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Climate Change Impact on Biodiversity and Ecosystems in Europe: Assessing the impact of Non-Indigenous Invasive Species (NIS) in European ecosystems

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Title: Climate Change Impact on Biodiversity and Ecosystems in Europe - Assessing the impact of Non-Indigenous Invasive Species (NIS) in European ecosystems.

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Abstract

This Science Project (SP) contributes to the estimation of the impacts of the invasive species on the European Biodiversity and Ecosystems. This topic is important for European Green Deal and the new European Biodiversity Strategy. The SP is also linked with the socio-economic issues because of the NIS implications to the local ecosystems and their services, and their societal goods and services. Since many of the above impacts may be of local scale, they may alter common practices in circular economies. The SP is implemented by: (a) Combining different sources of data and information; (b) Using a dual workflow to analyse the data; (c) Integrating its resources with core EOSC services and potentially horizontal services available; (d) Engaging the relevant scientific communities. The users will be able to: (a) Analyse distribution patterns of invasive species from different sources of data; (b) Compare the above patterns; (c) Provide managerial suggestions to relevant authorities; (d) Build on the existing infrastructure to address more complex questions (e.g. future scenarios).

Key words

EOSC Future; Science Clusters; e-Infrastructures; Science Projects; Community engagement; Invasive Species; Virtual Research Environments

Description

Existing situation: Several reports (e.g., IPCC, UN Global Assessment Study) and conferences (e.g., COP21) demonstrate that climate change poses severe threats to our life supporting system, the biosphere. The current knowledge needs to be improved by seeking evidence from cross-domain analyses. A promising option is to investigate and monitor the rapid increase of Non-Indigenous Invasive Species (NIS) in European ecosystems. These species may not only replace indigenous ones but also alter habitats, interacting with the changing environment and eventually severely influence established socio-economic regimes. The challenge here is to adopt a comprehensive approach by considering the bulk of the biotic and abiotic variables and their interactions, which may be even more important for the distribution of the NIS than the occurrence of the NIS. Such approaches require access to big datasets (from genomics to in situ and satellite borne environmental data) and high computational power, especially for those models with iterative algorithms.

Objectives: 1) to integrate data from different scientific disciplines in the marine subdomain (e.g. chemistry, physics, biodiversity, ecosystems, genomics, socio-economics) into an analytical framework in order to advance our knowledge on the impact of NIS on European marine biodiversity and ecosystems; 2) to connect the analytical framework and federate access to relevant data infrastructures at the EOSC portal in order to mobilise and empower a larger community of researchers and potential data providers; and 3) to demonstrate and promote the benefits and potential of web-based science using EOSC.

Compliance to criteria developed by EOSC Future:

Eligibility: This SP has a truly interdisciplinary and cross-domain character. It encompasses many research groups scattered in several ERICs and RIs but it's also open to scientists from legal entities which are not members of the EOSC Future Consortium. It will be based on previous experience on mobilising relevant communities in the context of projects such as ASSEMBLE Plus, core projects of many ERICs (e.g. the Internal Joint Initiative (IJI) of LifeWatch ERIC), etc.

Contribution to EOSC: The proposing entity (LW ERIC) not only comes to the SP with the relevant web services but also with its own Technical Composability Layer (Tesseract, which includes an additional option with Jupyter Notebook). This layer can be used in order to achieve the horizontal composability of the services in other SPs, too.

Quality: Only FAIR-compliant datasets will be used in this SP. However, because the nature of the project is primarily multidisciplinary and cross-domain, the only way to guarantee that the results deriving by the different disciplines/domains are comparable is to FAIR-ify the web services used, too. This way, the SP ensures that both the quality and process potential in the

different disciplines and domains are comparable and therefore so are their results. For this to happen, the Consortium will engage existing frameworks, such as RO-Crate, developed by ELIXIR.

Relevance: The SP contributes to the estimation of the impacts of the invasive species on the European Biodiversity and Ecosystems, which is directly linked to the mission of climate change but also to the new Biodiversity Strategy and therefore the European Green Deal. The topic is also linked with the socio-economic issues because of the NIS implications to the local ecosystems and their services, and their societal goods and services. Since many of the above impacts may be of local scale, they may alter common practices in circular economies. The SP endorses an inclusive participatory approach to all partners and also to any other interested party outside the Consortium. Both data and services used are in line with the open access, open code principles.

