

**Relationship Between
Cumulus Cloud Fraction
and Aerosol Optical Depth:
a Five-Year Climatology at
the ARM SGP Site**

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Outline

- Motivation & Objectives
- Approach
- Case Study & Climatology
- Conclusion
- Future Activities

Motivation: Satellite Observations

- Systematic **strong relationship** between **convective clouds** and **pollution**
- **Small** and **large** clouds may have **different** responses to increasing aerosol

Objectives

- Can we observe **strong** relationship between cumulus **CF** and **AOD** from **surface** observations?
- Does this relationship depend on horizontal **cloud size**?

CF – cloud fraction

AOD – aerosol optical depth

Approach

Long-term SGP data

Summers: 2000-2004

Aerosol: **AOS, MFRSR**

Clouds: **ARSCL**

Meteorology: **SMOS**

TSI (Visual inspection)



Case Study: Criteria

- **Similar Meteorology** (RH, wind, ...)
- **Similar Vertical Structure** of aerosol
- **Different AOD**

Case Study: 5 and 8 July, 2002

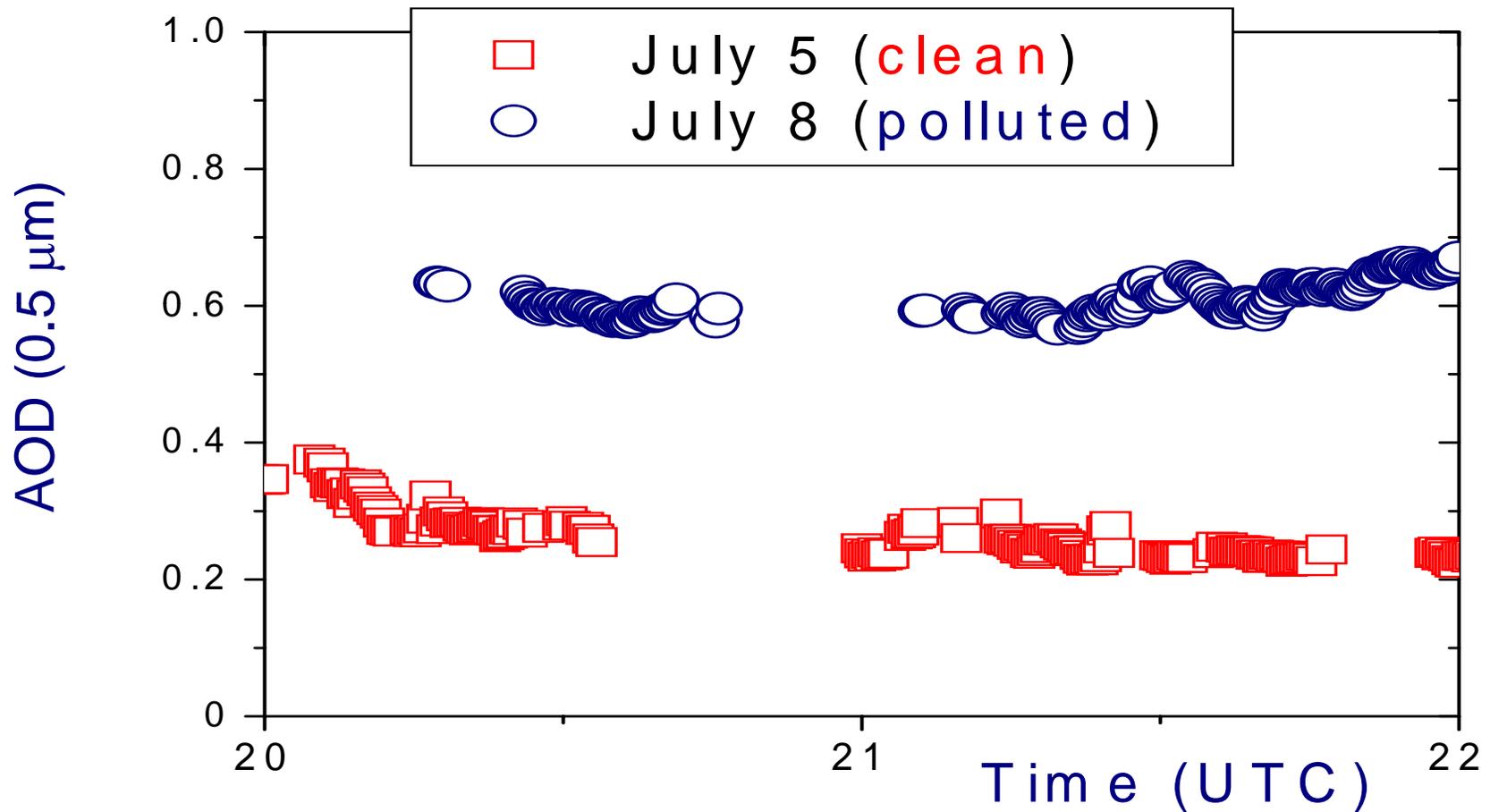


July 5 (clean)



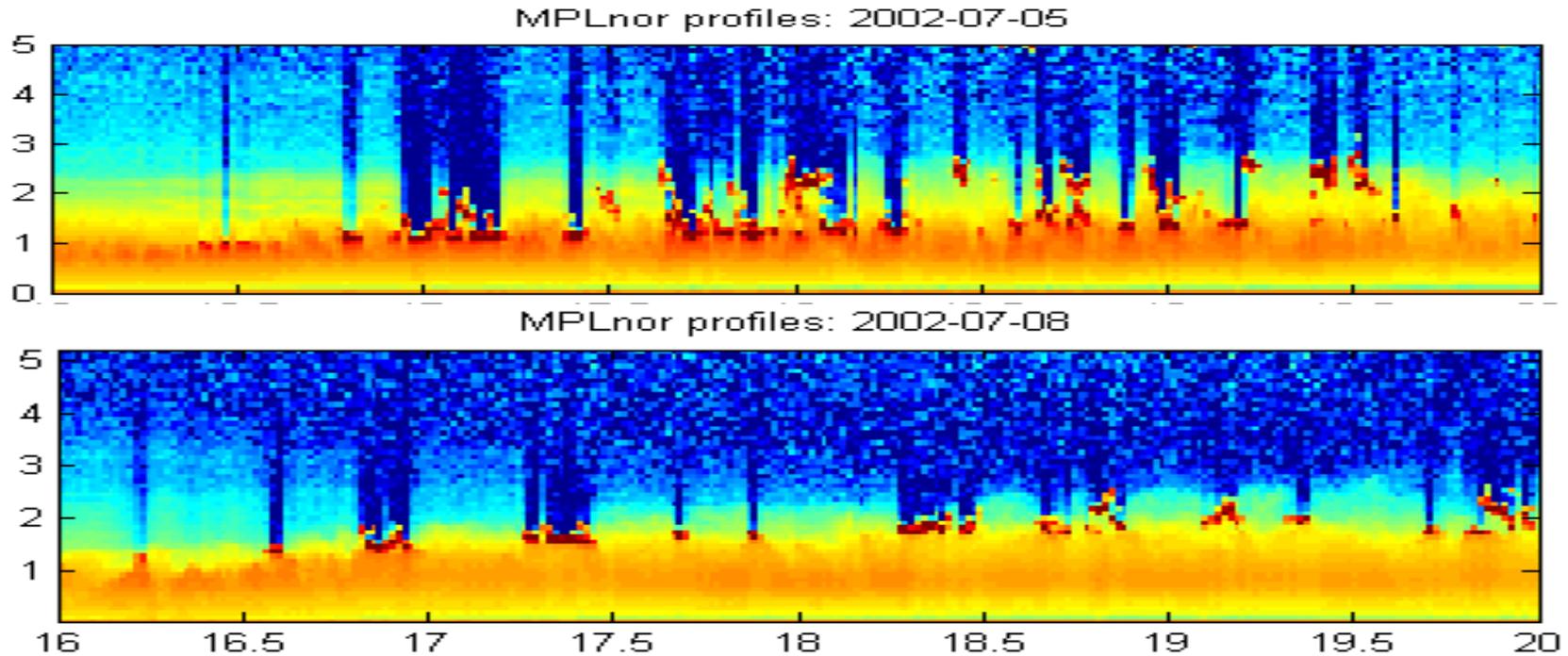
July 8 (polluted)

