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Convective available potential Energy (CAPE) in mixed Phase Cloud Conditions

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An approximate but practical approach is presented to define reversible Convective Available Potential Energy (CAPE) in mixed phase cloud conditions. The underlying process allows mixed (i.e. liquid and ice) phase parcels and assumes the liquid fraction to be an unique function of temperature. The approach is meant to represent average conditions.

Freezing increases temperature and, hence, buoyancy. If freezing occurs isobarically (as was often assumed in the past), all water freezes at a single level resulting in a finite jump in buoyancy at that level. By contrast, our new mixed phase parcel process implies a continuous phase transition in a finite range of temperature leading to a more gradual change of buoyancy with altitude and preventing a temperature inversion. The details of this gradual change depend on the location and the width of the specified temperature range. High in the troposphere, where all water is frozen irrespective of the assumed process, the differences between the different buoyancy profiles are small (but finite).

CAPE is very sensitive to the treatment of the freezing process. Ice formation in an isobaric process at around -5° C increases CAPE distinctly (about the same magnitude than CAPE in pseudo-adiabatic conditions) relative to CAPE of a pure water parcel. But, isobaric freezing at -20° C results in distinctly lower CAPE. About the same CAPE can be achieved by our new mixed phase parcel process when freezing is assumed to occur between -5° C and -40° C. To conclude, CAPE strongly depends on the depth and vertical level at which freezing occurs.