

# Properties of **Clean** and **Polluted** Fair-Weather Cumulus (FWC) Clouds at SGP site\*

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\* Kassianov et al., ACP, 2007 (in review)

# Motivation

- Relationships between cloud properties and aerosol loading have been obtained mostly for stratus/stratocumulus clouds
- Can we observe relationships between FWC properties and AOD from surface and satellite observations?
- Do these relationships depend on time of day (morning/afternoon)?

# Approach

- Select days with **FWC** clouds
- Obtain **FWC** properties for **clean** and **polluted** conditions
- Examine relationship between **FWC** properties and **AOD**

## Cloud properties:

**Reff** – *effective radius of droplets*

**COD** – *cloud optical depth*

**CF** – *cloud fraction*

# Selection Criteria

- **Single** layer of **FWC** clouds
- **Well-mixed** boundary conditions
- Relatively **non-absorbing** aerosols
- Long-term **ARM** and **NASA** data  
Summers: 2000-2004 (SGP site)

# Aerosol and Cloud Properties

## ARM

Aerosol: AOS, MFRSR

Clouds: ARSCL, TSI

Meteorology: SMOS

Fluxes: SKYRAD

## NASA

Reff, COD: MODIS

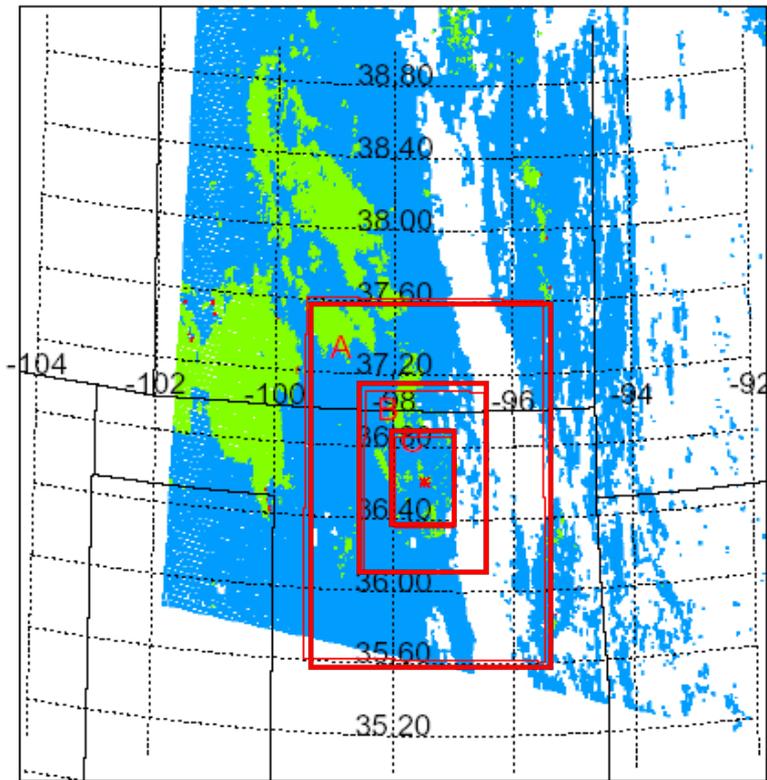
Terra (11:30 LST)

Aqua (14:00 LST)



# MODIS Images & SGP site

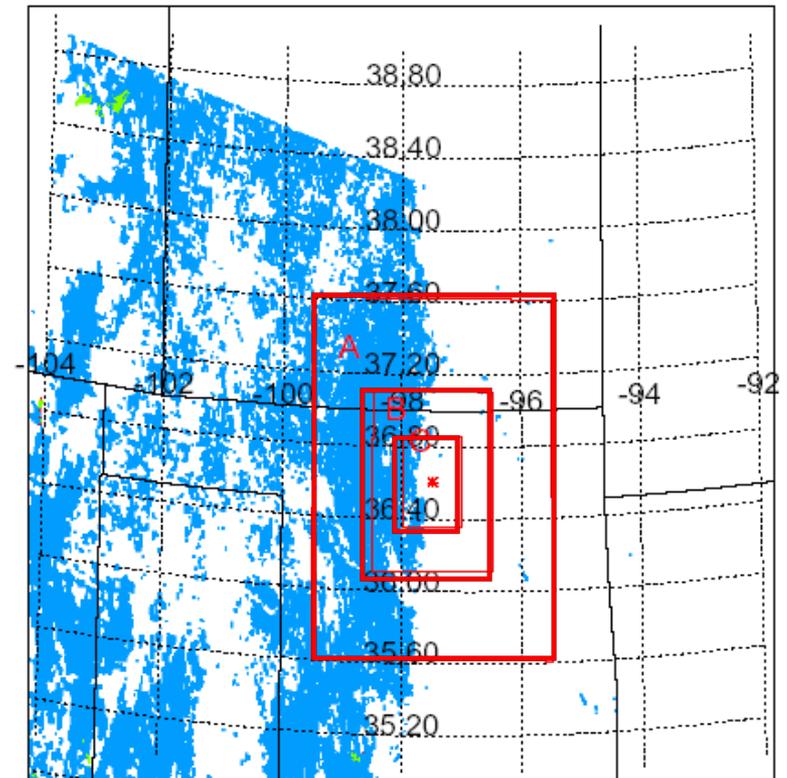
MODIS Cloud Phase ; Jul 5



Cloud Phase



MODIS Cloud Phase ; Jul 8

