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Documentation of the Conversion of HYDMOD for MODFLOW-2005

HYDMOD (Hanson and Leake, 1998) is an output capability for the MODFLOW ground-water flow model that saves data at specified locations for all time steps in a model simulation. The data can then be used to construct hydrographs. The time-series data that can be saved are head, drawdown, streamflow, stream stage, stream seepage, compaction, subsidence, and critical head. HYDMOD was originally developed for MODFLOW-96 (McDonald and Harbaugh, 1996). HYDMOD was subsequently converted to MODFLOW-2000 (Harbaugh and others, 2000), and now it is converted to MODFLOW-2005 (Harbaugh, 2005).

This documentation provides input instructions for HYDMOD in MODFLOW-2005 and describes the changes to HYDMOD to convert it to work with MODFLOW-2005. The modified code is designated version 7, and this code has the functionality of version 1, which is the version used in MODFLOW-2000, as well as some enhancements. The enhancements allow the capture of time series from the Subsidence (SUB) Package (Hoffmann and others, 2003) and from the SFR2 Streamflow Routing Package (Niswonger and Prudic, 2004). Note that the capture of subsidence and compaction time series from the SUB Package in this new version of HYDMOD currently only supports the instantaneous compaction features and not the delayed compaction features. This updated version now also supports the retrieval of separate elastic and inelastic components of compaction and total land subsidence summed from the deepest non-delay system specified by the user to the uppermost active layer of the systems used. These new components to the SUB package are explained with updated user input instructions in the new Farm Process Report (FMP2) (Schmid and Hanson, 2009) in Appendix B (Hanson and others, 2009).

HYDMOD INPUT INSTRUCTIONS

Input to the HYDMOD option is read from the file name and unit specified in the MODFLOW Name File. The file type in the name file is HYD. The input instructions for the Basic (BAS) (Harbaugh, 2005), Streamflow Routing (STR) (Prudic, 1989), and Interbed Storage Packages (IBS) (Leake and Prudic, 1991) are the same as for the original version. The input for the Subsidence (SUB) Package follows the form used for IBS, and the input for the SFR2 Package follows the form used for STR. All input uses free format

FOR EACH SIMULATION

1. Data: **NHYD IHYDUN HYDNOH**

2. Data: **PCKG ARR INTYP KLAY XL YL HYDLBL**

(Input item 2 consists of one record for each hydrograph. No more than NHYD hydrograph records will be read.)

Explanation of Fields Used in Input Instructions

NHYD is the maximum number of observation points that may be read in.

IHYDUN is a unit number to which hydrograph records are written.

HYDNOH is a user-specified value that is output if a value cannot be computed at a hydrograph location. For example, the cell in which the hydrograph is located may be a no-flow cell.

PCKG is a 3-character flag to indicate which package is to be addressed by HYDMOD for the hydrograph of each observation point. The current packages are:

BAS for the Basic Package,
IBS for the Interbed-Storage Package,
SUB for the Subsidence Package,
STR for the Streamflow Routing Package, and
SFR for the SFR2 Streamflow Routing Package.

ARR is a text code indicating which model data value is to be accessed for the hydrograph of each observation point. The table of available values:

ARR	Data recorded by HYDMOD
HD	Head array (BAS Package)
DD	Drawdown array (BAS Package)
HC	Preconsolidation-head array (SUB and IBS Packages)
CP	**Total instantaneous** Compaction array (SUB and IBS Packages)
CE	**Instantaneous Elastic** Compaction array (SUB Package only)
CV	**Instantaneous Inelastic** Compaction array (SUB Package only)
SB	**Total instantaneous** Subsidence array (SUB and IBS Packages)
SE	**Instantaneous Elastic** Subsidence array (SUB Package only)
SV	**Instantaneous Inelastic** Subsidence array (SUB Package only)
ST	Streamflow-stage array (STR and SFR Packages)
SI	Streamflow into reach array (STR and SFR Packages)
SO	Streamflow out of reach array (STR and SFR Packages)
SA	Streamflow into or out of aquifer array (STR and SFR Packages)

INTYP is a 1-character value to indicate how the data from the specified feature are to be accessed. The two options are I for interpolated value or C for cell value. Interpolated value indicates that the value is linearly interpolated from values at the 4 nodes surrounding the hydrograph location. Cell value means the value at the node closest to the hydrograph location. INTYP must be C for STR and SFR hydrographs.

