Improving and Assessing Organized Convection Parameterization in the Unified Model

Zhixiao Zhang¹, Hannah Christensen¹, Mark Muetzelfeldt², Tim Woollings¹, Bob Plant², Alison Stirling³, Michael Whitall³, Mitchell Moncrieff⁴, and Chih-Chieh Chen⁴

¹Department of Physics, University of Oxford, Oxford, United Kingdom
²Department of Meteorology, University of Reading, Reading, United Kingdom
³Met Office, Exeter, United Kingdom
⁴National Center for Atmospheric Research, Boulder, United States

Improving weather and climate prediction cannot avoid accurately representing organized convection, as its convective and stratiform components distinctly reshape large-scale circulations via redistributing momentum and heat. For latent heating, the stratiform heating in organized convection shifts to higher altitudes compared to convective regions, presenting a significant challenge for representation in models across scales. The Multiscale Coherent Structural Parameterization (MCSP), introduced by Moncrieff et al. (2017), offers a promising solution by generating the top-heavy profile from convective heating in slantwise layer overturning scenarios. As part of the MCS: PRIME project, the PRIME-MCSP implementation by Zhang et al. (submitted, 2024) couples MCSP with the CoMorph-A convection scheme in the UK Met Office Unified Model with the following improvements: 1) CoMorph permits unstable air to rise from any height, diverging from the conventional CAPE trigger for deep convection, thereby enhancing continuity and facilitating storm tracking. 2) We activate MCSP selectively for deep mixed-phase clouds, recognizing the limited ability of shallow clouds to produce a stratiform component. 3) We configure the global model runs to include both a fixed convective-stratiform heating fraction and a fraction proportional to cloud top temperature.

MCS tracks in ensembles of weather runs show that PRIME-MCSP suppresses cloud deepening and reduces precipitation areas by dampening low-level updrafts. 20-year climate simulations show that PRIME-MCSP improves the precipitation seasonal cycle over the Indian Ocean, while increasing the warm-season wet bias over the Western Pacific. Additionally, PRIME-MCSP intensifies the Madden Julian Oscillation (MJO). The model run using a variable convective-stratiform fraction more accurately represents the MJO frequency and aligns better with reanalysis. Future plans focus on the stochastic representation of stratiform effects, steered by insights from data assimilation increments.