Implementation, Plan of work

Two approaches:

(a) Combined metabarcoding with species occurrences data coming from EMBRC (ASSEMBLE Plus) and environmental data from multiple resources (e.g. multiple sources: COPERNICUS, ICOS, EMSO, EuroARGO, etc.). These data don't go much back in time and so only statistical models can be applied;

(b) Species occurrences from OBIS + environmental data. Because of the vast quantities of data, we may be able to apply mechanistic models (of SD) - if not, statistical models will take over. This approach will also be combined with an exploration of data available by ENA/BOLD (metabarcoding) and an attempt will be made in order to compare patterns (and inferred processes, where possible) from both approaches.

Establish access to marine biotic and abiotic datasets from relevant data infrastructures, such as EurOBIS, ELIXIR-ENA, SeaDataNet, CMEMS (DIAS), EurOBIS, ICOS, EMBRC ERIC, EMSO ERIC, GBIF ENA and others, benefiting from ongoing efforts in the ENVRI FAIR H2020 cluster project for FAIR improvements, and in the Blue-Cloud pilot H2020 project for a federated Blue-Cloud discovery and access service, and integrating with the appropriate EOSC core technical layers and web services. Types of data to be used: 1) for conventional community analysis: (a) Taxon distribution to sampling areas, as collected by ARMS samples and identified by taxonomists, experts in certain taxa; (b) Environmental data; (c) Socio-economic data; (d) Values of data: (a) taxon presence-absence, abundance or density; (b) actual values of the

environmental and socio-economic variables measured. 2) for metabarcoding community analysis: (a) Taxon/OTU distribution to sampling areas, as collected by ARMS samples and identified through genetic screening; (b) (metabarcoding) by genetisists; (c) Environmental data; (d) Socio-economic data. Values of data: (a) taxon/OTU presence-absence or abundance; (b) actual values of the environmental and socio-economic variables measured.

Provide access to the Lifewatch Species Information Backbone (WoRMS and WRIMS) used as the core reference set for identifying species and their traits (e.g. invasive or native), by augmenting its semantic provisions, streamlining the M2M access, updating its links to genomics-based taxonomies, and increasing the hypermedia properties of the existing services.

Specify and develop the analytical framework as required to analyse data sets from different disciplines into pipelines and workflows and finally deploy it as a Virtual Research Environment (VRE), and plug it in to the EOSC portal;

Identify marine NIS hotspots in Europe and provide strategies to mitigate their impacts on the marine environment, biodiversity and ecosystems, as well as economy and society.

SP_01_MS01: All services onboarded and integrated in the EOSC platform; M14.

SP_01_MS02: All relevant data accessed and collated; M20.

SP_01_MS03: Results of analyses available in the form of scientific documents; M30.

Use of resources: Open-access data-sets provided by RI partners in ENVRI-FAIR and Blue-Cloud, as well as from other relevant RIs and data repositories (e.g. those referred to above). Open code web services delivered by all partners, which have to do with the data access, their management and their analysis.

What are the demands of the SP from EOSC Future platform: technical support for onboarding and integrating the web services, computing resources, interactions with several WPs.

What the SP brings to EOSC Future platform: 1) engagement of ENVRI-FAIR + EOSC Life clusters, of Blue-Cloud, OGS and other relevant partners with long-track experience in the field; 2) multidisciplinary and web-based use case, of major interest for science, policy and public; 3) technology on the management of the environmental data (e.g. LifeBlock to solve many of issues on the interoperability of data: durability and scalability, etc.) and on the horizontal technical composability of the web services (Tesseract, including Jupyter Notebook).

Partners: 1) LifeWatch ERIC (member of ENVRI-FAIR cluster); 2) MARIS (member of ENVRI-FAIR cluster); 3) EMBRC ERIC, (member of EOSC Life cluster), represented by Nicolas Pade; 4) HCMR (TLP to EMBRC ERIC); 4) UGOT (TLP to EMBRC ERIC); 5) VLIZ; 6) OGS (on behalf of SeaDataNet, member of ENVRI-FAIR cluster), subcontractor of MARIS; 7) NOC-

BODC (on behalf of SeaDataNet, member of ENVRI-FAIR cluster), subcontractor of MARIS; 8) IFREMER (on behalf of
EuroArgo, member of ENVRI-FAIR cluster), subcontractor of MARIS, represented by Thierry Carval;

Impact

Strategic: With the marine NIS impact assessment SP, EOSC Future aims to: 1) offer a prototype which makes available a suite of web services of multidisciplinary and cross-domain origin, properly orchestrated in the form of a workflow; 2) engage a vast scientific community, once again both multidisciplinary and cross-domain, working on the impacts of major drivers on the marine biodiversity and ecosystems in the EOSC ecosystem. Through ENVRI-FAIR, EOSC Life, and the association with Blue-Cloud and other relevant partners, as well as within the INFRAEOSC03 framework, new services will be added to the EOSC portal, with a proper integration so that it will be possible to be used in combination with both the core services of EOSC (vertically) and to each other (horizontally). Such a prototype with a connected community behind it does not yet exist. Finally, this SP will bring together scientists making basic research on biodiversity and ecosystems, computer engineers, including software and web developers, in order to create a FAIR-compliant virtual research environment (VRE) to achieve both the scientific goals and the community engaged.

Scientific/User communities: This is the most important impact for this EOSC Future SP. The SP brings a suite of multidisciplinary and cross-domain communities which currently work primarily in isolation from each other. Accordingly, they have developed their own data and analytical systems and their own ways for interpreting the results of their research. Through this SP, these communities will come to work together on a major environmental problem with lots of consequences: environmental, social, economic. Therefore, they need to make sure that their working protocols, including data and analytical machinery they employ, are interoperable and also comparable to each other. One of the best ways to achieve the latter is to make sure that both the data and the analytical pipelines are FAIR-compliant and therefore they can guarantee a FAIR operation of the web services. Perhaps, this is the most challenging part of the SP and maybe of all the SPs.

EU Policies: At least the following EU Policies are directly linked to the NIS process of establishment in the native habitats of Europe: 1) Habitats Directive, 2) Water Framework Directive, 3) Marine Strategy Framework Directive, where NIS form a descriptor for its

implementation, and 4) Maritime Spatial Planning Directive. In addition, the NIS are considered by the new Biodiversity Strategy of the EU as well as the European Green Deal. Finally, NIS forms an important component of the implementation of the UN decade of Ocean, which has already been adopted by the EU.

Engagement Plan

Target groups: Researchers/engineers working on Invasive Alien Species (Scientific communities Internal Joint Initiative LifeWatch ERIC and relevant networks); Academicians and students; BON participants/managers; Environmental Agencies; Stakeholders (e.g. management authorities, tour operators, planners, developers, navy); Policy Makers; Citizens.

SP key concept: The SP contributes to the hot topic of the impacts of invasive species on European marine biodiversity and ecosystems. There are also links to society and economy because of their implications to the local ecosystems and their services, as well as the associated societal goods and services. The SP will be applied by: 1) Combining different sources of data and information; 2) Using workflows to analyse the data; 3) Integrating its resources with core EOSC services and potentially horizontal services available; 4) Engaging the relevant scientific communities. Users will be able to: 1) Analyse distribution patterns of invasive species from different sources of data; 2) Compare the above patterns; 3) Provide managerial suggestions to relevant authorities; 4) Build on the existing infrastructure to address more complex questions (e.g. future scenarios).

Dissemination measures

- Scientific publications: Scientific publication of the template of the SP; Data paper; Scientific publications on the results of the workflow.
- Conferences: Symposium on "Advanced facilities for the ecological research: the European Research Infrastructures" on SFE2, GFÖ & EEF Joint Meeting - Metz 2022, International Conference on Ecological Sciences (21-25 November);
- Webinars: December 2022, May-June 2023;
- Workshops: IJI workshop on SFE2, GFÖ & EEF Joint Meeting - Metz 2022, International Conference on Ecological Sciences (21-25 November);
- Demonstrations to other communities: BioDT project, MARBEFES project, MARINE SABRES project;
- Education and training events: LifeWatch ERIC supported MSc curriculum;
- Networking: Using top policy venues (e.g. SS-UNGA events – 2022).

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Endnotes

Dr. Arvanitidis, Prof Basset, Dr. Obst, Dr. Pavloudi, Dr. Pade, Dr. Kotoulas, Dr. Santi and Dr. Huertas Olivares, have worked on the concept, design of the SP and the development of the article.

Dr. González-Aranda, Prof. López, Dr. Fiore, Mr. Minadakis, Dr. Schaap, Dr. Exter, Dr. Portier and Dr. Vaira, have worked on the technical development of the SP and on the drafting of the technical part of the article.

Dr. Carval, Dr. Giorgetti, Dr. Hebden, Dr. Meyer and Dr. Thijsse, have participated to the drafting of the article.

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