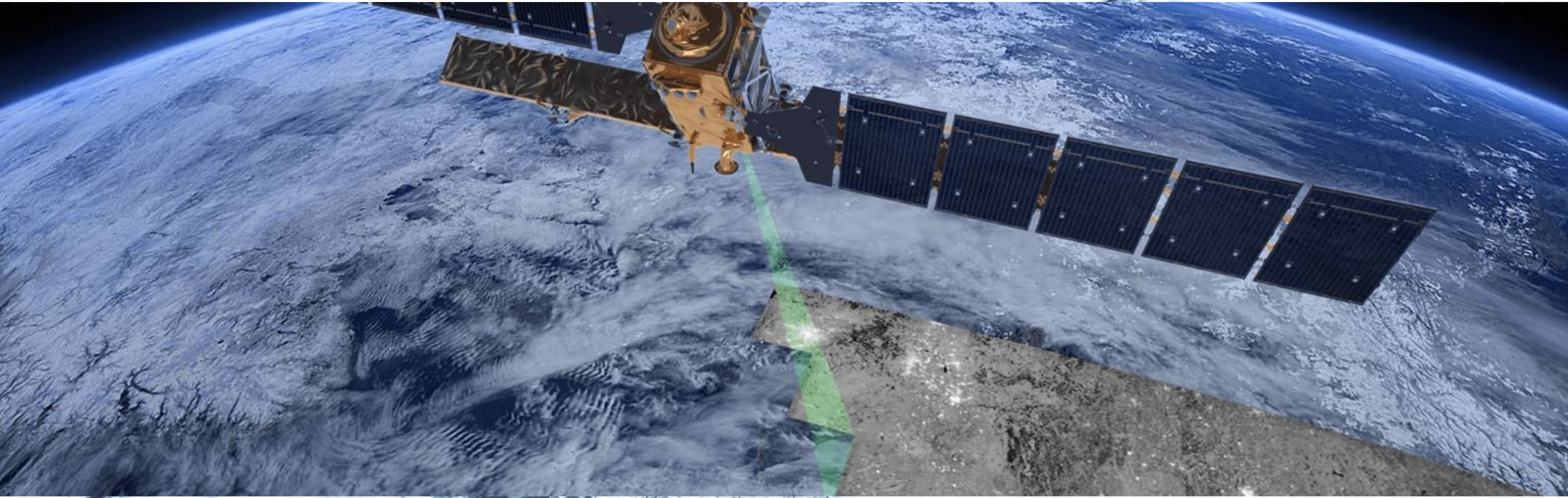
Data Collection and Analysis using Remote Sensing

Insights, Tools, and Innovations

Arab Water Council – Arab Water Academy



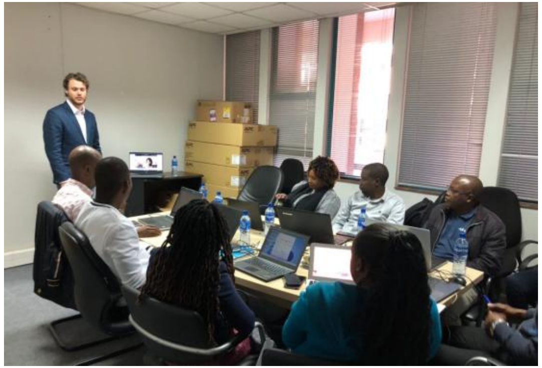
Tijmen Schults

23 June 2025, Online

FutureWater

Introduction

- **Tijmen Schults, MSc.**
  - Hydrologist and Remote Sensing Expert
  - FutureWater, The Netherlands



About FutureWater

Research and consultancy for a sustainable future of our water resources

- **Offices**: Wageningen (Netherlands), Cartagena (Spain)
- **Team:** 14 members (all MSc. or PhD)
- **Geographical focus**: Europe (20%), Asia, Africa, others (80%)
- **Outputs**: technical reports, policy reports, scientific publications, training, datasets, models, operational services

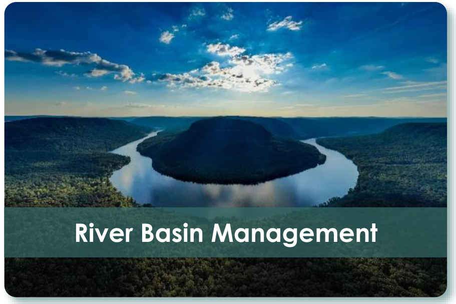
Expertise

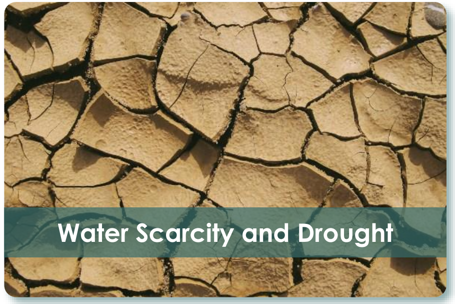

Climate Change


Water Productivity and Irrigation


Capacity Building


Mountain Hydrology


River Basin Management


Water Scarcity and Drought


Hydropower


Ecosystem Services

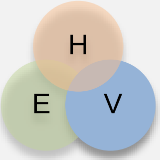
Expertise

Tools and Methods

Remote sensing

Tailor-made Trainings

Hydrological Modelling



Climate Risk and Adaptation Assessment

Water resources evaluation, allocation and planning

Clients and partners

International Financial Institutions and Intergovernmental Organizations

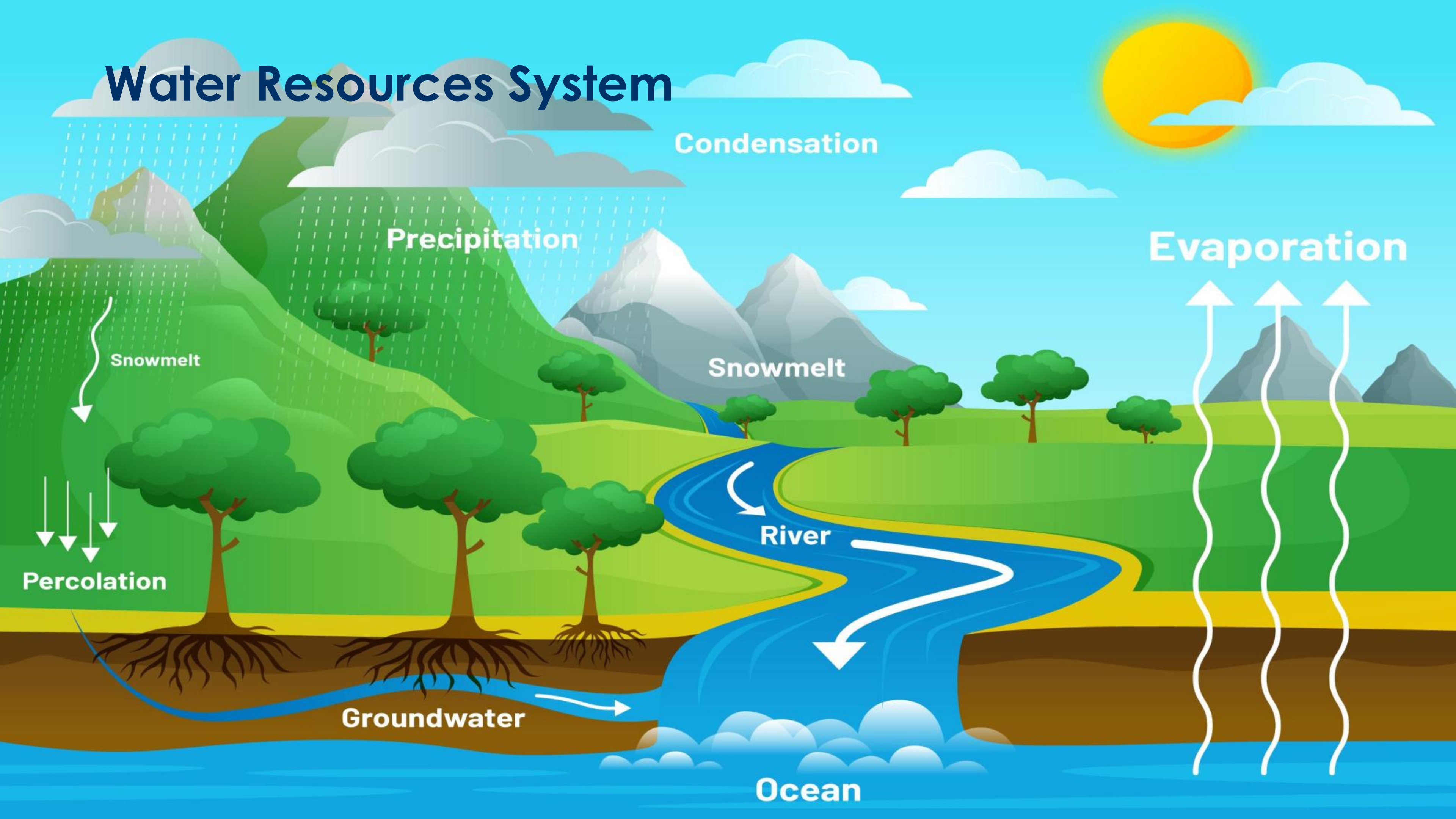
Governmental Institutions and Research Entities

