CHaMP

STATUS OF GEOMORPHIC CHANGE DETECTION OF 2011 TO 2012 SURVEYS

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Wally Macfarlane
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CHaMP Post-Season Workshop
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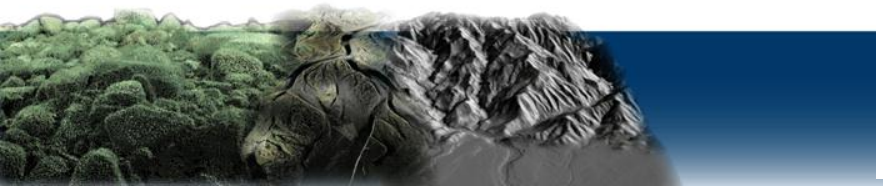
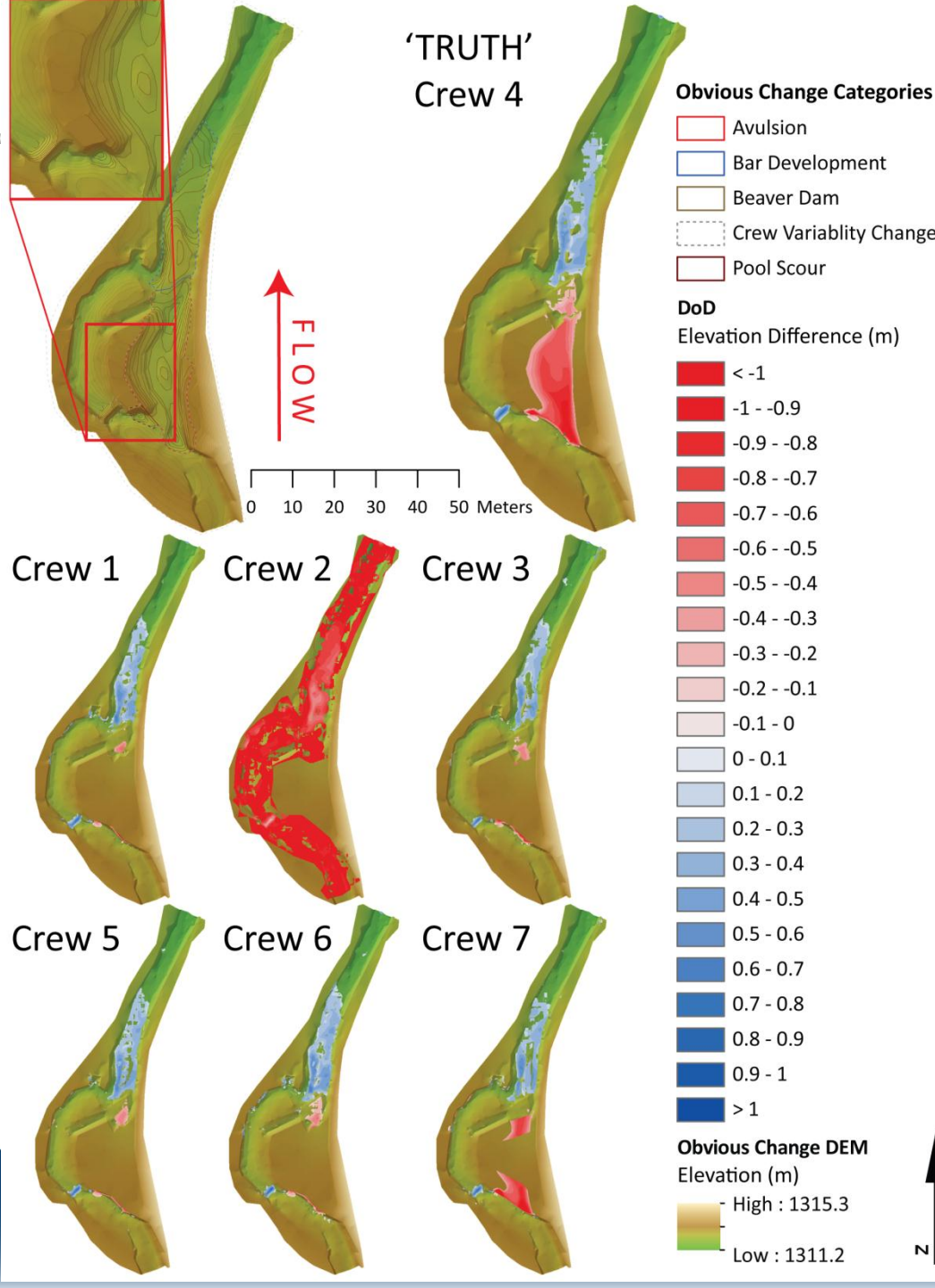
UtahStateUniversity
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY

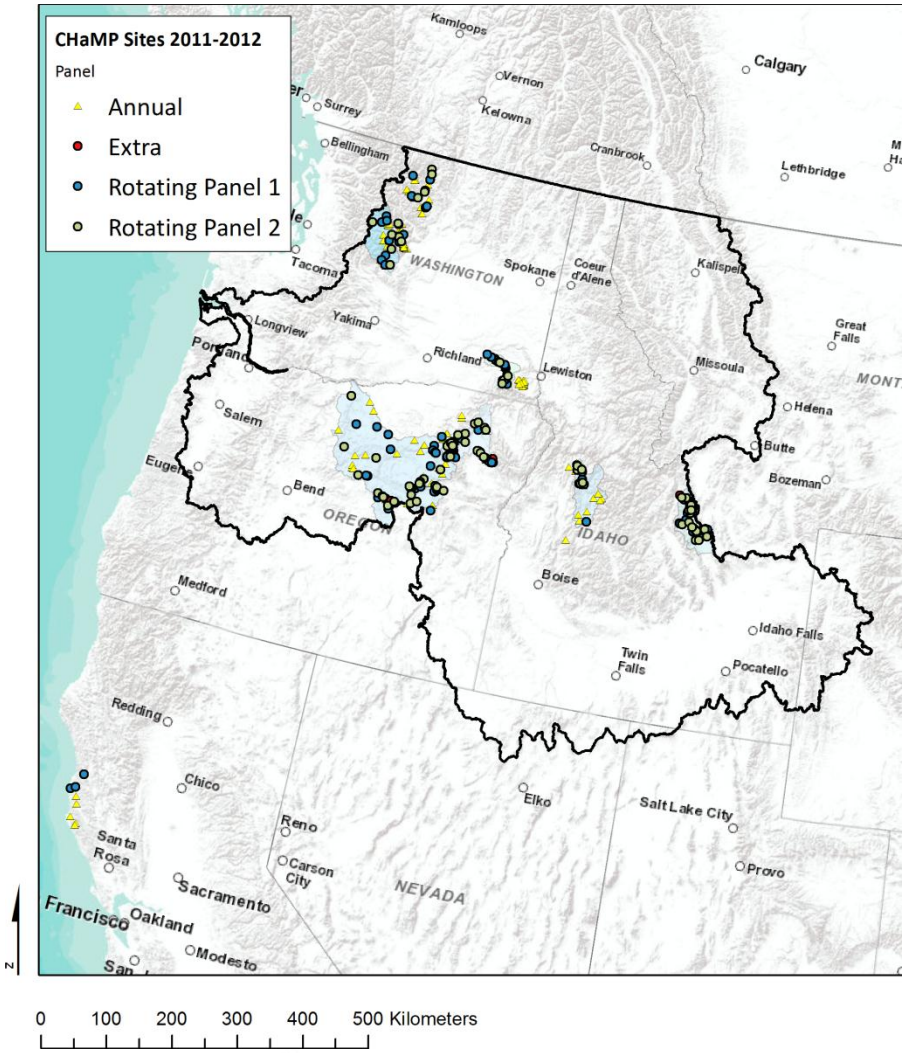
ACKNOWLEDGEMENTS

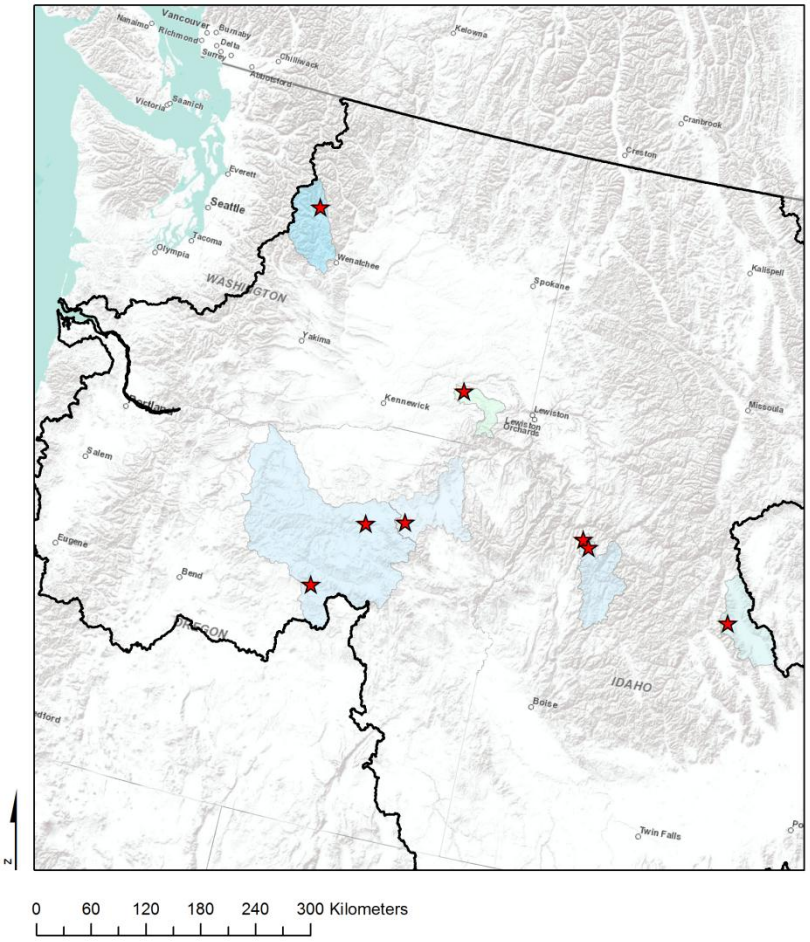
- All the CHaMP Crews
- Boyd Bouwes
- Andy Hill & Entire ELR Team
- Kelly Whitehead & Carol Volk
- Steve Rentmeister & SITKA
- ET-AL





