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The impact of ENSO on wave breaking and Southern Annular Mode events

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This study examines the relationship between Southern Annular Mode (SAM) events and the El Niño–Southern Oscillation (ENSO) using daily ERA-40 data. The data coverage spans the years 1979 through 2002, for the austral spring and summer seasons. The focus of this study is on the question of why positive SAM events dominate during La Niña and negative SAM events during El Niño. A composite analysis is performed on the zonal-mean zonal wind, Elliassen-Palm fluxes, and two diagnostic variables, the meridional potential vorticity gradient, a quantity that is used to estimate the likelihood of wave breaking, and a wave breaking index, which is used to evaluate the frequency of the wave breaking.

On the equatorward side of the eddy-driven jet, positive SAM events are associated with strong anticyclonic wave breaking, and negative SAM events with weak anticyclonic wave breaking. On the poleward side of the eddy-driven jet, positive SAM events coincide with little wave breaking and negative SAM events by weak cyclonic wave breaking. These wave breaking events are found to occur far from the critical latitudes. With the exception of the El Nino and La Nina years, these SAM events decayed within 7 to 10 days of their establishment through mixing.

The results of this investigation suggest that the background zonal-mean flow associated with La Niña (El Niño) is preconditioned for strong (weak) anticyclonic wave breaking on the equatorward side of the eddy-driven jet, the type of wave breaking that is found to drive positive (negative) SAM events. A probability density function analysis indicates that strong (weak) anticyclonic wave breaking takes place with a much higher frequency during La Niña (El Niño). It is suggested that these wave breaking characteristics, and their dependency on the background flow, can explain the strong preference for SAM events of one phase during ENSO.

The analysis also showed that austral spring SAM events that coincide with ENSO are preceded by strong stratospheric SAM anomalies, and then followed by a prolonged period of wave breaking that lasts for about 30 days. These findings suggest that the ENSO background flow also plays a role in the excitation of stratospheric SAM anomalies, and that the presence of these stratospheric SAM anomalies in turn excites and then maintains the tropospheric SAM anomalies via a positive eddy feedback.