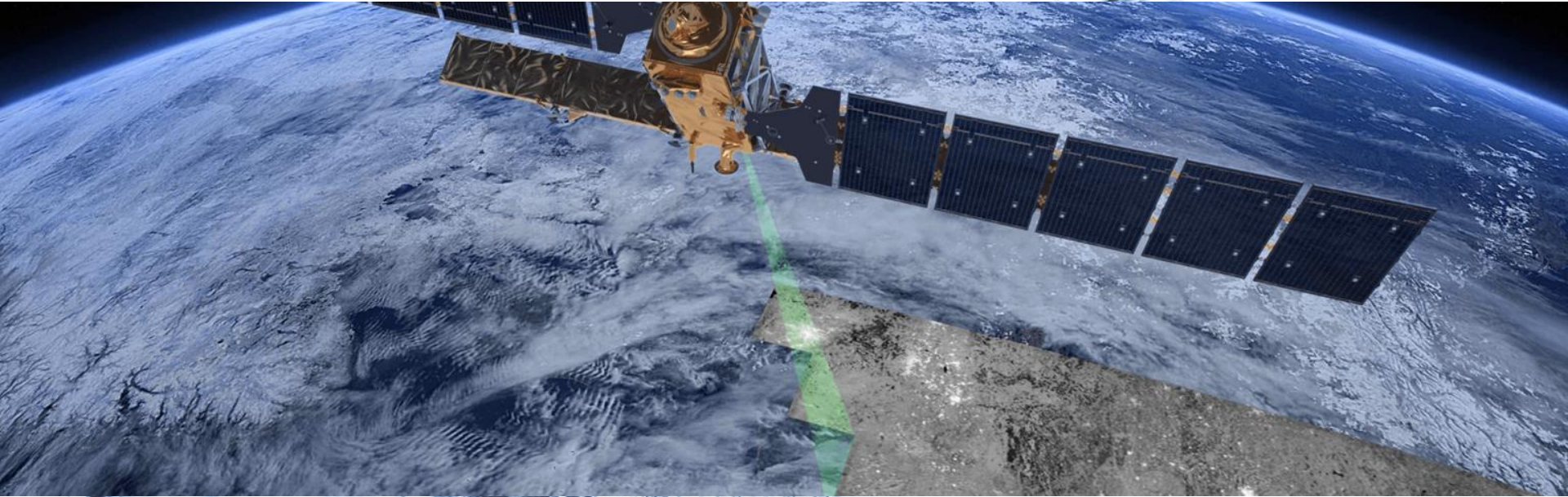


Data Collection and Analysis using Remote Sensing

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

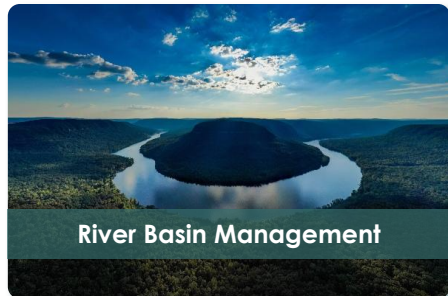
Research and consultancy for a sustainable future of our water resources

- **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

FutureWater



Expertise



Expertise



Tools and Methods



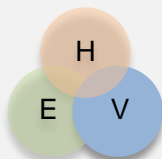
Remote sensing



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



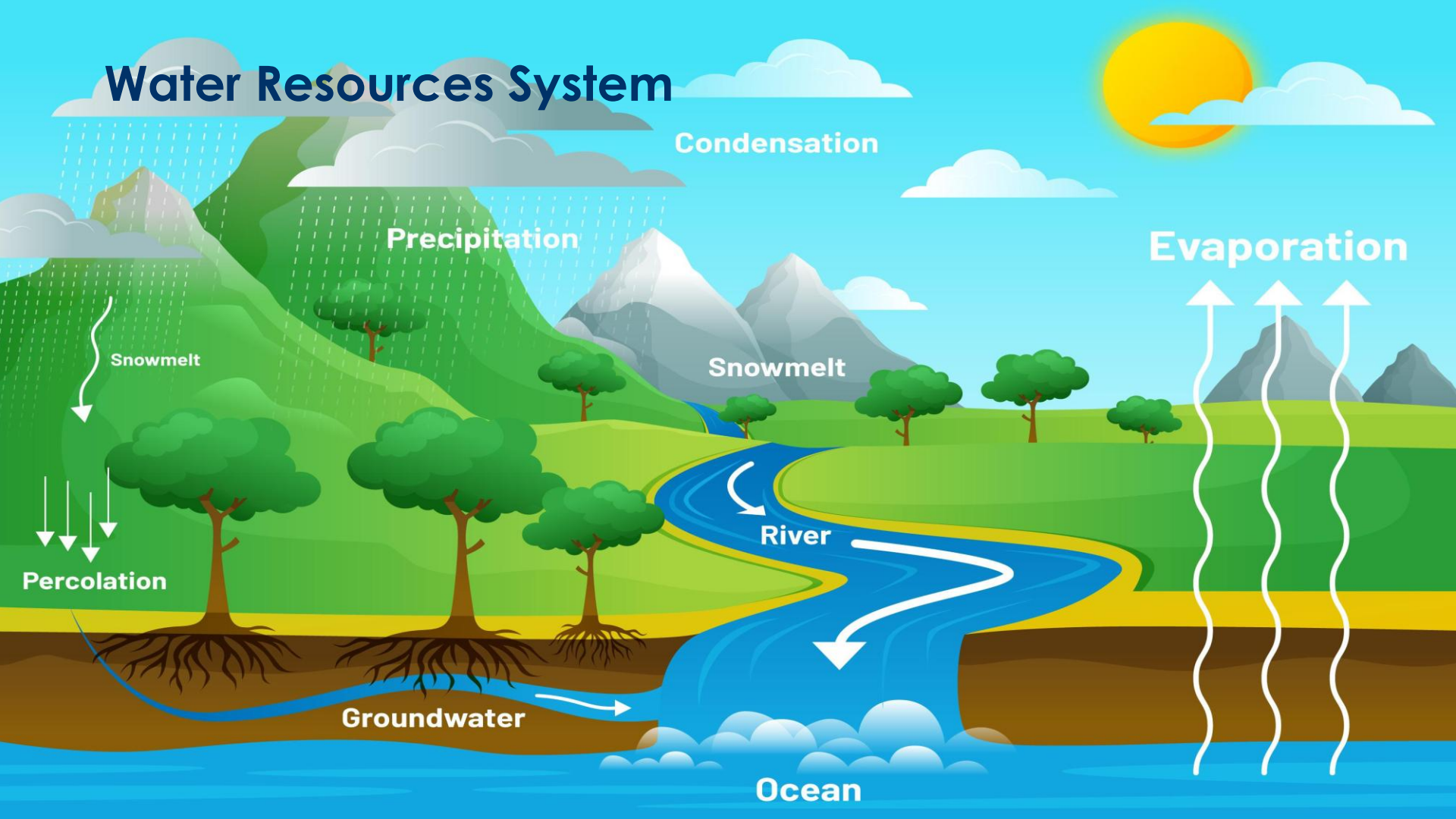
NGOs, Foundations and Private Initiatives



