Providing computing platforms and analytical services to facilitate the collaboration between researchers

An EOSC in Practice Story where a common workspace is provided to researchers in the marine world to analyse, process, share data and co-develop research products

The project involved

Blue-Cloud is the flagship initiative of the H2020 Future of the seas and oceans programme of the European Commission (Grant Agreement no 862409). The project delivers a collaborative virtual environment to enhance FAIR and Open Science in the marine domain. Started in October 2019, Blue-Cloud is deploying a cyber platform with smart federation of an unprecedented wealth of multidisciplinary data repositories, analytical tools, and computing facilities to explore and demonstrate the potential of cloud-based Open Science and address ocean sustainability, EU Green Deal, UN Ocean Decade, and G7 Future of the Oceans objectives. In January 2026, a follow-up project, **Blue-Cloud 202**6, has been funded to further expand the ecosystem and the core services offered to researchers of oceans, seas, coastal and inland waters.

The Challenge

There are several research infrastructures or other data services running in Europe that cover a multitude of marine-related sciences, providing specific datasets coming from observations collected with different methods. These infrastructures constitute a diverse world, each looking at a piece of the big picture, sometimes hindering collaboration and data sharing. Blue-Cloud aims to overcome fragmentation and build a bridge between thematic science clusters - such as marine, climate, food and agriculture sciences - and EOSC, creating a data federation and providing a common access to a so-called thematic EOSC for marine data. By connecting leading marine data management infrastructures with horizontal e-infrastructures, the project aims to maximise the exploitation of data resources available from different sources. The Blue-Cloud framework consists of two major technical components:

(1) a Blue-Cloud Data Discovery and Access service, already presented in a previous EOSC in practice story, to serve federated discovery and access to blue data infrastructures, and

(2) a Blue-Cloud Virtual Research Environment (VRE) to provide computing platforms and analytical services facilitating the collaboration between researchers, which is detailed hereafter.

"Blue-Cloud VRE, backed by the D4Science infrastructure, enriches EOSC with a community of 18k potential users and new services for researchers which are available in the EOSC Marketplace."

Pasquale Pagano, Senior Researcher at the InfraScience Laboratory @ Italian National Research Council (CNR)

The solution – Virtual Research Environment

The Blue-Cloud Virtual Research Environment (VRE) facilitates collaborative research using a variety of data sets, analytical tools, and computing services that allow data access, processing, harmonisation, sharing, publishing, as well as the (co-)creation of new research products that can be stored in the same environment and shared with other users. Within the Blue-Cloud VRE, a set of analytical workflows facilitate the creation of shared workspaces that enable open science, relying on data sources and inputs that can be retrieved from the blue data infrastructures by means of the Blue-Cloud Data Discovery and Access, or can be retrieved from different other data portals and resources. The key value of the VRE is therefore to allow scientists and practitioners not only to easily access different sets of marine data but also to process and experiment with them via the analytical and visual tools made available by each demonstrator. The various VRE functionalities can be accessed logging into the Blue-Cloud Gateway via Single Sign On (SSO) and can be used in different ways based on the user needs.

For instance, if we consider data processing and analytics, users may exploit different types of support as shown in the examples below:

» **Use of standard technologies**, such as notebooks (The Blue-Cloud VRE has integrated **JupyterHub**) to create an environment and develop codes in any programming languages. The notebook is connected to the storage workspace of the infrastructure of the Blue-Cloud VRE and enables access to the data collected via the DD&AS. The notebook can be shared with other users to cooperate with collaborators

» A more advanced approach would be to use tools that allow **combining specific programming languages**. For instance, researchers could start a process in a notebook elaborating some data with a code in Python, but then continue the data analysis in R, which is one of the most used languages in the marine research domain, relying on a specific environment available in Blue-Cloud VRE, namely **RStudio**.

» An even more sophisticated type of usage is **high-throughput computing** (HTC) which allows elaborating large quantities of data relying on distributed computing facilities. By developing a code in any programming languages and registering it to the VRE, the analysis will be executed in a series of machines in the cloud, which are assigned to the research group and the result of the data processing will be available to all the members of the storage workspace

The Blue-Cloud VRE hosts to date **5 specific demonstrators** developing Virtual Labs for the benefit of the wider community, in order to demonstrate Blue-Cloud's potential in different fields of marine research, ranging from biodiversity to environmental science, as well as fisheries and aquaculture. An additional Lab, named Blue-Cloud Lab, offers access to common services as open-access facilities.

Overview of Blue-Cloud VRE in the Blue-Cloud Gateway
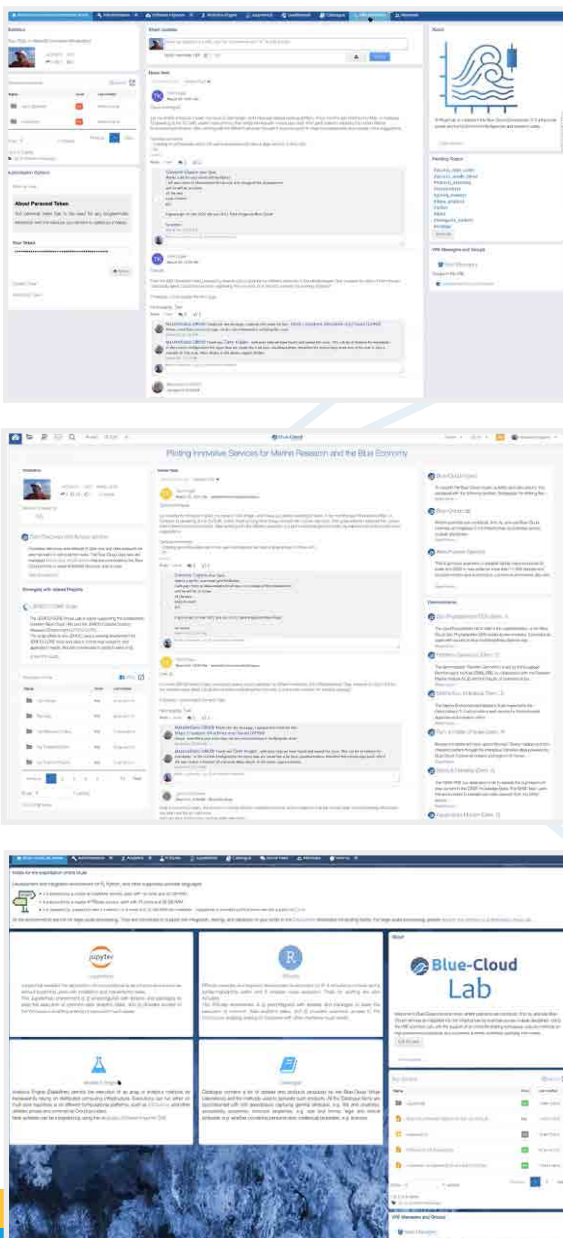
The service provider

The Blue-Cloud VRE is developed by the Italian National Research Council (CNR), based upon the existing D4Science e-infrastructure as developed and managed by CNR-ISTI. This e-infrastructure already hosts multiple Virtual Labs and offers a variety of services, which can be adopted for Blue-Cloud. The D4Science e-infrastructure also has proven solutions for connecting to external computing platforms and means for orchestrating distributed services, which will be instrumental for smart connections to the other e-infrastructures in the Blue-Cloud ecosystem.

The Users

Researchers and Scientists in the marine environment can exploit Blue-Cloud services to find a broad variety of marine data and resources. More generally, researchers in other areas, such as environmental and social sciences, climate science, as well as business and industry players, can discover and use marine data for cross-domain research.

What the users say

"Thanks to the RStudio component offered by the Blue-Cloud VRE, I was able to reduce the computing time from hours to minutes when running the model that quantifies the relative contributions of the drivers in phytoplankton dynamics, as part of the Zoo and Phytoplankton EOV Demonstrator".

Viviana Otero (Flanders Marine Institute - VLIZ)

Why do I need EOSC?

Blue-Cloud services will bring the following benefits to their users being a provider on EOSC:

» A pilot **thematic EOSC as a role model** for the development of other thematic clouds. The cyber-platform of Blue-Cloud provides FAIR access to multidisciplinary data, analytical tools and computing and storage facilities that support research.

» **Blue-Cloud Services** showcased through five Demonstrators for oceans, seas and freshwater bodies for ecosystems research, conservation, forecasting and innovation in the Blue Economy, and making innovative use of seamless access to multidisciplinary data, algorithms, and computing resources - accelerating cross-discipline science.

» A **methodology for researchers interacting with e-infrastructure developers** to establish a cyber platform with tools and services, which support multiple scientific challenges and are fit-for-purpose, while built upon generic core principles and services.

» A **mechanism to easily access and discover blue data**. Blue-Cloud partners manage important volumes of blue data (e.g. SeaDataNet, EMODnet, CMEMS, etc.) and links have been established with major European observing networks to increase the data volume.

» APIs to access blue services that will **complement EOSC base services** providing blue thematic functionalities.

» Dynamic examples of how a framework like Blue-Cloud can **address one or several of the policy challenges** defined in the Bioeconomy Strategy, the Circular Economy Strategy, the Blue Growth Strategy, the Common Fisheries Policy, the Maritime Spatial Planning Directive, the Marine Strategy Framework Directive, the International Ocean Governance Communication and the UN SDGs.

- » **A global Blue Economy community** close to the EOSC vision, including the marine and maritime industry.
- » The opportunity of **bringing EOSC in the Blue Economy long-term vision** via the policy-oriented Blue-Cloud Roadmap to 2030 which seeks a series of EU Calls for further development and uptake of the Blue Cloud by multiple VRE applications and connecting additional marine data infrastructures.

Societal impact

The Marine Strategy Framework Directive, the European strategy for green management governance, the Sustainable Development Goals set up by the United Nations and obviously the EU Green Deal represent major political measures whose implementation is supported also by the enhanced awareness and sensitivity that initiatives like Blue-Cloud have on the socio-political European and international environment. BlueCloud's role is also to inform interested stakeholders that in order to implement these initiatives and understand if a sustainable practice is feasible, scientists need to study its economical and social impacts. Therefore, a multidisciplinary approach is fundamental to plan future business practices.

Across disciplines

The collaboration between EOSC and Blue-Cloud is thus an effective way to foster the adoption of a multidisciplinary approach. Many of the teams involved in the Blue-Cloud VRE already require professionals with different profiles and generate metrics and indicators that combine multiple perspectives. In this particular case, the interaction among marine and socio economic domains is critical to understand their feasibility and impact.

Future developments

Blue-Cloud aims to receive more feedback from the user base about the services developed. A first step is the Strategic Roadmap to 2030, for which interviews were conducted with key stakeholders to understand if the services developed indeed meet the user's needs. A wide variety of dissemination and promotional activities have been planned and carried out to increase the visibility of Blue-Cloud services and stimulate their uptake, such as: articles, conferences, workshops, joint workshops and a highly successful Hackathon. Widening the user base is fundamental for feedback collection, and provides developers with important information to refine the Blue-Cloud services.

In addition, Blue-Cloud is set to improve quality of data through the validation of data sets so that the data models can run better.

Sustainability for an EOSC in practice

Copernicus Marine Service and EMODnet are the two main Research Infrastructures (RI) that are funded and sustained by the European Commission. Blue-Cloud is federating data from both Copernicus Marine Service and EMODnet RIs, aiming to create an environment with shared resources from multiple domains. Blue-Cloud services are also supported by D4Science which has a self-sustained infrastructure listed among the strategic infrastructural assets and resources of national interest in Italy.

Future funding model scenarios

Blue-Cloud supports the creation of the Digital Twin of the Ocean (DTO), the realisation of a digital image of the real ocean. The DTO is also part of the Digital Ocean Knowledge System under the EU Mission Restore our Ocean and Waters. The way forward is to build a business plan to detail options and scenarios on how the strong network of Blue-Cloud stakeholders could ingest and exploit the results of the initiative. The recently awarded Blue-Cloud 2026 project (January 2023 - June 2026) will further evolve this pilot ecosystem into a **Federated European Ecosystem to deliver FAIR & Open data and analytical services**, instrumental for deepening research of oceans, EU seas, coastal & inland waters. Blue-Cloud 2026 will expand the federated approach of Blue-Cloud, involving more aquatic data stakeholders, and interacting with EOSC developments, in support of the EU Green Deal, UN SDG, EU Destination Earth, and the EU Mission Starfish on healthy oceans, seas, coastal and inland waters, mobilising and making available major additional data resources as validated and harmonised in-situ data by means of Data Lakes.

Useful material related to this story

- » Blue-Cloud Gateway @D4Science
- » Blue-Cloud VRE
- » Blue-Cloud Data Discovery & Access Service
- » Blue-Cloud Hackathon pilots
- » Blue-Cloud Services on the EOSC Marketplace

Want to learn more about the other services being developed by **Blue-Cloud**? Read here
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