Improved retrievals of optical depth for optically thin clouds using MFRSR measurements

Qilong Min and Tianhe Wang

State University of New York at Albany

Optically thin clouds: ice or water

- Optical depth is the most fundamental cloud optical property
- Radiation is most sensitive to changes in cloud optical depth at low optical depths

- Ice, water, and mixed phase clouds
- Broken clouds

Phase Function

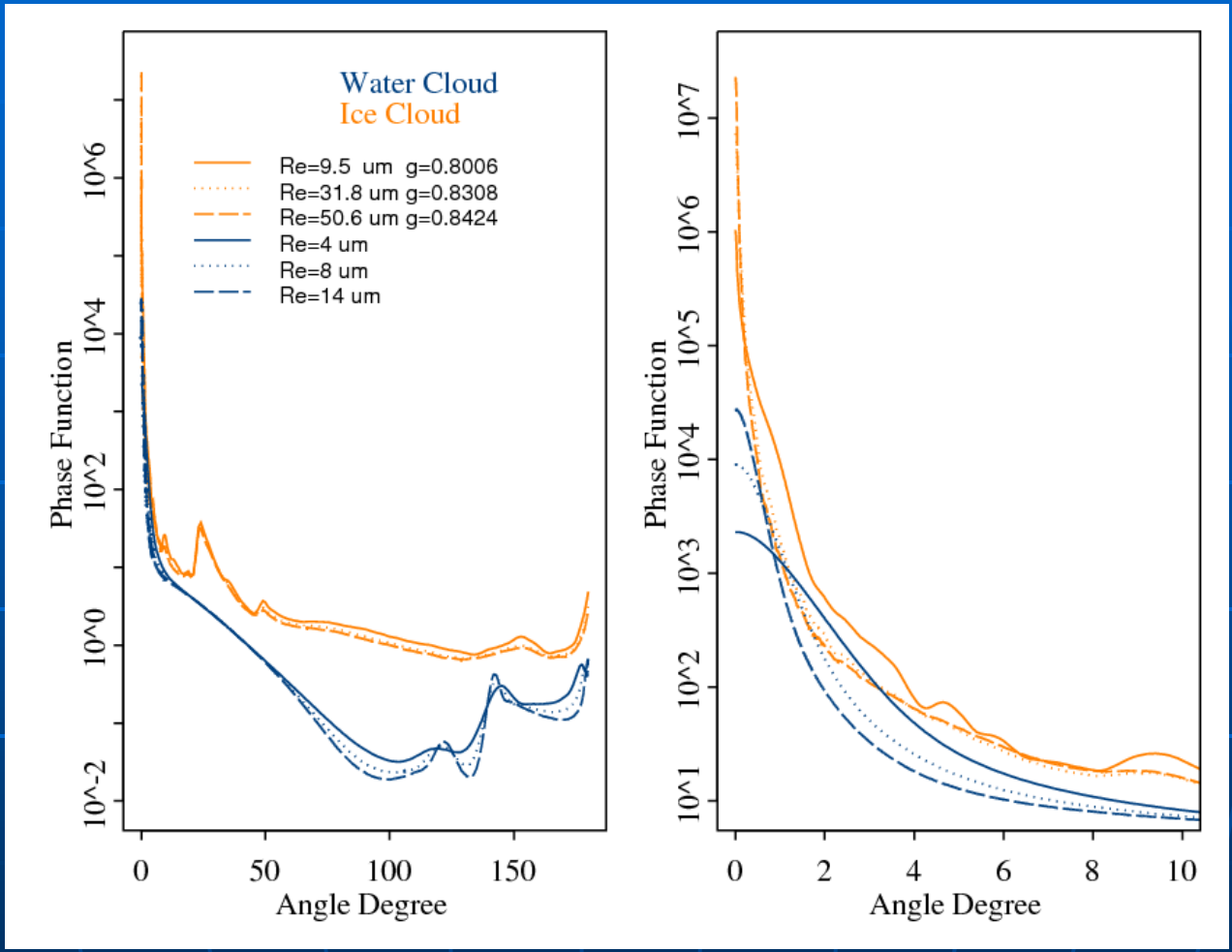


Figure 1. Water cloud and ice cloud phase functions at 415 nm for different effective radii.

Water clouds and ice clouds have different phase functions and thus have different partitions between direct and diffuse radiation.

Retrieval Algorithm

Direct beam [Min et al. 2004]

$$I^{dir}(\mu_0, \tau_{aer}, \tau_{cld}, \mathrm{Re}) = \exp[-(\tau_{ray} + \tau_{aer} + \tau_{cld}) / \mu_0] + (B_0 - B_9)$$

Total irradiance [Min and Harrison, 1996]

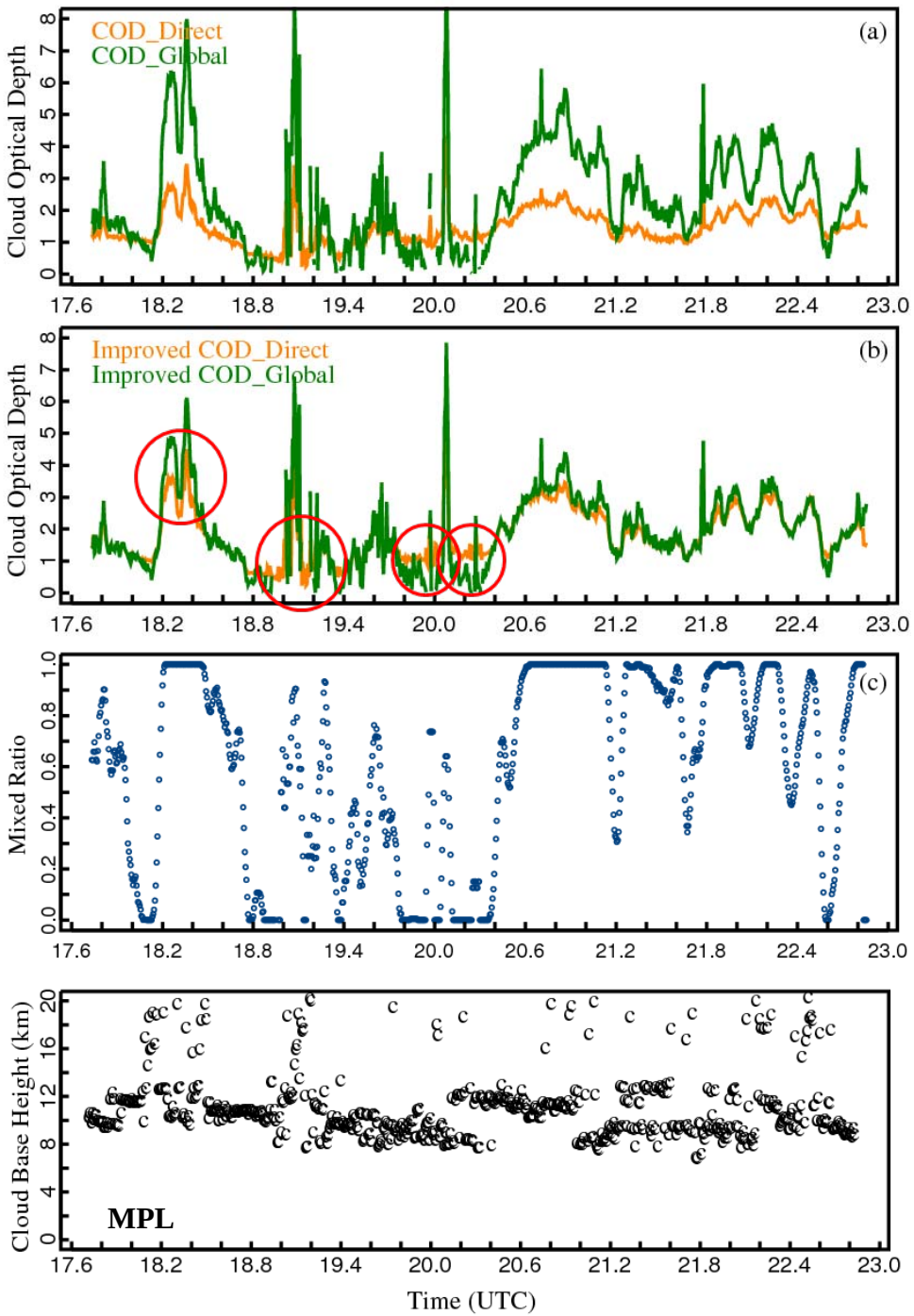
$$I^{tot}(\mu_0, \tau_{aer}, \tau_{cld}, \mathrm{Re}) = \mu_0 I^{dir}(\mu_0, \tau_{aer}, \tau_{cld}, \mathrm{Re}) + I^{dif}(\mu_0, \tau_{aer}, \tau_{cld}, \mathrm{Re})$$

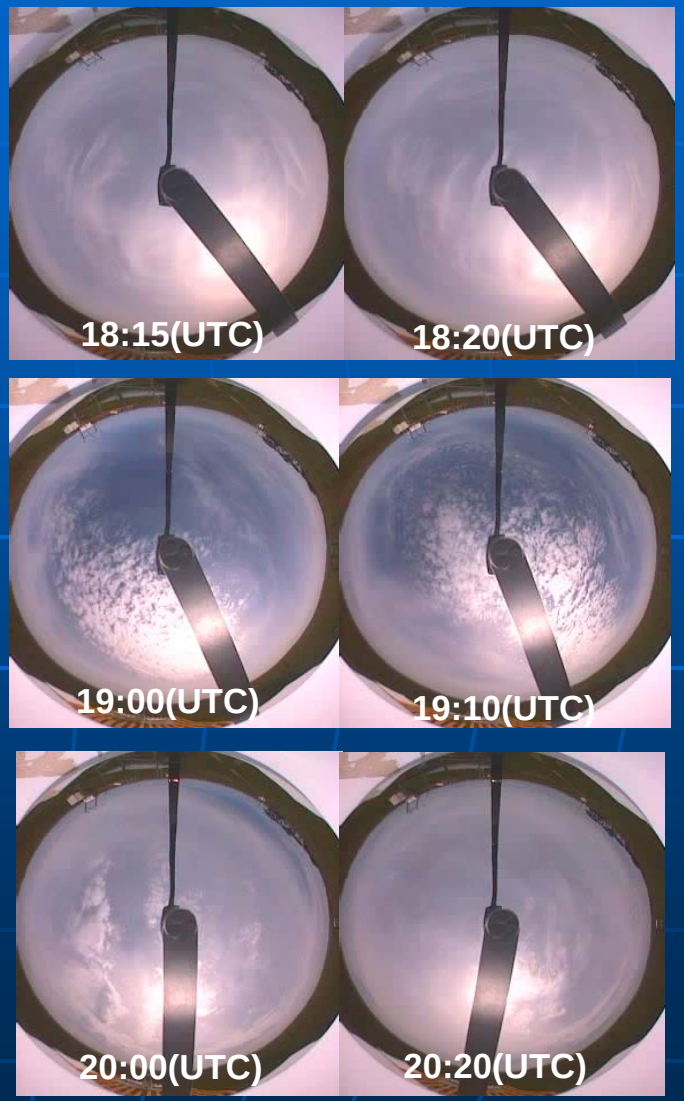
Radiation closure:

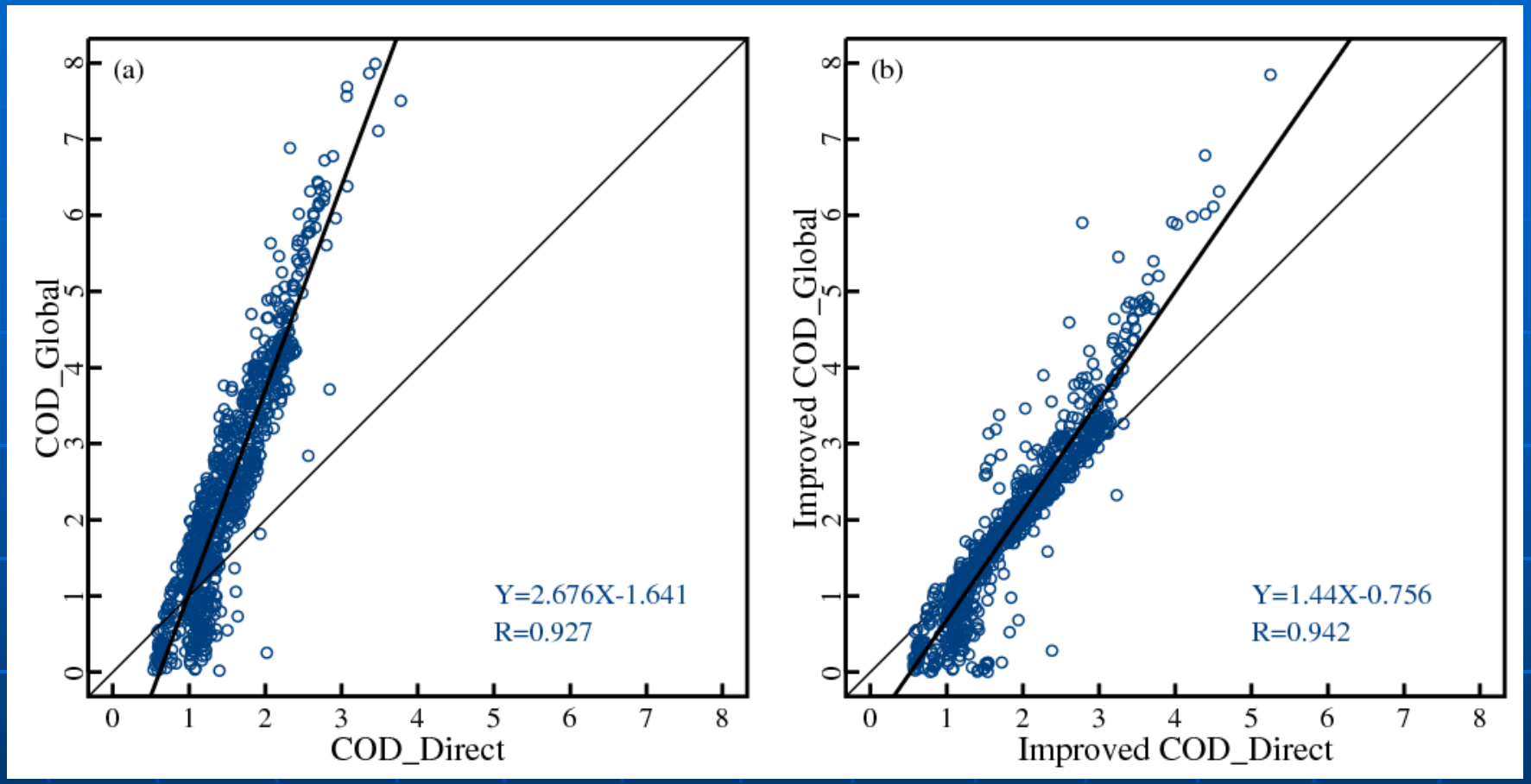
$$(1-\alpha)\tau_{wtr}^{dir} + \alpha\tau_{ice}^{dir} \approx (1-\alpha)\tau_{wtr}^{tot} + \alpha\tau_{ice}^{tot}$$

Case Study:

Mar 26, 2005

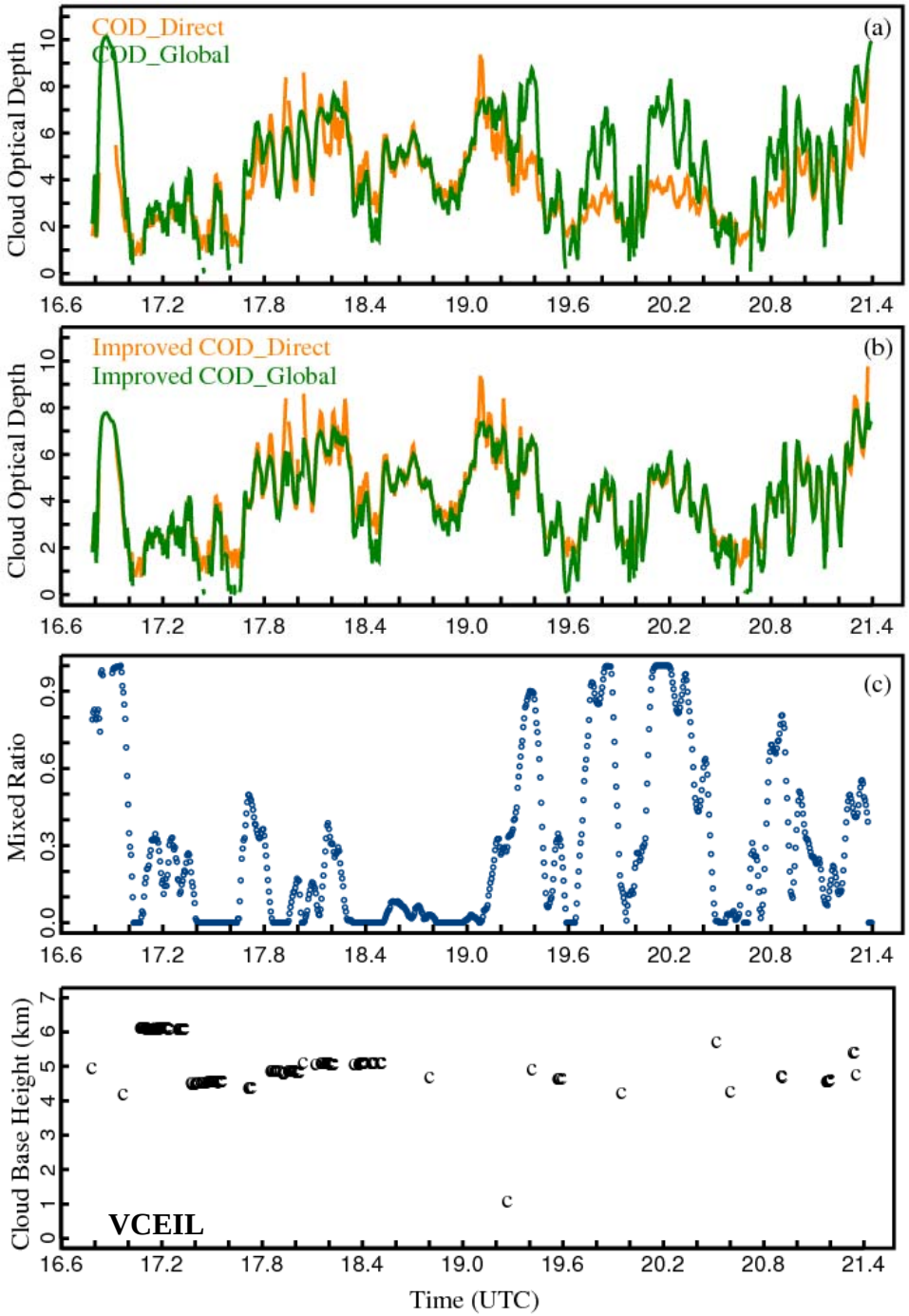


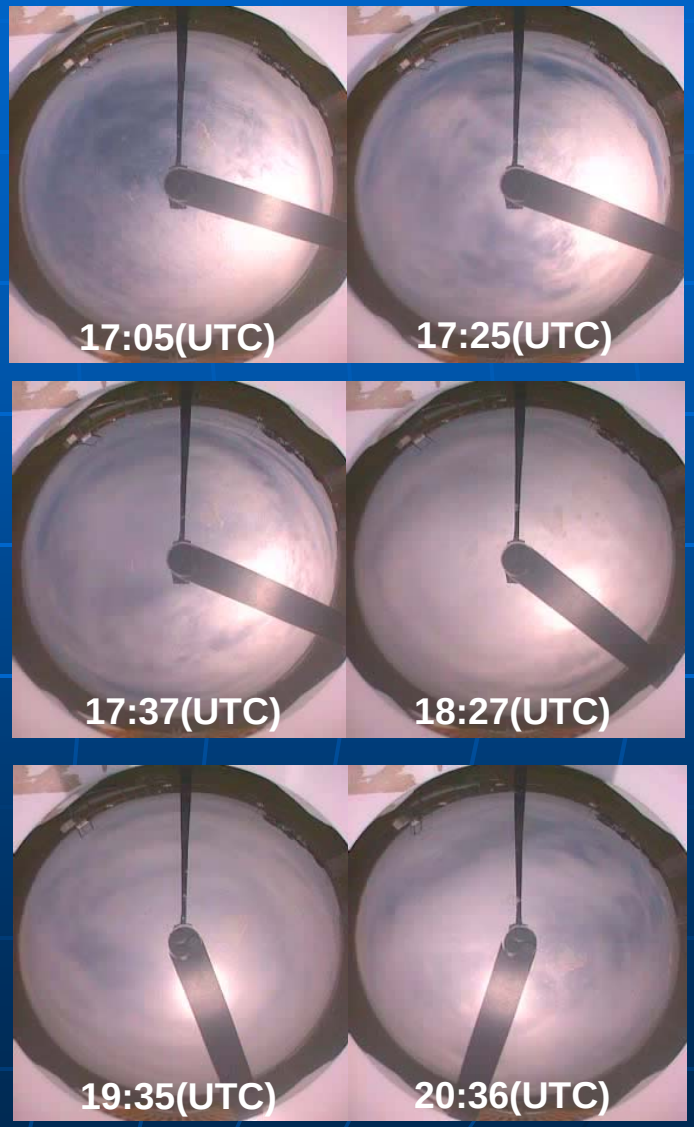


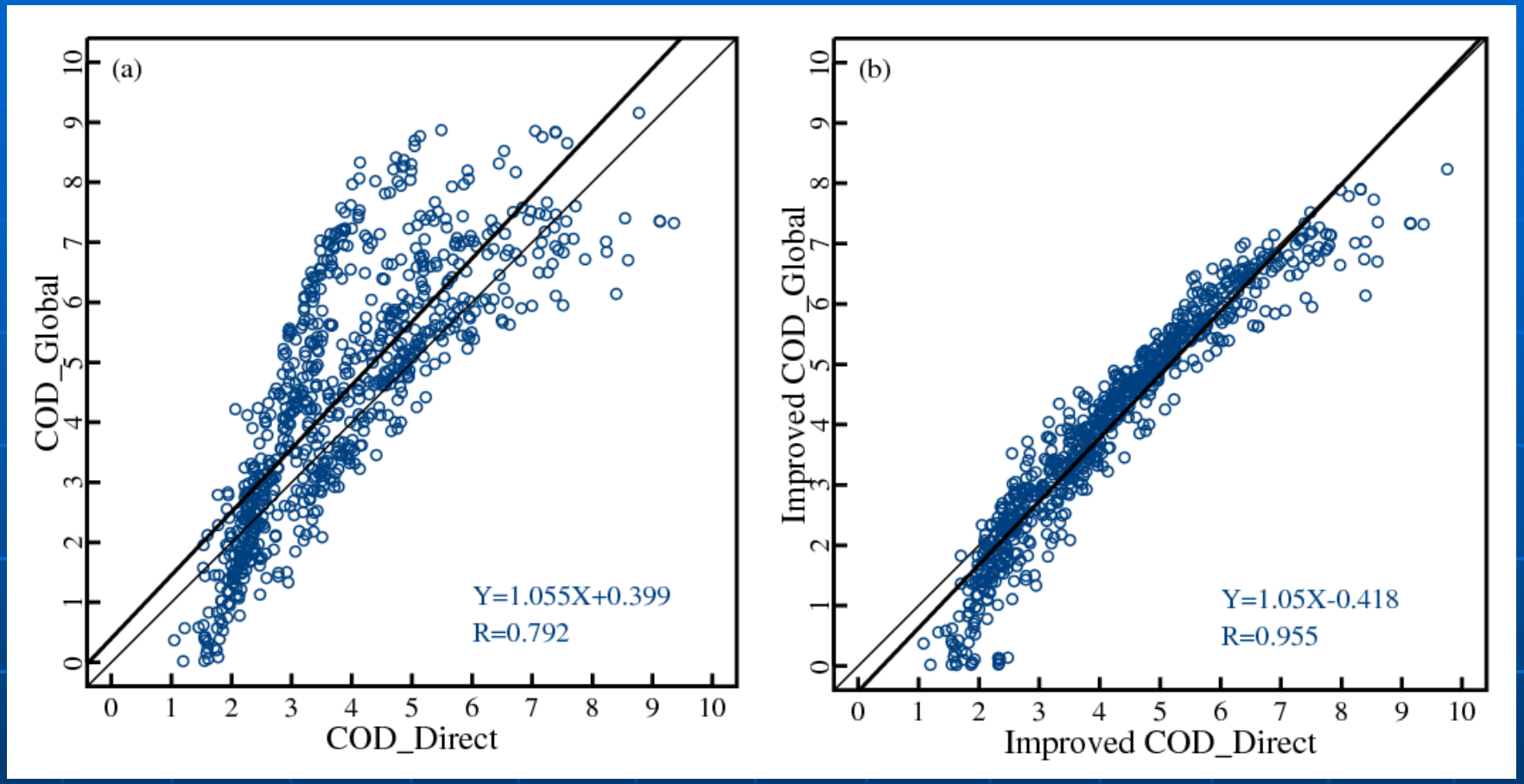


Relationship between the COD derived from the direct and global transmittance for Mar 26, 2005.

