New findings from the NASA ABoVE AirSWOT flight campaigns

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NASA Arctic-Boreal Vulnerability Experiment (ABoVE)

https://above.nasa.gov/

AirSWOT flight campaigns (2017)

https://doi.org/10.3334/ORNLDAAC/1646

ABoVE: AirSWOT Ka-band Radar over Surface Waters of Alaska and Canada, 2017

Get Data

Documentation Revision Date: 2019-03-29

Dataset Version: 1

Summary

AirSWOT is an airborne calibration and validation instrument for the upcoming Surface Water Topography Mission (SWOT) satellite. AirSWOT is capable of producing high resolution digital elevation models over land and water bodies. This dataset provides AirSWOT Ka-band (35.75 GHz) radar data products collected from an airborne platform over parts of Alaska and Canada during the period 2017-07-09 to 2017-08-17. Flights targeted specific surface water features, including rivers, lakes, ponds, and wetlands in the ABoVE domain. The radar data include six products: elevation (above the WGS84 ellipsoid), incidence angle, magnitude (backscatter), interferometric correlation (coherence), DHDPHI (incidence angle dependent height sensitivity), and error (estimated height random error, 1-sigma standard deviation). The flight lines were selected to span a full spectrum of permafrost conditions (permafrost-free to continuous permafrost, low to high ground ice content), ecosystems, climatic regions, topographic relief, and geological substrates across the ABoVE domain to investigate surface water responses to thawing permafrost and spatial and temporal variability in terrestrial water storage by measuring elevation and extent of surface waters. The data are provided in two forms: 1) the original output (outer-swath products only) at 3.6 m2 resolution in UTM coordinates from the AirSWOT processing group at the Jet Propulsion Laboratory (JPL), and 2) the ABoVE Projection at 3.6 m2 resolution, clipped to the ABoVE reference grid tiles using the C grid.

The core of NASA AirSWOT is the Ka-band SWOT Phenomenology Airborne Radar (KaSPAR). Ka-band radar uses interferometry to measure surface elevation, particularly focusing on open surface water, producing novel swath water surface elevation measurements. AirSWOT collects two swaths of across-track interferometry data - between nadir and 1 km and between 1 km and 5 km, respectively - which can be used to obtain centimeter-level topographic maps of water surfaces. Only the outer-swath products are included in this release.

There are 1,547 radar output product files in GeoTIFF format provided with this dataset. This includes 768 files (128 swaths x 6 products) in original output at 3.6-m2 resolution in UTM coordinates, and 779 files (one for each ABoVE tile) provided in the ABoVE projection and clipped to the ABoVE 5-m2 C grid. A shapefile (.shp) is provided for visualization of all radar swaths with an index to the ABoVE grid files. This dataset also includes the following companion files: a *.kmz of the shapefile with an index to the ABoVE grid files, and 779 *.kml files of elevation data corresponding to the elevation product for the ABoVE grids.

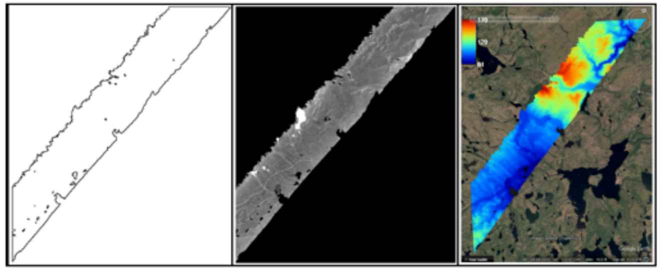
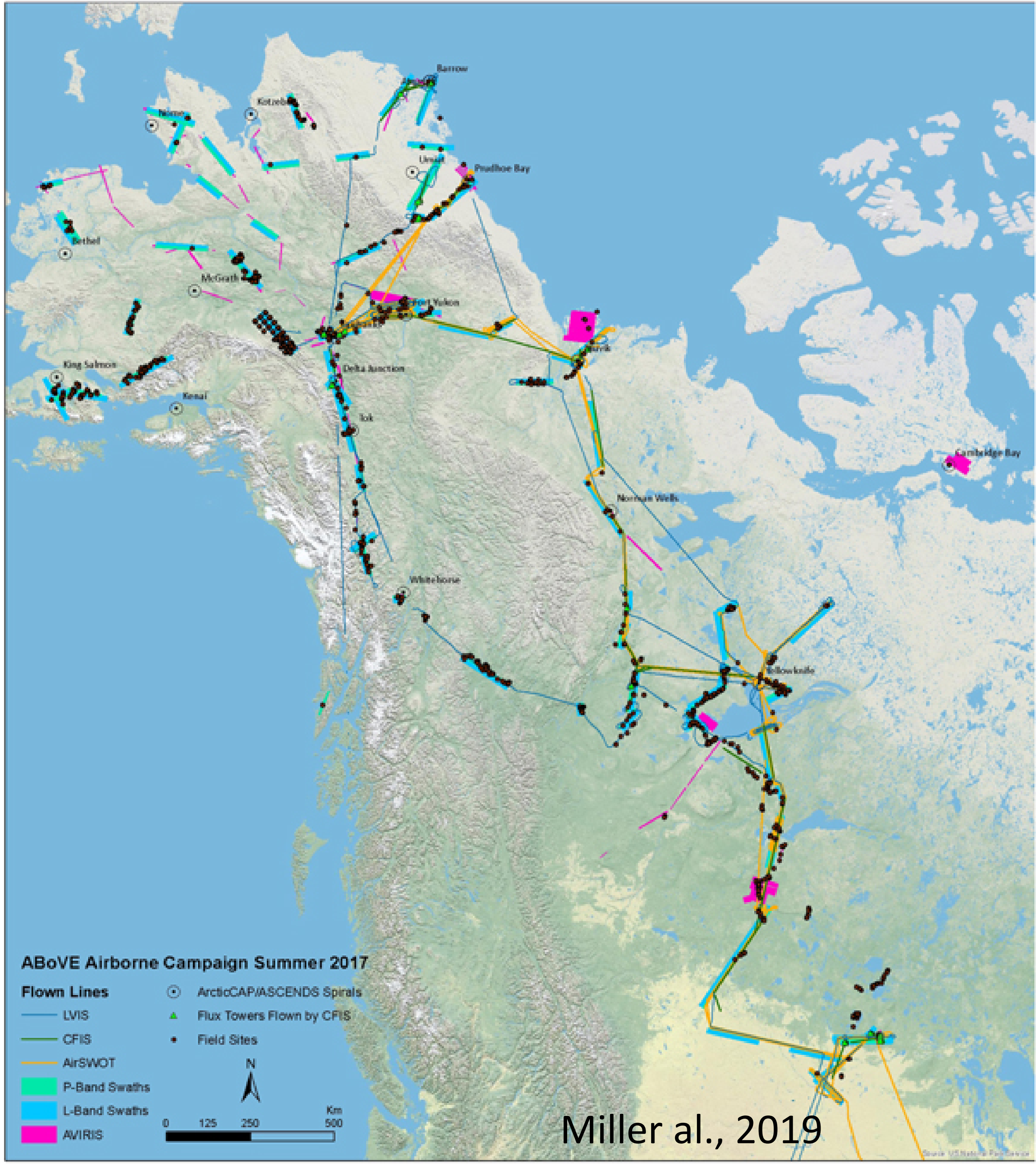


Figure 1. Example of AirSWOT radar products in ABoVE Projection at 3.6 m2 resolution, for a flight over the ABoVE C grid Ch065v034. Left: Shape for backscatter image. Middle. The magnitude image shows bright reflection in the near range, and no returns - yielding regions of no data in the far range. Right: Elevation product image.

(Fayne et al., 2019; 2020)



