

Supplementary Material For: Return levels of extreme European windstorms, their dependency on the NAO, and potential future risks

Matthew D. K. Priestley¹, David B. Stephenson¹, Adam A. Scaife^{2,1}, Daniel Bannister³, Christopher J. T. Allen⁴, and David Wilkie⁴

¹Department of Mathematics and Statistics, University of Exeter, UK

²Met Office, Exeter, UK

³WTW Research Network, WTW, UK

⁴Model Research & Evaluation, Gallagher Re, UK

Correspondence: Matthew D. K. Priestley (m.priestley@exeter.ac.uk)

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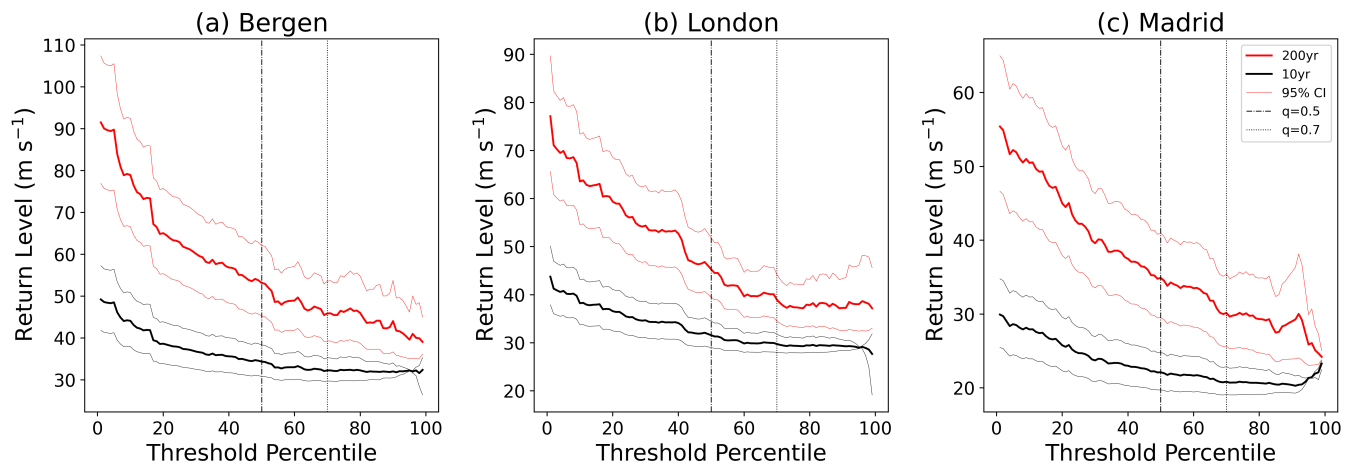


Figure S1. The sensitivity of the 10-year (black solid) 200-year (red solid) return level to the choice of quantile threshold for (a) Bergen, (b) London, and (c) Madrid. Vertical black lines indicate the 0.5 and 0.7 quantiles. Thin red and black lines represent the 95% confidence interval based upon the estimate of the σ parameter.