Case Study:
Apr 30, 2005

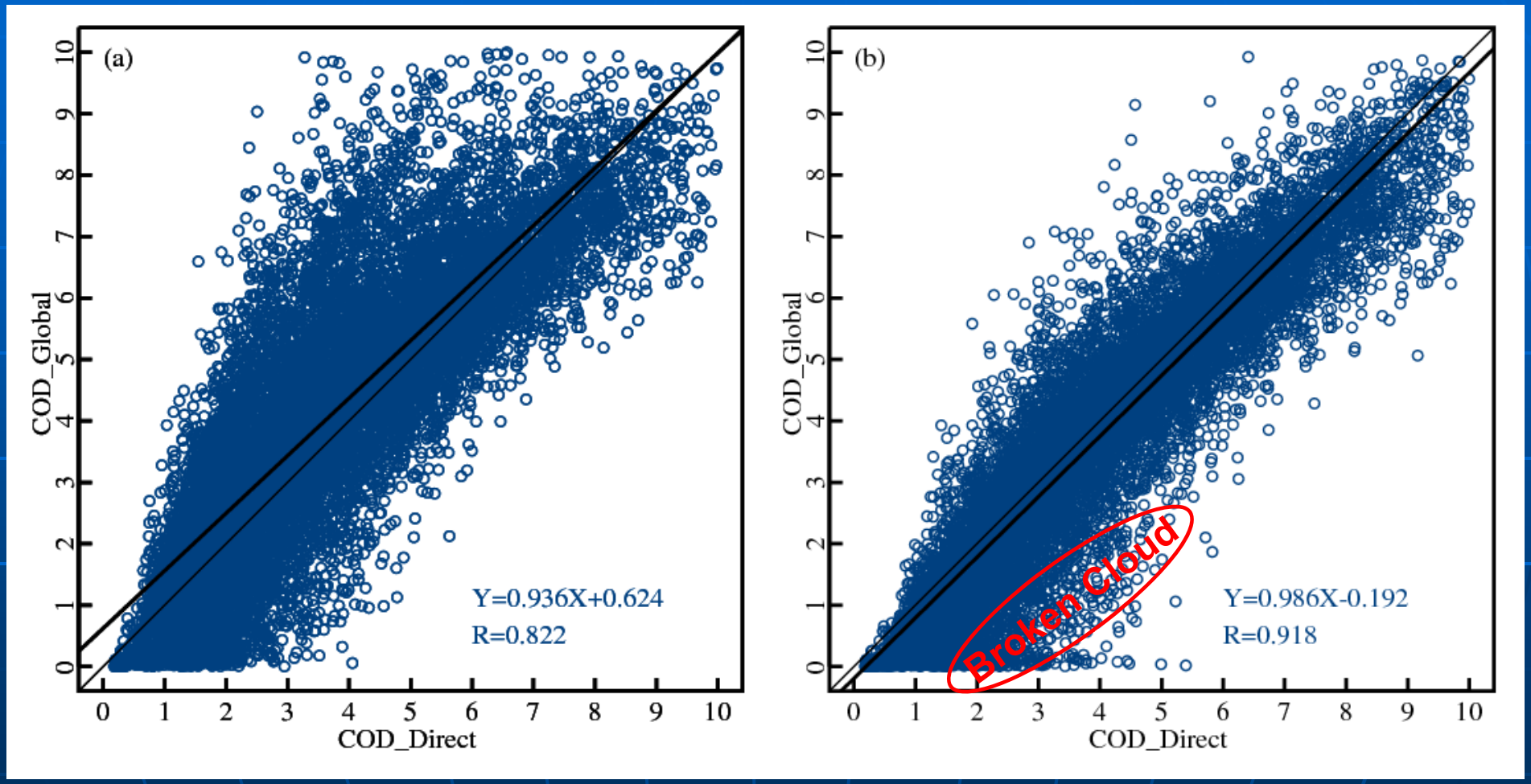




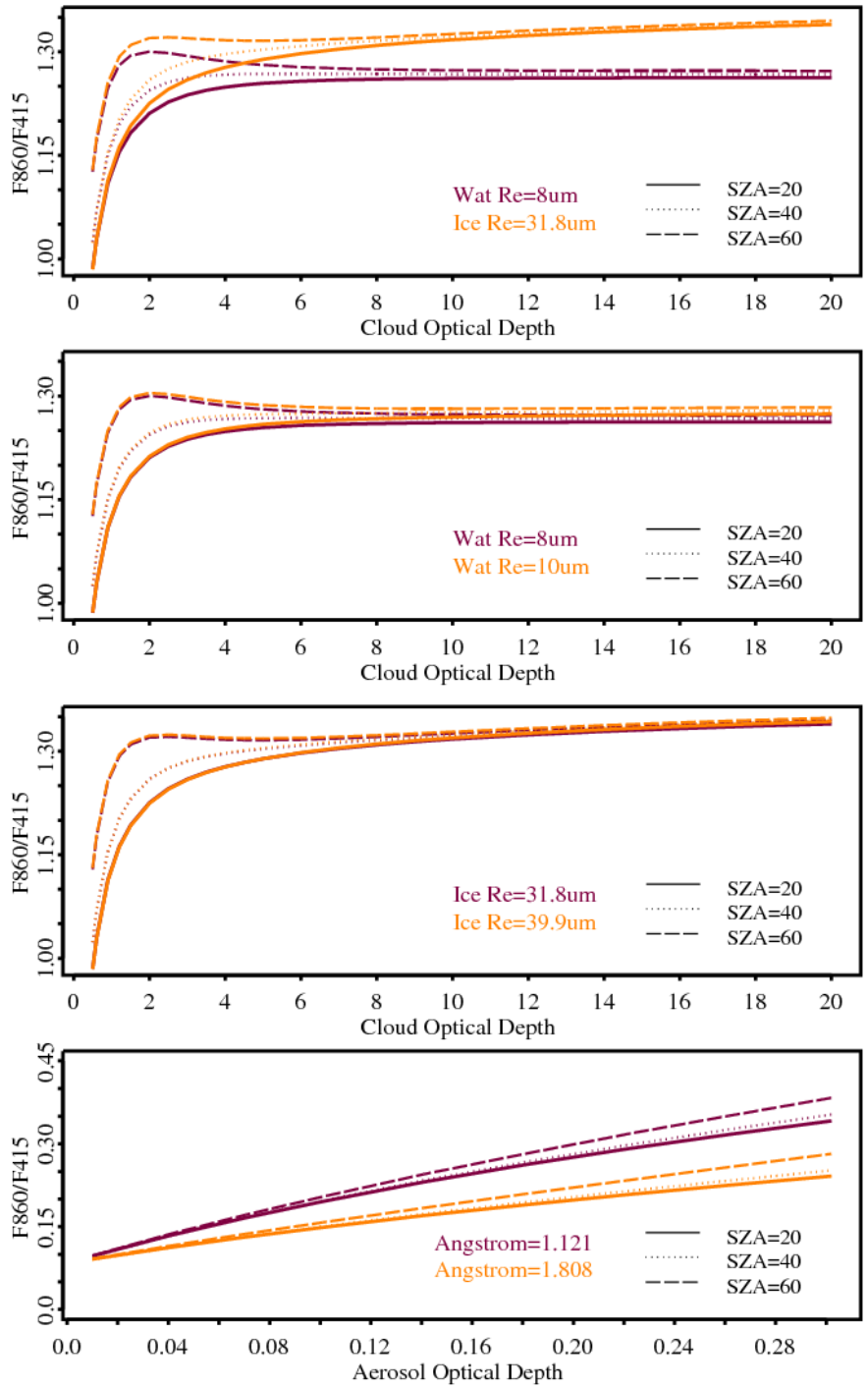


Relationship between the COD derived from the direct and global transmittance for Apr 30, 2005.

Statistical Analysis (15 cases)



Retrieving Cloud Cover from MFRSR measurement



Spectral Albedo at 415 and 860 nm have big difference at clear and cloudy sky and thus have different partition between cloud and aerosol.