Miller al., 2019

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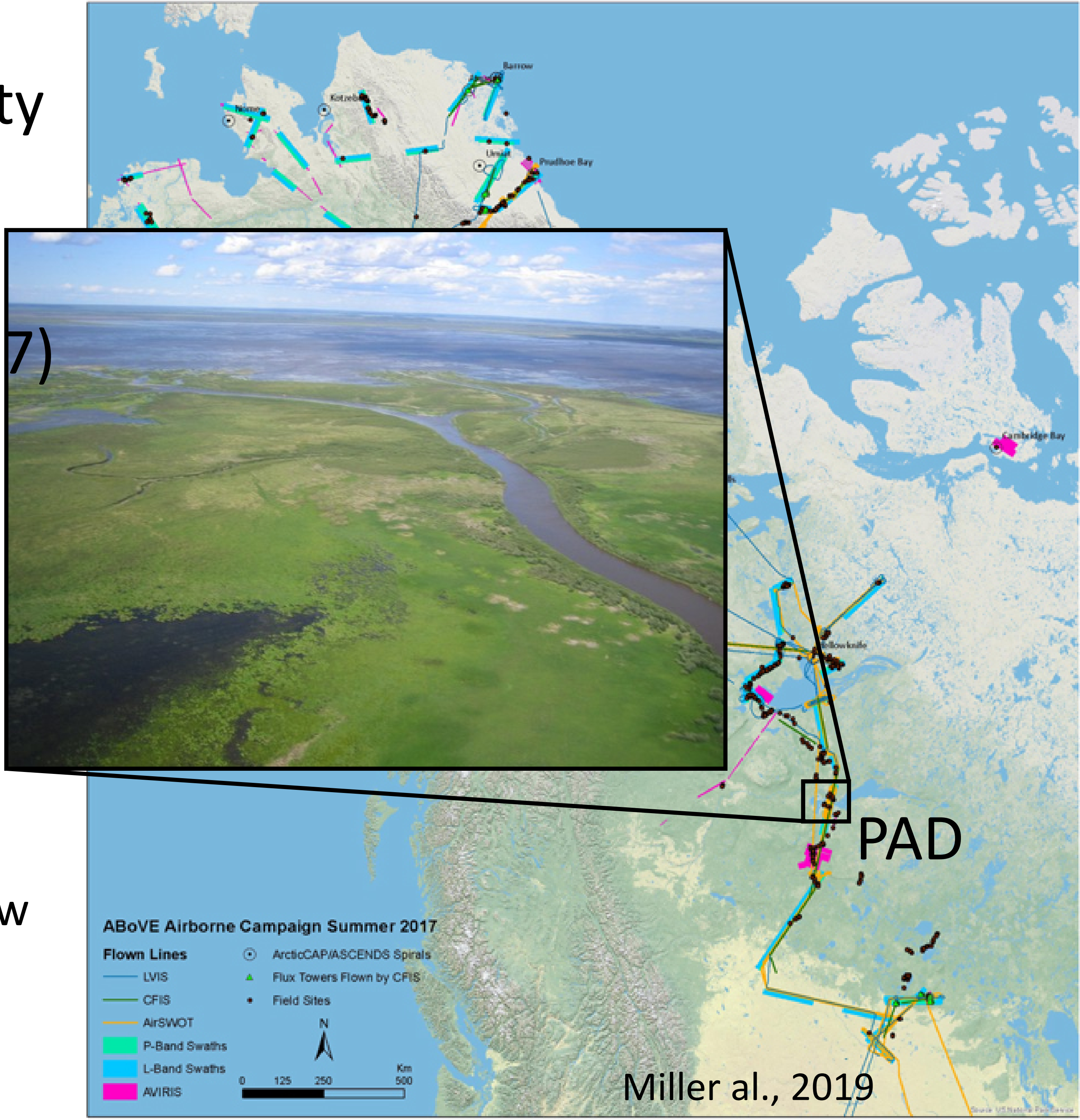
Peace-Athabasca Delta (PAD)

- RAMSAR Wetland of International Importance

- UNESCO World Heritage Site

- Home to Athabasca-Chipewyan, Mikisew Cree, and Métis Indigenous peoples

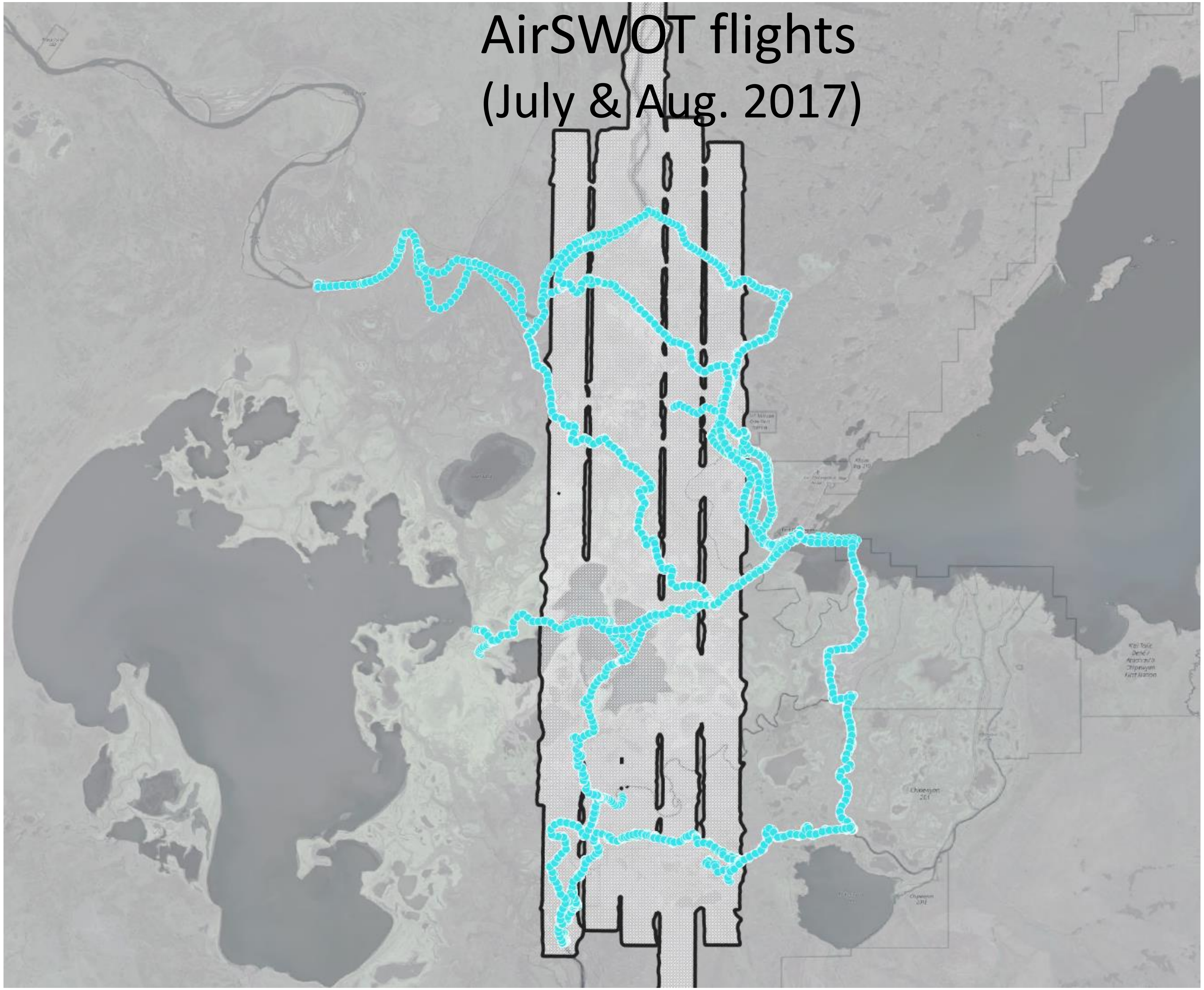


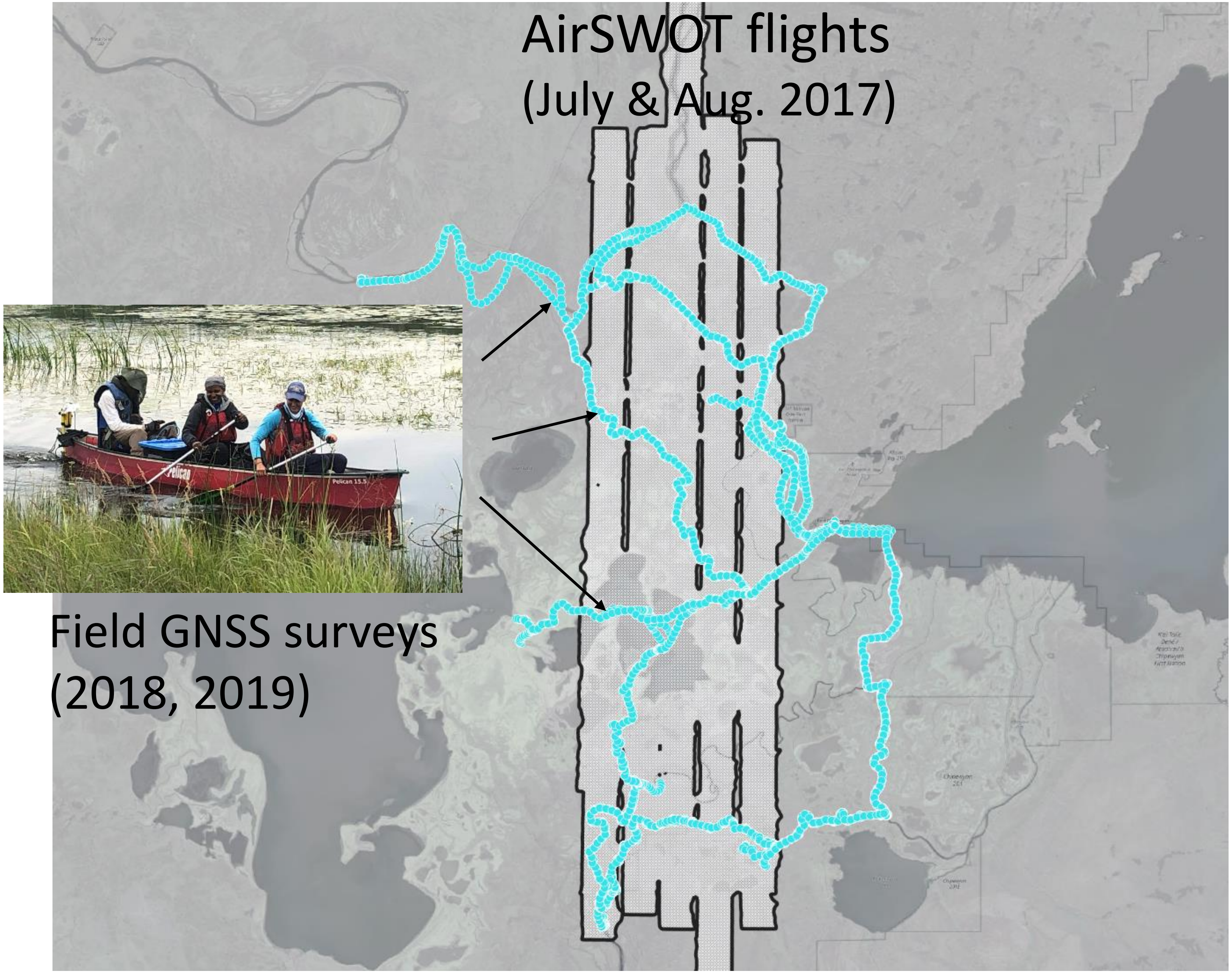
Miller al., 2019

Study objectives:

1) Examine AirSWOT Ka-band InSAR returns over a large, low-gradient ecologically important inland delta (PAD)
2) Estimate WSE and WSS to determine if channel flow directions and slopes can be retrieved from low-gradient channels
3) Assess the importance of reach averaging for estimating channel flow direction and WSS
4) Assess a potential river avulsion site using AirSWOT

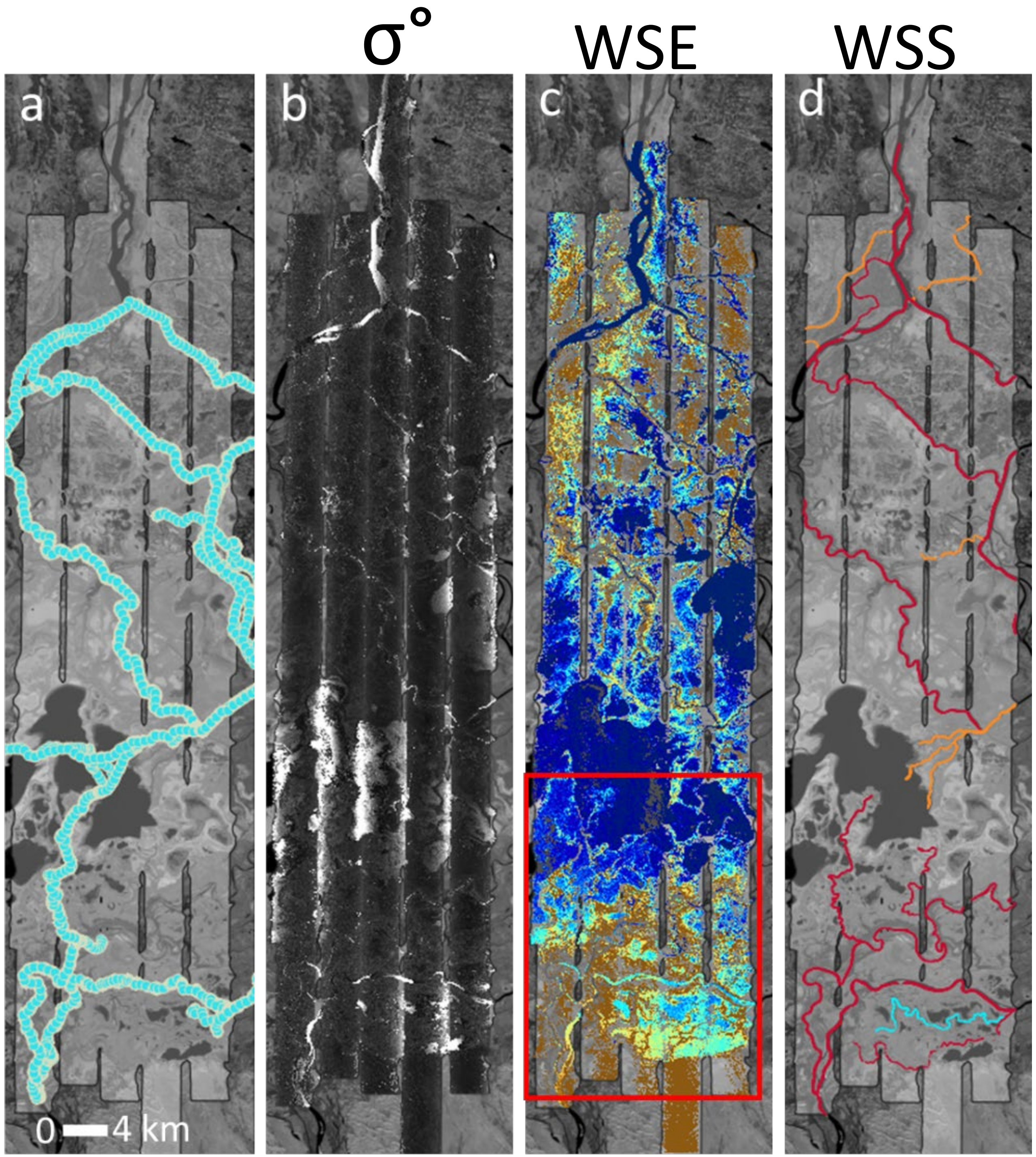
AirSWOT flights
(July & Aug. 2017)



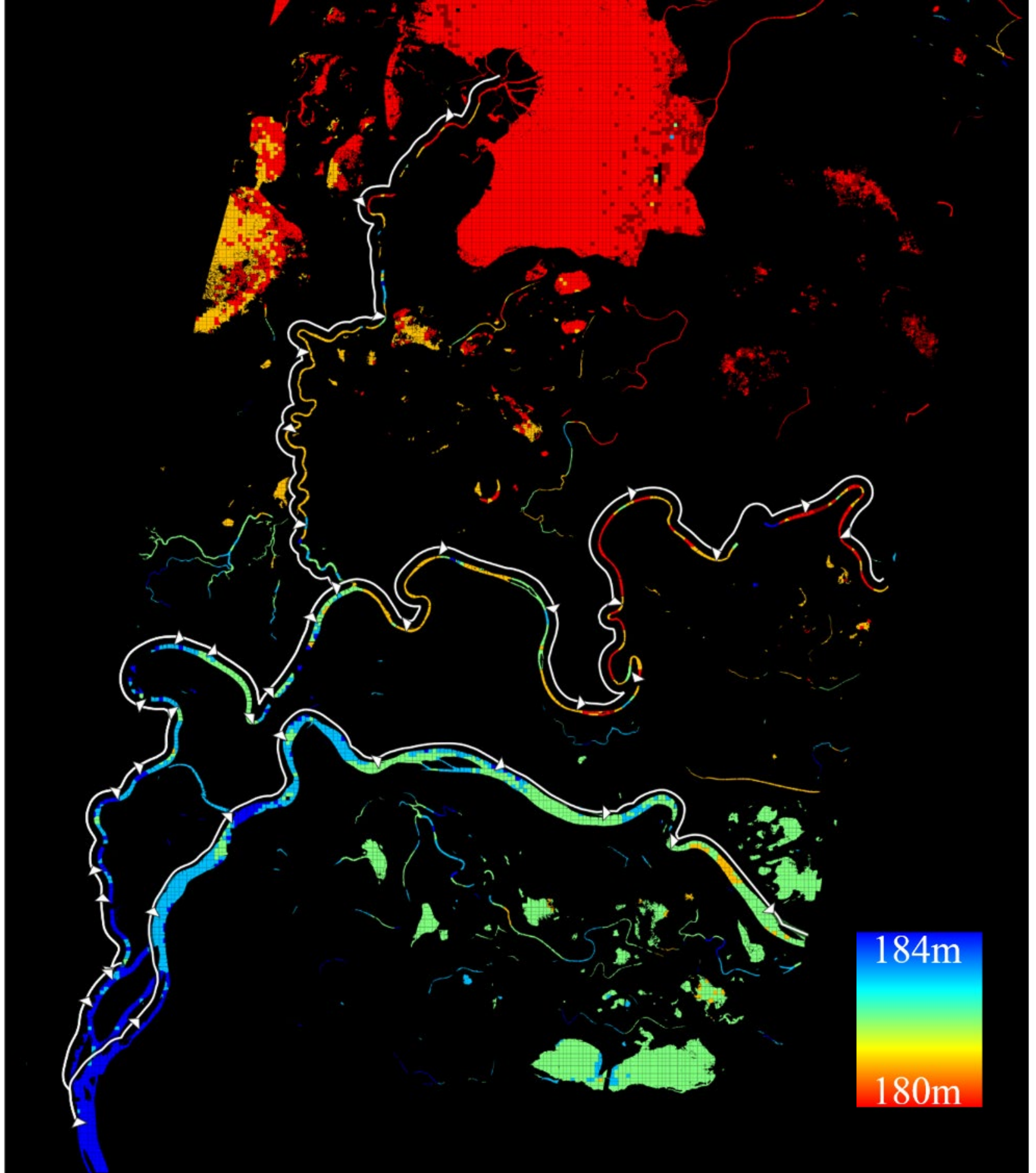


AirSWOT flights
(July & Aug. 2017)

