Pan-European standardised database of hazard information

Deliverable D1.2

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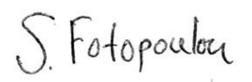
Stavroula Fotopoulou	WP Leader		22/12/2023

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Executive Summary

This document provides a summary of the Deliverable 1.2 - MIRACA Climate Hazard Database. The report gives an overview of the categories of hazards included in the hazard database, highlighting the key findings and gaps of data that should be considered when using the climate hazard database as input for a climate risk assessment.

The MIRACA Climate Hazard database is available in the MIRACA Zenodo page: https://doi.org/10.5281/zenodo.10421815.

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1. Introduction

Critical infrastructure (CI) is exposed to a wide range of climate hazards. At an asset, network and system-level, there are different hazard indicators that can be used to quantify the critical infrastructure risk. This also applies to a specific critical infrastructure: roads, electric grid, bridges,... they all can be affected differently by climate. The Deliverable 1.2 provides a compilation of the most up-to-date hazard datasets at a local, regional and global level that can be used for climate risk assessment.

This report contains a summary of the main categories considered and the key considerations for using the hazard data, based on the findings of the hazard database. The access to the complete Climate Hazard Database is available in the Zenodo MIRACA page: https://doi.org/10.5281/zenodo.10421815

2. Description of hazard database

The hazard database is organised in 3 categories: meteorological/climatological, hydrological and geological (Table 1). For each one, priority has been given to hazard indicators that are available at a Pan-European level and have the highest spatial and temporal resolution, to allow for regional and local climate risk assessment.

Table 1. *List of hazard categories collected in the assessment*

Hazard class	Hazard class
Meteorological / Climatological	Wind, Hail, Drought, Extreme temperature, Wildfire, Storm surge, Climate change
Hydrological	River flooding, Coastal Flooding and Mass movement
Geological	Earthquake, Landslides

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In the database we make the distinction between datasets that provide the hazard footprint, with the extent and date of a specific event, from modelled/reanalysis hazard indicators.

- Hazard footprint: Hazard footprint provides the spatial and temporal extent of historical events. Some examples of this include shakemaps for earthquakes, the water extent from the Global Archive of Large Flood Events[1], landslide events from the Landslide Global Catalog[2] Database or hail events from the European Severe Weather Database[3].
- Model and reanalysis data: For some natural hazards where no footprint database exist, reanalysis and model data is provided. This is the case of heat waves or wind speed.

In the Climate Database, there are datasets available at different processing levels. For example, for drought, standardised drought indicators, such as the Standardised Precipitation Index (SPI) or Standardised Precipitation Evapotranspiration Index (SPEI) are given, in addition to also raw meteorological data that is normally used to generate these indicators. This is done to cover differences in spatial and temporal resolution. For Europe, some meteorological datasets, such as E-OBS have a large temporal coverage and higher spatial resolution compared to standardised drought indicators. By including meteorological datasets in the database, we aim to provide more flexibility during WP1-WP4 for generating specific hazard indicators from raw meteorological data, if needed.

3. Summary of hazard indicators

Overall, through this deliverable we have collected over 70 climate hazard indicators covering both the historical period and future climate projections. For some of the 70 datasets, there are multiple indicators available, which significantly increases the total number of indicators provided in the MIRACA Climate Hazard database. For all the hazards

[1] Brakenridge, G.R. . Global Active Archive of Large Flood Events. Dartmouth Flood Observatory, University of Colorado, USA. http://floodobservatory.colorado.edu/ Archives/ (Accessed 9 October 2023).
[2] Kirschbaum, D.B., Adler, R., Hong, Y., Hill, S., & Lerner-Lam, A. (2010). A global landslide catalog for hazard applications: method, results, and limitations. Natural Hazards, 52, 561-575. doi:10.1007/s11069-009-9401-4
[3] Hulton, F., & Schultz, D. M. (2023). Climatology of Large Hail in Europe: Characteristics of the European Severe Weather Database. EGUsphere, 1-24.

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reviewed, there are at least 3 datasets available with metrics for present and future characterisation (Figure 1).

