As shown in Figure 22, click the arrow within the Location field to expand the list of possible location units. Choose **Degrees Minutes Seconds**.

6. Write down **CELL_X = 308, Cell_Y = 2635.** The cell origin is **(308, 2635)**.

7. Repeat previous steps to find coordinates for **upper right** corner of the grid**.** Write down **CELL_X = 372, CELL_Y = 2692** (Figure 23).

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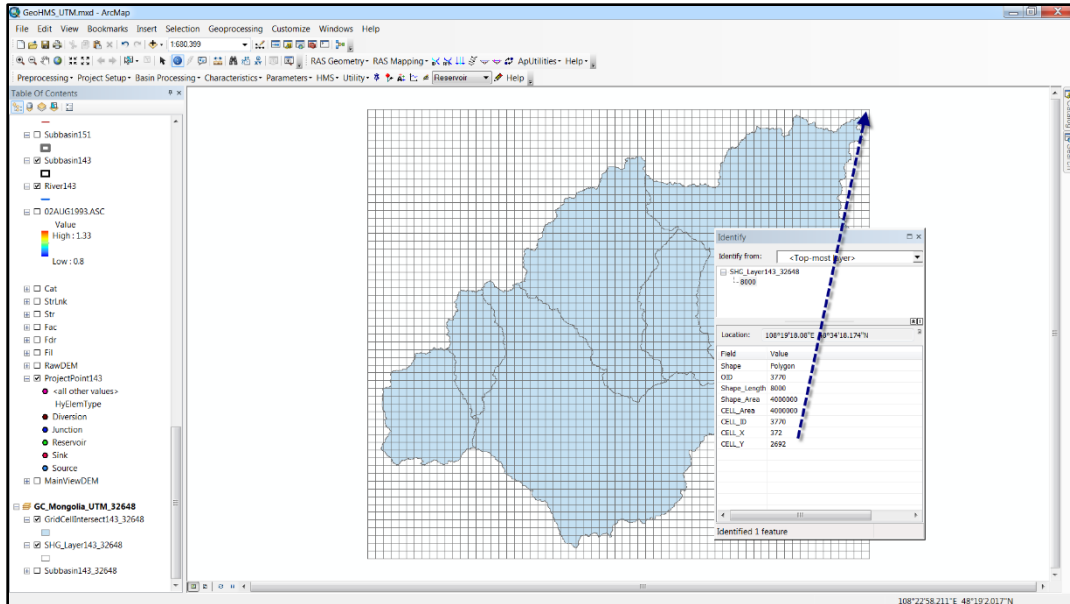
Figure 23: Upper Right Corner Information

8. The number of grid columns can be computed by subtracting the upper right column number from the lower left column number and adding a value of 1.

GridCols = (CELL_X$_{(Upper\ cell)}$ - CELL_X $_{(Lower\ Cell)}$)) + 1

GridRows= (CELL_Y$_{(Upper\ cell)}$ - CELL_Y $_{(Lower\ Cell)}$)) + 1

So the grid is 65 columns wide and 58 rows high.

To finish the GageInterp Control File, insert the lines for the origin and ranges of the output grid extent. The result should look like Figure 24.

The GageInterp control file is located in the …\GageInterp directory and the filename is **Mongolia_UTM.CTL**. As shown in Figure 24, the control file can be completed with the dimensions of the output grids, expressed as row and column numbers. The third block of text is now completed, showing the location of the lower left grid cell (cell origin) and the number of rows and columns.

```
Mongolia_UTM.ctl

*Mongolia gageInterp control file

* Grid Times are GMT
TimeStart: 01JAN1993, 0000
TimeEnd:31DEC1993, 1200
TimeStep: 720

GridType: UTM 48N
CellSize: 2000

* Specify grid extent as a range of row and column numbers

GridOrigin: 308, 2635          Grid Origin and number or
GridCols: 65                   Rows and Columns
GridRows: 58
* Bottom Left Cell (origin) (x=308, y=2635)
* Top Right Cell (x=372, y=2692)

Outfile: PrecipGrid.dss
OutPath: /UTM/Mongolia/precip///INTERPOLATED/

DSSFile: Observed.dss

*
gage: Gage1, 107.5, 48.0
path: /MONGOLIA/Gage1/PRECIP-INC//12HOUR/OBS/
timezone: GMT, N
Datum: WGS84

*
gage: Gage2, 106.9, 47.9
path: /MONGOLIA/Gage2/PRECIP-INC//12HOUR/OBS/
timezone: GMT, N
Datum: WGS84
```

Figure 24: GageInterp Control File

With the control file compete, we can now create precipitation grids using the gageInterp program.

B. GageInterp Analysis Software

Before proceeding, make sure that you have read the accompanying "Program Setup" document and that the utility programs required by this workshop are installed as described there.

Figure 25: Command Prompt

1. Using a Windows explorer, navigate to the folder that contains the gageInterp control file "Mongolia_UTM.ctl". This is the "Before\GageInterp" folder as the files are provided.

2. Type **CMD** in address tool bar **(**Figure 25**)** to open the DOS command prompt.

3. Refering to the "Program Setup" document, verify that you can run the gageInterp program from the command prompt in this directory. You may need to use the "set" command to add the directory where gageInterp is located to the PATH system variable.

4. Input the following command:

   GAGEINTERP CON=Mongolia_UTM.CTL

Figure 26 GageInterp Command

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5. Click **Enter** and watch **GageInterp** run (Figure 27).


```
C:\Windows\System32\cmd.exe

=- Cell Counts:
        null: 0; =0: 3944; >0: 0; >=3: 0; >=12: 0; >=25: 0

Grid: Mongolia from 1 January 1993, 00:00 to 31 December 1993, 12:00 UTC
Values (MM):
        max of max: 37.66; min of min: 0.00; mean of mean: 0.59

gageInterp run end:  20 January 2017, 14:56:50
Releasing NAD83 definition conus.nad

C:\Mongolia\GageInterp>
```

Figure 27: Command Run Result

GageInterp should run to competeion with the data and control files provided. If the program doesn't run, verify the PATH enviroment variable includes the directory where gageInterp is installed, and that the the "sup" directory is installed in the same directory as the gageInterp executable.

6. A successful GageInterp run will create precipitation grids in a DSS file named **PrecipGrid.DSS** in the directory where it was run. Figure 28 shows a gridded estimate of the 12 hours of precipitation ending **02AUG1993 at 12:00** as displayed in the HEC-DSSVue program. (You must use version 2.5 or later of DSSVue to visualize the grids as the version of DSSVue on the webpage will not support display grids in the UTM projection. Refer again to the "Program Setup" document for suggestions about running an up-to-date version of DSSVue.)

There were a limited number of precipitation gages used for this workshop, only two gages were available for the entire watershed. Notice in Figure 28 how GageInterp created the interpolation surface. A "bullseye" pattern is evident as theinverse distance (ID2W) interpolation method was used, the ID2W method is the default method.

A copy of the GageInterp User's Manual is included in the Mongolia_UTM\docs directory.
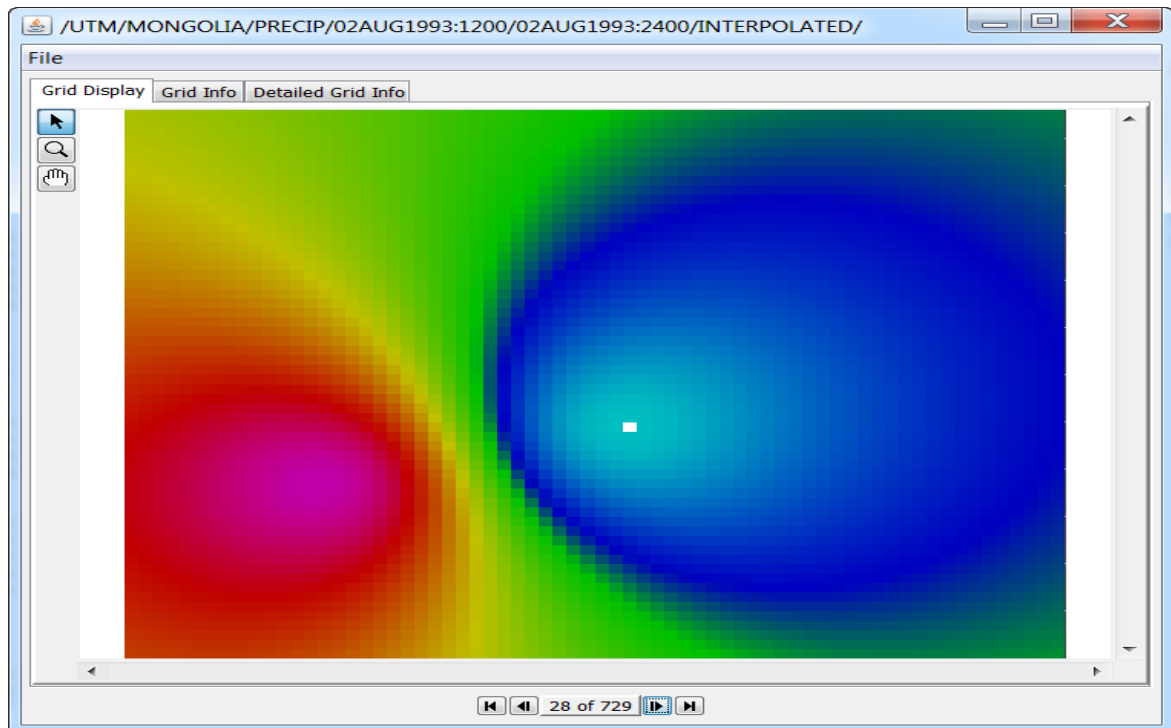
Figure 28: Grid-based Precipitation on 02AUG1993 at 12:00 in HEC-DSSVue Program

After a successful gageInterp run, the PrecipGrid.DSS file should contain 729 precipitation grids, each representing estimated precipitation over the study area at a time step of 720 minutes. In order to visualize the precipitation grids over subbasin shapefiles and to verify that precipitation grid is in alignment with ModClark grid, the utility program DSS2ASCIIGrid.exe can be used to export individual precipitation grids from DSS as ASCII files. Then, the ASCII files can be imported into an ArcGIS project and viewed with other GIS data layers. Below are steps for using DSS2ASCIIGrid program. A copy of the DSS2ASCGrid program is in the \...\Mongolia_UTM\exe directory.

7. From the same DOS command prompt that you used to run gageInterp, type this command

   dss2ascGrid

   You should see a usage message in response to this command. If you don't see the usage message, review the "Program Setup" document and make sure that the "dss2ascGrid.exe" file is in the same directory as gageInterp and that the PATH includes that directory.

   The following command – with its arguments – will read the precipiation grid named by DSS file and path and write its contents to a text file that can be read as a grid by ArcGIS.

   dss2ascGrid.exe DSS=PRECIPGRID.DSS PATH=/UTM/MONGOLIA/PRECIP/02AUG1993:1200/02AUG1993:2400/INT ERPOLATED/ OUT=02AUG1993.ASC PREC=2

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A brief document describing the dss2ascGrid and asc2dssGrid programs is provided in the "docs" directory.

Figure 29 shows the precipitation grid for 02AUG1993 at 12:00 shown in ArcMap with the subbasins and gridcells for the created with GeoHMS.
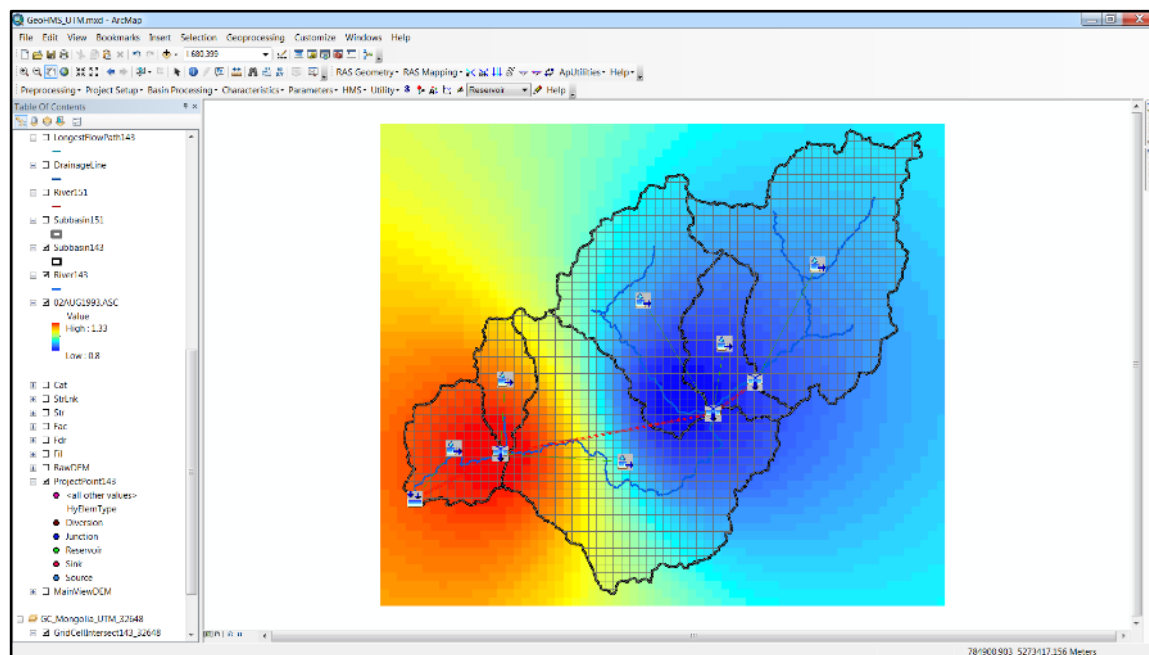
Figure 29: Grid-based Precipitation on 02AUG1993 at 12:00 in ArcMap

Task 3: Develop Grid-Based Precipitation with Satellite Data

This task goes through the steps of gathering satellite based precipitation data, reformatting the data, and then converting the data into a DSS record that HEC-HMS can use. As stated at the beginning of this workshop, the PERSIANN-CDR data set was used; however, the steps included here could be used for other satellite based precipitation estimates. The PERSIANN-CDR data set is not being promoted for other hydrologic modeling studies; it is up to the hydrologic modeler to verify the quality of the precipitation data used for modeling purposes.

