Impact of climate change on Australian flood risk: A review of recent evidence

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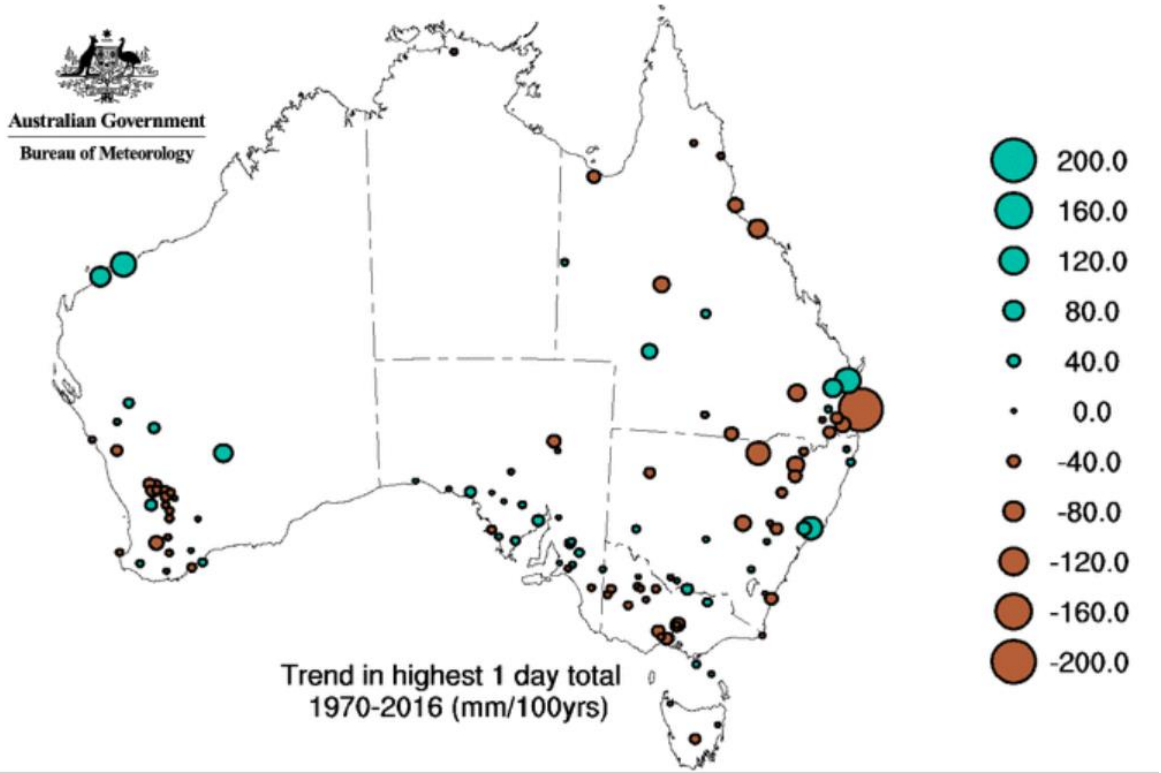
The 2016 IFDs provide significant improvements … but we cannot be complacent with future revisions

2016 IFDs (new)

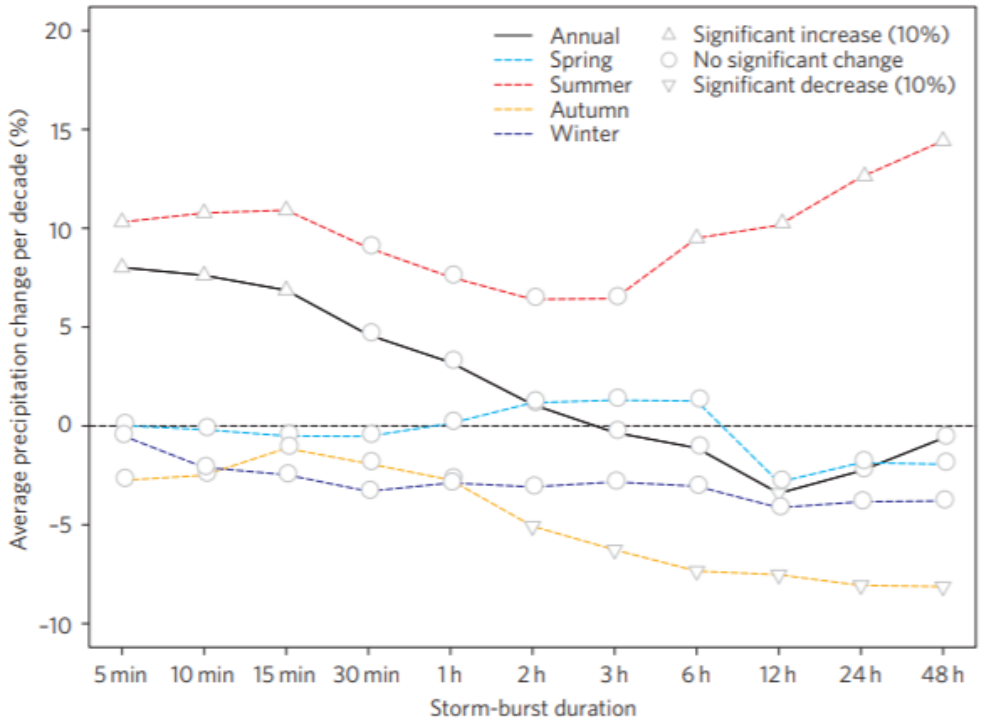
Should be used:

