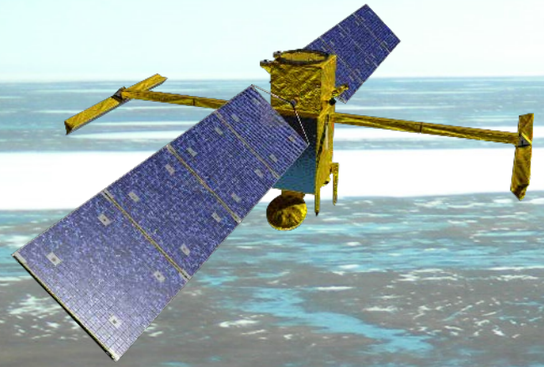


SWOT

SURFACE WATER & OCEAN TOPOGRAPHY

SWOT's capabilities and early science results for global lakes and reservoirs

Jida Wang, Sylvain Biancamaria, Melanie Trudel, on behalf of the SWOT Lake and Wetland Sciences (SLeW) Working Group

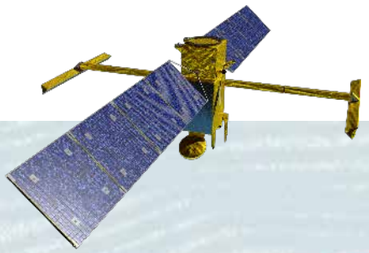
Baseline Science Mission Specifications

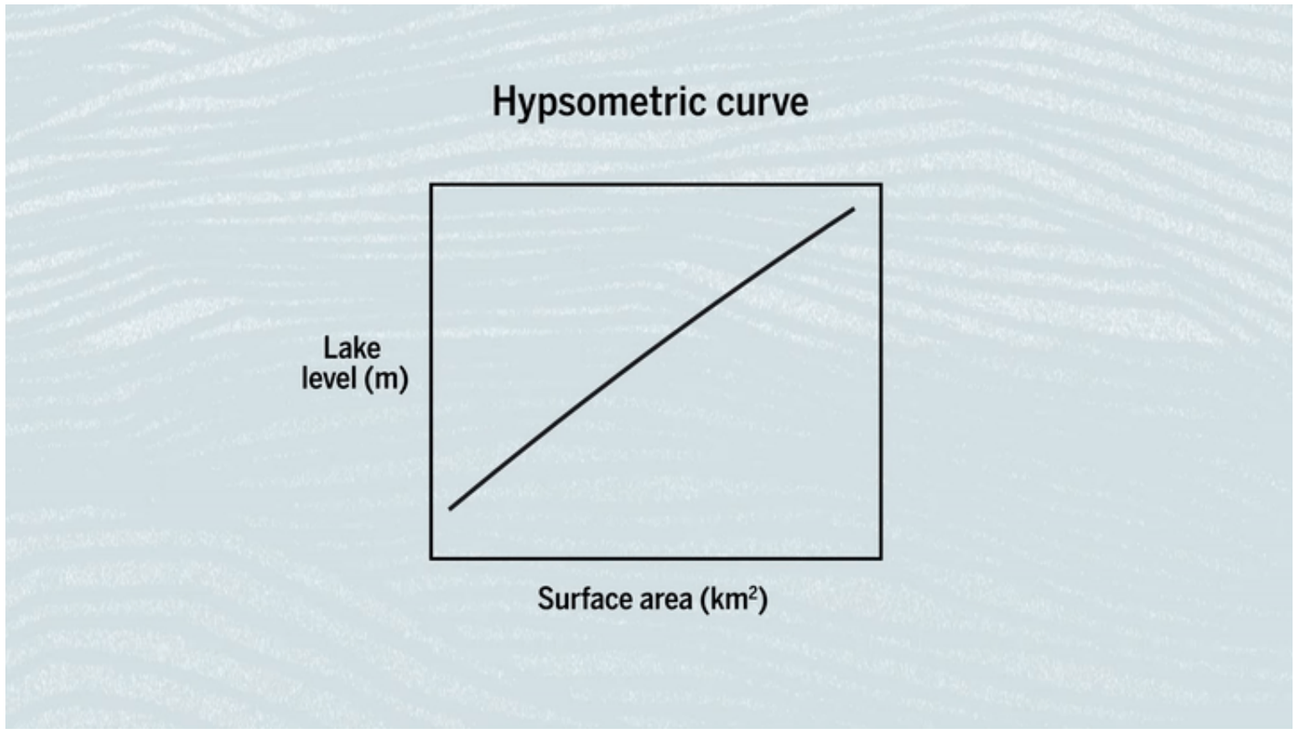
Non-vegetated lakes and reservoirs

	Requirement	Goal
Observed water	250 m × 250 m (6.25 ha)	100 m × 100 m (1 ha)
Error (1•)		
Water area	<15% for lakes >$(250\ m)^2$	<25% for lakes >$(100\ m)^2$
Elevation	<10 cm for lakes >1 km^2 <25 cm for lakes >$(250\ m)^2$	—
Flag	>68% accuracy for rain, layover, frozen flags	—

Vegetated water and wetlands

- Due to complexity of vegetation characteristics, there is no specific performance target for wetland for now.
- However, it is important that SWOT wetland capabilities be assessed for a range of different wetland types. JPL-D-61923





Biancamaria et al. (2016, doi:10.1007/s10712-015-9346-y)

Desai (2018) SWOT Project Science Requirements Document (Rev B)

Cantwell, M. (2023, doi:10.1126/science.adj0801)

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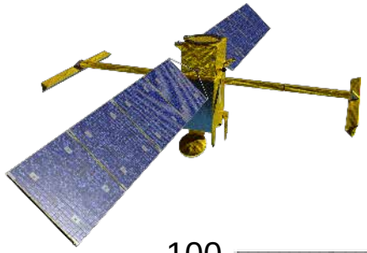
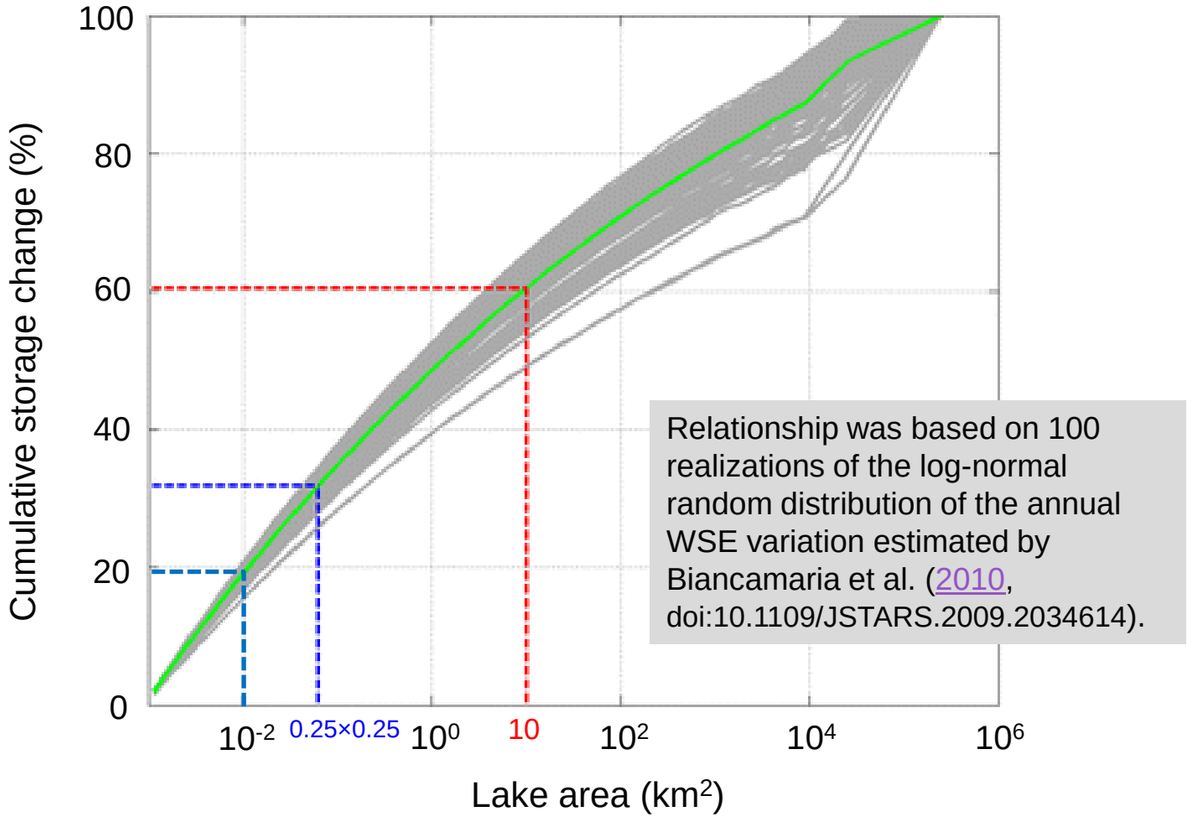
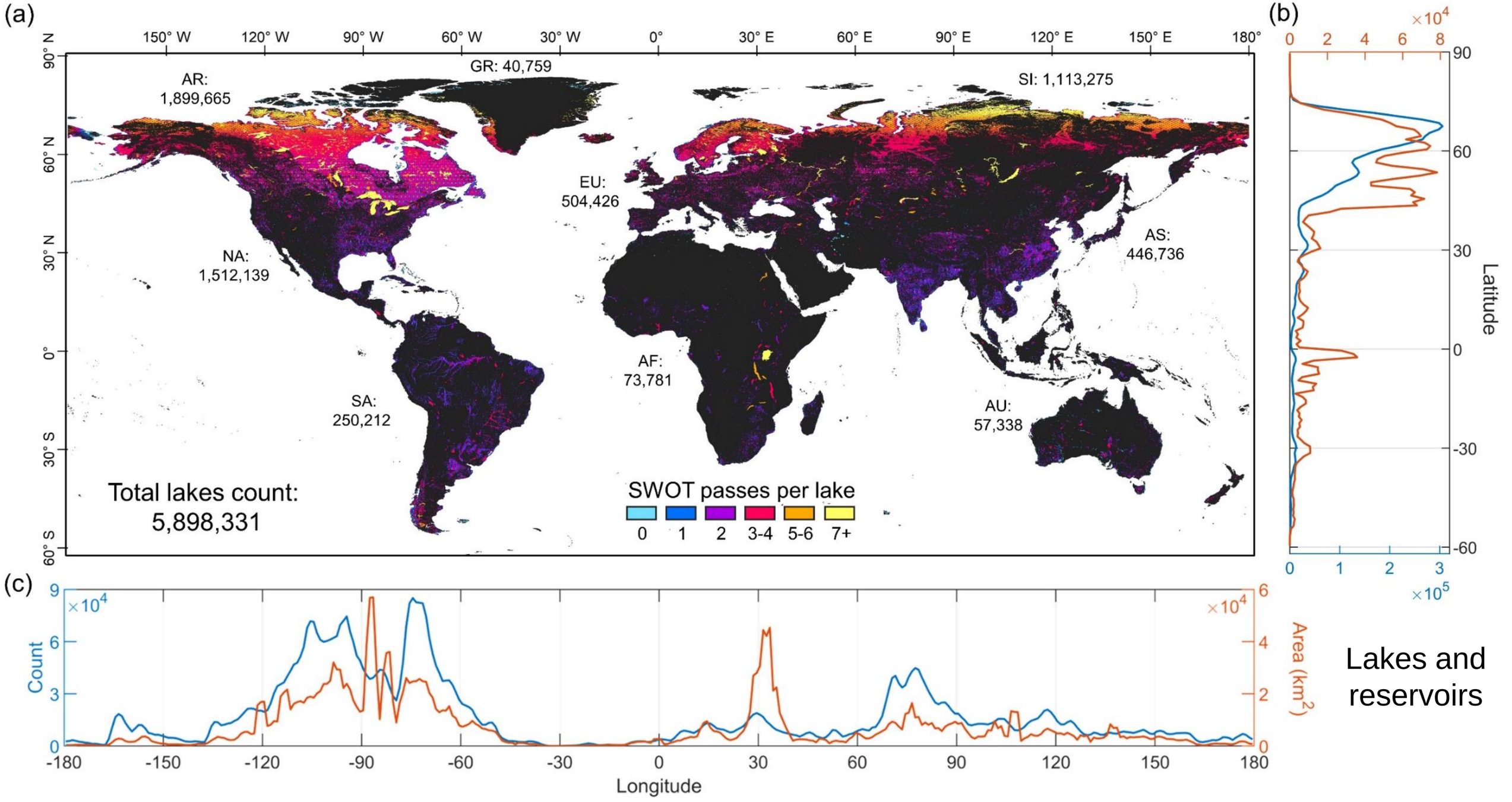


