



Watershed Sciences 4930 & 6920

GEOGRAPHIC INFORMATION SYSTEMS

WEEK THREE—

INTRODUCTION TO GEOPROCESSING & UNCERTAINTY IN GIS...

Joe Wheaton

UTAH AGRC SGID – JUST TO MAKE SURE

- SGID (State Geographic Information Database) Data & Map Servers
- Alternative to 'Add Basemap' from ESRI

SGID Data Services



Online Base Maps

Fast and free online map services from AGRC featuring local data.



SGID Image Server

Utah aerial photography without the need to download data.



SGID ArcSDE Database Server

Direct connect to AGRC's ArcSDE database, the most current data.



SGID Raster Discovery Application

Download aerial photography, LiDAR, DEMs, contour lines and USGS topographic maps via the Utah Raster Discovery App.



Download SGID Data Via FTP

Download data directly through AGRC's FTP site.

UTAH AGRC
Automated Geographic Reference Center

Home » Data » Using SGID Base Map Services in ArcMap

Need a quick, fast base map for your ArcMap project?

AGRC provides several multi-scale base map service options that deliver pre-rendered base maps. Base map native projected coordinate system is UTM Zone 12N, NAD83.

Instructions for ArcMap 9.3 or 10 users:

1. In ArcMap, click the *Add Data* button
2. At the top of the Add Data window, set the Look In: pick list to point at *GIS Servers*
3. Select *Add ArcGIS Server* and then choose the *Use GIS Services* option
4. Set the Internet Server URL to: <http://mapserv.utah.gov/arcgis/services>
5. Click *Finish* and then double click the newly added item "*arcgis on mapserv.utah.gov*"
6. Select the base map(s) of your choice from the list below:
 - UtahBaseMap-Hillshade
 - UtahBaseMap-Hybrid (streets and other vector layers atop imagery,)
 - UtahBaseMap-Imagery
 - UtahBaseMap-Lite (gray, muted tone)
 - UtahBaseMap-Terrain (hillshade, streets, parks, forest, water, etc)
 - UtahBaseMap-Topo (multiscale mosaic of USGS topo maps)
 - UtahBaseMap-Vector (streets, land ownership, and boundaries)
7. Click Add or OK

Web developers can embed any of these base map services in web-based and internet-connected applications.

- More information about the base maps and for application developers.

Lite Imagery Streets Hybrid Terrain Hillshade Topo

HOUSEKEEPING

- I've got nothing else...
- Any questions?



TODAY'S PLANS... 1st GEOPROCESSING

I. Geoprocessing

II. ModelBuilder

III. Batch Processing

I. A right-click away

II. Scripting

TODAY'S *OTHER* PLAN... UNCERTAINTY IN GIS

I. Uncertainty & Error

II. GIS Errors

III. Error Propagation

IV. All Bad?

V. Summary of GIS Fundamentals

WHAT IS GEOPROCESSING?

An ESRI term...

Introduction to Topic

From ESRI's Help:

"Geoprocessing is for everyone that uses ArcGIS. Whether you're a beginning user or a pro, geoprocessing will become an essential part of your day-to-day work with ArcGIS.

The fundamental purposes of geoprocessing are to **allow you to automate your GIS tasks and perform spatial analysis and modeling**. Almost all uses of GIS involve the **repetition of work**, and this creates the need for methods to automate, document, and share multiple-step procedures known as workflows. Geoprocessing supports the automation of workflows by providing a rich set of tools and a mechanism to combine a series of tools in a sequence of operations using models and scripts...." - ...[READ MORE](#).

Why we're Covering it

Geoprocessing is what helps make you efficient in your spatial analyses. Whether its combining multiple tools into one using model builder, batch processing a large quantity of data, writing some simple Python scripts, or leveraging the functionality of the Results window, geoprocessing is what can help you move from a novice GIS user, to a highly proficient power user.

Learning Outcomes


This topic supports [primary learning outcomes](#) 1, 2, 3 and 4 for the course.

TYPES OF GEOPROCESSING IN ARCGIS


- Tools 

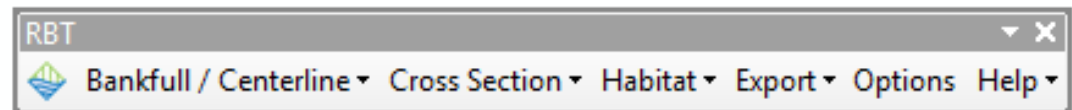
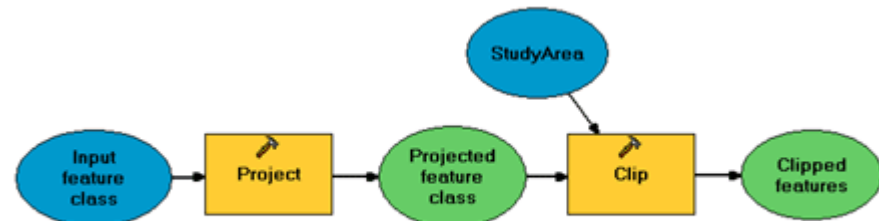
- Models 

- Scripts 

- Add-Ins 

- Plug-Ins

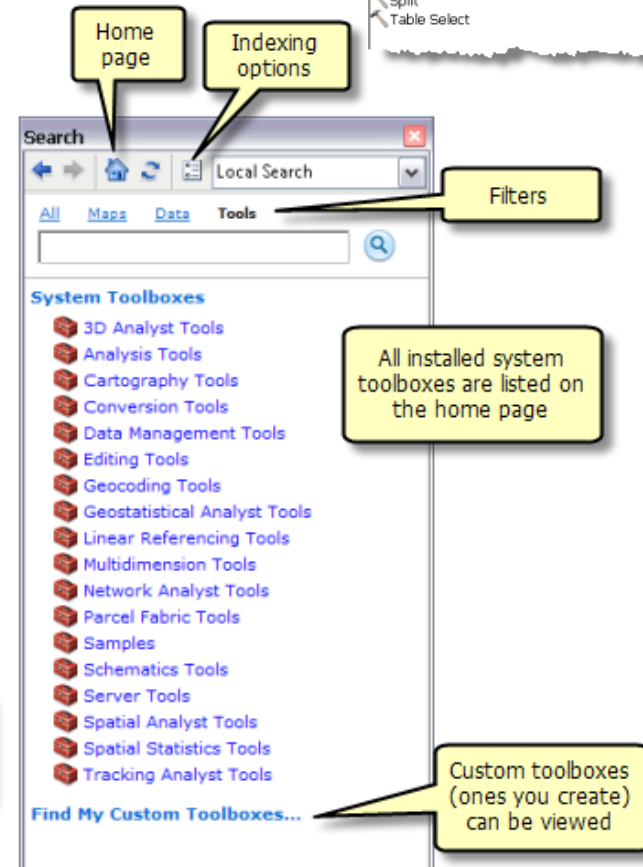
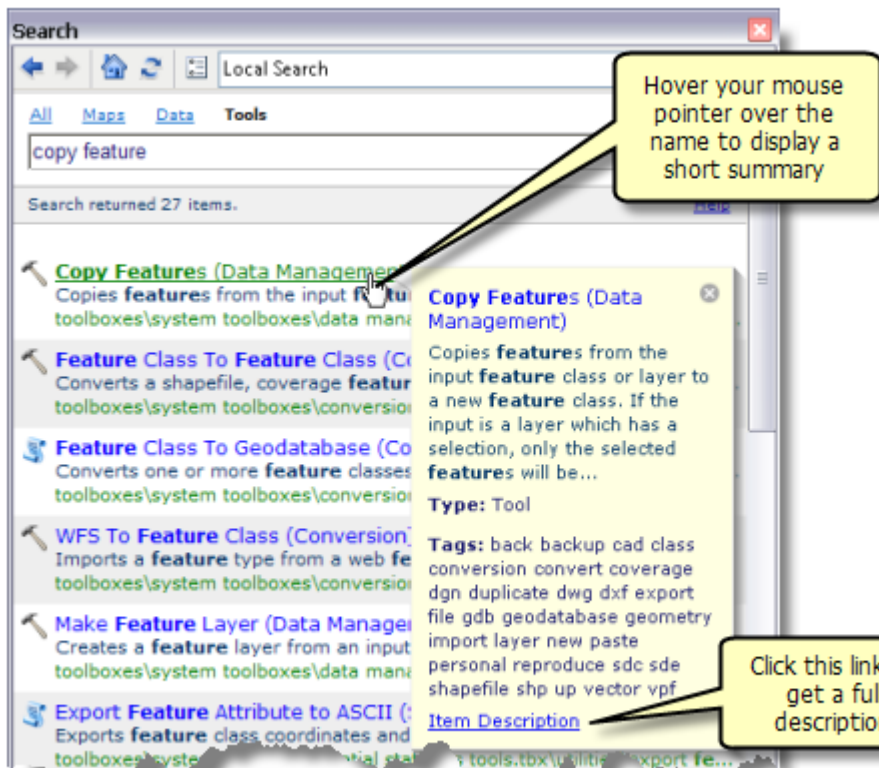
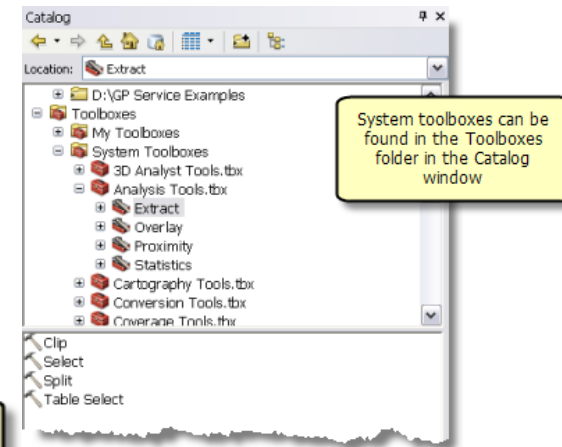
 RBT_Arc10_3_0_0.msi



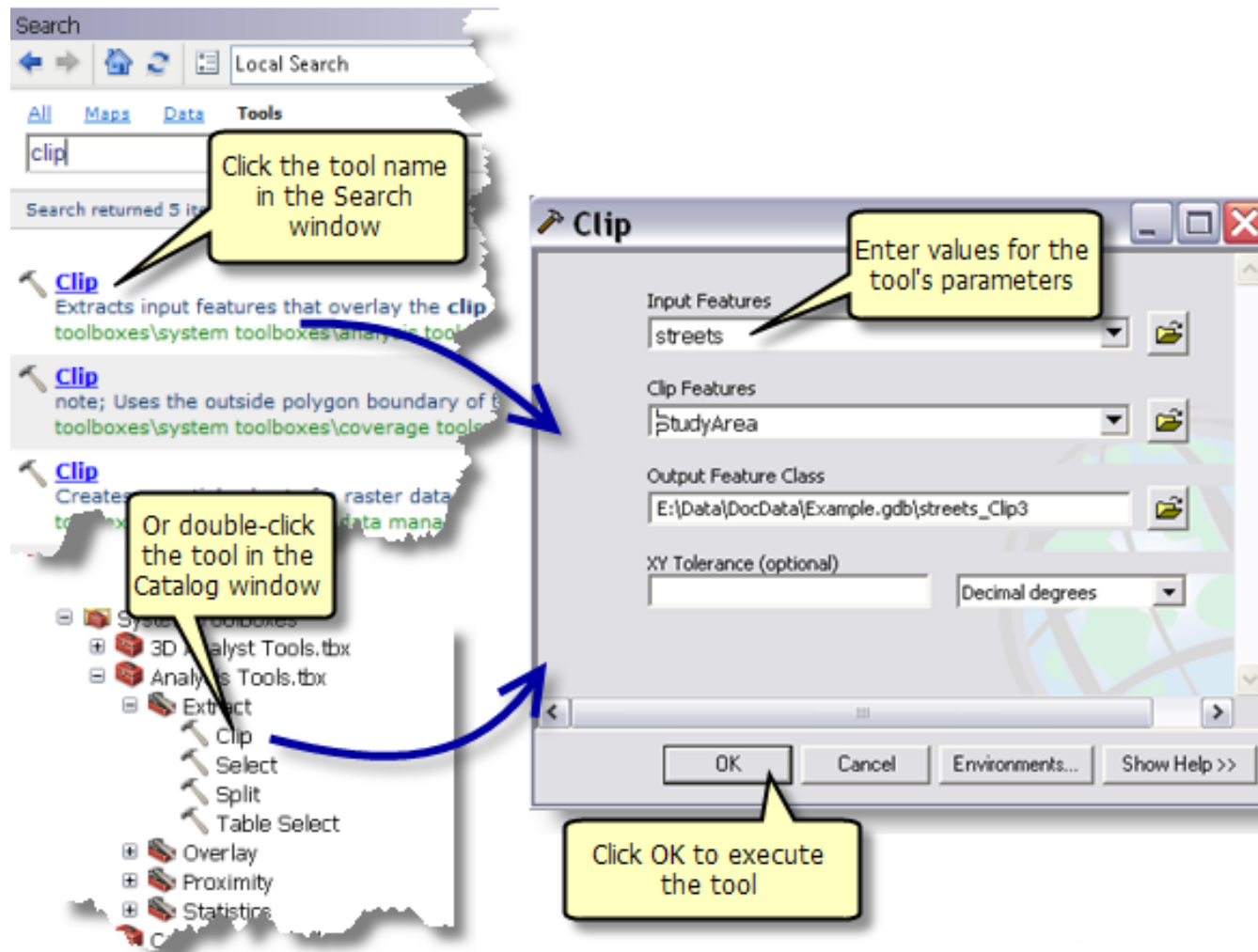
- These differ from some of the Toolbars you've used...

PLACES TO GET GEOPROCESSING TOOLS

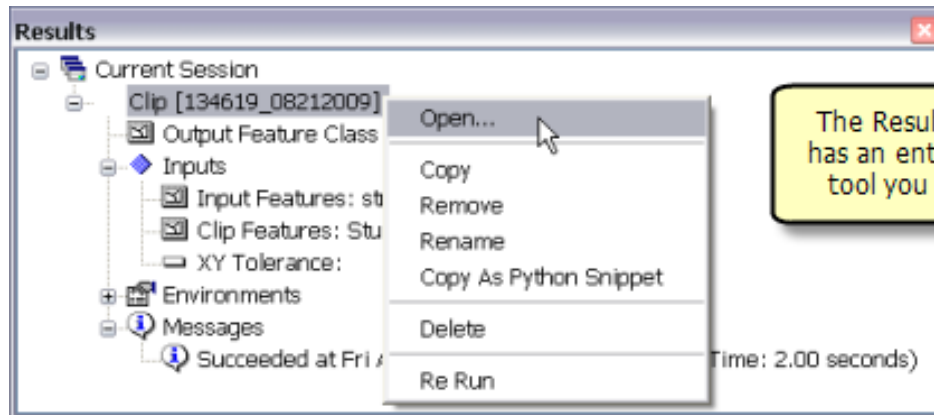
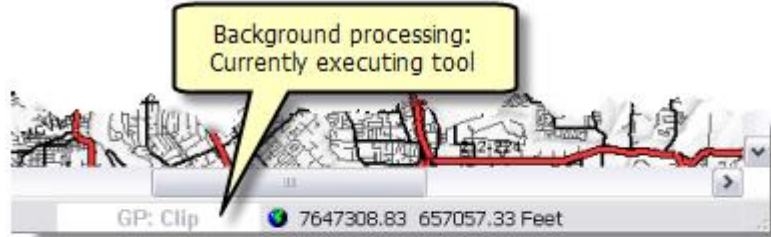
- Toolbox
- ArcGIS Resource... Gallery
- From Specific Places...



LOTS OF WAYS TO ACCESS A TOOL



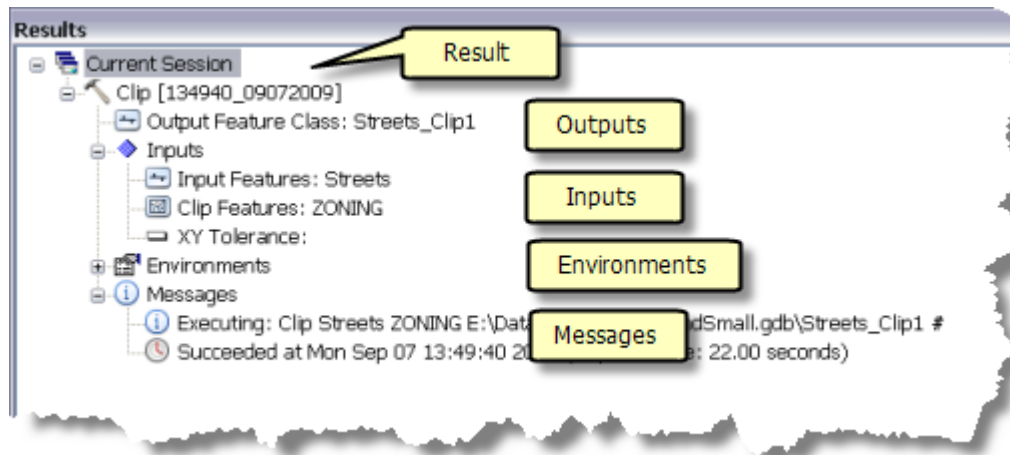
WHEN A TOOL RUNS...



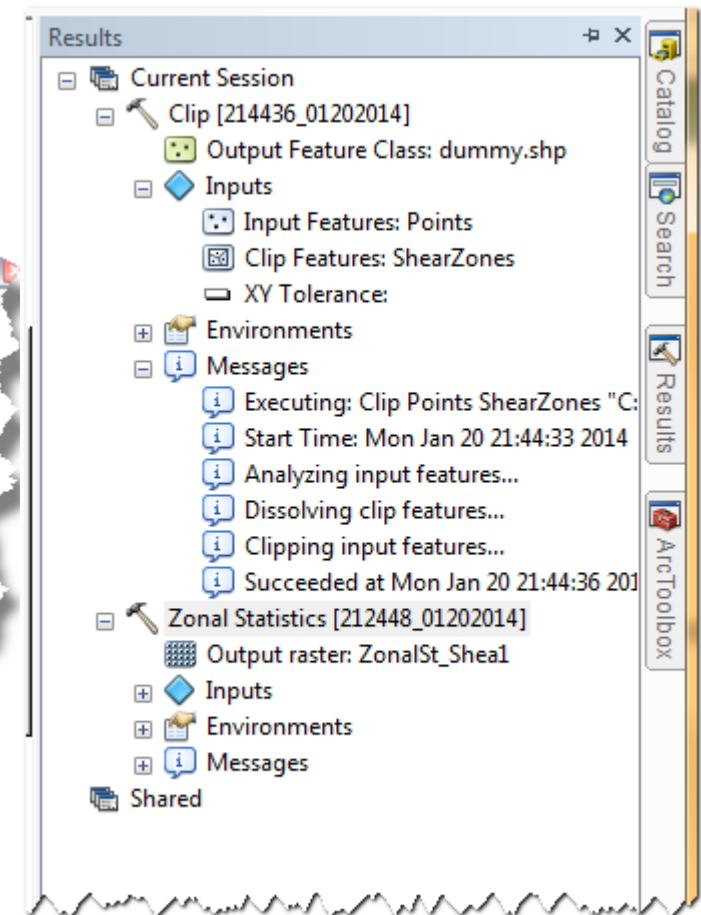
- Be patient...
- Two places to track status:
 - Progress bar
 - Results Window!
- Use that results window!

GEOPROCESSING RESULTS WINDOW

- A Plethora of Useful Information...



