Investigation of the Aerosol Indirect Effect Using Ground-Based Remote Sensors

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Previous Work

- Feingold et al. 2003, Feingold et al. 2006
- Detection of first indirect effect
    - sub-cloud aerosol extinction (lidar)
    - LWP (MWR)
    - cloud properties (radar)

New Science Questions

- sensitivity of effective radius to sub-cloud aerosol
- how does this sensitivity respond to :
    - cloud type/cloud bulk properties
    - boundary layer properties
    - aerosol size distribution
    - aerosol composition/properties
- what aerosol observations are good CCN proxies

Approach

Multivariate statistical analysis

Various sites:

- **SGP**
- **Pt. Reyes**
- **NSA**

Data Sorting

- **updrafts**
- **wind direction**
- **aerosol types**

Effective Radius Retrievals

- MFRSR (Min and Harrison 1996)
  - r_e=1.5 LWP/τ

- Radar reflectivity (Frisch et al. 2002)
  - column
  - f(z)

- Adiabatic (Brenguier et al. 2000)
- Sub-adiabatic
  - N_d derived from LWP and r_e
  - Cloud base T and P

- Radiometry
  - column
  - f(z)

Observations

Cloud observations:

Effective radius

- **MFRSR**
- **radar reflectivity**
- **adiabatic/sub-adiabatic**
- **radiometry/RT model retrievals**

- **Optical depth**

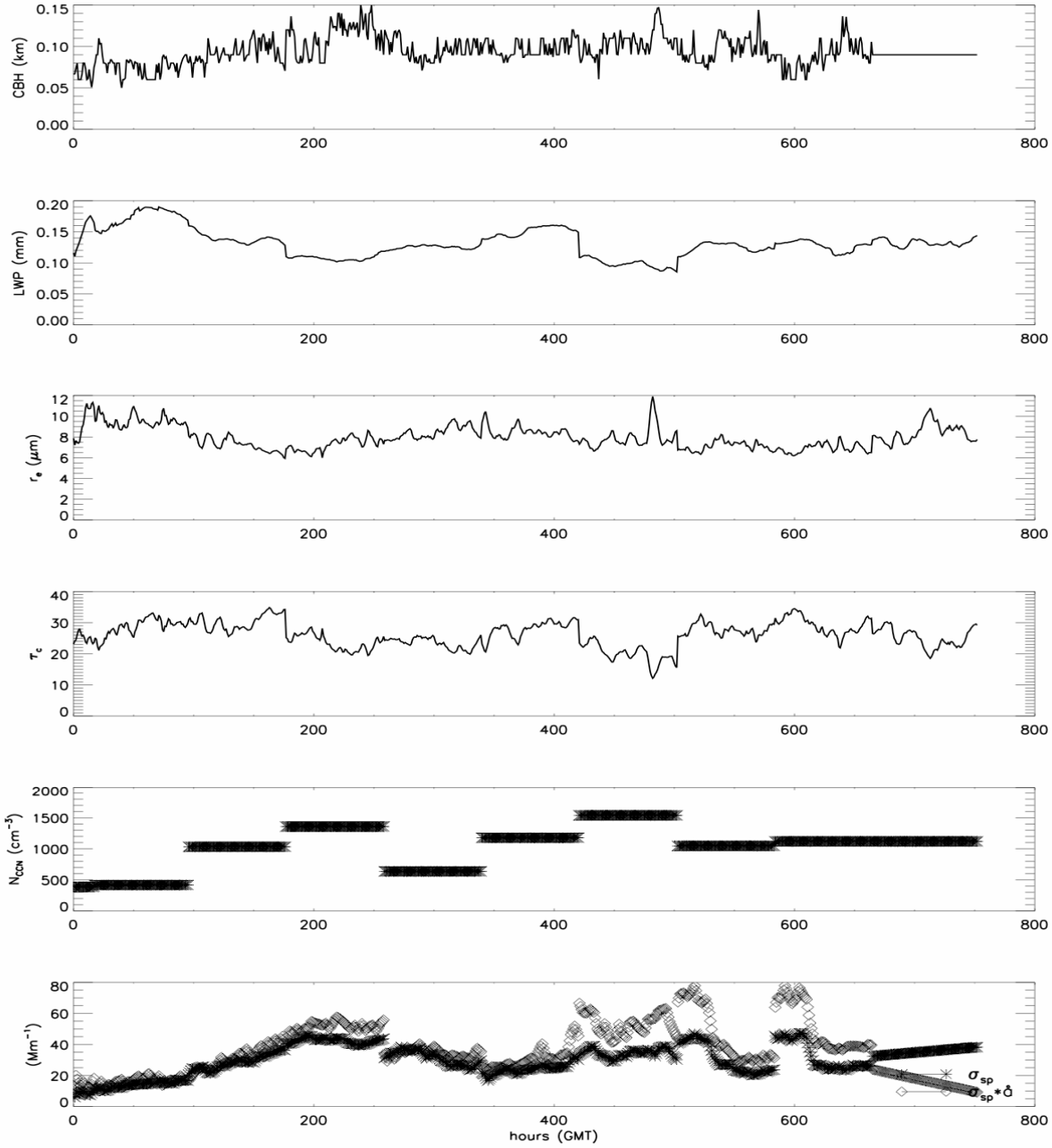
Aerosol observation:

