UNIVERSITY OF CALIFORNIA, SAN DIEGO
SCRIPPS INSTITUTION OF OCEANOGRAPHY
VISIBILITY LABORATORY
SAN DIEGO, CALIFORNIA 92152

ATMOSPHERIC OPTICAL MEASUREMENTS IN THE VICINITY OF CRATER LAKE, OREGON. PART I.

Almerian R. Boileau

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AFCRL, U. S. Air Force, Bedford, Massachusetts
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The following corrections apply to SIO Ref. 68-18, **ATMOSPHERIC OPTICAL MEASUREMENTS in the Vicinity of Crater Lake, Oregon, Part I**, and SIO Ref. 68-19, **ATMOSPHERIC OPTICAL MEASUREMENTS in the Vicinity of Crater Lake, Oregon, Part II.**

SIO Ref. 68-18, Part I

Page	Location	Reads	Should Read
17	Figure 14 (Replace reflectance scale magnitude values)	0.001 0.010	0.010 0.100
18	Figure 15 – Replace entire page		

SIO Ref. 68-19, Part II

Page	Location	Reads	Should Read
1	Abstract, lines 2 and 3, second sentence	Three of the descents were before local apparent noon, the fourth descent was after local apparent noon.	All descents were before local apparent noon. Simultaneous . . .
2	The Flight, last sentence, paragraph 2	Local apparent noon occurred between the third and fourth descents, at approximately 1215.	Local apparent noon occurred at approximately 1315.
6	Figure 3 Caption, lines 3, 4, and 5	Delete the last sentence on this Figure Caption.	
9	Figure 6 (Replace horizontal path function scale magnitude values in both graphs)	150 150	500 500
20	Figure 17 (Replace reflectance scale magnitude values in both graphs)	0.001 0.010 0.001 0.010	0.010 0.100 0.010 0.100
23	Figure 20 (Replace entire page)		
24	Figure 21 (Replace entire page)		
	DD Form 1473, Abstract, lines 2 and 3 second sentence	Three of the descents were before local apparent noon; the fourth descent was after local apparent noon.	All descents were before local apparent noon. Simultaneous . . .

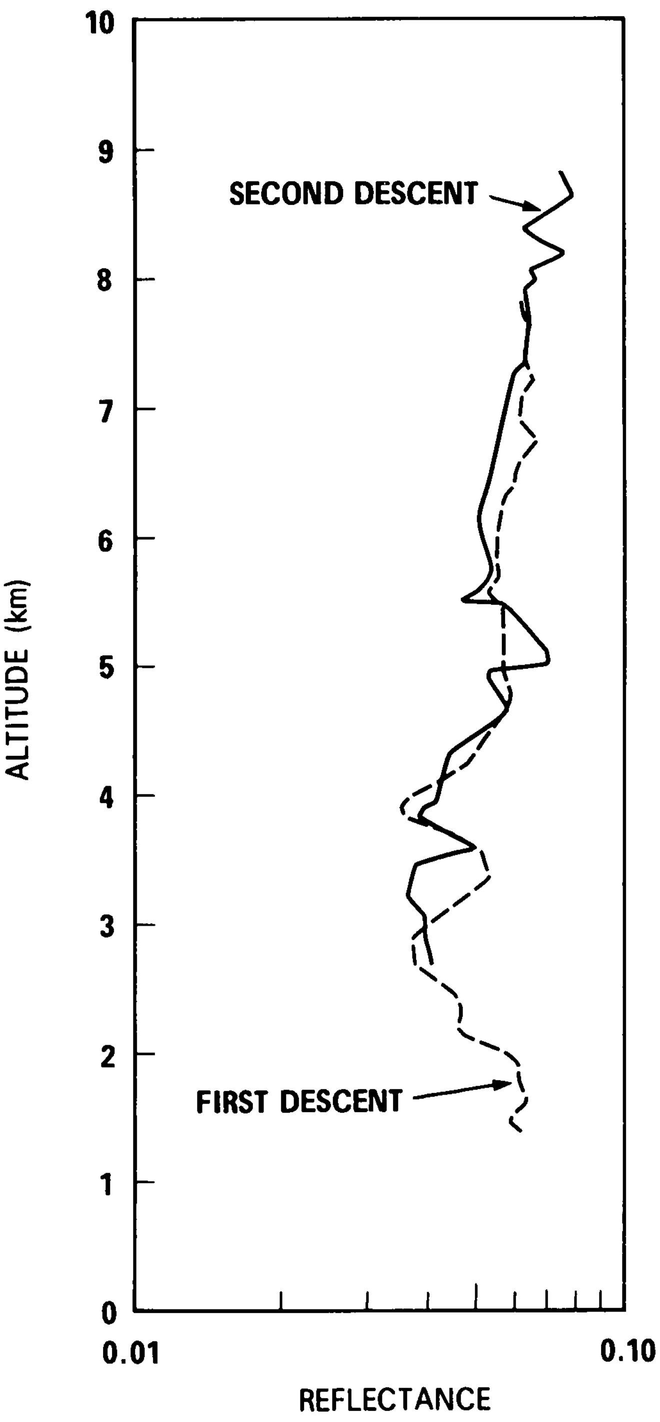

Fig. 14. Ratios of upwelling and downwelling illuminances during both descents.

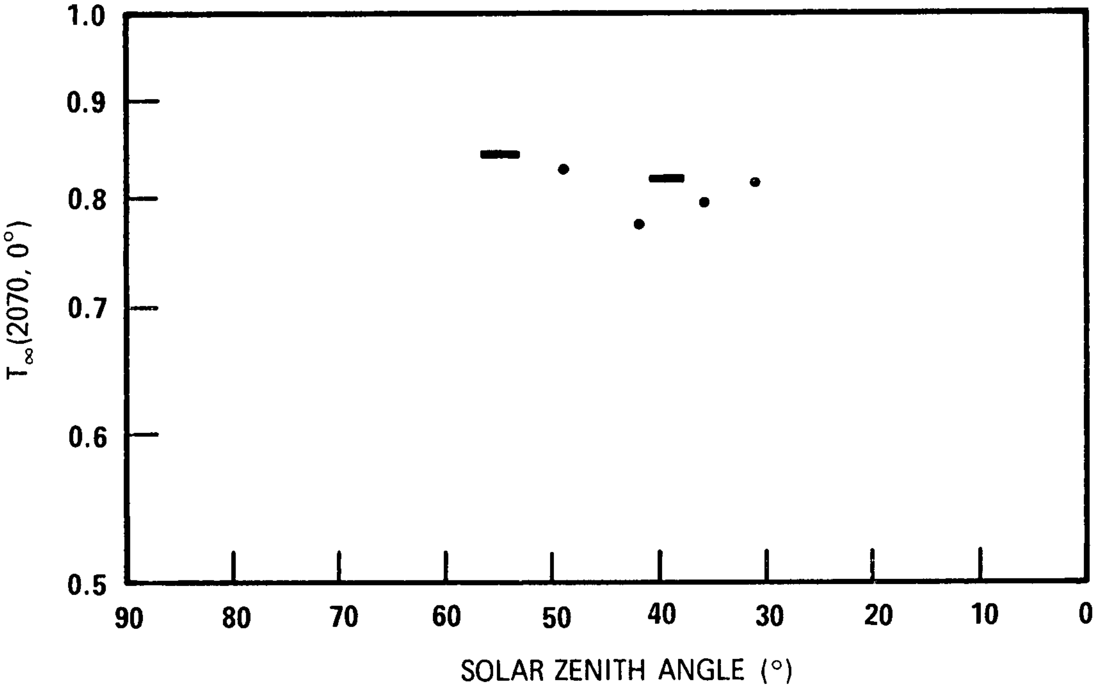

Fig. 15. Beam transmittances for vertical path of sight as a function of solar zenith angle. The four data points represent transmittances calculated from the ground-based transmissometer. The two elongated data points represent the transmittances calculated from aircraft data, extrapolated to ground level, the amount of elongation representing the change of solar zenith angle during the time of each descent.

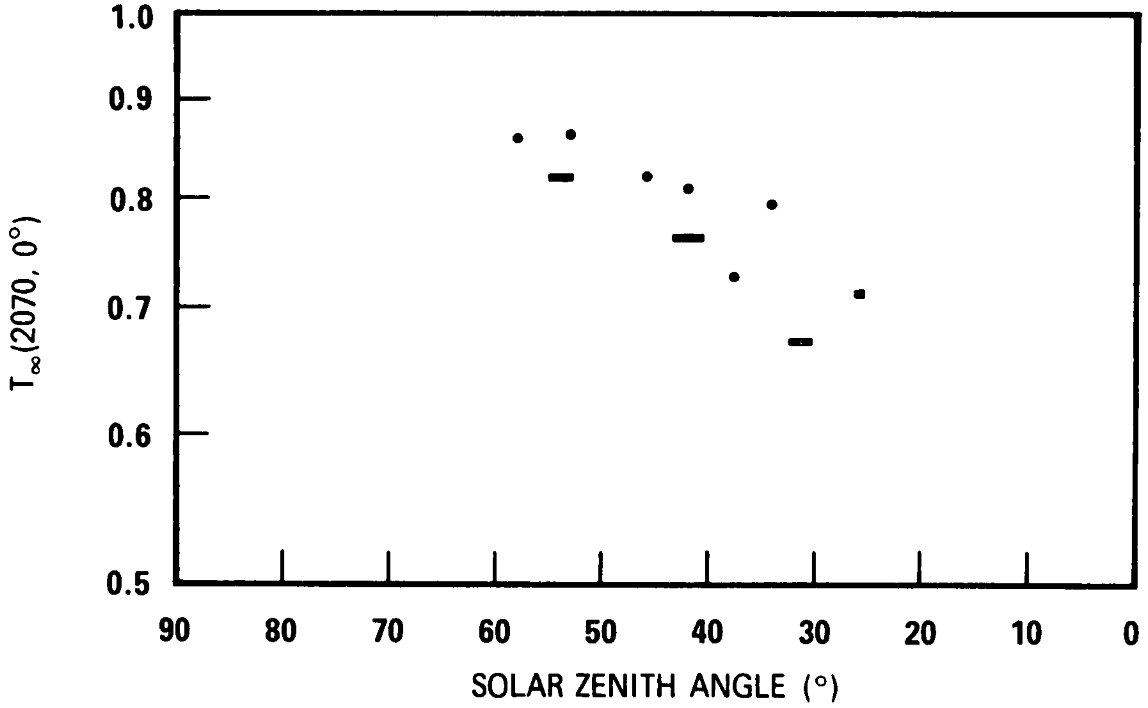

Fig. 20. Beam transmittance for the vertical path of sight as a function of the solar zenith angle. The data shown by filled circles were calculated from ground-based data and the equation

$$T_\infty(2070, 0°, 0°) = \left[\frac{{}_sB_\infty(2070, \theta_s, \phi_s)}{{}_sB_o}\right]^{\cos\theta_s}$$

The data shown by elongated data points were from extrapolated aircraft data and the equation

$$T_\infty(2070, 0°, 0°) = \exp\left[-\Sigma\Delta z / L(z)\right].$$

During the forenoon the beam transmittance for the vertical path of sight decreased as the solar zenith angle decreased. At 1315 (local apparent noon) the solar zenith angle was 25.75°.

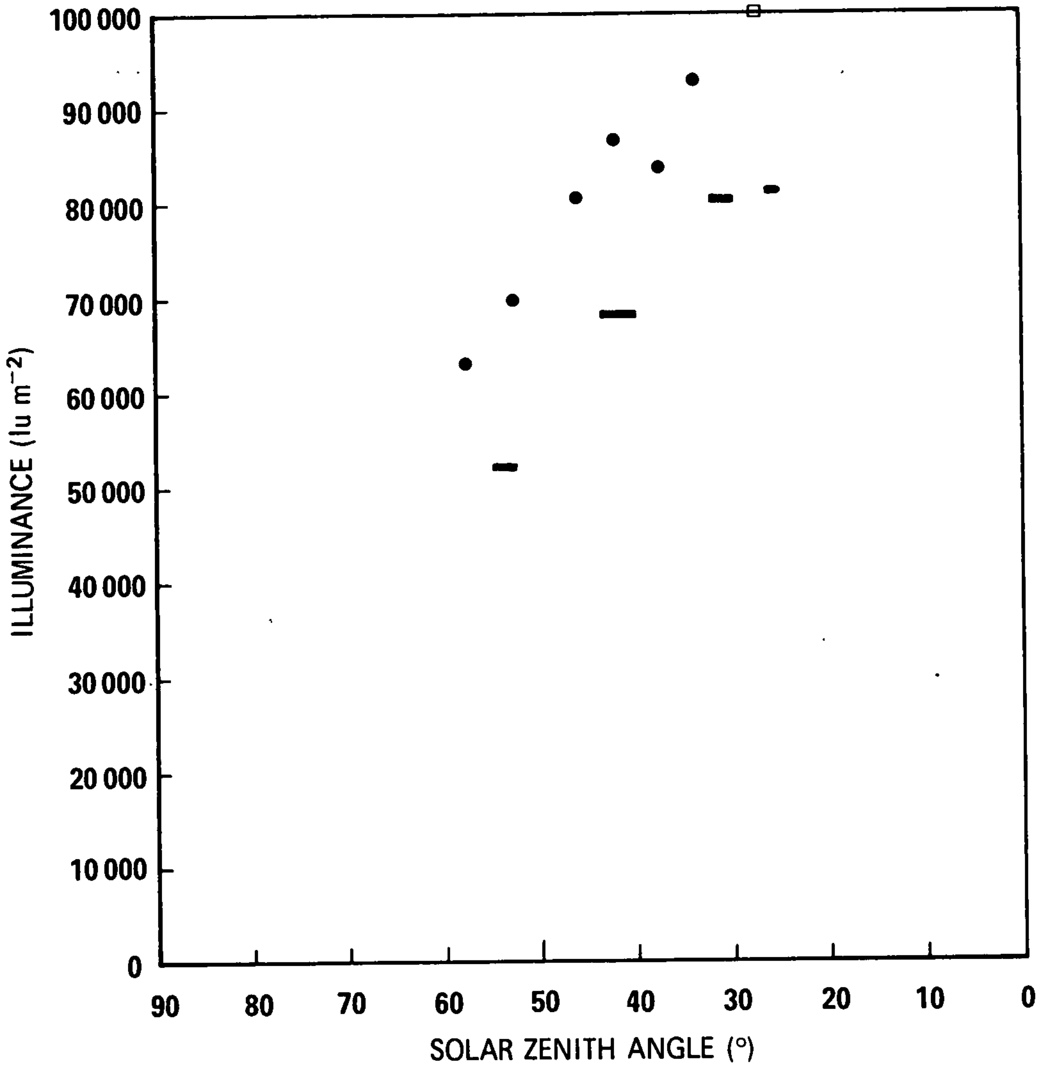

Fig. 21. Downwelling illuminance E(2070, −) as a function of solar zenith angle. The data indicated by the filled circles are those recorded by ground based irradiometer, the elongated data points are from extrapolated aircraft irradiometer data, and the open box ☐ from spectroradiometric data weighted by the luminance efficiency function, recorded at the surface of Crater Lake. The ground station location was at an altitude of 2070 m. The surface of Crater Lake is at an altitude of 2020 m.

ATMOSPHERIC OPTICAL MEASUREMENTS
IN THE VICINITY OF CRATER LAKE, OREGON
Part 1

Almerian R. Boileau

ABSTRACT

This report presents new atmospheric optical data measured by airborne optical and meteorological sensors recorded near Crater Lake, Oregon, during the first day of a three day period in August 1966. Two data gathering descents were made, from 7800 m to 1400 m, and from 8800 m to 2700 m. The times of these descents were 0913 and 0930 and 1045 to 1101, Pacific Daylight Time. Atmospheric beam transmittances were measured also by a ground station located south of Crater Lake at an altitude of 2070 m. Data presented are altitude profiles of heading of aircraft, temperature, relative humidity, equilibrium luminance, horizontal path function, attenuation length, nadir luminances, and downwelling and upwelling illuminances and their ratios.

INTRODUCTION

This report is part I of a report which presents atmospheric optical and meteorological data recorded in the vicinity of Crater Lake, Oregon, on the first and third days of a three day period, 2-4 August 1966. The data are of the same type as data which have been presented in a series of journal papers[1-5] for use in visibility calculations as illustrated in Ref. 1. The airborne instrumentation was the same as previously reported[5] with the exception that the downward looking telephotometer was oriented to record nadir luminance. The ground-based instrumentation was the same as previously reported.[5]

This report is the final report under U. S. Navy Ship Systems Command Contract NObs-92058, Task II.

THE FLIGHT[*]

The aircraft, Air Force C-130 No. 022, took off from Siskyou County Airport at 0801[†] 2 August 1966 and proceeded to the vicinity of Crater Lake. The sky cloud cover was estimated as being 5%. The dry air temperature was 20° C, the atmospheric pressure was 926 mb, and the relative humidity was 49%.

At 0913 a continuous, level-attitude descent was initiated from a position north of Crater Lake, at an altitude of 7800 m, on a southerly course so as to pass directly over Crater Lake. This descent was terminated over Upper Klamath Lake, south of Crater Lake, at an altitude of 1400 m, at 0930. A second level-attitude descent was started at 1045, at an altitude of 8800 m, from a position south of Crater Lake, on a northerly heading so as to again pass directly over Crater Lake. This descent ended north of Crater Lake, at an altitude of 2700 m, at 1101. Optical and meteorological data were recorded during both descents.

During the time that the descents were being made, optical data were recorded at the ground station. This ground station was set up on a site on the southern slope of Mt. Mazama, the caldera of which holds Crater Lake, at an altitude of 2070 m.

DATA

The headings of the aircraft during the two descents are shown in Fig. 1. The temperature and relative humidity profiles for both descents are shown in Figs. 2 and 3. There was little change in the temperature or relative humidity profiles in the hour and a half between the descents showing that atmospheric conditions were relatively stable during the data-taking periods.

Fig. 4 is a plot of altitude of the aircraft as a function of time during the two descents and from these plots it is inferred that the attitude of the aircraft varied very little during the descents.

Optical data are presented in Figs. 5 through 15. Fig. 5 shows the profiles of the equilibrium luminances during the first and second descents. These profiles are essentially the same, varying only in details of the profiles. The limiting maximum value envelope shows a gradual decrease of the maximum values with decrease of altitude which is attributed to the change of sky radiance distribution with change of altitude.

Figs. 6 and 7 are the profiles of the horizontal path functions for the two descents. In both profiles, at the higher altitudes where the relative humidity was measured at 58% and 55% for the two descents, the profiles are quite regular. Below the altitudes where the relative humidity increased drastically, that is, at 5750 m and 5300 m during the first and second descents, the profiles differ considerably.

Figs. 8 and 9 are the profiles of the attenuation length L(z) and the equivalent attenuation length $\bar{L}(z)$ for the two descents. These L(z) profiles are calculated by the equation

$$L(z) = B_q(z, 90°, \phi) / B_*(z, 90°, \phi) \qquad (1)$$

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[*] Flight identification No. 660802.

[†] Pacific Daylight Time is used throughout this report.

and, accordingly reflect the profile structure of the individual equilibrium luminance and horizontal path function profiles. The two L(z) profiles are similar from the upper altitudes down to 4700 m, but below this altitude they are quite dissimilar.

Figs. 10 and 11 show the nadir luminances for both descents. The nadir luminance telephotometer had a circular field stop of 5° and, as a result of this relatively small field, has produced noisy profiles. There was no glitter on the surface of the lake during the time the aircraft was over the lake.

Figs. 12 and 13 show the downwelling and upwelling illuminances for the two descents. Fig. 14 shows the ratio of these illuminances with altitude for both descents.

Atmospheric beam transmittances for the vertical path of sight as a function of the solar zenith angle are shown in Fig. 15. All of these data points represent transmittances for the vertical path of sight between 2070 m, the altitude of the ground station, and space. Four of the points resulted from ground station data, and two were calculated from airborne data.