NGOs, Foundations and Private Initiatives

Outline

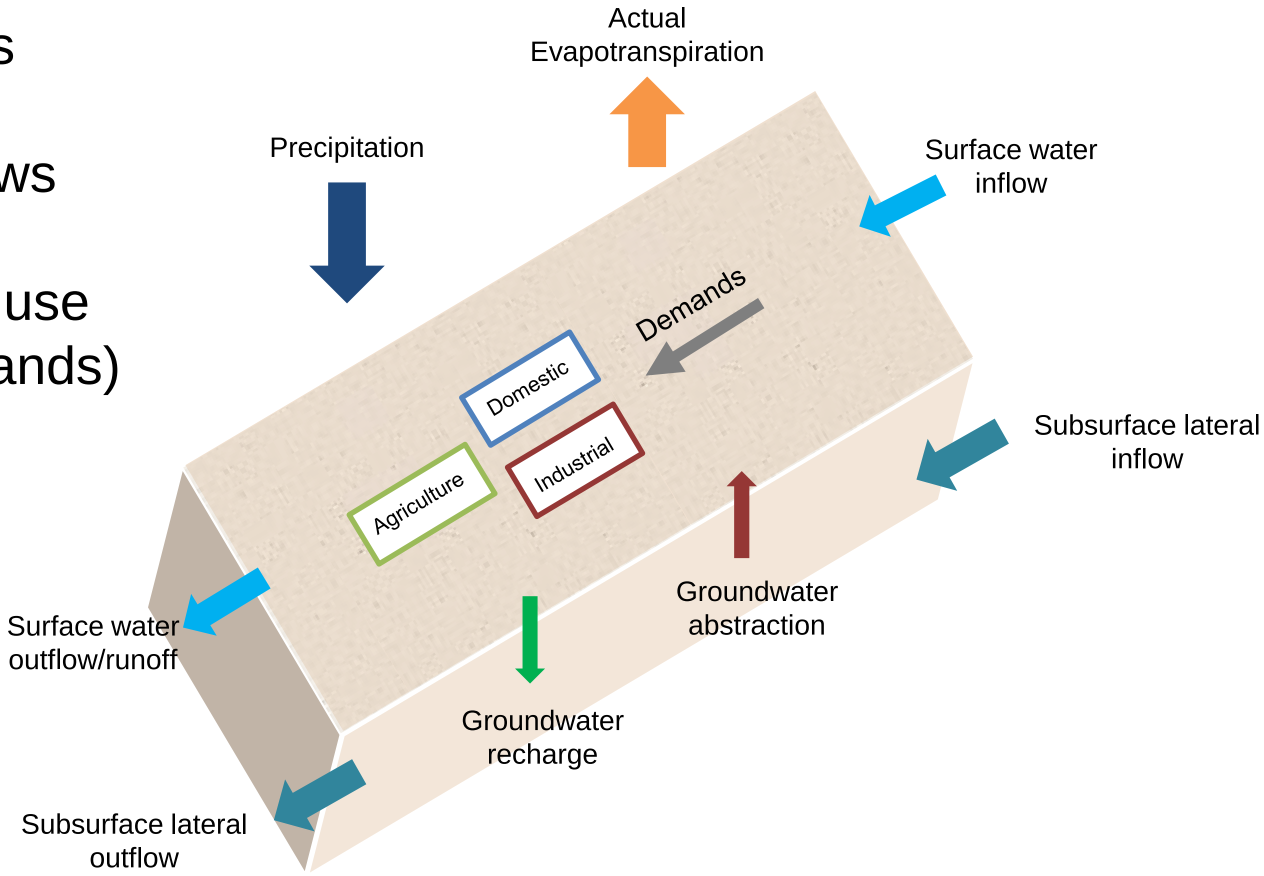
1. Why use remote sensing in the water sector?
2. Tools for collecting and analysing RS data
3. Innovations in RS for the water sector
4. Take-home messages

Water Resources System



Water Resources → Process Overview

- Inflows
- Outflows
- Water use (demands)



Integrating remote sensing in water management

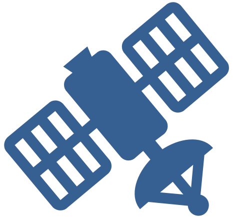
- **Lack of in-situ measurements** can hinder water resources management

Rain gauge

Discharge gauge

Piezometer

- Remote sensing can be used to quantify:
  - Precipitation inputs
  - Changes in the spatial extent of lakes, rivers and wetlands
  - Evapotranspiration from different land uses
  - Soil moisture
  - Groundwater recharge based on RS-based hydrological modelling



Why should we consider remote sensing?

- **Readily available, open-access** datasets
- **Reliable source of data** when ground monitoring data does not exist or is not in the public domain
- **Able to quantify flows** that are difficult to measure in the field (e.g. ET)

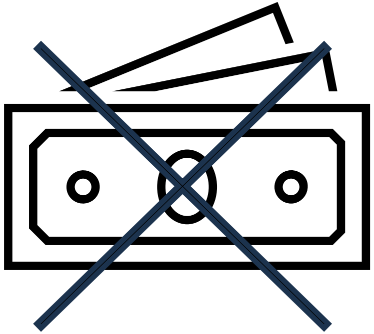
Google Earth Engine

esa

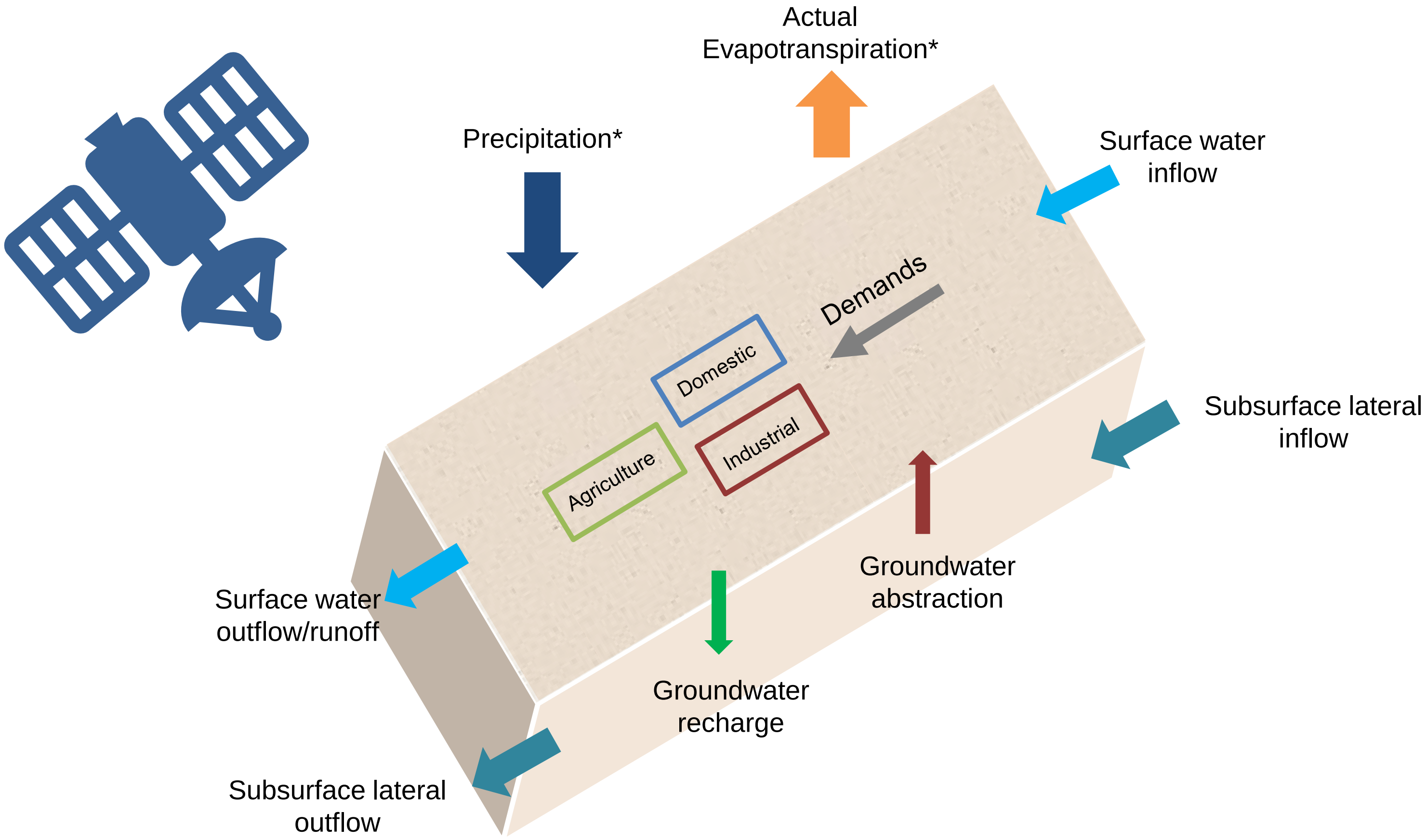
NASA

Why should we consider remote sensing?

