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Hydrologic Engineering Center

Hydrologic Modeling System HEC-HMS

Release Notes

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Hydrologic Modeling System HEC-HMS, Release Notes

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Introduction

Version 4.1 of the Hydrologic Modeling System (HEC-HMS) was completed in July 2015 and released for general use shortly thereafter. Since that time, several new features have been added to the forecast alternative to assist with setting initial conditions. A new probability distribution function has been added to the uncertainty analysis. Also, a new evapotranspiration method has been added to the meteorologic model to make it easier to develop simple potential evapotranspiration demands. Finally, it is possible to compute a simulation run or forecast alternative to a computation point. The development team has also continued careful and systematic testing of the program since the last release. The results of that testing in combination with reports from users have allowed the identification and repair of various problems. Some of these affected simulation results and are described in detail later in this document. The result is this Version 4.2 release. It is currently available for the Microsoft Windows® operating system and the Linux® operating system.

The program has been designed to be easy to use. However, an understanding of how the program works is critical to producing accurate results. It is suggested that a new user read the *HEC-HMS Quick Start Guide* (Version 4.2 August 2016). The guide briefly describes the basic features of the program in enough detail to begin using it. The guide also includes a step-by-step tutorial.

Installation

The installation package and all documentation are available on the HEC website at http://www.hec.usace.army.mil/. This new release is installed independently of any previous versions of the program so you will need to uninstall the previous versions if you do not wish to use them anymore. However, you may keep different versions of the program installed for parallel use or testing if you choose. This new version will automatically open projects developed with any previous version of the program. <u>However, once a project has been opened in Version 4.2, it will not be possible to open it with older versions of the program</u>.

Windows

The new installation package is designed to be easy to use. It will take you through the steps of selecting a directory for the program files and making other settings. Use the following steps to install the program on the Microsoft Windows® operating system:

1. Download the installation package from the HEC website to a temporary folder on the computer.

2. Run the installation program. In Windows Explorer, double-click the icon for the installation program. You <u>must have administrator privileges</u> to run the installer.

3. Follow the on-screen prompts to install the program.

Linux

The installation package is delivered as a compressed TAR file. It has several dependencies that must be installed before extracting the installation package. The following commands can be used to configure the dependencies prior to extraction of the installation package.

Red Hat Enterprise Linux 7

```
yum install libldb.i686 libXext.i686
libXrender.i686 libXtst.i686 libgcc.i686
libstdc++.i686
```

Ubuntu 14.04

```
sudo apt-get install libc6-i386 libstdc++6:i386
libxtst6:i386 libxrender1:i386 libgcc1:i386
libxi6:i386
```

New Capabilities

A total of four new capabilities have been added to the program. Summary descriptions are given below.

Forecast Baseflow Automatic Initialization

Observed stream flow data is collected in many watersheds. The data can be compared to the simulated flow at subbasins, reaches, and junctions to evaluate model performance. Expert evaluations of the differences between observed and simulated flow can lead to improvements in the model structure or parameters. Observed stream flow also provides an excellent data source for initializing the baseflow throughout a watershed at the beginning of a forecast alternative. Observed flow at the outlet of a subbasin can be used directly as the initial baseflow. When several subbasins are upstream of an observed flow location, setting the initial baseflow as a flow rate per area can still make good use of the data.

This new feature in the forecast alternatives allows a discharge gage to be selected for each subbasin. The observations of the discharge gage are automatically used to set the initial baseflow in the subbasin. A ratio is applied to the observation to accommodate cases where subbasin area is not equal to the drainage area of the gage. Optional data screening parameters make certain that the observed discharge is only used for initialization when the reported data is within a reasonable range. You can find more information in the *HEC-HMS Version 4.2 User's Manual* on page 439.

Forecast Reservoir Automatic Initialization

Observed pool elevation data is collected at many reservoirs. This data can be compared to the simulated pool elevation to evaluate model performance. Differences between the observed and simulated pool elevation may indicate errors in the simulated reservoir inflows or errors in the simulated reservoir outflows. Observed pool elevation also provides an excellent data source for initializing the reservoir at the beginning of a forecast alternative.

This new feature in the forecast alternative allows a stage gage to be selected for each reservoir. The observations of the stage gage are automatically used to set the initial pool elevation when the forecast alternative simulation starts. Optional data screening parameters make certain that the observed stage is only used for initialization when the reported data is within a reasonable range, otherwise substituting a default value. Additionally, the observed stage can be used to reset the reservoir pool elevation at the forecast time to remove any accumulated errors between the start time and the forecast time. You can find more information in the *HEC-HMS Version 4.2 User's Manual* on page 441.

