IRISCC

D4.1 Report on the full Demonstrator design

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Abstract	
Key words	Demonstrator, concept, new service, 2nd service release

Within the IRISCC project six new demonstrator services are developed as showcases of the added value of cross-RI service provision. These demonstrators combine the existing capacities and capabilities of the participating RIs to produce new data and services for strengthening the societies' resilience against climate change impact and to increase understanding of climate change related risks affecting various fields. This document describes the six demonstrators and provides the plan and schedule when implementing them from concept to operational services.

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Key terminology / Acronyms	
Term/Acronym	Definition
AQ	Air Quality
CDR	Carbon Dioxide Removal
CMIP	Coupled Model Intercomparison Study
CORDEX	Coordinated Regional Climate Downscaling Experiment
Demo	Demonstrator
EO	Earth Observations
FAIR	Findable, Accessible, Interoperable and Re-usable
IRISCC	Integrated Research Infrastructure Services for Climate Change risks (Horizon Europe project 101131261)
M	Month (of project)
NRT	Near Real Time
RI	Research Infrastructure
VRE	Virtual Research Environment
WP	Work Package (of project)

This table does not contain organization, RI, or product names, nor does it contain acronyms that appear only in the annexes.

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Executive summary

Within the IRISCC (Integrated Research Infrastructure Services for Climate Change risks) project, and more specifically in Work Package (WP) 4, there are six new cross-RI services or products planned for development as demonstrators of the added value of cross-RI work. The demonstrator concept is to combine existing capabilities and services of the participating Research Infrastructures (RIs) to create new services or products with added value to users. This requires not only combination or re-grouping of data, but also technical work and new capabilities to connect the services into user-friendly packages. WP4 will work closely together with WP6 to support the technical implementation of the Demonstrators and to seek adoption of the interoperability framework that WP6 is offering for ensuring that services provided through the Demonstrators will be harmonised towards users and make optimal use of computing resources and gateways to data resources.

The new services are expected to be launched to users in the second service release in IRISCC in September 2026, and to be maintained in the service portfolio of participating RIs, if found relevant enough.

The demonstrator concept and the six individual demonstrators are described in this document, along with the timeline for specification, development, and implementation from starting point to release of the service or product. The demonstrators are presented at a more general level in the actual report, while a further detailed description of each demonstrator, their possible technical requirements, and initial roadmap of implementation is annexed. The detailed descriptions and roadmaps provided in this document are to be treated as conceptual plans and are subject to change during the implementation of the demonstrators.

1. Demonstrator concept

Adaptation to climate change requires in-depth understanding of climate change driven risks, including their determinants (hazards, exposure and vulnerabilities) and impacts to human, production and natural systems. IRISCC is a project bringing together 14 RIs (Research Infrastructures) with a goal to enable more comprehensive research and thereby understanding of these risks. The goal of IRISCC project is to support society's capacity to address and strengthen resilience to climate change risks through the establishment of a service portfolio with transnational and virtual access provision to integrated RI services. The access is provided to complementary and interdisciplinary cutting-edge European and national research infrastructures, including observatories, experimental facilities, modelling services, and data infrastructures. IRISCC fosters challenge-driven and interdisciplinary research on climate-change-related multi-hazard risks to support evidence-based policymaking, decision-making, and to improve Europe's resilience to climate change.

Within the IRISCC service portfolio there will be three types of services provided, linked to three service releases in March 2025, September 2026, and March 2028. The first type are the climate change risk services already available through the RIs. The second type are new services and products created from combining data, services and / or expertise from multiple RIs. The third type are services created together with the future users in service design labs.

The work described in this document focuses on the second type of services, referred to as demonstrators. The demonstrators combine the data, services and/or expertise from several RIs. They are demonstrating the added value created when multiple RIs produce services together. Each of the six demonstrators targets a specific risk and provides a new product or service for studying the risk with a more comprehensive approach than what was available earlier. The foreseen users of these services are from the academia, but also from operational risk management services and governance bodies. If the services are succeeding to provide added value to the users and to receive significant interest from the users' side, ways to make them available beyond the timescale of IRISCC will be sought.

The six demonstrators are:

1. Risk on human health in urban areas during heatwaves associated with deteriorated air quality
2. Risk on coastal regions due to flooding caused by sea level rise and storm surges
3. Risk on terrestrial ecosystems functioning and services due to droughts and heatwaves
4. Risk on marine ecosystem biodiversity, functioning and services caused by ocean acidification, warming and deoxygenation
5. Risk on food security due to multi-hazard risks (pests, floods, droughts, heatwaves)
6. Risk on multiple systems (human health environmental matrices, and socio-economic sectors) due to wildfires in Europe

While developing and launching the Demonstrators, IRISCC strives for harmonisation and interoperability of the new services towards users. This could be achieved by adopting the interoperability framework that Work package (WP) 6 is offering by means of the D4Science e-infrastructure. D4Science brings along an integrated offer of standard functionalities, software packages, and computing and storage resources. D4Science can be used as implementation platform, to harmonise access to the demonstrators for IRISCC users, and to streamline the gateways to data resources of common relevance for Demonstrators. Therefore, WP4 will work closely together with WP6 from the conceptual start to the launch of the demonstrator services.

2. Overview of each demonstrator

In this section the demonstrators are described shortly, giving an overview of each of them. This includes the demonstrator's name and participating RIs, but more importantly the underlying challenge, a short description of the product / service to be created, the target users and the foreseen added value provided by the demonstrator. The project beneficiary leading each demonstrator is also listed. After the project this beneficiary or the linked RI is usually the one with most knowledge and incentive for keeping the demonstrator service operational, though it might also be another entity.

A more detailed description of each demonstrator is provided as annex to this document (see Section 4). As the demonstrators aim to demonstrate the added value of inter-RI collaboration in service provision, the RIs and other international initiatives participating in each demonstrator and their initial roles are listed in the Table 1 below. It is to be noted that the work is done by the IRISCC project beneficiaries, and Table 1 shows the foreseen long-term role of each RI in enabling and operating the services.

Table 1. RIs and their foreseen roles in each demonstrator. Here data provider means that data produced by the RI is used, and platform provider means that the RI provides the computational platform on which the data from various RIs are combined to create new product. Only demonstrator 4 provides physical access.

RIs and other initiatives participating in the demonstrators						
RI or initiative	Demo 1	Demo 2	Demo 3	Demo 4	Demo 5	Demo 6
ACTRIS	Data provider					Platform and data provider
AnaEE			Data provider		Data provider	
Copernicus Climate		Data provider				
Copernicus Marine		Data provider				
EIRENE	Platform and data provider					

eLTER			Data provider				
EMBRC				Platform provided			
IAGOS	Data provider						Data provider
ICOS			Data provider	Data provider	Data provider	Data provider	
IS-ENES		Data provider					
SeaDataNet		Lead developer		Data manage ment			

2.1 Demonstrator 1

Demonstrator name:
Risk on human health in urban areas during heat waves associated with deteriorated air quality.

What is the challenge / risk to which the demonstrator will provide answers:
Summer periods in Europe have become synonymous with extreme heat and poor air quality (AQ). The combination of both hazards can be particularly detrimental for human health. More research is needed to understand the nexus between climate change and air quality. To foster this research linkage between air quality, climate and health data is needed. While within the environmental community air pollution and weather information is used in health analyses, they may not use the most advanced information and modelling of air quality and climate data.

Product / service created in the demonstrator:
The demonstrator makes available and integrates air-quality relevant data (e.g., ozone, fine particles, black carbon, oxidative stress potential of particles, chemical composition from ACTRIS, IAGOS) through the EIRENE Exposome-Maps platform. This will allow users to easily link air quality and climate data to health records to further research in this area.

Foreseen main users of the product / service:
Target users are academics, public authorities, relevant sectors (e.g., urban planners, construction, housing, health), and the public.

How will the product / service benefit the main users:
The product will make it simpler for users to link a wide variety of sources containing information on air quality and climate to health outcomes collected in cohort studies in a single access point. These data can be used to study the relation between air quality, climate and disease and can inform public authorities and policy makers on regional variation in health risks of air pollution in the context of climate change.

Involved Research Infrastructures and their roles:

- EIRENE: Provision of platform for linkage of environmental data to health records
- ACTRIS: Provision of air quality and climate data
- IAGOS: Provision of air quality and climate data

Project beneficiary leading the demonstrator:
Utrecht University (UU), Netherlands

2.2 Demonstrator 2

Demonstrator name:
Risk on coastal regions due to flooding caused by sea-level rise and storm surges.

What is the challenge / risk to which the demonstrator will provide answers:
Coastal flooding is a major hazard for many coastal regions that causes damages in the order of tens of billions of dollars per year. Worldwide, the number of people and economic assets exposed to flooding in the low-lying coastal zone are increasing, while the frequency and intensity of this hazard are aggravated by climate change, causing sea level rise, more extreme rainfall, and changes in storminess. At the same time, more and more people migrate to coastal regions. Analysing the risks, studying the potential impact of climate change and changes to the land-use, as well as design and study measures to improve coastal defence or to reduce the damages, requires a wide range of data. Here models are a key tool to study the causal effects and compare scenarios. However, creating all the required models, creating the necessary connections, running all the computations, and visualizing and studying the output, requires much effort which is currently hampering detailed studies of flood risk. The tools provided in this demonstrator aim to make the setup, running and visualization much faster, by automating a large part of the work.
Product / service created in the demonstrator:
Environmental in situ data, Earth Observation (EO) data (remote sensing) and derived information, and socio-economic data can advance capabilities for coastal flooding risk analyses. In IRISCC, a Jupyter notebook will be developed to facilitate the assessment of flooding in coastal areas due to storms in combination with long-term sea-level rise due to climate change.

Foreseen main users of the product / service:
Researchers working on the assessment of coastal flood risks and its impacts, as well as on adaptation measures development. Engineering companies that play an important role in the development and design of measures to mitigate or cope with changes in flood risk.

How will the product / service benefit the main users:
Impact assessment of coastal flood risk requires a sequence of modelling steps that are time-consuming to set up. The service aims to provide a flexible and relocatable workflow, that can be adapted to many studies around the globe. This service will also allow users to specify multiple climate- or anthropogenic-based scenarios to simulate.

Involved Research Infrastructures and their roles:
- SeaDataNet: Lead developer
- IS-ENES: Climate data provider
- Copernicus Climate: Data provider
- Copernicus Marine: Data provider

Project beneficiary leading the demonstrator:
Mariene Informatie Service Maris BV (MARIS), Netherlands, together with Deltares, Netherlands, and RBINS, Belgium, all members of SeaDataNet.

2.3 Demonstrator 3

Demonstrator name:
Risk on terrestrial ecosystems functioning and services due to droughts and heatwaves

What is the challenge / risk to which the demonstrator will provide answers:
Global warming has increased the frequency, intensity, and duration of hydro-meteorological extreme events, which has led to major impacts on the functioning and service provisioning of terrestrial ecosystems.

Product / service created in the demonstrator in one line:
Online data visualization dashboard showing drought risks and impacts on ecosystem functioning for the past, present and future scenarios.

Foreseen main users of the product / service:
Academics, public authorities, water, forestry, and agriculture sector.

How will the product / service benefit the main users:
Enable best-informed decision making in managing water resources and carbon balance based on scientific modelling and evaluations with ground-truth data.

Involved Research Infrastructures (RI acronym and role):

- eLTER: Data provider
- ICOS: Data provider
- AnaEE: Data provider

Project beneficiary leading the demonstrator:
Forschungszentrum Jülich GmbH (FZJ), Denmark

2.4 Demonstrator 4

Demonstrator name:
Risk on marine ecosystem biodiversity, functioning and services caused by ocean acidification, warming and deoxygenation.

