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Data-driven super-parameterization of subgrid-scale processes using deep learning[1] PEDRAM HASSANZADEH, ASHESH CHATTOPADHYAY, ADAM SUBEL, YIFEI GUAN, Rice Univ — A common approach to simulating turbulent flows is parameterization, in which the large-scale flow is numerically solved for on a low-resolution grid and the small-scale processes are represented in terms of the resolved flow using a parameterization scheme. Another approach, computationally more demanding but often more accurate, is called super-parameterization (SP), which involves integrating the equations of small-scale processes on high-resolution grids embedded within the low-resolution grid. Recently, a number of studies have explored applications of deep learning to find data-driven parameterization (DD-P) schemes. Leveraging recurrent neural networks (RNNs), here we introduce a data-driven super-parameterization (DD-SP) approach, in which the equations for small-scale processes are integrated data-drivenly, and thus inexpensively, using RNNs and the equations for the large-scale flow are integrated numerically on a low-resolution grid. Using a chaotic multi-scale Lorenz system and forced Burgers' turbulence, we show that DD-SP provides accuracy comparable to that of the SP (and better than DD-P) but at the low computational cost of parameterized low-resolution models and DD-P. Earlier results are presented at preprint arXiv:2002.11167: Data-driven super-parameterization using deep learning: Experimentation with multi-scale Lorenz 96 systems and transfer-learning.

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