THE IMPLEMENTATION OF THE SNOWMELT RUNOFF MODEL IN ARCGIS

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ABSTRACT

To provide water resource managers and other end-users with operational forecast products and tools, we have implemented an enhanced version of the Snowmelt Runoff Model (SRM) that operates within ArcGIS 9.2. We have also implemented tools within ArcGIS that generate the necessary inputs to SRM. This ArcGIS-SRM system allows the user to easily: 1) delineate watersheds, 2) incorporate remote sensing images of snow cover, meteorological forecasts, and real-time streamflow values via the Internet, 3) compute several SRM model parameters, and 4) generate streamflow forecasts.

INTRODUCTION

In response to end-user requests to have an easy to use hydrologic model that can be spun up and run in real-time with ease, we have written the Snowmelt Runoff Model to run within the ArcGIS environment. The objective of this project is to provide a suite of tools that prepare and compute the necessary data and inputs for running the Snowmelt Runoff Model in ArcGIS. The wide array of tools available through the Snowmelt Runoff Model Toolbar are discussed in the following three sections: Basin GIS Tools, Meteorologic Tools, and Hydrologic Tools.

BASIN GIS TOOLS

The tools defined under Basin GIS Tools (Table 1) are used to delineate a watershed, disaggregate the delineated watershed, and export the disaggregated watershed as a database file (.dbf) that can be integrated into the ArcGIS version of the Snowmelt Runoff Model. In order to perform a majority of the tasks available under the Basin GIS Tools menu, the ESRI's Spatial Analyst extension must be licensed. If it is not, a watershed can not be delineated using this toolbar. To delineate a watershed, the user must have a DEM of the area of interest and a shapefile containing information about hydrologic units. Once these files are acquired, delineating a watershed is a matter of a few mouse clicks. Since the Snowmelt Runoff Model is a semi-distributed model, all parameters and variables are computed and input per zone. We have provided a number of options for dividing a basin into zones including disaggregation by elevation, aspect, slope, or vegetation. Figure 1 shows an example of a basin that has been disaggregated by elevation. Statistics can be summarized for each zone by using the "Zonal Information" button available on the toolbar.

Table 1. Tools and description of tools available under the Basin GIS Tools menu of the Snowmelt Runoff Model Toolbar

Menu Tool	**Description**
Basin Initialization	*merge DEMs and extract buffered HUC*
Basin Preparation	*fills sinks; computes flow direction, flow accumulation, and streams*
Gauge Location	*places user-defined point for stream gauge location for delineation*
Delineate Watershed	*delineates watershed*
Convert Watershed	*creates DEM and shapefile of delineated watershed*
Disaggregate by Aspect	*disaggregates watershed into zones of aspect*
Disaggregate by Elevation	*disaggregates watershed into 1-10 zones of elevation*
Disaggregate by Slope	*disaggregates watershed into 1-10 zones of slope*
Disaggregate by Vegetation	*disaggregates watershed into zones of similar vegetation*
Zonal Information	*generates database file of Area and Median elevation for all zones*

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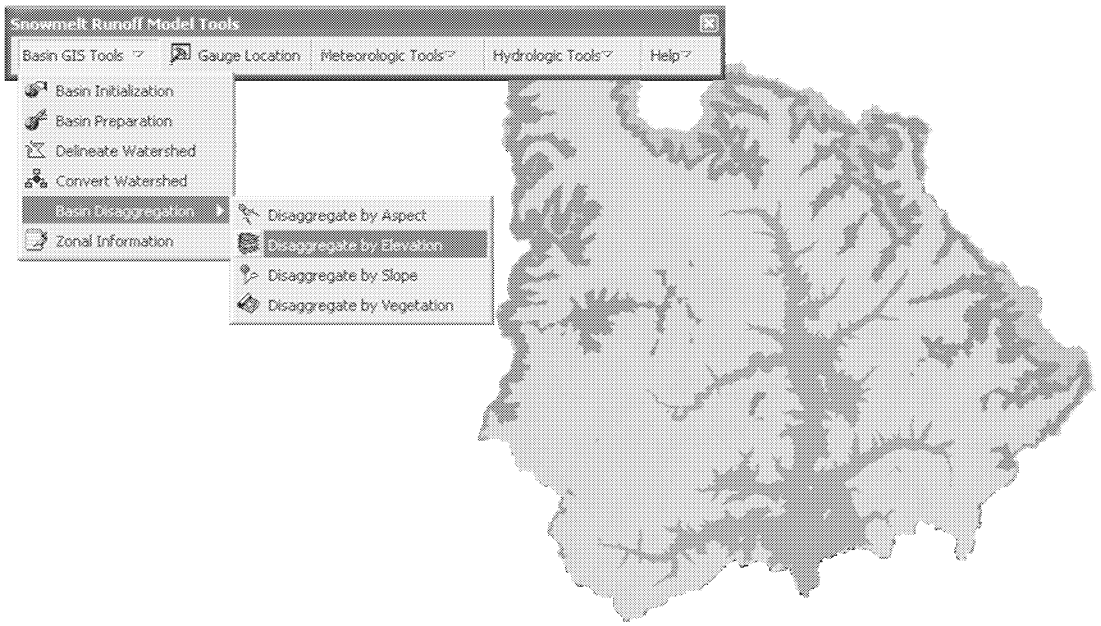

