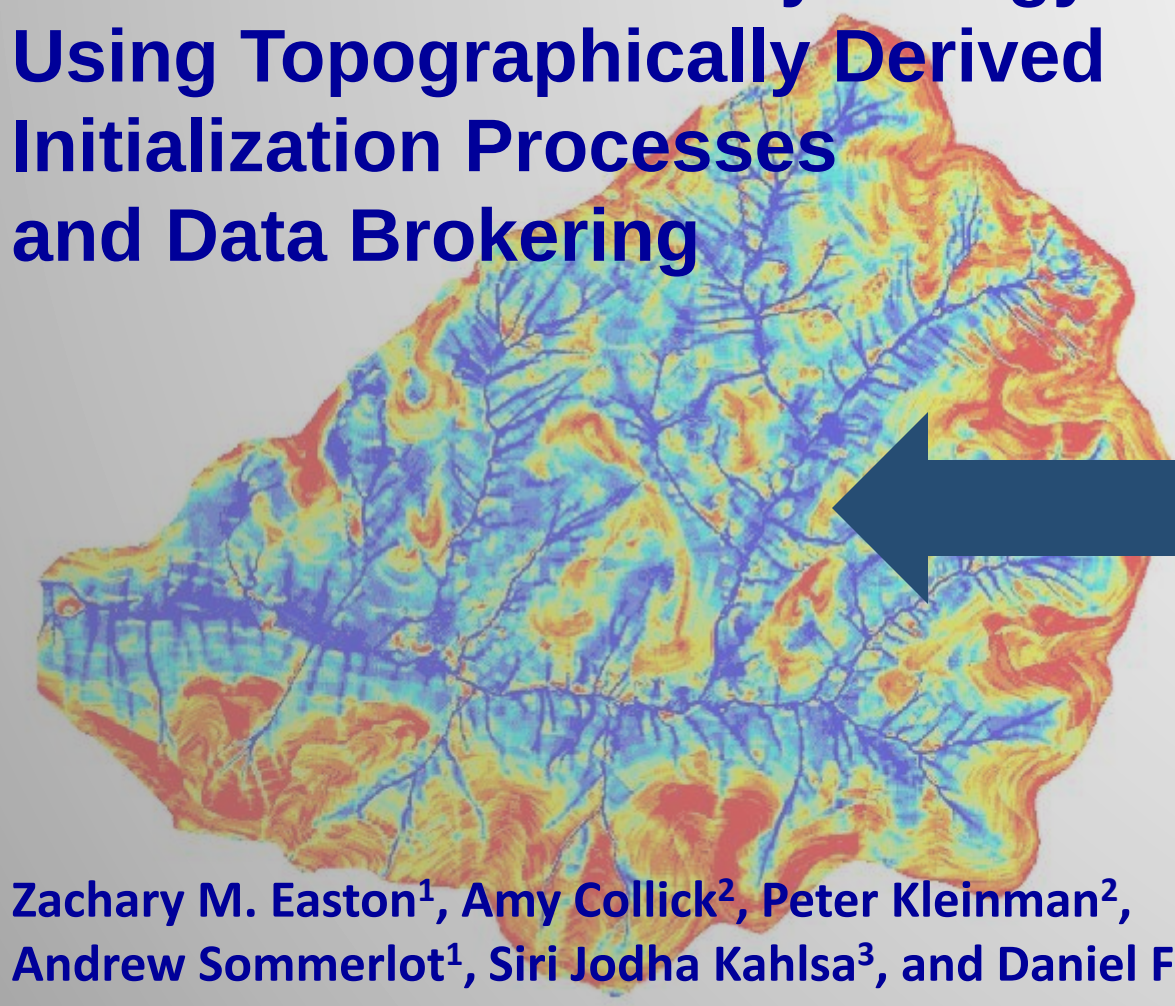
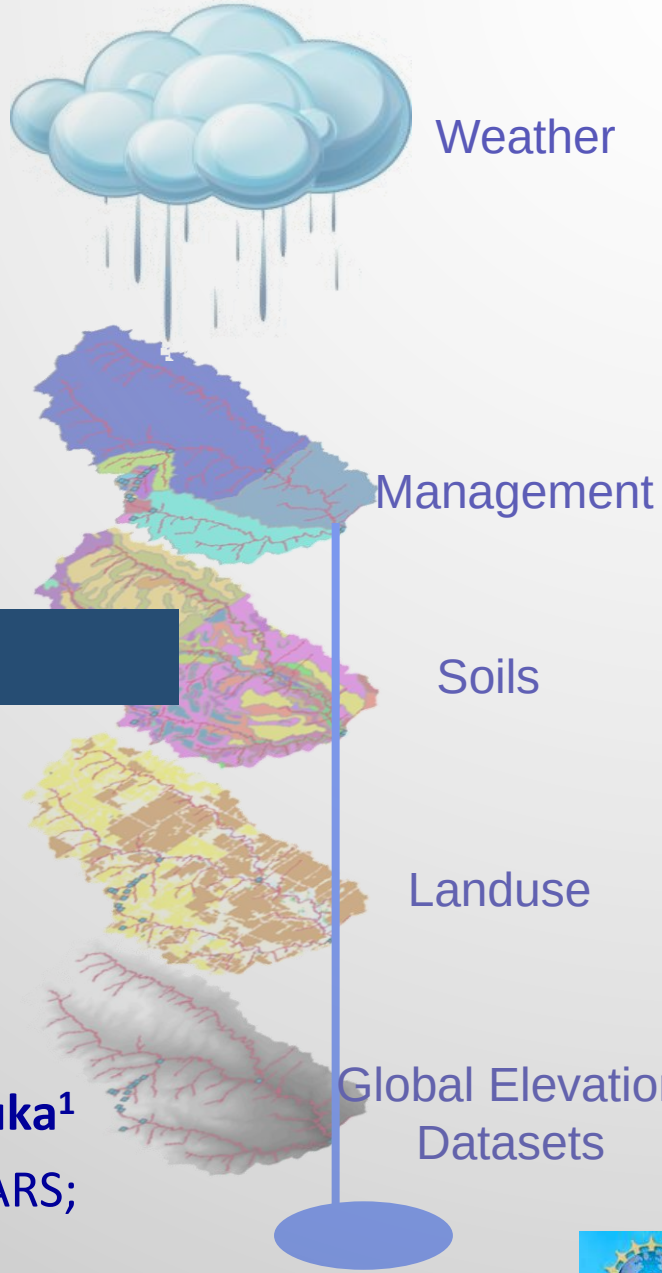
Improving Representation of Soil Characteristics and Hydrology Using Topographically Derived Initialization Processes and Data Brokering





Zachary M. Easton[1], Amy Collick[2], Peter Kleinman[2], Andrew Sommerlot[1], Siri Jodha Kahlsa[3], and Daniel Fuka[1]

[1]Biological Systems Engineering, Virginia Tech; [2]USDA-ARS; [3]National Snow and Ice Data Center

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Outline

- Introduction to Brokering and NSF's BCube
- Topography, Soils, and TopoSWAT
- VSA / Non-Hortonian Case
  - USDA WE-38, PA
- Extending VSA methods to Hortonian
  - Reisel, TX
- What does this imply for SWAT model development

EarthCube and Open Data Sharing

A community of communities

EarthCube

Accelerating Scientific Discovery

Credits: from top to bottom: NOAA Okeanos Explorer Program (CC BY-SA 2.0), NASA/Kathryn Hansen (CC BY 2.0), and Canyonlands National Park/Neal Herbert (CC BY-NC-SA 2.0).

What is Data Brokering?

Science Discipline Interoperability

Two Complementary Approaches

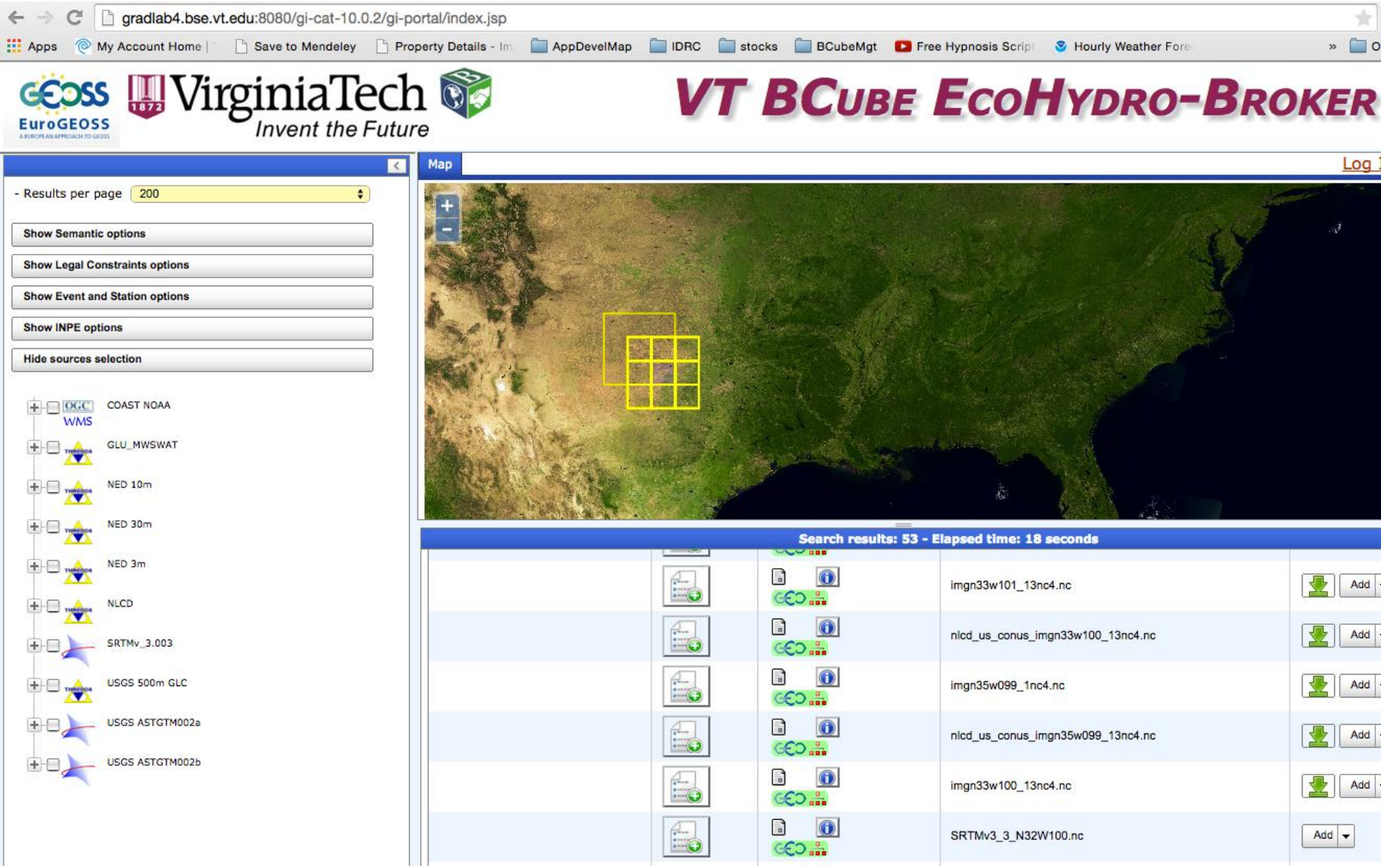
- Standardization
  - Systems Federation
    - A group of people agreeing on a format
  - Controlled and mature environments
- Intermediation (i.e. System Brokering)
  - Complex data types supported
  - Allows rapidly evolving environments

