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1 Introduction

Freshwater ecosystems are some of the most important ecosystems on the planet, providing a range of ecosystem services to humans, including clean water, food, and recreation. They are also home to a vast array of biodiversity, including many species that are found nowhere else on earth. Unfortunately, freshwater ecosystems are under threat from a range of human activities, including pollution, habitat destruction, and climate change. Current biodiversity policies and strategies as well as assessments of progress towards set targets, point out that there has been a general failure to halt the negative trend of biodiversity loss and that different approaches are needed to reverse the situation. This includes revision of targets and the indicators that inform the targets and a greater emphasis on the links between biodiversity, ecosystems and their services and people.

The European Space Agency (ESA) activity called Biodiversity+ Precursors is a contribution to the joint EC-ESA Earth System Science Initiative launched in February 2020 to jointly advance Earth System Science and its response to the global challenges that society is facing. The ESA Biodiversity+ Precursors include four projects on different themes and BIOMONDO is the freshwater project, and has a focus on biodiversity in lakes, wetlands, rivers, and streams.

BIOMONDO aims to improve our understanding of freshwater biodiversity around the world and to support freshwater biodiversity monitoring through development of solutions that integrate EO data and state-of-the-art biodiversity modelling using advanced data science and information and communications technology. Three BIOMONDO Pilots have been developed and will demonstrate how novel Earth Observation and Biodiversity modelling products can be integrated to enhance scientific understanding and support decision systems for biodiversity monitoring addressing policy priorities such as the EU Biodiversity Strategy for 2030.

To develop a broad outlook on ongoing changes in freshwater biodiversity and how these changes can be monitored using EO data, our three BIOMONDO pilots each address pilot objectives and knowledge gaps corresponding to one of the following three drivers of global environmental change in freshwater ecosystems: ‘pollution and nutrient enrichment’ (Pilot 1 - Eutrophication), ‘climate change’ (Pilot 2 – Heat Tolerance of Fish), and ‘habitat change’ (Pilot 3 – River Connectivity). The resulting combination of data from Earth Observation, in-situ measurements and model outputs is made available to the scientific and policy community through the BIOMONDO Freshwater Biodiversity Laboratory.

2 Scope of this document

Within the BIOMONDO project Experimental Datasets have been generated covering significant spatial coverages and suitable time frames as demonstrations of the scalability and potential operationalisation of biodiversity monitoring of freshwater ecosystems. The Experimental Datasets contain all the output products (i.e., EO products and model outputs) of the three BIOMONDO pilot sites and are the results of the practical work performed in the BIOMONDO project.
This document provides information about the characteristics and properties of the dataset, such as its format, spatial and temporal resolution. This information helps the users to understand how to use the datasets and can inform decisions about how to integrate the dataset into their own analyses or models.
Furthermore, the experimental dataset descriptions help users to assess the suitability of a dataset for their specific needs. It provides important context for interpreting the results of analyses or models that use the dataset.
Finally, the BIOMONDO Freshwater Laboratory is described and demonstrated how to access and investigate the Experimental Datasets.

Table 1 shows the reference documents where additional information can be accessed for the description of the algorithms, their validation and how to access the described experimental datasets.

Table 1 References of related documents

Document	Version	Short description
Development Database	D2.1 v.2.1	A detailed structure of all input datasets and how to access them.
Algorithm Theoretical Baseline Document	D2.2 v2.1	A detailed specification of the final versions of the algorithms/models.
Product Validation Report	D2.3 v2.0	A detailed specification of the validation methods, metrics and description of the reference data.

3 Experimental Dataset Description

3.1 Lake Balaton

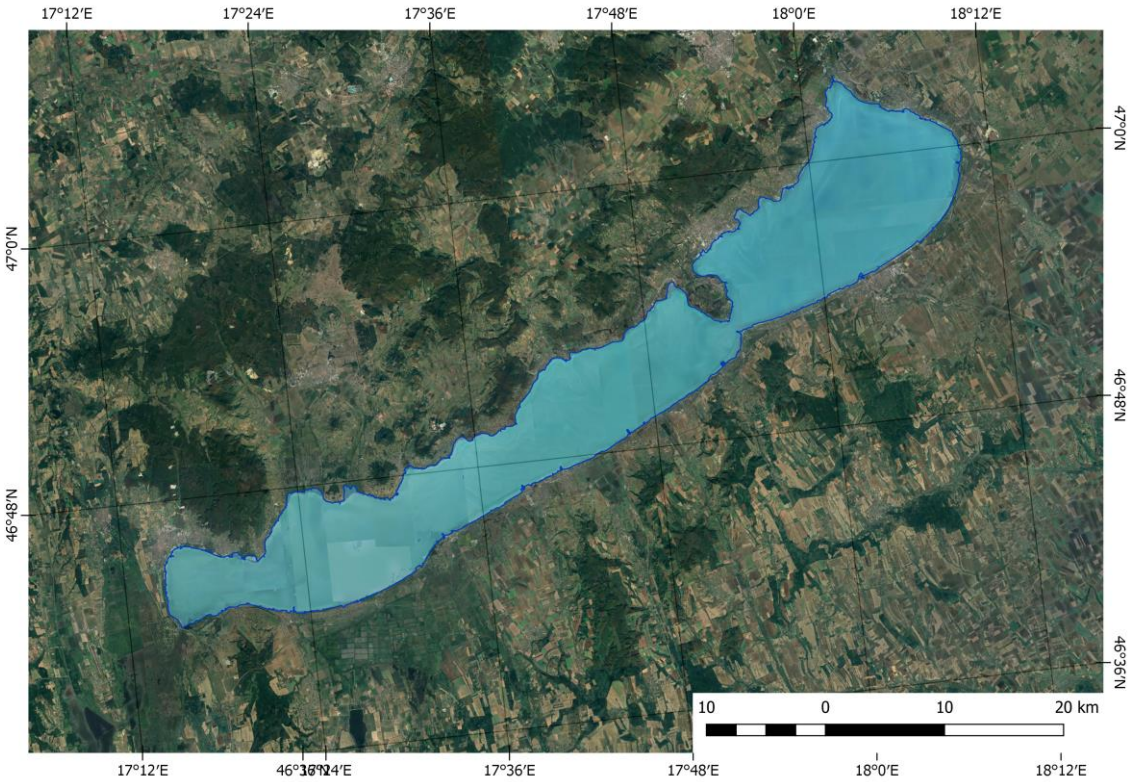

Figure 1: Pilot Site Lake Balaton

Lake Balaton is a large freshwater lake located in western Hungary and is one of the country's most popular tourist destinations. The lake stretches for over 50 kilometers and is up to 12 kilometers wide, with a maximum depth of 12 meters. Lake Balaton plays an important role in the region's ecosystem and has been the subject of extensive scientific research. The lake is characterized by its high alkalinity, high calcium and magnesium levels, and relatively low nutrient concentrations. These properties contribute to the lake's distinctive food web and biodiversity, with a diverse range of plant and animal species found in and around the lake.

