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Tornadoes in Europe: Risk and vulnerability assessment

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The frequencies of tornadoes are in general lower over Europe compared with the United States. Although the threat is smaller in Europe, the true magnitude of the problem is not known because of the lack of assembled datasets which are essential for developing climatologies of tornadoes over Europe. Recently, new pan-European datasets have become available that will allow a step-change in our understanding of severe storms on a European scale. One of these datasets is the European Severe Weather Database (ESWD), a unique database maintained by the European Severe Storm Laboratory. In this study, an objective analysis of the tornado risk in Europe is performed using data from the ESWD between 1900 and 2013. There are significant observational uncertainties associated with tornadoes in Europe, since only few European countries have systematically collected tornado reports and also because of the inhomogeneous population distribution. As a first step in assessing the risk of tornadoes in Europe, a Bayesian hierarchical model was used to correct for the population bias on tornado reporting. Kernel density analysis (KDA) was then performed for multiple historical periods (prior to 2000s) during which tornado reports where systematically collected in some European countries (e.g., Germany, Baltic countries) and for recent period (after 2000s) that correspond to the development of the ESWD. The KDA was based on the number of tornado reports and tornado path length, since the path length is proportional with the area impacted by tornadoes. The tornado vulnerability in Europe was also analysed by considering the vulnerability as a function of tornado incidence and societal exposure. The societal exposure was determine based on the population and property exposure for European administrative divisions. The tornado vulnerability was then assessed by considering separately the tornado incidence and societal exposure.