Aerosol Effects on Deep Convection

QUESTION: What aerosol-related processes control deep convective cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?

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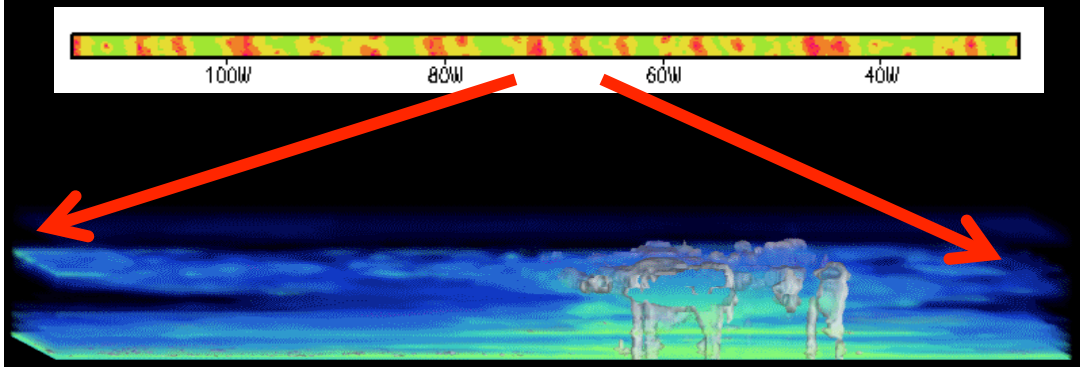
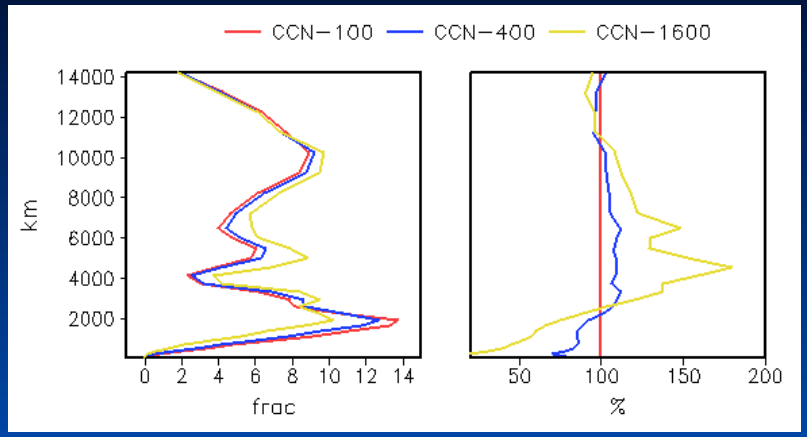
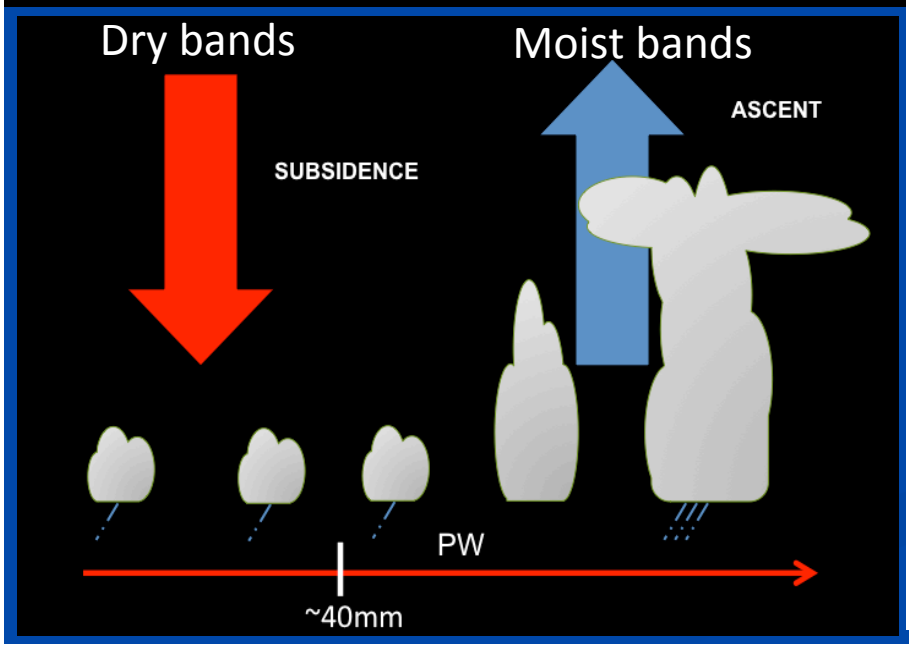
Multiscale Thermodynamic and Dynamic Responses





RCE Simulations: The volume plot (colored haze) is relative humidity (wrt liquid) and the white isosurfaces are total cloud mass mixing ratio at a threshold of 0.1 g/kg. Only 10% of the domain is shown in the animation.

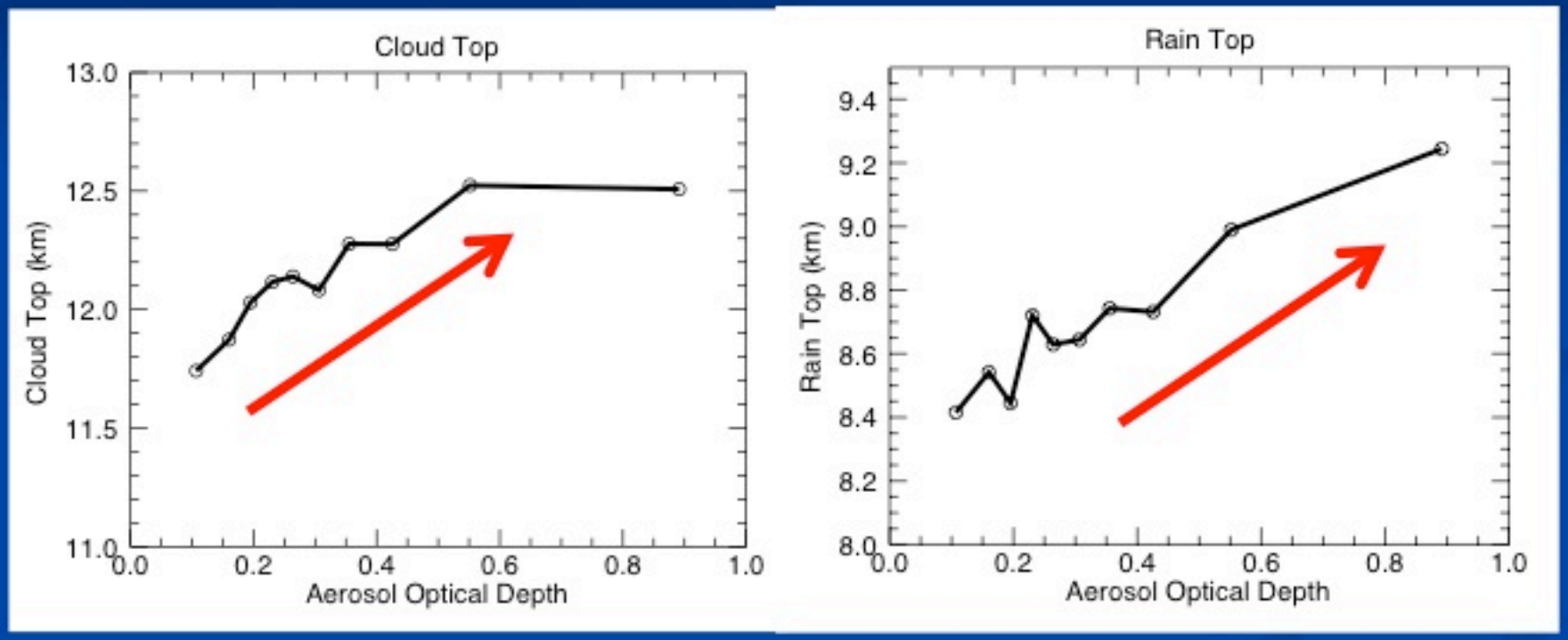


RCE Simulations

- Enhanced aerosol concentrations:
  - Increased congestus and deep cloud fraction (10-60%) and reduced shallow cloud fraction (10-50%)
  - Enhanced latent heating => stronger updrafts => greater convective mass flux in deep convection => greater corresponding subsidence in dry bands => reduction in shallow cloud fraction
- van den Heever et al. (2011, 2013)