- in conjunction with ARR2016
- for new flood studies and flood assessments but must be used with the other ARR2016 design inputs
- for sensitivity assessments of older studies and studies already underway

Precipitation extremes are not stationary … but the picture is complicated (duration, season, …)



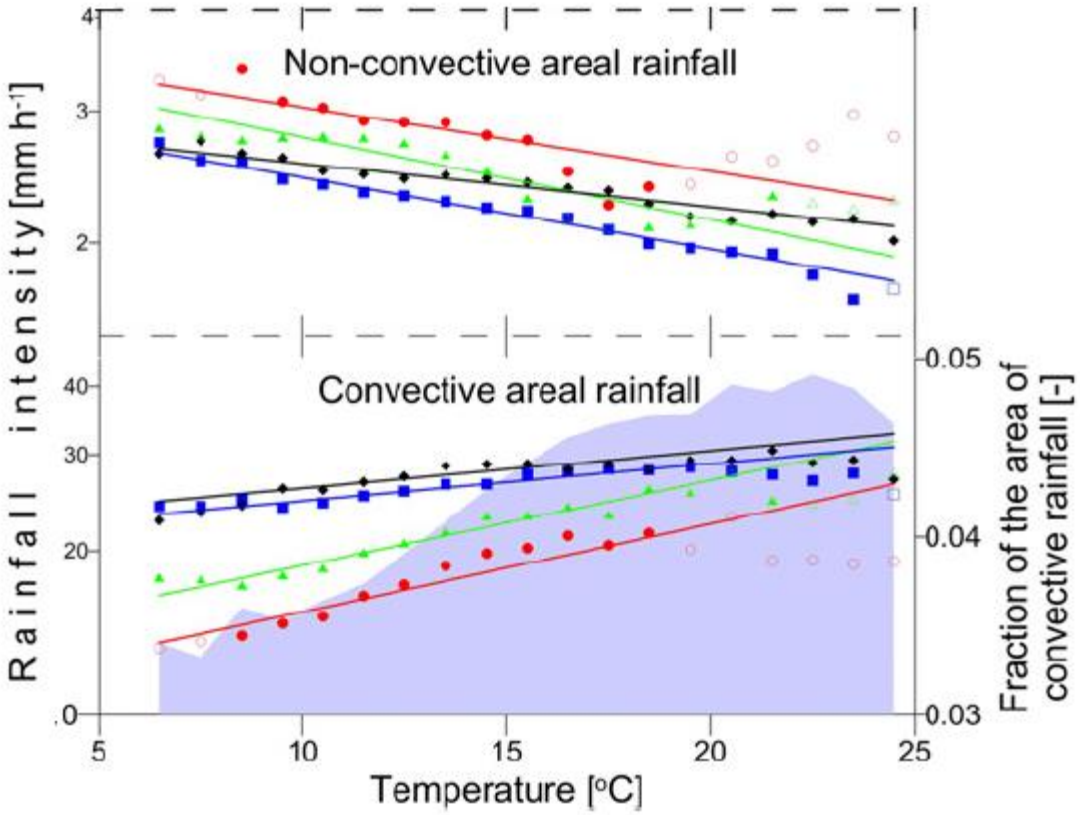
http://www.bom.gov.au/climate/change/index.shtm