Outline

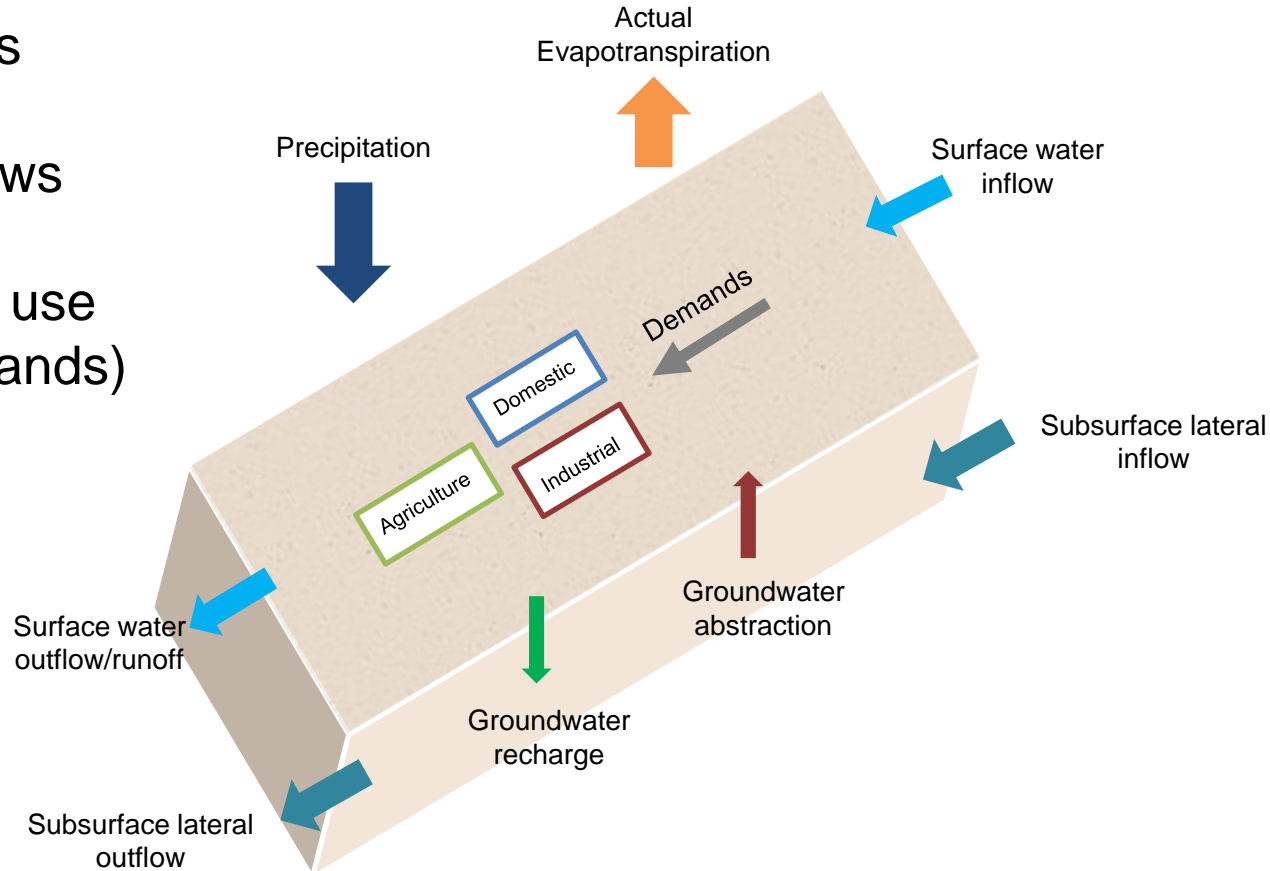
1. Why use remote sensing in the water sector?
2. Tools for collecting and analysing RS data
3. Innovations in RS for the water sector
4. Take-home messages

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

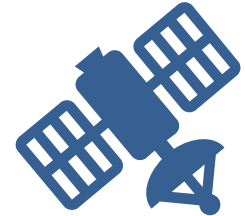


Discharge gauge



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



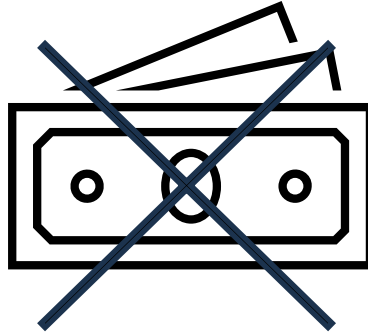
Why should we consider remote sensing?

- **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)

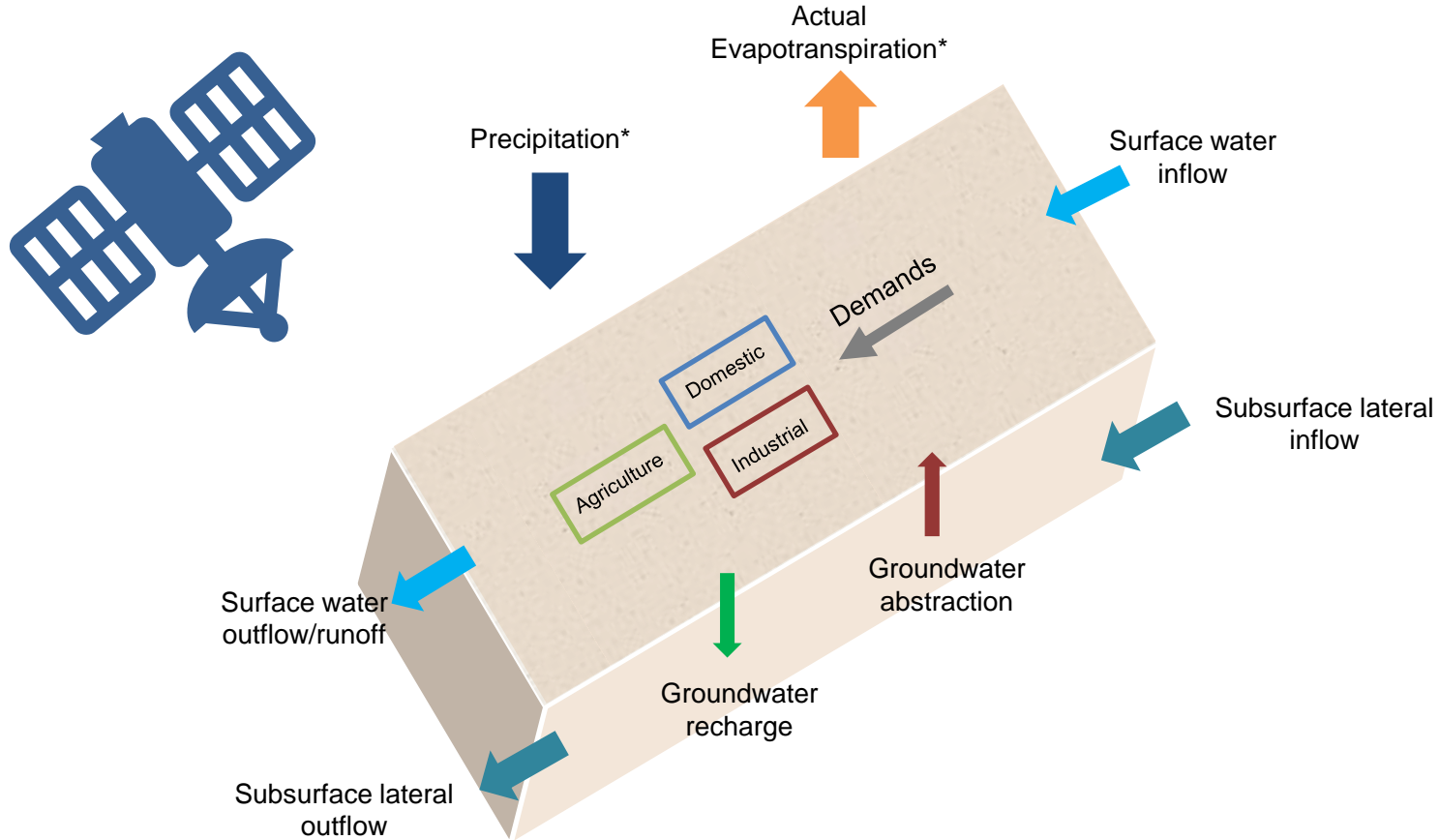


Why should we consider remote sensing?

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



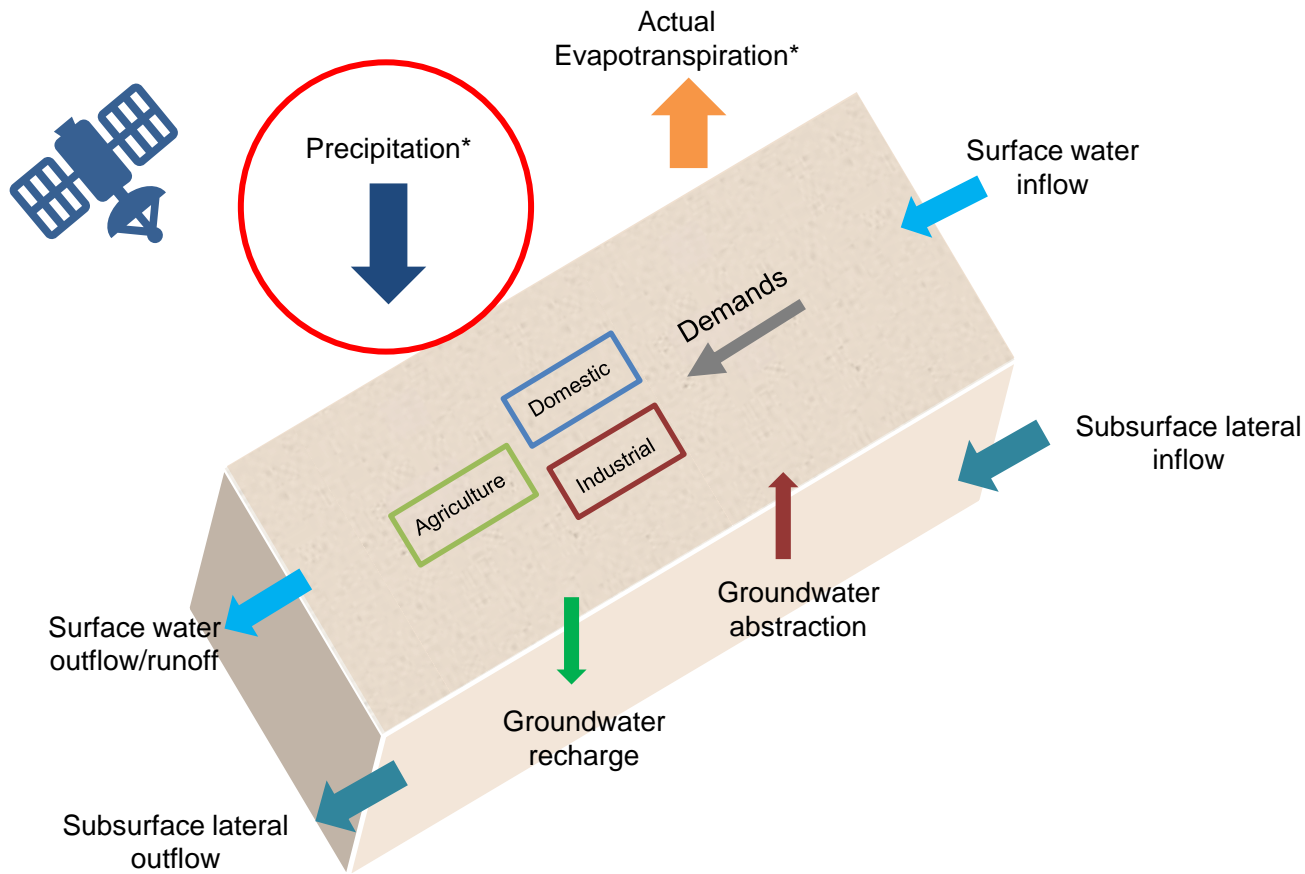
Suitability of RS for different components



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



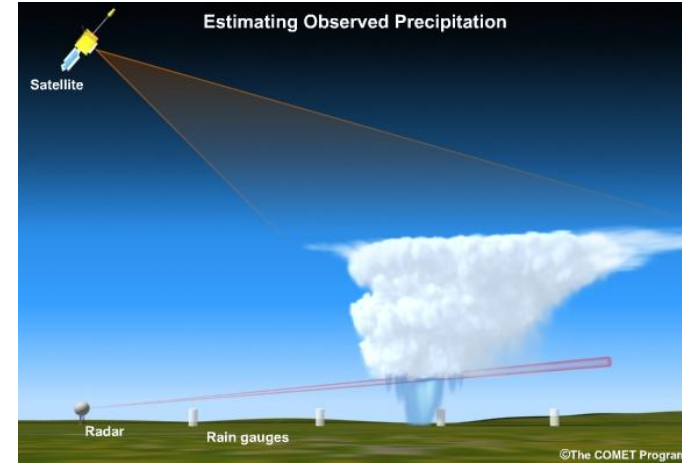
How does RS measure precipitation?

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



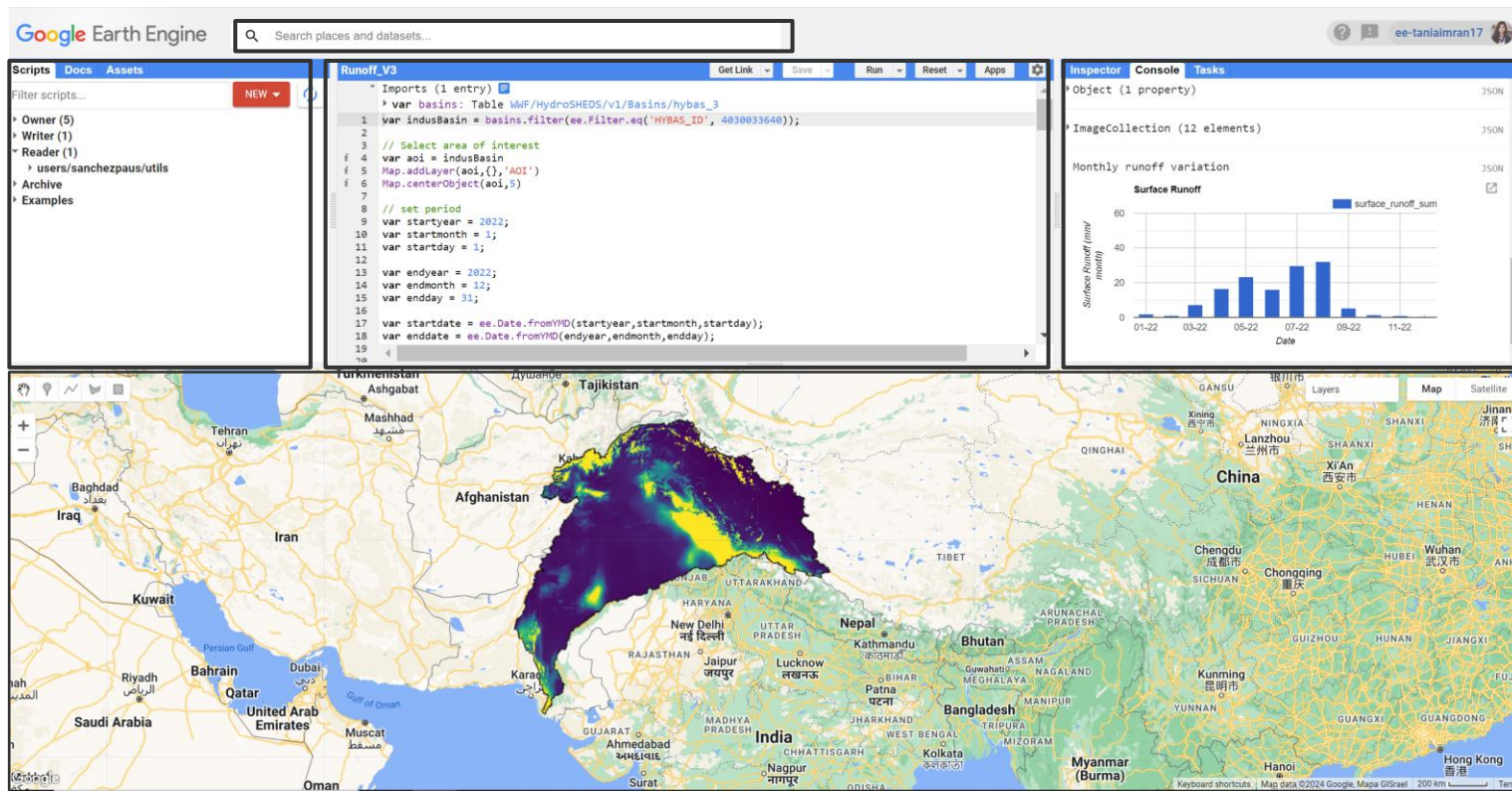
Precipitation datasets based on RS

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

Open-source platforms for RS analysis: Google Earth Engine



Google Earth Engine

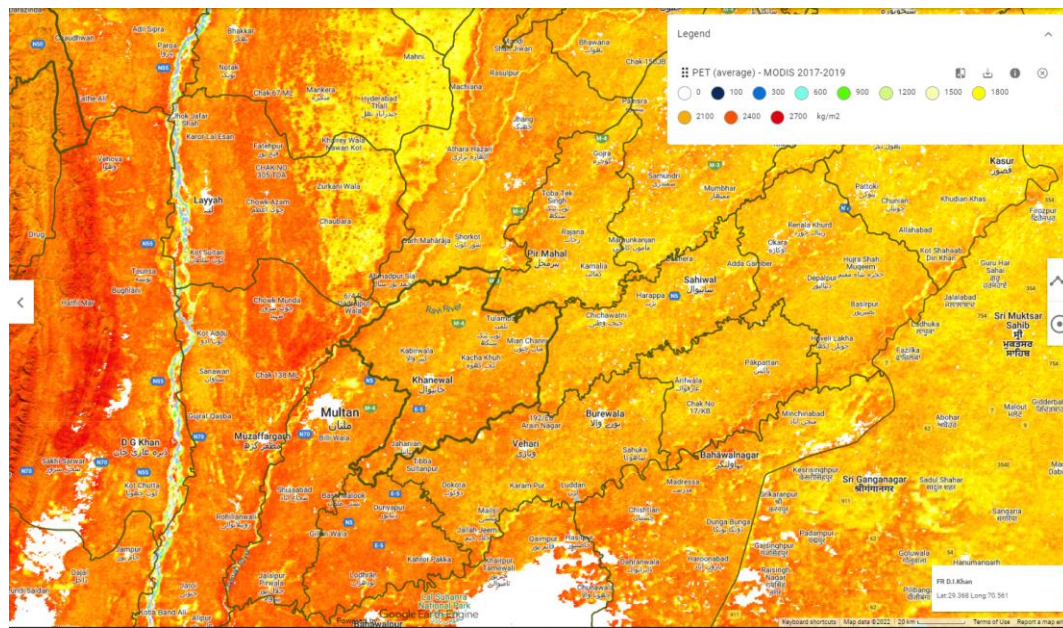


Open-source platforms for RS analysis: Earth Map

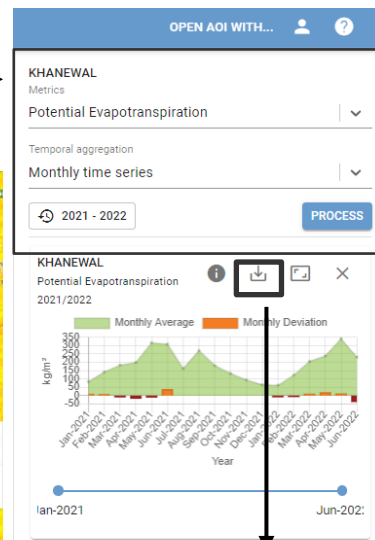
The screenshot shows the Earth Map web application interface. At the top, there is a search bar with the text "Enter a location". Below it, a dropdown menu shows "Select an area of interest" with "Pakistan" selected. Further down, there are options for "Boundaries" and "District". The main sidebar lists various dataset categories: Agriculture, Biodiversity, Climate, GHG Emissions, Fire, Forestry, Geophysical, Geosocial, Hydrology, and Land use/ land cover. Under "Land use/ land cover", several datasets are listed with toggle switches: Copernicus CGLS-LC100 Land Cover (Proba-V), Dynamic World, ESRI 2020 Land Cover, GlobCover - ESA, and IPCC Land Use Classification - CCI/ESA.

Choose country and boundaries

Retrieve data for your area of interest



Choose from the available global datasets

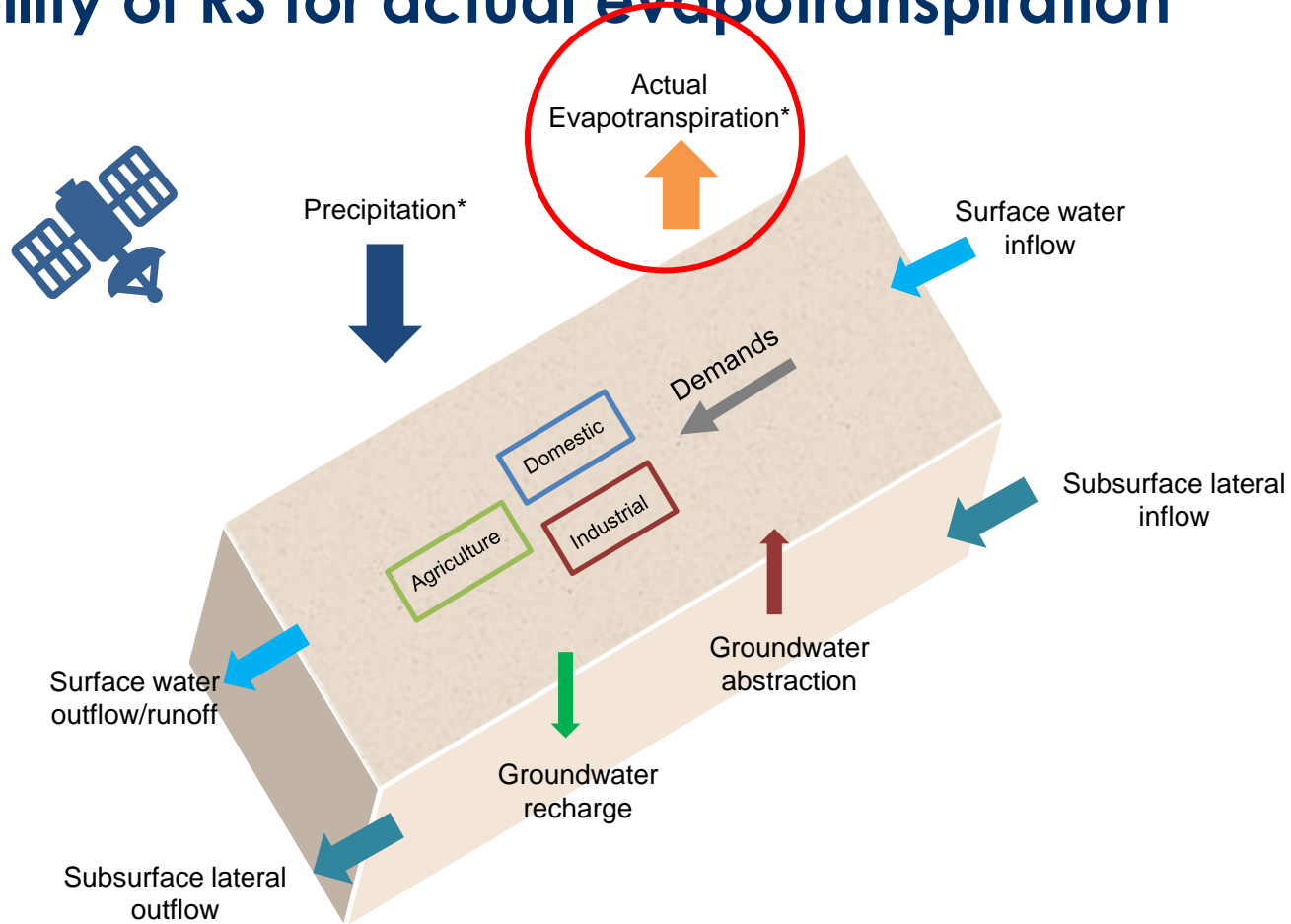


Download data as CSV

<https://earthmap.org/>

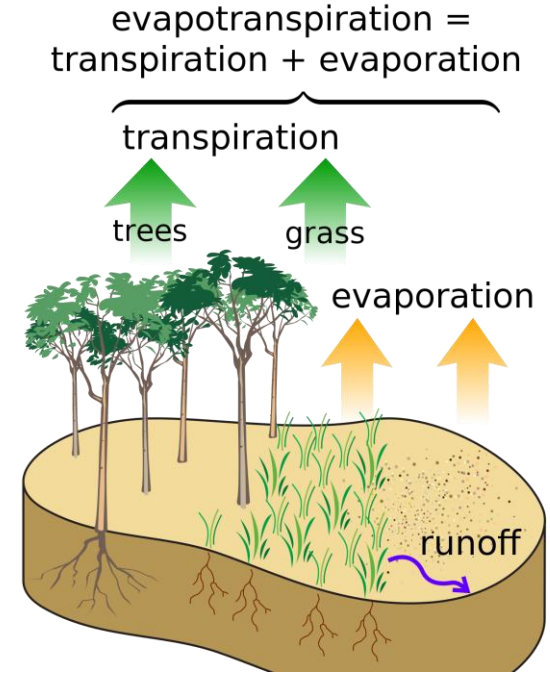


Suitability of RS for actual evapotranspiration



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

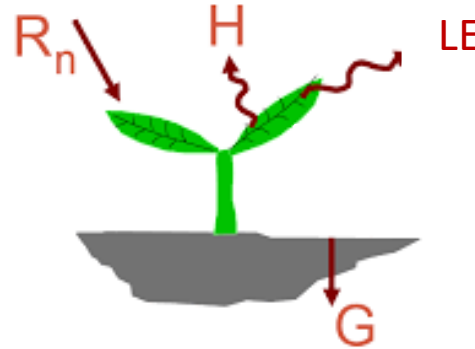


How is ET derived from remote sensing?

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

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

- $LE = R_n - G - H$



where:

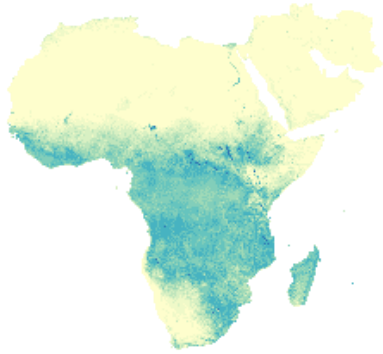
R_n = Net radiation at the land surface (difference between incoming and outgoing radiation)

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

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

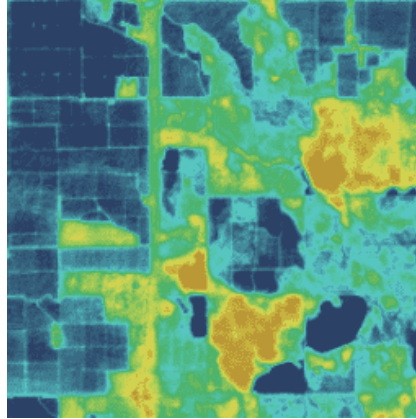
LE = Latent heat flux (energy transferred through evapotranspiration)

Which ET datasets are available on GEE?



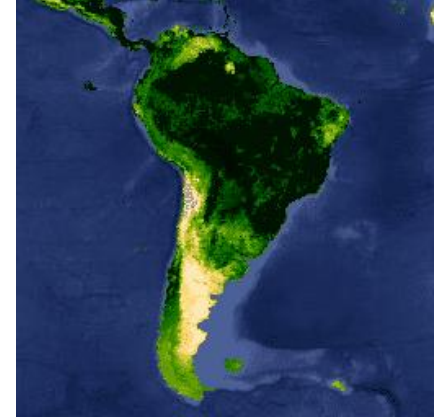
**WaPOR Actual
Evapotranspiration**

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



OpenET

(Monthly
Evapotranspiration 30 m)



**MOD16: Terra Net
Evapotranspiration**

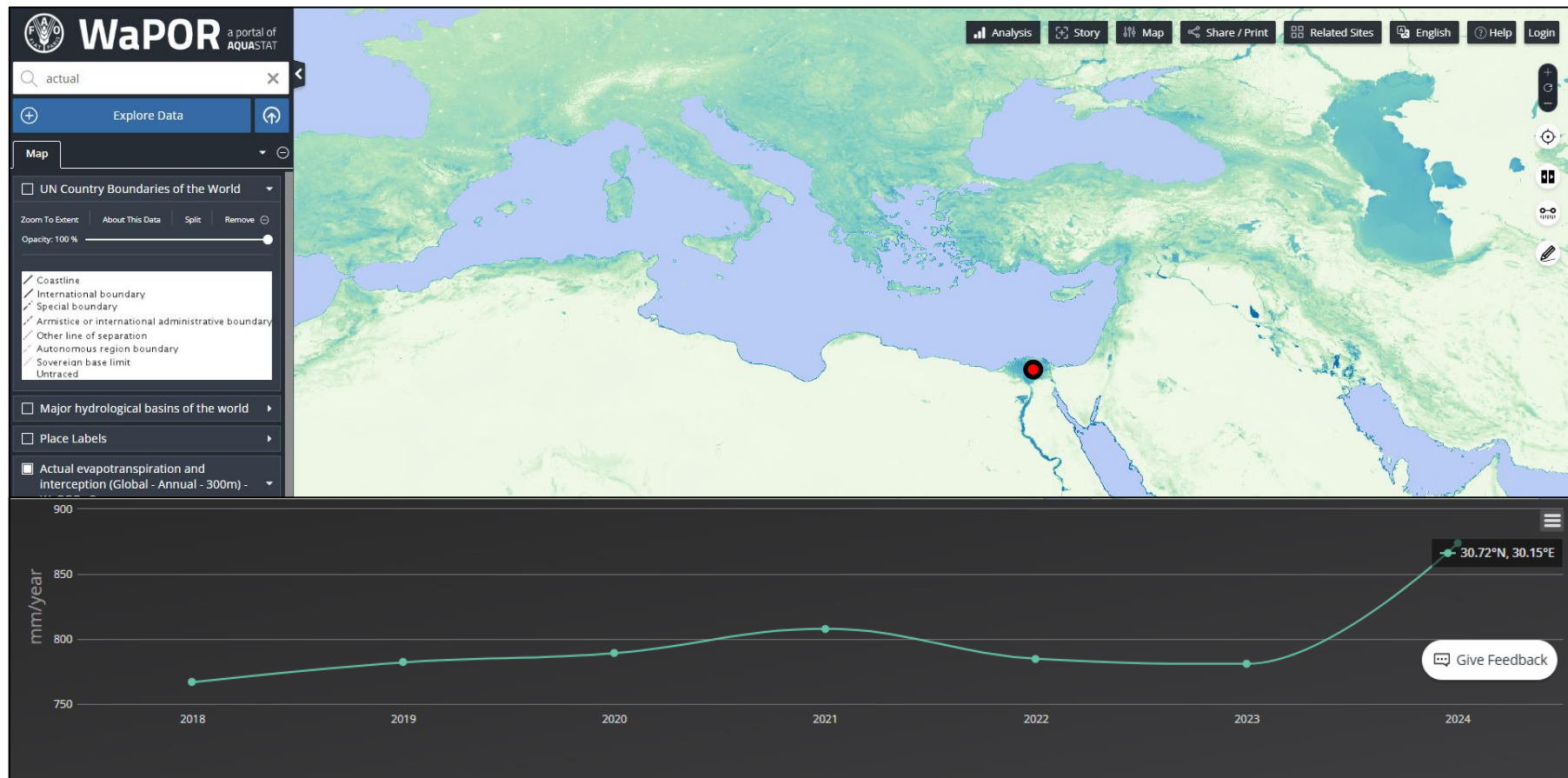
(8-Day Global 500 m)

Open-source platforms: ET from WaPOR

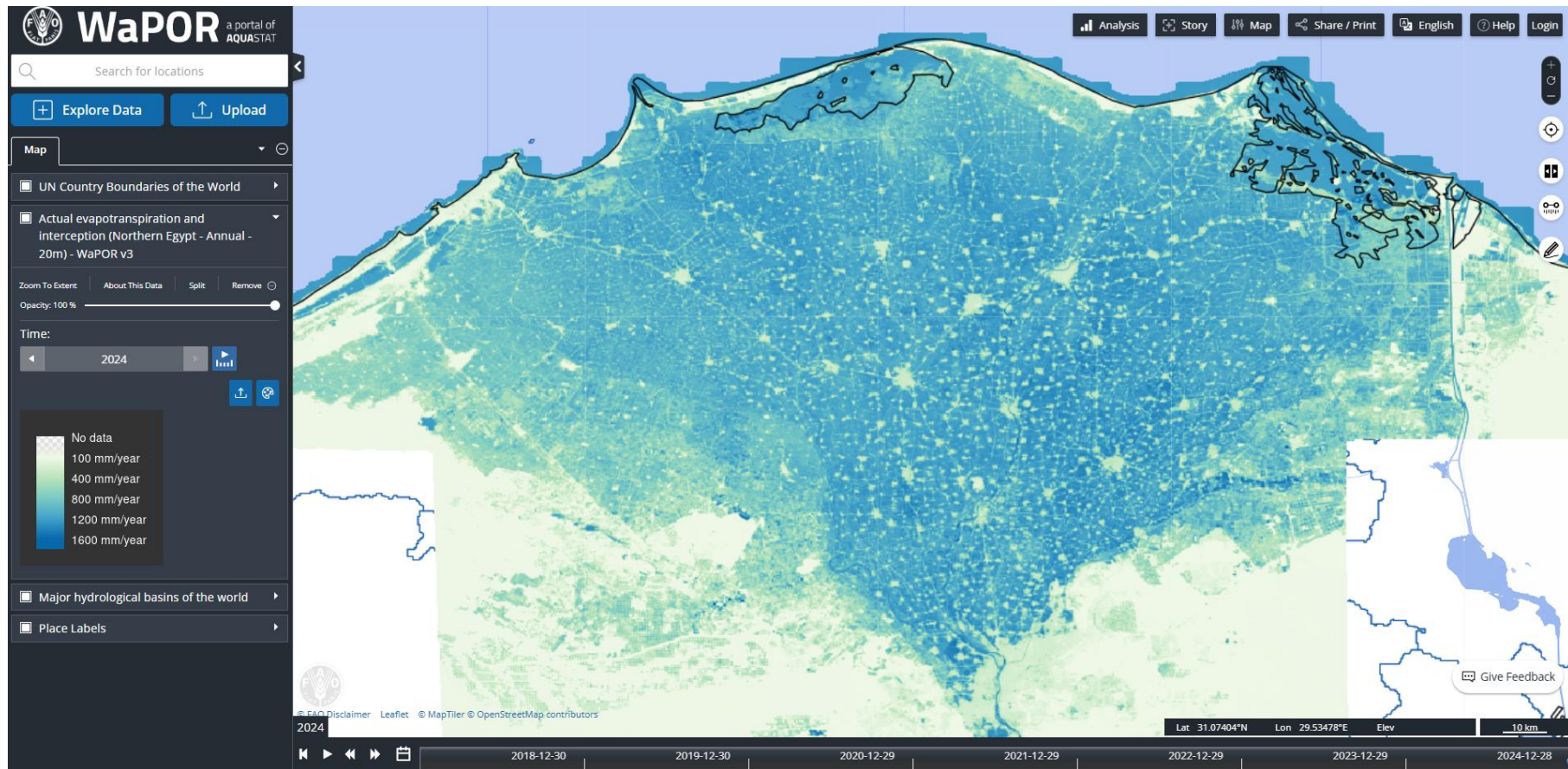
The screenshot displays the WaPOR (Water and Agriculture Portal) interface, which is a platform for accessing and analyzing water and agricultural data. The interface is divided into several sections:

- Header:** The top header includes the WaPOR logo and the text "a portal of AQUASTAT".
- Search Bar:** A search bar is located at the top left, with the text "actual" entered. A red arrow points to the "Explore Data" button below the search bar.
- Map View:** The main map area shows a world map with a blue overlay representing the selected data layer. A "Remove from the map" button is visible in the top right corner of the map area.
- Search Results:** A list of search results is displayed on the left side of the map. The results include:
 - Actual evapotranspiration and interception (Global - Annual - 300m) - WaPOR v3
 - Actual evapotranspiration and interception (Global - Monthly - 300m) - WaPOR v3
 - Actual evapotranspiration and interception (Global - Dekadal - 300m) - WaPOR v3
 - Evaporation (Global - Annual - 300m) - WaPOR v3
 - Evaporation (Global - Dekadal - 300m) - WaPOR v3
 - Transpiration (Global - Annual - 300m) - WaPOR v3
 - Transpiration (Global - Dekadal - 300m) - WaPOR v3
 - Interception (Global - Annual - 300m) - WaPOR v3
 - Interception (Global - Dekadal - 300m) - WaPOR v3
 - Net primary production (Global - Monthly - 300m) - WaPOR v3
 - Net primary production (Global - Dekadal - 300m) - WaPOR v3
 - Relative soil moisture (Global - Dekadal - 300m) - WaPOR v3
- Data Preview:** A detailed view of the selected data layer is shown on the right side of the map. It includes a "DATA PREVIEW" section with a world map and a "Remove from the map" button. Below this, the title "Actual evapotranspiration and interception (Global - Monthly - 300m) - WaPOR v3" is displayed, followed by a "Description" section. The description states: "The actual evapotranspiration and interception (ETia) is the sum of the soil evaporation (E), canopy transpiration (T), and evaporation from rainfall intercepted by leaves (I). The value of each pixel represents the ETia in a given month." Below the description, the "Data publication" date is listed as "2023-09-13". The "Supplemental Information" section includes the following details:
 - No data value: -9999
 - Unit: mm/month
 - Scale Factor: 0.1
 - Map code: L1-AETI-M

