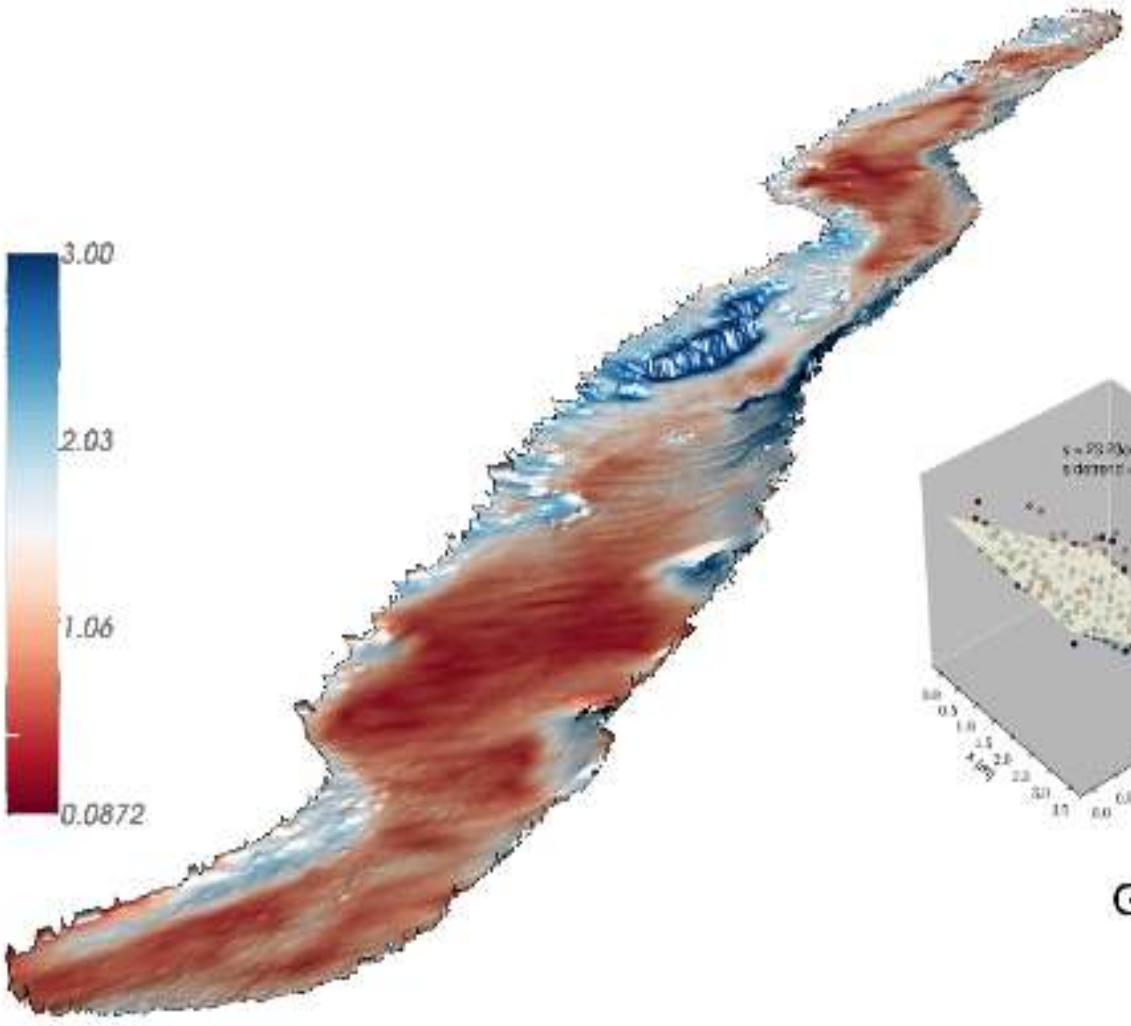
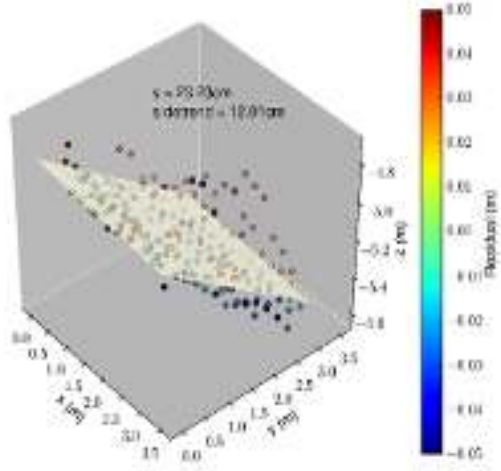
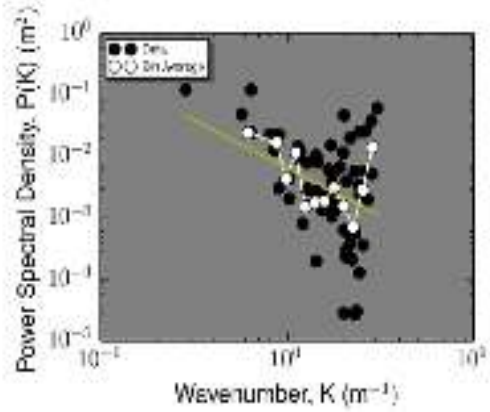
Topographic and Acoustic Estimates of Grain-Scale Roughness from High-Resolution Multibeam Echo-sounder

Examples from the Colorado River in Marble Canyon



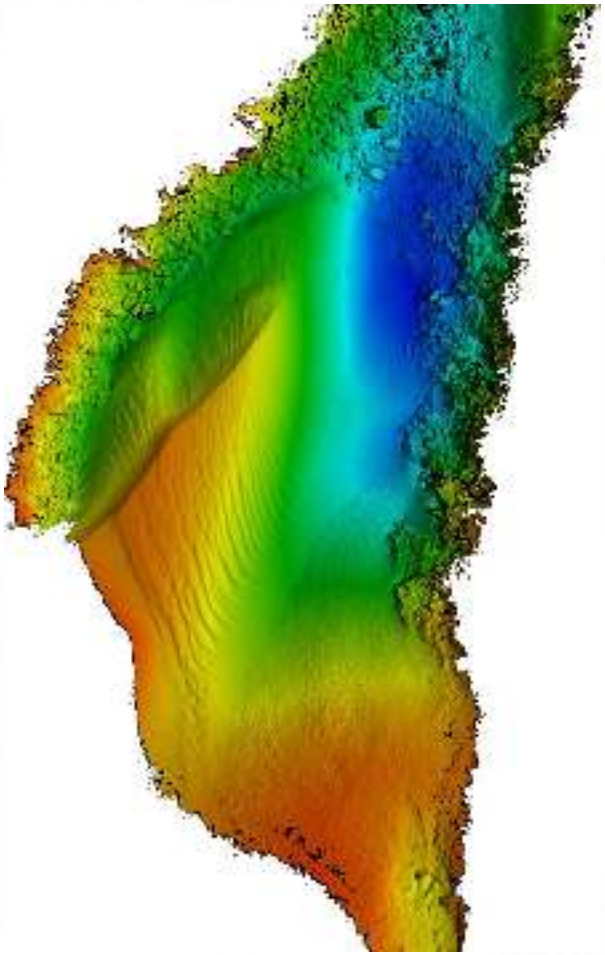




Daniel Buscombe,
Paul E. Grams,
Grand Canyon Monitoring and Research Center, U.S. Geological Survey.

Multibeam echosounder measures depth & echo strengths

- High-resolution soundings ...
- Submerged aquatic vegetation
- Definition of physical habitats
- Bed substrate classification
- Appeal of backscatter = hardness + roughness (?)
- Topography, Acoustic Backscatter, or both?



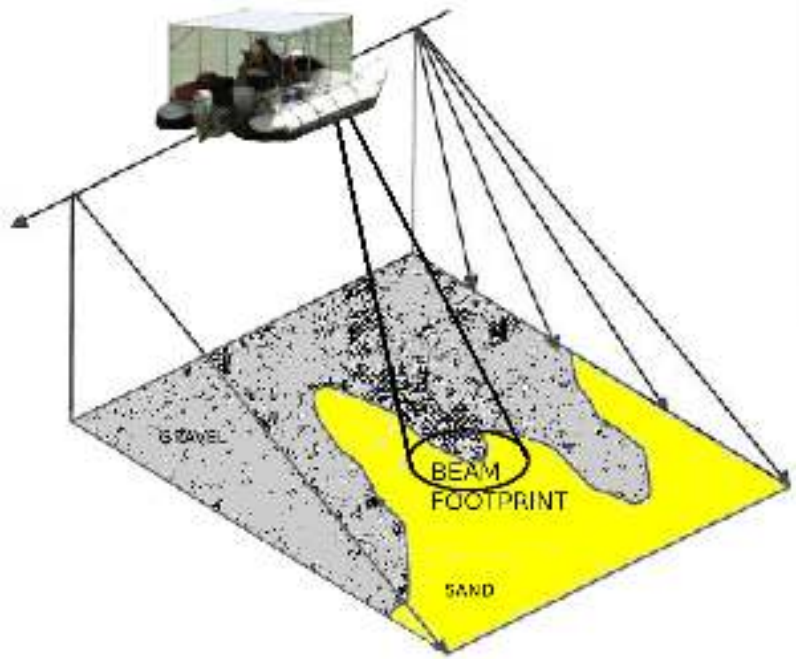
Bathymetry at RM 61, Marble Canyon, May 2014

Multibeam echosounder measures depth & echo strengths

- High-resolution soundings ...
- Submerged aquatic vegetation
- Definition of physical habitats
- Bed substrate classification
- Appeal of backscatter = hardness + roughness (?)
- Topography, Acoustic Backscatter, or both?

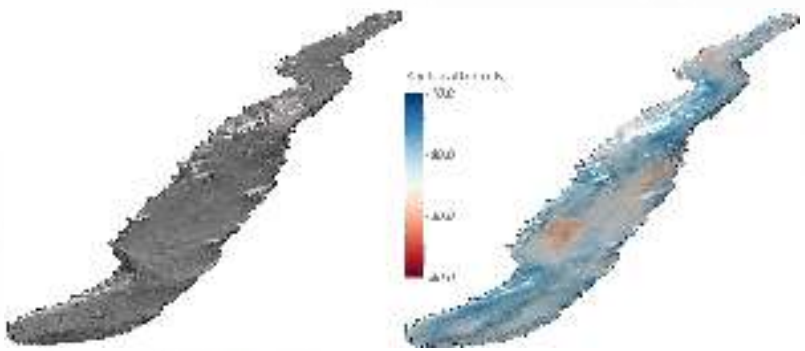
Multibeam echosounder measures depth & echo strengths

- High-resolution soundings ...
- Submerged aquatic vegetation
- Definition of physical habitats
- Bed substrate classification
- Appeal of backscatter = hardness + roughness (?)
- Topography, Acoustic Backscatter, or both?



