Aerosol effects on precipitation: A global model intercomparison under AEROCOM

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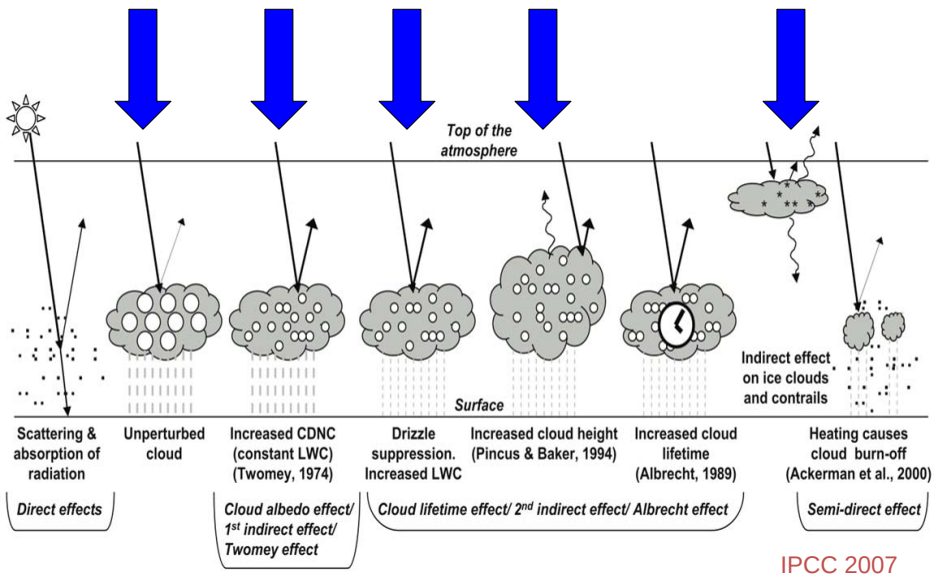
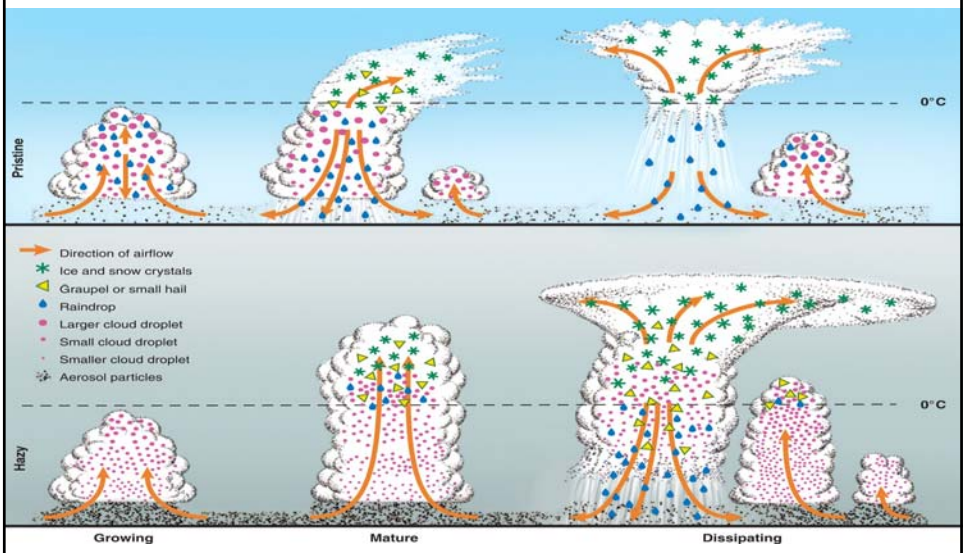
Pacific Northwest NATIONAL LABORATORY

