Interim report on exploitation activities

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Abbreviations Used

CERRA	Copernicus European Regional Reanalysis
CORDEX	Coordinated Regional climate Downscaling Experiment
CPRCM	Convection-permitting Regional Climate Model
EOSC	European Open Science Cloud
ESD	Empirical-Statistical Downscaling
ESGF	Earth System Grid Federation
GWL	Global Warming Level

1 Summary for Publication

Exploitation activities ensure the long-term impact and accessibility of I4C outputs. As a first update of the exploitation plan (D7.4), we describe in this deliverable the progress of the exploitation pillars that the plan presented: Open Science tools and code, Modelling, Hazards toolkit and Adaptation Support Packs. In preparation for the European Open Science Cloud (EOSC) I4C Data Space, a cloud data hub has been setup for test access. GitHub and Zenodo spaces are in place to accommodate open code and documents. I4C climate models are simulating at the global scale (WP2) and down to km-scale (WP3) over our demonstrator cities, producing data that will be published through open community standards. Emulators require new open archiving standards that have also been developed and published (D3.4). Hazard indicators are being customized for each Demonstrator to meet specific user needs. A new guideline will help users understand global warming levels (GWL), which will shape future adaptation support packs and the co-production roadmap.

2 Contribution to the top-level objectives of Impetus4Change

Objective	Contribution from Deliverable
Overall Objective: to improve the quality, accessibility and usability of near-term climate information and services at local to regional scales – where impacts are most keenly felt and on-the ground adaptation is implemented – to strengthen and support end-user adaptation planning and action	The exploitation plan, and its successful implementation is a key metric by which we will measure the success of the project. This deliverable describes the steps taken towards improving the accessibility and usability of near-term climate information.
7) Ensure high impact and visibility through robust and targeted communication and engagement;	Visibility of the project's outcomes has been initiated through open publication
8) Commit to Open Science through development of open access tools and exploitation of data/model outputs via relevant platforms thereby ensuring improved accessibility and usability of climate knowledge.	Progress has been made in the development of open tools and standards using platforms such as Zenodo and GitHub, along with a local cloud prototype of a data space to be later delivered through EOSC.

3 Detailed Report

3.1 Introduction

This deliverable outlines the progress made on the I4C project's exploitation activities, aimed at ensuring the long-term impact and accessibility of its outputs. Central to the project's exploitation plan[1] is the creation of a legacy data space, which integrates core datasets and user-relevant software packages for climate data analysis. This data space will be embedded within the European Open Science Cloud (EOSC) to ensure that the project's results remain accessible and usable beyond its duration, allowing users to reproduce key data processing workflows.

We also highlight initial steps in making raw model output and processed data available through more traditional archives, such as the Earth System Grid Federation (ESGF). These archives are essential for maintaining long-term accessibility for the scientific community. Next efforts include the development of a climate hazard toolkit tailored for urban planning, alongside adaptation support packs. These resources are designed to extend the project's impact by providing practical tools and roadmaps for climate adaptation planning.

In addition to reporting on the initial setup of these resources, we cover early engagements with external stakeholders and organizations that can sustain these efforts after the project's conclusion. These activities are essential to ensure that the solutions developed within I4C, including datasets, toolkits, and guidance, continue to be used and maintained by broader communities beyond the project's lifetime.

3.2 Work Carried Out

Regarding the development of open tools, the code of the CNRS-MF emulator has been published openly (https://github.com/antoinedoury/RCM-Emulator). Tools developed for ESD (Task 3.1) through the collaboration between BSC and CSIC can also be accessed and developed as Jupyter Notebooks at the T31-ESD-hub repository in the I4C GitHub organization (https://github.com/impetus4change/T31-ESD-hub). Executable notebooks are a key element in the FAIR context, as they provide transparency and reproducibility in research efforts.

CSIC has deployed a local, cloud-based data lab (I4C-Hub) to advance in the EOSC data space deployment. We have tested an initial image for this virtual computing environment, based on JupyterHub and including data connections and software tools for ESD (Task 3.1). This example reproduces the current results from this Task and enables their reutilization for different locations/variables/etc. This initial seed of the I4C-Hub (https://i4c.climate.ifca.es/hub) is in testing phase for internal use in the context of Tasks 3.1, 3.4 and 8.4, and will be extended to showcase other project results and migrated to dedicated resources benefiting from the EOSC services.

[1] https://impetus4change.eu/wp-content/uploads/2024/06/I4C-D7.4_Exploitation_Plan.pdf

The resources currently available are:

- Data:
  - Decadal predictions (CMIP6-DCPP) for the EC-Earth3 model hindcast
  - The CERRA reanalysis as the ESD observational reference
  - Seasonal Prediction System 5 Forecasts
  - Sea level pressure of the ERA5 reanalysis
- Software libraries:
  - Python libraries (xarray, pandas, geopandas, …)
  - R frameworks: CSDownscale and climate4R
  - Command-line tools (CDO, NCO, …)
- Scripts and notebooks related to Task 3.1 to apply ESD techniques to seasonal and decadal forecasts

The modelling pillar is work in progress, with global predictions (WP2) and CPRCM simulations (WP3) currently running. These raw data will be made available through ESGF, as they follow the existing CMIP and CORDEX archiving specifications. Emulators (WP3) are being developed and will also produce output by mid-2025. New specifications (D3.4) have been developed to ease the publication of emulator outputs in ESGF.

Hazard metrics have been identified (D4.1) and they have been already computed for EURO-CORDEX. Currently, they are being computed using existing CPRCM simulations. These indicators will be made available beyond the project by means of the hazards toolkit, which is about to start development (Task 4.4, M24) and will be delivered as D4.4.

The hazard indicators are further being tailored for individual Demonstrators to address user requirements co-designed in the previous year. The demonstrator- specific impacts, such as the calculation of heatwave using the local Hydromet services (MeteoCat) definition, are plotted for different global warming levels (GWL). This launched the co-development phase of the Demonstrators, to see what indicators would indeed serve the users and be considered to inform the Adaptation support packs. An interesting aspect that emerged is the discussion around GWL, a new approach that the contacted users were not familiar with. The project is preparing a user guideline for interpreting this new approach to presenting and communicating future projections in a way that will be accessible to a wider user community. This aspect will also be considered in the coproduction Roadmap.

Blended forecasts are currently being produced under WP5, which will be made available for exploitation depending on their final format.

The main results are summarized in Table 1, updated from the I4C Exploitation Plan.

Table 1: Exploitation measures description, target audience and status

Exploitation Pillar	Description	Target audience(s)	Status	Means of verification
Open Science	• European Open Science Cloud	VIACS community members;	I4C GitHub organization with several	Code and tools available in an I4C GitHub

tools and code	(EOSC) I4C Dataspace	climate science community; stakeholders	open repositories. I4C-Hub deployed on cloud resources and available for testing.	repository and documentation (Zenodo) in addition to availability on EOSC dataspace.
Modelling	• Raw model output from S2D predictions (WP2) • Raw model output from CPRCM simulations (WP3) • Blended forecasts (WP5) • Statistical downscaling and statistical emulator data (WP3)	High level users, the broader scientific community	Modelling work in-progress. Metadata standards developed to allow publication on ESGF (D3.4).	Raw GCM output accessible via ESGF or similar (e.g., C3S) A selection of blended forecasts shared via public data repositories (e.g. EuDAT, Zenodo). CPRCM data solution is in discussion.
Hazards toolkit	• User-driven identification of hazard metrics • Development of new metrics based on stakeholder needs • Extremes/hazards analysis across diverse high-resolution products	Stakeholders within the project and beyond. VIACS community	D4.1 completed (Jun 2023). Metrics for EURO-CORDEX ready, and ongoing for existing CPCM simulations.	Make toolkit available via e.g., EEA's climate-adapt portal; implemented in workflow of demonstrator cities and beyond. Critical risk is to ensure legacy beyond project lifetime.
Adaptation Support Packs	• Strategic guide for innovative climate data to support urban adaptation • "Roadmap" based on I4C learnings from implementing the coproduction framework in the four demonstrator cities and trialing the approach in two testbed cities	Stakeholders in demonstrator and testbed cities (WP6); policy makers; broader stakeholder community engaged via knowledge networks (WP1). Also the VIACS community.	Co-exploration work is completed in all the demonstrators and the results from the co-design activities were published in M18. Co-development and co-evaluation of the Demonstrators is in progress. Second Adaptalab will take place in	Make adaptation support packs and roadmap available via e.g., EEA's climate-adapt portal or other that will ensure continuity and accessibility beyond project lifetime. Share through WP1 Knowledge Networks. Link to EU's Adaptation Mission.

			March 2025 to advance the co-development work and test the project climate data outputs, such as hazard indicators.	

3.3 Progress Beyond State of the Art

One key progress beyond the state of the art is on the development of CPRCM emulators and new standards to archive their output to be delivered for further exploitation beyond the I4C specific work.

4 Impact

Operational climate services of the countries / cities covered by the CPRCM and the Emulator domains are also a targeted audience here. E.g., Meteo-France has a plan to include, after validation, those CPM / Emulator simulations in the operational climate services that target both the general public and the stakeholders (private companies, national/regional/local agencies).

New metrics based on stakeholder needs and developed in WP4 can also be used in operational climate services if relevant, therefore being more visible to the public and decision makers.

5 Links Built

This deliverable reports cross-WP work contributing to the I4C exploitation plan. It builds on links to international initiatives such as several ongoing CORDEX and CMIP activities (EURO-CORDEX, CORDEX FPS-URB-RCC, DCPP). Feedback between I4C and these initiatives helped in developing aligned experimental and archival frameworks, facilitating the legacy of the project. We link also with past initiatives, such as CORDEX FPS-CONV or H2020 EUCP, which provide inputs for co-developed hazard metrics.

As mentioned above, we are collaborating also with national operational climate services, e.g. Météo-France, to adopt some of the products developed in I4C.

IMPETUS4CHANGE (I4C)

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