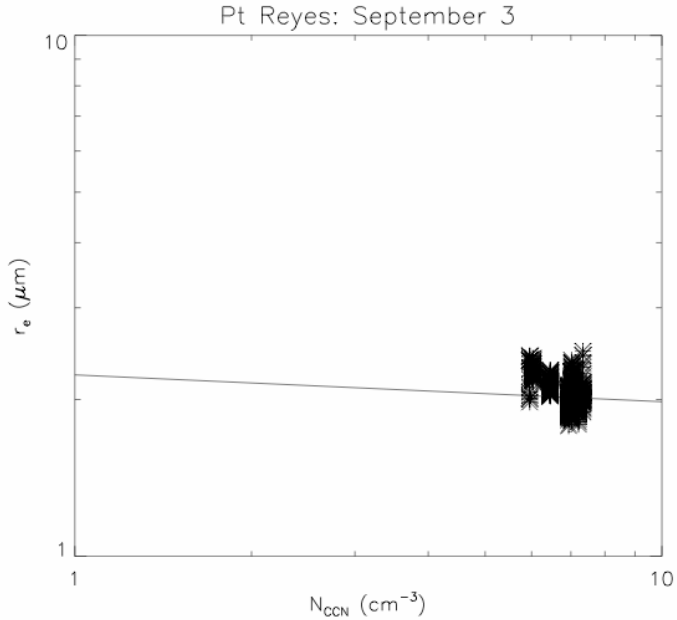
- **CCN**
- **σ_{sp}**
- **åi**
- **α (lidar)**

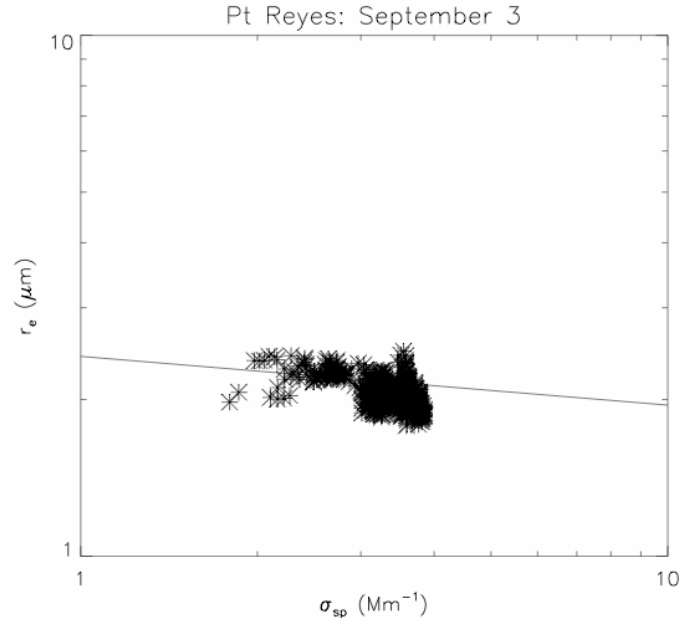
What are the most robust indicators of the aerosol indirect effect?

