Lidar solar background for retrievals of cloud optical depth

Alexander Marshak
Christine Chiu
Warren Wiscombe

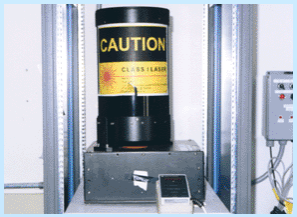
Raman lidar

MP
L

Lidar solar background for retrievals of cloud optical depth

Raman lidar

MPL



Idea:

Use a lidar solar background "noise" as a *very*-narrow-field-of-view one-channel radiometer.

Technique:

A double-value "zenith radiance vs. cloud optical depth" relationship

plus

a binary information from the same lidar on whether cloud is "thick" or "thin."

Advantages:

- New use of freely available information;
- Both cloud and aerosol properties can be retrieved using a single lidar.

Limitations:

- Cloud brokenness may cause serious problems;
- Optical depth between 4 and 12 is hard to discriminate.

The Main Idea

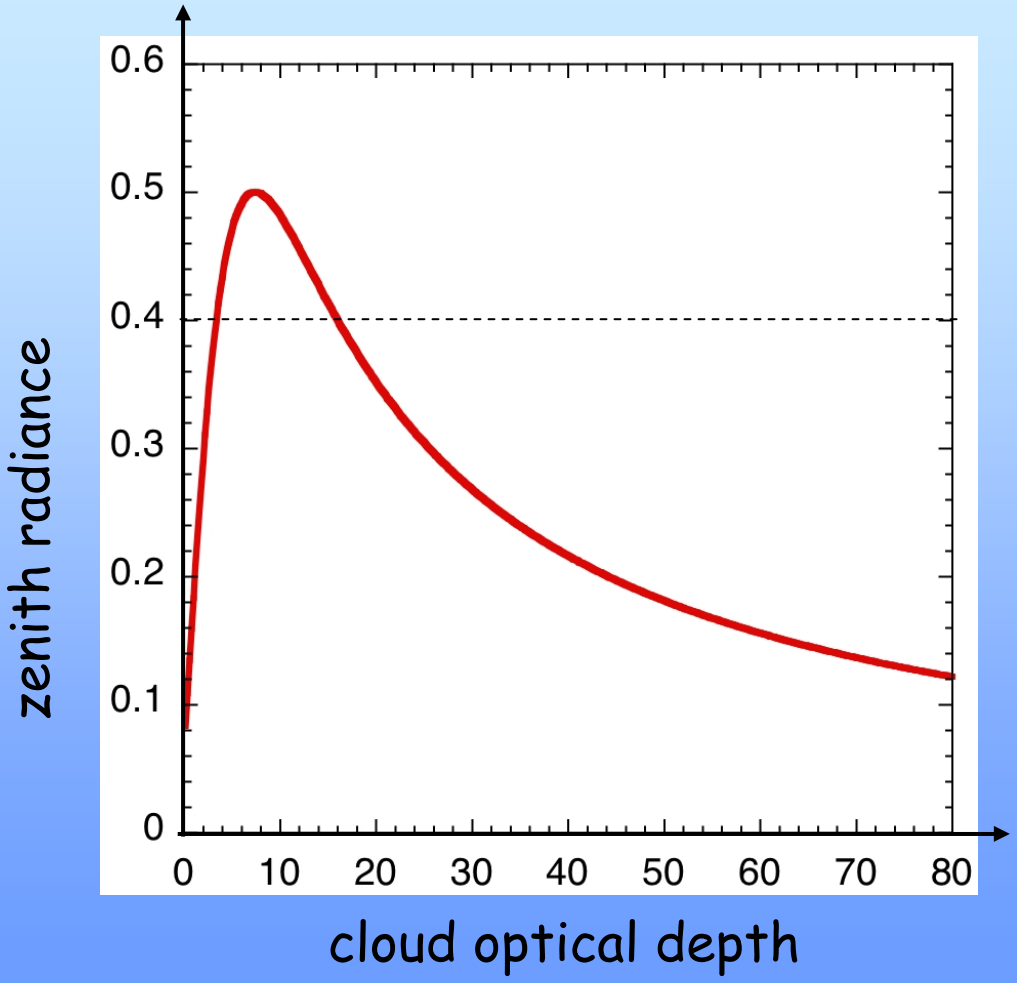
To use a lidar as a *very*-narrow-field-of-view one-channel radiometer with *calibrated* solar background "noise" as measured zenith radiance.

MPL handbook says only that
"to reduce uncertainty in cloud base determination, solar background *noise* should be subtracted."

Is it anything else in the solar background signal that can be used for retrievals of cloud optical properties?

