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Cause for opposite propagation direction between El Niño and La Niña temperature anomalies

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One manifestation of non-linear behaviour of the El Niño Southern Oscillation (ENSO) is an asymmetry in which sea surface temperature (SST) anomalies propagate eastward during extreme El Niño events and westward during La Niña events. The strongest El Niño events in modern record (1982/83 and 1997/98), as characterised most apparently by eastward anomaly propagation, generated drastically different global climatic teleconnections with far-reaching and costly impacts. The cause of this propagation asymmetry, which is most apparent in the post-1976 period, is currently unknown, demonstrating a gap in our understanding of ENSO dynamics. Here we show that this asymmetry arises from the fact that the westward flowing current along the equatorial Pacific is enhanced during La Niña but reversed during extreme El Niño events. We diagnose this mechanism through a heat budget analysis utilising various ocean reanalysis products that assimilate available observations.

The zonal propagation of ENSO SST anomalies has been understood as to arise from three main competing positive feedback processes, namely the zonal advective, Ekman pumping, and thermocline feedbacks. During extreme El Niño, the effect of the equatorial currents reinforces the eastward propagation induced by thermocline feedback processes. During La Niña, on the other hand, this weakens the thermocline feedback effect, thus favouring westward propagation as also induced by the zonal advective and Ekman pumping feedbacks. Our results illustrate that the strength and direction of the ENSO-related current anomaly relative to the climatological current determines the way the currents along the equatorial Pacific influence zonal propagation. This suggests that an emergence of propagation asymmetry is linked to changes in ENSO intensity and mean climate. Our study has implications for understanding future ENSO dynamics and ENSO behaviour across climate models.