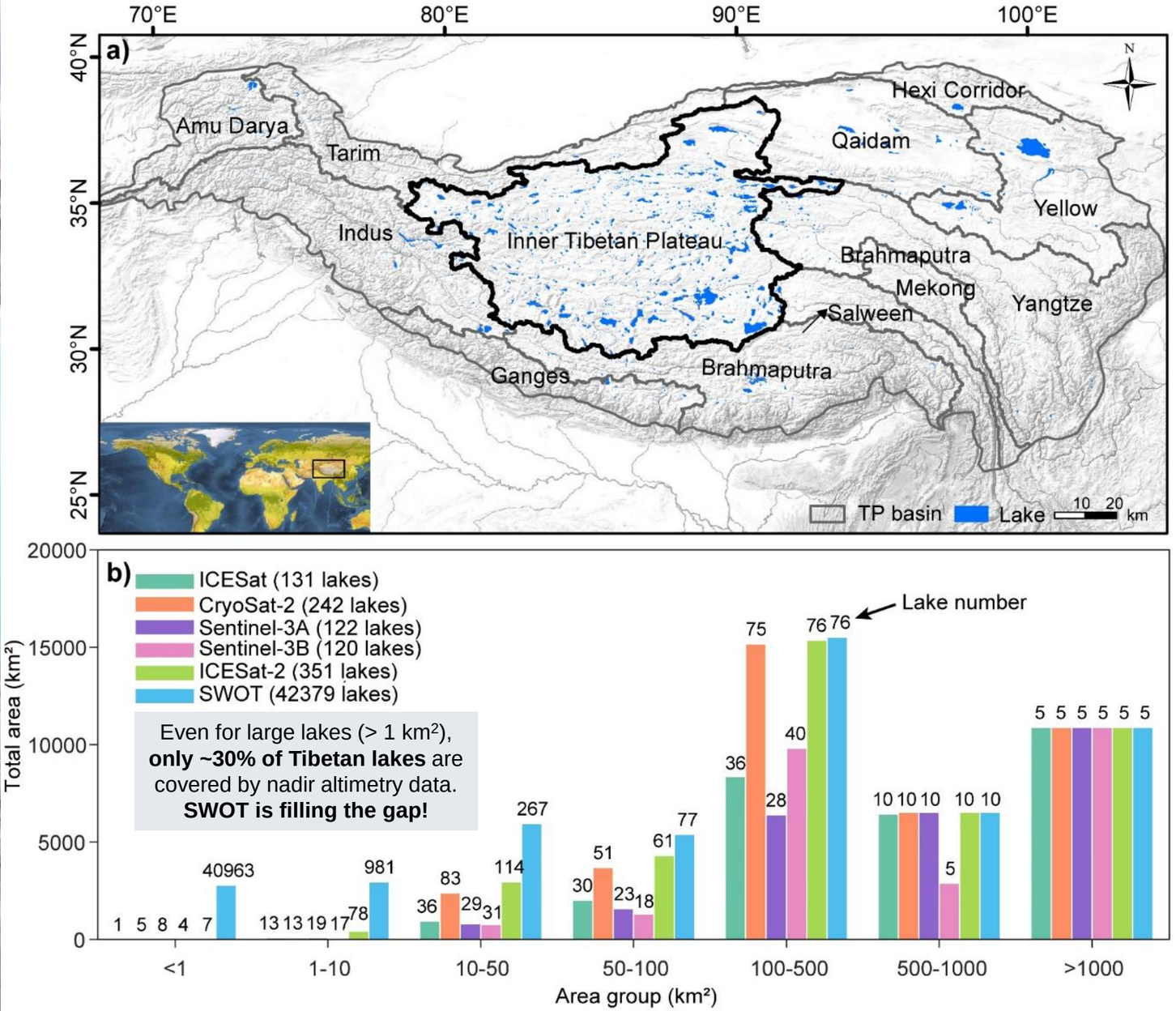


Relationship was based on 100 realizations of the log-normal random distribution of the annual WSE variation estimated by Biancamaria et al. (2010, doi:10.1109/JSTARS.2009.2034614).

- **> 6.25 ha or (250 m • 250 m) area**: Expected to capture up to ~65% of the global lake storage variation
- **> 1 ha or (100 m • 100 m) area**: Expected to capture up to ~80% of the global lake storage variation



