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Fluvial Geomorphological Applications of LiDAR, Remote Sensing and Drone Technology

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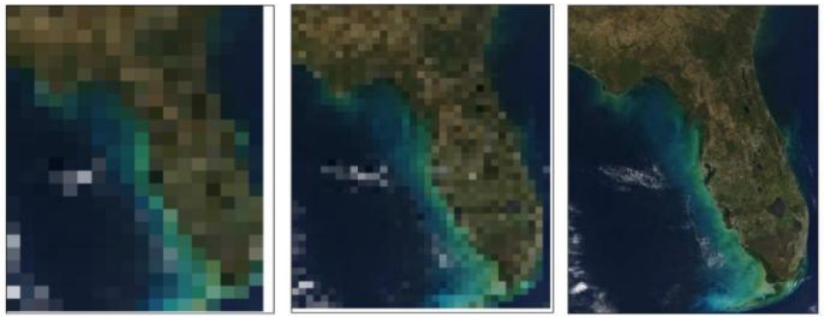
Earth Observation Data - all about “Resolutions”

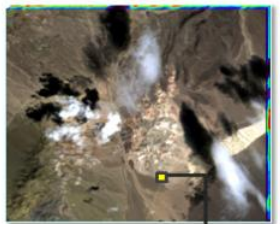
Spatial

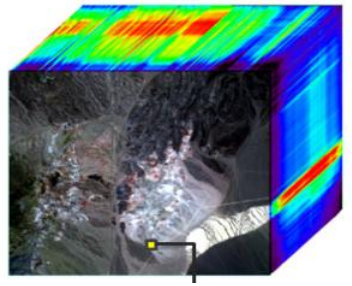
– Extent and how detailed / pixel size



Spectral

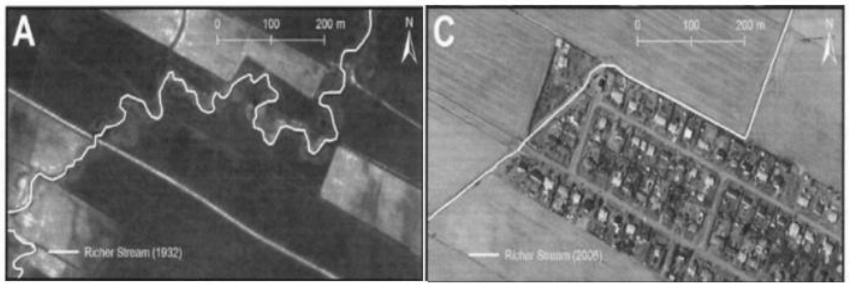
– Colours / Number of bands / Band widths





Temporal

– Time of day ; Season ; Year
– Time-lapse between two images
– Change Detection



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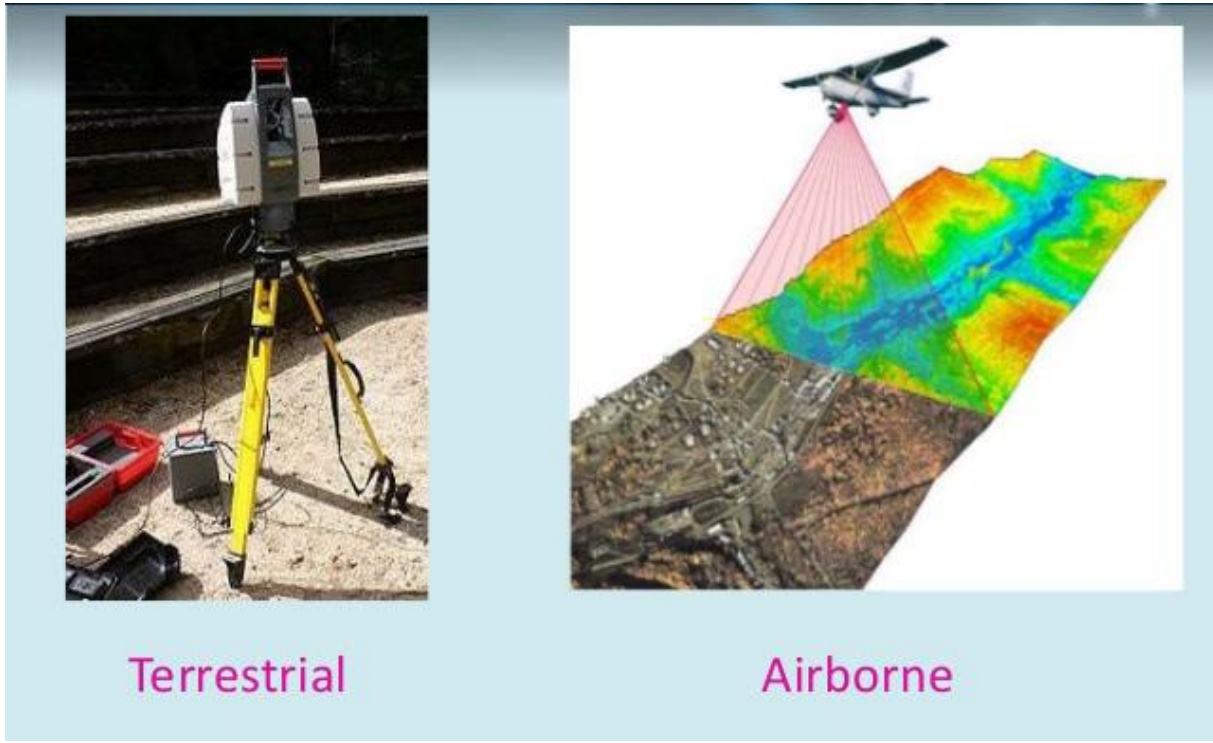
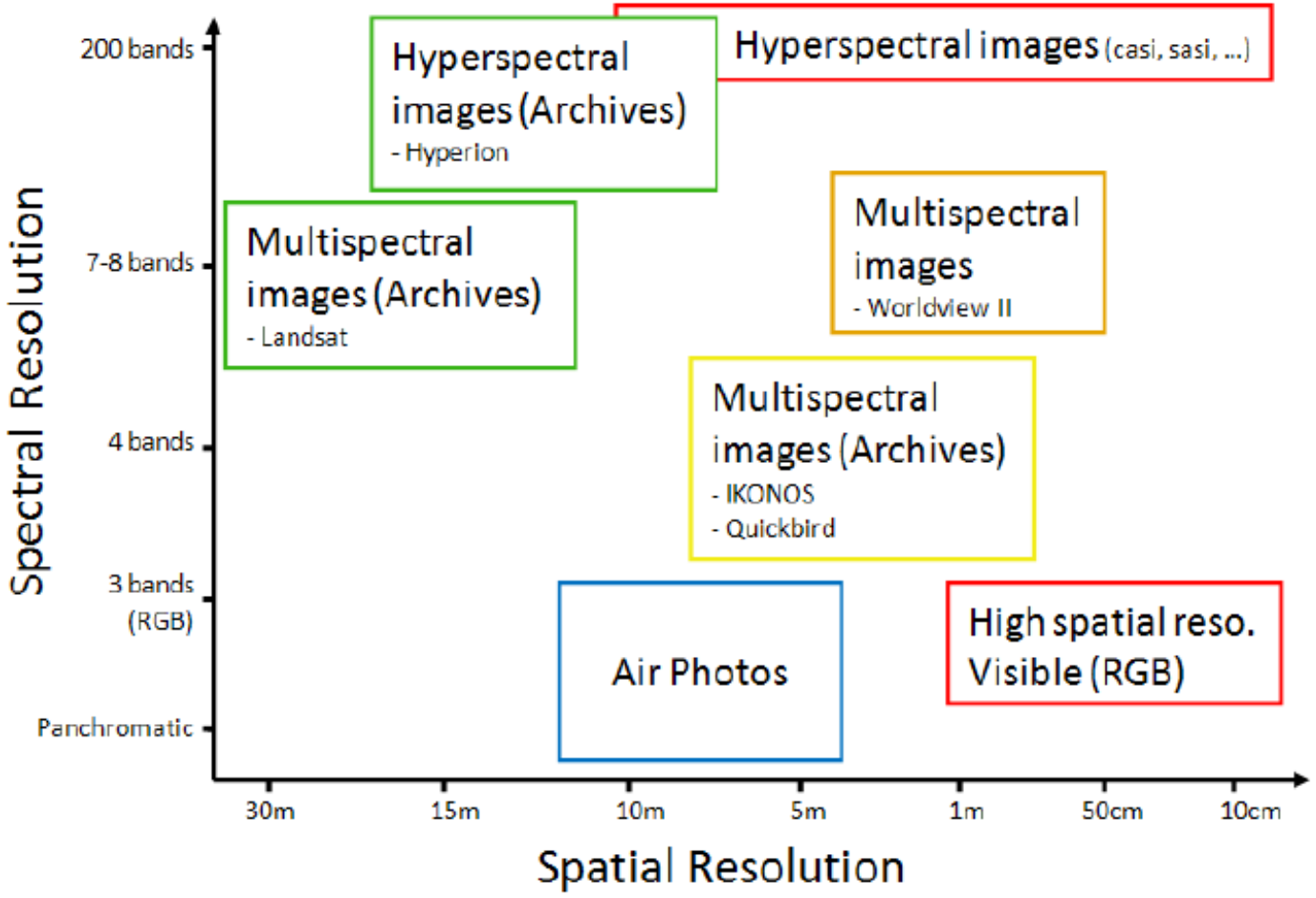
What is LiDAR?