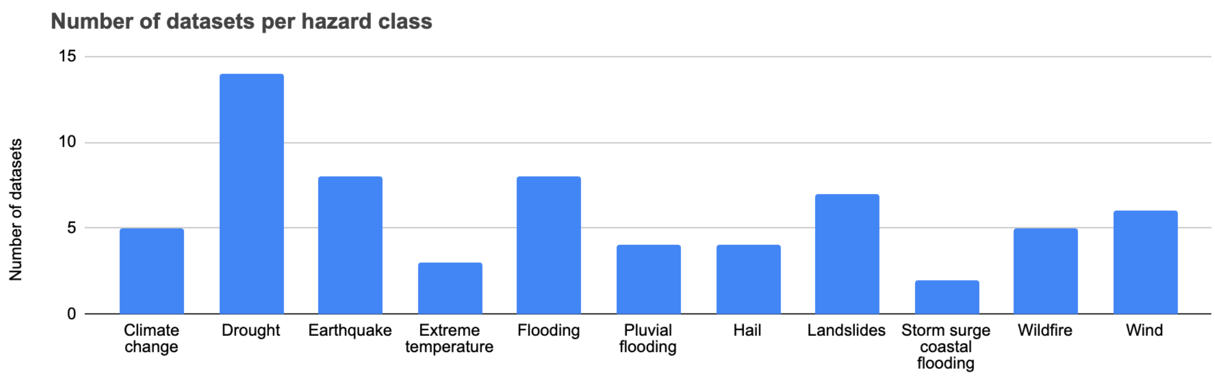

Figure 1. *Number of datasets collected for each hazard class*

Drought is the hazard class with the largest number of datasets. This is mainly due to the wide range of scales of drought that exist (meteorological, agricultural, hydrological drought). For other hazards, such as flooding, the same indicator (water extent) is available from datasets, differing mainly in the spatial extent and methodology used to retrieve the flood map, but not on the indicator metric.

4. Highlights of the Climate hazard database

4.1. Single and Multi-hazard event set

The Climate Hazard database provides indicators for a single-hazard level. One of the goals of MIRACA is to evaluate the impact of compound and cascading climate hazard events. For that, in the MIRACA Climate Hazard database, footprints of past events are provided. To go from single hazard to multi-hazard events, the MIRACA project will build on the work of the MYRIAD-EU[4], an Horizon Europe project that has developed a methodology to generate a multi-hazard event set (the MYRIAD-HESA) from hazard footprints that occur at the same time and location. This methodology will be further explored in Deliverable 1.3.

[4] MYRIAD-EU project is a European Union's Horizon 2020 research and innovation programme. https://www.myriadproject.eu/

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4.2. Climate change scenarios

The indicators within the Climate Hazard Database cover both the historical period and projections under different climate change scenarios. Specifically for the future periods, each dataset has its own methodology, using different numbers of climate models, downscaling techniques, climate scenarios considered and time aggregation. For consistency purposes, it is important to take those into account when performing single and multi-hazard risk assessment. In general, for Europe, most climate change projection data is based on regional climate models (EURO-CORDEX) which have higher resolution than Global Circulation Models. Table 2 shows an example of different datasets with climate projection data and their differences.

Table 2. *Example of climate hazard indicators with climate projection data*

Hazard category	Dataset	Climate Model	Spatial resolution	Scenarios and future Periods
Climate change	*CMIP 5 Bioclimatic Indicators downscaled*	10 Global Circulation Models from CMIP-5	1km x 1km Downscaled based on orography.	RCP 4.5 and RCP 8.5 20-year climate averages
Extreme temperatur e	*Heat wave and cold spell*	8 model combinations from CMIP 5	Bias-adjusted from Regional Climate model EURO-CORDEX	RCP 4.5 and RCP 8.5 30-year climate averages
Wildfire	*Fire weather indicator*	-	0.11° x 0.11°	RCP 2.6, RCP 4.5 and RCP 8.5

4.3. Variability in spatial and temporal resolution

Optimal climate risk assessment at a regional level requires high spatial resolution, which provides finer detail on the part of a critical infrastructure that might be affected by natural hazards. Within the provided climate hazards, there is a range of spatial scales of information. Table 3 below shows an example of the variability of spatial resolution for some hazards.

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Table 3. *Examples of spatial resolution of hazard indicators*

Hazard category	Hazard	Source	Spatial resolution
Flooding	River flooding water depth	Joint Research Centre (JRC)	100 metres
Wind	Maximum 3-second wind gust	Windstorm Information Service	1 kilometre
Drought	Combined drought indicator	Global Drought Observatory	5 kilometre

Another important aspect to consider is the format of data. In general, most of the datasets are available in a Gridded raster format. However, for past events or hazard footprints, such as hail or past flooding events, data is available as Vector layers (either polygon of hazard extent or point of the location of the hazard).

4.4. Availability of data for present and future hazard characterisation

As part of the hazard database, we have retrieved climate hazard indicators for both the present and future climate projections. Table 4 shows the datasets available with future climate projection for each hazard category.

