

2008 ESRI User Conference
Technical Workshops
August 4–8, 2008

Please!
Turn OFF cell phones
and paging devices



ArcGIS Spatial Analyst Hydrologic Modeling

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Overview

- **DEM data**
- **Basic tools for surface hydrologic analysis**
 - Demo
- **Application tools for Hydrologic and Hydraulic Modeling**
 - Demo
- **Q&A**

Surface Water Quantity

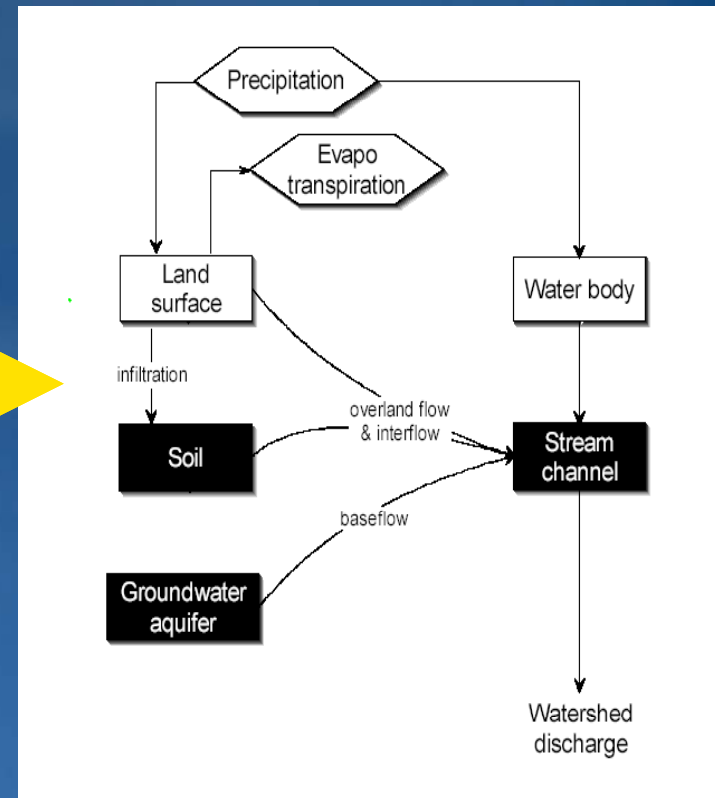
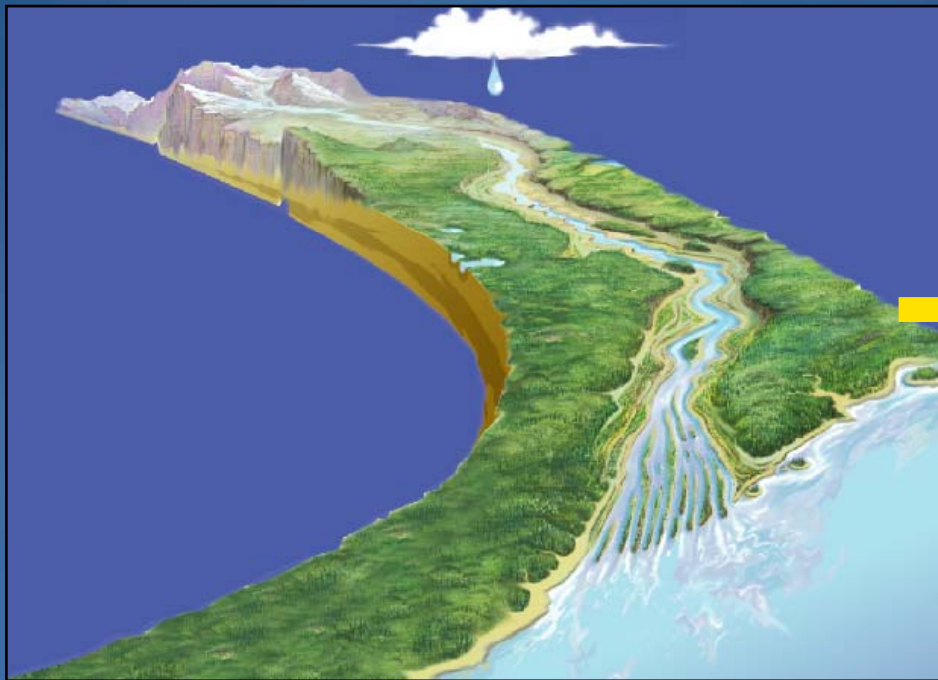
- **How much water is there?**
 - Rainfall runoff modeling, a type of hydrologic modeling, determines for a given storm on a landscape, how much water will become runoff.
- **Where will it go?**
 - Hydraulic modeling takes the quantity of water and the shape of the landscape and stream channel and determines how deep the water will be and what area it will cover in the event of a flood.

Hydrologic Modeling

- **Goal:** Find stream discharge, Q , at a location for a given precipitation.
- GIS is used to summarize terrain and hydrologic characteristics of the watershed for input to a model.
- Many ways to calculate Q .
 - Statistical methods
 - USGS regression equations (NFF, StreamStats)
 - “Physical” modeling (rainfall-runoff models)
 - HEC-HMS (successor to HEC-1), TR-20, etc.

Hydrologic Modeling

- Map natural processes onto software tasks
- Aggregate landscape characteristics to simplify
 - “Lumped parameter model”



Hydraulic Modeling

- **Goal:** to predict water surface elevations for the creation of flood inundation maps.
 - Also velocity, sedimentation, quality
- **Input:** channel and floodplain geometry with hydraulic characteristics, plus discharge and initial water surface level.
- **Output:** water surface elevation at each cross section and other characteristics.

GIS Data for Hydrologic and Hydraulic Modeling

- Digital Elevation Model and Landcover
 - <http://seamless.usgs.gov/>
 - <http://edna.usgs.gov/>
- Watershed boundaries
 - <http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/>
- Hydrography
 - <http://nhd.usgs.gov/>
- Soils
 - <http://soils.usda.gov/survey/geography/ssurgo/>
 - <http://www.soils.usda.gov/survey/geography/statsgo/>
- Current and historic water records
 - <http://waterdata.usgs.gov/nwis>
 - <http://www.epa.gov/STORET/index.html>
 - <http://his.cuahsi.org/>
- Climate, weather, rainfall
 - <http://www.ncdc.noaa.gov/oa/ncdc.html>
 - <http://www.nws.noaa.gov/ndfd/>
 - <http://www.weather.gov/gis/>
- Channel geometry (cross sections)

