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Large deviation probabilities for correlated Gaussian stochastic processes and daily temperature anomalies

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As we have one and only one earth and no replicas, climate characteristics are usually computed as time averages from a single time series. For understanding climate variability, it is essential to understand how close a single time average will typically be to an ensemble average. To answer this question, we study large deviation probabilities (LDP) of stochastic processes and characterize them by their dependence on the time window. In contrast to iid variables for which there exists an analytical expression for the rate function, the correlated variables such as auto-regressive (short memory) and auto-regressive fractionally integrated moving average (long memory) processes, have not an analytical LDP. We study LDP for these processes, in order to see how correlation affects this probability in comparison to iid data. Although short range correlations lead to a simple correction of sample size, long range correlations lead to a sub-exponential decay of LDP and hence to a very slow convergence of time averages. This effect is demonstrated for a 120 year long time series of daily temperature anomalies measured in Potsdam (Germany).