2011-2012 ANNUAL SITES w/ GCD

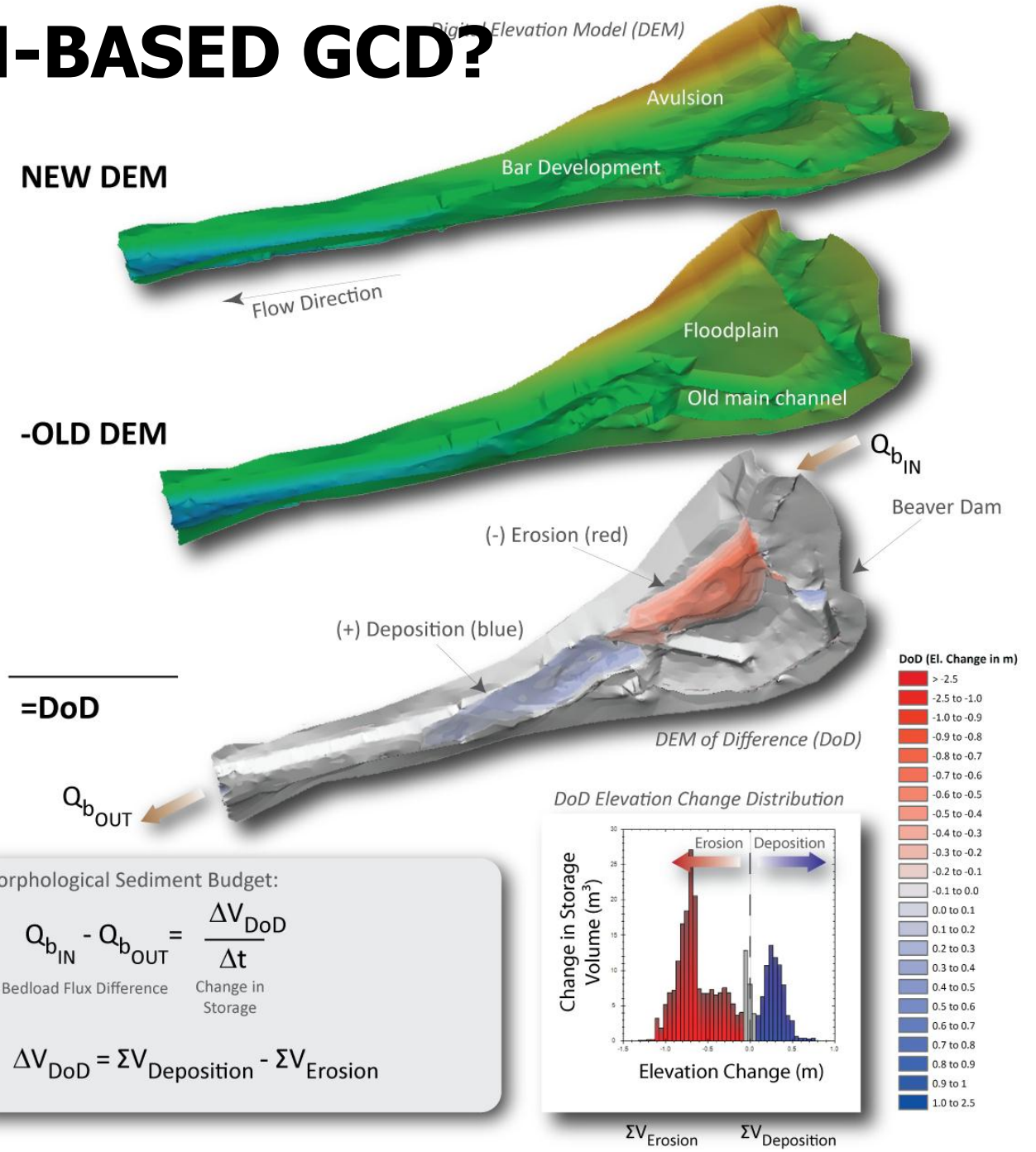




WHAT IS DEM-BASED GCD?

A little background…

- DEM -> digital elevation model
- GCD -> geomorphic change detection
- Of everything that CHaMP measures, GCD is one of most sensitive to the quality of the data and influences like crew variability



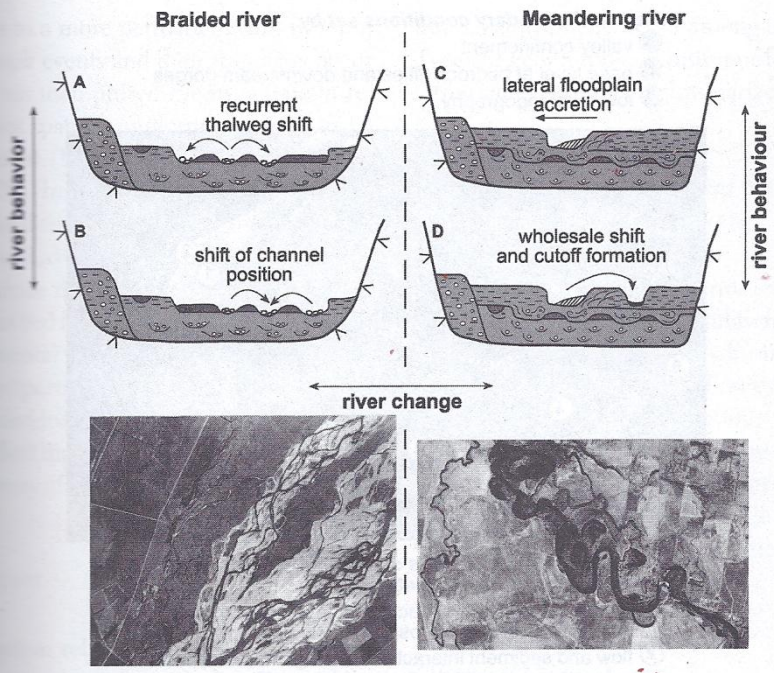
Morphological Sediment Budget:

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

Bedload Flux Difference — Change in Storage

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

CHANGE VS. BEHAVIOR



...River behavior and river change. River *behavior* reflects adjustments that occur within the natu-...for adjustment of a river such as those depicted for the braided river in sections A and B and for ...ering river in sections C and D. River *change* reflects a wholesale shift in river type as depicted by ...from a braided to a meandering river.

SOCIETY FOR ECOLOGICAL RESTORATION INTERNATIONAL

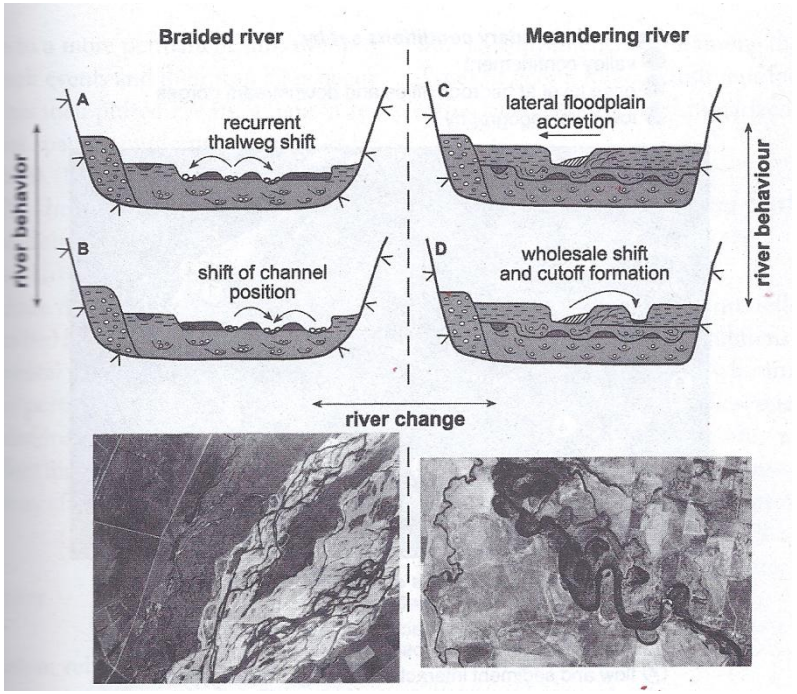
River Futures

An Integrative Scientific Approach to River Repair

Edited by Gary J. Brierley and Kirstie A. Fryirs

WAYS A RIVER CAN ADJUST LOCALLY

- Adjustments (Erosion/Deposition)
  - Channel morphology
    - Channel Size
    - Channel Shape
  - Bed Character
  - Planform
  - Arrangement of geomorphic units

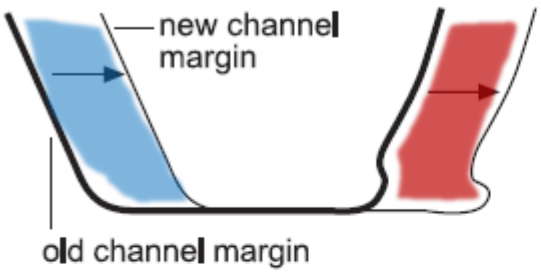


- An adjustment is not a *change* in river type!
- "River *behavior* equates to adjustments around a characteristic assemblage of geomorphic units"

