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The parameterization of slantwise convection in a numerical model

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Slantwise convection and the associated release of conditional symmetric instability (CSI) have been recognized as important baroclinic processes. Recent climatological studies have highlighted its significant association with midlatitude cyclone activities, raising questions about whether large-scale models can resolve slantwise convection and whether it should be parameterized.

To address this issue, the present study simulates isolated free moist slantwise convection in an initially statically stable environment using the 2D idealized, non-hydrostatic Weather Research and Forecasting (WRF) Model. We first examined the sensitivity of the slantwise convection to the cross-band grid spacing (Δy; varied from 40 to 1 km) and found that experiments with Δy> 5 km fail to capture the band dynamics and larger-scale feedbacks robustly and thus require parameterization. As most of the current convective parameterization schemes target upright convection in a local column, we implemented an additional 2D slantwise convective parameterization scheme and evaluated its impact for coarse-grid runs.

The slantwise convective parameterization scheme operates along a sloped trajectory on a horizontally-variant cross section perpendicular to the local thermal wind, adjusting the environment toward a natural state to CSI within a given time scale. With the addition of the slantwise convective parameterization scheme, significant improvements are found in precipitation and the strength of the slantwise updraft, bringing the coarser-grid (Δy=40 km) simulation closer to the finer-grid (converged) results than its counterpart with only the upright convection scheme. After testing the slantwise convective parameterization scheme under idealized frameworks, we will further apply it to regional models to evaluate its benefit to the weather forecasting in real cases.