- Offers **spatiotemporally consistent data**
- **Cost-effective** for large scale studies
- Enables to **access** and **investigate remote regions**



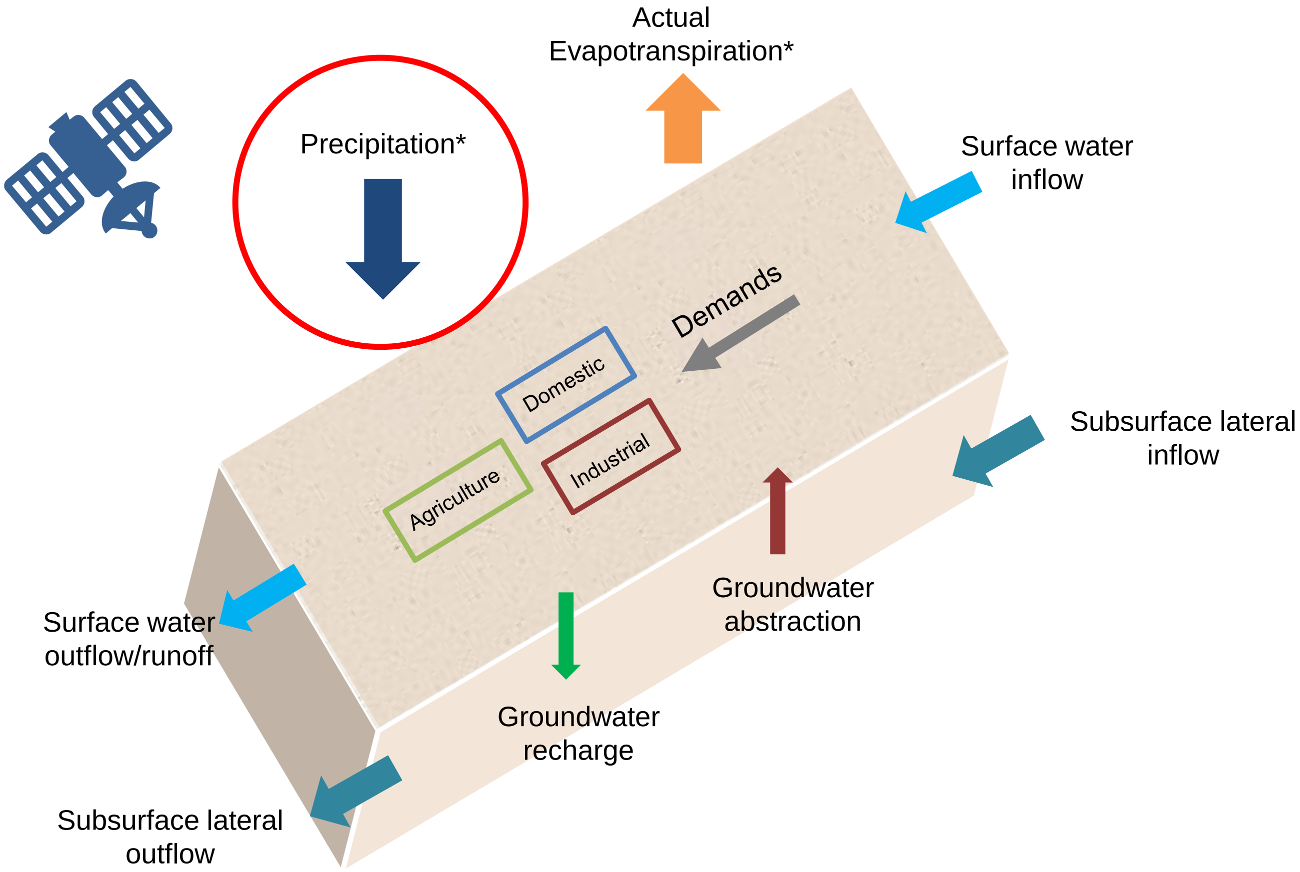
Suitability of RS for different components



Suitability of RS for different components

Water Resources Component	Suitability
Precipitation	✓✓✓
Evapotranspiration	✓✓✓
Sectoral demands	✓
Change in storage (GW, soil moisture)	✓✓✓
Surface flows (e.g. rivers, streams)	✓✓
Land use assessment for mapping key features/activities	✓✓✓

Suitability of RS for precipitation



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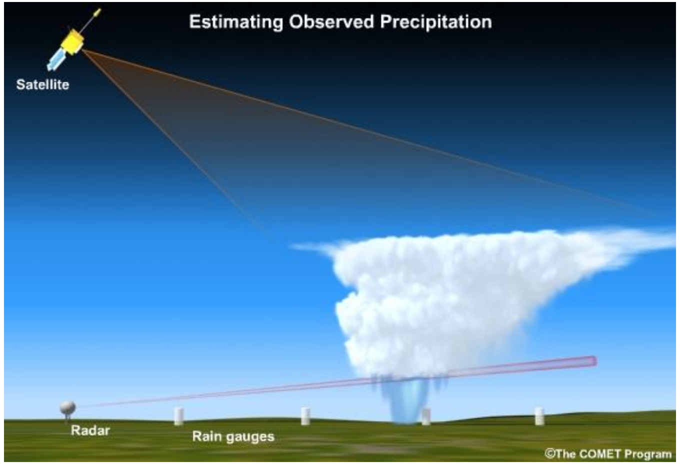
How does RS measure precipitation?

Passive microwave (satellite-based):

- Detects Earth's natural microwave emissions
- Clouds and rain scatter radiation, reducing what the satellite measures
- Less radiation = Higher rainfall intensity



Active microwave (ground radar):

- Measures radar signal reflection to estimate rain distance & intensity
- Tracks storms and predicts movement using weather models

Precipitation datasets based on RS

Product	Developer	Spatial resolution	Covering area	Temporal resolution	Time span	Ground measurement
TRMM 3B43 v7	NASA, JAXA	0.25°	0°E-360°E/50°N-50°S	3 hourly	Jan 1998 - present	Yes
GPCP V2.2	WCRP (GEWEX)	2.5°	0°E-360°E/90°N-90°S	Monthly	Jul 1987 - present	Yes
GPCP1DD	WCRP (GEWEX)	1°	0°E-360°E/90°N-90°S	Daily	Oct 1996 - present	Yes
CRU TS3.21	University of East Anglia	0.5°	0°E-360°E/90°N-90°S	Monthly	Jan 1901 - present	Yes
ERA-interim	ECMWF	0.75°	0°E-360°E/90°N-90°S	6 Hourly	Jan 1979 - present	Yes
RFE 2.0	NOAA (CPC)	0.1°	20°E-55°E/40°N-40°S	Hourly	Jan 2001 - present	Yes
ARC 2.0	NOAA (CPC)	0.1°	20°E-55°E/40°N-40°S	Hourly	Jan 1983 - present	Yes
CHIRPS v1.8	CHG	0.05°	0°E-360°E/50°N-50°S	Pentads (Daily for Africa)	Jan 1983 - present	Yes
PERSIANN	University of California	0.25°	0°E-360°E/60°N-60°S	30 minutes	Mar 2000 - present	No
CMORPH	NOAA (CPC)	0.25°	0°E-360°E/60°N-60°S	3 Hourly	Dec 2002 - present	No
GSMaP_MVK	JAXA (JST)	0.1°	0°E-360°E/60°N-60°S	Hourly	May 2000 - present	No
TAMSAT	University of Reading	0.0375°	Africa	Decadal	Jan 1983 - present	Yes
GPCC	DWD	0.5°	0°E-360°E/90°N-90°S	Monthly	Jan 1901 - present	Yes

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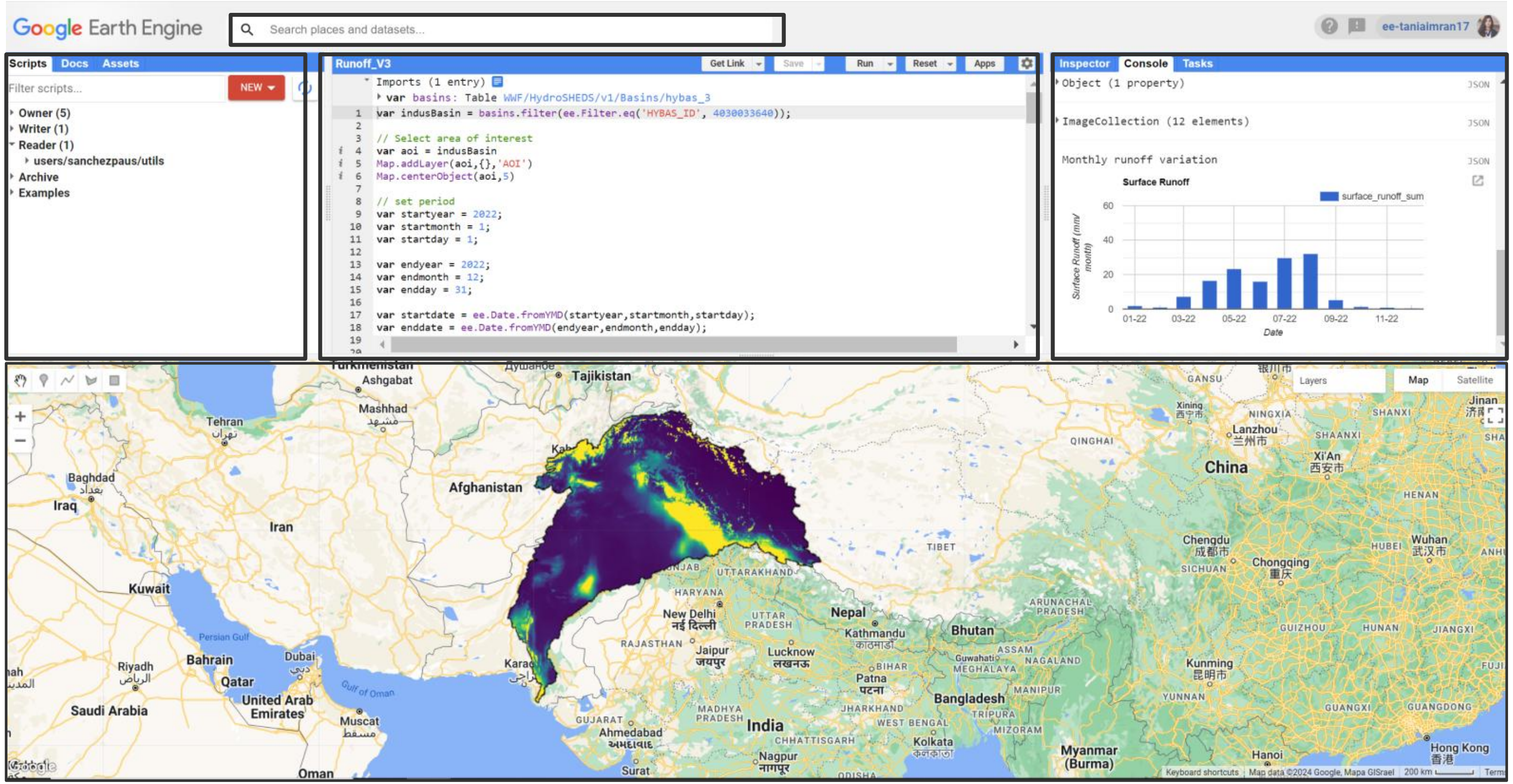
Open-source platforms for RS analysis: Google Earth Engine

