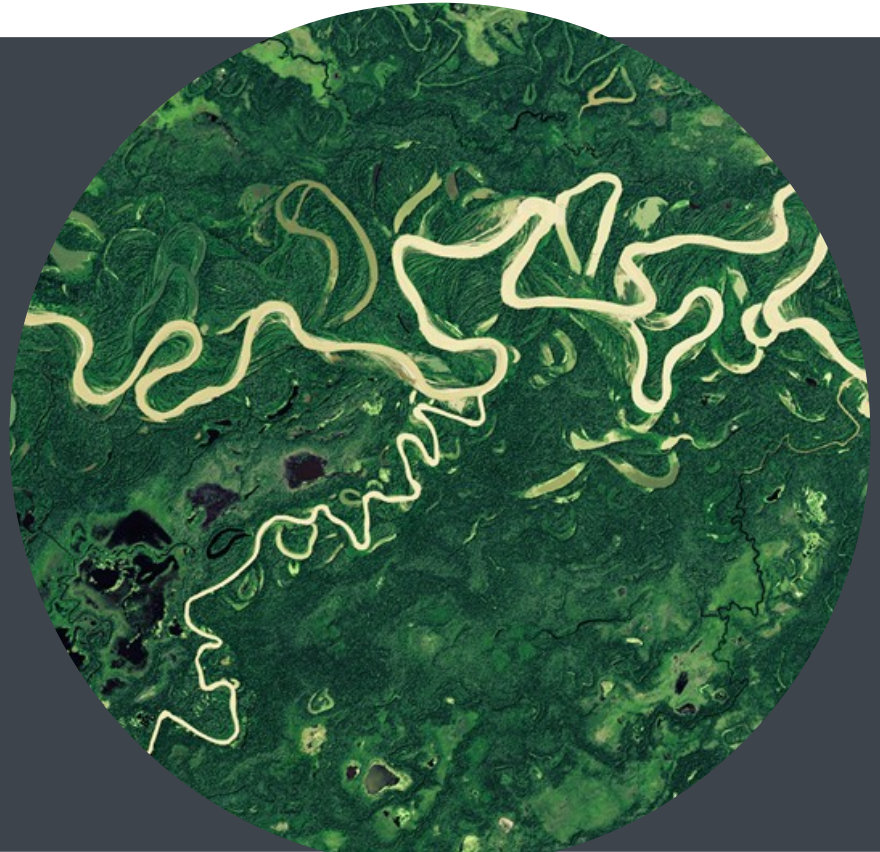
University of Stuttgart
Institute of Geodesy

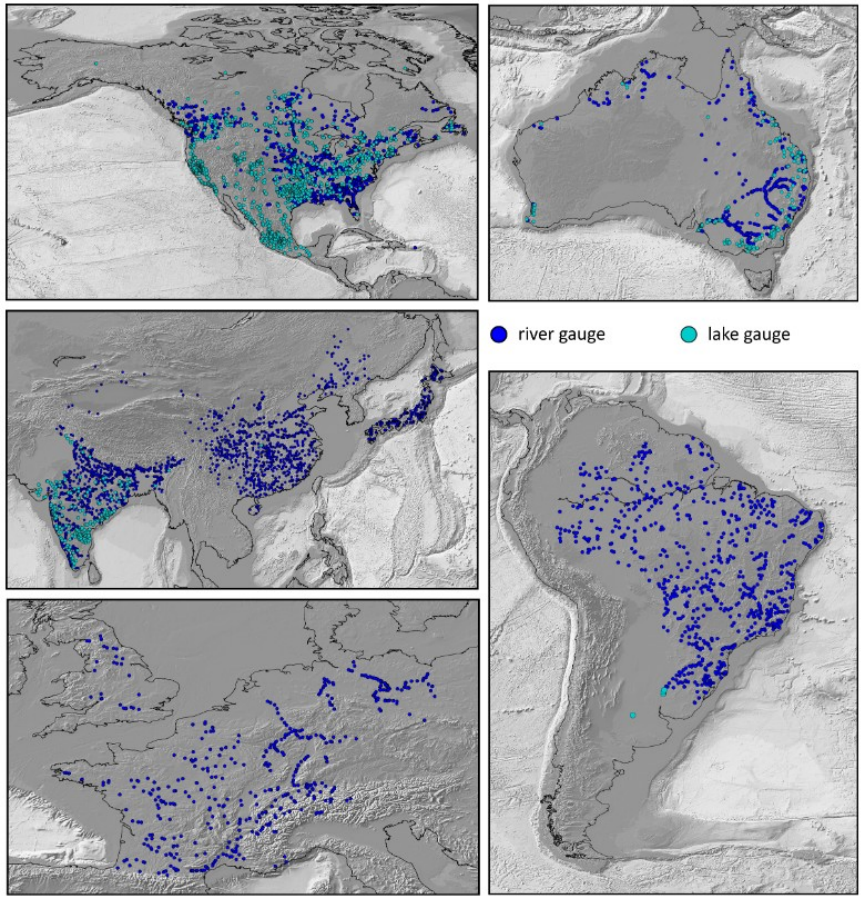
Rivers from space: monitoring rivers with altimetry and imaging satellites progress and challenges



MJ Tourian

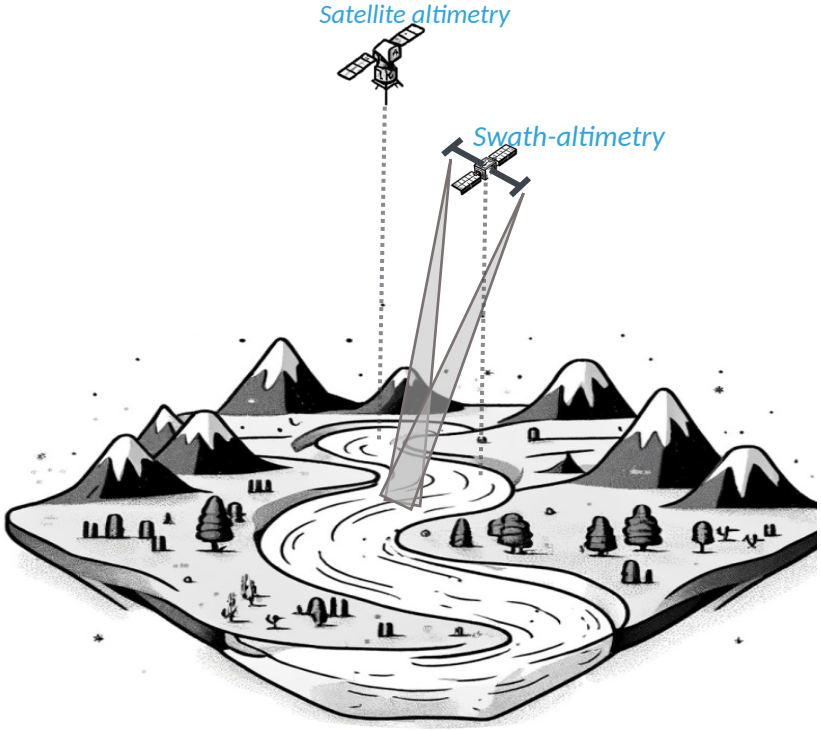
14.04.2026

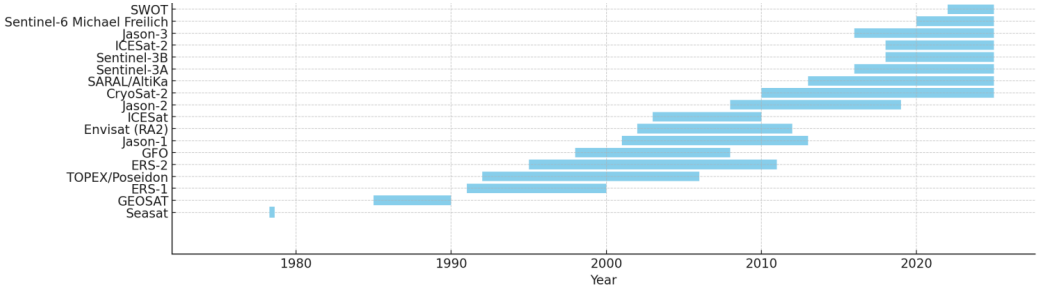
Publicly available water surface elevation gauges



