AD-A134 246 VISIBILITY AND VERTICAL STRUCTURE MEASUREMENTS IN SOUTHERN GERMANY(U) FRAUNHOFER-INST FUER ATMOSPHAERISCHE UMWELTFORSCHUNG GARMISCH-PARTENKIRCHEN (GERMANY F R) R REITER 21 MAR 83 F/G 4/1

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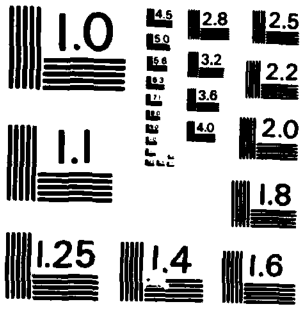

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Betrifft: Garmisch-Partenkirchen,

21 March 1983

Title of the Research Project:

VISIBILITY AND VERTICAL STRUCTURE MEASUREMENTS IN SOUTHERN GERMANY

Principal Investigator:

Dr. Reinhold Reiter, Director

Name of Contractor:

Fraunhofer-Institut für
Atmosphärische Umweltforschung
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Contract Number:

DAJA45-83-C-0023

2nd INTERIM REPORT

for the period:

21 December 1982 - 21 March 1983

The research reported in this document has been made possible through the support and sponsorship of the U.S. Government through its European Research and Standardization Group. ~~The report is intended only for internal management use of the Contractor and the U.S. Government.~~

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1. Technical Status of the Lidar System

In the 1st Interim Report it was mentioned that the sensitivity of the PIN diode detector for the 694 and 1060 nm wavelengths is too high for the measurement of lidar returns from close-range fog or clouds. In the meantime two neutral density filters with 50 and 25% transmissivity, respectively, have been mounted in free positions of the interference filter wheel in front of the detector. Furthermore, the gain of the diode amplifier can now be reduced by a factor of ten, allowing an up to 40fold overall signal reduction, in addition to the input attenuator of the transient recorder. Through these modifications it is now possible to measure the strongest occurring backscatter signals without overloading.

The achromatic lens for the beam expanding telescope of the neodymium laser has just been delivered by the optical company and will be installed in the near future. The exchange of the telescopes is then no longer required.

2. Software Developments

As is well known, the principle of Klett's method for solution of the lidar equation is to choose the boundary value for the attenuation coefficient at the far end of the range interval, not at the close one. This latter method, which is already well known for a longer time, tends, in contrary to Klett's method, to deliver results which are unstable with respect to the particular choice of the boundary value. In order to compare both methods, we developed a program for that method also. For this purpose only a few modifications of the Klett program were necessary, essentially the replacement of the sum in the denominator of the analytical expression for $\sigma(r)$ by a difference and the reversal of the iteration direction. An example for the application of both methods is given below.

3. Measurements

During the reporting period some interesting low-visibility conditions, suitable for lidar measurements and the application of both above-mentioned solution methods, occurred.

On February 4, 8, 9, 10, 15, and March 3 stratiform clouds were present between ground level (740 m above MSL) and 1500 m. In some cases the clouds were partially transparent, in others completely opaque. Also the degree of homogeneity of the clouds varied considerably. 16 series of lidar returns from these clouds were measured during these days, mostly in all four wavelengths.

On February 16, a ground fog layer with 160 m thickness was observed in the morning, and one lidar profile for each wavelength was obtained. At 10 AM the layer had dissolved.

On March 16, the aerosol concentration in the ground layer was extremely high, and the recorded visual range was only 2.5 to 4 km. Since the relative humidity was always below 80%, the presence of fog could be excluded. The sky was completely overcast, but neither the altitude nor the type of the clouds could be recognized by eye observation. A total of 16 lidar profiles were obtained, with elevation angles of 19.2° (the inclination angle of our transmission path) and 35°. In the lidar profiles the top of the turbid layer could be located at 1000 m above MSL, and stratus clouds seemed to be present at this altitude.

On March 17, the aerosol concentration remained extremely high, the visual range at ground level did not exceed 4 km. The turbid layer, however, extended up to more than 1600 m above MSL and was fairly homogeneous, thus allowing a good estimation of the lidar extinction by the slope method. The optical depth at 2 km slant range was about 1.9 in 694 nm and 2.3 in 530 nm wavelength. A brief discussion of lidar data from this day and their evaluation by the two methods follows in chapter 4.

Transmissometer data are available from February 9 and 10, and March 3, 15, and 17.

4. Comparison of Klett's Method and the Standard Method for Evaluating Lidar Returns

The evaluation method where the boundary value of the extinction coefficient is selected close to the lidar and the iteration proceeds away from it shall be named here "close-range boundary value (CRBV)"-method for brevity.

For comparison of both methods we chose lidar returns from March 17, when the aerosol concentration was extremely high for our measurement site, but fairly homogeneously distributed along the lidar path. Figs. 1a and 1b show range-corrected backscatter profiles in 694 and 530 nm wavelength, respectively. The nearly logarithmic decay of the curves indicates the homogeneity of the aerosol. The mean slope of the profiles results in average extinction coefficients of .94 km^{-1} for 694 nm and 1.17 km^{-1} for 530 nm. Using these data and a set of further ones below and above them as boundary values at 2 km range, the profiles have been evaluated by the Klett method, resulting in $\sigma(r)$ curves shown in Figs. 2a and 3a. We see that, in contrary to the example presented in the first interim report, at moderate optical depths the magnitude of the boundary value still has a noticeable influence on $\sigma(r)$. However, the average extinction coefficient varies much less than the boundary value σ_m. Whereas σ_m's have been varied by a factor of 10, the average extinction coefficients along the considered path length varied only by a factor of about 2. Moreover, we see in the diagrams Fig. 2a and 3a, the lower parts of the $\sigma(r)$-curves tend to stabilize if σ_m is increased beyond the most probable value, in our case that one which has been derived by the slope method. This confirms our statement made in the previous interim report at the end of chapter 3.

The same two lidar returns have now been evaluated by the CRBV-method, using the same set of boundary values σ_0 as with the Klett method. The resulting $\sigma(r)$ profiles are shown in Figs. 2b and 3b for the two wavelengths. We see that the curves vary extremely with the magnitude of σ_0. Especially if too high a σ_0 is assumed, the $\sigma(r)$ curves go to infinity at a certain distance decreasing with σ_0, and to negative, i.e. meaningless values beyond that distance. This singularity is caused by the difference in the denominator of the $\sigma(r)$ expression, which becomes zero and negative if the selected σ_0 is only slightly too high. For too small a σ_0 the resulting σ-curves tend to zero more or less rapidly.

We, therefore, see that the Klett method is still by far superior to the standard CRBV method even for only moderate optical depths at the reference distance r_m. Furthermore, we made the experience that electronic signal errors, especially inaccuracies in the determination of the signal baseline, which can occur if detectors with DC-coupled amplifiers are used, may affect the resulting $\sigma(r)$ function more severely than erroneous boundary values.

5. Preparations for the Measurements at Greding

In order to get the permission for lidar measurements within the military area at Greding, we contacted the Military Geophysical Service at Traben-Trarbach.

6. Future Plans

The achromatic beam expanding telescope for the Neodymium laser will be installed and aligned in the next future, allowing measurements in 530 and 1060 nm wavelength within shorter time intervals. The computer programs for the Klett and CRBV methods permit up to now only the plot of the $\sigma(r)$ curves on the X-Y plotter of the mobile lidar system. They should be modified and extended in such a way that the curves may be plotted in any desired scale on a more precise incremental plotter using, on the one hand, already existing subroutines and enabling otherwise tabulation of data in numerical form as well as printing and/or storage on magnetic tape with reduced range resolution if desired.

The lidar measurements in turbid atmospheres are to be continued.

Garmisch-Partenkirchen, March 21, 1983

(Dr. R. Reiter)
Director

FIGURES 1-3

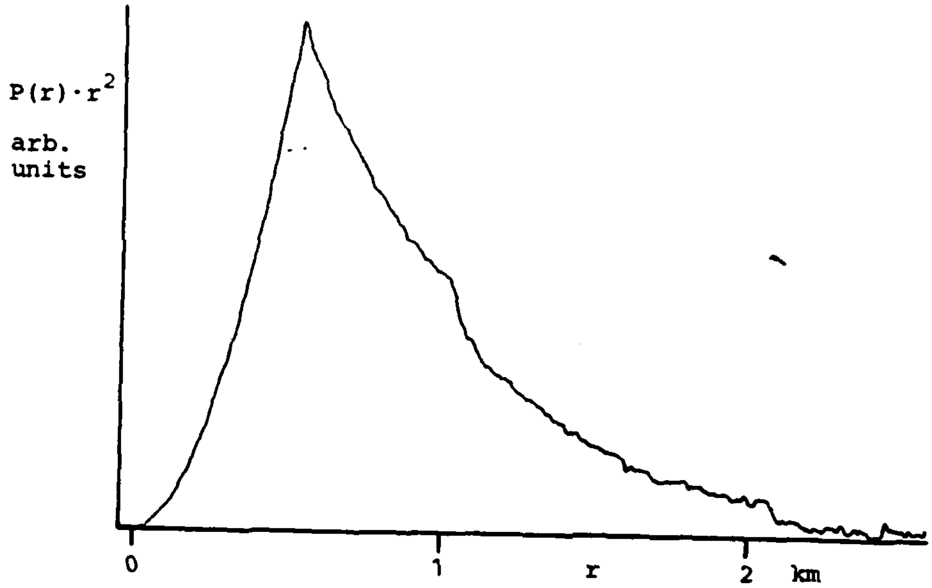


Fig. 1a:
range-corrected lidar backscatter profile,
wavelength 694 nm, March 17, 1983, 08.45 CET

