Cloud property retrievals from Shortwave spectrometer

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The cloud optical properties of interest are:

- Cloud optical depth τ — the great unknown
- Radiative cloud fraction
- Cloud effective drop size, r_{eff}

$$\tau = \frac{3}{2}\frac{LWP}{r_{eff}}$$

r_{eff} in μm, LWP in g/m²

What is our aim in cloud retrieval?

- View the part of the cloud field also viewed by the radar, microwave, & lidars
  - instead of the whole hemisphere
- Work for broken cloud situations
  - instead of overcast clouds only
- Work at cloud speed: 1 sec
  - instead of 20-sec to 1-min resolution or worse

Can achieve all these by using narrowband zenith radiance !!

Review: The family tree of ARM zenith radiance measurements

1NFOV

2NFOV

4NFOV
6NFOV

SWS
418NFOV

AERONET

Cimel at SGP now works in "cloud mode"

Normal aerosol mode
(sun-seeking)

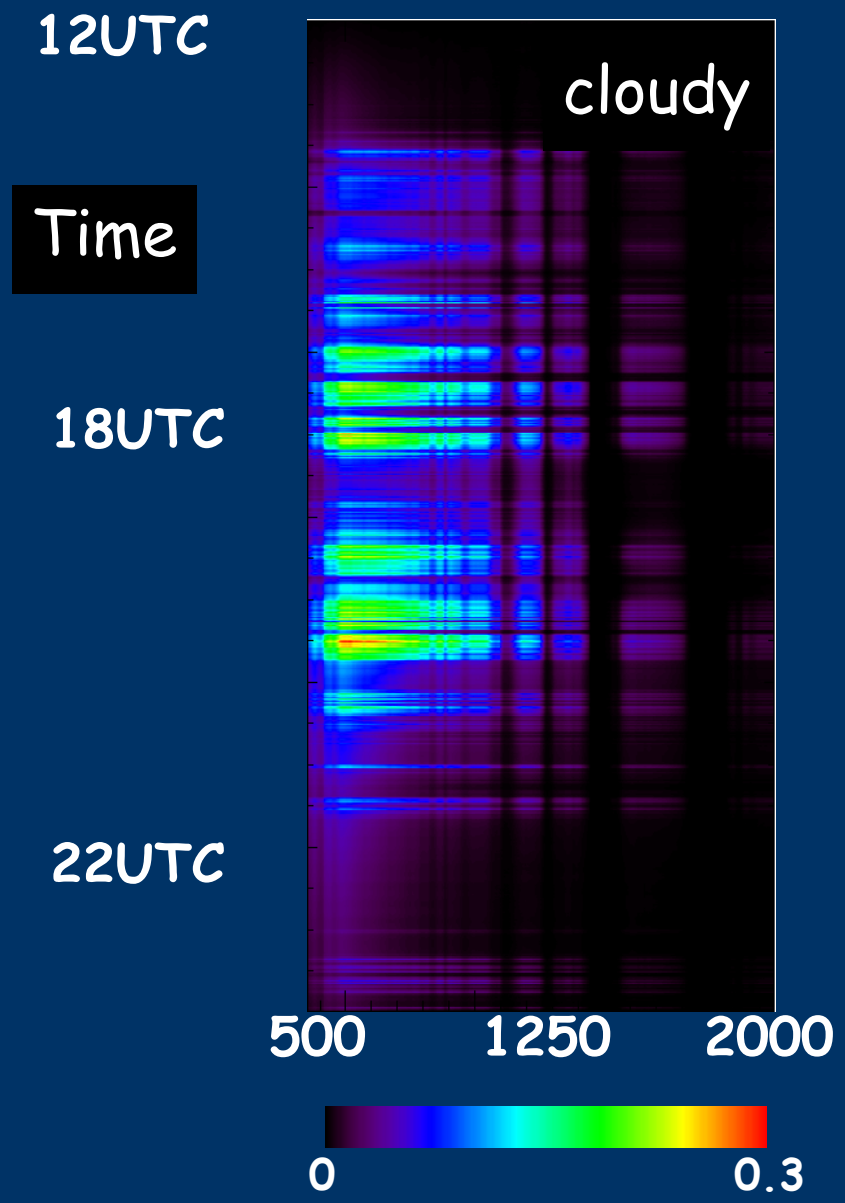
Cloud mode
(zenith-pointing)

ARM Shortwave Spectrometer (SWS)

- FOV = 1.4°
- wavelength range: 350-2170 nm
- 1-s sampling
- installed in Apr 06
- weekly calibrated

Courtesy of Dr. Pilewskie

SWS zenith radiance : time-wavelen contours



- 675 nm (RED)
- 870 nm (NIR)
- 1640 nm (MIR)

From REDvsNIR method :
retrieve Cloud optical depth & effective cloud fraction

Courtesy of Dr. Pilewskie

Use 1640 nm (water absorbing wavelength) to retrieve drop size

Larger droplets have:

- Stronger forward scattering
- Stronger absorption

From satellites:

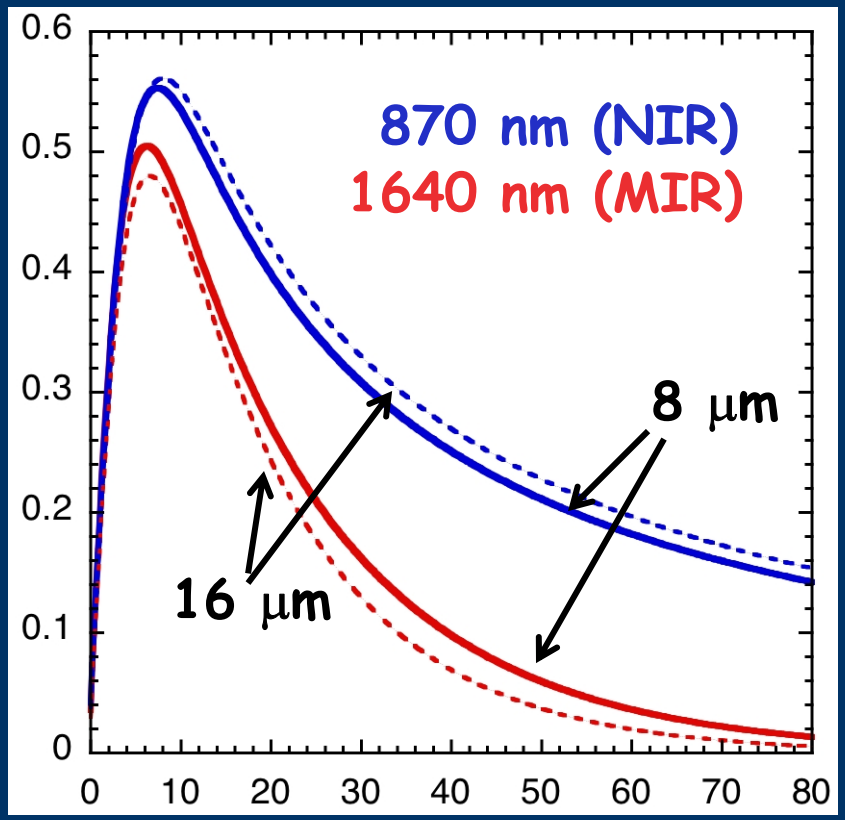
- These two factors both reduce reflectance (Nakajima & King, 1990)

From surface:

- These two factors compete (Rawlins & Foot, 1990; Platnick, 2000)

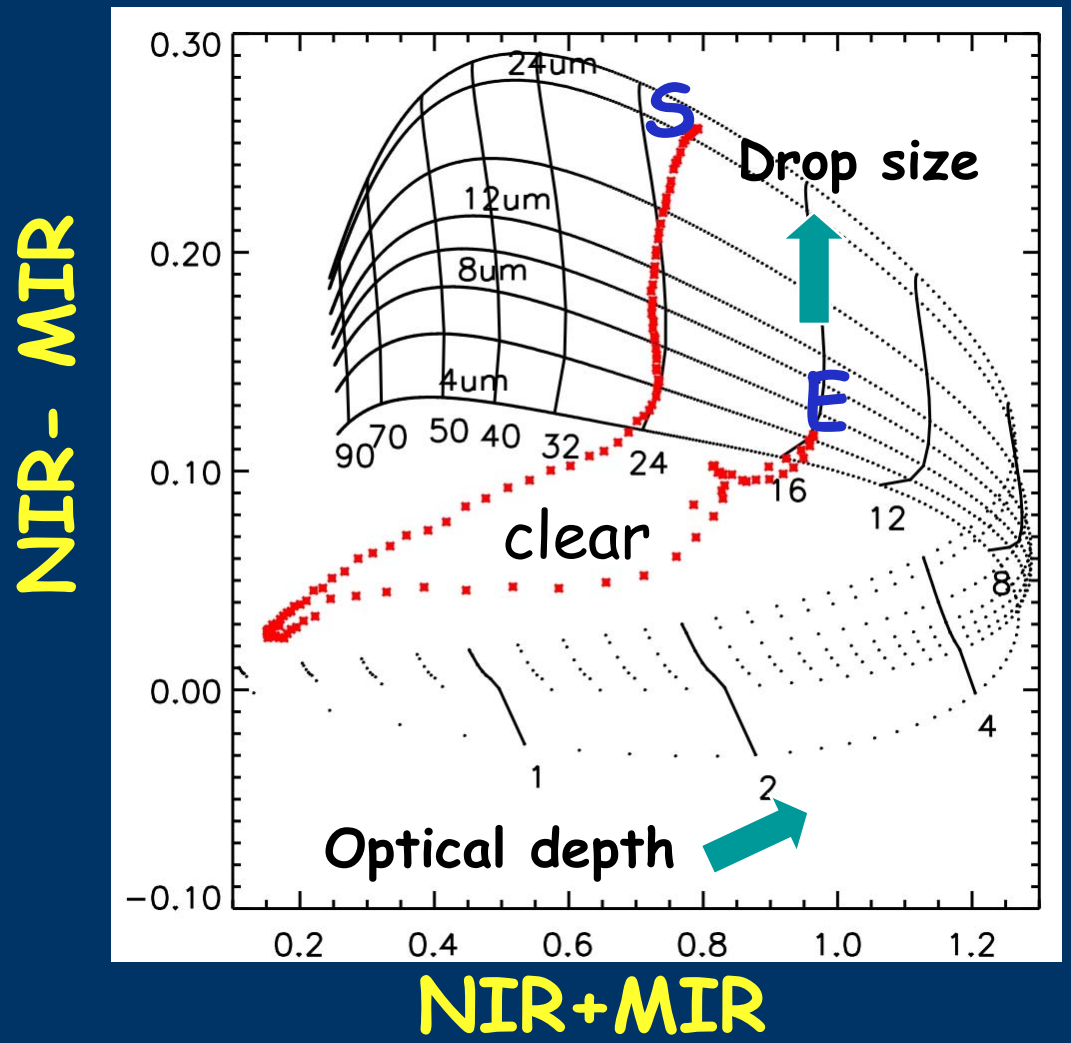
Retrieve effective radius of cloud droplets from 870 (NIR) & 1640 nm (MIR)

