Use of satellite and in-situ data to assess global water resources and to forecast floods

Stefan Uhlenbrook, Sulagna Mishra and Fatih Kaya

From ground to orbit: Combining in-situ and satellite monitoring of water and forest resources for adaptation to climate change

10 Nov 2025, 18:30-20:00, Side Event room 9
Organised by INBO, One Water Vision, INRAE and fwp

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USGS

atmospheric moisture over ocean

atmospheric moisture over land

transport of moisture from ocean to land

precipitation over land

precipitation over land

ice sheets and glaciers

snowpack

snowmelt

evapotranspiration

streamflow to closed basins

lakes saline

permafrost

reservoirs

precipitation over ocean

runoff

groundwater recharge

wetlands fresh

evapotranspiration

domestic water use

lakes fresh

wetlands brackish

rivers

urban runoff

municipal

ocean evaporation

industrial water use

ocean circulation

streamflow to ocean

groundwater

ocean mixed zone

ocean deep water zone

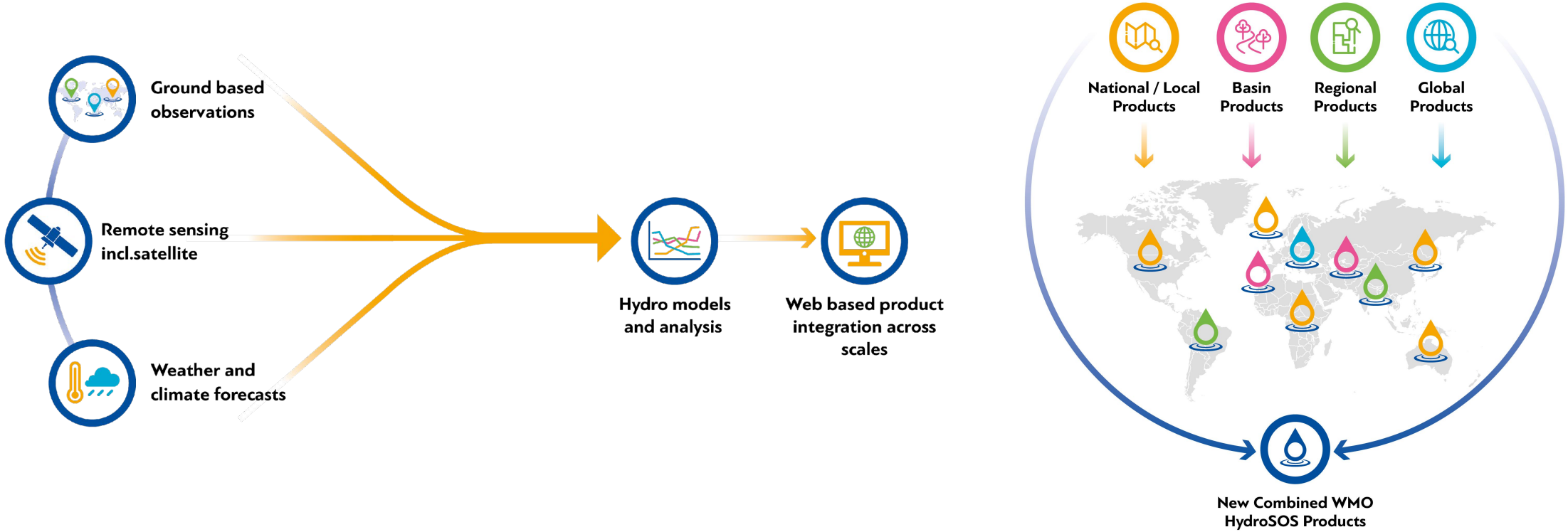
groundwater discharge to ocean

Pools and *Fluxes*

On Earth, water can be **fresh**, **saline**, or a mix of both. **Pools** are places where water is stored, like the ocean. ***Fluxes*** are the ways that water moves between pools, such as evaporation, precipitation, discharge, recharge, or human use.

See www.usgs.gov/water-cycle for definitions.

