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Dependence properties of spatial rainfall extremes and areal reduction factors

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10 Keywords: areal reduction factor, asymptotic dependence, asymptotic independence, extreme

11 rainfall, inverted max-stable process, max-stable process

12 Abstract

Areal reduction factors (ARFs) transform an estimate of extreme rainfall at a point to an estimate of 13 extreme rainfall over a spatial domain, and are commonly used in flood risk estimation. For 14 15 applications such as the design of large infrastructure, dam safety and land use planning, ARFs are needed to estimate flood risk for very rare events that are often larger than the biggest historical 16 events. The nature of the relationship between ARFs and frequency for long return periods is unclear 17 as it depends on the asymptotic dependence structure of rainfall over a region, i.e., the extent to which 18 rainfall from a surrounding region is extreme as rainfall at a point becomes more extreme. 19 20 Miscalculating this for very rare events could lead to poor design of infrastructure. To investigate this, spatial rainfall processes are simulated using asymptotically dependent and independent models, and 21 the implications for ARFs of the asymptotic assumptions are explored in a synthetic study. The 22 23 models are then applied to a case study in Victoria, Australia, using 88 daily rainfall gauges with 50 years of data. The analysis shows that the observed data follow the behaviour of an asymptotically 24 independent process, leading to ARFs that decrease with increasing return period. The study 25 demonstrates that the use of inverted max-stable process models to simulate ARFs can provide a 26 rigorous alternative to empirical approaches, particularly for long return periods requiring significant 27 28 extrapolation from the data.

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