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Dependence of Indian summer monsoon rainfall forecast skill of CFSv2 on initial conditions and the role of bias in SST boundary forcing

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Indian summer monsoon seasonal reforecasts by CFSv2, initiated from January (4-month lead time, L4) through May (0-month lead time, L0) initial conditions (ICs), are analysed to investigate causes for the highest Indian summer monsoon rainfall (ISMR) forecast skill of CFSv2 with February (3-month lead time, L3) ICs. Although theory suggests forecast skill should degrade with increase in lead-time, CFSv2 shows highest skill with L3, due to its forecasting of ISMR excess of 1983 which other ICs failed to forecast. In contrast to observation, in CFSv2, ISMR extremes are largely decided by sea surface temperature (SST) variation over central Pacific (NINO3.4) associated with El Niño-Southern Oscillation (ENSO), where ISMR excess (deficit) is associated with La Niña (El Niño) or cooling (warming) over NINO3.4. In 1983, CFSv2 with L3 ICs forecasted strong La Niña during summer, which resulted in 1983 ISMR excess. In contrast, in observation, near normal SSTs prevailed over NINO3.4 and ISMR excess was due to variation of convection over equatorial Indian Ocean, which CFSv2 fails to capture with all ICs. CFSv2 reforecasts with late-April/early-May ICs are found to have highest deterministic ISMR forecast skill, if 1983 is excluded and Indian monsoon seasonal biases are also reduced. During the transitional ENSO in Boreal summer of 1983, faster and intense cooling of NINO3.4 SSTs in L3, could be due to larger dynamical drift with longer lead time of forecasting, compared to L0. Boreal summer ENSO forecast skill is also found to be lowest for L3 which gradually decreases from June to September. Rainfall occurrence with strong cold bias over NINO3.4, is because of the existence of stronger ocean-atmosphere coupling in CFSv2, but with a shift of the SST-rainfall relationship pattern to slightly colder SSTs than the observed. Our analysis suggests the need for a systematic approach to minimize bias in SST boundary forcing in CFSv2, to achieve improved ISMR forecasts.