Climate Adaptation Digital Twin (DE340)

The HydroMet Use Case: Extreme rain event analysis and catalogization

C. Hartick, S. Sayed

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

INTRODUCTION

The impact of climate change is often experienced through extreme events. The Eifel floods (12 - 15 July 2021 in Western Europe) specifically led to considerable loss of life and an estimated €50 bn in property losses. The HydroMet use case scopes to detect and identify extreme rainfall events in the Climate Adaptation Digital Twin (Climate DT) data stream. The summarized data and information will be listed within an event catalogue. The main software components and packages for this application are the KOSTRADAMUS and WetCat packages, adapted and updated versions of DWD (Deutscher Wetterdienst) internally developed codes. The application is being implemented by closely interacting with the German Adaptation Strategy to Climate Change (DAS) Core Service "Climate and Water", which provides data and information about climate change for adaptation management and the Bavarian Environment Agency.

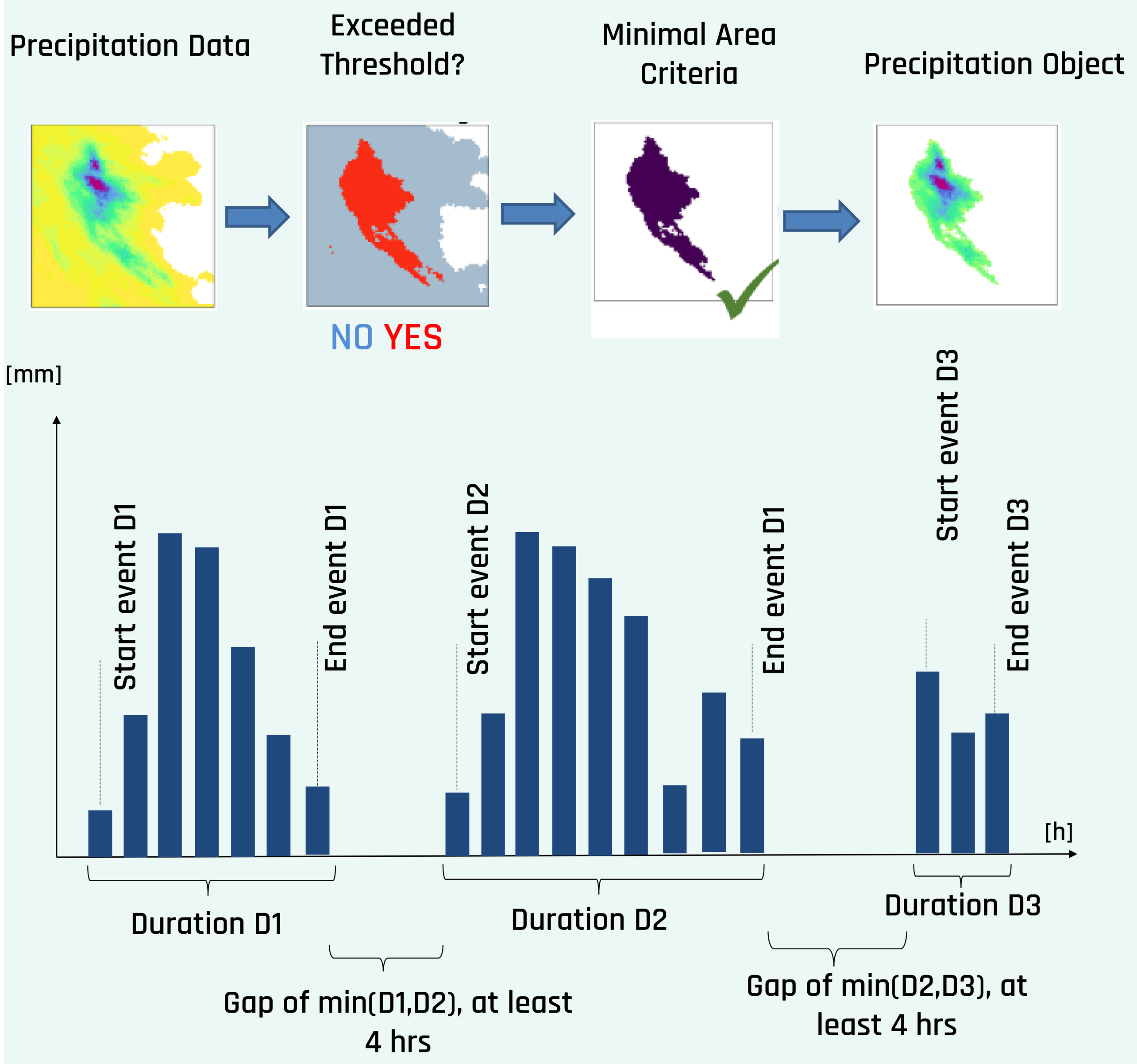
IMPLEMENTATION IN THE CLIMATE DT WORKFLOW

The HydroMet use case operates on total precipitation (tp) data from Climate DT simulations, undergoing multiple processing steps via distinct software and sub-routines. A pre-processing script, integrated into the One-pass layer, computes and aggregates historical data necessary for extreme rain statistics calculation in the KOSTRADAMUS component. The WetCat software defines precipitation objects based on exceeded thresholds, considering temporal and spatial independencies for each object. It utilizes statistical output from KOSTRADAMUS and reads directly from the GSV. Two criteria are applied to select events while accounting for spatial and temporal dependencies:

How can the initiative help to improve the state of the art methods in the hydrology sector?

For this we can identify the user needs and requirements that the ClimateDT will be able to address:

Needs	Requirements
Estimate likelihood of extreme precipitation events.	Observe and analyse return time of extreme rain events, cover extreme value statistics for sub-hourly durations to several days.
Detect and observe areas of high risk.	Deal with regionality of rain events. Ability to detect convective weather patterns (<10 km).
Observe and estimate temporal trends of extreme precipitation.	Deal with transient behaviour of rain events, especially extreme rain e.g. Thunderstorms (<30 minutes).
Observe and estimate spatial trends of extreme precipitation.	Analyse spatial distribution of heavy rain in Germany, determine small scale/regional patterns (<10 km) and trends.



1. Spatial independency
Events must not spatially overlap in case a time step includes objects of several duration windows.

2. Temporal independency
Between two events covering the same or similar area, there has to be a time gap, the length of the duration window of the shorter event, but at least 4 hours.

Fig. 1 The two criteria of a rain event selection.

