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: Environmental/Policy Integrated Climate model (EPIC), 10/2008, v. 0810

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Brief Description: EPIC is a field scale, daily time step model composed of physically based components for soil and crop processes such as erosion, nutrient balance, crop growth, and related processes. It is designed to simulate drainage areas that are characterized by homogeneous weather, soil, landscape, crop rotation, and management. Since the initial development, EPIC has been continually improving through the additions of algorithms to simulate water quality, climate change and the effect of atmospheric CO_2 concentration, and nitrogen and carbon cycling.

Model Type: EPIC is a continuous precipitation runoff/water quality model.

Model Objective(s): Assess the effect of soil erosion on productivity. Predict the effects of management decisions on soil, water, nutrient and pesticide movements and their combined impact on soil loss, water quality and crop yields for areas with homogeneous soils and management.

Model Structure or Mathematical Basis:

1. The fields may be rural, urban, or agricultural.
2. Simulation area size should be kept to a small area—field size.
3. The simulations are continuous.
4. Components of the hydrologic cycle represented in the model include: Precipitation, Infiltration, Evapo-transpiration, Interception, Detention storage, Overland flow, Channel flow, Groundwater flow, Surface runoff and Snow melt runoff.
5. <u>Precipitation</u>: The EPIC precipitation model developed by Nicks (1974) is a first-order Markov chain model. Thus, input for the model must include monthly probabilities of receiving precipitation.
   <u>Surface Runoff:</u> The runoff model simulates surface runoff volumes and peak runoff rates, given daily rainfall amounts. Two methods are provided for estimating runoff volume – a modification of the Soil Conservation Service (SCS) curve number technique (U.S. Department of Agriculture, Soil Conservation Service 1972) and the Green and Ampt infiltration equation (Green and Ampt, 1911).
   <u>Subsurface Flow:</u> The subsurface flow model includes vertical and horizontal components. Vertical and horizontal subsurface flows are computed simultaneously using storage routing and pipe flow equations. The vertical or percolation component flows to groundwater storage and is subject to deep percolation from the system and return flow. Return flow is added to channel flow from the subarea. Horizontal flow is partitioned into lateral and quick return flow. Lateral subsurface flow enters the subarea immediately downstream and is added to that subareas soil water storage. Quick return flow is added to the channel flow from the subarea.
   <u>Interception:</u> Rainfall interception by the plant canopy is estimated using the maximum possible intercepted rainfall for an event, the above ground plant material, and the leaf area index for the plant stand. When rainfall exceeds interception, the excess falls to the soil surface.
   <u>Evapo-transpiration:</u> The model offers five options for estimating potential evaporation--Hargreaves and Samani (1985), Penman (1948), Priestley-Taylor (1972), Penman-Monteith (Monteith, 1965), and Baier-Robertson (1965). The Penman and Penman-Monteith methods require solar radiation, air temperature, wind speed, and relative humidity as input. If wind speed, relative humidity, and solar radiation data are not available, the Hargreaves or Priestley-Taylor methods provide options that give realistic results in most cases. The Baier-Robertson method developed in Canada performs well in cold climates.
   <u>Snow melt runoff:</u> If snow is present, it may be melted on days when the second soil layer temperature exceeds 0 ^{o}C. Snow is melted as a function of the snow pack temperature. Melted snow is treated the same as rainfall for estimating runoff volume and percolation, but rainfall energy is set to 0.0 and peak runoff rate is estimated by assuming uniformly distributed rainfall for a 24-h duration.

Mathematical formulation of the model components is distributed.

Spatial Scale Employed in the Model: The model simulates a single homogeneous field with no run-on from surrounding fields.

Temporal Scale Employed in the Model: The model is based on a daily time step.

Input Data Requirement:
<u>Field characteristics data</u>: channel lengths, routing lengths, field area, channel and upland slopes
<u>Climate data (daily)</u>: precipitation, minimum temperature, maximum temperature, solar radiation (not required), relative humidity (not required), wind speed (not required)
<u>Soils data</u>: Type, structure, texture, infiltration characteristics.
<u>Crop data</u>: Growth parameters for each crop (growth temperatures, leaf area index, rooting depth, etc.)

Model Output: EPIC produces output for subsurface flow, surface flow, percolation, drainage system flow, soil erosion (wind and water), soluble nutrient yield, sediment yield, plus many other output data too numerous to list.

Input Data Format: Input data for EPIC is in the form of text files.

Output Data Format: All output data for AEPIC is in the form of text files.

Parameter Estimation/Model Calibration: The user can set parameters in EPIC or can use the parameters supplied with the model.

Model Testing and Verification: EPIC has been tested throughout the United States and the world. EPIC has been used in assessments of sediment and nutrient losses as a function of different tillage systems, crop rotations, and fertilizer rates, nutrient losses from livestock manure applications, nitrate-nitrogen losses via subsurface tile drainage, nutrient cycling as a function of cropping system, soil loss due wind erosion, climate change impacts on crop yield and/or soil erosion, losses from field applications of pesticides, irrigation impacts on crop yields, estimation of soil temperature and soil carbon sequestration as a function of cropping and management systems.

Model Sensitivity:
1. The NRCS curve number and curve number index coefficient (if the variable daily soil moisture index used) are influential for runoff and water related output variables, such as soil loss by water, N and P losses in runoff.
2. RUSLE C factor coefficients (parm46 and parm47) and P factor are influential for erosion, sediment yield and N and P losses in sediment.
3. The available soil water capacity (the difference of soil water contents at field capacity and wilting point), potential heat units (PHU), biomass-energy ratio (WA), and harvest index are influential for the crop growth component.

4. Microbial decay rate coefficient and fraction of humus in passive pool are influential for the soil organic C component.
5. The Hargreaves PET equation exponent (if Hargreaves is used for PET), moisture fraction required for seed germination.
6. Nitrate leaching ratio (nitrate concentration in surface runoff to nitrate concentration in percolate), soluble P runoff coefficient (P concentration in sediment divided by that of the water) are influential to nutrient loss.

Model Reliability: EPIC is widely accepted around the world among researchers as a complete field scale hydrological and crop growth model.

Model Application/Case Studies:

1. 2nd Resource Conservation Act (1980-1987)
2. 3rd Resource Conservation Act (HUMUS) (1992-1996)
3. USDA-National Nutrient Loss Database (NNLD) (2001-2004)
4. Conservation Effects Assessment Program (CEAP) (2003-present)
5. Accepted by USDA and EPA and is used in most major U.S. universities and more than 20 foreign countries.
6. Used or cited in more than 200 refereed journal articles and major publications.

Global applications

1. Wingard (1996) used EPIC to assess typical agricultural cropping systems and practices used by the Mayan culture and the impact these practices had on erosion and the development of the Mayan civilization.
2. Rinaldi (2001) used EPIC to assess irrigation timing and amount strategies for sunflower in Southern Italy to determine the most critical growth stage for applying irrigation.

Platform/Operating System: EPIC runs in DOS and requires very little storage space. It can be run on any computer with DOS capabilities.

Programming language and software: EPIC is written in FORTRAN.

Web-based or desk-top application? EPIC is a desktop application.

Is the application flexible to couple with external programs and user created executables? It is possible to tie other subroutines into the program.

Are system and user documentation available? http://epicapex.brc.tamus.edu/

Are example applications available? An example simulation is included with the software. http://epicapex.brc.tamus.edu/

Is there a user group or hotline-type support? User support is provided via emails directly to Jimmy Williams (jwilliams@brc.tamus.edu) or Evelyn Steglich (esteglich@brc.tamus.edu)