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Adapative non-hydrostatic dynamics for exploring multiscale climate interactions

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Many of the atmospheric phenomena with the greatest potential impact in future warmer climates are inherently multiscale. Such meteorological systems include hurricanes and tropical cyclones, atmospheric rivers, and other types of hydrometeorological extremes. These phenomena are challenging to simulate in conventional climate models due to the relatively coarse uniform model resolutions relative to the native nonhydrostatic scales of the phenomenological dynamics. To enable studies of these systems with sufficient local resolution for the multiscale dynamics yet with sufficient speed for climate-change studies, we have built a new type of atmospheric model by combining adaptive mesh dynamics with the cloud-resolving physics from the Multiscale Modeling Framework (MMF).

The model features adaptive mesh refinement in both space and time, nonhydrostatic dynamics, and high-order numerical accuracy. By using both space-and time-adaptive mesh refinement, the solver allocates computational effort only where greater accuracy is needed, in particular to resolve emergent multiscale phenomena such as synoptic storm systems. We show initial simulations of tropical cyclones using this new model that can be refined over several orders of magnitude without loss of accuracy to study the evolution of these cyclones at ultra-high resolution while simultaneously retaining the two-way interactions between the cyclones and the rest of the climate system.