Growing ideas through networks

Drones for River Monitoring: a ten-year perspective

James T. Dietrich

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HARMONIOUS
uas for environmental monitoring

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

Advances in Environmental Monitoring with UAS, Debrecen, Hungary (30 March 2022)

Where it started (for me)…

EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms **38**, 421–430 (2013)

Published online 25 January 2013 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/esp.3366

Letters to ESEX

Topographic structure from motion: a new development in photogrammetric measurement

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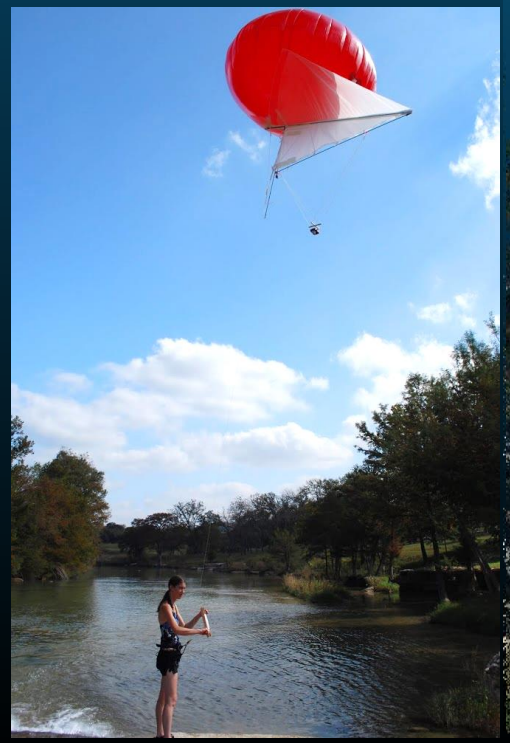


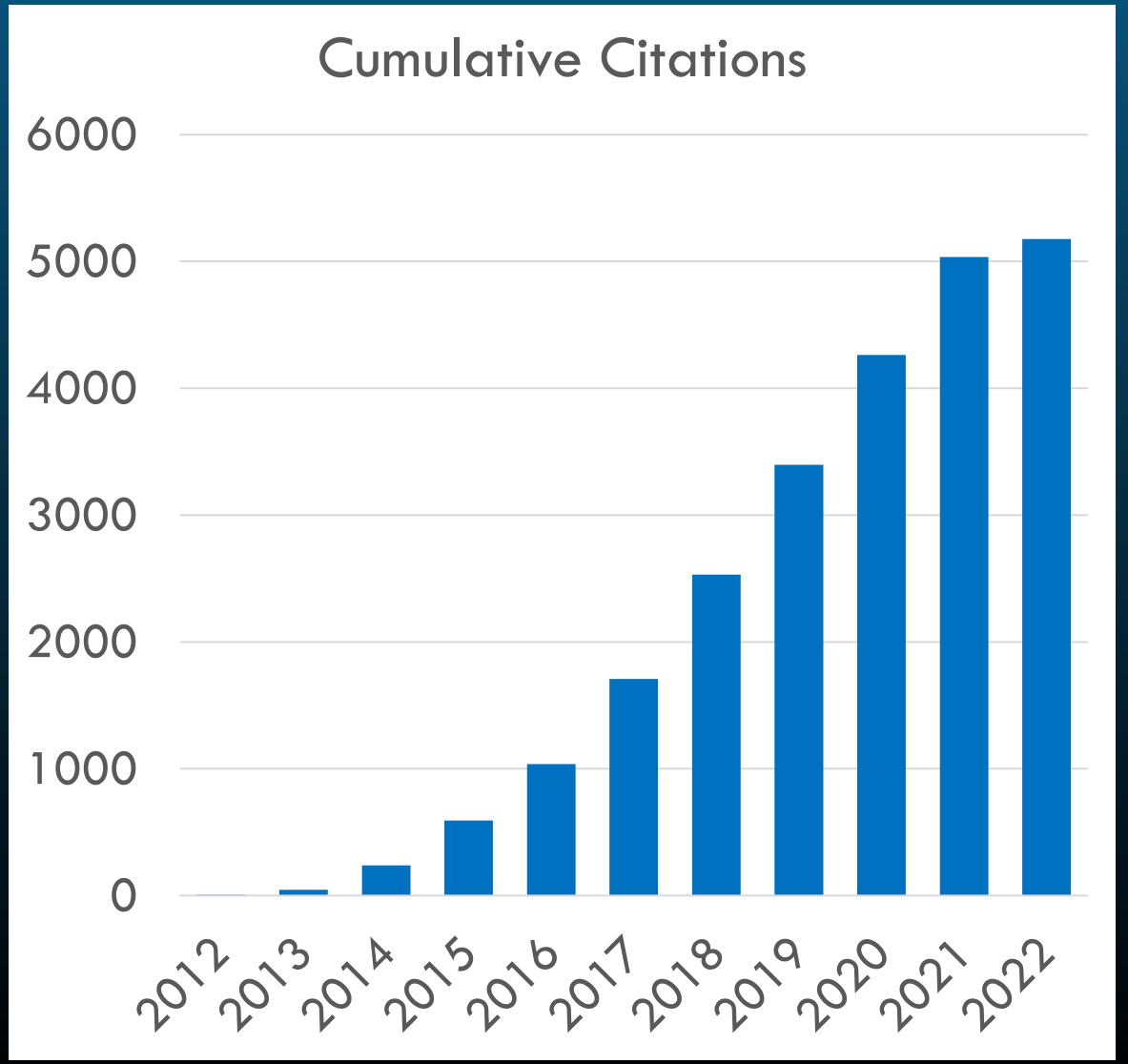
5,088,097 points
Original Point Cloud
Agisoft Photoscan

3D Robotics Arducopter
Middle Fork John Day River, 2012

Growth of SfM (and UAS)

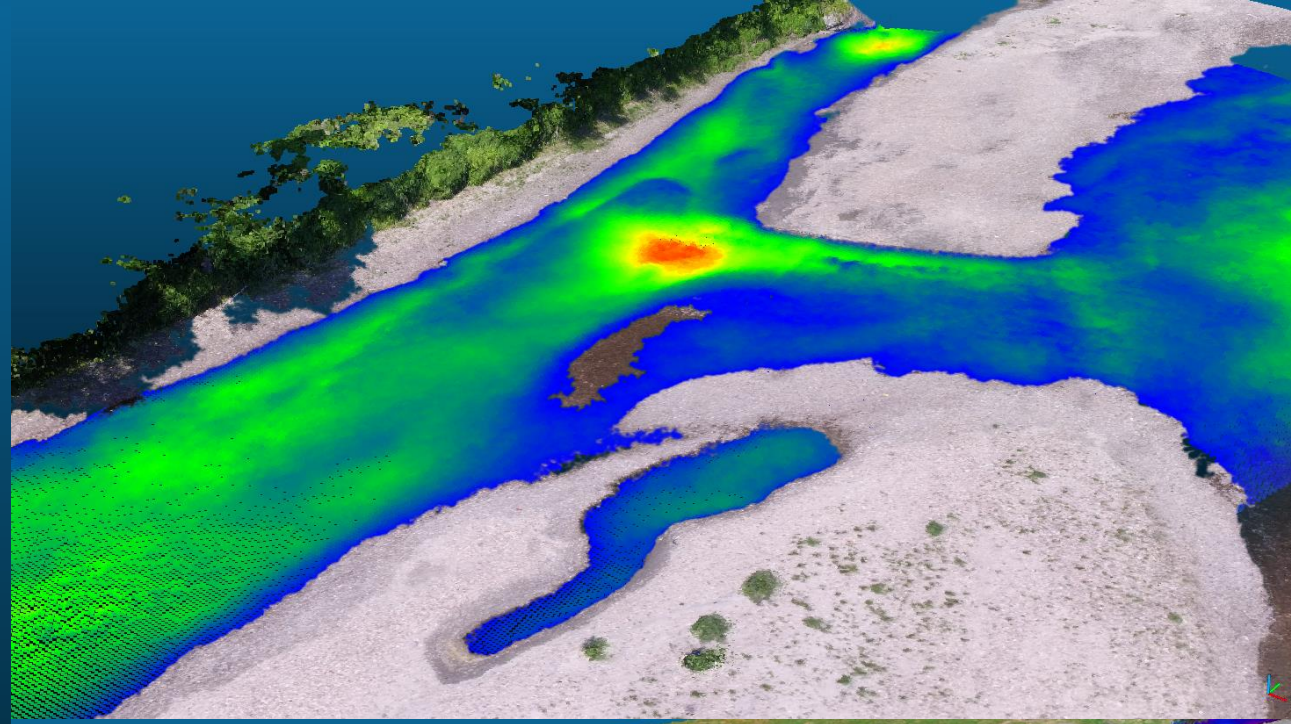
The originating articles for SfM in earth and environmental science

