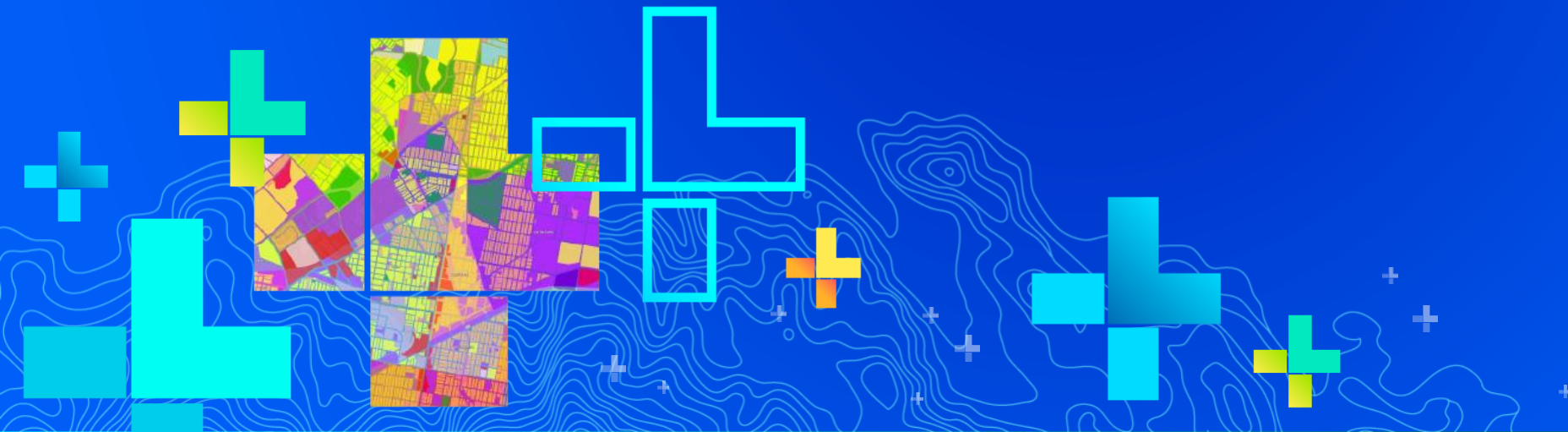


3D Feature & Sub-Surface Analysis

Jie Chang

Khalid H. Duri



Workshop Outline

- What's New
- 3D Data Types
- Sub-Surface Analysis
- Examples
- Q & A

Workshop Overview

- **What's New**
- **3D Data Models**
- **Sub-Surface Analysis**
- **Examples**
- **Q & A**