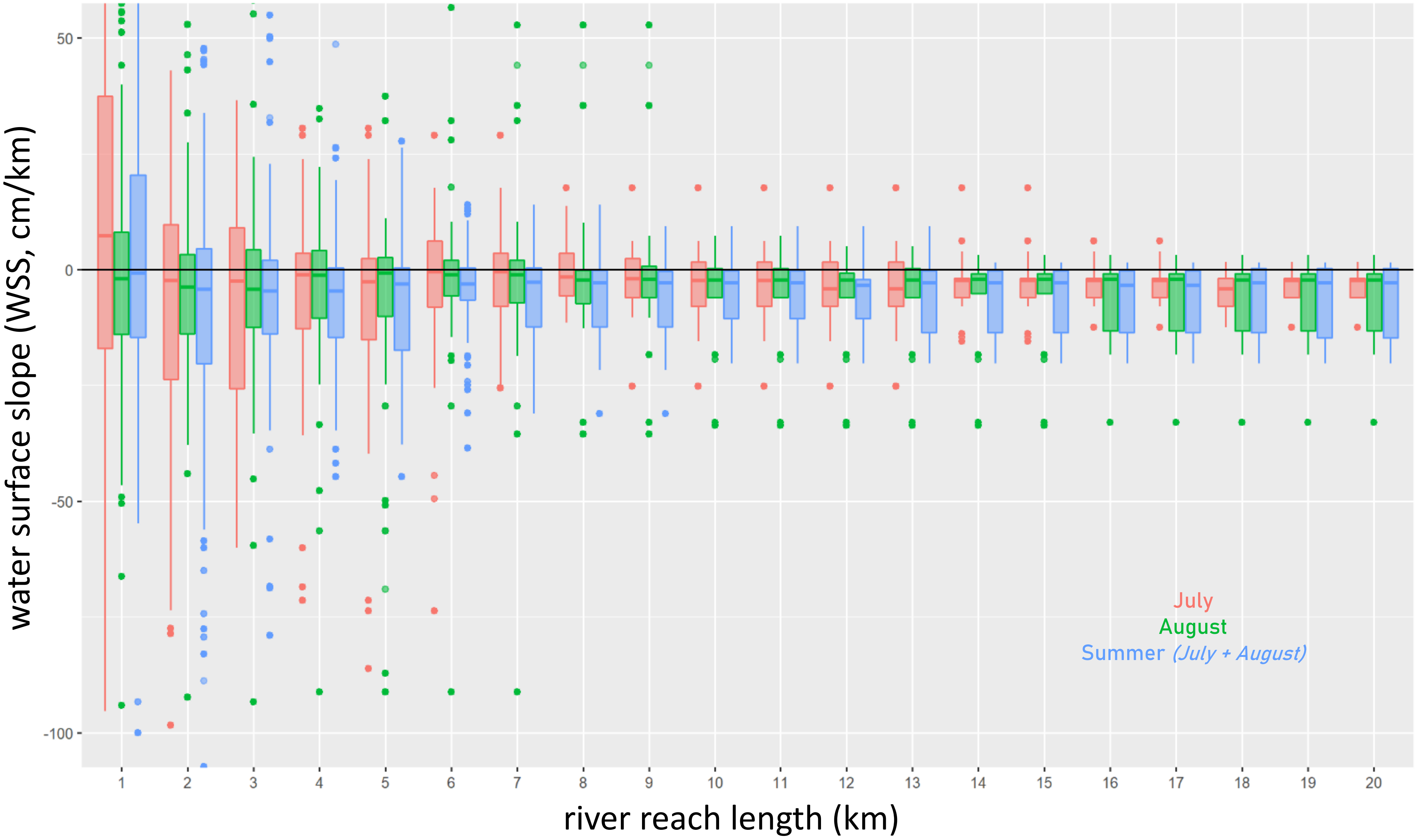
Field GNSS surveys
(2018, 2019)

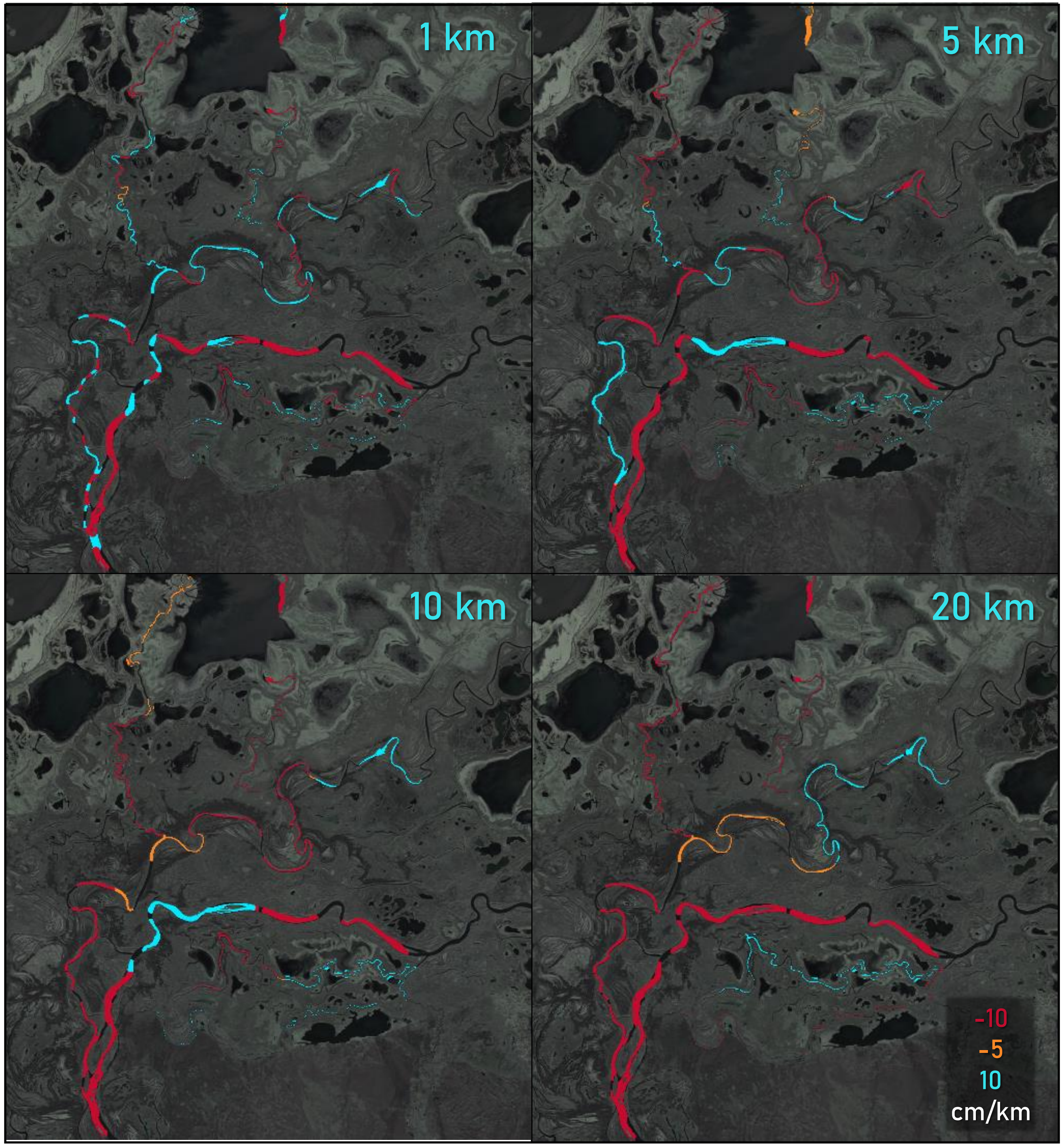

σ°
WSE
WSS
a
b
c
d
0 4 km

Inferred flow direction from AirSWOT WSE mapping (dh/dx)



