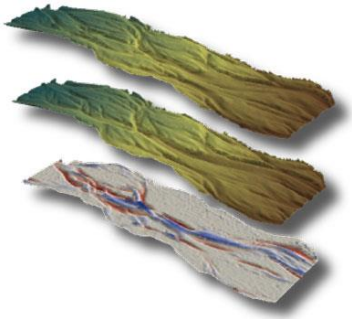
GEOMORPHIC CHANGE DETECTION

E. TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION



NORTH ARROW RESEARCH

DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. **Background Problem**

2. Basic DEM Differencing

3. Raster Calculator DoD Example

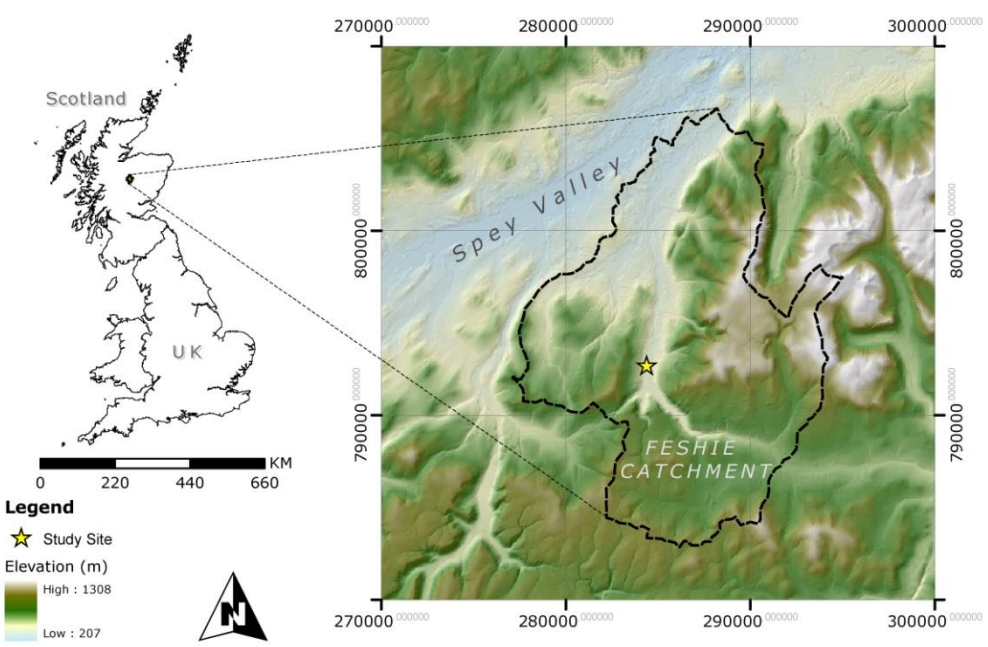
4. Simple Thresholding

5. Raster Calculator Threshold Example

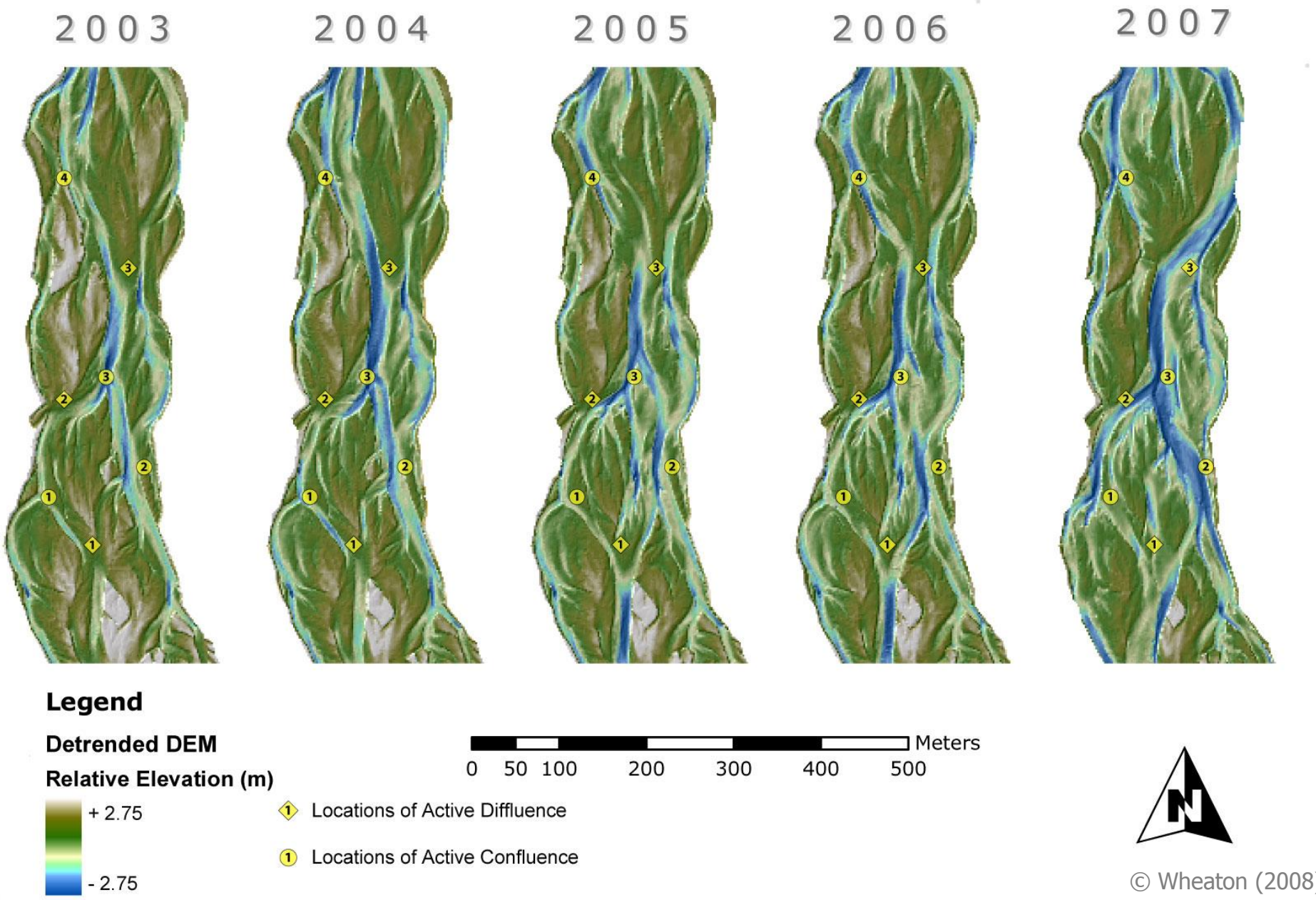
6. Alternatives to traditional raster based GCD (point cloud based)

THE BACKGROUND PROBLEM

- Rivers change through time… how do we detect that change?



BECOMING EASIER TO TRACK CHANGE…

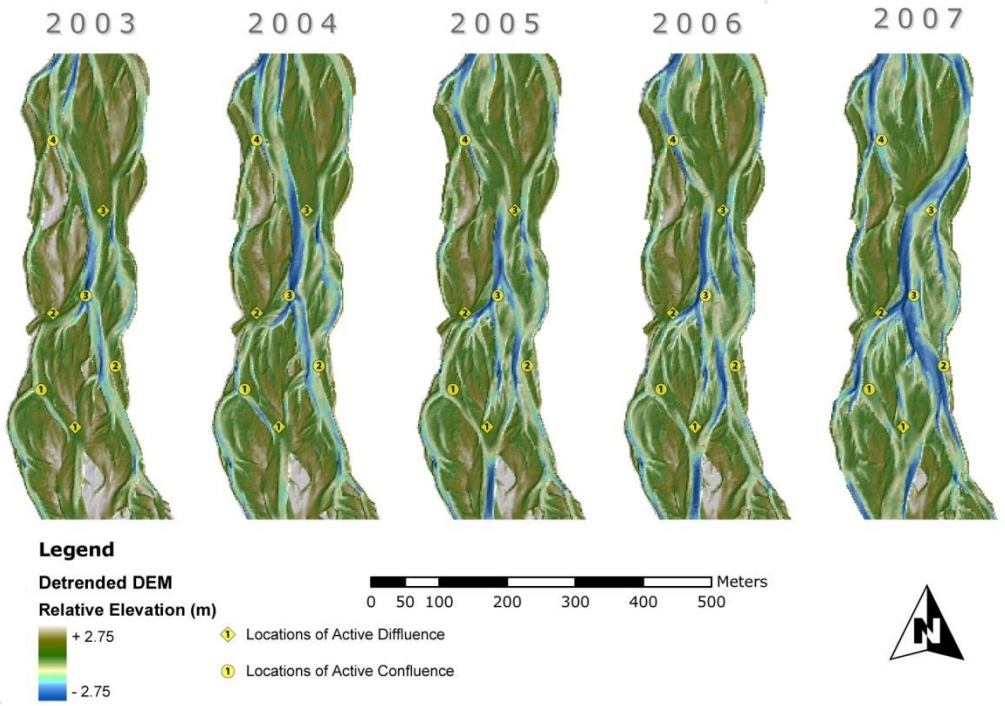


© Wheaton (2008)

