Irreversible phase change in the TTL forced by low-latitude deep convection

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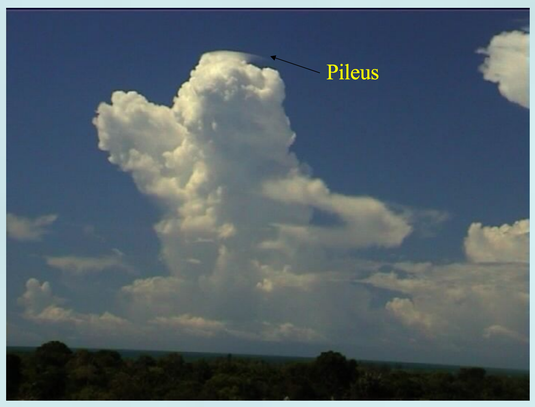
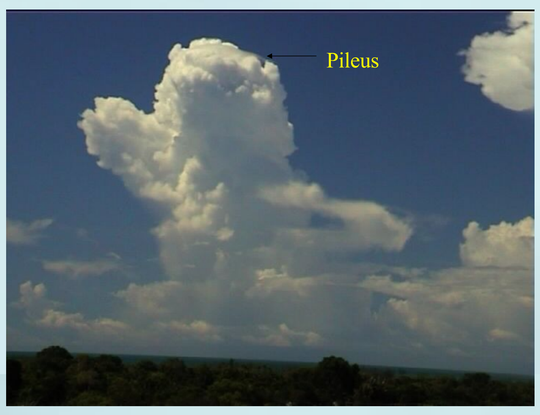
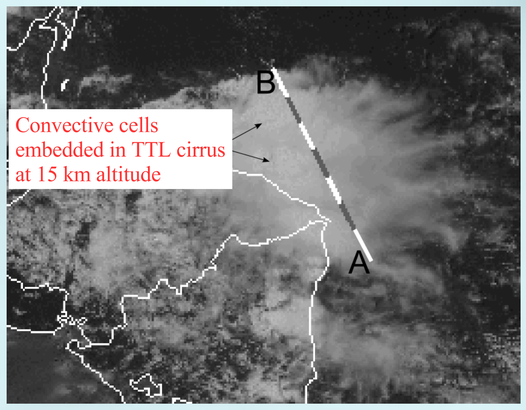
HECTOR (TWP-ICE 2006)

Courtesy Roger Smith, U. Munich

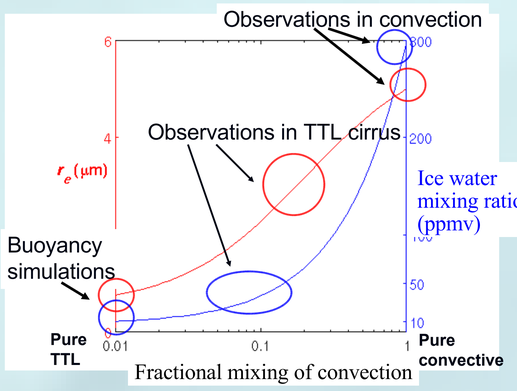




Aircraft Observations

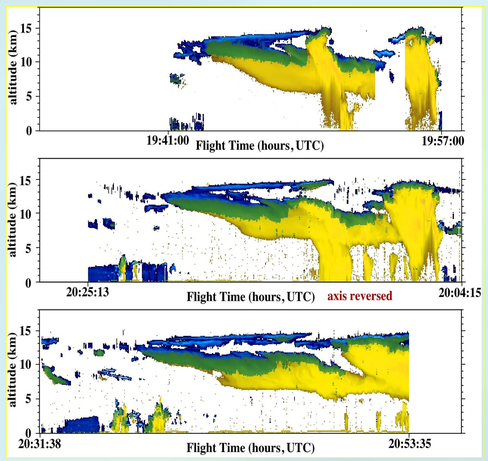


On 9 July 2002, the NASA WB-57 flew through tenuous TTL cirrus at 15 km with two intercepts through penetrating convection (A to B). Coincident GOES-8, and ER-2 CRS and CPL imagery indicated the TTL cirrus was above a warmer anvil cirrus layer.



Values of ice water mixing ratio and effective radius measured in the TTL cirrus were most consistent with the cloud being a mixture of 90 % high frequency, high amplitude wave cloud, and 10 % deep convective outflow

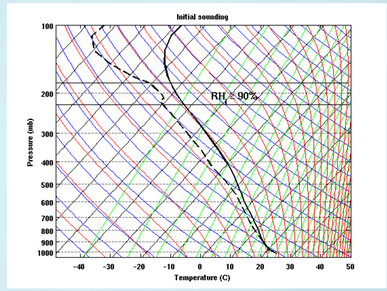
Inferred explanation: Deep convection formed a pileus cloud, punctured it, mixed with it, and the pileus either propagated or was pushed outward as the convection subsided. The convection became anvil outflow. The pileus became TTL cirrus at a higher level.