- Keeps track of all past geoprocessing commands!
- Also... double click any..
- Troubleshoot

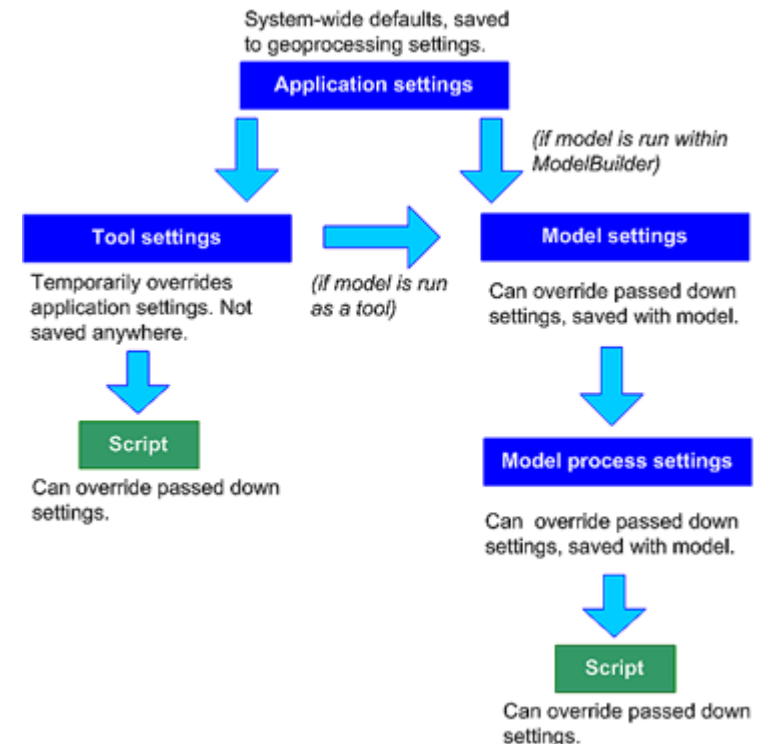
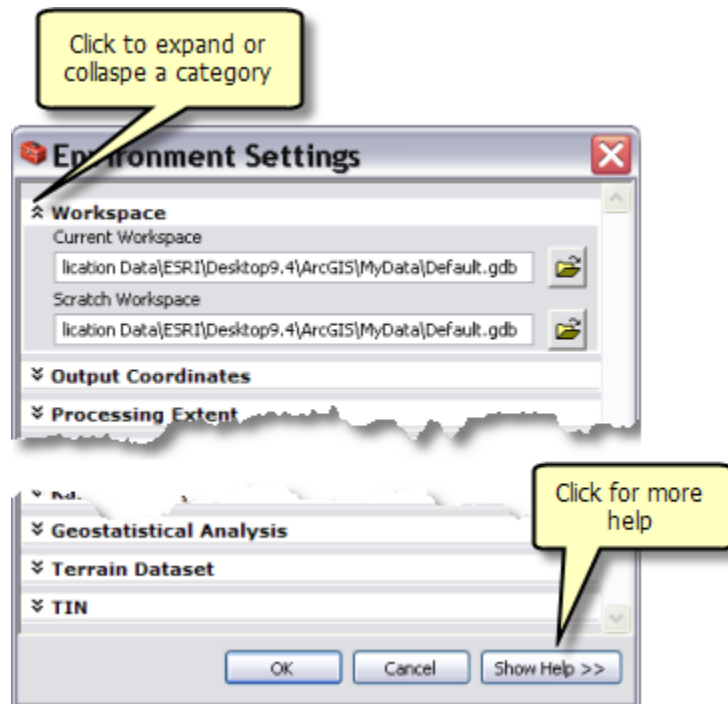


ENVIRONMENT SETTINGS

There are four levels of environment settings:

- 1. Application level** settings are the default settings that will be applied to any tool when it is executed.
- 2. Tool level** settings are applied to a single run of a tool and override the application level settings.
- 3. Model level** settings are specified and saved with a mode and override tool level and application level settings.
- 4. Model process level** settings are specified at the model process level, are saved with the model, and override model level settings.

ENVIRONMENT SETTINGS

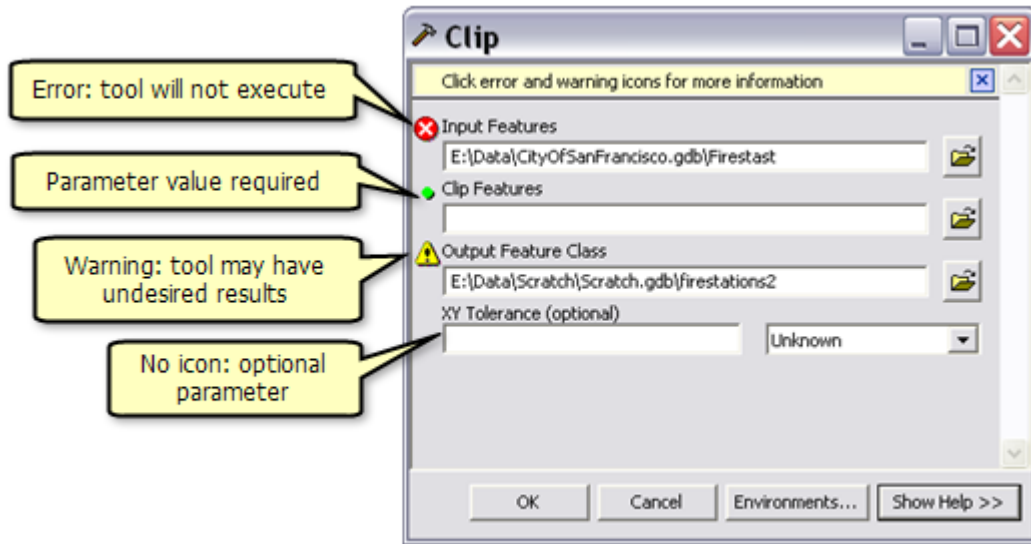


Tool environment settings

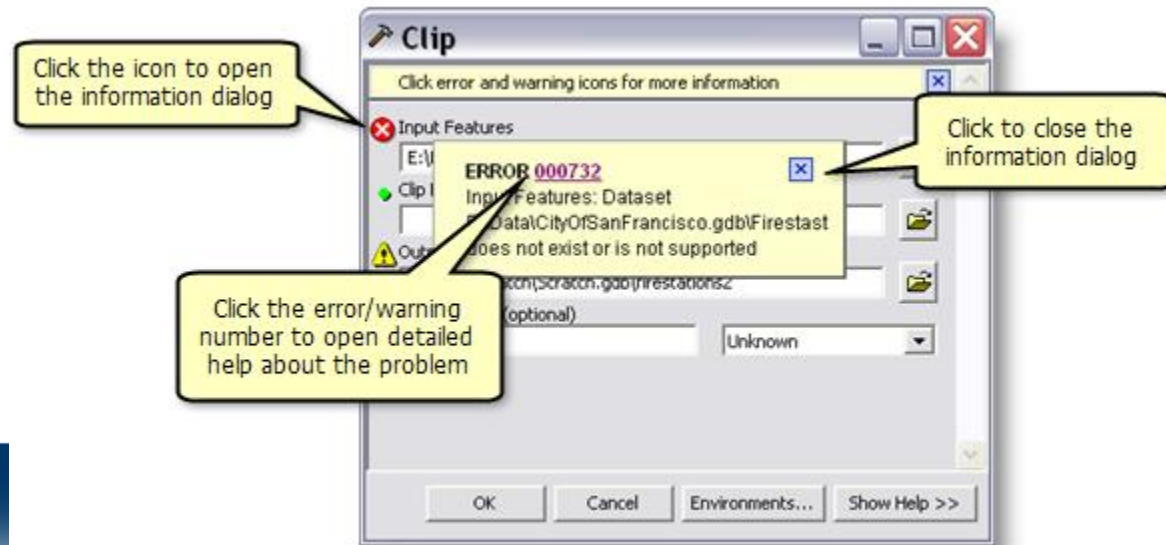
Tool environment settings inherit from application environment settings: when you open a tool's dialog box and click the **Environments** button, the application environment settings are used as the initial values for the tool's environment settings.

Note: Tool environment settings only apply to the current run of the tool and do not update the application environment settings.

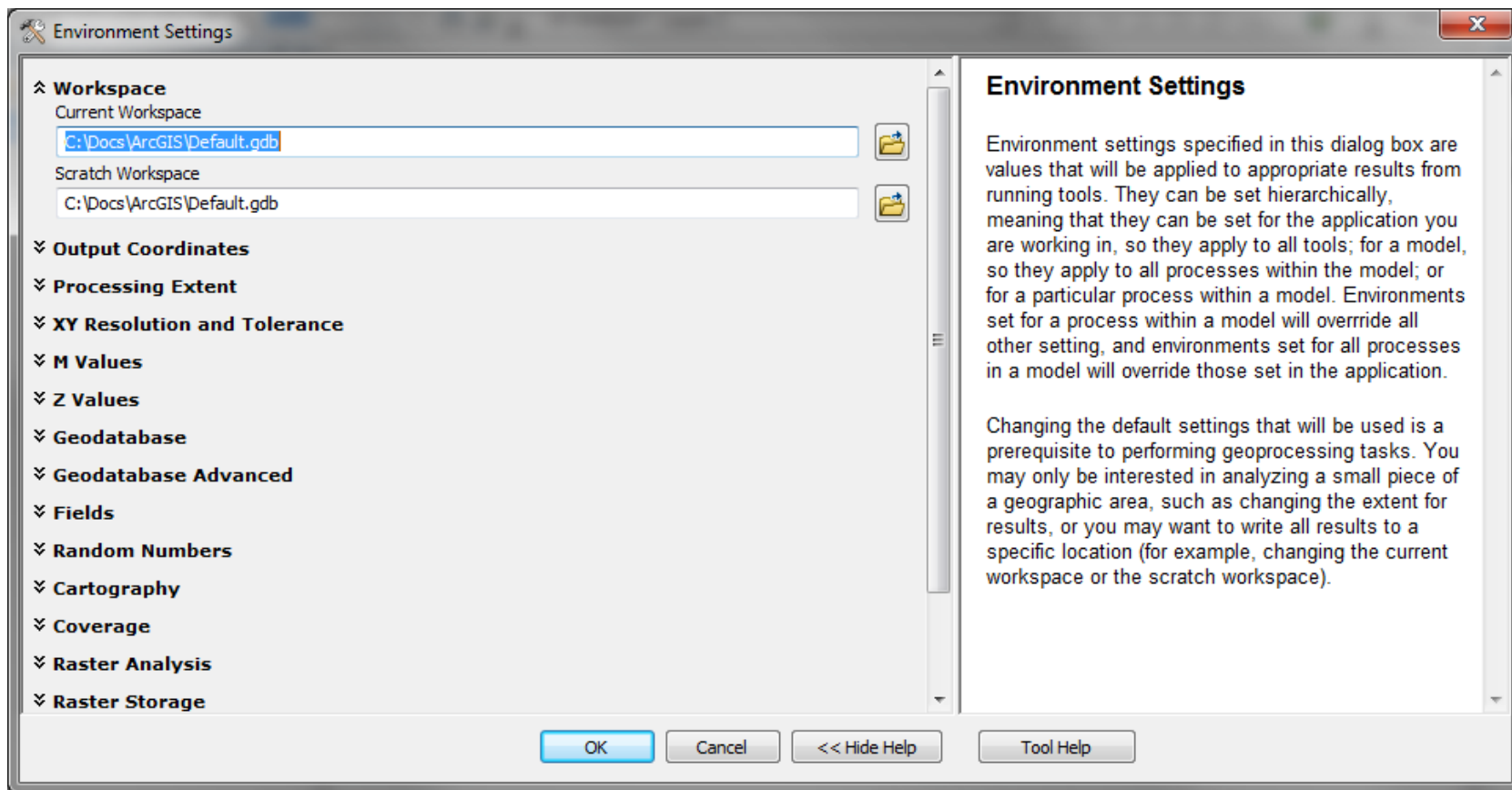
EVERY TOOL HAS ENVIRONMENT SETTINGS



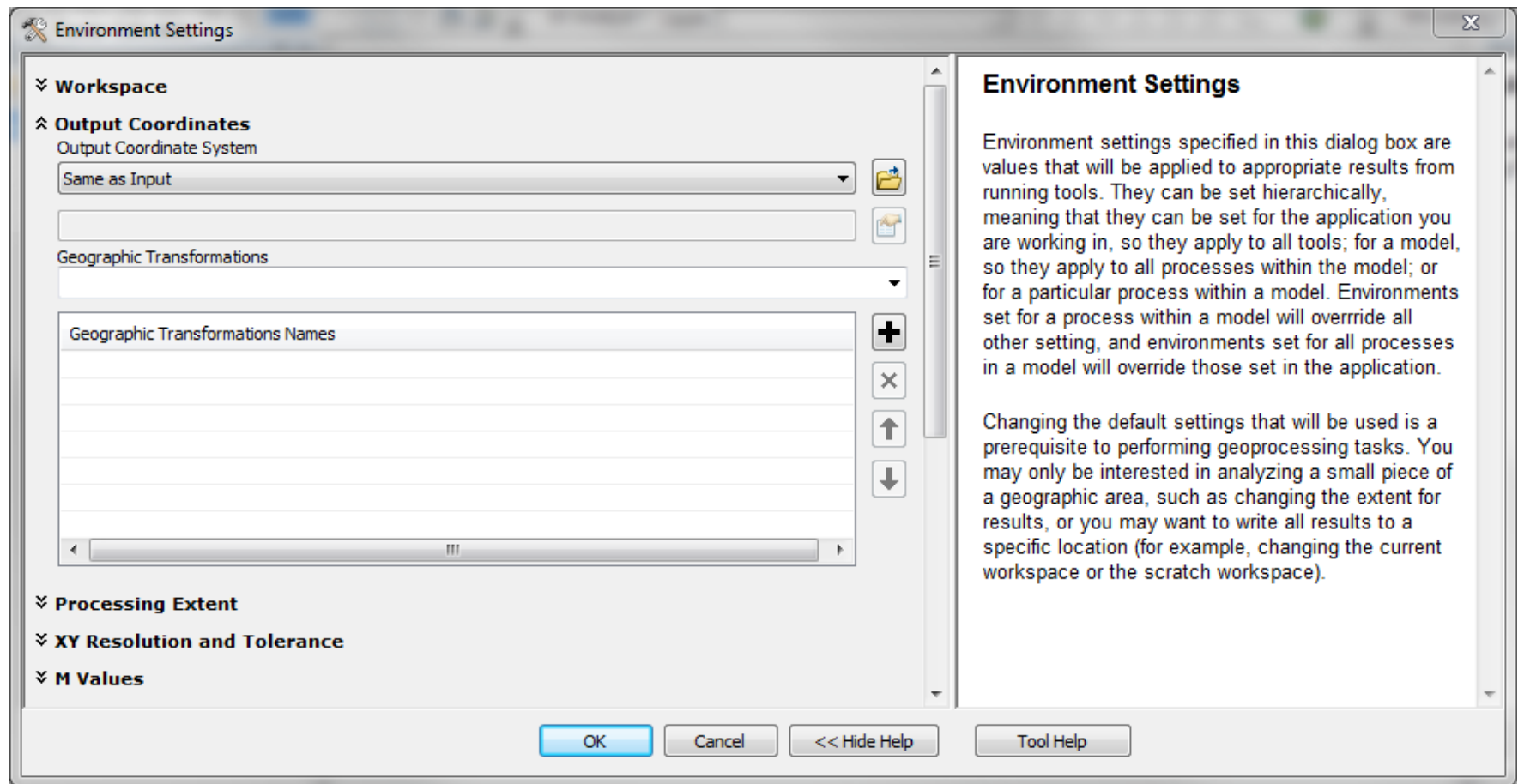
- Tools validate parameter values as you enter them...
- They also can override environment settings



BRING THEM UP... & EXPAND TO USE

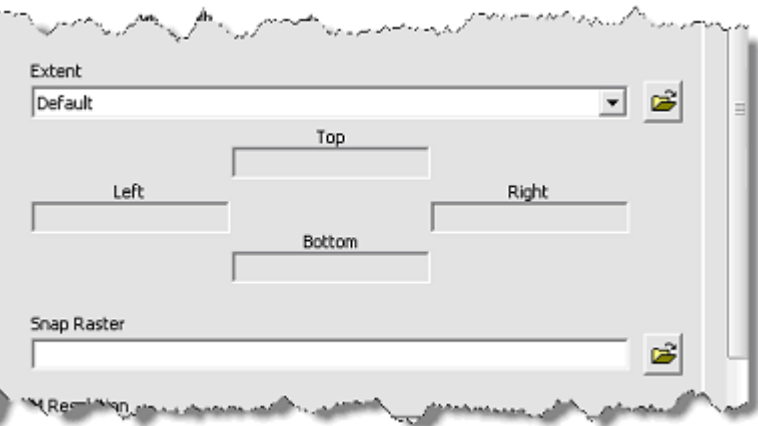
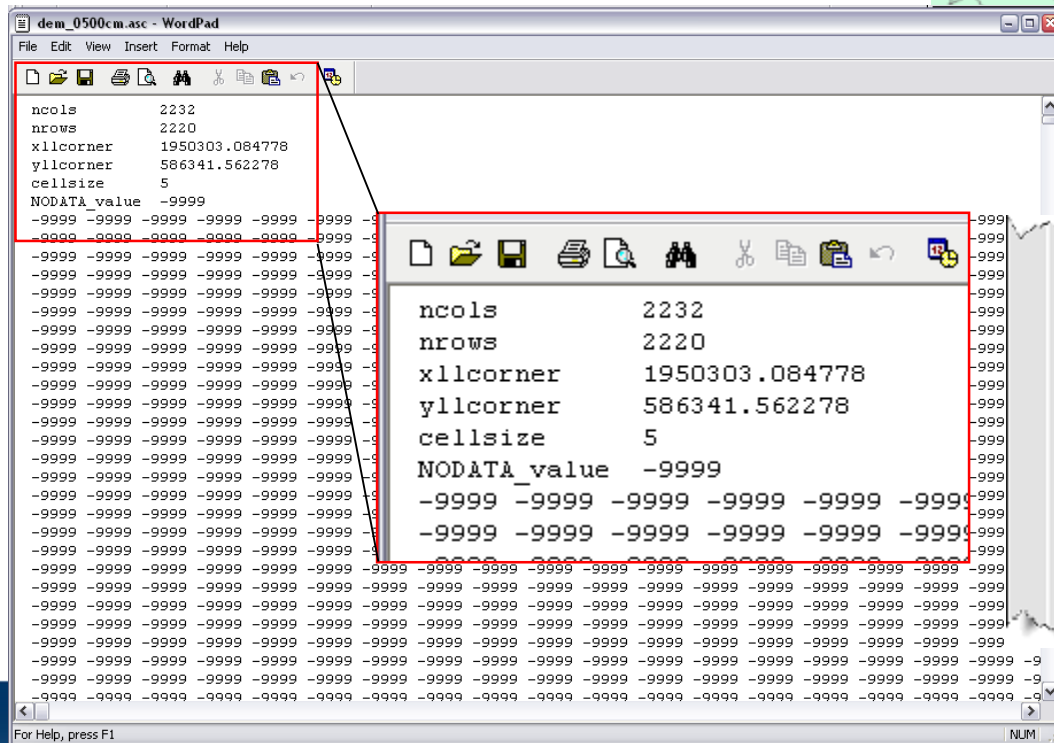
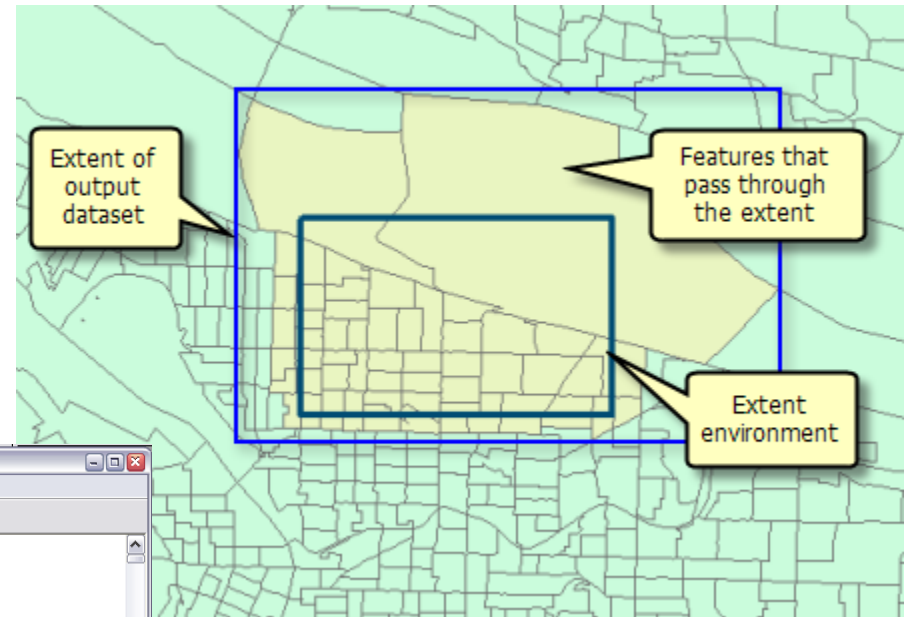


OUTPUT COORDINATE SYSTEM



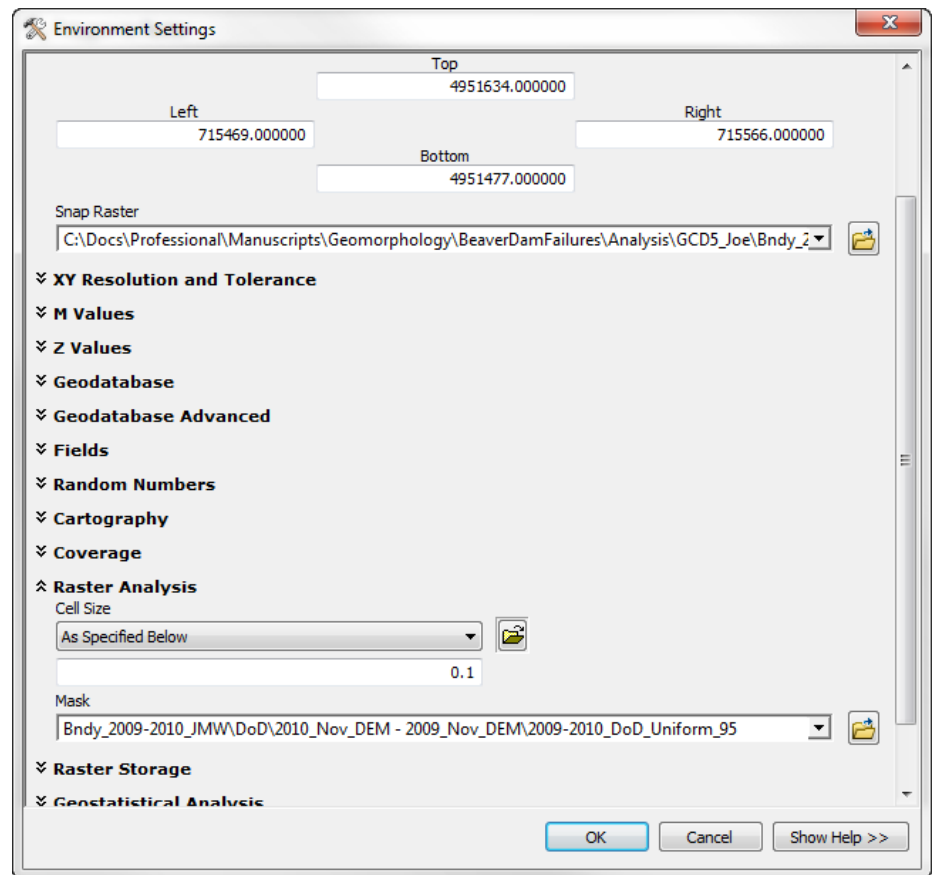
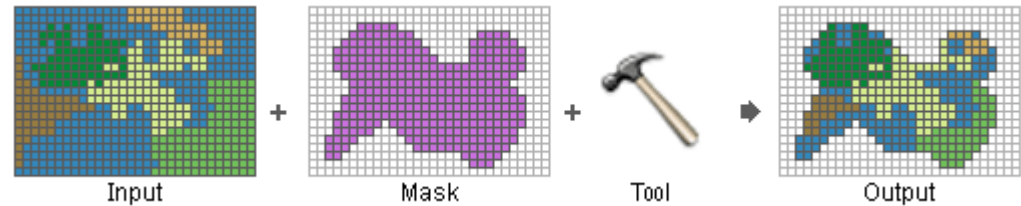
PROCESSING EXTENT-> ENV. SETTINGS

- This is how you force grid concurrency
- Extent -> Limits
- Snap... aligns



RECALL MASKED EXTENTS

- Rasters that have the same masked extents, simply have the same nodata cells
- The mask can be derived from a polygon or a raster
- A concurrent raster mask is the most accurate!