Table 4. *Datasets with future climate projection data*

Hazard category	Dataset with future climate hazard data
Drought	• Global Infrastructure Resilience Index (GIRI) 2023[5] • European Drought Risk Atlas[6]

[5] Camalleri, C., Naumann, G., Rossi, L., Ghizzoni, T., Isabellon, M., Campo, L., & Rudari, R., (2023). Global Drought impact on Hydropower, Water Use and Fluvial Navigation. https://giri.unepgrid.ch/sites/default/files/2023-09/CIMA_GIRI_Drought_BGpaper.pdf

[6] Rossi, L., Wens, M., De Moel, H., Cotti, D., Sabino Siemons, A.-S., Toreti, A., Maetens,W., Masante, D., Van Loon, A., Hagenlocher, M., Rudari, R., Meroni, M., Isabellon, M., Avanzi, F., Naumann, G., Barbosa P. - European Drought Risk Atlas, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/608737, JRC135215

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Extreme temperature	• Global Infrastructure Resilience Index (GIRI) 2023[5] • Copernicus Heat wave and cold spell[7] • CMIP5, CMIP6, CORDEX[8]
Flooding	• Global Infrastructure Resilience Index (GIRI) 2023[5] • Aqueduct Floods[9] • Copernicus River discharge[10]
Pluvial flooding	• CMIP5, CMIP6, CORDEX[8]
Hail	• RAIN FP7 Project[11]
Landslide	• Global Infrastructure Resilience Index (GIRI) 2023[5]
Storm surge	• Global Sea Level Change[12]
Wildfire	• Copernicus Fire Weather Index[13] • RAIN FP7 Project[11]
Wind	• CORDEX Wind speed[14]

For most of the hazards, there are multiple datasets available which provide information on future climate change conditions. However, there are some hazards, such as wind or landslides where only one dataset provides future hazard information. In these cases

[7] Hooyberghs, H., Berckmans, J., Lefebre, F., De Ridder, K. (2019): Heat waves and cold spells in Europe derived from climate projections. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.9e7ca677

[8] Copernicus Climate Change Service (C3S) (2023): Gridded monthly climate projection dataset underpinning the IPCC AR6 Interactive Atlas. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: '10.24381/cds.5292a2b0'

[9] Ward, P. J., Winsemius, H. C., Kuzma, S., Bierkens, M. F., Bouwman, A., De Moel, H., ... & Luo, T. (2020). Aqueduct floods methodology. World Resources Institute, 1-28.

[10] Berg, P., Photiadou, C., Bartosova, A., Biermann, J., Capell, R., Chinyoka, S., Fahlesson, T., Franssen, W., Hundecha, Y., Isberg, K., Ludwig, F., Mook, R., Muzuusa, J., Nauta, L., Rosberg, J., Simonsson, L., Sjökvist, E., Thuresson, J., and van der Linden, E., (2021): Hydrology related climate impact indicators from 1970 to 2100 derived from bias adjusted European climate projections. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.73237ad6.

[11] European Severe Storms Laboratory; Faculty of Civil Engineering and Geosciences Department of Hydraulic Engineering TU Delft; Institute of Meteorology Freie Universität Berlin; Finnish Meteorological Institute (2016): RAIN: Pan-European gridded data sets of extreme weather probability of occurrence under present and future climate. Version 1. 4TU.ResearchData. collection. https://doi.org/10.4121/collection:ab70dbf9-ac4f-40a7-9859-9552d38fdccd.

[12] Muis, S., Irazoqui, M., Álvarez, JA., Verlaan, M., Yan, K., Dullaart, J., Aerts, J., Duong, T., Ranasinghe, R., le Bars, D., Haarsma, R., Roberts, M (2022a): Global sea level change time series from 1950 to 2050 derived from reanalysis and high resolution CMIP6 climate projections. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.a6d42d60.

[13] Copernicus Climate Change Service, Climate Data Store, (2020): Fire danger indicators for Europe from 1970 to 2098 derived from climate projection. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.ca755de7.

[14] Copernicus Climate Change Service, Climate Data Store, (2019a): CORDEX regional climate model data on single levels. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.bc91edc3.

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there is a lack of the intensity expected under different climate scenarios. Some approaches exist that can be used to overcome this limitation.

One example of the applicable approaches is to determine a change in intensity by changing the expected return-level in the future. To determine the potential change in intensity, one can use the trend during the historical period, which shows the existing change patterns over the last years.

Another approach that can be followed is to use proxy indicators to determine expected changes in certain indicators. For example, for future landslide risk, incorporate the expected change from extreme precipitation. In order to help characterise future climate hazards, one approach is to establish impact-relevant thresholds. For example, determine a hazard based on the number of days exceeding a certain temperature, or a number of *mm* of rainfall in a day. This can help identify, already for the historic period, the number of times a specific threshold has been exceeded, find whether the change is significant and determine different future scenarios with percentage increases and decreases of the threshold.

For all these approaches, there are limitations associated with the uncertainty in predicting future changes. As a starting point, the MIRACA Climate Hazard database presented in this report covers a wide range of datasets that allow for historical and future climate hazard characterisation in Europe.

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