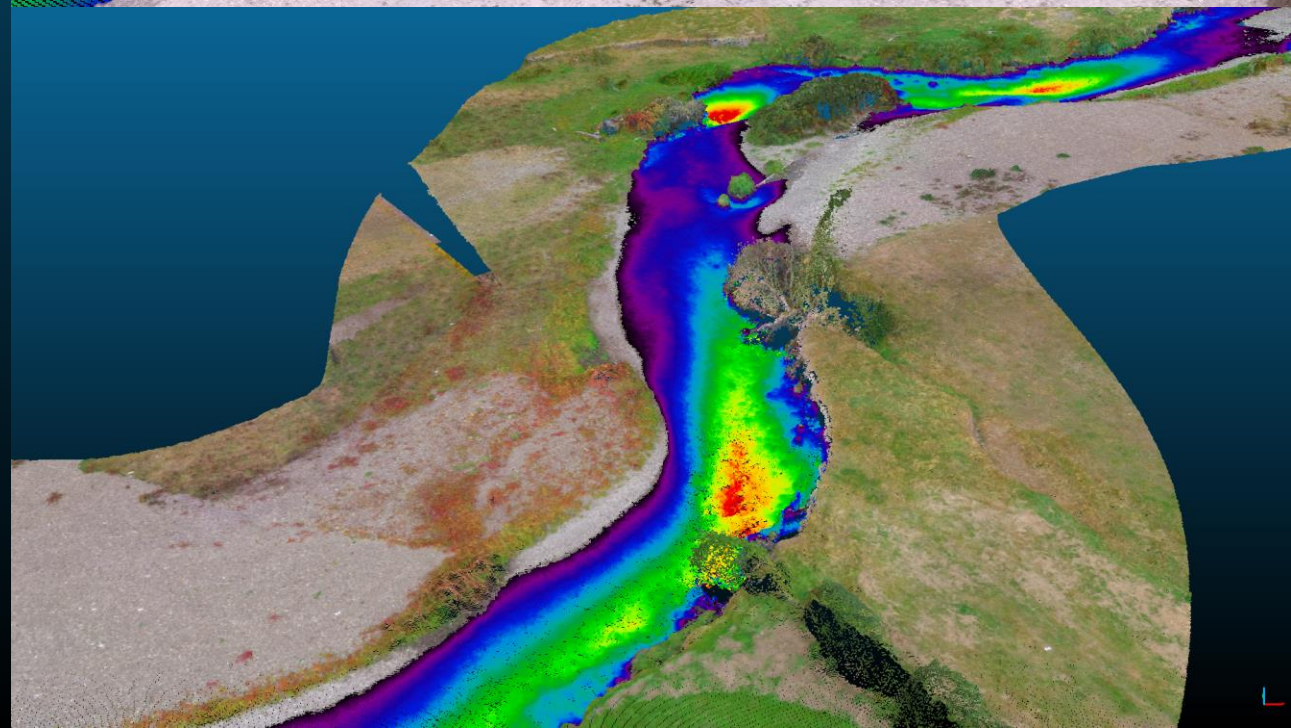
- James and Robson (2012), JGR-ES
- Westoby et al. (2012), Geomorphology
- Fonstad et al. (2013), ESPL



How it is Going…

Bathymetric Structure from Motion and Below-Water Fluvial Geomorphic Change Detection

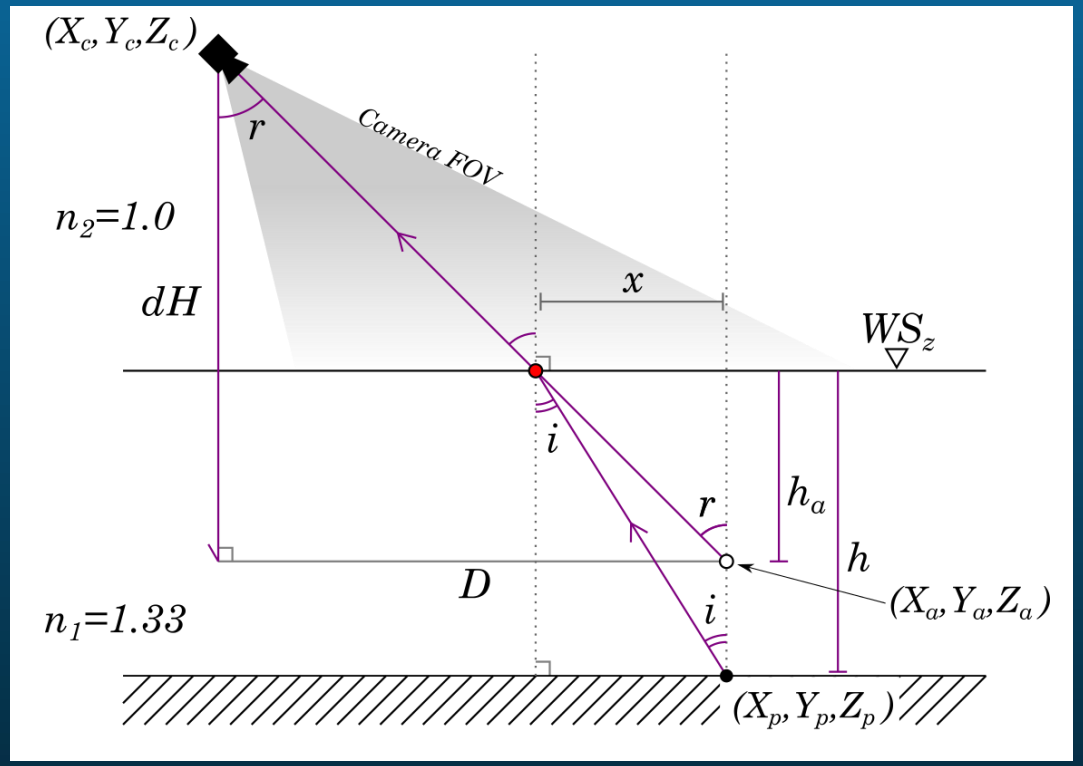


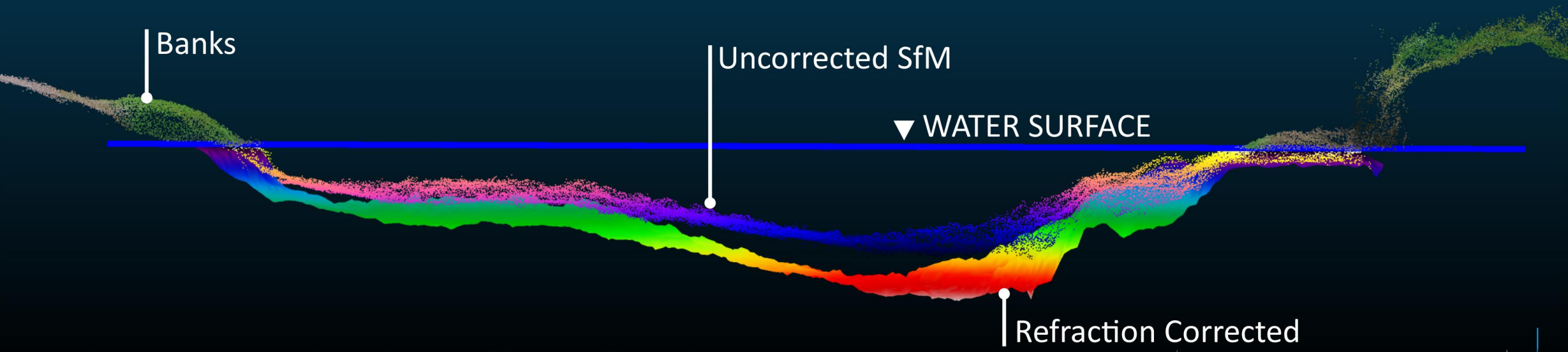


GitHub py_BathySfM

Dietrich. 2017. Bathymetric Structure-from-Motion. Earth Surface Processes and Landforms.