FORMS OF ADJUSTMENT TO CHANNEL SHAPE

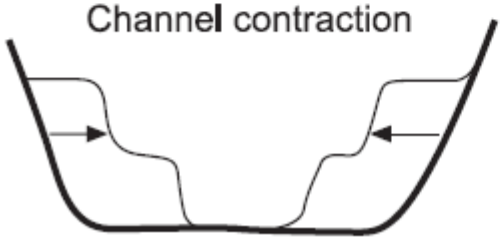
Lateral adjustment proceses

Lateral migration



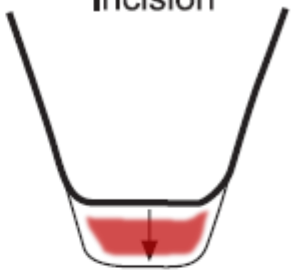
Channel expansion

Channel contraction

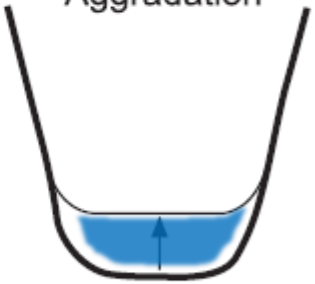


Vertical adjustment proceses

Incision



Aggradation

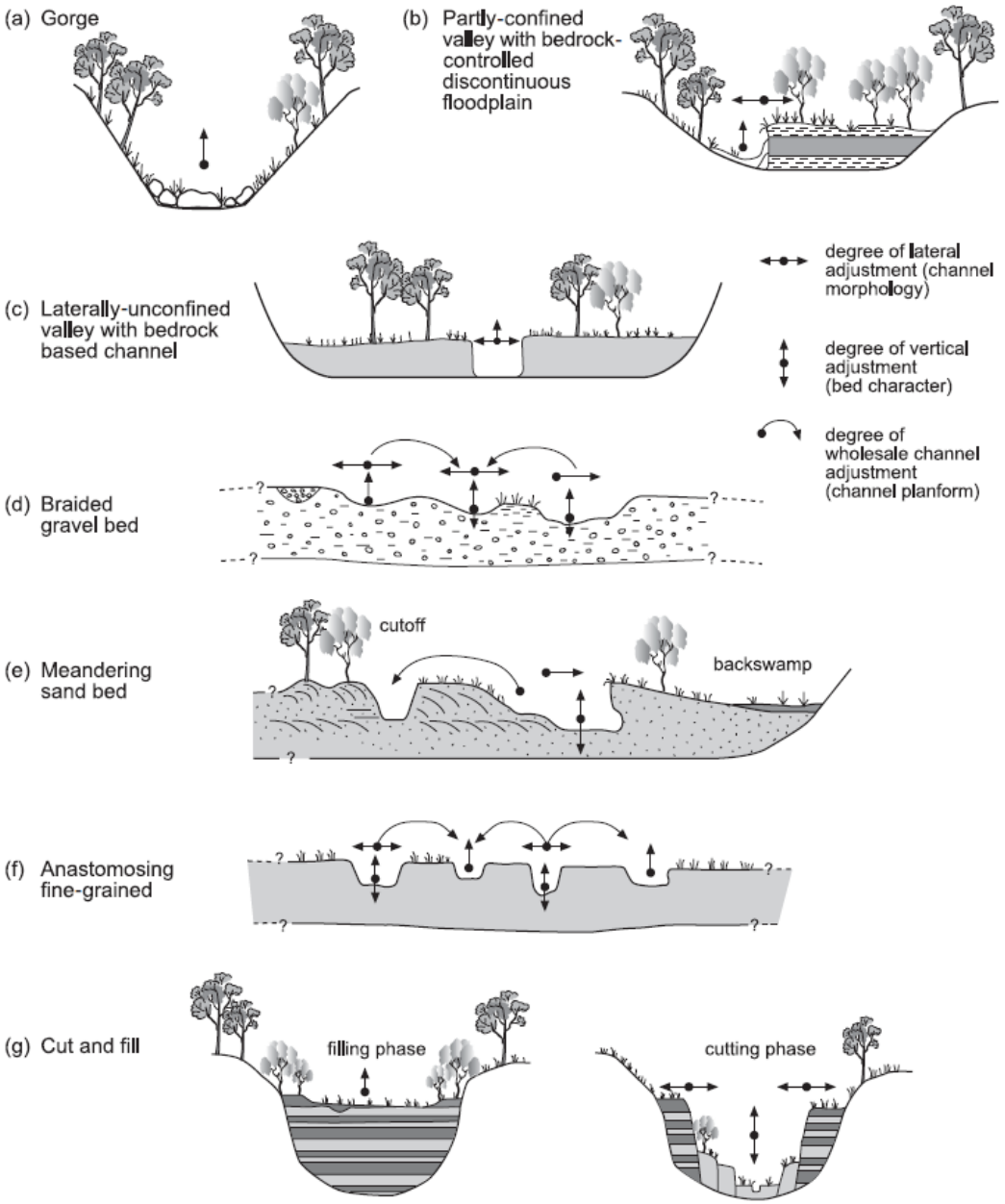


- Geomorphologists have lots of special names for things…
- Basically, all expressions or special cases of erosion or deposition

From Brierley & Fryirs (2005)

NATURAL CAPACITY FOR ADJUSTMENT

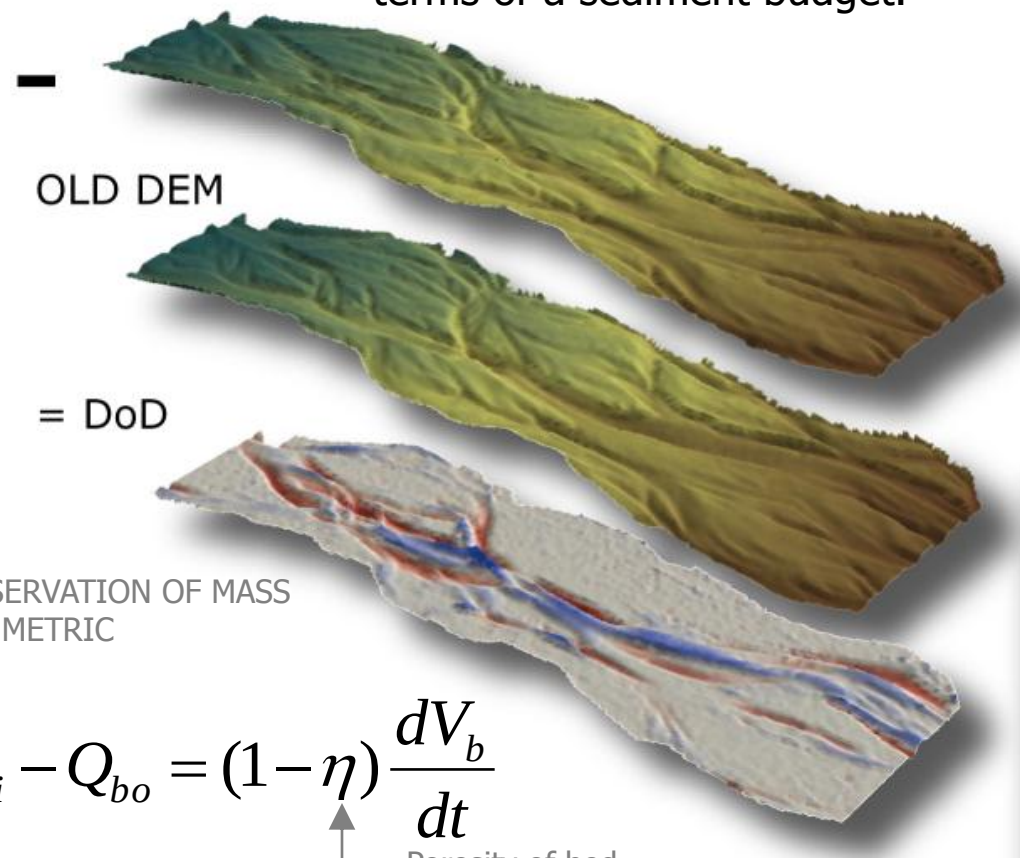
- Plausible limits on what adjustments are possible

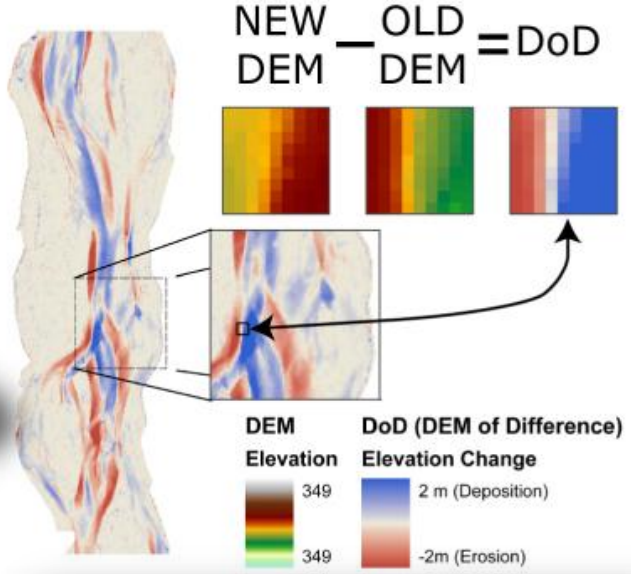


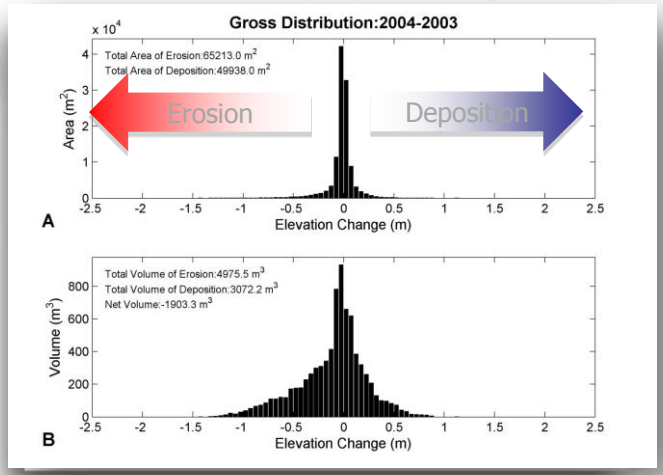
From Brierley & Fryirs (2005)

CHANGE DETECTION WITH DEM DIFFERENCING

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







CONSERVATION OF MASS
VOLUMETRIC

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

- $Q_{bi} - Q_{bo}$: Volumetric rate of bed material transport
- η: Porosity of bed material

Mclean & Church (1988) – Water Resources Research

© Wheaton (2008)

IN A PERFECT WORLD…

- The signal (the change we're trying to detect) is much greater than our noise….

$$\frac{\partial z}{\partial t} >> \delta(z)$$

- In many instances, the noise is of similar magnitude to our noise…

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

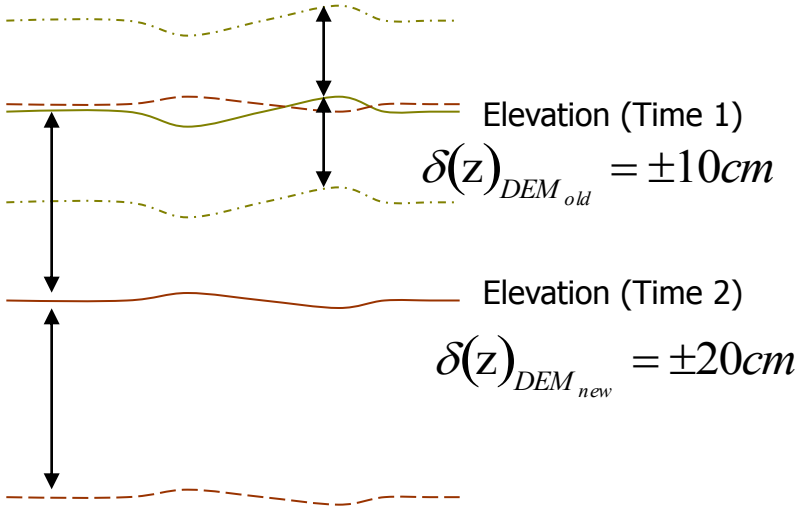
- Better in places where vertical changes are large!