Lakes and reservoirs

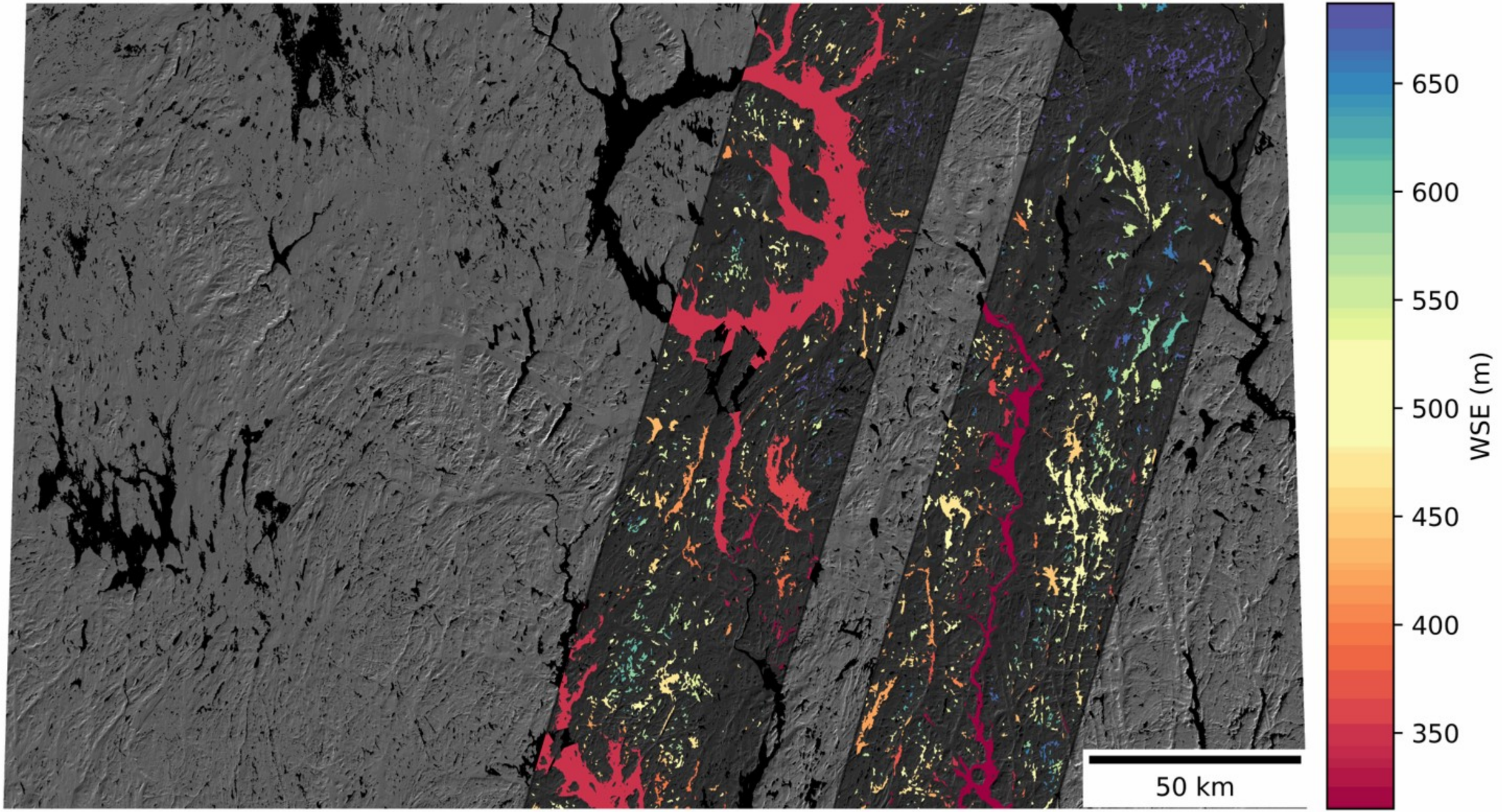


Xu et al. (2022, doi:10.1016/j.jhydrol.2021.127251)

Guoqing Zhang (ITP-CAS)

Pass:035_NA, Date:2024-01-26

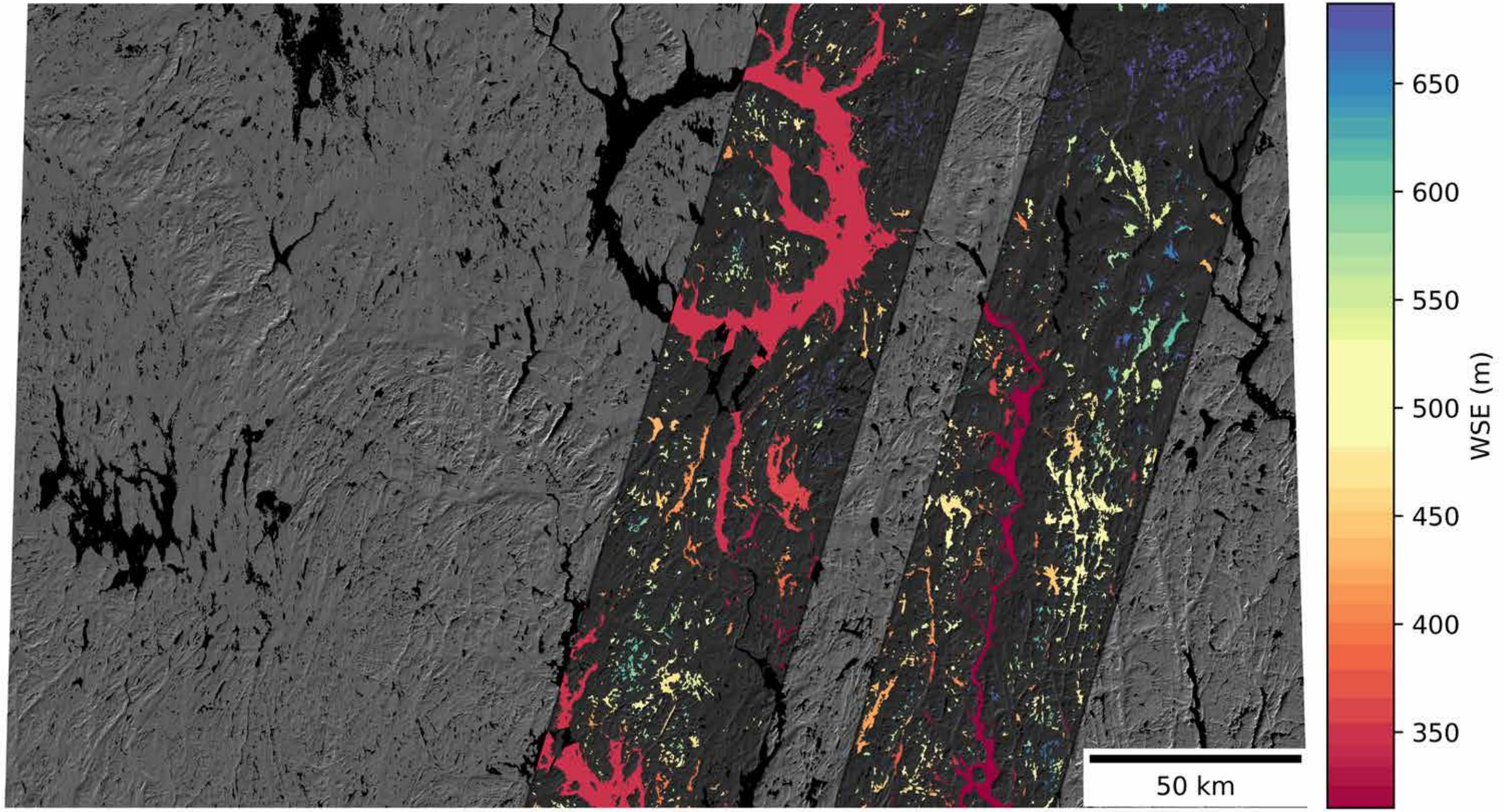
Lake Manicouagan region, Quebec



Katie McQuillan (Virginia Tech), et al.

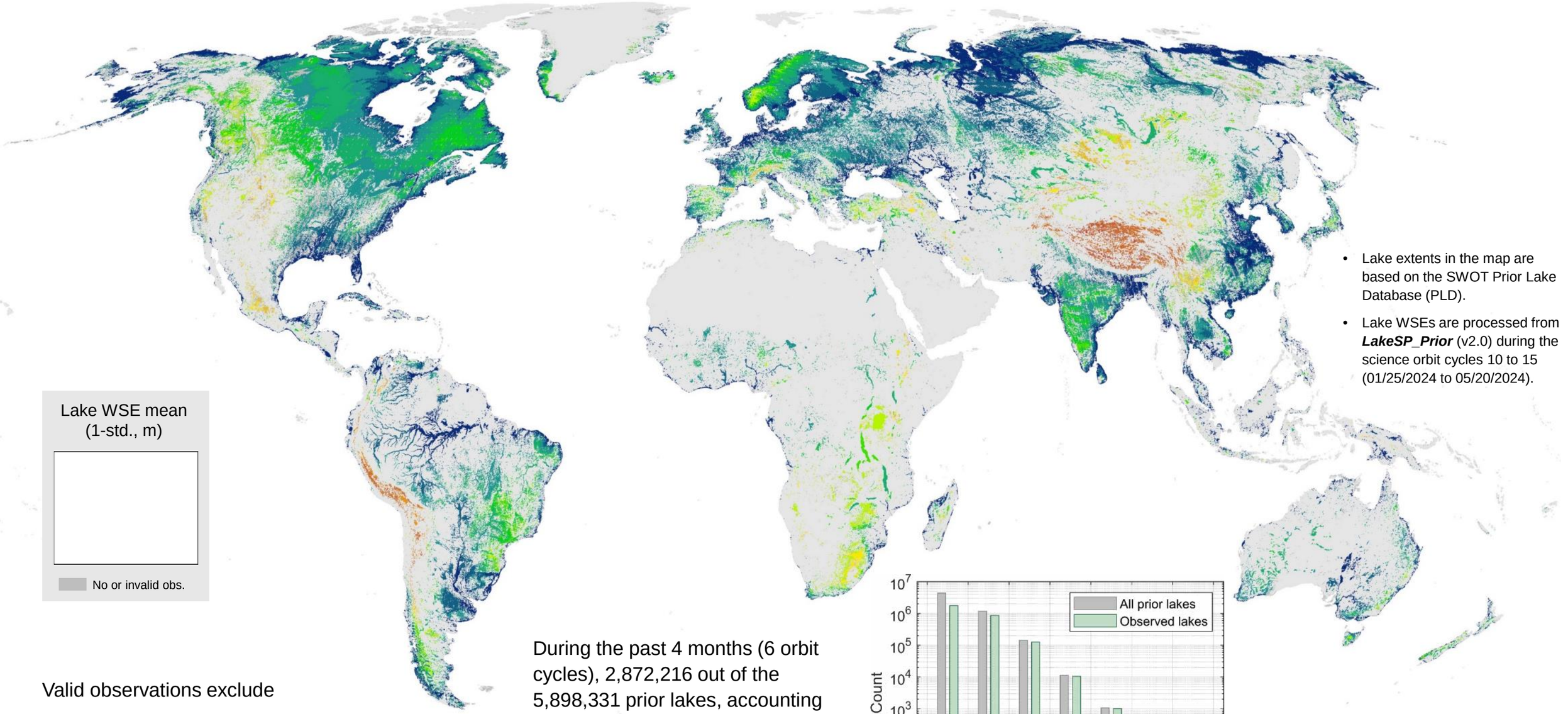
Pass:035_NA, Date:2024-01-26

Lake Manicouagan region, Quebec



Katie McQuillan (Virginia Tech), et al.

