PROGRAMME OF THE EUROPEAN UNION

co-founded with esa

COPERNICUS4REGIONS 2025

SENTINEL-2 DATA FOR AUTOMATIC DETECTION AND MONITORING FRESHWATER ALGAL BLOOMS

Emanuele Ciancia, Gaetano Caricato, Achille Palma, Nicola Pergola, Teresa Trabace, Valerio Tramutoli
National Research Council (CNR) | Regional Agency for Environmental Protecion of the Basilicata Region (ARPAB)
University of Basilicata (UNIBAS) | Italy



> The Sentinel2-based application allowed for a better cost-effective monitoring of algal blooms in a reservoir threatened by anthropic activities
>
> **Achille Palma**
> *Technical-Scientific Director of ARPAB*

Location of the Pertusillo lake within the Basilicata region (Southern Italy). The magnification of the study area is an example of a Sentinel 2 image in RGB false colors where the main towns and the oil field are also shown | Getty Images

Harmful algal blooms are one of the most relevant threats for the ecological status of freshwater bodies. By using 10 years of Sentinel 2/MSI data, a semi-automatic tool has been developed and proposed to regional environmental agencies for an early detection of potential anomalous algal blooms in small reservoirs.

THE CHALLENGE

Freshwater bodies provide multiple services to local communities, being crucial sources of drinking water and major hubs for recreational activities. Climate change and increased pressure from agricultural and anthropogenic activities have caused several environmental threats for inland waters, including harmful algal blooms. Satellite data can be used to complement in situ algal monitoring by providing timely, continuous, and easily accessible information on bio-optical indicators, such as chlorophyll-a (proxy of phytoplankton). In this scenario, it is of paramount importance to provide a satellite-based tool for supporting regional environmental agencies in early identifying potential harmful algal blooms and characterizing their spatio-temporal dynamics.

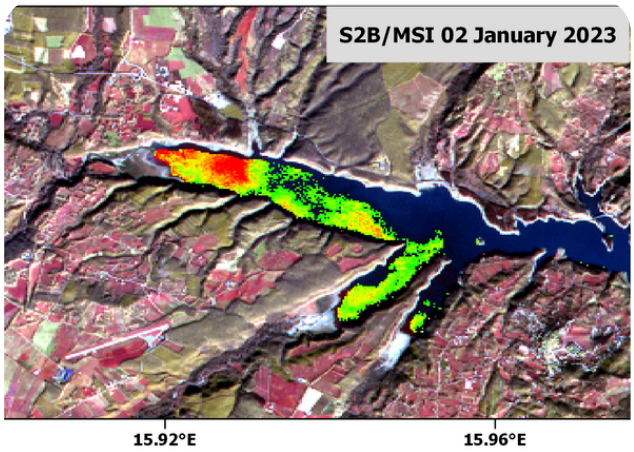
THE SPACE SOLUTIONS

The long-term availability of satellite data acquired by medium-resolution multispectral sensors (i.e., Multispectral Instrument – MSI of Sentinel-2 – S2) made feasible multi-temporal analysis approaches to investigate the spatio-temporal variability of water quality parameters.

Among these, it is worth mentioning the Normalized Difference Chlorophyll Index (NDCI) that, for its inherent construction, is sensitive to variations in chlorophyll-a concentrations along the water column. By using 10 years of S2/MSI data, a statistically based change detection index was developed and implemented to identify anomalous algal blooms in a sensitive test site, namely the Pertusillo lake (Basilicata region, Southern Italy), located within an area of high anthropogenic pressure.

Starting from the NDCI estimation, it was possible to compute, at pixel level, only its statistically infrequent variations respect to its climatological value. The satellite tool revealed the occurrence of an anomalous algal bloom affecting mostly the Western side of the lake in January 2023.

The proposed change detection index was exploited by the Regional Agency for Environmental Protection of the Basilicata Region (ARPAB) to complement their own institutional monitoring activities.



Application of the S2B/MSI-NDCI anomaly map of 02 January 2023 during a phytoplankton bloom. The background image is in RGB false colors. The three different colors indicate increasing (from green to red) intensity levels of algal bloom | Screenshot

THEMATIC AREA

Climate, Water and Energy

REGION OF APPLICATION

Basilicata Region

SENTINEL MISSION USED

S2

COPERNICUS SERVICE USED

-

THE BENEFITS AND THE BENEFICIARIES

The European Water Framework Directive (WFD) highlighted the need to adopt efficient monitoring methods to ensure the good quality status of water bodies.

In this framework, the creation of such a tool for an early detection of harmful algal blooms could be profitably exploited by regional environmental agencies to support the monitoring program phases (i.e., surveillance, operational and investigative phases).

To this aim, such a tool has been useful for ARPAB in promptly establishing the actions to be taken for a better management of this environmental threat within the operational phase.

In detail, the identification of the most exposed area led to select specific locations requiring more additional sampling or bloom mitigation procedures (i.e., phosphate reduction or cyanobacteria removal).

The adoption of this semi-automatic tool allowed ARPAB at using near-real time information in a cost-effective way by accelerating decision-making processes, optimizing measurement campaigns and reducing costs. Furthermore, the possibility to share maps of anomalous algal blooms on the ARPAB website could enable citizens in autonomously verifying the ecological status of reservoirs of increasing environmental relevance.

	TIER 1 SERVICE PROVIDER	TIER 2 PRIMARY USER	TIER 3 SECONDARY USER	TIER 4 END USER BENEFICIARIES
SERVICES AND BENEFITS	Sentinel 2A/B	Daily maps of S2/MSI-Normalized Difference Chlorophyll Index (NDCI), Daily maps of NDCI anomalies obtained by implementing the change detection index	Support to monitoring activities; Identification of the most exposed area, Adoption of bloom mitigation procedures, Reduction of decision-making times	Improve in water quality;, Increase in water transparency, Sustainable exploitation of water resources for human consumption, irrigation, sanitation and recreational activities
BENEFICIARIES	Institute of Methodologies for Environmental Analysis, Italian National Research Council (CNR-IMAA)	Regional Agency for Environmental Protection of the Basilicata Region (ARPAB)	Local authorities managing water resources, Researcher or expert in water quality monitoring by satellite data	Citizens, Farmers, Tourists, Fishermen

EU POLICY / DIRECTIVE

EU Water Framework Directive

TYPE OF SERVICE PROVIDER

Public Service

TYPE OF FUNDING SOURCE

Other

USAGE MATURITY LEVEL

3



A FUTURE WITH COPERNICUS

Ensuring the implementation of this satellite-based tool in the future is a crucial challenge to maintain the solution working and further increase its reliability and robustness. To this aim, the recent launch of S2-C will ensure continuity of the Copernicus S2 data for the years to come, thus providing consistent data stream for a systematic detection and tracking of environmental changes over time.



DID YOU KNOW?

The self-adaptive nature of the proposed index and its independence on ancillary data will allow for its exportability on other freshwater bodies with different bio-optical conditions, thus providing benefits for other Regional Authorities managing water resources.

