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Improving the Rapid Refresh and High Resolution Rapid Refresh physics to better perform across a wide range of spatial scales

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Model development at NOAA/GSD spans a wide range of spatial scales: global scale (Flow-following finite-volume Icosohedral Model, FIM; 10-250 km grid spacing), continental scale (RAP; 13 km grid spacing), CONUS scale (HRRR; 3 km grid spacing), and regional modeling (experimental nesting at 1 km grid spacing over complex terrain). As the model resolution changes, the proportion of resolved vs unresolved physical processes changes; therefore, physical parameterizations need to adapt to different model resolutions to more accurately handle the unresolved processes. The Limited Area Model (LAM) component of the Grey Zone Experiment was designed to assess the change in behavior of numerical weather prediction models between 16 and 1 km by simulating a cold-air outbreak over the North Atlantic and North Sea. The RAP and HRRR model physics were tested in this case study in order to examine the change in behavior of the model physics at 16, 8, 4, 2, and 1 km grid spacings with and without the use a convective parameterization. The primary purpose of these tests is to better understand the change in behavior of the boundary layer and convective schemes across the grey zone, such that further targeted modifications can then help improve general performance at various scales.

The RAP currently employs a modified form of the Mellor-Yamada-Nakanishi-Niino (MYNN) PBL scheme, which is an improved TKE-based scheme tuned to match large-eddy simulations. Modifications have been performed to better match observations at 13 km (RAP) grid spacing but more multi-scale testing is required before modifications are introduced to make it scale-aware. A scale-aware convective parameterization, the Grell-Freitas scheme (both deep- and shallow-cumulus scheme), has been developed to better handle the transition in behavior of the sub-grid scale convective processes through the grey zone. This study examines the change in behavior of both schemes across the grey zone. Their transitional behavior is characterized and strategies to improve each scheme are explored. Further tests are performed to elucidate the impacts of specific model configurations and parameters that may improve weather prediction across the grey zone.