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El Nino and La Nina are not mirror images of drought and rain – but how do they differ?

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El Niño and La Niña have an almost mythical status when it comes to Australia's climate. Their potential arrival is heralded in news reports as a turn to either a drier Australia or a wetter Australia. This could be all you need to know to give you an idea about what could be down the track, but if you needed more detail to help you plan for the coming months rain, it's important to really know the extent of the impact that El Niño or La Niña can have on Australia's rainfall. Because although El Niño and La Niña are known to be 'climate drivers', as we'll show by their impact on rainfall probabilities, a term more aligned with the times, like 'climate influencer' could be more apt.

Whenever making a decision based on seasonal forecasting, the first port of call should be the Bureau of Meteorology. Their forecasts are based on models using physical equations and the latest observations, and contain more information about what can impact Australian rainfall than just whether there's an El Niño and La Niña. These forecasts can change with updated observations as you get closer to the month your care about, so remember to keep checking the most recent forecast if that information matters to you.

An inescapable aspect of any forecast, however, is that there is chaos in the system, the "butterfly effect". The climate system has such complexity in that a small kick can cause something to randomly grow. That something could be a rainstorm, or an El Niño, they're active for very different lengths of time, but both can come from a relatively small random kick. This leads us to talk about forecasts in terms of probability, not because we're guessing, but because we know about these complexities and it's the best way to provide this information. Likewise, for thinking about past impacts from El Niño and La Niña, rather than just think dry or wet, we can also use this probability framework to have a more accurate idea of what to expect (see here for further reading).

New research from the NESP Climate Systems Hub is helping us better understand these probabilities in both location of rainfall and seasonal timing. A useful way to think about rainfall probabilities is with a spinner on a wheel. The wheel shows all possibilities for what the monthly rainfall anomaly could be, ordered from the highest on record to the lowest on record and every rainfall anomaly that has historically happened in between. The spinner will be our method of a random pick. Each month the spinner is spun and could land anywhere. For example, in Fig. 1, the spinner landed at a rainfall anomaly between the 75th percentile of rainfall (i.e., less than wettest one quarter of months) and the median of rainfall (i.e., more than the driest one half of months). Ignoring the effect of El Niño and La Niña, there is normally a one in four chance of landing in this sector.

When and El Niño or La Niña event occurs, instead of just thinking dry or wet, a better way to think about their impact would be by changing the size of the sectors on the wheel. The rainfall anomalies within the sector is not changed, but the probability of landing within the sector is increased. For example, with a 50% increase in the size of the lowest rainfall sector, we see that the same random pick (i.e. the same location of the spinner in the first example) still did not land in the expanded sector, so we actually saw no difference in rainfall. For a 50% increase in the size of the highest rainfall sector, the same random pick got a rainfall anomaly that is now in the top quarter of rainiest months on record.

Getting into actual data, we have assessed how El Niño and La Niña change the probability of the lowest and highest sectors of rainfall, in the eastern states of Australia, in all months of the year (Fig. 2). In eastern Australia, if a La Niña is active, you can expect an increase in the size of the highest rainfall sector in most months of the year ranging from 70% to up to 250% (Fig. 2). Months with no bar means there is not a clear enough signal that La Niña affects this rainfall sector. If El Niño is active, you can only expect the lowest rainfall sector to increase in size in three months of the year. This is a result that you may not have expected, [but these clues have been seen for a while now.]

These results used a rainfall average from all eastern states of Australia, but if we looked at a smaller region do we still see the same result? We can choose a modest change of 50% increase in probability of the highest and lowest rainfall sectors (i.e., the examples in Fig. 1), and simply count how many months of the year we can expect a significant change of this magnitude during a La Niña and El Niño. Although there are some regional differences, the previous results largely hold through most of eastern Australia (Fig. 3). La Niña influences high rainfall (to our defined threshold) for up to seven months of the year when active, whereas El Niño generally only manages to influence low rainfall in three months or less, with some isolated pockets of longer-term influence.

