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Predictability of precipitation and its spatio-temporal variation across the United States

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Reliability of climate predictions is often adversely affected by the limited predictability. Predictability of major climatic variables such as precipitation is known to be limited to a few days to a few weeks. Major factor which limits the predictability is the inherent nonlinear characteristic of the climate system due to the sensitivity to initial conditions and chaotic nature. However, any generalization of predictability limit, especially of precipitation, should be carefully made, considering the highly nonlinear nature and the known influence of localized causal factors on many climate variables. We investigate the spatial distribution of the predictability of daily precipitation and its extent & rate of the possible improvement with spatio-temporal averaging. For this, three predictability statistics (maximum predictability, predictive error and predictive instability) are defined, based on the nonlinear finite time Lyapunov exponent. Predictability is found to be monotonically increasing with temporal averaging, as expected. While, spatial averaging has minimal influence on predictability, possibly due to the spatially invariant nature of precipitation dynamics. Observed significant changes in the predictability characteristics of daily precipitation across the United States and associated non-stationarity are found to be consistent with the observed changes in the precipitation characteristics such as reduction in non-rainy days, increase in signal-to-noise ratio, increase in average precipitation events, and increase in extremes. The error growth is affected by various aspects of precipitation such as signal-noise-ratio, inter-quantile range, non-rainy days and heavy precipitation days. We observed that any persistent variation in precipitation behavior, though not necessarily related to extremes, has an impact on predictability. The study highlights the importance of considering predictability as a function of location, season, pressure level, lead time, spatial and temporal scales.