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Initialization strategies for decadal climate predictions

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We test three different initialization approaches for a coupled climate model to improve decadal climate predictions. At the timescale, decadal predictions come between seasonal-to-interannual (S2I) forecasts and long-term climate change projections (CCP). To date, several operational S2I forecast systems provide climate information, which can be useful for adaptation strategies, food production, managing extreme weather events etc., whereas long-term CCP provide information on possible climate far into the future under different emissions scenarios. Similarly to S2I prediction systems, operational decadal prediction systems are expected to find application in economic sector for timescales from a couple of years to several decades into the future. The uniqueness of decadal predictions is that they incorporate some features from both S2I and CCP, namely the dependency of S2I forecast on a starting point – an initial state of a climate system and the dependency of CCP on changes in atmospheric composition.

Previous studies suggest that at decadal timescales, in contrast to natural climate variability, the signal from changes in external forcing is relatively small and internal variability uncertainties dominate the total uncertainty of decadal predictions. On the other hand, perfect model studies have shown that predictability due to initialization is dominant in the first years of 10yr simulations and the external forcing becomes more relevant to the end of simulations. A common practice in assessing how good decadal predictions perform, is to carry out an ensemble of model simulations for the past climate (hindcasts) and compare decadal hindcasts against observations. It is also known that due to systematic errors decadal hindcasts will drift away from their initial state and therefore it is necessary to remove this drift or use alternative initialization approaches that account for drift. It is expected that proper initialization with accurate observations might reduce the uncertainty due to internal variability. Though much effort has been spend to improve decadal prediction, the question remains about the best initialization approach for decadal predictions.

Hence, we investigate the sensitivity of a climate model to three different initialization approaches; specifically, we are interested in regions and timescales at which initialized hindcasts show significant predictive skill taking into account details of a particular initialization method. We found that for the current climate model, the initialization method that keeps the model closest to the mean state of the real climate system shows the highest predictive skill for several important climate variables. Moreover, on decadal timescales the properties of the ocean that are under the direct influence of the atmosphere (or climate noise) yield shorter predictability time than those that are shielded from the atmosphere by the ocean mixed layer. After identifying regions and duration of high predictive skill, we perform an analysis to explain physical causes of predictability on decadal timescales.