MOSAIC

Deliverable Report

D.2.1.1

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Executive Summary

The deliverable **D.2.1.1 "Field and lab experiments database"** encompasses field data, laboratory data, derived products, and models developed or used within the project and published and documented in open-access data repositories. The database is designed around the FAIR principles (Findability, Accessibility, Interoperability, and Reusability) to support data sharing, transparency, and reuse, and consists of publicly accessible data through several online repositories, such as Figshare, Dryad, or Zenodo. Notably, several data curated within the project will be made publicly accessible through the MOSAIC WebAtlas, accessible at https://alpineresilience.org/.

The deliverable report is structured in five chapters. The first chapter *Introduction* provides an overview of the deliverable, its purpose, and related documents. The second chapter, *Field and Lab Experiments Database*, is the basic table with data records and models currently included in the database, describing their thematic scope, data type, responsible partners, and access links. The third chapter, *Standardized Metadata Submission Framework*, introduces the standardized submission form and metadata framework to guide partners in contributing additional datasets and models in a consistent, interoperable, and FAIR-compliant manner. The fourth and fifth chapters encompass conclusions and references, respectively.

1. Introduction

1.1 Purpose of Deliverable

This deliverable documents the release of the MOSAIC database developed under **Work Package 2 (WP2): NAZCA – *NaturAl haZards modelling platform for analysing climate change (CC) compound events on Alpine Space (AS) protective forests***. The overarching goal of WP2 is to provide a modelling platform and associated datasets integrating natural hazard (e.g. rockfalls, avalanches, wildfires, windthrows) and risk models upgraded to account for the consequences of CC - such as changes in species suitability - and the effects of compound events on forest composition, structure, and protective functions of the AS.

Within this framework, **Activity 2.1** focuses on generating missing empirical evidence through **field surveys and field and laboratory experiments** addressing key processes related to CC-driven compound events threatening AS forests. These include, among others, mechanical properties of trees, fire and windthrow susceptibility, snowpack characteristics, regeneration dynamics, and the prioritisation of post-disturbance management practices. The data produced enable an improved understanding of CC impacts on hazard behaviour, forest and disturbance dynamics, and ultimately on the effectiveness of protective forests as **Ecosystem-based solutions for Disaster Risk Reduction (Eco-DRR)**.

The objective of this deliverable is to organise, document, and publish these datasets and associated models in a structured, open-access database designed around the **FAIR principles** (Wilkinson et al., 2016). By ensuring standardized documentation, persistent identification, and open accessibility, the deliverable supports the long-term availability, traceability, and usability of project outputs for scientific research, technical applications, and policy-oriented decision-making, and provides a foundation for their integration into the MOSAIC WebAtlas and modelling platform.

1.2 Deliverable Overview

Climate change (CC) is increasingly responsible for the rise in climate-related disasters across Europe, resulting in substantial socio-economic losses and impacts on human well-being (IPCC 2022). Many of these disasters are driven by compound and cascading events, i.e. the interaction of multiple climate-related hazards occurring simultaneously or sequentially, which together amplify socio-ecological risks (Cutter 2018). Addressing such risks requires **integrated, spatially explicit data and models at different scales** that capture interactions between CC, natural hazards, forest ecosystems, and human systems.

In this context, forests play a dual role. They provide essential ecosystem services that support climate change mitigation and adaptation, and in the AS they represent a key **Eco-DRR** by protecting people and infrastructure against natural hazards (Dorren et al. 2004, Moos et al. 2023). At the same time, forest health, structure, and protective functions are themselves increasingly threatened by CC-driven disturbances such as wildfires, windstorms, pest outbreaks, and changes in snow and hydrological regimes (Bastit 2023). Ensuring hazard-resilient and sustainable forest management therefore requires proactive, transnational strategies supported by harmonised data and models.

This deliverable presents a **harmonised inventory of datasets, models, and derived products** generated within MOSAIC or sourced from relevant external initiatives. These resources directly support the development and implementation of NAZCA, which integrates climate-related compound events into natural hazard and risk models adapted to Alpine-specific conditions (e.g. topography, forest types, and management systems). The database contributes to assessing socio-ecological risks associated with CC impacts on AS forests, with a particular focus on protective forests and their capacity to deliver Eco-DRR services under changing climatic conditions.

The database integrates **quantitative field and laboratory data, spatial datasets, and modelling tools** addressing multiple natural hazards and forest dynamics across spatial and temporal scales. These resources respond to key MOSAIC objectives, including: (i) collecting, harmonising, and sharing **Alpine-wide data** on historic and current climate-related hazards and forest disturbances; (ii) quantifying **past trends and future projections** under plausible climate scenarios; and (iii) **upgrading risk models** to account for CC-driven compound events affecting forest resilience and protective functions.