Problems Brokering Fixes

- "Process" based modeling requires many disparate data source with different formats from different locations
- Sources are not necessarily consistent
- With many options, repeatability decreases
- More frequently watershed initialization is a result of derived datasets with source specific transformations and manipulations
- Derived datasets are rarely "Repeatable" from traditional literature methods sections.

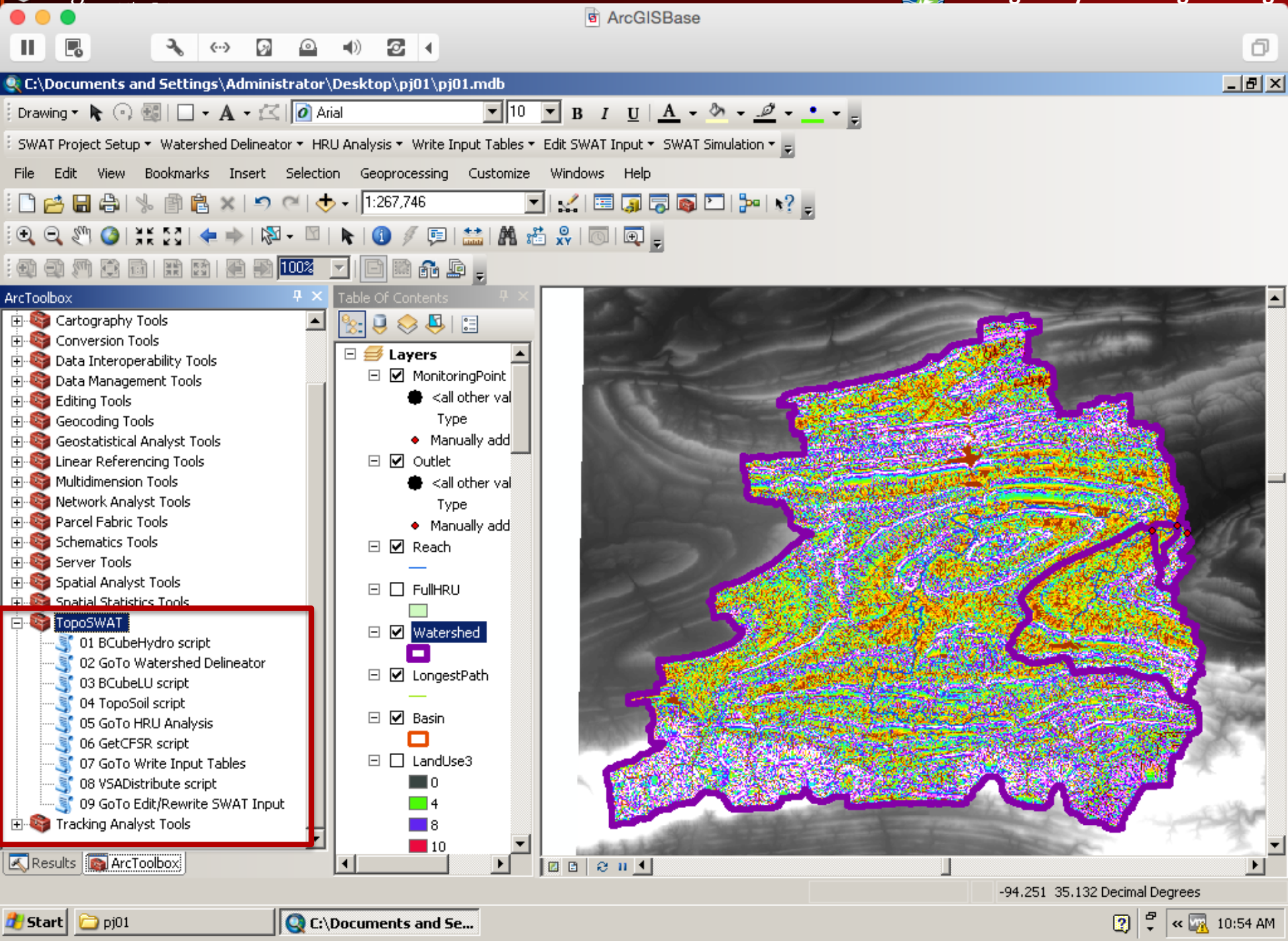
Brokering Framework Principles

- A broker connects information resources by mediating interactions between those resources without requiring the maintainers of those resources to adapt new conventions or install software components
- User likewise need not understand and be able to manipulate all data formats


gradlab4.bse.vt.edu:8080/gi-cat-10.0.2/gi-portal/index.jsp
Apps
My Account Home
Save to Mendeley
Property Details
AppDevelMap
IDRC
stocks
BCubeMgt
Free Hypnosis Scrip
Hourly Weather Fore
GEOSS
EuroGEOSS
VirginiaTech
Invent the Future
VT BCUBE ECOHYDRO-BROKER
- Results per page 200
Show Semantic options
Show Legal Constraints options
Show Event and Station options
Show INPE options
Hide sources selection
COAST NOAA
WMS
GLU_MWSWAT
NED 10m
NED 30m
NED 3m
NLCD
SRTMv_3.003
USGS 500m GLC
USGS ASTGTM002a
USGS ASTGTM002b
Map
Log
Search results: 53 - Elapsed time: 18 seconds
imgn33w101_13nc4.nc
nlcd_us_conus_imgn33w100_13nc4.nc
imgn35w099_1nc4.nc
nlcd_us_conus_imgn35w099_13nc4.nc
imgn33w100_13nc4.nc
SRTMv3_3_N32W100.nc
Add

Eco-Hydro Use Case Datasets Brokered

- Elevation
  - Global SRTM
    - 30m, 90m
  - Global GDEM 30m
  - US 30m NED
  - US 10m NED
  - US 3m NED
- Landuse
  - Global MODIS
  - Global USGS NLCD
- Soils
  - Global FAO Vector
  - US SSURGO Vector
- Historical Daily Weather
  - Global CFSR Gridded
  - Global GHCN Point
- Forecasts
  - Daily Global 16day
- Climate
  - Global Last Century Gridded
  - Global Next Century Gridded


