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Extreme subtropical precipitation in Australia: reasons for decline

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A long-term reduction in southern Australian rainfall has been a focus of many studies. In south-eastern Australia it has been shown that after the Millennium Drought (1997 – 2009), the average precipitation has not recovered to the pre-drought values. Our analysis reveals a decline not only in the average precipitation but also in daily extreme rainfall amounts in the cold season. This study explores the physical processes leading to changes in extreme rainfall.

High rainfall extremes are related, on the one hand, to a certain combination of weather systems at various height levels through the troposphere and, on the other hand, to moisture availability. We first identify which synoptic conditions lead to extreme rainfall events in south-eastern Australia and backtrack their development for a few days. Australia is believed to be affected by Rossby waves (RWs) propagating from the tropics. However, we show that extreme events in the southern part of the country are associated with breaking synoptic RWs propagating from the extratropical Indian Ocean. Interestingly, we find that the frequency of cut-off lows, that form following the breaking of RWs, have not declined over the recent decades. This fact highlights that not all cut-off lows necessarily lead to extreme rainfall. We find that the strongest events occur in the presence of a Tasman High pressure system at the surface and a vertically developed low-pressure system to the west of it. We show that, despite little change in the frequency of cut-off lows in the upper troposphere, vertically developed lows have become less frequent after 1997 and when they occur, a larger moisture influx is required to produce an intense rainfall event.