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AIRBORNE AND GROUND-BASED MEASUREMENTS OF OPTICAL ATMOSPHERIC PROPERTIES IN CENTRAL NEW MEXICO

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ABSTRACT

This report presents atmospheric optical data collected in the daytime chiefly with airborne instruments during a field expedition to central New Mexico in the Fall of 1970. Results from six flights are presented. The data include irradiance, directional reflectance of terrain, total volume scattering coefficients, atmospheric beam transmittance, path radiance, and directional path reflectance. Data for sunlight and overcast conditions were derived for downward-looking paths of sight inclined at seven zenith angles (93, 95, 100, 105, 120, 150, and 180 degrees) from altitudes of 4500 meters above ground level and lower in four spectral regions, as follows: three narrow band optical filters with mean wavelengths of 478, 664, and 765 nanometers; and one broad band sensitivity representing the photopic response with a mean wavelength of 557 nanometers.

SUMMARY

This report which describes portions of the Project ATOM (ATmospheric Optical Measurements) effort was prepared under AFCRL Contract F19628-70-C-0054. The principal project task was to take daytime atmospheric optical measurements in central New Mexico during Project ATOM and, from these measurements, to determine optical properties for various downward-inclined paths of sight. These properties include atmospheric beam transmittance, path reflectance, terrain reflectance, irradiance, total volume scattering coefficient, and path radiance.

The field trip was made to New Mexico during October and November of 1970. Data were recorded near the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush.

The instrumentation developed at the Visibility Laboratory and mounted in Air Force C-130A, aircraft No. 50022, consisted of a total scattering meter (or integrating nephelometer) for determining the total scattering coefficient, two sky scanning radiometers for recording upper and lower sky radiances, a dual irradiometer for recording alternately the downwelling and upwelling irradiances, an equilibrium radiance telephotometer, and a variable direction path function meter. The meteorological instrumentation included a Royco particle counter, pressure transducers, a dewpoint hygrometer, and an AN/AMQ-17 aerograph for measuring ambient temperature and humidity.

Each optical instrument was fitted with five optical filters causing it to measure at three narrow band wavelengths of the spectrum and two broad pass bands. The measurements were made using the three narrow band filters at mean wavelengths of 478, 664, and 765 nanometers and a filter representing the photopic response with a mean wavelength of 557 nanometers.

All but the Royco data were recorded on magnetic tape in the aircraft by means of a 42-channel magnetic tape data logger. The data tapes were returned to the Visibility Laboratory to be processed using the computer facilities at the University of California, San Diego.

A ground-based station near the flight track contained effectively duplicate instrumentation for obtaining optical data. In addition, it contained a contrast reduction meter for measuring earth-to-space beam transmittance and path radiance.

CONTENTS

LIST OF ILLUSTRATIONS

GLOSSARY AND NOTATION

The notation used in reports and journal articles produced by the Visibility Laboratory staff follow, in general, the rules set forth in pages 499 and 500, Duntley *et al* (1957). These rules are:

Each optical property is indicated by a basic (parent) symbol.

A presubscript may be used with the parent symbol as an identifier, e.g., b indicates background while t denotes an object.

A postsubscript may be used to indicate the length of a path of sight, e.g., r denotes an *apparent* property as measured at the end of a path of sight of length r, while o denotes an *inherent* property based on the hypothetical concept of a photometer located at zero distance from an object.

A postsuperscript *, or a postsubscript$_*$, is employed as a mnemonic symbol signifying that the radiometric quantity has been generated by the scattering of ambient light reaching the path from all directions.

The parenthetical attachments to the parent symbol denote altitude and direction. The letter z indicates altitude in general; z_t is used to specify the altitude of an object. The direction of a path of sight is specified by the zenith angle θ and the azimuth ϕ. In the case of irradiances, the downwelling irradiance is designated by d, the upwelling by u.

The glossary for meteorological symbols is presented in Section 6.

A(z)	Albedo at altitude z, defined by the equation $A(z) \equiv H(z,u)/H(z,d)$. (*Scalar Albedo*, at altitude z, is the ratio $h(z,u)/h(z,d)$.)
AGL	Above ground level.

$C_o(z_t,\theta,\phi)$ Inherent universal contrast determined for a path of sight of zero length at altitude of the object z_t in the direction of zenith angle θ and azimuth ϕ. This property is defined by the equation

$$C_o(z_t,\theta,\phi) \equiv \frac{{}_tN_o(z_t,\theta,\phi) - {}_bN_o(z_t,\theta,\phi)}{{}_bN_o(z_t,\theta,\phi)} .$$

$C_r(z,\theta,\phi)$ Apparent universal contrast as determined at altitude z from the end of path of sight of length r in the direction of the zenith angle θ and azimuth ϕ. This property is defined by the equation

$$C_r(z,\theta,\phi) \equiv \frac{{}_tN_r(z,\theta,\phi) - {}_bN_r(z,\theta,\phi)}{{}_bN_r(z,\theta,\phi)} .$$

g Acceleration of gravity.

$H(z)$ Scale height at altitude z, the height of a homogeneous atmosphere having the density of the layer at altitude z.

$H(z,d)$ Irradiance produced by downwelling flux as determined on a horizontal flat plate at altitude z. In this report d is used in place of the minus sign in the notation $H(z_t,-)$ which appears in Duntley (1969). This property may be defined by the equation

$$H(z,d) \equiv \int_{2\pi} N(z,\theta',\phi')\cos\theta' \, d\Omega .$$

$H(z,u)$ Irradiance produced by upwelling flux as determined on a horizontal flat plate at altitude z. Here u is substituted for the plus sign formerly used in the notation $H(z,+)$.

$h(z)$ Scalar irradiance. This may be defined as the radiant flux arriving at a point, from all directions about that point, at altitude z (Tyler and Preisendorfer, 1962):

$$h(z) \equiv h(z,d) + h(z,u) .$$

$h(z,d)$ Scalar irradiance produced by downwelling flux. This may be defined as the radiant flux from the upper hemisphere arriving at a point at altitude z.

${}_kh(z,d)$ Scalar irradiance defined as the radiant flux from the upper hemisphere sky (flux from the sun is not included) arriving at a point at altitude z.

${}_sh(z)$ Scalar irradiance defined as the radiant flux from the sun arriving at a point at altitude z.

$h(z,u)$ — Scalar irradiance produced by upwelling flux. This may be defined as the radiant flux from the lower hemisphere arriving at a point at altitude z.

$L(z)$ — Attenuation length at altitude z. This property is the reciprocal of the attenuation coefficient, that is,

$$L(z) \equiv \alpha(z)^{-1} .$$

$\bar{L}(z)$ — Equivalent attenuation length is defined as

$$\bar{L}(z) = \frac{-z}{\ln T_z(0,0)} .$$

$m_\infty(z,\theta)/m_\infty(z,0)$ — Relative optical airmass.

$N(z,\theta,\phi)$ — Radiance as determined from altitude z in the direction specified by zenith angle θ and azimuth ϕ.

${}_bN_o(z_t,\theta,\phi)$ — Inherent background radiance as determined at altitude of the photometer z_t at zenith angle θ and azimuth ϕ.

${}_bN_r(z,\theta,\phi)$ — Apparent background radiance as determined at altitude z from the end of a path of sight of length r at zenith angle θ and azimuth ϕ. This property may be defined by the equation

$${}_bN_r(z,\theta,\phi) \equiv {}_bN_o(z_t,\theta,\phi)\, T_r(z,\theta) + N_r^*(z,\theta,\phi) .$$

${}_tN_o(z_t,\theta,\phi)$ — Inherent radiance of an object as determined at altitude of the photometer z_t at zenith angle θ and azimuth ϕ.

${}_tN_r(z,\theta,\phi)$ — Apparent radiance of an object as determined at altitude z from the end of a path of sight of length r at zenith angle θ and azimuth ϕ. This property may be defined by the equation

$${}_tN_r(z,\theta,\phi) \equiv {}_tN_o(z_t,\theta,\phi)\, T_r(z,\theta) + N_r^*(z,\theta,\phi) .$$

$N_q(z,\theta,\phi)$ — Equilibrium radiance at altitude z with the direction of the path of sight specified by zenith angle θ and azimuth ϕ. This property is a point function of position and direction.

$N_*(z,\theta,\phi)$ — Path function at altitude z with the direction of the path of sight specified by zenith angle θ and azimuth ϕ. This property is defined by the equation

$$N_*(z,\theta,\phi) \equiv \int_{4\pi} \sigma(z,\beta')\, N(z,\theta',\phi')\, d\Omega .$$

This property also is a point function of position and direction.

$N_r^*(z,\theta,\phi)$	Path radiance as determined at altitude z at the end of a path of sight of length r in the direction specified by zenith angle θ and azimuth ϕ.
n(z)	Index of refraction at altitude z.
P(z)	Pressure at altitude z.
psia	Pressure, absolute, pounds per square inch.
psid	Pressure, differential, pounds per square inch.
${}_bR_o(z_t,\theta,\phi)$	Inherent background reflectance as determined at the altitude of an object z_t and viewed at zenith angle θ and azimuth ϕ.
$R_r^*(z,\theta,\phi)$	Directional path reflectance as determined at altitude z at the end of a path of sight of length r in the direction specified by zenith angle θ and azimuth ϕ.
$R_q(z,\theta,\phi)$	Equilibrium reflectance is defined as $R_q(z,\theta,\phi) = N_q(z,\theta,\phi)\,\pi/H(z,d)$.
R/M(0)	Universal gas constant.
$\overline{S_\lambda T_\lambda}$	Standardized relative spectral response of filter/cathode combination where S_λ is spectral sensitivity of the multiplier phototube cathode and T_λ is spectral transmittance of optical filter.
s(z)	Total volume scattering coefficient as determined at altitude z. This property may be defined by the equation $s(z) \equiv \int_{4\pi} \sigma(z,\beta)\, d\Omega$. In the absence of atmospheric absorption, the total volume scattering coefficient is numerically equal to the attenuation coefficient.
${}_Ms(z)$	Total volume scattering coefficient for Mie scattering at altitude z.
${}_Rs(z)$	Total volume scattering coefficient for Rayleigh scattering at altitude z.
T(z)	Temperature in degrees Kelvin at altitude z.
$T_r(z,\theta)$	Beam transmittance as determined at altitude z for a path of sight of length r at zenith angle θ. This property is independent of azimuth in atmospheres having horizontal uniformity. It is always the same for the designated path of sight or its reciprocal.
${}_b\tau_r(z,\theta,\phi)$	Contrast transmittance as determined at altitude z at the end of a path of sight of length r and specified by zenith angle θ and azimuth ϕ. This property is *not* independent of azimuth and is *not* the same for the designated path of sight and its reciprocal.

W_λ — Spectral emittance (power/unit of area) of electromagnetic flux from a plane surface.

$\bar{y}$ — Symbol for visual efficiency function.

ZSV — Zero scale value. The zero point on the linear scale when the radiometric or photometric quantity x is equal to a reference radiometric or photometric quantity x_o as shown in equation

$$\log [x_o / x] = 0 .$$

z — Altitude, usually used as above ground level.

z_t — Altitude of an object.

$\alpha(z)$ — Volume attenuation coefficient as determined at altitude z. In the absence of atmospheric absorption, the attenuation coefficient is numerically equal to the volume scattering coefficient.

β — Symbol for scattering angle of flux from a light source. It is equal to the angle between the line from the source to the observer and the path of sight.

β' — Symbol for scattering angle of flux from a discrete part of the sky. It is equal to the angle between the direction specified by θ' and ϕ' and the path of sight.

Δ — Symbol to indicate incremental quantity and used with r and z to indicate small, discrete increments in path length r and altitude z.

δ_λ — Response area is defined as $\delta_\lambda = \Sigma(\overline{S_\lambda T_\lambda})\, \Delta\lambda$.

ϵ_λ — Spectral emissivity of tungsten filament.

ζ — Symbol for radius of the earth in Eq. 2-11 and 2-13 and Figure 2-2.

θ — Symbol for zenith angle. This symbol is usually used as one of two coordinates to specify the direction of a path of sight.

θ' — Symbol for zenith angle usually used as one of two coordinates to specify the direction of a discrete portion of the sky.

λ — Symbol for wavelength.

$\bar{\lambda}$ — Mean wavelength is defined as $\bar{\lambda} = \Sigma\lambda\, (\overline{S_\lambda T_\lambda})\, \Delta\lambda / \delta\lambda$.

$\rho(z)$ — Density at altitude z.

σ — Symbol for volume scattering function. Parenthetical symbols may be added; for example, β may be used to designate the scattering angle from a source. In Gordon (1969) the parenthetical symbols are z and β for altitude and scattering angle.

$\sigma(z,\beta)/s(z)$ Proportional directional volume scattering function. This may be defined by the equation

$$\int_{4\pi} [\sigma(z,\beta)/s(z)] \equiv 1 .$$

ϕ Symbol for azimuth. The azimuth is the angle in the horizontal plane of the observer between a fixed point and the path of sight. The fixed point may be, for example, true north, the bearing of the sun, or the bearing of the moon. This symbol is usually used as one of two coordinates to specify the direction of a path of sight.

ϕ' This symbol for azimuth is usually used as one of two coordinates to specify the direction of a discrete portion of the sky.

Ω Symbol for solid angle. For a hemisphere

$$\Omega = 2\pi \text{ steradians;}$$

for a sphere $\Omega = 4\pi$ steradians.

1. INTRODUCTION

The field measurement program described in this report was organized under the project title ATOM, an acronym for ATmospheric Optical Measurements. The overall operation of this project was coordinated as a part of Air Force Cambridge Research Laboratory's Project 7621, specified in WSMR OR48501, 21 August 1970.

The ATOM mission was conducted during October and November 1970. Data acquisition flights were made in central New Mexico. A typical flight track location is illustrated in Figure 1-1.

Fig. 1-1. Typical Project ATOM Flight Track.

This report has been prepared under Contract No. F19628-70-C-0054. It contains the optical properties of various downward-inclined paths of sight based on daytime atmospheric optical measurements made at the northern end of the White Sands Missile Range. These properties include irradiance, directional background reflectance, total volume scattering coefficient, beam transmittance, path radiance, and path reflectance.

The methods used in the derivation of these optical properties are discussed in detail in Section 2 and are the same as those presented in Duntley *et al.* (1972). There are four principal modifications from the methods outlined in Duntley *et al.* (1970). First, extrapolations of total volume scattering coefficient are made here according to the density ratios of the U. S. Standard Atmosphere, 1962. Second, the refraction effect has been added to the effect of earth curvature for the computation of the incremental path length for the near horizontal slant paths. Third, the selection of the shape of the volume scattering function from the Barteneva (1960) catalog is now based upon the *in situ* measurements of the volume scattering function at 30 and 150 degrees. Finally, when the sky near the sun is unclouded, the apparent sun radiance value is based upon the theoretical value of the sun radiance out-of-the-atmosphere and the beam transmittance from out of the atmosphere to the altitude of measurement (based on an extrapolation of beam transmittance from the highest flight altitude).

The optical instrumentation, developed at the Visibility Laboratory and installed in Air Force C-130A aircraft No. 50022, is reported in detail in Duntley *et al.* (1970). The instrumentation which generated the raw data upon which the reported properties are based consisted of an integrating nephelometer for determining the total scattering coefficient and two sky scanning radiometers for recording upper and lower sky radiances. A ground-based integrating nephelometer similar to the airborne instrument provided the ground level value of the total volume scattering coefficient.

The basic characteristics of the instrumentation were reviewed in Section 3 of Duntley *et al.* (1972). All significant modifications and updates accomplished subsequent to the issuance of AFCRL-70-0137, Duntley *et al.* (1970), were included wherever appropriate within that report. The major revisions to the hardware were initiated in order to convert their operating characteristics to permit daytime as well as nighttime data gathering. Two general modifications were required. First, all optical filter changers were altered to permit the automatic insertion of neutral density filters into the optical paths of each radiometer system, and second, a revised air inlet was devised for the airborne integrating nephelometer. The radiometer spectral responses were standardized for this deployment, as illustrated in Figure 1-2, and were discussed in Section 3.5 of Duntley *et al.* (1972). Three new instrument systems have been added to those previously reported and they are discussed in Section 3 of this report.

Data collection methods are similar to those reported by Duntley *et al.* (1972). The flight profile which covers all altitudes between ground level and 20 000 feet (6100 meters) above ground level is illustrated in Figure 4-1. As inferred in the previous paragraph, data collection can now be accomplished under both daytime and nighttime illumination levels, although no flights were made at night during Project ATOM.

The computer techniques used for processing the data included in this report are summarized in Section 5. They are, in general, similar to the techniques reported by Duntley *et al.* (1972). Several adjustments and improvements to the routines have been made to speed up the overall processing and diagnostic sequences, as well as to expand the display options. See Figure 5-1. The addition of graphic displays to supplement data tables is maintained in this report. Changes in automatic processing and validating of the pre- and post-deployment calibration data are probably the most significant technical improvement to the data processing technique.

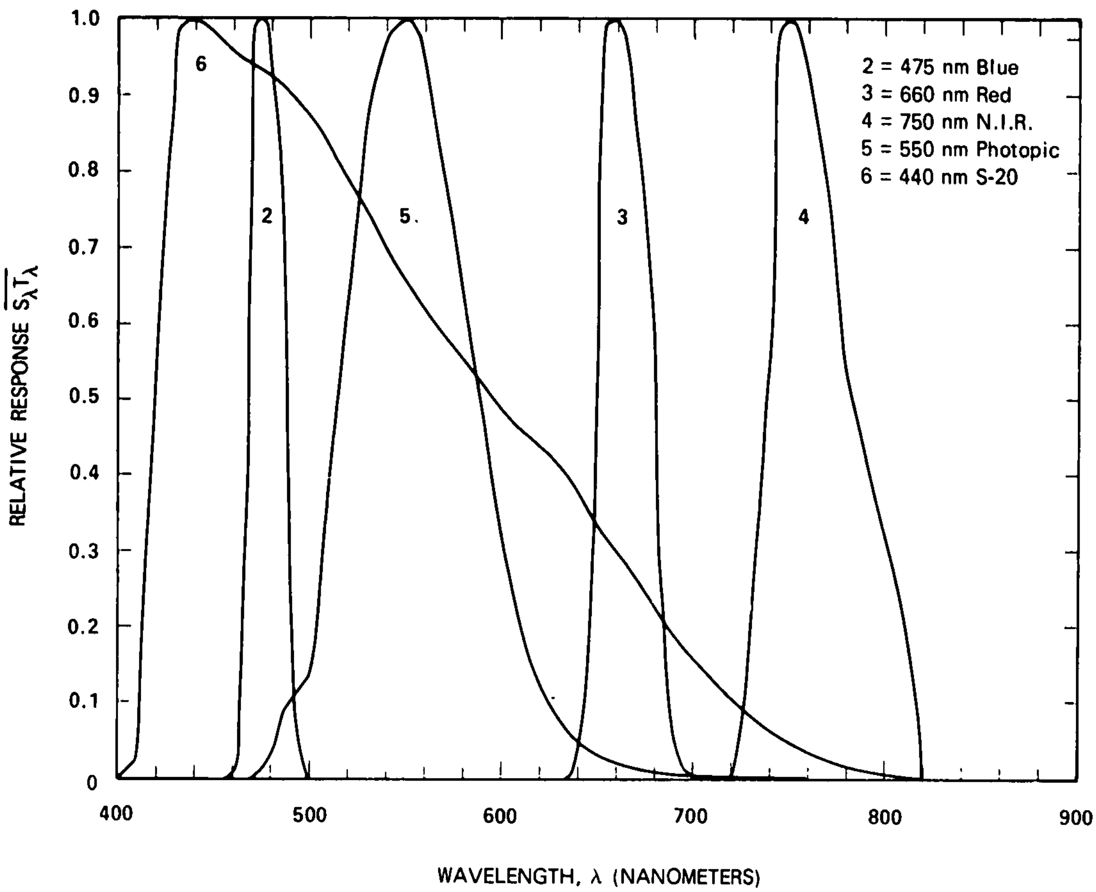


Fig. 1-2. Standard Spectral Responses for Project ATOM.

A general discussion of the weather patterns that predominated in the area of the White Sands Missile Range during the data collection is presented in Section 6. This section, in conjunction with the typical flight track photographs shown in Figures 7-1 and 7-2, is intended as an aid to the data-user's interpretation and evaluation. The most significant update in format is the inclusion of graphical representations as a supplement to the basic tabular format. The graphical presentations are limited in number but their inclusion is intended to further facilitate a user's rapid and generalized evaluation of weather type and quality.

The radiometric data representing the six flights covered in this report are presented in Section 7. The presentation format is similar to that used in AFCRL-72-0255, Duntley *et al.* (1972).

The ground data logger did not function properly during the ATOM deployment. As a result, only manually recorded data for the nephelometer and contrast reduction meter could be processed. These ground measurements are summarized in Section 7.5.

2. THEORY

2.1 CONTRAST TRANSMITTANCE

Contrast transmittance ${}_b\tau_r(z,\theta,\phi)$ is defined as the ratio of the apparent contrast $C_r(z,\theta,\phi)$ to the inherent contrast $C_o(z_t,\theta,\phi)$:

$$ {}_b\tau_r(z,\theta,\phi) \equiv C_r(z,\theta,\phi) / C_o(z_t,\theta,\phi) \; . \tag{2.1}$$

The parenthetical modifiers indicate the altitude z of the sensor and the zenith angle θ and azimuth ϕ of the path of sight. In this report, ϕ will always be in terms of azimuth from light source (sun or moon). The path length r in the direction of the path of sight is between the altitude of the target z_t and the sensor altitude z. For the inherent contrast the path length is zero. The presubscript b on the contrast transmittance ${}_b\tau_r(z,\theta,\phi)$ indicates background. The contrast transmittance is a function of the inherent background radiance ${}_bN_o(z_t,\theta,\phi)$, the atmospheric beam transmittance $T_r(z,\theta)$, and the path radiance $N_r^*(z,\theta,\phi)$ of the path of sight as shown in Eq. 2-2 (Duntley (1964) Eq. 2.4):

$$ {}_b\tau_r(z,\theta,\phi) = [1 + N_r^*(z,\theta,\phi) / {}_bN_o(z_t,\theta,\phi) \, T_r(z,\theta)]^{-1} \; . \tag{2.2}$$

2.2 DIRECTIONAL PATH REFLECTANCE

The concept of directional path reflectance (Duntley (1969) p. 3) is utilized in an alternate form of Eq. 2-2,

$$ {}_b\tau_r(z,\theta,\phi) = [1 + R_r^*(z,\theta,\phi) / {}_bR_o(z_t,\theta,\phi)]^{-1} \; , \tag{2.3}$$

where ${}_bR_o(z_t,\theta,\phi)$ is the directional background reflectance. By definition, the directional path reflectance is

$$R_r^*(z,\theta,\phi) = \pi N_r^*(z,\theta,\phi)/[H(z_t,d)\,T_r(z,\theta)]\,, \qquad (2.4)$$

where $H(z_t,d)$ is the downwelling irradiance. We have chosen to present the atmospheric data in the form of directional path reflectance since, in this form, it can be easily utilized with the directional reflectance of a variety of backgrounds smaller in extent but different from the heterogeneous background which contributed to the path radiance and downwelling irradiance. The directional path reflectance is also the most convenient form of presenting the atmospheric data for easy use to obtain contrast transmittance.

2.3 BACKGROUND REFLECTANCE

The inherent background reflectance is defined as

$${}_bR_o(z_t,\theta,\phi) = \pi\,{}_bN_o(z_t,\theta,\phi)/H(z_t,d)\,, \qquad (2.5)$$

where $H(z_t,d)$ is the downwelling irradiance at the target altitude (Gordon (1964) p. 558 or Boileau and Gordon (1966) p. 805). The inherent background reflectance may be obtained from either (1) a measurement by a ground-based telephotometer† or (2) measurements by an airborne telephotometer. In this report airborne telephotometer data from the lowest altitude of flight not interpolated to ground level were used to obtain the terrain reflectances reported here for each flight.

2.4 DOWNWELLING IRRADIANCE

The irradiance used to compute the directional path reflectance $R_r^*(z,\theta,\phi)$ and the airborne terrain reflectance is computed from data at the lowest altitude of flight by the equation

$$H(z,d) = \int_{2\pi} N(z,\theta',\phi')\cos\theta'\,d\Omega\,, \qquad (2.6)$$

where $N(z,\theta',\phi')$ is the sky or sun radiance at direction θ',ϕ'. When $\theta' = \theta_s$ and $\phi' = 0$, $N(z,\theta_s,0)$ is the sun or moon radiance.

Using Eq. 2.6, the upwelling irradiance $H(z,u)$ is computed by replacing the sky radiances with apparent terrain radiances from the lower hemisphere scanner. The θ' would then be the nadir angle so that $\cos\theta'$ is positive. The albedo $A(z)$ is the ratio of the upwelling to downwelling irradiance $H(z,u)/H(z,d)$.

† Although the measurements are radiometric as opposed to photometric, the instrument used to perform these measurements is referred to herein as a "telephotometer" in lieu of the more precise term "teleradiometer". This is in keeping with the practice established in previous publications.

A second type of irradiance is the scalar or nondirectional irradiance:

$$h(z,d) = \int_{2\pi} N(z,\theta',\phi')\, d\Omega . \tag{2.7}$$

The scalar irradiance is not weighted by the cosine. The upwelling irradiance from zenith angles between 90 and 180 degrees is designated by $h(z,u)$ and computed by using Eq. 2.7 also. The total scalar irradiance is the sum of the upwelling and downwelling scalar irradiances $h(z) = h(z,u) + h(z,d)$. The scalar albedo is defined as the ratio of upwelling to downwelling scalar irradiance, $h(z,u)/h(z,d)$. For a full discussion of scalar irradiances and scalar albedo uses refer to Gordon (1969).

2.5 BEAM TRANSMITTANCE

The beam transmittance $T_r(z,\theta)$ is obtained directly from the total scattering coefficient $s(z)$ by means of Eq. 2.8. (Refer also to Boileau (1964) p. 570). When there is no significant atmospheric absorption in the pass bands of the measurements, e.g., from smoke, dust, or smog, the attenuation coefficient $\alpha(z)$ is equivalent to the scattering coefficient $s(z)$. Therefore,

$$T_r(z,\theta) = \exp\left[-\sum_{i=1}^{n} \alpha(z_i)\Delta r\right] = \exp\left[-\sum_{i=1}^{n} s(z_i)\Delta r\right] . \tag{2.8}$$

The incremental path length Δr used is 30 meters (98.4 feet). The measured total scattering coefficient data are extrapolated to ground level when no ground-based measurements are available. The extrapolation assumes that the scattering particles are the same at all altitudes, but decrease or increase according to the density at each altitude $\rho(z)$:

$$s(o) = \frac{s(z)\rho(o)}{\rho(z)} . \tag{2.9}$$

Similarly, upward extrapolations are made to the highest observer altitude above ground level (6 kilometers maximum) when the highest flight altitude is less. Extrapolation in this case is based on the scattering coefficient measured at highest flight altitude. The densities used for the extrapolations are for the U. S. Standard Atmosphere (1962). The density at each altitude is obtained by truncated Chebyshev expansion using the coefficients for the atmosphere 0 to 80 kilometers (U. S. Standard Atmosphere Supplements (1966) p. 69).

All altitudes reported are between ground level and 6 kilometers. For all paths of sight at zenith angles greater than 95 degrees, Δr equals $\Delta z \sec\theta$ for these altitudes. The Δr is always nonnegative since Δz is defined as $z_1 - z_2$ (the subscripts increase with the flux direction). See Fig. 2-1. For zenith angles greater than 95 degrees, the beam transmittance can also be expressed as a function of the vertical beam transmittance $T_r(z,180)$ as follows:

$$T_r(z,\theta) = T_r(z,180)^{|\sec\theta|} . \tag{2.10}$$

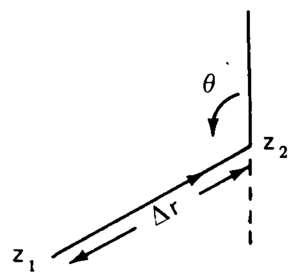


Fig. 2-1. Path Length Geometry for Steeply Inclined Paths of Sight.

2.6 EARTH CURVATURE AND REFRACTION

For the paths of sight at 93 and 95 degree zenith angles, the Δr for $\Delta z = 30$ meters (98.4 feet) is significantly longer at ground level than at 6 kilometers due to the curvature of the earth. Therefore, for these paths of sight, the incremental path length Δr_i is computed from

$$\Delta r_i = \left\{ 1 - \left[\frac{n(z)}{n(z_i)} \frac{(\zeta + z)}{(\zeta + z_i)} \sin\theta \right]^2 \right\}^{-1/2} \Delta z . \tag{2.11}$$

This is the classical equation for computing incremental path length at paths of sight affected by earth curvature and refraction. The $n(z)$ is the refractive index, z is the sensor or observer altitude, ζ is the radius of the earth. Equation 2.11 was derived as follows. The Δr_i due to earth curvature is a function of the angle θ'' which is the angle of the flux path at altitude z_i (see Figure 2-2 for the relationship of θ and θ'' for the downward path of sight):

$$\Delta r_i = \sec\theta'' \, \Delta z = (1 - \sin^2\theta'')^{-1/2} \, \Delta z . \tag{2.12}$$

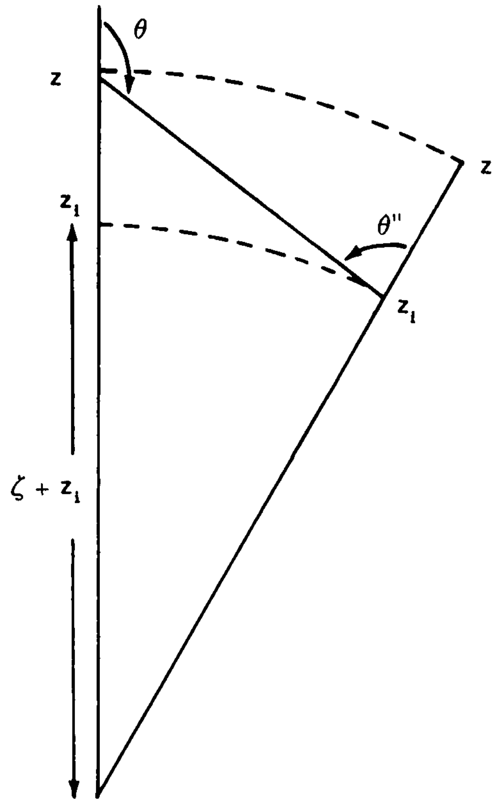


Fig. 2-2. Path Length Geometry for Grazing Paths of Sight in Refractive Spherical Atmospheres.

Since sin x = sin(180° − x), the law of sines can be used to express Δr as a function of the path of sight θ:

$$\sin\theta'' = \frac{\zeta + z}{\zeta + z_1} \sin\theta . \qquad (2.13)$$

The refraction effect is added by recourse to Snell's law, thus resulting in Eq. 2.11.

The square of the refractive index ratio is given in an alternate form by Kasten (1965) as

$$\left[\frac{n(z)}{n(z_1)}\right]^2 = 1 + 2\,[n(z) - 1]\,[1 - \rho(z_1)/\rho(z)] . \qquad (2.14)$$

This can be rewritten in terms of the refractive index at ground level $z = o$ as follows:

$$\left[\frac{n(z)}{n(z_i)}\right]^2 = 1 + 2\,[n(o) - 1]\left[\frac{\rho(z)}{\rho(o)} - \frac{\rho(z_i)}{\rho(o)}\right] . \qquad (2.15)$$

The density values for computing the refraction effect are, as before, based on the U. S. Standard Atmosphere (1962). The refractive index used for ground level was 1.000276, appropriate to a wavelength of 700 nanometers at 15°C. The maximum error in using the Δr based on 700 nanometers for wavelengths of 478 to 770 nanometers is 0.2 percent.

2.7 PATH RADIANCE

Path radiance $N_r^*(z,\theta,\phi)$ for the downward-looking path of sight is the integration or summation of the path function $N_*(z,\theta,\phi)$ weighted by the beam transmittance $T_{ri}(z,\theta)$. Path length ri is from the incremental path Δr to the sensor at z:

$$N_r^*(z,\theta,\phi) = \sum_{i=1}^{m} N_*(z_i,\theta,\phi)\, T_{ri}(z,\theta)\, \Delta r . \qquad (2.16)$$

(Refer to Duntley, *et al.* (1957) Eq. 17 on p. 502). The path function $N_*(z_i,\theta,\phi)$ is the product of the equilibrium radiance $N_q(z_i\theta,\phi)$ and total scattering coefficient $s(z_i)$ [Duntley, *et al.* (1957) Eq. 11 on p. 502 since $s(z) = 1/L(z)$]:

$$N_*(z_i,\theta,\phi) = N_q(z_i,\theta,\phi)\, s(z_i) . \qquad (2.17)$$

2.8 EQUILIBRIUM RADIANCE

The equilibrium radiance (Duntley, *et al.* (1957) p. 502, and Gordon (1969) p. 15) is first computed from the measurements made at each of the altitudes of level flight and then interpolated and extrapolated to obtain values at each 30 meter (98.4 foot) interval z_i. To compute the equilibrium radiance the following equation is used (refer to Gordon (1969), Eq. 16* on p. 16):

$$N_q(z,\theta,\phi) = \int_{4\pi} N(z,\theta',\phi')\, \frac{\sigma(z,\beta')}{s(z)}\, d\Omega , \qquad (2.18)$$

---

* Since the sun or moon radiance was included in the sky measurements, the separate term for the scalar irradiance of the sun (or full moon) h_s (the first term of the right member of Eq. 16) reduces to zero. Equation 16 applies equally well to real and model atmospheres.

where $N(z,\theta',\phi')$ is the apparent radiance of the sky, sun or moon, or ground for direction θ' and ϕ'. The ratio $\sigma(z,\beta')/s(z)$ is the proportional directional scattering coefficient at angle β' and altitude z. The β' is the angle between the path of sight at θ,ϕ and the radiance θ',ϕ'. It is found by

$$\cos\beta' = \sin\theta \sin\phi \sin\theta' \sin\phi' + \sin\theta \cos\phi \sin\theta' \cos\phi' + \cos\theta \cos\phi' \,. \tag{2.19}$$

It is the scalar irradiance which designates the flux that enters into the computations of equilibrium radiance and path function when the directional radiances are not known or used. It is the directionality of that flux combined with the directionality of the volume scattering function which produces the unique equilibrium radiance associated with each path of sight.

2.9 PROPORTIONAL DIRECTIONAL SCATTERING COEFFICIENT

The proportional directional scattering function is found by combining the Rayleigh scattering component and the Mie scattering component:

$$\sigma(z,\beta')/s(z) = \left\{ {}_{R}s(z) \; {}_{R}\left[\frac{\sigma(z,\beta')}{s(z)}\right] + {}_{M}s(z) \; {}_{M}\left[\frac{\sigma(z,\beta')}{s(z)}\right] \right\} /s(z) \,. \tag{2.20}$$

The Rayleigh scattering coefficient ${}_{R}s(z)$ for each pass band is based upon monochromatic values of Rayleigh volume scattering coefficient computed using the Penndorf (1957) Eq. 14 for 15°C sea level pressure. The Rayleigh scattering coefficient is corrected to ambient temperature and pressure by the ideal gas law equation. Since the Rayleigh scattering is a direct function of density,

$${}_{R}s(z) = {}_{R}s(0)P(z)/[T(z)\ 3.516E3] \,, \tag{2.21}$$

where $P(z)$ is pressure in dynes cm^{-2}, $T(z)$ is temperature in degrees Kelvin, and 3.516E3* has units of dynes $cm^{-2}\,{}^{\circ}K^{-1}$ and is the density at standard sea level pressure and 15°C temperature times the universal gas constant. The proportional directional scattering function for Rayleigh scattering ${}_{R}[\sigma(\beta)/s]$ is not a function of altitude so the parenthetical modifier is not used; it is found by

$${}_{R}[\sigma(\beta)/s] = (1 + \cos^2\beta)3/(16\pi) \,. \tag{2.22}$$

The Mie scattering coefficient at measurement altitude z is the measured scattering coefficient minus the Rayleigh coefficient computed from Eq. 2.21 above:

* The form of 3.516E3 is an alternate format for 3.516×10^3. This computer form is used throughout this report.

$$_{M}s(z) = s(z) - {}_{R}s(z) \ . \tag{2.23}$$

The Mie volume scattering function $_{M}[\sigma(z,\beta)/s(z)]$ is taken from a catalog of values derived from data on photopic volume scattering functions published by Barteneva (1960) for a range of total scattering coefficients from near Rayleigh atmosphere to heavy fog. The Barteneva volume scattering functions show a good correlation with the ratio of directional scattering coefficients at scattering angles $\beta = 30°$ and 150°: ($_{M}[\sigma(z,30)/\sigma(z,150)]$). The Mie volume scattering functions at 30 and 150 degrees are obtained from the measured volume scattering function at 30 and 150 degrees by subtracting the Rayleigh component, as follows:

$$_{M}\sigma(\beta) = \sigma(\beta) - {}_{R}s(z)\ {}_{R}[\sigma(\beta)/s] \ . \tag{2.24}$$

2.10 APPARENT SUN RADIANCE

The sky radiances used to compute the irradiance and the equilibrium radiance include the sun radiance but the values often are beyond the calibrated span of the instrument. To compensate for this, an apparent sun radiance value is substituted when there is no cloud cover. This apparent sun radiance is based upon the inherent sun irradiance $_{s}H_{o}(\infty,d)$ for the appropriate broad band filter, the beam transmittance from out of the atmosphere to altitude z, $T_{\infty}(z,\theta_{s})$, and the appropriate $\Delta\Omega^{*}$ used for the numerical integration indicated in Eq. 2.6, 2.7, and 2.18:

$$_{s}N_{\infty}(z,\theta_{s},0) = {}_{s}H_{o}(\infty,d)\ T_{\infty}(z,\theta_{s})/\Delta\Omega \ . \tag{2.25}$$

The inherent sun irradiance values are computed from spectral sun irradiances from Johnson (1954).

The transmittance from out of the atmosphere to the highest flight altitude is computed by using the concept of the scale height H(z). The scale height is the height of a homogeneous atmosphere having the density of the layer at altitude z:

$$H(z) = \frac{T(z)\,R}{g\,M(o)} \ , \tag{2.26}$$

where T(z) is the temperature in degrees Kelvin at altitude z. The universal gas constant R/M(o) is 2.8705E2 $m^{2}sec^{-2}\,°K^{-1}$. The acceleration of gravity g(z,1) is a function of altitude z and latitude 1.

* The $\Delta\Omega$ equals $2\pi \sin\theta\,\Delta\theta/60$, where $\Delta\theta = 0.08727$ rad (5°). The θ is the scanner zenith angle in the grid 2.5° → 87.5°, $\Delta\theta = 5°$.

The value for 45°32'40'' at $z = 0$ is 9.80665 m sec^{-2}. The error in considering it as a constant for z 0 to 6 kilometers and for all latitudes is less than 1/2 percent. The transmittance from out of the atmosphere to altitude z is

$$T_\infty(z,o) = e^{-H(z)s(z)} . \quad (2.27)$$

The transmittance for the lower flight altitudes is the product of the transmittance from out of the atmosphere to the highest altitude $T_\infty(z_m,o)$ and the transmittance between the two flight altitudes $T_r(z,o)$ as obtained by Eq. 2.8:

$$T_\infty(z,o) = T_\infty(z_m,o)\, T_r(z,o) . \quad (2.28)$$

The conversion from vertical transmittance to transmittance at the zenith angle of the sun is made using the relative airmass $m_\infty(z,\theta_s) / m_\infty(z,o)$:

$$T_\infty(z,\theta_s) = T_\infty(z,o)^{m_\infty(z,\theta_s)/m_\infty(z,o)} . \quad (2.29)$$

The relative airmass equals $\sec\theta$ for $\theta_s \leqq 70°$ to an accuracy of 1 percent. Also the relative airmass at altitudes up to 6 kilometers equals the relative airmass at sea level, $m_\infty(6,\theta_s)/m_\infty(6,0) = m_\infty(o,\theta_s)/m_\infty(o,o)$, to an accuracy of 1 percent for $\theta_s \leqq 86°$. Sea level relative airmass values from Kasten (1965) are used for θ_s 70 → 86°.

3. INSTRUMENTATION

The scientific instrumentation utilized for the Project ATOM task was basically the same as that reported in AFCRL-70-0137, Duntley *et al.* (1970). Several hardware modifications were required, however, to convert system sensitivities from nighttime to daytime operating levels. These modifications were described in the appropriate subsections of AFCRL-72-0255, Duntley *et al.* (1972).

For convenience of the reader, all significant instrument systems assigned during the Project ATOM exercise are tabulated in Table 3-1 and depicted in Figures 3-1 and 3-2.

Table 3-1. Project ATOM Instrumentation

I. Radiometric

    A. Multiplier Phototube Assembly

    B. Temperature Control Housing Assembly

    C. Optical Filter Assembly

    D. Radiometer Measuring Circuit Assembly

    E. Optical Collector Assembly

1. Automatic 2π Scanner Assembly
2. Integrating Nephelometer Mode Selector Head Subassembly
3. Dual Irradiometer Assembly
4. Large Aperture Telescope Assembly
5. Variable Path Function Meter Assembly
6. Equilibrium Radiance Telephotometer
7. Contrast Reduction Meter

II. Meteorological

A. Royco Model 220 Particle Counter
B. Cambridge Model 137-C3 Aircraft Hygrometer System
C. AN/AMQ-17 Aerograph Set
D. Bourns Model 430/530 Absolute Pressure Transducer
E. Bourns Model 509 Differential Pressure Transducer
F. Bendix Model 566 Aspirated Hygrometer
G. Science Associates Windspeed and Direction Set
H. Taylor Model SMT-5-51 Aneroid Barometer

III. Control and Communication

A. 2π Scanner Control Console
B. Photometer Temperature Control Panel
C. Optical Filter Control Panel
D. Ten Slide Photometer Module
E. Camera Control Panel
F. Flight Dynamics Display Panel
G. 42 Channel Data Logger
H. 20 Channel Data Logger

IV. Photographic

A. Airborne Automax G-1 Camera System
B. Ground-Based Soligor System

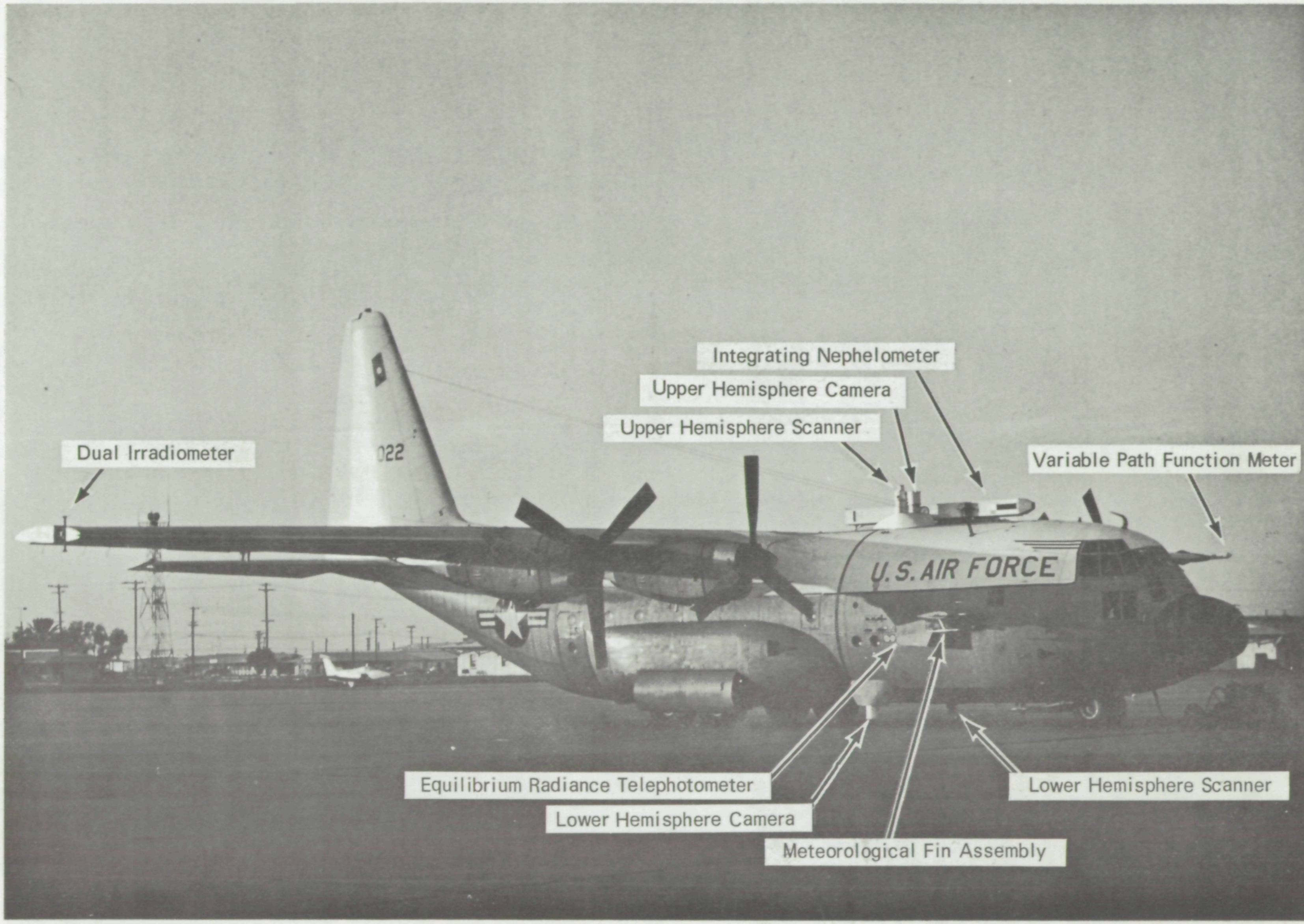


Fig. 3-1. C-130 Airborne Instrument System.

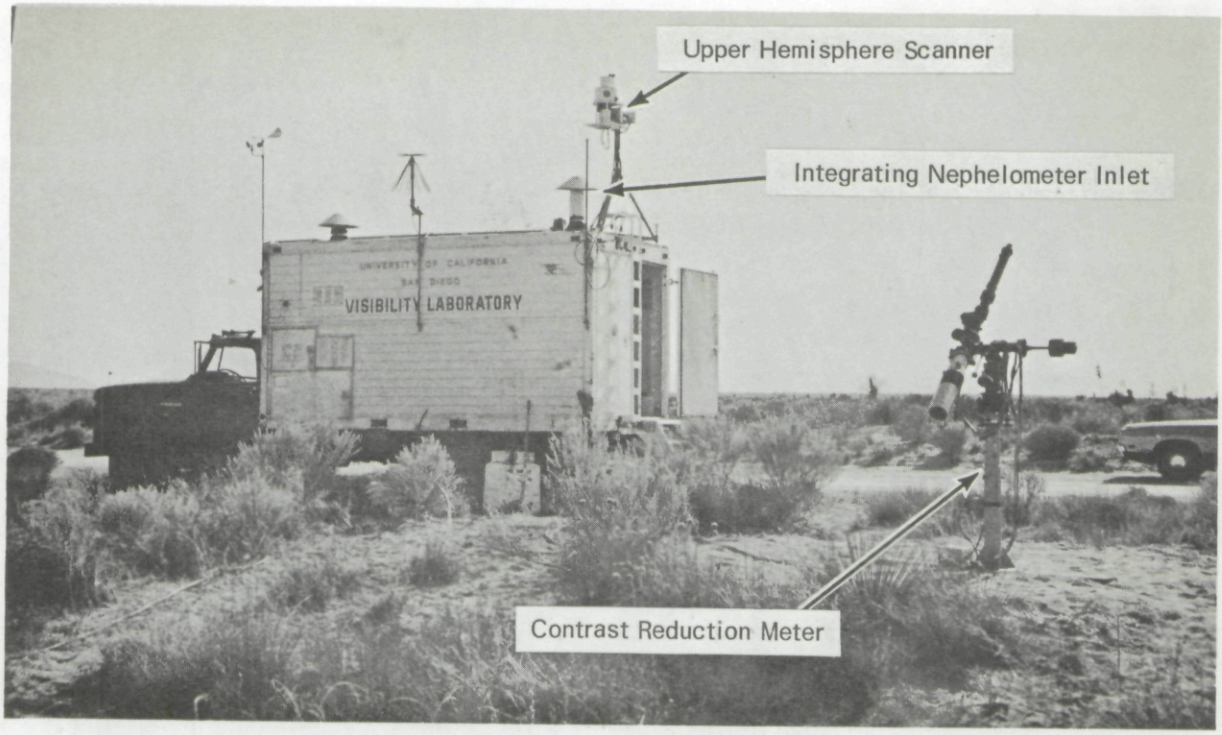


Fig. 3-2. Ground-Based Instrument System.

3.1 RADIOMETRIC SYSTEMS

A standardized radiometer, typical of those used during this data collection interval, consists of five major assemblies as listed below.

1. Multiplier Phototube Assembly
2. Temperature Control Housing Assembly
3. Optical Filter Assembly
4. Radiometer Measuring Circuit Assembly
5. Optical Collector Assembly

These assemblies are generally interchangeable between different radiometer systems, allowing easy field cannibalization in the event of a catastrophic failure of any assembly within a key system. All assemblies mate in pressure seals which allows each section to be purged with dry nitrogen and maintained at approximately 5 pounds per square inch positive pressure.

MULTIPLIER PHOTOTUBE ASSEMBLY

The basic detector in all these systems is an EMR 541E fourteen stage, end on multiplier phototube. This series tube has an S-20 spectral response with typical cathode quantum efficiencies of 25 percent at 420 nanometers and 6.5 percent at 630 nanometers. The multiplier phototube assembly is automatically maintained at either 25°C ±0.5°C or 10°C ±0.5°C by the temperature control housing. Isolite photometric reference sources are also mounted within this assembly in order to ensure their temperature stability. For use in Project ATOM, the multiplier phototube assemblies are unchanged from their previously reported configuration.

TEMPERATURE CONTROL HOUSING ASSEMBLY

The temperature control housing mechanically surrounds the multiplier phototube assembly and provides the heat pumping necessary for maintaining internal temperature stability. The active elements are Cambion model 3951 thermoelectric junctions. For use in Project ATOM, the temperature control housing assemblies are unchanged from their previously reported configuration.

OPTICAL FILTER ASSEMBLY

The optical filter assemblies are mechanisms designed to mechanically and optically interface with all temperature control housings and optical collector assemblies. Each of these mechanisms is an electrically independent device which can, upon electrical command, interpose any two of six optical filter holders into the optical path. The capability for inserting two filters simultaneously is a major revision from the previously reported configuration for this device.

For use in Project ATOM, each of these filter changers contained two Baird-Atomic type B-3 visible spectrum interference filters, two laminated Kodak Wratten gelatin filters, one Optics Technology, Inc. nickel neutral density filter, and one memory reference system mirror.

The electrical control circuit for the filter holder carrying the memory system mirror is the electrical inverse of those circuits controlling the optical filters. Thus, whenever filter control power is off, the memory mirror automatically drops into place. This mirror completes the optical path between the Isolite standard source and the multiplier phototube cathode, providing a constant flux storage and standby condition.

The neutral density filter can be stacked in series with any one of the four color filters. It is the insertion or retraction of this density 6.0 neutral filter that allows the radiometer to function satisfactorily at either daytime or nighttime flux levels. The insertion and/or retraction of this neutral filter is accomplished upon electrical command by the system operator and can be accomplished independently from the control of the four color filters.

RADIOMETER MEASURING CIRCUIT ASSEMBLY

A standardized radiometer measuring circuit has been utilized with all systems described in this section. It is a solid state package designed for use on the 28 volt dc aircraft power. It consists of three basic subassemblies: a multiplier phototube and emitter/follower stage, a high voltage and readout section, and a general purpose power supply. In the operational mode, all three subassemblies are linked in a closed loop feedback circuit which servos the high voltage applied to the multiplier phototube. The feedback loop maintains a constant anode current by inversely varying the high voltage with the flux incident at the photocathode. A typical electrical schematic of the Visibility Laboratory model 5 photometer circuit is illustrated in Figure 3-3.

For packaging convenience, nine high voltage and readout systems plus a single shared power supply are grouped into a single module. This composite assembly is referred to in the Control and Communications Section as the ten slide photometer module.

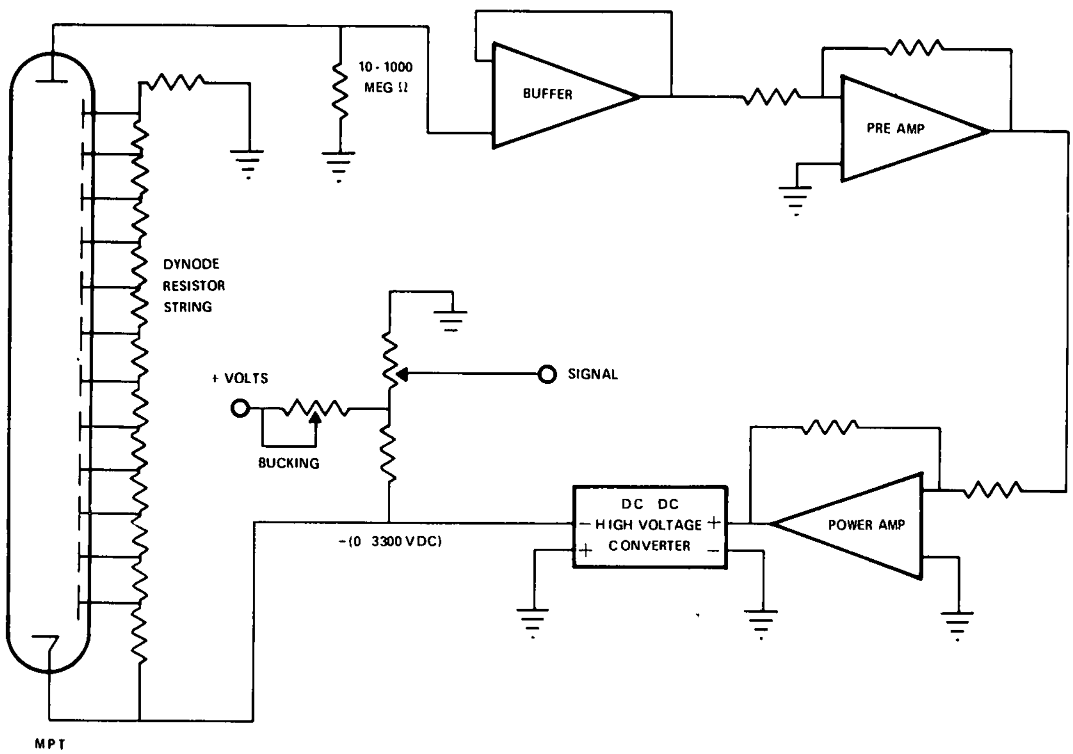


Fig. 3-3. Typical Visibility Laboratory Model 5 Photometer Circuit.

For use in Project ATOM, radiometer measuring circuits and the ten slide photometer modules are unchanged from their previously reported configuration.

OPTICAL COLLECTOR ASSEMBLY

Seven basic collector assemblies were used in combination with the basic detector configurations described in the preceding sections. The only major differences between the various radiometer systems described in this report are the differences in these seven collector assemblies. The basic assemblies tabulated in Table 3-1 are listed below for convenience.

1. Automatic 2π Scanner Assembly (UHS and LHS)
2. Integrating Nephelometer Mode Selector Head Subassembly (NEPH)
3. Dual Irradiometer Assembly (DI)
4. Large Aperture Telescope Assembly (LAT)
5. Variable Path Function Meter Assembly (VPFM)
6. Equilibrium Radiance Telephotometer (ERT)
7. Contrast Reduction Meter (CRM)

The first five items on the list immediately above were described in Duntley *et al.* (1970 and 1972). No major modifications were made to the instrumentation in the interval between Project HAVEN VIEW and Project ATOM and, consequently, a detailed description of the instrumentation is not repeated in this report. One new device was added to the ground-based radiometric system which replaced the large aperture telephotometer discussed in Duntley *et al.* (1972). This new device is referred to as the contrast reduction meter (CRM). A general discussion of its description and application is included in the following paragraphs. One new radiometer system was also activated for airborne application. It is designated the equilibrium radiance telephotometer and is also discussed in the following paragraphs.

Contrast Reduction Meter. The contrast reduction meter consists of a standard detector and filter changing assembly, fitted with a multiple purpose optical collector. The optical schematic for the CRM is illustrated in Figure 3-4, while the entire device is shown at the ground site in Figure 3-5.

The function of the CRM is to measure apparent solar radiance, sky and terrain radiances, and downwelling irradiances, all with the same detector and measuring circuit. These measurements allow direct computation of earth-to-space universal contrast transmittance.

The detector and filter combinations used with this device are the same as all of the other airborne and ground-based radiometer systems used during Project ATOM. Thus, its data are immediately usable during clear weather missions in establishing the total atmospheric path contrast transmittance, against which the computed partial path transmittances derived from airborne measurements can later be evaluated.

The basis for the measurement techniques utilizing the CRM was first presented by Gordon *et al.* (1963) and validated by Duntley *et al.* (1964). It is also discussed in both Edgerton (1967) and Gordon *et al.* (1969). A similar configuration of the device is described in Duntley, Edgerton, and Petzold (1970).

The operational and computational procedures are summarized in the following paragraphs and are illustrated in Table 3-2. They are both stylized to yield values for the vertically downward look, i.e., $\theta = 180°$.

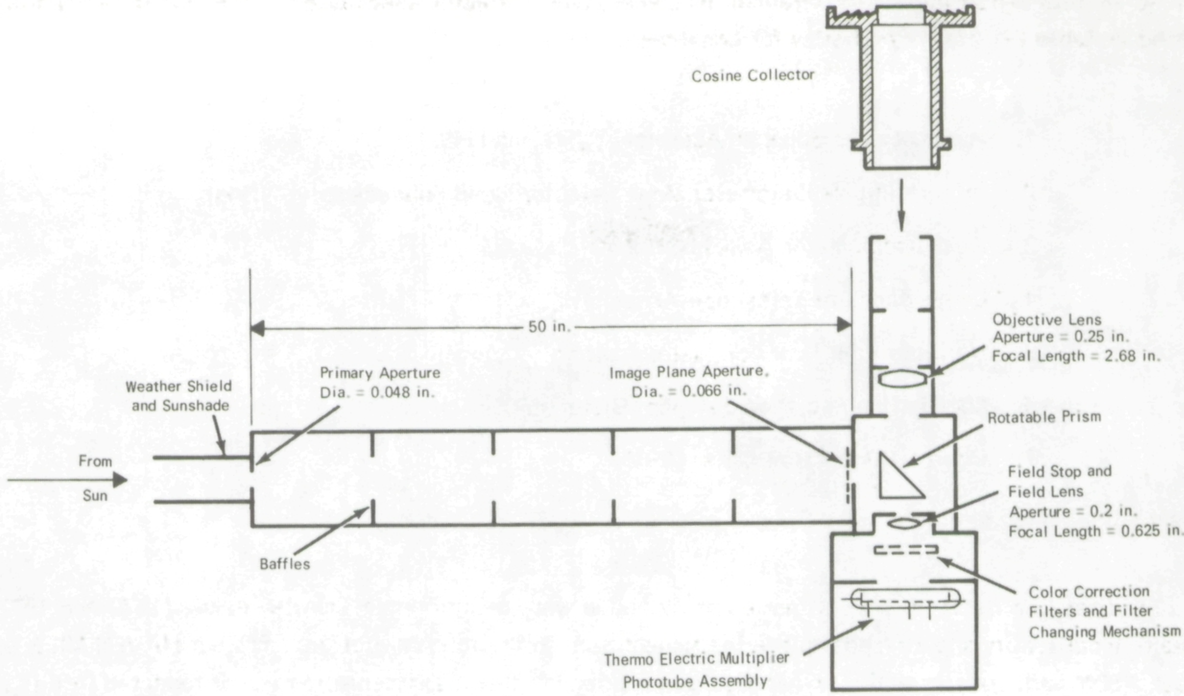


Fig. 3-4. Schematic of Collection Optics for CRM.

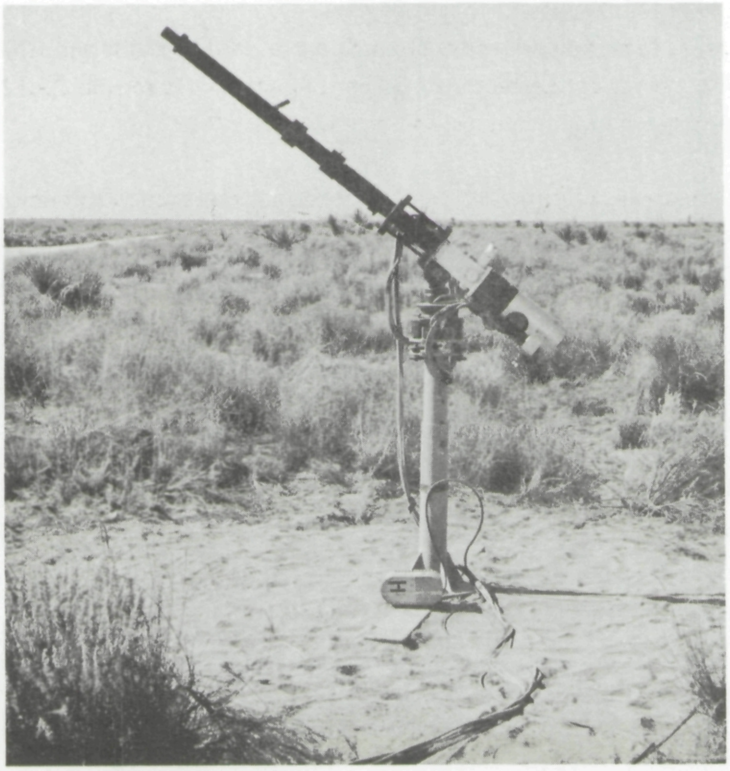


Fig. 3-5. CRM at ATOM Ground Site.

Four basic measurements by the CRM are required in order to provide proper inputs to the computation of earth-to-space universal contrast transmittance. They are:

Item No.	Measured Quantity	Instrumentation Mode Identification
1	Apparent solar radiance	STD
2	Path radiance at an appropriate scattering angle	SS/β90
3	Total downwelling irradiance	SS/ECAP
4	Inherent terrain radiance	SS/TERRAIN

The beam transmittance for the path of sight from space-to-earth in the direction of the sun, $T_\infty(0,\theta_s)$, is obtained directly from solar transmissometer measurements of the apparent radiance, ${}_sN_\infty(0,\theta_s,0°)$, at the center of the solar disk, and the previously established inherent solar radiance,† ${}_sN_o(\infty,\theta_s,0°)$, by the following equation:

$$T_\infty(0,\theta_s) = \frac{{}_sN_\infty(0,\theta_s,0°)}{{}_sN_o(\infty,\theta_s,0°)} \; . \tag{3.1}$$

It should be noted that in all cases, the azimuth angle, ϕ, is defined as azimuth with respect to sun; i.e., a path of sight directed toward the sun has an azimuth $\phi = 0°$. This should not be confused with the scattering angle, β, which is illustrated in Fig. 3-6. As noted in the glossary, beam transmittance is considered as being independent of azimuth, and thus its notation is typically simplified from the general form by omitting the azimuth designator ϕ.

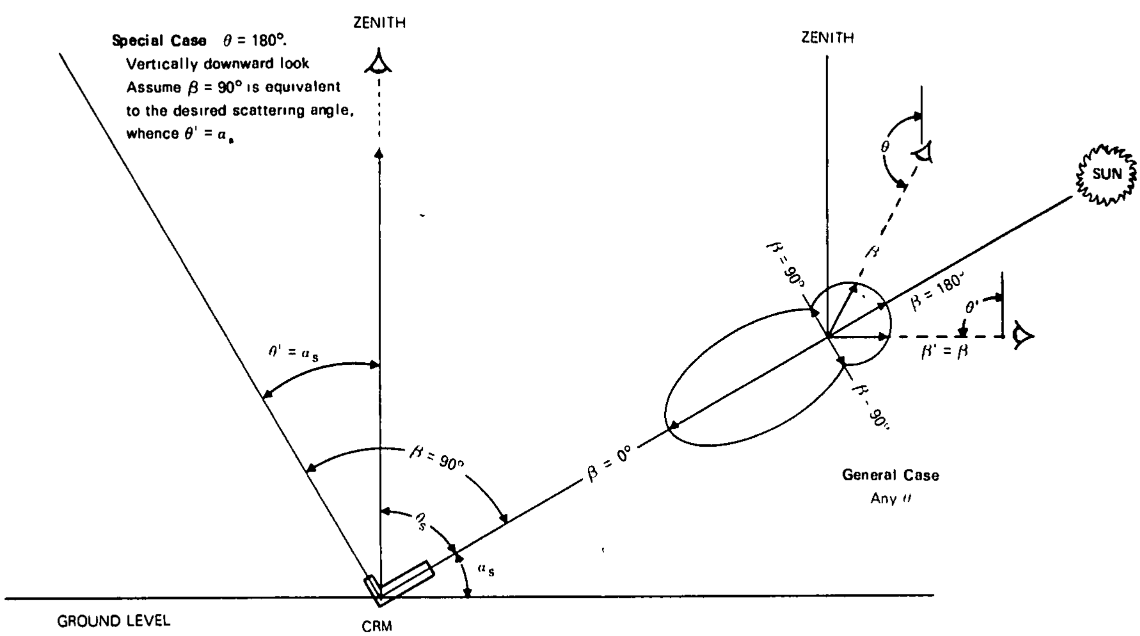


Fig. 3-6. Scattering Angle Relationships for Typical CRM Operations.

† The values for inherent solar radiance at the center of the disk are based upon the solar irradiances out of the atmosphere from Johnson (1954).

Table 3-2

CRM Procedure for Determining ${}_b\tau_\infty(z,180^\circ)$

Sequence	Equip. Mode	Operational Function
1.	**STD**	Measure – ${}_sN_\infty(0,\theta_s,0^\circ)$. Read out solar elevation angle, α_s. ($\alpha_s = 90^\circ - \theta_s$)
2.		Compute – $T_\infty(0,\theta_s)$. $T_\infty(0,\theta_s) = T_\infty(\infty,180^\circ - \theta_s) = \dfrac{{}_sN_\infty(0,\theta_s,0^\circ)}{{}_sN_o(\infty,\theta_s,0^\circ)}$. Convert to vertical path of sight: $T_\infty(0,0^\circ) = T_\infty(\infty,180^\circ) = \left[\dfrac{{}_sN_\infty(0,\theta_s,0^\circ)}{{}_sN_o(\infty,\theta_s,0^\circ)}\right]^{\sin\alpha_s}$.
3.	**SS**	Measure – $N^*_\infty(0,\theta',\phi)$. Measure sky radiance in $\beta 90$ direction, i.e., $\theta' = 90^\circ - \theta_s$ and $\phi = 180^\circ$ in the simplest case.
4.		Compute – $N^*_\infty(\infty,180^\circ) = N^*_\infty(0,\theta',180^\circ)\left[\dfrac{1 - T_\infty(\infty,180^\circ)}{1 - T_\infty(0,\theta')}\right] = N^*_\infty(0,\theta',180^\circ)\left[\dfrac{1 - T_\infty(\infty,180^\circ)}{1 - T_\infty(0,0^\circ)^{\sec\alpha_s}}\right]$.
5.	**SS/ECAP**	Measure – $H(o,d)$.
6.	**SS/TERRAIN**	Measure – ${}_bN_o(0,180^\circ)$. Measure both terrain and calibration targets.
7.		Compute – ${}_bR_o(0,180^\circ) = \dfrac{\pi\, {}_bN_o(0,180^\circ)}{H(o,d)}$.
8.		Compute – $R^*_\infty(\infty,180^\circ) = \dfrac{\pi N^*_\infty(\infty,180^\circ)}{H(o,d)\,T_\infty(\infty,180^\circ)}$.
9.		Compute – ${}_b\tau_o(\infty,180^\circ) = \dfrac{{}_bR_o(0,180^\circ)}{{}_bR_o(0,180^\circ) + R^*_\infty(\infty,180^\circ)} = \left[1 + \dfrac{N^*_\infty(\infty,180^\circ)}{{}_bN_o(0,180^\circ)\,T_\infty(\infty,180^\circ)}\right]^{-1}$.

The path radiance for any downward path of sight from earth-to-space can be derived from an appropriate ground-based measurement of sky radiance. The computation utilizes the following equation:

$$N_{\infty}^{*}(\infty,\theta,\phi) = N_{\infty}^{*}(0,\theta',\phi')\left[\frac{1 - T_{\infty}(\infty,\theta)}{1 - T_{\infty}(0,\theta')}\right], \tag{3.2}$$

where

$N_{\infty}^{*}(\infty,\theta,\phi)$ is the path radiance of a downward-inclined path of sight at zenith angle θ, and azimuth angle ϕ, from the surface of the earth to any point outside the earth's atmosphere. The effective path length is designated as ∞.

$N_{\infty}^{*}(0,\theta',\phi')$ is the path radiance of an upward-inclined path of sight, (θ',ϕ'), which has the same angle β from the sun as does the downward-inclined path of sight, (θ,ϕ). This quantity is in fact the apparent sky radiance as measured from the surface of the earth in the direction (θ',ϕ').

$T_{\infty}(\infty,\theta)$ is the beam transmittance of the downward-inclined path of sight, (θ,ϕ), from the surface of the earth to any point outside the earth's atmosphere (∞).

$T_{\infty}(0,\theta')$ is the beam transmittance of the upward-inclined path of sight (θ',ϕ').

The appropriate values of beam transmittance for use in Eq. 3.2 are obtained by operating on the beam transmittance, determined by Eq. 3.1, in the following manner:

$$T_{\infty}(\infty,\theta) = T_{\infty}(0,\theta_s)^{\cos\theta_s/\cos(180^\circ-\theta)} \tag{3.3}$$

and

$$T_{\infty}(0,\theta') = T_{\infty}(0,\theta_s)^{\cos\theta_s/\cos\theta'}. \tag{3.4}$$

Typical CRM procedures employ two simplifying conditions.

First, all data are processed for the vertically downward path of sight only, i.e., $\theta = 180^\circ$. This immediately simplifies Eq. 3.3 to

$$T_{\infty}(\infty,180^\circ) = T_{\infty}(0,0^\circ) = T_{\infty}(0,\theta_s)^{\sin\alpha_s}. \tag{3.5}$$

The solar elevation angle α_s, which equals $90^\circ - \theta_s$, is read directly off of the equipment, eliminating the need for ephemeris or tabular data in the field.

Second, the scattering at 90 degrees from the sun is assumed to be equivalent to the scattering toward the vertically downward path of sight. This assumption simplifies the definition of the equivalent look-angle θ' to $90° - \theta_s$, or simply α_s. See Fig. 3-6. Equation 3.4 can now be rewritten as

$$T_\infty(0,\theta') = T_\infty(0,\theta_s)^{\sin\alpha_s \sec\alpha_s} = T_\infty(0,0°)^{\sec\alpha_s} . \qquad (3.6)$$

The equipment illustrated in Fig. 3-4 is built to mechanically insure that the sky radiance is measured at a 90 degree angle from the sun.

Total downwelling irradiance, $H(z,d)$, is measured directly by orienting the CRM assembly and its attached cosine collector cap in a horizontal position. In this position, the measurement represents total downwelling irradiance from the full 2π upper hemisphere on a flat plate, cosine-weighted collector.

Terrain radiances, ${}_bN_o(z,\theta,\phi)$, are measured directly by orienting the CRM telescope toward the ground. This is the same telescope through which measurements of sky radiances are made.

Computations for inherent background reflectance, ${}_bR_o(z,\theta,\phi)$, are made using the following equation:

$${}_bR_o(z,\theta,\phi) = \frac{\pi \, {}_bN_o(z,\theta,\phi)}{H(z,d)} . \qquad (3.7)$$

As in all stylized CRM operations, these measurements and computations are generally restricted to the vertically downward path of sight where $\theta = 180°$ and thus, ϕ becomes undefined.

From the measurements and computations described in the preceding paragraphs, the final special case computations for the vertically downward directional path reflectance, $R^*_\infty(\infty,180°)$, and universal contrast transmittance, ${}_b\tau_o(\infty,180°)$, become simple and straightforward. The defining equations are as follows:

$$R^*_\infty(\infty,180°) = \frac{\pi \, N^*_\infty(\infty,180°)}{H(o,d)T_\infty(\infty,180°)} , \qquad (3.8)$$

$${}_b\tau_o(\infty,180°) = \frac{{}_bR_o(0,180°)}{{}_bR_o(0,180°) + R^*_\infty(\infty,180°)} , \qquad (3.9)$$

and

$${}_b\tau_o(\infty,180°) = \left[1 + \frac{N^*_\infty(\infty,180°)}{{}_bN_o(0,180°)T_\infty(\infty,180°)}\right]^{-1} . \qquad (3.10)$$

Equilibrium Radiance Telephotometer. Many image transmission phenomena are most clearly understandable in terms of the concept of equilibrium radiance. This quantity is discussed in both Duntley *et al.* (1957) and in Section 2 of this report. As noted in the reference above, when the path of sight is horizontal and optically uniform both in terms of the composition of the aerosol and its lighting, the equilibrium radiance is identical with the apparent radiance of the horizon. Also, the apparent radiance of distant objects, which are inherently more radiant than the equilibrium value, decreases with increasing range toward the equilibrium radiance as an asymptote. Conversely, the apparent radiance of any dark distant object approaches the same asymptote.

In order to take experimental advantage of the equilibrium radiance characteristics summarized above, it was decided to activate a recently updated telephotometer system which would measure the apparent radiance of the horizon along a horizontal path of sight. This telephotometer system is identified as the equilibrium radiance telephotometer (ERT).

The equilibrium radiance telephotometer consists of a standard detector and filter changing assembly, fitted with a servo-controlled optical collector. The detector and filter combinations used with this device are the same as all of the other airborne and ground-based radiometer systems used during Project ATOM.

The optical collector assembly is the unique component in the ERT. It is basically a simple telescope with a few special features added. The field of view is rectangular, 1.0 degree wide and 0.2 degree high, and is oriented with the wide dimension horizontal.

The special features are designed to maintain the path of sight horizontal and the wide dimension of the field of view parallel with the horizon. Both of these characteristics are attained through servo-controlled optical elements slaved to an auxiliary vertical reference gyro. Under normal operating conditions, the specified path of sight and field of view orientations are maintained during aircraft pitch excursions of up to 10 degrees nose high and 5 degrees nose low. Aircraft roll excursions are compensated for up to 360 degrees, a maneuver not recommended with the C-130A.

One additional feature is available in the pitch control circuit. At the discretion of the operator, a 2.5 degree step function can be superimposed on the normal reference signal. In this condition the path of sight is alternately directed horizontally and 2.5 degrees above horizontal. The radiance measurements made at these two zenith angles determine the near horizon radiance gradient. The application of this radiance gradient as a corrective term in the determination of the volume attenuation coefficient for stratified spherical atmospheres is presented by Preisendorfer (1958) and is not repeated here.

3.2 METEOROLOGICAL SYSTEMS

All of the meteorological systems utilized in this project were purchased items. The operating characteristics of each are available in their manufacturer's brochures. For use in Project ATOM, the meteorological systems are unchanged from the previously reported configurations.

The airborne meteorological package consists of one Royco model 220 particle counter, one Cambridge model 137-C3 aircraft hygrometer system, one AN/AMQ-17 aerograph set, and two Bourns aneroid pressure transducers.

All the airborne meteorological transducers and sampling probes are located on an external fin which extends outward from the aircraft fuselage. The fin is located on the right side of the aircraft and forward of the propellers. It is illustrated in Figure 3-1.

The ground-based meteorological package was less extensive, consisting only of one Royco model 220 particle counter, one Bendix model 566 aspirated hygrometer, one Science Associates windspeed and direction set, and one Taylor model SMT-5-51 aneroid barometer.

Since all of the meteorological systems were described in Duntley *et al.* (1972), no further discussion is included in this report.

3.3 CONTROL AND COMMUNICATION SYSTEMS

The control panels, consoles and other support facilities listed in Table 3-1 are described fully in AFCRL-70-0137, Duntley *et al.* (1970), and are not discussed further in this report.

No significant modifications from the previously reported configurations have been accomplished on any of the control and communication systems.

3.4 PHOTOGRAPHIC SYSTEMS

Photographic documentation of the experimental environment performed simultaneously with the radiometric and meteorological measurements has always been a highly desirable adjunct to any field activity. For Project ATOM, this photographic capability was materially enhanced through the reactivation of two previously used, but recently revised, camera systems.

AIRBORNE AUTOMAX G-1 CAMERA SYSTEM

Two 35 millimeter Automax G-1 cameras, modified to accept Traid 735 Periphoto (180 degree) lenses, are mounted on the project aircraft (Figure 3-1). One camera is oriented to photograph the 2π upper hemisphere and the other covers the 2π lower hemisphere. Either or both cameras may be run in either cine or single frame modes at the discretion of the project operator.

The photographs from these cameras are used only as general background for the interpretation of the radiometric measurements. Thus, no special controls are placed upon the film or its processing. For this general purpose application, the cameras are normally loaded with Kodak Ektacolor Professional S, No. 5026 film. Typical photographs from this system are used as illustrations in Section 7 of this report and were shot with a fixed f6.3 aperture in the single frame mode.

GROUND-BASED SOLIGOR SYSTEM

The ground site documentation photographs have historically been limited to 35mm color snapshots, taken on a casual basis during lulls in the experimental sequences. For Project ATOM this procedure was supplemented with a scheduled routine of site photographs using a Soligor Conversion Fish-eye lens. This lens possesses almost universal adaptability to a wide variety of cameras and prime lenses. During Project ATOM it was used on a Yashica, Lynx 1000. Typical photographs from this system were utilized during data analysis to insure general compatability between airborne and ground-based data sets.

3.5 RADIOMETRIC CALIBRATION PROCEDURES

All the radiometers used in this project are calibrated in essentially the same manner. In each case, the system is calibrated by first determining its relative flux versus high voltage characteristics over the anticipated operating span and second by establishing known absolute flux levels on this voltage curve. The entire calibration procedure is conducted using standard photometric practices, a 3-meter optical bench, and incandescent standards of luminous intensity traceable to the National Bureau of Standards.

A detailed discussion of these calibration procedures is contained in Duntley *et al.* (1970 and 1972) and is, therefore, only summarized in this report.

LINEARITY CALIBRATION PROCEDURE

The process of establishing the relative flux versus high voltage characteristic curve for each system is simple and direct. The radiometer system is positioned on the optical bench and irradiated with flux from a stabilized incandescent lamp. The mechanical and optical arrangement is such that the amount of flux presented to the detector can be readily varied in increments of 0.10 log unit. The mechanical constraints on positioning the movable lamp housing ensure compliance with the desired inverse square relationship between lamp position and flux at the detector. Therefore, through an iterative process of relocating the lamp housing at a predetermined set of locations on the optical bench and recording the resulting radiometer output signal, one can generate a set of data illustrating the system electrical response to known changes of input radiance. This set of data is commonly referred to as the system linearity calibration.

The linearity calibrations for all radiometers employed in the Project ATOM task extended over a radiance span of 5 log cycles. The electrical circuitry was adjusted to yield an output signal which swung from +250 to −1000 millivolts for this five decade swing in radiant input. The pseudo-logarithmic characteristic of the radiometer measuring circuit results in a linearity calibration curve typified in Figure 3-7.

ABSOLUTE CALIBRATION PROCEDURE

Once the linearity calibration for the radiometer system has been established, a similar procedure is followed to convert the calibration into absolute units. For this portion of the calibration sequence, an incandescent standard of luminous intensity is used as the flux source. Then absolute levels of irradiance can be presented to the radiometer either directly or via a calibrated reflectance standard.

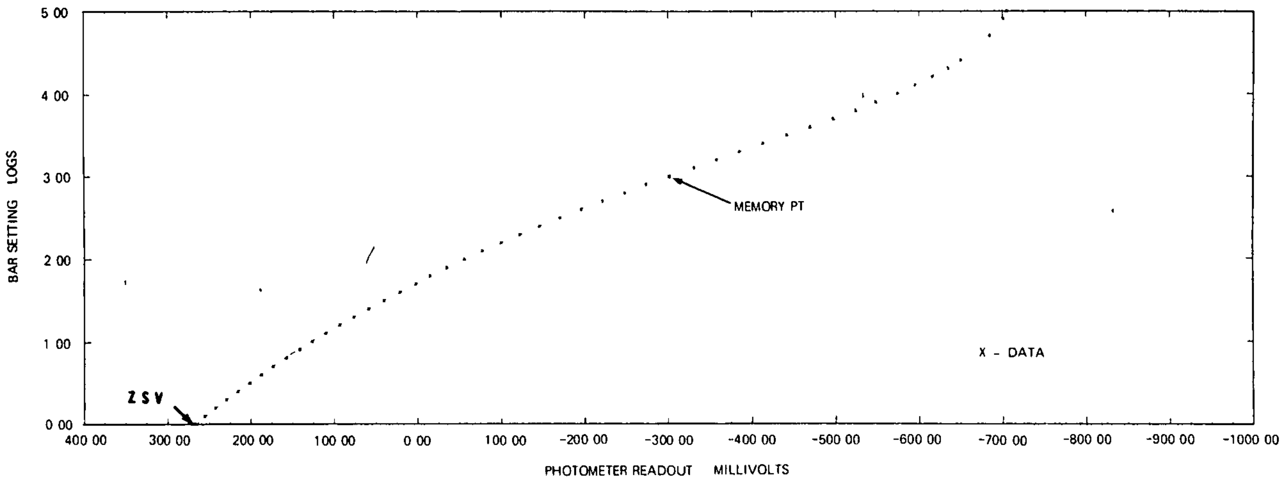


Fig. 3-7. Typical Computer-Generated Linearity Calibration Curve.

A typical data sheet for the absolute calibration of a Project ATOM radiometer is shown in Figure 3-8. Five different levels of input radiance are used in the determination of the calibration constant for the system. The calibration constant is referred to as the zero scale value and is labeled ZSV on the calibration forms.

ABSOLUTE CALIBRATION DATA FOR SCAN-3 15DEC70 9846 NITE FILTER NO. 2 DAY SKY 7000 DEG

DATE IS YR 1970 MONTH 12 DAY 15 TASK ASSIGNMENT POSTATOM INSTRUMENT TYPE RADIOMETER

REFLECTANCE OF PATH ATTENUATOR = 5.0 PERCENT REFLECTANCE OF CALIBRATION TARGET 96.0 PERCENT

D1 = LAMP POSITION = D1 + D2 D2 = 164.0 CM.
TOTAL DISTANCE = D1+D2

SPAN ID	D1 CM	TOTAL DIST. CM	TOTAL DIST.SQ. CM.SQ.	CALC.TGT. B OR E	DETEC. RAW OUTPUT	LOG OF (KO/K)	RAW ZSV	AV. RAW ZSV	F1 LUM. TO RAD. WATTS/LUM.	F2 COLOR MATCH	CORRECTED ZSV
1	40	204.000	4.162E 04	3.183E-06	-214	2.360	7.291E-04	7.285E-04	1.306E-04	9.985E-01	9.498E-08
2	70	234.000	5.476E 04	2.419E-06	-246	2.475	7.215E-04				
3	120	284.000	8.066E 04	1.642E-06	-295	2.642	7.206E-04				
4	200	364.000	1.325E 05	9.998E-07	-364	2.864	7.311E-04				
5	300	464.000	2.153E 05	6.153E-07	-434	3.074	7.304E-04				
4	200	364.000	1.325E 05	9.998E-07	-365	2.867	7.363E-04				
3	120	284.000	8.066E 04	1.642E-06	-297	2.649	7.317E-04				
2	70	234.000	5.476E 04	2.419E-06	-247	2.478	7.273E-04				
1	40	204.000	4.162E 04	3.183E-06	-214	2.360	7.291E-04				

RADIOMETER UNITS
CALCULATED TARGET LUMINANCE EXPRESSED AS LUMENS/STERADIAN SQ.CM.

CORRECTED ZERO SCALE VALUE IS 9.4985E-08 WATTS/STERADIAN SQ. CM.

TO CHNGE POSTATOM FLT 2 FROM(W/SR SQ.CM)TO(W/SR SQ.M MICRO M)MULTIPLY BY 5.03100E 05

WITH ABOVE UNIT CONVERSION APPLIED,NEW ZSV IS 4.77869E-02 WATTS/STER. SQ M MICRO M.

STANDARD DEVIATION = 4.9447E-06

FRACTIONAL STANDARD DEVIATION = .68 PERCENT

COMPONENTS OF FILTER FACTORS F1 AND F2 ARE
580YBARSUM= 2.7003E 07 WESTSTD= 3.5259E 03 WSTSTD= 4.1098E 06 WESTINST= 3.5142E 03 WSTINST= 4.1023E 06

CALIBRATION LAMP IDENTIFICATION
SERIAL NUMBER = VL-8166A
LUMINOUS INTENSITY = 8.67
DISTRIBUTION TEMPERATURE = 2854

IF MILLIVOLT DATA IS LESS THAN THE END OF RULE CUTOFF =-1025.0 IGNORE DATA

Fig. 3-8. Typical Absolute Calibration Form.

Nine determinations of the calibration constant are made during each calibration run. The average value of the nine determinations is assumed to be the most probable value for the calibration constant. Due to precision limitations, stray light, and related procedural errors, typical standard deviations for the calibration constant are on the order of ±5 percent. Table 3-3 illustrates the quality of typical calibration constants associated with data tabulated in Section 7. It should be noted that the term standard deviation is not rigorously correct in this application since the calibration data set includes some obvious systematic errors due to detector dynamic response as well as some procedural stray light errors. These systematic errors are not removed from the calibration data and as a result, the standard deviation of the calibration constant determination represents a worst-case type of index.

Table 3-3

Radiometer Calibration Constants (ZSV) and Related Fractional Standard Deviations (δ%) for Daylight Flights

Radiometer Ident System	MPT SN	Calib Mode	Calib Units	Filter 2 ZSV	δ%	Filter 3 ZSV	δ%	Filter 4 ZSV	δ%	Filter 5 ZSV	δ%	Filter 6 ZSV	δ%	Average % for System
SCAN3	9846	Night*	$w/\Omega m^2 \mu m$	2.25E+04	±1	3.99E+04	±1	7.46E+04	±2	1.46E+04	±1	1.34E+03	±1	±1
SCAN4	9858	Night*	$w/\Omega m^2 \mu m$	1.05E+05	±1	1.18E+05	±1	2.15E+05	±2	5.03E+04	±1	4.17E+03	±1	±1

NEPH1-Σ	9828	Night	$w/m^2 \mu m$	9.82E-02	±2	1.46E-01	±2	6.00E-01	±1	3.63E-02	±2	4.65E-03	±1	±2
NEPH1-β	9828	Night	$w/\Omega m^2 \mu m$	8.21E-02	±1	1.62E-01	±2	1.22E-00	±4	3.84E-02	±1	4.96E-03	±1	±2

D I. 1 LAT 1	11783	Night*	$w/m^2 \mu m$	1.89E+04	±1	7.07E+04	±18**	4.77E+04	±1	2.90E+04	±2	2.99E+03	±2	

VPFM	14531	Night	$w/\Omega m^2 \mu m$	1.94E+01	±1	6.77E+01	±12	1.63E+03	±9	7.03E+00	±1	8.75E-01	±1	±3
ERT	9869	Night*	$w/\Omega m^2 \mu m$	3.94E+04	±1	7.29E+04	±1	6 29E+04	±1	1.98E+04	±1	2.74E+03	±4	±2

NEPH3-Σ	14509	Night	$w/m^2 \mu m$	6.97E-02	±2	7 15E-02	±2	8.75E-02	±1	1.21E-02	±2	2.75E-03	±1	±2
NEPH3-β	14509	Night	$w/\Omega m^2 \mu m$	5.80E-02	±1	7 70E-02	±1	1.28E-02	±2	1.28E-02	±2	3.00E-03	±2	±2

CRM/SS	9861	Day	$w/\Omega m^2 \mu m$	6.61E+03	±2	1.16E+04	±2	9.67E+02	±1	1.92E+03	±2	3.07E+02	±1	±2
CRM/E	9861	Day	$w/m^2 \mu m$	7.49E+04	±1	1.06E+05	±1	7.88E+03	±3	1.85E+04	±3	2.66E+03	±2	±2
CRM/STD		***	$w/\Omega m^2 \mu m$	6.94E+08		1.34E+09		1.91E+08		2.37E+08		3.93E+07		

* Indicates that the basic night mode absolute calibration was adjusted for daylight using calibrated day/night neutral density filter.

** Improperly labeled data point included which results in this ZSV being 7% too high.

*** Indirect field calibration using CRM/SS channel as reference.

It should also be noted that in some cases, the basic calibration of the radiometer system is accomplished in the night mode. The conversion of the calibration constant to day mode, which allows calibrated measurements at daylight flux levels, is made by applying the day/night neutral density factor. Obviously, an error in the determination of this factor will also contribute to the overall probable error.

All procedural and precision uncertainties are, of course, independent of the absolute accuracy of the standard lamp calibration, which is assumed to be ±3 percent.

At regular intervals during the calibration procedure, the radiometer is automatically exposed to its internal reference source, i.e., Isolite standard of luminous intensity. Since this integral, exceptionally stable source is always available for reinspection by the radiometer during subsequent measurement activities, the long term stability of the detector can be monitored and, when necessary, automatic adjustments to the calibration constant can be readily effected.

CALIBRATION SUMMARY

Two sets of radiometric calibration data are available for application to the Project ATOM field data.

A. The pre-deployment calibration is dated October 1970. Day/night systems were calibrated against both the low intensity night source (8.67 horizontal candlepower and 05 percent reflectance mirror) and the high intensity day source (592 horizontal candlepower and no mirror attenuator). Most of the day source data are very near the dark cutoff flux level and should be used with caution. The 20 channel incremental data logger was used for recording portions of this calibration data set. The data logger was found to be intermittently faulty in operation and much of the data was lost. The backup, manually recoraed data were converted to card input for computation of the pre-deployment calibration constants.

B. The post-deployment calibration is dated December 1970. During this calibration sequence, all day/night radiometers were calibrated in the night mode only. They were calibrated against the low intensity night source (8.67 horizontal candlepower and 05 percent reflectance mirror). The VPFM and ERT being day-only radiometers were calibrated against the high intensity day source (592 horizontal candlepower). All post ATOM radiometer calibrations were recorded manually and converted to card input for computation of the post-deployment calibration constants. The day/night neutral density filter associated with each day/night radiometer system was individually calibrated during the linearity calibration sequence. The equivalent neutral density for each of these filters, in each spectral band used during Project ATOM, was established. This calibrated offset may be used to convert the night mode absolute calibration data into day mode calibration constants.

Analysis of these two data sets indicates that for the most consistent results, the post-deployment calibration constants should be used. A summary of these adjusted day mode calibration constants is presented in Table 3-3. A mechanical failure of SCAN4 during the Project ATOM field deployment necessitated the use of the pre-deployment calibration constants for this system.

CALIBRATION CORRECTION FACTORS

Two calibration correction factors are shown in Figure 3-8. The first, F1, is a luminance to radiance conversion factor which is used in the specification of nonphotopic system responses. The second, F2, is a color-matching factor which is used to compensate for small mismatches between system spectral responses. The generation of these factors is covered in AFCRL-70-0137 and is not repeated here. However, since the Project ATOM data include two new spectral responses, a summary of the Project ATOM luminance to radiance conversion factors is presented in Table 3-4.

Table 3-4

Luminance to Radiance Conversion Factors
Peak and Mean Wavelength, Response Area, F1 and F3 for Standard Responses

	Filter 2	Filter 3	Filter 4	Filter 5*	Filter 6	Filter 9
Peak Wavelength (nm)	475	660	750	550	440	555
Mean Wavelength (nm)	478	664	765	557	532	560
Response Area (nm)	19.9	30.2	50.4	78.5	183.5	106.9
F1 (w/lu)						
W_ϵ(2800°K)	1.263E-04	7.136E-04	1.561E-03	1.050E-03	2.112E-03	
W_ϵ(2854°K)	1.306E-04	6.958E-04	1.492E-03	1.052E-03	2.111E-03	
F3 (Sq cm/Sq m μm)	5.031E+05	3.315E+05	1.983E+05	1.273E+05	5.448E+04	

Unit Conversion Factor. The units of distance used on the optical bench during instrument calibrations are cm. The units in which the data are to be published are radiance in $w/\Omega\, m^2 \mu m$ and irradiance in $w/m^2 \mu m$. In order to change from the calibration units of w/cm^2 a factor of F3 is used defined as follows:

$$F3 = \frac{10^4\, cm^2}{m^2} \frac{1}{\delta\lambda}, \tag{3.11}$$

where $\delta\lambda$ is the response area of the standard. The response area is defined as the area under the relative spectral response curve, $\overline{S_\lambda T_\lambda}$, which is normalized to one at the maximum response:

$$\delta\lambda = \Sigma\, (\overline{S_\lambda T_\lambda})\, \Delta\lambda\, . \tag{3.12}$$

Since the response area is evaluated in units of nm, Eq. 3.11 must be rewritten as

$$F3\ \frac{cm^2}{m^2 \mu m} = \frac{10^4\, cm^2}{m^2} \frac{1}{\delta\lambda\, nm} \frac{10^3\, nm}{\mu m} = \frac{10^7\, cm^2\, nm}{\delta\lambda nm\; m^2 \mu m}\, . \tag{3.13}$$

The application of factors F1, F2, and F3 is included in Program CALIB.

Photometric Conversion Factor. The pseudo-photopic filter, ATOM Filter 5, is calibrated radiometrically and the data presented in radiometric units. In order to compare these data to photometric values, the values are converted to photometric quantities by means of F4, the photometric conversion factor:

$$F4 \; \frac{\text{lu}\,\mu\text{m}}{\text{w}} = \frac{680 \text{ lu}}{\text{w}} \; \frac{\Sigma W_\lambda(T)\,\bar{y}\,\Delta\lambda}{\Sigma W_\lambda(T)\,(\overline{S_\lambda T_\lambda})\,\Delta\lambda} \times \frac{\delta\lambda\text{nm } 10^{-3}\mu\text{m}}{\text{nm}} \quad , \qquad (3.14)$$

where $\bar{y}$ is the photopic luminosity function.

In F4, the spectral emittance of the target in the field $W_\lambda(T)$ depends upon the instrument being calibrated. Since the term appears in the numerator and the denominator of the factor, the exact spectral emittance does not need to be used. A relative spectral curve may be substituted so long as the same function is used for both numerator and denominator.

For the nephelometer data, the light source is a Xenon arc lamp whose spectral distribution is approximated by a blackbody radiator of 5500°K. For the scanners, the daytime sky is approximated by a blackbody radiator at 7000°K and the nighttime sky is from data by Johnson *et al.* (1965).

Instrument	**T (°K)**
Nephelometer	5500°K
Scanners	
Day	7000°K
Night	Johnson *et al.* (1965)

Application of factor F4 changes radiance units of $w/\Omega m^2 \mu m$ to luminance units of $lu/\Omega m^2$ or nit and changes irradiance units of $w/m^2 \mu m$ to illuminance units of lu/m^2 or lux.

The four correction factors are calculated in Program SUPERCK6 which is an update of two previous programs which produced the various spectral summations but did not combine them into factors. Factors F1, F3, and F4 are presented in Tables 3-4 and 3-5, which were generated by Program SUPERCK6.

Table 3-5

Radiance to Luminance Conversion Factors
F4 for Photopic Filter No. 5*

Radiant Emittance

	4000°K	5500°K	7000°K	10 000°K	20 000°K	Night
F4 (lu μm/w)	7.299E+01	7.222E+01	7.200E+01	7.195E+01	7.211E+01	6.834E+01

3.6 STANDARD RESPONSE CHARACTERISTICS FOR BROAD BAND SENSORS

All the radiometric instruments both ground-based and airborne used by the Atmospheric Visibility Branch are equipped with automatic filter changing assemblies. Thus, any one of five different spectral filters can be interposed into each instrument's optical path. The combination of the sensor sensitivity S_λ and the filter transmittance T_λ is the resultant sensitivity of the filtered phototube $S_\lambda T_\lambda$. The standard responses which each individual optical system approaches are indicated as $\overline{S_\lambda T_\lambda}$.

PEAK WAVELENGTH

The peak or maximum value of the standard sensor response $\overline{S_\lambda T_\lambda}$ is used to normalize the response values. The wavelength of the maximum value of the standard response is called the "peak wavelength".

RELATIVE SPECTRAL RESPONSE OF STANDARDS

The relative spectral response of a standard $\overline{S_\lambda T_\lambda}$ curve is obtained by normalizing the curve values so that the maximum relative response is 1. The Program RAYLIMIT checks to see if the input standard spectral response curve is normalized, and renormalizes if necessary. It also interpolates to wavelength increments of 5 nanometers if the standard has been specified for only 10 nanometer increments. It is more reasonable to interpolate the relatively smooth response values than to ignore the fine spectral structure of the sun irradiance out of the atmosphere.

A graph of the relative spectral response for the standards used for Project ATOM is presented in Figures 1-2 and 3-9. In Figure 3-9, which is the computer-generated plot, a point is plotted for each 5 nanometers in wavelength, but an identifying symbol is printed on only every second point. The relative spectral response values are also presented in Table 3-6.

Fig. 3-9.

Computer-Generated Plot of Standard Spectral Responses for Project ATOM.

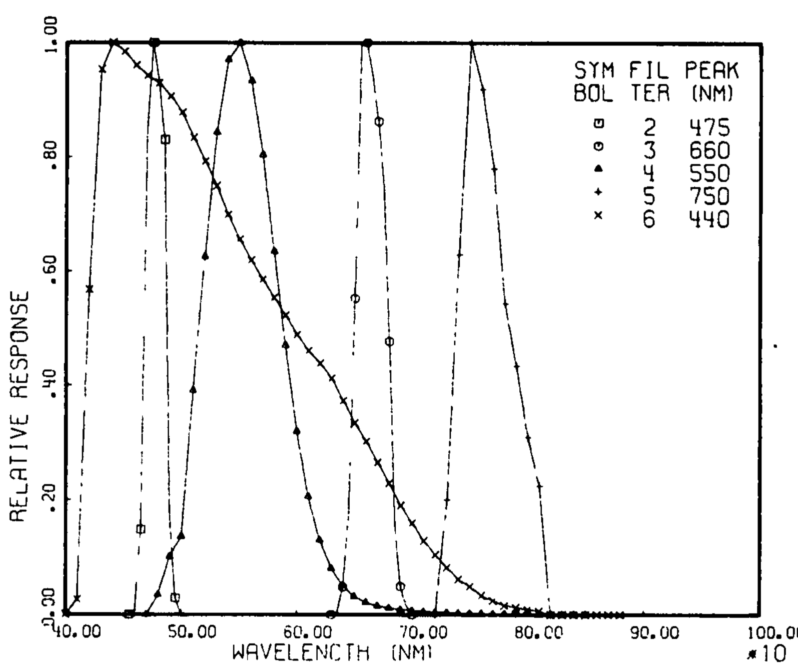


Table 3-6

Relative Spectral Response of Standards for Project ATOM

Filter Identification and Mean Wavelength

Wavelength (nm)	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6
	478 nm	664 nm	765 nm	557 nm	532 nm
400	0	0	0	0	0
405	0	0	0	0	.0129
410	0	0	0	0	.0258
415	0	0	0	0	.2969
420	0	0	0	0	.5680
425	0	0	0	0	.7605
430	0	0	0	0	.9530
435	0	0	0	0	.9765
440	0	0	0	0	1.0000
445	0	0	0	0	.9920
450	0	0	0	0	.9840
455	0	0	0	0	.9720
460	.0070	0	0	0	.9600
465	.1487	0	0	0	.9510
470	.8481	0	0	0	.9420
475	1.0000	0	0	.0172	.9355
480	.9329	0	0	.0343	.9290
485	.8304	0	0	.0677	.9175
490	.1790	0	0	.1010	.9060
495	.0292	0	0	.1185	.8920
500	0	0	0	.1360	.8780
505	0	0	0	.2635	.8560
510	0	0	0	.3910	.8340
515	0	0	0	.5085	.8135
520	0	0	0	.6260	.7930
525	0	0	0	.7345	.7715
530	0	0	0	.8430	.7500
535	0	0	0	.9065	.7250
540	0	0	0	.9700	.7000
545	0	0	0	.9850	.6785
550	0	0	0	1.0000	.6570
555	0	0	0	.9665	.6385
560	0	0	0	.9330	.6200
565	0	0	0	.8685	.6030
570	0	0	0	.8040	.5860
575	0	0	0	.7195	.5700
580	0	0	0	.6350	.5540
585	0	0	0	.5525	.5385
590	0	0	0	.4700	.5230
595	0	0	0	.3950	.5060
600	0	0	0	.3200	.4890
605	0	0	0	.2630	.4750
610	0	0	0	.2060	.4610
615	0	0	0	.1680	.4500
620	0	0	0	.1300	.4390
625	0	0	0	.1055	.4260
630	0	0	0	.0810	.4130
635	0	.0020	0	.0657	.3935
640	0	.0486	0	.0504	.3740
645	0	.1798	0	.0411	.3545

Table 3-6 (Cont)

Relative Spectral Response of Standards for Project ATOM

Filter Identification and Mean Wavelength

Wavelength (nm)	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6
	478 nm	664 nm	765 nm	557 nm	532 nm
650	0	.5531	0	.0318	.3350
655	0	.9948	0	.0268	.3190
660	0	1.0000	0	.0218	.3030
665	0	.9421	0	.0188	.2845
670	0	.8625	0	.0157	.2660
675	0	.7482	0	.0139	.2480
680	0	.4774	0	.0120	.2300
685	0	.1585	0	.0105	.2105
690	0	.0495	0	.0090	.1910
695	0	.0166	0	.0080	.1755
700	0	0	0	.0070	.1600
705	0	0	0	.0061	.1445
710	0	0	0	.0053	.1290
715	0	0	0	.0048	.1170
720	0	0	0	.0042	.1050
725	0	0	.1005	.0038	.0938
730	0	0	.2010	.0033	.0826
735	0	0	.4155	.0030	.0723
740	0	0	.6300	.0026	.0619
745	0	0	.8150	.0025	.0558
750	0	0	1.0000	.0023	.0497
755	0	0	.9595	.0020	.0416
760	0	0	.9190	.0018	.0335
765	0	0	.8495	.0017	.0292
770	0	0	.7800	.0016	.0249
775	0	0	.6620	.0014	.0206
780	0	0	.5440	.0013	.0162
785	0	0	.4890	.0012	.0144
790	0	0	.4340	.0012	.0125
795	0	0	.3720	.0012	.0107
800	0	0	.3100	.0011	.0088
805	0	0	.2675	.0005	.0075
810	0	0	.2250	0	.0062
815	0	0	.1125	0	.0031
820	0	0	−0	0	0
825	0	0	−0	0	0
830	0	0	−0	−0	0
835	0	0	−0	−0	0
840	0	0	−0	−0	0
845	0	0	−0	−0	0
850	0	0	−0	−0	0
855	0	0	−0	0	0
860	0	0	−0	0	0
865	0	0	−0	0	0
870	0	0	−0	0	0
875	0	0	−0	0	0
880	0	0	−0	0	0
885	0	0	−0	0	0
890	0	0	−0	0	0
895	0	0	−0	0	0

MEAN WAVELENGTH

The mean wavelength $\bar{\lambda}$ is defined as

$$\bar{\lambda} = \frac{\sum_{o}^{\infty} \lambda \overline{S_\lambda T_\lambda} \Delta\lambda}{\sum_{o}^{\infty} \overline{S_\lambda T_\lambda} \Delta\lambda} . \tag{3.15}$$

The λ is the wavelength of the relative spectral response $\overline{S_\lambda T_\lambda}$.

RESPONSE AREA

The response area is the area under the relative spectral response curve; it is equal to the width of the pass band of a rectangular filter of equivalent area, hence, it is designated as $\delta\lambda$, and defined as illustrated in Eq. 3.12. The radiometric units of watts/m$^2\mu$m are obtained from units of watts/m^2 by dividing by the response area $\delta\lambda$, in appropriate units.

A summary of the response characteristics of the standards for Project ATOM is presented in Table 3-7. The first four columns give filter code, peak wavelength, mean wavelength, and response area. The derivation of the values for inherent solar properties and Rayleigh limits in the final column are described in the Visibility Laboratory in-house Technical Note No. 36. The tables and graphs contained in Section 3.6 were produced by Program RAYLIMIT.

Table 3-7

Spectral Characteristics Summary for Project ATOM

Spectral Characteristics for Project ATOM				Inherent Sun Properties (Johnson)			Rayleigh Atmosphere Properties (15°C)		
Filter Code No	Peak Wavelength (nm)	Mean Wavelength (nm)	Response Area (nm)	Irradiance (w/m$^2\mu$m)	Radiance (w/Ωm$^2\mu$m) Average	Center	Attenuation Length (m)	Total Scattering Coefficient (Per m)	Vertical Beam Transmittance
2	475	478	19.9	2.14E+03	3.13E+07	4.07E+07	4.84E+04	2.07E-05	.839
3	660	664	30.2	1.57E+03	2.30E+07	2.75E+07	1.86E+05	5.41E-06	.955
4	750	765	50.4	1.23E+03	1.80E+07	2.10E+07	3.28E+05	3.08E-06	.974
5	550	557	78.5	1.90E+03	2.78E+07	3.47E+07	8.93E+04	1.15E-05	.907
6	440	532	183.5	1.91E+03	2.80E+07	3.55E+07	7.22E+04	1.64E-05	.867

4. DATA COLLECTION METHODS

During Project ATOM, two independent activities were maintained simultaneously. The airborne instrument system was one activity and the ground-based instrument system was the other. The basic concept of the experiment was built around the joint operation of these two systems in a highly coordinated and simultaneous measurement routine. The procedural routine was for each system to run full data collection sequences at every opportunity, on a daily schedule. If for any reason the joint sequences were aborted, both systems were to automatically revert to independent operation. Partial data sets were thus often obtained even when the inevitable exigencies of joint field operations defeated the basic routine.

4.1 AIRBORNE SYSTEM

The data collection sequence for the airborne system was broken into five standardized elements: (1) preflight warmup and calibration check, (2) straight and level sequences, (3) vertical profile sequences, (4) in-flight calibration checks, and (5) post-flight calibration check.

The airborne data collection was accomplished through the use of an instrumented C-130A aircraft in a manner similar to that reported in AFCRL-70-0137, Duntley *et al.* (1970). During each data collection flight, the aircraft flew a predetermined pattern within the specified test area. An illustration of the typical flight pattern is shown in Figure 4-1. In this stylized pattern, two basic elements, the straight and level and the vertical profile, are combined to yield the total mission flight plan. A more detailed description of all flight pattern elements is presented in AFCRL-70-0137 and also in AFCRL-72-0255, Duntley *et al.* (1972). The two primary elements are summarized in the following paragraphs.

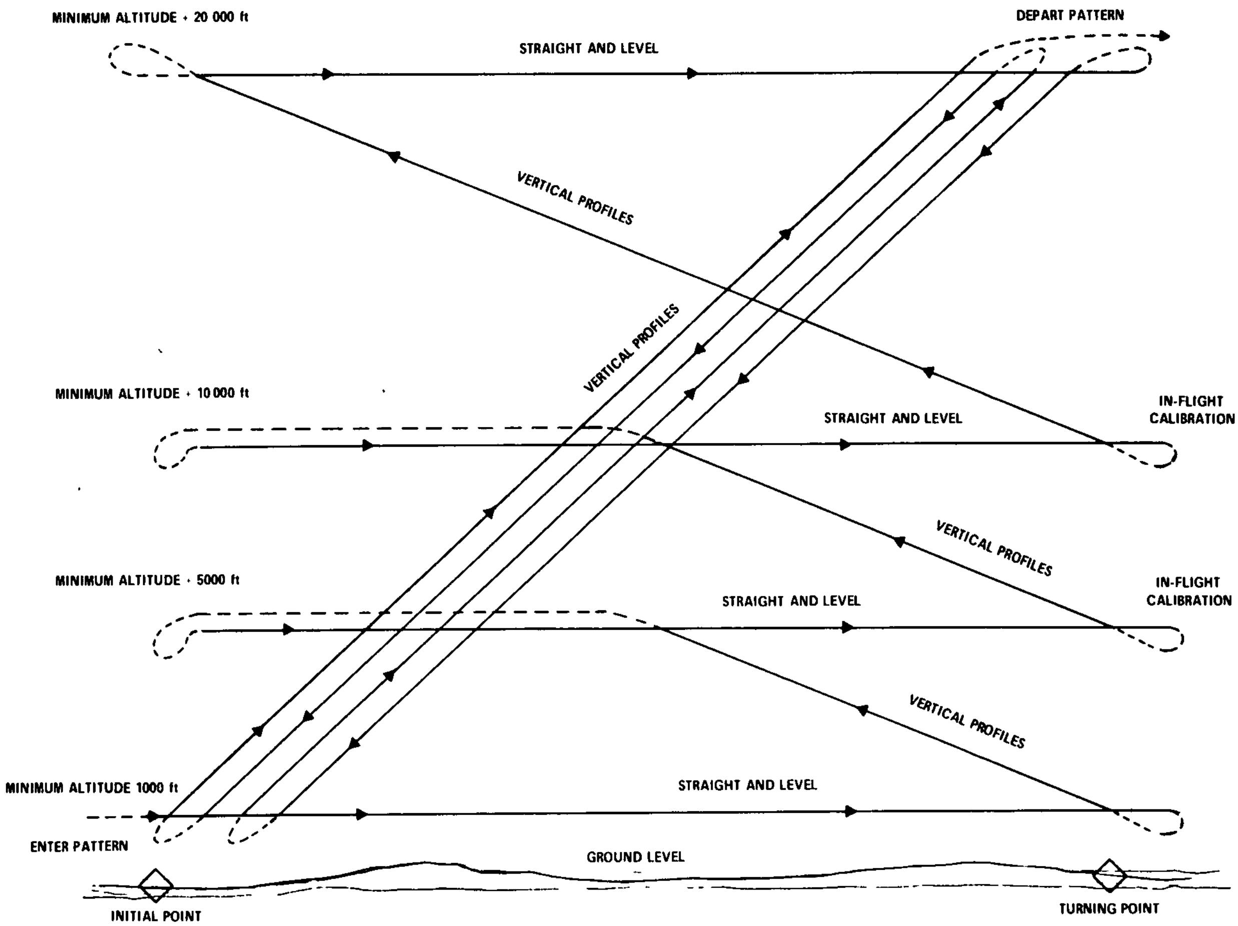


Fig. 4-1. Typical ATOM Flight Profile.

STRAIGHT AND LEVEL SEQUENCE

During each straight and level element of the data collection sequence, the pilot maintains a straight and level flight attitude at a maximum indicated airspeed of 150 knots. If weather and terrain permit, the aircraft heading is established crosswind. The ideal pattern for the straight and level sequences would result in all four ground tracks falling on a single line between the initial point and the turn point. See Figure 1-1. The four straight and level elements are actually stacked in a vertical slab of atmosphere approximately 45 miles long, 0.5 mile wide, and 4 miles high.

VERTICAL PROFILE SEQUENCE

During each vertical profile element of the data collection sequence, the pilot maintains an approximately level attitude, a straight heading, a maximum indicated airspeed of 150 knots, and an average rate of descent or ascent of 1000 feet per minute. Up to five vertical profile elements are run during each data collection sequence. These elements are conducted in the same vertical slab of atmosphere that was defined by the preceding four straight and level elements.

During each mission, top priority is given to those systems essential for the recovery of beam transmission and path radiance data. Thus, the primary systems are the integrating nephelometer and the upper and lower hemisphere scanners. All other systems are either peripheral or backup and are therefore subject to cannibalization or abandonment in the event of any malfunction which affects a primary system.

At the conclusion of each mission, the data which have been recorded and stored on magnetic tape are returned to the Laboratory for computer reduction and analysis.

4.2 GROUND-BASED SYSTEM

The ground-based data collection sequence was designed to supplement the airborne data whenever the aircraft was operating in the immediate vicinity. However, it is also complete enough to stand alone when the aircraft mission is diverted or aborted.

The ground-based instrument system has several operational responsibilities. First, it must supply a ground level data base to allow interpolation of various measurements between ground altitude and the lowest attainable aircraft altitude. Second, it must supply long term temporal sampling of those meteorological and radiometric quantities which relate to the project task. The ground station has run several 24-hour data sequences to monitor temporal variations in particle concentrations and scattering coefficients. This long term continuous measurement capability may in fact be the most significant capability inherent in the system. Third, the ground system serves as a spare parts and repair facility for the entire air/ground operation. In the event of a catastropic failure in a primary airborne instrument or assembly, the equivalent piece of instrumentation is reassigned to the aircraft from the ground-based system. The aircraft can then return to service with a minimum of "down time" and repairs can be accomplished under the more convenient ground station conditions.

DATA COLLECTION SEQUENCE

The ground-based system was assigned three radiometer systems, three meteorological instruments, a Royco particle counter system, and communications equipment. The ground-based data collection sequence is not as automatic as the airborne sequence, but is otherwise quite similar. However, there is a basic difference in priorities. During each ground-based data sequence, top priority was given to those systems essential for the recovery of inherent background radiances and beam transmittance. Consequently, the primary systems were the automatic 2π scanner and the contrast reduction meter.

The ground-based data collection was accomplished through the use of an instrumented van in a manner similar to that reported in AFCRL-70-0137. This van was located on the White Sands Missile Range near the Stallion Station and was maintained in this location throughout the entire deployment.

Ground-based data were collected in a fixed pattern on a repetitive basis during each designated data day. The Project ATOM ground station data collection pattern consisted of the radiometric sequence listed below, plus a continuous Royco sampling at 10-minute accumulation intervals. A detailed description of each of these data collection sequences is presented in AFCRL-70-0137, and thus, is not repeated here.

1. Nephelometer Set, Σ, $\beta 30$, $\beta 150$
2. 2π Scanner Set, upper and lower hemispheres
3. Nephelometer Set, Σ only
4. CRM Set (see Section 3)

As with the airborne data, all ground-based measurements were recorded in digital format on magnetic tape for computerized reduction and analysis upon return to the Laboratory.

Upon return to the Laboratory, analysis of the data tapes indicated that in spite of the major overhaul and repair effort expended prior to deployment, the ground-based data logger still experienced serious intermittent abnormalities. These intermittent malfunctions within the logic circuitry were undetectable by the field technician, but were severe enough to defeat all subsequent attempts at automatic processing. A dump of the contents of the magnetic tapes indicated that little or no useful data would be retrievable by existing computer techniques. Thus, selected backup data which had been manually recorded were hand-transcribed to punch cards and then processed by computer. Since the process of hand selection was time-consuming and costly, retrieval was limited to the total volume scattering coefficient data from the nephelometer and CRM data corresponding to the six Project ATOM flight days for which airborne data had been processed.

5. DATA PROCESSING

5.1 AIRBORNE DATA

As in any reasonably complex, multi-input sample data system, there is a large amount of data handling required before the scientific analyst ever sees the package. The degree of sophistication utilized for this portion of Project ATOM data is illustrated in Figure 5-1. In this generalized flow chart, the step-by-step processing of the raw field data is illustrated for the convenience of project organization and control and does not include the details of the actual computer programming. A description of each phase in the processing sequence is presented in fuller detail in Duntley *et al.* (1972).

The airborne data and ground-based data are processed separately as illustrated in the data flow schedule. There are two primary reasons for this approach. First, the recording format of the two data loggers is significantly different. Second, each data collection sequence, airborne and ground-based, is considered to be a completely independent activity and therefore must be reduced to useable format in the most direct manner possible.

As described in Duntley *et al.* (1972), several classes of data are recorded during an airborne data set: (1) radiometer outputs, (2) selector control codes, (3) transducer orientation and flight attitude signals, and (4) calibration voltages, etc. All systems, regardless of type, have been designed for an electrical output between 0 and ±1 volt dc for full scale. The data logger has a least count of ±1 millivolt and records in digital format at a multiplex rate of 240 samples per second and a tape rate of 3.56 inches per second at a recording density of 200 bits per inch.

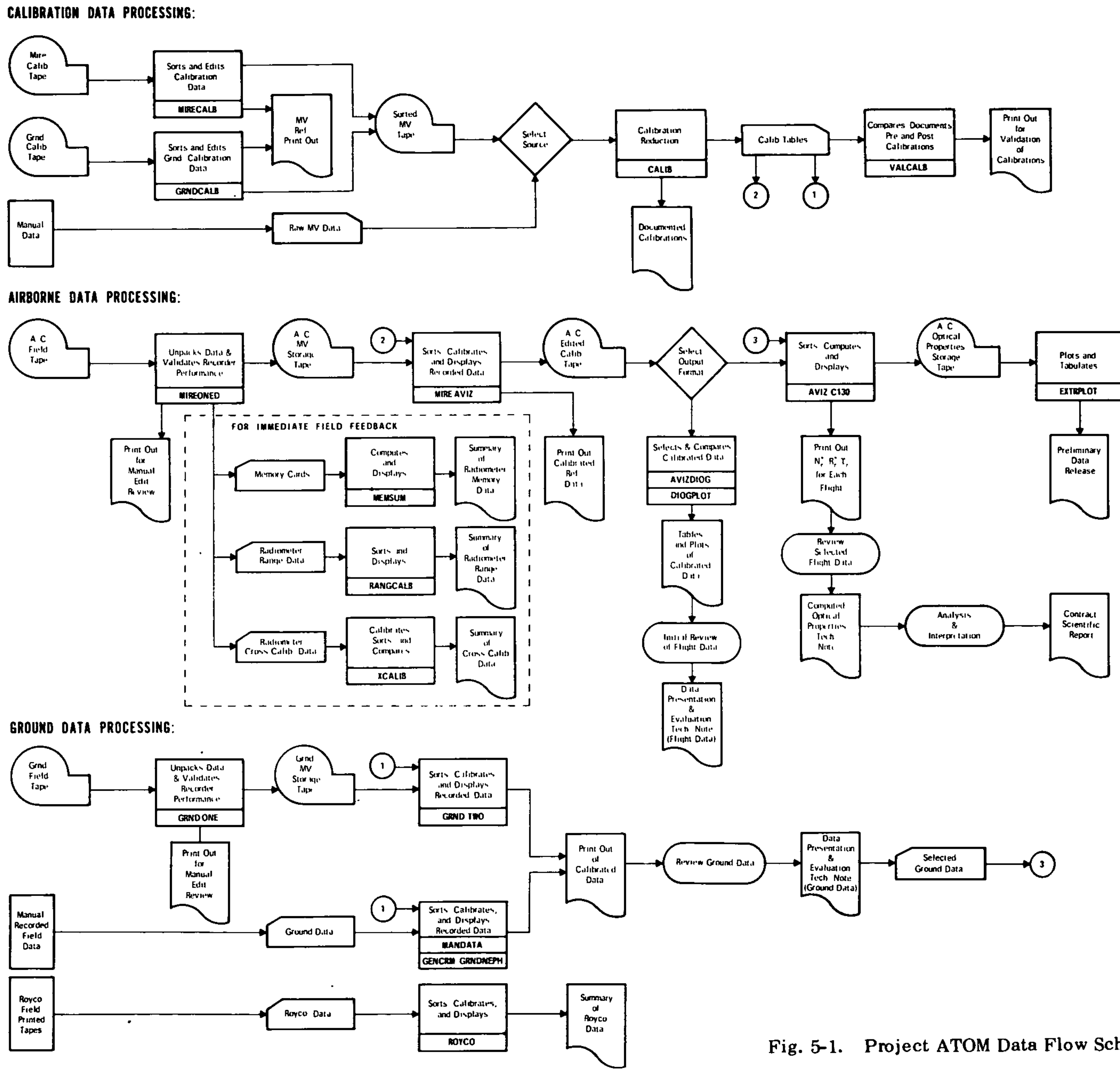


Fig. 5-1. Project ATOM Data Flow Schedule.

5.2 GROUND-BASED DATA

The data processing associated with the ground-based data set is similar in concept to that applied to the airborne data. The primary differences are the result of a different recording format between the two data loggers and the significantly lesser amount of data resulting from the ground station. As noted in Duntley *et al.* (1972), the same general classes of data are handled, but in much smaller quantities. Again, all systems, regardless of type, have been designed for an electrical output between 0 and ±1 volt dc for full scale. The data logger is normally adjusted for a least count of ±0.1 millivolt. It also records in digital format; however, the normal incremental sample rate is only approximately eight samples per second.

The processing of nonstandard tape-recorded data sets requires the revision back to card format for efficient processing. To handle this procedure, Program GRNDCNVT (not illustrated in Fig. 5-1) is used to reduce the data to the radiometer system card format. This card format is then used to complete this phase of the processing in the manual data mode.

Ground-based data that were recorded manually are also processed in a systematic fashion. The data are transcribed and punched onto cards in a generalized radiometer system format. Each system measurement, in each of the spectral bands, is recorded on one card with its memory and identifying information. This one card format was designed for conciseness and to facilitate processing procedures.

The manual data are presently being processed by separate programs, depending upon the system from which the data were derived. Program GENCRM is used to process the contrast reduction meter data. The program is suitable for use with all contrast reduction meter data modes (sky scanning, solar transmissometer disk, and irradiometer), as well as other system ground gonio or downwelling irradiance measurements. Program GRNDNEPH is used for ground nephelometer data reduction.

5.3 CALIBRATION DATA

The calibration data are the heart of the data processing system in that any data processed are only as good as the calibrations applied to them. The calibration data are presently being recorded on tape to help eliminate the human bias in the system and are being handled in a phased procedure similar to that used in the general data processing technique. The data can be recorded on either the airborne or the ground data logging system. In a Phase I procedure, these data go through the programs MIRECALB or GRNDCALB respectively to verify the electrical quality of the radiometer data and associated monitored parameters. The data are sorted and stored in set fashion for Phase II processing. Program CALIB performs this processing by generating documentation printouts and standard radiometer calibration card decks which can be used by any of the system's programs for calibrating field data. These card decks are also used by Program VALCALB which, in its documentation mode, can be used to generate printout for direct insertion into a technical note. This program also has a comparison mode which is used to compare pre- and post-deployment calibration sets. This mode is a particularly useful tool in calibration verification.

5.4 DATA TAPES

The data processing sequences discussed in the previous paragraphs produce output tapes containing a broad catalog of calibrated data. These tapes are useable as data inputs to a multiplicity of diverse problems requiring a knowledge of atmospheric optical properties. Thus the data tape numbers and the computer job numbers that produced the data tables and graphs reported herein are summarized in Table 5-1 to simplify future retrieval.

Table 5-1

Processed Data Tapes and Runs of Programs for Producing
Tables (AVIZC130) and Graphs (EXTRPLOT)

ATOM Flight No.	AVIZDIOG		AVIZC130				EXTRPLOT	
	Tape No.	File No.	Job No.	Date	Tape No.	File No.	Job No.	Date
C-151	VL-331C	1	4954	4-28-72	VL-355C	1	3353	5-15-72
C-152	VL-331C	2	4163	4-11-72	VL-355C	5	3357	5-15-72
C-154	VL-331C	4	4126	4-10-72	VL-355C	4	3351	5-15-72
C-155	VL-331C	5	4362	4-19-72	VL-355C	6	3359	5-15-72
C-157	VL-331C	6	4094	4-07-72	VL-355C	3	3358	5-15-72
C-158	VL-331C	3	4036	5-02-72	VL-355C	2	3352	5-15-72

6. GENERAL WEATHER SUMMARY

6.1 GENERAL SUMMARY

Meteorological data available for analysis included daily surface synoptic charts prepared by the U. S. Department of Commerce, Environmental Science Services Administration, Environmental Data Service. The surface charts were for 7:00 a.m., EST (1200 GMT). Portions of these charts are presented in Figure 6-1. The 500-millibar charts were also for 7 a.m., EST (1200 GMT). Surface charts plotted and analyzed by the staff at the North Island Fleet Weather Facility at 6-hour intervals were used to ascertain finer details of the synoptic situation. Also available for days when flights were conducted were the hourly reports made by the radiosonde station at Stallion and the Weather Office at Holloman Air Force Base. The Stallion data are preferred due to the station's proximity to the test site.

During the period of deployment there were weak gradients at the surface. There was only one weak frontal passage which did little to bring a modification of the ill-defined airmass.

This section includes a discussion of the surface and 500-millibar charts for all of the flights. Listed in tabular form are the hourly reports made by the observers at the Stallion radiosonde station. The meteorological data taken by the Visibility Laboratory ground station (on site near Stallion) are in agreement with the weather station data.

Also included in Section 6 are graphical representations of the ambient temperature profiles measured during each data flight, shown in Figure 6-2. These temperatures are measured continuously by an AMQ-17 aerograph system described briefly in Duntley *et al.* (1970), and more completely in USN TP-133. The profile identification symbols used in Figure 6-2 are related to the spectral filter sequence during which the temperature was measured; i.e., the temperature profile identified with the Filter 2 symbol was measured during the same time interval when the Filter 2 radiometric measurements were being made; the temperatures coded Filter 3 were taken simultaneously with the Filter 3 radiometric measurements, etc.

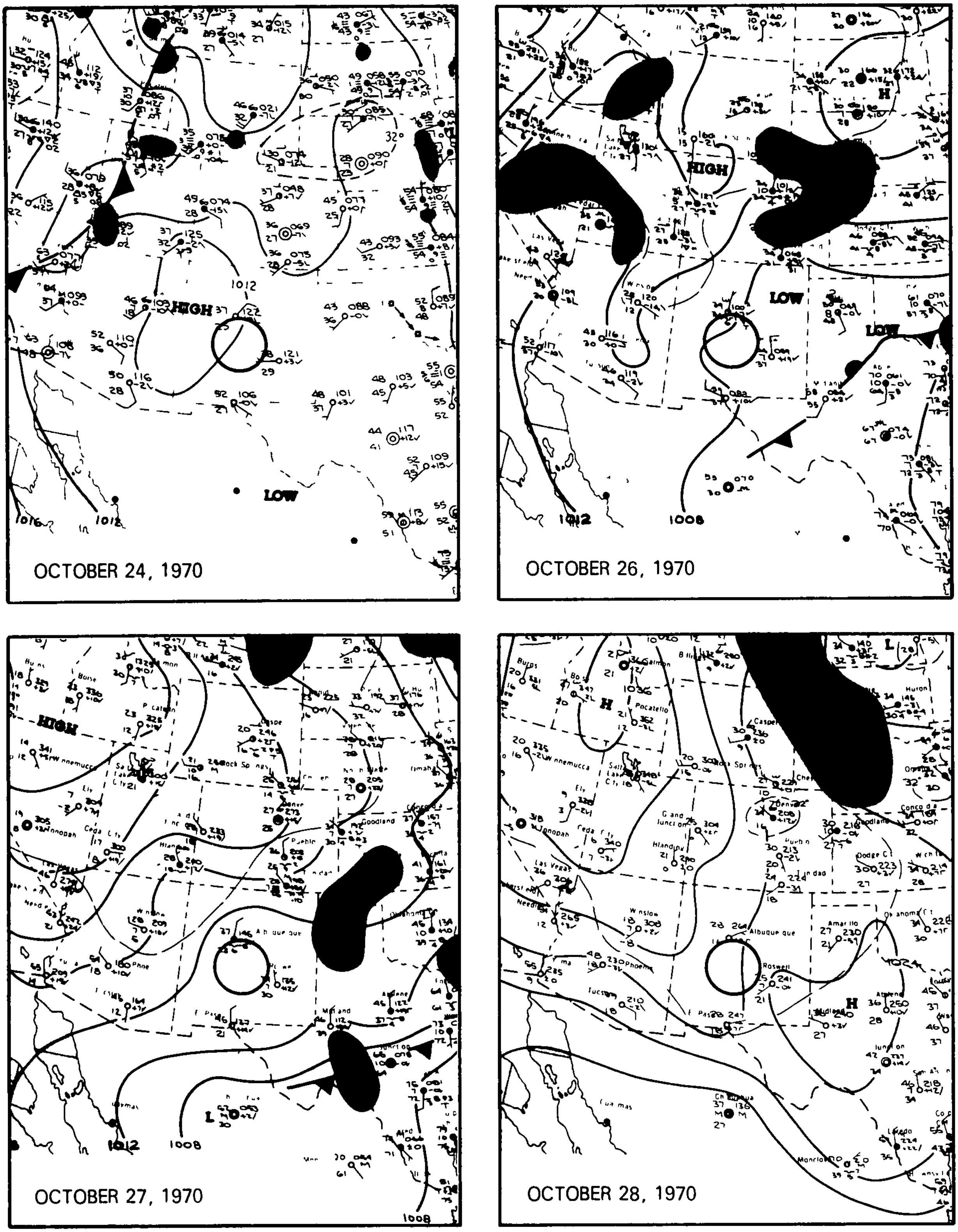


Fig. 6-1. Synoptic Charts of White Sands Area During Project ATOM.

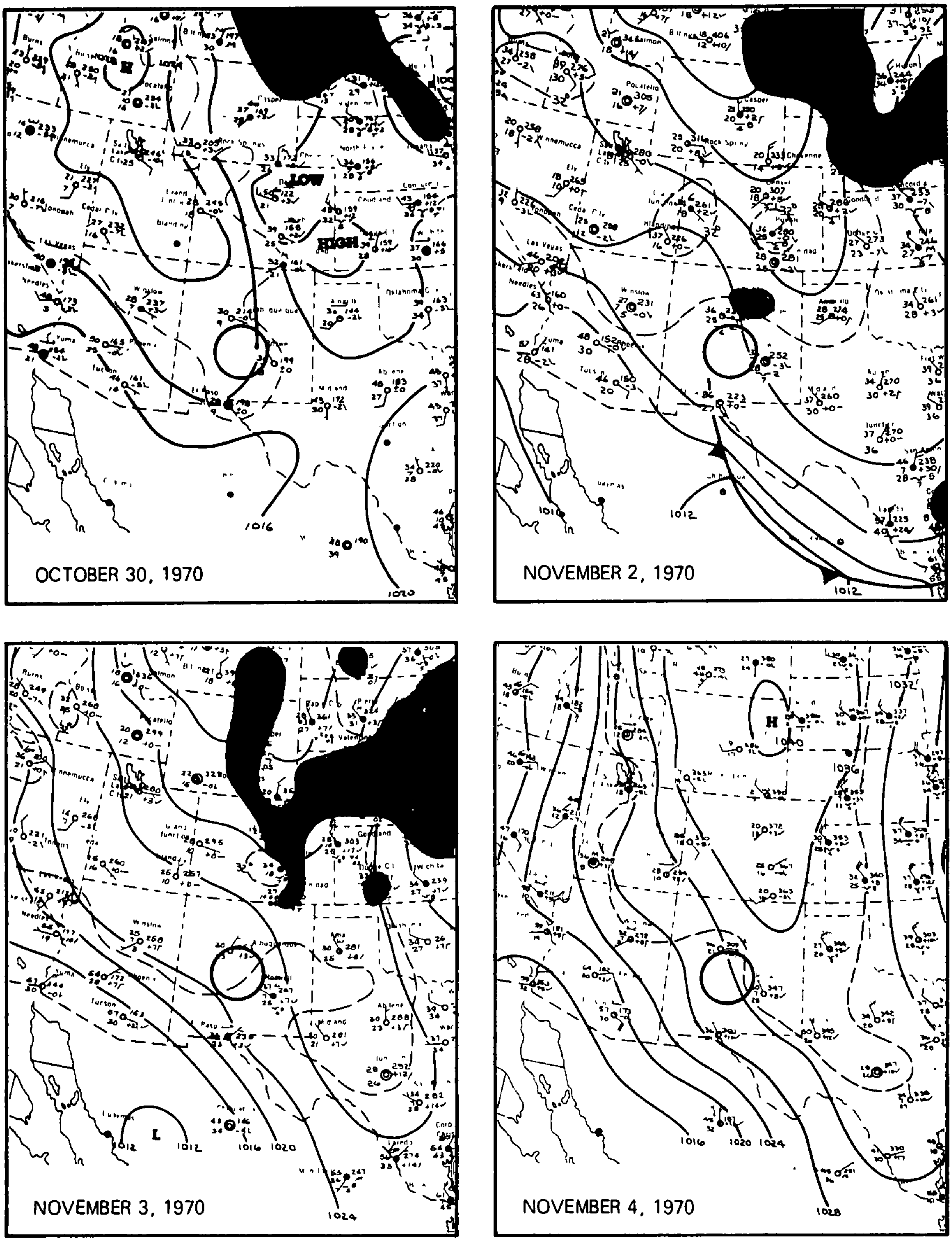


Fig. 6-1. (cont.) Synoptic Charts of White Sands Area During Project ATOM.

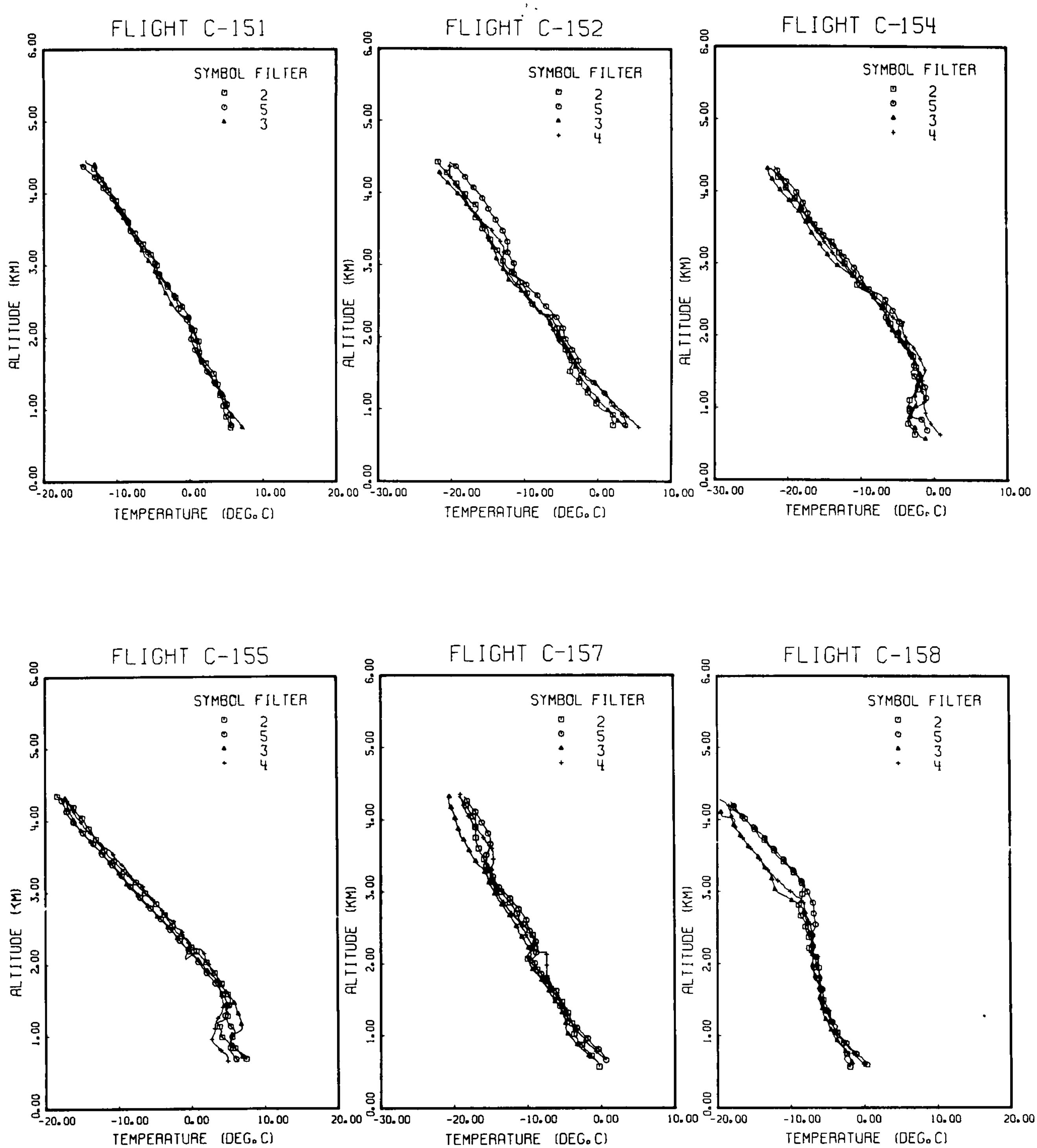


Fig. 6-2. Temperature Versus Altitude for Six Project ATOM Flights.

6.2 SYNOPTIC CONDITIONS

During the period of deployment for Project ATOM, the surface meteorological conditions in the region of interest were mostly of weak circulations. There was only one weak frontal passage during the entire period.

FLIGHT C-150 22 OCTOBER 1970

The area was in a col with very weak circulation at the surface. A 1011-millibar high was centered near Rapid City, North Dakota, and a small 1012-millibar high was located west of the Arizona border. A cold front extended through Fargo, Omaha, Wichita, and Amarillo. Another weak cold front was on a line through Cut Bank, west of Pocatello, and south of San Francisco. There were moderate westerly winds at 500 millibars with a weak trough from Port Hardy south southeastward to Baja, California. The airmass characteristics were diffuse and well-modified unstable maritime polar.

NO FLIGHT 23 OCTOBER 1970

No airborne data were collected on this date but there was a weak high of 1016 millibars centered over all of Utah which was causing a weak northerly flow over the White Sands area. A cold front extended from western Alberta, through central Washington, passing southwest into the Pacific at the Washington/Oregon border. A warm front, part of this same system, extended along 120° longitude from 36 to 41° North. There was a strong northwesterly flow at 500 millibars. The airmass was well-modified unstable maritime polar.

FLIGHT C-151 24 OCTOBER 1970

A weak 1012-millibar high over the area weakened still more during the day. A cold front extended from central Montana through western Utah to just south of the Channel Islands. This front had little weather associated with it in the southern portion. By 1800 GMT a trough of low pressure extended from eastern Montana and the western Dakotas southward to New Mexico. There was a very weak ridge with westerly flow at 500 millibars. The airmass was ill-defined.

NO FLIGHT 25 OCTOBER 1970

No data were collected on this day but there was a weak cold frontal passage through White Sands about noon. There were moderate to strong westerlies at 500 millibars.

FLIGHT C-152 26 OCTOBER 1970

At the surface there was a weak northerly flow and the area was in a zone of transition from weak low pressure to weak high pressure. High pressure was moving in over Washington and Oregon. From a low centered north of Lake Winnepeg an occluded front extended to west of Lake Head, then became a stationary front through Moline, Springfield, Missouri, and Midland, Texas, with a wave along the southwestern border of Oklahoma. At 500 millibars the area was at the base of a trough with moderate to strong westerly winds. A cold low was centered in Saskatchewan. The airmass characteristics were diffuse.

FLIGHT C-153 27 OCTOBER 1970

There was a surface high centered near the southern border of Oregon and Idaho with a weak northerly flow over New Mexico which was in the southeast sector of the high. This high covered the western half of the United States. At 500 millibars the area was at the base of a trough with moderate to strong westerly flow. Cold lows were centered near Bismark and in central Saskatchewan. The airmass was unstable continental polar.

FLIGHT C-154 28 OCTOBER 1970

At the surface there was high pressure over the area with a weak northerly flow. This high pressure cell covered the western two-thirds of the United States. There were high centers in western Texas and central Idaho. There was a strong northerly flow at 500 millibars which resulted from a ridge that covered the Pacific coast states and a trough from a cold low over the Dakotas southward to Texas. The airmass was unstable continental polar.

FLIGHT C-155 30 OCTOBER 1970

The surface chart shows that the area was at the southeastern edge of a high pressure cell with weak circulation. This high pressure dominated the western third of the country with a center in central Idaho. The high weakened slowly through the day. At 500 millibars the area was on the front side of a ridge with moderate northwesterly flow. There was a low in the eastern Dakotas. The airmass was continental polar.

FLIGHT C-156 2 NOVEMBER 1970

High pressure covered most of the western half of the United States. The area of interest was on the south central portion of the cell. The 1042-millibar center of the high was located near Saskatoon, Saskatchewan. The 500-millibar chart indicates that the region was in the southwest quadrant of a low centered over Minnesota and Iowa. The winds were moderate northwesterly. There was a ridge along the west coast of the United States and Canada. The airmass was modified continental polar.

FLIGHT C-157 3 NOVEMBER 1970

The area lay on the back side of a high with streamlines from the southeast. From a high centered in central Saskatchewan a ridge extended south southeastward through Texas. High pressure dominated the western half of the country. At 500 millibars there was a strong low centered over Kansas with moderate to strong northwesterly flow over the area of interest. There was a ridge along the west coast of the United States and throughout the western half of Canada. The airmass was well-modified continental polar.

FLIGHT C-158 4 NOVEMBER 1970

The area was still on the back side of the high with southeasterly flow. The 1040-millibar center of the high was located in northeastern Wyoming and high pressure covered the Great Plains. A cold front was moving over southwestern Oregon and extended along a line from Klamath Falls to Yosemite to Santa Ana. At 500 millibars there was a moderate to strong northwesterly flow with a weak ridge over Arizona. The airmass was well-modified continental polar.

6.3 TABULAR SUMMARY AND GLOSSARY

A summary of the daily meteorological observations taken at the Stallion Station on the days during which data flights were made is presented in Table 6-1. A glossary of the most often used symbols is also included. All Stallion data were reported in local standard time (LST).

METEOROLOGICAL GLOSSARY AND ABBREVIATIONS

Sky and Ceiling. Sky cover symbols are in ascending order. Figures preceding symbols are heights in hundreds of feet above station. Sky cover symbols are:

○	Clear: less than 0.1 sky cover
⦶	Scattered: 0.1 to less than 0.6 sky cover
⦷	Broken: 0.6 to 0.9 sky cover
⊕	Overcast: more than 0.9 sky cover
-	Thin (when prefixed)
-X	Partial obscuration: 0.1 to less than 1.0 sky hidden by precipitation or obstruction to vision (bases at surface)
X	Obscuration: 1.0 sky hidden by precipitation or obstruction to vision (bases at surface)

Letter preceding height of layer identifies ceiling layer and indicates how ceiling height was obtained. Thus:

A	Aircraft
B	Balloon (pilot or ceiling)
D	Estimated height of cirriform clouds on basis of persistency
E	Estimated height of noncirriform clouds
M	Measured
R	Radiosonde balloon or radar
U	Height of cirriform ceiling layer unknown
/	Height of cirriform nonceiling layer unknown
"V"	Immediately following numerical value indicates a varying ceiling
W	Indefinite

Visibility (VV). Reported in statute miles.

Weather and Obstruction to Vision Symbols.

A	Hail	IF	Ice fog
AP	Small hail	K	Smoke
BD	Blowing dust	L	Drizzle
BN	Blowing sand	R	Rain
BS	Blowing snow	RW	Rain showers
D	Dust	S	Snow
E	Sleet	SG	Snow grains
EW	Sleet showers	SP	Snow pellets
F	Fog	SW	Snow showers
GF	Ground fog	T	Thunderstorms
H	Haze	ZL	Freezing drizzle
IC	Ice crystals	ZR	Freezing rain

Cloud Abbreviations.

Ac	Altocumulus	Cs	Cirrostratus
As	Altostratus	Cu	Cumulus
Cb	Cumulonimbus	Ns	Nimbostratus
Cc	Cirrocumulus	Sc	Stratocumulus
Ci	Cirrus	St	Stratus

Wind. Direction in ten's of degrees from true north, speed in knots. A 0000 indicates calm. A G indicates gusty. A Q indicates squall. Peak speed of gusts, when reported, follows G or Q. The contraction WSHFT in remarks followed by time group (GMT) indicates wind shift and its time of occurrence.

EXAMPLES:

0129 is 010 degrees, 29 knots.

3627G40 is 360 degrees, 27 knots, peak speed in gusts of 40 knots.

Relative Humidity (RH). Reported in percents. Computed from wet bulb and dry bulb readings.

Table 6-1

STANDARD METEOROLOGICAL DATA SHEET

Field Site: White Sands Missile Range — Data Source: Stallion RAOB Station

Flight No.	Date/Time (GMT-LST)	Sky and Ceiling (Hundreds of Feet)	Visibility (mi)	Temp. (°F)	Dewpoint (°F)	RH (%)	Wind Direction and Speed (Ten's of Degrees/Knots)	Remarks Cloud Type and Amount
None	**22 Oct 70**							
	1458–0758	E100 ⦷	35	45	33	63	3402	8/10 As
	1558–0858	E100 ⦷	40	49	38	65	0000	9/10 As
	1658–0958	E100 ⊕	40	49	37	63	0000	10/10 As
	1758–1058	E100 ⊕	40	56	39	53	2108G12	10/10 As
	1958–1158	E100 ⦷	40	60	35	39	1910G17	6/10 As
	2058–1258	55 ⦶ E65 ⦷	40	64	36	35	1910G17	1/10 Cu 3/10 As
None	**23 Oct 70**							
	1458–0758	○	40	46	32	58	3604	
	1558–0858	○	40	51	30	44	3104	
	1658–0958	○	40	55	30	38	3112G16	
	1758–1058	○	40	58	32	37	3312G18	
	1858–1158	○	40	60	32	34	3214	
	1958–1258	○	40	63	30	29	3212G22	
C-151	**24 Oct 70**							
	1455–0755	○	40	48	29	48	1903	ATOM data for 24 Oct 70 from Holloman AFB only
	1557–0857	○	40	56	33	42*	1608	
	1657–0957	○	40	65	31	28*	1709	
	1757–1057	○	40	70	35	28	1611	
	1855–1155	○	40	72	37	28	1906	

*Note correlation with Visibility Laboratory data: 46% at 1530 GMT; 30% at 1650 GMT

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET

Field Site: White Sands Missile Range – Data Source: Stallion RAOB Station

Flight No.	Date/Time (GMT-LST)	Sky and Ceiling (Hundreds of Feet)	Visi-bility (mi)	Temp. (°F)	Dew-point (°F)	RH (%)	Wind Direction and Speed (Ten's of Degrees/Knots)	Remarks Cloud Type and Amount
C-152	**26 Oct 70**							
	1558–0858	○	40	53	35	51	0802	
	1658–0958	○	40	57	36	45	1302	Wnd Lgt & Vrbl Cu
	1758–1058	○	40	58	34	40	1506	Few Cu
	1858–1158	○	40	60	31	33	1906G13	Few Cu Gusts 13 Kt
	1958–1258	○	40	64	31	29	2014G12	Cu Gusts 21 Kt
C-153	**27 Oct 70**							
	1658–0958	E55 ⦷ 60 ⦷	40	44	23	43	3510	6/10 Cu 1/10 Ac
	1758–1058	E55 ⦷	40	46	20	35	3218G20	6/10 Cu Gusts to 20 Kt
C-154	**28 Oct 70**							
	1458–0758	○	40	31	16	53	0000	
	1558–0858	○	40	39	21	49	0000	
	1658–0958	○	40	45	11	25	3410G17	
	1758–1058	○	40	46	21	35	3015G23	
	1858–1158	○	40	50	14	23	3410G18	
	1958–1258	○	40	52	15	24	3412G18	
	2058–1358	○	40	54	17	22	3410G19	
	2158–1458	○	40	55	17	22	3410G18	

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET

Field Site: White Sands Missile Range — Data Source: Stallion RAOB Station

Flight No.	Date/Time (GMT-LST)	Sky and Ceiling (Hundreds of Feet)	Visi-bility (mi)	Temp. (°F)	Dew-point (°F)	RH (%)	Wind Direction and Speed (Ten's of Degrees/Knots)	Remarks Cloud Type and Amount
C-155	**30 Oct 70**							
	1558–0858	○	40	47	11	23	3602	
	1658–0958	○	40	56	07	14	0000	
	1758–1058	○	40	60	13	15	0000	
	1858–1158	○	40	63	18	17	2702	
	1958–1258	○	40	65	18	16	0000	
	2058–1358	○	40	67	16	14	2902	
C-156	**2 Nov 70**							
	1958–1258	55 ⦶ 200 ⦶	40	54	28	37	0000	1/10 Cu 1/10 Ci
	2058–1358	55 ⦶ 200 ⦶	40	54	29	37	0000	1/10 Cu 2/10 Ci
C-157	**3 Nov 70**							
	1558–0858	○	40	42	24	49	0000	H South of field
	1658–0958	○	40	48	30	49	1302	H South of field
	1758–1058	○	40	50	27	40	1202	H South Sc South 0/10 Sc 60
	1858–1158	○	40	52	29	40	1202	H South Few Cu 0/10 Cu 60
	1958–1258	○	40	53	31	42	1803	Wnd Lgt & Vrbl Few Cu 0/10 Cu 60
	2058–1358	60 ⦶	40	55	30	38	1508	

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET

Field Site: White Sands Missile Range — Data Source: Stallion RAOB Station

Flight No.	Date/Time (GMT-LST)	Sky and Ceiling (Hundreds of Feet)	Visi-bility (mi)	Temp. (°F)	Dew-point (°F)	RH (%)	Wind Direction and Speed (Ten's of Degrees/Knots)	Remarks Cloud Type and Amount
C-158	**4 Nov 70**							
	1558–0858	150 ⦶ E200 ⦷	40	41	23	49	0502	1/10 As 5/10 Ci
	1658–0958	E150 ⦷	40	45	22	40	0000	6/10 As
	1758–1058	150 ⦶	40	48	23	37	0000	1/10 Ac
	1858–1158	○	40	49	26	40	0000	
	1958–1258	○	40	51	26	37	0000	H South Ac North 0/10 Ac 150
	2058–1358	150 ⦶	40	53	24	32	1808	Ac North 1/10 Ac

6.4 ANALYSIS OF RADIOMETRIC AND METEOROLOGICAL RELATIONSHIPS

A continuing goal of the Visibility Laboratory's measurement program is the accumulation of a body of data appropriate for direct application to the interpretation of the relationships between the optical properties of the atmosphere and the meteorological specification of that atmosphere.

One set of field data regularly examined for suitability of inclusion into this selected body is the ground-based measurement set made with the contrast reduction meter. These data are presented tabularly in Section 7.5 of this report.

During the ATOM deployment, the airmass characteristics were not well-defined but, rather, were diffuse and well-modified. These effects were due to either the persistence of the same airmass in the area, or to prolonged travel from the source region. Thus, there are no clear-cut comparisons by airmass discrimination that can realistically be made, as in Edgerton (1967). Consequently, the ATOM data will become a subset for comparison with other data subsets from subsequent deployments.

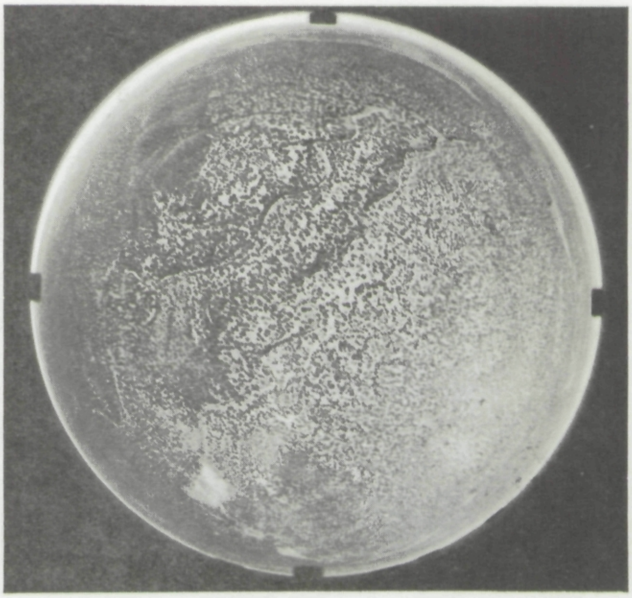
7. DATA PRESENTATION

7.1 AIRBORNE DATA AND FLIGHT SUMMARY

Between 22 October and 4 November, 13 flights were made in central New Mexico. The flights were conducted along a north northeast to south southwest track on the northern end of the White Sands Missile Range (see Figure 1-1). Typical sky conditions encountered during these flights are illustrated in Figures 7-1 through 7-4. The left sides of these figures contain pictures of the upper hemisphere taken with the 180 degree camera lens mounted on top of the C-130A. Most of these were taken at the same time as the sky radiance data taking, during the straight and level portion of the flight. The pictures illustrate the basic flight descriptions: the clear sky of Flight C-155, the scattered clouds of Flight C-157 at the lower altitude, and the tenuous clouds of Flight C-158 at the lower altitudes. The white area near the sun in the sky picture in the lower half of Figure 7-4 is due to ice crystals forming on the camera lens cover; the sky was clear at 4300 meters AGL for Flight C-158.

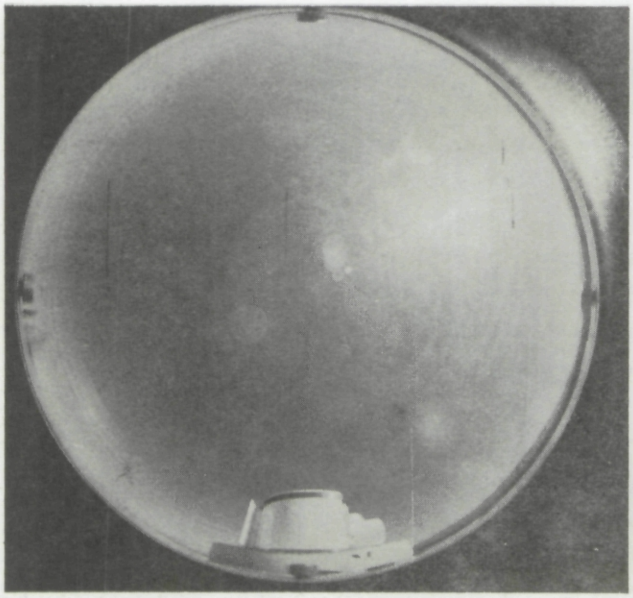
The typical terrain beneath the flight track was desert sand and low scattered brush as illustrated in the right-hand pictures of Figures 7-1 through 7-4. These are pictures of the lower hemisphere taken with the 180 degree camera lens mounted beneath the C-130A. The picture for Flight C-152 (upper portion of Figure 7-1) is indicative of the southern end of the flight track which was more verdant. At the northern end of the track the vegetation was sparse and there were rocky outcroppings as illustrated by the terrain pictures for Flight C-158 (Figures 7-3 and 7-4). The shadows of the scattered clouds during Flight C-157 are clearly evident in the terrain pictures (lower portion of Figure 7-2 and upper portion of Figure 7-3).

Six of the flights were selected as having data appropriate for obtaining path radiance and path reflectance. Data are presented tabularly and graphically in sets by flight number. A detailed description and report of weather characteristics are given as the introductory page of each data set.

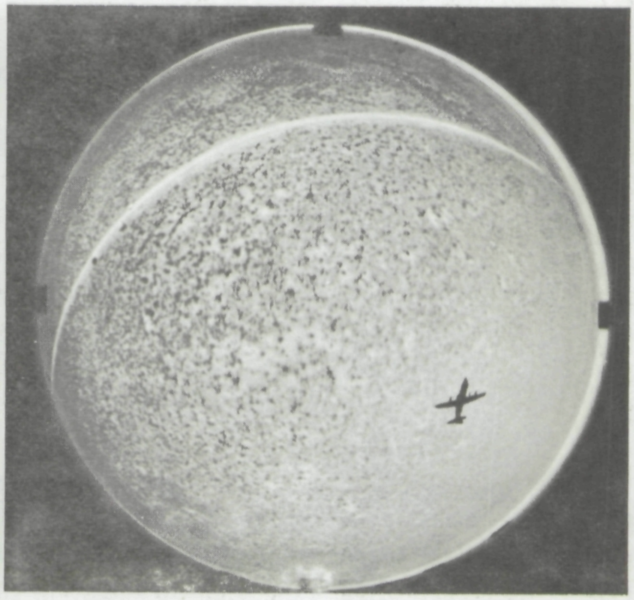


Lower Hemisphere
748 meters AGL at 1628 GMT

FLIGHT C-152



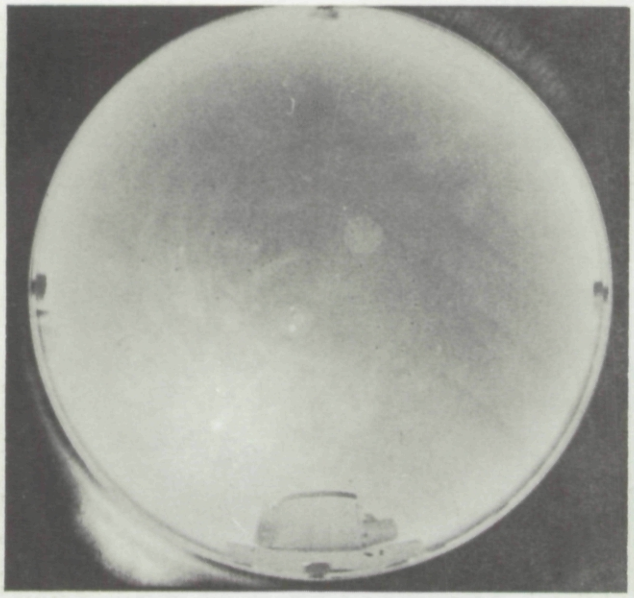
Upper Hemisphere
690 meters AGL at 1737 GMT



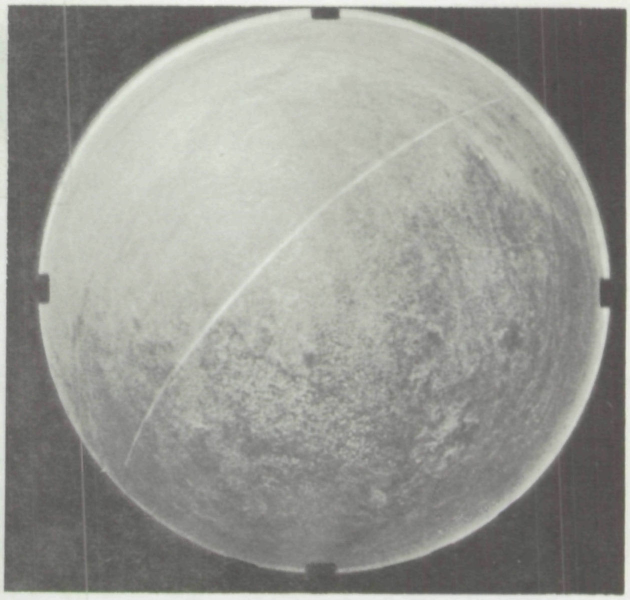
Lower Hemisphere
690 meters AGL at 1737 GMT

FLIGHT C-154

Fig. 7-1. Typical Sky and Terrain Photographs for Flights C-152 and C-154.

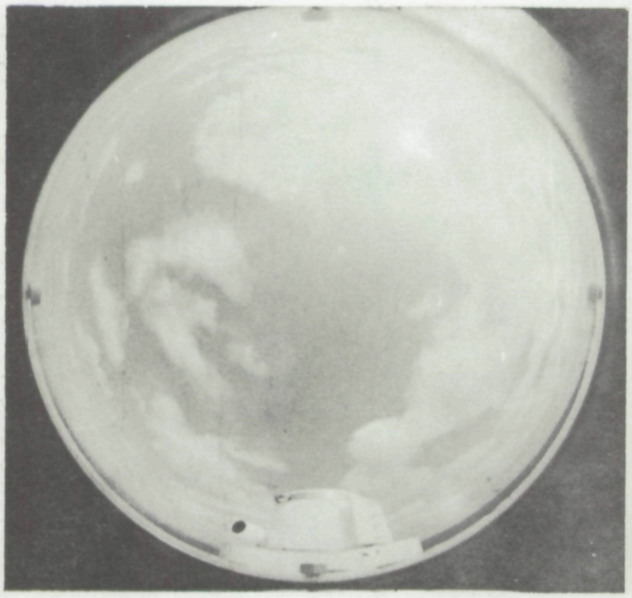


Upper Hemisphere
686 meters AGL at 2014 GMT

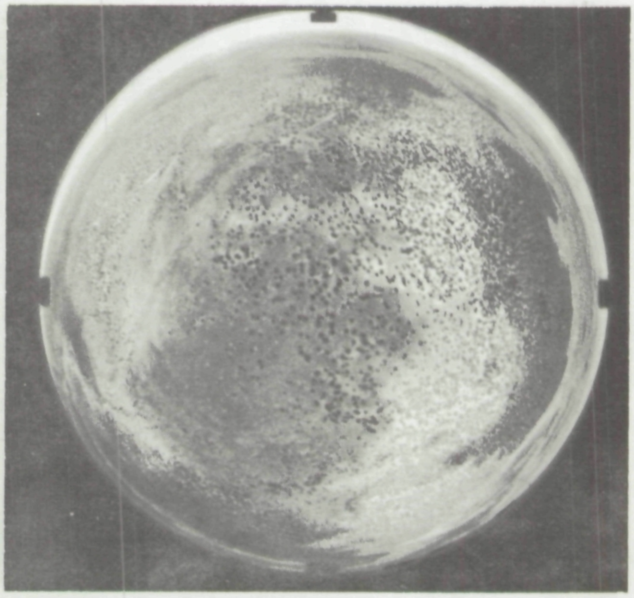


Lower Hemisphere
686 meters AGL at 2014 GMT

FLIGHT C-155



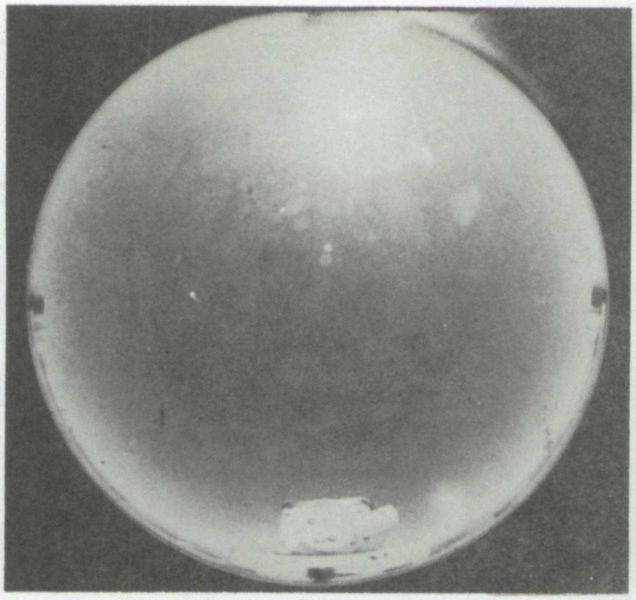
Upper Hemisphere
649 meters AGL at 1825 GMT

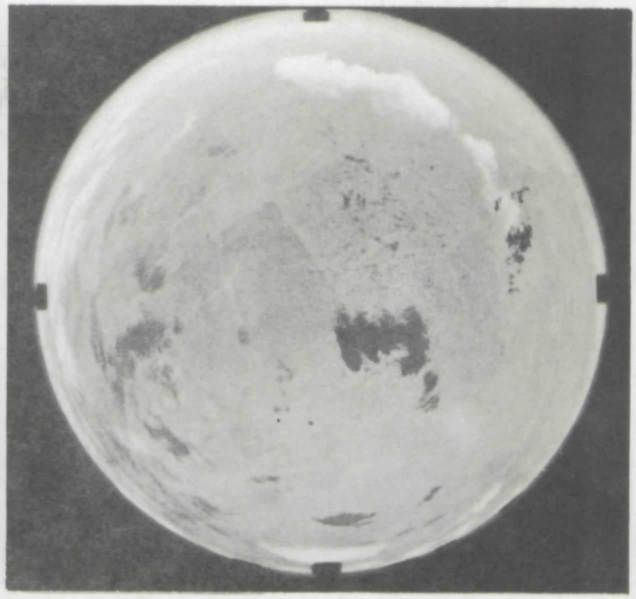


Lower Hemisphere
649 meters AGL at 1825 GMT

FLIGHT C-157

Fig. 7-2. Typical Sky and Terrain Photographs for Flights C-155 and C-157.

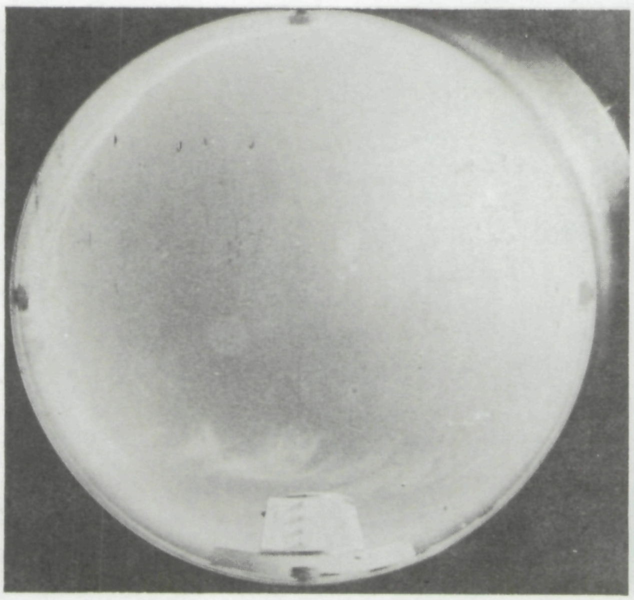


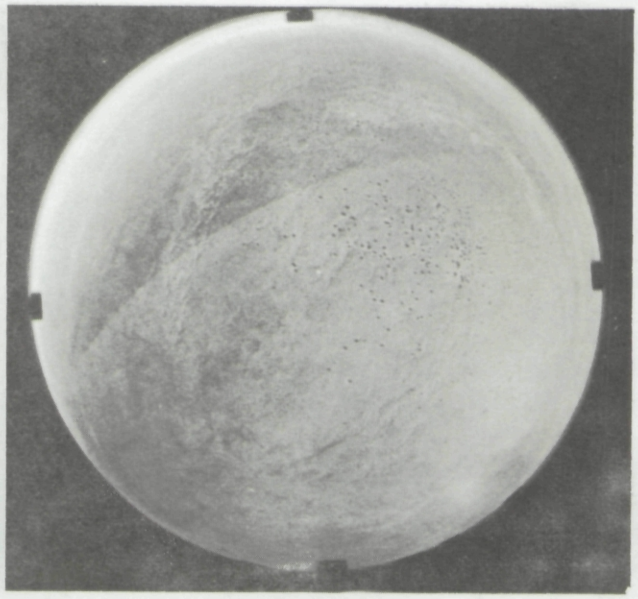


Upper Hemisphere
2183 meters AGL at 1945 GMT

Lower Hemisphere
2183 meters AGL at 1945 GMT

FLIGHT C-157



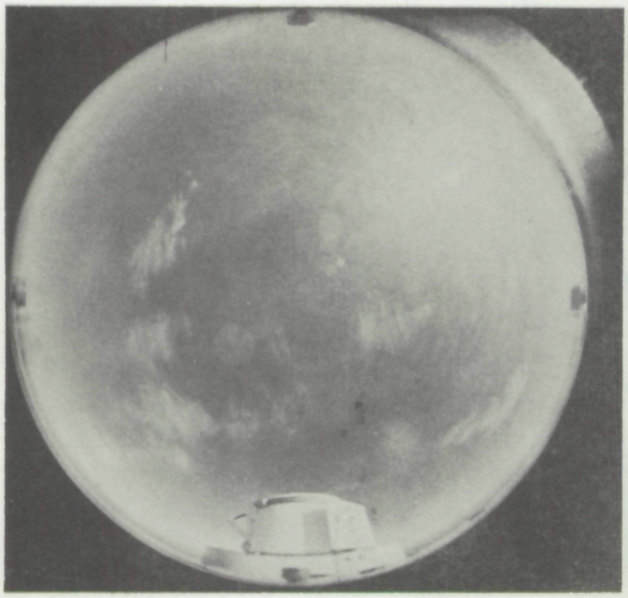


Upper Hemisphere
603 meters AGL at 1620 GMT

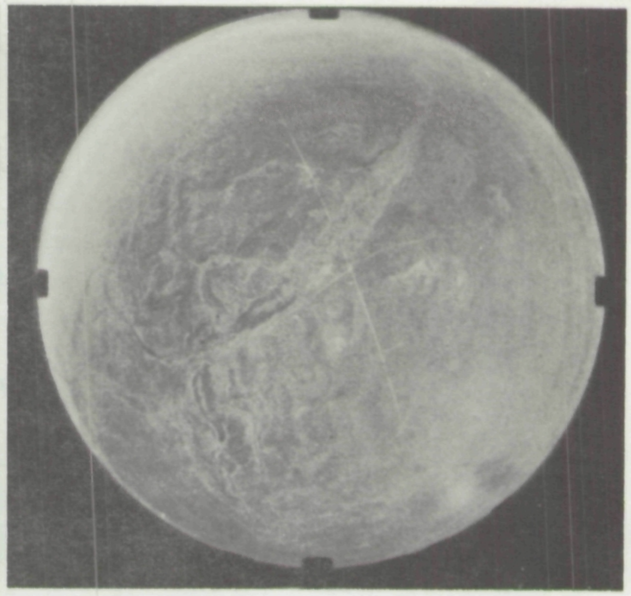
Lower Hemisphere
603 meters AGL at 1620 GMT

FLIGHT C-158

Fig. 7-3. Typical Sky and Terrain Photographs for Flights C-157 and C-158.

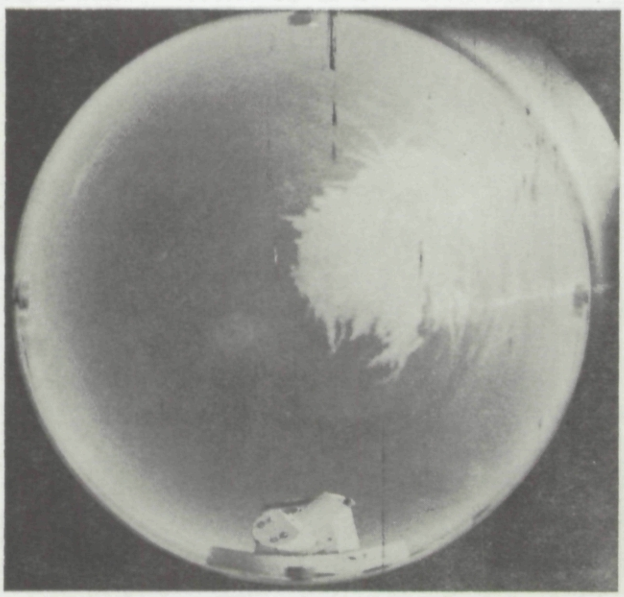


Upper Hemisphere
2136 meters AGL at 1652 GMT

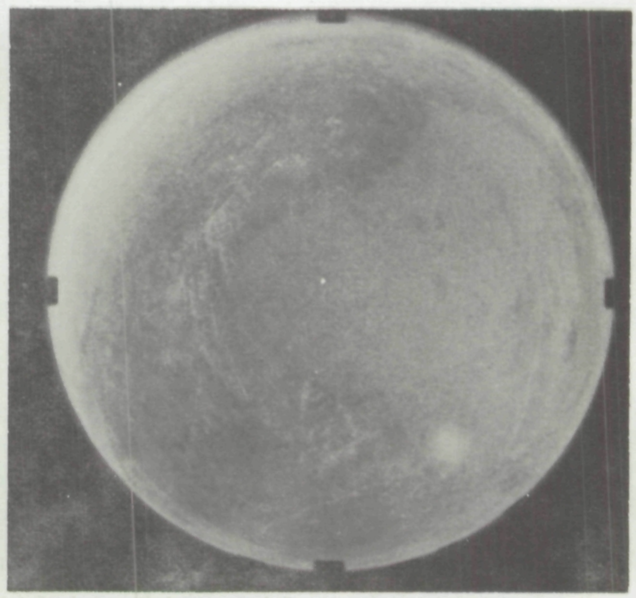


Lower Hemisphere
2136 meters AGL at 1652 GMT

FLIGHT C-158



Upper Hemisphere
4308 meters AGL at 1735 GMT



Lower Hemisphere
4308 meters AGL at 1735 GMT

FLIGHT C-158

Fig. 7-4. Typical Sky and Terrain Photographs for Flight C-158.

Table 7-1 contains a summary of pertinent data for the six flights being reported. The flight numbers are sequential. The times under the Total Time of Data-Taking column are Greenwich mean time (GMT) and in parentheses, local civil time (LCT). For all activities preceding 25 October, i.e., Flights C-150 and C-151, LCT is local daylight savings time which is equal to GMT-6. For all activities subsequent to 25 October, i.e., Flights C-152 through C-158, LCT is local standard time which is equal to GMT-7. In the description of the Sky Near Sun column, clear indicates that the apparent sun radiance was calculated according to Section 2.10 and cloud indicates that the highest measured sky radiance was accepted as the apparent sun radiance. The sun zenith angles are tabulated for the time when sky radiance data-taking began and at the conclusion of the sky radiance data-taking. The sun zenith angle is noted separately for Filter 4 since these data were measured in a separate flight sequence either before or after all the data for Filters 2, 3, and 5 were obtained. The maximum flight altitude is noted in column 12.

Table 7-1

ATOM Flight Data Summary

Flight No.	Date 1970	Total Time of Data-Taking Start GMT	LCT	End GMT	LCT	Sky Near Sun	Filters	Sun Zenith Angle Start	Transit	End	Maximum Flight Altitude (Meters AGL)
C-151	24 Oct	1513	0913	1725	1125	Clear	2,3,5	68.8	–	55.3	4425
C-152	26 Oct	1625	0925	1946	1246	Clear	2,3,5	57.9	–	49.5	4495
							4	46.3	–	47.9	
C-154	28 Oct	1552	0852	1945	1245	Clear	2,3,5	63.2	–	52.6	4375
							4	47.1	46.9	48.3	
C-155	30 Oct	1609	0909	1916	1216	Clear	4	61.0	–	53.7	4371
							2,3,5	50.7	47.6	47.6	
C-157	3 Nov	1653	0953	2010	1310	Clear	2,3,5	54.7	–	49.2	4374
							4	49.5	–	52.4	
C-158	4 Nov	1617	0917	1931	1231	Clear	2,3,5	61.2	–	52.0	4308
							4	49.3	49.2	50.0	

The beam transmittance is extrapolated from space to the highest altitude of flight as described in Section 2.10 only when there is a clear sky above. The results of this extrapolation are not included in the standard sets of data tables by flight. These extrapolations and the resultant space-to-ground beam transmittance, when combined with the beam transmittance based on the total scattering coefficient profile, are presented for the six clear-day flights in Table 7-2.

Table 7-2

Space-to-Sensor Vertical Beam Transmittance

Date 1970	Flight No.	Sensor Altitude (Meters AGL)	Vertical Beam Transmittance			
			Filter 2	Filter 5	Filter 3	Filter 4
24 Oct	C-151	4500	0.551	0.652	0.691	–
		0	0.364	0.483	0.537	–
26 Oct	C-152	4500	0.555	0.624	0.708	0.728
		0	0.367	0.452	0.553	0.588
28 Oct	C-154	4500	0.578	0.668	0.713	0.778
		0	0.400	0.510	0.573	0.663
30 Oct	C-155	4500	0.566	0.644	0.702	0.743
		0	0.393	0.487	0.565	0.617
3 Nov	C-157	4500	0.668	0.759	0.811	0.883
		0	0.471	0.595	0.670	0.780
4 Nov	C-158	4500	0.673	0.766	0.800	0.891
		0	0.477	0.605	0.668	0.806

7.2 DESCRIPTION OF AIRBORNE DATA TABLES AND GRAPHS

DATA TABLES

Data are presented in tables of:

Irradiance
Directional Reflectance of Background
Total Scattering Coefficient
Beam Transmittance from Ground to Altitude
Path Radiance from Ground to Altitude
Directional Path Reflectance from Ground to Altitude.

Each optical property is tabulated in the tables as a function of altitude above ground level except for the directional reflectance of background which is tabulated as a function of zenith angle. The data are further divided by optical filters which are given in order of increasing wavelength. The tables of directional reflectance of background, path radiance from ground to altitude, and direction path reflectance from ground to altitude are presented in four sets of four azimuths with respect to the sun of 0, 90, 180, and 270 degrees.

Irradiances. The downwelling irradiances $H(z,d)$ and upwelling irradiances $H(z,u)$, albedos $H(z,u)/H(z,d)$, scalar irradiances $h(z,d)$, $h(z,u)$, and $h(z)$, and scalar albedos $h(z,u)/h(z,d)$ are presented in columnar form as a function of altitude. The irradiances are computed from measurements of sky and terrain radiance made by the airborne hemispherical scanner system at each of the flight profile level altitudes.

The altitudes are given in meters above ground level for the altitudes of flight. There are four tables of irradiance for each flight, one table for each optical filter. The dimensions and units for the irradiances are "$w\ m^{-2}\mu m^{-1}$." Albedos are, of course, dimensionless.

The irradiances for Filter Code Number 5 can be converted to illuminance values in units of lumens per square meter by multiplying each irradiance by the factor 72.0 $lu\mu m/w$.

Directional Reflectance of Background. The directional background reflectance ${}_bR_o(z,\theta,\phi)$ is tabulated by zenith angle in four columns for the four optical filters. A table is presented for each of the four azimuthal points. Reflectance is dimensionless. These reflectances are based on the apparent terrain radiance and the downwelling irradiance measured at the minimum aircraft altitude.

It should be stressed again that the reflectances presented in this section are typical of the average terrain beneath the flight path. The lower hemisphere scanner has a 5 degree circular field of view and during the data interval, the aircraft is traveling at approximately 150 knots. Both of these characteristics contribute to the optical smearing of the measurement area and the attendant radiometric averaging.

The background reflectance required as input to a contrast transmittance computation must represent the actual background at the immediate boundary of the target object. This will not necessarily be the same as the average reflectance of the surrounding general area.

Inherent and Apparent Background Radiances. The background radiance is not included in these tables. The inherent radiance of the background immediately surrounding the target may be computed from the directional reflectance of the background ${}_bR_o(0,\theta,\phi)$ and the downwelling irradiance $H(z_t,d)$:

$$ {}_bN_o(z_t,\theta,\phi) = \frac{1}{\pi}\, {}_bR_o(z_t,\theta,\phi)\, H(z_t,d)\ . \qquad (7.1)$$

The downwelling irradiance at the lowest flight altitude for each filter may be used as the ground level irradiance with reasonable accuracy (Duntley *et al.* (1970), p. 7-25). The apparent background radiance ${}_bN_r(z,\theta,\phi)$ at the sensor altitude z can be computed as follows:

$$ {}_bN_r(z,\theta,\phi) = {}_bN_o(z_t,\theta,\phi)\, T_r(z,\theta) + N_r^*(z,\theta,\phi)\ . \qquad (7.2)$$

The beam transmittances $T_r(z,\theta)$ and the path radiances $N_r^*(z,\theta,\phi)$ from ground altitude are given in the tables to be described later.

The background radiances for Filter Code Number 5 may be converted to luminance values with units of $lu/\Omega m^2$ by multiplying the radiance by the factor 72.0 $lu\mu m/w$.

Total Scattering Coefficient. The total volume scattering coefficient $s(z)$ is tabulated by altitude in four columns for the four optical filters. The altitude is given in meters, above ground level, at 30 meter (98.4 foot) increments. The dimension and unit for the total scattering coefficient is "m^{-1}".

At the bottom of the total scattering coefficient table are given the first and last data altitudes. This is the lowest and highest altitude of data measurements. When ground-based measurements of total scattering coefficient are available, the first data altitude is ground level.

The total scattering coefficient is used for the calculation of atmospheric beam transmittance in the next set of tables using the equations of the Theory, Section 2.

Beam Transmittance from Ground to Altitude. The atmospheric beam transmittance is tabulated for the slant paths of sight, between ground and the altitude shown, for the seven zenith angles from 93 to 180 degrees. There are four tables, one for each optical filter. This property is dimensionless.

The beam transmittance is computed from measurements of total scattering coefficient. The assumption is made that there is no significant atmospheric absorption in the pass bands of the measurements, whence the atmospheric attenuation coefficient $\alpha(z)$ is assumed equivalent to the scattering coefficient $s(z)$.

Path Radiance from Ground to Altitude. Path radiance $N_r^*(z,\theta,\phi)$ is tabulated for the slant paths of sight, between ground and the altitude shown, for the seven zenith angles from 93 to 180 degrees. The path radiance is computed from measurements of total scattering coefficient, measurements of sky and terrain radiances, and a catalog of proportional directional scattering coefficients based upon the work of Barteneva (1960).

There are four sets of data tables, one set for each of the four cardinal azimuths from the sun, 0, 90, 180, and 270 degrees. Each set is listed on a single sheet and contains four tables, one for each spectral filter. The dimensions and units are "$w\Omega^{-1}m^{-2}\mu m^{-1}$".

The path radiance values for Filter 5 may be converted to path luminance values with units of $lu/\Omega m^2$ by multiplying the radiance by the factor 72.0 $lu\mu m/w$.

Directional Path Reflectance from Ground to Altitude. Directional path reflectance $\dot{R}_r^*(z,\theta,\phi)$ is also tabulated for the downward-looking slant paths of sight, between ground and the altitude shown, for the seven zenith angles from 93 to 180 degrees. The directional path reflectance is computed from the previously derived values of path radiance, beam transmittance, and total downwelling irradiance.

There are four sets of data tables, one set for each of the four cardinal azimuths from the sun, 0, 90, 180, and 270 degrees. Each set is listed on a single sheet and contains four tables, one for each spectral filter. This property is dimensionless.

Contrast Transmittance. Contrast transmittance ${}_b\tau_t(z,\theta,\phi)$ is not tabulated. This optical property is a function of the directional path reflectance and the directional background reflectance against which an object is viewed. The directional background reflectance reported herein is measured by the airborne radiometer. Thus, it is the average reflectance of many individual areas integrated into one value by the 5 degree circular field of the radiometer. The background reflectance against which the object is viewed will probably never be the same as the reflectance of the average terrain. If the area of the background is sufficiently small, its reflectance will have no appreciable effect on the path reflectance. In such cases, **decoupling** exists between the object background area and the atmospheric path reflectance and the contrast transmittance may be calculated by Eq. 3 of Duntley (1969) repeated below:

$$ {}_b\tau_r(z,\theta,\phi) = \left\{ 1 + [R_r^*(z,\theta,\phi) / {}_bR_o(z_t,\theta,\phi)] \right\}^{-1} . \tag{7.3} $$

DATA GRAPHS

Data are also presented in graphs of:

Downwelling Irradiance
Total Scattering Coefficient
Equivalent Attenuation Length from Ground to Altitude
Vertical Beam Transmittance from Ground to Altitude
Path Radiance from Ground to Altitude
Directional Path Reflectance from Ground to Altitude.

Downwelling Irradiance. The downwelling irradiance H(z,d) is graphed as a function of altitude AGL. These irradiances are from column 2 of the irradiance table. They are computed from the sky and terrain measurements at each of the flight profile level altitudes.

Total Scattering Coefficient. The total volume scattering coefficient s(z) in m^{-1} is graphed using a single average value for each 30 meter change in altitude. Identifying symbols for the spectral filters appear at every fifth data point, or at 150 meter intervals. These same data were tabulated in the total scattering coefficient table.

Equivalent Attenuation Length from Ground to Altitude. The attenuation length L(z) is the reciprocal of the attenuation coefficient $\alpha(z)$. The equivalent attenuation length $\bar{L}(z)$ is a pseudo attenuation length which when combined with its altitude z, can be used directly in the equation (Boileau (1964) Eq. 6.1):

$$ T_r(z,\theta) = \exp \left\{ [-z/\bar{L}(z)] \sec\theta \right\} . \tag{7.4} $$

The equivalent attenuation length permits easy calculation of the atmospheric beam transmittance between ground level and altitude z above ground level for a downward path of sight, or between altitude and ground level for the upward path of sight.

The equivalent attenuation length $\bar{L}(z)$ in kilometers, for the path between ground and altitude, is graphed for each 30 meter change in altitude. Spectral identifying symbols appear at 150 meter intervals or every fifth data point.

Vertical Beam Transmittance from Ground to Altitude. The vertical beam transmittance $T_r(0,0)$ or $T_r(z,180)$ between ground and altitude is graphed for each 30 meter interval. Spectral identifying symbols appear at 150 meter intervals or every fifth data point. This represents smaller altitude increments than in the tabular display of beam transmittance.

Path Radiance from Ground to Altitude. The path radiance $N_r^*(z,\theta,\phi)$ is graphed for downward-looking slant paths between ground and the altitude shown. Each graph is for one path of sight for all four optical filters. The first graph is for the vertical downward path of sight, the second and third are for zenith angles 120 and 100 degrees toward the azimuth of the sun. These are data selected from the path radiance tables.

Directional Path Reflectance from Ground to Altitude. The directional path reflectance $R_r^*(z,\theta,\phi)$ is also graphed for downward-looking slant paths between ground and the altitude shown. Each graph is for one path of sight and four optical filters. The first graph is for the vertical downward path of sight, the second and third are for zenith angles 120 and 100 degrees toward the azimuth of the sun. These selected paths of sight are the same as for the path radiance graphs. The data were selected from the many paths of sight tabulated in the directional path reflectance tables.

7.3 PRESENTATION OF AIRBORNE DATA

Tabular listings and graphical displays of the data discussed in Section 7.2 are presented in the pages immediately following. Users should be aware that regardless of the display format, the data values are valid to, at best, only three significant figures. The tables of beam transmittance and directional reflectance of the background, in particular, should be rounded off to two digits prior to further application.

It should also be remembered that all values in the data tables except scattering coefficient are computed values based upon the measured values of upper and lower hemisphere radiances. All other direct radiometric measurements made by the airborne data systems are used only for corroboration and cross-checking.

All altitudes presented in the data tables, in the flight description, and in the graphs are given as above ground level (AGL).

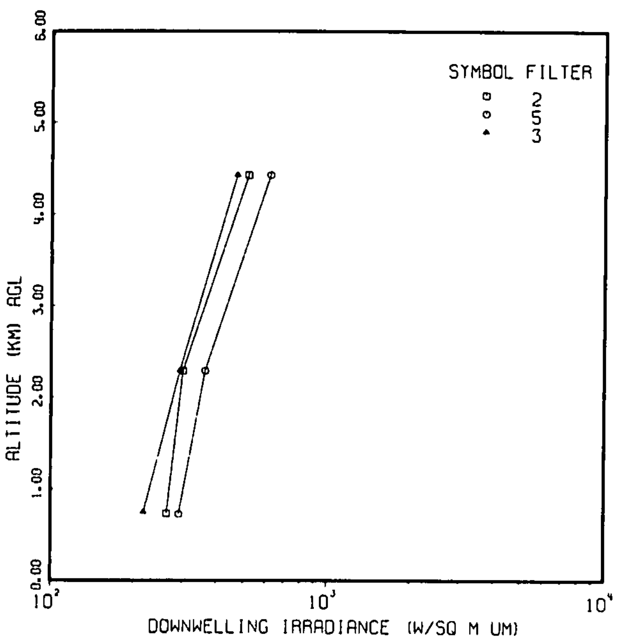
FLIGHT C-151 – 24 OCTOBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

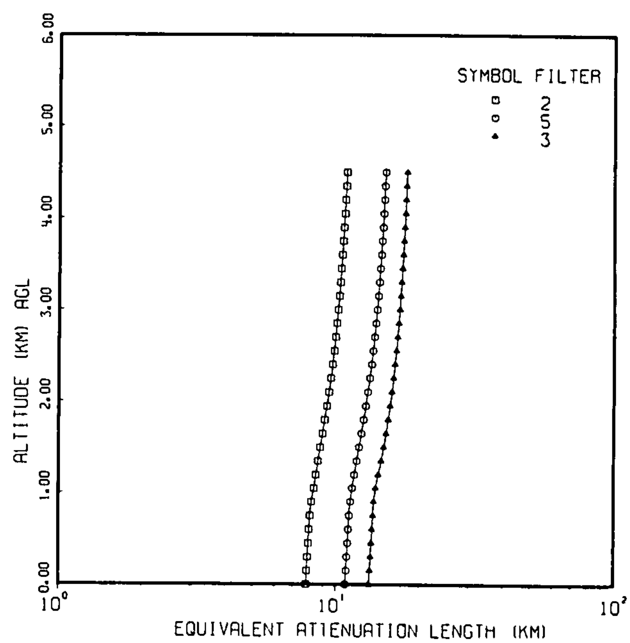
It was a sunlit morning flight. The sky was clear overhead with some scattered thin clouds. The flight was conducted over a broad desert on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0913 local time (1513 GMT) and continued until 1125 local time (1725 GMT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 5 was 68.8 degrees at the start and 55.3 degrees at the end. The highest flight altitude was 4425 meters AGL.

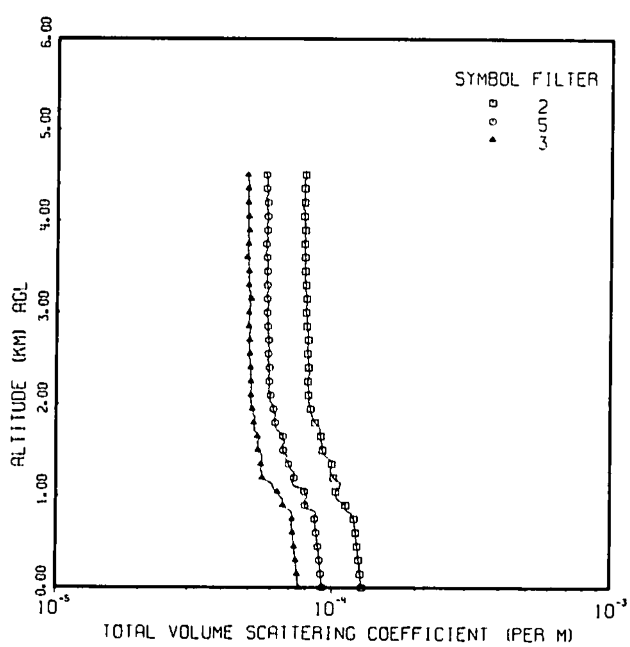
> At the beginning of data-taking, Holloman was reporting clear skies with 40 mile (64 kilometer) visibility. The ground station description was clear and sunny.
>
> During the flight, the aircrew reported some scattered thin clouds and moderate haze on the horizon. At the maximum flight altitude moderate haze was still visible on the horizon and it was clear overhead.
>
> At the end of data-taking, Holloman was reporting clear skies and visibility of 40 miles (64 kilometers).
>
> Data were not taken at Stallion on weekends and therefore are unavailable. Holloman data for this date are included on the meteorological data sheets.

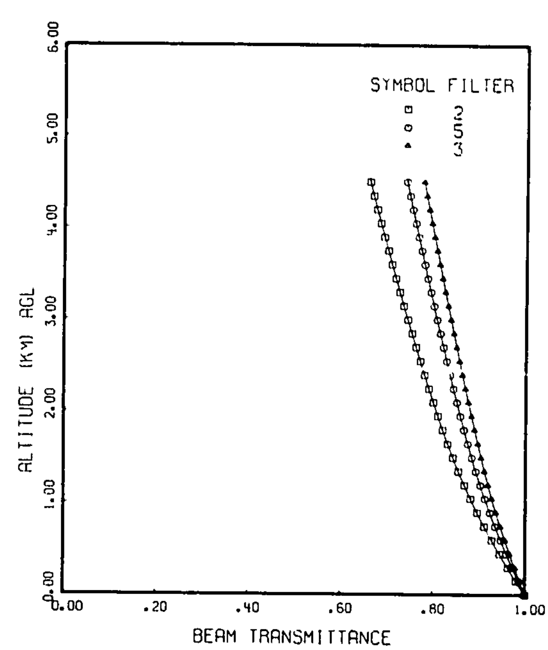
A weak 1012-millibar high over the area weakened still more during the day. A cold front extended from central Montana through western Utah to just south of the Channel Islands. This front had little weather associated with it in the southern portion. By 1800 GMT a trough of low pressure extended from eastern Montana and the western Dakotas southward to New Mexico. There was a very weak ridge with westerly flow at 500-millibars. The airmass was ill-defined.

FLIGHT NO. C-151

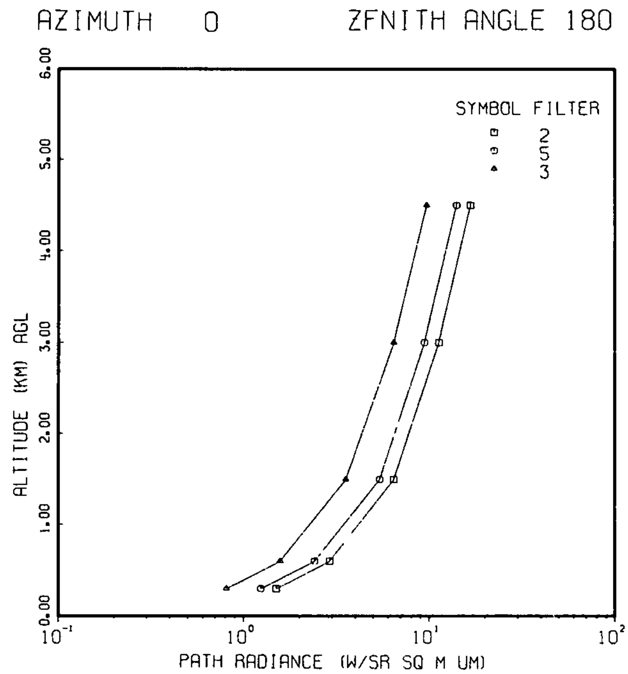


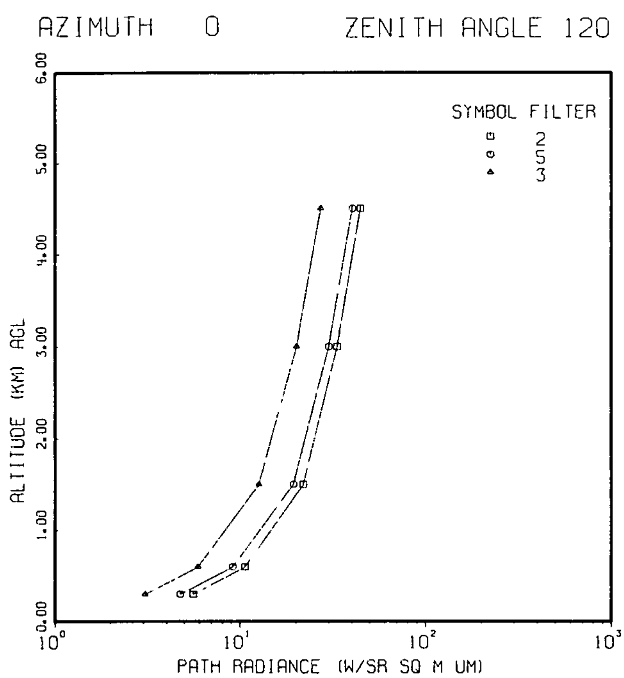


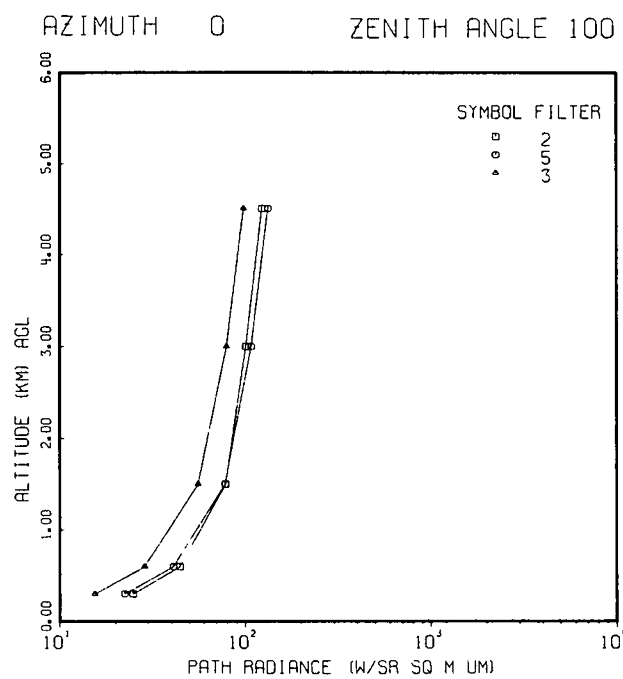




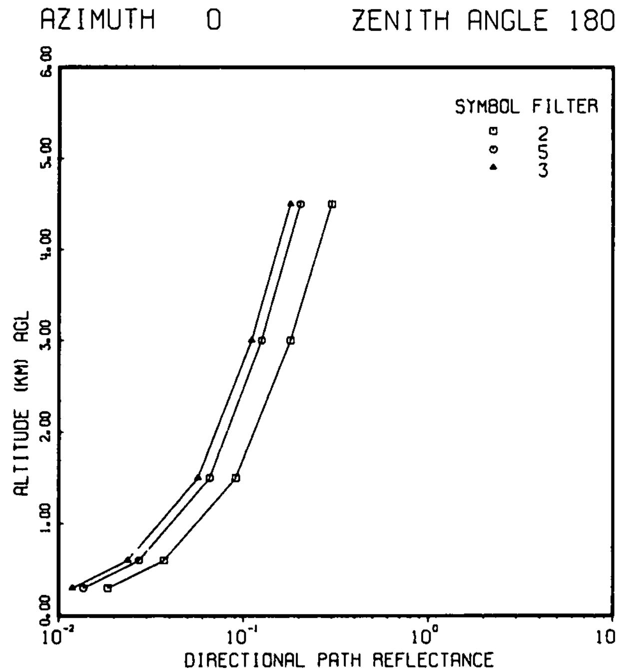
FLIGHT NO. C-151

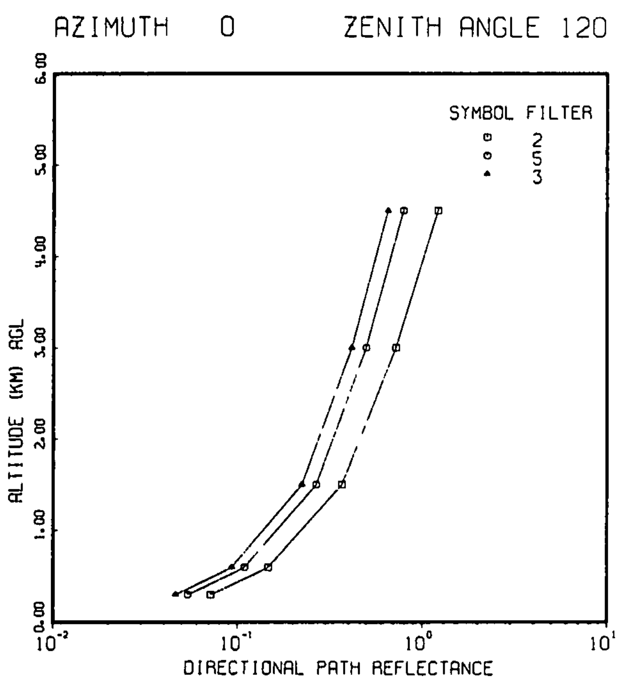


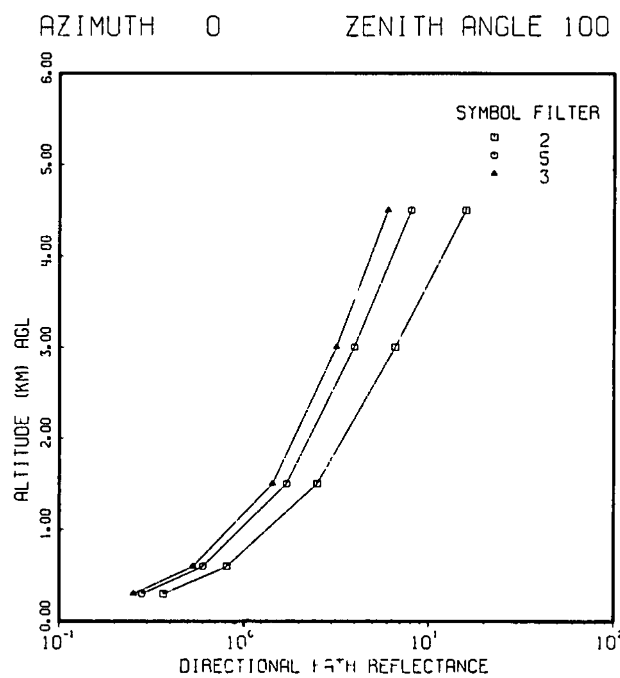




FLIGHT NO. C-151







FLIGHT NO. C-151
IRRADIANCE

FLIGHT NO.C-151 FILTER NO. 2
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
733	2.644E 02	4.833E 01	.183	8.003E 02	1.264E 02	9.267E 02	.158
2288	3.015E 02	7.903E 01	.262	7.459E 02	2.102E 02	9.562E 02	.282
4423	5.169E 02	1.058E 02	.205	1.097E 03	2.816E 02	1.378E 03	.257

FLIGHT NO.C-151 FILTER NO. 5
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
726	2.930E 02	7.038E 01	.240	8.740E 02	1.735E 02	1.047E 03	.199
2288	3.621E 02	8.677E 01	.240	9.035E 02	2.172E 02	1.121E 03	.240
4422	6.197E 02	1.106E 02	.179	1.278E 03	2.718E 02	1.550E 03	.213

FLIGHT NO.C-151 FILTER NO. 3
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
749	2.182E 02	6.702E 01	.307	6.349E 02	1.555E 02	7.904E 02	.245
2290	2.939E 02	9.178E 01	.312	6.823E 02	2.017E 02	8.841E 02	.296
4425	4.708E 02	1.118E 02	.238	9.359E 02	2.390E 02	1.175E 03	.255

FLIGHT NO. C-151
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-151
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3
93	.80414	.68237	.76288
95	.69734	.71751	.46230
100	.28625	.35869	.35330
105	.20738	.27636	.22469
120	.13738	.25728	.25053
150	.13313	.14848	.21324
180	.13445	.12542	.25835

FLIGHT NO. C-151
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3
93	.65330	.51563	.58734
95	.46715	.43130	.40232
100	.23935	.31022	.29083
105	.19119	.24229	.25833
120	.15547	.20682	.26970
150	.14340	.14392	.25051
180	.13445	.12542	.25835

FLIGHT NO. C-151
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3
93	.63312	.58123	.74409
95	.49377	.50818	.69324
100	.41915	.51489	.62943
105	.40046	.48769	.56097
120	.28017	.39033	.42274
150	.18732	.24379	.36315
180	.13445	.12542	.25835

FLIGHT NO. C-151
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3
93	.33139	.40960	.53875
95	.31229	.31045	.56819
100	.22864	.29145	.48485
105	.22158	.26943	.40965
120	.16620	.24018	.37595
150	.15213	.21122	.30171
180	.13445	.12542	.25835

FLIGHT NO. C-151
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102470   FLIGHT NO. C-151   GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3
0	1.282E-04	9.250E-05	7.593E-05
30	1.275E-04	9.203E-05	7.555E-05
60	1.272E-04	9.180E-05	7.536E-05
90	1.269E-04	9.157E-05	7.517E-05
120	1.266E-04	9.134E-05	7.499E-05
150	1.263E-04	9.111E-05	7.480E-05
180	1.260E-04	9.088E-05	7.460E-05
210	1.256E-04	9.064E-05	7.441E-05
240	1.253E-04	9.041E-05	7.422E-05
270	1.250E-04	9.017E-05	7.402E-05
300	1.246E-04	8.993E-05	7.383E-05
330	1.243E-04	8.969E-05	7.363E-05
360	1.240E-04	8.945E-05	7.344E-05
390	1.236E-04	8.921E-05	7.324E-05
420	1.233E-04	8.897E-05	7.304E-05
450	1.230E-04	8.873E-05	7.284E-05
480	1.226E-04	8.848E-05	7.264E-05
510	1.223E-04	8.824E-05	7.244E-05
540	1.220E-04	8.799E-05	7.224E-05
570	1.216E-04	8.775E-05	7.203E-05
600	1.213E-04	8.750E-05	7.183E-05
630	1.209E-04	8.725E-05	7.163E-05
660	1.206E-04	8.700E-05	7.142E-05
690	1.202E-04	8.676E-05	7.122E-05
720	1.199E-04	8.651E-05	7.102E-05
750	1.196E-04	8.626E-05	7.157E-05
780	1.176E-04	8.601E-05	7.171E-05
810	1.173E-04	8.768E-05	7.136E-05
840	1.124E-04	8.600E-05	7.070E-05
870	1.114E-04	8.006E-05	6.806E-05
900	1.115E-04	7.950E-05	6.618E-05
930	1.085E-04	8.134E-05	6.607E-05
960	1.047E-04	7.923E-05	6.633E-05
990	1.031E-04	8.115E-05	6.517E-05
1020	1.028E-04	8.042E-05	6.379E-05
1050	1.027E-04	7.924E-05	6.319E-05
1080	1.054E-04	7.952E-05	6.128E-05
1110	1.063E-04	7.292E-05	6.084E-05
1140	1.070E-04	7.176E-05	6.049E-05
1170	1.045E-04	7.169E-05	5.766E-05
1200	1.008E-04	7.264E-05	5.574E-05
1230	9.998E-05	7.220E-05	5.576E-05
1260	9.843E-05	7.296E-05	5.562E-05
1290	9.849E-05	7.064E-05	5.500E-05
1320	9.866E-05	7.046E-05	5.515E-05
1350	9.943E-05	6.932E-05	5.511E-05
1380	9.945E-05	6.902E-05	5.576E-05
1410	9.686E-05	6.750E-05	5.575E-05
1440	9.398E-05	6.870E-05	5.567E-05
1470	9.237E-05	6.652E-05	5.506E-05
1500	9.187E-05	6.627E-05	5.376E-05

FLIGHT NO. C-151
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102470   FLIGHT NO. C-151   GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3
1530	9.069E-05	6.557E-05	5.351E-05
1560	9.182E-05	6.601E-05	5.380E-05
1590	9.083E-05	6.706E-05	5.337E-05
1620	9.024E-05	6.605E-05	5.418E-05
1650	9.069E-05	6.624E-05	5.354E-05
1680	8.984E-05	6.535E-05	5.379E-05
1710	9.012E-05	6.352E-05	5.208E-05
1740	8.984E-05	6.238E-05	5.216E-05
1770	8.864E-05	6.215E-05	5.199E-05
1800	8.624E-05	6.195E-05	5.189E-05
1830	8.525E-05	6.166E-05	5.212E-05
1860	8.444E-05	6.174E-05	5.254E-05
1890	8.393E-05	6.196E-05	5.149E-05
1920	8.306E-05	6.107E-05	5.157E-05
1950	8.317E-05	6.107E-05	5.123E-05
1980	8.289E-05	6.137E-05	5.075E-05
2010	8.215E-05	6.019E-05	5.080E-05
2040	8.129E-05	5.917E-05	5.066E-05
2070	8.260E-05	5.885E-05	5.040E-05
2100	8.161E-05	5.955E-05	5.062E-05
2130	8.184E-05	5.880E-05	5.035E-05
2160	8.196E-05	5.882E-05	5.075E-05
2190	8.140E-05	5.881E-05	5.071E-05
2220	8.105E-05	5.900E-05	5.067E-05
2250	8.132E-05	5.894E-05	5.062E-05
2280	8.178E-05	5.866E-05	5.058E-05
2310	8.152E-05	5.852E-05	5.054E-05
2340	8.253E-05	5.900E-05	5.049E-05
2370	8.191E-05	5.834E-05	5.045E-05
2400	8.176E-05	5.896E-05	5.041E-05
2430	8.177E-05	5.816E-05	5.033E-05
2460	8.165E-05	5.870E-05	5.014E-05
2490	8.117E-05	5.779E-05	5.024E-05
2520	8.155E-05	5.895E-05	4.944E-05
2550	8.099E-05	5.837E-05	5.008E-05
2580	8.090E-05	5.873E-05	4.993E-05
2610	8.094E-05	5.891E-05	4.987E-05
2640	8.106E-05	5.837E-05	4.996E-05
2670	8.092E-05	5.851E-05	4.952E-05
2700	8.143E-05	5.852E-05	4.996E-05
2730	8.133E-05	5.860E-05	5.009E-05
2760	8.134E-05	5.832E-05	4.978E-05
2790	8.129E-05	5.807E-05	4.988E-05
2820	8.052E-05	5.808E-05	5.033E-05
2850	8.039E-05	5.805E-05	4.967E-05
2880	8.071E-05	5.787E-05	4.931E-05
2910	8.035E-05	5.816E-05	4.963E-05
2940	8.055E-05	5.786E-05	4.976E-05
2970	8.031E-05	5.749E-05	4.980E-05
3000	7.970E-05	5.772E-05	4.963E-05

FLIGHT NO. C-151
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102470 FLIGHT NO. C-151 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3
3030	7.990E-05	5.747E-05	4.970E-05
3060	7.994E-05	5.799E-05	4.989E-05
3090	8.002E-05	5.832E-05	5.035E-05
3120	8.010E-05	5.797E-05	4.960E-05
3150	8.015E-05	5.766E-05	5.054E-05
3180	7.989E-05	5.803E-05	4.926E-05
3210	7.976E-05	5.735E-05	5.038E-05
3240	7.927E-05	5.795E-05	4.967E-05
3270	7.899E-05	5.818E-05	4.940E-05
3300	7.953E-05	5.762E-05	4.944E-05
3330	7.941E-05	5.744E-05	4.959E-05
3360	7.878E-05	5.747E-05	4.968E-05
3390	7.867E-05	5.744E-05	4.931E-05
3420	7.926E-05	5.771E-05	4.944E-05
3450	7.905E-05	5.771E-05	4.942E-05
3480	7.878E-05	5.756E-05	4.949E-05
3510	7.886E-05	5.773E-05	4.934E-05
3540	7.889E-05	5.773E-05	4.905E-05
3570	7.892E-05	5.756E-05	4.943E-05
3600	7.878E-05	5.741E-05	4.858E-05
3630	7.872E-05	5.704E-05	4.929E-05
3660	7.866E-05	5.667E-05	4.905E-05
3690	7.874E-05	5.740E-05	4.879E-05
3720	7.855E-05	5.704E-05	4.902E-05
3750	7.852E-05	5.699E-05	4.919E-05
3780	7.783E-05	5.726E-05	4.894E-05
3810	7.901E-05	5.751E-05	4.942E-05
3840	7.832E-05	5.721E-05	4.881E-05
3870	7.842E-05	5.744E-05	4.905E-05
3900	7.876E-05	5.758E-05	4.940E-05
3930	7.886E-05	5.741E-05	4.902E-05
3960	7.851E-05	5.709E-05	4.888E-05
3990	7.844E-05	5.743E-05	4.907E-05
4020	7.843E-05	5.779E-05	4.910E-05
4050	7.815E-05	5.761E-05	4.931E-05
4080	7.792E-05	5.761E-05	4.933E-05
4110	7.832E-05	5.767E-05	4.891E-05
4140	7.729E-05	5.698E-05	4.892E-05
4170	7.729E-05	5.725E-05	4.890E-05
4200	7.834E-05	5.760E-05	4.900E-05
4230	7.809E-05	5.727E-05	4.870E-05
4260	7.826E-05	5.676E-05	4.903E-05
4290	7.821E-05	5.759E-05	4.882E-05
4320	7.801E-05	5.771E-05	4.900E-05
4350	7.823E-05	5.705E-05	4.900E-05
4380	7.867E-05	5.742E-05	4.928E-05
4410	7.786E-05	5.741E-05	4.914E-05
4440	7.786E-05	5.723E-05	4.898E-05
4470	7.900E-05	5.705E-05	4.883E-05
4500	7.876E-05	5.687E-05	4.868E-05
FIRST DATA ALT	750	780	720
LAST DATA ALT	4470	4410	4410

FLIGHT NO. C-151

BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-151 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.4821063	.6466779	.8039816	.8638279	.9270269	.9571957	.9628223
600	.2341850	.4219755	.6501015	.7490734	.8610910	.9172771	.9279499
1500	.0331358	.1368173	.3739147	.5168475	.7106004	.8209863	.8429712
3000	.0019278	.0300825	.1818841	.3186968	.5532602	.7105264	.7438146
4500	.0000985	.0068539	.0921229	.2019149	.4368463	.6199314	.6609435

FLIGHT NO. C-151 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.5907256	.7301471	.8543475	.8997708	.9467971	.9689289	.9730350
600	.3508597	.5365902	.7329340	.8118366	.8977130	.9396020	.9474772
1500	.0847044	.2366487	.4902971	.6198997	.7807242	.8668291	.8835860
3000	.0108651	.0793051	.2914732	.4373063	.6517140	.7809905	.8072880
4500	.0012444	.0269637	.1774134	.3134196	.5484988	.7069896	.7406071

FLIGHT NO. C-151 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.6491187	.7724488	.8787733	.9169498	.9561117	.9744210	.9778096
600	.4232404	.5998685	.7748683	.8427141	.9152279	.9501429	.9566755
1500	.1335865	.3088066	.5592940	.6771509	.8172527	.8900183	.9040203
3000	.0236896	.1225988	.3601635	.5040162	.7014132	.8148413	.8375042
4500	.0037454	.0487406	.2353470	.3788468	.6050576	.7482044	.7778545

FLIGHT NO. C-151
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-151 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	9.195E 01	5.352E 01	2.486E 01	1.520E 01	5.592E 00	1.924E 00	1.501E 00
600	1.260E 02	8.603E 01	4.437E 01	2.801E 01	1.065E 01	3.719E 00	2.909E 00
1500	1.436E 02	1.231E 02	7.850E 01	5.338E 01	2.199E 01	8.116E 00	6.458E 00
3000	1.464E 02	1.353E 02	1.010E 02	7.387E 01	3.349E 01	1.362E 01	1.127E 01
4500	1.770E 02	1.603E 02	1.230E 02	9.221E 01	4.465E 01	1.949E 01	1.668E 01

FLIGHT NO. C-151 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	9.194E 01	5.030E 01	2.237E 01	1.337E 01	4.758E 00	1.596E 00	1.237E 00
600	1.362E 02	8.508E 01	4.102E 01	2.511E 01	9.148E 00	3.102E 00	2.409E 00
1500	1.733E 02	1.356E 02	7.787E 01	5.041E 01	1.943E 01	6.859E 00	5.413E 00
3000	1.833E 02	1.614E 02	1.077E 02	7.380E 01	3.023E 01	1.149E 01	9.442E 00
4500	2.095E 02	1.866E 02	1.326E 02	9.330E 01	4.036E 01	1.637E 01	1.403E 01

FLIGHT NO. C-151 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	6.751E 01	3.570E 01	1.545E 01	9.039E 00	3.072E 00	9.986E-01	8.074E-01
600	1.042E 02	6.191E 01	2.868E 01	1.712E 01	5.934E 00	1.946E 00	1.576E 00
1500	1.403E 02	1.033E 02	5.572E 01	3.486E 01	1.267E 01	4.333E 00	3.557E 00
3000	1.490E 02	1.268E 02	7.944E 01	5.242E 01	2.022E 01	7.581E 00	6.449E 00
4500	1.644E 02	1.447E 02	9.909E 01	6.666E 01	2.733E 01	1.104E 01	9.698E 00

FLIGHT NO. C-151
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-151 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.942E 01	2.373E 01	1.189E 01	7.910E 00	3.726E 00	1.819E 00	1.501E 00
600	5.401E 01	3.814E 01	2.122E 01	1.458E 01	7.093E 00	3.516E 00	2.909E 00
1500	6.206E 01	5.496E 01	3.792E 01	2.812E 01	1.491E 01	7.730E 00	6.458E 00
3000	6.416E 01	6.157E 01	5.032E 01	4.057E 01	2.394E 01	1.326E 01	1.127E 01
4500	7.625E 01	7.260E 01	6.230E 01	5.244E 01	3.309E 01	1.926E 01	1.668E 01

FLIGHT NO. C-151 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.363E 01	1.923E 01	9.403E 00	6.250E 00	2.987E 00	1.489E 00	1.237E 00
600	4.983E 01	3.253E 01	1.724E 01	1.173E 01	5.743E 00	2.895E 00	2.409E 00
1500	6.336E 01	5.186E 01	3.287E 01	2.372E 01	1.236E 01	6.441E 00	5.413E 00
3000	6.695E 01	6.181E 01	4.616E 01	3.564E 01	2.009E 01	1.101E 01	9.442E 00
4500	7.647E 01	7.187E 01	5.796E 01	4.676E 01	2.801E 01	1.608E 01	1.403E 01

FLIGHT NO. C-151 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.924E 01	1.075E 01	5.221E 00	3.489E 00	1.727E 00	9.296E-01	8.074E-01
600	2.971E 01	1.864E 01	9.696E 00	6.608E 00	3.336E 00	1.812E 00	1.576E 00
1500	4.069E 01	3.154E 01	1.914E 01	1.370E 01	7.293E 00	4.070E 00	3.557E 00
3000	4.585E 01	4.068E 01	2.886E 01	2.197E 01	1.256E 01	7.322E 00	6.449E 00
4500	5.218E 01	4.822E 01	3.735E 01	2.966E 01	1.791E 01	1.086E 01	9.698E 00

FLIGHT NO. C-151
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-151 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.908E 01	2.990E 01	1.545E 01	1.056E 01	5.036E 00	2.083E 00	1.501E 00
600	6.724E 01	4.806E 01	2.758E 01	1.945E 01	9.586E 00	4.026E 00	2.909E 00
1500	8.175E 01	7.254E 01	5.146E 01	3.929E 01	2.134E 01	9.123E 00	6.458E 00
3000	9.616E 01	9.245E 01	7.759E 01	6.476E 01	4.032E 01	1.717E 01	1.127E 01
4500	1.153E 02	1.129E 02	1.026E 02	9.096E 01	6.312E 01	2.759E 01	1.668E 01

FLIGHT NO. C-151 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.398E 01	2.558E 01	1.306E 01	9.018E 00	4.402E 00	1.762E 00	1.237E 00
600	6.516E 01	4.326E 01	2.395E 01	1.693E 01	8.464E 00	3.426E 00	2.409E 00
1500	8.860E 01	7.299E 01	4.824E 01	3.628E 01	1.960E 01	7.940E 00	5.413E 00
3000	1.103E 02	1.016E 02	7.891E 01	6.392E 01	3.872E 01	1.529E 01	9.442E 00
4500	1.283E 02	1.239E 02	1.067E 02	9.165E 01	6.136E 01	2.492E 01	1.403E 01

FLIGHT NO. C-151 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.649E 01	1.517E 01	7.858E 00	5.548E 00	2.832E 00	1.156E 00	8.074E-01
600	4.091E 01	2.631E 01	1.459E 01	1.051E 01	5.470E 00	2.254E 00	1.576E 00
1500	6.020E 01	4.732E 01	3.054E 01	2.315E 01	1.288E 01	5.273E 00	3.557E 00
3000	8.155E 01	7.251E 01	5.442E 01	4.401E 01	2.720E 01	1.072E 01	6.449E 00
4500	9.425E 01	8.986E 01	7.543E 01	6.450E 01	4.371E 01	1.766E 01	9.698E 00

FLIGHT NO. C-151
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-151 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.041E 01	2.430E 01	1.215E 01	8.083E 00	3.796E 00	1.845E 00	1.501E 00
600	5.537E 01	3.906E 01	2.169E 01	1.489E 01	7.226E 00	3.565E 00	2.909E 00
1500	6.338E 01	5.611E 01	3.864E 01	2.863E 01	1.512E 01	7.821E 00	6.458E 00
3000	6.488E 01	6.225E 01	5.076E 01	4.086E 01	2.403E 01	1.335E 01	1.127E 01
4500	7.693E 01	7.317E 01	6.262E 01	5.265E 01	3.320E 01	1.947E 01	1.668E 01

FLIGHT NO. C-151 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.436E 01	1.964E 01	9.595E 00	6.386E 00	3.052E 00	1.521E 00	1.237E 00
600	5.090E 01	3.322E 01	1.759E 01	1.199E 01	5.869E 00	2.956E 00	2.409E 00
1500	6.490E 01	5.307E 01	3.360E 01	2.428E 01	1.267E 01	6.596E 00	5.413E 00
3000	6.891E 01	6.354E 01	4.739E 01	3.664E 01	2.075E 01	1.136E 01	9.442E 00
4500	7.790E 01	7.336E 01	5.923E 01	4.791E 01	2.889E 01	1.660E 01	1.403E 01

FLIGHT NO. C-151 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.052E 01	1.150E 01	5.629E 00	3.790E 00	1.982E 00	9.831E-01	8.074E-01
600	3.168E 01	1.994E 01	1.045E 01	7.177E 00	3.636E 00	1.916E 00	1.576E 00
1500	4.288E 01	3.341E 01	2.044E 01	1.474E 01	7.882E 00	4.287E 00	3.557E 00
3000	4.665E 01	4.176E 01	2.992E 01	2.295E 01	1.325E 01	7.626E 00	6.449E 00
4500	5.303E 01	4.918E 01	3.838E 01	3.072E 01	1.877E 01	1.130E 01	9.698E 00

FLIGHT NO. C-151
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-151 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.266E 00	9.835E-01	3.674E-01	2.091E-01	7.168E-02	2.389E-02	1.853E-02
600	6.393E 00	2.422E 00	8.110E-01	4.444E-01	1.469E-01	4.818E-02	3.725E-02
1500	5.151E 01	1.069E 01	2.495E 00	1.227E 00	3.678E-01	1.175E-01	9.103E-02
3000	9.024E 02	5.346E 01	6.595E 00	2.754E 00	7.193E-01	2.278E-01	1.801E-01
4500	2.136E 04	2.779E 02	1.586E 01	5.427E 00	1.215E 00	3.735E-01	2.999E-01

FLIGHT NO. C-151 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.669E 00	7.388E-01	2.808E-01	1.594E-01	5.389E-02	1.766E-02	1.363E-02
600	4.163E 00	1.700E 00	6.002E-01	3.317E-01	1.093E-01	3.540E-02	2.727E-02
1500	2.194E 01	6.146E 00	1.703E 00	8.720E-01	2.669E-01	8.486E-02	6.569E-02
3000	1.810E 02	2.183E 01	3.963E 00	1.810E 00	4.974E-01	1.578E-01	1.254E-01
4500	1.805E 03	7.423E 01	8.012E 00	3.192E 00	7.892E-01	2.484E-01	2.032E-01

FLIGHT NO. C-151 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.497E 00	6.654E-01	2.531E-01	1.419E-01	4.627E-02	1.476E-02	1.189E-02
600	3.546E 00	1.486E 00	5.330E-01	2.925E-01	9.336E-02	2.950E-02	2.373E-02
1500	1.512E 01	4.817E 00	1.435E 00	7.413E-01	2.233E-01	7.010E-02	5.665E-02
3000	9.058E 01	1.489E 01	3.176E 00	1.498E 00	4.151E-01	1.340E-01	1.109E-01
4500	6.319E 02	4.274E 01	6.001E 00	2.533E 00	6.504E-01	2.125E-01	1.795E-01

FLIGHT NO. C-151
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-151 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	9.716E-01	4.360E-01	1.757E-01	1.088E-01	4.776E-02	2.258E-02	1.853E-02
600	2.741E 00	1.074E 00	3.879E-01	2.312E-01	9.788E-02	4.555E-02	3.725E-02
1500	2.225E 01	4.773E 00	1.205E 00	6.465E-01	2.493E-01	1.119E-01	9.103E-02
3000	3.955E 02	2.432E 01	3.288E 00	1.513E 00	5.141E-01	2.218E-01	1.801E-01
4500	9.200E 03	1.259E 02	8.036E 00	3.086E 00	9.000E-01	3.691E-01	2.999E-01

FLIGHT NO. C-151 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.106E-01	2.825E-01	1.180E-01	7.449E-02	3.383E-02	1.648E-02	1.363E-02
600	1.523E 00	6.502E-01	2.523E-01	1.550E-01	6.860E-02	3.304E-02	2.727E-02
1500	8.021E 00	2.350E 00	7.189E-01	4.104E-01	1.698E-01	7.969E-02	6.569E-02
3000	6.608E 01	8.358E 00	1.698E 00	8.739E-01	3.307E-01	1.512E-01	1.254E-01
4500	6.590E 02	2.858E 01	3.503E 00	1.600E 00	5.477E-01	2.439E-01	2.032E-01

FLIGHT NO. C-151 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.269E-01	2.004E-01	8.555E-02	5.479E-02	2.601E-02	1.374E-02	1.189E-02
600	1.011E 00	4.475E-01	1.802E-01	1.129E-01	5.248E-02	2.746E-02	2.373E-02
1500	4.386E 00	1.470E 00	4.926E-01	2.914E-01	1.285E-01	6.585E-02	5.665E-02
3000	2.787E 01	4.778E 00	1.154E 00	6.275E-01	2.579E-01	1.294E-01	1.109E-01
4500	2.006E 02	1.424E 01	2.285E 00	1.127E 00	4.262E-01	2.089E-01	1.795E-01

FLIGHT NO. C-151
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-151 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.210E 00	5.494E-01	2.283E-01	1.452E-01	6.455E-02	2.586E-02	1.853E-02
600	3.412E 00	1.353E 00	5.041E-01	3.086E-01	1.323E-01	5.216E-02	3.725E-02
1500	2.932E 01	6.300E 00	1.635E 00	9.033E-01	3.569E-01	1.320E-01	9.103E-02
3000	5.927E 02	3.652E 01	5.069E 00	2.415E 00	8.660E-01	2.872E-01	1.801E-01
4500	1.391E 04	1.958E 02	1.324E 01	5.353E 00	1.717E 00	5.288E-01	2.999E-01

FLIGHT NO. C-151 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	7.984E-01	3.757E-01	1.640E-01	1.075E-01	4.986E-02	1.950E-02	1.363E-02
600	1.992E 00	8.646E-01	3.505E-01	2.236E-01	1.011E-01	3.910E-02	2.727E-02
1500	1.122E 01	3.307E 00	1.055E 00	6.276E-01	2.693E-01	9.822E-02	6.569E-02
3000	1.088E 02	1.374E 01	2.903E 00	1.567E 00	6.371E-01	2.099E-01	1.254E-01
4500	1.106E 03	4.930E 01	6.450E 00	3.136E 00	1.200E 00	3.780E-01	2.032E-01

FLIGHT NO. C-151 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	5.877E-01	2.828E-01	1.288E-01	8.712E-02	4.265E-02	1.709E-02	1.189E-02
600	1.392E 00	6.315E-01	2.712E-01	1.795E-01	8.606E-02	3.416E-02	2.373E-02
1500	6.489E 00	2.206E 00	7.862E-01	4.922E-01	2.269E-01	8.530E-02	5.665E-02
3000	4.957E 01	8.516E 00	2.176E 00	1.257E 00	5.583E-01	1.894E-01	1.109E-01
4500	3.623E 02	2.655E 01	4.615E 00	2.451E 00	1.040E 00	3.398E-01	1.795E-01

FLIGHT NO. C-151
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH CF PATH OF SIGHT = 27C

FLIGHT NO. C-151 FILTER NC. 2
CIRECTICNAL PATH REFLECTANCE FROM GRCUND TC ALTITLCE

ALTITUDE M	ZENITH ANGLE CF PATH CF SIGHT (DEG) 93	95	1C0	1C5	12C	150	180
300	9.960E-01	4.466F-01	1.796E-01	1.112F-01	4.865E-02	2.290E-02	1.853E-02
600	2.809E 00	1.100E 00	3.965E-01	2.363E-01	9.971E-C2	4.619E-02	3.725E-02
1500	2.273E 01	4.873E 00	1.228E CC	6.582E-C1	2.529E-C1	1.132E-01	9.103E-02
3000	3.999E 02	2.459E 01	3.316E 0C	1.523E CC	5.160E-C1	2.233E-01	1.801E-01
4500	9.283E 03	1.269E C2	8.C78E 00	3.098E C0	9.031E-C1	3.733E-01	2.999E-01

FLIGHT NO. C-151 FILTER NC. 5
DIRECTICNAL PATH REFLECTANCE FROM GRCUND TC ALTITLDE

ALTITUDE M	ZENITH ANGLE CF PATH CF SIGHT (DEG) 93	95	1CC	1C5	120	150	180
300	6.237E-01	2.884E-C1	1.2C4E-C1	7.611F-02	3.457E-02	1.683E-02	1.363E-02
600	1.556E C0	6.638E-01	2.574E-C1	1.584E-01	7.011E-C2	3.374E-02	2.727E-02
1500	8.216E 00	2.405F 00	7.349E-01	4.2C1F-01	1.740E-C1	8.160E-02	6.569E-02
3000	6.801F 01	8.592E 00	1.743E CC	8.985F-01	3.415E-C1	1.560E-01	1.254E-01
4500	6.713F 02	2.917E C1	3.580E CC	1.639E 0C	5.649E-C1	2.517E-01	2.032E-01

FLIGHT NO. C-151 FILTER NC. 3
CIRECTICNAL PATH REFLECTANCE FROM GRCUND TC ALTITLCE

ALTITUDE M	ZENITH ANCLE CF PATH CF SIGHT (CEG) 93	95	1CC	1C5	120	150	180
3CC	4.552F-01	2.144F-C1	9.223E-C2	5.951E-02	2.835E-C2	1.453E-02	1.189E-02
600	1.078E 00	4.787E-01	1.942E-01	1.226E-01	5.720E-C2	2.904E-02	2.373E-02
1500	4.622E C0	1.558E CC	5.261F-01	3.135E-01	1.389E-C1	6.936F-02	5.665E-02
3C00	2.836E 01	4.905E 0C	1.196E CC	6.557E-01	2.720E-C1	1.348E-01	1.109E-01
4500	2.039E 02	1.453E 01	2.348F CC	1.167E C0	4.467E-01	2.174E-01	1.795E-01

FLIGHT C-152 – 26 OCTOBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

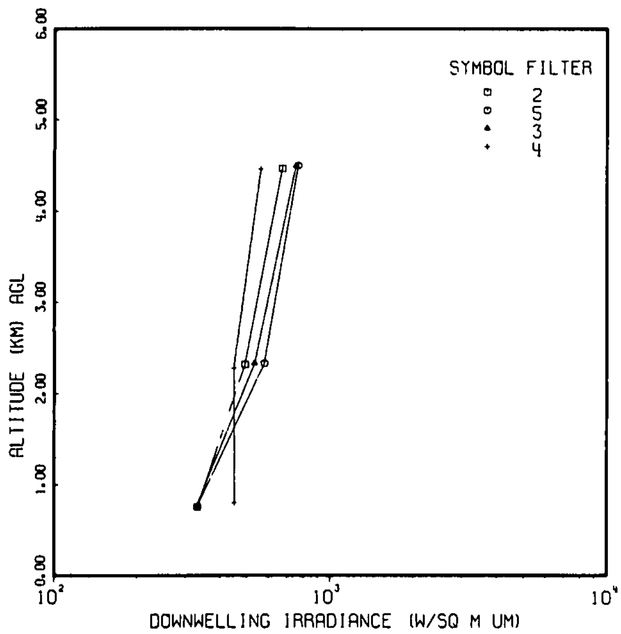
It was a sunlit morning flight. The sky was clear overhead with some clouds on the horizon. The flight was conducted over a broad desert valley on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0925 local time (1625 GMT) and continued until 1246 local time (1946 GMT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 5 was 57.9 degrees at the start and 49.5 degrees at the end. Sky radiance data-taking for Filter 4 started after solar noon; the sun zenith angle was 46.3 degrees at the beginning and 47.9 degrees at the end. The highest flight altitude was 4495 meters AGL.

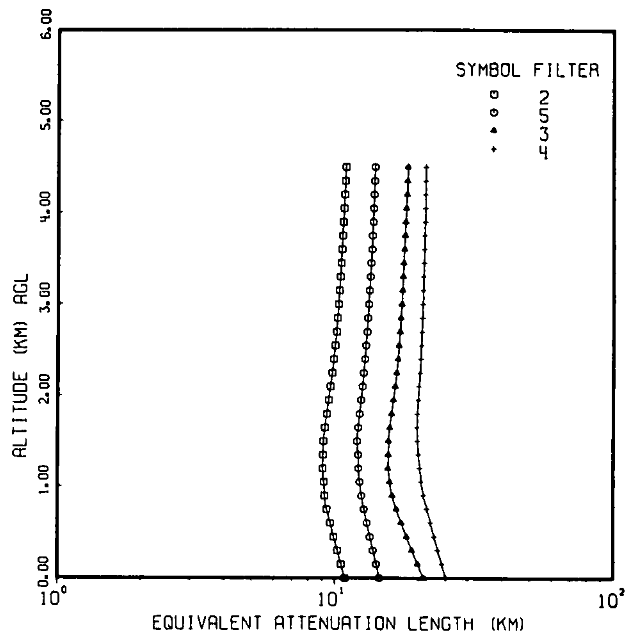
> At the beginning of data-taking, Stallion was reporting clear skies with 40 mile (64 kilometer) visibility. During the course of the data-taking, there were few (less than 0.1) cumulus recorded south of the station. The ground station reported clear, sunny, light haze on the horizon and scattered cumulus on the eastern horizon.
>
> During the flight, the aircrew reported light ground haze and moderate haze on the horizon. There were also some cumulus buildups on the horizon. During the flight, the clouds were below 2210 meters and there were many cumulus to the northwest. At the maximum flight altitude the wind was 75 knots from the bearing of 130 degrees. At 1751 GMT, there were cumulus clouds to starboard on the descent to 685 meters.
>
> At the end of data-taking, Stallion was reporting few cumulus (less than 0.1) north to south of the station with visibility of 40 miles (64 kilometers).

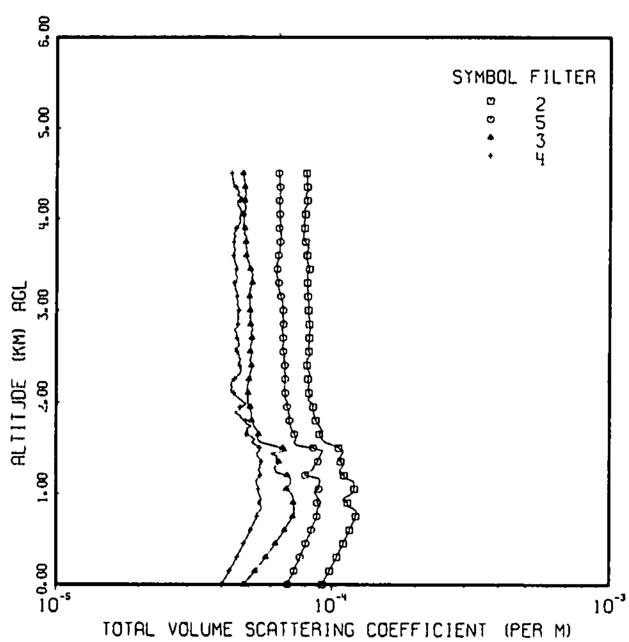
It was noted on several of the flights, including C-152, that there were considerably more clouds over the northern end of the track. This frequently obscured the ground at the northern end while the southern portion of the track, including the ground station, remained in the clear. The pictures taken with the all-sky camera show that the amounts reported are not overestimated.

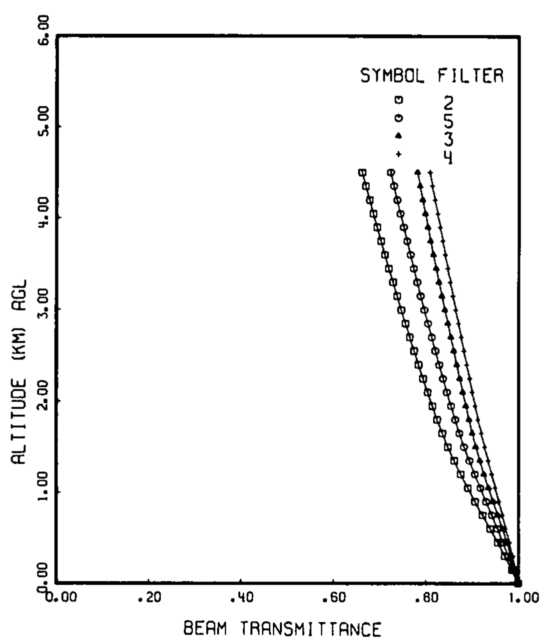
At the surface there was a weak northerly flow and the area was in a zone of transition from weak low pressure to weak high pressure. High pressure was moving in over Washington and Oregon. From a low centered north of Lake Winnepeg an occluded front extended to west of Lake Head, then became a stationary front through Moline, Springfield, Missouri, and Midland, Texas, with a wave along the southwestern border of Oklahoma. At 500 millibars the area was at the base of a trough with moderate to strong westerly winds. A cold low was centered in Saskatchewan. The airmass characteristics were diffuse.

FLIGHT NO. C-152

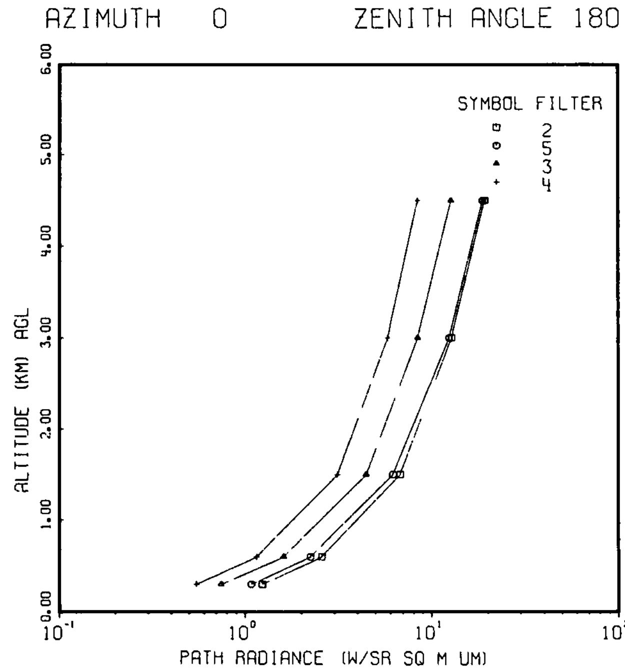


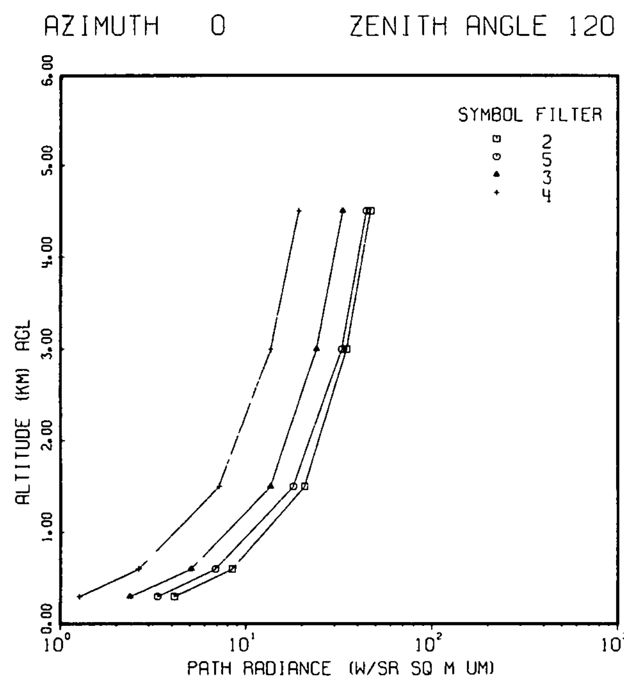


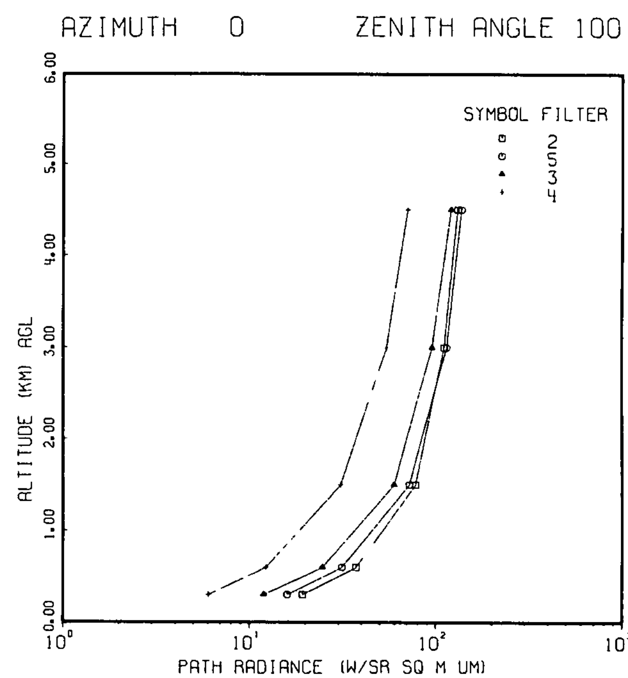




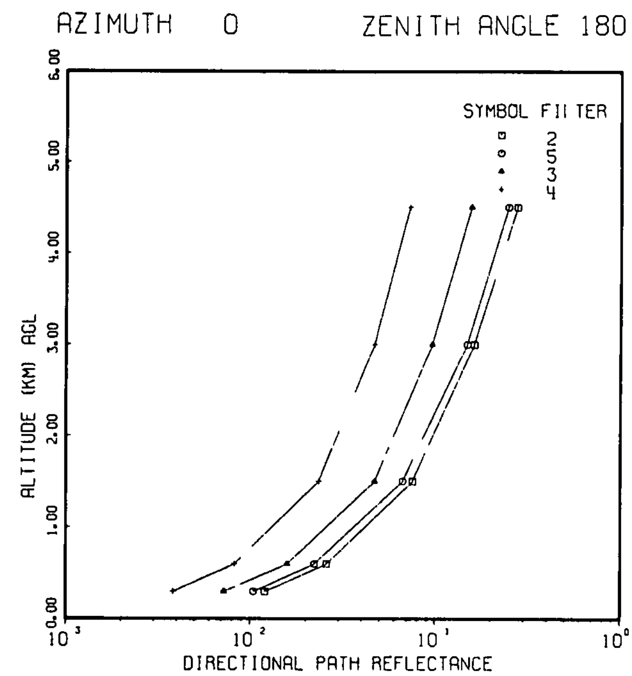
FLIGHT NO. C-152

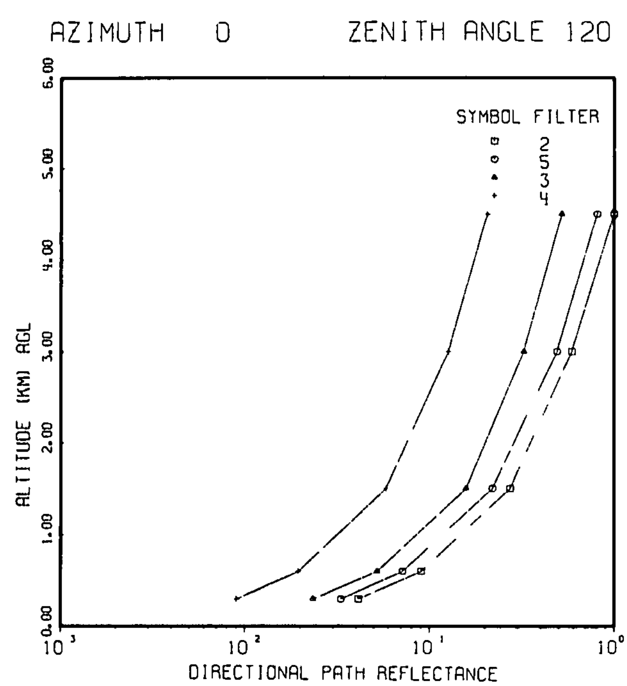


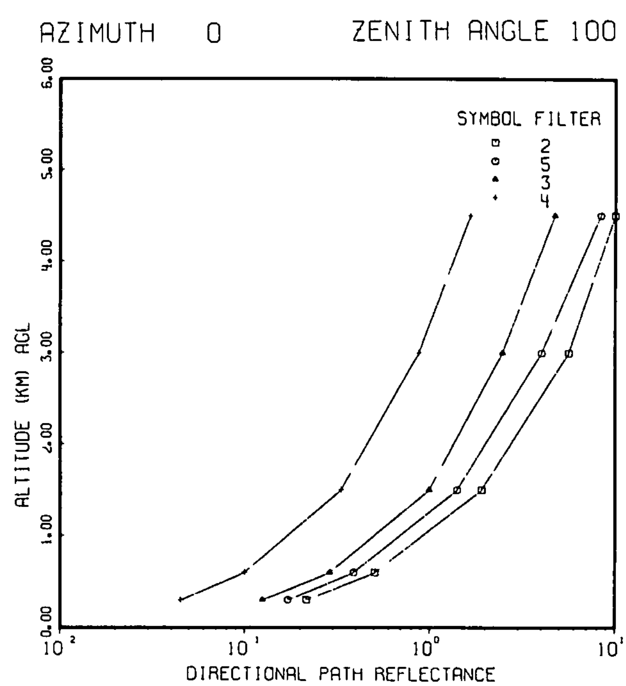




FLIGHT NO. C-152







FLIGHT NO. C-152
IRRADIANCE

FLIGHT NO.C-152 FILTER NO. 2
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
750	3.327E 02	5.863E 01	.176	7.978E 02	1.463E 02	9.440E 02	.183
2319	4.928E 02	6.818E 01	.138	1.069E 03	1.959E 02	1.265E 03	.183
4463	6.717E 02	1.125E 02	.167	1.258E 03	2.867E 02	1.544E 03	.228

FLIGHT NO.C-152 FILTER NO. 5
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
755	3.311E 02	9.396E 01	.284	7.903E 02	2.141E 02	1.004E 03	.271
2333	5.787E 02	1.157E 02	.200	1.259E 03	2.657E 02	1.525E 03	.211
4495	7.672E 02	1.379E 02	.180	1.383E 03	3.095E 02	1.693E 03	.224

FLIGHT NO.C-152 FILTER NO. 3
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
748	3.288E 02	9.641E 01	.293	7.623E 02	2.040E 02	9.662E 02	.268
2333	5.334E 02	9.299E 01	.174	1.073E 03	1.991E 02	1.272E 03	.186
4486	7.523E 02	1.217E 02	.162	1.295E 03	2.556E 02	1.551E 03	.197

FLIGHT NO.C-152 FILTER NO. 4
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
798	4.521E 02	9.365E 01	.207	7.144E 02	1.935E 02	9.079E 02	.271
2280	4.485E 02	9.345E 01	.208	7.675E 02	2.006E 02	9.631E 02	.263
4454	5.625E 02	9.988E 01	.178	8.673E 02	2.162E 02	1.083E 03	.249

FLIGHT NO. C-152
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-152
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.55041	.85869	.57206	.25722
95	.35213	.47315	.25388	.20266
100	.16069	.31524	.21083	.16027
105	.14023	.23633	.19821	.12941
120	.13549	.20845	.20054	.12695
150	.12854	.19288	.23405	.15563
180	.14229	.29591	.27550	.16686

FLIGHT NO. C-152
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.56506	.59289	.42821	.19242
95	.45679	.43083	.33184	.18009
100	.19148	.26617	.22349	.19234
105	.15060	.23307	.20337	.17272
120	.14188	.22346	.25384	.15747
150	.13033	.25132	.23198	.18962
180	.14229	.29591	.27550	.16686

FLIGHT NO. C-152
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.36601	.58351	.43270	.27907
95	.32220	.56799	.45486	.27708
100	.28134	.51830	.43469	.33331
105	.23777	.45369	.48730	.33469
120	.26602	.44621	.50343	.28658
150	.17793	.38645	.34606	.27516
180	.14229	.29591	.27550	.16686

FLIGHT NO. C-152
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.24663	.36280	.26928	.27537
95	.16437	.34028	.30280	.26726
100	.17322	.34714	.32996	.25800
105	.16374	.30692	.26511	.21209
120	.18776	.31172	.29407	.19454
150	.16035	.27654	.32881	.19531
180	.14229	.29591	.27550	.16686

FLIGHT NO. C-152
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102670 FLIGHT NO. C-152 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
0	9.201E-05	6.900E-05	4.790E-05	3.990E-05
30	9.320E-05	6.976E-05	4.887E-05	4.044E-05
60	9.439E-05	7.052E-05	4.984E-05	4.098E-05
90	9.557E-05	7.128E-05	5.081E-05	4.152E-05
120	9.676E-05	7.204E-05	5.178E-05	4.206E-05
150	9.795E-05	7.280E-05	5.276E-05	4.260E-05
180	9.914E-05	7.357E-05	5.373E-05	4.313E-05
210	1.003E-04	7.433E-05	5.470E-05	4.367E-05
240	1.015E-04	7.509E-05	5.567E-05	4.421E-05
270	1.027E-04	7.585E-05	5.664E-05	4.475E-05
300	1.039E-04	7.661E-05	5.761E-05	4.529E-05
330	1.051E-04	7.737E-05	5.858E-05	4.583E-05
360	1.063E-04	7.813E-05	5.955E-05	4.637E-05
390	1.075E-04	7.889E-05	6.053E-05	4.691E-05
420	1.086E-04	7.965E-05	6.150E-05	4.745E-05
450	1.098E-04	8.041E-05	6.247E-05	4.799E-05
480	1.110E-04	8.118E-05	6.344E-05	4.853E-05
510	1.122E-04	8.194E-05	6.441E-05	4.906E-05
540	1.134E-04	8.270E-05	6.538E-05	4.960E-05
570	1.146E-04	8.346E-05	6.635E-05	5.014E-05
600	1.158E-04	8.422E-05	6.732E-05	5.068E-05
630	1.170E-04	8.498E-05	6.829E-05	5.122E-05
660	1.181E-04	8.574E-05	6.927E-05	5.176E-05
690	1.193E-04	8.650E-05	7.024E-05	5.230E-05
720	1.205E-04	8.726E-05	7.121E-05	5.284E-05
750	1.217E-04	8.802E-05	7.218E-05	5.338E-05
780	1.229E-04	8.878E-05	7.328E-05	5.364E-05
810	1.229E-04	8.850E-05	7.272E-05	5.486E-05
840	1.188E-04	8.894E-05	7.297E-05	5.564E-05
870	1.137E-04	9.061E-05	7.260E-05	5.533E-05
900	1.134E-04	8.834E-05	7.244E-05	5.437E-05
930	1.093E-04	9.030E-05	7.238E-05	5.553E-05
960	1.117E-04	8.850E-05	7.205E-05	5.503E-05
990	1.167E-04	8.759E-05	7.172E-05	5.440E-05
1020	1.190E-04	8.591E-05	7.024E-05	5.408E-05
1050	1.201E-04	8.944E-05	6.843E-05	5.399E-05
1080	1.202E-04	8.981E-05	6.961E-05	5.385E-05
1110	1.198E-04	8.961E-05	7.099E-05	5.315E-05
1140	1.194E-04	9.069E-05	7.070E-05	5.306E-05
1170	1.118E-04	8.910E-05	7.046E-05	5.398E-05
1200	1.102E-04	7.995E-05	6.878E-05	5.488E-05
1230	1.064E-04	8.129E-05	6.284E-05	5.503E-05
1260	1.068E-04	8.501E-05	6.229E-05	5.402E-05
1290	1.087E-04	8.564E-05	6.195E-05	5.491E-05
1320	1.098E-04	8.647E-05	6.370E-05	5.472E-05
1350	1.073E-04	8.871E-05	6.422E-05	5.559E-05
1380	1.054E-04	8.899E-05	6.267E-05	5.462E-05
1410	1.078E-04	9.068E-05	6.339E-05	5.372E-05
1440	1.088E-04	9.137E-05	5.992E-05	5.327E-05
1470	1.101E-04	9.269E-05	6.866E-05	5.495E-05
1500	1.055E-04	8.550E-05	6.634E-05	5.469E-05

FLIGHT NO. C-152
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102670 FLIGHT NO. C-152 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
1530	1.014E-04	7.437E-05	6.032E-05	5.306E-05
1560	9.485E-05	7.290E-05	5.515E-05	5.111E-05
1590	9.227E-05	7.396E-05	5.389E-05	5.272E-05
1620	9.108E-05	7.387E-05	5.364E-05	5.130E-05
1650	8.990E-05	7.306E-05	5.422E-05	4.881E-05
1680	9.305E-05	7.224E-05	5.402E-05	4.967E-05
1710	9.125E-05	7.108E-05	5.292E-05	4.885E-05
1740	8.993E-05	7.069E-05	5.207E-05	5.112E-05
1770	8.837E-05	7.001E-05	5.168E-05	4.855E-05
1800	8.713E-05	6.998E-05	5.119E-05	4.860E-05
1830	8.636E-05	6.954E-05	5.109E-05	4.672E-05
1860	8.627E-05	7.026E-05	5.090E-05	4.622E-05
1890	8.561E-05	6.943E-05	5.096E-05	4.429E-05
1920	8.515E-05	6.966E-05	5.036E-05	4.627E-05
1950	8.526E-05	6.861E-05	5.057E-05	4.643E-05
1980	8.579E-05	6.841E-05	4.954E-05	4.893E-05
2010	8.286E-05	6.897E-05	4.954E-05	4.743E-05
2040	8.123E-05	6.749E-05	4.953E-05	4.603E-05
2070	8.428E-05	6.749E-05	4.937E-05	4.479E-05
2100	8.226E-05	6.755E-05	4.961E-05	4.407E-05
2130	8.262E-05	6.774E-05	4.925E-05	4.265E-05
2160	8.181E-05	6.716E-05	4.935E-05	4.357E-05
2190	8.248E-05	6.767E-05	4.938E-05	4.289E-05
2220	8.151E-05	6.711E-05	4.987E-05	4.337E-05
2250	8.155E-05	6.744E-05	5.003E-05	4.424E-05
2280	8.246E-05	6.731E-05	5.054E-05	4.512E-05
2310	8.306E-05	6.760E-05	5.041E-05	4.626E-05
2340	8.211E-05	6.700E-05	5.073E-05	4.656E-05
2370	8.117E-05	6.773E-05	5.110E-05	4.692E-05
2400	8.093E-05	6.730E-05	5.107E-05	4.611E-05
2430	8.123E-05	6.720E-05	5.057E-05	4.562E-05
2460	8.082E-05	6.694E-05	5.040E-05	4.664E-05
2490	8.185E-05	6.698E-05	5.081E-05	4.595E-05
2520	8.320E-05	6.693E-05	5.110E-05	4.593E-05
2550	8.226E-05	6.639E-05	5.050E-05	4.518E-05
2580	8.191E-05	6.610E-05	5.056E-05	4.425E-05
2610	8.195E-05	6.608E-05	5.051E-05	4.602E-05
2640	8.232E-05	6.645E-05	5.077E-05	4.583E-05
2670	8.229E-05	6.644E-05	5.096E-05	4.580E-05
2700	8.240E-05	6.638E-05	5.116E-05	4.502E-05
2730	8.308E-05	6.625E-05	5.128E-05	4.486E-05
2760	8.233E-05	6.623E-05	5.059E-05	4.480E-05
2790	8.300E-05	6.569E-05	5.153E-05	4.412E-05
2820	8.293E-05	6.579E-05	5.099E-05	4.528E-05
2850	8.231E-05	6.639E-05	5.053E-05	4.544E-05
2880	8.246E-05	6.630E-05	5.036E-05	4.526E-05
2910	8.230E-05	6.632E-05	5.034E-05	4.541E-05
2940	8.209E-05	6.603E-05	5.018E-05	4.557E-05
2970	8.159E-05	6.593E-05	5.040E-05	4.521E-05
3000	8.168E-05	6.630E-05	5.045E-05	4.576E-05

FLIGHT NO. C-152
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102670   FLIGHT NO. C-152   GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
3030	8.203E-05	6.619E-05	5.053E-05	4.570E-05
3060	8.221E-05	6.592E-05	5.007E-05	4.501E-05
3090	8.177E-05	6.610E-05	5.027E-05	4.544E-05
3120	8.142E-05	6.503E-05	4.994E-05	4.517E-05
3150	8.127E-05	6.492E-05	5.011E-05	4.505E-05
3180	8.148E-05	6.474E-05	4.982E-05	4.514E-05
3210	8.151E-05	6.422E-05	5.041E-05	4.477E-05
3240	8.107E-05	6.380E-05	5.041E-05	4.424E-05
3270	8.132E-05	6.314E-05	5.076E-05	4.467E-05
3300	8.094E-05	6.383E-05	5.129E-05	4.387E-05
3330	8.116E-05	6.355E-05	5.090E-05	4.487E-05
3360	8.112E-05	6.283E-05	5.102E-05	4.511E-05
3390	8.082E-05	6.247E-05	5.153E-05	4.461E-05
3420	8.127E-05	6.239E-05	5.066E-05	4.436E-05
3450	8.233E-05	6.301E-05	5.039E-05	4.480E-05
3480	8.171E-05	6.359E-05	4.985E-05	4.489E-05
3510	8.115E-05	6.265E-05	4.975E-05	4.422E-05
3540	8.114E-05	6.331E-05	4.948E-05	4.417E-05
3570	8.011E-05	6.392E-05	4.883E-05	4.408E-05
3600	8.068E-05	6.360E-05	4.863E-05	4.366E-05
3630	7.989E-05	6.393E-05	4.886E-05	4.385E-05
3660	8.149E-05	6.449E-05	4.882E-05	4.423E-05
3690	8.173E-05	6.436E-05	4.842E-05	4.383E-05
3720	8.060E-05	6.430E-05	4.830E-05	4.368E-05
3750	7.951E-05	6.448E-05	4.839E-05	4.380E-05
3780	7.842E-05	6.473E-05	4.849E-05	4.353E-05
3810	7.833E-05	6.525E-05	4.849E-05	4.437E-05
3840	7.826E-05	6.454E-05	4.767E-05	4.374E-05
3870	7.903E-05	6.484E-05	4.776E-05	4.430E-05
3900	7.893E-05	6.378E-05	4.802E-05	4.465E-05
3930	7.853E-05	6.463E-05	4.723E-05	4.538E-05
3960	7.882E-05	6.470E-05	4.772E-05	4.596E-05
3990	7.885E-05	6.426E-05	4.756E-05	4.615E-05
4020	7.898E-05	6.449E-05	4.767E-05	4.578E-05
4050	7.942E-05	6.418E-05	4.723E-05	4.739E-05
4080	7.888E-05	6.425E-05	4.808E-05	4.619E-05
4110	7.912E-05	6.408E-05	4.835E-05	4.611E-05
4140	8.006E-05	6.407E-05	4.844E-05	4.546E-05
4170	8.105E-05	6.398E-05	4.779E-05	4.504E-05
4200	8.080E-05	6.397E-05	4.800E-05	4.604E-05
4230	8.030E-05	6.491E-05	4.787E-05	4.692E-05
4260	7.969E-05	6.435E-05	4.839E-05	4.511E-05
4290	8.024E-05	6.430E-05	4.833E-05	4.590E-05
4320	8.125E-05	6.450E-05	4.818E-05	4.523E-05
4350	8.062E-05	6.434E-05	4.804E-05	4.449E-05
4380	8.041E-05	6.447E-05	4.789E-05	4.360E-05
4410	8.055E-05	6.403E-05	4.774E-05	4.347E-05
4440	8.064E-05	6.413E-05	4.759E-05	4.333E-05
4470	8.039E-05	6.393E-05	4.744E-05	4.320E-05
4500	8.014E-05	6.373E-05	4.729E-05	4.306E-05
FIRST DATA ALT	0	0	0	0
LAST DATA ALT	4440	4440	4290	4380

FLIGHT NO. C-152
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-152 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.5679226	.7131435	.8443209	.8926723	.9429232	.9666381	.9710423
600	.2984387	.4872153	.6983941	.7859649	.8827885	.9305514	.9395683
1500	.0374640	.1463945	.3862483	.5282244	.7186547	.8263460	.8477350
3000	.0021182	.0314902	.1856715	.3231341	.5572343	.7134686	.7464813
4500	.0001047	.0069757	.0926737	.2027240	.4377516	.6206728	.6616280