Multibeam echosounder measures depth & echo strengths

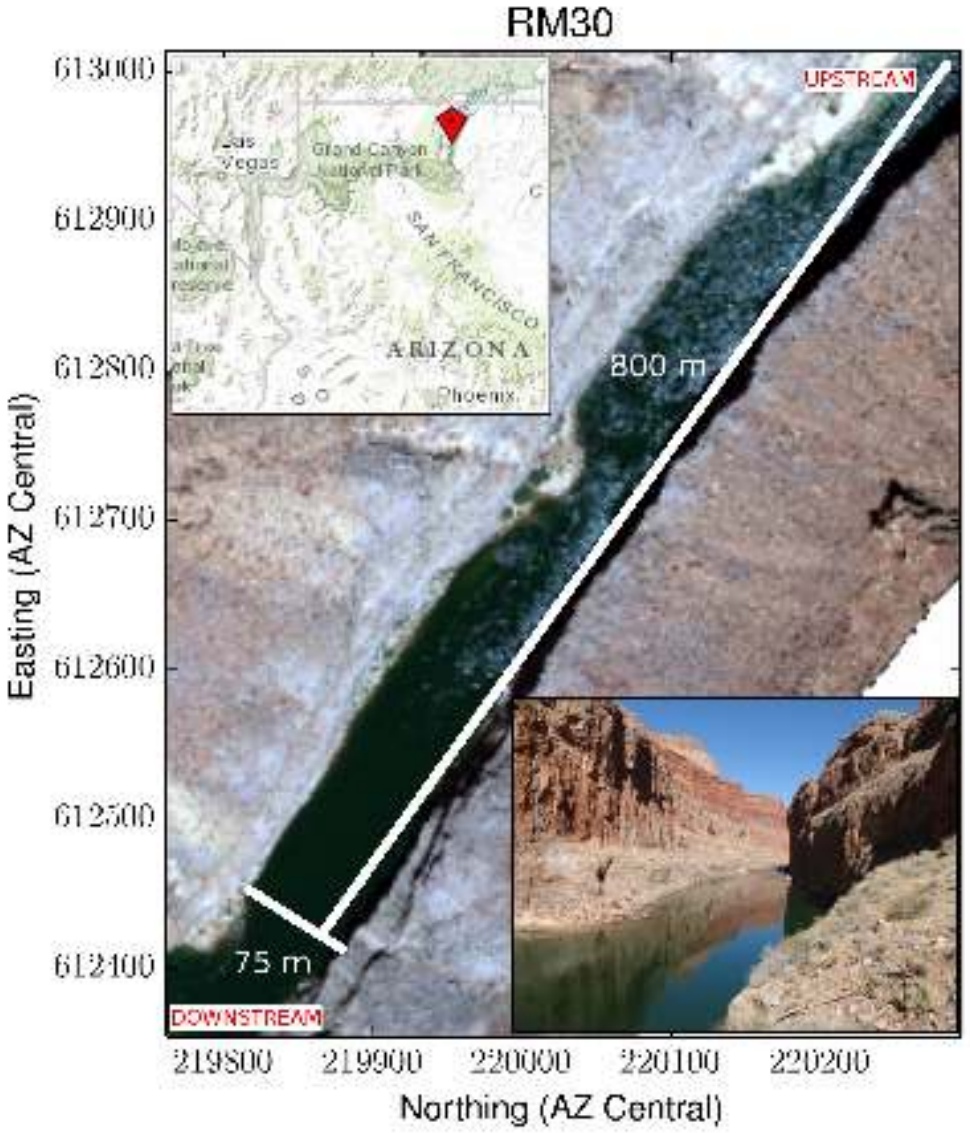
- High-resolution soundings ...
- Submerged aquatic vegetation
- Definition of physical habitats
- Bed substrate classification
- Appeal of backscatter = hardness + roughness (?)
- Topography, Acoustic Backscatter, or both?

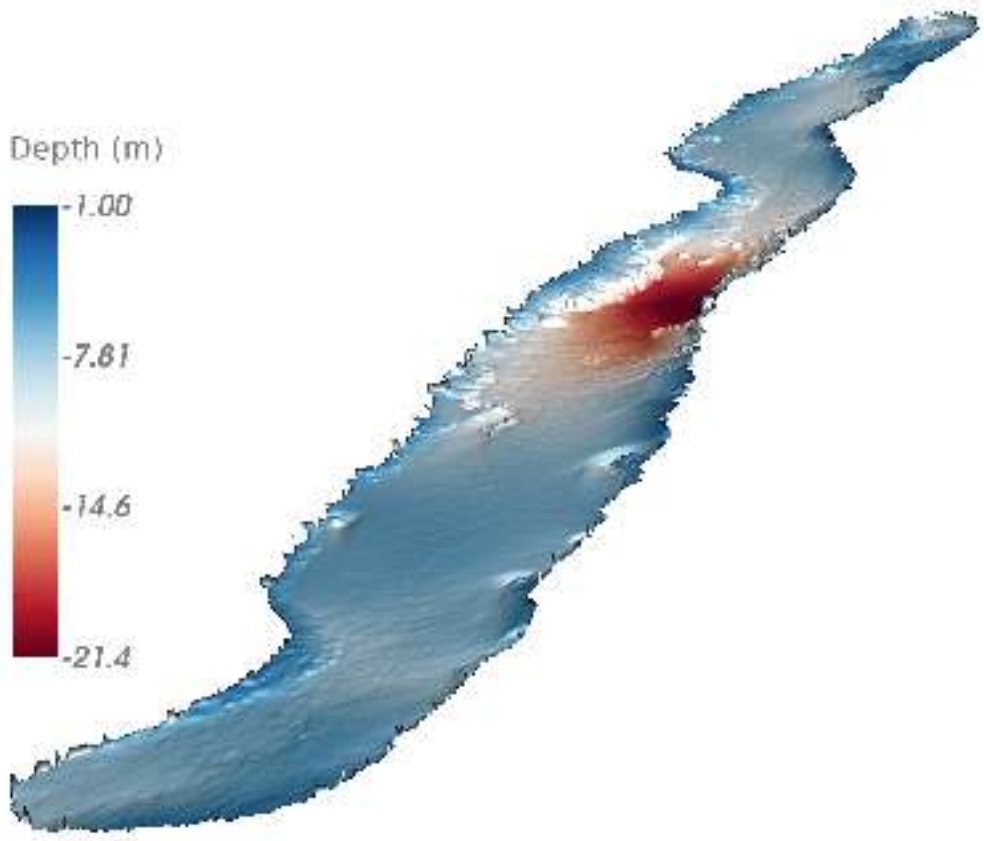


Talk Outline

- What are the relevant deterministic and stochastic descriptions of riverbed?
- What's the relationship between them?
- What's the relationship to sediment type?