- **Li**ght **D**etection **A**nd **R**anging
- Surveying technology that uses laser light to measure distances
- Key benefits over traditional surveys
  - Very **high density** of elevation points
  - Laser light can **penetrate vegetation** and get accurate measurements through forest cover.
- Traditionally **airbourne**
- Growing application of **terrestrial LiDAR**…



Technology, affordability and availability are rapidly evolving……



….and so are applications!

a) Use of LiDAR and Earth Observation data in Fluvial Geomorphological Analyses

b) Use of Repeat Drone Survey in Monitoring

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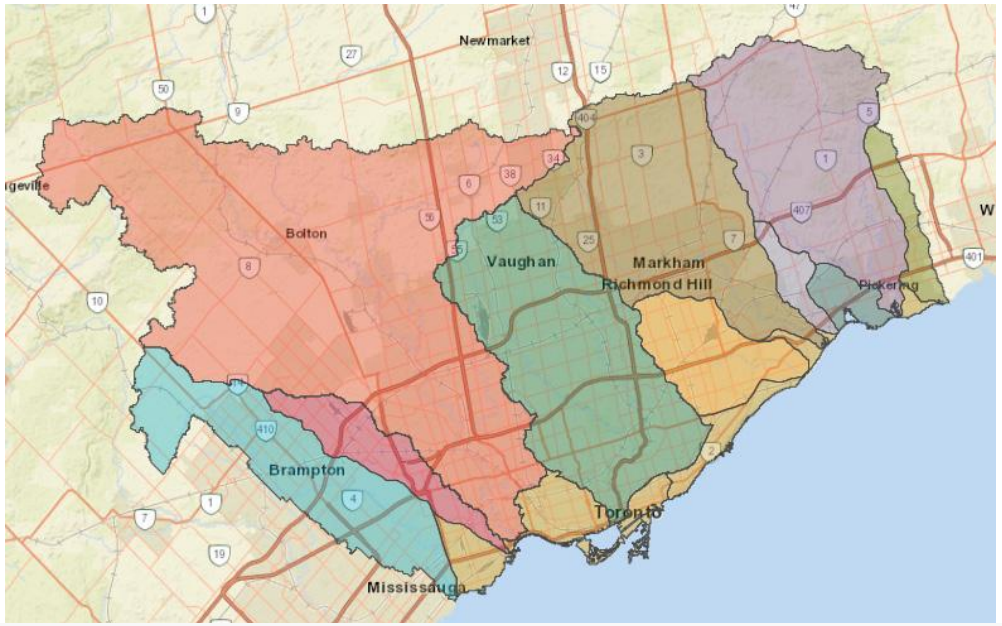
LiDAR Coverage is Rapidly Expanding in Canada

TRCA Jurisdiction

- 3,467 km^2
- 9 watersheds
- Point Density = 10 points / m2
- Vertical Accuracy = 10 cm
- Horizontal Accuracy = 25 cm



Source:TRCA
http://camaps.maps.arcgis.com/apps/MapJournal/index.html?appid=f92aabd42f5144d8895989b8bb46a7aa

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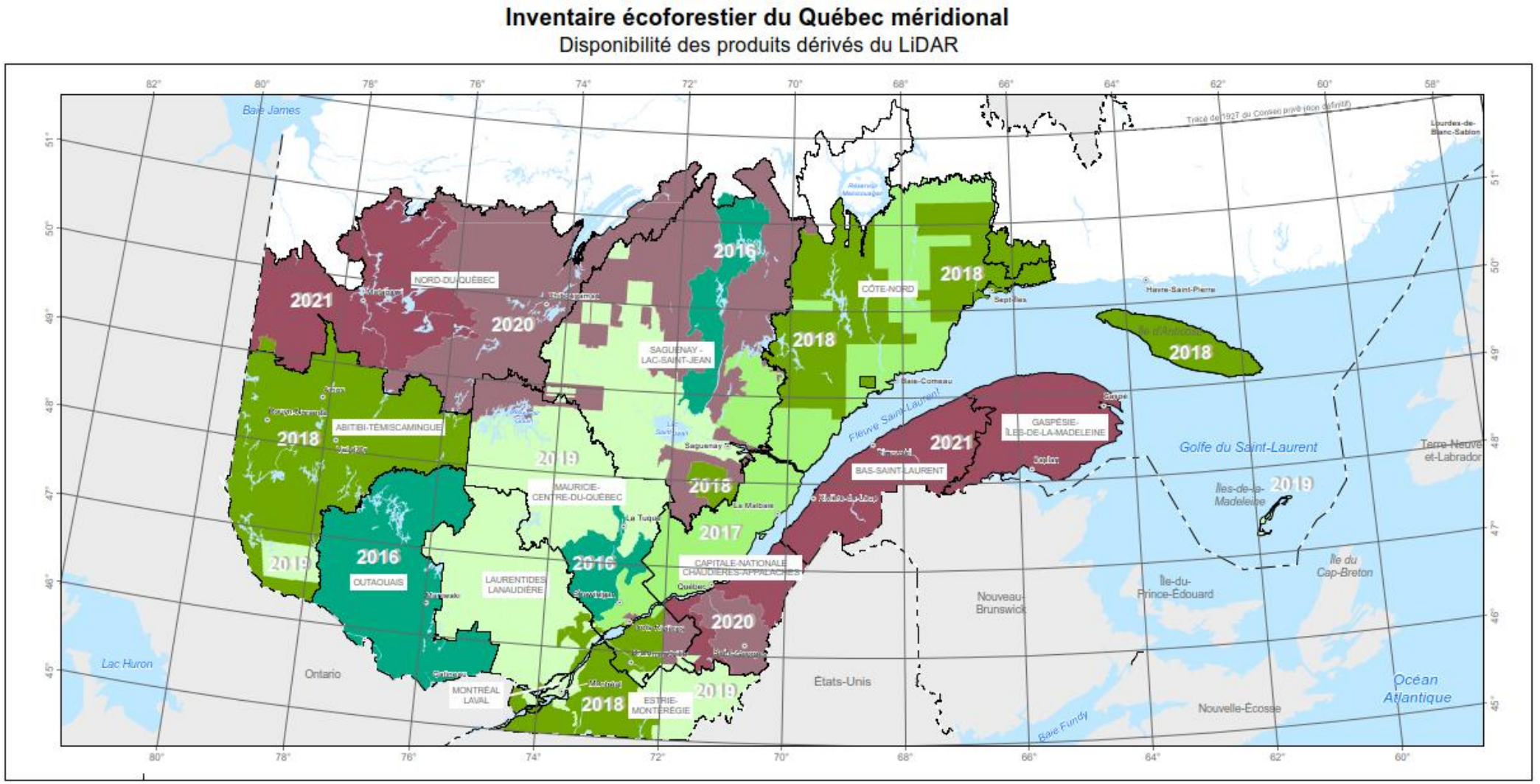
LiDAR Coverage is Rapidly Expanding in Canada



Acquisition by Ministry of Forest, Fauna and Parks (MFFP)
Complete Coverage by 2022

Source:
https://mffp.gouv.qc.ca/forets/inventaire/pdf/Planification_LIDAR_produits_derives.pdf

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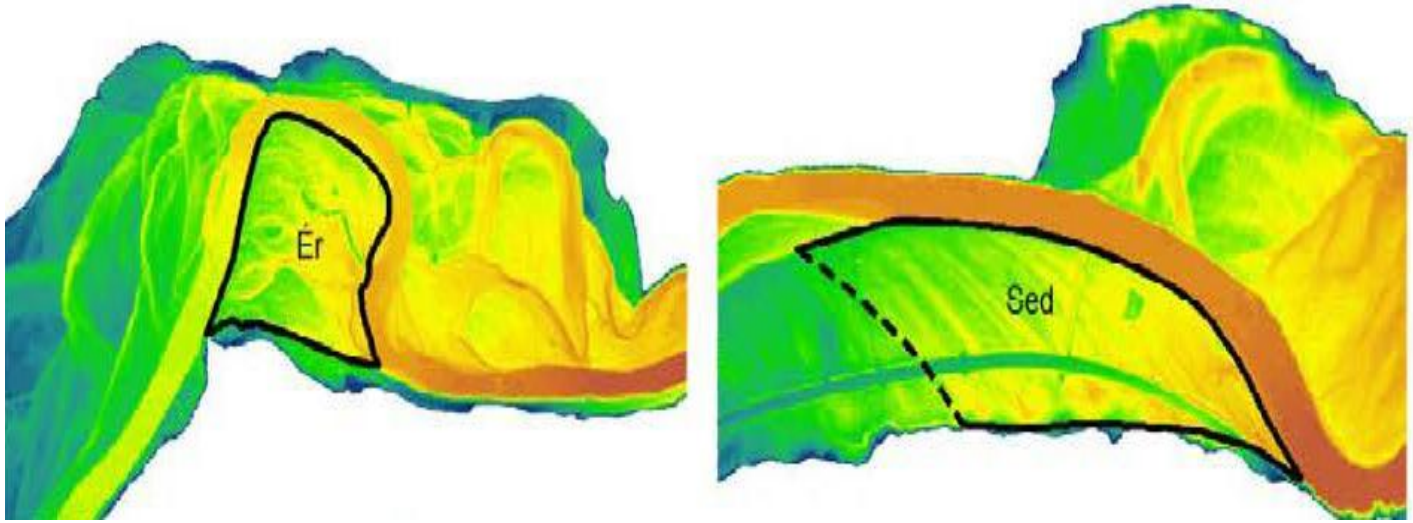
Use of LiDAR for Fluvial Geomorphological Analyses

- Indicators of flooding mechanisms (complementary to 2D-Flood Mapping)
- Indicators of geomorphological processes and channel evolution

  - **Er** = Cross-meander bend flows
  - **Sed** = Accumulation of sediment on inside of meander bend



(Source:
Demers et al. 2014).