FLIGHT NO. C-152 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.6566956	.7778012	.8818091	.9190739	.9572575	.9750951	.9783954
600	.4099468	.5884628	.7674318	.8372792	.9121678	.9483074	.9550748
1500	.0834530	.2337323	.4868418	.6169653	.7788090	.8656008	.8825015
3000	.0083783	.0678621	.2696245	.4150326	.6343147	.7688836	.7964388
4500	.0007695	.0204223	.1548377	.2860672	.5231752	.6879563	.7233085

FLIGHT NO. C-152 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.7373475	.8335354	.9128876	.9406823	.9688422	.9818908	.9842978
600	.5115302	.6711926	.8194981	.8749781	.9332017	.9608716	.9660237
1500	.1476853	.3264155	.5743950	.6893637	.8248495	.8947855	.9082123
3000	.0262026	.1290523	.3688185	.5121107	.7072218	.8187304	.8409648
4500	.0042549	.0516831	.2416953	.3856729	.6106766	.7522082	.7814580

FLIGHT NO. C-152 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.7818964	.8632800	.9290532	.9518261	.9747665	.9853528	.9873026
600	.5902973	.7309107	.8551381	.9003294	.9471013	.9691087	.9731913
1500	.2219522	.4142328	.6462912	.7461249	.8593348	.9161966	.9270031
3000	.0474047	.1792632	.4324896	.5698584	.7474389	.8452961	.8645455
4500	.0092278	.0779558	.2937554	.4396007	.6534817	.7822129	.8083821

FLIGHT NO. C-152
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-152 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.955E 01	4.410E 01	1.934E 01	1.163E 01	4.116E 00	1.490E 00	1.235E 00
600	1.195E 02	7.749E 01	3.746E 01	2.319E 01	8.453E 00	3.101E 00	2.578E 00
1500	1.541E 02	1.285E 02	7.805E 01	5.202E 01	2.078E 01	8.046E 00	6.797E 00
3000	1.731E 02	1.562E 02	1.109E 02	7.869E 01	3.497E 01	1.472E 01	1.283E 01
4500	1.858E 02	1.709E 02	1.300E 02	9.765E 01	4.707E 01	2.146E 01	1.934E 01

FLIGHT NO. C-152 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.048E 01	3.746E 01	1.598E 01	9.537E 00	3.350E 00	1.243E 00	1.078E 00
600	1.132E 02	6.838E 01	3.145E 01	1.918E 01	6.883E 00	2.580E 00	2.241E 00
1500	1.674E 02	1.295E 02	7.230E 01	4.668E 01	1.803E 01	7.079E 00	6.215E 00
3000	2.028E 02	1.753E 02	1.144E 02	7.779E 01	3.291E 01	1.394E 01	1.250E 01
4500	2.081E 02	1.895E 02	1.364E 02	9.616E 01	4.471E 01	2.041E 01	1.882E 01

FLIGHT NO. C-152 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.672E 01	2.900E 01	1.196E 01	7.019E 00	2.375E 00	8.660E-01	7.434E-01
600	9.929E 01	5.654E 01	2.479E 01	1.479E 01	5.091E 00	1.871E 00	1.609E 00
1500	1.605E 02	1.157E 02	5.998E 01	3.753E 01	1.363E 01	5.152E 00	4.481E 00
3000	1.944E 02	1.590E 02	9.553E 01	6.243E 01	2.408E 01	9.496E 00	8.469E 00
4500	2.072E 02	1.810E 02	1.198E 02	8.179E 01	3.333E 01	1.388E 01	1.276E 01

FLIGHT NO. C-152 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.981E 01	1.468E 01	6.024E 00	3.482E 00	1.266E 00	5.664E-01	5.448E-01
600	5.313E 01	2.856E 01	1.230E 01	7.205E 00	2.654E 00	1.195E 00	1.150E 00
1500	9.445E 01	6.300E 01	3.100E 01	1.891E 01	7.192E 00	3.257E 00	3.132E 00
3000	1.241E 02	9.697E 01	5.450E 01	3.493E 01	1.366E 01	6.127E 00	5.836E 00
4500	1.297E 02	1.106E 02	7.010E 01	4.697E 01	1.935E 01	8.848E 00	8.441E 00

FLIGHT NO. C-152
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-152 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.011E 01	1.739E 01	8.532E 00	5.695E 00	2.753E 00	1.440E 00	1.235E 00
600	4.526E 01	3.055E 01	1.653E 01	1.136E 01	5.654E 00	2.998E 00	2.578E 00
1500	6.115E 01	5.261E 01	3.553E 01	2.635E 01	1.423E 01	7.833E 00	6.797E 00
3000	7.574E 01	7.027E 01	5.488E 01	4.355E 01	2.547E 01	1.457E 01	1.283E 01
4500	8.386E 01	8.048E 01	6.855E 01	5.729E 01	3.603E 01	2.156E 01	1.934E 01

FLIGHT NO. C-152 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.454E 01	1.366E 01	6.627E 00	4.450E 00	2.218E 00	1.227E 00	1.078E 00
600	3.943E 01	2.494E 01	1.304E 01	8.948E 00	4.558E 00	2.546E 00	2.241E 00
1500	6.200E 01	4.966E 01	3.126E 01	2.276E 01	1.231E 01	7.030E 00	6.215E 00
3000	8.463E 01	7.526E 01	5.467E 01	4.209E 01	2.413E 01	1.405E 01	1.250E 01
4500	8.868E 01	8.461E 01	6.894E 01	5.600E 01	3.434E 01	2.080E 01	1.882E 01

FLIGHT NO. C-152 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.643E 01	8.864E 00	4.250E 00	2.868E 00	1.472E 00	8.420E-01	7.434E-01
600	2.876E 01	1.728E 01	8.806E 00	6.045E 00	3.155E 00	1.819E 00	1.609E 00
1500	4.735E 01	3.596E 01	2.158E 01	1.557E 01	8.541E 00	5.045E 00	4.481E 00
3000	6.029E 01	5.180E 01	3.562E 01	2.701E 01	1.559E 01	9.474E 00	8.469E 00
4500	6.749E 01	6.160E 01	4.665E 01	3.687E 01	2.237E 01	1.407E 01	1.276E 01

FLIGHT NO. C-152 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.101E 01	5.805E 00	2.767E 00	1.869E 00	9.748E-01	5.940E-01	5.448E-01
600	1.962E 01	1.130E 01	5.650E 00	3.868E 00	2.044E 00	1.253E 00	1.150E 00
1500	3.350E 01	2.404E 01	1.387E 01	9.905E 00	5.458E 00	3.402E 00	3.132E 00
3000	3.973E 01	3.367E 01	2.269E 01	1.711E 01	9.966E 00	6.324E 00	5.836E 00
4500	4.272E 01	3.889E 01	2.914E 01	2.293E 01	1.399E 01	9.070E 00	8.441E 00

FLIGHT NO. C-152
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-152 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.602E 01	2.130E 01	1.110E 01	7.859E 00	4.237F 00	1.800E 00	1.235E 00
600	5.413E 01	3.743E 01	2.150E 01	1.567E 01	8.701E 00	3.747E 00	2.578E 00
1500	7.912E 01	6.882E 01	4.914E 01	3.877F 01	2.364E 01	1.038E 01	6.797E 00
3000	1.109F 02	1.045E 02	8.657E 01	7.347E 01	4.982E 01	2.207E 01	1.283E 01
4500	1.212E 02	1.212E 02	1.123E 02	1.017E 02	7.649F 01	3.600E 01	1.934E 01

FLIGHT NO. C-152 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.104E 01	1.775E 01	9.187E 00	6.564E 00	3.637E 00	1.582E 00	1.078E 00
600	4.986E 01	3.240E 01	1.808F 01	1.320E 01	7.473E 00	3.284E 00	2.241E 00
1500	8.366E 01	6.824E 01	4.583E 01	3.563F 01	2.174E 01	9.619E 00	6.215E 00
3000	1.261E 02	1.146E 02	8.938E 01	7.410E 01	4.948E 01	2.187E 01	1.250E 01
4500	1.306E 02	1.301E 02	1.163E 02	1.032F 02	7.613E 01	3.566F 01	1.882E 01

FLIGHT NO. C-152 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.213E 01	1.233F 01	6.377E 00	4.617E 00	2.632E 00	1.113E 00	7.434E-01
600	3.874E 01	2.404E 01	1.321E 01	9.733E 00	5.642F 00	2.404E 00	1.609E 00
1500	6.300E 01	4.950E 01	3.216E 01	2.492E 01	1.537E 01	6.725E 00	4.481E 00
3000	7.776E 01	6.936E 01	5.212E 01	4.254E 01	2.851E 01	1.295E 01	8.469E 00
4500	8.549E 01	8.112E 01	6.718E 01	5.753E 01	4.162E 01	1.993E 01	1.276E 01

FLIGHT NO. C-152 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.238E 01	6.729E 00	3.393E 00	2.398F 00	1.395E 00	7.816E-01	5.448E-01
600	2.207E 01	1.309E 01	6.927E 00	4.962E 00	2.924E 00	1.648E 00	1.150E 00
1500	3.765E 01	2.785E 01	1.700E 01	1.272F 01	7.825E 00	4.474E 00	3.132E 00
3000	4.454E 01	3.890F 01	2.781E 01	2.201E 01	1.437E 01	8.312E 00	5.836E 00
4500	4.774E 01	4.486E 01	3.569E 01	2.949E 01	2.027E 01	1.201E 01	8.441E 00

FLIGHT NO. C-152
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-152 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.023E 01	1.749E 01	8.637E 00	5.797E 00	2.841E 00	1.493E 00	1.235E 00
600	4.543E 01	3.074E 01	1.673E 01	1.156E 01	5.834E 00	3.108E 00	2.578E 00
1500	6.155E 01	5.302E 01	3.599E 01	2.684E 01	1.469E 01	8.120E 00	6.797E 00
3000	7.650E 01	7.100E 01	5.562E 01	4.435E 01	2.628E 01	1.512E 01	1.283E 01
4500	8.423E 01	8.092E 01	6.911E 01	5.802E 01	3.697E 01	2.244E 01	1.934E 01

FLIGHT NO. C-152 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.504E 01	1.399E 01	6.849E 00	4.634E 00	2.345E 00	1.284E 00	1.078E 00
600	4.023E 01	2.553E 01	1.348E 01	9.318E 00	4.819E 00	2.665E 00	2.241E 00
1500	6.299E 01	5.062E 01	3.212E 01	2.355E 01	1.291E 01	7.328E 00	6.215E 00
3000	8.520E 01	7.592E 01	5.539E 01	4.286E 01	2.487E 01	1.452E 01	1.250E 01
4500	8.854E 01	8.461E 01	6.916E 01	5.644E 01	3.500E 01	2.149E 01	1.882E 01

FLIGHT NO. C-152 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.689E 01	9.151E 00	4.437E 00	3.019E 00	1.569E 00	8.897E-01	7.434E-01
600	2.956E 01	1.784E 01	9.195E 00	6.363E 00	3.364E 00	1.922E 00	1.609E 00
1500	4.786E 01	3.662E 01	2.225E 01	1.619E 01	9.000E 00	5.294E 00	4.481E 00
3000	5.874E 01	5.105E 01	3.568E 01	2.727E 01	1.600E 01	9.793E 00	8.469E 00
4500	6.581E 01	6.057E 01	4.658E 01	3.717E 01	2.301E 01	1.461E 01	1.276E 01

FLIGHT NO. C-152 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.146E 01	6.114E 00	2.961E 00	2.027E 00	1.076E 00	6.367E-01	5.448E-01
600	2.043E 01	1.190E 01	6.046E 00	4.194E 00	2.255E 00	1.343E 00	1.150E 00
1500	3.483E 01	2.530E 01	1.484E 01	1.075E 01	6.035E 00	3.652E 00	3.132E 00
3000	4.119E 01	3.537E 01	2.433E 01	1.862E 01	1.109E 01	6.828E 00	5.836E 00
4500	4.449E 01	4.102E 01	3.138E 01	2.509E 01	1.571E 01	9.877E 00	8.441E 00

FLIGHT NO. C-152
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-152 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.323E 00	5.839E-01	2.163E-01	1.230E-01	4.122E-02	1.455E-02	1.201E-02
600	3.782E 00	1.502E 00	5.065E-01	2.786E-01	9.042E-02	3.147E-02	2.591E-02
1500	3.884E 01	8.287E 00	1.908E 00	9.299E-01	2.730E-01	9.195E-02	7.571E-02
3000	7.718E 02	4.684E 01	5.641E 00	2.299E 00	5.926E-01	1.948E-01	1.623E-01
4500	1.676E 04	2.314E 02	1.325E 01	4.549E 00	1.015E 00	3.265E-01	2.760E-01

FLIGHT NO. C-152 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.018E 00	4.570E-01	1.720E-01	9.847E-02	3.320E-02	1.710E-02	1.045E-02
600	2.621E 00	1.103E 00	3.888E-01	2.173E-01	7.160E-02	2.582E-02	2.227E-02
1500	1.904E 01	5.257E 00	1.409E 00	7.180E-01	2.197E-01	7.760E-02	6.683E-02
3000	2.297E 02	2.451E 01	4.026E 00	1.778E 00	4.923E-01	1.720E-01	1.489E-01
4500	2.566E 03	8.804E 01	8.356E 00	3.256E 00	8.109E-01	2.815E-01	2.469E-01

FLIGHT NO. C-152 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	7.350E-01	3.324E-01	1.252E-01	7.129E-02	2.342E-02	8.428E-03	7.217E-03
600	1.855E 00	8.049E-01	2.890E-01	1.616E-01	5.213E-02	1.861E-02	1.591E-02
1500	1.039E 01	3.387E 00	9.979E-01	5.203E-01	1.578E-01	5.502E-02	4.714E-02
3000	7.089E 01	1.177E 01	2.475E 00	1.165E 00	3.253E-01	1.108E-01	9.623E-02
4500	4.652E 02	3.346E 01	4.734E 00	2.026E 00	5.215E-01	1.763E-01	1.560E-01

FLIGHT NO. C-152 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.650E-01	1.181E-01	4.506E-02	2.542E-02	9.027E-03	3.995E-03	3.835E-03
600	6.255E-01	2.715E-01	9.996E-02	5.561E-02	1.948E-02	8.566E-03	8.215E-03
1500	2.957E 00	1.057E 00	3.333E-01	1.762E-01	5.816E-02	2.470E-02	2.348E-02
3000	1.820E 01	3.759E 00	8.757E-01	4.260E-01	1.270E-01	5.037E-02	4.691E-02
4500	9.765E 01	9.860E 00	1.658E 00	7.425E-01	2.058E-01	7.861E-02	7.257E-02

FLIGHT NO. C-152
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-152 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.007E-01	2.302E-01	9.542E-02	6.024E-02	2.757E-02	1.407E-02	1.201E-02
600	1.432E 00	5.921E-01	2.235E-01	1.365E-01	6.048E-02	3.043E-02	2.591E-02
1500	1.541E 01	3.393E 00	8.685E-01	4.711E-01	1.870E-01	8.951E-02	7.571E-02
3000	3.377E 02	2.107E 01	2.791E 00	1.273E 00	4.316E-01	1.929E-01	1.623E-01
4500	7.562E 03	1.090E 02	6.985E 00	2.668E 00	7.771E-01	3.280E-01	2.760E-01

FLIGHT NO. C-152 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.546E-01	1.667E-01	7.131E-02	4.595E-02	2.199E-02	1.194E-02	1.045E-02
600	9.126E-01	4.021E-01	1.612E-01	1.014E-01	4.742E-02	2.548E-02	2.227E-02
1500	7.050E 00	2.016E 00	6.094E-01	3.501E-01	1.499E-01	7.706E-02	6.683E-02
3000	9.585E 01	1.052E 01	1.924E 00	9.622E-01	3.610E-01	1.734E-01	1.489E-01
4500	1.094E 03	3.931E 01	4.225E 00	1.858E 00	6.229E-01	2.869E-01	2.469E-01

FLIGHT NO. C-152 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.129E-01	1.016E-01	4.448E-02	2.913E-02	1.452E-02	8.194E-03	7.217E-03
600	5.373E-01	2.460E-01	1.027E-01	6.602E-02	3.231E-02	1.809E-02	1.591E-02
1500	3.064E 00	1.053E 00	3.589E-01	2.158E-01	9.894E-02	5.388E-02	4.714E-02
3000	2.199E 01	3.836E 00	9.229E-01	5.040E-01	2.106E-01	1.106E-01	9.623E-02
4500	1.516E 02	1.139E 01	1.844E 00	9.136E-01	3.501E-01	1.787E-01	1.560E-01

FLIGHT NO. C-152 FILTER NO. 4

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	9.786E-02	4.673E-02	2.070E-02	1.365E-02	6.950E-03	4.189E-03	3.835E-03
600	2.310E-01	1.074E-01	4.591E-02	2.985E-02	1.499E-02	8.983E-03	8.215E-03
1500	1.049E 00	4.034E-01	1.491E-01	9.225E-02	4.414E-02	2.580E-02	2.348E-02
3000	5.825E 00	1.305E 00	3.647E-01	2.087E-01	9.266E-02	5.199E-02	4.691E-02
4500	3.217E 01	3.467E 00	6.894E-01	3.625E-01	1.488E-01	8.058E-02	7.257E-02

FLIGHT NO. C-152
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-152 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.990E-01	2.820E-01	1.241F-01	8.314E-02	4.243E-02	1.758E-02	1.201E-02
600	1.713E 00	7.254E-01	2.907E-01	1.883E-01	9.308E-02	3.802E-02	2.591E-02
1500	1.994E 01	4.439E 00	1.201E 00	6.930E-01	3.106E-01	1.186E-01	7.571E-02
3000	4.943E 02	3.134E 01	4.403E 00	2.147E 00	8.442E-01	2.921E-01	1.623E-01
4500	1.093E 04	1.640E 02	1.144E 01	4.739E 00	1.650E 00	5.477E-01	2.760E-01

FLIGHT NO. C-152 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.484E-01	2.165E-01	9.886E-02	6.777E-02	3.605E-02	1.540E-02	1.045E-02
600	1.154E 00	5.224E-01	2.235E-01	1.496E-01	7.774E-02	3.286E-02	2.227E-02
1500	9.512E 00	2.770E 00	8.932E-01	5.480E-01	2.649E-01	1.054E-01	6.683E-02
3000	1.428E 02	1.602E 01	3.146F 00	1.694E 00	7.402E-01	2.699E-01	1.489E-01
4500	1.610E 03	6.044E 01	7.129E 00	3.422E 00	1.381E 00	4.918E-01	2.469E-01

FLIGHT NO. C-152 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.868E-01	1.413E-01	6.675E-02	4.690E-02	2.595E-02	1.083E-02	7.217E-03
600	7.237E-01	3.422E-01	1.541E-01	1.063E-01	5.777E-02	2.391E-02	1.591E-02
1500	4.076E 00	1.449E 00	5.349E-01	3.454E-01	1.780E-01	7.181E-02	4.714E-02
3000	2.836E 01	5.136E 00	1.350E 00	7.938F-01	3.851E-01	1.511E-01	9.623E-02
4500	1.920E 02	1.500E 01	2.656E 00	1.425E 00	6.512E-01	2.532E-01	1.560E-01

FLIGHT NO. C-152 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.101E-01	5.417E-02	2.538E-02	1.751E-02	9.944E-03	5.513E-03	3.835E-03
600	2.598E-01	1.245E-01	5.630E-02	3.830F-02	2.146E-02	1.182E-02	8.215E-03
1500	1.179F 00	4.672E-01	1.828E-01	1.184E-01	6.328E-02	3.393E-02	2.348E-02
3000	6.530E 00	1.508E 00	4.469E-01	2.684E-01	1.336E-01	6.834E-02	4.691E-02
4500	3.595E 01	3.999E 00	8.444E-01	4.662E-01	2.155E-01	1.067E-01	7.257E-02

FLIGHT NO. C-152
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-152 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.027E-01	2.316E-01	9.660E-02	6.132E-02	2.845E-02	1.459E-02	1.201E-02
600	1.437E 00	5.957E-01	2.262E-01	1.389E-01	6.241E-02	3.154E-02	2.591E-02
1500	1.551E 01	3.420E 00	8.798E-01	4.798E-01	1.930E-01	9.279E-02	7.571E-02
3000	3.410E 02	2.129E 01	2.829E 00	1.296E 00	4.453E-01	2.001E-01	1.623E-01
4500	7.595E 03	1.095E 02	7.042E 00	2.703E 00	7.976E-01	3.413E-01	2.760E-01

FLIGHT NO. C-152 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.618E-01	1.707E-01	7.370E-02	4.785E-02	2.325E-02	1.250E-02	1.045E-02
600	9.311E-01	4.117E-01	1.666E-01	1.056E-01	5.013E-02	2.667E-02	2.227E-02
1500	7.162E 00	2.055E 00	6.260E-01	3.621E-01	1.573E-01	8.033E-02	6.683E-02
3000	9.649E 01	1.061E 01	1.949E 00	9.799E-01	3.721E-01	1.792E-01	1.489E-01
4500	1.092E 03	3.931E 01	4.238E 00	1.872E 00	6.347E-01	2.964E-01	2.469E-01

FLIGHT NO. C-152 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.188E-01	1.049E-01	4.645E-02	3.067E-02	1.548E-02	8.659E-03	7.217E-03
600	5.521E-01	2.540E-01	1.072E-01	6.949E-02	3.444E-02	1.912E-02	1.591E-02
1500	3.097E 00	1.072E 00	3.702E-01	2.244E-01	1.043E-01	5.653E-02	4.714E-02
3000	2.142E 01	3.780E 00	9.243E-01	5.089E-01	2.161E-01	1.143E-01	9.623E-02
4500	1.478E 02	1.120E 01	1.842E 00	9.208E-01	3.600E-01	1.856E-01	1.560E-01

FLIGHT NO. C-152 FILTER NO. 4

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.019E-01	4.922E-02	2.215E-02	1.480E-02	7.669E-03	4.490E-03	3.835E-03
600	2.405E-01	1.131E-01	4.913E-02	3.238E-02	1.655E-02	9.629E-03	8.215E-03
1500	1.091E 00	4.245E-01	1.596E-01	1.001E-01	4.880E-02	2.770E-02	2.348E-02
3000	6.039E 00	1.371E 00	3.910E-01	2.271E-01	1.031E-01	5.613E-02	4.691E-02
4500	3.351E 01	3.657E 00	7.423E-01	3.966E-01	1.671E-01	8.775E-02	7.257E-02

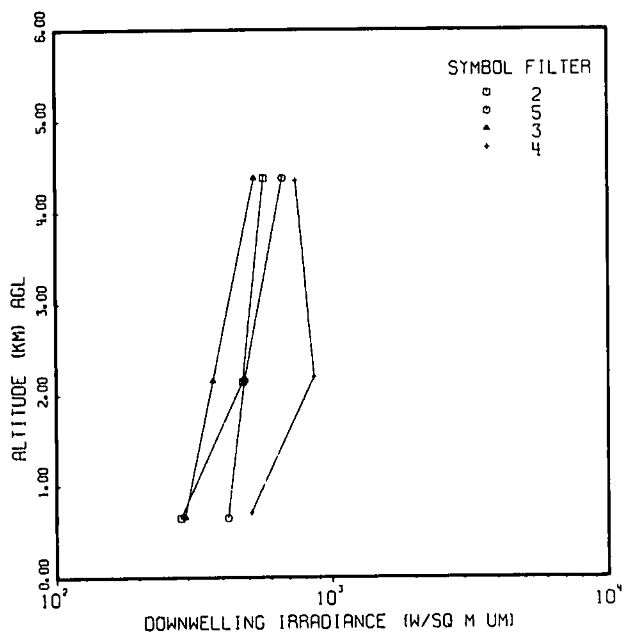
FLIGHT C-154 – 28 OCTOBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

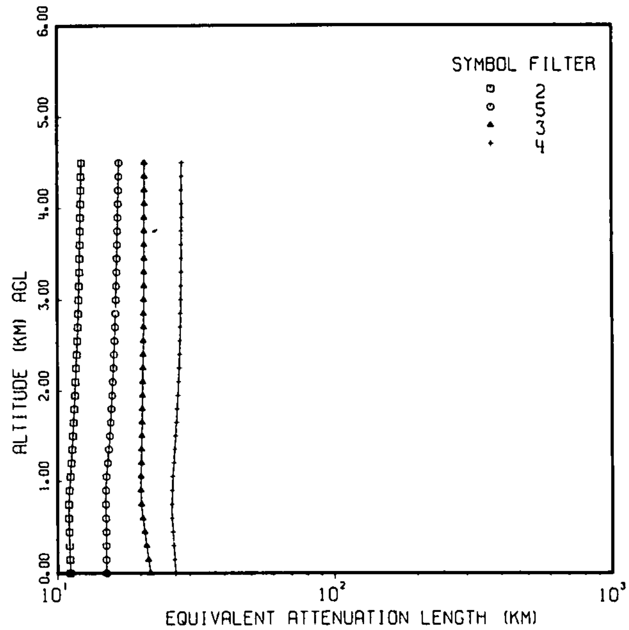
It was a sunlit morning flight. The day was clear with a light haze on the horizon. The flight was conducted over a broad desert valley on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0852 local time (1552 GMT) and continued until 1245 local time (1945 GMT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 5 was 63.2 degrees at the start and 52.6 degrees at the end. For Filter 4 the sun zenith angle was 47.1 degrees at the start, 46.9 degrees through noon, and 48.3 degrees at the end. The highest flight altitude was 4425 meters AGL.

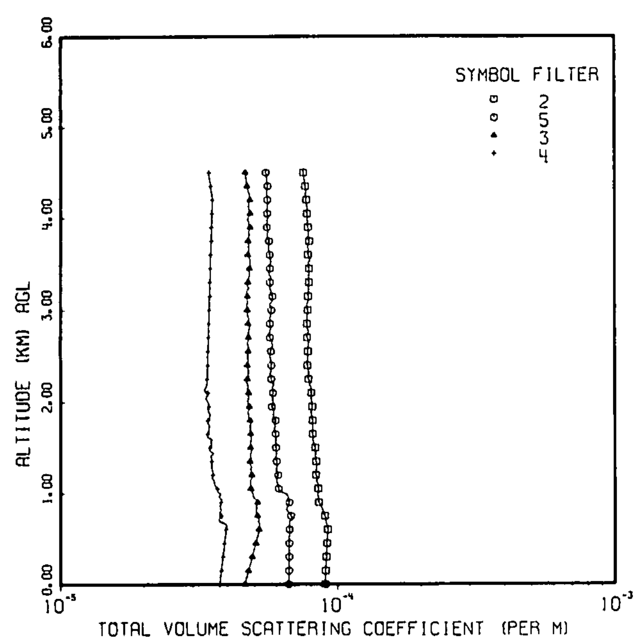
> At the beginning of the data-taking, Stallion was reporting clear skies with 40 mile (64 kilometer) visibility. The ground station reported clear and sunny.
>
> During the flight, the aircrew reported that it was clear and sunny with a light haze on the horizon. At 1632 GMT, at an altitude of 2210 meters, it was clear above and there was still some light haze visible on the horizon. At 1935 GMT, the sun was to the left front of the aircraft heading.
>
> At the end of data collection, Stallion was still reporting clear skies and 40 mile (64 kilometer) visibility.

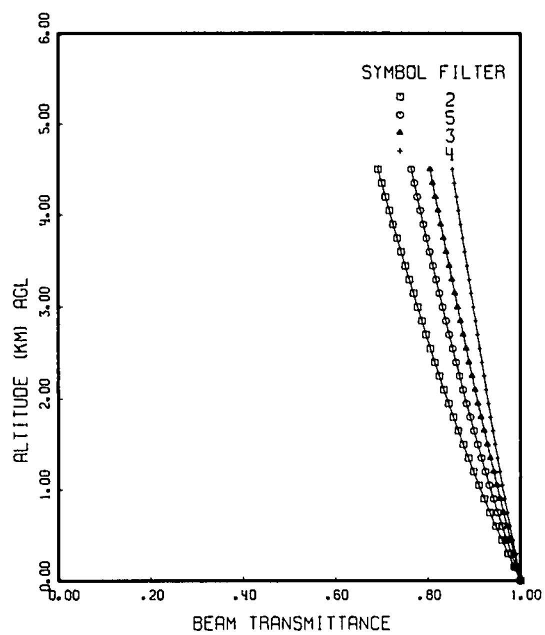
At the surface there was high pressure over the area with a weak northerly flow. This high pressure cell covered the western two-thirds of the United States. There were high centers in western Texas and central Idaho. There was a strong northerly flow at 500 millibars which resulted from a ridge that covered the Pacific coast states and a trough from a cold low over the Dakotas southward to Texas. The airmass was unstable continental polar.

FLIGHT NO. C-154

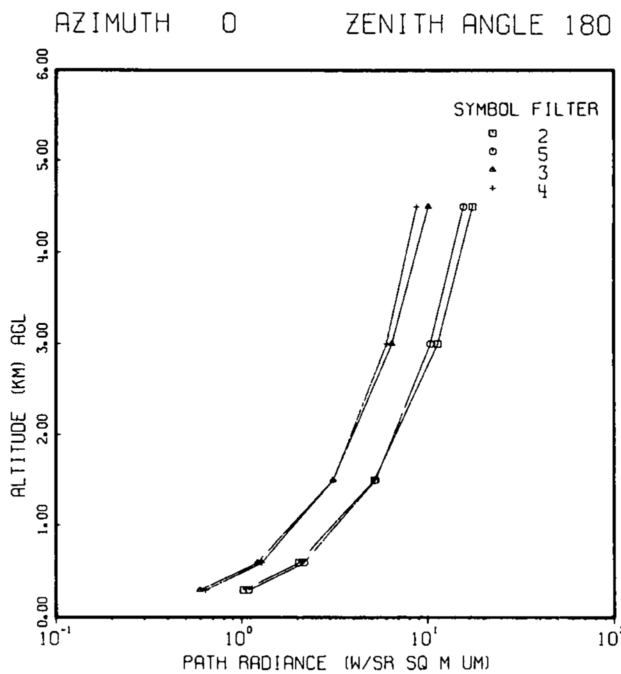


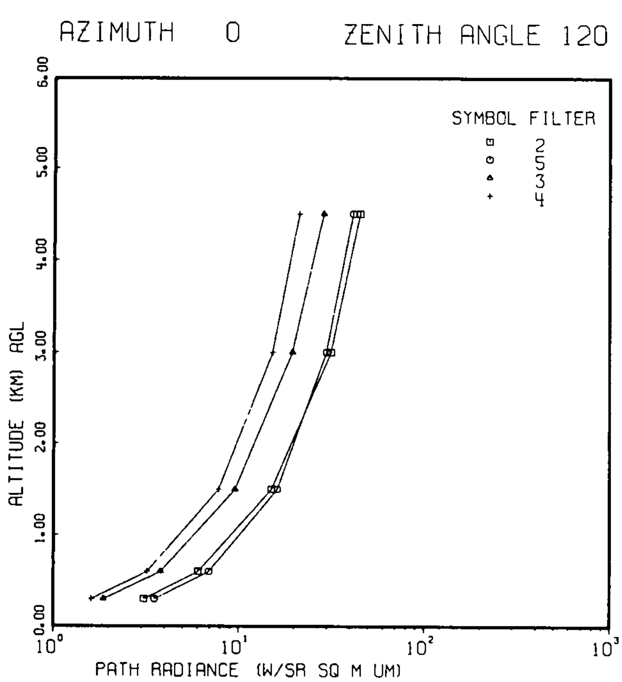


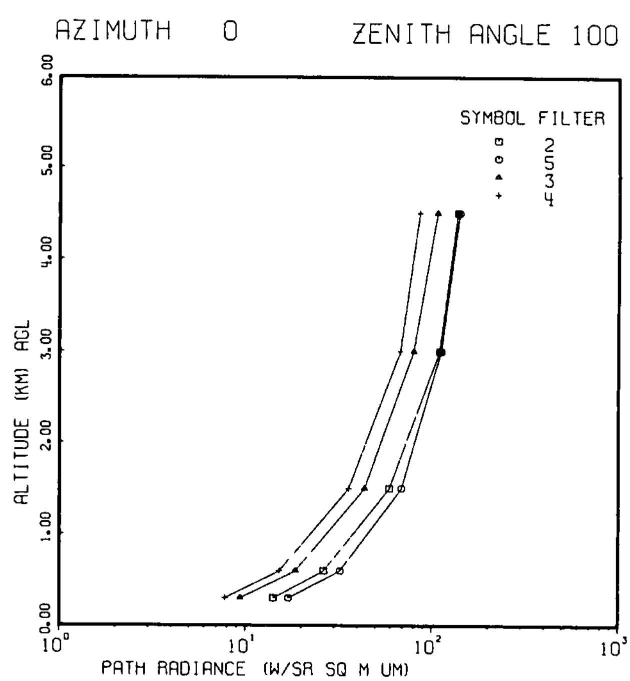




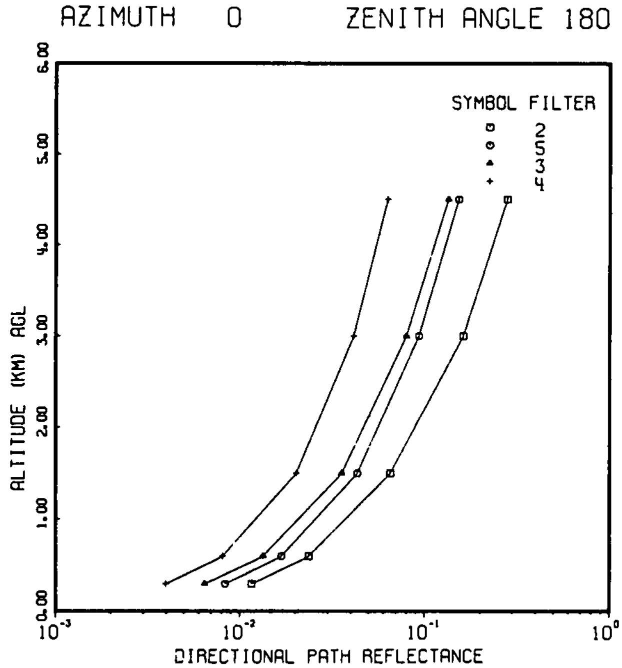
FLIGHT NO. C-154

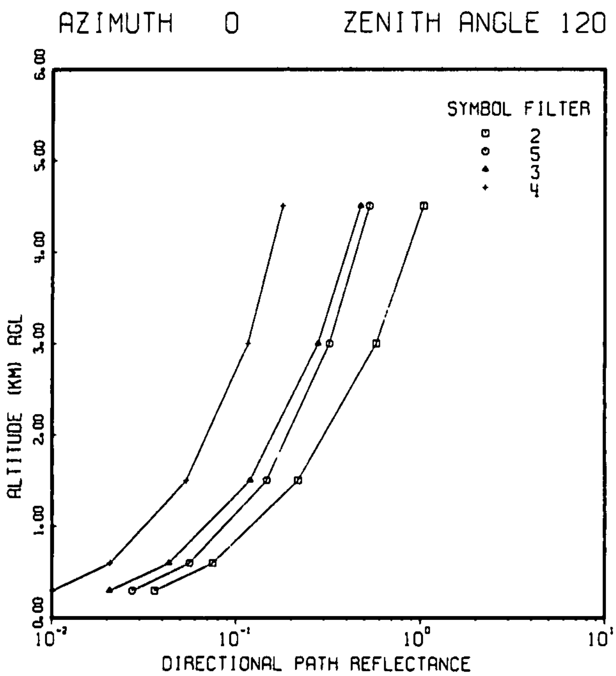


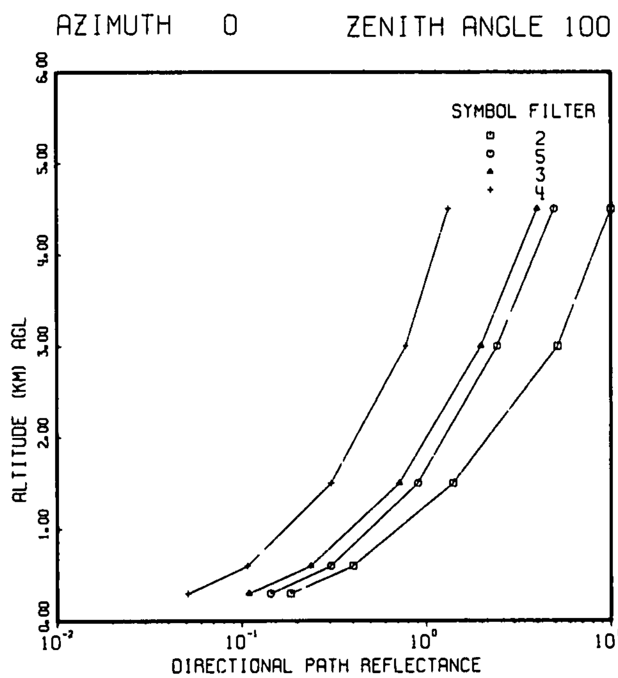




FLIGHT NO. C-154







FLIGHT NO. C-154
IRRADIANCE

FLIGHT NO.C-154 FILTER NO. 2
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
645	2.836E 02	4.543E 01	.160	7.008E 02	1.112E 02	8.120E 02	.159
2144	4.750E 02	7.774E 01	.164	1.130E 03	1.948E 02	1.325F 03	.172
4375	5.688E 02	1.047F 02	.184	1.179E 03	2.667E 02	1.446E 03	.226

FLIGHT NO.C-154 FILTER NO. 5
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
645	4.200E 02	6.490E 01	.155	1.073E 03	1.581E 02	1.231E 03	.147
2154	4.825E 02	1.064E 02	.221	1.164E 03	2.374E 02	1.401E 03	.204
4375	6.658E 02	1.362E 02	.205	1.312E 03	2.969E 02	1.609E 03	.226

FLIGHT NO.C-154 FILTER NO. 3
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
652	2.936E 02	8.112E 01	.276	6.867E 02	1.714E 02	8.580E 02	.250
2152	3.711E 02	9.719E 01	.262	8.673E 02	2.072E 02	1.074F 03	.239
4375	5.256F 02	1.192F 02	.227	1.036F 03	2.453E 02	1.282E 03	.237

FLIGHT NO.C-154 FILTER NO. 4
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
700	5.103E 02	1.310F 02	.257	8.684E 02	2.578E 02	1.126E 03	.297
2196	8.610F 02	1.293E 02	.150	1.405E 03	2.495E 02	1.654E 03	.178
4350	7.428E 02	1.283E 02	.173	1.132E 03	2.491E 02	1.381E 03	.220

FLIGHT NO. C-154
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-154
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH	FILTERS			
ANGLE	2	5	3	4
93	.28515	.26310	.32771	.20897
95	.15232	.19201	.18046	.16402
100	.13943	.19898	.16603	.16835
105	.13332	.14848	.15528	.18984
120	.12774	.14295	.17280	.20153
150	.11594	.13352	.20612	.23343
180	.13540	.14243	.21877	.22813

FLIGHT NO. C-154
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH	FILTERS			
ANGLE	2	5	3	4
93	.37815	.34472	.35854	.20189
95	.22362	.24145	.31837	.19215
100	.16204	.16615	.26529	.20445
105	.14650	.14958	.25624	.23347
120	.14835	.10886	.24940	.22990
150	.12601	.13127	.24100	.21325
180	.13540	.14243	.21877	.22813

FLIGHT NO. C-154
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH	FILTERS			
ANGLE	2	5	3	4
93	.68759	.45065	.48755	.25249
95	.33451	.41108	.48709	.24640
100	.29890	.28977	.45319	.30611
105	.28990	.30185	.50389	.29900
120	.28976	.22351	.47326	.36816
150	.16890	.16919	.31616	.27895
180	.13540	.14243	.21877	.22813

FLIGHT NO. C-154
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH	FILTERS			
ANGLE	2	5	3	4
93	.24324	.31485	.26957	.21360
95	.18833	.31862	.30799	.21249
100	.15133	.26061	.26759	.24879
105	.12871	.21490	.27960	.26375
120	.15245	.18833	.29479	.28170
150	.13258	.14374	.25379	.25525
180	.13540	.14243	.21877	.22813

FLIGHT NO. C-154
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102870 FLIGHT NO. C-154 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
0	8.990E-05	6.660E-05	4.620E-05	3.750E-05
30	9.001E-05	6.662E-05	4.650E-05	3.761E-05
60	9.012E-05	6.663E-05	4.679E-05	3.771E-05
90	9.024E-05	6.665E-05	4.709E-05	3.782E-05
120	9.035E-05	6.667E-05	4.739E-05	3.792E-05
150	9.046E-05	6.669E-05	4.769E-05	3.803E-05
180	9.057E-05	6.670E-05	4.798E-05	3.814E-05
210	9.068E-05	6.672E-05	4.828E-05	3.824E-05
240	9.080E-05	6.674E-05	4.858E-05	3.835E-05
270	9.091E-05	6.676E-05	4.887E-05	3.845E-05
300	9.102E-05	6.677E-05	4.917E-05	3.856E-05
330	9.113E-05	6.679E-05	4.947E-05	3.867E-05
360	9.124E-05	6.681E-05	4.977E-05	3.877E-05
390	9.136E-05	6.683E-05	5.006E-05	3.888E-05
420	9.147E-05	6.684E-05	5.036E-05	3.898E-05
450	9.158E-05	6.686E-05	5.066E-05	3.909E-05
480	9.169E-05	6.688E-05	5.095E-05	3.920E-05
510	9.180E-05	6.690E-05	5.125E-05	3.930E-05
540	9.192E-05	6.691E-05	5.155E-05	3.941E-05
570	9.203E-05	6.693E-05	5.185E-05	3.951E-05
600	9.214E-05	6.695E-05	5.207E-05	3.962E-05
630	9.225E-05	6.697E-05	5.238E-05	3.973E-05
660	9.125E-05	6.698E-05	5.228E-05	3.962E-05
690	9.045E-05	6.700E-05	5.176E-05	3.746E-05
720	9.090E-05	6.887E-05	5.195E-05	3.733E-05
750	8.989E-05	6.787E-05	5.137E-05	3.820E-05
780	8.909E-05	6.706E-05	5.077E-05	3.720E-05
810	8.826E-05	6.558E-05	5.095E-05	3.799E-05
840	8.771E-05	6.562E-05	5.107E-05	3.770E-05
870	8.716E-05	6.647E-05	5.081E-05	3.759E-05
900	8.549E-05	6.686E-05	5.151E-05	3.794E-05
930	8.549E-05	6.596E-05	5.075E-05	3.825E-05
960	8.513E-05	6.632E-05	4.957E-05	3.707E-05
990	8.453E-05	6.551E-05	4.952E-05	3.787E-05
1020	8.521E-05	6.175E-05	4.889E-05	3.683E-05
1050	8.491E-05	6.124E-05	4.859E-05	3.677E-05
1080	8.538E-05	6.144E-05	4.855E-05	3.602E-05
1110	8.466E-05	6.047E-05	4.839E-05	3.579E-05
1140	8.363E-05	6.017E-05	4.834E-05	3.580E-05
1170	8.484E-05	6.034E-05	4.898E-05	3.512E-05
1200	8.346E-05	6.096E-05	4.900E-05	3.550E-05
1230	8.380E-05	6.036E-05	4.865E-05	3.539E-05
1260	8.370E-05	6.006E-05	4.853E-05	3.522E-05
1290	8.396E-05	6.037E-05	4.891E-05	3.510E-05
1320	8.384E-05	6.043E-05	4.834E-05	3.536E-05
1350	8.366E-05	6.031E-05	4.835E-05	3.514E-05
1380	8.316E-05	5.991E-05	4.883E-05	3.502E-05
1410	8.294E-05	5.991E-05	4.861E-05	3.486E-05
1440	8.332E-05	6.019E-05	4.862E-05	3.574E-05
1470	8.260E-05	5.993E-05	4.898E-05	3.444E-05
1500	8.307E-05	5.987E-05	4.853E-05	3.461E-05

FLIGHT NO. C-154
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102870 FLIGHT NO. C-154 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
1530	8.233E-05	6.006E-05	4.876E-05	3.523E-05
1560	8.186E-05	5.986E-05	4.863E-05	3.483E-05
1590	8.124E-05	6.006E-05	4.891E-05	3.528E-05
1620	8.195E-05	5.958E-05	4.858E-05	3.381E-05
1650	8.135E-05	5.975E-05	4.860E-05	3.398E-05
1680	8.140E-05	5.935E-05	4.834E-05	3.435E-05
1710	8.143E-05	5.907E-05	4.840E-05	3.428E-05
1740	8.122E-05	5.969E-05	4.829E-05	3.458E-05
1770	8.103E-05	5.904E-05	4.867E-05	3.414E-05
1800	8.125E-05	5.976E-05	4.842E-05	3.404E-05
1830	8.087E-05	5.883E-05	4.790E-05	3.445E-05
1860	8.074E-05	5.883E-05	4.788E-05	3.474E-05
1890	8.024E-05	5.883E-05	4.752E-05	3.440E-05
1920	8.054E-05	5.889E-05	4.799E-05	3.404E-05
1950	8.113E-05	5.796E-05	4.811E-05	3.434E-05
1980	8.089E-05	5.902E-05	4.777E-05	3.431E-05
2010	8.081E-05	5.843E-05	4.736E-05	3.397E-05
2040	8.040E-05	5.849E-05	4.782E-05	3.349E-05
2070	8.057E-05	5.806E-05	4.771E-05	3.383E-05
2100	8.057E-05	5.859E-05	4.787E-05	3.412E-05
2130	8.009E-05	5.919E-05	4.742E-05	3.292E-05
2160	8.047E-05	5.807E-05	4.762E-05	3.357E-05
2190	7.924E-05	5.892E-05	4.761E-05	3.383E-05
2220	7.967E-05	5.805E-05	4.695E-05	3.386E-05
2250	7.869E-05	5.779E-05	4.732E-05	3.388E-05
2280	7.828E-05	5.770E-05	4.775E-05	3.390E-05
2310	7.875E-05	5.712E-05	4.771E-05	3.393E-05
2340	7.863E-05	5.749E-05	4.782E-05	3.395E-05
2370	7.844E-05	5.738E-05	4.736E-05	3.397E-05
2400	7.797E-05	5.781E-05	4.734E-05	3.400E-05
2430	7.800E-05	5.779E-05	4.767E-05	3.402E-05
2460	7.806E-05	5.744E-05	4.760E-05	3.404E-05
2490	7.838E-05	5.707E-05	4.740E-05	3.407E-05
2520	7.774E-05	5.719E-05	4.752E-05	3.409E-05
2550	7.825E-05	5.758E-05	4.770E-05	3.411E-05
2580	7.800E-05	5.784E-05	4.806E-05	3.414E-05
2610	7.858E-05	5.837E-05	4.771E-05	3.416E-05
2640	7.881E-05	5.823E-05	4.736E-05	3.418E-05
2670	7.892E-05	5.789E-05	4.769E-05	3.421E-05
2700	7.784E-05	5.710E-05	4.778E-05	3.423E-05
2730	7.745E-05	5.655E-05	4.755E-05	3.425E-05
2760	7.863E-05	5.688E-05	4.775E-05	3.428E-05
2790	7.800E-05	5.737E-05	4.795E-05	3.430E-05
2820	7.751E-05	5.745E-05	4.828E-05	3.432E-05
2850	7.759E-05	5.715E-05	4.759E-05	3.435E-05
2880	7.751E-05	5.705E-05	4.781E-05	3.437E-05
2910	7.772E-05	5.725E-05	4.786E-05	3.439E-05
2940	7.758E-05	5.734E-05	4.737E-05	3.442E-05
2970	7.820E-05	5.727E-05	4.730E-05	3.444E-05
3000	7.812E-05	5.779E-05	4.730E-05	3.446E-05

FLIGHT NO. C-154
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 102870 FLIGHT NO. C-154 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
3030	7.743E-05	5.808E-05	4.713E-05	3.449E-05
3060	7.751E-05	5.681E-05	4.712E-05	3.451E-05
3090	7.802E-05	5.773E-05	4.737E-05	3.453E-05
3120	7.879E-05	5.817E-05	4.723E-05	3.456E-05
3150	7.831E-05	5.830E-05	4.728E-05	3.458E-05
3180	7.823E-05	5.757E-05	4.714E-05	3.461E-05
3210	7.879E-05	5.763E-05	4.714E-05	3.463E-05
3240	7.862E-05	5.674E-05	4.792E-05	3.465E-05
3270	7.848E-05	5.744E-05	4.718E-05	3.468E-05
3300	7.897E-05	5.710E-05	4.757E-05	3.470E-05
3330	7.877E-05	5.731E-05	4.769E-05	3.472E-05
3360	7.893E-05	5.759E-05	4.808E-05	3.475E-05
3390	7.900E-05	5.642E-05	4.821E-05	3.477E-05
3420	7.887E-05	5.689E-05	4.799E-05	3.479E-05
3450	7.903E-05	5.709E-05	4.819E-05	3.482E-05
3480	7.889E-05	5.692E-05	4.861E-05	3.484E-05
3510	7.856E-05	5.747E-05	4.840E-05	3.486E-05
3540	7.943E-05	5.753E-05	4.853E-05	3.489E-05
3570	7.937E-05	5.709E-05	4.815E-05	3.491E-05
3600	7.838E-05	5.701E-05	4.762E-05	3.493E-05
3630	7.823E-05	5.710E-05	4.813E-05	3.496E-05
3660	7.850E-05	5.636E-05	4.780E-05	3.498E-05
3690	7.803E-05	5.658E-05	4.777E-05	3.500E-05
3720	7.846E-05	5.657E-05	4.787E-05	3.503E-05
3750	7.919E-05	5.667E-05	4.769E-05	3.505E-05
3780	7.834E-05	5.613E-05	4.790E-05	3.507E-05
3810	7.852E-05	5.578E-05	4.815E-05	3.510E-05
3840	7.867E-05	5.612E-05	4.786E-05	3.512E-05
3870	7.882E-05	5.588E-05	4.807E-05	3.514E-05
3900	7.826E-05	5.575E-05	4.853E-05	3.517E-05
3930	7.809E-05	5.588E-05	4.806E-05	3.519E-05
3960	7.806E-05	5.596E-05	4.779E-05	3.521E-05
3990	7.770E-05	5.587E-05	4.740E-05	3.524E-05
4020	7.776E-05	5.627E-05	4.784E-05	3.526E-05
4050	7.767E-05	5.577E-05	4.847E-05	3.528E-05
4080	7.740E-05	5.568E-05	4.821E-05	3.531E-05
4110	7.786E-05	5.583E-05	4.773E-05	3.533E-05
4140	7.753E-05	5.606E-05	4.790E-05	3.535E-05
4170	7.723E-05	5.616E-05	4.796E-05	3.538E-05
4200	7.722E-05	5.592E-05	4.830E-05	3.540E-05
4230	7.716E-05	5.617E-05	4.820E-05	3.529E-05
4260	7.655E-05	5.558E-05	4.813E-05	3.518E-05
4290	7.696E-05	5.575E-05	4.781E-05	3.507E-05
4320	7.669E-05	5.577E-05	4.738E-05	3.496E-05
4350	7.645E-05	5.604E-05	4.723E-05	3.485E-05
4380	7.621E-05	5.587E-05	4.709E-05	3.475E-05
4410	7.598E-05	5.569E-05	4.694E-05	3.464E-05
4440	7.574E-05	5.552E-05	4.679E-05	3.453E-05
4470	7.550E-05	5.535E-05	4.665E-05	3.442E-05
4500	7.527E-05	5.518E-05	4.650E-05	3.432E-05
FIRST DATA ALT	0	0	0	0
LAST DATA ALT	4320	4350	4320	4200

FLIGHT NO. C-154
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-154 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.5929899	.7318103	.8553186	.9004569	.9471707	.9691497	.9732270
600	.3464730	.5325477	.7301562	.8097710	.8965299	.9388869	.9468526
1500	.0722109	.2152796	.4677009	.6005835	.7680353	.8586670	.8763762
3000	.0051274	.0513757	.2353391	.3788382	.6050505	.7481994	.7778499
4500	.0002957	.0120616	.1200158	.2411227	.4788758	.6536972	.6920085

FLIGHT NO. C-154 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.6802812	.7943909	.8911786	.9256144	.9607778	.9771638	.9801927
600	.4594888	.6298650	.7939608	.8565894	.9229976	.9547915	.9607277
1500	.1448037	.3233104	.5719630	.6874040	.8236350	.8940246	.9075434
3000	.0208604	.1132110	.3458867	.4905228	.6916294	.8082596	.8316426
4500	.0026213	.0395388	.2122215	.3534485	.5837090	.7328472	.7640085

FLIGHT NO. C-154 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.7592252	.8482421	.9209191	.9462269	.9717941	.9836169	.9857962
600	.5641438	.7115255	.8437550	.8922709	.9427037	.9665082	.9709293
1500	.2279406	.4212273	.6518630	.7504346	.8619006	.9177749	.9283860
3000	.0469111	.1781806	.4311826	.5687025	.7466537	.8447833	.8640912
4500	.0083274	.0735675	.2854683	.4312411	.6470193	.7777375	.8043751

FLIGHT NO. C-154 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.8027673	.8769862	.9364103	.9568766	.9774404	.9869125	.9886559
600	.6382642	.7657330	.8752603	.9144889	.9547826	.9736387	.9771298
1500	.3271103	.5204655	.7238822	.8050960	.8938470	.9372637	.9454348
3000	.1050899	.2812076	.5386225	.6604200	.8067372	.8833885	.8981855
4500	.0296220	.1472172	.3985238	.5394296	.7265060	.8315463	.8523532

FLIGHT NO. C-154
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-154 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.783E 01	3.188E 01	1.416E 01	8.524E 00	3.093E 00	1.204E 00	1.022E 00
600	8.660E 01	5.471E 01	2.642E 01	1.629E 01	6.057E 00	2.384E 00	2.028E 00
1500	1.356E 02	1.043E 02	5.920E 01	3.843E 01	1.504E 01	6.065E 00	5.187E 00
3000	1.932E 02	1.666E 02	1.099E 02	7.541E 01	3.148E 01	1.316E 01	1.138E 01
4500	2.011E 02	1.847E 02	1.369E 02	9.878E 01	4.492E 01	1.983E 01	1.749E 01

FLIGHT NO. C-154 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.463E 01	3.949E 01	1.705E 01	1.009E 01	3.519E 00	1.296E 00	1.092E 00
600	1.187E 02	7.016E 01	3.227E 01	1.946E 01	6.909E 00	2.566E 00	2.166E 00
1500	1.764E 02	1.289E 02	6.886E 01	4.344E 01	1.615E 01	6.177E 00	5.261E 00
3000	2.127E 02	1.795E 02	1.123E 02	7.476E 01	2.966E 01	1.197E 01	1.038E 01
4500	2.266E 02	2.022E 02	1.399E 02	9.679E 01	4.120E 01	1.764E 01	1.562E 01

FLIGHT NO. C-154 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.522E 01	2.292E 01	9.422E 00	5.527E 00	1.874E 00	6.861E-01	5.950E-01
600	7.759E 01	4.306E 01	1.862E 01	1.107E 01	3.807E 00	1.403E 00	1.218E 00
1500	1.321E 02	8.898E 01	4.359E 01	2.690E 01	9.589E 00	3.580E 00	3.105E 00
3000	1.784E 02	1.406E 02	7.997E 01	5.177E 01	1.946E 01	7.433E 00	6.453E 00
4500	1.945E 02	1.662E 02	1.066E 02	7.172E 01	2.860E 01	1.142E 01	1.011E 01

FLIGHT NO. C-154 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.937E 01	1.949E 01	7.787E 00	4.535E 00	1.606E 00	6.964E-01	6.379E-01
600	6.889E 01	3.672E 01	1.527E 01	8.992E 00	3.219E 00	1.403E 00	1.286E 00
1500	1.270E 02	7.902E 01	3.584E 01	2.150E 01	7.802E 00	3.408E 00	3.119E 00
3000	1.891E 02	1.351E 02	6.785E 01	4.146E 01	1.523E 01	6.648E 00	6.045E 00
4500	1.836E 02	1.491E 02	8.553E 01	5.441E 01	2.111E 01	9.578E 00	8.751E 00

FLIGHT NO. C-154
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-154 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.529E 01	1.449E 01	7.137E 00	4.789E 00	2.337E 00	1.207E 00	1.022E 00
600	3.786E 01	2.486E 01	1.331E 01	9.151E 00	4.577E 00	2.391E 00	2.028E 00
1500	5.701E 01	4.596E 01	2.915E 01	2.120E 01	1.126E 01	6.071E 00	5.187E 00
3000	7.732E 01	7.011E 01	5.224E 01	4.058E 01	2.330E 01	1.315E 01	1.138E 01
4500	8.032E 01	7.768E 01	6.543E 01	5.409E 01	3.361E 01	1.992E 01	1.749E 01

FLIGHT NO. C-154 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.985E 01	1.642E 01	7.880E 00	5.225E 00	2.494E 00	1.277E 00	1.092E 00
600	4.750E 01	2.917E 01	1.492E 01	1.007E 01	4.896E 00	2.528E 00	2.166E 00
1500	6.864E 01	5.250E 01	3.140E 01	2.229E 01	1.145E 01	6.103E 00	5.261E 00
3000	7.756E 01	6.947E 01	4.963E 01	3.772E 01	2.110E 01	1.189E 01	1.038E 01
4500	7.991E 01	7.622E 01	6.118E 01	4.914E 01	2.957E 01	1.756E 01	1.562E 01

FLIGHT NO. C-154 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.362E 01	7.279E 00	3.470E 00	2.335E 00	1.191E 00	6.756E-01	5.950E-01
600	2.337E 01	1.367E 01	6.856E 00	4.679E 00	2.419E 00	1.381E 00	1.218E 00
1500	3.935E 01	2.799E 01	1.593E 01	1.128E 01	6.055E 00	3.512E 00	3.105E 00
3000	5.224E 01	4.360E 01	2.885E 01	2.152E 01	1.219E 01	7.260E 00	6.453E 00
4500	5.786E 01	5.244E 01	3.886E 01	3.039E 01	1.821E 01	1.124E 01	1.011E 01

FLIGHT NO. C-154 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.242E 01	6.528E 00	3.119E 00	2.129E 00	1.132E 00	6.921E-01	6.379E-01
600	2.174E 01	1.230E 01	6.118E 00	4.222E 00	2.269E 00	1.394E 00	1.286E 00
1500	3.768E 01	2.518E 01	1.384E 01	9.820E 00	5.433E 00	3.390E 00	3.119E 00
3000	4.959E 01	3.882E 01	2.426E 01	1.791E 01	1.035E 01	6.622E 00	6.045E 00
4500	5.021E 01	4.412E 01	3.114E 01	2.400E 01	1.456E 01	9.535E 00	8.751E 00

FLIGHT NO. C-154
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-154 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.929E 01	2.321E 01	1.229E 01	8.763E 00	4.719E 00	1.737E 00	1.022E 00
600	5.884E 01	3.983E 01	2.292E 01	1.675E 01	9.242E 00	3.442E 00	2.028E 00
1500	8.999E 01	7.474E 01	5.106E 01	3.954E 01	2.328E 01	8.859E 00	5.187E 00
3000	1.244E 02	1.167E 02	9.427E 01	7.845E 01	5.055E 01	1.990E 01	1.138E 01
4500	1.290E 02	1.297E 02	1.195F 02	1.067E 02	7.605E 01	3.177E 01	1.749E 01

FLIGHT NO. C-154 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.826E 01	2.748E 01	1.432E 01	1.018E 01	5.469E 00	1.936E 00	1.092E 00
600	7.678E 01	4.883E 01	2.711E 01	1.963E 01	1.074E 01	3.832E 00	2.166E 00
1500	1.133E 02	8.943E 01	5.801E 01	4.415E 01	2.551E 01	9.324E 00	5.261E 00
3000	1.331E 02	1.230E 02	9.535E 01	7.783E 01	4.913E 01	1.875E 01	1.038E 01
4500	1.361E 02	1.356E 02	1.200E 02	1.046E 02	7.275E 01	2.948E 01	1.562E 01

FLIGHT NO. C-154 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.863E 01	1.026E 01	5.247E 00	3.769E 00	2.113E 00	8.903E-01	5.950E-01
600	3.196E 01	1.927E 01	1.037E 01	7.551E 00	4.293E 00	1.820E 00	1.218E 00
1500	5.385E 01	3.948F 01	2.412E 01	1.825E 01	1.078E 01	4.633E 00	3.105E 00
3000	7.140E 01	6.147E 01	4.382E 01	3.494F 01	2.198E 01	9.646E 00	6.453E 00
4500	7.823E 01	7.326E 01	5.892E 01	4.932E 01	3.350E 01	1.524E 01	1.011E 01

FLIGHT NO. C-154 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.373F 01	7.421E 00	3.756E 00	2.689F 00	1.593E 00	8.747E-01	6.379E-01
600	2.403E 01	1.399E 01	7.368E 00	5.333F 00	3.192E 00	1.762E 00	1.286E 00
1500	4.081E 01	2.815E 01	1.644E 01	1.225E 01	7.566E 00	4.246E 00	3.119E 00
3000	5.096E 01	4.157E 01	2.785E 01	2.167E 01	1.405E 01	8.122E 00	6.045E 00
4500	5.107E 01	4.666E 01	3.532E 01	2.871E 01	1.956E 01	1.166E 01	8.751E 00

FLIGHT NO. C-154
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-154 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.574E 01	1.472E 01	7.217E 00	4.831E 00	2.352E 00	1.221E 00	1.022E 00
600	3.854E 01	2.525E 01	1.346E 01	9.232E 00	4.607E 00	2.418E 00	2.028E 00
1500	5.716E 01	4.617E 01	2.926E 01	2.127E 01	1.131E 01	6.144E 00	5.187E 00
3000	7.618E 01	6.926E 01	5.178E 01	4.035E 01	2.335E 01	1.333E 01	1.138E 01
4500	7.979E 01	7.702E 01	6.485E 01	5.374E 01	3.367E 01	2.022E 01	1.749E 01

FLIGHT NO. C-154 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.543E 01	1.688E 01	8.127E 00	5.410E 00	2.602E 00	1.316E 00	1.092E 00
600	4.299E 01	2.999E 01	1.539E 01	1.043E 01	5.108E 00	2.606E 00	2.166E 00
1500	6.802E 01	5.386E 01	3.230E 01	2.300E 01	1.191E 01	6.283E 00	5.261E 00
3000	7.788E 01	7.082E 01	5.069E 01	3.864E 01	2.177E 01	1.223E 01	1.038E 01
4500	7.933E 01	7.715E 01	6.215E 01	5.014E 01	3.046E 01	1.812E 01	1.562E 01

FLIGHT NO. C-154 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.431E 01	7.668E 00	3.680E 00	2.488E 00	1.275E 00	7.109E-01	5.950E-01
600	2.455E 01	1.441E 01	7.271E 00	4.984E 00	2.591E 00	1.453E 00	1.218E 00
1500	4.093E 01	2.925E 01	1.678E 01	1.196E 01	6.465E 00	3.694E 00	3.105E 00
3000	5.334E 01	4.484E 01	3.004E 01	2.257E 01	1.295E 01	7.632E 00	6.453E 00
4500	5.928E 01	5.401E 01	4.051E 01	3.191E 01	1.938E 01	1.185E 01	1.011E 01

FLIGHT NO. C-154 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.224E 01	6.520E 00	3.197E 00	2.227E 00	1.234E 00	7.506E-01	6.379E-01
600	2.142E 01	1.229E 01	6.272E 00	4.415E 00	2.473E 00	1.512E 00	1.286E 00
1500	3.674E 01	2.492E 01	1.407E 01	1.019E 01	5.870E 00	3.644E 00	3.119E 00
3000	4.727E 01	3.766E 01	2.419E 01	1.823E 01	1.095E 01	6.975E 00	6.045E 00
4500	4.849E 01	4.313E 01	3.110E 01	2.442E 01	1.536E 01	1.005E 01	8.751E 00

FLIGHT NO. C-154
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-154 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.080E 00	4.825E-01	1.834E-01	1.048E-01	3.617E-02	1.376E-02	1.163E-02
600	2.768E 00	1.138E 00	4.007E-01	2.228E-01	7.483E-02	2.813E-02	2.373E-02
1500	2.080E 01	5.367E 00	1.402E 00	7.086E-01	2.168E-01	7.823E-02	6.556E-02
3000	4.173E 02	3.592E 01	5.171E 00	2.205E 00	5.762E-01	1.948E-01	1.620E-01
4500	7.532E 03	1.696E 02	1.264E 01	4.537E 00	1.039E 00	3.360E-01	2.800E-01

FLIGHT NO. C-154 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	8.205E-01	3.718E-01	1.431E-01	8.156E-02	2.739E-02	9.919E-03	8.336E-03
600	1.933E 00	8.331E-01	3.040E-01	1.699E-01	5.598E-02	2.010E-02	1.686E-02
1500	9.111E 00	2.982E 00	9.005E-01	4.726E-01	1.467E-01	5.167E-02	4.335E-02
3000	7.624E 01	1.186E 01	2.428E 00	1.140E 00	3.208E-01	1.107E-01	9.338E-02
4500	6.465E 02	3.826E 01	4.930E 00	2.048E 00	5.279E-01	1.800E-01	1.530E-01