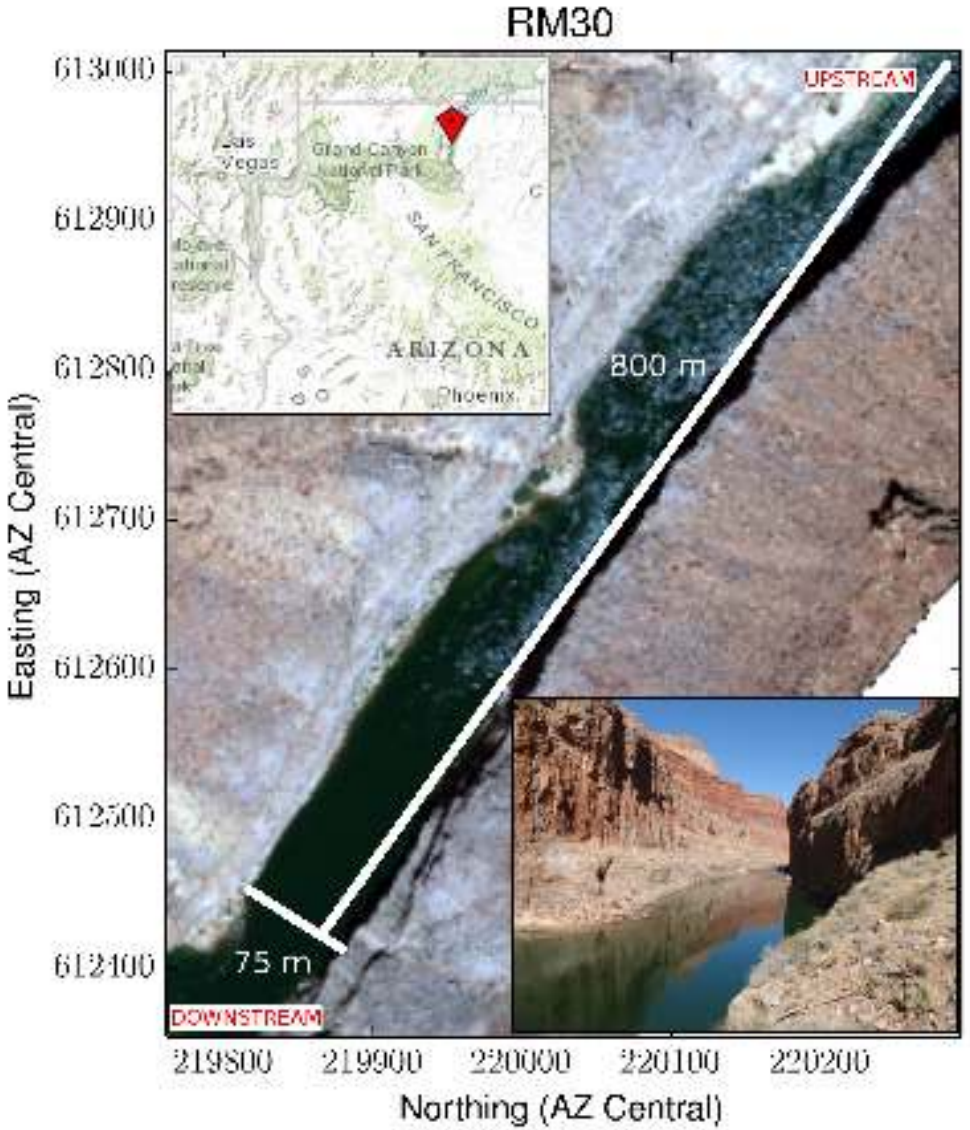
RM30, Marble Canyon, August 2013

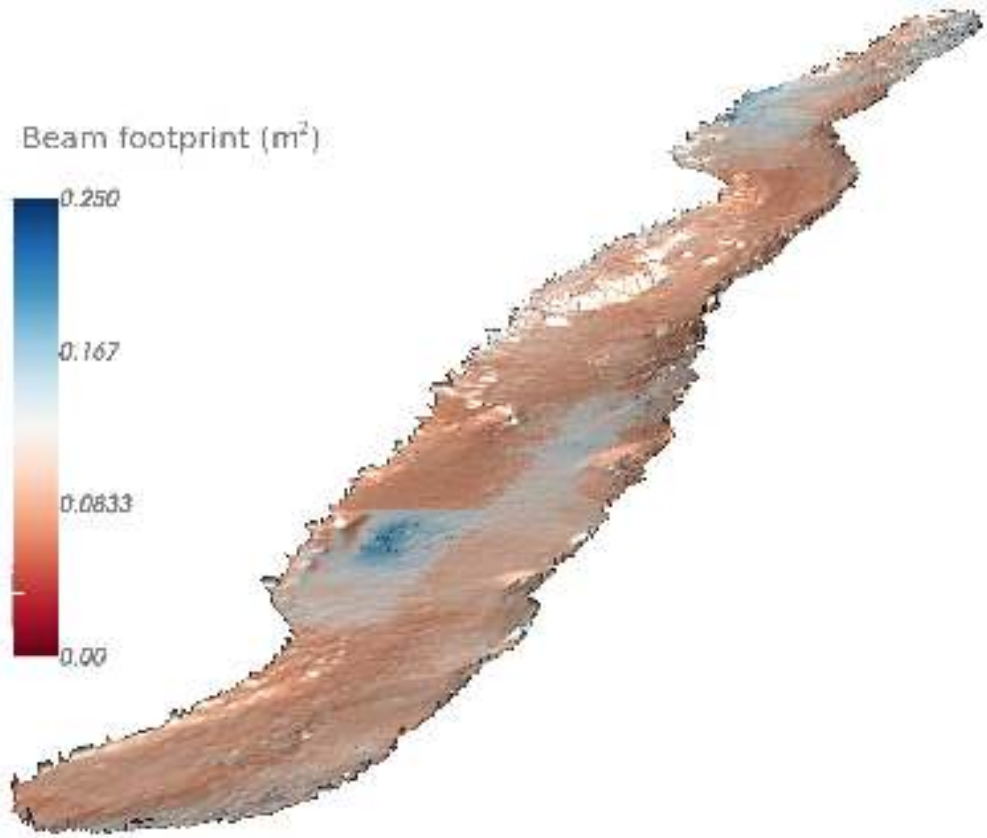




11 million soundings
25 cm grid

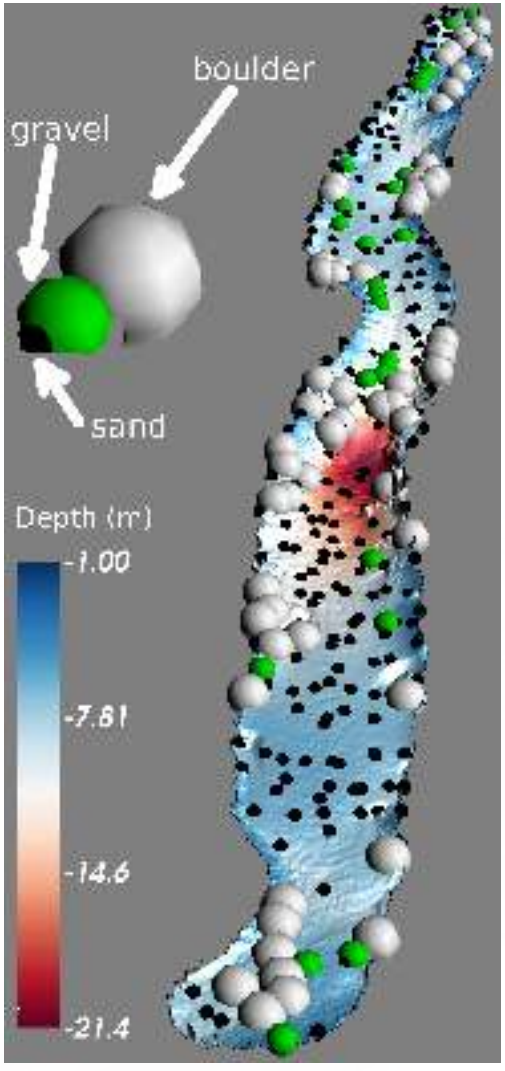
RM30, Marble Canyon, August 2013

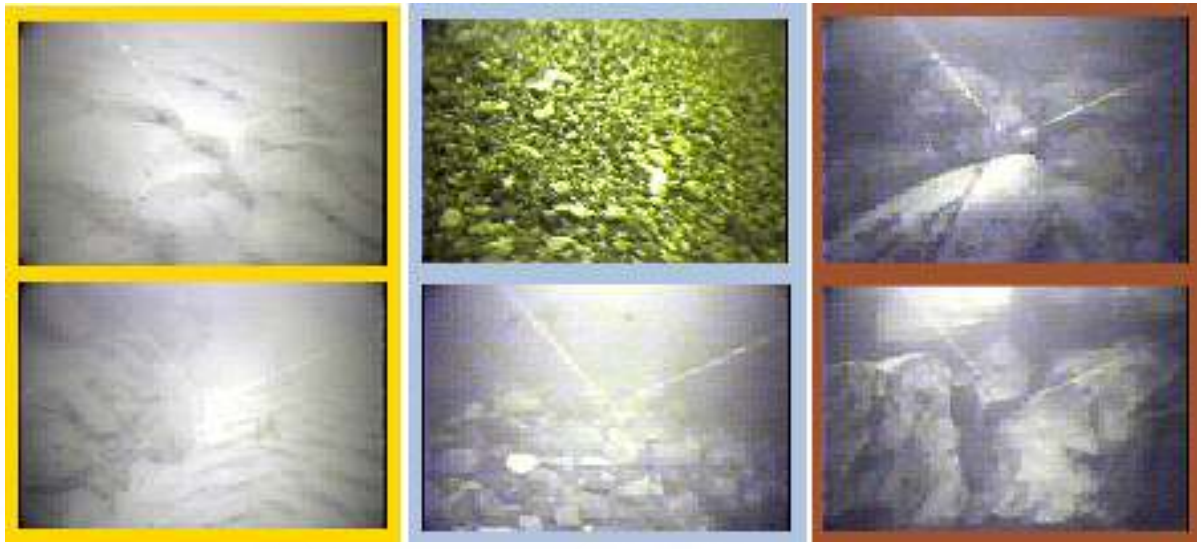




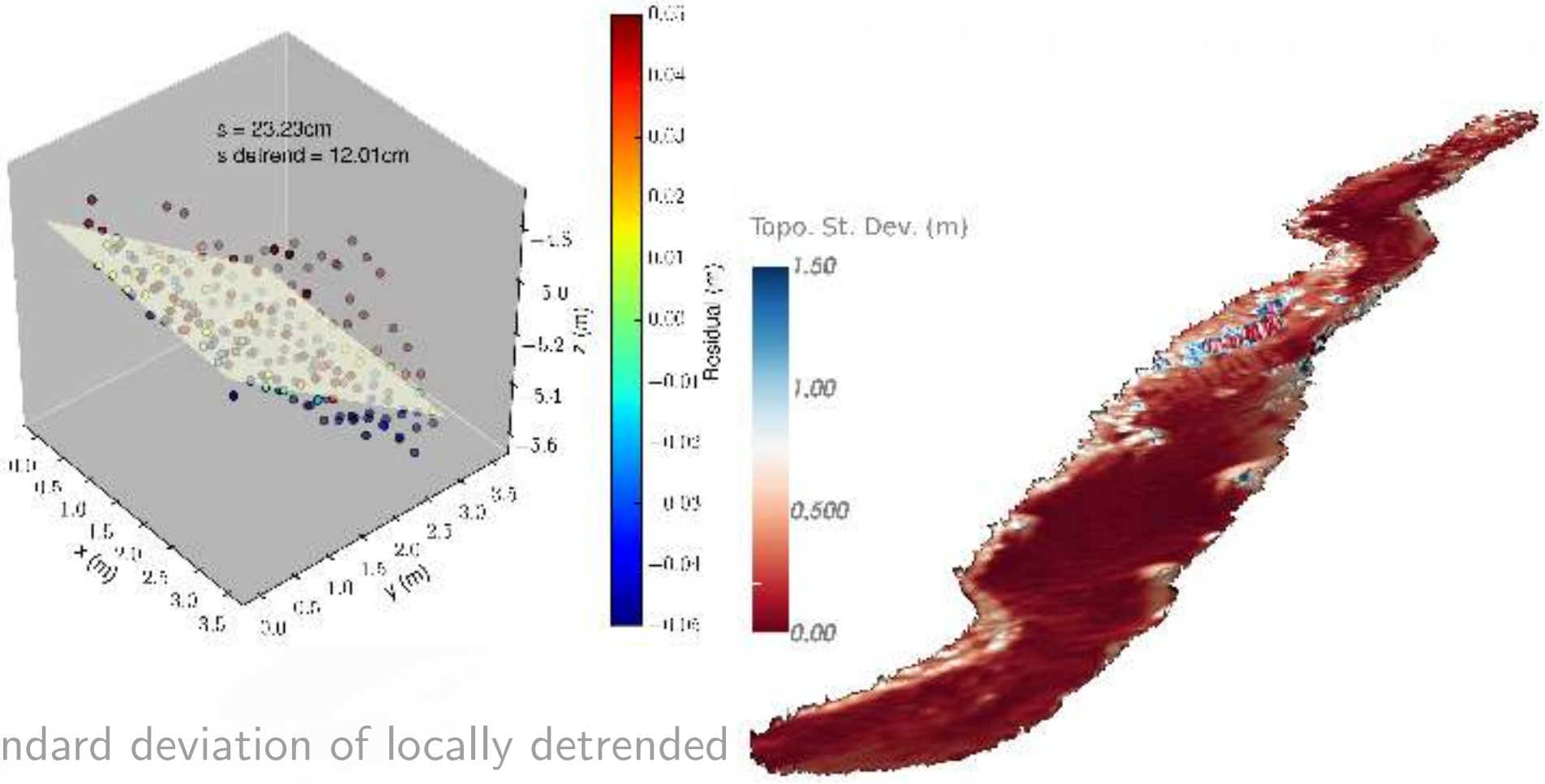
11 million soundings
25 cm grid

Wentworth sediment type





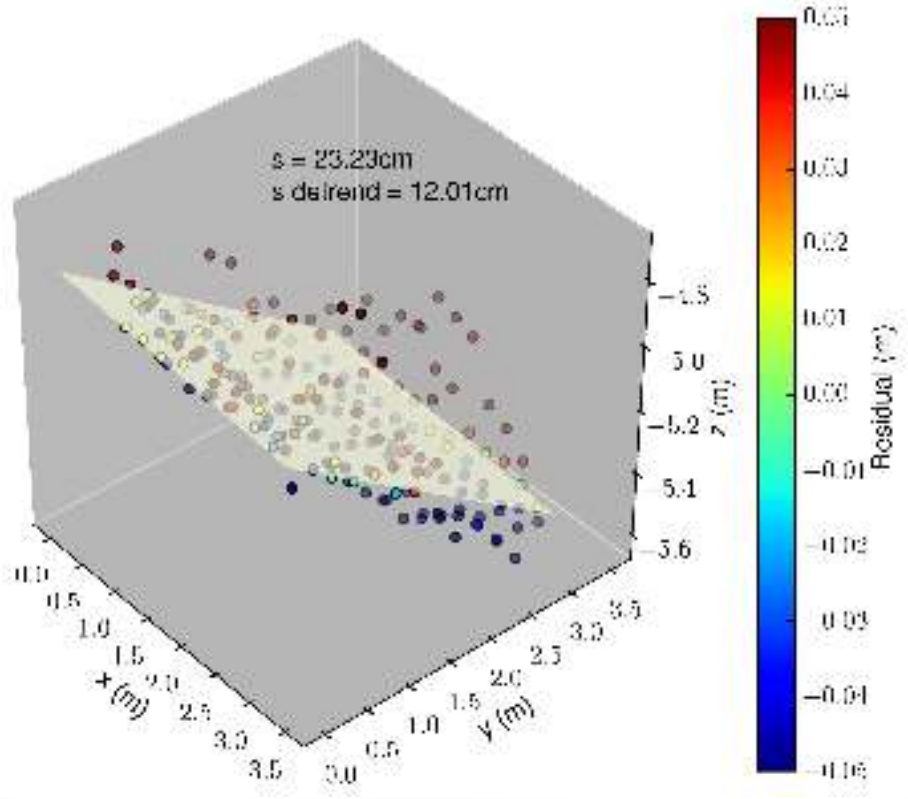
Topography: deterministic geometry

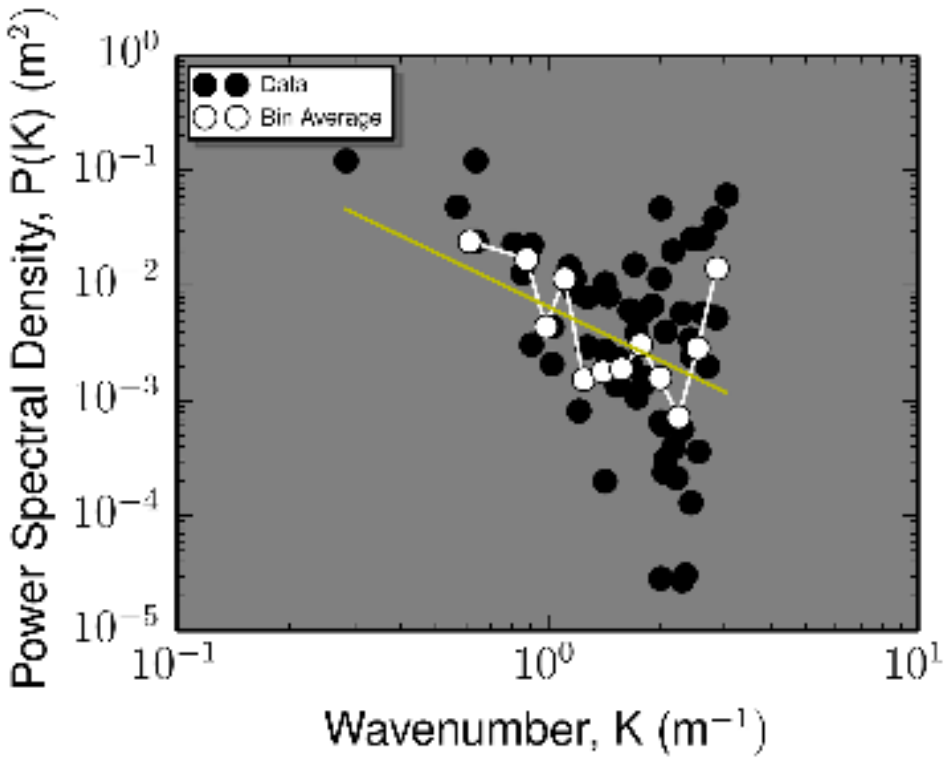


