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1) Abstract title:

Lidar observations of tropical high-altitude cirrus clouds: Results from dual wavelength Ramanlidar measurements during the ALBATROSS campaign 1996

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Background

Recent satellite and aircraft observations have shown the frequent occurrence of optically thin, high-altitude cirrus clouds in the tropics. Due to their ubiquitous nature these cloud layers are an important regulator of the atmospheric radiation budget, Furthermore, tropical cirrus clouds play an important role in the dehydration of air entering the stratosphere (Jensen *et al.*, 1996).
In this paper we present results from lidar observations of tropical cirrus clouds above the Atlantic ocean during the ALBATROSS campaign (Atmospheric chemistry and lidar studies above the Atlantic ocean related to ozone and other trace gases in the tropo- and stratosphere) in October-November 1996.

Materials and Methods

The measurements were performed with a mobile aerosol Raman lidar aboard the German research vessel "POLARSTERN". The instrument transmits simultaneously at wavelengths of 355 and 532 nm. Elastic and inelastic components of the backscattered light (Rayleigh- and Mie-scattering, vibrational Raman-scattering on molecular nitrogen) are detected, Additionally, the cross-polarized signals at 355 and 532 nm are recorded. Currently the instrument operates during night-time only. Further technical details can be found in Schafer *et al.* (1995),
After applying background and saturation corrections to the raw signals the backscatter ratio is derived by dividing the Rayleigh and corresponding Raman profile and normalizing to unity at an aerosol-free altitude range between 18 and 22 km. Similarly, volume depolarization is calculated by forming the ratio of the signals in the cross- and aligned-polarization channels and normalizing to 0.014.

Results and Discussion

During the campaign lidar measurements were performed on the Atlantic ocean between 35"N and 45°S; here, we report on the tropical and subtropical observations (30" N-30" S). Based on one hour averages a total of 126 lidar profiles were obtained within this latitude range. The measurements show that volume depolarization is an extremely sensitive parameter for the detection of subvisible cirrus clouds as non-spherical cirrus ice particles cause depolarizations reaching 100% whereas for molecular scattering volume depolarization is 1.4%. In the tropics (23.5 °S–23.5°N) we find in 44% out of 90 profiles maximum volume depolarizations exceeding 10% within the altitude range 12-16 km. In the subtropics (23.5-30°S and 23.5–30°N) this percentage reduces to 11% based on 36 profiles.
Frequently several distinct layers were found within the cirrus cloud with the highest layers reaching tropopause. We found no indication for the presence of cirrus clouds in the lower stratosphere, Frequently, highly de-polarizing cloud layers caused only modest values of backscatter ratio. For 21% of the observations with backscatter ratio less than 1.5 we find enhanced aerosol depolarizations exceeding 10%.
Based on the ratio of aerosol backscatter coefficients at 532 and 355 nm an estimate of the particle sizes are derived within the framework of Mie scattering theory. As Mie theory is based on the assumption of spherical particles only measurements with aerosol depolarization below 0.1 were included. The temperature dependence of the resulting ice water content (IWC) can be described by the linear fit, $IWC = \exp(-32.35 + 0.114\ K^{-1} \cdot T)$ g/m^3, in good agreement with a parameterization by Suzuki *et* al. (1993).

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8) Brief biography:

Georg Beyerle was born April 28, 1960 in Freiburg, Germany. Study of physics at University of Heidelberg, Germany (1981-89). Doctorate at University of Bremen, Germany (1993): Multiwavelength lidar measurements of stratospheric volcanic aerosols and polar stratospheric clouds on Spitsbergen (79°N, 12° E). G. B. is with Alfred Wegener Institute for Polar and Marine Research, Germany since 1991. He currently holds a NRC research associateship at the Jet Propulsion Laboratory, USA.