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STATISTICAL NATURE OF CLOUD GEOMETRICAL AND OPTICAL PARAMETERS FOR ATMOSPHERIC MODELLING FROM ECLIPS I AND II MEASUREMENTS

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INTRODUCTION

At present operational radiative transfer models assume homogeneous and plane parallel clouds, a situation that has never been observed in any lidar measurements. The radiative transfer in a cloud and upwelling reflectance are a function of solar zenith angle θ, cloud base height r_b, cloud amount A_c, cloud type and their optical properties (Barker and Davies, 1992). Since a lidar is capable of providing such cloud parameters with a high accuracy the effect of cloud assumptions on GCM calculations can be investigated to some degree for more realistic situations (Barker et al., 1992). The lidar time series measured during the two ECLIPS (Experimental Cloud Lidar Pilot Study) phases, provide a 2-D grid of cloud parameters such as r_b , cloud top r_t , cloud thickness $\Delta_T = r_t - r_b$, extinction σ and optical depth τ and their frequency distribution for model calculation. An automated cloud base algorithm (Pal et al.,1992) is utilized to determine geometrical parameters. The optical parameters are routinely determined by the Klett (1981) inversion procedure augmented for boundary conditions by the available radiosonde information. This paper summarizes the behaviour of these cloud parameters from the two ECLIPS phases (Phase 1: Sept-Oct 1989; Phase 2: Jun-Jul 1991) carried out at Toronto.

GEOMETRICAL PARAMETERS

The frequency distribution of the cloud base height r_b and its relationship with several other cloud parameters is discussed. The cloud vertical thickness, Δ_T , defines the vertical dimension in a GCM transfer and its average behaviour depends on the cloud type and height regime. A study of Δ_T has been carried out and the frequency distribution of Δ_T for low, medium and high clouds is found to exhibit maxima, below cloud thickness of about 1 km with a varying positive skewness for all three height regimes in both ECLIPS seasons.

When the cloud bottom is not well defined due to the presence of virga and other inversion situations not uncommon, r_p the altitude of the lidar peak signal, can be used as a cloud height descriptor in place of r_b. Under such situations r_p can generally be determined unambiguously. The location of r_p in a cloud strongly depends on its optical properties and inhomogeneity and is customarily observed below the presumed mid-cloud height. The relationship between the cloud thickness Δ_T and the thickness $\Delta_P = r_p - r_b$ is shown as the frequency distribution of the ratio Δ_P / Δ_T in Fig.1 for both ECLIPS phases and the two wavelengths (532 nm, 1064 nm). The Fig. 1 shows that the mean of this ratio is around 0.5. Therefore, for practical purposes and model calculations where statistically significant cloud descriptors suffice, a mid-cloud height can be represented by r_p. The other cloud geometrical parameters and their statistical nature is also discussed in relation to the measurements by other methods.

OPTICAL PARAMETERS

Our observations show that the histograms of average extinction ⟨σ⟩ or optical depth, τ, with respect to the cloud base height do not provide a specific functional form as shown in Fig.2. It shows that the lower clouds contribute maximum attenuation and that the cirrus component provides an enhancement superimposed over the general decrease of ⟨σ⟩ with r_b. The frequency distribution of ⟨σ⟩ for low, mid and high clouds for the two ECLIPS seasons is also discussed.

The aim of these lidar cloud studies has been to make available for climatic models, cloud information as realistic as possible on specific cloud systems as well as on their seasonal statistical nature. In addition to the analyses of geometrical (Carswell et al. 1994) and optical parameters, the cloud dynamics (Pal et al., 1994) is also discussed in this paper.