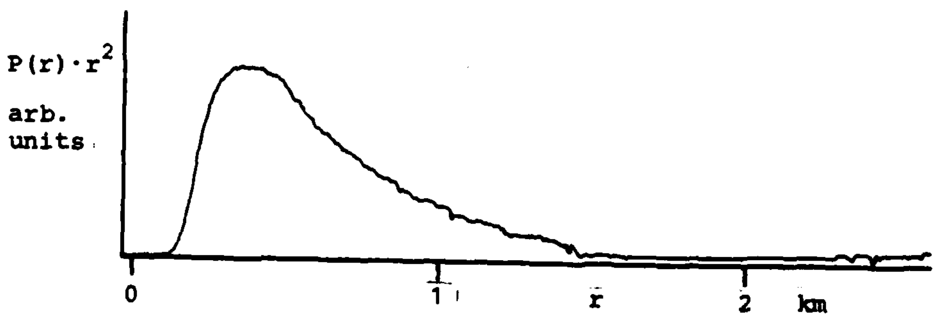


Fig. 1b:
range-corrected lidar backscatter profile,
wavelength 530 nm, March 17, 1983, 08.58 CET

Fig. 3a:
profiles of extinction coefficient $\sigma(r)$, calculated from return signal shown in Fig. 1b, using Klett's method with boundary values σ_m at range r_m as indicated

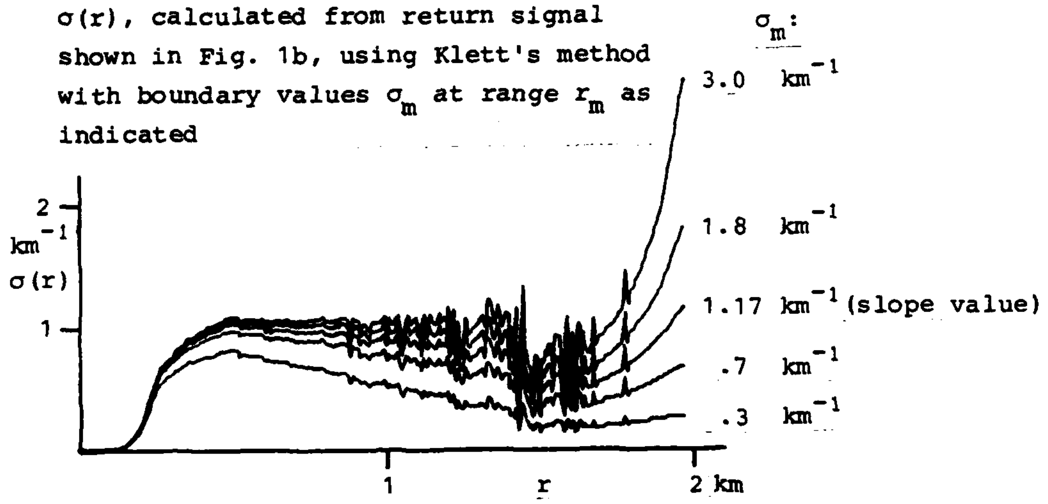


Fig. 3b:
profiles of extinction coefficient $\sigma(r)$, calculated from return signal shown in Fig. 1b, using CRBV method with boundary values σ_o at range r_o as indicated

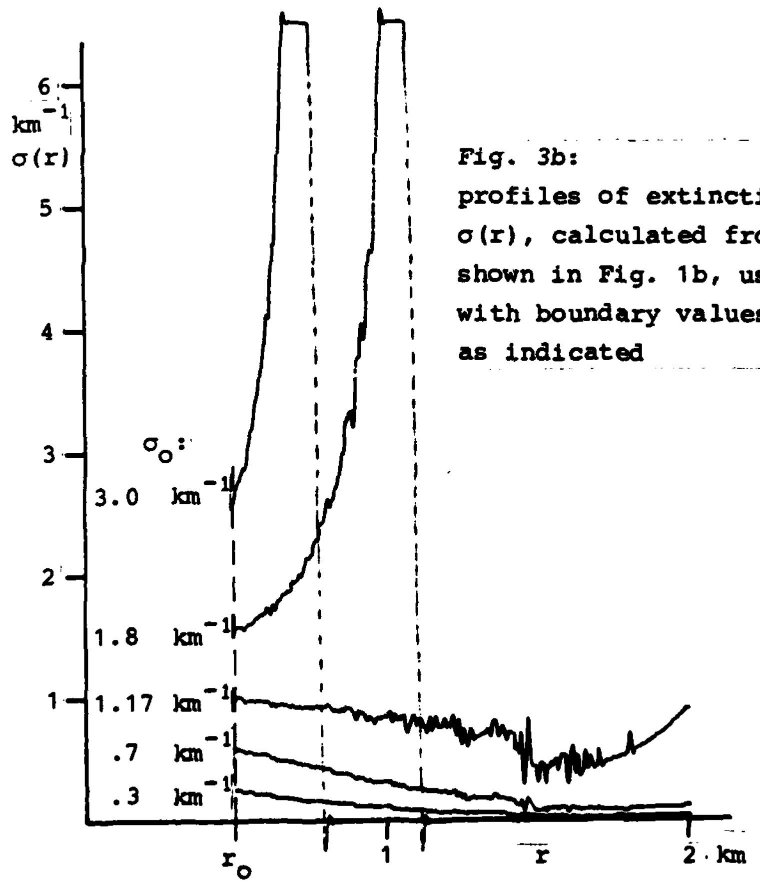
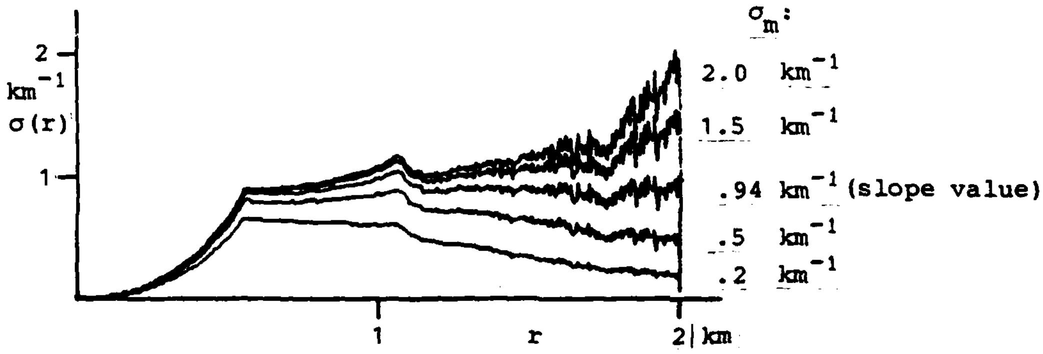


Fig. 2a:
profiles of extinction coefficient σ(r), calculated from return signal shown in Fig. 1a, using Klett's method with boundary values σ_m at range r_m as indicated



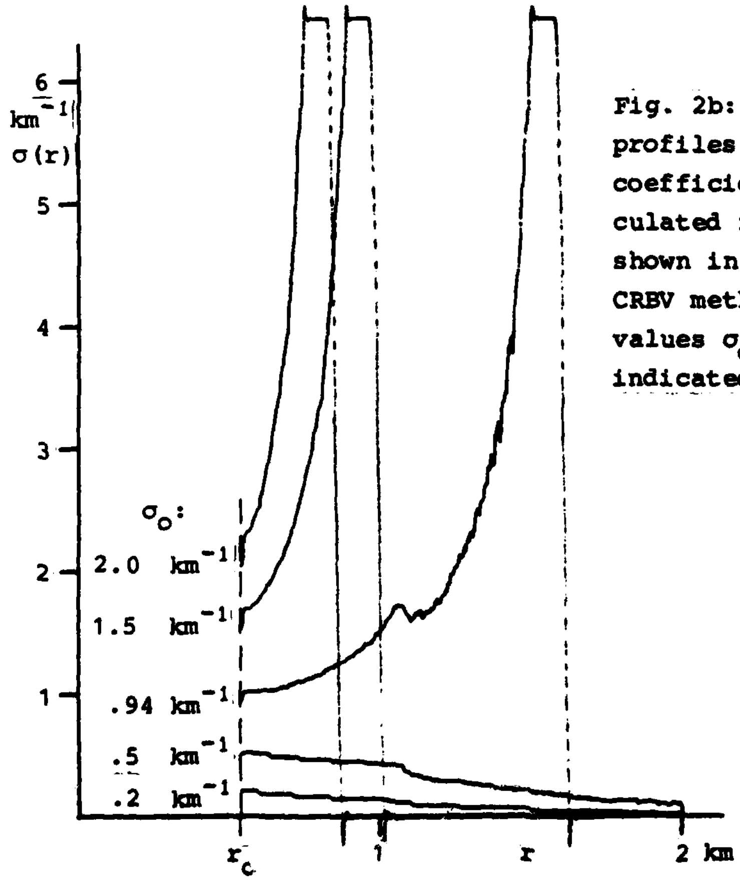


Fig. 2b:
profiles of extinction coefficient σ(r), calculated from return signal shown in Fig. 1a, using CRBV method with boundary values σ_o at range r_o as indicated

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