Engineer Research and Development Center
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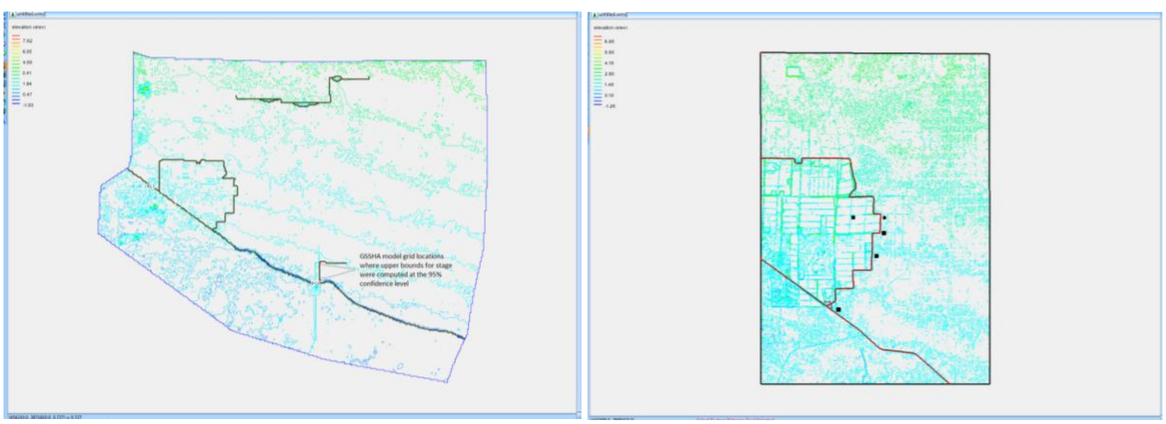
Gridded Surface Subsurface Hydrologic Analysis (GSSHA)

Process Based Hydrologic 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 across watershed-scale areas. GSSHA was originally developed by Drs. Charles W. Downer (ERDC-CHL) and Fred L. Ogden (UWYO) with the explicit purpose of developing a hydrologic analysis tool capable of simulating the processes that produce streamflow in any type of climatic or hydrologic setting. GSSHA is a process-based hydrologic model that simulates overland, channel, and subsurface flow in an integrated fashion. Since its inception GSSHA has continued to be developed, improved upon and applied from the tropics to artic. GSSHA is currently developed, maintained and distributed by ERDC-CHL under the direction of Dr. Downer.

Hydrologic Analysis for More Cost Efficient/Safer Engineering Design

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 that cannot be adequately represented in an implicit manner. As a result of its numerical formulation, GSSHA has the ability to bring outside influences into the problem domain, such as streamflow, groundwater, or overland flow from outside sources making GSSHA applicable as a watershed model in coastal areas and in areas influenced by large water bodies. GSSHA has the ability to predict flooding from multiple sources, such as from excess rainfall, storm surge, stream overbank discharge, and reservoir expansion or backwater. Because GSSHA is a fully distributed model, it has the capability to analyze the effects of localized projects, such as wetlands restoration, the removal of storm/tile drains, channel modifications, best management practices (BMPs), etc. that cannot be explicitly simulated in traditional lumped parameter or semi-distributed models.



Maximum Flooding with Project at Picayune Strand Restoration Project at Varying Scales

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

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. From the beginning GSSHA was developed to simulate watershed processes in an integrated, holistic fashion and has thus already accomplished what retro-fitting of single purpose hydrologic and hydraulic codes can never do.

Applications

GSSHA is approved by FEMA for hydrology and was recently used for a level of service (LOS) flood study for the Picayune Strand Restoration Project in southwest Florida, depicted in the figure above. This study was successful because of many unique features in GSSHA, such as time varying overland boundary conditions, overland flow structures, inset models of varying detail (as shown in the figure), and automated calibration methods. As a result of the GSSHA analysis, flood control feature design details were refined, resulting in the saving of $40M in construction cost for the project. In a similar fashion, GSSHA is being used in the Philadelphia District to help design flood abatement measures to prevent storm surge flooding, such as that occurring during Hurricane Sandy. Proposed abatement measures include sand dunes with drainage features that hold back storm surge while allowing rainfall runoff to drain out from behind the dunes. However, GSSHA is not just for flood damage reduction. GSSHA is currently being applied in the Minnesota River Integrated Watershed Study simulate hydrology, sediment transport, and nutrient dynamics to help understand the hydrology in the basin and inform simpler large scale models being applied in this agriculturally intensive, highly drained, basin. Similarly, GSSHA is currently being applied for total maximum daily loadings (TMDL) analysis at multiple military facilities on the island of Oahu, Hawaii. GSSHA is being used to estimate water, sediment, and associated contaminant loadings from the training areas, as well as being used to help design management features.

Availability

The GSSHA model runs on Windows, LINUX, and within the supercomputing environment. Currently the release version of GSSHA (version 6.1) 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.

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.

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