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On climate prediction: How much can we expect from climate memory?

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Slowing variability in climate system is an important source of climate predictability. However, it is still challenging for current dynamical models to fully capture the variability as well as its impacts on future climate. In this study, instead of simulating the internal multi-scale oscillations in dynamical models, we discussed the effects of internal variability in terms of climate memory. By decomposing climate state x(t) at a certain time point t into memory part M(t) and non-memory part ε(t), climate memory effects on climate prediction are quantified. For variables with strong climate memory, high variance (over 20%) in x(t) is explained by the memory part M(t), and the effects of climate memory are non-negligible for most climate variables, but the precipitation. Regarding of multi-steps climate prediction, a power law decay of the explained variance was found, indicating long-lasting climate memory effects. The explained variances by climate memory can remain to be higher than 10% for more than 10 time steps. Accordingly, past climate conditions can affect both short (monthly) and long-term (interannual, decadal, or even multidecadal) climate predictions. With the memory part M(t) precisely calculated from Fractional Integral Statistical Model, one only needs to focus on the non-memory part ε(t), which is an important quantity that determines climate predictive skills.