Lake Balaton is used as a pilot site in the BIOMONDO Pilot 2 and the dataset parameters are shown in Table 2. The dataset contains the calculated warming tolerance of existing species in Lake Balaton and the lake surface water temperature. More information about the calculation of the warming tolerance and the lake surface water temperature can be found in the reference documents in Table 1. As well as information about the validation of the lake surface water temperature.

Table 2: Dataset description of the dataset Balaton Warming Tolerance

Variable Name	Temporal Extent	Spatial Extent
Warming Tolerance Abramis brama	1999-09-01, 2020-09-01	(17.24583, 46.71250, 18.15416, 47.04583)
Warming Tolerance Alburnus alburnus		
Warming Tolerance Ameiurus melas		
Warming Tolerance Anguilla anguilla		
Warming Tolerance Ballerus ballerus		
Warming Tolerance Barbus barbus		
Warming Tolerance Blicca bjoerkna		
Warming Tolerance Carassius carassius		
Warming Tolerance Carassius gibelio		
Warming Tolerance Ctenopharyngodon idella		
Warming Tolerance Cyprinus carpio		
Warming Tolerance Esox lucius		
Warming Tolerance Gymnocephalus cernua		
Warming Tolerance Lepomis gibbosus		
Warming Tolerance Leuciscus idus		
Warming Tolerance Lota lota		
Warming Tolerance Neogobius fluviatilis		
Warming Tolerance Pelecus cultratus		
Warming Tolerance Perca fluviatilis		
Warming Tolerance Proterorhinus semilunaris		
Warming Tolerance Pseudorasbora parva		
Warming Tolerance Rhodeus sericeus		
Warming Tolerance Romanogobio vladykovi		
Warming Tolerance Rutilus rutilus		
Warming Tolerance Salmo trutta		
Warming Tolerance Sander lucioperca		
Warming Tolerance Sander volgensis		
Warming Tolerance Scardinius erythrophthal-mus		
Warming Tolerance Silurus glanis		
Warming Tolerance Squalius cephalus		
Warming Tolerance Tinca tinca		
Warming Tolerance Umbra krameri		
Lake Surface Water Temperature		

3.2 Lake Mälaren

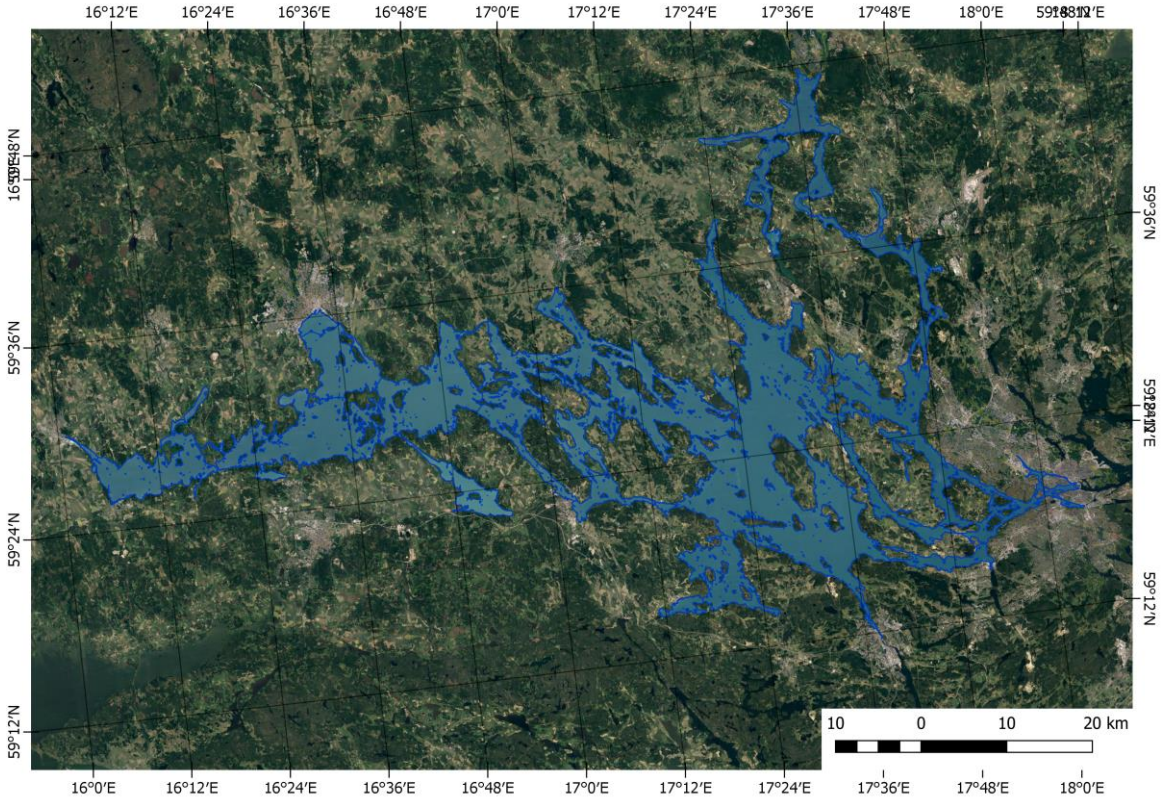

Figure 2: Pilot Site Lake Mälaren

Lake Mälaren is a large freshwater lake located in central Sweden and is an important resource for the region's water supply, transportation, and recreation. The lake is over 120 kilometers long and up to 64 meters deep and is surrounded by numerous cities and towns that rely on it for drinking water and other uses. As with many freshwater lakes, Lake Mälaren has unique biochemical properties that influence its ecological health and sustainability. The lake is characterized by its relatively high alkalinity, low nutrient concentrations, and complex food web, which supports a diverse range of plant and animal species. However, the lake has also experienced issues with eutrophication, or excess nutrient accumulation, which can lead to harmful algal blooms and other negative impacts on water quality and ecosystem health.

