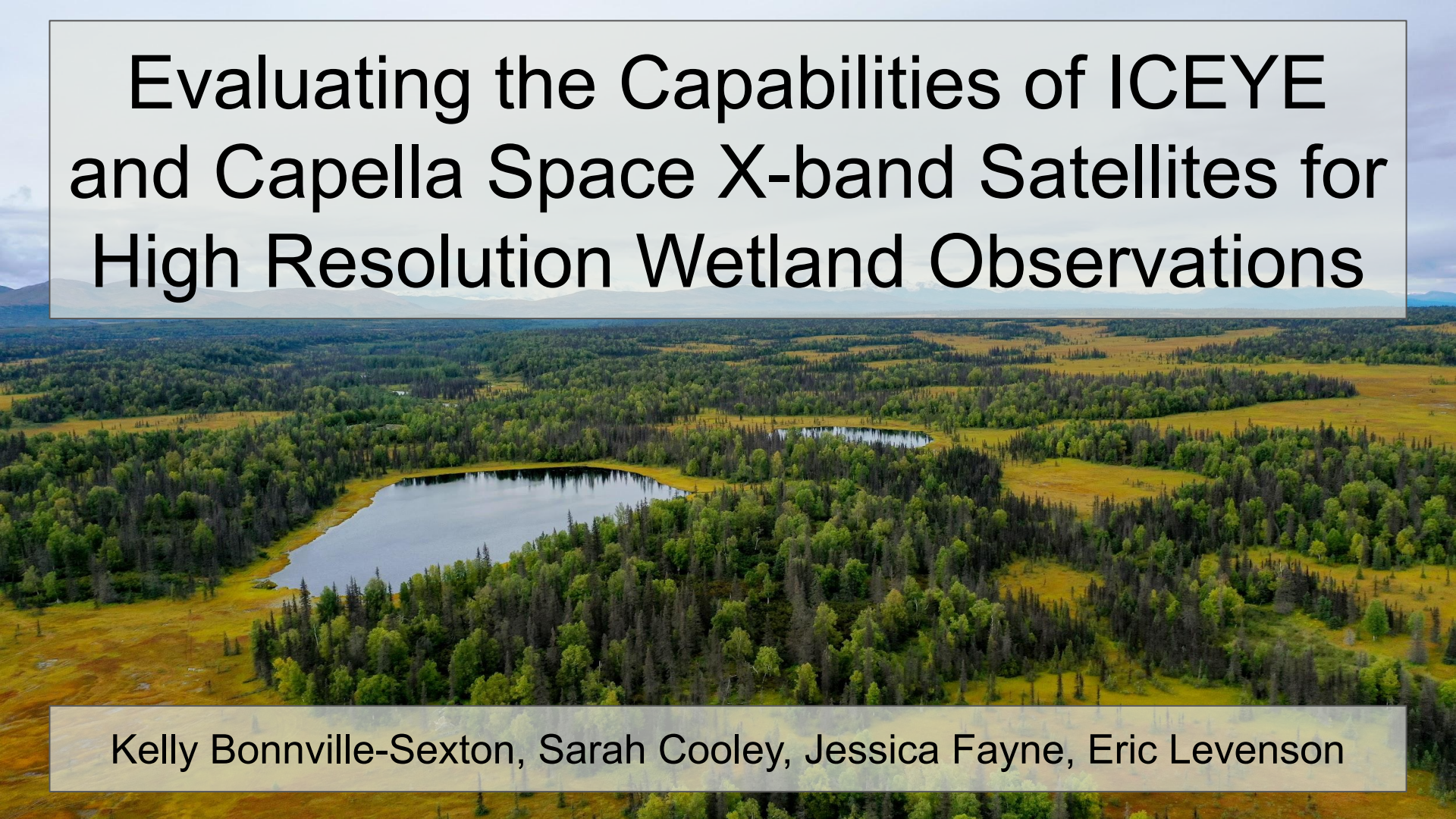
Evaluating the Capabilities of ICEYE and Capella Space X-band Satellites for High Resolution Wetland Observations



Kelly Bonnville-Sexton, Sarah Cooley, Jessica Fayne, Eric Levenson

Background

- Surface water extent is essential for understanding hydrologic processes, managing water resources, mitigating flood risks, monitoring ecosystems, and assessing climate and human impacts on water systems.