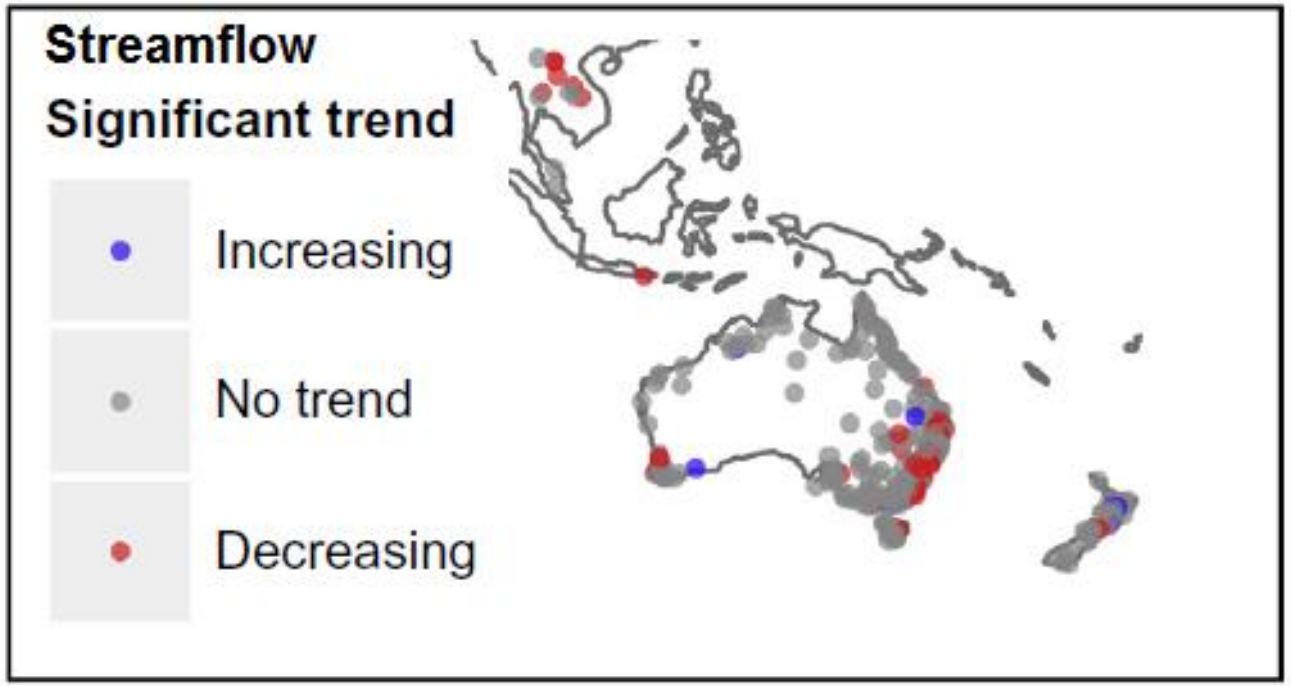
Zheng, F., Westra, S., & Leonard, M. (2015). Opposing local precipitation extremes. *Nature Climate Change*, *5*(5), 389.

Precipitation extremes are not stationary … but the picture is complicated (rain type)

Peleg, N., Marra, F., Fatichi, S., Molnar, P., Morin, E., Sharma, A., & Burlando, P. (2018). Intensification of convective rain cells at warmer temperatures observed from high-resolution weather radar data. *Journal of Hydrometeorology*, *19*(4), 715-726.



There are declines in streamflow extremes, but more is needed to establish consistency with rain



Do, H. X., Westra, S., & Leonard, M. (2017). A global-scale investigation of trends in annual maximum streamflow. *Journal of hydrology*, *552*, 28-43.

