Stability

No simple criterion based on entropy:

$$s_d = c_p \ln\left(\frac{T}{T_0}\right) - R_d \ln\left(\frac{p}{p_0}\right)$$

$$\alpha = \alpha\left(s_d, p\right)$$

$$s = c_p \ln\left(\frac{T}{T_0}\right) - R_d \ln\left(\frac{p}{p_0}\right) + L_v \frac{q}{T} - qR_v \ln\left(H\right)$$

$$\alpha = \alpha\left(s, p, q_t\right)$$

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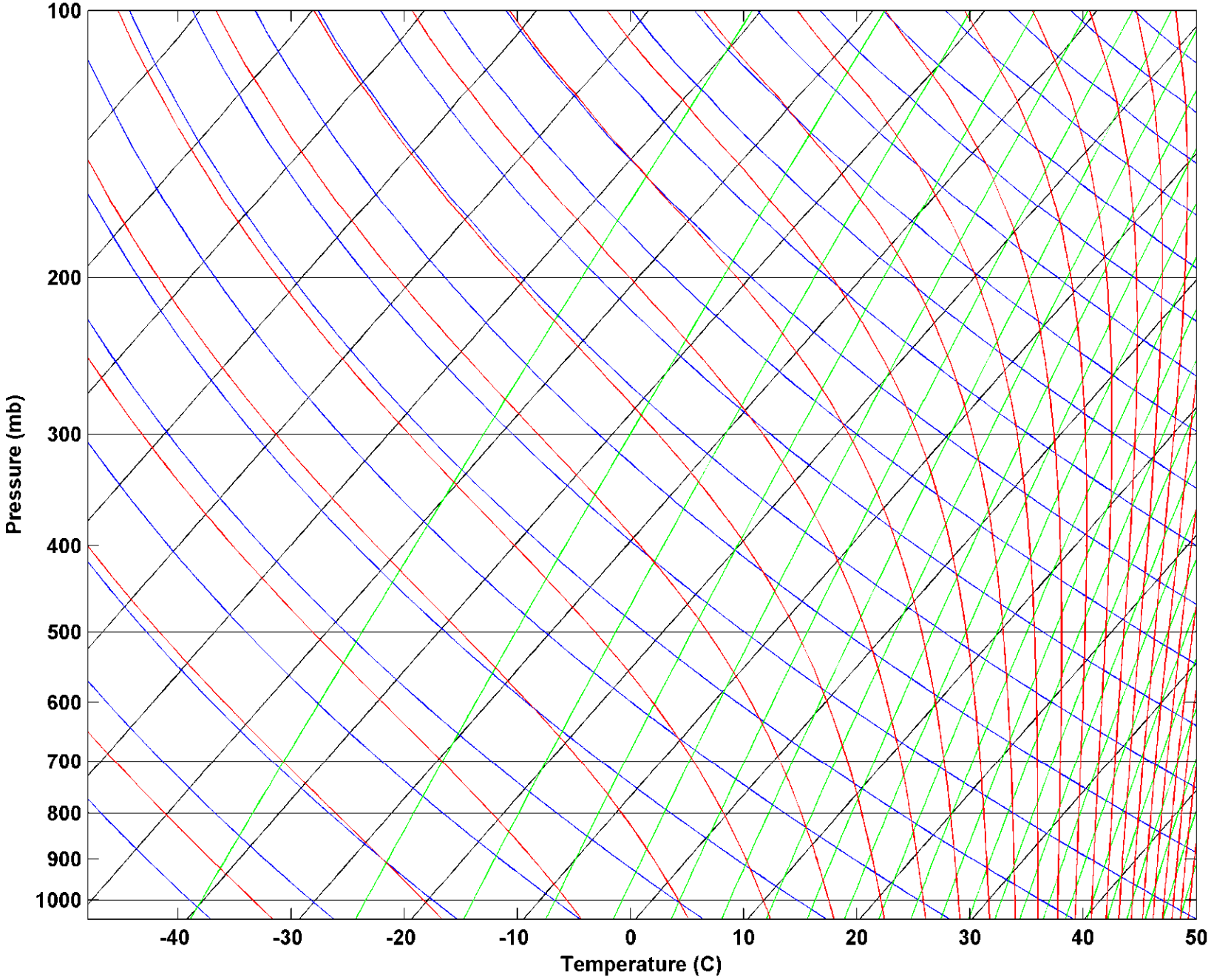
The Thermodynamic Diagram

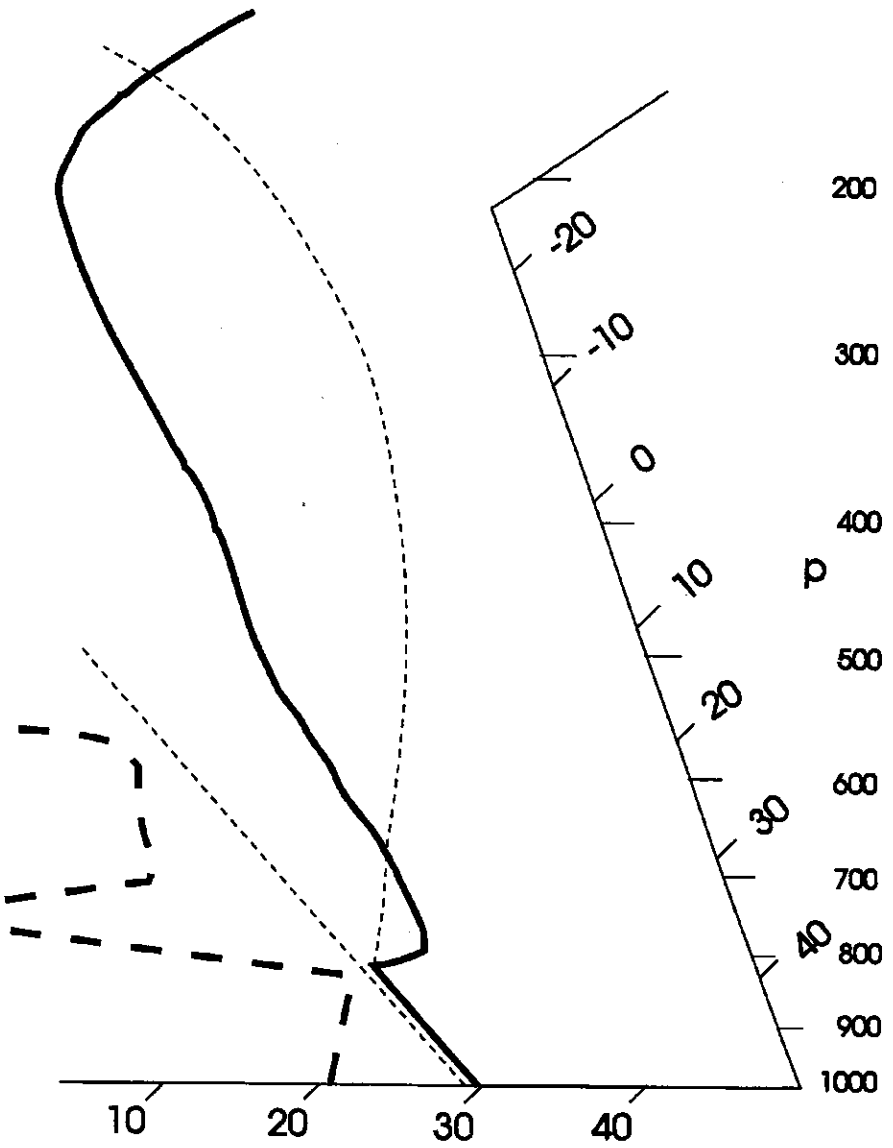


Stability Assessment using Tephigrams:

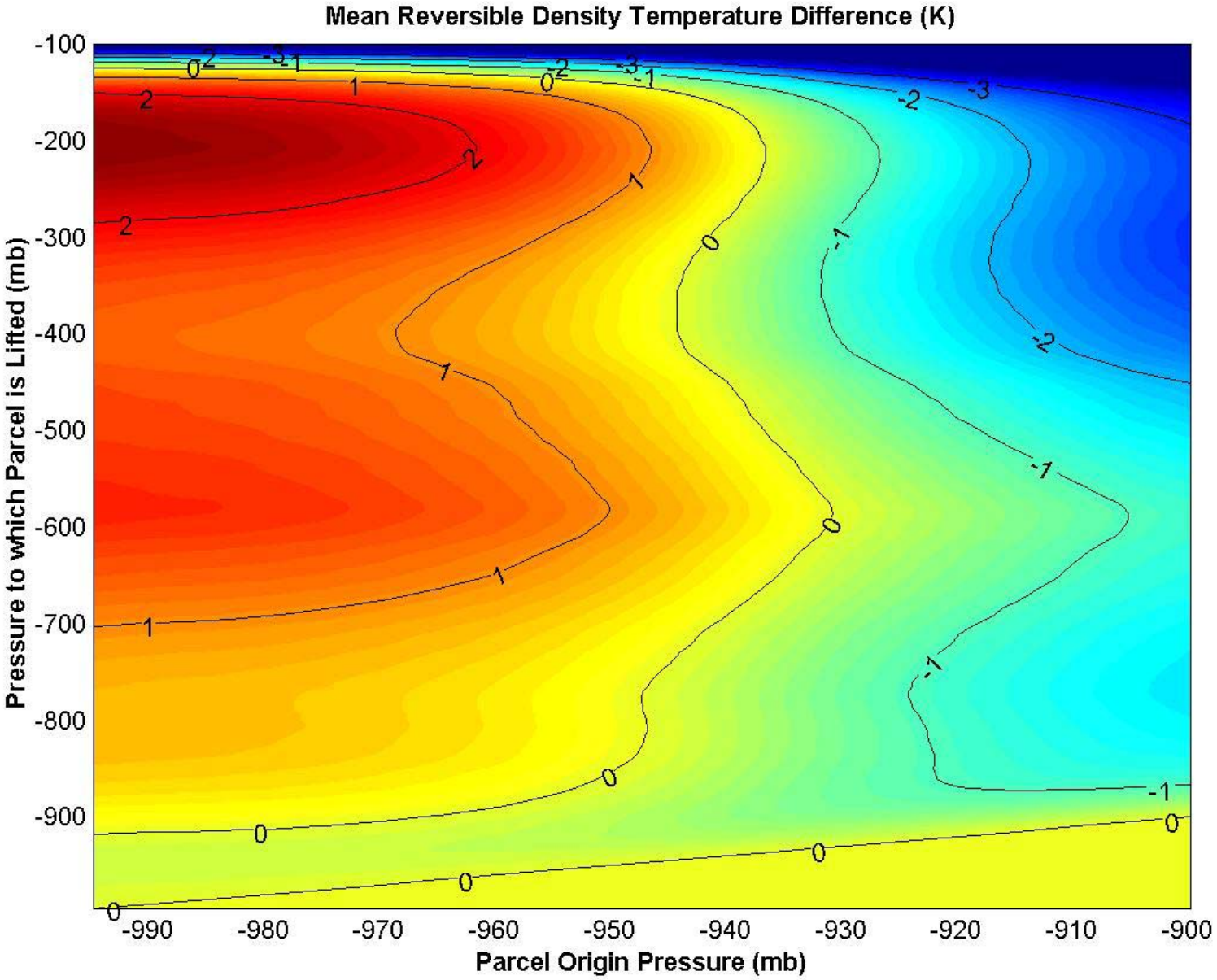
Convective Available Potential Energy (CAPE):

$$CAPE_i \equiv \int_{p_n}^{p_i} \left(\alpha_p - \alpha_e \right) dp$$

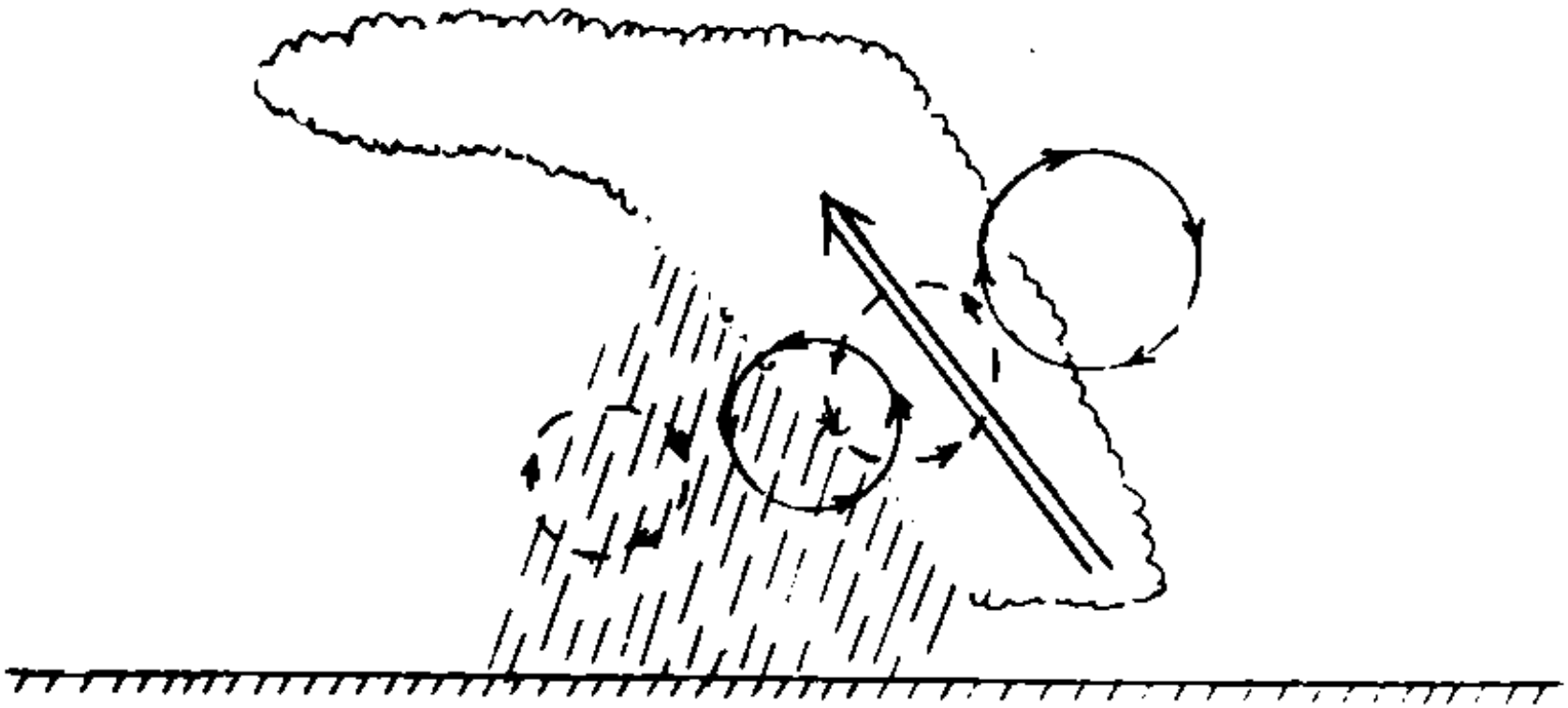
$$= \int_{p}^{p_i} R_d \left(T_{\rho_p} - T_{\rho_e} \right) d\ln(p)$$