ACKNOWLEDGEMENTS

Visibility Laboratory personnel during this field trip were: R. W. Johnson, Senior Development Engineer, supervisor; G. C. Barnett, Assistant Development Engineer, responsible for airborne activities; K. W. McMaster, Senior Electronics Technician, and R. L. Sydnor, Senior Laboratory Mechanician, assisting Mr. Barnett in the aircraft; and G. F. Simas, Senior Electronics Technician, assisting Mr. Johnson at the ground station.

The crew of the C-130 aircraft consisted of Capt. Paul Griswold, USAF, aircraft commander, 1st Lt. Roger Lowther, USAF, pilot, and Sgt. Castro, USAF, crew chief. Their fullest cooperation in flying the aircraft as requested by Mr. Barnett was much appreciated.

Many members of the Crater Lake park staff assisted in this field trip, and their assistance is gratefully acknowledged. Ranger John Chapman was especially helpful in assisting Mr. Johnson in his selection of a site for the ground station.

REFERENCES

1. S. Q. Duntley, **et al**, Appl. Opt. **3**, 549 (1964).
2. J. I. Gordon and P. V. Church, Appl. Opt. **5**, 793 (1966).
3. A. R. Boileau and J. I. Gordon, Appl. Opt. **5**, 803 (1966).
4. J. I. Gordon and P. V. Church, Appl. Opt. **5**, 919 (1966).
5. A. R. Boileau, Appl. Opt. **7**, 407 (1968).

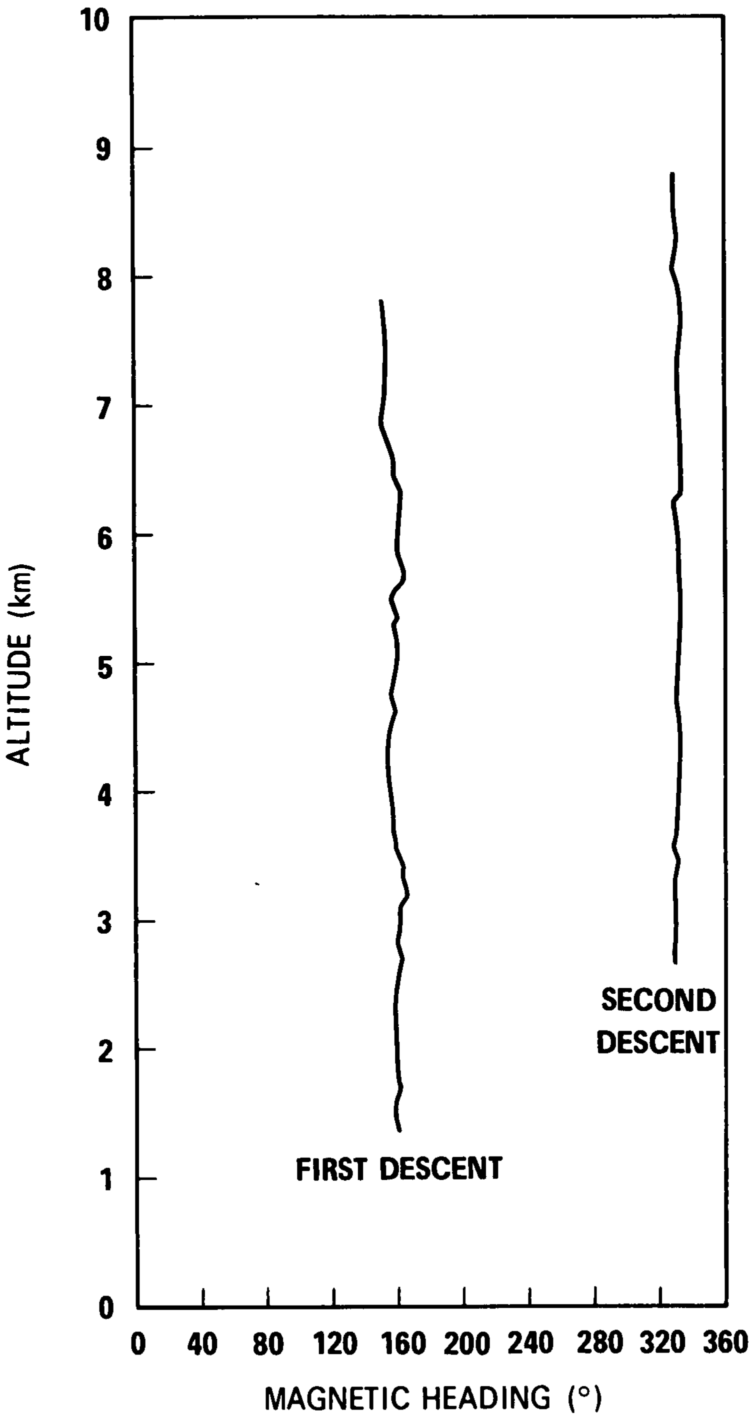

Fig. 1. Magnetic heading of aircraft for both descents. The aeronautical chart of this area shows magnetic variation in the vicinity of Crater Lake to be slightly less than 20°E. Accordingly, the true heading of aircraft was as shown plus 20°.

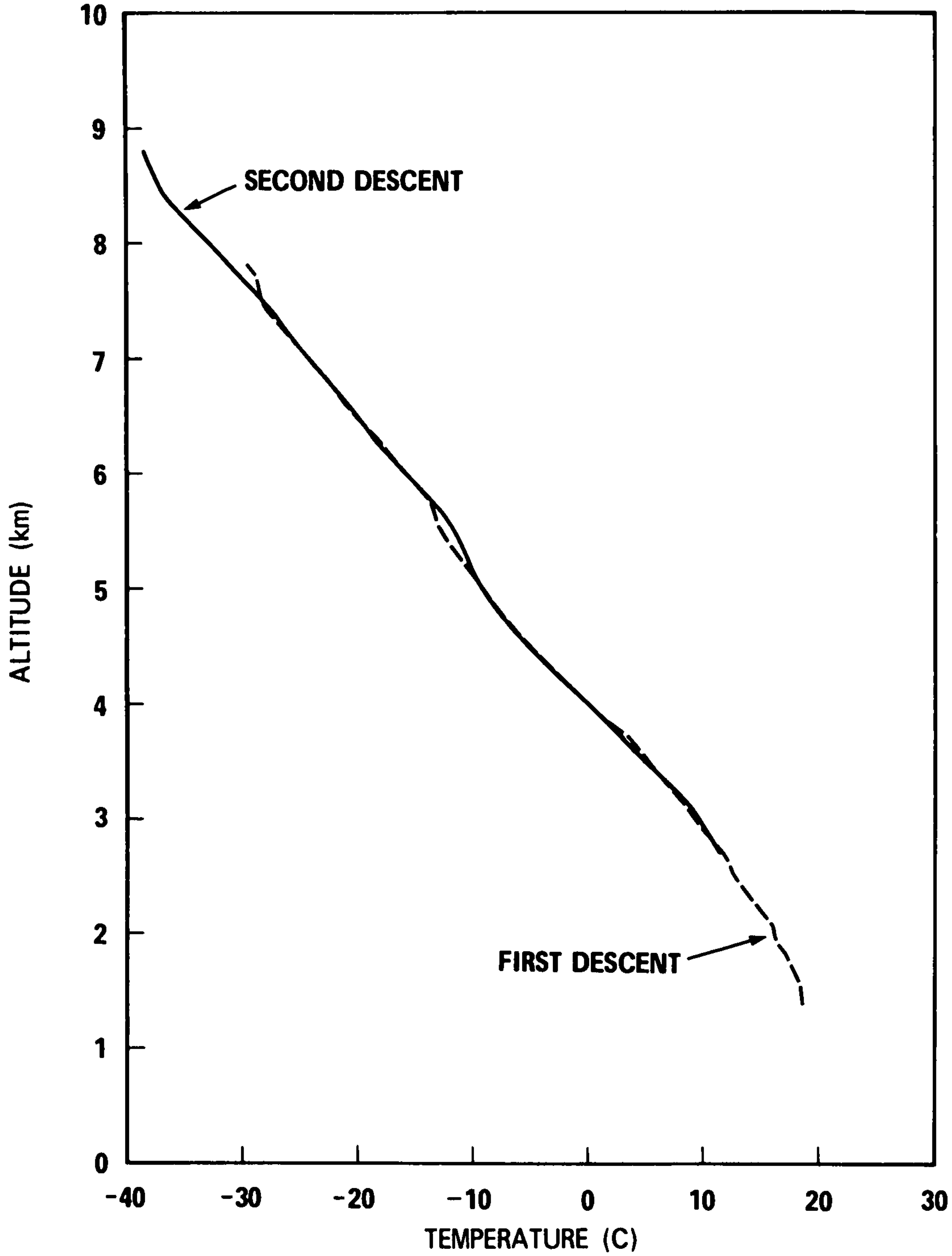

Fig. 2. Temperature profiles. The first descent was from 0913 to 0930, the second descent was from 1045 to 1101. These two profiles are virtually the same except that in the profile of the first descent there is a suggestion of an inversion between 5500 m and 5750 m which corresponds to the structure in the relative humidity profile, Fig. 3, at that altitude range. In the second descent profile this occurs between 5000 m and 5250 m, corresponding to the large change of relative humidity during the second descent, as shown in Fig. 1.