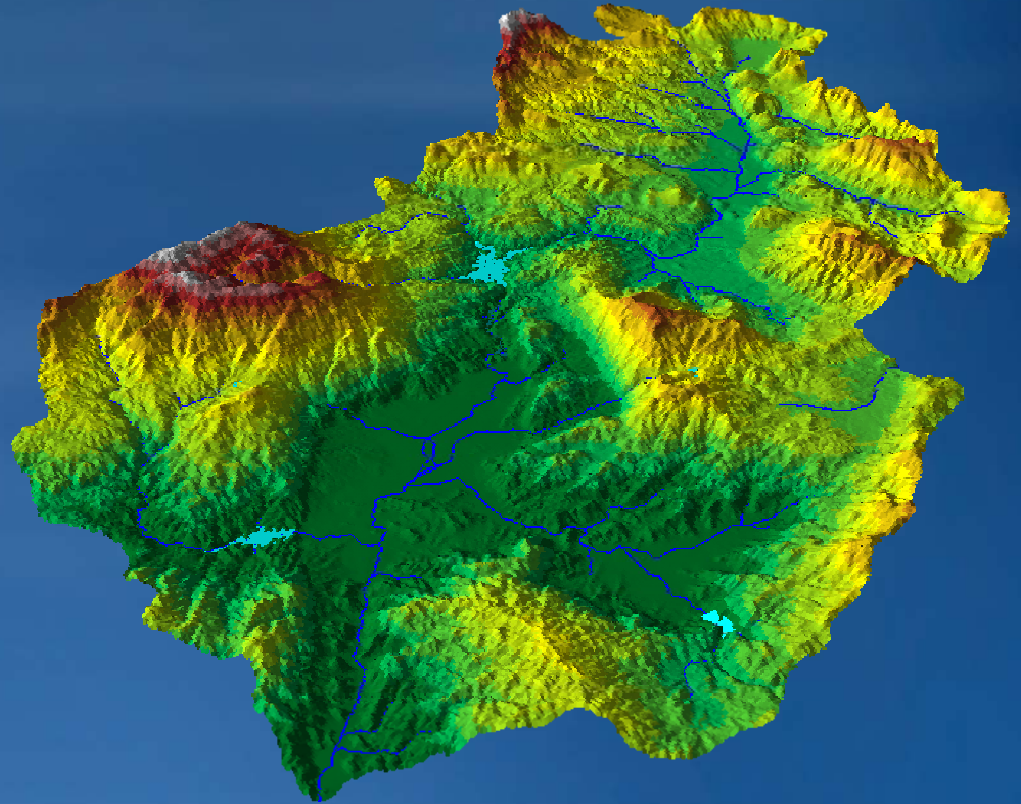
Elevation Data

- **Types**

- DEM : Digital Elevation Model
- DSM : Digital Surface Model

- **Data Structure**

- Raster
- TIN
- Terrain



Where do you get DEM data?

- **Sources**

- USGS DEM, NED, DTED, ETOPO30, SRTM
- Interpolated from points and lines
- Generated photogrammetrically
- LiDAR, IfSAR

- **Created with interpolation tools**

- especially TopoToRaster

- **What cellsize and accuracy?**

- Horizontal and Vertical resolution must be appropriate for the landscape and scale being modeled.

DEM Construction

- **DEM construction issues**
 - Resolution and extent
 - Projection (for hydrology - equal area)
 - Source elevation data
 - Interpolation techniques (IDW, Spline, via TIN)
- **Problems with contour input**
 - TopoToRaster interpolator – works well with contours, creates hydrologically correct DEM

Drainage System

Watershed

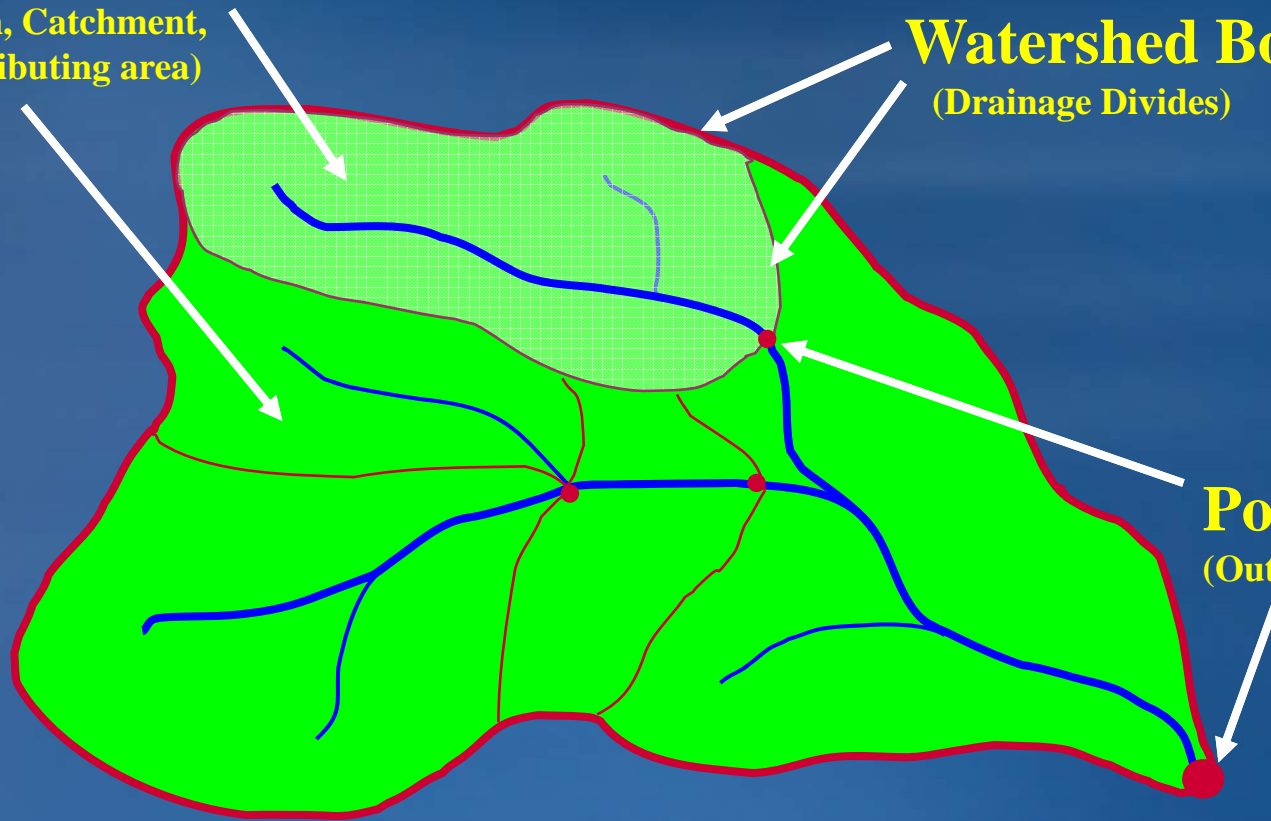
(Basin, Catchment, Contributing area)

Watershed Boundaries

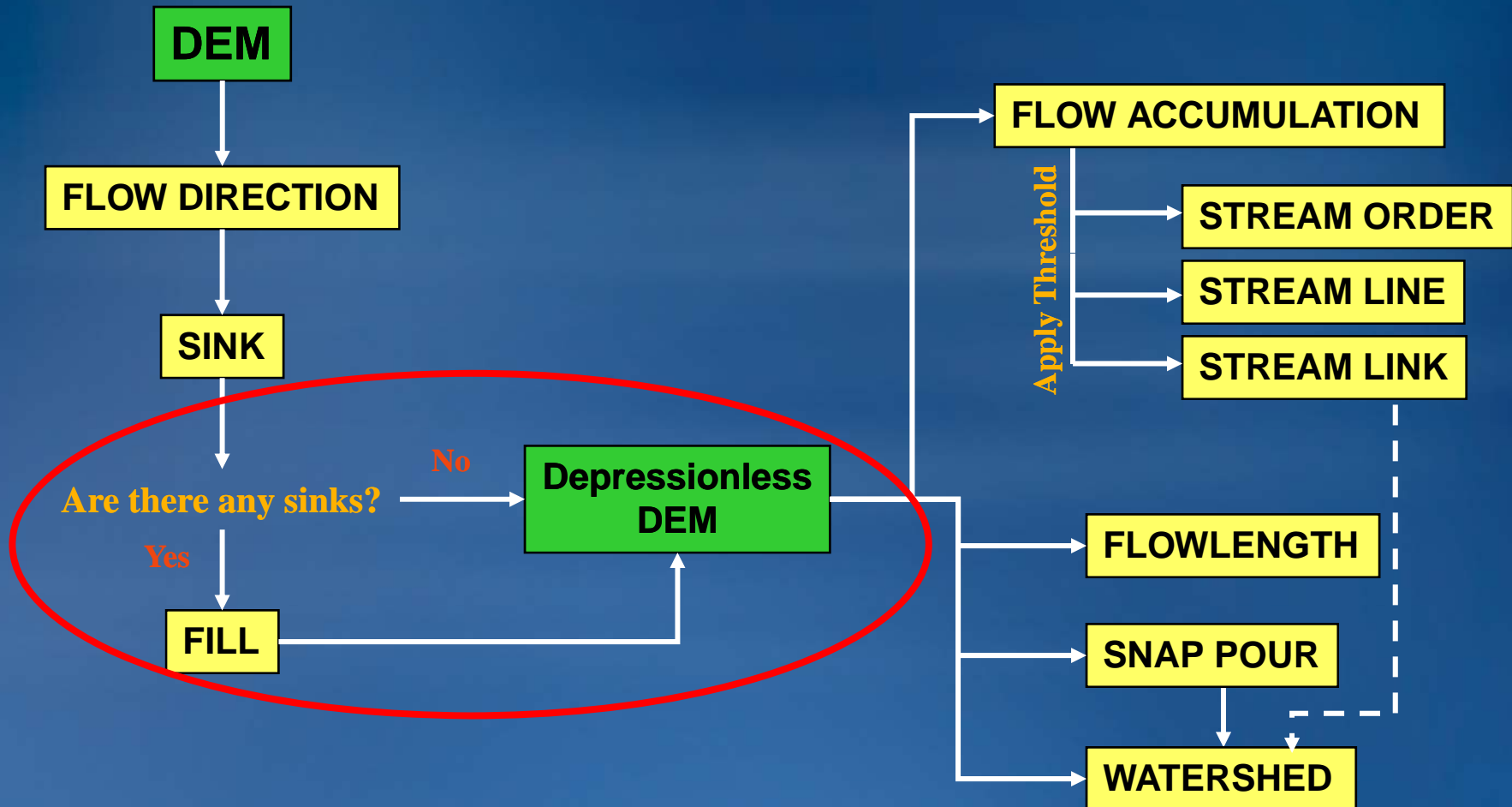
(Drainage Divides)