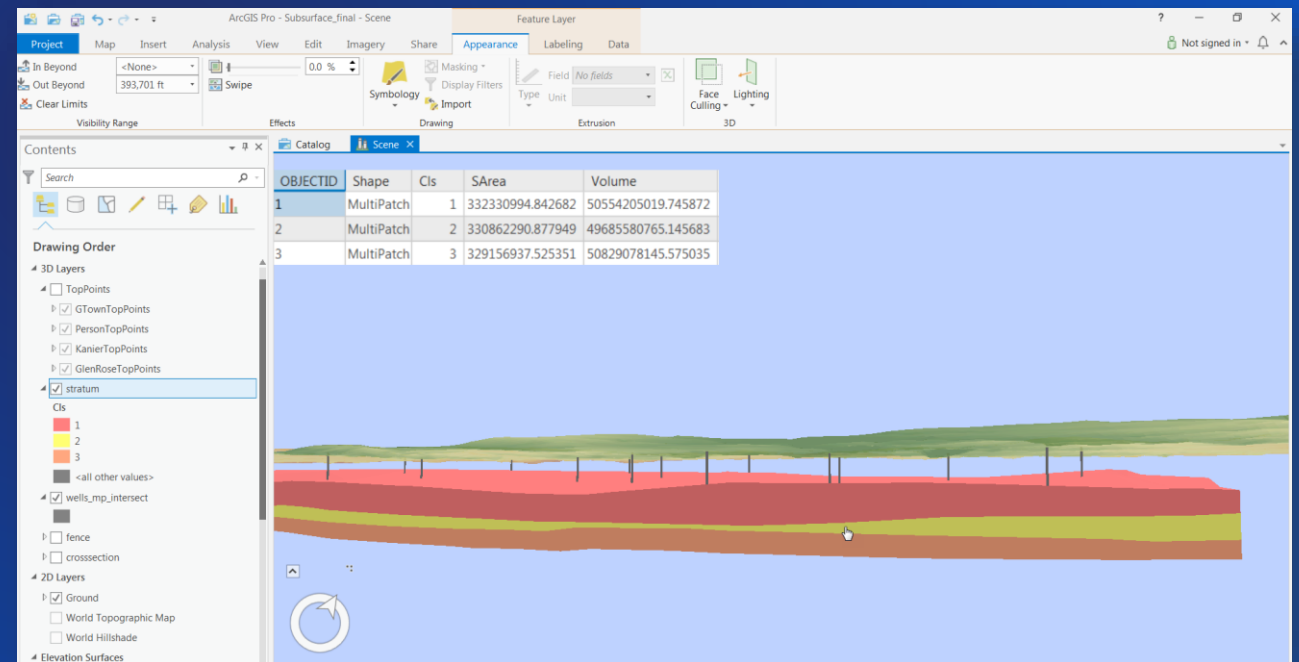
What's New in ArcGIS Pro

- 3D interpolation with Empirical Bayesian Kriging 3D (EBK3D) [2.3]
- Generate reports from statistical aggregations [2.3]
- Enhanced shading to emphasize depth characteristics of 3D data [2.4]
- Easily add multiple surfaces as separate elevation sources [2.4]
- Generate a profile view to interactively examine a 3D cross section [2.4]
- Interactively edit raster elevation data with the Pixel Editor [2.4]
- Interactively assess the cut-fill needed to level an elevation surface [2.4]



Subsurface GIS

- **Construct 3D models**
 - ▮ Interpolate surfaces
 - ▮ Construct fence diagrams & volumetric shells of geologic strata
 - ▮ Visualize infrastructure assets
- **Analyze spatial properties**
 - ▮ Compute volume & area
 - ▮ Find intersection of wells, tunnels, & boreholes with geologic strata
- **Communicate results**
 - ▮ Create charts & reports
 - ▮ Share on multiple platforms



Modeling in 3D Space

Overview of Data Types



Storing XYZ Information

Vector Geometry

Points | Lines| Polygon

Point Cloud

Mesh

Surface Model

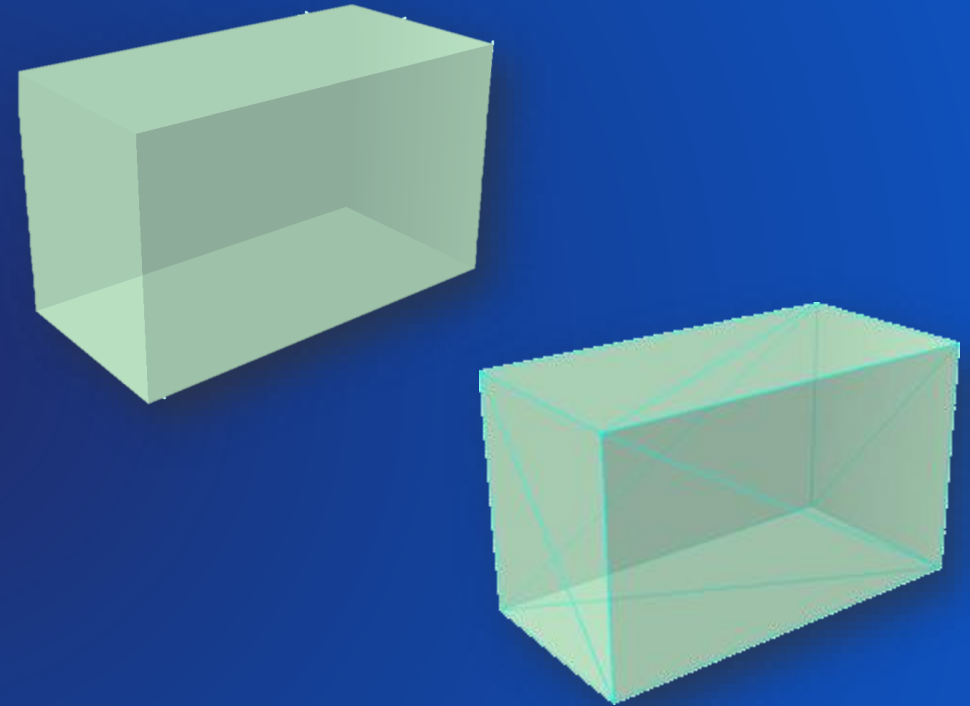
Triangulated Irregular Network

Raster



Understanding Mesh Geometry

- **Collection of triangles**
- **Support textures, colors, and transparency**
- **Represent many types of data:**
 - Discrete objects
 - Outer shell of a volume
 - Continuous measurements
 - ↳ Terrain with overhangs and enclosed spaces
 - ↳ Isosurface with multiple Z values at an XY

