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# **Hydrologic Modeling System HEC-HMS**

## ***Release Notes***

Version 4.1  
July 2015

## Hydrologic Modeling System HEC-HMS, Release Notes

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## **Introduction**

Version 4.0 of the Hydrologic Modeling System (HEC-HMS) was completed in December 2013 and released for general use shortly thereafter. Since that time, new components for shortwave radiation, longwave radiation, precipitation, and evapotranspiration have been added to the meteorologic model. Subbasin elements have two new options in the transform component. Forecast alternative parameter adjustments and element overrides can now be changed using a slider editor. Finally, a major new simulation component has been created for performing an uncertainty analysis. 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 4.1 release. It is currently available for the Microsoft Windows<sup>®</sup> operating system and the Linux<sup>®</sup> 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 *Quick Start Guide* (Version 4.1 July 2015). 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. However, once a project has been opened in Version 4.1, it will not be possible to open it with older versions of the program.

### **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<sup>®</sup> 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 must have administrator privileges 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 number of new capabilities have been added to the program. Summary descriptions are given below.

### ***Bristow Campbell Shortwave Radiation***

The Bristow Campbell method uses a conceptual approach to computing incident shortwave radiation. The only requirement for atmospheric data is air temperature. The actual daily range between minimum and maximum temperature is correlated with the mean monthly range to compute a reduction of the extraterrestrial radiation. You can find more information in the User's Manual on page 293.

### ***FAO56 Shortwave Radiation***

The method follows the approach outlined in the FAO Irrigation and Drainage Paper 56. The procedure begins with computing extraterrestrial radiation. The radiation is reduced by the ratio of

the actual sunshine hours to maximum possible sunshine given the day of the year and location of the watershed. Finally a regression equation is used to represent reduction of the radiation by cloudy conditions. You can find more information in the User's Manual on page 295.

### ***Satterlund Longwave Radiation***

The Satterlund method uses air temperature and vapor pressure to compute the longwave radiation contribution from the atmosphere to the land surface. The Stefan-Boltzmann equation is used with an empirical formulation of the emissivity coefficient based on observed data. The emissivity is automatically calculated from the atmospheric data. You can find more information in the User's Manual on page 303.

### ***FAO56 Longwave Radiation***

The method follows the approach outlined in the FAO Irrigation and Drainage Paper 56. The Stefan-Boltzmann equation is used with a conceptual formulation of the emissivity coefficient based on water vapor in the air and the ratio of actual shortwave to clear-sky shortwave radiation. You can find more information in the User's Manual on page 300.

### ***HMR52 Precipitation***

One approach to computing the probable maximum precipitation is described in Hydrometeorological Report No 52 (HMR52). This common approach in the Eastern half of the United States is now available directly within the program instead of relying on external utility software. Subbasin outlines are retrieved from a GIS file and combined with additional parameter data in order to compute the precipitation for each subbasin. You can find more information in the User's Manual on page 315.

### ***Penman Monteith Evapotranspiration***

The Penman Monteith method offers an energy balance approach to computing evapotranspiration. It considers both the surface resistance of water moving through plant stomata and the aerodynamic resistance of water vapor moving into the air above the plants. The method implements the equations found in the FAO Irrigation and Drainage Paper 56. It can be used with any shortwave and longwave radiation method but is perhaps most complete when used with the FAO56 options. You can find more information in the User's Manual on page 330.

### ***Clark Unit Hydrograph***

The Clark unit hydrograph includes a time-area curve that represents the temporal runoff pattern of the subbasin. There is now an option to use the default curve or specify a custom curve. You can find more information in the User's Manual on page 207.

### ***SCS Unit Hydrograph***

The peak rate factor qualitatively describes the steepness or flatness of the subbasin where the standard peak rate factor is 484. A collection of peak rate factors have been added ranging from 100 up to 600 in increments of 50. You can find more information in the User's Manual on page 212.

### ***Forecast Alternative Slider Editor***

The forecast alternative simulation component includes tabular editors for entering zone parameter adjustments and element overrides. It is now possible to use a slider editor for changing the adjustments and overrides. Configuration is required first to set the range of the adjustments and overrides and then the slider editor can be accessed directly from the tabular editor. You can find more information in the User's Manual beginning on page 426.