Case Study: AOD



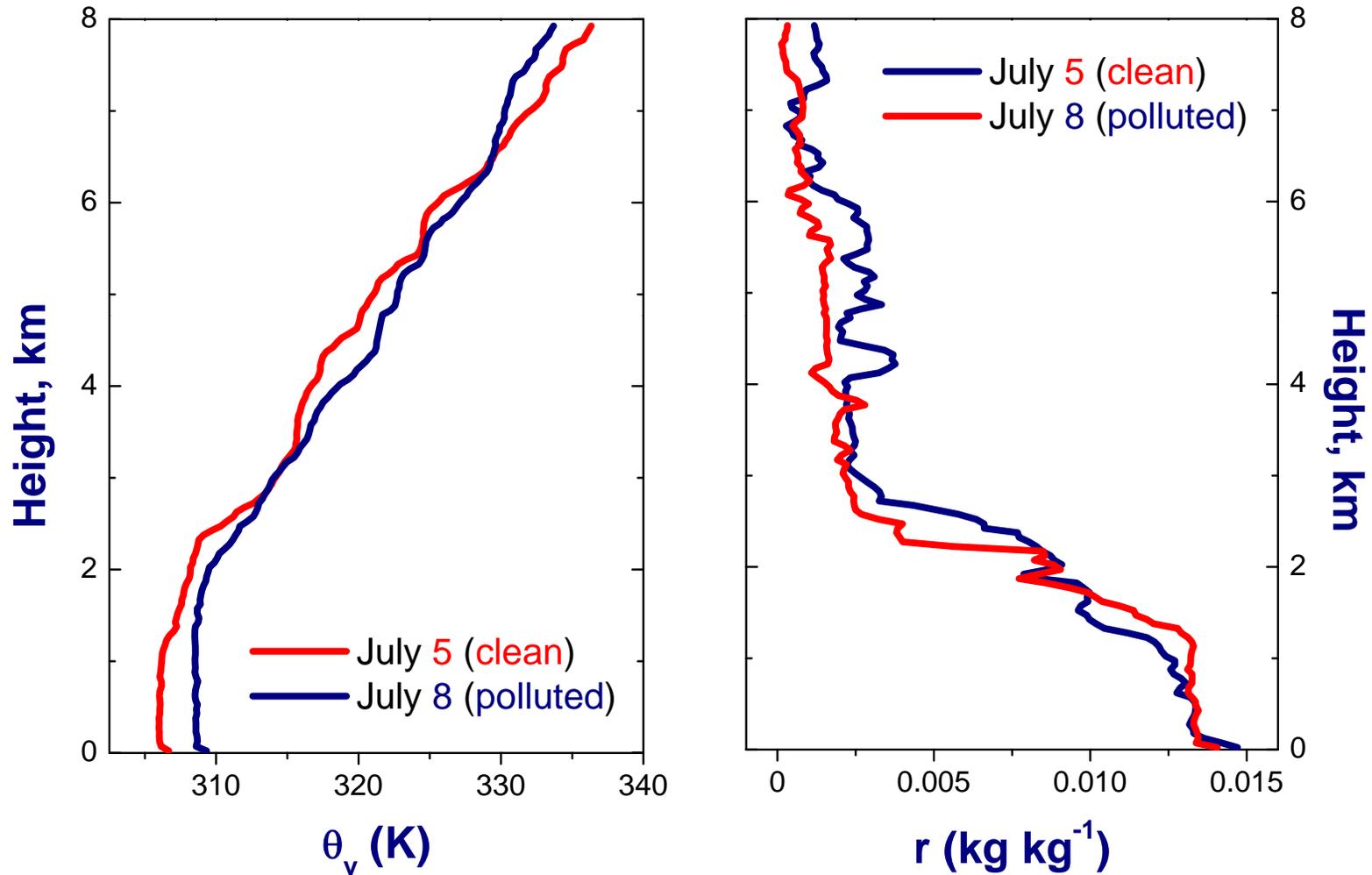
- AOD (polluted) is twice as large as AOD (clean)