KLAY is the layer sequence number of the array to be addressed by HYDMOD. For arrays that exist for each model layer, such as head (HNEW), KLAY is the layer number. For arrays that exist for only certain model layers, KLAY is the sequence number of the array starting with the uppermost array as 1, the next lower array as 2, and so forth. For the subsidence array (ARR =

'SB'), KLAY designates the range of layers (from layer 1 to layer "KLAY") used to sum compaction from individual layers into total subsidence for these layers.

XL is the coordinate of the hydrograph point in model units of length measured parallel to model rows, with the origin at the lower left corner of the model grid. The value of XL does not need to correspond with the location of any particular model node. For streamflow-related data, XL designates the segment number that contains the reach from the streamflow-input data set for which data are to be output.

YL is the coordinate of the hydrograph point in model units of length measured parallel to model columns, with the origin at the lower left corner of the model grid. The value of YL does not need to correspond with the location of any particular model node. For streamflow-related data, YL designates the reach number that is the cell location from the streamflow-input data set for which data are to be output.

HYDLBL is used to form a label for the hydrograph. The purpose of the label is to identify output and allow users to reorder, add, or subtract from the input list and still maintain location identity. HYDLBL is up to 14 characters for the BAS, IBS, and SUB Packages. An additional 6 characters are added as a prefix to make a 20-character label. The first two characters of the prefix are the ARR characters. The third character is the INTYP value. Characters 4 through 6 are the KLAY value. For stream hydrographs, HYDLBL is up to 12 characters. The constructed prefix consists of the 2-character ARR value, the 3-digit stream-segment number (character locations 3 to 5), and the 3-digit stream-reach number (character locations 6 to 8). The prefix is added to HYDLBL to again make a 20-character hydrograph label.

CONVERSION OF HYDMOD TO WORK WITH MODFLOW-2005

The MODFLOW-2005 conversion required some internal coding changes due to the change in structure to allow local grid refinement; however, the functionality of the code has not been changed. See Chapter 9 of Harbaugh (2005) for further information about the MODFLOW-2005 program.

Although HYDMOD can save data from multiple packages, the original HYDMOD code has a single output subroutine (HYDMOT) that computes and saves the output of all of the data. HYDMOD has been modified so that each package has its own subroutine to compute the output data. A single output subroutine still writes all of the data to disk.

Fortran modules HYDBASMODULE, HYDIBSMODULE, HYDSTRMODULE, HYDSUBMODULE, and HYDSUBMODULE were created to store the shared data; these modules incorporate the capability to support Local Grid Refinement. The following tables describe the data.

Table 1. List of variables defined in FORTRAN module HYDBASMODULE

Variable Name	Size	Description
NHYDTOT	Scalar	Total number of hydrographs of all types
HYDVAL	NHYDTOT,2	Hydrograph values for initial conditions and the current time

HYDLBL	C*2,NHYDTOT	Hydrograph labels
IHYDMUN	Scalar	Unit number for saving hydrograph data
NHYDBAS	Scalar	Number of hydrographs for BAS Package
HYDNOH	Scalar	The value to save if a cell at the hydrograph location is dry
IBHYDBAS	NHYDBAS	A flag indicating if IBOUND should be tested
INTRPHYDBAS	NHYDBAS	A flag indicating if the values should be interpolated between nodes.
JIKHYDBAS	3,NHYDBAS	Column, row and layer location of hydrograph site
HYDBASWT	4,NHYDBAS	Weighting factors for nearest 4 nodes when interpolating between nodes
HYDBASARR	C*4,NHYDBAS	Type of data being saved

