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Atmospheric properties and the ENSO cycle

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This study systematically characterizes the main feedbacks in the ENSO cycle and (nonlinear) atmospheric properties with the help of a reduced model tuned to the couplings of reanalyses or GCM output. Most climate models are found to underestimate the response of SST to wind stress anomalies, which is compensated by a damping term that is lower than observed. Furthermore they do not show the correct SST skewness and underestimate the wind variability and the nonlinear response of wind stress to SST.

First, the linear dynamics of ENSO is examined from observations. These are the relations between SST, zonal wind stress (τ_x) and the thermocline depth or 20°C isotherm in the ocean (Z_{20}). In addition some nonlinear terms in the atmosphere are studied. These are the nonlinear response of τ_x to SST, the standard deviation and skewness of the component of the noise in τ_x (the component that is not part of the ENSO cycle) and the relation between background SST and this wind noise.

An Intermediate Complexity Model (ICM) is built with these findings. This reduced model in which all couplings are fitted to observations can simulate the main properties of ENSO. In this initially linear model we systematically introduce the extra terms in the atmospheric component. We study the influence of these terms on ENSO properties like amplitude, period and skewness from this ICM.

Then we investigate the differences between observations and coupled general circulation models (CGCMs). We compare the linear dynamics of ENSO in CGCMs with observations in the models with the best linear dynamics. For these models we compare the nonlinear terms with observations. The influence of differences between the CGCMs and observations on ENSO properties is examined with the ICM, now fitted to the CGCMs. The reduced model can simulate the main properties of ENSO in GCMs.

Our reduced model can be used to trace back those changes to physical coupling parameters, and further back to model parameters. This will allow models to be tuned for more realistic ENSO simulations, enhancing the skill of seasonal forecasts and increasing our confidence in climate change projections.