- Traditionally been estimated using field surveys, optical remote sensing, and SAR data (L-band and C-band), each with limitations such as restricted spatial coverage, cloud interference, or lower resolution.

- X-band SAR provides high-resolution, all-weather, and frequent monitoring capabilities, making it ideal for detecting small water bodies, dynamic hydrologic changes, and integrating with other data sources for comprehensive analysis.

X-Band SAR

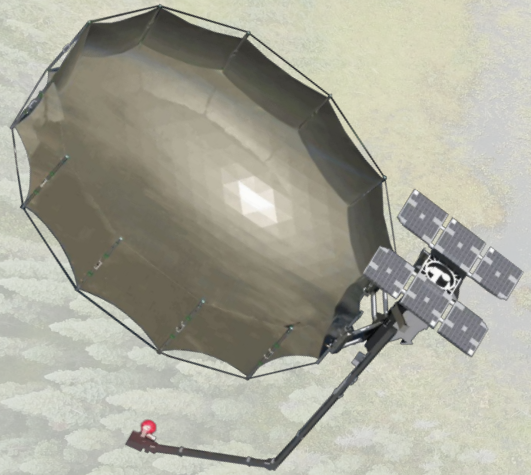
Band	Frequency (GHz)	Wavelength (cm)
P	0.255 – 0.390	133 – 76.9
L	0.390 – 1.550	76.9 –19.3
S	*1.550 – 4.20*	*19.3 –7.1*
C	4.20 – 5.75	7.1 – 5.2
X	5.75 – 10.90	5.2 –2.7
Ku	10.90 – 22.0	2.7 – 1.36
Ka	22.0 – 36.0	1.36 – 0.83

Jessica Fayne

Typically offers high spatial resolution.

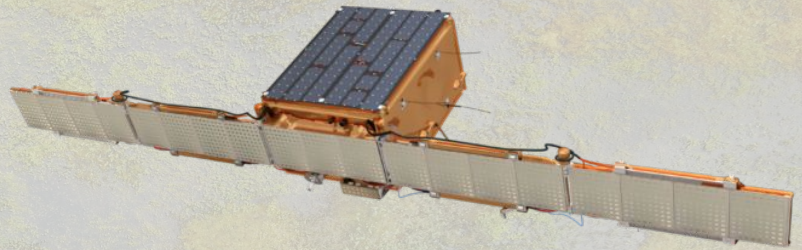
Relatively limited penetration capabilities.

Highly sensitive to surface roughness and dielectric variations.



Capella Space

9.65 GHz
VV Polarization
~3m Spatial Resolution
15-35° Incidence angle range
1-22 day repeat



ICEYE

9.4 – 9.9 GHz
HH Polarization
~3m Spatial Resolution
15-30° Incidence angle range
1-22 day repeat

Research Motivation

- Prior studies using optical data faced limitations like cloud cover and sunlight dependency.
- X-band radar data provides higher resolution observations than many optical sources while lessening these limiting effects.
- Beyond just water surface perimeter, SAR data captures texture information which can provide further hydrological insights.
- Increasing availability of X-band SAR data including commercial companies.

Research Questions

1. What is the utility of X-Band SAR data in investigating wetland surface water extent?
2. What value does X-Band SAR data provide that more common datasets can not?

