

Aerosol-Cloud-Precipitation Interactions: Shallow Cumulus

Objectives

1. The transition from shallow to deep cumulus convection

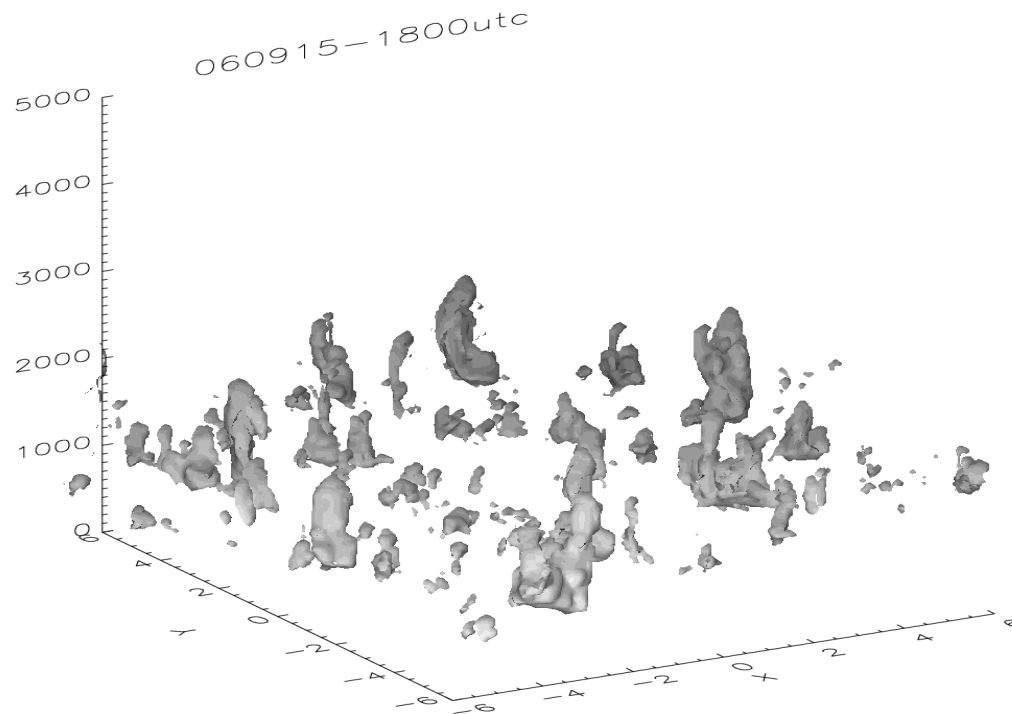
- Diurnal cycle of convection*
- Preconditioning for deep convection*
- Land-surface influences (including gradients)*

2. Aerosol effects on scattered cumulus clouds

- radiative forcing of cloud system*
- impact of absorbing aerosol (semi-direct effects)*
- Gradients in aerosol: mesoscale circulations?*
- Aerosol removal by rain*
- Aqueous production of aerosol (sulfate, organics)*