ArcGISBase
C:\Documents and Settings\Administrator\Desktop\pj01\pj01.mdb
Drawing
Arial
10
SWAT Project Setup
Watershed Delineator
HRU Analysis
Write Input Tables
Edit SWAT Input
SWAT Simulation
File
Edit
View
Bookmarks
Insert
Selection
Geoprocessing
Customize
Windows
Help
1:267,746
100%
ArcToolbox
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Spatial Analyst Tools
Spatial Statistics Tools
TopoSWAT
01 BCubeHydro script
02 GoTo Watershed Delineator
03 BCubeLU script
04 TopoSoil script
05 GoTo HRU Analysis
06 GetCFSR script
07 GoTo Write Input Tables
08 VSADistribute script
09 GoTo Edit/Rewrite SWAT Input
Tracking Analyst Tools
Table Of Contents
Layers
MonitoringPoint
Outlet
Reach
FullHRU
Watershed
LongestPath
Basin
LandUse3
0
4
8
10
Results
ArcToolbox
-94.251 35.132 Decimal Degrees
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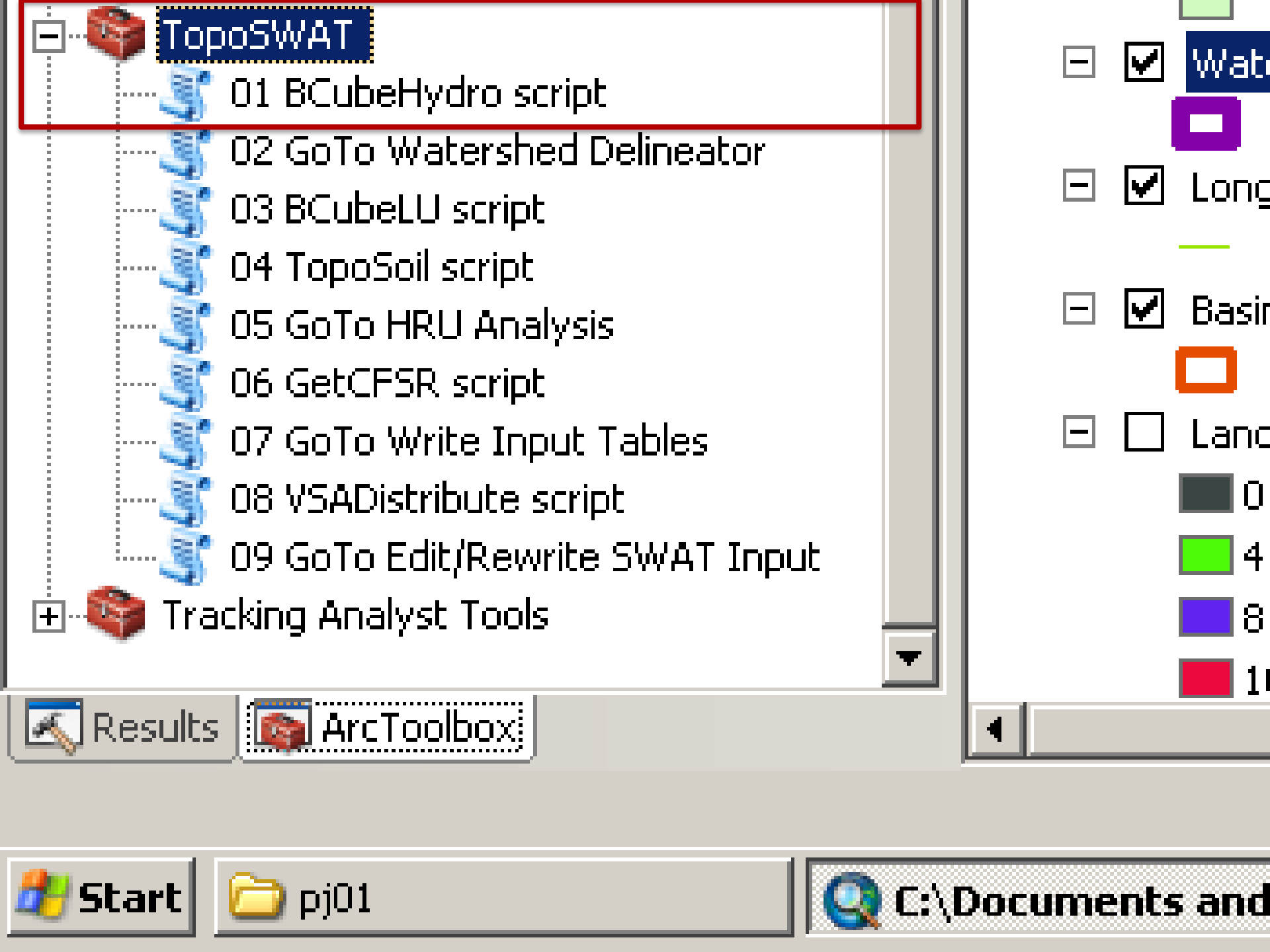
10:54 AM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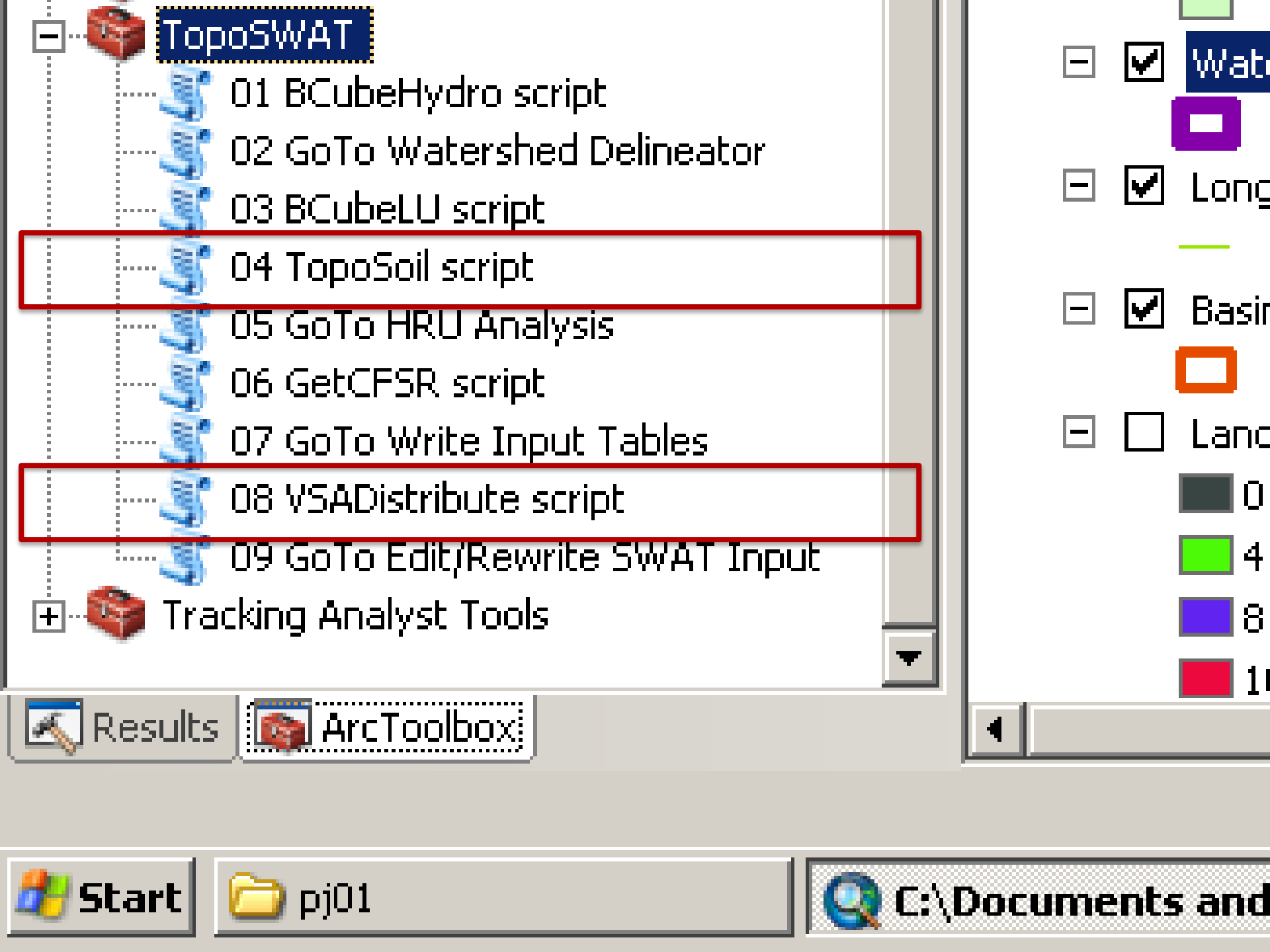
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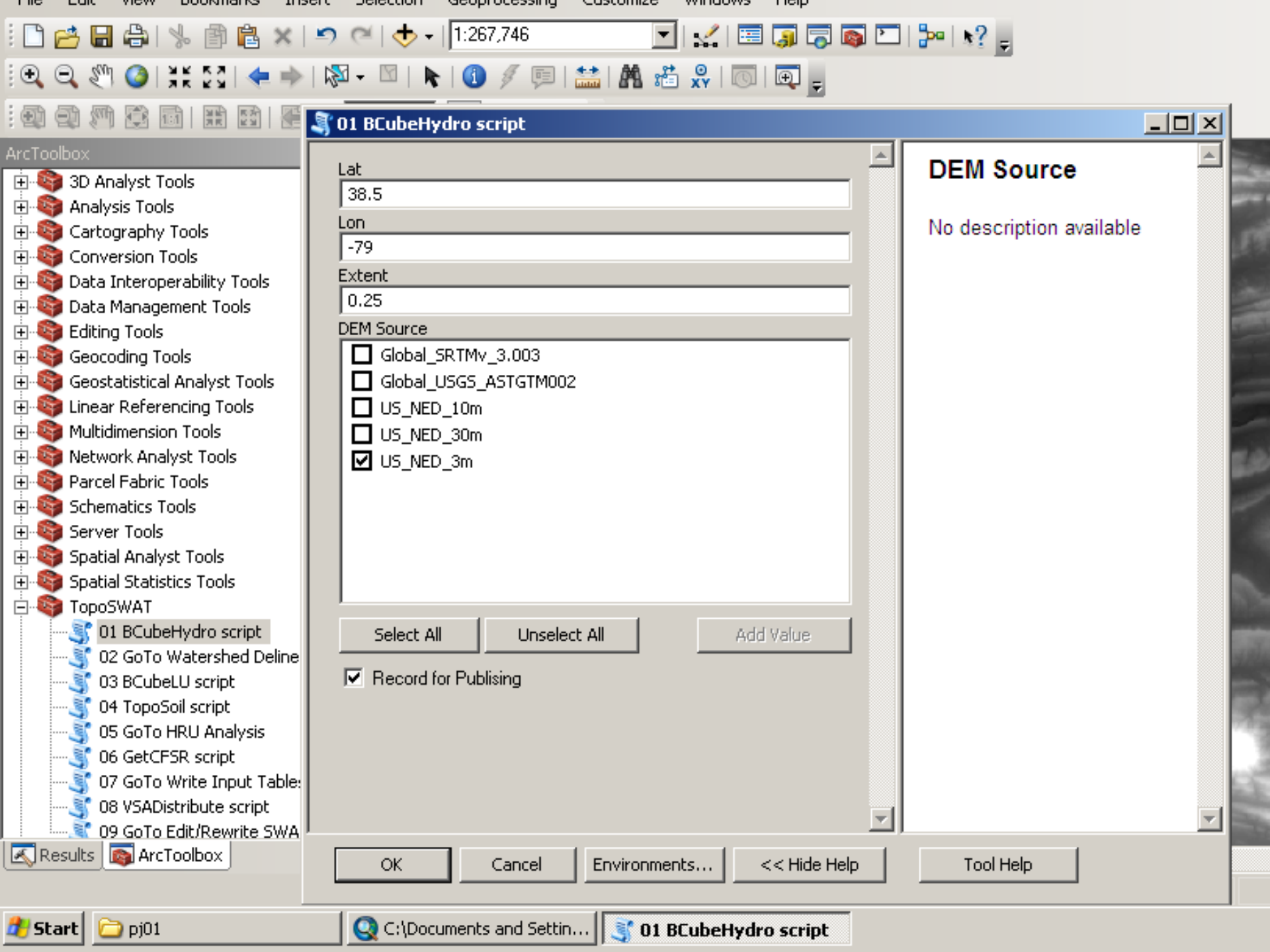
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ArcToolbox
3D Analyst Tools
Analysis Tools
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
Geocoding Tools
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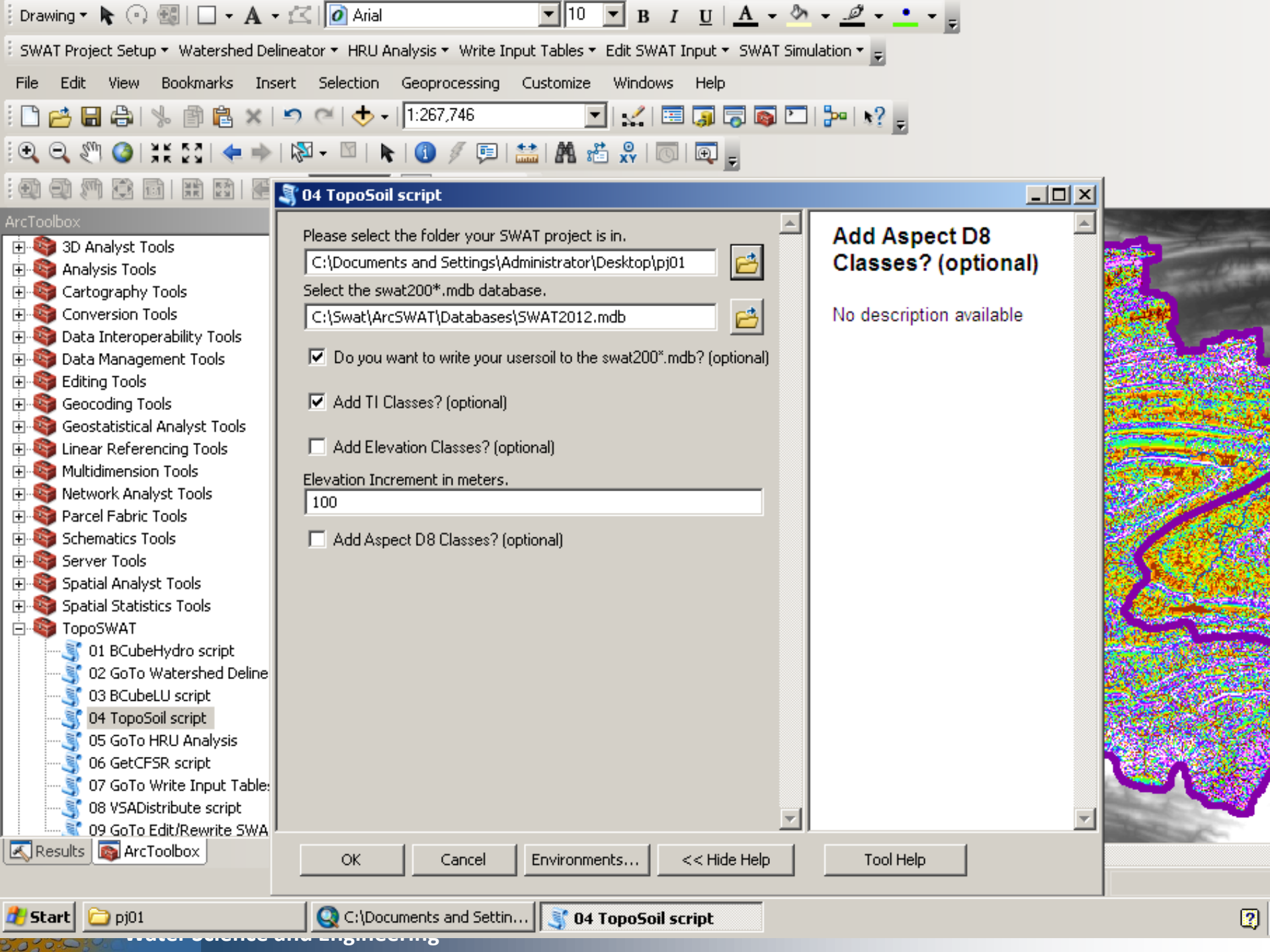
06 GetCFSR script
07 GoTo Write Input Table
08 VSADistribute script
09 GoTo Edit/Rewrite SWA
Results
ArcToolbox
01 BCubeHydro script
Lat
38.5
Lon
-79
Extent
0.25
DEM Source
Global_SRTMv_3.003
Global_USGS_ASTGTM002
US_NED_10m
US_NED_30m
US_NED_3m
Select All
Unselect All
Add Value
Record for Publising
DEM Source
No description available
OK
Cancel
Environments...
<< Hide Help
Tool Help
Start
pj01
C:\Documents and Settin...
01 BCubeHydro script