Contacts

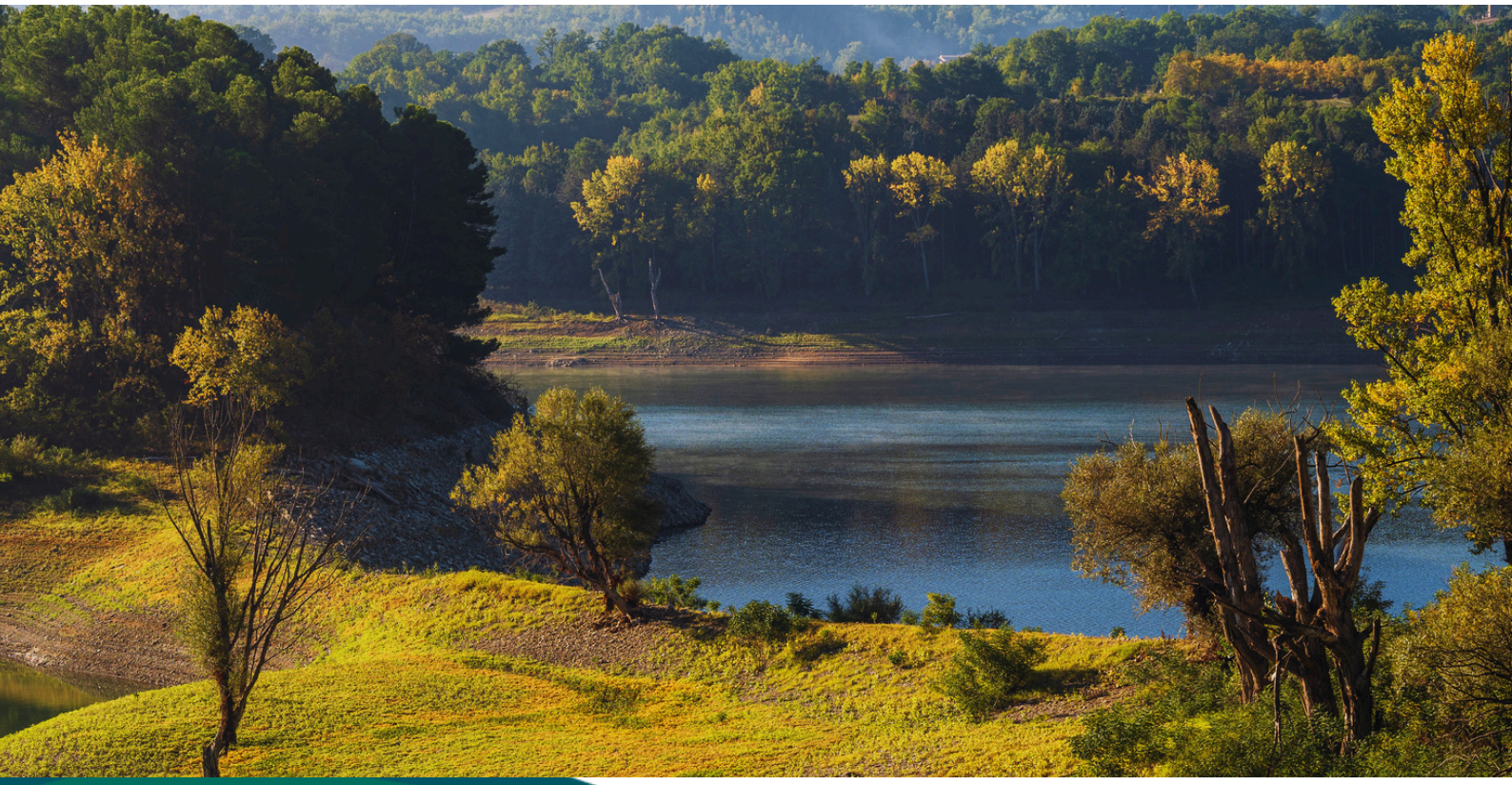
Emanuele Ciancia | emanuele.ciancia@cnr.it
Gaetano Caricato | gaetano.caricato@arpab.it
Achille Palma | achille.palma@arpab.it
Nicola Pergola | nicola.pergola@cnr.it
Teresa Trabace | teresa.trabace@arpab.it
Valerio Tramutoli | valerio.tramutoli@unibas.it

ABOUT COPERNICUS4REGIONS

This user story is part of the Copernicus4Regions collection, which is managed by NEREUS under an assignment from ESA. The views expressed in the Copernicus User Stories are those of the Authors and can in no way be taken to reflect the official opinion of the European Space Agency or of the European Commission. Copernicus4Regions is funded by the European Union, in collaboration with NEREUS. Paging, printing and distribution funded by the European Space Agency. Graphical design by the ESA EO Graphics Bureau.
IPR Provisions apply. Copernicus4Regions material may be used exclusively for non commercial purposes and provided that suitable acknowledgment is given.

www.copernicus.eu
www.nereus-regions.eu/copernicus4regions

Browse this story at :
https://www.nereus-regions.eu/copernicus4regions/2024-user-stories-2



ABOUT COPERNICUS4REGIONS

This user story is part of the Copernicus4Regions collection, which is managed by NEREUS under an assignment from ESA. The views expressed in the Copernicus User Stories are those of the Authors and can in no way be taken to reflect the official opinion of the European Space Agency or of the European Commission. Copernicus4Regions is funded by the European Union, in collaboration with NEREUS. Paging, printing and distribution funded by the European Space Agency. Graphical design by the ESA EO Graphics Bureau.
IPR Provisions apply. Copernicus4Regions material may be used exclusively for non commercial purposes and provided that suitable acknowledgment is given.

www.copernicus.eu
www.nereus-regions.eu/copernicus4regions

Browse this story at :
https://www.nereus-regions.eu/copernicus4regions/2024-user-stories-2