Lake Mälaren is used as a pilot site in the BIOMONDO Pilot 2. The parameters of the Mälaren Warming Tolerance dataset are shown in Table 3. The dataset contains the calculated warming tolerance of existing species in Lake Mälaren and the lake surface water temperature. More information about the calculation of the warming tolerance and the lake surface water temperature can be found in the reference documents in Table 1. As well as information about the validation of the lake surface water temperature.

Table 3: Dataset description of the dataset Mälaren Warming Tolerance

Variable Name	Temporal Extent	Spatial Extent
Warming Tolerance Abramis brama	1999-09-04, 2020-09-01	(16.05416, 59.21250, 18.13749, 59.63749)
Warming Tolerance Alburnus alburnus		
Warming Tolerance Coregonus albula		
Warming Tolerance Gasterosteus aculeatus		
Warming Tolerance Gymnocephalus cernua		
Warming Tolerance Lampetra fluviatilis		
Warming Tolerance Osmerus eperlanus		
Warming Tolerance Perca fluviatilis		
Warming Tolerance Pungitius pungitius		
Warming Tolerance Sander lucioperca		
Lake Surface Water Temperature		

Furthermore, the parameters of the Mälaren Biological dataset are shown in Table 4. The dataset is based on the CyanoAlert EU project, a collaborative effort between several European institutions and organizations aimed at developing an early warning system for harmful algal blooms (HABs) in freshwater bodies. HABs, which are caused by certain types of cyanobacteria, can produce toxins that can be harmful to human health and the environment. The CyanoAlert project addressed this issue by developing a monitoring system that can detect the presence and growth of cyanobacteria in freshwater bodies, and provide real-time information to water managers and other stakeholders. The CyanoAlert project was funded by the European Union's Horizon 2020 program and contributed to improved water quality and ecosystem health across Europe. The dataset used in BIOMONDO contains EO retrieved biological water quality parameters (CyanoAlert project, Schaeffer et al. 2022, Matthews et al. 2015).

Table 4: Dataset description of the dataset Mälaren Biological

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a Concentration	2016-06-01, 2022-09-30	(16.05416, 59.21250, 18.13749, 59.63749)
Cyanobacteria Abundance		

The Copernicus Riparian Zone dataset is a product of the European Union's Copernicus program, which provides open-access Earth observation data and services for environmental monitoring and management. The dataset provides information on the location, extent, and characteristics of riparian zones - the areas of land adjacent to rivers and other water bodies. Specifically, the dataset includes information on land cover and land use, vegetation indices, and water-related variables such as water bodies, wetlands, and floods. This information can be used for a range of applications, including water resource management, land use planning, and biodiversity conservation (Copernicus Ri-

parian Zones). The dataset parameters of the Mälaren Riparian Zones dataset are shown in Table 5.

Table 5: Dataset description of the dataset Mälaren Riparian Zones

Variable Name	Temporal Extent	Spatial Extent
Riparian Zone Class	2012 and 2018	(16.05416, 59.21250, 18.13749, 59.63749)

3.3 Markermeer-IJsselmeer

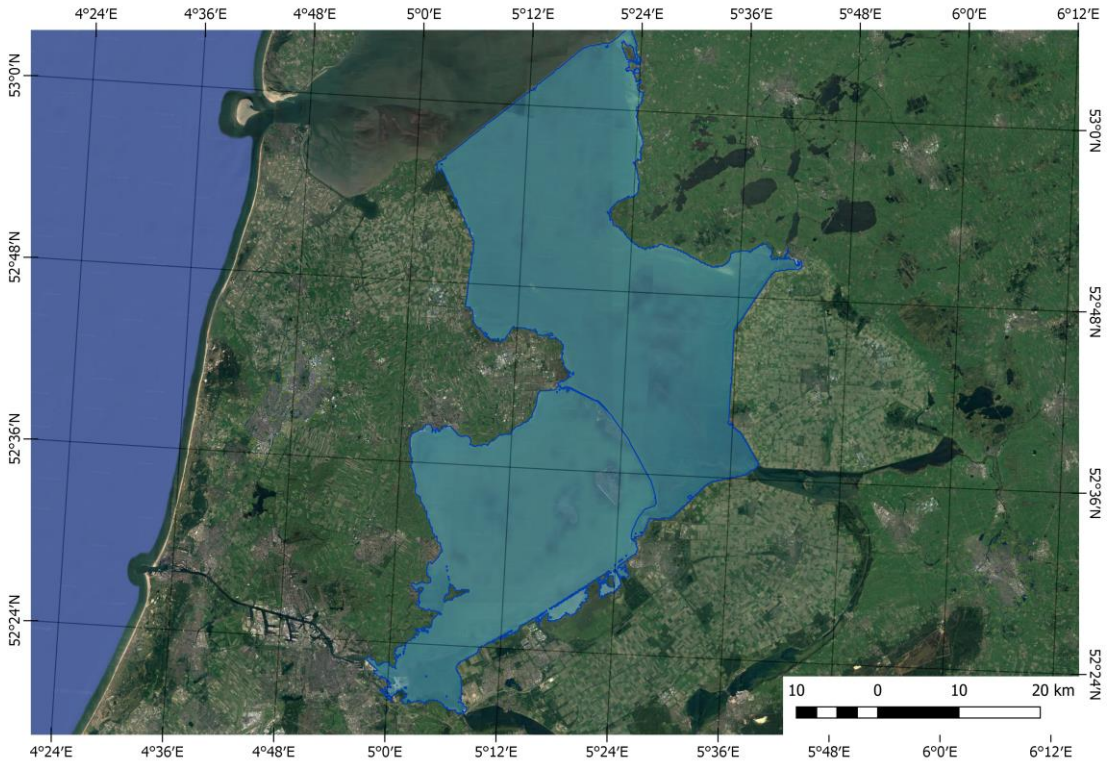

Figure 3: Pilot Site Markermeer-IJsselmeer

Markermeer-IJsselmeer is a large freshwater system located in the Netherlands, and is an important resource for the region's water supply, transportation, and recreation. The system is composed of two interconnected lakes, Markermeer and IJsselmeer, which are separated by a dike. As with many freshwater lakes, the Markermeer-IJsselmeer system has unique biochemical properties that influence its ecological health and sustainability. The lakes are characterized by relatively high turbidity, high nutrient concentrations, and a complex food web that supports a diverse range of plant and animal species. While Markermeer and IJsselmeer share many similarities in terms of their physical and chem-

ical properties, there are some notable biological differences between them. One key difference is in the composition of the plankton community. Markermeer has been shown to have a higher abundance of small-sized phytoplankton compared to IJsselmeer, which tends to have a higher proportion of larger phytoplankton species.

The Markermeer is used as a pilot site in the BIOMONDO Pilot 1 and Pilot 2. The parameters of the Markermeer Delft3D Biological dataset are shown in Table 6. Delft3D is a numerical modelling framework for simulating a wide range of physical processes in aquatic environments, including coastal and estuarine hydrodynamics, sediment transport, and morphodynamics (Delft3D Model). The same variables apply to a second dataset called Delft3D Biological RS forced where the output of the model was produced with EO LSWT as input dataset. More information about the Delft3D model can be found in the reference documents in Table 1. As well as information about the validation of the model output parameters.

Table 6: Dataset description of the dataset Markermeer Delft3D Biological and Delft3D Biological RS forced

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration (mg/m3)	2016-01-01, 2016-12-25	(4.6106, 52.2262, 5.93319, 53.09416)
Total extinction coefficient visible light (1/m)		
Total net primary production (gC/m2/d)		
Freshwater Diatoms (gC/m3)		
Freshwater flagellates (gC/m3)		
Green algae (gC/m3)		
Anabaena (gC/m3)		
N-fixing Aphanizomenon (gC/m3)		
Oscillatoria (gC/m3)		
Microcystis (gC/m3)		

The parameters of the Markermeer-IJsselmeer Warming Tolerance dataset are shown in Table 7. The dataset contains the calculated warming tolerance of existing species in the Markermeer and the lake surface water temperature. More information about the calculation of the warming tolerance and the lake surface water temperature can be found in the reference documents in Table 1. As well as information about the validation of the lake surface water temperature.

Table 7: Dataset description of the dataset Markermeer-IJsselmeer Warming Tolerance

Variable Name	Temporal Extent	Spatial Extent
Warming Tolerance Abramis brama	1999-09-10, 2020- 08-29	(4.97916, 52.32916, 5.69583, 53.05416)
Warming Tolerance Alburnus alburnus		
Warming Tolerance Blicca bjoerkna		
Warming Tolerance Carassius gibelio		
Warming Tolerance Chelon labrosus		

Warming Tolerance Chelon ramada		
Warming Tolerance Cobitis taenia		
Warming Tolerance Cottus perifretum		
Warming Tolerance Cyprinus carpio		
Warming Tolerance Esox lucius		
Warming Tolerance Gasterosteus aculeatus		
Warming Tolerance Gobio gobio		
Warming Tolerance Gymnocephalus cernua		
Warming Tolerance Leucaspius delineatus		
Warming Tolerance Leuciscus idus		
Warming Tolerance Neogobius fluviatilis		
Warming Tolerance Neogobius melanostomus		
Warming Tolerance Osmerus eperlanus		
Warming Tolerance Perca fluviatilis		
Warming Tolerance Platichthys flesus		
Warming Tolerance Ponticola kessleri		
Warming Tolerance Proterorhinus semilunaris		
Warming Tolerance Pungitius pungitius		
Warming Tolerance Rhodeus amarus		
Warming Tolerance Rutilus rutilus		
Warming Tolerance Sander lucioperca		
Warming Tolerance Scardinius erythrophthal-mus		
Warming Tolerance Tinca tinca		
Lake Surface Water Temperature		

The CCI Lakes dataset is a global dataset of inland water quality parameters, developed by the European Space Agency's Climate Change Initiative (CCI) program. The dataset provides information on several key water quality parameters, including chlorophyll-a concentration, lake surface water temperature and turbidity, for over 2000 lakes worldwide. The CCI Lakes dataset is designed to be used by researchers, policymakers, and water resource managers for a variety of applications, including monitoring and managing water quality, assessing the impacts of climate change on inland waters, and understanding the role of lakes in the global carbon cycle (ESA Climate Change Initiative Lakes).

The parameters of the Markermeer-Ijsselmeer ESA CCI Lakes geophysical dataset are shown in Table 8 representing a subset of the available CCI Lakes dataset parameters. For the BIOMONDO project only the relevant geophysical parameters were selected.

Table 8: Dataset description of the dataset Markermeer-Ijsselmeer ESA CCI Lakes geophysical

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration	1992-09-27, 2020-12-24	(4.61063, 52.22623, 5.93319, 53.09416)
Relative uncertainty in Chlorophyll-a concentration		
Lake Ice Cover		
Relative uncertainty in Lake Ice Cover		
Lake Water Extent		
Relative uncertainty in Lake Water Extent		
Lake Surface Water Temperature		
LSWT Quality Level		
Relative uncertainty in LSWT		
Turbidity		
Relative uncertainty in Turbidity		

The Copernicus Land Cover dataset is a European-wide initiative to produce detailed and accurate land cover maps of the entire continent. The project is part of the European Union's Copernicus program, which is aimed at providing Earth observation data for a wide range of environmental and societal applications.

The dataset provides information on land cover types, including forests, grasslands, wetlands, croplands, and urban areas (Copernicus Global Land Service – Land Cover, Buchholz et al. 2020).

The parameters of the Markermeer-Ijsselmeer ESA CCI Land Cover dataset are shown in Table 9.

Table 9: Dataset description of the dataset Markermeer-Ijsselmeer ESA CCI Land Cover

Variable Name	Temporal Extend	Spatial Extend
Land Cover Class	2015, 2016, 2017, 2018 and 2019	(4.606, 52.222, 5.935, 53.098)

3.4 Mekong Basin

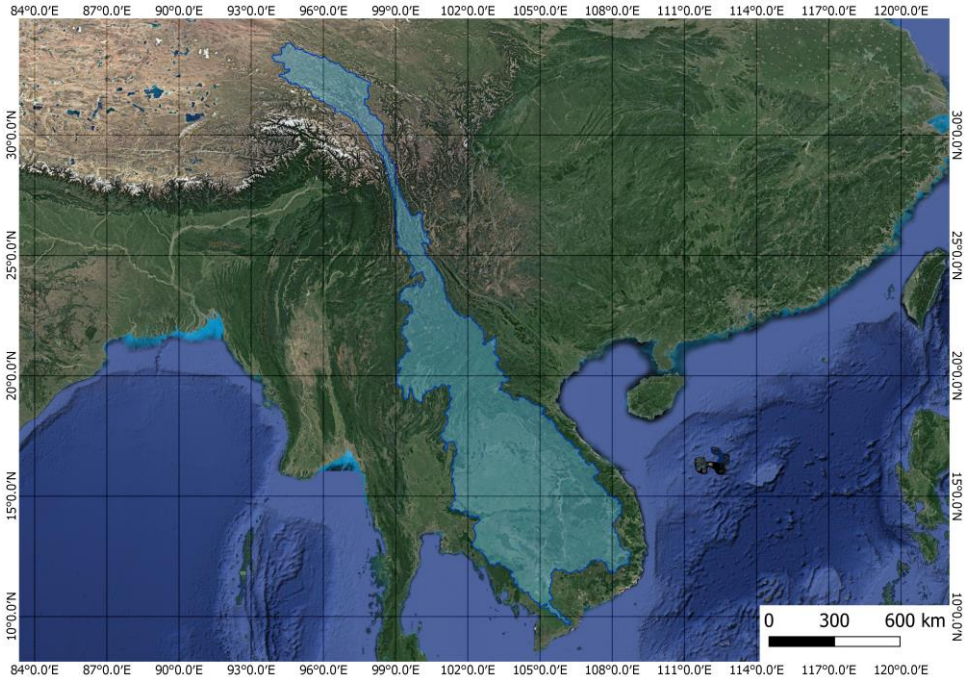

Figure 4: Pilot Site Mekong Basin

The Mekong Basin is a large river system that flows through six countries in Southeast Asia: China, Myanmar, Thailand, Laos, Cambodia, and Vietnam. The basin is home to one of the most diverse freshwater ecosystems in the world, with over 1,300 fish species, many of which are found nowhere else on Earth. The Mekong Basin is also home to a variety of other aquatic species, including amphibians, reptiles, crustaceans, and molluscs.

The freshwater biodiversity of the Mekong Basin is of great importance for several reasons. First, many of the fish species in the basin are an important source of food and livelihoods for local communities and play a critical role in the region's food security. Second, the basin's freshwater ecosystems provide a wide range of ecosystem services, such as water purification, flood control, and nutrient cycling, that are essential for the region's ecological and economic well-being. Finally, the Mekong Basin's freshwater biodiversity is of global importance, as many of the species found in the basin are rare and endangered and are therefore of significant conservation value.

Despite its importance, the freshwater biodiversity of the Mekong Basin is under threat from a range of human activities, including hydropower development, overfishing, pollution, and habitat destruction. Conservation efforts are therefore needed to protect the basin's unique and valuable aquatic ecosystems, and to ensure that they continue to provide benefits to both local communities and the wider world.

The Mekong Basin is used as a pilot site in the BIOMONDO Pilot 3 and several datasets were used to study this site.

The Copernicus Land Cover dataset is a European-wide initiative to produce detailed and accurate land cover maps of the entire continent. The project is part of the European Union's Copernicus program, which is aimed at providing Earth observation data for a wide range of environmental and societal applications.

The dataset provides information on land cover types, including forests, grasslands, wetlands, croplands, and urban areas (Copernicus Global Land Service – Land Cover, Buchholz et al. 2020). The parameters of the Mekong Land Cover dataset are shown in Table 10.

Table 10: Dataset description of the dataset Mekong ESA CCI Land Cover

Variable Name	Temporal Extent	Spatial Extent
Land Cover Class	2015, 2016, 2017, 2018 and 2019	(100.0004, 0.0004, 120.0004,20.0004)

The SERVIR-Mekong Land Cover in Cambodia dataset is a high-resolution land cover map of Cambodia, developed as part of the SERVIR-Mekong program, a joint initiative of the United States Agency for International Development (USAID) and the National Aeronautics and Space Administration (NASA). The dataset provides information on land cover types, such as forests, agricultural land, wetlands, and urban areas, at a spatial resolution of 30 meters (SEVIR Mekong – Land Cover). The parameters of the Mekong Cambodia Land Cover dataset are shown in Table 11 and were selected to get a better understanding of the land cover change of earlier year. This expands the Copernicus Global Land dataset with earlier years at least for Cambodia.

Table 11: Dataset description of the dataset Mekong Cambodia Land Cover

Variable Name	Temporal Extent	Spatial Extent
Land Cover Class	2012, 2013, 2014, 2015 and 2016	(102.3, 10.34, 107.7, 14.71)

The JRC Global Surface Water dataset is a global map of water bodies, including rivers, lakes, and reservoirs, created using a spatial resolution of 30 meters. It provides information on the location, extent, and temporal dynamics of water bodies, including changes in water extent over time. The dataset has a wide range of applications, including water resource management, flood forecasting, and biodiversity conservation. It has been used in a variety of studies, including assessments of global surface water changes, mapping of wetlands and other important water habitats, and analyses of the impacts of climate change on water resources (JRC Global Surface Water, Pekel et al. 2016).

The parameters of the Mekong Global Surface Water dataset are shown in Table 12 and are only available for one year. The dataset includes only the Mekong Basin as a subset of the global dataset.

Table 12: Dataset description of the dataset Mekong Global Surface Water

Variable Name	Temporal Extent	Spatial Extent
Water Occurrence	1984-2021	(93.8581, 10.0001, 108.7753, 29.9998)
Water Occurrence Change	2021	
Water Seasonality	2021	

3.4.1 Dams

Dams can have both positive and negative impacts on biodiversity, depending on their design, location, and management. In some cases, dams can be beneficial for biodiversity by creating new aquatic habitats, such as reservoirs, and regulating water flow in rivers. These habitats can support a variety of aquatic species, including fish, amphibians, and invertebrates. However, dams can also have negative impacts on biodiversity. They can block the migration of fish species, preventing them from reaching their spawning grounds, and can alter the flow and temperature of rivers, negatively affecting aquatic ecosystems.

