Overview of the SHAW Model

The Simultaneous Heat and Water (SHAW) Model is a one-dimensional model originally developed to simulate soil freezing and thawing. The model's ability to simulate heat and water movement through plant cover, snow, residue and soil for predicting climate and management effects on soil freezing, snowmelt, runoff, soil temperature, water, evaporation, and transpiration has been demonstrated (Flerchinger and Saxton, 1988; Flerchinger and Hanson, 1989; Flerchinger et al., 1990; Flerchinger and Pierson, 1991; and Xu et al., 1991, Flerchinger et al., 1994, Hayhoe, 1994, and Flerchinger et al. 1996).

The SHAW model simulates a one-dimensional vertical profile extending from the top of a plant canopy or the snow, residue or soil surface to a specified depth within the soil. The system is represented by integrating detailed physics of vegetative cover, snow, residue and soil into one simultaneous solution. The model is sufficiently flexible to represent a broad range of conditions and the system may or may not include a vegetative canopy, snow, or a residue layer. Interrelated heat, water and solute fluxes are computed throughout the system and include the effects of soil freezing and thawing. Daily or hourly predictions include evaporation, transpiration, soil frost depth, snow depth, runoff and soil profiles of temperature, water, ice and solutes.

Weather conditions above the upper boundary and soil conditions at the lower boundary define heat and water fluxes into the system. Water and heat flux at the surface boundary include absorbed solar radiation, long-wave radiation exchange, and turbulent transfer of heat and vapor. A layered system is established through the vegetation canopy, snow, residue and soil, with each layer represented by a node.

Soil Freezing and Thawing

The Simultaneous Heat and Water (SHAW) model represents one of the more detailed models of snowmelt and soil freezing and thawing. The Simultaneous Heat and Water model, originally developed by Flerchinger and Saxton (1989) and later updated by Flerchinger and Pierson (1991) and Flerchinger et al. (1996) is capable of simulating the complex wintertime phenomena of snow accumulation and melt, detailed soil freezing and thawing including freezing-induced moisture migration, solute effects frost formation, solute translocation, and frozen soil related runoff. Heat, water and solute equations are solved iteratively until a simultaneous solution is found.

Transpiration from a Multi-Species Plant Comunity

The model is capable of simulating the effects of a multi-species plant canopy (including standing dead plant material) on heat and water transfer. Amount of dry matter, size and leaf area index of each plant species over the year is defined by the user. Provisions for a plant canopy in the SHAW model as described by Flerchinger and Pierson (1991) were made using detailed physics of heat and water transfer through the soil-plant-atmosphere continuum. The plant canopy may be divided into several layers (up to 10) and transfer of water vapor and energy are solved for each layer within the canopy. Heat and water flux within the canopy include solar and long-wave radiation, turbulent transfer of heat and water vapor, and transpiration from plant leaves. Transpiration from plants is linked mechanistically to soil water by flow through the roots and leaves. Within the plant, water flow is controlled mainly by changes in stomatal resistance, which is computed as a function of leaf water potential.

Snow Accumulation and Melt

Energy and mass transfer calculations for snow within the SHAW model are patterned after the point energy and mass balance model developed by Anderson (1976). The energy balance of the snow includes solar and long-wave radiation exchange, sensible and latent heat transfer at the surface, and vapor transfer within the snowpack. Absorbed solar radiation, corrected for local slope, is based on measured incoming short-wave radiation, with albedo estimated from grain size, which in turn is estimated from snow density. Liquid water is routed through the snowpack using attenuation and lag coefficients, and the influence of metamorphic changes of compaction, settling and grain size on density and albedo are considered.

Input to the SHAW model includes: initial snow depth and density; initial soil temperature and water content profiles; daily or hourly weather conditions (temperature, wind speed, humidity, precipitation and solar radiation); general site information; and parameters describing the vegetative cover, snow, residue and soil. General site information includes slope, aspect, latitude, and surface roughness parameters. Residue or litter properties include residue loading, thickness of the residue layer, percent cover and albedo. Input soil parameters are bulk density, saturated conductivity, coefficients for the matric potential-water content relation, and albedo-water content relation.

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