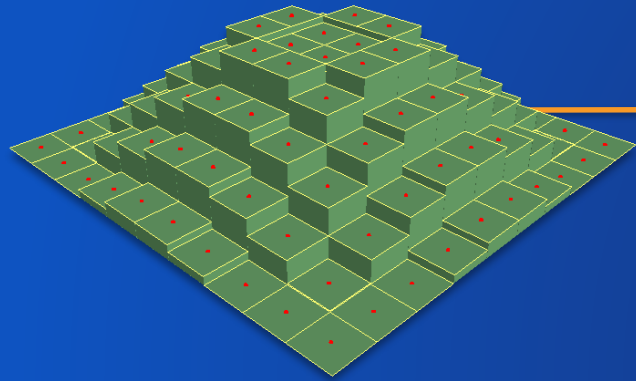


Constructing 3D Features

- Interactive digitization
- Symbolize points, lines and polygons:
 - Procedural rules to create complex models driven by feature attributes
 - Extrusion/base height properties to create walls from lines, volumes from polygons, and cylinders from points
 - Standard 3D marker symbols for points, tube symbols for lines
- Derive from spatial operations
- Import 3D models from a variety of data sources:
 - Collada
 - OpenFlight
 - Wavefront OBJ (*Pro only*)
 - 3D Studio Max
 - VRML/GeoVRML
 - SketchUp (*Desktop only*)

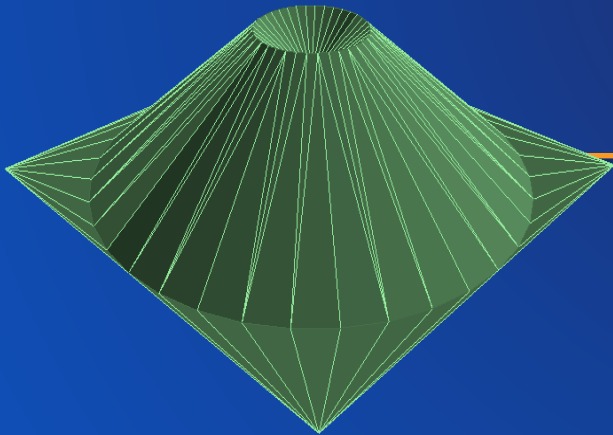


Surface Data Models



Raster Surface

- Made by interpolation, generalize source measurements to cell size
- Fast to process, support robust math operations



TIN Based Surfaces

- Created by triangulation, maintain source measurements
- Support robust surface definitions & data