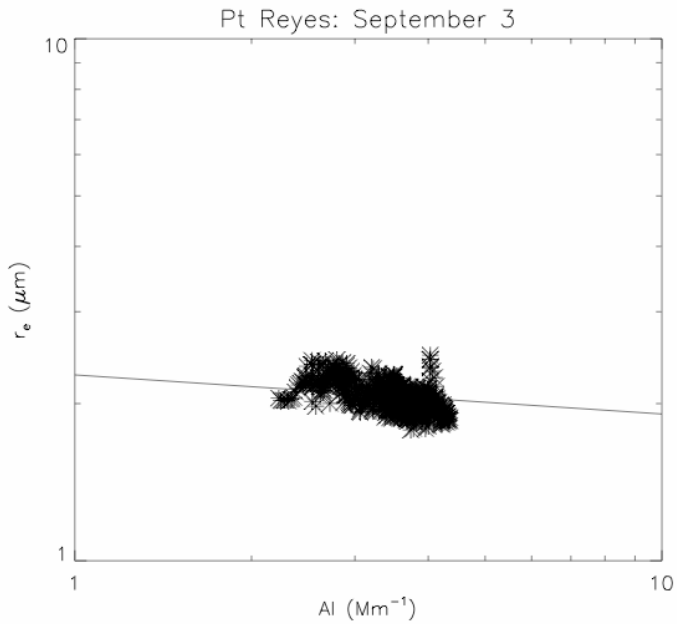
Data Time Series

- cloud base height (km)
- LWP (mm)
- effective radius (μm)
- optical depth
- CCN (cm^{-3})
- σ_{sp} (550 nm)
- åi (450/700 nm)





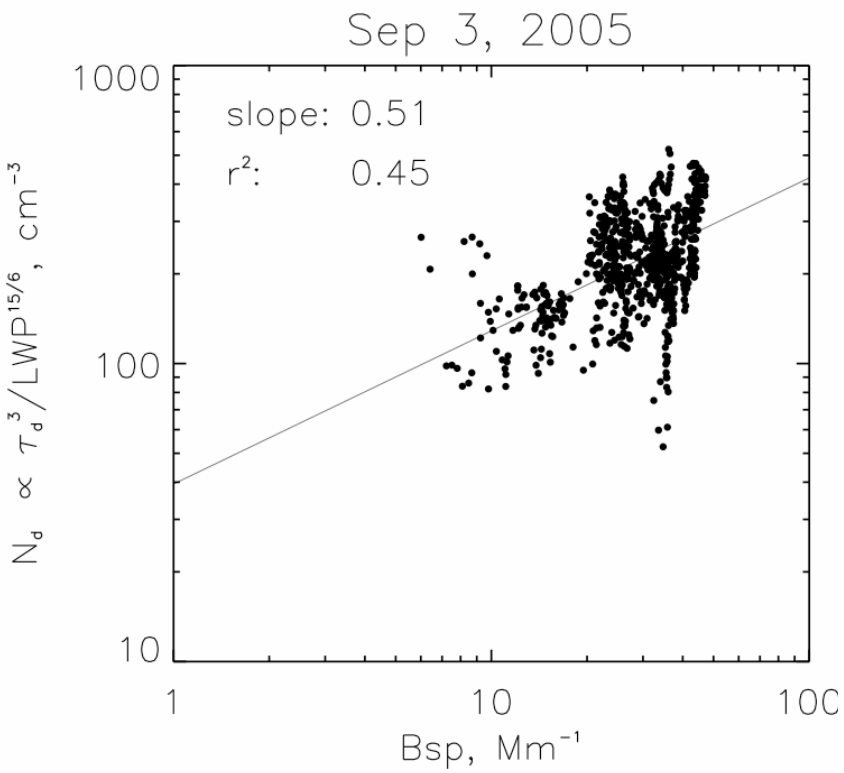


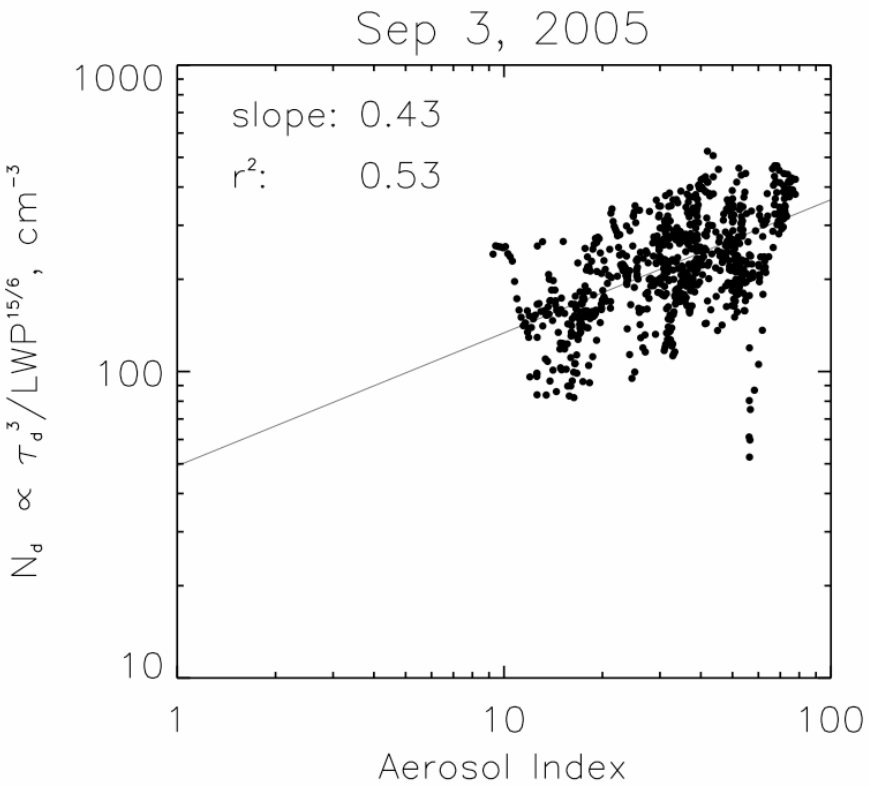


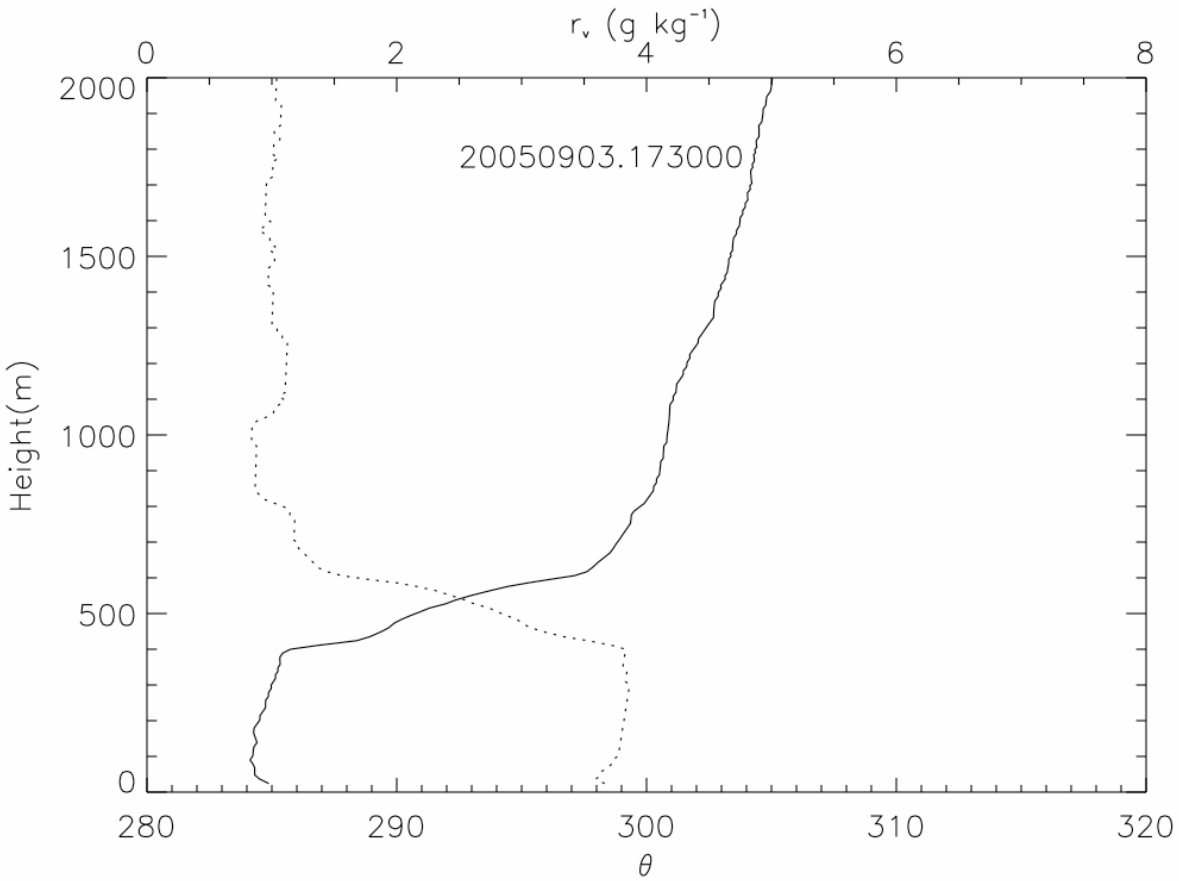
- **Regressions**
- **Multiple regressions/ Canonical correlations**
- **Correlation matrices**

Adiabatic retrievals

(Cloud base T and P fixed)





Data Sorting

- **Soundings for vertical mixing**
- **Wind direction**
- **Updraft velocities**
- **Aerosol composition**