From:

WHERE TO LEARN MORE ABOUT GEOPROCESSING

Additional Resources

Geoprocessing in ArcGIS

- [Geoprocessing ArcGIS Resource Center](#) - This is the main hub of information on Geoprocessing and getting yourself up to speed.
- [The Geoprocessing Forum](#) - Trying to do something with Geoprocessing and having trouble? Try posting a thread or searching this forum.
- [Geoprocessing Help](#) - An overview of Geoprocessing in ArcGIS
- [Using the Results Window](#) - An essential new feature of Geoprocessing in ArcGIS

Batch Processing

- [A quick Tour of Batch-Processing](#) - ArcGIS 10 Help topic

Finding Existing Tools and Scripts

- [Geoprocessing Model and Script Tool Gallery](#) - A hub of tools you can download and install in ArcGIS that other users have made. Very useful!
- See also this week's lab [Tutorial Topic 1](#)

Geoprocessing with Model Builder

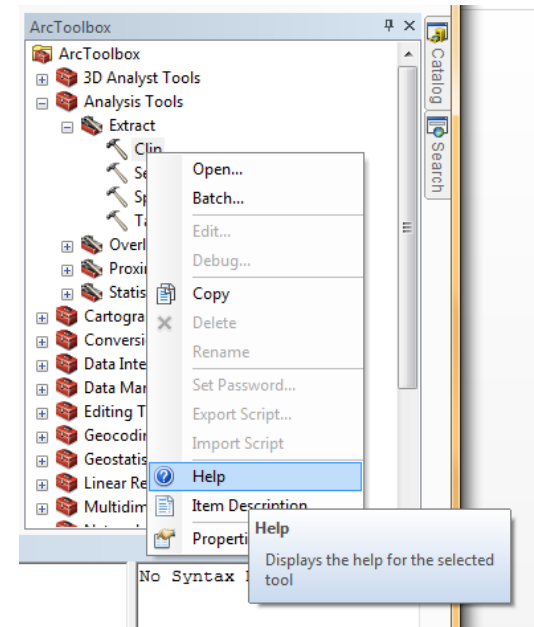
- [Designing and Building Geoprocessing Tools](#) - This video walks you through the basics of building Geoprocessing Tools using Model Builder in ArcGIS 10.
- [A quick tour of creating tools with ModelBuilder](#) - ArcGIS 10 Help
- [Tutorial for Building Tools with Model Builder](#) - ArcGIS 10 Help Tutorial

Add-Ins

- [Add-Ins for ArcGIS 10](#) - Add-Ins are a new feature in ArcGIS. This video describes them.
- [Add-Ins Blog](#) -

Plug-Ins

Plug-Ins are typically tool-bars that are installed externally and produced by someone other than ESRI, to work



- <- Links on our website
- Plus,
 - Other Classes
 - ESRI Courses
 - ESRI Tutorials

TODAY'S PLAN...

I. Geoprocessing

II. ModelBuilder

III. Batch Processing

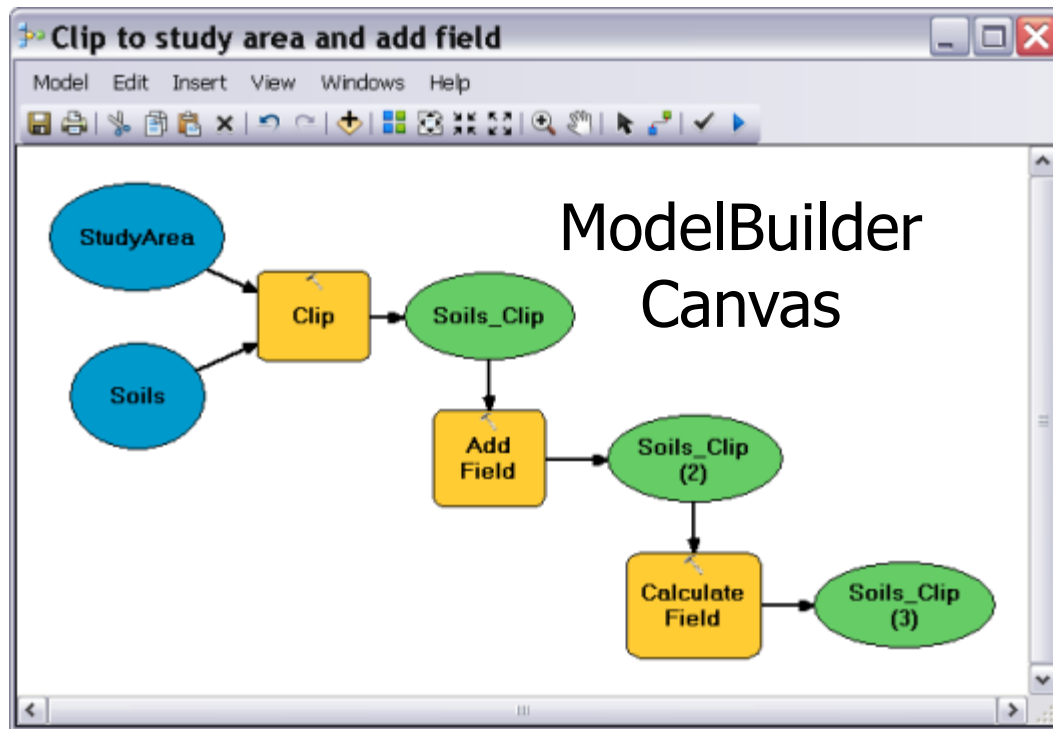
I. A right-click away

II. Scripting



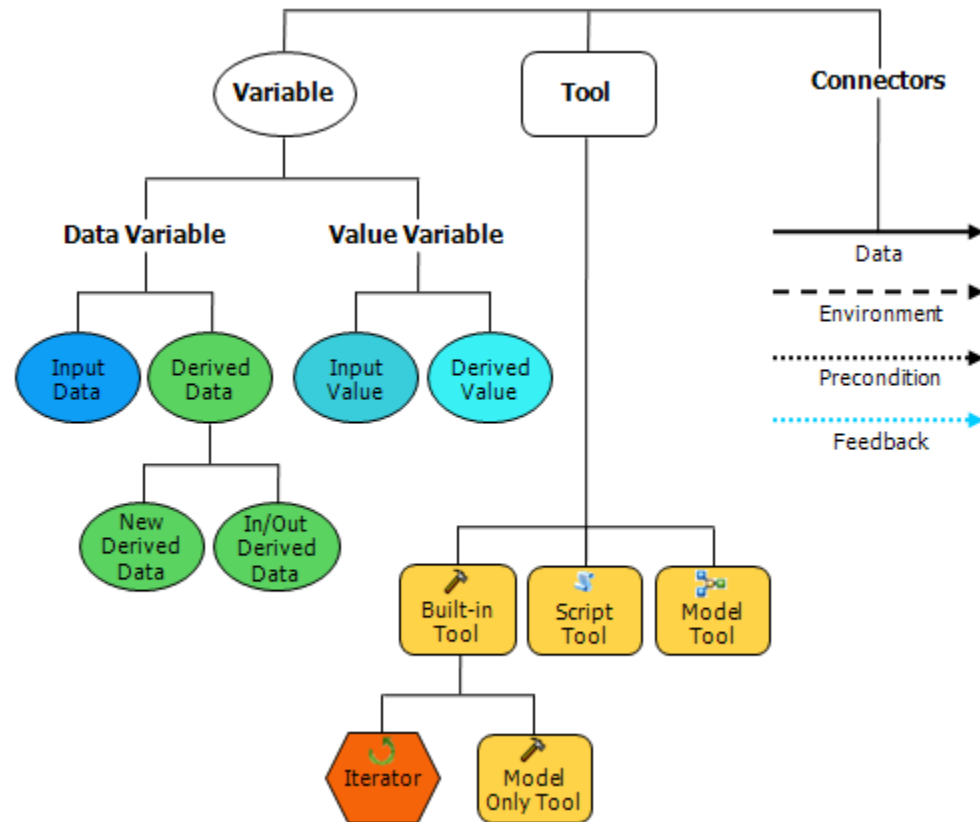
THE MODELBUILDER INTERFACE

- ModelBuilder window: where you edit, test and run models



MODEL ELEMENTS:

- **Variables:** Variables are elements in a model that hold a value or a reference to data stored on disk. There are two types of variables:
 - **Data:** Data variables are model elements that contain descriptive information about data stored on disk. Properties of data that are described in a data variable include field information, spatial reference, and path.
 - **Values:** Value variables are values such as strings, numbers, Booleans (true/false values), spatial references, linear units, or extents. Value variables contain anything but references to data stored on disk.
- **Connectors:** Connectors connect data and values to tools. The connector arrows show the direction of processing. There are four types of connectors:
 - **Data:** Data connectors connect data and value variables to tools.
 - **Environment:** Environment connectors connect a variable containing an environment setting (data or value) to a tool. When the tool is executed, it will use the environment setting.
 - **Precondition:** Precondition connectors connect a variable to a tool. The tool will execute only after the contents of the precondition variable are created.
 - **Feedback:** Feedback connectors connect the output of a tool back into the same tool as input.



THE MODELBUILDER INTERFACE, CONT.

- Model elements have 3 states
- Not ready to run (parameters aren't defined)



- Ready to run (all elements are colored)



- Already run (elements are colored and shaded)



TODAY'S PLAN...

- I. Geoprocessing
- II. ModelBuilder
- III. Batch Processing**
 - I. A right-click away
 - II. Scripting
- IV. Python Scripting
- V. Efficiency

BRUTE FORCE...

- If you do something once or twice, brute force may suffice...
- If you start doing it more than that, make yourself a tool
 - Limits opportunity for sloppy mistakes
 - Makes
 - If good enough, share it with others...



BATCH PROCESSING

- I got to do this same thing 100 times
- AGHHH
- Brute force or Batch Process?
- Use right-click in Arc Toolbox and click 'batch'
- Write a script that loops through same thing (input varies)

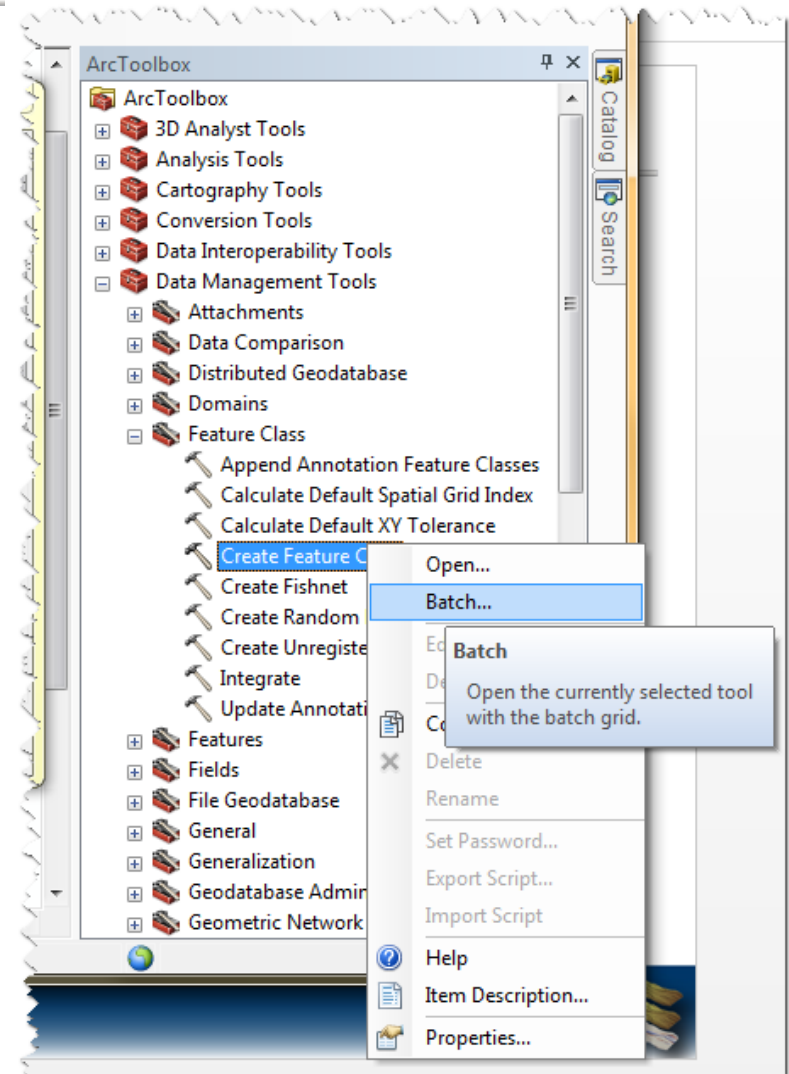
TODAY'S PLAN...

- I. Geoprocessing
- II. ModelBuilder
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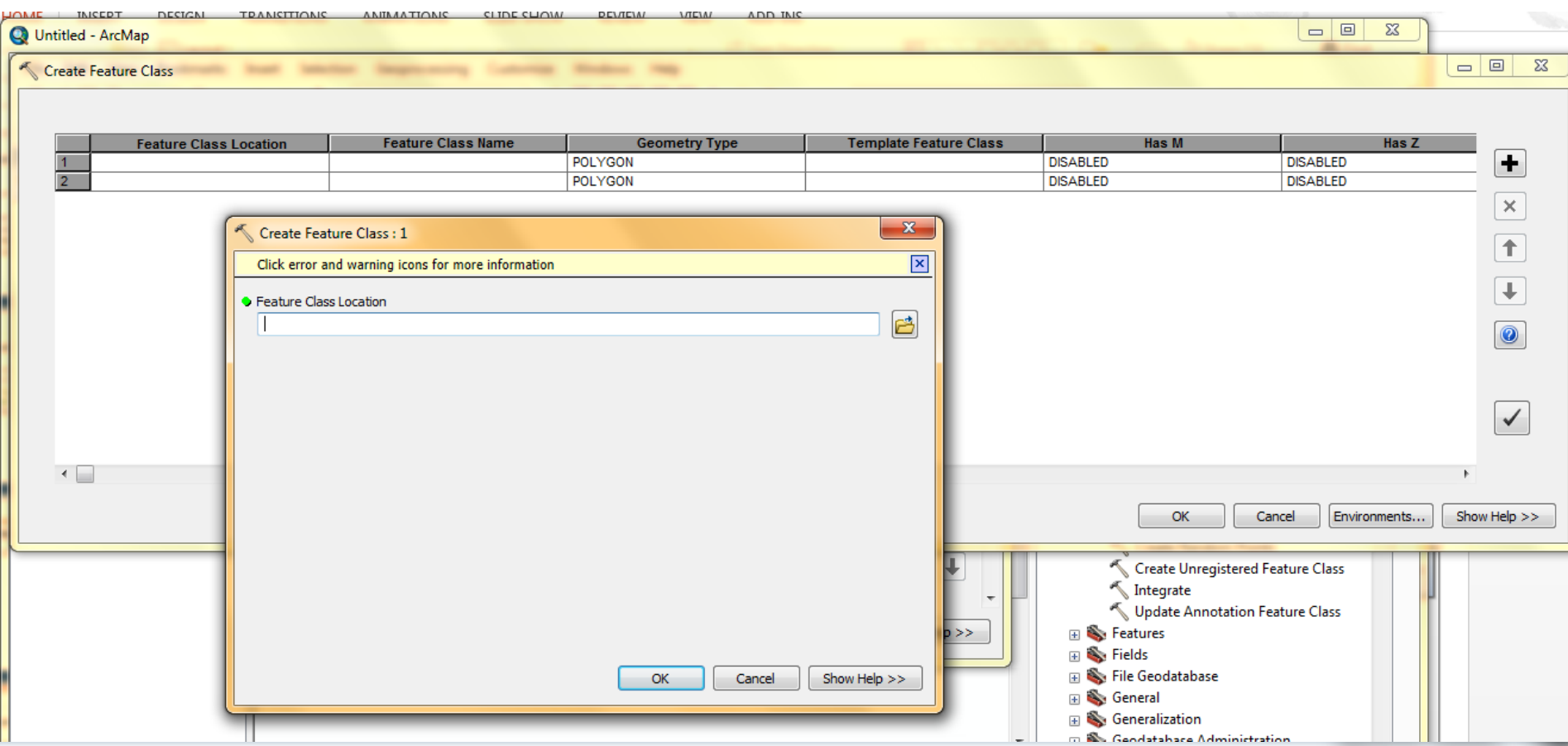
ANY GEOPROCESSING TASK:

- That you think you want to do more than once...
- Just right click...



THEN.... FILL OUT BATCH GRID

- Add as many rows as you want (batch)...
- Double click on each cell to fill out...
- Copy and Paste from above.



TODAY'S PLAN...

- I. Geoprocessing
- II. ModelBuilder
- III. Batch Processing**
 - I. A right-click away
 - II. Scripting**




SCRIPTING IN GIS

- Sequences of GIS operations that can be stored and shared
 - Native languages: Arc Macro Language, Avenue
 - Software independent languages such as Visual Basic for Applications, Perl, or Python
 - a model can be written and executed as a script
- Scripts can be manipulated visually
 - e.g., through ESRI's ModelBuilder

PROGRAMMING?