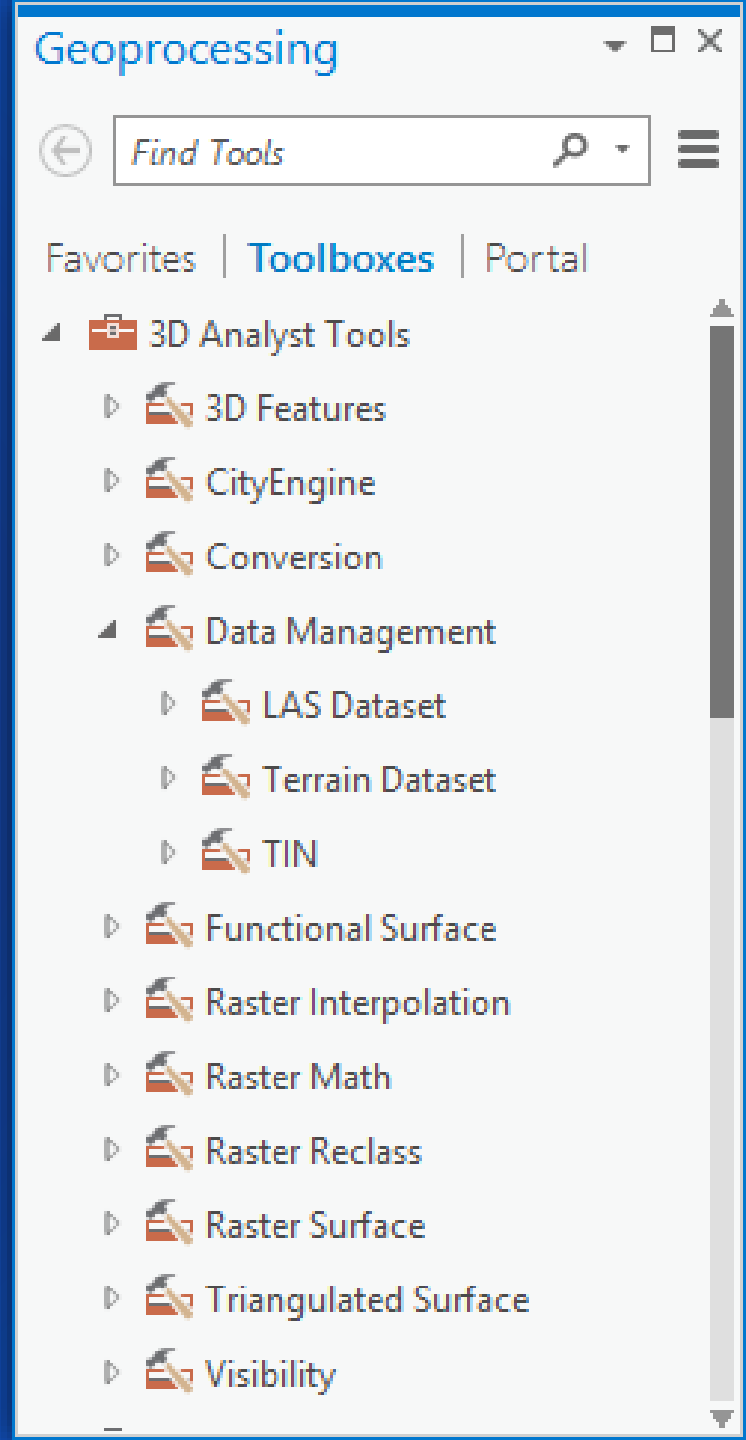


Analysis & Data Management

Working with Sub-surface Data

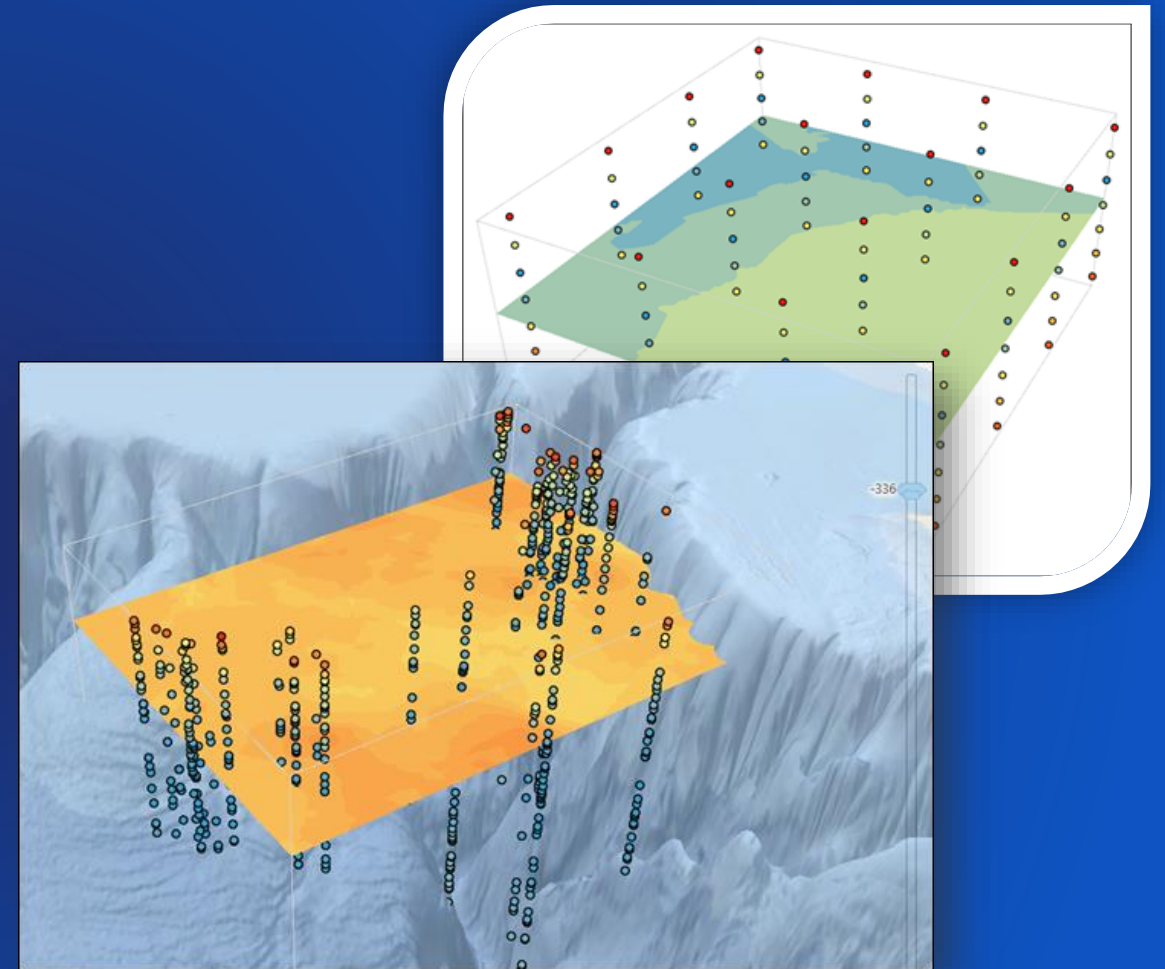
Analysis Framework

- **Geoprocessing capabilities**
 - Analysis
 - Data conversion
 - Data management
- **Exploratory analysis**
 - Empirical Bayesian Kriging (EBK) + EBK3D
 - Visibility tools (viewshed, line of sight)
 - Profile view
- **Automate workflows**