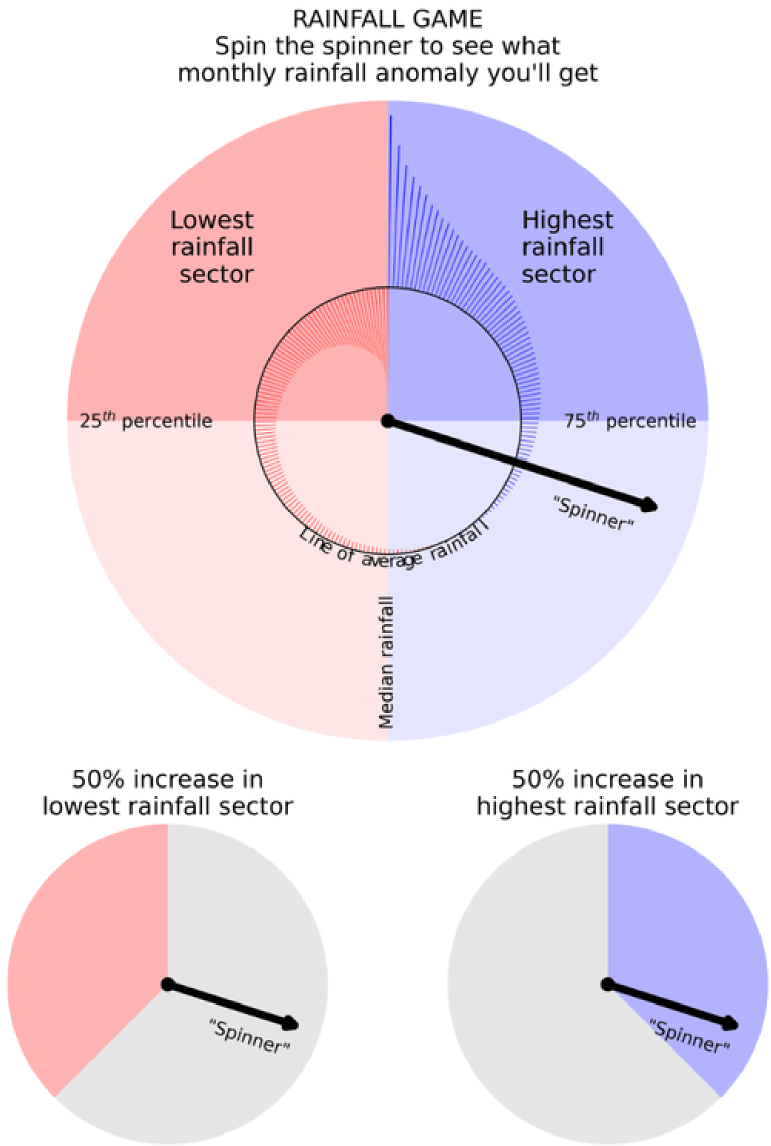

Fig 1: The rainfall game. We line up all months in a row from wettest to driest along the "line of average rainfall". We then join the wettest month to the driest month to form a circle to allow our spinner to randomly pick a rainfall anomlay for the month. An El Niño or La Niña can increase the probability of receiving a rainfall anomaly from different sectors.

It's tempting to look at individual locations, like those isolated pockets and have more confidence in the results, but care should be taken when doing so. Picking the exact location you care about and just using that information for that location is not recommended. There is a reason climate scientists use area averaged information. Remember the chaos in the system, it applies over space too. Rain could be forecast for a region, but there could be pockets where rain hits harder that is much smaller compared to the forecast region. This aspect could introduce two complexities for whether El Niño and La Niña could have an influence on rainfall in that location: either the rain does not occur over that small pocket, reducing the apparent influence of these events; or an event occurs that is out of expectation, giving an unclear signal.

When focusing on one small region, it would also be wise to look at the surrounding regions to see if there is consistent signal, that way we capture some of that chaotic nature, but still focus on a target region. We go into methods to do this in our paper. Furthermore, we do not need to only focus on the highest rainfall sector, any percentile or rainfall value can be used as a threshold if that value makes sense to you.

This research shows that ENSO's influence is not uniform in space and time, and that localised, month-specific assessments can better inform planning and decision making. La Niña can have a far-reaching and sustained influence on Australian rainfall, while El Niño's effects can be more limited in both time and space, offering a more nuanced understanding of their effect.