Woodget, Dietrich, Wilson. 2019. Quantifying Below-Water Fluvial Geomorphic Change. Remote Sensing.





Point cloud cross-section illustrating the different SfM surfaces

Woodget, Dietrich, Wilson. 2019.
Remote Sensing

2016

FLOW

701 Photos
15 & 35m altitudes

Google Earth

N

100 m

2017

FLOW

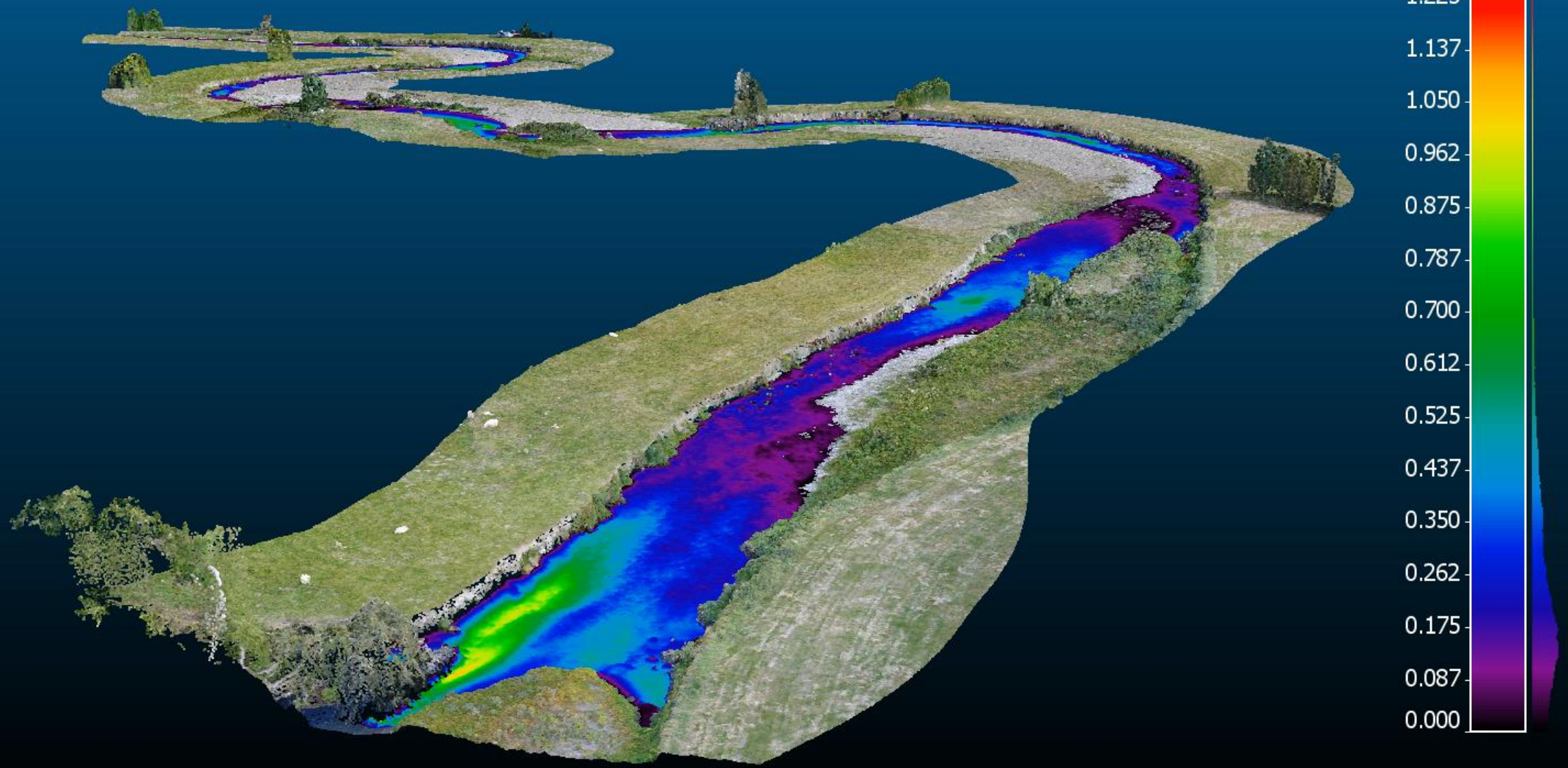
1040 Photos
35m altitudes

N

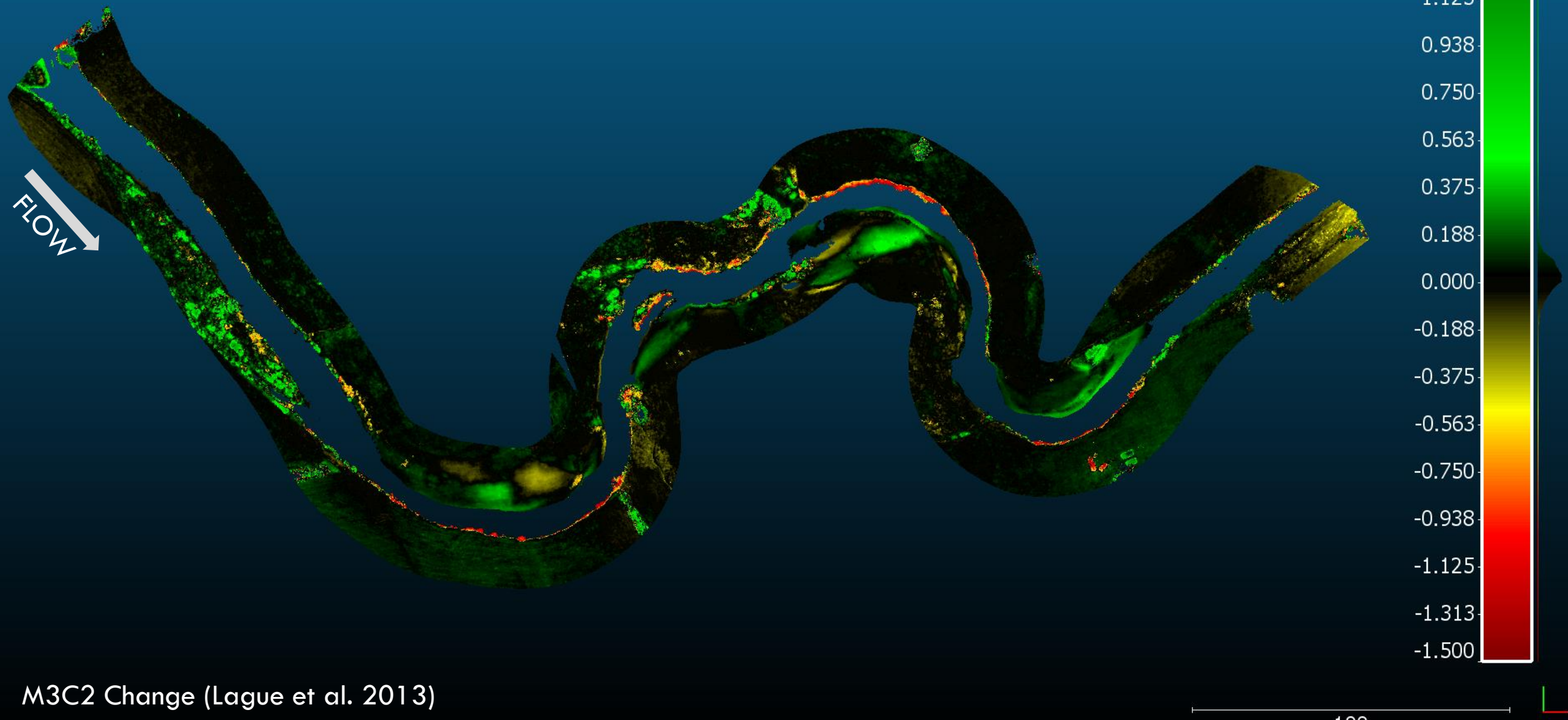
100 m

Google Earth

2017 Corrected Depth

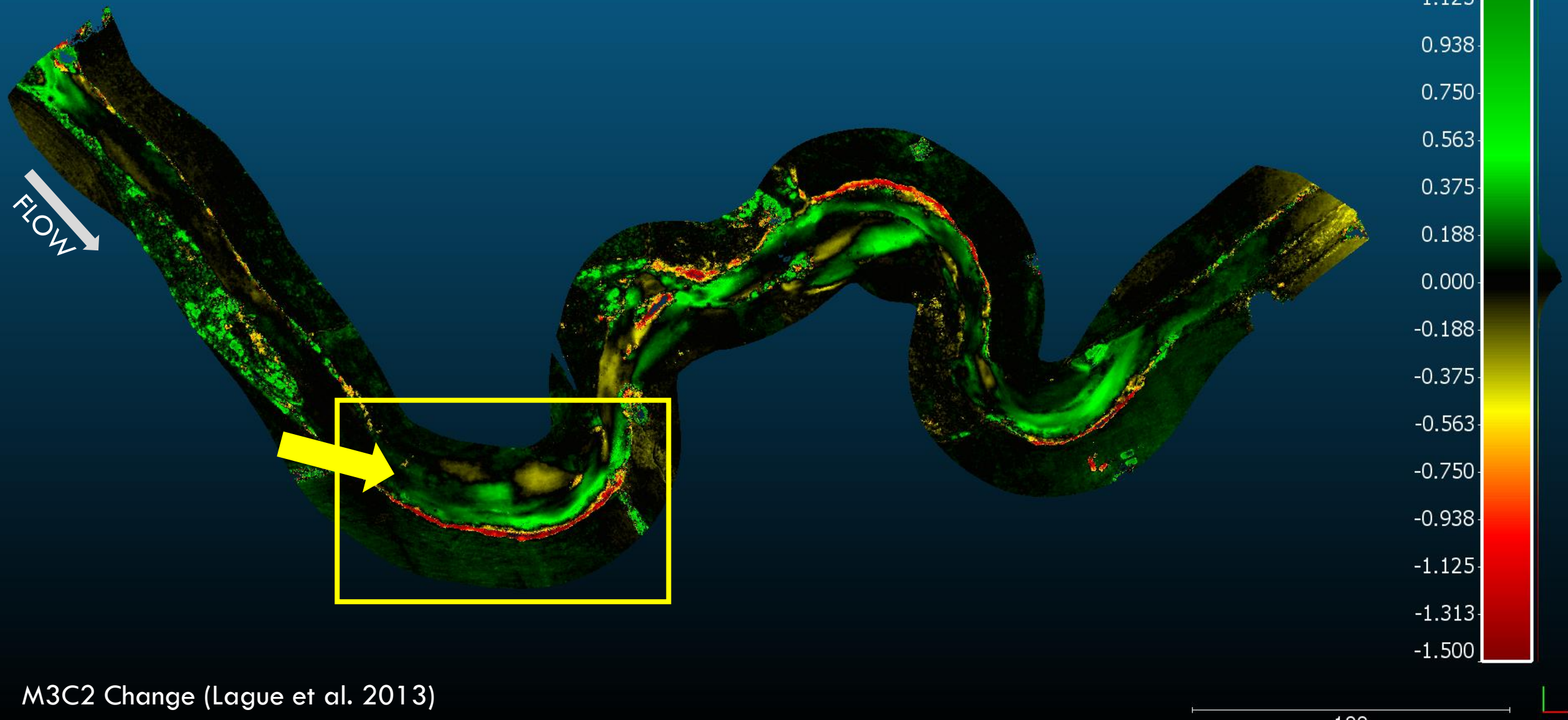


