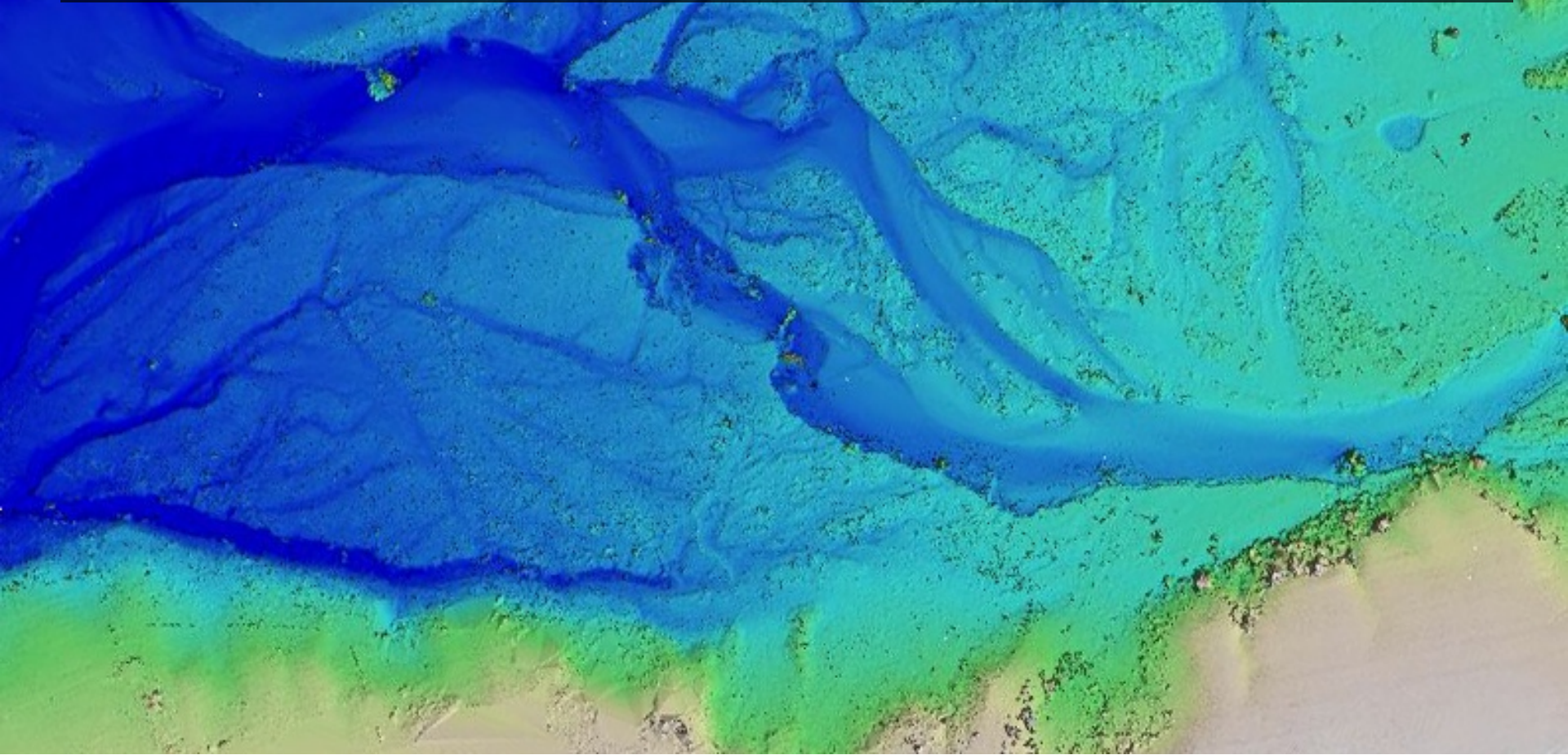


# Monitoring fluvial geomorphic change using unmanned aircraft system (UAS) photogrammetry and laser scanning



03-19-2018

Scott D. Hamshaw, Ph.D., P.E.,  
M. Dewoolkar, J. O'Neil-Dunne, T. Engel, D. Rizzo, Jeff. Frolik, & T. Bryce



# Project Goals

- ❑ Evaluate UAS-based photogrammetry system
- ❑ Accuracy comparison to ground survey
- ❑ Geomorphic change measurement



SenseFly eBee UAS



Ground survey:  
RIEGL VZ-1000 TLS  
TopCon HiperLite+ GPS

# What we get from UAS

## 1. Orthomosaic imagery

Computer vision:  
Structure-from-motion (SfM)  
& multi-view stereo

## 2. Photogrammetric point cloud (RGB colorized)

Filtering and/or  
Machine learning  
classification and processing

## 3. Derived products:

- Digital surface model (DSM)
- Digital elevation model (DEM)



