Resolution Sensitivity of GRIST Nonhydrostatic Model during DYAMOND winter from 120 km to 5 km (3.75 km)

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Key Points:

- Resolution sensitivity of GRIST nonhydrostatic model is assessed from O (100 km) to O (km) scales.
- The model gradually improves its representation of fine-scale fluid structures.
- Better representation of process-level model-weather events do not necessarily lead to improved coarse-resolution model climatic features.

Abstract

This work investigates the resolution sensitivity of a global nonhydrostatic model featured by explicit dynamics-microphysics coupling, with varying uniform resolutions (120 km, 60 km, 30 km, 15 km, 5 km). The experiments follow the DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains) winter protocol that covers a 40-day integration. These simulations do not activate parameterized convection. One 120-km test with parameterized convection is performed to serve as a coarse-resolution reference. Other model configurations for different simulations are kept as consistent as possible. Results demonstrate that the model gradually improves its representation of the fine-scale features as the resolution increases. The 5-km simulation is overall close to a finer-resolution 3.75 km simulation during the first 12 days of DYAMOND winter. Regarding the mean climate, the 5-km simulation has a more realistic rainfall distribution than lower-resolution simulations without parameterized convection. Most zonally averaged coarse-resolution climate statistics are less prone to be altered by the resolution, except those fields associated with cloud water (e.g., shortwave cloud radiative forcing). The tropical rainfall frequency-intensity spectra become more realistic in the 5-km explicit-convection simulation, but the 120-km run with parameterized convection shows a more realistic mean climate. This can be attributed to the apparent diabatic heating structure of the coarse-resolution averaged flow. Thus, better fine-scale details in the explicit-convection simulation do not necessarily contribute to improved coarse-resolution climatic features when compared to a parameterized-convection model, implying that much room remains to constrain the kilometer-scale global models.