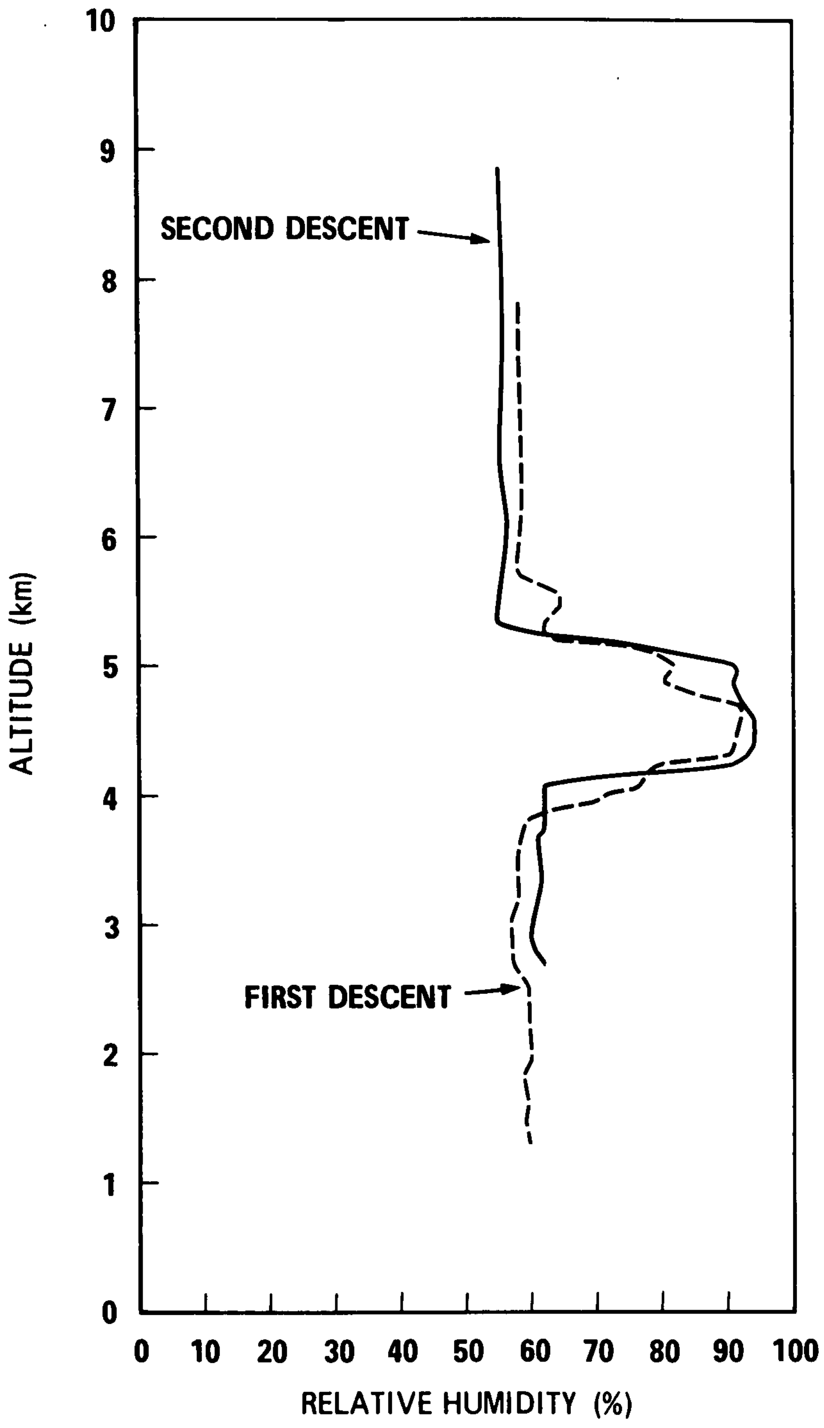

Fig. 3. Relative humidity profiles for both descents. Very little change in relative humidity occurred during the hour and a half between descents thus showing, in connection with the temperature profiles, that the atmosphere was quite stable.

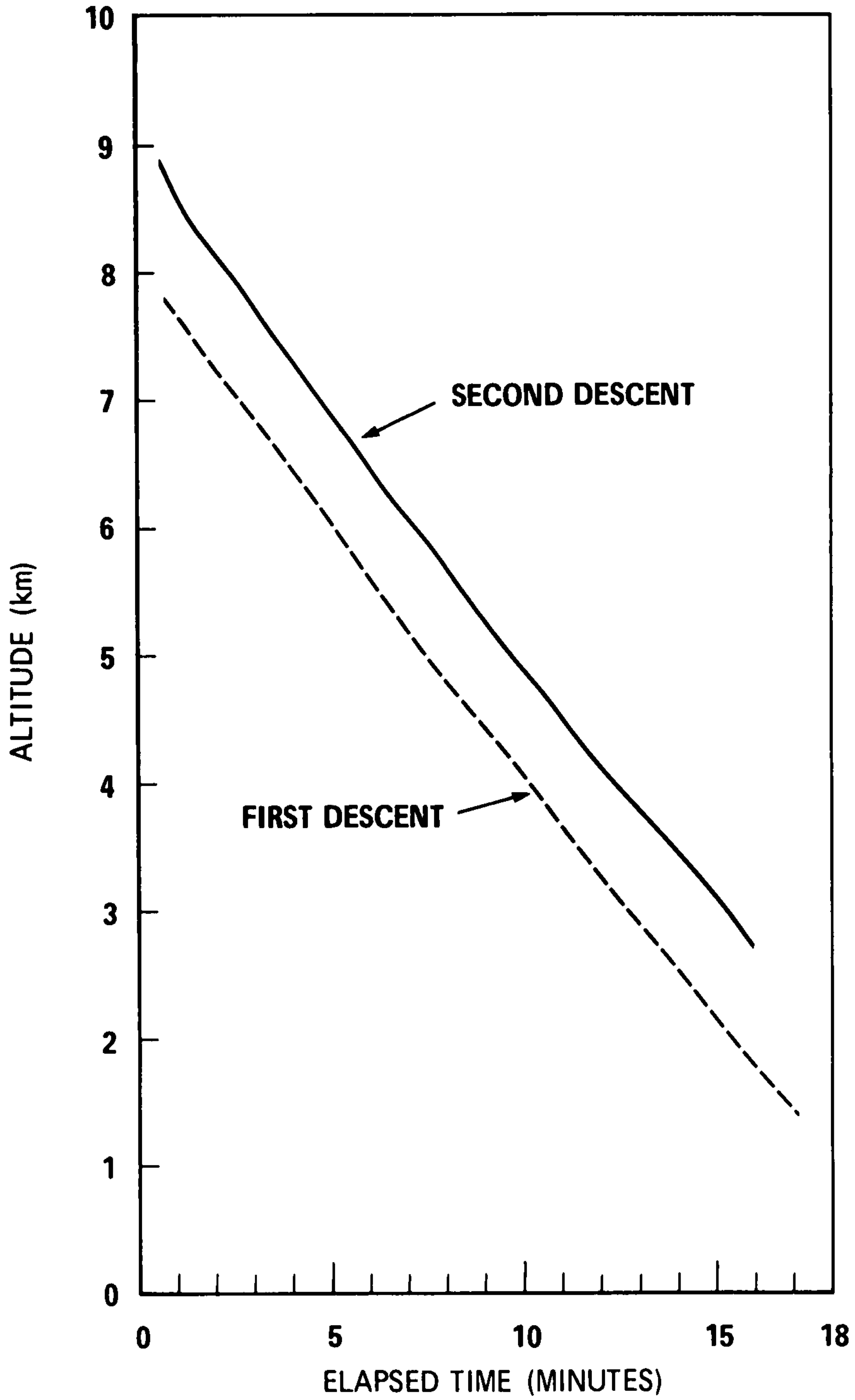

Fig. 4. Altitude of the aircraft plotted as a function of time. It can be inferred from these graphs that the attitude of the aircraft remained constant during both descents, with the possible exception in the range from 8750 m down to 7500 m during the second descent. The deviation from a straight slope in this range may be indicating a very slight vertical pitching of the aircraft.

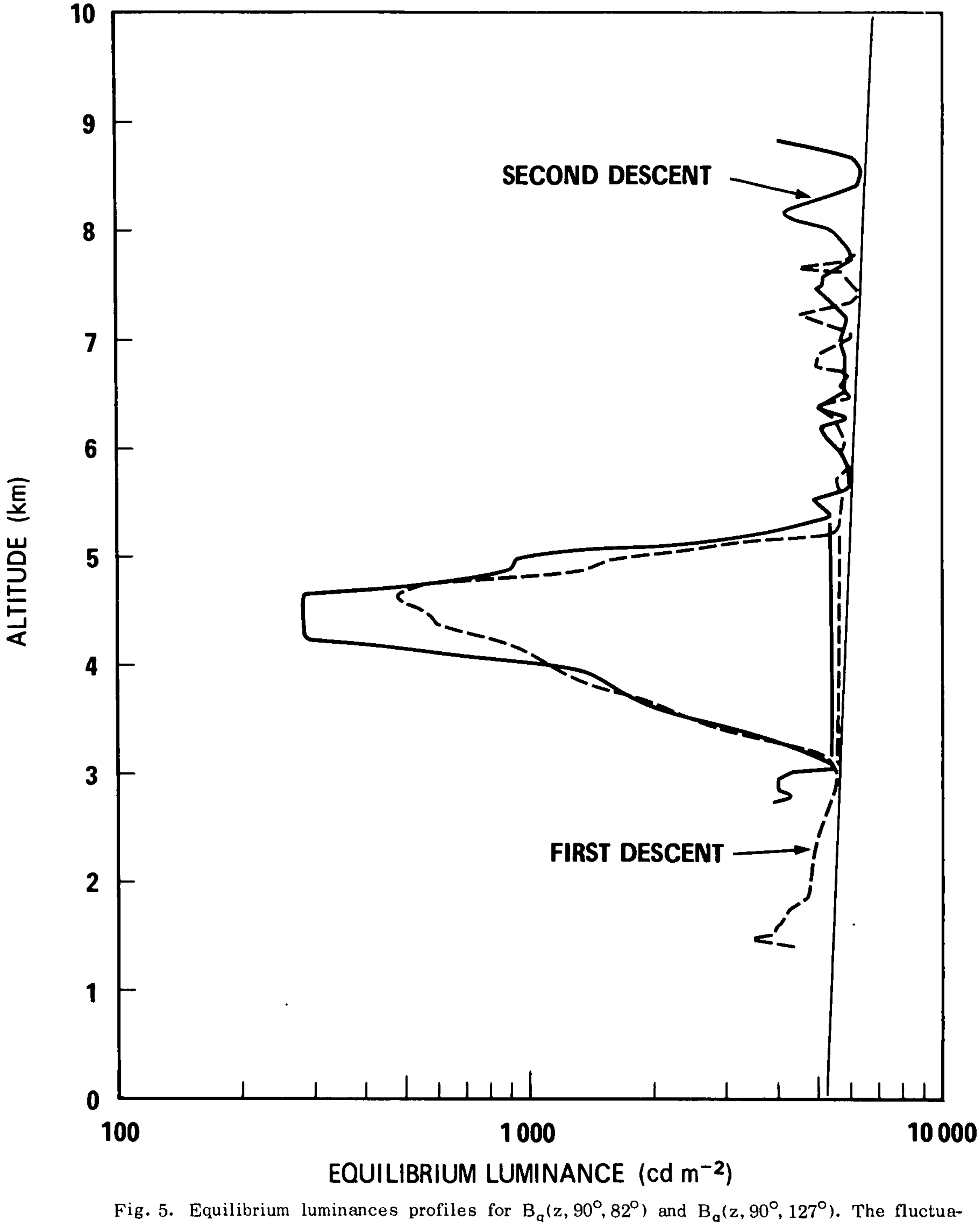

Fig. 5. Equilibrium luminances profiles for $B_q(z, 90°, 82°)$ and $B_q(z, 90°, 127°)$. The fluctuations from the starting altitude down to 5300 m, in each case are believed to be the results of thin cloud strata, although it is possible they are partially due to changes in aircraft attitude, as discussed in the caption of Fig. 4. The radical decrease in value between 5300 m and 3000 m in each profile is the result of condensation of moisture on the front optical surface of the telephotometer.