Standard deviation of locally detrended elevations

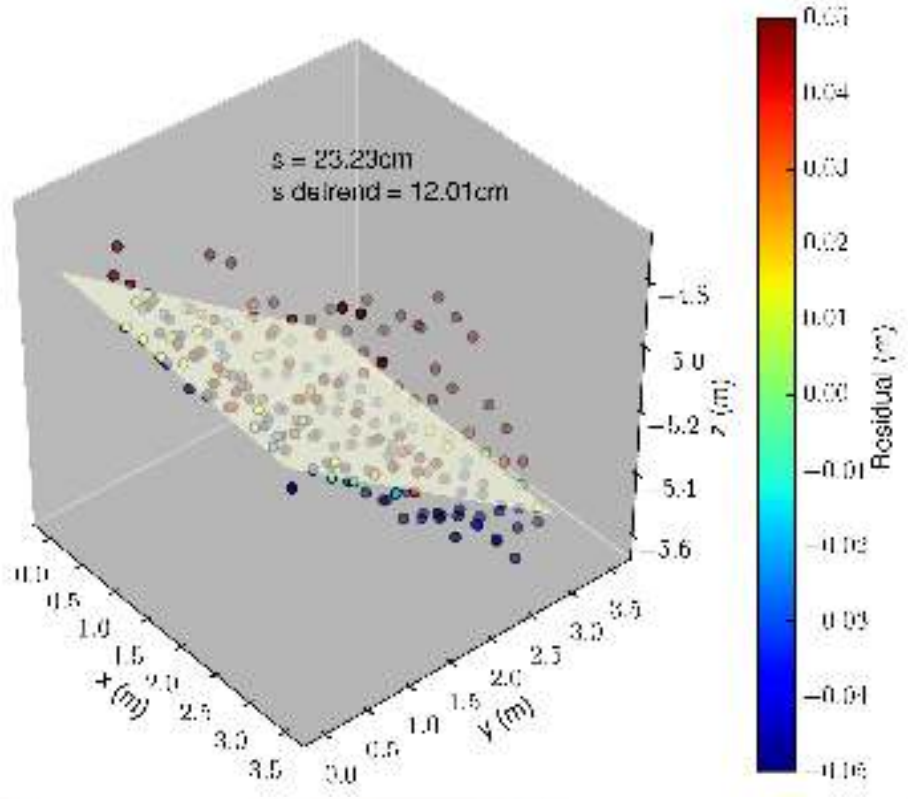
Brasington et al 2012, WRR

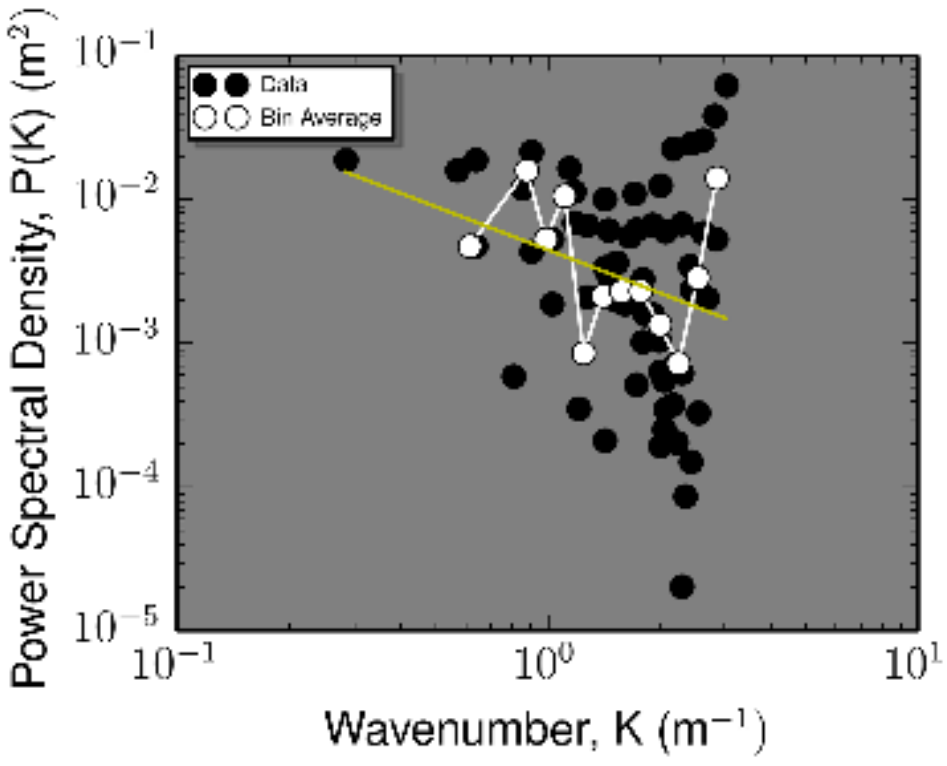
Topography power spectrum: 1) 'global' detrend





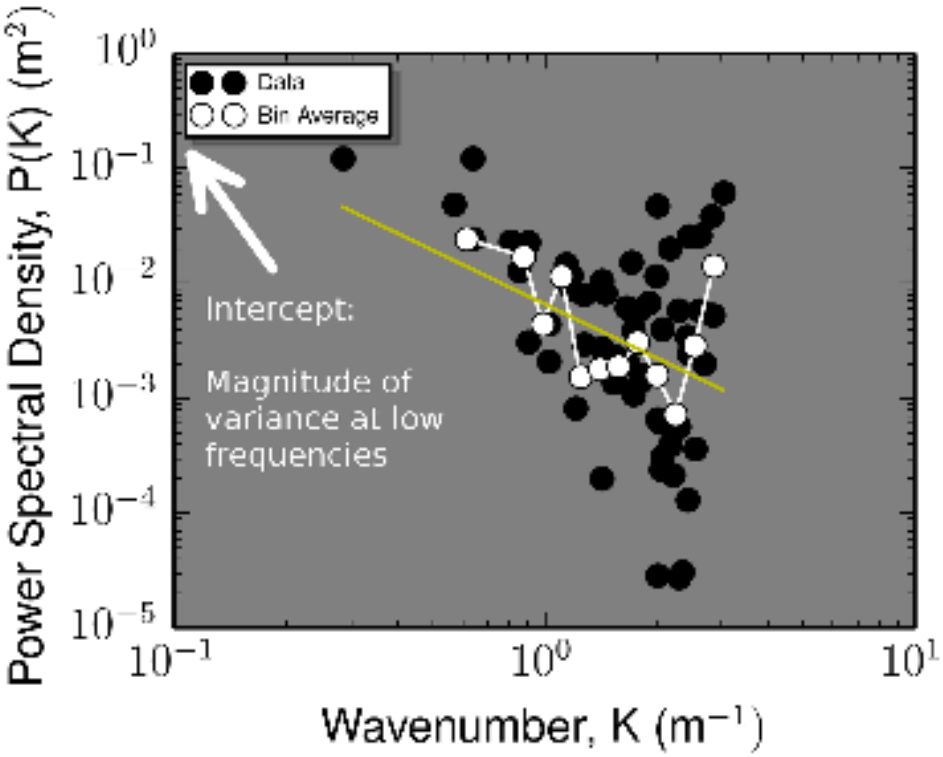
Topography power spectrum: 2) local detrend with plane

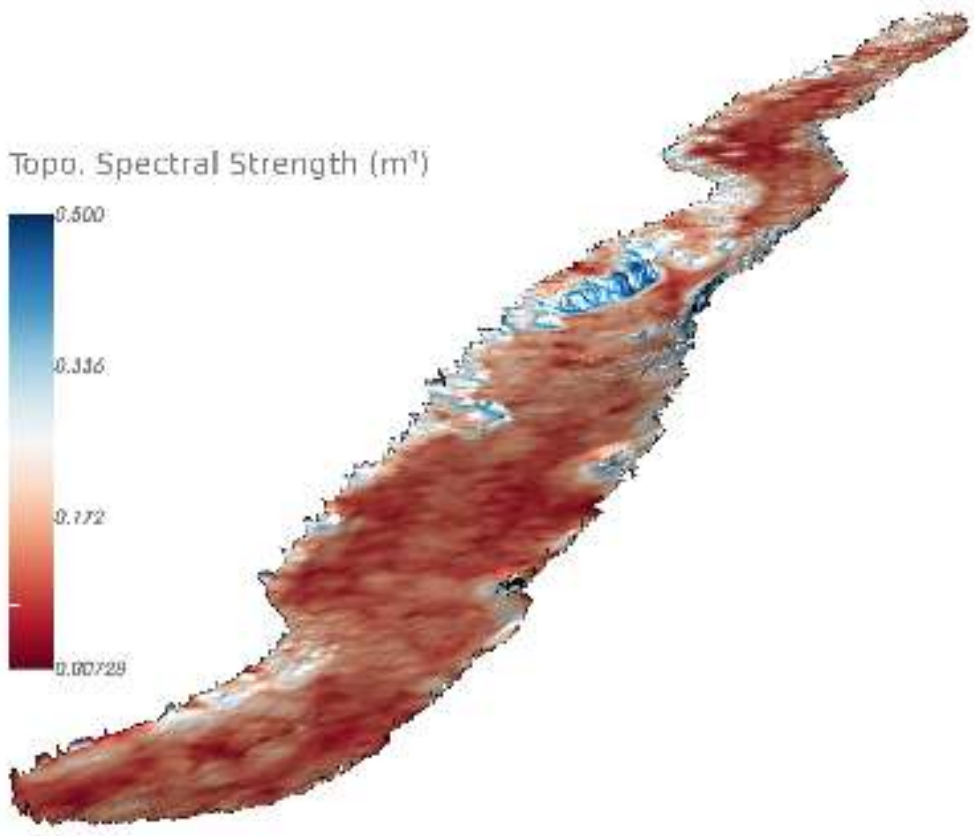




Stochastic geometry. 1) Spectral Strength

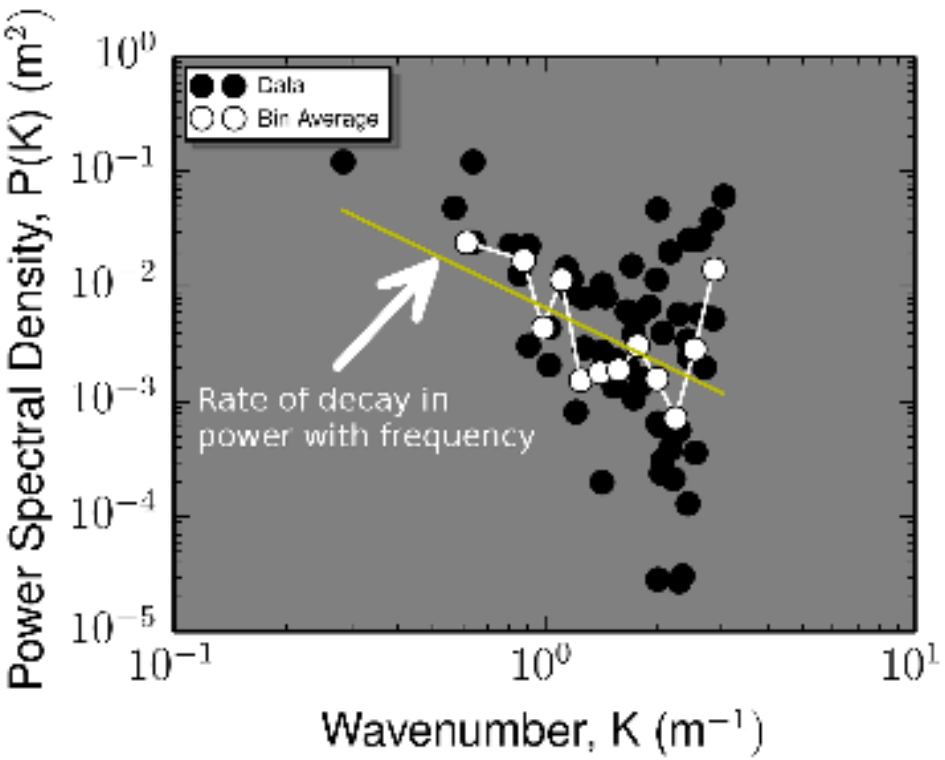
$$\widehat{P_1(\mathbf{K})} = \frac{\omega_1}{(h_0|\mathbf{K}|)^{\gamma_1}}$$

