Using Lidars to Retrieve Optical Depth of Thick Clouds

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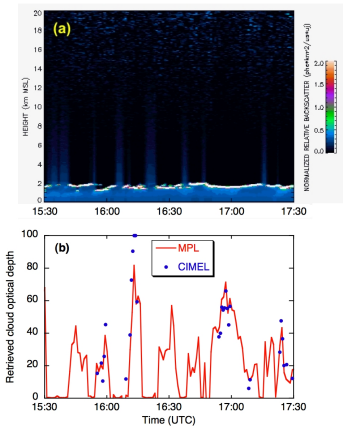
Research Highlight

Surface based pulsed lidars are increasingly used to retrieve vertical distributions of cloud and aerosol layers, for example in the growing network called MPLNET. It is widely believed that lidar cloud retrievals (other than cloud base altitude) are limited to optically thin clouds, because the active laser pulse becomes attenuated very quickly in thick clouds. However, recent ARM research demonstrated that lidars can retrieve optical depths of thick clouds as well.

This new finding is achieved by using the lidar's solar background measurement as a signal. Lidars receive this solar background light in addition to backscattered laser light. These measured photon counts are typically converted to attenuated backscatter profiles (upper figure). During the process, the solar background light is treated as a noise and removed. However, one person's noise is another person's signal. When lidars point straight up, the solar background noise is the solar zenith radiance, which can be used to retrieve cloud optical depth (lower figure).

This idea was tested for various cloud cases and locations. Validations against competing instruments show that retrieved cloud optical depths agree within 10-15% for cases of overcast stratus and broken clouds. Thus, for broken clouds, using a lidar in both passive and active mode, one can retrieve the aerosol properties in clear-sky periods and also the optical depth of clouds in cloudy periods. This makes possible the study of aerosol-cloud interactions with a single instrument.

This new method also provides an excellent opportunity to explore the relationship between cloud-base height and optical depth for all clouds. Such relationships are important for understanding the overall laws of cloud behavior and for parameterizing clouds in climate models.



The upper figure illustrates the micropulse lidar (MPL) backscatter vertical profile during a period of patchy cloud cover (Oct. 29, 2005). The lower figure shows the time series of corresponding cloud optical depth retrieved from an MPL and from a co-located AERONET cimel sunphotometer operated in "cloud mode." These figures show the retrieval ability of lidars for broken clouds. For instance, at 17:00 UTC when lidar pulses are completely attenuated--clouds have larger cloud optical depths. There are some differences in retrievals between lidar and cimel, which is due to different fields of view in these two instruments and slightly different locations. This line of research makes possible the study of aerosol-cloud interactions with a single instrument.

Reference(s)

Chiu, J. C., A. Marshak, W. J. Wiscombe, S. C. Valencia, and E. J. Welton, 2007: Cloud optical depth retrievals from solar background "signal" of micropulse lidars. IEEE Geosci. Remote Sens. Lett., 4(3), 456-460, doi:10.1109/LGRS.2007.896722.

Working Group(s)

Radiative Processes