Objective 1: shallow \rightarrow deep convection

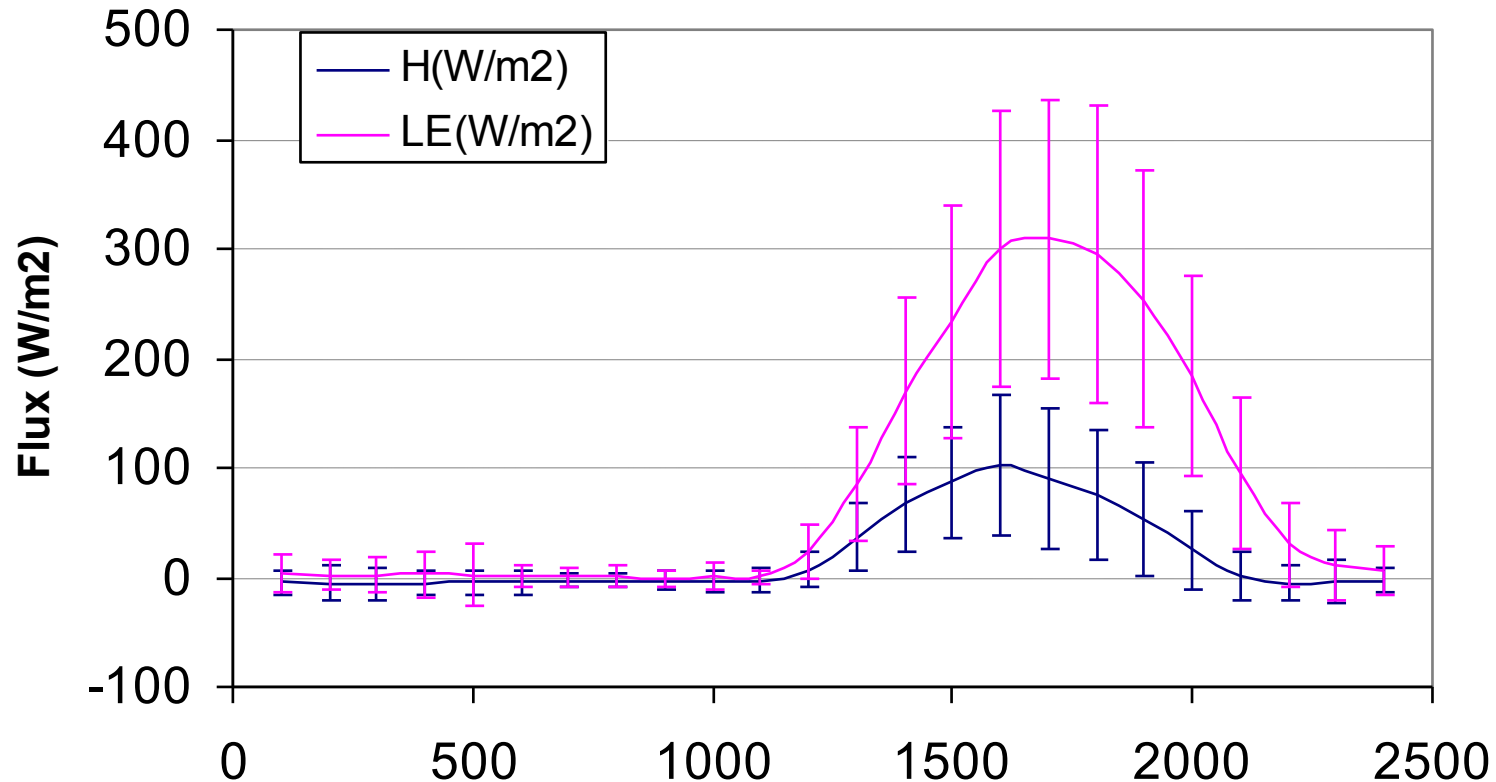
Focus on Cloud Field Statistics



Objective 1: shallow \rightarrow deep convection

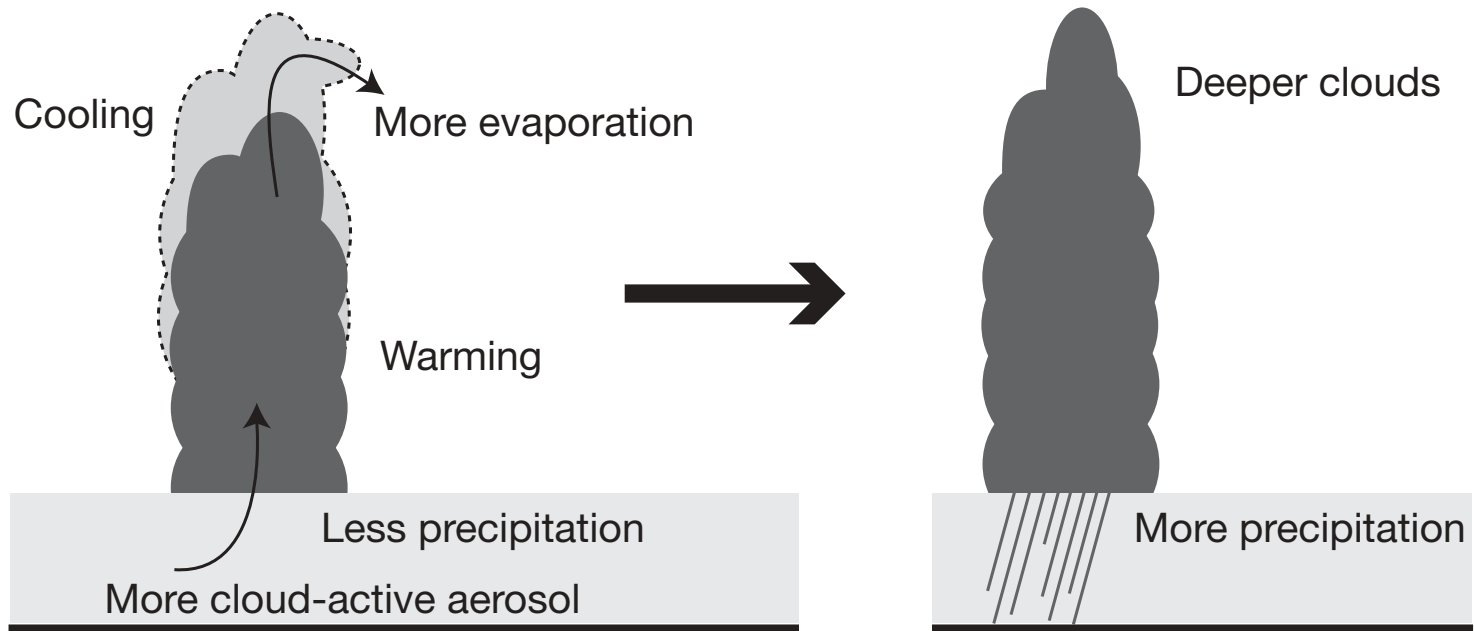
Diurnal cycle of convection

Average and STDev (Jan - Oct 2002)