Drawing
Arial
10
SWAT Project Setup
Watershed Delineator
HRU Analysis
Write Input Tables
Edit SWAT Input
SWAT Simulation
File
Edit
View
Bookmarks
Insert
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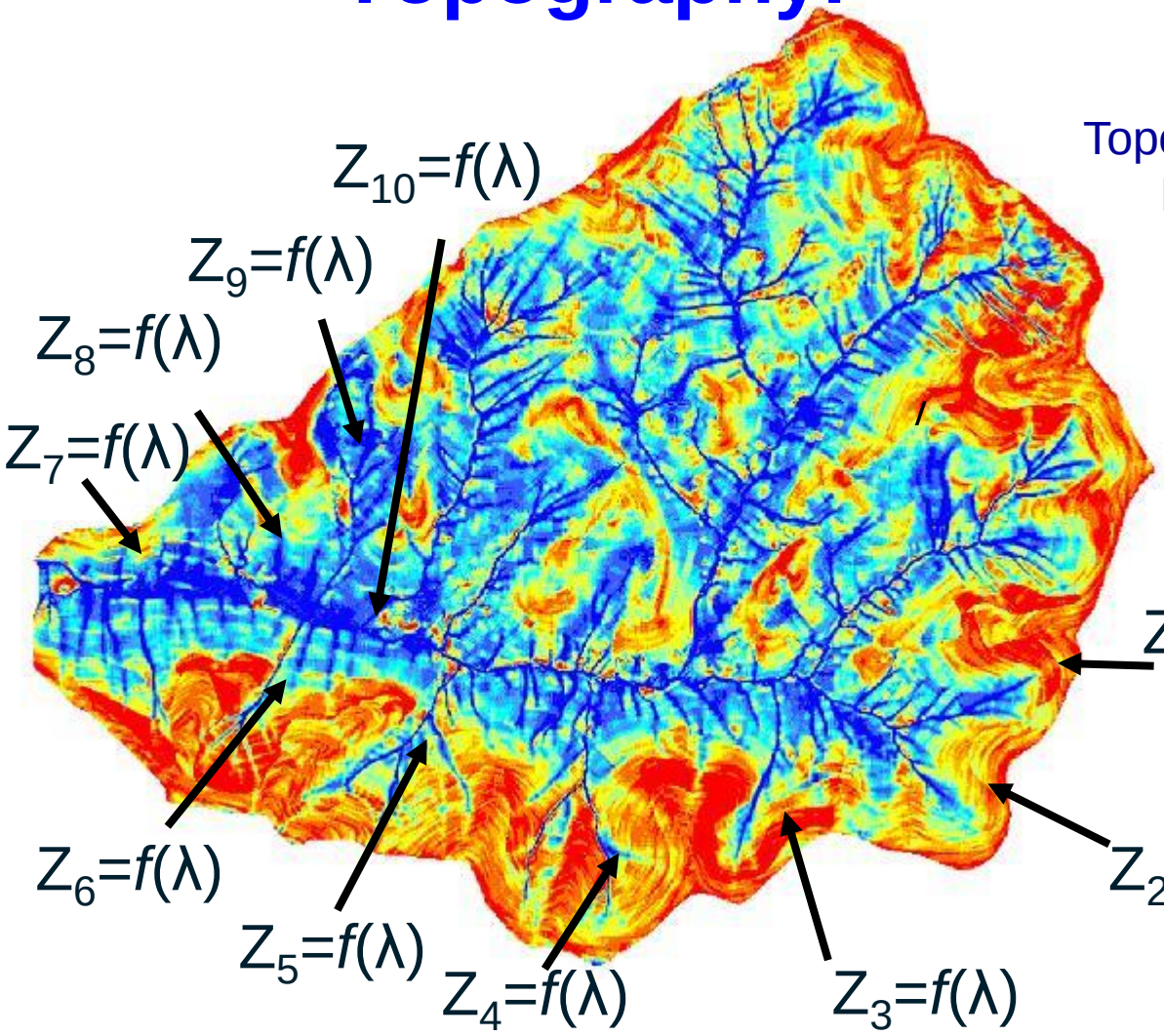
05 GoTo HRU Analysis
06 GetCFSR script
07 GoTo Write Input Table
08 VSADistribute script
09 GoTo Edit/Rewrite SWA
Results
ArcToolbox
04 TopoSoil script
Please select the folder your SWAT project is in.
C:\Documents and Settings\Administrator\Desktop\pj01
Select the swat200*.mdb database.
C:\Swat\ArcSWAT\Databases\SWAT2012.mdb
Do you want to write your usersoil to the swat200*.mdb? (optional)
Add TI Classes? (optional)
Add Elevation Classes? (optional)
Elevation Increment in meters.
100
Add Aspect D8 Classes? (optional)
Add Aspect D8 Classes? (optional)
No description available
OK
Cancel
Environments...
<< Hide Help
Tool Help
Start
pj01
C:\Documents and Settin...
04 TopoSoil script