A. Visualize and download the Satellite data

To access data from the **Center for Hydrometeorology and Remote Sensing (CHRS)** from the **University of California at Irvine,** follow the steps below to visualizing, select, and download the data:

1. Go to http://chrs.web.uci.edu/.
2. Click on **Research Areas** => **Satellite Precipitation** => **Data Access** (Figure 30).
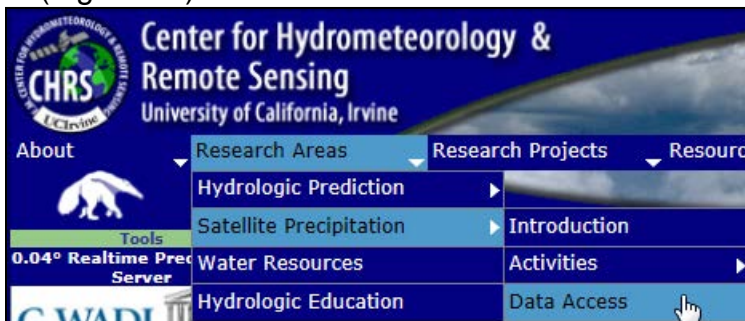
Figure 30: Center for Hydrometeorology and Remote Sensing (CHRS)

3. Click the **Visualization** tab, **Select Dataset: PERSIANN-CDR, Time Step: Daily, Domain: Country, select Mongolia** on map (Figure 31)**.**
4. **Enter DateTime (yyyy-mm-dd)** and click **Visualize** to see the availability of data for the period of time.
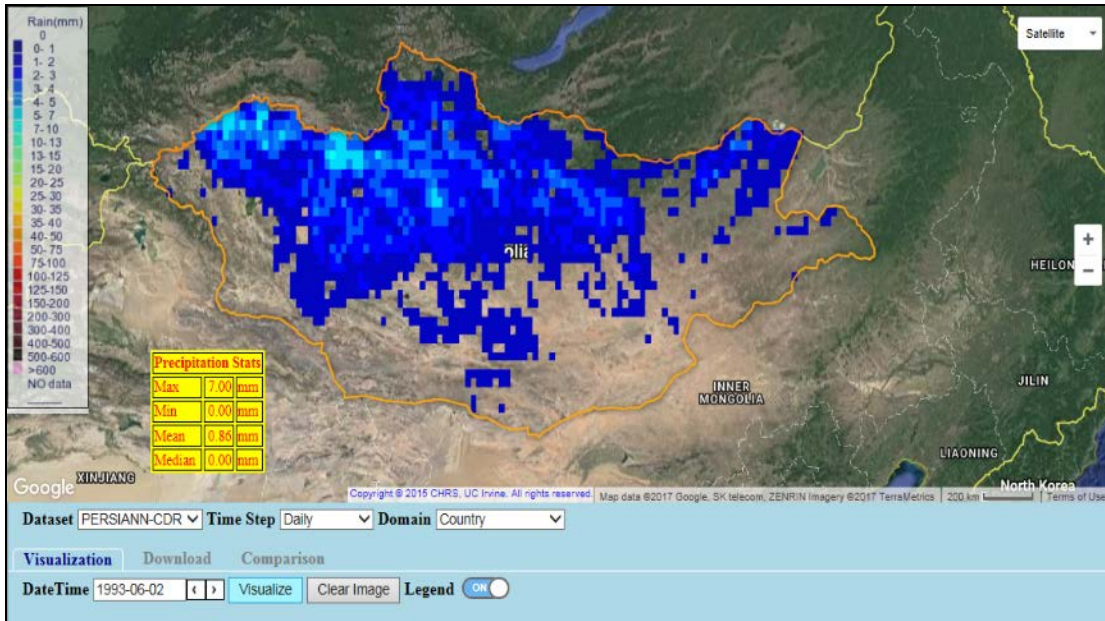
Figure 31: Visualization of Available Precipitation Data

Click the **Download** tab, select **Dataset: PERSIANN-CDR, Time Step: Daily, Domain: Country,** enter **DateTime 1993-06-01 to 1993-09-30**, **Format: ArcGrid**, **Compression: Zip**, click **Download**.

Figure 32: Download PERSIANN-CDR Data

5. A window will prompt the user for an email to send a download link to when the data is ready.

Figure 33: Download Email Window Prompt

6. Create folder \...\Mongolia_UTM\Before\Persiann\ASCII with Windows Explorer.
7. When the file has been downloaded, unzip the file to the empty folder \...\Mongolia_UTM\Before \Persiann\ASCII. Using the time window defined in step 5, there should be 122 ASCII files. These precipitation grids are initially 25,000 meter by 25,000 meter and in the World Geographic System (WGS) projection. The following section describes the steps necessary to process the precipitation grids into DSS so they can be used by HEC-HMS.

B. Prepare the Data

The PERSIANN-CDR data, as downloaded, does not include geographical references or projection. The data, as downloaded, is in grids with a spacing of 1/4 degree in un-projected longitude and latitude. (We have assumed that these coordinates are relative to the WGS84 geographic reference system.) Before the precipitation data can be used by HEC-HMS, the data must: 1) Converted from ASCII file form to an ESRI raster, 2) The projection must be defined, 3) The raster files must be reprojected to UTM zone 48N and grid must be resampled to a 2000 meter cell size, and 4) the raster files must be converted back to the ASCII file format. The ModelBuilder tool within ArcMap is useful in processing multiple files with standard ArcGIS tools. These four steps to process the satellite data are shown in detail below.

Step 1 – Convert ASCII files to the ESRI Raster file format

The PERSANN data was downloaded and extracted to an empty folder. The PERSIANN data consisted of a number of files with each file containing precipitation data with the date in the file name. For example, the file CDR_19930601z.asc is an ASCII file with precipitation for year as 1993, month 06 (June), and day 01 (first). As shown below, these ASCII files were converted to rasters files and save in another output folder. In order to preserve the date information in the raster name, the ModelBuilder tool iterates through each ASCII file in the folder and creates a precipitation raster with the same name in the output folder.

- Folder of Input data = \...\Mongolia_UTM\Before\Persiann\ASCII
- Folder of Output data = \...\Mongolia_UTM\Before\Persiann\Raster
- Name of ModelBuilder tool = Model_ASCII_to_Raster

ArcMap 10.2.1 was used for this workshop. You can create the following ModelBuilder tool from steps in this workshop. However, a completed ModelBuilder tool (**Precip_Tools.tbx**) is provided in the folder \...\Mongolia_UTM\Before\Persiann\ModelBuilder and can be added and used in ArcToolbox.

To create your own Model Builder tool:

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a. Open **ArcMap** => **Blank Map** => **OK**.
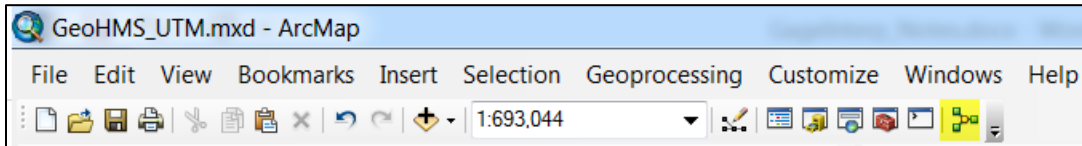b. Click on the **ModelBuilder** tool or **Geoprocessing** => **ModelBuilder** (highlighted in Figure 34).

Figure 34: ModelBuilder Tool

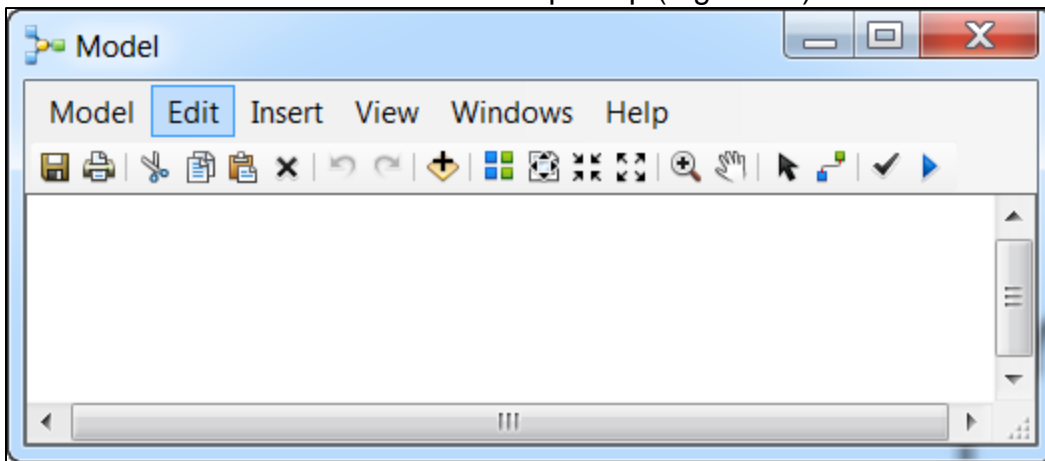c. A blank ModelBuilder window will open up (Figure 35).

Figure 35: ModelBuilder Window

d. Click **Insert** => **Iterators** => **Files** to add an iterator to the ModelBuilder project which will loop through all of the files in a folder**.**
e. Double-click **Iterate Files.**
f. Select **Folder** => **ASCII** (the location of the folder that holds all the ASCII files) (Figure 36)**.**
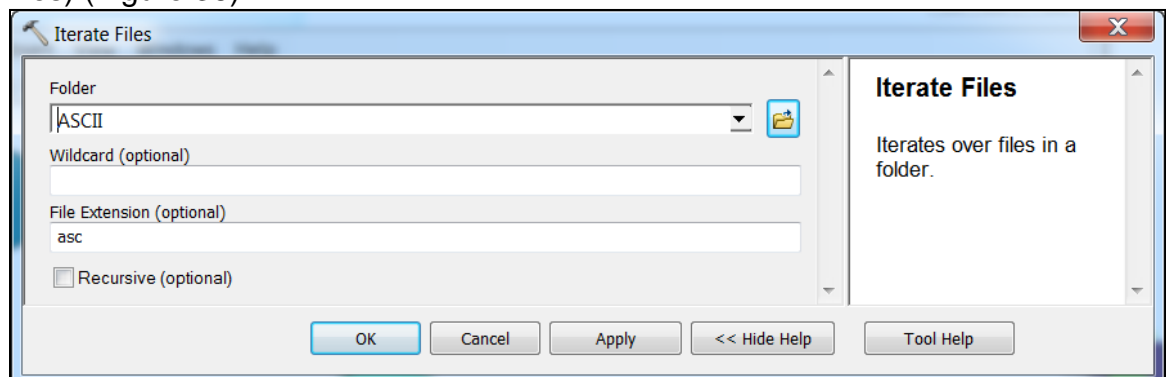
Figure 36: Iterate Files

g. Enter **File Extension** => **asc** (this will specify the extension of the files that will only be used in the process).
h. Click **OK.**

i. **Click on Geoprocessing** => **ArcToolbox** => **Conversion Tools** => **To Raster** => **Drag ASCII to Raster** (Figure 37) into the ModelBuilder project.
j. Click on **Connect Tool** (Figure 38) and **connect File.asc** to **ASCII to Raster.**
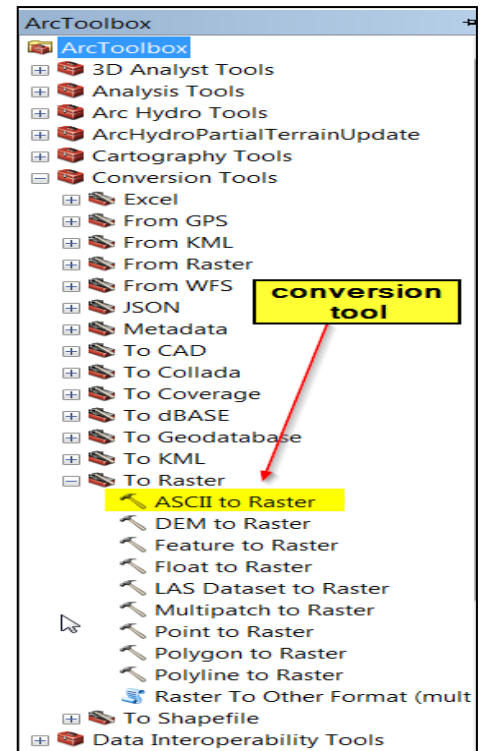
Figure 37: ASCII to Raster Tool
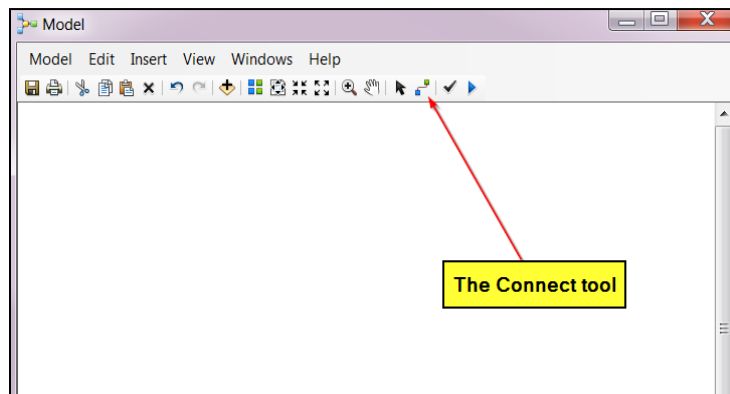
Figure 38: The Connect Tool

k. Within the ModelBuilder window, double-click **ASCII to Raster.**
l. **Input ASCII raster file** => **File.asc (**Figure 39**).**
m. Create folder \...\Mongolia_UTM\Before\Persiann\Raster with Windows Explorer.
n. **Output raster** should be saved to a different folder \...\Mongolia_UTM\Before\Persiann\Raster\ **%name%.** The variable, %name%, is used to preserve the filename (containing date information) of the input data.
o. **Enter Output data type (optional): FLOAT.**
p. Click **OK.**
q. **Model** => **Run.**
r. Click **Close.**

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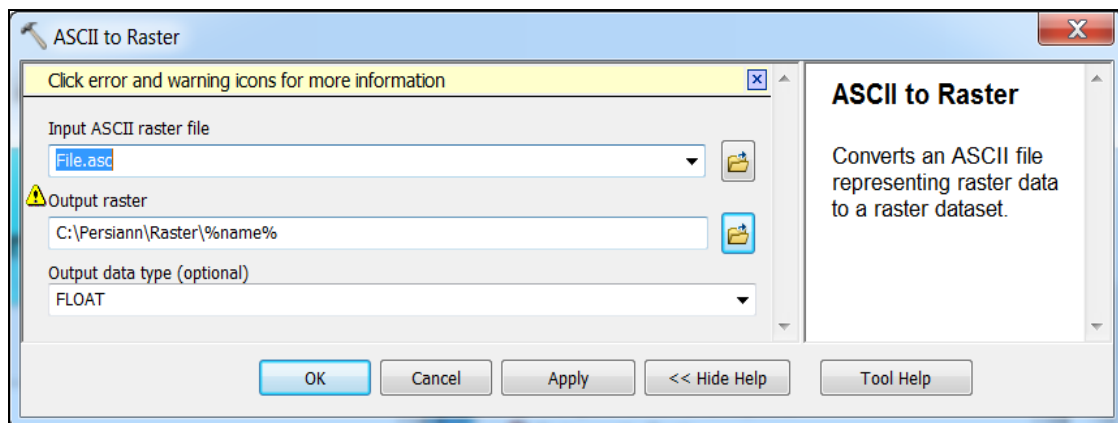
Figure 39: ASCII to Raster Parameters

