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The impact of stochastic physics on the El Niño Southern Oscillation in the EC-Earth coupled model

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The impact of stochastic physics on El Niño - Southern Oscillation (ENSO) is investigated in the EC-Earth global coupled climate model. By comparing an ensemble of three members of control historical simulations with three ensemble members of historical simulations including stochastic physics in the atmosphere, we find that the stochastic schemes help to improve the excessively weak representation of ENSO in the model. Specifically, the amplitude of both El Niño and, to a lesser extent, La Niña increase. Stochastic physics ameliorates the temporal variability of ENSO at interannual time scales, demonstrated by the emerging of peaks in the power spectrum with periods of 5-7 years and 3-4 years. Based on the analogy with the behaviour of an idealized delayed oscillator model (DO) with stochastic noise, we propose a possible explanation for the positive impact of stochastic perturbations in EC-Earth. In the simplified model, we find that the impact of noise changes dramatically as a function of the coupling parameter, triggering a noise-induced amplification (reduction) of the amplitude of the oscillations when the coupling parameter is small (large). This would imply that a too weak atmosphere and ocean coupling might be responsible for the underestimated ENSO variability in the EC-Earth control runs. The analysis of wind in atmosphere-only simulations carried out with the same version of the model shows an increase of Westerly Wind Burst (WWB) occurrences with stochastic physics, which - in coupled mode - can help to trigger El Nino events. Further analysis of the mean state bias of EC-Earth suggests that the cold SST and dry precipitation in the central tropical Pacific, together with the warm SST and wet precipitation in the western tropical Pacific, are responsible for the coupled feedback bias (weak coupling) in the tropical Pacific that results in the weak ENSO simulation in EC-Earth. The same analysis of the ENSO behaviour in a future scenario experiment (RCP8.5 forcing) which represents a coupled model with an extreme SST warm bias (strong coupling), enhances our argument that the mean state bias of the tropical Pacific region is the main reason for the deficiency in the representation of ENSO in the coupled climate model.