Study Sites

Yukon Flats

South Central Alaska

Everglades

Pantanal Wetlands

Yukon Flats

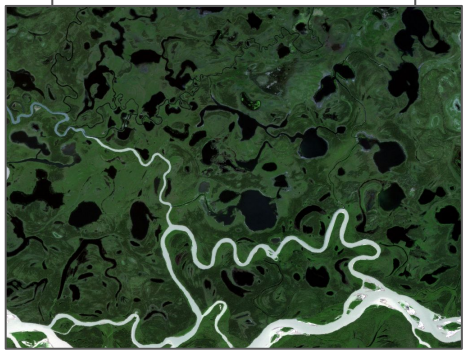
South Central Alaska

Everglades

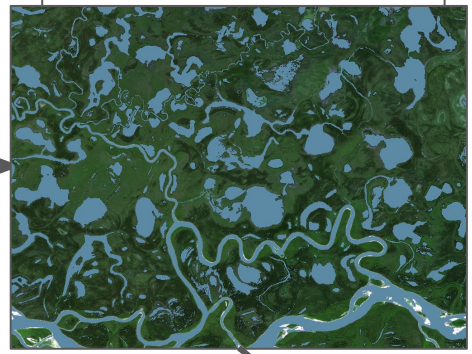
Pantanal Wetlands

Methodology

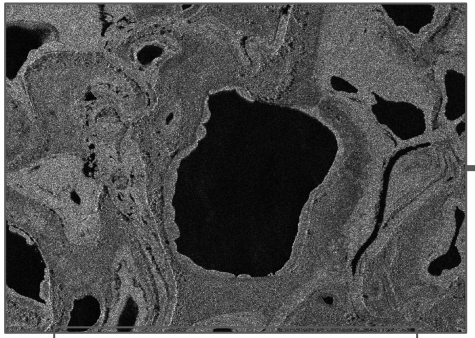
Planet Composite



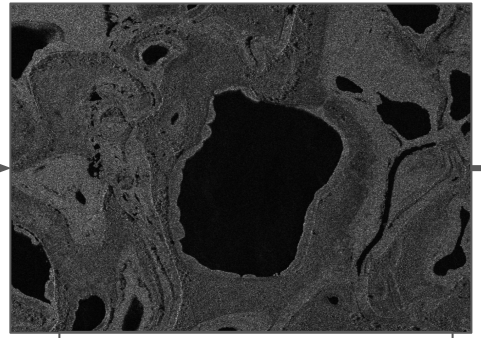
Binary Classification



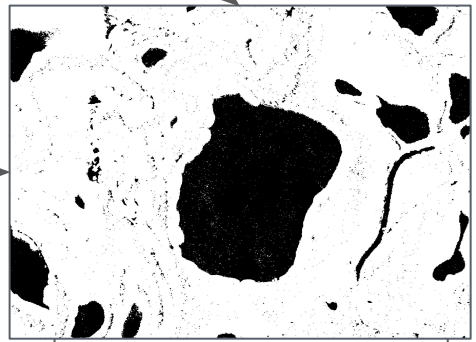
Validation



