

Recent Results from LITE on aerosols and thin clouds in the upper troposphere

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The Lidar In-space Technology Experiment (LITE) provided near-global observations of clouds and aerosols during a 10-day Space Shuttle mission in September 1994. Here we present recent results based on LITE observations of clouds and aerosols in the upper troposphere.

Extended, thin layers of tenuous cloud in the vicinity of the tropical tropopause were observed by LITE. Data acquired by LITE is particularly interesting in that it provides our first 'instantaneous snapshot' showing the distribution and spatial structure of subvisible cirrus on a near-global scale. The cloud layers were observed to have thicknesses generally between a few hundred meters and one kilometer and to be unusually homogenous, with horizontal extents of hundreds to thousands of kilometers. Because of the extreme aspect ratios of these clouds we refer to them as 'laminar' cirrus. Laminar cirrus was observed near and possibly above the mean tropical tropopause and was observed to be spread widely in longitude. Most, but not all, nighttime orbital passes through the tropics observed laminar cirrus somewhere along the track. Although the laminar cirrus was often observed to be associated with tropical convective systems, many laminar cirrus clouds were also observed in locations far from convective sources. No laminar clouds were observed below 14 km or outside a latitude band between 35N and 20S. Laminar cirrus was observed in about 7% of the profiles included in this study. The cloud fraction of laminar cirrus found within the band of 30N to 20S is 14%.

Two global data sets - LITE and SAGE II - have been used to characterize the distribution of aerosols in the upper troposphere of the southern hemisphere. LITE provides high resolution information on aerosol layering and optical characteristics. The SAGE II dataset covers the time period 1984 - 1996 and provides information on the aerosol distribution and long-term climatology. LITE observed many distinct layers of enhanced aerosol scattering in the upper troposphere of the southern hemisphere within a latitude band between 20S and 40S and extending to almost all longitudes. This is consistent with results from the SAGE II tropospheric aerosol climatology which show enhanced aerosol loading in the upper troposphere in each hemisphere during local spring. The geographic and altitude distribution and optical characteristics of the aerosol suggest biomass burning as the source of the aerosol. Once transported into the upper troposphere, efficient longitudinal transport occurs resulting in a near-global distribution of the aerosol in the southern mid-latitudes.

References:

Kent, G. S., C. R. Trepte, K. M. Skeens, and D. M. Winker, 1998: LITE and SAGE II measurements of aerosols in the southern hemisphere upper troposphere. *J. Geophys. Res.* (accepted, Feb 1998)

Winker, D. M., and C. R. Trepte: Laminar Cirrus Observed Near the Tropical Tropopause by LITE. (submitted GRL, Jan 98)

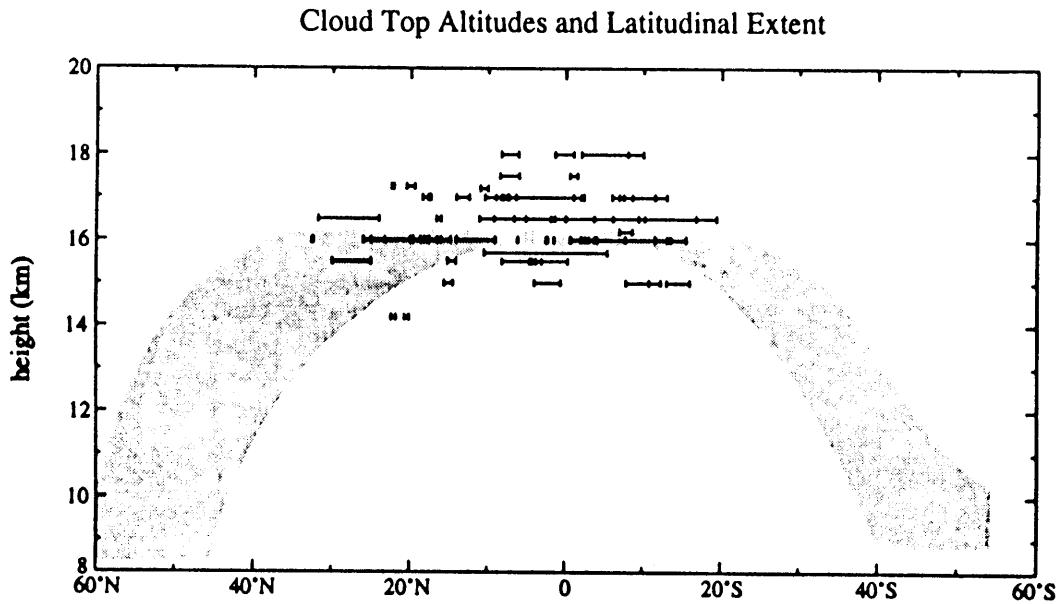


Figure 1. Horizontal extent and altitudes of thin subvisible cirrus layers observed by LITE. The range of NCEP tropopause heights during the mission is shown by the shaded region.