What is the challenge / risk to which the demonstrator will provide answers:
Carbon dioxide removal will be likely necessary to limit global warming to no more than 2 °C compared to pre-industrial era. The ocean, with its potential for CO_2 storage, appears as the most efficient reservoir to be artificially increased. The urgency of the challenge and important knowledge gaps are causing a rapid increase in the engagement of the research community (e.g., **https://oceanvisions.org**) and a technological race between start-ups (e.g., **https://www.equatic.tech**, **https://capturacorp.com**, **https://limenet.tech**). Despite small-scale testing, fundamental questions remain about the additionality and durability of CO_2 sequestered, the scalability and the environmental impact of different technologies. Field trials or large-scale implementation of non-fully validated techniques pose new risks to the marine ecosystem health (diversity, composition and functional integrity) and derived services, which need to be assessed through research and demonstration across relevant scales in controlled environments (for a thorough introduction, see **https://oceanvisions.org/wp-content/uploads/2023/10/A-Comprehensive-Program-to-Prove-or-Disprove-Marine-Carbon-Dioxide-Removal-Technologies-by-2030_FINAL.pdf**). To this aim, marine mesocosms, large (>1 m^3) experimental systems that allow for long (weeks-months) ecosystem-scale research, are ideally suited for connecting small-scale testing and development with controlled assessment of ecosystem risks related to climate change mitigation efforts.

Product / service created in the demonstrator:
A harmonized across-system mesocosm experimental service to support design, evaluation and risk assessment of ocean CO_2 removal techniques.

Foreseen main users of the product / service:
Researchers, modelers, and companies focused on developing, testing and optimizing ocean-based CDR technologies for potential scaling.

How will the product / service benefit the main users:
It will provide a novel integrated service for near-real ecosystem-scale experimentation in distinct coastal marine environments, suitable for assessment of both specific local risks and supersite cross-validation to assess the generality of the findings.

Involved Research Infrastructures and their roles:
- EMBRC (affiliated entities: HCMR, UH, CCMAR, UVIGO): Provision of mesocosm experimental services
- SeaDataNet (RBINS): Data management
- ICOS (UH): Data provider

Project beneficiary leading the demonstrator:
Universidade de Vigo (UVIGO), Spain

2.5 Demonstrator 5

Demonstrator name:
Risk on food security due to multi-hazard risks (pests, diseases, drought, heatwaves)

What is the challenge / risk to which the demonstrator will provide answers:
Increasing hazards of multiple biotic and abiotic risks related to climate change and expected increased weather variability, including increased frequency, duration and intensity of extreme events. Unknown impacts on food production quantity and quality, difficult to predict and thus difficult to apply measures against the impacts of risks, including difficult long-term adaptation, especially in the case of biotic risks.

Product / service created in the demonstrator in one line:
Online tool providing spatial (map) visualization of individual and combined biotic and abiotic risks in agriculture (AgroRisk portal) based on available models and weather data including weather forecast.

Foreseen main users of the product / service:
Farmers, government, insurance companies, academia

How will the product / service benefit the main users:
The web portal will enable farmers informed decision-making when applying preventive measures or measures to limit the increase in losses caused by multiple biotic and abiotic stresses. It will also enable the state administration to build the network supporting long-term risk reduction measures, and to make informed decisions on research priorities to address risks with increasing severity. It will enable insurance companies to develop tools that will allow for informed estimation of crop, fruit and vegetable damages and also their prevention.

Involved Research Infrastructures (RI acronym and role):

- AnaEE: Data provider
- ICOS: Data provider

Project beneficiary leading the demonstrator:
USTAV VYZKUMU GLOBALNI ZMENY AV CR VVI (CzechGlobe), Czech Republic

2.6 Demonstrator 6

Demonstrator name:
Risk on multiple systems due to wildfires in Europe

What is the challenge / risk to which the demonstrator will provide answers:
The main risk addressed by the Demo 6 is the enhancement of wildfire emissions and related risks on multiple (eco)systems. Demo 6 will provide improvement of knowledge, for answering also the following related questions:

- Which regions are most affected by wildfires and how high are the modelled and observed atmospheric concentrations during such events?
- Are there significant differences in chemical and physical properties of fresh and long range transported fires emissions? How well are these represented into models?

Product / service created in the demonstrator:
Improved knowledge, automatic flagging system, and an integrated data set on 4-dimensional distributions of wildfires emissions

Foreseen main users of the product / service:
Researchers in climate, air quality, health, carbon neutrality, ecosystems:
Copernicus services like CEMS, CAMS and C3S, and EOSC
Socio-economic sector users (e.g. air quality management systems)

How will the product / service benefit the main users:
The collected information will provide a dedicated in situ dataset of high quality describing 4d wildfire plumes. This would be highly valuable for scientific studies but also as a diagnostics tool for assessing the ability of the Copernicus models to reproduce such plumes (spatial extent and chemical composition). Finally, this collection of wildfires information will form the scientific basis for the evaluation of the impacts of such events.

Involved Research Infrastructures and their roles:

- ACTRIS: Provision of specific products from aerosol vertical profiling and aerosol-trace gases in situ observations related to fires. Improving near real time (NRT) provision of these data for fires cases. Platform implementation. Provision of Flexpart footprint analysis and forward analysis for ACTRIS and ICOS observatories

- IAGOS: provision of CO, ozone and other fires-related species. Provision of Flexpart footprint analysis for all IAGOS observations and forward analysis for selected extreme events over IAGOS airports
- ICOS: provision of CO, CO_2, isotopes

Project beneficiary leading the demonstrator:
Consiglio Nazionale delle Recerche (CNR), Italy

3. Implementation timeline and reporting

The development and implementation of the demonstrators can be summarized in the following steps:

- Demonstrator identification during the IRISCC project planning phase
- Demonstrator concept full design M1–M6
- Demonstrator technical specification M7–M12
- Demonstrator implementation and onboarding M13–M30
- Second Service Release in M30
- Demonstrator evaluation and service provision M31–54

Annex 7 (See Section 4) gives a listing of WP4 and WP6 tasks and deliverables which are relevant for the specification, development and implementation of the demonstrators, and which are mentioned in the more detailed process description below in sections 3.1-3.4.

3.1 M1–M6 activities and results

The demonstrators were planned at conceptual level and presented already in the IRISCC project proposal in March 2023, but the timeline and process for implementing the demonstrators started in April 2024 at the onset of the IRISCC project. The first six months of the project included more detailed planning and initial design of the demonstrators, which resulted in the initial concept descriptions and plans as provided in IRISCC Deliverable D4.1 (this document).

For the realization of the demonstrators, a close cooperation is planned between WP4 and WP6. Related to the demonstrators, the objective of WP6 is to deploy and provide the technical interoperability framework for integrated IRISCC services. For that purpose, WP6 will interact with the teams developing integrated services via demonstrators in WP4, to arrange that their services will achieve required FAIR-ness (Findable, Accessible, Interoperable and Re-usable) and technical interoperability. WP6 offers to WP4 the D4Science Virtual Research Environment (VRE) for development, integration, deploying, supporting operations and exploitation of services.

Considering WP4 and WP6 activities, the actions proposed in sections 3.2-3.4 for going from concept and initial plan to more detailed specifications for each demonstrator and the way in which demonstrators can make optimal use of D4Science to the actual development and implementation.

3.2 M7–M12 activities and results

As part of Task 6.3 the adoption and possible expansion of the D4Science VRE e-infrastructure functionalities managed by CNR-ISTI will be analysed, to support the development of functional and technical specifications for the demonstrators. This has started with producing public Deliverable D6.2 "Analysis report of D4Science VRE fitness for purpose and adaptation required" published in Zenodo in September 2024 (Month 7, DOI **10.5281/zenodo.13866275**).

Deliverable D6.2 together with this Deliverable D4.1 will provide input for setting-up a joint WP4–WP6 Workshop in Autumn 2024. The Workshop will bring the developers of the demonstrators and D4Science VRE closer together and this should result in better mutual understanding and more firm ideas about the proposed integration. These ideas will need to be elaborated and therefore it is proposed to set-up six parallel specification trajectories as part of Task 6.3 for formulating functional and technical specifications for the integration of each demonstrator. This will be followed by a second joint online Workshop in early 2025 with the aim to get a set of functional and technical specifications and a more detailed development plan by March 2025 (M12).

Task 6.3 will also work on configuring and launching a version of the D4Science VRE for IRISCC, on which demonstrators can get an account and start their initial steps for getting more acquainted. These activities will lead to Deliverable D6.4 due in M10 which will report on the deployed and launched IRISCC interoperability framework with guidance documentation for service developers.

Task 6.5 will look into arranging a gateway from IS-ENES Virtual Research Environment (VRE) to the IRISCC D4Science VRE for providing access to climate model data. As part of Task 4.2 IS-ENES partners will make available all the historical and future climate projection information from climate modelling to support the demonstrators.

3.3 M13–M30 activities and results

The development and implementation of the demonstrators, following the agreed specifications, will continue until September 2026 (M30), when the demonstrators are released in the IRISCC service release 2. This will be done again in close cooperation between WP4 demonstrator teams and WP6 VRE experts, namely by means of Task 4.3 and Task 6.3. This implementation includes also the needed connections to climate modelling products when needed, and the technical onboarding of the services into the IRISCC service catalogue. The full technical description of each demonstrator service will be provided in IRISCC Deliverables D4.3 – 4.8, all due in September 2026.

In the same timeframe, Task 4.2 aims to make available and tailor all the historical and future climate projection information from climate modelling to support the demonstrators, where needed. This will include specific work to identify the best possible information that can be made available to each demonstrator using global (CMIP) and regional (CORDEX) climate modelling data. This analysis will be performed, and the results utilized along the path of the demonstrator development and the results will be summarized in Deliverable D4.2 in May 2026 (M26).

Task 6.3 will provide technical support to the demonstrator teams during development, implementation, and following operation. This will also apply to possibly making connections to external services, such as for data and computing.

In the meantime, from M12 to M18, Task 6.4 will design and implement a test procedure for newly integrated and developed IRISCC Scientific and Knowledge Services to steer and ensure the technical interoperability and propose their acceptance for operational deployment after testing to the IRISCC Catalogue of services (WP7) and connecting to transnational and virtual access provision (WP9 and WP10). The technical test procedure for approving integrated IRISCC digital services will be documented in Deliverable D6.8 in September 2026 (M18).

3.4 M31–M54 activities and results

The final stage of the demonstrator work is the maturity assessment of the services, done during the late implementation phase and the months following the service release. The results of this work will be presented in Deliverable D4.9 in March 2027 (M36), after which WP4 ends. The demonstrator development work is over at that point, but the services will be available to users via IRISCC service catalogue until the end of the project, and via other channels after that time point, if proven to be relevant.