# Orthomosaic imagery



3.2 cm UAS



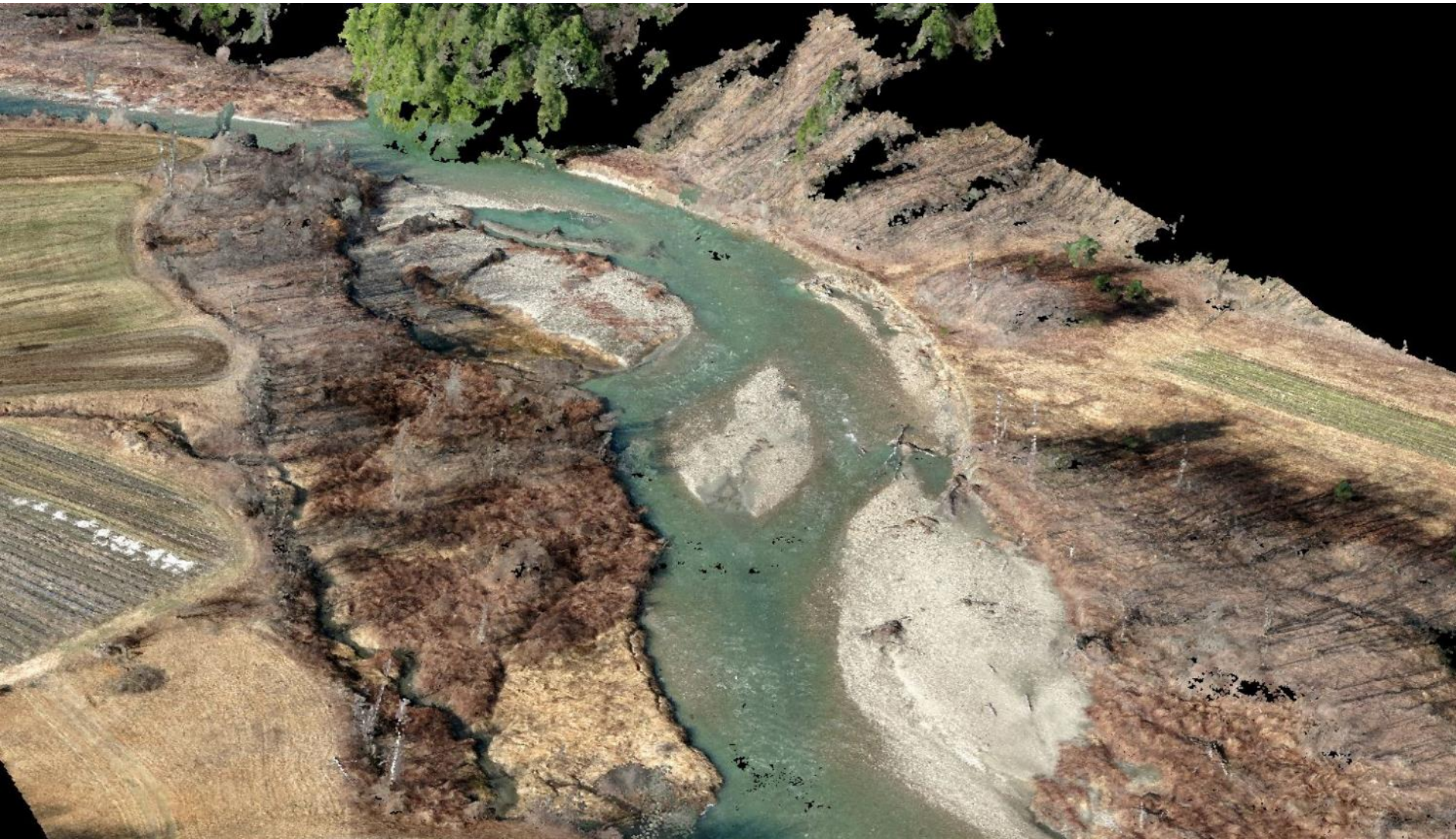
0.5 m Ortho



1 m NAIP

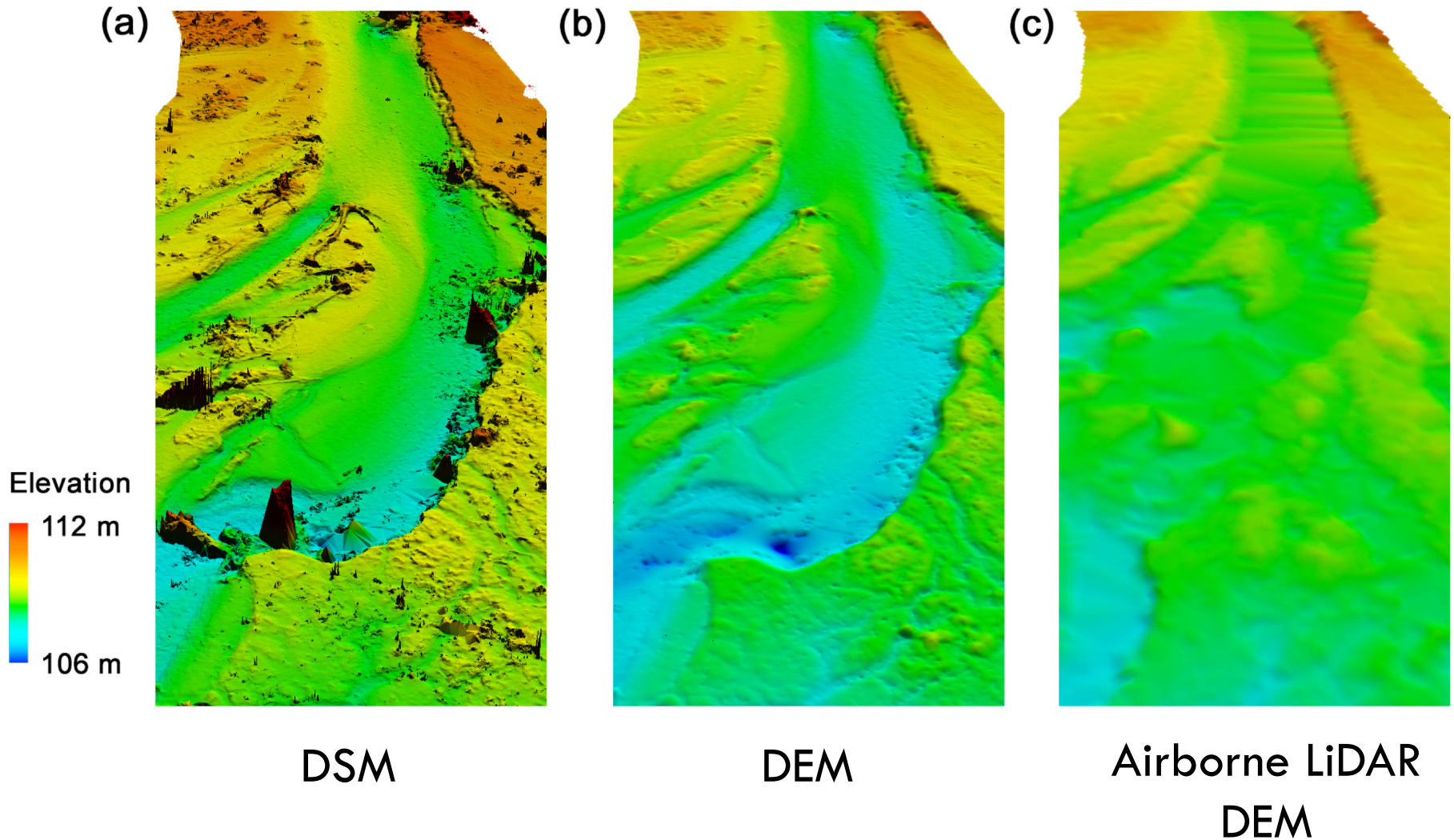


# Photogrammetric point cloud





# Digital