SERVICIOS CLIMÁTICOS DE ALTA RESOLUCIÓN PARA MEJORAR LA RESILIENCIA CLIMÁTICA DE ACTIVOS CRÍTICOS (ICARIA)

HIGH-RESOLUTION CLIMATE SERVICES FOR IMPROVING CLIMATE RESILIENCE OF CRITICAL ASSETS (ICARIA) PROJECT

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SUMMARY

The Horizon Europe project "Improving Climate Resilience of Critical Assets" (ICARIA) addresses concerns about the increasing impacts of climate change on critical infrastructures and socioeconomic activities. Focused on the Metropolitan Area of Barcelona (AMB), the project aims to design high-resolution climate services to assess climate hazards and enhance asset resilience. Utilizing the FICLIMA statistical downscaling method and climate models, ICARIA generates local climate projections, particularly focusing on extreme events like flooding and temperature extremes. The project evaluates risks and damages to critical infrastructures, emphasizing the assessment of compound multi-hazard events. Through advanced modeling techniques, including hydrodynamic and hydrostatic models, ICARIA assesses risks associated with floods, storm surges, heatwaves, and droughts in the AMB. The project's outcomes provide crucial insights for decision-making processes and adaptation strategies to mitigate climate risks in the region.

Impacts on critical infrastructures and on the linked socioeconomic activities are a rising concern derived from the rapid climate change that human societies are causing and experiencing. However, the available climate projections are spatially too coarse to adequately simulate extreme climate events at a local scale. Under this context, the Horizon Europe project “Improving Climate Resilience of Critical Assets” (ICARIA) aims to design high-resolution climate services to assess the main hazards derived from climate change and, thereby, increase the resilience of critical assets to face the impacts (Russo et al., 2023).

To reach that goal, different approaches have been taken within ICARIA in order to provide the best climate information and hazard simulation for the vulnerable infrastructure and services identified in the three ICARIA pilot cases: Metropolitan Area of Barcelona (AMB), the Salzburg Region and the South Aegean Region. For this specific dissemination case, the area considered of interest is the AMB, with whom climate services were codesigned together, taking advantage of their extensive experience on the field and the weather data provided as an observation database of reference (from Servei Meteorologic de Catalunya -SMC- and Agencia Estatal de Meteorología -AEMet-). As a basis to develop the required climate services, the FICLIMA statistical downscaling method (Ribalaygua *et al*. 2013, Monjo *et al.*, 2023) was applied with the use of ERA5-Land and 10 CMIP6 Earth System Models to produce high-resolution climate projections for the three pilot cases. Statistics such as the MAE, Bias or Kolmogorov-Smirnov test were used to verify the methodology for each observatory and model. Those that passed filters of quality and performance in the representation of past climate were used to generate local downscaled climate projections at daily resolution for each location for the Tier 1 SSPs (1.26, 2.45, 3.70 and 5.85). Statistical downscaling outputs will serve to compare results and better assess the inherent uncertainties of climate projections.

Climate services on extreme events to support AMB’s decision-making processes are then designed. AMB’s main source of worry is hazards related to flooding, so these were the main focus to study, although others were identified as of concern such as temperature-related events. These extremes are modelled for three time periods (2011-2040, 2041-2071 and 2071-2100) considering the 10 CMIP6 ESM and their 4 Tier 1 SSPs in relation to different global warming levels (1.5°C, 2°C, 3°C and 4°C), and are defined through several indicators that include related local impacts as well as compound extreme events (such as heatwaves and drought, storm surge and coastal flooding, or pluvial/fluvial flooding). Therefore, among others, climate services will include suitable indicators on extreme sea level, precipitation intensity estimates through future IDF curves (Monjo *et al.*, 2023) and return periods of 1, 2, 5, 10, 20, 50, 100, 500 years, or heatwaves and drought indices (SPI, SPEI).

With these data as input, sectorial hazard and impact models are being developed to quantify the risk and damage (in economic terms) that future extreme weather events can cause to critical infrastructures of a region. Importantly, in project ICARIA, special emphasis is being put on assessing the risk associated with compound multi-hazard events, which have been recognized as a growing threat to infrastructure and urban areas (IPCC 2022). In the case study of the AMB, results of the regional climate downscaling are being used to quantify the risk associated with the following events: pluvial floods, storm surges, heatwaves, droughts and forest fires.

Pluvial IDF curves, corresponding to different climate change scenarios, are used to determine synthetic rain events with different return periods, and to assess the consequences of flooding events that can derive from extreme rainfall events. More specifically, such rainfall data is introduced in a 1D/2D hydrodynamic model capable of simulating in a realistic manner how floods can affect urban areas. Such a model is capable of representing the complex interactions between the surface runoff (2D domain of the model) and the water flow in the urban drainage system of a city (1D domain) (Henonin *et al.*, 2013).

As for assessing coastal flooding events, based on the projections of extreme sea levels, a hydrostatic sea level model is being developed to assess the extent of low-lying areas of the AMB coast that can be affected by sea-induced flooding (Russo *et al.*, 2020).

The projections of daily mean temperature and of the evolution of heatwave frequency are incorporated in a heat island effect model that helps to assess the actual temperature stress that will be experienced by citizens during prolonged exposure to extreme heat conditions. The consequences of that exposure are translated to quantifiable impacts such as increases in mortality rates or raises in hospitalisation costs (Zuccaro & Leone 2021).

Finally, the daily time series of precipitation and temperature, as well as evapotranspiration, are included in a physical hydrological model representing the basins of the main reservoirs supplying the AMB. The results of this model enable projections of the volume of stored water that will be available in these reservoirs during the coming decades according to different climatic scenarios. Based on these simulations, it is possible to estimate the frequency, duration, and severity of future drought events that may affect this territory (Forero-Ortiz *et al.*, 2020).

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