By making these resources openly accessible and interoperable, the deliverable supports knowledge transfer to professional actors, including **policymakers**, **risk managers**, **forest practitioners**, and **stakeholders** involved in forest living labs (FLLs). In doing so, it contributes to increasing awareness, fostering adaptive forest management approaches, and supporting evidence-based climate change mitigation and adaptation strategies within regional to transnational Alpine climate action plans.

1.3 Data Management, FAIR Principles, and Accessibility

All datasets and models included in this deliverable are documented following the project data management plan and the FAIR principles (Wilkinson et al., 2016), ensuring that project outputs are findable, accessible, interoperable, and reusable throughout and beyond the MOSAIC project lifetime. To this end, each resource is accompanied by standardized metadata describing its content, methods, spatial and temporal characteristics, access conditions, and recommended citation.

Adherence to the FAIR principles is implemented as follows:

- **Findable**

  Each dataset and model is uniquely identified through a persistent identifier, preferably a **Digital Object Identifier (DOI)**, and described using rich, searchable metadata. These metadata enable discovery through the MOSAIC WebAtlas and external indexing services, facilitating visibility and traceability of project outputs.

- **Accessible**

  Data and models are made openly accessible through stable repositories, using standard web protocols. The preferred solution is publication through dedicated services integrated within the MOSAIC **WebAtlas**, one of the main project results, which provides a centralized access point for project outputs. Where appropriate, links to established external open-access repositories are also supported to ensure continuity and broad dissemination.

- **Interoperable**

  Resources are provided using open, **well-documented file formats and standardised metadata fields**, enabling integration with modelling platforms, GIS software, and other analytical tools. In particular, tables are provided preferably as csv, raster files as GeoTiff or ASCII, model codes as R or Python scripts or packages or through the upgrading of existing modeling platforms. The metadata framework is designed to support interoperability across datasets, models, and external platforms relevant to natural hazard and forest dynamics research.

- **Reusable**

  Clear documentation, explicit licensing, and standardized citation guidelines are provided for each resource to enable correct interpretation and reuse. Metadata include methodological descriptions, assumptions, and known limitations, ensuring that datasets and models can be reliably reused in scientific, technical, and policy-oriented applications.

The preferred publication pathway for datasets and models is through an internal upload and curation within the MOSAIC WebAtlas (https://alpineresilience.org/), ensuring consistency, harmonization, and direct integration with project tools and visualization services. At the same time, the framework accommodates resources already published in established external repositories, which are referenced and linked within the MOSAIC database. This complementary approach ensures flexibility while maintaining a coherent and sustainable data infrastructure. Overall, this strategy guarantees long-term accessibility, citability, and traceability of MOSAIC outputs, supporting knowledge transfer, reproducibility, and reuse beyond the project duration.

1.4 Structure of the Deliverable

This deliverable is organised into two main parts. The first part provides an overview of the datasets, models, and derived products currently available in the MOSAIC database (*Chapter 2*). The second part introduces a standardized metadata submission framework designed to support consistent contributions from project partners and future extensions of the database (*Chapter 3*).

1.5 Related Documents

This deliverable is complemented by an Excel-based dataset inventory consisting of the table illustrated in Chapter 2 *Field and Lab Experiments Database*.

2. Field and Lab Experiments Database

2.1 Chapter introduction

This chapter presents the current inventory of datasets, models, and derived products included in the MOSAIC database under WP2, the core of **D.2.1.1**. The inventory provides an overview of resources generated within the project as well as selected external datasets and models that are relevant for analysing CC-driven compound events affecting AS protective forests.

The database is structured to ensure **clarity, traceability, and interoperability** across heterogeneous data types, supporting both integration into the NAZCA modelling platform and dissemination through the MOSAIC WebAtlas. Each record represents a distinct dataset or model and is documented using a standardised set of descriptive fields to facilitate discovery, reuse, and correct citation.

2.2 Structure of the database table

The database is presented as a **tabular inventory** in which **each row corresponds to a single data record** (dataset, model, or derived product), and **each column describes a specific attribute** of that record. The fields are defined as follows:

- **Code**: Unique identifier synthesizing the development source, main topic, and data type of the record.
- **Source**: Origin of the record, distinguishing between resources developed within MOSAIC and those sourced from external initiatives.
- **Main Topic**: The primary thematic focus of the record (e.g. wildfires, species suitability, rockfalls).
- **Data Type**: Classification of the resource as either data (e.g. raster files, tables) or model/code (e.g. R or Python scripts, software packages).