SWOT-measured **mean water surface elevation** on global lakes during January to May 2024

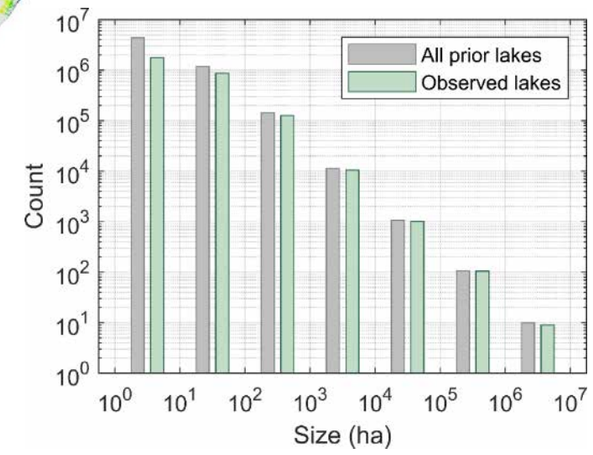


- Lake extents in the map are based on the SWOT Prior Lake Database (PLD).
- Lake WSEs are processed from ***LakeSP_Prior*** (v2.0) during the science orbit cycles 10 to 15 (01/25/2024 to 05/20/2024).

Valid observations exclude

1) statistical outliers, and
2) off-nominal measurements.

During the past 4 months (6 orbit cycles), 2,872,216 out of the 5,898,331 prior lakes, accounting for **89% of the global lake area** with a minimum size of 1 ha, were observed with at least one valid measurement by SWOT.



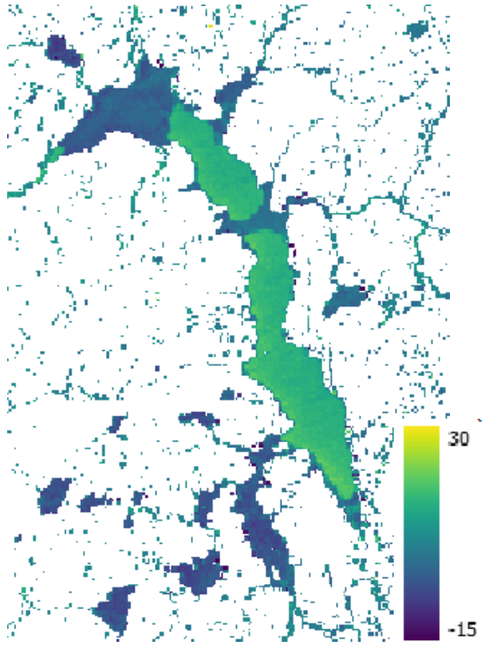
Jida Wang (U of Illinois), et al.

Lake Ice: SWOT shows potential for observing lakes under thin/low ice cover.

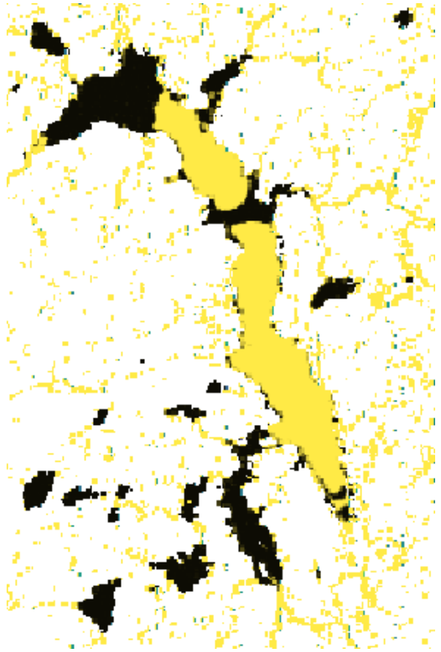
PLD lake ID :7251005983,
January 2nd, 2024

Sentinel-2

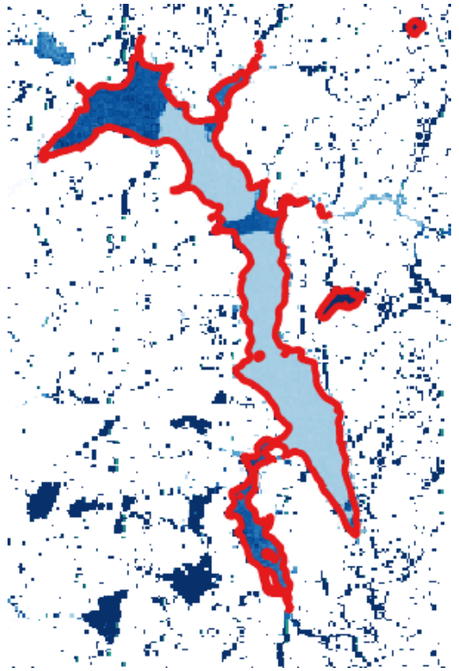
Sig0 (dB)



Darkwater



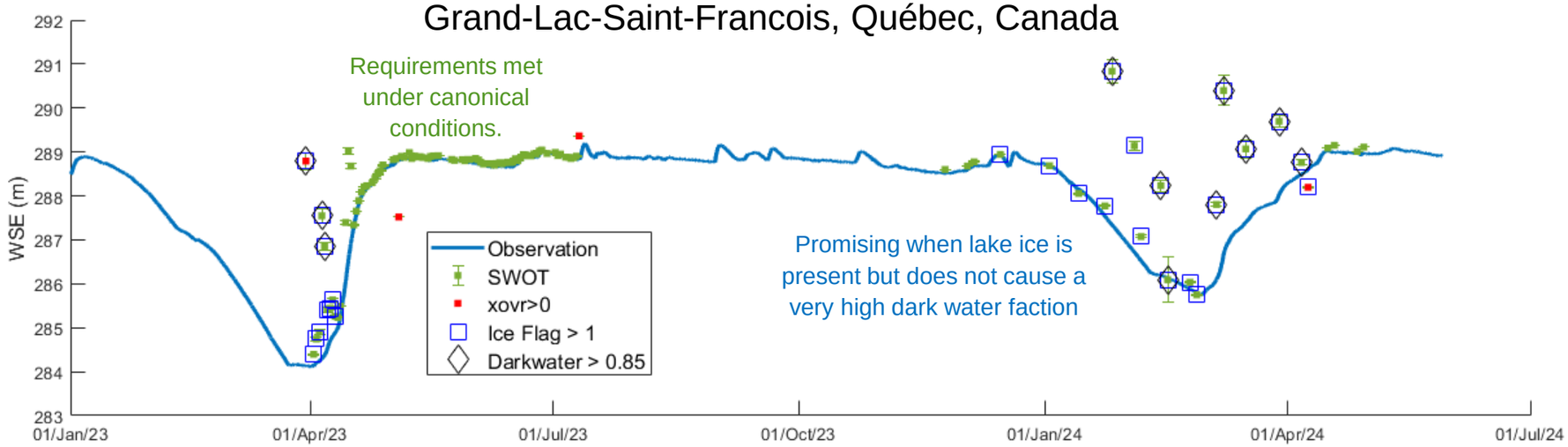
LakeSP_obs



Dark water : 39.6 %
WSE = 288.68 m
WSE_std = 0.27 m
Area_detec = 29.55 km2
Area_total = 48.95 km2

WSE (m)

Grand-Lac-Saint-Francois, Québec, Canada



Mélanie Trudel (U Sherbrook), Sylvain Biancamaria (CNES), et al.

