Cloud edge energy adjusts to the saturated tropospheric mean independent of climate state

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Cloud Edge Adjustment to Saturated Energy (CEASE) Hypothesis

The key parameter is the saturated static energy $h^*(T,z) = c_pT + gz + Lq^*(T)$

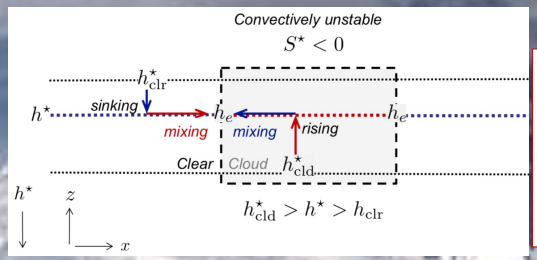
We introduce a constraint on cloud LNB height: The average moist static energy at the edge of clouds equals the layer-averaged saturated static energy of the atmosphere. ***Knowing the mean temperature profile may be enough to determine mean cloud height***

Note: all energies are normalized by the specific heat to be stated in units of Kelvin

Tropical convective cloud fields are difficult to simulate

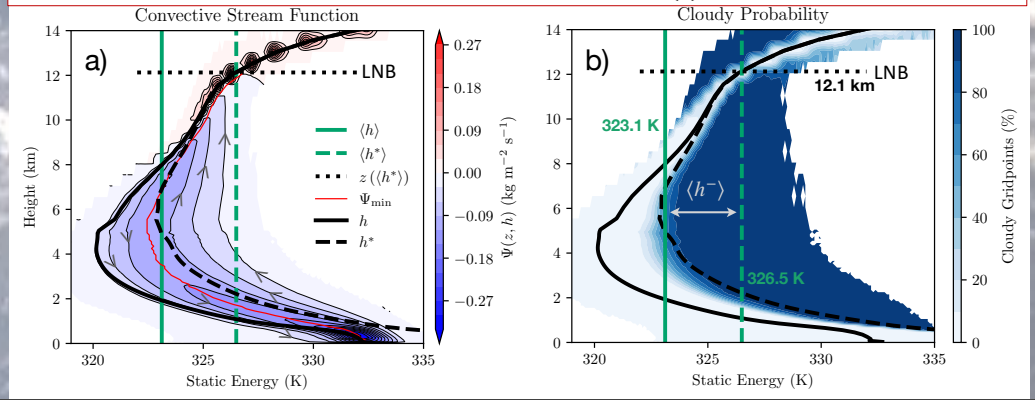
Thermodynamic reasoning, supported by high-resolution simulations and observations, argues for simplicity:

- The level of neutral buoyancy for clouds coincides with the height z at which the saturated static energy profile $h^*(z)$ matches the tropospheric mean saturated static energy $\langle h^* \rangle$, that is $h^*(z) = \langle h^* \rangle$.
- Cloud edge acts as a dividing line between regions of higher energy (cloudy air) and lower energy (clear air), with mixing ensuring a dynamic equilibrium.
- Surface air energy $h^*(T_{SST})$ may be a primary driver of cloud height and mean energy. A linear relationship is observed in idealized tropical RCE simulations at 500 m resolution.

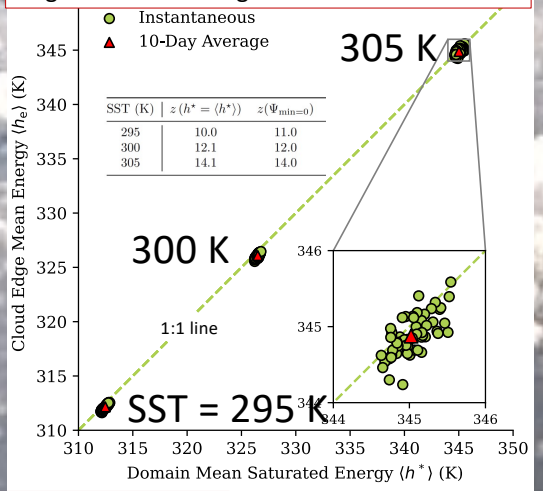


In a convectively unstable atmosphere, cloudy air rises while clear air radiatively cools and sinks. Clear and cloudy air mix to form a cloud edge parcel at its LNB with the same edge energy h_e as the domain mean saturated energy $\langle h^\star \rangle$ at that height

The LNB adjusts to the height of the mean saturated energy $\langle h^\star \rangle$. Cloud edge energy at any height adjusts to the profile of the mean saturated energy $h^\star(z)$



Mean cloud edge energy equals the tropospheric mean saturated energy for wide a range of SSTs covering a warmer climate



SST (K)	$z(h^\star = \langle h^\star \rangle)$	$z(\Psi_{min=0})$
295	10.0	11.0
300	12.1	12.0
305	14.1	14.0

$$z\left(h^\star = \langle h^\star \rangle\right) = 0.091\left(h^\star\left(T_{\mathrm{SST}}\right) - 226\,\mathrm{K}\right).$$

The LNB is tied to the SST