Implementation of HydroSOS:
From Data to Information to Decision and Policy Support



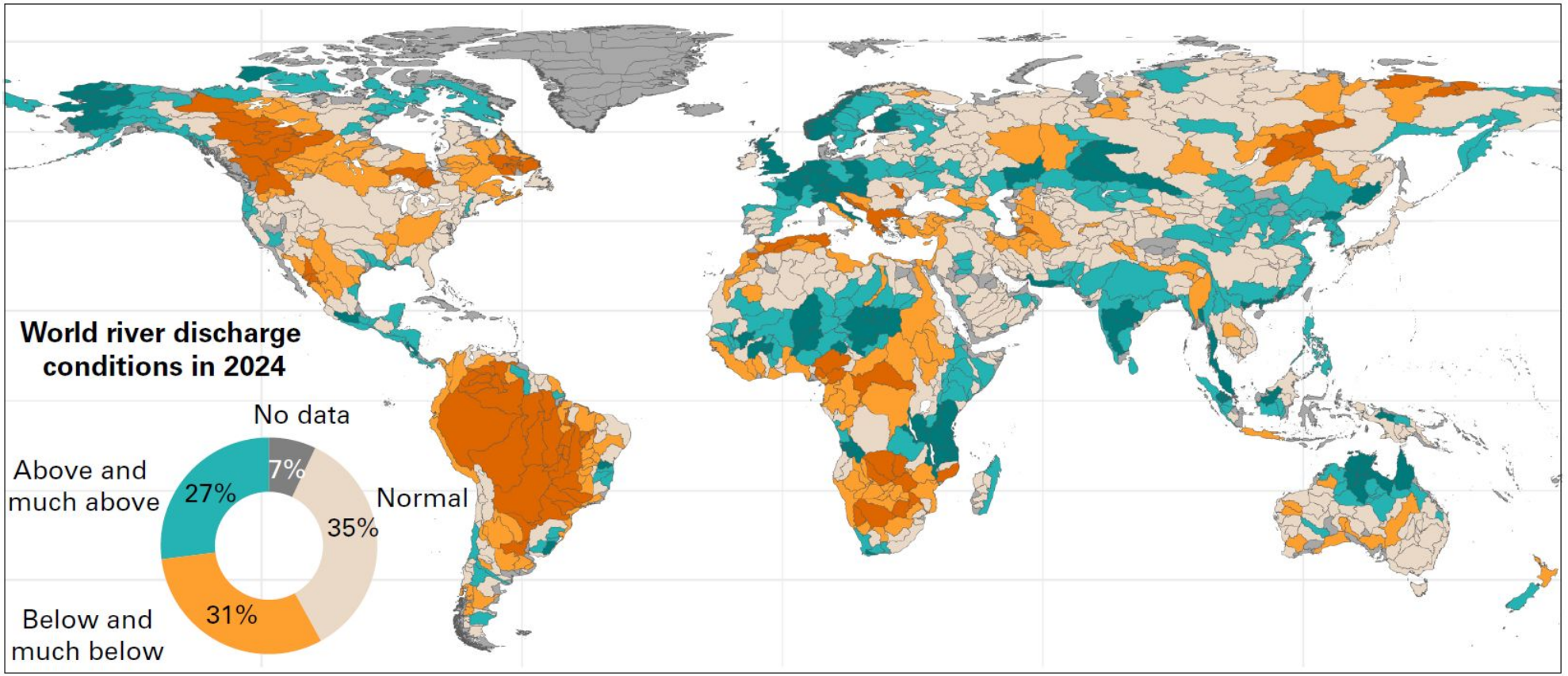
Globally consistent and accessible water information across scales: *basin, national, regional and global scales*

#StateOfWater

#StateOfClimate

2024: WETTER THAN 2023, BUT PREDOMINANTLY DRY RIVER DISCHARGE CONDITIONS (12 models)

Mean river discharge for the year 2024 compared to the period 1991–2020 (for basins larger than 10 000 km^2)