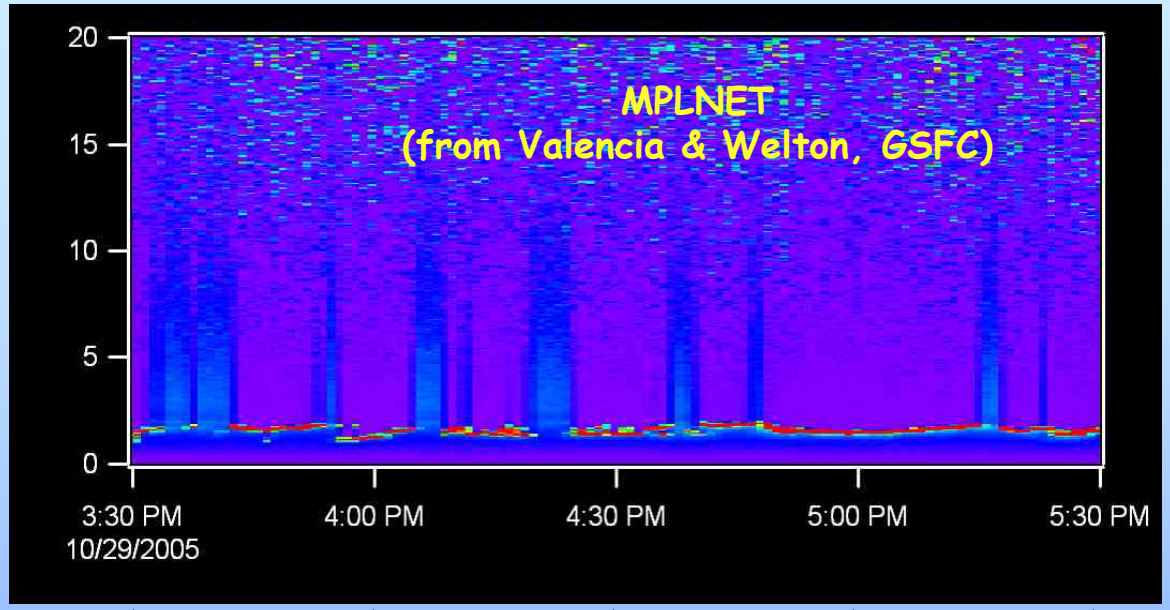
Physics behind

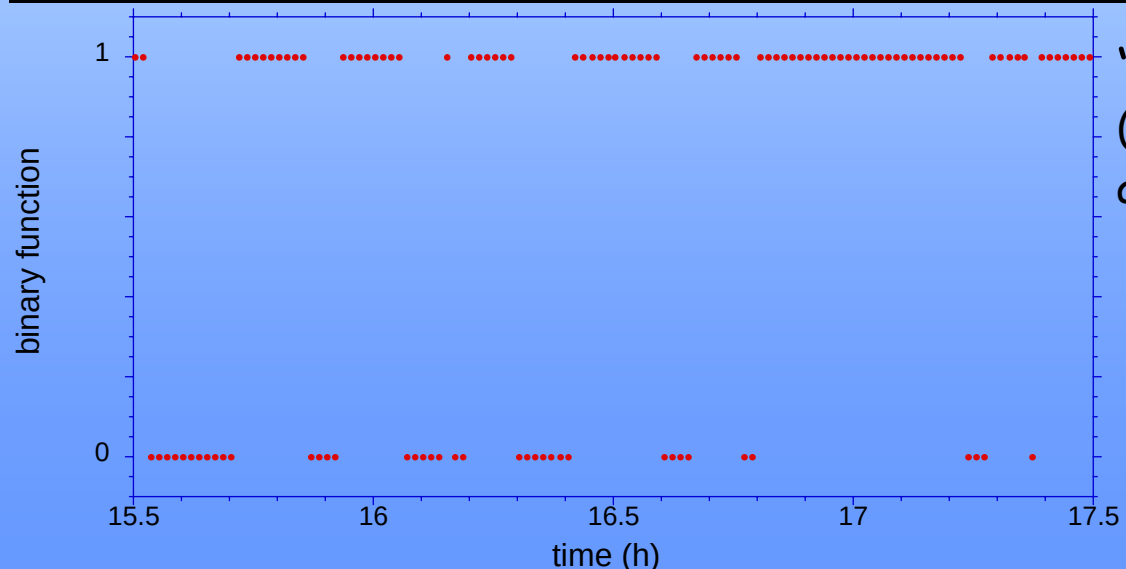
A double-value "zenith radiance vs. cloud optical depth" relationship.



