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Original Article

High Spatial Resolution Soil Data for Watershed Modeling: 1. Development of a SSURGO-ArcSWAT Utility

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Abstract

Modeling of watersheds greatly benefits from high spatial resolution soil data. Watersheds models need to be compatible with a format in which soil data are stored. In the United States, the Soil Survey Geographic (SSURGO) database provides higher-spatial resolution soil data, but AVSWAT and ArcSWAT, two GIS-enabled interfaces for preparation of input data and post-processing for the Soil and Water Assessment Tool (SWAT) model, are compatible only with the State Soil Geographic (STATSGO) database, which is normally prepared at 10 to 20 times coarser scale. Available SSURGO processing tools currently work with AVSWAT, but not with the latest version of ArcSWAT. The objective of this study was to develop and demonstrate a utility for ArcMap GIS that is capable of processing SSURGO soil data into a modified STATSGO format that is readable by ArcSWAT. The SSURGO-ArcSWAT utility was applied to the State of Kansas, USA to test for regional differences between STATSGO and SSURGO databases in identification of soil hydrologic attributes. The utility was successful in translating SSURGO soil data into a format useable in ArcSWAT. When SSURGO data were compared with STATSGO data for the State of Kansas, about one-third of the total area had different soil hydrologic group classification, with greater than 10% differing by more than one group. Use of the SSURGO-ArcSWAT tool by watershed modelers will allow simple implementation of SSURGO data into ArcSWAT modeling projects.

Key words: *ArcObjects, GIS, Hydrologic Modeling, Soil database, SSURGO, STATSGO, SWAT*

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INTRODUCTION

Soils are important characteristics that significantly influence hydrologic and physical processes in watersheds. Accurate evaluation of numerous soil properties is essential to watershed modeling. Properties included in a soil database typically consist of general soil characteristics, such as texture, taxonomy, and number of layers (or horizons), and depth-specific soil characteristics, such as saturated hydraulic conductivity, soil moisture at field capacity, and wilting point, which are assumed to be constant within each soil layer.

In the United States, several publicly available geospatially linked soil databases were developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) (USDA-NRCS 2009a,b; USDA-SCS 1994). The State Soil Geographic (STATSGO) database (USDA-SCS 1994) was the first geospatial soil database that consisted of an inventory of soils and non-soil areas that occur on the landscape and contained a wide range of soil physical properties. This 1:250,000-scale dataset was created by generalizing detailed soil survey maps in 1- by 2-degree topographic quadrangle units, and its attributes were determined by statistically expanding the more detailed soil data statistics to the whole map unit. In 2006, the STATSGO spatial and tabular dataset was revised, updated, and renamed as the U.S. General Soil Map or STATSGO2 (USDA-NRCS 2009b). Another soil database, the Soil Survey Geographic (SSURGO), was developed by the NRCS in 2006 and became the most detailed soil survey database available in the U.S. (USDA-NRCS 2009a). STATSGO dataset currently is available for the entire U.S., whereas the SSURGO coverage has been completed for 95% of the country, with the remaining unprocessed areas mainly in the western U.S. (USDA-NRCS 2011).

Both STATSGO and SSURGO soil maps were compiled and generalized from the same soil surveys conducted by the NRCS. The 1:24,000-scale SSURGO dataset was structured on a county basis with a typical spatial resolution of 10 to 20 times greater than STATSGO, and consisted of sets of multiple spatial and tabular data files. The difference in source-data generalization influences the intended use of the datasets. The STATSGO dataset was intended for general land-use planning and management at the multicounty, state, or river basin scale, whereas the SSURGO dataset was recommended for the farm, township, or county scale.

In both STATSGO and SSURGO datasets, spatial soil variability is represented by *map units*. Each map unit assigns an identifier to an area that contains several soil components, each of which is assumed to cover a certain percentage of the area without spatial reference. Because both datasets were developed from the same NRCS soil survey dataset, the lower-resolution map units in STATSGO cover larger areas and have greater numbers of individual soil components (up to 21 components) than the map units in SSURGO (up to 3 components). Each soil component consists of multiple layers with unique properties.

In environmental applications, soil components covering the largest area in a map unit are likely to be used to represent the entire map unit area. SSURGO's greater map unit spatial data resolution provides more detailed geospatial representation of soil properties and more easily recognizes dominant soil components compared to STATSGO. This makes using SSURGO soils preferable for smaller-scale projects, such as modeling catchments or individual fields. SSURGO soils can also be acceptable for larger-scale projects providing more soil groups and better representation of the soil spatial distribution than STATSGO soils. However, greater spatial resolution of the SSURGO dataset requires a greater number of smaller cells for modeling the processes at or below the surface, often causing increased computing time.