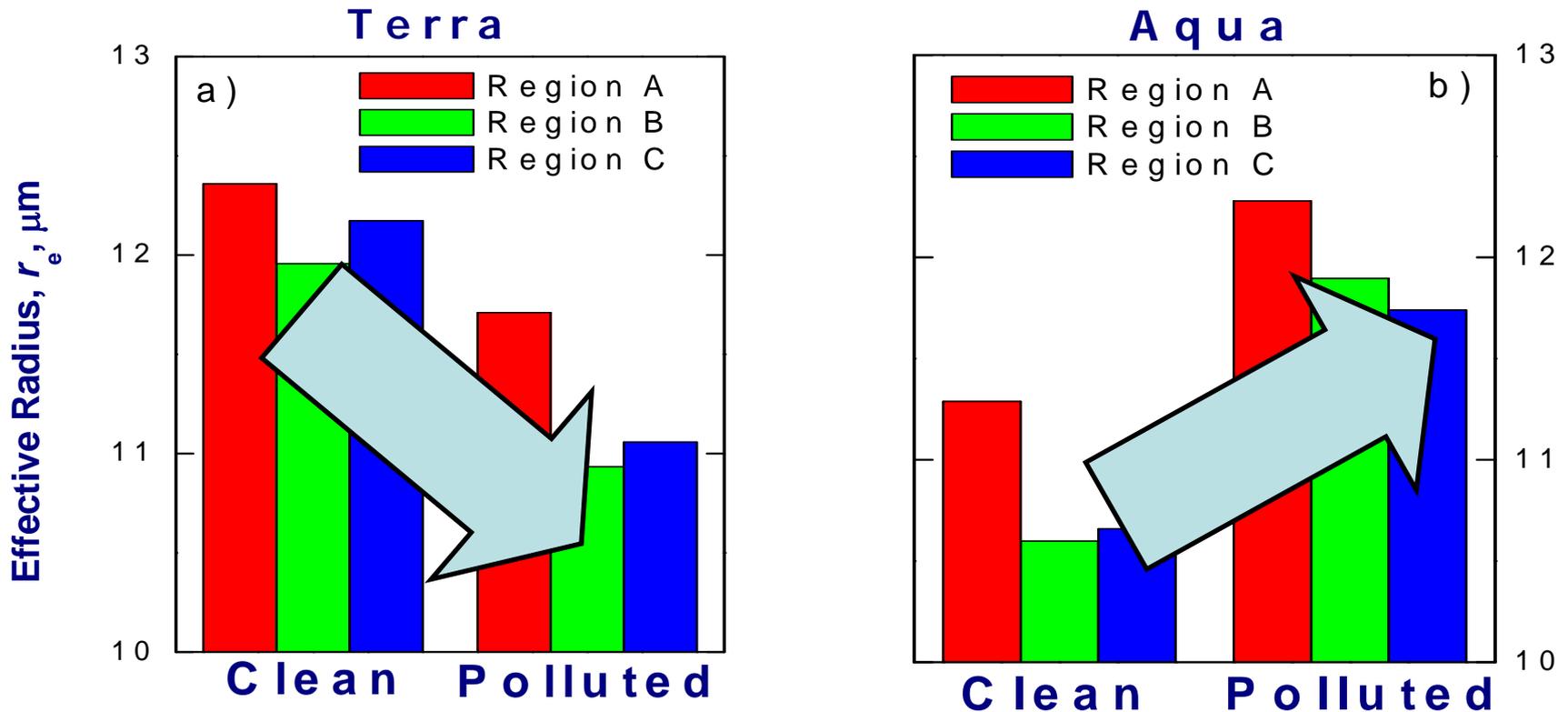


Cloud Phase



- Consider **three** areas surrounding SGP site