Physics behind

A laser beam cannot penetrate through a cloud thicker than opt. depth 2-3



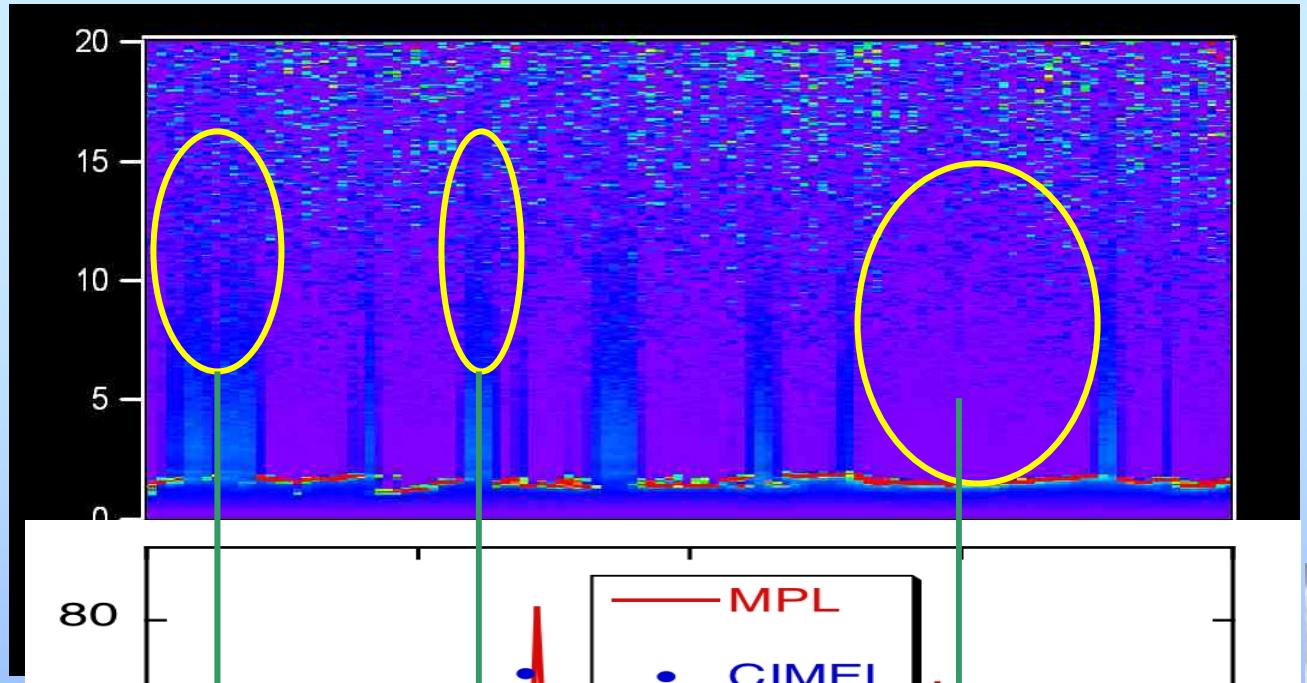


"Thick" cloud
(signal is completely attenuated)

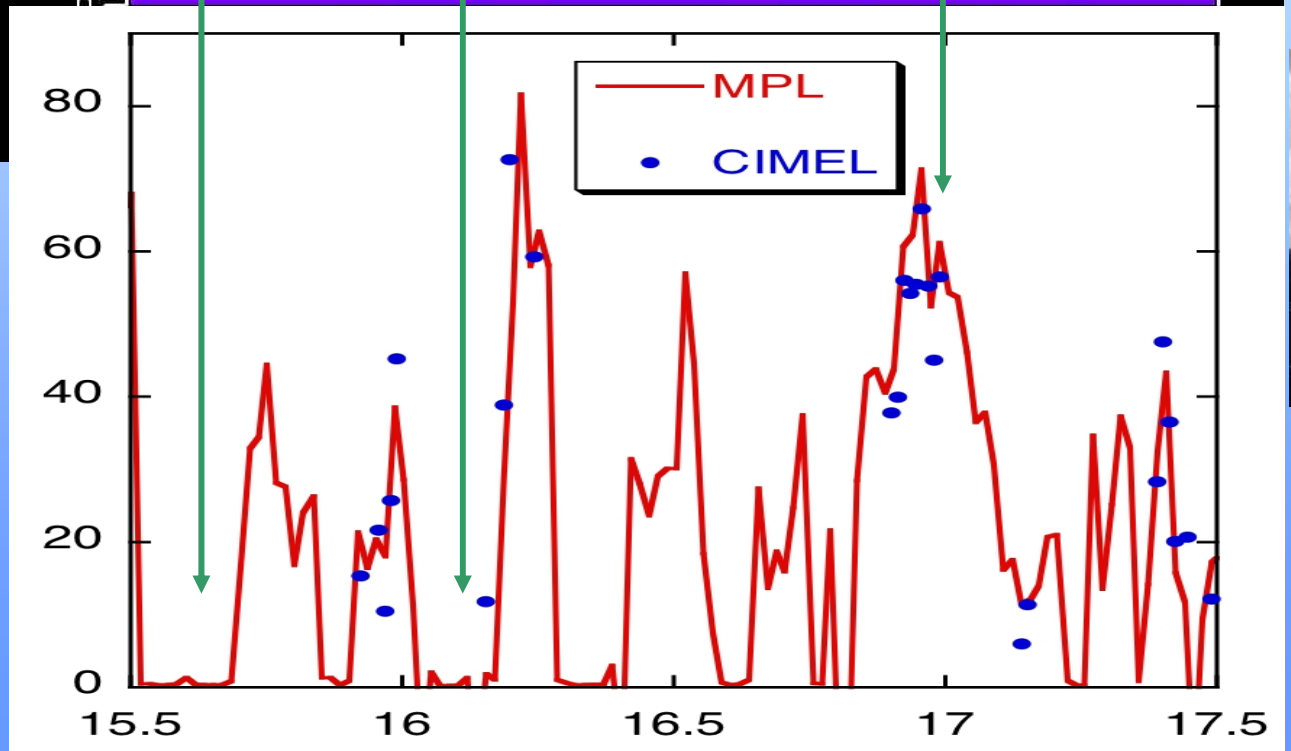
"Thin" cloud

Example: Goddard MPL (Oct. 29, 2005)

Altitude (km)



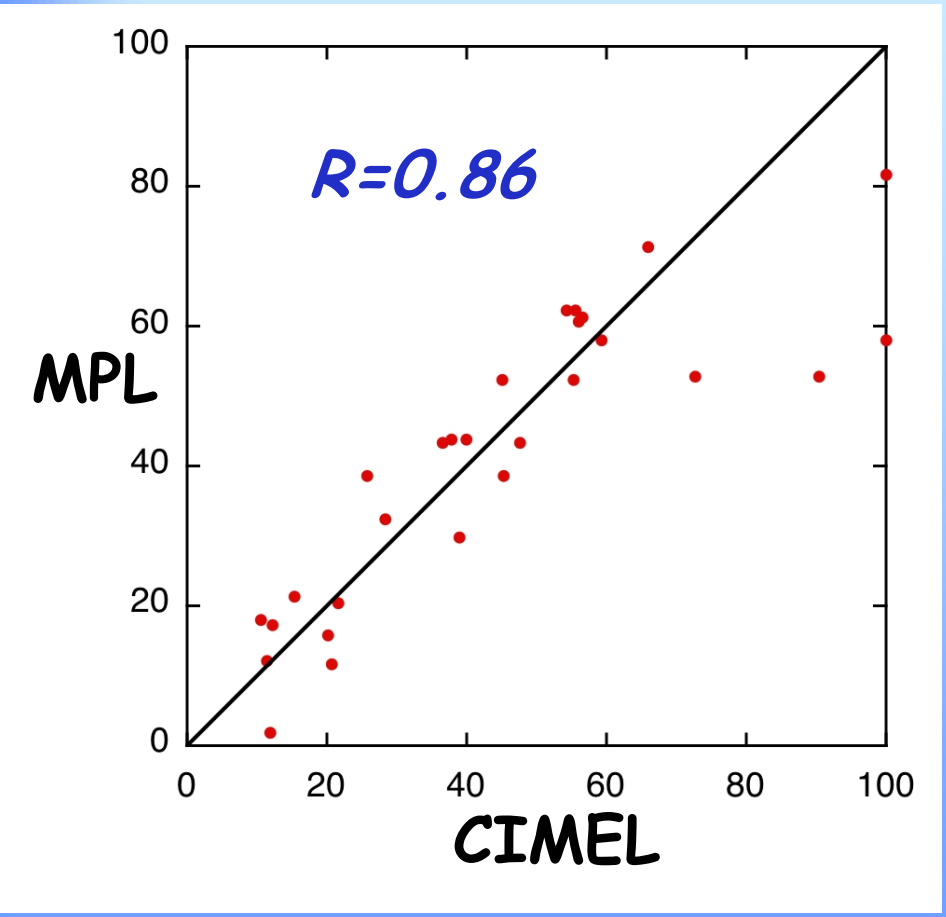
Retrieved cloud optical depth

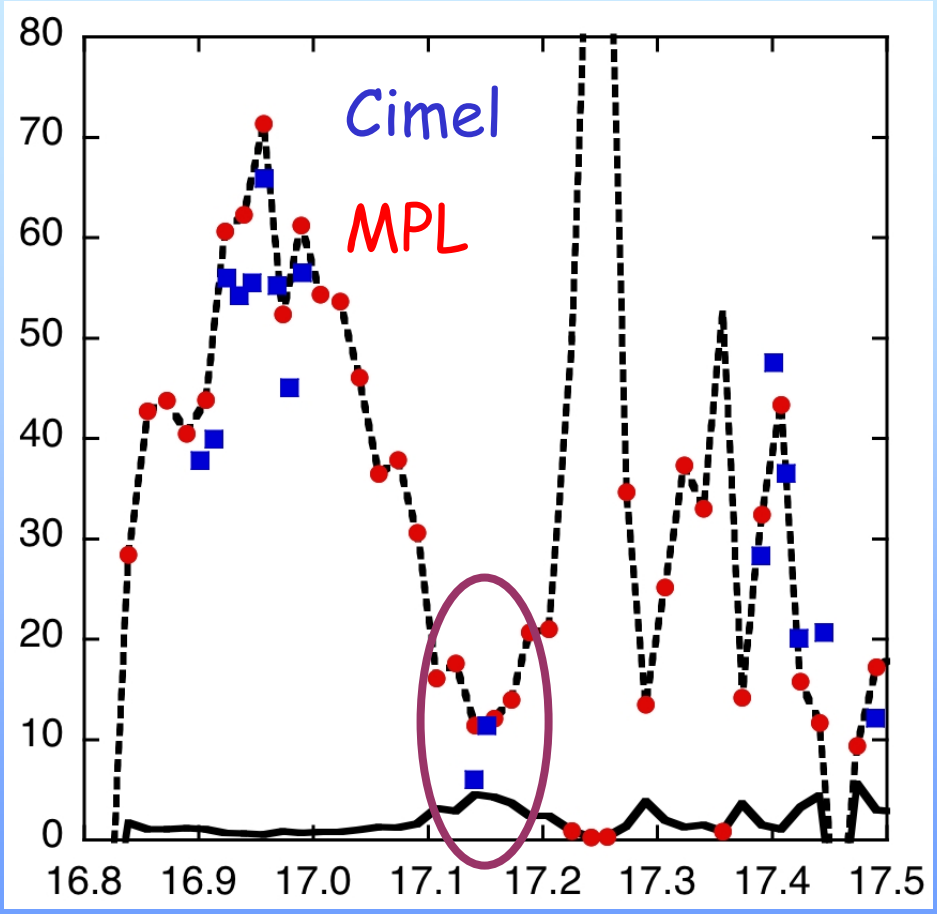


Time (UTC)

