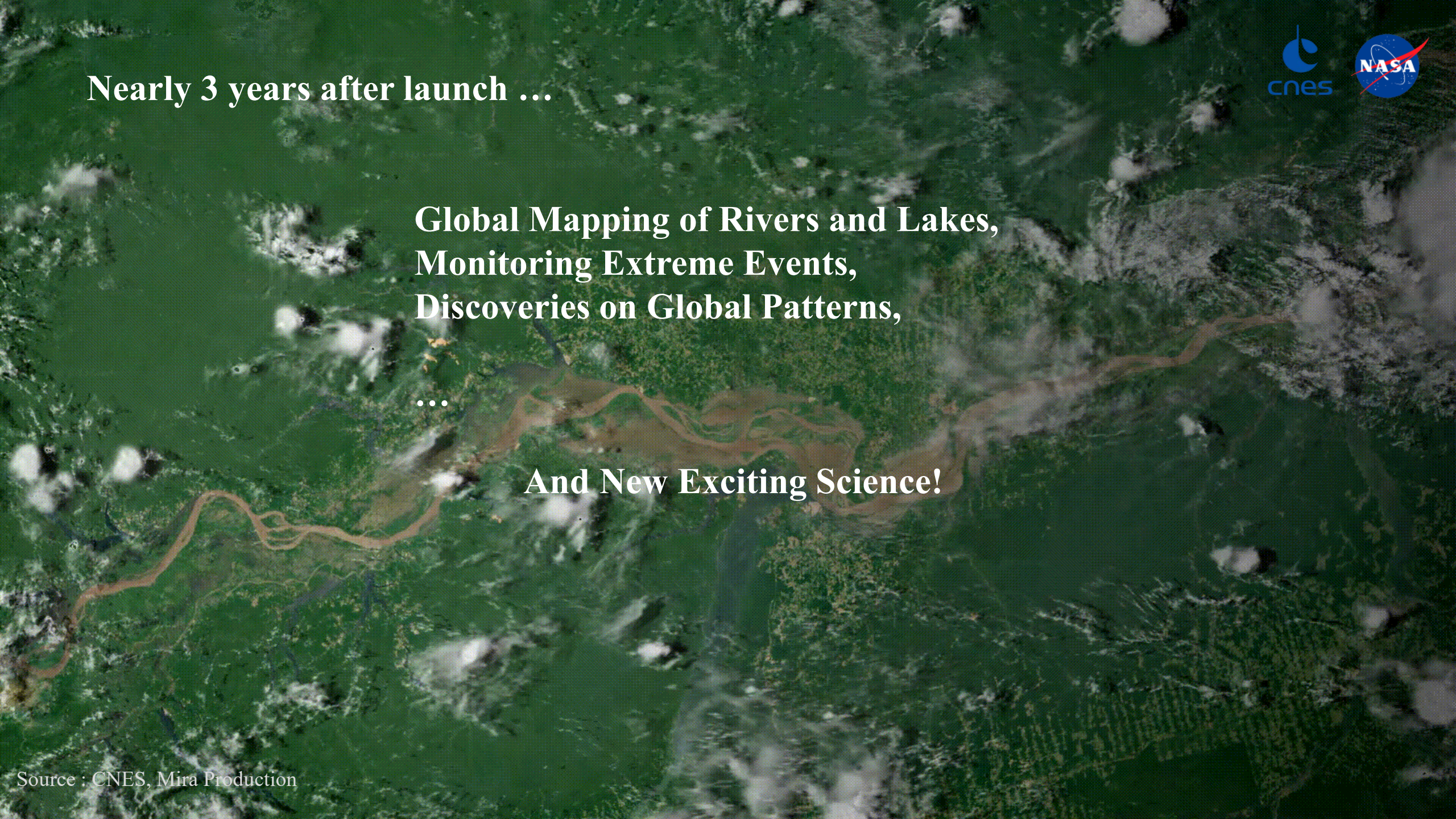
SWOT over Inland Water

Hind Oubanas & Tamlin Pavelsky
On behalf of the SWOT Science Team

Source : CNES, Mira Production



Nearly 3 years after launch …

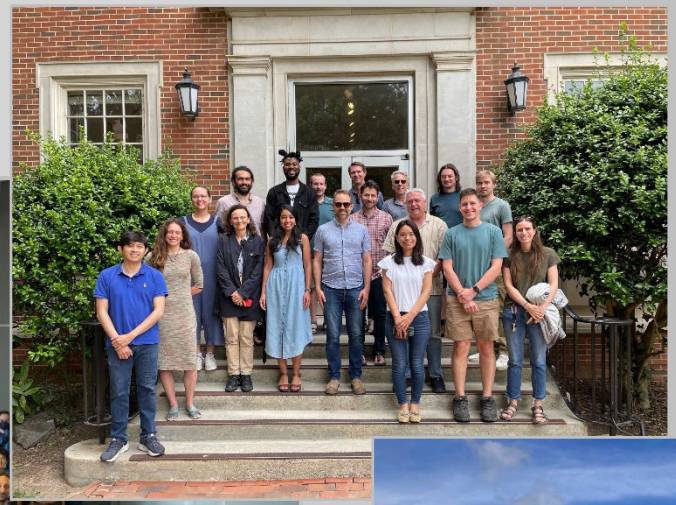
Global Mapping of Rivers and Lakes,
Monitoring Extreme Events,
Discoveries on Global Patterns,

…

And New Exciting Science!

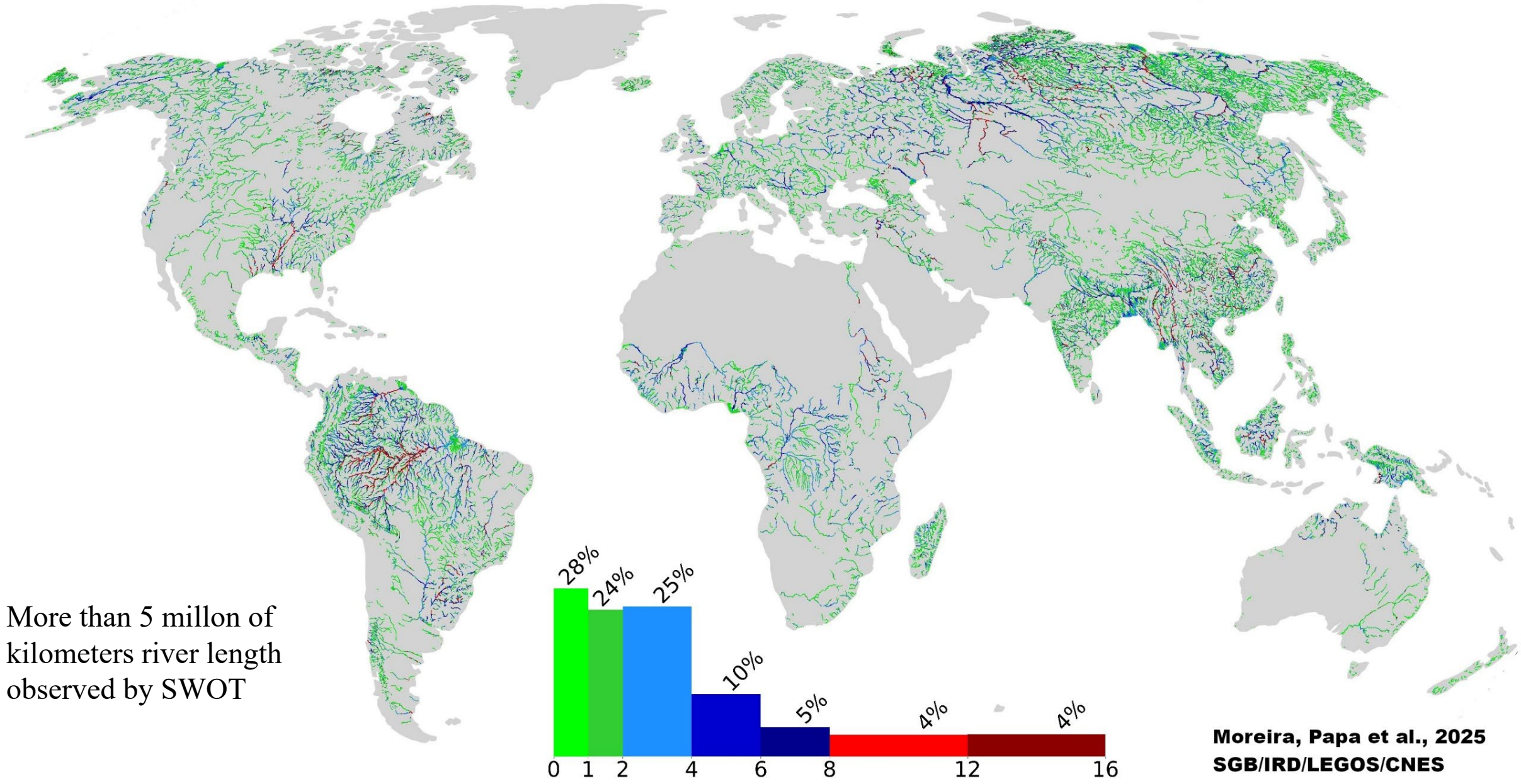
Source : CNES, Mira Production

SWOT is a Community



Decades-long working groups
Early career promising opportunities

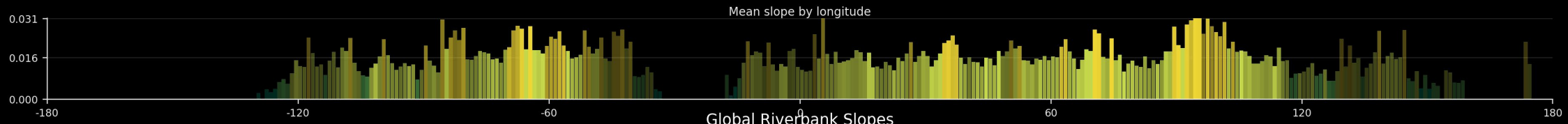
SWOT Maps Global River Water Amplitude

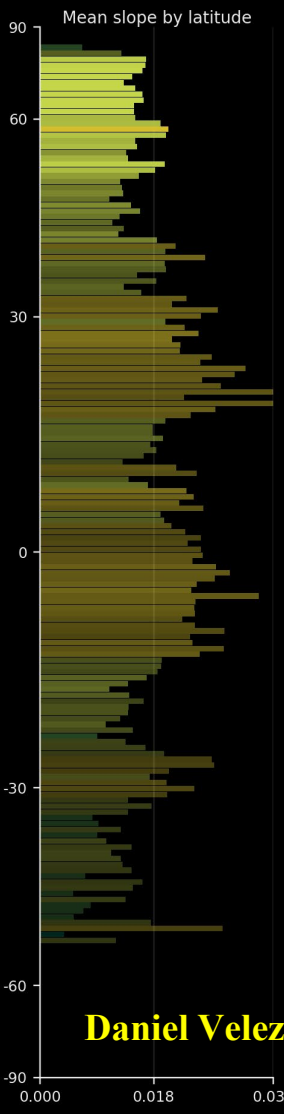


More than 5 millon of kilometers river length observed by SWOT

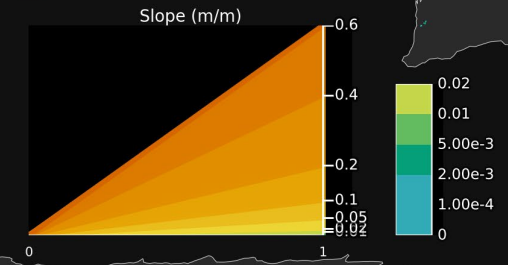
Moreira, Papa et al., 2025
SGB/IRD/LEGOS/CNES

SWOT Reveals Global Node-Scale Width-Stage Relationships





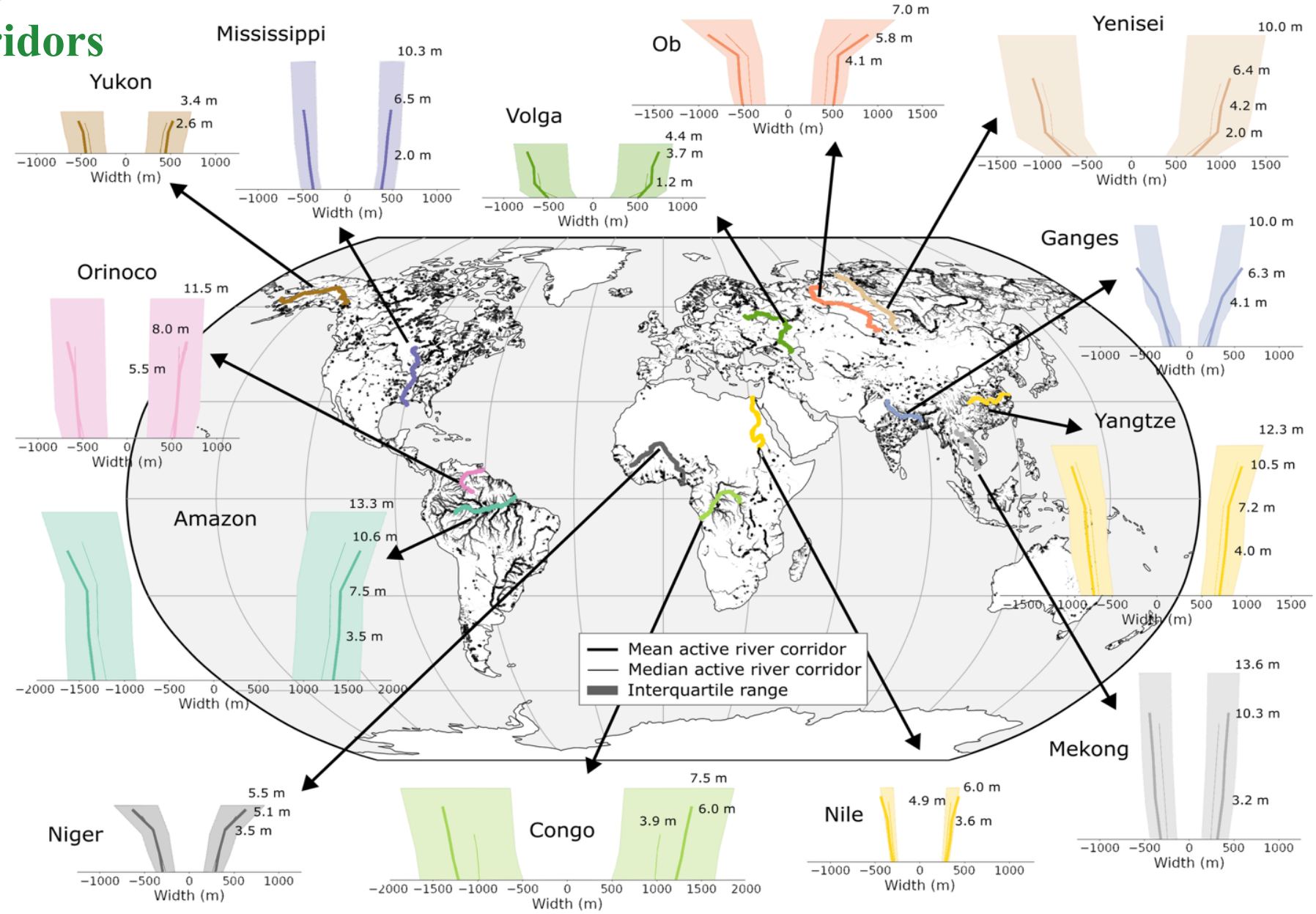
Global Riverbank Slopes



Daniel Velez, et al. In prep

SWOT Observes the Variability of River Corridors Globally

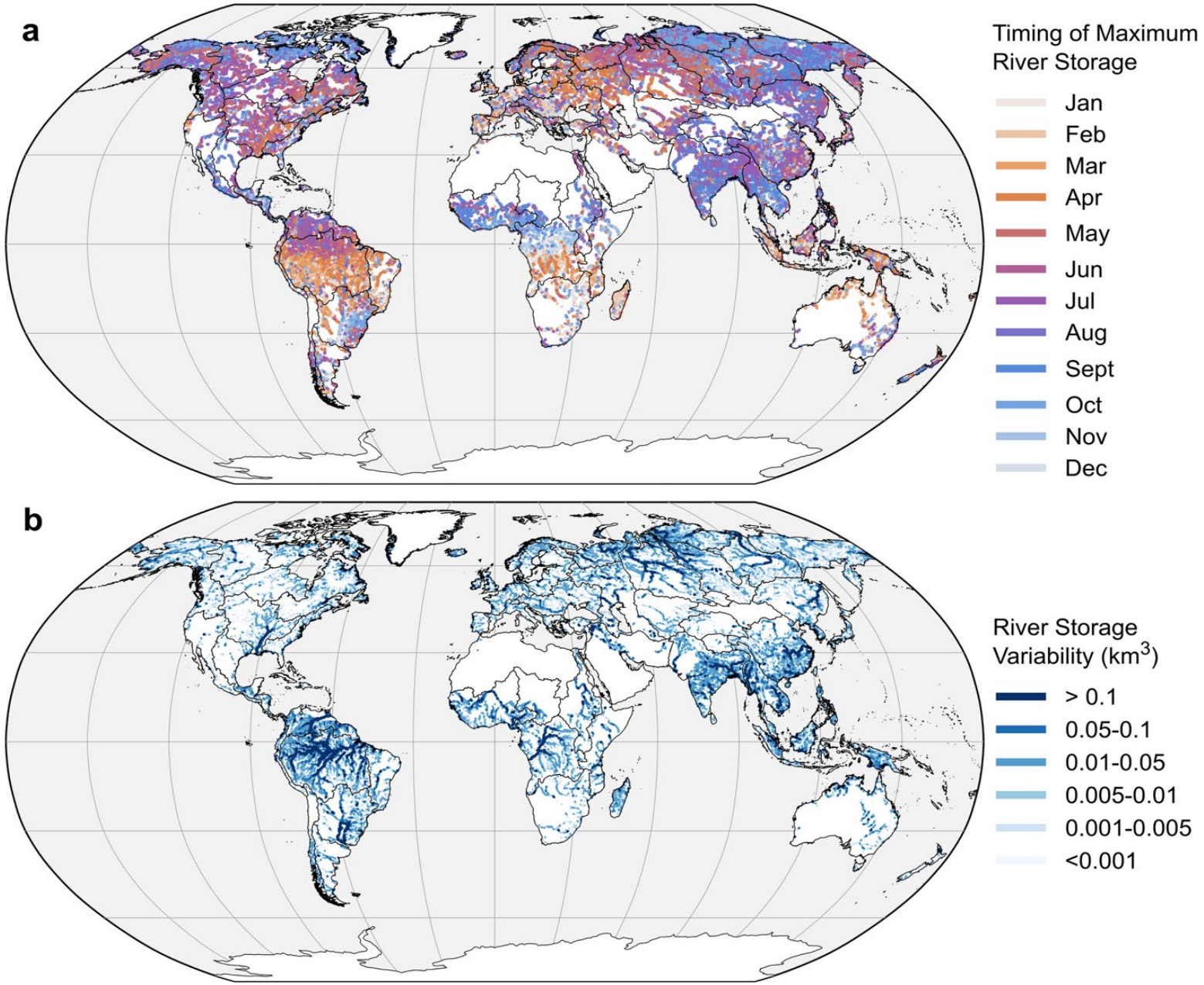
Shape of the active river corridors along major global rivers as observed by SWOT. The shapes result from one year of SWOT measurements between the lowest and highest observed water levels.



Wade, J., Cerbelaud, A., David, C., Durand, M., Frasson, R., Pavelsky, T., Oubanas, H. "Wide-Swath Altimetry Maps Bank Shapes and Storage Changes in Global Rivers". In review.

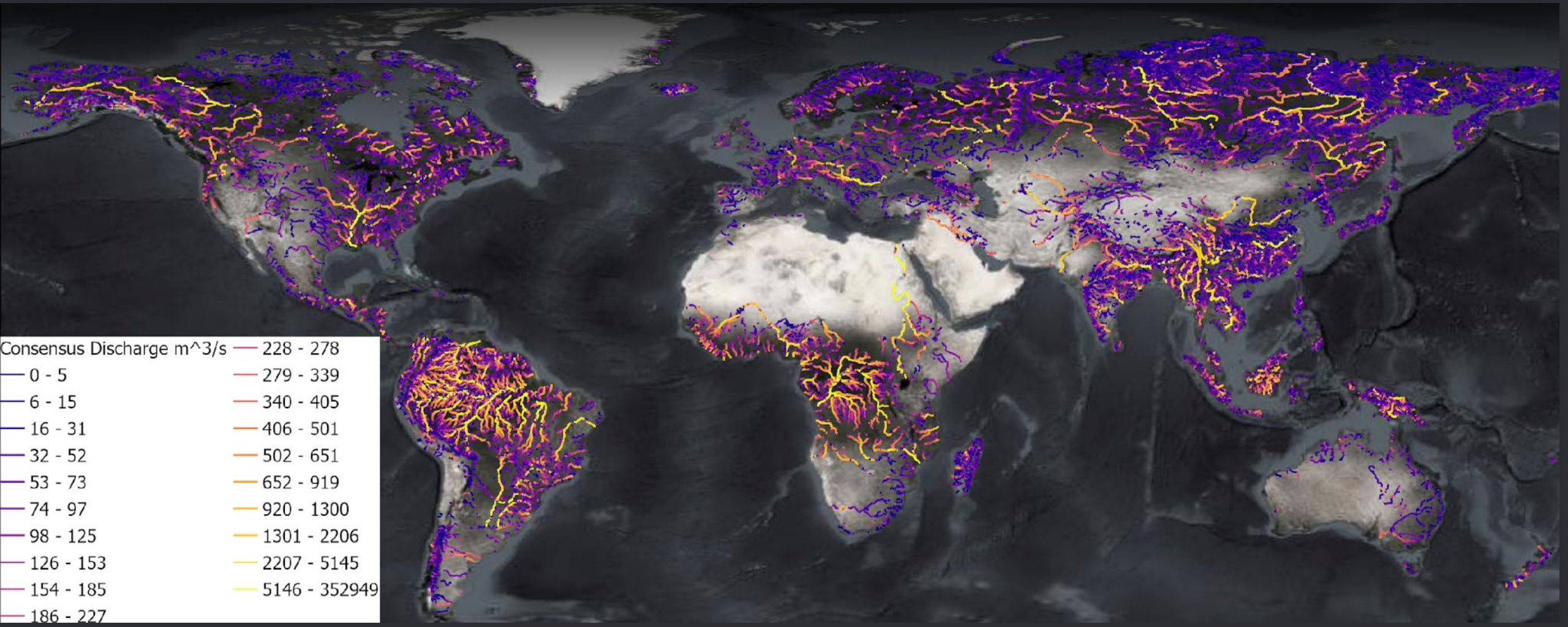
SWOT Observes the Variability of River Storage Globally

Global map of river storage variability observed by SWOT between October 2023 and September 2024. a, SWOT observed timing of the peak river storage anomaly . b, SWOT annual observed river storage variability .

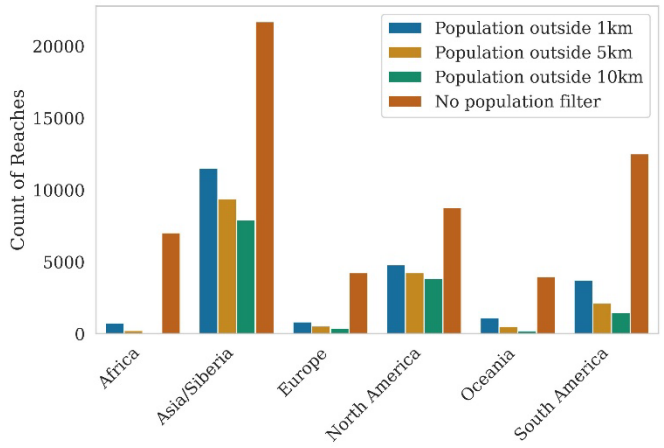


Wade, J., Cerbelaud, A., David, C., Durand, M., Frasson, R., Pavelsky, T., Oubanas, H. "Wide-Swath Altimetry Maps Bank Shapes and Storage Changes in Global Rivers". In review.

SWOT Estimates Global River Discharge



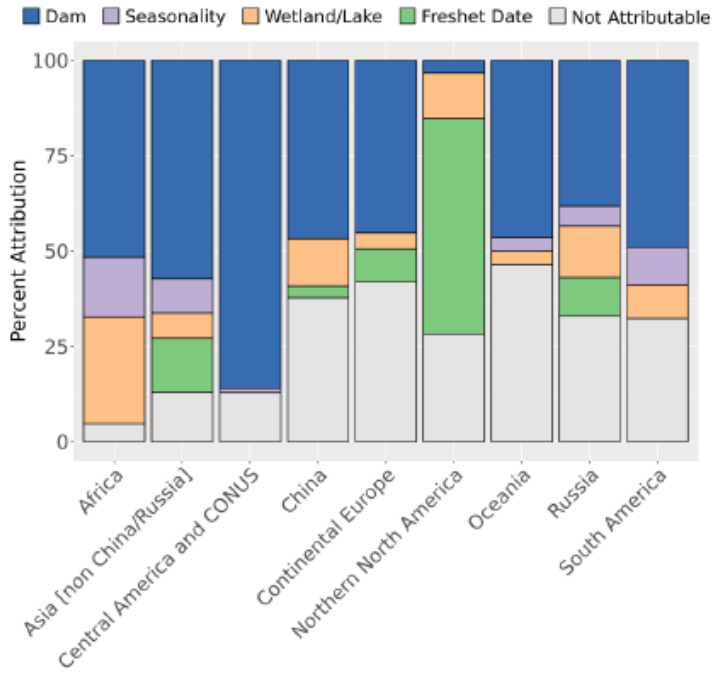
SWOT Reveals Baseline Hydropower Potential Globally

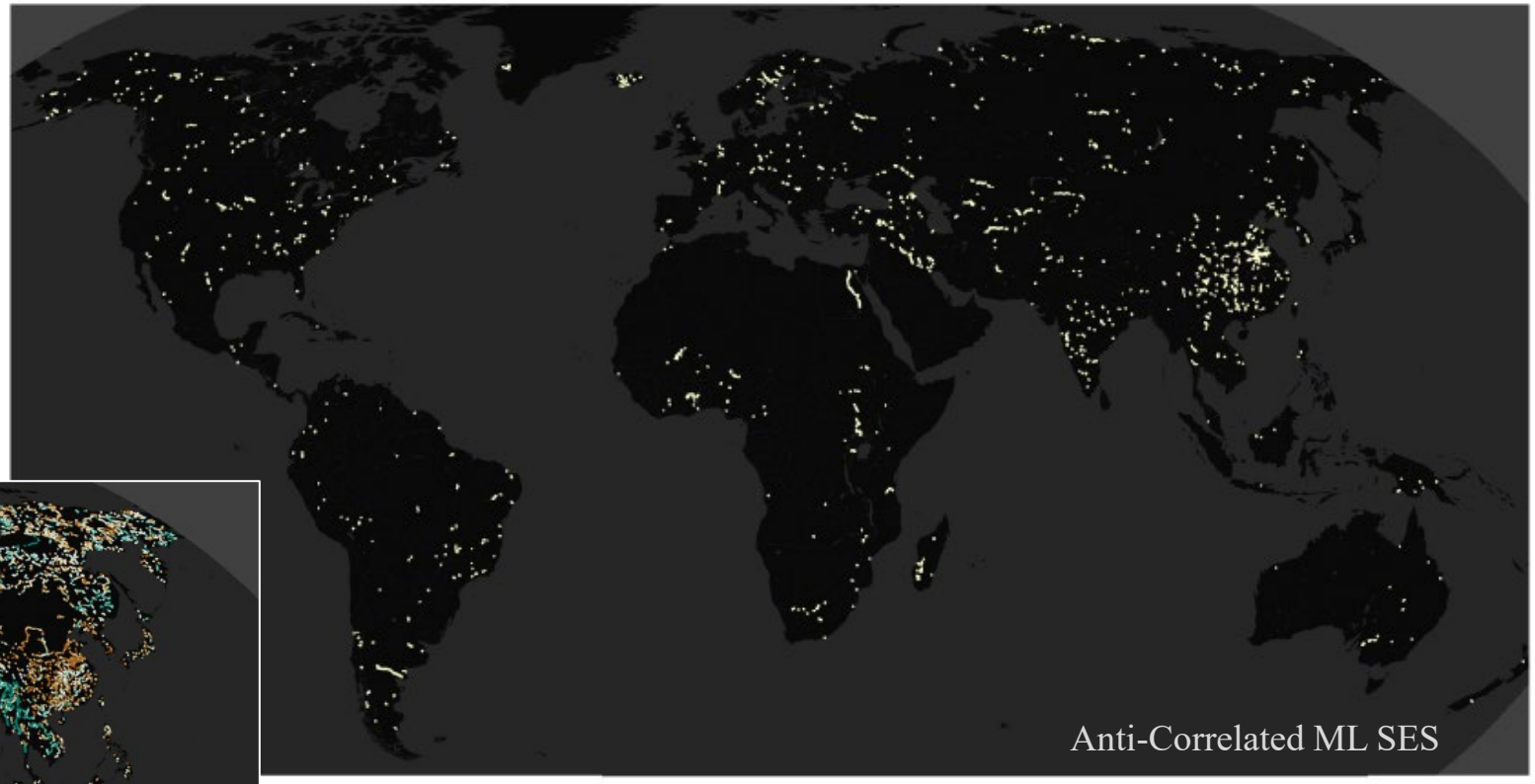


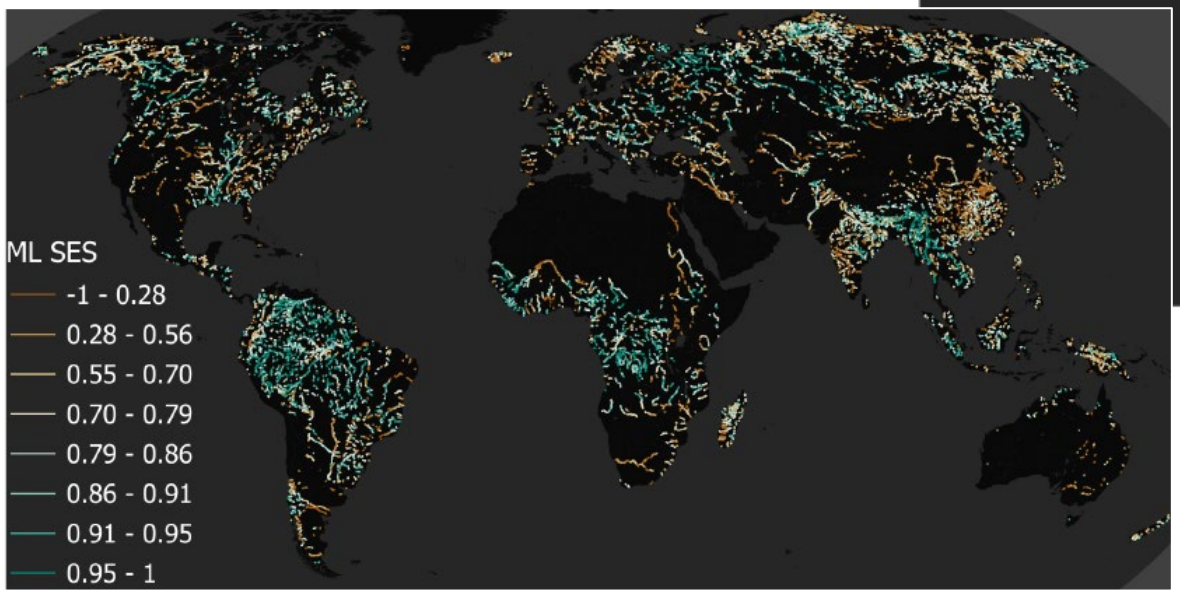
Identifying reaches for hydropower generation

Jonathan, Flores, et al. In prep

SWOT Reveals Strengths and Weakness of Global River Models



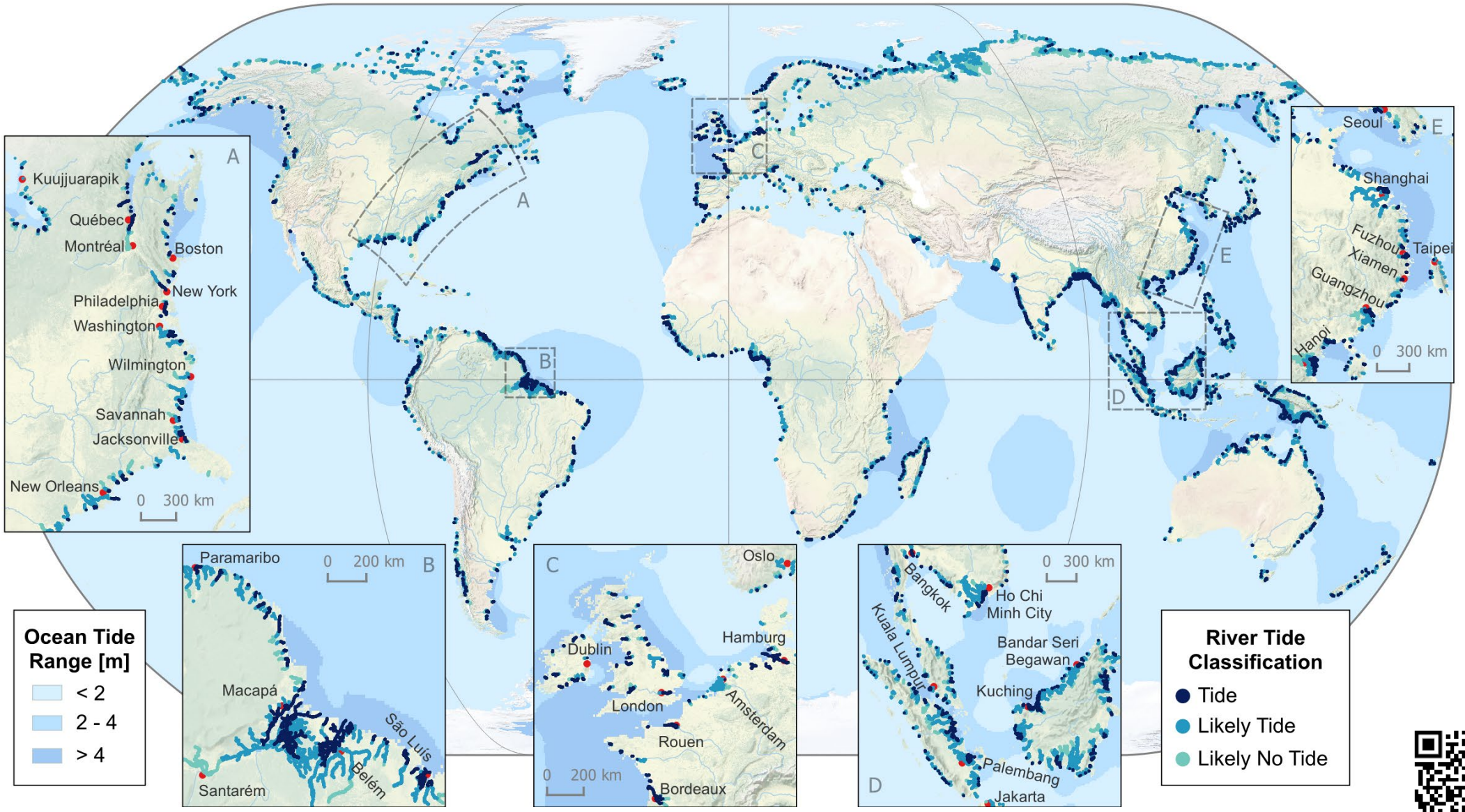




Direct indicator of model dynamic error and an indirect indicator of its bias, and thus these maps are a reflection of the state of globally modelled river knowledge.

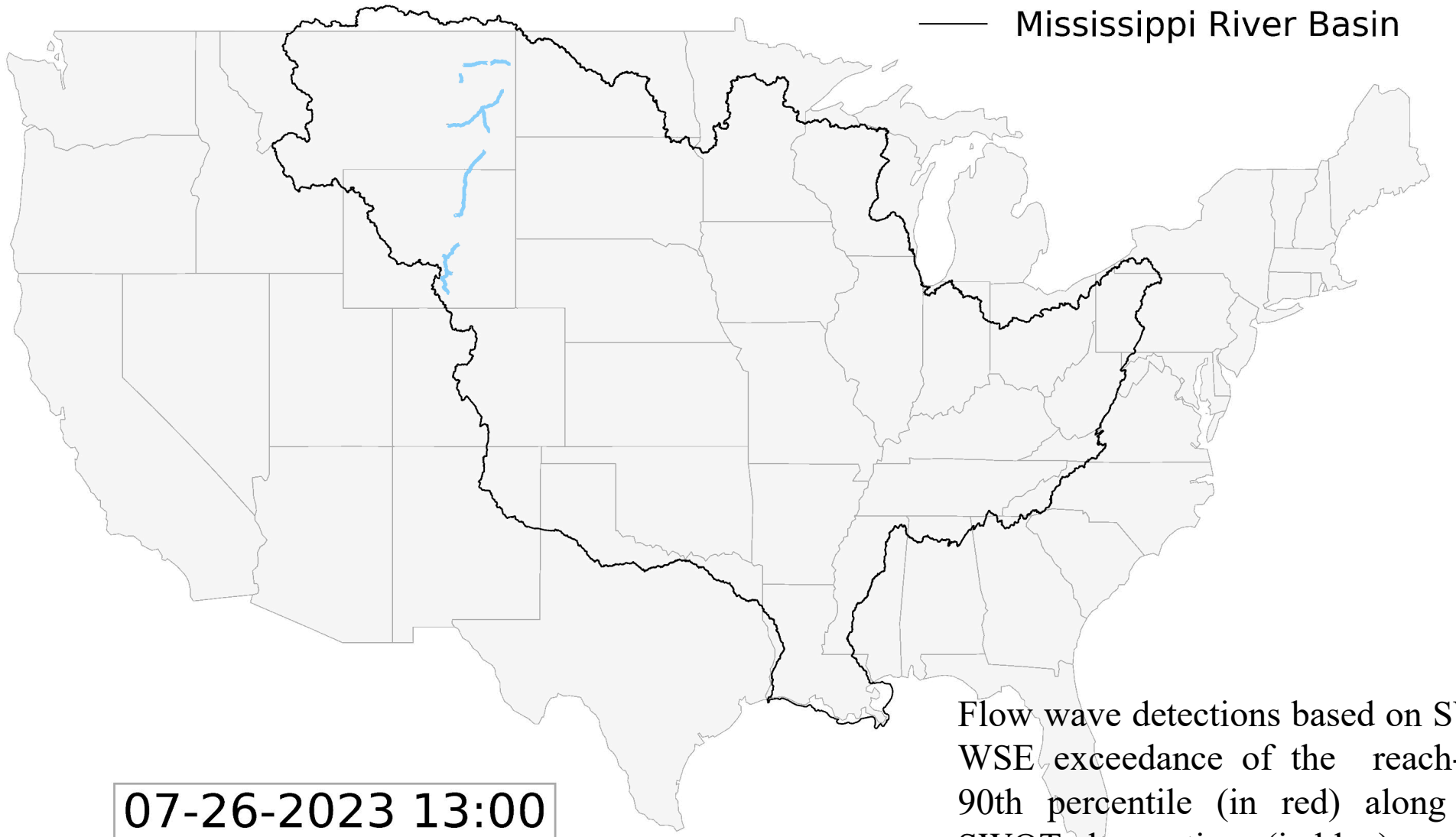
Gleason, C., Bates, P, et al. "Using the SWOT satellite to assess the strengths and weaknesses of global river models".

Tides in Rivers from SWOT



Hart-Davis M., Scherer D., Schwatke C., Pavelsky T., Sawyer A., Ray R., Dettmering D, Seitz F.. Observing the pulse of tidal rivers: A first global analysis from the SWOT satellite mission. ***In review.***

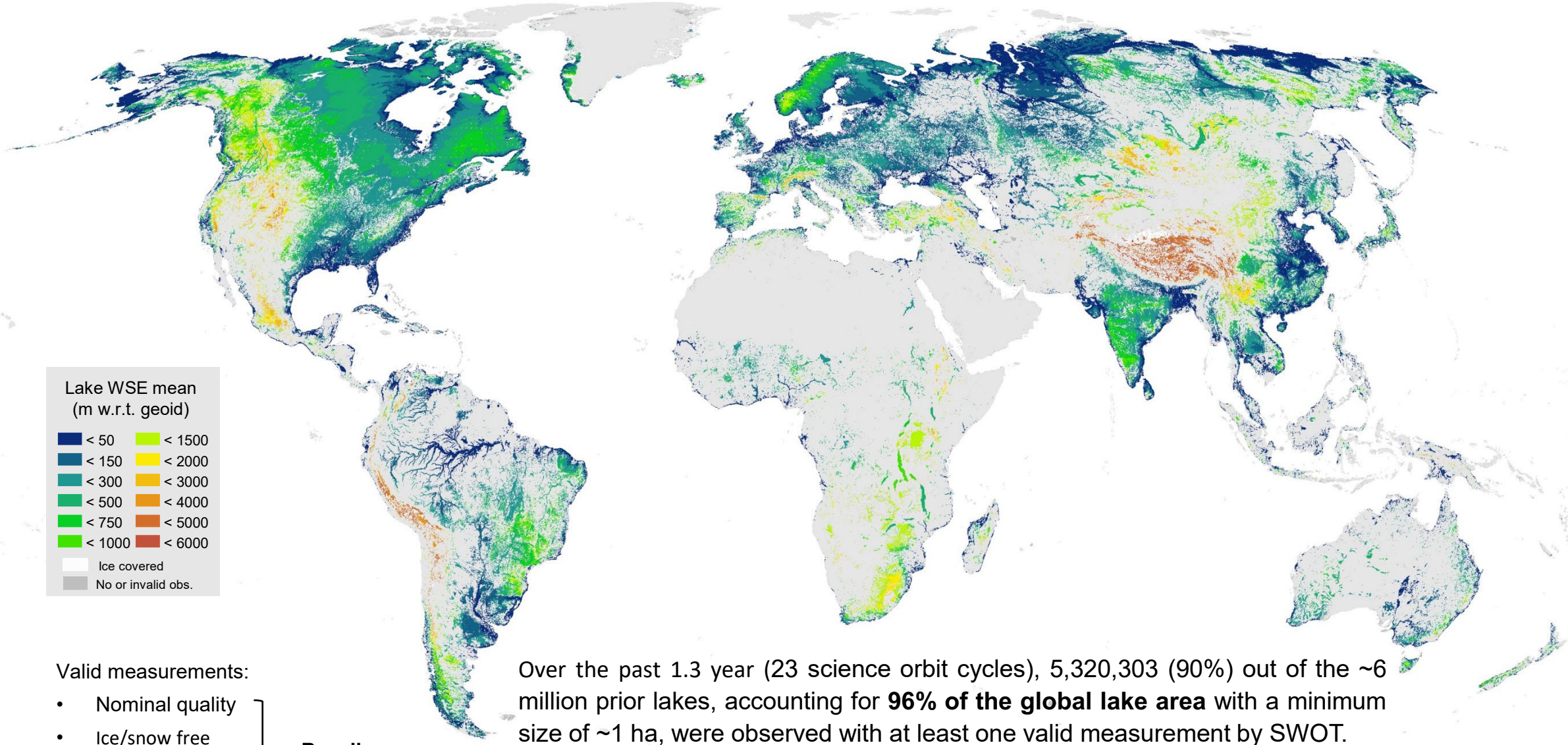
SWOT Captures Downstream Changes in River Height during a Flow Wave



Flow wave detections based on SWOT WSE exceedance of the reach-level 90th percentile (in red) along with SWOT observations (in blue).

Thurman et al. 2025. Geophysical Research Letters

SWOT Maps Water Surface Elevations on Global Lakes



Valid measurements:

- Nominal quality
- Ice/snow free
- Good crossover calibration

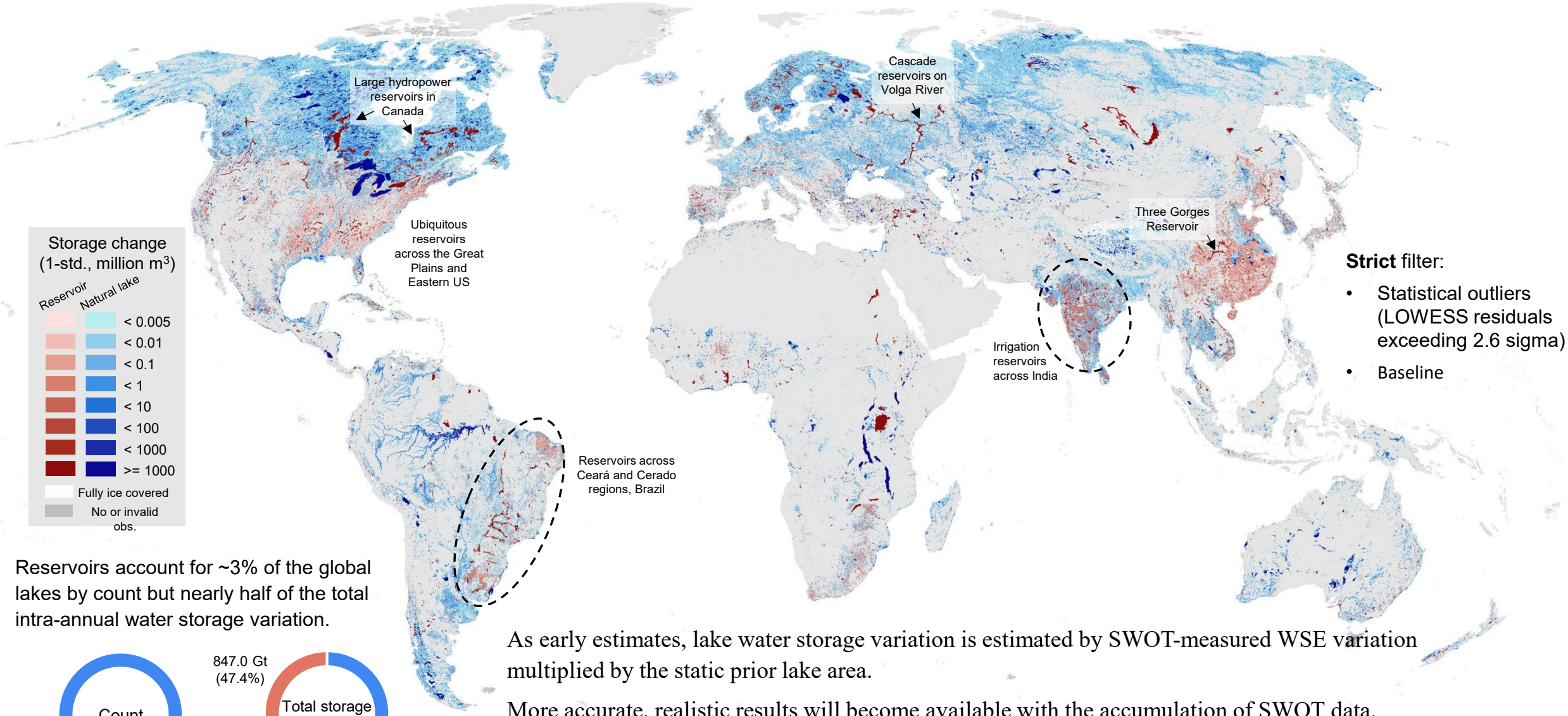
Baseline filter

Over the past 1.3 year (23 science orbit cycles), 5,320,303 (90%) out of the ~6 million prior lakes, accounting for **96% of the global lake area** with a minimum size of ~1 ha, were observed with at least one valid measurement by SWOT.

- Lake extents in the map are based on the SWOT Prior Lake Database (PLD v103).
- Lake WSEs are processed from ***LakeSP_Prior*** (v2/C) during the science orbit cycles 1 to 23 (07/21/2023 to 11/11/2024).

Jida Wang (U of Illinois), et al.

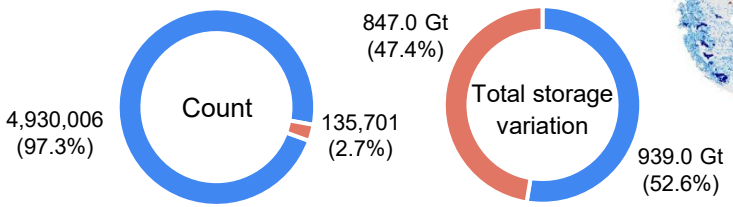
SWOT Captures Variability in Global Lake Storage Change



Strict filter:

- Statistical outliers (LOWESS residuals exceeding 2.6 sigma)
- Baseline

Reservoirs account for ~3% of the global lakes by count but nearly half of the total intra-annual water storage variation.



Lakes with only one measurement are excluded from change statistics.

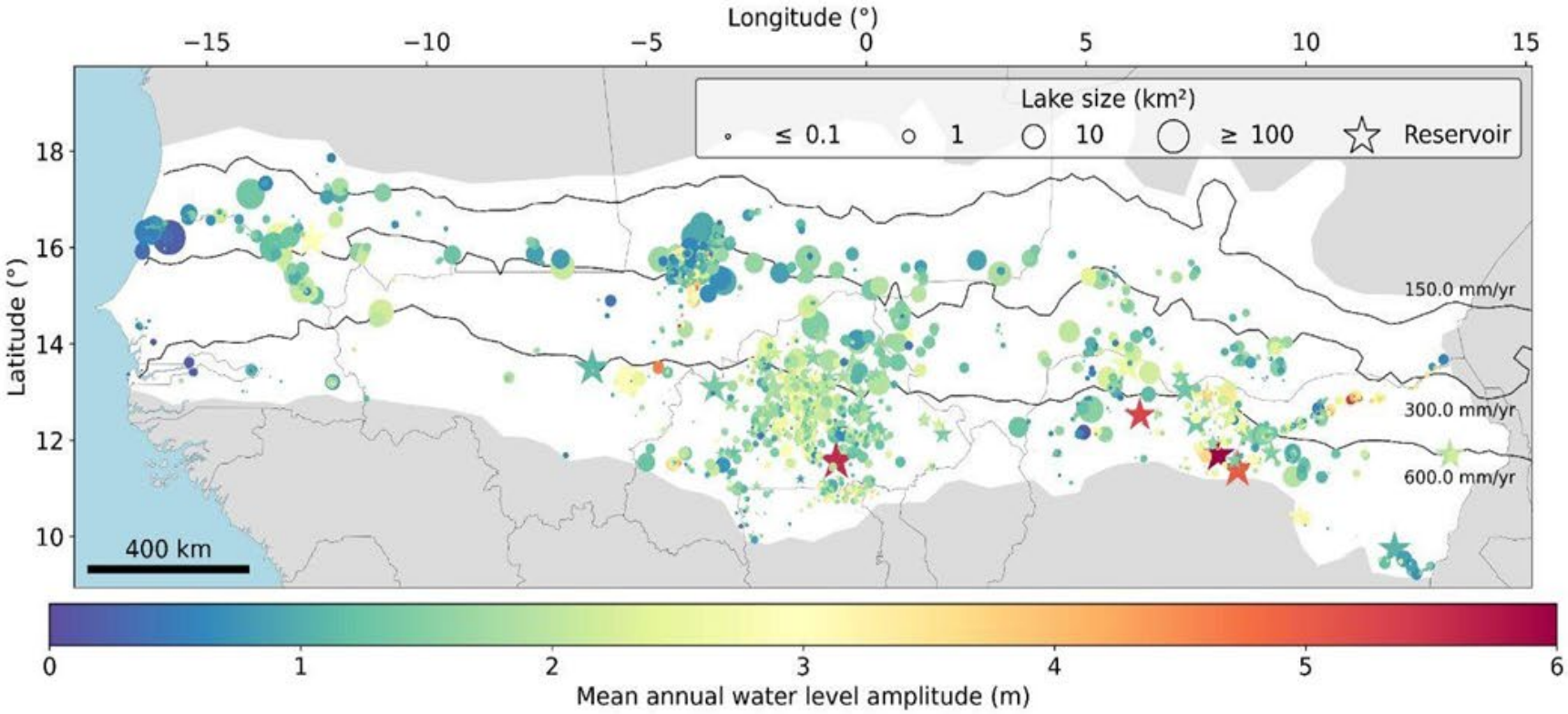
As early estimates, lake water storage variation is estimated by SWOT-measured WSE variation multiplied by the static prior lake area.

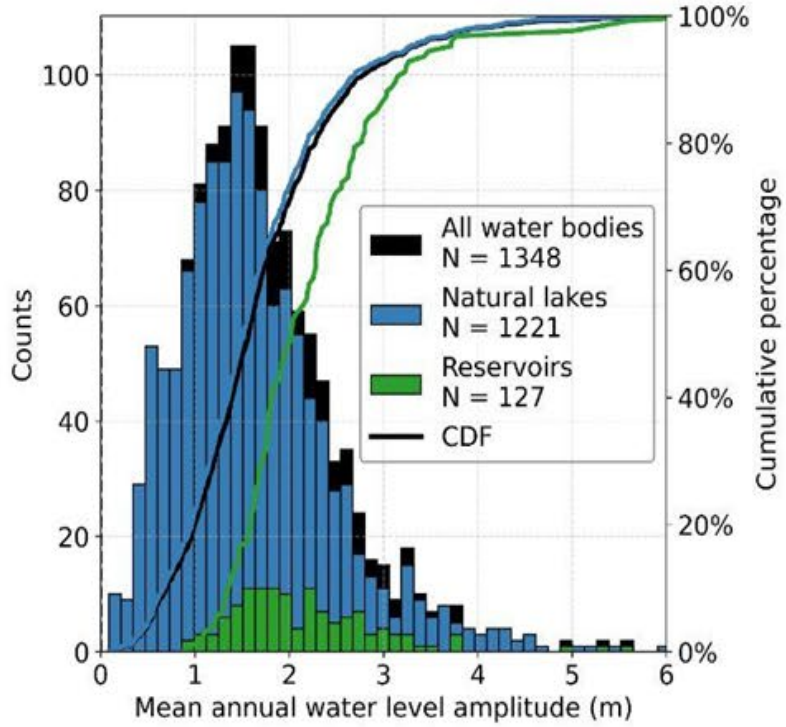
More accurate, realistic results will become available with the accumulation of SWOT data.

Reservoirs experience ~54–620% more intra-annual storage variation than natural lakes due to direct human water management.

Jida Wang (U of Illinois), et al.

SWOT Provides Unprecedented Lake dynamics Overview on West African lakes





SWOT allows estimating mean annual water level amplitude of **1300+ lakes**

75% lakes show amplitude < 2 m comparable to average evaporation loss, suggesting **limited human use**

Girard et al. 2025b, IEEE JSTARS

Good agreement between SWOT HR and in situ GNSS data over lake/river ice near Fairbanks, AK

Mean bias: 15cm Mean absolute bias: 37cm

Performance varies spatially and warrants further investigation

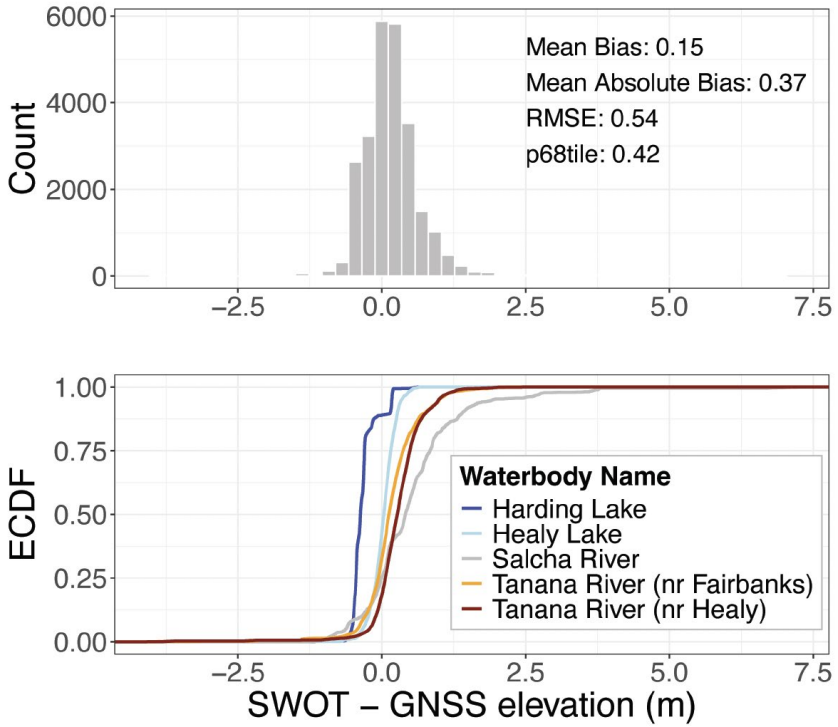
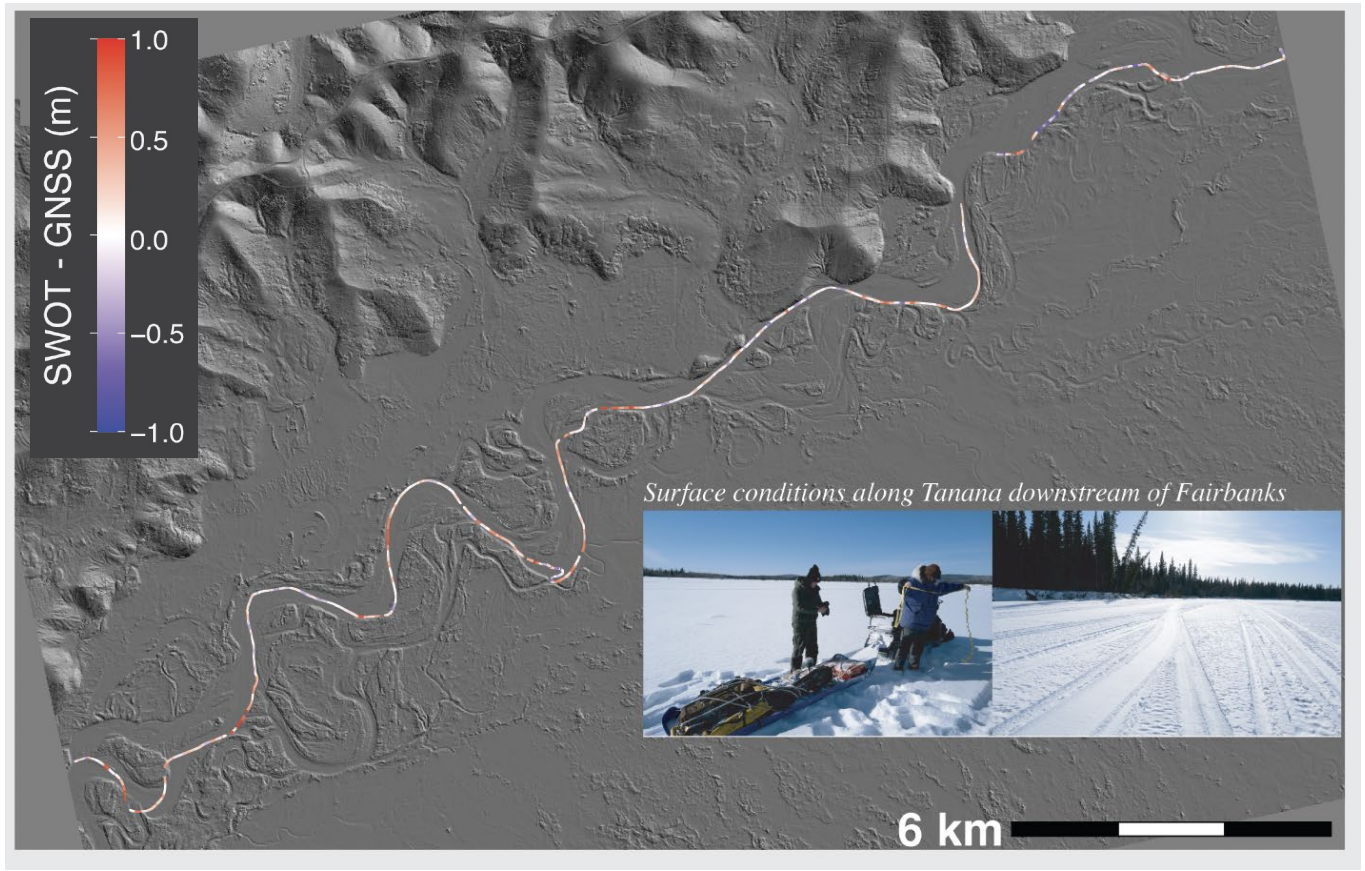


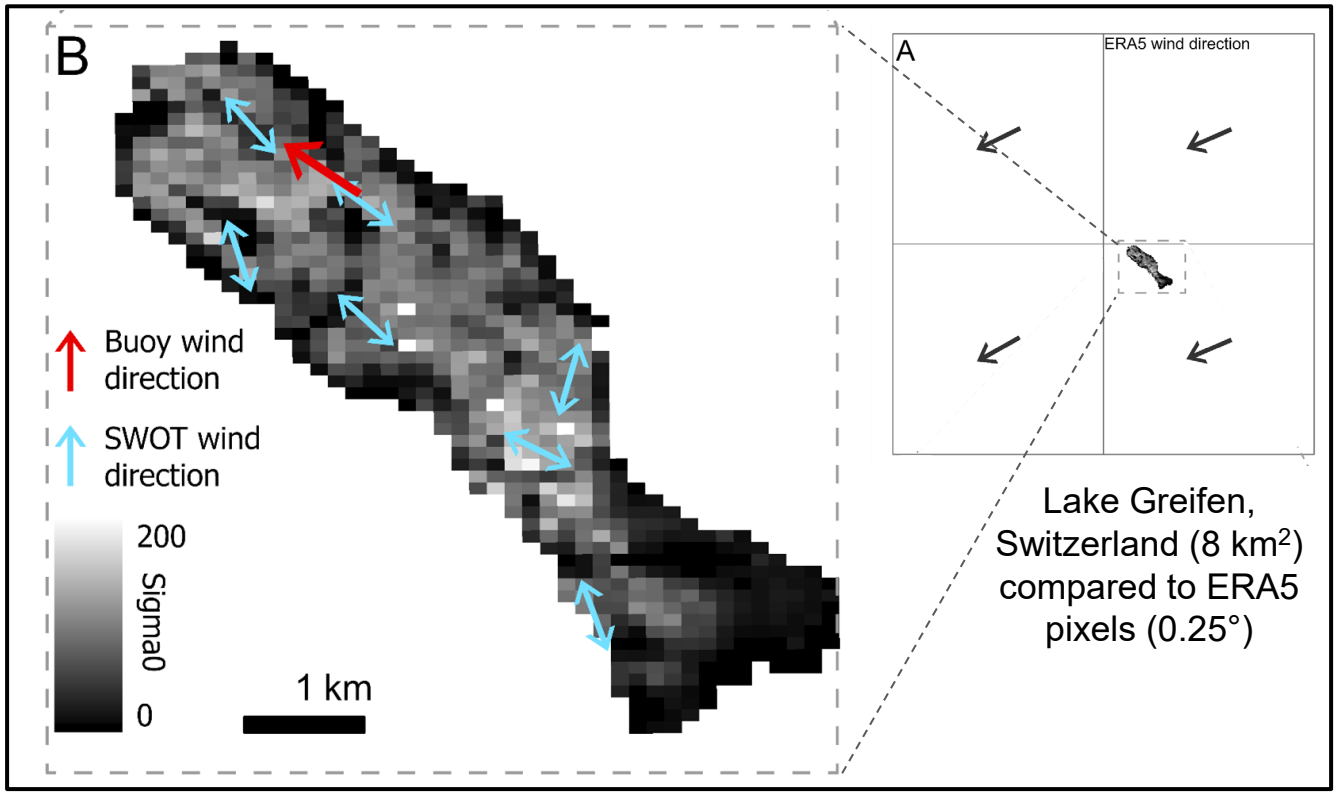
Figure 2. A. Histogram of the elevation difference between SWOT and GNSS agreement and B. Empirical cumulative distribution function for each waterbody.

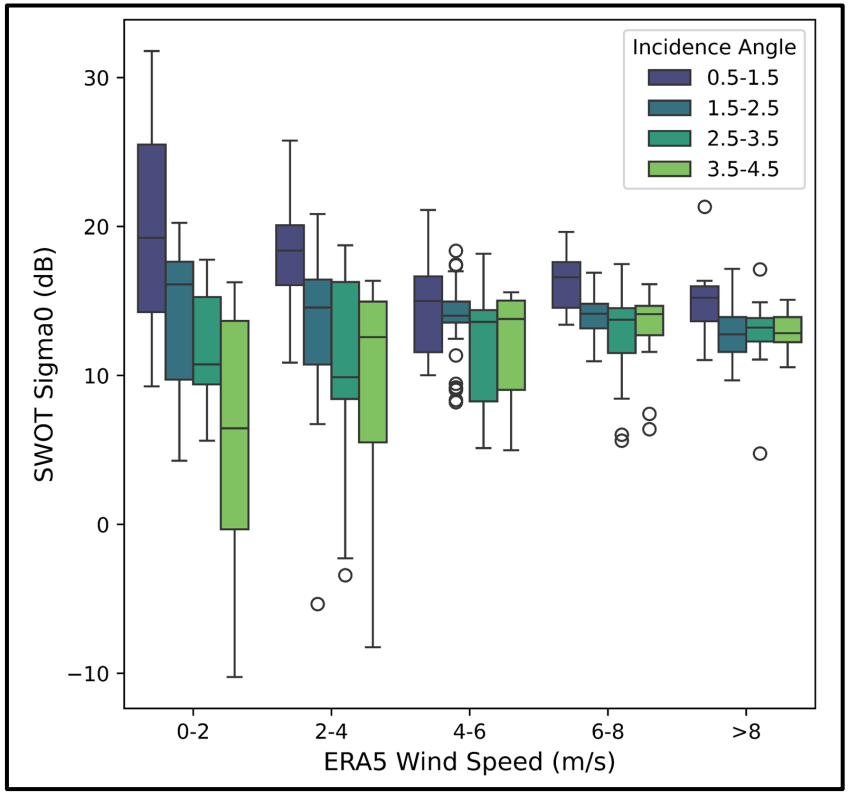


Spatially varying differences between SWOT and GNSS elevation.

Xiao Yang

SWOT Estimates Wind over Lakes using Backscatter Information





- Above: Wind direction at 1-km resolution over Lake Greifen, Switzerland by extracting the orientation of wind streaks in the SWOT backscatter
- Compared to wind direction from ERA5 (0.25°), SWOT produces higher resolution estimates and is able to resolve lakes a fraction of the size of a single ERA5 grid cell
- SWOT backscatter sensitivity to wind speed is promising for the development of a lake wind speed model
- These results can be used to model lake evaporation and lake-air greenhouse gas exchange at very high resolution

McQuillan, K., Allen, G.H., Fayne, J., Gao, H. Wang, J. (2025) Estimating wind direction and wind speed over lakes with SWOT and Sentinel-1 satellite observations. *Earth and Space Science.*

Preview of Coming Attractions

- Improved width and area representation (discussed Wednesday)
- Availability of floodplain DEMs (Weds)
- Lake and Reservoir water storage dynamics (Weds & Fri)
- Preparation of the first global discharge product (Weds & Thurs)
- Tracking lake and river ice with SWOT (Thurs)
- Updating global hydrology & flood models with SWOT (Thurs & Fri)

Goal for 12 months from now: submit a community paper to *AGU Advances* (or similar) showing how SWOT has advanced hydrology science and applications


Merci!
Thank you!
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SWOT


Extra
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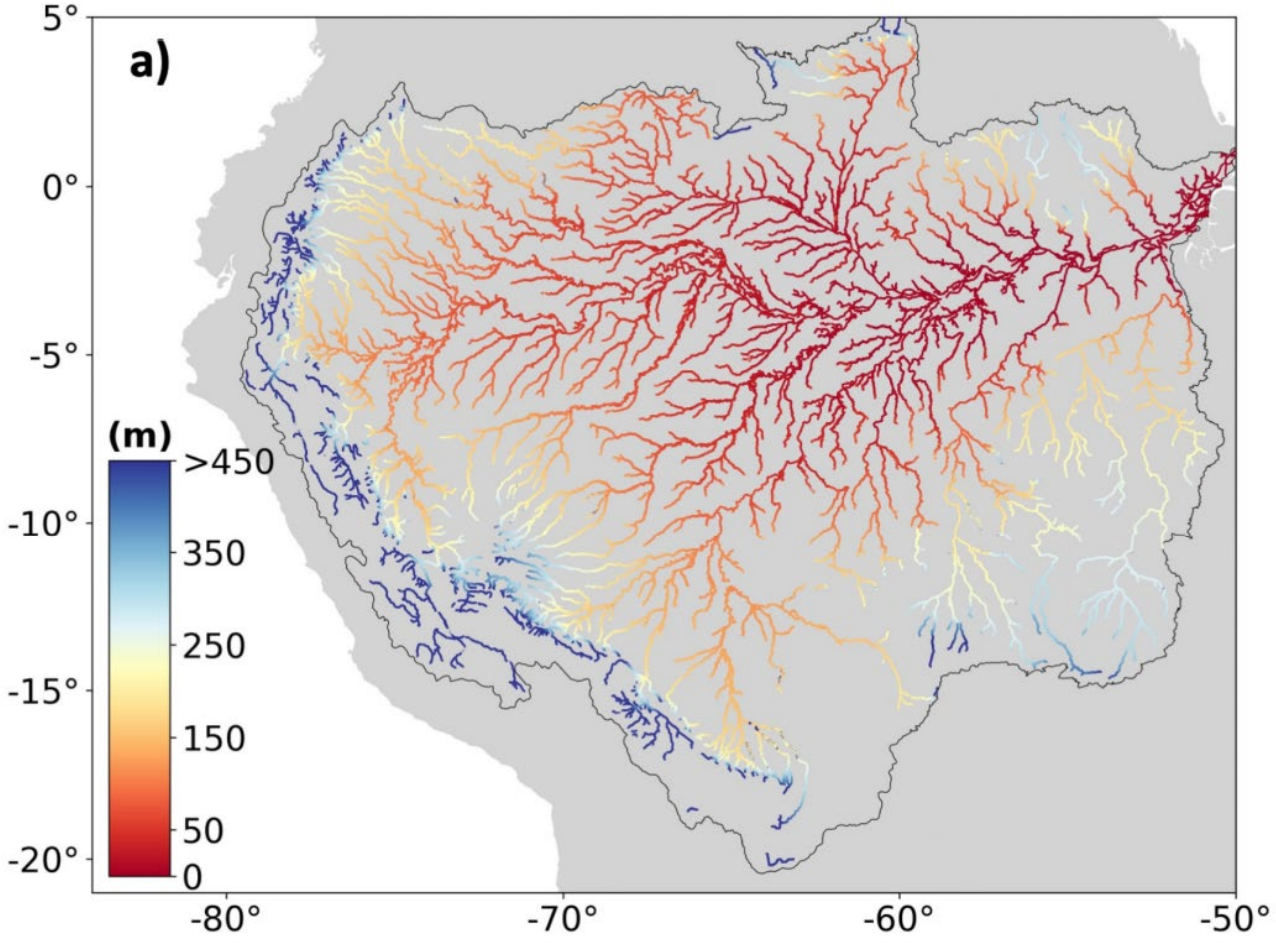
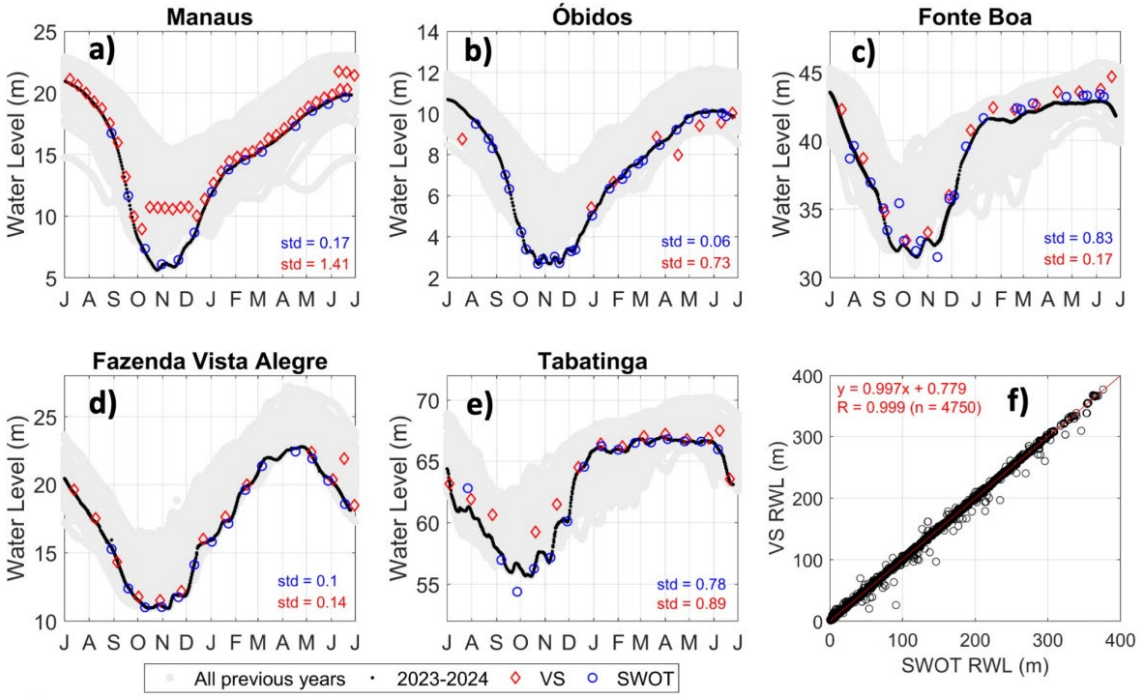
SWOT Captures Extreme Drought on the Amazon Basin

Minimum River Water Levels (RWL) recorded from SWOT in 2023.

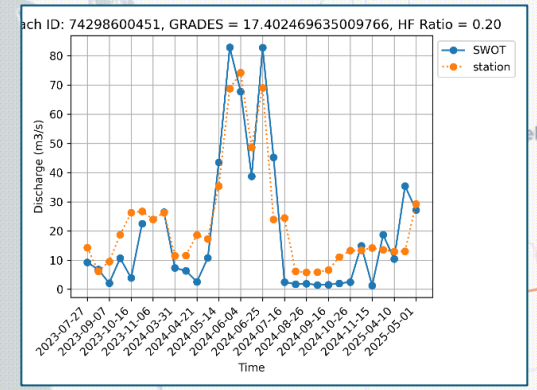


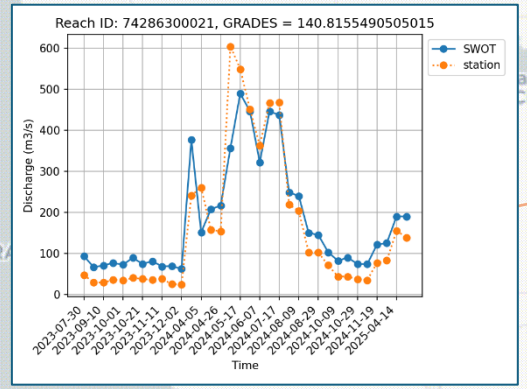


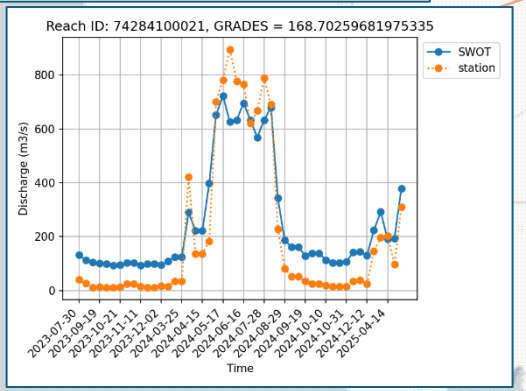
a-e) July to June annual variations (light grey lines) of daily River Water Levels at 276 five gauging stations from 1970 to 2022. The dotted black line is for July 2023 to June 2024, along with River Water Level estimates from nadir altimetry at Virtual stations (red diamond) and from SWOT (blue circle). f) Scatterplot between River Water Level estimates from Virtual Stations and SWOT during the drought period (October and November 2023)

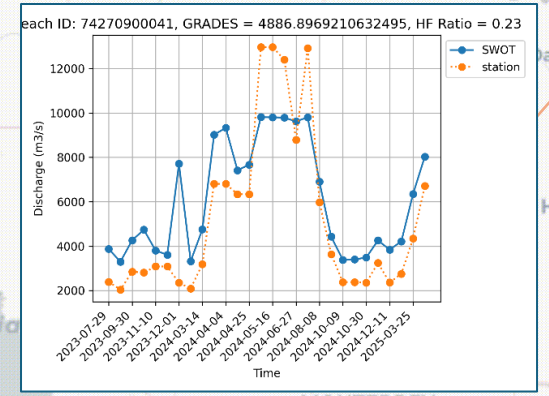
Moreira, et al. 2025. Geophysical Research Letters. https://doi.org/10.1029/2025GL116180

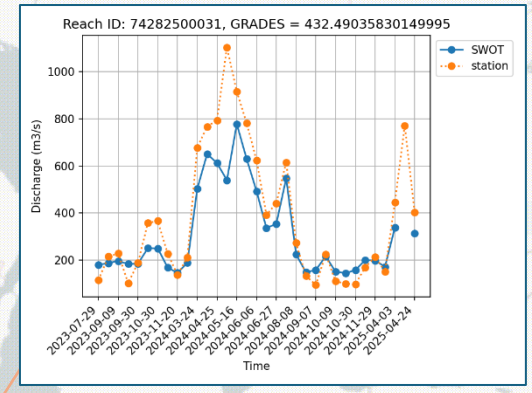
SWOT Provides Synoptic Discharge

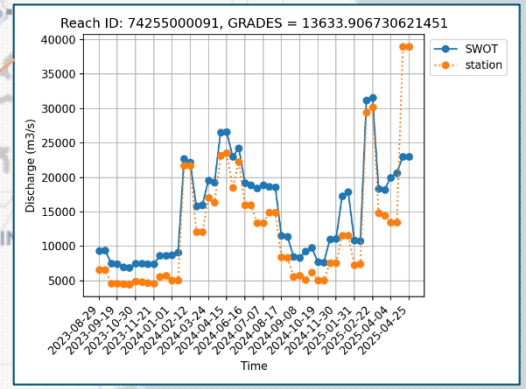


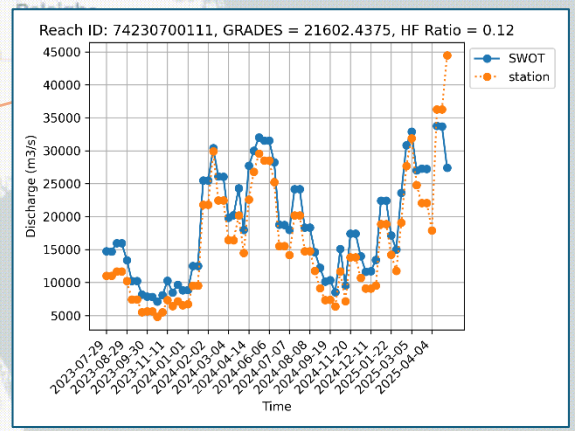












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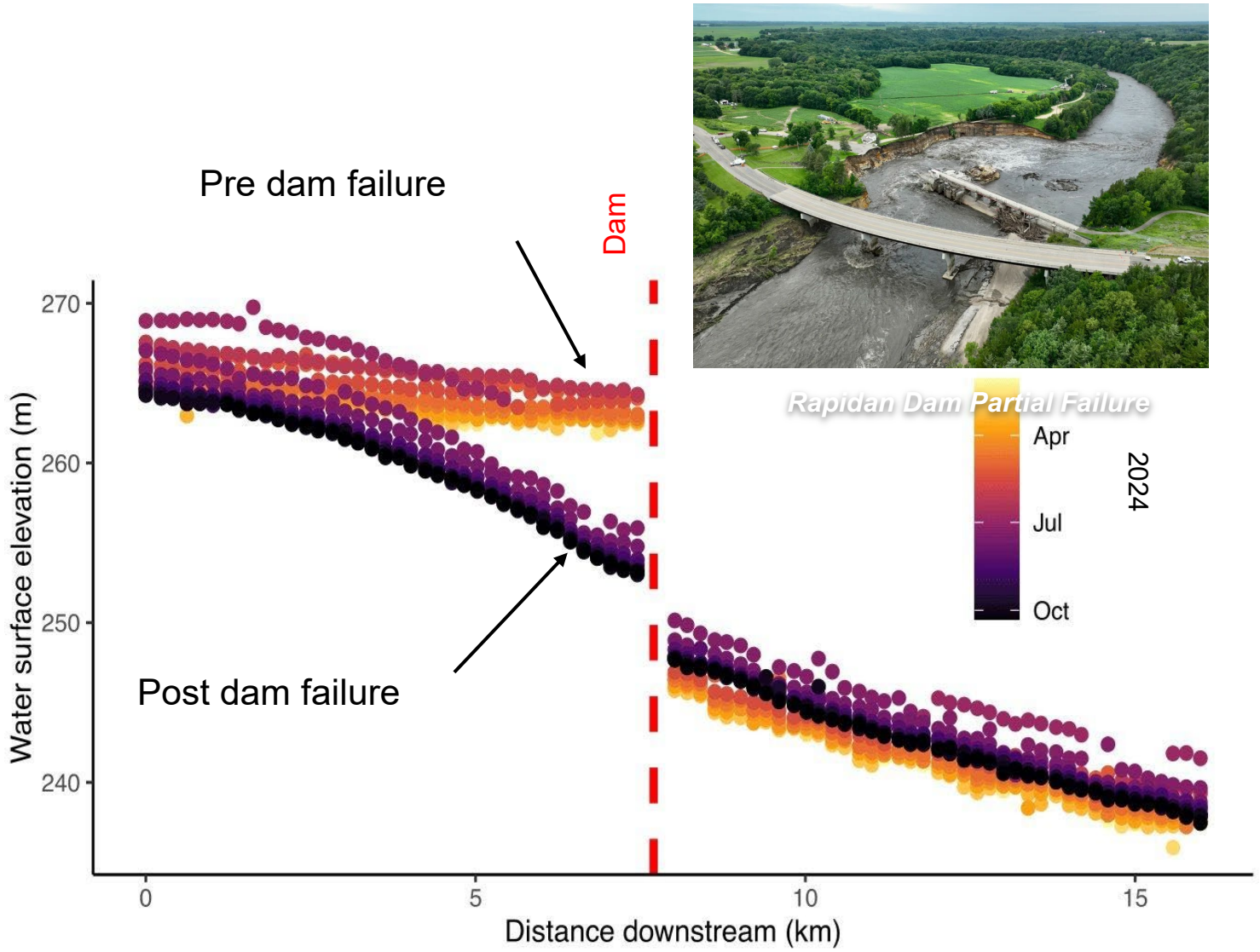
sic4dvar

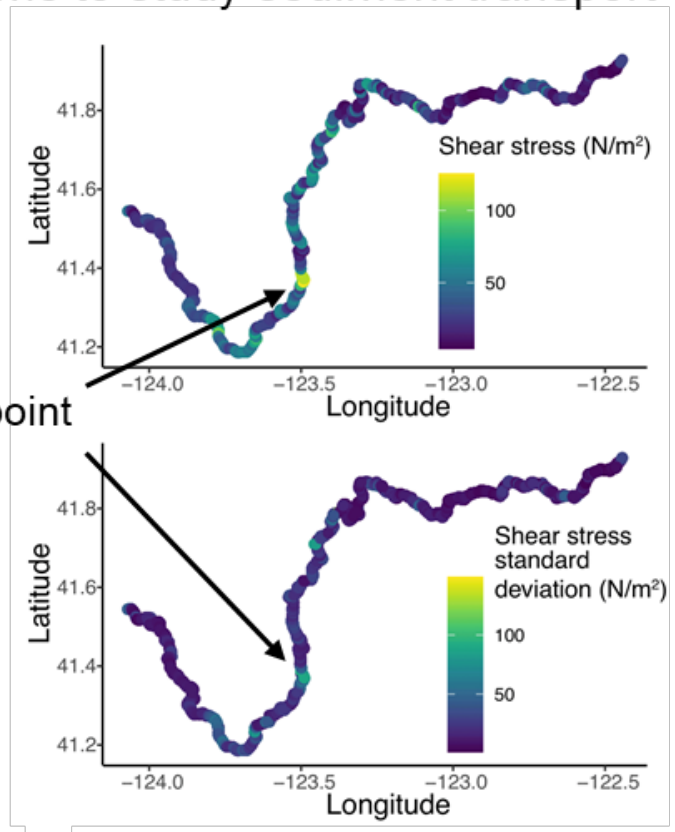
Date: 2023-07-26

Oubanas et al. 2025. In Prep

SWOT Monitors fluvial geomorphology



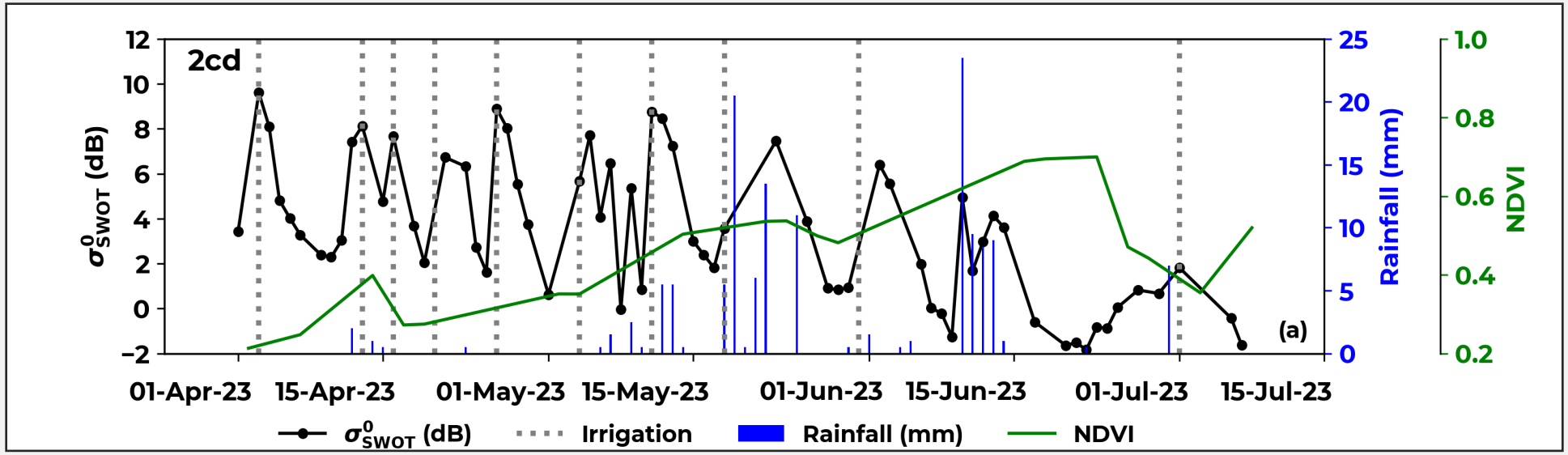
Example 1: SWOT can track shear bed stress along rivers through space and time to study sediment transport

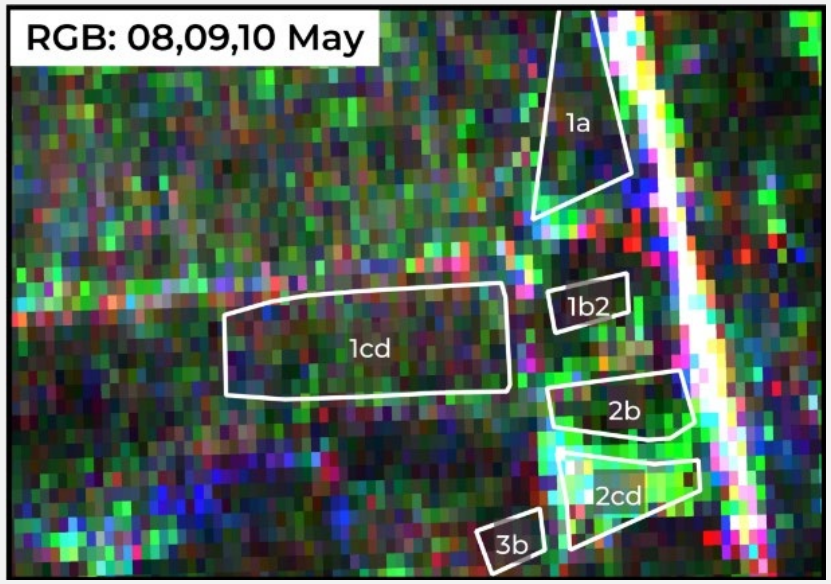


Klamath River, CA

Stroud, M., Allen, G.H., Minear, J.T., Cisneros, J., Smith, L.C. (in review) The SWOT Satellite: A New Tool for Fluvial Geomorphology. *GSA Today*.

Potential in Detection of Irrigation Events





Irrigation as seen with SWOT images

Acquisition before irrigation (May 8th)

Acquisition on irrigation date (May 9th)

Acquisition after irrigation (May 10th)

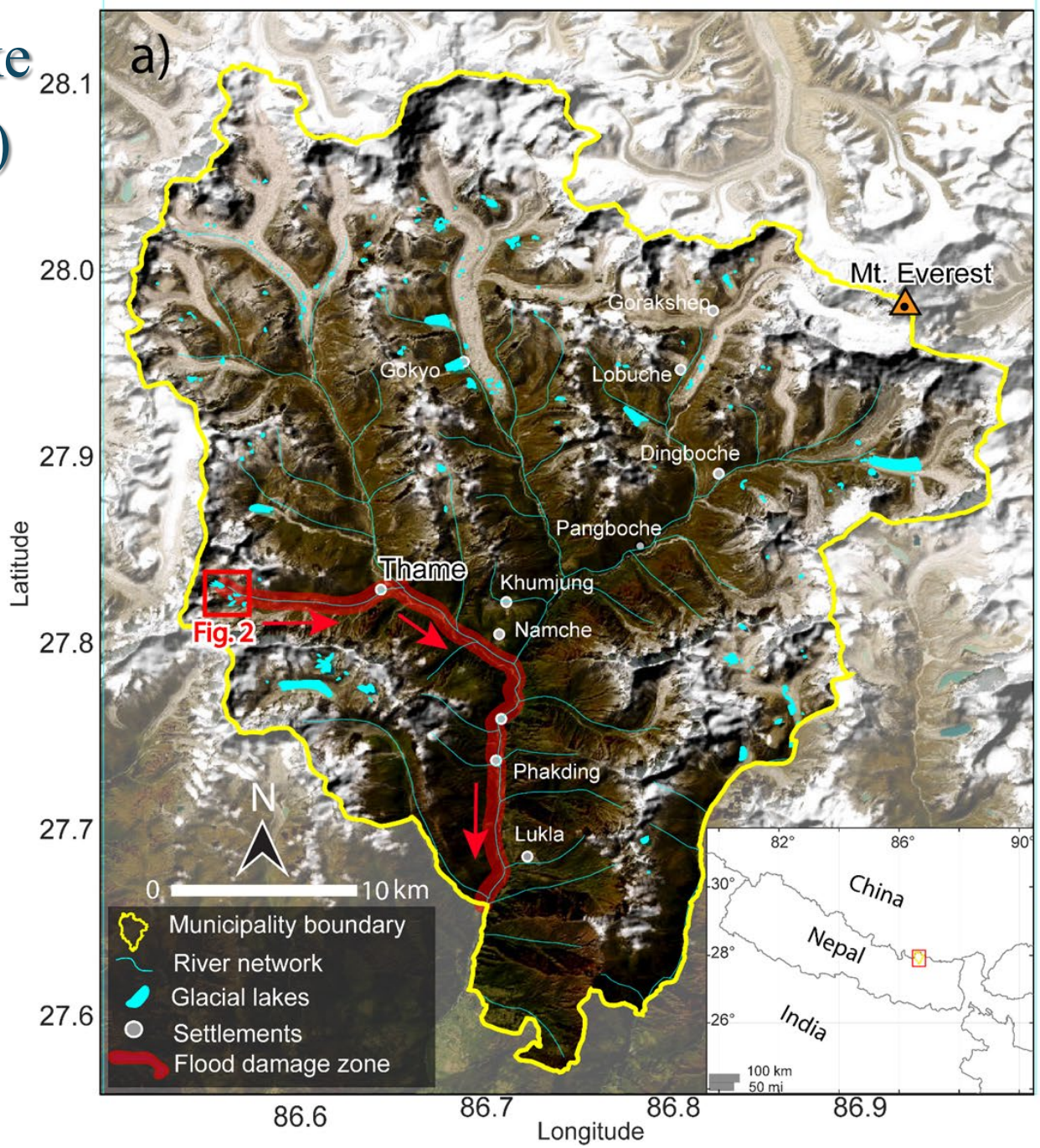
Water depth persisting after an irrigation event.

Bazzi *et. al.*, 2025, under revision

Monitoring Glacial Lake Outburst Flood (GLOF)

16 August 2024, Nepal

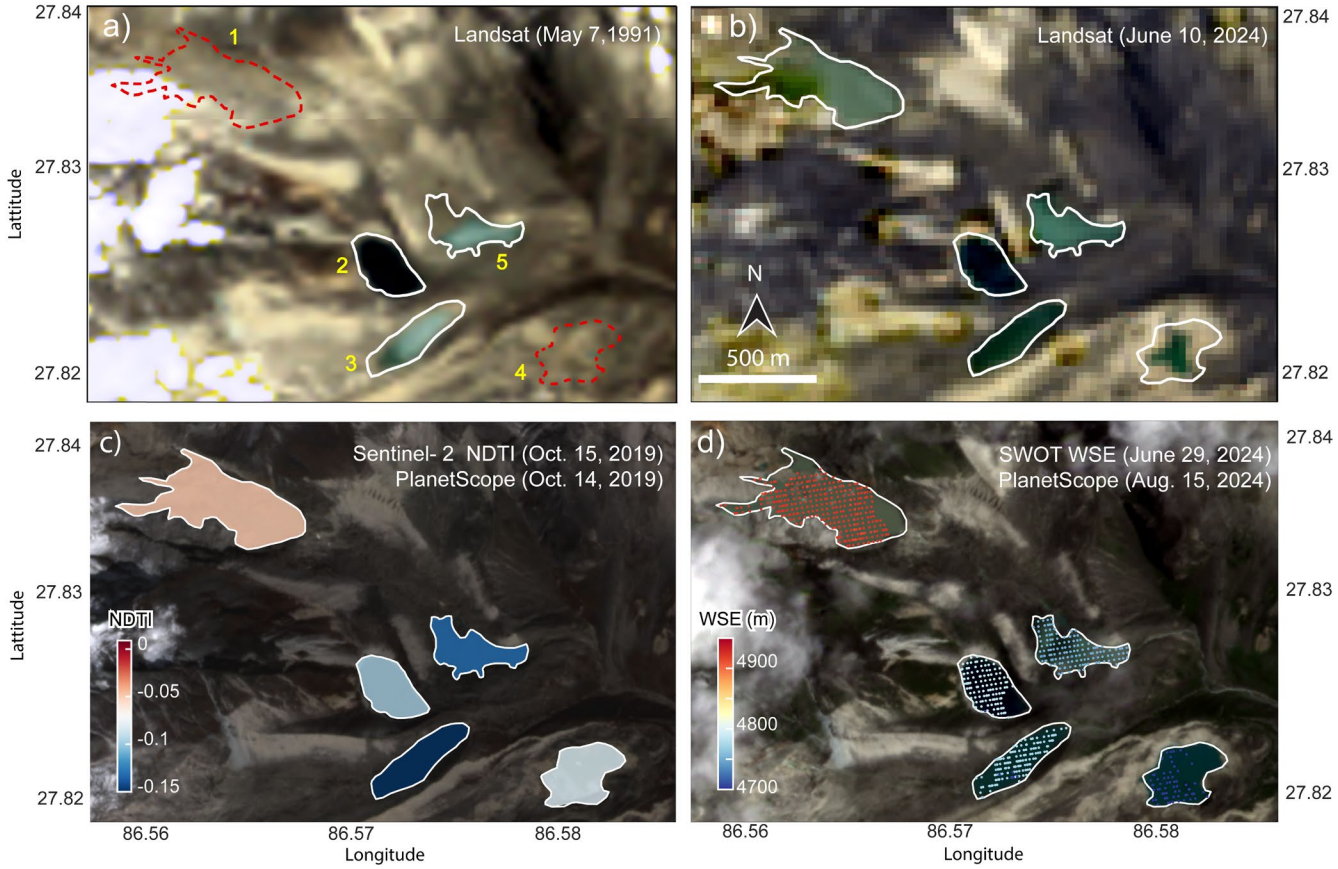
GLOF triggered by the overtopping of a newly formed glacial lake that cascaded into a downstream lake, causing both to suddenly drain.



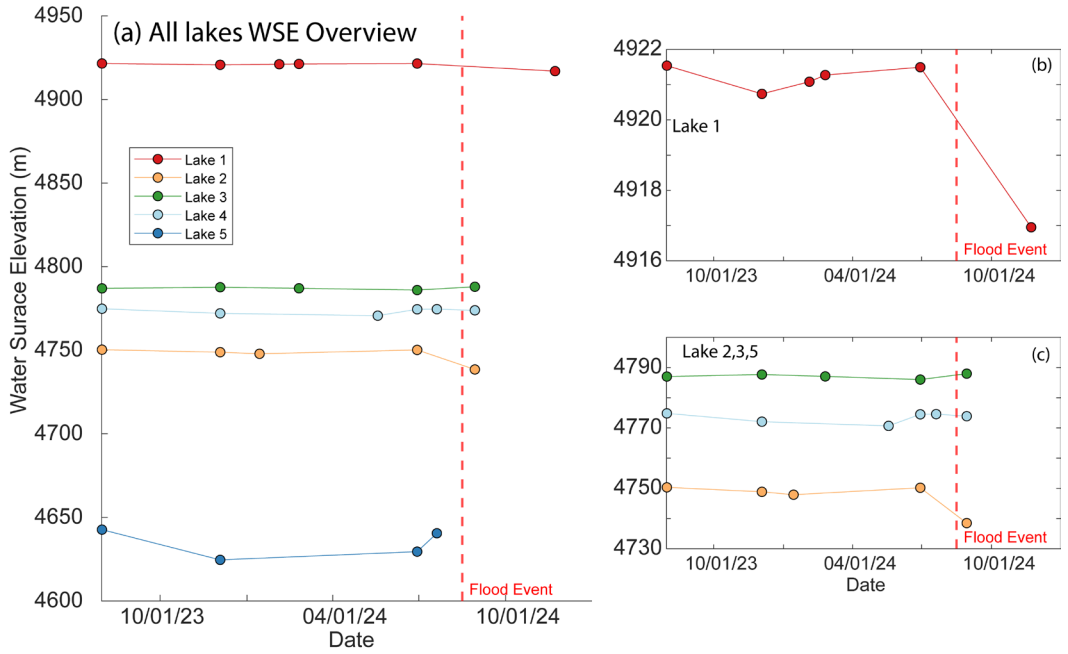
Sherpa, S. F., Smith, L. C., Wang, B., and Stuurman, C.: A Case Study Demonstration of how Multisource Remote Sensing Can Aid Early Detection of Glacial Lake Outburst Flood Hazards (Under review).

Funding support: NASA SWOT Science Team (grant 80NSSC20K1144) and National Science Foundation (NSF) Earth Sciences Postdoctoral Fellowship

Monitoring Glacial Lake Outburst Flood (GLOF)



- Detection of newly forming glacial lakes from space using Landsat
- High water turbidity from Sentinel-2 (glacial meltwater indicator)
- SWOT water surface elevations reveal high pre-GLOF hydraulic head differences, suggesting high stream power, bed shear stress, and erosive power potential between the two lakes (lakes 1&5).



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