- Lots of languages (syntax is critical to speak)
- Loops (for or do)
- Conditional (if, then, else)



2.23

IF Statement

```
IF condition THEN
    action(s);
END IF;
```

```
IF condition THEN
    action(s);
ELSE
    action(s);
END IF;
```

```
IF condition THEN
    action(s);
ELSIF condition THEN
    action(s);
ELSIF condition THEN
    action(s);
[ELSE
    action(s);]
END IF;
```

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PROGRAMMING - LOOPS

2.27

Simple Loops

```
LOOP
  EXIT [WHEN <condition>] ;
END LOOP;
```

Initialize counter!

```
SQL> declare
2   counter number := 0;
3   begin
4     LOOP
5       counter := counter + 1;
6       dbms_output.put_line(counter);
7       EXIT WHEN counter = 5;
8     END LOOP;
9   end;
10  /

1
2
3
4
5

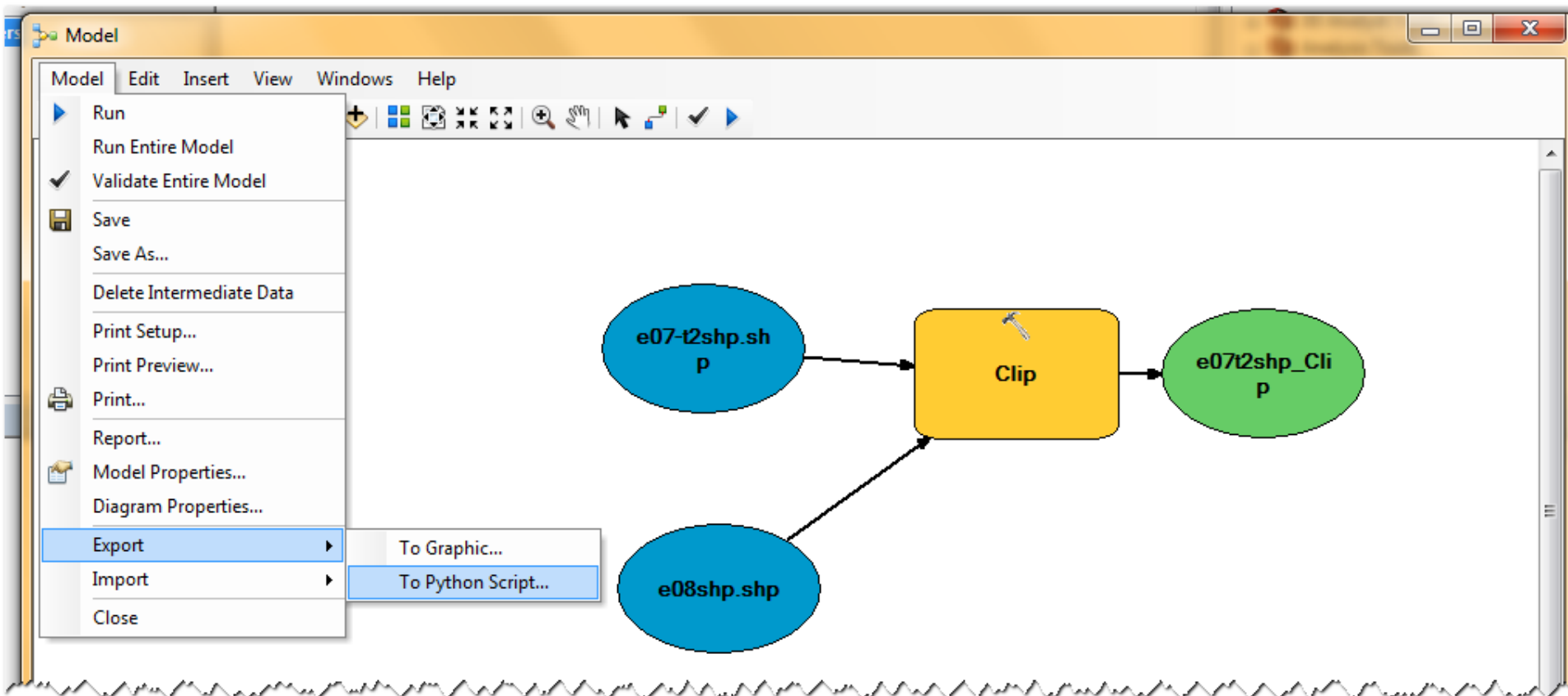
PL/SQL procedure successfully completed.
```

Use the EXIT statement to exit loop

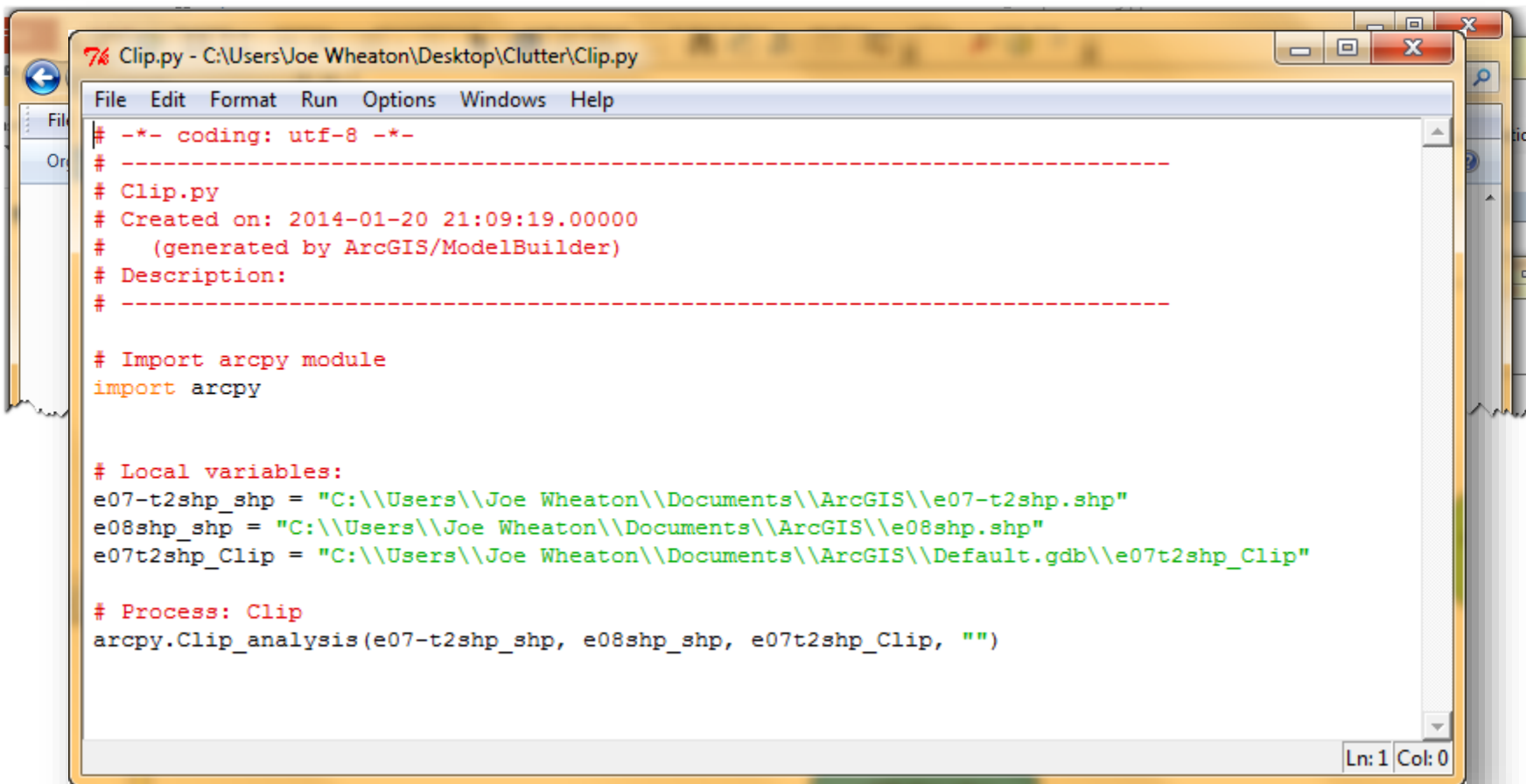
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BUT I DON'T KNOW HOW TO CODE?

- Three simple tricks to learning:
 1. Build a model (visually) and then 'Export -> To Python Script...'
 2. Try Geoprocessing Results -> 'Copy as Python Snippet...'
 3. Python scripting window and help!



1. OPEN IT UP... AND READ IT...



The screenshot shows a Python script editor window titled "Clip.py" with the following code:

```
7% Clip.py - C:\Users\Joe Wheaton\Desktop\Clutter\Clip.py
File Edit Format Run Options Windows Help
# -*- coding: utf-8 -*-
# -----
# Clip.py
# Created on: 2014-01-20 21:09:19.00000
# (generated by ArcGIS/ModelBuilder)
# Description:
# -----

# Import arcpy module
import arcpy

# Local variables:
e07-t2shp_shp = "C:\\Users\\Joe Wheaton\\Documents\\ArcGIS\\e07-t2shp.shp"
e08shp_shp = "C:\\Users\\Joe Wheaton\\Documents\\ArcGIS\\e08shp.shp"
e07t2shp_Clip = "C:\\Users\\Joe Wheaton\\Documents\\ArcGIS\\Default.gdb\\e07t2shp_Clip"

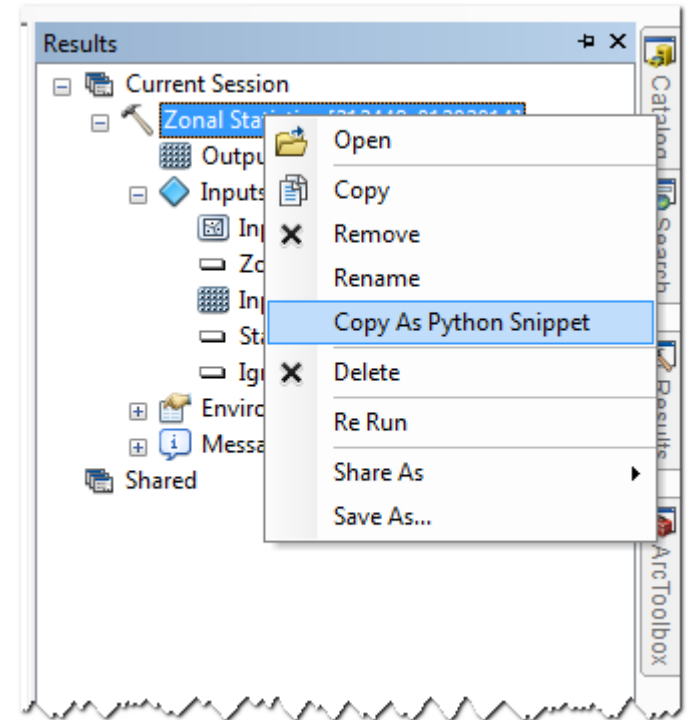
# Process: Clip
arcpy.Clip_analysis(e07-t2shp_shp, e08shp_shp, e07t2shp_Clip, "")
```

The status bar at the bottom right indicates "Ln: 1 Col: 0".

- Try and run it at command prompt!

2. COPY AS PYTHON SNIPPET

- The snippet shows the syntax for any geoprocessing command you just ran...



```
# Replace a layer/table view name with a path to a dataset (which can be a layer file) or create the layer/table view within the script
# The following inputs are layers or table views: "ShearZones", "Velocity_All"
arcpy.gp.ZonalStatistics_sa("ShearZones", "OBJECTID", "Velocity_All", "C:/Users/Joe Wheaton/Documents/ArcGIS/Default.gdb/ZonalSt_Sheal", "MEAN", "DATA")
```

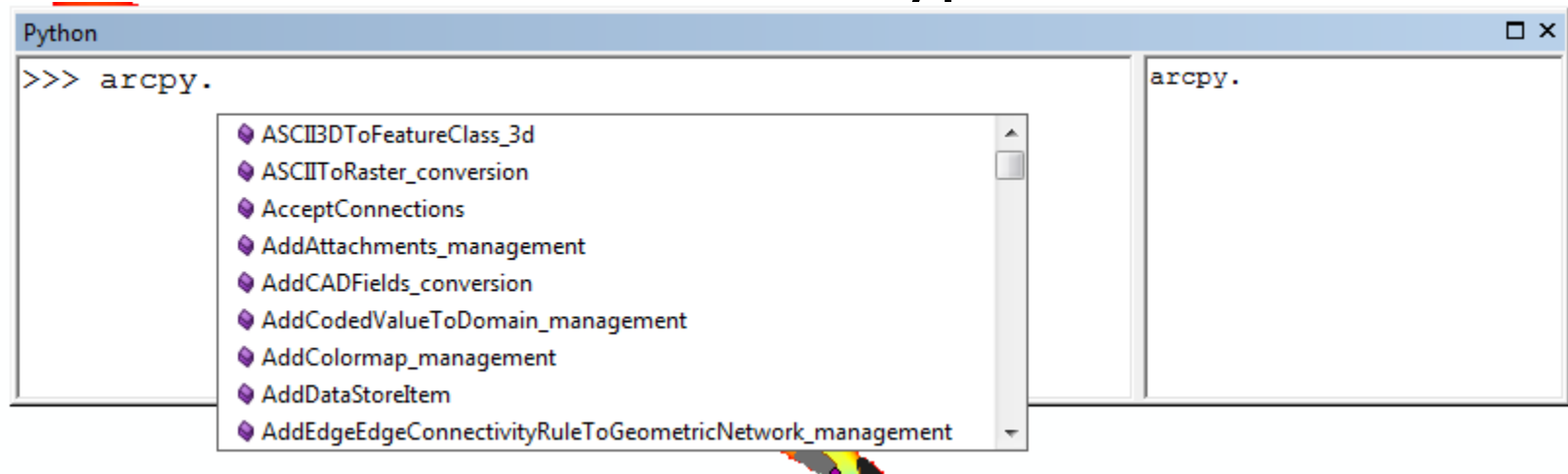

3. PYTHON WINDOW



- Start typing... & let auto-complete help



- Then tab select then tab... Type dot '.'



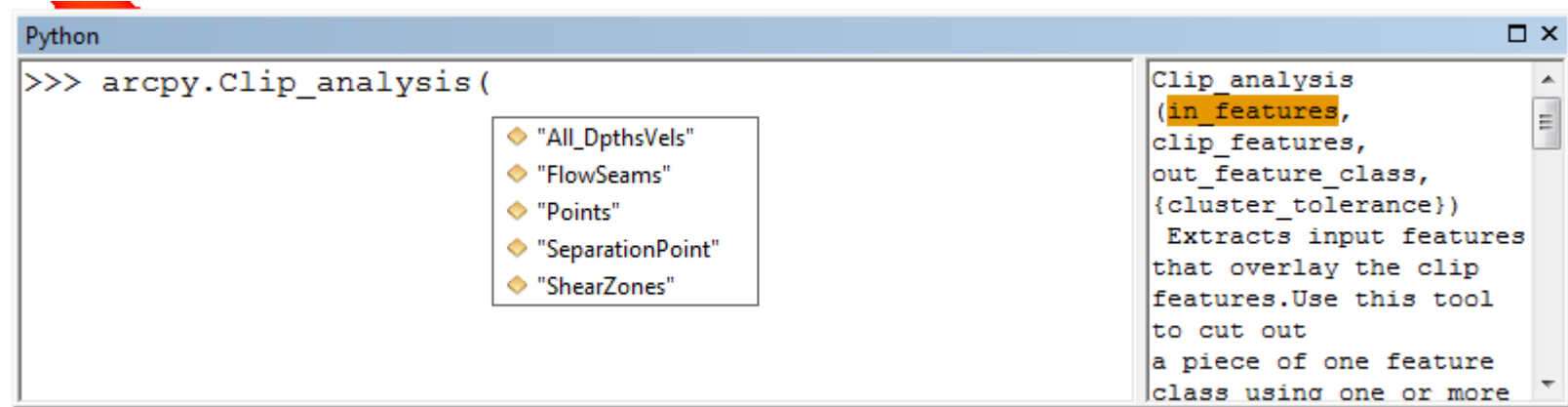
3. PYTHON WINDOW



- Start typing first few letters of command...



- Then tab select then tab... Type `,' & fill out:



3. PYTHON WINDOW



- Then run it...

The screenshot displays the ArcGIS desktop environment. On the left, the **Layers** panel shows a list of layers: **dummy** (checked), **All_DpthsVels** (unchecked), **Points** (unchecked), **SeparationPoint** (checked), **FlowSeams** (checked), **ZonalSt_Shea1** (checked), and **ShearZones** (checked). A legend for **ZonalSt_Shea1** indicates a value range from Low: 0.0299643 to High: 0.362461. In the center, the **Python** window shows the execution of the `arcpy.Clip_analysis` tool with the following code and output:

```
>>> arcpy.Clip_analysis  
      ("Points", "ShearZones", "dummy.shp")  
<Result 'C:\\Users\\Joe Wheaton\\Documents\\ArcGIS  
  \\dummy.shp'>  
>>>
```

On the right, the **Results** panel shows the execution history:

- Current Session
 - Clip [214436_01202014]
 - Output Feature Class: dummy.shp
 - Inputs
 - Environments
 - Messages
 - Zonal Statistics [212448_01202014]
 - Shared

The status bar at the bottom of the Results panel indicates the operation succeeded at Mon Jan 20 21:44:36 2014, with an elapsed time of 3.00 seconds.

- It runs, shows you status, saves to geoprocessing results, and adds to display...

JUST PLAY....

- If you really want to learn this stuff:
 - Find a problem you need to solve, have a play, try to bolt pieces together, try to get it to work
 - Lots of help and forums and examples to draw off of
- OR:
 - Take Python Class in Fall (WILD 6900) – 5 week espresso course
 - Take Ethan White's BIOL 4040/6040 – 'Python Programming for Biologists' in Fall

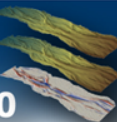
TODAY'S PLAN...

- I. Geoprocessing
- II. ModelBuilder
- III. Batch Processing
 - I. A right-click away
 - II. Scripting



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TODAY'S *OTHER* PLAN... UNCERTAINTY IN GIS

I. Uncertainty & Error

II. GIS Errors

III. Error Propagation

IV. All Bad?

V. Summary of GIS Fundamentals

“But there are also unknown unknowns: the ones we don't know we don't know.”

-Donald Rumsfeld

“It's not the things you don't know that matter, it's the things you know that ain't so.”

- Will Rogers

UNCERTAINTY...

Lack of sureness about something... NOT a lack of knowledge.

To the general public
and decision makers:

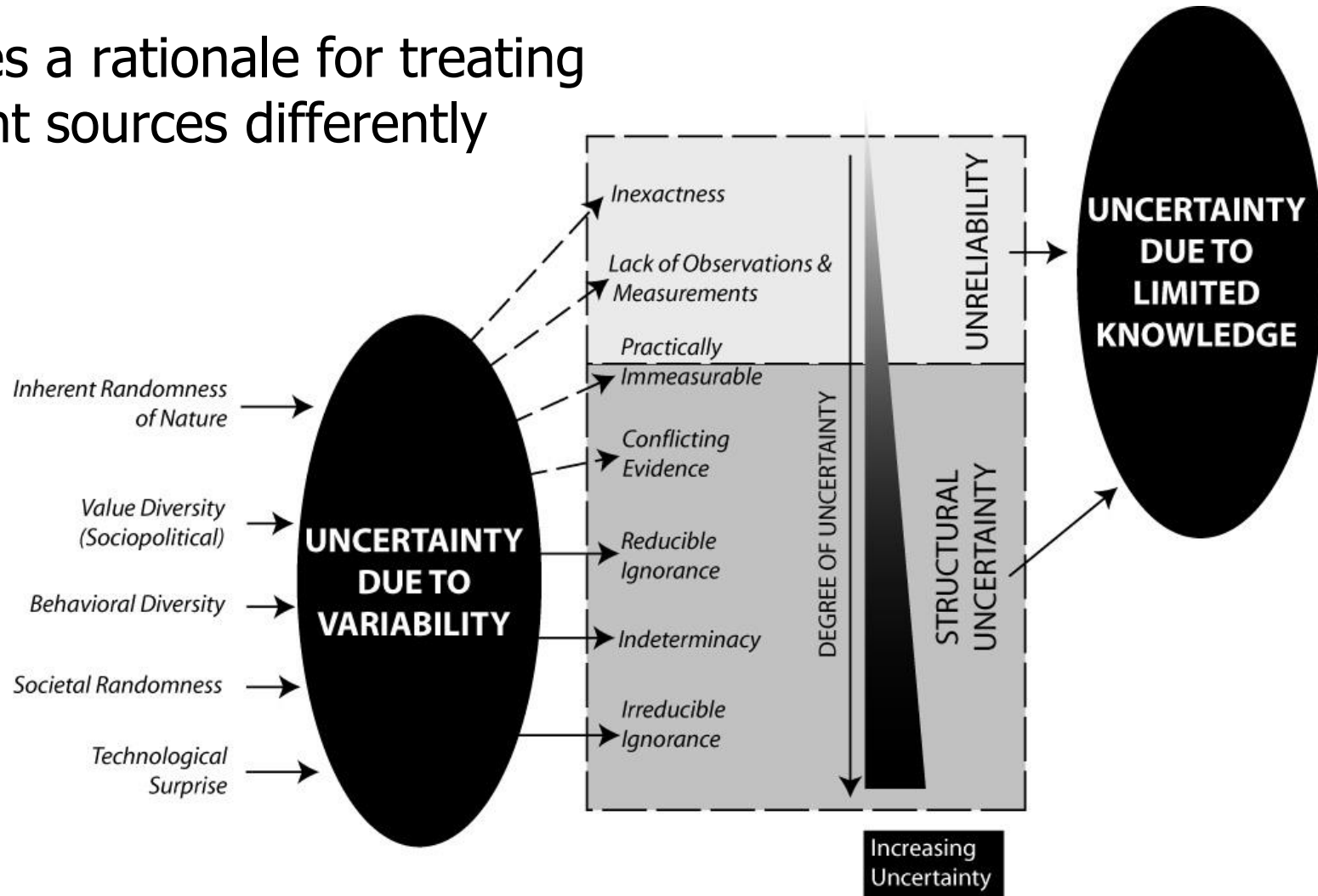
- Sign of weakness
- Like saying you don't know anything
- Confusing

To you and I (scientists):

- A statement of knowledge
- Useful information
- Full-employment act

MORE CONSTRUCTIVE DEFINITION

- Considered in terms of sources
- Provides a rationale for treating different sources differently



UNCERTAINTY REVISED

- Uncertainty does not equate to a lack of knowledge
- A statement of uncertainty is not a sign of weakness... it is useful information
- ‘What in life is worth having that you didn’t have to take a risk to get?’ – Mike Clark

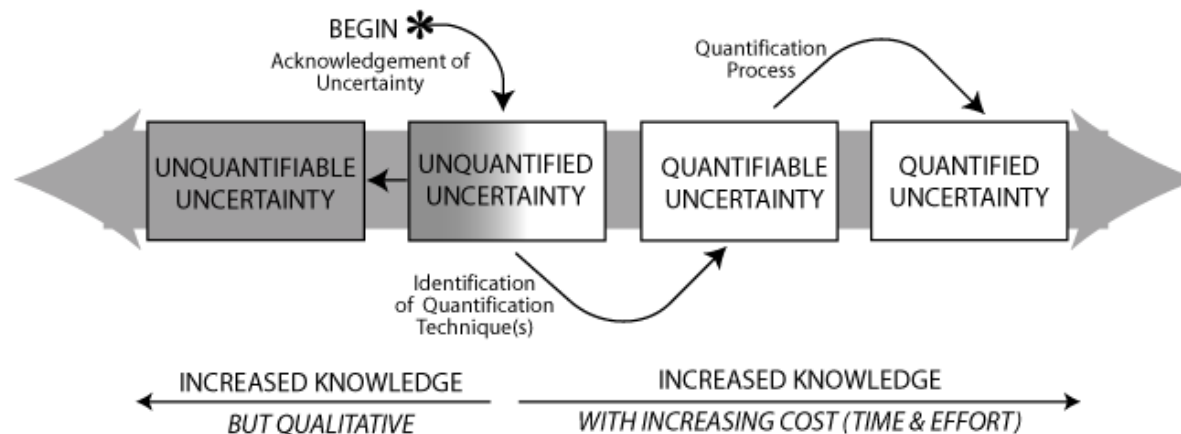


Figure from Wheaton et al. (2008)

TODAY'S PLAN...