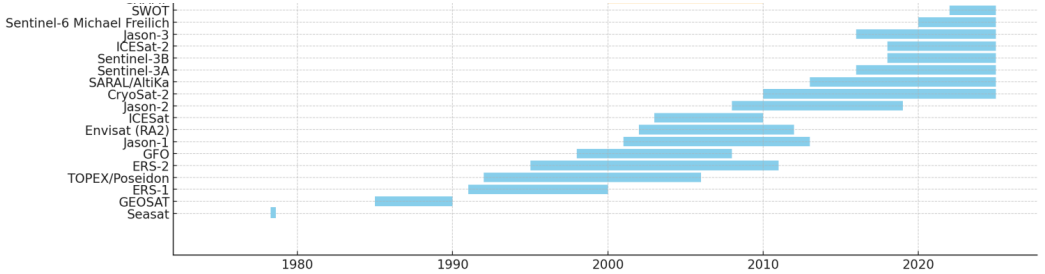
Yu S.., Tourian, M. J., Saemian, P., et al. (2026). **Diagnosing environmental and observational drivers of SWOT inland water elevation errors**. *Under preparation*

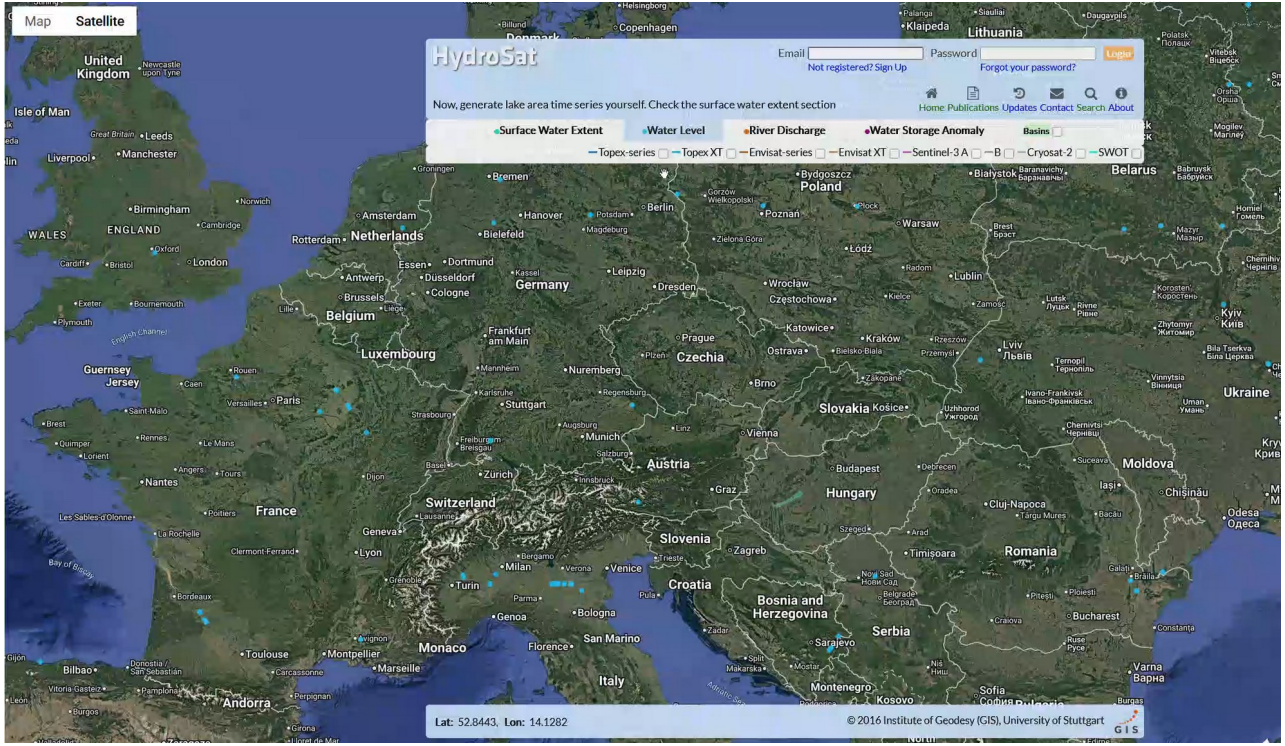
Satellites for monitoring rivers



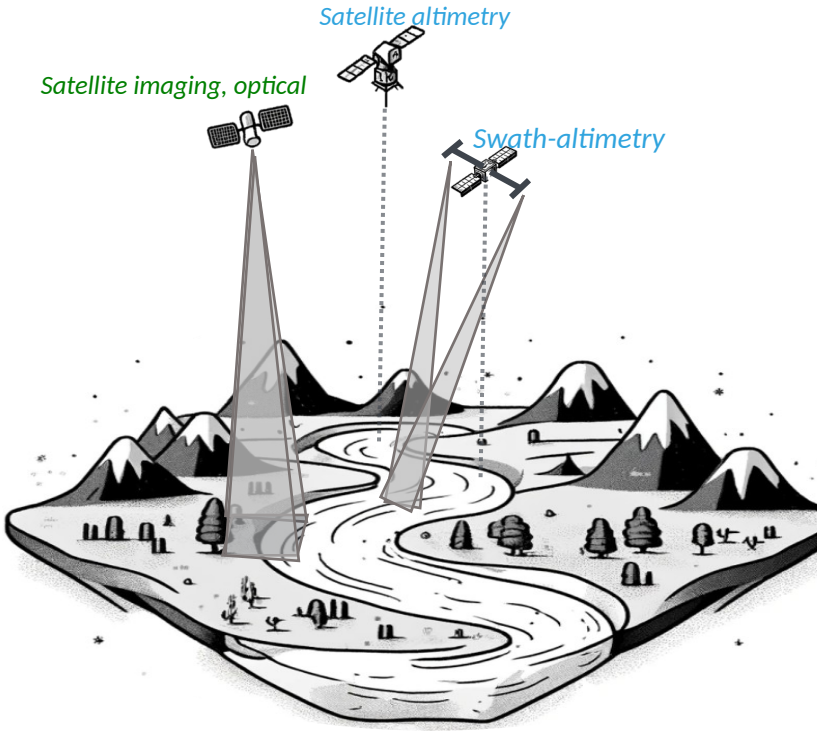


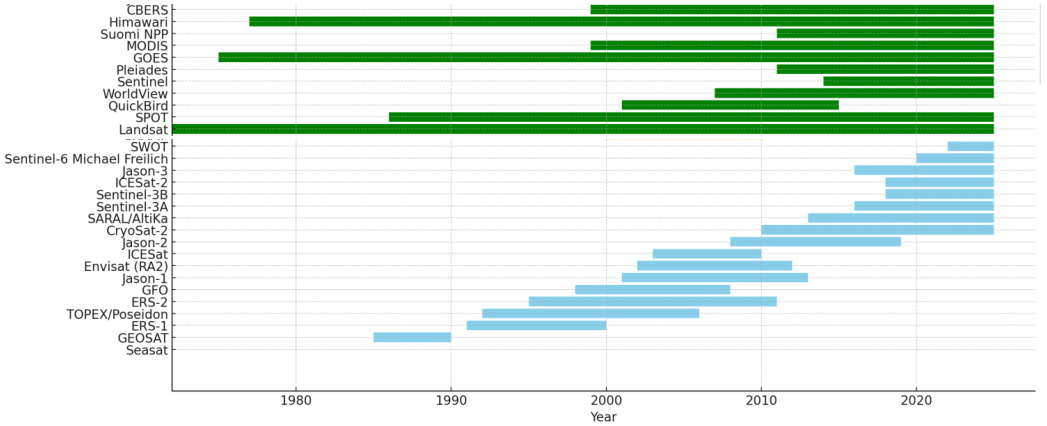
Satellite altimetry



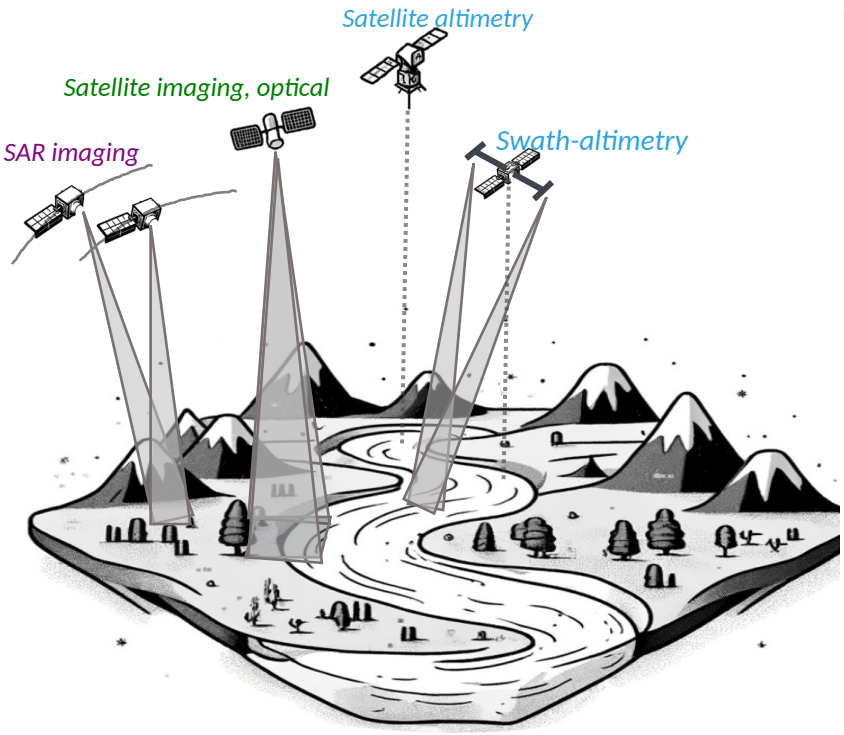


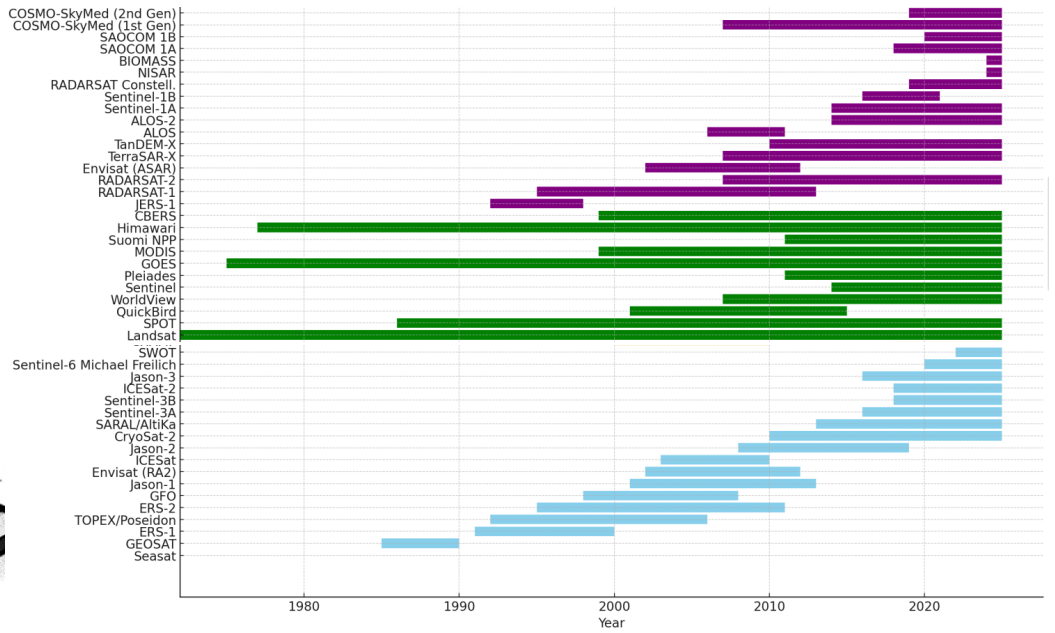
Satellites for monitoring rivers





Satellites for monitoring rivers



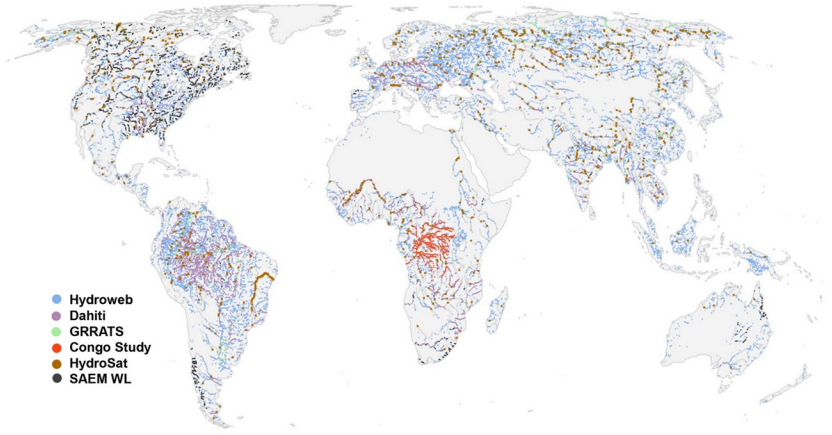


Height and width from space

- Water height from altimetry

Product	Operated by	Source	Remark
Hydroweb	CNES	http://hydroweb.theia-land.fr*	NRT available for some lakes and rivers
River & Lake	ESA	http://altimetry.esa.int/riverlake*	No longer maintained
DAHITI	Deutsches Geodätisches Forschungsinstitut (DGFI), TU Munich	https://dahiti.dgfi.tum.de* Schwatke et al. (2015a)	Kalman filter approach
HydroSat	Institute of Geodesy University of Stuttgart	http://hydrosat.gis.uni-stuttgart.de*	High-rate products are available
G-REALM	United States Department of Agriculture	https://ipad.fas.usda.gov/cropexplorer/global_reservoir*	Lakes and reservoirs only
GRRATS	The Ohio State University	https://doi.org/10.5067/PSGRA-SA2V1 Coss et al. (2020)	Envisat and Jason series over 39 rivers
