

The Texas A&M University and U.S. Bureau of Reclamation Hydrologic Modeling Inventory (HMI) Questionnaire

December 19, 2009

This document is the Texas A&M University (TAMU)-U.S. Bureau of Reclamation (USBR) Hydrologic Modeling Inventory (HMI) Questionnaire. Your response to this questionnaire will provide the basis for the HMI on-line database accessed through the HMI Web page. Modelers can interactively obtain information about your model through this Web-enabled model inventory complete with search capabilities. The information you provide will hopefully foster wider interest in your model. A designated contact will be explicitly acknowledged and posted within the HMI Web page database.

Given more and more applications of GIS and remote sensing techniques to hydrologic modeling, water resources and watershed management, the Subcommittee on Hydrology has recently set up a workgroup to organize and publicize information on GIS applications in the fields of hydrology and hydraulics. This scope has been expanded to include related water quality, watershed management, and ecological sciences GIS applications. This work is intended to make information on GIS applications in hydrology and hydraulics more generally available. This questionnaire is also designed to gather limited but key information about a particular GIS application in order for a potential user to decide if the application fits his/her computer system, data requirements, and physical system to be modeled.

These applications should be public domain and supported by user documentation. Availability on the Web is not necessary if the application can be distributed on CD ROM or through e-mail requests. If a short abstract, fact sheet, or technical paper is available on the application, please attach a copy. Please respond this email before **22 January, 2010**.

Name of Model, Date, Version Number:

UCODE 08/10/2009 1.017

Contact (with e-mail, web site, and/or phone number):

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Brief Description:

UCODE_2005 and six post-processors are included in this distribution. These programs can be used with existing process models to perform sensitivity analysis, data needs assessment, calibration, prediction, and uncertainty analysis. Any process model or set of models can be used; the only requirements are that models have numerical (ASCII or text only) input and output files, that the numbers in these files have sufficient significant digits, that all required models can be run from a single batch file or script, and that simulated values are continuous functions of the parameter values. Process models can include pre-processors and post-processors as well as one or more models related to the processes of interest (physical, chemical, and so on), making UCODE_2005 extremely powerful. An estimated parameter can be a quantity that appears in the input files of the process model(s), or a quantity used in an equation that produces a value that appears in the input files. In the latter situation, the equation is user-defined.

UCODE_2005 can compare observations and simulated equivalents. The simulated equivalents can be any simulated value written in the process-model output files or can be calculated from simulated values with user-defined equations. The quantities can be

model results, or dependent variables. For example, for ground-water models they can be heads, flows, concentrations, and so on. Prior, or direct, information on estimated parameters also can be considered. Statistics are calculated to quantify the comparison of observations and simulated equivalents, including a weighted least-squares objective function. In addition, data-exchange files are produced that facilitate graphical analysis.

UCODE_2005 can be used fruitfully in model calibration through its sensitivity analysis capabilities and its ability to estimate parameter values that result in the best possible fit to the observations. Parameters are estimated using nonlinear regression: a weighted least-squares objective function is minimized with respect to the parameter values using a modified Gauss-Newton method or a double-dogleg technique. Sensitivities needed for the method can be read from files produced by process models that can calculate sensitivities, such as MODFLOW-2000, or can be calculated by UCODE_2005 using a more general, but less accurate, forward- or central-difference perturbation technique. Problems resulting from inaccurate sensitivities and solutions related to the perturbation techniques are discussed in the report. Statistics are calculated and printed for use in (1) diagnosing inadequate data and identifying parameters that probably cannot be estimated; (2) evaluating estimated parameter values; and (3) evaluating how well the model represents the simulated processes.

Results from UCODE_2005 and codes RESIDUAL_ANALYSIS and RESIDUAL_ANALYSIS_ADV can be used to evaluate how accurately the model represents the processes it simulates. Results from LINEAR_UNCERTAINTY can be used to quantify the uncertainty of model simulated values if the model is sufficiently linear. Results from MODEL_LINEARITY and MODEL_LINEARITY_ADV can be used to evaluate model linearity and, thereby, the accuracy of the LINEAR_UNCERTAINTY results. UCODE_2005 can also be used to calculate nonlinear confidence and predictions intervals, which quantify the uncertainty of model simulated values when the model is not linear. CORFAC_PLUS can be used to produce factors that allow intervals to account for model intrinsic nonlinearity and small-scale variations in system characteristics that are not explicitly accounted for in the model or the observation weighting.

The six post-processing programs are independent of UCODE_2005 and can use the results of other programs that produce the required data-exchange files.

UCODE_2005 and the other six codes are intended for use on any computer operating system. The programs consist of algorithms programmed in Fortran 90/95, which efficiently performs numerical calculations. The model runs required to obtain perturbation sensitivities can be performed using multiple processors. The programs are constructed in a modular fashion using JUPITER API conventions and modules. For example, the data-exchange files and input blocks are JUPITER API conventions and many of those used by UCODE_2005 are read or written by JUPITER API modules. UCODE-2005 includes capabilities likely to be required by many applications (programs) constructed using the JUPITER API, and can be used as a starting point for such programs.

Model Type: Parameter Estimation, Uncertainty, Sensitivity

Model Objective(s): Calibrating models, Evaluating models, Estimating parameters and predictions and their uncertainty

Model Structure or Mathematical Basis: Parameters are estimated using nonlinear regression: a weighted least-squares objective function is minimized with respect to the parameter values using a modified Gauss-Newton method or a double-dogleg technique. Additional results are based on statistical analyses based on the regression data.

Spatial Scale Employed in the Model: Any scale.

Temporal Scale Employed in the Model: Any scale.

Input Data Requirement: A working model and definition of parameters to be estimated, observations for calibration and their associated uncertainty, and options defining the tasks to be performed.

Model Output: Estimated parameters and predictions and associated statistics and uncertainty.

Input Data Format: ASCII text files and using a GUI from the USGS

Output Data Format: ASCII text files that can be accessed from various GUIs especially GWChart a free code from the USGS

Parameter Estimation/Model Calibration: This is the primary goal of the code

Model Testing and Verification: This is a secondary goal of the code

Model Sensitivity: Calculated by perturbation or read from a process model evaluation such as a sensitivity file from MODFLOW.

Model Reliability: Excellent. Results have been checked by THE USGS and benchmarked against MODFLOW parameter estimation.

Model Application/Case Studies:

Platform/Operating System: Any platform on which Fortran can be compiled and executed. PC, UNIX, LINUX, MAC

Programming language and software: Fortran

Web-based or desk-top application? Desk-top

Is the application flexible to couple with external programs and user created executables? Yes it can be given system commands to run other codes.

Are system and user documentation available? (Web site)

Yes: <http://water.usgs.gov/software/lists/groundwater/>

Are example applications available? (Web site)

Yes: <http://water.usgs.gov/software/lists/groundwater/>

Is there a user group or hotline-type support? (Website)

No. Rapid replies are provided by epoeter@mines.edu and mghill@usgs.gov

Other Comments: