Thermodynamic constraints on the size distributions and amount of tropical clouds

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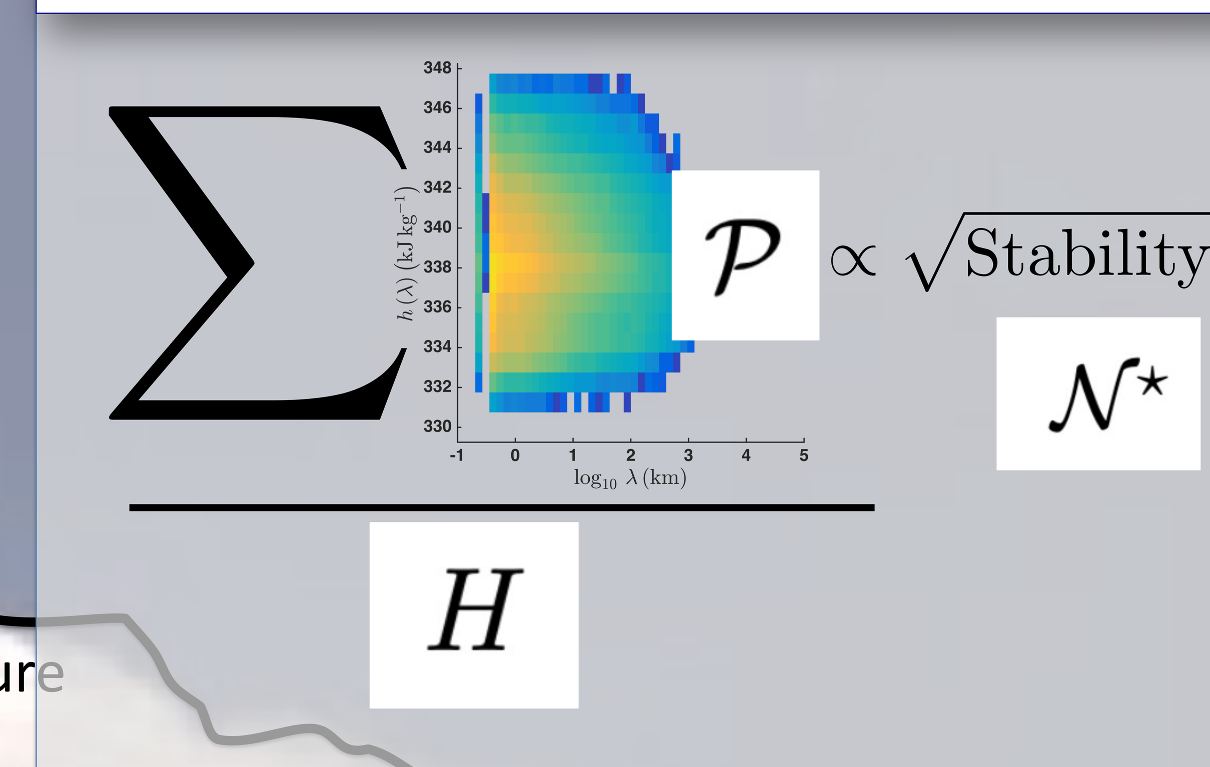
An equilibrium cloud field can ``emerge'' statistically from a single point value of stability.
Stability scales with surface temperature. Will cloud amount increase but cloud size distributions stay the same?
Total cloud perimeter can be predictably related to resolution between 1 mm and 10,000 km

Theory and Simulations: Total perimeter density (km/km^2) scales as the saturated buoyancy frequency



Perimeter λ along a surface of constant saturated static energy $h^* = c_pT + gz + Lq^*$ or SSE

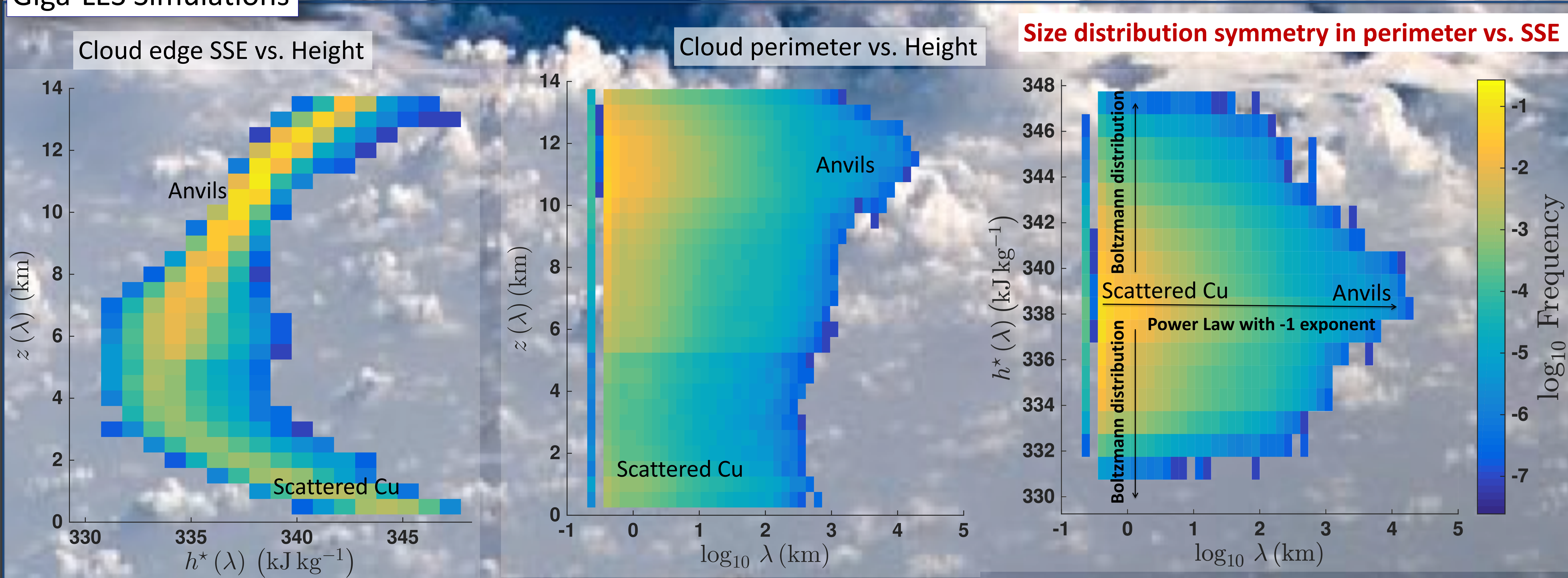
Tropical convective cloud fields have high spatial and temporal variability that is difficult to simulate
Thermodynamic reasoning, supported by high-resolution simulations and observations, argues that:

- For a given saturated static energy (SSE), number distributions for perimeters of clouds follow a simple power law
- Total cloud perimeter follows a negative exponential, or Boltzmann distribution, with respect to the departure of the SSE from the domain-averaged SSE of the entire cloud field, also equal to (1 – RH)Lq*
- The total cloud perimeter per unit area of all layers, divided by the scale height, scales with the square root of the bulk moist static stability or the saturated buoyancy frequency N^*
- Stability scales as 6%/K surface warming, so total cloud perimeter as 3%/K

-- Cloud size distributions along moist isentropes should not change

See also posters by Thomas DeWitt and Corey Bois

Giga-LES Simulations



Theory, Simulations, and Observations: Total perimeter density scales with resolution and a 5/3 fractal dimension covering a range between the microscale and the Rossby Scale