US Army Corps of Engineers®

Urban Flood Demonstration Program

Improved Snowmelt Simulation within GSSHA

Snow and ice melt in Alaska

Products

In an effort to improve the volumes and timing of snowmelt from the Gridded Surface Subsurface Hydrologic Analysis (*GSSHA*) model (Downer et al. 2005) we have made significant enhancements to the original *GSSHA* snowmelt algorithm to include selected snow pack dynamics found within the National Weather Service River Forecast System (Anderson, 1973) model.

A report will detail the effectiveness of the updated *GSSHA* snowmelt algorithm when compared to observed snow accumulation at 6 SNOTEL (snow telemetry) sites in the western United States. The report will also include a section describing the effectiveness of *GSSHA* for a typical watershed application.

Benefits

This product provides hydrologic modelers with an improved physics-based snow accumulation and melt model within the distributed hydrologic model *GSSHA*.

Issue

In many mountainous regions water from snowmelt is a critical resource. In the face of changing climate conditions and increasing population centers that rely on snowmelt runoff, we must better understand our current and future water resource availability and management through numerical modeling. A model heavily used by the United States Army Corps of Engineers is the *GSSHA* model. *GSSHA* is physics based distributed hydrologic model capable of simulating numerous components of the hydrologic cycle, including: soil moisture, evapotranspiration, groundwater, streamflow, and snow

melt/accumulation. *GSSHA* currently incorporates an energy balance method of estimating snowfall accumulation and melting with a simple conceptualization of the snow pack. Recent work in mountainous regions indicates that the simplifications lead to timing errors in the production of snowmelt and subsequent runoff.

Description

Task 1: The snow pack dynamics from the National Weather Service River Forecasting System *SNOW-17* model were incorporated into the existing energy balance snowmelt algorithms within GSSHA. This new snowmelt algorithm is an option within *GSSHA* and is known as the hybrid snowmelt routine. The hybrid snowmelt routine does not require calibration and typically outperformed the original energy balance snowmelt routine within *GSSHA* when compared to observed snow accumulations.

Task 2: Another option was created within *GSSHA* to use the temperature-index based snowmelt/accumulation algorithm in *SNOW-17* as an alternative to the energy balance method. When properly calibrated, this method typically outperformed the energy balance snowmelt and the hybrid snowmelt routines.

Task 3: Other options were included into the *GSSHA* model to improve melt-water timing as it travels through the snowpack and watershed. Based on the *SNOW-17* model, a retention equation was included to simulate the lag time for melt-water to move vertically through the snowpack. Another option was included to simulate horizontal flow through the snow pack as Darcy flow, instead of free surface flow. Simulating flow through the pack as free surface flow typically results in an overestimation of peak flow and timing errors. An option was included that simulates frozen ground which inhibits infiltration in cells with snow. To simulate mountainous regions with orographic effects, an option was included to calculate the temperature of each grid cell based on the difference in elevation of the cell and the temperature gage station.

Task 4: A watershed model for the Trout Creek River Basin (TCB) near Lake Tahoe, CA was developed to test the updated *GSSHA* model. Although the TCB model needs further calibration, the updated *GSSHA* model generally outperformed the original snowmelt routines in simulating snow water equivalent, outflow volumes, and timing of flows.

Sponsor

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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