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Looking for relationships between the ENSO and the Indian summer monsoon in MPI-ESM and CESM ensembles under increasing greenhouse-gas forcing

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The El Niño–Southern Oscillation (ENSO) is a natural, irregular fluctuation in the tropical Pacific region, which strongly affects the tropical and the subtropical regions. In our work, we study the relation between the ENSO and the Indian summer monsoon in ensemble simulations of state-of-the-art general circulation models, the Max Planck Institute Earth System Model (MPI-ESM) and the Community Earth System Model (CESM), under increasing CO_2 concentration. We choose two simple variables, the Tahiti–Darwin sea-level pressure difference and the Northern Indian precipitation, to characterise the investigated phenomena. We apply the snapshot method, utilizing an ensemble converged to the snapshot attractor of the system, for analysing possible changes in the relation (called a teleconnection) between the fluctuations of these variables, and also in the climatic means of the same variables. We find that the strength of the teleconnection undergoes a considerable increase in the MPI-ESM under historical forcing between 1890 and 2005 – which is in strong contrast with the scientific consensus about a decreasing strength in the late 20th century. In the same model, the strength of the teleconnection seems to change less in a time interval of the same length under a 1-percent pure CO_2 scenario, as well as in the CESM in the 1960–2100 time interval subject to historical forcing and to the Representative Concentration Pathway 8.5. Regardless of the particular magnitudes of the changes, the linear susceptibility of the strength of the teleconnection with respect to radiative forcing is at least an order of magnitude larger in the first simulation than in the latter two. Unlike with the teleconnection, we found that the climatic mean is strongly displaced in all simulations in the phase space projection spanned by the same two variables. In spite of the strong displacements, a linear relation between the responses of the climatic means of the two quantities was revealed. However, the slope was found to exhibit a very strong seasonality, falsifying a hypothesis of a universal, one-to-one relation, an emergent constraint, between these two quantities.