AltEx	USAID and NASA	https://altex.servirglobal.net/* Markert et al. (2019)	Web application for exploring altimetry data from Jason-2, Jason-3 and SARAL/AltiKa
C3S LWL	CLS on behalf of Copernicus and the European Commission	https://doi.org/10.24381/cds.5714c668	94 selected lakes are available
Water level On VITO	Copernicus Global Land Operations CNES, LEGOS and CLS	https://land.copernicus.eu/global/products/wl*	NRT time series are available

* Last access: 18 May 2022



Saemian, P., Elmi, O., Stroud, M., Riggs, R., Kitambo, B. M., Papa, F., ... & Tourian, M. J. (2024). Satellite Altimetry-based Extension of global-scale in situ river discharge Measurements (SAEM). *Earth System Science Data Discussions*, *2024*, 1-29.

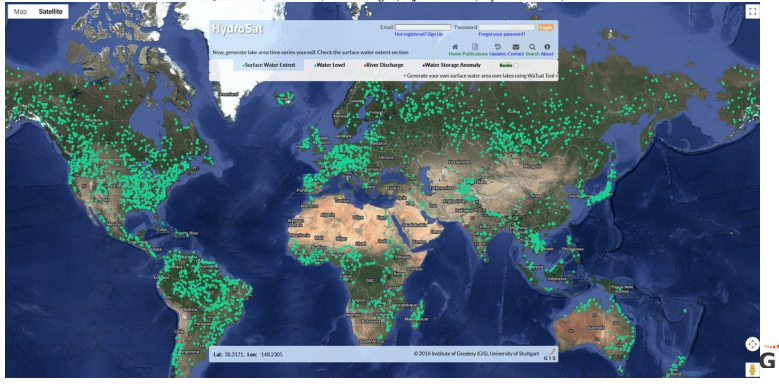
Earth System Science Data

- Surface water extent from satellite imagery

Product	Operated by	Source	Remark
Hydroweb	CNES	http://hydroweb.theia-land.fr*	Available for lakes
DAHITI	Deutsches Geodätisches Forschungsinstitut (DGFI)	https://dahiti.dgfi.tum.de*	Available for lakes
HydroSat	Institute of Geodesy, University of Stuttgart	http://hydrosat.gis.uni-stuttgart.de*	Available over rivers and lakes
Bluedot Observatory	Copernicus, European Commission, ESA, USGS, Amazon Web Services	https://blue-dot-observatory.com*	Available for lakes and reservoirs