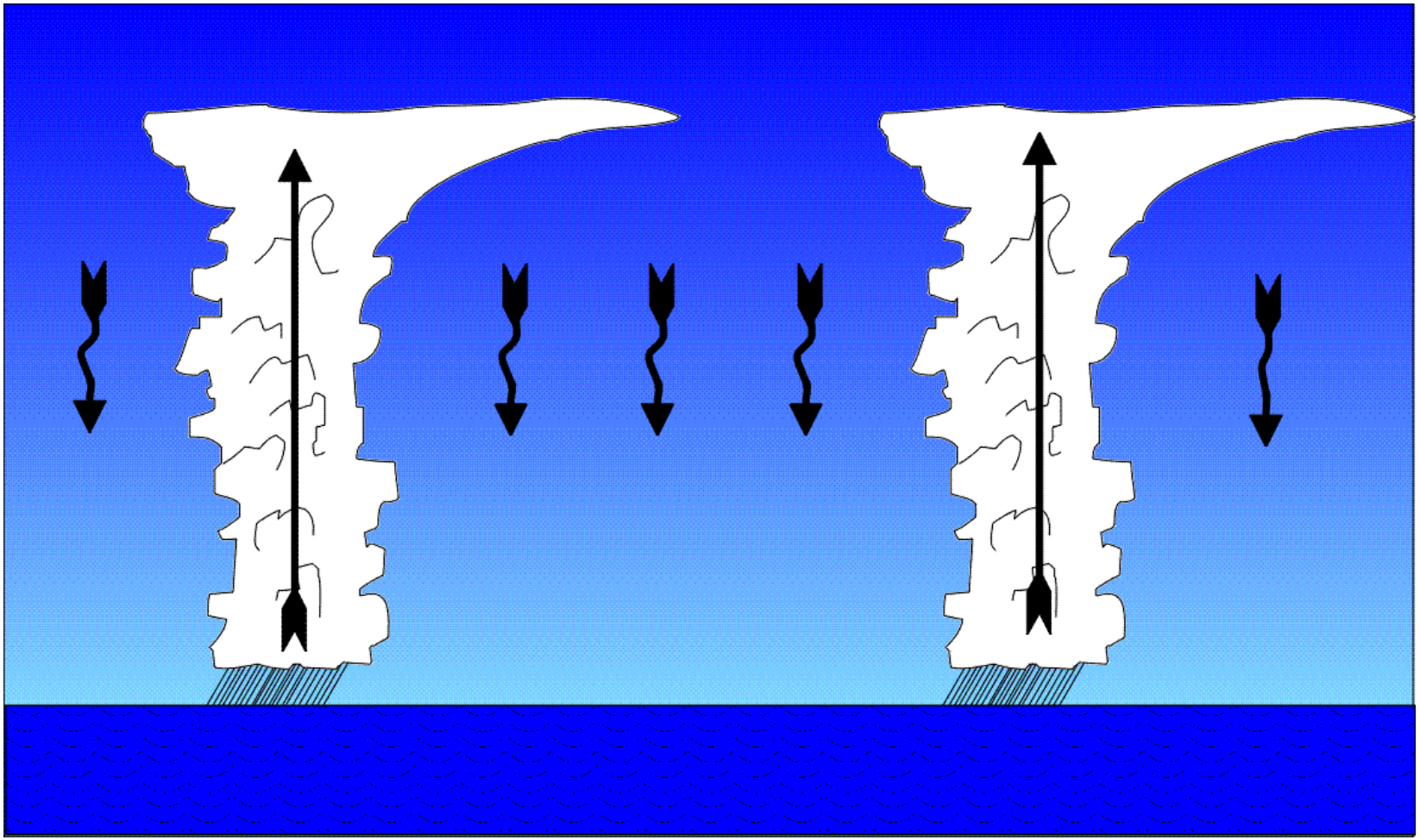
Other Stability Diagrams:



Precipitation Effects:



Precipitating Convection favors Widely Spaced Clouds (Bjerknes, 1938)