Pour Points

(Outlets)



Function Processing

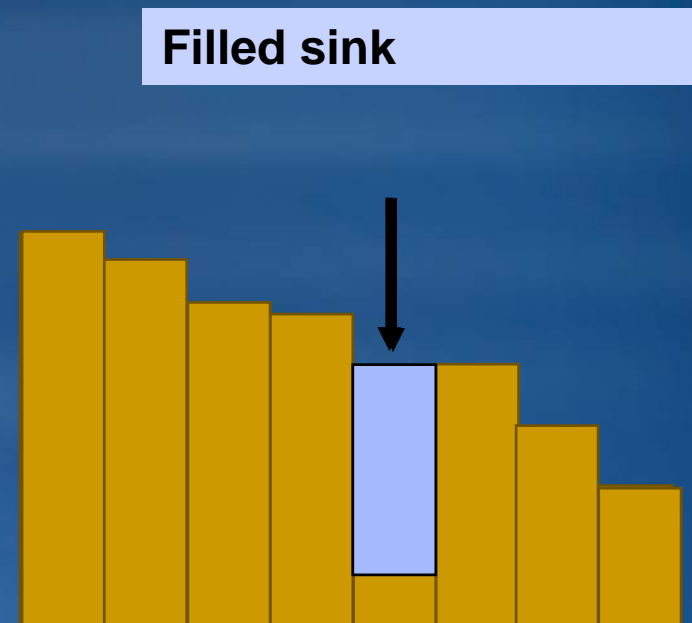


Hydrologically Correct DEM

- **Sinks**
 - Some sinks are real
 - **Do not fill in the Great Salt Lake**
- **Streams in the correct place?**
 - To burn or not to burn
- **Watershed boundaries in the correct place?**
 - To fence or not to fence

DEM Errors – Sinks and Spikes

- Sinks: when sinks are (or are not) sinks
- E.g. Lakes, depressions, karst and glacial landscapes
 - Global fill
 - Dealing with internal basins
 - Selective fill
 - Depth
 - Area
- New Algorithm in 9.3
 - Used when a depth is not specified
 - Up to 45x faster, works on much larger input data



Flow Direction

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12

Elevation



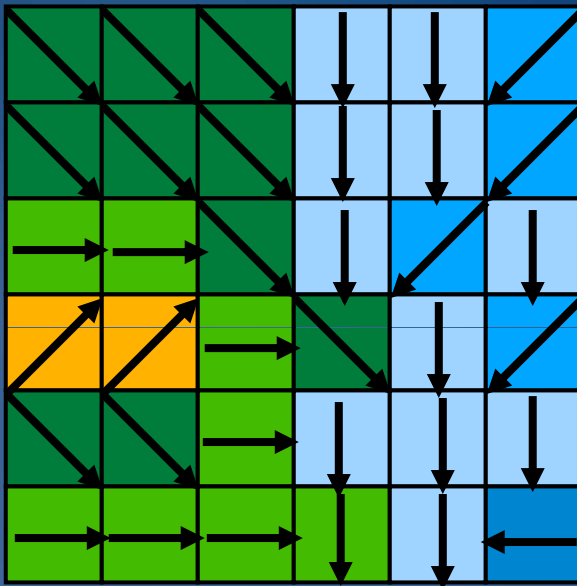
2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
128	128	1	2	4	8
2	2	1	4	4	4
1	1	1	1	4	16