Effectiveness of higher-resolution SSURGO soil data on regional hydrologic characteristics of watersheds was studied by Mednick (2010) and Juracek and Wolock (2002). Direct analysis of the impact of soil data resolution on rainfall-runoff relationships in 298 watersheds in Wisconsin mapped at the 10-digit Hydrologic Unit Code scale found an underprediction bias in STATSGO-based runoff over the majority of the watersheds, whereas SSURGO-based distributed models typically produced the most accurate results (Mednick 2010). The bias toward underpredicting runoff and streamflow with STATSGO soils related in part to the differences in soil classification at the same location on the landscape when compared to SSURGO soils. The difference in soil attributes, such as a hydrologic soil group, will be called soil misclassification in this study. A direct comparison of soils in twelve target watersheds in Kansas showed that soil attributes in corridors along perennial streams were often distinctly different from adjacent upland areas, with greater prevalence of soils with hydrologic soil groups A and B near streams (Juracek and Wolock 2002).

Soil and Water Assessment Tool (SWAT) model is a hydrologic model widely used for watershed and river-basin modeling (Arnold et al. 1998; Santhi et al. 2001; Gassman et al. 2007; Douglas-Mankin et al. 2010; Tuppad et al. 2011). Three versions of the SWAT model have geographic information system (GIS) support: SWAT 2000, SWAT 2005, and SWAT 2009. Two graphical user interface modules, AVSWAT and ArcSWAT, were developed to work with ESRI's GIS desktop software suite (ESRI 2011). The AVSWAT was developed in early 2000s as an extension to ArcView GIS and uses SWAT 2000 (Di Luzio et al. 2002). It was later updated to AVSWAT-X to accommodate a newer version of SWAT. The ArcSWAT was designed as an ArcMap GIS extension for SWAT 2005 (ArcSWAT 2.x) and SWAT 2009 (ArcSWAT 2009) models (Olivera et al. 2006). The ArcSWAT model works with ArcGIS 9.x but not with the most recent version of ArcGIS 10.

For AVSWAT, a SSURGO processing tool was developed by Di Luzio et al. (2004). Another external utility was presented by Peschel et al. (2003; 2006) and is available at http://lcluc.tamu.edu/ssurgo/. A transition from SWAT 2000 to SWAT 2005 and from AVSWAT to ArcSWAT changed the soil data storage approach, along with many other essential improvements, and made the aforementioned SSURGO processing tool incompatible with ArcSWAT. For ArcSWAT, an independent procedure outside of the SWAT GIS module is needed to convert the soil dataset into an ArcSWAT-compatible format (Sheshukov et al. 2009). A conversion procedure that includes processing of both spatial and tabular files is required.

The objectives of this study were (1) to design an approach for processing SSURGO soils in a format compatible with ArcSWAT, (2) to develop a set of tools, in the form of an extension to ArcMap GIS application that allows the user to seamlessly integrate SSURGO soils in ArcSWAT, and (3) to use the developed SSURGO-ArcSWAT tool to analyze soil misclassification at the regional scale.

MATERIALS

Soil and Water Assessment Tool (SWAT)

The SWAT model is a hydrologic and water-quality model designed for watersheds of various sizes, from catchment to river basin scale, that has been developed and supported since 1990s (Arnold et al. 1998, Gassman et al. 2007; Douglas-Mankin et al. 2010;Tuppad et al. 2011). In SWAT, a watershed is divided into subwatersheds according to flow accumulation and stream network delineation procedures. Within each subwatershed, geo-referenced homogeneous units with uniform average slope, land use, and soil type are further identified and aggregated into HRUs. SWAT components calculate various hydrologic and physical parameters within each HRU and stream network on a daily basis. SWAT model was written in FORTRAN and used a collection of ASCII text files with each contained essential watershed properties (Neitsch et al. 2004).

ArcGIS

ArcGIS is the desktop software suite for Windows operating system and a system for working with maps and geographic information developed by Environmental Systems Research Institute (ESRI 2011). It is widely used for compiling geographic data, analyzing mapped information, and managing geographic information in a database. The current version in November 2011 is ArcGIS 10.

ArcGIS provides a platform for additional functuanality through software extensions. For hydrologic and watershed modeling applications, extensions in ArcGIS,e.g., ArcHydro (Maidment 2002) and ArcSWAT (Olivera et al. 2006), were developed that provide a GIS interface for assembling inventory of geospatial input data, map editing and manipulation,and invoking model execution commands for data modeling.

SWAT extension in GIS Software

The latest versions of the SWAT model (versions2000, 2005 and 2009) are linked with the GIS graphical interface developed as an extension to ESRI's GIS software (Olivera et al. 2006). The GIS interface modules developed for AVSWAT and ArcSWAT simplify the process of data input, watershed delineation, stream network creation, HRU creation, and invocation of SWAT executable files.