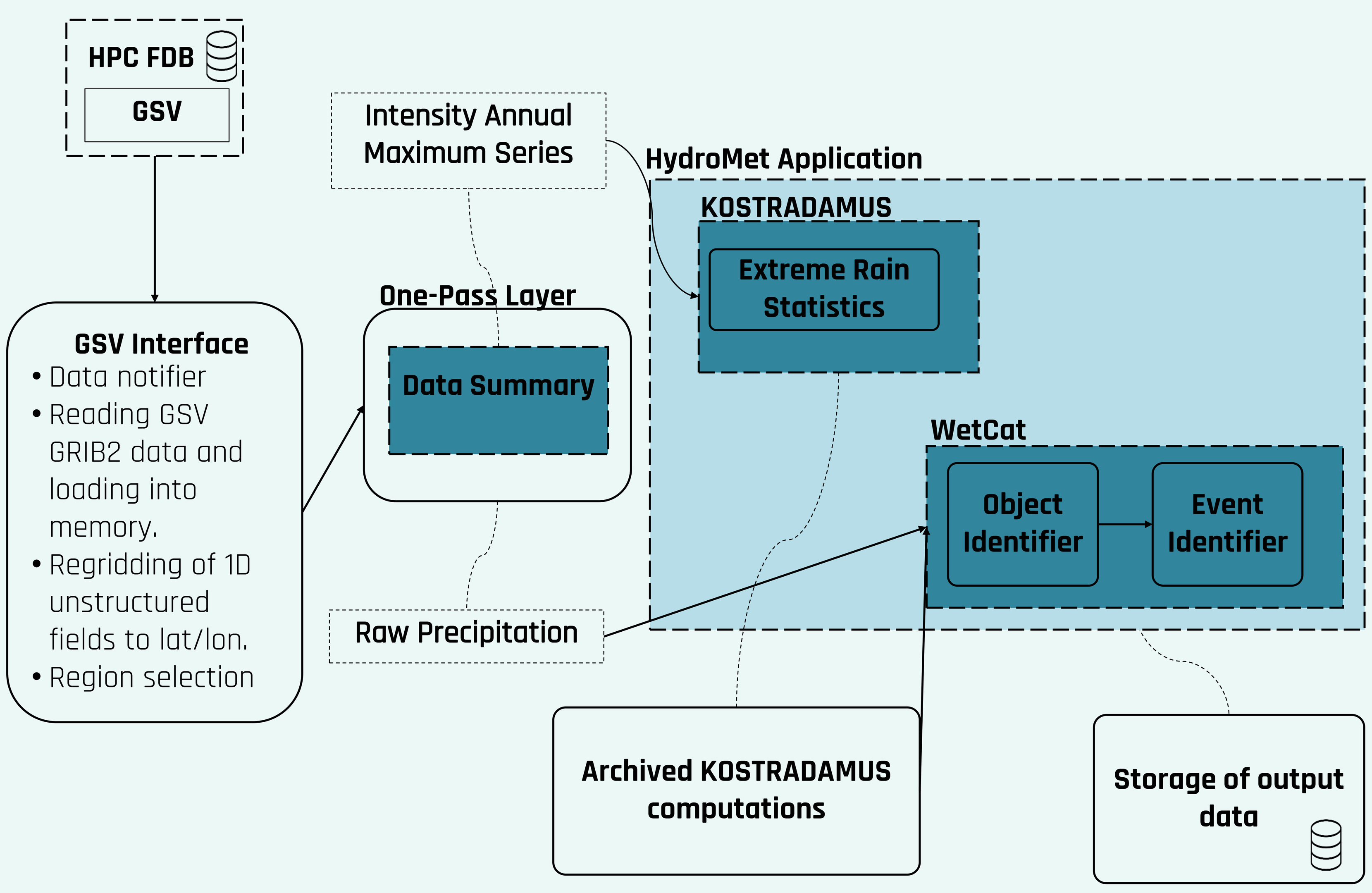


Fig. 2 Architecture of the HydroMet application and its implementation to the Climate DT workflow.

RESULTS

The analysis here is performed on the latest Climate DT 10 km resolution IFS NEMO runs. Figures 3 and 4 show examples of the HydroMet output for the period 1990 to 2039. The map in figure 3 shows the projected changes in 100-year, 1-hour extreme precipitation across Europe under the high-emission SSP3-7.0 scenario, covering the period from 2020 to 2039, relative to the historical period of 1990-2019. Red areas indicate increases, suggesting a higher risk of flash floods due to more intense short-duration rainfall.

The bar chart in figure 4 shows the annual number of extreme precipitation events for the same period, grouped by the affected area size. Over time, the total number of events increase with notable rises in medium (250 – 1000 km²) and large (>1000 km²) area events after 2020. The trend in these simulations indicates a growing frequency and spatial extent of extreme rainfall, underscoring the need for large-scale flood preparedness and infrastructure adaptation.