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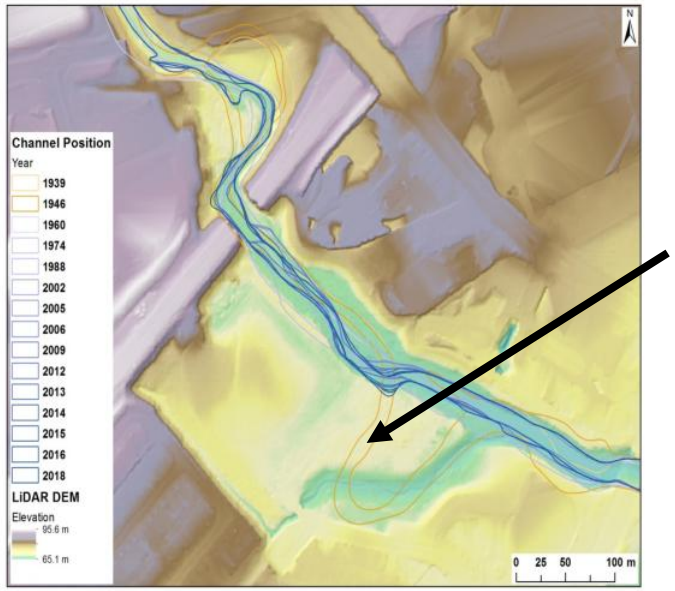
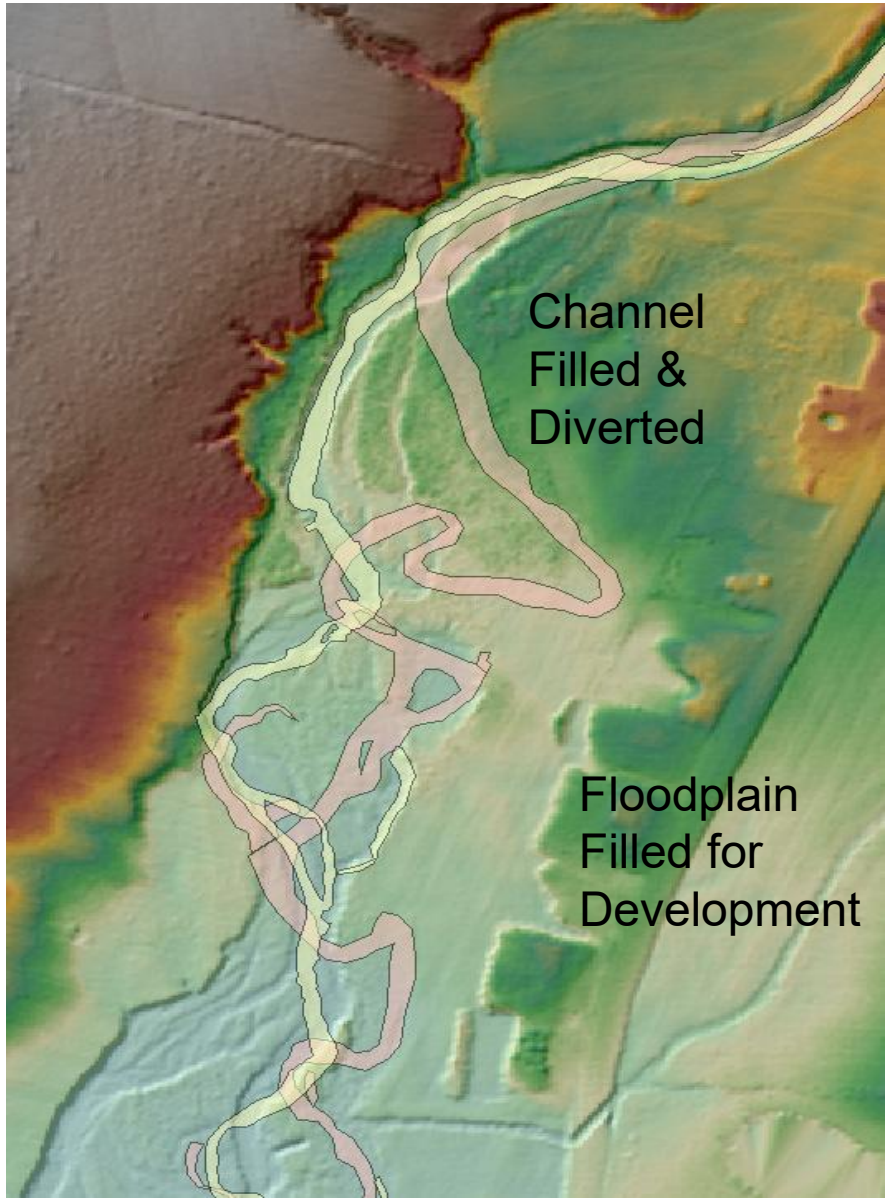
Additional Historical Insight

- LiDAR combined with historical aerial photography
- Anomalies resulting from anthropogenic intervention become clearer in the context of fine topography



Historic meander bend filled and used by manmade tributary



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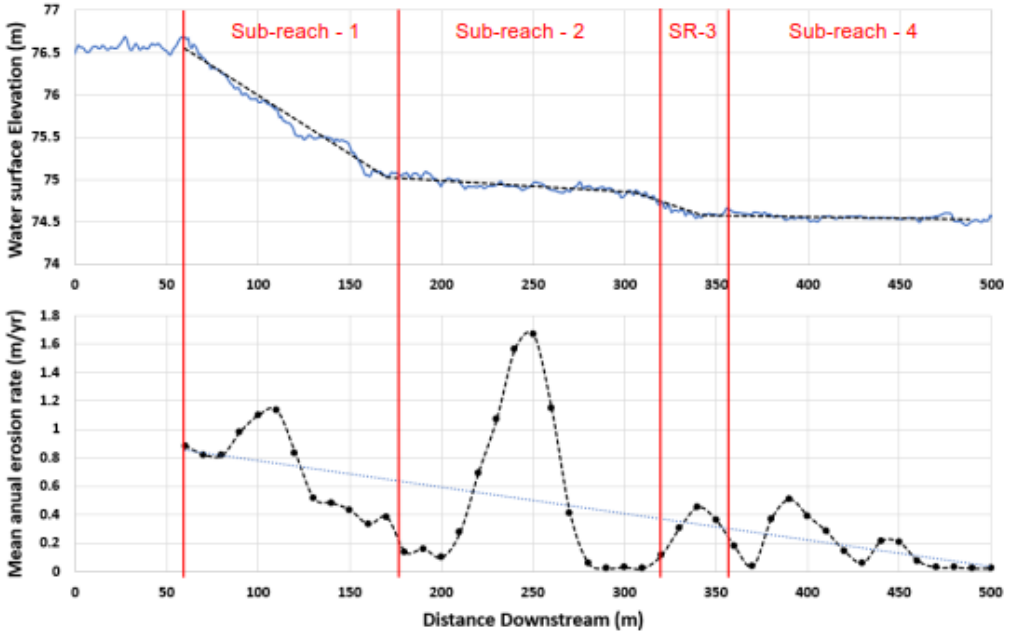
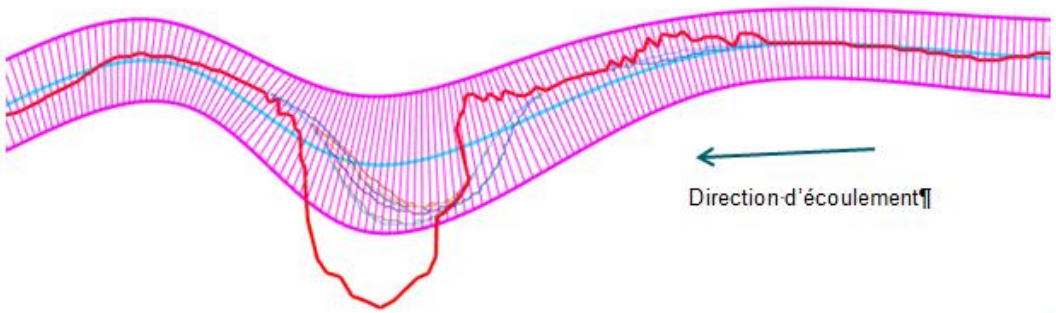
Automating Geomorphological Analyses