The final product for the ModelBuilder tool should be similar to Figure 40 and the folders should look like Figure 41 (ASCII Input Data) and Figure 42 (ESRI raster Output Data).
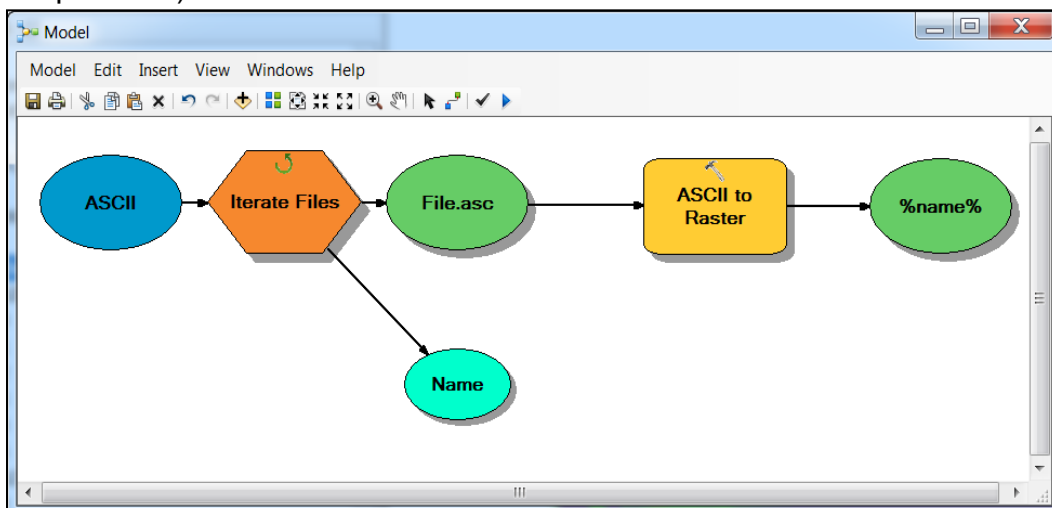
Figure 40: ModelBuilder with ASCII to Raster
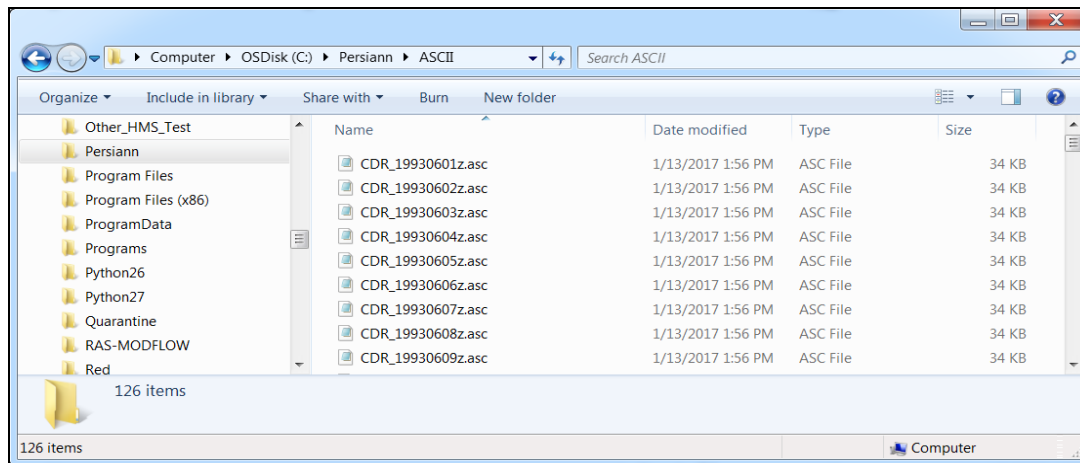
Figure 41: ASCII Input Folder
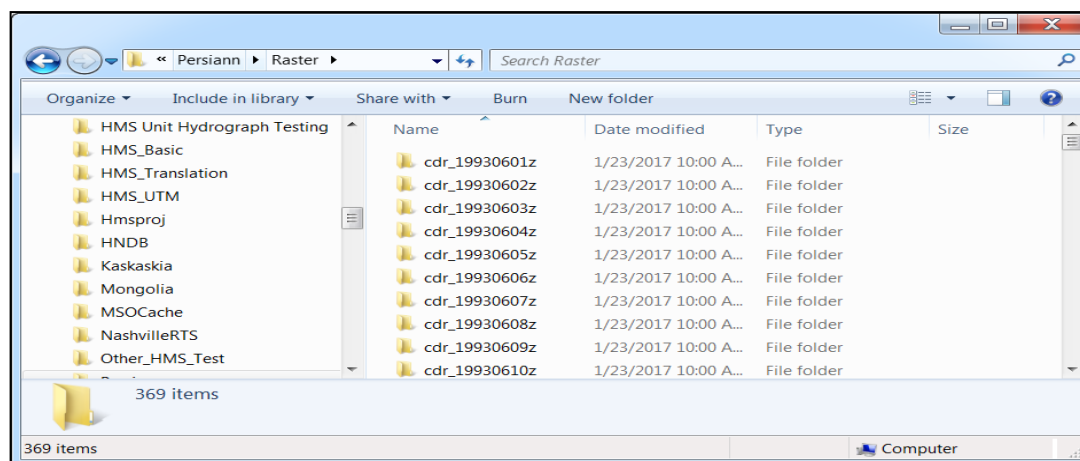
Figure 42: Raster Output Folder

Step 2 – Assign Projection Information to the Precipitation Raster Files

In this step, a new ModelBuilder tool is created to iterate through each precipitation raster and add the projection information (file prj.adf) into each raster folder. The projection is defined as World Geographical System (WGS84).

- Folder of Input data = \...\ Mongolia_UTM\Before\Persiann\Raster
- Folder of Output data = \...\Mongolia_UTM\Before\Persiann\Raster
- Name of ModelBuilder tool = Define_Projection_WGS

a. Open a blank ModelBuilder tool.
b. Click **Insert** => **Iterators** => **Rasters.**
c. Double-click **Iterate Rasters.**

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d. Enter **Workspace or Raster Catalog** => **Raster** and select the folder that has Raster data.
e. Click **OK.**
f. Click on **Geoprocessing** => **ArcToolbox** => **Data Management Tools** => **Projections and Transformations** => Drag **Define Projection** (Figure 43) into ModelBuilder.
g. Click on the **Connect tool** and connect **cdr_19930601z.asc** to **Define Projection.**
h. Double-click on **Define Projection.**
i. **Input Dataset or Feature Class** should already be filled.
j. **Enter Coordinate System** => **Geographic Coordinate Systems** => **World** => **WGS 1984** (Figure 44).
k. Click **OK.**
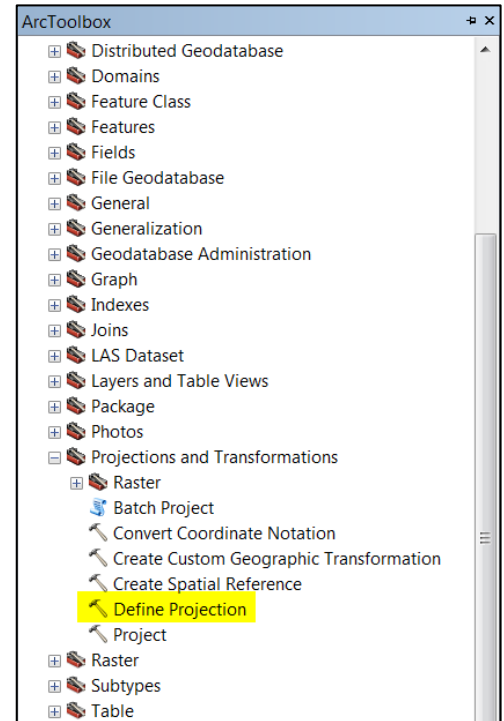
Figure 43: Define Projection Tool
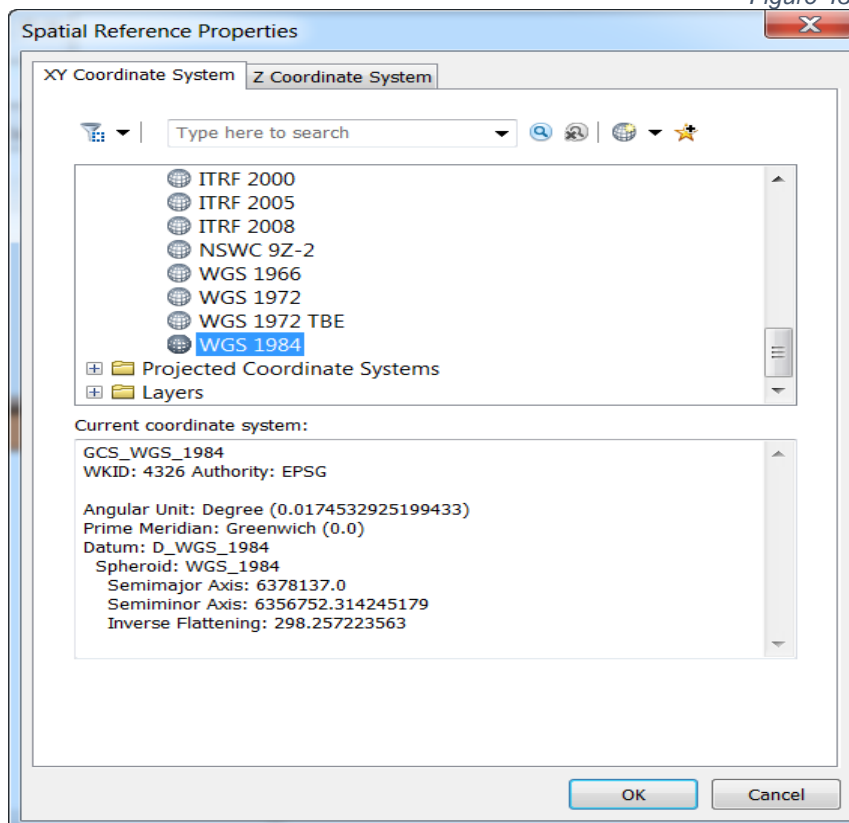
Figure 44: Spatial Reference Properties

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l. **Model** => **Run** as shown in Figure 45.
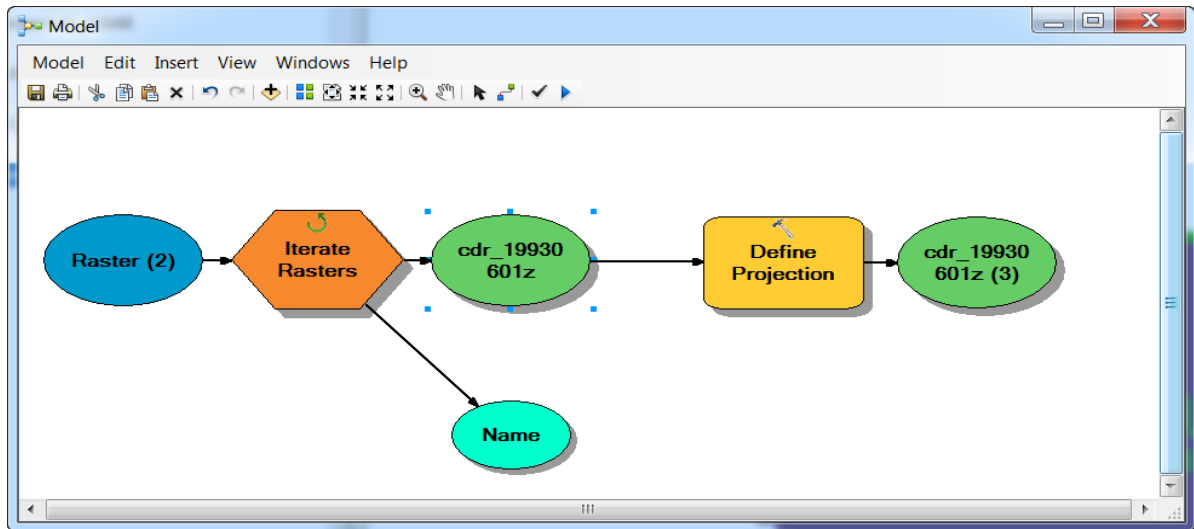
Figure 45: ModelBuilder Define Projection

m. The resulting projection file, **prj.adf**, is added to each raster as shown in Figure 46.
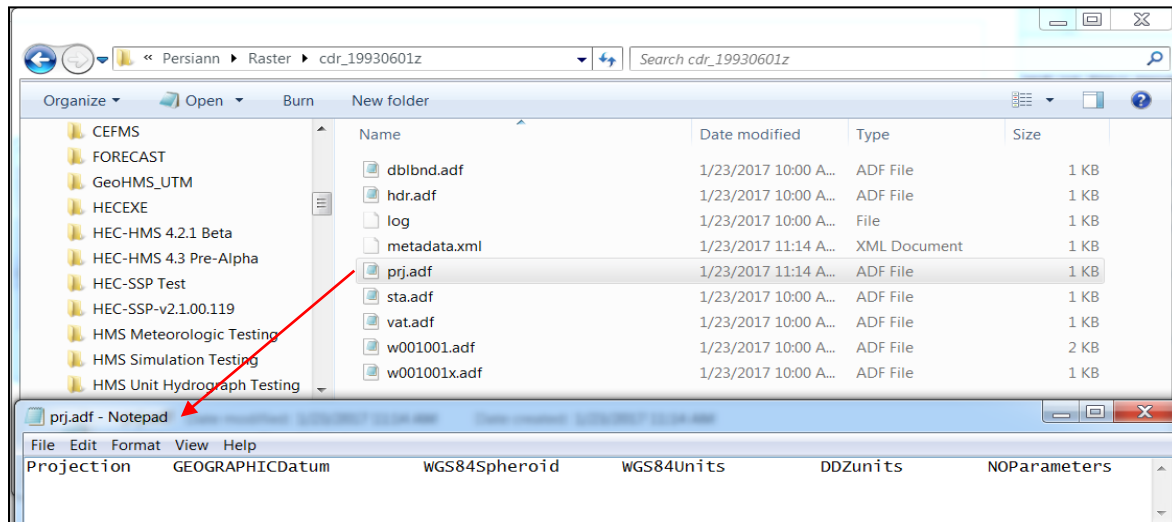
Figure 46: Output Projection File WGS

Step 3 – Reproject from WGS to UTM zone 48N and Resample the Cell Size to 2000 Meters

In this step, a new ModelBuilder tool is created to iterate through each precipitation raster and re-project the raster to UTM Zone 48 N and save projected rasters in another output folder. It is also important to resample the grid to a 2000 meter cell size so that the precipitation rasters are aligned with the ModClark grid created using GeoHMS. The ModelBuilder tool iterates through each raster file in the folder and creates a reprojected raster with the same name in the output folder.