- Discard days with **cirrus contamination**

# MODIS-derived Reff



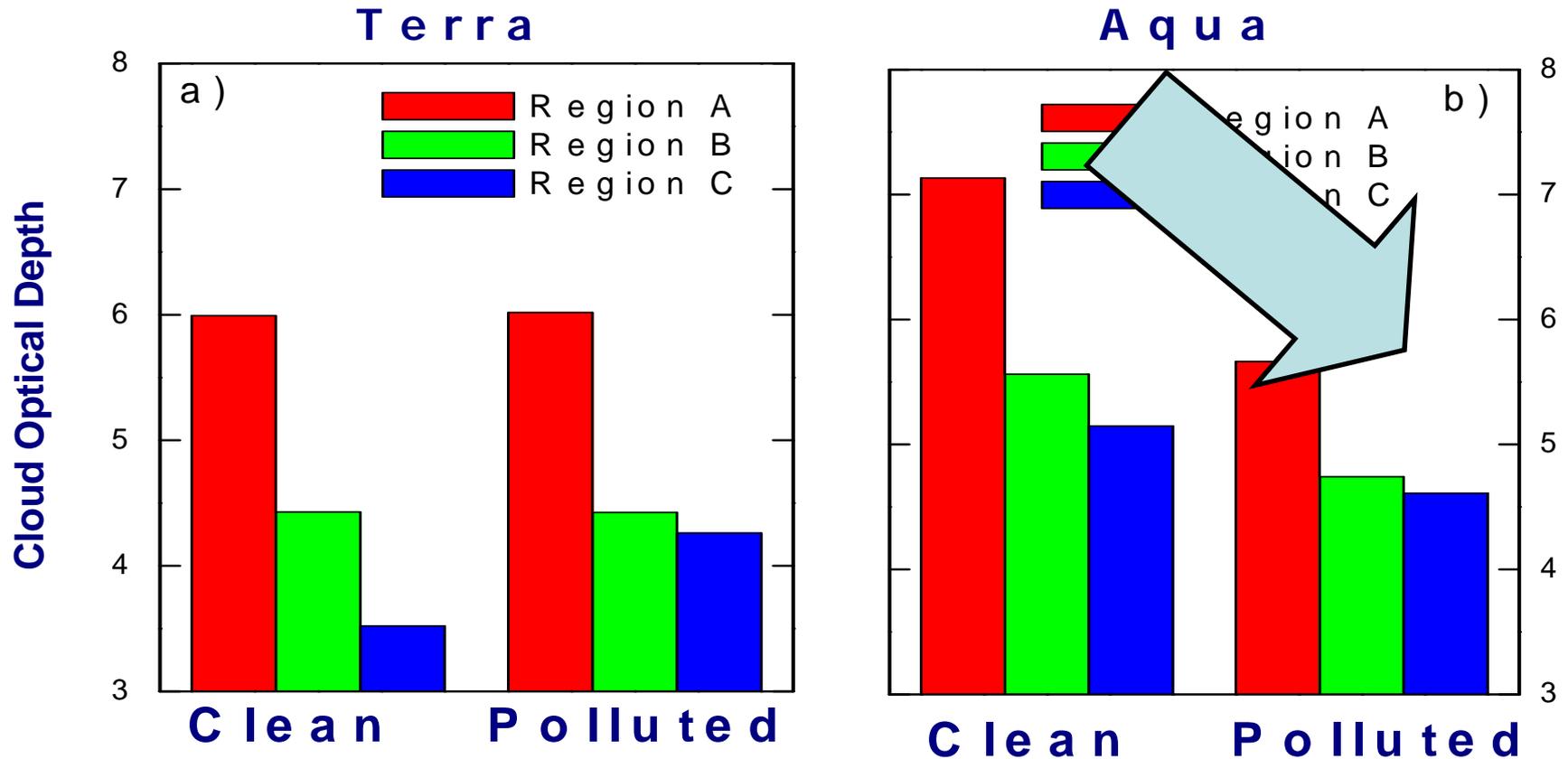
Clean (AOD < 0.2), Polluted (AOD > 0.2)