- Detect the watercourse at different dates
  Avoid hand digitizing of channel positions
- Objectively identify homogenous reaches
  Reaches identified based on metrics
- Semi-automated erosion rate assessment
  Calculations throughout the reach not hand measurements at selected bends
- Projection of channel positions
  Based on average erosion rates





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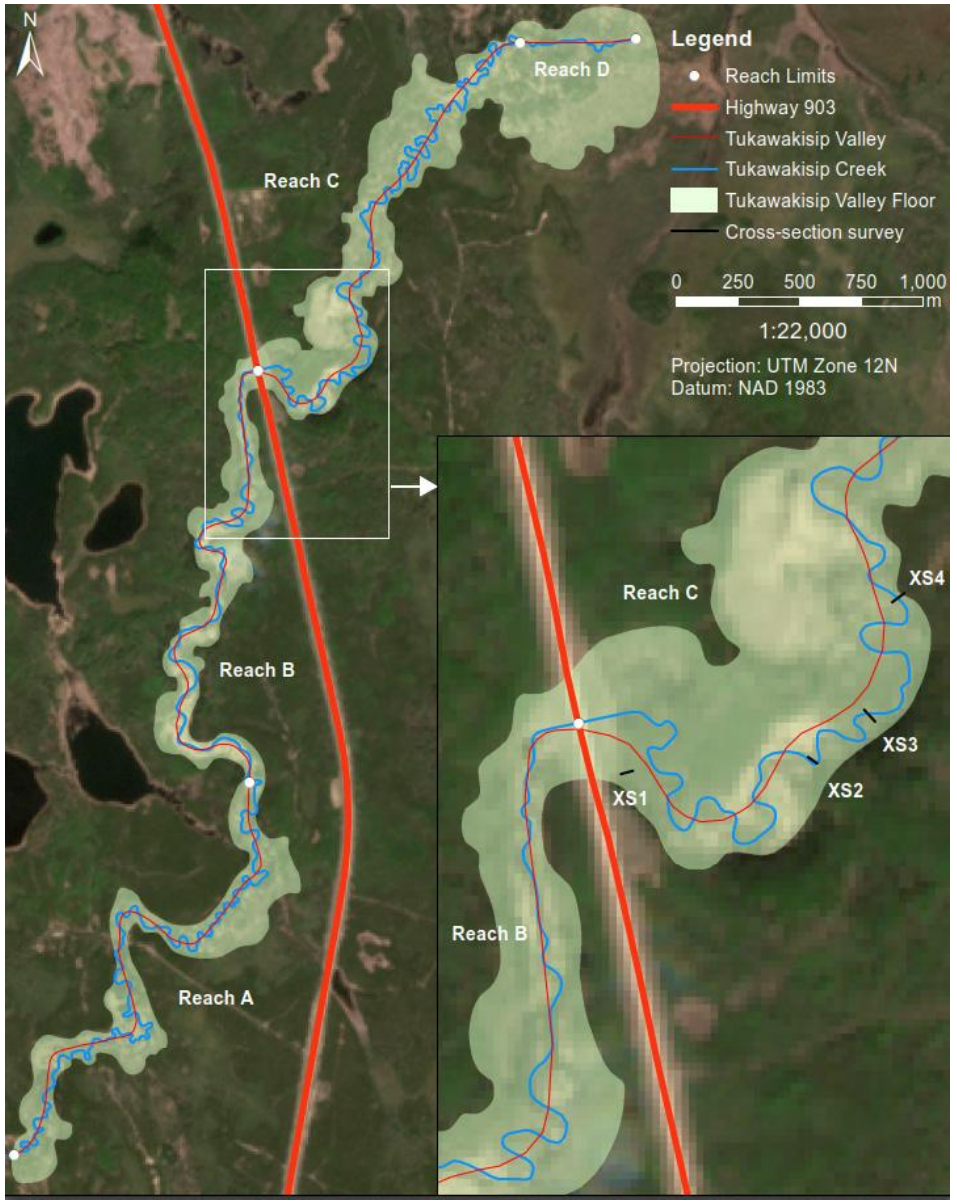
Assessment of Valley Floor Extent

- Alternative approach to assessing the lateral extent of the valley floor using remote sensing data (Sentinel)
- Uses the Normalized Difference Moisture Index (NDMI) (Wilson and Sader, 2002)
- Spatial analysis based on the near infrared band and the middle infrared band
- Does not correspond to the zone of flood and erosion risk, but provides initial indication of valley floor extent using freely available information



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a) Use of LiDAR and Earth Observation data in Fluvial Geomorphological Analyses

b) Use of Repeat Drone Survey in Monitoring

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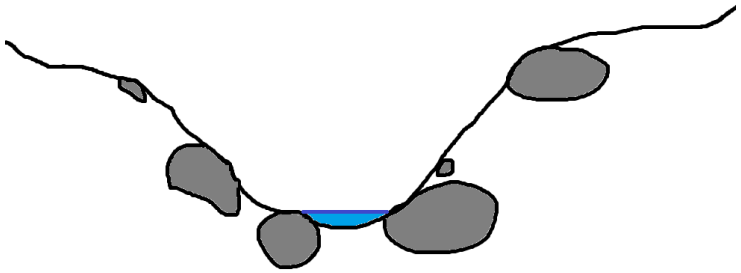
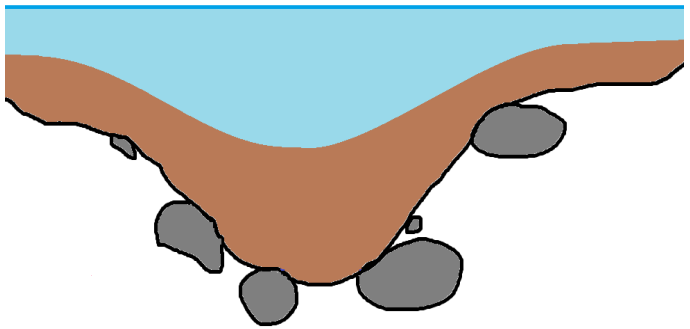
Case Study 1: Geomorphological Response to Dam Removal

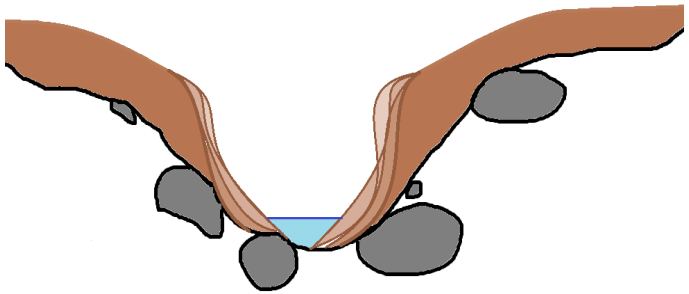


Stage – 1
Natural Channel



Stage – 2
Tributary submerged by water in reservoir

Fine sediment deposit on top of the channel



Stage – 3
Dam removal

Tributary starts eroding the fine sediments.
New channel is degrading and widening