Observations of Clouds by LITE

September 18, 1994 Orbit 146

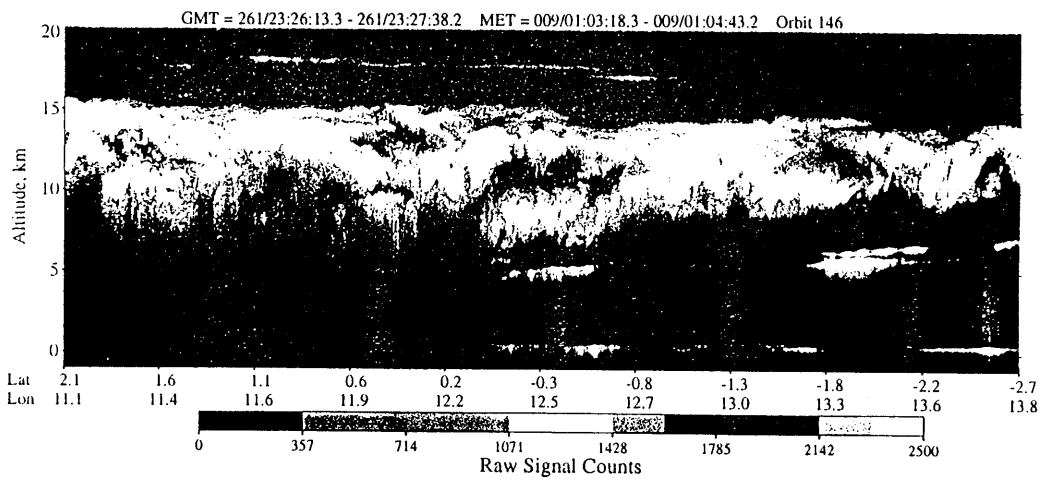
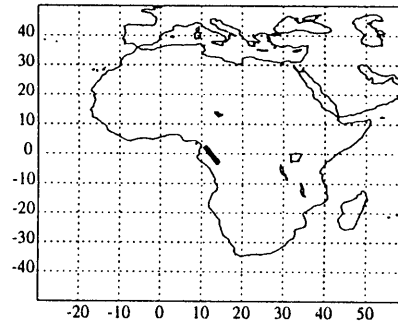


Figure 2. Observation of a laminar cirrus cloud located about 3 kilometers above a tropical storm system.



Parameterizations

- optical depth is computed using (E. Uthe, IAMAP, 1976):
 $\sigma/\beta = 50$
- in the geometric optics approximation, the extinction cross-section is twice the projected area of the particle
- a relation between surface area and ice water content was derived from in situ measurements made during CEPEX (A. Heymsfield):
 $IWC = 0.073 A^{1.135}$

Figure 3. Parameterizations used to obtain optical depths and ice water path of thin (laminar) cirrus.



Properties of laminar cirrus: four cases from orbits 73 and 146

center height = 16.3 - 18.0 km
avg thickness = 330 - 680 m
horizontal extent = 200 - 900 km

optical depth (vis) = 0.002 - 0.06
average optical depth (vis) = 0.013 - 0.027

$IWP = 2.4 \times 10^{-4} - 5.5 \times 10^{-4} \text{ (g/m}^2\text{)}$

Figure 4. Typical properties of laminar cirrus observed by LITE, based on four of the clouds observed.

LITE Measurements of Aerosol Layers in the Upper Troposphere
(10-19 September 1994)

