Island Based Radar and Microwave Radiometer Measurements of Stratus Cloud Parameters During the Atlantic Stratocumulus Transition Experiment (ASTEX)

A. S. Frisch
CIRA Colorado State University
Fort Collins, Colorado

C. W. Fairall and J. B. Snider
NOAA Environmental Technology Laboratory
Boulder, Colorado

D. H. Lenshow and S. D. Mayer
National Center for Atmospheric Research
Boulder, Colorado

Introduction

During the Atlantic Stratocumulus Transition Experiment (ASTEX) in June 1992, simultaneous measurements were made with a vertically pointing cloud sensing radar and a microwave radiometer. The radar measurements are used to estimate stratus cloud drizzle and turbulence parameters. In addition, with the microwave radiometer measurements of integrated cloud liquid water and radar measurements of reflectivity, we estimated the profiles of cloud liquid water and effective radius.

We used radar data for computation of vertical profiles of various drizzle parameters such as droplet concentration, modal radius, and spread. A sample of these results is shown in Figure 1. In addition, in non-drizzle clouds, with the radar and radiometer we can estimate the vertical profiles of stratus cloud parameters such as liquid water concentration and effective radius. This is accomplished by assuming a droplet distribution with droplet number concentration and width constant with height. A sample of these results is shown in Figure 2.

Turbulence measurements are also available in low reflectivity regions of the cloud where droplet mean fall velocity is negligible. We used the Doppler shift to estimate the vertical velocity variance and skewness throughout the cloud. Figure 3 shows an example of the variance and skewness in a stratus cloud. The variance is small compared to the clear air convective boundary layer, and the negative skewness at cloud top indicates that the convection is driven from the top by radiative cooling.

The Doppler shift at several range gates in the cloud can be used to compute the temporal and spatial vertical covariance (Figure 4). Using Taylor's hypotheses, we estimate the vertical integral scale to be about 70 m and the horizontal integral scale about 100 m. In a clear boundary layer driven by surface heating, the horizontal scale would be about 300 m (Lenschow and Stankov 1986). We also estimate the turbulent dissipation rate to

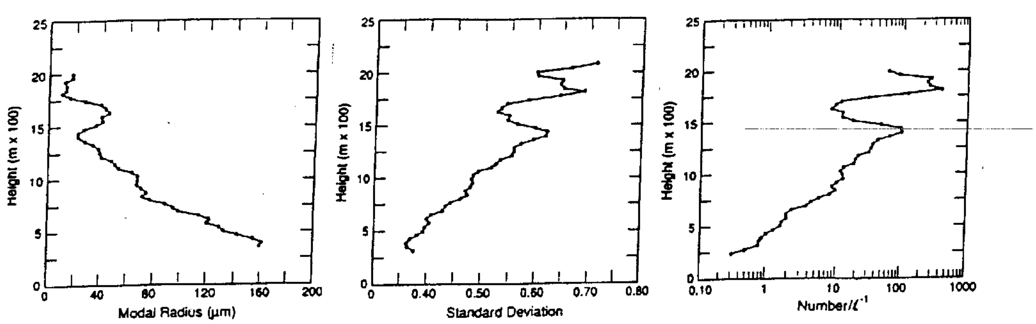

Figure 1. Drizzle parameters. The data for these measurements were taken on June 6, 1992, at 6 am. The first three Doppler moments from the vertically pointing radar were used in a log-normal three parameter cloud droplet model to determine the vertical profiles of modal radius, the standard deviation, and the number of droplets.

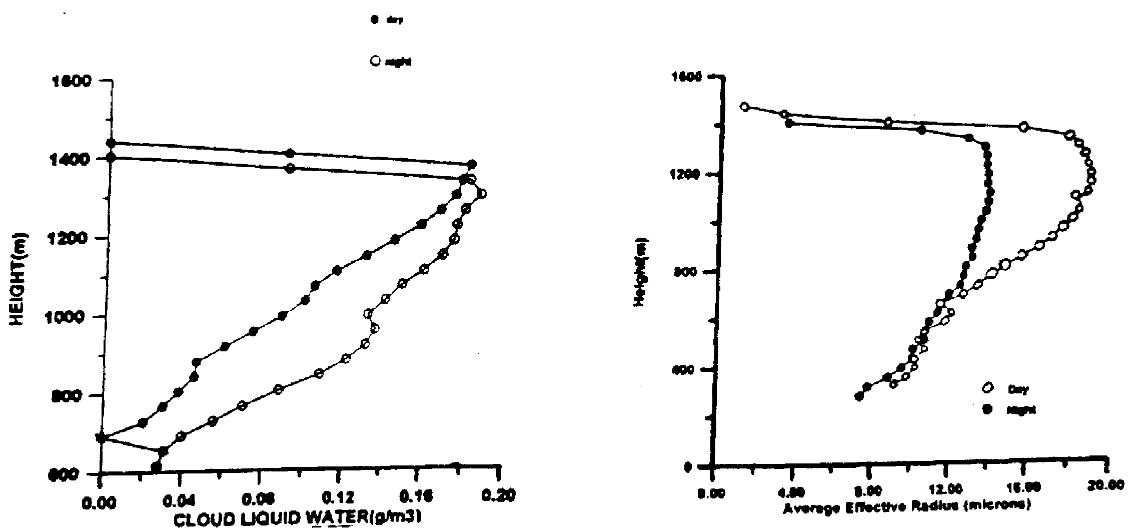

Figure 2. Cloud parameters. These measurements were taken on June 17, 1992, and separated into a daytime and nighttime average. Profiles of cloud liquid water and effective radius were calculated from the radar backscattered power and the radiometer integrated liquid water measurements.