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SOURCE: GHMSs

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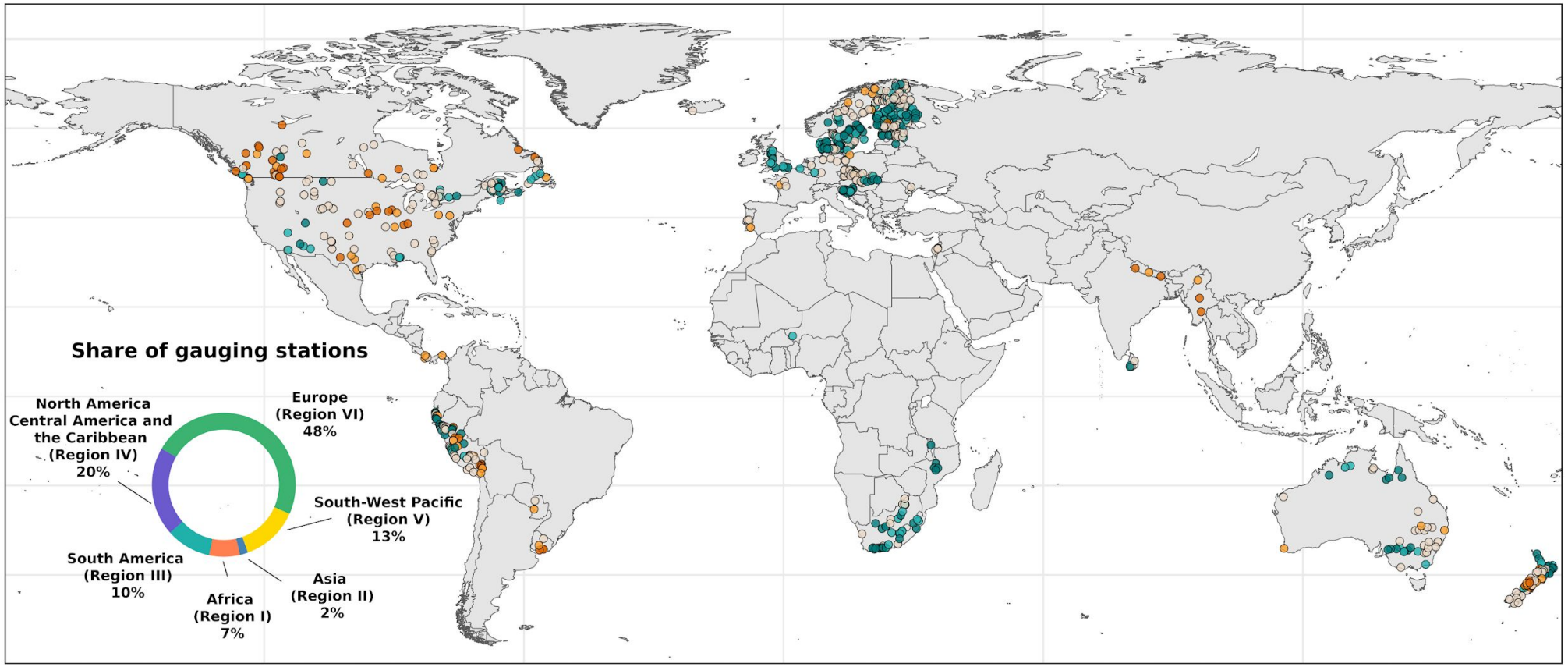
RIVER DISCHARGE (observed) – LARGE DATA GAPS

Observed mean river discharge for the year 2023 compared to the period 1991–2020 (with a minimum of 20 years of data availability