Cimel in a cloud mode

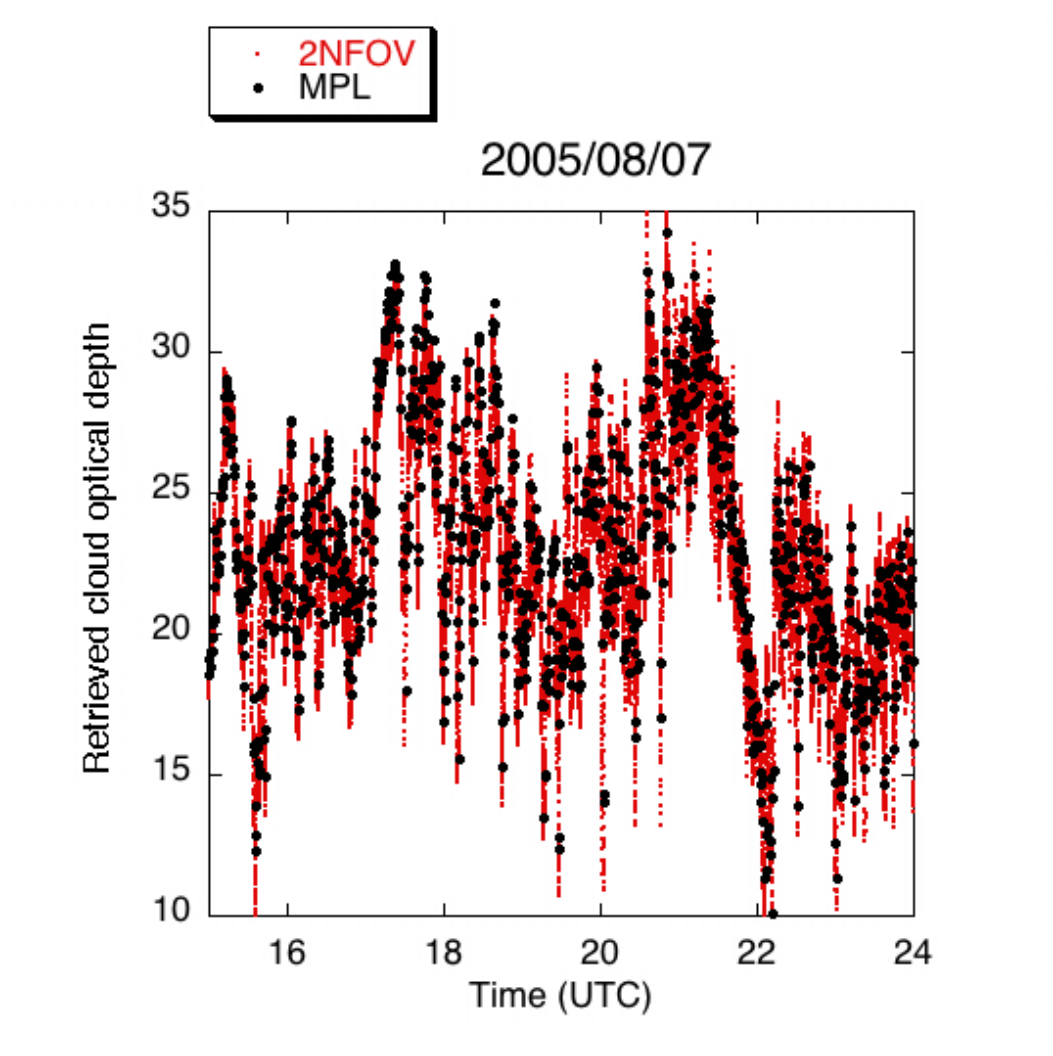
Example: Goddard MPL (Oct. 29, 2005)



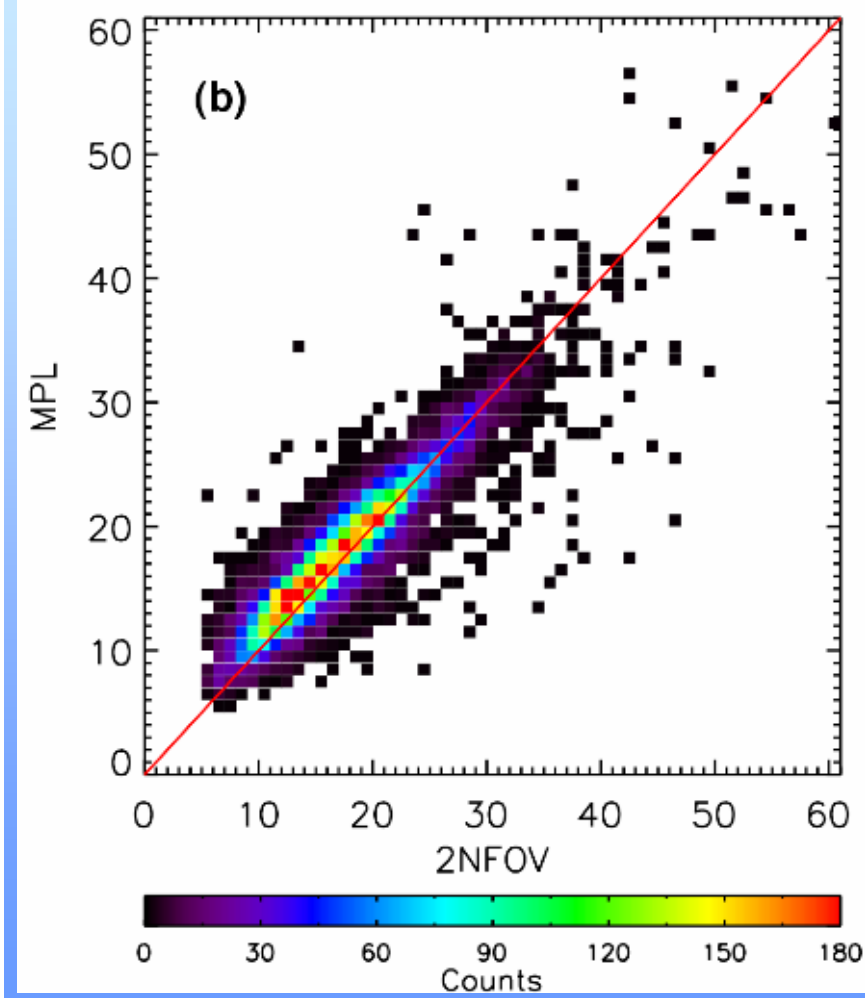


Example: ARM MF MPL (Point Reyes, CA)