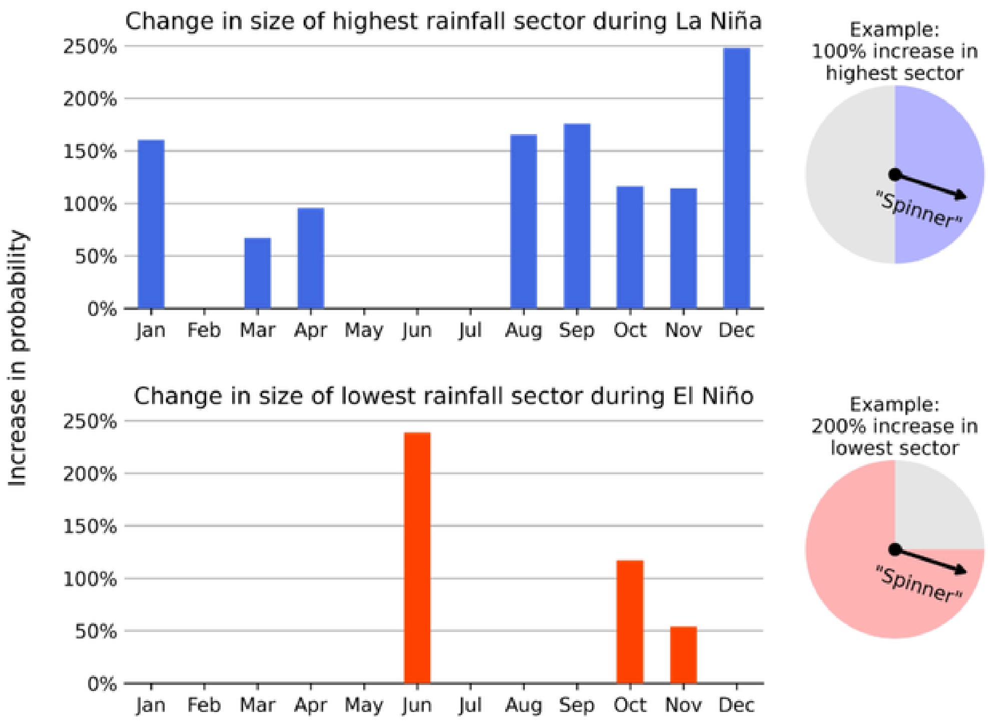

Fig. 2: Eastern Australia change in rainfall probability associated with La Niña and El Niño (top). Probability increase of the high monthly rainfall sector during La Niña. (bottom) Probability increase of the low monthly rainfall sector during El Niño. The spinners show examples of how the rainfall game changes with different probability increases.

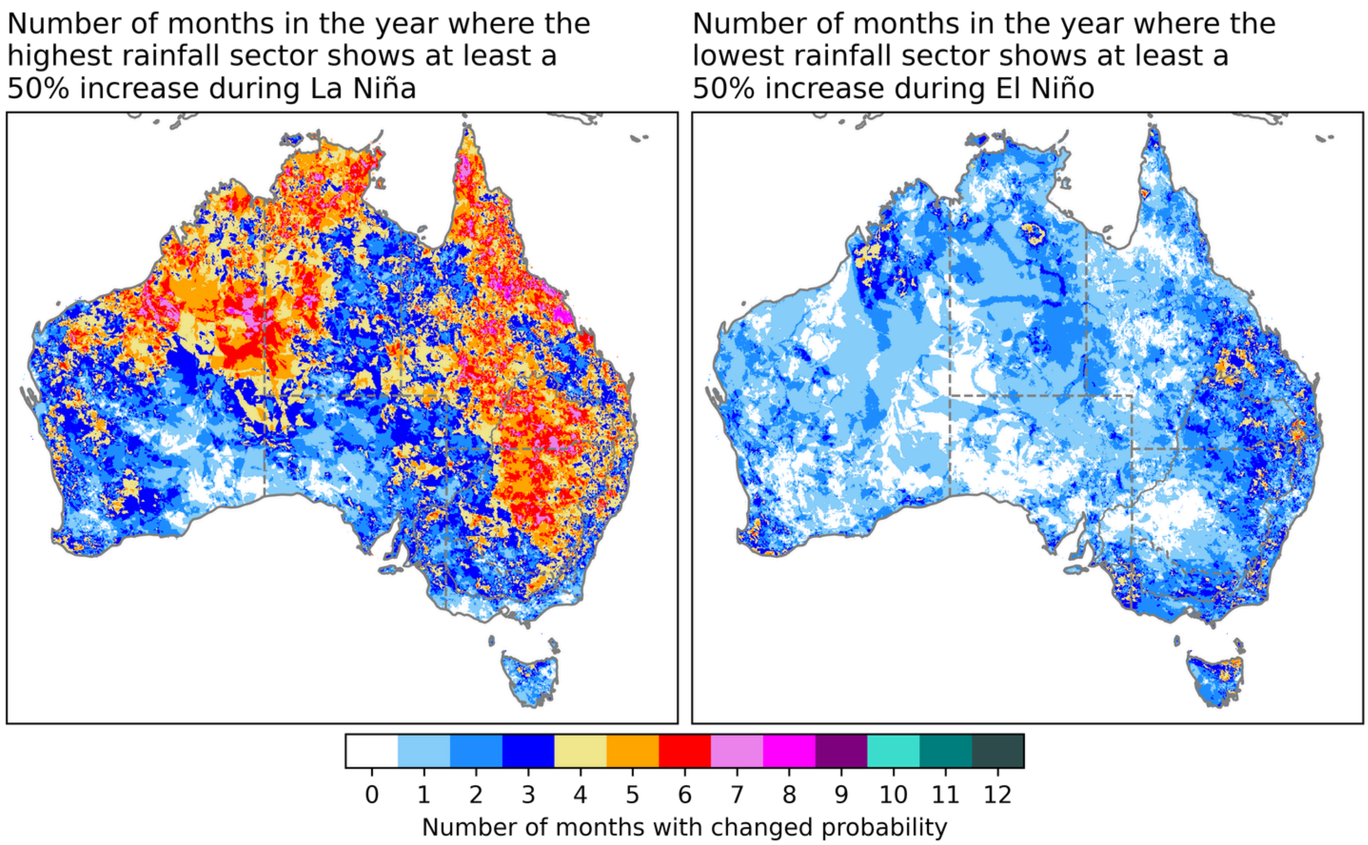

Fig 3: (left) The number of months where you can expect La Niña to increase the probability of the high monthly rainfall sector by 50%. (right) The number of months where you can expect El Niño to increase the probability of the low monthly rainfall sector by 50%.

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