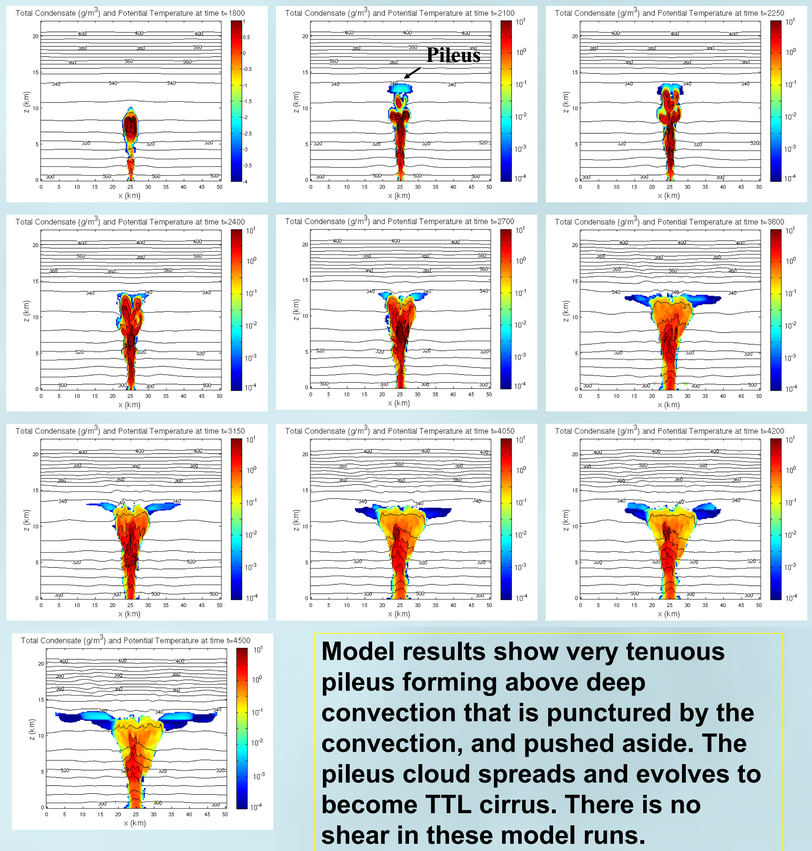
Combined lidar and radar imagery from the NASA ER-2 showing the evolution of a cirrus anvil on 23 July during CRYSTAL-FACE. Blue represents a signal was seen by the lidar only (tenuous/small crystals), yellow the radar only (low attenuation, large crystals), and green both combined. (courtesy M. McGill)

- Florida cirrus anvil outflow often has not one but two layers, separated by about 1 km.
- The upper layer at the tropopause is thin and tenuous ($\tau < 0.3$). The lower layer is the thicker anvil.
- The tropopause layer appears to originate at deep convective tops.

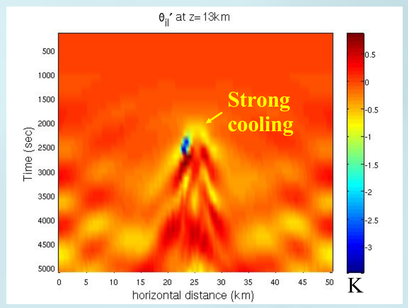
LES Model

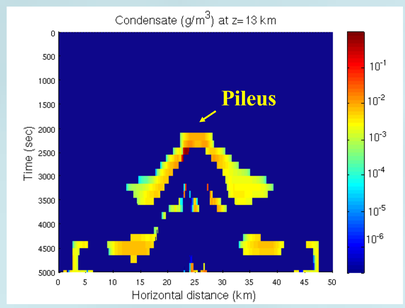


Initial Sounding: Sub-tropical atmosphere with a clear moist layer near the tropopause. Model initialized with a warm bubble at the surface



Model results show very tenuous pileus forming above deep convection that is punctured by the convection, and pushed aside. The pileus cloud spreads and evolves to become TTL cirrus. There is no shear in these model runs.





Hovmuller Plots show that the biggest temperature perturbation, and the only perturbation of sufficient magnitude to induce homogeneous nucleation of new ice, occurs within the pileus cloud.