Uncertainty Analysis Empirical Distribution

The uncertainty analysis provides a classical Monte Carlo simulation for computing the uncertainty in output variables like peak flow or volume given uncertainty in the hydrologic model parameters. A total of eight analytical distributions are available for representing each selected model parameter: beta, exponential, gamma, log-normal, normal, triangular, uniform, and Weibull. Generally speaking, an analytical distribution is fit to a sample of the parameter data. In some cases no distribution fits the sample data within an acceptable error limit.

This new feature in the uncertainty analysis provides an empirical distribution for use when none of the available analytical distributions provides an acceptable fit to the parameter sample data. The empirical distribution is entered as a cumulative

distribution function in the paired data manager. The distribution is then selected in the uncertainty analysis when choosing a parameter. In this way unusual sample data can be accommodated including bimodal distributions. You can find more information in the *HEC-HMS Version 4.2 User's Manual* on page 499.

Annual Pattern Evapotranspiration

This new feature for continuous simulation applications provides a simple approach to specifying potential evapotranspiration and allowing it to change throughout the year. The primary parameter is the potential evapotranspiration rate specified in millimeters or inches per day. The rate is automatically adjusted for simulation time intervals less than one day. An annual percentage pattern can optionally be added to specify changes throughout the year. Without the annual pattern, the specified rate is simply used as a constant for the entire simulation time window. The annual pattern is entered in the paired data manager in a table of dates and percentages. The same annual pattern is repeated each year of the simulation. You can find more information in the *HEC-HMS Version 4.2 User's Manual* on page 330.

Compute to a Point

This new feature makes it possible to compute only some of the hydrologic elements in a basin model when computing a simulation run or forecast alternative. The feature is integrated with the computation point. Any element in the basin model may be designated as a computation point and there is no limit to the number of elements that can be designated. Once a simulation run or forecast alternative is selected, then right-clicking on a computation point in the basin map reveals the option to compute to that point. Only the elements upstream of the computation point will be computed. This can provide significant time savings when performing calibration in a basin model with many elements. You can find more information in the *HEC-HMS Version 4.2 User's Manual* on page 368 and page 447.

Changes in Operation

A number of existing capabilities in the program have changed. Complete descriptions of each change are given below. These changes in operation may result in changes in the computed results when compared to previous program versions.

Negative Precipitation

The program has always included special processing for missing precipitation data, offering the option of stopping the simulation or substituting a zero value. However, the precipitation algorithms in the meteorologic model where designed without any special consideration for negative precipitation values. A recent application study revealed poor precipitation records that contained negative values which caused errors. All precipitation data is now automatically screened for negative values and appropriate error messages provided. Any negative values are now replaced with zero values which may lead to changes in the computed precipitation amounts.

ModClark and Non-gridded Precipitation

All previous versions of the program required the use of gridded precipitation in the meteorologic model if the basin model included at least one subbasin with the ModClark transform method. An option was provided for using gridded precipitation with all of the transform methods, including those that are not based on grid cells. Conversely, it was only possible to use non-gridded precipitation with subbasins utilizing unit hydrograph and kinematic wave transform methods that do not use grid cells. It is now possible to use non-gridded precipitation methods with the ModClark transform. This change in operation will facilitate using so-called design storms with the ModClark transform, including: frequency storm, SCS storm, standard project storm, and HMR52. Non-gridded precipitation methods are computed for the whole subbasin and then the same value is applied to each grid cell in the ModClark subbasin.

Precipitation and Evapotranspiration

Previous versions of the program allowed only precipitation or evapotranspiration to occur during a time interval. This limitation made it difficult to apply continuous simulation methods with a daily time interval when a small amount of precipitation during a day resulted in no evapotranspiration for the whole day. This limitation also affected snowmelt simulation where a small amount of melt from the snow pack each day resulted in no evapotranspiration. There is now an option in the canopy component to control simultaneous precipitation and evapotranspiration. The first option is to maintain the past operation where precipitation in a time interval results in no evapotranspiration. The second option is to allow the normal calculation of evapotranspiration in addition to any

precipitation that may occur. Using this second option will change the computed results and likely require recalibration of old models.

Crop Coefficient

The crop coefficient is used in the canopy component to adjust the soil water use of a specific plant relative to the reference standard. Previous versions of the program allowed the crop coefficient to range from 1.0 to 1.5. After performing a literature review, it was found that many plant growth models use a crop coefficient less than 1.0 during early and late phases of the growth cycle. It is now possible to use a crop coefficient from 0.01 up to 1.50.