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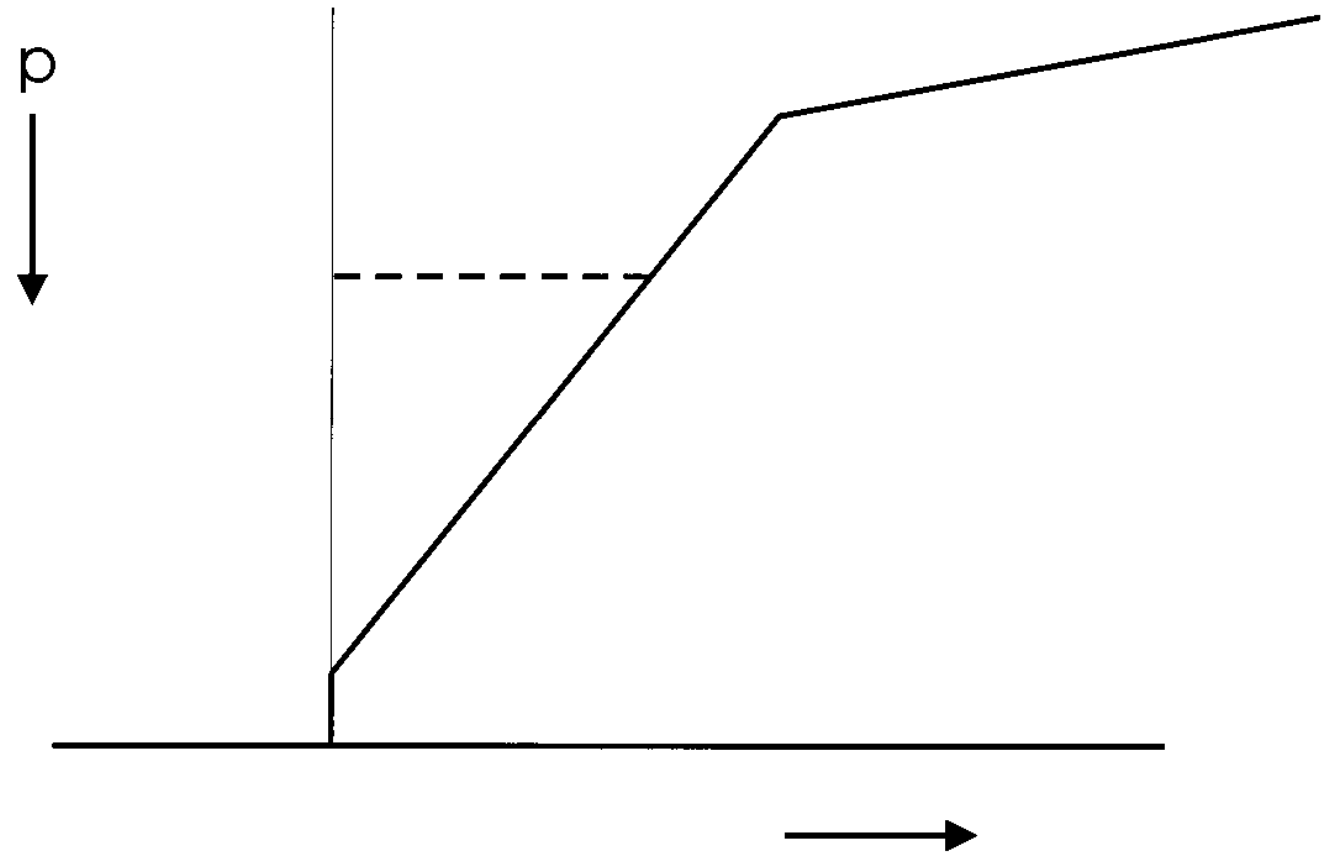
Buoyancy Reversal:

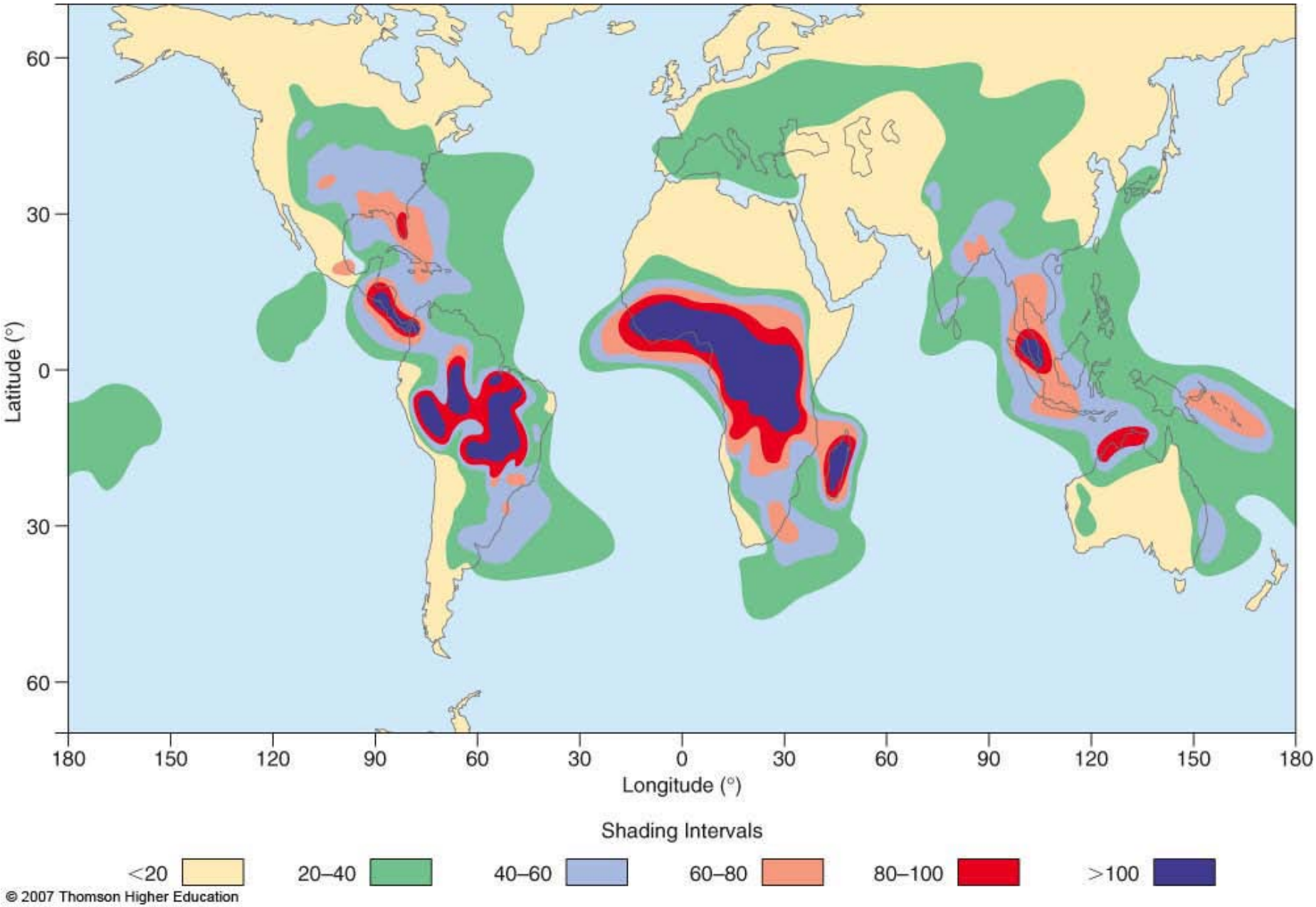


$$h_{lv} = C_p T_v + gz - L_v \ell$$

Summary of Differences Between Dry and Moist Convection:

- Possibility of metastable states
- Strong asymmetry between cloudy and clear regions
- Typically, only thin layers near surface are unstable to upward displacements
- Mixing can cause buoyancy reversal
- Large potential for evaporatively cooled downdrafts
- Buoyancy of unsaturated downdrafts depends on supply of precipitation