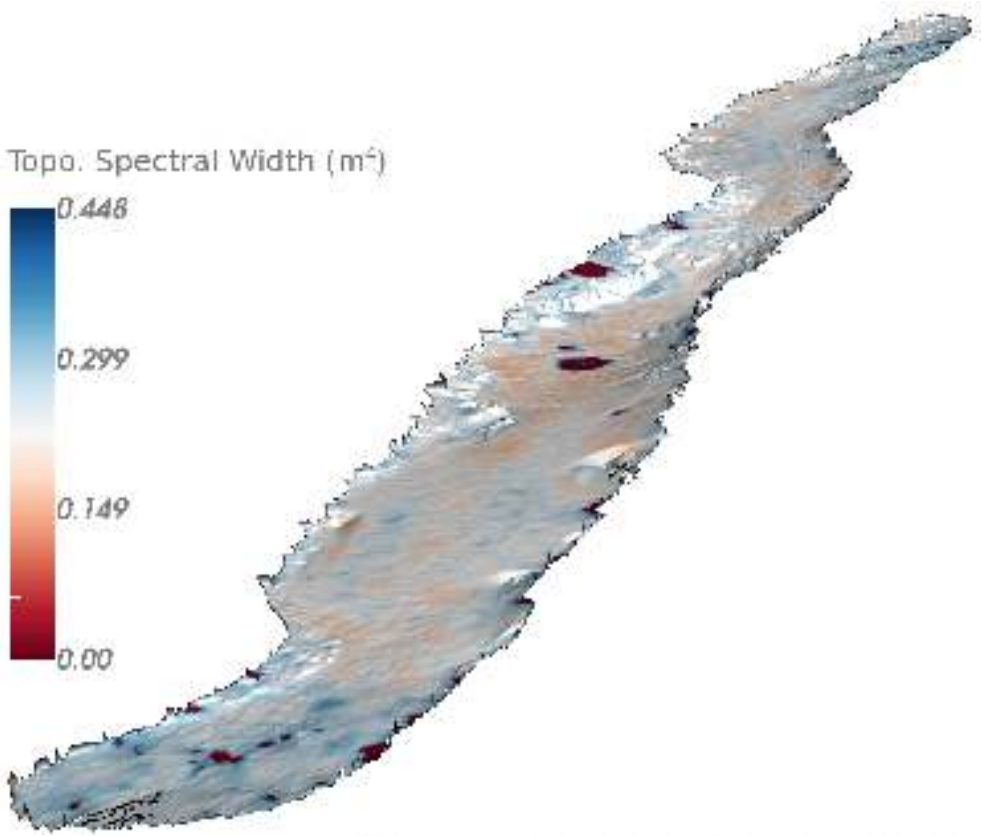




Stochastic geometry. 2) Spectral Width

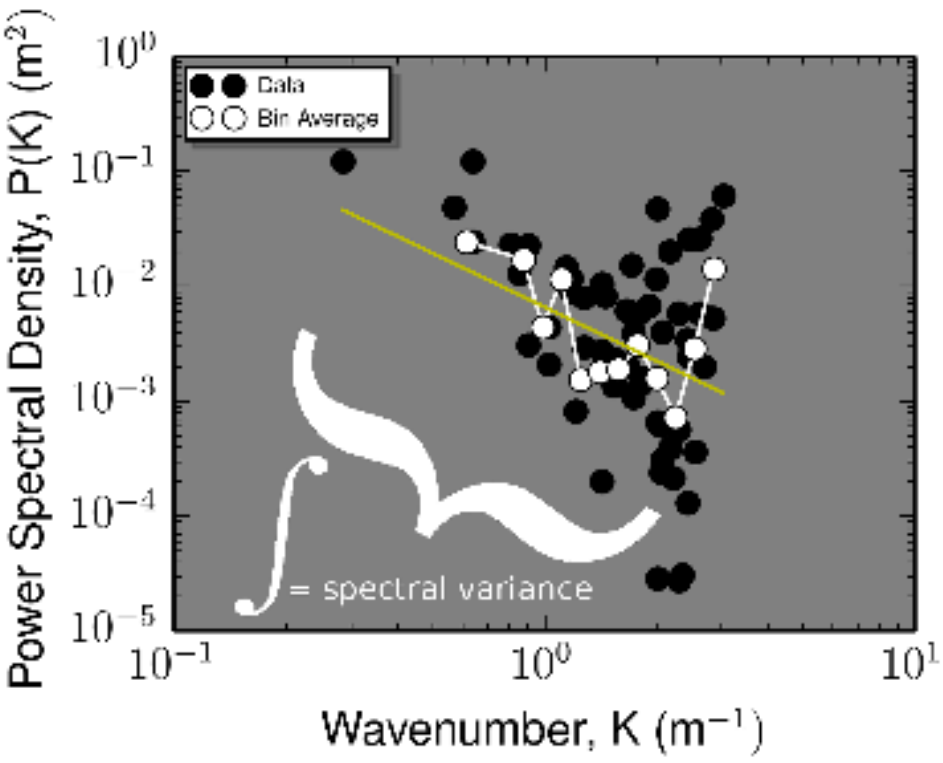
$$\widehat{P_1(\mathbf{K})} = \frac{\omega_1}{(h_0|\mathbf{K}|)^{\gamma_1}}$$

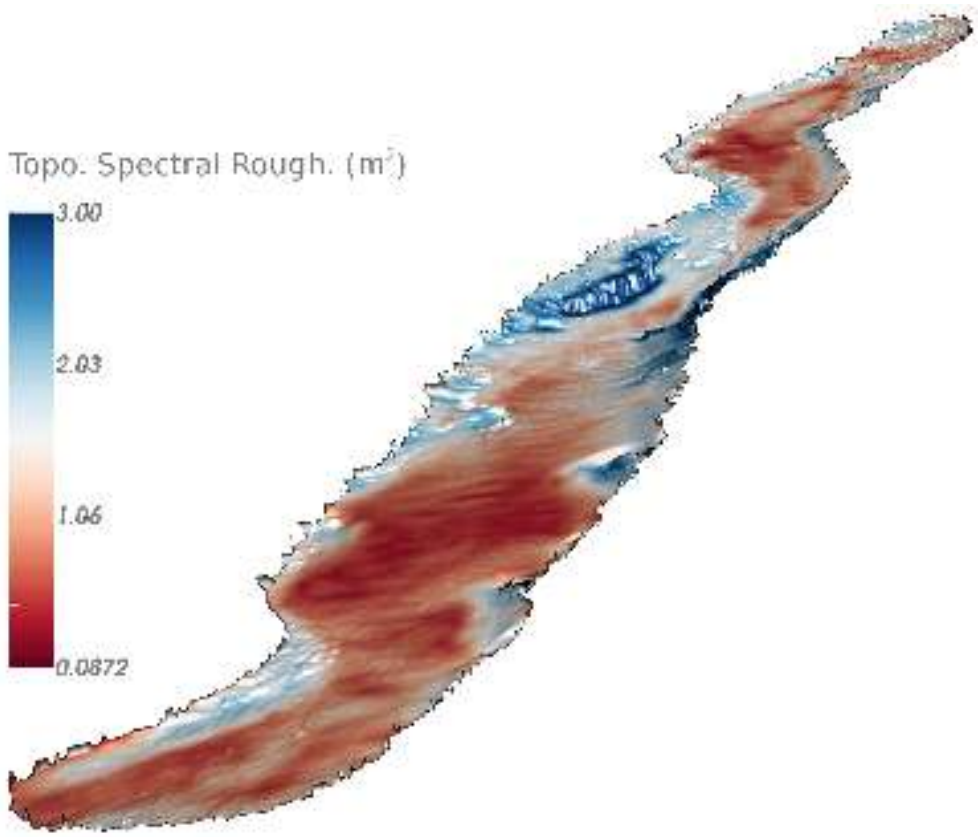




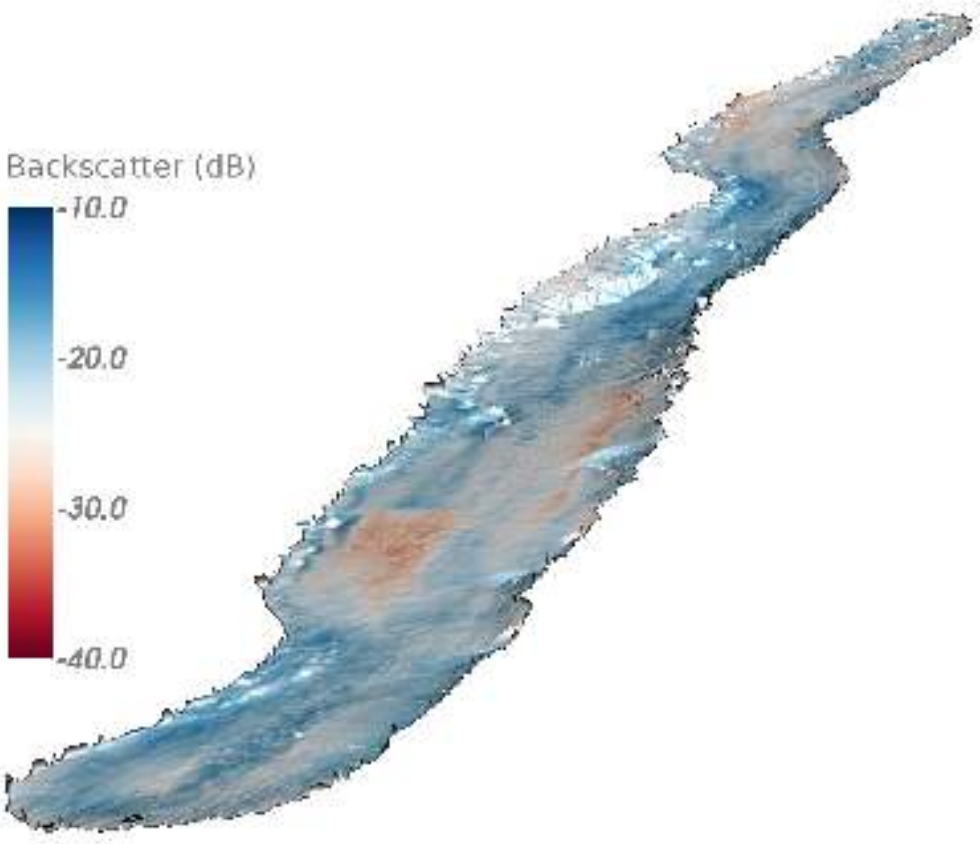
Stochastic geometry. 3) Spectral Variance

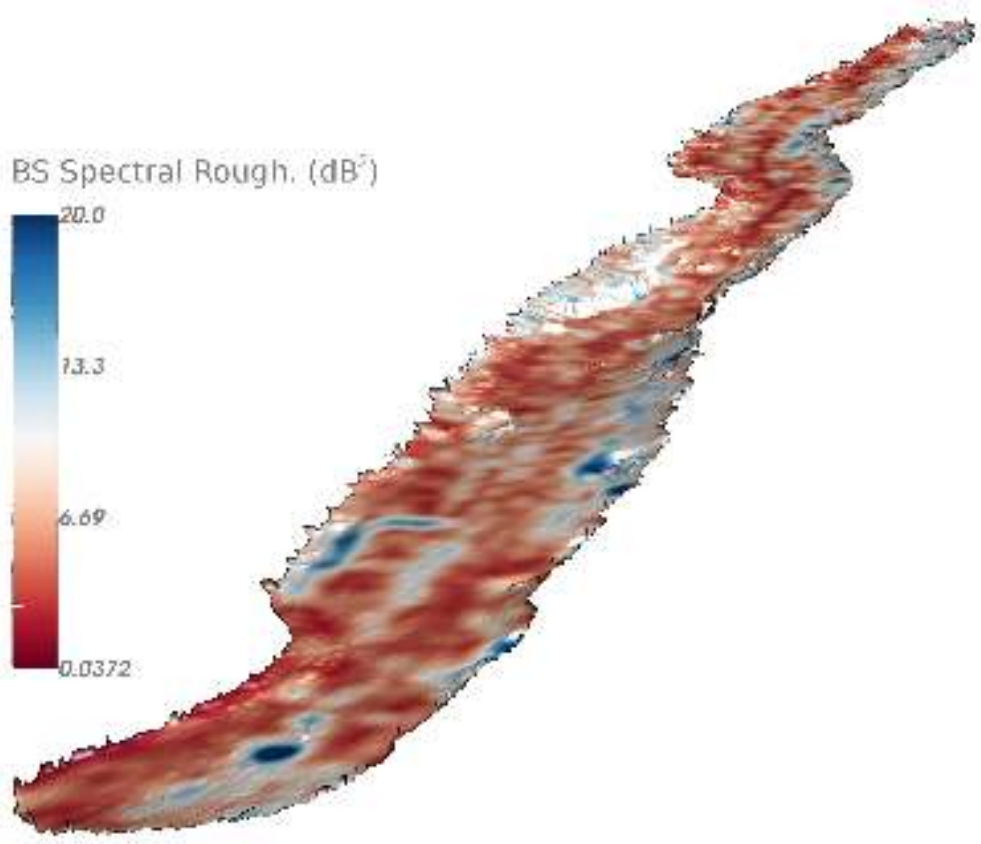
$$\sigma_1^2 = 2\sqrt{\int_{\mathbf{K}_0} P_1(\mathbf{K}) d\mathbf{K}}$$



