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LAKE MONITORING AND PROTECTION USING COPERNICUS SATELLITE DATA

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> We can only protect what we know–with satellite data we gain a consistent and near-real-time overview of lake water quality across the whole federal state
>
> **- Kristina Popp, Scientist**
> *LRA Bodenseekreis*

The Argen River flows into Lake Constance and forms a river plume. During the flood event, a large amount of sediment and other water constituents are transported into the lake, affecting water quality. Credits LUBW

In the federal state of Baden-Württemberg, Germany, the State Institute for the Environment (LUBW) has implemented a satellite based water quality monitoring system for over 200 lakes using Copernicus satellite data. This enables the LUBW to perform a robust and cost-efficient water quality assessment on a scale which can not be achieved by classical in situ monitoring techniques, thus supporting the protection of precious fresh water bodies and their ecosystems.

THE CHALLENGE

Natural waters and their ecosystems are a very precious part of nature and important for all people in Europe. At the same time lakes undergo all kinds of stressors like industrial usage, extensive water extraction, anthropogenic impacts and also neozoa which influence the water quality of these waters.

There are 28 water bodies greater than 50 hectares and 1300 lakes greater than 1 hectare situated in the federal state of Baden Württemberg. This manifold of lakes can't be monitored by classical in situ measures. So often only lakes mandated by EU WFD are generally monitored (usually 8-10 lakes per year).

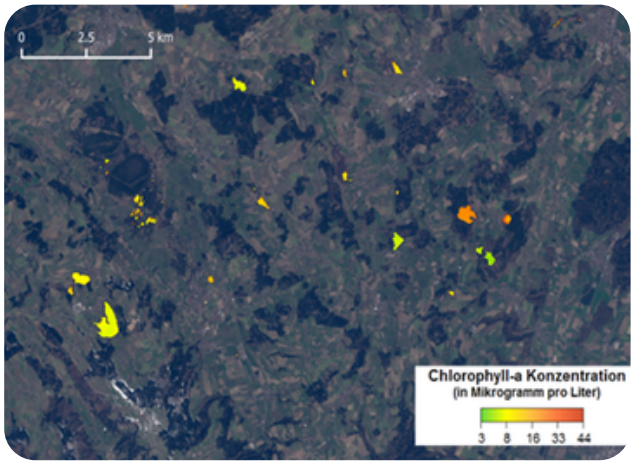
Satellite remote sensing offers, for the first time, the opportunity to obtain consistent and reliable information on water quality for a very large number of lakes (approx. 200 lakes) in Baden-Württemberg. These new possibilities and tools provide federal state authorities - e.g. LUBW - with the information they need to better monitor and protect our lakes thoughout the federal state.

THE SPACE SOLUTIONS

In order to face the above challenges the Institute for Lake Research (ISF) of the LUBW, in collaboration with the German company EOMAP, has implemented a monitoring system for water bodies which is based on data from the Copernicus Sentinel-2 and Sentinel-3 satellites. These satellites enable the retrieval of quantitative water quality parameters, including e.g.:

- Chlorophyll-a concentration – an indicator for algal biomass and eutrophication
- Secchi depth approximation – indicating overall water clarity
- Cyanobacteria indicator – to support bathing water safety assessments

The system allows for the routine monitoring of around 200 lakes with an area of over 10 hectares in Baden-Württemberg. EOMAP carries out the processing of the satellite data delivering georeferenced water quality information to LUBW, which further processes these data for regulatory water monitoring purposes and validates the satellite data with own in situ monitoring data. Ongoing steps aim to extend this monitoring system to lakes as small as 5 hectares, potentially covering over 460 water bodies in the region.



Satellite images show the chlorophyll-a-concentrations for a group of small lakes in the state of Baden-Württemberg. In this way, water quality in this area can be monitored very efficiently. Credit: EOMAP.

Moreover, a near-real-time application eoApp AQUA - a satellite based monitoring tool provided by EOMAP - is being implemented, that delivers lake water quality information shortly after satellite overpass - thus improving operational monitoring capabilities.

THEMATIC AREA

Biodiversity and Environmental Protection

REGION OF APPLICATION

Baden-Württemberg

SENTINEL MISSION USED

S2, S3

COPERNICUS SERVICE USED

CLMS

THE BENEFITS AND THE BENEFICIARIES

The benefits of this satellite based water quality monitoring system are manifold (see also SeBS Report SeBS CR-008 "Lake Water Quality Management in Germany"). First and foremost, thanks to this solution, LUBW has for the first time a methodology which gives not only robust and comparable information about the water quality of large lakes but also for a large number of smaller lakes, which usually can't be monitored at all– or which can be monitored only very rarely every few years - due to the limitations of resources.

LUBW offers the water quality information to different levels of administrational authorities – e.g. regional councils and district councils such as the Lake District Council (Bodenseekreis) – and will make it available in the future also to the interested public and NGOs. Right now, collaborations with the SOS-lake protection program and the federal State Health Office are starting.

Furthermore, LUBW shares the Sentinel-based water quality information for Lake Constance with the neighboring countries - Austria and Switzerland - in the frame of the International Commission for the Protection of Lake Constance (IGKB).

In general this satellite based monitoring system provides water protection authorities with a new level of monitoring information. Annual and seasonal changes of water quality can be detected and unusual signals (e.g. blue algae blooms or sudden changes in water quality) can trigger detailed monitoring measures on site. The near real-time processing of satellite information helps to respond to potentially harmful developments in lakes.

	TIER 1 SERVICE PROVIDER	TIER 2 PRIMARY USER	TIER 3 SECONDARY USER	TIER 4 END USER BENEFICIARIES
SERVICES AND BENEFITS	Satellite images from Sentinel 2 and Sentinel 3 and Landsat 8/9 - other HR and VHR-imagery as well	Atmosphere corrected and georeferenced water quality information (GeoTIFFs) and near real time monitoring system eoApp AQUA	User-friendly information about water quality in lakes in the federal state of Baden-Württemberg	Better water quality data and information for environmental and water management agencies, public health authorities, policy makers and the general public
BENEFICIARIES	EOMAP - Earth Observation Services	State Institute for the Environment Baden-Wuerttemberg (LUBW), Institute for Lake Research (ISF)	Regional councils, district councils, SOS lake protection program of the federal state Baden-Württemberg, IGKB - FB See	Water and nature protection agencies in the federal state of Baden-Württemberg, country citizens, the society as a whole

EU POLICY / DIRECTIVE

EU Water Framework Directive

TYPE OF SERVICE PROVIDER

Commercial Service

TYPE OF FUNDING SOURCE

National Space Programmes, National or regional non space Programme

USAGE MATURITY LEVEL

5



A FUTURE WITH COPERNICUS

The new generation of Earth observation satellites— such as e.g. hyperspectral missions like CHIME or EnMAP — will further enhance monitoring capabilities. They will allow the identification of specific algae groups, including harmful cyanobacteria, and support finer-scale analysis of nutrient loads and ecological trends, even in lakes smaller than 5 hectares. Additionally, higher revisit frequencies and improved spatial resolutions will enable local councils and water authorities in the future to act within days rather than weeks - a major step forward in proactive water governance.



DID YOU KNOW?

Satellite-based monitoring of freshwater quality not only protects the ecosystem, but also helps to ensure safety during swimming and recreational activities. During the summer months, real-time insights into algal blooms or peak turbidity levels can help manage and communicate potential risks associated with swimming, especially in small and popular local lakes that are not regularly monitored on site.

Acknowledgements

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