HydroSat: geometric quantities of the global water cycle from geodetic satellites

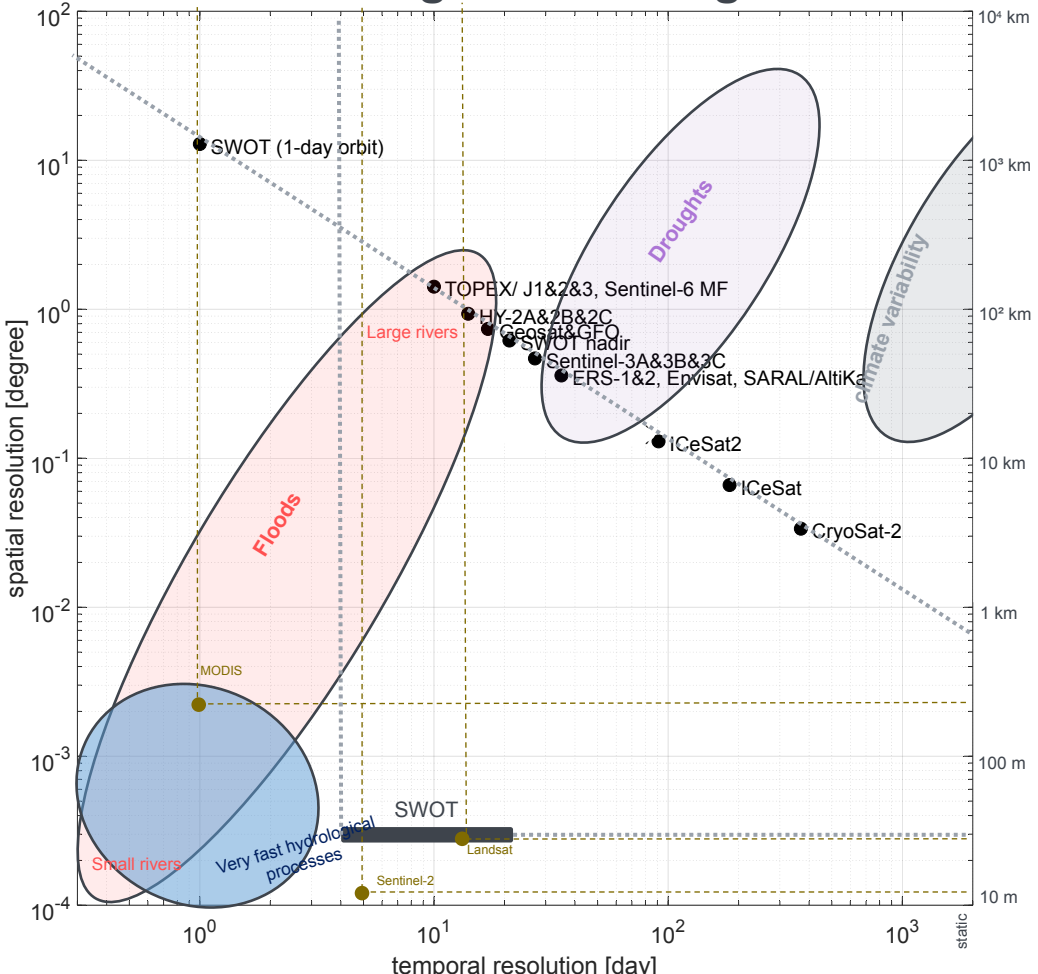
Mohammad J. Tourian[1], Omid Elmi[1], Yasin Shafaghi[2], Sajedeh Behnia[1], Peyman Saemian[1],



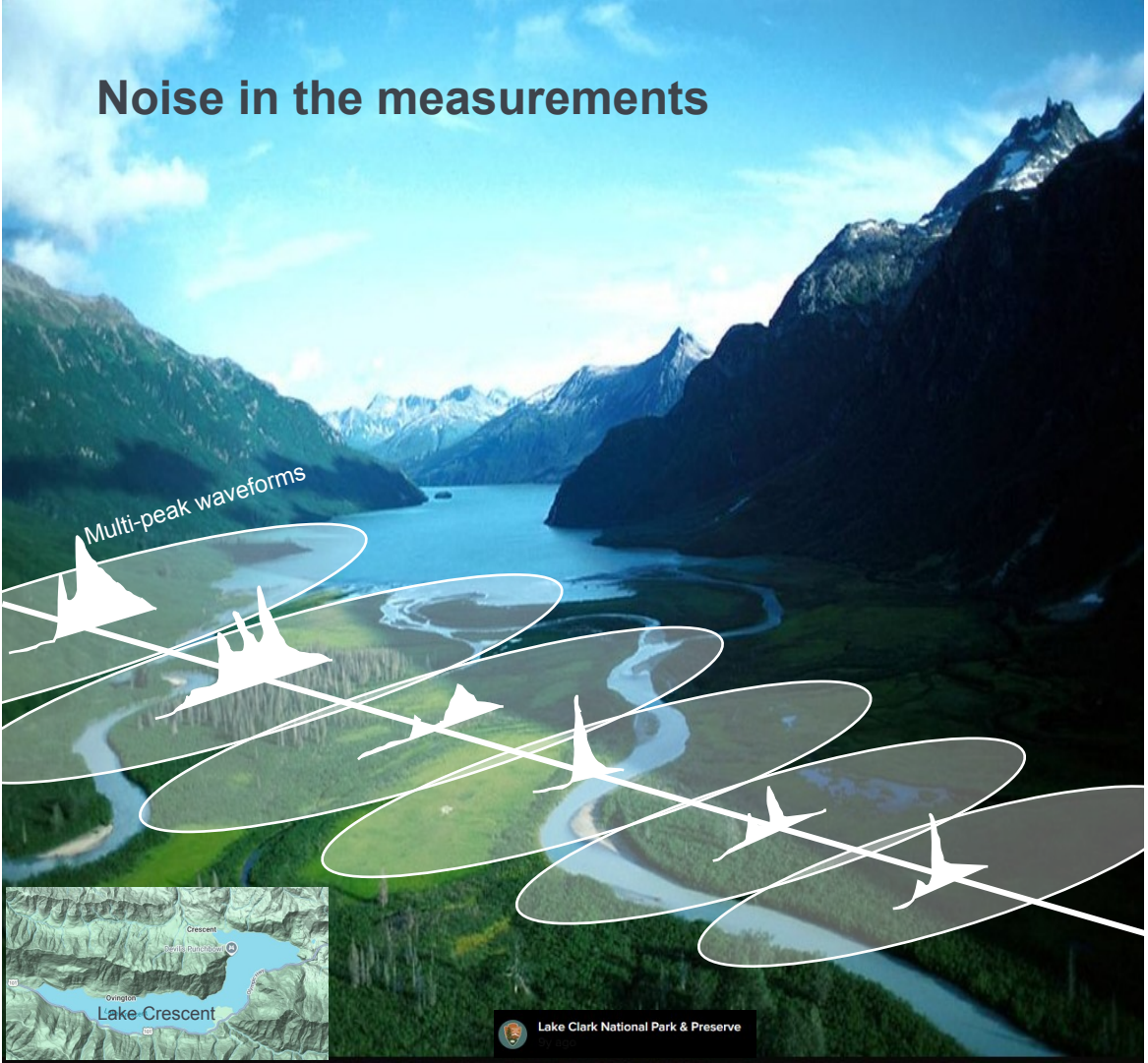
Satellite observations are becoming the new in situ.

