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: Agricultural Policy / Environmental eXtender Model (APEX), 6/2008, v. 0806

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Brief Description: The APEX model was developed to extend the EPIC model capabilities to whole farms and small watersheds. In addition to the EPIC functions, APEX has components for routing water, sediment, nutrients, and pesticides across complex landscapes and channel systems to the watershed outlet. APEX also has groundwater and reservoir components. A watershed can be subdivided as much as necessary to assure that each subarea is relatively homogeneous in terms of soil, land use, management, and weather. The routing mechanisms provide for evaluation of interactions between subareas involving surface runoff, return flow, sediment deposition and degradation, nutrient transport, and groundwater flow. Water quality in terms of nitrogen (ammonium, nitrate, and organic), phosphorus (soluble and adsorbed/mineral and organic), and pesticides concentrations (GLEAMS pesticide model is used to estimated pesticide fate.) may be estimated for each subarea and at the watershed outlet.

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

Model Objective(s): The model APEX was constructed to evaluate various land management strategies considering sustainability, erosion (wind, sheet, and channel), economics, water supply and quality, soil quality, plant competition, weather and pests.

Model Structure or Mathematical Basis:

1. The basins may be rural, urban, or agricultural.
2. Basin size should be kept in the small size range.
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, and Snow melt runoff, Surface runoff.
5. Precipitation: The APEX 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.

   Surface Runoff: 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).

   Subsurface Flow: 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.

   Interception: 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.

   Evapo-transpiration: 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.

   Snow melt runoff: 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 small watershed can be divided into numerous smaller subareas connected hydrologically.

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

Input Data Requirement:
Watershed characteristics data: channel lengths, channel depths, routing lengths, watershed area, channel slopes, channel widths
Climate data (daily): precipitation, minimum temperature, maximum temperature, solar radiation (not required), relative humidity (not required), wind speed (not required)
Stream flow data: used for calibration and validation
Soils data: Type, structure, texture, infiltration characteristics.
Crop data: Growth parameters for each crop (growth temperatures, leaf area index, rooting depth, etc.)

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

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

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

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

Model Testing and Verification: APEX has been used around the world. Among many uses, the model is currently used to evaluate conservation practices throughout the United States in millions acres of cropland in the Conservation Effects Assessment Project (CEAP)

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: APEX is widely accepted around the world among researchers as a complete hydrological and crop growth model.

Model Application/Case Studies:

1. Used to study livestock environmental problems on a watershed basis in response to the USEPA pilot project: "Livestock and the Environment".
2. Dairy manure management to maintain water quality in Erath and Hopkins Counties, TX, (Flowers, et al., 1996)
3. A national study to assess the effectiveness of filter strips in controlling sediment and other pollutants (Arnold, et al., 1998)
4. Harman et al. (2004) evaluated alternative runoff control practices for atrazine use in corn and sorghum production for the Aquilla Watershed in central Texas.
5. Saleh et al. (2004) used APEX in an assessment of silvicultural practices on stream flow, sediment loads, and nutrient losses for nine small watersheds in eastern Texas.
6. It is currently being used to evaluate conservation practices throughout the United States in the Conservation Effects Assessment Project (CEAP).

Global applications

7. Two micro-catchments located in the Marche region of Italy (Spescia and Bottiglie) have been monitored since 1998 in order to assess the impact of cropping practices on nitrate and phosphorus pollution, runoff and soil erosion by water. APEX was calibrated based on these measurements and will be used to simulate the impact of climate change scenarios on current cropping systems as well as the adaptation strategies and/or prescriptions for cropping systems based on the expected climate change outcomes.
8. A study was conducted in the Middle Huaihe River watershed in China to evaluate the performance of APEX using daily runoff and sediment yields. The results suggested that APEX is a useful tool for evaluating soil and water loss for different management practices in the river watershed.

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

Programming language and software: APEX is written in FORTRAN 90.

Web-based or desk-top application? APEX 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)

Other Comments: