Satellite Remote Sensing in Support of Water Quality Management

Striving to Ensure Confidence in EO Water Quality Data

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Workshop on Protecting Water Quality and Biodiversity for Improved Water Management

Beirut, 9-10 July 2024

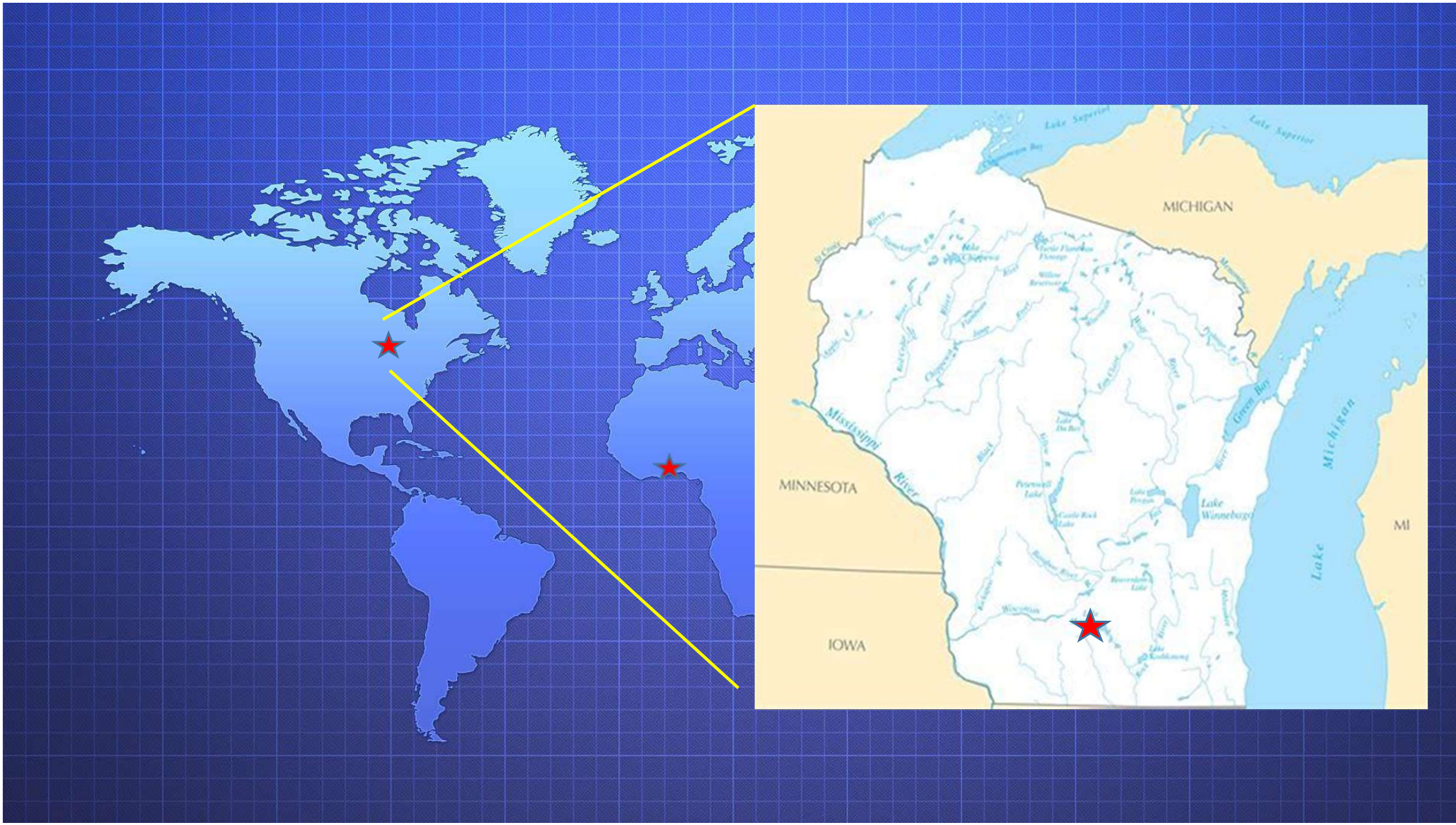
Water Quality in the Mashreq Region

- Inland lakes and reservoirs provide important human and ecosystem services (drinking water, hydropower, habitat)
- Inland waters reflect environmental changes such as climate change, land cover, and land use
- There are chronic and serious challenges in securing reliable water sources for its growing population, mainly due to intense regional conflicts
- Climate change impacts volume, timing, temperature, increasing water insecurity.
- Water quality inextricably linked to water quantity. Imperative to protect what precious water is left.

[Khalil Mazraawi/AFP]

Wehdeh dam on Yarmouk River, Jordan. (Source: Mark Zeitoun, Water Alternatives Photos, Flickr)

Reuters News photo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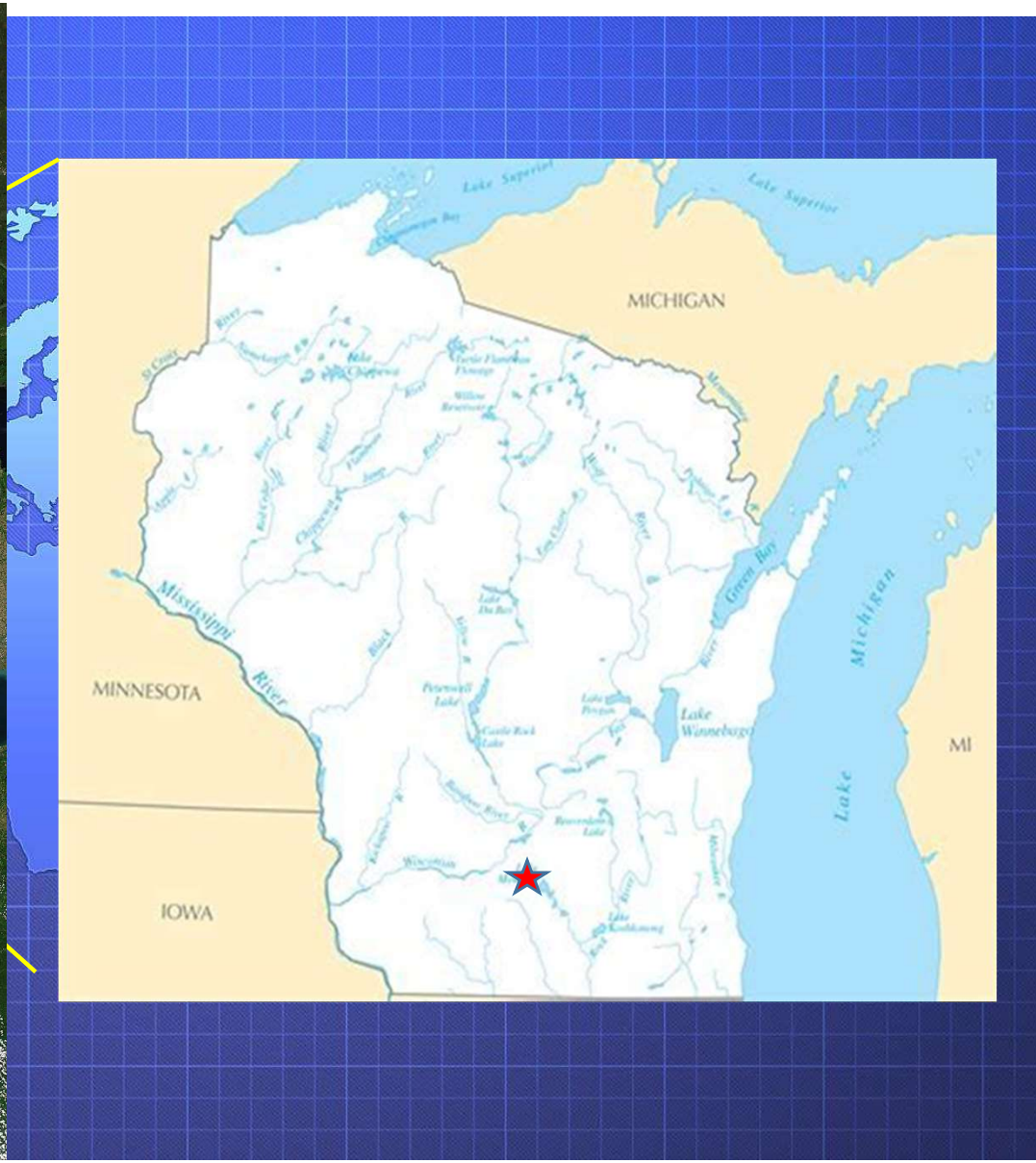
MINNESOTA
IOWA
MI
Lake Superior
Lake Michigan
Green Bay
Lake Winnebago
Mississippi River


Lake Superior
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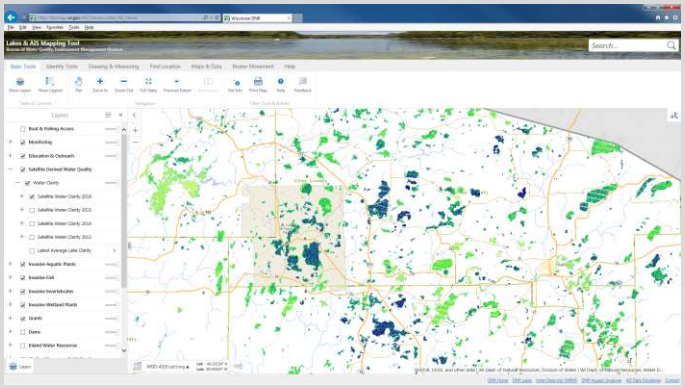
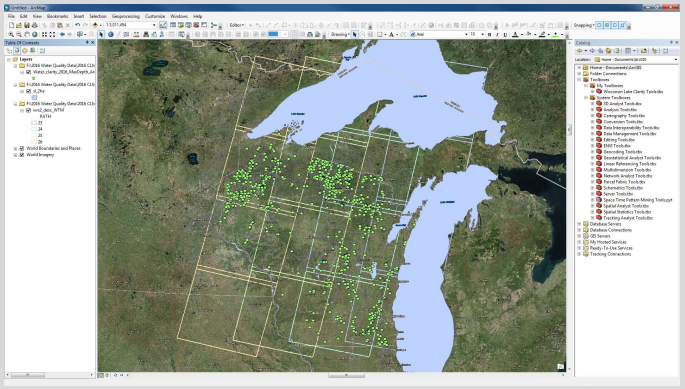
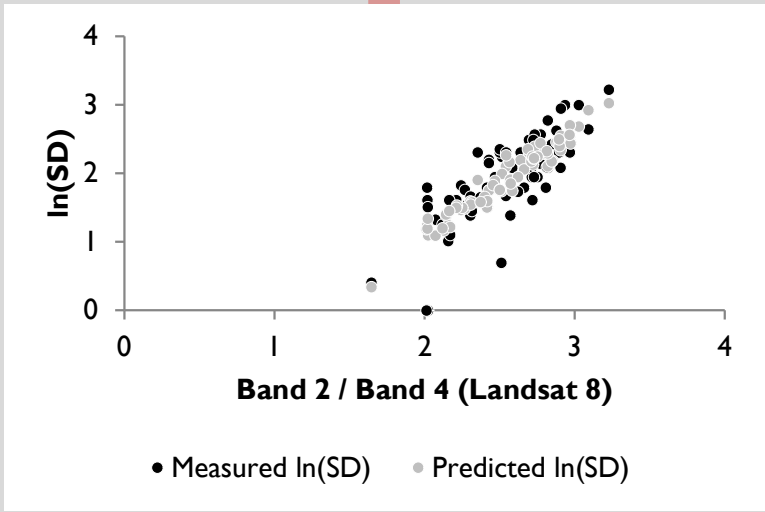
MICHIGAN
Mississippi
River
MINNESOTA
Green Bay
Lake Michigan
Lake Winnebago
MI
IOWA

Systematic processing of satellite data



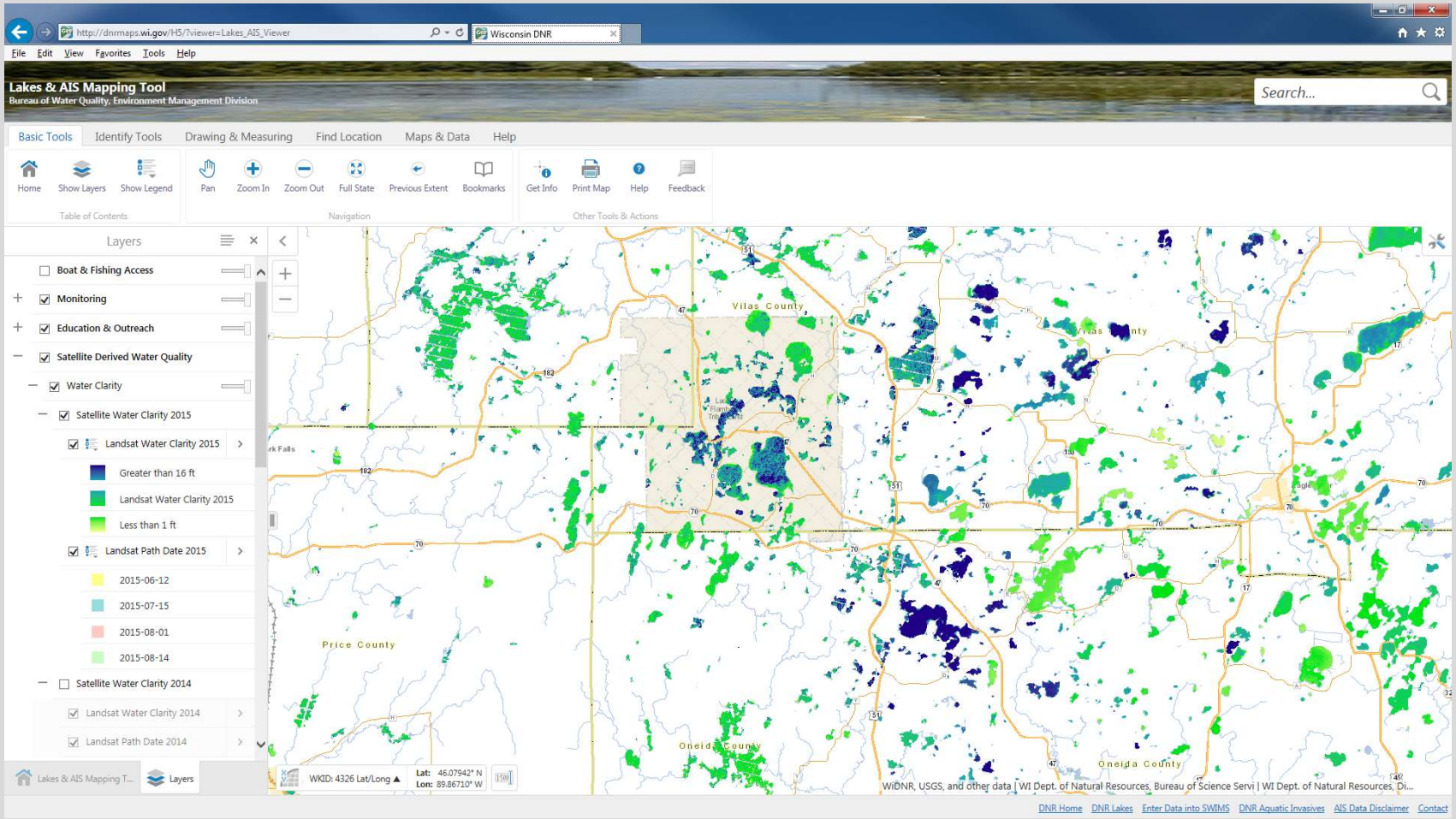




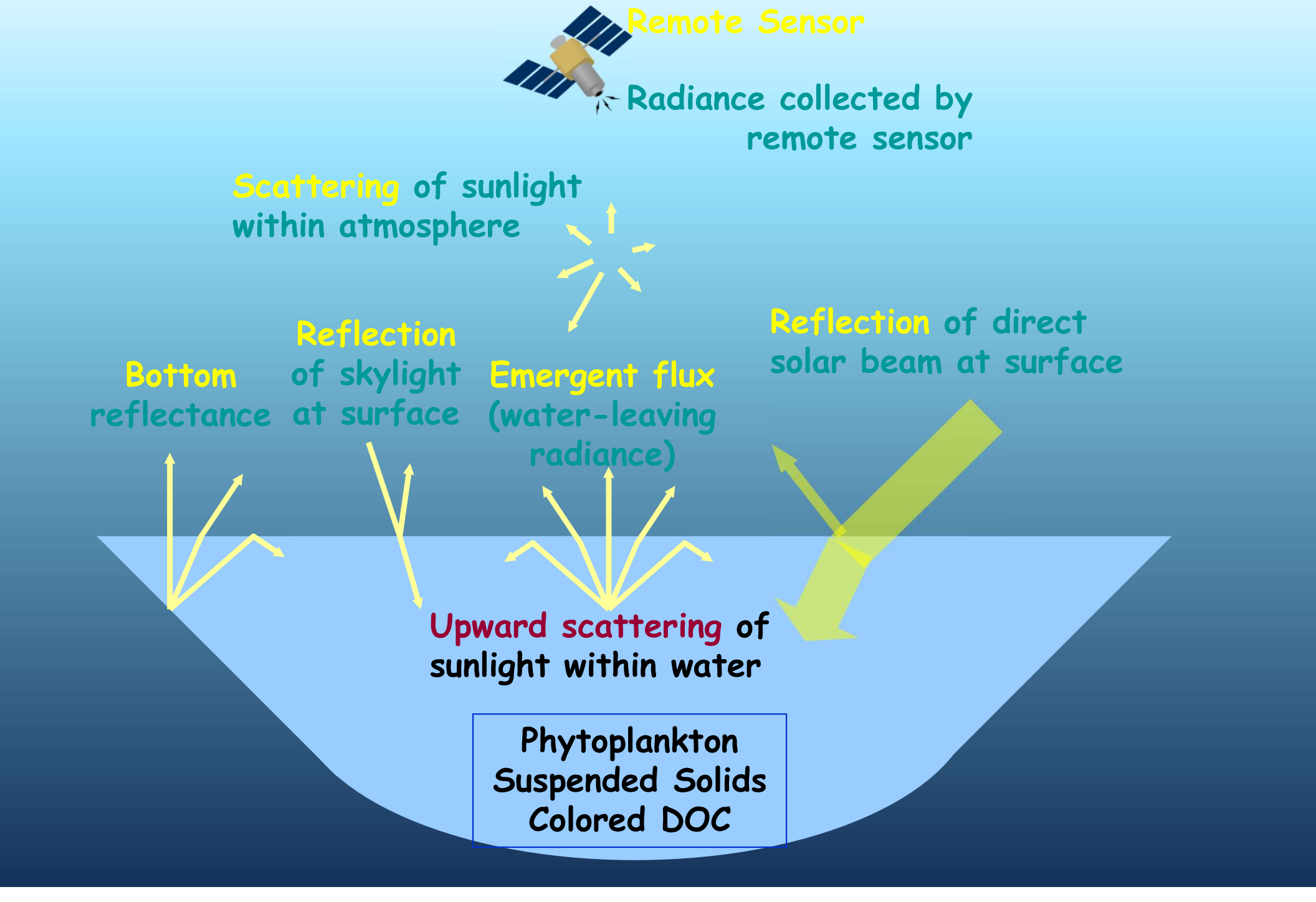
Systematic processing of satellite data

http://dnr.wi.gov/lakes/viewer/

Link to web site



REMOTE SENSING OF FRESHWATERS



Credit:New York Times

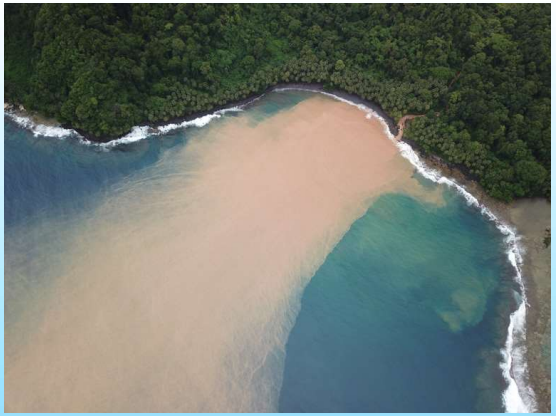
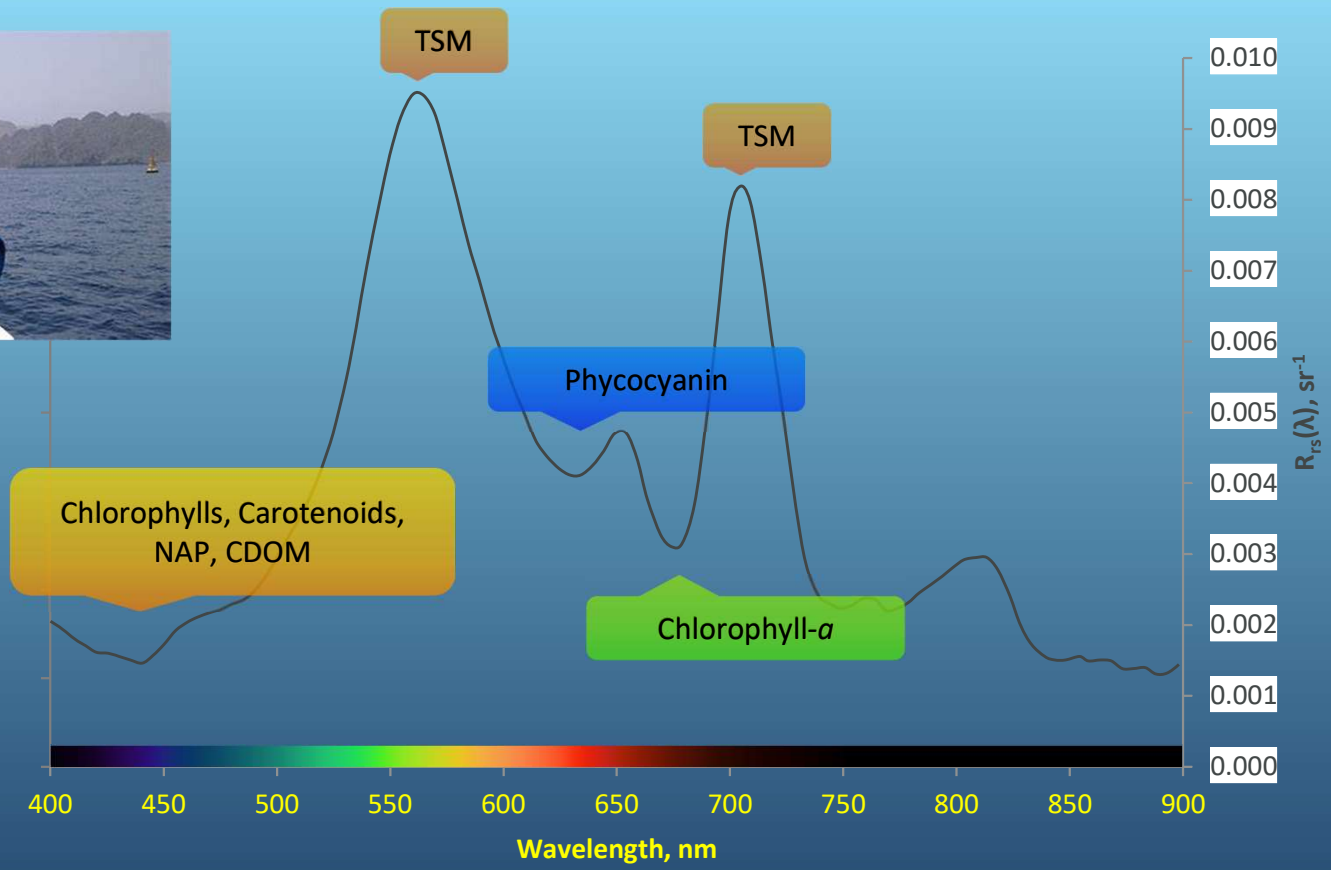


Image by Wade Fairley/WCS

Photo by Steve Rohrs



Comparison of Earth observation sensors

Comparison of Earth observation sensors suitable for water quality assessment with public access data policy

	Landsat-7	Landsat-8	Sentinel-2	Sentinel-3
Satellite and sensor details				
Satellite sensor system	ETM+	OLI/TIRS	MSI	OLCI
Spatial resolution (m)	15, 30, 60	15, 30, 100	10, 20, 60	300
Spectral Bands	8	11	12	21
Revisit cycle (days)	16	16	5	2
Swath width (km)	185	185	290	1270
Launch date	April 1999	February 2013	June 2015	Feb 2016
Years in orbit/minimum design life (years)	18/5	4/5	2/7	1/7
Suitability for water quality assessment	●-Highly Suited; ●-Suitable; ●-Potential			
CHL	●	●	●	●
Cyan	●	●	●	●
TSM	●	●	●	●
CDOM	●	●	●	●
SD	●	●	●	●
K_d	●	●	●	●

CHL – Chlorophyll, **Cyan** – Cyanophycocyanin, **TSM** – Total Suspended Matter, **CDOM** – Colored Dissolved Organic Matter, **SD** – Secchi Disk Transparency, **K_d** – Vertical Attenuation of Light

Suitability for water quality assessment from Dekker, A.G. & Hestir, E. L. (2012) *Evaluating the Feasibility of Systematic Inland Water Quality Monitoring with Satellite Remote Sensing*. CSIRO: Water for a Healthy Country National Research Flagship

Advantages and Disadvantages

Advantages of the remote sensing of water quality

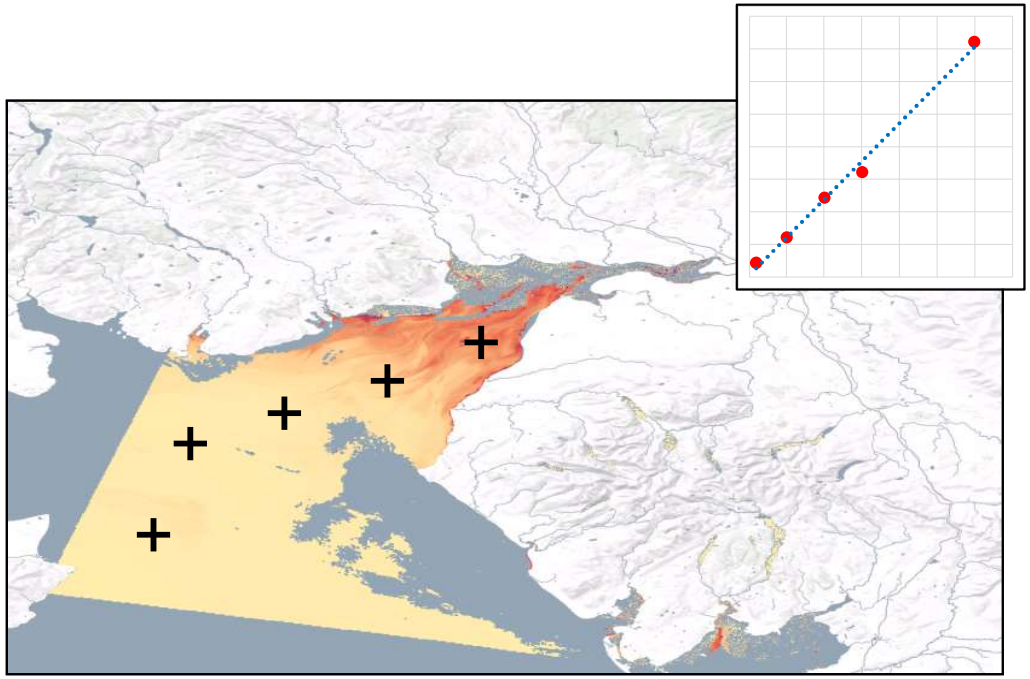
- Water quality data with a high spatial and temporal resolution for multiple water bodies at a time
- Affordable
- Historical data for studies of trends in water quality
- Near real-time data for current information
- Accuracy continuing to improve (30%)
- Low Risk

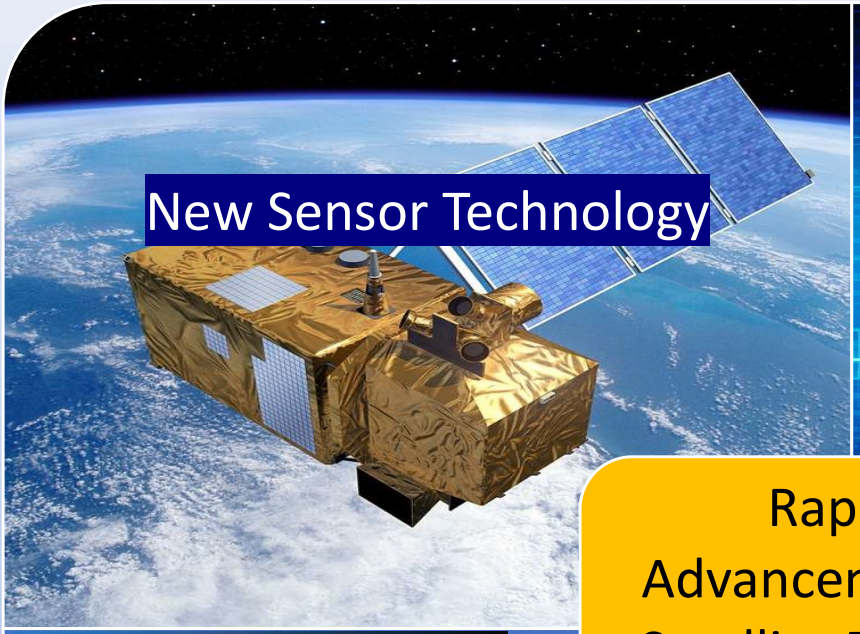
Disadvantages of the remote sensing of water quality

- Optically complex conditions found in lakes
- Potential interference from the lake bottom in shallow lakes
- Clouds! (US 46%, Jordan 21%)
- Dynamic changes in water quality
- Limited number of water quality parameters (phytoplankton, organic and inorganic suspended solids, and colored dissolved organic matter), not directly measure nutrients, metals
- Calibration and validation of models typically requires the collection of ground truth data

Why we need *in situ* observations

- Optimize algorithm parameterizations **for full range of OWTs** or regions
- Validate algorithms and data products **over the lifetime** of satellite missions
- Fill spatial and temporal gaps in satellite data coverage





New Sensor Technology

Big Data and Cloud Processing

Rapid Advancement in Satellite Remote Sensing

Algorithm Advancement and Machine Learning

$$r_{rs}(\lambda) \approx \sum_{i=1}^{2} g_i \left(\frac{b_b(\lambda)}{b_b(\lambda)+a(\lambda)} \right)^i \quad (\mathrm{sr}^{-1}),$$

Education and Capacity Development

Entrance ramps to data products

Web applications/
portals

PC Softwares

Cloud Resources

Related Regional Activities

Using GIS and Remote Sensing Techniques to Study Water Quality Changes and Spectral Analysis of Tigris River within Mosul City, North of Iraq

Muthanna F. Allawai[1], Bushra A. Ahmed[2]
[1]University of Baghdad, College of Science, Physics Department
[2]University of Baghdad, College of Science, Remote Sensing and GIS Department

water

MDPI

Article

Assessment of Water Quality in Lake Qaroun Using Ground-Based Remote Sensing Data and Artificial Neural Networks

Salah Elsayed [1,*], Hekmat Ibrahim [2], Hend Hussein [3], Osama El
Farahat S. Moghanm [6], Adel M. Ghoneim [7,*], Subhan Danish [8,*]

Environ Monit Assess (2015) 187: 367
DOI 10.1007/s10661-015-4607-2

Open Access Article

Assessment of Water Quality Parameters Using Temporal Remote Sensing Spectral Reflectance in Arid Environments, Saudi Arabia

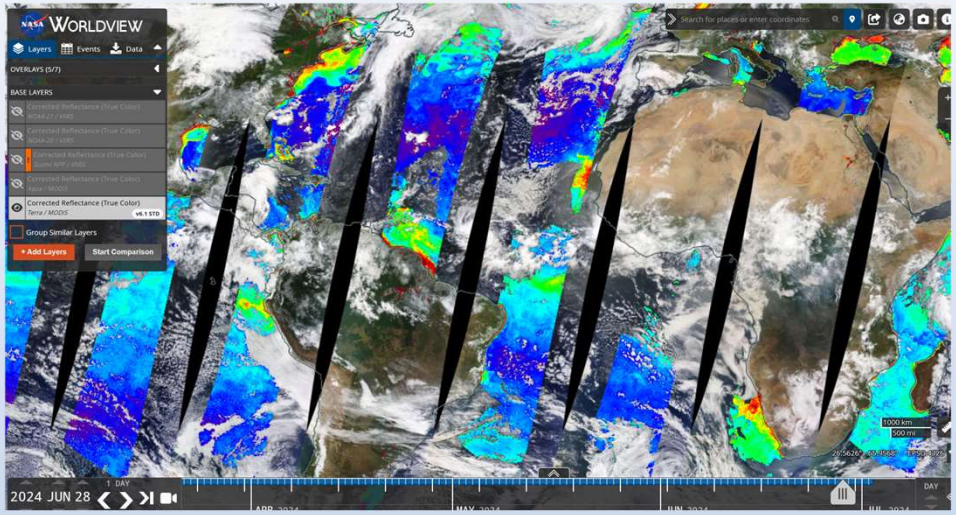
by Mohamed Elhag [1,*], Ioannis Gitas [2], Anas Othman [1], Jarbou Bahrawi [1] and Petros Gikas [3]

1 Department of Hydrology and Water Resources Management, Faculty of Meteorology, Environment & Arid Land
sity, Jeddah 21589, Saudi Arabia
t and Remote Sensing, School of Forestry and Natural Environment, Aristotle
loniki 54124, Greece
ring, Technical University of Crete, Chania 73100, Greece
should be addressed.

Water quality monitoring of Al-Habbaniyah Lake using remote sensing and in situ measurements

Ahmed A. H. AL-Fahdawi · Adel M. Rabee · Shaheen M. Al-Hirmizy

Operational Water Quality Satellite Data



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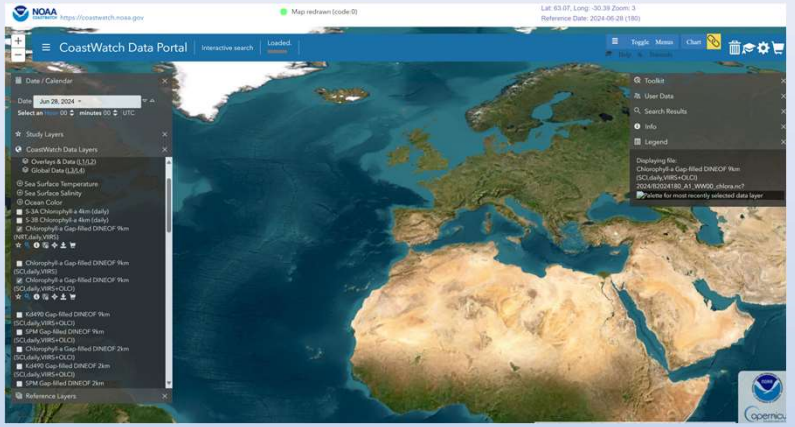

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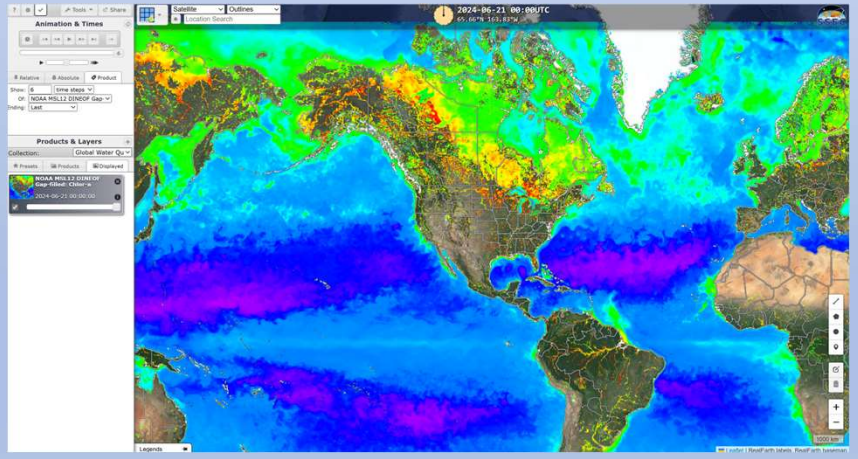
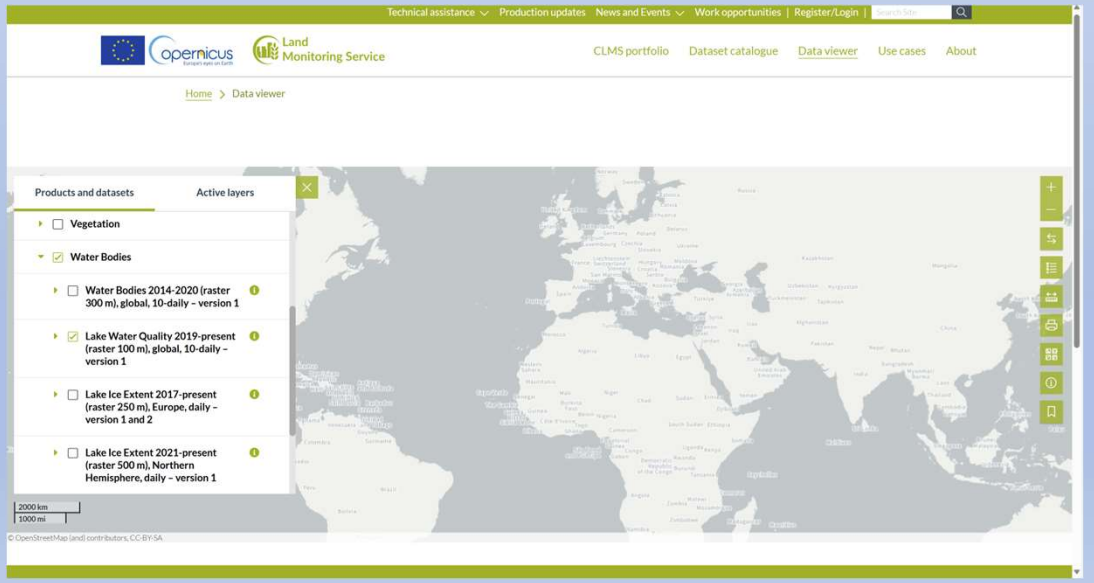
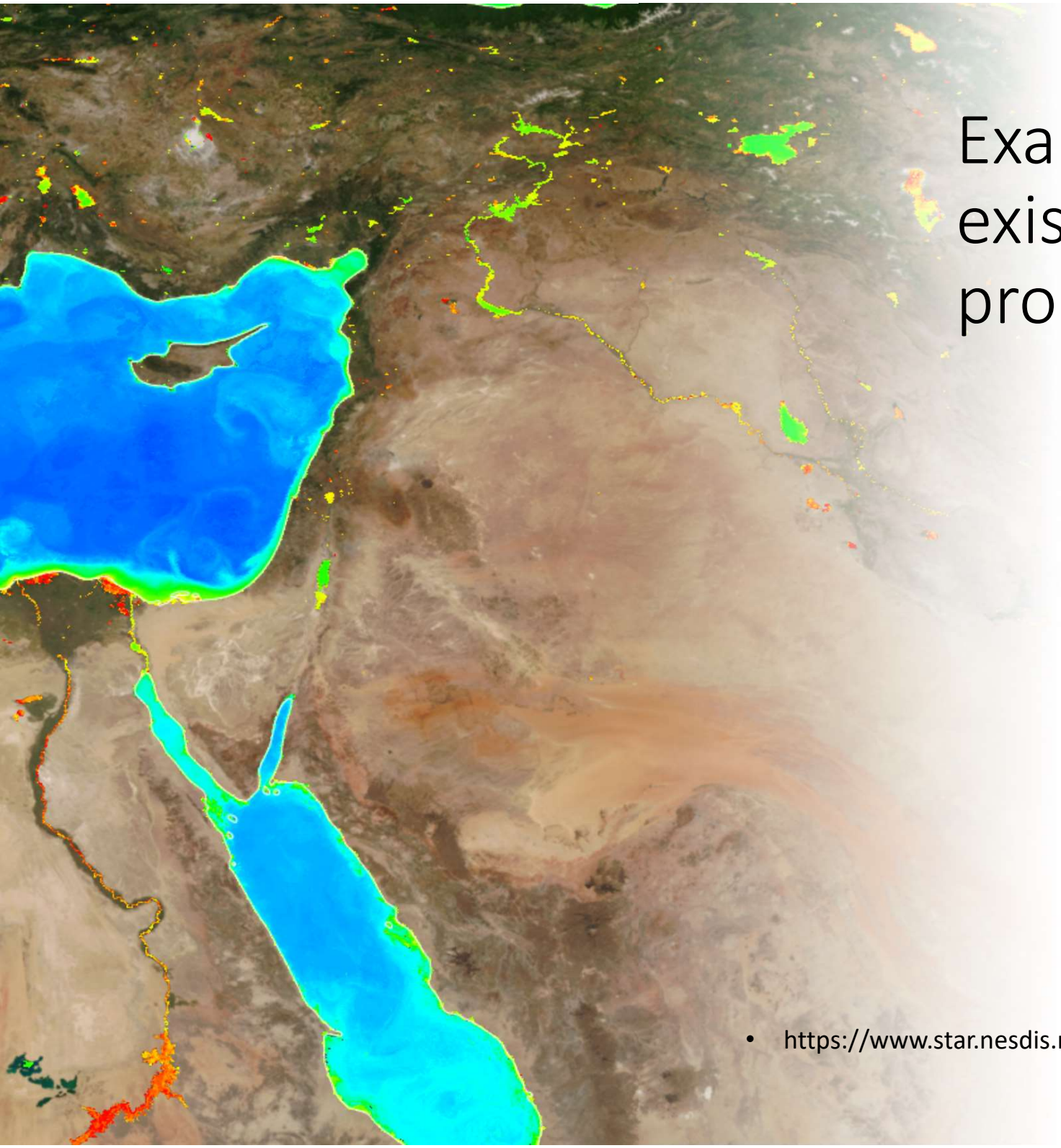


https://realearth.ssec.wisc.edu/



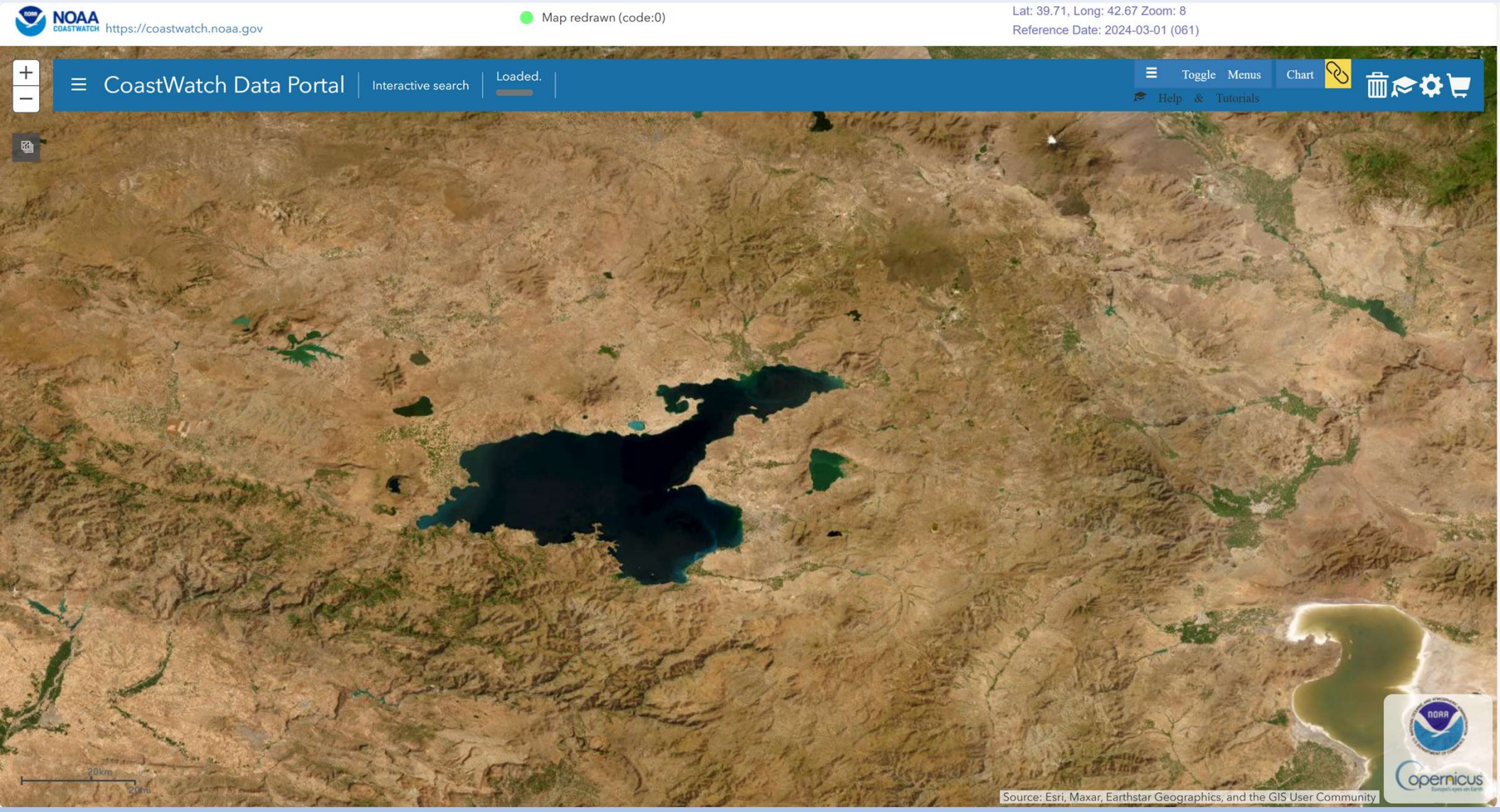
https://land.copernicus.eu/en/map-viewer



Examples of existing products

- https://www.star.nesdis.noaa.gov/

Lake Van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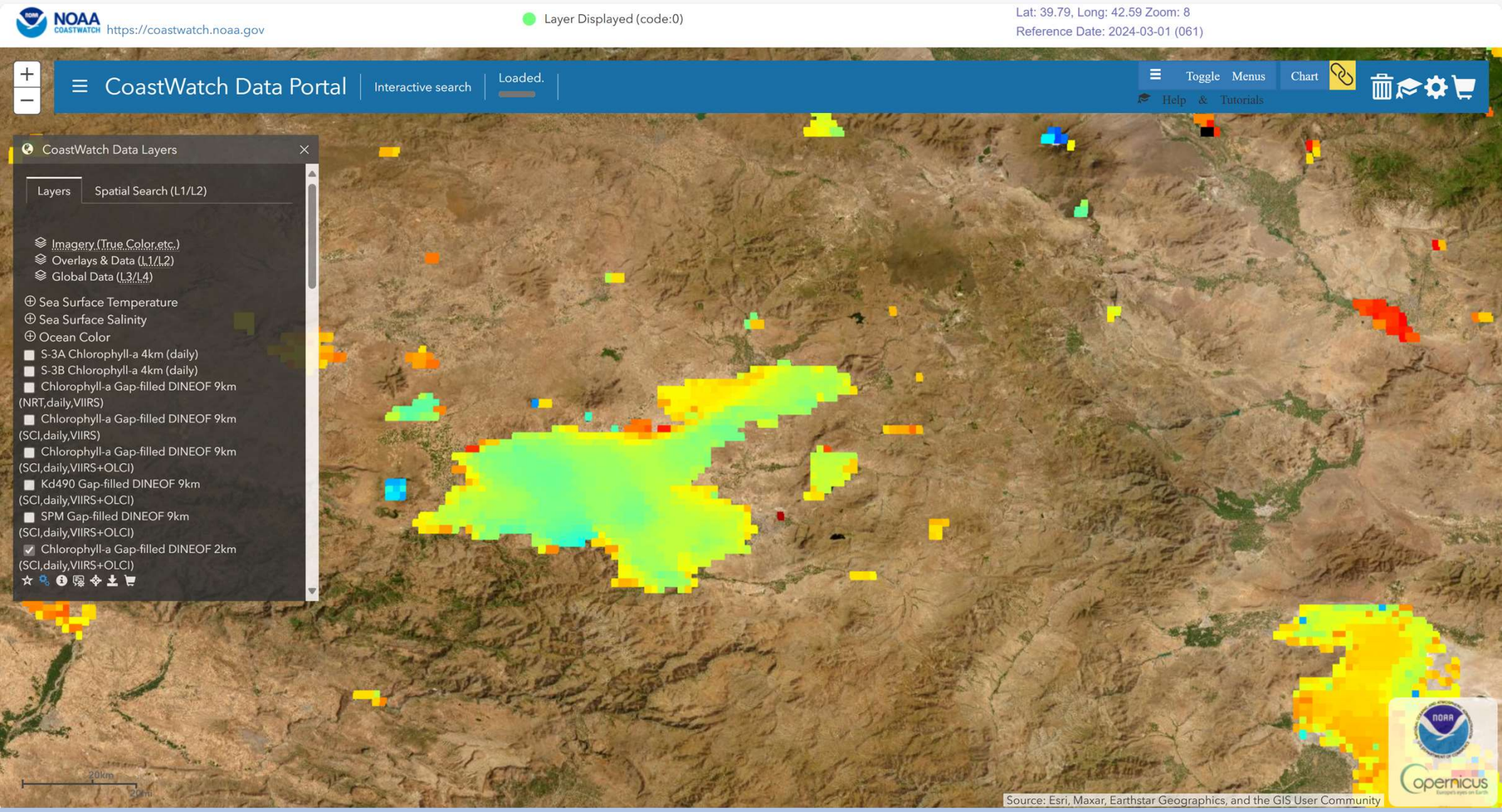
Toggle Menus
Chart
Help & Tutorials
20km
20mi
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Copernicus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Help & Tutorials
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Spatial Search (L1/L2)
Imagery (True Color,etc.)
Overlays & Data (L1/L2)
Global Data (L3/L4)
Sea Surface Temperature
Sea Surface Salinity
Ocean Color
S-3A Chlorophyll-a 4km (daily)
S-3B Chlorophyll-a 4km (daily)
Chlorophyll-a Gap-filled DINEOF 9km (NRT,daily,VIIRS)
Chlorophyll-a Gap-filled DINEOF 9km (SCI,daily,VIIRS)
Chlorophyll-a Gap-filled DINEOF 9km (SCI,daily,VIIRS+OLCI)
Kd490 Gap-filled DINEOF 9km (SCI,daily,VIIRS+OLCI)
SPM Gap-filled DINEOF 9km (SCI,daily,VIIRS+OLCI)
Chlorophyll-a Gap-filled DINEOF 2km (SCI,daily,VIIRS+OLCI)
20km
20mi
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
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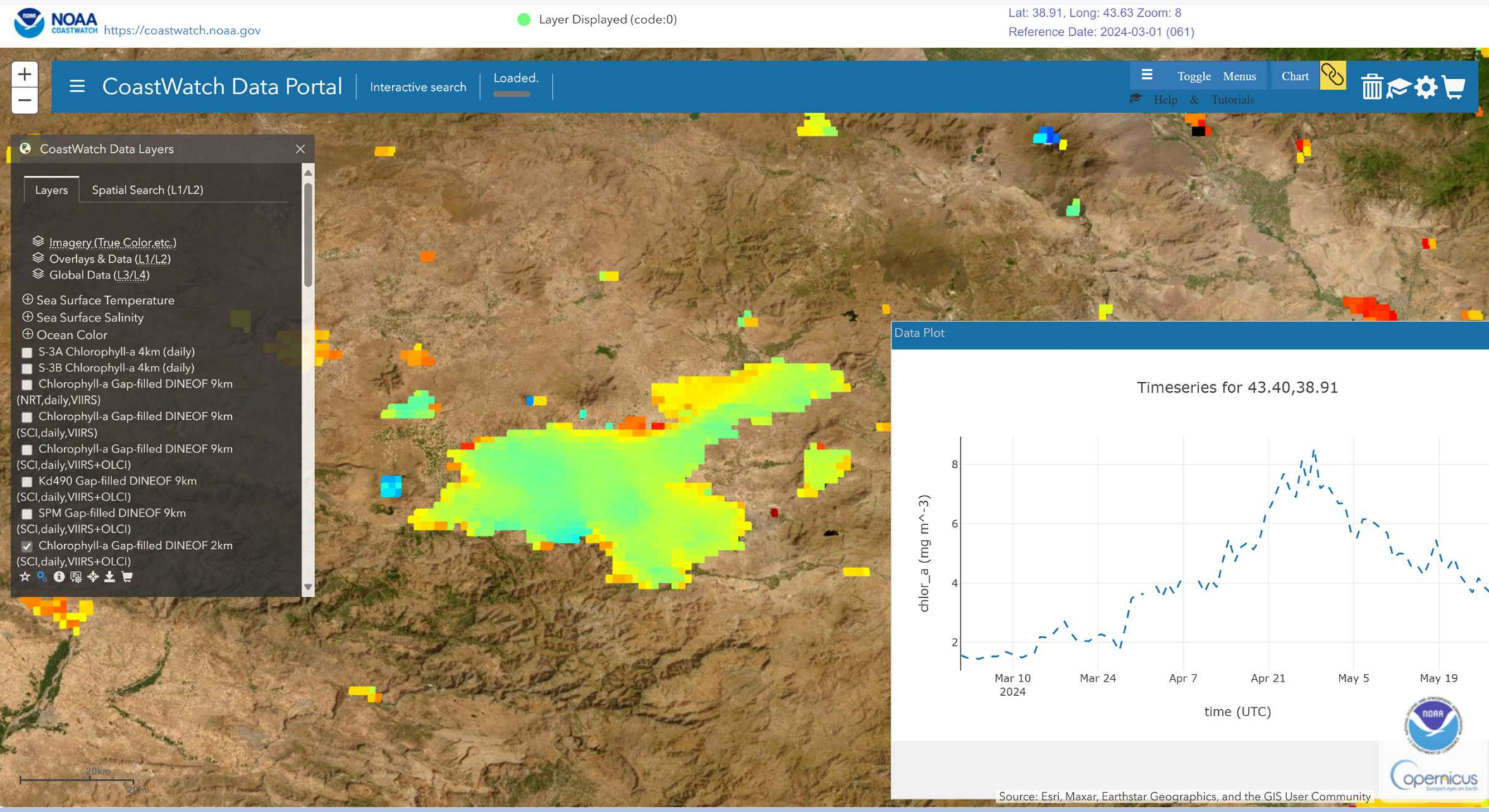
Copernicus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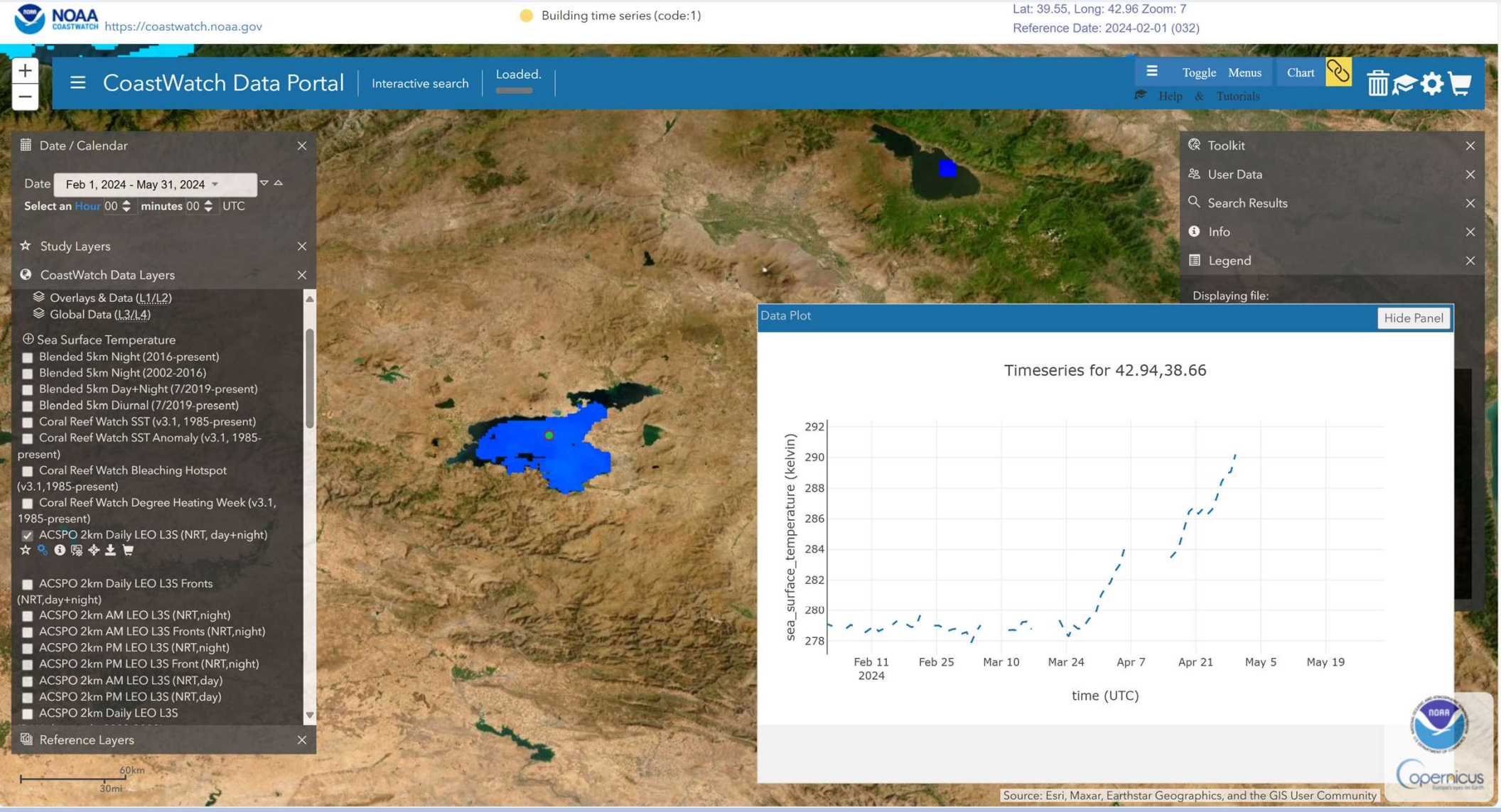
Kd490 Gap-filled DINEOF 9km (SCI,daily,VIIRS+OLCI)
SPM Gap-filled DINEOF 9km (SCI,daily,VIIRS+OLCI)
Chlorophyll-a Gap-filled DINEOF 2km (SCI,daily,VIIRS+OLCI)
20km
20mi
Data Plot
Timeseries for 43.40,38.91
chlor_a (mg m^-3)
8
6
4
2
Mar 10 2024
Mar 24
Apr 7
Apr 21
May 5
May 19
time (UTC)
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community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Help & Tutorials
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Study Layers
CoastWatch Data Layers
Overlays & Data (L1/L2)
Global Data (L3/L4)
Sea Surface Temperature
Blended 5km Night (2016-present)
Blended 5km Night (2002-2016)
Blended 5km Day+Night (7/2019-present)
Blended 5km Diurnal (7/2019-present)
Coral Reef Watch SST (v3.1, 1985-present)
Coral Reef Watch SST Anomaly (v3.1, 1985-present)
Coral Reef Watch Bleaching Hotspot (v3.1,1985-present)
Coral Reef Watch Degree Heating Week (v3.1, 1985-present)
ACSPO 2km Daily LEO L3S (NRT, day+night)
ACSPO 2km Daily LEO L3S Fronts (NRT,day+night)
ACSPO 2km AM LEO L3S (NRT,night)
ACSPO 2km AM LEO L3S Fronts (NRT,night)
ACSPO 2km PM LEO L3S (NRT,night)
ACSPO 2km PM LEO L3S Front (NRT,night)
ACSPO 2km AM LEO L3S (NRT,day)
ACSPO 2km PM LEO L3S (NRT,day)
ACSPO 2km Daily LEO L3S
Reference Layers
60km
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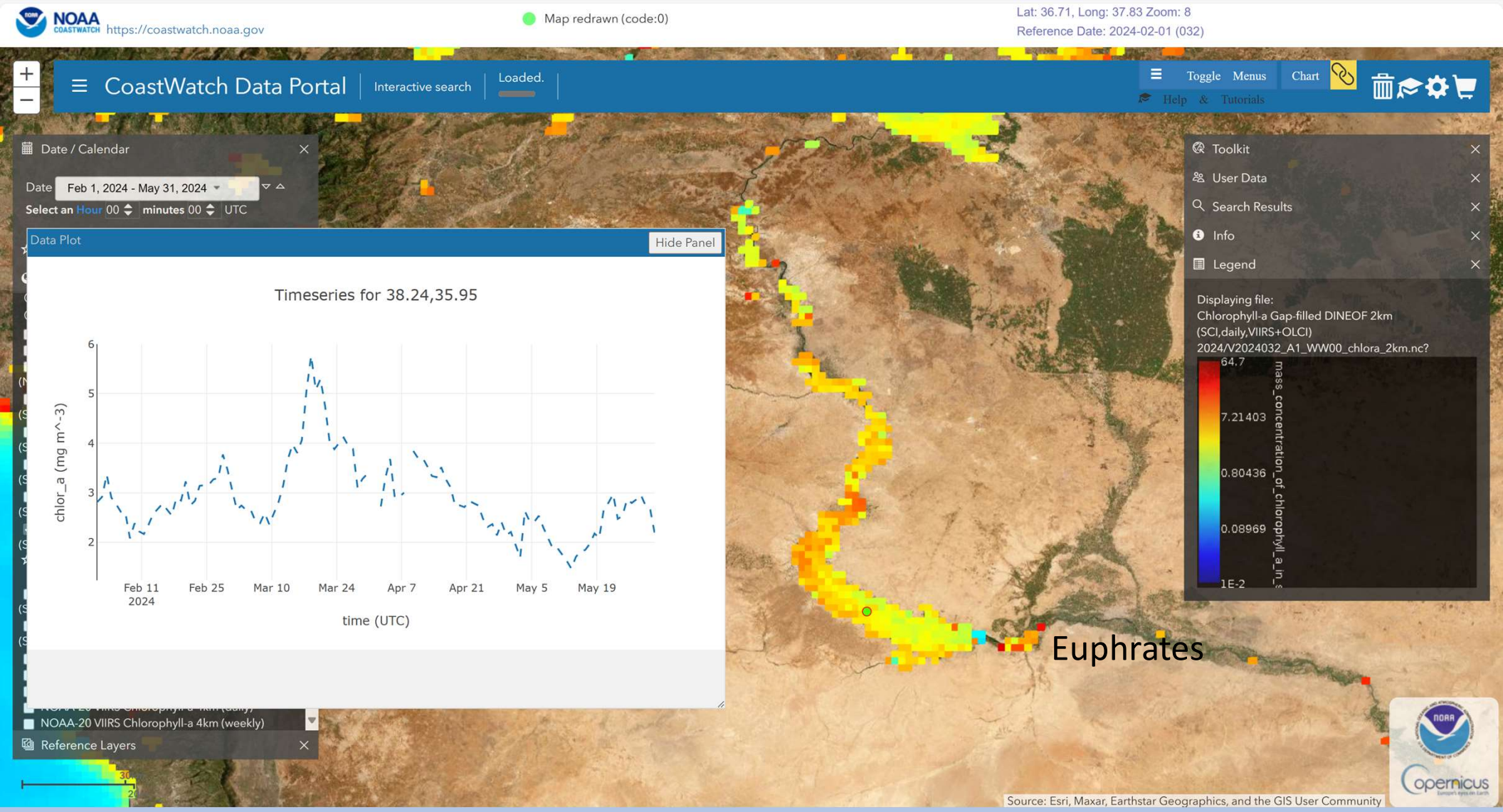
Toolkit
User Data
Search Results
Info
Legend
Displaying file:
Data Plot
Hide Panel
Timeseries for 42.94,38.66
sea_surface_temperature (kelvin)
292
290
288
286
284
282
280
278
Feb 11 2024
Feb 25
Mar 10
Mar 24
Apr 7
Apr 21
May 5
May 19
time (UTC)
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Lake Assad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Help & Tutorials
Date / Calendar
Date Feb 1, 2024 - May 31, 2024
Select an Hour 00 minutes 00 UTC
Data Plot
Hide Panel
Timeseries for 38.24,35.95
chlor_a (mg m^-3)
time (UTC)
Feb 11 2024
Feb 25
Mar 10
Mar 24
Apr 7
Apr 21
May 5
May 19
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User Data
Search Results
Info
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(SCI,daily,VIIRS+OLCI)
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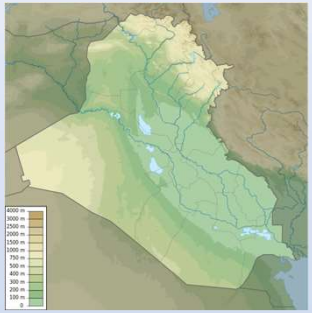
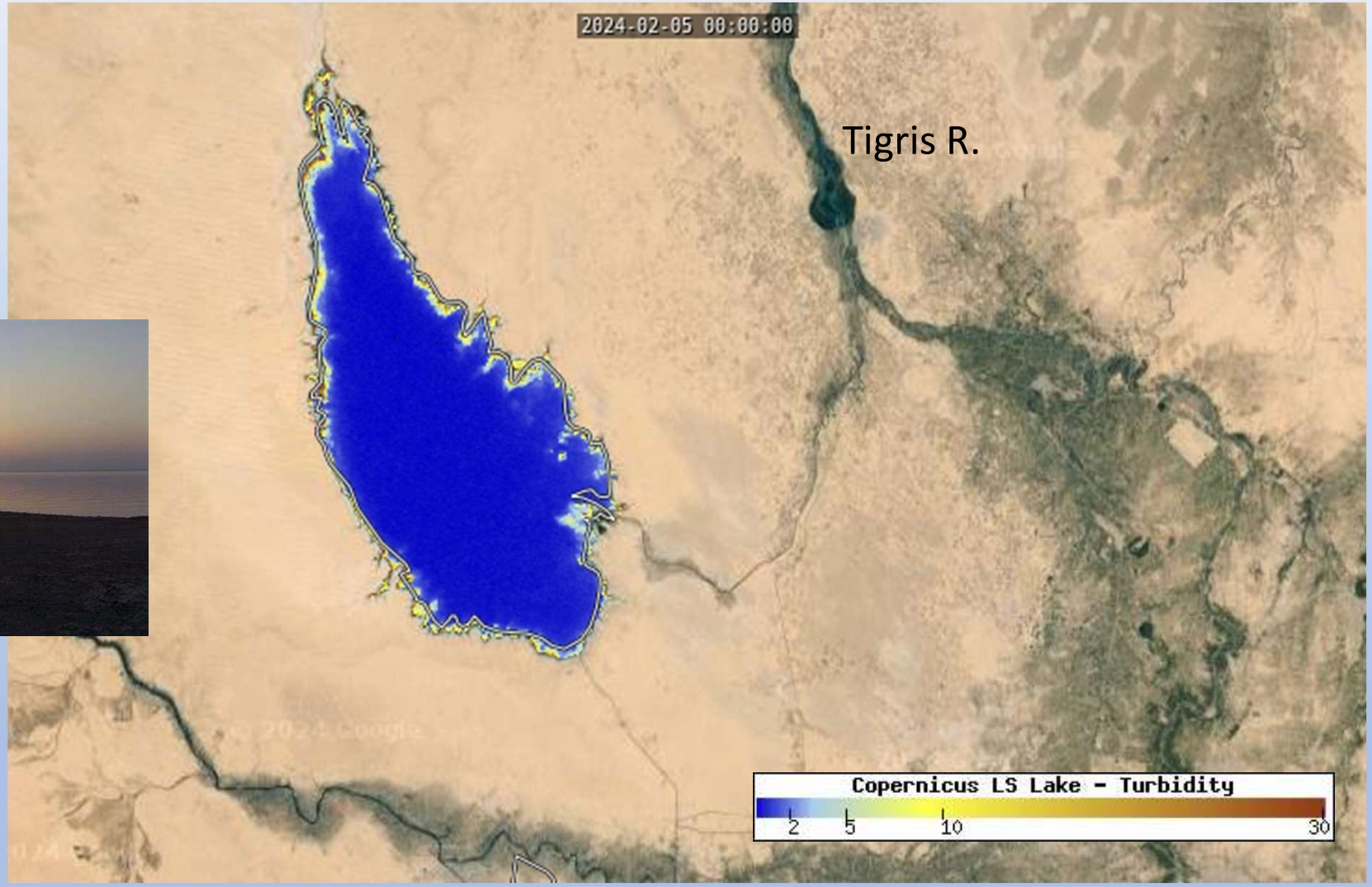
Euphrates
NOAA-20 VIIRS Chlorophyll-a 4km (weekly)
Reference Layers
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

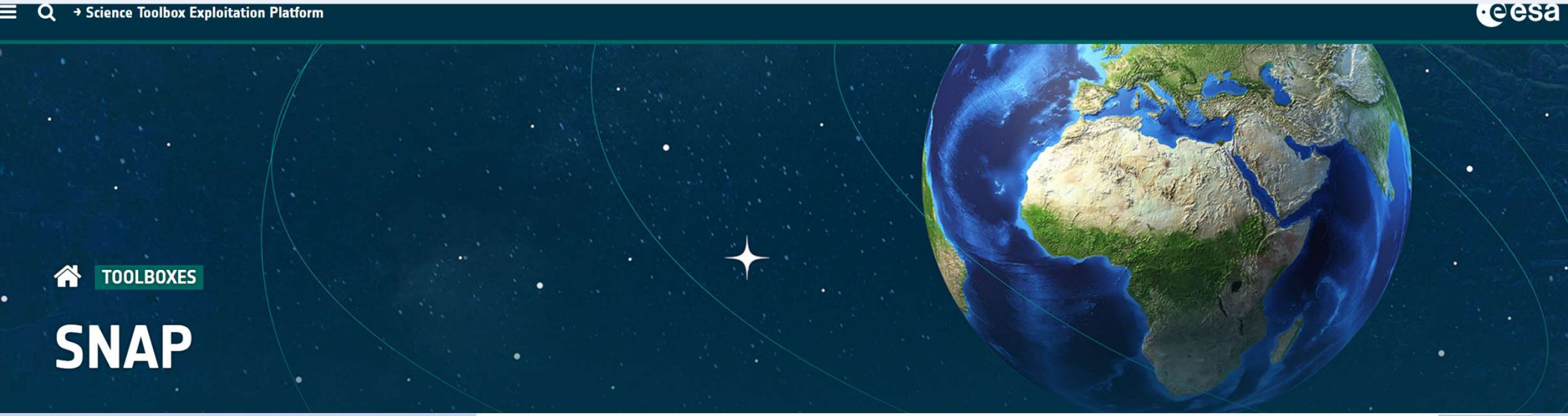
Lake Tharthar Arabic: (بحيرة الثرثار)

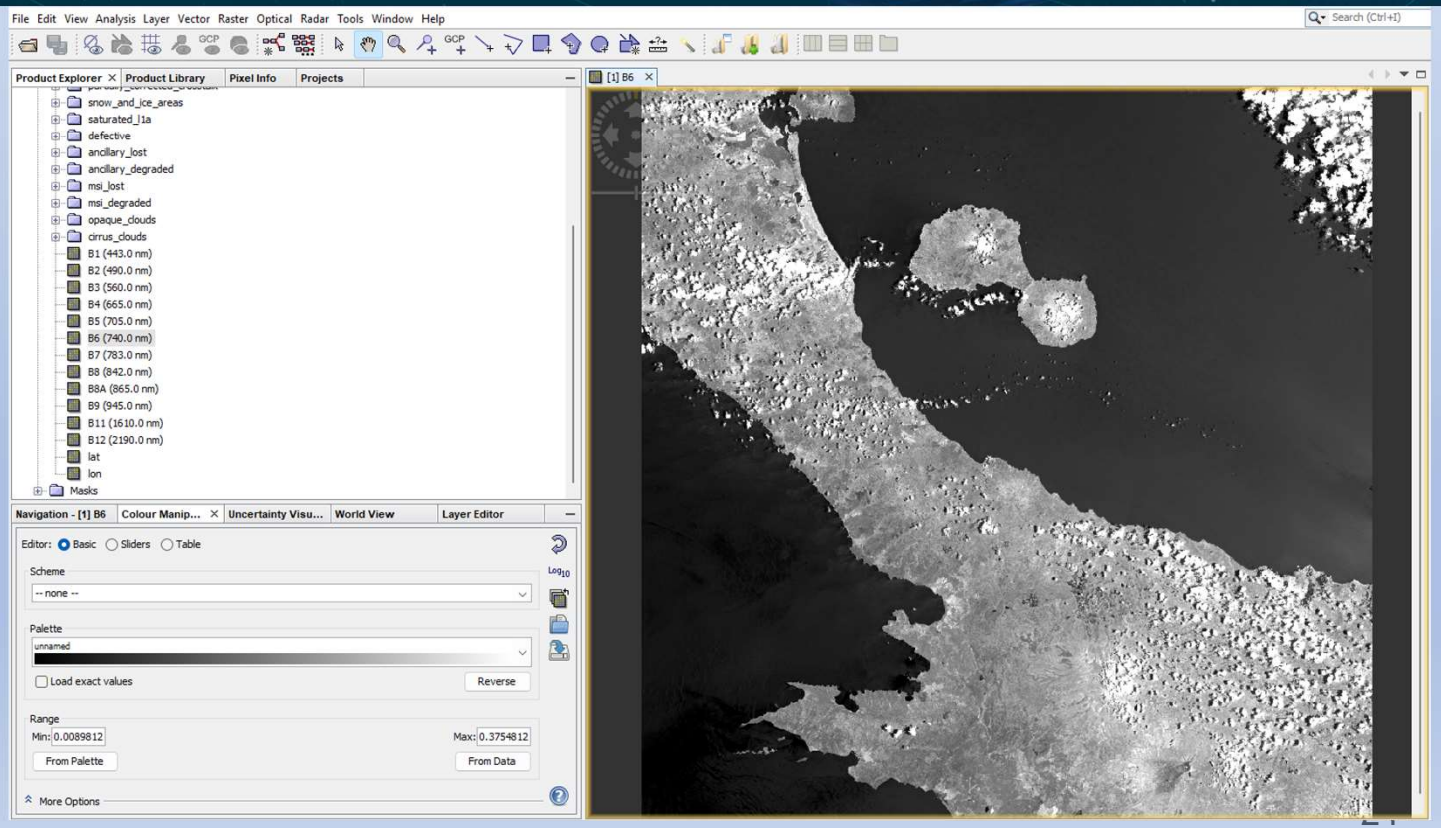




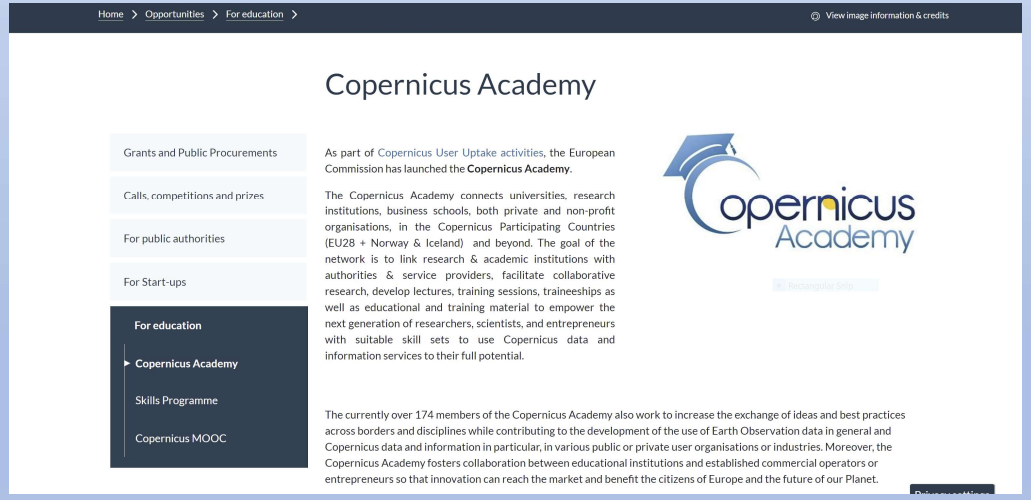
Copernicus 10-day Turbidity

Tools to generate your own satellite-derived Water Quality data

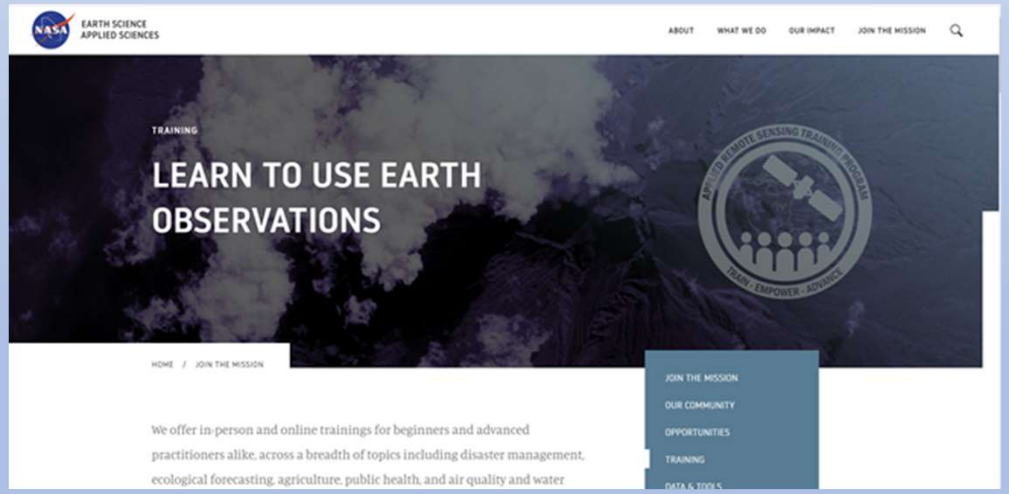




Education and Capacity Development



https://www.copernicus.eu/en/opportunities/education/copernicus-academy



https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

GEO AquaWatch

The GEO Water Quality Community of Practice

AquaWatch aims to develop and build the global capacity and utility of Earth Observation-derived water quality data, products and information to support water resources management and decision making.

Website

DNR photo by Diane Glodoski

GROUP ON EARTH OBSERVATIONS

AquaWatch The GEO Water Quality Initiative