Empirical Bayesian Kriging 3D

- Predict subsurface geological properties
- Preview an iso-surface at any elevation
- Requires minimal interactive modeling
- Provides accurate results for moderately non-stationary data
- Dynamically view or export contours and raster dataset slices at any elevation
- Export regularly spaced prediction points



Using Living Atlas Data & ArcGIS Pro for 3D Interpolation, Thursday 2:30, Room 30C
Kriging: An Introduction to Concepts and Applications, Thursday 4:00, Room 15B

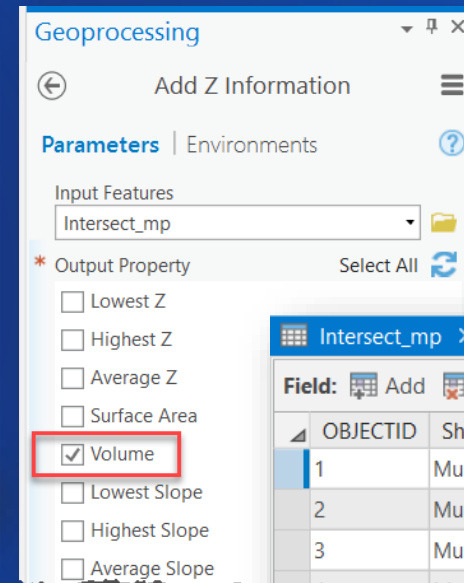
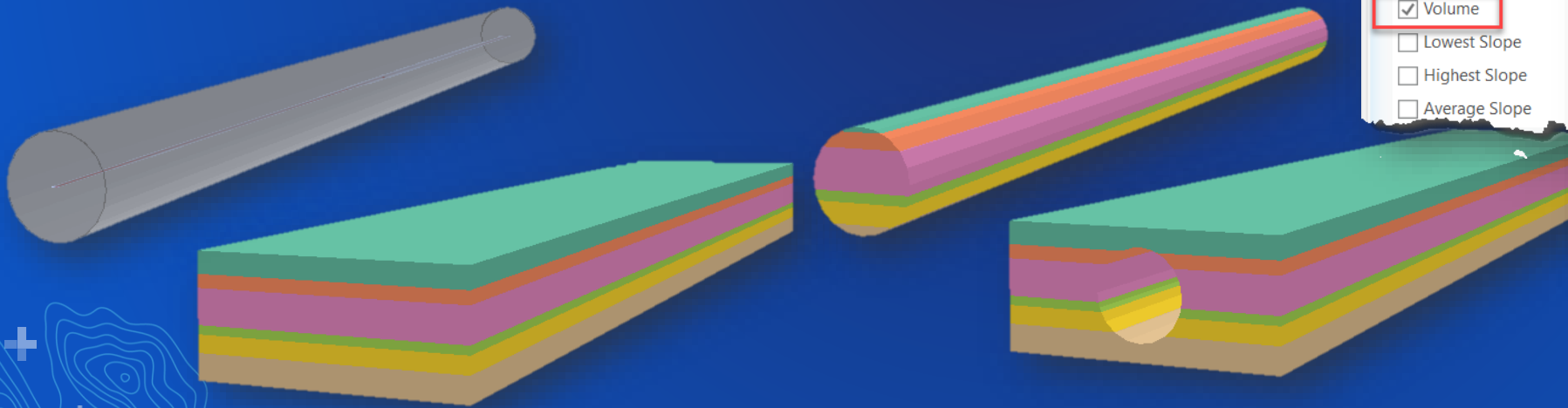
Elevation Surfaces

- Add each subsurface strata as its own elevation surface
- Apply lighting to accentuate slope characteristics
- Cached for optimal display experience
- Can be sourced from:
 - ↳ Raster
 - ↳ TIN
 - ↳ Web elevation layer from ArcGIS Portal
 - ↳ Elevation service from ArcGIS Server



