EOSC | Federation

Scientific use case:
Biological sequestration of carbon in the ocean

EOSC Node | Digital Twin of the Ocean (Environment)
EOSC Node | Poland
EOSC Node | Life Sciences Connect (Health & Food)
EOSC Node | Data Terra (Environment)

This briefing is based on an interview with Stéphane Pesant, a marine biologist and data specialist at EMBL's European Bioinformatics Institute. Pesant has expertise in marine ecology and environmental genomics, particularly in understanding how microscopic life contributes to global carbon cycles. Pesant's work helps the marine science community to curate and re-use open data, advancing ecological modelling using interoperable European research infrastructures.

This scientific use case addresses the ocean's critical role in mitigating climate change through **biological carbon sequestration**, a process by which marine microorganisms capture atmospheric carbon dioxide and store it in the deep ocean for centuries. Despite its global importance for **climate modelling**, this mechanism remains poorly represented in current models, which still rely on simplified representations of marine ecosystems. The use case seeks to fill this knowledge gap by integrating genomic, environmental, and modelling data within a unified, open, and interoperable framework provided by the EOSC Federation.

Problem addressed

Marine microscopic communities—collectively known as the ocean microbiome—are responsible for much of the carbon fixation in the marine biological carbon pump. However, **current climate models inadequately represent the biological processes of carbon sequestration** in oceans due to the significant technical and scientific challenge of integrating, annotating, and modelling **massive metagenomic datasets**. The result is that current global assessments, including those by the International Panel on Climate Change (IPCC), rely on coarse estimates of biological activity, leaving major gaps in understanding how microbial communities influence carbon storage.

EOSC Association AISBL
Rue du Luxembourg 3, BE-1000 Brussels, Belgium
+32 2 537 73 18 | info@eosc.eu | www.eosc.eu
Reg. number: 0755 723 931 | VAT number: BE0755 723 931

Technical solutions

The use case's scientific workflow proceeds in two main stages that are seamlessly connected via the EOSC Federation. First, **genomic data from the global ocean** are compiled and annotated to identify the taxonomy of marine microorganisms and their metabolic and ecological functions that may be diagnostic of carbon capture, transformation, and long-term sequestration. This is executed via repositories and services of the **Life Sciences Connect EOSC Node** hosted by the European Bioinformatics Institute, and powered by European computing platforms such as Galaxy and ELIXIR. Second, these observations are analysed using an ensemble of global distribution models in order to **predict the carbon sequestration potential** under past, present, and projected climate scenarios. This is made possible by the development of **modelling components on the Digital Twin of the Ocean EOSC Node's Blue-Cloud environment** hosted by the Italian National Research Council.

Scientific outcomes

The use case's models will generate **global maps of biological carbon sequestration potential**, that will contribute to a more accurate representation of ocean biology in climate assessments. The goal is to incorporate these results into next-generation ocean system models by 2030, including those that inform IPCC assessments. The use case also **strengthens Open Science** practices: all models and datasets are made publicly available through EOSC Federation catalogues ensuring the results are FAIR, encouraging reuse and collaboration. Early-career researchers and bioinformaticians particularly benefit, using the platform as both a training and discovery environment. **Future potential innovation** is suggested by spin-offs such as marine biodiversity monitoring, ecosystem management, and the anticipated discovery of novel bioactive compounds from the ocean microbiome.

Added value of the EOSC Federation

The EOSC Federation provides **the essential infrastructure** for interoperability, open access, and scalability. The use case enables distinct scientific domains—genomics, oceanography, and climate modelling—to interconnect seamlessly across distributed infrastructures. Connecting with other EOSC Nodes, such as **France's Data Terra EOSC Node and Poland's national Node**, offers future opportunities for regional scale modelling as well as the integration of imaging with genomic data. By **bridging life and ocean sciences within a single federated ecosystem** and enabling broad European collaboration, the EOSC Federation lays the groundwork for **more integrated Earth-system modelling**. The EOSC Federation's computational capacity, storage scalability, and alignment with emerging initiatives like the Digital Twin of the Ocean represent key enablers of scientific progress and long-term sustainability.

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