A Comparison of Idealized Squall Line "Climates" from WRF and MPAS

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Over the past decade, non-hydrostatic global numerical models have increasingly been tested at convective permitting scales to examine how these global model's solutions compare to well-known solutions from models that were originally designed only to study and diagnose storm dynamics (e.g., Weisman and Klemp, 1982; 1984). For example, ten global models are compared by Zarzycki et al. (2019) using an idealized sounding typical of supercell environments and similar to that originally proposed by Weisman and Klemp (1982) and discussed in detail by Klemp et al (2015). These studies use simple physics and environments to constrain the solution to only generate a few storms that are easily compared. For example, Zarzycki et al. (2019) use a supercell sounding with a single thermal perturbation to initialize the convective storm. Subsequently, the convective storm evolution is rather straightforward. As the convective storm matures, the storm splits, and the left and right components are a mirror of each other. As a result, most of the models produce only a few storms during the simulations. While this provides a simple framework for comparison, the number of storms in each model is limited and does not provide a large database from which to draw statistical conclusions.

While the supercell environment is representative of the U.S. spring severe season environments, there are other important convective weather systems. Another important type of storm environment, also prevalent in both the spring and summer seasons in the U.S., is characterized by moderate to large instability where the vertical wind shear is much shallower and smaller than the supercell environment. These environments produce most of the squall lines observed in the U.S. and are a primary convective mode during the warm season. Squall lines and their attendant mesoscale convective systems are responsible for much of the rainfall in the central U.S. during the spring and summer.

As part of a dynamical core comparison conducted during the last few years, this work will examine updraft intensities and rainfall patterns from a series of idealized tests using the WRF and MPAS models using squall line environments. Squall lines, initialized by a line of thermal perturbations, are a useful mode to study. This study uses a six-hour simulation length, and due to the system dynamics, will often generate hundreds of storm cells. Characteristics from the populations of convective cells are then used to generate statistics having a large sample size.

This study will be one of the first to present a comparison of idealized MPAS squall lines to similar WRF solutions. The study will also present results from several different versions of the WRF model and possibly from CM1 as well. These results should help characterize the variability in solutions from different model dynamical cores as well as from their evolving formulations and help guide users looking to understand potential model biases. It also should provide a baseline set of solutions for future non-hydrostatic models to help validate the model's dynamical and physical parameterizations needed for convection.

References

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