Google Earth Engine



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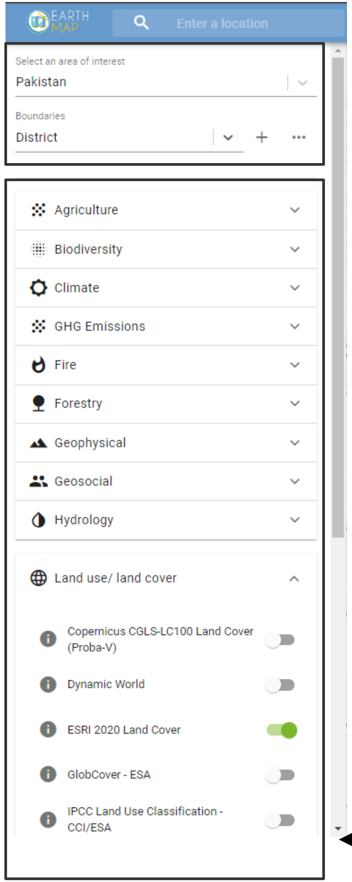
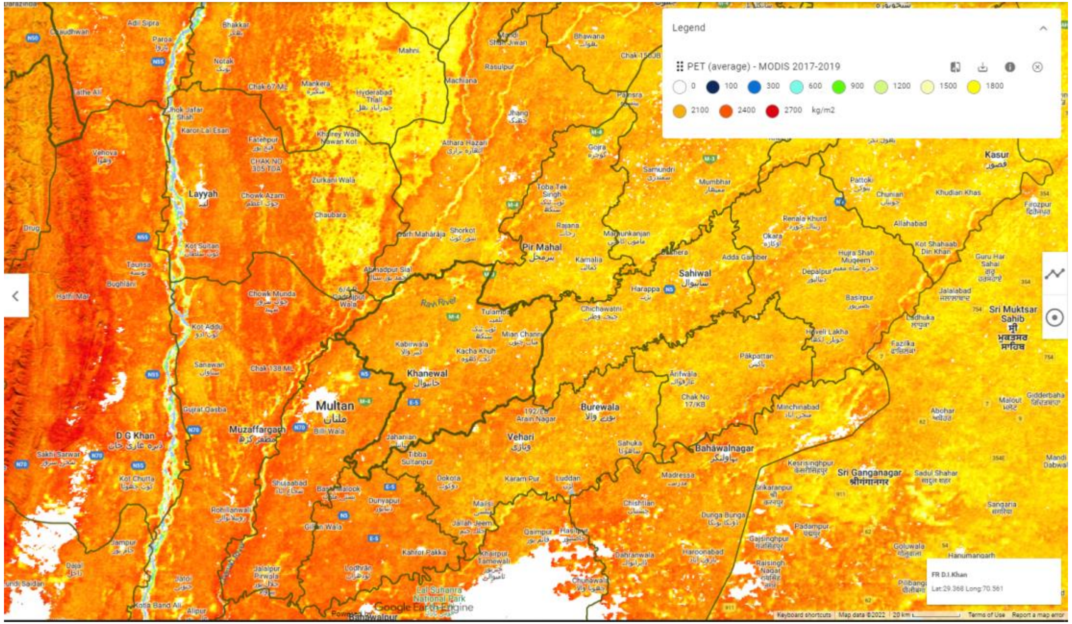
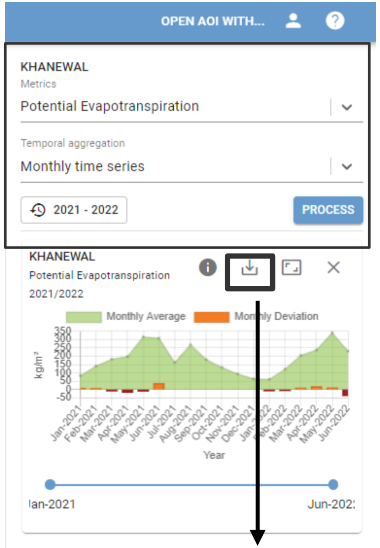
Open-source platforms for RS analysis: Earth Map



Choose country and boundaries

Retrieve data for your area of interest



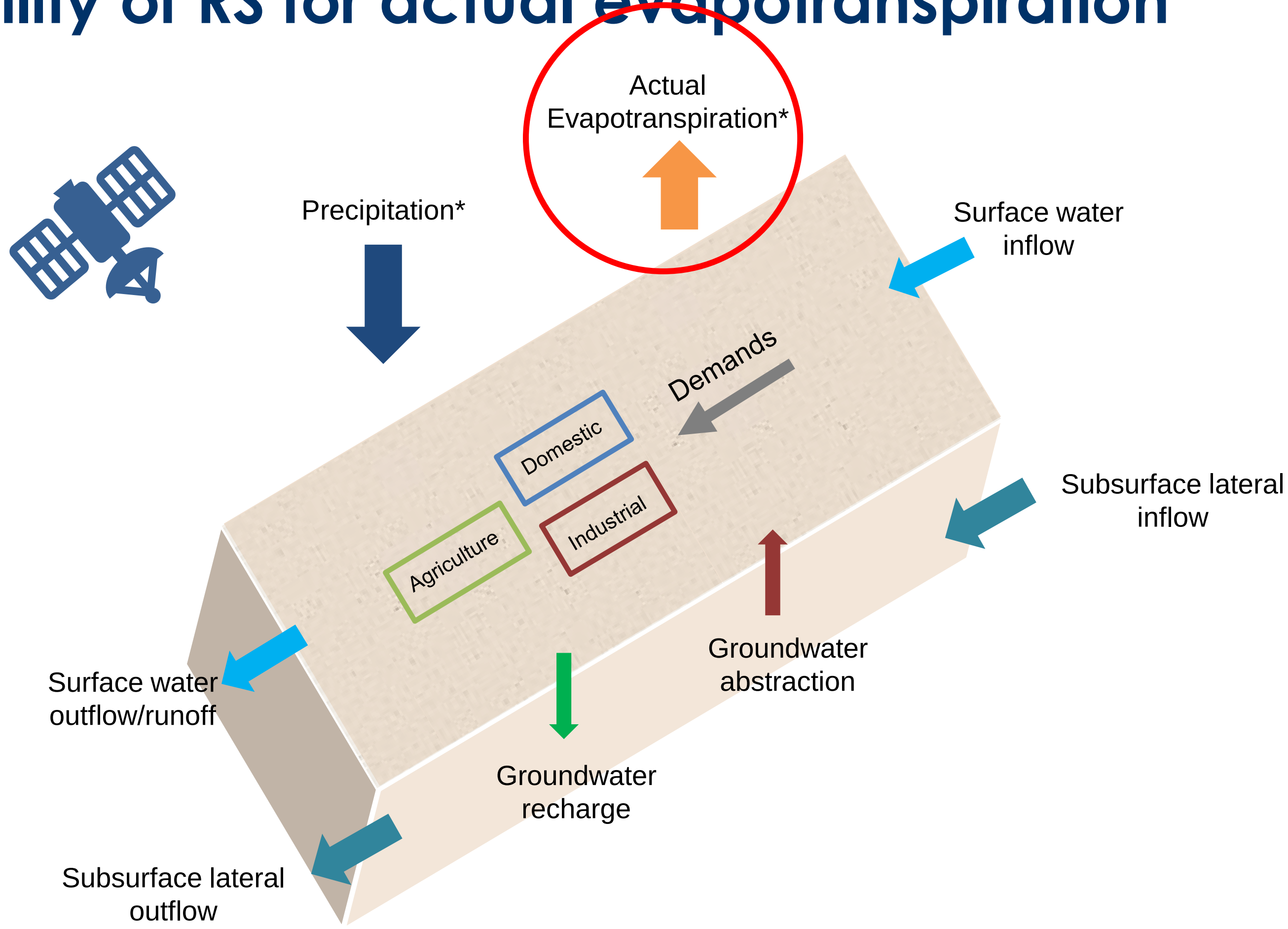


Download data as CSV

Choose from the available global datasets

https://earthmap.org/

Suitability of RS for actual evapotranspiration



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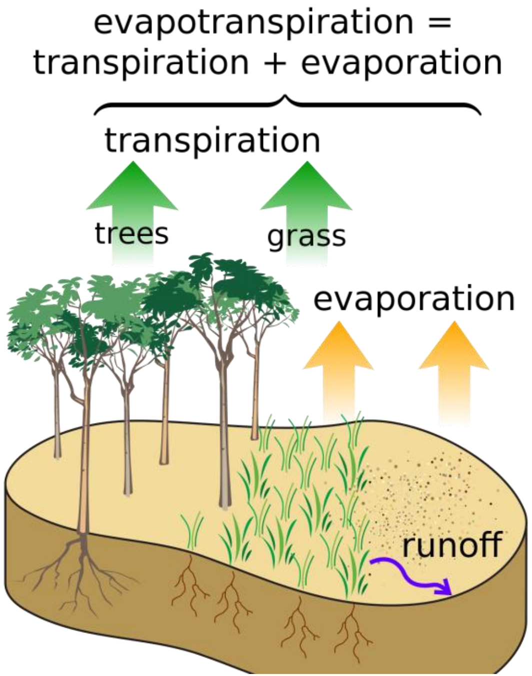
Suitability of RS for actual evapotranspiration

- Evapotranspiration represents consumptive use of water especially in the agricultural sector

- Amount of water consumed by the crops = actual evapotranspiration

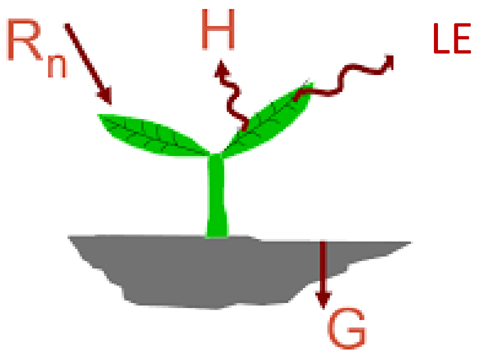
- Amount of water used by other landscapes e.g. forest cover, grassland can be also estimated based on actual evapotranspiration



How is ET derived from remote sensing?