A first look at global **lake level changes** from SWOT (January to May 2024)

Large hydropower reservoirs in Canada

Ubiquitous reservoirs across the Great Plains and Eastern US

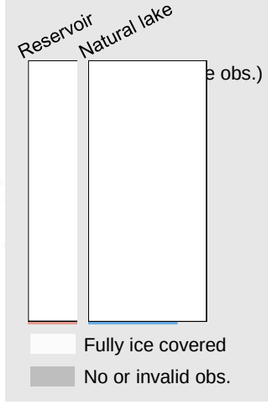
Cascade reservoirs on Volga River

Three Gorges Reservoir

Irrigation reservoirs across India

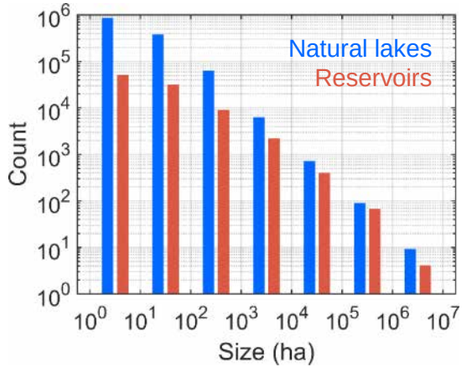
Reservoirs across Ceará and Cerado regions, Brazil

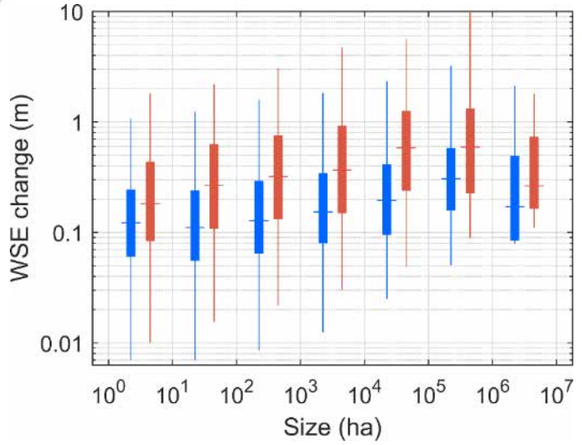
Lake WSE change (1-std., m)



Observations flagged as possible **full lake ice cover** were removed.

- Changes in **natural lakes** and **reservoirs** are contrasted.
- Nearly 160,000 reservoirs, including controlled lakes, are identified using GeoDAR v2.0 .

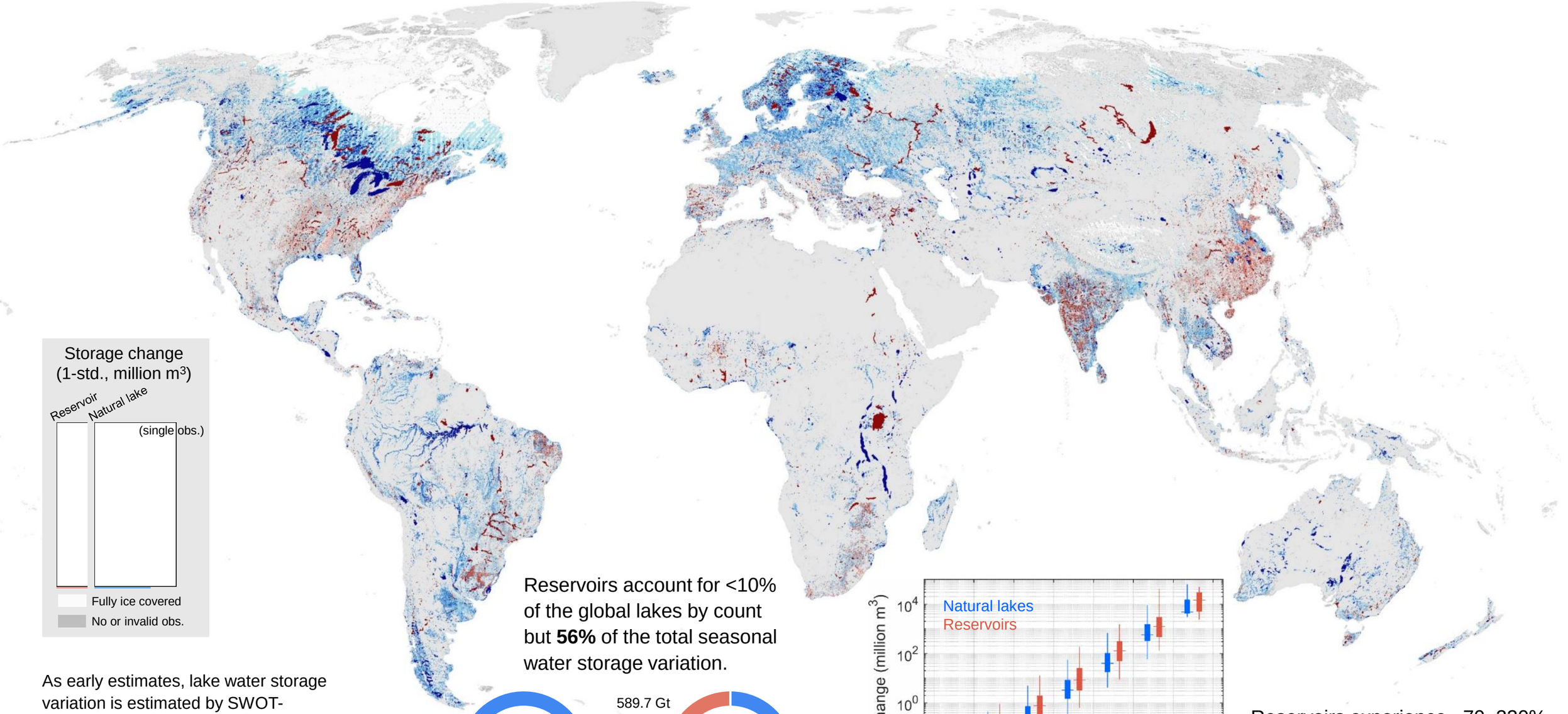




Reservoirs account for <10% of the global lakes by count but show **greater intra-annual water level variations** (0.18–0.59 m, or 1.5–3.0 times of natural lake variations).

Jida Wang (U of Illinois), et al.

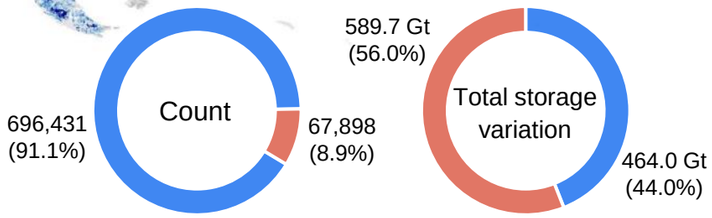
A first look at global **lake storage changes** from SWOT (January to May 2024)



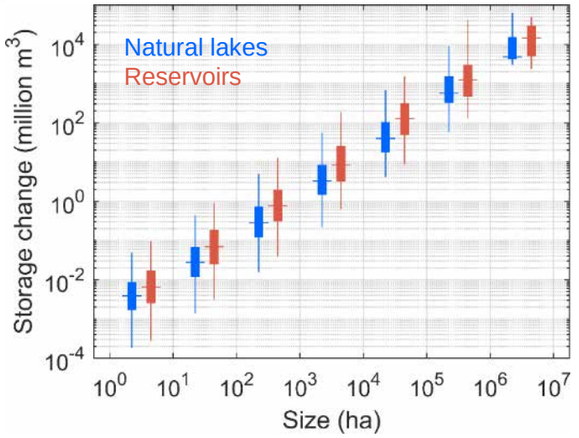
As early estimates, lake water storage variation is estimated by SWOT-measured WSE variation multiplied by the static prior lake area.

More accurate, realistic results will become available with the accumulation of SWOT data.

Reservoirs account for <10% of the global lakes by count but **56%** of the total seasonal water storage variation.