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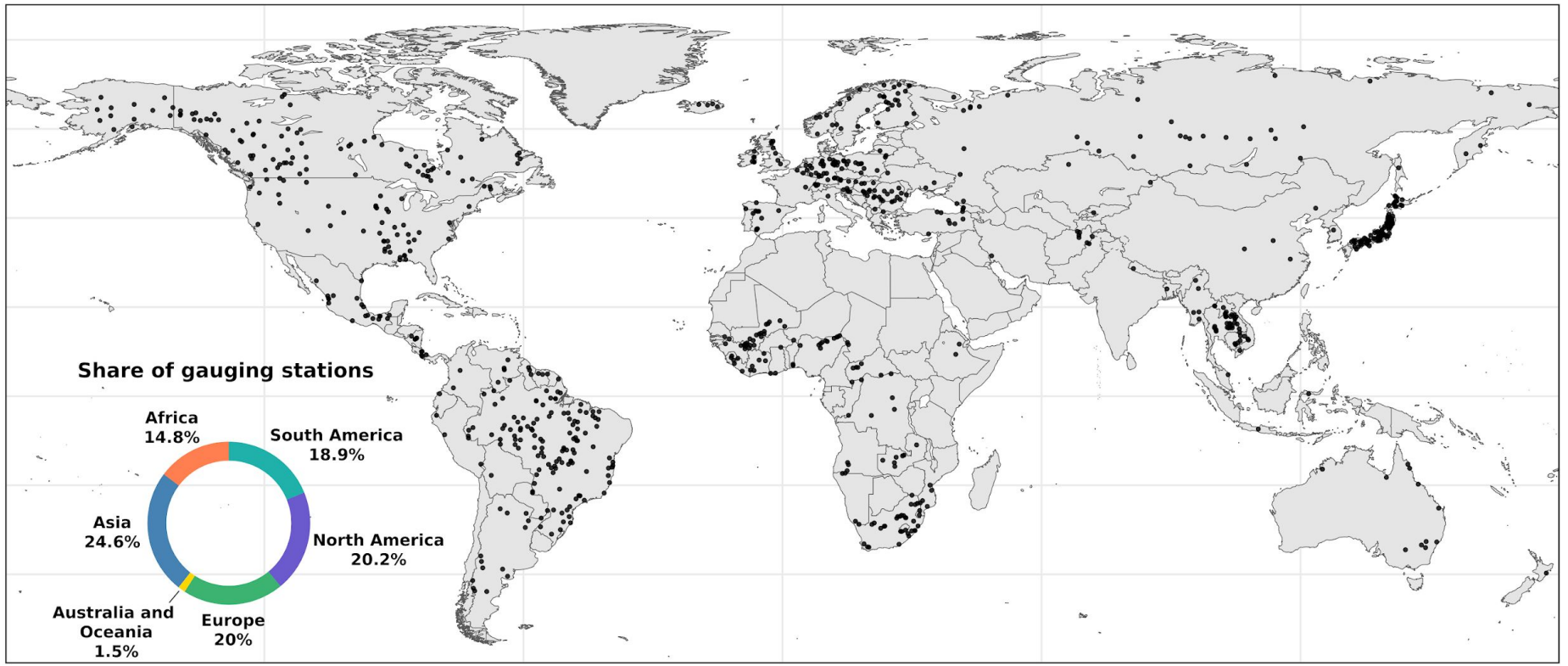
INNOVATION IS THE KEY:
g. EARTH OBSERVATIONS FOR INFILLING OF DATA GA



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SOURCE: UNIVERSITY OF STUTTGART, 2024

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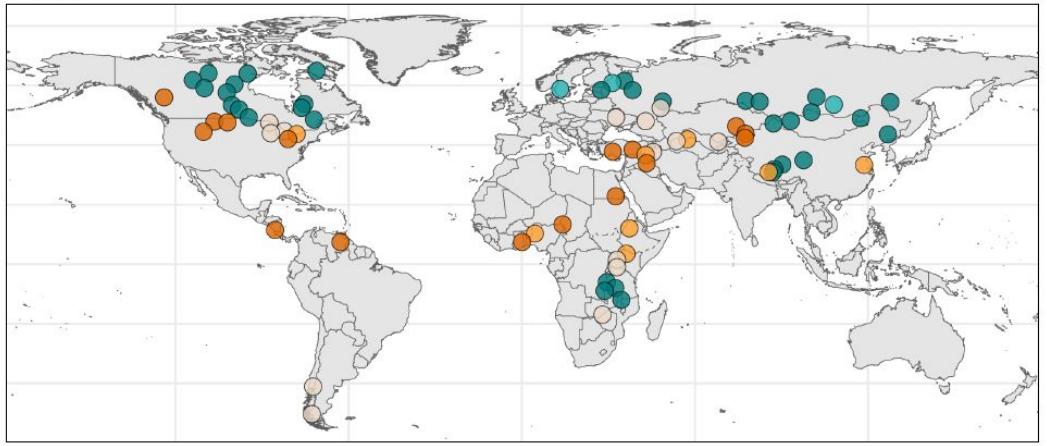
EXAMPLE of 2024 Report: LAKES (Temperature)