- Basis of different EO ET datasets: **Surface energy balance model**

  - $R_n - G - H - LE = 0$
  - $LE = R_n - G - H$



where:

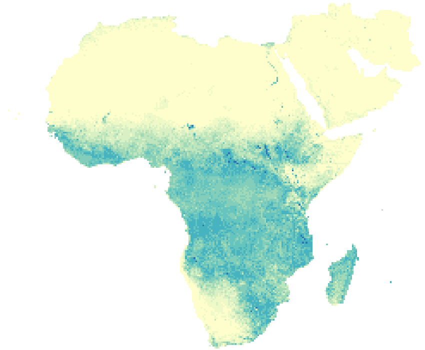
R_n = Net radiation at the land surface (difference between incoming and outgoing radiation)

G = Ground/soil heat flux (energy transferred from land to subsurface by conduction)

H = Sensible heat flux (energy transferred through convection and turbulence)

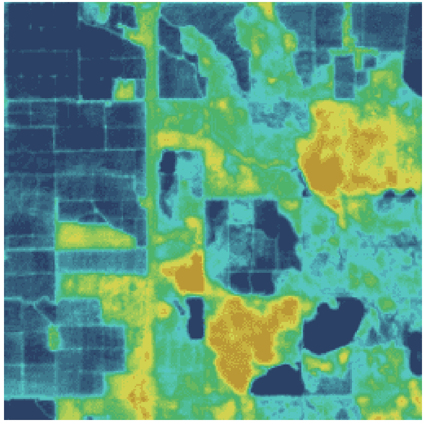
LE = Latent heat flux (energy transferred through evapotranspiration)

Which ET datasets are available on GEE?



WaPOR Actual Evapotranspiration

(300m globally, 100 meter nationally, 30 meter regionally)



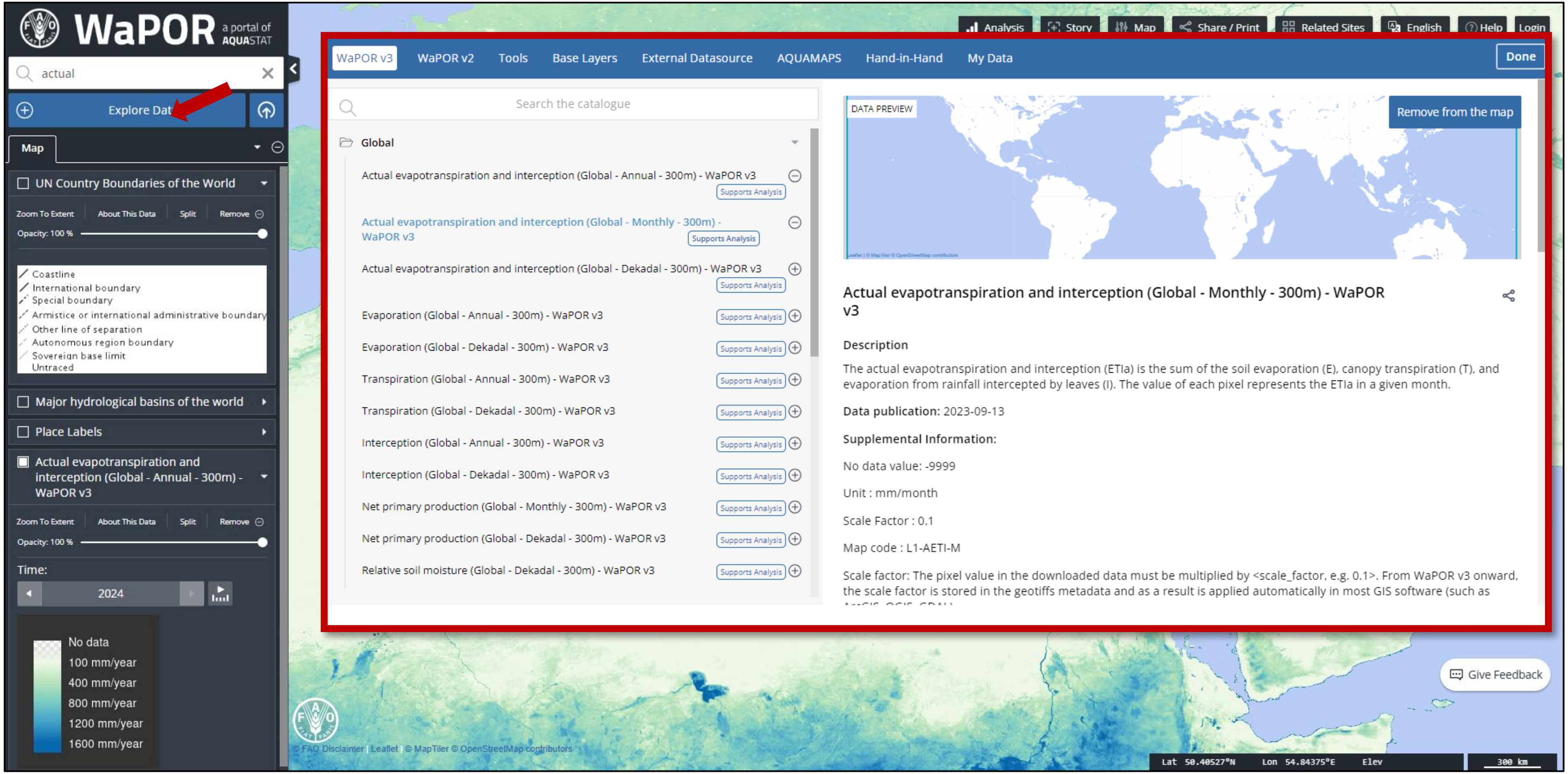
OpenET

(Monthly Evapotranspiration 30 m)

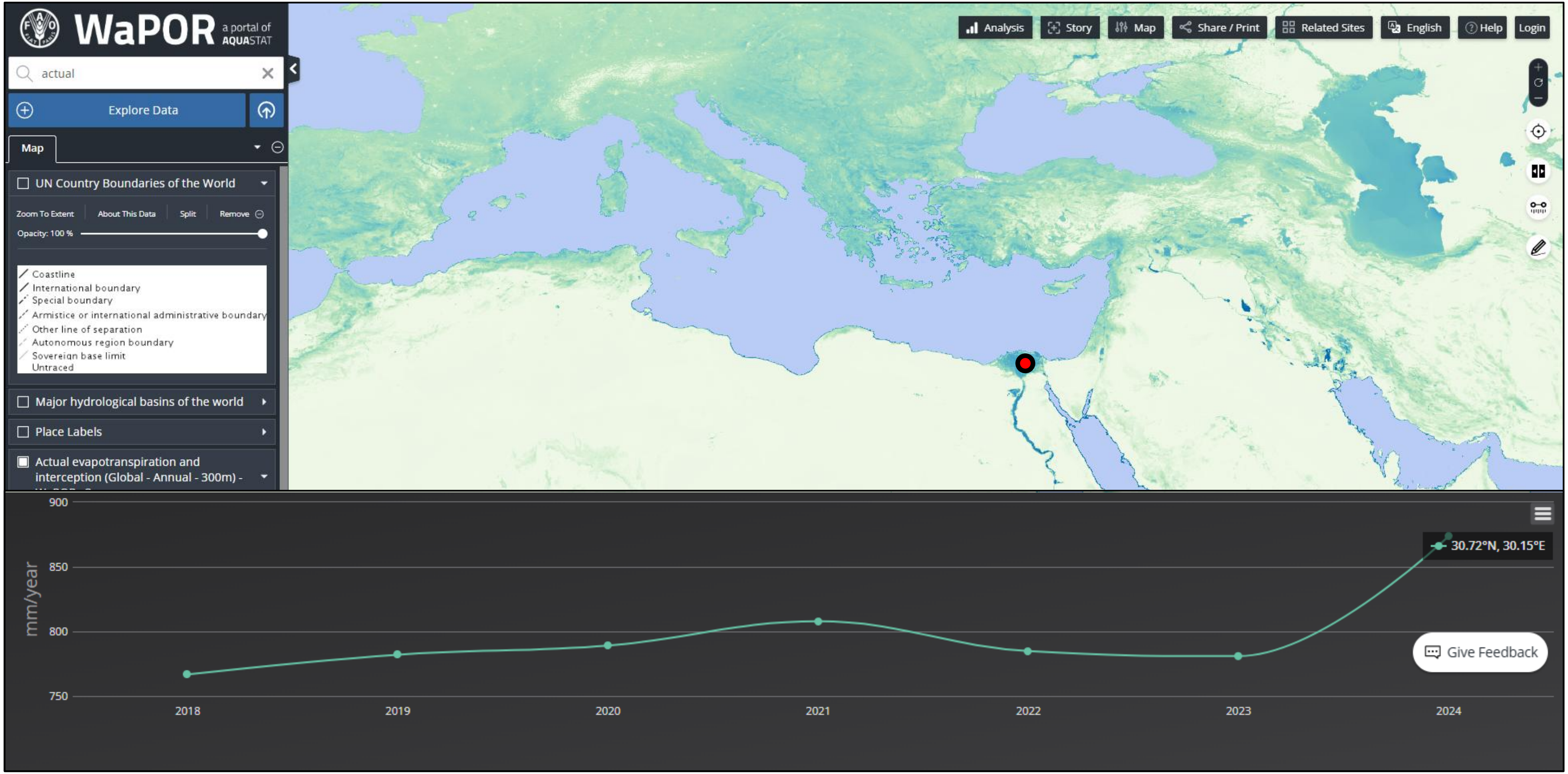
MOD16: Terra Net Evapotranspiration

(8-Day Global 500 m)

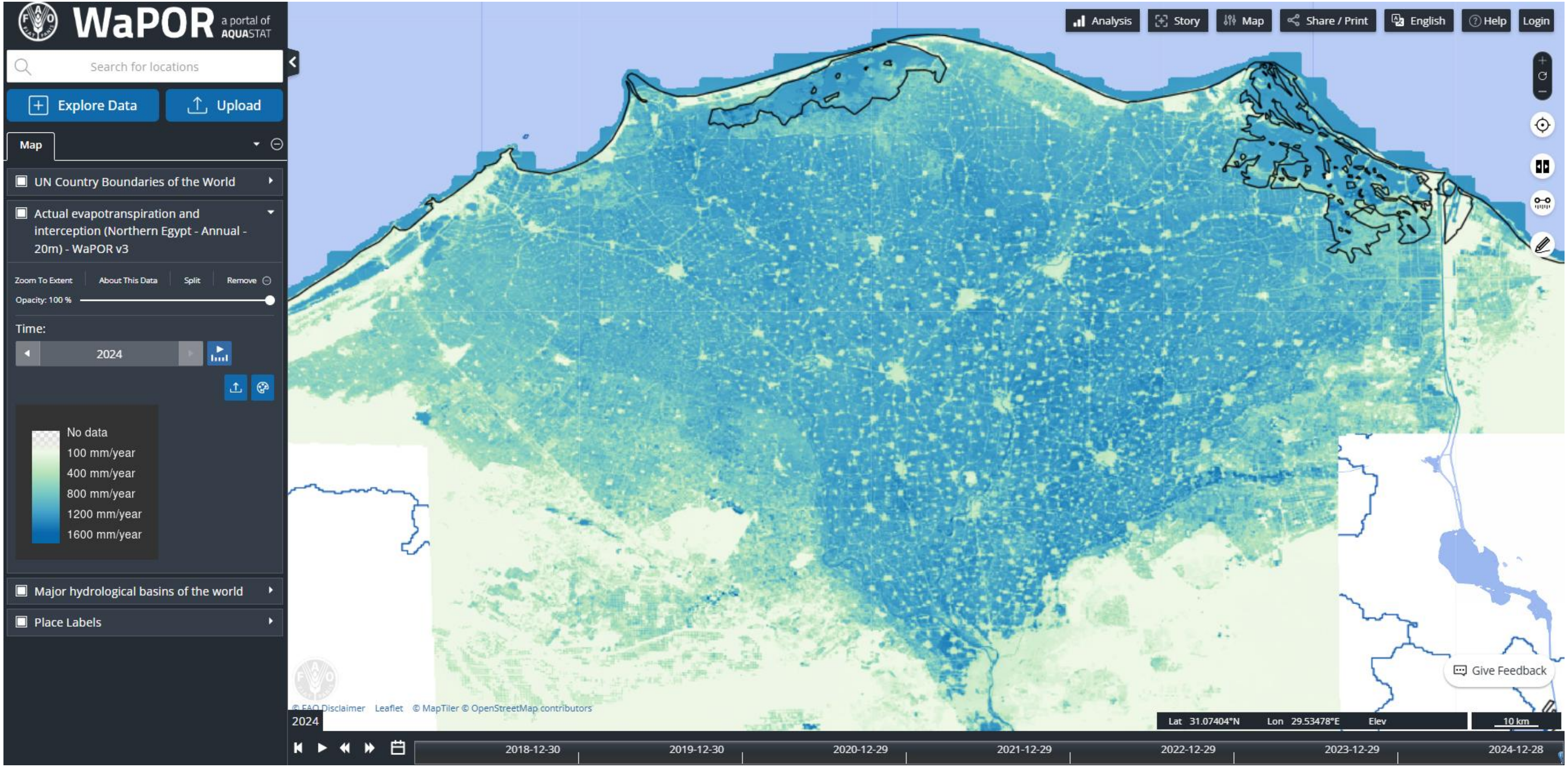
Open-source platforms: ET from WaPOR



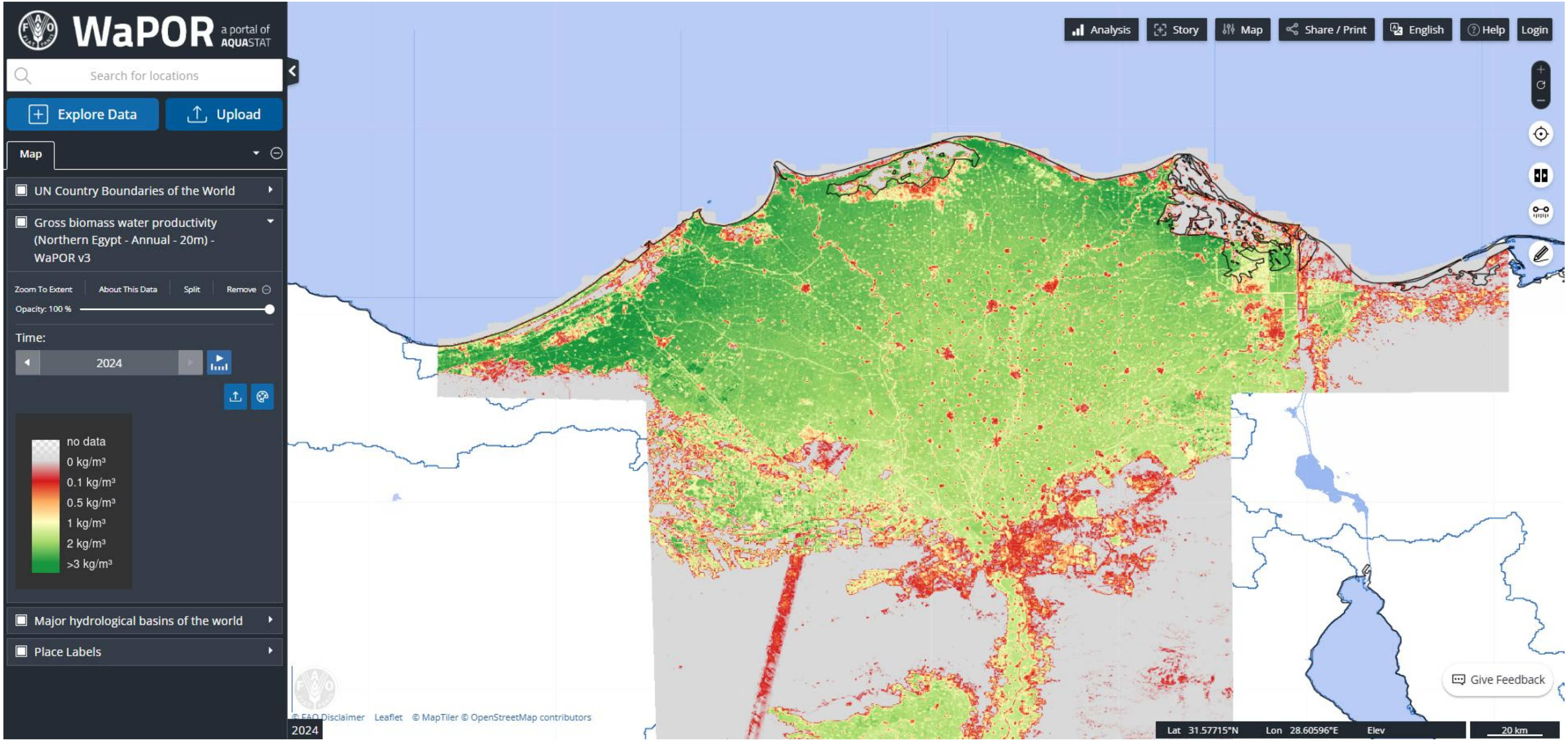
Open-source platforms: ET from WaPOR



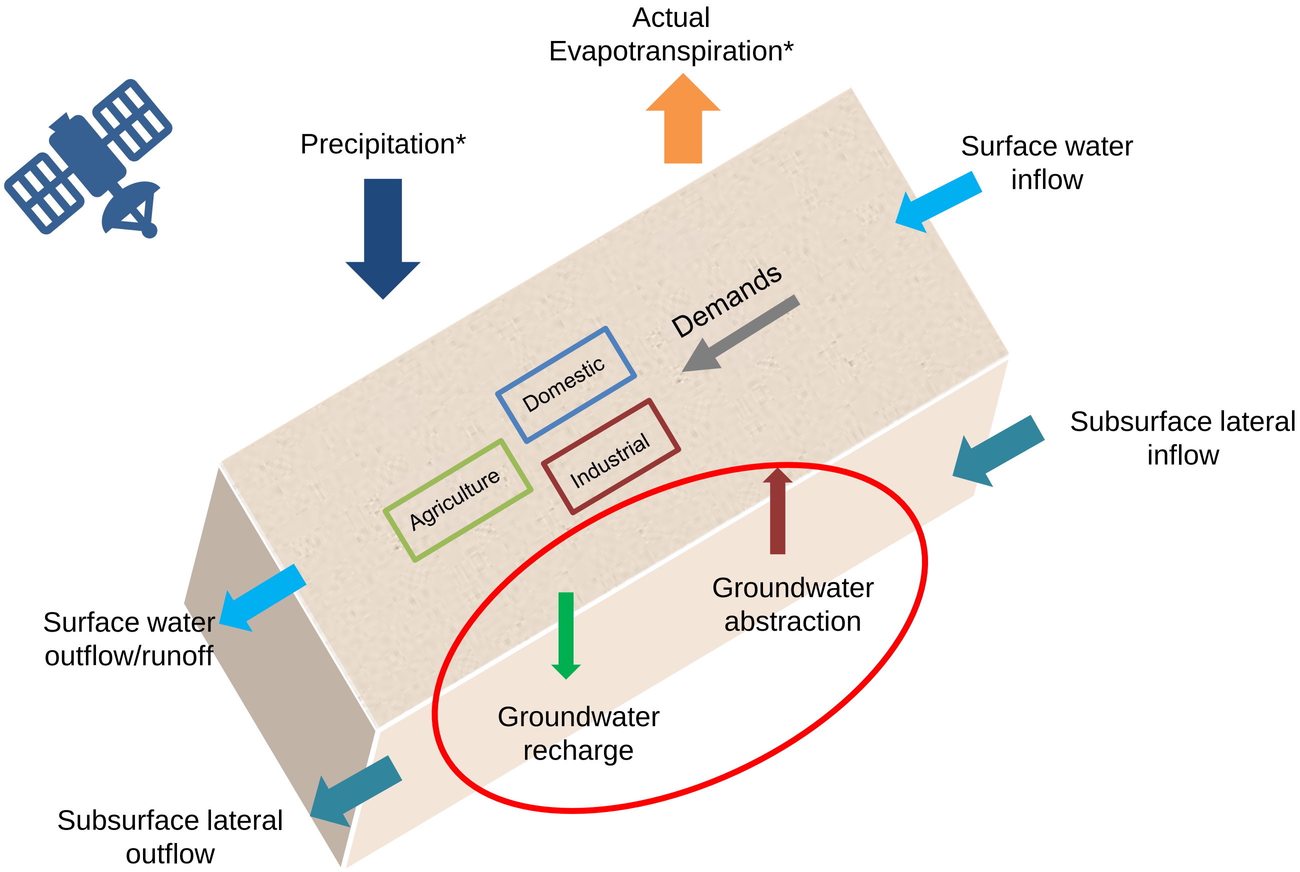
WaPOR – Actual ET (20 m) – 2024



WaPOR – Water Productivity (20 m) - 2024



Suitability of RS for groundwater storage