- **Title**: A concise and descriptive title summarizing the content of the record.
- **Description**: A short explanation of the record, including its purpose, methodological approach, and/or novelty.
- **PP(s)**: Project Partner(s) responsible for data collection, development, and/or curation.
- **Link to Data**: Persistent link or DOI to the repository where the record is stored, either within the MOSAIC WebAtlas or in an external open-access repository.
- **Reference**: Bibliographic reference and/or DOI to publications describing or using the record, if available.

This standardized structure ensures consistency across contributions and supports both human interpretation and machine-readable integration with the MOSAIC web atlas.

2.3 The Database

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Win01_Rast	MOSAIC	Windthrows	Data (raster files)	*The protective effect of a windthrown forest: biological legacies and rockfalls*	The dataset uses the rockyfor3d model to assess the protective effect of a windthrown forest. Three scenarios are implemented: no forest, pre-storm forest conditions, and windthrown forest (i.e., post-storm conditions). The data are composed of three rasters, each representing one scenario. The rasters show the number of passages in the study area. The resolution is 2x2 meters.	PP4 (UNIPD)		Costa, M., Marchi, N., Bettella, F., Bolzon, P., Berger, F., & Lingua, E. (2021). Biological Legacies and Rockfall: The Protective Effect of a Windthrown Forest. Forests, 12(9), 1141. https://doi.org/10.3390/f12091141
M_Win02_Rast	MOSAIC	Windthrows	Data (raster files)	*Maps of forest wind vulnerability from remote sensed data through a novel semi-automatic methodology*	The dataset reports a new, innovative procedure for precisely assessing forest vulnerability to wind using remote-sensed data (LiDAR) and incorporating the ForestGALES model. This method automatically maps forest wind vulnerability at a high resolution (20x20 meters) and provides an example of a regional-scale application in the municipality of Rocca Pietore, Italy. The maps are rasters with a resolution of 20x20 meters.	PP4 (UNIPD)		Baggio, T., Costa, M., Marchi, N., Locatelli, T., & Lingua, E. (2025). Improve the estimation of forest wind vulnerability through remote sensed data: a new methodology. Environmental Modelling & Software, 106825. https://doi.org/10.1016/j.envsoft.2025.106825
M_Win03_Mod	MOSAIC	Windthrows	Model	*A semi automatic methodology to assess forest wind vulnerability from remote sensed data*	The model is an innovative procedure that uses remote-sensed data (LiDAR) and incorporates the ForestGALES model to precisely assess forest vulnerability to wind. This method automatically maps forest wind vulnerability at a high resolution.	PP4 (UNIPD)	https://github.com/TommBagg/CWS_calculation_fgr	Baggio, T., Costa, M., Marchi, N., Locatelli, T., & Lingua, E. (2025). Improve the estimation of forest wind vulnerability through remote sensed data: a new methodology. Environmental Modelling & Software, 106825. https://doi.org/10.1016/j.envsoft.2025.106825

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Fir01_Mod	MOSAIC	Wildfires	Model	*Models for post-fire applied nucleation under different restoration scenarios to improve degraded ecosystems - Bourra case study*	The dataset provides R code for developing a a machine learning correlative model (Bayesian Additive Regression Tree, BART) at the landscape scale to model the occurrence of natural tree regeneration. Its goal is to provide a set of applied nucleation datasets for prioritizing post-fire intervention practices. Together with R code, the dataset comes with a table with data input for the Bourra site (Verrayes, Aosta, Italy).	PP3 (UNITO)		Mantero, G., Anselmetto, N., Morresi, D., Meloni, F., Bolzon, P., Lingua, E., ... & Marzano, R. (2024). Modeling post-fire regeneration patterns under different restoration scenarios to improve forest recovery in degraded ecosystems. Forest Ecology and Management, 551, 121520. https://doi.org/10.1016/j.foreco.2023.121520
M_Fir02_Rast	MOSAIC	Wildfires	Data (raster files)	*Applied nucleation maps of post-fire management under different restoration scenarios to improved degraded ecosystems - Bourra case study*	The dataset provides raster maps for the simulations of the machine learning correlative model (Bayesian Additive Regression Tree, BART). They include a set of applied nucleation datasets for prioritizing post-fire intervention practices (EPSG:32632, resolution of 10m). Simulations for the Bourra site (Verrayes, Aosta, Italy).	PP3 (UNITO)	https://doi.org/10.6084/m9.figshare.23619018	Mantero, G., Anselmetto, N., Morresi, D., Meloni, F., Bolzon, P., Lingua, E., ... & Marzano, R. (2024). Modeling post-fire regeneration patterns under different restoration scenarios to improve forest recovery in degraded ecosystems. Forest Ecology and Management, 551, 121520. https://doi.org/10.1016/j.foreco.2023.121520
M_Fir03_Rast	MOSAIC	Wildfires	Data (raster files)	*Modeling post-fire regeneration patterns under different restoration scenarios to improve forest recovery in degraded ecosystems - Mompantero case study*	The dataset provides raster maps for the simulations of the machine learning correlative model (Bayesian Additive Regression Tree, BART). They include a set of applied nucleation datasets for prioritizing post-fire intervention practices (EPSG:32632, resolution of 10m). Simulations for the Mompantero site (Turin, Italy).	PP3 (UNITO)		Mantero, G., Anselmetto, N., Morresi, D., Meloni, F., Bolzon, P., Lingua, E., ... & Marzano, R. (2024). Modeling post-fire regeneration patterns under different restoration scenarios to improve forest recovery in degraded ecosystems. Forest Ecology and Management, 551, 121520. https://doi.org/10.1016/j.foreco.2023.121520

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
E_Suit01_Rast	External	Species Suitability	Data (raster files)	*Species distribution models built with local species data and regional climate models for the European Alps*	Collection of raster related to the historic and future distribution of 22 tree species for Piedmont Region, Italy and the European Alps extent produced by using correlative species distribution models. Rasters are projected to EPSG:3034 with a spatial resolution of 1km. Files are provided as both binary maps (0 = absence, 1 = presence) or continuous probability of presence (0-1).	PP3 (UNITO)	https://doi.org/10.6084/m9.figshare.26232551	Anselmetto, N., Morresi, D., Barbarino, S., Loglisci, N., Betts, M. G., & Garbarino, M. (2025). Species distribution models built with local species data perform better for current time, but suffer from niche truncation. Agricultural and Forest Meteorology, 362, 110361. https://doi.org/10.1016/j.agrformet.2024.110361
M_Suit02_Tab	MOSAIC	Species Suitability	Data (table file)	*Construction of suitability maps for non-native tree species under climate change scenarios in the Alpine region*	This resource provides modeled suitability information for native and non-native tree species in the Alpine region under historical and future climate conditions. Suitability was modeled using presence-only occurrence data from National Forest Inventory (NFI) datasets and the iNaturalist platform. Predictor variables are the 19 bioclimatic variables from the CHELSA v1.2 climatologies at 30 arc-second (~1 km) resolution. Future climate scenarios use output from the Hadgem-A0 climate model. Outputs are provided as one CSV file per species (28 files), containing grid-cell coordinates (latitude, longitude) and suitability values for the historical period 1979–2013 and two future periods (2041–2060 and 2061–2081) for two RCP scenarios (RCP4.5 and RCP8.5).	PP7 (IIASA)	https://bfwwebm.bfw.ac.at/nextcloud/index.php/s/ajPcDsLRJtAgGZn?path=%2FIIASA%20Suitability%20Maps	-

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Suit03_Vect	MOSAIC	Species Suitability	Data (polygon vector files)	*Forest Specie Composition for the French Alps*	Multi-source maps of forest stand species composition in the French Alps, providing for each forest stand: • Up to four species representing more than 20 % of the stand's composition • Relative shares of each of these species • Source information used to map the stand composition The dataset combines two main sources: BD Forêt® v2 (IGN / IFN), which offers full geographic coverage but limited species-level precision; and ONF management plan description units, which provide precise species information but partial coverage. A k-nearest-neighbor approach was applied to merge these sources, producing a dataset with full spatial coverage and species-level precision.	PP2 (ONF)		Institut National de l'Information Géographique et Forestière (IGN), BD Forêt® version 2.0 Licence Ouverte / Open Licence version 2.0
M_Suit04_Rast	MOSAIC	Species Suitability	Data (raster files)	*High-Resolution Maps of Climate-Suitable Tree Species (%) in French Alpine Forests*	High-resolution (50 m) maps showing the proportion of French Alpine forest stands currently supported by climate-suitable tree species under different climate change scenarios. Climate suitability was assessed using the IKS species distribution model. The dataset includes three future climate scenarios, each combined with three different assumptions regarding maximum soil water capacity, allowing users to evaluate the influence of this crucial, yet difficult-to-map, parameter on species' climatic suitability.	PP2 (ONF)		IKS climate compatibility model. (n.d.). ClimEssences – Presentation of the IKS model. Retrieved 01-19-26, from https://climessences.fr/modele-iks/presentation/presentation-du-modele-iks