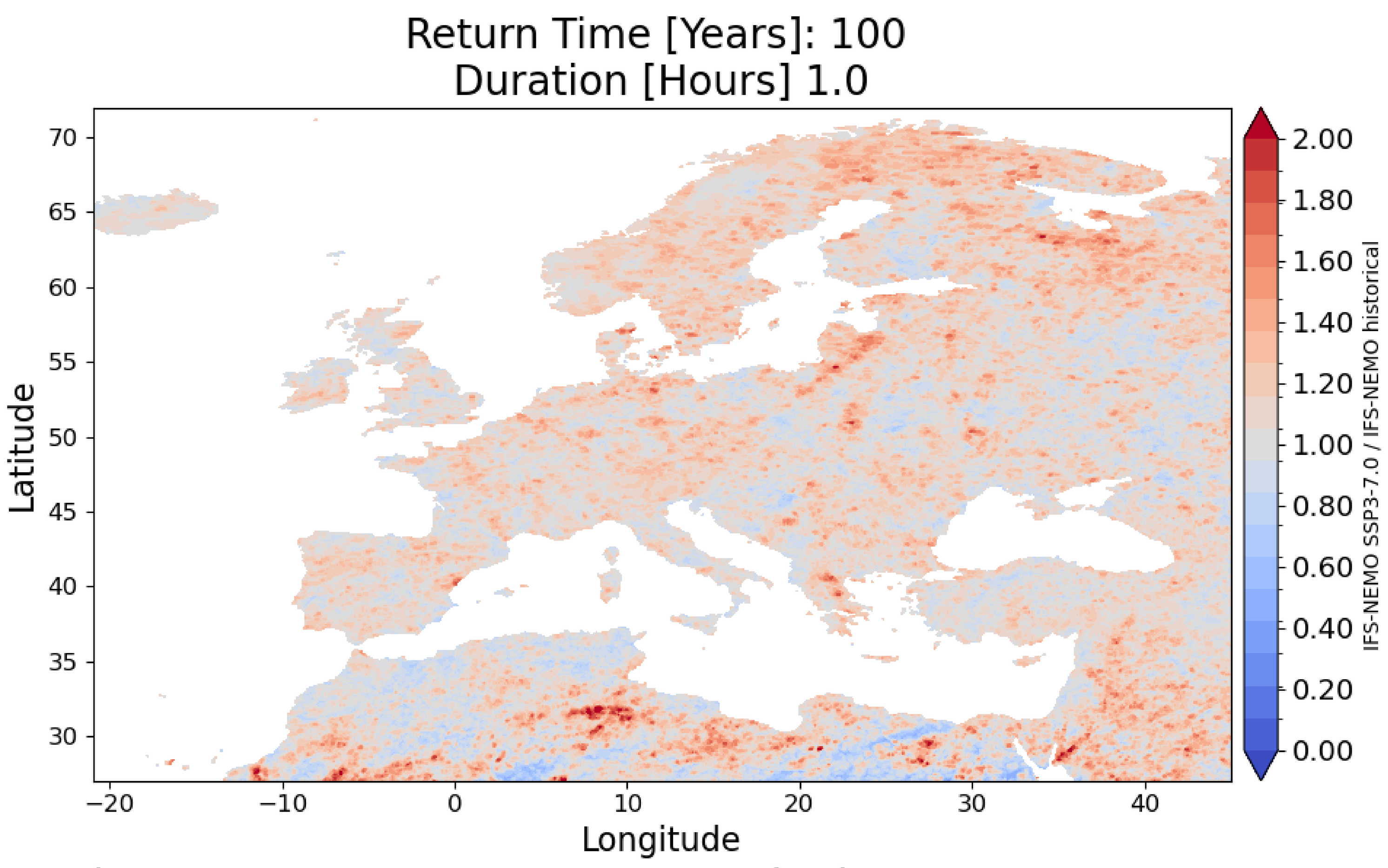


Fig. 3 KOSTRADAMUS output over Europe for the IFS NEMO run.