Flow Direction

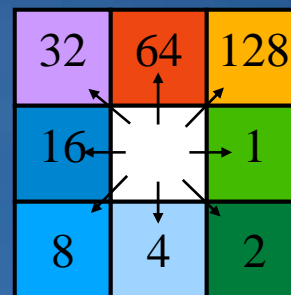
32	64	128
16		1
8	4	2

Direction Coding

Flow Accumulation

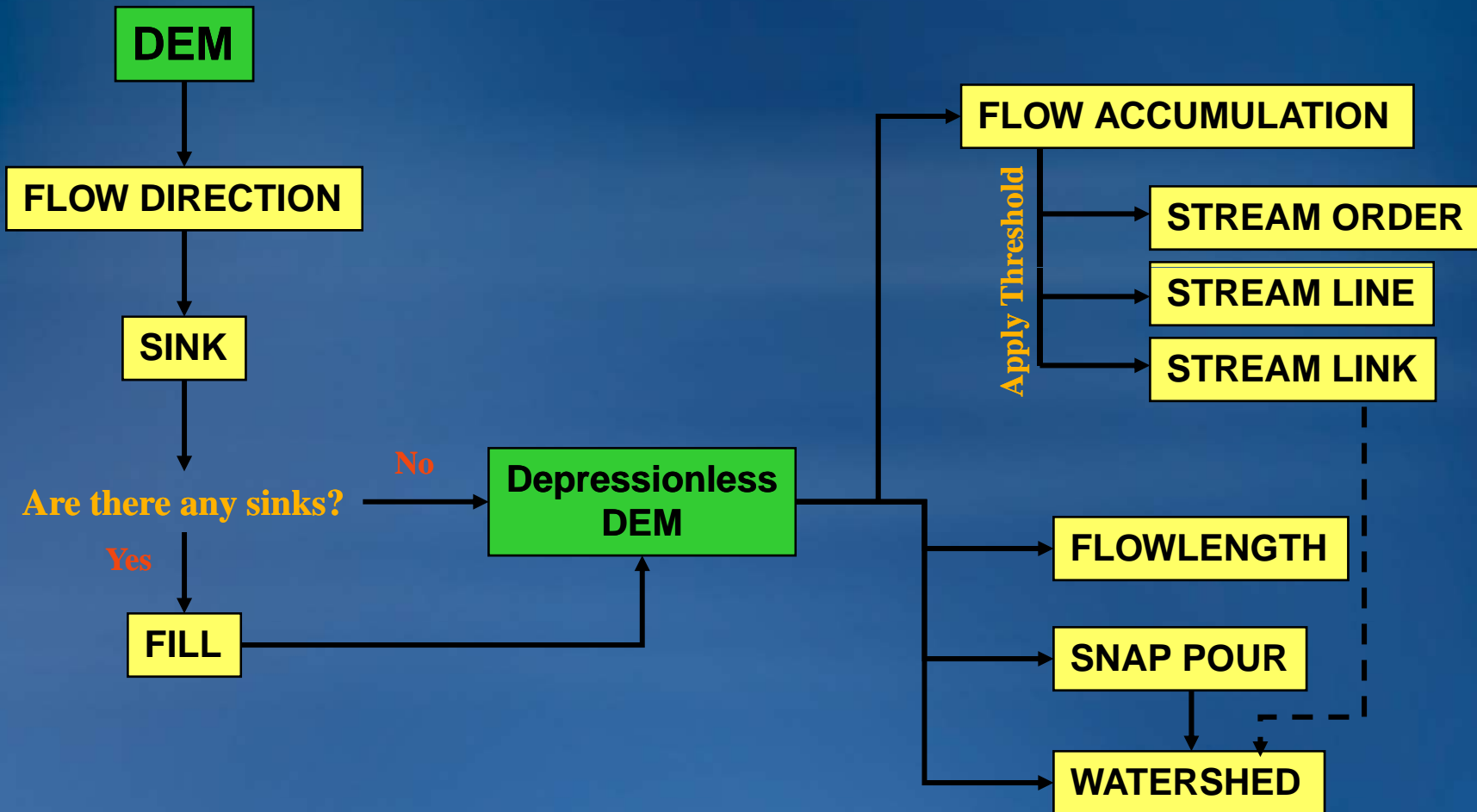


0	0	0	0	0	0
0	1	1	2	2	0
0	3	7	5	4	0
0	0	0	20	0	1
0	0	0	1	24	0
0	2	4	7	35	2



Direction Coding

Function Processing

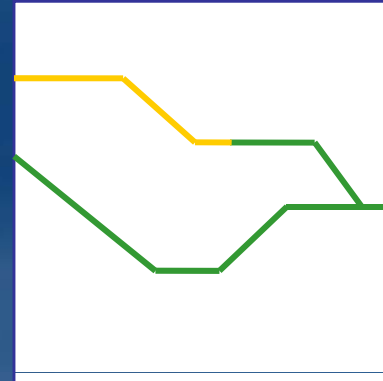


Creating Vector Streams

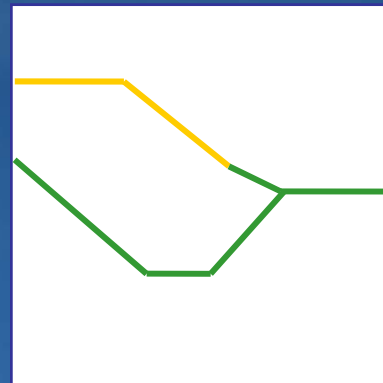
Value = No Data

1	1				
		1	2	2	
2			2	2	2
	2	2			

NET_GRID



StreamToFeature



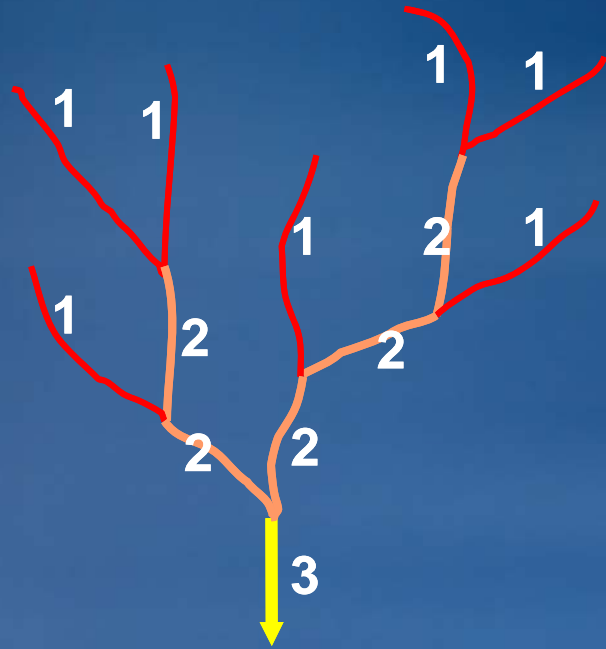
RasterToFeature

Stream Link

- **Assign a unique value to each stream segment.**
 - Can be used as input to Watershed



Stream Ordering



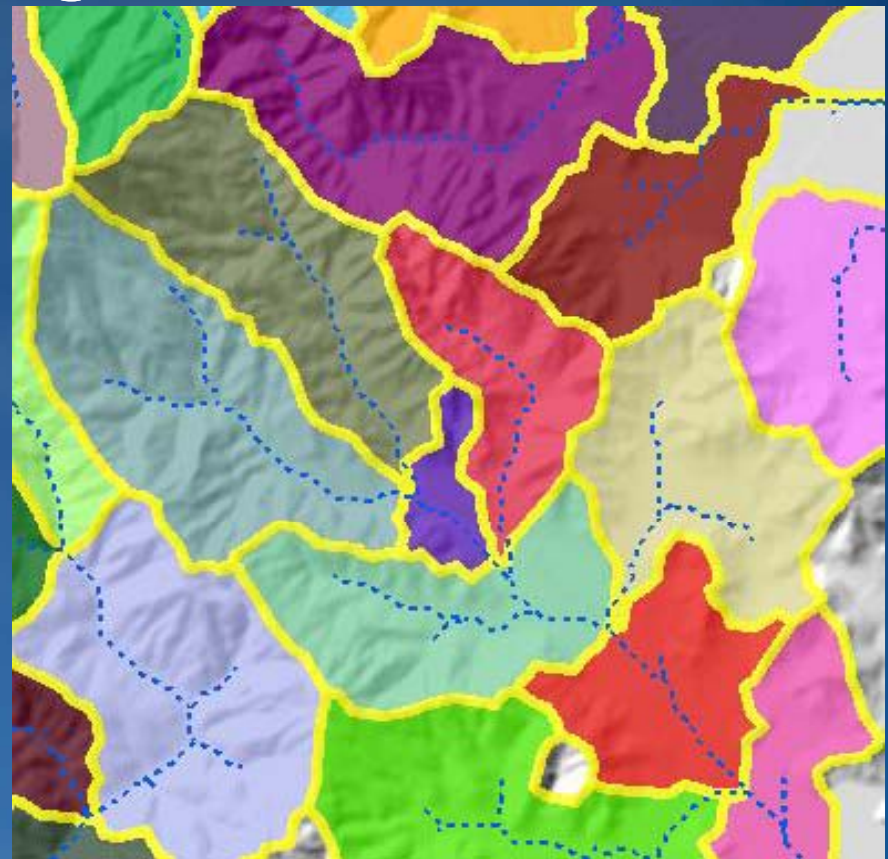
Strahler



Shreve

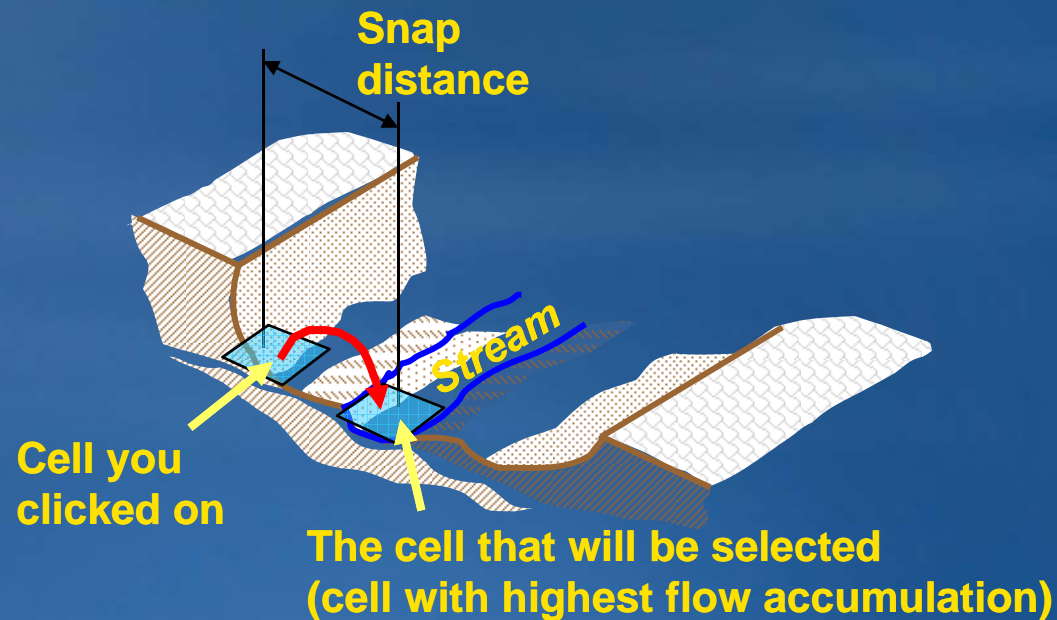
Watershed

- Delineate the contributing area to a cell or group of cells.