Proximity Analysis

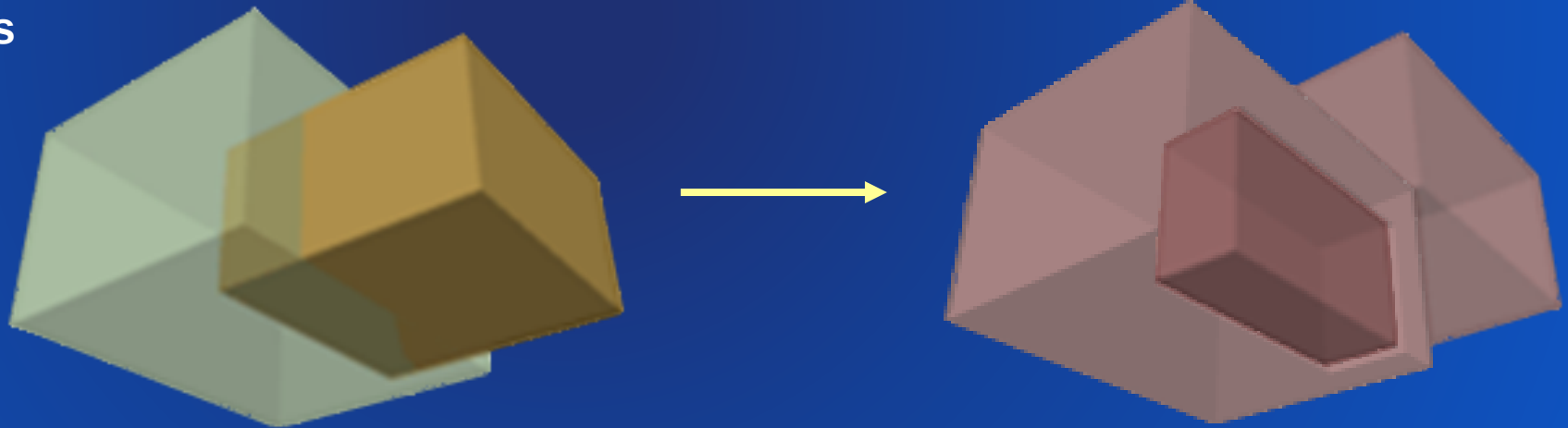
- Create 3D buffers
- Identify closest objects
- Find intersection of 3D lines with surfaces & multipatch shapes
- Construct the minimum bounding volume encompassing a cluster of points



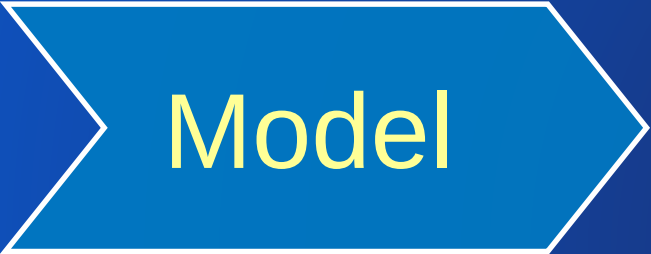
Intersect_mp				
Field: Add Delete Calculate Select				
OBJECTID	Shape	Name	Volume	
1	MultiPatch	A	203.580354	
2	MultiPatch	B	1493.97974	
3	MultiPatch	C	5922.449044	
4	MultiPatch	D	5922.449044	
5	MultiPatch	E	1486.024207	
6	MultiPatch	F	2437.399569	
7	MultiPatch	G	602.092299	

Volumetric Overlay Analysis

- Identify features that are inside volumetric enclosures
- Perform geometric operations:
 - ▮ Difference between volumes
 - ▮ Overlap of volumes
 - ▮ Union of volumes