Soil genesis as explained by **Topography!**

$$I = \ln\left(\frac{a}{\tan b}\right)$$



Topographic Index

33.10

3.52

Wetness Index Classes

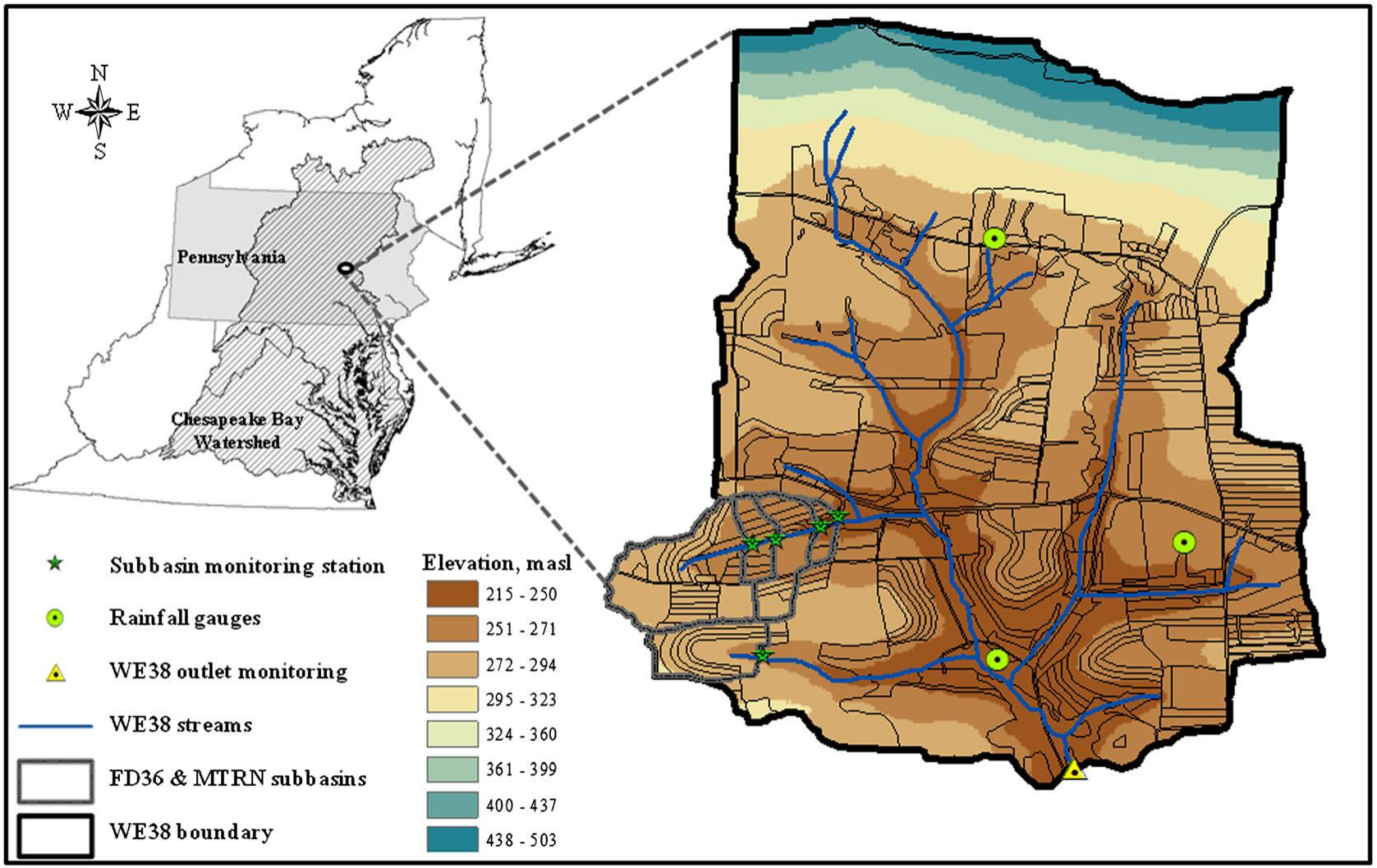
10

1

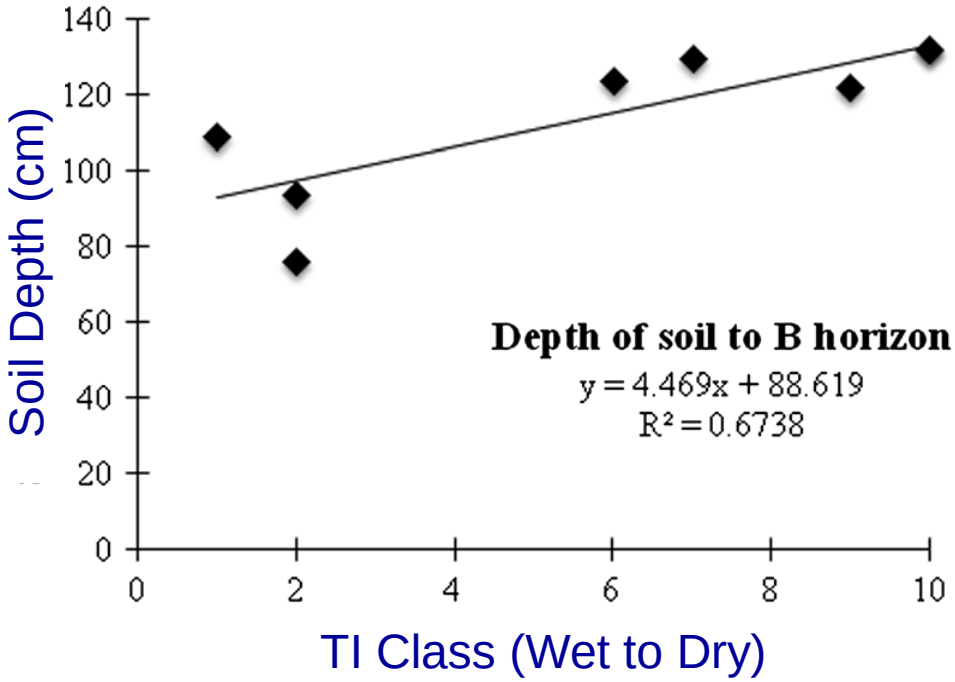
Z_i = local soil depth

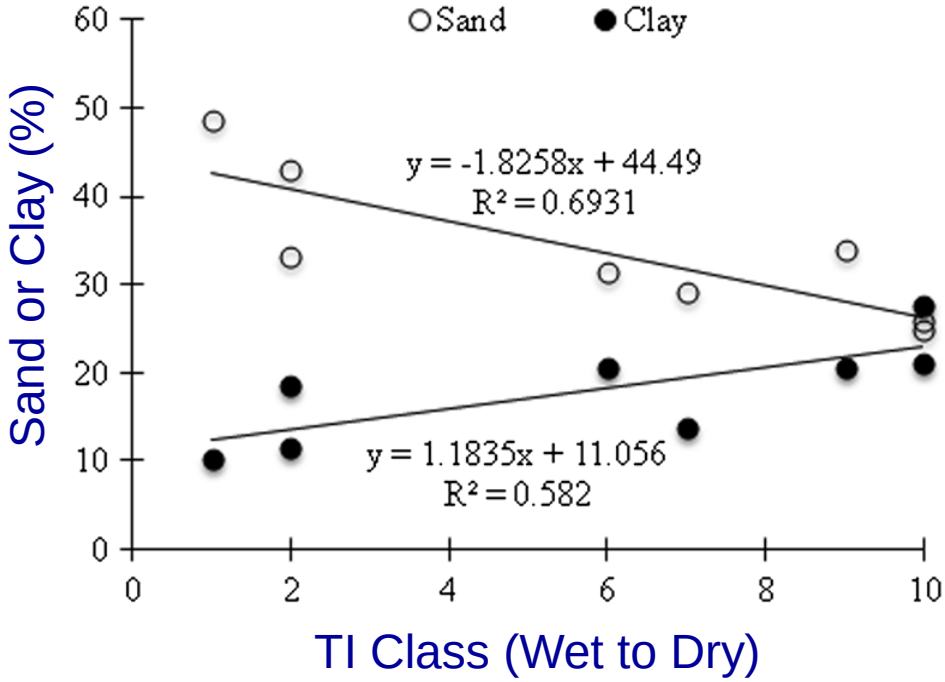
Saxton and Rawls, 2006; Easton et al. 2008; Collick et al. 2014;Fuka et al. 2015