Drone images used in analyzing channel adjustments during Stage 3

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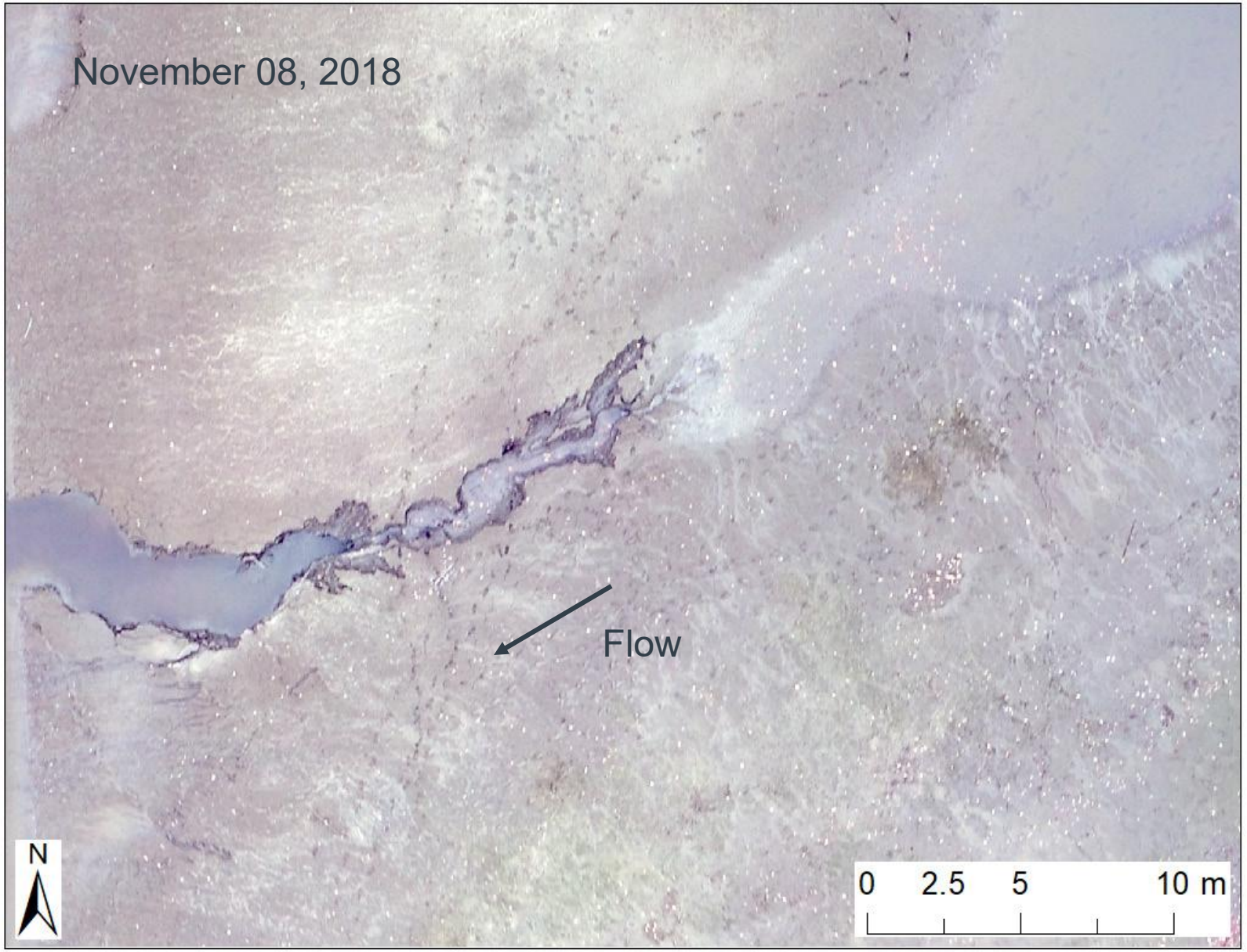
Evolution of Tributaries: Drone Images



Evolution of Tributaries: Drone Images

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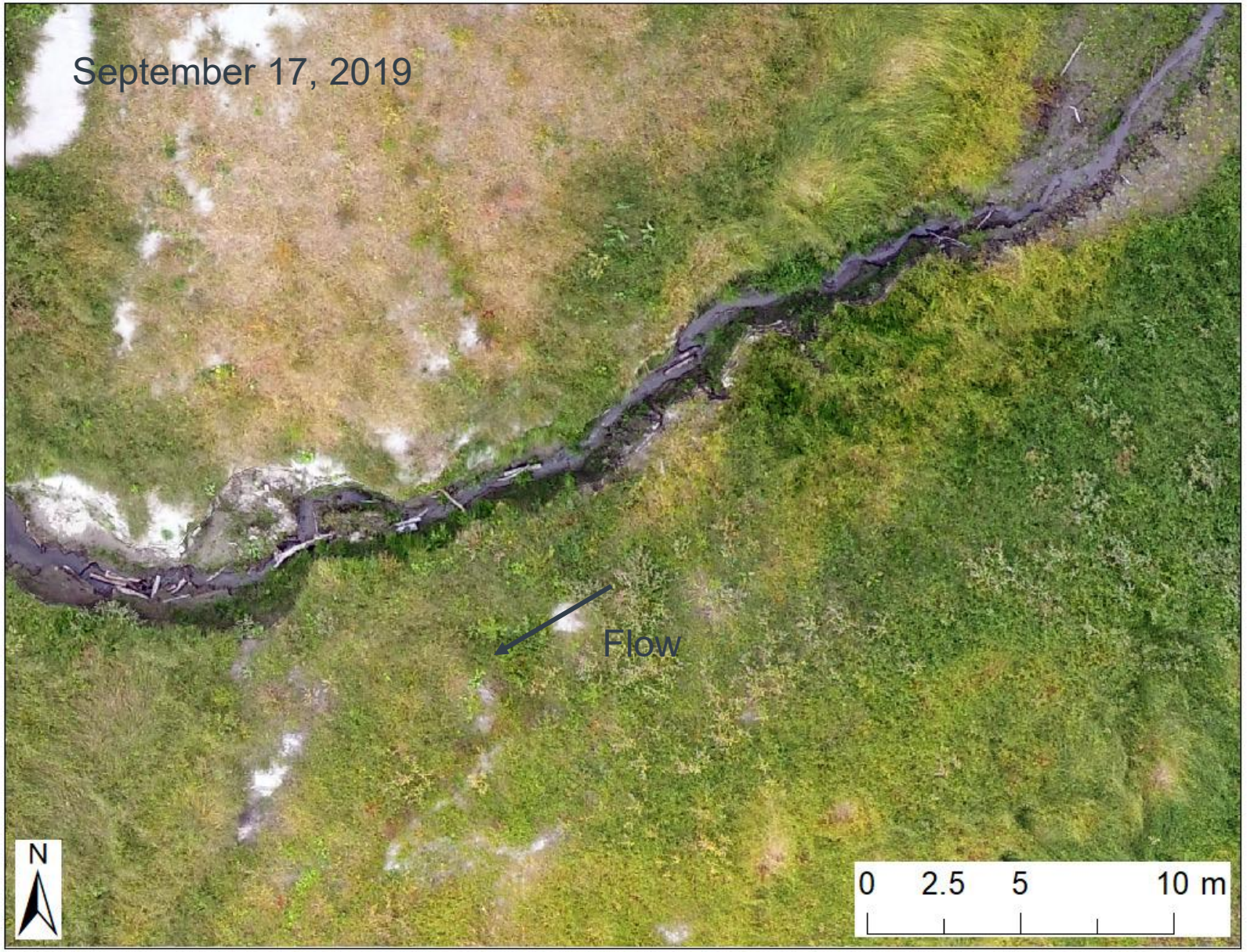
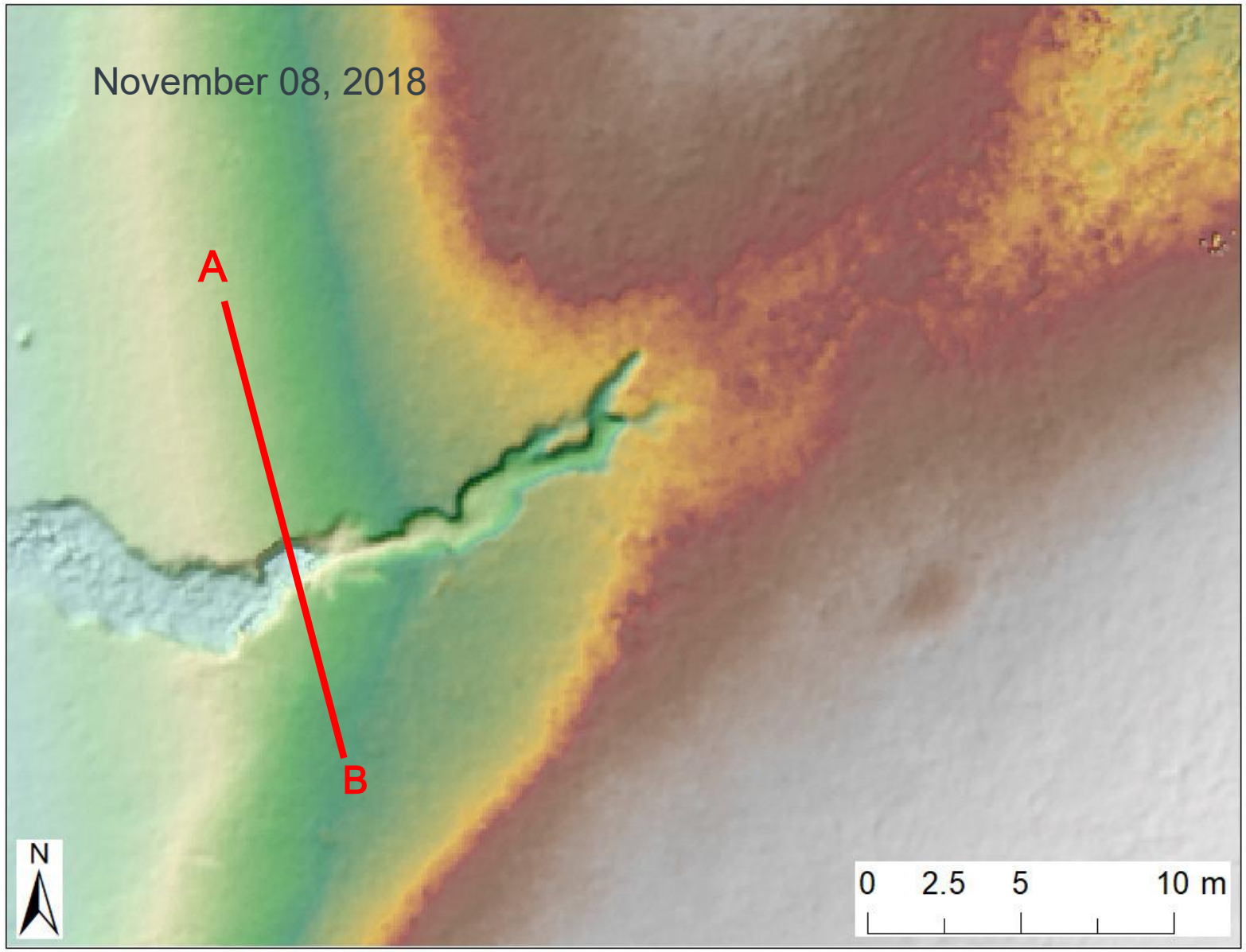


