Morondava

Extreme Flood Preparedness Service

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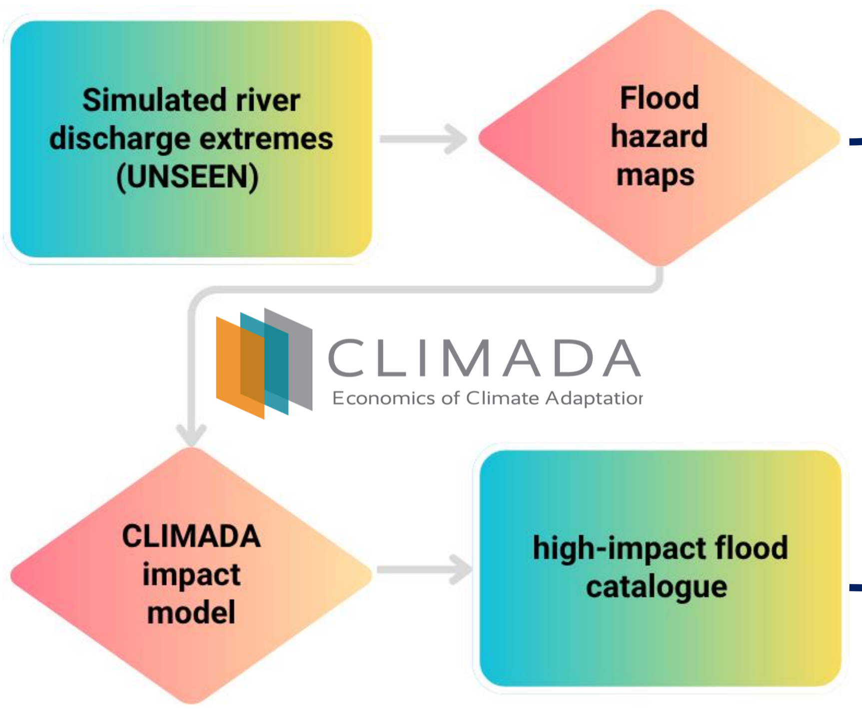
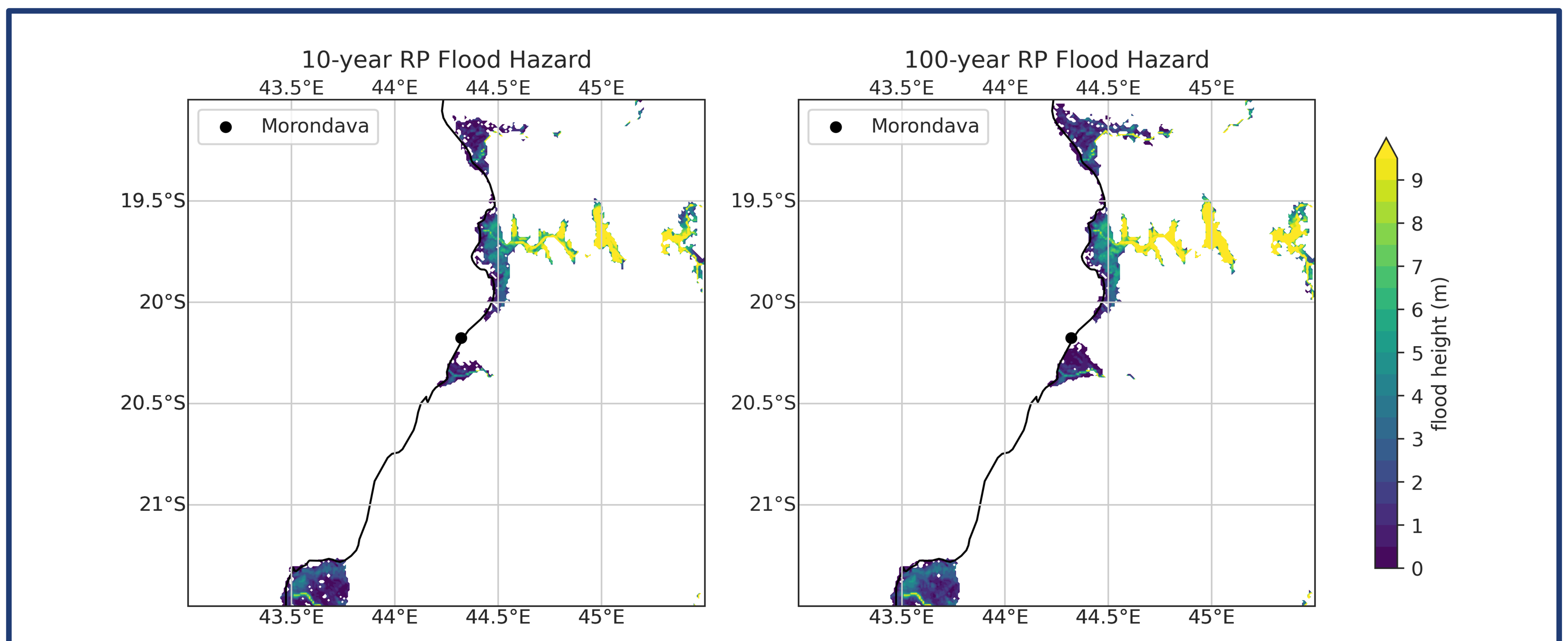
The **UNSEEN** framework (Unprecedented Simulated Extremes Using Ensembles; Osinski et al. 2026; Thompson et al., 2017) is an established methodology that leverages ensemble prediction systems to generate large event sets of **physically plausible, yet unrealized weather-related extremes.** The core advantage of UNSEEN lies in the ability to overcome the limited availability of historical extreme events by treating ensemble predictions as alternative realizations of the past climate. The resulting **event sets** are typically used to explore **counterfactual developments** of observed events or to better infer the **frequency** and characteristics **of the most impactful events**.

