Title:	Effect of heterogeneity in a model of El NiÃ±o Southern Oscillations
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Abstract:	The emergence of oscillations in models of the El-Niño effect is of utmost relevance. Here we investigate a coupled nonlinear delay differential system modeling theEl-Niño/ Southern Oscillation (ENSO) phenomenon, which arises through the strong coupling of the ocean-atmosphere system. In particular, we study the temporal patterns of the sea surface temperature anomaly of the two sub-regions. For identical sub-regions we typically observe a co-existence of amplitude and oscillator death behavior for low delays, and heterogeneous oscillations for high delays, when inter-region coupling is weak. For moderate inter-region coupling strengths one obtains homogeneous oscillations for sufficiently large delays and amplitude death for small delays. When the inter-region coupling strength is large, oscillations are suppressed altogether, implying that strongly coupled sub-regions do not exhibit ENSO-like oscillations. Further we observe that larger strengths of self-delay coupling favours oscillations, while oscillations die out when the delayed coupling is weak. This indicates again that delayed feedback, incorporating oceanic wave transit effects, is the principal cause of oscillatory behaviour. So the effect of trapped ocean waves propagating in a basin with closed boundaries is crucial for the emergence of ENSO. Further, we show how non-uniformity in delays, and difference in the strengths of the self-delay coupling of the sub-regions, affect the rise of oscillations. Interestingly we find that larger delays and self-delay coupling strengths lead to oscillations, while strong inter-region coupling kills oscillatory behaviour. Thus, we find that coupling sub-regions has a very significant effect on the emergence of oscillations, and strong coupling typically suppresses oscillations, while weak coupling of non-identical sub-regions can induce oscillations, thereby favouring ENSO.
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