Zenith Radiance



Cloud optical depth

Retrieval method for drop size: example time series (red dots)

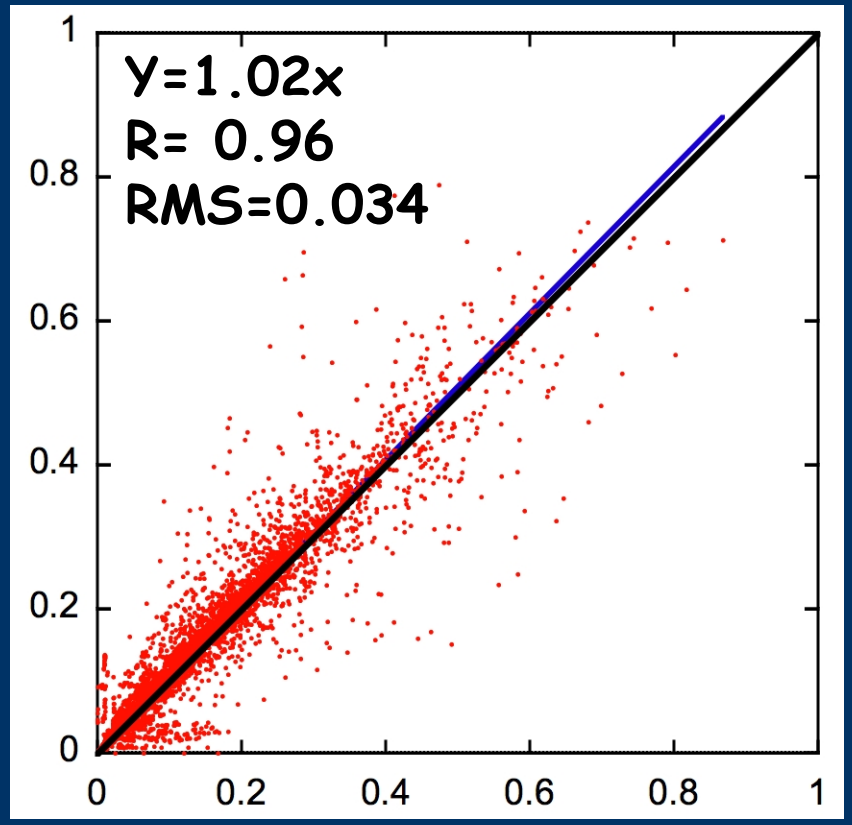


can watch drops shrinking into a clear-sky period

SWS & Cimel are set up next to each other

Scatter plot of SWS vs Cimel radiance at *675* nm (RED)

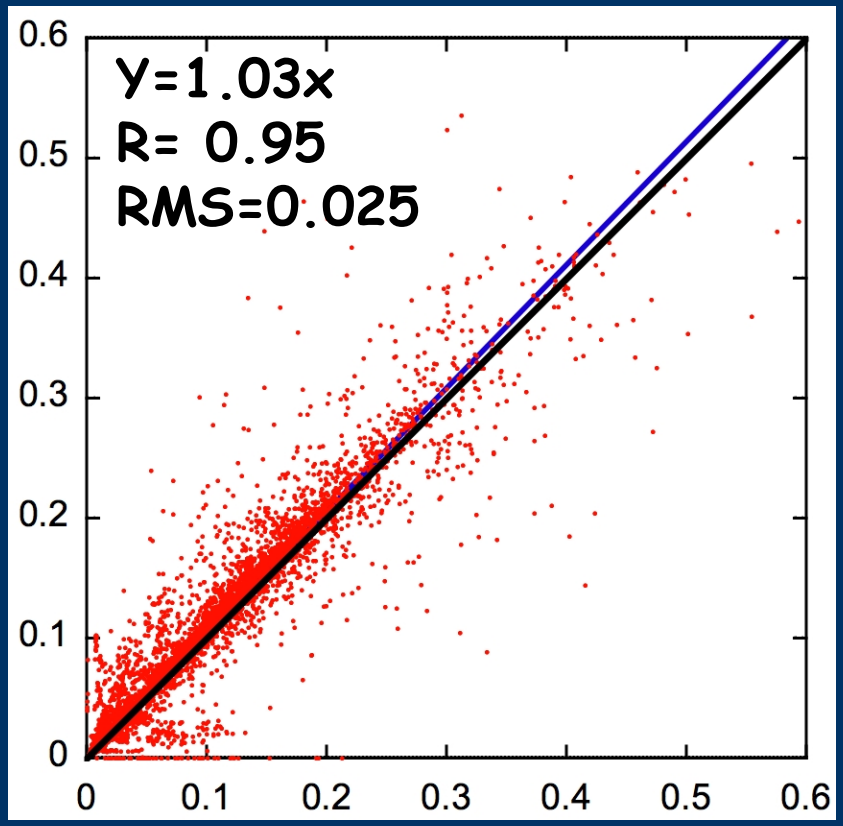
SWS



Zenith radiance (W m^{-2} nm^{-1} sr^{-1}) from Cimel

Scatter plot of SWS vs Cimel radiance at *870* nm (NIR)

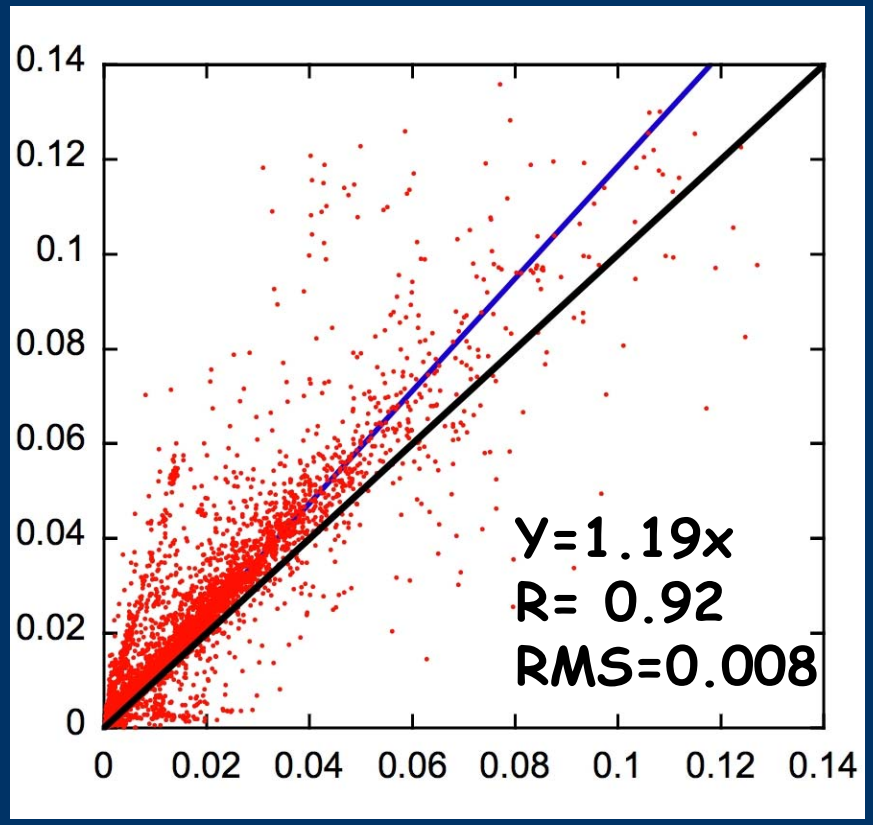
SWS



Zenith radiance (W m^{-2} nm^{-1} sr^{-1}) from Cimel

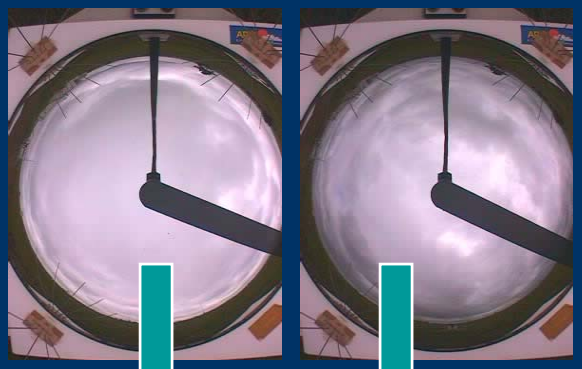
Scatter plot of SWS vs Cimel radiance at *1640* nm

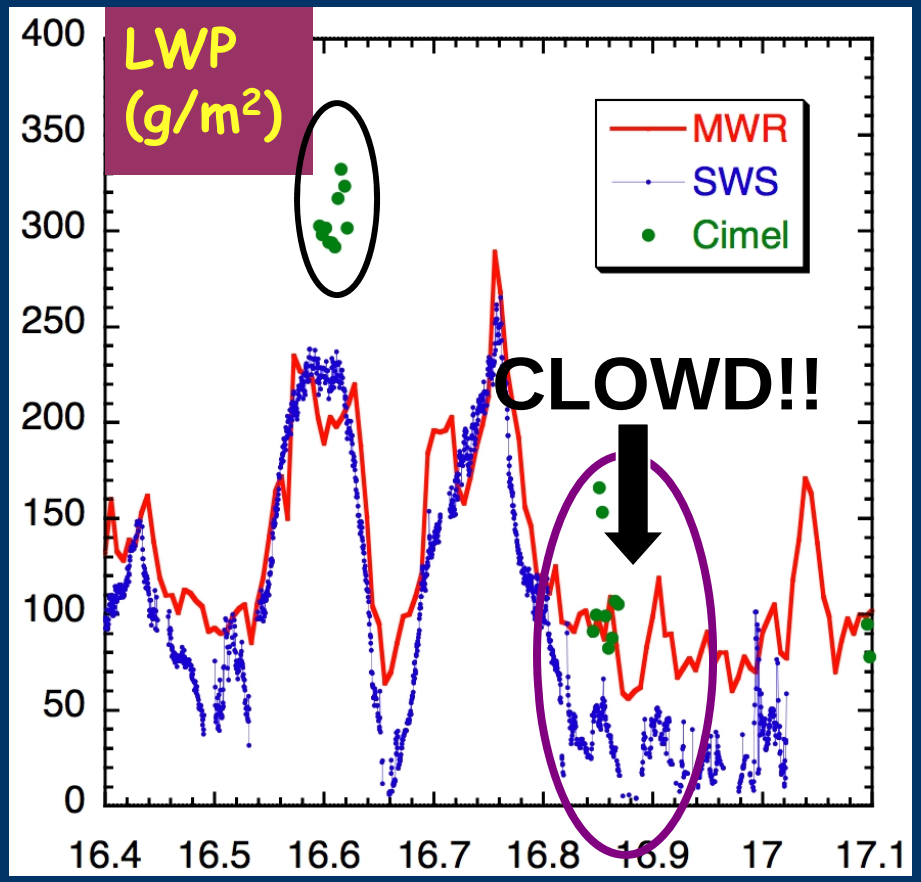
SWS

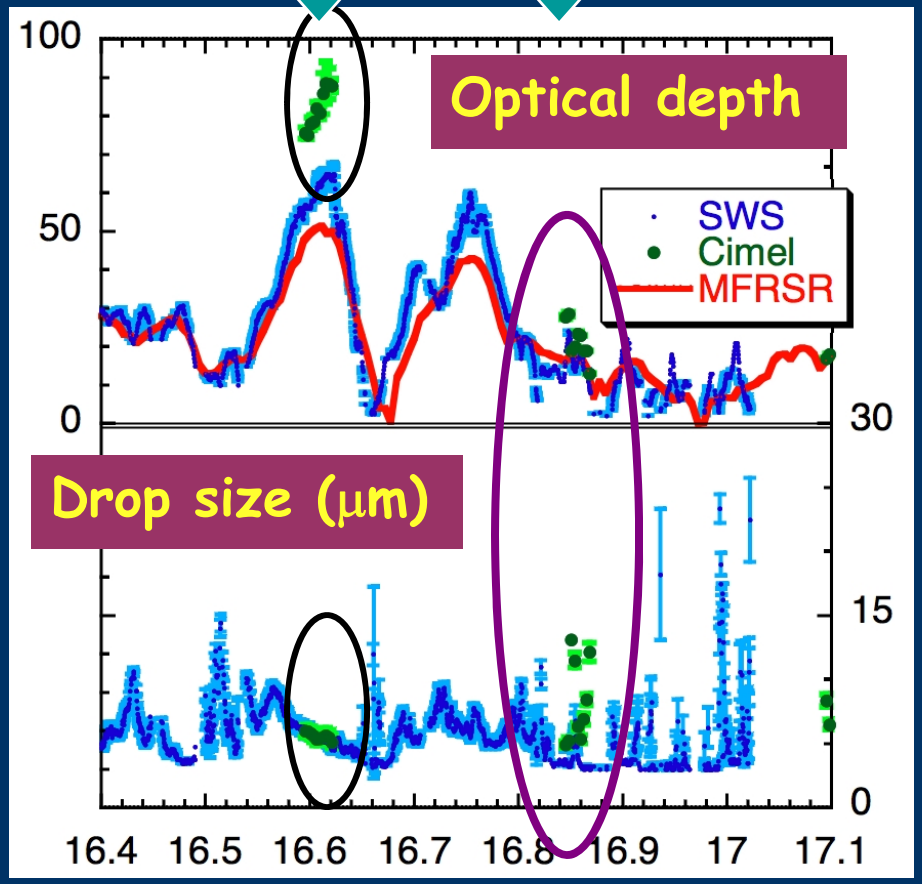


Zenith radiance (W m^{-2} nm^{-1} sr^{-1}) from Cimel

Compare liquid water path retrieved from MWR, SWS and Cimel







Time (UTC)

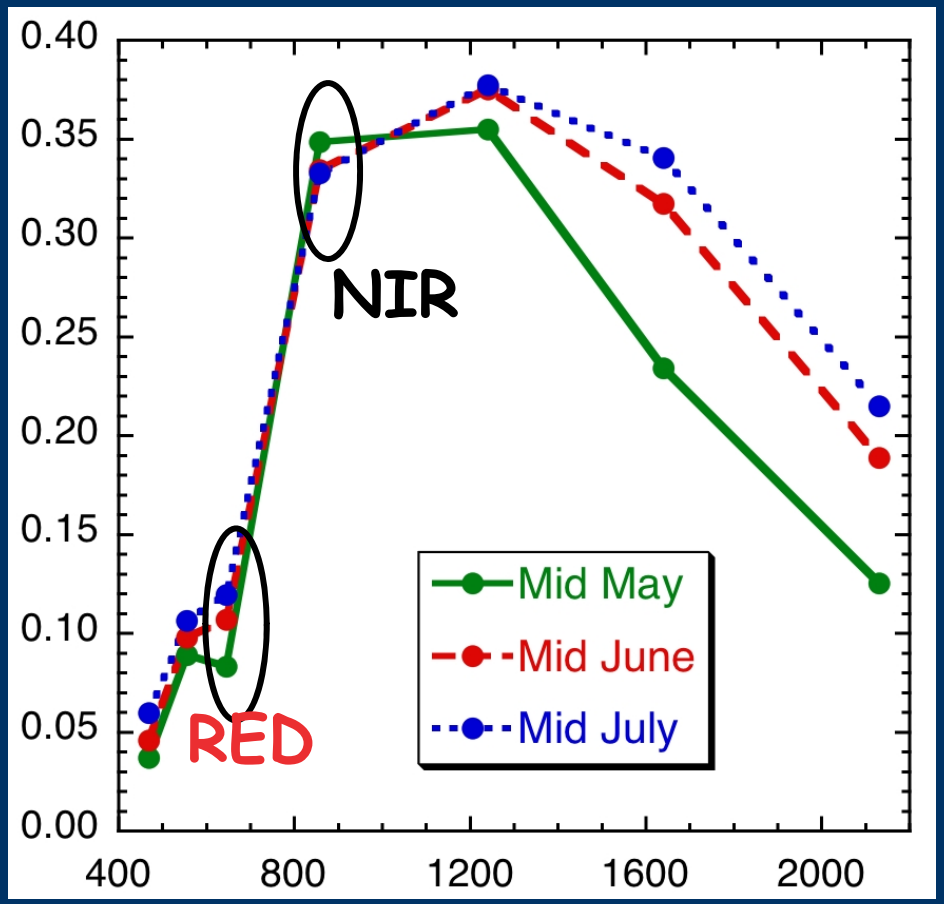
Summary

- Retrieval results are promising even though there is a significant uncertainty in measurements at 1640 nm for both shortwave spectrometer (SWS) and Cimel sunphotometer.
- We will check CLASIC data to see if they can help to evaluate liquid water path retrieved from microwave radiometer, SWS, and Cimel.
- We will move on and take full advantage of the whole SWS's spectrum .

