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Deep Convolutional Autoencoders for Predicting Wind-Driven Spatial Patterns

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Wind-driven spatial patterns are of great interest in the climate and geophysical sciences. Examples include features in Aeolian dunes and the deposition of volcanic ash, wildfire smoke, and air pollution plumes. Machine learning models are attractive because they can make accurate and fast predictions in situations where the physical processes are not fully understood, experiments are not available, or, computer simulations are too costly. In this paper, we explore deep convolutional neural network based autoencoders to exploit relationships in geophysical spatial patterns to reduce their dimensionality. Reducing the dimension size with an encoder allows us to train regression models linking geographic and meteorological scalar input quantities to the encoded space. Once this is achieved, full predictive spatial patterns are reconstructed using the decoder. We demonstrate this approach on images of spatial deposition from a pollution source, where the encoder compresses the dimensionality to 0.02% of the original size and the full predictive model performance on test data achieves an accuracy of 92%.

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