- Folder of Input data = \...\ Mongolia_UTM\Before\Persiann\Raster
- Folder of Output data = \...\Mongolia_UTM\Before\Persiann\UTM
- Name of ModelBuilder tool = Project_UTM

a. Create the folder \...\Mongolia_UTM\Before\Persiann\UTM with Windows Explorer.
b. Start a new ModelBuilder project.
c. Click **Insert** => **Iterators** => **Rasters.**
d. Double-click **Iterate Rasters.**
e. Enter **Workspace or Raster Catalog** => **Raster** (the folder that has Raster data).
f. Click **OK.**
g. Click on **Geoprocessing** => **ArcToolbox** => **Data Management Tools** => **Projections and Transformations** => **Raster** => drag **Project Raster** (Figure 47) into the ModelBuilder project.
h. Click on **Connect** and connect **cdr_19930601z to Project Raster.**
i. Double-click on **Project Raster.**
j. **Input Raster** should already be filled.
k. **Output Raster Dataset** should be a different folder \...\Mongolia_UTM\Before\Persiann\UTM \%name%
l. Select **Output Coordinate System** => **Projected Coordinate Systems** => **UTM =>** **WGS 1984** => **Northern Hemisphere** => **WGS 1984 UTM Zone 48N (**Figure 48**).** Click **OK.**
m. Select **Sample Technique (optional): Bilinear.**
n. Enter **Output Cell Size (optional): X = 2000** and **Y= 2000.** The output cell size of 2000 is important in order to match the 2000-meter cell size in the ModClark grid cell file.
o. Enter **Registration Point (optional): X Coordinate = 0** and **Y Coordinate = 0.** The registration point at (0, 0) is important in order to match with the origin coordinate of the ModClark grid cell file.
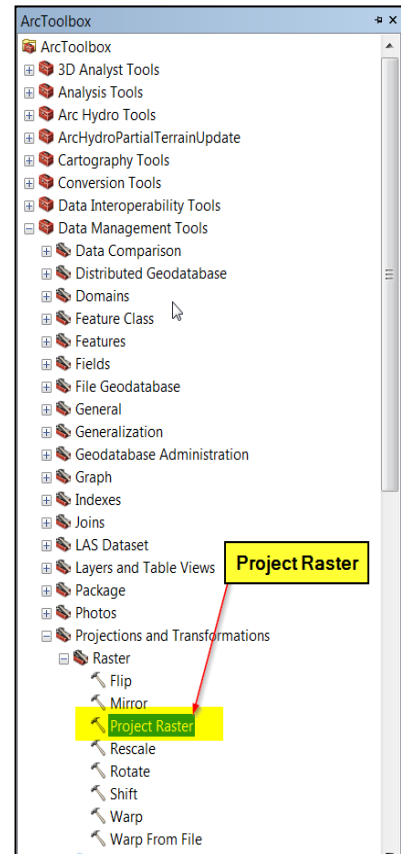
Figure 47: Project Raster

p. Click **OK.**

Figure 48: Project Raster Parameters
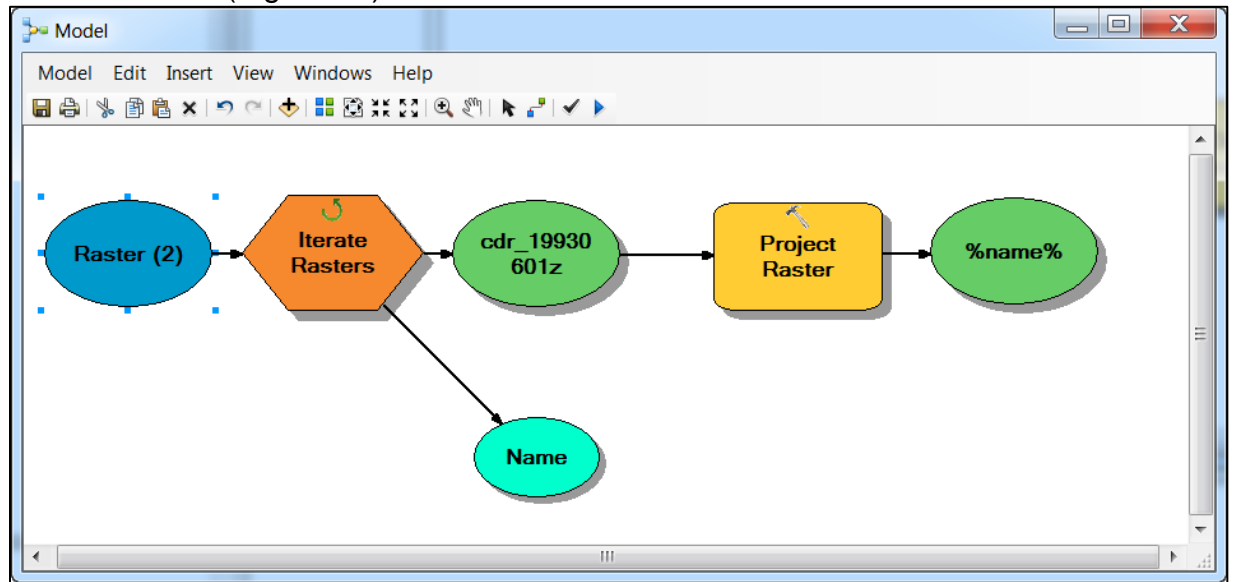
q. **Model** => **Run** (Figure 49).

Figure 49: ModelBuilder Project UTM

r. The resulting Raster is in UTM folder (Figure 50)**.**
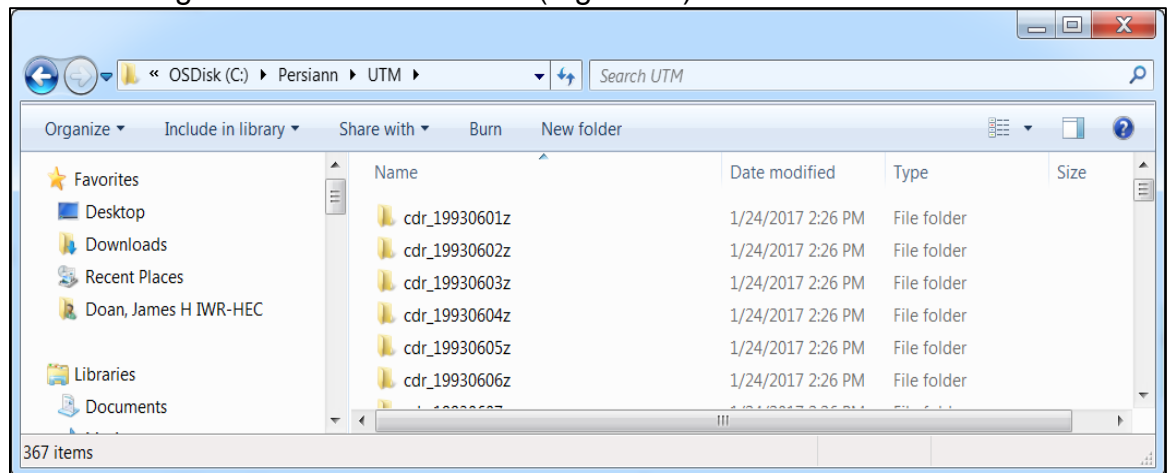

Figure 50: Project Raster Output Folder

Step 4 – Convert UTM Rasters to ASCII Files

The PERSIANN data is now in raster format with the desired UTM coordinate system and cell size. The last ModelBuilder tool described below will iterate through each raster and export the raster to an ASCII file in another output folder. The resulting ASCII files also contain the same name as the input raster files. These ASCII files will be imported later into a DSS file for use within HEC-HMS.

- Folder of Input data = \...\Mongolia_UTM\Before\Persiann\UTM
- Folder of Output data = \...\Mongolia_UTM\Before\Persiann\UTM-ASCII
- Name of ModelBuilder tool = Raster UTM to ASCII

a. Create folder
   \...\Mongolia_UTM\Before\Persiann\UTM-ASCII
   using Windows Explorer.
b. Create a new ModelBuilder project.
c. Click **Insert** => **Iterators** => **Rasters.**
d. Double-click **Iterate Rasters** (Figure 52).
e. Enter **Workspace or Raster Catalog** => **UTM**
   the folder that has UTM Raster data.
f. Enter Raster Format (optional): **GRID.**
g. Click **OK.**
h. Click on **Geoprocessing** => **ArcToolbox** =>
   Conversion Tools => **From Raster** => Drag
   Raster to ASCII (Figure 51) into the
   ModelBuilder project.
i. Click on **Connect** and connect **cdr_19930601z**
   to **Raster to ASCII**.
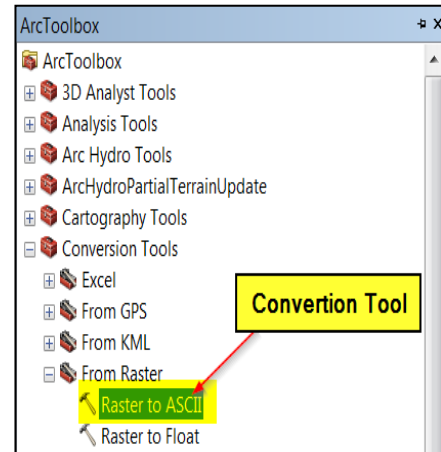
Figure 51: Raster to ASCII Conversion Tool
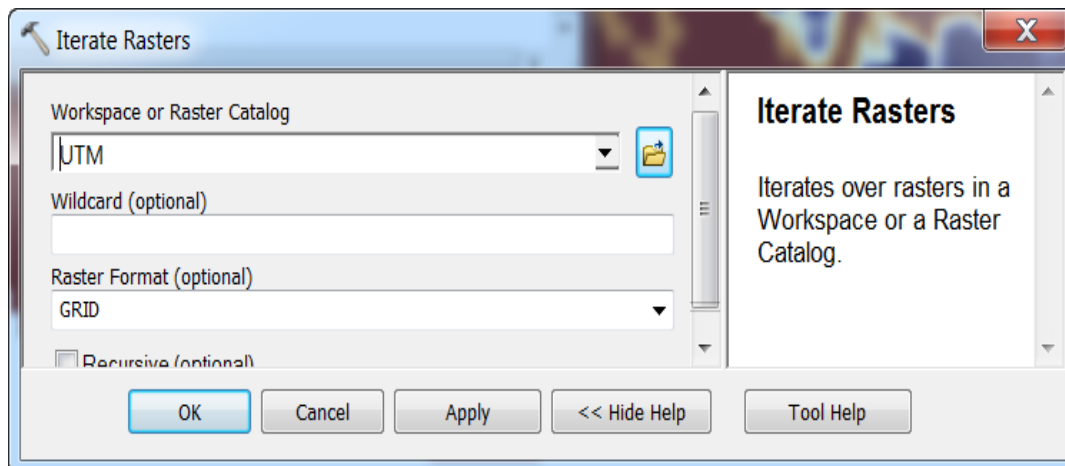
Figure 52: Iterate Rasters

j. Double-click on **Raster to ASCII.**
k. **Input Raster** (Figure 53) should already be filled.
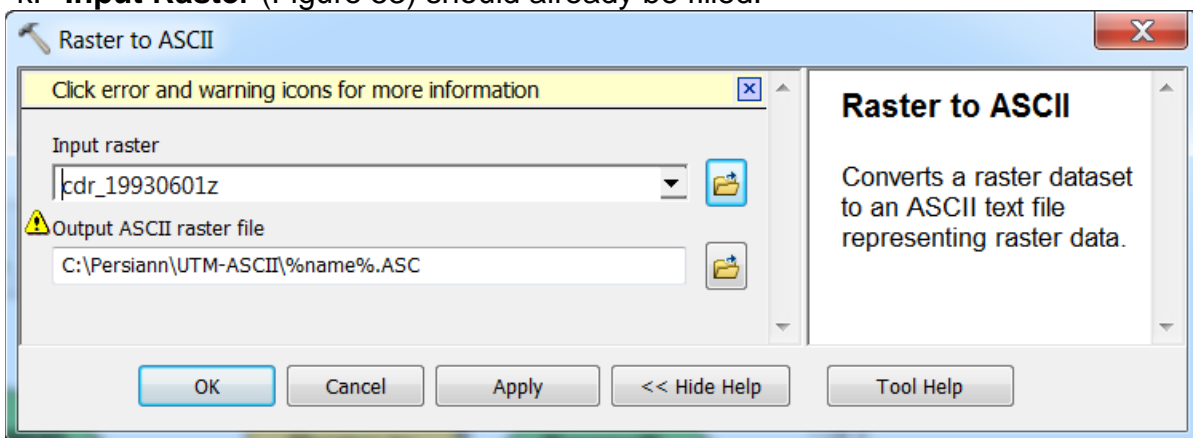
Figure 53: Raster to ASCII Parameters

l. **Output Raster Dataset** should be in a different folder
\...\Mongolia_UTM\Before\Persiann\ UTM-ASCII\%name%.ASC

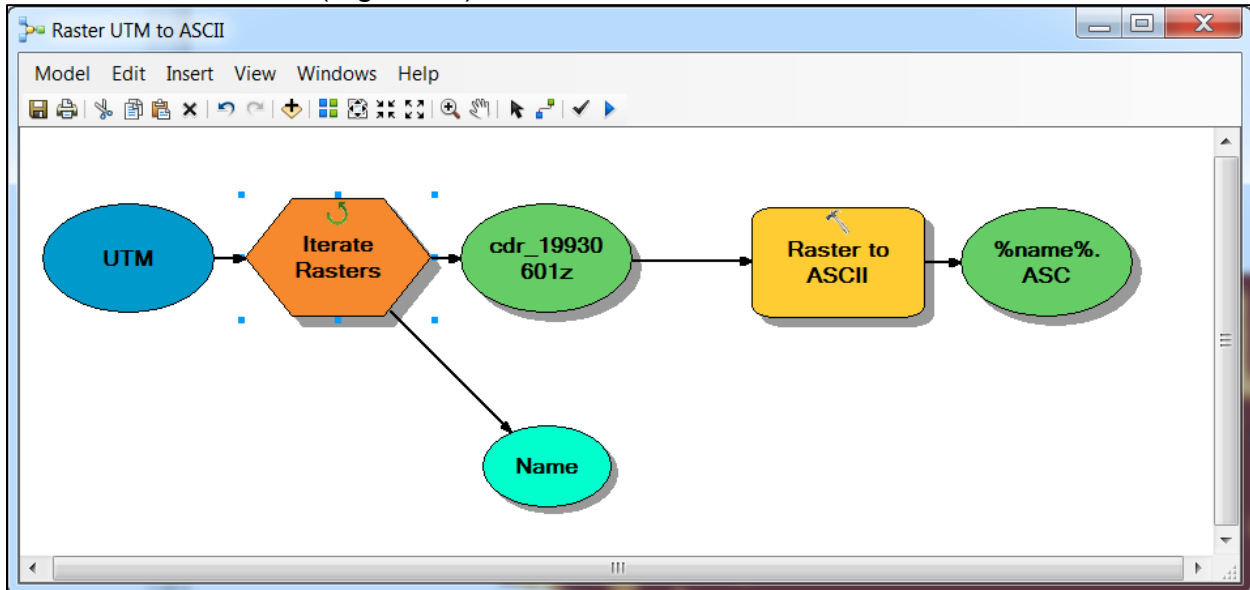m. Click **OK.**

n. **Model** => **Run** (Figure 54).

Figure 54: ModelBuilder Raster UTM to ASCII

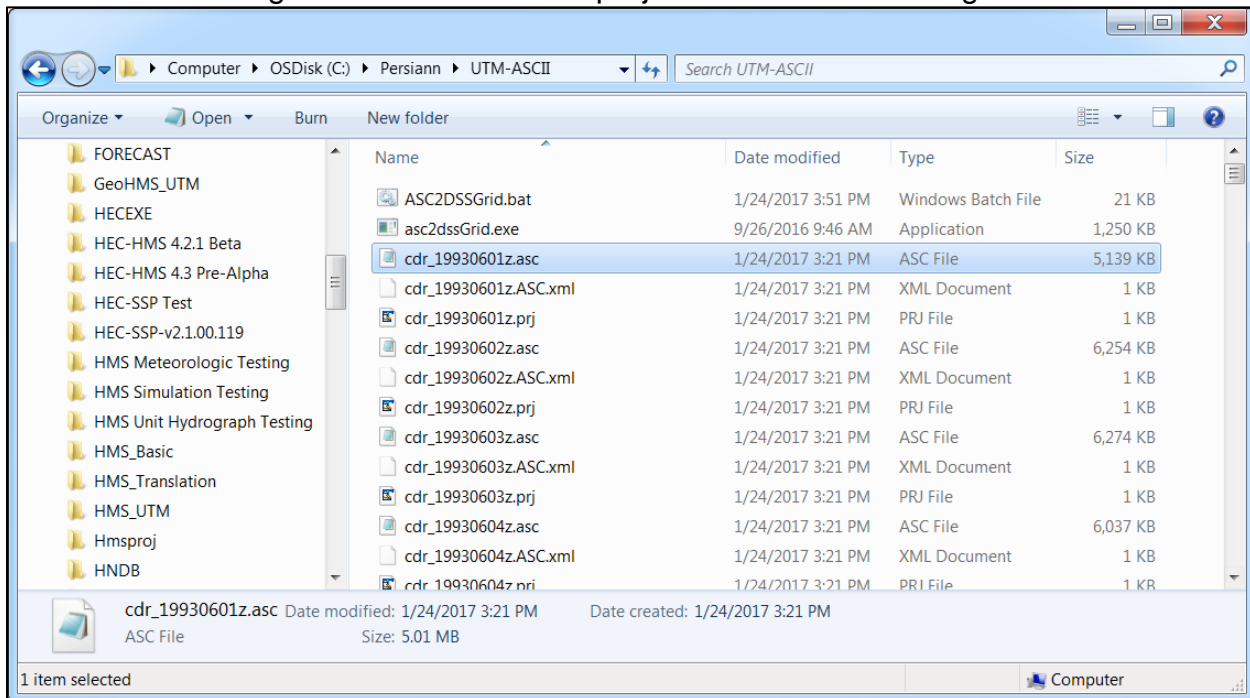o. The resulting ASCII files with UTM projection are shown in Figure 55.