Raw SAR Image

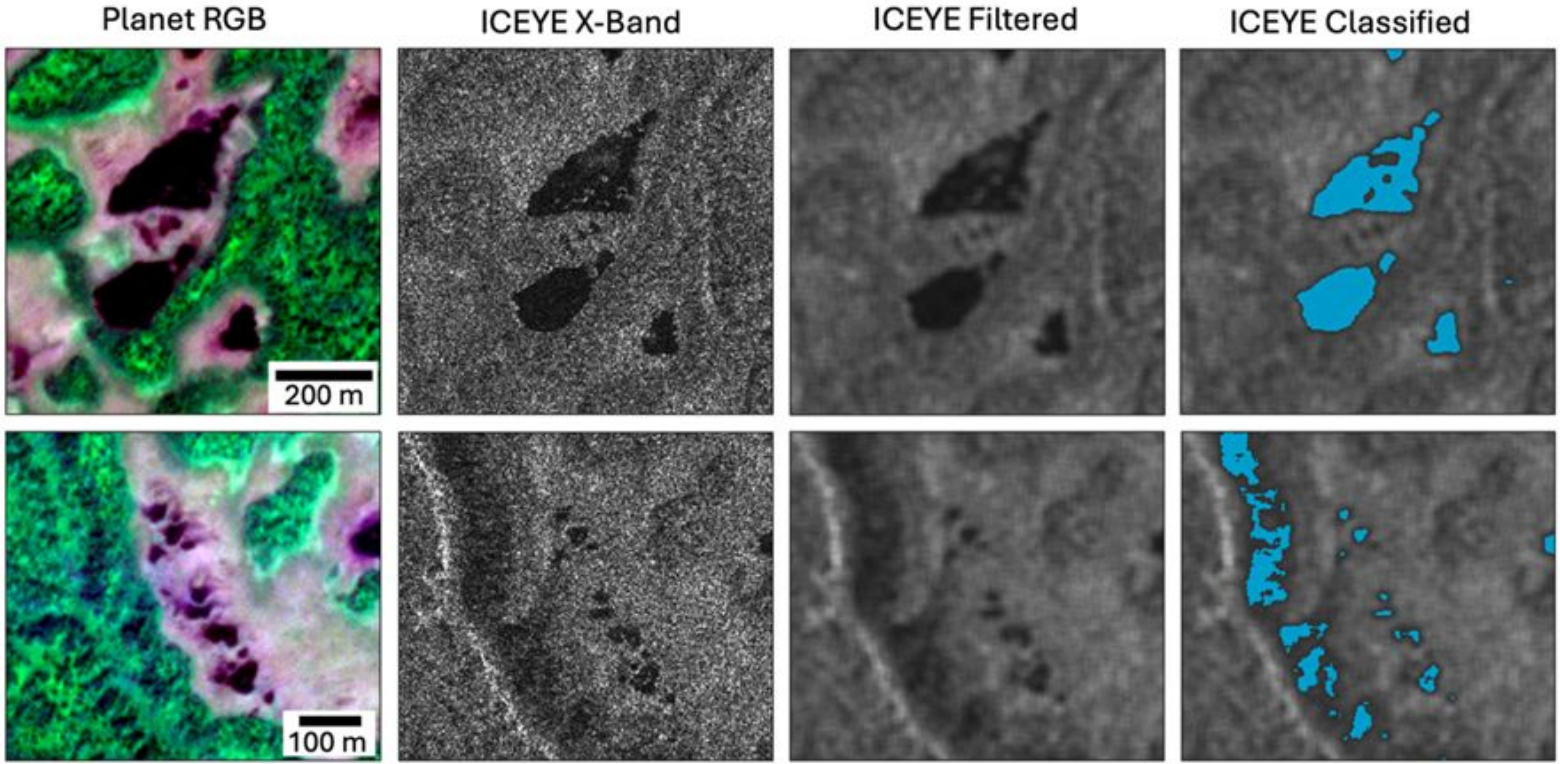


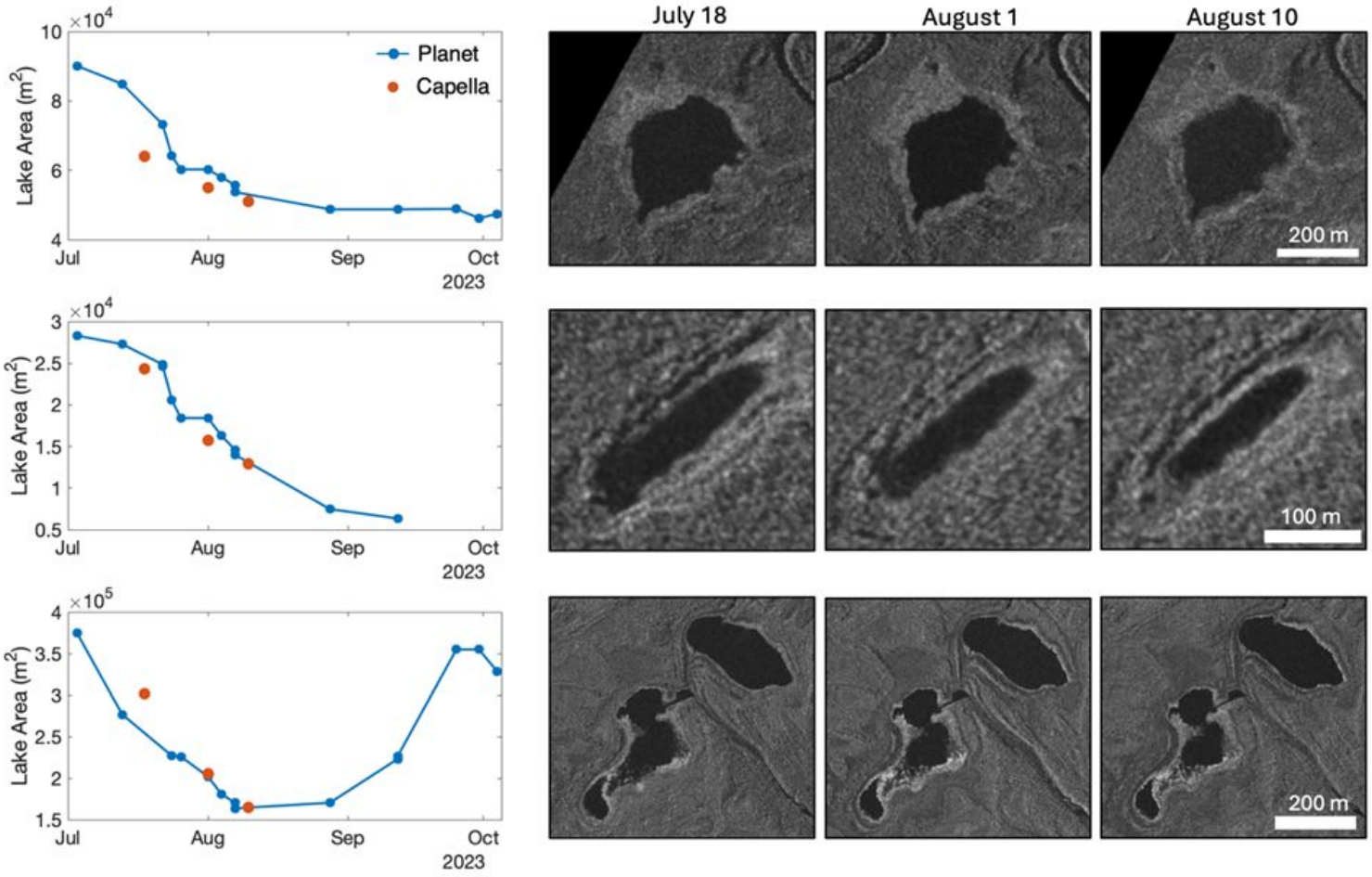
Gaussian Filtered



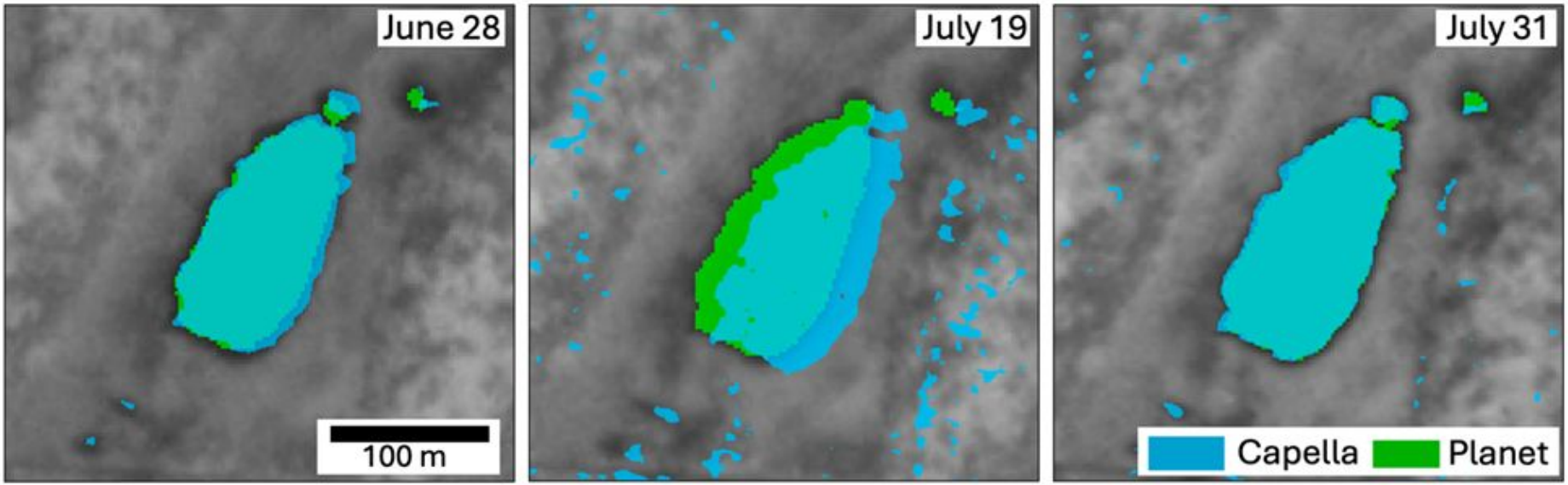
Binary Classification