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
E_Rock01_Tab	External	Rockfalls		Rockfall database in Alpine Space	Data from the INTERREG Project ROCKtheALPS.	-		
M_Dist01_Mod	MOSAIC		Model	*High-dimensional detection of Landscape Dynamics: a Landsat time series-based algorithm for forest disturbance mapping and beyond*	R package for HILANDYN (High-dimensional detection of Landscape Dynamics) algorithm, which exploits spatial and spectral information provided by Landsat time series to detect forest disturbance dynamics. HILANDYN is a novel and unsupervised procedure for changepoint detection in high-dimensional time series to segment inter-annual time series into linear trends. The algorithm embeds a noise filter to remove spurious changepoints caused by residual spectral noise in the time series.	PP3 (UNITO)	https://github.com/donatomorresi/hilandyn	Morresi, D., Maeng, H., Marzano, R., Lingua, E., Motta, R., & Garbarino, M. (2024). High-dimensional detection of Landscape Dynamics: a Landsat time series-based algorithm for forest disturbance mapping and beyond. GIScience & Remote Sensing, 61(1). https://doi.org/10.1080/15481603.2024.2365001
M_Fir04_Rast	MOSAIC		Data (raster/table files)	*Wildfire Hotspot Mapping in the Alps - Austria Fire Futures*	This dataset provides spatially explicit wildfire danger maps for Austria produced with the wildfire climate impacts and adaptation model (FLAM) at 1 km resolution. It integrates daily climate variables (FFMC and wind speed), fuel load and canopy cover, topography, and an anthropogenic ignition layer based on socioeconomic and infrastructure predictors. Historical reprojection uses 2001-2020 data with calibration over 2006-2015 and validation over the remaining years. Outputs include total ignition probability, suppression efficiency expressed as expected fire duration (hours), and burned area (annual totals, including the 2001-2020 baseline and future averages for 2041-2060, 2061-2080, 2081-2100) under five climate models (MPI45, MPI85, KNMI, SMHI-RCA4, MOHC-HadGEM2).	PP7 (IIASA)	-	Krasovskii, A., Khabarov, N., Pirker, J., Kraxner, F., Yowargana, P., Schepaschenko, D., & Obersteiner, M. (2018). Modeling Burned Areas in Indonesia: The FLAM Approach. Forests, 9(7), 437. https://doi.org/10.3390/f9070437 https://iiasa.ac.at/models-tools-data/flam

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Suit05_Vect	MOSAIC	Species Suitability	Data (polygon vector files)	*French Public Protective Forests Classified by Climate Suitability of Their Species Composition*	Dataset of French public protective forests, enriched with information on stand composition, projected climate suitability, protected assets, and relevant natural hazards.	PP2 (ONF)		-
M_Ava01_Rast	MOSAIC	Avalanche	Data (raster files)	*Avalanche Protective Forest Map of the Alps*	This dataset consists of a map of Alpine forests that are likely to provide protection for human assets and infrastructure against avalanches. The map was produced using a modified version of the Flow-Py model, developed within the MOSAIC project.	PP1 (INRAE) & PP2 (ONF)		D'Amboise, G., et al. (2022). Flow-Py v1.0: A customizable, open-source simulation tool to estimate runout and intensity of gravitational mass flows. Geoscientific Model Development, 15(6), 2423–2439. https://doi.org/10.5194/gmd-15-2423-2022
M_Fir05_Tab	MOSAIC	Wildfires	Data (table file)	*Post-fire natural regeneration across the Alps*	The data record represents a large dataset covering the countries of the Alpine Space to investigate short- and medium-term post-fire regeneration dynamics (from one to twenty years after disturbance). The dataset encompasses 14 fires distributed in Austria, France, Italy, Slovenia, and Switzerland. The database is presented as a table format, containing data derived from field surveys, historical and multitemporal data, and remote sensing analysis. The dataset presents information about the single regeneration tree and environmental variables about the plot. For the single plant we report: species, height class, number of forest regeneration stems. For each plot we report: GPS coordinates of the center, altitude, fire severity, soil cover, and other climatic and topographical variables.	All PPs	https://alpineresilience.org/data	-

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_RS01_Rast	MOSAIC	Remote Sensing	Data (raster files)	*Orthophoto and structure-from-motion digital surface model (SfM-DSM) of UAV surveys for avalanche risk characterisation*	-	PP4 (UNIPD) & PP6 (BFW)		-
M_Fir06_Tab	MOSAIC	Wildfires	Data (table file)	*Soil water content and drought index from Cosmic Rays Neutron Sensing*	The table file contains daily data on (i) volumetric water content (VWC) in the soil obtained using CRNS (Cosmic Rays Neutron Sensing) proximal probes - which quantify the absorption of neutrons produced by cosmic rays by water in the environment - and dimensionless drought index ("Finapp Dryness Index") derived from VWC through appropriate inversion and rescaling on a dimensionless scale.	PP5 (DPC/SPL)		-
M_Ava02_Vect	MOSAIC	Avalanche and Rockfall	Data (polygon vector files)	*Decision-Support Maps of French Public Protective Forest*	This dataset provides vector polygon maps of French public protective forests, integrating information on areas prone to rockfalls and avalanches. Hazard extents were modeled using large-scale simulation approaches: Sylvarock for rockfalls and Flow-Py for avalanches, applied on a 10 m resolution digital terrain model. • Based on model results, the dataset includes the following spatial information: • Functional zoning of protective forests • Importance of protected assets • Nature of protected assets The dataset is specifically designed to support forest planning and management, providing a basis for identifying protective forests and prioritizing management actions.	PP1 (INRAE) & PP2 (ONF)		D'Amboise, G., et al. (2022). Flow-Py v1.0: A customizable, open-source simulation tool to estimate runout and intensity of gravitational mass flows. Geoscientific Model Development, 15(6), 2423–2439. https://doi.org/10.5194/gmd-15-2423-2022 Dupire, S., Toe, D., (2022). Cartographie indicative à l'échelle départementale des aléas rocheux et des forest à fonction de protection. https://doi.org/10.15454/O93984