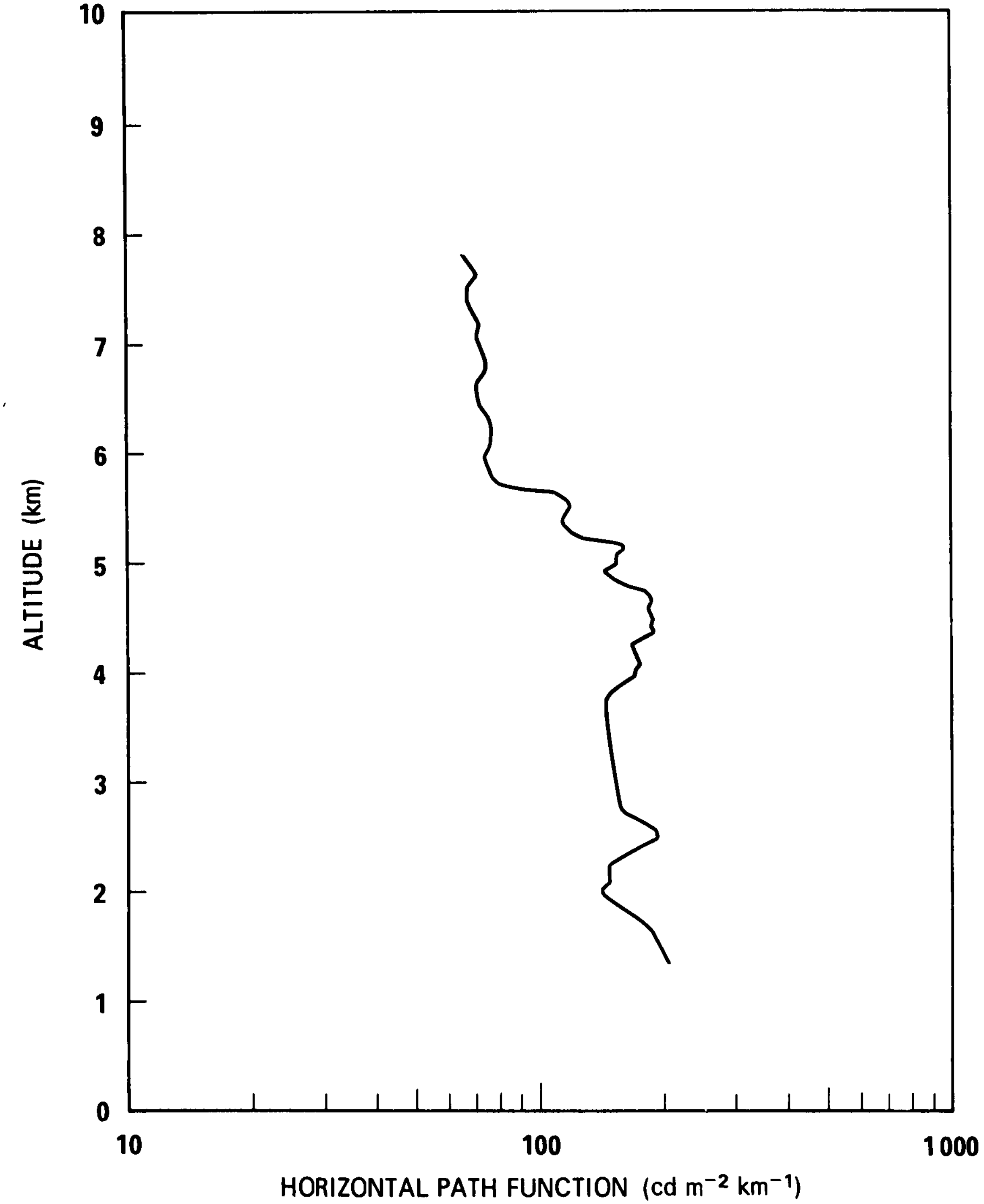

Fig. 6. Horizontal path function $B_*(z, 90^\circ, 82^\circ)$ profile. The fluctuation in the profile with altitude are attributed to atmospheric inhomogeneities and haze layers. The fluctuations from 5700 m down to 3700 m are very similar to the fluctuations of the relative humidity profile in that range during the first descent.

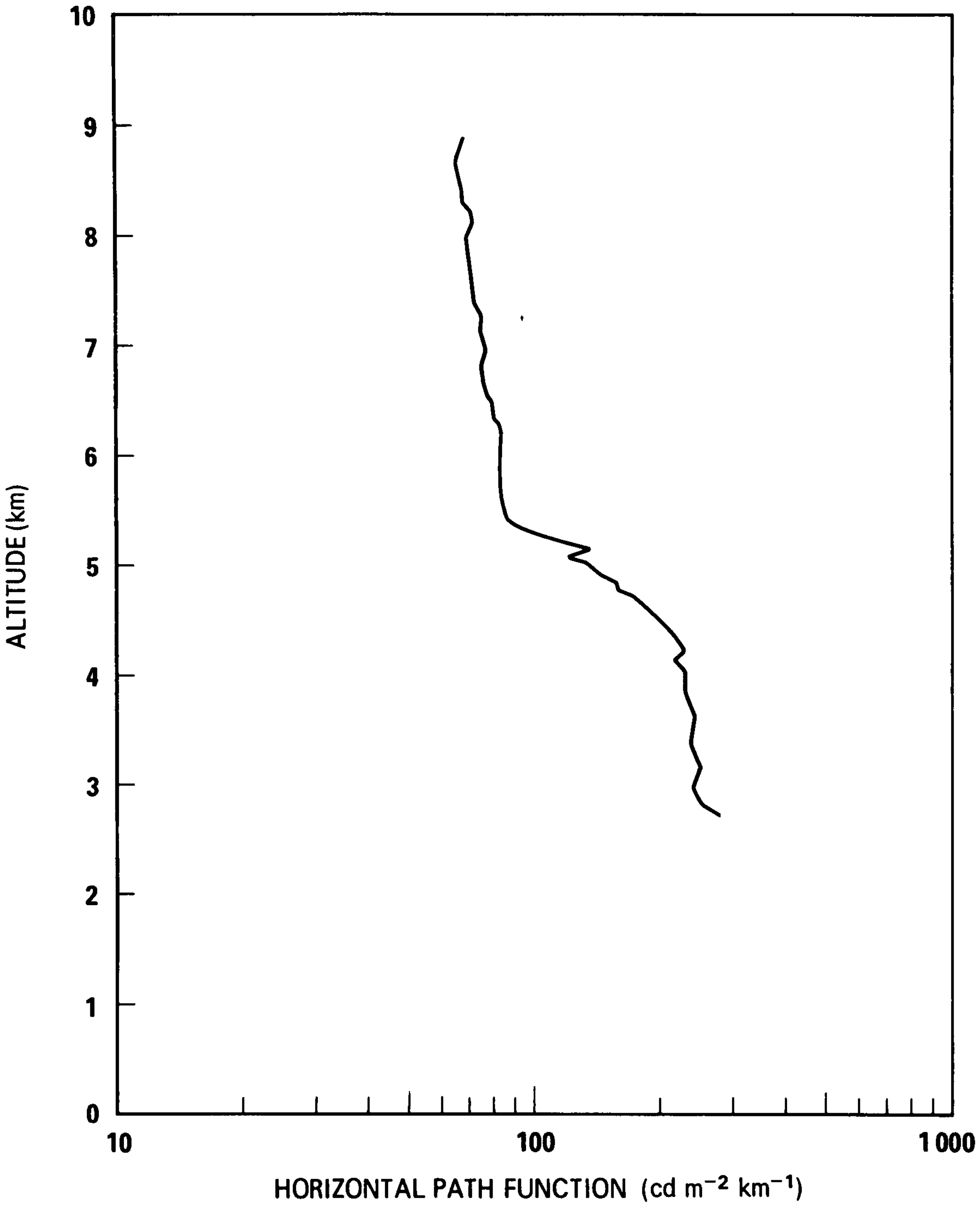

Fig. 7. Horizontal path function $B_*(z, 90°, 127°)$ profile. This profile shows less structure in the atmosphere than does the profile in Fig. 6. Other than the big change of path function value occurring at 5350 m there seems to be little relationship between this profile and the relative humidity profile for the second descent.