WHETHER IN RIVERS… OR RESERVOIRS

HOW CAN WE CALCULATE CHANGE?

- Given these DEMs through time, what could we use to calculate change?



DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. Background Problem

2. Basic DEM Differencing

3. Raster Calculator DoD Example

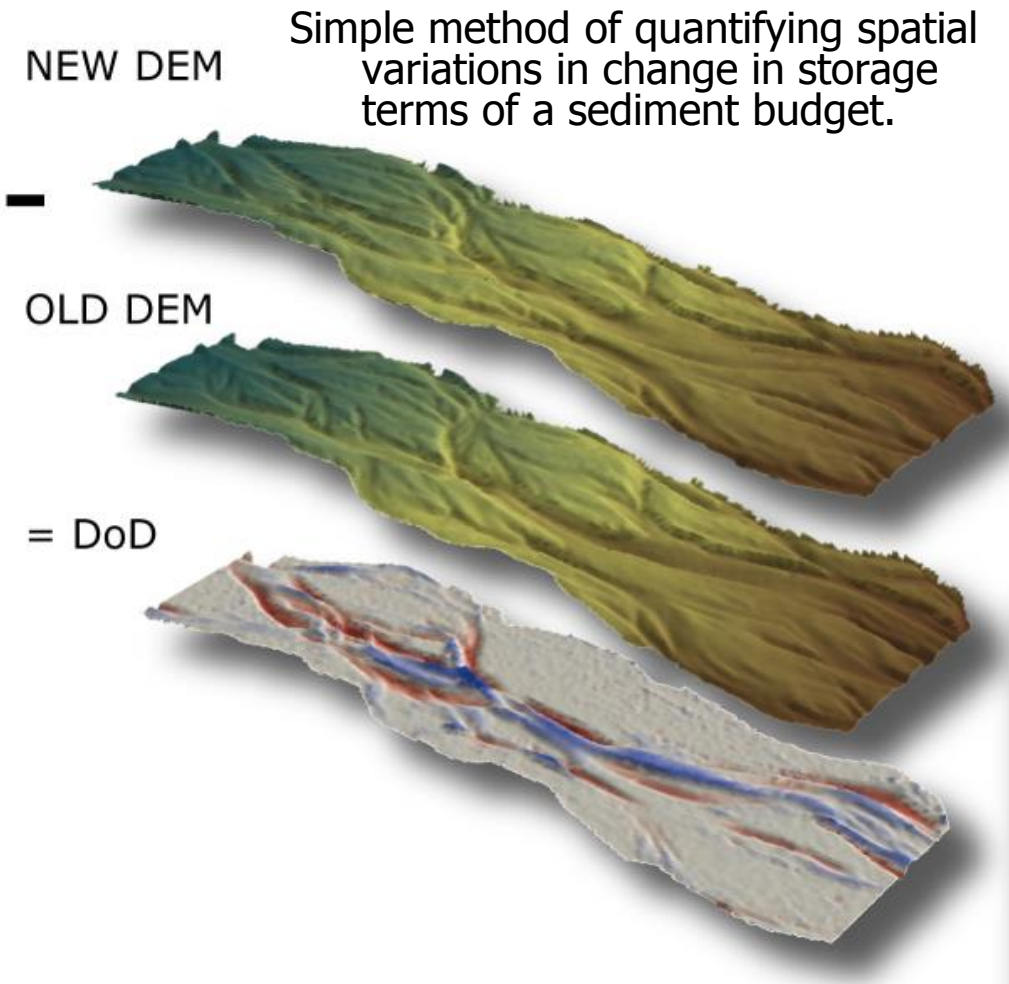
4. Simple Thresholding

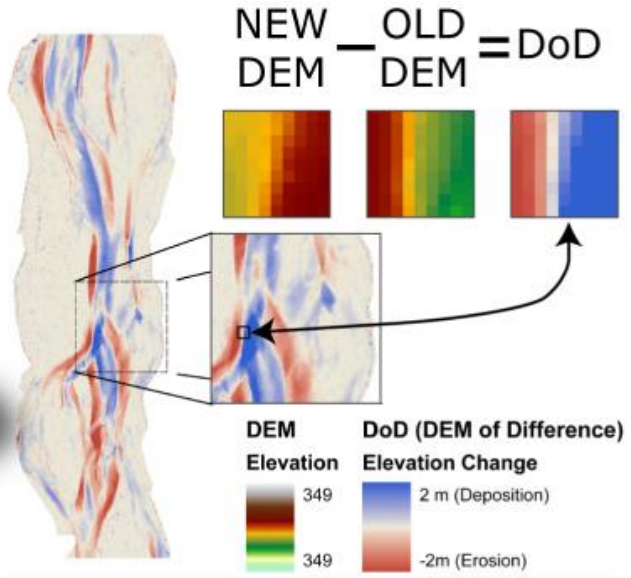
5. Raster Calculator Threshold Example

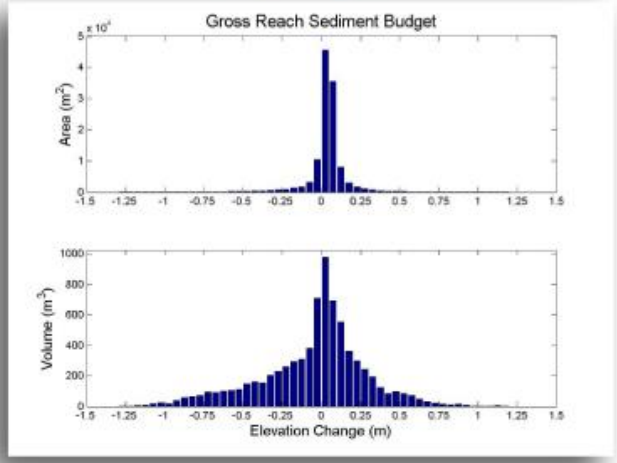
6. Alternatives to traditional raster based GCD (point cloud based)

