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Predictability of the western North Pacific summer climate demonstrated by the coupled models of ENSEMBLES

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The Asian monsoon system, including the western North Pacific (WNP), East Asian, and Indian monsoons, dominates the climate of the Asia-Indian Ocean-Pacific region, and plays a significant role in the global hydrological and energy cycles. The prediction of monsoons and associated climate features is a major challenge in seasonal time scale climate forecast. In this study, a comprehensive assessment of the interannual predictability of the WNP summer climate has been performed using the 1-month lead retrospective forecasts (hindcasts) of five state-of-the-art coupled models from ENSEMBLES for the period of 1960–2005. Spatial distribution of the temporal correlation coefficients shows that the interannual variation of precipitation is well predicted around the Maritime Continent and east of the Philippines. The high skills for the lower-tropospheric circulation and sea surface temperature (SST) spread over almost the whole WNP. These results indicate that the models in general successfully predict the interannual variation of the WNP summer climate. Two typical indices, the WNP summer precipitation index and the WNP lower-tropospheric circulation index (WNPMI), have been used to quantify the forecast skill. The correlation coefficient between five models' multi-model ensemble (MME) mean prediction and observations for the WNP summer precipitation index reaches 0.66 during 1979–2005 while it is 0.68 for the WNPMI during 1960–2005. The WNPMI-regressed anomalies of lower-tropospheric winds, SSTs and precipitation are similar between observations and MME. Further analysis suggests that prediction reliability of the WNP summer climate mainly arises from the atmosphere–ocean interaction over the tropical Indian and the tropical Pacific Ocean, implying that continuing improvement in the representation of the air–sea interaction over these regions in CGCMs is a key for long-lead seasonal forecast over the WNP and East Asia. On the other hand, the prediction of the WNP summer climate anomalies exhibits a remarkable spread resulted from uncertainty in initial conditions. The summer anomalies related to the prediction spread, including the lower-tropospheric circulation, SST and precipitation anomalies, show a Pacific-Japan or East Asia-Pacific pattern in the meridional direction over the WNP. Our further investigations suggest that the WNPMI prediction spread arises mainly from the internal dynamics in air–sea interaction over the WNP and Indian Ocean, since the local relationships among the anomalous SST, circulation, and precipitation associated with the spread are similar to those associated with the interannual variation of the WNPMI in both observations and MME. However, the magnitudes of these anomalies related to the spread are weaker, ranging from one third to a half of those anomalies associated with the interannual variation of the WNPMI in MME over the tropical Indian Ocean and subtropical WNP. These results further support that the improvement in the representation of the air–sea interaction over the tropical Indian Ocean and subtropical WNP in CGCMs is a key for reducing the prediction spread and for improving the long-lead seasonal forecast over the WNP and East Asia.