Texas A & M University and U.S. Bureau of Reclamation
Hydrologic Modeling Inventory
Model Description Form

JUNE 18, 1999

Name of Model:

A Kinematic Runoff and Erosion Model, Version 2 (KINEROS2)

Model Type:

A distributed-parameter, event-based rainfall-runoff-erosion model

Model Objective(s) :

KINEROS2 interpolates spatially distributed breakpoint rainfall and routes water and sediment through a cascading system of dynamically infiltrating and eroding planes, trapezoidal open channels, circular closed conduits and detention reservoirs.

Agency and Office:

Southwest Watershed Research Center
USDA-ARS
2000 East Allen Road
Tucson, AZ 85719
USA

http://www.tucson.ars.ag.gov

Technical Contact and Address:

Carl Unkrich
Southwest Watershed Research Center
USDA-ARS
2000 East Allen Road
Tucson, AZ 85719
USA

Phone: (520) 670-6380-178
Fax: (520) 670-5550
e-mail: **unkrich@tucson.ars.ag.gov**

http://www.tucson.ars.ag.gov/kineros

Model Structure or Mathematical Basis:

KINEROS2 is appropriate for a range of scales, from small experimental plots of several square meters to natural, agricultural or partly urbanized watersheds of several hundred square kilometers.   The model is event-based, with breakpoint rainfall intensities as input, kinematically routed over dynamically infiltrating and eroding planes representing upland overland flow areas. Planes contribute water and sediment to infiltrating, eroding trapezoidal open channels, detention ponds, or closed circular conduits (storm drains).

Rainfall data is either time-depth or time-intensity breakpoint pairs. Rainfall is modeled as spatially uniform over each element, but can vary between elements. The spatial and temporal variability of rainfall is expressed by interpolation from up to twenty rain gage locations to each plane, pond or urban element (and optionally channels). An element's location is represented by a single pair of x,y coordinates, commonly its areal centroid. Initial soil moisture can also be interpolated using the same spatial interpolation coefficients.

As implemented in KINEROS2, interception is the portion of rainfall that initially collects and is retained on plant surfaces. The net effect of interception is controlled by two parameters: the interception depth and the fraction of the surface covered by intercepting vegetation. The interception depth parameter reflects the average depth of rainfall retained by the particular vegetation type or mixture of vegetation types present on the surface. Rainfall rate is reduced by the cover fraction (i.e., a cover fraction equal to 0.50 gives a 50% reduction) until the amount retained reaches the interception depth.

KINEROS2 uses a version of the Smith-Parlange infiltration model that allows either a one- or two-layer soil profile. There is also a physically based approximation for the redistribution of soil water, including recovery of infiltration capacity during a hiatus, and a method for determining appropriate infiltration conditions following the hiatus. Lognormally distributed spatial variation of saturated hydraulic conductivity can also be simulated.

Overland flow depth profiles at each time step are obtained from Iterative solution of a four-point implicit finite difference approximation to the kinematic equation for one-dimensional flow across a unit width. Similarly, open channels flow is modeled as one-dimensional kinematic flow through a trapezoidal cross section, and for closed conduits, a circular section. Open channels can have a compound section, with a primary channel and a secondary, or overbank channel, each having their own hydraulic, infiltrative and erosive parameters.

Rain splash and hydraulic erosion are the detachment mechanisms operating on overland flow planes, and hydraulic erosion alone in channels. Eroded sediment may be routed through any type of element, even those with nonerodable surfaces. Soil and sediment are characterized by a distribution of up to five particle size classes rather than a single median particle size.

Detention reservoirs are implemented through user-defined, depth versus (volume, surface area, discharge) rating tables. Seepage through the wetted area and rainfall onto the reservoir are accounted for, and the initial storage volume can be specified.

Model Parameters:

Each element in the model network is assigned unique parameter values. The number and type of parameters required varies, depending on the type of element and the number of processes represented. For example, a simple impervious plane requires only length, width, slope and Manning n or Chezy C. At the other end of the spectrum, an eroding, infiltrating plane with a two-layer soil, represented by five particle size classes, with spatially variable saturated conductivity, subsurface rock and intercepting vegetation will require a total of 18 parameters. Of course, parameter values do not necessarily vary between elements, and neighboring elements often differ only in length, width and slope.

