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Controls of seasonal ENSO phase locking in the Kiel Climate Model

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The El Niño/Southern Oscillation (ENSO) is characterized by a seasonal phase locking, with strongest SST anomalies in the eastern and central equatorial Pacific during boreal winter and weakest anomalies during boreal spring. Coupled general circulation models (CGCMs) tend to have strong difficulties in capturing the seasonal phase locking of ENSO. In this study, the Kiel Climate Model is used to identify the key processes that determine the seasonal phase locking in that model. An analysis based on the Bjerknes Stability Index reveals that the zonal advection feedback, the Ekman feedback and the thermocline feedback are strongest towards the end of the calendar year and can thus account for the variability maximum in December/January. Despite also being relatively strong in boreal spring, these feedbacks are damped by air-sea heat fluxes and mean ocean currents, which are strongest at that time of the year. Our findings compare well with those obtained from observations.

It is further shown that insufficient simulation of the seasonal phase locking can be attributed to a wrong representation of the Bjerknes feedback. That includes weaker zonal advection, Ekman and thermocline feedback towards the end of the calendar year, which reduces variability in boreal winter, and a weaker air-sea heat flux damping during the beginning of the year. This smaller damping can not balance the relatively strong positive feedback processes during boreal spring and, consequently, contributes to a spurious increased variability in boreal spring/summer. Finally, increasing the model resolution of the atmospheric component of the KCM, horizontally and vertically, generally reduces model bias but does not necessarily improve simulation of seasonal ENSO phase locking. Tuning of model parameters is an alternative option by which a realistic phase locking can be achieved at coarse resolution.