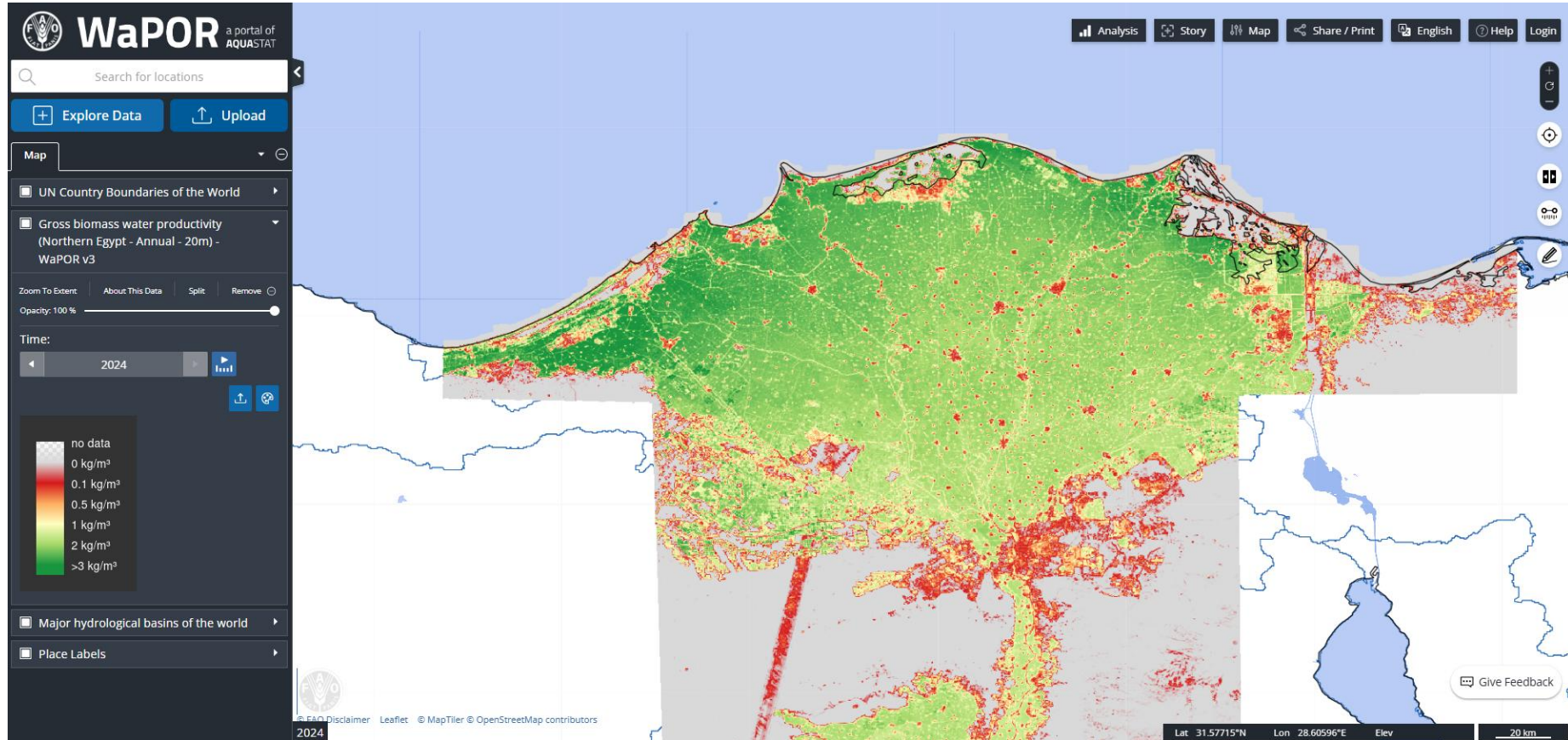
Open-source platforms: ET from WaPOR



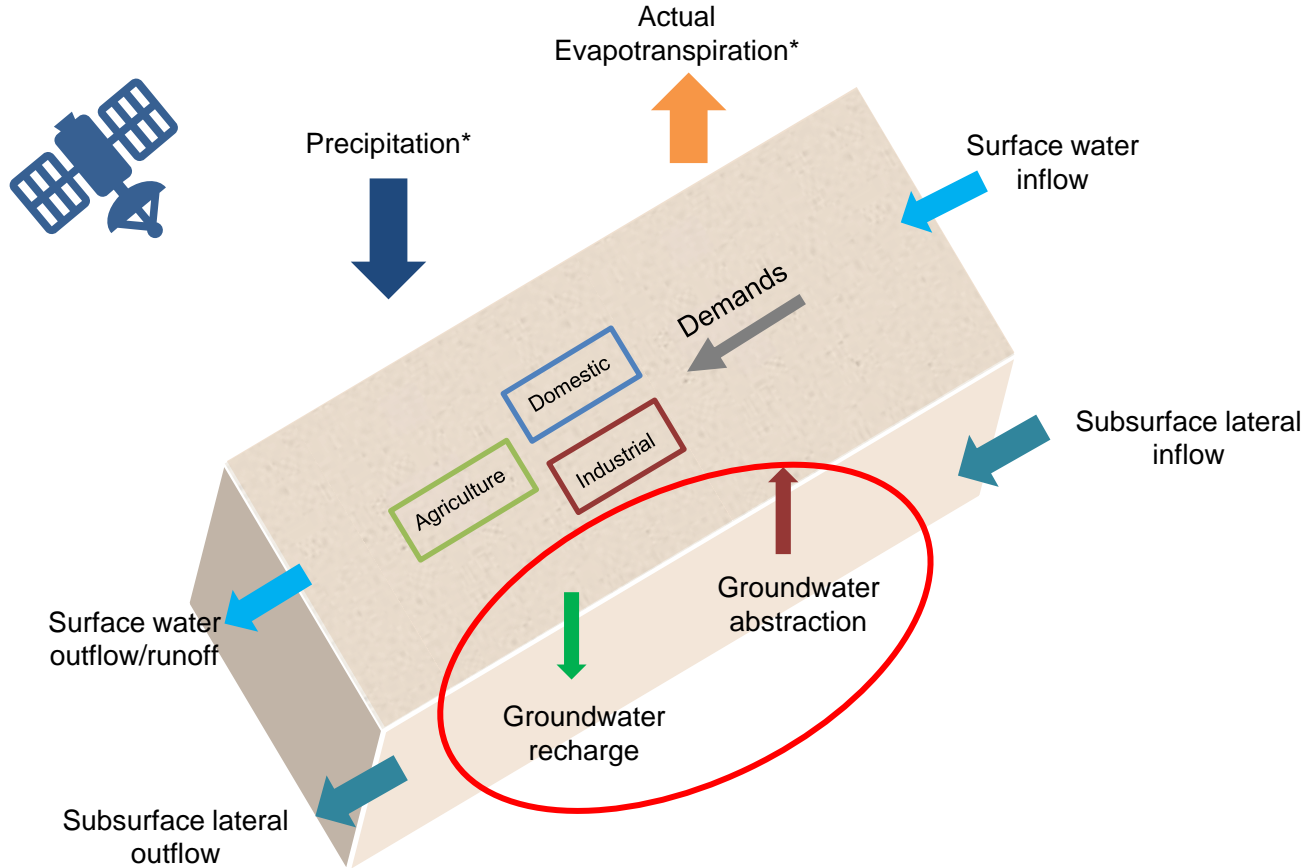
WaPOR – Actual ET (20 m) – 2024



WaPOR – Water Productivity (20 m) - 2024

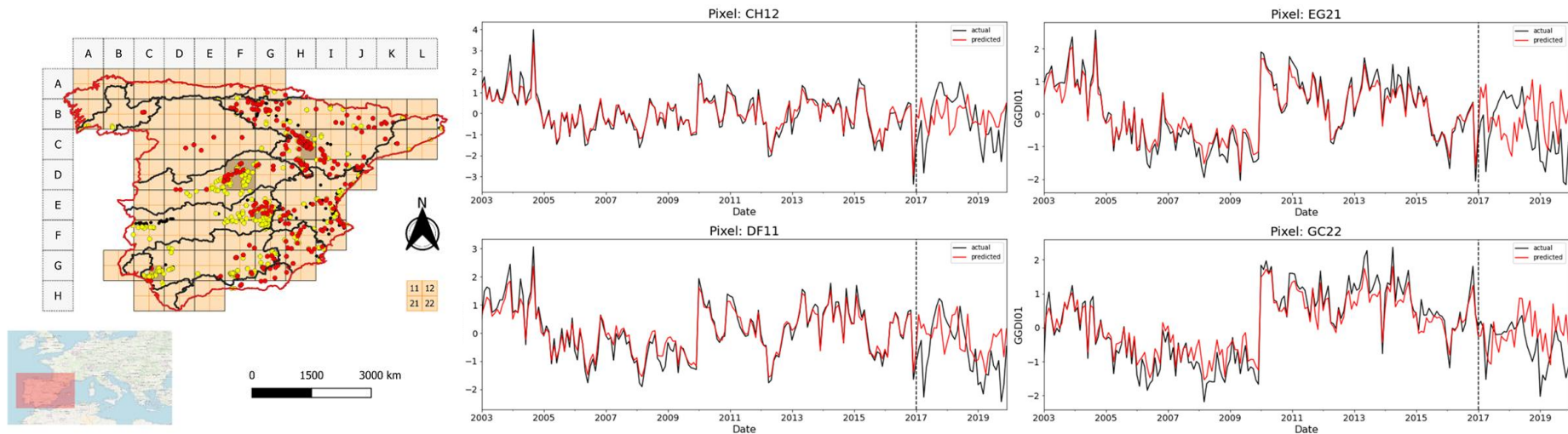


Suitability of RS for groundwater storage



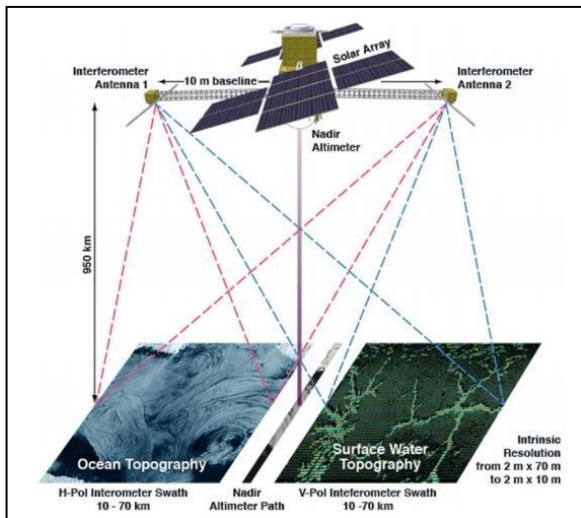
RS for estimating changes in groundwater storage

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

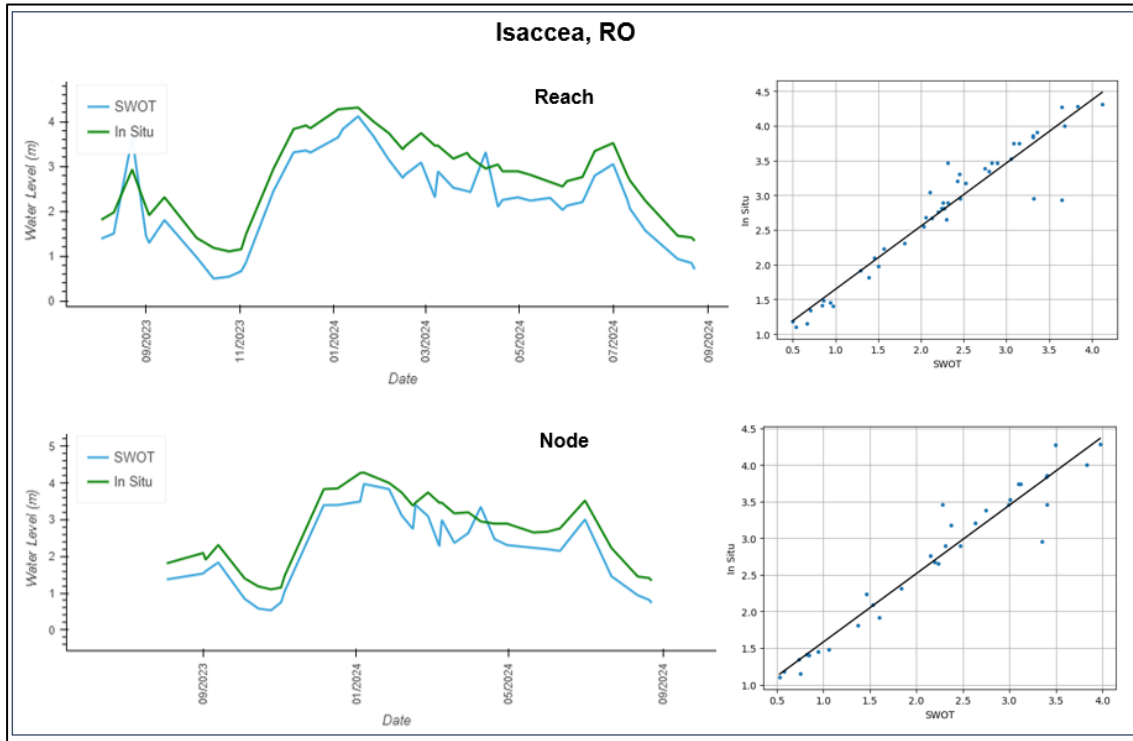


RS for estimating surface water extent/elevation (2022)

