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Forced synchronization of large-scale circulation to increase predictability of surface states

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Numerical models are key tools in the projection of the future climate change. The lack of perfect initial condition and perfect knowledge of the laws of physics, as well as inherent chaotic behavior limit predictions. Conceptually, the atmospheric variables can be decomposed into a predictable component (signal) and an unpredictable component (noise). In ensemble prediction the anomaly of ensemble mean is regarded as the signal and the ensemble spread the noise. Naturally the prediction skill will be higher if the signal-to-noise ratio (SNR) is larger in the initial conditions. We run two ensemble experiments in order to explore a way to reduce the SNR of surface winds and temperature. One ensemble experiment is AGCM with prescribing sea surface temperature (SST); the other is AGCM with both prescribing SST and nudging the high-level temperature and winds to ERA-Interim. Each ensemble has 30 members. Larger SNR is expected and found over the tropical ocean in the first experiment because the tropical circulation is associated with the convection and the associated surface wind convergence as these are to a large extent driven by the SST. However, small SNR is found over high latitude ocean and land surface due to the chaotic and non-synchronized atmosphere states. In the second experiment the higher level temperature and winds are forced to be synchronized (nudged to reanalysis) and hence a larger SNR of surface winds and temperature is expected. Furthermore, different nudging coefficients are also tested in order to understand the limitation of both synchronization of large-scale circulation and the surface states. These experiments will be useful for the developing strategies to synchronize the 3-D states of atmospheric models that can be later used to build a super model.