Objective 1: shallow \rightarrow deep convection

Preconditioning for deep convection



Stevens and Feingold 2009

Objective 1: shallow \rightarrow deep convection

Forest



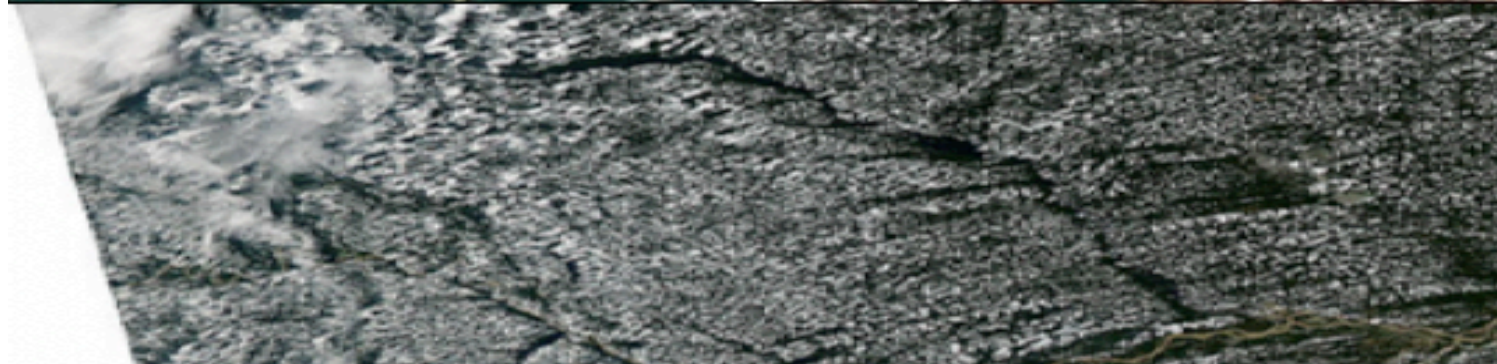
Pasture



Land-surface Influences



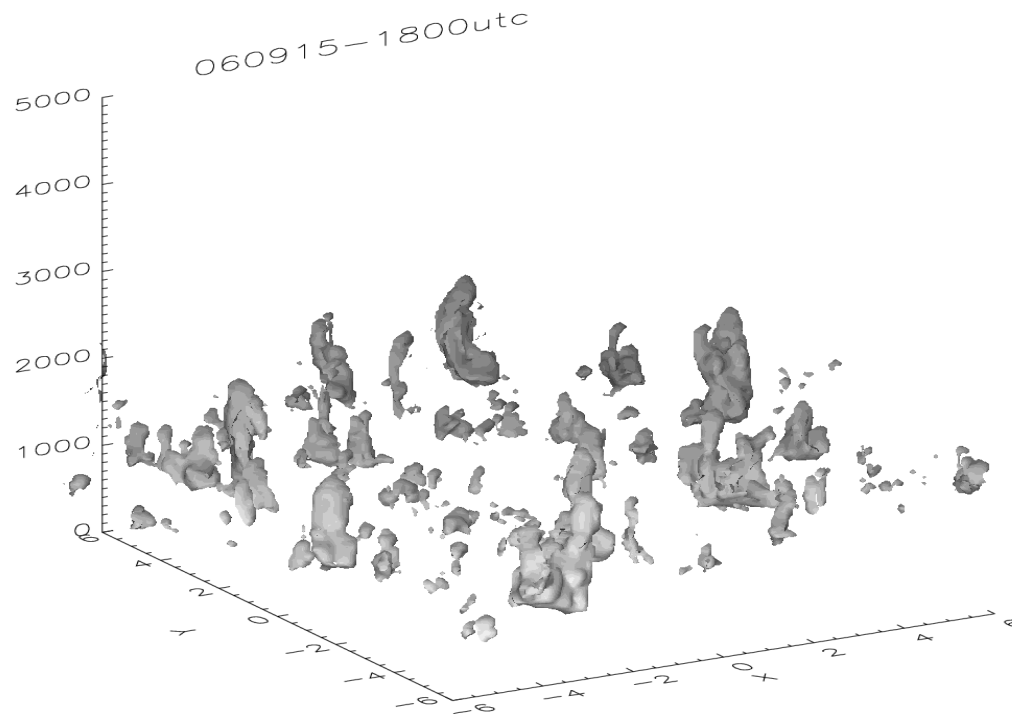
Fewer clouds over forest



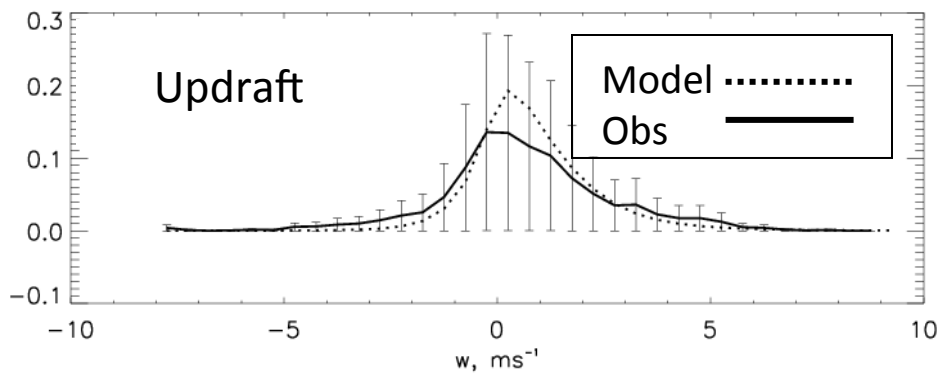
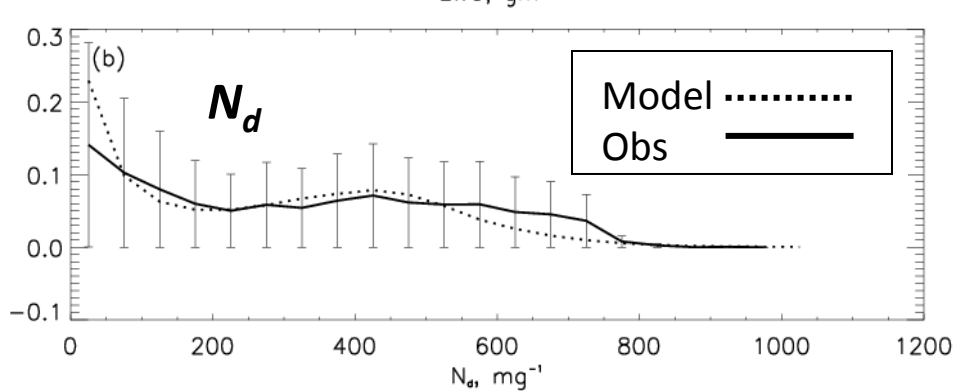
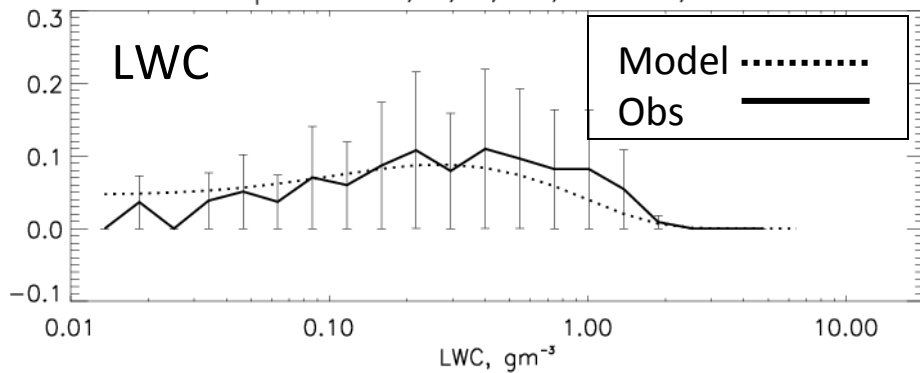
No clouds over rivers