4. Annexes

List of Annexes:

- Annex 1: Detailed description of demonstrator 1
- Annex 2: Detailed description of demonstrator 2
- Annex 3: Detailed description of demonstrator 3
- Annex 4: Detailed description of demonstrator 4
- Annex 5: Detailed description of demonstrator 5
- Annex 6: Detailed description of demonstrator 6
- Annex 7: Overview of WP4 and WP6 tasks and deliverables

Annex 1: detailed description of demonstrator 1

Risk on human health in urban areas during heatwaves associated with deteriorated air quality

Part 1: Meta data

Demonstrator number:
#1

Demonstrator name:
Risk on human health in urban areas during heatwaves associated with deteriorated air quality

Leading beneficiary (participant number in IRISCC, acronym and full name):
15, UU, Universiteit Utrecht

Demonstrator leader (person(s)):
Roel Vermeulen

Other participating beneficiaries (participant number, acronym, and main contact person):
To be determined

Involved Research Infrastructures (RI acronym and role):

- EIRENE: Provision of platform for linkage of environmental data to health records
- ACTRIS: Provision of air quality and climate data
- IAGOS: Provision of air quality and climate data

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
Challenges: Summer periods in Europe have become synonymous with extreme heat and poor air quality (AQ). The combination of both hazards can be particularly detrimental for human health. More research is needed to understand the nexus between climate change and air quality. To foster this research linkage between air quality, climate and health data

is needed. While within the environmental community air pollution and weather information is used in health analyses this may not use the most advanced information and modeling of air quality and climate data.

Product / service created in the demonstrator in one line:
The demonstrator makes available and integrates air-quality (AQ) relevant data (e.g., ozone, fine particles, black carbon, oxidative stress potential of particles, chemical composition from ACTRIS, IAGOS) through the EIRENE Exposome-Maps platform. This will allow users to link air quality and climate data to health records to further research in this area.

More detailed description of the product / service:
Data on air pollution and climate are a very valuable resource for scientists and policy makers, however using these data from different sources can be difficult. Data can be difficult to combine because they are hard to find or are offered in formats that are not easily combined. In addition, exposure maps are large datasets which makes linking computationally intensive.

The product will provide a single access point for linking coordinates to data on air pollution and climate to health outcomes. The access point will be a catalogue that lists and describes available data from different sources and the possibility to upload coordinates to link to these exposure data. In the back end, a harmonization strategy will be developed that enables combining geospatial data.

The Exposome-Maps facility will also offer other environmental data such as noise, built environment variables (e.g. green, blue, grey space, walkability, Fig A1-1). Such information is valuable in etiological research to accurately study the effect of air pollutants and climate and helps in studying potential mitigation measures such as increasing greenness.

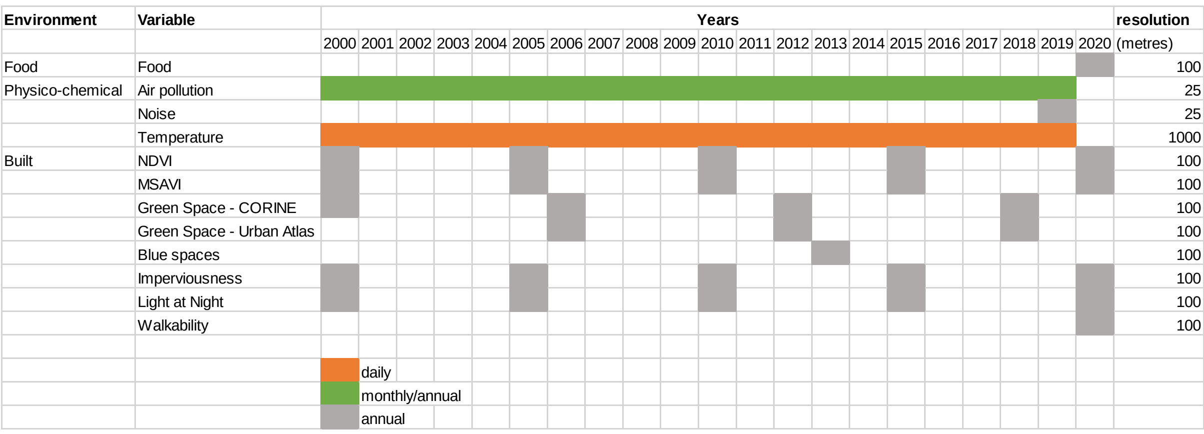

Figure A1-1. Temporal and Spatial resolution of the external exposome variables currently available through the Exposome-Maps platform.

To date the following information is available on air pollution and climate in the exposome-maps facility.

Air pollution: Air pollution models do exist for Europe but not at the required extent (Europe), spatial resolution and not for the timeline needed (2000-2019). New models were therefore developed, building on previous work in the ELAPSE project where hybrid LUR models for Western Europe were developed for 2010 combining routine monitoring, satellite observations, chemical-transport modelling and fine spatial resolution traffic and land use predictors. Shen and colleagues developed models predicting monthly and annual average concentrations (2000 – 2019) for ambient NO2, PM2.5, PM10 and O3 for Europe at a fine spatial scale (25x25 m). Compared to the ELAPSE model, we modelled individual years for a 20-year period, instead of a single year combined with back-extrapolation based on a CTM; improved the spatial resolution (100*100m to 25*25m); increased spatial coverage (more countries) and allowed different relationships between predictors and concentrations across Europe. The development of the annual models is described in detail elsewhere. In brief, geographical weighted regression (GWR) outperformed supervised linear regression and random forest explaining on average 0.66, 0.77, 0.62 and 0.58 of the spatial variation for respectively NO2, PM10, PM2.5 and O3 (five-fold hold-out-validation). Air pollution concentrations measured at AIRBASE monitoring sites were used to calibrate and validate the models and a range of spatial and temporal predictor variables were used to help explain the variation in these measurements. The development of monthly models followed a similar methodology as with the annual models. A five-fold cross validation yielded moderate to good performances (R2: 0.31-0.66 for NO2, 0.4-0.79 for O3, 0.4-0.78 for PM10, 0.46-0.87 for PM2.5). For the remainder of the analysis presented here we will focus on the annual air pollution models.

Temperature: Minimum, maximum and mean daily temperatures over a long time series are important to investigate influences of cold spells and heatwaves on health. This data is globally available from ERA5, but the resolution (10x10 km) is too coarse to detect within city variability needed for health studies. Time series studies are typically based upon measurements from weather stations, which are typically located outside urban areas. Weather stations therefore also do not take the typically higher urban temperatures (urban-heat island effect) into account. We therefore aimed to model ambient temperature at the finer 1x1 km resolution. In short, a 2-stage hybrid approach was used to estimate daily minimum, maximum and mean temperature at a 1x1km resolution for Europe between 2003 and 2020. The first stage developed random forest models to impute missing values in day and night Land Surface Temperature (LST) from the MODIS instrument on board the AQUA and TERRA satellites (4 products). Stage 1 models explained on average 81% of spatiotemporal variability in LST measurements. In the second stage ambient temperature (Ta) was modelled using random forest. Ta measurements were collected from global (GSOD), regional (ECAD) and local (METEOSwiss & Chequia) ground monitoring networks. Stage 2 predictor variables included LST (from stage 1), CORINE Land-Use classes (CLC), CORINE impervious density, population density, and meteorological variables. Stage 2 models explained on average 93% of the variability in minimum, maximum and mean daily Ta measurements (in degrees Celsius) (using 5-fold cross-validation) with and average mean of RMSE of 1.4, 2.0 and 1.9 °C for respectively mean, min and max Ta.

Type of product / service (data, virtual access, physical access, other)
Virtual access

Foreseen main users of the product / service:
Target users are academics, public authorities, relevant sectors (e.g., urban planners, construction, housing, health), and the public.

How will the product / service benefit the main users:
The product will allow users to link a wide variety of sources containing information on air quality and climate to health outcomes collected in cohort studies in a single access point. These data can be used to study the relation between air quality, climate and disease and can inform public authorities and policy makers on regional variation in health risks of air pollution in the context of climate change.

How will the users access the product / service:
Curators of geospatial exposure information on air pollution and climate can upload their resource in the Exposome-Maps platform. Data will be curated and made FAIR so that stakeholders can find the data resources.
For health analyses users will be able to upload a dataset containing geolocations of interest. These geolocations will then be linked to the exposures of interest and returned to the user. This will allow health analyses on these factors.

Is there a limit for amount of use of the product / service:
There is no limit for the amount of use. However, the linkage procedure is computationally intensive so linkage needs to be coordinated, especially for large datasets.

What support is needed from the provider side for the use of the product / service:
Because of the complexity of the data and to ensure data requests meet privacy standards and limitations to data use, each linkage require some manual work. Scripts to perform the linkage are available but an environment needs to be set up to run them. In addition, some administrative tasks have to be performed to register which linkages have been performed. Exposure maps might be updated occasionally, this involves some work for instance in keeping up to date the metadata.

How will the usefulness of the service be measured:
Usefulness of the service will be measured by the the following KPIs.

- Number of requests for information on the service
- Number of usage of the service
- Number of scientific and policy outputs referencing the service

Other comments:
-

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:
The product will provide a single access point for data on climate together with data on air pollution allowing linkage to health records. There are no explicit modelling needs as we expect that the exposure surfaces are made temporally and spatially explicit.

General description of use:
The platform has dual use purposes.

1. It allows the curator of air quality and climate data to make their resource available for linkage to health records.
2. It allows health scientists to link health records to geospatial information of these factors.

Needed spatial coverage:
The current exposure maps included in Exposome-Maps are calculated at different resolutions (25m, 100m or 1000m) for the whole of Europe (EU27 (minus Malta, Republic of Cyprus) + United Kingdom, Norway, Switzerland, Serbia, Kosovo, Albania and North Macedonia), unless otherwise indicated. We used the ETRS89-LAEA projection (ESPG:3035) in all our GIS analysis and GIS datasets.

Needed spatial resolution:
The current exposure maps included in Exposome-Maps are calculated at different resolutions (25m, 100m or 1000m). As health studies are increasingly interested in hyper-local variations it is preferable to have resolutions below 100m.

Needed temporal resolution:
Data on air pollution are available per month from the year 2000 till the year 2019. Currently this is extended to the year 2023. For temperature daily information is available for the same time period. These are minimal time-scales needed for current health investigations.

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
Users can upload a dataset with coordinates that they can link to the climate and air pollution data made available on the platform. There are various levels of automation that will increase the complexity of the portal infrastructure.
The portal will consist of a landing page that documents all available sources from which data of interest can be selected to be linked to the users health data. In addition, it will provide the option to upload a set of coordinates that can be linked to the exposure data.
At the back end, a set of scripts will run to link the health data to the exposures of interest and log every data request. A D4Science VRE could provide the necessary computational

power to link these large datasets, provide storage for the data and a Shiny dashboard can be used to create the catalogue of data.

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, …):
Galaxy workflows in combination with a Python environment with Jupyterhub on the Analytics Engine could be used to create reproducible workflows to perform the linkage. A shiny app could be used to create the catalogue.

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
For efficient linkage of geolocations to climate and air pollution data, the platform needs sufficient (fast) storage linked to a high performance virtual machine. Because the volume of data storage is large, an efficient network connection between the storage location and the VRE that performs the linkage is crucial. For a single data linkage, an 8 core machine with 32GB of RAM is sufficient for processing large datasets (millions of coordinates). There needs to be the option to flexibly scale up in case parallel data linkage requests have to be handled.

What programming language(s) is/are used within your demonstrator:
Python

What data formats are used within your What demonstrator:
GeoTIFF, csv, Cloud Optimized GeoTIFF and NetCDF4

How much storage space will be needed for using the service and storing the input/output:
The total storage for all current Exposome-Maps data amounts to around 10TB. In addition, 2TB of output storage is needed to provide sufficient space to temporarily store linked data. As the products coming from ACTRIS and IAGOS are currently unknown it is difficult to estimate total storage demands.

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
Initially, we will work with data from EIRENE and ACTRIS and IAGOS.

Other technical details

Other comments you want to provide:
-

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:

The portal still needs to be further designed and developed. However, we will be able to reuse experience gained for similar projects and built from the current version of Exposome-Maps.

What data / capacity / capabilities exists already:
Exposure maps for air pollution and temperature are available. Python scripts to perform linkages are available too.

What data / capacity / capabilities need to be developed:
The portal that users interact with has to be further designed. Data from ACTRIS and IAGOS have to be harmonized to be used with the Exposome-Maps data.

Roles of each participating beneficiary in creating the product / service:

- EIRENE: Provision of operational parameters for geospatial data.
- IAGOS: Provision of exposure maps. These need to be spatially and temporally explicit. Linkage to individual points, measurements stations will not be facilitated.
- ACTRIS: Provision of exposure maps. These need to be spatially and temporally explicit. Linkage to individual points, measurements stations will not be facilitated.

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):
September 2024 – November 2024: create an inventory (selection) of available data sources on ACTRIS and IAGOS that are suitable for offering on the platform.

How will the progress of implementation be measured / followed:

Main challenges and risks in implementing the product / service:
The main challenges and risk are:

- Information on air pollution and climate are not in the correct format (spatially explicit and fine spatial and temporal resolution)
- Data recourses are too big for the infrastructure to allow for secure linkage to health records.

Other considerations for implementing the product / service:

Annex 2: detailed description of demonstrator 2

Risk on coastal regions due to flooding caused by sea-level rise and storm surges

Part 1: Meta data

Demonstrator number:
#2

Demonstrator name:
Risk on coastal regions due to flooding caused by sea-level rise and storm surges

Leading beneficiary (participant number in IRISCC, acronym and full name):
7, MARIS, MARIENE INFORMATIE SERVICE MARIS BV

Demonstrator leader (person(s)):
Dick Schaap

Other participating beneficiaries (participant number, acronym, and main contact person):

- 25, Deltares, Martin Verlaan
- 23, RBINS, Serge Scory

Involved Research Infrastructures (RI acronym and role):
Under consideration: SeaDataNet, IS-ENES, Copernicus Climate, Copernicus Marine

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
Coastal flooding is a major hazard for many coastal regions that causes damages in the order of tens of billions of dollars per year. Worldwide, the number of people and economic assets exposed to flooding in the low-lying coastal zone are increasing, while the frequency and intensity of this hazard are aggravated by climate change, causing sea level rise, more extreme rainfall, and changes in storminess. At the same time, more and more people migrate to coastal regions. Analyzing the risks, studying the potential impact of climate change and changes to the land-use, as well as design and study measures to improve coastal defence or to reduce the damages, requires a wide range of data. Here models are

a key tool to study the causal effects and compare scenarios. However, creating all the required models, creating the necessary connections, running all the computations, and visualizing and studying the output requires much effort, which is currently hampering detailed studies of flood risk. The tools provided in this demonstrator aim to make the setup, running and visualization much faster, by automating a large part of the work.

Product / service created in the demonstrator in one line:
Environmental in situ data, Earth Observation (EO) data (remote sensing) and derived information, and socio-economic data can advance capabilities for coastal flooding risk analyses. In IRISCC, a Jupyter notebook will be developed to facilitate the assessment of flooding in coastal areas due to storms in combination with long-term sea-level rise due to climate change.

More detailed description of the product / service:
The IRISCC flood risk service will be accessible through a website/portal and doesn't require installing any software locally. It provides a wide range of tools within an automated workflow (Fig. A2-1). The main interface uses Jupyter and allows for workflow control with a graphical user interface. Yet, it also exposes the scripts that control the workflow and the underlying processing steps, which provides enormous flexibility to those who need it. The components of the service can be divided in a few categories:

- **Interface**: a collection of Jupyter notebooks with buttons, figures and other graphical elements allow for control of the main functions. However, the python code in the notebook can be adjusted as desired, e.g. to import additional data.
- **Workflow manager**: the collection of tools is connected in workflows, which can be run in pieces, but the entire workflow can also be scheduled in one go.
- **Imports**: a flood risk assessment requires a wide range of information. The IRISCC flood risk service will come with all the necessary datasets for a basic analysis preconfigured. Some of the imports are:
    - **Meteorological reanalysis or climate map**s. A prime example is the excellent and widely used ERA5 global weather reanalysis that provides global grids of meteorological variables such as air pressure and surface winds. These are necessary to drive storm surge and waves.
- **Model runs**: a workflow generally contains multiple models that connected together relate the meteorological and climate drivers to the potential damages. The core models are:
    - **Tide and surge model**: this model can compute the sea level time-series near the coast using winds tidal forcing and SLR.
    - **Wave model**: this model can compute wave spectra and parameters such as wave-height and wave period using wind as input.
    - **Wave transformation models**: close to the coast waves are transformed by the presence of the coast. This can be very complex, and many physical processes may be involved. For example, waves can run up against a levee, may overtop a seawall or erode a barrier island and eventually create a breach. In addition, bound infra-gravity waves may be released and aggravate the attack against the coast.

  - **Flood model**: When Sea water starts to flow over land, this is called flooding. This can happen locally behind a seawall or cover many square kilometers after a breach.
  - **Damage models**: these models relate flooding to damage. Larger flood depths will generally result in more damage, but early warning leading to evacuation or moving the most vulnerable assets can reduce damage significantly. Other models may consider critical infrastructure and compute which areas cannot be reached over the road during a flood.
  - **River models**: Most storms also produce rain in addition to strong winds. Especially in deltas, this may lead to an additional pressure to flooding when the rain accumulates in rivers that also flow to the delta.
- **Measures**: To mitigate the effects of flooding, several measures can be taken. These will affect for example the computations of the flood model, the damage models or both.
- **Model builders**: All of the models above need to be configured for an application to a specific region. This can be a time-consuming task that also requires detailed knowledge of each model. Some of the steps are collecting data used by the model and converting it to a format that is accepted by the model. Configuration files typically have many options, e.g. to switch between different parametrizations and set parameters for these parametrizations. Model builders aim to automate this task. Ideally, all model input is generated simply by selecting the area and timespan of interest.
- **Visualization and analysis**: A final but crucial step is the creation of figures and tables that summarize the results of the assessment clearly and support the analysis.

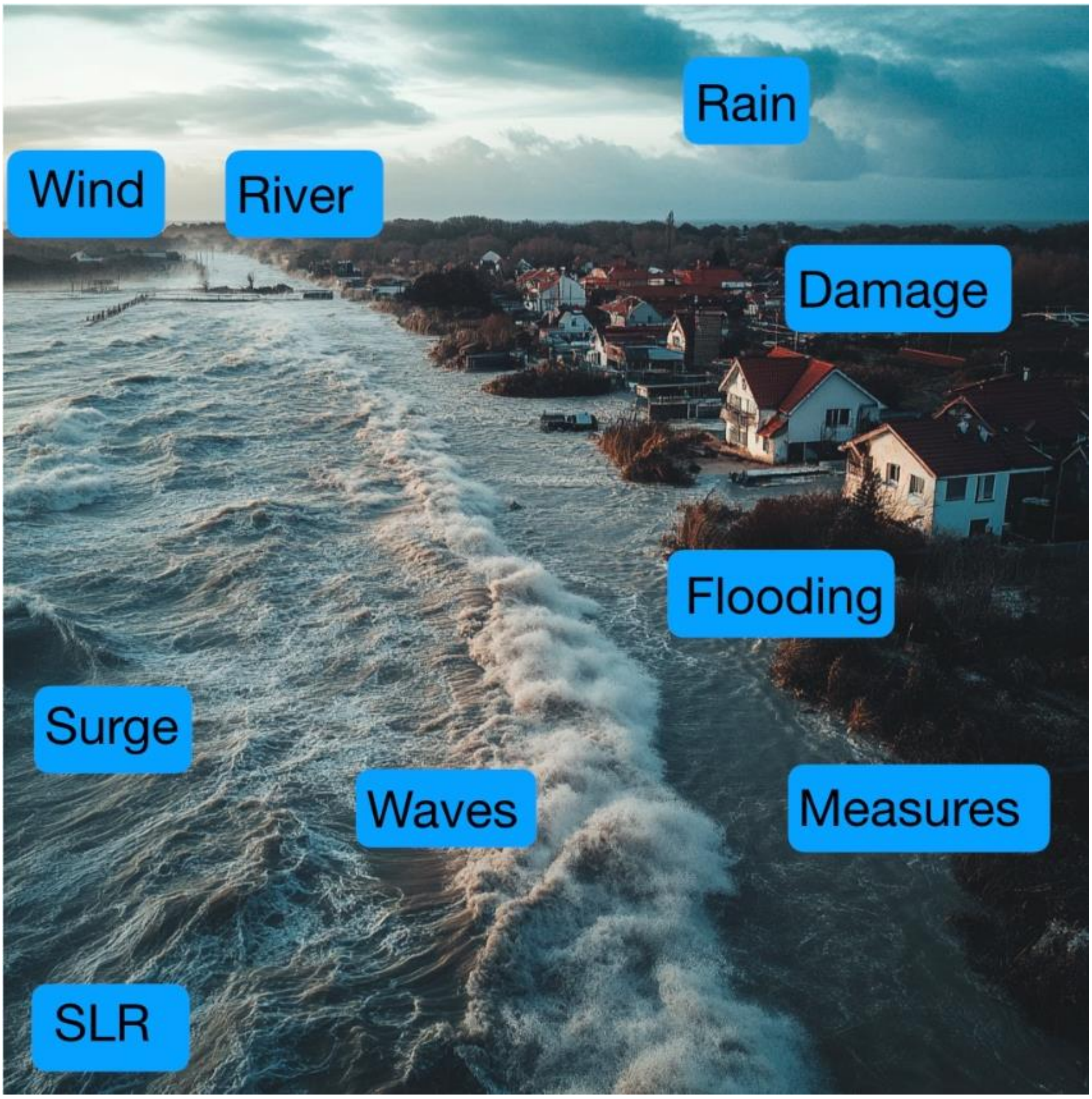

Figure A2-1: A workflow for flood risk assessment consists of a workflow with numerous steps.

For example, the output of storm surge models and wave models are in turn input to the flood model. These components together allow the user to run and assess several scenarios of storm surges, sea level rise, and climate change for their impact on flooding, using the existing geometry and to vary geometry and vegetation etc.

Generating full workflows with accurate models from scratch anywhere in Europe is not possible yet, but many parts are already working. Within IRISCC the starting point will be a use case for the flooding in the Humber estuary on December 6, 2013.

Storm Xaver: On December 5th, 2013, a large and deep low-pressure system developed over the North Sea. The resulting storm surge that coincided with spring tides caused severe flood risk for Northern Europe. In the Humber Estuary, it resulted in the highest water levels in measurement history (Fig. A2-2). In the Humber Estuary 1100 properties and over 7000 hectares of land were flooded (Fig. A2-3). The tidal surge also had a significant impact on industry and infrastructure around the estuary, which had cascading effects on trade, transport and production.