Case Study: MPL profiles



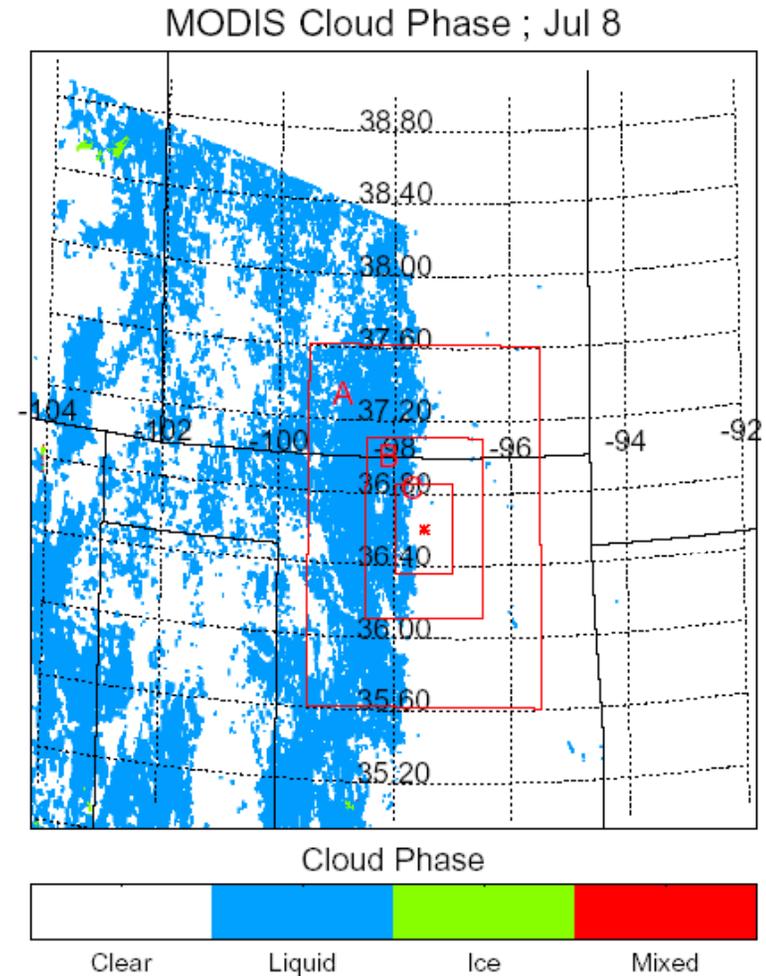
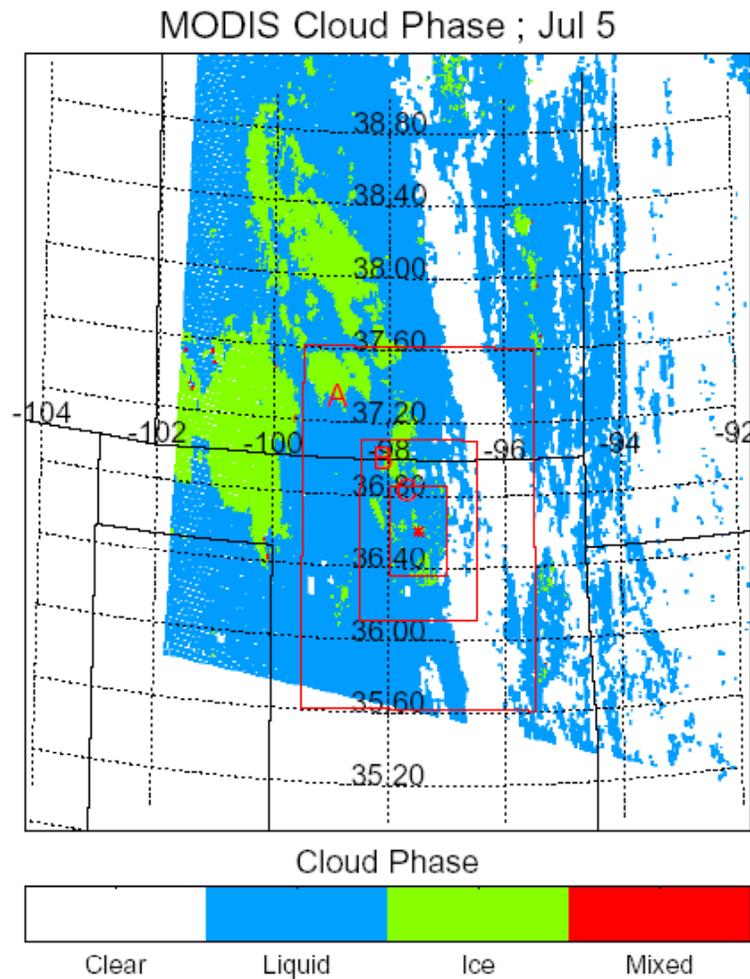
- Cloud base heights are similar (~1.5 km)
- Elevated aerosol layers are not observed