Reach-averaging of noisy InSAR data is critical for WSS estimation

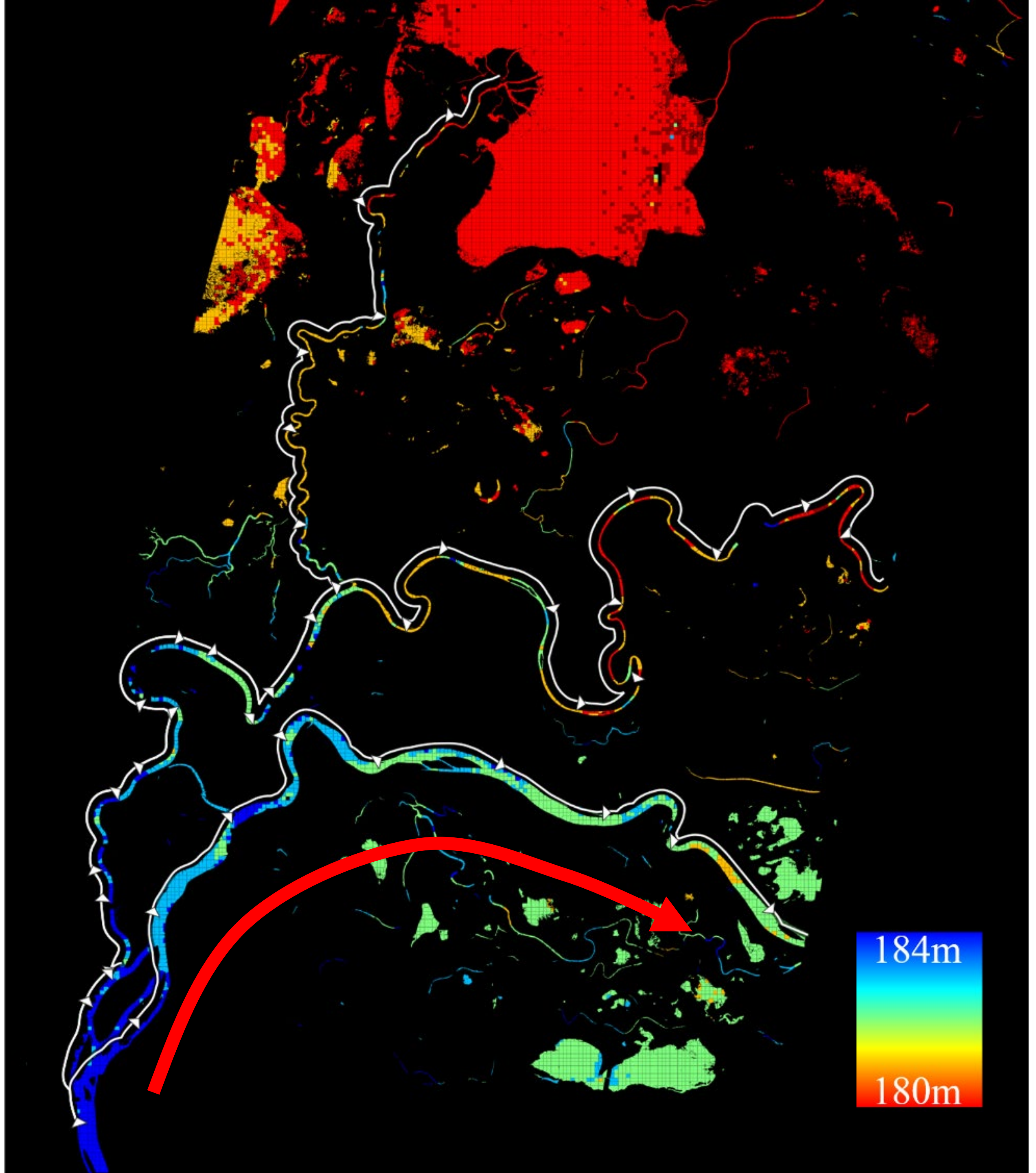




1 km
5 km
10 km
20 km
-10
-5
10
cm/km

Remote sensing of avulsion potential?

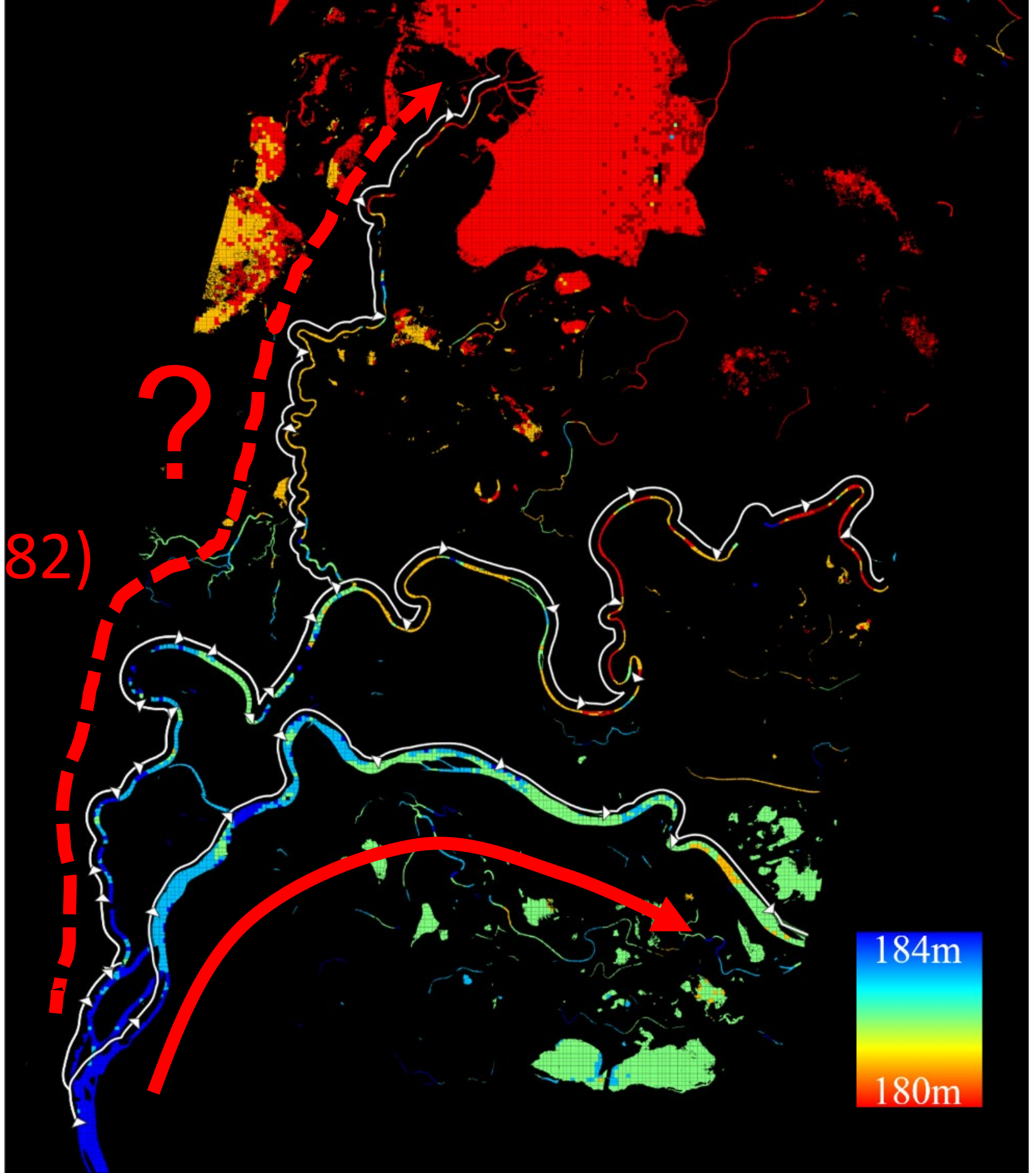
Athabasca River



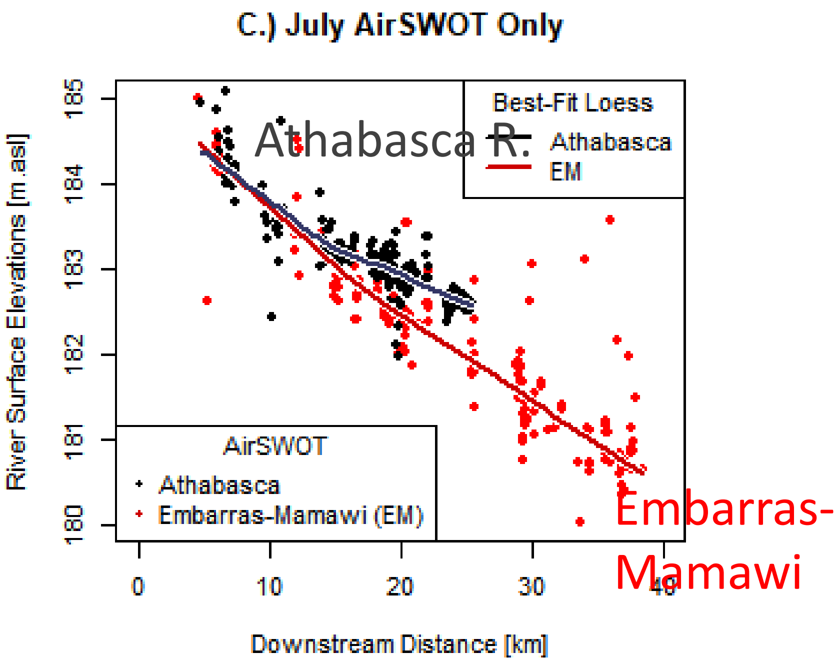
Remote sensing of avulsion potential?