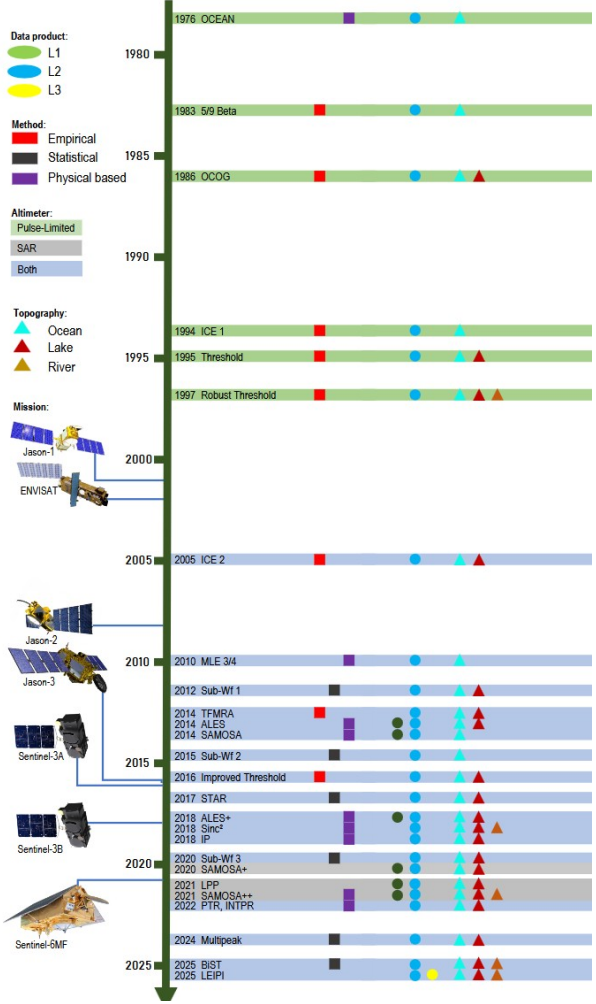
…but

Spatio-temporal resolution/coverage: A challenge



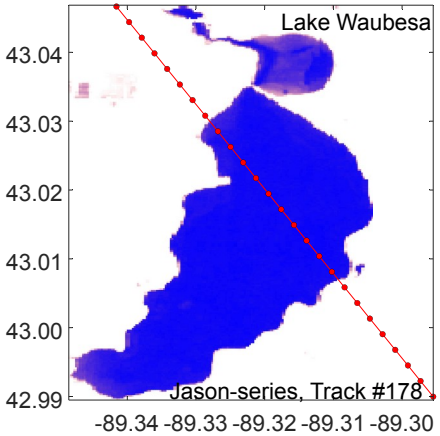
Noise in the measurements

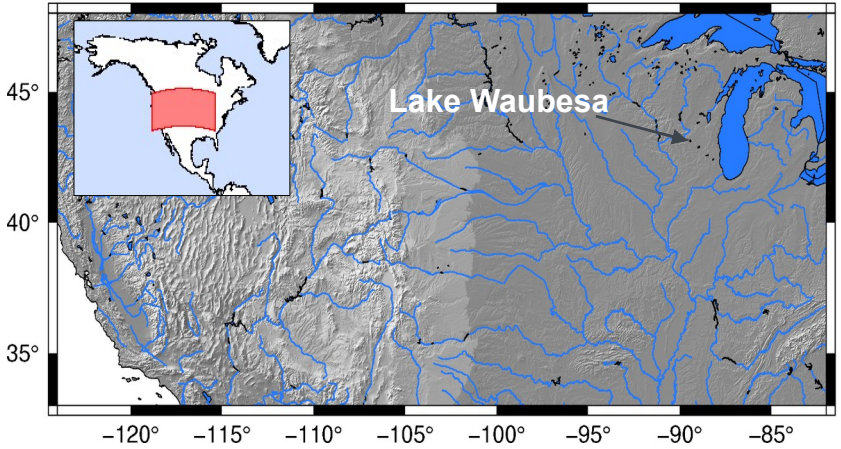


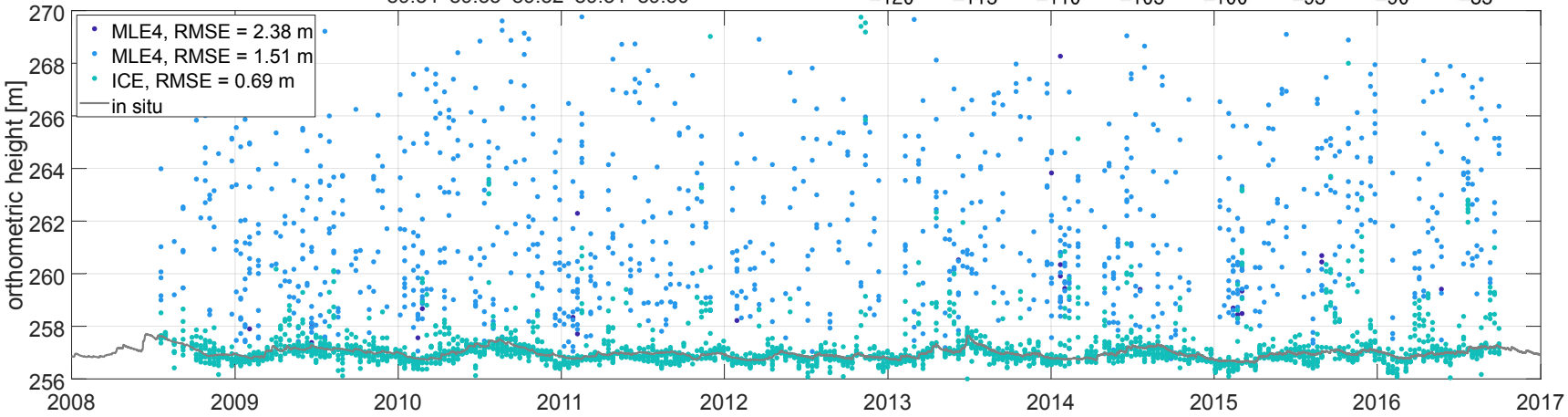


Khalili S., Tourian MJ, et al. (2026). **Advances in Retracking Techniques for Satellite Altimetry: A Survey of Methods and Performance**. *Under preparation*