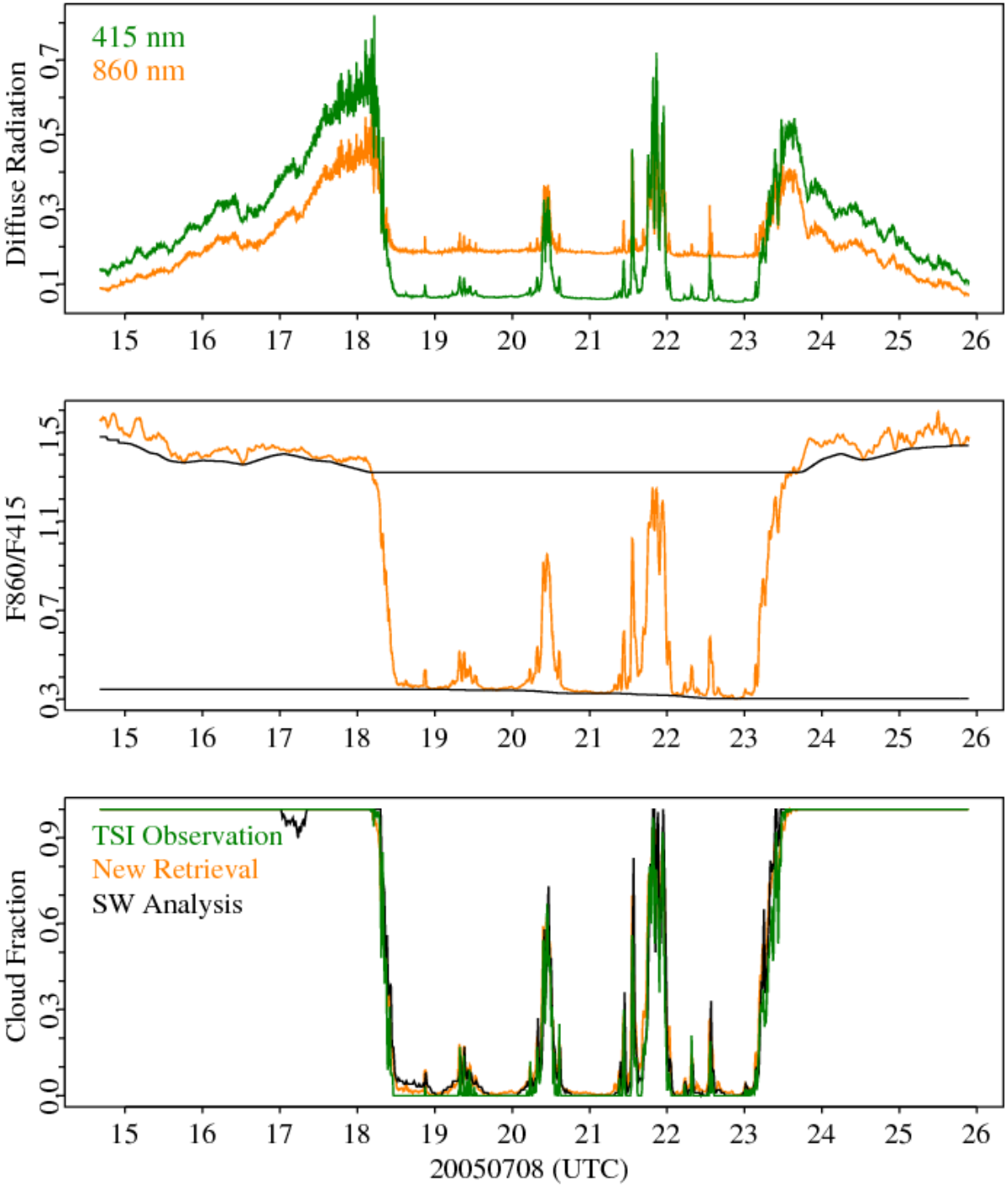
OVERCAST SKY

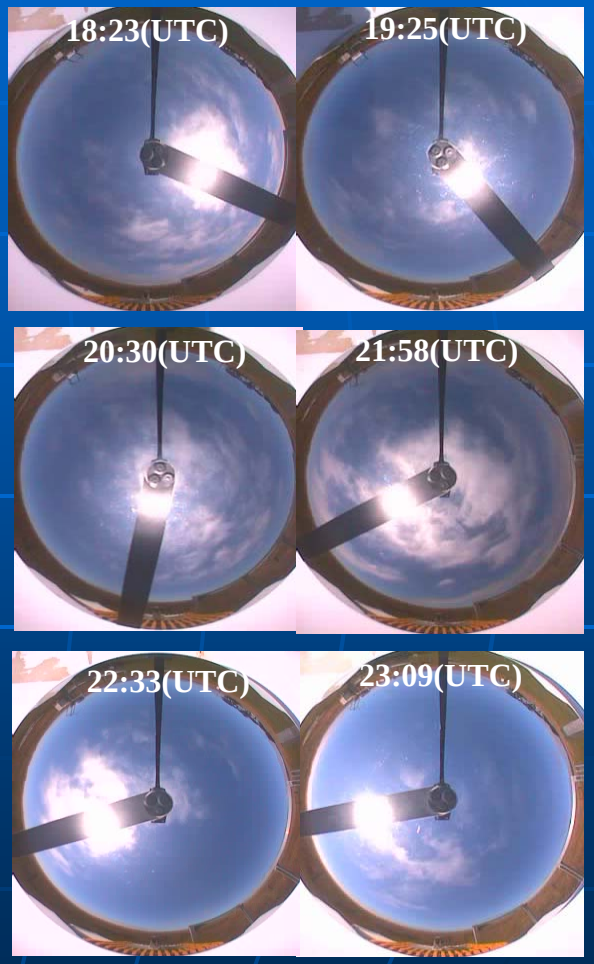
SZA and Re are minor effects on (F860/F415) value .

CLEAR-SKY

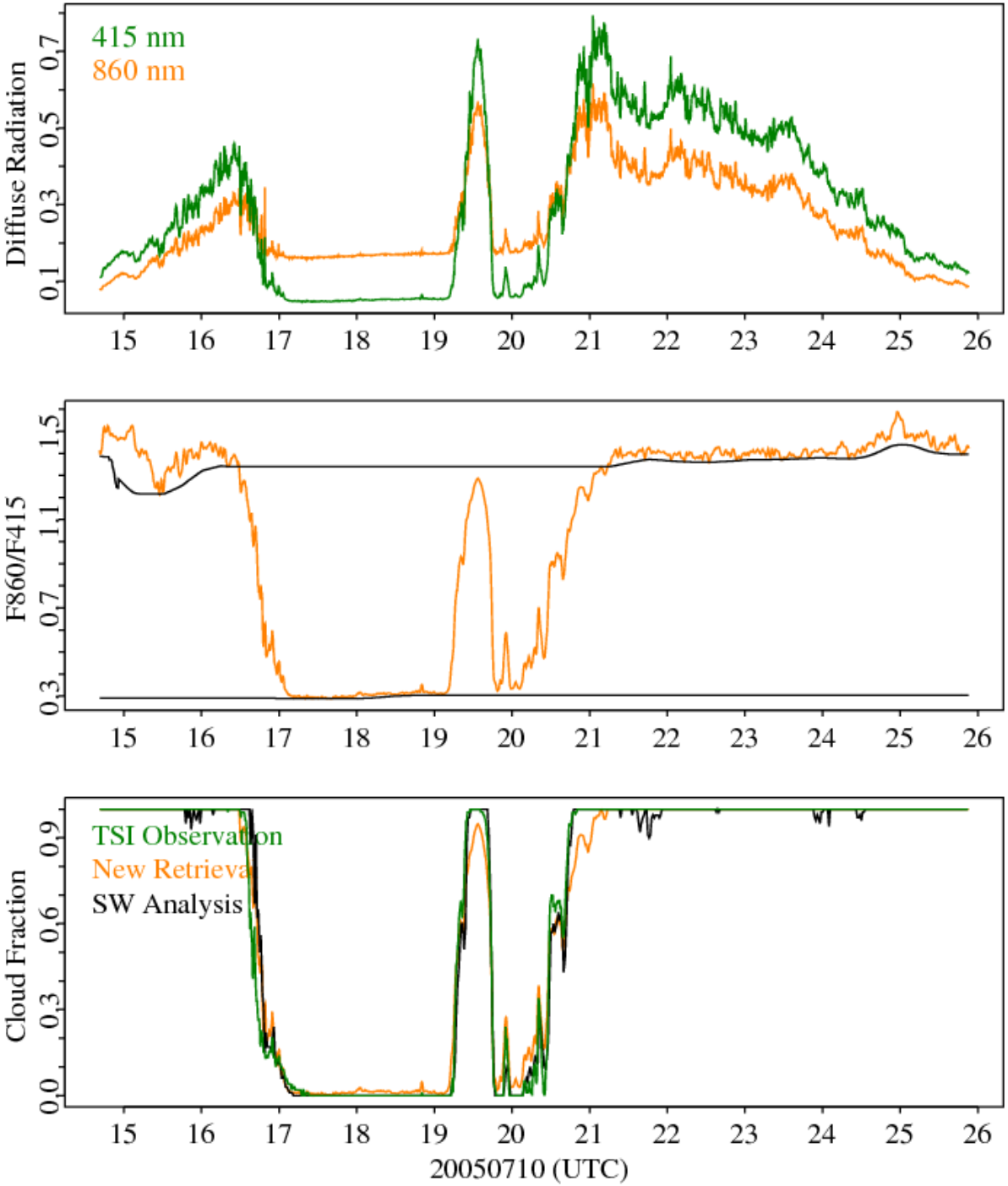
SZA and Angstrom Coefficient also have minor impacts on (F860/F415) value