Case Study: Thermodynamics



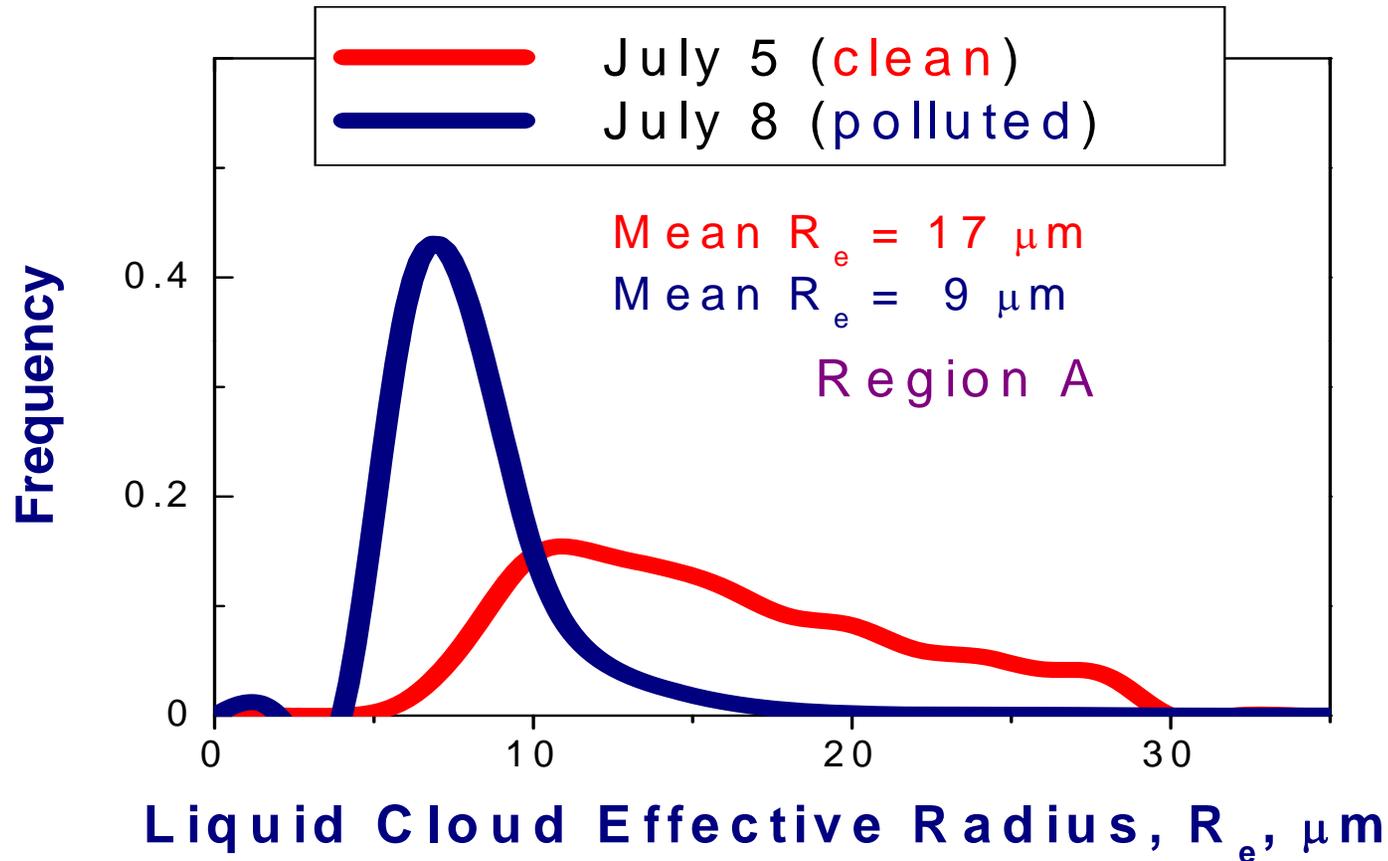
- Thermodynamical profiles are similar

Case Study: Cloud Phase



- Liquid clouds + cirrus contamination (~10%)