The two wavelengths of the 2NFOV were chosen on either side of the "red edge" in vegetation albedo to implement our REDvsNIR method

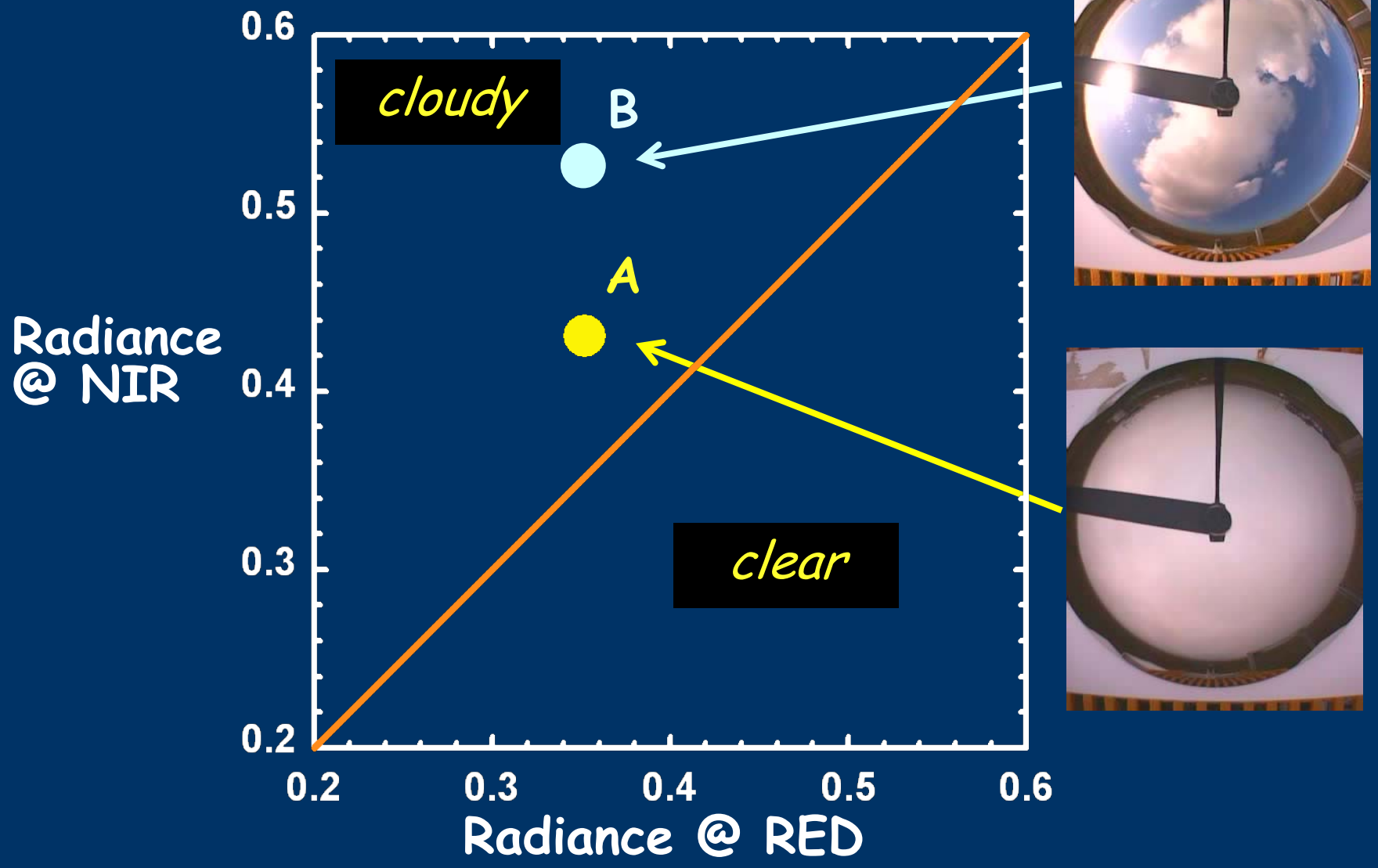
Surface albedo

(MODIS/ Terra)