Reservoirs with Culverts

The outlet structures routing method in the reservoir element can include outlets representing culverts. It was found that certain configurations of the culvert could cause the reservoir algorithm to fail. Generally speaking, the configurations causing failure used a culvert with a very high flow capacity relative to the storage volume at the bottom of the reservoir. Dead storage below the culvert invert was also a factor. In these cases the simulation often aborted with an error message. The reservoir algorithm has been enhanced to handle these difficult configurations. This enhancement to the algorithm may result in changes in computed discharge at small storage volumes. Typically, the changes in computed storage result in changes in the computed reservoir pool elevation on the order of 0.01 meters (0.03 feet).

MUSLE Default Flow Threshold

The Modified Universal Soil Loss Equation (MUSLE) can be used for computing subbasin surface erosion. It is based on the concept of computing erosion for each storm event. A threshold is included for identifying the minimum surface flow necessary to initiate erosion. Previous versions of the program automatically initialized the threshold to zero. A recent application study using continuous simulation found that a threshold of zero often resulted in the entire simulation being treated as a single event for purposes of computing erosion. The threshold is now set to a default of 1.0 cubic meters per second (1.0 cubic feet per second). Old project data will continue to use the previously specified threshold. Newly created project data will include the new default value. The threshold value can be easily changed in either old or new project data through the erosion Component Editor.

Entry and Display of Calendar Dates

Previous versions of the program processed calendar dates using the language setting on the computer. All dates entered by the user were processed using this setting and all computed results were displayed using this setting. Date processing failures were supposed to revert to processing in English but it was inconsistent. Often it was necessary to change the language setting on the computer to English in order for the program to process calendar dates correctly. There is now an option in the Program Settings to select the language and country for processing calendar dates. Dates should be entered using two digits for the day, followed by the natural abbreviation of the month in the selected language and country, followed by the four-digit year. Computed results will be displayed using the same convention.

Problems Repaired

Several errors were found in the program and repaired. Complete descriptions of each error are given below.

Graphs and Tables after Unit System Change

Graphs, summary tables, and time-series tables are designed to remain open during a simulation and automatically update after the simulation is completed. It was found that the displayed units often did not update correctly after changes to the basin or meteorologic model unit system. All results now display the correct units after changes the unit system.

Renaming a Project

Many projects include HEC-DSS files for storing time-series, paired, and grid data. It was discovered that links to these HEC-DSS files could become corrupted while renaming a project. Enhancements have been made to correctly update links to all HEC-DSS files during the process of renaming a project.

Project Name Ending in a Space

It was found that entering a project name ending with a space could lead to significant problems with file management in the project directory. Now, when creating a new project, any spaces at the beginning or end of the name are automatically removed. Removing leading and trailing spaces keeps the file management of the project operating normally.

Clipboard Paste into Global Editors

The clipboard paste feature would fail if used in a global editor that included a selection box also known as a combo-box. The feature has been improved to work with all possible types in a global editor.

Gridded Green Ampt

The gridded Green Ampt loss rate method was essentially unusable in previous versions. Corrections have been made and new tests developed. It is now fully available for use when combined with the ModClark transform method.

Gridded Simple Surface

The gridded simple surface component in the subbasin allows the user to specify a different surface storage depth for each grid cell in the subbasin. The storage depths are specified using a parameter grid. It was discovered that missing data in the parameter grid was not processed correctly in the gridded simple surface components, leading to errors in the computed cell storage. New error checking has been added to screen for missing data values in the parameter grid in order to avoid errors in the computations.

Start States with ModClark

Save states can be created during a simulation run and then used later to initialize a different simulation run. This feature can be used to create perfectly continuous simulation results using multiple runs, even if the runs stop and start in the middle of a precipitation event. It was found that start states would fail to initialize the second simulation run if the same grid cell coordinates occurred more than once in a subbasin. However, using the same cell multiple times in a subbasin may be necessary if the cell is located on the boundary of the subbasin. Enhancements in the save state file have been made to fully support multiple grid cells with the same coordinates.

Soil Moisture Accounting and Baseflow

The program is designed to allow any loss rate method to be used in conjunction with any baseflow method. However, special capabilities exist when using the soil moisture accounting loss rate method with the linear reservoir baseflow method. Lateral outflow from groundwater layers in the loss rate method are transferred to the equivalent layers in the baseflow method. It was discovered that the lateral outflow was not transferred correctly, leading to errors in computed baseflow, if the loss rate method specified zero storage for the upper groundwater layer while using storage greater

than zero in the lower groundwater layer. It was determined that it would be impossible to support this specific configuration of the groundwater layers. Therefore, new error checking was added to prevent incorrect lateral outflow calculations. Soil moisture accounting can now use no groundwater layers by setting the storage to zero in both layers. It can use both layers by specifying a storage value in each. If only one layer will be used, then it must be the upper layer, which is achieved by setting the storage in the lower layer to zero.

