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New Frontiers: Tropical Cyclone Modeling with NCAR's Variable-Resolution General Circulation Model CAM-SE

Christiane Jablonowski and Colin Zarzycki
University of Michigan, Atmospheric, Oceanic & Space Sciences, Ann Arbor, United States (cjablono@umich.edu)

Modeling of tropical cyclones in General Circulation Models (GCMs) has traditionally proved challenging. Tropical cyclones are significantly under-resolved, if not completely unresolved, at traditional GCM grid resolutions of 50-300 km. However, recent gains in computational resources and advances in GCM model design now allow for GCM simulations with grid spacings as small as 12-30 km. At these resolutions, models are able to more effectively capture key features of tropical cyclones.

This talk surveys a novel variable-resolution mesh approach that allows for high spatial resolutions in areas of interest. The statically-nested, variable-mesh option has recently been introduced into the cubed-sphere Spectral Element (SE) dynamical core of the Community Atmosphere Model (CAM) which is under development at various U.S. Department of Energy laboratories and the National Center for Atmospheric Research (NCAR). The talk gives an overview of the variable-resolution mesh approach, and evaluates its scientific properties. In particular, we will discuss the characteristics of tropical cyclone simulations in a variety of modeling frameworks. They include the representation of tropical cyclones in aqua-planet experiments, and showcase short-term and multi-decadal tropical cyclone simulations in CAM-SE when driven with prescribed sea surface temperatures. Special attention is paid to the characteristics of tropical cyclones in the grid transition regions, and the comparison of variable- and uniform-resolution experiments. It is shown that the variable-resolution CAM-SE model has the potential to become a future tool for regional climate assessments. In addition, we assess the performance of the CAM4 and CAM5 physical parameterization packages in variable-resolution aqua-planet simulations. In particular, we discuss the question whether current physics packages are scale-aware and whether or not the addition of increased resolution patches adds bias to key climate metrics such as rainfall and cloud fraction at the regional level.