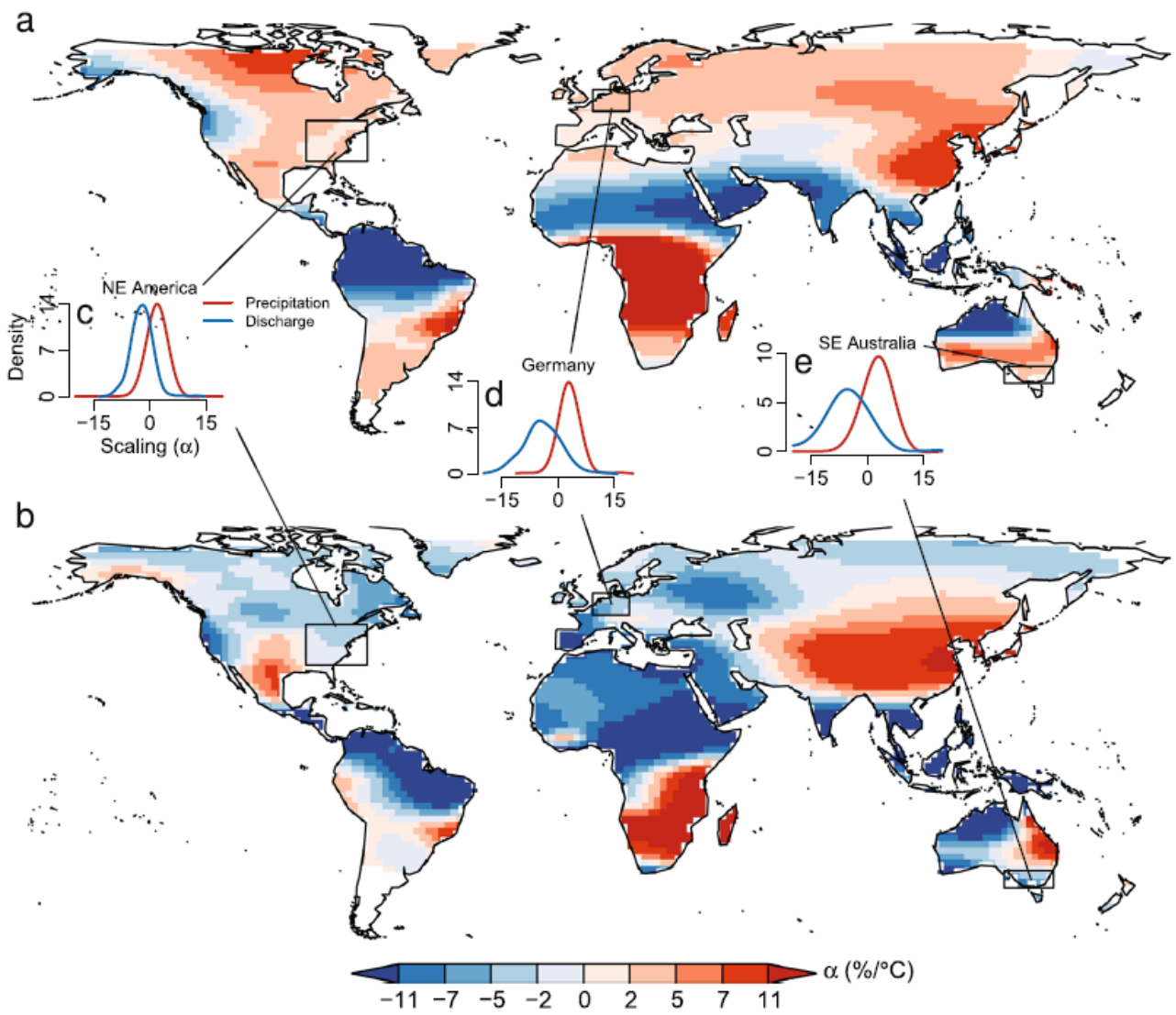
Table 1. Annual Maximum Rainfall Trends in Various Regions and Continents[a]

Region/Continent	Extreme Rainfall Trend	Preextreme Antecedent Precipitation Trend (API)
R1	Positive	Negative
R2	*Positive*	*No trend*
R3	**Positive**	**Positive**
North America	*Positive*	*No trend*
South America	*Positive*	*No trend*
Africa	**Positive**	**Positive**
Eurasia	Positive	Negative
Australia	Negative	Positive

[a]"Positive" and "negative" denote increasing and decreasing trends, respectively. The bold emphasis indicates regions where both causative factors (extreme rain and API) are increasing, pointing to a marked increase in flooding, while the italic emphasis indicates regions where one of these factors is increasing, and the other not exhibiting significant change.