elevation and surface models



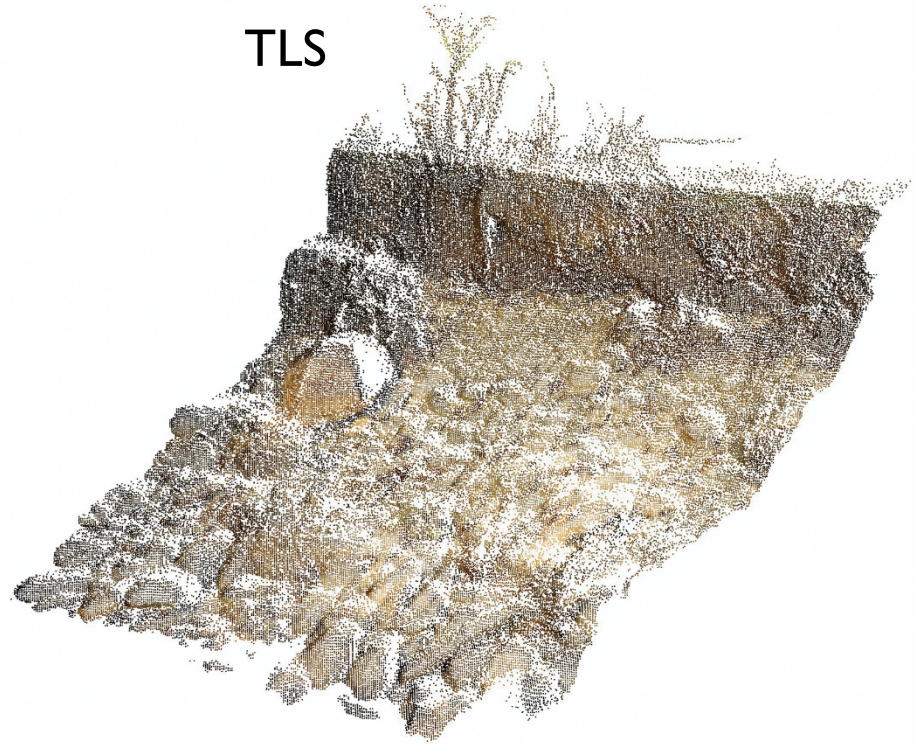


# Comparison between UAS & TLS

UAS

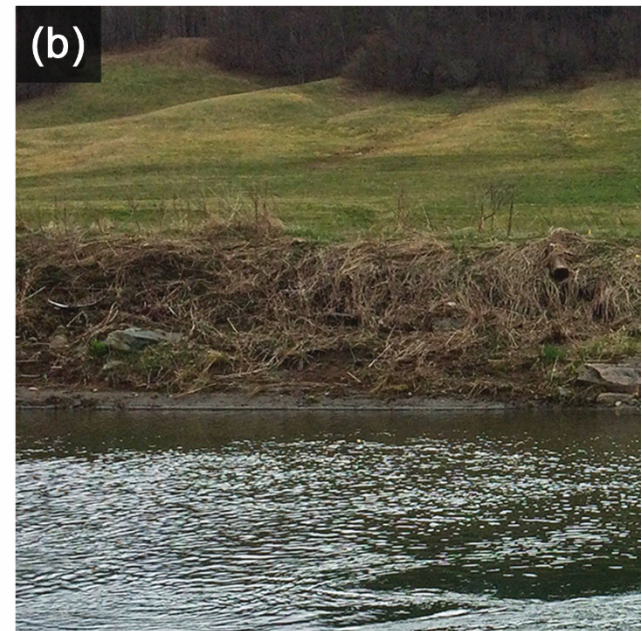
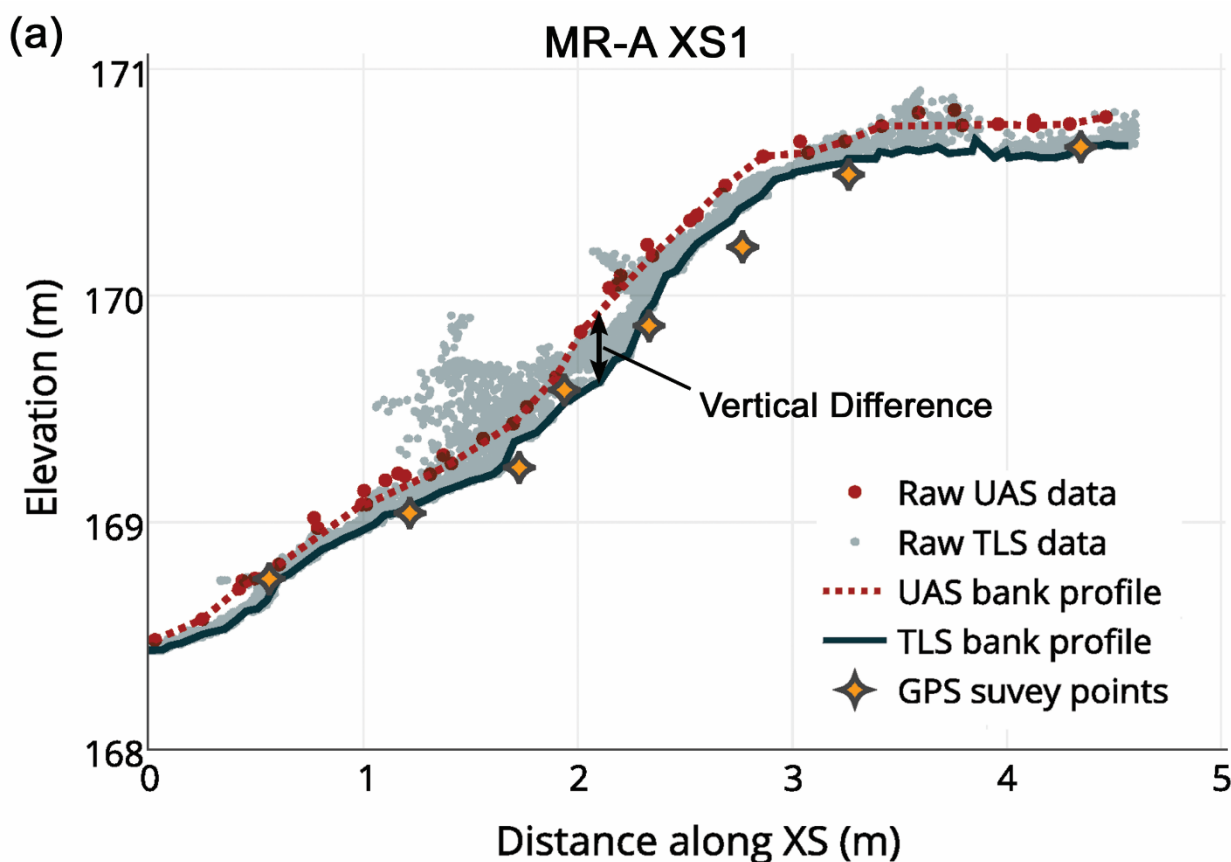