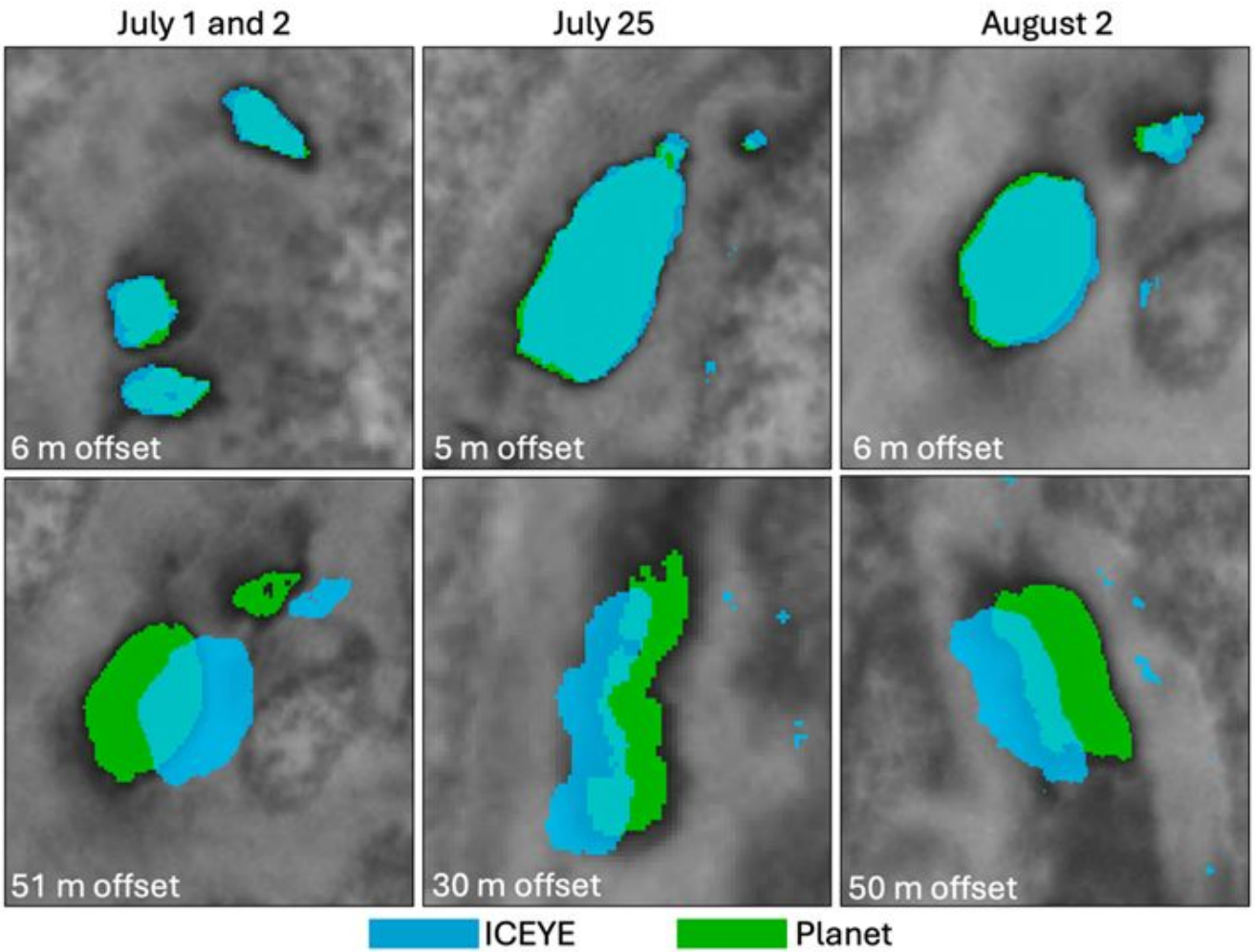
Results


Planet RGB
ICEYE X-Band
ICEYE Filtered
ICEYE Classified
200 m
100 m


July 18
August 1
August 10
Planet
Capella
Lake Area (m²)
×10⁴
×10⁵
Jul
Aug
Sep
Oct
2023
200 m
100 m
200 m