Change – Banks only

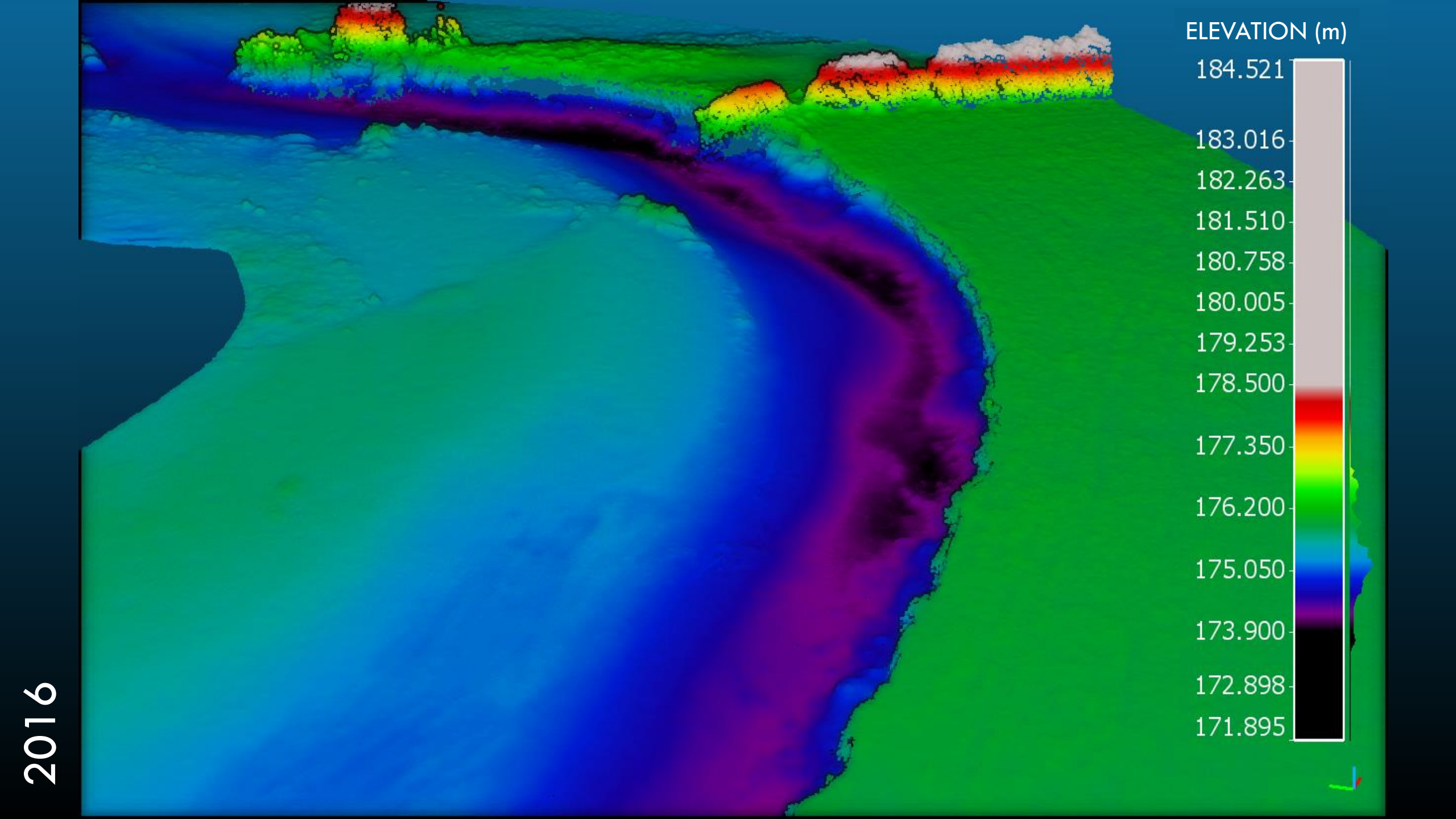


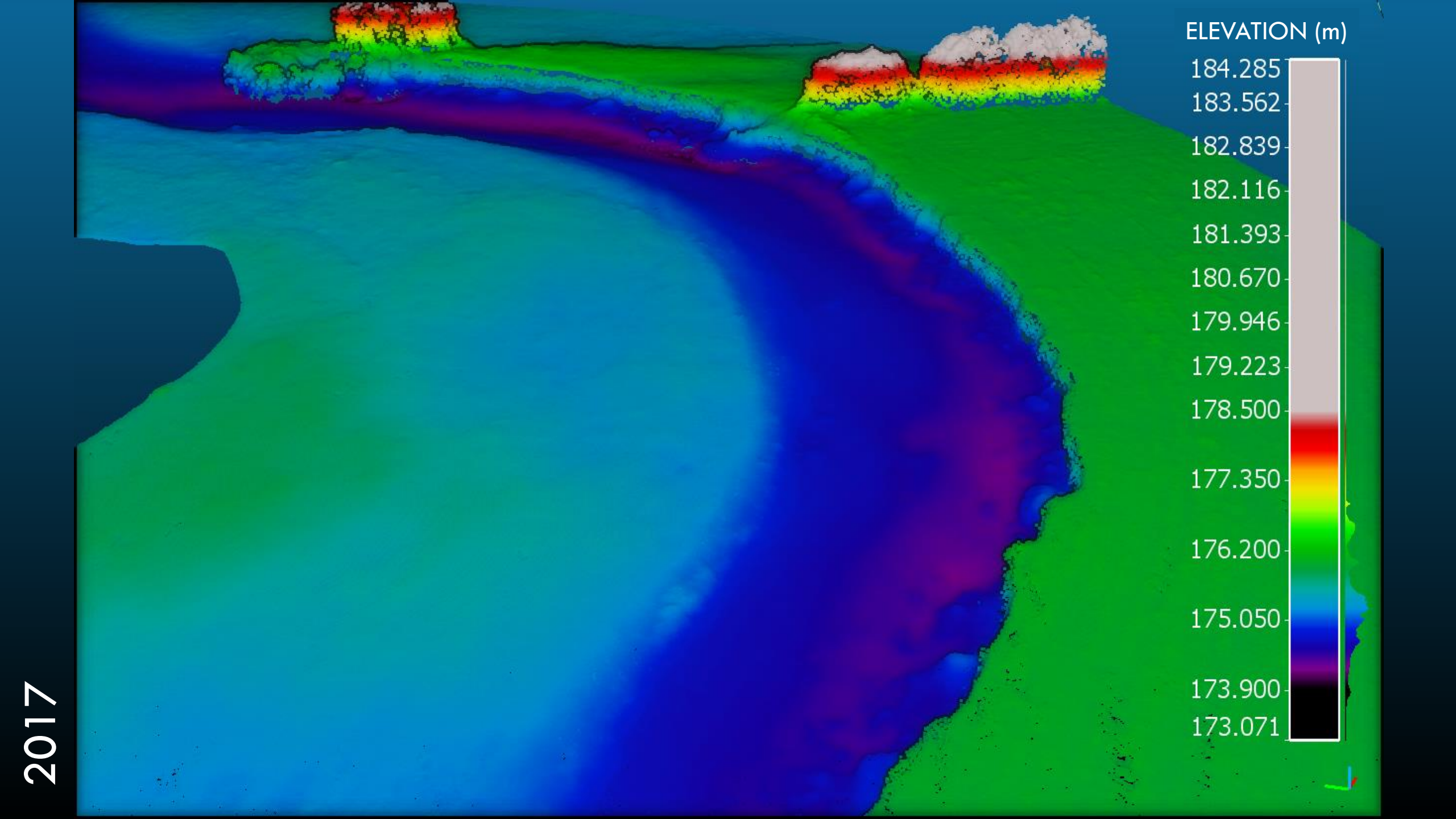
M3C2 Change (Lague et al. 2013)

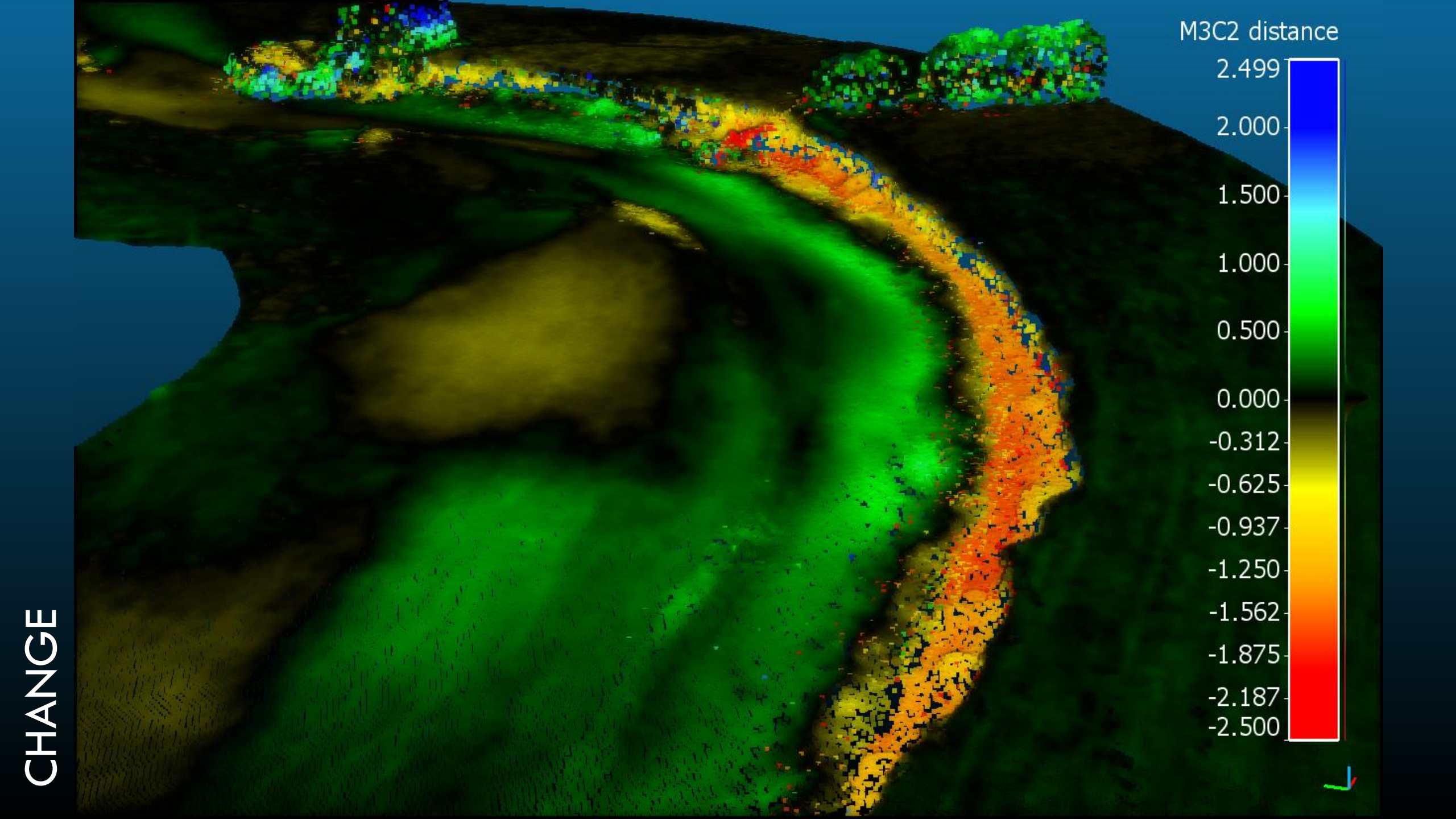
Change



M3C2 Change (Lague et al. 2013)


ELEVATION (m)
184.521
183.016
182.263
181.510
180.758
180.005
179.253
178.500
177.350
176.200
175.050
173.900
172.898
171.895
2016


ELEVATION (m)
184.285
183.562
182.839
182.116
181.393
180.670
179.946
179.223
178.500
177.350
176.200
175.050
173.900
173.071
2017


M3C2 distance
2.499
2.000
1.500
1.000
0.500
0.000
-0.312
-0.625
-0.937
-1.250
-1.562
-1.875
-2.187
-2.500
CHANGE

Next Steps with BathySfM

- More Geomorphic Change Detection
  - Validating geomorph/evolution models (e.g. Caesar Lisflood)
- Post-Bathy Correction Flow Modelling
  - High-resolution, spatially variable shear stress
  - Sediment transport / Sediment budgeting
  - Habitat Modelling
- How to extend surveys beyond short reaches (>1km)?
- Water surfaces are the key…

