Australia-wide projections of extreme rainfall and flooding

C. Wasko [a], D. Guo [b], M. Ho [a], R. Nathan [a] and E. Vogel [c,d,e]

[a] Department of Infrastructure Engineering, The University of Melbourne, Parkville, Australia
[b] School of Engineering, College of Engineering, Computing and Cybernetics, The Australian National University, Canberra, Australia
[c] Water Research Centre, School of Civil Engineering, University of New South Wales, Sydney, Australia
[d] ARC Centre of Excellence for Climate Extremes, University of New South Wales, Sydney, Australia
[e] Melbourne Climate Futures, The University of Melbourne, Parkville, Australia
Email: conrad.wasko@unimelb.edu.au

Abstract: Engineering design, floodplain management, and water resources planning all require estimates of extreme rainfall and flooding. However, as we plan and design for the future, the historical records we have used in the past are no longer representative of the future due to climate change. Our climate system is experiencing many changes: rising temperatures are increasing the saturation vapor pressure increasing extreme rainfalls; changes in circulation patterns are shifting the frequency of rainfall events; and changes in the mean annual rainfall and time between rainfall events are impacting on the soil moisture conditions before a rainfall event. Hence, if we are to correctly specify the level of risk in future design and planning and decisions, all these changes need to be accounted for in our estimates of extreme rainfall and flooding.

Here, we project extreme rainfall and flooding (in the form of frequency curves) across Australia's diverse climate and, in doing so, develop a simple, robust methodology that can be readily used for flood projections. We first calibrate the rainfall-runoff model GR4J across 467 Hydrologic Reference Stations using observed rainfall, potential evapotranspiration (PET), and streamflow. The calibration uses a novel objective function which aims to match flood quantiles. The hydrological models across all catchments are then evaluated in terms of flood frequency, Nash-Sutcliffe Efficiency (NSE), and the trend in annual maxima, to ensure that the processes causing changes in flood frequency are captured. For use in future projections, rainfall and PET climate model data from four GCMs and four different bias-correction methods are obtained from the Australian Bureau of Meteorology (https://awo.bom.gov.au/). Finally, projections of streamflow, and hence flooding, are produced by forcing the calibrated GR4J models both for the historical time period (1976-2005) and two future time horizons (2036-2065 and 2070-2099) for two emission scenarios (RCP4.5 and RCP8.5)

We find that, by the end of the century, frequent rainfall maxima, in the order of the 1-in-2 Annual Exceedance Probability (AEP), are projected to increase in the south-east of Australia but decrease elsewhere. For rare rainfall maxima (in the order of the 1-in-50 AEP) increases of approximately 20% are projected continent wide. Frequent floods (1-in-2 AEP) are projected to decrease across the continent with only rare floods (1 in 50 AEP) increasing in line with rainfall maxima. We deduce that frequent floods are more likely to be modulated by drying soils, particularly in the southern temperate and arid regions of Australia. Rare flooding, however, is less dependent on antecedent moisture conditions and hence is projected to increase in line with rainfall maxima projections. Due to the range of event severities studied, the results presented here are likely to be of interest to both the scientific and engineering community. The projection of increases in rare floods suggests an increased risk to life from catastrophic flooding with climate change. The projected decreases in frequent floods across tropical, arid, and temperate regions suggest decreases in water availability with climate change across Australia.

REFERENCES

Wasko, C., Guo, D., Ho, M., Nathan, R., Vogel, E., 2023. Diverging projections for flood and rainfall frequency curves. J. Hydrol. 620, 129403. https://doi.org/10.1016/j.jhydrol.2023.129403.

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