Surface Noise:

- LiDaR : +/- 10 to 25 cm (14 to 36 cm $_{min}$LoD)
- Total Station: +/- 2 to 10 cm (3 to 14 cm $_{min}$LoD)

SMALL PROBLEM…

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



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

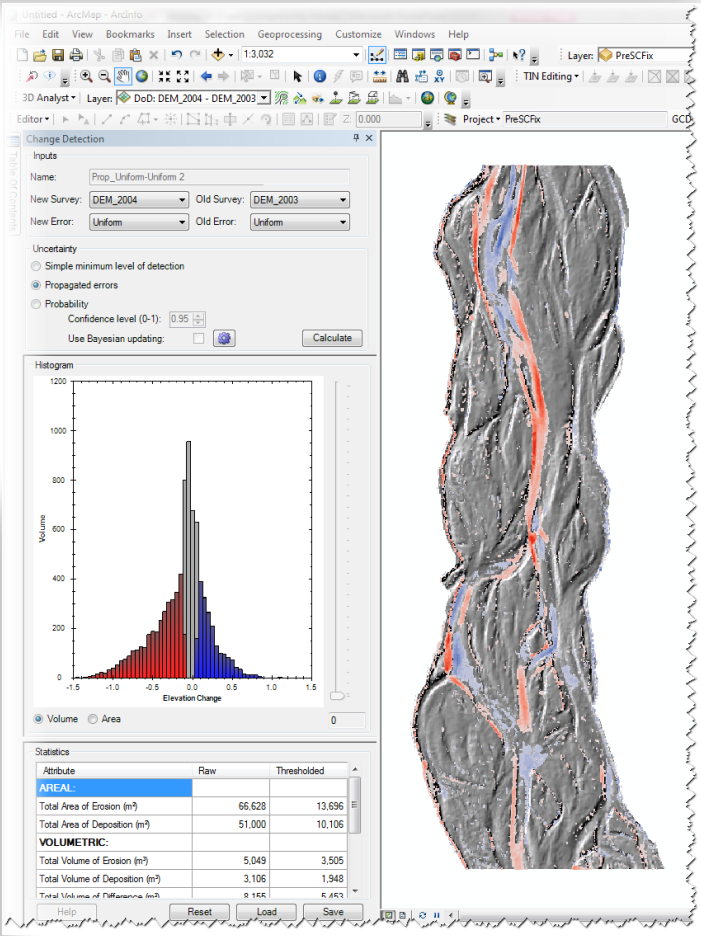
e.g. $\delta(z) = \sqrt{(10)^2 + (20)^2} = 22.36$

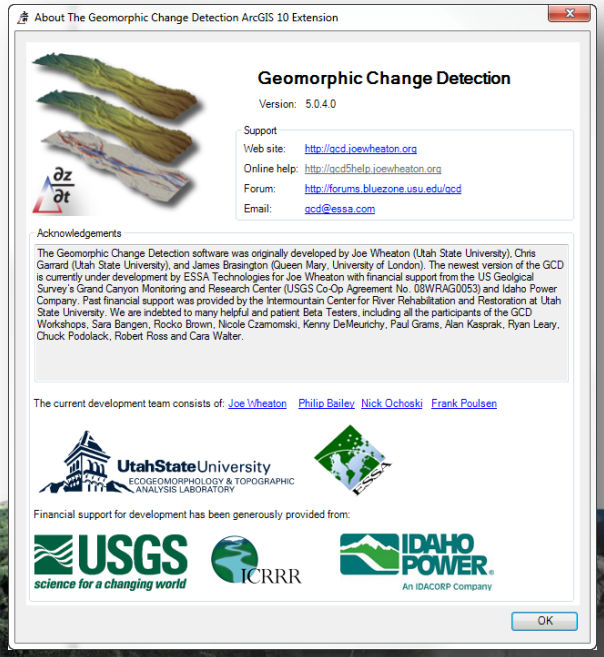
22.36 cm ≈ 8.8 in

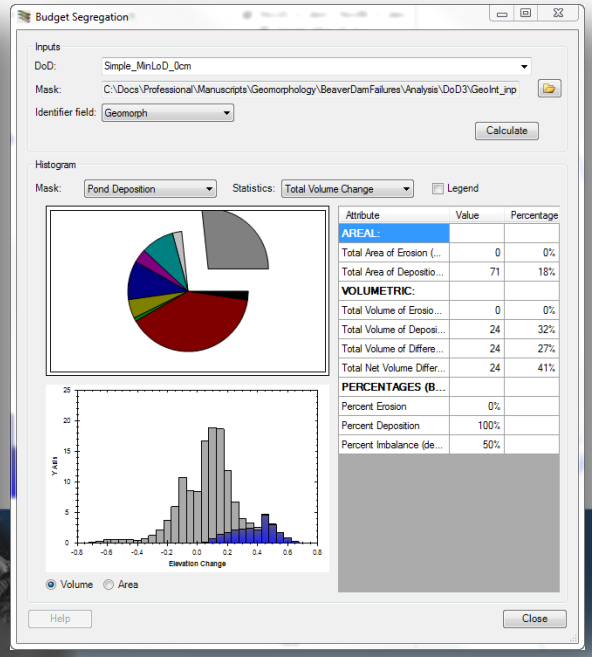
See
- Brasington et al (2000): *ESPL*
- Lane et al (2003): *ESPL*
- Brasington et al (2003): *Geomorphology*

GCD NOW IN RBT-CHAMP

- **GCD 5** makes it easy to:
  - Robustly estimate errors in DEMs
  - Determine significance of uncertainty on DoD & Sediment Budget
  - Calculate change in storage sediment budgets (with +/- vol.)
  - Quantitatively interpret and spatially segregate budget







http://gcd.joewheaton.org

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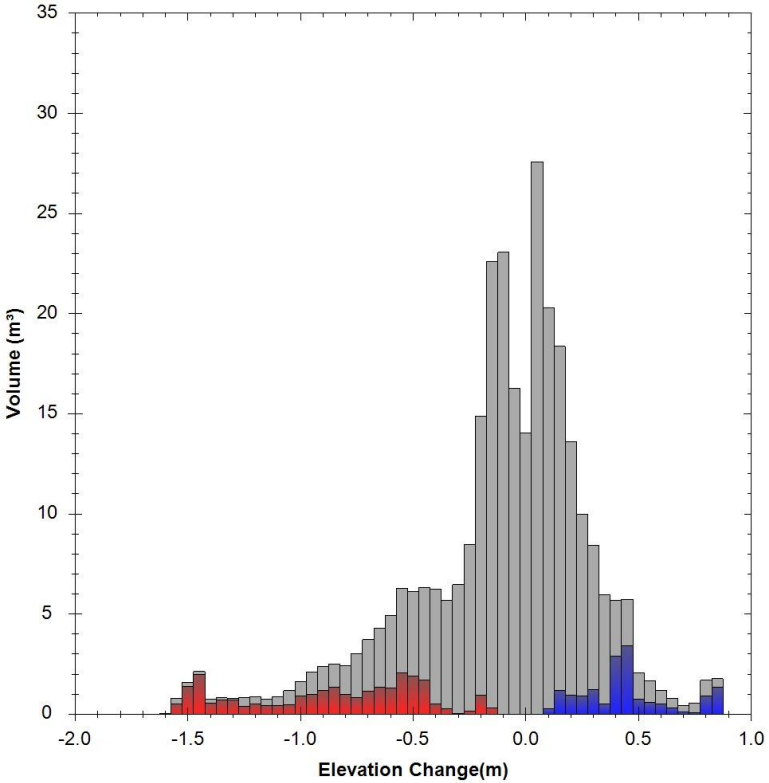
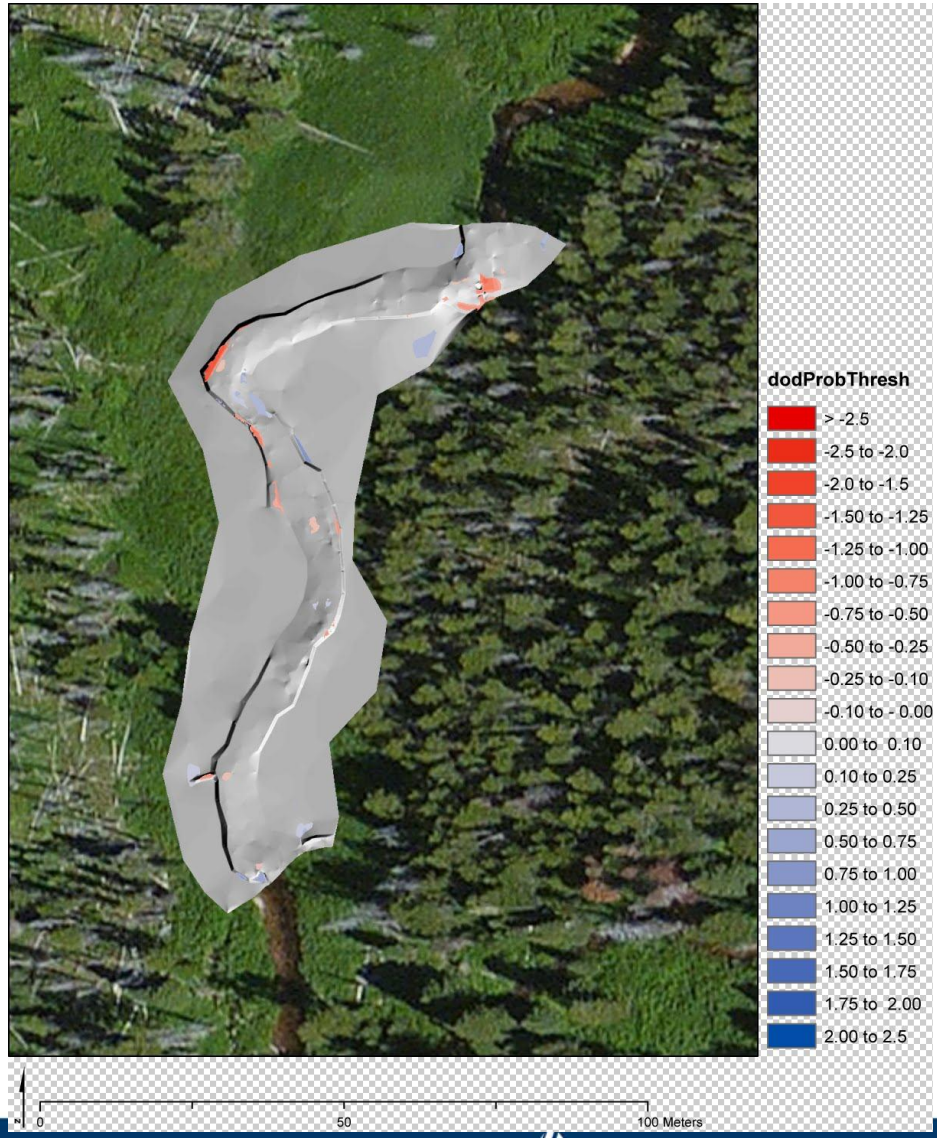
A TYPICAL 2012 STORY….