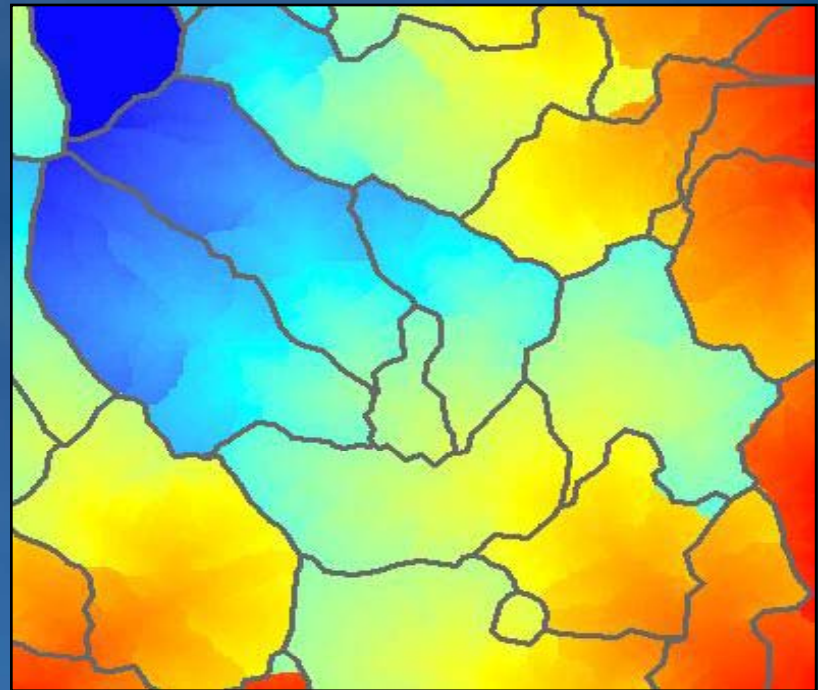
SnapPour

- Snap the “pour point” of a watershed to the cell of highest flow accumulation within a neighborhood.
 - Prevents accidental creation of tiny watersheds on channel side slopes.



Flow Length

- Calculate the length of the upstream or downstream flow path from each cell.



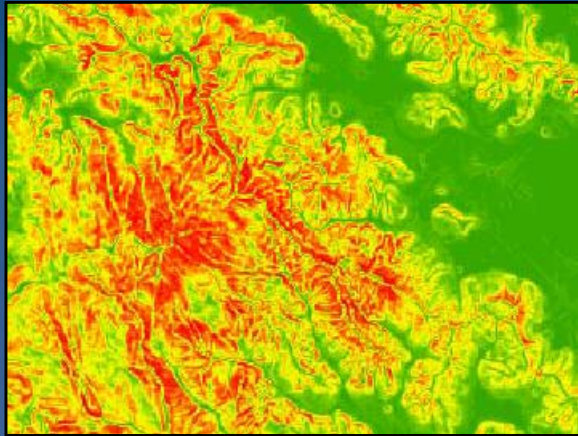
Summarizing Watershed Characteristics for Model Input

- Use the Zonal Statistics tool
- A “**zone**” is all the areas/cells with the same value
- Calculate a statistic within the zones for each cell in a raster
- Input zones can be feature or raster
- Output as a raster, summary table, or chart
 - Max flow length per watershed
 - Average slope per watershed
 - Average curve number per watershed

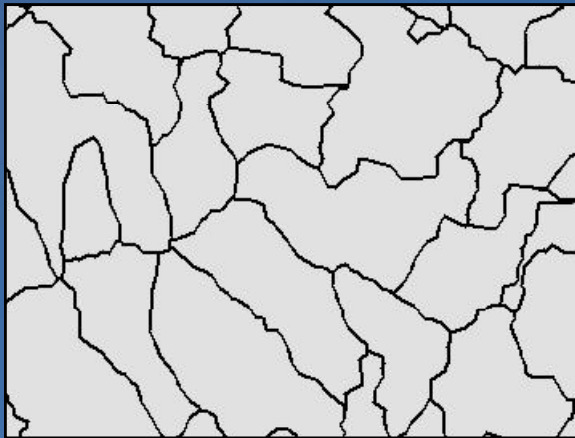
Summarizing Watershed Characteristics

Using Zonal Statistics

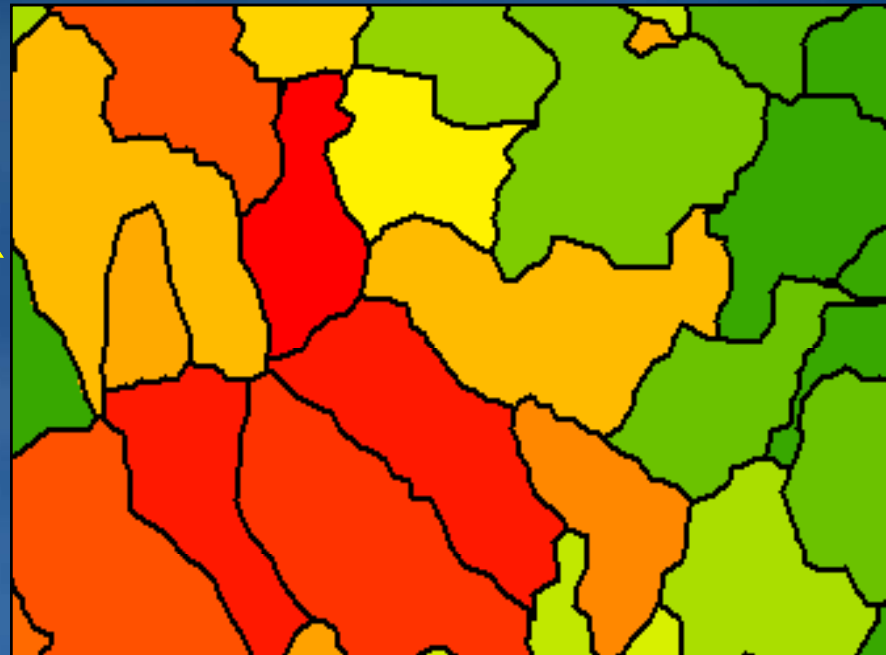
Slope



Watersheds



Mean Slope per Watershed



Where is this functionality?