Evolution of Tributaries: DEM-Derived Data



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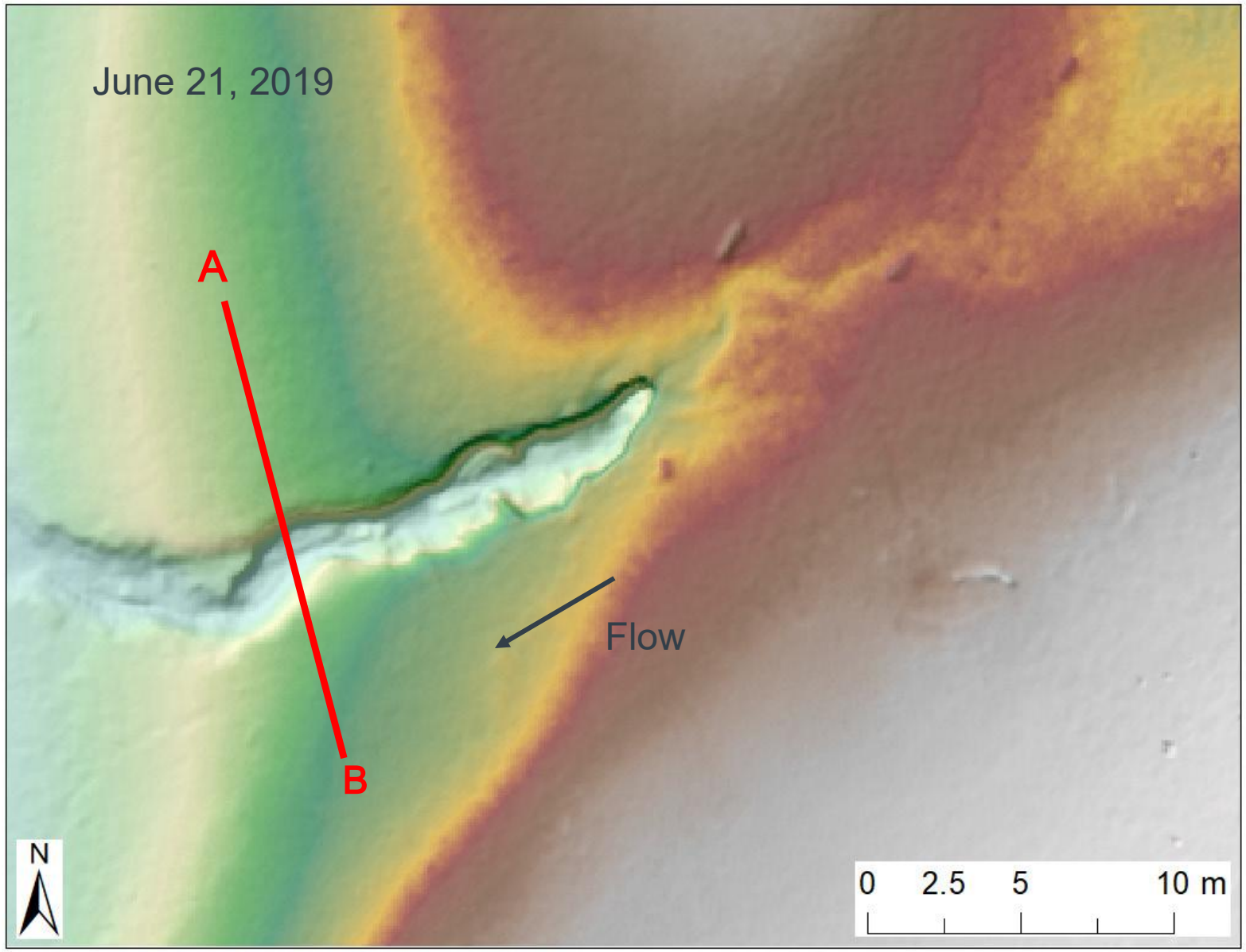
Evolution of Tributaries: DEM-Derived Data



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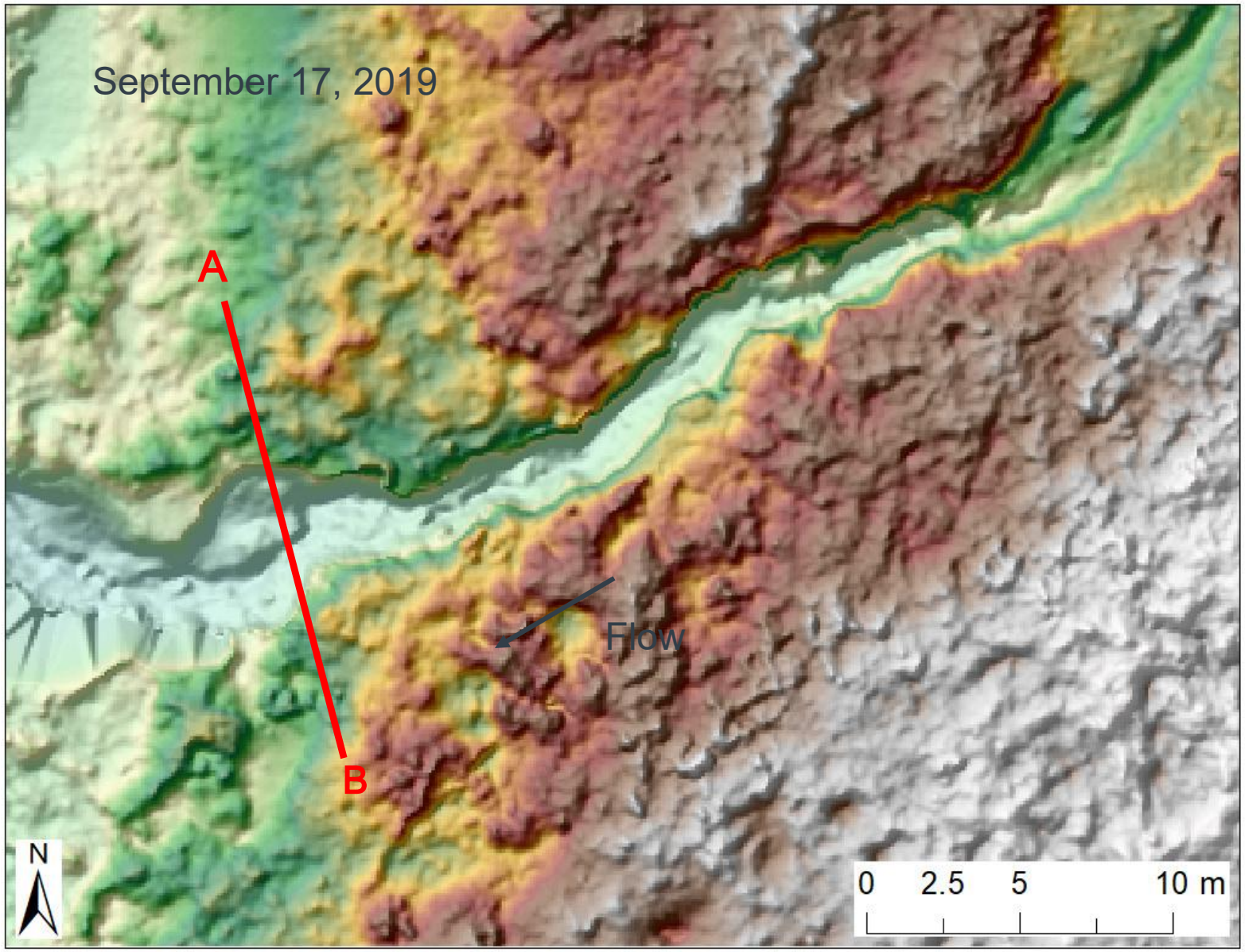
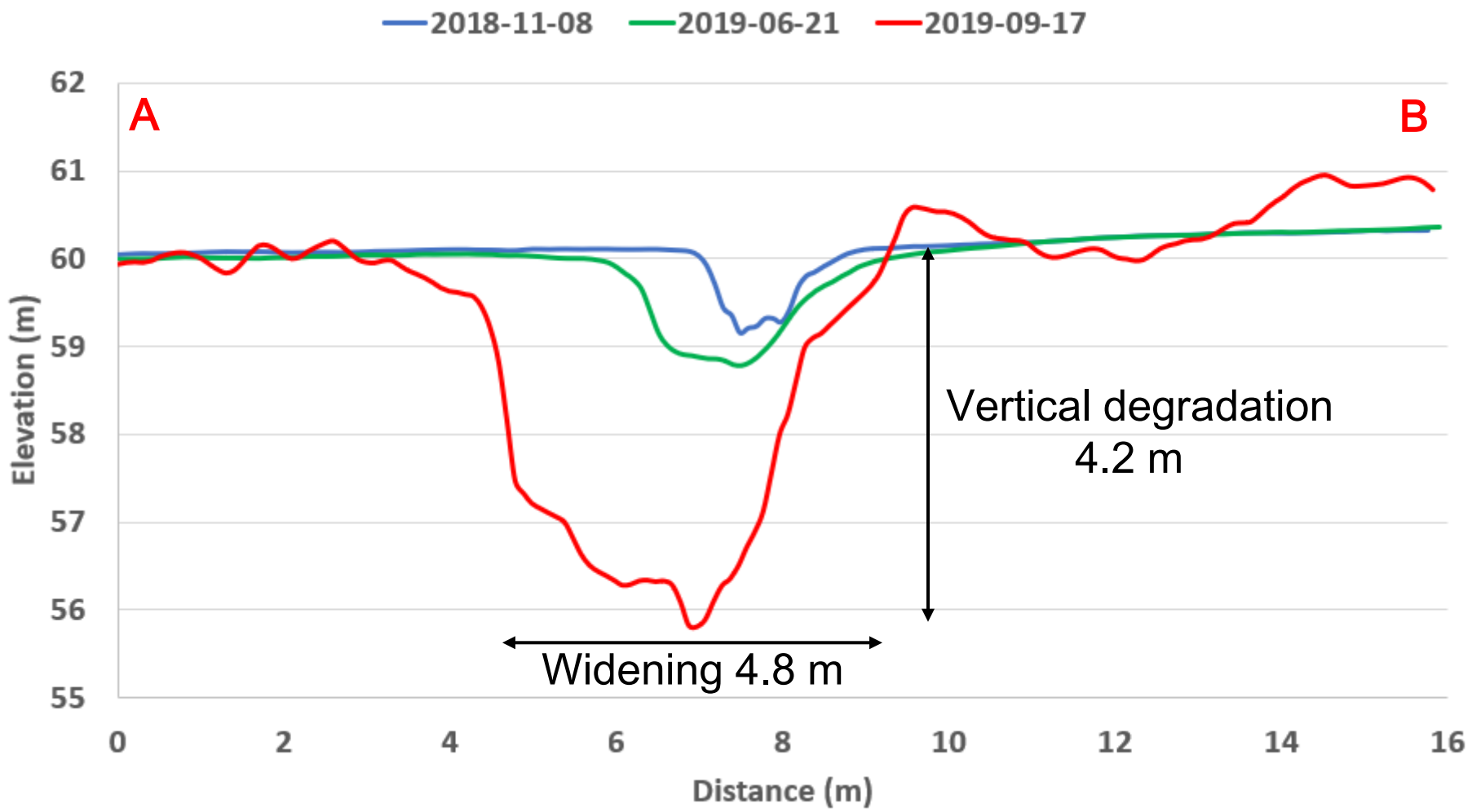
Evolution of Tributaries: DEM-Derived Data



