AquaINFRA: An EOSC-Compliant Interaction Platform for FAIR Multi-Disciplinary Aquatic Data and Services Contributing to Digital Twins of the Ocean

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The AquaINFRA project is a transformative initiative funded under the European Union's Horizon Europe programme. Its objectives are to develop a virtual environment equipped with FAIR multi-disciplinary data and services to support marine and freshwater scientists and stakeholders in their efforts to restore healthy oceans, seas, coastal, and inland waters by 2030. Recognising the urgent need for high-quality data across aquatic domains, AquaINFRA aims to transcend national borders and disciplinary silos, fostering collaboration across research infrastructures by leveraging the European Open Science Cloud (EOSC) and other operational dataspaces.

https://aquainfra.eu/

AquaINFRA is constructing an EOSC-compliant research infrastructure that integrates existing domain services with EOSC core services. A key component is the intelligent Data Discovery and Access Service (DDAS), which utilises hydrological connectivity as a backbone for its search engine. Alongside this, the project is developing harmonisation and processing services and a robust interactive platform – the AquaINFRA Interaction Platform (AIP) – all adhering to the EOSC interoperability framework. The AIP will provide researchers with access to a Virtual Research Environment (VRE), offering computational tools and services necessary for sophisticated data analysis and modelling, supporting languages such as R and Python and including customisable notebook services.

Contribution to Digital Twins of the Ocean and Interoperability

A specific objective of AquaINFRA is to ensure interoperability with the Digital Twin of the Ocean (DTO) projects and initiatives, notably EDITO and Iliad. The project aims to ensure a two-way synergy, whereby AquaINFRA data and services can be utilised as input for these DTO frameworks, and conversely, relevant DTO data and services can be accessed and used within the AquaINFRA environment.

The AquaINFRA Data Space will play a crucial role in providing FAIR data to DTOs. It will connect an extensive selection of marine and freshwater data resources through the DDAS, facilitating seamless search, access, and harmonisation via external data provider APIs and Digital Twin APIs. The data within the AquaINFRA Data Space will be organised into bronze (raw data), silver (curated and harmonised data), and gold (analysis-ready data attached to a pan-European hydrography) zones. The seamless, high-resolution pan-European hydrography database is a significant asset, accounting for spatio-temporal connectivity and temporal lag-effects across freshwater and marine realms, which is essential for comprehensive DTOs.

The **AIP** will act as a central gateway for interacting with EOSC and accessing AquaINFRA resources, including harmonisation and processing services, research products, and the

VRE. It will be made interoperable with DTO projects like Iliad and EDITO, ensuring that underlying data and models from the Digital Twins are accessible from AqualNFRA, and vice versa. This will be demonstrated through strategic use cases across various European waters, including a Pan-European use case, as well as focused use cases in the Baltic Sea and the North Sea, which will serve to co-design and test these interoperable services.

Technical Framework for Interoperability

AqualNFRA's technical methodology is multi-faceted, explicitly aiming for interoperability, usability, and service integration within the VRE. Key aspects include:

- **Data Harmonisation and Integration:** Standardising data formats, metadata, and vocabularies to align with FAIR principles is a cornerstone. Harmonised data will feed into the AqualNFRA Data Space and be linked to the pan-European hydrography database, reflecting spatial-temporal connectivity.
- **Interoperable Architecture and Standards:** Adherence to international standards from ISO TC211, the Open Geospatial Consortium (OGC), and the EU INSPIRE Directive will ensure broad usability and integration into global systems. AqualNFRA will also contribute to emerging standards like the Environmental Data Retrieval API and Cloud-Native Geospatial, indicating a commitment to technological advancement.
- **Cross-Domain Discovery Services:** The framework is designed to enhance cross-domain research, enabling seamless discovery and access to marine and freshwater data via interdisciplinary discovery services such as EUDAT B2FIND and OpenAIRE EXPLORE, facilitated by the DDAS.
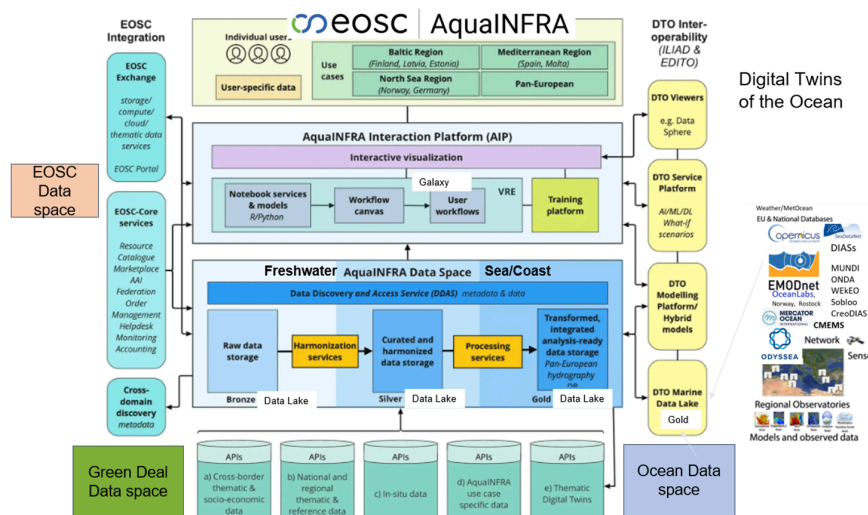
At the workshop, a summary of the project will be provided and further details of the AqualNFRA Data Discovery and Access Service (DDAS), AqualNFRA Interaction Platform (AIP) and Virtual Research Environments (VRE).