Figure 55: Output Folder UTM-ASCII

Step 5 – Import ASCII Files to DSS

The previous steps showed how to reproject and resample the gridded PERSIANN satellite based precipitation data. The final step to process the ASCII files from Step 4 to gridded records in DSS rely on using the **ASC2DSSGrid** utility program. The ASC2DSSGrid program is a DOS based program that requires input information to convert an ASCII file to a DSS record. We will create a batch file to automate the import process. The batch file can be created with a text editor and saved with a *.**bat** extension. Each line in the batch file executes the ASC2DSSGrid utility program with parameters like input file, output DSS file, DSS pathname, dates, grid type, unit, and data type. After using the copy/paste command in the text editor, the user can edit the input file name, dates, etc. to import each ASCII file to DSS.

- Folder of Input data = \...\Mongolia_UTM\Before\Persiann\UTM-ASCII
- Folder of Output data = \...\Mongolia_UTM\Before\Persiann\UTM-ASCII

Copy the ASC2DSSGrid.exe file from the \...\Mongolia_UTM\Before\GageInterp\exe directory to the \...\Mongolia_UTM\Before\Persiann\UTM-ASCII Directory.

  a. Create a batch file, **GRID2DSSGrid.bat**, with a text editor.
  b. The first line in the file should call the set command to put the directory containing asc2dssGrid.exe onto the PATH environment variable:

      Set PATH=C:\HECEXE\;%PATH%

      Substitute your actual install directory for "C:\HECEXE\ if it's different.
  c. For each ASCII file, a command line should be used as shown below. With copy and paste, the user can edit each command line with appropriate input filename and time **(**Figure 56**)**.
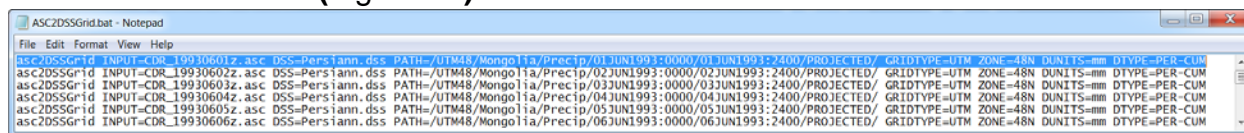

Figure 56: ASCE2DSSGrid Batch File

The following command is used to convert the ASCII file with precipitation on June 1, 1993 to a DSS record.

asc2DSSGrid INPUT=CDR_19930601z.asc DSS=Persiann.dss PATH=/UTM48/Mongolia/Precip/01JUN1993:0000/01JUN1993:2400/PROJECTED/ GRIDTYPE=UTM ZONE=48N DUNITS=mm DTYPE=PER-CUM

  d. Run the batch file by double-clicking on the **GRID2DSSGrid.bat** file.

e. The resulting DSS file, PERSIANN.DSS, contains gridded precipitation records from each data file from June 1 to September 30, 1993 and is shown in HEC-DSSVue in Figure 57 and Figure 58.
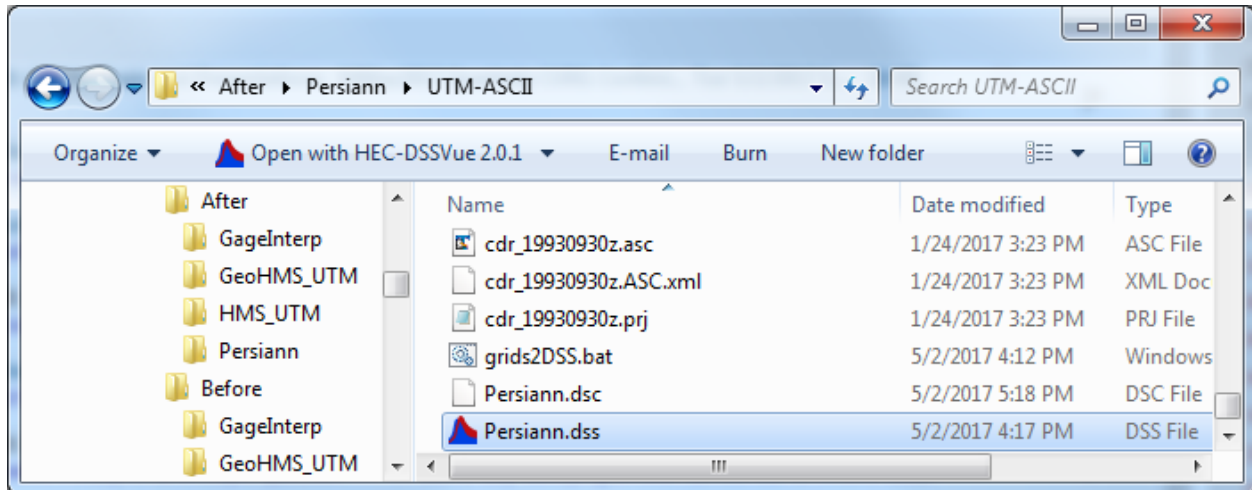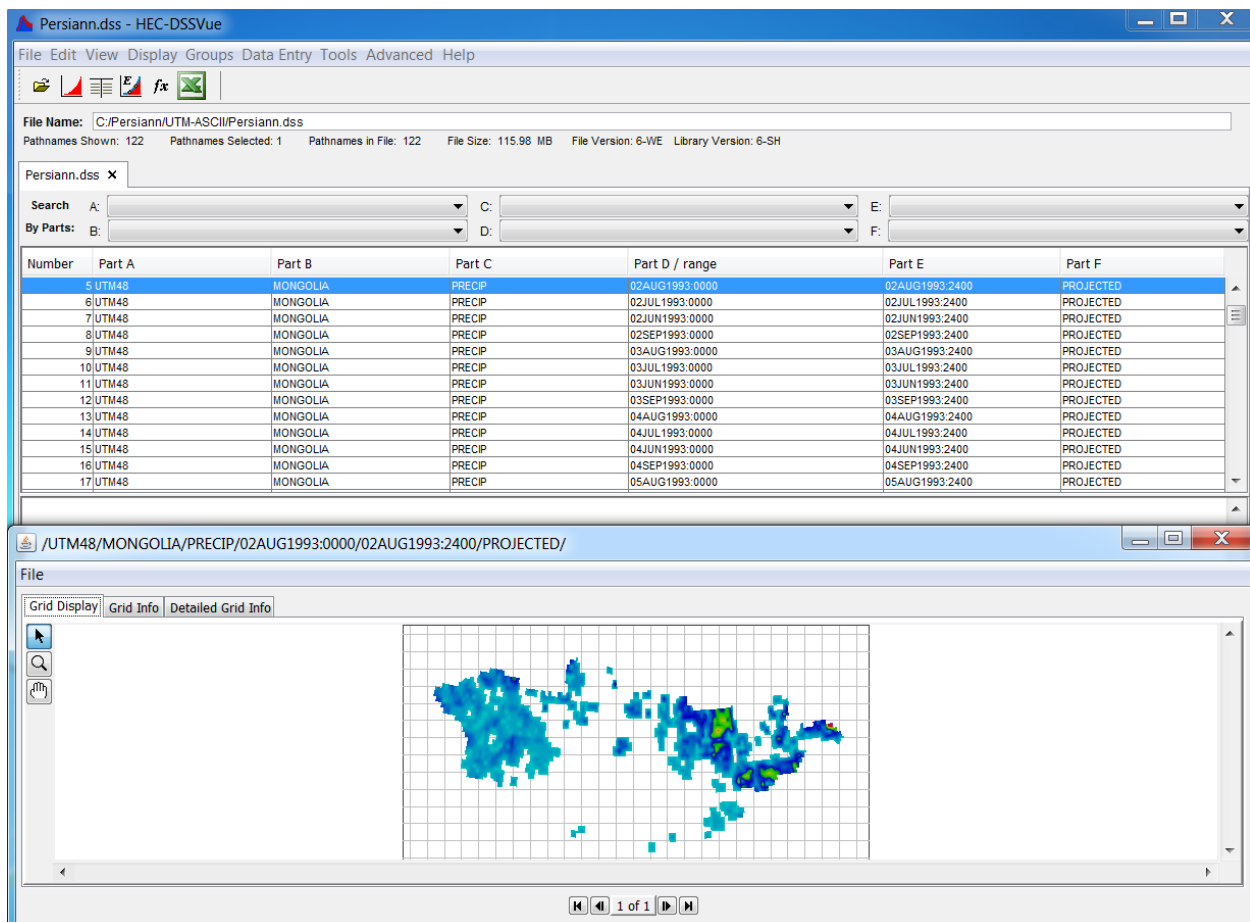

Figure 57: PERSIANN-CDR DSS File

Figure 58: HEC-DSSVue with PERSIANN-CDR Data

Task 4: Calibrate an HEC-HMS Model to Multiple Precipitation Sources.

This task demonstrates how to add gridded precipitation to an HEC-HMS project. Many of the steps needed to create and configure an HEC-HMS project have already been completed for you. In this task, we will use the previously developed precipitation data (from GageInterp and the satellite based information) and create simulation runs with HEC-HMS model. The HEC-HMS model contains the following four simulation runs below.

A. Point Rainfall with the Clark unit hydrograph method,
B. Gridded precipitation from GageInterp with the Clark unit hydrograph method,
C. Gridded Precipitation from GageInterp with the ModClark transform method,
D. Gridded Precipitation from PERISIANN-CDR with the ModClark transform method.

With most of the HMS model setup already completed, we only will need to setup the meteorologic models. The HEC-HMS model was setup by importing the basin model from the GeoHMS project and the subbasin and stream shapefiles for background map visualization. The grid cell file was imported as well in order to use gridded precipitation. Refer to the HEC-HMS User's manual for loading the grid cell parameter file into a basin model. After populating required hydrologic modeling parameters, the model was calibrated to observed streamflow gages. The HEC-HMS data structure is shown in the Watershed Explorer (Figure 59) and the Basin Model (Figure 60).
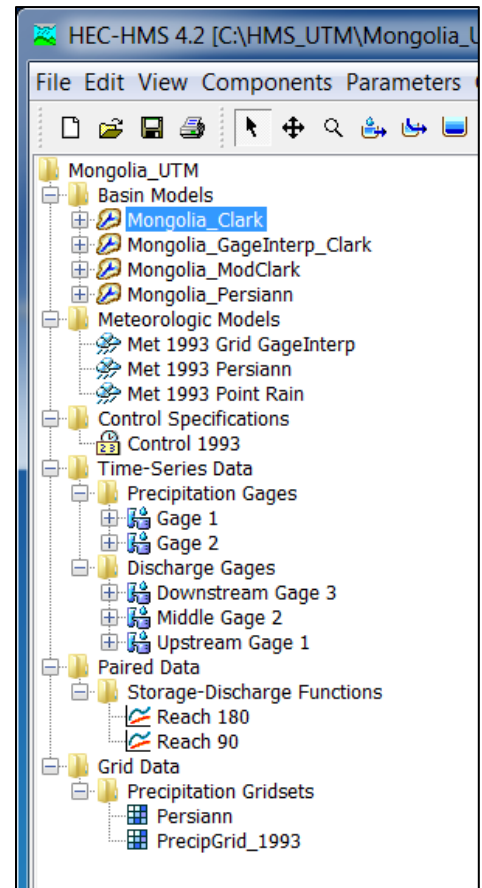
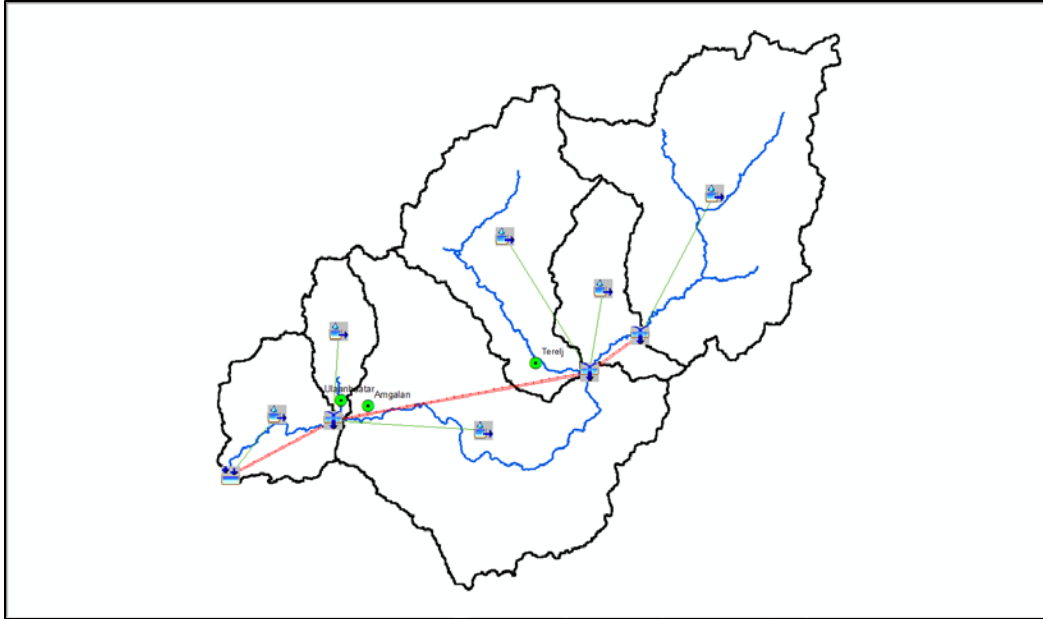*Figure 59: HMS Data Structure*

Figure 60: Overview HEC-HMS Basin Model

Below are HEC-HMS model calibration steps for adjusting hydrologic parameters and comparing simulated and observed hydrographs at gage locations. It is important to understand the impact from each model parameter and to adjust model parameters within a reasonable range.

Loss Parameters

- Loss parameters can be adjusted to increase the runoff volume
- Select the **Parameters ⇒ Loss ⇒ Initial and Constant Loss** menu option to open the *Initial and Constant Loss* global parameter editor.
- Adjust the loss rate to better match the computed runoff volume and peak flows with observed data.

Baseflow

- Adjust the **Baseflow** rate to better match the computed runoff volume with observed data.

Clark Unit Hydrograph Parameters

- Adjust the **Clark** unit hydrograph parameters control the hydrograph peak flow timing and magnitude.

Nash-Sutcliffe value

- Compare the **Nash-Sutcliffe** value with each calibrate run. This number should be close to 1. The total runoff volume should be similar to the observed runoff volume.

A. Point Rainfall Applied to the Clark Unit Hydrograph Transform Method

This modeling option has been completed for you. The precipitation gage data was loaded into the project and the model was calibrated to observed flow at two locations.