Case Study: MODIS data



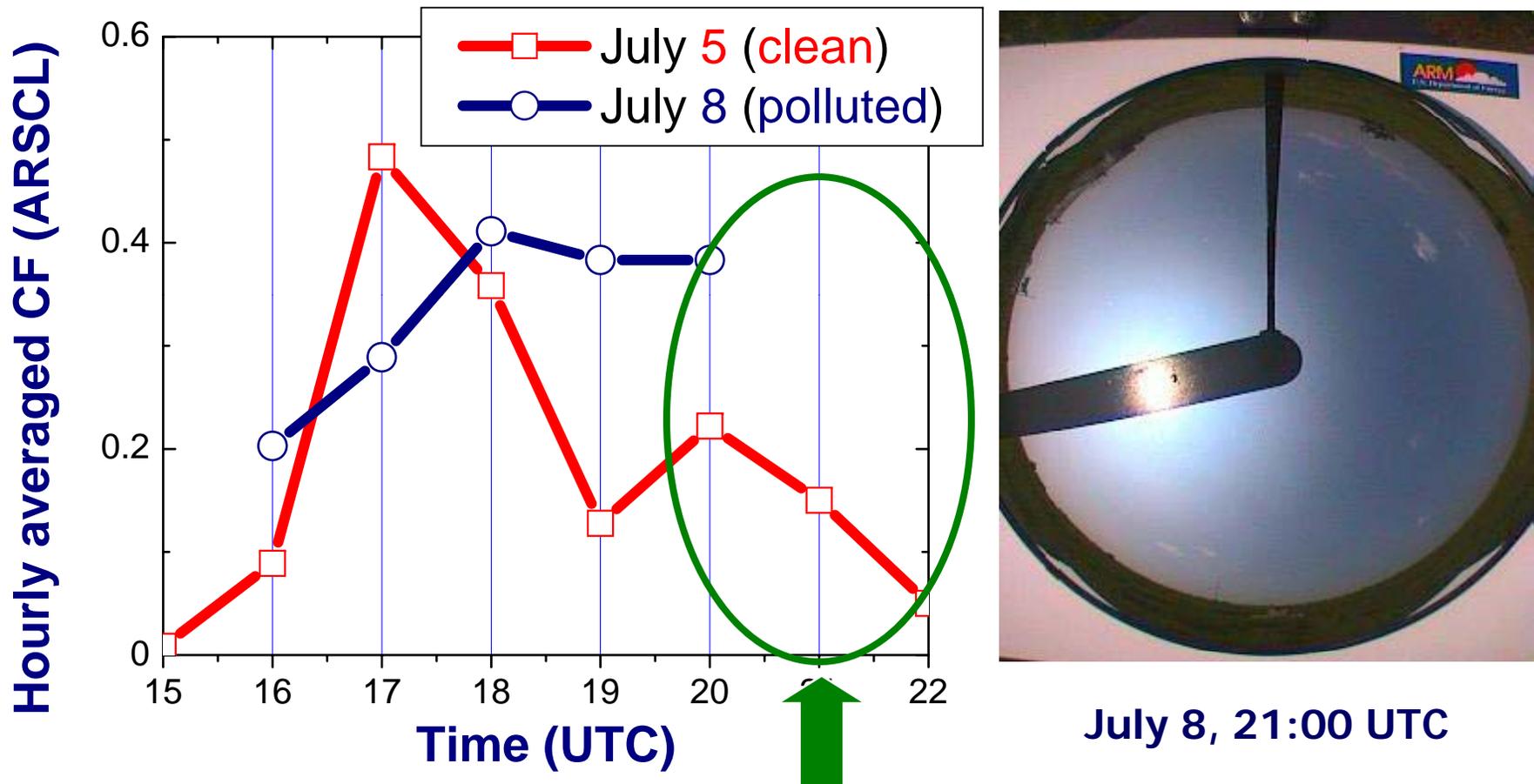
- Polluted clouds have smaller droplets

Model: Microphysical-dynamical feedback*

- **Polluted** clouds have **smaller droplets** and **faster evaporation rate**
- **Drop-size-dependent evaporation rates** may be responsible for changes of **cloud size** and **cloud fraction**