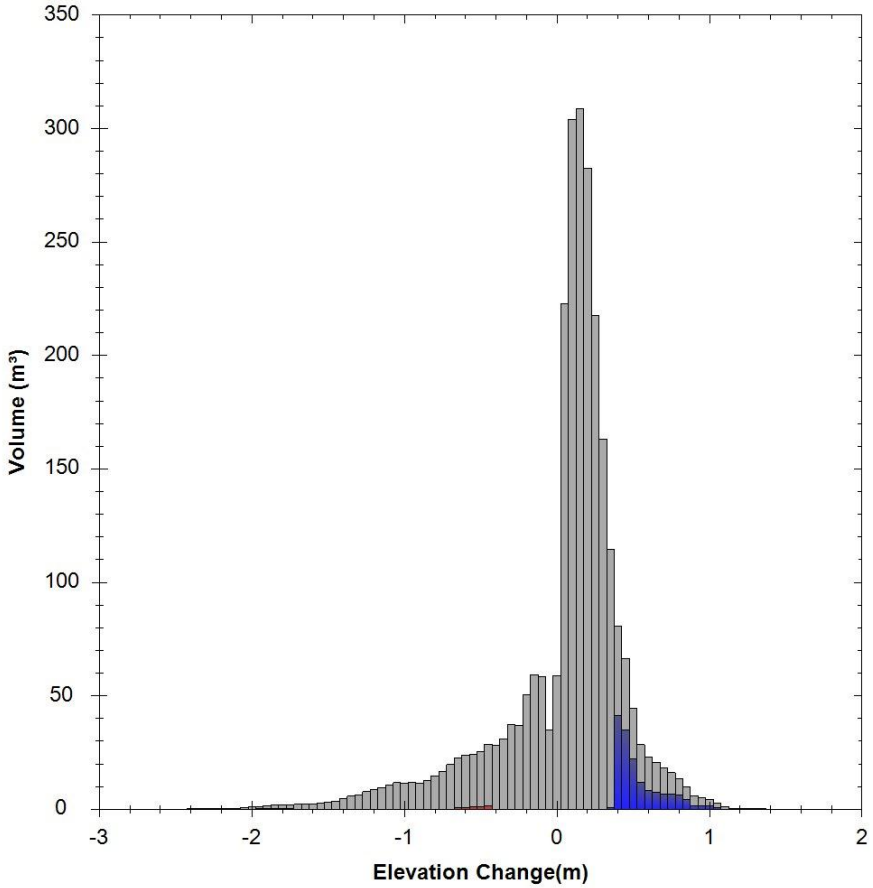
- Lake Creek: South Fork Salmon Watershed, ID

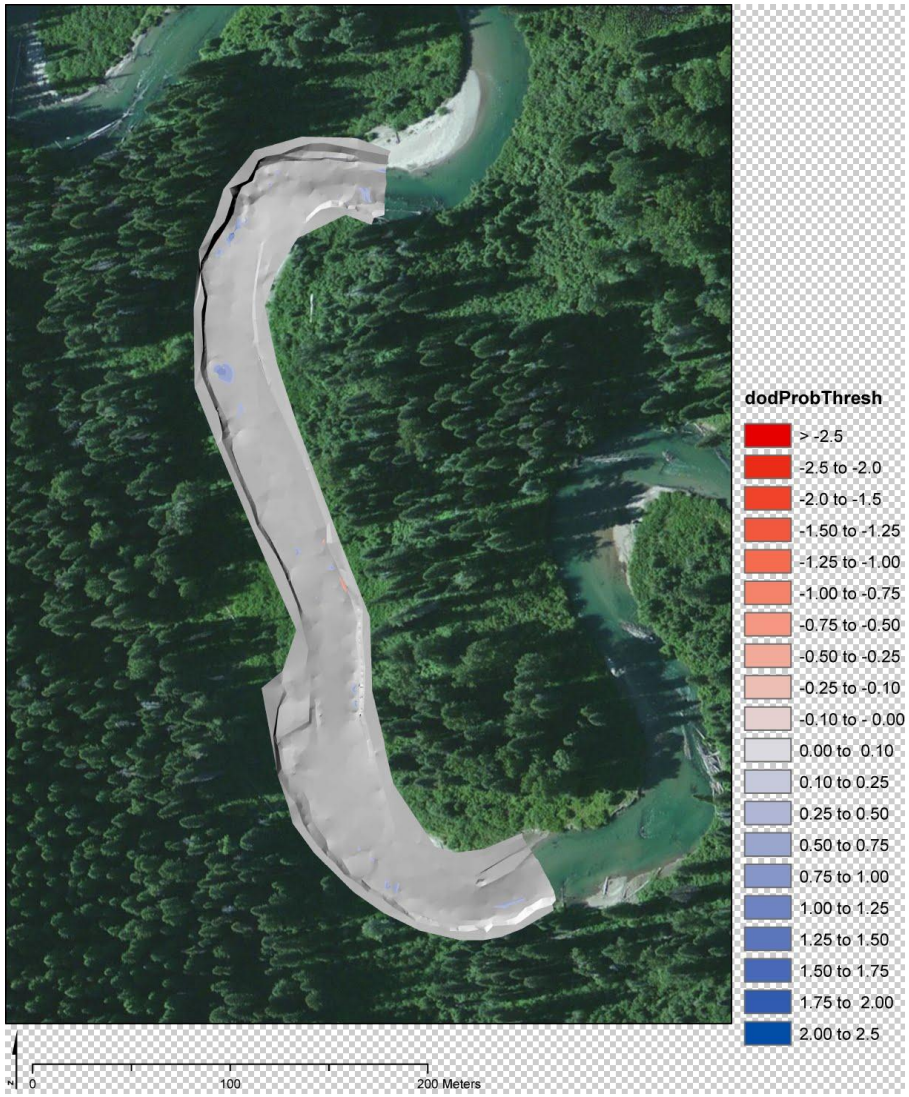




UTTERLY PLAUSIBLE… TOO CONSERVATIVE

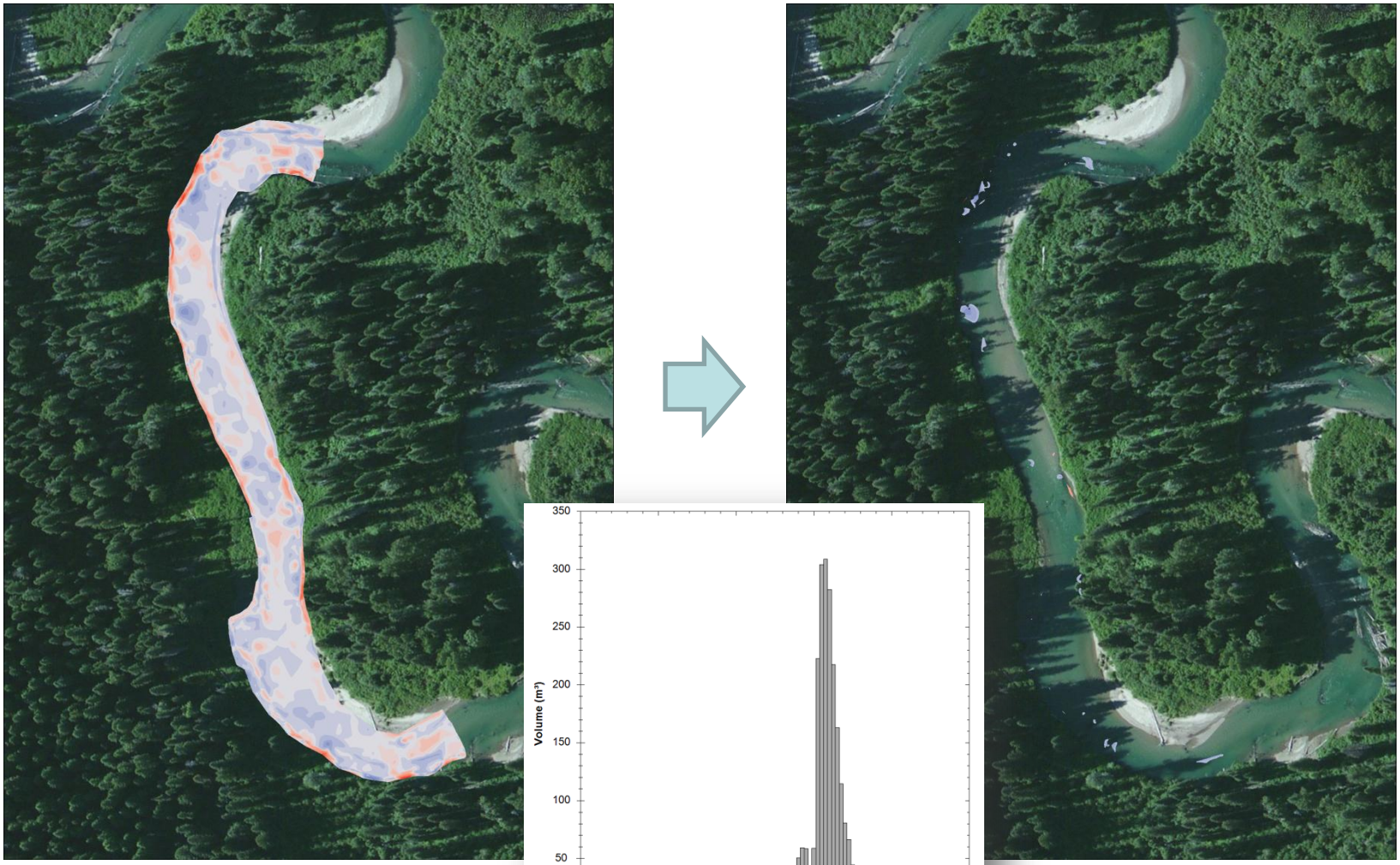
- Chiwawa River: Wenatchee Watershed, WA