The product in a nutshell:
A **catalogue** of unprecedented, **high-impact flood events** for the Morondava hub region will be produced by combining
(i) hazard information from ensemble hindcasts of extreme river discharge; and
(ii) socio-economic risk estimated from the impact model *Climada (Aznar-Siguan and Bresch, 2019).*

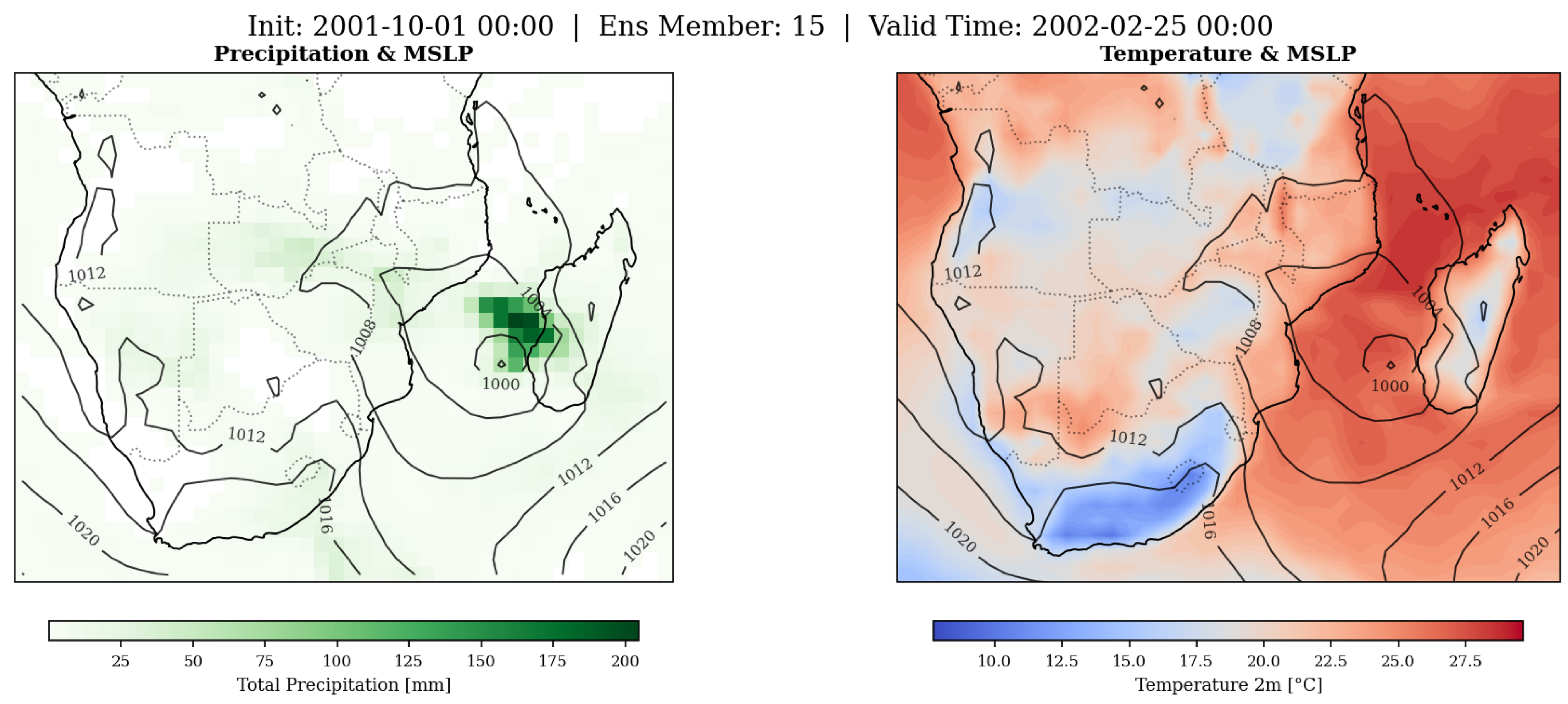




Flood hazard maps in the region surrounding Morondava, for a 10-year return period (left) and 100-year return period flood (right). Source data are obtained from Baugh et al. (2026) and provide estimated inundation heights associated with floods with occurrence probabilities ranging from 10 to 500 return periods. For the Morondava case study, this data product is used to interpolate the flood hazard associated with simulated (UNSEEN) river discharge extremes that could affect the region under present climate conditions.