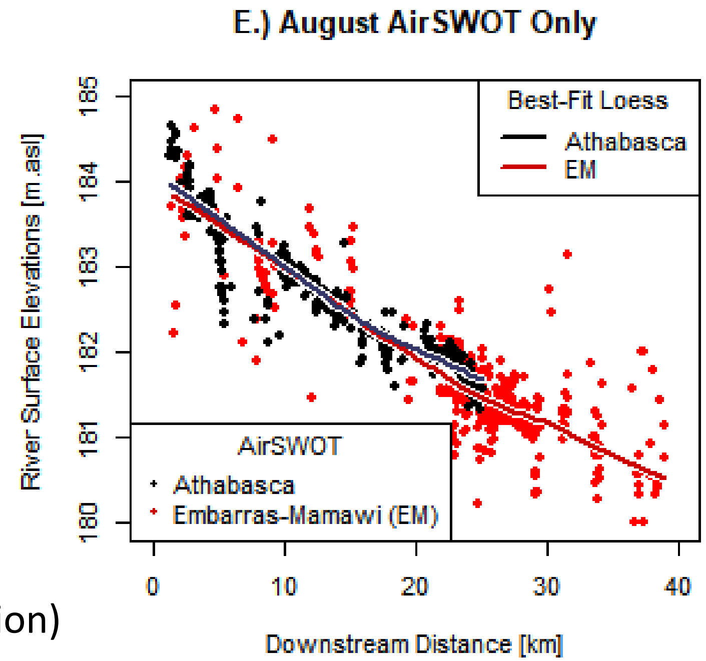
Embarras-Mamawi distributary (opened 1982)

Athabasca River



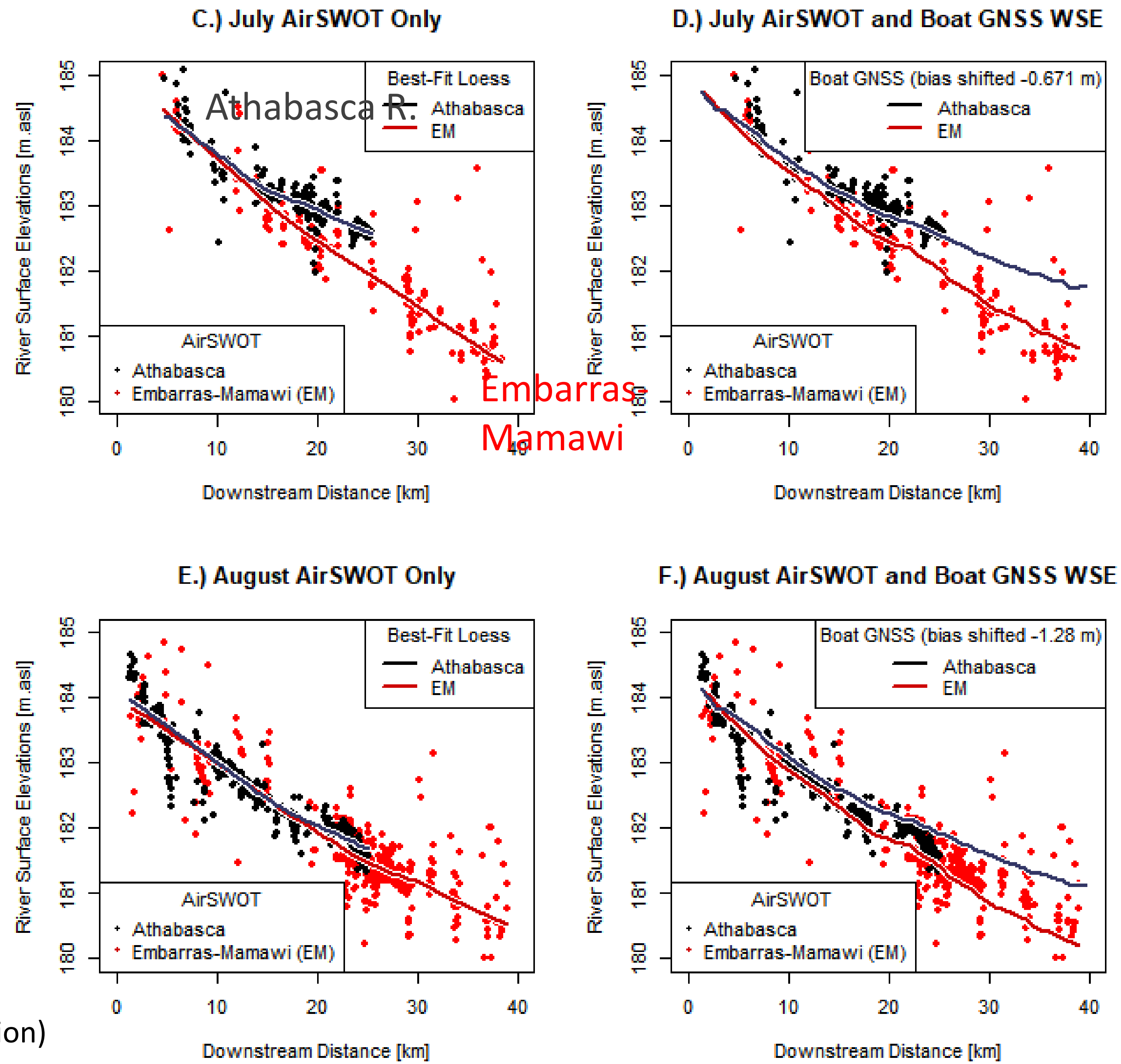
AirSWOT profiles reveal a WSS advantage along the Embarras-Mamawi flow path, during high flow (July) signifying **high avulsion potential**





(Smith, Fayne, Wang et al., in revision)

AirSWOT profiles suggest a WSS advantage along the Embarras-Mamawi flow path, during high flow (July) signifying **avulsion potential**



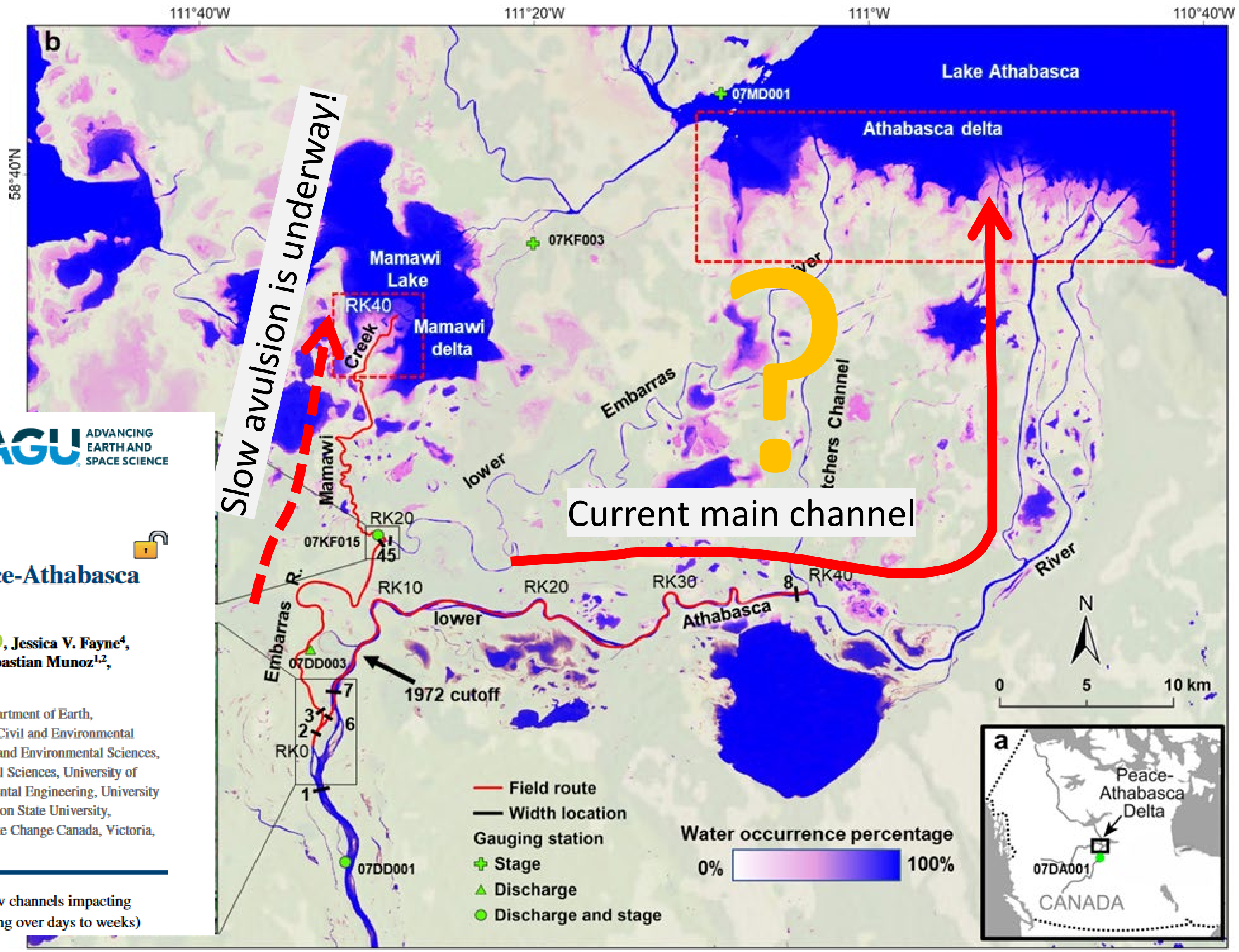
… a finding affirmed by in situ GNSS profiles (2018)

(Smith, Fayne, Wang et al., in revision)

A slow avulsion of the Athabasca River is indeed underway!

