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Analysis of the Non-linearity in the Pattern and Time Evolution of El Nin˜o Southern Oscillation

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In the study present here is is shown that the non-linearity (skewness) of El Niño Southern Oscillation (ENSO) that is usually described as differences in the amplitudes of El Nino and La Nina events, also extents to the spatial SST pattern of events and to the time evolution of events. The analysis presented is based on observations, the CMIP3 model data base and on idealized simplified ENSO models.
Is is shown that significant differences in the spatial pattern between positive (El Niño) vs. negative (La Niña) and strong vs. weak events exist, which is mostly describing the difference between central and east Pacific events.
The Bjerknes feedbacks and time evolution of strong ENSO events also show strong asymmetries, with strong El Niños being forced more strongly by zonal wind stress than by thermocline depth anomalies and are followed by La Niña events. The key non-linearity in the Bjerknes feedbacks is the zonal wind stress response to sea surface temperature anomalies, which during strong El Niño events is stronger and shifted to the east relative to strong La Niña events, supporting the eastward shifted El Niño pattern and the asymmetric time evolution.
The observational results are supported by analysis of state of the art coupled general circulation models and by a simplified hybrid coupled ENSO model. Out of the 24 CMIP3 coupled climate models only 4 models are capable of simulating the spatial pattern and time evolution non-linearity realistically. All these four models strongly support the asymmetric forcings of ENSO events by zonal wind stress and thermocline depth anomalies.
Based on the simplified hybrid coupled RECHOZ model of ENSO it can be shown that the non-linear zonal wind stress response to SST anomalies causes the asymmetric forcings of ENSO events. On the basis of 100 perfect model ensemble forecasts with the RECHOZ model it can further be illustrated, that strong La Niña events are more predictable than strong El Niño events due to the non-linear zonal wind stress response to SST anomalies.