DEM DIFFERENCING

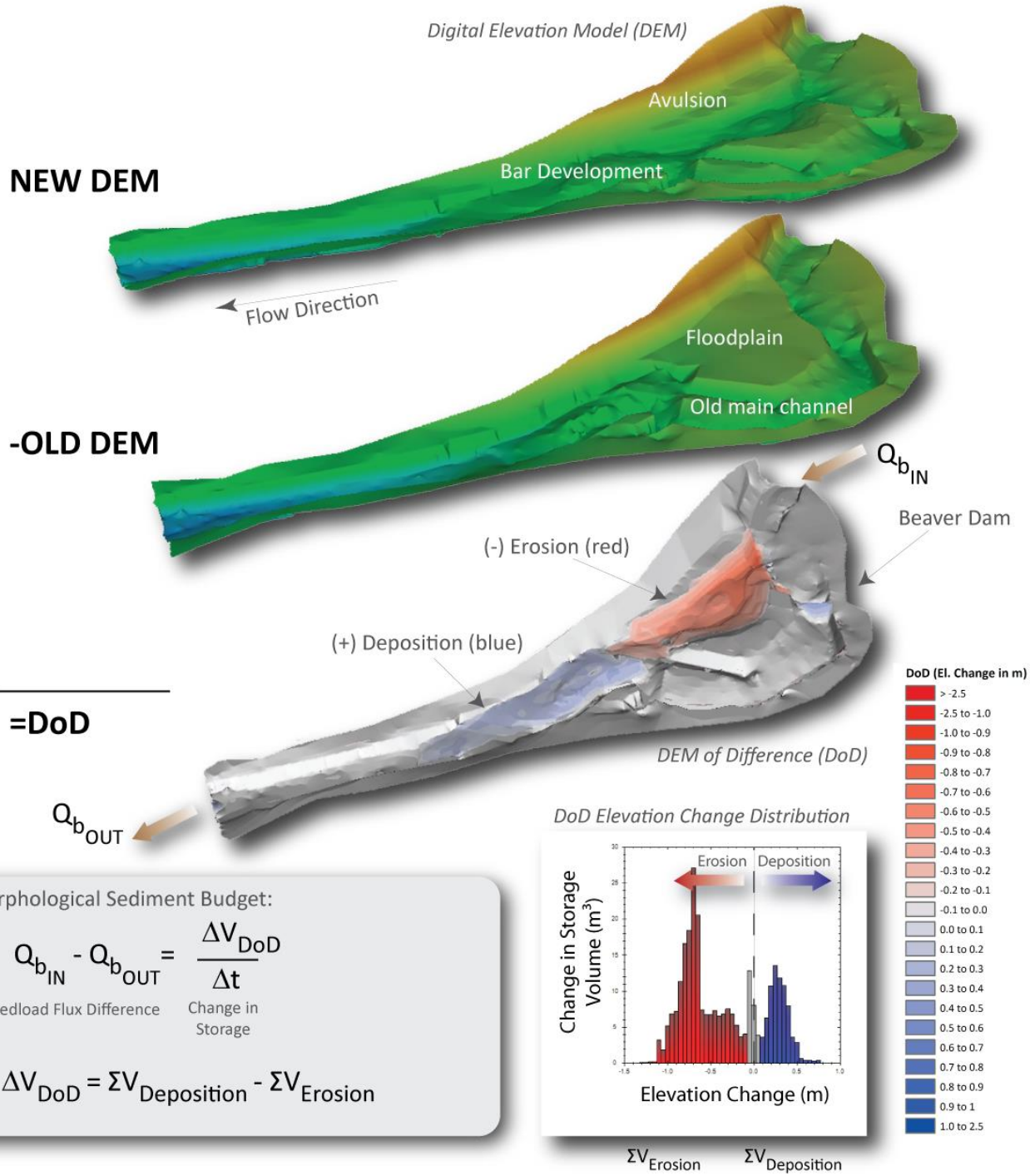
Simple method of quantifying spatial variations in change in storage terms of a sediment budget.







© Wheaton (2008)



Morphological Sediment Budget:

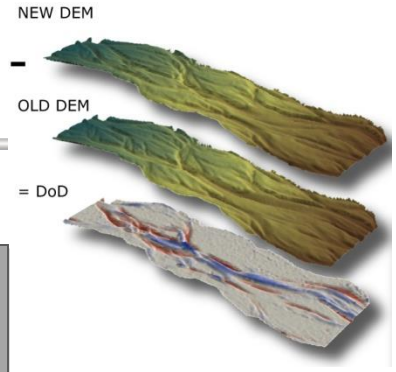
$$Q_{b_{IN}} - Q_{b_{OUT}} = \frac{\Delta V_{DoD}}{\Delta t}$$

Bedload Flux Difference

Change in Storage

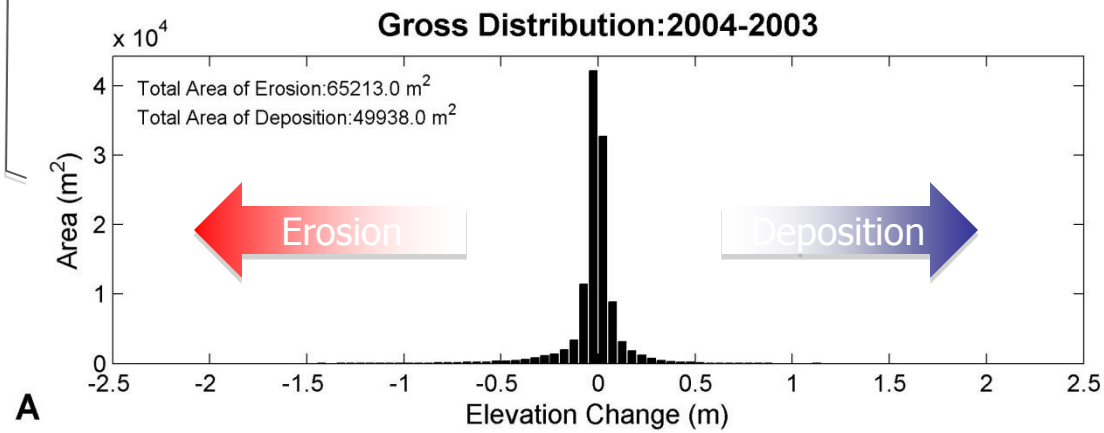
$$\Delta V_{DoD} = \Sigma V_{Deposition} - \Sigma V_{Erosion}$$

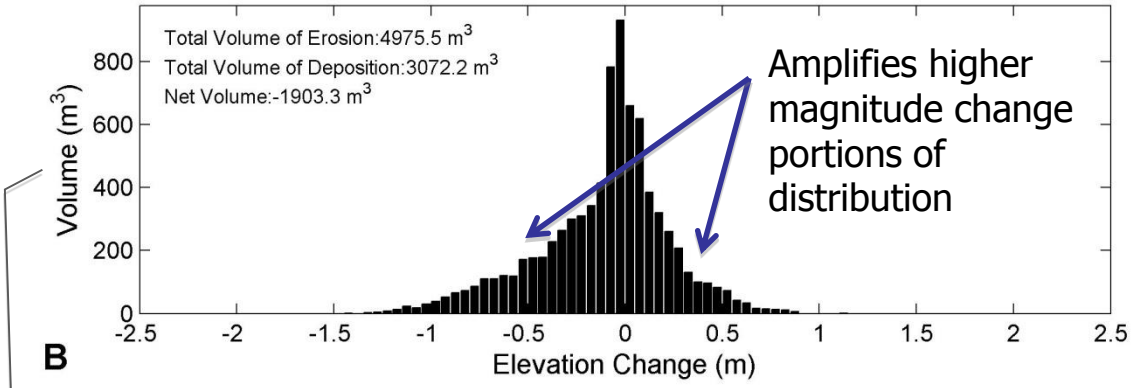
WHAT'S THE HISTOGRAM OF?



