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Physics-Constrained Convolutional LSTM Neural Networks for Generative Modeling of Turbulence[1] ARVIND MOHAN, DANIEL LIVESCU, Los Alamos National Laboratory, MICHAEL CHERTKOV, University of Arizona — High fidelity modeling of turbulence and related physical phenomena is often challenging due to its prohibitive computational costs or the lack of accurate theoretical models. In the recent years, deep learning approaches have shown much promise in modeling of complex systems. A major challenge in deep learning for generative modeling of turbulence is the chaotic, high dimensional and spatio-temporal nature of the data, which can make the learning process ineffective and/or expensive. Previous work by the authors (Mohan et al., 2018) showed the capability of Convolutional LSTM (ConvLSTM) neural networks in modeling high fidelity 3D turbulence. ConvLSTM augments the traditional architecture of a LSTM cell with a convolutional layer to learn spatial features in high dimensional datasets. In this work, we introduce various physical constraints of incompressible turbulent flows into ConvLSTM networks. We demonstrate its efficacy by learning and predicting physically consistent dynamics of a homogeneous isotropic turbulence DNS dataset. Statistical tests are also performed on the predicted turbulence to assess the quality of the physical constraints on the "learned" physics. Finally, we discuss challenges and opportunities with ConvLSTM when enforced with physical constraints, with additional focus on computational scaling of this approach to large datasets.

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