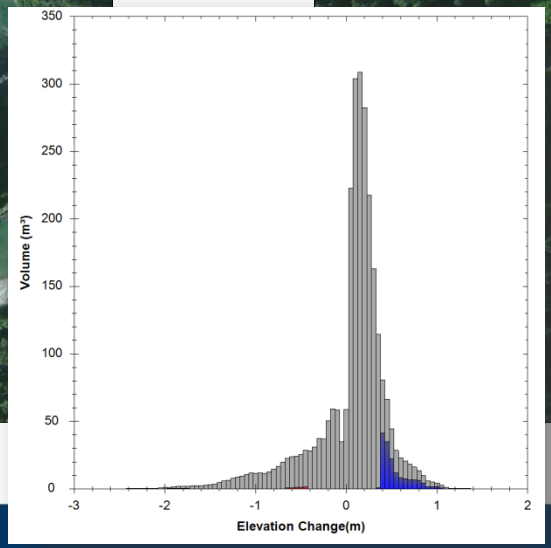




THRESHOLDING…

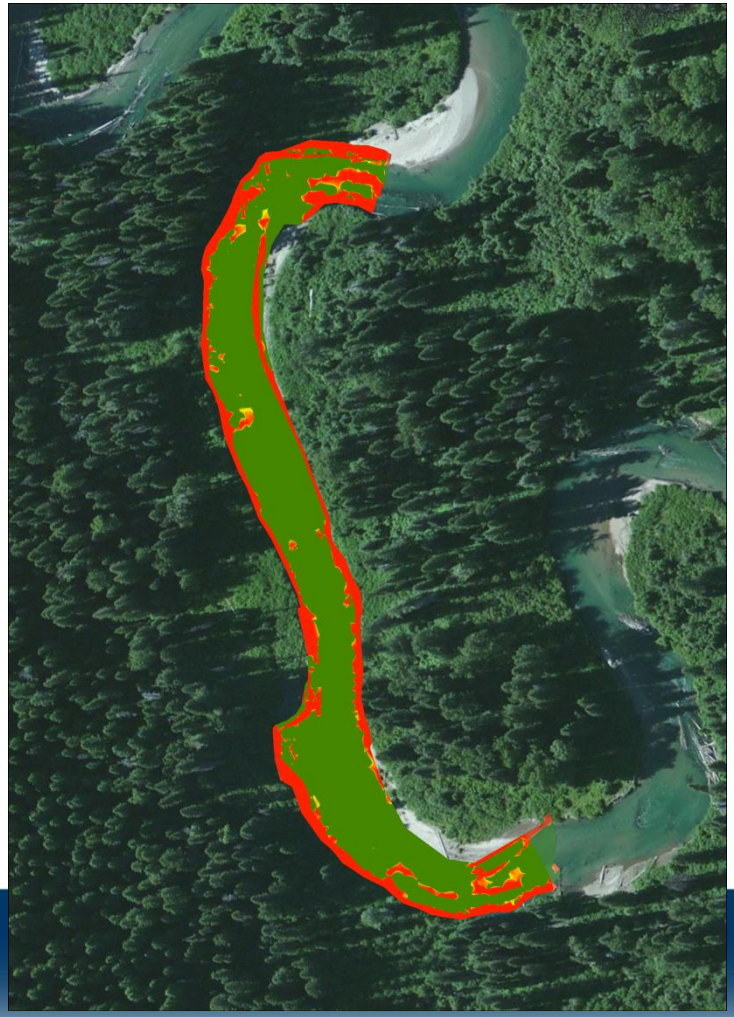
- NOISE?

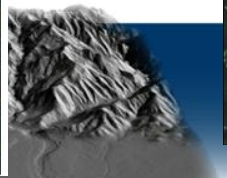




WHY? WHAT'S GOING ON?

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





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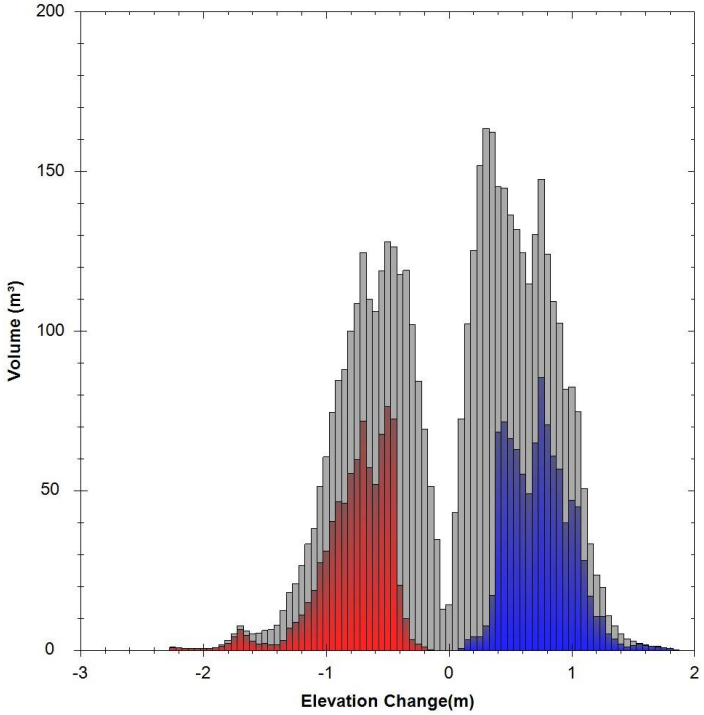
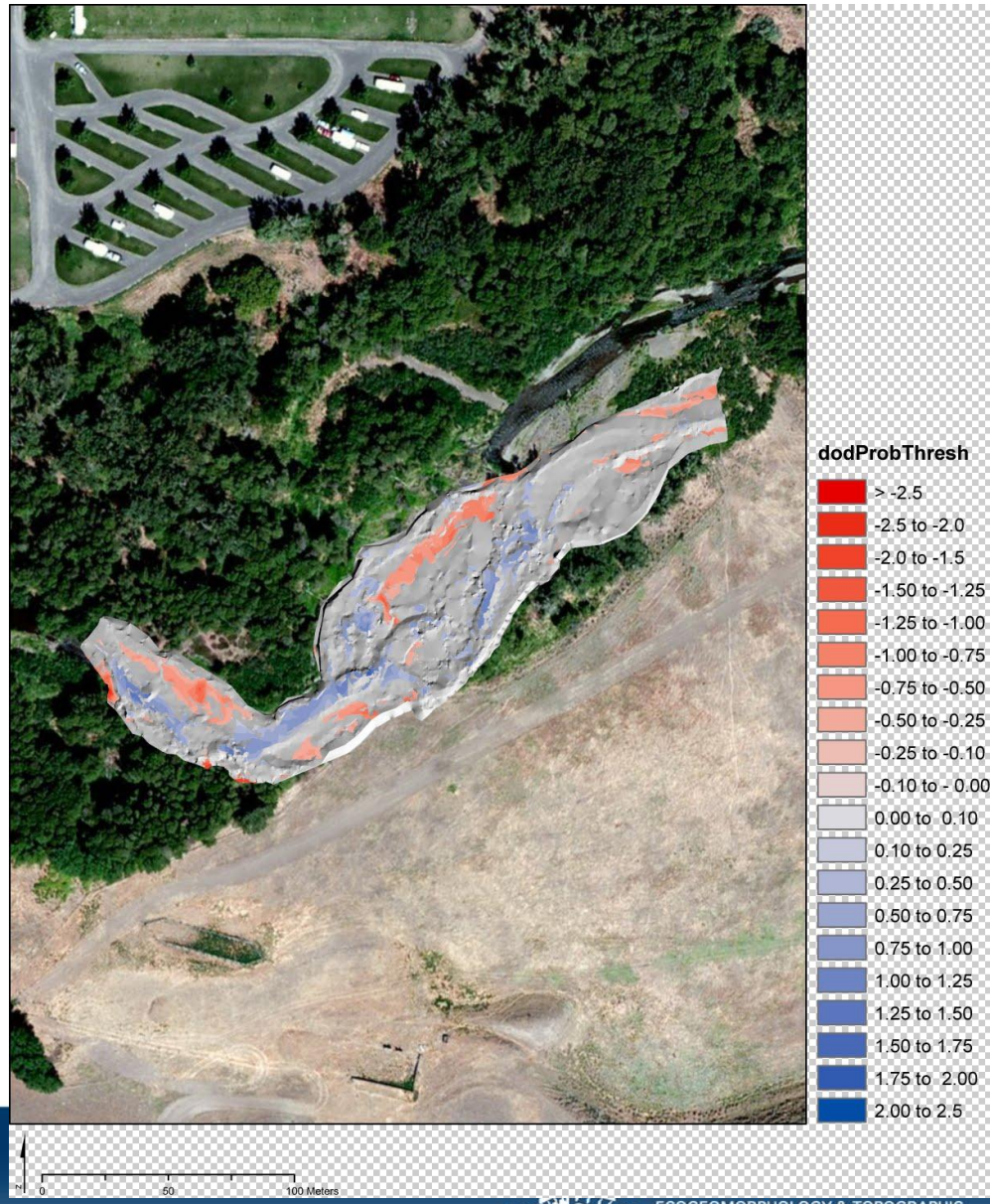
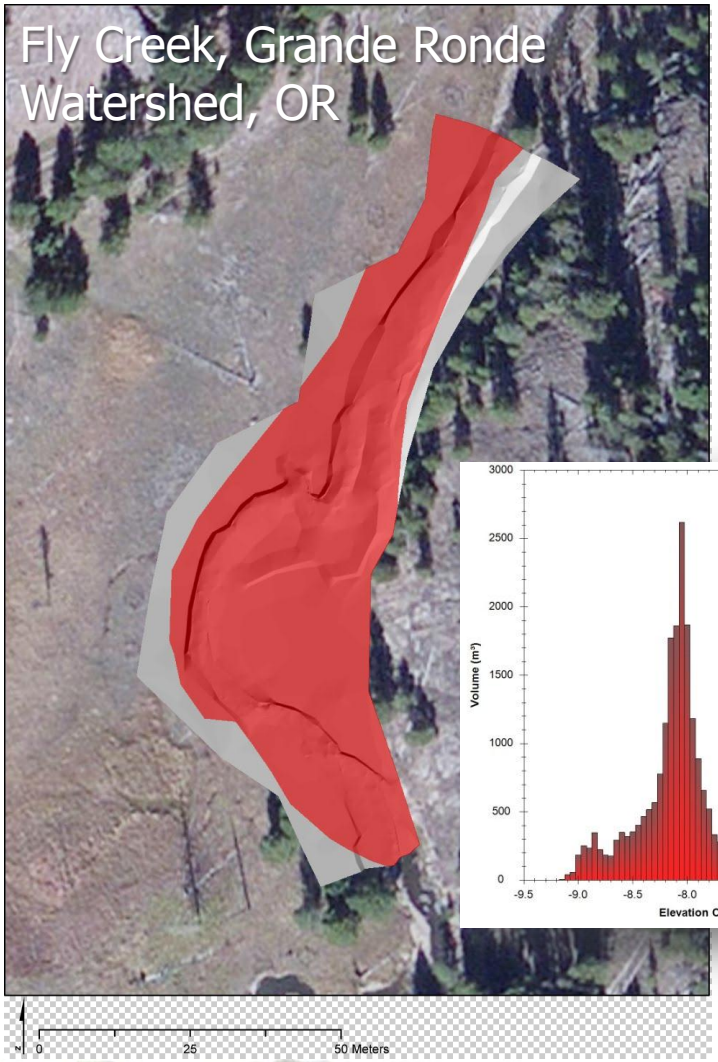
A REALLY ACTIVE SITE…