Variable Source Area Hydrology
USDA WE38, PA, USA



Topography to explain soil depth and fractions





Using measured pedon data from ARS long term watershed

Soil genesis as explained by **Topography!**

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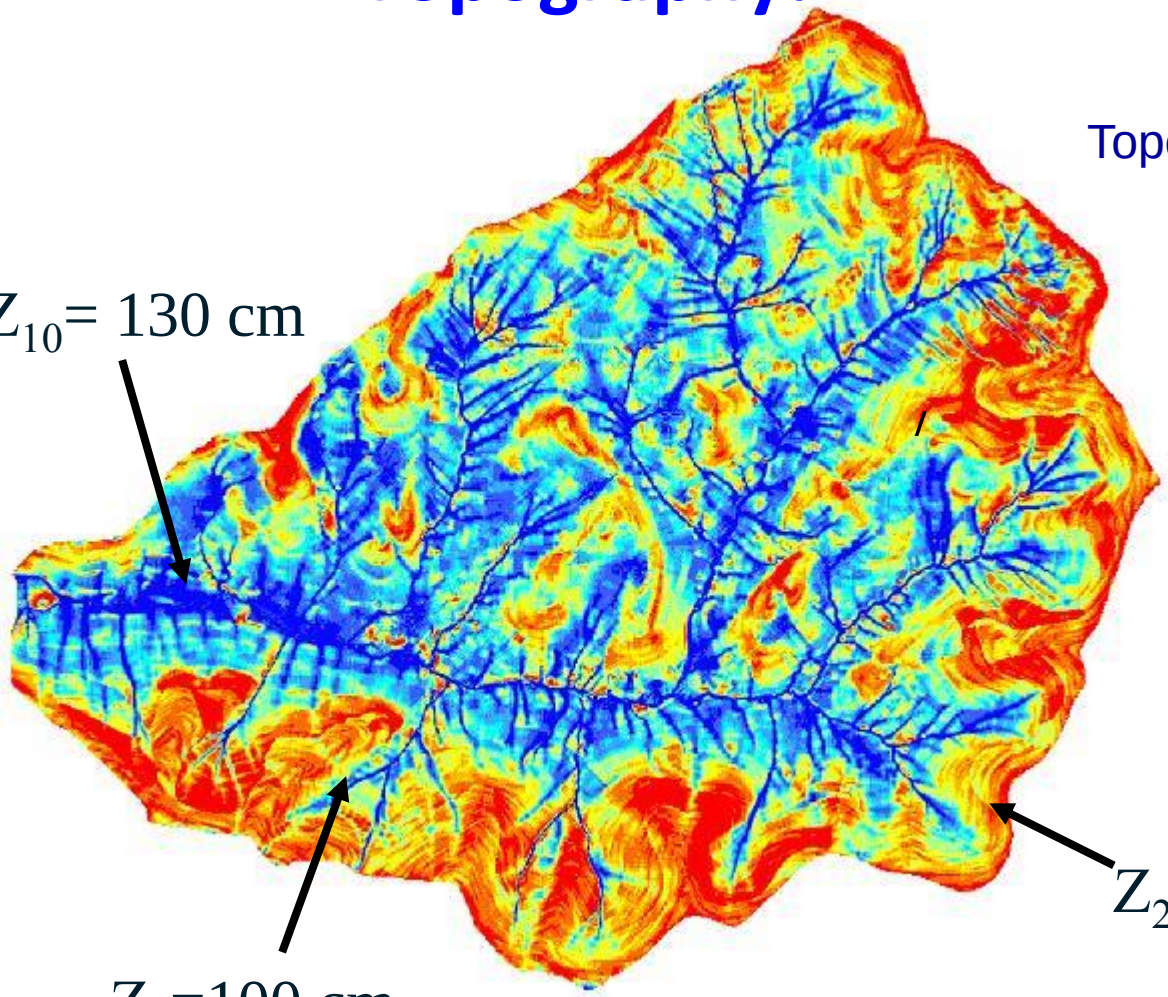

Topographic Index

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Wetness Index Classes

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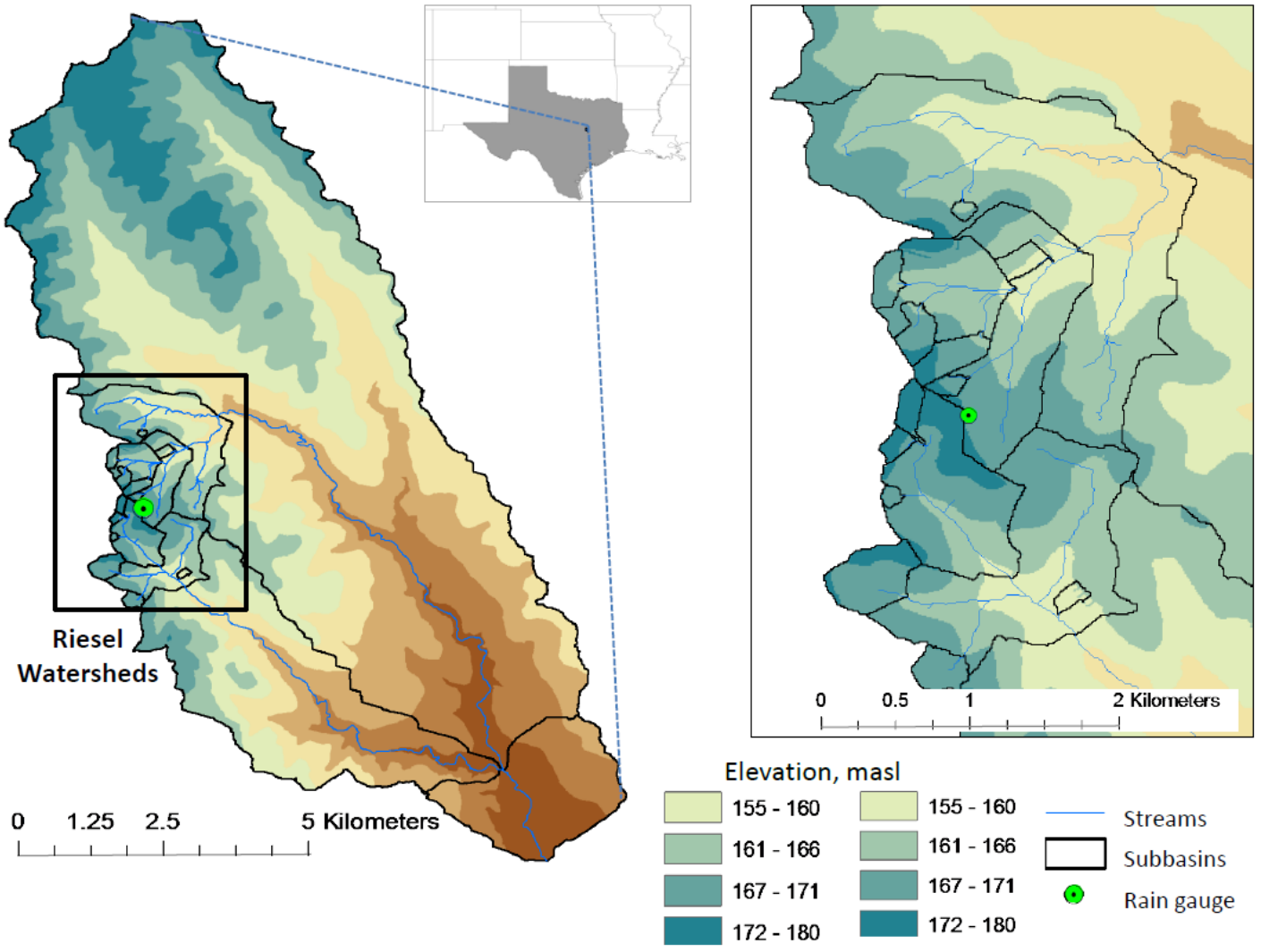
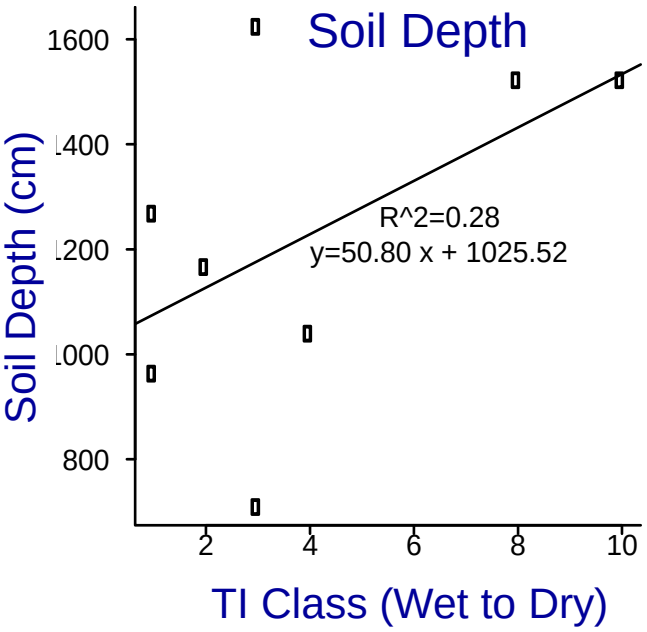
1

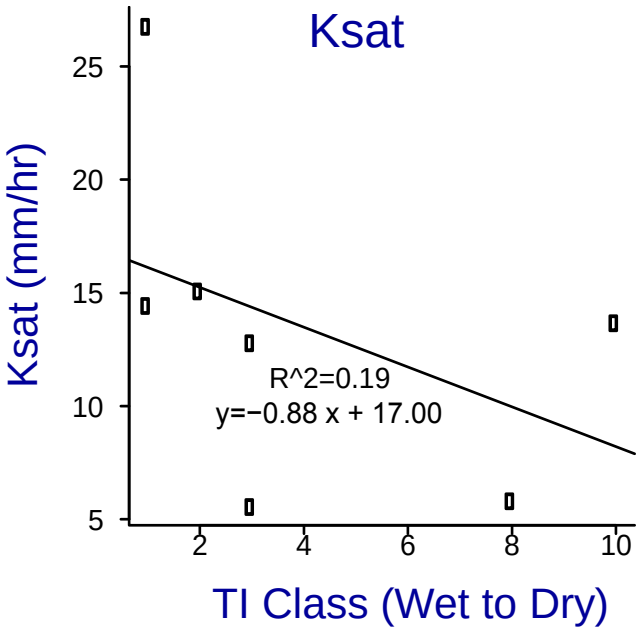
Z_i = local soil depth

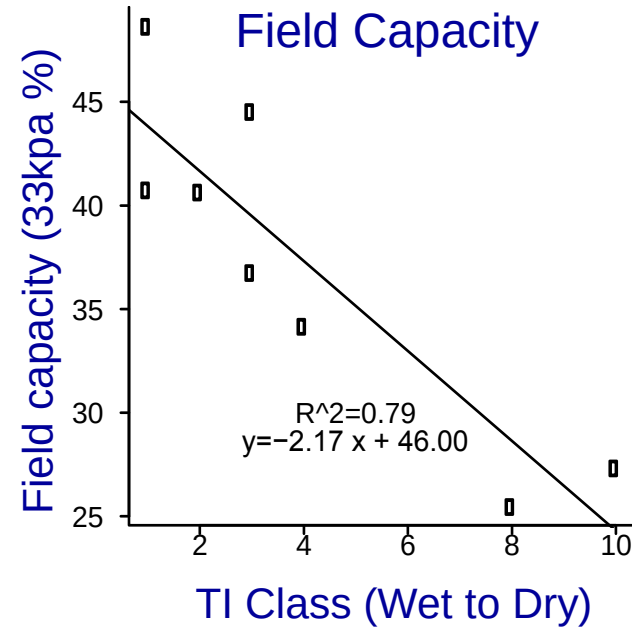
Easton et al. 2008
Collick et al. 2014
Fuka et al. 2015