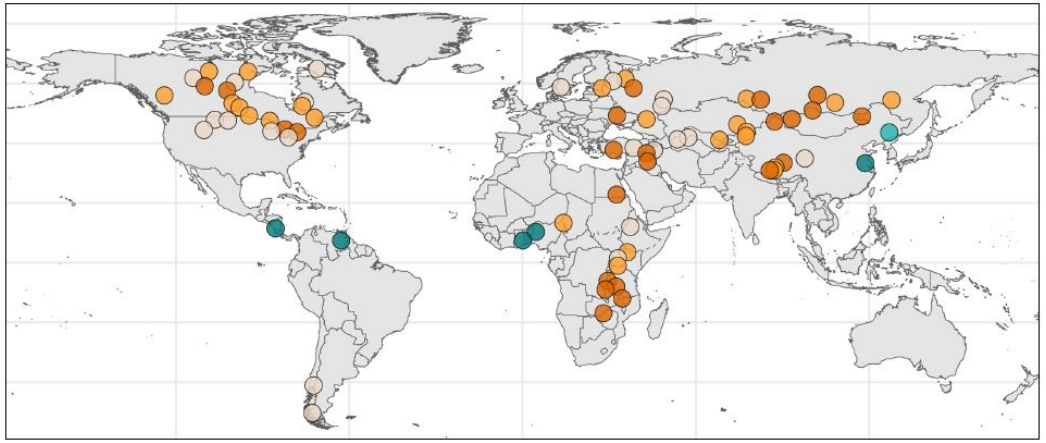
Linked to air temperatures, and drives seasonal ecosystem cycles

Lake surface water temperature anomalies in January and July for 2024 with respect to the historical period 1995–2020