Objective 2: aerosol-cloud interactions

Model-observation comparison of cloud field statistics

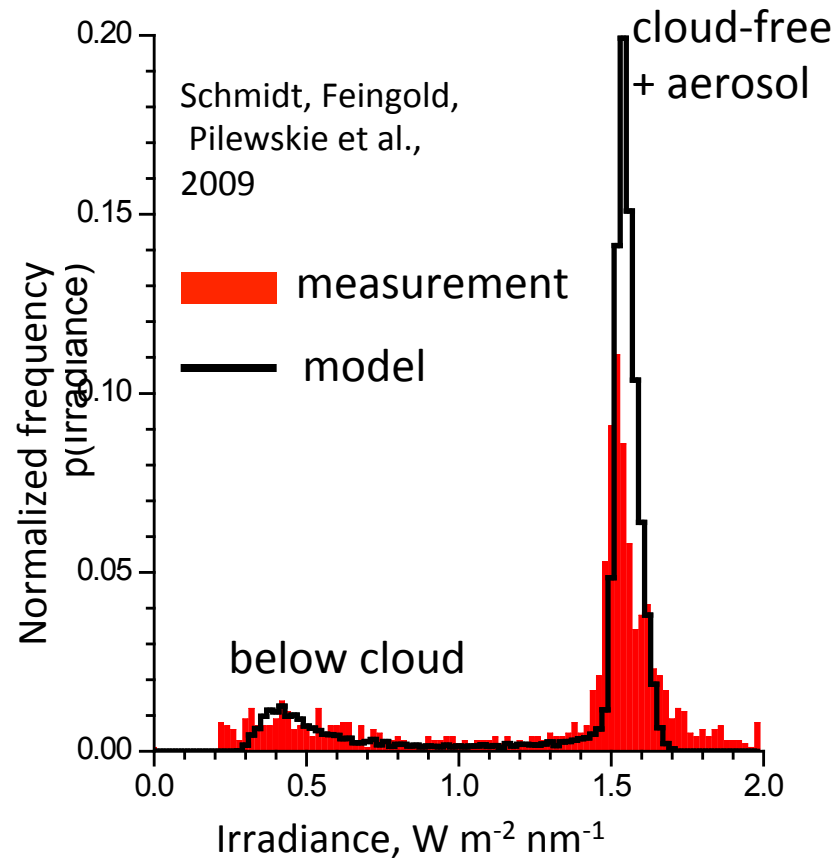


Statistical Comparisons

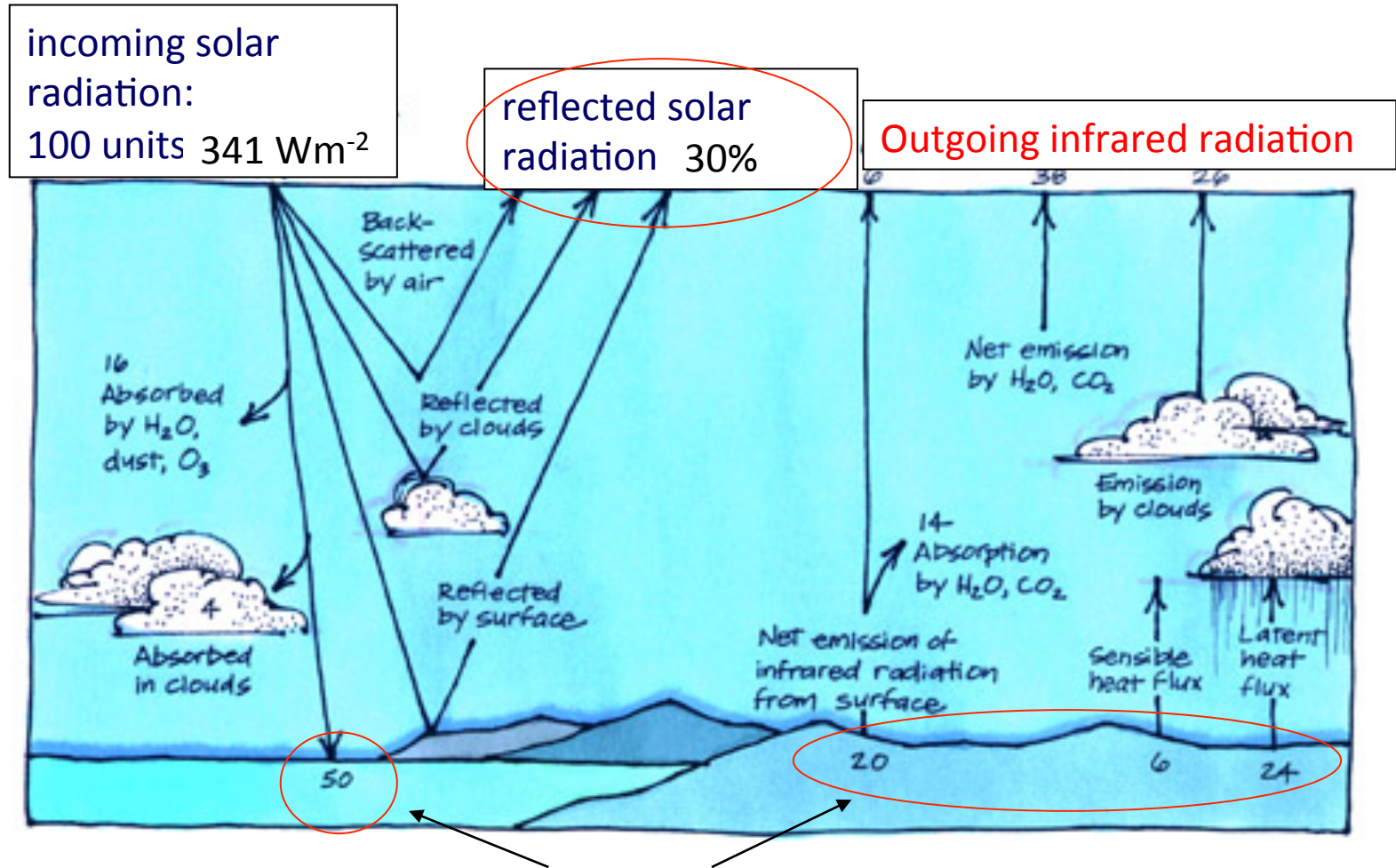


Comparison of 100s of clouds: Houston, TX

Comparison
between model and
in-situ measurements:
LWC, N_d , updraft;
Irradiance (aerosol + cloud)