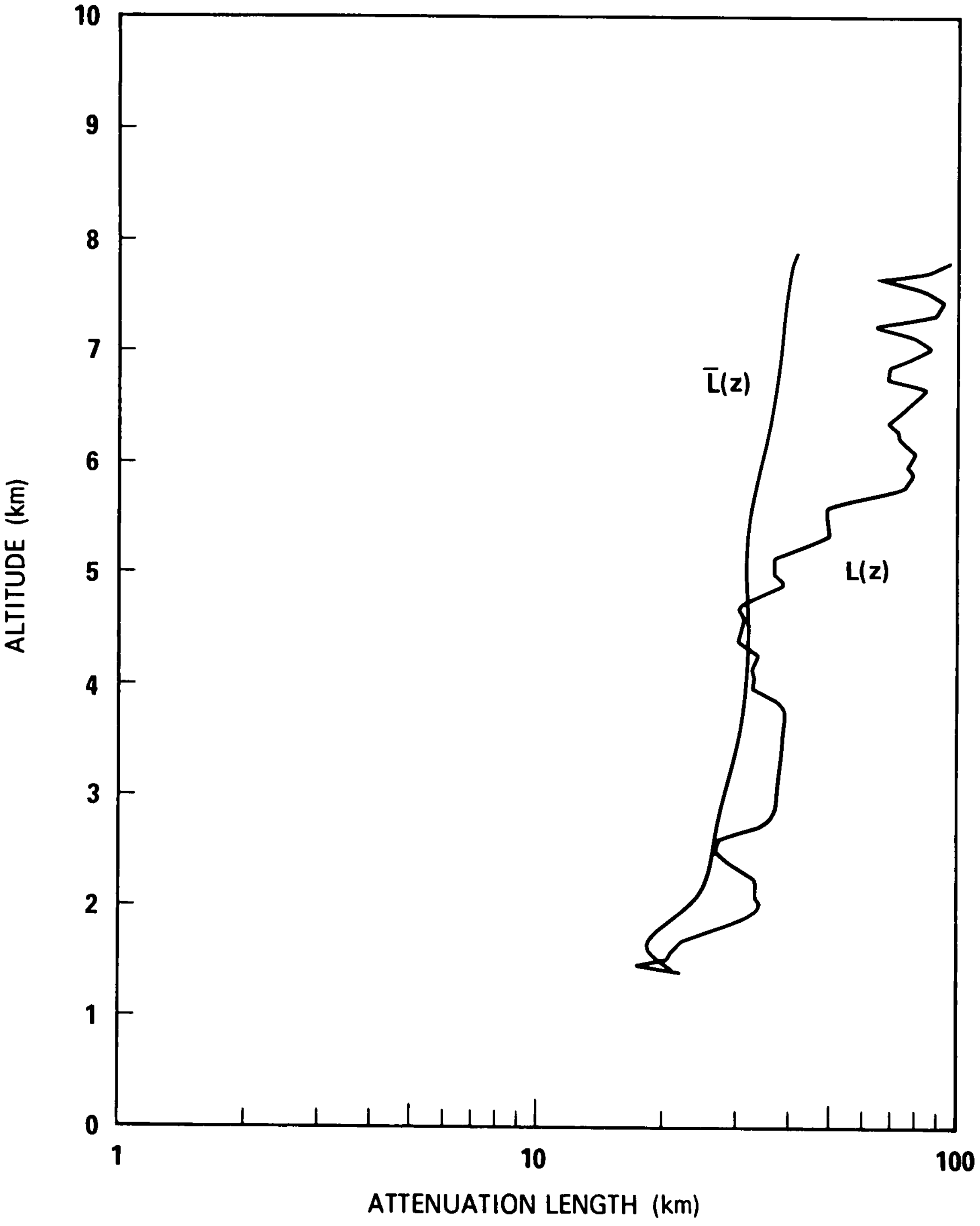

Fig. 8 Attenuation length L(z) and equivalent attenuation length $\overline{L}(z)$ for the first descent. The $\overline{L}(z)$ profile is a summative curve of z/L(z) and is used in the equation $T_r(z, 180^\circ) = \exp[-z/\overline{L}(z)]$, for finding the atmospheric transmittance for the vertical path of sight.

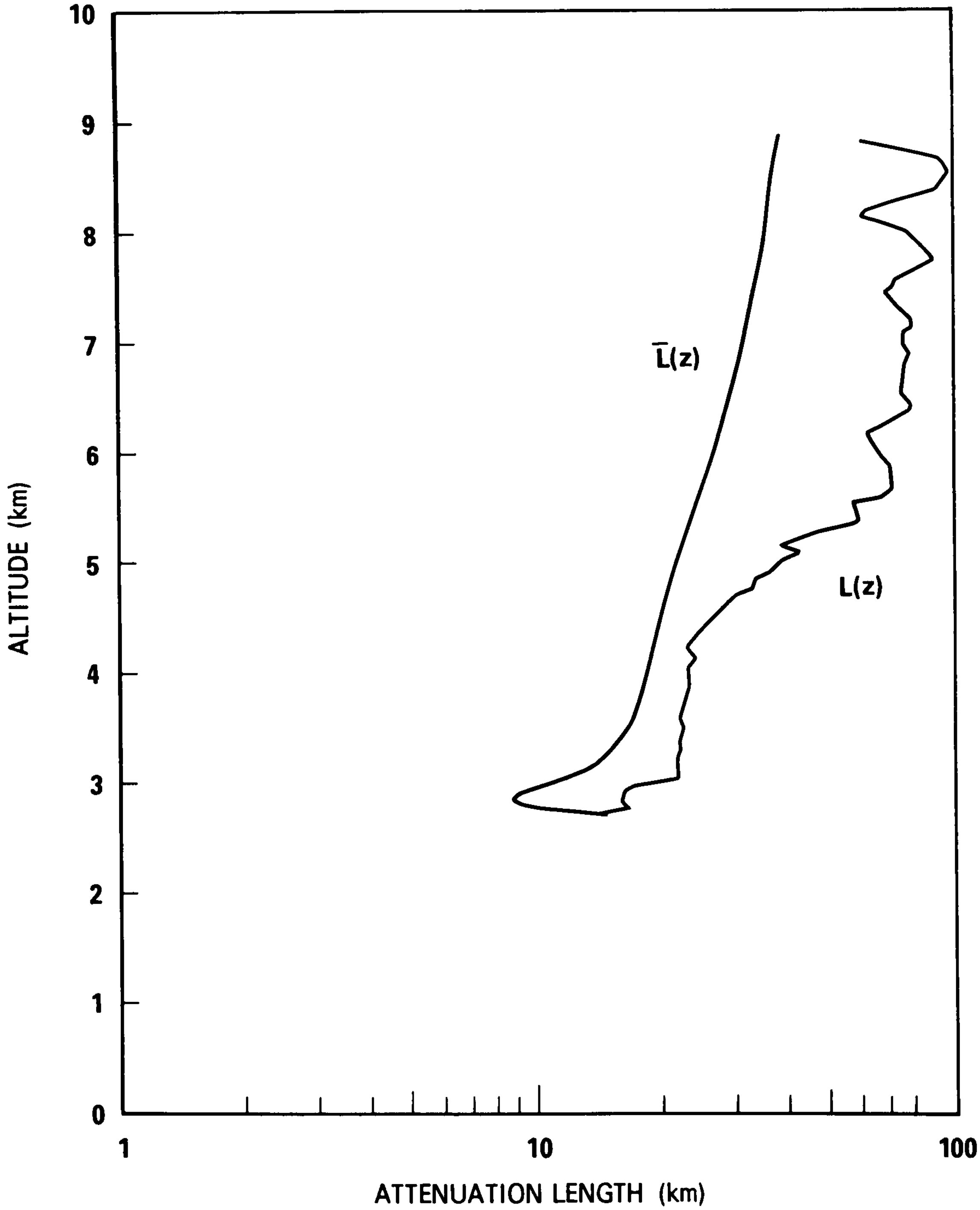

Fig. 9. Attenuation length L(z) and equivalent attenuation length $\overline{L}(z)$ for the second descent.

