High Plains Cold Pools Obey a Theoretical Propagation Speed Equation

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Improving our understanding of cold pool propagation speeds, along with other fundamental cold pool properties, will help improve our ability to forecast high-impact weather. Storm initiation, intensity, organization, and longevity are frequently driven by convective cold pools. Cold pools can also generate hazardous straight-line winds and dust storms. Despite these significant impacts, cold pools are not well represented in either global or high-resolution forecast models. A theoretically derived equation exists which relates the propagation speed of a cold pool to the vertical integral of its negative buoyancy. This equation could be used to evaluate and improve the representation of cold pools in forecast models, but the applicability of this theoretical equation to cold pools in the real atmosphere must be conducted first. Thus, this study uses targeted observations from two recent field campaigns to evaluate the theoretical cold pool propagation speed equation. These campaigns are the Colorado State University Convective CLoud Outflows and UpDrafts Experiment (C^3LOUD-Ex) and BioAerosols and Convective Storms (BACS), both of which took place in the US High Plains.

To apply the theoretical cold pool propagation speed equation, pairs of radiosondes launched inside and outside of a cold pool are used. The radiosonde launched outside of the cold pool is used as a base state from which buoyancy inside the cold pool can be calculated. Propagation speeds obtained from this equation are referred to as “theoretical propagation speeds”. To obtain “observed propagation speeds”, cold pool boundaries are tracked manually in NEXRAD reflectivity data. Observed propagation speeds are also corrected to account for advection due to the background wind. There is a stronger relationship between observed and theoretical cold pool propagation speeds for BACS (r^2=0.71) compared to C^3LOUD-Ex (r^2=0.31). However, the variance explained for C^3LOUD-Ex increases to 84% when data from a single outlier cold pool is removed. Since most cold pools have the predominance of their negative buoyancy near the surface, theoretical propagation speeds are generally insensitive to different methods of determining cold pool depth. Alternative versions of the theoretical cold pool propagation speed equation, which make different assumptions, are compared against each other. The implications of these results to forecasting and nowcasting cold pools on the High Plains will be discussed.