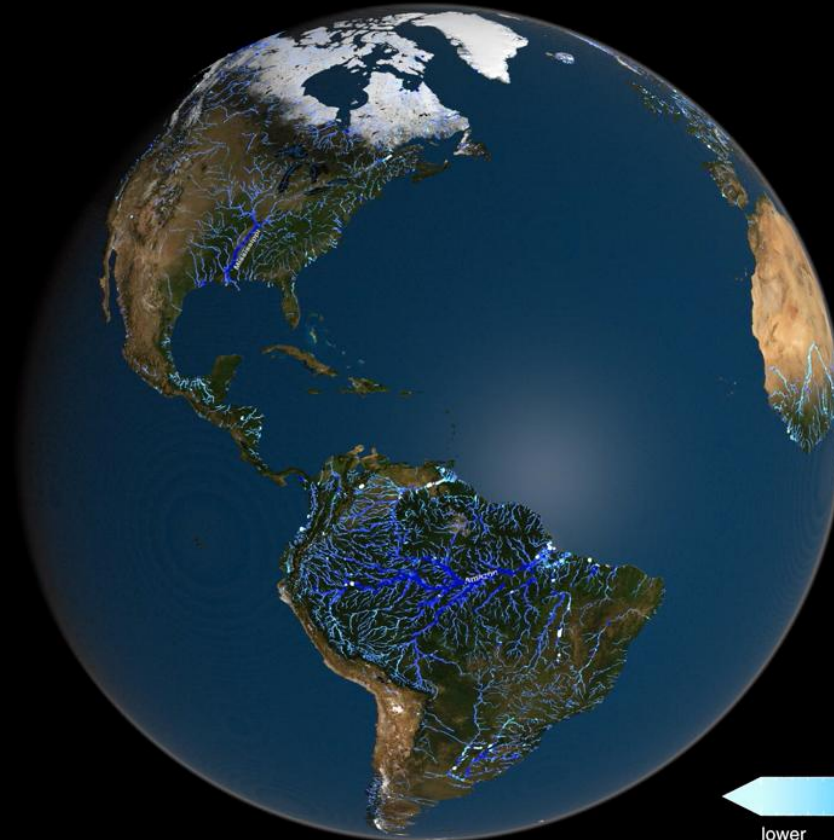


An aerial photograph of a river delta, likely the Colorado River, showing a complex network of channels and sandbars. The image is overlaid with a semi-transparent dark blue filter. The title text is centered in the upper half of the image.

# **NASA Streamflow and Surface Water Remote Sensing: Capabilities and Future Plans**

Tamlin Pavelsky, Toby Minear, Colin Gleason, Fritz Policelli,  
Jida Wang, Steven Chan, and Bruce Chapman

# Global River Water Storage from Space



River water storage measurements from SWOT observations, not from a global model.

May 2024

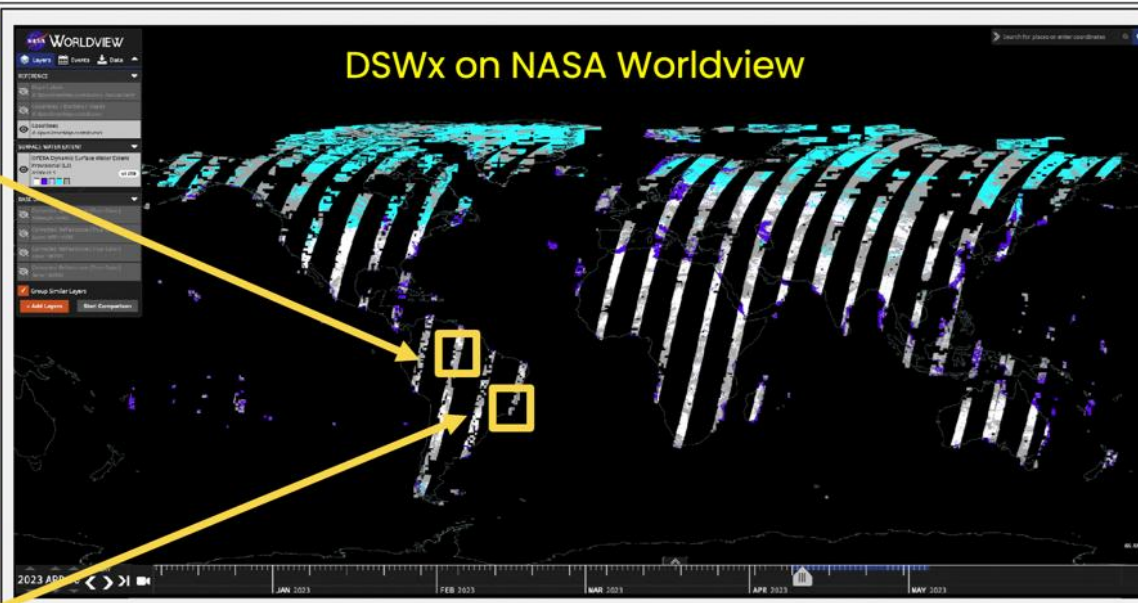
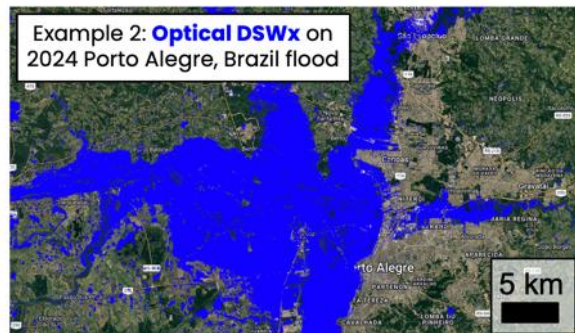
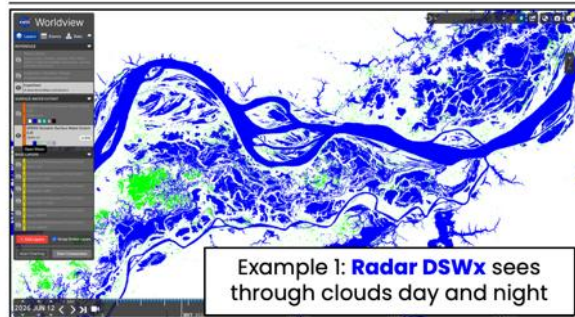


# Dynamic Surface Water Extent (DSWx) Product Suite

High Spatiotemporal Sampling



Jet Propulsion Laboratory  
California Institute of Technology



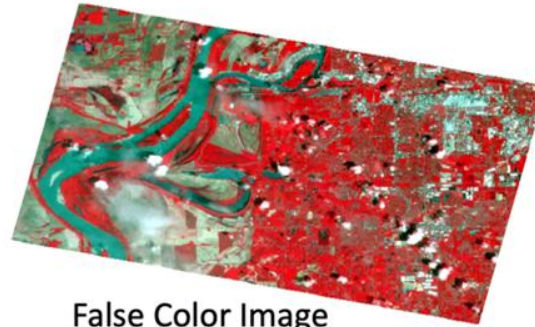
- Radar and optical DSWx provide **near-global coverage** (without the Antarctic)
- Temporal revisit: **subweekly (optical)** to **weekly (radar)**
- All OPERA data products are free and available through the **[SNWG Data Portal on NASA Earthdata Search](#)**



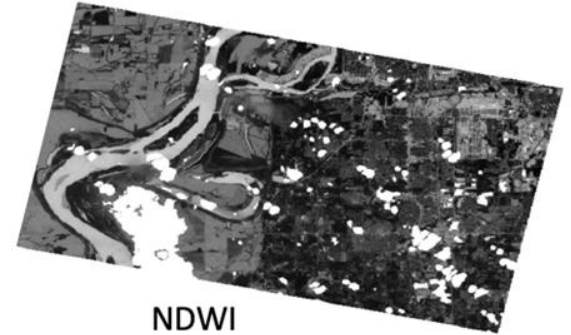
# Demonstrated Automated Production of High Resolution (Planetscope) Water and Flood – Related Products

## Flood Scene

- False Color Image
- NDWI Map
- NDVI Map
- Water Map



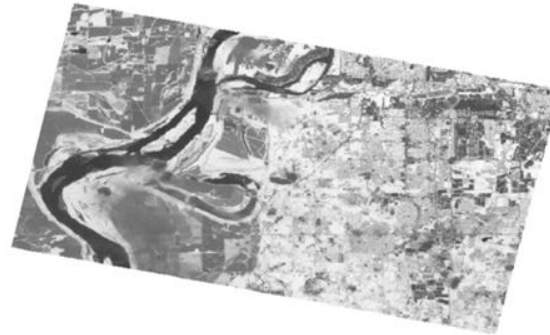
False Color Image  
(Histogram Stretched)



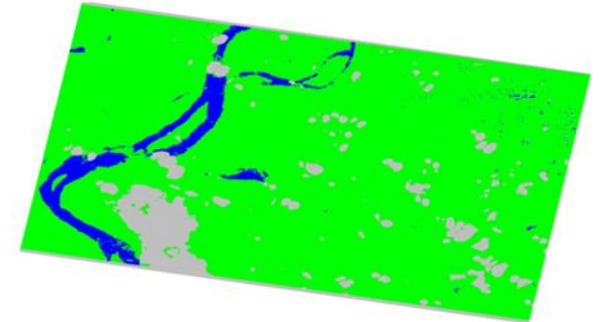
NDWI

## Reference Scene

- False Color Image
- NDWI Map
- NDVI Map
- Water Map



NDVI



Water Map

## Water Change Map

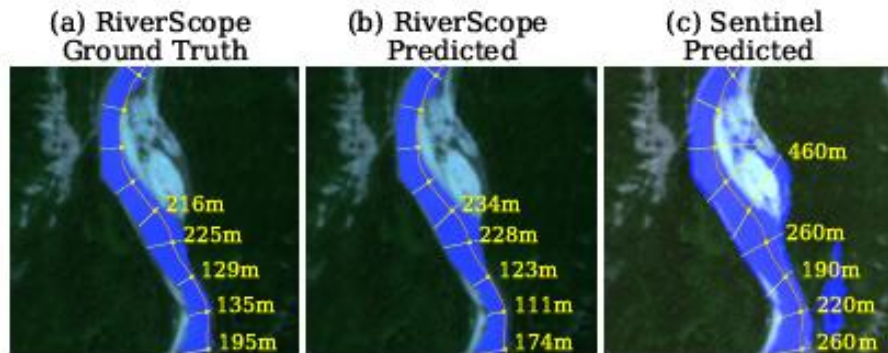
<https://floodmapping.gsfc.nasa.gov/>

Policelli et al., <https://doi.org/10.1144/gh2025-7>

Products derived from Planet Labs, Inc. ©Planetscope data under NASA license

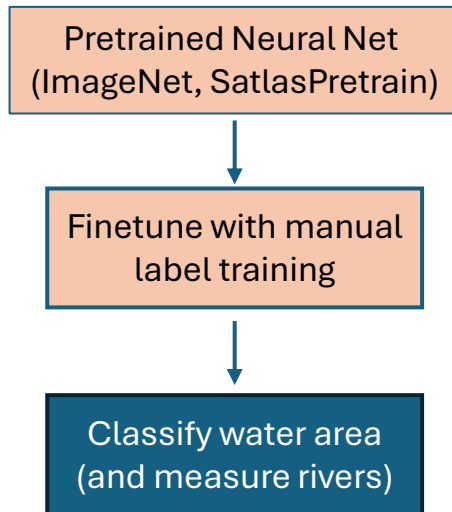
# RiverScope Model (segmentation w/ 3 m Planet)

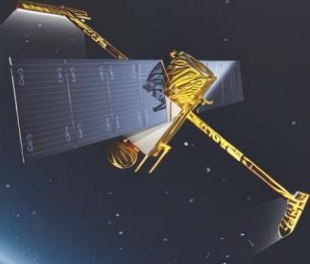
Daroya et al 2025 (CVPR)



|                         | Mean Abs Err (m) | Median Abs Err (m) | Bias (pred-gt) (m) | % Bias | F1    |
|-------------------------|------------------|--------------------|--------------------|--------|-------|
| Sentinel-2 Model        | 120.0            | 79.2               | 98.1               | 70.3%  | 74.7% |
| PlanetScope NDWI        | 50.4             | 38.8               | 8.9                | 9.9%   | 66.6% |
| OPERA DSWx              | 70.6             | 41.2               | 61.2               | 43.6%  | 75.0% |
| RiverScope Model (Ours) | 16.1             | 9.1                | -2.8               | -1.6%  | 92.3% |

- ML Architecture 30x faster than DSWx workflow
- Substantially improves skill of water masking validated against hand-labelled images
- Deployable globally- runs automatically inside Confluence SSC module and has been run for every river with SWOT data (to help validate SWOT)





## CURRENT AFFAIRS

Ocean eddies and waves captured in unprecedented detail by SWOT satellite

**Top ranking**  
The most cited research papers of the twenty-first century

**Ancient features**  
Spanish cave yields earliest human face in Western Europe

**Natural killer**  
Bacterial compound targets phospholipids to eliminate fungi

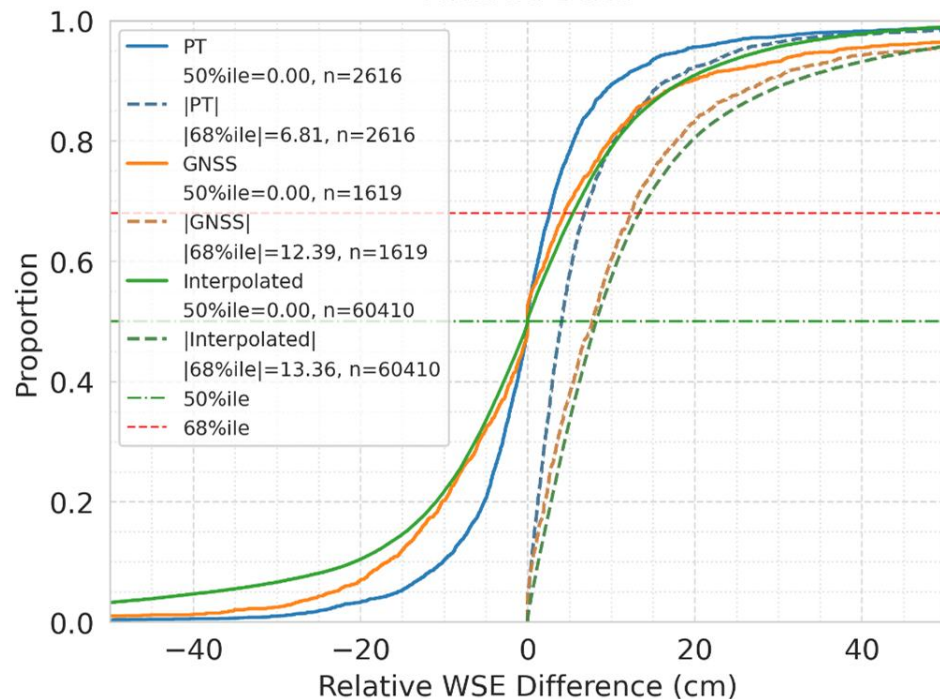
## SWOT: Moving from Validation to Science

The Surface Water and Ocean Topography Mission (SWOT) uses Ka-band radar interferometry to measure **water surface elevation** and inundation extent in oceans, rivers, lakes, and wetlands. Launched December 16, 2022.

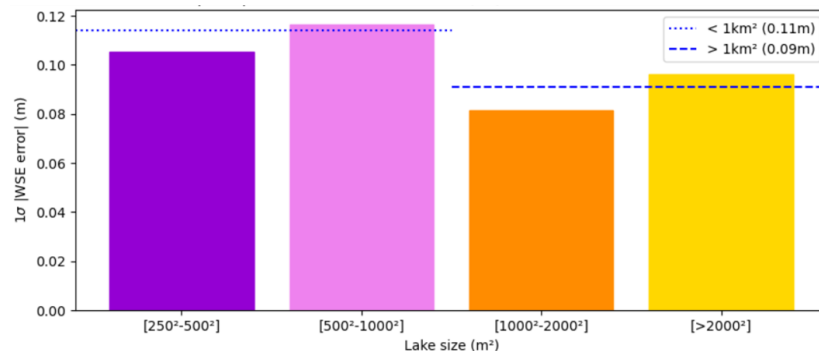
- 339 papers using SWOT data published to date
- 5 papers in *Nature/Science* in 2025-26
- Canonical hydrology validation papers are in press, in review, or soon to be submitted.
- SWOT data are actively being used for science across a broad range of domains including:
  - River Discharge
  - Flood Dynamics
  - Reservoir Management
  - Lake Monitoring
  - Quantifying Surface Water in the Global Water Cycle

# SWOT Validation: Rivers & Lakes

Filtered Data

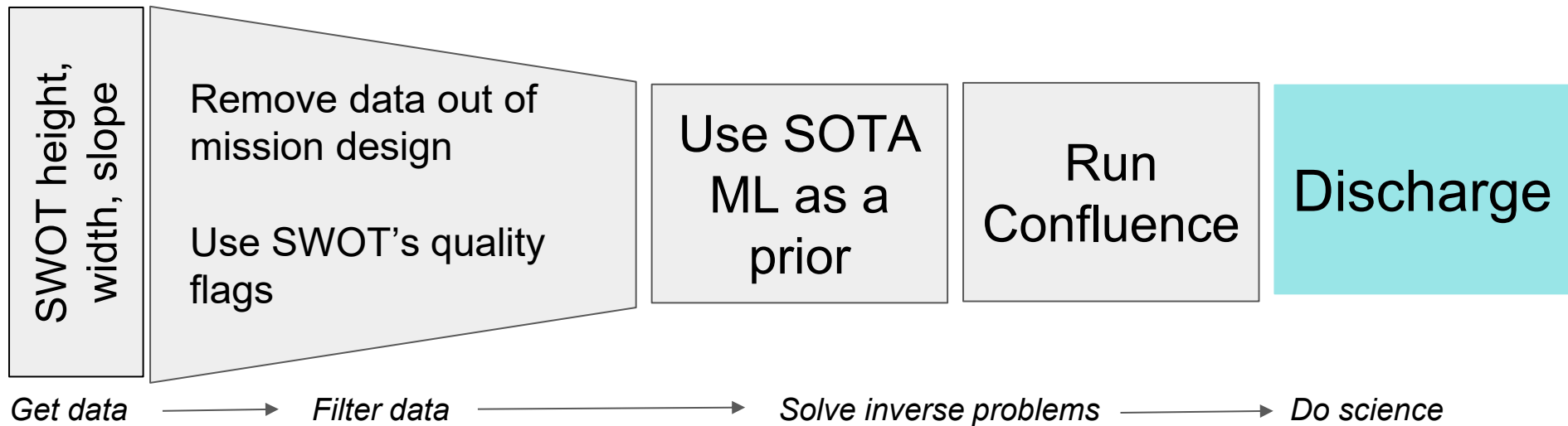


|68%ile| SWOT WSE vs. In Situ for ~200 m river nodes: **7-13 cm**



|68%ile| SWOT WSE vs. In Situ for lakes: **9-11 cm**

# SWOT Discharge



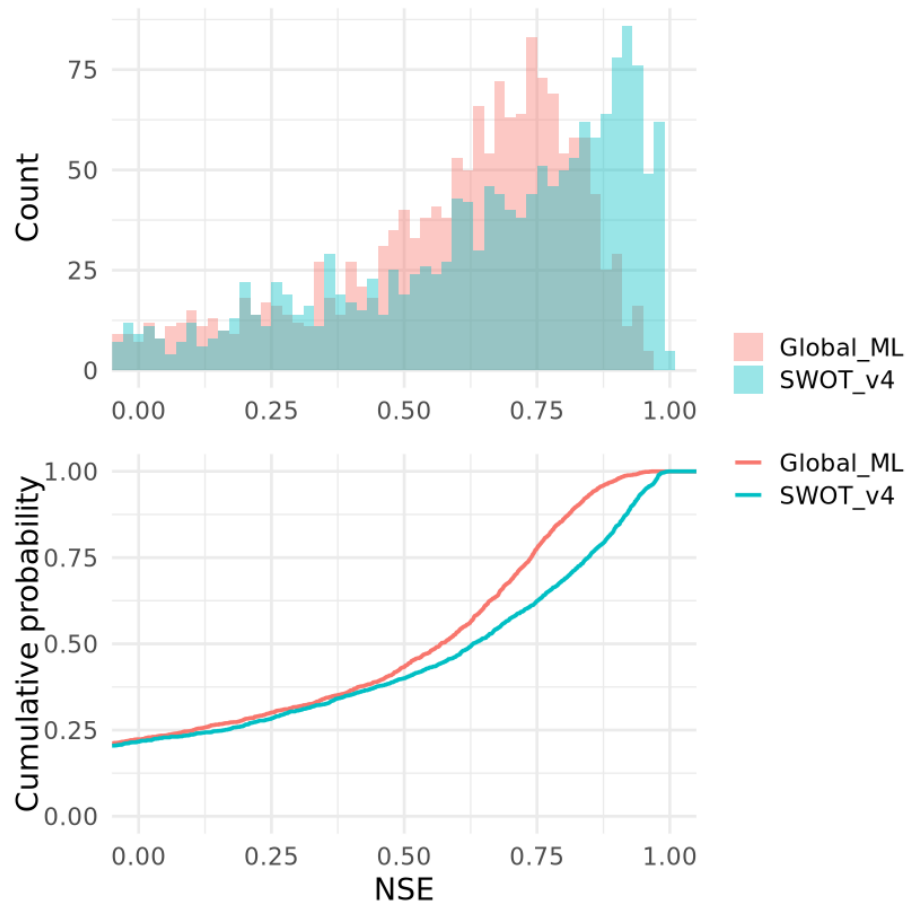
Latest discharge: Version 4. 50-70% more accurate than Version 2 (Andreadis et al., 2025)

# SWOT Discharge

- At 2,138 gauges, SWOT discharge clearly outperforms the ML prior
- NSE: 1 is perfect, 0 is equivalent skill to the data mean

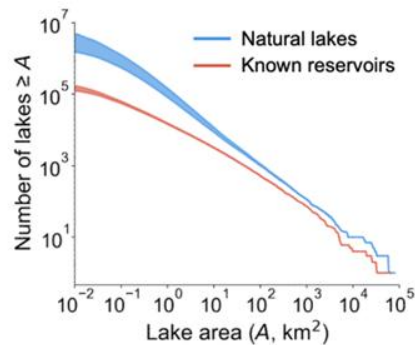
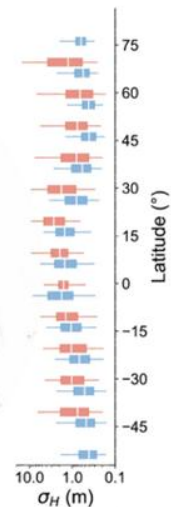
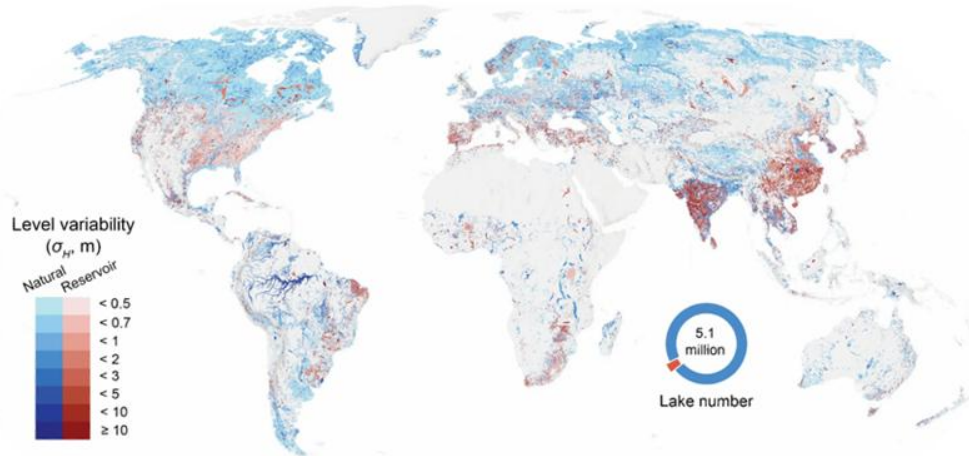


Map of which discharge is better

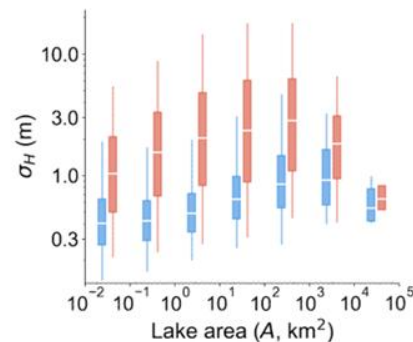


SWOT and ML on matched gauges/time periods

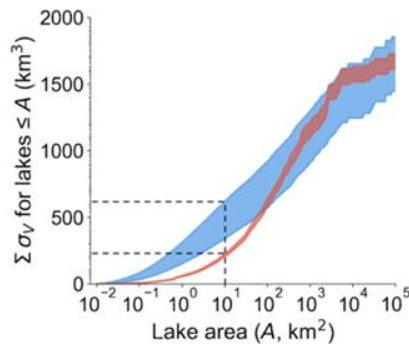
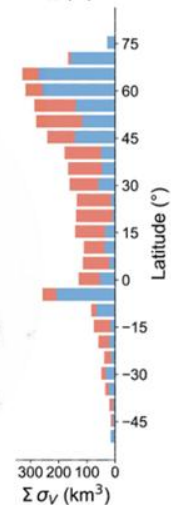
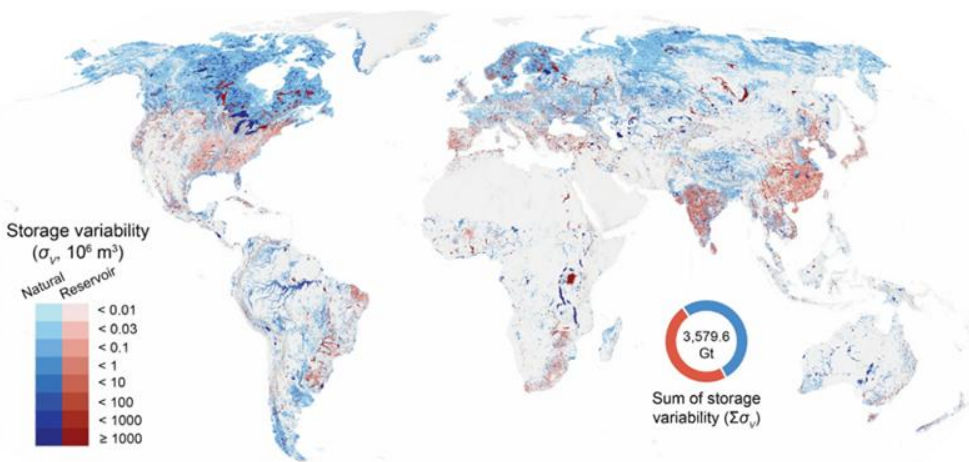
# A near-global census of seasonal lake storage variability from SWOT



SWOT observes >20× more lakes than previous global studies, especially small lakes (e.g., < 1–10 km<sup>2</sup>).



- Lake-level variability increases moderately with lake area.
- Reservoirs remain 2–5 times more variable than natural lakes.

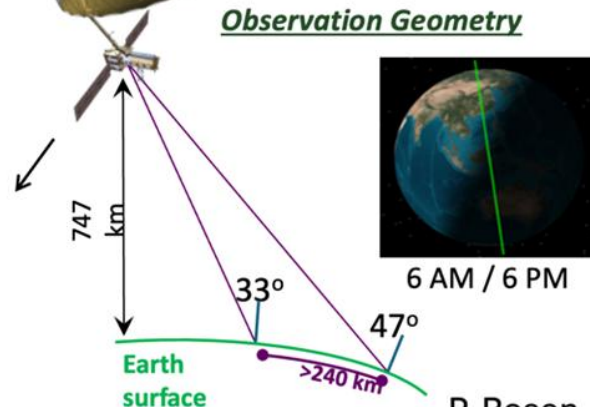
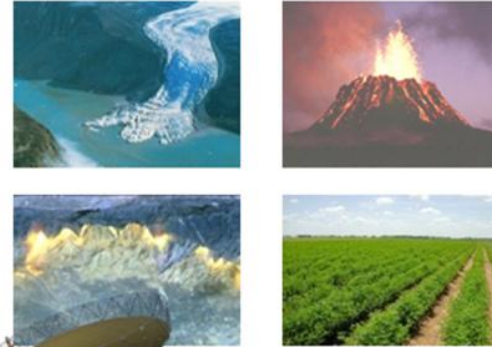


- Global cumulative individual-lake variability: 3,056–3,580 Gt, exceeding previous observations ( $\leq 2,048$  Gt)
- Known reservoirs: <5% of global lakes, 48–53% of variability
- Lakes  $\leq 10$  km<sup>2</sup>: 18–25% of variability

# NISAR Science Observation Overview

| NISAR Characteristic:                          | Would Enable:                                              |
|------------------------------------------------|------------------------------------------------------------|
| L-band (24 cm wavelength)                      | Low temporal decorrelation and foliage penetration         |
| S-band (9.4 cm wavelength)                     | Sensitivity to light vegetation                            |
| SweepSAR technique with Imaging Swath > 240 km | Global data collection                                     |
| Polarimetry (Single/Dual/Quad)                 | Surface characterization and biomass estimation            |
| 12-day exact repeat                            | Rapid Sampling                                             |
| 3 – 10 meters mode-dependent SAR resolution    | Small-scale observations                                   |
| 3 yrs (NASA) / 5 yrs (ISRO) science operations | Time-series analysis                                       |
| Pointing control < 273 arcseconds              | Deformation interferometry                                 |
| Orbit control < 500 meters                     | Deformation interferometry                                 |
| > 10% (S) / 50% (L) observation duty cycle     | Complete land/ice coverage                                 |
| Left-only pointing (Left/Right capability)     | Uninterrupted time-series<br>Rely on Sentinel-1 for Arctic |

## NISAR Will Uniquely Capture the Earth in Motion



P. Rosen, 2021

Sentinel imagery composite  
from Jan. 17th/19th, 2026

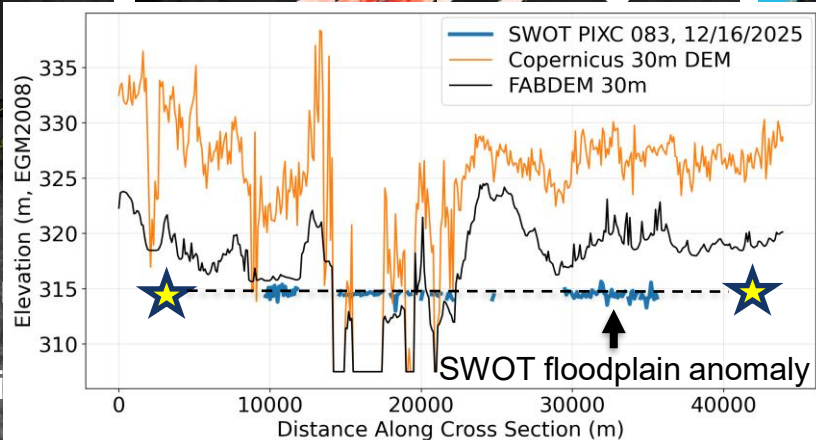
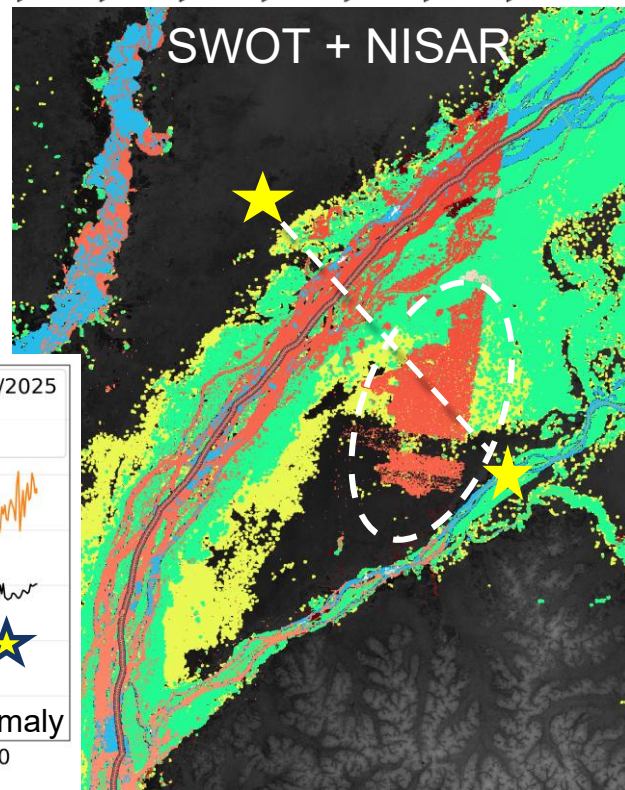
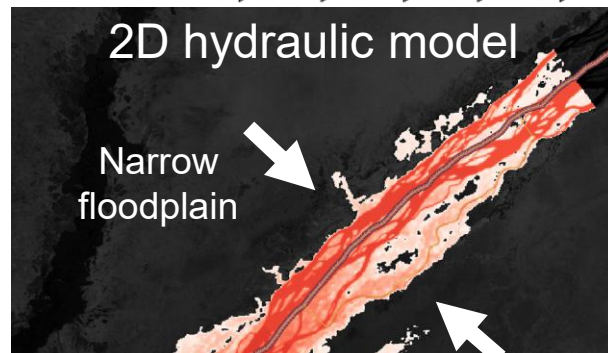
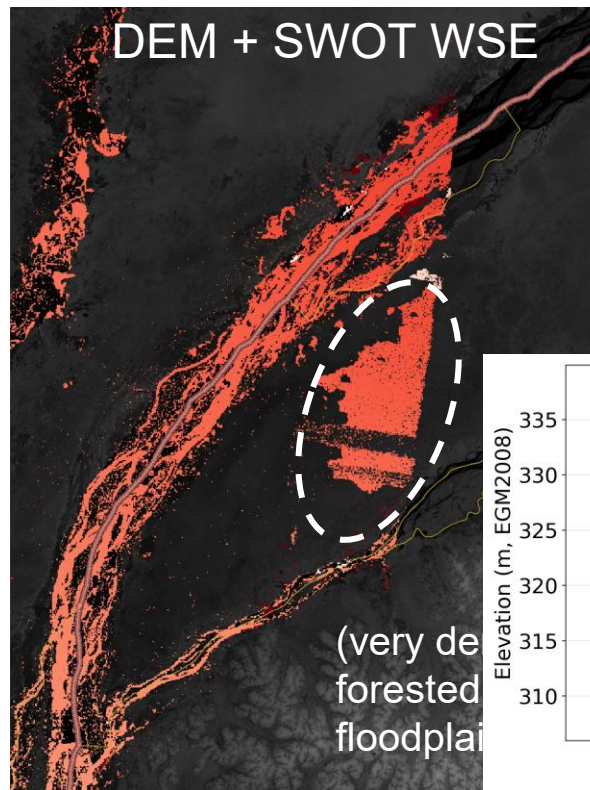
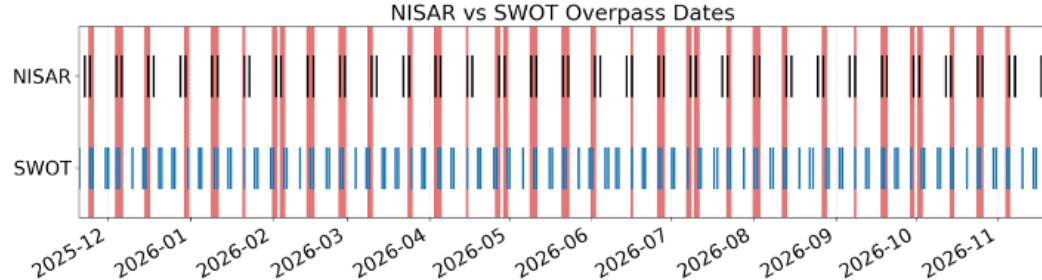


0 20 40 km

# SWOT + NISAR

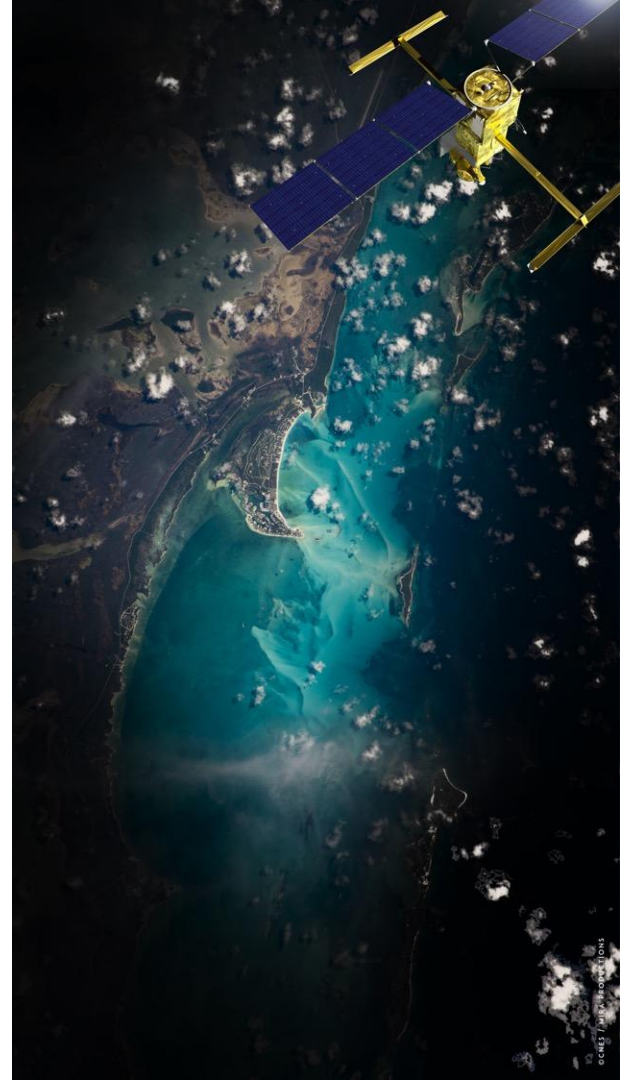
## Middle Congo River, DRC

December 16, 2025



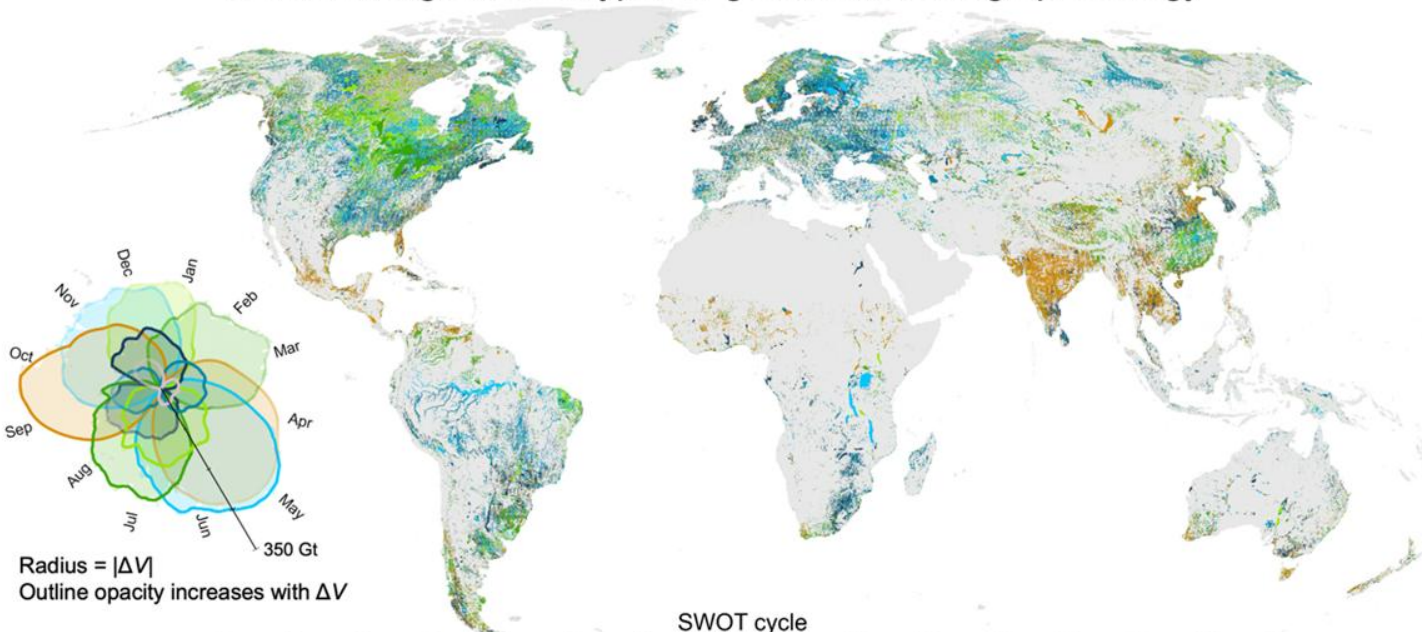
# Take-home Messages

- Optical & SAR Surface Water Extent are mature and now regularly used operationally
  - Ongoing improvements using high-res commercial imagery
- SWOT has recently moved from understanding signals to doing big science, including river discharge
- NISAR is still in the understandings signals phase, but exciting science will come soon.
- SWOT + NISAR has the potential to change how we monitor floods, wetlands, and other processes



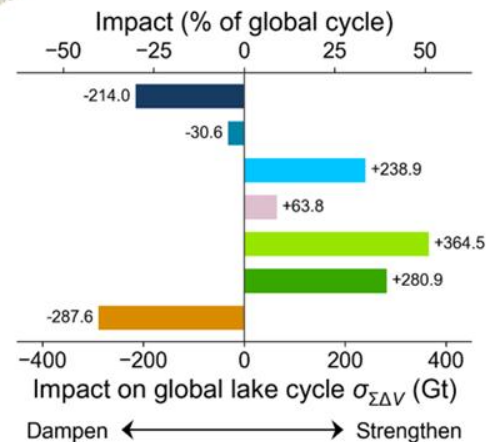
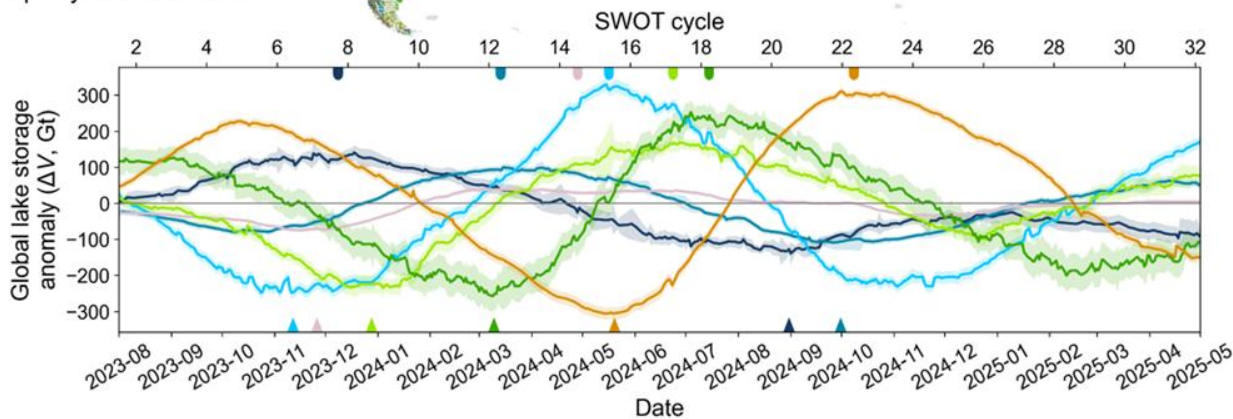
# Supplemental Slides

# Seven emergent archetypes of global lake storage phenology



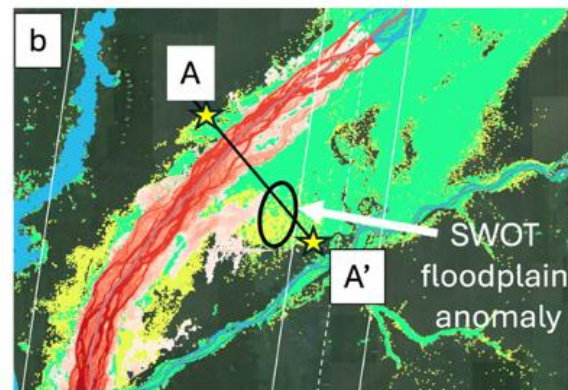
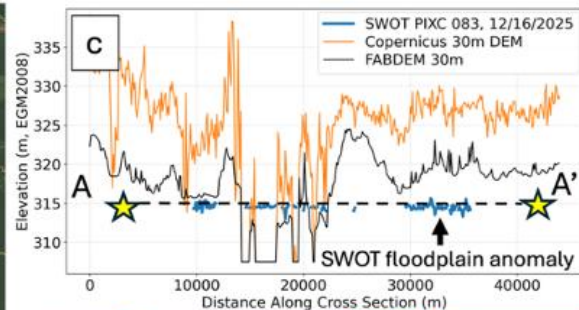
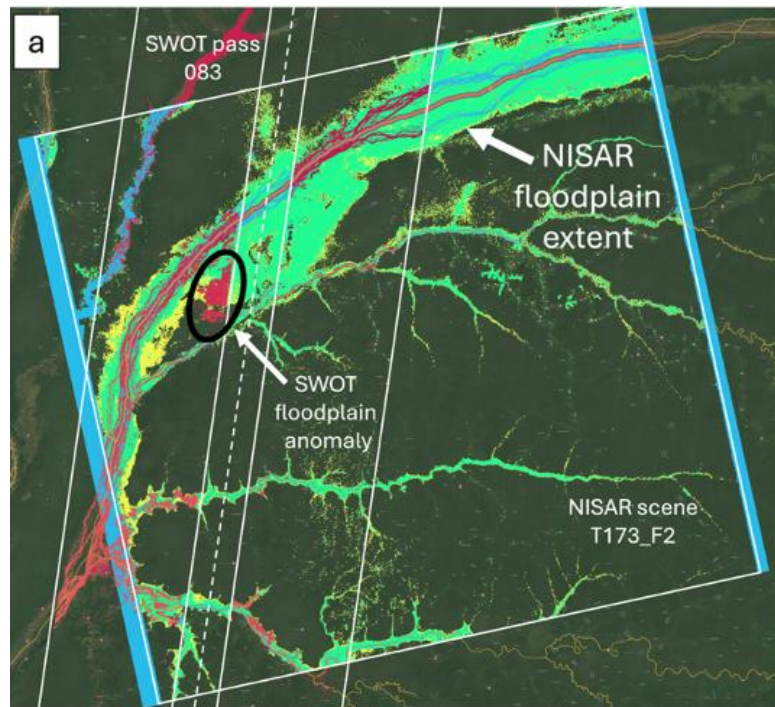
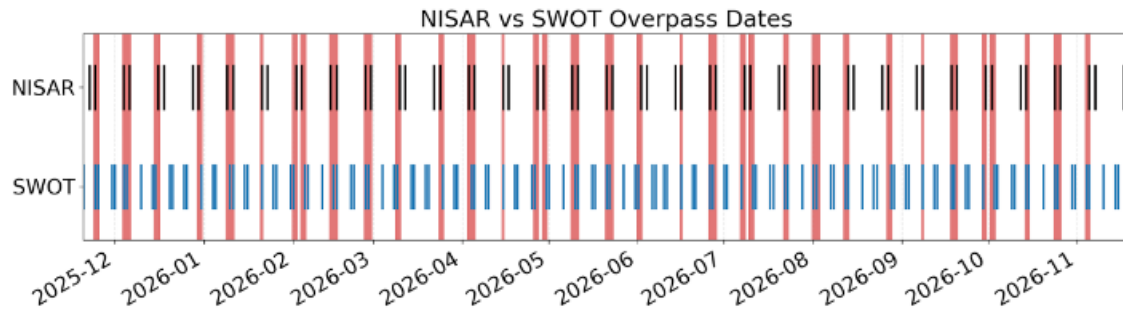
- P1** Cold-season high, warm-season low
- P2** Winter–early-spring peak; Austral summer peak
- P3** Spring peak, early winter low; Tropica wet-seasonal phase
- P4** Early-winter low, winter-spring plateau
- P5** Middle-winter trough, strong spring-summer recovery
- P6** Late-winter drawdown, summer crest
- P7** Monsoon summer–fall high, pre-monsoon low

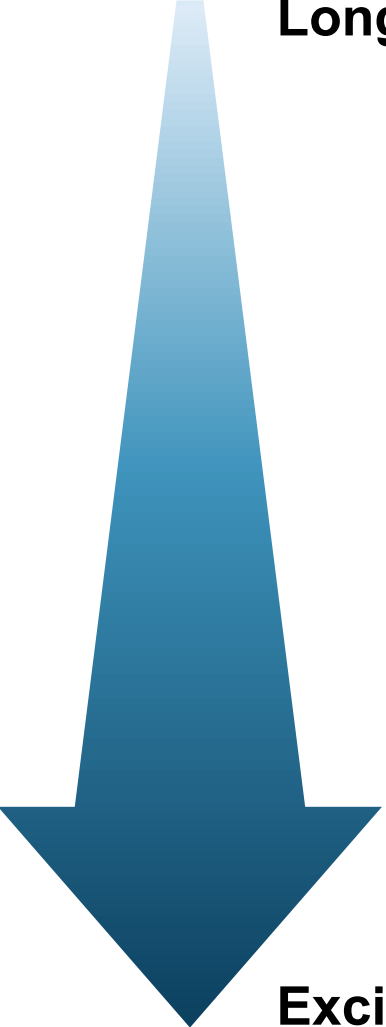
Season names follows Northern Hemisphere convention.



Dampen ← → Strengthen

# SWOT + NISAR





## Long-standing capabilities

Inundation Extent from Optical and Radar Imagery

Water Surface Elevation from Nadir Altimetry

Inundation extent from high-res commercial imagery

Global river discharge from SWOT

Global lake water storage from SWOT

Inundation extent and global wetland dynamics from NISAR

Fusing SWOT and NISAR for expanded scientific capabilities

## Exciting future directions