TLS



# Accuracy Assessment – X-Sections

□ 11 cm vertical / 28 cm horizontal





# Accuracy Assessment - GCPs

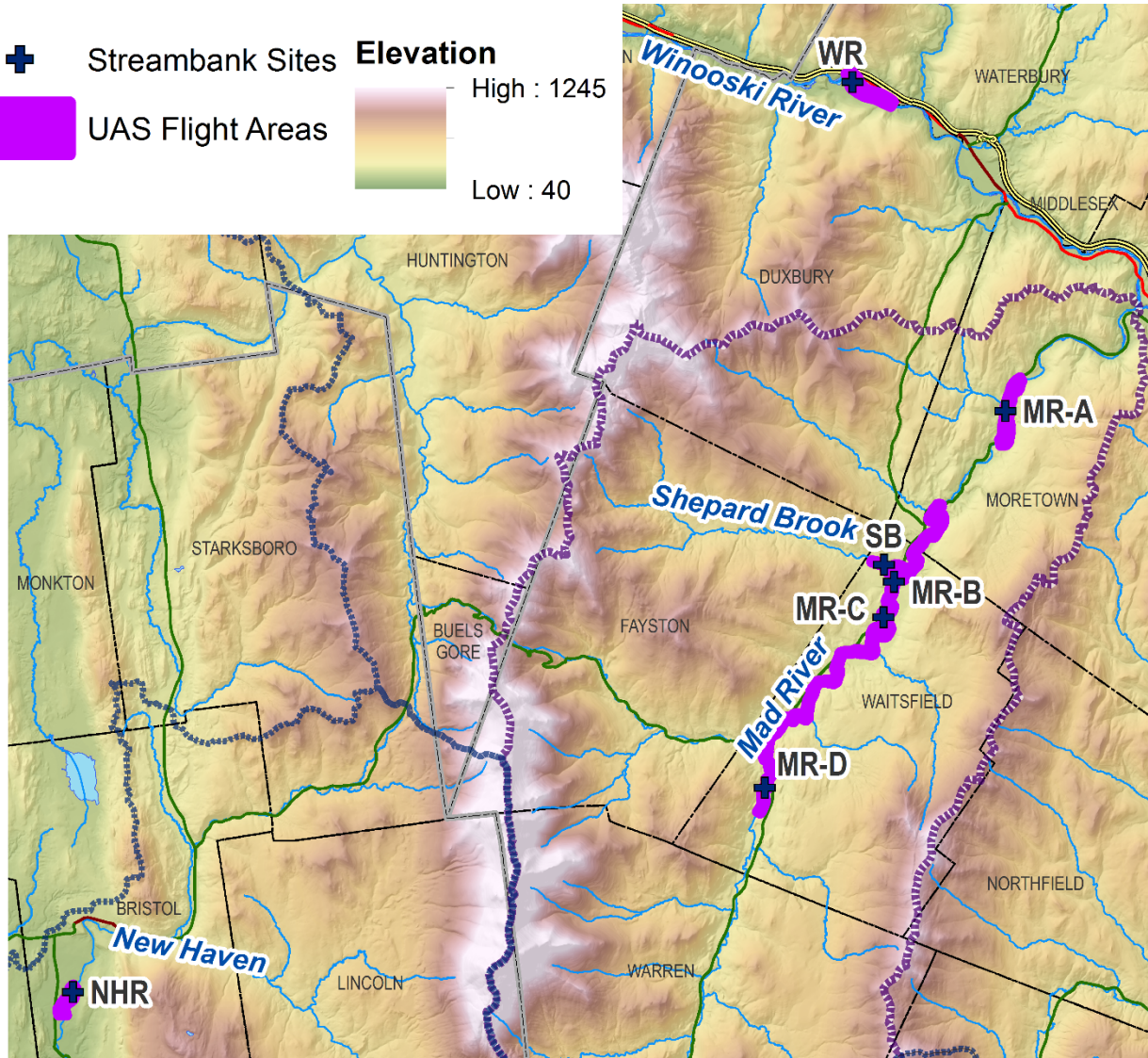
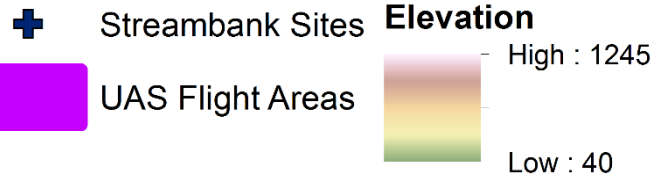
## *New Haven River Site (n = 16)*

	<b>2012 ALS</b>	<b>2015 UAS</b>	<b>2016 UAS</b>	<b>2017 UAS</b>
Mean Error (m)	0.02	0.25	0.12	0.04
Median Error (m)	0.02	0.23	0.08	0.02
Standard Deviation Error (m)	0.09	0.09	0.15	0.12
RMSE (m)	0.09	0.26	0.19	0.12

## *Shepard Brook Site (n = 10)*

	<b>2014 ALS</b>	<b>2017 UAS</b>
Mean Error (m)	0.04	-0.09
Median Error (m)	0.00	0.03
Standard Deviation Error (m)	0.20	0.36
RMSE (m)	0.19	0.35

# Field Data Collection



(d)