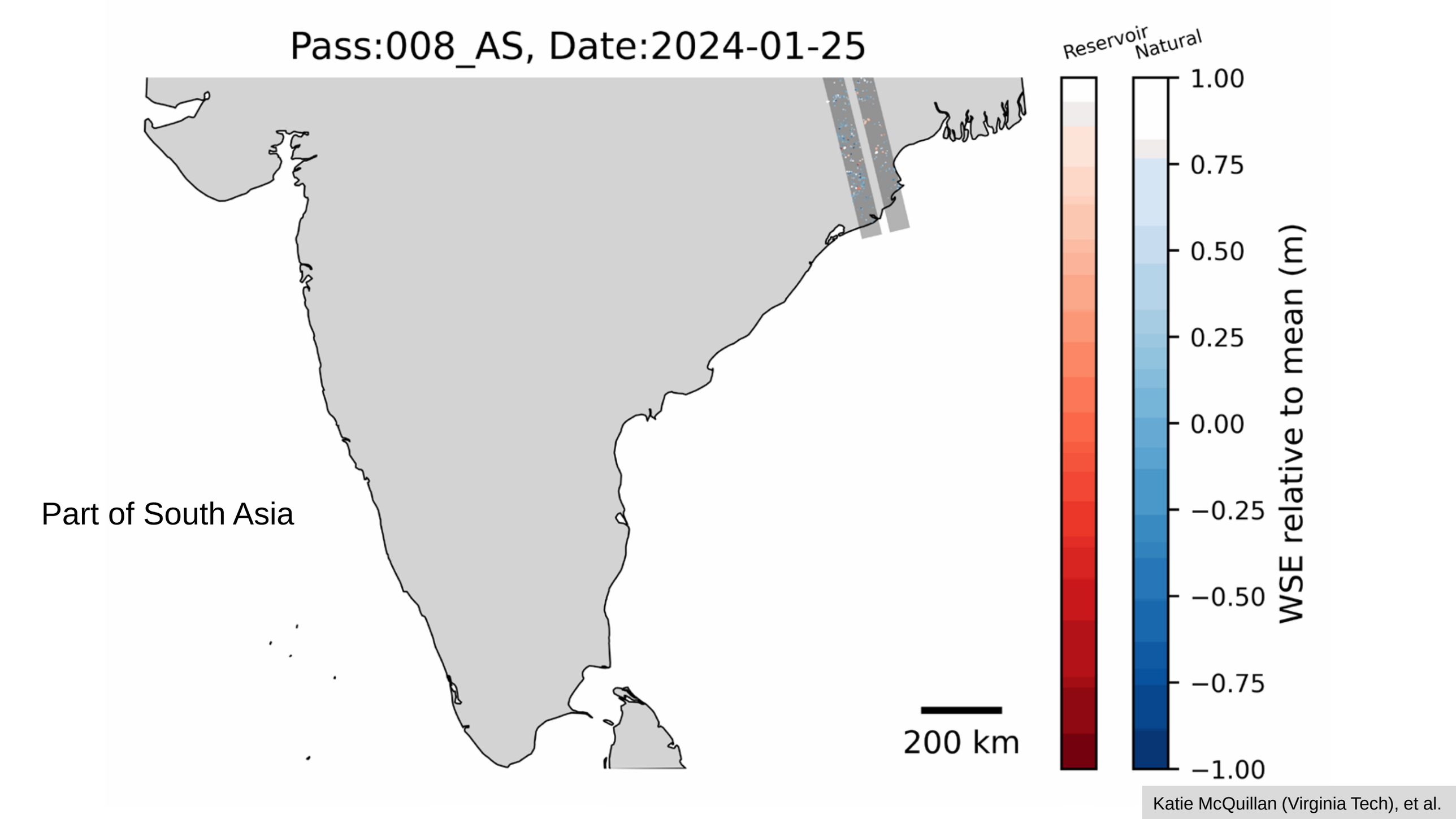


Lakes with only one measurement are excluded from change statistics.



Reservoirs experience ~70–220% **more seasonal storage variation** than natural lakes due to direct human water management.

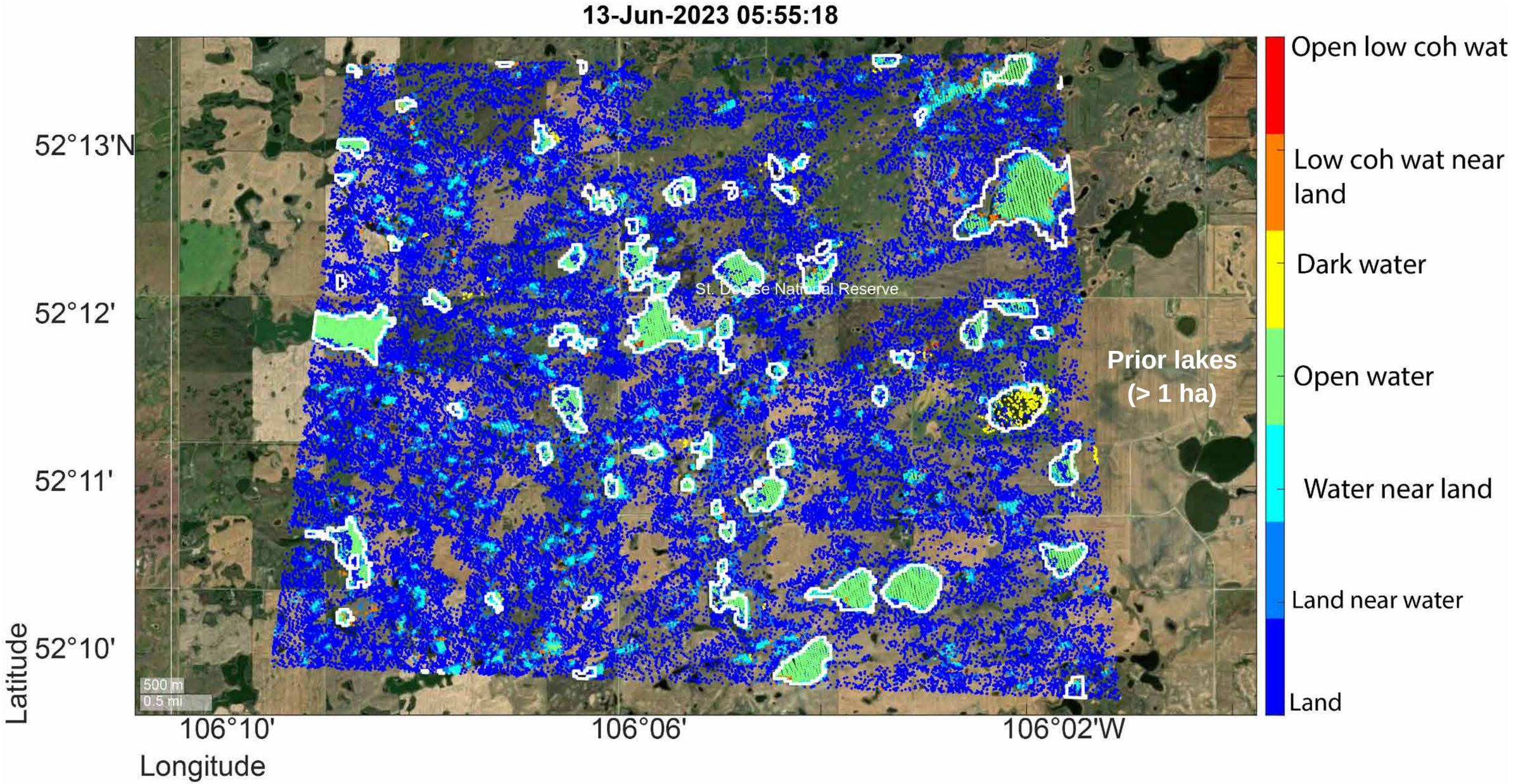
Jida Wang (U of Illinois), et al.



Part of South Asia

Katie McQuillan (Virginia Tech), et al.

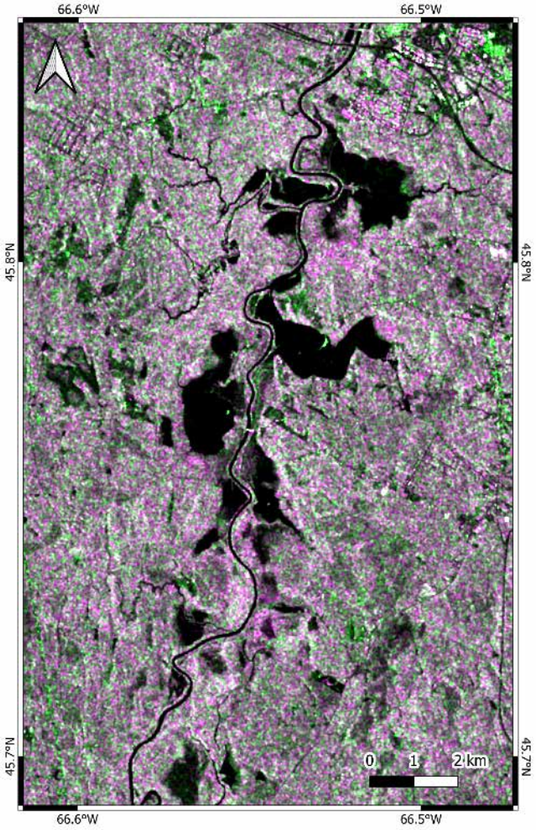
SWOT is able to resolve small prairie potholes.



Sonam Sherpa (Brown University), et al.

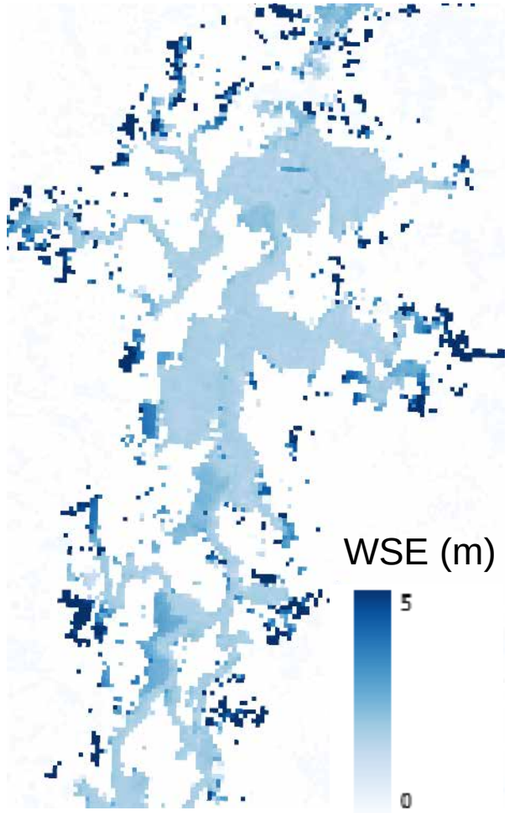
SWOT observed water levels and extents on inundated wetlands

Sentinel 1
November 29, 2023

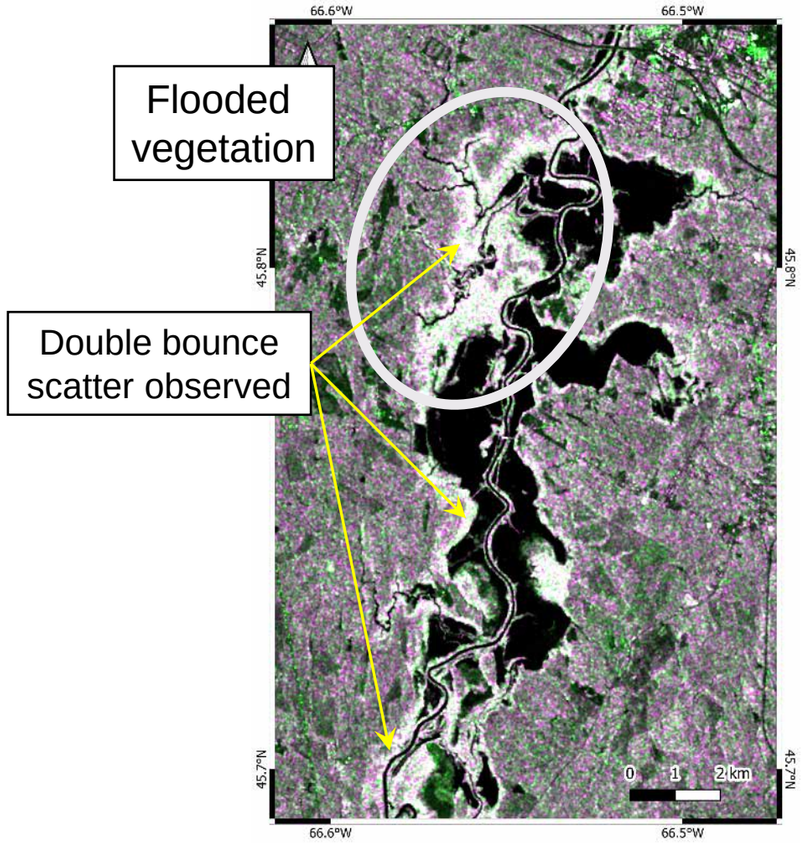


Sig0 VV : Red + Blue
Sig0 VH : Green

SWOT L2_HR_Raster
December 1st, 2023

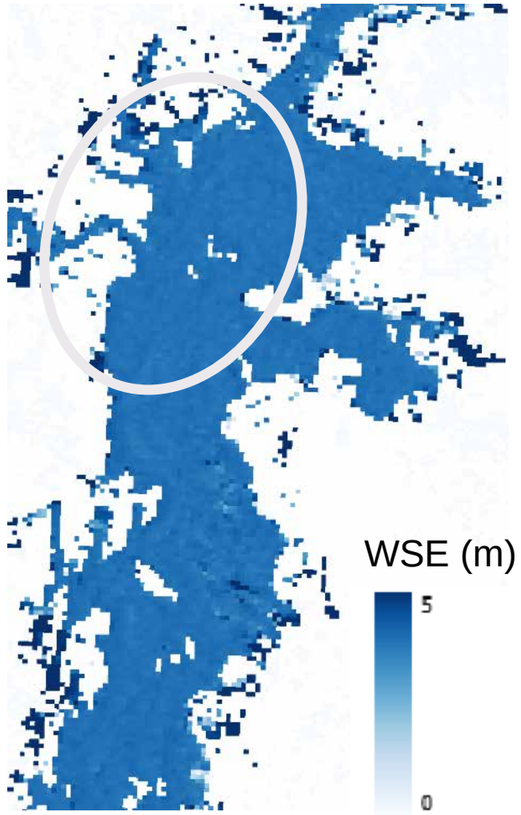


Sentinel 1
December 23, 2023



Sig0 VV : Red + Blue
Sig0 VH : Green

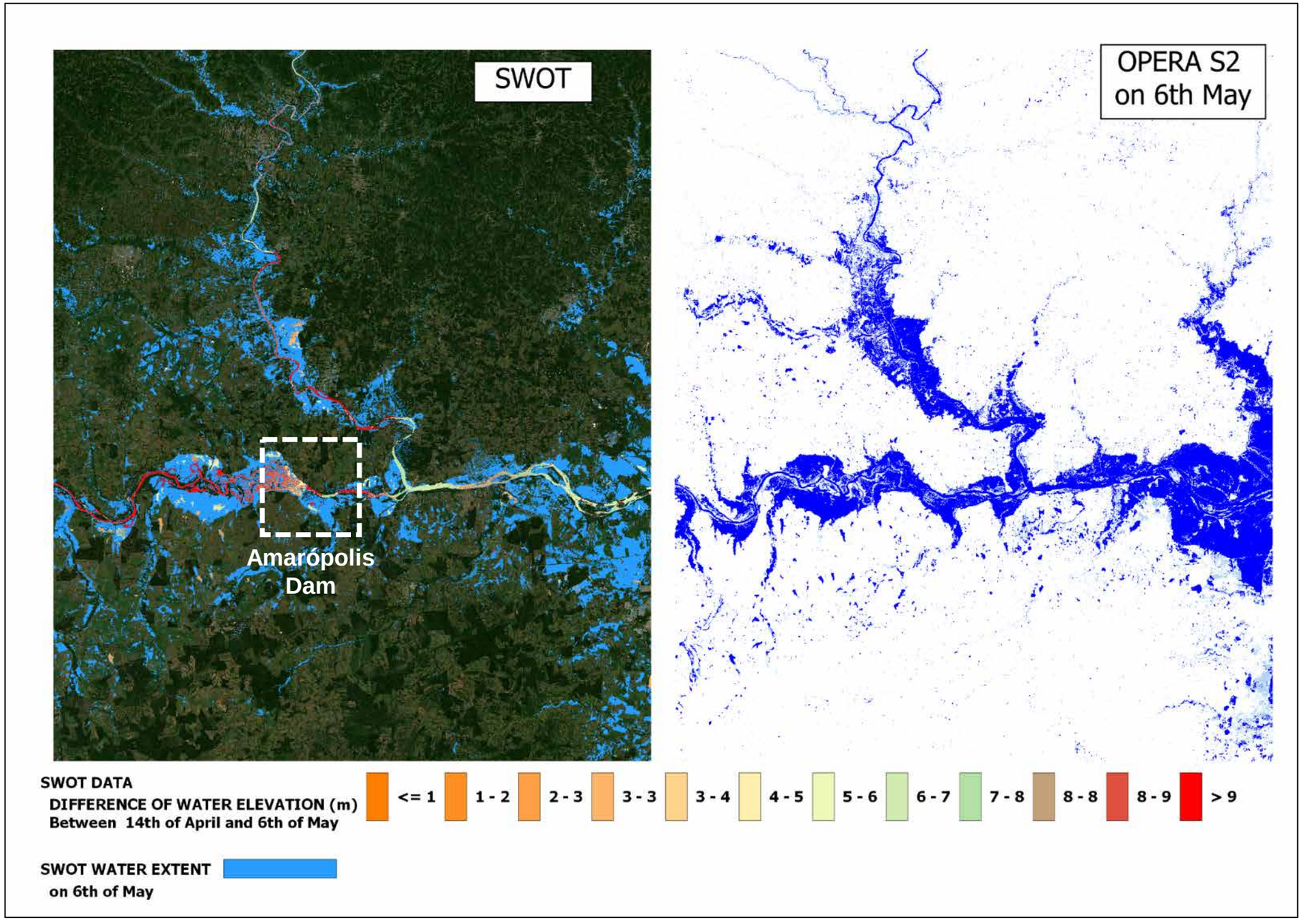
SWOT L2_HR_Raster
December 21st, 2023



Oromocto watershed, New Brunswick, Canada

Mélanie Trudel (U Sherbrook), Sylvain Biancamaria (CNES), et al.

Extensive floods in southern Brazil observed by SWOT



SWOT observed dam overflow during the flood

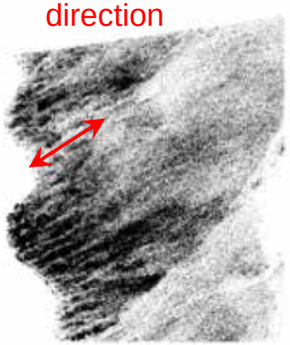
SWOT WSE (meters)

1 - 2 | 2 - 3 | 3 - 4 | 4 - 5 | 5 - 6 | 6 - 7 | 7 - 8 | 8 - 9 | 9 - 10 | 10 - 11

Daniel Medeiros Moreira (CPRM) and Fabrice Papa (LEGOS)

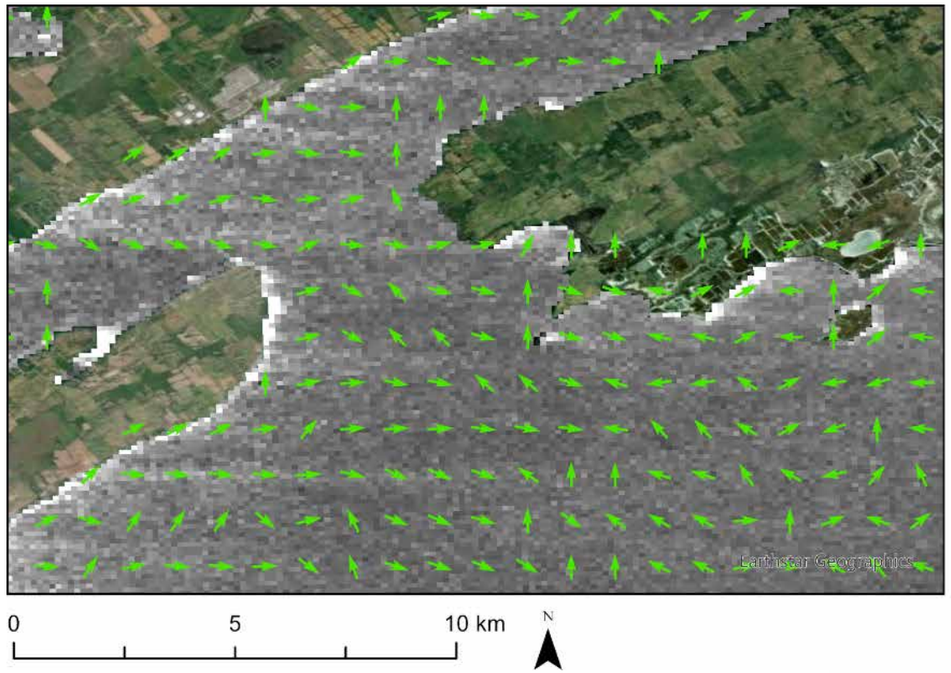
SWOT data shows promise for estimating **wind characteristics** over lakes

Buoy wind direction



SWOT backscatter was used to estimate wind **direction** on lake surface using , with a median MAE of 38° validated with 8 buoy anemometer stations in US and Europe.

SWOT-estimated wind direction on Lake Ontario



Estimated wind direction

Sig0

30

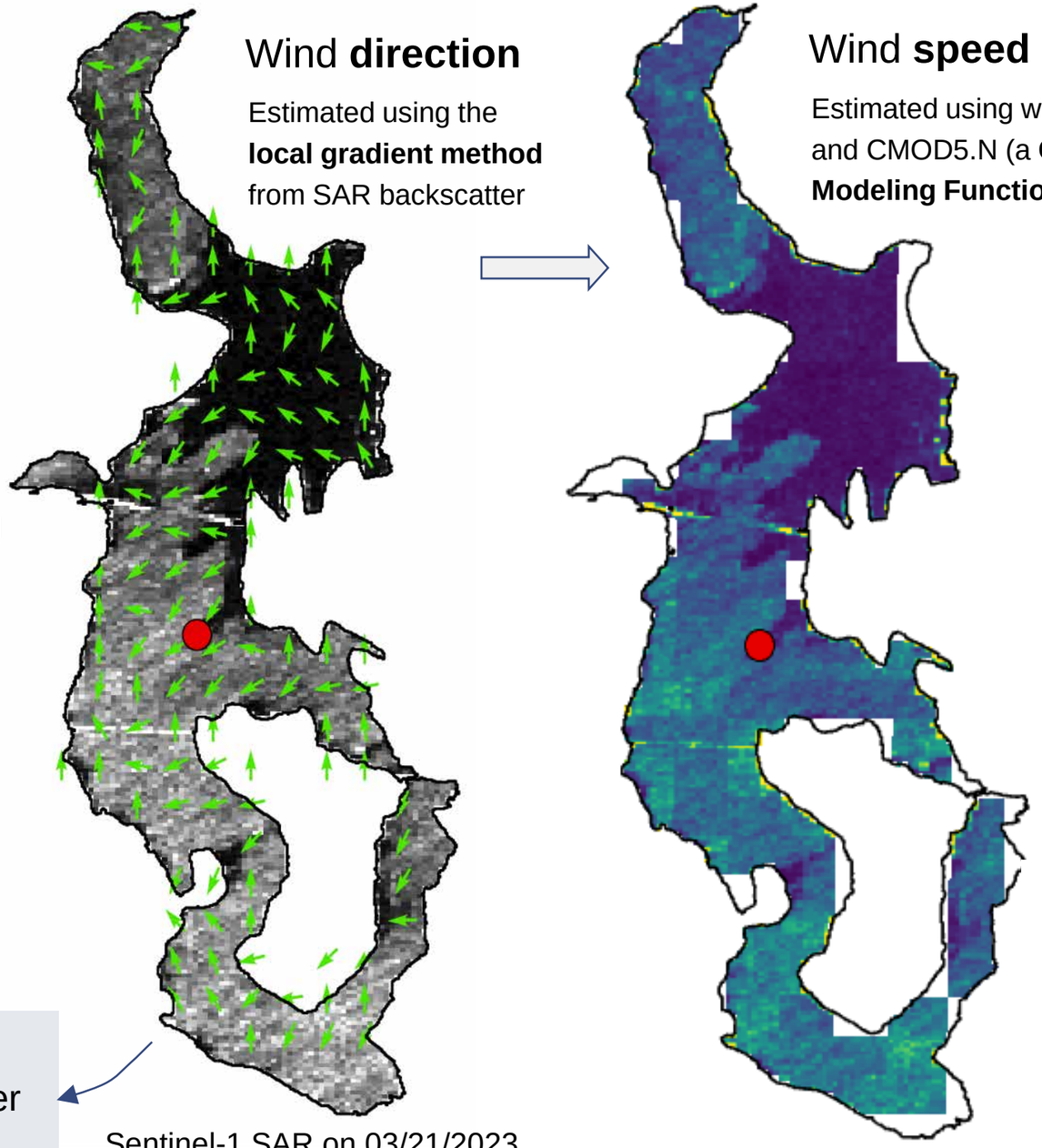
-2

Wind **direction**

Estimated using the **local gradient method** from SAR backscatter

Wind **speed**

Estimated using wind direction and CMOD5.N (a **Geophysical Modeling Function**)



Wind speed (m/s)

10

0.5

Sentinel-1 SAR on 03/21/2023, Lake Washington

SAR-derived wind speeds overperformance ERA5 wind speed over lakes, validated using 39 overwater buoy observations in North America and Europe.

Katie McQuillan (Virginia Tech), et al.

Potential for a SWOT-based **lake surface evaporation** product

Texas Water Development Board | DRI Desert Research Institute

Search places

TWDB Reservoir Evaporation

Time Step: daily

Select Reservoir: LAKE TRAVIS

Start Year: 2022

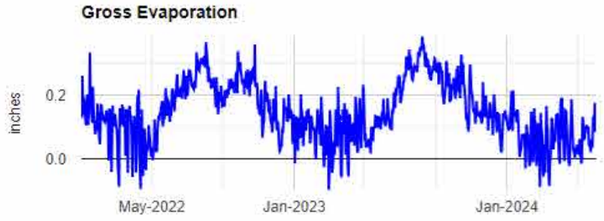
End Year: 2024

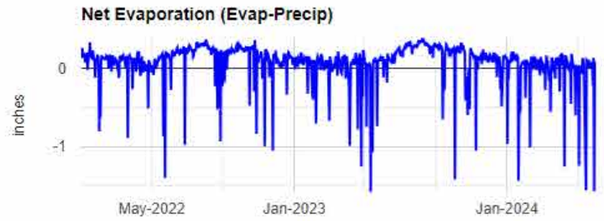
Historical Evaporation Rate (in/year)

50 65 80

Show Gross Evap | Show Net Evap | Show Evap Vol | Show Area | Show Precip

There is a delay in the climate dataset release, please check in at a later time. Lag is typically 2 days.





Penman-Monteith Equation

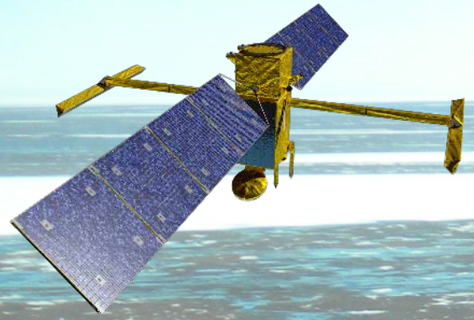
$$\frac{(\quad)}{(\quad)}$$

: slope of saturation vapor pressure curve
: net radiation
: change in the lake heat storage
: latent heat of vapourization
: psychrometric constant
: saturated vapor pressure
: actual vapor pressure
: wind speed over lake surface

https://dri-apps.earthengine.app/view/twdb-reservoir-evaporation

Zhao et al. (2024, doi:10.1029/2023WR036181)

Huilin Gao (Texas A&M)



SWOT
SURFACE WATER & OCEAN TOPOGRAPHY

Summary and Outlook

- SWOT is observing sub-monthly dynamics of 6 million or more lakes and reservoirs in the world.
- It's filling up the gap of traditional nadir altimeters for medium-size and small lakes – which are often dynamic and play a less-understood role for both water and carbon cycles.
- Despite a period of only 4 months (Science Orbit Cycles 10-15), as many as ~3 million lakes, accounting for nearly 90% of the global lake area, were observed by SWOT with at least one valid measurement.
- Observed known reservoirs, <10% of the global lakes by count, show greater intra-annual water level and storage variations than natural lakes, suggesting SWOT's capabilities to decipher human water management.
- Early SWOT results show exciting capabilities for studying a wide spectrum of surface phenomenology:
  - Lake levels and extents under thin ice cover, suggesting potential for monitoring lake ice phenology.
  - Different types of water bodies smaller than the science goal (1 ha)
  - Riparian wetlands and inundated vegetation
  - Floods and related hazards such as dam overflow
  - Wind characteristics, leading to potential improvements of lake surface evaporation
  - Many yet to explore...