Four dams were selected to support the BIOMONDO Pilot 3 and EO water quality parameters were processed for the surrounding area of the dams. Table 13 shows the selected dams and their properties.

Table 13: Selection of Dams for Pilot 3

Dam	**Operating since**	**Height**	**River**	***country***
Xe Kaman 1	Dec. 2017	120m	Xe Kaman	Laos
Lower Se San 2	Dec. 2018	75m	Se San	Cambodia
Xe-Pian,Xe-Namnoy	Dec. 2019	74m	Sekong	Laos
Nam Giep 1	Sep. 2019	167m	Ngiep	Laos

The C2RCC (Case 2 Regional Coast Colour) processor is used for the atmospheric correction and retrieval of water quality parameters from Sentinel-2 satellite imagery. It is specifically designed for processing imagery of coastal and inland water bodies, where the water is not perfectly clear and contains a variety of constituents, such as dissolved organic matter, suspended sediments, and phytoplankton. The processor uses a physics-based approach to estimate the water leaving radiance from the satellite image, and then applies a series of algorithms to retrieve the concentrations of different water quality parameters, such as chlorophyll-a, suspended matter, and colored dissolved organic matter. The processor is based on a radiative transfer model that simulates the interaction of light with water and other constituents and is calibrated using in situ measurements of water quality parameters (Brockmann et al. 2016, Doerffer et al. 2007, Wernand et al. 2020). Additionally, the watercolor is calculated based on the C2RCC water-leaving reflectance with the Forel Ule algorithm. More information about the algorithm

of the watercolor can be found in the reference documents in Table 1. As well as information about the validation of the water quality parameters.

The Lower Se San 2 hydropower dam is located on the Se San River in Cambodia. It has a capacity of 400 MW and provides electricity to Cambodia's national grid. The dam has been controversial due to its impacts on local communities and the biodiversity, including displacement of communities and impacts on fish populations. The parameters of the Mekong-Lower Se San 2 EO Water Quality dataset are shown in Table 14.

Table 14: Dataset description of the dataset Mekong-Lower Se San 2 EO Water Quality

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration	2016-01-07, 2021-12-31	(106.02326, 13.36067, 106.56979, 13.67005)
Watercolor		
Secci Depth		
Turbidity		
Number of Observations		
Top-of-Atmosphere B2 (RGB)		
Top-of-Atmosphere B3 (RGB)		
Top-of-Atmosphere B4 (RGB)		

Nam Giep 1 is a hydropower dam located on the Nam Giep River in Laos. It has a capacity of 290 MW and provides electricity to the national grid of Laos and Thailand. Like the Lower Se San 2 the dam has been controversial due to its impacts on the biodiversity. The parameters of the Mekong-Lower Se San 2 EO Water Quality dataset are shown in Table 15.

Table 15: Dataset description of the dataset Mekong-Nam Giep 1 EO Water Quality

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration	2016-01-03, 2021-12-31	(103.3471, 18.5581, 103.6323, 18.7877)
Watercolor		
Secci Depth		
Turbidity		
Number of Observations		
Top-of-Atmosphere B2 (RGB)		
Top-of-Atmosphere B3 (RGB)		
Top-of-Atmosphere B4 (RGB)		

The Xe Pian Xe Namnoy dam is a hydropower project located in southern Laos that was under construction when a catastrophic failure of a saddle dam occurred in July 2018. The failure resulted in severe flooding that killed dozens of people and displaced thou-

sands, and caused widespread environmental damage. The parameters of the Mekong-Lower Se San 2 EO Water Quality dataset are shown in Table 16.

Table 16: Dataset description of the dataset Mekong-Xe Pian Xe Namnoy EO Water Quality

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration	2016-01-17, 2021-12-31	(106.4673, 14.8353, 106.7023, 15.1096)
Watercolor		
Secci Depth		
Turbidity		
Number of Observations		
Top-of-Atmosphere B2 (RGB)		
Top-of-Atmosphere B3 (RGB)		
Top-of-Atmosphere B4 (RGB)		

Xekaman 1 is a hydropower dam located on the Xekaman River in Laos. It has a capacity of 322 MW and provides electricity to the national grid of Laos and Vietnam. The dam is part of a larger plan to develop a cascade of dams along the Xekaman River, which has raised concerns about cumulative impacts on the river and its ecosystems. The parameters of the Mekong-Lower Se San 2 EO Water Quality dataset are shown in Table 17.

Table 17: Dataset description of the dataset Mekong-Xekaman 1 EO Water Quality

Variable Name	Temporal Extent	Spatial Extent
Chlorophyll-a concentration	2016-01-04, 2021-12-31	(107.0392, 14.8639, 107.3410, 15.1727)
Watercolor		
Secci Depth		
Turbidity		
Number of Observations		
Top-of-Atmosphere B2 (RGB)		
Top-of-Atmosphere B3 (RGB)		
Top-of-Atmosphere B4 (RGB)		

Barbarossa et al. (2020) river connectivity model aims to simulate and visualize the connectivity of river networks, which is important for understanding the movement of aquatic species, the dispersal of nutrients and sediment, and the spread of contaminants. The model calculates metrics of river connectivity, such as the distance between habitat patches, the strength of hydrological connections, and the presence of barriers to movement. More information about the River Connectivity model can be found in the reference documents in Table 1. The parameters of the Mekong-Lower Se San 2 EO Water Quality dataset are shown in Table 18.