### ***Uncertainty Analysis***

The uncertainty analysis is a new type of simulation component based on a classical Monte Carlo sampling approach. The uncertainty of each parameter can be described using one of eight different analytical probability distributions. Alternately a parameter can be linked to a previously selected parameter. Available output results include sampled peak flow, flow volume, and reservoir pool elevation. Hydrographs can also be viewed with mean, standard deviation, minimum, and maximum. You can find more information in the User's Manual beginning on page 467.

## ***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 result in changes in the computed results when compared to previous program versions.

### ***User-Specified Unit Hydrograph Transform***

Each unit hydrograph is defined with a time interval. When the time interval (which is also the unit hydrograph duration) for defining the

unit hydrograph does not match the simulation time interval, then a duration conversion is performed so that the unit hydrograph will match the simulation time interval. Previously, a linear interpolation scheme was used during the conversion. Now, a cubic spline interpolation scheme is used. The new interpolation scheme helps to reduce the possibility of fluctuations and negative flow values in the tail of the unit hydrograph. As a final check, any negative flow values are set to zero.

### ***User-Specified S-Graph Transform***

Each s-graph is defined as the percentage of time lag and the percentage of unit runoff. The s-graph is scaled by the actual time lag and interpolated to the simulation time interval. Previously, a linear interpolation scheme was used. Now, a cubic spline interpolation scheme is used. The new interpolation scheme results in a smoother unit hydrograph when taking successive differences of the interpolated s-graph.

### ***Priestley Taylor Evapotranspiration***

The Priestley Taylor method uses atmospheric pressure in calculations of the potential evapotranspiration. In the past, a fixed value of 101.3 kPa was used. The value has been changed to 101.325 kPa in accordance with ISO 2533:1975.

### ***Canopy Plant Water Uptake***

Plant water uptake is represented by the canopy component in the subbasin element. It is now possible to use the "simple" uptake method with four different loss rate methods including deficit constant, soil moisture accounting, gridded deficit constant, and gridded soil moisture accounting. The "tension" uptake method can only be used with soil moisture accounting and gridded soil moisture accounting.

### ***Frequency Storm***

The frequency storm precipitation method includes a storm area parameter. The user may enter a specific storm area such as 200 km<sup>2</sup>. Alternately, leaving the storm area blank will compute a separate storm for each subbasin with a storm area equal to the subbasin area. It was discovered that entering a storm area of zero would result in the same behavior as leaving the area blank. Beginning with this release, entering a storm area of zero will result in all subbasins receiving the same precipitation time-series with no application of depth-area reduction.

The frequency storm includes a storm probability. Previous versions allowed the user to select from 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.4%, and 0.2%. The probability is only necessary when performing an annual-partial duration conversion. The duration conversion only applies for probabilities of 50%, 20%, and 10%. The available choices for the storm probability have been changed to 50%, 20%, 10%, and other. Old meteorologic models are automatically upgraded.

### ***Soil Moisture Accounting Loss Rate***

The soil moisture accounting method uses an adaptive time step scheme. In this scheme, the calculations are performed with a time step that ranges from one second up to the time interval selected in the control specifications. The actual time step for any instant in time depends on the current rate of change in soil storage, precipitation rate, and potential evapotranspiration rate, among others. The groundwater storage coefficient was not used to determine the actual time step. It was discovered that significant errors could occur if the time step was greater than approximately 1/3 of the groundwater storage coefficient. This was not discovered earlier because calibrated groundwater coefficients are typically large compared to the simulation time interval. The adaptive time step scheme has been enhanced to also consider the groundwater storage coefficient so that results remain numerically stable.

The soil moisture accounting method includes a soil layer, groundwater layer 1, and groundwater layer 2. It is often used in conjunction with the surface component. Precipitation fills the surface component, which in turn infiltrates into the soil layer of soil moisture accounting. It was discovered that if the maximum soil percolation rate was set to zero, that surface water could infiltrate in excess of the maximum soil storage capacity. A new check has been added to prevent soil storage from exceeding capacity. Any excess water in soil storage is transferred back to the surface component where it is subject to evapotranspiration and surface runoff.

### ***Negative Channel Flow***

The modified Puls and Muskingum routing methods can compute negative outflow if the parameters are unstable, resulting in a warning message about the parameter problems. Previously, negative flow entering a downstream reach would be replaced with zero. Now, negative flow is replaced with zero at the point where the reach outflow becomes inflow to another element including at junction, reach, diversion, reservoir, and sink element types. This

new behavior stops negative flow from impacting diversion and reservoir calculations as could happen in previous versions.