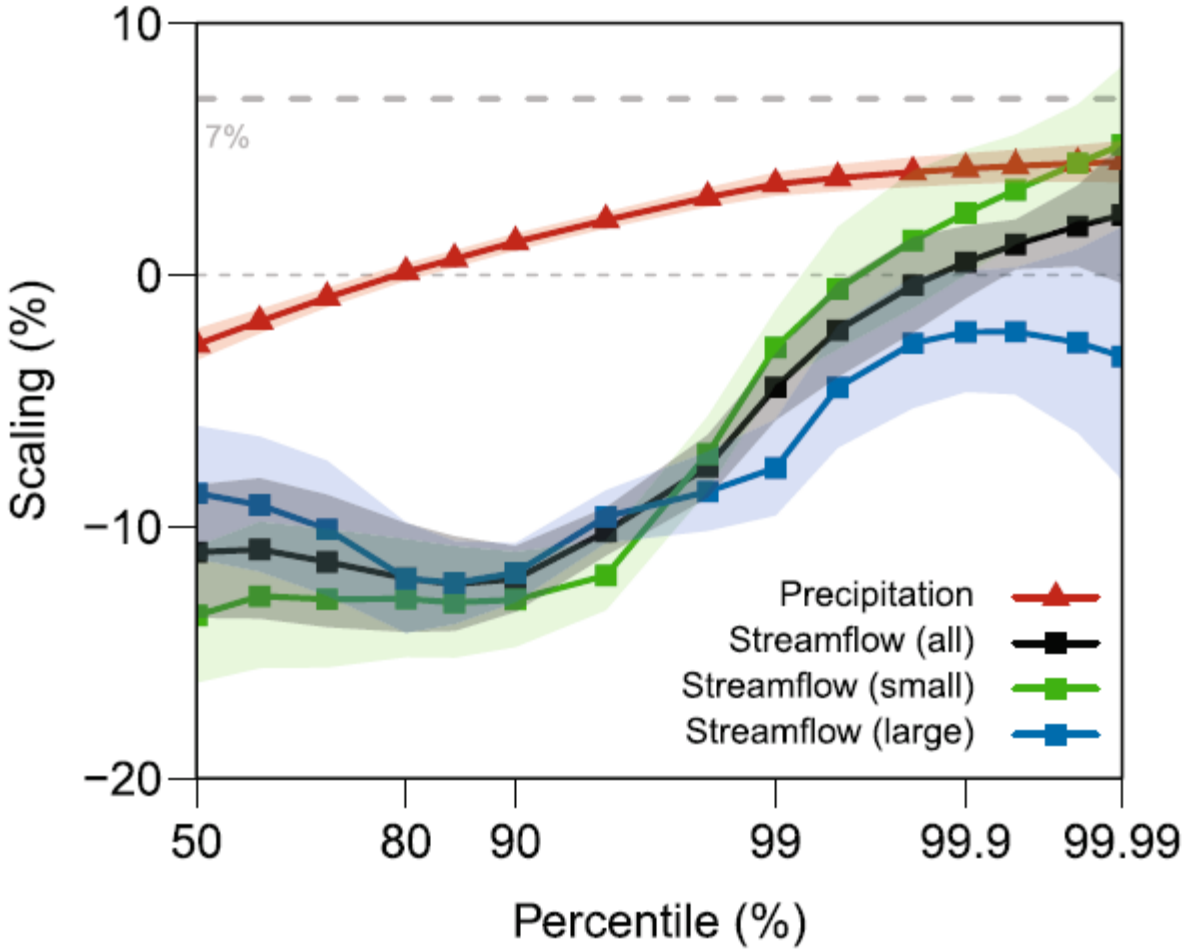
Woldemeskel, F., & Sharma, A. (2016). Should flood regimes change in a warming climate? The role of antecedent moisture conditions. *Geophysical Research Letters*, *43*(14), 7556-7563.

“Little evidence to suggest that increases in heavy rainfall events at higher temperatures result in similar increases in streamflow”