AVSWAT stores model data files in a tabular ASCII-text format, and the soil database is contained within a single tabular file. ArcSWAT uses Component Object Protocol (COM) and has a geodatabase structure consistent with the Microsoft Access database and ArcGIS framework. For both interface modules, a default soil database is based on STATSGO data and stores soil properties for the U.S. Additional soils not included in this default database must be added manually outside of the SWAT project setup steps and stored in a separate table. For ArcSWAT the default soil database file is entitled '*Swat_US_Soils.mdb*', and the user soil database is stored as a data table entitled '*usersoil*' within the geospatial database file '*Swat2005.mdb*' in ArcSWAT 2.x or '*Swat2009.mdb*' in ArcSWAT 2009.

METHODS

SSURGO-SWAT conversion procedure

The SSURGO-ArcSWAT conversion procedure is composed of five steps. The steps require tabular and geospatial data acquisition from an online web-server, data preparation for processing, manipulation of tabular and geospatial datasets into an ArcSWAT-compatible format, linkage of the processed tabular and geospatial datasets, and export to ArcGIS extension (Figure 1).

Data acquisition and preparation

SSURGO data files can be downloaded from the Soil Data Mart web-server (USDA-NRCS 2011). The data files are stored in a compressed format and distributed on a county basis. The downloaded archived files are uncompressed, kept unmodified and placed in a single folder. The resulting file directory of data files are structured within two subfolders: a folder with geospatial coverage files and a folder with tabular dataset files.

Geospatial dataset

For each county, the geo-referenced coverage was stored in a folder entitled '*spatial*' within a downloaded package and contained vector shapefiles. This soil coverage was formed by a continuous network of multi-part polygons representing map units with soil spatial attributes stored in an accompanying attribute table. All polygons with the same soil type have a unique map unit key identifier acronymed as '`mukey`'. Depicted in the geospatial section of Figure 1, vector shapefiles from all counties were collected and merged into single geospatial coverage to create a continuous representation of soils.

Tabular dataset

Soil properties were contained in the tabular dataset. This dataset was formed by a set of tabular source data files in an ASCII text format stored in a folder entitled '*tabular*' within a downloaded package. Each tabular source file represented a table of soil data properties and had a unique 'mukey' or a primary key.

Five tabular files were used (see Figure 2 in Di Luzio et al. 2004):

1. The map unit (file entitled *Mapunit.txt*) table identifies the map units included in the referenced legend,
2. The legend (*Legend.txt*) table identifies the soil survey area that is related to the legend,
3. The soil layer (*Chorizon.txt*) table lists the layers and the related data for the referenced map unit component,
4. The mineral and organic constituents that occur in the referenced layer are collected in the horizon fragments (*Chfrags.txt*) table, and
5. The component (*comp.txt*) table lists the map unit components identified in the referenced map unit as well as their selected properties.

All files were connected through the one-to-many relationship between the primary keys of the tables: Map unit (primary key 'mukey'),Chorizon ('chkey'), Component ('cokey'), Chorizon fragments ('chkey'), and Legend ('lkey') which enabled retrieval of specific soil properties for a map unit by providing its unique primary key 'mukey.' A query was created and cascaded down from the main map unit table to other tables through the one-to-many relationships between the primary keys. By repeating this procedure for all the map units presented in the geospatial dataset, all soil variables were processed and collected in a single database (Table 1). To arrange for soil sub-types that were presented in SSURGO but not in STATSGO, a unique concatenated key 'snam' was generated consisting of 'muid', 'musym', and soil component counter 'seqn'. The resulting dataset was added to the list of user soils in the '*usersoil*' table within the SWAT parameter geodatabase (e.g. file *Swat2005.mdb* in ArcSWAT 2.x) that was formatted the same as the main ArcSWAT soil database in '*soildb_US_2000. mdb*' file.