FLIGHT NO. C-154 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.374E-01	2.892E-01	1.095E-01	6.251E-02	2.064E-02	7.465E-03	6.459E-03
600	1.472E 00	6.477E-01	2.361E-01	1.328E-01	4.322E-02	1.553E-02	1.342E-02
1500	6.203E 00	2.261E 00	7.156E-01	3.836E-01	1.191E-01	4.174E-02	3.579E-02
3000	4.070E 01	8.442E 00	1.985E 00	9.742E-01	2.789E-01	9.415E-02	7.991E-02
4500	2.499E 02	2.418E 01	3.995E 00	1.780E 00	4.729E-01	1.572E-01	1.345E-01

FLIGHT NO. C-154 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.019E-01	1.368E-01	5.120E-02	2.918E-02	1.012E-02	4.344E-03	3.973E-03
600	6.645E-01	2.953E-01	1.074E-01	6.054E-02	2.076E-02	8.869E-03	8.103E-03
1500	2.390E 00	9.347E-01	3.048E-01	1.644E-01	5.374E-02	2.239E-02	2.031E-02
3000	1.108E 01	2.958E 00	7.753E-01	3.866E-01	1.162E-01	4.633E-02	4.144E-02
4500	3.815E 01	6.237E 00	1.321E 00	6.210E-01	1.789E-01	7.091E-02	6.321E-02

FLIGHT NO. C-154
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-154 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.723E-01	2.192E-01	9.241E-02	5.890E-02	2.733E-02	1.379E-02	1.163E-02
600	1.210E 00	5.171E-01	2.019E-01	1.252E-01	5.655E-02	2.820E-02	2.373E-02
1500	8.744E 00	2.365E 00	6.904E-01	3.909E-01	1.624E-01	7.830E-02	6.556E-02
3000	1.670E 02	1.511E 01	2.459E 00	1.186E 00	4.265E-01	1.947E-01	1.620E-01
4500	3.008E 03	7.133E 01	6.039E 00	2.485E 00	7.774E-01	3.375E-01	2.800E-01

FLIGHT NO. C-154 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.282E-01	1.546E-01	6.613E-02	4.222E-02	1.941E-02	9.774E-03	8.336E-03
600	7.731E-01	3.464E-01	1.405E-01	8.796E-02	3.968E-02	1.980E-02	1.686E-02
1500	3.545E 00	1.214E 00	4.106E-01	2.425E-01	1.040E-01	5.105E-02	4.335E-02
3000	2.781E 01	4.589E 00	1.073E 00	5.751E-01	2.282E-01	1.100E-01	9.338E-02
4500	2.280E 02	1.442E 01	2.156E 00	1.040E 00	3.789E-01	1.792E-01	1.530E-01

FLIGHT NO. C-154 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.920E-01	9.183E-02	4.032E-02	2.641E-02	1.311E-02	7.350E-03	6.459E-03
600	4.433E-01	2.057E-01	8.695E-02	5.612E-02	2.746E-02	1.529E-02	1.342E-02
1500	1.847E 00	7.111E-01	2.614E-01	1.609E-01	7.517E-02	4.096E-02	3.579E-02
3000	1.192E 01	2.618E 00	7.160E-01	4.049E-01	1.748E-01	9.197E-02	7.991E-02
4500	7.435E 01	7.628E 00	1.457E 00	7.540E-01	3.011E-01	1.547E-01	1.345E-01

FLIGHT NO. C-154 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	9.529E-02	4.583E-02	2.051E-02	1.370E-02	7.130E-03	4.318E-03	3.973E-03
600	2.097E-01	9.892E-02	4.304E-02	2.842E-02	1.463E-02	8.816E-03	8.103E-03
1500	7.092E-01	2.978E-01	1.177E-01	7.509E-02	3.742E-02	2.227E-02	2.031E-02
3000	2.905E 00	8.499E-01	2.772E-01	1.670E-01	7.901E-02	4.615E-02	4.144E-02
4500	1.044E 01	1.845E 00	4.811E-01	2.739E-01	1.234E-01	7.060E-02	6.321E-02

FLIGHT NO. C-154
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-154 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.339E-01	3.513E-01	1.592E-01	1.078E-01	5.518E-02	1.986E-02	1.163E-02
600	1.881E 00	8.284E-01	3.477E-01	2.291E-01	1.142E-01	4.060E-02	2.373E-02
1500	1.380E 01	3.845E 00	1.209E 00	7.292E-01	3.357E-01	1.143E-01	6.556E-02
3000	2.688E 02	2.516E 01	4.437E 00	2.294E 00	9.254E-01	2.946E-01	1.620E-01
4500	4.832E 03	1.191E 02	1.103E 01	4.901E 00	1.759E 00	5.383E-01	2.800E-01

FLIGHT NO. C-154 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.306E-01	2.588E-01	1.202E-01	8.228E-02	4.257E-02	1.482E-02	8.336E-03
600	1.250E 00	5.798E-01	2.554E-01	1.714E-01	8.700E-02	3.002E-02	1.686E-02
1500	5.851E 00	2.069E 00	7.586E-01	4.803E-01	2.316E-01	7.801E-02	4.335E-02
3000	4.774E 01	8.127E 00	2.062E 00	1.187E 00	5.313E-01	1.735E-01	9.338E-02
4500	3.884E 02	2.565E 01	4.228E 00	2.213E 00	9.321E-01	3.009E-01	1.530E-01

FLIGHT NO. C-154 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.626E-01	1.294E-01	6.098E-02	4.262E-02	2.327E-02	9.686E-03	6.459E-03
600	6.063E-01	2.898E-01	1.315E-01	9.056E-02	4.873E-02	2.015E-02	1.342E-02
1500	2.528E 00	1.003E 00	3.960E-01	2.602E-01	1.339E-01	5.402E-02	3.579E-02
3000	1.629E 01	3.692E 00	1.087E 00	6.575E-01	3.150E-01	1.222E-01	7.991E-02
4500	1.005E 02	1.066E 01	2.209E 00	1.224E 00	5.540E-01	2.097E-01	1.345E-01

FLIGHT NO. C-154 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.053E-01	5.210E-02	2.470E-02	1.730E-02	1.003E-02	5.457E-03	3.973E-03
600	2.318E-01	1.124E-01	5.183E-02	3.590E-02	2.058E-02	1.114E-02	8.103E-03
1500	7.681E-01	3.330E-01	1.399E-01	9.371E-02	5.211E-02	2.789E-02	2.031E-02
3000	2.986E 00	9.100E-01	3.182E-01	2.020E-01	1.072E-01	5.661E-02	4.144E-02
4500	1.061E 01	1.952E 00	5.457E-01	3.276E-01	1.657E-01	8.636E-02	6.321E-02

FLIGHT NO. C-154
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-154 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.807E-01	2.227E-01	9.346E-02	5.942E-02	2.750E-02	1.395E-02	1.163E-02
600	1.232E 00	5.252E-01	2.042E-01	1.263E-01	5.691E-02	2.853E-02	2.373E-02
1500	8.767E 00	2.375E 00	6.930E-01	3.923E-01	1.632E-01	7.925E-02	6.556E-02
3000	1.646E 02	1.493E 01	2.437E 00	1.180E 00	4.274E-01	1.973E-01	1.620E-01
4500	2.988E 03	7.073E 01	5.985E 00	2.468E 00	7.787E-01	3.427E-01	2.800E-01

FLIGHT NO. C-154 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.796E-01	1.589E-01	6.820E-02	4.372E-02	2.026E-02	1.007E-02	8.336E-03
600	6.997E-01	3.561E-01	1.449E-01	9.107E-02	4.139E-02	2.041E-02	1.686E-02
1500	3.513E 00	1.246E 00	4.223E-01	2.503E-01	1.081E-01	5.256E-02	4.335E-02
3000	2.792E 01	4.679E 00	1.096E 00	5.892E-01	2.354E-01	1.131E-01	9.338E-02
4500	2.263E 02	1.459E 01	2.190E 00	1.061E 00	3.903E-01	1.850E-01	1.530E-01

FLIGHT NO. C-154 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.017E-01	9.673E-02	4.276E-02	2.814E-02	1.404E-02	7.734E-03	6.459E-03
600	4.658E-01	2.167E-01	9.221E-02	5.978E-02	2.941E-02	1.609E-02	1.342E-02
1500	1.921E 00	7.430E-01	2.755E-01	1.705E-01	8.026E-02	4.307E-02	3.579E-02
3000	1.217E 01	2.693E 00	7.455E-01	4.248E-01	1.856E-01	9.667E-02	7.991E-02
4500	7.619E 01	7.856E 00	1.518E 00	7.917E-01	3.205E-01	1.630E-01	1.345E-01

FLIGHT NO. C-154 FILTER NO. 4

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	9.389E-02	4.577E-02	2.102E-02	1.433E-02	7.773E-03	4.682E-03	3.973E-03
600	2.066E-01	9.880E-02	4.412E-02	2.973E-02	1.595E-02	9.560E-03	8.103E-03
1500	6.915E-01	2.948E-01	1.196E-01	7.790E-02	4.044E-02	2.394E-02	2.031E-02
3000	2.770E 00	8.246E-01	2.764E-01	1.699E-01	8.360E-02	4.861E-02	4.144E-02
4500	1.008E 01	1.804E 00	4.805E-01	2.787E-01	1.302E-01	7.440E-02	6.321E-02

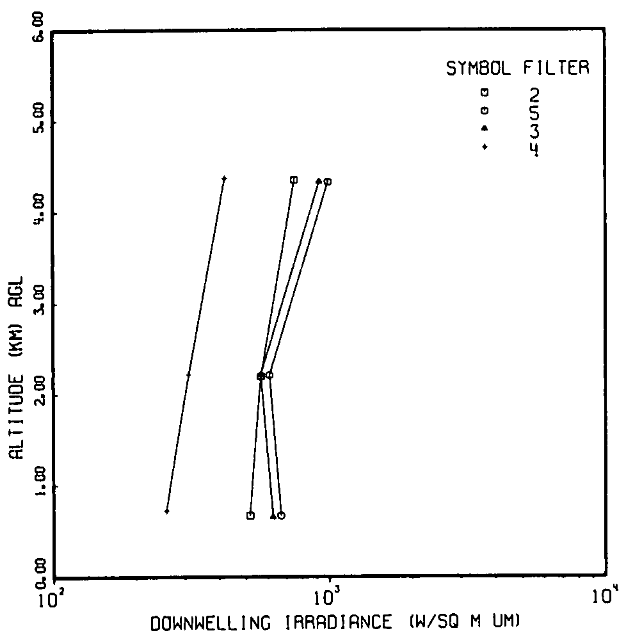
FLIGHT C-155 – 30 OCTOBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

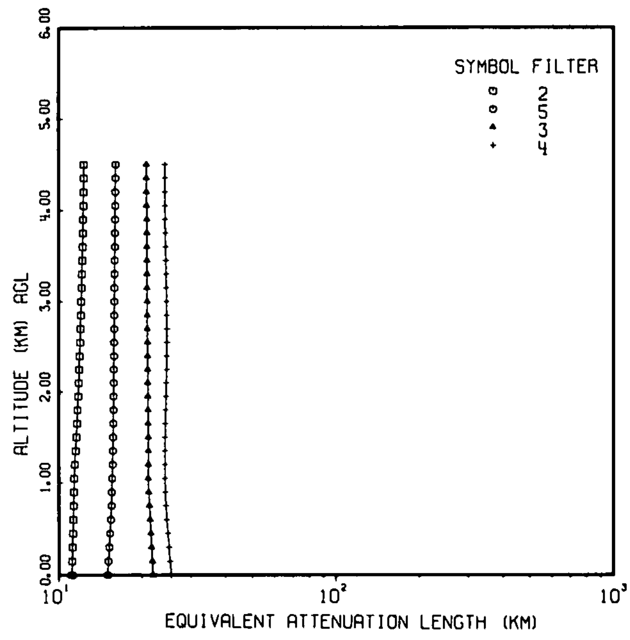
It was a sunlit morning flight. The sky was clear with some light haze on the horizon. The flight was conducted over a broad desert valley on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0909 local time (1609 GMT) and continued until 1216 local time (1916 GMT). The sun zenith angle during sky radiance data-taking for Filter 4 was 61.0 degrees at the start and 53.7 degrees at the end. For Filters 2, 3, and 5, the sun zenith angle at the start of the sky radiance data-taking was 50.7 degrees and at the end at noon was 47.6 degrees. The highest flight altitude was 4371 meters AGL.

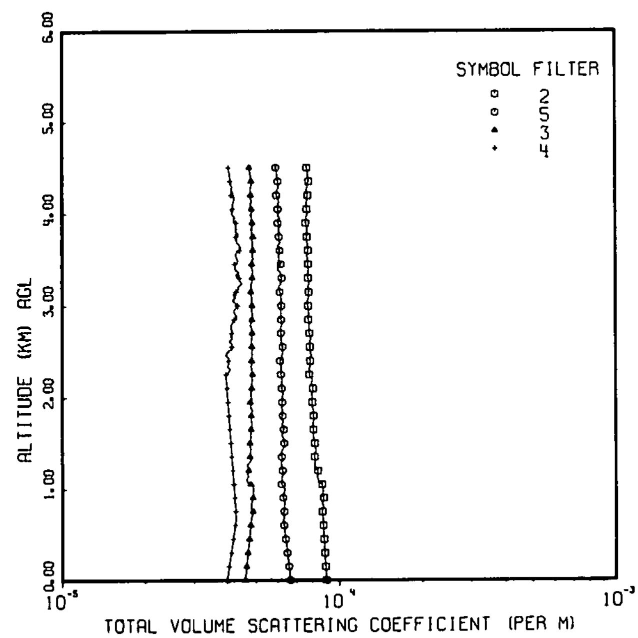
> At the beginning of the flight, Stallion was reporting clear skies and 40 mile (64 kilometer) visibility. The ground station recorded clear, sunny, and very dry.
>
> During the flight, the aircrew noted that the skies were clear with some light haze on the horizon. The flight was also in a haze layer at the maximum altitude of the flight.
>
> At the end of data-taking, Stallion was still reporting clear skies and 40 mile (64 kilometer) visibility.

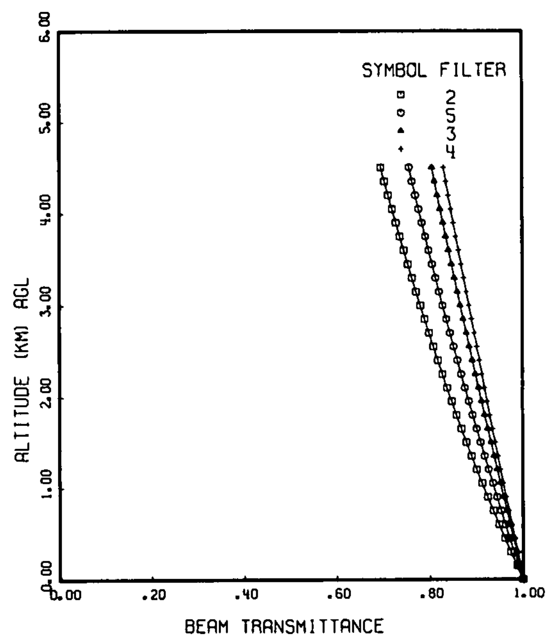
The surface chart shows that the area was at the southeastern edge of a high pressure cell with weak circulation. This high pressure dominated the western third of the country with a center in central Idaho. The high weakened slowly through the day. At 500 millibars the area was on the front side of a ridge with moderate northwesterly flow. There was a low in the eastern Dakotas. The airmass was continental polar.

FLIGHT NO. C-155

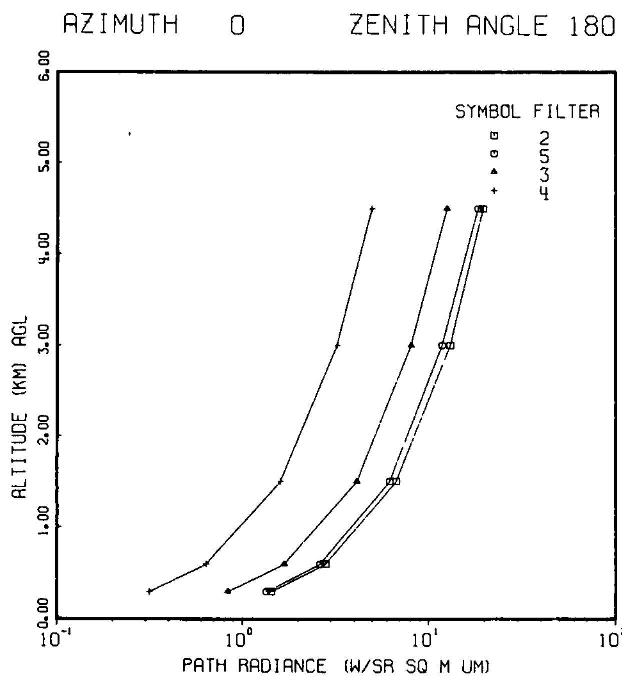


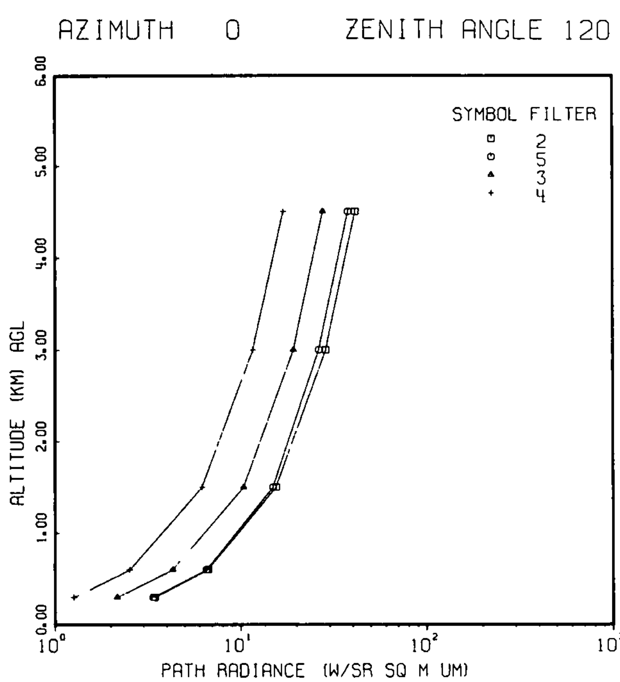


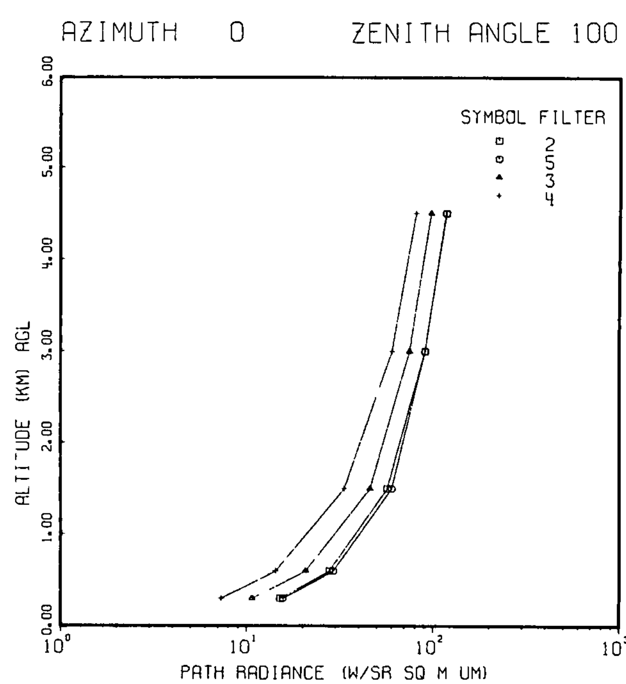




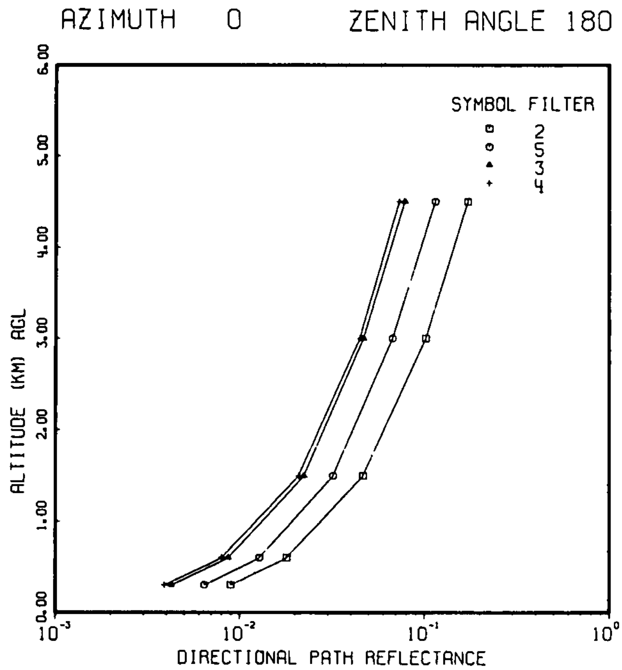
FLIGHT NO. C-155

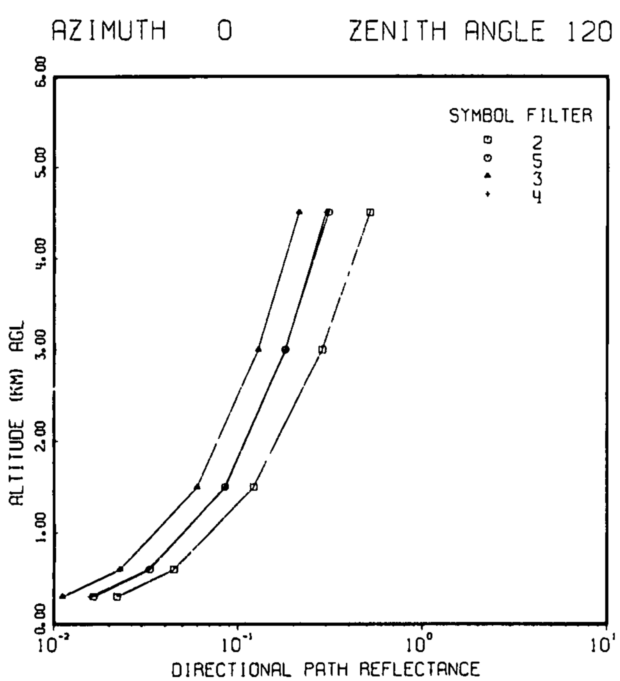


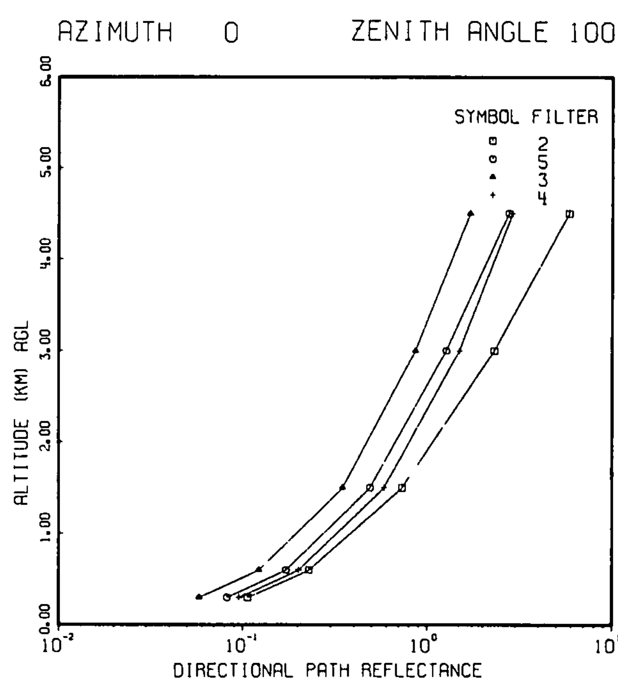




FLIGHT NO. C-155







FLIGHT NO. C-155
IRRADIANCE

FLIGHT NO.C-155 FILTER NO. 2

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
667	5.181E 02	5.126E 01	.099	9.888E 02	1.143E 02	1.103E 03	.116
2196	5.675E 02	7.343E 01	.129	1.095E 03	1.746E 02	1.270E 03	.159
4350	7.527E 02	9.355E 01	.124	1.384E 03	2.223E 02	1.607E 03	.161

FLIGHT NO.C-155 FILTER NO. 5

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
665	6.692E 02	6.971E 01	.104	1.315E 03	1.529E 02	1.468E 03	.116
2210	6.093E 02	9.394E 01	.154	1.125E 03	2.020E 02	1.327E 03	.180
4327	9.969E 02	1.060E 02	.106	1.669E 03	2.305E 02	1.899E 03	.138

FLIGHT NO.C-155 FILTER NO. 3

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
649	6.256E 02	8.861E 01	.142	1.117E 03	1.741E 02	1.291E 03	.156
2213	5.663E 02	9.822E 01	.173	9.962E 02	1.969E 02	1.193E 03	.198
4331	9.254E 02	1.034E 02	.112	1.401E 03	2.070E 02	1.608E 03	.148

FLIGHT NO.C-155 FILTER NO. 4

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
722	2.573E 02	5.165E 01	.201	5.741E 02	1.176E 02	6.917E 02	.205
2218	3.116E 02	6.585E 01	.211	6.899E 02	1.376E 02	8.275E 02	.199
4371	4.217E 02	6.991E 01	.166	8.057E 02	1.510E 02	9.568E 02	.187

FLIGHT NO. C-155
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-155
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.17722	.14382	.09794	.21878
95	.16348	.10821	.08557	.20357
100	.07612	.07797	.08082	.16709
105	.08002	.08732	.09229	.16047
120	.08315	.08406	.09301	.13809
150	.07746	.08645	.11467	.14386
180	.09171	.10213	.13372	.18617

FLIGHT NO. C-155
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.16617	.22108	.18217	.41044
95	.12776	.21750	.17019	.45410
100	.13297	.18357	.17476	.46223
105	.12225	.15863	.19349	.44523
120	.14472	.15596	.20077	.38326
150	.11611	.13672	.17084	.20659
180	.09171	.10213	.13372	.18617

FLIGHT NO. C-155
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.19490	.15203	.13668	.23255
95	.10152	.11402	.13154	.21867
100	.08297	.08956	.09972	.24219
105	.08032	.08099	.10251	.22651
120	.08798	.06731	.12111	.15433
150	.08299	.09025	.12900	.15531
180	.09171	.10213	.13372	.18617

FLIGHT NO. C-155
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.11557	.14381	.11710	.33778
95	.08871	.13784	.13455	.34185
100	.07357	.12140	.12237	.30866
105	.08929	.12519	.13899	.28450
120	.10412	.12764	.15986	.27078
150	.09873	.09415	.14572	.20959
180	.09171	.10213	.13372	.18617

FLIGHT NO. C-155
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 103070 FLIGHT NO. C-155 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
0	8.970E-05	6.660E-05	4.570E-05	3.930E-05
30	8.959E-05	6.643E-05	4.581E-05	3.944E-05
60	8.947E-05	6.625E-05	4.592E-05	3.958E-05
90	8.936E-05	6.608E-05	4.603E-05	3.972E-05
120	8.924E-05	6.590E-05	4.614E-05	3.986E-05
150	8.913E-05	6.573E-05	4.625E-05	4.000E-05
180	8.901E-05	6.555E-05	4.636E-05	4.015E-05
210	8.890E-05	6.538E-05	4.647E-05	4.029E-05
240	8.878E-05	6.520E-05	4.658E-05	4.043E-05
270	8.867E-05	6.503E-05	4.669E-05	4.057E-05
300	8.855E-05	6.485E-05	4.679E-05	4.071E-05
330	8.844E-05	6.468E-05	4.690E-05	4.085E-05
360	8.832E-05	6.451E-05	4.701E-05	4.099E-05
390	8.821E-05	6.433E-05	4.712E-05	4.113E-05
420	8.809E-05	6.416E-05	4.723E-05	4.127E-05
450	8.798E-05	6.398E-05	4.734E-05	4.141E-05
480	8.786E-05	6.381E-05	4.745E-05	4.155E-05
510	8.775E-05	6.363E-05	4.756E-05	4.170E-05
540	8.763E-05	6.346E-05	4.767E-05	4.184E-05
570	8.752E-05	6.328E-05	4.778E-05	4.198E-05
600	8.740E-05	6.311E-05	4.789E-05	4.212E-05
630	8.729E-05	6.293E-05	4.800E-05	4.226E-05
660	8.717E-05	6.276E-05	4.811E-05	4.240E-05
690	8.706E-05	6.347E-05	4.822E-05	4.234E-05
720	8.684E-05	6.231E-05	4.860E-05	4.227E-05
750	8.675E-05	6.323E-05	4.889E-05	4.221E-05
780	8.712E-05	6.378E-05	4.812E-05	4.215E-05
810	8.782E-05	6.304E-05	4.811E-05	4.209E-05
840	8.658E-05	6.364E-05	4.822E-05	4.202E-05
870	8.711E-05	6.316E-05	4.851E-05	4.196E-05
900	8.774E-05	6.258E-05	4.878E-05	4.190E-05
930	8.642E-05	6.257E-05	4.876E-05	4.184E-05
960	8.730E-05	6.309E-05	4.890E-05	4.177E-05
990	8.724E-05	6.365E-05	4.896E-05	4.171E-05
1020	8.637E-05	6.305E-05	4.887E-05	4.165E-05
1050	8.658E-05	6.183E-05	4.798E-05	4.159E-05
1080	8.414E-05	6.233E-05	4.651E-05	4.152E-05
1110	8.385E-05	6.195E-05	4.641E-05	4.146E-05
1140	8.319E-05	6.205E-05	4.703E-05	4.140E-05
1170	8.341E-05	6.308E-05	4.646E-05	4.134E-05
1200	8.363E-05	6.232E-05	4.718E-05	4.127E-05
1230	8.163E-05	6.211E-05	4.665E-05	4.121E-05
1260	8.160E-05	6.178E-05	4.660E-05	4.115E-05
1290	8.175E-05	6.157E-05	4.736E-05	4.109E-05
1320	8.177E-05	6.261E-05	4.819E-05	4.102E-05
1350	8.143E-05	6.203E-05	4.769E-05	4.096E-05
1380	8.130E-05	6.154E-05	4.780E-05	4.090E-05
1410	8.218E-05	6.202E-05	4.780E-05	4.084E-05
1440	8.223E-05	6.264E-05	4.792E-05	4.077E-05
1470	8.116E-05	6.340E-05	4.763E-05	4.071E-05
1500	8.153E-05	6.329E-05	4.767E-05	4.065E-05

FLIGHT NO. C-155
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 103070   FLIGHT NO. C-155   GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
1530	8.152E-05	6.318E-05	4.784E-05	4.059E-05
1560	8.077E-05	6.286E-05	4.809E-05	4.052E-05
1590	8.038E-05	6.200E-05	4.782E-05	4.046E-05
1620	8.102E-05	6.251E-05	4.792E-05	4.040E-05
1650	8.070E-05	6.314E-05	4.818E-05	4.034E-05
1680	8.060E-05	6.308E-05	4.853E-05	4.027E-05
1710	8.019E-05	6.215E-05	4.849E-05	4.021E-05
1740	8.082E-05	6.308E-05	4.822E-05	4.015E-05
1770	8.114E-05	6.160E-05	4.809E-05	4.009E-05
1800	8.080E-05	6.248E-05	4.822E-05	4.002E-05
1830	8.051E-05	6.224E-05	4.811E-05	3.996E-05
1860	8.096E-05	6.259E-05	4.891E-05	3.990E-05
1890	8.020E-05	6.218E-05	4.796E-05	3.984E-05
1920	7.979E-05	6.237E-05	4.803E-05	3.977E-05
1950	7.999E-05	6.232E-05	4.784E-05	3.971E-05
1980	7.982E-05	6.235E-05	4.856E-05	3.965E-05
2010	7.998E-05	6.232E-05	4.825E-05	3.959E-05
2040	7.957E-05	6.280E-05	4.819E-05	3.952E-05
2070	8.059E-05	6.242E-05	4.822E-05	3.946E-05
2100	8.049E-05	6.212E-05	4.848E-05	3.940E-05
2130	8.071E-05	6.275E-05	4.829E-05	3.933E-05
2160	7.929E-05	6.205E-05	4.855E-05	3.927E-05
2190	8.029E-05	6.232E-05	4.874E-05	3.921E-05
2220	7.917E-05	6.199E-05	4.853E-05	3.915E-05
2250	7.805E-05	6.171E-05	4.879E-05	3.908E-05
2280	7.880E-05	6.199E-05	4.851E-05	4.014E-05
2310	7.806E-05	6.164E-05	4.843E-05	4.050E-05
2340	7.853E-05	6.202E-05	4.812E-05	3.962E-05
2370	7.862E-05	6.146E-05	4.847E-05	4.006E-05
2400	7.873E-05	6.136E-05	4.844E-05	4.005E-05
2430	7.844E-05	6.286E-05	4.866E-05	4.010E-05
2460	7.965E-05	6.209E-05	4.868E-05	3.907E-05
2490	7.876E-05	6.273E-05	4.851E-05	3.948E-05
2520	7.885E-05	6.232E-05	4.872E-05	4.075E-05
2550	7.846E-05	6.260E-05	4.853E-05	4.114E-05
2580	7.822E-05	6.210E-05	4.833E-05	4.114E-05
2610	7.845E-05	6.195E-05	4.820E-05	4.015E-05
2640	7.909E-05	6.174E-05	4.855E-05	4.139E-05
2670	7.865E-05	6.209E-05	4.853E-05	4.069E-05
2700	7.815E-05	6.182E-05	4.866E-05	4.113E-05
2730	7.812E-05	6.219E-05	4.856E-05	4.121E-05
2760	7.803E-05	6.168E-05	4.830E-05	4.075E-05
2790	7.792E-05	6.227E-05	4.799E-05	4.097E-05
2820	7.833E-05	6.225E-05	4.836E-05	4.136E-05
2850	7.759E-05	6.188E-05	4.857E-05	4.196E-05
2880	7.743E-05	6.182E-05	4.888E-05	4.294E-05
2910	7.788E-05	6.193E-05	4.874E-05	4.228E-05
2940	7.775E-05	6.179E-05	4.847E-05	4.176E-05
2970	7.726E-05	6.157E-05	4.848E-05	4.230E-05
3000	7.740E-05	6.197E-05	4.874E-05	4.317E-05

FLIGHT NO. C-155
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 103070 FLIGHT NO. C-155 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
3030	7.677E-05	6.169E-05	4.845E-05	4.224E-05
3060	7.721E-05	6.211E-05	4.842E-05	4.131E-05
3090	7.785E-05	6.176E-05	4.863E-05	4.251E-05
3120	7.767E-05	6.188E-05	4.818E-05	4.159E-05
3150	7.792E-05	6.115E-05	4.825E-05	4.260E-05
3180	7.775E-05	6.151E-05	4.868E-05	4.340E-05
3210	7.747E-05	6.060E-05	4.826E-05	4.340E-05
3240	7.814E-05	6.176E-05	4.836E-05	4.482E-05
3270	7.801E-05	6.165E-05	4.883E-05	4.403E-05
3300	7.746E-05	6.229E-05	4.874E-05	4.373E-05
3330	7.760E-05	6.199E-05	4.879E-05	4.247E-05
3360	7.736E-05	6.161E-05	4.898E-05	4.369E-05
3390	7.774E-05	6.001E-05	4.892E-05	4.223E-05
3420	7.737E-05	6.063E-05	4.831E-05	4.230E-05
3450	7.744E-05	6.184E-05	4.857E-05	4.209E-05
3480	7.746E-05	6.066E-05	4.855E-05	4.329E-05
3510	7.735E-05	6.098E-05	4.917E-05	4.288E-05
3540	7.678E-05	6.058E-05	4.868E-05	4.255E-05
3570	7.681E-05	6.101E-05	4.875E-05	4.252E-05
3600	7.750E-05	6.116E-05	4.898E-05	4.391E-05
3630	7.760E-05	6.092E-05	4.896E-05	4.426E-05
3660	7.737E-05	6.042E-05	4.885E-05	4.382E-05
3690	7.695E-05	6.144E-05	4.894E-05	4.294E-05
3720	7.625E-05	6.067E-05	4.848E-05	4.280E-05
3750	7.669E-05	6.081E-05	4.906E-05	4.249E-05
3780	7.647E-05	6.088E-05	4.869E-05	4.343E-05
3810	7.669E-05	6.100E-05	4.849E-05	4.244E-05
3840	7.674E-05	6.036E-05	4.834E-05	4.271E-05
3870	7.678E-05	6.149E-05	4.875E-05	4.245E-05
3900	7.591E-05	6.023E-05	4.879E-05	4.266E-05
3930	7.645E-05	6.058E-05	4.834E-05	4.156E-05
3960	7.625E-05	6.121E-05	4.862E-05	4.217E-05
3990	7.669E-05	5.998E-05	4.809E-05	4.131E-05
4020	7.672E-05	6.070E-05	4.863E-05	4.109E-05
4050	7.666E-05	6.023E-05	4.845E-05	4.137E-05
4080	7.680E-05	6.064E-05	4.809E-05	4.150E-05
4110	7.636E-05	6.053E-05	4.793E-05	4.156E-05
4140	7.671E-05	6.074E-05	4.857E-05	4.179E-05
4170	7.638E-05	6.047F-05	4.784E-05	4.220E-05
4200	7.723E-05	5.961E-05	4.815E-05	4.087E-05
4230	7.680E-05	6.005E-05	4.831E-05	4.152E-05
4260	7.648E-05	6.007E-05	4.793E-05	4.074E-05
4290	7.704E-05	6.058E-05	4.814E-05	4.126E-05
4320	7.661E-05	6.039E-05	4.847E-05	4.074E-05
4350	7.782E-05	6.020E-05	4.832E-05	4.061E-05
4380	7.758E-05	6.001E-05	4.817E-05	4.049E-05
4410	7.733E-05	5.983E-05	4.802E-05	4.036E-05
4440	7.709E-05	5.964E-05	4.787E-05	4.024E-05
4470	7.685E-05	5.946E-05	4.772E-05	4.011E-05
4500	7.662E-05	5.927E-05	4.757E-05	3.999E-05
FIRST DATA ALT	0	0	0	C
LAST DATA ALT	4350	4290	4320	4320

FLIGHT NO. C-155
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-155 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.5975672	.7351852	.8572922	.9018503	.9479292	.9695977	.9736165
600	.3565263	.5417088	.7364094	.8144174	.8991891	.9404937	.9482558
1500	.0759726	.2217387	.4745789	.6064950	.7719392	.8611842	.8786007
3000	.0054577	.0531283	.2391629	.3829571	.6084469	.7506213	.7800300
4500	.0003250	.0126793	.1228941	.2449873	.4828336	.6568109	.6948623

FLIGHT NO. C-155 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.6840529	.7970240	.8926573	.9266445	.9613311	.9774886	.9804749
600	.4698189	.6382734	.7992434	.8604090	.9251258	.9560619	.9618346
1500	.1499474	.3298645	.5776207	.6919587	.8264554	.8957908	.9090959
3000	.0192664	.1077866	.3374390	.4824523	.6857155	.8042622	.8280794
4500	.0021136	.0348972	.1995540	.3391509	.5713648	.7238590	.7558868

FLIGHT NO. C-155 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.7655480	.8524605	.9232100	.9478055	.9726330	.9841071	.9862216
600	.5798946	.7233002	.8507059	.8971959	.9453936	.9680994	.9723135
1500	.2427403	.4369726	.6637962	.7596240	.8673479	.9211193	.9313151
3000	.0495434	.1833602	.4370738	.5739039	.7501809	.8470851	.8661298
4500	.0086432	.0748060	.2875470	.4333454	.6486517	.7788697	.8053891

FLIGHT NO. C-155 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	.7936637	.8710295	.9332211	.9546889	.9762830	.9862376	.9880704
600	.6224990	.7544272	.8687841	.9099436	.9523231	.9721899	.9758704
1500	.2921625	.4869940	.7003814	.7874647	.8836601	.9310817	.9400320
3000	.0771759	.2357171	.4941608	.6231729	.7828554	.8681945	.8847912
4500	.0169657	.1080681	.3431674	.4879320	.6897360	.8069814	.8305035

FLIGHT NO. C-155
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-155 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.518E 01	3.538E 01	1.508E 01	9.109E 00	3.446E 00	1.531E 00	1.433E 00
600	9.734E 01	6.031E 01	2.785E 01	1.722E 01	6.671E 00	2.996E 00	2.811E 00
1500	1.320E 02	1.029E 02	5.712E 01	3.752E 01	1.549E 01	7.165E 00	6.749E 00
3000	1.583E 02	1.380E 02	9.078E 01	6.407E 01	2.871E 01	1.383E 01	1.310E 01
4500	1.872E 02	1.669E 02	1.182E 02	8.717E 01	4.127E 01	2.055E 01	1.969E 01

FLIGHT NO. C-155 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.269E 01	3.784E 01	1.562E 01	9.278E 00	3.383E 00	1.440E 00	1.343E 00
600	1.150E 02	6.657E 01	2.922E 01	1.765E 01	6.550E 00	2.811E 00	2.626E 00
1500	1.612E 02	1.171E 02	6.021E 01	3.822E 01	1.494E 01	6.615E 00	6.218E 00
3000	1.704E 02	1.460E 02	9.091E 01	6.200E 01	2.632E 01	1.238E 01	1.185E 01
4500	1.936E 02	1.697E 02	1.172E 02	8.380E 01	3.776E 01	1.861E 01	1.845E 01

FLIGHT NO. C-155 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.236E 01	2.635E 01	1.068E 01	6.216E 00	2.161E 00	8.910E-01	8.367E-01
600	8.911E 01	4.885E 01	2.076E 01	1.224E 01	4.312E 00	1.788E 00	1.681E 00
1500	1.417E 02	9.522E 01	4.610E 01	2.827E 01	1.037E 01	4.394E 00	4.142E 00
3000	1.609E 02	1.302E 02	7.508E 01	4.887E 01	1.922E 01	8.489E 00	8.073E 00
4500	1.746E 02	1.506E 02	9.747E 01	6.626E 01	2.773E 01	1.287E 01	1.258E 01

FLIGHT NO. C-155 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.823E 01	1.881E 01	7.291E 00	4.131E 00	1.262E 00	3.892E-01	3.154E-01
600	6.663E 01	3.543E 01	1.433E 01	8.211E 00	2.536E 00	7.864E-01	6.379E-01
1500	1.185E 02	7.505E 01	3.349E 01	1.969E 01	6.196E 00	1.958E 00	1.608E 00
3000	1.641E 02	1.209E 02	6.041E 01	3.648E 01	1.165E 01	3.817E 00	3.233E 00
4500	1.748E 02	1.420E 02	8.109E 01	5.054E 01	1.696E 01	5.780E 00	4.977E 00

FLIGHT NO. C-155
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-155 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.082E 01	1.760E 01	8.653E 00	5.814E 00	2.882E 00	1.587E 00	1.433E 00
600	4.602E 01	3.000E 01	1.598E 01	1.099E 01	5.581E 00	3.107E 00	2.811E 00
1500	6.266E 01	5.137E 01	3.291E 01	2.403E 01	1.298E 01	7.416E 00	6.749E 00
3000	7.433E 01	6.863E 01	5.242E 01	4.116E 01	2.410E 01	1.427E 01	1.310E 01
4500	8.321E 01	7.939E 01	6.650E 01	5.502E 01	3.455E 01	2.130E 01	1.969E 01

FLIGHT NO. C-155 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.231E 01	1.773E 01	8.508E 00	5.653E 00	2.737E 00	1.472E 00	1.343E 00
600	5.112E 01	3.120E 01	1.591E 01	1.076E 01	5.300E 00	2.873E 00	2.626E 00
1500	7.110E 01	5.460E 01	3.273E 01	2.327E 01	1.212E 01	6.766F 00	6.218E 00
3000	7.458E 01	6.784E 01	4.943E 01	3.786E 01	2.156E 01	1.272E 01	1.185E 01
4500	8.889E 01	8.248E 01	6.524E 01	5.221E 01	3.150E 01	1.937E 01	1.845E 01

FLIGHT NO. C-155 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.852E 01	9.802E 00	4.625E 00	3.093E 00	1.563E 00	9.116E-01	8.367E-01
600	3.151E 01	1.818E 01	8.992E 00	6.092E 00	3.118E 00	1.830E 00	1.681E 00
1500	5.010E 01	3.544E 01	2.000E 01	1.410E 01	7.518E 00	4.495F 00	4.142E 00
3000	5.754E 01	4.899E 01	3.292E 01	2.464E 01	1.407E 01	8.710E 00	8.073E 00
4500	6.541E 01	5.913E 01	4.407E 01	3.446E 01	2.078E 01	1.337E 01	1.258E 01

FLIGHT NO. C-155 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.578E 00	3.985E 00	1.872E 00	1.255E 00	6.339E-01	3.554E-01	3.154E-01
600	1.321E 01	7.506E 00	3.679E 00	2.495E 00	1.274E 00	7.181E-01	6.379E-01
1500	2.225E 01	1.526E 01	8.412E 00	5.907E 00	3.128E 00	1.800E 00	1.608E 00
3000	2.732E 01	2.237E 01	1.441E 01	1.067E 01	5.989E 00	3.583E 00	3.233E 00
4500	3.102E 01	2.752E 01	1.973E 01	1.526E 01	8.989E 00	5.514E 00	4.977E 00

FLIGHT NO. C-155
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-155 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	4.287E 01	2.560E 01	1.400E 01	1.044E 01	6.537E 00	2.974E 00	1.433E 00
600	6.403E 01	4.363E 01	2.585E 01	1.973E 01	1.266E 01	5.821E 00	2.811E 00
1500	8.705E 01	7.462E 01	5.315E 01	4.308E 01	2.943E 01	1.394E 01	6.749E 00
3000	1.039E 02	1.001E 02	8.493E 01	7.404E 01	5.508E 01	2.713E 01	1.310E 01
4500	1.196E 02	1.191E 02	1.107E 02	1.018E 02	8.143E 01	4.146E 01	1.969E 01

FLIGHT NO. C-155 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	4.697E 01	2.707E 01	1.458E 01	1.085E 01	6.796E 00	2.991E 00	1.343E 00
600	7.430E 01	4.763E 01	2.727E 01	2.065E 01	1.316E 01	5.837E 00	2.626E 00
1500	1.036F 02	8.354E 01	5.624E 01	4.481E 01	3.016E 01	1.376E 01	6.218E 00
3000	1.073E 02	1.031E 02	8.496E 01	7.317E 01	5.415E 01	2.624E 01	1.185E 01
4500	1.201E 02	1.191E 02	1.090E 02	9.913F 01	7.994E 01	4.204E 01	1.845E 01

FLIGHT NO. C-155 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	2.321F 01	1.270E 01	6.464E 00	4.705E 00	2.961E 00	1.392E 00	8.367E-01
600	3.950F 01	2.354E 01	1.257E 01	9.268F 00	5.908E 00	2.793E 00	1.681E 00
1500	6.277E 01	4.588E 01	2.792E 01	2.141F 01	1.420E 01	6.850E 00	4.142E 00
3000	7.137E 01	6.294E 01	4.561E 01	3.711F 01	2.635E 01	1.331E 01	8.073E 00
4500	7.827E 01	7.396E 01	5.994E 01	5.090E 01	3.865E 01	2.108E 01	1.258E 01

FLIGHT NO. C-155 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	9.431E 00	5.098E 00	2.558E 00	1.801E 00	9.773E-01	4.520E-01	3.154E-01
600	1.644E 01	9.604E 00	5.026E 00	3.580E 00	1.965E 00	9.135E-01	6.379E-01
1500	2.760E 01	1.946E 01	1.146E 01	8.441E 00	4.798E 00	2.286E 00	1.608E 00
3000	3.322E 01	2.808E 01	1.935E 01	1.501E 01	9.056E 00	4.529E 00	3.233E 00
4500	3.616E 01	3.337F 01	2.582E 01	2.097E 01	1.346E 01	6.955E 00	4.977E 00

FLIGHT NO. C-155
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-155 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.096E 01	1.768E 01	8.698E 00	5.863E 00	2.937E 00	1.658E 00	1.433E 00
600	4.623E 01	3.013E 01	1.607E 01	1.109E 01	5.685E 00	3.246F 00	2.811E 00
1500	6.301E 01	5.162E 01	3.307E 01	2.421E 01	1.320E 01	7.745E 00	6.749E 00
3000	7.472E 01	6.894E 01	5.259E 01	4.137E 01	2.443E 01	1.489E 01	1.310E 01
4500	8.309E 01	7.936E 01	6.653E 01	5.520E 01	3.498E 01	2.218E 01	1.969E 01

FLIGHT NO. C-155 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.234E 01	1.780E 01	8.596E 00	5.760E 00	2.848E 00	1.569E 00	1.343E 00
600	5.116E 01	3.132E 01	1.608E 01	1.096E 01	5.514E 00	3.062E 00	2.626E 00
1500	7.090E 01	5.462E 01	3.296E 01	2.363E 01	1.256E 01	7.194E 00	6.218E 00
3000	7.378E 01	6.731E 01	4.933E 01	3.810F 01	2.212E 01	1.347E 01	1.185E 01
4500	8.844E 01	8.207E 01	6.508E 01	5.243E 01	3.222E 01	2.057E 01	1.845E 01

FLIGHT NO. C-155 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.796E 01	9.599E 00	4.616E 00	3.138E 00	1.645E 00	9.786E-01	8.367E-01
600	3.056E 01	1.780F 01	8.974E 00	6.180E 00	3.283E 00	1.964F 00	1.681E 00
1500	4.858E 01	3.470E 01	1.994E 01	1.428E 01	7.898E 00	4.820E 00	4.142E 00
3000	5.578E 01	4.791E 01	3.273E 01	2.487F 01	1.470F 01	9.310F 00	8.073E 00
4500	6.337E 01	5.780E 01	4.372E 01	3.470F 01	2.165E 01	1.428E 01	1.258E 01

FLIGHT NO. C-155 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	8.067E 00	4.282E 00	2.059E 00	1.402E 00	7.244E-01	3.904E-01	3.154E-01
600	1.406E 01	8.066F 00	4.045E 00	2.787E 00	1.456E 00	7.889E-01	6.379E-01
1500	2.344E 01	1.624E 01	9.156E 00	6.527E 00	3.539E 00	1.970E 00	1.608E 00
3000	2.790E 01	2.314E 01	1.524E 01	1.145E 01	6.596E 00	3.874E 00	3.233E 00
4500	3.161E 01	2.832E 01	2.074E 01	1.624E 01	9.804E 00	5.912E 00	4.977E 00

FLIGHT NO. C-155
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-155 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.614E-01	2.918E-01	1.067E-01	6.124E-02	2.204E-02	9.573E-03	8.927E-03
600	1.656E 00	6.750E-01	2.293E-01	1.282E-01	4.498E-02	1.932E-02	1.798E-02
1500	1.054E 01	2.814E 00	7.298E-01	3.751E-01	1.217E-01	5.045E-02	4.657E-02
3000	1.759E 02	1.575E 01	2.301E 00	1.014E 00	2.861E-01	1.117E-01	1.018E-01
4500	3.493E 03	7.983E 01	5.831E 00	2.157E 00	5.183E-01	1.897E-01	1.718E-01

FLIGHT NO. C-155 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.988E-01	2.229E-01	8.215E-02	4.700E-02	1.652E-02	6.917E-03	6.432E-03
600	1.149E 00	4.896E-01	1.716E-01	9.632E-02	3.324E-02	1.380E-02	1.282E-02
1500	5.048E 00	1.667E 00	4.893E-01	2.593E-01	8.485E-02	3.466E-02	3.211E-02
3000	4.151E 01	6.361E 00	1.265E 00	6.033E-01	1.802E-01	7.225E-02	6.718E-02
4500	4.300E 02	2.283E 01	2.758E 00	1.160E 00	3.102E-01	1.207E-01	1.146E-01

FLIGHT NO. C-155 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.435E-01	1.552E-01	5.808E-02	3.293E-02	1.116E-02	4.546E-03	4.261E-03
600	7.717E-01	3.392E-01	1.225E-01	6.853E-02	2.291E-02	9.277E-03	8.684E-03
1500	2.931E 00	1.094E 00	3.488E-01	1.869E-01	6.007E-02	2.395E-02	2.233E-02
3000	1.630E 01	3.566E 00	8.626E-01	4.276E-01	1.287E-01	5.032E-02	4.680E-02
4500	1.015E 02	1.011E 01	1.702E 00	7.679E-01	2.147E-01	8.295E-02	7.841E-02

FLIGHT NO. C-155 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.880E-01	2.636E-01	9.537E-02	5.283E-02	1.578E-02	4.817E-03	3.897E-03
600	1.307E 00	5.733E-01	2.013E-01	1.102E-01	3.251E-02	9.875E-03	7.980E-03
1500	4.950E 00	1.881E 00	5.838E-01	3.052E-01	8.560E-02	2.567E-02	2.089E-02
3000	2.596E 01	6.260E 00	1.492E 00	7.146E-01	1.816E-01	5.367E-02	4.461E-02
4500	1.258E 02	1.604E 01	2.885E 00	1.264E 00	3.002E-01	8.744E-02	7.315E-02

FLIGHT NO. C-155
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-155 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	3.127E-01	1.451E-01	6.120E-02	3.909E-02	1.844E-02	9.926E-03	8.927E-03
600	7.827E-01	3.357E-01	1.316E-01	8.184E-02	3.763E-02	2.003E-02	1.798E-02
1500	5.001E 00	1.405E 00	4.204E-01	2.402E-01	1.019E-01	5.222E-02	4.657E-02
3000	8.258E 01	7.832E 00	1.329E 00	6.517E-01	2.402E-01	1.153E-01	1.018E-01
4500	1.552E 03	3.796E 01	3.281E 00	1.362E 00	4.339E-01	1.966E-01	1.718E-01

FLIGHT NO. C-155 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	2.218E-01	1.045E-01	4.474E-02	2.864E-02	1.337E-02	7.070E-03	6.432E-03
600	5.108E-01	2.295E-01	9.346E-02	5.869E-02	2.689E-02	1.411E-02	1.282E-02
1500	2.226E 00	7.770E-01	2.660E-01	1.579E-01	6.882E-02	3.546E-02	3.211E-02
3000	1.817E 01	2.955E 00	6.876E-01	3.684E-01	1.476E-01	7.426E-02	6.718E-02
4500	1.974E 02	1.109E 01	1.535E 00	7.227E-01	2.588E-01	1.256E-01	1.146E-01

FLIGHT NO. C-155 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	1.215E-01	5.774E-02	2.516E-02	1.639E-02	8.068E-03	4.652E-03	4.261E-03
600	2.729E-01	1.262E-01	5.308E-02	3.410E-02	1.656E-02	9.492E-03	8.684E-03
1500	1.036E 00	4.073E-01	1.513E-01	9.319E-02	4.353E-02	2.451E-02	2.233E-02
3000	5.833E 00	1.342E 00	3.782E-01	2.156E-01	9.421E-02	5.163E-02	4.680E-02
4500	3.800E 01	3.970E 00	7.697E-01	3.994E-01	1.609E-01	8.619E-02	7.841E-02

FLIGHT NO. C-155 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	1.166E-01	5.585E-02	2.449E-02	1.605E-02	7.927E-03	4.399E-03	3.897E-03
600	2.591E-01	1.215E-01	5.169E-02	3.347E-02	1.634E-02	9.017E-03	7.980E-03
1500	9.298E-01	3.825E-01	1.466E-01	9.157E-02	4.321E-02	2.361E-02	2.089E-02
3000	4.321E 00	1.158E 00	3.560E-01	2.090E-01	9.340E-02	5.039E-02	4.461E-02
4500	2.232E 01	3.109E 00	7.019E-01	3.818E-01	1.591E-01	8.341E-02	7.315E-02

FLIGHT NO. C-155
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-155 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.350E-01	2.111E-01	9.899E-02	7.017E-02	4.182E-02	1.860E-02	8.927E-03
600	1.089E 00	4.884E-01	2.129E-01	1.469E-01	8.535E-02	3.753E-02	1.798E-02
1500	6.948E 00	2.040E 00	6.790E-01	4.306E-01	2.312E-01	9.811E-02	4.657E-02
3000	1.155E 02	1.143E 01	2.153E 00	1.172E 00	5.489E-01	2.192E-01	1.018E-01
4500	2.231E 03	5.693E 01	5.460E 00	2.519E 00	1.023E 00	3.827E-01	1.718E-01

FLIGHT NO. C-155 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.223E-01	1.595E-01	7.669E-02	5.498E-02	3.319E-02	1.436E-02	6.432E-03
600	7.424E-01	3.503E-01	1.602E-01	1.127E-01	6.677E-02	2.866E-02	1.282E-02
1500	3.243E 00	1.189E 00	4.571E-01	3.040E-01	1.713E-01	7.209E-02	3.211E-02
3000	2.615E 01	4.492E 00	1.182E 00	7.120E-01	3.707E-01	1.532E-01	6.718E-02
4500	2.667E 02	1.602E 01	2.565E 00	1.372E 00	6.568E-01	2.726E-01	1.146E-01

FLIGHT NO. C-155 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.522E-01	7.479E-02	3.516E-02	2.493E-02	1.529E-02	7.101E-03	4.261E-03
600	3.421E-01	1.635E-01	7.419E-02	5.187E-02	3.138E-02	1.449E-02	8.684E-03
1500	1.299E 00	5.273E-01	2.112E-01	1.415E-01	8.221E-02	3.735E-02	2.233E-02
3000	7.234E 00	1.724E 00	5.241E-01	3.247E-01	1.764E-01	7.893E-02	4.680E-02
4500	4.548E 01	4.965E 00	1.047E 00	5.898E-01	2.992E-01	1.359E-01	7.841E-02

FLIGHT NO. C-155 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.451E-01	7.145E-02	3.346E-02	2.303E-02	1.272E-02	5.595E-03	3.897E-03
600	3.224E-01	1.554E-01	7.062E-02	4.803E-02	2.518E-02	1.147E-02	7.980E-03
1500	1.153E 00	4.879E-01	1.997E-01	1.309E-01	6.629E-02	2.998E-02	2.089E-02
3000	5.255E 00	1.454E 00	4.780E-01	2.941E-01	1.412E-01	6.369E-02	4.461E-02
4500	2.602E 01	3.770E 00	9.185E-01	5.246E-01	2.382E-01	1.052E-01	7.315E-02

FLIGHT NO. C-155
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-155 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.141E-01	1.458E-01	6.152E-02	3.942E-02	1.878E-02	1.037E-02	8.927E-03
600	7.863E-01	3.373E-01	1.323E-01	8.254E-02	3.834E-02	2.093E-02	1.798E-02
1500	5.029E 00	1.411E 00	4.225E-01	2.421E-01	1.037E-01	5.453E-02	4.657E-02
3000	8.301E 01	7.867E 00	1.333E 00	6.550E-01	2.434E-01	1.203E-01	1.018E-01
4500	1.550E 03	3.795E 01	3.282E 00	1.366E 00	4.393E-01	2.048E-01	1.718E-01

FLIGHT NO. C-155 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.220E-01	1.048E-01	4.520E-02	2.918E-02	1.391E-02	7.534E-03	6.432E-03
600	5.112E-01	2.303E-01	9.442E-02	5.981E-02	2.798E-02	1.503E-02	1.282E-02
1500	2.220E 00	7.773E-01	2.678E-01	1.603E-01	7.132E-02	3.770E-02	3.211E-02
3000	1.798E 01	2.931E 00	6.863E-01	3.707E-01	1.514E-01	7.861F-02	6.718E-02
4500	1.964E 02	1.104E 01	1.531E 00	7.257E-01	2.647E-01	1.334E-01	1.146E-01

FLIGHT NO. C-155 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.178E-01	5.655E-02	2.511E-02	1.662E-02	8.495E-03	4.994E-03	4.261E-03
600	2.646E-01	1.236E-01	5.298E-02	3.459E-02	1.744E-02	1.019E-02	8.684E-03
1500	1.005E 00	3.988E-01	1.509E-01	9.439E-02	4.573E-02	2.628E-02	2.233E-02
3000	5.654E 00	1.312E 00	3.760E-01	2.176E-01	9.842E-02	5.519E-02	4.680E-02
4500	3.682E 01	3.880E 00	7.636E-01	4.021E-01	1.676E-01	9.206E-02	7.841E-02

FLIGHT NO. C-155 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.241E-01	6.001E-02	2.693E-02	1.793E-02	9.059E-03	4.833E-03	3.897E-03
600	2.758E-01	1.305E-01	5.684E-02	3.738E-02	1.867E-02	9.906E-03	7.980E-03
1500	9.794E-01	4.070E-01	1.596E-01	1.012E-01	4.890E-02	2.583E-02	2.089E-02
3000	4.413E 00	1.198E 00	3.766E-01	2.242E-01	1.029E-01	5.447E-02	4.461E-02
4500	2.274E 01	3.200E 00	7.379E-01	4.063E-01	1.735E-01	8.943E-02	7.315E-02

FLIGHT C-157 – 3 NOVEMBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit noon flight. At the beginning, the sky was clear; scattered clouds formed during the flight. The flight was conducted over a broad desert valley on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0953 local time (1653 GMT) and continued until 1310 local time (2010 GMT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 5 was 51.2 degrees at the start and 49.2 degrees at the end. The sky radiance data-taking for Filter 4 started after solar noon; the sun zenith angle was 49.5 degrees at the start and 52.3 degrees at the end. The highest flight altitude was 4374 meters AGL.

At the beginning of the data-taking, Stallion was reporting clear skies with 40 mile (64 kilometer) visibility. Haze was noted to the south. The ground station recorded clear, sunny, and moderate haze. Later in the data-taking period, there were some cumulus clouds on the horizon.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized.

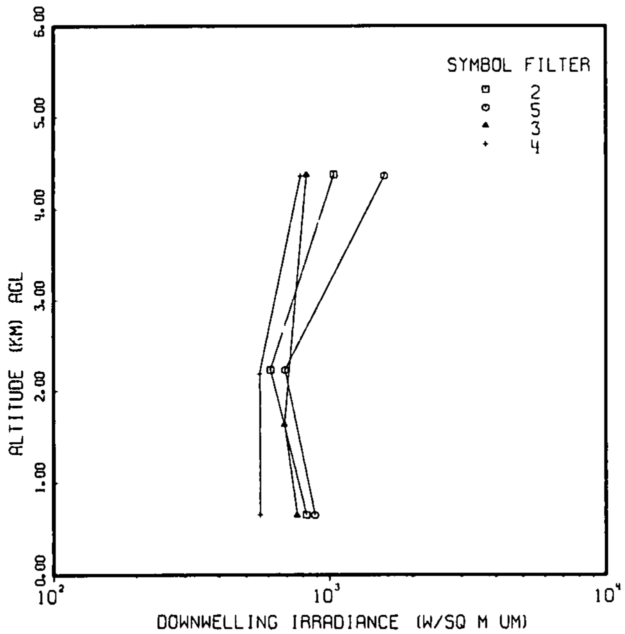
Time (GMT)	Altitude (meters AGL)	
1707	2066	Moderate haze, clear above
1713	2066	Moderate to heavy haze below the flight path, some scattered clouds to the east
1753	4374	Top flight altitude, intermittent cloud layer below the flight path
1807	0648	Weather not good at north end of the flight track
1907	4355	Scattered to broken low clouds below, clear overhead
1945	2066	Low cloud layer increased to broken

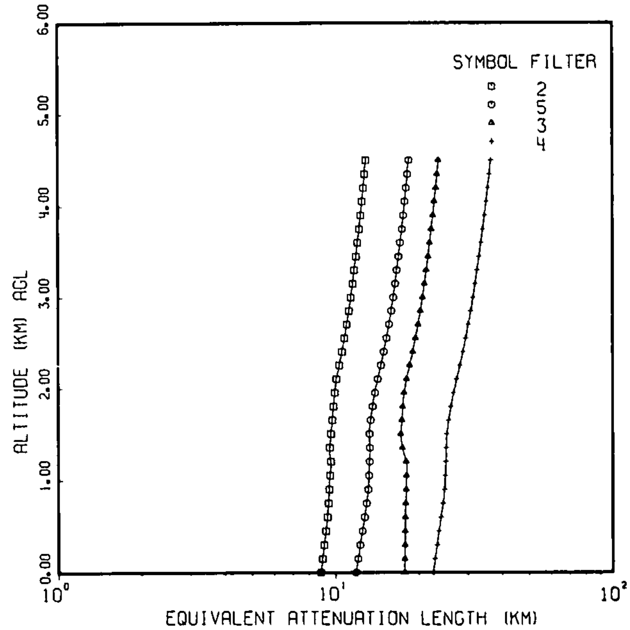
At the end of data-taking, Stallion was reporting 0.1 cumulus at 6000 feet (1800 meters). The visibility was reported as 40 miles (64 kilometers).