- What about the DoD?
- Values on vertical derived in different ways
- Same information revealed differently…

Multiply count by cell size^2 to get area

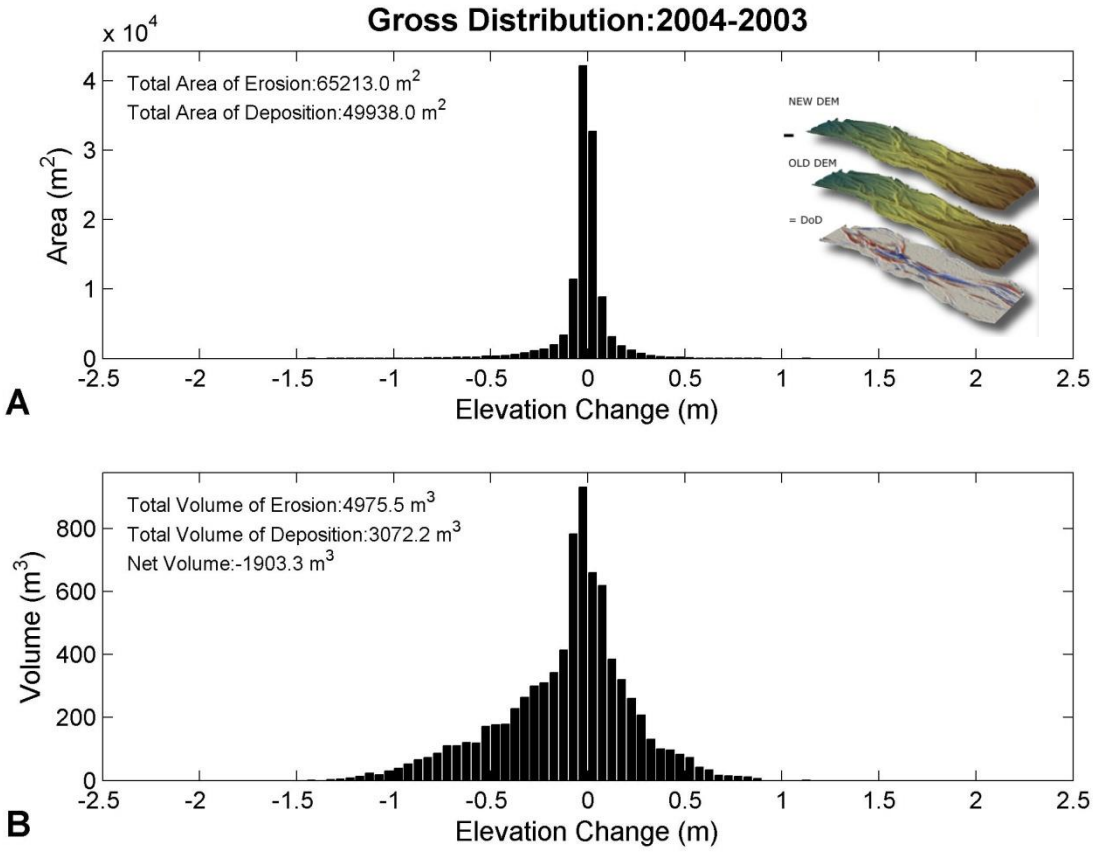




Multiply area by elevation change to get volume

WHY IS SO MUCH OF DoD DISTRIBUTION CENTERED AROUND ZERO?

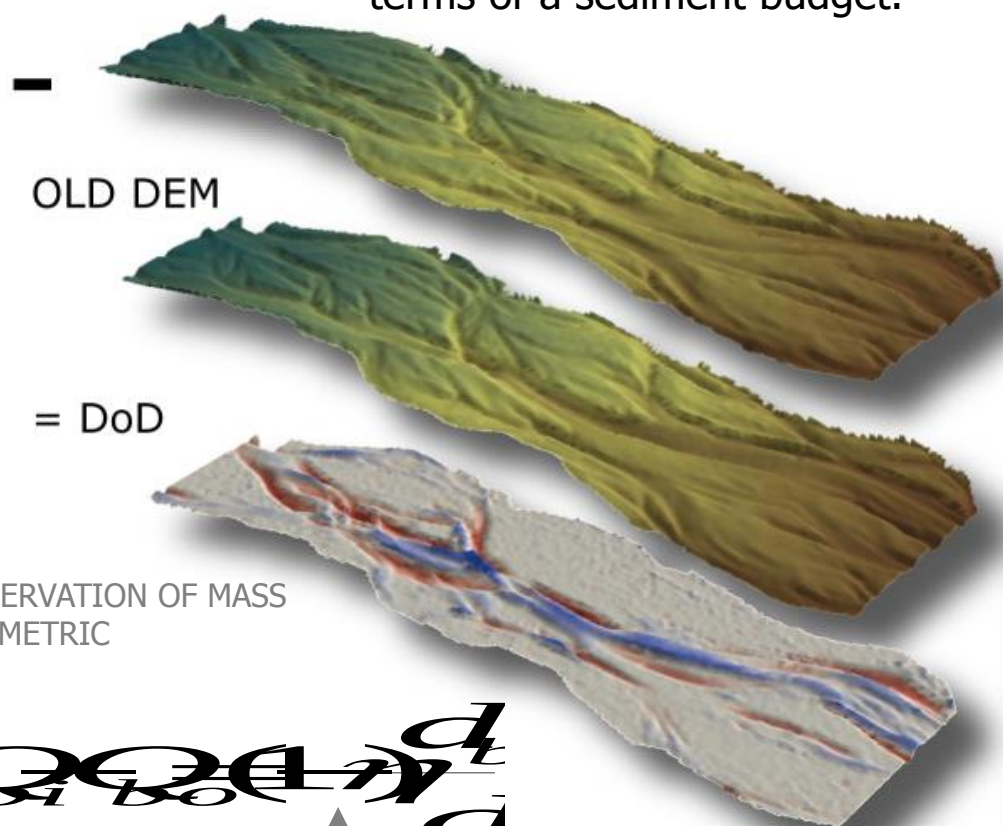
- Is it real?
- Are there just a lot of small changes?
- What needs to happen to get NO change?
- What is likelihood of measuring exact same value?

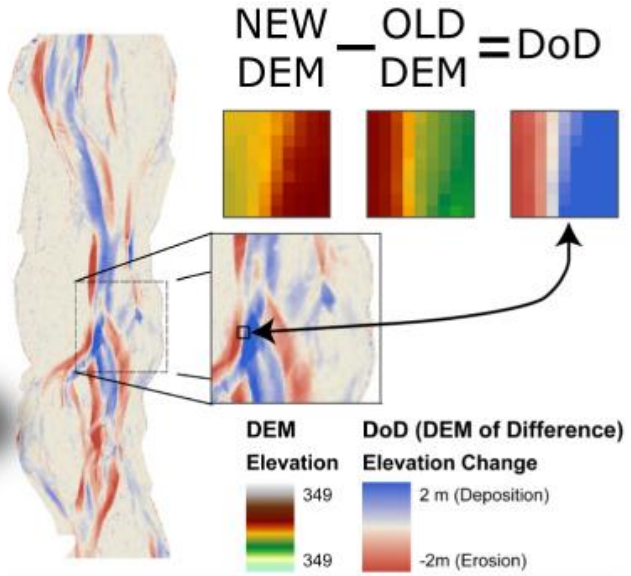


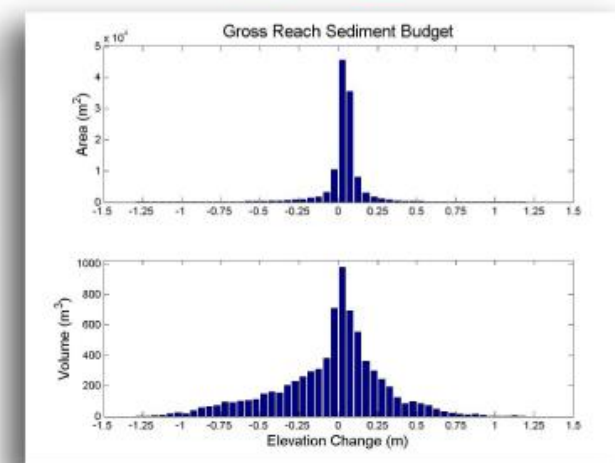
DEM DIFFERENCING

RASTER CALCULATOR….

