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Data Driven Approaches for Climate Predictability

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Reduced-order dynamical models play a central role in developing our understanding of predictability of climate. In this context, the Linear Inverse Modeling (LIM) approach (closely related to Dynamic Mode Decomposition DMD), by helping capture a few essential interactions between dynamical components of the full system, has proven valuable in being able to give insights into the dynamical behavior of the full system. While nonlinear extensions of the LIM approach have been attempted none have gained widespread acceptance. We demonstrate that Reservoir Computing (RC), a form of machine learning suited for learning in the context of chaotic dynamics, by exploiting the phenomenon of generalized synchronization, provides an alternative nonlinear approach that comprehensively outperforms the LIM approach. Additionally, the potential of the RC approach to capture the structure of the climatological attractor and to continue the evolution of the system on the attractor in a realistic fashion long after the ensemble average has stopped tracking the reference trajectory is highlighted. Finally, other dynamical systems based methods and probabilistic deep learning methods are considered and a broader perspective on the use of data-driven methods in understanding climate predictability is offered