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Using an ICM ensemble prediction system outputs to explore the "spring predictability barrier" for 2015/2016 El Niño event

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Using predictions for the sea surface temperature anomaly (SSTA) generated by ICM ensemble prediction system (ICM EPS), we explore the "spring predictability barrier" (SPB) problem for 2015 El Niño event from the perspective of error growth. By analyzing the seasonal dependence of the prediction error growth for ensemble forecast members, we conclude that the prediction errors for 2015 El Niño event generated by the ICM EPS tend to have an obvious season-dependent evolution with the prominent growth in spring or the beginning of the summer, finally yielding a significant SPB phenomenon. We find that there exist very high similarities among the initial errors that correspond to significant SPB, those that fails to cause a SPB, and between them. It is inferred that the SPB occurred in the 2015 El Niño predictions generated by the ICM EPS is not due to the uncertainties in initial uncertainties, but the model errors. As such, the mean of ensemble forecast members, because of filtering the effect of model errors, weakened the effect of SPB and reduced the prediction error for 2015 El Niño event. By investigating the model errors characterized by the tendency errors for SSTA component, we show the prominent features of the tendency errors that often cause a SPB for 2015 El Niño event generated by ICM EPS and explain why the 2015 El Niño was under-predicted by the ICM EPS. What's more, we reveal the typical feature of the tendency error that does not only cause a SPB but also an aggressively large prediction error, with a zonal dipolar pattern with the west poles of positive anomalies in the equatorial western Pacific and the east poles of negative anomalies in the equatorial eastern Pacific, which bears great similarities with the tendency error of the nonlinear forcing singular vector (NFSV) structure reported by Duan et al. (2015) and shows the existence of NFSV tendency error in realistic predictions. Results shown in the present study suggest that the forecast skill of ICM EPS for El Niño events could be greatly enhanced by increasing the diversity of ensemble forecast initial perturbations and/or using the NFSV-like tendency error to correct the model.