I. Uncertainty & Error

II. GIS Errors

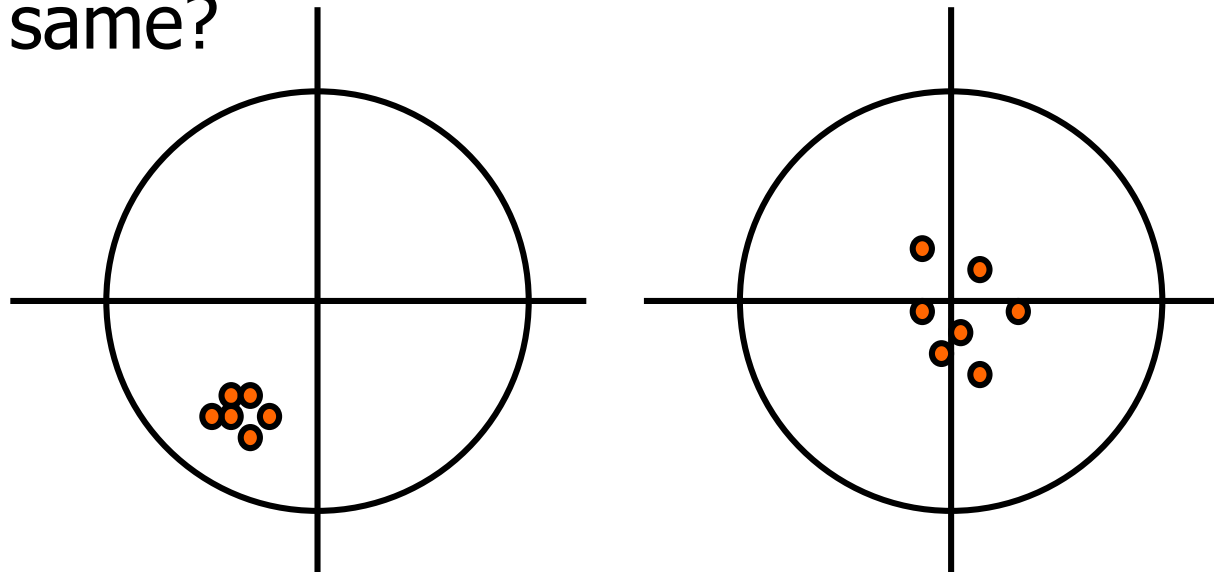
III. Error Propagation

IV. All Bad?

V. Summary of GIS Fundamentals

GIS DATA ACCURACY

- *Accuracy* is how close an observation (or GIS data layer) is to the *truth*
- *Error* is the measure of how far a measure or observation deviates from the truth
- Many different ways to have errors or blunders
- Are they same?



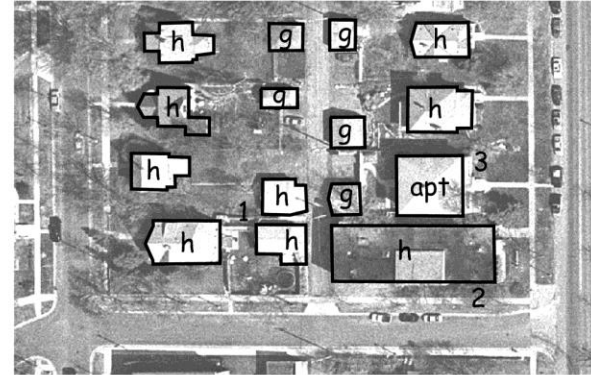
OTHER WAYS TO BE WRONG...

- Spatial data accuracy issues:

a) Positional accuracy



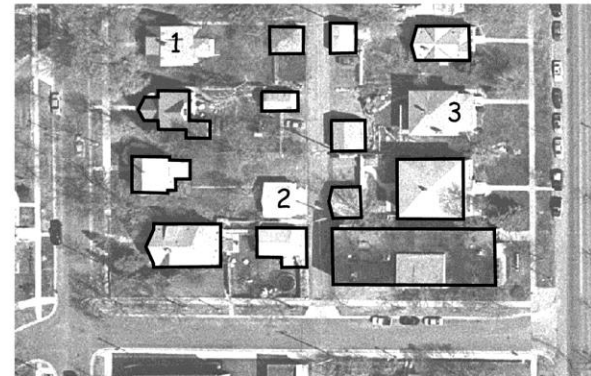
b) Attribute accuracy



c) Logical consistency



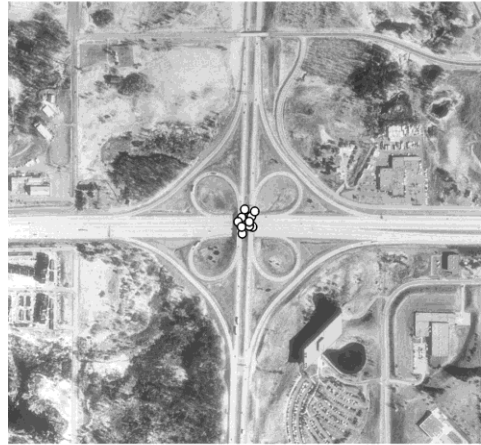
d) Completeness



FOUR END MEMBERS

- Positional accuracy of intersection of two freeways

high average accuracy,
high precision



low average accuracy,
high precision



high average accuracy,
low precision



low average accuracy,
low precision



PRECISION OR RESOLUTION

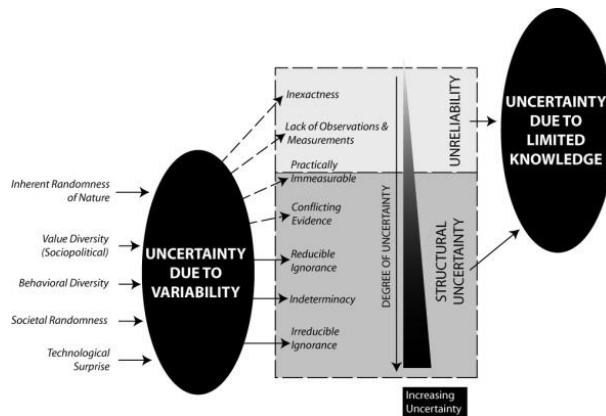
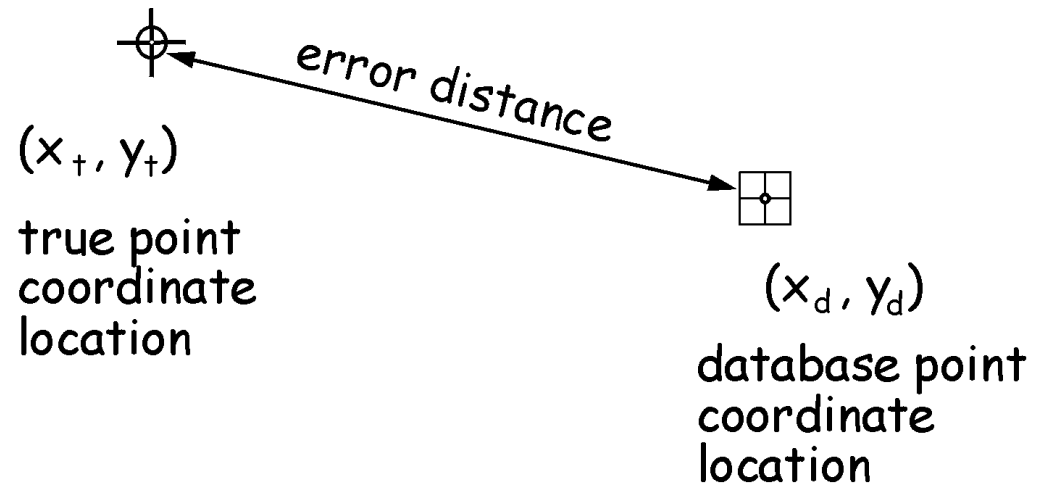
NOT THE SAME AS ACCURACY!

Precision: the exactness of measurement or description

- the “size” of the “smallest” feature that can be displayed, recognized, or described
- For raster data, it is the size of the pixel (resolution)
- For vector point data, it is the point density
- resolution and positional accuracy
 - you can see a feature (resolution), but it may not be in the right place (accuracy)
 - higher accuracy generally costs *much* more to obtain than higher resolution

HOW POSITIONAL ACCURACY IS CALCULATED

- All you need is measured coordinates and 'true' coordinates
- The lower the error distance, the more accurate...

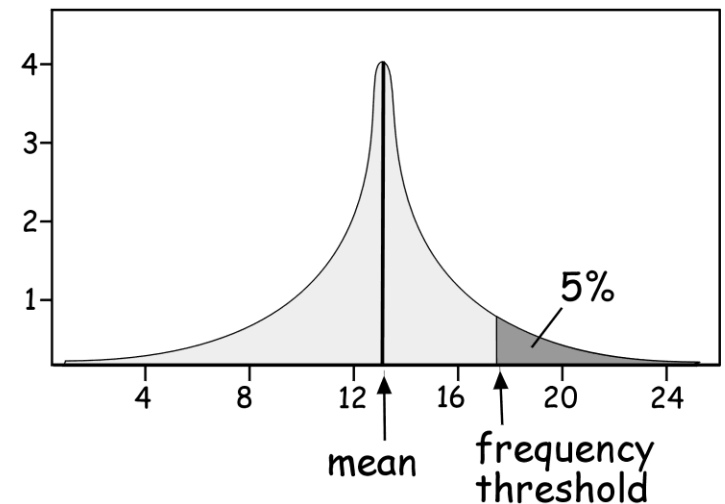
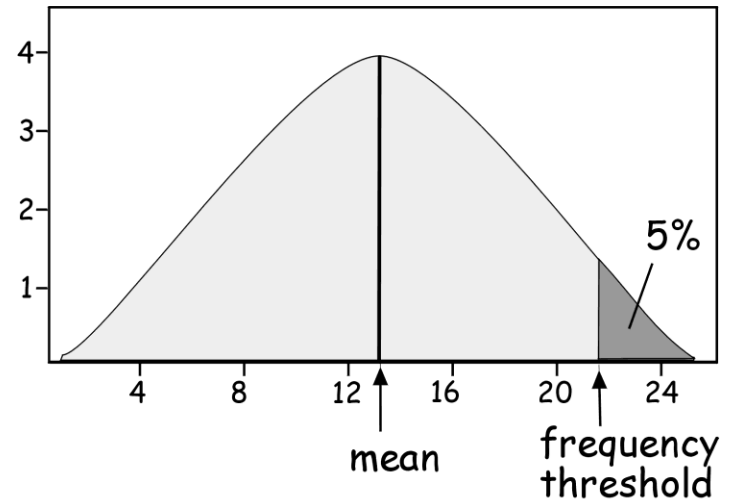


$$\text{error distance} = \sqrt{(x_t - x_d)^2 + (y_t - y_d)^2}$$

From Chapter 14 of Bolstad (2008)

IMPLICATION OF ERROR DISTRIBUTIONS

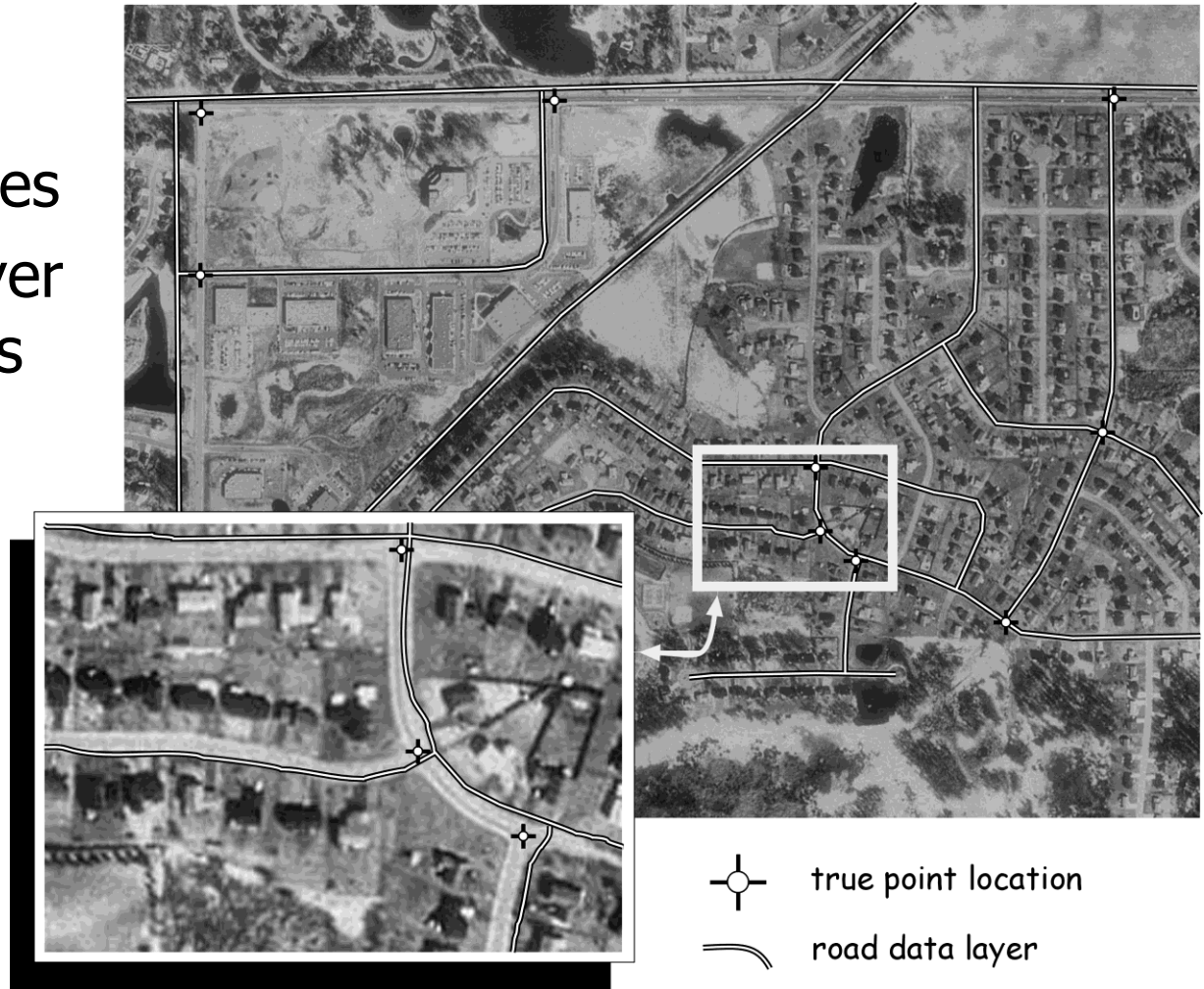
- How would I get a plot like this?
- If we take 95% of the error...
- With same mean, but different distributions, implications are quite different...



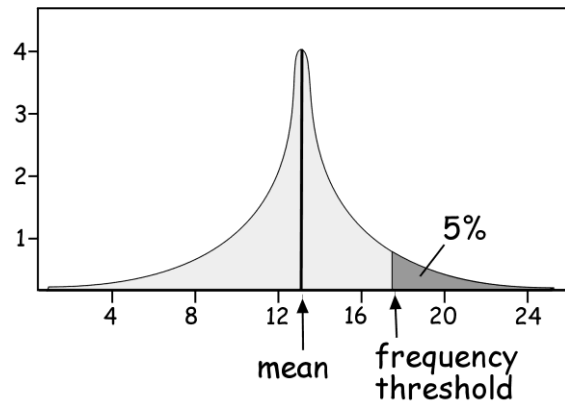
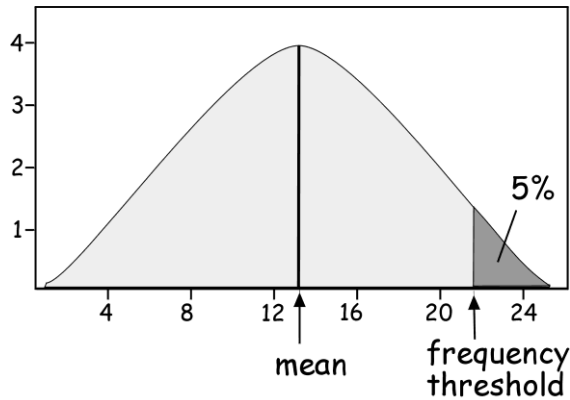
positional error

HOW TO CALCULATE THOSE POSITIOINAL ERRORS

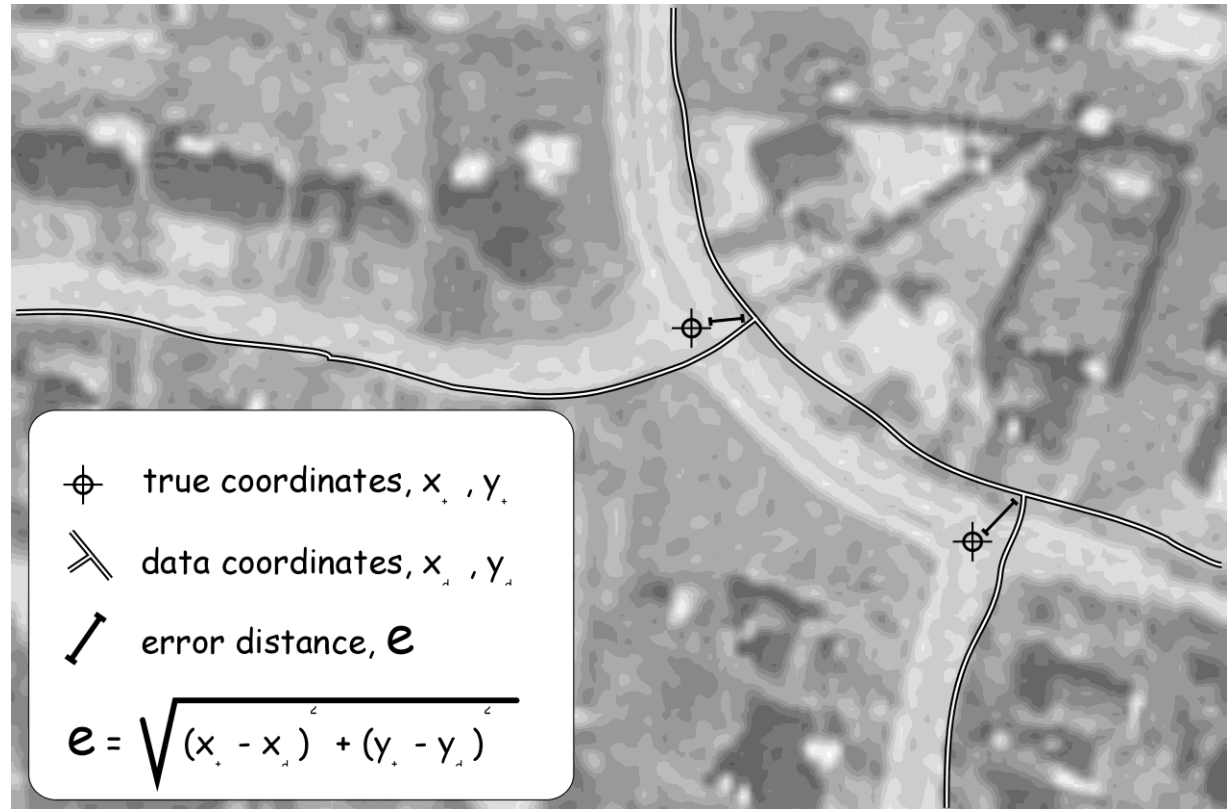
- Find, define or assume *true* values
- Find values of layer to calculate errors for
- Create error field
- Plug and chug
- THIS IS NOT TECHNICALLY CORRECT



A CLOSER LOOK



positional error



- 95% of the data... depends on distribution shape...