- **ArcGIS Spatial Analyst 8.x**
 - HydrologyOp containing VB methods
 - Sample Toolbar on ArcObjectOnline
 - Arc Hydro data model tools

- **ArcGIS Spatial Analyst 9.x**
 - All the above plus...
 - Tools in the Spatial Analyst Toolbox
 - Sample ModelBuilder model on Geoprocessing Resource Center

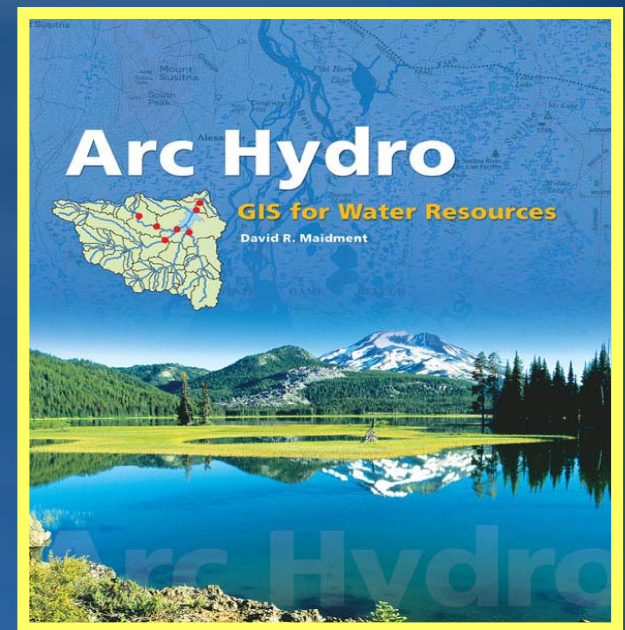
Demonstration

Application Tools for Hydrologic and Hydraulic Modeling

- **ArcHydro Data Model and Tools**
- **Hydrologic Modeling**
- **Hydraulic Modeling**

ArcGIS Hydro Data Model

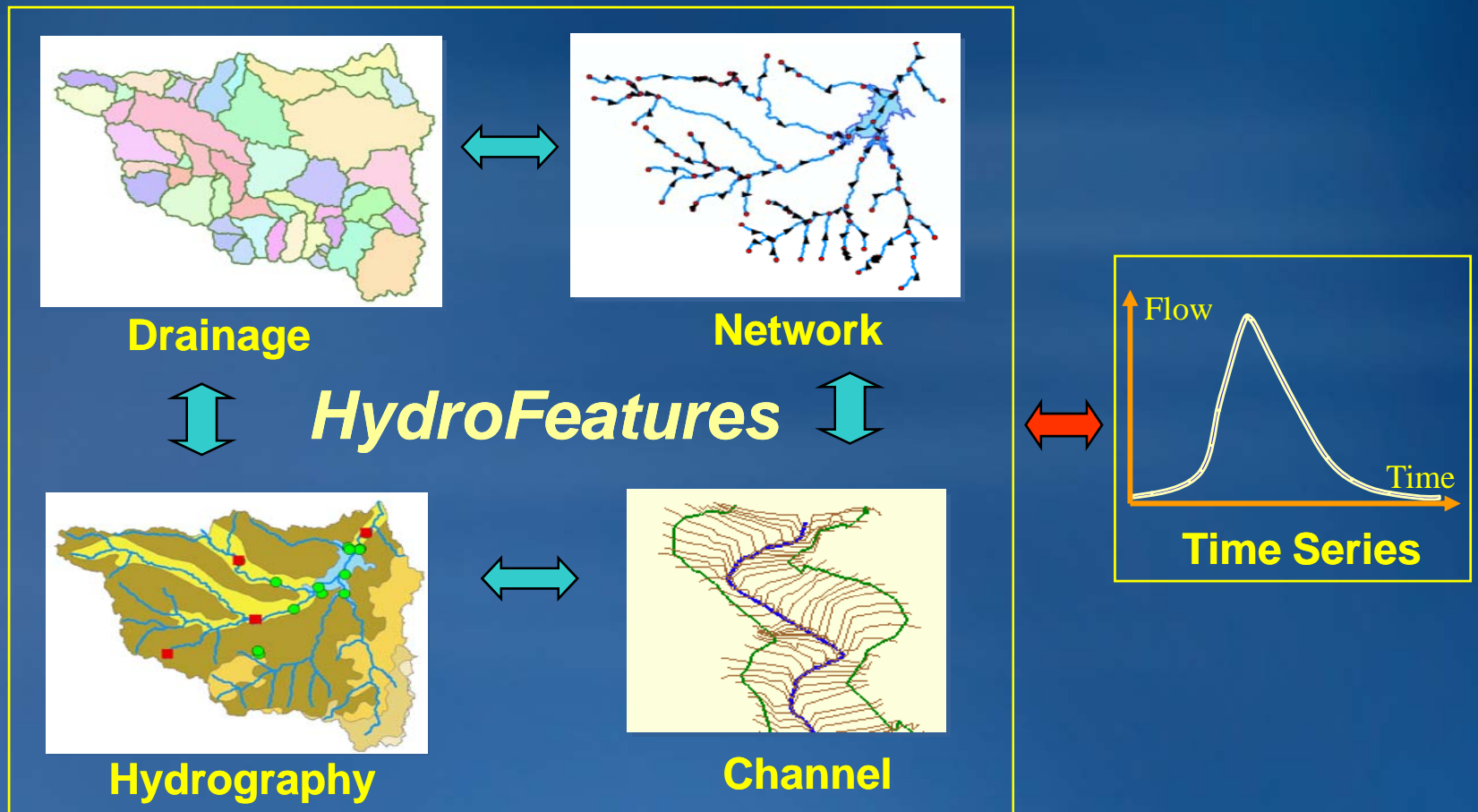
- Extension of geodatabase model for support of water resources applications
 - Data Model
 - Free tools
 - Community
- <http://www.crwr.utexas.edu/giswr>



ArcGIS Hydro Data Model

- **A geospatial and temporal data model for water resources that operates within ArcGIS**
- **Five key areas:**
 - **Drainage**
 - **Flow network**
 - **Hydrography**
 - **Channel description**
 - **Time series**