Sub-Surface Analysis Workflow



Model

- Interpolate surfaces
- Construct 3D features
- Symbolize data



Analyze

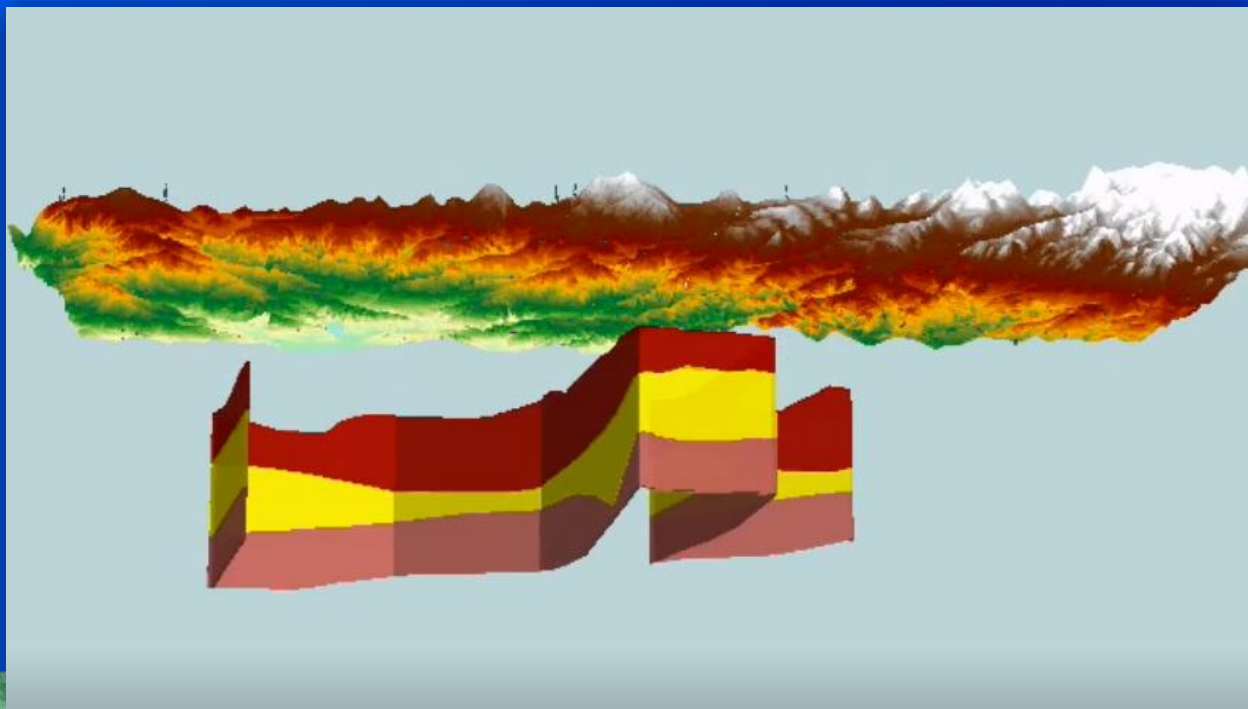
- Visual analysis
- Spatial analysis
- Create charts



Share

- Printed maps
- Digital static maps
- Interactive online maps





Model Geological Structures

Jie Chang

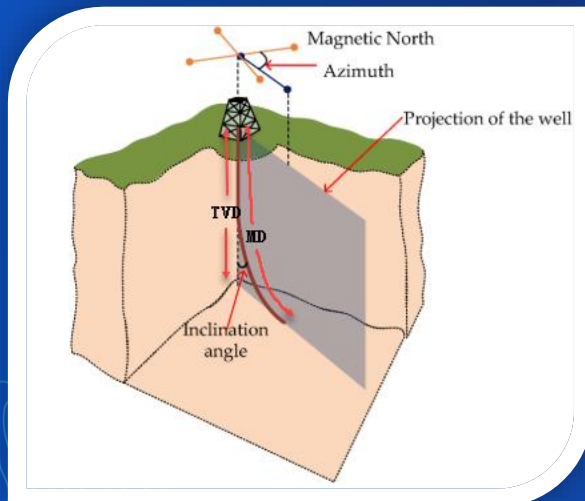
Construct Strata & Fence Diagrams



Model Direction Wells

■ Custom sample to convert ASCII records to line features from survey measurements:

- Measured depth (MD)
- True vertical depth (TVD)
- Inclination
- Azimuth



```
import arcpy
import os

filePath = r"C:\Shared\Subsurface\UC2018\DirectionalSurvey.txt"

file = open(filePath, "r")

lateralfc = r"C:\Shared\Subsurface\UC2018\Data.gdb\Lateral"

XStart = 2114464.393702
YStart = 10315414.494273

array = arcpy.Array()
point = arcpy.Point()

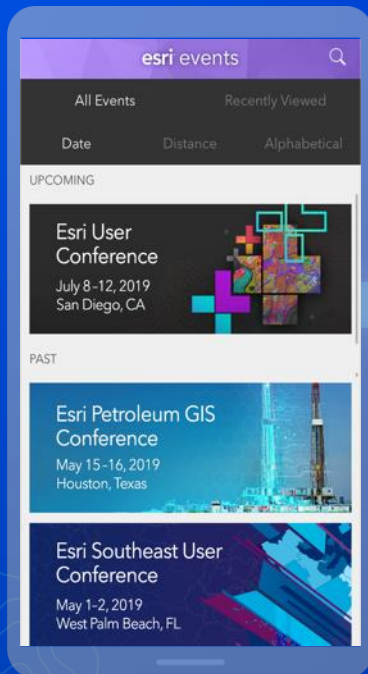
for line in file:
    M, Z, NS, EW = line.split()
    point.Z = float(Z) * -1
    point.X = XStart + float(EW)
    point.Y = YStart + float(NS)
    point.M = float(M)
    array.add(point)
```

