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Increased frequency of ENSO extremes under greenhouse warming

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The El Nino Southern Oscillation (ENSO) is Earth's largest source of year-to-year climate variability which exerts significant environmental and socio-economic impacts worldwide. The rise of ENSO, signified by large changes in ocean and atmospheric circulations, occurs through a suite of Bjerknes coupled feedback processes in the equatorial Pacific Ocean. Observations over recent decades have seen some peculiar behaviour of ENSO that has challenged our scientific understanding of this remarkable phenomenon. 1982 and 1997 saw the strongest El Nino events in modern records, uniquely characterised by eastward propagating sea surface temperature anomalies, a behaviour not seen during moderate events and La Nina. The impacts were severe, causing multi billion dollars in damages, thousands of human lives lost, and destruction of marine habitats. The 1997 El Nino was followed by an exceptionally strong 1998 La Nina event which was also catastrophic. Given their significant impacts, one of the most pressing issues our society needs to address is whether and how ENSO will respond to the increase in atmospheric greenhouse gas concentrations. The increasing breadth of climate models available under the efforts of the Coupled Model Intercomparison Project (CMIP) has made addressing this issue possible. In contrast to previous finding of no robust ENSO response, recent research utilising the large CMIP database has found intermodel consensus of significant increases in the frequency of both El Nino and La Nina events that are 'extreme like', analogous to the 82, 97, and 98 events. The weakened westward flowing mean equatorial Pacific currents are expected to give rise to more frequent eastward propagating El Nino under greenhouse warming. The projected faster warming of the eastern equatorial Pacific Ocean than the surrounding regions would make it easier for atmospheric convection to shift eastward to generate rainfall response similar to that during an extreme El Nino. The Maritime Continent is also projected to warm faster, thus making it more favourable for extreme La Nina events to be generated. These results suggest that extreme ENSO events and their associated impacts will likely to occur more frequently in the future as the climate warms.