Optimal Error Analysis of MJO Prediction Associated with Uncertainties in Sea Surface Temperature over Indian Ocean

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In this study, the predictability of the Madden-Julian Oscillation (MJO) is investigated using the coupled Community Earth System Model (CESM) and the climatically relevant singular vector (CSV) method. The CSV method is an ensemble-based strategy to calculate the optimal growth of the initial error on the climate scale. We focus on the CSV analysis of MJO initialized at phase II, facilitating the investigation of the effect of the initial errors of the sea surface temperature (SST) in the Indian Ocean on it. Six different MJO events are chosen as the study cases to ensure the robustness of the results.

The results indicate that for all the study cases, the optimal perturbation structure of the SST, denoted by the leading mode of the singular vectors (SVs), is a meridional dipole-like pattern between the Bay of Bengal and the southern central Indian Ocean. The MJO signal tends to be more converged and significant in the Eastern Hemisphere while the model is perturbed by leading SV. The moist static energy analysis results indicate that the eastward propagation is much more evident in the terms of vertical advection and radiation flux than others. Therefore, the SV perturbation can strengthen and converge the MJO signal mostly by increasing the vertical advection of the moist static energy.

Further, the sensitivity studies indicate that the structure of the leading SV is not sensitive to the initial states, which suggests that we might not need to calculate SVs for each initial time in constructing the ensemble prediction, significantly saving computational time in the operational forecast systems.