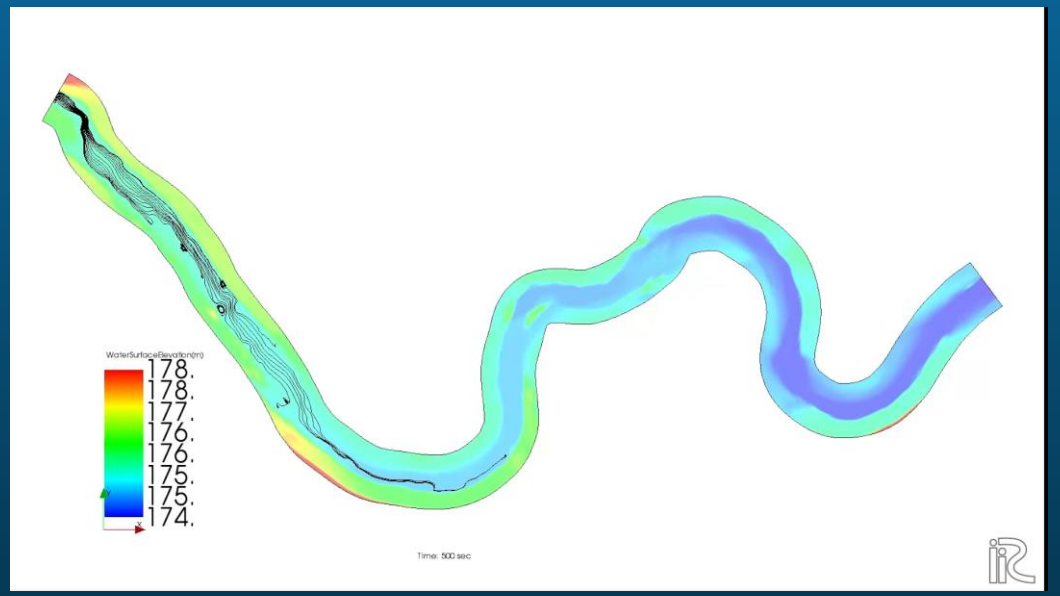
Modelling Water Surfaces

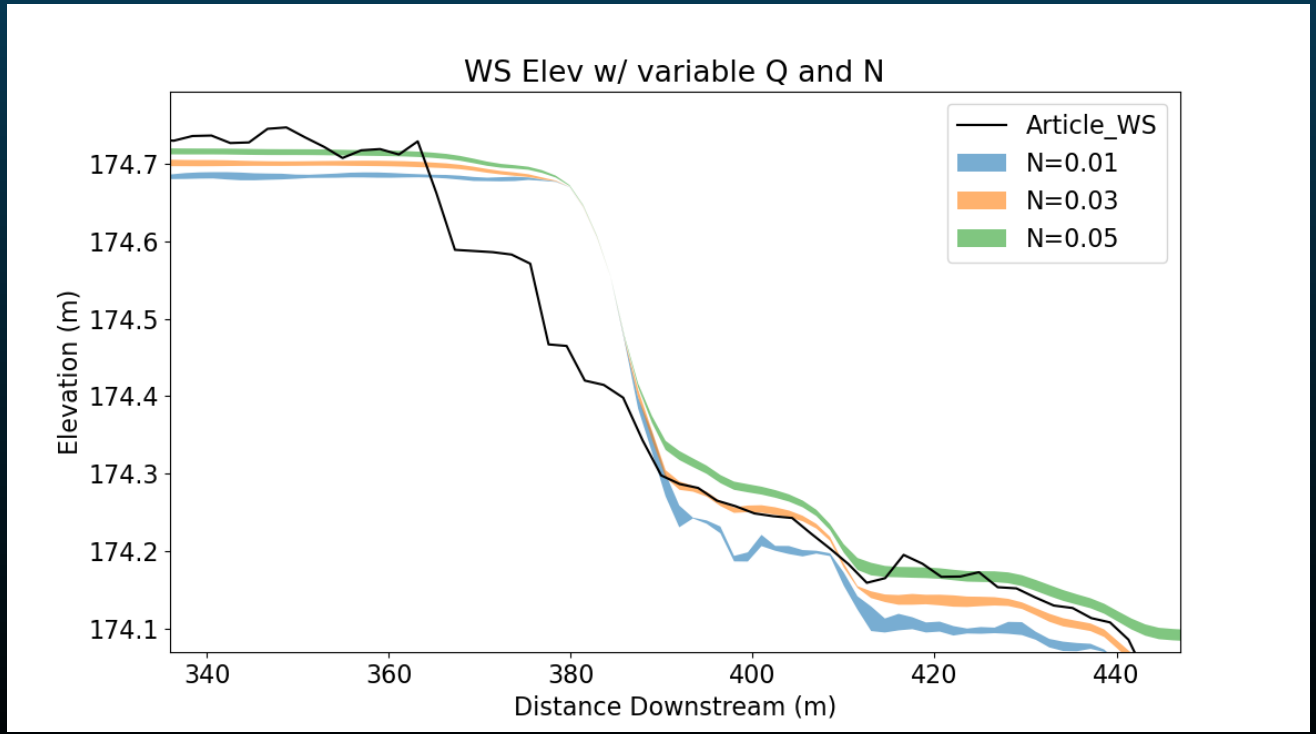
- Idea:
  - Run a 2D flow model over the uncorrected elevation data
- Challenge:
  - What are the model inputs for a fictional river?

1. Uncorrected Bathymetry (artificially shallow, apparent depths)

2. “Scaled” Discharge and Velocity

3. “Scaled” Roughness





Where to next…

- For rivers…
  - Change Detection / Monitoring
  - Image Processing Derivatives
    - PIV, Sediment Size
  - Multi- / Hyperspectral
  - Thermal
  - Data fusion
  - Machine learning (when appropriate)

  - Riverscapes
    - Longer surveys, combining geomorphology with ecology

- General UAS…
  - UAS for science communication
  - Accuracy reporting
  - Precision positioning
  - Open Source

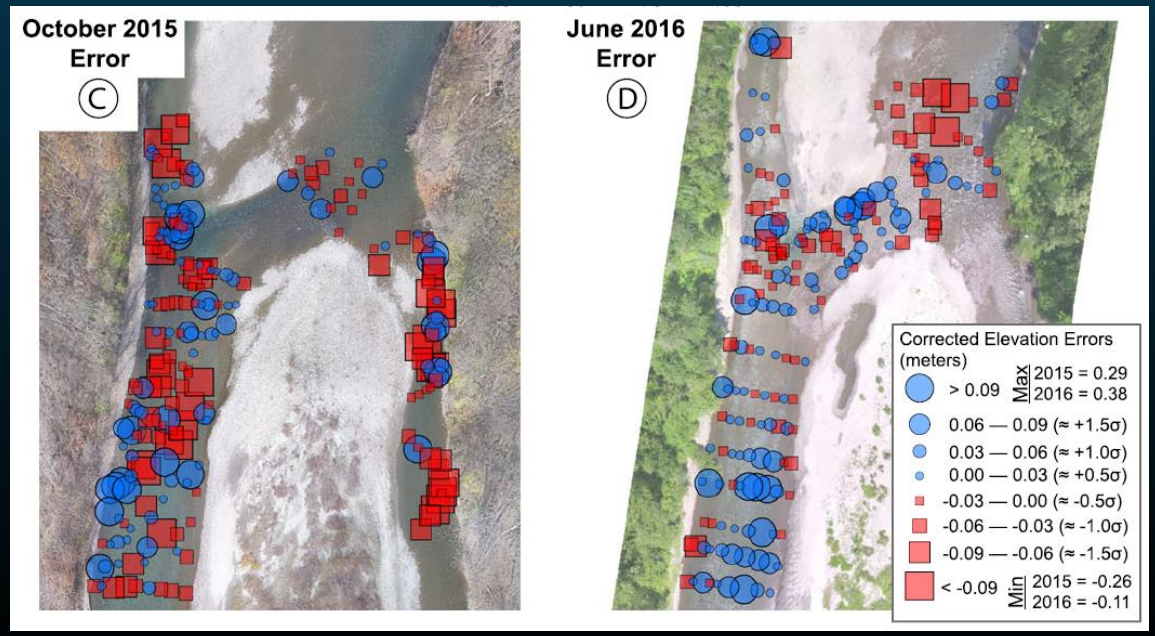
Science Communication

Accuracy/Precision Reporting

- More consistent reporting
  - RMSE is fine…but we can do better
- Lots of different stats available that are more informative than RMSE
- Spatial representations of error
- Especially important for change detection studies

