



Prototype of the operational use case

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1. Executive summary

This deliverable presents the Prototype of the Operational Use Case developed within Task 4.3 of the COMPASS project. The demonstrator, available at <https://ouc.compass-climate.eu/>, showcases an operational climate and impact attribution service implemented for Use Case 5 (Poland). Unlike event-specific attribution studies, the prototype demonstrates a continuous operational workflow capable of producing near real-time climate and impact attribution products.

The operational demonstrator integrates climate observations, climate processing toolboxes, attribution frameworks, and impact models developed within COMPASS and by project partners. The system automatically processes meteorological data from Copernicus services and other European datasets, generates factual and counterfactual climate conditions, and calculates associated impacts on agricultural production. The workflow is executed through automated processing chains and delivers regularly updated attribution indicators through a web-based interface.

The demonstrator represents a proof-of-concept showing that operational attribution services are already feasible for selected hazards and impact sectors. It combines climate hazard attribution with impact attribution, enabling users to compare observed conditions with a hypothetical world without anthropogenic climate change and to quantify attributable impacts on crop production and associated economic losses.

This deliverable focuses on presenting the operational prototype and its main functionalities, while detailed technical documentation, workflow specifications, and software implementation details will be provided in Deliverable D5.3 Technical Documentation.

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1. Introduction

The overarching objective of COMPASS is to develop “a harmonized and flexible methodological framework for attributing climate and impact to complex extreme events, including compound, sequential, and cascading hazards”. To achieve this objective, the project has developed and tested a suite of attribution methodologies through a series of use cases covering different hazard types, geographical regions, and impact pathways (Jack et al., 2025a, b).

The first results of these analyses are presented through the COMPASS web demonstrator, a separate deliverable (Terefenko and Śledziowski, 2026), which transforms technical attribution workflows into graphical storylines that enable users to explore both the scientific evidence and the broader societal context of extreme events. The platform combines quantitative attribution results with qualitative narratives, thereby supporting both probabilistic and storyline-based approaches to event attribution. The demonstrator (available at: <https://uc.compass-climate.eu/>) currently presents a collection of use cases developed within the project, including UC1–UC4, illustrating how climate change interacts with hazards, exposure, vulnerability, governance, and societal conditions to shape disaster outcomes.

Building upon these methodological developments, COMPASS also aims to demonstrate that operational climate and impact attribution services can be implemented using existing observational datasets, climate processing methods, and impact modelling frameworks. Task 4.3 addresses this objective through the development of an **Operational Use Case Toolbox focused on the Polish drought and heatwave use case (UC5)**.

The use case demonstrates that an operational attribution service is already feasible using currently available European datasets, climate processing workflows, and impact assessment models. The prototype integrates multiple datasets and processing components developed throughout the project. These include meteorological observations from Copernicus Climate Change Service products, climate processing workflows such as *CLIMB - Framework for CLIMate data bias-adjustment and downscaling* (Śledziowski et al., 2026), tool for counterfactual simulations generated with *ATTRICI - Statistics-based counterfactual climate data toolbox* (Mengel et al., 2025), and impact assessment workflows based on crop yield prediction models. The system performs automated calculations and publishes results through an online demonstrator.

The operational workflow follows the COMPASS attribution framework by comparing two internally consistent worlds:

- Factual world, representing observed climate conditions;
- Counterfactual world, representing hypothetical climate conditions based on the statistical relationship between global mean temperature (GMT) and the local distribution of climate variables.

The comparison between these two worlds allows attribution of both climate anomalies and resulting impacts to climate change.

The demonstrator also serves as a prototype architecture for future operational attribution services. It integrates data acquisition, climate processing, attribution methodologies, impact modelling, and web-based dissemination into a single automated workflow capable of producing regularly updated results for decision support and climate adaptation planning.

2. Operational Use Case

The operational use case is organized around three major workflow components: the factual climate processing branch, the counterfactual climate attribution branch, and the impact attribution branch. Together, these

components form an end-to-end operational chain capable of transforming meteorological observations into climate and impact attribution products.

2.1. Factual Climate Processing Workflow

The factual branch provides the operational representation of observed climate conditions. The workflow starts with automated acquisition of ERA5 and ERA5-Land meteorological data from the Copernicus Climate Data Store. Input datasets are transformed into daily climate variables and harmonized using reference information derived from EMO-1 observations.