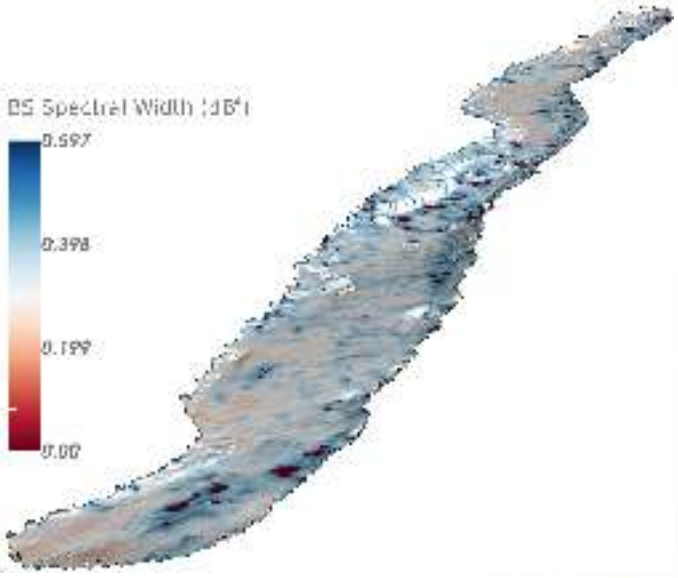


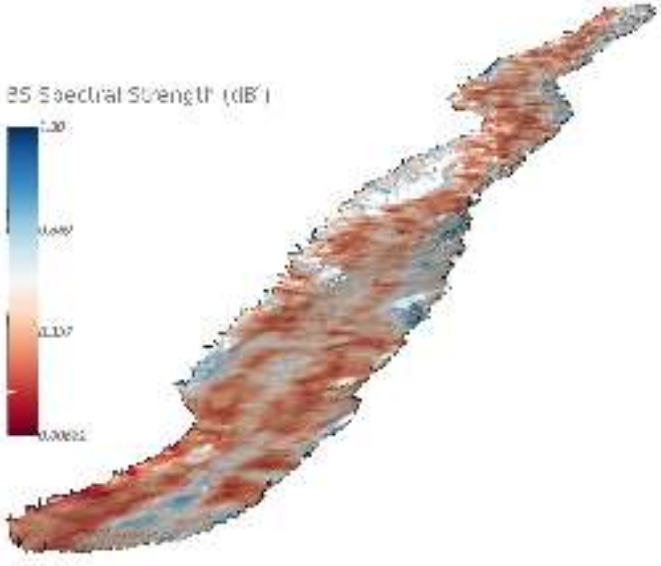
Median Backscatter & Spectral Variance

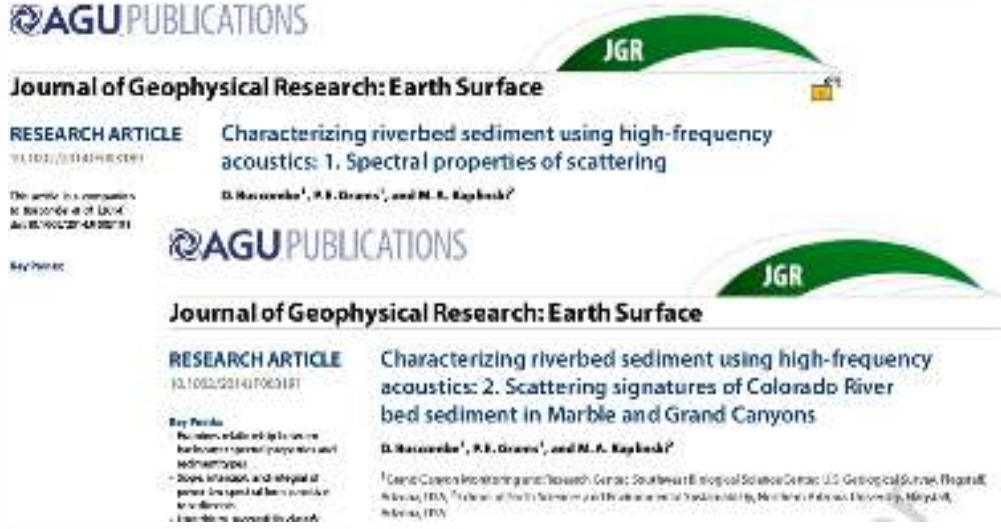




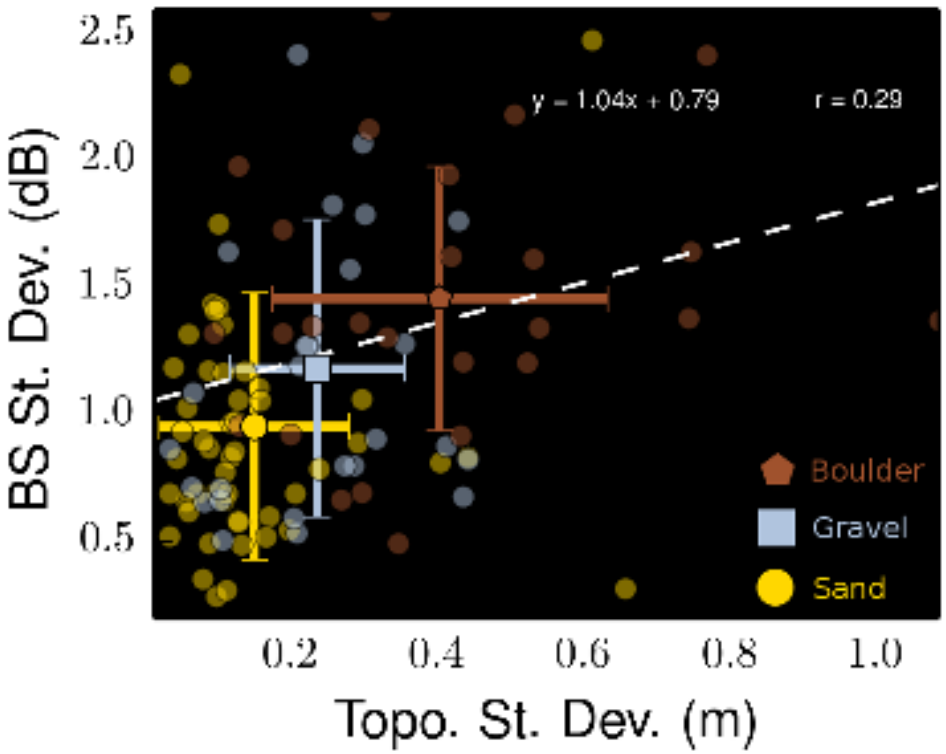
Backscatter Spectral Width & Strength

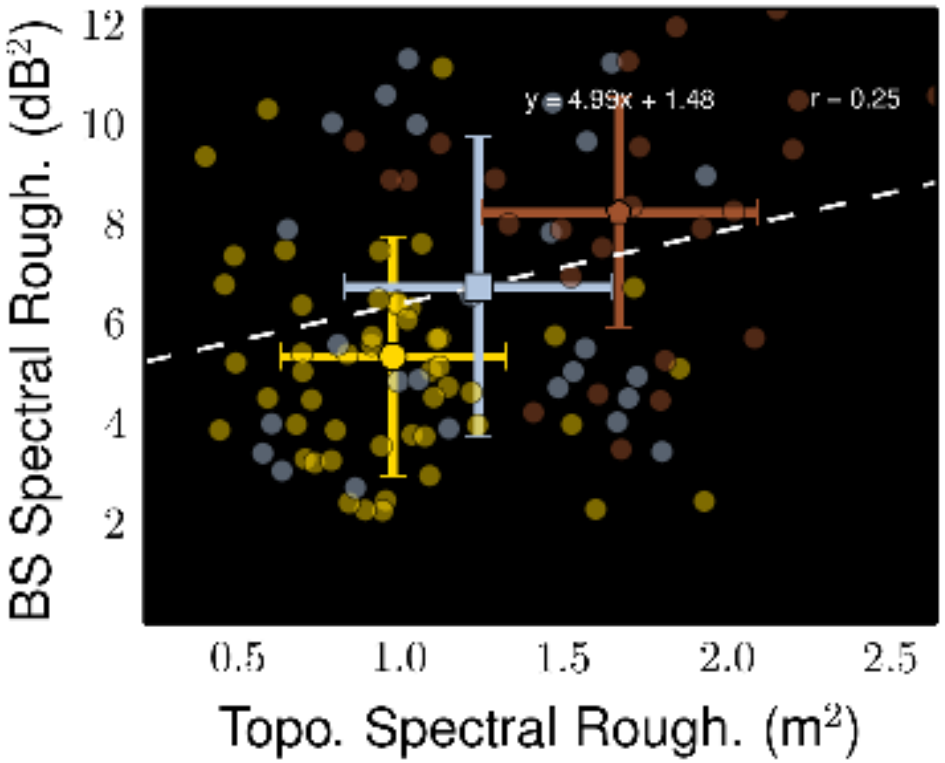






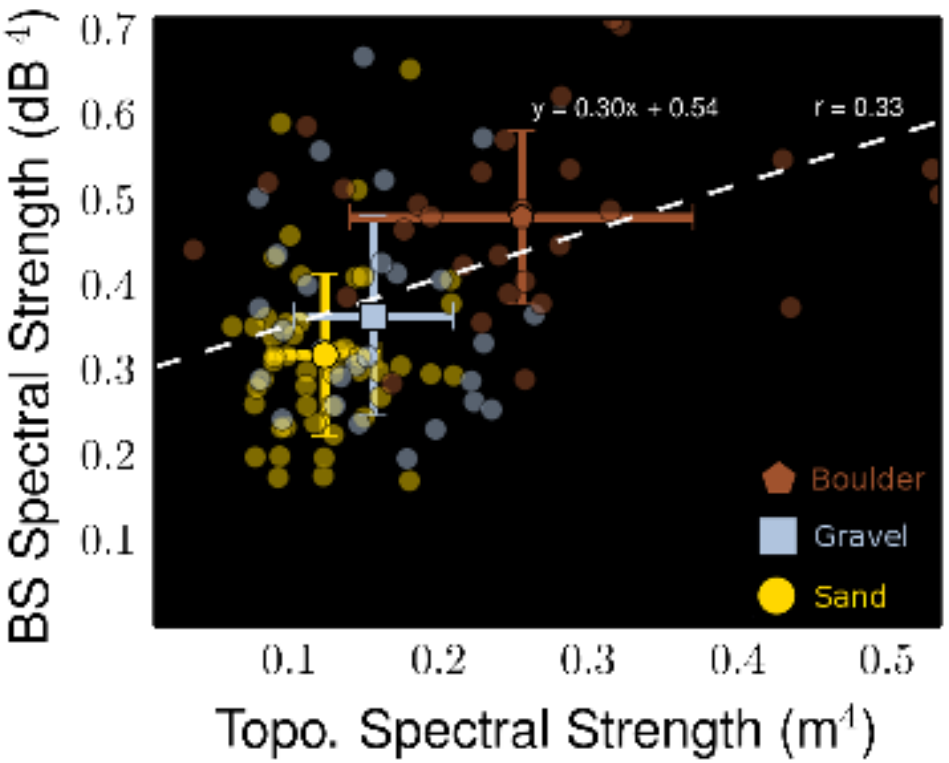
Relationship between sediment type & 'roughness'

