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Understanding regional teleconnections from strong El Niño events: a case study of east Australian springtime rainfall

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Eastern Australia typically experiences reduced spring (September – November) rainfall during El Niño events, but this relationship does not always scale with El Niño intensity. Three strong El Niño events occurred during the 1979-2015 period, the 1982-1983, 1997-1998 and 2015-2016 events, but not all of them were associated with a clear springtime rainfall deficit in eastern Australia. Although spring of 1982 showed an expected significant rainfall deficit over a large portion of eastern Australia, the spring of 1997 resulted in near average rainfall, with 2015 showing only slightly less than average spring rainfall. By many metrics, the El Niño of 1997 is considered to be the strongest in our analysis period, but this did not translate to a strong east Australian teleconnection.
It has been speculated that the spring rainfall received during 1997 was the result of atmospheric processes unrelated to sea surface temperatures (SSTs), i.e. stochastic weather. To test this we used atmospheric general circulation models forced with observed global SSTs, finding that the observed SSTs contributed to the observed rainfall anomalies for all three strong El Niño years. This suggests that SSTs played an important role in producing the observed rainfall anomalies during these three events, and cannot be explained by atmospheric processes alone.
Our results show that SST forcing was a strong contributor to the observed rainfall during the three El Niño years, however different processes must be responsible for the different rainfall totals. We find that local SSTs were important in producing the widespread rainfall deficit in spring of 1982. During this spring, significantly cool SSTs were observed off the northeast coast of Australia. Using the ACCESS 1.3 model forced with 1982 SSTs to the northeast Australia, an intensification of a southeasterly wind anomaly over northeast Australia is simulated, this resulted in a reduction in rainfall in the region.
A significant local SST anomaly was absent during the spring of 1997, but a significant sea level pressure (SLP) anomaly was observed and modelled to the north of Australia when forced with global 1997 SSTs. It is hypothesised that this SLP anomaly combined with a high SLP anomaly to the south of Australia to form a near average pressure gradient over the eastern half of Australia. This resulted in near average winds, and therefore near average rainfall in much of eastern Australia.
Finally, the east Australian rainfall in spring of 2015 was more stochastic in origin than the other two events. Although the modelled ensemble mean was able to simulate less than average rainfall in eastern Australia, reminiscent of the observed, the modelled SLP anomaly did not match the observations. This suggests that an atmospheric process largely unforced by SSTs were in fact responsible for the SLP anomaly, and therefore less than average rainfall.