Annual Percentage Pattern and Leap Year

The annual percentage pattern is one type of paired data that can be used in some components to modify a parameter throughout the year. The input data for the pattern is a table of dates specified as day and month, along with a percentage to apply to the parameter. It was found that entering 29Feb for the date would cause problems in the annual pattern. The annual pattern has been enhanced to support leap year. Data entered for 29Feb is only used during a leap year otherwise it is ignored.

Deleted Gage Reappears

A time-series gage can be deleted from the gage manager or directly from the Watershed Explorer. It was found that deleted gages reappeared the next time the project was opened for use. This was because the gage was not removed from the list of available resources in the project. The gage is now correctly removed from the resources and will not reappear the next time the project is used.

Deleted Forecast Alternative Not Removed

A forecast alternative can be deleted from the forecast manager or directly in the Watershed Explorer. It was discovered that deleted alternatives were not removed from the project. This was because the deleted alternative was not removed from the list of project resources. It is now correctly removed as part of the deletion operation.

Optimization Trial Missing Parameters

Parameters could be lost from an optimization trial under certain conditions. The parameters were most likely to be lost when switching back and forth between two new trials. Parameters were typically maintained correctly for established trials. Parameters are now correctly managed for both established and new trials.

New Depth-Area Analysis Not Saved

A new depth-area analysis can be created using a wizard accessed from the Compute menu or the analysis manager. It was discovered that a depth-area analysis could be created, analysis points selected, and a simulation completed. However, the new analysis disappeared after the program was closed. Existing analyses were not similarly affected. It was found that the new analysis was not correctly added to the list of available resources in the project. The new analysis is now correctly added to the resources and will be part of the project the next time it is used.

Documentation

The *Hydrologic Modeling System HEC-HMS: <u>Quick Start Guide</u>* (Version 4.2 August 2016) provides a brief description of the program for new users. It describes the different parts of the interface and the basic steps necessary to obtain simulation results. A tutorial takes the user through the creation of a new project and shows how to obtain results. The guide has been updated to reflect changes in the interface.

The *Hydrologic Modeling System HEC-HMS: <u>User's Manual</u>* (Version 4.2 August 2016) contains extensive information on installing and using the program. Details on the use of each of the features and capabilities in the program are included. The manual has been updated with information describing new features added to the program for this Version 4.2 release.

The *Hydrologic Modeling System HEC-HMS: <u>Validation Guide</u>* (Version 4.2 August 2016) contains information on the procedures used to certify the software for release. The manual describes the tests that have been established and the procedures used for determining the correct result for each test. An accompanying data kit includes all of the project data necessary to replicate the tests performed at HEC prior to certifying a new release for distribution.

The *Hydrologic Modeling System HEC-HMS: <u>Applications Guide</u>* (March 2015) illustrates how to apply the program in a variety of different studies. Data requirements, calibration procedures, and typical results presentation styles are provided for studies ranging from flood risk management to sediment yield.

The *Hydrologic Modeling System HEC-HMS: <u>Technical Reference Manual</u>* (March 2000) continues to accurately describe the mathematical models included in the program. New simulation capabilities have been added to the program and are not included

in the manual. The manual is currently undergoing a major revision to expand documentation of existing mathematical models and fully describe the newly added models.

Support Policy

Technical support for program users within the U.S. Army Corps of Engineers is provided through an annual subscription service. Subscribing offices can expect full support from HEC staff in the routine application of the program. Users are strongly urged to consult with HEC staff on the technical feasibility of using the program before beginning a project with unique requirements such as grid cell hydrology, snow melt, continuous simulation, sediment transport, or water quality. Special guidance is also available for the development of models for flow forecasting. Extended support for large or complex projects can be arranged under a separate reimbursable project agreement.

Support cannot be provided to users outside the U.S. Army Corps of Engineers. Several companies and organizations offer varying levels of support, some through a fee-for-service support similar to the support provided to subscribing Corps offices. Such service agreements are between the user and the vendor and do not include HEC staff. Vendors can be located through internet searches.

Reporting of suspected program errors is unrestricted and we will reply to all correspondence concerning such errors. We are continuously working to improve the program and possible bugs should always be reported. Reports should include a written description of the steps that lead to the problem and the effects that result from it. If we cannot reproduce the reported problem, we may ask you to send a copy of your project.

Request support or report program errors through the following channels:

- Visit our web site at http://www.hec.usace.army.mil.

- Send email to *hec.hms@usace.army.mil* on the internet.

- Fax 530.756.8250 any time.

- Call +1.530.756.1104, 7:30 am to 4:30 pm Pacific Time Monday through Friday.

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