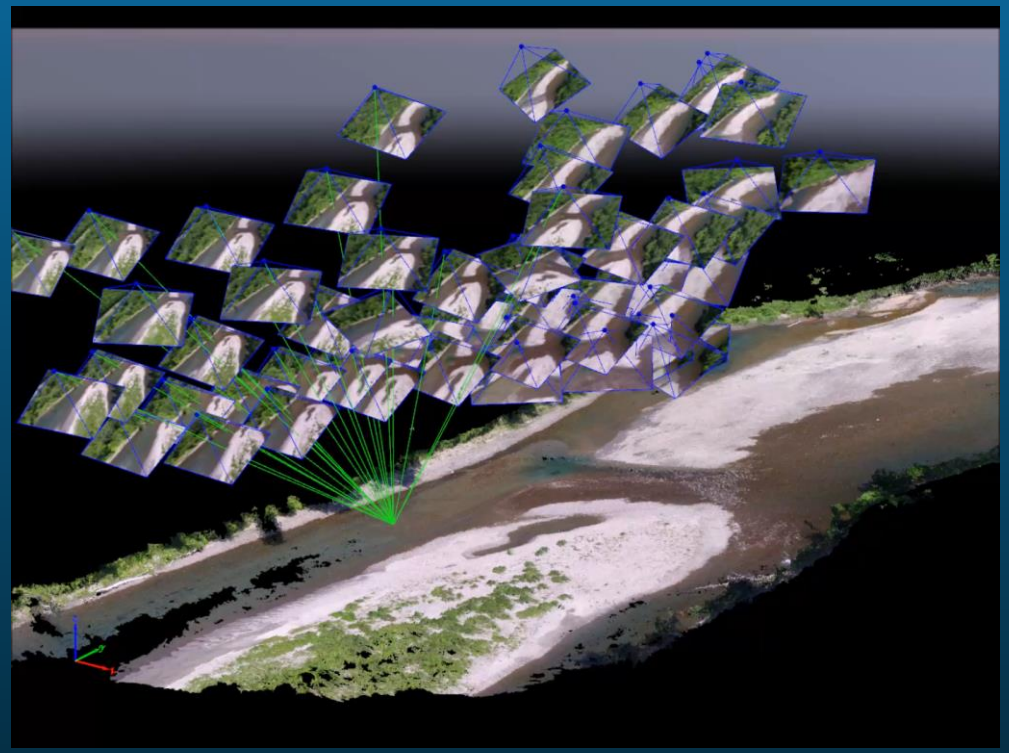
Table 2. Georeferencing accuracy statistics (all values in metres).

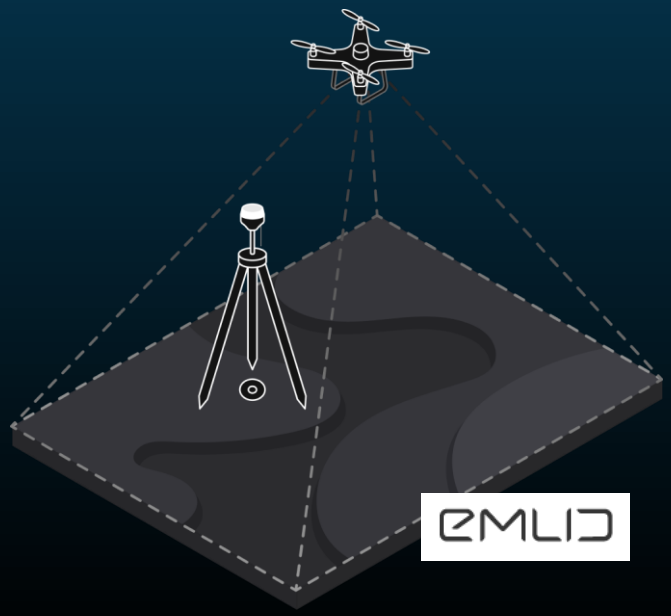
		Mean	St Dev	95% Conf.	RMSE	MIN	MAX
2016	X	0.000	0.021	0.041	0.020	–0.047	0.030
	Y	0.000	0.027	0.052	0.026	–0.046	0.047
	Z	–0.001	0.017	0.034	0.017	–0.029	0.035
2017	X	0.000	0.035	0.068	0.034	–0.054	0.056
	Y	0.000	0.059	0.116	0.057	–0.096	0.076
	Z	0.000	0.006	0.013	0.006	–0.018	0.006



Precision Positioning

- Lower cost RTK / PPK GNSS
- Better positional accuracy
  - Easier direct georeferencing
  - (Does not exempt from independent accuracy assessments)
- Covering larger areas
- Precise data in harder to access areas



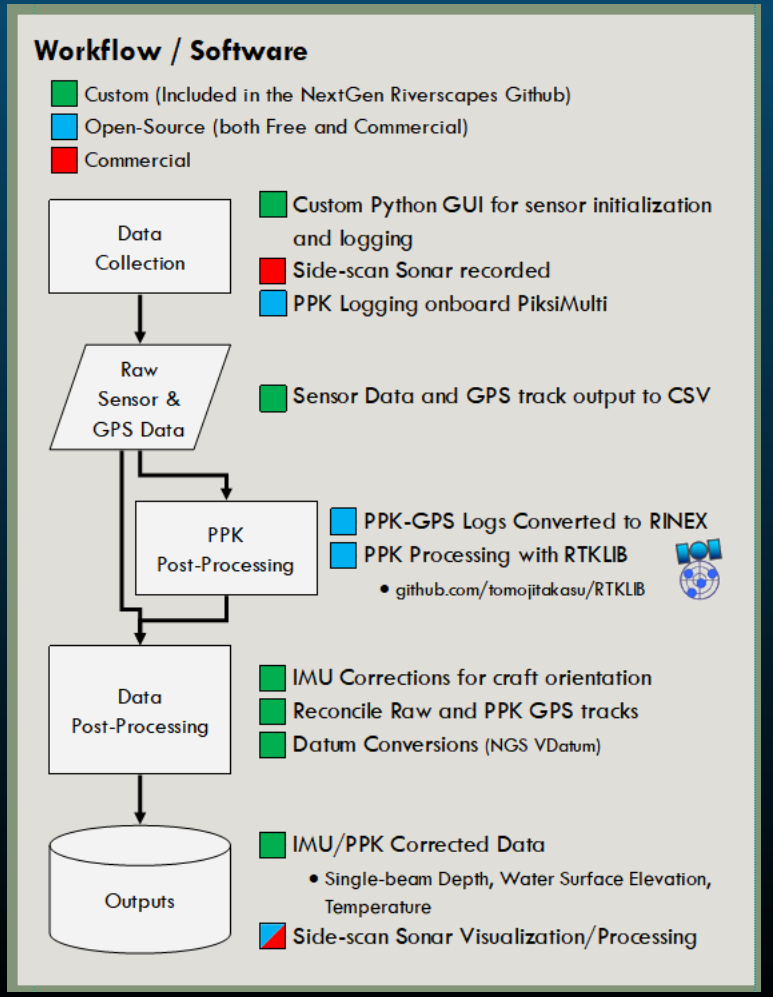


Open Source Methods

- New methods without instructions are practically useless

- More in-depth instructions/workflows are needed
  - For students and other professionals
  - Written or video
  - Starting to be publishing outlets for this

- Software/Code
  - Code need to be available too
  - Multiple platforms, easily citable



Thank You

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Ask me about my drone boat…

Acknowledgments

Original SfM – Mark Fonstad, Jennifer Jensen, Brittney Courville, Patrice Carbonneau

Bathy SfM – Amy Woodget, Robin Wilson

Patrice Carbonneau, Fleur Visser, James Atkins, Robbie Austrums, Cat Fyffe, Jenna Duffin, Christina Shintani