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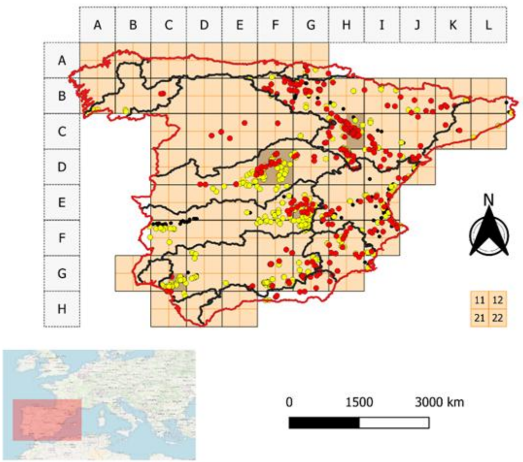
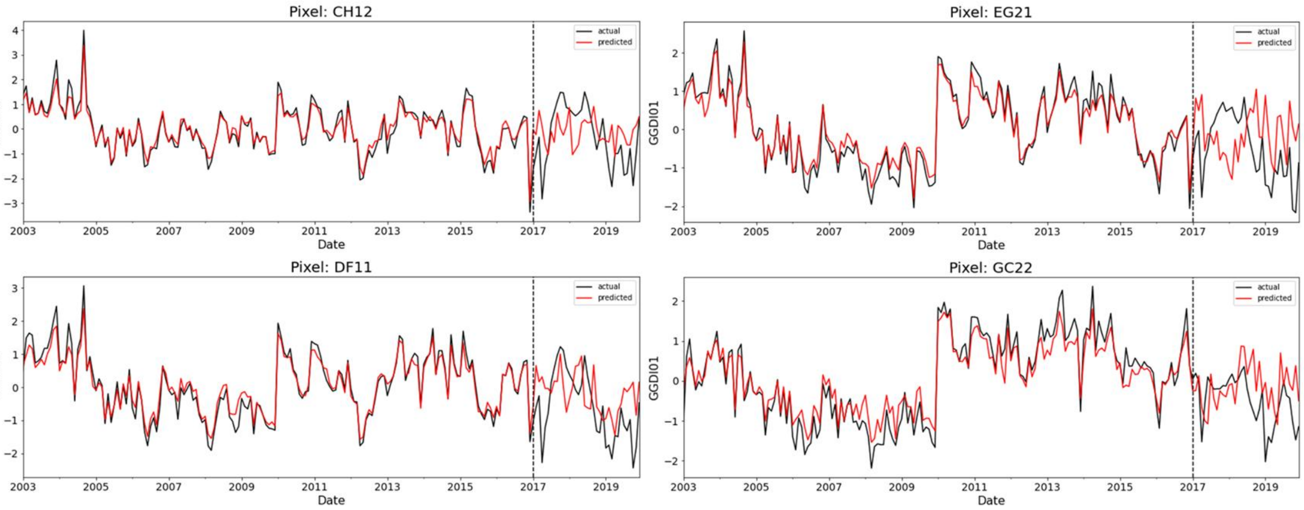
RS for estimating changes in groundwater storage

Global Gravity-Based Groundwater Product in Spain (GRACE satellite)

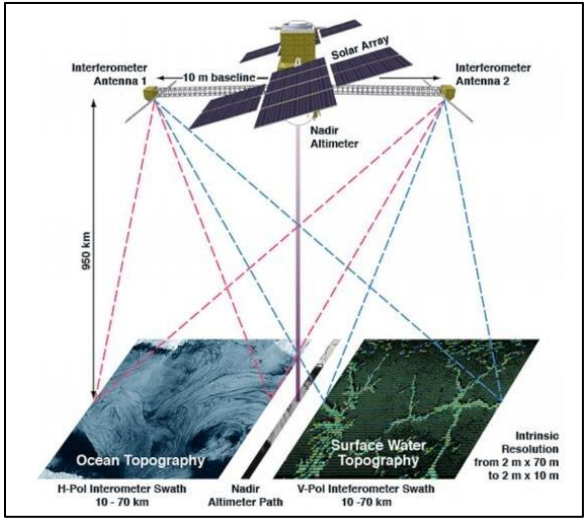




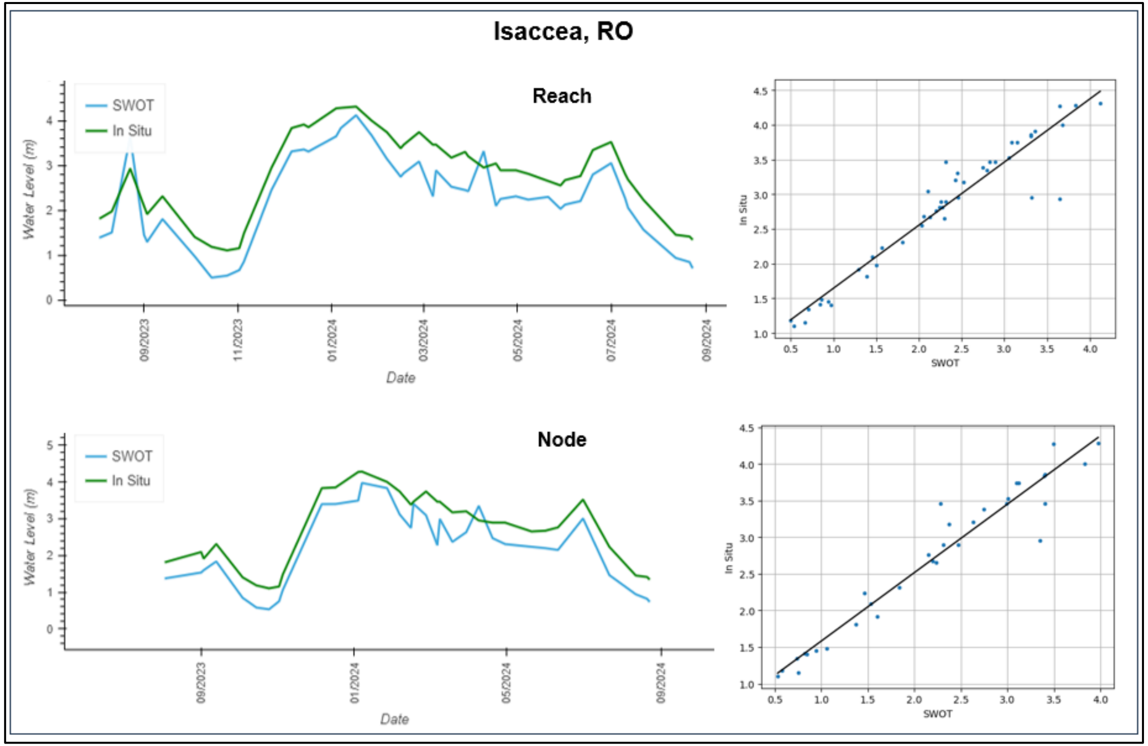
Contreras & Rodriguez (2023) - FutureWater