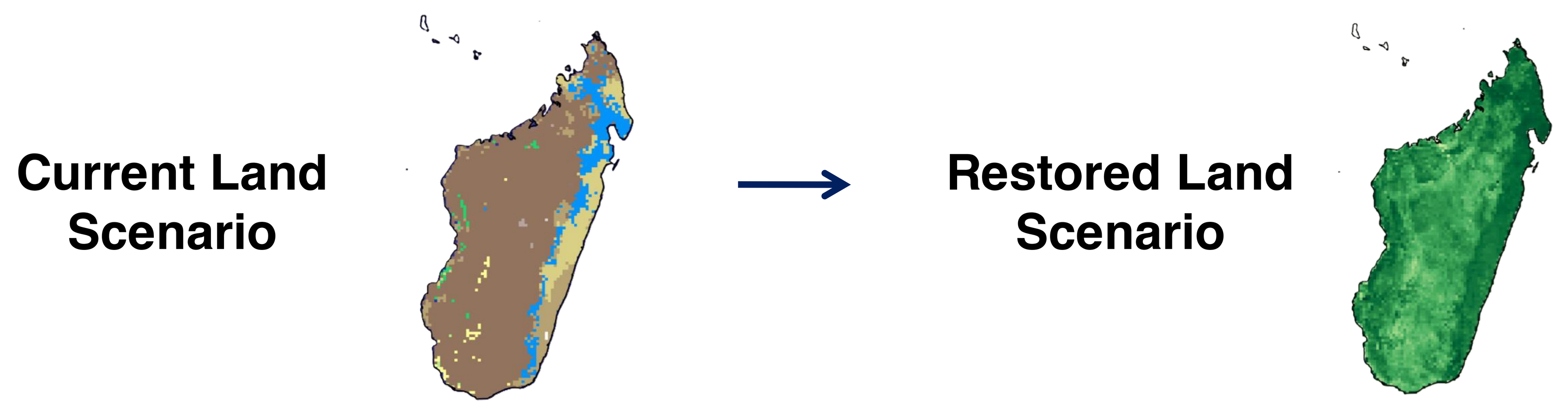
Combining UNSEEN with impact modelling

The added value of ensemble prediction systems is that they provide a large ensemble of physically plausible extreme events. Although unrealized, such events are possible under the present climate. Through an **end-to-end flexible framework**, simulated flood extremes are mapped to the open-source impact model **CLIMADA**. The resulting risk catalogue incorporates a subset of events that would cause severe economic damage to the Morondava region.



Unpacking the extremes: Meteorological drivers of simulated high-impact events. The event catalogue allows us to trace severe floods back to their driving weather patterns. By retrieving the corresponding fields from the Copernicus Climate Data Store, we can reconstruct the physical dynamics of these unrealized extremes.

This figure illustrates the synoptic conditions (Mean Sea Level Pressure overlaid on Precipitation and 2m Temperature) of a simulated February tropical cyclone, which triggers a high-return-period rainfall extreme over Madagascar.



These extracted synthetic weather forcings offer opportunities far beyond risk cataloguing. They provide the baseline for running **twin experiments** to evaluate the effectiveness of **large-scale land restoration**. By driving hydrological models under both "current" and "restored" land scenarios using these extreme events, we can quantify the mitigating effect of nature-based solutions. Ultimately, these insights, currently being explored in collaboration with the University of Cape Town, aim to directly inform adaptation policies and targeted investments.

Users and envisaged applications in the hub

The Morondava Hub, located within the Kirindy Mitea Biosphere Reserve in southwestern Madagascar, faces critical climate-induced challenges, including coastal erosion, soil degradation, and disrupted seasonal predictability.

This CS targets a diverse network of end-users: **Civil Protection and Disaster Risk Managers** will leverage the hazard data to enhance early warning and emergency preparedness; **Local Authorities, Municipal Planners, and Technical Services** can integrate these climate insights into land-use planning. Technical experts, including **Meteorologists, Hydrologists, and Civil Engineers,** can exploit the simulations to model local hydrological responses and design climate-resilient infrastructure.

The product offers **several application opportunities**, including:
- reducing risk uncertainty via the identification of the key meteorological drivers of flood events affecting the hub;
- exploring the possible socio-economic impact of extreme events;
- assessing region-specific stress levels;
- developing ex-ante mitigation strategies to improve infrastructure and socio-economic resilience.

Hub coordinator and main implementer of interventions: UNESCO & OXFAM South Africa

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Funded by the European Union

Funded by the European Union under G.A. NO 101137895. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Commission. Neither the European Union nor the European Commission can be held responsible for them.