(Wang et al., WRR, 2023)

Profound implications for long-term inundation, ecology, and human use of the PAD



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Water Resources Research

RESEARCH ARTICLE
10.1029/2022WR034114

Key Points:

- We assess a potential avulsion of the Athabasca River in the Peace-Athabasca Delta, Canada using field measurements and remote sensing
- Analysis of hydrological and morphological observations affirm that a slow avulsion is currently underway
- The avulsion may accelerate in the future and cause transformative effects on the delta's vegetation, habitat, and ecosystems

Supporting Information:
Supporting Information may be found in the online version of this article.

Athabasca River Avulsion Underway in the Peace-Athabasca Delta, Canada

Bo Wang[1,2], Laurence C. Smith[1,2], Colin Gleason[3], Ethan D. Kyzivat[1,2], Jessica V. Fayne[4], Merritt E. Harlan[3], Theodore Langhorst[5], Dongmei Feng[6], Emily Eidam[7], Sebastian Munoz[1,2], Julianne Davis[5], Tamlin M. Pavelsky[5], and Daniel L. Peters[8]

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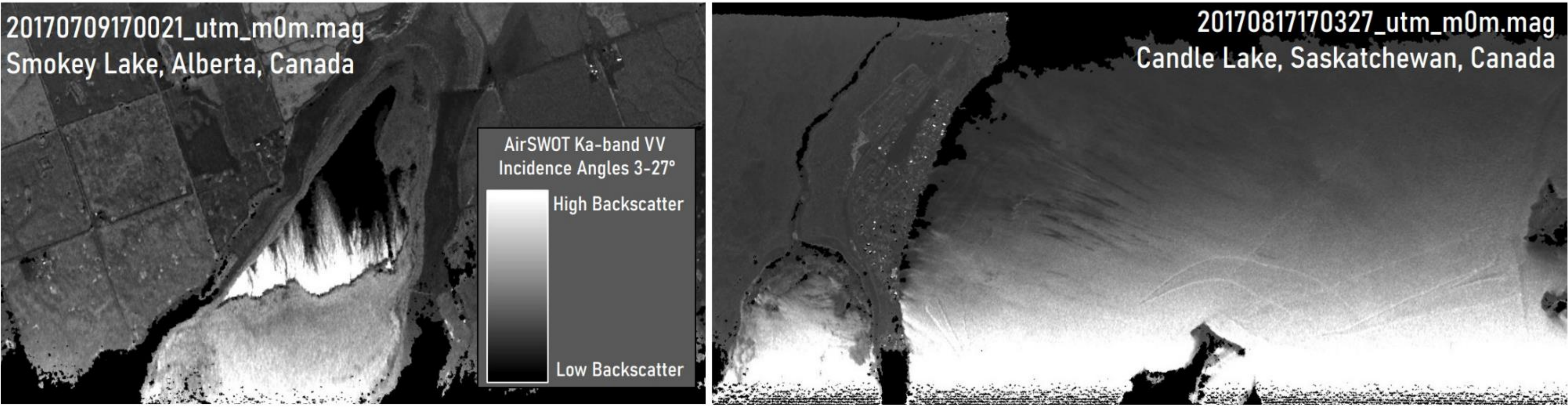
Abstract Avulsions change river courses and transport water and sediment to new channels impacting infrastructure, floodplain evolution, and ecosystems. Abrupt avulsion events (occurring over days to weeks)

How does wind impact Ka-band backscatter? Comparison of ERA-5 wind speed (10m) with observed Ka-band backscatter for ~11,000 lakes (Jessica Fayne)

Wind-driven roughening is noticeable across water surfaces in the AirSWOT Ka-band VV backscatter images.



How does wind speed variability and resultant wind-driven water surface roughness impact the backscattered signal?

Open Access Article

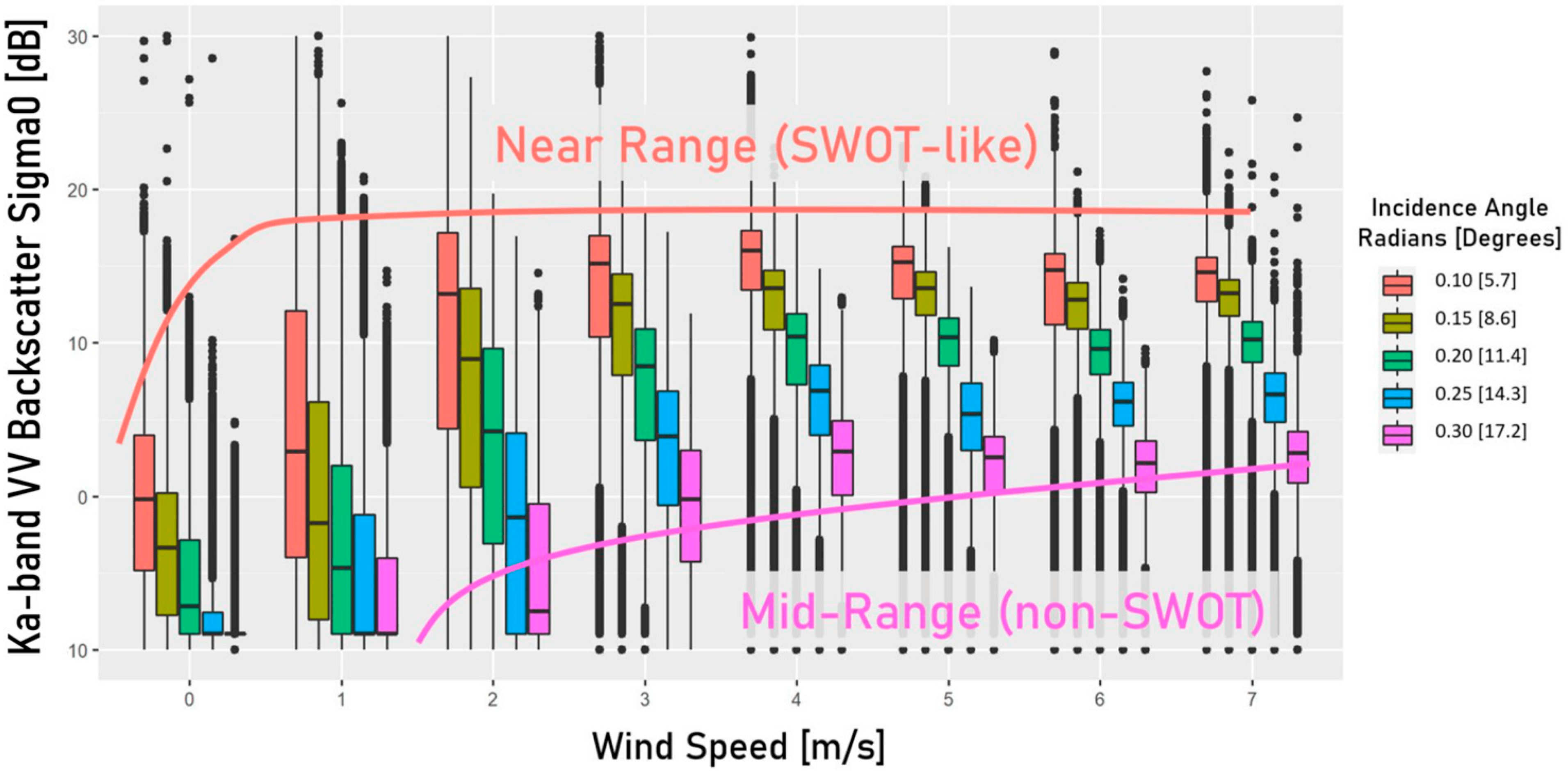
How Does Wind Influence Near-Nadir and Low-Incidence Ka-Band Radar Backscatter and Coherence from Small Inland Water Bodies?

by Jessica V. Fayne [1,*] and Laurence C. Smith [2]

Remote Sens. **2023**, *15*(13), 3361; https://doi.org/10.3390/rs15133361

How does wind impact Ka-band backscatter? Comparison of ERA-5 wind speed (10m) with observed Ka-band backscatter for ~11,000 lakes (Jessica Fayne)

For the most "SWOT-like" range of AirSWOT (~2.8-5.7 degrees, vs. ~0.5-4.1 for SWOT), wind speeds of ~3 m/s or higher are needed to achieve necessary minima in backscatter (>10 dB) and coherence (>0.75) to consistently separate water from land



(Fayne & Smith, 2023)