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

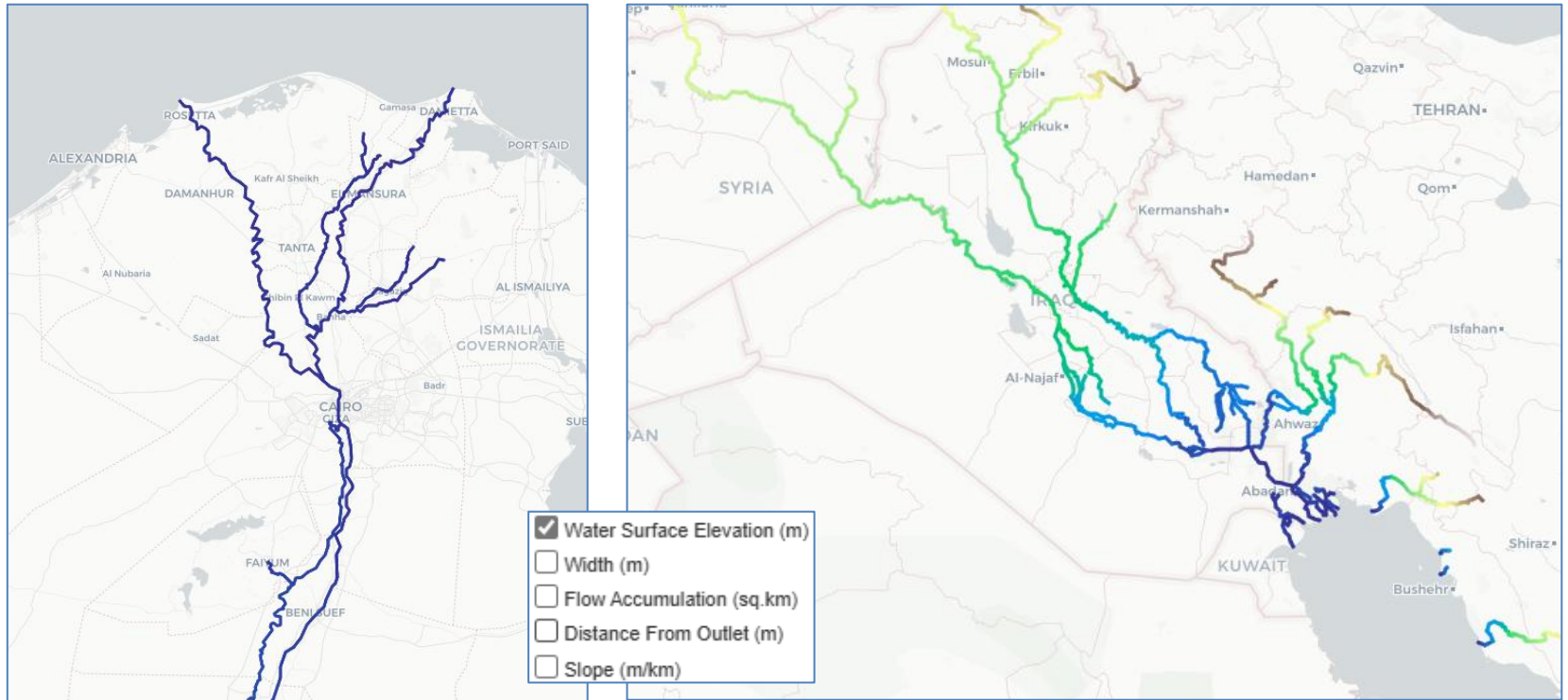


Source: NASA

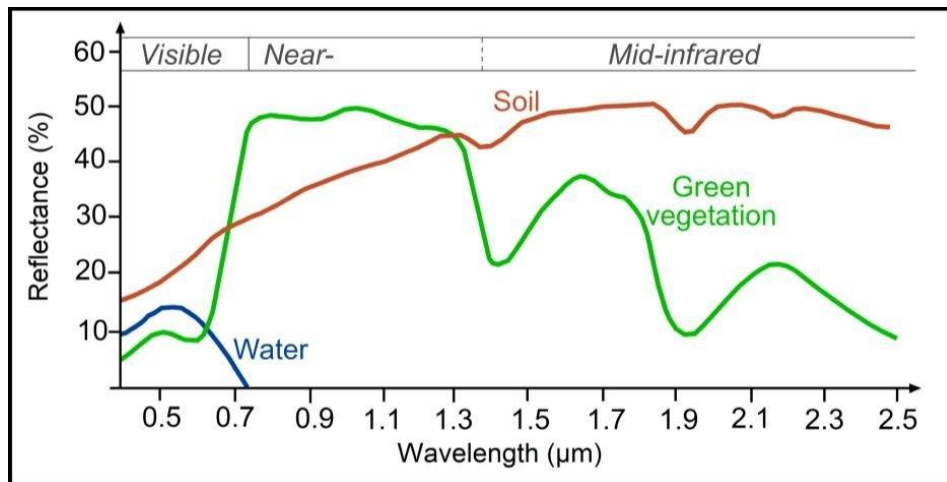


RS for estimating surface water level + reservoirs

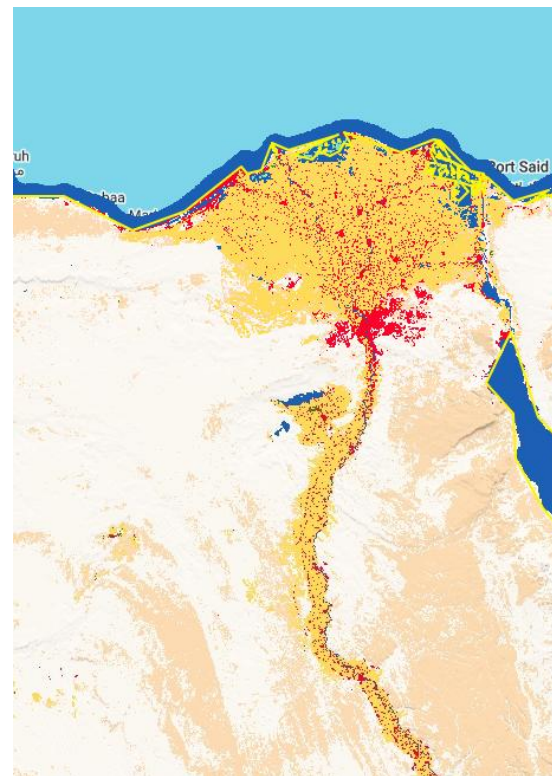
SWOT River Database (SWORD) → www.swordexplorer.com



Remote sensing for land use assessments



Source: grindgis.com



ESRI Land Cover (2017/2023)

Machine learning techniques within GEE

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



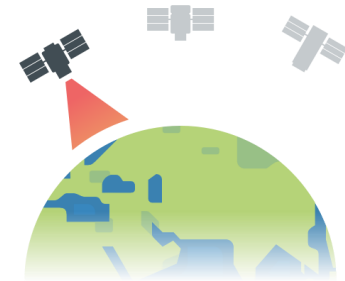
High Spatial Resolution



Medium Spatial Resolution



Low Spatial Resolution



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	✓✓✓

Thank you!

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Connect on LinkedIn:

www.linkedin.com/in/tijmenschults