Data-based attribution of changes in flood quantiles across Europe between 1960 and 2010

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INTRODUCTION Recent studies have shown evidence of increasing and decreasing trends in mean annual floods and flood quantiles across Europe. Studies attributing observed changes in flood peaks to their drivers mostly focused on the average flood behaviour.

RESEARCH QUESTIONS (a) Is it possible to identify the relative contributions of different drivers to observed flood changes across Europe as a function of the return period? (b) What is the magnitude of these contributions?

FLOOD DATA We analyse 2370 annual maximum discharge series, selected from a newly available pan-European flood database, with record lengths of at least 40 years over the period 1960-2010 and catchment areas ranging from 5 to 100'000 km^2 (Fig. 1).

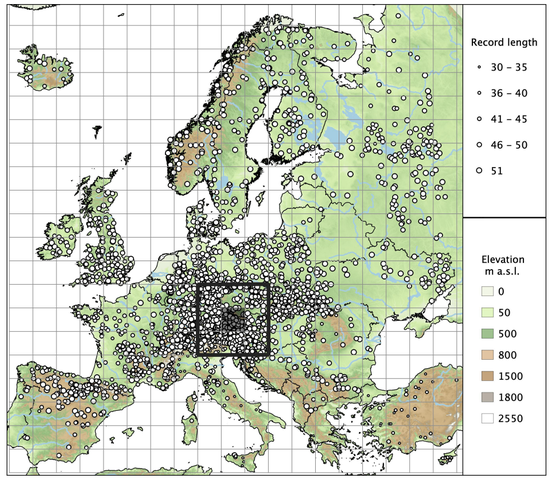


Figure 1. Location of 2370 hydrometric stations in Europe. The grid size is 200 km. The black bordered region shows the size of the spatial moving windows (600x600km).

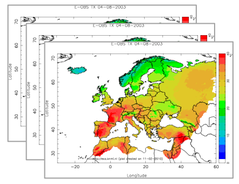
METHODS We assume flood peaks to follow a non-stationary regional Gumbel distribution, where the median flood and the 100-year growth factor are used as alternative parameters to the Gumbel location and scale parameters. They are allowed to vary in time and between catchments as a function of drivers quantified by covariates. A Bayesian Markov Chain Monte Carlo (MCMC) approach is used for parameter estimation.

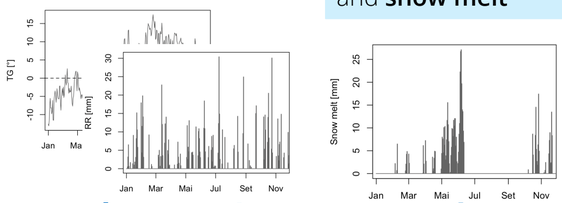
DRIVERS OF FLOOD CHANGE Extreme precipitation, antecedent soil moisture and snowmelt are the potential drivers of flood change considered.

E-OBS gridded database for Europe 1960-2010 of daily **precipitation** and mean **temperature**

→ 2370 daily series of **catchment-averaged** precipitation and mean temperature

→ Degree-day model: 2370 daily sereis of catchment averaged snow accumulation and **snow melt**





Annual series based on flood seasonality:

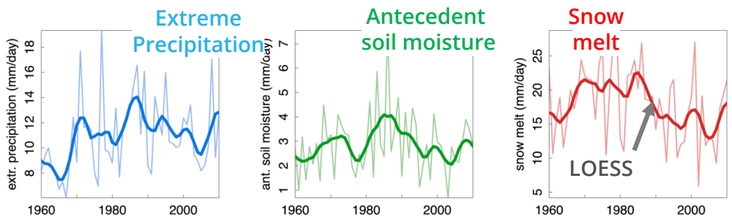
7-day max precipitation	30-day antec precipitation	7-day max snowmelt

Corresponding driver:

Extreme precipitation	Antecedent soil moisture	Snowmelt

REGIONAL DRIVER INFORMED MODEL Regional Gumbel with alternative parameters: 2-yr flood q_2 and 100-yr growth factor x'_{100}

$$\ln q_2 = \ln \alpha_{2_0} + \gamma_{2_0} \cdot \ln S + \alpha_{2_1} \cdot \ln X_1 + \alpha_{2_2} \cdot \ln X_2 + \alpha_{2_3} \cdot \ln X_3 + \varepsilon$$
$$\ln x'_{100} = \ln \alpha_{g_0} + \gamma_{g_0} \cdot \ln S + \alpha_{g_1} \cdot \ln X_1 + \alpha_{g_2} \cdot \ln X_2 + \alpha_{g_3} \cdot \ln X_3 \quad \varepsilon \sim N(0, \sigma)$$



with $q_{100} = q_2(1 + x'_{100})$

CONTRIBUTIONS OF DRIVERS TO FLOOD CHANGE

Elasticity of q_T to X_i (%/%): $S_{T,X_i} = \frac{X_i}{q_T}\frac{\partial q_T}{\partial X_i} = \alpha_{2_i} + \alpha_{g_i}\left(1 - \frac{1}{1+a_T x'_{100}}\right)$

Contribution of X_i to changes in q_T (%/decade): $C_{T,X_i} = \frac{X_i}{q_T}\frac{\partial q_T}{\partial X_i} \cdot \frac{1}{X_i}\frac{dX_i}{dt}$

Relative contribution of X_i to changes in q_T (-): $R_{T,X_i} = \frac{abs(C_{T,X_i})}{\sum_i abs(C_{T,X_i})}$; $\sum_i R_{T,X_i} = 1$

RESULTS In northwestern Europe, extreme precipitation mainly contributes to changes in both the 2- and 100-year flood, while the contributions of antecedent soil moisture are of secondary importance. In southern Europe, both antecedent soil moisture and extreme precipitation contribute to flood changes, and their relative importance depends on the return period. Antecedent soil moisture is the main contributor to changes in q_2, while the contributions of the two drivers to changes in larger floods are comparable. In eastern Europe, snowmelt drives changes in both q_2 and q_{100}.

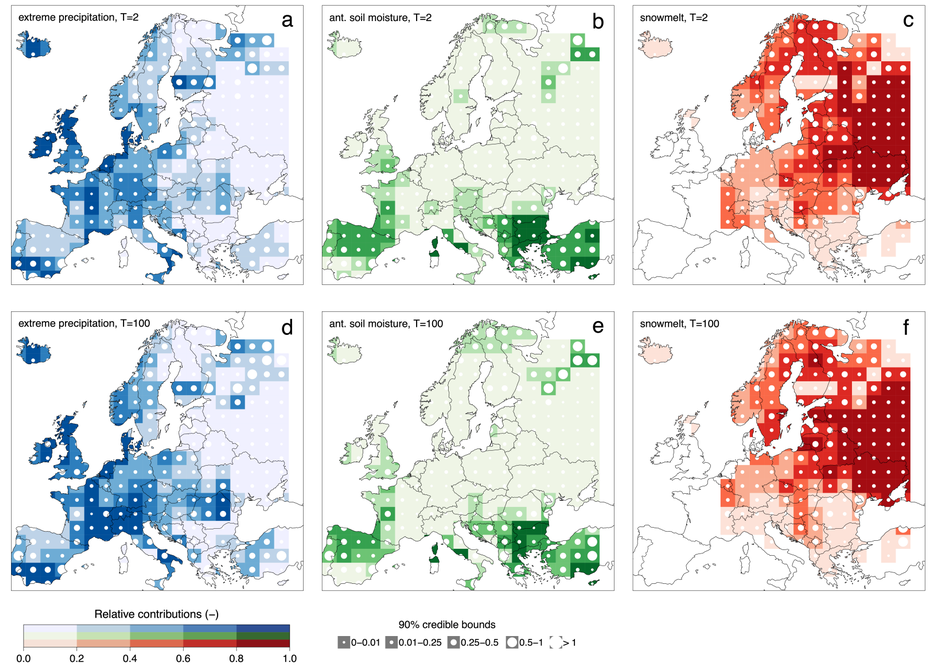


Figure 2. relative contributions of extreme precipitation (a, d), antecedent soil moisture (b, e) and snow melt (c, f) to changes in the median flood q_2 and the 100-year flood q_{100}.

CONCLUSION This study represents a continental-scale attribution analysis and complements recent research on past changes in European floods by formally attributing the detected trends to potential drivers as a function of return period. The results of this study contribute to improve the understanding of past flood regime changes across Europe and are useful for interpreting decadal changes in flood magnitudes at the regional scale.

CONTACT INFORMATION

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