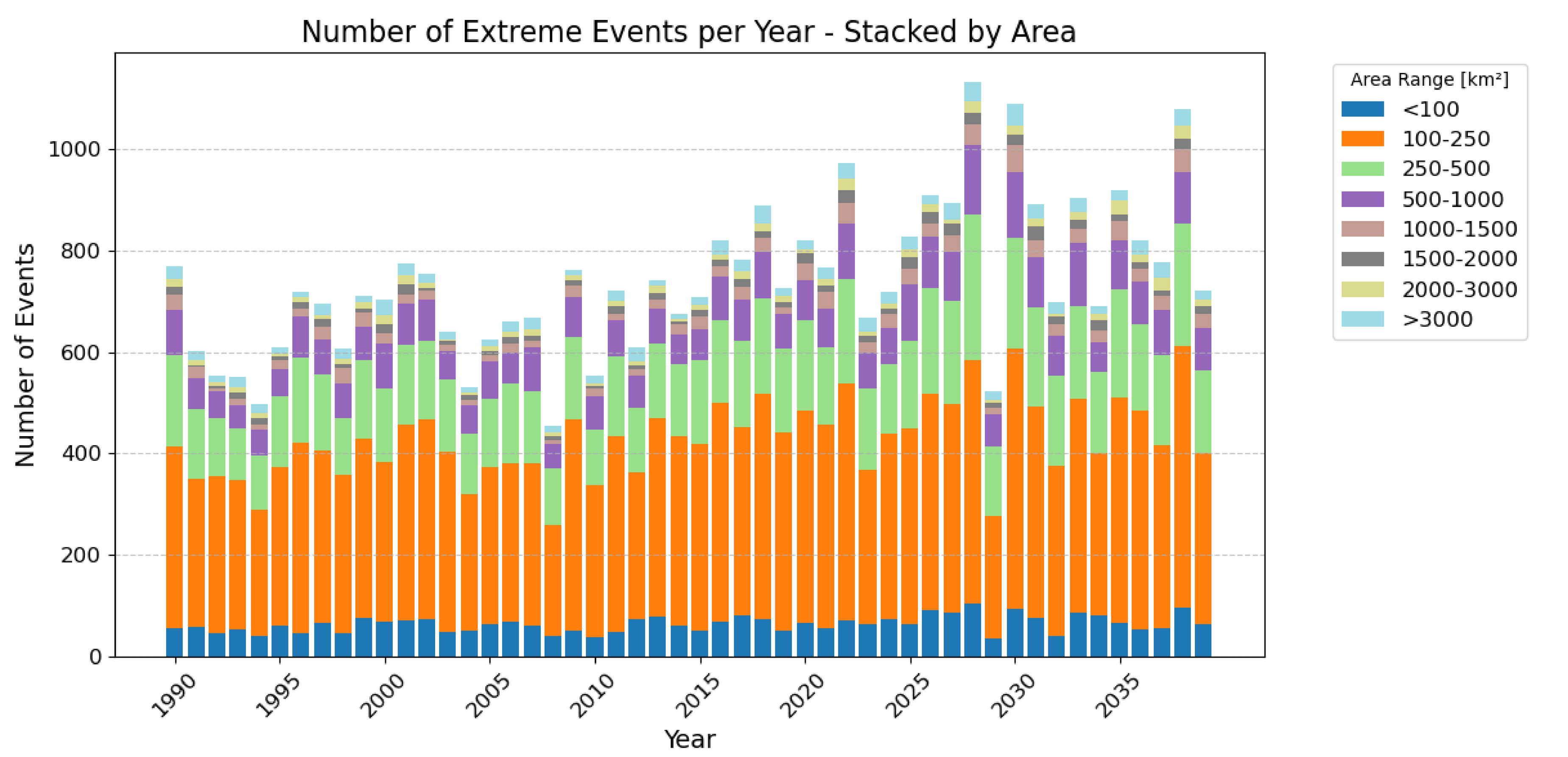


Fig. 4 Number of events per year for the IFS NEMO run over Germany.

Funded by the European Union
Destination Earth
implemented by ECMWF esa EUMETSAT