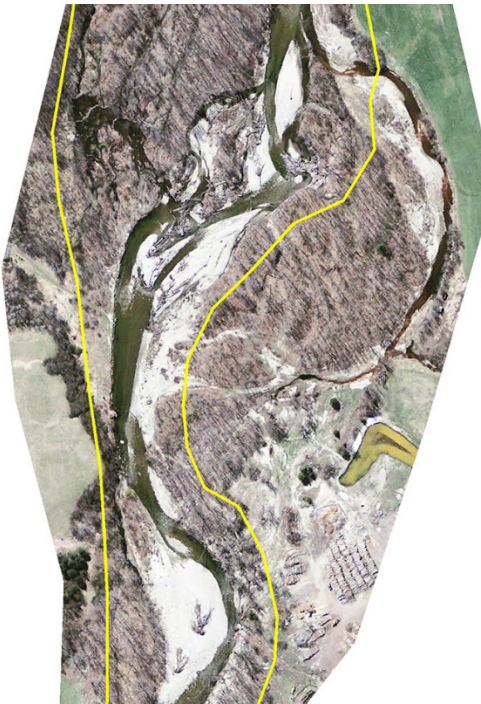
# Data collection metrics

- 43% of survey days rescheduled/shortened
- 2-3 person survey team
- Direct georeferencing with sparse GCPs for check

Year	Number of flights	Total Length of River Surveyed (km)	Mean Length of River per Flight (m)	Total days** in field for surveying	Number of days impacted* by weather
2015	55	21.7	395	12	3
2016	18	13.7	760	5	5
2017	17	14.3	843	4	1

