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Multiresolution Formulation of a Global Circulation Model Specifically Designed for Data-Driven Machine Learning Assistance

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Most weather related catastrophic events are caused by the non-linear interactions between global atmospheric circulation and local atmospheric dynamics. Good examples are stalled tropical cyclones like Harvey and Florence, the devastating floods caused by omega blocking and the atmospheric rivers caused by interactions between the Madden–Julian oscillation and the polar vortex. While state-of-the-art global numerical models can represent some of these effects, the simulated atmospheric dynamics is not necessarily close to the observed one (in terms of reanalysis), especially when considered at a regional scale and with focus on catastrophic events. Most importantly, these models are not designed to allow for the correction of the leading dynamic modes locally in space and time, thus prohibiting the bias correction of a model attractor.
In this talk we will introduce a novel framework in which a new global circulation model with a multi-resolution structure is dynamically assisted by deep learning. The new circulation model uses expansions in a wavelet basis, a formulation falling between the familiar spatial discretizations (e.g. finite difference, finite elements, finite volume, etc.) and the classical spectral expansion schemes. Our formulation allows for simultaneous localization in the space and frequency domains and, consequently, offers means of leading energy mode adjustment within the integration process. A data assisted dynamic adjustment is implemented within the integration process by a recurrent neural network acting on the wavelet coefficients and trained on reanalysis data projected onto the basis. In the talk we will discuss the framework and report some preliminary results on our multi-resolution formulation specifically tailored to the needs of catastrophe modeling.