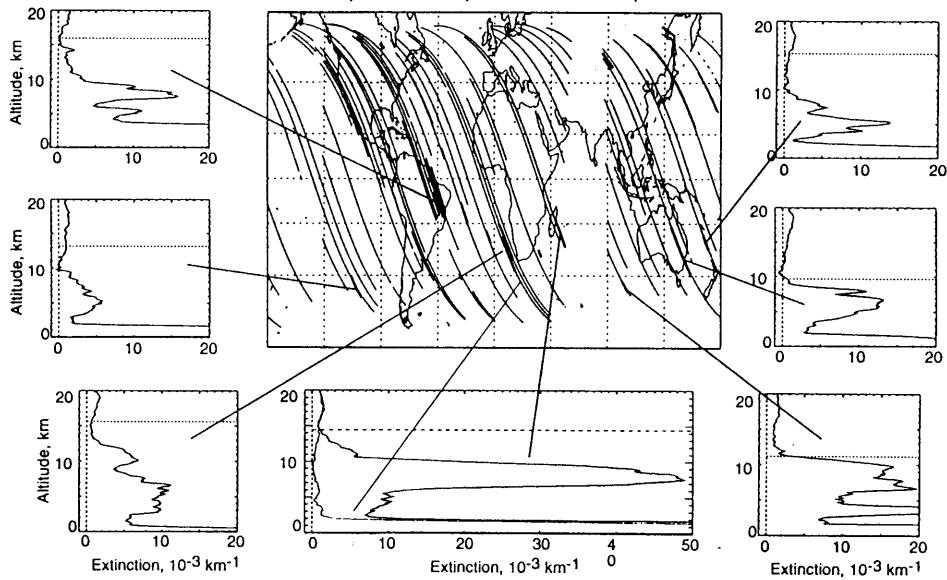


Figure 5. Central map indicates LITE groundtracks and highlights locations where prominent aerosol layers in the upper troposphere were observed. Surrounding plots show typical profiles of aerosol extinction retrieved from LITE 532 nm channel.

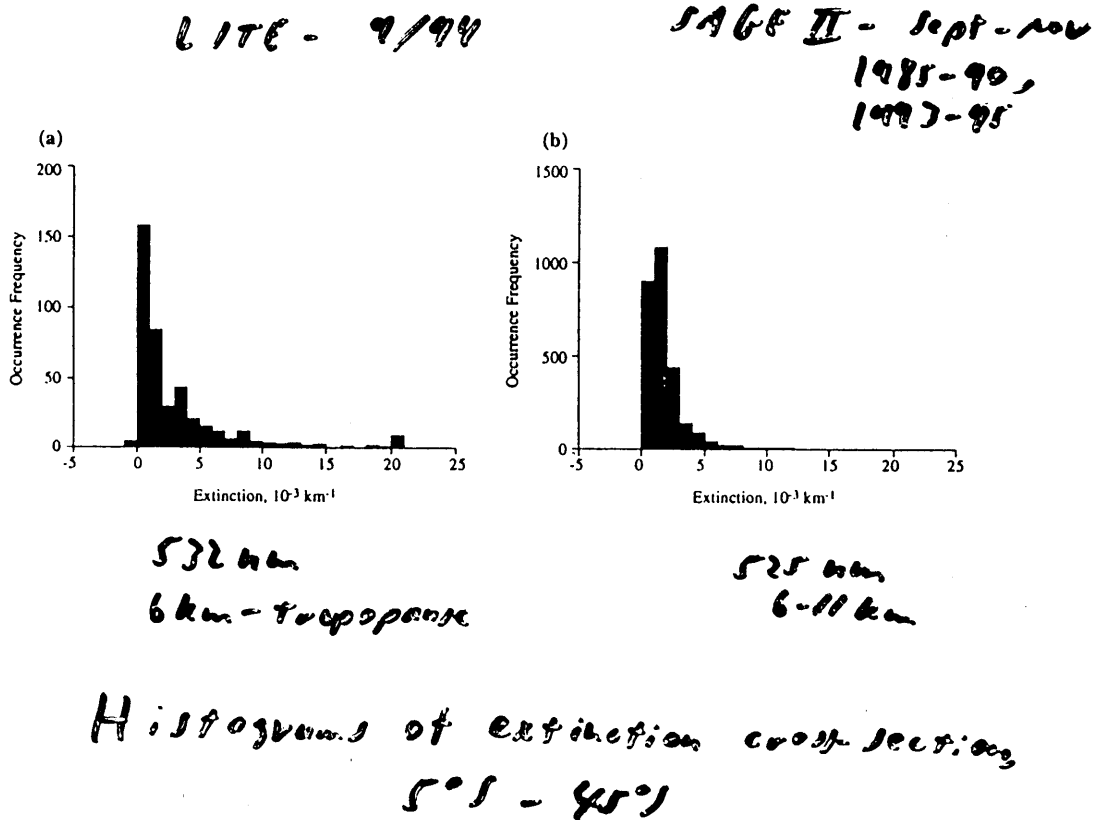


Figure 6. Comparison of the frequency distribution of aerosol extinction in the latitude band 5S to 45S and from 6 km to the tropopause from LITE and from SAGE II. The LITE observations are from September 1994 and the SAGE II observations are from the months September-November in 1985-1990 and 1993-1995.