Rapid Prototyping Capabilities for Evaluating Current and Future NASA Data in Multi-Scale Sensitivity Analysis in Watershed Hydrology Modeling

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BACKGROUND

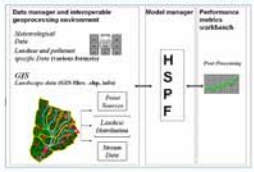
One of the Rapid Prototyping Capability (RPC) general goals is to "Speed the evaluation of potential uses of NASA research products and technologies to improve future operational systems by reducing the time to access, configure, and assess the effectiveness of NASA products and technologies" (NASA, 2005.)

Oftentimes, current watershed hydrology modeling activities rely on:

- Temporally non-dynamic land-cover/land-use maps
- Topographical characterization with low-resolution data
- Limited soil moisture data

In the context of watershed hydrology modeling and the RPC philosophy this project's motivation is to improve current modeling activities by using NASA products that offer:

- Updated land-use/land-cover maps (MODIS, VIIRS, global coverage)
- High-resolution topographical data (SRTM, global coverage)
- Spatial estimation of soil moisture for calibration/validation (NASA-LIS)



HSPF integration into RPC

GOALS AND OBJECTIVES

Goal: assess the NASA Earth observing and predictive capabilities for quantifying non-point watershed hydrological processes and in-stream water quantity and quality.

Specific objective: evaluate usefulness of the following NASA products for providing parameter data for input into hydrological models:

- MODIS land cover data,
- Simulated VIIRS land-cover data
- SRTM topographical data,
- Land Information System (LIS) soil moisture output data,

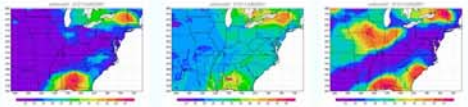
Decision Support Tool: NASA's topographic, landuse/landcover, soil moisture and meteorological data-products are used for generation of input time-series and maps for the **Hydrological Simulation Program Fortran (WinHSPF)** into RPC. Geoprocessing was performed using the **BASINS** methodology. The results of this research, however, can also be extended to other hydrological models.

RESPONSE TO SOCIETAL NEEDS

MODerate Resolution Imaging Spectroradiometer (MODIS) land cover data, simulated Visible Infrared Imager Radiometer Suite (VIIRS) land-cover data, NASA Shuttle Radar Topography Mission (SRTM) topographical data, and NASA-LIS soil moisture maps, cover the societal needs in terms of data resolution, geographical coverage, and up-to-date requirements.

MODIS land-cover

SRTM topography (DEM)



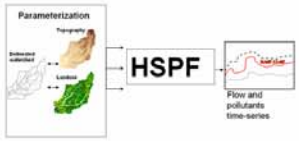
NASA-GSFC-LIS output data using a combination of the CLM, NOAH, and VIC models and the GDAS and GEOS forcing datasets (1KM resolution)

SOCIETAL NEEDS

The introduction of new/updated land-use maps and time series generated with NASA-products would enhance the performance of water resources models in general, and HSPF in particular, along with facilitating the design of pollutant's Total Maximum Daily Loads of (TMDLs), and agricultural Best Management Practices (BMPs). This has a direct impact in society since water quality and hydrological models allow the generation of several water resources management scenarios from which environmental managers, stakeholders and public in general, could choose the best option.

SENSITIVITY ANALYSIS

Sensitivity in terms of percentage change is calculated after swapping topographical maps (NED, SRTM, USGS-DEM, IFSAR) or land-use maps (NLCD, MODIS, GIRAS, VIIRS) with respect to reference cases. Reference cases refer to watershed characterization using the reportedly best quality topographical or land-use maps available (NED and NLCD respectively).



Sensitivity analysis for HSPF output time series

TOPOGRAPHY VISUALIZATION

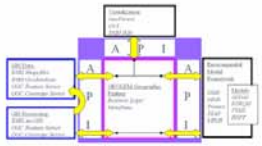
Hydroshading algorithms are applied to NASA's Shuttle Radar Topography Mission (SRTM) Digital Elevation datasets for visualization of water divides and stream networks. The visualization technique is applied to coastal and inland watersheds in Mississippi.

Visualization of water divides and stream network

GEOPROCESSING

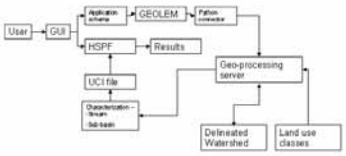
Access and manipulation of geographical data within the interoperable geoprocessing environment are done using GEOLEM.

