ArcMap Tool for Pre-processing SSURGO Soil Database for ArcSWAT

Aleksey Sheshukov
Prasad Daggupati
Ming-Chieh Lee
Kyle Douglas-Mankin

Biological and Agricultural Engineering
Kansas State University

Presented at the 5th SWAT International Conference in Boulder, CO - 5-7 Aug, 2009
Outline

- STATSGO vs SSURGO
- SSURGO in SWAT
- Conversion Methodology
  - Tabular Datasets
  - Spatial Datasets
  - Linkage
- Case Study
- Conversion Tool for ArcSWAT
  - GIS Desktop Extension
Objectives

- To develop/adopt methodology for processing SSURGO soils
- To design a procedure/tool that converts SSURGO soil datasets into an ArcSWAT compatible format
- To validate the conversion results
- To make the tool user-friendly by creating an extension to ArcMap GIS
Soil Databases

- **STATSGO (1994) – State Soil Geographic Database**
  - The map data are collected in 1- by 2-degree topographic quadrangle units and merged into a seamless national dataset with mapping scale about 1:250,000
  - Distributed in state/territory and national extents
  - Designed for state level, river basin applications

- **The U.S. General Soil Map or STATSGO2 (2006)**
  - Revised STATSGO
  - Distributed by the Natural Resources Conservation Service (NRCS)
  - Available at http://soils.usda.gov/survey/geography/statsgo

- **SSURGO – Soil Survey Geographic Database**
  - Distributed by the Natural Resources Conservation Service (NRCS)
  - Mapping scales generally range from 1:12,000 to 1:63,360
  - Most detailed level of soil mapping
  - Structured on county basis
  - Designed for use by landowners, townships, and county natural resource planning and management
  - Consists of spatial and tabular data files
  - Available at http://soildatamart.nrcs.usda.gov
STASTGO versus SSURGO

- Databases structured differently
  - SSURGO – Data spread over 56 tables
  - STATS GO – One table
- Soil name
- Texture
- Hydraulic Soil Group
- Saturated Conductivity
- USLE K-Factor
Soils in SWAT

- SWAT utilizes STATSGO tabular format
- The default U.S. soil database stored in State-named tables in Swat_US_Soils.mdb
- All user defined soils must be added to ‘usersoil’ table in Swat2005.mdb
- SWAT uses lookup table to link soil map grid with soil database
- Lookup table fields used for linking:
  - Name
  - StMUID
  - StMUID+Name
  - StMUID+Seqn
  - S5ID
Available Conversion Tools

- No Conversion Utilities for ArcSWAT
- SSURGO SWAT 2.0 Extension by J. M. Peschel
  - http://lcluc.tamu.edu/ssurgo/
  - Developed as an extension to Arcview 3.x
  - Works with Arcview SWAT
  - Does tabular datafiles conversion and clips spatial dataset to watershed boundary
  - Not adjusted for ArcMap
  - Not adjusted for ArcSWAT

References:

- Manual step-by-step instructions found in discussion forums and SWAT community online
  - Have flaws and do not present a complete conversion utility
SSURGO Soil Database

- 56 Tables with various data
- Each table has a unique key identifier
- Tables connected through *one-to-many* relationships
- 5 tables identified for processing

- Unique key identifiers
  - chkey
  - cokey
  - mukey
  - lkey

- Map unit - identifies the map units included in the referenced legend
- Component - lists the map unit components identified in the referenced map unit, and selected properties of each component
- Legend - identifies the soil survey area
- Horizon - lists the horizons
- Horizon fragments - lists the mineral and organic fragments that generally occur in the referenced horizon

Unique key identifiers
- chkey
- cokey
- mukey
- lkey
## SWAT and SSURGO Variables

<table>
<thead>
<tr>
<th>SWAT Variable</th>
<th>Description</th>
<th>Calculated</th>
<th>SSURGO Variable</th>
<th>SSURGO Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>** MUID **</td>
<td>Mapping Unit Identifier</td>
<td>** Areasymb **</td>
<td>** Legend **</td>
<td>** **</td>
</tr>
<tr>
<td>SEQN</td>
<td>Record Counter</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>** SNAM **</td>
<td>Soil Identifying Name (concatenated key)</td>
<td>** Areasymb</td>
<td>** Musym **</td>
<td>** Legend **</td>
</tr>
<tr>
<td>S5ID</td>
<td>Soil interpretation record</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>CMPPCT</td>
<td>Percent of Soil component</td>
<td>** Comp **</td>
<td>** Comp **</td>
<td>** Comp **</td>
</tr>
<tr>
<td>NLAYERS</td>
<td>Number of soil layers, not more than 10</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>HYDGRP</td>
<td>Soil hydrologic group</td>
<td>** Hydgrp **</td>
<td>** Comp **</td>
<td>** Comp **</td>
</tr>
<tr>
<td>ANION_EXCL</td>
<td>Fraction of porosity for which anions are excluded</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>SOL_CRK</td>
<td>Potential or maximum crack volume of soil profile expressed as fraction of total volume</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>TEXTURE</td>
<td>Texture of soil layer – not required by ArcSWAT</td>
<td>** Taxpartsz **</td>
<td>** Comp **</td>
<td>** Comp **</td>
</tr>
<tr>
<td>SOL_Z</td>
<td>Depth from soil surface to bottom of layer (mm)</td>
<td>** Hzdepb **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SOL_ZMX</td>
<td>Maximum rooting depth of soil profile (mm)</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>SOL_BD</td>
<td>Moist bulk density (g/cm³)</td>
<td>** Db3bar **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SOL_AWC</td>
<td>Available water capacity of soil layer (mm H₂O/mm soil)</td>
<td>** Awc **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SOL_K</td>
<td>Saturated hydraulic conductivity (mm/hr)</td>
<td>** Ksat **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SOL_CBN</td>
<td>Organic carbon content (percent of soil weight)</td>
<td>** Om **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>CLAY</td>
<td>Clay content (percent of soil weight)</td>
<td>** Claytot **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SILT</td>
<td>Silt content (percent of soil weight)</td>
<td>** Silttot **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SAND</td>
<td>Sand content (percent of soil weight)</td>
<td>** Sandtot **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>ROCK</td>
<td>Rock fragment content (percent of soil weight)</td>
<td>** Fragvol **</td>
<td>** Chfrags **</td>
<td>** Chfrags **</td>
</tr>
<tr>
<td>SOL_ALB</td>
<td>Moist soil albedo</td>
<td>** Albedody **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>USLE_K</td>
<td>USLE soil erodibility K factor (0.013 metric ton m² hr/m³ metric ton cm)</td>
<td>** Kffact **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
<tr>
<td>SOL_EC</td>
<td>Electrical conductivity (dS/m)</td>
<td>** Ec **</td>
<td>** Chorizon **</td>
<td>** Chorizon **</td>
</tr>
</tbody>
</table>