ArcGIS Hydro Data Model

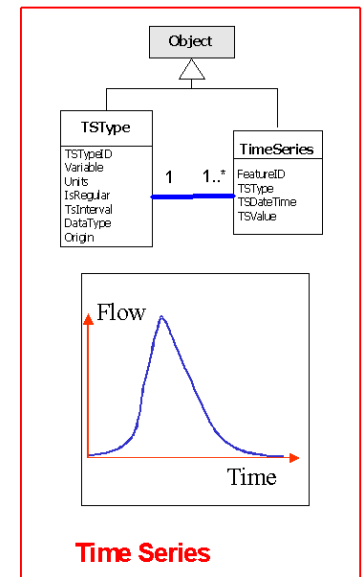
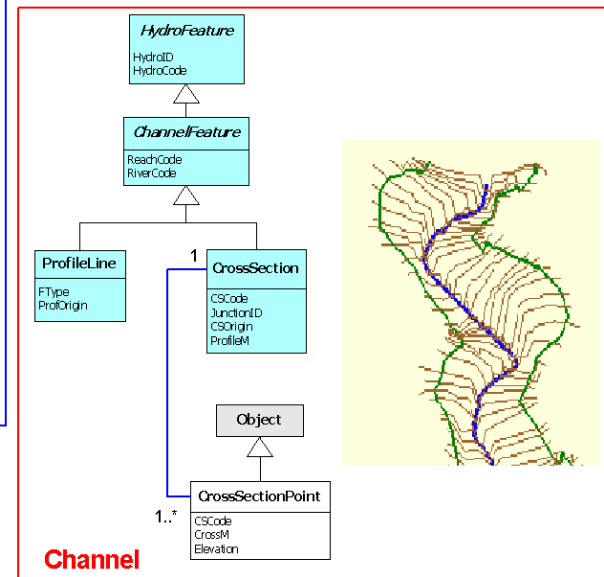
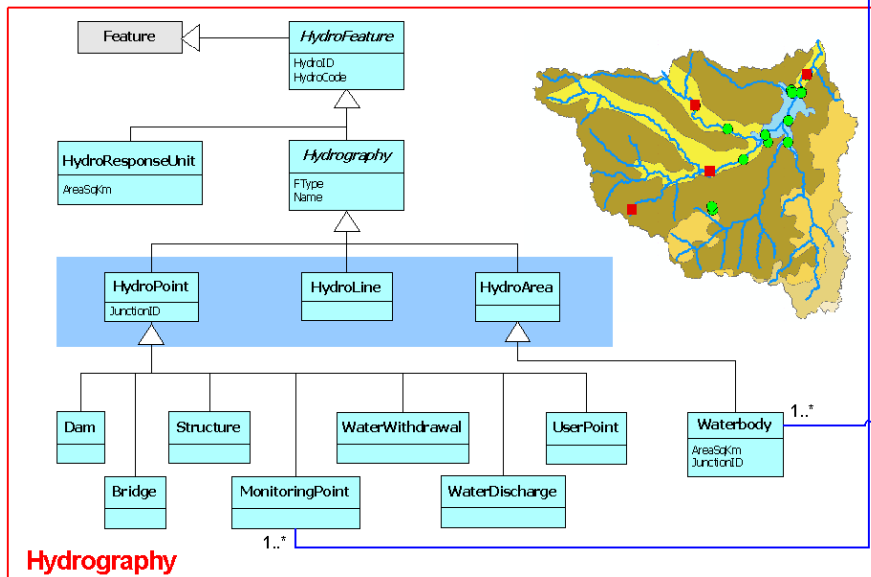
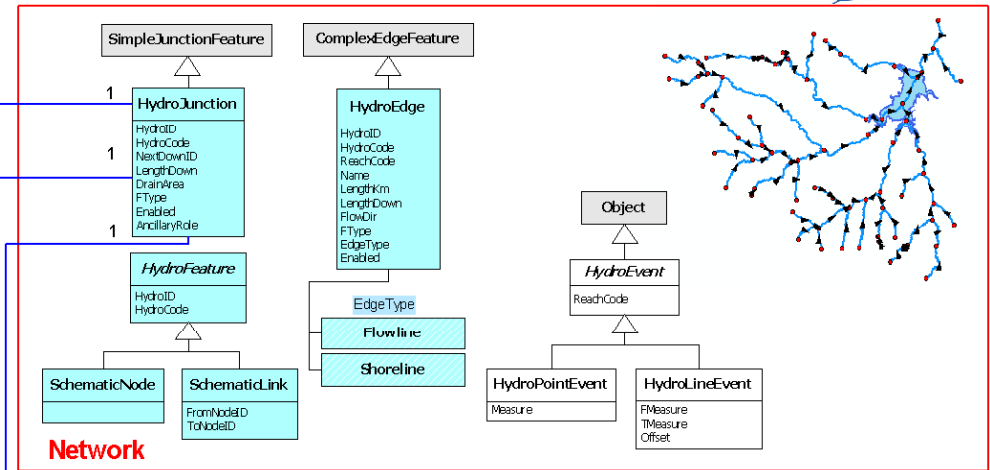
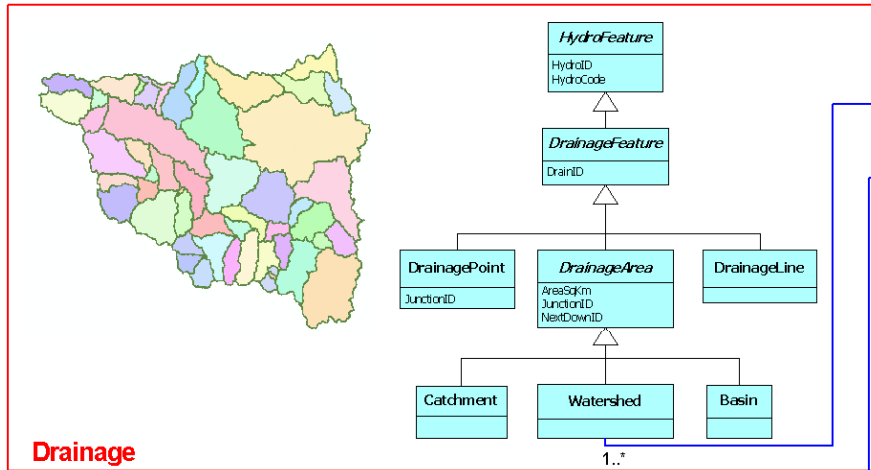


ArcGIS Hydro Data Model

<http://arconline.esri.com/arconline/datamodels/water.cfm>

<http://www.cwr.utexas.edu/giswr>

GIS in Water Resources Consortium



Arc Hydro Tools

- **Collection of tools for support of Arc Hydro geodatabase design and basic water resources functions**
- **Starting point** for water resources database and application development

Hydrologic Modeling

- **Goal:** Find stream discharge, Q , at a location for a given precipitation.
- GIS is used to summarize terrain and hydrologic characteristics of the watershed for input to a model.
- Many ways to calculate Q .
 - Statistical methods
 - USGS regression equations (NFF, StreamStats)
 - “Physical” modeling (rainfall-runoff models)
 - HEC-HMS (successor to HEC-1), TR-20, etc.

Statistical Approach

- Regionalized regression equations for the prediction of *high* and *low* flows based upon a collection of physical landscape parameters and historic precipitation.

$$Q = \text{Constant} * \text{Area}^{C1} * \text{Slope}^{C2} * \dots$$

HEC – HMS Model

- **Rainfall – Runoff model, the successor to HEC-1 from Corps of Engineers.**
- **Inputs are physical landscape parameters derived from GIS data, plus precipitation, aggregated into hydrologically similar units.**
- **Outputs are hydrographs at points of interest (time vs discharge).**

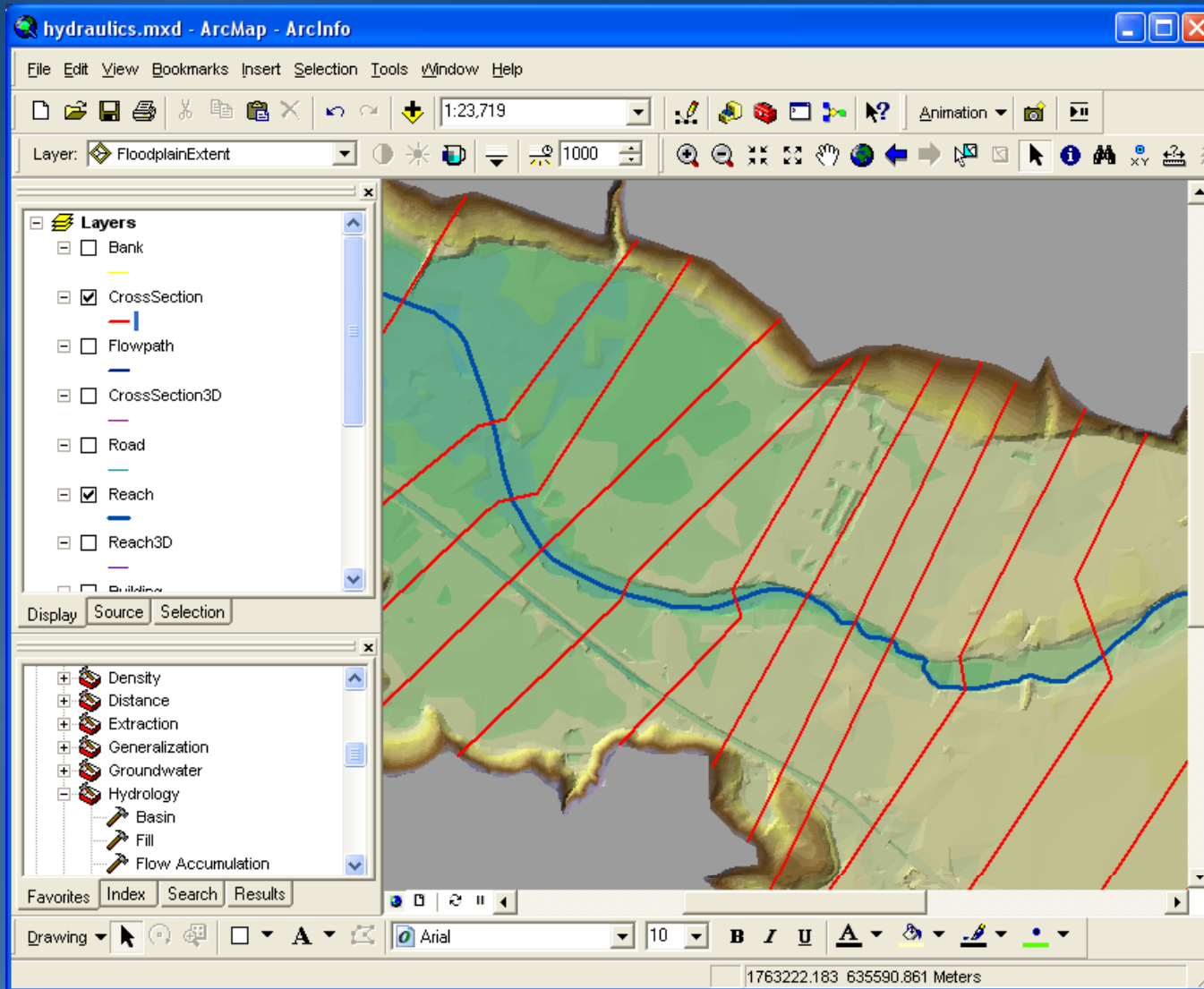
GIS Integrated Hydrologic Modeling tools