What is GEOLEM



- Library of basic geoprocessing functions, e.g., "flow direction", "reclassify"
- Library of complex geoprocessing logic, e.g., "make map of hillslopes", "make map of affected areas"
- Knowledge handling infrastructure
- System to encode modeling knowledge into metadata
- Metadata handling infrastructure

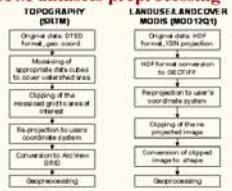
HSPF and GEOLEM interaction



Currently, the integration of GEOLEM into the RPC architecture is in process. Additionally, soil moisture and meteorological data from NASA's LIS are still being processed for input in the hydrological models. The HSPF implementation in RPC has successfully tested MODIS's landuse/landcover and SRTM's topographical data.

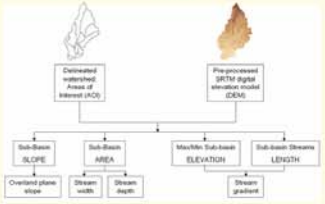
GEOPROCESSING FOR HYDROLOGICAL MODELING

MODIS and SRTM datasets preprocessing



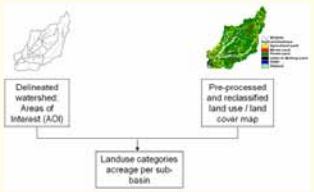
SRTM and MODIS data required some preprocessing before extraction of hydrological parameter values. Delineation using SRTM data proved to be almost as straight forward as when using the standard USGS-DEM or NED datasets.

Extraction of topographical parameters



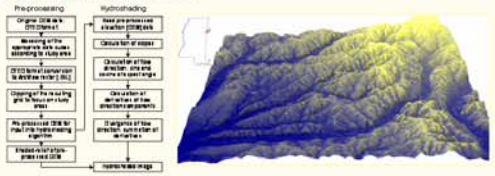
During delineation, BASINS (GEOLEM) summarizes the topographic information per sub-basin and per stream in: attributes of sub-basins (area, slope, overland plane slope, stream width, stream depth) and attributes of streams (length, maximum/minimum elevation, stream gradient).

Extraction of landuse parameters



Before extraction of landuse/landcover parameters, the original landuse classes in the three datasets (NLCD, USGS-GIRAS and MODIS) were grouped into six categories: forest land, urban or built-up land, agricultural land, barren land, water, and wetlands. This consolidation was performed to be able to compare results in terms of landuse area and for outputting parameters easily assimilable by HSPF.

Watershed visualization



SRTM data cubes do not cover completely the geographical boundaries of the areas under study. A mosaic needs to be generated from several SRTM cubes and clipped to a manageable size for input into the hydroshading algorithm.

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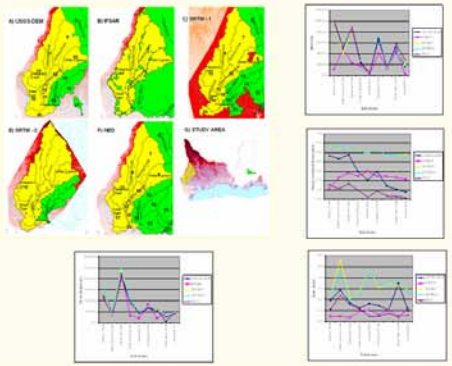
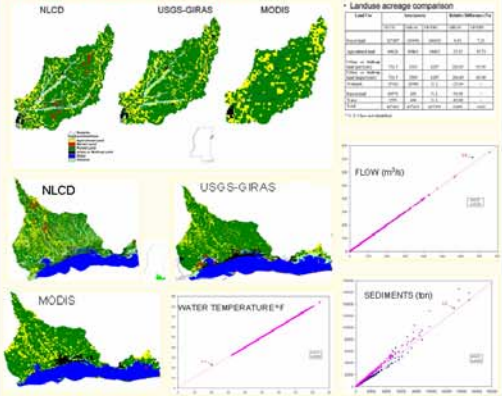
RESULTS

Comparative delineation of watersheds



The SRTM dataset provides similar distribution and demarcation of sub-basins when compared to the NED dataset. The topographical parameters sub-basin area and river length are almost identical to NED's. Sub-basin slopes and river slopes are the topographical parameters that are more dissimilar to NED's. These results need to be further investigated because they could be significant for hydrological simulation.

Landuse parameters comparison



MODIS landuse/landcover datasets provide landuse acreage comparable to NLCD and GIRAS. Flow, sediments, and water temperature sensitivity to landuse swaping was performed. The exploration revealed that flow and water temperature estimations are insensitive to landuse data in yearly time-steps, while sediment estimations were affected up to -15% when comparing MODIS against NLCD and +8% when comparing MODIS against USGS-GIRAS.

Watershed visualization

Hydrohsading provides an effective mean for identification of water divides and streams. Ease and speed make it a good option for watershed delineation.

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