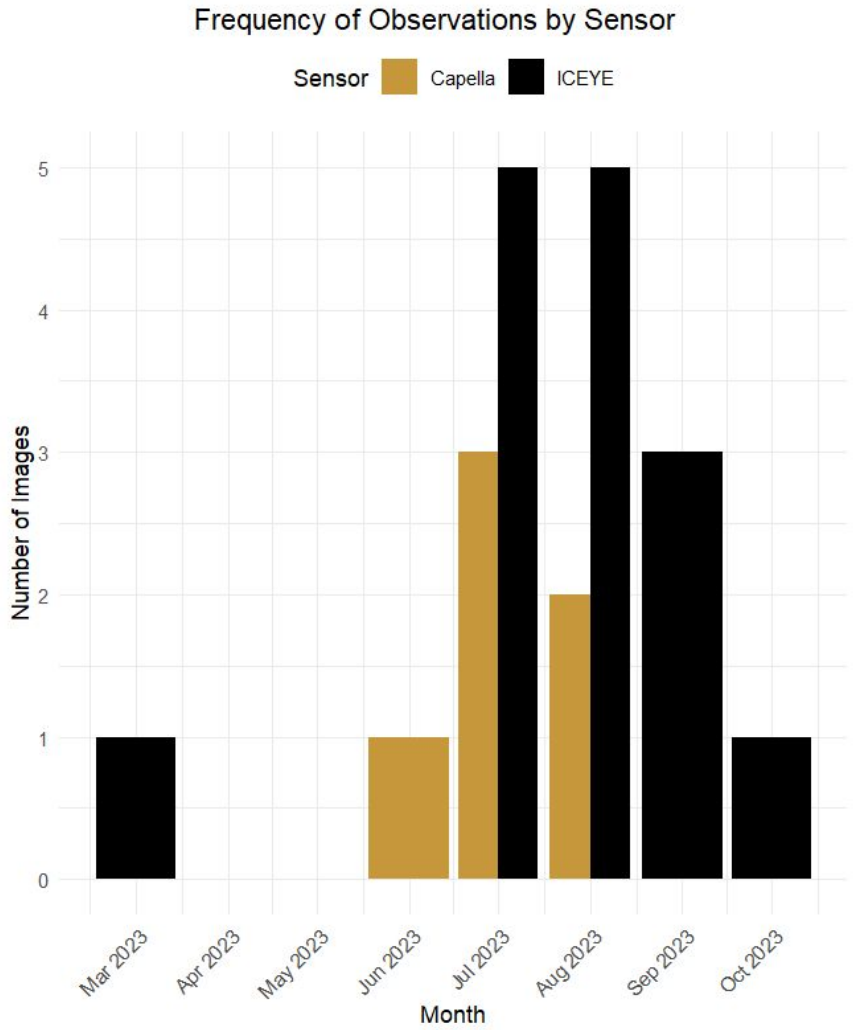
Geolocation Error



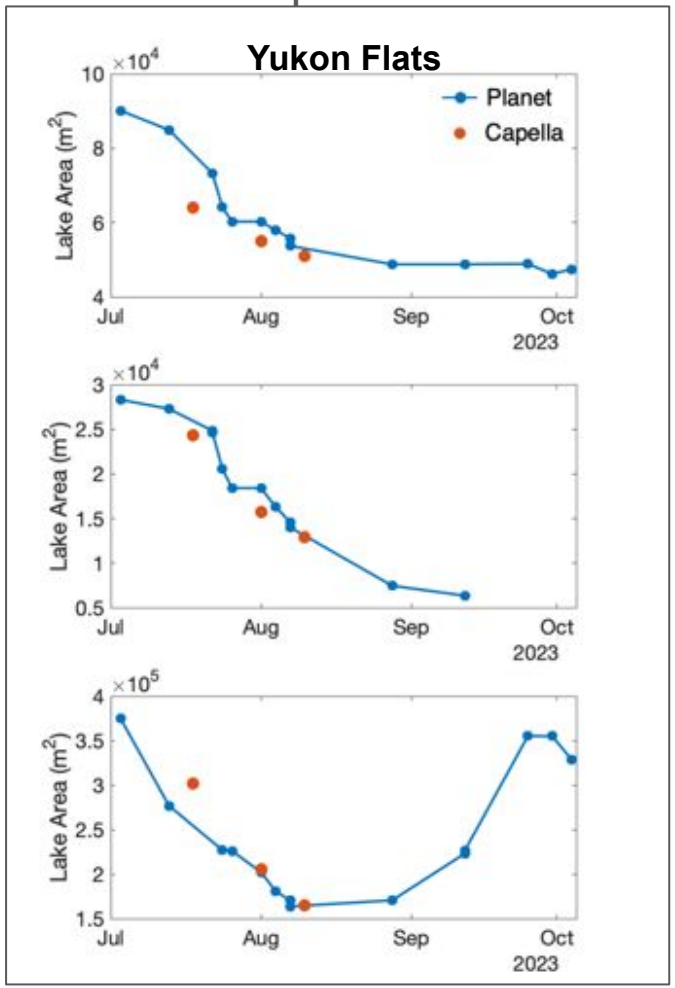

July 1 and 2
July 25
August 2
6 m offset
5 m offset
6 m offset
51 m offset
30 m offset
50 m offset
ICEYE
Planet