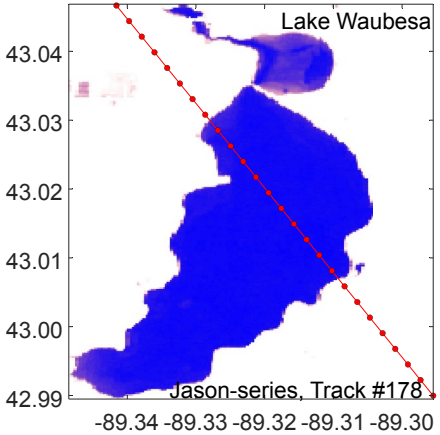
Noise in the measurements

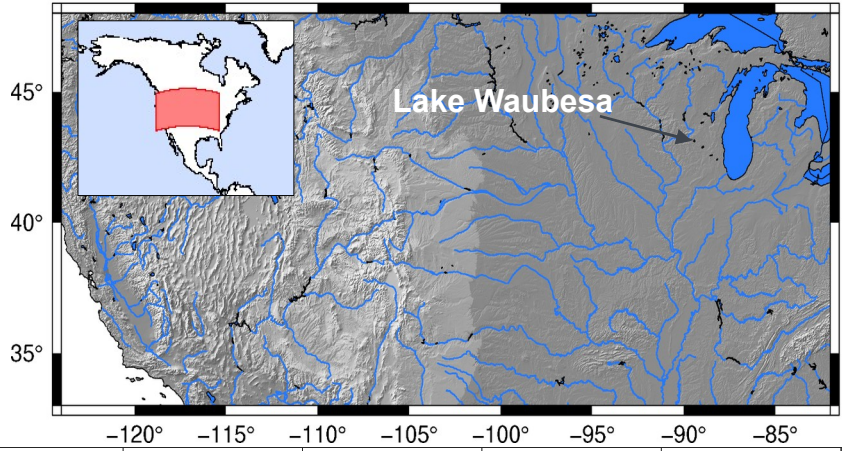


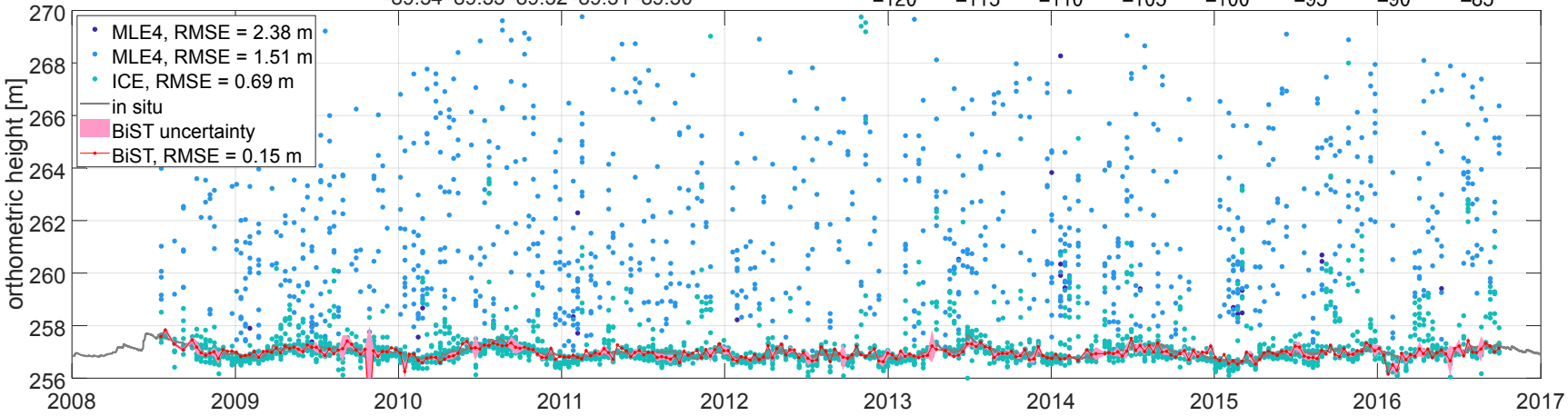




Improved water level time series





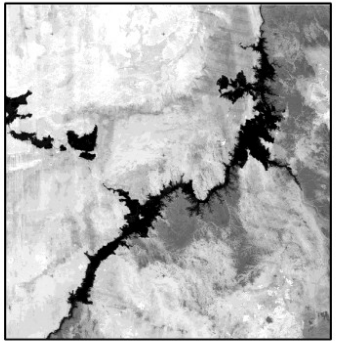


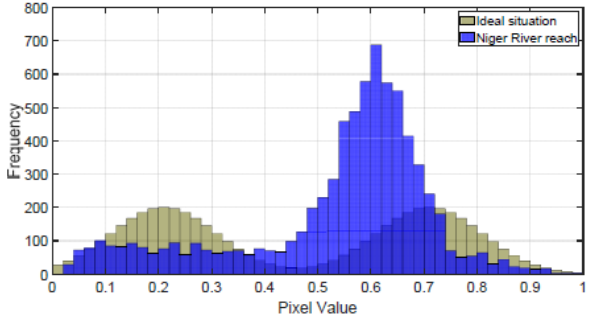
Tourian, M. J., Elmi, O., Khalili, S., & Engels, J. (2025). **Improving inland water altimetry through Bin-Space-Time (BiST) retracking: A Bayesian approach to incorporate spatio-temporal information**. *IEEE Transactions on Geoscience and Remote Sensing*.

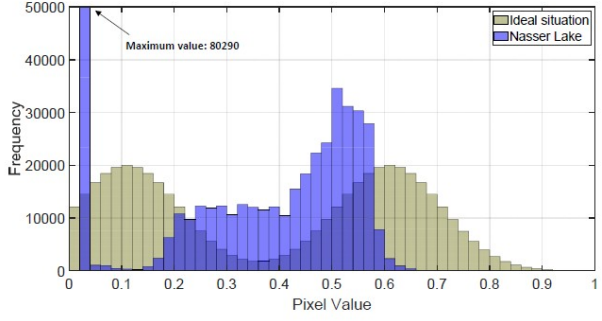
Water extraction from satellite image: is it really that simple?

NIR Image of Niger river from Landsat 8

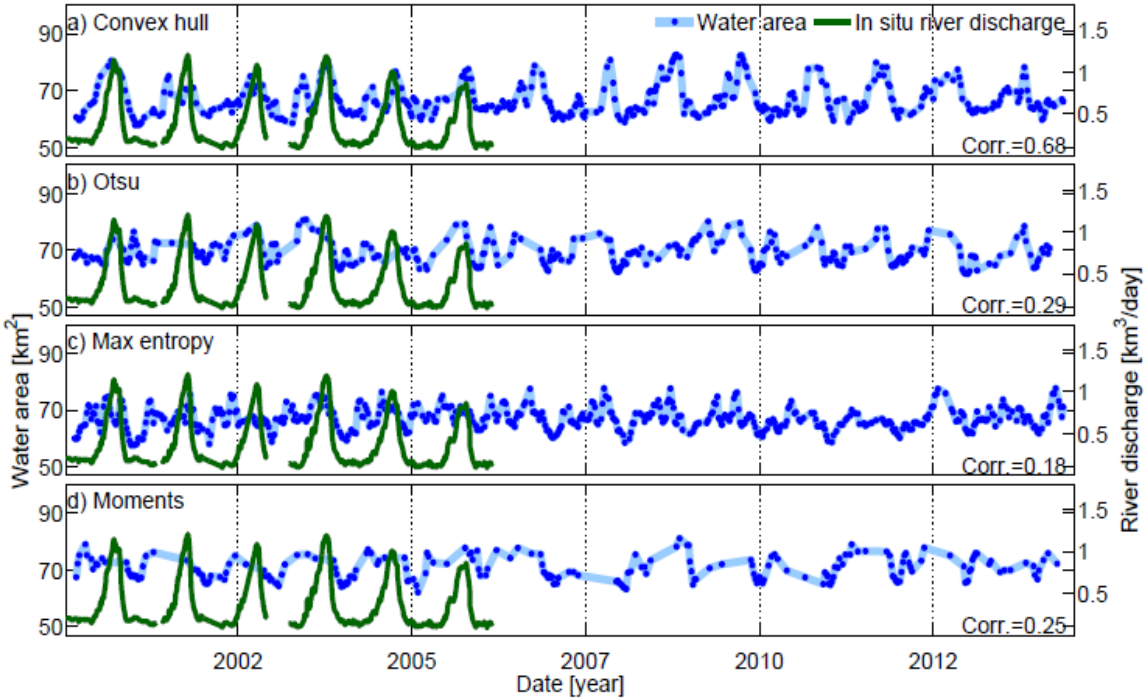
NIR Image of Nasser Lake from MOIDS

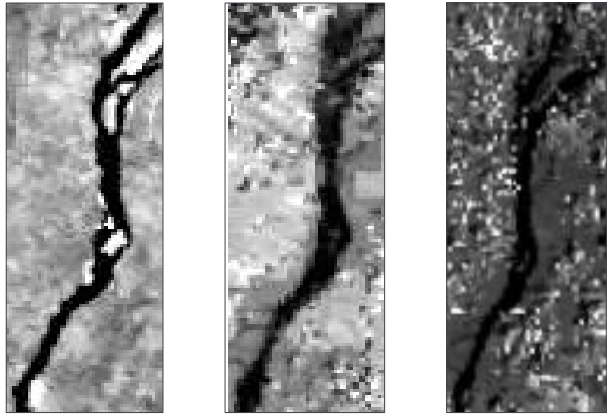






Water extraction from satellite image: is it really that simple?