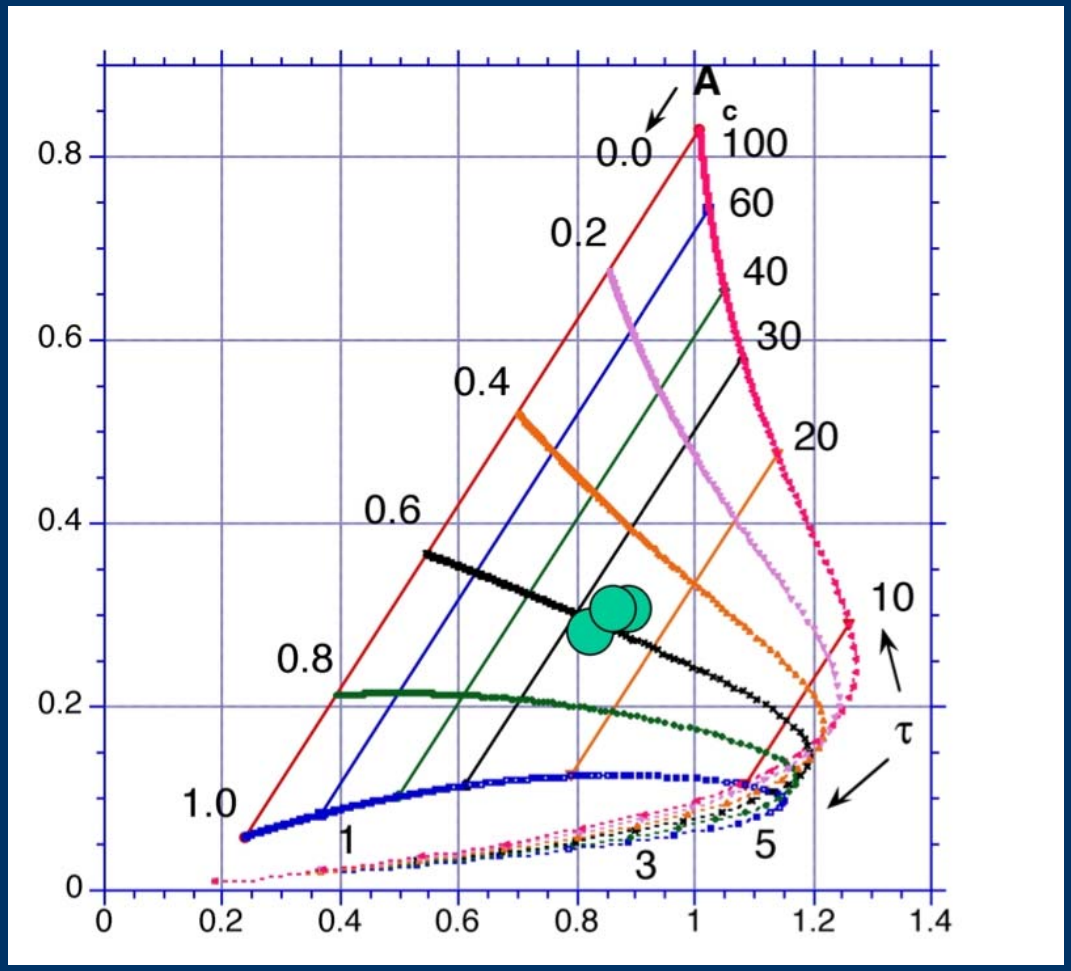
Wavelength (nm)

A schematic illustration of our REDvsNIR retrieval method



Retrieval method for cloud optical depth & effective cloud fraction (REDvsNIR)