In this step, we will utilize point rainfall **(**Figure 61 to Figure 63**)** as specified hyetographs in the meteorologic model. The same two precipitation gages used to create gridded precipitation were used directly for subbasin rainfall. The closest precipitation gage was assigned to each subbasin. The user can refer the **HEC-HMS User's and Technical Reference Manuals** for description about the Clark and ModClark Unit Hydrograph transformation method.
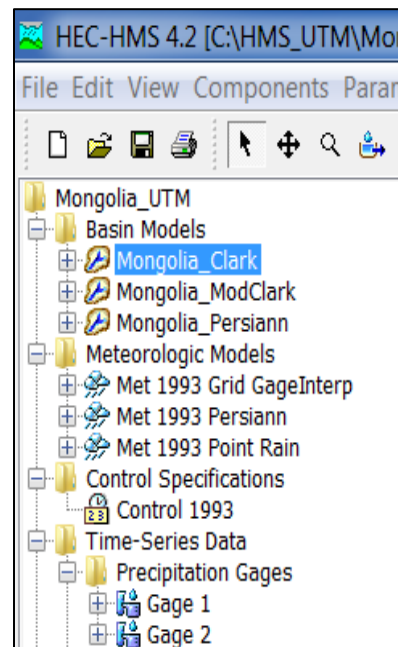
Figure 61: Point Rainfall
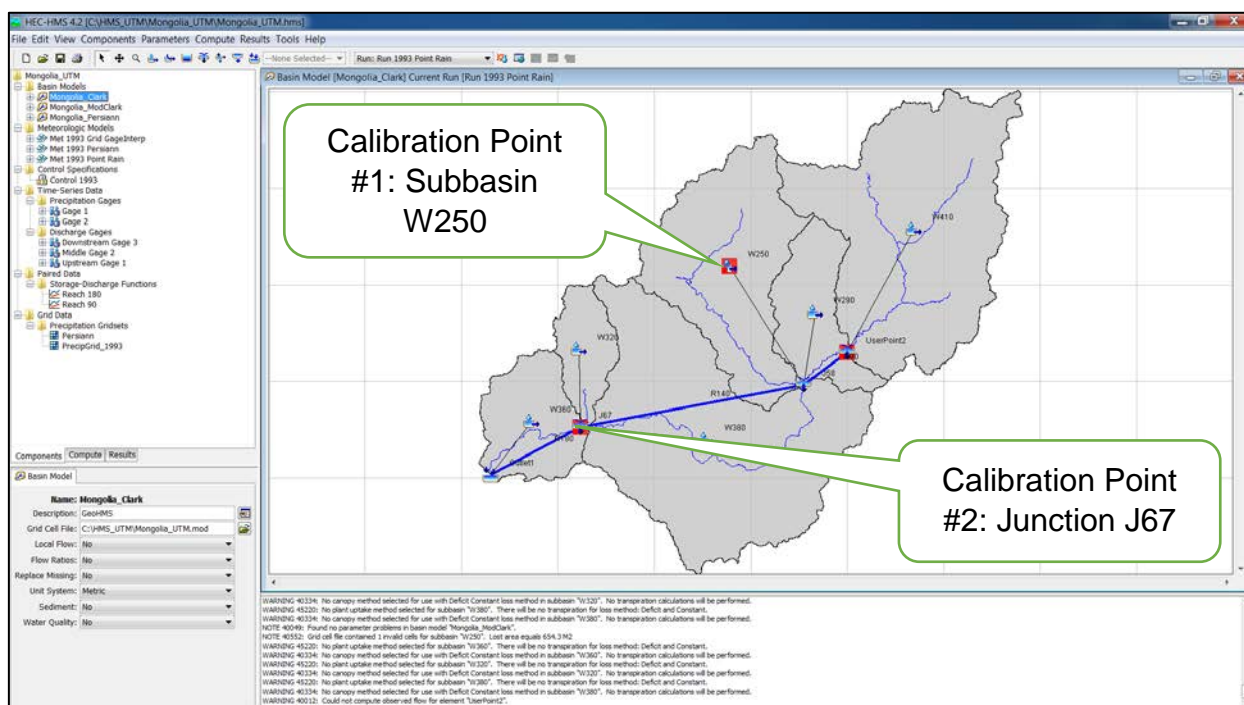
Figure 62: Calibration Points

The **Observed.DSS** contains point rainfall and streamflow gage data. Two precipitation gages were added to the HEC-HMS project and they were linked to records in the observed.dss file, as shown in Figure 63.

Below are the steps for setting up the meteorologic model:
1. Add a new meteorological model to the project.

      a. Select the Specified Hyetograph method and link the meteorologic model to the correct basin model.
2. Add 2 new precipitation gages and link them with the observed.dss DSS file (Figure 63).
3. Within the meteorological model created in step 1, link each subbasin to the closest precipitation gage.
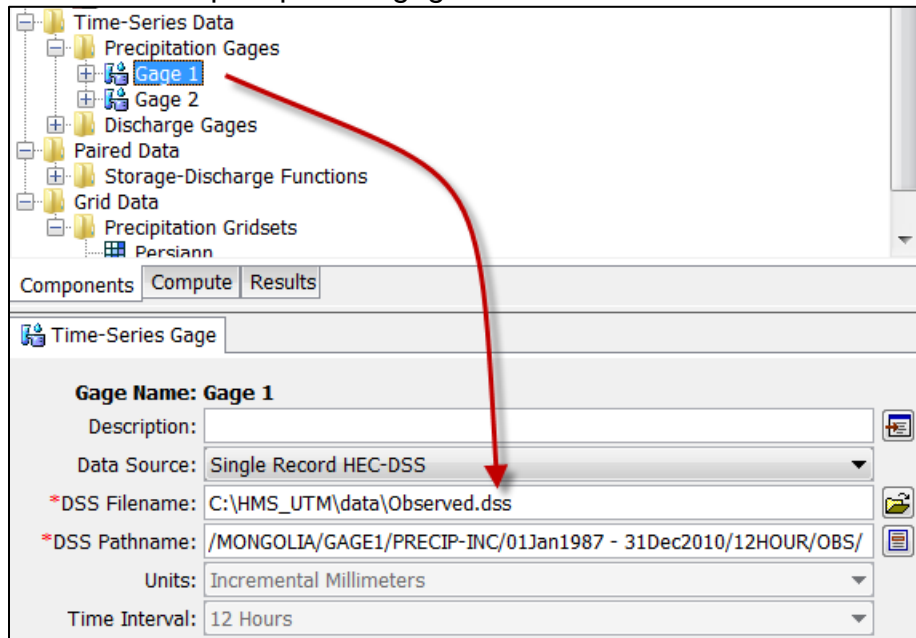

Figure 63: Point Rainfall Precipitation Gage

As shown in Figure 64, a simulation run was created and named Run 1993 Point Rain Clark. The simulation run combines the "Mongolia_Clark" basin model, the "Met 1993 Point Rain" meteorologic model, and the "Control 1993" control specifications. The simulation was computed and the simulated and observed flow hydrographs were compared at gage locations. Model parameters were adjusted to improve the model.
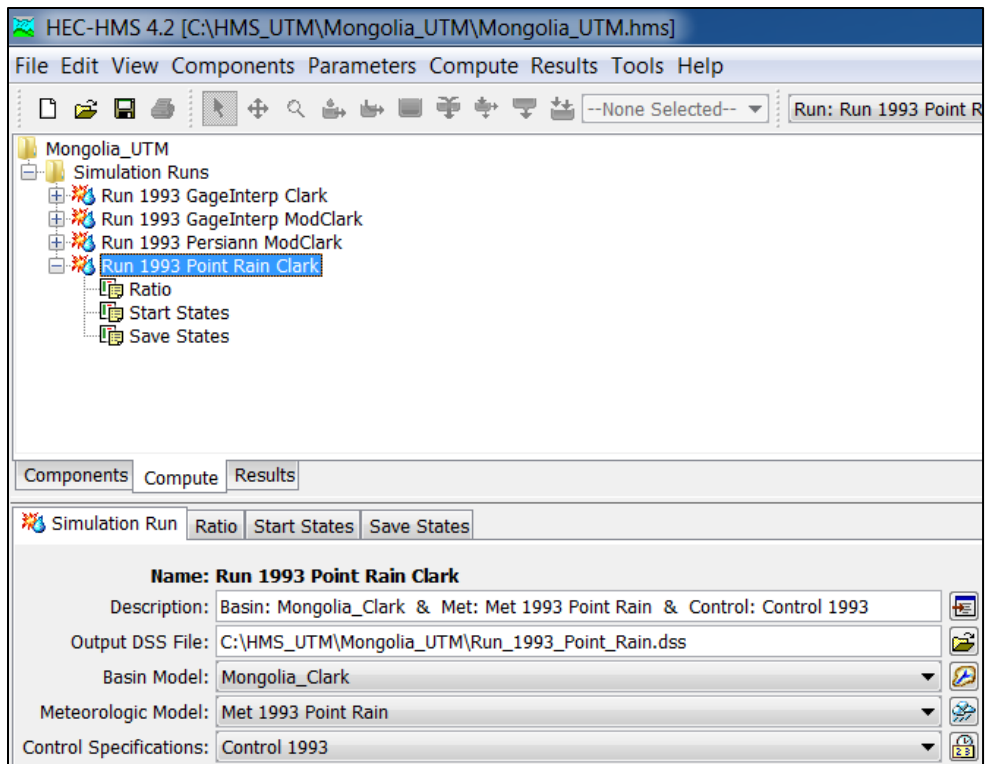
Figure 64: Simulation Run - Point Rain Clark Configuration

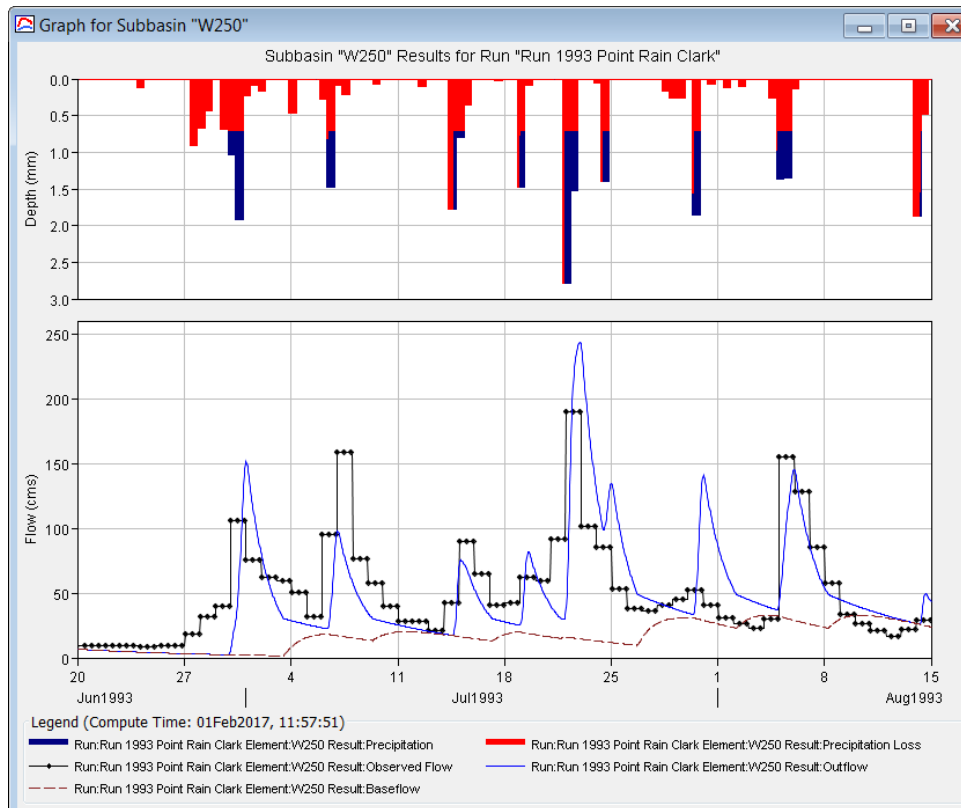Below are results at calibration point #1 at Subbasin W250 (Figure 65).

Figure 65: Graph Subbasin W250

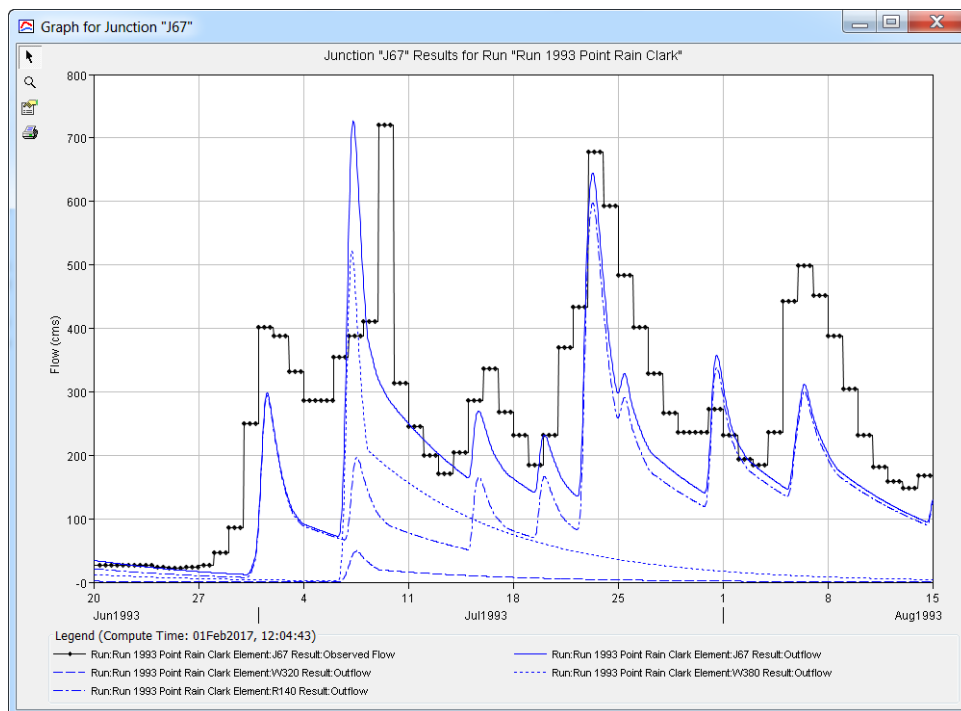Below are results at calibration point #2 at Junction J67 (Figure 66).

Figure 66: Graph for Junction J67

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B. Gridded Precipitation from GageInterp Applied to the Clark Unit Hydrograph Transform Method

Most of the steps in this modeling option have been completed for you. The gridded precipitation records created by GageInterp (Task 2) were loaded into the project. The only required step remaining is to select the right precipitation gridset in the meteorologic model. The basin model has already been calibrated for the gridded precipitation data set.
The following steps show how to load a new precipitation gridset.

1. Click **Components** => **Grid Data Manager** => **Precipitation Gridsets** and add two new precipitation gages, one can be named GageInterp and then other gridset can be named Persiann. Link the GageInterp gridset to the DSS file created by GageInterp in Task 2, the DSS file should be named PrecipGrid.dss.

2. Select Data Source: **Single Record HEC-DSS.**

3. Browse and select DSS Filename:
    \...**\Mongolia_UTM\Before\HMS_UTM\Mongolia_UTM\data\PrecipGrid.dss.**

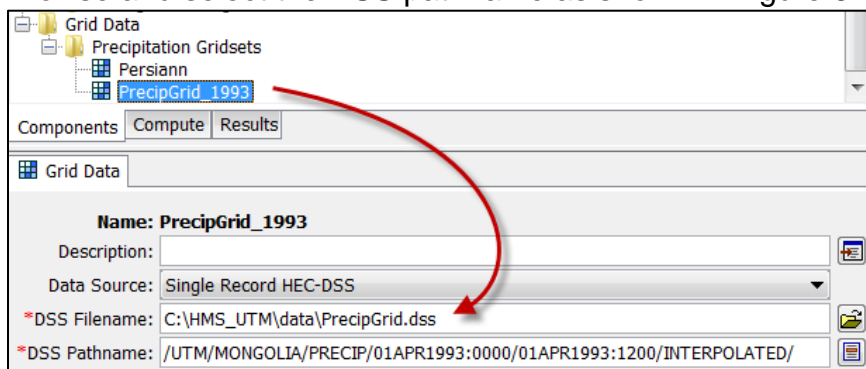4. Browse and select the DSS pathname as shown in Figure 67.