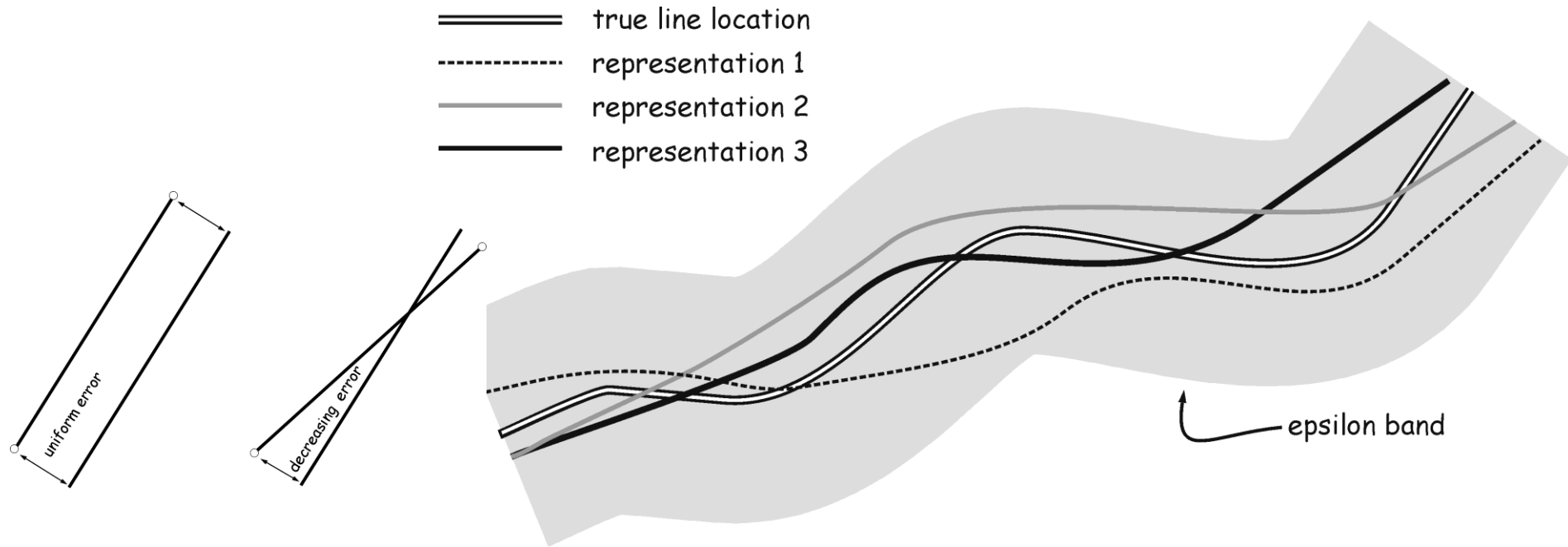
PUT IT ALL TOGETHER...

- Simple excel or field calculator exercise?
- How would you do it?

ID	x (true)	x (data)	x differ- ence	(x differ- ence) ²	y (true)	y (data)	y differ- ence	(y differ- ence) ²	sum x diff ² + y diff ²
1	12	10	2	4	288	292	-4	16	20
2	18	22	-4	16	234	228	6	36	52
3	7	12	-5	25	265	266	-1	1	26
4	34	34	0	0	243	240	3	9	9
5	15	19	-4	16	291	287	4	16	32
6	33	24	9	81	211	215	-4	16	97
7	28	29	-1	1	267	271	-4	16	17
8	7	12	-5	25	273	268	5	25	50
9	45	44	1	1	245	244	1	1	2
10	110	99	11	121	221	225	-4	16	137
11	54	65	-11	121	212	208	4	16	137
12	87	93	-6	36	284	278	6	36	72
13	23	22	1	1	261	259	2	4	5
14	19	24	-5	25	230	235	-5	25	50
15	76	80	-4	16	255	260	-5	25	41
16	97	108	-11	121	201	204	-3	9	130
17	38	43	-5	25	290	288	2	4	29
18	65	72	-7	49	277	282	-5	25	74
19	85	78	7	49	205	201	4	16	65
20	39	44	-5	25	282	278	4	16	41
21	94	90	4	16	246	251	-5	25	41
22	64	56	8	64	233	227	6	36	100
Sum									1227
Average									55.8
RMSE									7.5
NSSDA									12.9

WHAT ABOUT POSITIONAL ACCURACY OF SHAPES AS OPPOSED TO VERTICIES?

- Compare true line location to various representations of actual to define epsilon band...



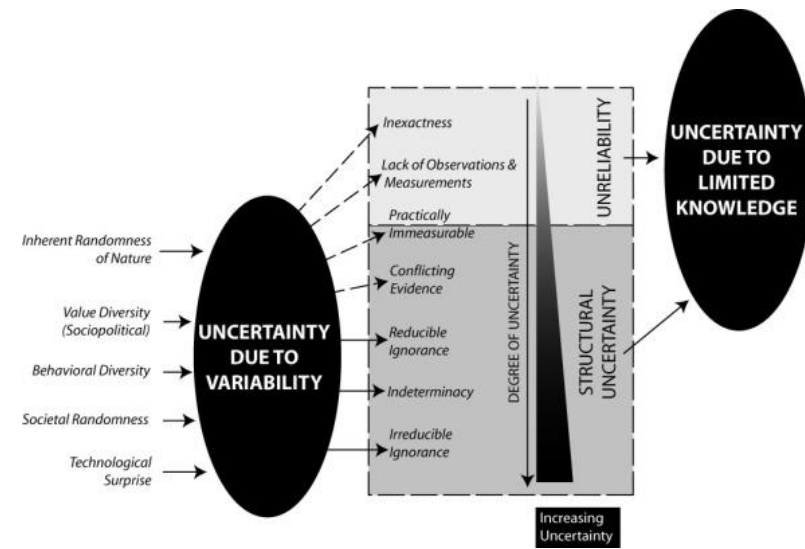
From Chapter 14 of Bolstad (2008)

MEASUREMENT OF POSITIONAL ACCURACY

- Usually measured by root mean square error: *the square root of the average squared errors*
- $RMSE = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + \dots + e_n^2}{n-1}}$ where e_i is the distance (horizontally or vertically) between the true location of point i on the ground, and its location represented in the GIS.
- Loosely we say that the RMSE tells us *how far recorded points in the GIS are from their true location on the ground, on average.*
- More correctly, based on the normal distribution of errors, 68% of points will be RMSE distance or less from their true location, 95% will be no more than twice this distance, providing the errors are random and not systematic (i.e., the mean of the errors is zero)

DIGITIZATION ERRORS

- Manual digitizing
 - significant source of positional error (roads, streams, polygons)
- Source map error
 - scale related generalization
 - line thickness
- Operator error
 - under/overshoot
 - time related boredom factor

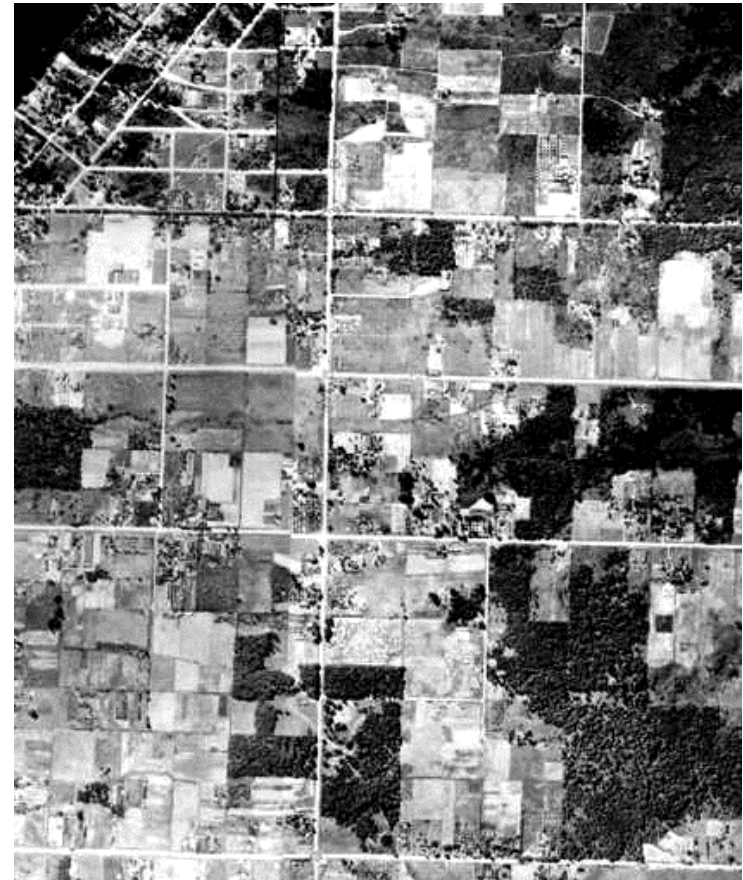


ERROR – OUT OF DATE

- Belvue Washington... At one time it was 'right'



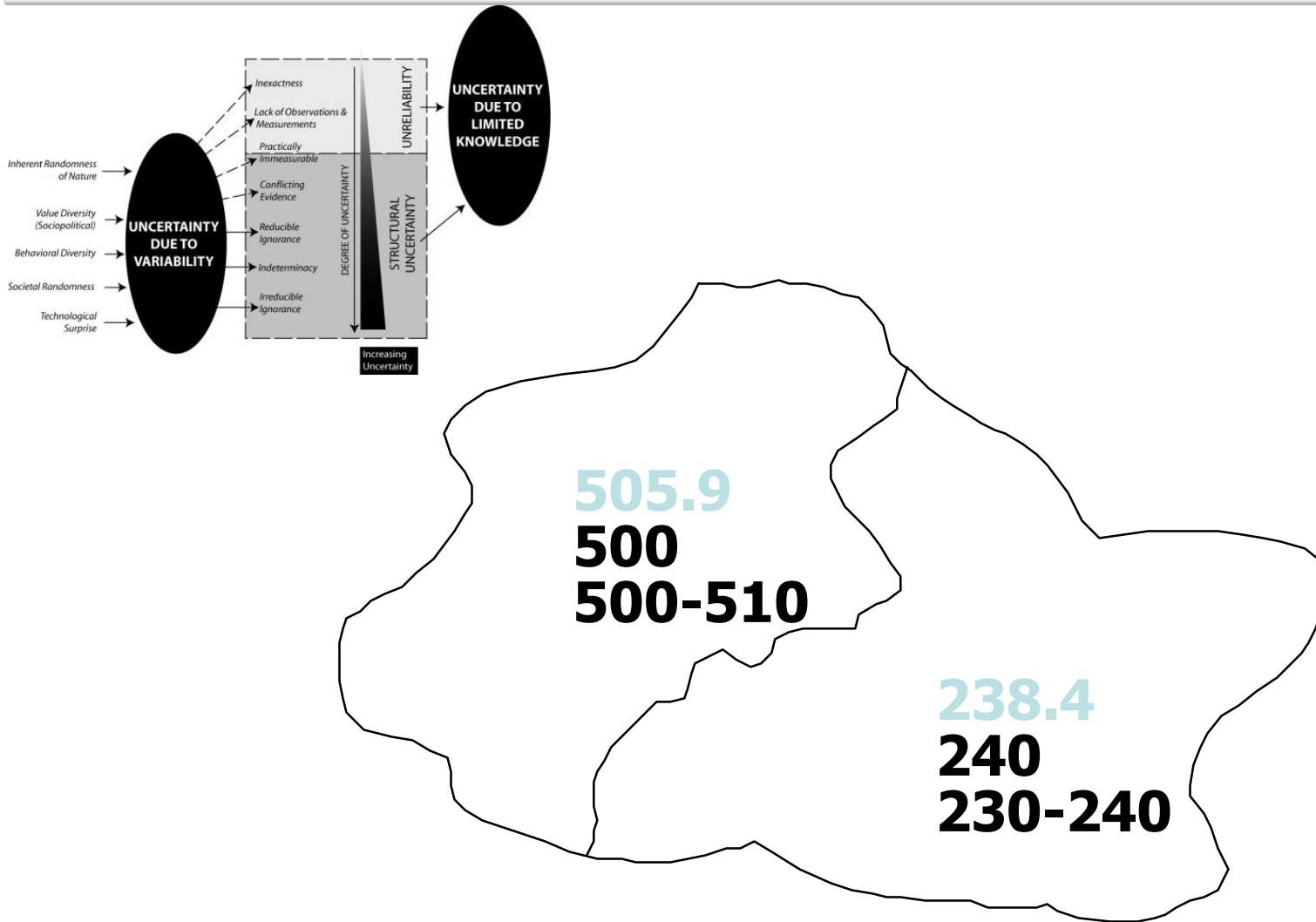
1997



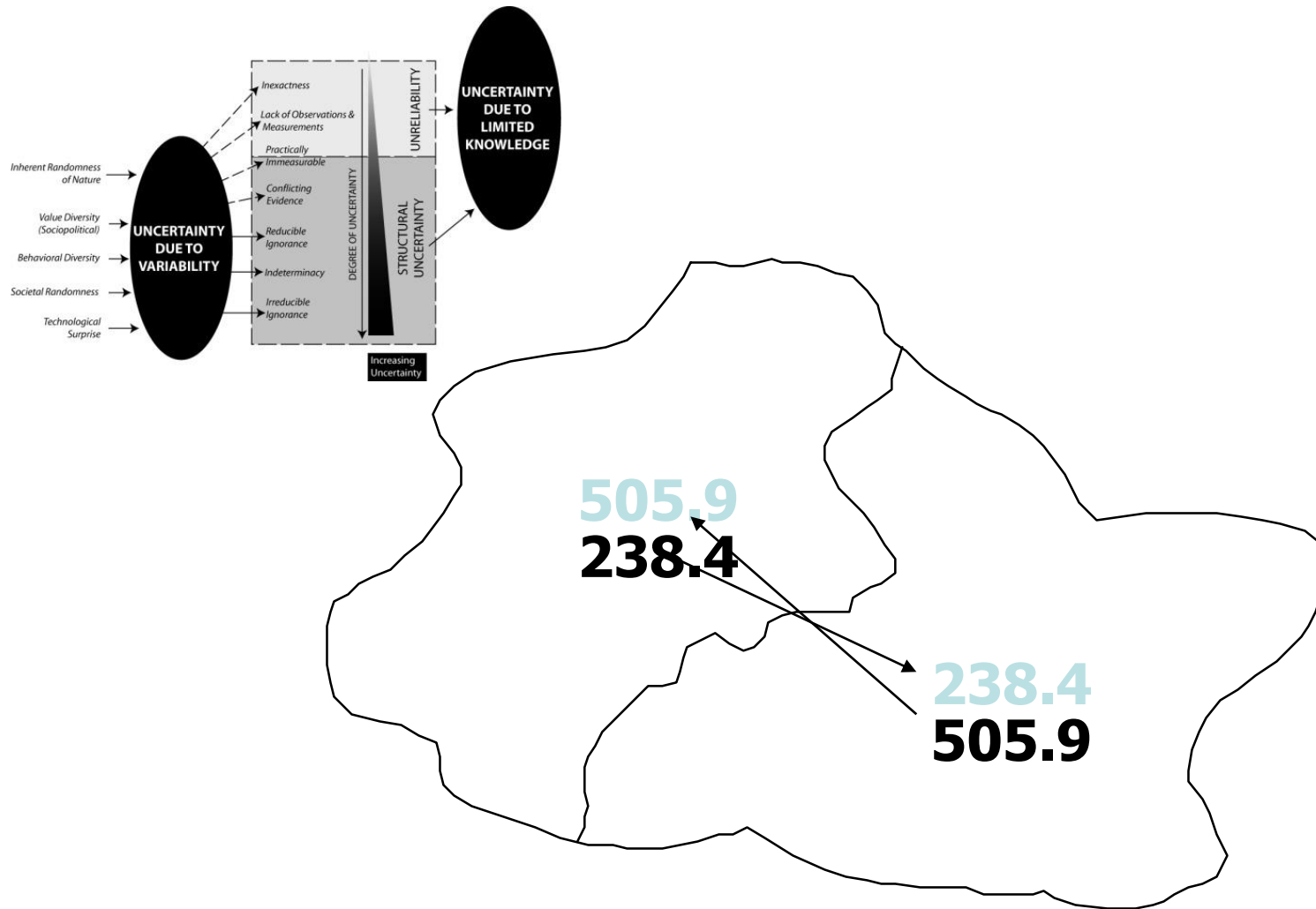
1936

From Chapter 14 of Bolstad (2008)

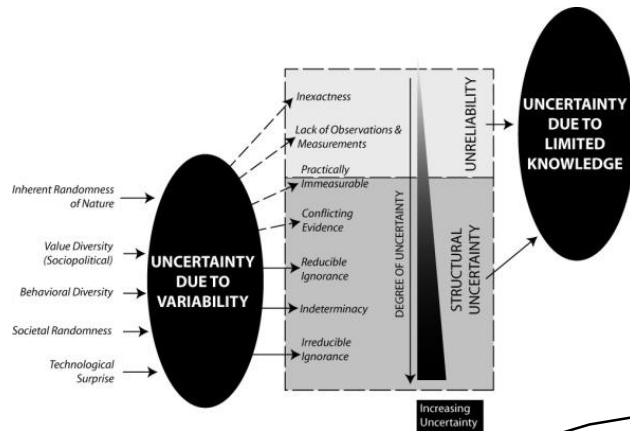
IMPRECISE AND VAGUE



MIXED UP



JUST WRONG



GENERALIZATION

1:3M

1:500,000

1:25,000

1:10,000

City of Sapporo, Japan

UNCERTAINTY IN ANALYSIS

- Just cause you think it will work does not guarantee success—Always LOOK at the results of your analysis!
 - What would a certain combination of inputs result in?
 - How is that likely to change across all inputs?
- Functional REDUNDANCY:
 - There is almost always another (often faster) way of performing any analysis
 - Should produce the *same* result... try it?

DATA QUALITY: *HOW GOOD IS YOUR DATA?*

- Scale
 - Can be an output issue; at what scale do I wish to display?
 - Analyses are only as good as the coarsest input
- Precision or Resolution
 - the exactness of measurement or description
 - Determined by input; can output at lower (but not higher) resolution
- Accuracy
 - the degree of correspondence between data and the real world
 - Fundamentally controlled by the quality of the input
- Lineage
 - The original *sources* for the data and the *processing steps* it has undergone
- Currency
 - the degree to which data represents the world at the present moment in time
- Documentation or Metadata
 - data about data: recording all of the above
- Standards
 - Common or “agreed-to” ways of doing things
 - Data built to standards is more valuable since it’s more easily shareable

ERROR HANDLING 101

- Awareness
 - knowledge of types, sources and effects
- Minimization
 - use of best available data
 - correct choices of data model/method
- Communication
 - to end user via metadata, honest and thorough reporting of uncertainties

TODAY'S PLAN...

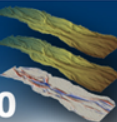
I. Uncertainty & Error

II. GIS Errors

III. Error Propagation

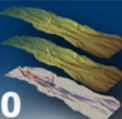
IV. All Bad?

V. Summary of GIS Fundamentals



ERROR PROPAGATION

- Methods for assessing the effects of known degrees of error in a model's inputs
 - Producing measures of confidence in model outputs
 - Normally by simulation



DEM DIFFERENCING

RASTER CALCULATOR....

Simple method of quantifying spatial variations in change in storage terms of a sediment budget.