NIR – RED

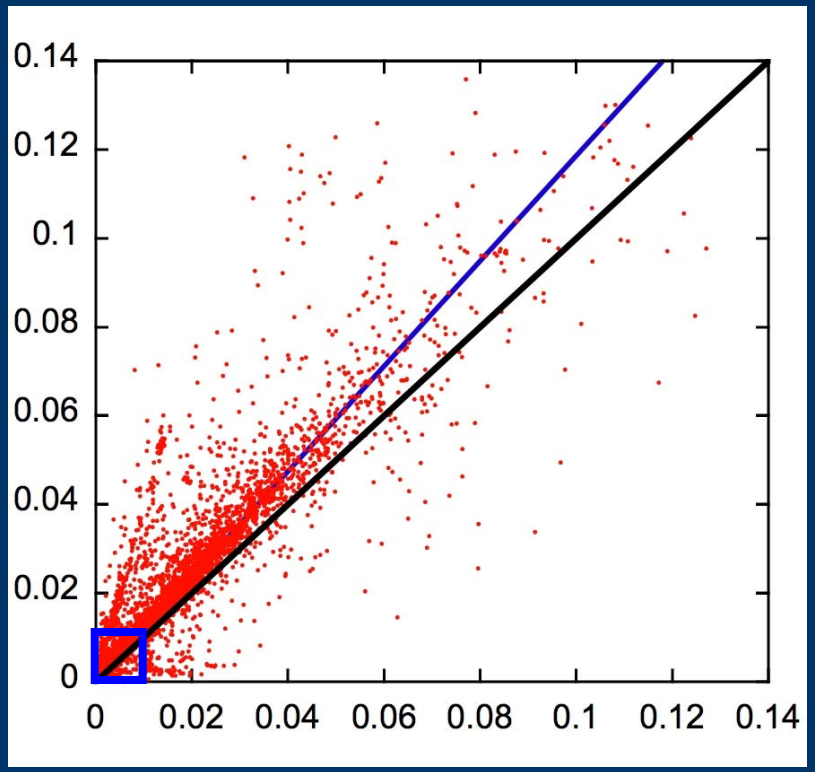


NIR + RED

There might be a number of factors contributing the difference

Zenith radiance

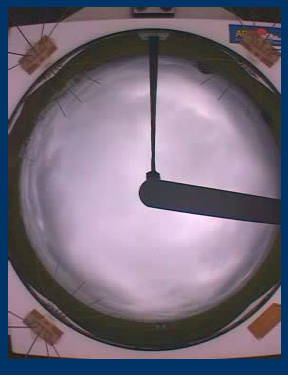
SWS

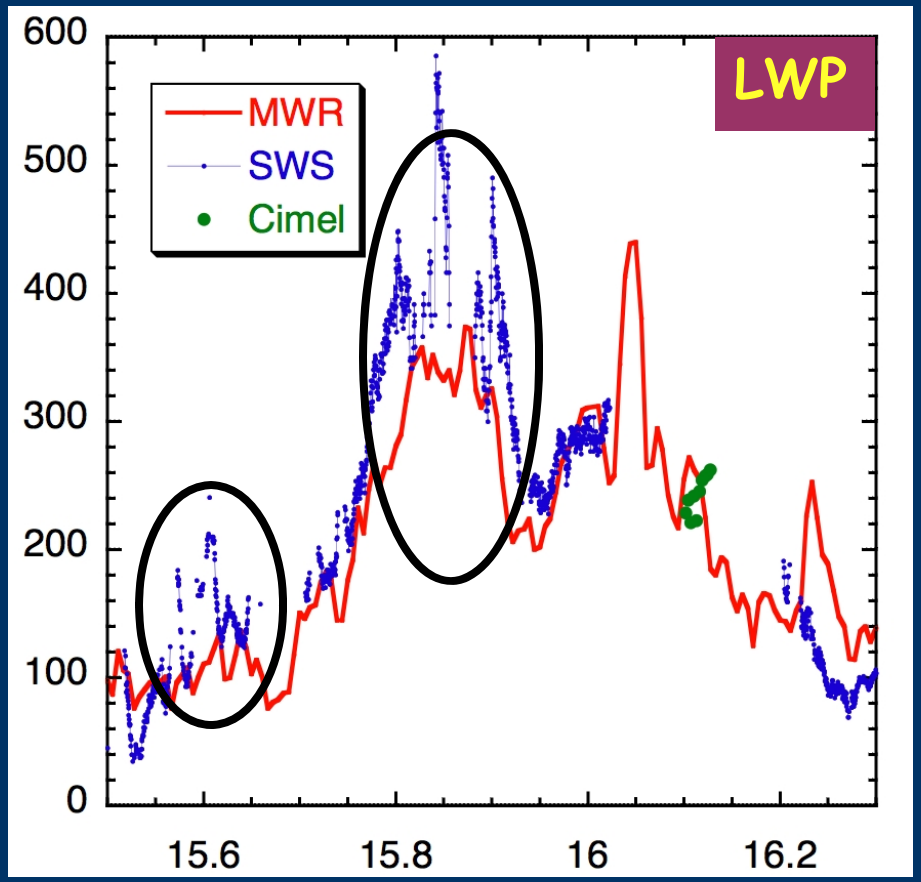


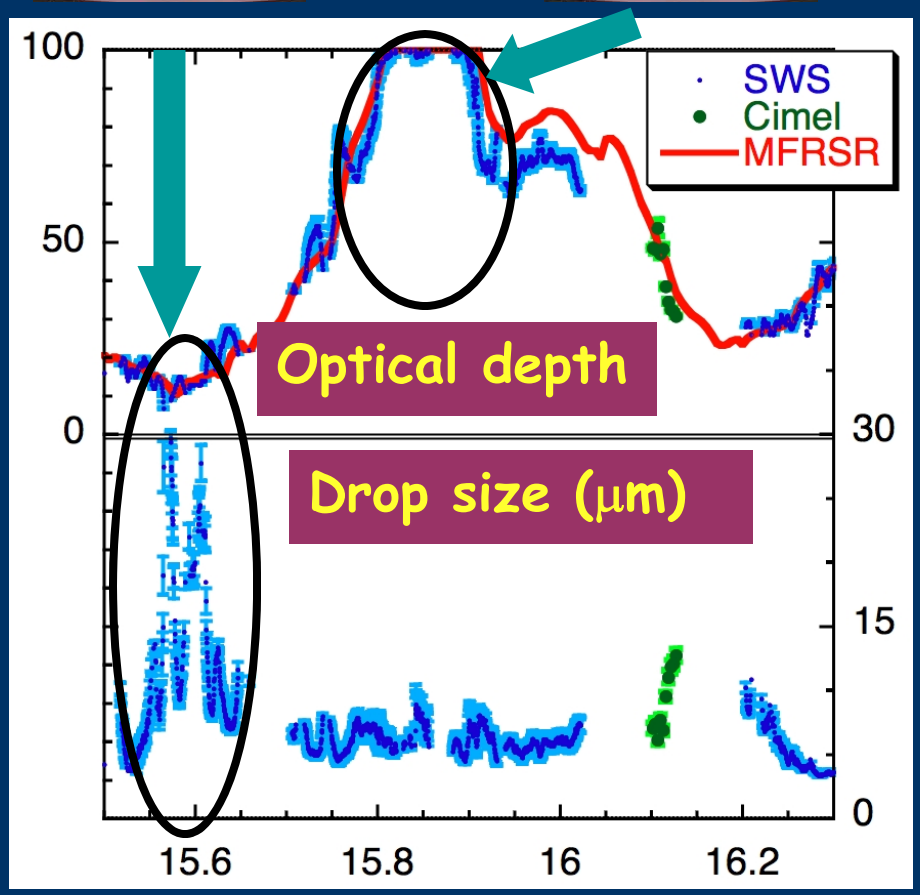
Cimel_K

- Thermal drift
- Integration time: 300 ms vs instantaneous
- Filter response function
  Cimel has a much broader filter function than SWS does at 1640 nm

Compare liquid water path retrieved from MWR, SWS and Cimel







Time (UTC)