One day

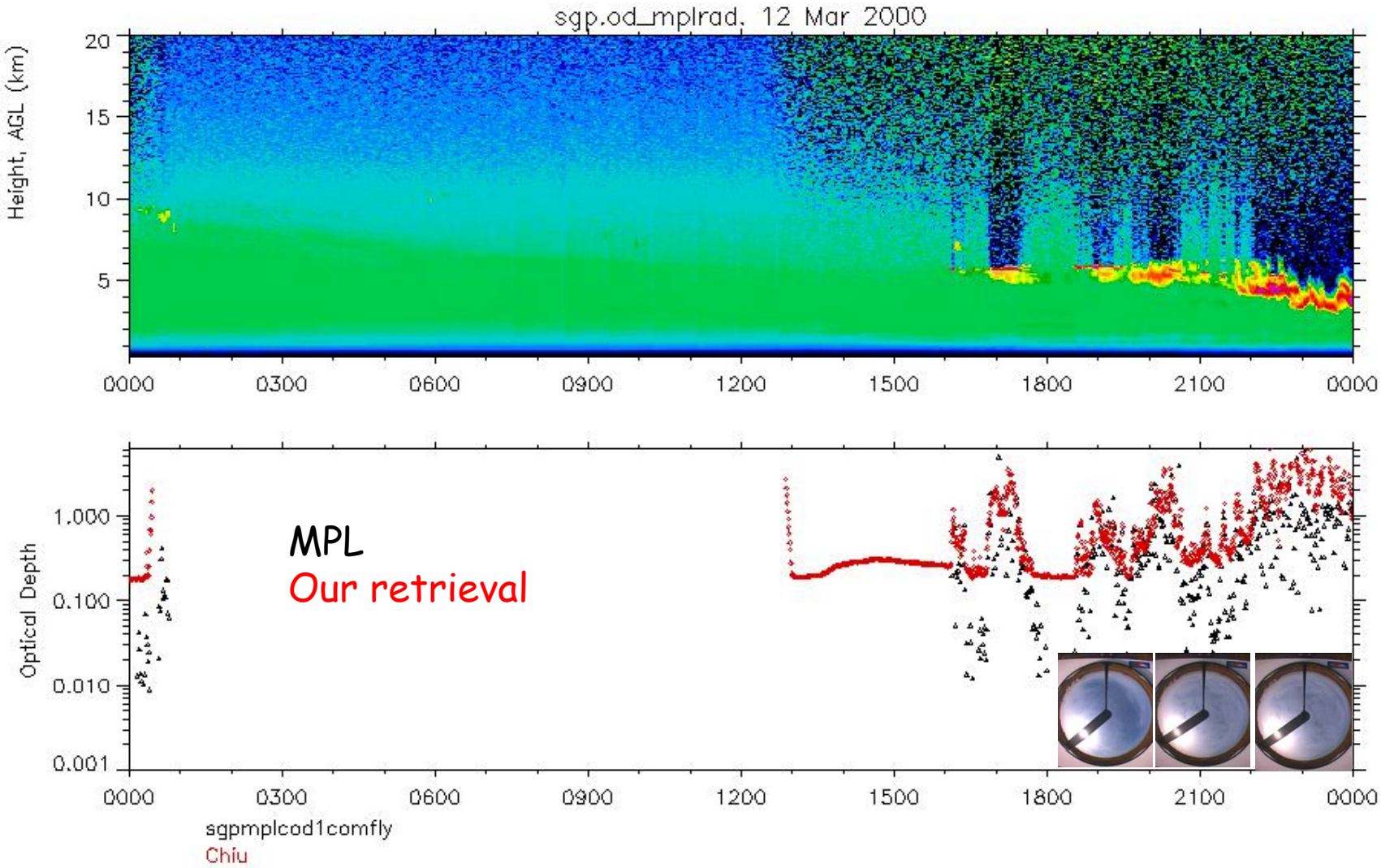


Total statistics (Jun. -Sep., 05) for overcast days

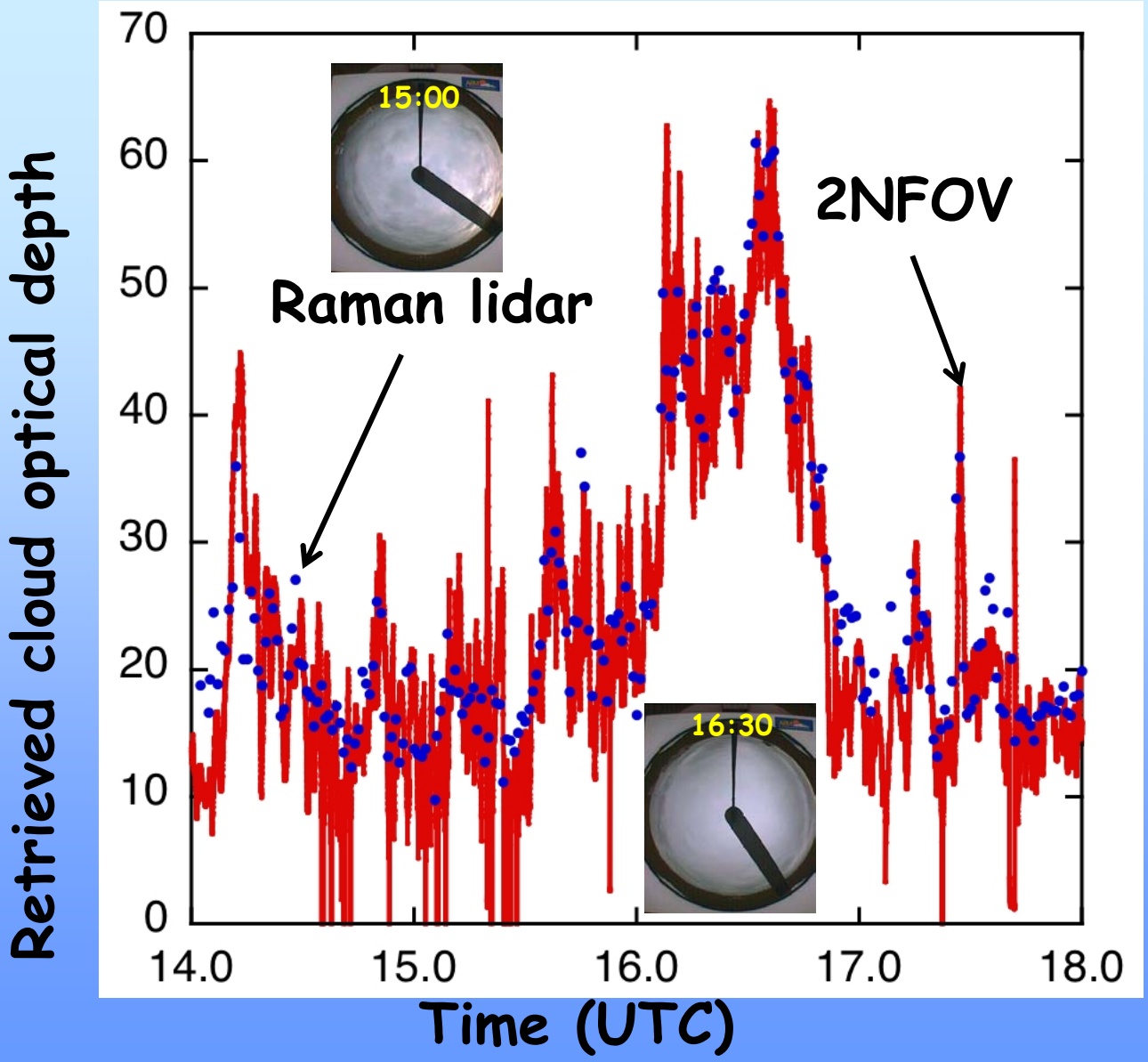


Example: SGP MPL (Mar. 12, 2000)