January



July



Lake temperature anomalies

much below | below | normal | above | much above

Summer
Southern
Hemisphere

Summer
Northern
Hemisphere

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SOURCE: ESA Lake CCi

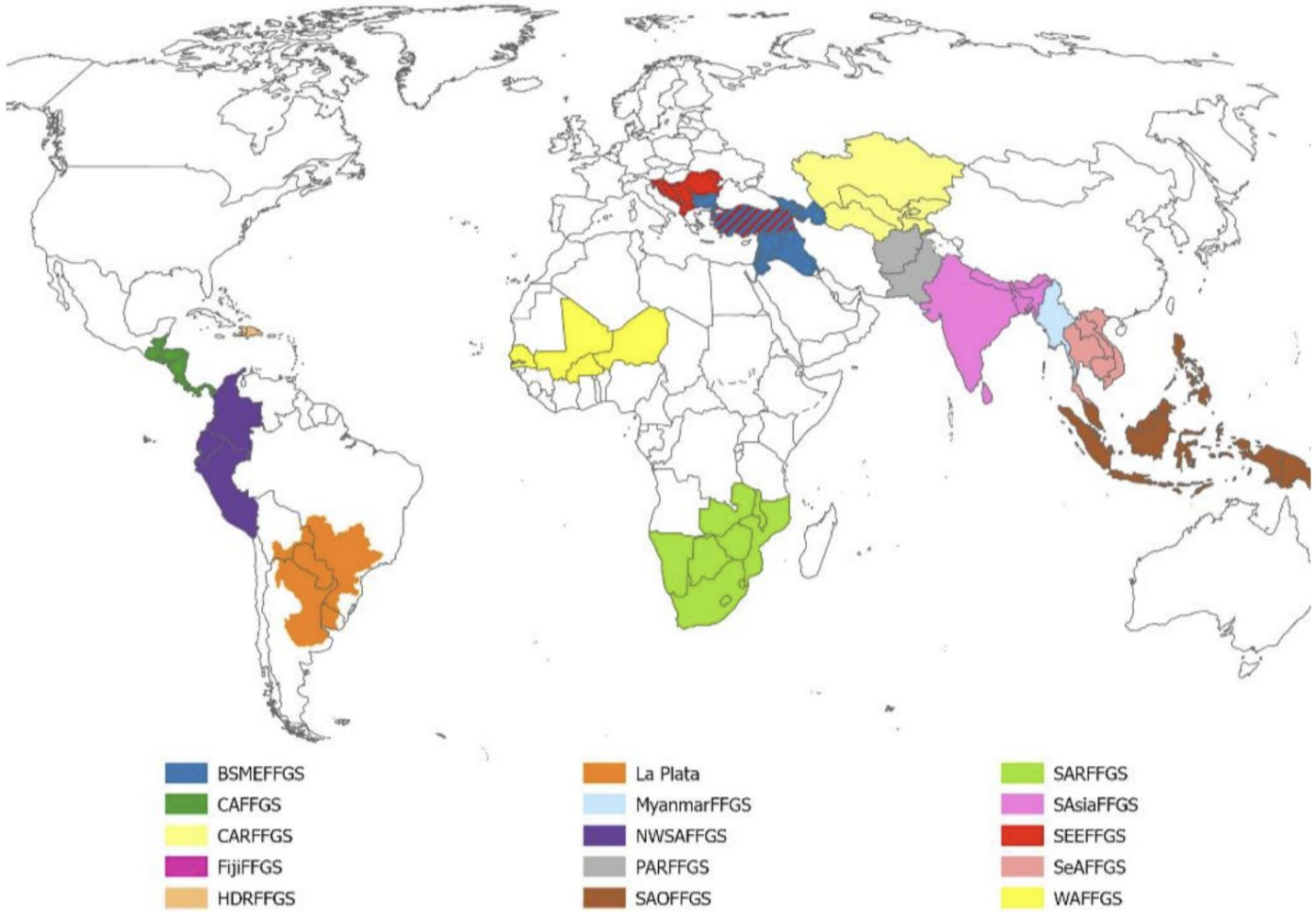
FFGS Overview

2025

- 70+ Countries
- 13 Regional FFGS Projects
- 2 National Projects

Centers are providing

- Flash flood guidance
- Risk products
- Operational support



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https://wmo.int/projects/ffgs
https://www.hrcwater.org/projects/project-1/