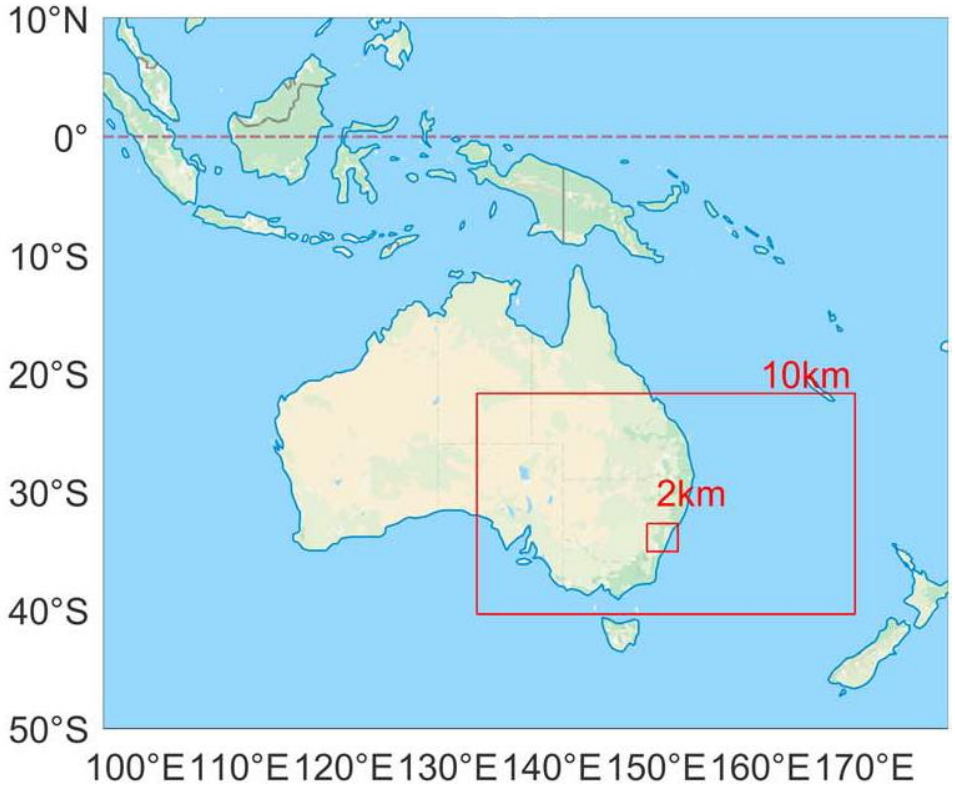
Wasko, C., & Sharma, A. (2017). Global assessment of flood and storm extremes with increased temperatures. *Scientific reports*, *7*(1), 7945.

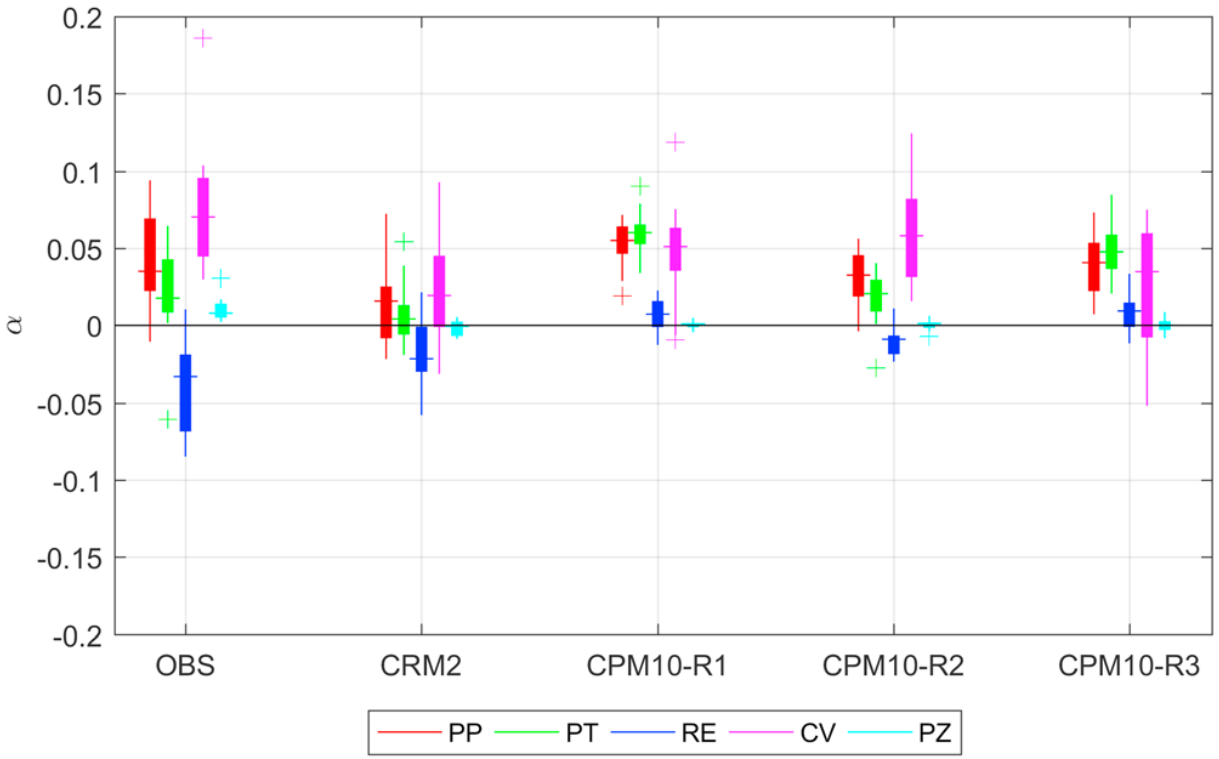
The magnitude of change, and the relative role of flood-producing mechanisms is likely to be location-specific



Wasko, C., & Sharma, A. (2017). Global assessment of flood and storm extremes with increased temperatures. *Scientific reports*, *7*(1), 7945.

