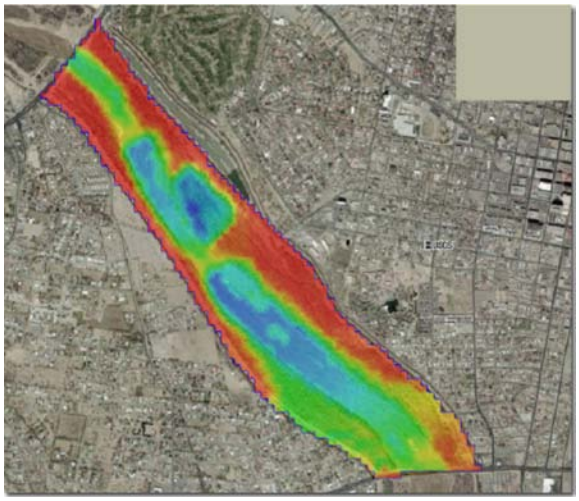
System-Wide Water SWWRP Resources Program

Gridded Surface Subsurface Hydrologic Analysis (GSSHA)



Description: 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. In addition to surface-water analysis, GSSHA has the ability to simulate saturated and unsaturated groundwater, allowing use of the model in a variety of climates and watersheds. Coupling surface and groundwater simulations makes GSSHA capable of simulating streamflow generated by infiltration excess saturated source areas, exfiltration, and groundwater discharge to streams. GSSHA is also capable of simulating soil moistures and groundwater levels at the grid scale as well as wetlands, hydraulic structures, reservoirs, storm drainage networks in urban areas, and tile drainage networks in agricultural areas.

Applications: Recent GSSHA applications include the Kishwaukee watershed in Illinois (just outside of Chicago) with a focus on providing flood and groundwater level information for a watershed management plan that includes removing tile drains and restoring native wetlands. Another application for flood protection is in south Washington County, Minnesota, where an urbanizing area in glacially influenced terrain is being modeled. A third application involves modeling a portion of the Rio Grande River to predict local groundwater level changes due to a small dam being inserted in the river. The results of the GSSHA model will be tied to ecological models to predict ecological change based on changes in water levels. GSSHA is currently being applied for TMDL analysis of multiple military training sites 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.

Benefits: GSSHA is a complete watershed analysis model, allowing the simulation of coupled surface water and groundwater hydrology. Because of its numerical formulations, GSSHA is able to be applied as a watershed model in coastal areas and in areas around large water bodies. GSSHA can predict flooding from rainfall events and also from storm surge events. Since GSSHA is a fully distributed model, it has the capability to analyze the effects of localized projects, such as wetlands restoration, the removal of tile drains, channel modifications, best management practices, etc. that cannot be explicitly simulated in traditional lumped parameter or semi-distributed models.

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In addition, for simulations where the flow path matters, such as sediment and contaminant transport or the effects of land use change, the distributed modeling approach is clearly superior in comparison to hydrologic models that do not include the flow path as part of the calculations, i.e., lumped parameter and semi-distributed models. GSSHA is supported by the graphical user interface Watershed Modeling System (WMS). Using WMS to utilize GSSHA enables users to take advantage of greater levels of data detail, more realistically simulate physical processes, and reduce the data collection, model setup, and post-processing time.

Data Requirements: Since GSSHA is a spatially explicit hydrologic model that includes many different processes, GSSHA requires spatially explicit data for each process. Typical data needed are a Digital Elevation Model (DEM) of the watershed, land use and soil type shape files, stream cross-sections, and subsurface characterization data. Additionally, streamflow, precipitation, and meteorological data are needed to simulate a defined time period and to calibrate the simulations.

Future Capabilities: Currently, water quality routines for in-stream, overland, and in-soil processes are undergoing final testing and are being fielded at multiple sites. These routines include basic nutrient cycle processes including plant uptake and contaminant kinetics. It is anticipated that this capability will be in the release version of GSSHA.

Future developments include improved snowmelt modeling, frozen soil modeling, improved linkage to water quality and habitat models, and improved numerical schemes for decreased run-time and increased stability.

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