Status and Performance of the New Polarized Micro Pulse Lidars

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Introduction

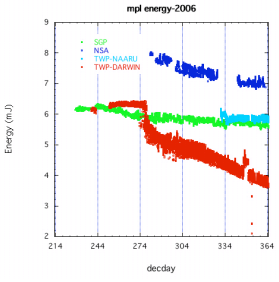
Micro pulse lidars (MPLs) have been used at almost all ARM permanent sites for many years, principally for cloud detection to large heights (15 km or more). In response to a desire for better definition of the ice content of clouds, all the ARM MPLs have been replaced during the past 6 months with new, polarized versions. The effort has been generally successful and all new systems are up and running continuously.

Operation

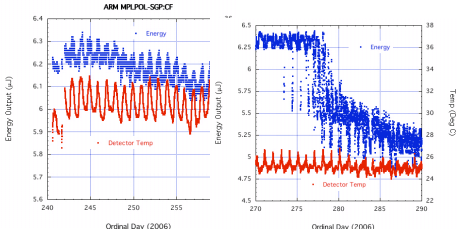
The polarized MPL differs from the previous system by producing alternate 3-sec averages of circularly- and perpendicularly-polarized light at 0.532 nm (green). Parallel polarized light is readily detected by the MPL when scattered from either water, ice, or mixed phase clouds. Perpendicularly polarized light is not detected when scattered from water droplets because they are symmetric. On the other hand, ice crystals are asymmetric and often flat, oriented horizontally; in this case significant scattering of perpendicular polarized light is detectable. Thus a measure of the ratio of the two, called the depolarization ratio, is indicative of the relative amount of ice and water within a cloud. The three-second interleaved data are available from the ARM Data Archive. A more easily managed value added product produces separate data streams of the two polarization states averaged over equivalent 30-sec intervals. This provides data similar in time resolution and data file size to that available from the previous MPLs.

Energy Output

It was anticipated that the transmitter diode would have a lifetime of approximately 1 year before needing replacement. Figure 1 shows the energy output of the polarized mpls through Jan 2007, beginning at their respective deployments. Clearly this may be a problem, at least with some diodes.



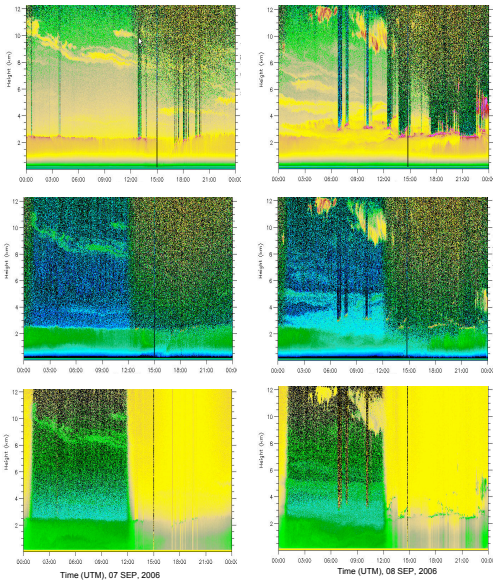
Energy monitor values for four MPLs for 2006. Data are unaveraged, samples at roughly 1 min intervals from both polarization states.



Energy output (blue) and detector temperature (red) as function of time; a) On short time scales, cycling of the air conditioner at SGP is well correlated with energy monitor output variations, b) a similar dependence at Darwin on short time scales is seen but the sudden and continuing decrease in energy output beginning on day 278 is not related to temperature changes.

Example Data

The ARM DQHands web site operated by the data quality team provides excellent examples of the type of data available from the new systems. The figure below shows an example from two consecutive days at the SGP. Perusal of the plots, particularly the lowest, ratio plot shows the presence of significant quantities of ice on the second day (depolarization values approaching the order of 1), but not the first (depolarization ratio values on order 0.1). Note also that polarization returns for aerosols (within the lowest 2 km) are generally small, as is expected from assumed symmetric aerosols.



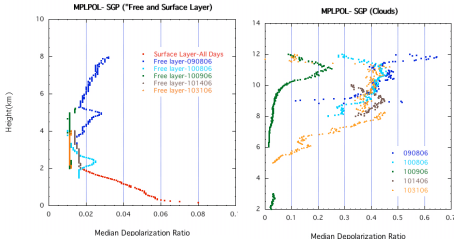
Circularly polarized (top), cross polarized (middle) and ratio of Circular- to Cross-polarized MPL returns from Sept 7 (left) and Sept 8 (right). Note that a logarithmic color scale is used in all cases.

Depolarization Ratios

In order to make some minimal determination that the polarized mpl was making useful measurements of depolarization ratios, 5 days in Sept – Oct at the SGP CF were chosen based on the apparent existence of clouds. The depolarization ratio was calculated in three regions, determined subjectively:

1. From within the surface layer, with no clouds present, between 0.2 and 2 km..
2. From within the so-called "free" layer chosen such that no clouds were present and the signals were distinctly above the "surface" layer.
3. From within clouds or nearby.

The average surface layer data varied little from day to day. The free-layer data is differentiated by date because of the presence of elevated stable layers. Values in air relatively unaffected by surface-emitted aerosols and clouds tends to values between 0.01 and 0.02. Surface layer values decrease linearly with height from maximum values near 0.1. Within clouds, the median values increase as expected to values approaching 1.



Depolarization estimates from SGP MPL:
left) within the surface layer (180 – 2000 m) or above the surface layer but not within clouds
right) within, or near, clouds
as a function of height for five days during which clouds were evident at least part of the time. Dates are given as mmddyy.

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