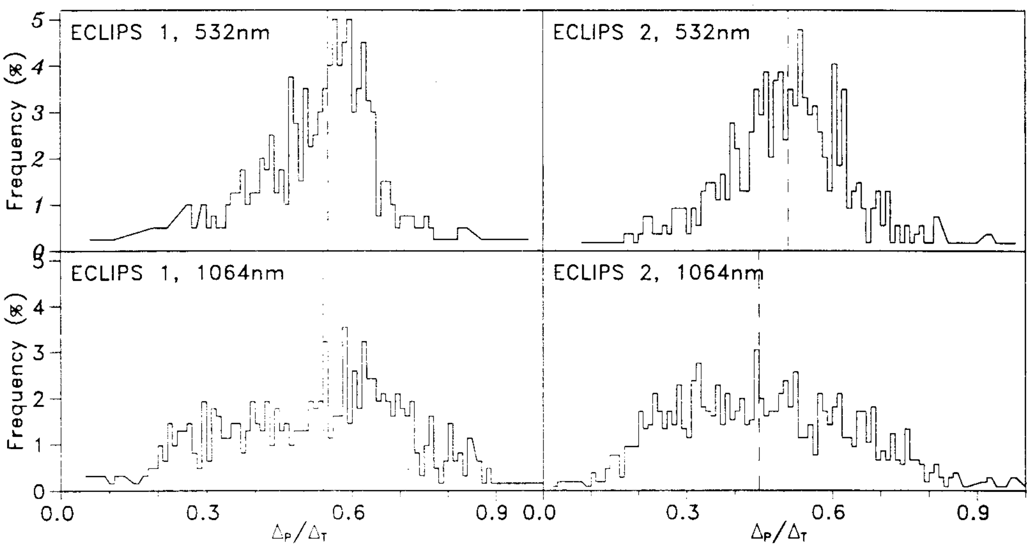

Figure 1. Frequency distributions of the ratio Δ_P/Δ_T showing the relative location of the peak signal within the cloud.

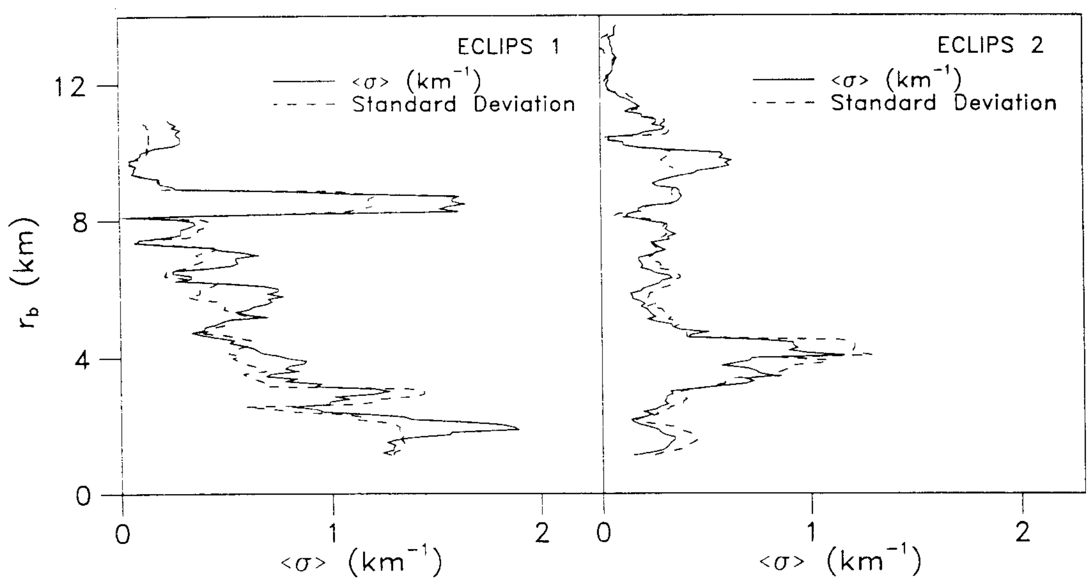

Figure 2. Variation of average extinction coefficient, <σ>, with cloud base height r_b.

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