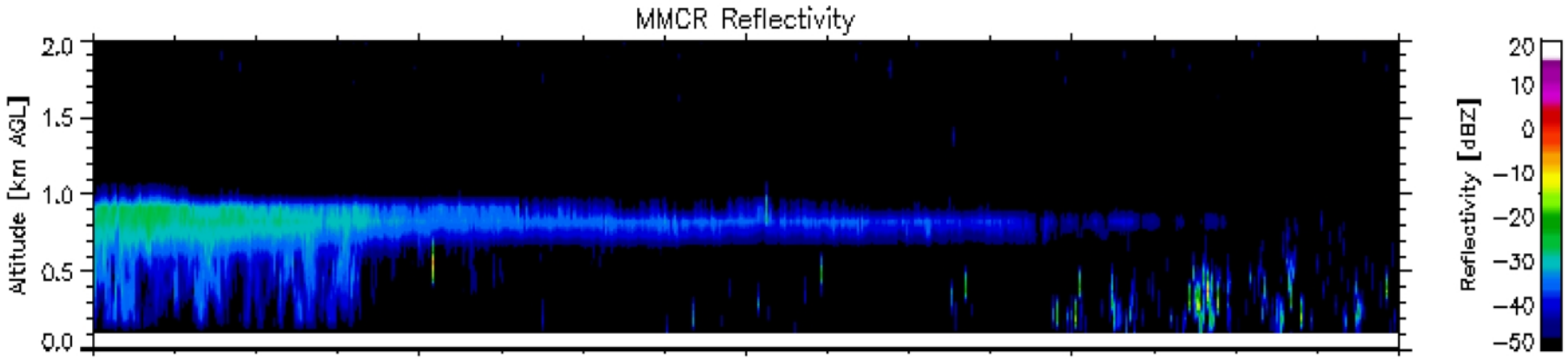
Thin clouds

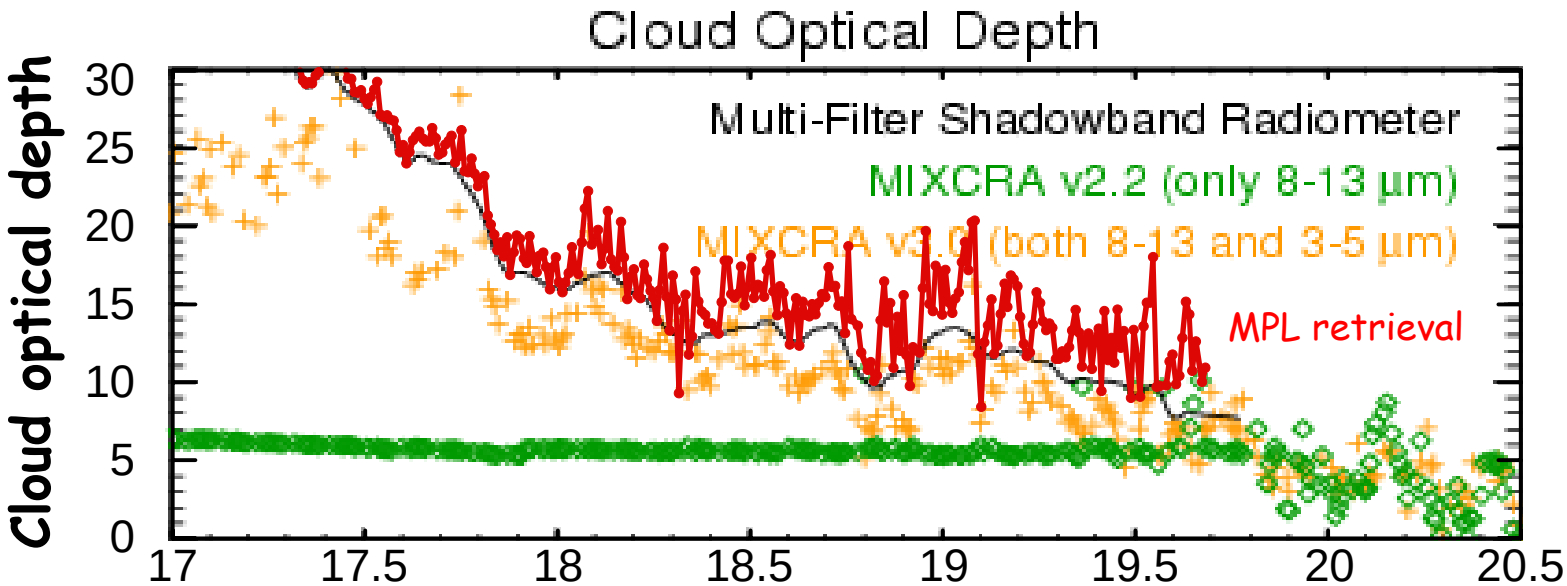


Example: SGP Raman Lidar (Nov. 11, 2004)



Final example: CLOWD case (Nov. 6, 2003)





Advantages

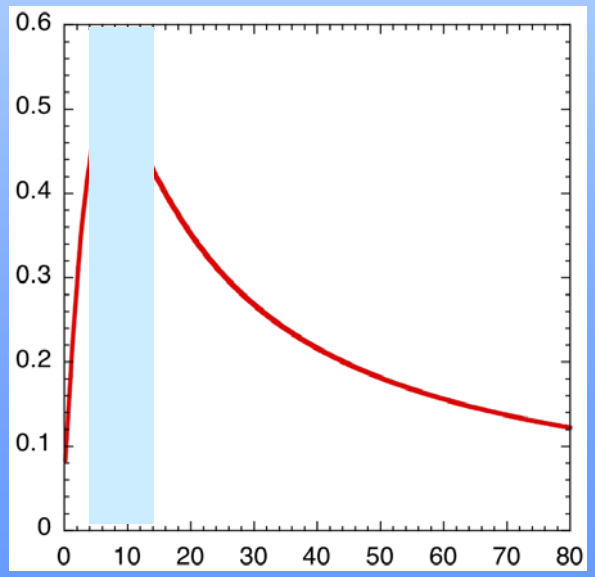
- New use of freely available information;

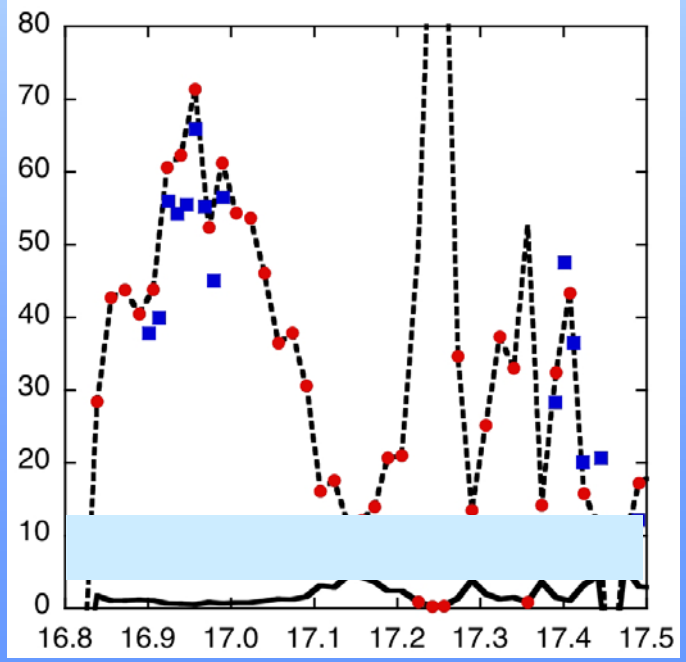
- In general, both cloud and aerosol properties can be retrieved (simultaneously) using a single instrument.

Limitations

- Cloud brokenness may cause serious problems. This is a one-channel 1D retrieval.

- Optical depth in the range between ~4 and ~12 is hard to discriminate.





Help needed

- Calibration of the solar background
  - Solar background signal is estimated in units of photon counts;
  - Need to convert to actual radiance;
  - The conversion is instrument dependent.
- Retrieval of aerosol optical depth below thick clouds
  - make assumptions on the backscattering-extinction ratio;
  - use clear sky intervals for reference;
  - … .

Summary

Idea:
Use a lidar solar background "noise" as a *very*-narrow-field-of-view one-channel radiometer.

Technique:
A double-value "zenith radiance vs. cloud optical depth" relationship
plus
a binary information from the same lidar on whether cloud is "thick" or "thin."

Advantages:
- New use of freely available information;
- Both cloud and aerosol properties can be retrieved using a single lidar.

Limitations:
- Cloud brokenness may cause serious problems;
- Optical depth between 4 and 12 is hard to discriminate.

Help is needed:
- to calibrate the solar background (signal) noise;
- to retrieve aerosol optical depth below thick clouds.

Reference:
Chiu J.C., A. Marshak, W. J. Wiscombe, E. J. Welton, and S. C. Valencia, 2006. Cloud optical depth retrievals from solar background "signal" of micropulse lidars. *Geosci. Remote Sens. Lett.* (in press)