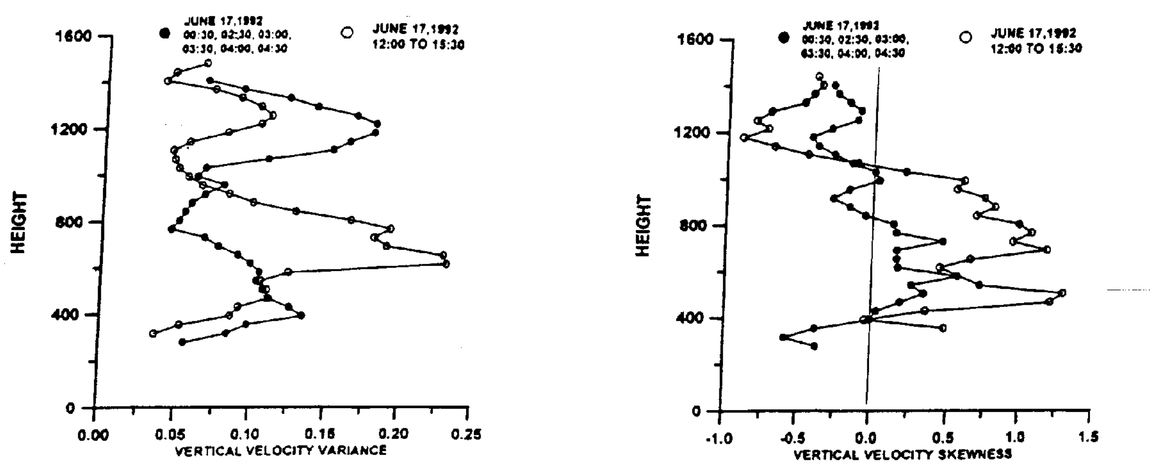

Figure 3. Cloud turbulence parameters. The radar can be used to determine various turbulence quantities in the non-drizzling clouds. Profiles of vertical velocity variance and skewness were computed for June 17, 1992. The start times of the measurements are shown in the figure. The averaging time interval was 23 minutes.

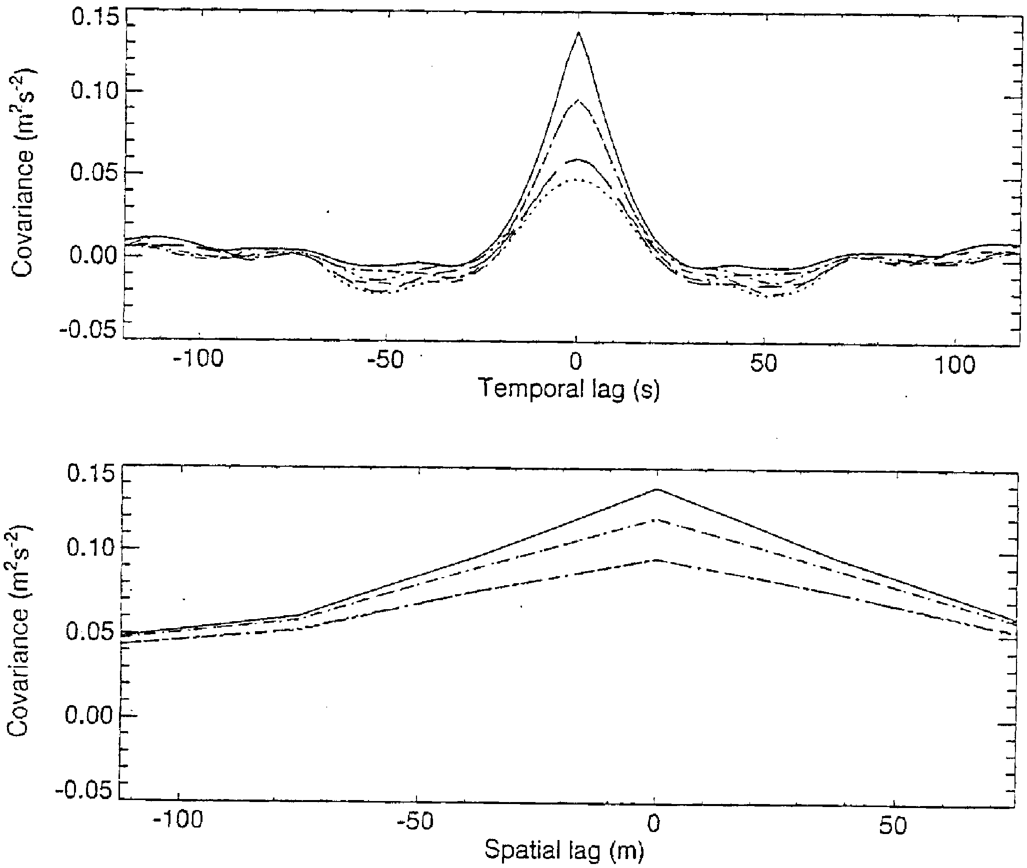

Figure 4. Doppler radar vertical velocity vertical and temporal covariance measurements. The top panel shows the temporal lag and the bottom panel the spatial lag. Sampling is done every 3 seconds and every 37.5 meters.

be about $0.35 cm^2/s^3$. Our results show that the stratus turbulence scales are about a factor of 3 smaller than the clear air boundary layer. This result supports our skewness measurements which show that the cloud turbulence is not surface driven, but most likely from radiative cooling at cloud top.

Reference

Lenschow, D. H., and B. B. Stankov. 1986. Length scales in the convective boundary layer, *J. Atmos. Sci.*, **43**, 1199-1209.