Open Access Article

Dynamic River Masks from Multi-Temporal Satellite Imagery: An Automatic Algorithm Using Graph Cuts Optimization

by Omid Elmi *, Mohammad J. Tourian and Nico Sneeuw

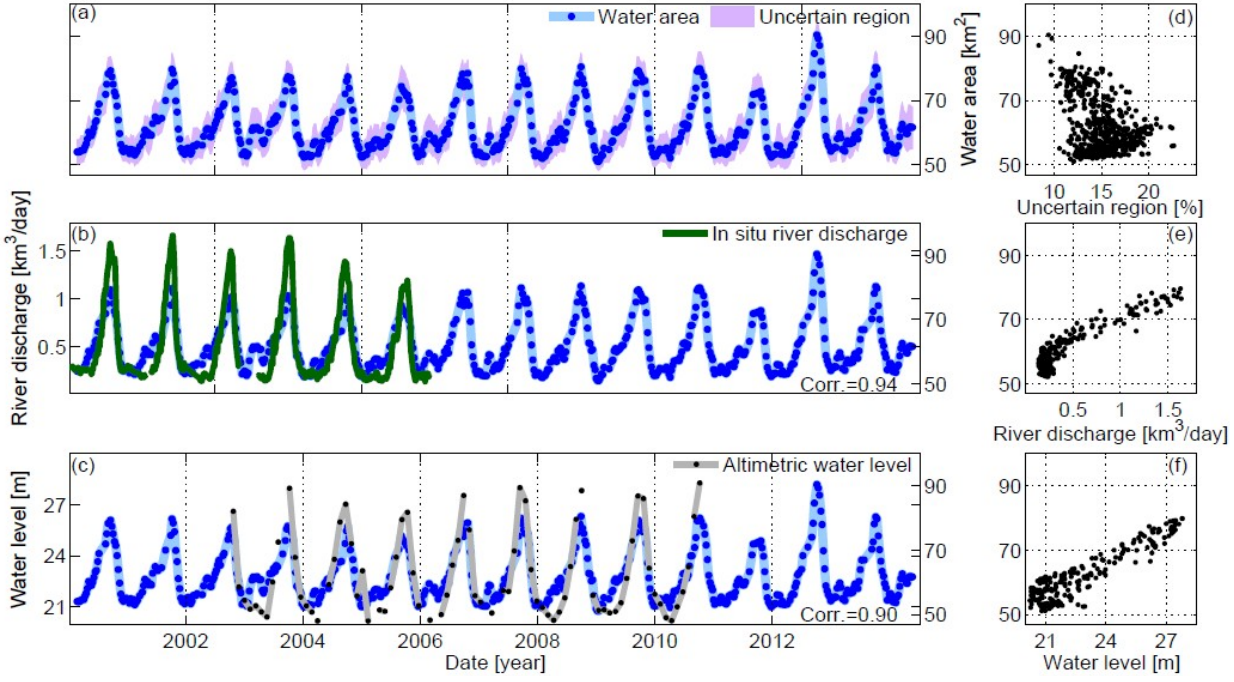
Institute of Geodesy, University of Stuttgart, Stuttgart 70174, Germany

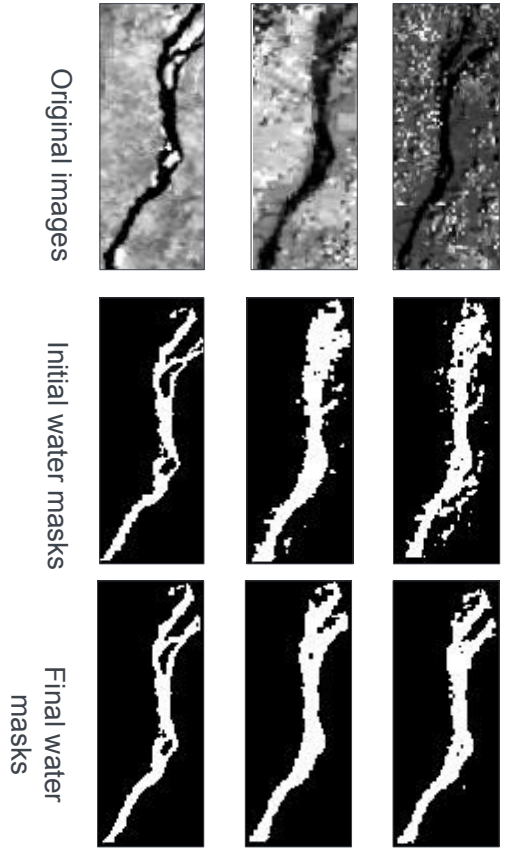
* Author to whom correspondence should be addressed.

Remote Sens. **2016**, *8*(12), 1005; **https://doi.org/10.3390/rs8121005**

Received: 20 September 2016 / Revised: 16 November 2016 / Accepted: 28 November 2016 / Published: 8 December 2016

River width estimation: benefiting from spatio-temporal information





Open Access Article

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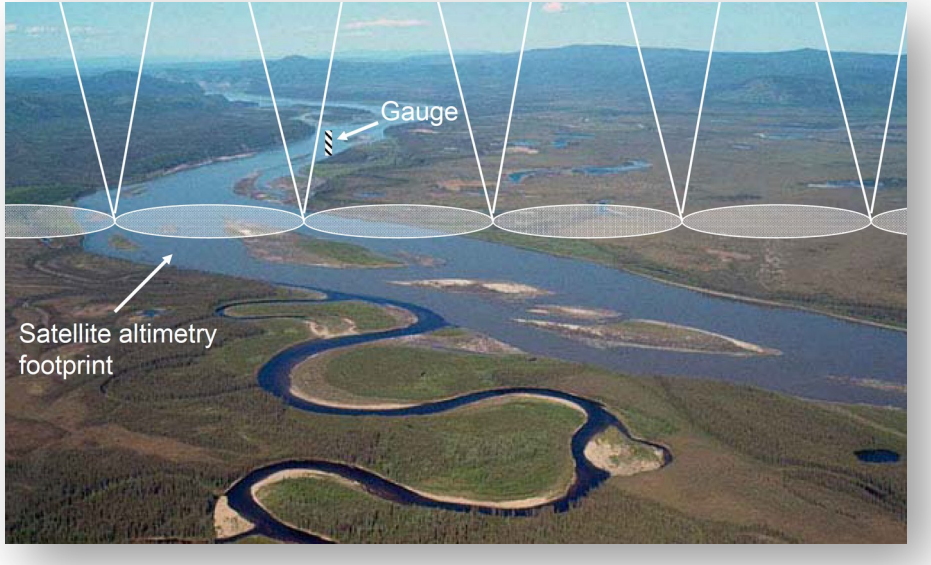
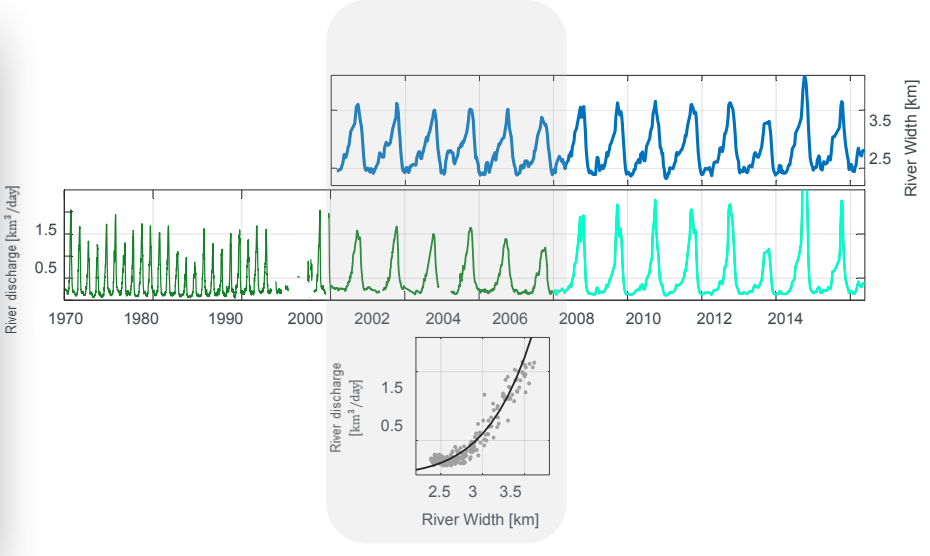
River discharge





$$Q = aW^b$$

Water Resources Research

Regular Article | Free Access

A quantile function approach to discharge estimation from satellite altimetry (ENVISAT)

M. J. Tourian, N. Sneeuw, A. Bárdossy

First published: 07 June 2013 | https://doi.org/10.1002/wrcr.20348 | VIEW METRICS

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Water Resources Research

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Spaceborne River Discharge From a Nonparametric Stochastic Quantile Mapping Function

Omid Elmi, Mohammad J. Tourian, András Bárdossy, Nico Sneeuw

First published: 03 December 2021 | https://doi.org/10.1029/2021WR030277 | VIEW METRICS