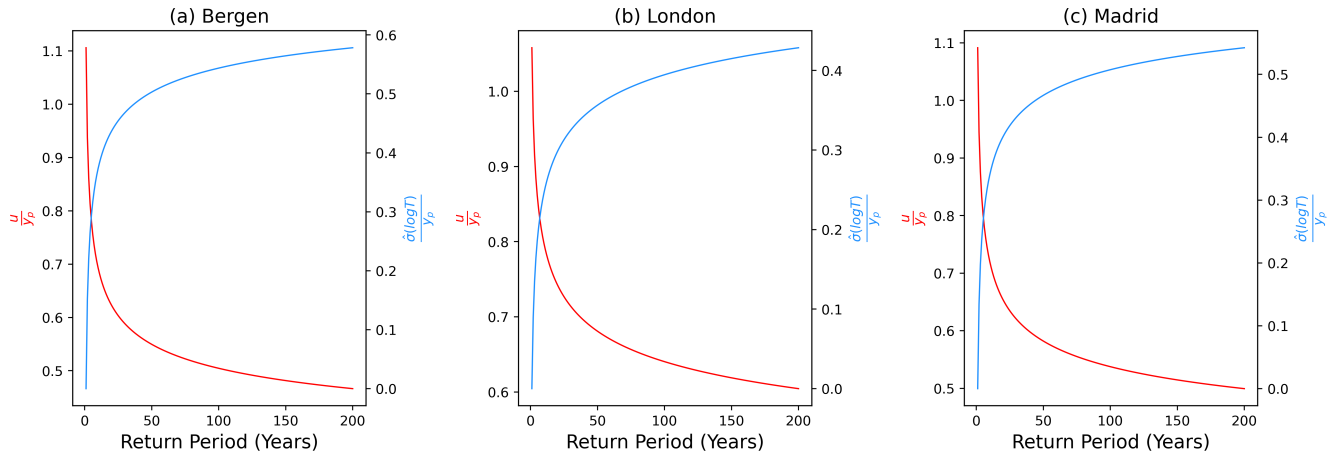


Figure S2. Ratio of the threshold (u) and excess ($\delta(\log T)$) in the formulation of the return level for a range of return periods. Ratios are shown for (a) Bergen, (b) London, and (c) Madrid.

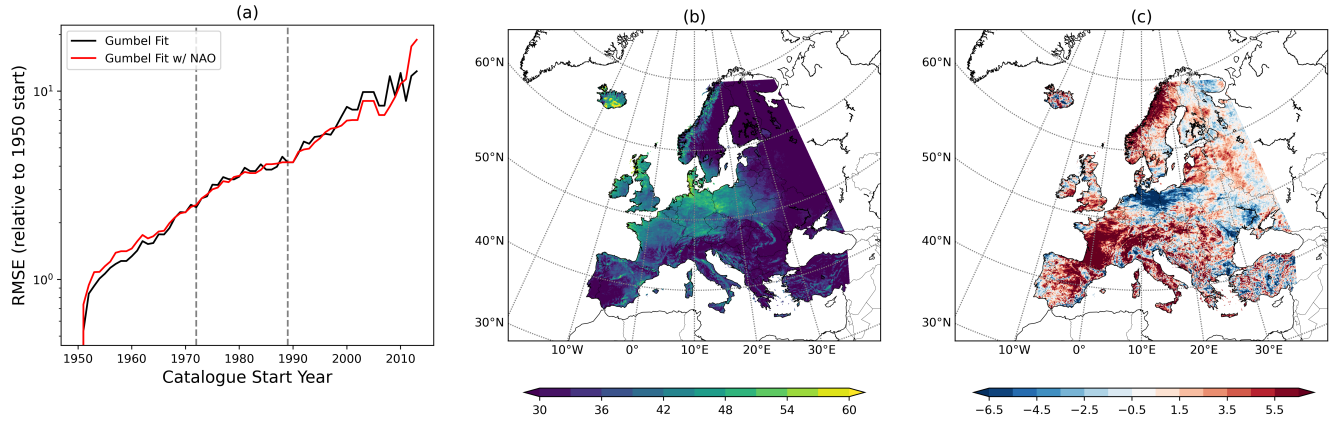


Figure S3. (a) Root mean square error of the 200-year return level estimated from different length historical catalogues, relative to a catalogue from 1950-2014. Black line is for the standard Gumbel fit, and red line is for the fit including the NAO covariate. (b) The 200-year return level for a catalogue from 1950-2014. (c) Difference in the 200-year return level for a catalogue from 1990-2014, relative to (b). Units of (b) and (c) are m s^{-1} .