A climatology of the average number of thunderstorm days in a year



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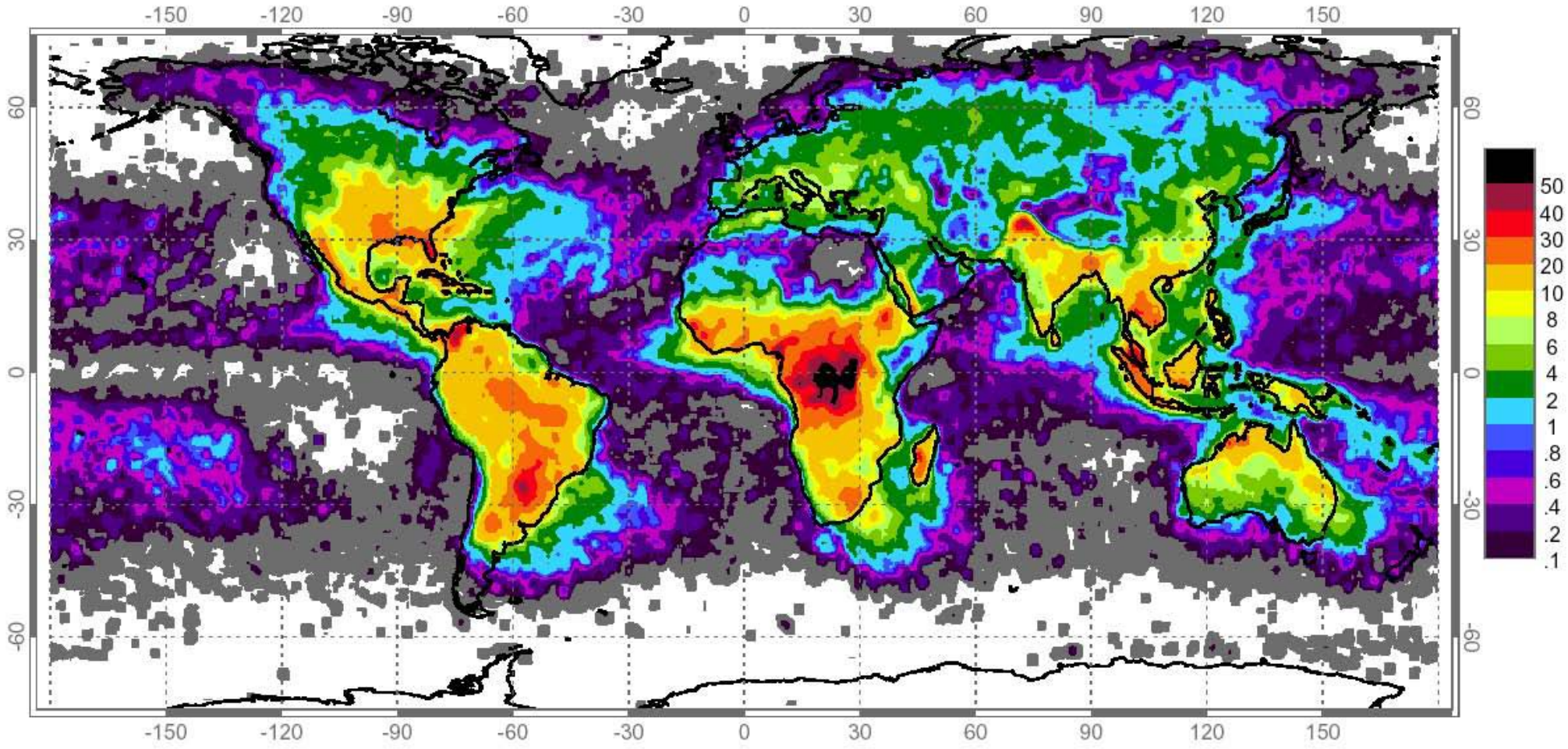
Annual Lightning Frequency (from satellite)



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