Spatial Scale Employed in the Model:

There are no inherent assumptions in the model about the scale of individual elements, beyond the requirement that overland flow surfaces are sufficiently rough and flow velocities are high enough to guarantee turbulent flow. However, the interpretation of certain parameters may change with scale. For example, at a scale where pure sheet flow exists, interpretation of flow depth and the surface roughness parameter is quite literal, while at larger scales, which may include a mixture of sheet and rill flow, flow depth should be viewed an average, and the roughness parameter reduced to reflect the presence of more efficient, concentrated flow.

Temporal Scale Employed in the Model:

Being an event oriented model, appropriate time steps for KINEROS2 generally range from less than one minute to several minutes, depending on the scale of the watershed elements. KINEROS2 can automatically reduce its internal, computational time step to maintain numerical accuracy while continuing to generate output at the user-specified time step.

Input Data Requirements:

Being a physically based model, the input requirements for KINEROS2 can be quite extensive. The exact nature of these requirements will vary depending on the application. Essential resources in most cases are topographic and channel cross section data, as the watershed in question must be divided into overland flow and channel elements, where the extent of the channel network determines the minimal number of overland flow elements These primary overland flow areas can then be further subdivided to reflect the spatial variation of soils, vegetation, land use, etc. Individual parameters can be estimated from field or laboratory measurements or from published data. In particular, infiltration parameters can be estimated from tables based on soil texture classes

Computer Requirements:

The current core source code is standard Fortran77. The source code has been successfully compiled and run on MS DOS and Windows PCs, as well as Sun, Silicon Graphics and Digital (VMS) workstations. In addition to the source code, there are precompiled versions with rudimentary user interfaces and graphics for MS DOS and Windows95/98/NT. Work is underway to encapsulate KINEROS2 with an object interface, so that future GUI designs will not be limited to Fortran and no GUI code will need to be imbedded in the model itself. This will greatly simplify maintenance and development of both the model and the GUI.

Model Output:

For any element, KINEROS2 can list runoff rate, interpolated rainfall rate and sediment discharge rate by particle class at each time, as well as a water volume and sediment mass balance summary.

Parameter Estimation / Model Calibration:

As an aid to calibration, KINEROS2 provides a mechanism to adjust certain parameters globally at run time, e.g., increase hydraulic roughness by ten percent for all elements. This allows for correction of systematic error or bias in estimation while preserving the relative variability between elements. The DOS/Windows versions will also plot observed runoff and sediment discharge with the simulated hydro/sedigraph.

Model Testing and Verification:

The overland flow component was extensively tested and validated during its development at the Colorado State University Outdoor Rainfall-Runoff Experimental Facility during the 1970's. KINEROS has been included in several studies to evaluate and compare event-driven runoff and erosion models. Split sample calibration and validation has been carried out, using data from the semiarid Walnut Gulch Experimental Watershed in southern Arizona, on subwatersheds ranging in size from 0.36 to 630 hectares.

Model Sensitivity:

As a distributed model, KINEROS2 is sensitive to the spatial resolution of its constituent elements, although in practice this sensitivity can be limited by the spatial resolution of the rainfall data.

Model Reliability:

KINEROS has performed consistently well with Walnut Gulch data, which is characterized by extreme spatial variability of rainfall, wide infiltrating channels and low runoff to rainfall ratios, making it a crucible for rainfall-runoff models. Because of its reputation as a consistent and accurate model, KINEROS was chosen by the European Community to be the rainfall-runoff engine driving their next generation erosion model, EUROSEM.

Model Application / Case Studies:

Although KINEROS has primarily been used as a research tool, it has also been applied to engineering problems by a number of consulting firms. For example, it was used in a major FERC flood and emergency spillway design project, and currently it is being used to estimate ground water recharge from ephemeral channels adjacent to a proposed nuclear waste repository.

Documentation:

Documentation can be found online at the KINEROS2 web site, including PDF versions of the online documents. Copies of the user manual from the 1990 release of KINEROS are available upon request.

Other Comments: