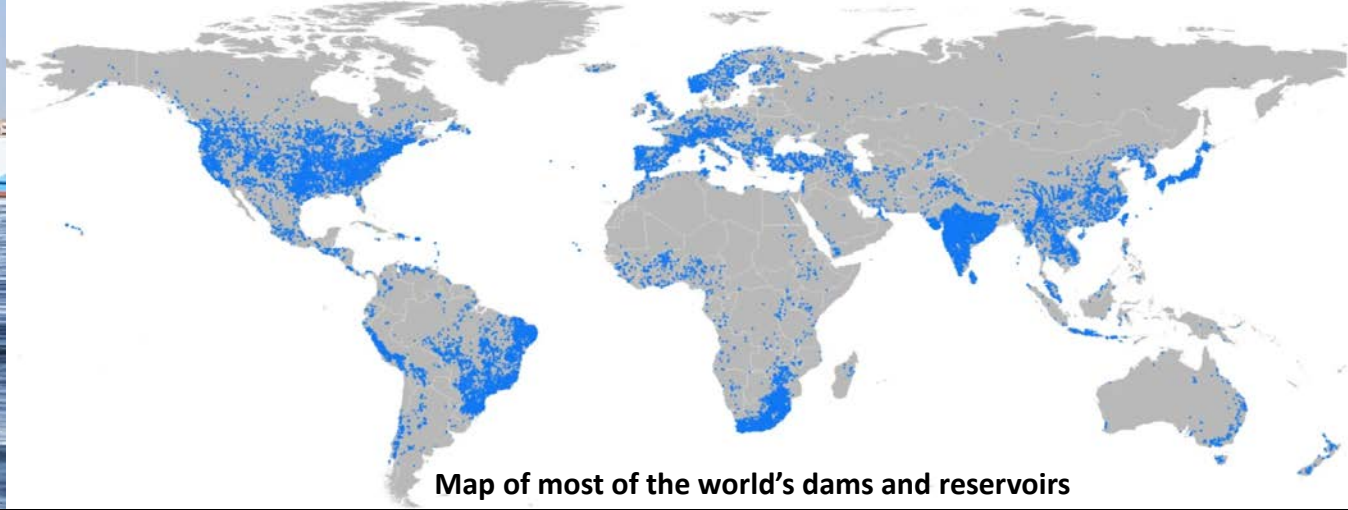
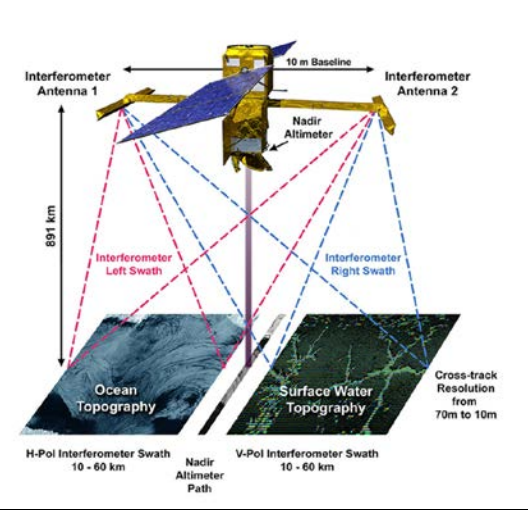




Low Aswan Dam, Egypt
(taken on December 2019)



Map of most of the world's dams and reservoirs



How Well Can We Track Global Reservoir Storage in the SWOT era?

Faisal Hossain

Department of Civil and Environmental Engineering
UNIVERSITY OF WASHINGTON



Galaxy S21 5G
2:16 PM

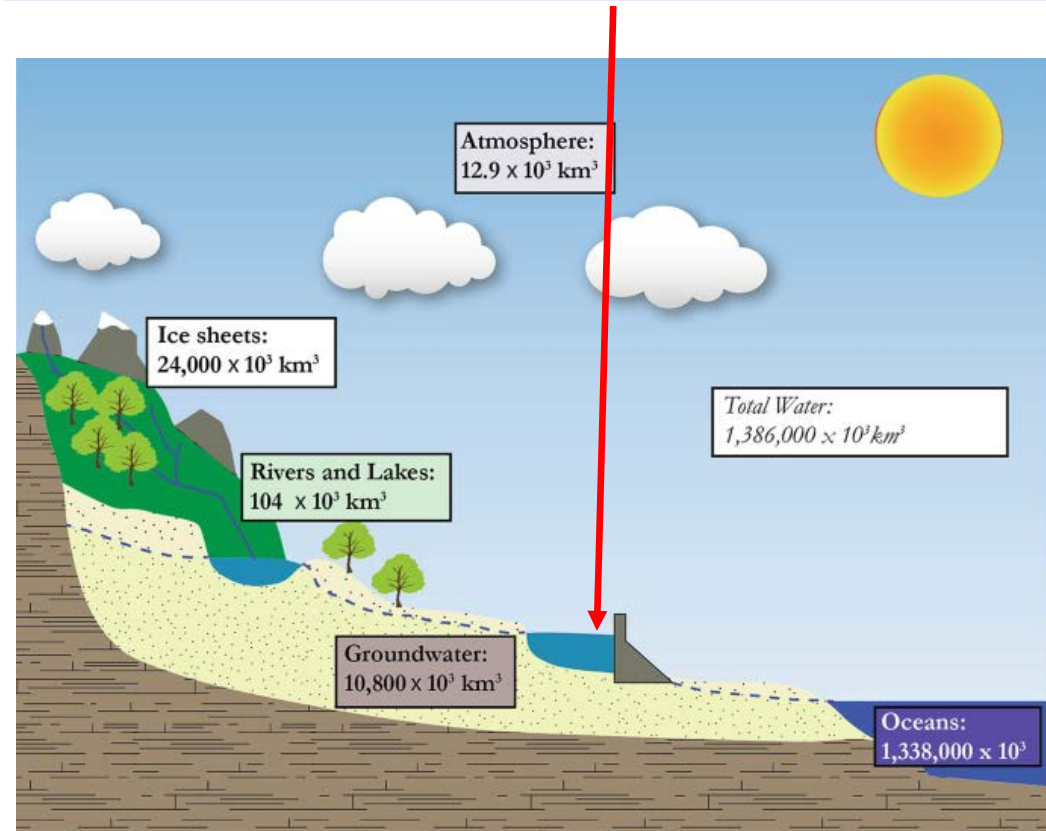
Itaipu Dam, Brazil (taken
on October 2024)

Regulated Surface Water Budget

Distribution of Earth's Water



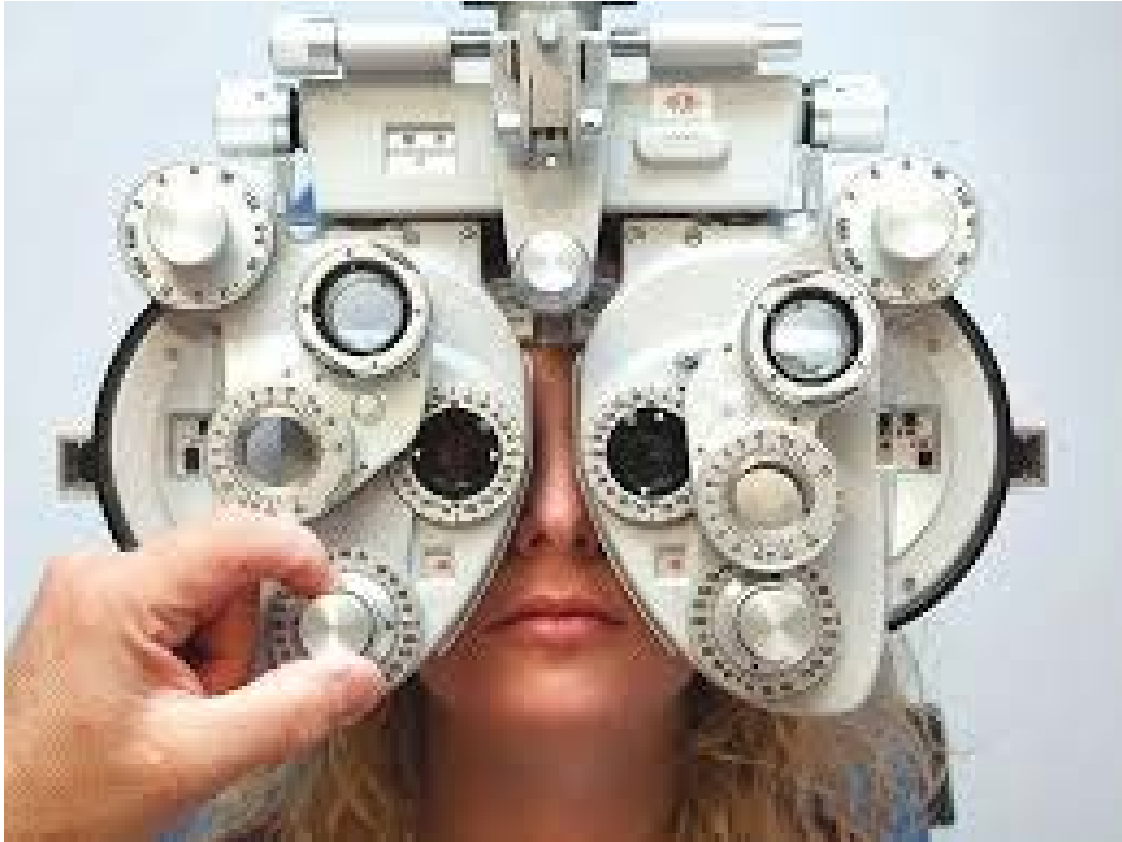
**How did we arrive at these numbers?
How much trust should we put on them?**



The FIRST Question

How well does SWOT capture reservoir storage relative to the non-SWOT (pre-2023) era?

The FIRST Question



E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
P E Z O L C F T D	11	

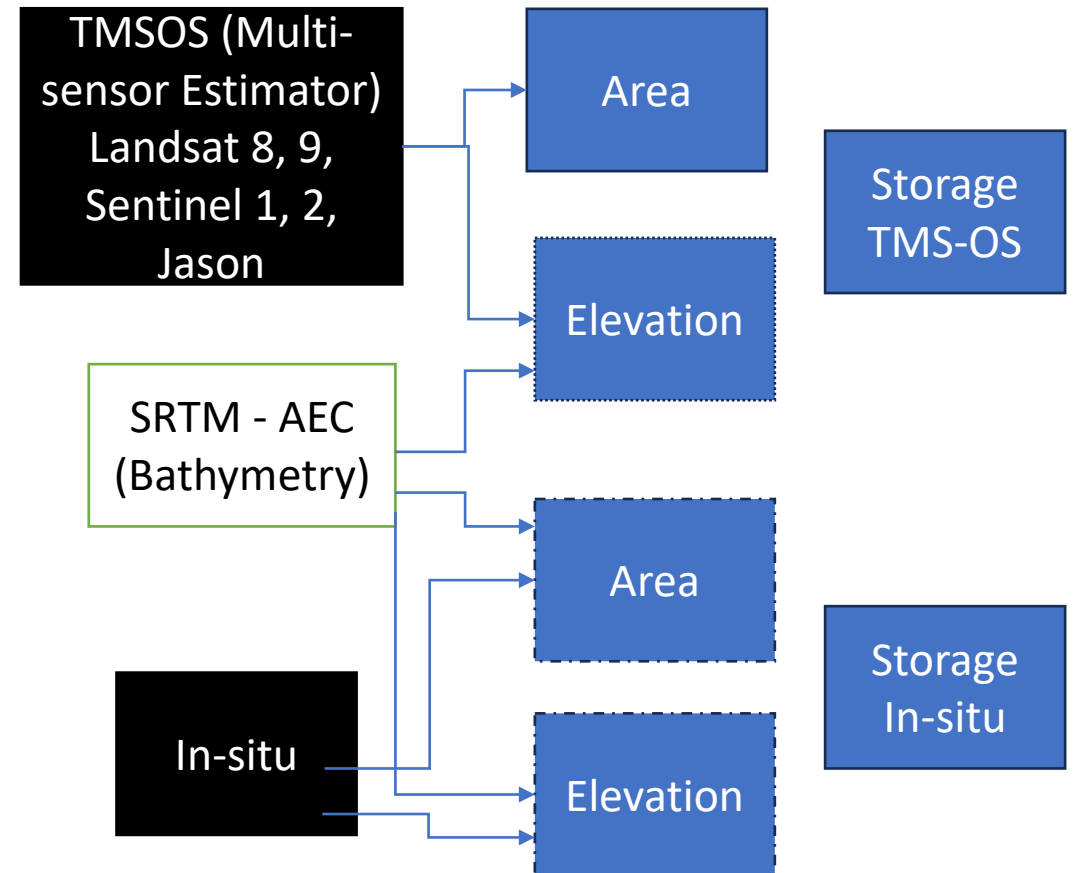
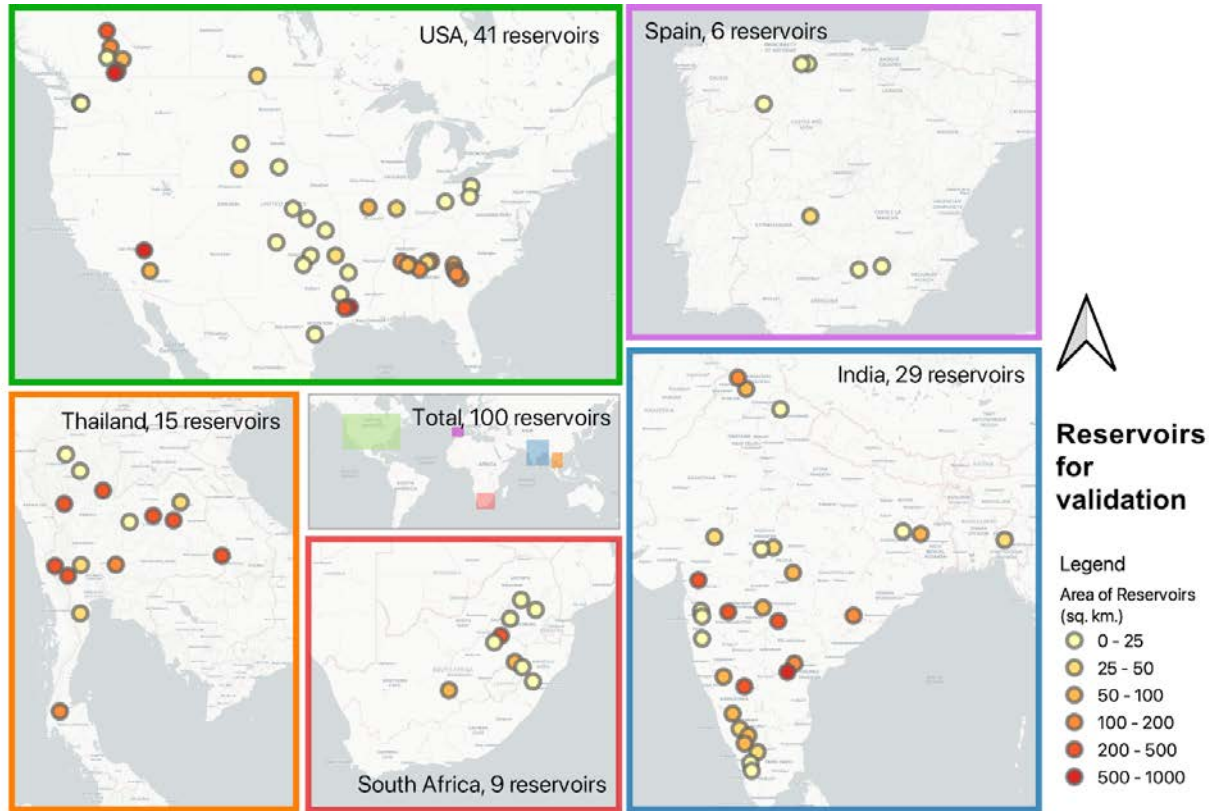
MODIS
Landsat
Sentinel 1,2
Sentinel-6
Jason series

SWOT - ?

How much does SWOT lens improve “20/20 vision” for regulated surface water storage?

Our Experimental Test-Bed

Non-SWOT (Pre-SWOT) Baseline: Multi-sensor Reservoir Storage Estimator (**TMS-OS**)

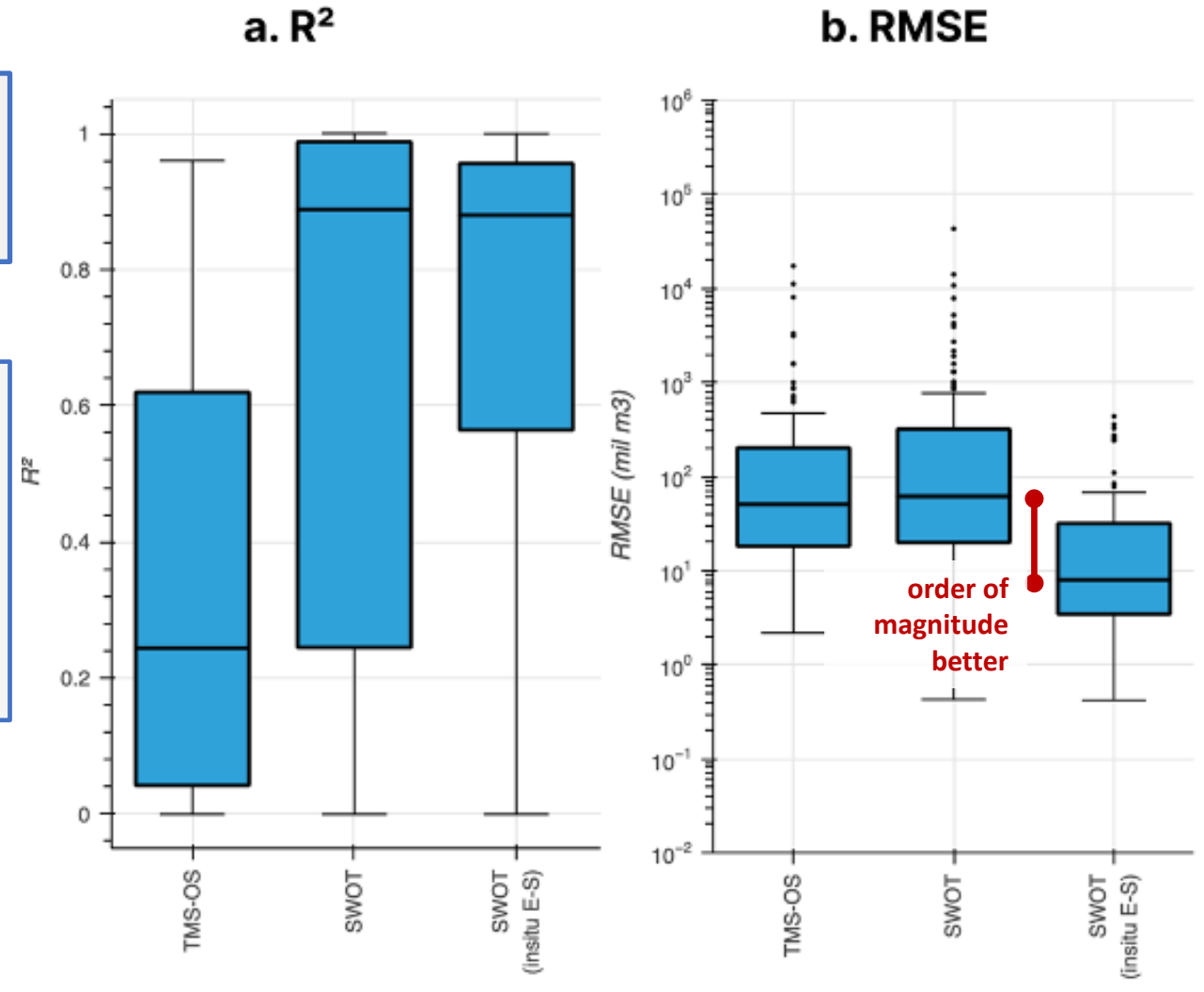


245 Reservoirs with in-situ and quality controlled observations on storage (direct or derived) reported by agencies

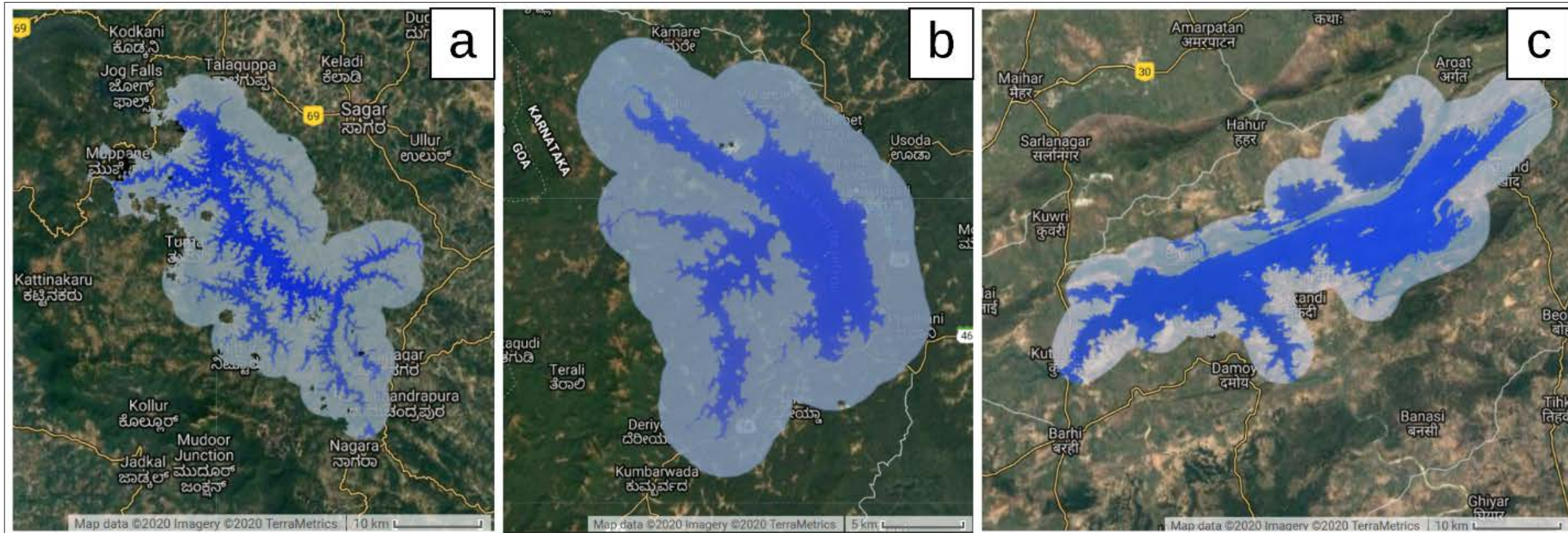
How well does SWOT really perform?

- SWOT captures **trends** in Storage better.

- Absolute storage **RMSE** decreases by an order using in-situ Elevation-Storage relation (in-situ bathymetry). R^2 remains the same.

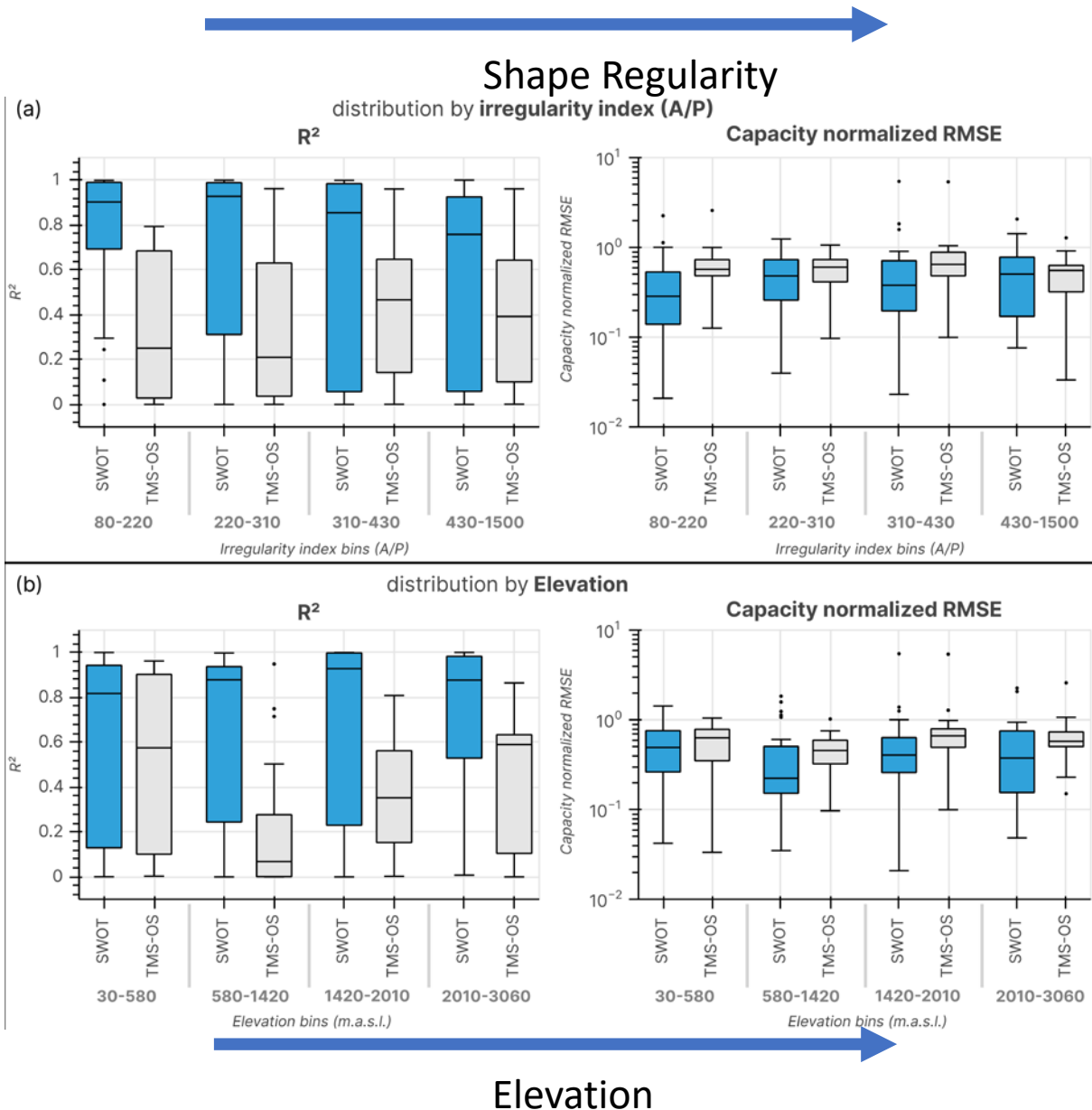


What about Reservoir Shape and Elevation?



Shape irregularity can be quantified as ratio of Area to shoreline length (A/P)

What about Reservoir Shape and Elevation?



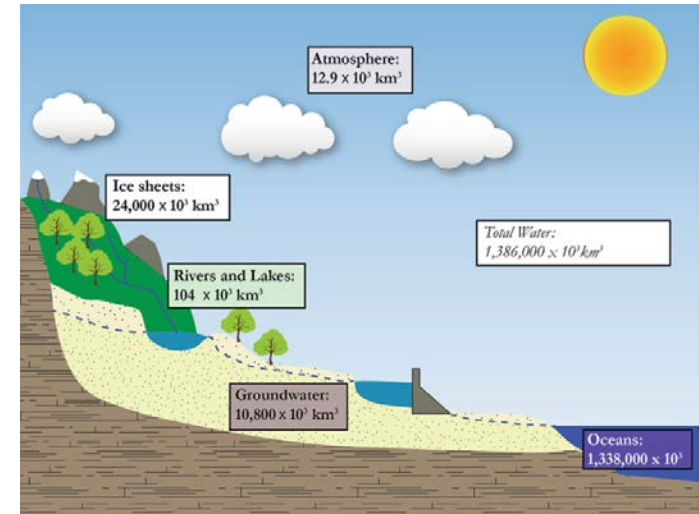
Relative to Pre/Non-SWOT:

- SWOT performance 'holds up'
- Trends are better and more consistently captured

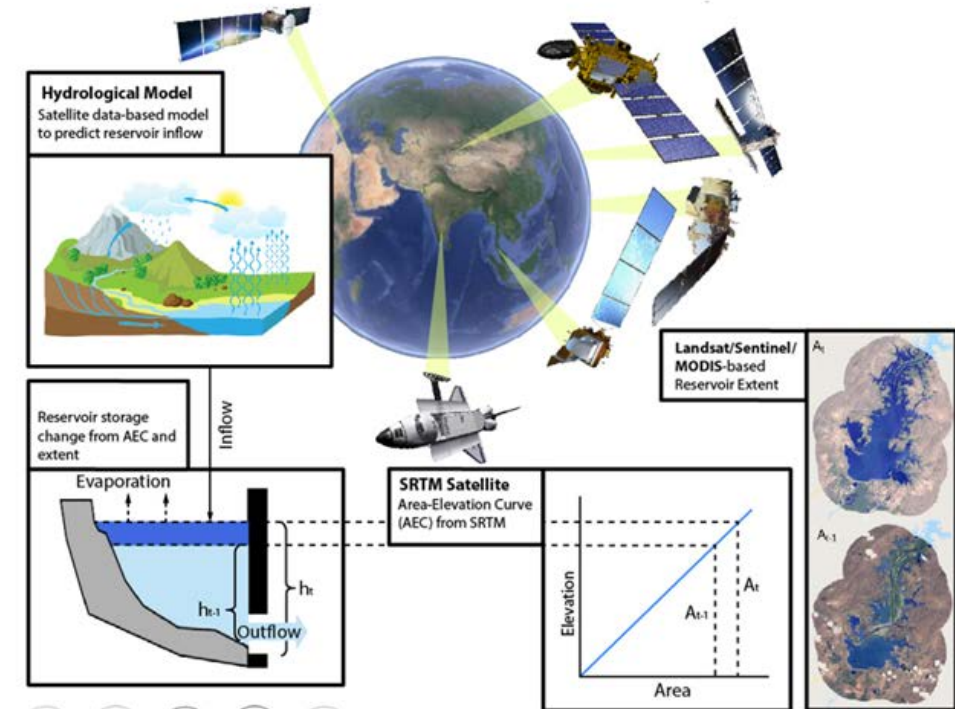
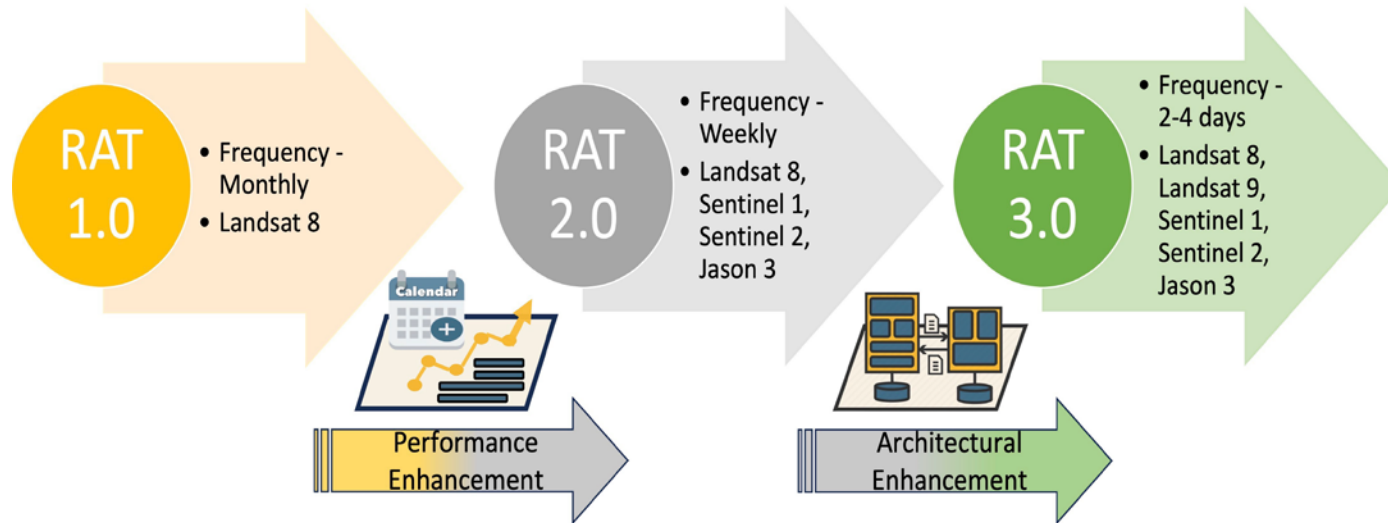
Das, P. and F. Hossain (2025), Multi-satellite Tracking of Surface Water Storage Change in the SWOT Era, *Earth and Space Science*, vol. 12

On-going Work: Extrapolating Globally

- *How much more precisely are we able to 'nail' Global Reservoir Storage estimate with the help SWOT? (down to 1, 10, or 100 km³ uncertainty?)*
- *Can we use SWOT to create High-Resolution Multi-sensor Reservoir Storage 'Reanalysis' going back to 1980s?*
- *How to improve water management & food security?*



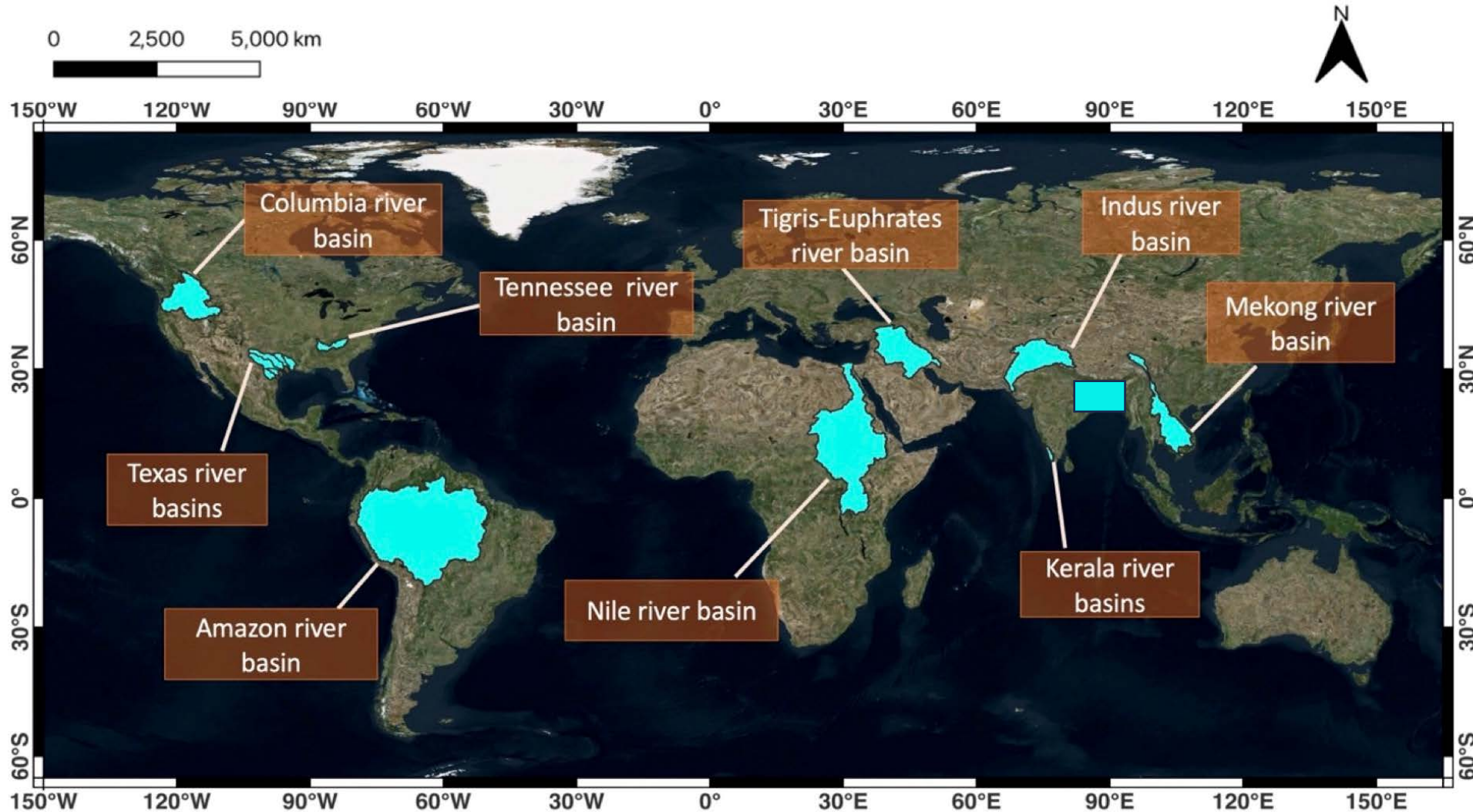
On-going Work: Extrapolating Globally



RAT – Reservoir Assessment Tool ver 3.0
<http://ratdocs.io> www.satellitedams.net (15k downloads since 2023)

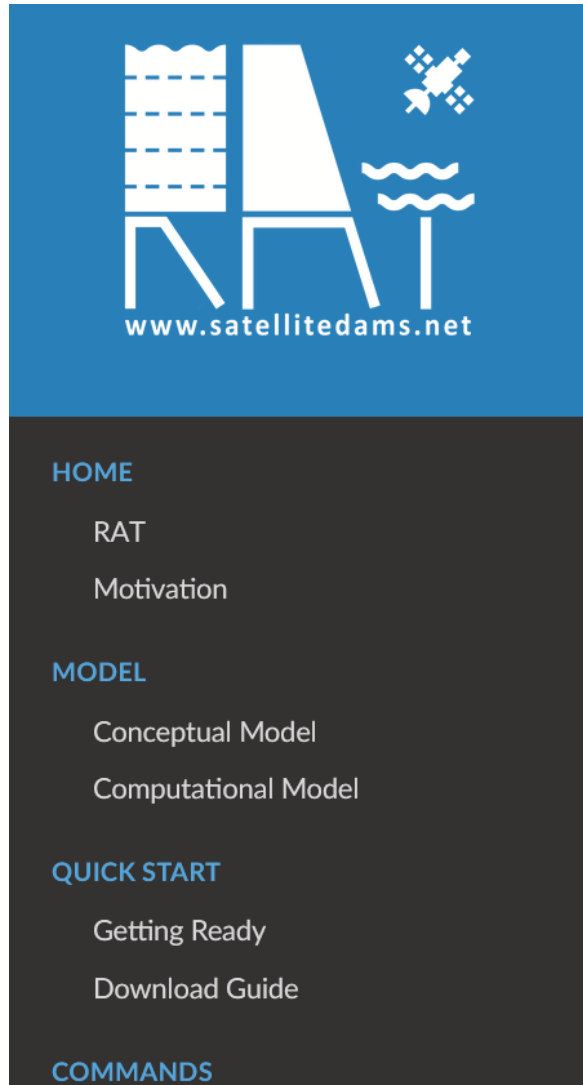
Minocha, S., et al. (2024) Reservoir Assessment Tool Version 3.0: A Scalable and User Friendly Software Platform to Mobilize the Global Water Management Community, *Geoscience Model Development*, vol. 17(8)

Global Water Management Implications



A growing user base for Satellite-based Reservoir Tracking using RAT 3.0

SWOT Plugin for Reservoir Tracking



» Plugins » SWOT

[Edit on GitHub](#)

<https://rat-satellitedams.readthedocs.io/en/latest/>

RAT-SWOT

Developed under JPL summer internship program 2025

The **SWOT Plugin** integrates with RAT to enable estimation of reservoir storage change, evaporation, and outflow using SWOT-derived surface water observations. It leverages the **Hydrocron API** to extract **surface area** and **water surface elevation** time series for reservoirs and lakes.

The plugin requires a set of parameters in the configuration file. Outputs are organized methodically into sub-directories inside the `final_outputs/swot/` directory.

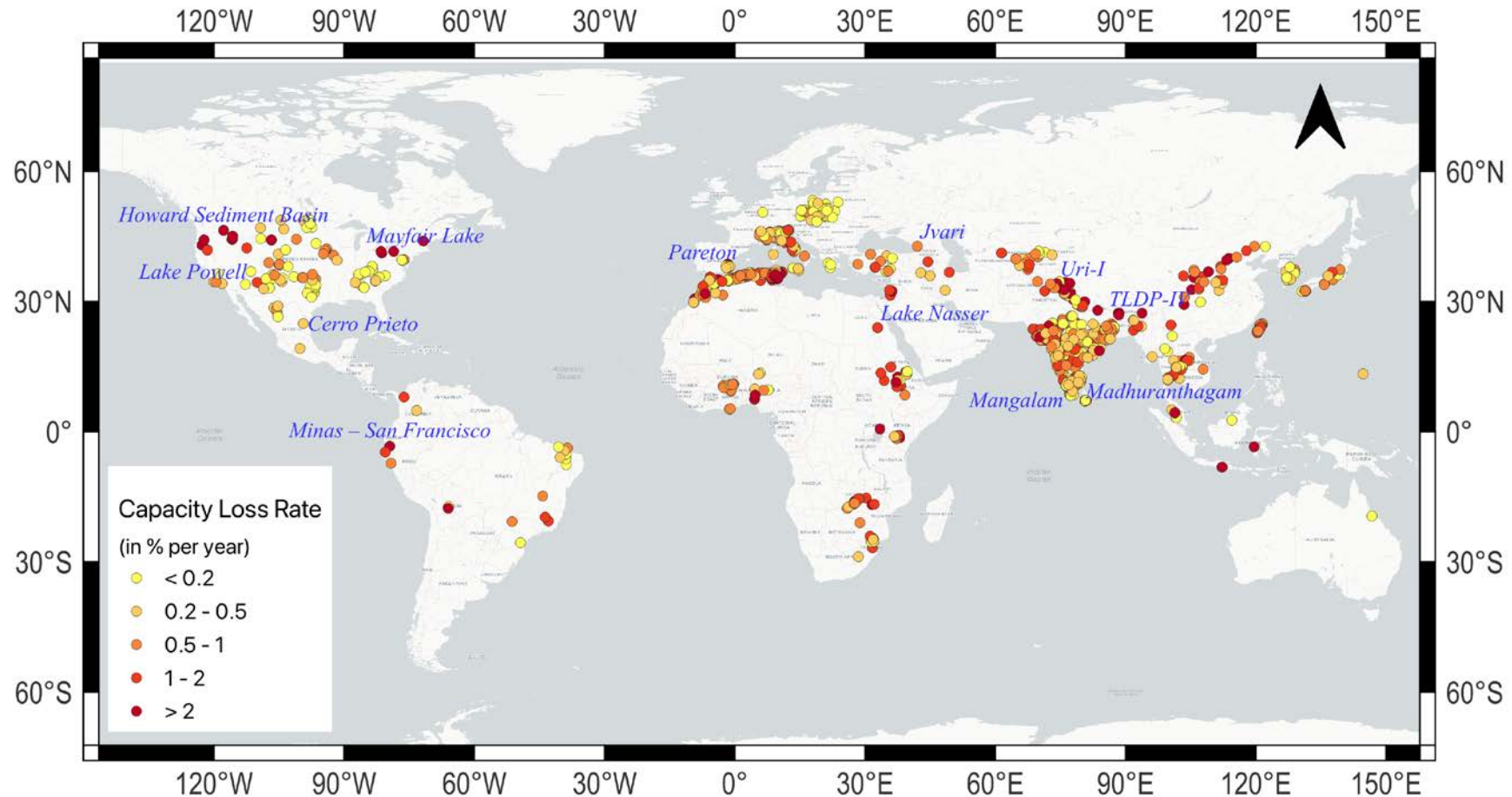
Note

The SWOT plugin currently supports three estimation methods:

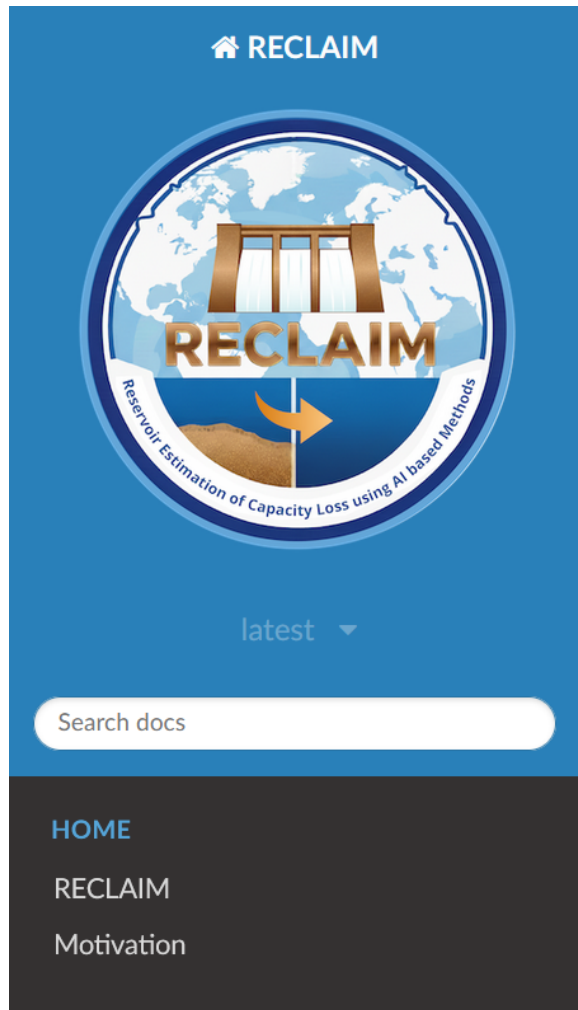
- `elevation_based`
- `sarea_based`
- `elevation_sarea_based`

Each method differs in how SWOT data (area/elevation) and AEC (Area-Elevation Curve) are utilized to estimate storage change

Global Reservoir Inventory of Lost Storage by Sedimentation (GRILSS)



Reservoir Estimation of Capacity Loss Using AI Methods (RECLAIM)



🏠 / RECLAIM

[View page source](#)

RECLAIM <https://reclaimio.readthedocs.io/en/latest/>

First-of-its-kind globally scalable tool to predict reservoir sedimentation, screen vulnerable reservoirs, and pinpoint those struggling the most.

RECLAIM (*Reservoir Estimation of Capacity Loss using AI-based Methods*) is a globally scalable framework for predicting **absolute sedimentation rates** in reservoirs. It integrates observed records with multi-decadal Earth observations from satellites to provide:

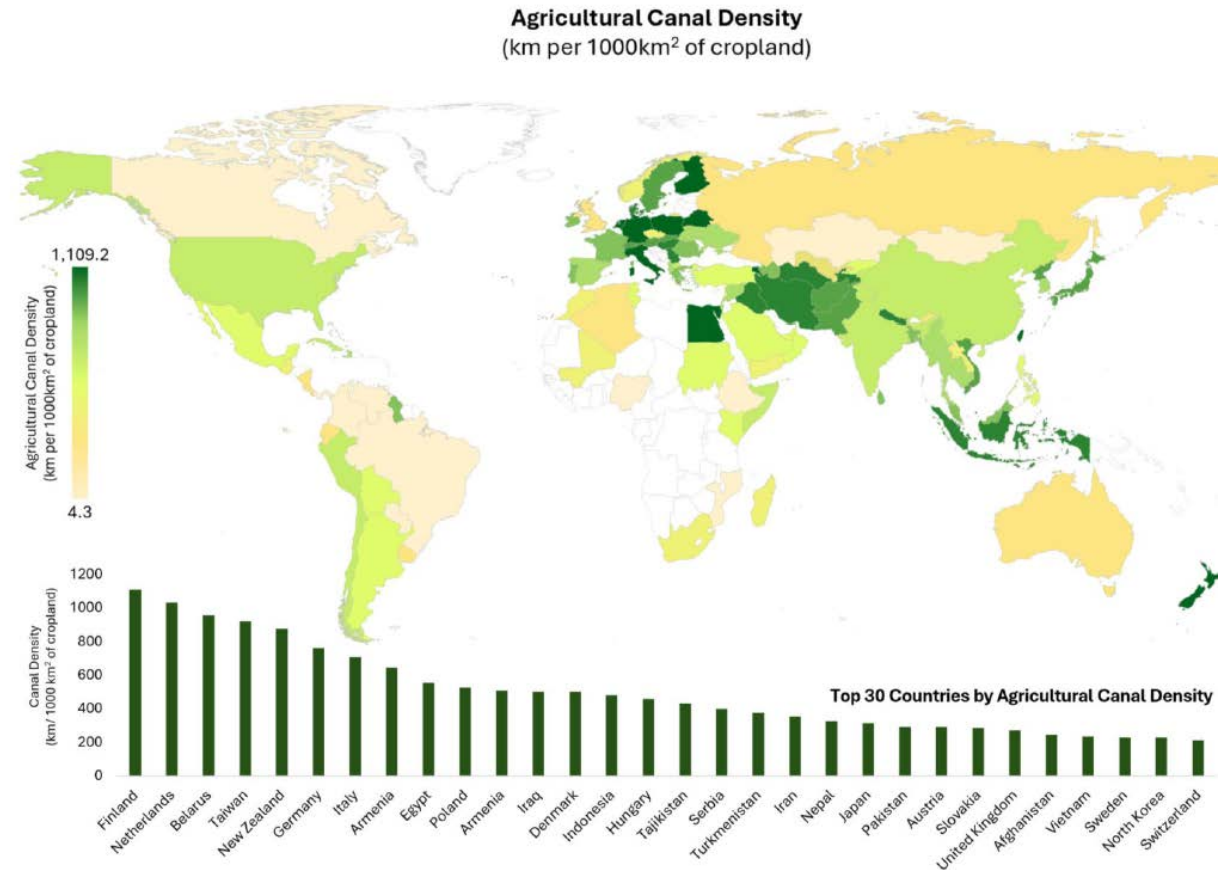
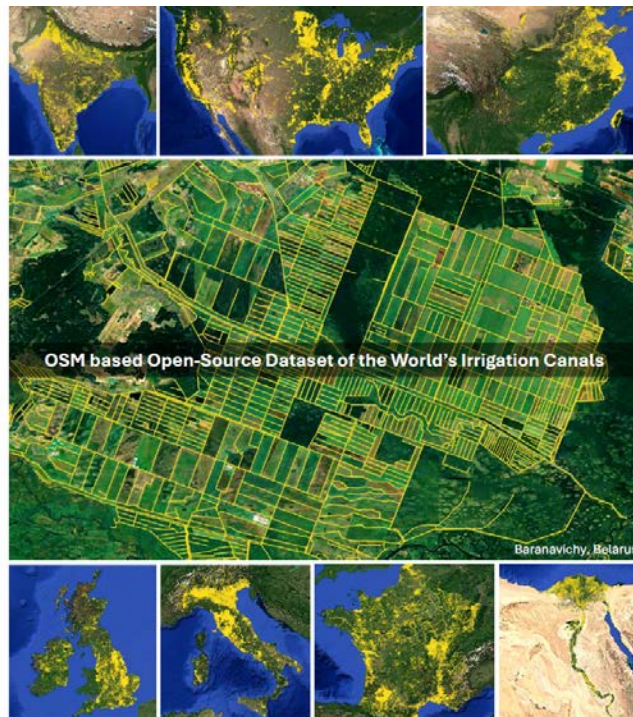
- **Rapid assessment** of sedimentation risk
- **Scalable predictions** across diverse climates and geographies
- **Cost-effective screening** to prioritize reservoirs for detailed surveys
- **Decision support** for planning mitigation interventions where they are most urgently needed

Note

RECLAIM is designed as a screening tool – not a replacement for detailed field surveys, but a way to guide **where and when to act first**.

Minocha, S., F. Hossain, J Zhao, E Istanbuluoglu (2025), RECLAIM: A Globally Scalable Machine Learning Framework to Predict Reservoir Sedimentation and Capacity Loss from Satellite-based Earth Observations (*In review*)

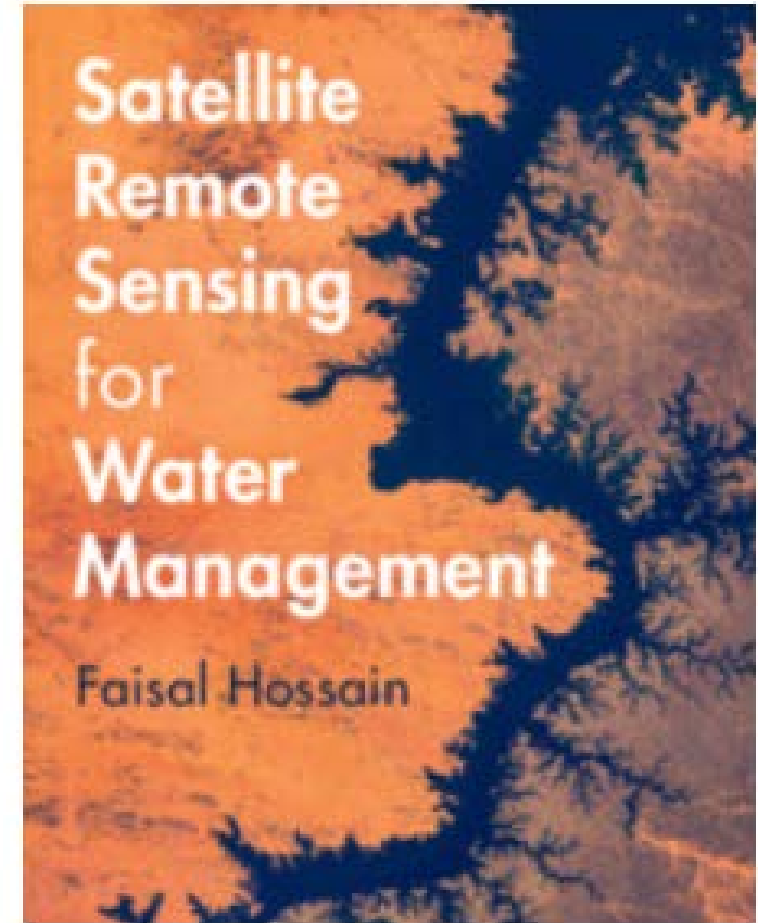
Global Registry of Agricultural Irrigation Networks (GRAIN) – For a SWOT-based Irrigation Canal Product



Suresh, S. F. Hossain and V. Mishra. (2025), [GRAIN](#): Global Registry of Agricultural Irrigation Networks, *Earth System Science Data* (In review)

ACKNOWLEDGEMENTS

- UW - Pritam Das, Sanchit Minocha, Shahzaib Khan, Sarath Suresh, George Darkwah
- NASA Physical Oceanography Program
- NASA Earth Action (Water)
- NSF Future Rivers (NRT Program)
- NASA-USAID SERVIR program

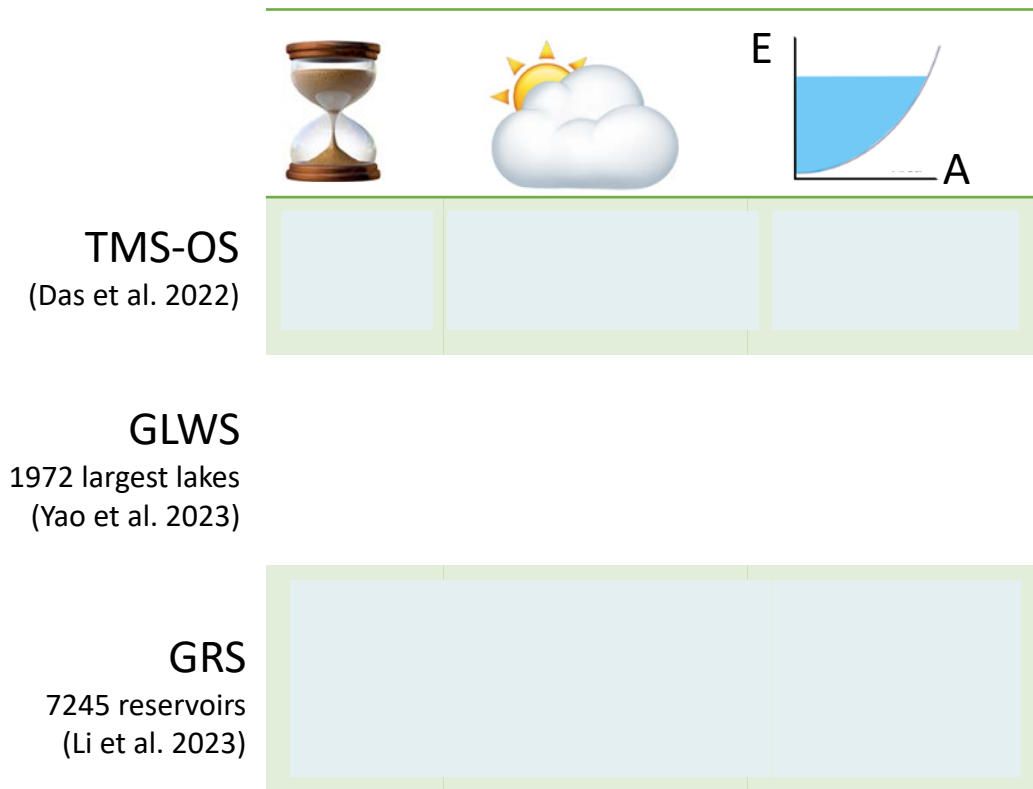


SWOT is covered in one of the chapters

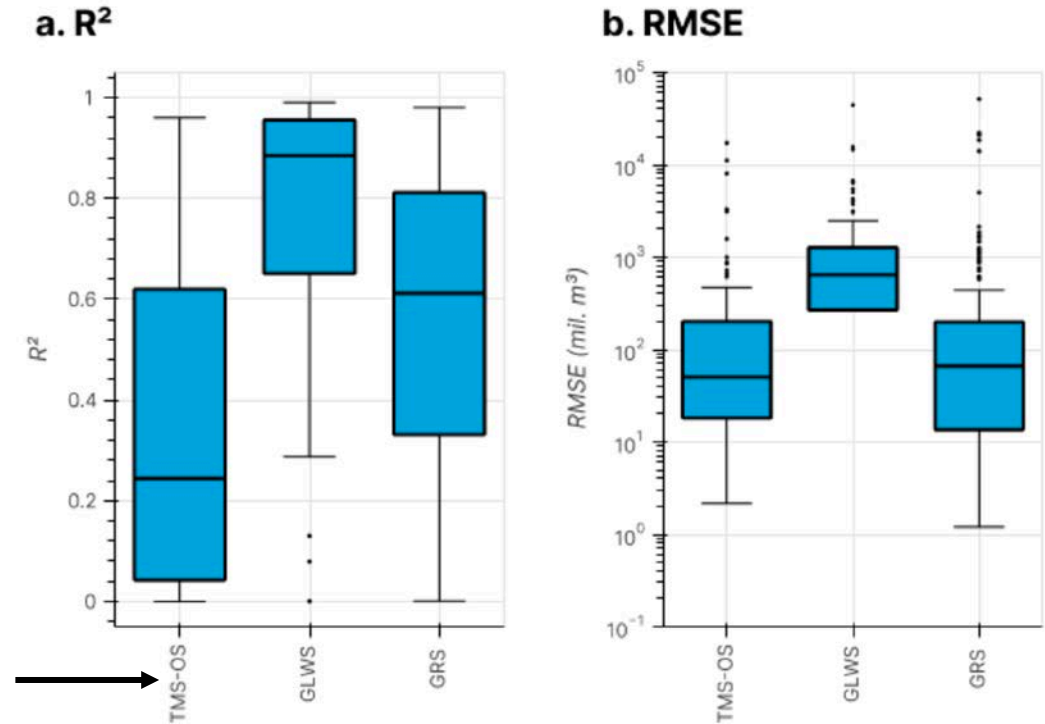
THANK YOU

Questions?

TMS-OS as a Non-SWOT Baseline for Reservoir Storage Estimator

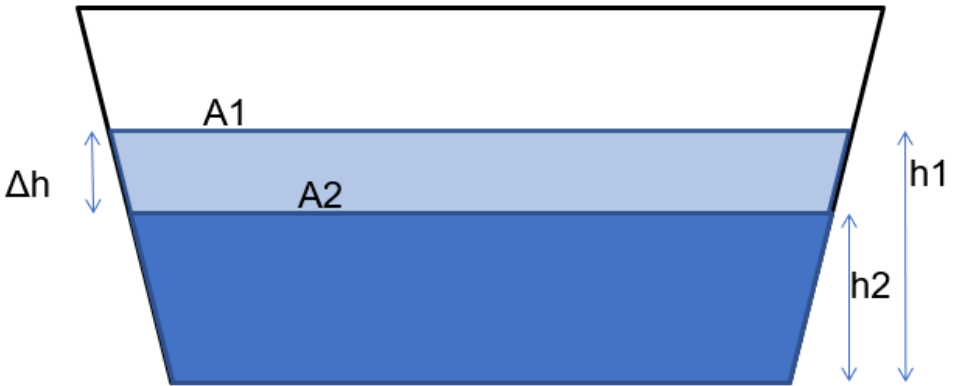
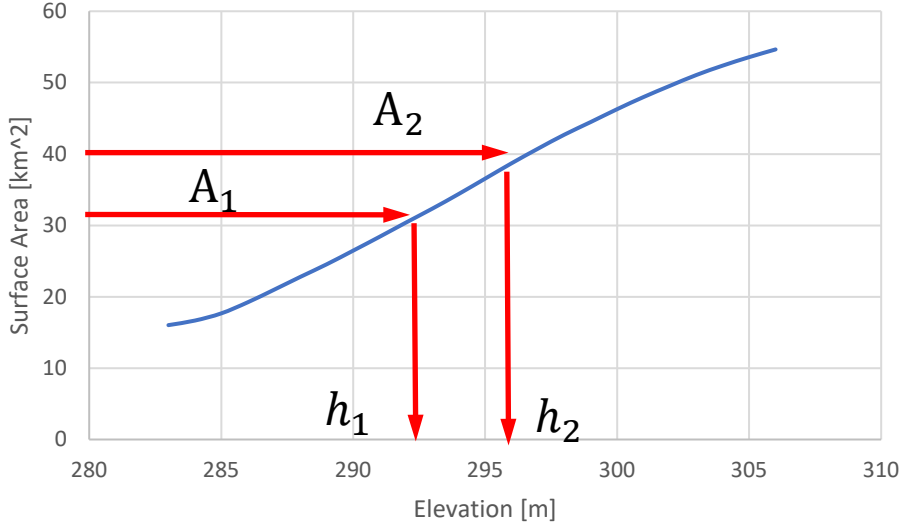
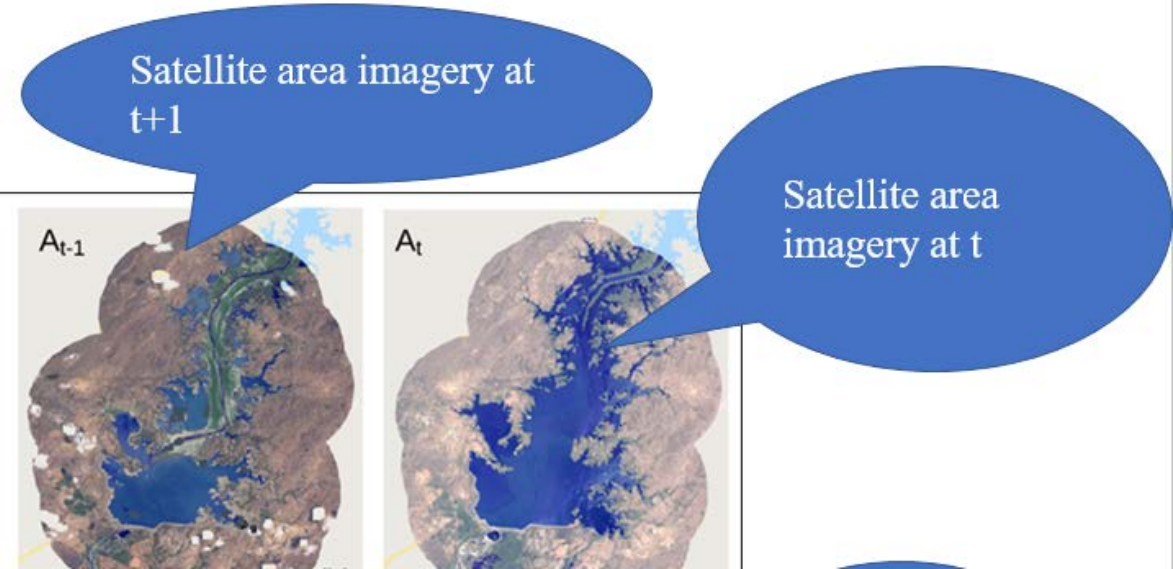


The only algorithm that has coincidental temporal coverage with SWOT.



- TMS-OS estimates ***S trends*** less accurately but **errors** in storage estimation is on-par with comparable datasets.
- TMS-OS is a suitable Pre/Non-SWOT baseline.

Satellite-based Reservoir Storage & Change: The Basics



$$\Delta S = A_{avg.} * \Delta h = \frac{(A_2 + A_1)}{2} * (h_2 - h_1)$$

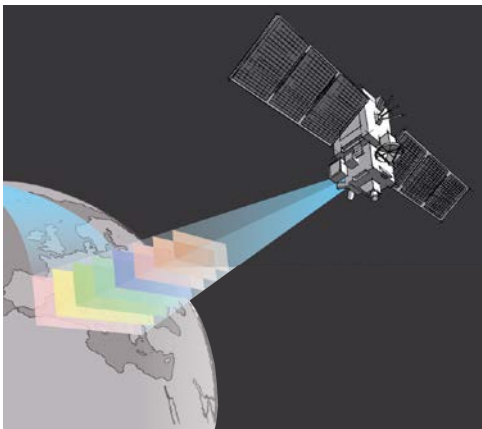
- **A (surface area)** – from optical/SAR satellite
- **h (water elevation)** – from AEC
- Alternately, **h** can be from satellite altimeters & A estimated from AEC. Both are not available simultaneously (NOT TRUE after 2022), hence AEC

TMS-OS as a Non-SWOT Baseline for Reservoir Storage Estimator

Tiered Multi-Satellite – Optical & SAR-

Addresses **individual (non-SWOT) sensor's weaknesses** using **additional sensors with complementary strengths** (*Das et al., 2022, Environ Mod Soft*)

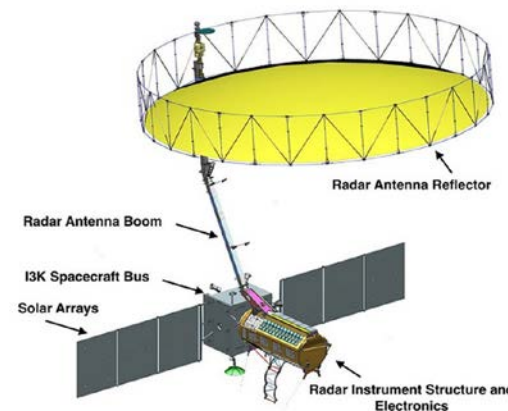
Optical Sensors



- ✗ Clouds, high sediments, algae are problems (challenging conditions)
- ✓ Accurate during good imaging conditions

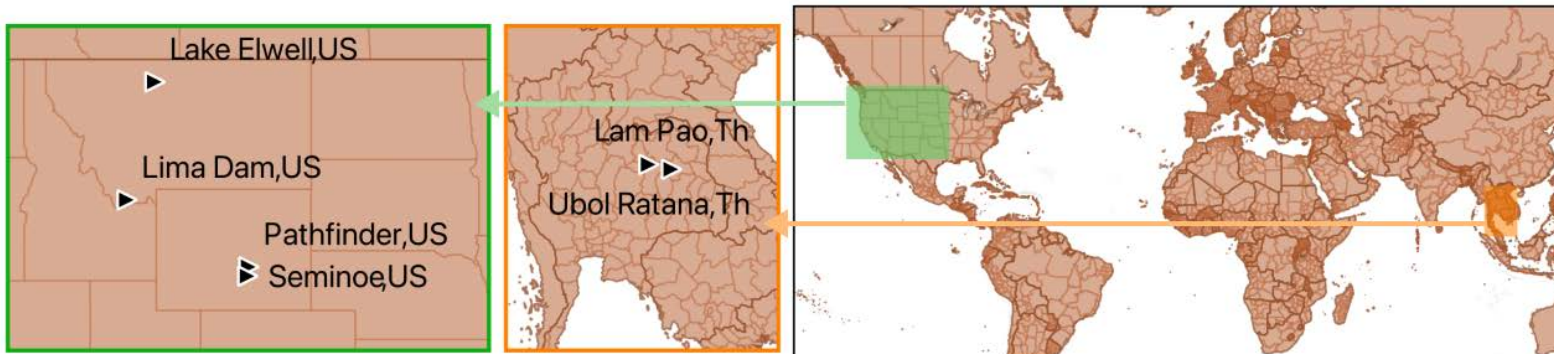
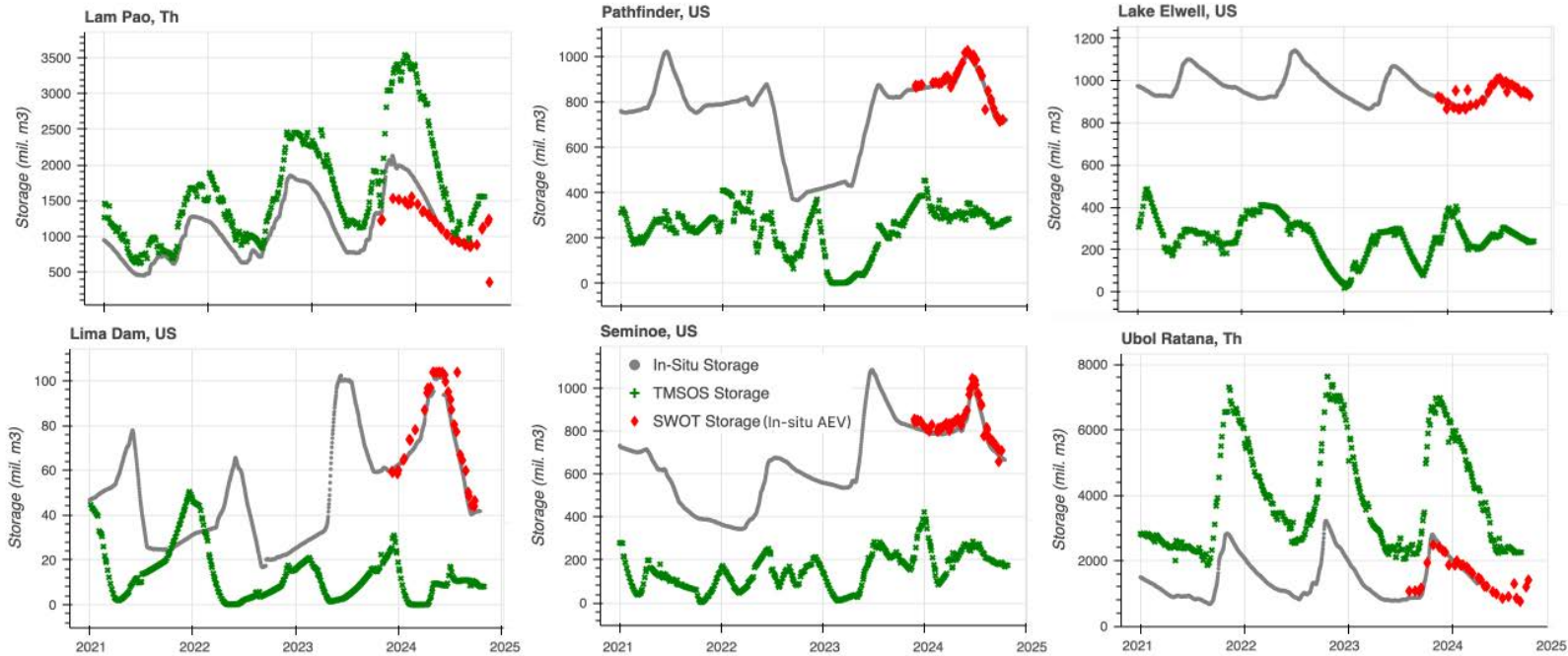
Source: https://www.materionbalzersoptics.com/userdata/Images_Applications/optics_balzers_application_remote_multi-spectral_imaging_space_0516.jpg

Synthetic Aperture Radar (SAR)



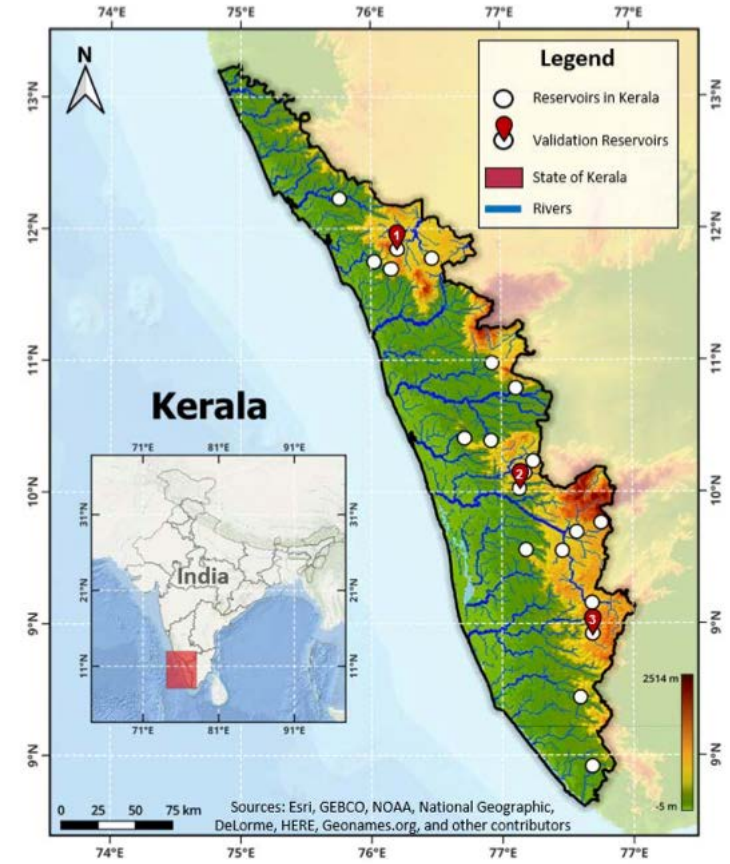
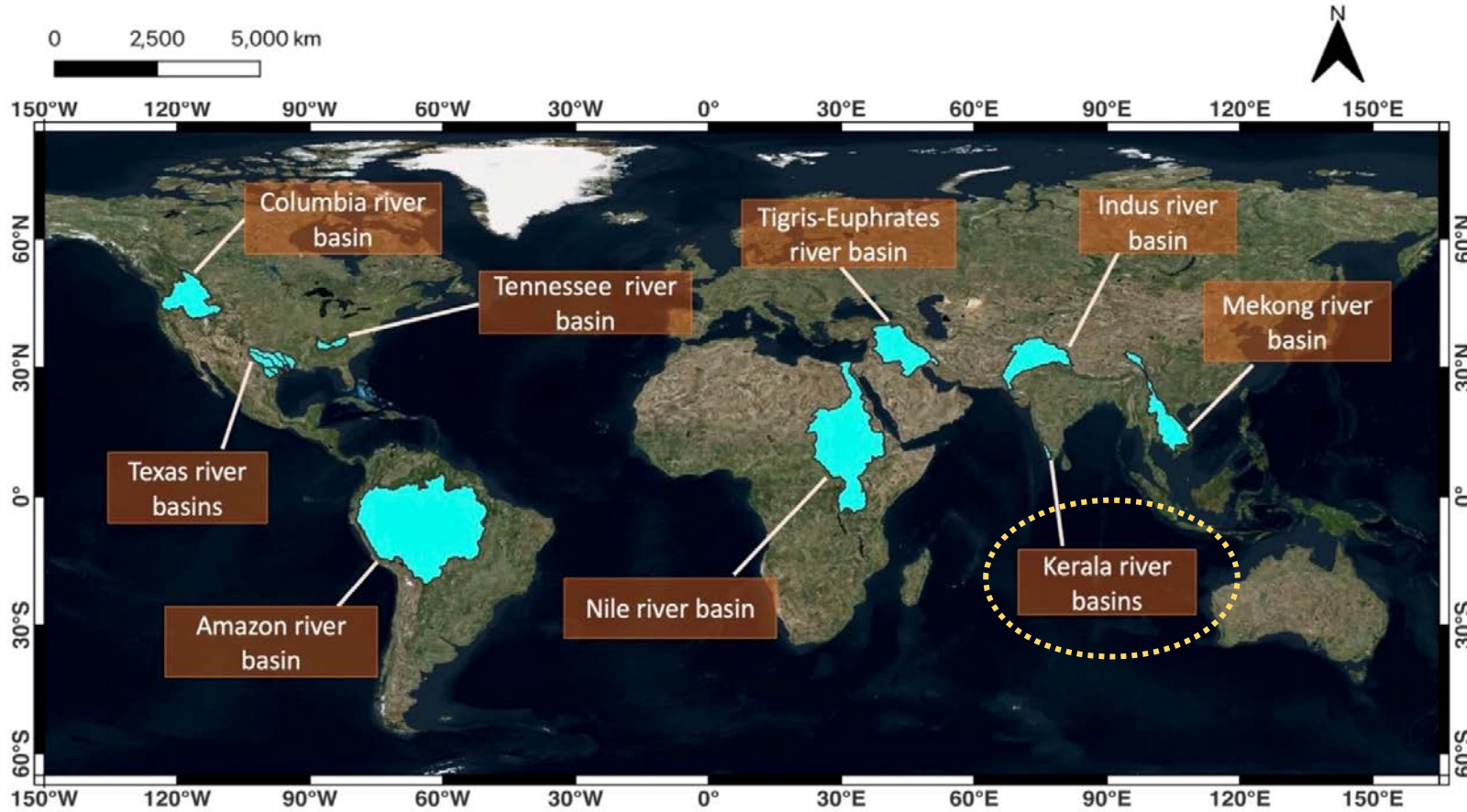
- ✓ Can penetrate clouds, relies on specular reflection
- ✗ Struggles with vegetation, shoreline – Bias problem

Key Takeaway



Time-series comparing TMS-OS and SWOT (with in-situ AEC) 21

Global Water Management Implications



RAT 3.0 was used to gauge the effectiveness of RAT 3.0 in tracking the events of the 2018 flood in Kerala, India

Global Water Management Implications

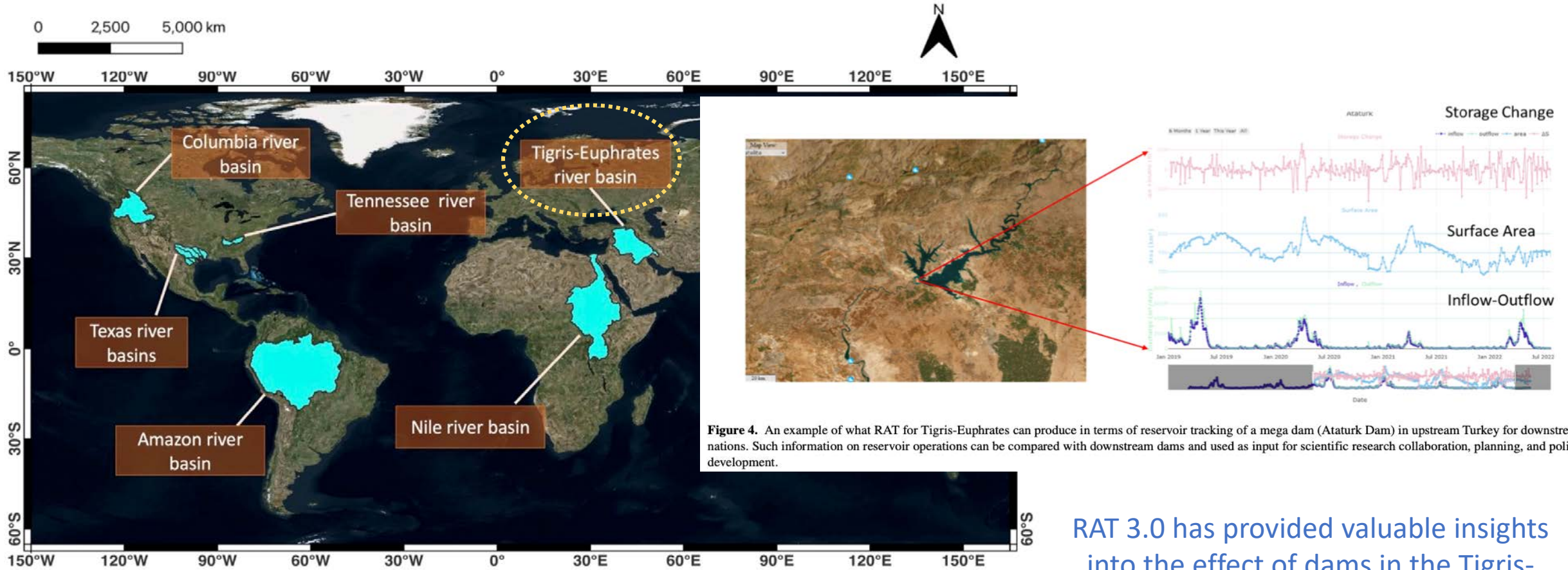
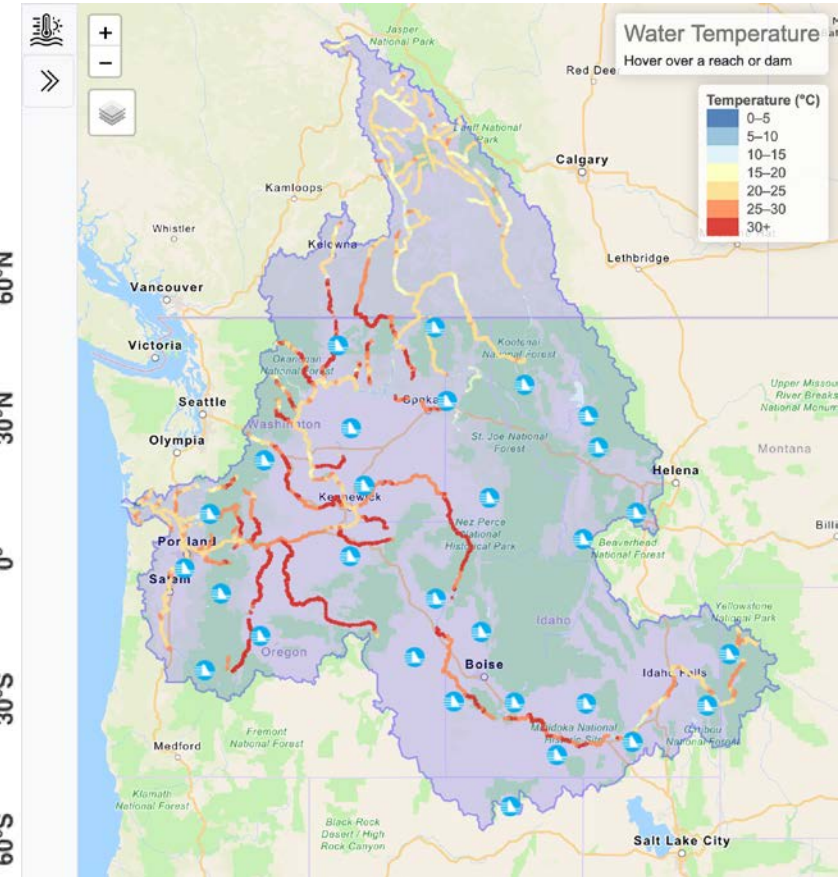
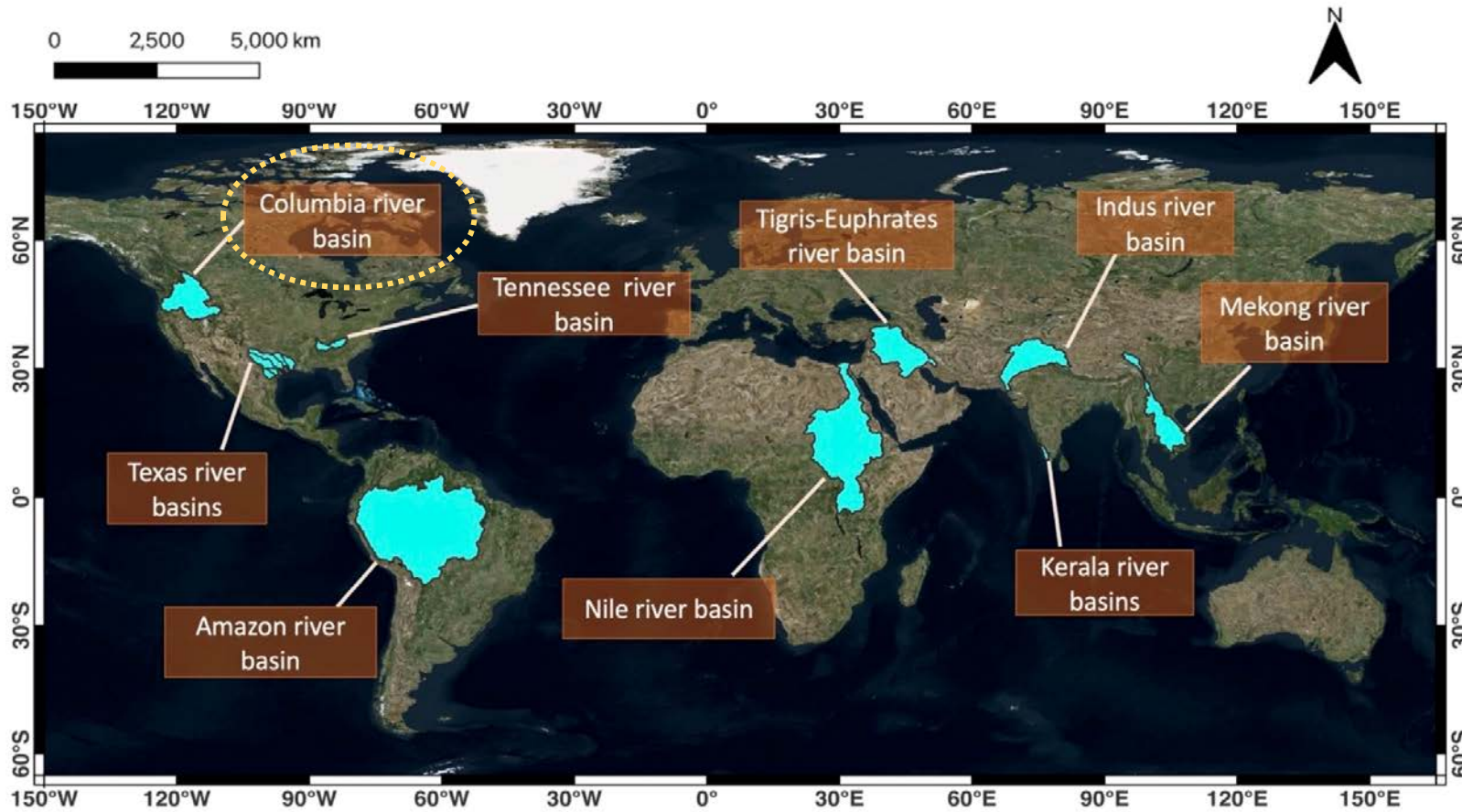


Figure 4. An example of what RAT for Tigris-Euphrates can produce in terms of reservoir tracking of a mega dam (Ataturk Dam) in upstream Turkey for downstream nations. Such information on reservoir operations can be compared with downstream dams and used as input for scientific research collaboration, planning, and policy development.

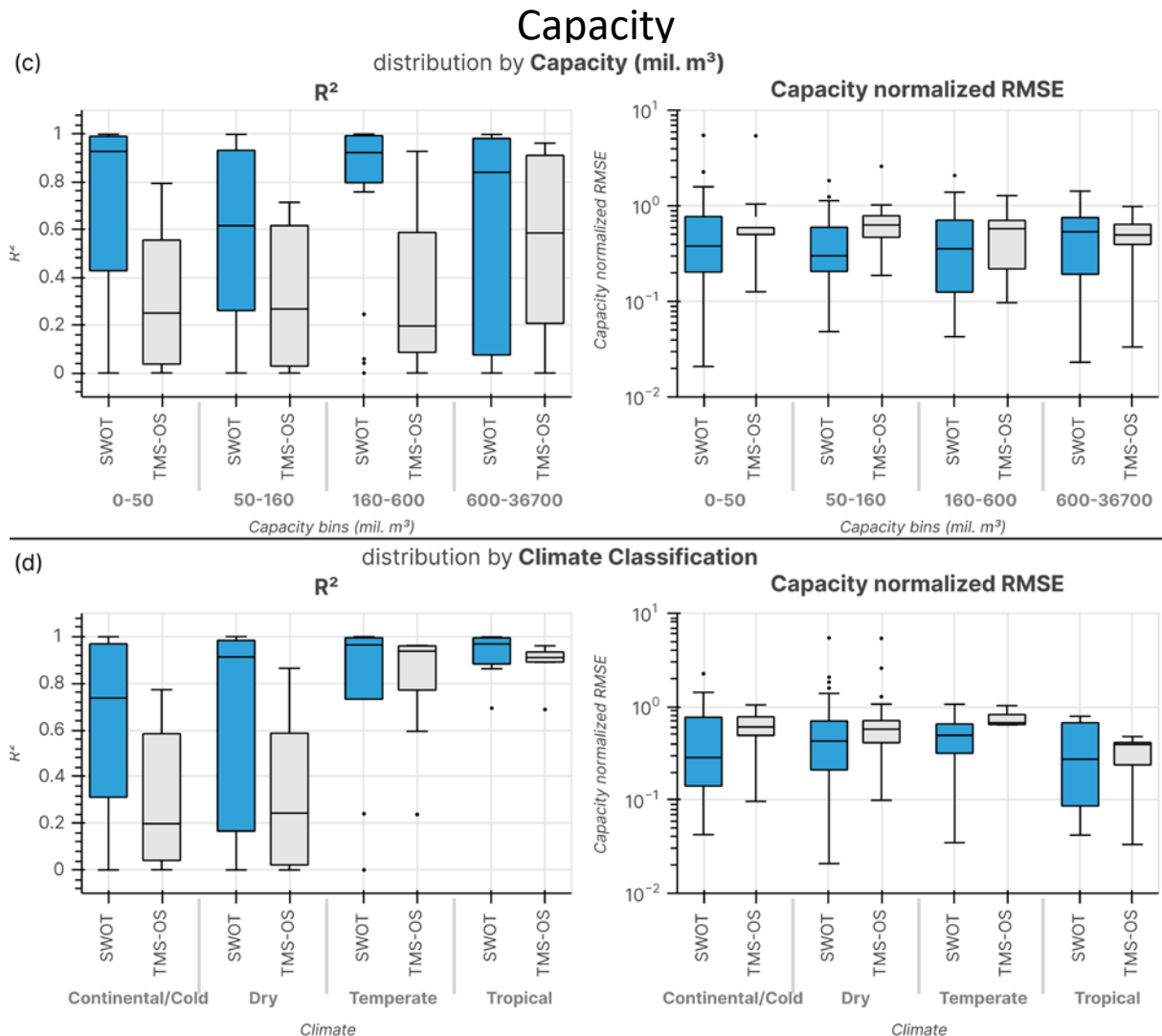
RAT 3.0 has provided valuable insights into the effect of dams in the Tigris-Euphrates river basin.

Global Water Management Implications



RAT 3.0 can be used to understand the effect of dams on downstream river temperature

What about Reservoir Capacity and Climate?



Relative to Pre/Non-SWOT:

- SWOT performance 'holds up'
- Trends are better and more consistently captured
- Accuracy comparable

Climate Classes (Koppen)