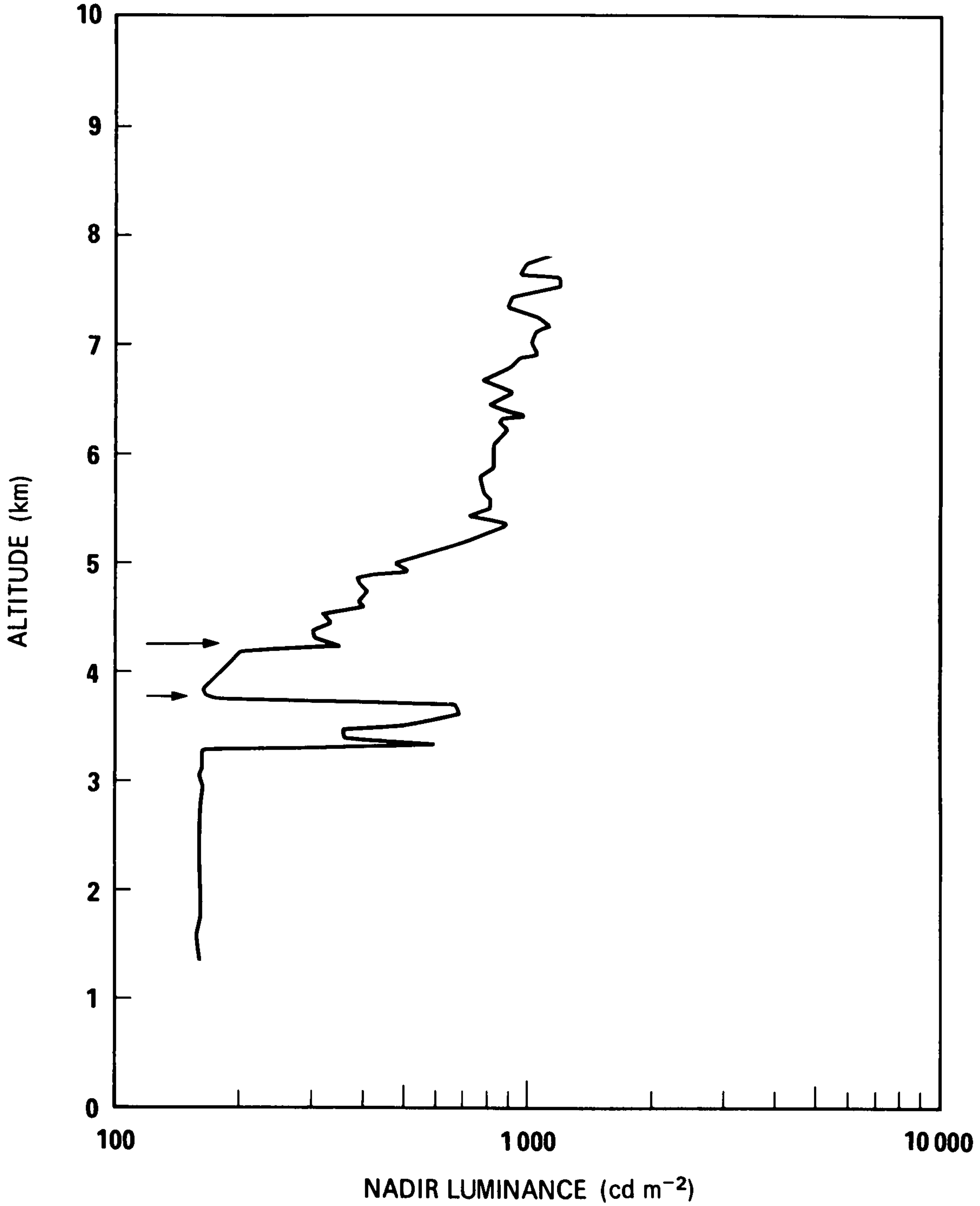

Fig. 10. Nadir luminance $B_r(z, 180°, 0°)$ for first descent. The range of altitudes within which the aircraft was over Crater Lake is indicated by the arrows. From 3300 m down to 1400 m the aircraft was over Upper Klamath Lake.

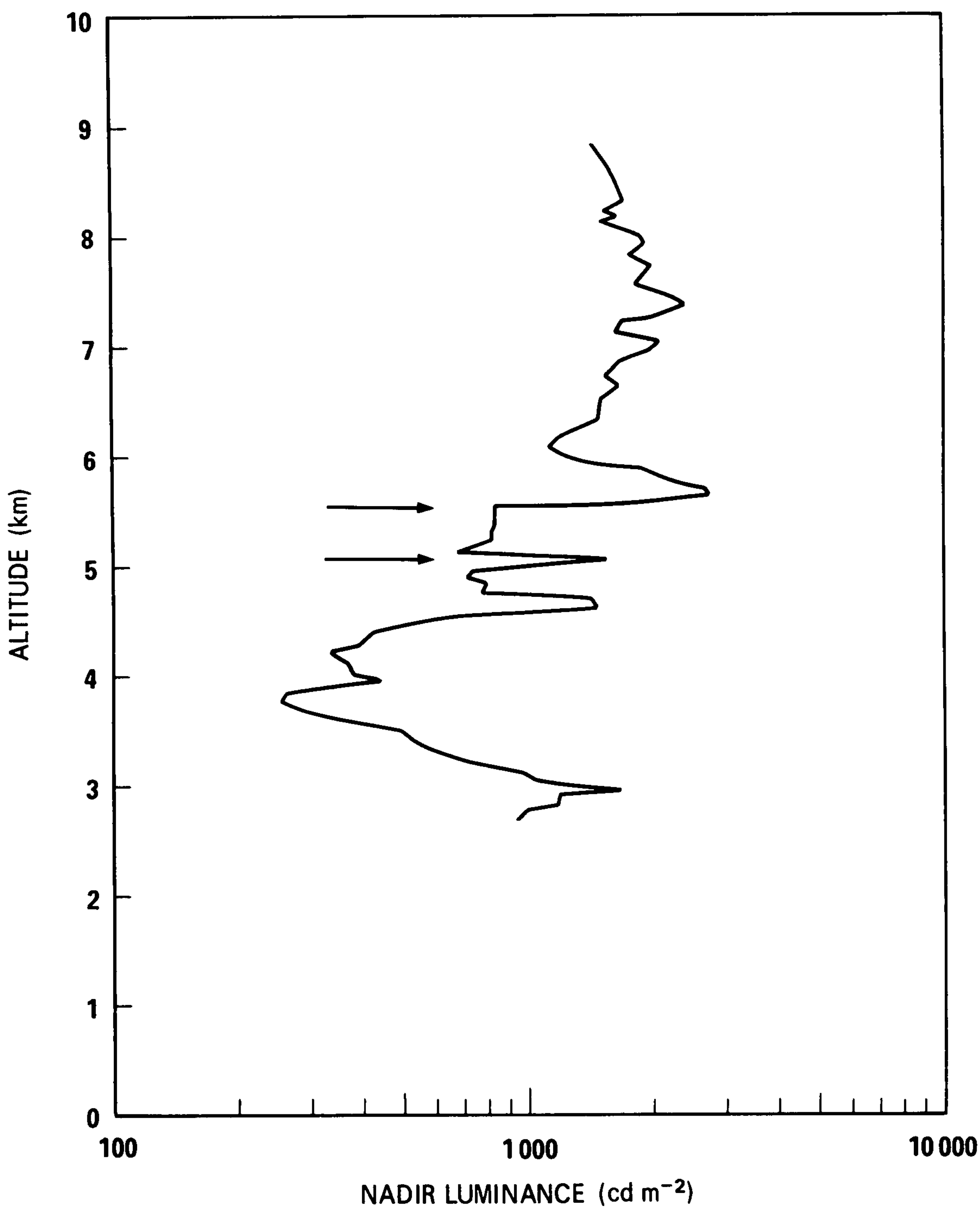

Fig. 11. Nadir luminance $B_r(z, 180^\circ, 0^\circ)$ for second descent. The arrows indicate the range of altitudes in which the aircraft was over Crater Lake.

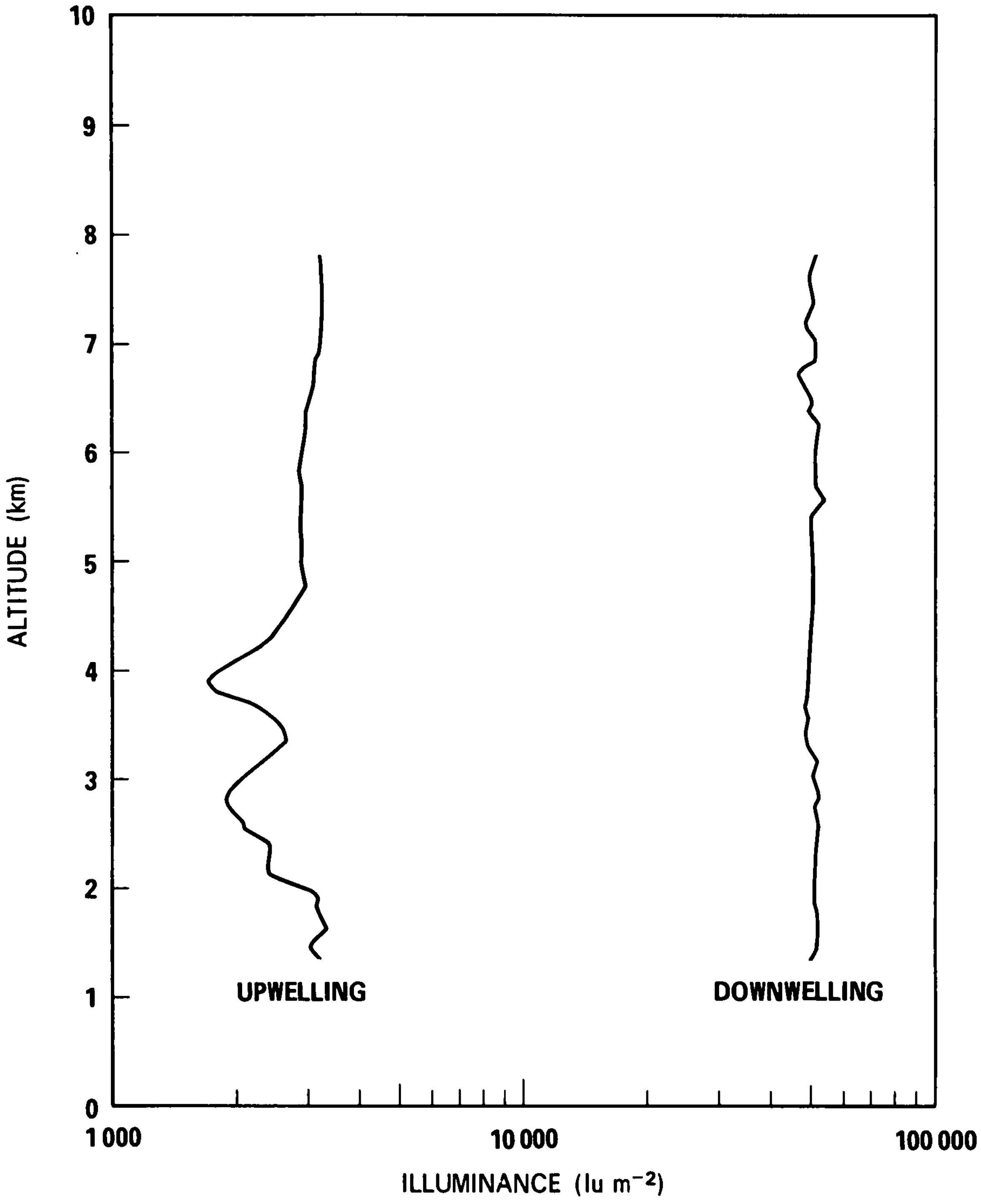

Fig. 12. Downwelling and upwelling illuminance, E(z,−) and E(z,+), respectively, for the first descent.

