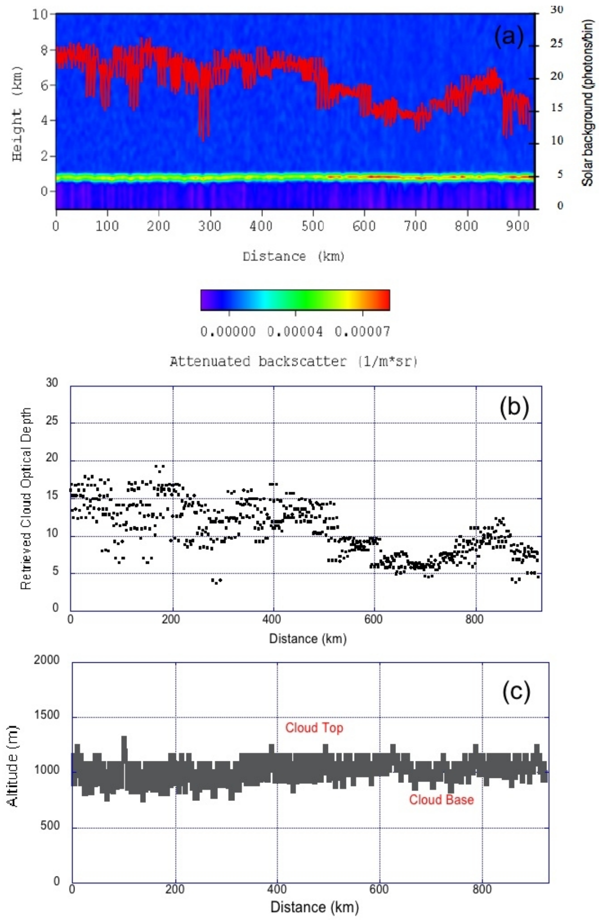
Retrieving thick cloud optical depth from space-borne lidar observations



By emitting laser pulses and measuring the reflected signal, space-borne lidar systems, such as the Geoscience Laser Altimeter System (GLAS) aboard the Ice Cloud and Elevation Satellite (ICESat) spacecraft, provide vertical distribution of cloud and aerosol layers. This retrieval technique is called active remote sensing. For polar regions, space-borne lidars accurately retrieve cloud top height and distinguish clouds from clear areas, which is very difficult to accomplish for passive remote sensing techniques. However, laser beams emitted from space-borne lidars can only penetrate clouds to a limit of a few optical depths. As a result, only the optical depth of thin clouds can be retrieved from the reflected lidar signal. Is it possible to obtain thick cloud optical depths from GLAS and other space-borne lidar instruments? The answer is YES. This can be achieved by calibrating the reflected solar background light received by the GLAS photon detectors. For lidars, the reflected sunlight has been regarded as a noise that needs to be subtracted from the reflected laser signal. However, once calibrated, it becomes a signal that can be used to studying the properties of optically thick clouds. In other words, we use the GLAS detector as a visible radiometer at the lidar wavelength. The above images show how optical depth of thick clouds can be obtained from the calibrated GLAS solar background. Panel (a) displays a marine stratocumulus scene over the southern Pacific Ocean observed by GLAS on November 1, 2003. We plotted here the GLAS 532 nm backscatter image along with the corresponding solar background (red curve). The cloud deck is optically thick and the standard GLAS active remote sensing is unable to retrieve its optical depth. Instead, panel (b) illustrates the cloud optical depth information retrieved from GLAS solar background signal. Finally, panel (c) shows the cloud top and base height of the cloud deck. The cloud top height is detected from GLAS active remote sensing while the cloud geometrical thickness is calculated using an empirical relationship between cloud optical and geometrical thicknesses. More details about these results can be found in a paper Retrievals of thick cloud optical depth from the Geoscience Laser Altimeter System (GLAS) by calibration of solar background signal recently submitted to the Journal of Atmospheric Sciences. To learn how solar background light can be used for ground-based micropulse lidars, see this previous image.

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