NEW DEM

OLD DEM

= DoD

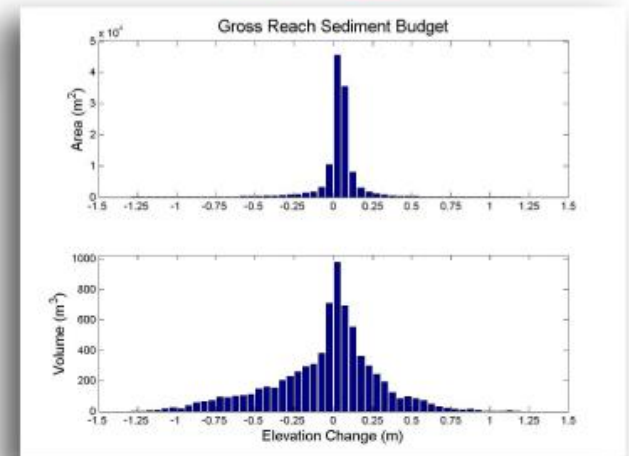
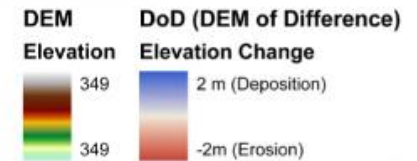
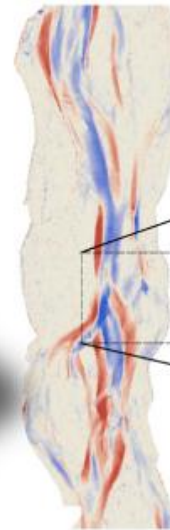
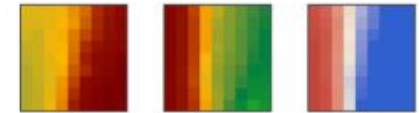
CONSERVATION OF MASS
VOLUMETRIC

$$Q_{bi} - Q_{bo} = (1 - \eta) \frac{dV_b}{dt}$$

\uparrow Volumetric rate of bed material transport
 \uparrow Porosity of bed material

McLean & Church (1988) – Water Resources Research

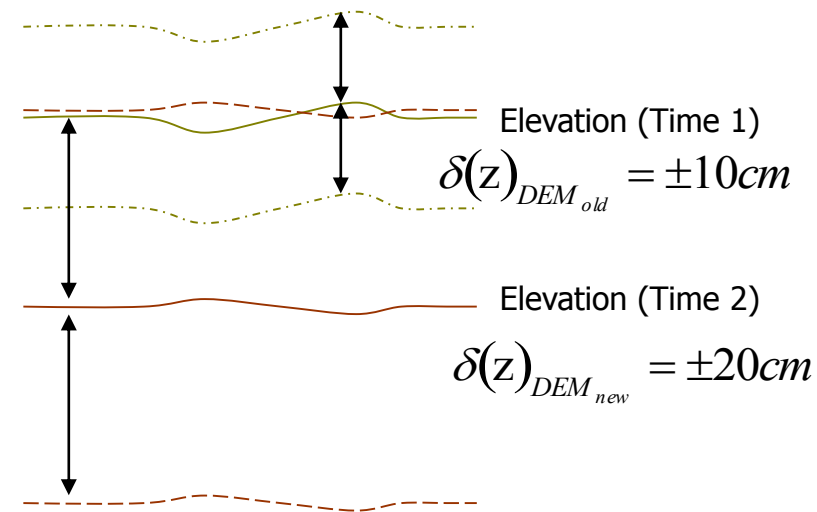
$$\text{NEW DEM} - \text{OLD DEM} = \text{DoD}$$



© Wheaton 2008

MINIMUM LEVEL OF DETECTION

- Distinguish those changes that are real from noise
- Use standard Error Propagation
- Errors assumed to be spatially uniform, but can vary temporally



$$\delta(z) = \sqrt{\left(\delta(z)_{DEM_{old}}\right)^2 + \left(\delta(z)_{DEM_{new}}\right)^2}$$

e.g. $\delta(z) = \sqrt{(10)^2 + (20)^2} = 22.36$

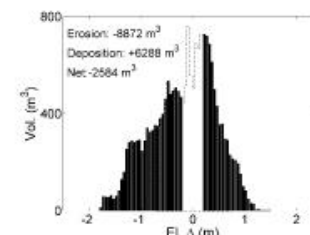
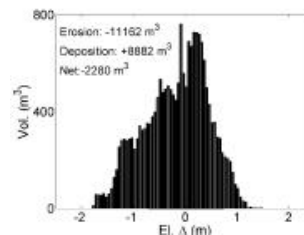
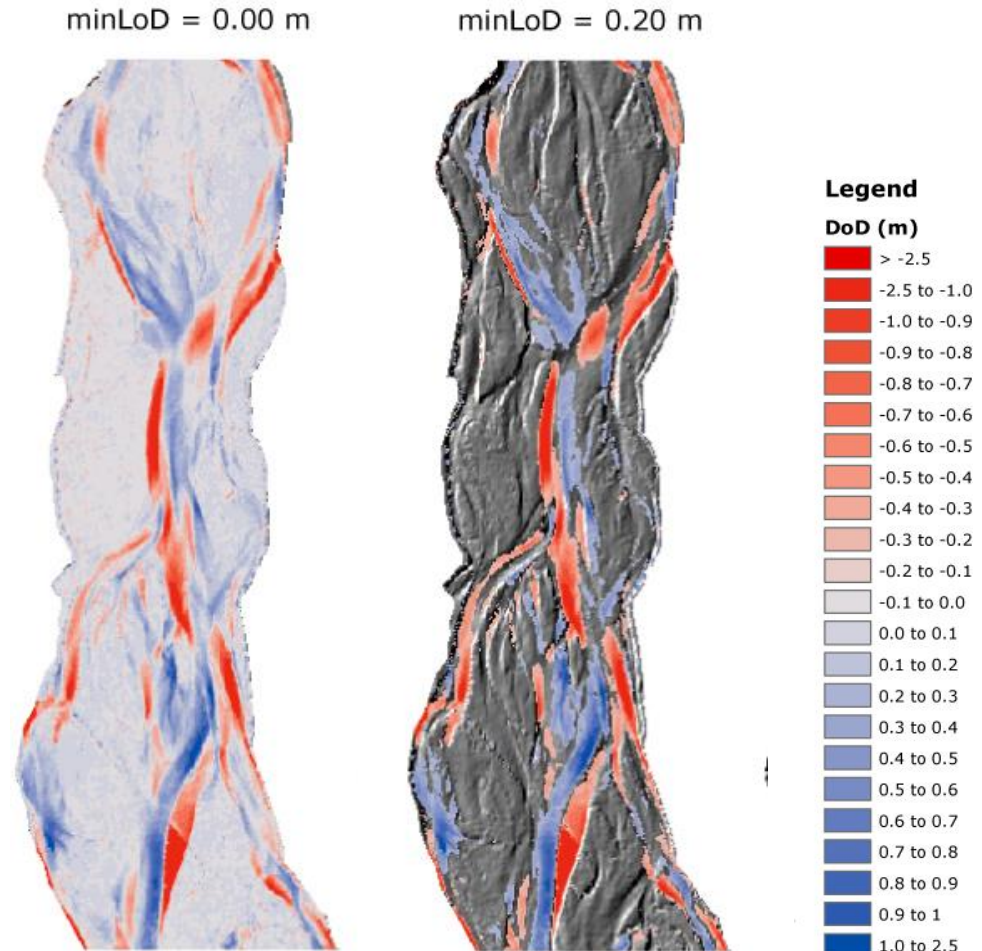
22.36 cm \approx 8.8 in

See

- Brasington et al (2000): *ESPL*
- Lane et al (2003): *ESPL*
- Brasington et al (2003): *Geomorphology*

HOW DOES A minLoD GET APPLIED?

- You take original DoD, and remove all changes $\leq \text{minLoD}$
- For example ± 20 cm
- How would you do that?
- What is the assumption here?



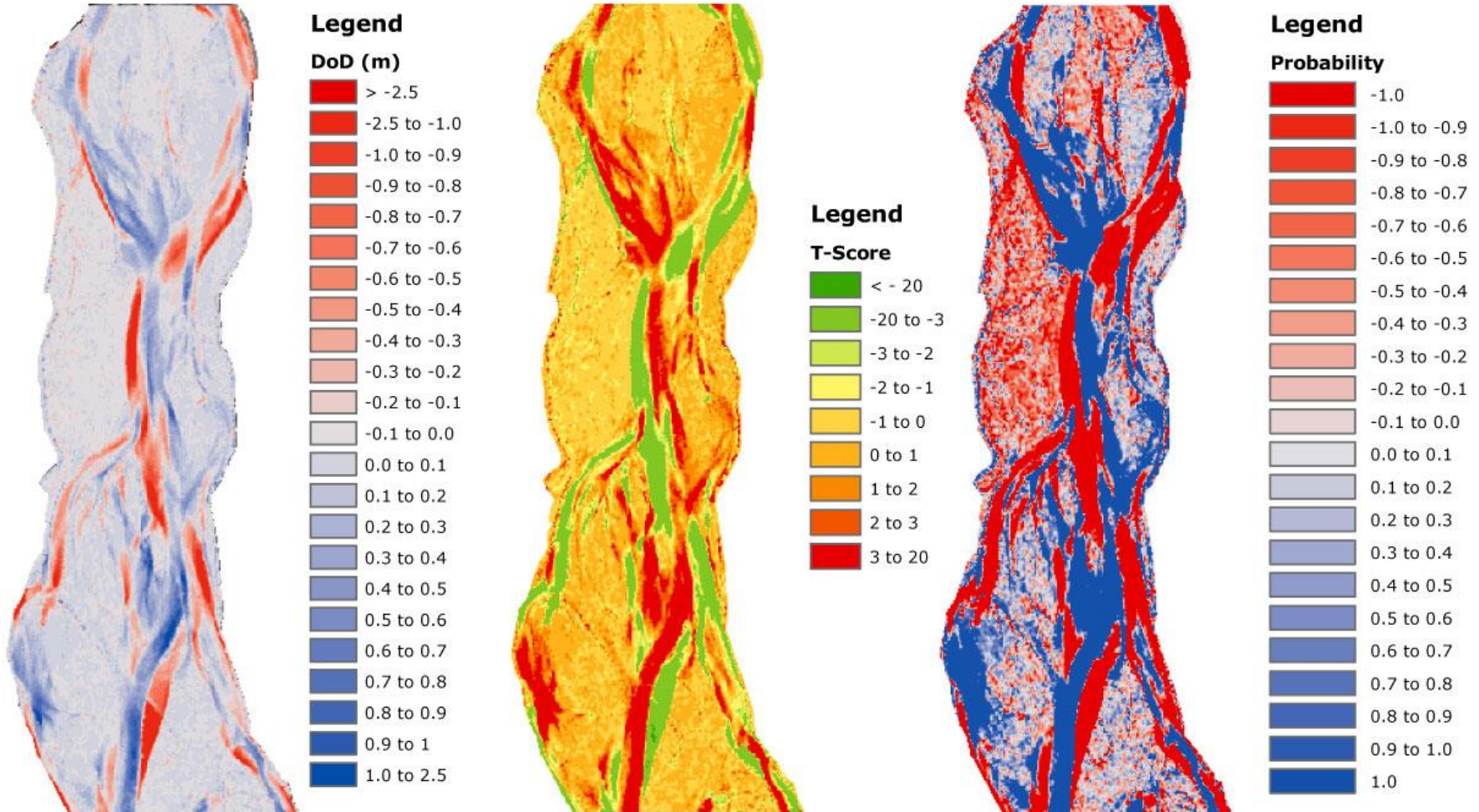
HOW COULD I REPRESENT AS PROBABILITY?

- Using inferential statistics, we'll calculate a t-score
- σ_{DoD} is the characteristic uncertainty
 - In this case $\sigma_{DoD} = \min LoD$
- Just the ratio of actual change to $\min LoD$ change
- Assuming two-tailed test, t is significant at:
 - 68% confidence limit when $t = 1$
 - 95% confidence limit when $t = 1.96$

$$t = \frac{|Z_{DEM_{new}} - Z_{DEM_{old}}|}{\sigma_{DoD}}$$

PROBABILITY THAT CHANGE IS REAL

Original DoD → Propagated DoD Uncertainty → Calculated T-Score → Converted Probability

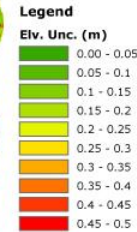
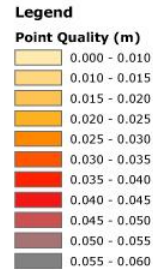
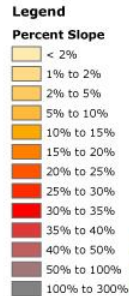
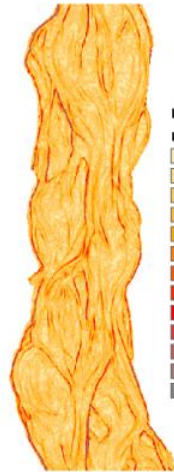
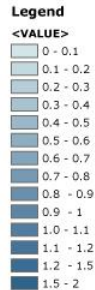
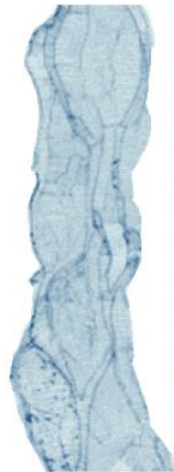


© Wheaton (2008)

Even when \min LoD is spatially constant,
probability varies in space... why?

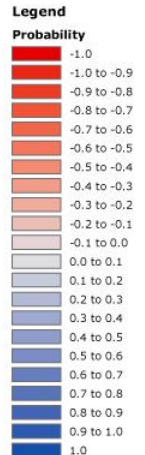
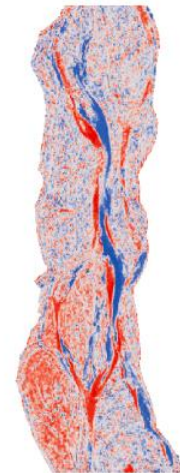
APPLY FIS ON CELL BY CELL BASIS

2006

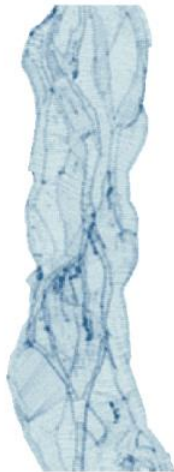


FIS Input 1 (Point Density) + FIS Input 2 (Slope) + FIS Input 3 (GPS Quality) = FIS Surface (El. Unc (m))

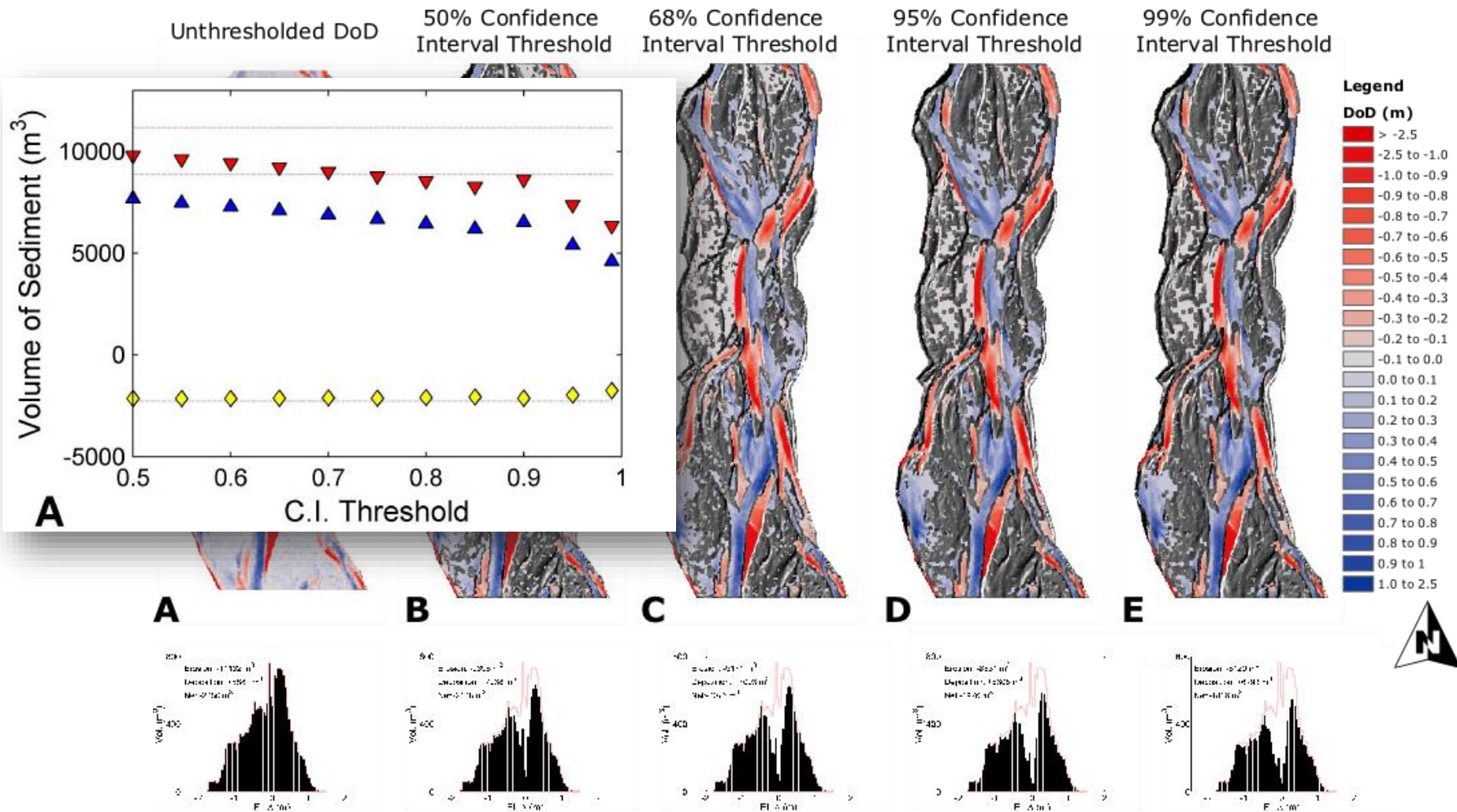
Both FIS Surfaces Combined to DoD Probability



2005



SENSITIVITY OF THRESHOLD?

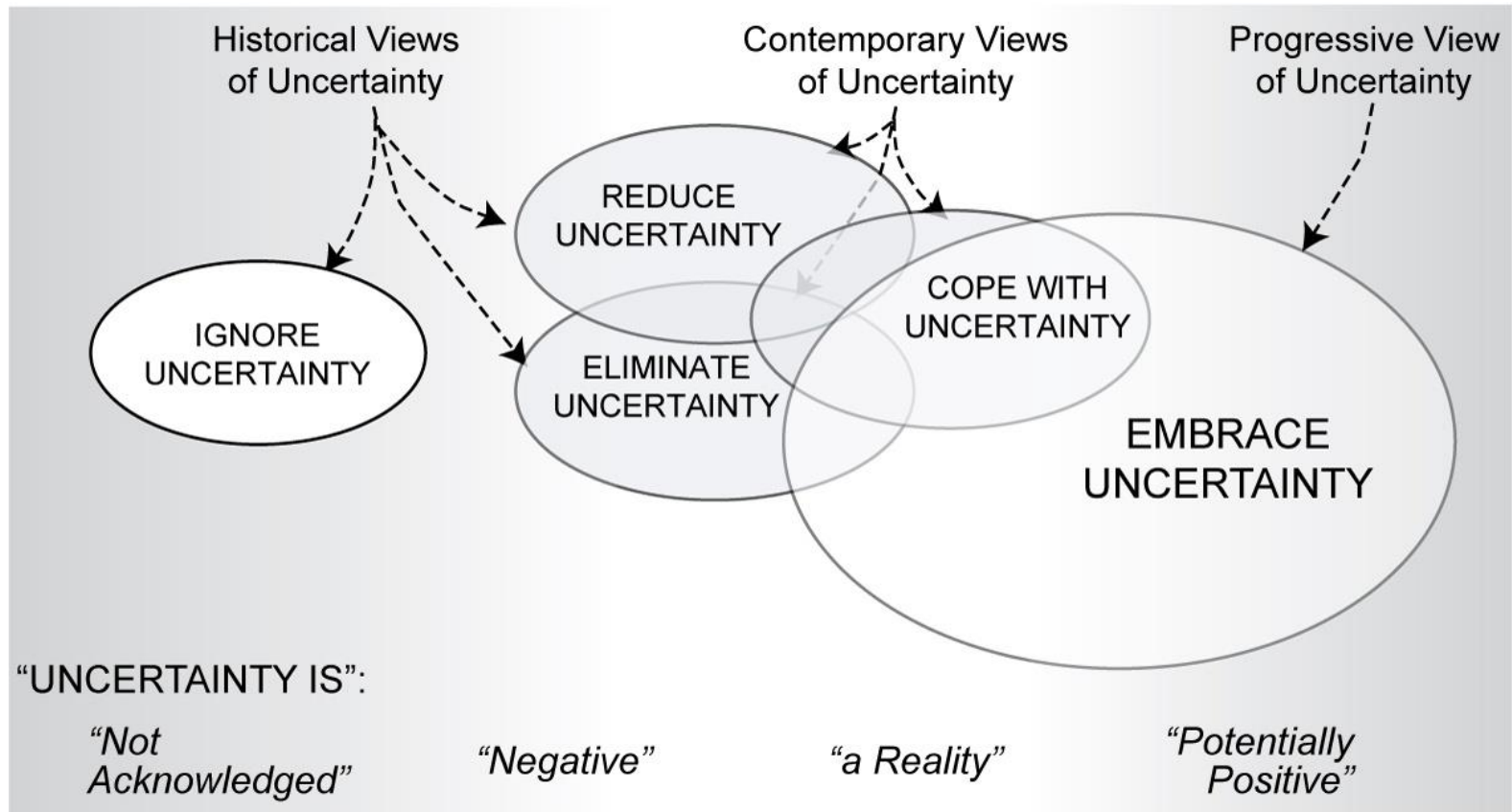


TODAY'S PLAN...