Impacts of Aerosol on Cloud & Precipitation



IPCC 2007

AEROSOL INVIGORATION EFFECTS ON PRECIPITATION

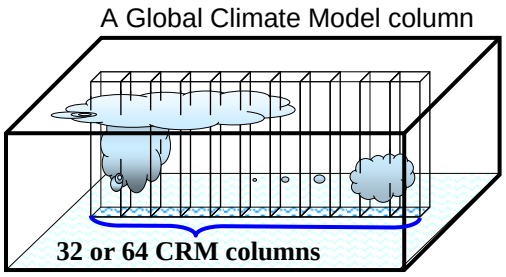


Rosenfeld et al., 2008

Aerosol-Cloud Interactions in NCAR CAM5

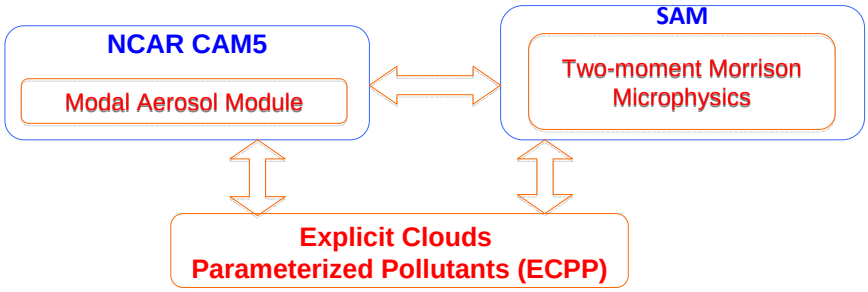
- 2-moment Modal Aerosol Module (*Liu et al. 2010*)
  - Prognostic *mass* and *number* concentration of 7 and 3 aerosol modes (log-normal function size distributions)
  - Internal mixing of aerosol components within mode and external mixing between modes
- 2-moment stratiform microphysics (*Morrison & Gettelman 2008; Gettelman et al. 2010)*
  - Prognostic '*cloud mass*' and '*cloud droplet number*' (Γ-function size distributions)
  - Diagnostic 'precipitation mass' and 'precipitation droplet number'
- Cloud liquid droplet activation (*Abdul-Razzak & Ghan 2002*)
- Cloud ice crystal nucleation (*Liu et al. 2007*)
  - Homogeneous freezing on Sulfate
  - Heterogeneous nucleation on Dust
- Aerosol effects on convective clouds through microphysics not included

Multiscale Modeling Framework Approach (MMF) (Superparameterization)



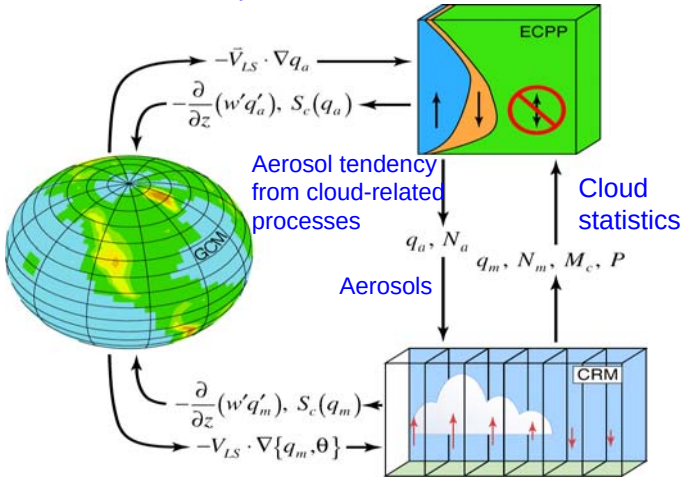
Grabowski, 2001; Khairoutdinov and Randall, 2001.

The MMF approach permits explicit simulations of deep convective clouds.



Explicit clouds Parameterized Pollutants (ECPP) Approach (Gustafson et al., 2008)

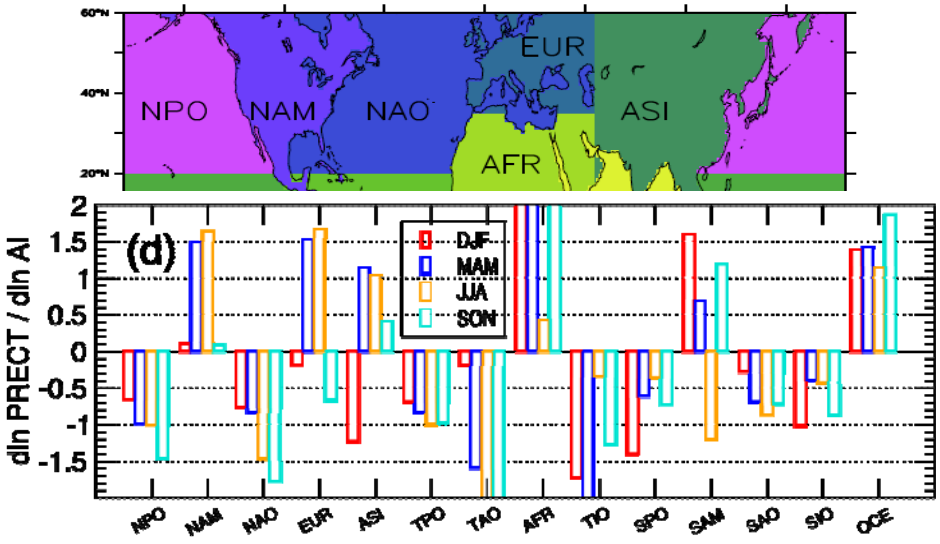
Use cloud statistics to drive a physically-based treatment of aerosol and trace gas processing by clouds, which replaces conventional treatment of these processes in CAM5.



See Ghan et al. poster

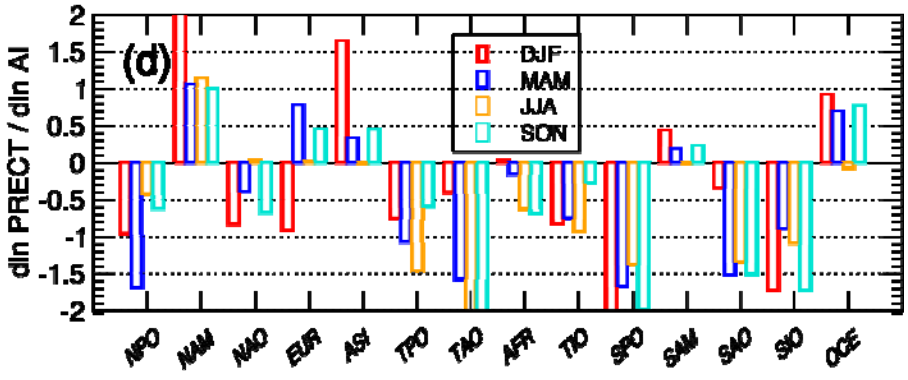
PRECIPITATION SUSCEPTIBILITY FROM THE CAM5 MODEL

d(lnPRECT)/d(lnAI)



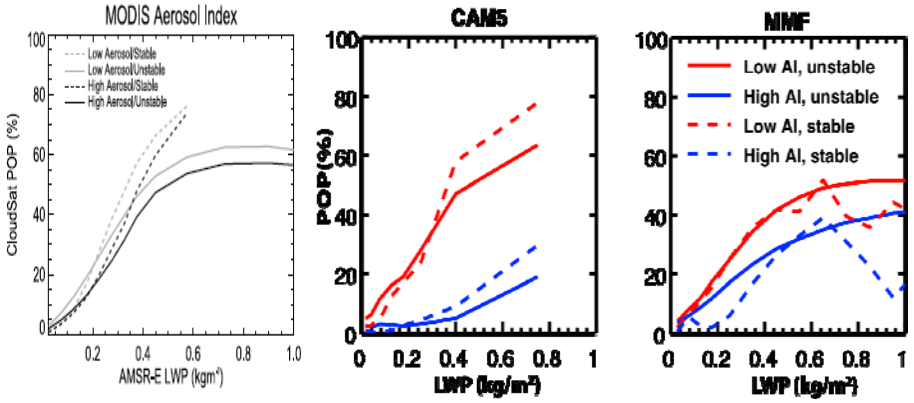
3 year daily data at satellite overpass

d lnPRECT /d lnAI: MMF



3 year daily data at satellite overpass

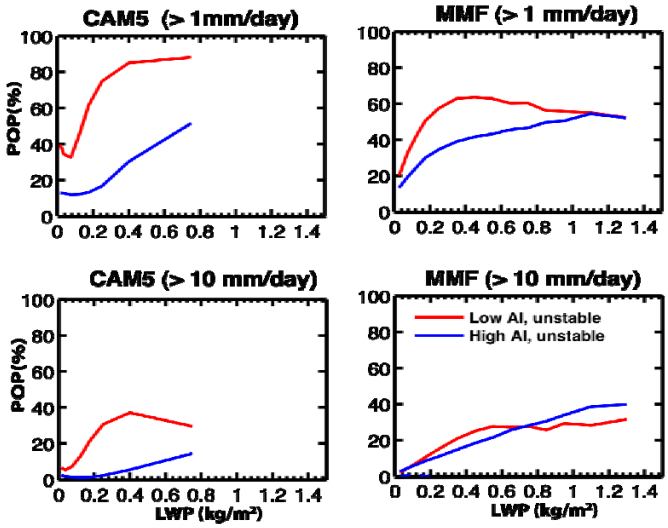
Probability of Precipitation (POP) (cloud top warmer than 273 K)