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Ava03_Rast	MOSAIC	Avalanche	Data (raster files)	*Orthophoto and structure-from-motion digital surface model (SfM-DSM) of UAV surveys for avalanche risk characterisation in windthrow areas*	High-resolution snow and snow free drone data from windthrow areas in mountain forests in Tyrol, Austria and Veneto, Italy. Data acquisition was conducted using unoccupied aerial vehicles (UAV). The windthrow areas were caused by Storm Vaia in 2018 and has since been used as a study site to monitor the protective effect of lying deadwood against snow avalanche release using drone based data. Details on data processing in Agisoft Metashape, including ground sampling distance, accuracy, and processing settings, are documented in the accompanying Agisoft report. The final outputs include a an orthophoto and a digital surface model (DSM).	PP6 (BFW) & PP4 (UNIPD)	-	-
M_Suit06_Rast	MOSAIC	Species Suitability	Data (raster files)	*Presence map of several alpine species*	This dataset consists of presence maps for several Alpine species, produced by spatializing point-based species observations. The spatialization process assigns species to each map pixel by identifying the observation points most similar to that pixel. Similarities are computed based on the coordinates of the points, their altitude, and current climate variables (temperature and precipitation). The resulting hypothesized species composition is then cross-checked against a climate-based species distribution model to remove any species that would not be climatically suitable for the pixel.	PP2 (ONF)		IKS climate compatibility model. (n.d.). ClimEssences – Presentation of the IKS model. Retrieved 01-19-26, from https://climessences.fr/modele-iks/presentation/presentation-du-modele-iks

Code	Source	Main Topic	Data Type	Title	Description	PP(s)	Link to Data	Reference
M_Suit07_Rast	MOSAIC	Species Suitability	Data (raster files)	*Climate-Suitability Indicator of Several Alpine Species*	This dataset provides raster maps at kilometre-scale resolution representing, for each species, the percentage of selected climate change scenarios (from the ClimEssences website) under which the species remains climatically suitable. Maps are masked to the current distribution of each species, allowing users to quickly identify areas where the species' future is most at risk. The dataset also includes a multi-species map, calculated as the mean of the individual species maps per pixel. This multi-species map highlights areas where the current forest species composition is likely to be most affected by climate change.	PP2 (ONF)		IKS climate compatibility model. (n.d.). ClimEssences – Presentation of the IKS model. Retrieved 01-19-26, from https://climessences.fr/modele-iks/presentation/presentation-du-modele-iks
M_Fir07_Tab	MOSAIC	Wildfires	Data (table file)	*FWI Projections for the Triveneto Region*	The analysis estimates the future evolution of the Fire Weather Index (FWI) using maximum temperature and daily precipitation. The observed data and the calculated FWI were used to train a Random Forest model, which was then applied to data from four EURO-CORDEX models, bias-corrected and downscaled to the Triveneto region, for the RCP 4.5 and RCP 8.5 scenarios, for ten station points. A file is produced for each model station, containing FWI estimates for the period 1990-2100.	PP5 (DPC/SPL)		https://clima.arpa.veneto.it/cline_approfondimento.pdf https://clima.arpa.veneto.it/info

3. Standardized Metadata Submission Framework

3.1 Introduction

This chapter describes the **standardised submission form** used to document and publish datasets, models, and derived products in the MOSAIC WebAtlas. The form defines a common set of metadata fields to ensure consistency, transparency, and interoperability across contributions from different PPs.

The submission form is designed to support the implementation of the **FAIR principles** by enabling clear identification, standardized documentation of methods, explicit access and licensing conditions, and persistent citation of project outputs, and is consistent with the metadata collection of common scientific repositories such as Dryad, Zenodo, Figshare, etc. It also ensures that contributed resources can be efficiently integrated into the MOSAIC WebAtlas, while **remaining reusable beyond the project lifetime**.

All partners contributing data or models to the MOSAIC database are required to complete this form. Mandatory fields are clearly indicated, while optional fields allow contributors to provide additional contextual information when relevant.

3.2 Submission Form Fields

3.2.1 Identification

***Title** ** (*text box*)

Description: Mandatory. A clear and descriptive title that summarizes the dataset, model, or derived product. Avoid acronyms unless they are widely recognised. A length of approximately 120 characters is recommended. *Example*: *Post-fire natural regeneration across the Alps*

Data Code / ID (*auto-generated*)

Description: No user input required. The identifier is assigned by the moderators and synthesizes the development source (M = MOSAIC, E = External), the main topic (e.g. wildfires, windthrows, species suitability), and the data type (e.g. model, raster, table). *Example*: *M_Fir01_Mod*

***Authors and Affiliations** ** (*text box*)

Description: Mandatory. Full names of authors (preferably including ORCID identifiers), institutional affiliations, and roles if relevant. *Example*: *Maria Rossi (ORCID: 0000-0002-…), University of North Pole, Department of Ecology; Thomas Schmidt (ORCID: 0123-4567-…), University of South Pole, Department of Ecology*

***Contact Person(s) ** (*text box*)

Description: Mandatory. Name and stable email address of the person responsible for the dataset or model. A project role may be added if useful. *Example*: *Maria Rossi – Data Curator – maria.rossi@uninp.np*

3.2.2 Description

***Type** ** (*drop-down menu + optional text box*)

Options: Dataset | Model/Code | Derived Product

Description: Mandatory. Select the primary resource type and, if relevant, specify a short subtype. *Examples*: *Dataset – Raster time series; Model – Python code; Derived product – Gridded indicator*

***Abstract** ** (*text box*)

Description: Mandatory. A plain-language summary describing the purpose, methods (1–2 lines), geographic and temporal coverage, main variables, key quality notes, and intended reuse. Internal jargon should be avoided. Recommended length: 1,000–2,000 characters.

Recommended Visualization (*text box*)

Description: Optional. Short indication (1–3 lines) of the most informative visualization for the web atlas (e.g. map, time series, histogram, dashboard). A small PNG/JPEG thumbnail may be provided if available.

***Keywords (3–5)** ** (drop-down menu)

Description: Mandatory. Select 3–5 concise keywords from the predefined list. If necessary, select "other" and specify a new keyword. *Example*: *Regeneration; Wildfire; Recovery; Post-fire management*

***Version Number** ** (*text box + changelog*)

Description: Mandatory. Provide a semantic version number (MAJOR.MINOR, e.g. 1.0) and a brief changelog describing updates since the previous version.

Date of Last Upload (*calendar field*)

Description: Mandatory. Date of the most recent update in ISO 8601 format (YYYY-MM-DD). *Example*: *2025-10-30*

3.2.3 Spatial and temporal scales

(Displayed only if the resource is spatial or a spatially derived product)

Coordinate Reference System / Projection * (*text box*)

Description: Mandatory. Provide the CRS using an EPSG code. *Example*: *EPSG:4326*

Geographic Extent * (*four text boxes*)

Description: Mandatory if applicable. Bounding box in WGS84 (EPSG:4326): West, East, South, North. *Example*: *W: 5.6; E: 16.0; S: 43.0; N: 48.5*

Spatial Resolution (*text box*)

Description: Optional. Smallest spatial unit represented, including units. *Examples*: *1-km grid; 10-m pixels; 1:25,000 scale; 6-m radius plots*

Temporal Extent (*text box*)

Description: Optional. Start and end dates following ISO 8601. Use a single start date for ongoing datasets. *Examples*: *2018/2025; 2019-06-01/2020-10-31; 2015-01-01/*

Temporal Resolution (*text box*)

Description: Optional. Time interval between observations, if applicable. *Examples*: *Daily; Monthly; Annual; Single observation*

3.2.4 Methods

Data Collection / Modelling Methods** * (multiple text boxes)

Description: Mandatory. Provide a concise but complete description of how the dataset or model was produced, sufficient to ensure transparency, reproducibility, and correct reuse. Include the following elements as applicable:

- Purpose and context
- Data sources and preprocessing
- Sampling or experimental design
- Data processing and quality control
- Modelling approach (for models or derived products), including software, calibration, and validation
- Assumptions, limitations, and sources of uncertainty
- References to detailed methodological descriptions (e.g. publications, repositories)

Data Structure (*text box*)

Description: Optional. Description of file structure, variables, units, CRS (if spatial), table schemas, and folder organisation. A README file and, for tabular data, a data dictionary are strongly recommended.
Example: *One CSV file with 10,000 rows and 15 variables; each row represents a 1 km² grid cell; coordinates in EPSG:4326.*

File Format, Access, and Licensing * (*drop-down menus + text box*)

*Description***:** Mandatory. Specify:

- File formats (prefer open standards such as CSV, GeoTIFF, GeoPackage, NetCDF/HDF5)
- Access link or repository URL
- Copyright holder and license (e.g. CC BY 4.0 for data; MIT/BSD/GPL for code)

Acceptance of Responsibilities (*tick box*)

*Description***:** Mandatory. Confirmation that the contributor takes responsibility for the accuracy, ownership, and licensing of the submitted resource.