Latent Heating and Convective Invigoration

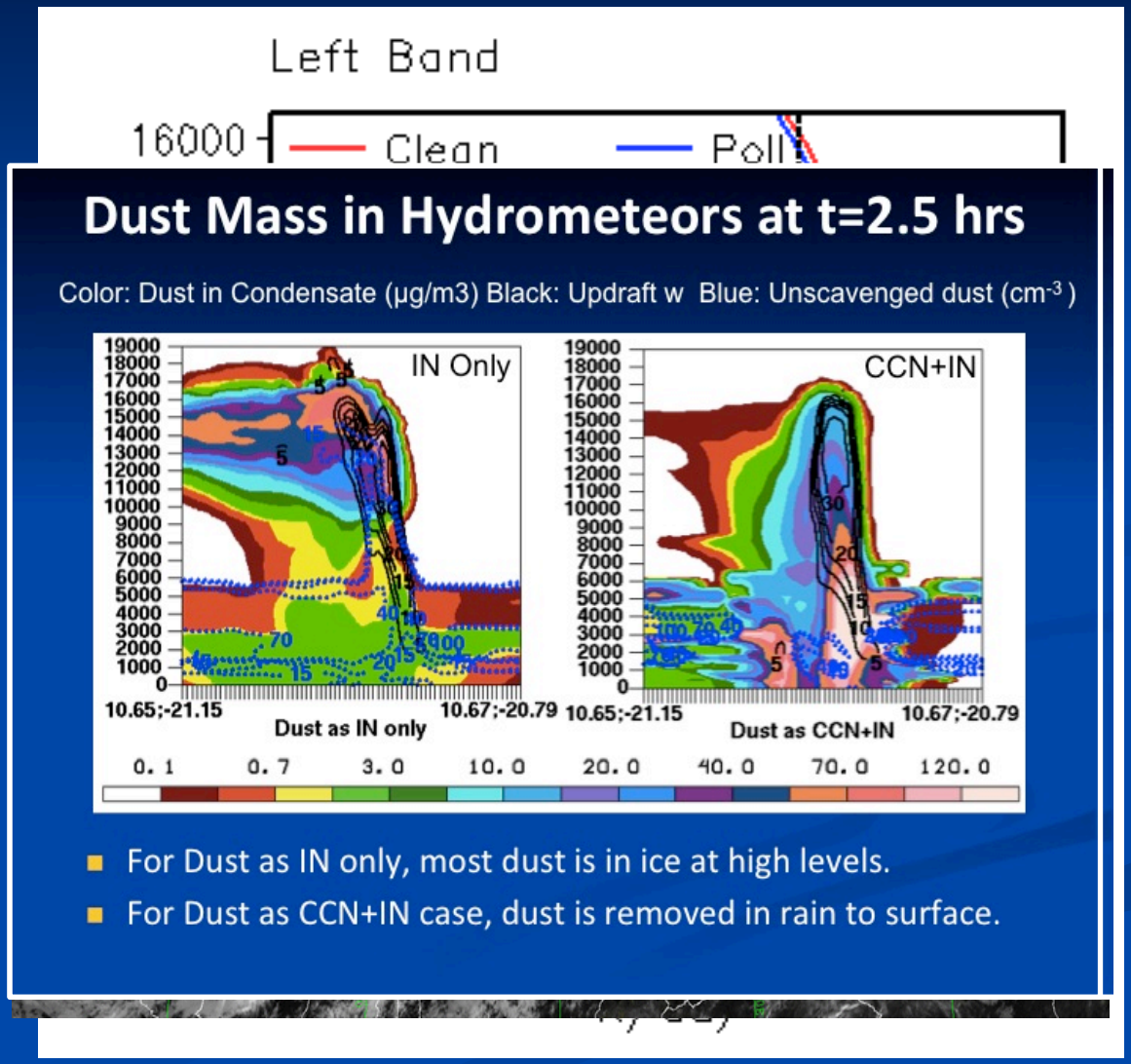
In search for observational evidence of convective invigoration …
Storer, van den Heever and L'Ecuyer (2013)



CLOUDSAT: Cloud top and rain top as a function of aerosol optical depth

Aerosol Indirect Effects on Deep Convection Current Considerations

- Greater anvil cloud radiative heating in more polluted conditions (van den Heever et al 2013)
- Cold pool responses and subsequent updraft forcing (van den Heever 2013)
- Dust ingestion, transport and redistribution (Seigel and van den Heever 2012)
- Role of dust as immersion freezing nuclei (Saleeby, Twohy, van den Heever, DeMott and Herbener, 2013)



DEBRA (V4.3) – Image from Steve Miller