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Relative Contribution of Anthropogenic Forcing and Natural Processes to Rainfall Variability over Victoria, Australia

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Victoria is the second-most populated and most densely populated state in Australia with a population of over 6.5 million. Over two thirds of the population live in greater Melbourne. It is also a major area for agriculture and tourism and is the second largest economy in Australia, accounting for a quarter of Australia's Gross Domestic Product. Any changes in Victoria's climate has huge impacts in these sectors. Rainfall over Victoria during the cool season (e.g. April to October) has been unusually low since the beginning of the Millennium Drought in 1997 (~12% below the 20th century average). Cool season rainfall contributes two-third to annual rainfall and is very important for many crops and for replenishing reservoirs across the state. Here we examine the extent to which this reduction in cool season rainfall is driven by external forcing, and the prospects for future multi-decadal rainfall, taking both external forcing and internal natural climate variability into account.

We analyse simulations from 40 global climate models from phase 5 of the Coupled Model Intercomparison Project (CMIP5) under preindustrial and historical forcing, as well as three scenarios for the 21st century: Representative Concentration Pathway (RCP)2.6, RCP4.5 and RCP8.5, which vary markedly in the amount of greenhouse gas emitted over the coming century. While the 1997-2018 average rainfall for cool season is below the preindustrial average in more than two-thirds of models under the three scenarios, the magnitude of the externally-forced drying is very small (median decline is around -2.5% in all three scenarios with an interquartile range around -5% to +1%). The model ensemble results suggest that external forcing contributed only 20% (interquartile range -41% to 4%) to the drying observed in 1997-2018, relative to 1900-1959. These results suggest that the observed drying was dominated by natural, internal rainfall variability. While the multi-model median is below average from 1997-2018 onwards, the externally-forced drying only becomes clear from 2010-2029, when the proportion of models exhibiting drying increases to over 90% under all three scenarios. This agreement reflects the increase in the magnitude of the externally-forced drying. We estimate that there is a 12% chance that internal rainfall variability will completely offset the externally-forced drying averaged over 2018-2037, regardless of scenario. By the late 21st century the externally forced change under RCP8.5 is so large that drying – even after taking internally variability into account - appears inevitable.

Confidence in the modelled projections is lowered because models have difficulty in simulating the magnitude of the observed decline in rainfall. Some of this difficulty appears to arise because most models seem to underestimate multidecadal rainfall variability. Other candidates are: the observed drying may have been primarily due to the occurrence of an extreme, internally-driven event; the models underestimate the magnitude of the externally-forced drying in recent decades; or some combination of the two. If externally-forced drying is underestimated because the response to greenhouse gases is underestimated then the magnitude of projected changes might also be underestimated.