Evolution of Tributaries: Degradation and Widening as Recover Natural Bed



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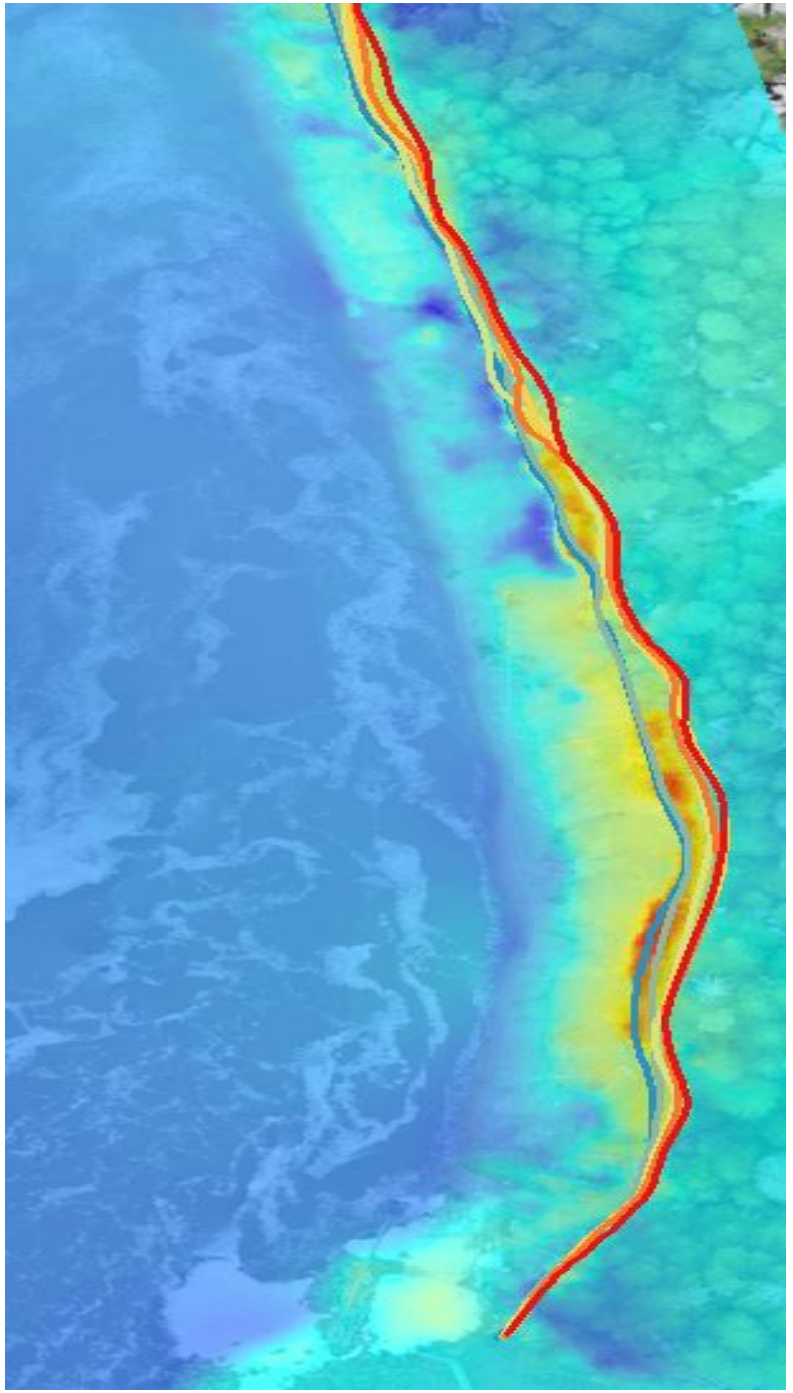
Case Study 2: Quantitative Bank Profile Retreat from Drone Data

– 7 Drone surveys in 4 months

- May 3, 2018
- May 14, 2018
- May 22, 2018
- May 30, 2018
- June 06, 2018
- June 14, 2018
- September 13, 2018

→ Delineation of top of bank limit

→ Comparison in DEM



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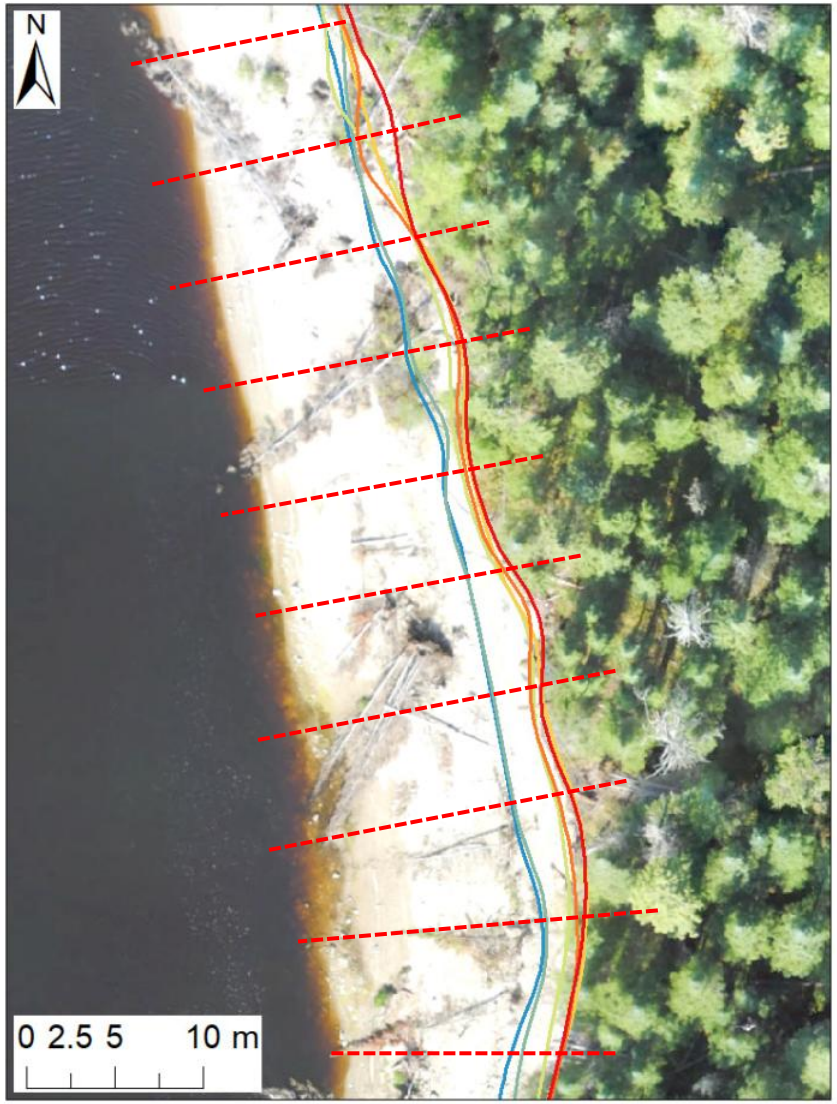
Use of Imposed Cross-Sections to Measure Change over Time