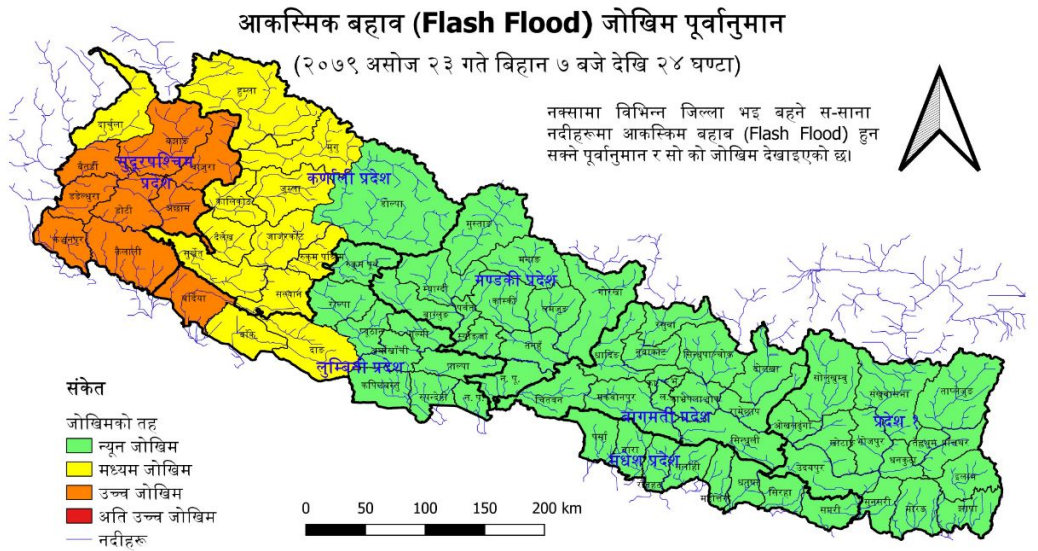
Remote Sensing Data for Saving Lives

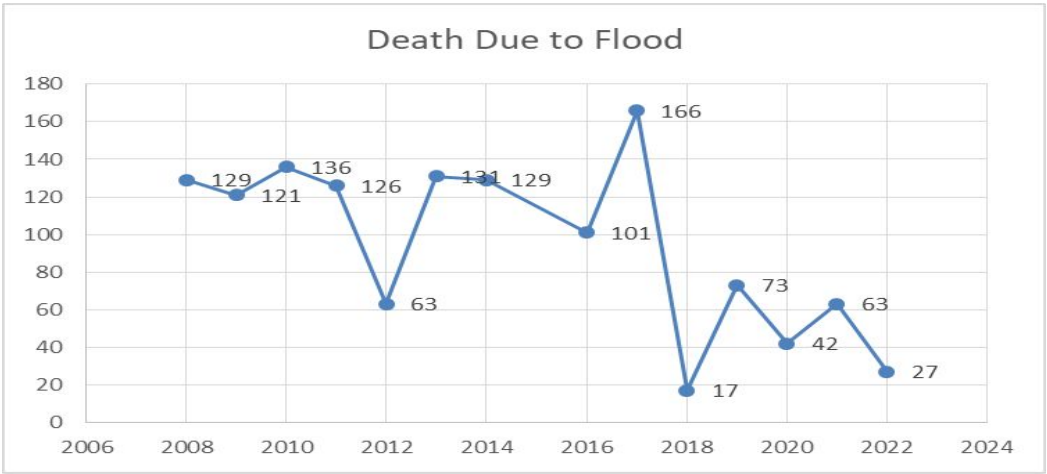
Nepal (South Asia FFGS)

The Department of Hydrology and Meteorology (DHM) **launched the Flood Forecasting and Early Warning Services (FFEWS) in 2016**, evolving to incorporate SMS and social media for effective communication.

The system uses stations for real-time monitoring and provides timely warnings. The addition of the **South Asian Flash Flood Guidance System (SAsiaFFGS) in 2018 expanded the scope to include flash flood warnings using satellite data and forecasting tools.**

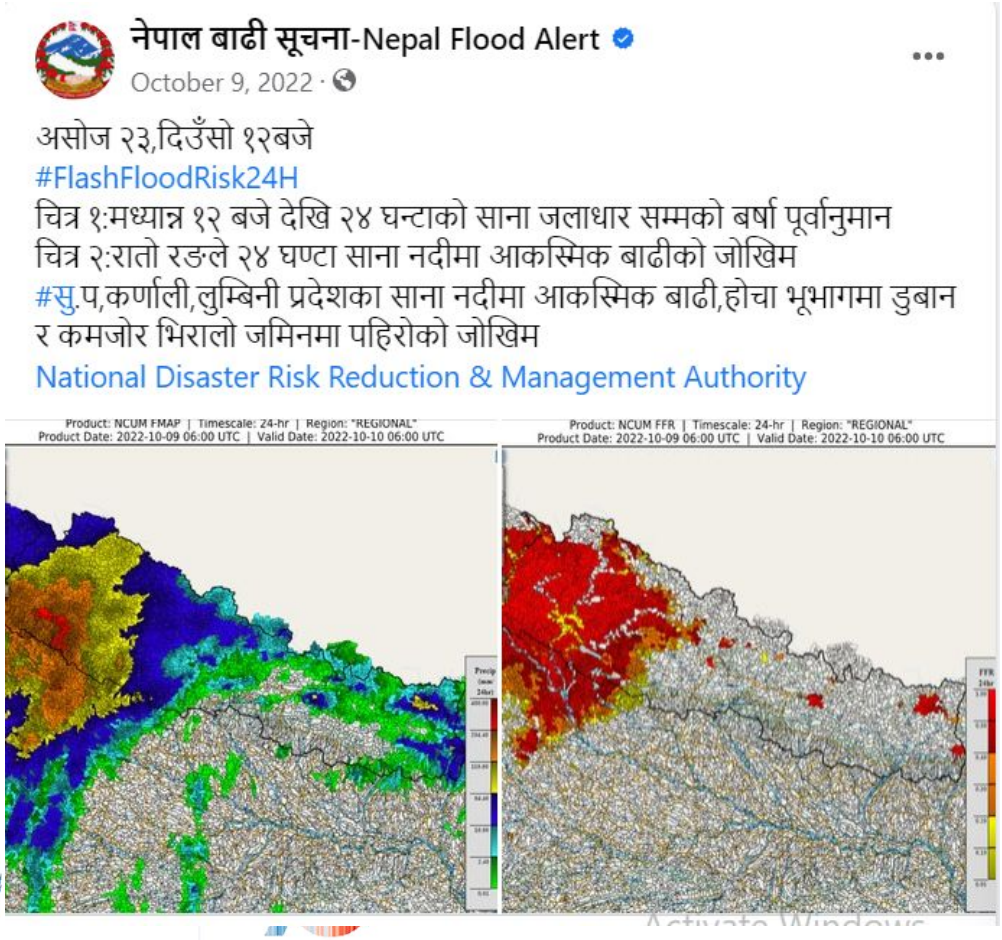
Flood-related casualties has significantly reduced: For example, in 2014, a flood with a peak discharge of 9'100 m³/s resulted in 30 deaths, while in 2022, a larger flood (10'550 m³/s) caused no casualties. This highlights the effectiveness of the early warning systems in reducing human casualties and increasing community awareness.





