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# Long term oscillations in Danish rainfall extremes

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The frequent flooding of European cities within the last decade has motivated a vast number of studies, among others addressing the non-stationary behaviour of hydrological extremes driven by anthropogenic climate change. However, when considering future extremes it also becomes relevant to search for and understand natural variations on which the anthropogenic changes are imposed. This study identifies multi-decadal variations in six 137-years-long diurnal rainfall series from Denmark and southern Sweden, focusing on extremes with a reoccurrence level relevant for Danish drainage design. By means of a Peak over Threshold model series of the annual number of events ( $\lambda$ ) and the mean annual magnitude of events ( $\mu$ ) are generated and analysed separately. A moving window with a length of ten years is used to highlight the multi-decadal variations and a perturbation factor is calculated for each time step, comparing the given subseries with the full series. A general increase is found for  $\lambda$ , together with an oscillation pattern with a period of 25-40 years. Oscillations also are identified for  $\mu$  but with a period of 15-30 years. Furthermore, regional differences and similarities are analysed, together with a possible link to different climatic drivers, like sea level pressure and sea surface temperature. Regarding Danish drainage design, the found oscillations have implied a substantial variation in the design intensities over time and are partly responsible for the most recent increase observed from 1979 to 2012. This illustrates the importance of understanding and accounting for the natural variation of extremes. The applied methodology can easily be transferred to other hydrological variables.

*Keywords: Extreme events, multi-decadal variation, oscillation, Peak over Threshold*