- **Terra:** Reff **decreases** with AOD (Twomey)
- **Aqua:** Reff **increases** with AOD (?!)

# MODIS-derived Reff

- **Terra** and **Aqua** observations are performed in **morning** and **afternoon**, respectively
- **Reff-AOD** relationships may be either **negative** (**morning**) or **positive** (**afternoon**)
- **Twomey** effect is observed during **development** of FWC clouds (**morning**)

# MODIS-derived COD



- Terra: COD depends **weakly** on AOD
- Aqua: COD **decreases** with AOD (?!)

# MODIS-derived Properties

- **COD** and **Reff** appear to have **opposite** behavior with **AOD** in *afternoon*:
  - **Larger Reff** (asymmetry parameter)
  - **Smaller COD**
- **COD** reduction and **Reff** **increase** make clouds more *transparent*

# MODIS- & ARSCL-derived properties

- Relationships between MODIS-derived properties (**COD**, **Reff**) and **AOD** appear to be **time-dependent**.
- Can we observe similar relationship between ARSCL-derived **CF** and **AOD**?

# Time-Dependent Changes

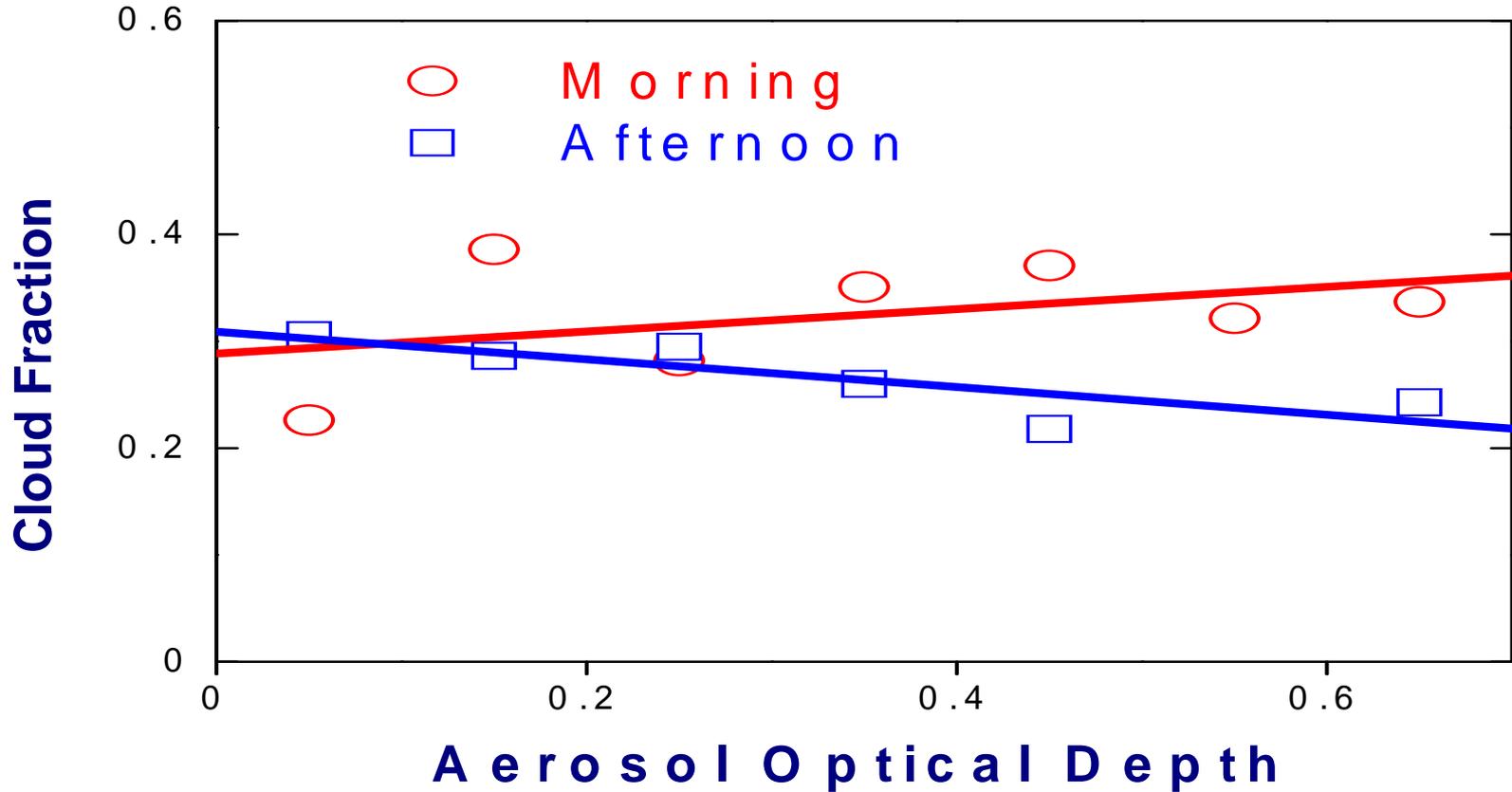
- Two groups
  - “Morning”: before 14 LST
  - “Afternoon”: after 14 LST

Why?

- **CF** maximum mean value\* (~14 LST)
- **Growth** (morning)/**Dissipation** (afternoon)

\*Berg and Kassianov, Climate, (in review)