Results (Case Studies and Verification)

09 Oct, 2022, 06: UTC
Warning Valid for 24 Hour



नेपाल बाढी सूचना-Nepal Flood Alert

October 9, 2022 ·

असोज २३,दिउँसो १२बजे

#FlashFloodRisk24H

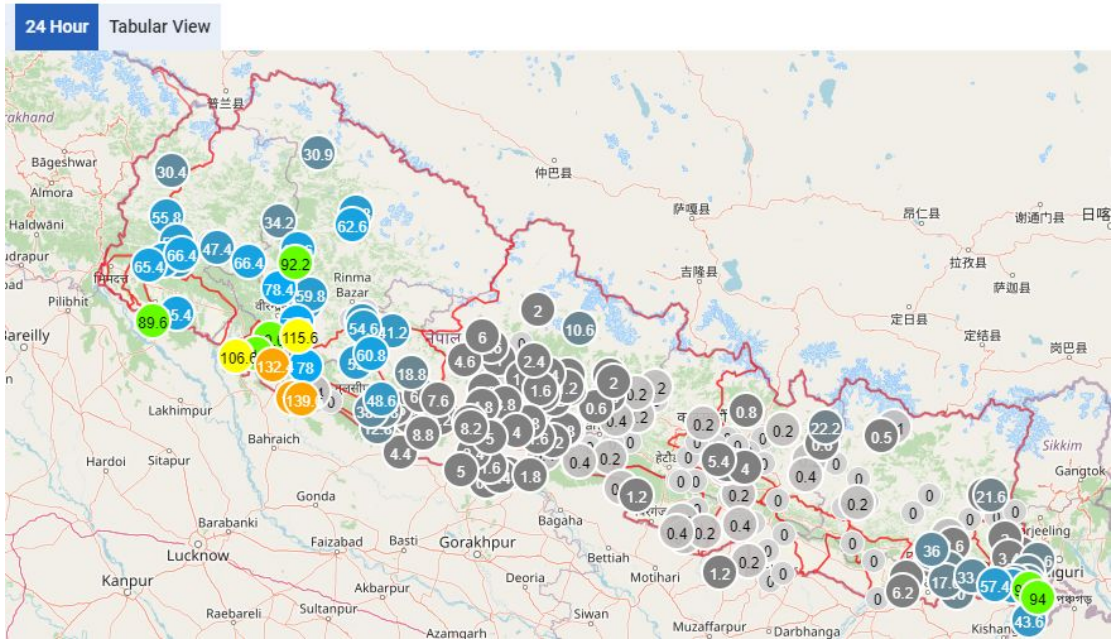
चित्र १:मध्यान्न १२ बजे देखि २४ घन्टाको साना जलाधार सम्मको बर्षा पूर्वानुमान

चित्र २:रातो रङले २४ घण्टा साना नदीमा आकस्मिक बाढीको जोखिम

#सु.प,कर्णाली,लुम्बिनी प्रदेशका साना नदीमा आकस्मिक बाढी,होचा भूभागमा डुबान र कमजोर भिरालो जमिनमा पहिरोको जोखिम

National Disaster Risk Reduction & Management Authority

10 Oct, 2022, 03: UTC Rainfall Measurement Hour (21 Hour)



Flash Flood Forecast Bulletin Verification (DHM)

	Overall Accuracy			PoD of Flood		
	Day-1	Day-2	Day-3	Day-1	Day2	Day-3
West Rapti Kusum	90.84	87.02	90.08	60.2	33.33	20.2
Babai Chepang	91.6	89.31	91.6	92.31	61.54	38.46

A generation lost or found?

Picture: Carl Ganter, Circle of Blue, 2022