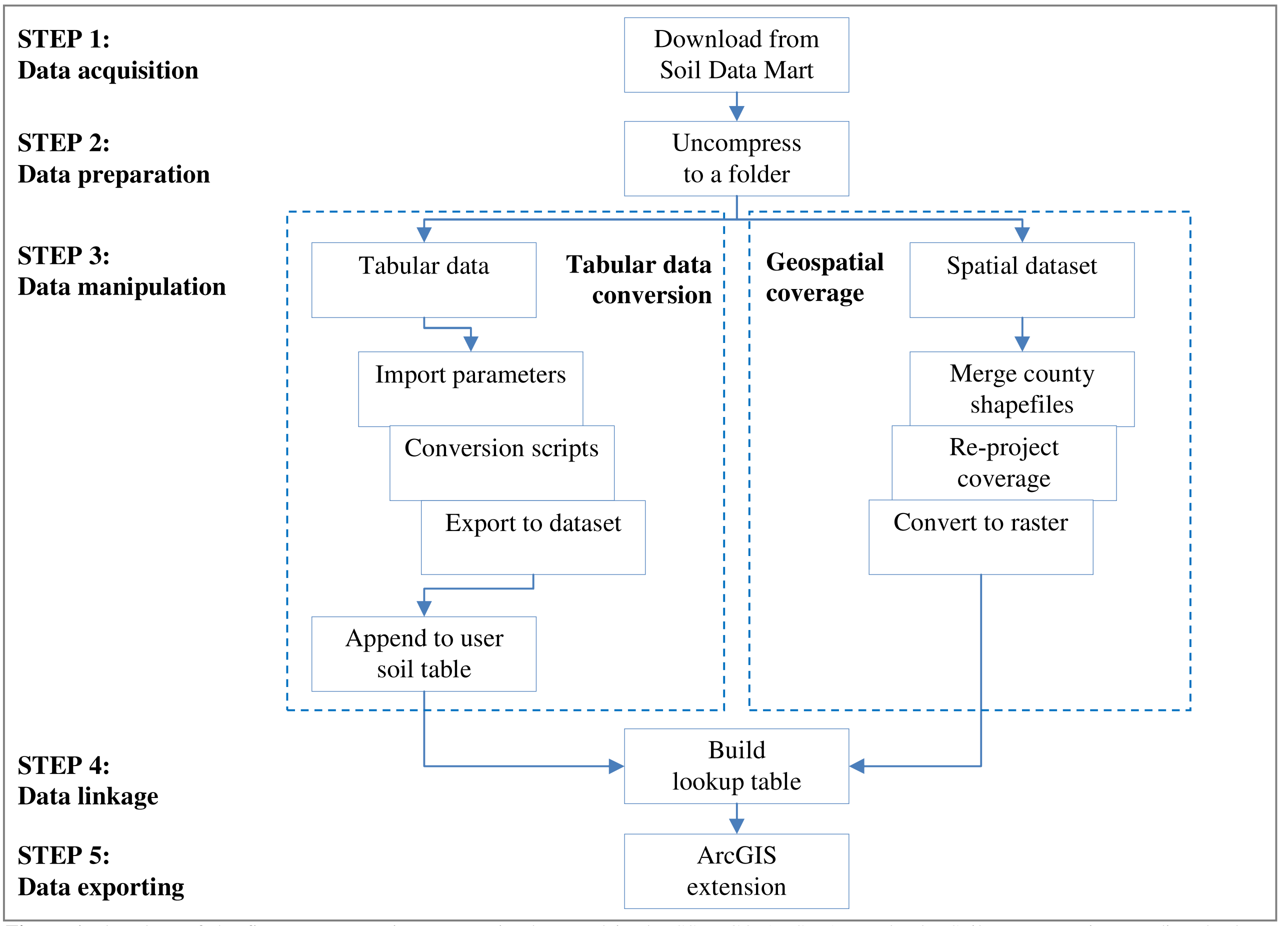

Figure 1 Flowchart of the five-step conversion process implemented in the SSURGO-ArcSWAT tool. The Soil Data Mart is an online database of SSURGO soil data (USDA-NRCS, 2009a)

Table 1 Compatibility between SWAT variables and SSURGO variables

SWAT Variable	Description	SSURGO Variable	SSURGO Table
Lumped parameters			
MUID	Map unit identifier	`Areasymb`	Legend
SEQN	Soil component record counter	**	–
SNAM	Soil identifying name (concatenated key of MUID, MUSYM, SEQN)	`Areasymb` `Musym`	Legend Map unit
S5ID	Soil interpretation record	***	–
CMPPCT	Percent of soil component	`Comppct`[2]	Comp
NLAYERS	Number of soil layers, not more than 9	**	–
HYDGRP	Soil hydrologic group	`Hydgrp`[1]	Comp
SOL_ZMX	Maximum rooting depth of sol profile (mm)	**	Chorizon
ANION_EXCL	Fraction of porosity for which anions are excluded	***	–
SOL_CRK	Potential or maximum crack volume of soil profile expressed as fraction of total volume	***	–
TEXTURE	Texture of soil layer – not required by ArcSWAT	`Taxpartsz`	Comp
Layer parameters			
SOL_Z	Depth from soil surface to bottom of layer (mm)	`Hzdepb`[1,2]	Chorizon
SOL_BD	Moist bulk density (g/cm^3)	`Db3bar`[1,2]	Chorizon
SOL_AWC	Available water capacity of sol layer (mm H_2O/mm soil)	`Awc`[1,2]	Chorizon
SOL_K	Saturated hydraulic conductivity (mm/hr)	`Ksat`[1,2]	Chorizon
SOL_CBN	Organic carbon content (percentage of soil weight)	`Om`[2]	Chorizon
CLAY	Clay content (percentage of soil weight)	`Claytot`[1,2]	Chorizon
SILT	Silt content (percentage of soil weight)	`Silttot`[1,2]	Chorizon
SAND	Sand content (percentage of soil weight)	`Sandtot`[1,2]	Chorizon
ROCK	Rock fragment content (percentage of soil weight)	`Fragvol`[1,2]	Chfrags
SOL_ALB	Moist soil albedo	`Albedody`[1,2]	Chorizon
USLE_K	USLE soil erodibility K factor (0.013 Mg m^2 hr/(m^3 Mg cm))	`Kffact`[1]	Chorizon
SOL_EC	Electrical conductivity (dS/m)	`Ec`[2]	Chorizon