RCMs provide further lines of evidence: "as temperatures increase, short duration storm events will become more intense over smaller areas"



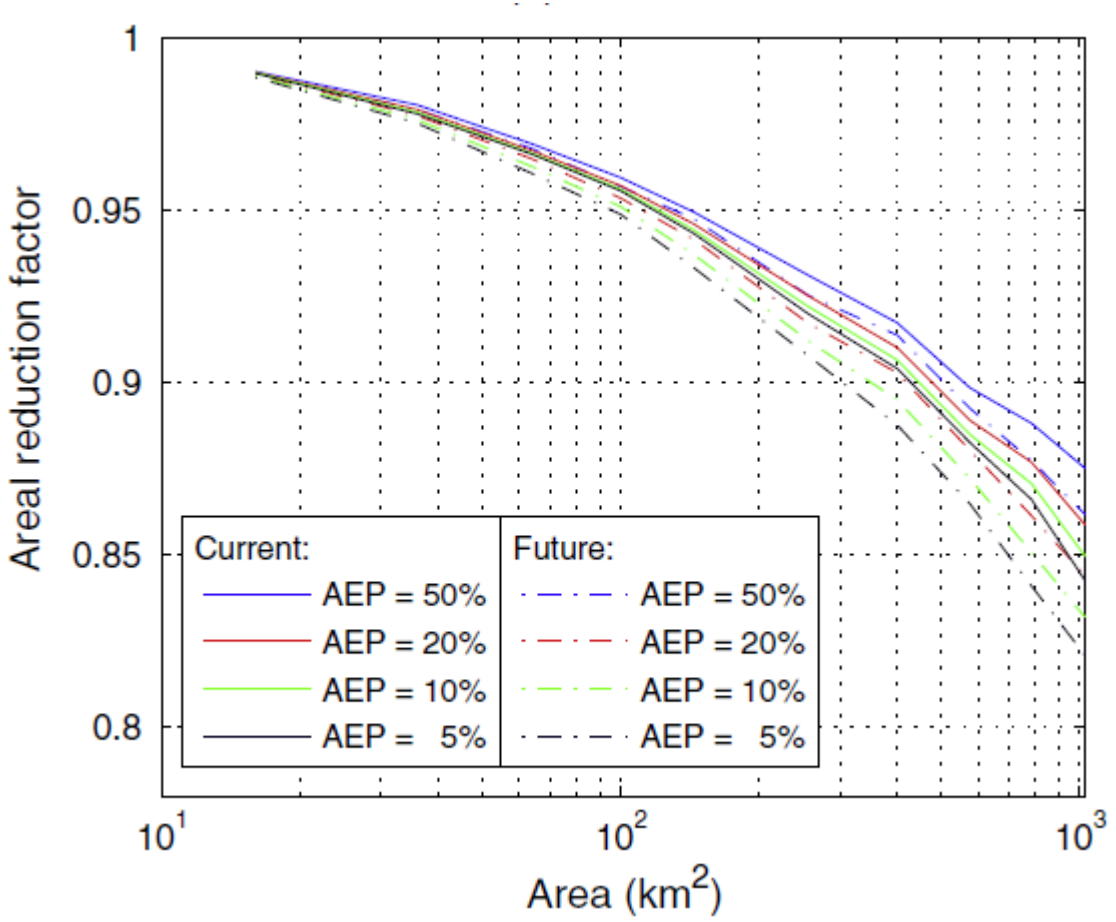


Li, J., Wasko, C., Johnson, F., Evans, J. P., & Sharma, A. (2018). Can Regional Climate Modeling capture the observed changes in spatial organization of extreme storms at higher temperatures?. *Geophysical Research Letters*.

RCMs also show changes to areal reduction factors

The Wilcoxon–Mann–Whitney test result at a 5% significance level for different AEPs.