# River corridor vegetation

Spring '12



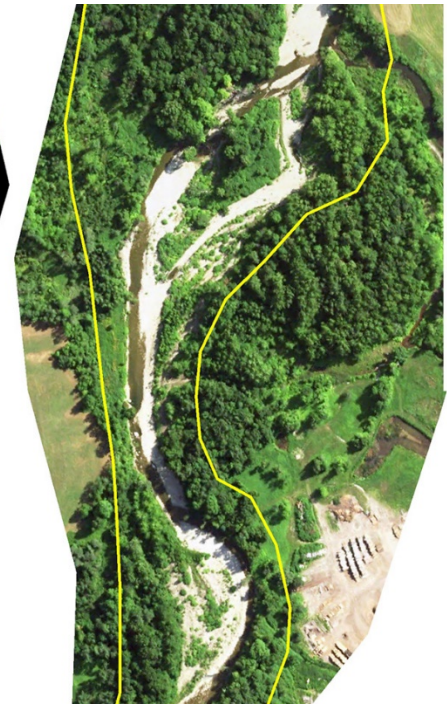
Fall '15



Spring '17



Summer '16



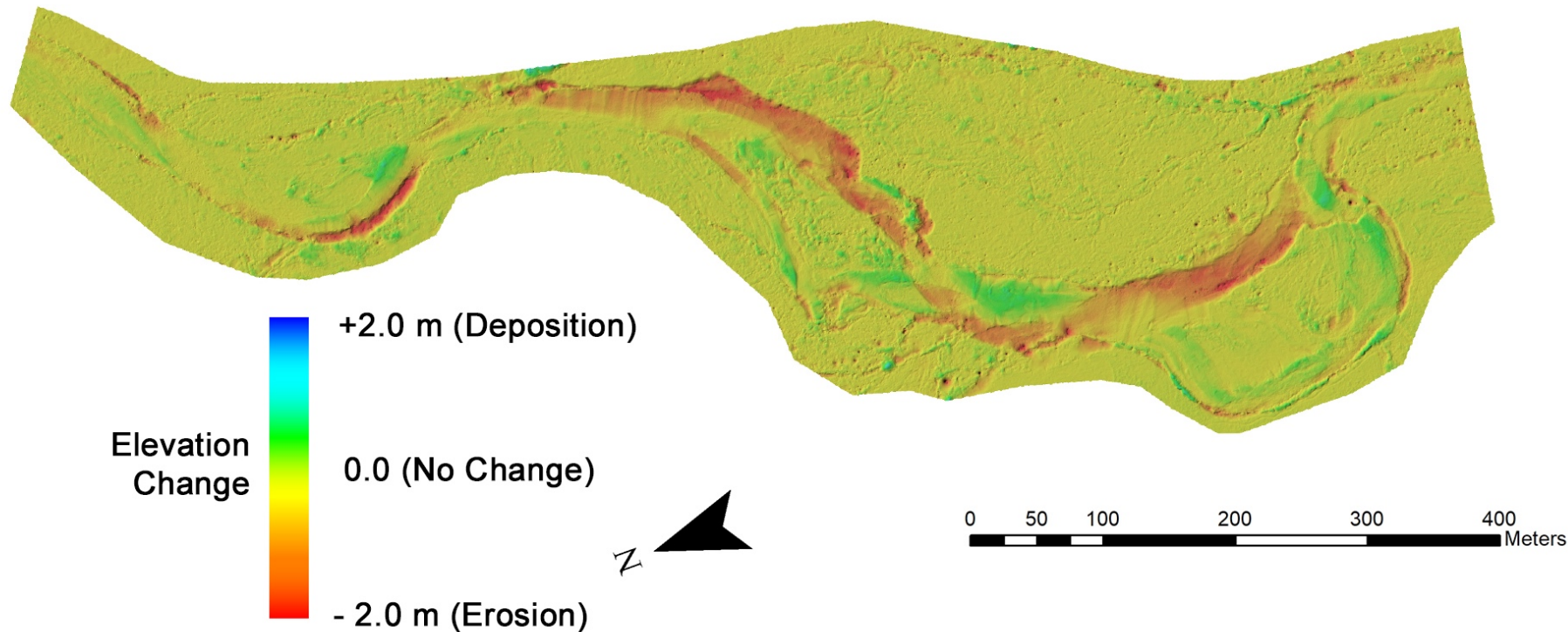
Bristol Flats, New Haven River



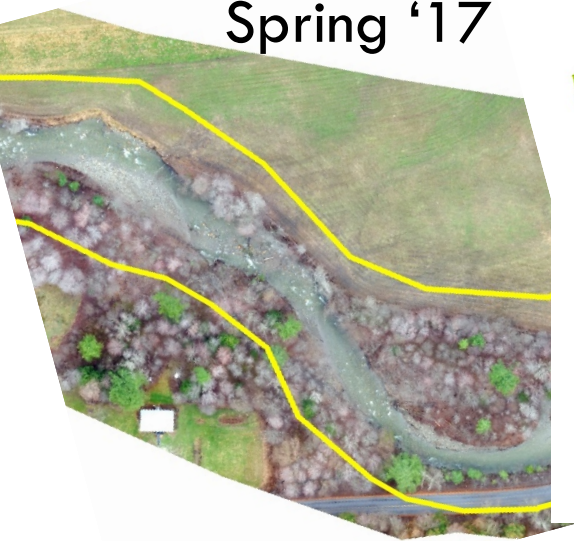
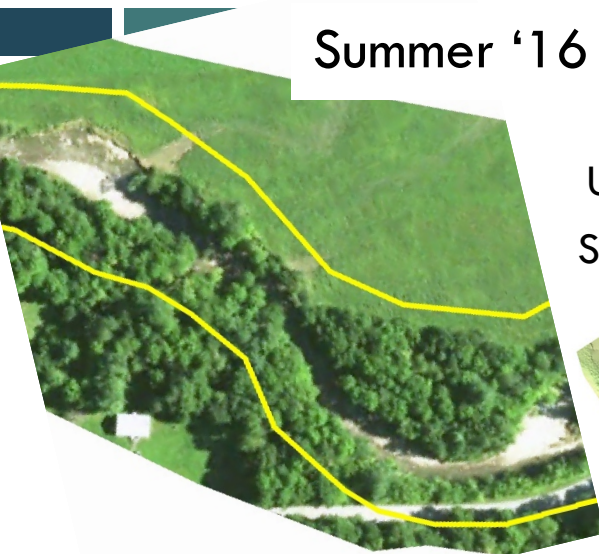
# Geomorphic Change Detection

## Volumetric Change Analysis

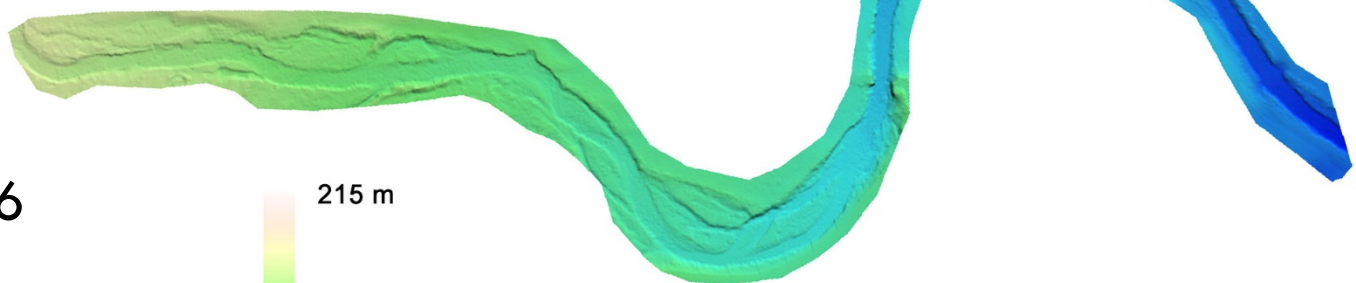
- Difference of DEMs (DoD) → '12 ALS to '17 UAS
- Net change of -19,920 m<sub>3</sub>



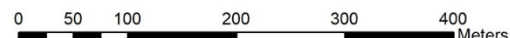
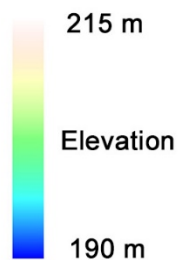
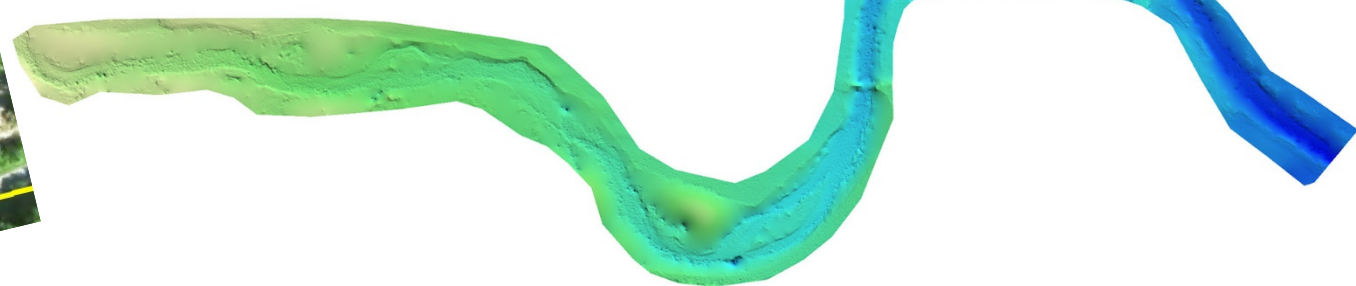
# Change Detection