1 Value may be missing for certain soils. Substitute with educated estimates.
2 Representative value of SSURGO variable identified by 'r' in metadata file is used.
** ArcSWAT variable requires additional calculation.
*** ArcSWAT does not require the value to be specified.

While processing SSURGO soils in the Midwestern region of the U.S., some attribute values were found to be undefined for certain soils. For example, soils with no distinct horizons, such as entisols (aquentos, arents, psamments, fluvents, orthents), soils perennially covered by water, some pits (pits, dumps, aquolls), and some quarries (quarry, rock outcrop, limestone quarry) were not classified, and their attribute values were not assigned. For such soils, only one horizon was assumed to be present with the properties assigned according to soil taxonomy (Buol et al. 2003,USDA-NRSC 1999). Example sets of parameters based on those used by Lee and Douglas-Mankin (2011) are presented in Table 2. Incorrect classification of soils perennially covered by water also was noted in Wang and Melesse (2006).

Certain soils in SSURGO database have two hydrologic soil groups assigned to variable '`Hydgrp`' (A/D, B/D, and C/D), which represent the soil drainage capabilities during seasonal high water table events. The first hydrologic group (A, B, or C) in the dual classification designates the soil condition when it is drained and the second hydrologic group (D) is for the undrained condition when water table is within 60 cm of the surface. The SWAT model assigns one letter to the variable HYDGRP and thus requires soils to be represented by only a single hydrologic group. For the Midwest, the dual hydrologic group soils prevalently occur in rural areas where soils stay seasonally wet or can be susceptible to preferential drainage. Therefore, the second classification (D) was used during the conversion procedure.

Table 2 Example set of soils with no classification in SSURGO and user assigned parameters

SWATVariable	Water	Entisols[1]	Pits[2]	Quarries[3]
HYDGRP	A	D	D	D
SOL_Z (mm)	25.4	600	1524	25.4
SOL_BD (kg/m^3)	1.0	1.5	1.3	1.9
SOL_AWC (mm H_2O/mm soil)	0.7	0.01	0.01	0.01
SOL_K (mm/hr)	600	3.6	0.03	0.03
CLAY (% of soil weight)	-	-	5	5
SILT (% of soil weight)	-	-	10	10
SAND (% of soil weight)	-	-	50	20
ROCK (% of soil weight)	-	-	35	65
SOL_ALB	0.12	0.23	0.25	0.35
USLE_K	0.01	0.01	0.01	0.01

[1] Entisol group contains aquentos, arents, psamments, fluvents, and orthents
[2] Pits group contains pits, dumps, and aquolls
[3] Quarries group contains quarry, rock outcrop, and limestone quarry

Linkage of datasets

Linkage of geospatial dataset and soil database was conducted with the use of the lookup table (Figure 1). The lookup table contained two primary fields, '`snam`' and '`mukey`', paired for each map unit to create a link between a soil spatial coverage and a soil in the user soil database. The soil dataset was used by ArcSWAT at the HRU creation step when slope, land use, and soil geospatial datasets were overlaid. At the soil processing step, the lookup table was substituted when asked to recognize the soils in the soil coverage and clip them to the watershed. Upon completion, each HRU had a unique soil type assigned in a project database file.

SSURGO-ArcSWAT utility

The SSURGO-ArcSWAT conversion utility was created in Visual Basic within the ArcObjects framework, works with 32-bit or 64-bit Windows operating system, requires 32-bit Microsoft Office XP or above, and is available for download at the Kansas State University website http://www.bae.ksu.edu/watershed/ssurgo/ (SSURGO-ArcSWAT 2011). For automating the conversion process, a set of scripts was written within the ArcObjects framework, thus enabling the conversion process to be assembled as an extension within the ArcMap GIS environment (Chang 2007). For each step of the conversion process, a custom class was created and an *ICommand* interface was implemented. All commands were hosted on a custom toolbar using the *IToolbar* interface. An extension application to ArcGIS was developed to maintain the state of individual items in the toolbar. Following registration with ArcGIS application, the extension provides easy access to the SSURGO conversion utility (Figure 2).