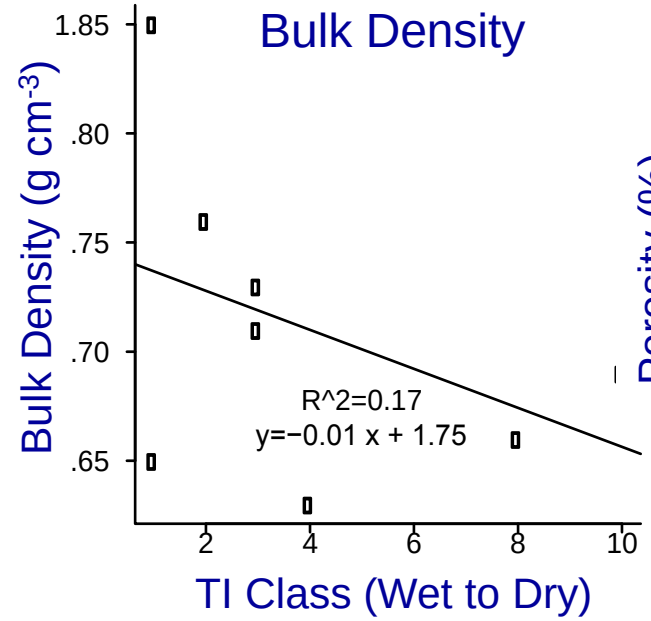
Hortonian Dominated Systems
Riesel, TX, USA

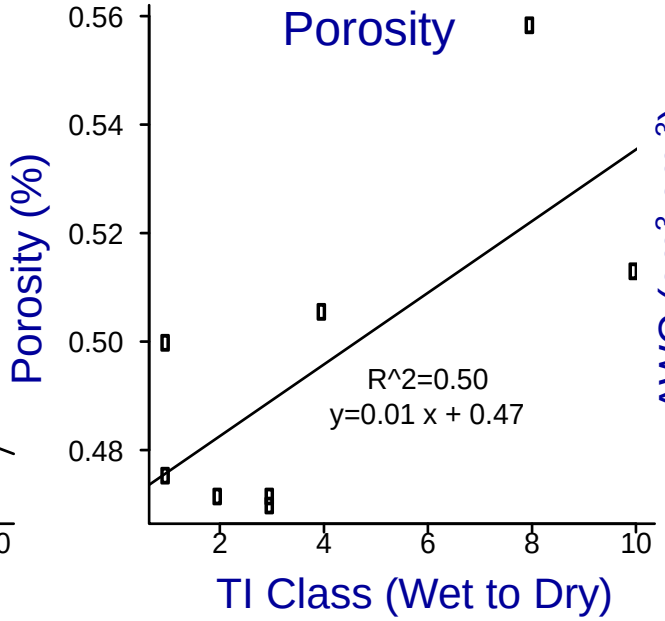


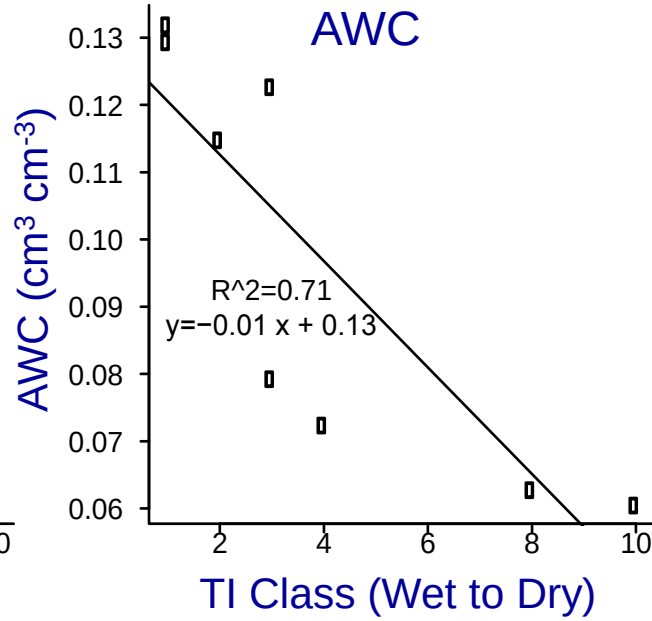

Soil Depth
Soil Depth (cm)
1600
1400
1200
1000
800
R^2=0.28
y=50.80 x + 1025.52
2
4
6
8
10
TI Class (Wet to Dry)


Ksat
Ksat (mm/hr)
25
20
15
10
5
R^2=0.19
y=−0.88 x + 17.00
2
4
6
8
10
TI Class (Wet to Dry)


Field Capacity
Field capacity (33kpa %)
45
40
35
30
25
R^2=0.79
y=−2.17 x + 46.00
2
4
6
8
10
TI Class (Wet to Dry)

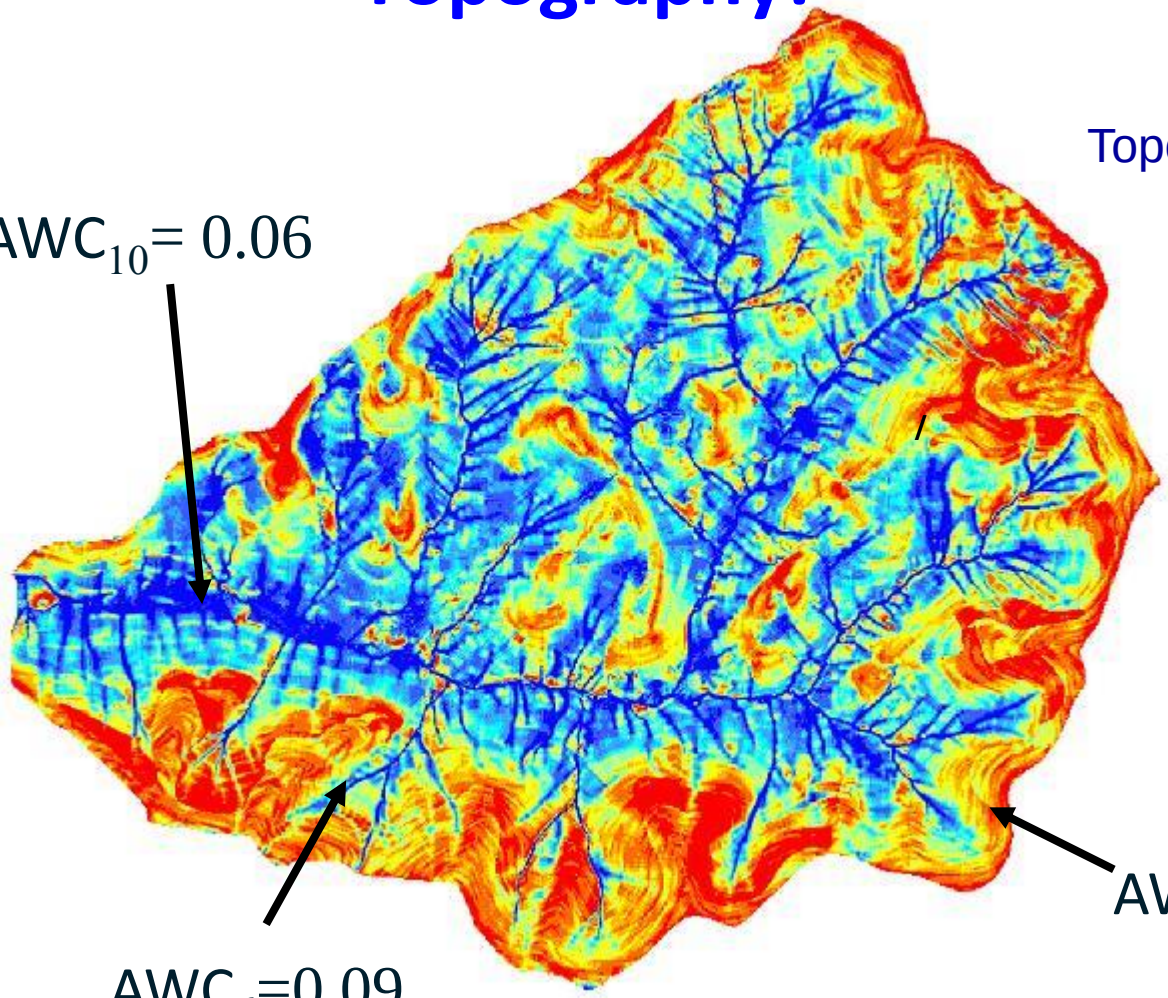

Bulk Density
Bulk Density (g cm-3)
1.85
.80
.75
.70
.65
R^2=0.17
y=−0.01 x + 1.75
2
4
6
8
10
TI Class (Wet to Dry)


Porosity
Porosity (%)
0.56
0.54
0.52
0.50
0.48
R^2=0.50
y=0.01 x + 0.47
2
4
6
8
10
TI Class (Wet to Dry)


AWC
AWC (cm3 cm-3)
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
R^2=0.71
y=−0.01 x + 0.13
2
4
6
8
10
TI Class (Wet to Dry)