L' Ecuyer et al., 2009

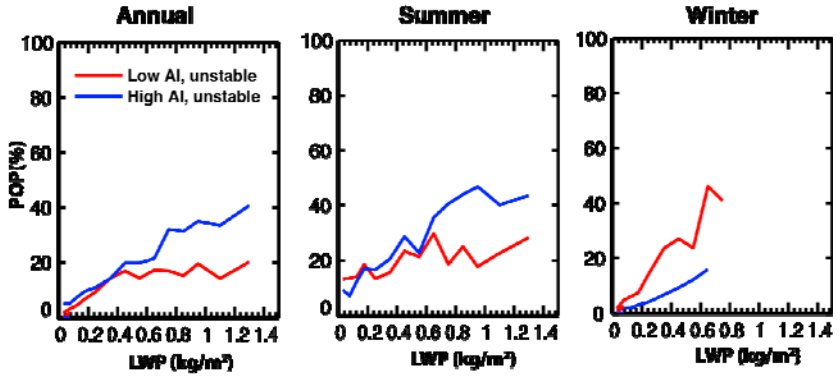
Global, 3 year daily data

Probability of precipitation (cloud top colder than 263 K)



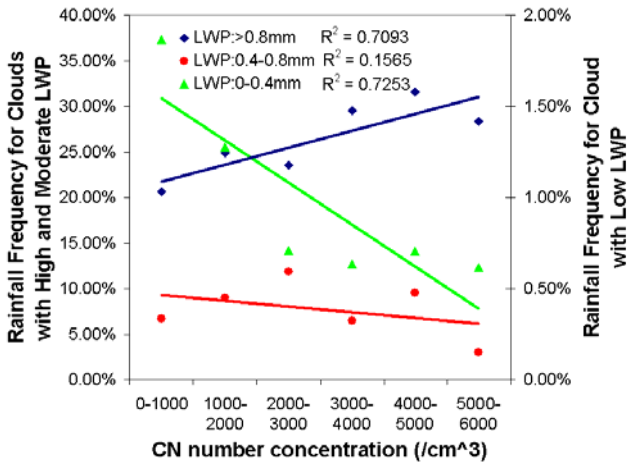
Global, 3 year daily data

Probability of precipitation in North America (MMF) (cloud top colder than 263 K, rain rate >10 mm/day)



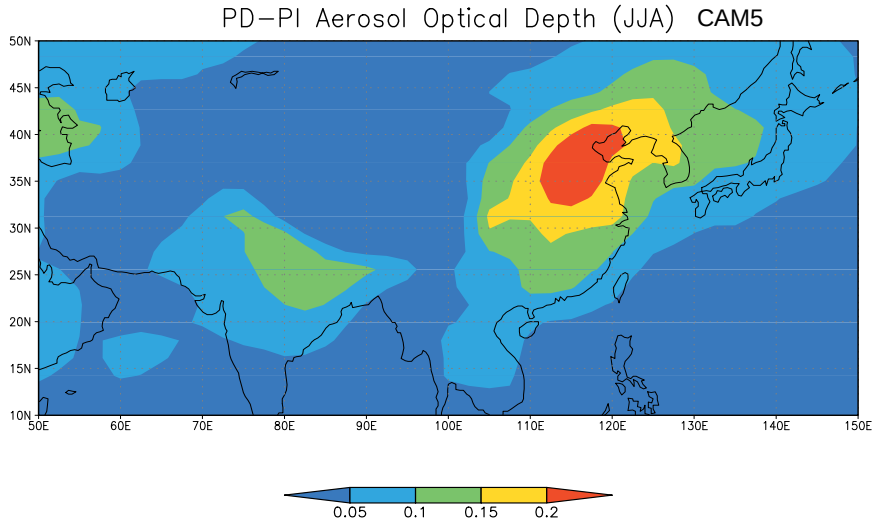
Probability of precipitation at ARM SGP site

10 years



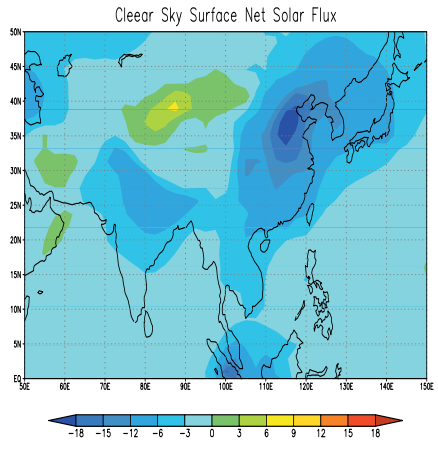
1. **For low LWP, rainfall occurrence is suppressed by aerosols (30-50%)**
2. **For large LWP, rainfall frequency is increased by aerosols (50%)**
3. **For moderate LWP, aerosols have little impact**