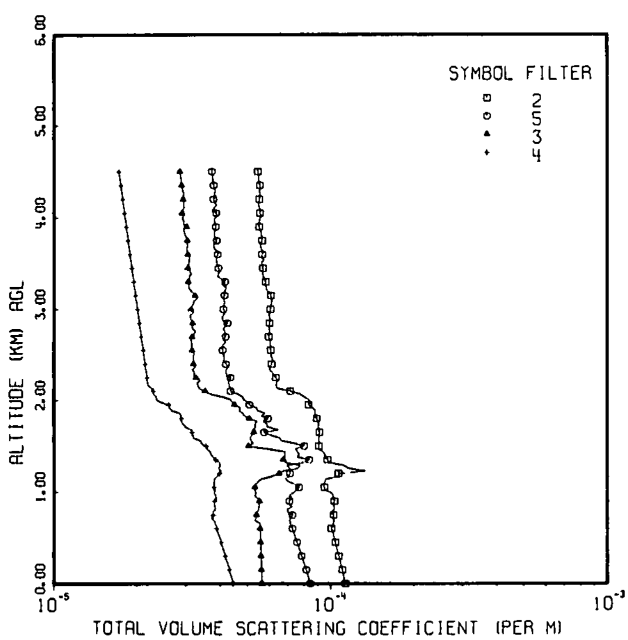
It was noted in several of the flights, including C-157, that there were considerably more clouds over the northern end of the track. This frequently obscured the ground at the northern end of the track while the southern portion, including the ground station, remained in the clear. The pictures taken with the all-sky camera show that the amounts reported are not overestimated.

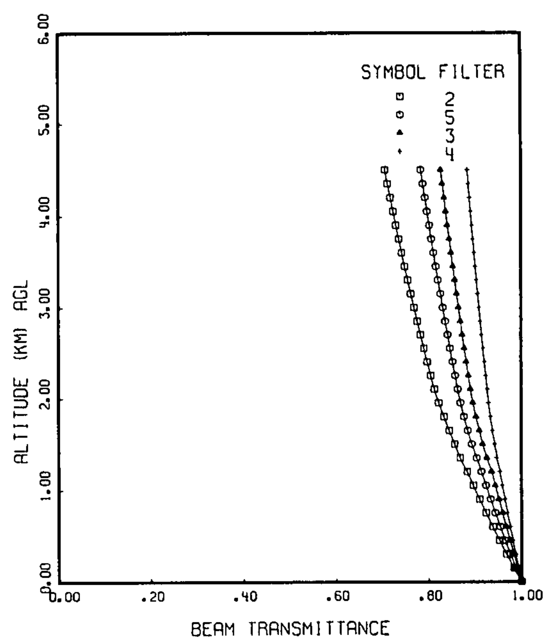
The area lay on the back side of the high with streamlines from the southeast. From a high centered in central Saskatchewan a ridge extended south southeastward through Texas. High pressure dominated the western half of the country. At 500 millibars there was a strong low centered over Kansas with moderate to strong northwesterly flow over the area of interest. There was a ridge along the west coast of the United States and throughout the western half of Canada. The airmass was well-modified continental polar.

FLIGHT NO. C-157

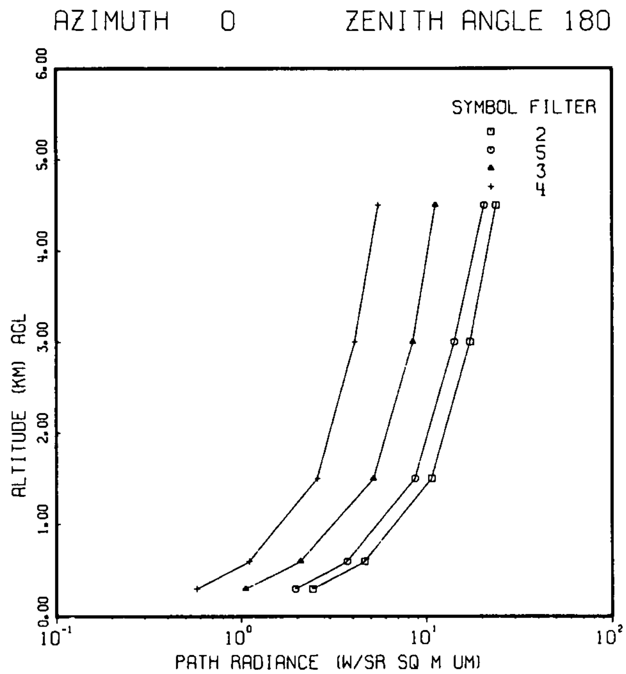


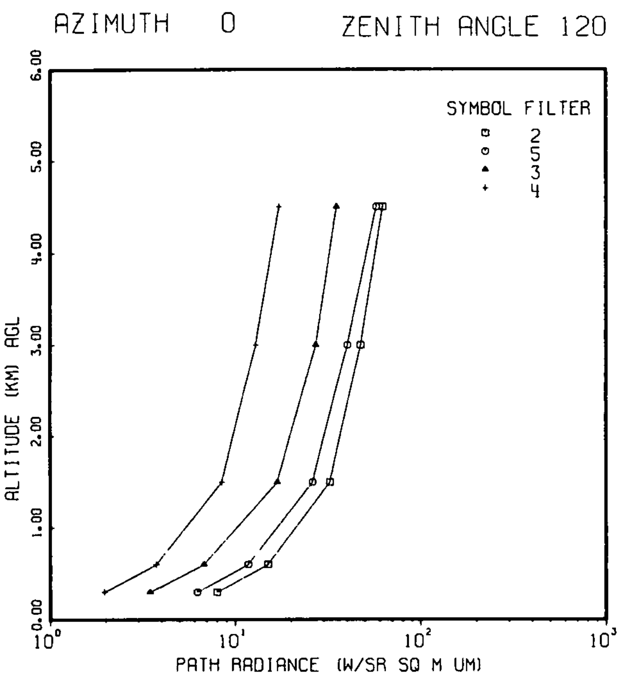


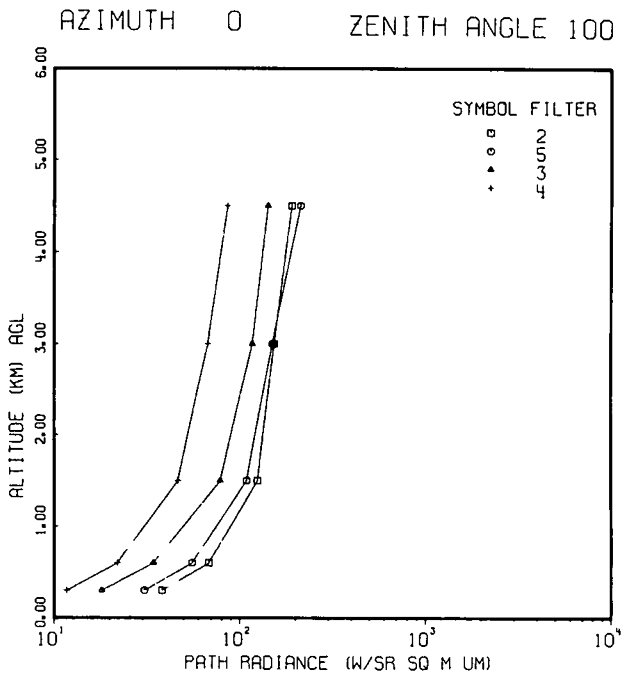




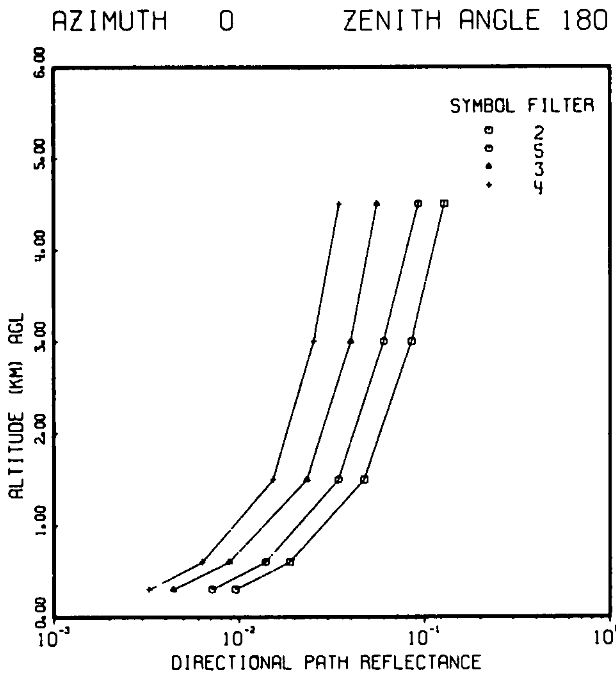
FLIGHT NO. C-157

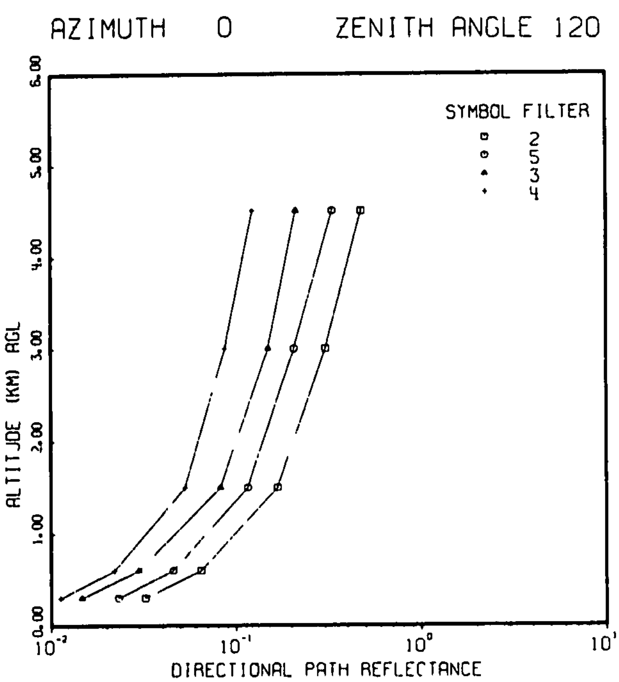


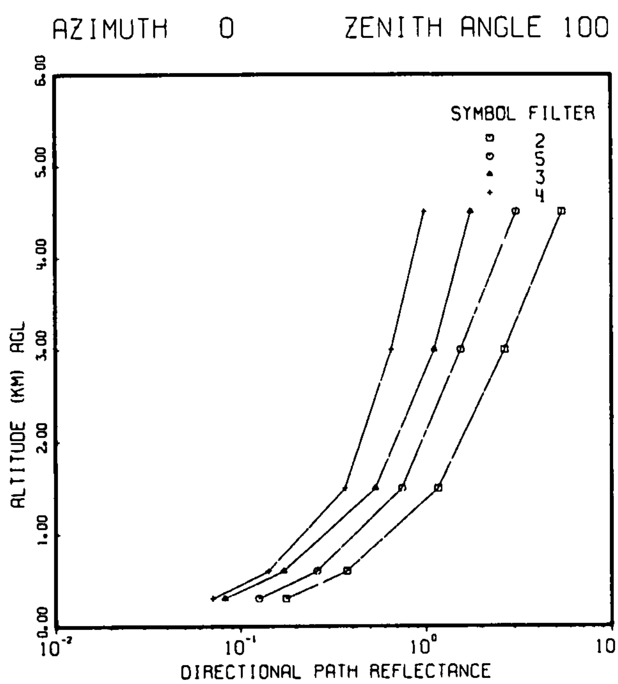




FLIGHT NO. C-157







FLIGHT NO. C-157
IRRADIANCE

FLIGHT NO.C-157 FILTER NO. 2
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
649	8.258E 02	5.866E 01	.071	1.682E 03	1.528E 02	1.834E 03	.091
2229	6.123E 02	7.313E 01	.119	1.319E 03	1.963E 02	1.515E 03	.149
4374	1.040E 03	1.211E 02	.116	2.064E 03	3.021E 02	2.366E 03	.146

FLIGHT NO.C-157 FILTER NO. 5
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
649	8.858E 02	9.765E 01	.110	1.804E 03	2.260E 02	2.030E 03	.125
2227	6.899E 02	1.058E 02	.153	1.471E 03	2.421E 02	1.713E 03	.165
4358	1.583E 03	1.089E 02	.069	3.074E 03	2.521E 02	3.327E 03	.082

FLIGHT NO.C-157 FILTER NO. 3
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
643	7.647E 02	9.630E 01	.126	1.461E 03	2.113E 02	1.672E 03	.145
1626	6.877E 02	9.751E 01	.142	1.419E 03	2.136E 02	1.633E 03	.151
4367	8.263E 02	9.750E 01	.118	1.587E 03	2.116E 02	1.799E 03	.133

FLIGHT NO.C-157 FILTER NO. 4
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
652	5.616E 02	9.607E 01	.171	1.090E 03	1.997E 02	1.290E 03	.183
2183	5.590E 02	9.896E 01	.177	1.072E 03	2.022E 02	1.275E 03	.189
4355	7.867E 02	1.467E 02	.186	1.491E 03	2.976E 02	1.789E 03	.200

FLIGHT NO. C-157
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-157
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.26388	.42805	.28675	.25941
95	.15645	.24178	.16050	.21198
100	.09565	.10893	.10992	.14379
105	.07613	.09002	.09499	.14476
120	.06769	.08406	.10399	.17128
150	.04696	.09397	.10006	.15997
180	.07284	.10387	.10785	.15791

FLIGHT NO. C-157
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.22267	.18094	.16733	.16167
95	.17280	.16579	.15191	.16324
100	.08684	.10907	.12536	.15372
105	.06296	.09208	.12146	.13176
120	.06896	.08894	.12379	.13739
150	.05221	.10154	.11116	.15520
180	.07284	.10387	.10785	.15791

FLIGHT NO. C-157
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.08999	.15772	.15267	.19357
95	.09106	.16850	.14837	.20593
100	.08740	.14771	.15303	.22150
105	.07401	.13841	.17372	.22092
120	.09539	.14196	.20199	.21266
150	.04552	.11923	.13791	.18946
180	.07284	.10387	.10785	.15791

FLIGHT NO. C-157
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.10682	.16625	.12756	.19336
95	.06293	.11242	.10642	.17276
100	.06404	.10170	.11263	.17594
105	.07895	.10476	.11503	.16163
120	.06123	.09894	.13025	.18322
150	.03960	.11898	.11903	.19240
180	.07284	.10387	.10785	.15791

FLIGHT NO. C-157
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110370 FLIGHT NO. C-157 GROUND LEVEL ALTITUDE (M)= 1446

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
0	1.130E-04	8.450E-05	5.650E-05	4.450E-05
30	1.124E-04	8.391E-05	5.646E-05	4.421E-05
60	1.118E-04	8.332E-05	5.641E-05	4.393E-05
90	1.112E-04	8.273E-05	5.637E-05	4.364E-05
120	1.106E-04	8.214E-05	5.633E-05	4.336E-05
150	1.100E-04	8.155E-05	5.628E-05	4.307E-05
180	1.094E-04	8.095E-05	5.624E-05	4.279E-05
210	1.088E-04	8.036E-05	5.620E-05	4.250E-05
240	1.082E-04	7.977E-05	5.615E-05	4.222E-05
270	1.075E-04	7.918E-05	5.611E-05	4.193E-05
300	1.069E-04	7.859E-05	5.607E-05	4.164E-05
330	1.063E-04	7.800E-05	5.602E-05	4.136E-05
360	1.057E-04	7.741E-05	5.598E-05	4.107E-05
390	1.051E-04	7.682E-05	5.594E-05	4.079E-05
420	1.045E-04	7.623E-05	5.589E-05	4.050E-05
450	1.039E-04	7.564E-05	5.585E-05	4.022E-05
480	1.033E-04	7.505E-05	5.581E-05	3.993E-05
510	1.027E-04	7.445E-05	5.576E-05	3.965E-05
540	1.021E-04	7.386E-05	5.572E-05	3.936E-05
570	1.015E-04	7.327E-05	5.568E-05	3.907E-05
600	1.006E-04	7.268E-05	5.563E-05	3.879E-05
630	1.025E-04	7.209E-05	5.559E-05	3.850E-05
660	1.022E-04	7.150E-05	5.555E-05	3.822E-05
690	1.029E-04	7.101E-05	5.317E-05	3.793E-05
720	1.016E-04	7.144E-05	5.381E-05	3.699E-05
750	1.023E-04	7.276E-05	5.399E-05	3.764E-05
780	1.005E-04	7.013E-05	5.422E-05	3.739E-05
810	1.029E-04	6.964E-05	5.496E-05	3.834E-05
840	1.026E-04	7.262E-05	5.501E-05	3.824E-05
870	1.020E-04	7.072E-05	5.518E-05	3.799E-05
900	1.032E-04	7.086E-05	5.537E-05	3.804E-05
930	1.019E-04	7.289E-05	5.449E-05	3.872E-05
960	1.022E-04	7.080E-05	5.320E-05	3.840E-05
990	1.007E-04	7.333E-05	5.378E-05	3.805E-05
1020	9.526E-05	7.478E-05	5.315E-05	3.829E-05
1050	9.482E-05	7.681E-05	5.327E-05	3.777E-05
1080	9.465E-05	7.496E-05	5.358E-05	3.784E-05
1110	9.511E-05	7.061E-05	5.463E-05	3.794E-05
1140	9.600E-05	6.874E-05	5.608E-05	3.803E-05
1170	1.072E-04	7.011E-05	6.127E-05	3.889E-05
1200	1.068E-04	7.135E-05	6.517E-05	3.963E-05
1230	1.341E-04	7.186E-05	6.758E-05	4.028E-05
1260	1.157E-04	7.104E-05	7.648E-05	3.934E-05
1290	1.113E-04	6.958E-05	7.769E-05	3.995E-05
1320	9.866E-05	7.948E-05	6.898E-05	3.979E-05
1350	9.731E-05	8.362E-05	6.750E-05	3.847E-05
1380	9.505E-05	7.559E-05	6.842E-05	3.760E-05
1410	9.545E-05	7.723E-05	6.841E-05	3.693E-05
1440	9.353E-05	7.585E-05	6.855E-05	3.671E-05
1470	9.044E-05	7.437E-05	5.968E-05	3.595E-05
1500	9.076E-05	8.018E-05	5.057E-05	3.556E-05

FLIGHT NO. C-157
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110370 FLIGHT NO. C-157 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
1530	9.130E-05	7.412E-05	5.259E-05	3.414E-05
1560	9.052E-05	6.629E-05	5.169E-05	3.399E-05
1590	9.079E-05	6.562E-05	5.109E-05	3.188E-05
1620	9.076E-05	6.076E-05	5.193E-05	3.193E-05
1650	9.109E-05	5.755E-05	5.286E-05	3.155E-05
1680	9.043E-05	6.505E-05	5.241E-05	3.132E-05
1710	9.036E-05	5.915E-05	5.366E-05	2.997E-05
1740	9.062E-05	5.909E-05	5.329E-05	2.943E-05
1770	8.975E-05	5.700E-05	5.432E-05	2.902E-05
1800	8.918E-05	5.940E-05	5.103E-05	2.891E-05
1830	8.735E-05	5.630E-05	4.906E-05	2.877E-05
1860	8.831E-05	5.794E-05	4.809E-05	2.861E-05
1890	8.808E-05	5.454E-05	4.685E-05	2.667E-05
1920	8.612E-05	5.396E-05	4.718E-05	2.626E-05
1950	8.334E-05	5.104E-05	4.500E-05	2.605E-05
1980	8.522E-05	5.030E-05	4.423E-05	2.438E-05
2010	8.300E-05	4.854E-05	4.336E-05	2.348E-05
2040	8.001E-05	4.818E-05	4.059E-05	2.355E-05
2070	7.762E-05	4.613E-05	3.667E-05	2.295E-05
2100	7.161E-05	4.356E-05	3.528E-05	2.290E-05
2130	6.429E-05	4.402E-05	3.363E-05	2.262E-05
2160	6.357E-05	4.310E-05	3.322E-05	2.191E-05
2190	6.397E-05	4.283E-05	3.294E-05	2.184E-05
2220	6.444E-05	4.287E-05	3.392E-05	2.177E-05
2250	6.342E-05	4.350E-05	3.268E-05	2.171E-05
2280	6.241E-05	4.210E-05	3.203E-05	2.164E-05
2310	6.166E-05	4.190E-05	3.230E-05	2.157E-05
2340	6.031E-05	4.189E-05	3.162E-05	2.150E-05
2370	6.049E-05	4.292E-05	3.248E-05	2.143E-05
2400	6.133E-05	4.189E-05	3.206E-05	2.137E-05
2430	6.219E-05	4.137E-05	3.215E-05	2.130E-05
2460	6.172E-05	4.131E-05	3.193E-05	2.123E-05
2490	6.096E-05	4.130E-05	3.207E-05	2.117E-05
2520	6.112E-05	4.087E-05	3.215E-05	2.110E-05
2550	6.088E-05	4.080E-05	3.162E-05	2.103E-05
2580	6.091E-05	4.077E-05	3.157E-05	2.097E-05
2610	6.061E-05	4.099E-05	3.161E-05	2.090E-05
2640	6.062E-05	4.189E-05	3.143E-05	2.084E-05
2670	6.034E-05	4.087E-05	3.141E-05	2.077E-05
2700	5.975E-05	4.186E-05	3.170E-05	2.071E-05
2730	6.054E-05	4.147E-05	3.219E-05	2.064E-05
2760	6.027E-05	4.168E-05	3.267E-05	2.058E-05
2790	6.007E-05	4.090E-05	3.171E-05	2.051E-05
2820	6.014E-05	4.185E-05	3.155E-05	2.045E-05
2850	6.022E-05	4.252E-05	3.178E-05	2.038E-05
2880	6.094E-05	4.101E-05	3.150E-05	2.032E-05
2910	6.041E-05	4.058E-05	3.119E-05	2.026E-05
2940	5.994E-05	4.104E-05	3.122E-05	2.019E-05
2970	6.059E-05	4.187E-05	3.210E-05	2.013E-05
3000	6.071E-05	4.107E-05	3.140E-05	2.007E-05

FLIGHT NO. C-157
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110370 FLIGHT NO. C-157 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
3030	6.065E-05	4.118E-05	3.158E-05	2.001E-05
3060	6.124E-05	4.143E-05	3.196E-05	1.994E-05
3090	6.142E-05	4.146E-05	3.215E-05	1.988E-05
3120	6.099E-05	4.102E-05	3.307E-05	1.982E-05
3150	6.100E-05	4.144E-05	3.249E-05	1.976E-05
3180	6.021E-05	4.138E-05	3.207E-05	1.970E-05
3210	5.890E-05	4.168E-05	3.127E-05	1.963E-05
3240	5.867E-05	4.217E-05	3.077E-05	1.957E-05
3270	5.802E-05	4.060E-05	3.077E-05	1.951E-05
3300	5.837E-05	4.159E-05	3.066E-05	1.945E-05
3330	5.758E-05	4.061E-05	3.105E-05	1.939E-05
3360	5.716E-05	3.907E-05	3.091E-05	1.933E-05
3390	5.682E-05	3.946E-05	3.142E-05	1.927E-05
3420	5.689E-05	3.993E-05	3.098E-05	1.921E-05
3450	5.703E-05	3.943E-05	3.063E-05	1.915E-05
3480	5.686E-05	3.919E-05	3.048E-05	1.909E-05
3510	5.643E-05	3.883E-05	3.090E-05	1.903E-05
3540	5.758E-05	3.867E-05	3.091E-05	1.897E-05
3570	5.628E-05	3.878E-05	3.098E-05	1.891E-05
3600	5.671E-05	3.916E-05	3.053E-05	1.885E-05
3630	5.739E-05	3.965E-05	3.037E-05	1.880E-05
3660	5.635E-05	3.819E-05	3.024E-05	1.874E-05
3690	5.596E-05	3.781E-05	3.044E-05	1.868E-05
3720	5.589E-05	3.799E-05	3.038E-05	1.862E-05
3750	5.672E-05	3.886E-05	3.044E-05	1.856E-05
3780	5.638E-05	3.847E-05	3.043E-05	1.851E-05
3810	5.647E-05	3.808E-05	2.977E-05	1.845E-05
3840	5.615E-05	3.807E-05	2.968E-05	1.839E-05
3870	5.572E-05	3.817E-05	2.939E-05	1.833E-05
3900	5.527E-05	3.856E-05	3.025E-05	1.828E-05
3930	5.480E-05	3.842E-05	2.939E-05	1.822E-05
3960	5.548E-05	3.817E-05	2.964E-05	1.816E-05
3990	5.558E-05	3.807E-05	2.918E-05	1.811E-05
4020	5.638E-05	3.880E-05	2.945E-05	1.805E-05
4050	5.565E-05	3.870E-05	2.914E-05	1.800E-05
4080	5.598E-05	3.754E-05	2.922E-05	1.794E-05
4110	5.551E-05	3.811E-05	2.960E-05	1.788E-05
4140	5.495E-05	3.877E-05	2.945E-05	1.783E-05
4170	5.531E-05	3.817E-05	2.952E-05	1.777E-05
4200	5.540E-05	3.780E-05	2.940E-05	1.772E-05
4230	5.583E-05	3.868E-05	2.926E-05	1.766E-05
4260	5.575E-05	3.807E-05	2.957E-05	1.761E-05
4290	5.527E-05	3.835E-05	2.931E-05	1.755E-05
4320	5.571E-05	3.799E-05	2.912E-05	1.750E-05
4350	5.554E-05	3.787E-05	2.903E-05	1.744E-05
4380	5.536E-05	3.775E-05	2.894E-05	1.739E-05
4410	5.519E-05	3.763E-05	2.885E-05	1.734E-05
4440	5.502E-05	3.752E-05	2.876E-05	1.728E-05
4470	5.485E-05	3.740E-05	2.867E-05	1.723E-05
4500	5.468E-05	3.728E-05	2.858E-05	1.718E-05
FIRST DATA ALT	0	0	0	0
LAST DATA ALT	4320	4320	4320	2160

FLIGHT NO. C-157
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-157 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DFG) 93	95	100	105	120	150	180
300	.5297491	.6841400	.8269672	.8803205	.9361469	.9626212	.9675468
600	.2877212	.4769407	.6910840	.7804359	.8795685	.9285901	.9378531
1500	.0451996	.1637090	.4084236	.5483836	.7327236	.8356476	.8559928
3000	.0038321	.0442832	.2196874	.3617433	.5907603	.7379454	.7686093
4500	.0004022	.0149553	.1344446	.2602064	.4981341	.6687485	.7057862

FLIGHT NO. C-157 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	.6242947	.7546695	.8685933	.9098094	.9522504	.9721471	.9758332
600	.4002621	.5803450	.7621960	.8334424	.9100017	.9470066	.9539401
1500	.1055199	.2686891	.5218961	.6464278	.7978440	.8777530	.8932211
3000	.0178225	.1114706	.3443326	.4890430	.6905485	.8075301	.8309925
4500	.0041765	.0527704	.2456838	.3899315	.6141578	.7546810	.7836822

FLIGHT NO. C-157 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	.7224168	.8234343	.9073409	.9368437	.9667938	.9806917	.9832567
600	.5204896	.6783190	.8238836	.8781168	.9349330	.9619004	.9669194
1500	.1770939	.3631459	.6055823	.7142570	.8401359	.9043222	.9165893
3000	.0465797	.1793830	.4336799	.5709102	.7481527	.8457621	.8649582
4500	.0139363	.1004935	.3339553	.4791049	.6832485	.8025904	.8265885

FLIGHT NO. C-157 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	.7796969	.8618494	.9282883	.9513003	.9744878	.9851901	.9871615
600	.6155932	.7495167	.8659810	.9079727	.9512548	.9715602	.9753229
1500	.3066308	.5012428	.7105515	.7951183	.8880955	.9337770	.9423882
3000	.1320308	.3224407	.5770699	.6915159	.8261816	.8956195	.9089453
4500	.0619619	.2253395	.4914896	.6209109	.7813832	.8672514	.8839588

FLIGHT NO. C-157
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-157 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.563E 02	8.676E 01	3.826E 01	2.254E 01	7.965E 00	2.888E 00	2.427E 00
600	2.204E 02	1.414E 02	6.830E 01	4.136E 01	1.502E 01	5.517E 00	4.648E 00
1500	2.487E 02	2.071E 02	1.252E 02	8.170E 01	3.241E 01	1.253E 01	1.069E 01
3000	2.339E 02	2.148E 02	1.542E 02	1.081E 02	4.759E 01	1.982E 01	1.724E 01
4500	3.023E 02	2.652E 02	1.913E 02	1.361E 02	6.258E 01	2.711E 01	2.383E 01

FLIGHT NO. C-157 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.353E 02	7.252E 01	3.075E 01	1.812E 01	6.242E 00	2.285E 00	1.963E 00
600	2.028E 02	1.223E 02	5.564E 01	3.347E 01	1.177E 01	4.347E 00	3.742E 00
1500	2.624E 02	2.006E 02	1.094E 02	6.961E 01	2.613E 01	1.000E 01	8.691E 00
3000	2.852E 02	2.399E 02	1.504E 02	1.005E 02	4.035E 01	1.606E 01	1.417E 01
4500	4.174E 02	3.376E 02	2.130E 02	1.426E 02	5.770E 01	2.299E 01	2.054E 01

FLIGHT NO. C-157 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	8.714E 01	4.444E 01	1.809E 01	1.044E 01	3.464E 00	1.237E 00	1.056E 00
600	1.424E 02	7.998E 01	3.438E 01	2.015E 01	6.787E 00	2.442E 00	2.087E 00
1500	2.281E 02	1.582E 02	7.900E 01	4.809E 01	1.690E 01	6.106E 00	5.203E 00
3000	2.651E 02	2.074E 02	1.176E 02	7.427E 01	2.729E 01	9.939E 00	8.463E 00
4500	2.803E 02	2.319E 02	1.423E 02	9.247E 01	3.526E 01	1.307E 01	1.120E 01

FLIGHT NO. C-157 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.391E 01	3.023E 01	1.172E 01	6.321E 00	1.962E 00	6.866E-01	5.762E-01
600	1.064E 02	5.424E 01	2.191E 01	1.194E 01	3.749E 00	1.318E 00	1.108E 00
1500	1.718E 02	1.040E 02	4.669E 01	2.618E 01	8.456E 00	3.037E 00	2.581E 00
3000	2.020E 02	1.373E 02	6.755E 01	3.885E 01	1.293E 01	4.769E 00	4.113E 00
4500	2.345E 02	1.669E 02	8.629E 01	5.053E 01	1.726E 01	6.449E 00	5.516E 00

FLIGHT NO. C-157
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-157 FILTER NO. 2

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.598E 01	3.278E 01	1.613E 01	1.077E 01	5.239E 00	2.823E 00	2.427E 00
600	7.893E 01	5.341E 01	2.880E 01	1.976E 01	9.881E 00	5.393E 00	4.648E 00
1500	9.314E 01	8.094E 01	5.441E 01	4.027E 01	2.182E 01	1.232E 01	1.069E 01
3000	9.354E 01	8.929E 01	7.111E 01	5.676E 01	3.359E 01	1.965E 01	1.724E 01
4500	1.106E 02	1.041E 02	8.630E 01	7.127E 01	4.439E 01	2.679E 01	2.383E 01

FLIGHT NO. C-157 FILTER NO. 5

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.930E 01	2.754E 01	1.317E 01	8.693E 00	4.161E 00	2.246E 00	1.963E 00
600	7.390E 01	4.645E 01	2.383E 01	1.605E 01	7.843E 00	4.272E 00	3.742E 00
1500	9.618E 01	7.672E 01	4.711E 01	3.368E 01	1.756E 01	9.878E 00	8.691E 00
3000	1.013E 02	9.066E 01	6.436E 01	4.883E 01	2.737E 01	1.600E 01	1.417E 01
4500	1.301E 02	1.150E 02	8.452E 01	6.571E 01	3.818E 01	2.296E 01	2.054E 01

FLIGHT NO. C-157 FILTER NO. 3

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.673E 01	1.436E 01	6.776E 00	4.504E 00	2.210E 00	1.209E 00	1.056E 00
600	4.368E 01	2.584E 01	1.288E 01	8.693E 00	4.331E 00	2.386E 00	2.087E 00
1500	6.652E 01	4.935E 01	2.864E 01	2.026E 01	1.058E 01	6.941E 00	5.203E 00
3000	7.355E 01	6.229E 01	4.115E 01	3.048E 01	1.673E 01	9.628E 00	8.463E 00
4500	7.692E 01	6.883E 01	4.917E 01	3.761E 01	2.144E 01	1.265E 01	1.120E 01

FLIGHT NO. C-157 FILTER NO. 4

PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.204E 01	6.381E 00	3.029E 00	2.052E 00	1.057E 00	6.337E-01	5.762E-01
600	2.005E 01	1.145E 01	5.661E 00	3.878E 00	2.020E 00	1.217E 00	1.108E 00
1500	3.232E 01	2.203E 01	1.217E 01	8.611E 00	4.640E 00	2.831E 00	2.581E 00
3000	3.769E 01	2.911E 01	1.783E 01	1.305E 01	7.295E 00	4.499E 00	4.113E 00
4500	4.274E 01	3.479E 01	2.258E 01	1.688E 01	9.644E 00	5.963E 00	5.516E 00

FLIGHT NO. C-157
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-157 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.923E 01	3.541E 01	1.847E 01	1.298E 01	7.173E 00	3.462E 00	2.427E 00
600	8.351E 01	5.769E 01	3.297E 01	2.382E 01	1.353F 01	6.615E 00	4.648E 00
1500	1.112E 02	9.655E 01	6.814E 01	5.320E 01	3.292E 01	1.596E 01	1.069E 01
3000	1.401E 02	1.315E 02	1.078E 02	9.074E 01	6.153E 01	2.859E 01	1.724E 01
4500	1.799E 02	1.712E 02	1.488E 02	1.304E 02	9.383E 01	4.270E 01	2.383E 01

FLIGHT NO. C-157 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.462E 01	3.105E 01	1.543E 01	1.054E 01	5.512E 00	2.752E 00	1.963E 00
600	8.188E 01	5.237E 01	2.793E 01	1.947E 01	1.039E 01	5.235E 00	3.742E 00
1500	1.118E 02	8.998E 01	5.736E 01	4.249E 01	2.437E 01	1.230E 01	8.691E 00
3000	1.299E 02	1.158E 02	8.510E 01	6.706E 01	4.193E 01	2.066E 01	1.417E 01
4500	1.716E 02	1.539E 02	1.194E 02	9.741E 01	6.480E 01	3.106E 01	2.054E 01

FLIGHT NO. C-157 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.964E 01	1.626E 01	8.038E 00	5.562E 00	3.033E 00	1.517E 00	1.056E 00
600	4.844E 01	2.927E 01	1.528E 01	1.073E 01	5.942E 00	2.994E 00	2.087E 00
1500	7.743E 01	5.809E 01	3.509E 01	2.570E 01	1.474E 01	7.439E 00	5.203E 00
3000	8.859E 01	7.583E 01	5.216E 01	3.993E 01	2.399E 01	1.211E 01	8.463E 00
4500	9.120E 01	8.347E 01	6.290E 01	5.006E 01	3.164E 01	1.612E 01	1.120E 01

FLIGHT NO. C-157 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.404E 01	7.611E 00	3.816E 00	2.681E 00	1.486E 00	7.740E-01	5.762E-01
600	2.338E 01	1.366E 01	7.132E 00	5.066E 00	2.839E 00	1.486E 00	1.108E 00
1500	3.834E 01	2.661E 01	1.542E 01	1.126E 01	6.485E 00	3.459E 00	2.581E 00
3000	4.616E 01	3.602E 01	2.286E 01	1.712E 01	1.010E 01	5.628E 00	4.113E 00
4500	5.257E 01	4.330E 01	2.907E 01	2.219E 01	1.339E 01	7.489E 00	5.516E 00

FLIGHT NO. C-157
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-157 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	5.841E 01	3.413E 01	1.671E 01	1.109E 01	5.322E 00	2.857E 00	2.427E 00
600	8.235E 01	5.560E 01	2.984E 01	2.034E 01	1.004E 01	5.458E 00	4.648E 00
1500	9.678E 01	8.395E 01	5.614E 01	4.128E 01	2.209E 01	1.246E 01	1.069E 01
3000	9.617E 01	9.176E 01	7.273E 01	5.774E 01	3.385E 01	1.991E 01	1.724E 01
4500	1.128E 02	1.064E 02	8.828E 01	7.276E 01	4.521E 01	2.752E 01	2.383E 01

FLIGHT NO. C-157 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	5.383E 01	3.013E 01	1.441E 01	9.480E 00	4.469E 00	2.339E 00	1.963E 00
600	8.068E 01	5.082E 01	2.608E 01	1.751E 01	8.424E 00	4.450E 00	3.742E 00
1500	1.038E 02	8.315E 01	5.115E 01	3.644E 01	1.874E 01	1.026E 01	8.691E 00
3000	1.051E 02	9.530E 01	6.830E 01	5.178E 01	2.879E 01	1.654E 01	1.417E 01
4500	1.269E 02	1.150E 02	8.678E 01	6.796E 01	3.980E 01	2.384E 01	2.054E 01

FLIGHT NO. C-157 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	3.011E 01	1.620E 01	7.628E 00	5.029E 00	2.409E 00	1.271E 00	1.056E 00
600	4.921E 01	2.917E 01	1.450E 01	9.706E 00	4.721E 00	2.509E 00	2.087E 00
1500	7.354E 01	5.481E 01	3.184E 01	2.236E 01	1.145E 01	6.227E 00	5.203E 00
3000	7.819E 01	6.706E 01	4.471E 01	3.301E 01	1.794E 01	1.007E 01	8.463E 00
4500	7.835E 01	7.162E 01	5.218E 01	4.001E 01	2.283E 01	1.325E 01	1.120E 01

FLIGHT NO. C-157 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	1.343E 01	7.151E 00	3.432E 00	2.329E 00	1.212E 00	6.975E-01	5.762E-01
600	2.235E 01	1.283E 01	6.414E 00	4.401E 00	2.315E 00	1.339E 00	1.108E 00
1500	3.508E 01	2.411E 01	1.349E 01	9.585E 00	5.242E 00	3.101E 00	2.581E 00
3000	3.897E 01	3.058E 01	1.909E 01	1.411E 01	8.093E 00	4.914E 00	4.113E 00
4500	4.491E 01	3.699E 01	2.454E 01	1.859E 01	1.099E 01	6.676E 00	5.516E 00

FLIGHT NO. C-157
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-157 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.122E 00	4.825E-01	1.760E-01	9.743E-02	3.237E-02	1.141E-02	9.543E-03
600	2.914E 00	1.128E 00	3.760E-01	2.016E-01	6.497E-02	2.260E-02	1.885E-02
1500	2.093E 01	4.813E 00	1.166E 00	5.668E-01	1.683E-01	5.706E-02	4.752E-02
3000	2.322E 02	1.846E 01	2.669E 00	1.136E 00	3.065E-01	1.022E-01	8.533E-02
4500	2.860E 03	6.745E 01	5.414E 00	1.990E 00	4.779E-01	1.542E-01	1.285E-01

FLIGHT NO. C-157 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	7.684E-01	3.408E-01	1.255E-01	7.065E-02	2.325E-02	8.336E-03	7.135E-03
600	1.797E 00	7.476E-01	2.589E-01	1.424E-01	4.585E-02	1.628E-02	1.391E-02
1500	8.820E 00	2.648E 00	7.435E-01	3.819E-01	1.162E-01	4.042E-02	3.451E-02
3000	5.102E 01	7.634E 00	1.549E 00	7.286E-01	2.072E-01	7.054E-02	6.045E-02
4500	3.545E 02	2.269E 01	3.074E 00	1.297E 00	3.332E-01	1.080E-01	9.295E-02

FLIGHT NO. C-157 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.956E-01	2.217E-01	8.191E-02	4.579E-02	1.472E-02	5.184E-03	4.414E-03
600	1.124E 00	4.845E-01	1.715E-01	9.428E-02	2.983E-02	1.043E-02	8.869E-03
1500	5.293E 00	1.790E 00	5.359E-01	2.766E-01	8.263E-02	2.774E-02	2.332E-02
3000	2.339E 01	4.750E 00	1.115E 00	5.345E-01	1.499E-01	4.828E-02	4.020E-02
4500	8.263E 01	9.479E 00	1.751E 00	7.929E-01	2.120E-01	6.690E-02	5.569E-02

FLIGHT NO. C-157 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.586E-01	1.962E-01	7.065E-02	3.717E-02	1.126E-02	3.899E-03	3.265E-03
600	9.670E-01	4.048E-01	1.415E-01	7.359E-02	2.205E-02	7.592E-03	6.352E-03
1500	3.134E 00	1.161E 00	3.676E-01	1.842E-01	5.327E-02	1.820E-02	1.532E-02
3000	8.559E 00	2.381E 00	6.548E-01	3.143E-01	8.752E-02	2.979E-02	2.531E-02
4500	2.117E 01	4.143E 00	9.822E-01	4.553E-01	1.236E-01	4.160E-02	3.491E-02

FLIGHT NO. C-157
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-157 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	4.020E-01	1.823E-01	7.420E-02	4.656E-02	2.129E-02	1.116E-02	9.543E-03
600	1.044E 00	4.260E-01	1.585E-01	9.634E-02	4.274E-02	2.209E-02	1.885E-02
1500	7.839E 00	1.881E 00	5.068E-01	2.794E-01	1.133E-01	5.607E-02	4.752E-02
3000	9.786E 01	7.671E 00	1.231E 00	5.969E-01	2.163E-01	1.013E-01	8.533E-02
4500	1.047E 03	2.647E 01	2.442E 00	1.042E 00	3.390E-01	1.524E-01	1.285E-01

FLIGHT NO. C-157 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.801E-01	1.294E-01	5.376E-02	3.389E-02	1.550E-02	8.192E-03	7.135E-03
600	6.548E-01	2.839E-01	1.109E-01	6.831E-02	3.057E-02	1.600E-02	1.391E-02
1500	3.233E 00	1.013E 00	3.202E-01	1.848E-01	7.808E-02	3.991E-02	3.451E-02
3000	1.813E 01	2.885E 00	6.629E-01	3.541E-01	1.405E-01	7.026E-02	6.045E-02
4500	1.105E 02	7.730E 00	1.220E 00	5.976E-01	2.205E-01	1.079E-01	9.295E-02

FLIGHT NO. C-157 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.520E-01	7.164E-02	3.068E-02	1.975E-02	9.393E-03	5.066E-03	4.414E-03
600	3.448E-01	1.565E-01	6.422E-02	4.067E-02	1.903E-02	1.019E-02	8.869E-03
1500	1.543E 00	5.583E-01	1.943E-01	1.165E-01	5.173E-02	2.699E-02	2.332E-02
3000	6.488E 00	1.427E 00	3.898E-01	2.194E-01	9.185E-02	4.677E-02	4.020E-02
4500	2.268E 01	2.814E 00	6.049E-01	3.225E-01	1.289E-01	6.478E-02	5.569E-02

FLIGHT NO. C-157 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	8.640E-02	4.142E-02	1.826E-02	1.207E-02	6.069E-03	3.598E-03	3.265E-03
600	1.822E-01	8.544E-02	3.657E-02	2.389E-02	1.188E-02	7.007E-03	6.352E-03
1500	5.897E-01	2.459E-01	9.579E-02	6.059E-02	2.923E-02	1.696E-02	1.532E-02
3000	1.597E 00	5.051E-01	1.728E-01	1.056E-01	4.940E-02	2.810E-02	2.531E-02
4500	3.859E 00	8.636E-01	2.570E-01	1.521E-01	6.904E-02	3.847E-02	3.491E-02

FLIGHT NO. C-157
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-157 FILTER NO. 2

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	4.253E-01	1.969E-01	8.496E-02	5.610E-02	2.915E-02	1.368E-02	9.543E-03
600	1.104E 00	4.602E-01	1.815E-01	1.161E-01	5.851E-02	2.710E-02	1.885E-02
1500	9.356E 00	2.244E 00	6.347E-01	3.691E-01	1.709E-01	7.265E-02	4.752E-02
3000	1.391E 02	1.130E 01	1.867E 00	9.542E-01	3.963E-01	1.474E-01	8.533E-02
4500	1.702E 03	4.354E 01	4.210E 00	1.906E 00	7.165E-01	2.429E-01	1.285E-01

FLIGHT NO. C-157 FILTER NO. 5

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.103E-01	1.459E-01	6.302E-02	4.110E-02	2.053E-02	1.004E-02	7.135E-03
600	7.255E-01	3.201E-01	1.300E-01	8.286E-02	4.049E-02	1.961E-02	1.391E-02
1500	3.759E 00	1.188E 00	3.898E-01	2.331E-01	1.083E-01	4.968E-02	3.451E-02
3000	2.324E 01	3.684E 00	8.765E-01	4.863E-01	2.153E-01	9.072E-02	6.045E-02
4500	1.457E 02	1.034E 01	1.723E 00	8.860E-01	3.742E-01	1.459E-01	9.295E-02

FLIGHT NO. C-157 FILTER NO. 3

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.685E-01	8.114E-02	3.640E-02	2.439E-02	1.289E-02	6.356E-03	4.414E-03
600	3.824E-01	1.773E-01	7.619E-02	5.022E-02	2.611E-02	1.279E-02	8.869E-03
1500	1.796E 00	6.572E-01	2.381E-01	1.478E-01	7.210E-02	3.380E-02	2.332E-02
3000	7.814E 00	1.737E 00	4.941E-01	2.873E-01	1.317E-01	5.883E-02	4.020E-02
4500	2.689E 01	3.412E 00	7.739E-01	4.293E-01	1.903E-01	8.252E-02	5.569E-02

FLIGHT NO. C-157 FILTER NO. 4

DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.008E-01	4.940E-02	2.300E-02	1.576E-02	8.531E-03	4.395E-03	3.265E-03
600	2.125E-01	1.019E-01	4.607E-02	3.121E-02	1.670E-02	8.558E-03	6.352E-03
1500	6.996E-01	2.970E-01	1.214E-01	7.925E-02	4.085E-02	2.073E-02	1.532E-02
3000	1.956E 00	6.248E-01	2.216E-01	1.385E-01	6.841E-02	3.453E-02	2.531E-02
4500	4.746E 00	1.075E 00	3.309E-01	1.999E-01	9.584E-02	4.830E-02	3.491E-02

FLIGHT NO. C-157
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-157 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	4.194E-01	1.898E-01	7.688E-02	4.792E-02	2.163E-02	1.129E-02	9.543E-03
600	1.089E 00	4.435E-01	1.642E-01	9.916E-02	4.341E-02	2.236E-02	1.885E-02
1500	8.145E 00	1.951E 00	5.229E-01	2.864E-01	1.147E-01	5.671E-02	4.752E-02
3000	9.547E 01	7.883E 00	1.259E 00	6.072E-01	2.180E-01	1.026E-01	8.533E-02
4500	1.067E 03	2.706E 01	2.498E 00	1.064E 00	3.453E-01	1.566E-01	1.285E-01

FLIGHT NO. C-157 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	3.058E-01	1.416E-01	5.884E-02	3.696E-02	1.664E-02	8.532E-03	7.135E-03
600	7.149E-01	3.106E-01	1.214E-01	7.450E-02	3.283E-02	1.666E-02	1.391E-02
1500	3.490E 00	1.098E 00	3.476E-01	1.999E-01	8.329E-02	4.144E-02	3.451E-02
3000	1.880E 01	3.032E 00	7.035E-01	3.755E-01	1.478E-01	7.263E-02	6.045E-02
4500	1.078E 02	7.728E 00	1.253E 00	6.181E-01	2.298E-01	1.120E-01	9.295E-02

FLIGHT NO. C-157 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	1.713E-01	8.085E-02	3.454E-02	2.206E-02	1.024E-02	5.327E-03	4.414E-03
600	3.884E-01	1.767E-01	7.231E-02	4.541E-02	2.075E-02	1.072E-02	8.869E-03
1500	1.706E 00	6.201E-01	2.160E-01	1.286E-01	5.602E-02	2.829E-02	2.332E-02
3000	6.897E 00	1.536E 00	4.235E-01	2.376E-01	9.852E-02	4.891E-02	4.020E-02
4500	2.310E 01	2.928E 00	6.420E-01	3.431E-01	1.373E-01	6.784E-02	5.569E-02

FLIGHT NO. C-157 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 93	95	100	105	120	150	180
300	9.632E-02	4.642E-02	2.068E-02	1.370E-02	6.956E-03	3.960E-03	3.265E-03
600	2.031E-01	9.577E-02	4.143E-02	2.712E-02	1.362E-02	7.712E-03	6.352E-03
1500	6.400E-01	2.691E-01	1.062E-01	6.744E-02	3.302E-02	1.858E-02	1.532E-02
3000	1.651E 00	5.306E-01	1.851E-01	1.141E-01	5.480E-02	3.069E-02	2.531E-02
4500	4.054E 00	9.182E-01	2.793E-01	1.675E-01	7.868E-02	4.307E-02	3.491E-02

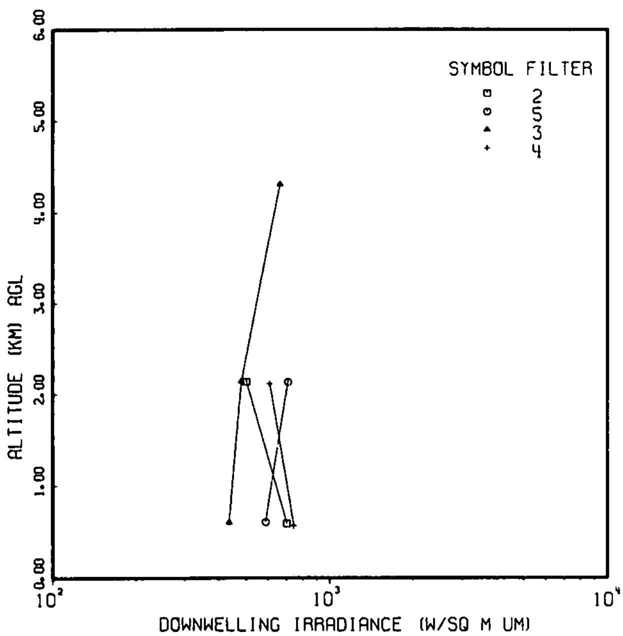
FLIGHT C-158 – 4 NOVEMBER 1970 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

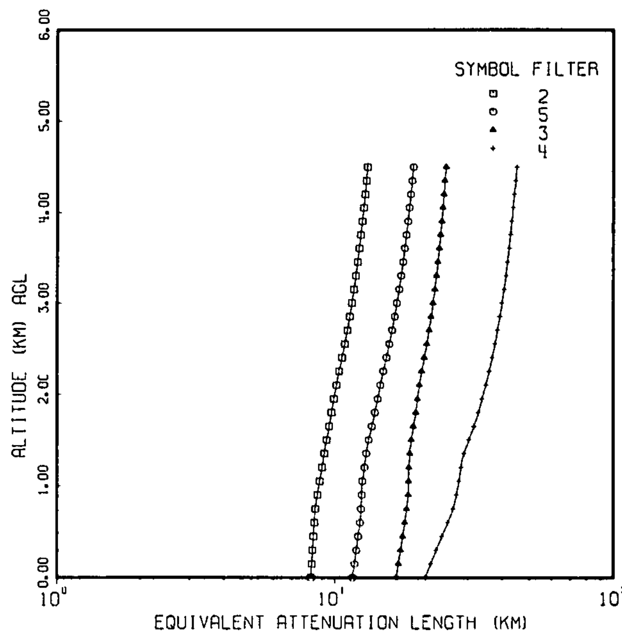
It was a sunlit, late morning flight. The sun was unobstructed but there were some scattered thin clouds. The flight was conducted over a broad desert valley on a north northeast to south southwest track on the northern end of the White Sands Missile Range. The typical terrain was desert sand and low scattered brush. The data-taking started at 0917 local time (1617 GMT) and continued until 1231 local time (1931 GMT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 5 was 61.2 degrees at the start and 52.0 degrees at the end. The sun zenith angle for the sky radiance data-taking for Filter 4 was 49.3 degrees at the start, 49.2 degrees at noon, and 50.0 degrees at the end. The highest flight altitude was 4308 meters AGL.

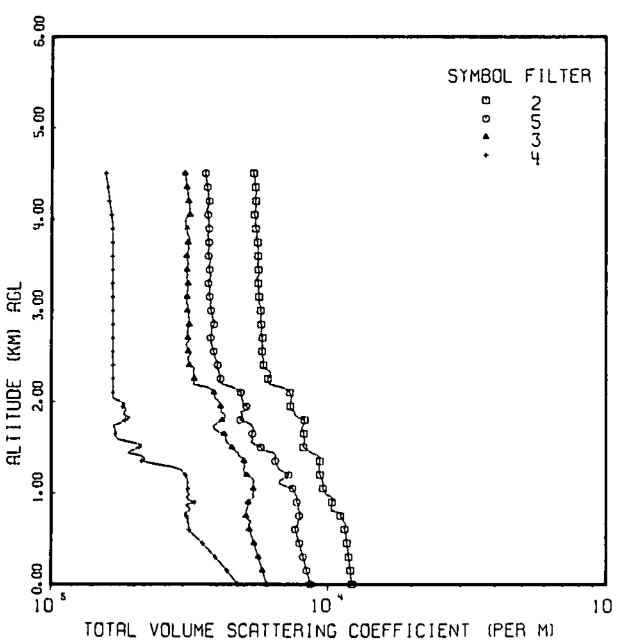
> At the beginning of the data-taking, Stallion was reporting 0.1 altostratus at 4500 meters and 0.5 cirrus at 6000 meters and a visibility of 40 miles (64 kilometers). The ground station recorded sunny, some cirrus but sun clear. Later during the data-taking, some cumulus on the horizon were recorded.
>
> During the flight, the aircrew reported that there were some scattered thin clouds above 685 meters. At 1617 GMT, there was moderate to heavy haze at 685 meters and also at 4300 meters. At 1832, there was moderate to heavy haze at 4300 meters and scattered cumulus on the horizon. At 1901 GMT, there was moderate to heavy haze with the top of the haze layer at 2210 meters.
>
> At the end of data-taking, Stallion was reporting few altocumulus (less than 0.1) to the north and 40 mile (64 kilometer) visibility.

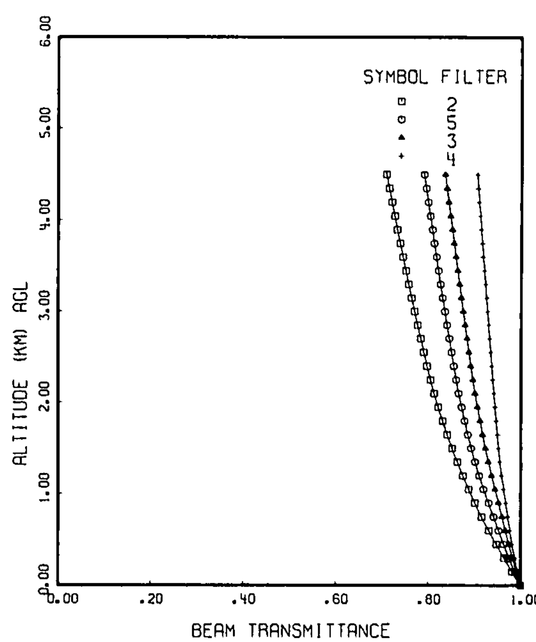
The area was still on the back side of the high with southeasterly flow. The 1040-millibar center of the high was located in northeastern Wyoming and high pressure covered the Great Plains. A cold front was moving over southwestern Oregon and extended along a line from Klamath Falls to Yosemite to Santa Ana. At 500 millibars there was a moderate to strong northwesterly flow with a weak ridge over Arizona. The airmass was well-modified continental polar.