Soil genesis as explained by **Topography!**

$$I = \ln\left(\frac{a}{\tan b}\right)$$



Topographic Index

33.10

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Wetness Index Classes

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1

Easton et al. 2008
Collick et al. 2014
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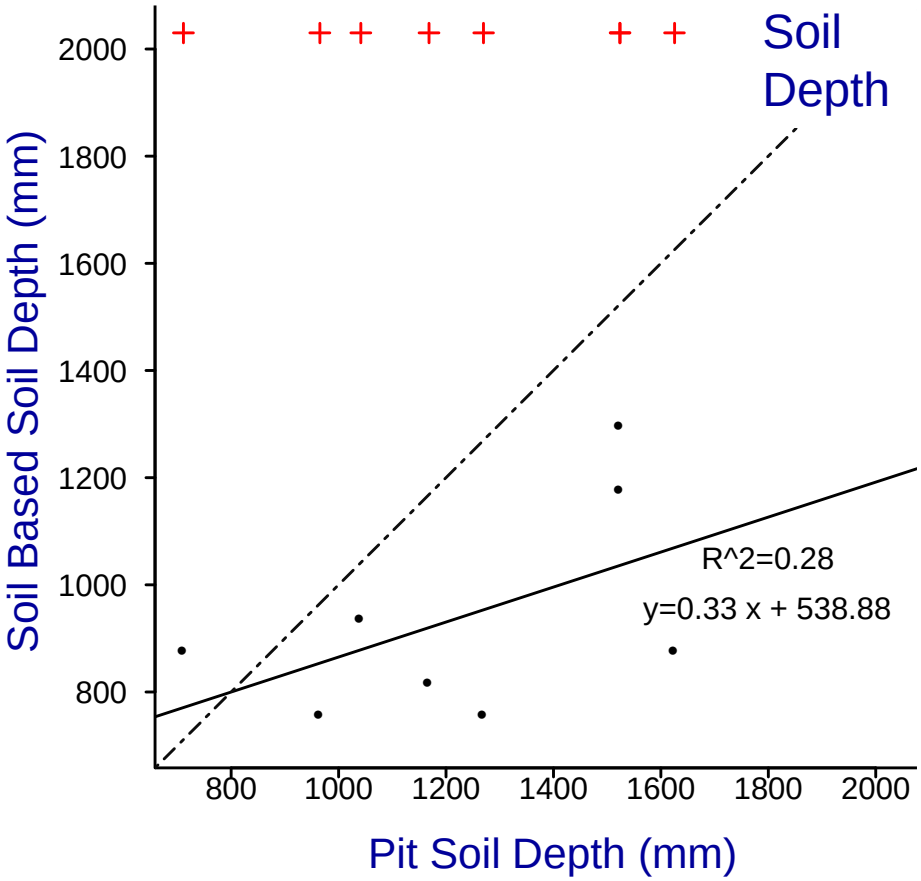
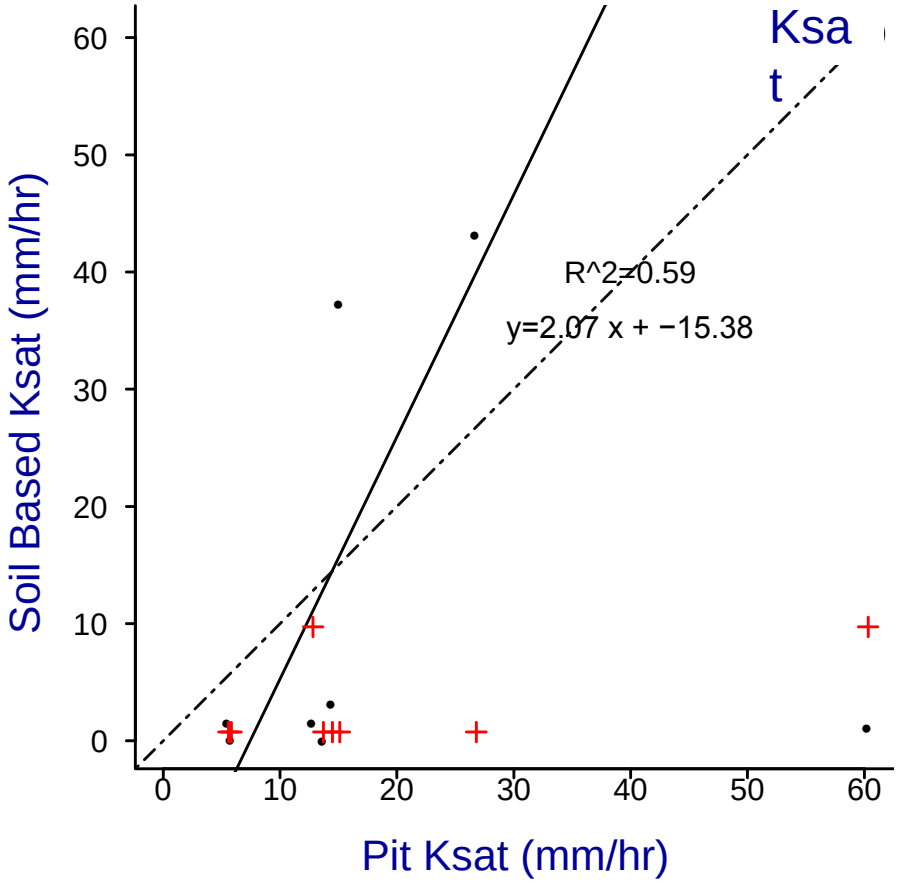
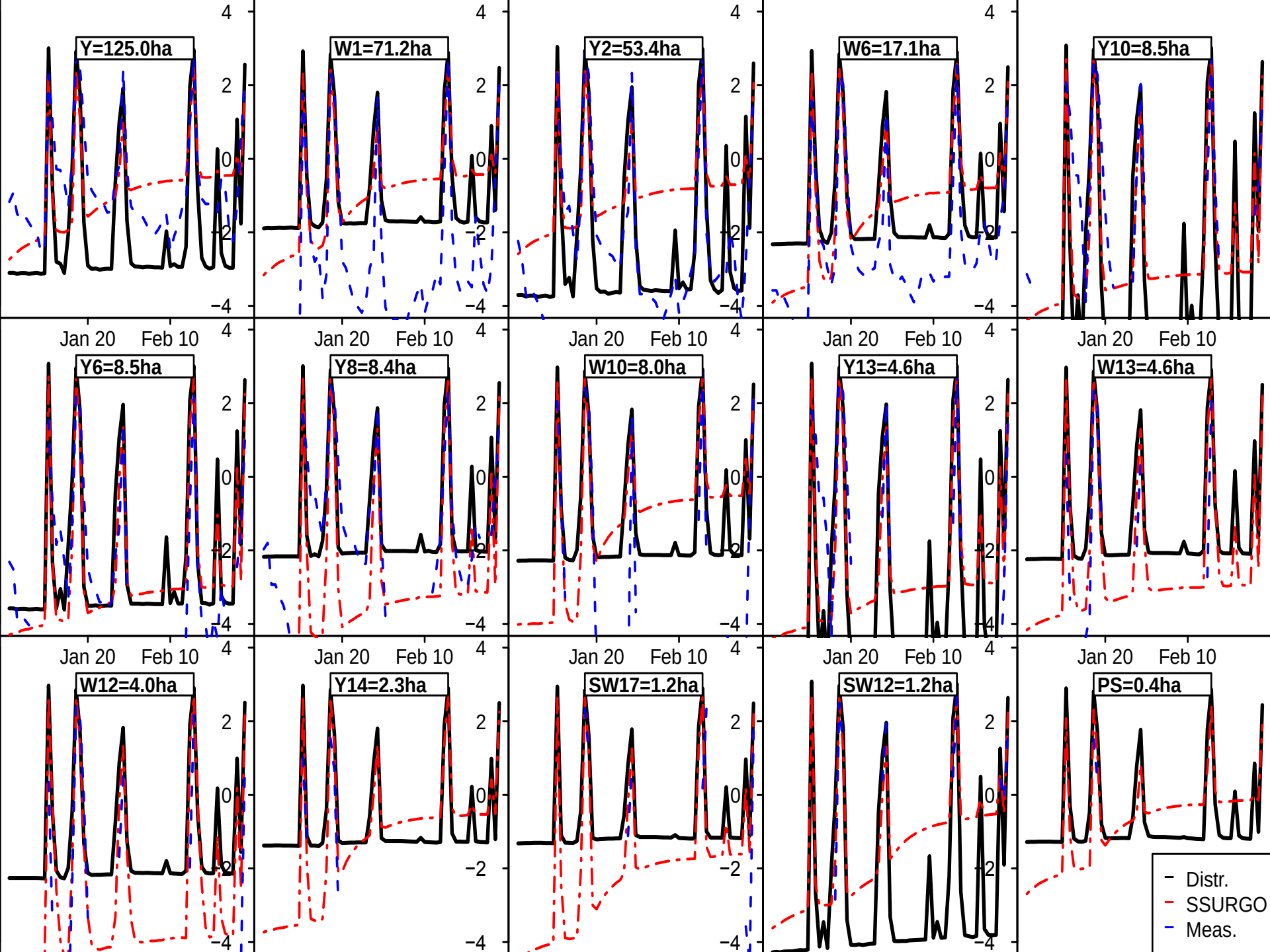
How does SSURGO perform?





TI adjusted FAO Soils (●) vs base SSURGO Soils (✚)


Y=125.0ha
W1=71.2ha
Y2=53.4ha
W6=17.1ha
Y10=8.5ha
Y6=8.5ha
Y8=8.4ha
W10=8.0ha
Y13=4.6ha
W13=4.6ha
W12=4.0ha
Y14=2.3ha
SW17=1.2ha
SW12=1.2ha
PS=0.4ha
Jan 20
Feb 10
4
2
0
−2
−4
Distr.
SSURGO
Meas.

Conclusions

- Data Brokering can increase the speed and repeatability of initialization and provide multiple data sources in (SWAT) specific formats
  - Users don't have to understand multiple formats
- SSURGO initialization captured soil properties and this hydrologic response poorly
  - Sometimes under predicting and sometimes over predicting, in part due to the overestimated soil depth and AWC
- TI initialization better captured soil characteristics and as a result hydrologic response
  - This can be used to inform spatially targeted agricultural and water resource management decisions