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Reservoir Computing as a Tool for Climate Predictability Studies

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Reduced-order dynamical models play a central role in developing our understanding of predictability of climate irrespective of whether we are dealing with the actual climate system or surrogate climate models. In this context, the Linear Inverse Modeling (LIM) approach, by helping capture a few essential interactions between dynamical components of the full system, has proven valuable in being able to provide insights into the dynamical behavior of the full system.

We demonstrate that Reservoir Computing (RC), a form of machine learning suited for learning in the context of chaotic dynamics, provides an alternative nonlinear approach that improves on the LIM approach. We do this in the example setting of predicting sea surface temperature in the North Atlantic in the pre-industrial control simulation of a popular earth system model, the Community Earth System Model version 2 (CESM2) so that we can compare the performance of the new RC based approach with the traditional LIM approach both when learning data is plentiful and when such data is more limited. The useful predictive skill of the RC approach over a wider range of conditions---larger number of retained EOF coefficients, extending well into the limited data regime, etc.---suggests that this machine learning approach may have a use in climate predictability studies. While the possibility of developing a climate emulator---the ability to continue the evolution of the system on the attractor long after failing to be able to track the reference trajectory---is demonstrated in context of the Lorenz-63 system, it is suggested that further development of the RC approach may permit such uses of the new approach in settings of relevance to realistic predictability studies.