- **GeoHMS for AV3 – Corps of Engineers**
- **HEC GeoHMS for ArcGIS – Corps of Engineers (Beta)**
- **NFF and StreamStats – USGS**
- **MIKE BASIN and MIKE SHE – DHI Water & Environment**
- **WISE – Watershed Concepts**
- **WMS – Brigham Young University**

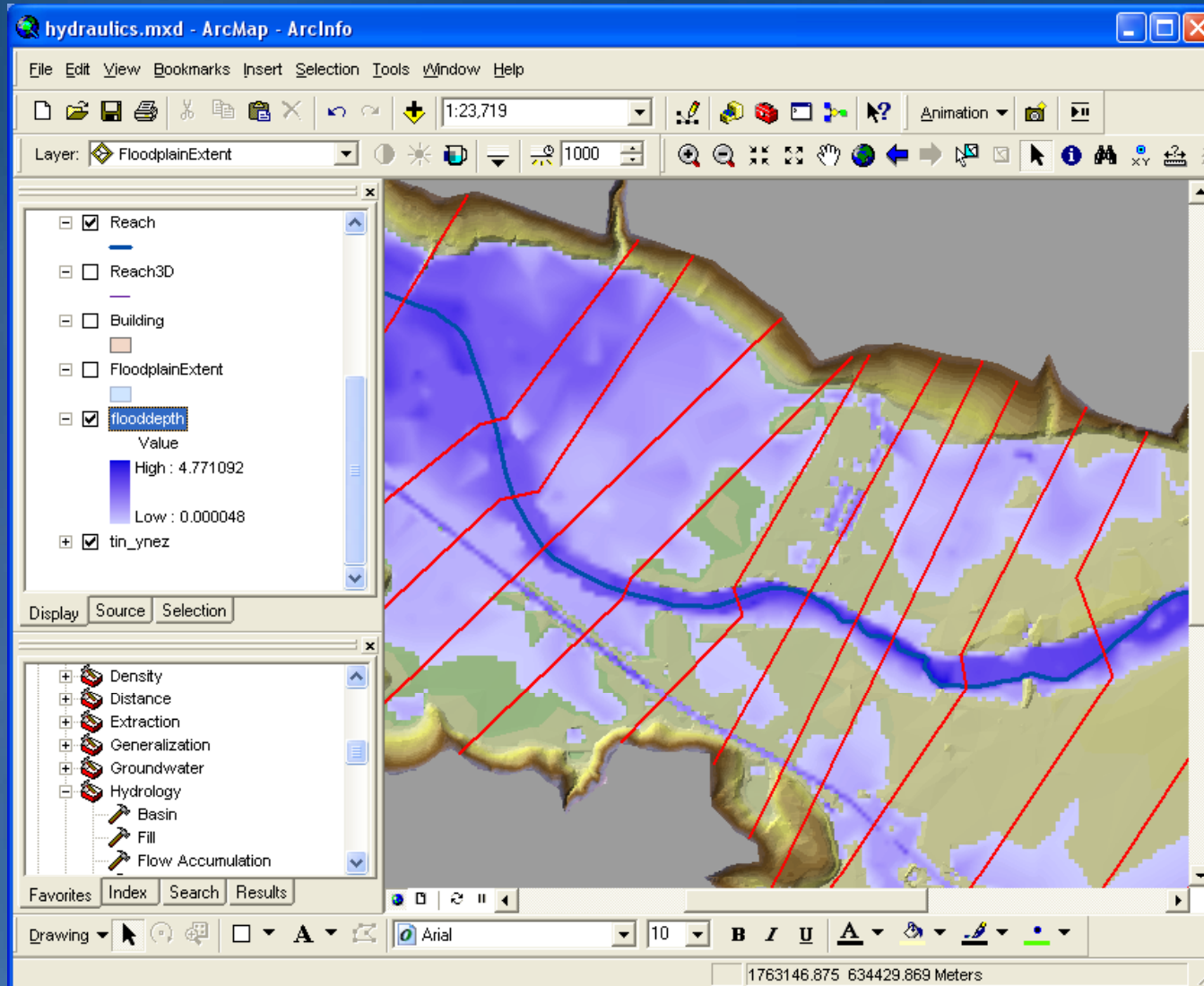
Hydraulic Modeling

- **Goal:** to predict water surface elevations for the creation of flood inundation maps.
 - Also velocity, sedimentation, quality
- **Input:** channel and floodplain geometry with hydraulic characteristics, plus discharge and initial water surface level.
- **Output:** water surface elevation at each cross section and other characteristics.

Channel and Floodplain Geometry



Flood Map



GIS Integrated Hydraulic Modeling tools

- **GeoRAS for AV3 – Corps of Engineers**
- **HEC GeoRAS for ArcGIS – Corps of Engineers**
- **MIKE FLOOD, MIKE 11 and MIKE 21 – DHI Water & Environment**
- **WISE – Watershed Concepts**
- **SMS – Brigham Young University**

Demonstration

Where to Learn More?

- **ESRI Virtual Campus Course**
- **Arc Hydro Data Model Book**
- **ArcHydro Training Course**
 - Redlands, CA October 7 - 9
- **Hydrologic and Hydraulic Modeling with ArcGIS**
 - Redlands, CA September 15 - 19

For a custom course, contact Dean Djokic ddjokic@esri.com

Questions & Answers

Please fill out workshop evaluations

Thank You!

Spatial Analyst sessions

Technical Workshops

- **ArcGIS Spatial Analyst – An Introduction**

- Tuesday, August 5th. 8:30 – 9:45. Rm 1A/B
- Wednesday, August 6th. 1:30 – 2:45. Rm 1A/B

- **ArcGIS Spatial Analyst – Suitability Modeling**

- Tuesday, August 5th. 1:30 – 2:45. Rm 1A/B
- Thursday, August 7th. 8:30 – 9:45. Rm 1A/B

- **ArcGIS Spatial Analyst – Statistical Modeling**

- Tuesday, August 5th. 3:15 – 4:30. Rm 1A/B
- Thursday, August 7th. 10:15 – 11:30. Rm 1A/B

- **ArcGIS Spatial Analyst – Hydrologic Modeling**

- Wednesday, August 6th. 8:30 – 9:45. Rm 5A/B
- Thursday, August 7th. 1:30 – 2:45. Rm 5A/B

- **An Introduction to Dynamic Simulation Modeling**

- Wednesday, August 6th. 10:15 – 11:30. Rm 5A/B
- Thursday, August 7th. 3:15 – 4:30. Rm 5A/B

Demo Theater Presentations

- **Site selection and suitability modeling**

- Tuesday, August 5th. 5:00 – 6:00. Exhibit Hall C

- **Water resource applications using Spatial Analyst and NetCDF data**

- Wednesday, August 6th. 12:00 – 1:00. Exhibit Hall C

- **Solar radiation modeling**

- Wednesday, August 6th. 4:00 – 5:00. Exhibit Hall C

- **Working with surface interpolation tools**

- Thursday, August 7th. 10:00 – 11:00. Exhibit Hall C