The main screen of the SSURGO-ArcSWAT utility consists of four text boxes to enter the following information: a location of the input SSURGO files folder, a folder for the processed output files, a path to the SWAT parameter geodatabase file, and the SSURGO-ArcSWAT installation folder. The maximum number of soil layers and the type of the geographic coordinate system projection are also offered to specify as conversion options.

The conversion process implemented in the SSURGO-ArcSWAT processing tool consists of processing data tabular files and geospatial files simultaneously followed by creation of the lookup table (Figure 2). The tabular data processing branch consisted of importing soil data from tabular files, converting the data into a SWAT-compatible format, and adding these data to user soil table in ArcSWAT. During the spatial coverage branch, the geospatial files were collected from all counties, merged, re-projected, and converted to a single unified raster layer. For each raster cell, an identification key stored in the field value was represented by '`mukey`' field obtained from the corresponding polygon of the original shapefile. The lookup table was built in the following step. At the final step, all data tables were exported into the dBASE-formatted files and saved in a folder.

REGIONAL ASSESSMENT

To test regional hydrologic impacts of soil databases and demonstrate the need for the SSURGO-ArcSWAT utility, STATSGO and SSURGO soil databases were obtained for the State of Kansas (214,218 km^2). STATSGO data were downloaded from Kansas Data Access and Support Center (KDASC 2009). The SSURGO data were downloaded from Soil Data Mart (USDA-NRCS 2009a) and processed for analysis using the SSURGO-ArcSWAT utility.

Analysis focused on hydrologic soil group, which is a fundamental soil property for runoff calculation using the NRCS curve number method (USDA-NRCS 2004). In the database, soils were assigned to groups A through D based on the infiltration rate *i* (USDA-NRCS 1986):

Group A: $i > 0.76$ cm/hr,
Group B: $0.38 < i < 0.76$ cm/hr,
Group C: $0.13 < i < 0.38$ cm/hr, and
Group D: $i < 0.13$ cm/hr.

Total area and percentage of total area classified as each hydrologic soil group (A, B, C, and D) in STATSGO and SSURGO soil datasets are presented in Table 3 for the State of Kansas. The map of the areas of consistent and inconsistent hydrologic soil group classification is shown in Figure 3. Analysis of the hydrologic soil groups showed that group B was dominant, occupying 55.7% of total area in STATSGO dataset and 58.3% in SSURGO, with 45.1% of total area classified consistently between datasets. A total of 66.5% of total area was classified consistently among all soil groups and represented by dark shaded cells in Table 3. Such areas with soils of the same hydrologic group in STATSGO and SSURGO databases were colored green in Figure 3. Severe misclassifications, when soil group differed by more than one category (cells shaded grey in Table 3 and areas colored red in Figure 3), totaled 11.3% of the total area. For example, areas designated by SSURGO as group B were classified differently by STATSGO as group A (1.1% of total area), group C (6.5%) or group D (5.6%). The classification is called moderately inconsistent if soil group differed by only one category. Areas of moderately inconsistent classification accounted for 22.3% of the total area and are shown colored white in Figure 3.