Figure 67: Grid-based Precipitation with GageInterp

The following step shows how to select the GageInterp gridset in the meteorologic model and then the results from the simulation using interpolated precipitation. The basin model parameters have already been adjusted so that the model matches observed flow. The model parameters are different than the basin model used in the rain gage modeling methods as the precipitation boundary condition is different. It is important to make the model is re-calibrated each time the boundary condition information changes.

5. Click on **Meteorologic Models** => **Met 1993 Grid GageInterp** => **Gridded Precipitation**. Select the Grid Name: **PrecipGrid_1993** from drop-down menu as shown in Figure 68.
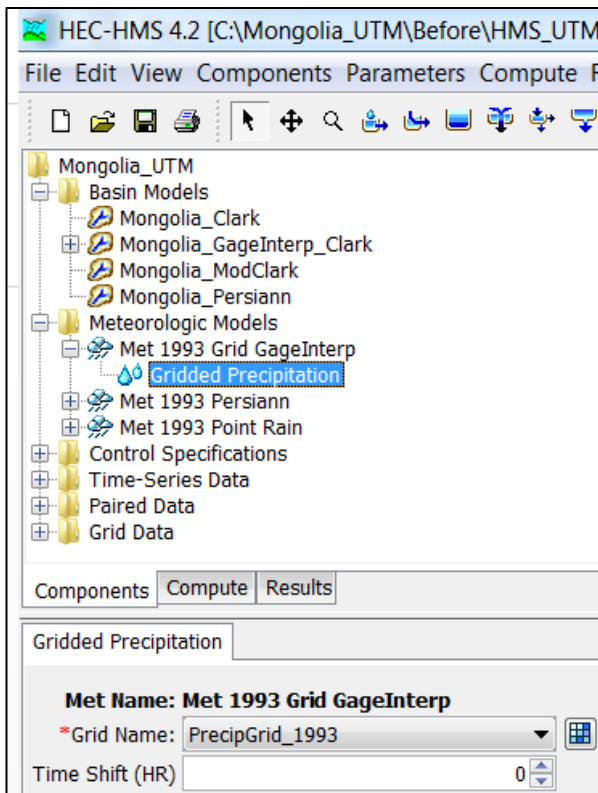
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Figure 68: GageInterp Gridded Precipitation

Below is Simulation Run 1993 GageInterp Clark in the Watershed Explorer, Figure 69.
The "Mondgolia_GageInterp_Clark" basin model is paired with the "Met 1993 Grid
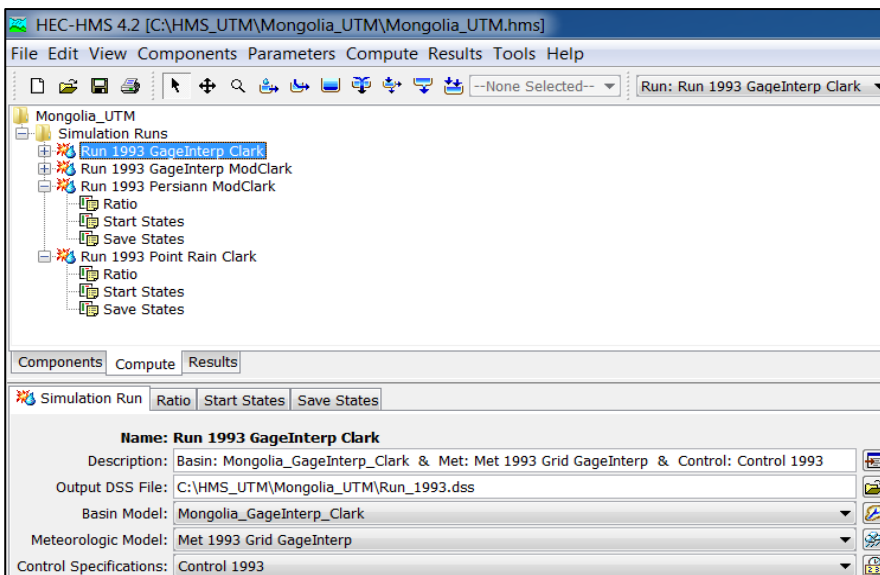GageInterp" meteorologic model.

Figure 69: Simulation Run - GageInterp Clark Configuration

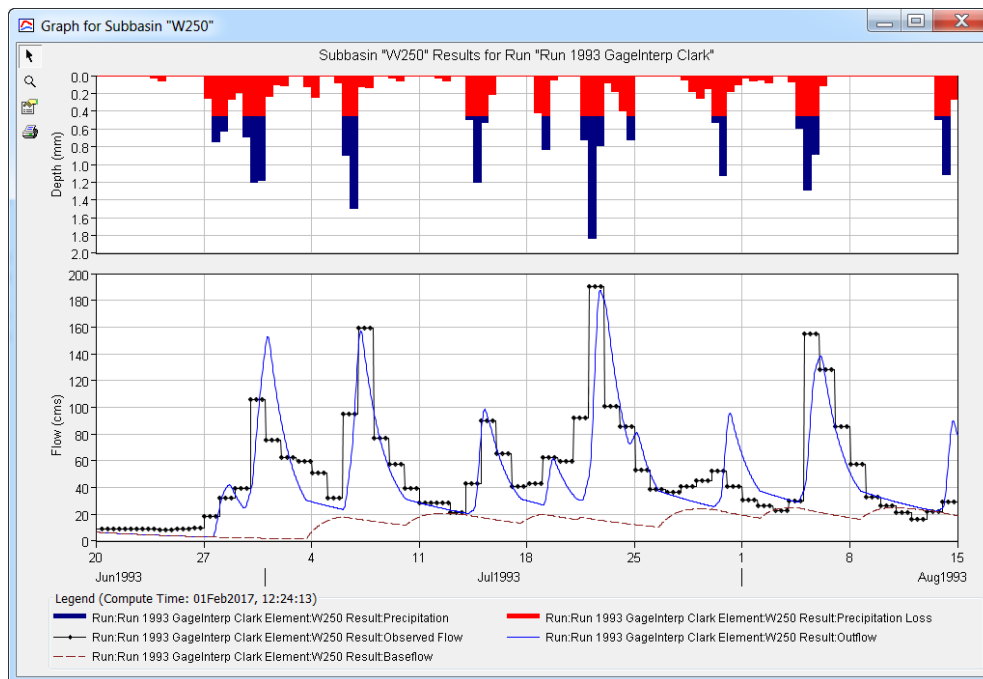Below are results at calibration point #1, at Subbasin W250 (Figure 70).

Figure 70: Result at Calibration Point #1 at Subbasin W250

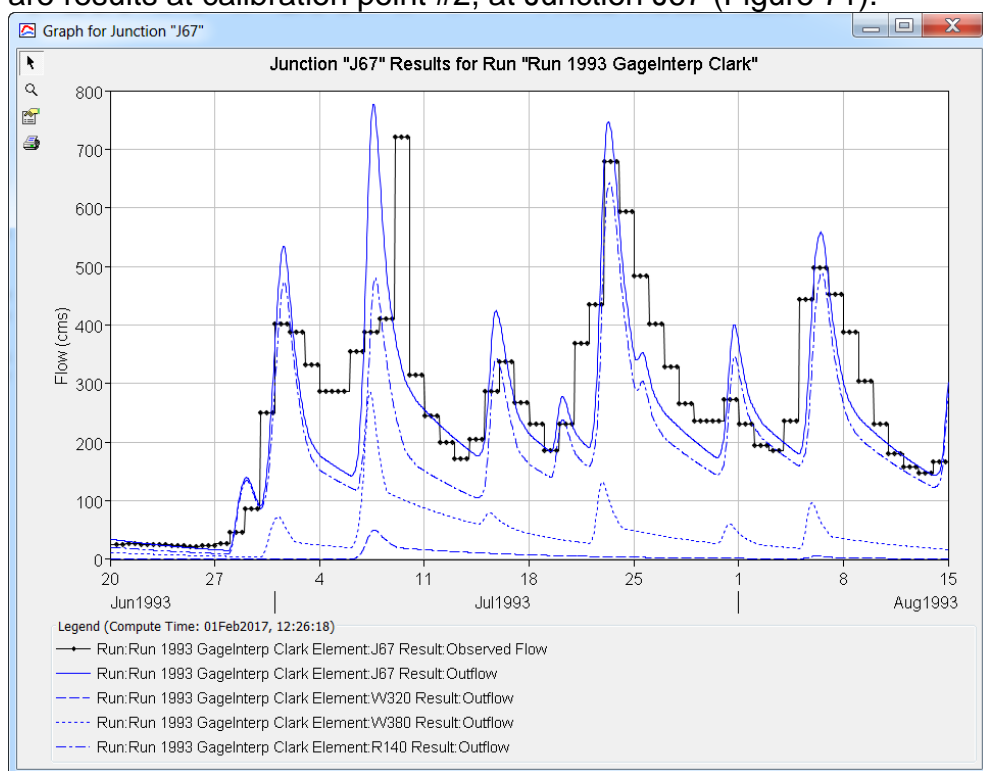Below are results at calibration point #2, at Junction J67 (Figure 71).

Figure 71: Result at Calibration Point #2 at Junction J67

C. Gridded Precipitation from GageInterp Applied to the ModClark Unit Hydrograph Transform Method

Most of the steps in this modeling option have been completed for you. The gridded precipitation records created by GageInterp (Task 2) were loaded into the project and the meteorologic model used in Task B above was already linked to the GageInterp precipitation gridset. The only required step remaining is to make sure the basin model has the grid cell file selected. The grid cell file is required so that HEC-HMS can map grid cells located within each subbasin to precipitation within the precipitation grids. The basin model has already been calibrated for the gridded precipitation data set and the change to the ModClark transform method.

Below is the simulation run named **Run 1993 GageInterp ModClark**, as shown in Figure. The simulation combines the "Mongolia_ModClark" basin model and the "Met 1993 Grid GageInterp" meteorologic model.
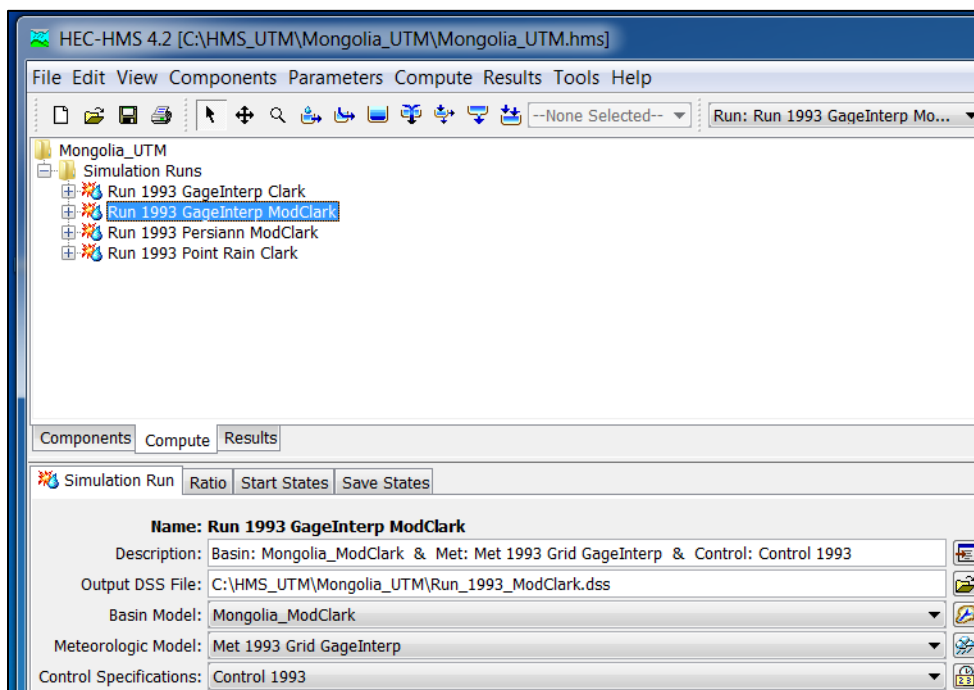

Figure 72: GageInterp ModClark Configuration

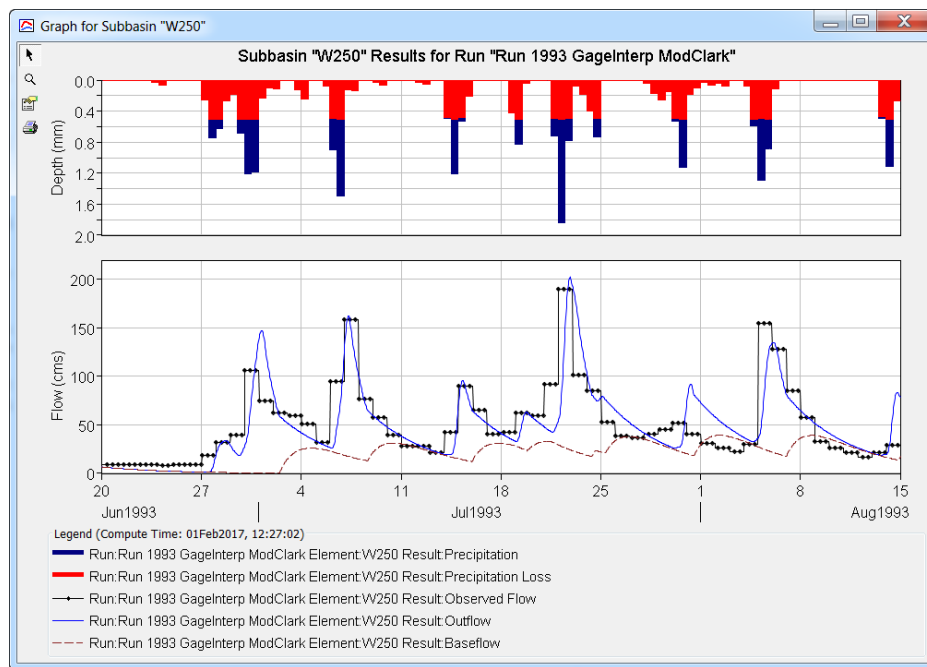Below are results at calibration point #1, at Subbasin W250 (Figure 73).

Figure 73: Calibration Point #1 at Subbasin W250

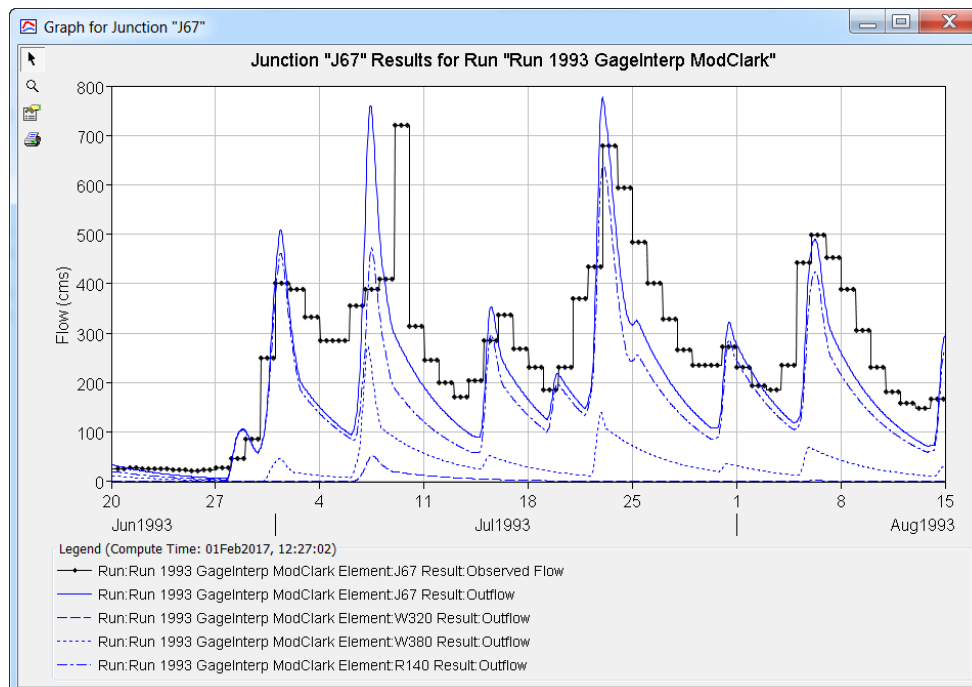Below are results at calibration point #2, at Junction J67 (Figure 74).