Regional impacts of aerosol on precipitation: East Asia

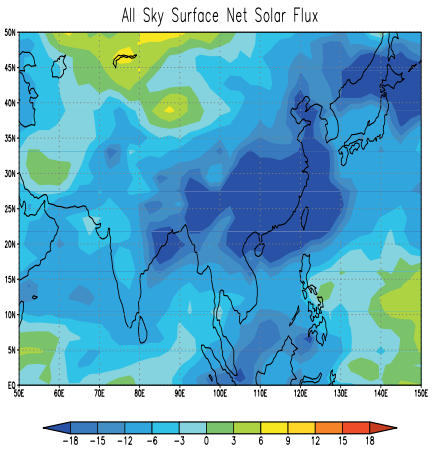


PD-PI: Surface solar flux

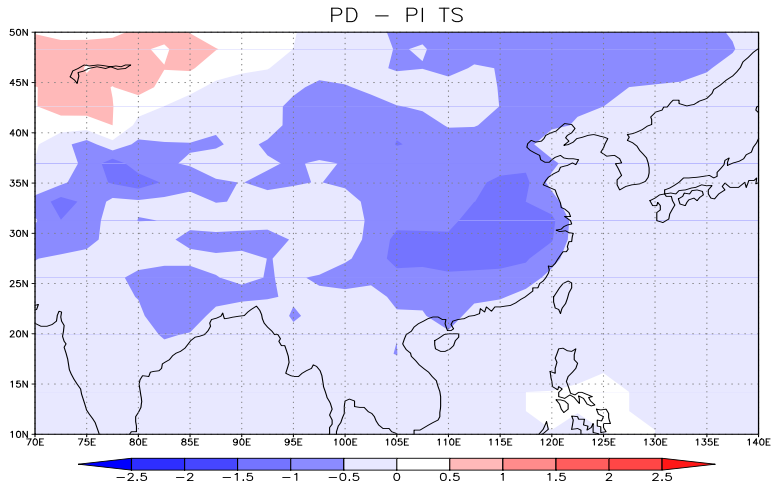
Clear-Sky



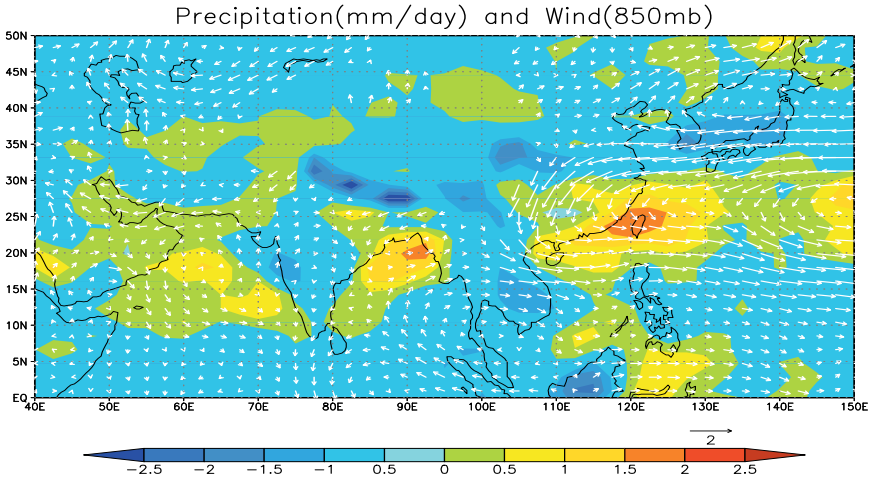
All-Sky



PD-PI: Surface temperature



PD-PI: Wind and precipitation



Intercomparison of Aerosol Effects on Precipitation under AEROCOM

- Invite GCMs with aerosol-cloud-precipitation interactions to participate; also satellite and in situ data analysis
- Submit GCM simulations: monthly & daily data at satellite overpass
  - PD & PI, PD with prescribed aerosol
- Analysis of
  - POP vs LWP; d lnR/d lnAI vs LWP
  - Segregated into regions and seasons
- Regional precipitation pattern change