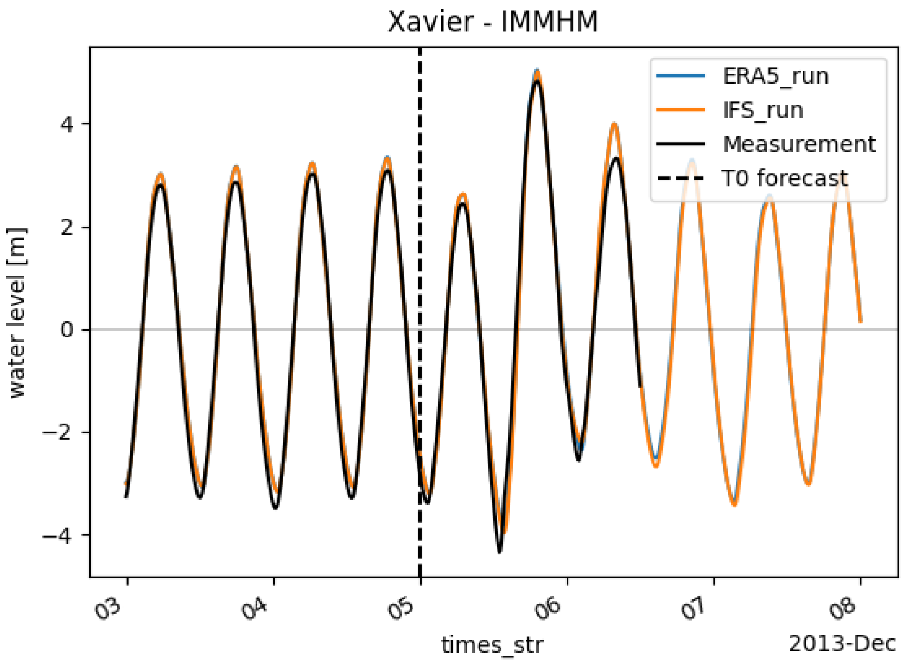

Figure A2-2. Time-series of measured and modeled sealevel at the tide gauge of Immingham in the Humber estuary.

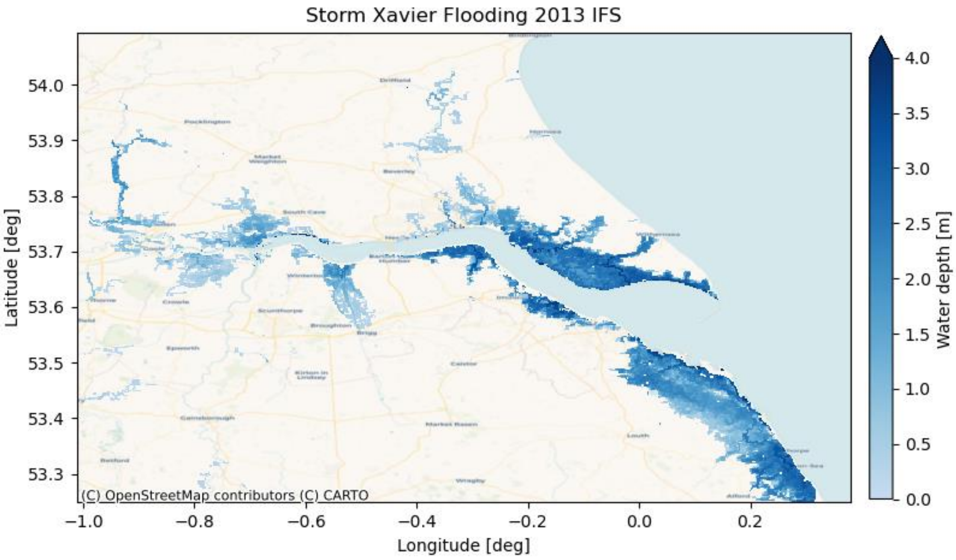

Figure A2-3. Computed flood map for Humber estuary during the storm Xaver.

Type of product / service (data, virtual access, physical access, other)
We're talking about an online service with access to data, but with at the core a workflow with several numerical models. Online (virtual) service that allows user interaction, creation of new datasets, and subsequent download. This service is based on a set of workflows with several numerical models to facilitate the creation of user defined data.

Foreseen main users of the product / service:
Researchers working on the assessment of coastal flood risks and its impacts, as well as on adaptation measures development. Engineering companies that play an important role in the development and design of measures to mitigate or cope with changes in flood risk.

How will the product / service benefit the main users:
Impact assessment of coastal flood risk requires a sequence of modelling steps that are time-consuming to set up. The service aims to provide a flexible and relocatable workflow, that can be adapted to many studies around the globe. This service will also allow users to specify multiple climate- or anthropogenic-based scenarios to simulate.

How will the users access the product / service:
Online through D4Science platform. This will require further knowledge about D4Science and interaction with D4Science experts to discuss technical aspects of the access and operation.

Is there a limit for amount of use of the product / service:
Yes, it's limited by the availability of the underlying resources, such as storage and computational capacity.

What support is needed from the provider side for the use of the product / service:
We aim to provide online guidance material and training material for the services.

How will the usefulness of the service be measured:

- Idea: Interview users about their experiences with the service.
- Idea: If possible, from technical side, it would be beneficial to record number of users, number of returning users, as well as other usage statistics (KPIs).
- Through community engagement during trainings / commentary option with online training materials.

Other comments:
-

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:
Service will use water and meteorological climate reanalyses for forcing of the underlying models. It will also create new simulated spatial series which will be available for the users.

General description of use:
User enters the service web page. They choose area of interest, modelling parameters, scenario (such as sea level rise value or protective measures), needed output (?). Then they start the model which runs centralised in the background using remote / cloud computing. User receives modelling results after specified runs have finished and have option to study or download (parts of) the output. Repeat if necessary.

Needed spatial coverage:
Worldwide or extended Europe

Needed spatial resolution:
To be determined. Could vary from global to local

Needed temporal resolution:
To be able to reflect extreme events, thus from daily to hourly or 10-minute intervals.

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
It is envisaged that the services of this demo will run on the D4Science environment. To make a plan of how this can be achieved the first step is to learn more about the technical details of the D4Science services.

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, …):
To be determined, however most likely at least infrastructure capacity and Jupyterhub

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
Depends on the scale of application and D4Science capacity

What programming language(s) is/are used within your demonstrator:
Python (Jupiter)

What data formats are used within your demonstrator:
Output as NetCDF

How much storage space will be needed for using the service and storing the input/output:
Depends on the scale of application and D4Science capacity

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
Water and meteorology forcing data from CMEMS, ERA5, and other. Bathymetry data from EMODnet. Will be obtained through relevant APIs within the produced workflow.

Other technical details

Other comments you want to provide:
We are in favour of having an online workshop to learn more about D4Science and this way to assess better how our use could be implemented as a service on D4Science.

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:
Underlying workflows for modelling procedures are in an advanced stage of development, however they still require further additions to functionality and robustness. Main effort within this project will be on adding relevant functionality / models related to flooding hazards and adapting the existing solutions to capabilities and restrictions of D4Science.

What data / capacity / capabilities exists already:
Underlying workflows for modelling procedures without certain functionality relevant for IRISCC scope.

What data / capacity / capabilities need to be developed:
Relevant functionality related to IRISCC scope for underlying modelling workflows. Adaptation of the existing solutions to capabilities and restrictions of D4Science.

Roles of each participating beneficiary in creating the product / service:
Deltares: Lead developer of the application
MARIS: Use case manager, interacting with D4Science, and data provision
RBINs: Application validator considering their expertise with water management

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):

Time Frame:	–	Ready:
August 2024	–	Draft implementation planning.
October 2024	–	Final planning and timeline.
January 2025	–	Start of implementation of pre-existing workflows on D4Science environment.
January 2026	–	Finished work on service's additional functionality.
June 2026	–	Training material is ready and disseminated.
September 2026	–	Service is fully developed and operational on D4Science.

How will the progress of implementation be measured / followed:
Through regular multi-level progress meetings within each of the participating organisations, between the participating demonstrator #2 entities, and whole Task 4.1 group.

Main challenges and risks in implementing the product / service:
Without explicit understanding of capabilities and capacity of D4Science services, there is high probability of facing restricting issues or lack of required resources / functionality along the way.

Other considerations for implementing the product / service:
-

Annex 3: detailed description of demonstrator 3

Risk on terrestrial ecosystems functioning and services due to droughts and heatwaves

Part 1: Meta data

Demonstrator number:
#3

Demonstrator name:
Risk on terrestrial ecosystems functioning and services due to droughts and heatwaves

Leading beneficiary (participant number in IRISCC, acronym and full name):
17, FZJ, Forschungszentrum Jülich GmbH

Demonstrator leader (person(s)):
Harry Vereecken. Other contacts: Alexandre Belleflamme and Christian Poppe Terán

Other participating beneficiaries (participant number, acronym, and main contact person):
18, UFZ, Luis Samaniego and Husain Najafi

Involved Research Infrastructures (RI acronym and role):
eLTER: Data provider
ICOS: Data provider
AnaEE: Data provide.

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
Increasing hazards of multiple biotic and abiotic risks related to climate change and expected increased weather variability, including increased frequency, duration and intensity of extreme events. Unknown impacts on food production quantity and quality, difficult to predict and thus difficult to apply measures against the impacts of risks, including difficult long-term adaptation, especially in the case of biotic risks.

Product / service created in the demonstrator in one line:
Online data visualization dashboard showing drought risks and impacts on ecosystem functioning for the past, present and future scenarios.

More detailed description of the product / service:
Output data from long-term simulations of hydrology (mHM) and ecosystem processes (CLM5) will be used to visualize the impact of drought risk on ecosystems functioning across Europe. There will be one section for each model (hydrology/carbon). Each section will present maps of expected drought risk, with a time slider to query a map for a specific point in time (decadal statistics). You can query a drought risk time series by clicking on the desired location on the map or giving latitude/longitude values. Depending on when the demonstrator is operational, the underlying model outputs can be updated (e.g., new atmospheric forcing new model setups). In the map and time series visualizations, the drought risk of a historical period will be displayed as a reference, as well as observations from eLTER and ICOS. The reference period can be updated, and new eLTER and ICOS measurements can be continuously implemented. In every section and visualization, we will provide uncertainty estimates based on atmospheric forcing uncertainty (and potentially model parameter uncertainty).

Type of product / service (data, virtual access, physical access, other)
Distilled data and visualization of relevant indices in an online dashboard.

Foreseen main users of the product / service:
Academics, public authorities, water, forestry, and agriculture sector.

How will the product / service benefit the main users:
Enable best-informed decision making in managing water resources and carbon states based on scientific modelling and evaluations with ground-truth data.

How will the users access the product / service:
Through a website.

Is there a limit for amount of use of the product / service:
No.

What support is needed from the provider side for the use of the product / service:
Operating the dashboard, connecting a data-set and visualizing user-selected sub-sets of the data.

How will the usefulness of the service be measured:
Track the number of total and returning users per week and evaluate the number and impact of supported decisions.

Other comments:
-

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:
As atmospheric forcing for simulations of terrestrial hydrology and land surface.

General description of use:
Input to both models, forcing the model with meteorological conditions. Needed variables are on one – surface – level: Temperature, precipitation, atmospheric pressure, relative humidity, wind speed, incoming shortwave radiation and incoming longwave radiation.

Needed spatial coverage:
European Cordex Domain (https://cordex.org/domains/cordex-region-euro-cordex/).

Needed spatial resolution:
Best case: 3 km

Needed temporal resolution:
Minimum 6 hourly, best case: 3 hourly or lower

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
Providing online dashboard service exhibiting the visualizations of the simulations. Potentially operating the containerized simulations workflow.

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, ...):
- *Shiny app, Dash app*

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
4 CPUs, 32 GB RAM

What programming language(s) is/are used within your demonstrator:
Python

What data formats are used within your demonstrator:
NETCDF

How much storage space will be needed for using the service and storing the input/output:
1 TB (conservative estimate)

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
Reference datasets for historical reference period e.g. ERA5-Land (Climate data store). The demonstrator team will obtain the data themselves.