RS for estimating surface water extent/elevation (2022)

Measuring river and reservoir elevation - Surface Water and Ocean Topography (SWOT)



Source: NASA



Fernandez del Castillo (2024) - FutureWater

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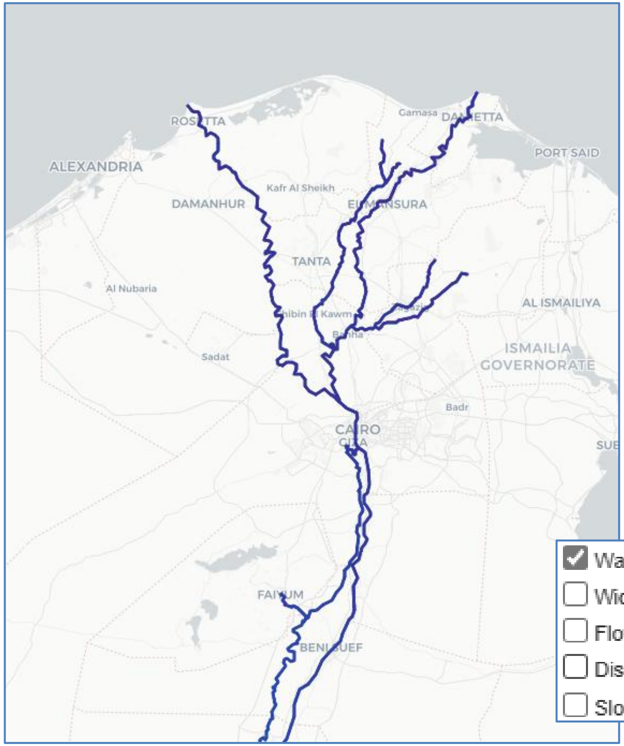
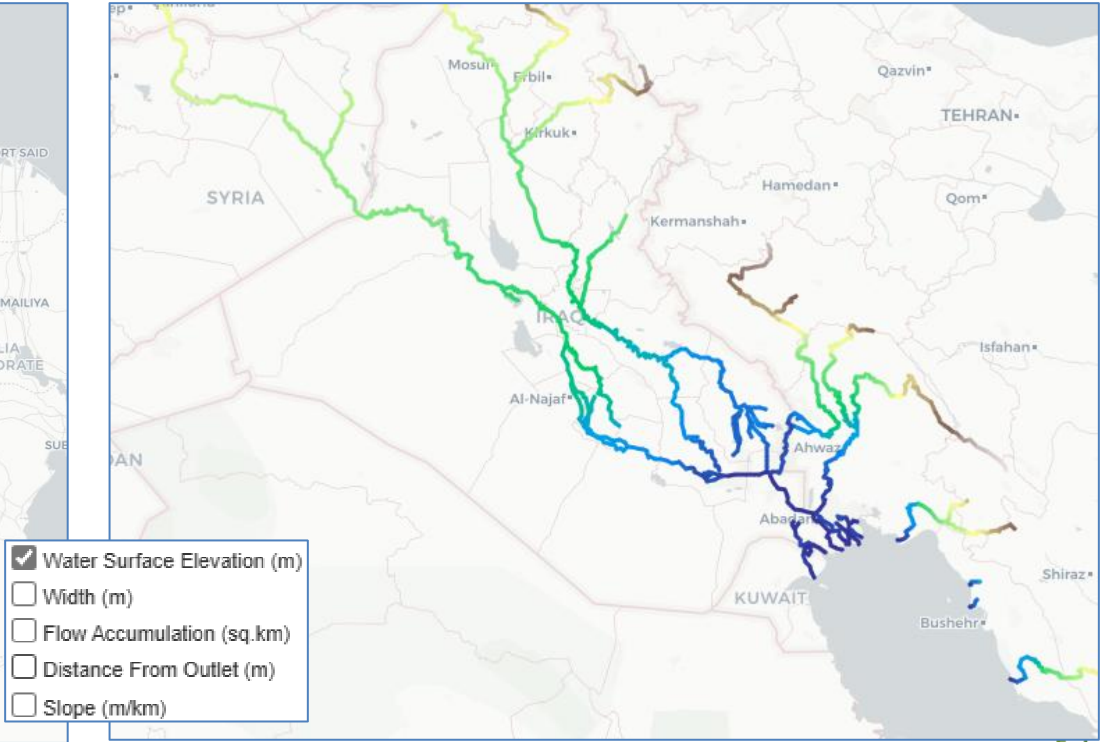
RS for estimating surface water level + reservoirs

SWOT River Database (SWORD) → **www.swordexplorer.com**





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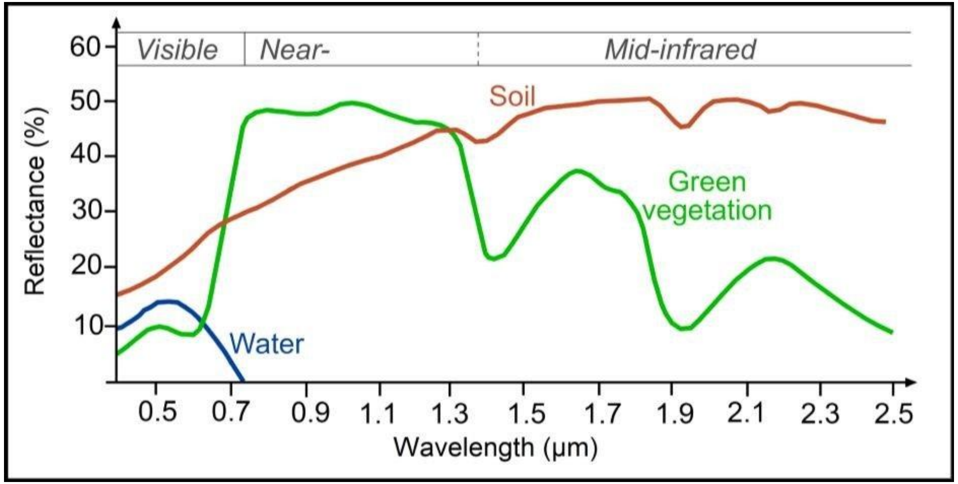
Remote sensing for land use assessments



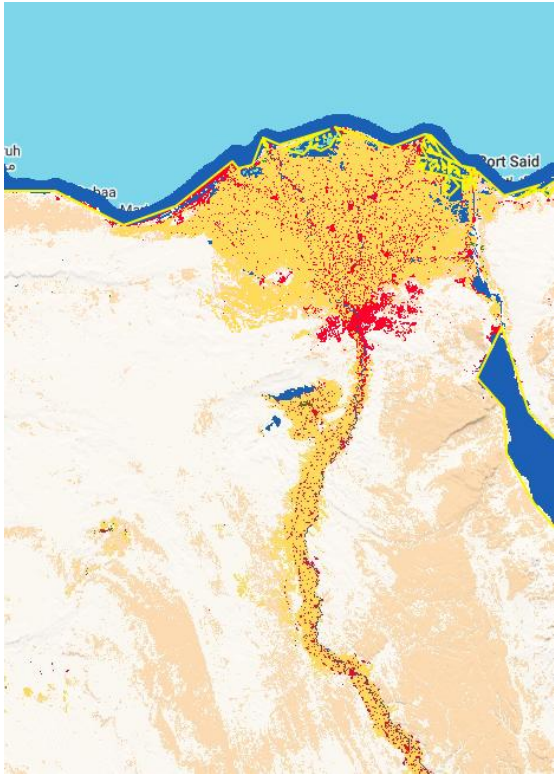
Source: grindgis.com

WaPOR

Google Earth Engine

Copernicus Europe's eyes on Earth

Land Monitoring Service



ESRI Land Cover (2017/2023)

Machine learning techniques within GEE

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NISAR satellite (2025 launch)

- NASA-ISRO Synthetic Aperture Radar

- Cloud-penetrating SAR data in
  L- and S-bands.

- Mapping of soil moisture,
  flood extent, land subsidence, and
  irrigation status.

- High resolution (5 - 10 m)

Source: NASA

Why (when) not use satellite remote sensing?

> When the **required level of detail** (in space or time) is higher than satellite RS can offer

> When the **required accuracy** is higher than satellite RS can offer

> When the measurement cannot be done with satellite RS (belowground parameters, dissolved solutes)

> When only point-based measurements are required

> When there is a lot of atmospheric disturbance, such as cloud cover in the tropics

Overpass time

Limitations of Remote Sensing

Quality of remote sensing data is highly susceptible to atmospheric conditions such as cloud cover

Limited spatial resolution which makes it unsuitable for small scale studies

Cannot effectively use it to quantify and analyse subsurface processes

Uncertainty in datasets and variation in validation results across the globe

Cannot retrieve real-time data and develop operational products solely based on remote sensing

Key takeaways

> **Spatio-temporally consistent data** for **long-term analysis**

> **Over 600 datasets are freely available** that can be used for analysis in **data-scarce regions**

> A **preliminary water balance** can be derived **solely from remote sensing**

> On-going developments and planned new sensors promise **improved and new applications for water resources monitoring** over the next decade

> More developments!

Water Resources Component	Suitability
Precipitation	√√√
Evapotranspiration	√√√
Sectoral demands	√
Change in storage (GW, soil moisture)	√√√
Surface flows (e.g. rivers, streams)	√√
Land use assessment for mapping key features/activities	√√√

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Thank you!

For more, please visit: futurewater.eu

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