Blue-Cloud
Piloting innovative services for Marine Research & the Blue Economy

Blue-Cloud
Virtual Labs
in support of
Sustainable
Development
Goals

The Blue-Cloud thematic Virtual Labs (VLabs) are the main test beds for users to get the hang of the Blue-Cloud framework, exploiting the 10+ million datasets available via the Data Discovery and Access Service (DD&AS), as well as the easy access to the collaborative VLabs via D4Science and the EOSC federated login.

These collaborative workspaces hosted in the Blue-Cloud Virtual Research Environment (VRE) are serving more than 1,300 users in total spread across more than 20 countries.

Virtual Labs and applications at a glance

Five Virtual Labs were developed and deployed in the Blue-Cloud pilot project, making use of the analytical tools and generic services as provided through the VRE, and the data repositories, as made accessible via the DD&AS and through external data services.
The Blue-Cloud VLabs are real-life demonstrators for web-based open science and are open and available for testing by different research communities. Each VLab comprises a series of applications for data processing, publishing of data results, and managing computation routines as well as services for collaboration, this way providing open science-friendly working environments for its users to analyse datasets and (re)generate research products.

- **Zoo & Phytoplankton EOV Products**
- **Plankton Genomics**
- **Marine Environmental Indicators**
- **Fish, a matter of scales**
- **Aquaculture Monitor**

12 thematic marine services are included in the VLabs and make extensive use of the Blue-Cloud framework and its rich set of resources. These services illustrate the wide range of subjects that can be addressed using such resources, from genomics to wildlife as well as environmental data coming from multiple disciplines and repositories, and all together demonstrate Blue-Cloud's potential in different fields of marine research, ranging from biodiversity to environmental science, as well as fisheries and aquaculture. In addition to these, this document also features factsheets for the three top teams awarded at the Blue-Cloud Hackathon 2022, providing additional examples of applications for Blue-Cloud assets in the blue economy.

- **Sea Clearly - A tool to assess ocean plastic impacts on and by aquaculture farms**
- **PerfeCt - Performance of Aquaculture under Climate change**
- **Wildlife Tracker for Oceans - MPA assessment with real-time wildlife tracking and ocean monitoring data.**

Discover the many possibilities for Open Science in marine research with Blue-Cloud

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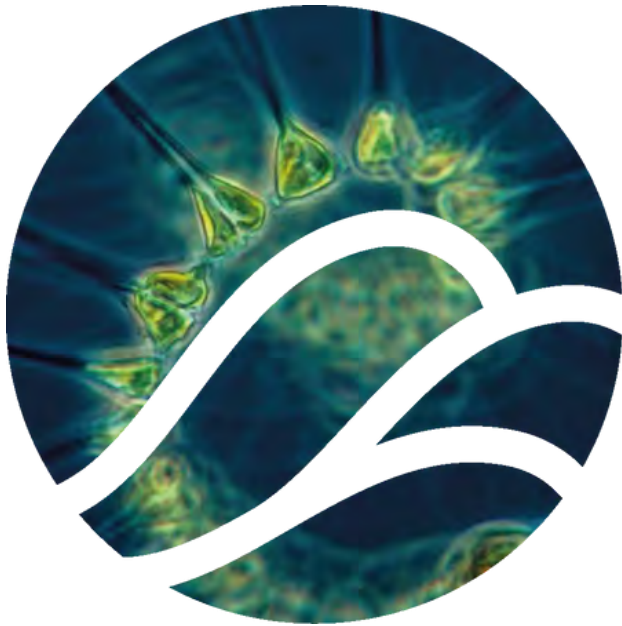
Zoo- & Phytoplankton Essential Ocean Variable products

This Virtual Lab provides a description of the current state of plankton communities and forecasts their evolution, representing valuable information for the modelling, assessment and management of the marine ecosystems.

Partners:

VLIZ   LOV   LIÈGE université

Data sources through Blue-Cloud:

EurOBIS, EMODnet Biology, LifeWatch, GEBCO, SeaDataNet, World Ocean Atlas, NOAA, Copernicus Marine Service, Argo GDAC, GlobColour

Main target users:

Plankton researchers, ocean modellers, data product developers and Blue Data infrastructures, for their data products catalogues and as use cases.

Services introduction:

The Vlab offers three independent services that consist of the combination of different data types (biological, physical and environmental data) to then apply models that generate an output. These are offered in a working space where data and scripts are accessible and reusable.

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Zooplankton Essential Ocean Variable

Zooplankton EOV generates zooplankton gridded maps of six zooplankton species in the North East Atlantic.The workflow uses the DIVAnd software tool (Data Interpolating Variational Analysis in n dimensions) that allows to interpolate sparse in situ measurements onto a regular grid in an optimal way.

Phytoplankton Essential Ocean Variable

Phytoplankton EOV generates global open ocean 3D gridded products of (1) chlorophyll a concentration (Chla), which is a proxy of the total phytoplankton biomass, and (2) Phytoplankton Functional Types (PFT), as a proxy for phytoplankton diversity, based on temperature and salinity in situ data matched up with ocean color satellite products.

Modelling phyto & zooplankton interactions

Modelling phyto and zooplankton interactions enables users to calculate the relative contribution that limits the growth of phytoplankton by the drivers: nutrients, phosphates, silicates, light and zooplankton grazing.

"Accessing data and methods in a collaborative working space with high computing resources helps us assess plankton communities and make data-driven informed decisions. For example, the "Wildlife Tracker for Oceans" tool developed by one of the winning teams at the Blue-Cloud Hackathon uses data from this VLab to perform real-time assessment of Marine Protected Areas.

PATRICIA CABRERA
Data manager at VLIZ

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Plankton Genomics

The aim of the plankton genomics demonstrator is to assess plankton functional distribution through a deep mining of biomolecular correlated with environmental data, through cutting edge machine learning.

Partners:

EMBL-EBI · SORBONNE UNIVERSITÉ · VLIZ

Data sources through Blue-Cloud:
EBI (MATOU version 1, MAGs), World Ocean Atlas

Main target users:
Plankton researchers, ocean modellers, data product developers and Blue Data infrastructures, for their data products catalogues and as use cases.

Services introduction:
The Vlab offers two notebooks. One explores the clustering of a massive genomic dataset and its taxonomic and functional annotation. The other uses machine learning to relate those clusters to the environment (and their parameters such as longitude/latitude, temperature, pH) and extrapolate their potential distribution worldwide.

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Genomics Notebook
The genomics notebook provides an extensive network of protein clusters from the ocean microbiome based on DNA sequences collected by the Tara Oceans expedition. The clustering is based on similarity of sequences found in Metagenomes Assembled Genomes (MAGs). Sequences are taxonomically and functionally annotated but the building of clusters also highlights the large proportion of sequences that cannot be annotated (i.e. ½ of the sequences).

Habitat Modelling Notebook
The habitat modelling notebook queries the protein clusters for a list of functions/enzymes involved in certain biogeochemical processes. The relative abundance of the target clusters is related to environmental variables through Multivariate Boosted Regression Trees (MBRT) and the fitted model is used to predict the potential proportions of each over the world's ocean.

"Computing remotely is becoming more and more common and makes it easier to reach other users. It should also increasingly place computing power close to the data from big repositories and hence allow researchers to be much more efficient in exploring vast datasets."

JEAN-OLIVIER IRISSON
Associate professor at Sorbonne Université

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Fish, a matter of scales

The objective is to deliver a scalable and robust open data portal for fisheries in EU waters and beyond, with a focus on the Global Tuna Atlas and the Global Record of Stocks and Fisheries (GRSF).

Partners:

FAO · IRD Institut de Recherche pour le Développement FRANCE · FORTH INSTITUTE OF COMPUTER SCIENCE

Data sources through Blue-Cloud:
EMODnet bathymetry, EMODNET Biology

Main target users:
Fisheries resource managers and fisheries research community, traceability experts and the general public.

Services introduction:
The VLab offers two independent services; the fisheries atlas (with Global Tuna Atlas as an example), and the Global record of Stocks and Fisheries that consist of a combination of a semantic knowledge base and data-flow, and a data integration service. Both services rely on ISO-OGC compliant data-flows and expose data in a catalogue and metadata-driven map viewer with R-Shiny components to expose data to the general public. Registered users can also access data using R, Jupyter notebooks, and dataminer.

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FIRMS Tuna Atlas

The FIRMS Tuna Atlas is one result of the Fisheries Atlas service. The service behind is a mature Spatial Data Infrastructure that is also used in Demonstrator 5. The service allows to harmonise and standardise fisheries data to become uniform global datasets. This requires a complex workflow that has to be validated with the data-providers in order to ensure high-quality datasets.

Global Record of Stocks and Fisheries

The Global Record of Stocks and Fisheries (GRSF) offers a Catalogue and a Map Viewer. The GRSF service enables a semantic workflow for data alignment and harmonisation, and attaches a stable UUID to validated records. The records can be enriched with ancillary information such as capture time series, model output, and assessment reports. This makes the GRSF the only global catalogue and particularly suited to traceability needs.

"The Fisheries Atlas is an innovative product that presents authoritative and standardised public data on fisheries. It was made possible thanks to a strong and long-lasting partnership and a broad range of scientific and technical expertise. By facilitating access to high-quality and spatialised data, it provides the information needed to address critical issues such as traceability and sustainable fisheries management."

MARC TACONET
FAO of the UN, Information and knowledge management Team

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Aquaculture Monitor

Support to a workflow spanning Blue-Cloud and CLS infrastructures to produce maps based on Copernicus data. The VLab shows how Blue Cloud can integrate ISO-OGC products in a VLab.

Partners:

Data sources through Blue-Cloud:
The workflow uses Copernicus data services. It combines the output in a ISO/OGC compliant spatial data infrastructure that can be used to discover and access Blue-Cloud datasets.

Main target users:
Remote sensing data product developers and Blue Data product managers.

Services introduction:
The VLab offers two independent services; one for cage detection, the other for land-type classification. The first service is implemented as a Jupyter notebook in the Blue-Cloud infrastructure to analyse S1 data over an area of interest, while the second interoperates with a CLS proprietary service that applies AI to S2 images. The results are accessible through a Blue-Cloud VLab that provides a map viewer.

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Aquaculture Cage Detection
The Jupyter notebook for aquaculture cage detection generates GEOPACKAGES over an ROI using Copernicus Sentinel 1 images. The first step is a tiling service to prepare the data for analysis, while in the second step the cages are detected. The output is ingested the Spatial data infrastructure that supports the VLab and is managed through D4Science, and shown in the ISO/OGC compliant Map viewer in the Aquaculture VLab.

Aquaculture Ponds Detection
The VLab ingests AI based land-types classifications as GEOPACKAGES over an ROI that provided the base for a validation based on in-situ data. The Blue-Cloud approach showed the technical feasibility to interoperate with external proprietary software and bring the results in a collaborative environment. The results can be mashed up with other Blue-Cloud products.

"Accessing remote sensing data and methods in a collaborative working space enables to bridge the gap between geospatial data experts and local information managers that need spatial data products to better inform their management decisions. With Blue Clou we have proven that Copernicus derived products can be brought into a VRE, can be brought into context with other spatial data, and can provide cost-effective and standardised views over aquaculture areas."

ANTON ELLENBROEK, FAO of the UN, Information and knowledge management Team

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Marine Environmental Indicators

The VLab provides support to analyse the quality of the marine environment, and inform decision makers about the good environmental status in a changing climate.

Partners:

CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici · Ifremer · KNMI · MERCATOR OCEAN INTERNATIONAL · UNIVERSITAS BERGENSIS

Data sources through Blue-Cloud:

Copernicus Marine Service, Copernicus Climate Service, EuroARGO, EMODnet

Main target users:

Environmental protection agencies and international stakeholders involved in environment management

Services introduction:

The VLab offers a web user interface and several scientific-based algorithms, that can be used to obtain environmental indicators and added-value data applying big data analysis and machine learning methods on multi-source data sets.

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MEI Generator

The Marine Environmntal Indicators Generator service is a web graphical interface for the exploitation of multiple data sources with multiple algorithms, that allows the user to generate and display value-added environmental data from generic marine data.

Ocean Patterns & Ocean Regimes Indicators

Ocean Patterns and Ocean Regimes indicators are based on machine learning methods. They consist in applying an unsupervised classification to profiles or time-series. Data are automatically gathered into clusters, depending on their vertical or temporal structure. When analysing the different clusters, spatial or temporal coherence can be revealed.

Storm Severity Index (SSI)

The SSI service calculates maps and time series of exceptional atmospheric wind or storm circumstances. Individual storms (Event SSI) and specific areas (Area SSI) can be calculated for a given time period and time step (for time series). Wind speed threshold data are used to relate the storm severity to specific impact (e.g. sea circulation, coastal damage).

Simple Access to Carbon Data

The service provides information on how to use ERDDAP servers to access and retrieve subsets of inorganic carbon data in their preferred format, removing the need to download large file(s) that the user may not be interested in.

This is a step forward for the exploitation of marine big data originated from many international initiatives, and to provide scientific support for preserving a healthy ocean

MASSIMILIANO DRUDI
CMCC Foundation

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The Wildlife Tracker for Oceans

The "Wildlife Tracker" is a cloud geo-framework dedicated to Marine Protected Areas (MPAs) management based on biologging and ocean satellite data. The platform offers a unique opportunity to overlay and enrich the movement tracks of wildlife over ecogeographical data layers such as Phytoplankton hot spots to observe in near real-time what may be influencing the animal activities and to spatially assess their meaningful habitats as MPAs.

Partners:

Wildlife Tracker
Real-time movement analytics

GALAPAGOS
whale shark
PROJECT

Data sources through Blue-Cloud:

The Global ocean three-dimensional (3D) key phytoplankton product of chlorophyll-a (Chla) concentration, as a proxy for total phytoplankton biomass from Vlabs.

Main target users:

Marine scientists dedicated to MPAs and conservation efforts

Services introduction:

The Wildlife Tracker has diversified its activities and it can offer real-time wildlife monitoring based on alert system, web map gallery creation, and biologging data enrichment with satellite data. As a cloud-based platform the service is done by monthly/yearly subscription and we offer cooperation to non-profit foundations based on blue economy model.

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Real-time alerts

Once the biologging data is connected to our database and the Wildlife Tracker is retrieving real-time data the alert system is connected. Alerts are customisable e.g. individuals out of MPAs, on land, or in high fishing pressure zone. Alerts are received via mobile.

Customisable visualisation

Wildlife Tracker enables users to customise the visualisation based on selected individuals and selected satellite data. The map animation can be downloaded as a web map that can be uploaded to our website and a web map gallery is created for specific purposes.

Environmental eco-annotation

The new enrichment algorithm annotates each location and date with historic spatio-temporal data generated from remote sensors. This product help scientists to understand wildlife behavior and support ecosystem modelling for MPAs management.

"Thanks to the development of geospatial technologies the "Wildlife Tracker" has discovered innovative ways for wildlife monitoring and MPAs assessment. Our vision is to cover extensively species in MPAs and understand via satellites how marine wildlife inhabits closely with human activities. The main goal is to provide protection to marine wildlife that might be undiscovered and affected by industrial activities and support the MPAs creation and management in nearly real-time."

BRYAN R VALLEJO
CEO at GIS4 Wildlife Movement Analytics

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Sea Clearly

Sea Clearly focuses on providing an environmental impact assessment tool to determine locations for lowest probability of plastic pollution from two perspectives: 1) Plastic pollution reaching aquaculture cages and 2) Plastic pollution from cages reaching Marine Protected Areas (MPAs)

Partners:

Data sources through Blue-Cloud:
Copernicus Marine Service and EMODnet

Main target users:
Policy-makers, aquaculture industry, general public.

Services introduction:
Sea Clearly is a Jupyter Notebook for analysis of plastic pollution in aquaculture. The main service is openly available on Github and also accessible on the Blue-Cloud VLab. A second service is an interactive web-application www.seaclearly.io where visualisations are accessible without any installation required.

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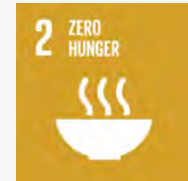
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Jupyter notebook
The Jupyter notebook consists of forward and backward in time simulations of marine plastic visualising the impact of plastic from aquaculture cages on MPAs, and the most likely sources of plastic pollution affecting aquaculture cages in the Mediterranean Sea. CMEMS data is used to advect the simulated plastic particles and the aquaculture cages and MPAs locations are obtained from EMODnet

Online simulation
The website seaclearly.io is a service with the aim of showing interested members of the public the impact of plastic to and from aquaculture cages. It shows stakeholders the potential of the Sea Clearly tool without having to install it first. This service uses ParticleViz software. It uses pre-loaded simulations to and from a number of selected farms. It works on mobile devices making it accessible for any user with a connection to the internet.

"Sea Clearly joint forces between early career researchers of different expertise, career levels, backgrounds and nationalities. This diverse team allowed us to apply our knowledge to a growing environmental problem, and provide an open source tool to contribute to its future management and understanding"

CLEO JONGEDIJK & LAURA GÓMEZ NAVARRO, Team members of Sea Clearly

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PerfeCt - Performance of Aquaculture under Climate change

PerfeCt is an innovative geospatial web application built to forecast the effects of climate change on key aquaculture performance factors and help stakeholders determine future conditions for aquaculture at a given site.

Partners:

Institut Ruđer Bošković

University of Osijek DEPARTMENT OF BIOLOGY

HrZZ

Data sources through Blue-Cloud:
Copernicus Marine Service, Copernicus Climate Service, EMODnet

Main target users:
Risk assessors, Aquaculture managers, Investors, Policy makers

Services introduction:
PerfeCt is a modular Jupyter notebook that hindcasts and forecasts the effects of IPCC climate change scenarios on three simple aquaculture performance factors - time-to-market, food conversion ratio, and risk of disease - using open-source data and services.

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User-friendly GIS framework
The application integrates a process-based modelling of fish growth built upon Dynamic Energy Budget theory, as well as an innovative index to identify the risk of vibriosis disease based on a Vibrio growth model, into a user-friendly GIS framework.

Models fed by open-source data
Three groups of open-source data feed the models to create predictions: (i) basic data layers (bathymetry, maps of aquaculture sites, marine protected areas), (ii) IPCC climate change scenarios, and (iii) model parameters for DEB fish growth model.

Easily accessible information
The application transforms science-based results to easily accessible and understandable information (graphical and colour-coded outputs) useful for target users, thus creating a valuable link between R&D and industry.

"PerfeCt is an innovative approach to answer the 'What if?' question when establishing and/or adapting aquaculture facilities in light of climate change. Our goal is to provide information necessary to strengthen investor confidence and support development of smart policies."

INES HABERLE
Research assistant at IRB

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