- ** Not required **
- ** Calculated **
- ** May be blank **
# Data Adjustment

<table>
<thead>
<tr>
<th>SWAT Soil Variable</th>
<th>Water</th>
<th>Aquents, Arents, Psammments, Fluvents, Orthents</th>
<th>Pits, Dumps, Aquolls, Urban land</th>
<th>Quarry, Rock outcrop, Limestone quarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYDGRP</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>SOL_Z</td>
<td>25.4</td>
<td>600</td>
<td>1524</td>
<td>25.4</td>
</tr>
<tr>
<td>SOL_BD</td>
<td>1.0</td>
<td>1.5</td>
<td>1.3</td>
<td>1.9</td>
</tr>
<tr>
<td>SOL_AWC</td>
<td>0.7</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>SOL_K</td>
<td>600</td>
<td>3.6</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>CLAY</td>
<td></td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>SILT</td>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>SAND</td>
<td></td>
<td></td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>ROCK</td>
<td></td>
<td></td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td>SOL_ALB</td>
<td>0.12</td>
<td>0.23</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>USLE_K</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**References:** SWAT Input/Output File Documentation; SSURGO Metadata - Table Column Descriptions; Agriculture Handbook. Soil Taxonomy. USDA; Buol, S. W., 2003. Soil genesis and classification. Ames, Iowa
Linking Database With Map

Lookup Table:

<table>
<thead>
<tr>
<th>SNAM</th>
<th>MUKEY</th>
</tr>
</thead>
<tbody>
<tr>
<td>KS1753491-1</td>
<td>662369</td>
</tr>
<tr>
<td>KS1753503-1</td>
<td>675347</td>
</tr>
<tr>
<td>KS1753765-1</td>
<td>633217</td>
</tr>
</tbody>
</table>

Dataset:

<table>
<thead>
<tr>
<th>MUID</th>
<th>SEQN</th>
<th>SNAM</th>
<th>S5ID</th>
<th>CMPPCT</th>
<th>NLAYERS</th>
<th>HYDGRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>KS175</td>
<td>1</td>
<td>KS1753491-1</td>
<td>100</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KS175</td>
<td>1</td>
<td>KS1753503-1</td>
<td>90</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KS175</td>
<td>1</td>
<td>KS1753765-1</td>
<td>10</td>
<td>3</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>KS175</td>
<td>1</td>
<td>KS1754589-1</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>
SSURGO Data Conversion Flowchart

Data Acquisition

Download Off SoilDataMart

Uncompress

GIS Preparation

Spatial Dataset

Merge County Maps

Project Layer

Convert to Raster

Data Preparation

Tabular Data

Import Parameters

Conversion Scripts

Export to Dataset

Append to USERSOIL

Build Lookup Table

ArcSWAT Extension

Soil Input

Data Linkage
Case Study: Black Kettle Creek Watershed

- Central Kansas
- HUC-12 (11030012) Subbasin in Little Arkansas River Basin
- Area – 7,818 ha
- Landuse: Cropland (84%)
- 9 subwatersheds (265-1845 ha)
- STATSGO – 3 soils
- SSURGO – 18 soils

Presented by Prasad Daggupati at the Session B3: Field-scale targeting of cropland sediment yields
Percentage of C- and D-group Soils

- STATSGO-D
- SSURGO-D
- STATSGO-C
- SSURGO-C

Subwatershed
Runoff and Sediment Yield

Sediment Yield (tons)

Runoff (cm)

Years of Simulation

STATSGO

SSURGO
ArcMap Tool

- Written in Visual Basic 6
- Data Access Objects (DAO) commands and queries used to import/export tabular datafiles
- ArcObjects used to process SSURGO soil spatial datasets
- ArcObjects used to create an extension, a toolbar, and a command in ArcMap GIS
- Created as a ‘one-click’ operation
ArcMap Conversion Tool

* Folder containing input SSURGO datafiles
* Folder containing processed files
* Projection
* Lookup table
* Backup usersoil table
* Delete individual soil data
Input/Output Files

- Input files downloaded off SoilDataMart (http://soildatamart.nrcs.usda.gov), unzipped, and placed in one folder

- Processed files placed in user-specified folder
  - Main database file
  - Lookup table
  - Shapefile feature class
  - Raster dataset
  - Soils for individual counties
    - 6 counties in KS
    - 3 counties in MO

- Soils for individual counties
Questions .. Thank You!

- Tool Availability
  - Developed by Biological and Agricultural Engineering at K-State
  - Download from: http://www.bae.ksu.edu/watershed/ssurgo
  - Questions and Comments: ashesh@ksu.edu