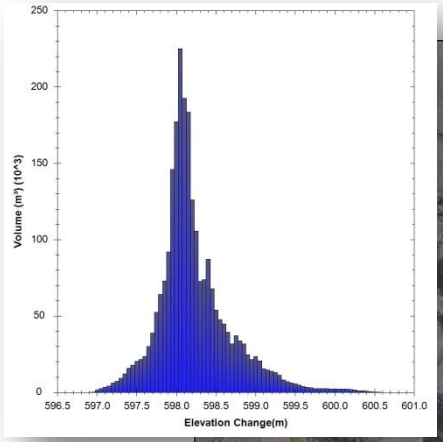
- Tucannon River, Tucannon River Watershed, WA

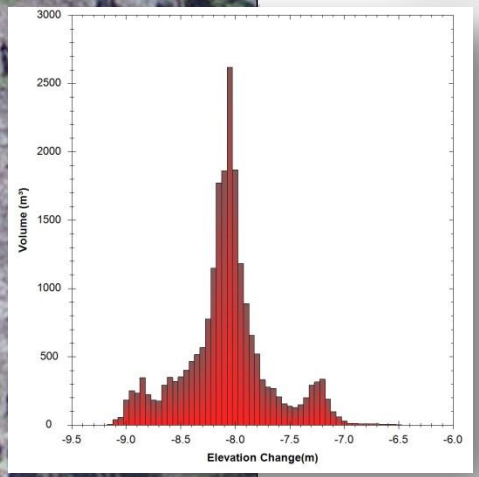


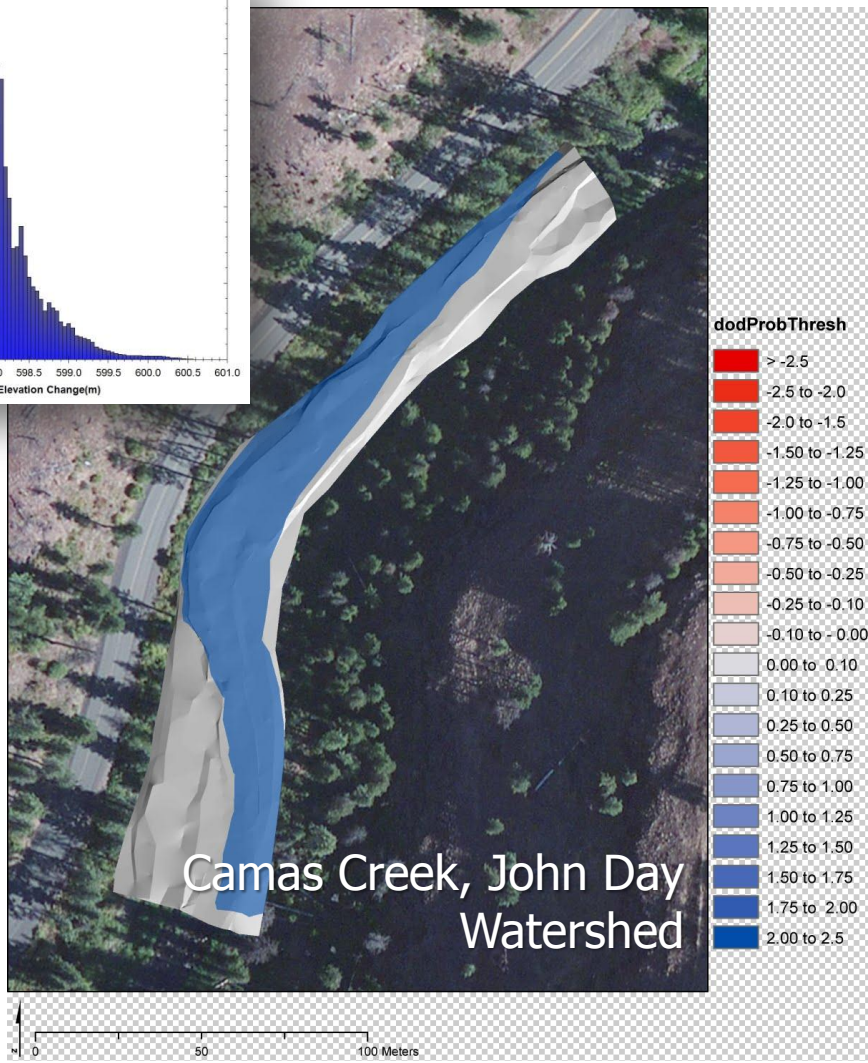


OBVIOUS DATUM PROBLEMS…

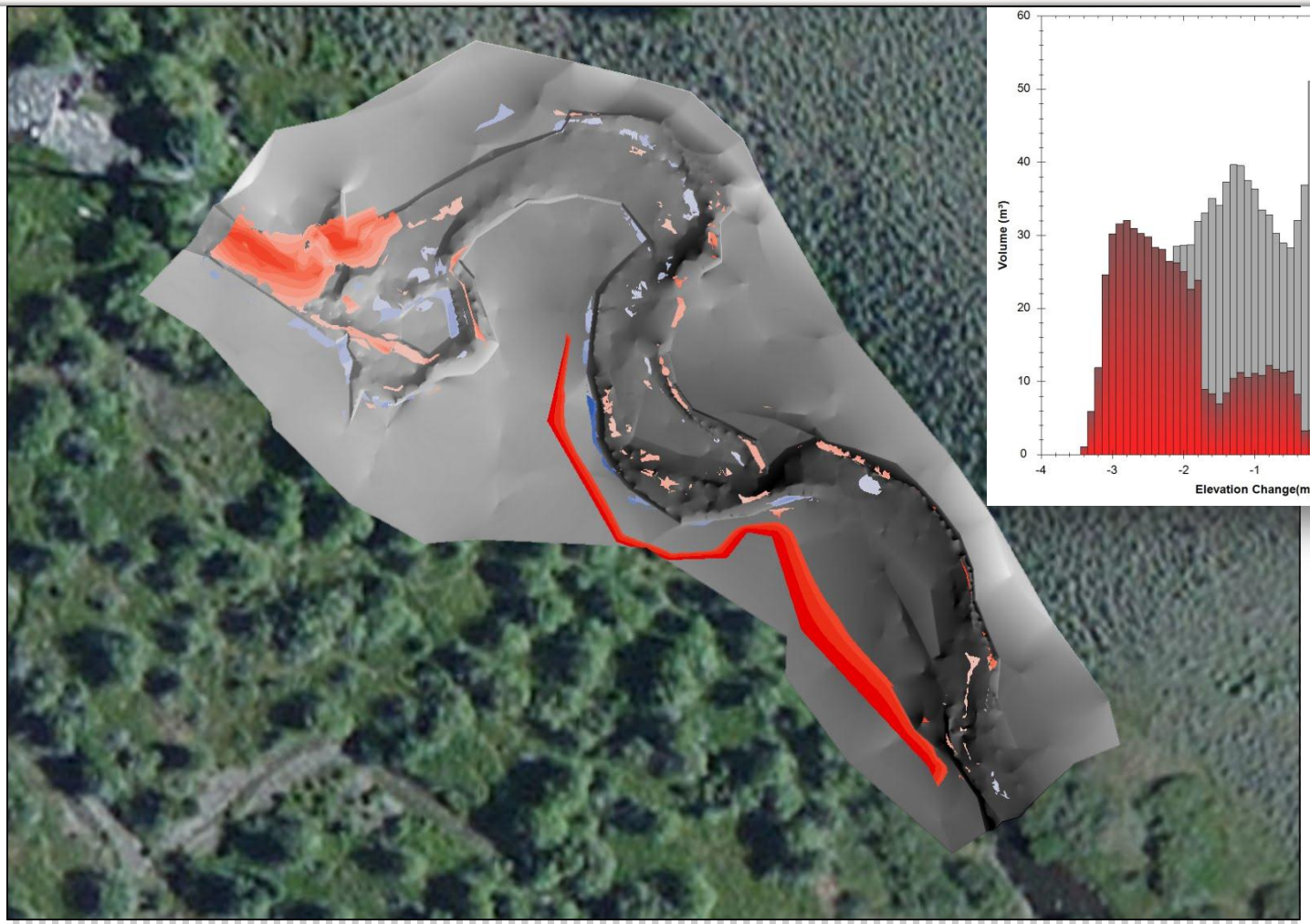








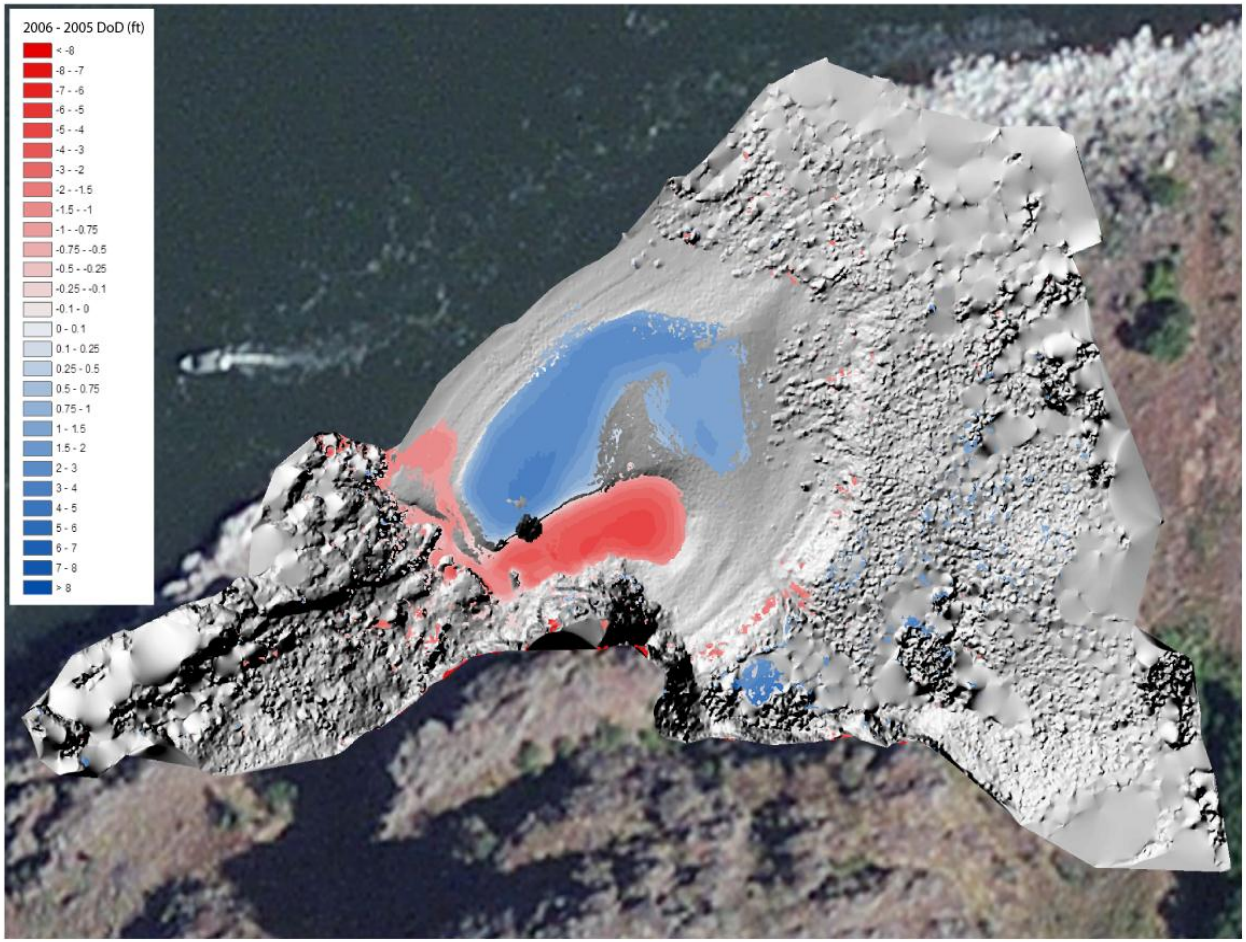
SOMETHING FISHY… BEAR VALLEY CREEK



SEDIMENT BUDGET

Components:

- Areal/Volumetric
- Raw/Thresholded
- +/- Estimates
- Percentages
- ECDs
- Change in Storage



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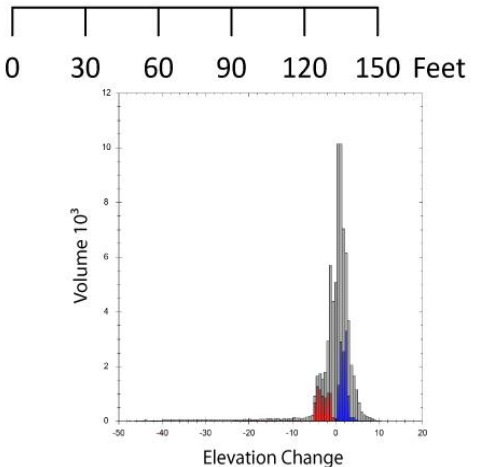
Bedload Flux Difference | Change in Storage

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

Attribute	Raw	Thresholded DoD Estimate:		
AREAL:				
Total Area of Erosion (ft²)	30,009	3,895		
Total Area of Deposition (ft²)	46,330	6,425		
VOLUMETRIC:			± Error Volume	% Error
Total Volume of Erosion (ft³)	25,108	7,629	± 1,164	15%
Total Volume of Deposition (ft³)	48,855	11,462	± 2,323	20%
Total Volume of Difference (ft³)	73,963	19,091	± 3,488	18%
Total Net Volume Difference (ft³)	23,747	**3,834**	**± 2,599**	68%
PERCENTAGES (BY VOLUME)				
Percent Erosion	34%	40%		
Percent Deposition	66%	60%		
Percent Imbalance (departure from equilibrium)	16%	10%		

N



A SUMMARY.XML FILE…

Attribute	Raw	Thresholded DoD Estimate:		
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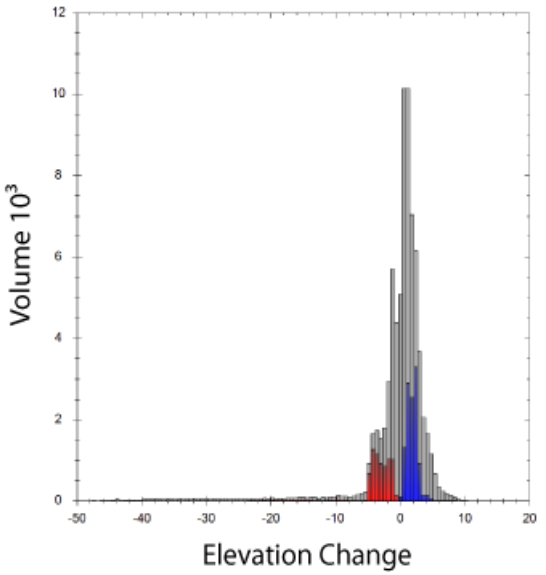
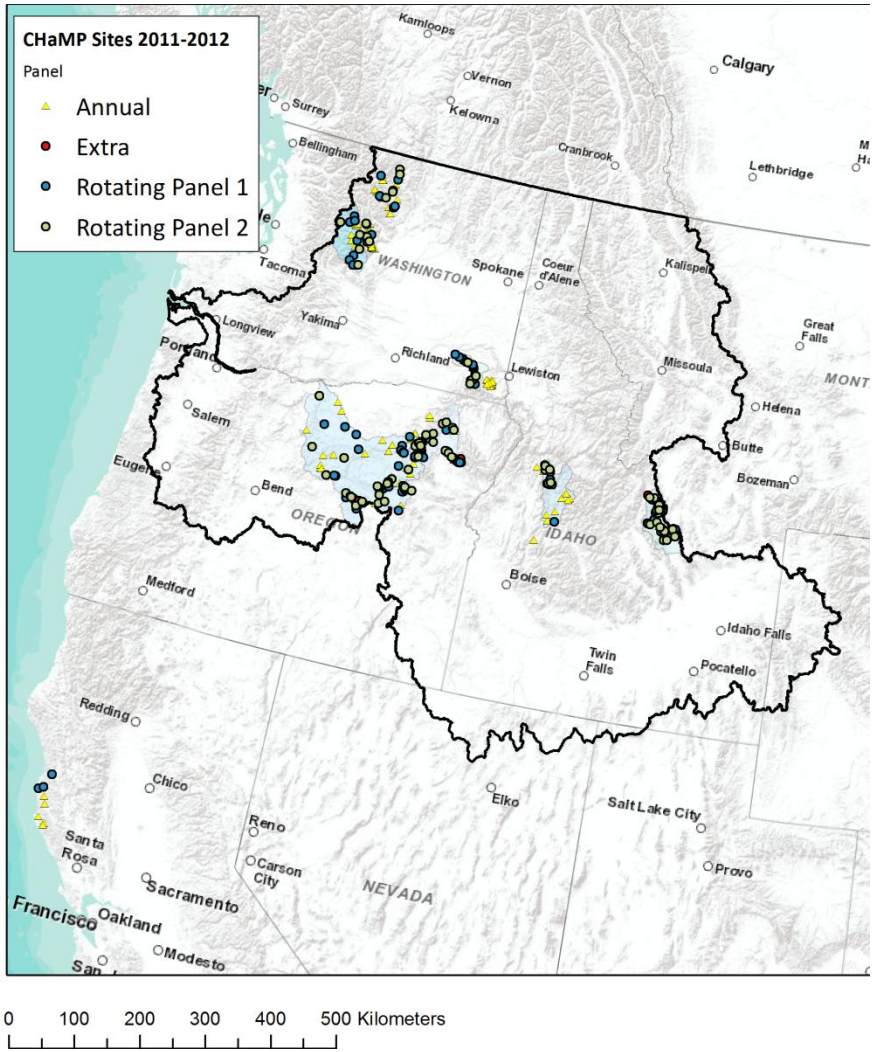


- What's here? Where did it come from?

SOON…. NOT YET


CHaMP Sites 2011-2012
Panel
Annual
Extra
Rotating Panel 1
Rotating Panel 2
Kamloops
Vernon
Kelowna
Calgary
Lethbridge
Cranbrook
Surrey
Bellingham
Tacoma
WASHINGTON
Spokane
Coeur d'Alene
Kalispell
Longview
Yakima
Great Falls
Portland
Richland
Lewiston
Missoula
Salem
Helena
Butte
Eugene
Bozeman
Bend
OREGON
IDAHO
Medford
Boise
Idaho Falls
Twin Falls
Pocatello
Redding
Chico
Elko
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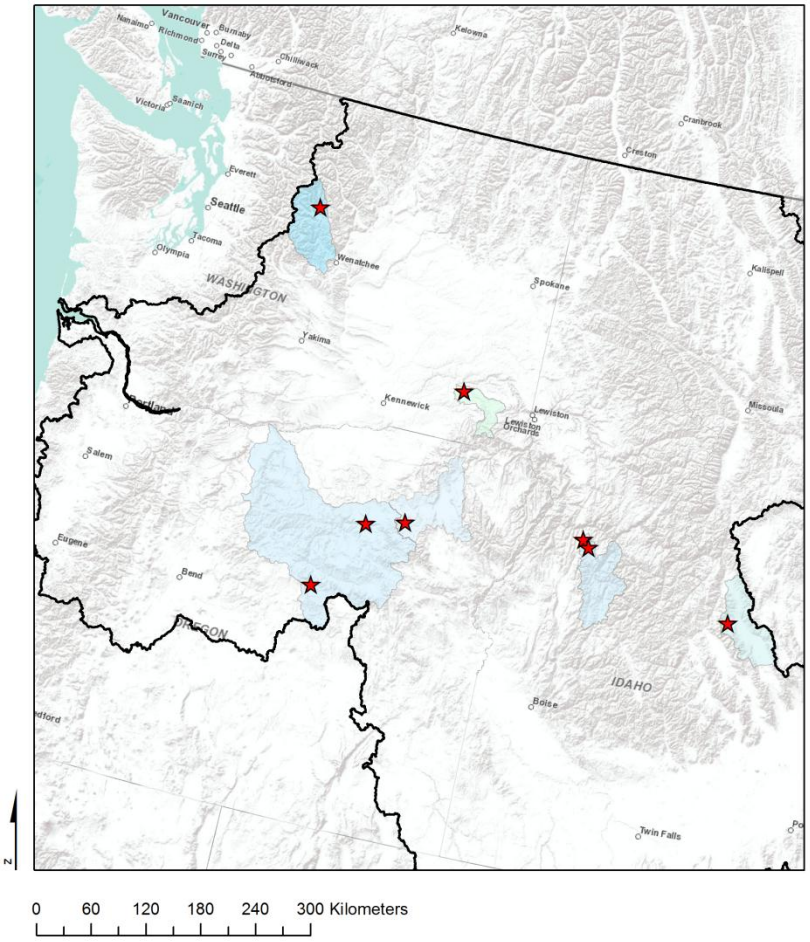
Nanaimo
Vancouver
Richmond
Burnaby
Delta
Surrey
Kelowna
Chilliwack
Victoria
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Cranbrook
Everett
Seattle
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WASHINGTON
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Yakima
Kennewick
Lewiston
Missoula
Salem
Eugene
Bend
IDAHO
Boise
Twin Falls
0 60 120 180 240 300 Kilometers

MAIN TAKE HOMES

- GCD Results Now Automated
- We're seeing that one-size fits all error model is too conservative
- We might want to show crews their error models
- Still QA/QC… Roughly 12 of 120 need further attention
- Some refinements required, but first cut is promising
- Too soon to inter-compare basins, but soon