Revisiting the parcel method and CAPE

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Although the parcel method and CAPE(Convective Available Potential Energy) are frequently used in predicting the strength and height of convections, they ignore the pressure perturbation and fail to explain strong updrafts observed in tropical cyclones and hurricanes without CAPE; or deep, strong warm downdrafts in the eye-wall of hurricanes, tropopause folds, or windstorms on the lee of mountain. It is also difficult to explain heavy rainfalls in India monsoon with minima CAPE, or deep convections without positive CAPE in the USA due to the conservation of KE (Kinetic Energy=0.5**V•V**), and PE (Potential Energy=gz). On the other hand, Bernoulli equation reveals energy conservation among KE, PE, and EN (Enthalpy $=c_pT+Lq_s$) in an inviscid fluid. When the temperature of an updraft or downdraft becomes cooler than the adiabatic lapse rate, part of enthalpy can be converted to KE, which is equivalent to induce dynamic pressure. Hence, the vertical velocity can increase. In a stable environment, an updraft imposed at surface or generated from flow encountering topography can increase under negative buoyancy in the lower atmosphere. The stronger updraft carries more moisture upward and results in more condensation. The updraft enhances due to the combination of EN conversion and the release of latent heat; therefore, the cloud can grow vigorously even CAPE being near zero or still negative. On the other hand, a deep, strong downdraft can develop without significant evaporative cooling and/or loading from precipitation, as shown in both observations and this study.

(Sun, W.Y., and O. M. Sun, 2019: Revisiting the parcel method and CAPE, Dynamics of Atmospheres and Oceans 86, 134-152).

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