WEPP: Water Erosion Prediction Project

Description of model

1. Model introduction:

Water Erosion Prediction Project model is a process-based, distributed parameter, continuous simulation, erosion prediction system for using on personal computers. The model has a user-friendly interface, and it built based on the fundamental of plant science, hydraulics, and erosion mechanics (Laflen et al., 1991). The objective for this model is to provide the new generation erosion prediction technology for used by the organizations involved in environmental assessment and conservation planning. The main users for WEPP model include the forest and natural resources conservation service of USDA, Bureau of Land Management, extension agents, farmers, ranchers, environmental consultants, and some local agencies.

2. History of development:

Beginning in 1985, the WEPP model was initiated by Dr. George R. Foster with USDA-ARS National Soil Erosion Research Laboratory in Indiana. The eventual goal to develop this model is for replace the Universal Soil Loss Equation, which is an empirically based equation (Wischmeier and Smith, 1978). With development of the model, the scientists collaborate with the user groups, in order to gain user requirement document for model improvement (Foster and Lane, 1987). The model parameterization data was also gained by conducting multiple field experiments with the basic hydrologic during this time period. In July 1995, on a symposium of Soil and Water Conservation Society, hillslope and watershed version of WEPP model was released (Flanagan and Nearing, 1995). After 1995, the development and modifications of the database and interface for WEPP model was continued.

3. Model inputs and outputs:

WEPP model require 4 inputs, the slope, soil, climate, and management. To be specific, the slope can also be refer to topography, the soil files may include texture, infiltration and erodibilities. The climate file may include storm precipitation, duration, daily maximum and minimum temperatures, wind, solar radiation. The management file include residue decomposition parameters, plant growth parameters, tillage parameters, residue management and dates of all operations.

For the model outputs, it provides a multiple type of outputs. The outputs include graphical depictions of erosion and deposition on hillslope profiles, graphical viewing of daily parameter and model output values, the daily, monthly, annual and average annual precipitation with runoff or soil loss. There are also some special text output files available with information on plant growth and water balance. Both surface runoff, surface flow and evapotranspiration belongs to the water balance.

Description of model methods

The WEPP model components include in water balance percolation, climate simulation, irrigation, winter processes, surface and subsurface hydrology, plant growth, residue decomposition and management, overland and channel flow hydraulics, surface impoundment element. In addition, multiple equations involved in calculating the hydrologic parameters, also a part of WEPP components, the hillslope erosion equation, channel erosion equation.
The most basic type of WEPP model simulation is for the single storm event and a single hillslope profile. It read the input climate information for everyday, if there is a rainfall, the model will perform the single storm simulation to determine the sediment and runoff losses and generation (Nicks et al., 1995). Two-stage Markov chain was used to predict the occurrence of rainfall. The furrow irrigation uses a special 2D infiltration function. In winter, the model is able to predict the snow accumulation and density. The WEPP will use equivalent plane procedure allow simulation of non-uniform hydrology on multiple overland flow elements (OFEs).

As applied in subsurface hydrology, it is a simple subsurface lateral flow model, and the drain tubes will be use for subsurface drainage. The soil water content affect the plant growth, irrigation scheduling, residue decomposition. The soil component, tillage have influence on roughness, ridge height, bulk density, hydraulic conductivity and erodibility. Residue decomposition and management include cropland simulations and rangeland simulations. The cropland simulations are based on decomposition day theory and the maximum decomposition rate was limited by temperature and moisture content. The rangeland simulations are the function of antecedent rainfall, average daily temperature, and carbon-nitrogen ratio of residue (Cochrane et al. 1999).

Hillslope erosion components related to a governing equation \( \frac{dG}{dx} = D_f + D_i \), where \( G \) is the sediment Load, \( x \) is the downslope distance, \( D_f \) is the rill erosion rate and \( D_i \) is the interrill sediment delivery. As to the channel hydrology and hydraulics, there are two ways to compute peak runoff, one is the modified rational, another is the CREAMS method. The governing equation for channel erosion is \( \frac{dG}{dx} = D_I + D_f \), where \( G \) is the sediment load in channel, and \( x \) is the distance of segment downslope, \( D_I \) is the lateral sediment inflow from adjacent hillslopes or ponds, \( D_f \) is the detachment or deposition by flow (Singh et al. 2009).

**Description of model limitations**
There are several limitations existed in WEPP model. As an example, some users may applied the WEPP models to the areas having the permanent channels, this is an inappropriate use of this model, because the processes undergoing in these type of channels are not simulated in WEPP model. Moreover, there is one weakness mentioned here is that, under the condition of dissected landscapes, which existing couple distinct slope shapes, the hillslopes need to simulated as single watershed simulation or separate run in the watershed interface. Another example for inappropriate use of WEPP model is that, some users may use WEPP hillslope component to evaluate the subsurface lateral flow. However, the hillslope component of WEPP model tends to overestimate the deep percolation and underestimate the subsurface lateral flow. The reason is that the WEPP enable the saturated hydraulic conductivity to be the input for the surface soil layer only, the different hydraulic conductivity value used will results in different value in measurement among various type of agricultural environment.

References