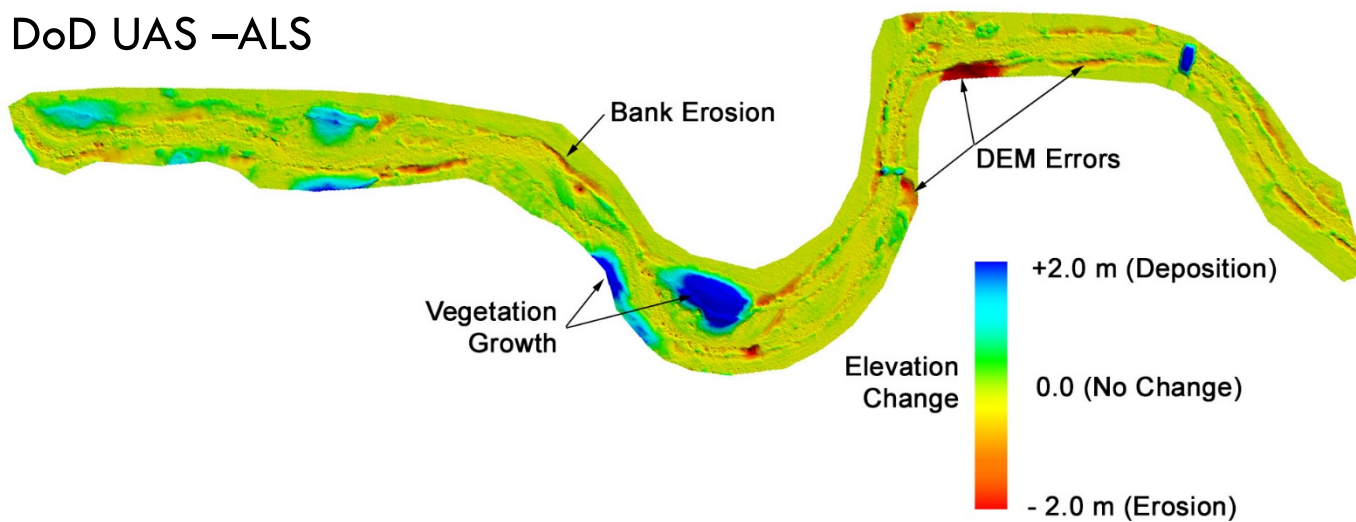
ALS DEM Spring '14



UAS DEM  
Spring '17



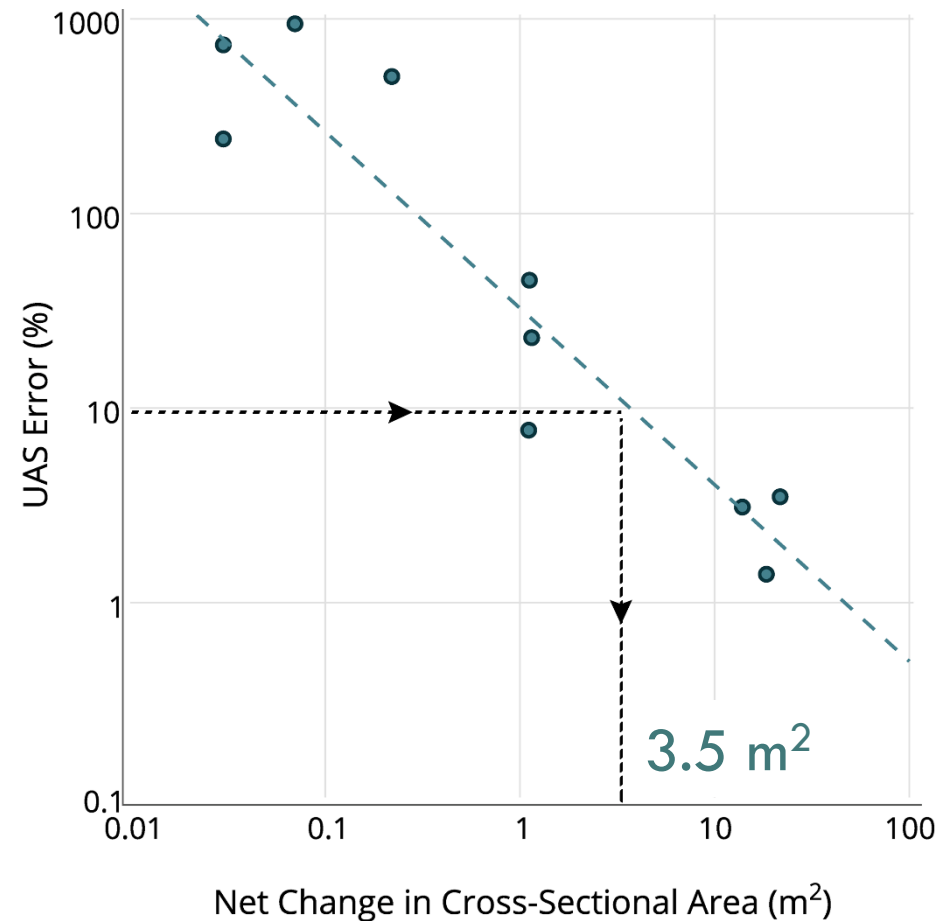
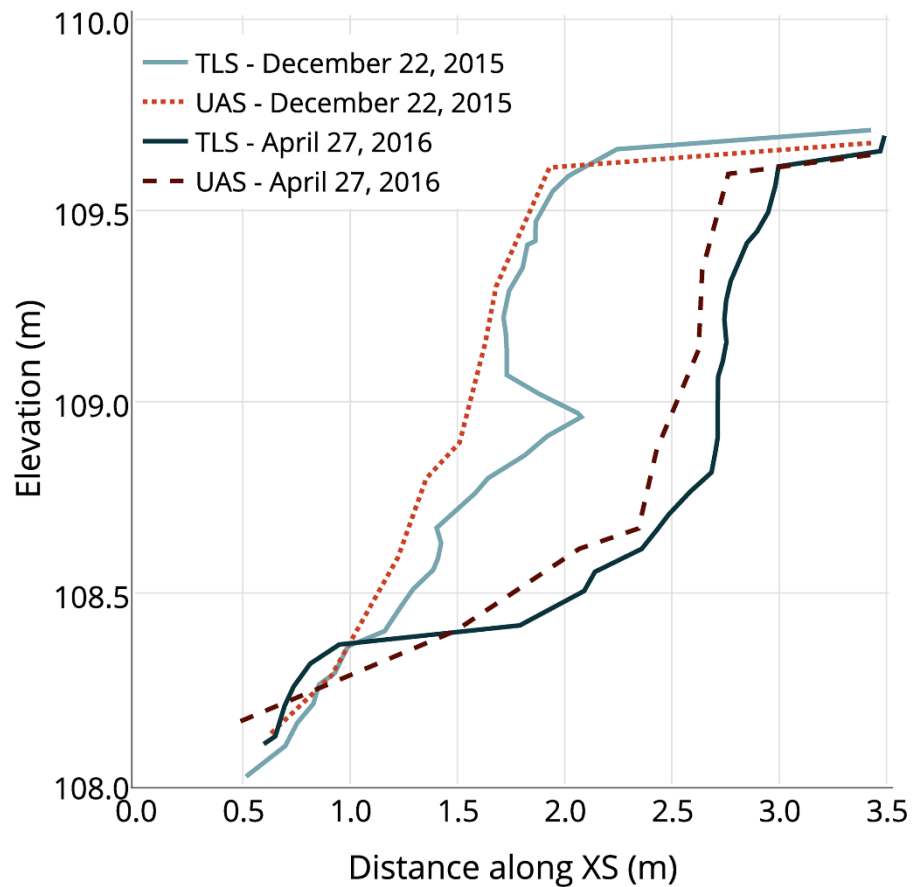
DoD UAS -ALS