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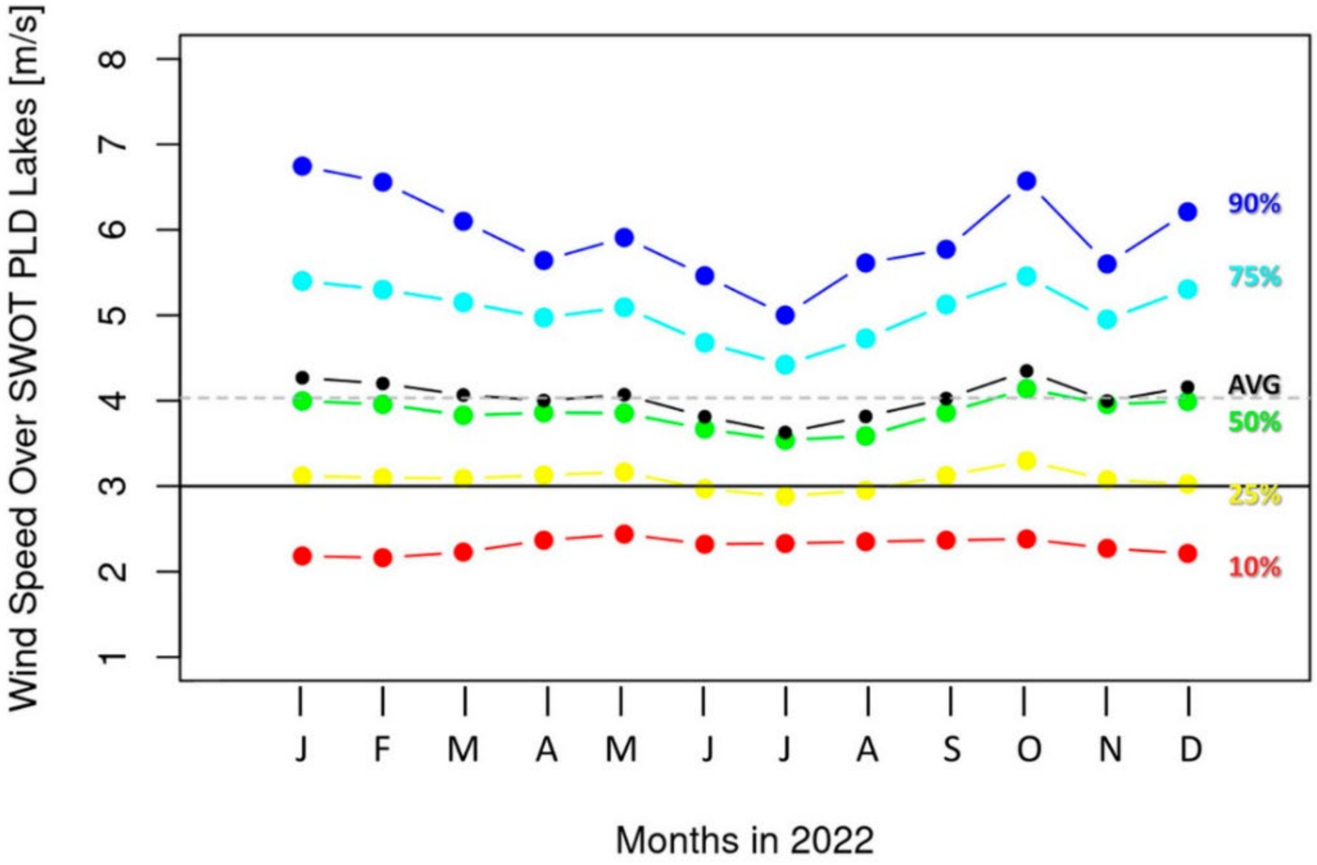
The mean Prior Lakes Database (PLD) wind speed globally was 4.03 m/s in 2022.

~75% of PLD lake areas meet or exceed the necessary 3 m/s



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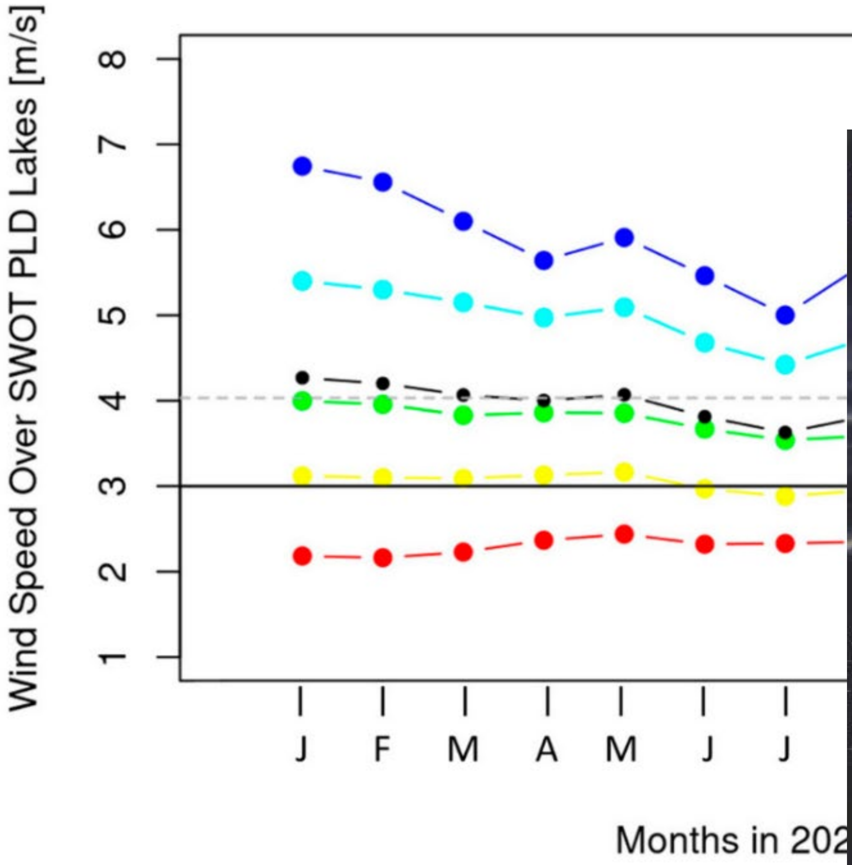

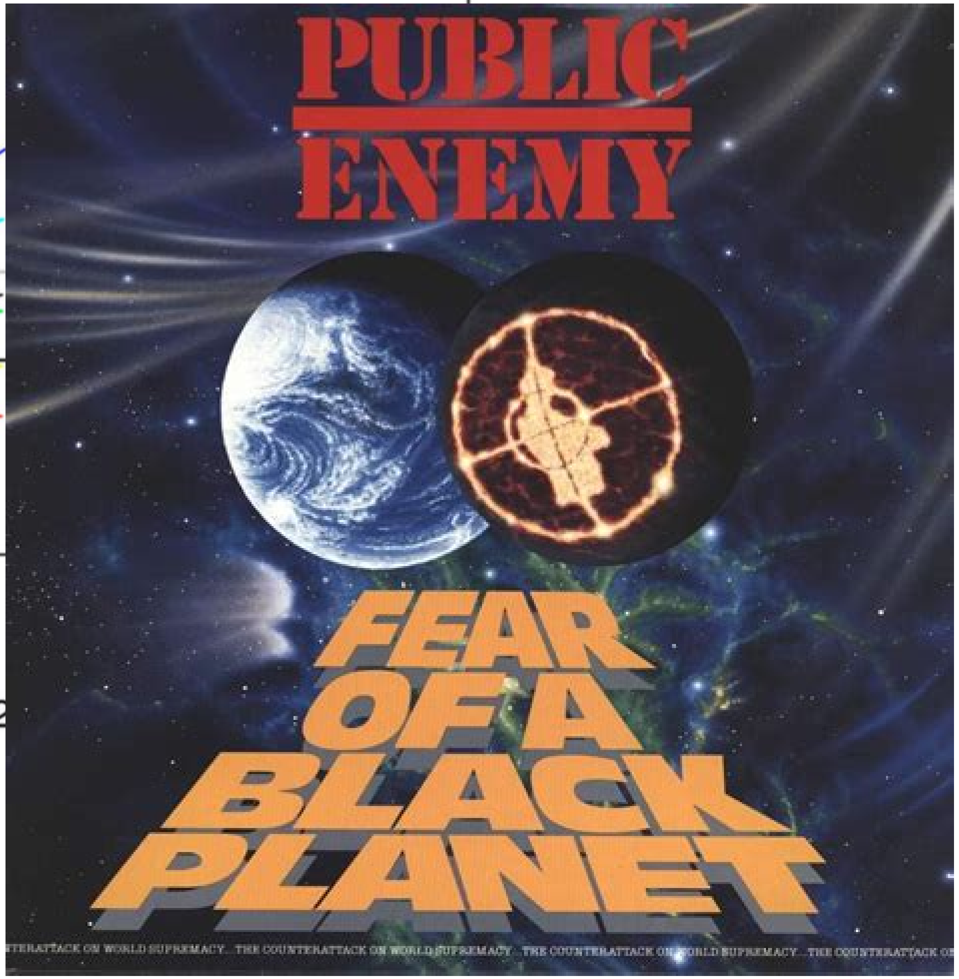

Conclusions:

1) AirSWOT correctly maps regional hydraulic gradients and channel flow directions in a low-gradient river/wetland complex (Peace-Athabasca Delta, Canada)
2) Long reach-averaging (at least >10 km) is **critical** for estimating river slope and flow direction
3) AirSWOT identifies avulsion potential of the Athabasca River in the Peace-Athabasca Delta, a conclusion supported by GNSS and other RS measurements
4) Dark water is problematic, but wind speeds of >3 m/s are commonplace globally suggesting it will be a manageable issue for SWOT