- I. Uncertainty & Error
- II. GIS Errors
- III. Error Propagation
- IV. All Bad?**
- V. Summary of GIS Fundamentals



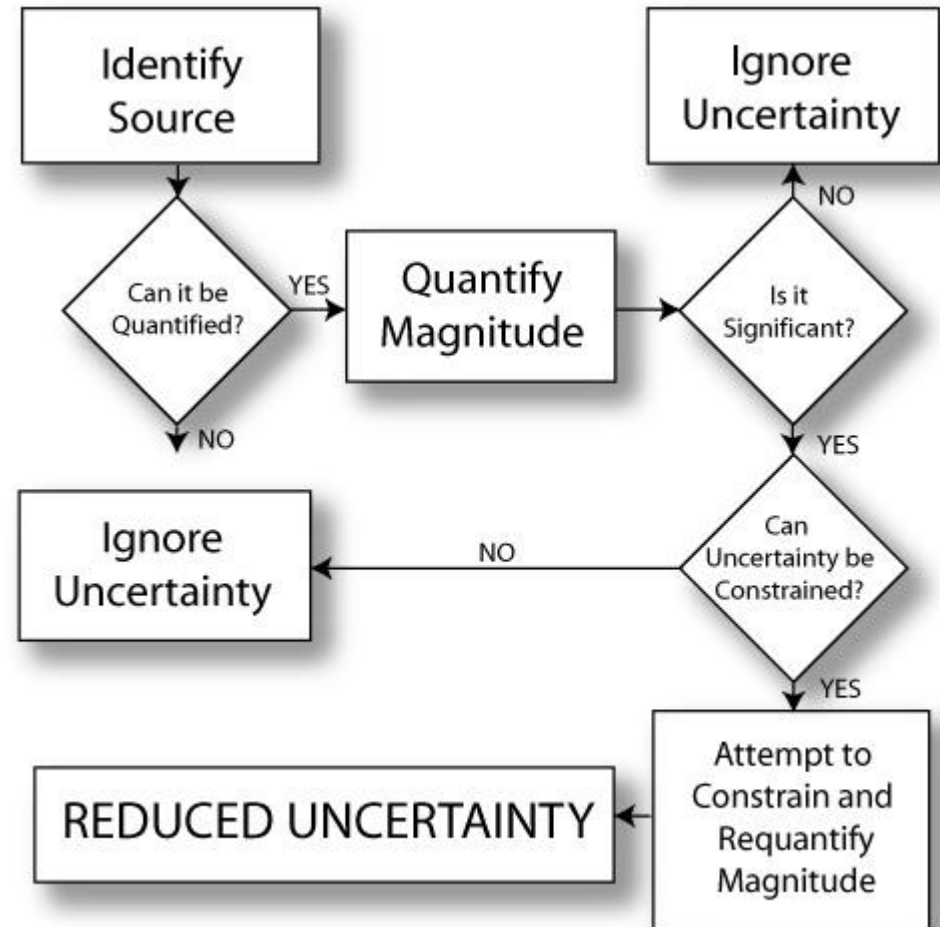
PHILOSOPHICAL ATTITUDES TO UNCERTAINTY



These contrasting philosophical approaches to dealing with uncertainty are rarely explicitly identified.

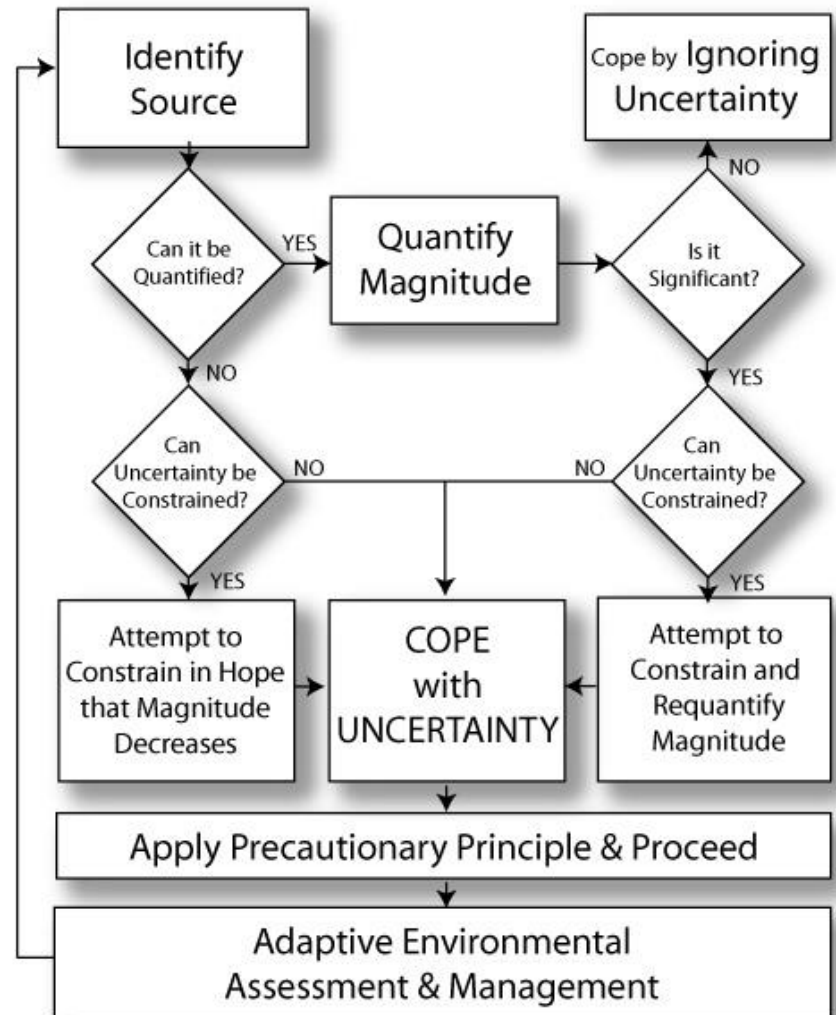
REDUCE UNCERTAINTY

- Uncertainty is a nuisance
- It should be constrained wherever possible
- Unquantifiable uncertainty difficult or impossible to constrain

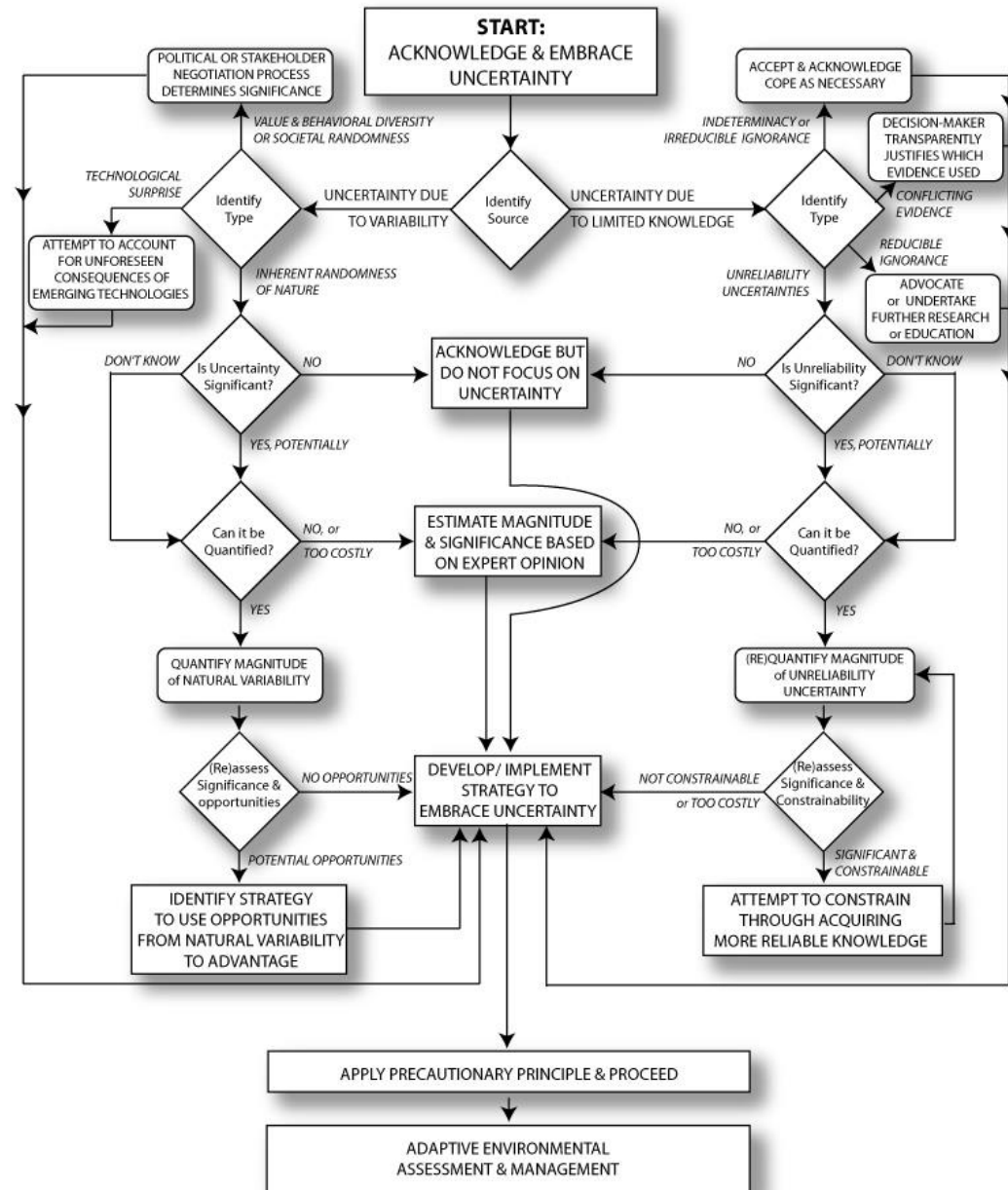


COPE WITH UNCERTAINTY

- Fuller appreciation of types of uncertainty
- Uncertainty still viewed as a nuisance
- Acceptance of uncertainty as a given
- Explicit link to adaptive management

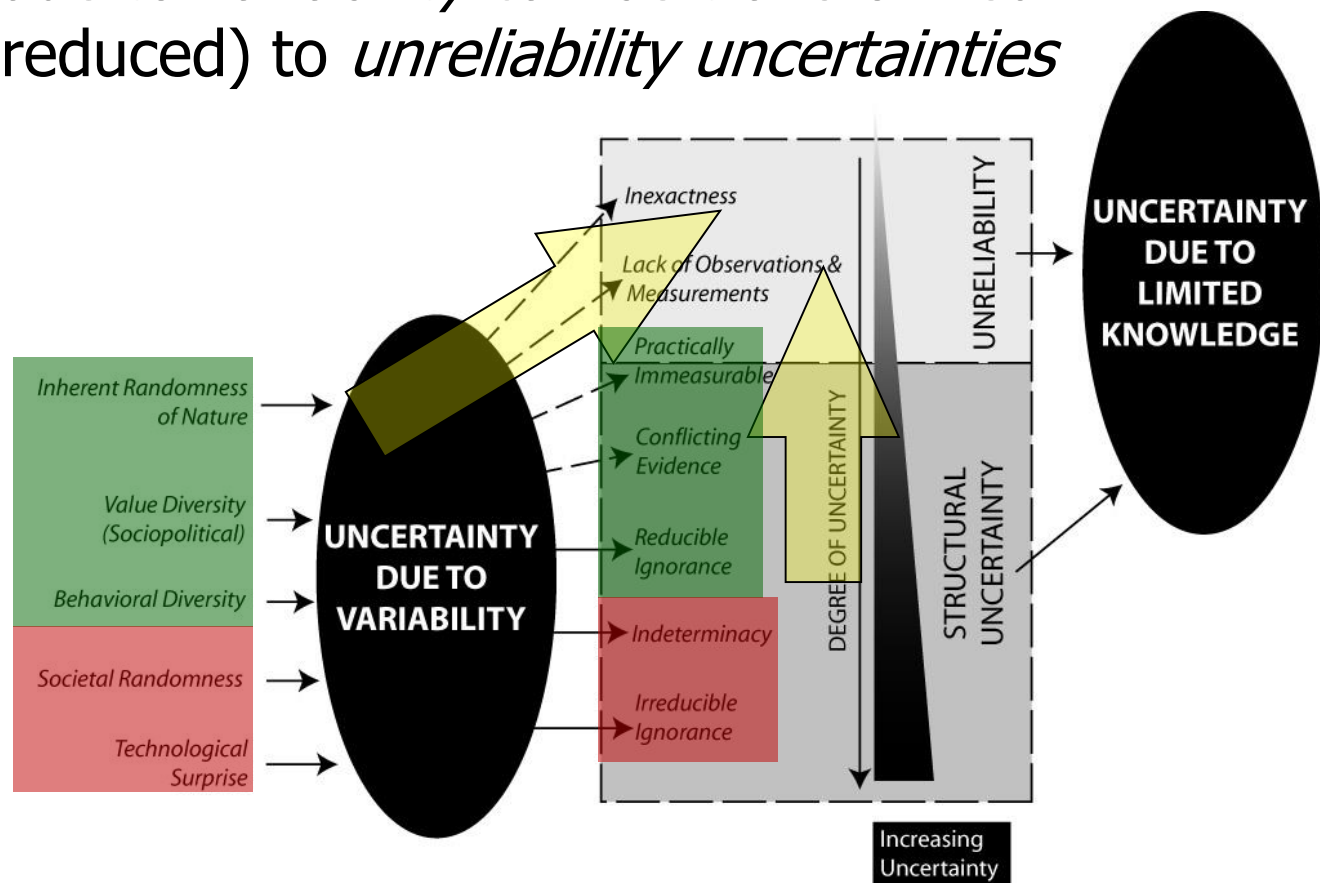


- Uncertainty seen as useful information
- Explicit recognition of uncertainty sources
- Use of natural variability as an opportunity
- Explicit linked to adaptive management



TRANSFORM UNCERTAINTY TYPES

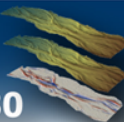
- Central to embracing uncertainty
- Many examples of *structural uncertainties* & *uncertainties due to variability* can be transformed (and thereby reduced) to *unreliability uncertainties*



HOW TO COMMUNICATE UNCERTAINTY WITHOUT SOUNDING LIKE A QUACK?

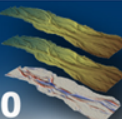


- Know the **audience** (general public vs. peers)
- Complete transparency of **source** and **type** of uncertainties
- Relate **significance** in terms of audience's criteria
- Clear identification of uncertainties leading to **risks** versus **opportunities** versus both
- Distinguish between **transformable** uncertainties & total unknowns (e.g. irreducible ignorance)
- Highlight **tradeoff** between cost of **knowing more** and taking **acceptable risks**



MIX OF COMMUNICATION OPTIONS

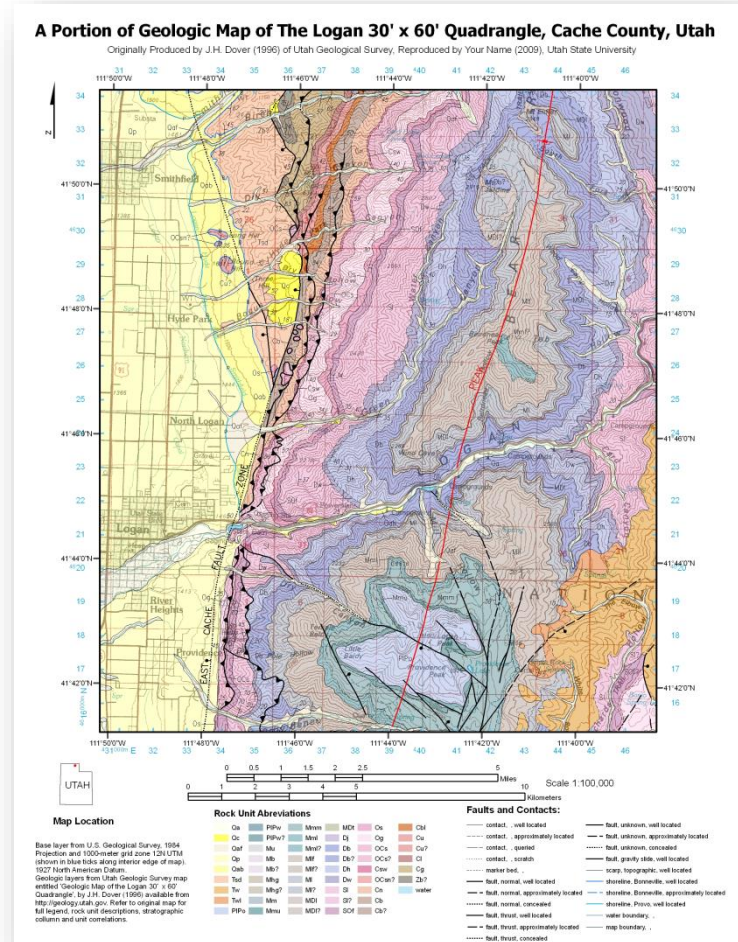
Method	Appropriate For
Qualitative Description	Unquantifiable and/or unquantified uncertainties
Probabilities	Expressions of confidence or likelihood
Measures of Variance	Uncertainties due to variability
Upper & Lower Limits (+/-)	Well constrained uncertainties due to inexactness
Fuzzy Numbers	Uncertainties due to vagueness and ambiguity
Scenarios & Conceptual Models or Simulation Models	Uncertainty about future (gets away from actual prediction)
Definition of Plausible Outcomes	Structural & Variability Uncertainties Leading to Predictive Uncertainty



THIS WEEK'S LAB

Lab 3: Reproducing Maps – Geologic Map

- Teach you how to manipulate display properties and symbology to reproduce a map in as close as possible a fashion to the original.
- Teach you how to extract summary statistics and data from existing data



GIS Classroom

Home

▼ About the Courses (Syllabi)

Grades
Instructors
Primary Learning Outcomes
Software

Course Topics

▼ Assignments

Labs
Project (4931/6921)
Reading Assignments

Class Announcements

Class Calendar

Great Maps!

Class Forum

GIS Class LibGuide

Help

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Utah State University Links

Canvas (Submit Assignments)
Department of Watershed Sciences
Banner Access
Current Students
Prospective Students

[Assignments](#) > [Reading Assignments](#) >

Reading for Tuesday, January 31st

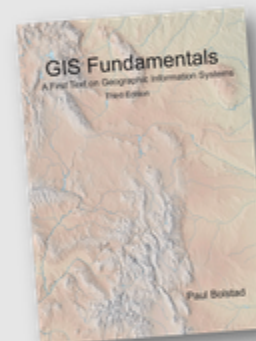
posted 19 minutes ago by Joe Wheaton

Finish reading the following by **Tuesday , January 31, 2011** (before lecture):

- Skim Chapters 6 & 7 of Bolstad (2008)
 - Just skim through everything and focus on the big picture concepts about what are the primary sources of GIS data... don't get bogged down in details
- Also, have a look through and read of the links and ESRI help topics below:

Data Sources

- [GIS Data Links](#) - *This is a page I maintain with some links to downloadable GIS Data sources*
- [GIS Class LibGuide](#) - *This is a custom page our librarian has put together just for this class!*
- [Datasets Provided with ArcGIS](#) - *These are known as ESRI Data and Maps*
- [A quick tour of ArcCatalog](#) - *ArcCatalog is the place to manage and browse your GIS data with ArcGIS*
- [Adding data from ArcGIS online](#) - *There are wealth of great basemap layers you can now load into your maps without having to download anything! Very convenient!*



Metadata & Displaying Data

- [What is metadata?](#)
- [A quick tour of metadata](#)
- [Editing Metadata](#) (in ArcGIS)