3.2.5 References

Related Publications (*text box*)

*Description***:** Optional. Full bibliographic references (including DOIs where available) to publications describing or using the dataset or model.

DOI (*automatically assigned*)

*Description***:** No user input required. A concept DOI will be assigned to the record, with version-specific DOIs for individual releases where applicable.

4. Conclusions and Outlook

This deliverable documents the first release of the MOSAIC database developed under WP2 NAZCA, providing a **harmonised and open-access collection** of datasets, models, and derived products addressing CC-driven compound events affecting AS protective forests. By integrating empirical data, spatial datasets, and modelling tools within a common framework, the deliverable establishes a critical foundation for the NAZCA modelling platform and for evidence-based climate adaptation and disaster risk reduction strategies in the AS.

***Transnational added value*.** Climate-related hazards and their impacts on forest ecosystems do not stop at administrative or national borders. In the AS, shared climatic drivers, interconnected ecosystems, and transboundary socio-economic systems shaped by centuries of land use require coordinated approaches to risk assessment and adaptation planning of Eco-DRR. The MOSAIC database provides clear **transnational added value** by harmonising datasets and models originating from multiple countries (Italy, France, Austria, Switzerland, Slovenia, Germany), institutions (the different PPs), and disciplinary backgrounds into a **coherent and interoperable framework**. Through standardized metadata, persistent identifiers (i.e., DOI), and OA publication, the database enables **cross-border analyses** of hazard dynamics, forest vulnerability, and protective functions. This transnational perspective supports the development of shared knowledge bases, facilitates comparison of management strategies across regions, and strengthens cooperation among Alpine stakeholders, contributing to a common understanding of climate risks and responses.

Replicability in other regions. The approach adopted in this deliverable is designed to be replicable beyond the AS. The database structure, metadata framework, and submission procedures are generic and scalable, allowing their application to other mountain regions or landscapes exposed to CC-related hazards. By adhering to **FAIR** principles and relying on open

standards and repositories, the MOSAIC database provides a **blueprint** for establishing similar platforms in different geographical and institutional contexts. This replicability enhances the broader relevance of MOSAIC, enabling the transfer of methods, tools, and data management practices to other regions facing comparable challenges related to CC, compound and cascade events, and Eco-DRR.

Key achievements of deliverable D.2.1.1. Deliverable D.2.1.1 achieves several key objectives. First, it establishes a **comprehensive inventory** of field and laboratory datasets, spatial products, and models relevant to CC-related compound events affecting AS protective forests. Second, it defines and implements a **standardised metadata framework** that ensures consistency, transparency, and interoperability across contributions. Third, it provides a **clear workflow** for data submission, documentation, and publication, facilitating ongoing contributions by project partners and integration into the MOSAIC WebAtlas. Together, these achievements lay the groundwork for sustained data sharing, model integration, and knowledge generation within WP2 NAZCA and across the MOSAIC project.

Contribution to scientific outputs. The MOSAIC database supports scientific research by providing **high-quality, well-documented datasets and models** that enable reproducible analyses of CC impacts, hazard dynamics, and forest ecosystem responses. By making these resources openly accessible and citable, the deliverable facilitates their use in peer-reviewed publications, comparative studies, and methodological developments. The integration of empirical data with modelling tools also fosters interdisciplinary research linking climate science, forest ecology, natural hazards, and socio-ecological systems.

Contribution to Policy Uptake. By translating complex data and models into accessible and interoperable resources, the database enhances the **uptake of scientific knowledge in policy and practice**. The integration of datasets into the MOSAIC WebAtlas directly supports decision-makers, risk managers, and forest practitioners in evaluating climate-related risks and adaptation

options. This contributes to the development of evidence-based climate action plans, adaptive forest management strategies, and ecosystem-based disaster risk reduction policies at regional and transnational levels.

Contribution to long-term project legacy. Beyond the project duration, the MOSAIC database represents a lasting legacy by ensuring **long-term availability, traceability, and reuse of project outputs**. The use of persistent DOIs, OA repositories, and standardized metadata supports continued access and updates after project completion. By embedding the database within the MOSAIC WebAtlas and aligning it with existing Alpine initiatives, this deliverable contributes to sustaining a shared knowledge infrastructure that can support future research, policy development, and climate adaptation efforts.

5. References

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