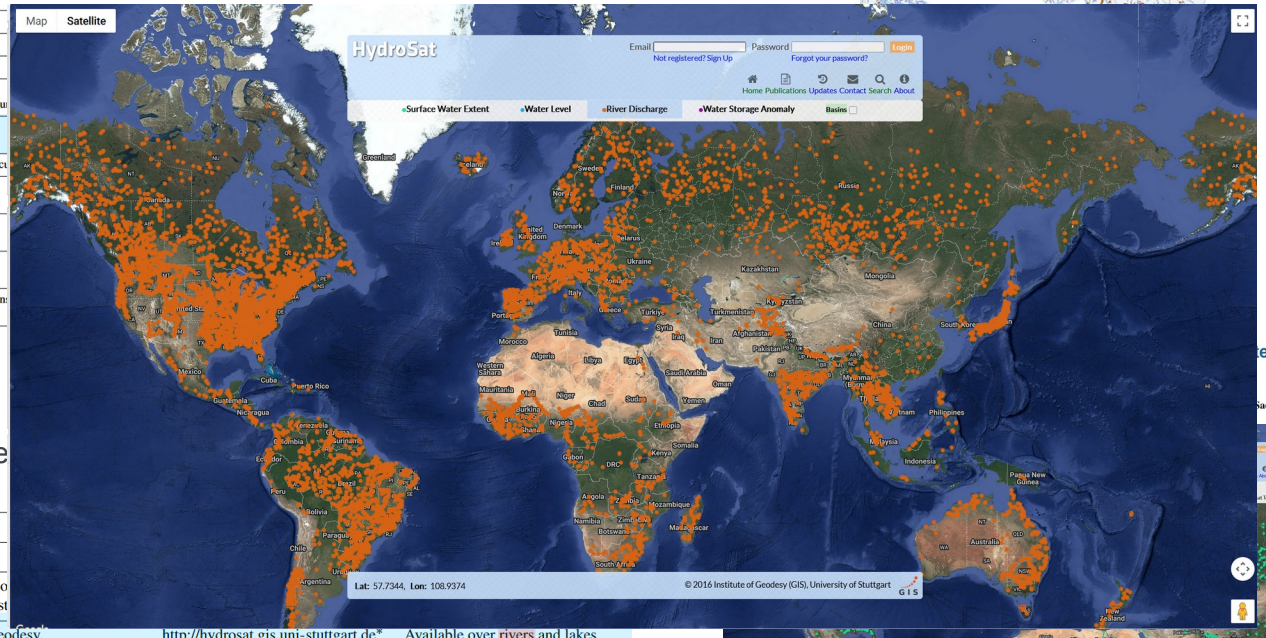
GIS

Height and width from space

- Water height from altimetry

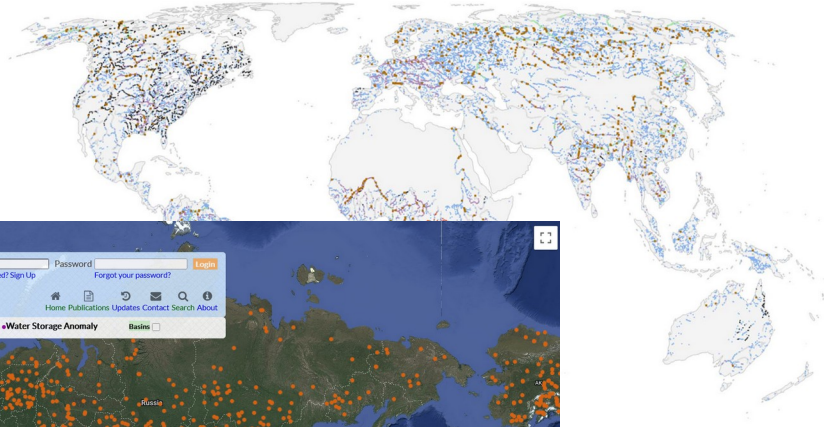
Product	Operated by
Hydroweb	CNES
River & Lake	ESA
DAHITI	Deutsches Geodätisches Forschungsinstitut (DGFI), TU Mu
HydroSat	Institute of Geodesy University of Stuttgart
G-REALM	United States Department of Agricu
GRRATS	The Ohio State University
AltEx	USAID and NASA
C3S LWL	CLS on behalf of Copernicus and the European Commission
Water level On VITO	Copernicus Global Land Operation CNES, LEGOS and CLS

* Last access: 18 May 2022



- Surface water exte

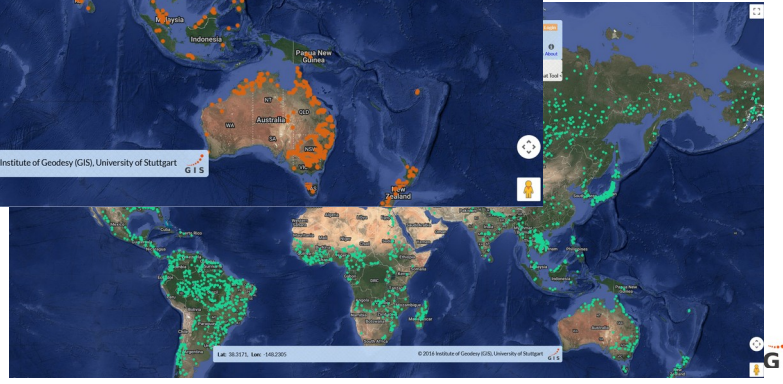
Product	Operated by		
Hydroweb	CNES		
DAHITI	Deutsches Geo Forschungsinst		
HydroSat	Institute of Geodesy, University of Stuttgart	http://hydrosat.gis.uni-stuttgart.de*	Available over rivers and lakes
Bluedot Observatory	Copernicus, European Commission, ESA, USGS, Amazon Web Services	https://blue-dot-observatory.com*	Available for lakes and reservoirs



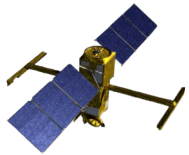
Earth System Science Data

er cycle

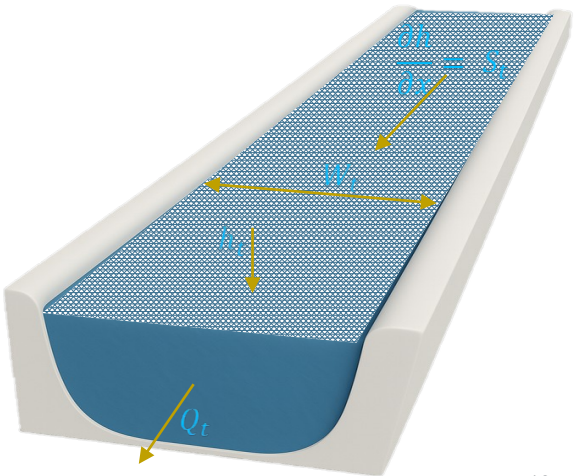
Saemian[1],



What we can estimate/measure over rivers?



geodetic quantities of water cycle		observed?	by	estimated?	through
river discharge	Q	no		yes	SWOT (e.g., Durand et al., 2014, 2023; Andreadis et al., 2025) satellite altimetry (e.g., Tourian et al., 2013; Paris et al., 2016; Saemian et al., 2025) satellite imaging (e.g., Smith and Pavelsky, 2008; Pavelsky, 2014; Tarpanelli et al., 2013b; Elmi et al., 2021; Scherer et al., 2024)
river surface water height	h	yes	satellite altimetry (Papa et al., 2010a; Tourian et al., 2016) SWOT (e.g., Biancamaria et al., 2016; Fu et al., 2024)		
river surface slope	$\partial h/\partial x$	yes	radar altimetry (e.g., Schwatke et al., 2024) laser altimetry (e.g., Scherer et al., 2023) SWOT (e.g., Biancamaria et al., 2016) GNSS-IR (e.g., Karegar et al., 2022)		
river flow velocity	v	no		yes	satellite imaging (e.g., Everard et al., 2023)
river depth	D	partially	Laser altimetry (e.g., Wang, 2024)	yes	SWOT (e.g., Durand et al., 2009; Yoon et al., 2012) satellite altimetry+imaging (e.g., Tourian et al., 2017a)
river width	W	yes	satellite imaging (e.g., Elmi et al., 2015; Allen and Pavelsky, 2018; Feng et al., 2022) SWOT (e.g., Biancamaria et al., 2016)		
groundwater discharge	Q_G	no		no	



University of Stuttgart
Institute of Geodesy

Thank you!

I acknowledge the contributions by


Omid Elmi


Peyman Saemian


Shahin Khalili


Nico Sneeuw

Rivers from space: monitoring rivers with altimetry and imaging satellites progress and challenges

MJ Tourian

14.04.2026