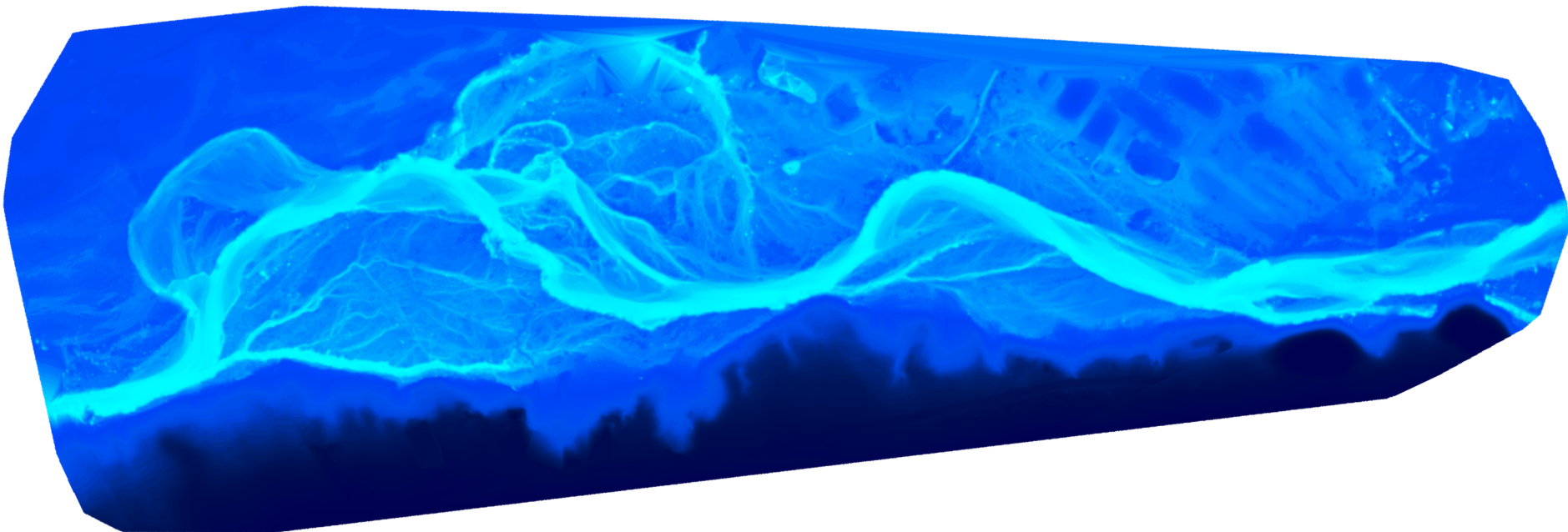
# Geomorphic Change Detection

## Cross Section Analysis



# UAS for monitoring river corridors

- Optimal survey time: early spring
- Sparse network of GCPs = check / bias adjustment
- Vegetation density dependent
- Quantification of bank erosion from UAS data effective for larger bank retreats ( $> 1\text{ m}$ )





# Contact Info & Acknowledgements

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- Scott Hamshaw, Ph.D., P.E.
  - Vermont EPSCoR | 23 Mansfield Ave, Burlington, VT
  - [scott.hamshaw@uvm.edu](mailto:scott.hamshaw@uvm.edu)
  - 802.324.6221
- Support provided by:
  - Vermont EPSCoR with (NSF) Grant EPS-1101317 and EPS-1556770
  - NSF Graduate Research Fellowship (Grant No. DGE-0925179NSF)
  - Vermont Water Resources and Lake Studies Center
  - Robert & Patricia Switzer Foundation
  - University of Vermont



The University of Vermont



**RACC**  
Research on Adaptation  
to Climate Change

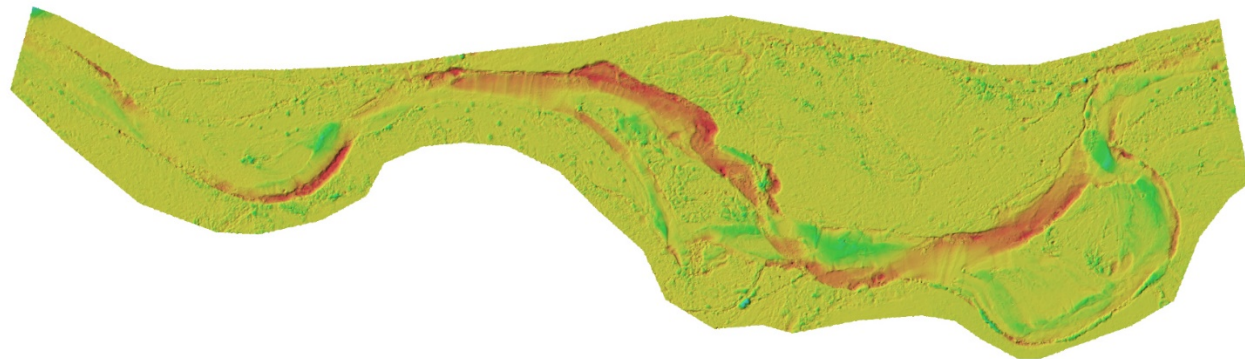


**BREE**  
Basin Resilience to  
Extreme Events  
in the Lake Champlain Basin

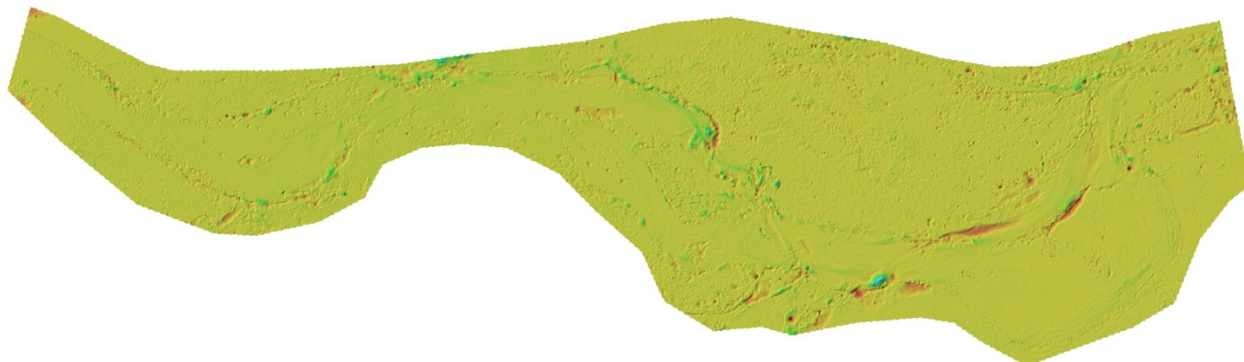
ROBERT & PATRICIA  
**SWITZER**  
FOUNDATION



(a)



(b)



(c)

