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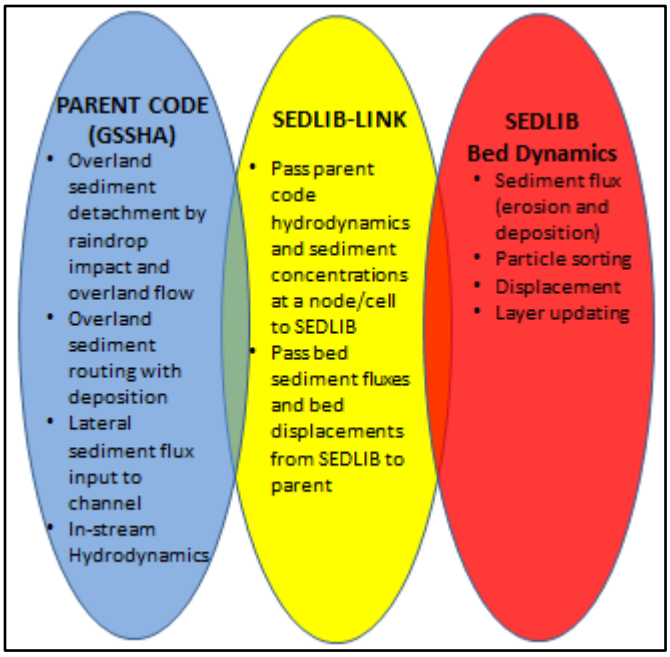
Integrated Watershed/Stream Sediment Simulation with GSSHA/SEDLIB

Process Based Sediment Analysis for a Diverse Planet

The Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model is a watershed analysis and management tool with the ability to simulate the movement of water, sediment, and associated constituents at the watershed-scale. GSSHA is a process-based hydrologic model that simulates overland, channel, and subsurface flow in an integrated fashion. Sediment Library (SEDLIB) is an in-stream sediment process library that includes detailed descriptions of sediment processes including bed dynamics such as erosion, layering, armoring, sorting, and percolation, along with sediment suspension and deposition. GSSHA and SEDLIB are currently developed, maintained and distributed by ERDC-CHL.

Model Integration for Improved Sediment Simulations

Unlike simple empirical and semi-distributed models often used in hydrologic analysis, GSSHA is a fully distributed, process-based numerical tool suitable for engineering analysis and design. GSSHA provides the ability to explicitly simulate important watershed features such as streams, hydraulic structures, embankments, subsurface drainage systems, as well as reservoirs, lakes and detention basins, storm and tile drains, best management practices (BMPs), etc. that cannot be adequately represented in an implicit manner. GSSHA delivers high fidelity simulations of overland and stream flow, as well as state of the art simulation of overland sediment, erosion, transport, and deposition modeling. However, in comparison to overland sediment, the simulation of in-stream sediments in GSSHA is overly simplistic, and misses significant processes, such as in-stream sources of fines, and complex bed dynamics, such as layering, armoring, etc.



SEDLIB was developed as a general in-stream sediment process library. It is non-parent hydrology and hydraulics (H&H) model specific. In theory, SEDLIB can be linked to any H&H source code. SEDLIB has already been linked with another ERDC H&H model, AdH (Adaptive Hydraulics). This coupling has proven very useful for simulation of sediment dynamics in large river and estuarine systems, such as the Mississippi River, and coastal Louisiana.

In this work unit, we have coupled SEDLIB to the GSSHA model to improve the in-stream sediment transport capability in the model. GSSHA and AdH are very different H&H simulation engines. Much of the linkage logic that worked for AdH had to be modified for GSSHA. A visualization of the approach taken is shown in Figure 1. The SEDLIB library has been linked to GSSHA such that all of the robust sediment transport, sorting, armoring, and bed layering features that are inherent to SEDLIB can be brought to bear for addressing in-stream sediment transport issues in GSSHA.

Figure 1 – GSSHA/SEDLIB Integration

Integrated Hydrologic/Hydraulic/Sediment Transport/Water Quality Analysis for More Robust and Realistic Simulation

GSSHA is a fully integrated surface and subsurface hydrologic, hydraulic, sediment transport, and surface water quality model.

GSSHA performs, in an integrated fashion, what might normally take four, or more, separate model applications to accomplish. In addition to the obvious reduction in effort to apply one model, as opposed to many models, analysis with GSSHA provides feedback mechanisms between model domains and processes, something that can't be accomplished when simulating surface water hydrology, groundwater hydrology, surface water hydraulics, sediment transport on the overland, sediment transport in the stream, sediment transport in reservoirs, and water quality in all these domains with separate modeling packages. In many climatic and hydrologic settings these feedback mechanisms can be critical and cause overwhelming effects, such as saturation excess runoff, stream baseflow, overbank flooding from streams, or backwater flooding from reservoirs. With the addition of SEDLIB to GSSHA, GSSHA becomes a very powerful, complete watershed sediment simulation package, capable of simulating the fate of sediments across the watershed, from the overland, to the streams, to lakes and reservoirs, while accounting for management and control features in any of these domains.

Applications

GSSHA has been applied in the Minnesota River Integrated Watershed Study to simulate hydrology, sediment transport, and nutrient dynamics to help understand the hydrologic processes in the basin and inform simpler large scale models being applied in this agriculturally intensive, highly drained basin. Similarly, GSSHA has been being applied for total maximum daily loadings (TMDL) analysis at multiple military facilities on the island of Oahu, Hawaii. GSSHA was used to estimate water, sediment, and associated contaminant loadings from training, residential, and mixed use areas, locate sediment and contaminant source areas, and help design management features in support regulatory environmental compliance.

Availability

The GSSHA model runs on Windows, LINUX, and within the supercomputing environment. Currently the release version of GSSHA (version 7.12) model executables for Windows (32 and 64 bit) and LINUX systems are available without restrictions from the GSSHA wiki http://www.gsshawiki.com. GSSHA is supported by the Watershed Modeling System (WMS) which facilitates model input development and results analysis. GSSHA with SEDLIB is still in development and will be available in October 2018.

Documentation, Training & Support

GSSHA documentation, including manuals, technical notes, a primer, and tutorials are available from the GSSHA wiki http://www.gsshawiki.com. Training is periodically provided by ERDC-CHL. Training is announced through the USACE H&H CoP and the GSSHA wiki. Specialized training can be arranged by webinar, at ERDC, at USACE or other agency locations, or offsite. Please contact us about how to best meet your specific training needs. More information can be found on the ERDC-CHL website http://chl.erdc.usace.army.mil/gssha.

SEDLIB is generally invoked via the numerical model with which it is associated. For AdH, SEDLIB is fully integrated into the AdH framework. Hence, SEDLIB documentation and guidance are available through AdH workshops, webinars, and the AdH webpage (https://chl.erdc.dren.mil/adh/main/index.html). For GSSHA, the attendant documentation will be made available when the release version of SEDLIB/GSSHA is made available.

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