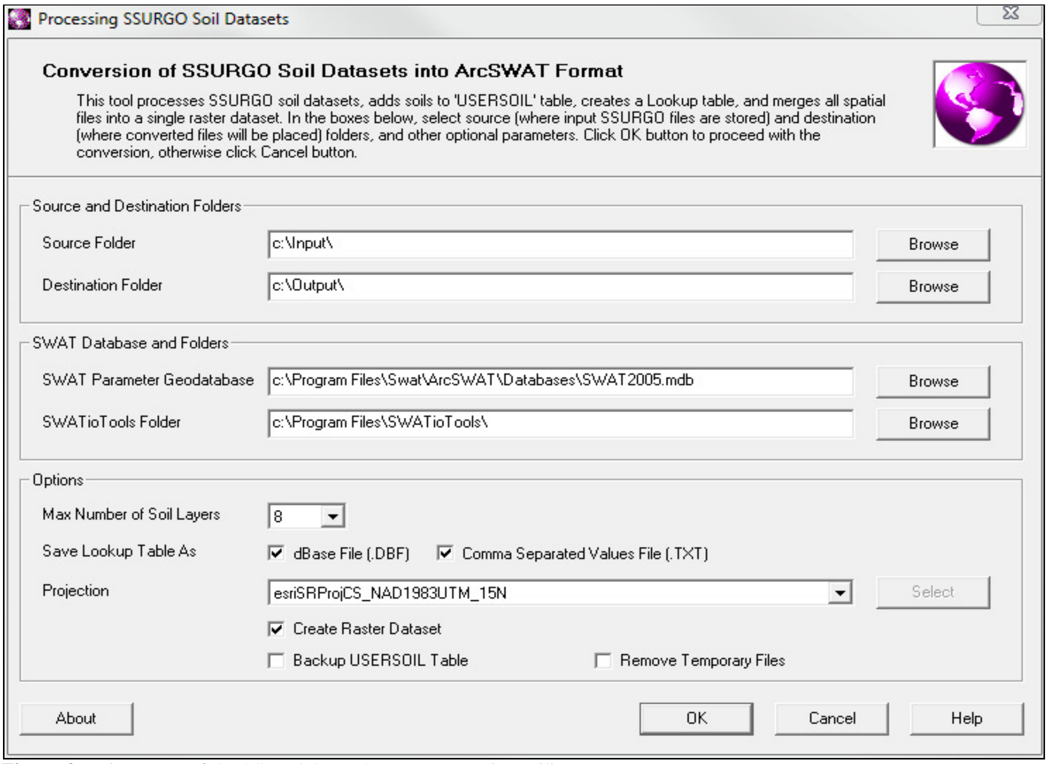

Figure 2 Main screen of the SSURGO-ArcSWAT conversion utility

Table 3 Total area (ha) and percentage of total area classified as each hydrologic soil group (A, B, C, and D) in STATSGO and SSURGO soil datasets for Kansas. Also highlighted are consistent classifications (shaded dark grey) and severely inconsistent classifications (shaded light grey)

		SSURGO (ha and %)				
		A	**B**	**C**	**D**	**Total**
STATSGO (ha and %)	**A**	524,888 2.5%	240,882 1.1%	40,407 0.2%	59,355 0.3%	865,532 4.0%
	B	297,949 1.4%	9,651,672 45.1%	1,026,672 4.8%	963,843 4.5%	11,940,136 55.7%
	C	56,104 0.3%	1,383,439 6.5%	2,251,977 10.5%	762,996 3.6%	4,454,516 20.8%
	D	84,884 0.4%	1,209,833 5.6%	1,054,430 4.9%	1,812,449 8.5%	4,161,596 19.4%
	Total	963,826 4.5%	12,485,826 58.3%	4,373,486 20.4%	3,598,644 16.8%	21,421,780 100.0%