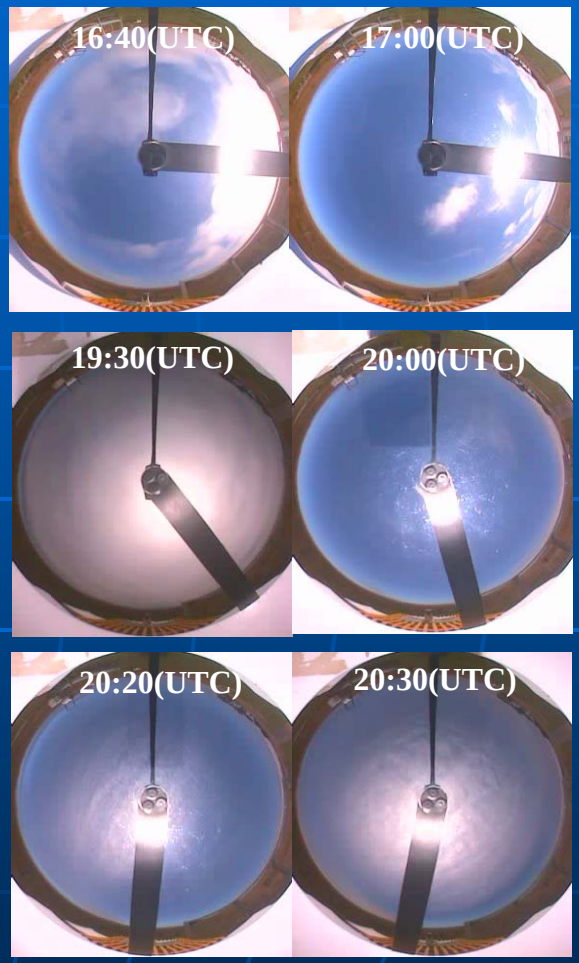
Good Case
Jul 8, 2005



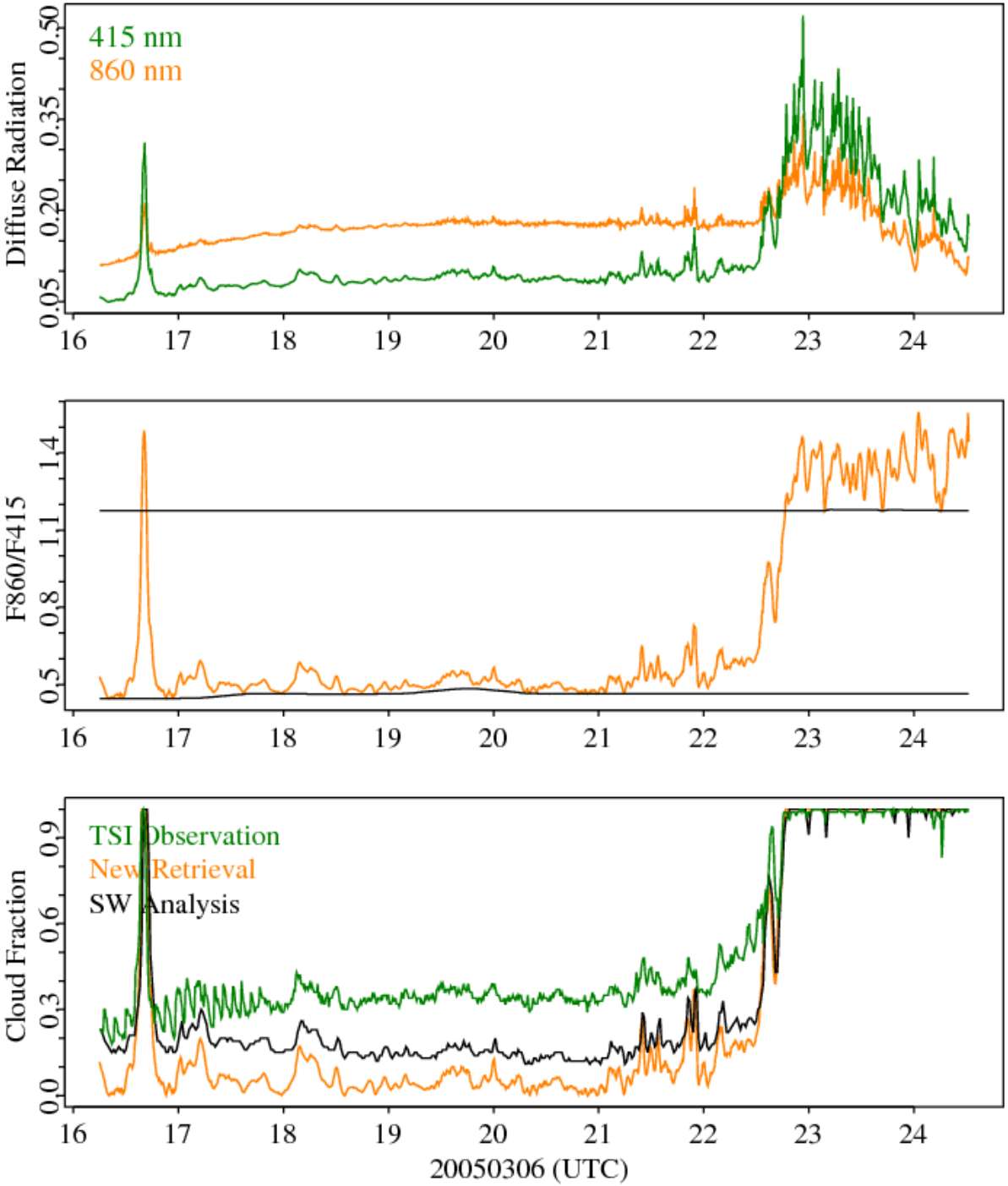


Good Case
Jul 10, 2005

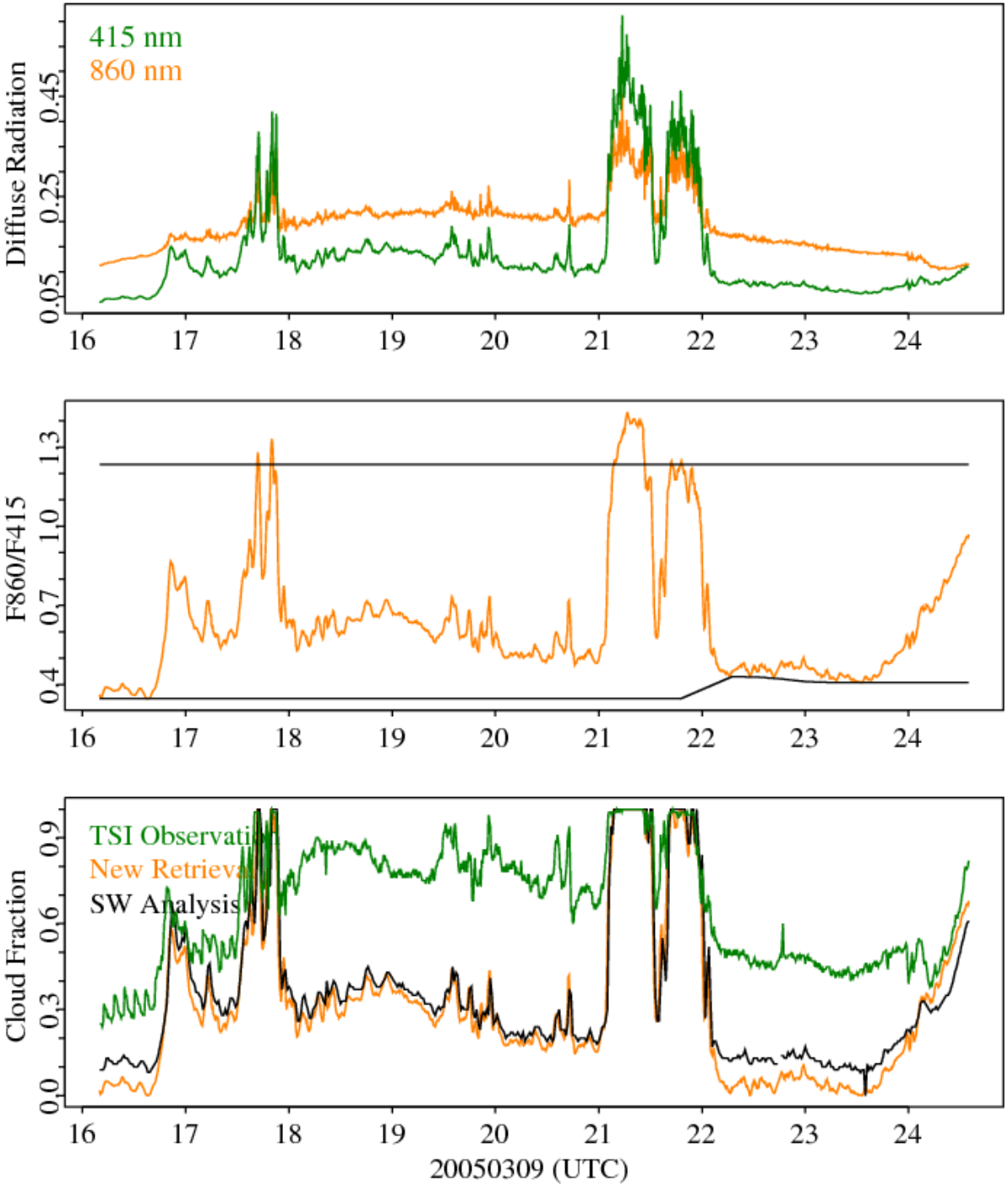