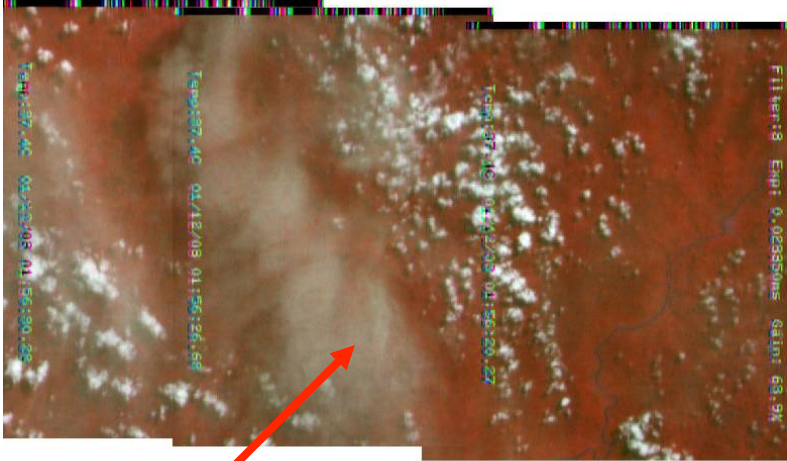
Objective 2: aerosol-cloud interactions (absorbing aerosol)



Incoming solar radiation is balanced by the net emission of IR + sensible heat flux + latent heat flux

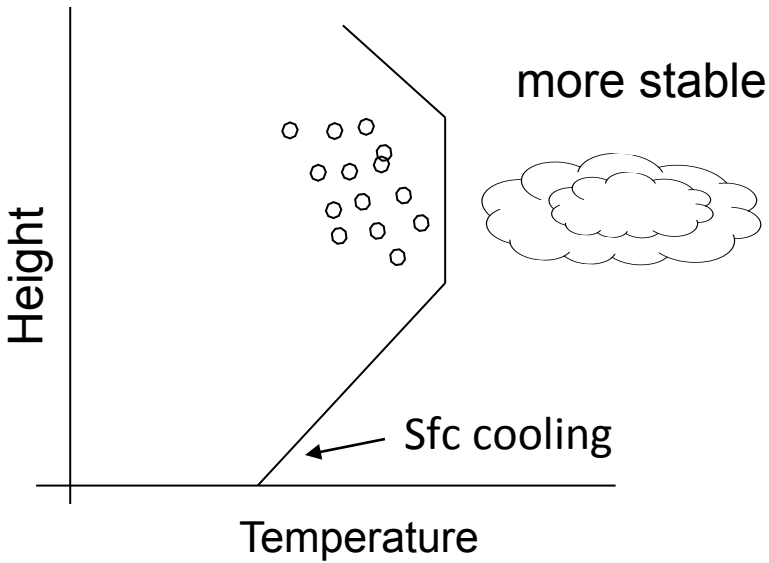
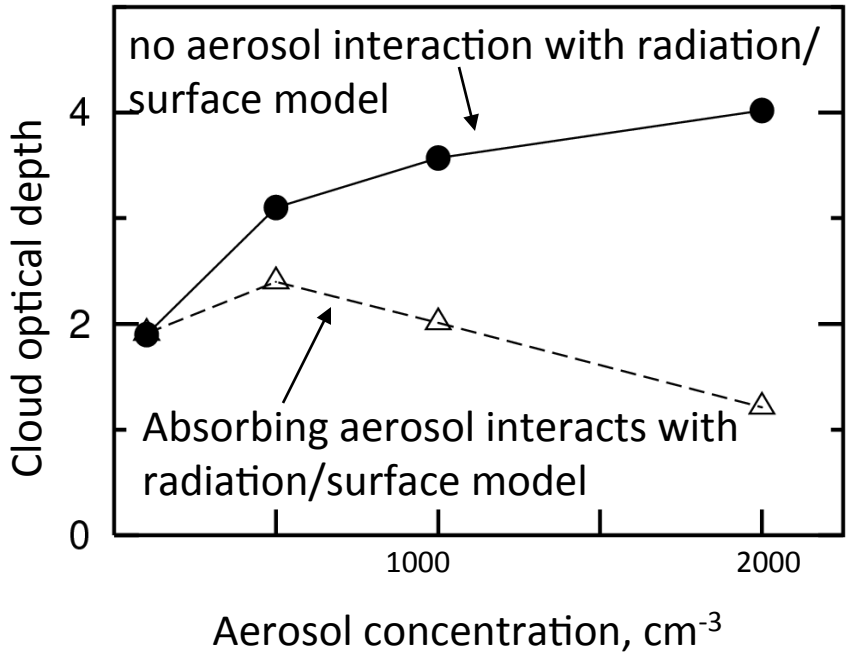
Absorbing Aerosol: Local Implications