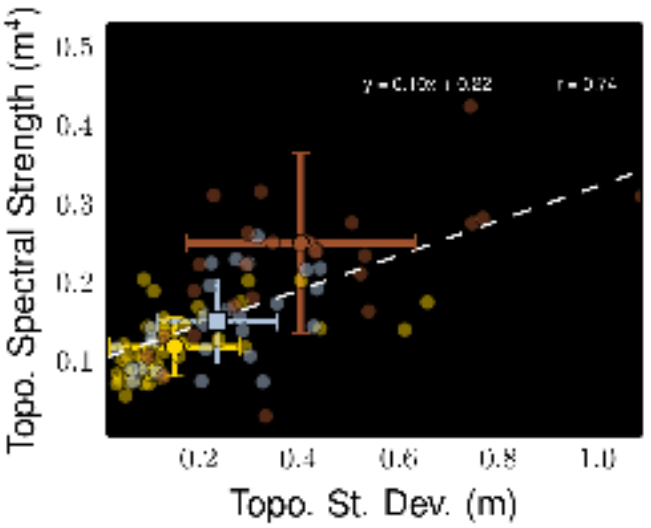


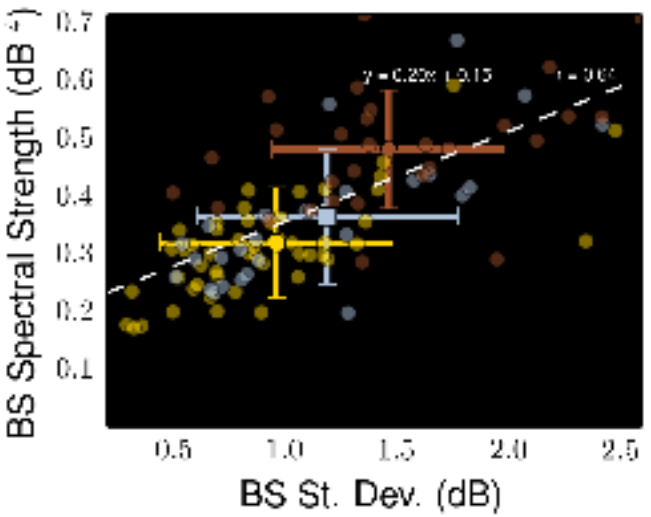


Variance in fluctuating part of both the topographic and backscatter signal increase with increasing clast size