RiverSeer

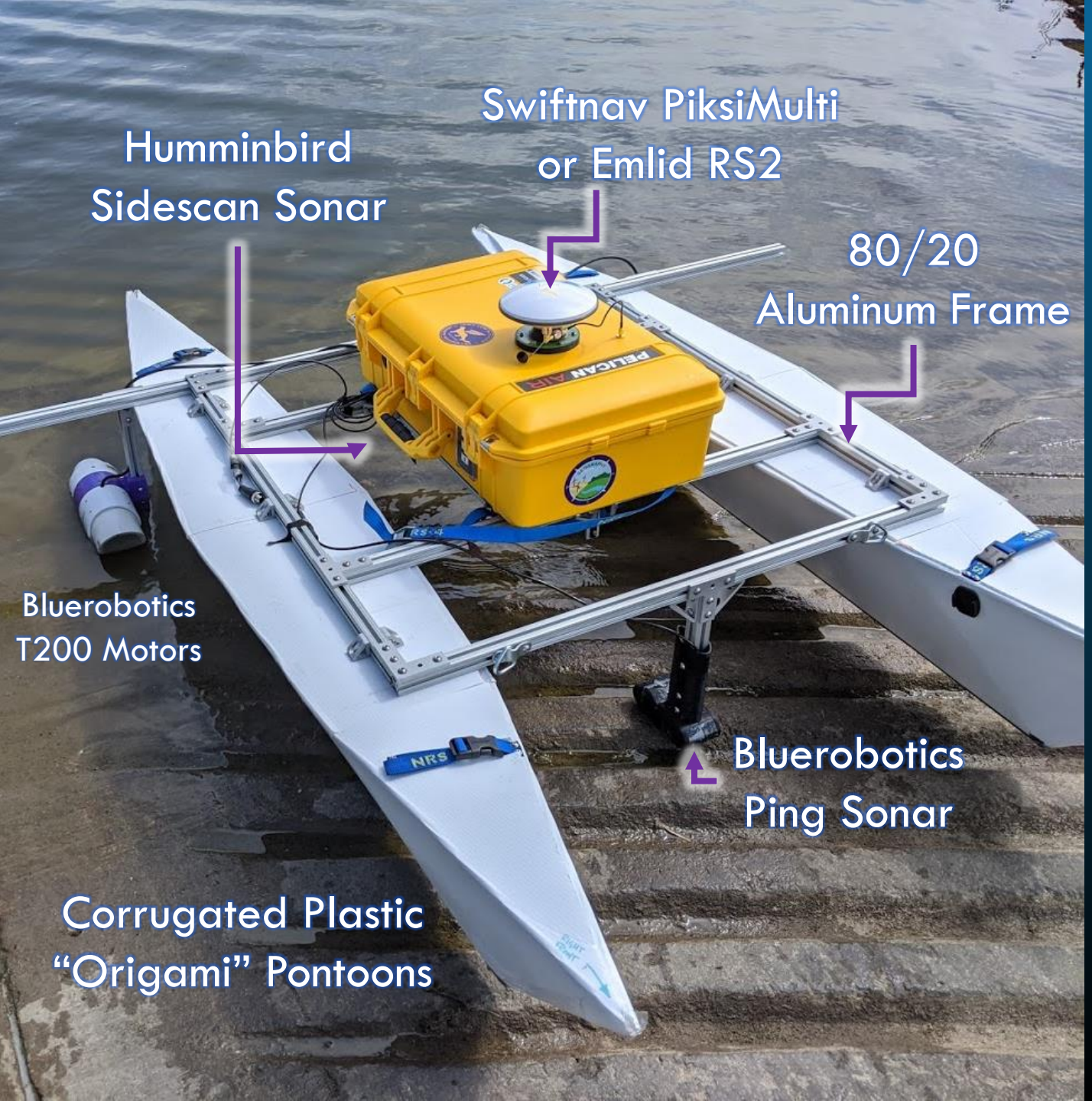
RiverSeer

- Low-cost, open-source, river data collection platform
  - Semi-autonomous
  - Garage-build friendly

- Longitudinal Data Collection
  - Accessing non-wadable parts of the river
  - Platform for remote sensing validation data

- Citizen science
  - Easy platform for data collection by watershed orgs., volunteer conservation orgs.

Project Team:
Mark Fonstad
James Dietrich
Aaron Zettler-Mann
Dion Webster



- RTK/PPK GPS
- IMU
- Sonar (Single beam/Sidescan)
- Water surface elevations
- Temperature

- Future Additions
  - Above and Below Water Photogrammetry
  - Close-range Laser scanning
    - ➢ Shallow Depths, Sed. Size

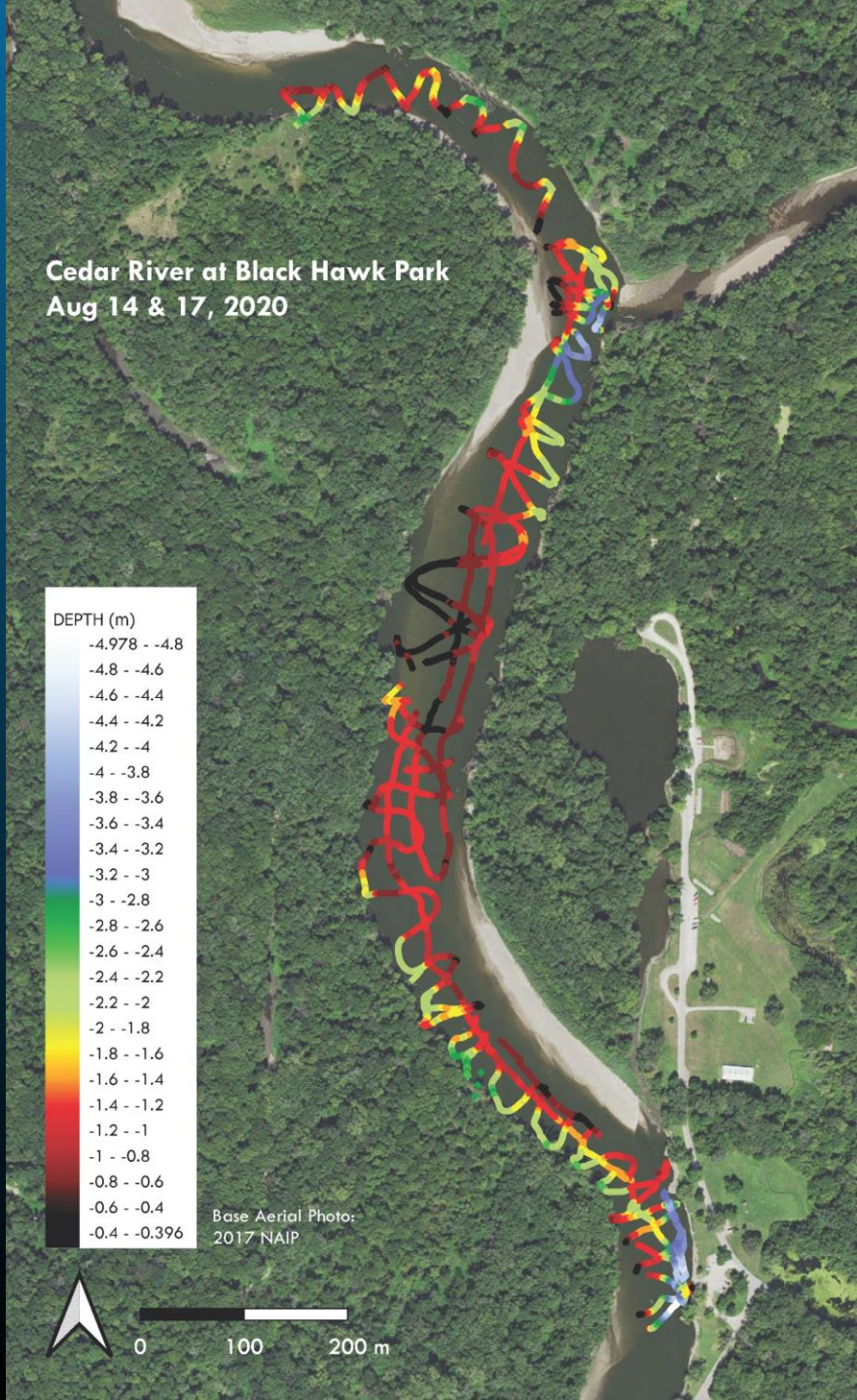

Camera
Mounting
Ultrasonic
Water Surface

Remote controlled

Towed

Data

- Custom Python Data Collection Software
  - Running on Raspberry Pi 3B+
- Depth and Water Surface Measurements
  - ~1 per second
- Temperature
  - 1 per 5 seconds
- Custom Python post-processing workflow
  - RTK-LIB (PPK post-processing)
  - IMU position adjustments



RiverSeer

geojames/NextGen_RiverscapeMapping

- Parts and sensors for DIY build ~$4,500

- Designs, Parts Lists, Build Log and Software will be available Spring 2020

- Next Steps:
  - Long distance longitudinal data collections (Oregon/California)
  - Integrating RiverSeer into the BathySfM workflow
    - Restoration monitoring

  - Lake and Coastal Monitoring?