Table 18: Dataset description of the dataset Mekong-River Connectivity

Variable Name	Temporal Extent	Spatial Extent
Name	None	124 dams in the Mekong Basin
Status		
Head		
Design Q		
Drainage Area		
Mean Q		
Installed Capacity		
Mean Annual Generation		
Cost		
Full Supply Level		
Low Supply Level		
Live Storage		
Gross Storage		
Reservoir Surface Area		
Dam Height		
Reference Year		
Commercial Operation Date		
CI_PR_all basin average Connectivity Index Post Removal of this dam considering all fish species		
ChangeCIall change in basin average Connectivity Index Post Removal of this dam considering all fish species		
CI_PR_diad basin average Connectivity Index Post Removal of this dam considering diadromous fish species		
ChangeCIdiad change in basin average Connectivity Index Post Removal of this dam considering diadromous fish species		
CI_PR_nondiad basin average Connectivity Index Post Removal of this dam considering non-diadromous fish species		
ChangeCInondiad change in basin average Connectivity Index Post Removal of this dam considering non-diadromous fish species		

4 BIOMONDO Freshwater Laboratory

The BIOMONDO Freshwater Lab allows the user to combine different information sources to analyse and compare the model output with observations made in-situ or by Earth Observation. The big advantage of the Biodiversity Lab is to compile these different inputs in one place, in a harmonized manner to allow its combination, synergistic analysis and thus to derive novel biodiversity products. The combination of time series of EBV, ecosystem functions and biodiversity drivers, and its analysis by machine learning techniques, allows to identify spots of biodiversity change and associated characterisation for the pilot sites in the Experimental dataset. The central part of the BIOMONDO Freshwater Laboratory is the BIOMONDO Viewer and its functionalities. It is used to access and work with the Experimental Datasets.

4.1 BIOMONDO Viewer

The BIOMONDO Viewer allows users to monitor and analyze the experimental datasets of the freshwater pilot sites. The viewer includes a range of analytical tools for analysing the datasets and is the web app to view data cubes and inspect the multi-dimensional data stored in any cube provided by xcube. Its intuitive usage and the possibility to operate it as a public web service makes xcube viewer the ideal tool for dissemination to expert as well as non-expert users. Figure 5 demonstrates the interface of the BIOMONDO Viewer. The viewer has the following capabilities:

- Browse and search cube datasets and variables
- Browse and search related points and polygons
- Show variable layer in map
- Show timeseries graph for selected point
- Show timeseries graph for selected polygon
- Add point to and delete from map
- Draw polygon in and delete from map
- Connect to any xcube web API server
- Start new xcube Web API server with given cube config

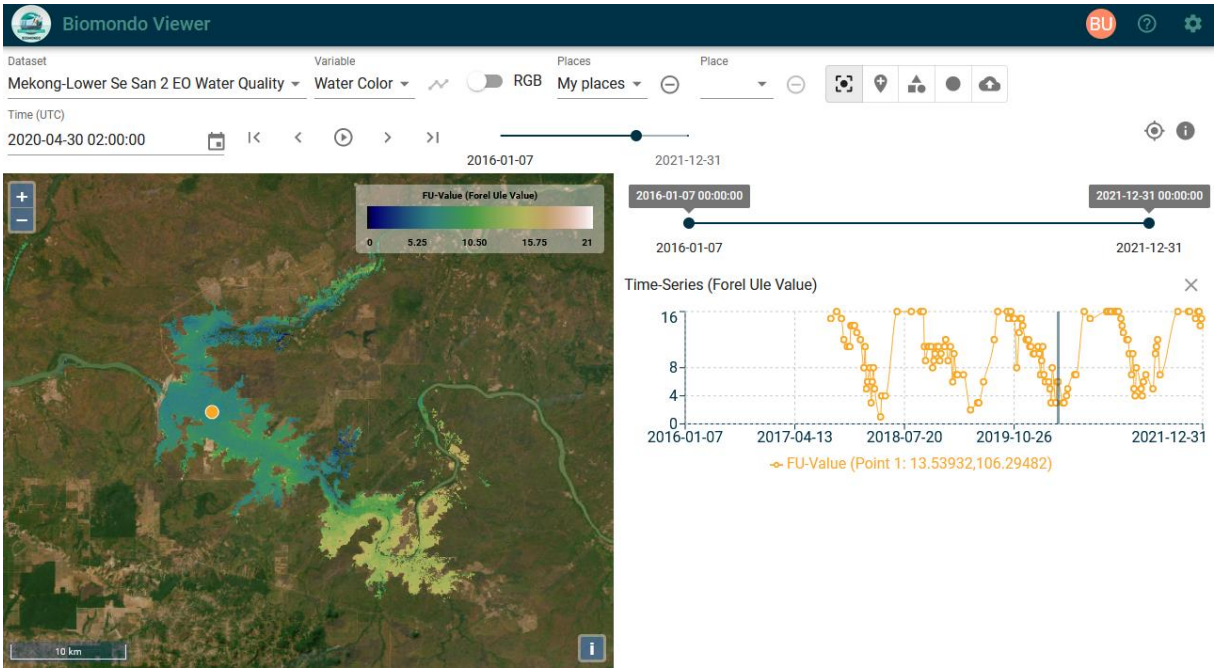

Figure 5 Interface of the BIOMONDO Viewer

To access the experimental dataset and work with them in a python environment each dataset can be accessed with xcube via the python API from the viewer (Figure 6). With xcube the dataset can be further analyzed.

The xcube Python package is a software tool for processing and analyzing Earth observation data. The package is designed to work with the datacube infrastructure, which is a framework for managing and analyzing large amounts of satellite data.

One of the key features of the xcube package is its ability to perform cloud-based processing, which allows users to work with large amounts of data without having to download it to their local machines.

