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MMM SEMINAR *NCAR*

Impacts of Updraft Size and Dimensionality on Cumulus Dynamics: Implications for "Convective-Permitting" Models and Convection Schemes

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The importance of updraft size and dimensionality (2D versus 3D) via perturbation pressure effects on cumulus dynamics has been long known. However, quantitative understanding is lacking and a simple, generalized theoretical framework describing these effects has not yet been developed. This is despite past studies showing near universal agreement on the effects of updraft size (a decrease of updraft velocity with increasing width) and dimensionality (weaker updrafts in 2D than 3D). This presentation will describe recent work addressing these issues.

A general review of convective dynamics will be given first to provide background. Approximate analytic solutions to the governing equations, describing relationships between perturbation pressure, vertical velocity, updraft size, and buoyancy in 2D and 3D, will then be presented. These expressions are compared with numerical solutions calculated directly from the buoyant perturbation pressure equation. Tests using buoyancy profiles derived from real and idealized thermodynamic soundings, representing a range from shallow to deep convection, will be presented, and show a close correspondence of the theoretical and numerical solutions. The theoretical and numerical solutions also give a scaling of updraft velocity with updraft radius (~Δx, horizontal grid spacing) consistent with fully dynamical 2D and 3D simulations in the "gray zone", with Δx ~1-10 km, where convection is generally under-resolved and updrafts are biased wide. These results suggest that an incorrect representation of perturbation pressure from spuriously wide updrafts are an important contributor to biases in convective characteristics at these resolutions, which may be difficult to address solely by modification of subgrid-scale mixing schemes. The analytic solutions also provide a concise physical interpretation of the "virtual mass" coefficient in convection parameterizations, and can be easily incorporated into these schemes to provide an improved representation of perturbation pressure effects.

This seminar will be webcast live at:
http://www.fin.ucar.edu/it/mms/fl2-live.htm

Recorded seminar link can be viewed here:
https://www.mmm.ucar.edu/events/seminars

Thursday, 13 November 2014, 3:30 PM
Refreshments 3:15 PM
NCAR-Foothills Laboratory
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