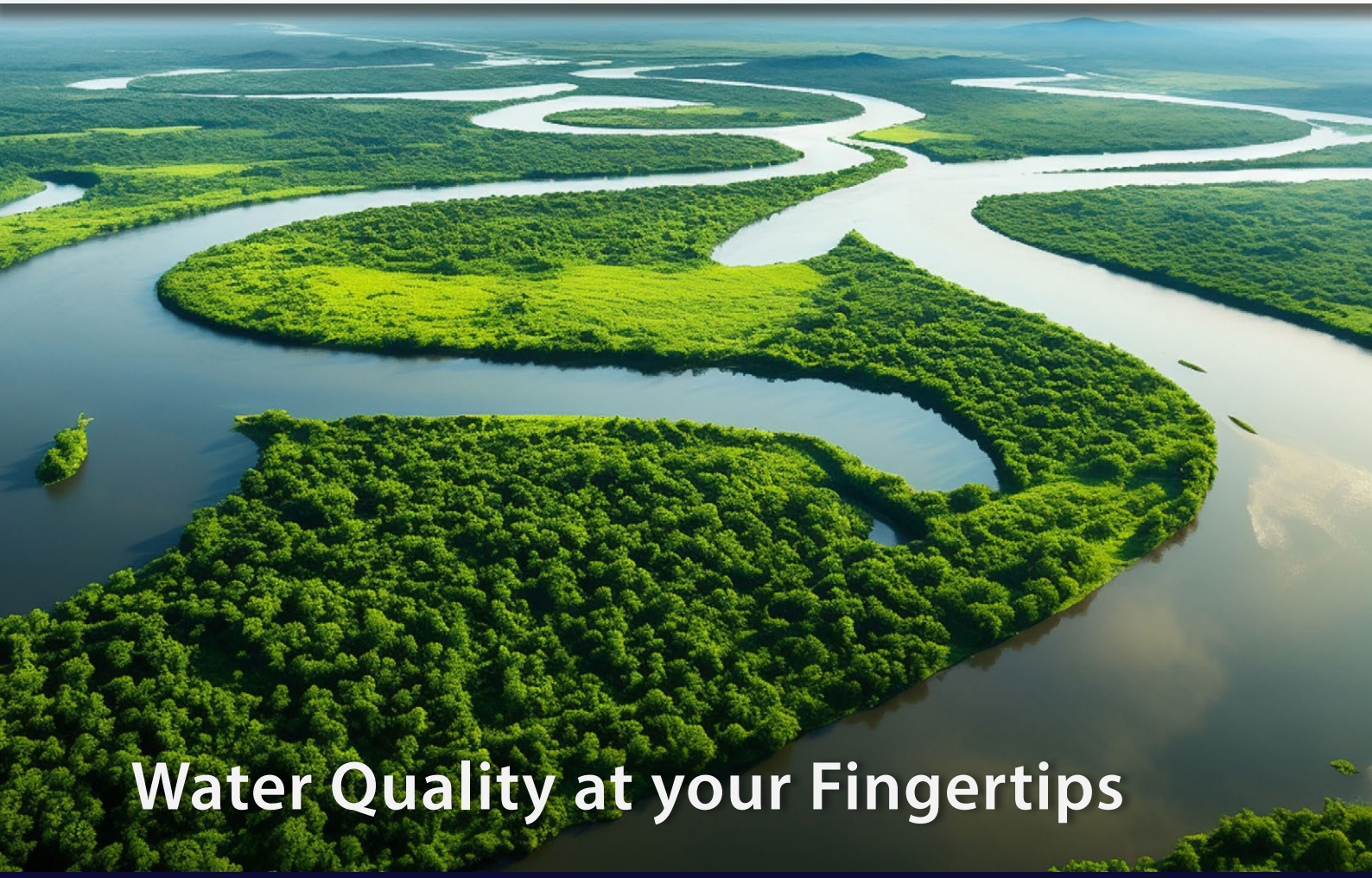
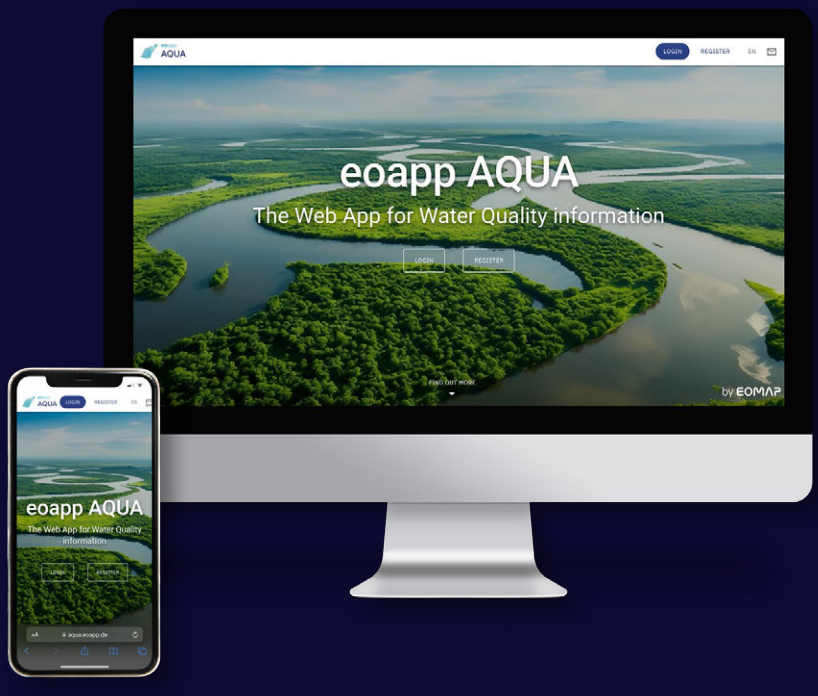
eoapp AQUA



Water Quality at your Fingertips

Keep an eye on key parameters, emerging algae blooms, seasonality, and long-term trends in coastal and inland waters worldwide



Version: July 2024

by EOMAP

Content

eoapp ™ AQUA is a game changer for water monitoring and surveillance

AQUA stands for 'Advanced Water Quality Analytics'. The new web app builds on satellite data to provide key water quality information for authorities and industry.

Upon a few mouse clicks only, the cloud-based solution offers an unprecedented wealth of data and a panoptic view of many water bodies.

Defining required parameters, area, and observation period, users can now conduct a data generation made to measure. Gaining comprehensive information on coastal and inland waters from space has thus become easier and more rapid than ever.

Benefits

Get the „big picture“

Thanks to an unprecedented wealth of data, you will detect seasonality, trends and natural variability, or identify spatial patterns and extreme values in a long-term context

Enjoy rapid access

Near-real-time processing of latest satellite overflights allow for a fast overview of all areas of interest (AOIs). User friendly dashboards support a rapid uptake.

Stay ahead of time

Critical developments, such as algal blooms, are visualised via a hands-on alert function upon individual thresholds. This helps you see emerging dangers in time.

Assess impacts

Get to the bottom of water quality information by looking back up to 40 years in time. Assess the impacts of potential sites, existing infrastructure or climate change risks.

Applications

Key information on the status of drinking water reservoirs, bathing waters, or river systems
EO-based monitoring of key water quality parameters are delivered as online accessible maps and time series.

Near-real-time states of coastal and inland waters
Up to daily reports on turbidity, chlorophyll, or alerts on potentially harmful algae blooms offer hands-on decision support.

Climate change and trend analysis
Historical data going back up to 40 years facilitate environmental monitoring and reporting duties, but also data-based infrastructure planning.

Rapid change detection
Daily, weekly or monthly statistics enable thorough mapping of construction works. The web app also simplifies assessing environmental impacts of human activities or natural hazards.

Drinking Water Safety

Habitat Protection (EIA)

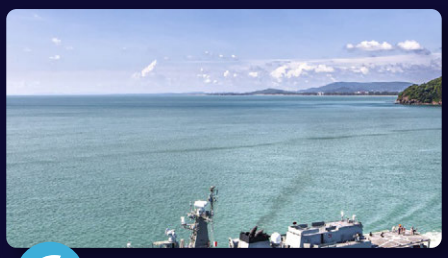
Coastal Engineering

Monitoring Ecological Status

Hydrodynamic Modelling

Hydropower Projects

Safer Navigation



Defense

Offshore Projects

The Concept

eoapp AQUA is a user-friendly and intuitive web application to **calculate, visualise, and analyse** satellite-based water quality information.
Set up in a cloud environment, it is a novel **fully scalable** water quality monitoring solution for water managers in public authorities, governmental agencies or industry, supporting drinking and bathing water monitoring, ecological monitoring duties, infrastructure planning and impact assessment or river management.
Operational processing services and satellite data analytics in eoapp AQUA are based on EOMAP's established **Modular Inversion and Processing System** (MIP), state-of-the-art, when it comes to high and very high-resolution satellite-derived water quality.
It emcompasses three main features:

Baseline enables the user to derive annual and monthly information as statistics, box plot figures, and maps. Compare the current situation to long-term behaviour or detect trends and seasonality of a water body or compare two water bodies directly.

Monitoring allows you to quickly gain an overview of the current situation and emerging developments. The dashboard is especially designed for the efficient supervision of large amounts of water bodies and supports management decisions and field work planning.

Alert is based on user-defined thresholds that can be individually set for each water body if needed. Once these thresholds are exceeded, the system automatically sends a notification email to the user to inform about a critical situation.

Monitoring of inland and coastal water quality for different applications

Parameters and typical applications

Parameter	Applications
TUR-Turbidity (NTU)	**Pollution Detection:** Identify areas with sediment runoff and industrial discharges. **Fisheries and Aquaculture:** Manage water quality for optimal fish health. **Coastal Management:** Understand sediment transport and erosion. **Stormwater Management:** Assess the impact of urban runoff on water quality. **Climate Change Studies:** Monitor long-term changes for understanding erosion, run off, and sedimentation.
SDD- Secchi Disc Depth (m)	**Industrial Discharge Monitoring:** Helps in monitoring an industrial discharge into the water and also indicate the presence of pollution. **Water Quality Monitoring:** Assess water clarity and detect pollution. **Ecosystem Health:** Evaluate habitat quality for aquatic species as suspended particles block sunlight essential for sustenance. **Recreational Safety:** Ensure water bodies are safe for swimming and boating.
CHL- Chlorophyll (µg/l)	**Recreational Water Safety:** Chlorophyll mapping helps in monitoring recreational water bodies, ensuring they are safe for public use . **Irrigation Water Quality:** In agricultural regions, monitoring chlorophyll-a in water bodies can help assess the quality of irrigation water, ensuring it is free from contaminants that could affect crop health. High concentrations of chlorophyll can indicate eutrophication, often due to nutrient pollution from agricultural runoff or wastewater discharge. **Phytoplankton Biomass Assessment:** Chlorophyll concentration serves as a proxy for phytoplankton biomass, which is crucial for understanding primary productivity in marine ecosystems. **Fishery Productivity:** Chlorophyll maps can help in mapping spatial distribution and also identifying productive fishing grounds by highlighting regions with high primary productivity. **Carbon Cycle Monitoring:** As phytoplankton play a significant role in carbon sequestration, chlorophyll data contribute to studies on the global carbon cycle and climate change models. **Water Body Health Indicators:** Long-term monitoring of chlorophyll-a can provide indicators of water body health and climate change impacts on marine ecosystems.
HAB- Harmful Algae Bloom Indicator	**Public Health Protection:** Early detection to issue warnings for drinking and recreational waters. **Marine Ecosystem Management:** Protect coral reefs and manage fish habitats. **Fisheries & Seafood health:** Prevent fish kills and manage aquaculture health which are caused by certain HABs. **Tourism:** Maintain safe conditions for recreational activities such as swimming, diving etc.
WEX-Water Body Extent	**Flood Management:** Monitor and predict flood events and impacts. **Wetland Conservation:** Map and protect wetland areas. **Agriculture:** Manage irrigation and monitor water availability. **Urban Planning:** Assess changes in water bodies due to urbanization.

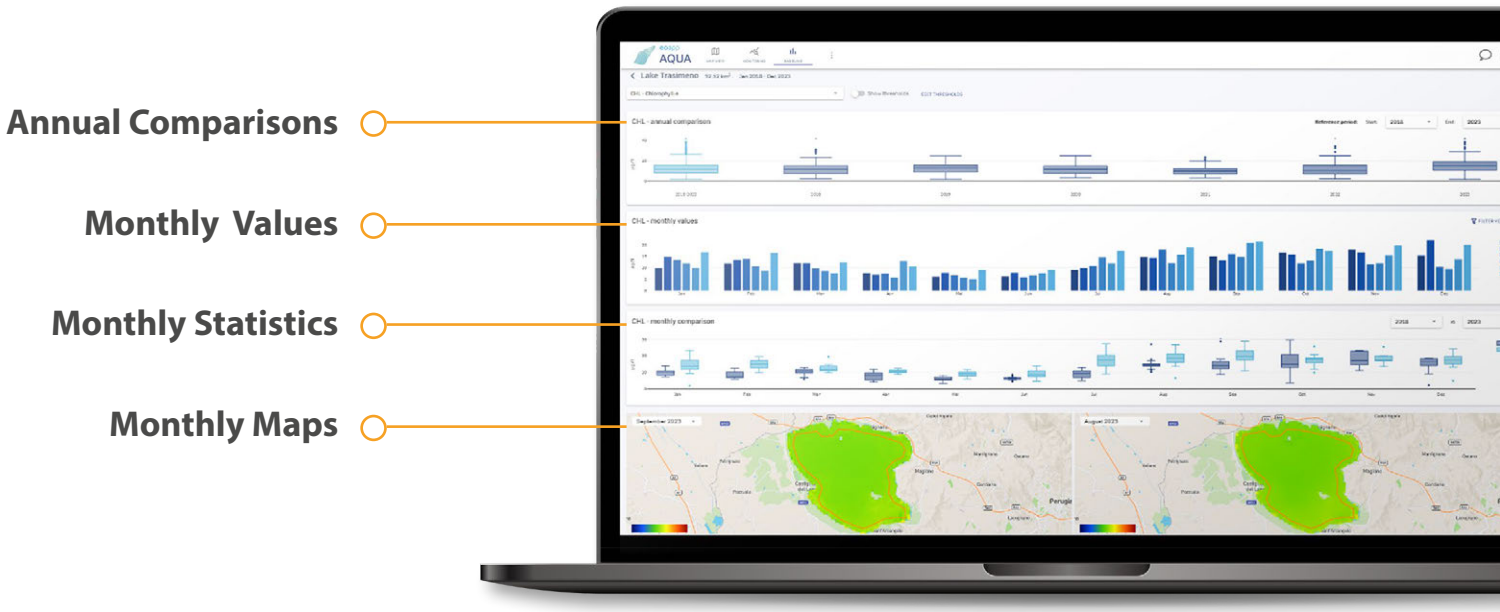
Feature: Baseline
Climate change and trend analysis

eoapp AQUA can be applied for

+ Ecological monitoring duties
+ Infrastructure planning and impact assessment

Therefore supports

+ Water authorities on any scale
+ Planners & engineers
+ Survey companies



Example:

Long-term assessment of catchment properties in Hydropower reservoirs

Cahora Bassa, Mozambique

Feature: Monitoring
Change detection

eoapp AQUA can be applied for

+ Drinking and bathing water monitoring
+ Ecological monitoring duties
+ Infrastructure planning and impact assessment

Therefore supports

+ Water authorities on any scale
+ Planners & engineers
+ Survey companies

Each dot is one satellite measurement

Visibility depth

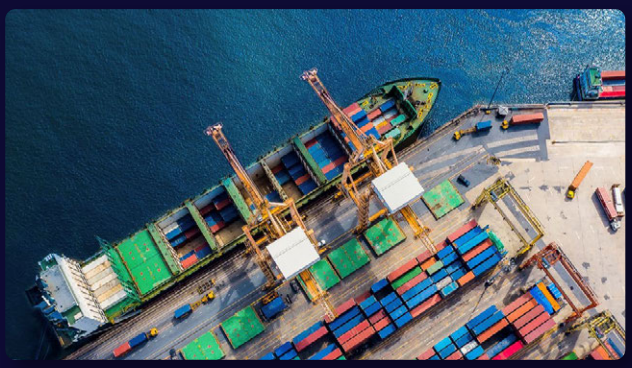
Chlorophyll concentration

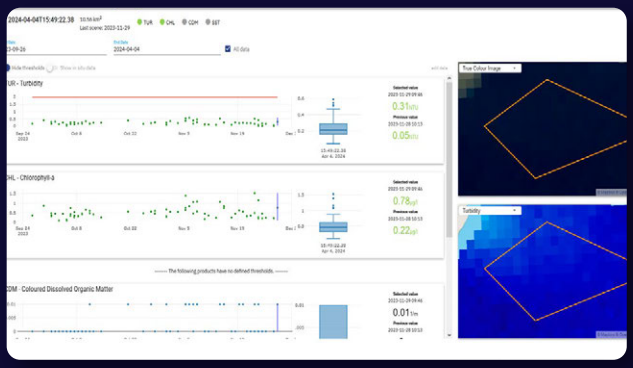
Algae bloom indicator

Example:

Monitoring pf coastal waters, XYLEM/IFREMER

Toulon/Baie de Hyères, France





Feature: Alert
Monitoring of Drinking and Bathing Waters

eoapp AQUA can be applied for

+ Drinking and bathing water monitoring
+ Ecological monitoring duties
+ River management

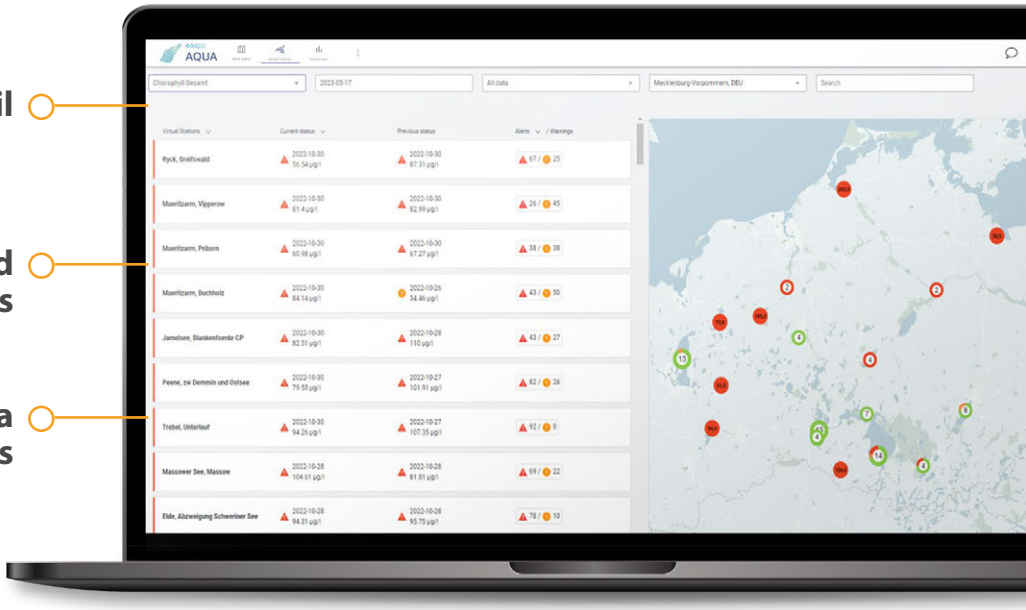
Therefore supports

+ Water authorities on any scale
+ Planners & engineers
+ Survey companies

Notification via E-Mail

Definition of own and site-specific thresholds

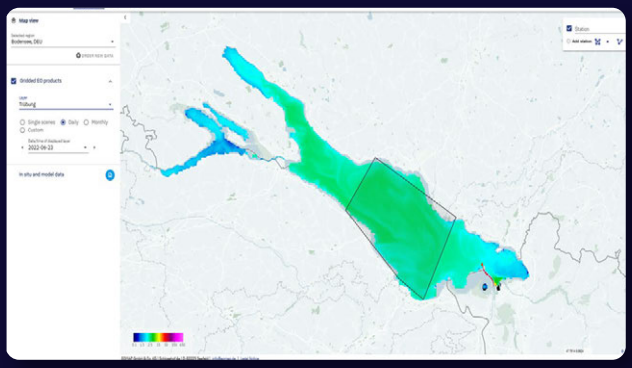
Combination of different data for early warning indicators



Example:

Drinking Water Monitoring

Lake Constance, Germany

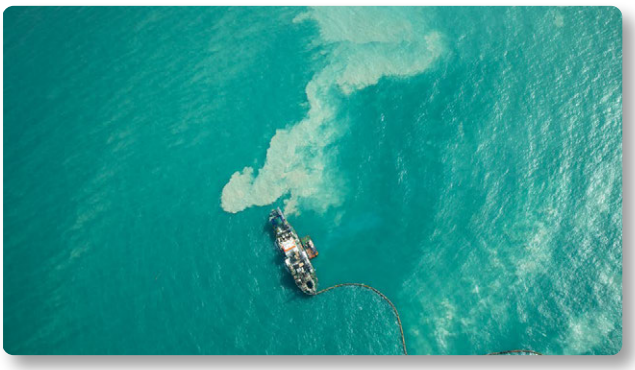


Product Line Overview

Parameter	Accuracy	Units of measure	Range	Comments
Turbidity	typically < 5% deviation between 0-30 NTU	NTU	EPA drinking water: < 1NTU Short-term stress to aquatic life: >10 NTU Unsafe level for most aquatic life: >100 NTU	The geometrical properties and wavelengths used by in-situ measurement devices may differ in comparison to the satellite product.
Total Suspended Matter (TSM)	typically < 5% deviation between 0-30 mg/l	mg/l	Typically in the range of Turbidity, during exceptional cases (e.g., flushing events of hydropower reservoirs) up to multiple grams per liter.	Mass concentrations of particles measured as Total Suspended Matter (TSM) are linearly related to turbidity at low to moderate values.
Chlorophyll	+/- 30% possible in comparisons with high concentration variability over small spatial areas and/or rapidly changing conditions.	µg/l or g/m^3	Marine waters or clear lakes: 0.01 - 10 µg/l mesotropic lakes: ~ 6-20 µg/l euthropic lakes: ~ 20-150 µg/l hypereutropic lakes: > 150 µg/l	Chlorophyll serves as proxy for phytoplankton and is calculated based on the spectral characteristics of various pigments, including Chlorophyll-a.
HABs Indicator	Calculation of ikelihood HAB presence sensitive to the appearance of Phycocyanin and Phycoerythrin pigments.	No HAB, Unlikely, Likely, Very Likely	In warm, nutrient-rich environments, cyanobacteria can multiply quickly, creating blooms that spread across the water surface.	The chlorophyll measurement can also be used in the assessment for the probability of the presence of HABs.
Visibility (Secchi Disk Depth, SDD)	Very good correlation with insitu measurements (R = 0.93)	meters	Ranging from few dm in very turbid waters to over 20m in very clear ocean conditions	Calculated from the attenuation coefficient based on in-water scattering and absorption.
Water Surface Temperature (SST)	+/- 0.5 to 2-degrees C or 5-10%. Temporal resolution, 1-week or greater. Spatial resolution appears 30m; however, actual measurement is 100m. For larger water bodies, daily measurements are possible with 1km spatial resolution.	Celsius	Typically between 0-35°C	Measures the skin of the water; doesn't average the visible water column. Only certain satellites have the thermal sensors which is what limits the resolution. New satellites may improve in the years after 2024
CDOM	~5-10 % deviation, e.g. tested in estonian waters	1 / m	CDOM occurs in all natural waters, especially in forested watersheds with wetlands. Antropogenic sources are wastewater and urban/agricultural runoff.	Very high CDOM absorption levels can make it difficult to calculate CDOM. It can also affect estimations for Chlorophyll.
Water Extent (WEX)	Land and water have very different spectral properties (water: low reflectance, land: high reflectance), therefore it can be differentiated successfully in almost any case.	Water yes/no	> 0.1 for clear lake waters > 1 for humic lakes > 5 for very humic and turbid rivers	Can be used for flood monitoring, reservoir capacity, river discharge, tidal impacts, and shoreline changes. Some other satellite sensors (e.g. radar) are immune to cloud cover interference, and can be used to supplement the standard optical measurements.

Turbidity and Total Suspended Matter

Turbidity (TUR), a key parameter for assessing the water quality in reservoirs and rivers, is caused by organic and inorganic particles in the water. High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality. Particles further provide attachment places for pollutants (e.g. metals, bacteria) and increased sedimentation and siltation can occur, which can result in harm to habitat areas for fish and other aquatic life.



Observe and track turbidity plumes from above

Typical Applications and Use Cases

- Dredge Monitoring
- Drinking Water Monitoring
- Hydropower Planning and Operations

Technical Characteristics:
Satellite-based turbidity is determined by backward scattering of light in a range of 450 to 800nm. The measurement unit is Nephelometric Turbidity Unit (NTU), which is similar to Formazine Turbidity Unit (FTU).

Mass concentrations of particles measured as Total Suspended Matter (TSM) are linearly related to turbidity at low to moderate values.

Additional Information:
As the shape, size, and spectral characteristics of particles vary, the exact relationship between scattering and TSM can vary from place to place and from season to season.

For example, this occurs when the composition of phytoplankton species changes or when other particals than during low flow periods are introducted during snow pelt periods with higher discharge. A regional and seasonal calibration of TSM further assures the accuracy of TSM estimates.

Literature & Useful Links:
Heege, T., Kelleher, D. (2018): Reducing economic risks in hydropower developments through independent satellite-based turbidity and sediment measurements in the river systems of Georgia. Proc. Hydro 2018 conference, Gdansk 15.-17.10.2018

Bresciani M, Giardino C., et. al. (2019): Monitoring water quality in two dammed reservoirs from multispectral satellite data, European Journal of Remote Sensing

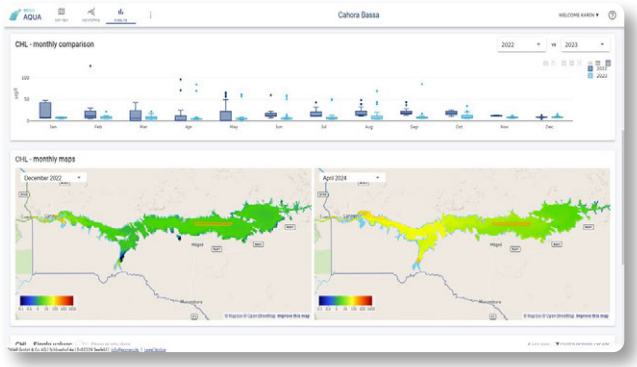
Online Story Map: "Starving the Mekong"

Range - Validation - Accuracy:
Turbidity and TSM products compare to in situ measured typically with < 5% deviation over a large concentration range (0-30 NTU or mg/l). For higher concentrations, the deviations can increase.

When comparing satellite-based turbidity against in situ measured total suspended matter the deviations can be higher, most likely due to changing of sediment compositions resulting in accompanied changes in the TSM vs. TUR relations.

Chlorophyll

Chlorophyll (CHL) is a pigment included in phytoplankton cells and can serve as a proxy for algae in natural waters. Phytoplankton are the foundation of the aquatic food web for primary producers from microscopic, animal-like zooplankton to multi-ton whales and can therefore provide information about food availability. Chlorophyll values vary over 4 magnitudes, for marine waters or clear lakes typical concentrations are expected between 0.01 and 10 µg/l, while for eutrophic lakes concentrations can reach 100 µg/l and more.



Monthly statisctis and spatial distribution of Chlorophyll concentrations over the course of a year

Typical Applications and Use Cases

- Ecological assessments
- Directive Monitoring (Bathing Water, Water Framework Directive…)
- Climate change studies

Technical Characteristics:

EOMAP's chlorophyll retrieval is based on derived pigment-specific in-water absorption and the spectral characteristics of various pigments. The unit is µg/l or mg/m^3.

The pigments contributing to this quantifiable absorption, which is measured by the spectral satellite sensors, not only include various Chlorophyll pigments, but also other pigments such as Phaeophytin.

Additional Information:

The liability of products is sensitive to the specifications of the underlying satellite sensors and their specific characteristics, such as radiometric or spectral sensitivity. Still, with physics-based analysis methods, the products are comparable, as long as the common reference properties, absorption and scattering spectra, are maintained as comparison standard. The applicability range for Chlorophyll products can be limited in waters with exceptional optical properties, e.g., in humic, calcareous or ferruginous waters.

Literature & Useful Links:

Karle, N., Wolf, T. et al. (2019): Satellite Remote Sensing of Chlorophyll and Secchi Depth for Monitoring Lake Water Quality – A Validation Study. Processings for the SPIE, Strasbourg

Bresciani M, Giardino C. et al. (2019): Monitoring water quality in two dammed reservoirs from multispectral satellite data, European Journal of Remote Sensing

Water Days (2022): High Resolution Bathing Water Monitoring

Range - Validation - Accuracy:

Chlorophyll is the parameter showing greater short-term variations due to intra-daily dynamics of phytoplankton.

Based on recent validation exercises comparing satellite with in situ measurments (Karle, 2019, Bresciani 2019), in large and small lakes, the mean value of both methods are very similar and their range of minimum and maximum values fits well, with r of 0.87 or an average remote sensing/ in situ factor of 0.8-1.2 in different ecological water bodies.

Harmful Algal Bloom

Harmful Algal Bloom Indicator (HAB) is a proxy for cyanobacteria and is sensitive to the appearance of Phycocyanin and Phycoerythrin. Cyanobacteria, also called blue-green algae, are microscopic organisms found naturally in all types of water. In warm, nutrient-rich environments, cyanobacteria can multiply quickly, creating blooms that spread across the water surface. Some cyanobacterial HABs can produce toxin and pose harm to people, animals, aquatic ecosystems, drinking water supplies, property values, and recreational activities, including swimming and fishing.

Algal Bloom in Lake Victoria

Typical Applications and Use Cases

- Bathing Water Monitoring
- Climate Change Studies
- Ecological Assessments

Technical Characteristics:
The product provides a qualitative indicator classifying the likelihood based on the identification of reflectance and absorption discrepancies between the 550nm and 650nm wavelength bands, which indicate the appearance of the Cyanobacteria-related pigments. It is classified into four likelihood classes: no HAB, unlikely, likely and very likely.

The quantification of cyanobacteria is currently under development.

Additional Information:
Chlorophyll-a and similar pigments are also present in cyanobacteria and can be used as an indicator of algal bloom events. However, not all bloom events are necessarily harmful algal blooms.

The applicability range for the HAB indicator is limited for water with exceptional optical properties, e.g., for extremely humic, calcareous or ferruginous waters or in rivers with high suspended sediment loads.

Literature & Useful Links:
Dörnhöfer, K., Klinger, P. et al. (2017): Multi-sensor satellite and in situ monitoring of phytoplankton development in a eutrophic-mesotrophic lake. Science of Total Environment 612C (2018)

International Journal on Hydropower& Dams, Vol. 31 - Issue 2

Range - Validation - Accuracy:
Latest validation of HAB indicator concludes that the peaks in the in situ data match well with the peaks found in the remote-sensing based indicator, as shown in use cases in Spain, Germany and Italy.

Also, seasonal trends are well represented in the HAB indicator, it is also used as an early warning parameter for bathing water surveillance.

Visibility

Secchi Disk Depth (SDD) is a measure of visibility in the water column, indicating how deep the light can penetrate into the water body. Visibility is related to the euphotic zone in the water and is a useful information source for divers.

The visibility within a water body as proxy for euphotic zones

Typical Applications and Use Cases

- Bathing water Monitoring
- Lidar Survey Planning
- Trophic state assessements

Technical Characteristics:
The SDD product is derived from the in-water scattering and absorption properties and is expressed in meters (m).

It is calculated from the attenuation coefficient Kd after Lee et al. 2005 and 2015 by calculating : SDD = 2.3 / (2.5 * Kdmin)with Kdmin being the min Kd from all channels of the visible spectrum.

Additional Information:
In general, the SDD (and other water quality related products as well) is only applicable for optically deep surface waters, which means that the bottom of the waterbody is not visible.

For optically shallow waters, increased errors will occur due to interferences of, e.g., proportions of seafloor in the water signal.

Literature & Useful Links:
Lee, Z. P., Du, K.-P., Arnone, R. (2005): A model for the diffuse attenuation coefficient of downwelling irradiance, Journal of Geophysical Research, Vol. 110, C02016

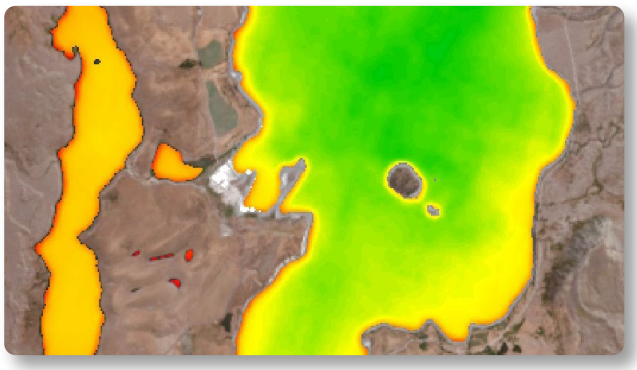
Lee, Z. P., Shang, S. et al. (2015): Secchi disk depth: A new theory and mechanistic model for underwater visibility, Remote Sensing of Environment 169, 139-149

Range - Validation - Accuracy:
Visibility (SDD) determined by satellite data corresponds very well with the in situ measurements in both large and smaller lakes, rivers, or coastal areas.

For example, as publish in Bresciani et al., the comparison between satellite-based SDD and in situ show very good correlation with r = 0.93 and a RMSE of 0.41 in the case of two damed reservoirs investigated.

Water Surface Temperature

Water Surface Temperature (SST, °C) corresponds to the temperature at the very surface of the water, also known as lake skin surface temperature. It is a fundamental parameter in the modelling of energy fluxes interesting the water-air interface. It also affects the quality of water, because it can contribute to the growing and proliferation of aquatic algae and cyanobacteria.



Satellites directly observe spatial differences in water temperature

Typical Applications and Use Cases

- Monitoring of Desalination Plants
- Climate Change Studies
- Early Warning on emerging algal blooms

Technical Characteristics:

Water Surface Temperature data are derived using thermal bands of the Landsat missions 5-9, delivered in 30m resolution, but stemming from the original 100m resolution TIRS band and with up to weekly coverage. For larger water bodies such as coastal areas, Sentinel-3A/B SLSTR temperature product in 1km resolution /up to daily coverage is used.

Further commercial high spatial and temporal resolution temperature products are likely available from the end of 2024.

Additional Information:

Data from Landsat are available from 1984 onwards. In general, for Water Surface Temperature product generation clear sky conditions at the satellite overpass time are required.

In case of Landsat, the originally coarser thermal bands are resampled to 30m, which needs to be considered when analysing small features such as rivers.

Literature & Useful Links:

Bresciani M, Giardino C., Stroppiana D., Dessena M.A., Buscarinu P., Cabras L, Schenk K., Heege T., Bernert H., Bazdanis G. & Tzimas A. (2019): Monitoring water quality in two dammed reservoirs from multispectral satellite data, European Journal of Remote Sensing.

International Journal on Hydropower& Dams, Vol. 31 - Issue 2

Range - Validation - Accuracy:

Comparison between SST and surface temperatures derived from in situ measurements typically show a mean deviation between 0.5-2°C or 5-10% (Bresciani et al. 2019, Bauer et al 2024).

Coloured Dissolved Organic Matter

Coloured Dissolved Organic Matter (CDOM, CDM) or Yellow Substance comprises all dissolved organic matter which influences the water colour, mainly consisting of humic or fulvic acids, originating often from fluvial or ground-water transport, degradation of phytoplankton and aquatic vegetation or surface run-off. In high CDOM areas, the absorption leads to reduced euphotic depth and affects the growth of macrophytes. In Finland, the CDOM is used in typing of water bodies for the Water Framework Directive.

Saidenbach drinking water reservoir, Germany

Typical Applications and Use Cases

- Drinking Water Reservoir Monitoring
- Water Framework Directive
- Global carbon budgets

Technical Characteristics:

CDOM absorbs light especially in the blue wavelengths and can thus affect the transparency of the water column.

CDOM is measured in terms of absorption and the measurement unit is 1/m.

Additional Information:

CDOM has significant impacts on surface water quality through its ability to affect pH, mobilize metals and hydrophobic organic chemicals and serve as a source of reactive intermediates in aquatic photochemistry.

CDOM also regulates heat transfer to water, controlling lake temperatures, mixing and stratification.

Literature & Useful Links:

Kutser, Tiit & Pierson, Donald & Tranvik, Lars & Noorma, Anu & Sobek, Sebastian & Kallio, Kari. (2005). Using Satellite Remote Sensing to Estimate the Colored Dissolved Organic Matter Absorption Coefficient in Lakes. Ecosystems. 8. 709-720.

Aurin D, Mannino A, Lary DJ. (2018): Remote Sensing of CDOM, CDOM Spectral Slope, and Dissolved Organic Carbon in the Global Ocean. Appl Sci (Basel). 8(12):2687.

Saxony drinking water reservoirs

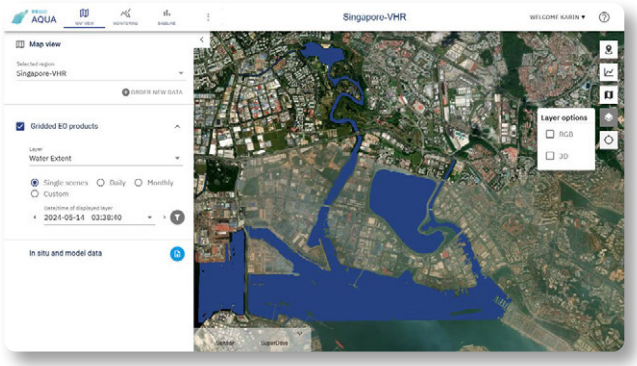
Range - Validation - Accuracy:

CDOM values can range from very clear oceanic waters with 0.02 1/m, greater than 0.1 for clear lake waters, up to more than 1 for humic lakes or more than 5 for very humic and turbid rivers.

Errors in the calculated CDOM absorption may appear in shallow water areas, where seafloor contributes to the signal measured by the satellite or when the CDOM absorption cannot be sufficiently discriminated from the phytoplankton pigment or detrital absorption.

Water Extent

The Water Body Extent (WEX) product discriminates between land and water pixels. The water extent can be applied for studies in temporally dynamic areas, e.g., in areas influenced by tidal processes, or to map the extent of flooding. The storage capacity of reservoirs is another possible application of the water extent, it is also used in the calculation of river discharge. Changes in the shoreline are another field of application for the WEX product.



Very high resolution water extent in Singapore visualized in eoapp AQUA, data source: Planet Superdoves

Typical Applications and Use Cases

- Flood mapping
- Shoreline changes
- Storage Capacity calculations

Technical Characteristics:
The WEX product is based on typical reflectance features in the visible and near- to shortwave infrared region. The WEX product is based on optical satellite data (multi- to hyperspectral).

Additional information:
The WEX product can be applied in any location to differentiate between water and land.

By combining data from additional data sources, especially from active remote sensing (i.e., radar) systems such as Sentinel-1, the value of the WEX product can be increased as these active systems are not subject to cloud cover, and therefore offer additional data to the purely optical-based WEX.

Literature & Useful Links:

Planet - Monitoring River Flushing and Hydropower from Space

Publications upon request available

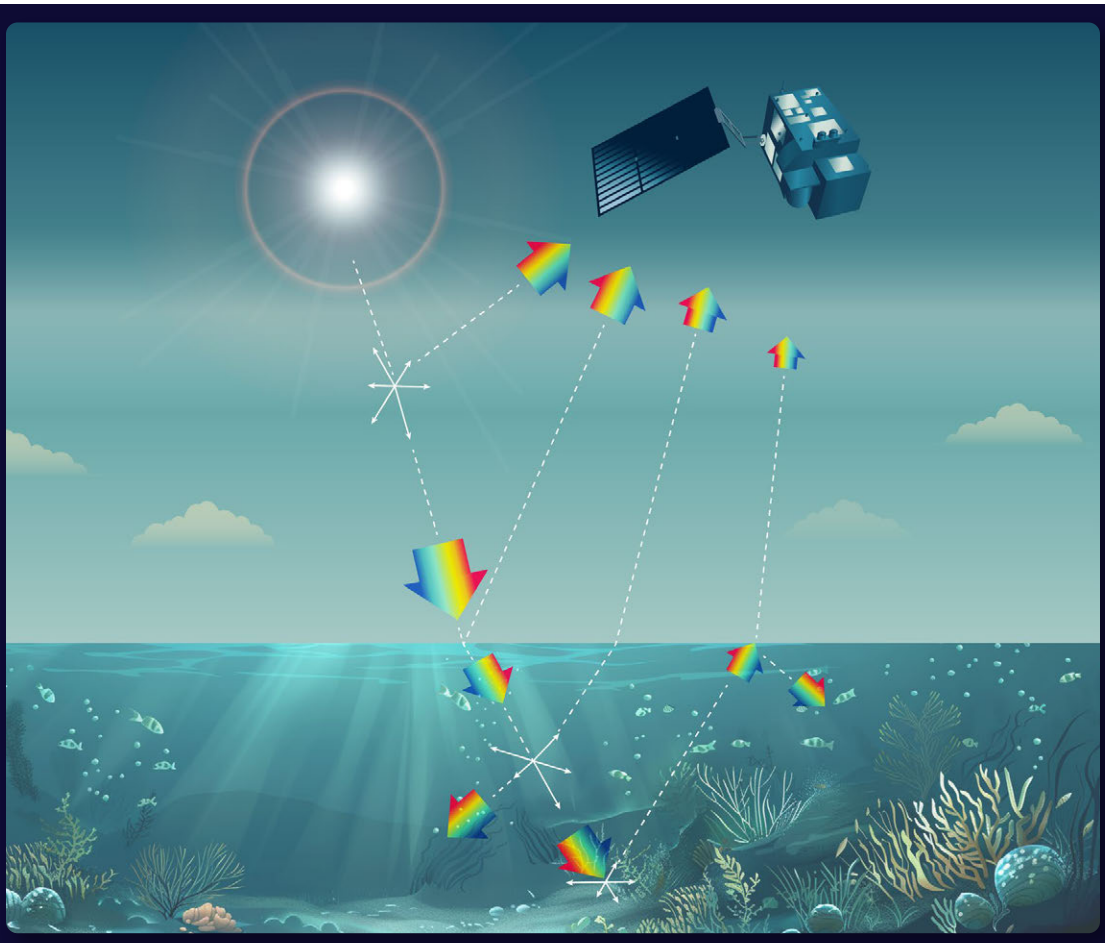
Range - Validation - Accuracy:
The validation of the water extent mainly occurs by directly comparing the true colour satellite imagery to the output product. From a spectral perspective, land and water have very different spectral properties (water: low reflectance, land: high reflectance), therefore it can differentiated successfully in almost any case.

Deep Dive - Methodology

Multispectral satellite sensors are capable of measuring water constituents using sunlight, as it penetrates the atmosphere and waterbody. This light is absorbed and scattered as a function of the particles and dissolved materials in the waterbody. The **reflected light spectrum** detected by the satellite sensors can be used to analyse the optically active water constituents, directly related to relevant water quality parameters such as turbidity and suspended matter, phyto-plankton and its main pigment Chlorophyll, detritus and dissolved colored organic matter. With the knowledge of their optical characteristics it is possible to retrieve quantitative values of the concentrations for these water constituents, solely based on the reflectance of light measured by satellite sensors.

In other words:
The water colour is used to derive water quality information.
However, the satellite signal is strongly modified by a number of further very variable impacts. These originate from varying atmospheric aerosols, water surface reflections, scattered light from adjacent land areas, and the observation geometry. The most accurate correction of all these impacts is thus a fundamental requirement of the satellite data analysis.

The final water quality products of EOMAP are generated within a **fully physics-based retrieval** approach, using the Modular Inversion and Processing System MIP. Such approaches are capable to provide harmonized, globally comparable products due to their relation to the absorption and scattering properties of water constituents. This concept ensures the long-term continuity of EOMAP's water quality data: Products related to physical units are in principle not restricted, neither to specific algorithms nor to dedicated production software.



Satellite Data Sources

The main data sources are either non-commercial data from Copernicus missions such as Sentinel-2A/B and Sentinel-3 A/B as well as Landsat missions 5-9, provided by NASA/USGS, which date back until 1984. In addition, Sentinel-1 is used to overcome gaps of passive optical sensors due to cloud coverage for the generation of water extent.

Satellite / Sensor	Spatial resolution	Temporal resolution	Start and end date	Application range
Landsat 5	30m	16 days	1984 – 2012	Finished satellite missions, but data can be used from archive since 1984
Landsat 7	30m	16 days	1999 – now	Reservoirs and rivers with up to weekly coverage
Landsat 8	30m	16 days	2013 – now	Reservoirs and rivers with up to weekly coverage
Landsat 9	30m	16 days	2021-now	Reservoirs and rivers with up to weekly coverage
Sentinel-2 A/B	10m	5 days	2015/2018 – now	Reservoirs and rivers with weekly coverage
Sentinel-3 A/B	300m	daily	2016/2018 – now	Large-scale, high temporal observations
MODIS Aqua/Terra	250m	daily	1999/2002 – now	Can be used for large-scale, high temporal observations
VIIRS (NOAA-20/21, SUOMI-NPP)	750m	daily	2011-now	Can be used for large-scale, high temporal scale observations
MERIS	300m	2-3 days	2002 – 2012	Instrument aboard Envisat-1, operational from 2002-2012
EnMap	30m	27 days	2022 -now	Hyperspectral satellite (228 spectral bands), high potential for specialized vegetation/algae mapping
PRISMA	30m	29 days	2019 -now	Hyperspectral satellite (237 spectral bands) , high potential for specialized vegetation/algae mapping

Overview on mainly used public satellite data with temporal and spatial specifications

For specific events and applications, also very high resolution satellite data from commercial service providers are used, yet come with additional data costs.

Satellite / Sensor	Spatial resolution	Temporal resolution	Start and end date	Application range
Planet Superdoves	3m	daily	2019-now	Small water bodies, lakes and rivers, hotspots
Maxar WorldView-2/3	2m	upon request	2009/2014	Commercially available, can be tasked over area of interest in a certain time window
Pleiades Neo 3,4	1.2m	upon request	2021-now	Hotspot analysis
Planet SkySAT	1m	up to daily/ upon request		Commercially available, can be tasked over area of interest in a certain time window. Mainly used for visual / true colour observations due to low number of spectral bands (4)
SPOT 6	6m	upon request	2012-now	Hotspot analysis
RapidEye 1-5	5m	upon request	2009-2020	Retrospective hotspot analysis

Overview of mainly used commercial satellite data with temporal and spatial specifications

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