Relationship between sediment type & spectral strength



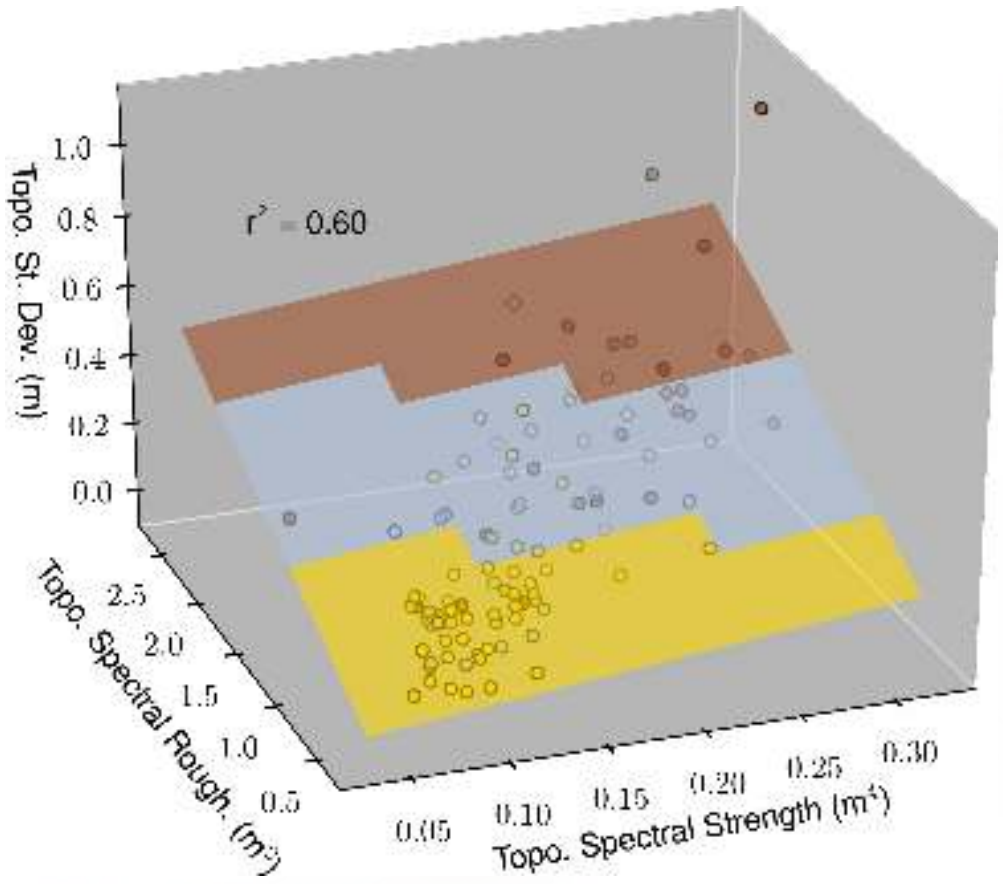


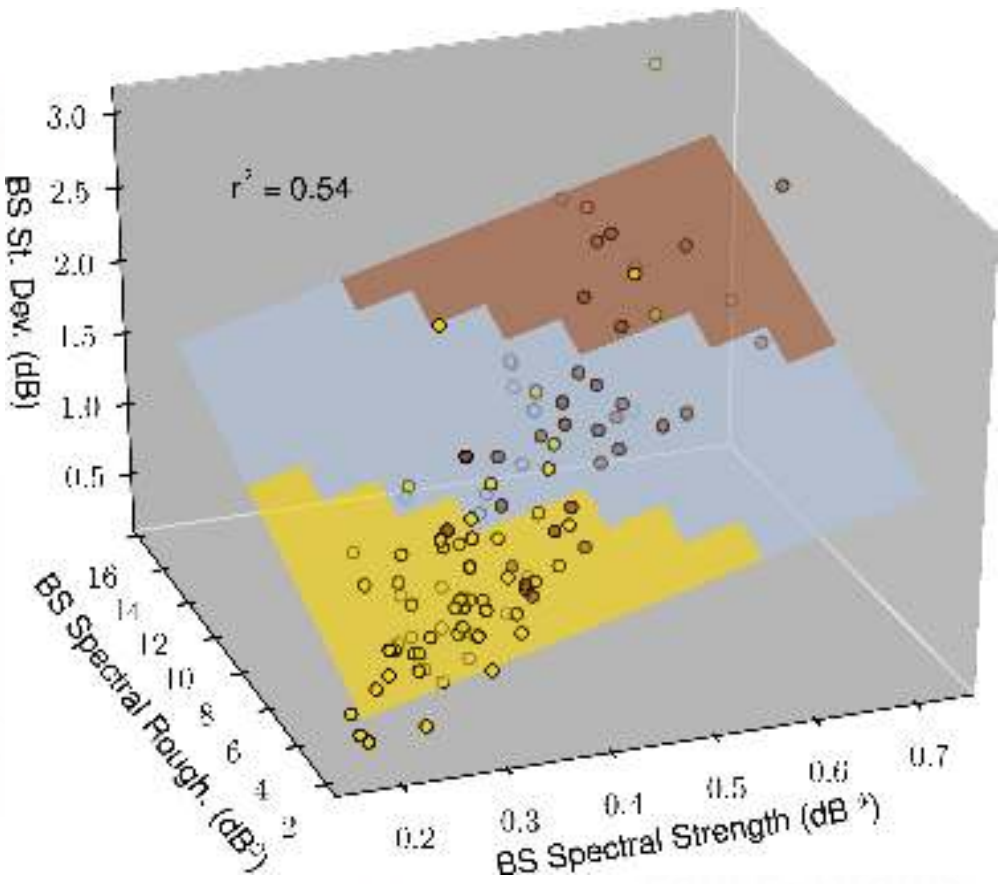


Low-frequency component increases with increasing clast size

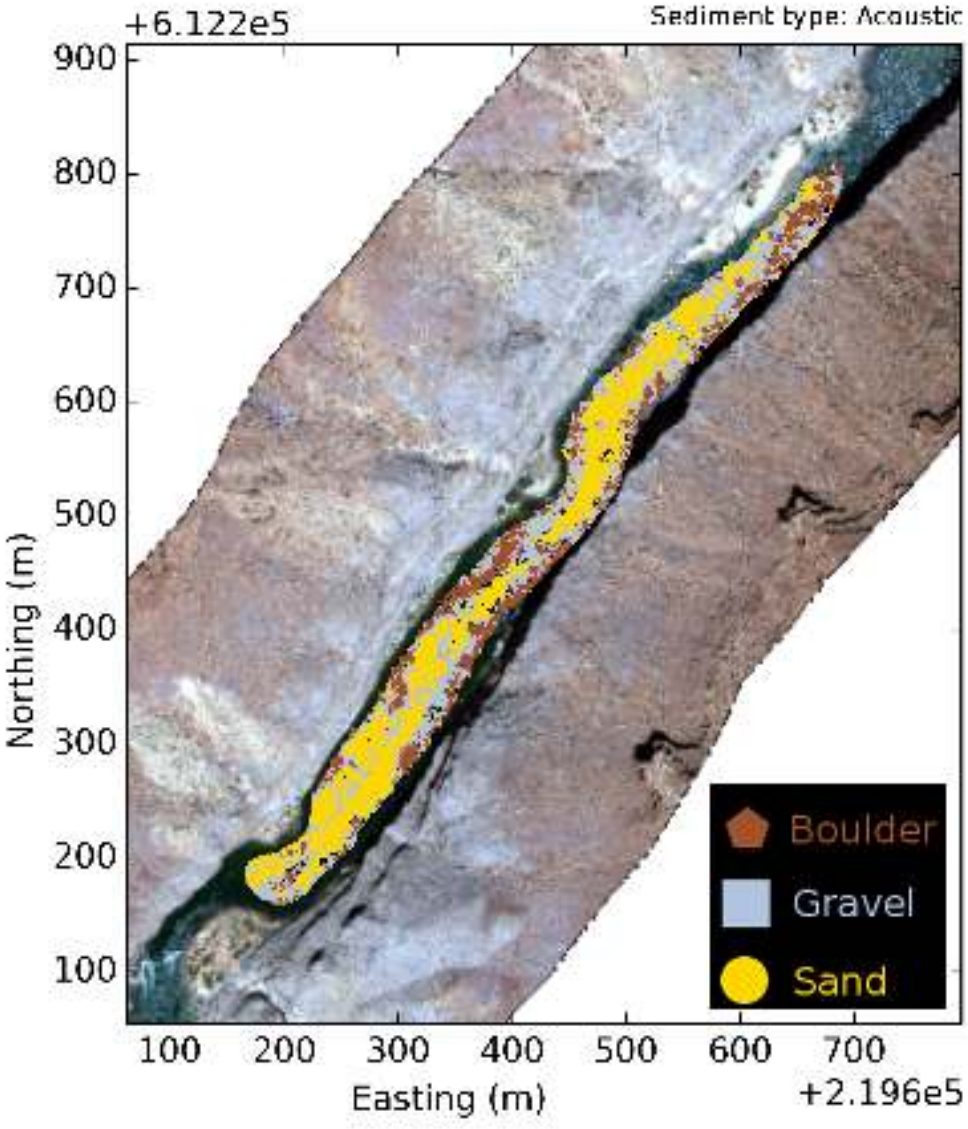
Strong relationships with roughness

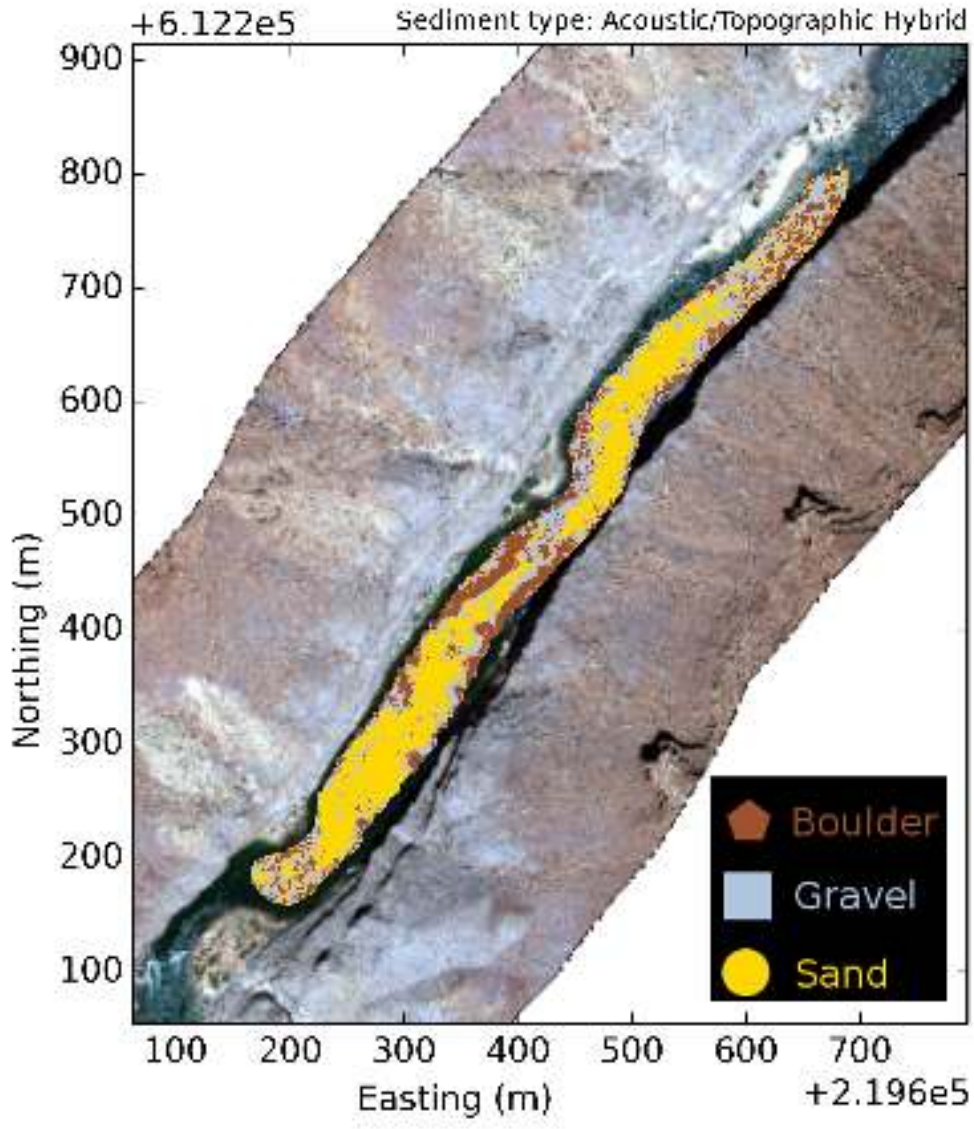
Linear relationships on a continuum





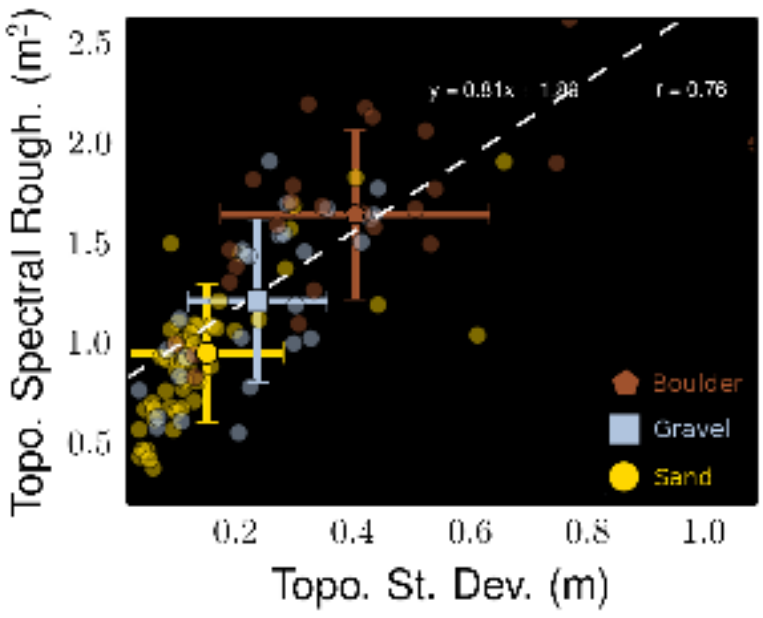
Sediment classification - either/or/both





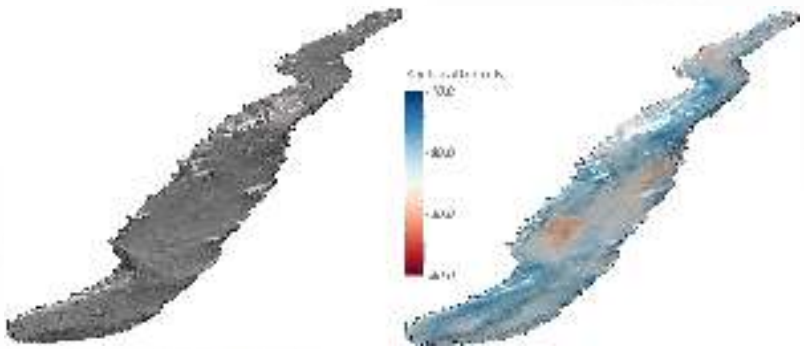
Summary

- High-resolution MBES data from a non-cohesive riverbed
- A suite of statistical parameters relate to sediment type
- Applicable to both topography and backscatter
- Lots of options for acoustic bed sediment classification
- Relative proportions of sand and gravel in mixtures?
- How would this change with silt/clay, or vegetated bottoms ?



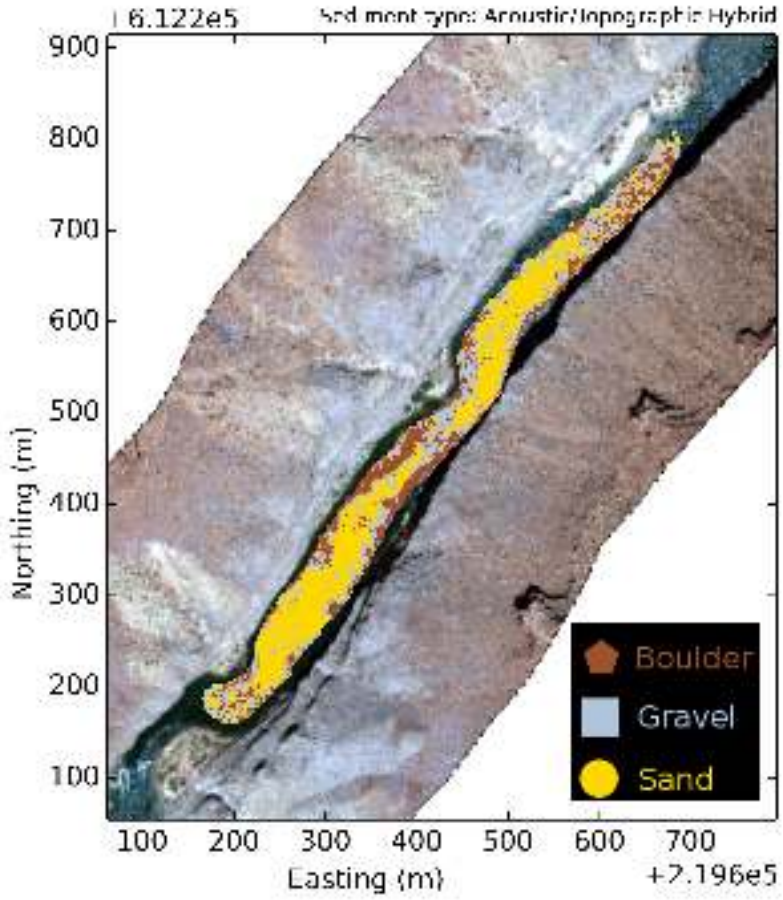
Summary

- High-resolution MBES data from a non-cohesive riverbed
- A suite of statistical parameters relate to sediment type
- Applicable to both topography and backscatter
- Lots of options for acoustic bed sediment classification
- Relative proportions of sand and gravel in mixtures?
- How would this change with silt/clay, or vegetated bottoms ?



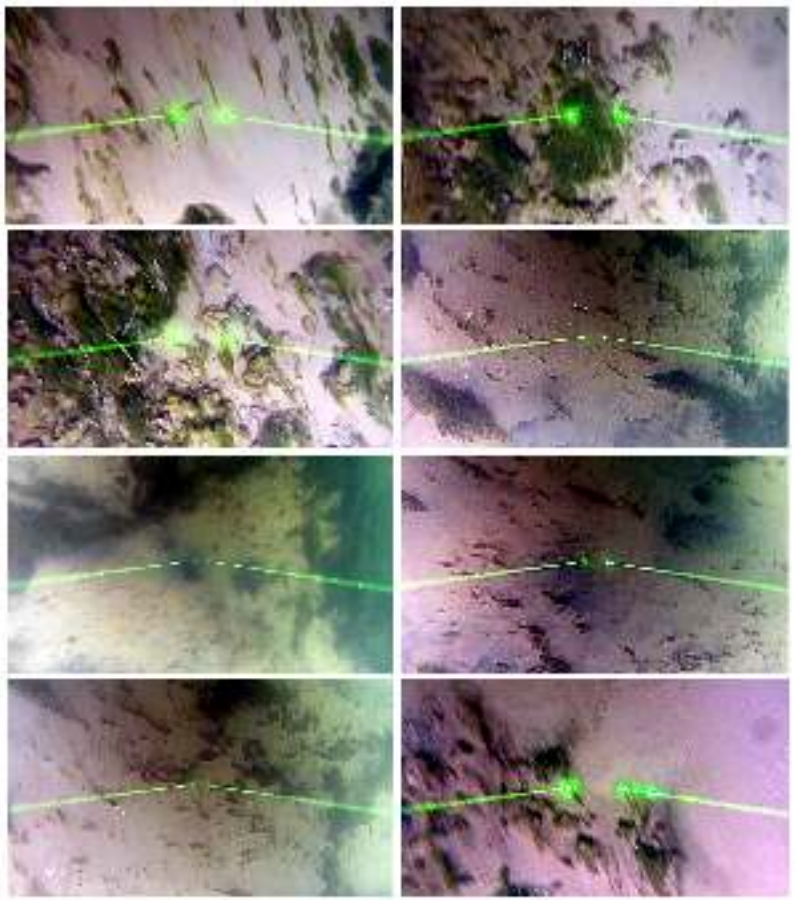
Summary

- High-resolution MBES data from a non-cohesive riverbed
- A suite of statistical parameters relate to sediment type
- Applicable to both topography and backscatter
- Lots of options for acoustic bed sediment classification
- Relative proportions of sand and gravel in mixtures?
- How would this change with silt/clay, or vegetated bottoms ?



Summary

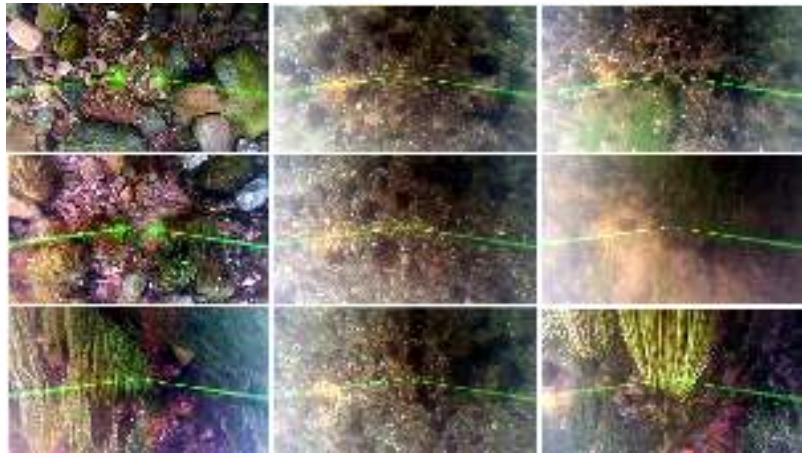
- High-resolution MBES data from a non-cohesive riverbed
- A suite of statistical parameters relate to sediment type
- Applicable to both topography and backscatter
- Lots of options for acoustic bed sediment classification
- Relative proportions of sand and gravel in mixtures?
- How would this change with silt/clay, or vegetated bottoms ?



Sandy gravels in Glen Canyon, Dec 2014

Summary

- High-resolution MBES data from a non-cohesive riverbed
- A suite of statistical parameters relate to sediment type
- Applicable to both topography and backscatter
- Lots of options for acoustic bed sediment classification
- Relative proportions of sand and gravel in mixtures?
- How would this change with silt/clay, or vegetated bottoms ?



Thanks for listening

dbuscombe@usgs.gov | pgrams@usgs.gov

2nd annual
Multibeam Echosounder in Rivers Workshop,
25-27 March 2015,
Flagstaff, AZ.
Email dbuscombe@usgs.gov if you're interested in attending.