Figure 1. Disaggregated watershed by elevation using the Snowmelt Runoff Model Toolbar

METEOROLOGIC TOOLS

The Meteorologic Tools menu on the Snowmelt Runoff Model Toolbar is available to incorporate two forecast datasets into the GIS environment. A list of the available tools under the Meteorologic Tools menu is given in Table 2. There are two options for obtaining forecast data with the Snowmelt Runoff Model toolbar. The first option is to generate a 15-day forecast of maximum and minimum temperature. To generate the forecasts, 15-day forecasts from the Global Forecasting System (GFS) model produced by NCEP are retrieved via the internet and are statistically downscaled to SnoTEL stations for Idaho and western Montana. The second option is to use the 7-day National Digital Forecast Database (NDFD) forecasts produced by the National Weather Service. Currently maximum and minimum temperature forecasts are retrieved for the Pacific Northwest. Other meteorological variables and geographic regions for the NDFD forecasts may be obtained by altering the python code (retrieve_ndfd.py) included in the SRM/scripts folder. Figure 2 illustrates an example of the NDFD data ingested into the ArcGIS environment as well as a time-series plot of the downscaled 15-day NCEP forecast at a particular SnoTEL station.

Table 2. Tools and description of tools available under the Meteorologic Tools menu of the Snowmelt Runoff Model Toolbar

Menu Tool	**Description**
Retrieve Past NCEP Forecasts	*retrieves historical NCEP forecasts via the internet*
Downscale Past NCEP Forecasts	*downscales historical NCEP forecasts to SnoTEL stations in Idaho and western Montana*
Retrieve NCEP Forecasts	*retrieves real-time NCEP forecasts via the internet*
Downscale NCEP Forecasts	*downscales real-time NCEP forecasts to SnoTEL stations in Idaho and western Montana*
Add Downscaled Forecasts to Map	*adds a user-defined downscaled NCEP forecast to the map*
Retrieve NDFD Forecasts	*retrieves real-time NDFD forecasts from the internet for the Pacific Northwest*
Convert NDFD to Shapefile	*converts real-time NDFD forecasts from a binary file to a shapefile*
Time-series plots of forecasts	*creates a time-series plot of forecasts from a SnoTEL station defined by the user*

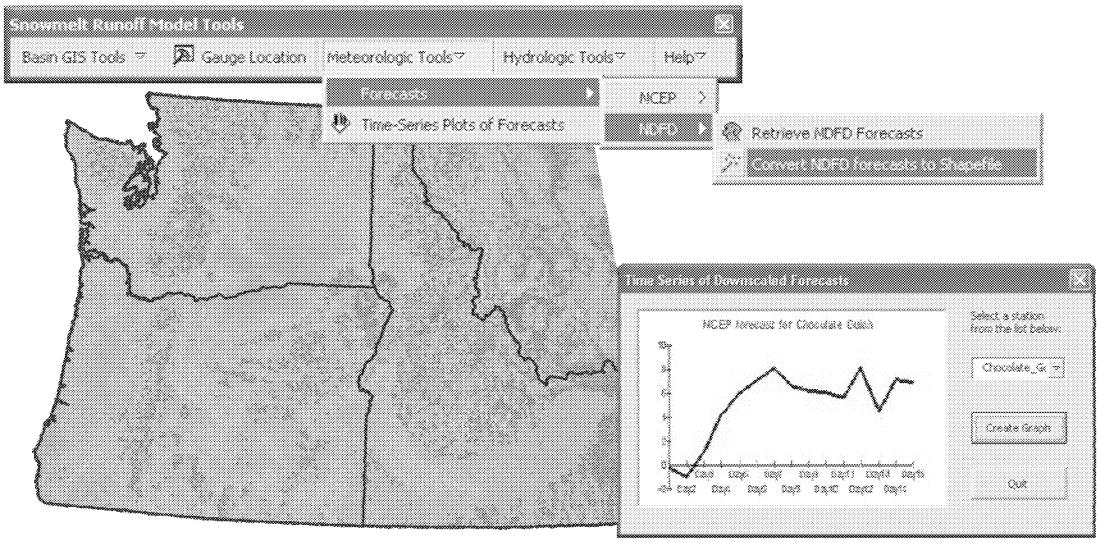

Figure 2. Example of NDFD data ingested into the ArcGIS environment and a time-series plot of the downscaled 15-day NCEP forecast at a particular SnoTEL station