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







CONSERVATION OF MASS VOLUMETRIC

$$Q_{bi} = Q_{bo} - (1-\lambda)\frac{d_b}{d_i}$$

Volumetric rate of bed material transport

Porosity of bed material

Mclean & Church (1988) – Water Resources Research

© Wheaton 2008

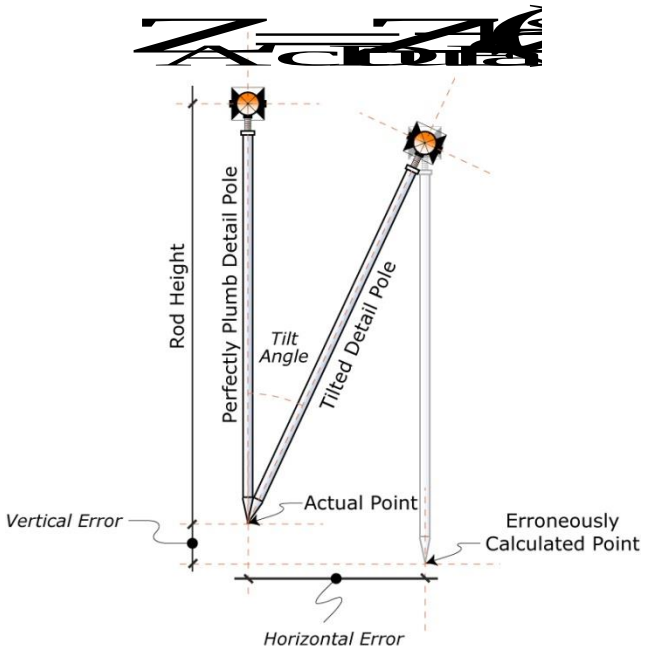
THE CRUX OF THE PROBLEM…

1. *Reliability Uncertainty:* Of the predicted changes, what can we actually distinguish from noise?

We want: $\delta(z) < \frac{\partial z}{\partial t}$

But, $\delta(z) \approx \frac{\partial z}{\partial t}$

2. *Structural Uncertainty:* Geomorphically, what do the calculated changes mean?

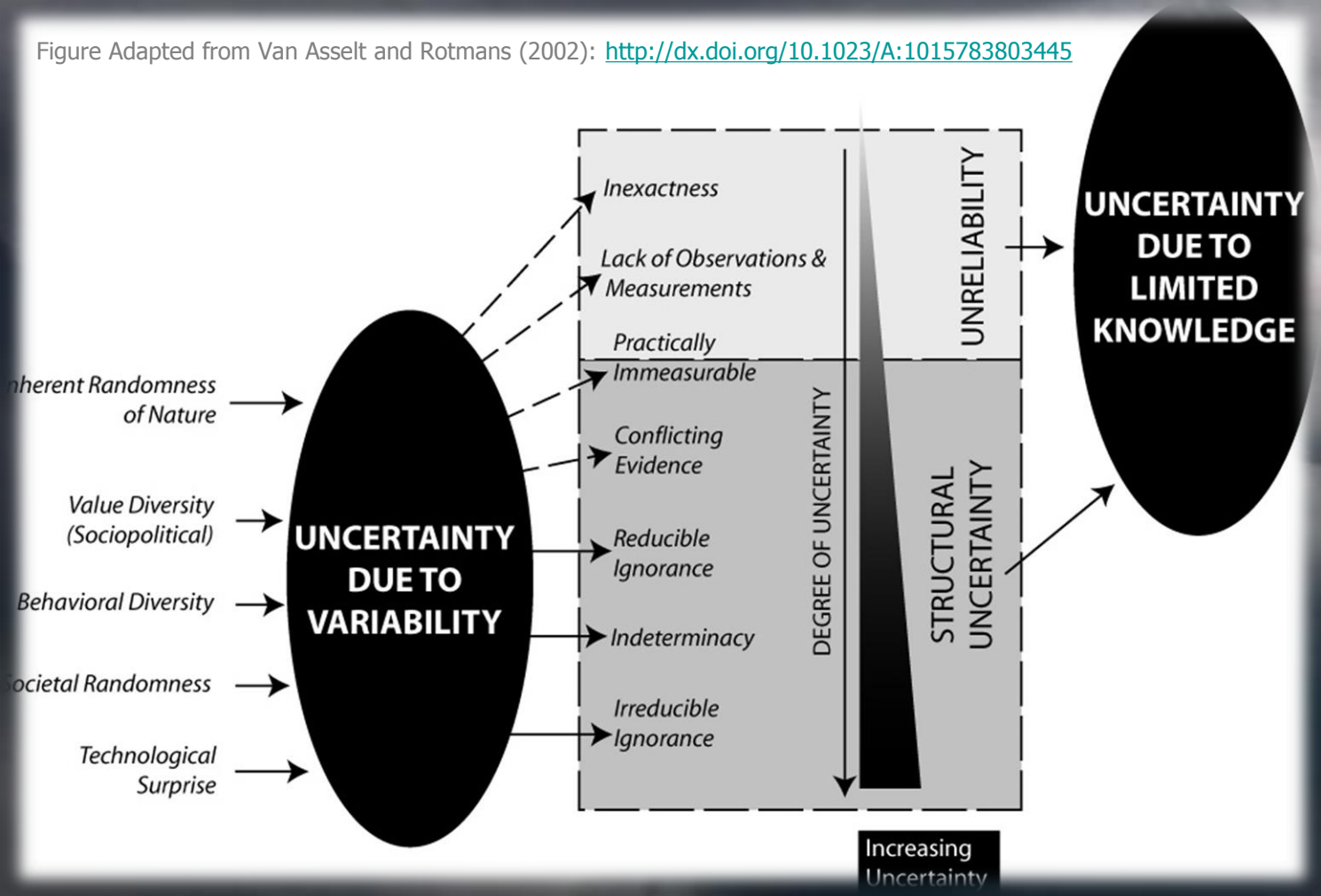


© Wheaton (2008)

UNCERTAINTY…

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

Figure Adapted from Van Asselt and Rotmans (2002): http://dx.doi.org/10.1023/A:1015783803445



DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. Background Problem

2. Basic DEM Differencing

3. Raster Calculator DoD Example

4. Simple Thresholding

5. Raster Calculator Threshold Example

6. Alternatives to traditional raster based GCD (point cloud based)

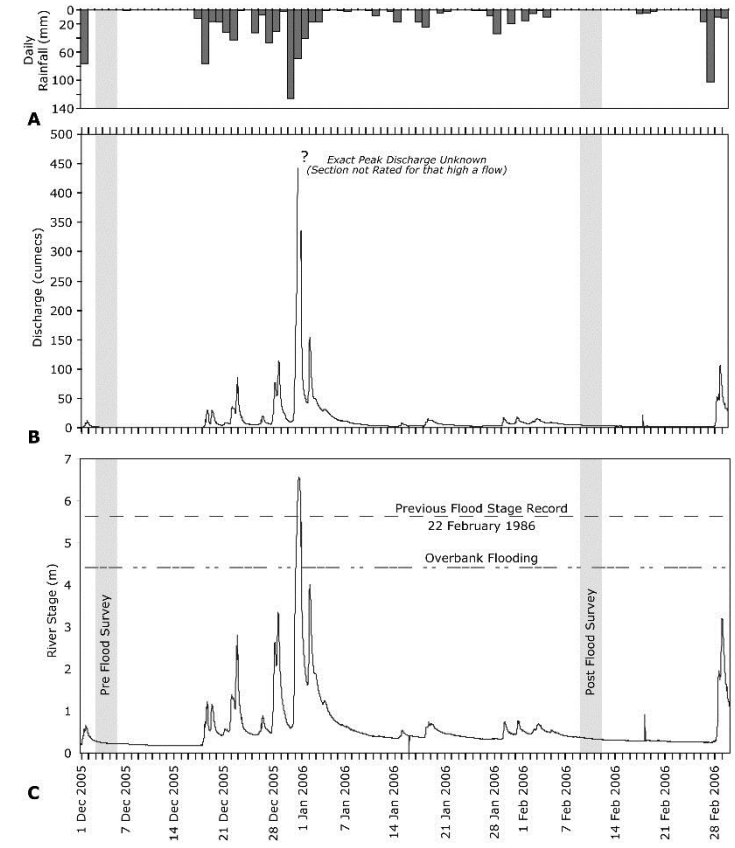
EXERCISE F – PART 1.A: RASTER CALC.

