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Physics-informed Echo State Networks for the prediction of chaotic systems LUCA MAGRI, FRANCISCO HUHN, University of Cambridge, NGUYEN ANH KHOA DOAN, Dept. of Mechanical Engineering, Technical Univ of Munich — We suggest Echo State Networks (ESN), a data science technique, to predict the evolution of chaotic dynamical systems, namely those of high-fidelity fluid dynamics simulations, LES and DNS. Data generated from high-fidelity simulations carry high computational cost and thus only small amounts are available. While this usually poses a limitation to data science techniques – unlike the traditional big data, this problem lives in the world of "small data" –, this can be balanced by leveraging physical knowledge of the system in study, that is, while ESNs can be trained purely on past observations, their performance can be improved, for example, by including a loss term that represents the system's physics and penalizes non-physical predictions in the training phase. We explore the characteristics and performance of physics-informed ESN models, from a nonlinear dynamics point-of-view, in reproducing chaotic dynamical systems. Finally, we look into potential applications to fluid dynamics problems, such as prediction of extreme events or sensitivities of time-averaged cost functionals.

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