HYDROLOGIC TOOLS

The Hydrologic Tools menu contains a set of tasks to perform analysis of snowcover, estimate model parameters, and execute the Snowmelt Runoff Model (Table 3). Currently, the snowcover and the model parameter estimation tasks are still under development. The snowcover tasks will retrieve a snowcover image via ftp and compute the snow-covered area per zone as a percent. The model parameter estimation tasks, including the approximation of the critical temperature, degree-day factor, recession coefficients, and temperature lapse rates, will compute the majority of the parameters needed to execute the Snowmelt Runoff Model. Once the toolbar has been used to generate all of the necessary model inputs, the user can execute the Snowmelt Runoff Model in a number of different modes. To evaluate how well the model can perform in a particular basin and to determine if any parameters need to be adjusted, the user can run SRM in Retrospective Mode with Actual Data. This mode allows the user to compare simulated streamflow to actual streamflow when observed data from local meteorological stations (SnoTEL) stations are used. The Toolbar also allows the user to run SRM in Retrospective Mode with Forecasted data and in true Forecast Mode, where streamflow predictions are being made up to 15-days in advance using meteorological forecasts from either the downscaled NCEP data or the National Weather Service's NDFD data.

Table 3. Tools and description of tools available under the Hydrologic Tools menu of the Snowmelt Runoff Model Toolbar

Menu Tool	**Description**
Retrieve Snow Cover Image	*retrieves a snowcover image via the internet*
Calculate Snow Cover Percent	*calculate snow cover percent for all zones and creates a database file*
Critical Temperature	*creates textfile of maximum and minimum critical temperatures for defined SnoTEL stations*
Degree Day Factor	*creates textfile of degree day factor for each zone for defined SnoTEL stations*
Recession Coefficient	*creates textfile of X and Y recession coefficients for defined SnoTEL stations*
Temperature Lapserate	*creates textfile of monthly temperature lapse rates for defined SnoTEL stations*
SRM Retrospective w/Actual Data	*runs SRM in retrospective mode using measured data for defined SnoTEL stations*
SRM Retrospective w/Forecast Data	*runs SRM in retrospective mode using forecasted temperature and precipitation for defined SnoTEL stations*
SRM Forecast Mode	*runs SRM in forecast mode using forecasted temperature and precipitation for defined SnoTEL stations*
View Streamflow Simulations	*allow user to view streamflow simulations generated from running SRM in the GIS environment*

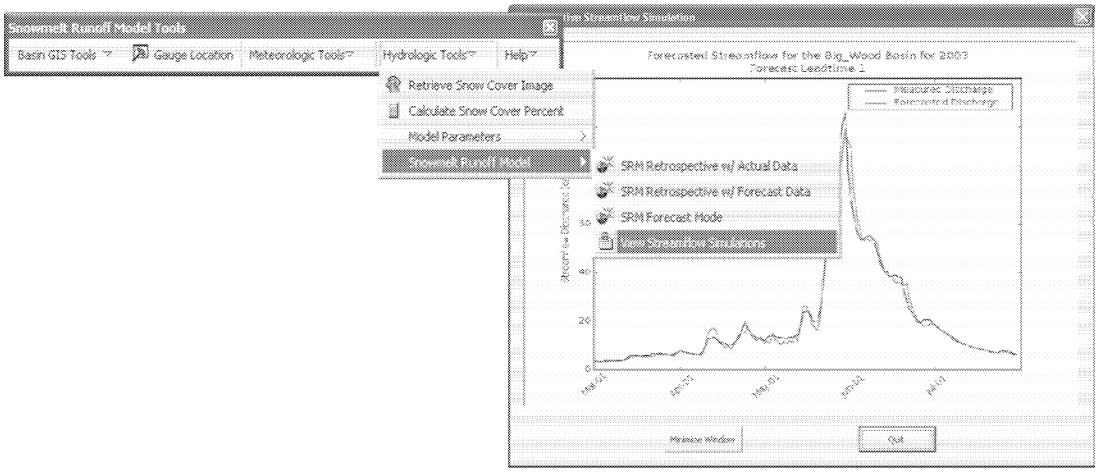

Figure 3. Displayed streamflow forecast simulated using the Snowmelt Runoff Model Toolbar

SUMMARY

This paper presents the integration of a hydrologic model with ArcGIS. Since hydrologic modeling is highly spatial, GIS is a perfect environment in which to compute, analyze, and display model inputs and output. The Snowmelt Runoff Model Toolbar was created with real-time, operation forecasters in mind. This allows users to prepare a basin, summarize the zonal statistics, and execute and display the model results efficiently. GIS allow model parameters, variables, and results to be easily "seen" in a spatial, geographic framework. The version of the Snowmelt Runoff Model toolbar presented here is currently in the beta stage of generation. As more tools become finalized, the toolbar will be made available for interested entities. For additional information on the Snowmelt Runoff Model Toolbar or how to obtain a version of the toolbar, please contact Brandon Moore at Brandon.Moore@vandals.uidaho.edu (208-835-5803).

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