`C:\0_GCD\Excercises\F_SimpleDoD\CA_SulphurCreek\Raw_OrthoInputs`

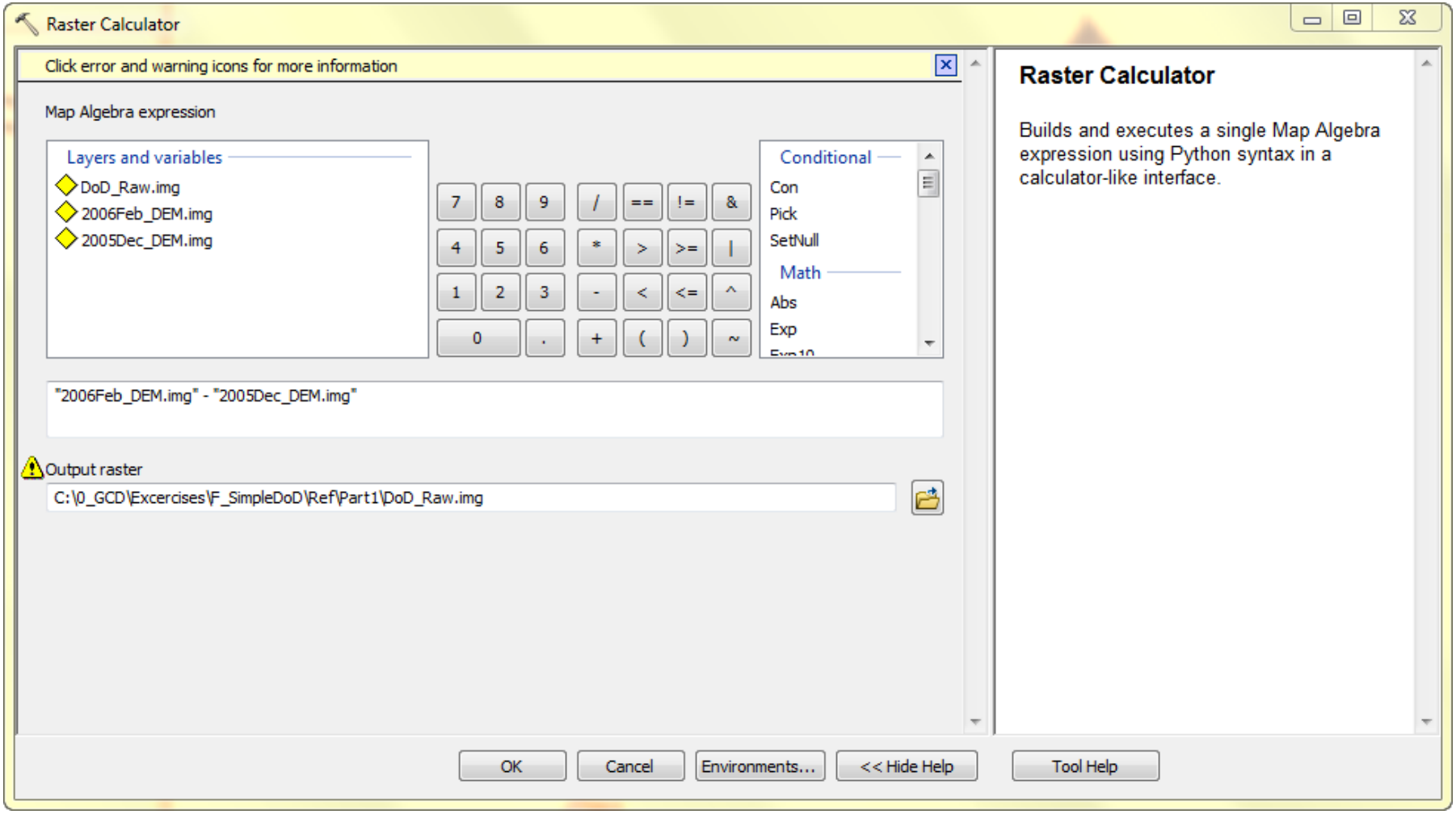
1. Load 2005 & 2006 DEMs
2. Start Raster Calculator
3. Subtract old (2005) from new (2006)
4. Import layer symbology from: `DoD_Raw.img.lyr` and apply to DOD

5 MINUTES…

- DoD w/ Sulphur Creek, CA



WHAT TO DO…


Raster Calculator
Click error and warning icons for more information
Map Algebra expression
Layers and variables
DoD_Raw.img
2006Feb_DEM.img
2005Dec_DEM.img
7 8 9 / == != &
4 5 6 * > >= |
1 2 3 - < <= ^
0 . + ( ) ~
Conditional
Con
Pick
SetNull
Math
Abs
Exp
"2006Feb_DEM.img" - "2005Dec_DEM.img"
Output raster
C:\0_GCD\Excercises\F_SimpleDoD\Ref\Part1\DoD_Raw.img
Raster Calculator
Builds and executes a single Map Algebra expression using Python syntax in a calculator-like interface.
OK
Cancel
Environments...
<< Hide Help
Tool Help

DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. Background Problem

2. Basic DEM Differencing

3. Raster Calculator DoD Example

4. Simple Thresholding

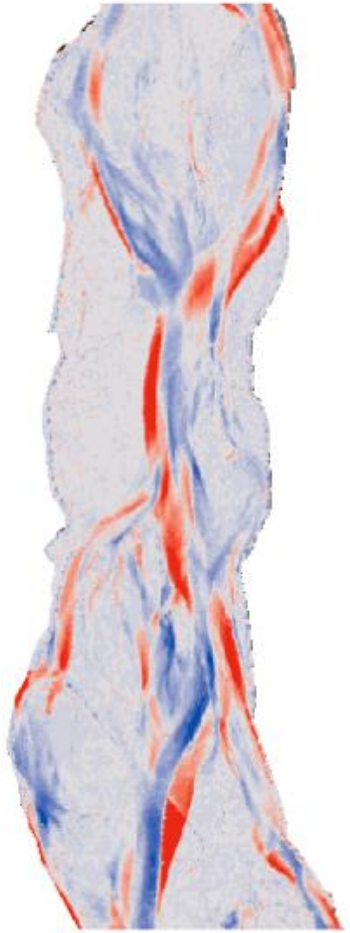
5. Raster Calculator Threshold Example

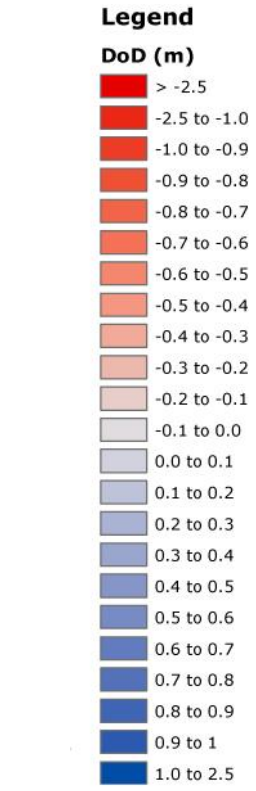
6. Alternatives to traditional raster based GCD (point cloud based)

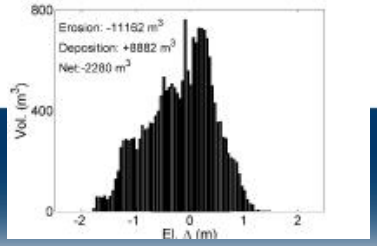
MINIMUM LEVEL OF DETECTION

- Should there be change everywhere?

