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Disaggregating from daily to sub-daily rainfall under a future climate

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We describe an algorithm for disaggregating daily rainfall into sub-daily rainfall 'fragments' (continuous fine-resolution rainfall sequences whose total depth sums to the daily rainfall amount) under a future, warmer climate. The basis of the algorithm is re-sample sub-daily fragments from the historical record conditional on the total daily rainfall amount and a range of atmospheric predictors representative of the future climate. The logic is that as the atmosphere warms, future rainfall patterns will be more reflective of historical rainfall patterns which occurred on warmer days at the same location, or at locations which have an atmospheric profile more reflective of expected future conditions.

When looking at the scaling from daily to sub-daily rainfall over the historical record, it was found that the relationship varied significantly by season and by location, with rainfall patterns on warmer seasons or at warmer locations typically showing more intense rain falling over shorter periods compared with cooler seasons and stations. Importantly, by regressing against atmospheric covariates such as temperature this effect was almost entirely eliminated, providing a basis for suggesting the approach may be valid when extrapolating sub-daily sequences to a future climate.

The method of fragments algorithm was then applied to nine stations around Australia, and showed that when holding the total daily rainfall constant, the maximum intensity of a short duration (6 minute) rainfall increased by between 4.1% and 13.4% per degree change in temperature for the maximum six minute burst, between 3.1% and 6.8% for the maximum one hour burst, and between 1.5% and 3.5% for the fraction of the day with no rainfall. This highlights that a large proportion of the change to the distribution of precipitation in the future is likely to occur at sub-daily timescales, with significant implications for many hydrological systems.