The three-dimensional spatial structure of cirrus clouds determined from lidar and satellite observations.

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Cirrus cloud fields exhibit complex spatial structure; only infrequently does the standard homogenous plane-parallel description used by most modelers provide a reasonable picture of real cirrus structure. Simultaneous imagery from the University of Wisconsin Volume Imaging Lidar (VIL) and Meteorological Satellites have been used to quantify spatial structure of cirrus clouds. The VIL data includes 120 km by 220 km 3-dimensional maps of cirrus cloud fields with 60 m resolution. This data has been used to compute quantities such as the spatial distributions of cloud base altitude, cloud top altitude, and mid-cloud altitude. Two-dimensional autocorrelation functions describing the mean shape of cirrus clouds have been computed. Because cirrus clouds seldom have distinct edges, these correlation functions are derived as a function of a threshold value which defines the cloud edge.

The lidar data and ray tracing algorithms have also been used to synthesis images of the cirrus cloud fields as they would appear at a wavelength of 1.06 microns observed from the vantage point of the GOES satellite. These images will be presented and compared with the simultaneous GOES imagery.

The complex spatial organization of cirrus makes measurements of area-averaged mean cloud properties difficult with fixed location instrumentation. It also suggests that statistics on the occurrence of clear lines of sight through the cloud fields are difficult to collect. Figure 1 illustrates this problem using a top-down image of a cirrus cloud field derived from VIL data. This image depicts the cirrus cloud as a solid object with edges defined by a backscatter threshold value. Plotted on this image are a series of sloping lines; these show the path of clouds passing over 12 zenith-pointing sensors placed along a north south line at 10 km intervals. Numbers on the right of the plot show the one-hour-average percentage cloud cover in the first hour of the data period and those on the left show the one-hour-average for the second hour. Notice that during the first hour of observation one-hour-average cloud cover varies from 0 to 73%. Interestingly, the maximum cloud cover the minimum would be observed only 10 km apart. Even in the second hour of observation, where the average cloud cover has increased, the one-hour-average cloud cover varies from 36 to 87%.

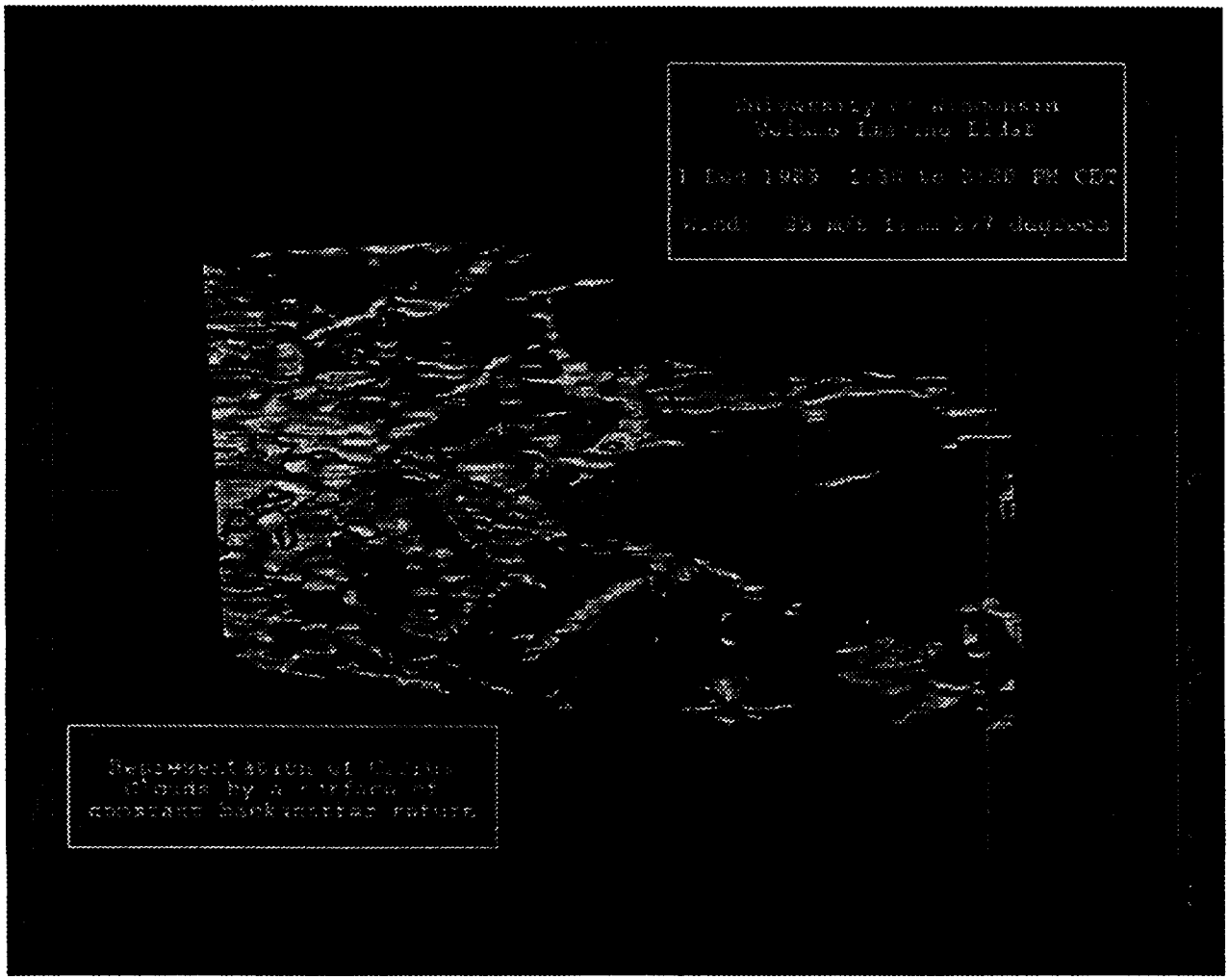

Figure 1:

A top-down view of the cirrus cloud field observed on Dec 1, 1989 with the Volume Imaging Lidar. The distance scale is given in kilometers. This image was constructed from two hours of VIL north-zenith-south image planes; the east-west dimension was constructed using loran-radiosonde winds. In the absence of temporal evolution of cloud elements this picture should be identical to a top-down picture of the cloud. The sloping black lines follow the cloud elements which would pass over 12 zenith-pointing radiometers placed at 10 km intervals along a north-south line. Figures at the right of the image represent the one-hour-average cloud cover seen by each radiometer in the first hour of observation and figures on the left for the second hour.