- Distinguish those changes that are real from noise
- Error assumed to be unbiased (toward erosion or deposition)

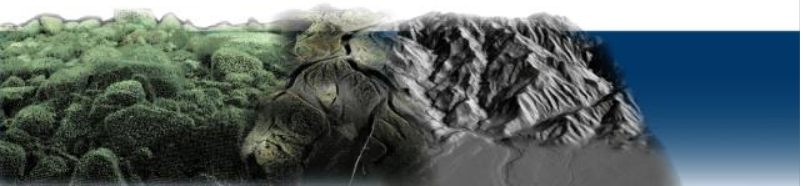


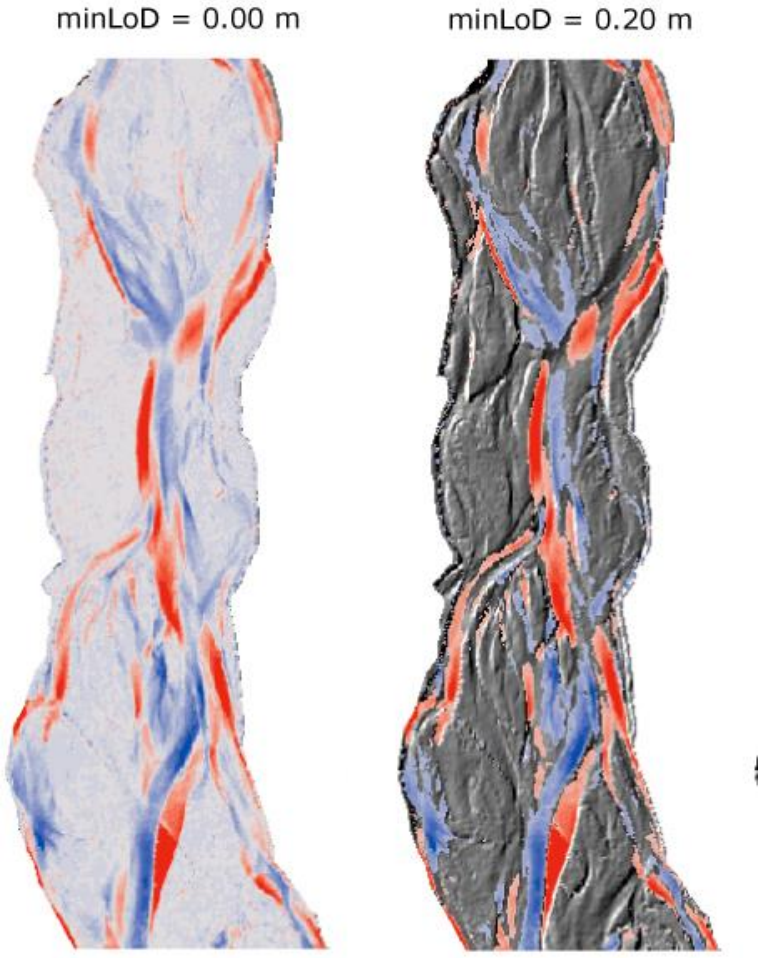


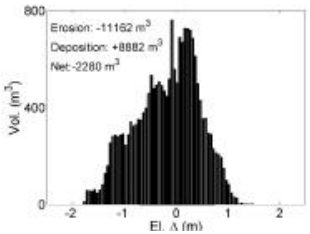


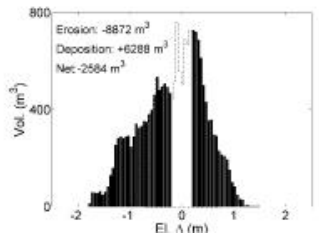
HOW DOES A $_{MIN}$LoD GET APPLIED?

- You take original DoD, and remove all changes <= $_{min}$LoD
- For example +/- 20 cm
- How would you do that?
- What is the assumption here?









DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. Background Problem

2. Basic DEM Differencing

3. Raster Calculator DoD Example

4. Simple Thresholding

5. Raster Calculator Threshold Example

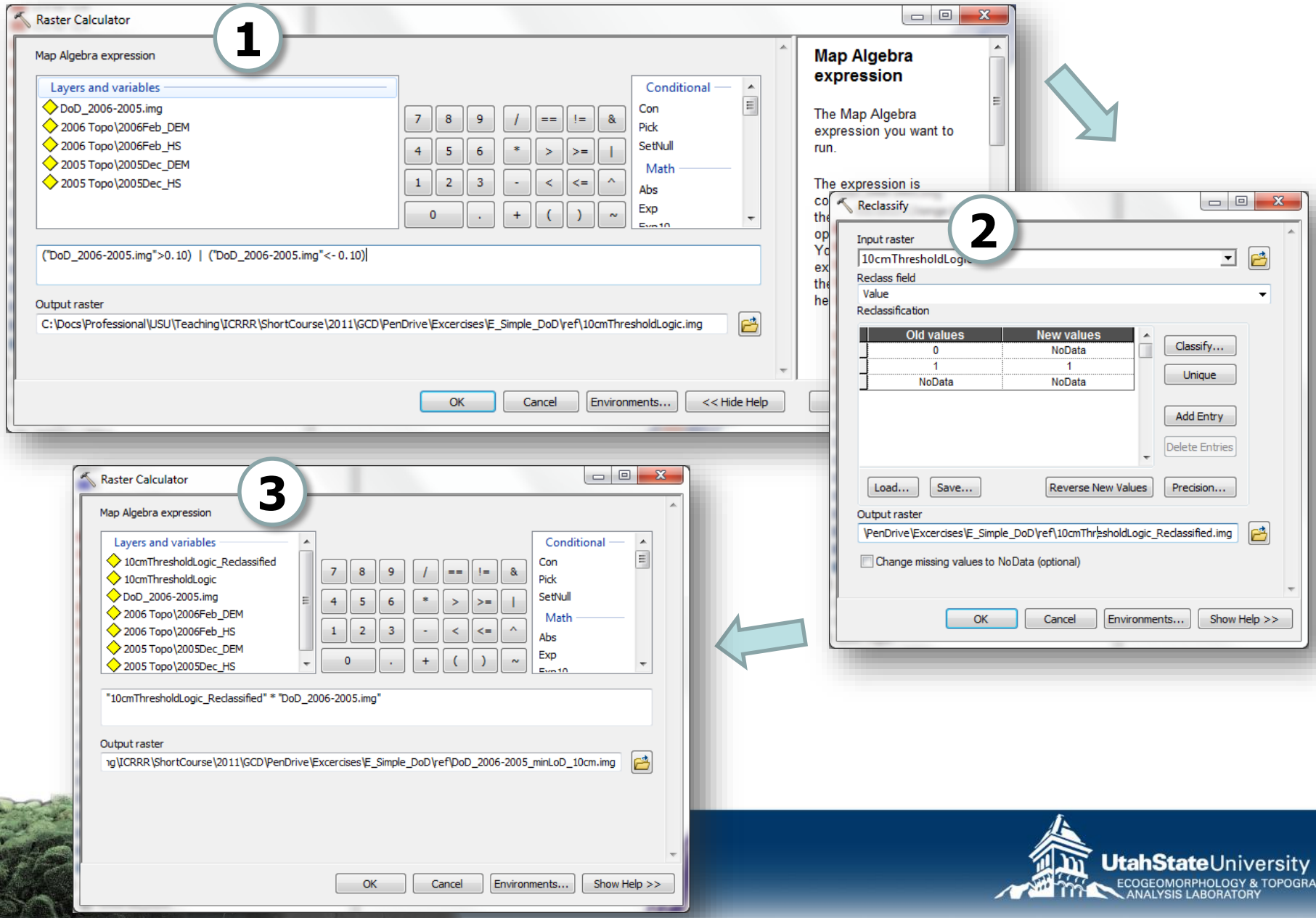
6. Alternatives to traditional raster based GCD (point cloud based)

EXERCISE F – PART 1.B: THRESHOLD

C:\0_GCD\Excercises\F_SimpleDoD\

1. Using Raster Calculator, apply conditional logic to identify mask for areas above a 10 cm threshold
2. Reclassify the mask such that 1s remain 1s, 0s turn to NoData and NoData remains NoData.
3. Using Raster Calculator, apply the Reclass Mask to DoD to 'threshold'
4. Apply DoD Symbology to thresholded DoD for direct visual comparison.

THRESHOLD THE DoD



EXERCISE F – PART 2: SAME THING IN GCD

C:\0_GCD\Excercises\F_SimpleDoD\

No real explanation… just follow steps.

1. Load Blank New Map Document… Save.
2. Create Project
3. Load 2005 and 2006 DEMs as Surveys
4. Calculate Change Detection using simple minLoD and specify
5. Explore and visualize output

DETAIL PLAN

TRADITIONAL APPROACHES TO GEOMORPHIC CHANGE DETECTION

1. Background Problem

2. Basic DEM Differencing

3. Raster Calculator DoD Example

4. Simple Thresholding

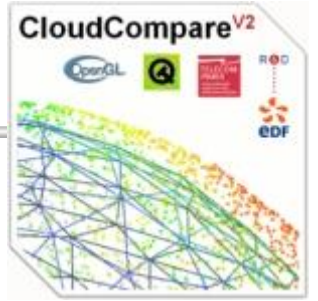
5. Raster Calculator Threshold Example

6. Alternatives to traditional raster based GCD (point cloud based)

ALTERNATIVES TO RASTER-BASED?