The processing chain applies the CLIMB framework (Śledziowski et al. 2026) to generate high-resolution climate products. Daily meteorological variables are processed through a sequence of harmonization, variable reconstruction, bias adjustment, and statistical downscaling procedures. Bias adjustment and downscaling are performed using the ISIMIP3BASD methodology, allowing the generation of spatially consistent climate fields while preserving observed variability and extremes.

The final outputs consist of daily gridded datasets representing key climate variables relevant for drought and heatwave assessment, including precipitation (pr), minimum temperature (tn), maximum temperature (tx), global radiation (rg), wind speed (ws), and vapour pressure deficit proxy (pd). These datasets are continuously updated and published through the Climate Maps component of the demonstrator.

2.2. Counterfactual Climate Attribution Workflow

The counterfactual branch reproduces the factual processing structure while removing the climate change signal from meteorological conditions. The workflow uses bias-adjusted climate fields generated within the factual branch as inputs to the ATTRICI attribution framework.

ATTRICI simulations generate full-grid counterfactual climate conditions representing a hypothetical world without long-term changes in climate. The resulting datasets are subsequently processed through dedicated reconstruction workflows that mirror the factual climate processing chain. This ensures methodological consistency and enables direct comparison between factual and counterfactual conditions for each variable, location, and date.

The resulting datasets provide operational estimates of how climate conditions would have evolved in the absence of global warming. By maintaining identical processing procedures for both worlds, the demonstrator allows robust attribution of observed climate anomalies to climate change and provides the basis for subsequent impact attribution analyses.

2.3. Impact Attribution Workflow

The impact branch translates climate attribution results into societal and economic consequences. Both factual and counterfactual climate datasets are used as inputs for agricultural impact modelling workflows.

Meteorological variables such as temperature and precipitation are first processed through the LISVAP framework – a model developed to provide potential reference evapotranspiration, potential evaporation from bare soil and open water. Further all indicators are used for crop yield prediction. The prediction models have been calibrated using historical crop yield records from Poland covering the period 1974–2025. Yield estimates are generated for multiple crop types and administrative regions.

The final attribution metrics are calculated as differences between factual and counterfactual outcomes. These include attributable changes in crop yield as well as associated economic impacts estimated from cultivated area and crop price information. Results are presented through the Crop Yield Analysis section of the demonstrator, providing operational indicators of climate change impacts on agricultural production.

Together, the climate and impact attribution components demonstrate how observational datasets, climate processing frameworks, attribution methodologies, and impact models can be integrated into a single operational service capable of delivering near real-time attribution information for decision support and climate risk management.

3. Demonstrator Access and Operational Status

The operational use case demonstrator is publicly available at <https://ouc.compass-climate.eu/>. The platform provides access to continuously updated climate attribution and impact attribution products generated for the Polish drought and heatwave use case (UC5). Users can explore climate variables, compare factual and counterfactual conditions, and assess attributable impacts on agricultural production through an interactive web interface.

The demonstrator operates through automated processing pipelines that acquire, process, and publish climate and impact information on a regular basis. Due to the computational complexity of the workflow, including climate processing, ATTRICI-based counterfactual simulations, and crop-impact calculations, the complete operational chain is executed at a multi-day cadence rather than continuously.

The counterfactual component is updated using ATTRICI as part of the operational chain. ATTRICI is not re-fitted from scratch to the full historical period at each update. Instead, the historical ATTRICI fit for 1950-2024 is stored as trace files and reused as the reference model. For each operational update, the latest current-year meteorological fields are passed through ATTRICI on the full grid to generate updated factual and counterfactual daily fields for the current year. These outputs are then converted into the same processing structure as the factual data and used to produce counterfactual climate maps and inputs for the crop-impact model. As a result, the information presented in the demonstrator is typically available with an approximate delay of ten days relative to the current date.

The demonstrator represents the first operational implementation of the COMPASS attribution framework and provides a proof-of-concept service integrating climate observations, attribution methodologies, and impact modelling into a single operational environment. The platform serves both as a research demonstrator and as a prototype for future operational climate and impact attribution services that could support decision-makers, stakeholders, and climate adaptation planning.

As this deliverable focuses on presenting the operational prototype and its functionality, detailed technical documentation, workflow specifications, software architecture descriptions, user guidance, and source code repositories are not included herein. These materials are being prepared as part of Deliverable D5.3 Technical Documentation and will be made available during the next stage of the project. Deliverable D5.3 will provide comprehensive documentation of the operational workflow, implementation details, software components, installation procedures, user guidance, and access to the latest version of the developed codebase.

2. References

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