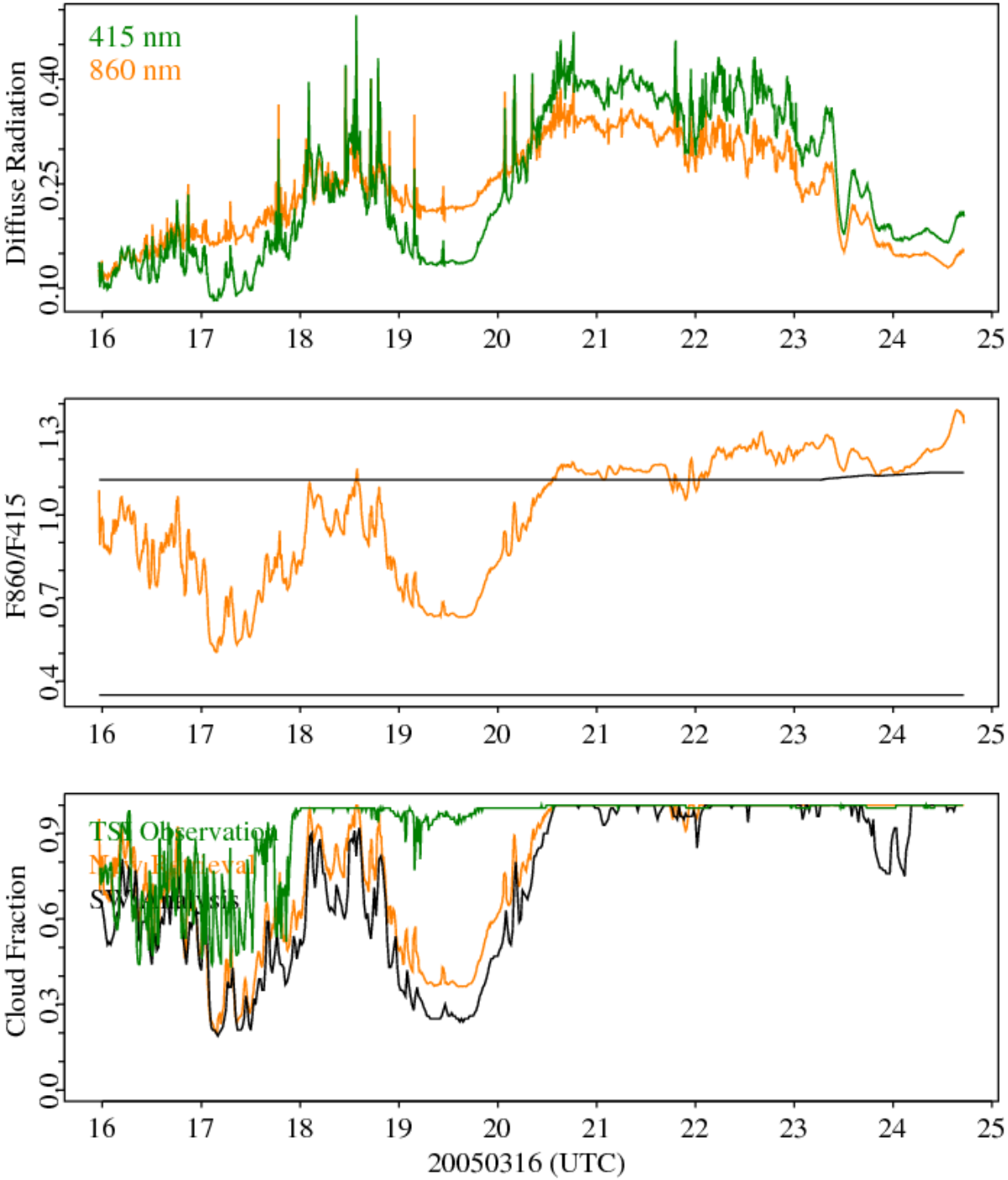
Bad Case? Mar 6, 2005

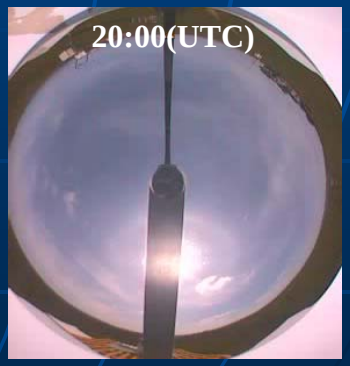


Bad Case ?
Mar 9, 2005

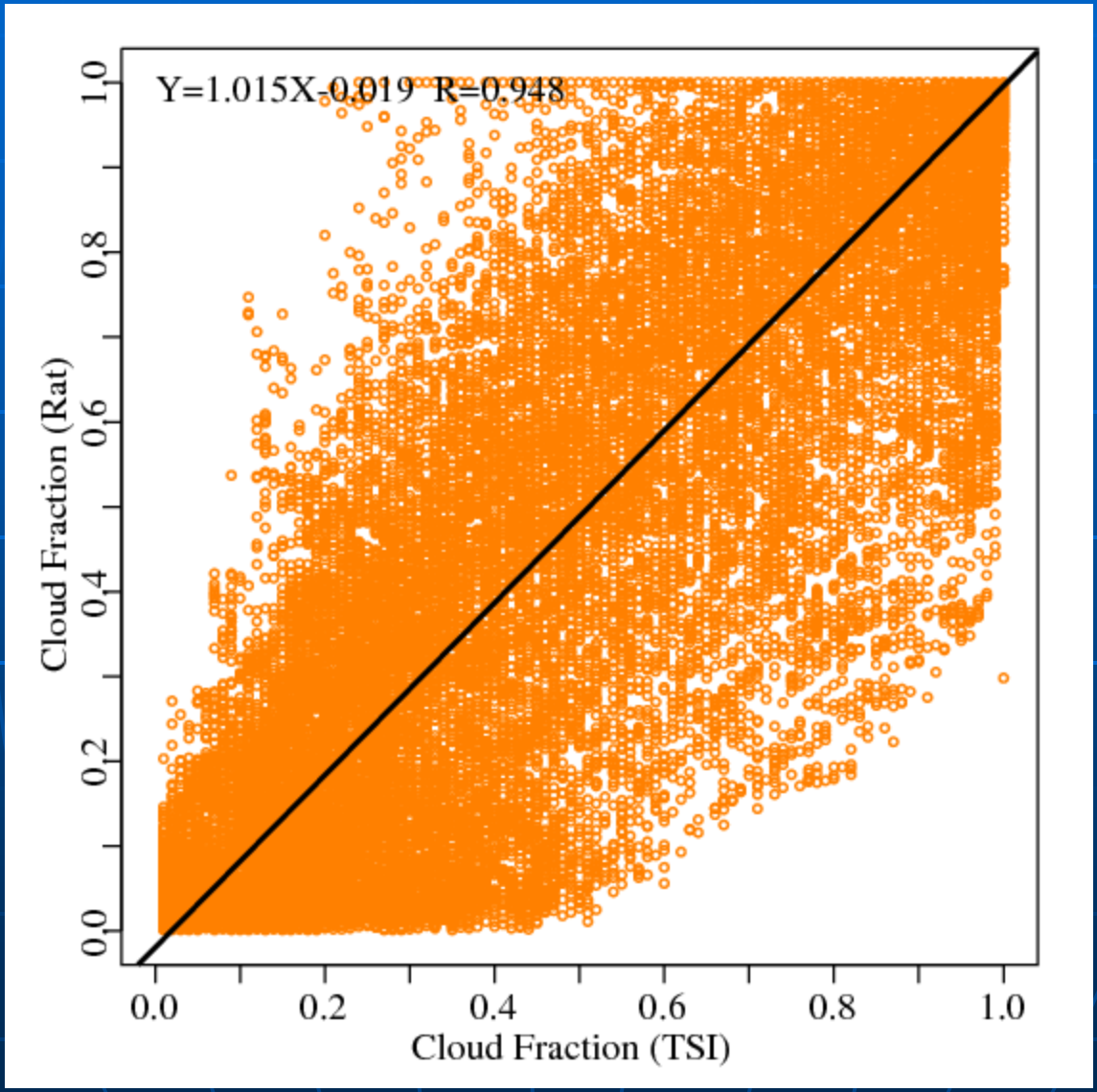


Bad Case ?
Mar 16, 2005