- With ALS, TLS, MBS, SFM point clouds very common

CloudCompare



www.danielgm.net/cc/

Gmail Voicemail G_Scholar Web of Knowledge ET-AL Egnyte G_Maps Reader Pandora GIS Class Netflix Picasa Other bookma

CloudCompare

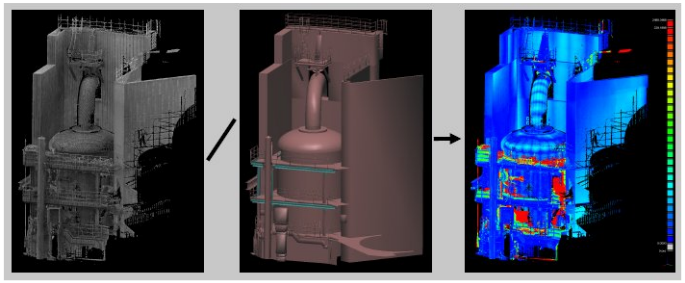
3D point cloud and mesh processing software
Open Source Project

Want to support/help us?
DONATE pledgie.com
We need your support!

Home - Presentation - Download - Tutorials - Documentation - Forum - Declare a bug

Introduction

CloudCompare is a 3D point cloud (and triangular mesh) processing software. It has been originally designed to perform comparison between two 3D points clouds (such as the ones obtained with a laser scanner) or between a point cloud and a triangular mesh. It relies on a specific octree structure that enables great performances[1] in this particular function. It was also meant to deal with huge point clouds (typically more than 10 millions points, and up to 120 millions[2] with 2 Gb of memory).



[1] *for instance, it takes about 10 s. to compute the distances of 3 million points to a 14.000 triangles mesh on a laptop wih dual-core processor*
[2] *however display and interactivity may be severely downgraded with so many points ;)*

Afterwards, it has been extended to a more generic point cloud processing software, including many advanced algorithms (registration, resampling, color/normal/scalar fields handling, statistics computation, sensor management, interactive or automatic segmentation, display enhancement, etc.).

User interface

- Free cloud visualization & analysis software
  - 3D (not 2.5D) Triangular Meshing
  - Very efficient
  - Nice Visualization

Available at: http://danielgm.net/cc

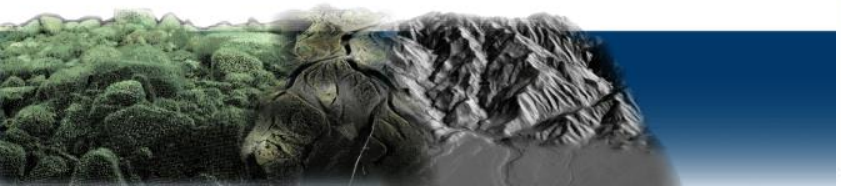
M3C2C

- High Precision 3D point cloud comparison
  - Nice command line utility
  - No documentation just yet…

Paper is not out yet… but:

Lague, D., Brodu, N., Leroux, J., In Review. Accurate 3D comparison of complex topography with terrestrial laser scanner : application to the Rangitikei canyon (NZ). ISPRS journal of Photogrammmetry and Remote Sensing.

Web site: http://www.geosciences.univ-rennes1.fr/spip.php?rubrique95&lang=fr



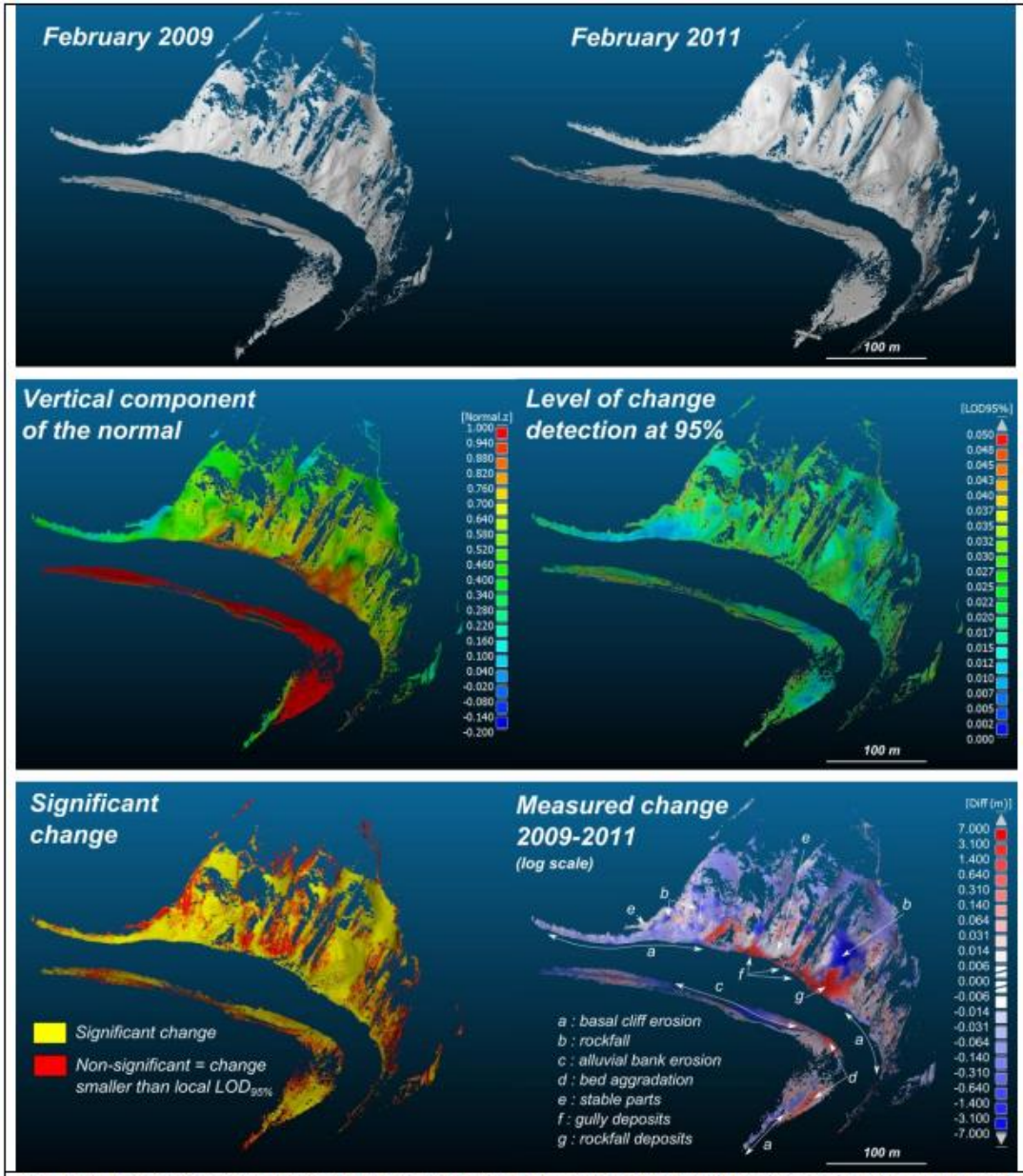


Figure 10: Application of the M3C2 algorithm to the Rangitikei canyon data. Raw input data are the February 2009 and 2011 surveys shown here without vegetation for clarity. The normal orientation are computed from the 2009 data at a fixed scale (D=15 m for the cliff, and 12 m for the inner bank). The $LOD_{95\%}$ is given by eq. (1) and includes a component of 5.88 mm due to registration uncertainty (1.96 x 3 mm). A change is considered statistically significant when the $LOD_{95\%}$ is smaller than the measured change and that a minimum of 4 points were used to compute the average position of each cloud. Surface change is presented in logarithmic scale with a minimum value of 6 mm corresponding to the minimum detectable change.