### ***Reservoir Structure Count***

The "outflow structures" reservoir routing method can include spillway, overflow, outlet, and pump components. Previously, up to 10 different components could be included in each category. Now, the limit has been increased to 20 different components of each type.

## ***Problems Repaired***

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

### ***Reservoir Spillway Gates***

The "outflow structures" reservoir routing method can include spillways with gates. It was discovered that the flow through a gate was computed as if the gate was as wide as the entire spillway. Results remained fully accurate when no gates were included for the spillway. The gate calculations have been corrected to use the width of the gate when calculating flow.

### ***Reservoir Emptied by Evaporation***

The "outflow structures" reservoir routing method can include evaporation. The reservoir simulation could fail under circumstances where evaporation was the only way water was being removed from the reservoir, no inflow was occurring, and evaporation for a time interval exceeded water in storage. The reservoir algorithm has been improved to correctly solve for the time when evaporation exactly empties the available storage.

### ***Lost Optimization Parameters***

The optimization trial component includes one or more parameters. It was discovered that under some circumstances certain subbasin parameters would disappear from the trial. This occurred after saving and closing the project containing the trial. The problem is resolved and parameters no longer disappear from the trial.

### ***Inability to Write Output HEC-DSS File***

All of the results for each simulation component (simulation run, optimization trial, depth-area analysis, forecast alternative, and uncertainty analysis) are written to an output HEC-DSS file. The

user can choose the directory and name of the output file. A problem arises when a project is moved to a different computer and placed in a directory structure that does not match the original source computer. All five simulation components have been enhanced to validate the output HEC-DSS file to make sure it exists and can accept new results. If the validation fails, then the output HEC-DSS file is automatically switched to the default (in the project directory) so that the simulation can proceed successfully.

### ***Basin Models and Meteorologic Models***

Each meteorologic model maintains a list of basin models for which it can compute meteorology results. The list of basin models is automatically kept current as basin models are created and deleted in the project, and as the *Component Editor* is used to select basin models for the meteorologic model. It was discovered that the list of basin models became corrupted if basin models were manually deleted from the project without using HEC-HMS to perform the deletion (for example using Windows Explorer). The corrupted basin model list caused significant problems when performing a simulation using the meteorologic model. The meteorologic model has been enhanced to automatically synchronize the basin model list if basin models are manually deleted. It is recommended that basin models only be deleted using the management tools in HEC-HMS.

### ***Keeping Subbasins Current in Meteorologic Models***

Each meteorologic model maintains a list of basin models for which it can compute meteorology results. The meteorologic model tracks all of the subbasins in each of the selected basin models while eliminating duplicates if a subbasin is found in multiple basin models. It was discovered that subbasins (and the data they represent) could be dropped from the meteorologic model under some circumstances when renaming a basin model. The management of subbasins in the meteorologic model has been enhanced so that renaming a basin model will no longer result in lost data.

### ***Kinematic Wave Transform Global Editor***

The kinematic wave transform global editor includes parameters for both runoff planes. The last two columns are for the "routing steps" and "area." It was discovered that the values displayed in these last two columns were swapped when compared to the column labels, and saving data was inconsistent. The problem has been

corrected so that all data is displayed in the correct column and saved correctly.

### ***Copying Control Specifications***

Control specifications include the output interval for grid data. This interval was not set correctly when making a copy of an existing control specifications. It is now copied correctly.

### ***Computer Memory Limitations***

Complex simulations could exhaust the available computer memory and cause the program to fail. For example, a continuous simulation model employing gridded precipitation and gridded loss rate with the addition of surface erosion and sediment transport operating for a multi-year time window. New data management techniques have been introduced to dramatically decrease the amount of memory required by complex models.

### ***Snowmelt Parameters at a Computation Point***

A computation point can be designated at any element in a basin model. Special features for a slider editor and custom results can be added to the computation point for aiding calibration of a simulation run. It was discovered that snowmelt parameters added to the slider editor at a computation point always disappeared after the project was saved and closed. It will no longer be possible to select snowmelt parameters at a computation point.

## ***Documentation***

The *Hydrologic Modeling System HEC-HMS: [Quick Start Guide](#)* (Version 4.1 July 2015) 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: [User's Manual](#)* (Version 4.1 July 2015) 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 4.1 release.

The *Hydrologic Modeling System HEC-HMS: [Validation Guide](#)* (Version 4.1 July 2015) 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: Applications Guide* (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 damage reduction to sediment yield.

The *Hydrologic Modeling System HEC-HMS: Technical Reference Manual* (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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