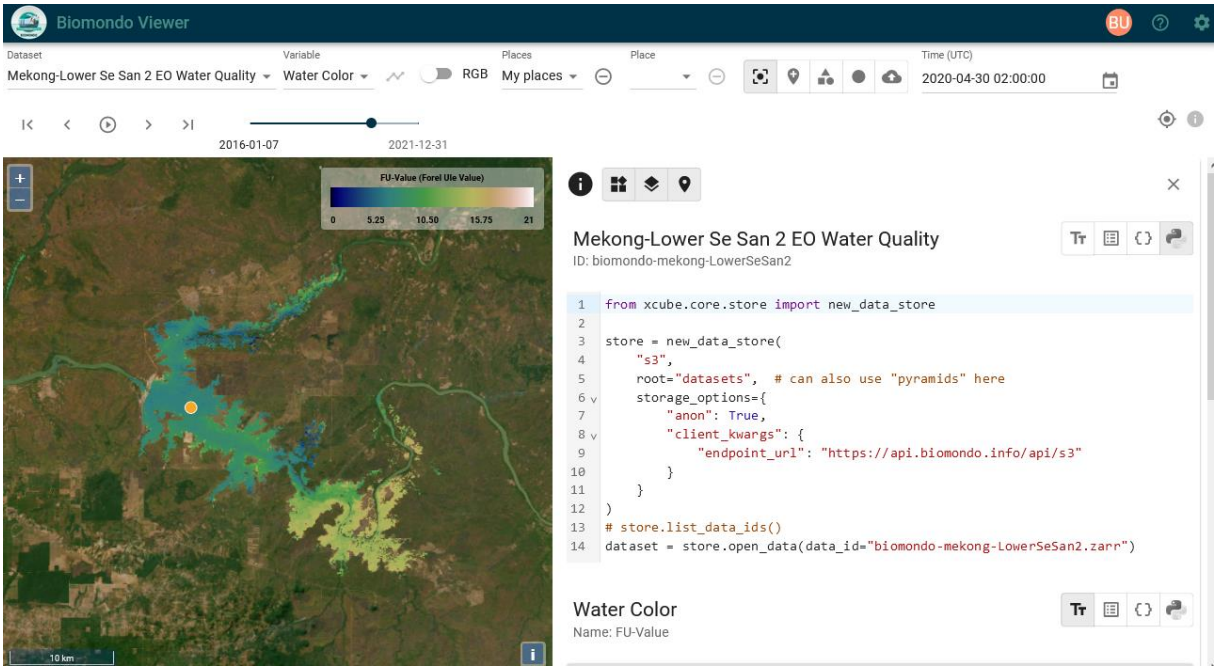

Figure 6 Python API dataset access with xcube

4.2 TECIs

Thematic ecosystem change indices (TECIs) provide information on the extent and intensity of changes in ecosystems. The developed TECIs in BIOMONDO are based on the analysis of various data collected within BIOMONDO, e.g. EO data, models and ground monitoring, and are designed to capture changes in water quality, habitat conditions of fish or land cover that are associated with specific ecosystem processes, including eutrophication or urbanization. TECIs can provide valuable information for understanding the drivers and impacts of ecosystem change, as well as for monitoring progress towards conservation and sustainable development goals. More information about the TECIs and how they are derived can be found in the D2.2 ATBD.

To work with the TECIs a Jupyter Notebook was created to visualize the TECIs from all pilot sites. Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations, and explanatory text. It supports many programming languages, including Python. Figure 7 shows the Jupyter Notebook which is used to retrieve and demonstrate the TECIs within the BIOMONDO project. The Jupyter Notebook is currently not public and will be used internally to calculate and visualize the TECIs. Resulting figures and statistics will be shared with users.

Thematic Ecosystem Change Index

Thematic ecosystem change indices (TECIs) provide information on the extent and in-tensity of changes in ecosystems. The developed TECIs in Blomondo are based on the analysis of various data, e.g. EO data, models and ground monitoring, and are designed to capture changes in water quality, habitat conditions of fish or land cover that are associ-ated with specific ecosystem processes, including eutrophication or urbanization. TECIs can provide valuable information for understanding the drivers and impacts of ecosys-tem change, as well as for monitoring progress towards conservation and sustainable development goals.

This notebook visualizes the TECIs developed in the Blomondo project.

1. Selection of Pilot Site

As a first step, please selet the pilot site.

In [2]:
```
# interactive selection of pilot site to investigate
pilot_site = Dropdown(options = ["Markermeer", "Mälaren", "Mekong Basin"])
waterbodys = Dropdown(options = ["None"])

@interact(Pilot = pilot_site, Waterbody = waterbodys)
def dropdown_waterbody(Pilot, Waterbody):
    waterbodys.options = tecis.select_waterbody(pilot_site.value)
```

Pilot: Mälaren

Waterbody: Granfjärden

2. Selection of TECI and Time Period

As a second step, please selet the season and which TECI should be visualised.

In [4]:
```
teci_list, tecis_df = tecis.select_teci(waterbodys.value)
tecis_dd = Dropdown(options = teci_list)
period_dd = Dropdown()

@interact(TECI = tecis_dd, Period = period_dd)
def dropdown_period(TECI, Period):
    period_dd.options = tecis.select_props()
```

TECI: 8 - Habitat Conditions for Fish

Period: Summer

3. Visualisation of a single TECI

The following barplot shows the TECI score of the selected TECI over the selected season. Higher scores show that anomalies are more often present in this year.

In [5]:
```
tecis.plot_teci(tecis_df, period_dd.value, tecis_dd.value, waterbodys.value)
```

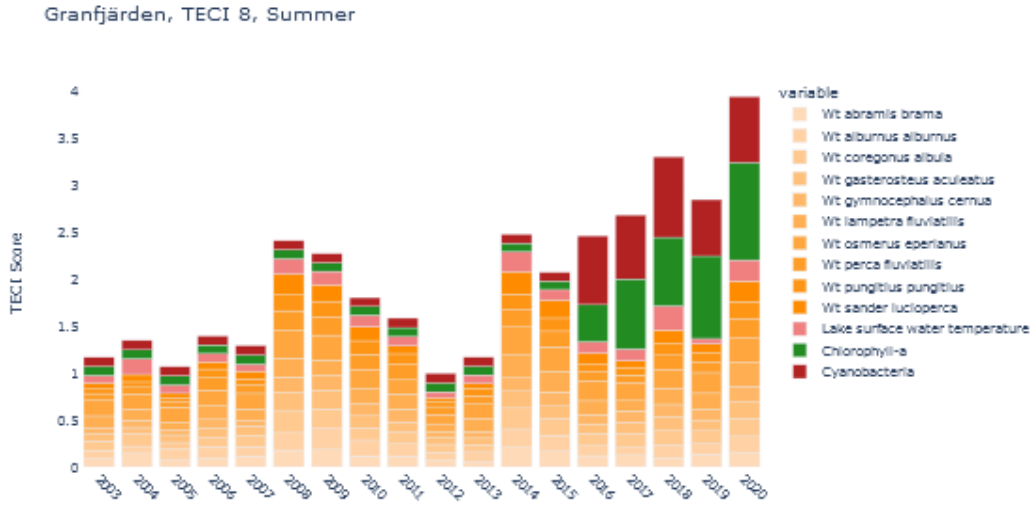

Figure 7 Interface of TECI Jupyter Notebook

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