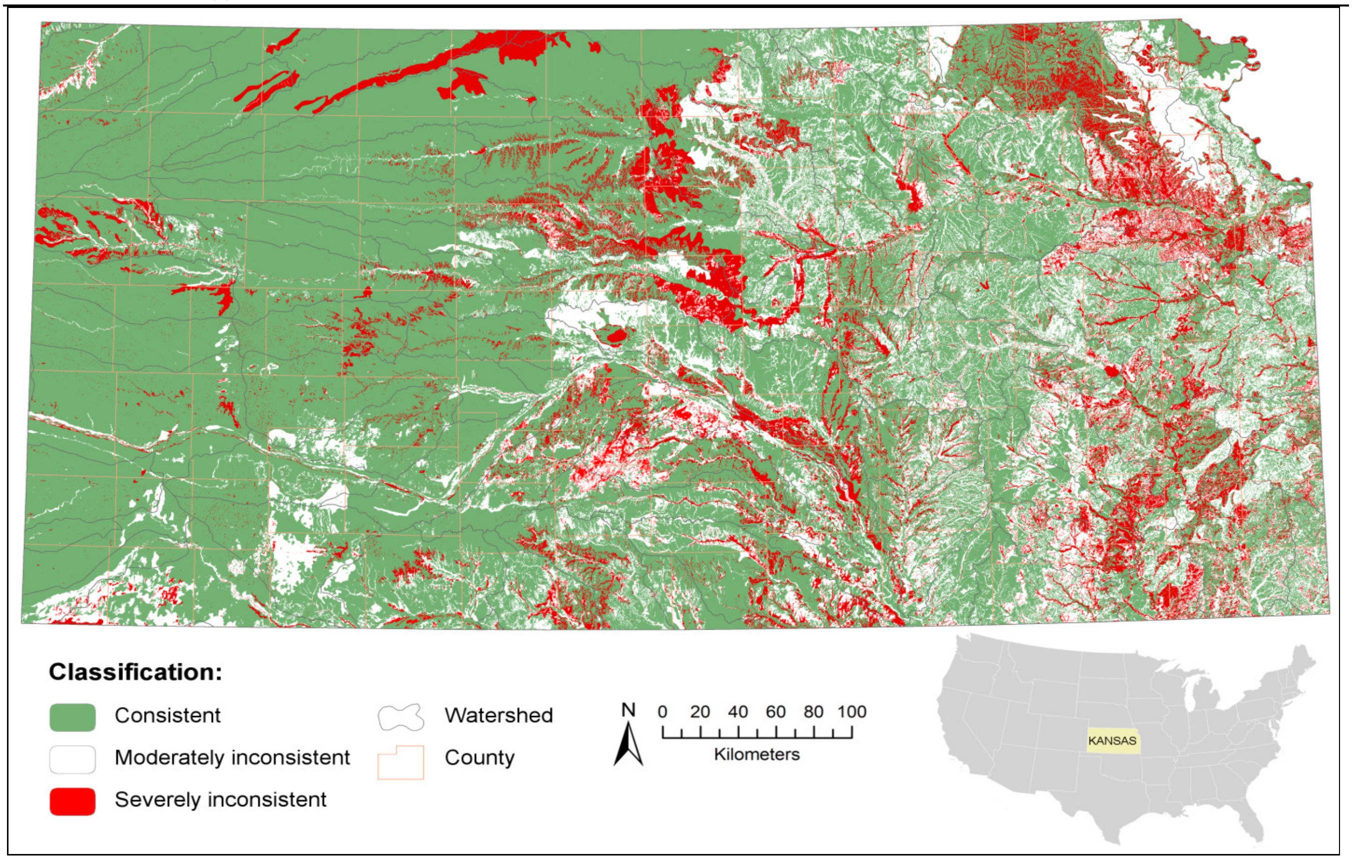

Figure 3 Map of agreement in soil hydrologic group classification between SSURGO and STATSGO databases in Kansas. Classifications are represented as consistent (green), moderately inconsistent (white, differed by 1 group), or severely inconsistent (red, differed by 2 groups).

Eastern and western parts of Kansas are topographically and environmentally different. Western Kansas is dominated by flat topography, cropland land use, and a coarse stream network. Eastern Kansas consists of many hills covered by forest, grazing land, and cropland. The stream network in eastern Kansas is denser and with greater average stream flow than western Kansas. Climate changes from semi-arid in western Kansas to humid continental in the East. Differences in environmental properties of two parts of Kansas also extend to differences in hydrologic properties of soils. Soils in western Kansas are less drainable and mainly of the group C while soil variability is greater in eastern Kansas.

In western Kansas, areas of the same soil groups were consistently classified by both databases, as shown by broad areas of continuous green color in Figure 3. Areas of severely inconsistent classification in western Kansas were clustered mainly in the north and east. Areas of moderately inconsistent classification were sparsely distributed throughout the area and often located along the stream network.

In eastern Kansas, soil variability was much greater and topographically dependent. Soils in the floodplain of major rivers were usually more variable and differed in hydrologic properties from soils in upland areas. In creating the STATSGO database, the process of averaging soil properties over larger areas eliminated soil variability present within the floodplain, while in the SSURGO database, map unit areas are smaller and soil variability is better represented.Therefore in eastern Kansas severe soil misclassifications were present within the stream corridors, while consistent classification was observed in the areas farther away from the flood plain. Areas of moderately inconsistent classification were also widely present in eastern Kansas.

Severe misclassification within the 300m floodplain occurred for group D soils in STATSGO assigned to group B in SSURGO in 11.2% of the floodplain area, while group B soils in STATSGO were misclassified as group D soils in SSURGO in 4.4% of the floodplain area. The latter misclassification also contained the incorrect classification of dual hydrologic group soils.

The bias in classification of SSURGO group B soils as groups C or D by STATSGO could significantly alter hydrologic modeling results. Hydrologic impacts of differential hydrologic soil group classifications at the watershed scale will be examined in the companion paper (Sheshukov et al. 2011).

CONCLUSIONS

An ArcMap extension utility for pre-processing SSURGO soil database was developed to assist in using SSURGO soils in ArcSWAT projects. A framework developed by Di Luzio et al. (2004) for AVSWAT was extended to ArcSWAT and incorporated in the form of an extension to ArcMap GIS. The developed SSURGO-ArcSWAT conversion utility is available online at http://www.bae.ksu.edu/watershed/ssurgo/ (SSURGO-ArcSWAT 2011).

The SSURGO-ArcSWAT utility was applied to the State of Kansas to calculate percentages of area covered with soils of the same hydrologic group and examine consistency in hydrologic classification between STATSGO and SSURGO databases. It was found that 33.6% of hydrologic soil groups were classified inconsistently between SSURGO and STATSGO, with 11.3% differing by more than one group. Analysis of soils in western and eastern parts of Kansas revealed substantial prevalence of consistent classification in western Kansas whereas soil misclassification was widely present in eastern Kansas.

Use of the SSURGO-ArcSWAT tool by watershed modelers will allow simple implementation of SSURGO data into ArcSWAT modeling projects.

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