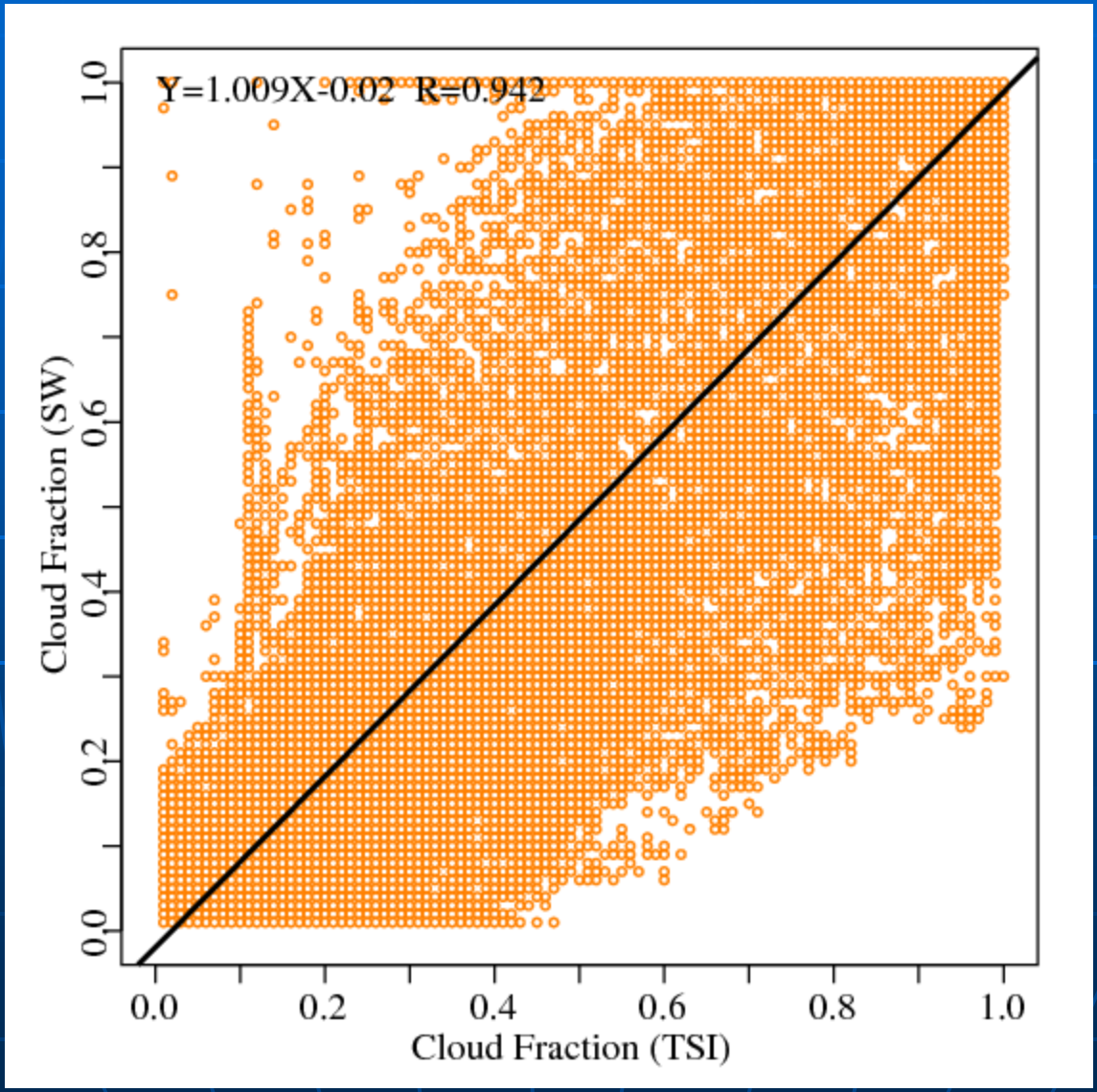
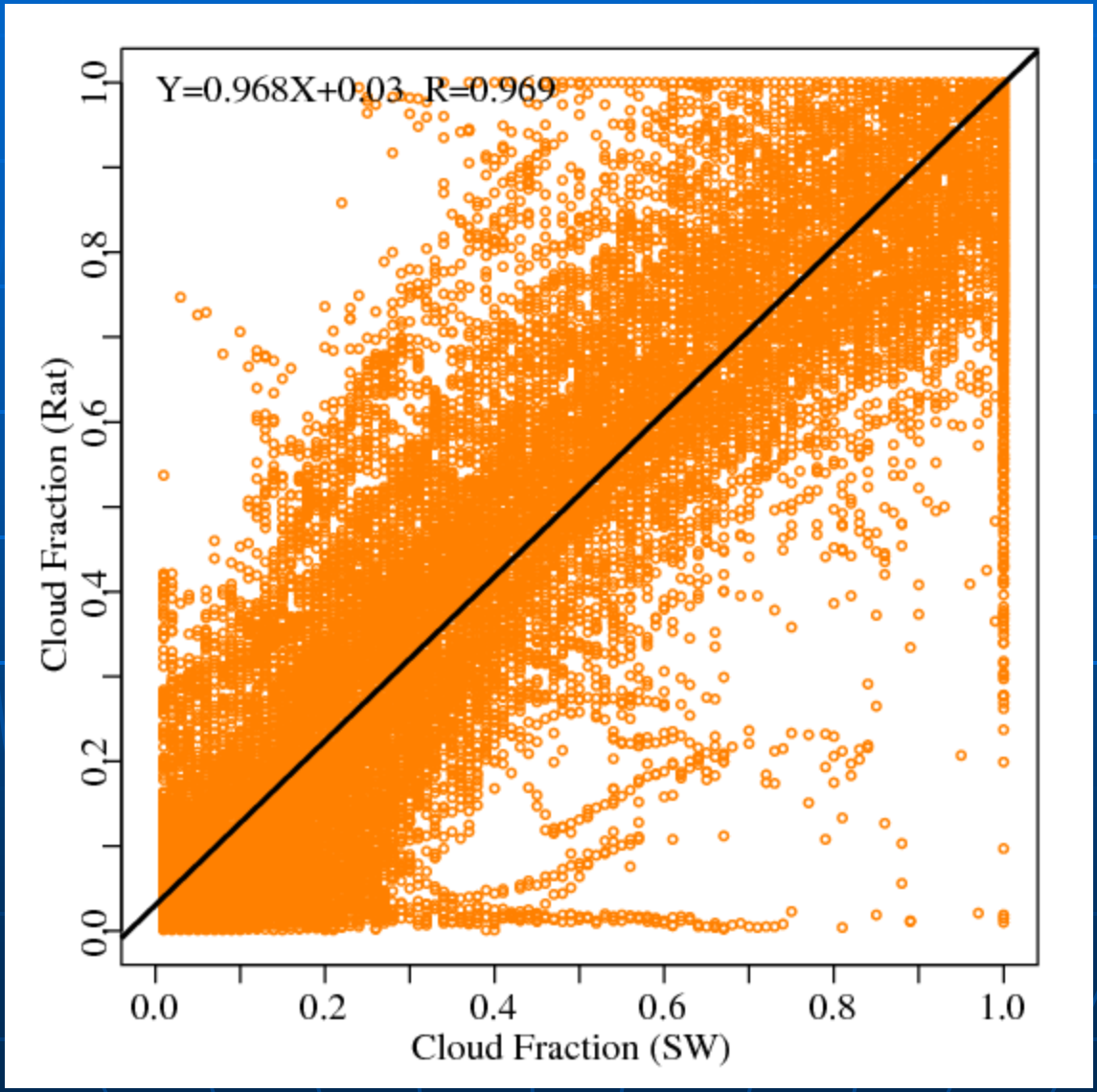




Ratio method & TSI Observation



SW Analysis & TSI Observation



Ratio method & SW Analysis