Measured Depth (ft)	Incl (deg)	Drift Dir (deg.)	TVD (ft)	Course Length (ft)	Vertical Section (ft)	T O T A L Rectangular Offsets (ft) (ft)		Closure Dist (ft)	Dir. (deg.)	DLS (dg/100ft)
TIED INTO DDC GYRO SURVEY @ 11,106' MD.										
11106.00	0.60	272.90	11105.00	0.00	-51.57	51.70 N	9.00W	52.48@	350.12	0.00
THE FOLLOWING ARE PATHFINDER MWD SURVEYS.										
11215.00	0.35	281.00	11214.00	109.00	-51.65	51.79 N	9.90W	52.73@	349.18	0.24
11246.00	0.53	255.25	11245.00	31.00	-51.63	51.77 N	10.13W	52.76@	348.93	0.85
11278.00	6.10	181.33	11276.93	32.00	-49.89	50.03 N	10.31W	51.09@	348.36	18.67
11309.00	15.04	178.61	11307.38	31.00	-44.21	44.36 N	10.25W	45.53@	346.99	28.88
11341.00	23.65	177.20	11337.54	32.00	-33.63	33.77 N	9.84W	35.18@	343.76	26.94
11373.00	32.54	177.55	11365.74	32.00	-18.61	18.74 N	9.15W	20.85@	333.96	27.79
11404.00	37.55	179.05	11391.11	31.00	-0.83	0.95 N	8.64W	8.69@	276.27	16.40
11436.00	42.30	181.60	11415.65	32.00	19.70	19.58 S	8.78W	21.46@	204.15	15.70
11468.00	47.66	183.18	11438.28	32.00	42.30	42.17 S	9.74W	43.28@	193.00	17.11
11500.00	55.75	181.24	11458.09	32.00	67.38	67.24 S	10.68W	68.08@	189.03	25.72

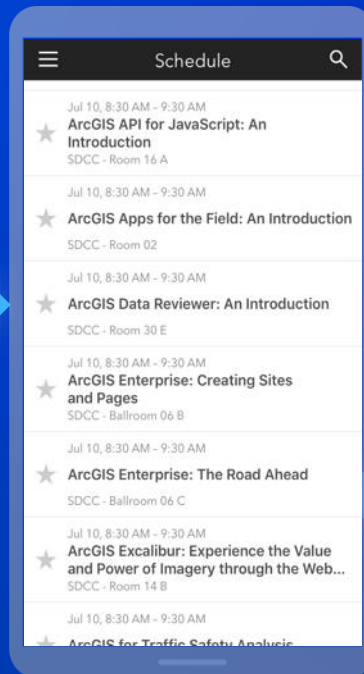
Sample data & Python script provided by University Lands: <https://github.com/ULGISSESRIUC2017>

Please Share Your Feedback in the App

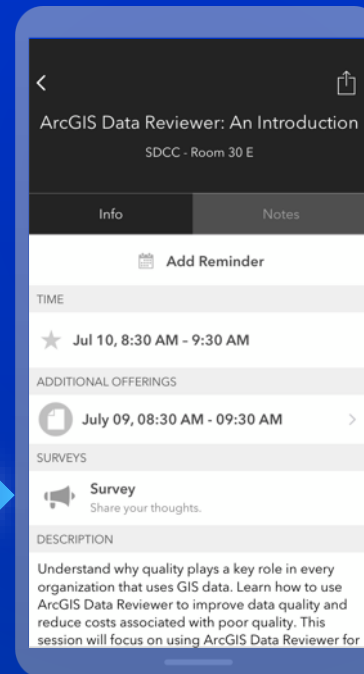
Download the Esri Events app and find your event



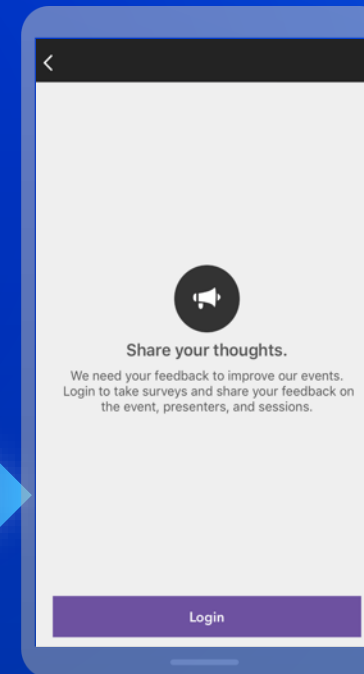
Select the session you attended



Scroll down to "Survey"



Log in to access the survey



Complete the survey and select "Submit"