Other technical details

Other comments you want to provide:

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:
We have prepared the model on the required scales and have the static input data. We need the forcing data to conduct first simulations / spin-ups to be ready for production simulations and to develop the analytical workflow and the dashboard visualization.

What data / capacity / capabilities exists already:
Static input data and model setups.

What data / capacity / capabilities need to be developed:
Forcing data, production simulations, analytical workflows and visualizations.

Roles of each participating beneficiary in creating the product / service:
FZJ: Land surface modelling, analysis and visualization.
UFZ: Hydrological modelling, analysis and visualization.

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):
April 2025: Indices of drought impact on ecosystem readily developed
June 2025: Successful test cases
December 2025: Analysis workflow with test cases complete
February 2026: Production simulations finished
June 2026: Dashboard implemented with production simulation output

How will the progress of implementation be measured / followed:
Functionality of the dashboard and availability to public.

Main challenges and risks in implementing the product / service:
Depending on how long the demonstrator is operational, the need to update the model simulations and therefore the underlying data in the operational demonstrator could arise.

Other considerations for implementing the product / service:

Annex 4: detailed description of demonstrator 4

Risk on marine ecosystem biodiversity, functioning and services caused by ocean acidification, warming and deoxygenation

Part 1: Meta data

Demonstrator number:
#4

Demonstrator name:
Risk on marine ecosystem biodiversity, functioning and services caused by ocean acidification, warming and deoxygenation

Leading beneficiary (participant number in IRISCC, acronym and full name):
12, EMBRC-ERIC, EUROPEAN MARINE BIOLOGICAL RESOURCE CENTRE EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

Demonstrator leader (person(s)):
Pablo Serret

Other participating beneficiaries (participant number, acronym, and main contact person):
23, RBINS, main contact person to be confirmed

Involved Research Infrastructures (RI acronym and role):

- EMBRC (affiliated entities: HCMR, UH, CCMAR, UVIGO): Mesocosm experimental service provider
- SeaDataNet (RBINS): Data management
- ICOS (UH): Data provider.

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
Carbon dioxide removal (CDR) will be likely necessary to limit global warming to no more than 2 °C compared to pre-industrial era. The ocean, with its potential for CO_2 storage,

appears as the more efficient reservoir to be artificially increased. The urgency of the challenge and important knowledge gaps are causing a rapid increase in the engagement of the research community (e.g., **https://oceanvisions.org**) and a technological race between start-ups (e.g., **https://www.equatic.tech**, **https://capturacorp.com**, **https://limenet.tech**). Despite small-scale testing, fundamental questions remain about the additionality and durability of CO_2 sequestered, the scalability and the environmental impact of different technologies. Field trials or large-scale implementation of non-fully validated techniques pose new risks to the marine ecosystem health (diversity, composition and functional integrity) and derived services, which need to be assessed through research and demonstration across relevant scales in controlled environments (for a thorough introduction, see **https://oceanvisions.org/wp-content/uploads/2023/10/A-Comprehensive-Program-to-Prove-or-Disprove-Marine-Carbon-Dioxide-Removal-Technologies-by-2030_FINAL.pdf**). To this aim, marine mesocosms, large (>1 m^3) experimental systems that allow for long (weeks-months) ecosystem-scale research, are ideally suited for connecting small-scale testing and development with controlled assessment of ecosystem risks.

Product / service created in the demonstrator in one line:
A harmonized across-system mesocosm experimental service to support design, evaluation and risk assessment of ocean CO_2 removal techniques.

More detailed description of the product / service:
Given the global ambition of CDR technologies, evaluation and risk assessment need to be 1) representative of ecosystem-scale impacts and 2) scalable across ecosystems. The new service will integrate the EMBRC mesocosm facilities of CretaCosmos (HCMR), FINMARI (UH-TZS), Ramalhete Marine Station (CCMAR) and ECIMAT (UVIGO) to provide a coordinated supersite experimental service for CDR testing across four contrasting marine ecosystems in three EU basins: the ultraoligotrophic E Mediterranean Sea, the brackish and land-subsidised N Baltic Sea, the Ria Formosa coastal lagoon in the South of Portugal (Atlantic Ocean), and the NW Iberia coastal upwelling in the Ría de Vigo (Atlantic Ocean). Common operational procedures, harmonization of outputs and service integration will be based on previous research activities of the participants and transnational collaboration during the EU project AQUACOSM-plus, and will be developed and defined during the implementation phase of the demonstrator (IRISCC Task 4.3). Experimental results, protocols and variables will be made FAIR through the SeaDataNet infrastructure, where possible, with the support of RBINS. This will reduce redundancies and will maximize impact of serviced experiments, providing the single data and variable repository needed for models and DTOs.

Type of product / service (data, virtual access, physical access, other)
Physical access

Foreseen main users of the product / service:
Researchers, modelers, companies focused on developing, testing and optimizing ocean-based CDR technologies for potential scaling.

How will the product / service benefit the main users:
It will provide a novel integrated service for near-real ecosystem-scale experimentation in distinct coastal marine environments, suitable for assessment of both specific local risks and supersite cross-validation to assess the generality of the findings.

How will the users access the product / service:
Users soliciting experimental services are expected to participate in the experiments requested. This is connected to the planned IRISCC TA calls. Users soliciting data from experiments carried out using this service will have access to the generated data through the SeaDataNet infrastructures through previous publications (RBINS).

Is there a limit for amount of use of the product / service:
ECIMAT, CretaCosmos, UH-TZS, CCMAR: There is no limit for the use of mesocosm facilities as long as calendars can be adjusted to commitments.
RBINS: There is no limit for the data access and re-use as all generated data should apply an open access license to comply with H2020 Open Research Data policy. However, an embargo can be requested to allow results publication in scientific journals if necessary. Restricted access to the data may be requested but should be well justified (e.g. commercial use, sensitive data).

What support is needed from the provider side for the use of the product / service:
Users will co-design the corresponding experimental design with support of the selected facility(ies). Each user will bring expertise in the CDR technology to test in order to set and monitor the experimental treatment(s) (e.g., preparation, addition, dissolution of chemicals for alkalinity enhancement). This may include physically bringing pilot or pre-commercial plants to the RI. Participating RIs will support the implementation of the experiment(s) by providing *in-situ* logistical, technical and analytical capacities, including preparation and sampling of mesocosms, monitoring of core and ancillary variables (to be defined, together with harmonised methods and protocols, in the implementation phase of the demonstrator) and supersite coordination. The participant RIs will provide their expertise in experimental design and evaluation of the impact on the marine environment (EMBRC) as well as support with the completion of Data Management Plans (DMPs) and subsequent data management activities (RBINS).

How will the usefulness of the service be measured:
Number of experiments completed, ratio of successful to total experiments carried out, number of published datasets on SeaDataNet reference marine repositories, number of access to data requested, variables implemented through models, publications, contribution to commercial advancement, patents.

Other comments:
-

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:
Not applicable.

General description of use:
Not applicable.

Needed spatial coverage:
Not applicable.

Needed spatial resolution:
Not applicable.

Needed temporal resolution:
Not applicable.

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
Not applicable

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, …):
Not applicable

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
Not applicable

What programming language(s) is/are used within your demonstrator:
Not applicable

What data formats are used within your What demonstrator:
Not applicable

How much storage space will be needed for using the service and storing the input/output:
Not applicable

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
Not applicable

Other technical details

Other comments you want to provide:

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:

- Mesocosm facilities at CretaCosmos (HCMR), FINMARI (UH-TZS), Ramalhete Marine Station (CCMAR) and ECIMAT (UVIGO) are all operational EMBRC services. The integrated service requires harmonization and coordination of capacities that will be developed through the implementation phase.
- SeaDataNet is operating and maintaining SEANOE, a marine data service allowing the publication of data in the field of marine sciences as citable resources. SeaDataNet SEANOE will be the reference data repository on which scientists will publish their generated dataset and get a DOI. In-situ environmental data, if any, will be automatically duplicated to the EMODnet Data Ingestion portal for wider publishing in the European data portals such as SeaDataNet CDI service, EurOBIS and EMODnet thematic portals, if the datasets are of interest for their portfolio.

What data / capacity / capabilities exists already:

- ECIMAT (UVIGO) has all functional capacities necessary to carry out seawater monitoring and benthic and pelagic mesocosm experiments with different simulated tidal range and pace, temperature and light conditions. Automated sensors include temperature, salinity, PAR, and dissolved oxygen concentration. Seawater analyses for inorganic nutrients (NO_3, NO2, NH_4, PO_4, Si), DOC concentration, total and size-fractionated chlorophyll-a, pico-, nano- and micro-eu- and prokaryotic cell size and abundance, ^{14}C net primary production, and O_2 gross primary production, net community production and respiration are available as service.
- CretaCosmos (HCMR-Crete) allows experimental hypothesis-testing at the ecosystem level, at the lower end of the productivity gradient. The facility includes 12 pelagic mesocosms (3 m3) and 9 benthocosms and is complemented by: chemical, radio-isotope, microscopy, flow cytometry and culture labs, sensors for temperature and pH and an automotive lab, inflatable zodiacs, and a 31 m R/V. Since 2009, it has hosted 16 mesocosm experiments and is supported by a research team with well-established experience for handling ultra-oligotrophic waters as well as for the analysis of abiotic (inorganic and organic nutrients) and biotic (chla, abundance/biomass and diversity from fempto- to micro-plankton using microscopy and molecular tools and productivity) variables.

- UH-TZS has capacity to set up flexible mesocosms of up to 5 m3 volume (12 units in a floating raft that can be deployed in different places around the station). In addition there are experimental facilities for aquarium experiments (controlled temperature and light regime, running seawater supply), including 12 indoor 600-litre mesocosms. UH-TZS offers access to the FINMARI Culture Collection, including approx. 100 species strains of Baltic Sea phytoplankton, which can be used in experimental work. Automated sensors include temperature, salinity, and dissolved oxygen concentration. Seawater analyses for inorganic nutrients (NO3, NO2, NH4, PO4, Si), DOC concentration and alkalinity are available as a service.
- CCMAR operates a land-based mesocosms infrastructure, incorporating two complementary mesocosm systems:
  1. Modular outdoor system, flow-through, with up to 40 independent flow-through tanks of variable volumes. Each experimental tank is linked to a dedicated head-tank, allowing true replication and random distribution of treatment levels across the system. The system was conceived to accommodate marine macrophytes (seagrasses and macroalgae) but it is adjustable to other organisms. CO_2 levels are controlled through real-time pCO_2 analysis (IRGA) and injection. PAR, temperature and O_2 levels are automatically monitored in each individual tank.
  2. Indoor flow-through system, with similar operating principle, suitable for smaller volume aquaria. Allows individual manipulation of pCO_2, temperature, PAR and nutrient levels.

Validated and harmonized in situ marine data are already existing in ICOS infrastructure and in the SeaDataNet infrastructures where for SeaDataNet CDI service data are exposed via the and EMODnet portal for diverse parameters such as eutrophication, acidification datasets in the different studied sea basins.

What data / capacity / capabilities need to be developed:

- ECIMAT: Improved mesocosm temperature and turbulence controls, fluorescence sensors and automation of plankton sample counting. Capability for dataset ingestion in SeaDataNet/EMODNET. Set up and calibration of a thermal incubator to assess the thermal sensitivity of plankton.
- CretaCosmos: Increase in sensor-automation capacity, automation of plankton sample counting.
- UH-TZS: Increase in sensor-automation capacity, automation of plankton sample counting.
- CCMAR: Increase in sensor-automation capacity, general infrastructure improvement, tank adaptation for phytoplankton experimentation.