Table 2. List of variables defined in FORTRAN module HYDIBSMODULE

Variable Name	Size	Description
NHYDIBS	Scalar	Number of hydrographs for IBS Package
IBHYDIBS	NHYDIBS	A flag indication if IBOUND should be tested
INTRPHYDIBS	NHYDIBS	A flag indicating if the values should be interpolated between nodes.
JIKHYDIBS	3,NHYDIBS	Column, row and layer location of hydrograph site
HYDIBSWT	4,NHYDIBS	Weighting factors for nearest 4 nodes when interpolating between nodes
HYDIBSARR	C*4,NHYDIBS	Type of data being saved

Table 3. List of variables defined in FORTRAN module HYDSTRMODULE

Variable Name	Size	Description
NHYDSTR	Scalar	Number of hydrographs for STR Package
ISTRHYD	NHYDSTR	A flag indication of IBOUND should be tested
HYDSTRARR	C*4,NHYDSTR	Type of data being saved

Table 4. List of variables defined in FORTRAN module HYDSUBMODULE

Variable Name	Size	Description
NHYDSUB	Scalar	Number of hydrographs for SUB Package
IBHYDSUB	NHYDSUB	A flag indication if IBOUND should be tested
INTRPHYDSUB	NHYDSUB	A flag indicating if the values should be interpolated between nodes.
JIKHYDSUB	3,NHYDSUB	Column, row and layer location of hydrograph site
HYDSUBWT	4,NHYDSUB	Weighting factors for nearest 4 nodes when interpolating between nodes
HYDSUBARR	C*4,NHYDSUB	Type of data being saved

Table 5. List of variables defined in FORTRAN module HYDSFRMODULE

Variable Name	Size	Description
NHYDSFR	Scalar	Number of hydrographs for SFR Package
ISFRHYD	NHYDSFR	A flag indication if IBOUND should be tested
HYDSFRARR	NHYDSFR	Type of data being saved

The following primary subroutines comprise the HYDMOD capability:

GWF2HYD7BAS7AR – Allocate memory and read input data for BAS Package hydrographs. This subroutine also allocates memory for the values to be saved for the hydrographs of all packages.

GWF2HYD7IBS7AR – Allocate memory and read input data for IBS Package hydrographs.

GWF2HYD7STR7AR – Allocate memory for stream hydrographs.
GWF2HYD7SUB7AR – Allocate memory and read input data for SUB Package hydrographs.
GWF2HYD7SFR7AR – Allocate memory for stream hydrographs.
GWF2HYD7STR7RP – Read input data for stream hydrographs. This is called after GWF2STR7RP reads data for a stress period so that the hydrograph locations can be checked to see if a stream exists at the locations.
GWF2HYD7SFR7RP – Read input data for stream hydrographs. This is called after GWF2SFR7RP reads data for a stress period so that the hydrograph locations can be checked to see if a stream exists at the locations.
GWF2HYD7BAS7SE – Compute simulated equivalent for BAS Package hydrographs for a time step.
GWF2HYD7IBS7SE – Compute simulated equivalent for IBS Package hydrographs for a time step.
GWF2HYD7STR7SE – Compute simulated equivalent for stream hydrographs for a time step.
GWF2HYD7SUB7SE – Compute simulated equivalent for subsidence hydrographs for a time step.
GWF2HYD7SFR7SE – Compute simulated equivalent for stream hydrographs for a time step.
GWF2HYD7BAS7OT – Output all hydrograph data.
GWF2HYD7DA – deallocate memory for all hydrograph data.

GWF2HYD7DA calls submodules for each package: SGWF2HYD7BAS7DA, SGWF2HYD7IBS7DA, SGWF2HYD7STR7DA, SGWF2HYD7SUB7DA, and SGWF2HYD7SFR7DA,

To support the Local Grid Refinement capability, subroutines SGWF2HYD7BAS7PNT, SGWF2HYD7IBS7PNT, SGWF2HYD7STR7PNTS, GWF2HYD7SUB7PNT, and SGWF2HYD7SFR7PNT were created to set pointers to a grid. Subroutines SGWF2HYD7BAS7PSV, SGWF2HYD7IBS7PSV, SGWF2HYD7STR7PSV, SGWF2HYD7SUB7PSV, and SGWF2HYD7SFR7PSV were created to save the pointers for a grid. The grid number, IGRID, was added as a subroutine argument to all of the primary subroutines, and the PSV and PNT subroutines are called as appropriate.

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