# ARSCCL-derived CF



- **Morning:** CF depends weakly on AOD
- **Afternoon:** CF decreases with AOD

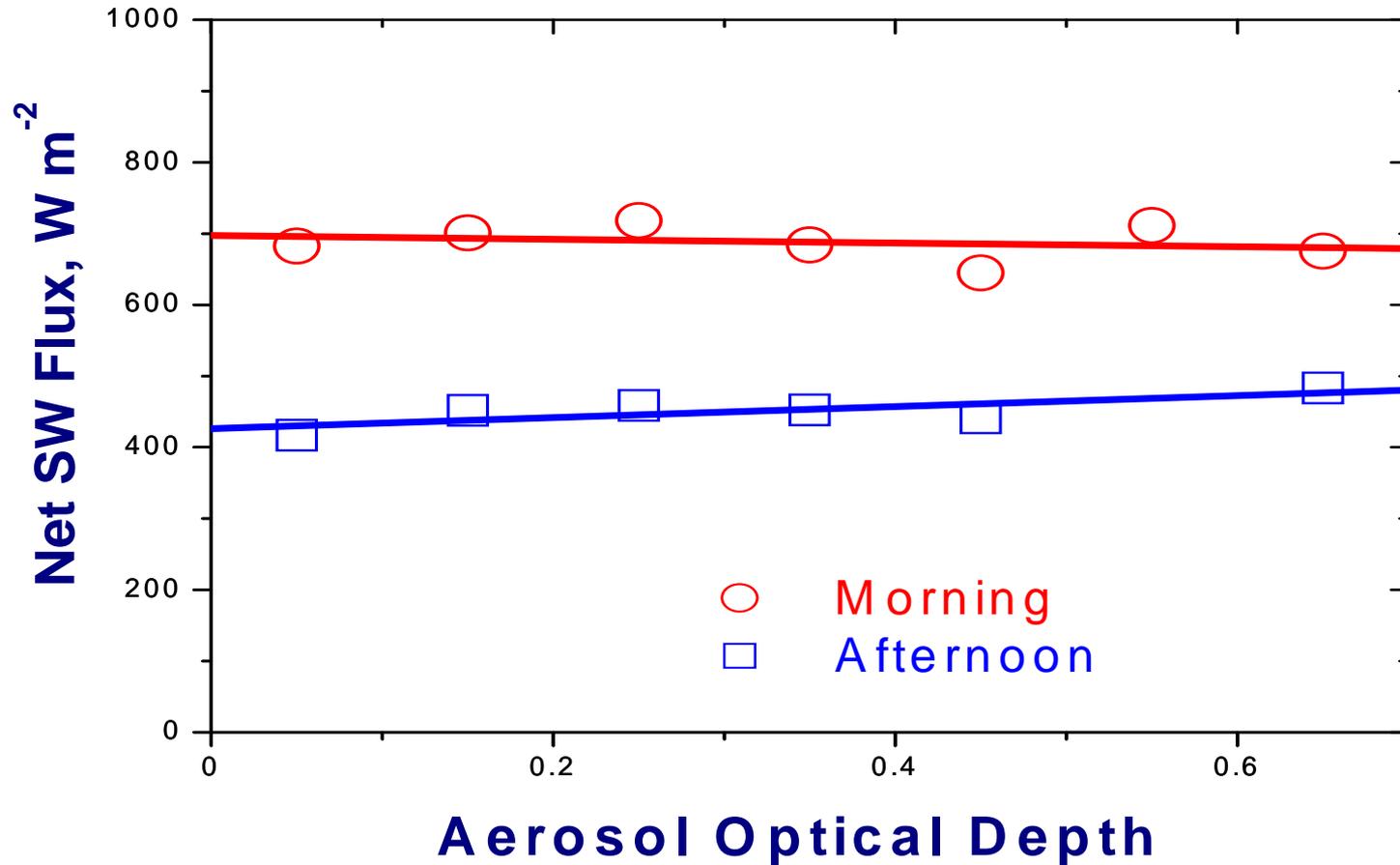
# Aerosol/FWC Radiative Effects

- **Aerosol** reduces surface insolation, convection and **CF** (cooling effect)

HOWEVER

- **CF** reduction **increases** surface insolation (**warming** effect)
- What is **combined effect** of aerosol/**FWC** on surface **SW flux**?

# SW Fluxes: FWC + Aerosol



- Partly Cloudy Sky: Trends appear NOT to be negative
- Clear Sky: Trends are negative (previous studies)

# Summary

- Contrary to **Clear-Sky** results (**cooling** effect), **SW-AOD** trends appear to be **neutral/positive** (**warming** effect) for **Partly Cloudy** (**FWC**) conditions.
- Relationships between FWC properties (**CF, COD, Reff**) and **AOD** appear to be **time-dependent** (morning vs afternoon).

**Physics/Uncertainties ?!**

# Issues: MODIS Retrievals

- FWC have

Low COD (Sensitivity)

Small (<1 km) sizes (Resolution)

Complex geometry (3D effects)

- Terra and Aqua retrievals may have consistent/systematic biases
- How large is their impact on observed trends?!

# Open Questions: FWC + Aerosol

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

*Thanks!*