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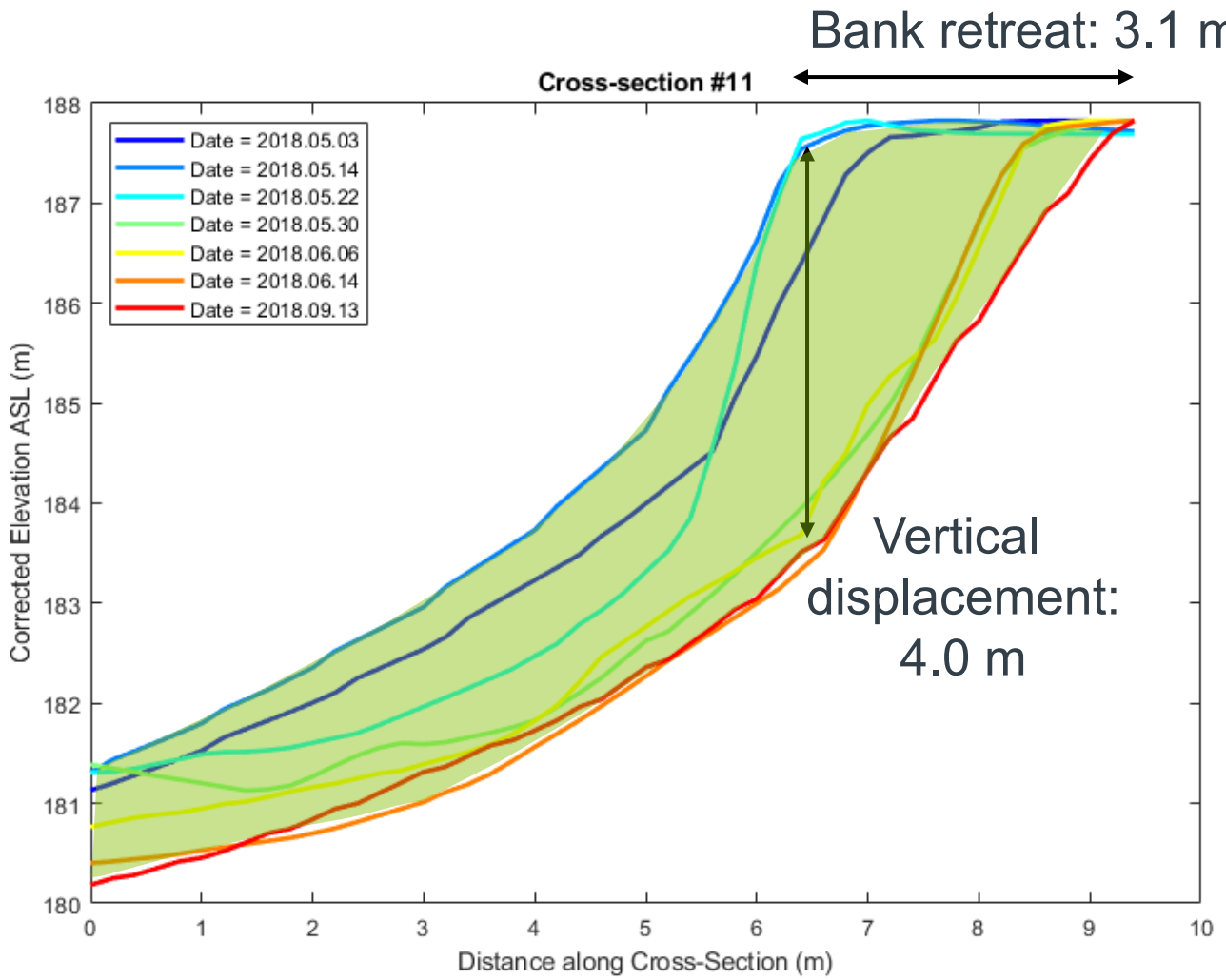
Quantification of Erosion Over Time



Calculate volume of erosion per cross section

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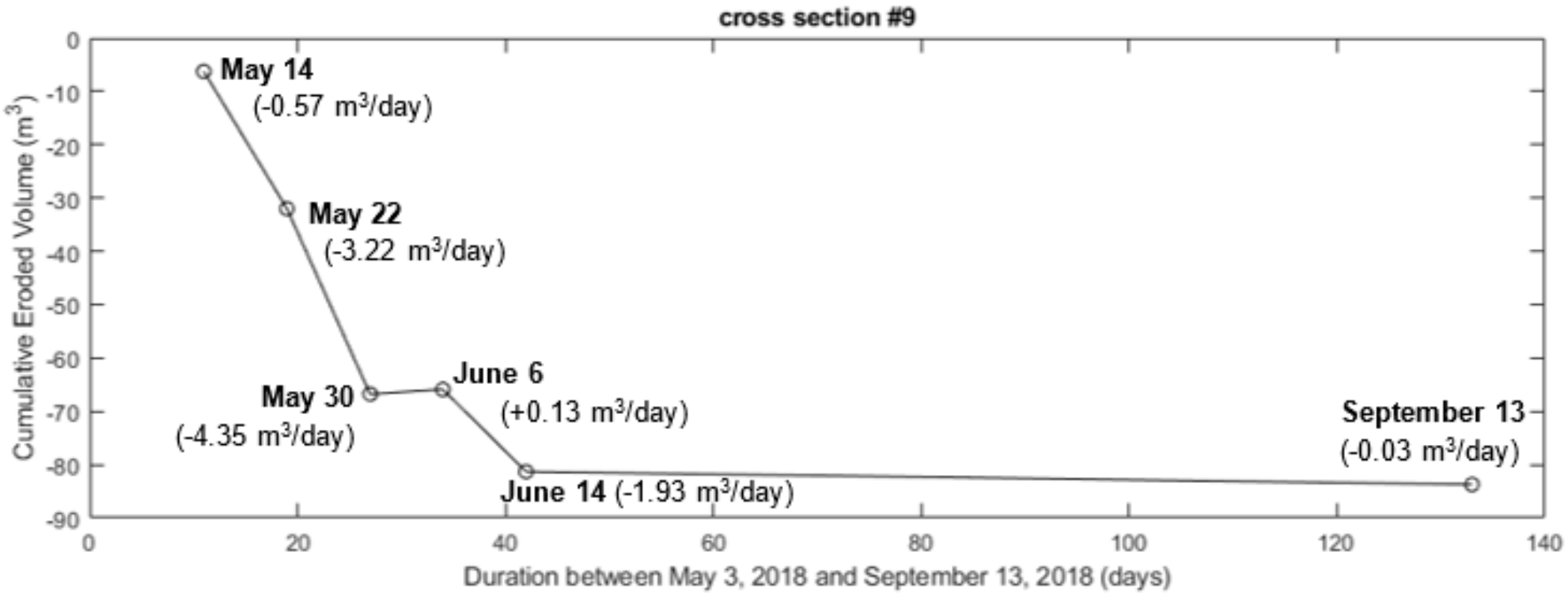
Quantification of Erosion Over Time



Measure rate of erosion per date for each cross-section (cumulative eroded volume)

Integrate eroded volumes along the river bank to obtain global bank erosion

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Advantages and Limitations

- Added **objectivity** in a science that often relies on professional judgement
- Additional insight to **past management** that may not be readily visible without fine topography
- **Automation** can speed up / provide fuller analysis
- Less reliance on topographic field survey measurements
  - Reduced costs
  - Particularly advantageous in remote / difficult to access locations
  - Field verification / observations often still required

- Need to thoroughly understand limitations (resolution, error, comparability)
- **Integration of geomatics specialists in our river management teams**

Questions?

Fluvial Geomorphological Applications of LiDAR, Remote Sensing and Drone Technology

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