* Xu and Feingold, 2006: LES simulations of trade wind cumuli: Investigation of AIE, JAS, 2006

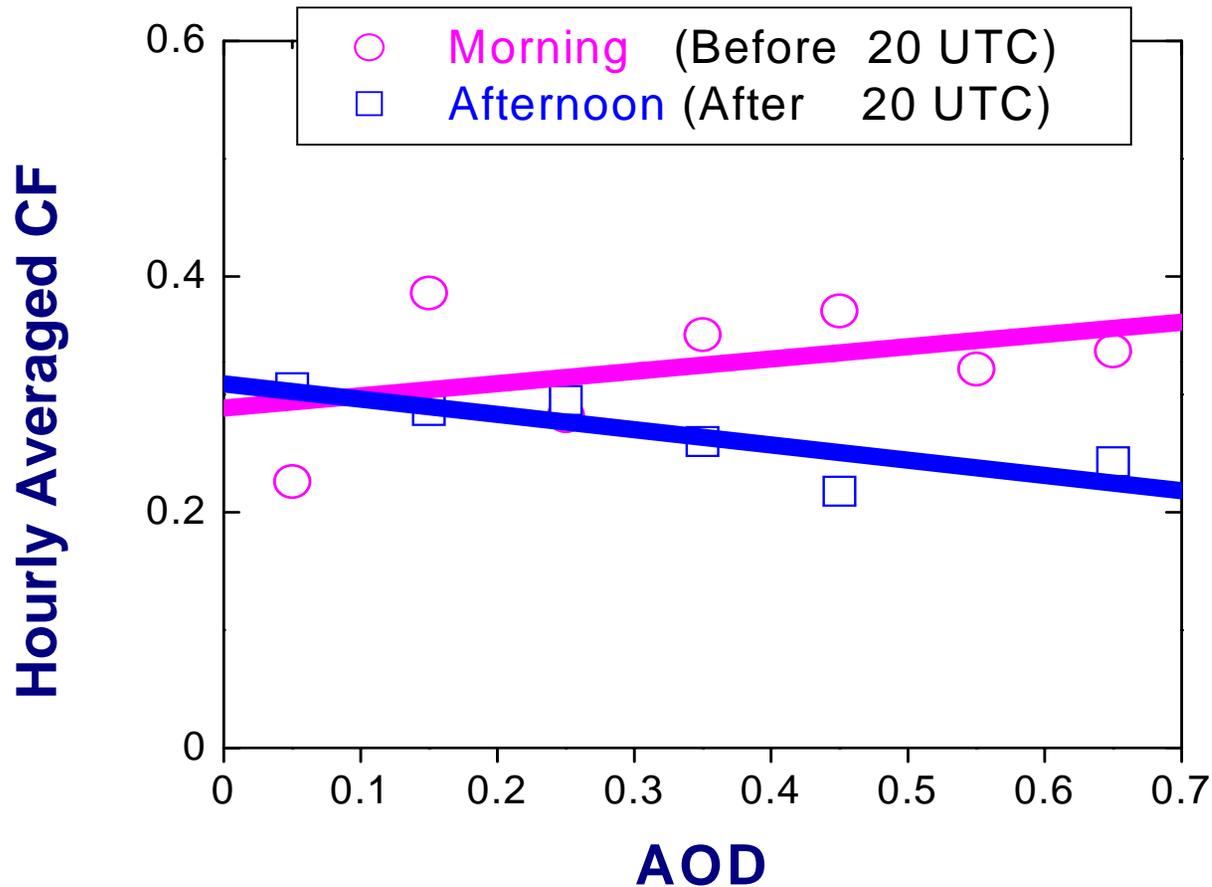
Case Study: Cloud Fraction



July 8, 21:00 UTC

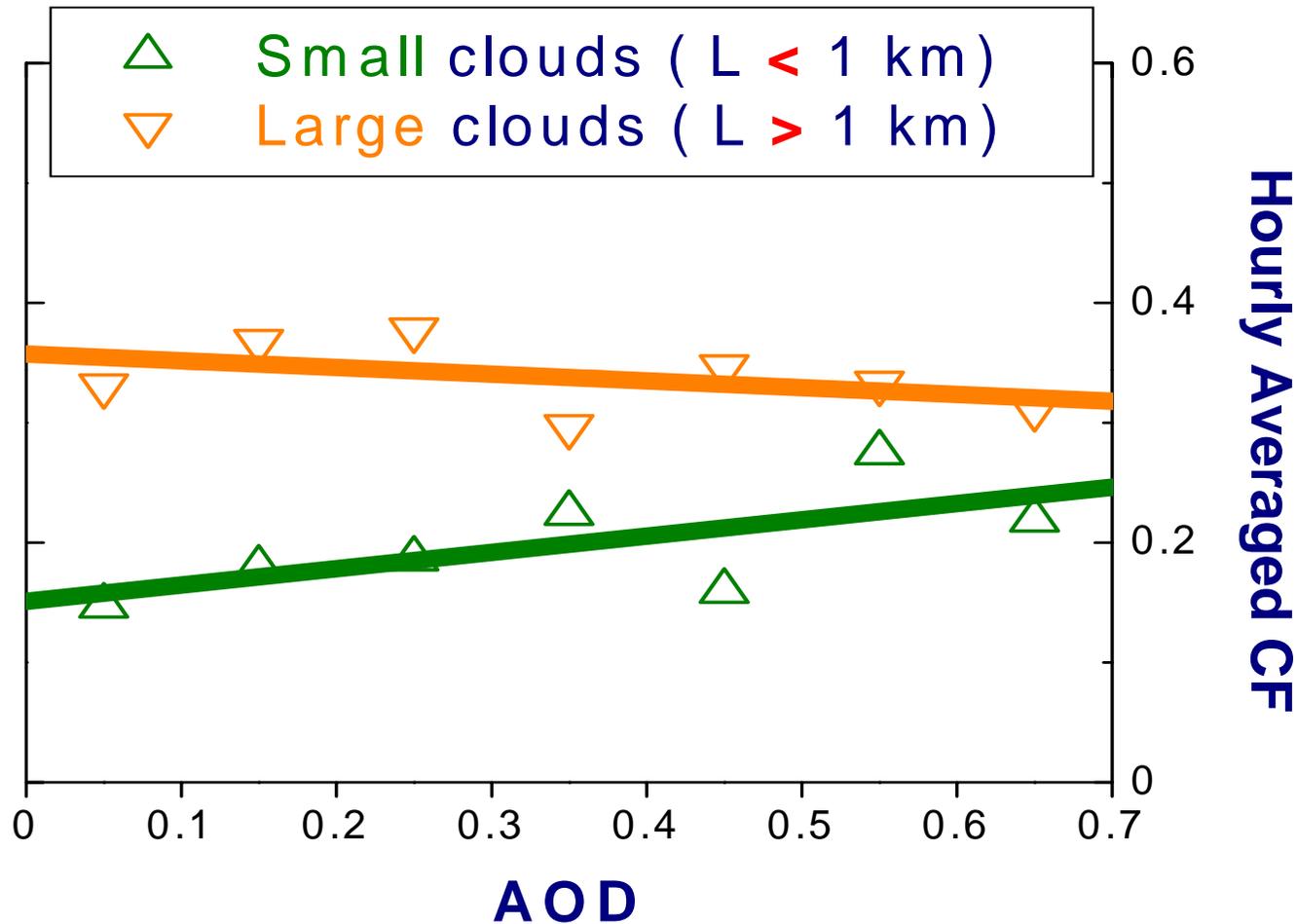
- Clouds fade away afternoon on July 8 (polluted)

Climatology: CF vs AOD



- Relationship between CF and AOD is time dependent: Positive (morning) and negative (afternoon)

Climatology: CF vs AOD



- Relationship between CF and AOD is cloud size dependent: Positive (small clouds) and negative (large clouds)

Conclusion

- Long-term ARM data benefits study of relationship between aerosol and Cu clouds.
- Small and large clouds appear to have opposite response to increase of AOD.
- Relationship between CF and AOD appear to be time dependent.

Open Questions: Cu + Aerosol

- How to derive **column aerosol** properties?
AWG,.....
- How to derive **microphysical** and **optical** properties of **Cu**? CWG/CLOWD,.....
- What **feedbacks** are important? CMWG,.....

Future Activities

- Repeat study for **hemispherical CF** and other **macrophysical cloud** properties.
- Examine effect of **aerosol vertical distribution** and **aerosol type** on **cloud** properties.
- Perform related **model** simulations.