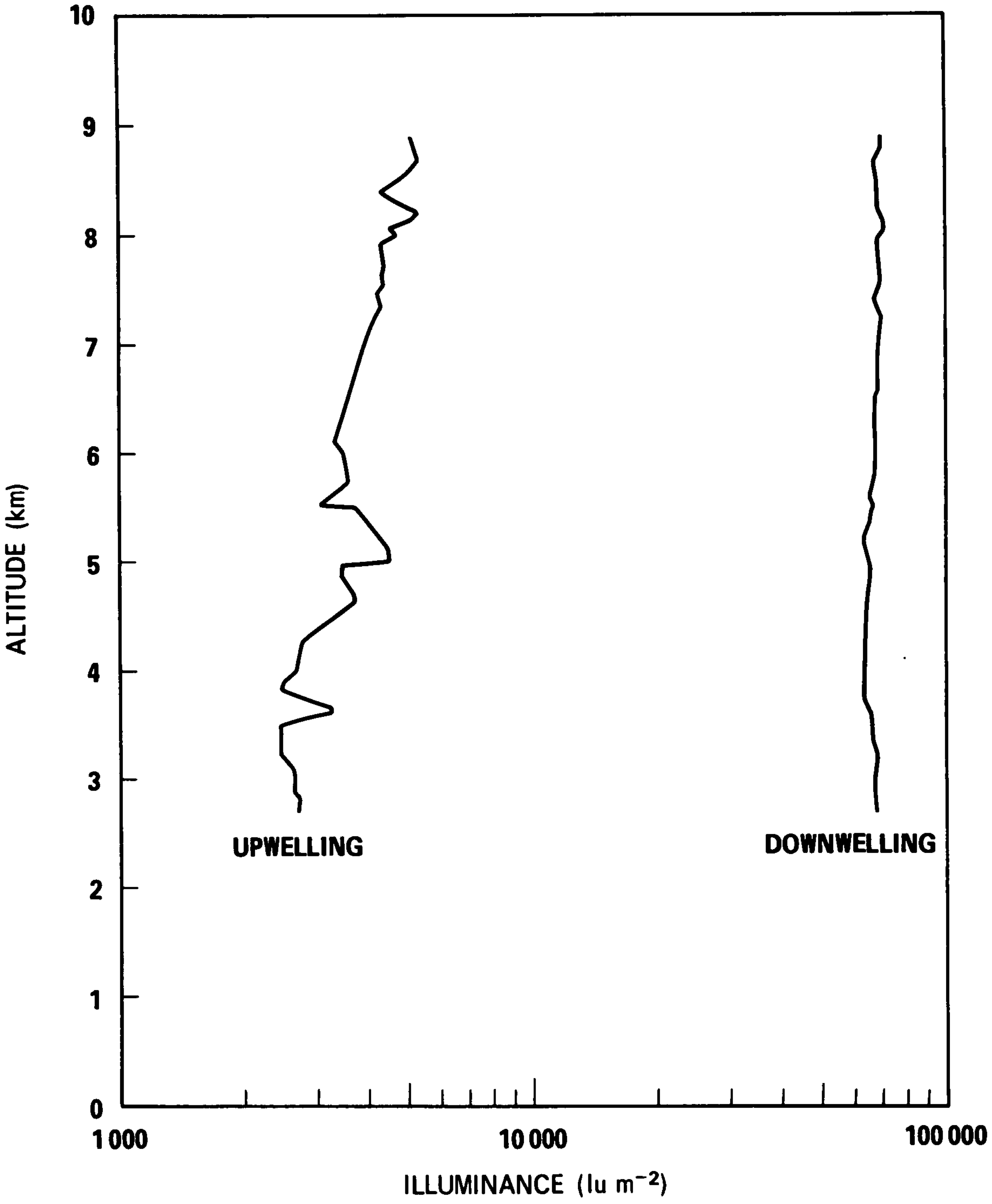

Fig. 13. Downwelling and upwelling illuminance, E(z,−) and E(z,+) for the second descent.

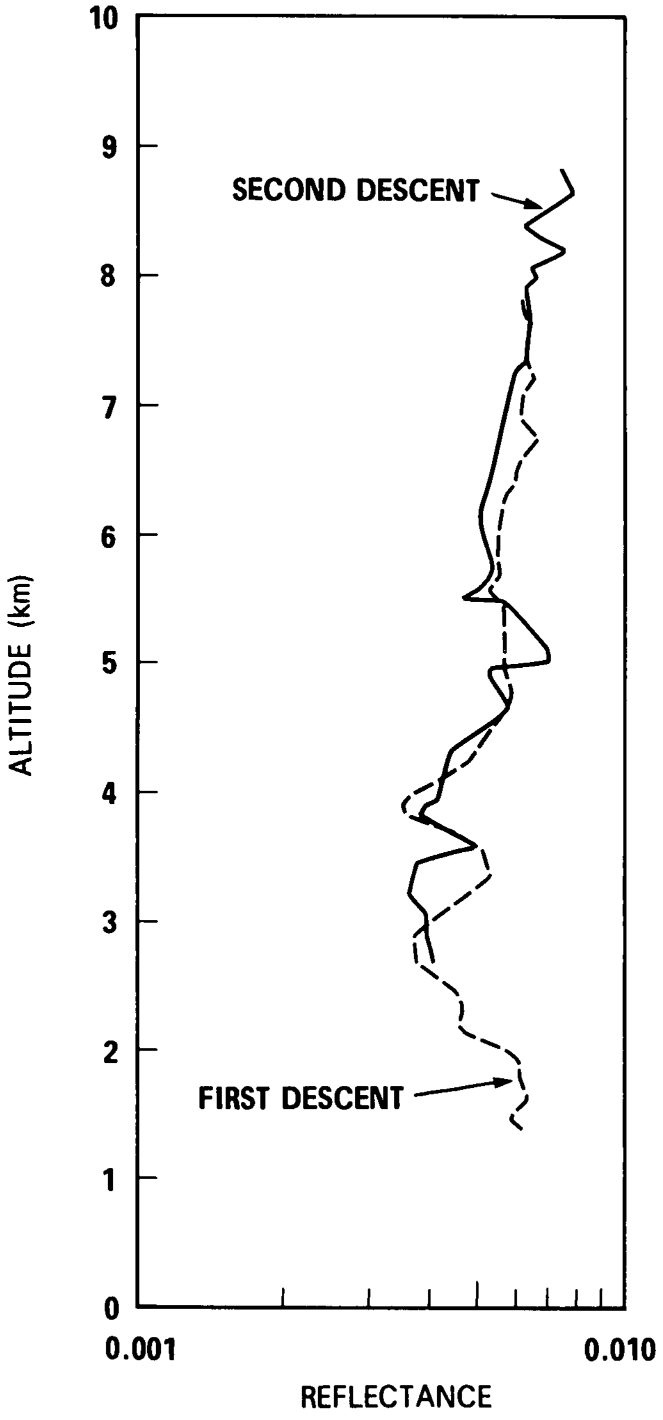

Fig. 14. Ratios of upwelling and downwelling illuminances during both descents.

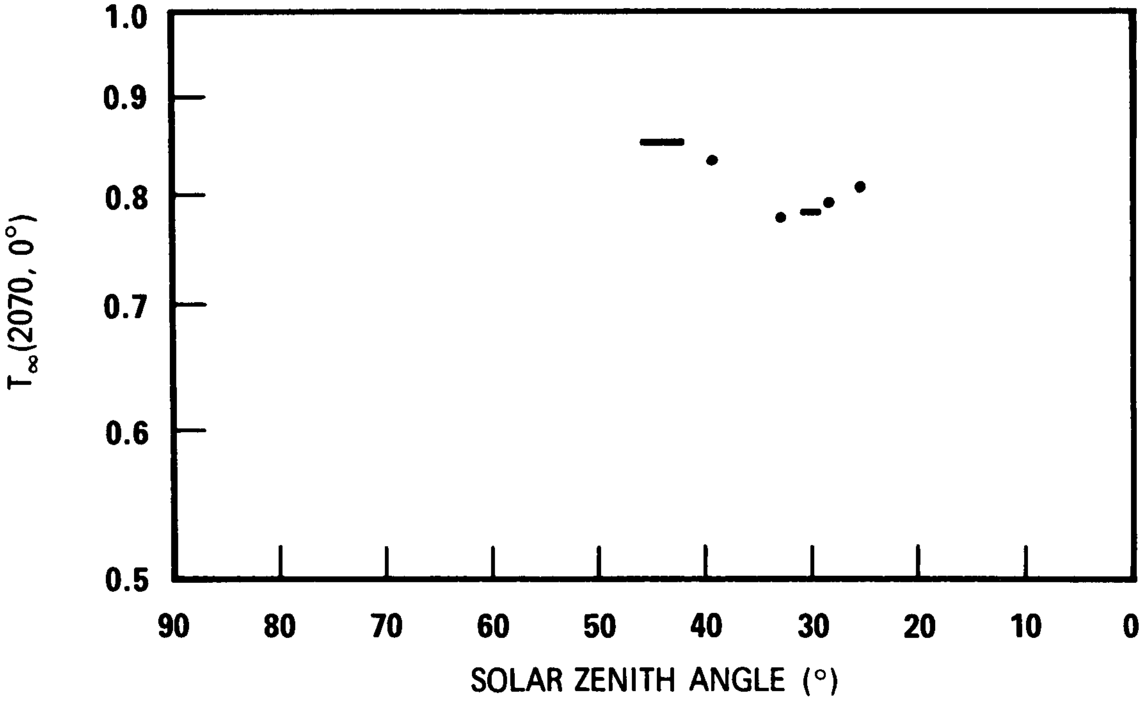

Fig. 15. Beam transmittances for vertical path of sight as a function of solar zenith angle. The four data points represent transmittances calculated from the ground-based transmissometer. The two elongated data points represent the transmittances calculated from aircraft data, extrapolated to ground level, the amount of elongation representing the change of solar zenith angle during the time of each descent.

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13 ABSTRACT

This report presents new atmospheric optical data measured by airborne optical and meteorological sensors recorded near Crater Lake, Oregon, during the first day of a three day period in August 1966. Two data gathering descents were made, from 7800 m to 1400 m, and from 8800 m to 2700 m. The times of these descents were 0913 and 0930 and 1045 to 1101, Pacific Daylight Time. Atmospheric beam transmittances were measured also by a ground station located south of Crater Lake at an altitude of 2070 m. Data presented are altitude profiles of heading of aircraft, temperature, relative humidity, equilibrium luminance, horizontal path function, attenuation length, nadir luminances, and downwelling and upwelling illuminances and their ratios.