Figure 74: Calibration Point #2 at Junction J67

D. Gridded Precipitation from PERSIANN-CDR Applied to the ModClark Unit Hydrograph Transform Method

Most of the steps in this modeling option have been completed for you. The gridded precipitation records created when processing the PERSIANN satellite based precipitation (Task 3) were loaded into the project. You will need to update the meteorologic model to use the PERSIANN gridset, as described below.

The following steps show how to add a gridset and link it to a DSS file.

1. Click **Components** => **Grid Data Manager** => **Precipitation Gridsets.** Add a new precipitation grid set. Name the new gridset "**Persiann**".

2. Select Data Source: Single Record HEC-DSS.

3. Browse and select DSS Filename:
   \...\Mongolia_UTM\Before\HMS_UTM\Mongolia_UTM\data\ Persiann.DSS.
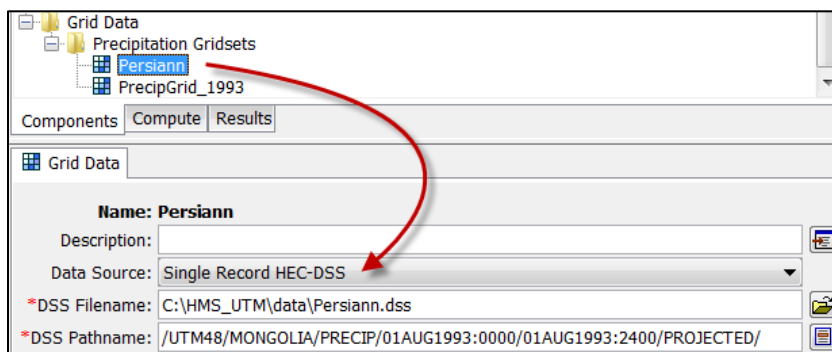
4. Browse and select DSS pathname as shown in Figure 75.

Figure 75: PERSIANN-CDR Precipitation Data

After the gridset has been added to the project, it can be reference in the "Met 1993 Persiann" meteorologic model.

- Click on **Meteorologic Models** => **Met 1993 Persiann** and open the **Gridded Precipitation** tab in the component editor.

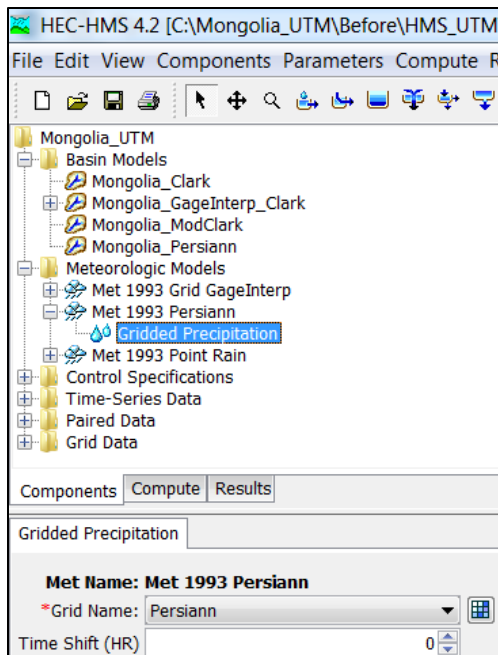- Select the **Persiann** grid from the drop-down menu as shown in Figure 76.

Figure 76: PERSIANN Gridded Precipitation

The simulation run named Run 1993 Persiann ModClark is shown in Figure 77. The simulation run combines the "Mongolia_Persiann" basin model and the "Met 1993 Persiann" meteorological model.
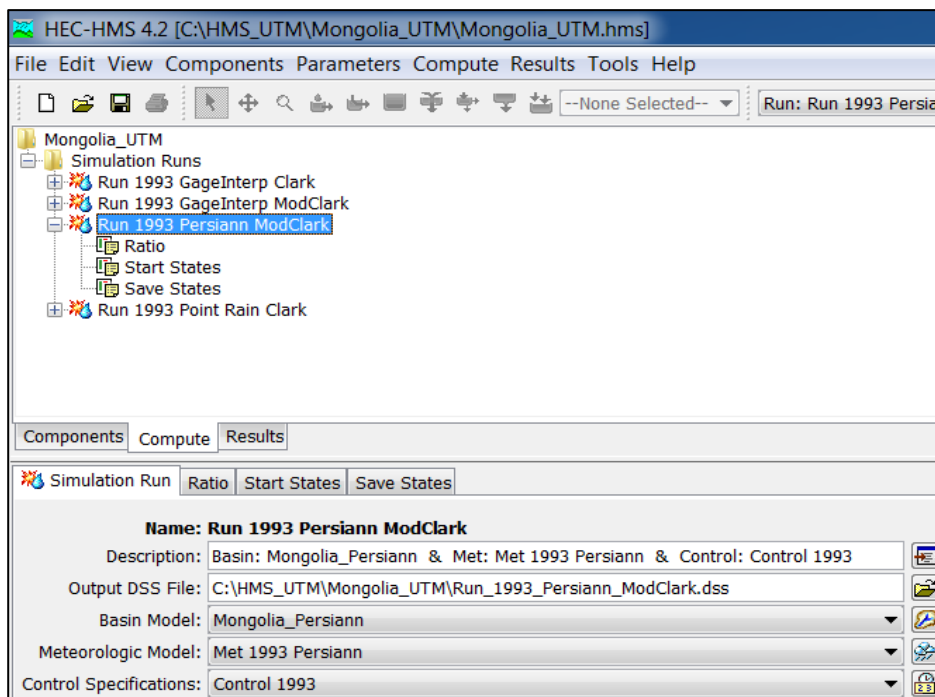

Figure 77: Simulation Run -PERSIANN ModClark

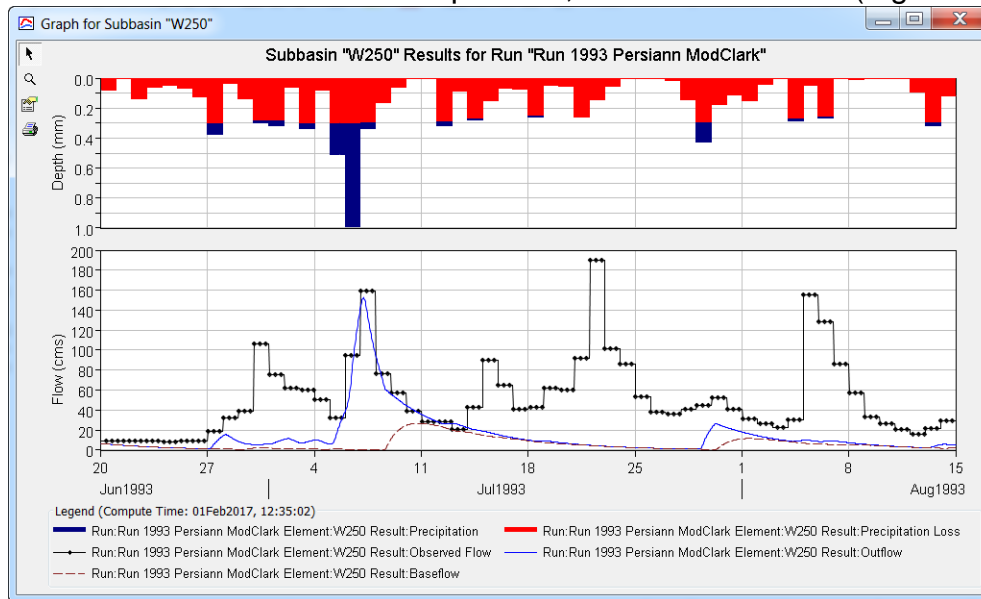Below are results at calibration point #1, at Subbasin W250 (Figure 78).

Figure 78: Calibration Point #1 at Subbasin W250

Below are results at calibration point #2, at Junction J67 (Figure 79).
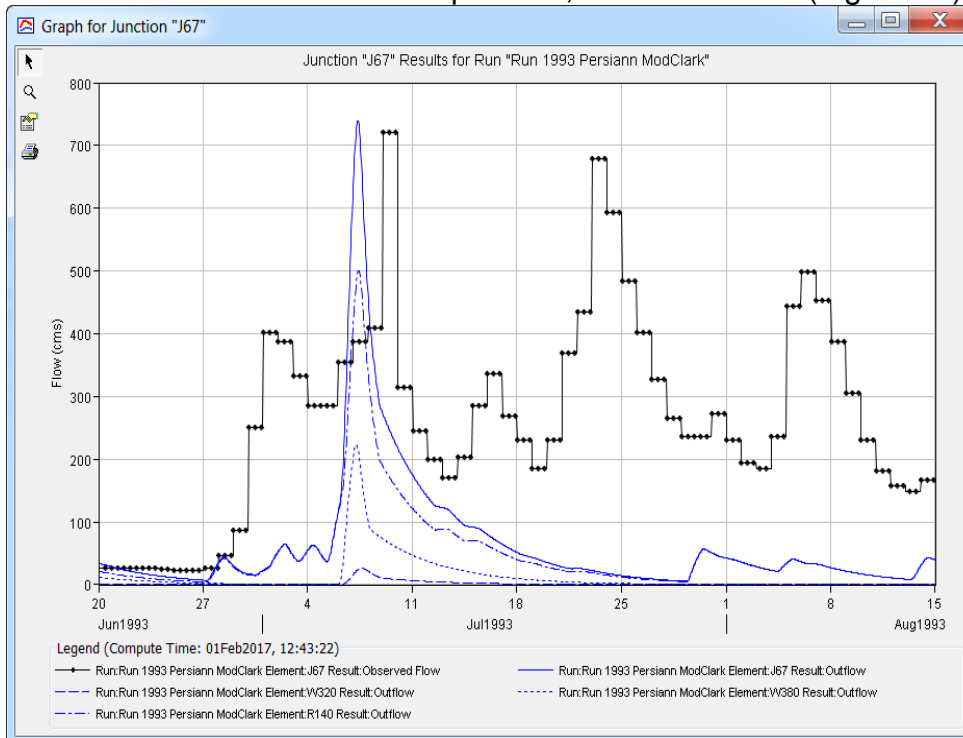

Figure 79: Calibration Point #2 at Junction J67

Even though the purpose of the workshop was not to compare precipitation products, Figure 80 shows the basin hyetographs for subbasin W250. The hyetographs include one developed by using only one precipitation gage, another created by interpolating a precipitation grid using two rain gages in the study area, and the third hyetograph shows results from the PERSIANN-CDR dataset. All precipitation data sources were converted to daily cumulative precipitation. The low precipitation intensity from the PERSIANN-CDR dataset explains the poor results shown in Figure 78 and Figure 79.
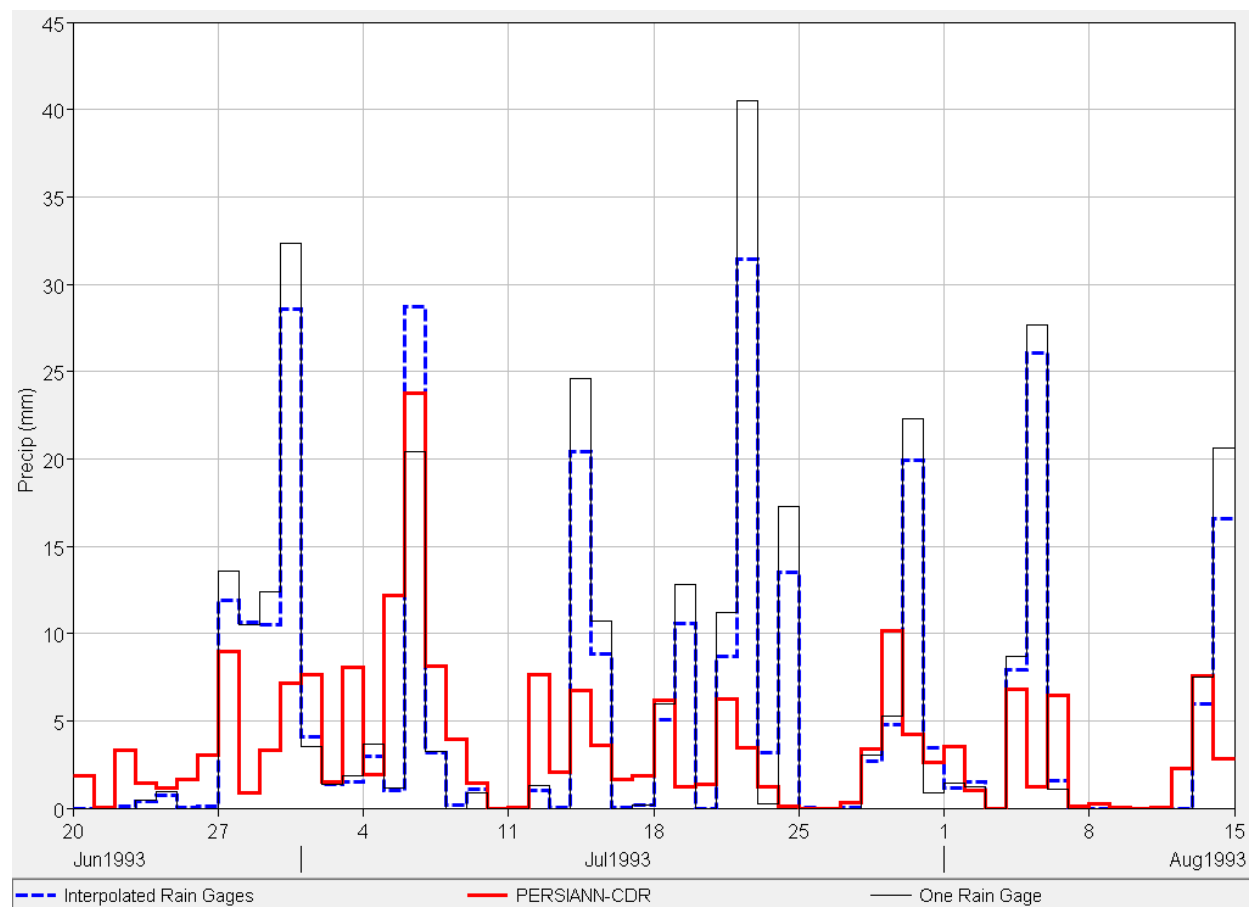

Figure 80: Comparison of Precipitation Products

As mentioned, the goal of this workshop was to demonstrate how gridded precipitation could be developed and applied to HEC-HMS models in watersheds outside of the United States. The required information to perform gridded modeling outside of the United States includes a Grid Cell file, created using HEC-GeoHMS (shown in Task 1), and gridded precipitation. Tasks 2 and 3 show how gridded precipitation, stored in DSS, can be created using the GageInterp program or using utility tools from HEC to convert ASCII grid files into DSS records. Task 4 shows how to load the precipitation grids into an HMS project and then incorporate the grids into a meteorologic model.