Non-monotonic response of cloud optical depth to increase in smoke aerosol



Absorbing aerosol suppresses clouds

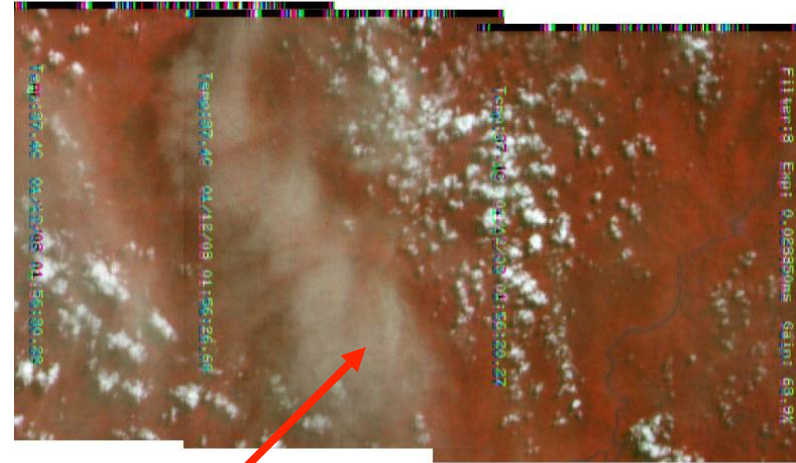
Columbia Shuttle



Modeling: Jiang and Feingold 2006

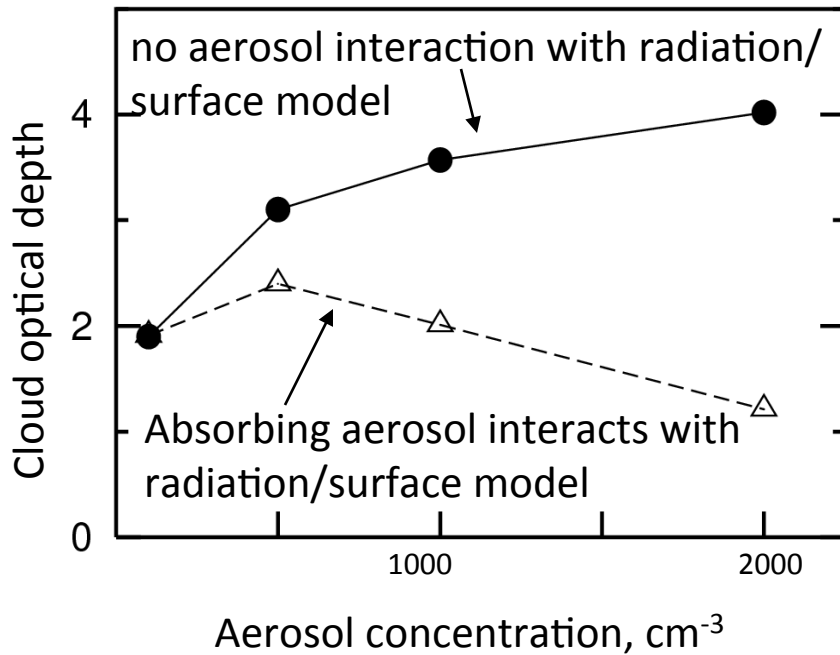
Absorbing Aerosol

Non-monotonic response of cloud optical depth to increase in smoke aerosol

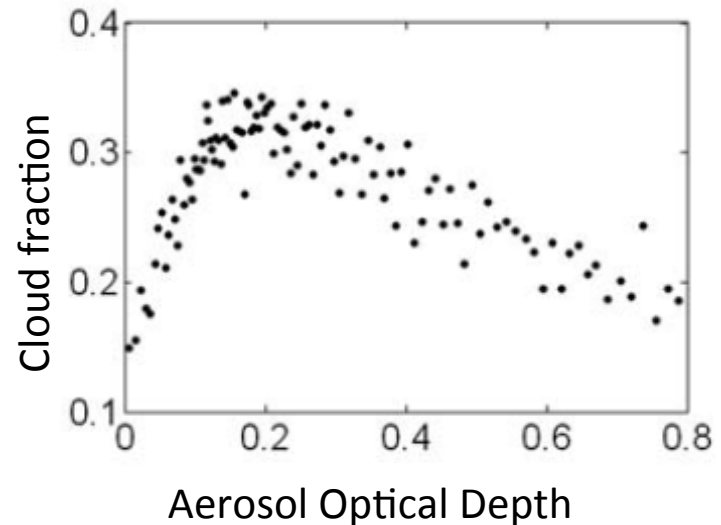


Absorbing aerosol suppresses clouds

Columbia Shuttle



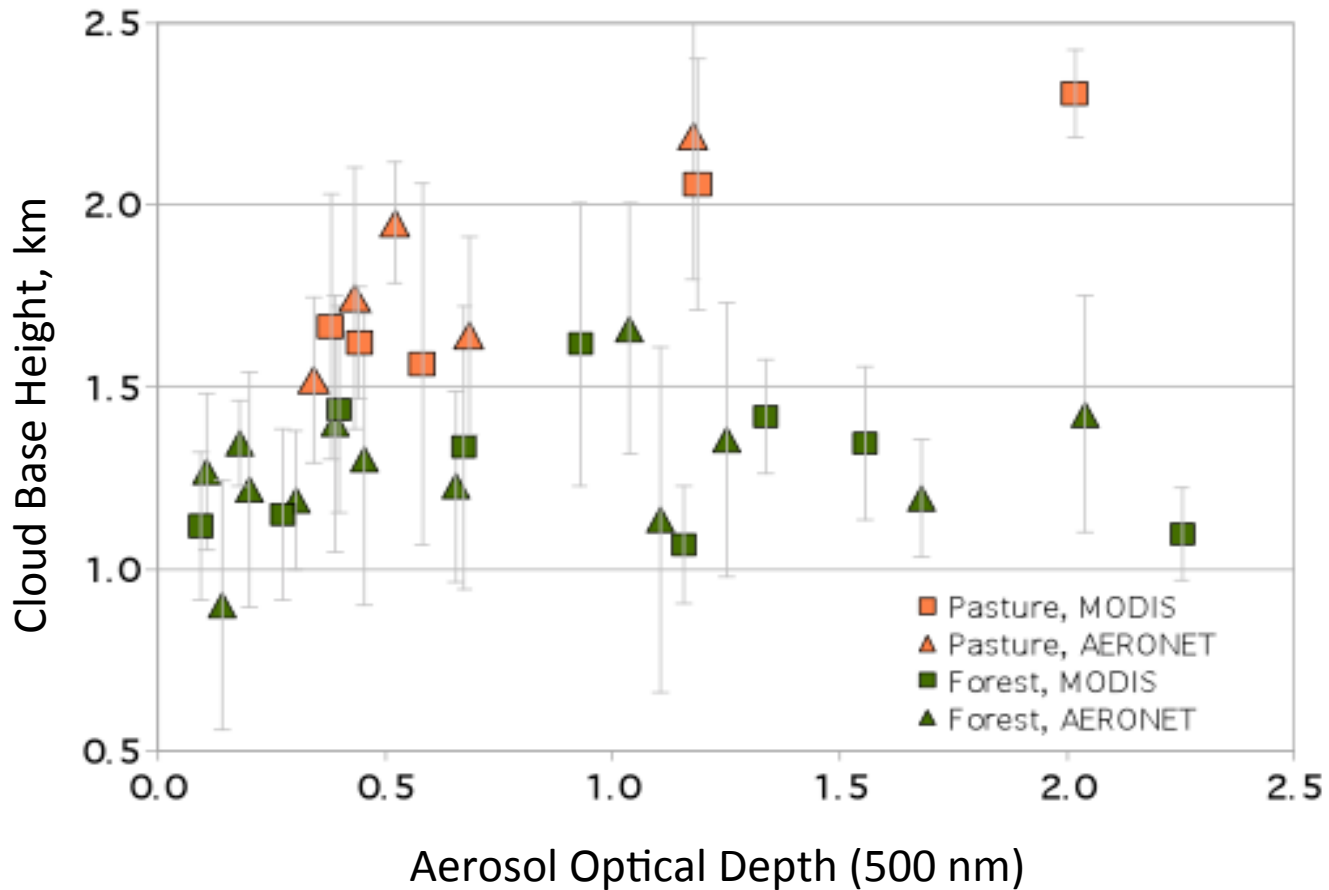
Modeling: Jiang and Feingold 2006



Observations: Koren et al. 2008 (Science)

Objective 2: aerosol-cloud interactions (focus on absorbing aerosol)

Aerosol Effects on Cloud Base Height: Influence of Land-surface



Deep convective clouds

- Aerosol-induced convective “invigoration”
 - Satellite studies see higher cloud tops in polluted conditions
 - Many models show it too; when, why?
 - But what about long timescales?
- Does the nature of precipitation change?
 - Spatial distribution, intensity
- What can we learn about wet scavenging?

Links to Other Programs

- Aerosol-Cloud-Precipitation-Climate (ACPC) group (IGAC-GEWEX-iLEAPS)
 - Amazon emerging as a focus area for large field campaign
 - SAMBBA (Fall 2012) BAE-146 airborne campaign