Frequency of Observations

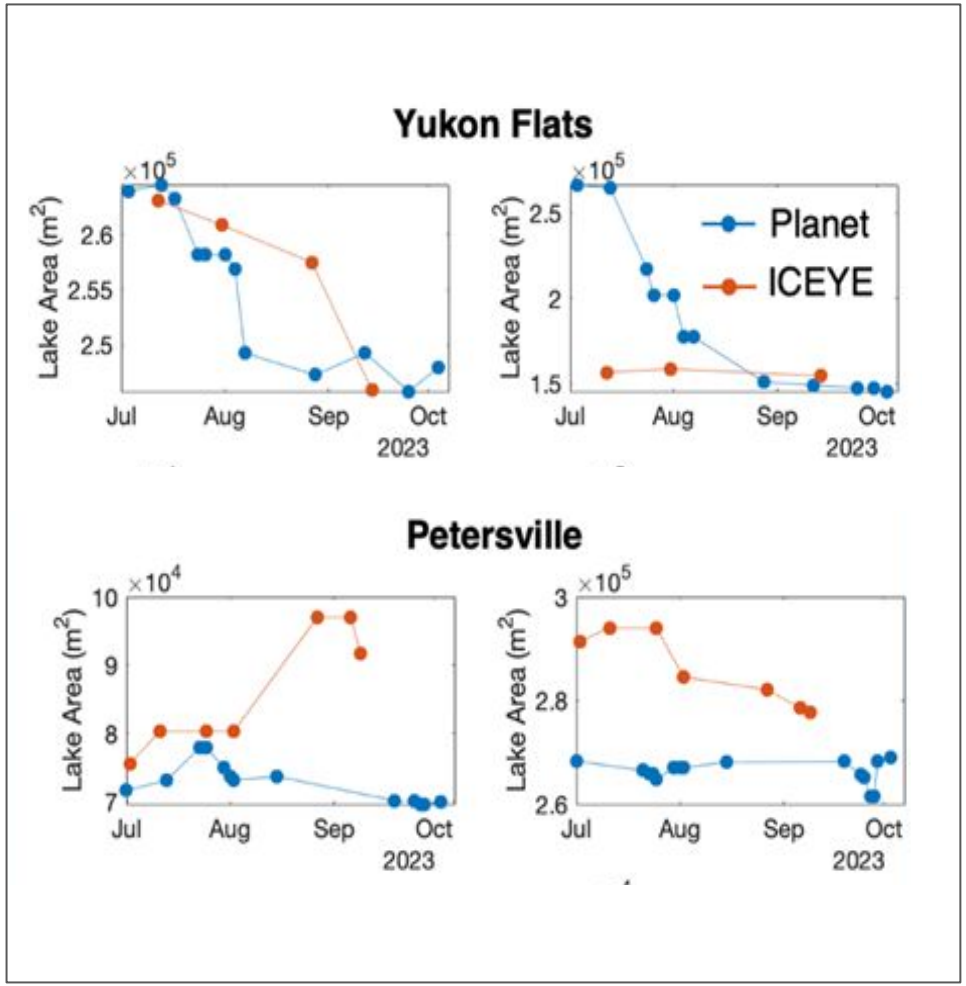
We were able to collect ~3 Capella images, ~8 ICEYE images, vs. ~18 cloud-free Planet images over our 3 month summer study period for one region of interest.



Capella



ICEYE



Conclusions

Photo by Eric Levenson

- X-band SAR data has potential and is capable of producing very high spatial resolution surface water maps.
- Given data limitations such as geolocation error and the infrequency of observations, optical sensors such as Planet are likely still generally preferable for tracking surface variability, but X-band data is useful in especially cloudy and/or night-time conditions.
- Additional work will continue to assess X-band's utility for distinguishing wetland conditions across diverse landscapes

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