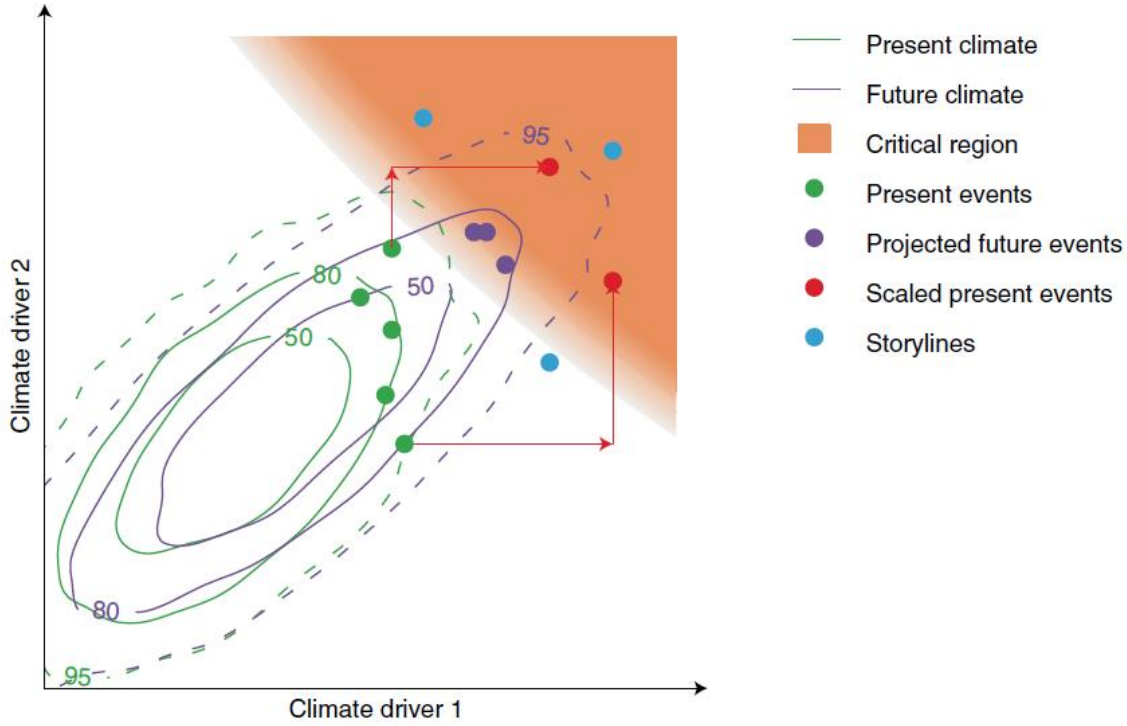
AEP (%)	Fraction of area-duration combinations with significant change in ARFs
50	16/120
20	40/120
10	53/120
5	66/120



Li, J., Sharma, A., Johnson, F., & Evans, J. (2015). Evaluating the effect of climate change on areal reduction factors using regional climate model projections. *Journal of Hydrology*, *528*, 419-434.

Informed decisions are made with appreciation of uncertainty and system performance

- **Risk-based methods** – seek to quantify likely changes and uncertainty
- **Robust methods** – are scenario based
- **Flexible methods** – focus on tipping points and timing of actions/pathways
- **Stress-testing** – map out system performance independently



Australian Rainfall and Runoff recommends a screening analysis

- **Step 1: Set the effective service life or planning horizon**
- **Step 2: Set the flood design standard.**
- **Step 3: Consider the purpose and nature of the asset or activity, and its consequences of failure.**
- **Step 4: Carry out a climate change screening analysis.** For example, if the interest is in the 1% AEP event, then the implications of flooding from the 0.5% and 0.2% events should be considered.
- **Step 5: Consider climate change projections and their consequences.**

Bates, B., McLuckie, D., Westra, S., Johnson, F., Green, J., Mummery, J., and Abbs, D. (2016). "Book 1, Chapter 6: Climate Change Considerations." *Australian Rainfall and Runoff*, J. Ball, ed., Commonwealth of Australia.

Implications …

- There are mounting studies showing trends in rainfall observations (subdaily, daily, seasonal, duration, area, antecedent). We cannot be complacent with future IFD revisions.
- Scaling relationships from observations and models provide a strong indication of the response of variables to temperature
- Evidence from high-resolution climate models suggests that the intensity of subdaily extreme rainfall is likely to increase in the future (~7% per °C)
- More work is needed to reconcile streamflow and rainfall observations and identify implications for rain-based design methods
- Appreciating uncertainty and system performance is critical to informed flood risk estimation