Data originators will need to complete a Data Management Plan to describe what data they will collect, how it will be curated and processed and preserved on the long term. Data originators will need to be trained and supported for their DMP completion as well as the dataset standardization and formatting and the data publication on the target SeaDataNet SEANOE infrastructure.

Roles of each participating beneficiary in creating the product / service:
EMBRC (HCMR, UH-TZS, CCMAR, UVIGO): Provider of the experimental mesocosm service.
SeaDataNet (RBINS): Data management.

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):
The implementation phase will focus on demonstrating the functionality of services integration by carrying out a coordinated experiment to assess the impact of ocean alkalinity enhancement (OAE) on the composition, diversity and functioning of planktonic and/or benthic communities.

A first step towards service integration is to share comprehensive descriptions of the existing experimental services at CCMAR, UH, HCMR and UVIGO, from the internal organisation, access and management to common and site-specific variables and methods. Existing commonalities and peculiarities will be identified prior to dealing with service integration and the implementation of the demonstrator.

The design of the OAE experiment, including the structure of the data and metadata sets for SeaDataNet, will stimulate and will run in parallel to discussions towards a comprehensive description of the integrated experimental service. These will include the type and management of mesocosms, a list of core and complementary variables and methods available, a set of common standard operating procedures (SOP), access conditions, quality control procedures and SeaDataNet data management protocols for making data/metadata FAIR. Methods and SOPs will be made public through internationally recognised repositories such as Ocean Best Practices (OBPS).

Demonstrator internal milestones:
MS1 (Mar 2025): Identification of commonalities and peculiarities in research facilities and service provision by each RI. SeaDataNet provides guidance to mesocosm RIs on making protocols and experimental results FAIR.
MS2 (Oct 2025): Experimental design of the OAE impact demonstrator.
MS3 (Dec 2025): Comprehensive description of the integrated service.

Although necessary, common operational procedures may not secure by themselves a harmonised, site-independent risk evaluation, which is essential for extrapolation. For instance, differences in seasonality of the physical forcing, or in the composition, growth rates or trophic structure in eu- and oligotrophic environments imply that different magnitude, extent and pace of the experimental treatments may be necessary to reach similar outputs. Harmonisation of outputs should hence be demonstrated through trans-site intercalibration that could be supported by IRISCC transnational access. As this is not clearly articulated, a specific milestone (MS4) for the actual execution of the OAE experiment is currently not possible (see below).

How will the progress of implementation be measured / followed:

- Completion of description of integrated service.
- Publication of SOPs in OBPS.
- OAE experiment design completed.
- OAE experiment carried out.
- Publication of OAE experiment data and metadata in SeaDataNet.

Main challenges and risks in implementing the product / service:

Discussion towards the experimental design and comprehensive description of service will be based on 1) previous shared experience of HCMR and UVIGO in OAE experiments (ECIMAT, 2022; CRETACOSM, 2023) funded by the EU project AQUACOSM-plus, 2) the expertise of all involved RI in mesocosm experimentation, and 3) the expertise and experience of RBINS in data management for SeaDataNet. No specific difficulty is hence identified in reaching milestones 1-3.

The actual realization of the OAE experiment that is key for the implementation phase, and its location(s), will depend on the availability of IRISCC funds (e.g., Transnational Access) and locally available resources, as consumables and person months associated to the mesocosm preparation, sampling and sample analyses, or external analytical services costs, are not included in the IRISCC budget of any of the RIs involved.

Other considerations for implementing the product / service:

-

Annex 5: detailed description of demonstrator 5

Risk on food security due to multi-hazard risks (pests, diseases, drought, heatwaves)

Part 1: Meta data

Demonstrator number:
#5

Demonstrator name:
Risk on food security due to multi-hazard risks (pests, diseases, drought, heatwaves)

Leading beneficiary (participant number in IRISCC, acronym and full name):
29, CzechGlobe, USTAV VYZKUMU GLOBALNI ZMENY AV CR VVI

Demonstrator leader (person(s)):
Karel Klem

Other participating beneficiaries (participant number, acronym, and main contact person):

- 1, LUKE, main contact person to be confirmed
- 43, FZJ, main contact person to be confirmed

Involved Research Infrastructures (RI acronym and role):

- AnaEE: Data provider
- ICOS: Data provider

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
Increasing hazards of multiple biotic and abiotic risks related to climate change and expected increased weather variability, including increased frequency, duration and intensity of extreme events. Unknown impacts on food production quantity and quality, difficult to predict and thus difficult to apply measures against the impacts of risks, including difficult long-term adaptation, especially in the case of biotic risks.

Product / service created in the demonstrator in one line:
Online tool providing spatial (map) visualization of individual biotic and abiotic risks in agriculture (AgroRisk portal) based on available models and weather data including weather forecast.

More detailed description of the product / service:
A web portal will be completed to calculate the risk of disease and pest infestation of agricultural crops, fruit trees and vegetables and to estimate the damage caused by both biotic and abiotic factors, in particular drought, high temperatures, late spring frosts and the risk caused by unfavorable conditions for pesticide application. The models will use current meteorological data and short-term weather forecasts calculated by the ALADIN model for individual cadastral areas (average size 7-10 km2). For each cadastral area, the risks will be translated into a risk scale of 1. negligible risk, 2. low risk, 3. medium risk, 4. high risk and 5. extreme risk, with each risk level corresponding to a coloured representation of the risk level in the form of an expanded traffic light. The coloured assessment of the risk level will allow not only to evaluate the spatial distribution of each risk, but also their temporal dynamics in the past or the prediction of the change of risks and their spatial distribution for the next 9 days. In addition to this colour display of individual risks, the portal will allow the display of combined risks as the intensity of colour when the number of risks increases. Thus, the portal will enable first the evaluation of areas with multiple biotic and abiotic risks, and then the analysis of individual risks. Testing of the portal will take place on the territory of the Czech Republic, for which a pipeline is provided with meteorological data from the Czech Hydrometeorological Institute, including the ALADIN forecast model, and the computational infrastructure for running the models on actual data is also prepared. Further development will continue on the new prediction models and in particular on the assessment of combined risks for agricultural crops such as the combination of drought and high temperatures and then also the combination of abiotic and biotic risks with the assessment of possible antagonistic or synergistic interactions.

Type of product / service (data, virtual access, physical access, other)
Virtual access to the spatially visualized data on biotic and abiotic risks for agricultural crops, fruit trees and vegetables (web portal).

Foreseen main users of the product / service:
Farmers, government, insurance companies, academia

How will the product / service benefit the main users:
The web portal will enable farmers informed decision-making when applying preventive measures or measures to limit the increase in losses caused by multiple biotic and abiotic stresses. It will also enable the state administration to build the network supporting long-term risk reduction measures, and to make informed decisions on research priorities to address risks with increasing severity. It will enable insurance companies to develop tools that will allow for informed estimation of crop, fruit and vegetable damages and also their prevention.

How will the users access the product / service:
Directly through web-site or by contacting the leader/developers to run the simulations with provided meteorological data, scenarios and for specific regions not included in the daily calculations.

Is there a limit for amount of use of the product / service:
Direct use by farmers in regions where meteorological data and forecasts are available is unlimited. Simulation for specific regions is limited by the availability/provision of specific meteorological data and forecasts and then also to the limits of computing time and work capacity required to prepare the data for the actual simulation.

What support is needed from the provider side for the use of the product / service:
Support from the provider, or cooperation between provider and user, is only necessary if the simulation runs on specific data for which the portal is not used on a daily basis, i.e. in the case of new countries that will provide data or in the case of simulations on future climate scenarios. Otherwise, the user should not need support for standard generated data.

How will the usefulness of the service be measured:
Records of number of users - portal accesses, feedback questionnaires for main users (farmers and government), number of users with simulation requests for specific data.

Other comments:
For many countries, the required meteorological data needed to run the simulations may not be available or may only be available for a fee and therefore the requirement for use by other countries should be carefully consulted in terms of meteorological data availability.

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:
As standard, the product will use current weather data and forecasts (ALADIN model) for the next 9 days. Simulations with past weather data and simulations using different future climate scenarios are possible on request if the necessary data is provided.

General description of use:
Common use means access to the actual data and forecast. If the simulations for other regions, future or past climate, the weather data at 2 m height and close to soil surface (temperature, humidity/VPD, wind, rainfall) in 1 h step are required.
Needed spatial coverage:
Whole Czech Republic, for specific simulations we can use the available data from Slovakia and part of Austria.

Needed spatial resolution:
It depends on the available meteorological data and the needs of the user. By default, meteorological data interpolated for cadastral areas (on average 7-10 km2) are used.

Needed temporal resolution:
Depends on the model, but for most the 1 h data temporal resolution is required

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
Due to the existing pipeline of data transfer and processing, running simulations, creating GIS outputs, D4Science is likely to be used only for specific and time-consuming simulations, for example in combination with future climate simulations.

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, …):
Probably RStudio and Jupyterhub.

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
There are different steps of meteorological data processing/interpolation and forecast and simulations with running the individual models on meteorological data. The second step requires 1CPU, less than 1 GB RAM

What programming language(s) is/are used within your demonstrator:
Models programmed in Delphi

What data formats are used within your demonstrator:
Input data: Geotif
Output data: txt

How much storage space will be needed for using the service and storing the input/output:
15 GB per year

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
Depends on the desired output - i.e. whether the current situation is simulated, long-term predictions or past data

Other technical details

Other comments you want to provide:
-

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:

It runs and provides data on a daily basis in test operations and for a large part of the planned biotic and abiotic risk estimation and prediction models. Currently the whole system is running only for the Czech Republic and therefore it is entirely in Czech language.

What data / capacity / capabilities exists already:

Currently eight abiotic stress factors (wind, high temperatures, frost, drought .....) and 27 biotic stresses.

What data / capacity / capabilities need to be developed:

Development and implementation specific risk models (e.g. risks of Fusarium head blight mycotoxins in grain).

Roles of each participating beneficiary in creating the product / service:

- CzechGlobe: translation to English, development and implementation of new models for biotic and abiotic stress.
- FZJ, LUKE, CzechGlobe: Testing on Finnish and German meteorological data and future predictions or past data.

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):

- April 2025: translation of main body of AgroRisk portal to English language.
- September 2025: development and implementation of new models
- April 2026: testing finished on data from another country (Finland and Germany)
- September 2026: testing finished on future meteorological data simulations and past data

How will the progress of implementation be measured / followed:

Availability to public, new models implemented, tested on data from other countries, tested simulations for future or past climate.

Main challenges and risks in implementing the product / service:

Specific meteorological data in required time or spatial resolution needed for simulations is not available.

Other considerations for implementing the product / service:

-

Annex 6: detailed description of demonstrator 6

Risk on multiple systems due to wildfires in Europe

Part 1: Meta data

Demonstrator number:
#6

Demonstrator name:
Risk on multiple systems due to wildfires in Europe

Leading beneficiary (participant number in IRISCC, acronym and full name):
9, CNR, Consiglio Nazionale delle Ricerche

Demonstrator leader (person(s)):
Lucia Mona

Other participating beneficiaries (participant number, acronym, and main contact person):

- 5, CNRS, Valérie Thouret
- 6, ICOS ERIC, Alex Vermeulen
- 10, NILU, Cathrine Lund Myhre
- 19, ULund, Ute Karstens

Involved Research Infrastructures (RI acronym and role):

- ACTRIS: Provision of specific products from aerosol vertical profiling and aerosol-trace gases in situ observations related to fires. Improving near real time (NRT) provision of these data for fires cases. Platform implementation. Provision of Flexpart footprint analysis and forward analysis for ACTRIS and ICOS observatories
- IAGOS: provision of CO, ozone and other fires-related species. Provision of Flexpart footprint analysis for all IAGOS observations and forward analysis for selected extreme events over IAGOS airports
- ICOS: provision of CO, CO_2, isotopes

Part 2: Demonstrator description

What is the challenge / risk to which the demonstrator will provide answers:
The main risk addressed by the demostrator 6 is the enhancement of wildfire emissions and related risks on multiple (eco)systems. This demonstrator will provide improvement of knowledge for answering also following related questions:

- Which regions are most affected by wildfires and how high are the modeled and observed atmospheric concentrations during such events?
- Are there significant differences in chemical and physical properties of fresh and long range transported fires emissions? How well are these represented into models?

Product / service created in the demonstrator in one line:
Improved knowledge about 4d distributions of wildfires emissions

More detailed description of the product / service:
The wildfire demonstrator will provide exploitation of wildfire emission and transport based on case studies arching over different RIs. Historical data as well as Near Real Time (NRT) data will be available. Historical analysis will be based on scientific literature, cases analyzed at RI levels, and anomalies investigation. Additionally, the wildfire demonstrator will set up a system for alerting the RIs about large forest fires, which triggers NRT data provision of specific relevant data from the RIs e.g. CO, CO_2, isotopes, and aerosols, on the ground and in the atmospheric column including airborne measurements. All data will be compiled and visualized together through a web user interface. Atmospheric model (FLEXPART) back trajectories and forecasts, providing a 4-d (time & space) distribution of the wildfire's emissions will be displayed and accessible.

Type of product / service (data, virtual access, physical access, other)
Virtual access to a visualization tool and to related data. Physical access related to wildfires can be offered within IRISCC at the platforms providing such access type.

Foreseen main users of the product / service:

- Researchers in climate, air quality, health, carbon neutrality, ecosystems
- Copernicus services like CEMS, CAMS and C3S, and EOSC
- Socio-economic sector users (e.g. air quality management systems)

How will the product / service benefit the main users:
The collected information will provide a dedicated in situ dataset of high quality describing 4d wildfire plumes. This would be highly valuable for scientific studies but also as a diagnostics tool for assessing the ability of the Copernicus models to reproduce such plumes (spatial extent and chemical composition). Finally, this collection of wildfires information will form the scientific basis for the evaluation of the impacts of such events.

How will the users access the product / service:

Virtual and open access

Is there a limit for amount of use of the product / service:

No

What support is needed from the provider side for the use of the product / service:

The provider will implement a user guide as a written document. Additionally, webinar(s) will be provided to a first bunch of users and this will be available as online material for all potential users.

How will the usefulness of the service be measured:

Number of accesses to data and visualization services, and, more relevant, data use in publication, evaluation and exploitation with other platforms.

Other comments:

-

Part 3: Technical details

Modelling needs

How will the product / service use model data of past and/or future climate:

The demonstrator 6 will use models related to source characterization for the observational sites as described in the next section.

General description of use:

Model calculations will be performed for the last 10 years for the ACTRIS, IAGOS and ICOS sites to identify the wildfire emissions into atmosphere. At the same time, it will be compared to other sources (e.g. anthropogenic) to see how important wildfire influence is. For these backward calculations showing the source regions and how they combine with one (or more?) wildfire emission, scenarios will be used.

Forward calculations based on wildfire emissions can be used to identify seasonality and affected regions that receive most of the biomass burning emissions. The model simulation will use COPERNICUS emissions, based on satellite observations as input. (e.g. GFAS).

Biomass burning is an important part of the carbon balance, and increased CH_4, CO and CO_2 levels observed at ICOS stations will be attributed to the fires by atmospheric inversions. When fires occur at larger distances from stations (>1000 km), signals will be low at the surface and pollution will have mixed to higher layers of the atmosphere, then detection of aerosol load from fire emissions using lidar and BC data will work better. The ICOS model work will concentrate on using the improved NRT estimates of the detected biomass burning on the European carbon balance.

The FLEXPART model will be used for backward originating at ACTRIS, IAGOS and ICOS measurement sites. Forward simulation will be performed on a global domain to connect the source regions and the concentration potentially observed over the measurement sites.

Needed spatial coverage:
We will focus on Europe for the chemical characterization over the stations and airports, but as was experienced in 2023 wildfire emissions from other continents (e.g. Canada) can also have a significant impact. Therefore, the calculations have to be done on a northern hemispheric scale to include important regions with abundant fires like Canada or Siberia.

Needed spatial resolution:
The global scale will be 0.5 degrees for FLEXPART, for case studies within Europe finer resolution down to 0.1 degrees can be used.

Needed temporal resolution:
A temporal resolution of 3 hours (or for fine resolution 1 hour) will be used to describe the transport and distribution of the wildfire aerosol

Computational needs

How do you envisage to make use of D4Science as an e-platform for hosting and powering (part) of your demonstrator services
D4Science can in general be useful for powering the demonstrator 6 through its capability of making available Jupiter /R platforms for the analysis on our identified wildfire cases. Anyhow, we are still evaluating different possibilities about the main platform where the demonstrator 6 will be hosted. Internal discussion will be held in autumn 2024 to fix this aspect.

What VRE services that D4Science offers might be useful for you and how (e.g. Jupyterhub, RStudio, Galaxy, ...):
Jupyterhub and Rstudio

What are the computational requirements for the product / service (e.g. number of CPUs, GB of RAM):
To be defined.

What programming language(s) is/are used within your demonstrator:
Typically, Python (sometimes Matlab) is used for simple routines and visualization of the data. The transport models are written in Fortran. In IRISCC we will build on those.

What data formats are used within your What demonstrator:
Data will be available in NetCDF format, images (typically JPEG will be also available).

How much storage space will be needed for using the service and storing the input/output:
To be defined

What data will be used for the product / service and who will provide it (e.g. Climate Data Store, EMODnet):
External data could be valuable to be used and visualized as complementary to RI observations. This could be satellite-based observations and CEMS/CAMS and C3S information.

Other technical details

Other comments you want to provide:
Interactions with stakeholders and users will be relevant to better define additional information of their interest, and therefore better answer their needs.

Part 4: Roadmap of implementation

Describe the current readiness of the product / service:
Demonstrator 6 concept starts from previous experience in the consortium about relevant and society affecting events like volcanic eruptions, desert dust outbreaks, and methane leaks. In particular, visualization tools and tailored products have been designed and implemented in experimental, or more operational modes, in the framework of projects or initiatives like e-shape, indust COST and ATMO-ACCESS. Some tools have been developed at each RI but need to be further harmonized and linked into one service.

What data / capacity / capabilities exists already:
Many cases of wildfires have been already in-depth analysed by the consortium and will be the base for developing the Demo 6 concept. The RI provides the following information of interest for wildfire investigation:

- ACTRIS quality assured aerosol profiles, and aerosol and short-lived trace gases in situ available in NRT at some sites and linked to CAMS
- IAGOS measurements of gases, particularly CO during the cruise of flight and vertical profiles close to the airports, even in NRT
- ICOS CO_2, CO and isotopes at the ground (in some cases at 100 m) even in NRT
- FLEXPART footprint analysis for different RIs sites (even vertically resolved at the measurement sites). This is a base of tools already available in ATMO-ACCESS, however there is no focus on biomass burning, this will be elaborated and also combined with observations in IRISCC.

What data / capacity / capabilities need to be developed:
The following main needs are identified:

- Improve the number and data products available in NRT relevant for wildfires

- Improve the availability of footprint analysis related to wildfires for RI facilities
- The identification of biomass burning events in observations based on case studies but also on historical records and synergistic approach has to be improved, developed and tested.
- Develop the availability of forward trajectories analysis on such selected "extreme events"
- Integration into a unique visualization framework

Roles of each participating beneficiary in creating the product / service:

- CNR (ACTRIS): Leading the demonstrator 6. Coordinating efforts for all implementation tasks. Provision of specific products from aerosol vertical profiling related to fires. Improving NRT provision of these data for fires cases. Platform implementation.
- NILU (ACTRIS): Provision of aerosol-trace gases in situ observations related to fires. Flexpart footprint analysis and forward analysis for ACTRIS and ICOS observatories
- CNRS (IAGOS): Provision of CO, ozone and other fires-related species. Flexpart footprint analysis for all IAGOS observations and forward analysis for selected extreme events over IAGOS airports
- ICOS-ERIC (ICOS): Connections to ICOS data
- ULund (ICOS): Connections to ICOS data
- All: design the platform modalities – developing synergistic methods

Timeline and main milestones of implementation of the product / service from June 2024 (now) till September 2026 (ready):

- Design of the service and definition of the workflow: December 2024
- Inventory of historical cases –analysis available January 2025
- Alerting system design February 2025
- Mock up of the service May 2025
- First release December 2025
- Milestone 31 (M24, March 2026): Scientific services from demonstrators ready for onboarding process
- Collection of feedback May 2026
- Second Service Release: September 2026
- Deliverable D4.8 (M30, September 2026): Report fully defining functionalities

How will the progress of implementation be measured / followed:

The milestones 31 will be verified through short report or tools available online.

Main challenges and risks in implementing the product / service:

None

Other considerations for implementing the product / service:

None

Annex 7: overview of WP4 and WP6 Tasks and Deliverables

The following tasks and deliverables are relevant for demonstrators' specification, development, and implementation.

WP4: Delivering of IRISCC integrated Scientific Services – ACTRIS (M1-M36):

T4.1: Defining the conditions for Demonstrators to successful implementation with KPIs – ACTRIS ERIC (M1–M6)

- D4.1: Report on the full Demonstrator design – ACTRIS ERIC (M6)

T4.2: Providing the necessary set of climate risk model output supporting Demonstrators – CERFACS (M1–M30)

- D4.2: Report on model data requirements – CERFACS (M26)

T4.3: Implementing the Demonstrators – ACTRIS ERIC and all demonstrator leads (M1–M30)

- D4.3: Report on DEMO #1 functionalities -UU (M30)
- D4.4: Report on DEMO #2 functionalities – MARIS (M30)
- D4.5: Report on DEMO #3 functionalities 3 – FZJ (M30)
- D4.6: Report on DEMO #4 functionalities – UVIGO (M30)
- D4.7: Report on DEMO #5 functionalities – CzechGlobe (M30)
- D4.8: Report on DEMO #6 functionalities – CNR (M30)

T4.4: Assessing maturity level for upscaling the integrated services – MARIS (M24–M36)

- D4.9: Report on DEMO #1-#6 maturity level for inclusion to Catalogue - MARIS (M36)

WP6: Harmonisation and technical interoperability – MARIS – M1–M48:

T6.3: Formulating and deploying a technical interoperability and FAIRness framework to support developments of integrated IRISCC services – CNR-ISTI (M1–M54)

- D6.2: Analysis report of D4Science VRE fitness for purpose and adaptations required – FZJ (M6)
- D6.4: Report on deployed and launched IRISCC interoperability framework with guidance documentation for service developers - CNR-ISTI (M10)

T6.4: Designing and implementing a test procedure for integrated IRISCC services – FZJ (M12 -M18)

- D6.8: Technical test procedure for approving integrated IRISCC digital services – FZJ (M18)

T6.5: Arranging a gateway from IS-ENES Virtual Research Environment (VRE) to the IRISCC e-infrastructure platform for providing access to climate model data – DKRZ (M1–M12)

- D6.7: Report on the established interoperable gateway between the IS-ENES VRE and central IRISCC VRE platform - DKRZ (M12)