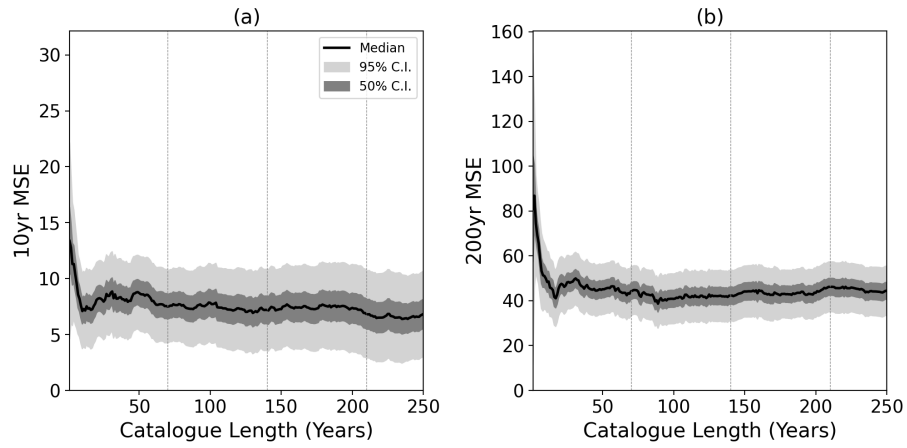


Figure S4. Mean square error the (a) 10-year and (b) 200-year return level estimation of different length historical catalogues against a subsequent 5 year period with events from a 1000-year simulation for London. Solid black line shows the median MSE from all possible periods. The dark and light gray areas represent the 50% and 95% confidence interval on the standard error respectively. Vertical dashed grey lines indicate the periodicity of the NAO used in simulations.

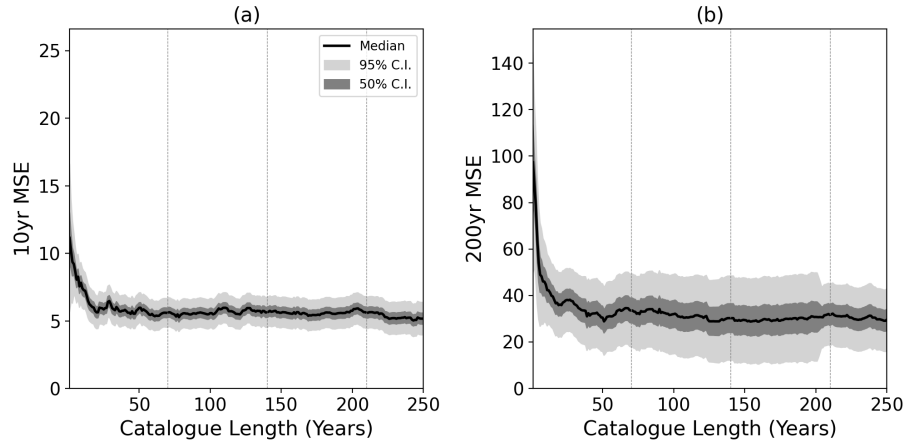


Figure S5. Mean square error the (a) 10-year and (b) 200-year return level estimation of different length historical catalogues against a subsequent 5 year period with events from a 1000-year simulation for Madrid. Solid black line shows the median MSE from all possible periods. The dark and light gray areas represent the 50% and 95% confidence interval on the standard error respectively. Vertical dashed grey lines indicate the periodicity of the NAO used in simulations.

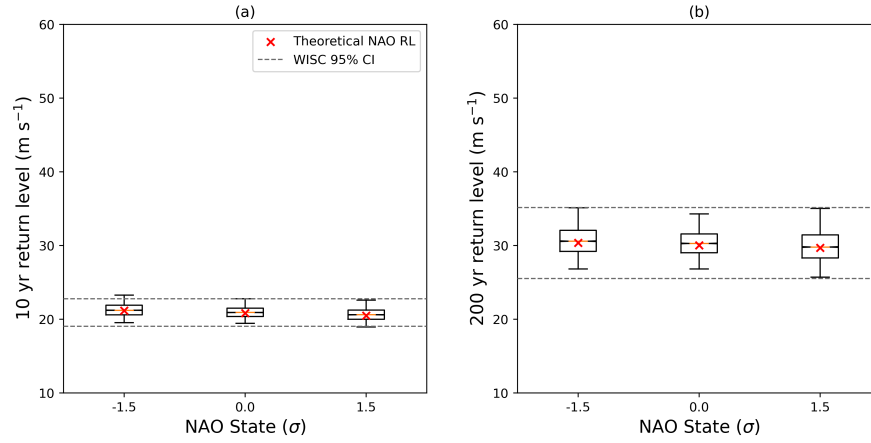


Figure S6. Boxplots of estimated (a) 10-year and (b) 200-year return levels for Madrid based upon simulated gusts. Return levels are estimated from 100,000 70-year simulations with NAO phase that varies to $\pm 0.5\sigma$ of a set NAO state. Boxplots show the median return level of these 100,000 simulations and boxes extend to the 25th and 75th percentiles, with whiskers extending to the 2.5th and 97.5th percentiles. Red crosses indicate the theoretical return level based upon a two-state NAO. Dashed horizontal grey lines indicate the 95% confidence interval of the WISC 10-year and 200-year return levels.