FLIGHT NO. C-158

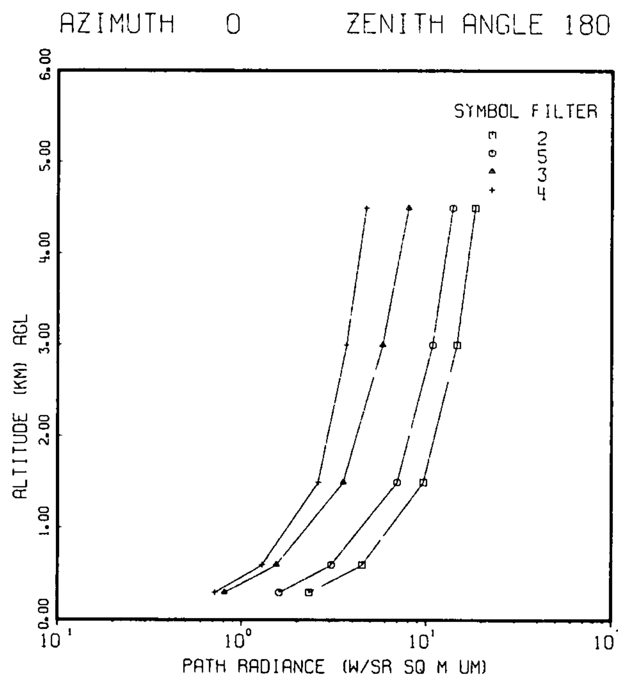


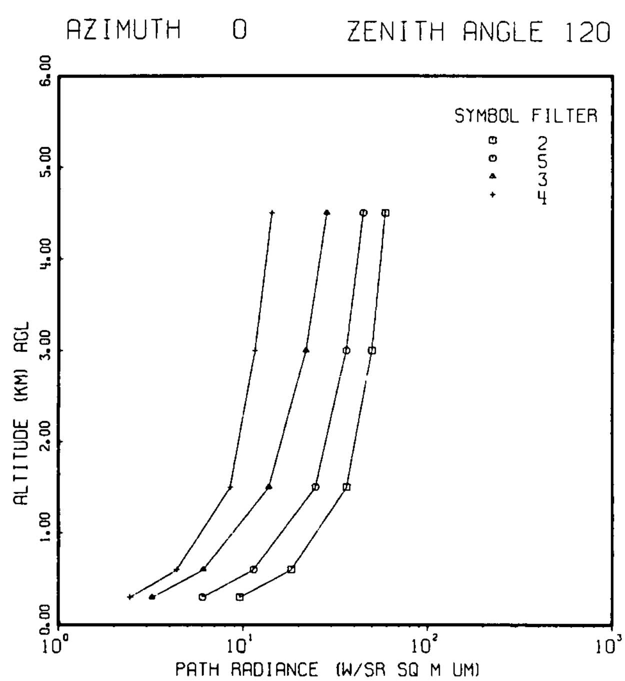


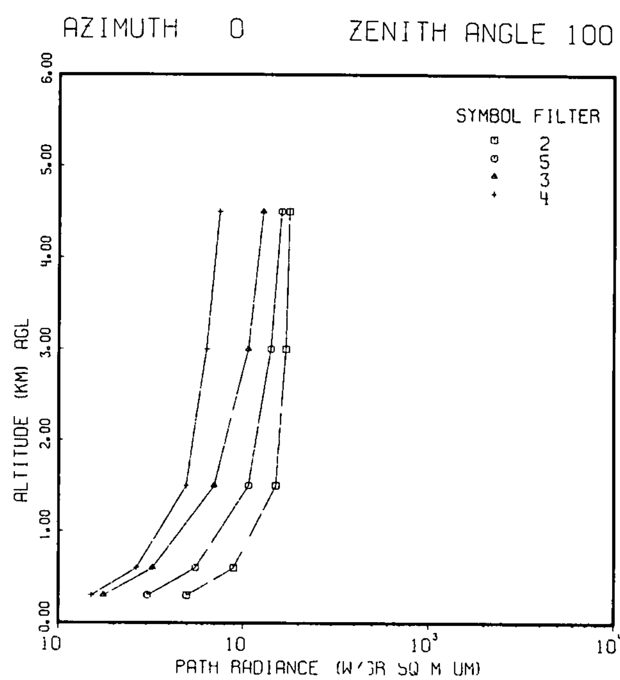




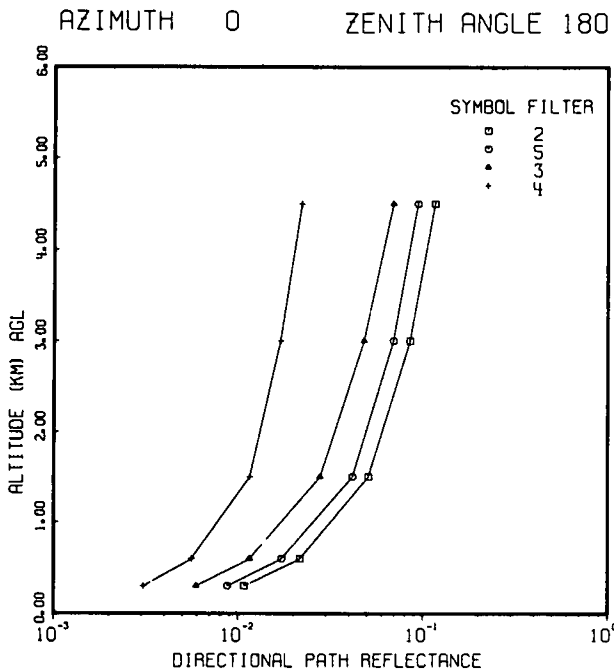
FLIGHT NO. C-158

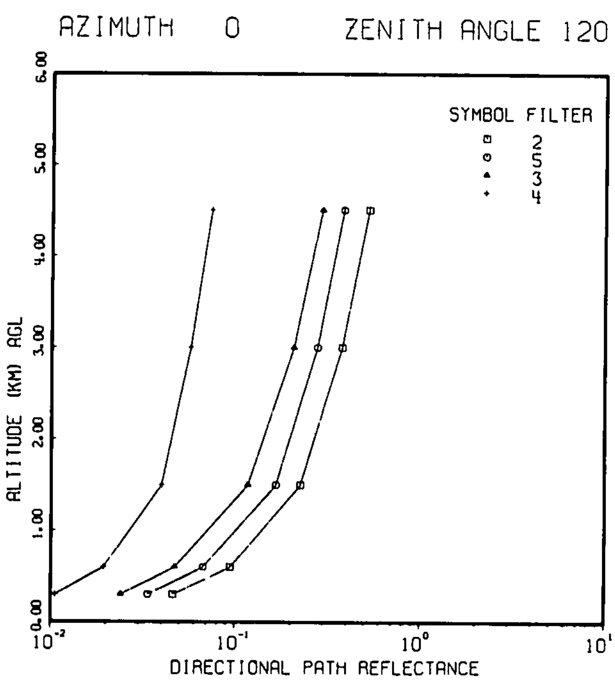


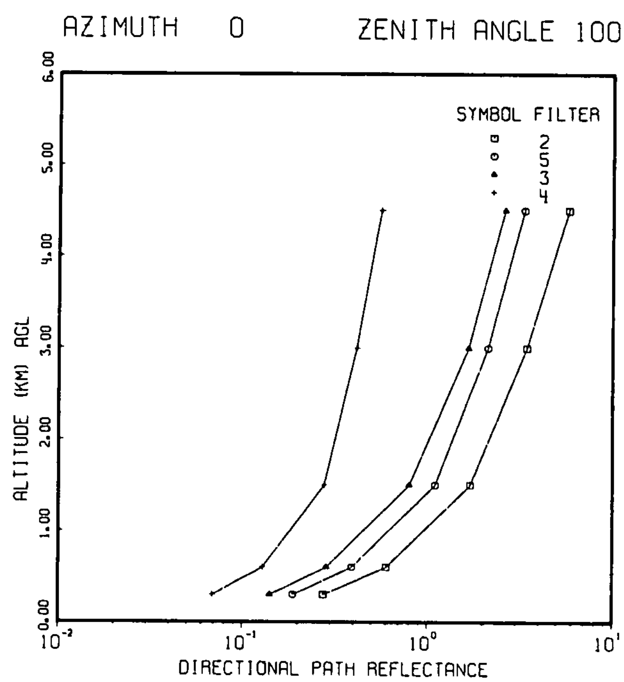




FLIGHT NO. C-158







FLIGHT NO. C-158
IRRADIANCE

FLIGHT NO.C-158 FILTER NO. 2
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
591	6.995E 02	4.490E 01	.064	1.677E 03	1.203E 02	1.797E 03	.072
2136	5.010E 02	6.955E 01	.139	1.186E 03	1.876E 02	1.374E 03	.158

FLIGHT NO.C-158 FILTER NO. 5
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
609	5.873E 02	7.474E 01	.127	1.428E 03	1.843E 02	1.612E 03	.129
2134	7.085E 02	8.434E 01	.119	1.462E 03	2.066E 02	1.669E 03	.141

FLIGHT NO.C-158 FILTER NO. 3
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
603	4.342E 02	7.966E 01	.183	1.034E 03	1.736E 02	1.208E 03	.168
2136	4.814E 02	8.279E 01	.172	1.117E 03	1.812E 02	1.299E 03	.162
4308	6.617E 02	1.234E 02	.187	1.309E 03	2.622E 02	1.571E 03	.200

FLIGHT NO.C-158 FILTER NO. 4
IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR DOWNWELLING	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
568	7.418E 02	1.103E 02	.149	1.427E 03	2.181E 02	1.645E 03	.153
2115	6.087E 02	1.016E 02	.167	1.152E 03	2.060E 02	1.358E 03	.179

FLIGHT NO. C-158
DIRECTIONAL REFLECTANCE OF BACKGROUND

FLIGHT NO. C-158
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.24644	.41259	.39323	.14334
95	.30197	.31523	.33502	.13027
100	.11187	.17676	.17357	.13592
105	.08288	.15534	.15810	.13463
120	.05922	.12021	.14779	.12477
150	.04909	.09941	.16959	.11618
180	.04331	.12812	.16076	.14258

FLIGHT NO. C-158
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.29757	.31270	.29101	.11911
95	.27350	.27153	.28722	.12420
100	.10389	.16979	.21158	.12793
105	.06895	.13093	.18113	.13133
120	.05462	.10010	.16591	.12559
150	.05037	.11412	.17259	.13475
180	.04331	.12812	.16076	.14258

FLIGHT NO. C-158
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.18300	.26848	.28164	.16709
95	.10263	.25394	.28831	.16801
100	.09928	.23592	.26731	.17053
105	.10326	.20819	.26157	.17450
120	.08957	.18816	.25250	.18419
150	.05636	.13017	.21427	.18734
180	.04331	.12812	.16076	.14258

FLIGHT NO. C-158
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	5	3	4
93	.06923	.19854	.17016	.13270
95	.05929	.17744	.14990	.13231
100	.06280	.14120	.17822	.13737
105	.06268	.12647	.17357	.13710
120	.06173	.13672	.20168	.14725
150	.05504	.10011	.17394	.14777
180	.04331	.12812	.16076	.14258

FLIGHT NO. C-158
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110470 FLIGHT NO. C-158 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
0	1.220E-04	8.640E-05	6.010E-05	4.730E-05
30	1.217E-04	8.589E-05	5.970E-05	4.650E-05
60	1.213E-04	8.538E-05	5.930E-05	4.569E-05
90	1.210E-04	8.487E-05	5.890E-05	4.489E-05
120	1.207E-04	8.436E-05	5.849E-05	4.409E-05
150	1.204E-04	8.385E-05	5.809E-05	4.328E-05
180	1.200E-04	8.334E-05	5.769E-05	4.248E-05
210	1.197E-04	8.283E-05	5.729E-05	4.168E-05
240	1.194E-04	8.232E-05	5.689E-05	4.087E-05
270	1.190E-04	8.181E-05	5.649E-05	4.007E-05
300	1.187E-04	8.130E-05	5.608E-05	3.927E-05
330	1.184E-04	8.079E-05	5.568E-05	3.846E-05
360	1.181E-04	8.028E-05	5.528E-05	3.766E-05
390	1.177E-04	7.977E-05	5.488E-05	3.686E-05
420	1.174E-04	7.926E-05	5.448E-05	3.605E-05
450	1.171E-04	7.875E-05	5.408E-05	3.525E-05
480	1.168E-04	7.824E-05	5.367E-05	3.445E-05
510	1.164E-04	7.773E-05	5.327E-05	3.364E-05
540	1.161E-04	7.722E-05	5.287E-05	3.284E-05
570	1.158E-04	7.671E-05	5.247E-05	3.204E-05
600	1.146E-04	7.620E-05	5.207E-05	3.150E-05
630	1.155E-04	7.647E-05	5.217E-05	3.138E-05
660	1.156E-04	7.811E-05	5.178E-05	3.148E-05
690	1.140E-04	7.768E-05	5.280E-05	3.089E-05
720	1.124E-04	7.941E-05	5.110E-05	3.145E-05
750	1.108E-04	7.873E-05	5.062E-05	3.081E-05
780	1.121E-04	7.971E-05	5.094E-05	3.022E-05
810	1.026E-04	7.854E-05	5.069E-05	3.171E-05
840	1.029E-04	7.790E-05	5.111E-05	3.167E-05
870	1.030E-04	7.853E-05	5.156E-05	3.052E-05
900	1.032E-04	7.696E-05	5.162E-05	3.307E-05
930	1.050E-04	7.750E-05	5.268E-05	3.132E-05
960	1.023E-04	7.736E-05	5.387E-05	3.083E-05
990	9.780E-05	7.601E-05	5.351E-05	3.161E-05
1020	9.761E-05	7.561E-05	5.369E-05	3.086E-05
1050	9.564E-05	7.444E-05	5.380E-05	3.120E-05
1080	9.667E-05	6.954E-05	5.366E-05	3.097E-05
1110	9.565E-05	6.638E-05	5.375E-05	3.111E-05
1140	9.529E-05	6.710E-05	5.388E-05	3.108E-05
1170	9.425E-05	7.019E-05	5.304E-05	3.096E-05
1200	9.347E-05	7.202E-05	5.089E-05	3.061E-05
1230	9.287E-05	7.011E-05	4.982E-05	2.996E-05
1260	9.318E-05	6.659E-05	4.952E-05	2.941E-05
1290	9.280E-05	6.577E-05	5.005E-05	2.726E-05
1320	9.309E-05	6.506E-05	4.995E-05	2.374E-05
1350	9.324E-05	6.441E-05	4.974E-05	2.116E-05
1380	9.372E-05	6.376E-05	4.961E-05	2.178E-05
1410	9.215E-05	6.497E-05	4.753E-05	2.122E-05
1440	8.670E-05	6.361E-05	4.754E-05	1.888E-05
1470	8.488E-05	5.833E-05	4.592E-05	1.967E-05
1500	8.144E-05	5.712E-05	4.501E-05	2.080E-05

FLIGHT NO. C-158
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110470 FLIGHT NO. C-158 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
1530	8.144E-05	5.472E-05	4.420E-05	2.134E-05
1560	8.230E-05	5.258E-05	4.304E-05	1.927E-05
1590	8.245E-05	5.360E-05	4.274E-05	1.747E-05
1620	8.149E-05	5.275E-05	4.285E-05	1.719E-05
1650	8.178E-05	5.330E-05	4.214E-05	1.700E-05
1680	8.151E-05	5.373E-05	3.989E-05	1.714E-05
1710	8.016E-05	5.390E-05	3.866E-05	1.694E-05
1740	8.118E-05	5.321E-05	3.858E-05	1.675E-05
1770	8.237E-05	5.149E-05	4.008E-05	1.786E-05
1800	8.216E-05	4.824E-05	4.144E-05	1.850E-05
1830	7.799E-05	4.887E-05	4.258E-05	1.926E-05
1860	7.578E-05	4.910E-05	4.247E-05	1.829E-05
1890	7.588E-05	4.839E-05	4.106E-05	1.836E-05
1920	7.336E-05	5.194E-05	4.116E-05	1.869E-05
1950	7.309E-05	5.078E-05	4.104E-05	1.812E-05
1980	7.354E-05	4.935E-05	4.101E-05	1.647E-05
2010	7.349E-05	4.927E-05	4.009E-05	1.762E-05
2040	7.388E-05	4.884E-05	3.914E-05	1.673E-05
2070	7.377E-05	4.874E-05	3.889E-05	1.673E-05
2100	7.287E-05	4.840E-05	3.879E-05	1.673E-05
2130	7.142E-05	4.719E-05	3.831E-05	1.672E-05
2160	6.770E-05	4.515E-05	3.650E-05	1.672E-05
2190	6.169E-05	4.183E-05	3.261E-05	1.672E-05
2220	6.080E-05	4.029E-05	3.293E-05	1.672E-05
2250	6.063E-05	4.091E-05	3.293E-05	1.672E-05
2280	6.204E-05	4.077E-05	3.311E-05	1.672E-05
2310	6.228E-05	4.058E-05	3.276E-05	1.672E-05
2340	6.107E-05	4.024E-05	3.268E-05	1.671E-05
2370	5.849E-05	3.967E-05	3.289E-05	1.671E-05
2400	5.855E-05	3.999E-05	3.163E-05	1.671E-05
2430	5.831E-05	3.993E-05	3.150E-05	1.671E-05
2460	5.846E-05	3.938E-05	3.126E-05	1.671E-05
2490	5.825E-05	3.908E-05	3.124E-05	1.671E-05
2520	5.751E-05	3.891E-05	3.195E-05	1.671E-05
2550	5.779E-05	3.865E-05	3.134E-05	1.670E-05
2580	5.789E-05	3.848E-05	3.147E-05	1.670E-05
2610	5.805E-05	3.817E-05	3.085E-05	1.670E-05
2640	5.782E-05	3.784E-05	3.080E-05	1.670E-05
2670	5.762E-05	3.771E-05	3.146E-05	1.670E-05
2700	5.804E-05	3.768E-05	3.119E-05	1.670E-05
2730	5.741E-05	3.803E-05	3.125E-05	1.669E-05
2760	5.728E-05	3.800E-05	3.101E-05	1.669E-05
2790	5.746E-05	3.790E-05	3.116E-05	1.669E-05
2820	5.794E-05	3.804E-05	3.123E-05	1.669E-05
2850	5.729E-05	3.876E-05	3.157E-05	1.669E-05
2880	5.702E-05	3.911E-05	3.141E-05	1.669E-05
2910	5.712E-05	3.840E-05	3.151E-05	1.669E-05
2940	5.723E-05	3.815E-05	3.125E-05	1.668E-05
2970	5.774E-05	3.806E-05	3.145E-05	1.668E-05
3000	5.712E-05	3.778E-05	3.108E-05	1.668E-05

FLIGHT NO. C-158
TOTAL VOLUME SCATTERING COEFFICIENT

DATE 110470 FLIGHT NO. C-158 GROUND LEVEL ALTITUDE (M)= 1448

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	5	3	4
3030	5.740E-05	3.784E-05	3.121E-05	1.668E-05
3060	5.681E-05	3.750E-05	3.116E-05	1.668E-05
3090	5.621E-05	3.768E-05	3.077E-05	1.668E-05
3120	5.630E-05	3.755E-05	3.083E-05	1.668E-05
3150	5.639E-05	3.740E-05	3.098E-05	1.667E-05
3180	5.640E-05	3.703E-05	3.100E-05	1.667E-05
3210	5.613E-05	3.729E-05	3.102E-05	1.667E-05
3240	5.610E-05	3.742E-05	3.121E-05	1.667E-05
3270	5.578E-05	3.730E-05	3.099E-05	1.667E-05
3300	5.589E-05	3.694E-05	3.128E-05	1.667E-05
3330	5.602E-05	3.722E-05	3.106E-05	1.666E-05
3360	5.530E-05	3.750E-05	3.077E-05	1.666E-05
3390	5.620E-05	3.771E-05	3.117E-05	1.666E-05
3420	5.638E-05	3.729E-05	3.081E-05	1.666E-05
3450	5.602E-05	3.733E-05	3.095E-05	1.666E-05
3480	5.588E-05	3.709E-05	3.082E-05	1.666E-05
3510	5.573E-05	3.715E-05	3.129E-05	1.666E-05
3540	5.579E-05	3.762E-05	3.111E-05	1.665E-05
3570	5.596E-05	3.741E-05	3.099E-05	1.665E-05
3600	5.578E-05	3.702E-05	3.086E-05	1.665E-05
3630	5.604E-05	3.680E-05	3.110E-05	1.665E-05
3660	5.573E-05	3.685E-05	3.123E-05	1.665E-05
3690	5.572E-05	3.705E-05	3.133E-05	1.665E-05
3720	5.538E-05	3.716E-05	3.121E-05	1.665E-05
3750	5.563E-05	3.706E-05	3.123E-05	1.664E-05
3780	5.530E-05	3.690E-05	3.163E-05	1.664E-05
3810	5.495E-05	3.681E-05	3.146E-05	1.664E-05
3840	5.524E-05	3.669E-05	3.104E-05	1.664E-05
3870	5.534E-05	3.713E-05	3.083E-05	1.664E-05
3900	5.476E-05	3.713E-05	3.105E-05	1.664E-05
3930	5.476E-05	3.732E-05	3.069E-05	1.663E-05
3960	5.452E-05	3.704E-05	3.060E-05	1.663E-05
3990	5.469E-05	3.692E-05	3.050E-05	1.654E-05
4020	5.448E-05	3.681E-05	3.075E-05	1.650E-05
4050	5.412E-05	3.681E-05	3.167E-05	1.645E-05
4080	5.440E-05	3.650E-05	3.154E-05	1.640E-05
4110	5.462E-05	3.642E-05	3.164E-05	1.635E-05
4140	5.472E-05	3.677E-05	3.154E-05	1.630E-05
4170	5.439E-05	3.682E-05	3.144E-05	1.625E-05
4200	5.471E-05	3.720E-05	3.135E-05	1.620E-05
4230	5.462E-05	3.678E-05	3.125E-05	1.615E-05
4260	5.463E-05	3.691E-05	3.115E-05	1.610E-05
4290	5.492E-05	3.679E-05	3.106E-05	1.605E-05
4320	5.475E-05	3.668E-05	3.096E-05	1.600E-05
4350	5.458E-05	3.656E-05	3.086E-05	1.595E-05
4380	5.441E-05	3.645E-05	3.077E-05	1.590E-05
4410	5.424E-05	3.634E-05	3.067E-05	1.585E-05
4440	5.408E-05	3.622E-05	3.058E-05	1.580E-05
4470	5.391E-05	3.611E-05	3.048E-05	1.575E-05
4500	5.374E-05	3.600E-05	3.039E-05	1.571E-05
FIRST DATA ALT	0	0	0	0
LAST DATA ALT	4290	4260	4110	4050

FLIGHT NO. C-158
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

FLIGHT NO. C-158 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.4989042	.6600474	.8122585	.8697844	.9303303	.9591635	.9645363
600	.2509323	.4396616	.6635615	.7594438	.8672414	.9210540	.9312580
1500	.0404290	.1537142	.3961117	.5372369	.7249759	.8305347	.8514551
3000	.0039001	.0451223	.2220323	.3643294	.5929427	.7395181	.7700277
4500	.0004292	.0156507	.1376474	.2643491	.5022238	.6719129	.7086775

FLIGHT NO. C-158 FILTER NO. 5
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.6160413	.7486906	.8651416	.9073821	.9509345	.9713713	.9751587
600	.3878481	.5695667	.7550934	.8282236	.9070476	.9452305	.9523905
1500	.1039979	.2667154	.5201482	.6449745	.7969149	.8771627	.8927009
3000	.0218705	.1183124	.3547272	.4988993	.6977181	.8123601	.8352952
4500	.0049388	.0581605	.2576311	.4025539	.6243698	.7619006	.7901707

FLIGHT NO. C-158 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.7148895	.8183059	.9045106	.9348821	.9657453	.9800775	.9827234
600	.5202734	.6782091	.8238360	.8780828	.9349143	.9618893	.9669097
1500	.2042666	.3953970	.6318936	.7349318	.8526374	.9120671	.9233837
3000	.0594932	.2059428	.4638746	.5972825	.7658472	.8572538	.8751270
4500	.0177441	.1142521	.3547386	.4989102	.6977259	.8123654	.8352999

FLIGHT NO. C-158 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	.7787155	.8612144	.9279498	.9510675	.9743643	.9851180	.9870989
600	.6326267	.7618694	.8731045	.9129770	.9539652	.9731574	.9767114
1500	.3720754	.5619732	.7521707	.8260714	.9058267	.9444957	.9517493
3000	.2010462	.4090055	.6481425	.7475582	.8601889	.9167222	.9274637
4500	.1044471	.2986734	.5621632	.6794796	.8187063	.8909319	.9048239

FLIGHT NO. C-158
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-158 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.032E 02	1.149E 02	4.961E 01	2.908E 01	9.575E 00	2.995E 00	2.323E 00
600	2.817E 02	1.862E 02	8.890E 01	5.372E 01	1.824E 01	5.789E 00	4.503E 00
1500	2.962E 02	2.515E 02	1.502E 02	9.816E 01	3.638E 01	1.217E C1	9.627E 00
3000	2.427E 02	2.336E 02	1.699E 02	1.211E 02	4.989E 01	1.798E 01	1.461E 01
4500	2.336E 02	2.248E 02	1.770E 02	1.329E 02	5.874E 01	2.221E 01	1.833E 01

FLIGHT NO. C-158 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.351E 02	7.250E 01	3.040E 01	1.787E 01	6.012E 00	2.016E 00	1.598E 00
600	2.020E 02	1.224E 02	5.522E 01	3.315E 01	1.139E 01	3.856E 00	3.064E 00
1500	2.628E 02	1.991E 02	1.069E 02	6.761E 01	2.470E 01	8.648E 00	6.955E 00
3000	2.676E 02	2.269E 02	1.407E 02	9.308E 01	3.625E 01	1.321E 01	1.081E 01
4500	2.678E 02	2.369E 02	1.602E 02	1.096E 02	4.473E 01	1.676E 01	1.386E 01

FLIGHT NO. C-158 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	8.619E 01	4.398E 01	1.760E 01	1.012E 01	3.209E 00	1.015E 00	8.075E-01
600	1.374E 02	7.697E 01	3.247E 01	1.895E 01	6.098E 00	1.941E 00	1.547E 00
1500	2.170E 02	1.469E 02	6.986E 01	4.211E 01	1.381E 01	4.450E 00	3.559E 00
3000	2.641E 02	2.015E 02	1.066E 02	6.610E 01	2.194E 01	7.188E 00	5.800E 00
4500	2.677E 02	2.191E 02	1.278E 02	8.134E 01	2.832E 01	9.669E 00	7.980E 00

FLIGHT NO. C-158 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	8.328E 01	3.929E 01	1.508E 01	8.071E 00	2.435E 00	8.213E-01	7.169E-01
600	1.324E 02	6.674E 01	2.655E 01	1.435E 01	4.372E 00	1.481E 00	1.294E 00
1500	1.951E 02	1.136E 02	4.922E 01	2.722E 01	8.531E 00	2.982E 00	2.602E 00
3000	2.057E 02	1.343E 02	6.326E 01	3.579E 01	1.161E 01	4.265E 00	3.706E 00
4500	2.088E 02	1.470E 02	7.418E 01	4.282E 01	1.430E 01	5.433E 00	4.713E 00

FLIGHT NO. C-158
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-158 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	5.865E 01	3.484E 01	1.718E 01	1.139E 01	5.391E 00	2.758E 00	2.323E 00
600	8.132E 01	5.643E 01	3.078E 01	2.104E 01	1.027E 01	5.332E 00	4.503E 00
1500	8.886E 01	7.844E 01	5.317E 01	3.922E 01	2.085E 01	1.130E 01	9.627E 00
3000	7.908E 01	7.793E 01	6.326E 01	5.056E 01	2.966E 01	1.694E 01	1.461E 01
4500	7.738E 01	7.698E 01	6.760E 01	5.676E 01	3.557E 01	2.108E 01	1.833E 01

FLIGHT NO. C-158 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	4.618E 01	2.583E 01	1.225E 01	7.998E 00	3.656E 00	1.915E 00	1.598E 00
600	6.904E 01	4.362E 01	2.225E 01	1.483E 01	6.927E 00	3.664E 00	3.064E 00
1500	8.752E 01	6.992E 01	4.264E 01	3.018E 01	1.513E 01	8.217E 00	6.955E 00
3000	8.477E 01	7.732E 01	5.495E 01	4.137E 01	2.253E 01	1.255E 01	1.081E 01
4500	8.362E 01	7.971E 01	6.191E 01	4.861E 01	2.799E 01	1.593E 01	1.386E 01

FLIGHT NO. C-158 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.180E 01	1.177E 01	5.547E 00	3.670E 00	1.776E 00	9.465E-01	8.075E-01
600	3.475E 01	2.060E 01	1.023E 01	6.870E 00	3.374E 00	1.811E 00	1.547E 00
1500	5.020E 01	3.663E 01	2.090E 01	1.465E 01	7.530E 00	4.138E 00	3.559E 00
3000	5.306E 01	4.486E 01	2.939E 01	2.163E 01	1.176E 01	6.674E 00	5.800E 00
4500	5.645E 01	5.052E 01	3.604E 01	2.751E 01	1.564E 01	9.123E 00	7.980E 00

FLIGHT NO. C-158 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.610E 01	8.498E 00	3.993E 00	2.682E 00	1.359E 00	8.002E-01	7.169E-01
600	2.559E 01	1.443E 01	7.032E 00	4.769E 00	2.440E 00	1.443E 00	1.294E 00
1500	3.744E 01	2.456E 01	1.314E 01	9.172E 00	4.848E 00	2.908E 00	2.602E 00
3000	3.887E 01	2.901E 01	1.715E 01	1.240E 01	6.833E 00	4.166E 00	3.706E 00
4500	3.911E 01	3.175E 01	2.031E 01	1.510E 01	8.598E 00	5.312E 00	4.713E 00

FLIGHT NO. C-158
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-158 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	6.710E 01	4.072E 01	2.122E 01	1.466E 01	7.835E 00	3.318E 00	2.323E 00
600	9.304E 01	6.596E 01	3.802E 01	2.709E 01	1.493E 01	6.415E 00	4.503E 00
1500	1.064E 02	9.497E 01	6.760E 01	5.211E 01	3.093E 01	1.377E 01	9.627E 00
3000	1.032E 02	1.017E 02	8.545E 01	7.158E 01	4.578E 01	2.117E 01	1.461E 01
4500	1.026E 02	1.032E 02	9.393E 01	8.283E 01	5.598E 01	2.666E 01	1.833E 01

FLIGHT NO. C-158 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.876E 01	2.559E 01	1.404E 01	9.809E 00	5.080E 00	2.260E 00	1.598E 00
600	6.180E 01	4.382E 01	2.549E 01	1.819E 01	9.623E 00	4.325E 00	3.064E 00
1500	9.045E 01	7.466E 01	4.995E 01	3.760E 01	2.130E 01	9.857E 00	6.955E 00
3000	9.874E 01	8.976E 01	6.716E 01	5.307E 01	3.243E 01	1.549E 01	1.081E 01
4500	1.005E 02	9.589E 01	7.727E 01	6.327E 01	4.074E 01	1.992E 01	1.386E 01

FLIGHT NO. C-158 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.374E 01	1.307E 01	6.472E 00	4.463E 00	2.337E 00	1.114E 00	8.075E-01
600	3.784E 01	2.287E 01	1.194E 01	8.355E 00	4.441E 00	2.130E 00	1.547E 00
1500	5.572E 01	4.133E 01	2.474E 01	1.805E 01	1.001E 01	4.886E 00	3.559E 00
3000	6.157E 01	5.250E 01	3.583E 01	2.735E 01	1.594E 01	7.944E 00	5.800E 00
4500	6.772E 01	6.086E 01	4.487E 01	3.529E 01	2.137E 01	1.096E 01	7.980E 00

FLIGHT NO. C-158 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.715E 01	9.321E 00	4.703E 00	3.321E 00	1.873E 00	9.970E-01	7.169E-01
600	2.727E 01	1.583E 01	8.282E 00	5.907E 00	3.364E 00	1.798E 00	1.294E 00
1500	4.046E 01	2.721E 01	1.552E 01	1.134E 01	6.612E 00	3.589E 00	2.602E 00
3000	4.333E 01	3.283E 01	2.039E 01	1.527E 01	9.129E 00	5.051E 00	3.706E 00
4500	4.438E 01	3.640E 01	2.425E 01	1.855E 01	1.134E 01	6.373E 00	4.713E 00

FLIGHT NO. C-158
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-158 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	5.621E 01	3.338E 01	1.650E 01	1.099E 01	5.290E 00	2.788E 00	2.323E 00
600	7.794E 01	5.408E 01	2.958E 01	2.029E 01	1.008E 01	5.390E 00	4.503E 00
1500	8.594E 01	7.570E 01	5.138E 01	3.802E 01	2.053E 01	1.144E 01	9.627E 00
3000	7.788E 01	7.640E 01	6.187E 01	4.953E 01	2.939E 01	1.720E 01	1.461E 01
4500	7.646E 01	7.590E 01	6.651E 01	5.589E 01	3.537E 01	2.144E 01	1.833E 01

FLIGHT NO. C-158 FILTER NO. 5
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	3.321E 01	2.152E 01	1.122E 01	7.498E 00	3.666E 00	1.948E 00	1.598E 00
600	5.295E 01	3.685E 01	2.037E 01	1.391E 01	6.945E 00	3.728E 00	3.064E 00
1500	7.751E 01	6.278E 01	3.992E 01	2.874E 01	1.517E 01	8.360E 00	6.955E 00
3000	8.461E 01	7.549E 01	5.368E 01	4.057E 01	2.258E 01	1.277E 01	1.081E 01
4500	8.608E 01	8.064E 01	6.176E 01	4.837E 01	2.806E 01	1.620E 01	1.386E 01

FLIGHT NO. C-158 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	2.160E 01	1.168E 01	5.537E 00	3.676E 00	1.796E 00	9.636E-01	8.075E-01
600	3.443E 01	2.044E 01	1.021E 01	6.881E 00	3.413E 00	1.843E 00	1.547E 00
1500	4.997E 01	3.650E 01	2.096E 01	1.475E 01	7.670E 00	4.239E 00	3.559E 00
3000	5.364E 01	4.528E 01	2.980E 01	2.201E 01	1.213E 01	6.914E 00	5.800E 00
4500	5.873E 01	5.212E 01	3.705E 01	2.824E 01	1.619E 01	9.479E 00	7.980E 00

FLIGHT NO. C-158 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	93	95	100	105	120	150	180
300	1.453E 01	7.766E 00	3.766E 00	2.592E 00	1.398E 00	8.411E-01	7.169E-01
600	2.310E 01	1.319E 01	6.632E 00	4.610E 00	2.510E 00	1.517E 00	1.294E 00
1500	3.421E 01	2.263E 01	1.241E 01	8.834E 00	4.918E 00	3.013E 00	2.602E 00
3000	3.648E 01	2.721E 01	1.627E 01	1.185E 01	6.747E 00	4.201E 00	3.706E 00
4500	3.726E 01	3.010E 01	1.931E 01	1.437E 01	8.350E 00	5.269E 00	4.713E 00

FLIGHT NO. C-158
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-158 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.829E 00	7.819E-01	2.743E-01	1.501E-01	4.622E-02	1.402E-02	1.082E-02
600	5.041E 00	1.902E 00	6.016E-01	3.177E-01	9.448E-02	2.823E-02	2.172E-02
1500	3.291E 01	7.347E 00	1.703E 00	8.206E-01	2.253E-01	6.581E-02	5.078E-02
3000	2.795E 02	2.325E 01	3.437E 00	1.493E 00	3.779E-01	1.092E-01	8.520E-02
4500	2.445E 03	6.449E 01	5.775E 00	2.258E 00	5.253E-01	1.484E-01	1.161E-01

FLIGHT NO. C-158 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	1.173E 00	5.180E-01	1.880E-01	1.054E-01	3.382E-02	1.110E-02	8.768E-03
600	2.786E 00	1.150E 00	3.911E-01	2.141E-01	6.717E-02	2.182E-02	1.721E-02
1500	1.351E 01	3.993E 00	1.100E 00	5.607E-01	1.658E-01	5.274E-02	4.167E-02
3000	6.544E 01	1.026E 01	2.122E 00	9.979E-01	2.779E-01	8.699E-02	6.924E-02
4500	2.901E 02	2.179E 01	3.326E 00	1.456E 00	3.832E-01	1.177E-01	9.384E-02

FLIGHT NO. C-158 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	8.723E-01	3.888E-01	1.408E-01	7.831E-02	2.404E-02	7.491E-03	5.945E-03
600	1.911E 00	8.211E-01	2.852E-01	1.561E-01	4.719E-02	1.460E-02	1.157E-02
1500	7.685E 00	2.688E 00	7.999E-01	4.145E-01	1.171E-01	3.530E-02	2.789E-02
3000	3.212E 01	7.079E 00	1.662E 00	8.007E-01	2.072E-01	6.066E-02	4.795E-02
4500	1.091E 02	1.387E 01	2.607E 00	1.180E 00	2.937E-01	8.611E-02	6.912E-02

FLIGHT NO. C-158 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	4.530E-01	1.932E-01	6.881E-02	3.594E-02	1.058E-02	3.531E-03	3.076E-03
600	8.863E-01	3.710E-01	1.288E-01	6.658E-02	1.941E-02	6.447E-03	5.611E-03
1500	2.220E 00	8.559E-01	2.771E-01	1.396E-01	3.989E-02	1.337E-02	1.158E-02
3000	4.333E 00	1.390E 00	4.134E-01	2.028E-01	5.716E-02	1.970E-02	1.692E-02
4500	8.468E 00	2.084E 00	5.589E-01	2.669E-01	7.395E-02	2.583E-02	2.206E-02

FLIGHT NO. C-158
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-158 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	5.280E-01	2.370E-01	9.498E-02	5.880E-02	2.602E-02	1.291E-02	1.082E-02
600	1.455E 00	5.764E-01	2.083E-01	1.244E-01	5.319E-02	2.600E-02	2.172E-02
1500	9.871E 00	2.292E 00	6.029E-01	3.279E-01	1.291E-01	6.109E-02	5.078E-02
3000	9.106E 01	7.756E 00	1.279E 00	6.233E-01	2.246E-01	1.029E-01	8.520E-02
4500	8.097E 02	2.209E 01	2.206E 00	9.643E-01	3.181E-01	1.409E-01	1.161E-01

FLIGHT NO. C-158 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	4.010E-01	1.846E-01	7.575E-02	4.715E-02	2.057E-02	1.055E-02	8.768E-03
600	9.522E-01	4.097E-01	1.576E-01	9.581E-02	4.085E-02	2.073E-02	1.721E-02
1500	4.501E 00	1.402E 00	4.385E-01	2.503E-01	1.016E-01	5.010E-02	4.167E-02
3000	2.073E 01	3.496E 00	8.285E-01	4.435E-01	1.727E-01	8.264E-02	6.924E-02
4500	9.057E 01	7.331E 00	1.285E 00	6.459E-01	2.398E-01	1.118E-01	9.384E-02

FLIGHT NO. C-158 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.206E-01	1.041E-01	4.437E-02	2.840E-02	1.330E-02	6.987E-03	5.945E-03
600	4.832E-01	2.198E-01	8.987E-02	5.661E-02	2.611E-02	1.362E-02	1.157E-02
1500	1.778E 00	6.702E-01	2.393E-01	1.442E-01	6.389E-02	3.282E-02	2.789E-02
3000	6.452E 00	1.576E 00	4.584E-01	2.620E-01	1.111E-01	5.633E-02	4.795E-02
4500	2.301E 01	3.199E 00	7.351E-01	3.990E-01	1.622E-01	8.125E-02	6.912E-02

FLIGHT NO. C-158 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	8.755E-02	4.179E-02	1.823E-02	1.194E-02	5.906E-03	3.440E-03	3.076E-03
600	1.713E-01	8.024E-02	3.411E-02	2.212E-02	1.083E-02	6.281E-03	5.611E-03
1500	4.261E-01	1.851E-01	7.397E-02	4.703E-02	2.267E-02	1.304E-02	1.158E-02
3000	8.189E-01	3.004E-01	1.121E-01	7.024E-02	3.364E-02	1.924E-02	1.692E-02
4500	1.586E 00	4.502E-01	1.530E-01	9.411E-02	4.448E-02	2.525E-02	2.206E-02

FLIGHT NO. C-158
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-158 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	6.040E-01	2.770E-01	1.173E-01	7.571E-02	3.782E-02	1.554E-02	1.082E-02
600	1.665E 00	6.737E-01	2.574E-01	1.602E-01	7.731E-02	3.128E-02	2.172E-02
1500	1.182E 01	2.775E 00	7.664E-01	4.356E-01	1.916E-01	7.446E-02	5.078E-02
3000	1.188E 02	1.012E 01	1.728E 00	8.823E-01	3.467E-01	1.285E-01	8.520E-02
4500	1.073E 03	2.960E 01	3.065E 00	1.407E 00	5.006E-01	1.782E-01	1.161E-01

FLIGHT NO. C-158 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	3.366E-01	1.828E-01	8.679E-02	5.782E-02	2.857E-02	1.245E-02	8.768E-03
600	8.523E-01	4.116E-01	1.806E-01	1.175E-01	5.675E-02	2.447E-02	1.721E-02
1500	4.652E 00	1.497E 00	5.136E-01	3.118E-01	1.430E-01	6.011E-02	4.167E-02
3000	2.415E 01	4.058E 00	1.013E 00	5.690E-01	2.486E-01	1.020E-01	6.924E-02
4500	1.088E 02	8.819E 00	1.604E 00	8.408E-01	3.491E-01	1.399E-01	9.384E-02

FLIGHT NO. C-158 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.402E-01	1.156E-01	5.176E-02	3.454E-02	1.751E-02	8.221E-03	5.945E-03
600	5.262E-01	2.440E-01	1.048E-01	6.884E-02	3.437E-02	1.602E-02	1.157E-02
1500	1.974E 00	7.563E-01	2.833E-01	1.777E-01	8.496E-02	3.875E-02	2.789E-02
3000	7.487E 00	1.844E 00	5.589E-01	3.313E-01	1.506E-01	6.704E-02	4.795E-02
4500	2.761E 01	3.854E 00	9.151E-01	5.118E-01	2.216E-01	9.762E-02	6.912E-02

FLIGHT NO. C-158 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	9.329E-02	4.584E-02	2.146E-02	1.479E-02	8.142E-03	4.286E-03	3.076E-03
600	1.825E-01	8.802E-02	4.017E-02	2.740E-02	1.493E-02	7.825E-03	5.611E-03
1500	4.606E-01	2.051E-01	8.739E-02	5.813E-02	3.092E-02	1.609E-02	1.158E-02
3000	9.129E-01	3.399E-01	1.333E-01	8.649E-02	4.495E-02	2.334E-02	1.692E-02
4500	1.800E 00	5.162E-01	1.827E-01	1.156E-01	5.868E-02	3.030E-02	2.206E-02

FLIGHT NO. C-158
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-158 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	5.060E-01	2.271E-01	9.126E-02	5.672E-02	2.553E-02	1.305E-02	1.082E-02
600	1.395E 00	5.524E-01	2.002E-01	1.200E-01	5.219E-02	2.628E-02	2.172E-02
1500	9.547E 00	2.212E 00	5.825E-01	3.178E-01	1.272E-01	6.185E-02	5.078E-02
3000	8.967E 01	7.604E 00	1.251E 00	6.105E-01	2.226E-01	1.045E-01	8.520E-02
4500	8.001E 02	2.178E 01	2.170E 00	9.494E-01	3.163E-01	1.433E-01	1.161E-01

FLIGHT NO. C-158 FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.884E-01	1.537E-01	6.936E-02	4.420E-02	2.062E-02	1.073E-02	8.768E-03
600	7.303E-01	3.461E-01	1.443E-01	8.982E-02	4.095E-02	2.109E-02	1.721E-02
1500	3.987E 00	1.259E 00	4.105E-01	2.384E-01	1.018E-01	5.098E-02	4.167E-02
3000	2.069E 01	3.413E 00	8.095E-01	4.350E-01	1.731E-01	8.409E-02	6.924E-02
4500	9.323E 01	7.416E 00	1.282E 00	6.427E-01	2.404E-01	1.138E-01	9.384E-02

FLIGHT NO. C-158 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	2.186E-01	1.033E-01	4.429E-02	2.845E-02	1.346E-02	7.113E-03	5.945E-03
600	4.788E-01	2.181E-01	8.970E-02	5.670E-02	2.641E-02	1.386E-02	1.157E-02
1500	1.770E 00	6.679E-01	2.400E-01	1.452E-01	6.508E-02	3.363E-02	2.789E-02
3000	6.523E 00	1.591E 00	4.648E-01	2.667E-01	1.146E-01	5.835E-02	4.795E-02
4500	2.395E 01	3.300E 00	7.556E-01	4.095E-01	1.678E-01	8.442E-02	6.912E-02

FLIGHT NO. C-158 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	93	95	100	105	120	150	180
300	7.905E-02	3.819E-02	1.719E-02	1.154E-02	6.076E-03	3.616E-03	3.076E-03
600	1.547E-01	7.334E-02	3.217E-02	2.139E-02	1.114E-02	6.601E-03	5.611E-03
1500	3.894E-01	1.706E-01	6.989E-02	4.529E-02	2.299E-02	1.351E-02	1.158E-02
3000	7.684E-01	2.817E-01	1.063E-01	6.716E-02	3.322E-02	1.941E-02	1.692E-02
4500	1.511E 00	4.268E-01	1.455E-01	8.957E-02	4.319E-02	2.505E-02	2.206E-02

7.4 GROUND-BASED DATA DAILY SUMMARY

The threefold purpose of the ground station was (1) to provide measurements of inherent background radiance and reflectance appropriate for use with airborne measurements, (2) to provide continuity of measurement by establishing ground-level values of downwelling irradiance and total scattering coefficient, and (3) to establish earth-to-space beam transmittance, path radiance, and path reflectance for the vertically downward path of sight for comparison with the partial path transmittance, path radiance, and path reflectance derived from airborne measurements.

Unfortunately, an undetected data logger fault made post-mission data retrieval difficult. As a result, only the manually logged data for the nephelometer and contrast reduction meter have been reduced, thus emphasizing the second and third basic functions of the ground station.

It was found in an earlier study (Duntley *et al.*, 1970) that it is reasonable to use the airborne downwelling irradiance at the lowest flight altitude to obtain directional path reflectance. On the other hand, the same study indicated that ground-based measurements of total volume scattering coefficient are needed because they cannot be adequately predicted by low altitude measurements. Thus, since data retrieval was limited, only the contrast reduction meter values and total volume scattering coefficient values were processed. They are presented herein.

Figure 1-1 presented the central New Mexico area in detail and the location of the flight track. The ground station was located near the south end of the track. It is identified in Figure 1-1 by the symbols GMS-L-333.

A summary of all the ground station data packages for central New Mexico is presented in Table 7-3. The contrast reduction meter and nephelometer data sets, which have been processed and are presented in the next section, are designated with an asterisk. The ground-based system data collection methods are described in detail in Section 4.2. The instruments employed are fully described in Section 3. The weather description and meteorological data available for the period 22 October through 4 November 1970 are described in Section 6. The theory and equations used to compute the desired quantities from the contrast reduction meter measurements are fully described in Section 3.

7.5 DESCRIPTION AND PRESENTATION OF GROUND-BASED DATA TABLES AND GRAPHS

Data are presented in tables of:

Irradiance
Directional Reflectance of Terrain
Total Scattering Coefficient
Vertical Beam Transmittance Earth-to-Space
Vertical Path Radiance Earth-to-Space
Vertical Path Reflectance Earth-to-Space

In each table, the data are presented chronologically and by filter, with the filters in order of increasing mean wavelength. Note that Filter 6, a broad band optical filter with a mean wavelength of 532 nanometers, has been included although airborne data were limited to Filters 2, 5, 3, and 4. (Refer to Figure 1-2 for further details on the spectral responses of the filters).

Users should be aware that regardless of the display format, the data values are valid to, at best, only three significant figures. The tables of beam transmittance and directional reflectance of the background, in particular, should be rounded off to two digits prior to further application.

IRRADIANCE

The downwelling irradiance H(o,d) measured by the contrast reduction meter is presented in Table 7-4. The radiometer data for Filter 5 (pseudo-photopic) have been corrected to units of lu/m^2 (lux) and are given in column 5.

DIRECTIONAL REFLECTANCE OF TERRAIN

The terrain reflectance ${}_bR_o(0,\theta,\phi)$ is tabulated in three tables, 7-5, 7-6, and 7-7. These reflectances are based upon the inherent terrain radiance and the downwelling irradiance measured with the contrast reduction meter (CRM). Reflectance is dimensionless.

The appearance of the terrain at the ground station site is depicted in Figures 3-2 and 3-5. The typical terrain here was desert sand and low scattered brush. Table 7-5 contains the nadir reflectance of the desert sand immediately beneath and surrounding the CRM. Table 7-6 contains the reflectance of this same sand at 90 degrees in zenith angle from the sun, in the azimuth of the sun. Table 7-7 contains the nadir reflectance of typical terrain features other than sand which contribute to the average terrain reflectance as measured by the airborne lower hemisphere scanner.

TOTAL SCATTERING COEFFICIENT

The total volume scattering coefficient s(o) measured by the ground-based integrating nephelometer and manually recorded is presented in Table 7-8. The dimension and unit for the total scattering coefficient is "m^{-1}".

These values were used as the ground-level total volume scattering coefficient s(o) for all the flights reported in Section 7 except Flight 151 on 24 October 1970, for which there are no ground-level values available. These ground-level values are the s(o) values presented in the tables and graphs of total volume scattering coefficient for each flight in Section 7.3.

VERTICAL BEAM TRANSMITTANCE EARTH-TO-SPACE

The contrast reduction meter determines earth-to-space beam transmittance based upon the ratio between a pre-established value of inherent solar radiance and a measurement of apparent solar radiance. The ratio is not corrected for small angle forward scattering due to historical evidence that for atmospheres clear enough to adequately image the solar disk within the device, the aureole radiance 15 minutes off the limb was generally 1 percent or less of the center disk radiance.

Table 7-3

ATOM Ground-Based Data Summary

Date 1970	Flight No.	Starting Time GMT	Nephe-lometer Set	Upper Hemisphere Scanner Set	Lower Hemisphere Scanner Set	Contrast Reduction Meter Set	Manual Contrast Reduction Meter	Manual Nephe-lometer
22 Oct	C-150	1548	2	–	–	–	–	–
23 Oct	None	1833	2	1	1	2	1*	–
24 Oct	C-151	1555	2	1	1	2	2*	–
26 Oct	C-152	1740	4	2	1	3	1*	1*
28 Oct	C-154	1711	5	2	1	3	1*	1*
30 Oct	C-155	1712	3	1	1	2	1*	1*
2 Nov	C-156	2005	3	1	1	2	1*	1*
3 Nov	C-157	1657	5	2	2	3	1*	1*
4 Nov	C-158	1742	5	2	–	3	1	1*

* Processed CRM and nephelometer data sets.

Table 7-4

Downwelling Irradiance Measured by the Contrast Reduction Meter during Project ATOM

Flight No.	Date 1970	Time GMT	Sun Zenith Angle (Degrees)	Converted Photopic (lu/m²)	Irradiance (w/m²μm)				
					Filter 2 (Blue)	Filter 6 (S-20)	Filter 5 (Psd. Phot)	Filter 3 (Red)	Filter 4 (N.I.R.)
None	23 Oct	–	54.0	6.02E+04	9.00E+02	7.77E+02	8.38E+02	6.91E+02	5.18E+02
C-151	24 Oct	1720	49.8	6.29E+04	9.60E+02	8.11E+02	8.76E+02	7.35E+02	5.44E+02
C-151	24 Oct	1818	46.0	6.98E+04	1.05E+03	8.81E+02	9.73E+02	8.02E+02	5.85E+02
C-152	26 Oct	–	46.2	6.74E+04	1.03E+03	8.74E+02	9.38E+02	7.90E+02	5.76E+02
C-154	28 Oct	1820	47.0	6.15E+04	9.41E+02	8.14E+02	8.57E+02	7.37E+02	5.92E+02
C-155	30 Oct	1900	47.8	6.03E+04	9.03E+02	8.00E+02	8.40E+02	7.07E+02	5.57E+02
C-156	2 Nov	–	49.8	5.66E+04	8.65E+02	7.57E+02	7.88E+02	6.69E+02	5.39E+02
C-157	3 Nov	–	49.2	5.68E+04	8.66E+02	7.64E+02	7.91E+02	6.78E+02	5.50E+02

Table 7-5

Nadir Reflectance of Sand Computed from Contrast Reduction Meter Measurements during Project ATOM

Date 1970	Sun Zenith Angle (Degrees)	Sand Nadir Reflectance ${}_bR_o$ (0,180°,0°)				
		Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
23 Oct	54.0	0.14	0.32	0.24	0.34	0.41
24 Oct	49.8	0.12	0.27	0.21	0.29	0.36
24 Oct	46.0	0.13	0.28	0.21	0.30	0.36
26 Oct	46.2	0.16	0.33	0.27	0.37	0.44
28 Oct	47.0	0.14	0.31	0.24	0.33	0.42
30 Oct	47.8	0.17	0.35	0.28	0.37	0.50
2 Nov	49.8	0.18	0.42	0.34	0.40	0.47
2 Nov	49.9	0.19	0.40	0.33	0.40	0.48
3 Nov	49.2	0.14	0.30	0.24	0.32	0.41

Table 7-6

Reflectance of Sand 90° from the Sun, Toward the Azimuth of the Sun During Project ATOM

		Path of Sight		Sand Directional Reflectance ${}_bR_o(0,\theta,\phi)$				
Date 1970	Sun Zenith Angle (Deg.)	Zenith Angle θ (Deg.)	Azimuth from Sun ϕ (Deg.)	Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
24 Oct	49.8	139.8	0	0.17	0.34	0.27	0.37	0.45
24 Oct	46.0	136.0	0	0.14	0.30	0.23	0.32	0.40
26 Oct	46.2	136.2	0	0.15	0.32	0.25	0.33	0.42
28 Oct	47.0	137.0	0	0.15	0.31	0.24	0.32	0.40
30 Oct	47.8	137.8	0	0.17	0.35	0.28	0.37	0.48

Table 7-7

Nadir Reflectance of Scattered Brush Features Which Contributed to Average Terrain during Project ATOM

Brush Description	Date 1970	Sun Zenith Angle (Degrees)	Nadir Directional Reflectance ${}_bR_o(0,180°,0°)$				
			Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
Yellow	2 Nov	49.8	0.09	0.13	0.09	0.20	0.27
	2 Nov	49.9	0.06	0.13	0.16	0.08	0.13
	3 Nov	49.2	0.07	0.13	0.09	0.14	0.23
Grey	2 Nov	49.8	0.03	0.06	0.06	0.07	0.14
	2 Nov	49.9	0.10	0.14	0.13	0.11	0.24
	3 Nov	49.2	0.06	0.11	0.09	0.09	0.17
Green	2 Nov	49.8	0.07	0.12	0.09	0.13	0.19
	2 Nov	49.9	0.05	0.15	0.10	0.04	0.35
	3 Nov	49.2	0.04	0.16	0.11	0.08	0.32

Table 7-8

Total Volume Scattering Coefficient during Project ATOM

Date 1970	Total Volume Scattering Coefficient (per meter)				
	Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
26 Oct	9.205E–05	7.391E–05	6.904E–05	4.789E–05	3.992E–05
28 Oct	8.990E–05	7.171E–05	6.657E–05	4.618E–05	3.746E–05
30 Oct	8.968E–05	6.883E–05	6.660E–05	4.573E–05	3.934E–05
2 Nov	1.088E–04	8.171E–05	7.921E–05	5.625E–05	4.289E–05
3 Nov	1.113E–04	8.817E–05	8.452E–05	5.650E–05	4.451E–05
4 Nov	1.225E–04	9.206E–05	8.637E–05	6.013E–05	4.727E–05

A summary of the vertical path earth-to-space beam transmittance $T_{\infty}(\infty,180^{\circ})$ measured during Project ATOM is presented in Table 7-9. The bottom row of the table contains the computed values for a Rayleigh atmosphere, establishing an upper limit against which the measured values of beam transmittance may be judged.

Table 7-9

Earth-to-Space Vertical Beam Transmittance during Project ATOM

Date 1970	Weather	Solar Zenith Angle (Degrees)	Vertical Beam Transmittance				
			Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
23-Oct	clear	54.0	0.61	0.66	0.69	0.72	0.66
24 Oct	clear	49.8	0.58	0.62	0.67	0.69	0.62
24 Oct	clear	46.0	0.56	0.61	0.64	0.66	0.61
26 Oct	light haze	46.2	0.58	0.61	0.61	0.68	0.60
28 Oct	thin haze	47.0	0.57	0.62	0.62	0.67	0.65
30 Oct	dry	47.8	0.57	0.64	0.64	0.67	0.65
2 Nov	moderate haze	49.8	0.51	0.58	0.59	0.64	0.61
3 Nov	moderate haze	49.2	0.53	0.58	0.59	0.64	0.62
Rayleigh Limit for Each Filter			0.84	0.87	0.91	0.95	0.97

VERTICAL PATH RADIANCE EARTH-TO-SPACE

The earth-to-space vertical path radiance $N^*_{\infty}(\infty,180^{\circ},0^{\circ})$ for the downward-looking path of sight is a derived quantity, computed from selected measurements of apparent sun and sky radiances. A summary of these computed values is presented in Table 7-10.

VERTICAL PATH REFLECTANCE EARTH-TO-SPACE

Earth-to-space vertical path reflectance $R^*_{\infty}(\infty,180^{\circ},0^{\circ})$ is presented in Table 7-11. The path reflectance is computed from the values of path radiance, beam transmittance, and total downwelling irradiance previously presented in Tables 7-10, 7-9, and 7-4 respectively. This property is dimensionless.

Table 7-10

Vertical Path Radiance Earth-to-Space during Project ATOM

Date 1970	Sun Zenith Angle (Degrees)	Vertical Path Radiance ($w/\Omega m^2 \mu m$)				
		Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
23 Oct	54.0	2.12E+01	1.18E+01	1.13E+01	5.32E+00	2.54E+00
24 Oct	49.8	2.22E+01	1.24E+01	1.23E+01	5.83E+00	2.83E+00
24 Oct	46.0	2.33E+01	1.32E+01	1.28E+01	6.12E+00	3.05E+00
26 Oct	46.2	2.27E+01	1.28E+01	1.24E+01	6.08E+00	3.02E+00
28 Oct	47.0	2.02E+01	1.13E+01	1.05E+01	4.99E+00	2.65E+00
30 Oct	47.8	1.89E+01	1.07E+01	9.91E+00	4.60E+00	2.42E+00
2 Nov	49.8	2.16E+01	1.24E+01	1.17E+01	5.78E+00	3.22E+00
3 Nov	49.2	2.25E+01	1.33E+01	1.26E+01	6.52E+00	3.76E+00

Table 7-11

Earth-to-Space Vertical Path Reflectance during Project ATOM

Date 1970	Sun Zenith Angle (Degrees)	Earth-to-Space Vertical Path Reflectance				
		Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
23 Oct	54.0	0.121	0.0724	0.0614	0.0336	0.0234
24 Oct	49.8	0.125	0.0777	0.0660	0.0364	0.0264
24 Oct	46.0	0.125	0.0768	0.0642	0.0363	0.0269
26 Oct	46.2	0.119	0.0753	0.0677	0.0358	0.0273
28 Oct	47.0	0.119	0.0708	0.0618	0.0316	0.0217
30 Oct	47.8	0.115	0.0661	0.0577	0.0306	0.0211
2 Nov	49.8	0.153	0.0881	0.0787	0.0426	0.0307
3 Nov	49.2	0.155	0.0935	0.0845	0.0474	0.0347

8. DATA INTERPRETATION AND EVALUATION

8.1 AIRBORNE DATA

The six flights reported herein were made during the morning in relatively clear weather with an unobscured sun. Flights C-154 and C-155 were described by the Stallion weather station and by both the ground- and aircrew of the Visibility Laboratory as being clear and cloudless throughout the flight. Flight C-152 had some clouds on the horizon (less than 0.1). Both Flights C-151 and C-158 were recorded as having some scattered thin clouds, whereas Flight C-157 started out clear, with scattered clouds developing in the flight path. For all six flights there were no clouds above the highest flight altitude.

METEOROLOGICAL DATA

The basic discussion of meteorological conditions is presented in Section 6, and is not enlarged upon here. A brief summary of the temperature profile data is presented below as an interpretive convenience.

Temperature. The six flights were conducted during the Fall at a latitude of 33°N and thus can be profitably compared to the U.S. Standard Atmosphere Supplements for 30°N latitude and for Spring/Fall 45°N latitude. (The supplement for Spring/Fall 45°N latitude is also called Mid-Latitude Spring/Fall and is equivalent to the U.S. Standard Atmosphere 1962.) To facilitate this comparison, the temperature profile (a graphical average of the temperatures measured during the vertical profile sequences) of each of the six flights is superimposed on a graph of the temperature for January and July 30°N and Spring/Fall 45°N in Figure 8-1. Note that the altitude scale is above mean sea level with the ground level value of 1448 meters indicated on the scale.

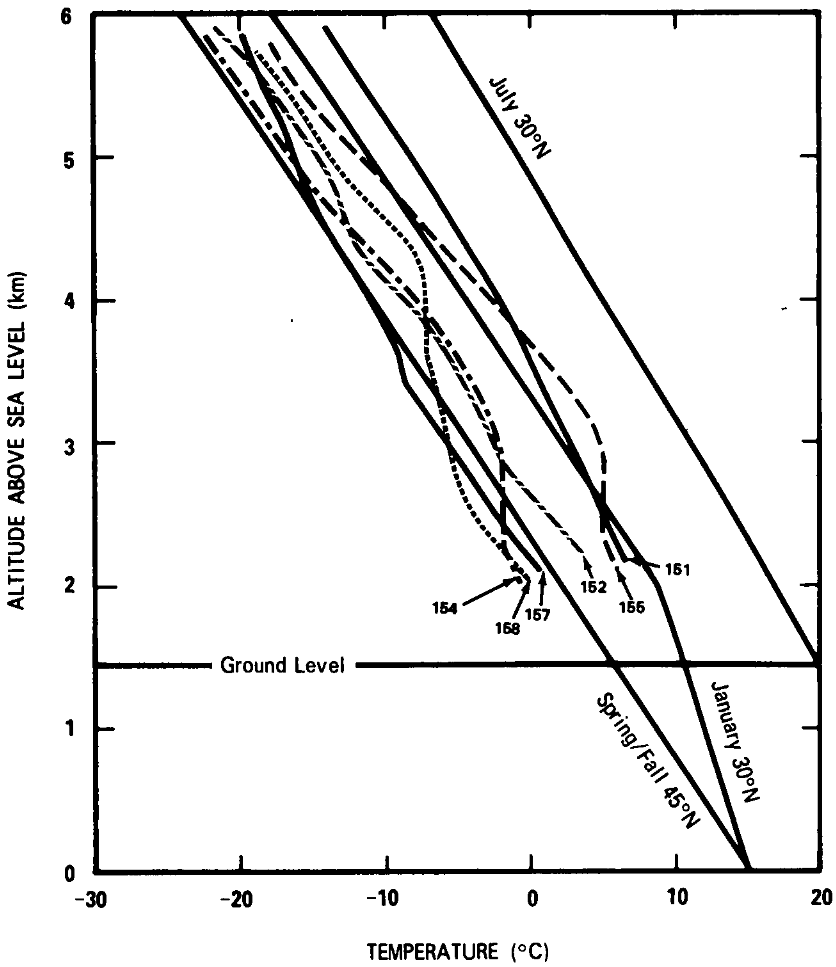


Fig. 8-1. Temperatures From the Six ATOM Flights and From the U. S. Standard Atmosphere Supplements for 30°N and Spring/Fall 45°N.

The temperatures for most of the flights are lower than for January at 30°N, tending more toward the temperatures of Spring/Fall 45°N. The temperature/altitude cross section for the January supplementary atmosphere (Figure 2.1 of U.S. Standard Atmosphere Supplements, 1966) indicates a rapid falloff of temperature with increased latitude above 30°N. Thus, it is reasonable for the October/November temperatures at 33.3°N to be less than those expected at 30°N. Also, the January 30°N values are radiosonde averages for January and therefore should not be interpreted as a lower limit for the 30°N temperatures.

The warmest temperatures were encountered on Flights C-151 and C-155; both are similar to the 30°N January temperature profile. Flight C-152 lies between the 30°N January and the 45°N Spring/Fall temperatures. Flights C-154, C-157, and C-158 are lower than the Spring/Fall 45°N temperature at low altitude and higher at high altitude.

RADIOMETRIC DATA

Since some of the radiometric data to be evaluated are derived quantities, it is preferable to discuss the primary quantities first and the derived values later. Thus, the radiometric data will be discussed in the following order:

- Total Volume Scattering Coefficient
- Equivalent Attenuation Length and Beam Transmittance
- Irradiance
- Terrain Reflectance
- Equilibrium Radiance
- Path Radiance
- Contrast Transmittance
- Path Reflectance

Total Volume Scattering Coefficient. The total volume scattering coefficient data were measured during the vertical profile sequences of each flight. Between the time of the first vertical profile sequence and the last, there was a period of 3 hours in each of five flights having Filter 4 measurements. The elapsed time for Flight C-151, with no Filter 4 data, was only 2 hours. For simultaneous data, the order of the scattering coefficient data by filter generally should be the inverse of the mean wavelength of the filters, i.e., s(Filter 2) > s(5) > s(3) > s(4). All the flights exhibit this characteristic, indicating that the optical characteristics of the atmosphere in the flight track were relatively stable during the flight period.

It was possible to take airborne data as low as 0.6 to 0.75 kilometer. Also, ground-based nephelometer data measured during the flights were available and were used for all but Flight C-151. Thus, for most of the flights, the low altitude total scattering profile is well-documented.

Anomalies were found in the Filter 4 scattering data for one of the vertical profile sequences between two of the straight and level sequences in four of the flights: C-154, C-155, C-157, and C-158. These anomalies were deleted. The graphs for these flights indicate smooth curves where the data were extrapolated between acceptable data values. For Flights C-154, C-157, and C-158, the data were extrapolated between data near 4.2 to 4.5 kilometers and about 2.2 kilometers. For Flight C-157, the data were extrapolated at low altitudes between values at 0.6 and 2.1 kilometers.

The lapse rate of the measured total scattering coefficients at the higher altitudes between 2 and 4.5 kilometers for all the flights and from ground level to 4.5 kilometers for Flights C-154 and C-155 is less than the density lapse rate. This characteristic was also noted for the high altitude data measured in Memmingen, Germany, Duntley *et al.* (1972). Since the lapse rate for total scattering coefficient should be similar to the density lapse rate, an investigation is underway to determine if this characteristic could be due to instrument error.

In order to compare the scattering characteristics of the six flights, the total volume scattering coefficient for Filter 5 (pseudo-photopic) was graphed for each flight in Figure 8-2. The lower altitude data, between ground level and 1.5 kilometers, are similar in magnitude for the six flights. Four of the flights (C-151, C-152, C-154, and C-155) change very little above 1.5 kilometers as well, whereas Flights C-157 and C-158 reach a haze top at about 2.5 kilometers and have a clearer area between 2.5 and 4.5 kilometers.

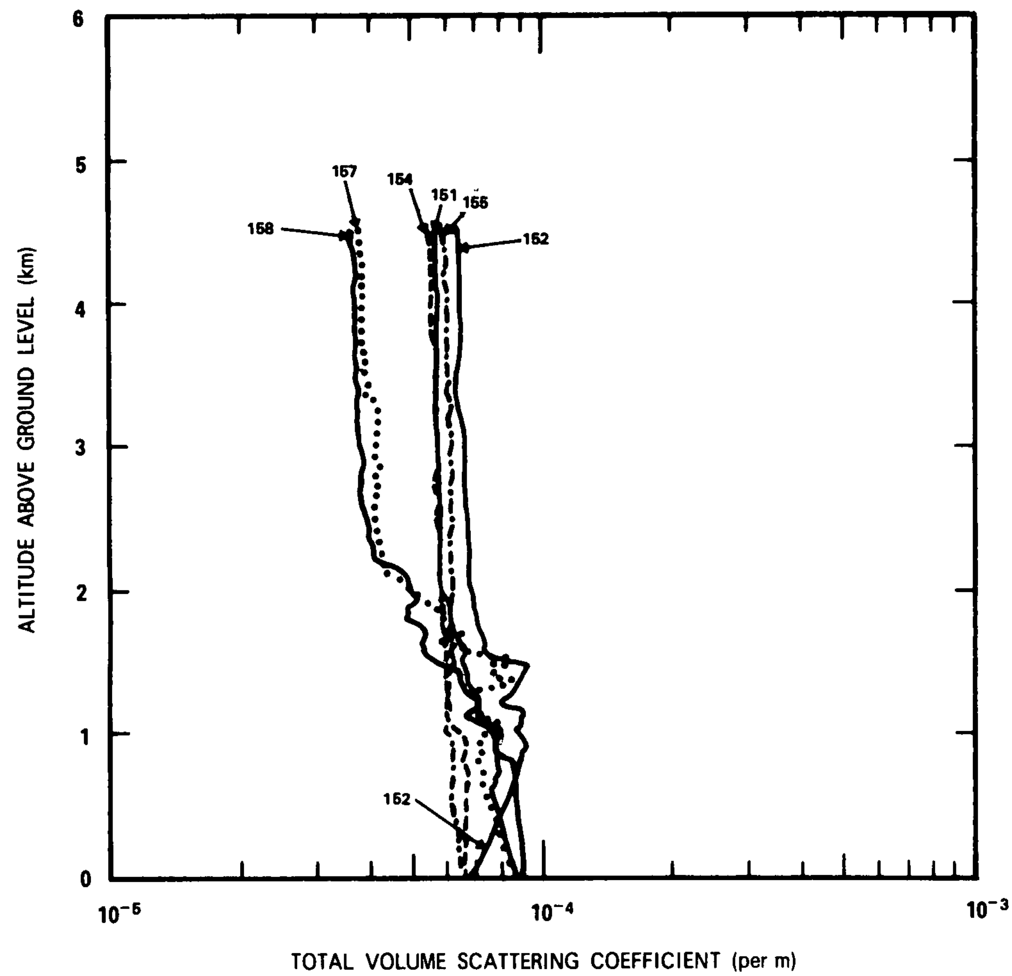


Fig. 8-2. Total Volume Scattering Coefficient for Filter 5 (Pseudo-Photopic) for the Six ATOM Flights.

Equivalent Attenuation Length and Beam Transmittance. At ground level the equivalent length is the reciprocal of the total scattering coefficient. As altitude increases, the equivalent attenuation length shows the cumulative effect of summing $s(z)$ from ground level to the altitude z. The vertical beam transmittance starts at 1.0 and similarly shows the cumulative effect of the summation of the total scattering coefficient. For simultaneous data, the order by filter of the equivalent attenuation length $\bar{L}$ and the beam transmittance should be the same as the mean wavelength of the filter, i.e., $\bar{L}$(Filter 4) > $\bar{L}(3) > \bar{L}(5) > \bar{L}(2)$. All of the flights display this feature due to the atmospheric optical stability during the flights.

Irradiance. The downwelling irradiance at the lowest straight and level altitude is used as the irradiance for computing the directional reflectance of the terrain and the directional path reflectance. The low altitude irradiance for the photopic Filter 5 can be compared to the ground level values of Brown (1952). The illuminance values of Brown have been converted to irradiance units for unobscured sun and average cloud conditions and are depicted in Figure 8-3. Superimposed on the same figure are the low altitude downwelling irradiance values for Filter 5 for the six flights. The altitudes for the lowest straight and level sequence ranged between 0.6 and 0.75 kilometers above ground level.

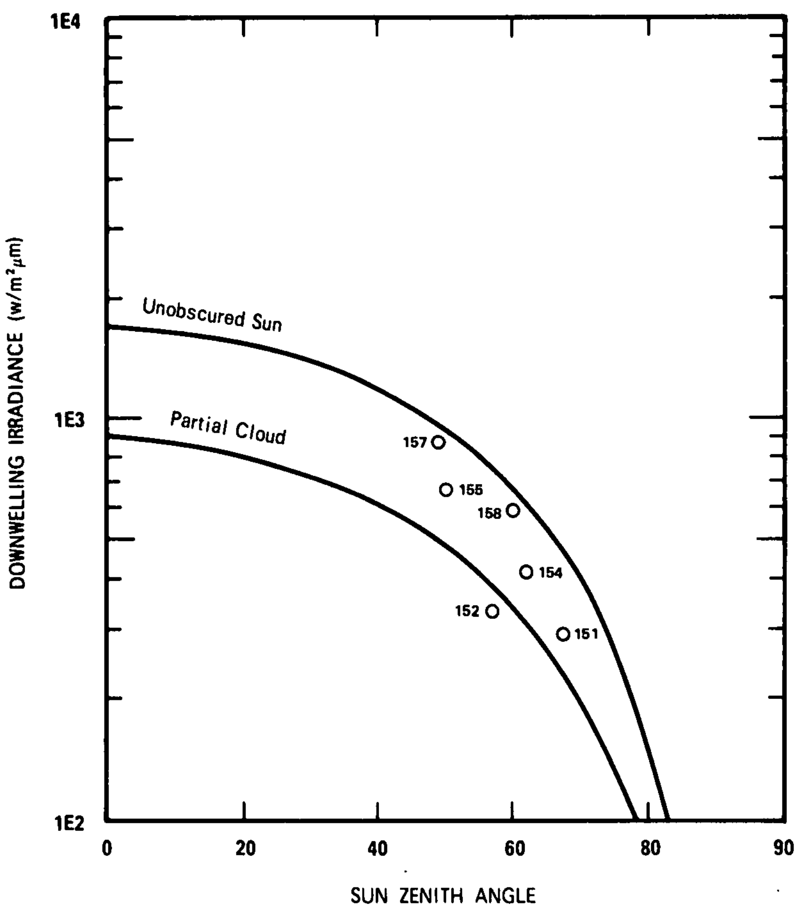


Fig. 8-3. Low Altitude Downwelling Irradiance for Filter 5 (Pseudo-Photopic) as Compared to Brown (1952).

The irradiances are low in comparison to the Brown curves. From the flight descriptions, the irradiances should cluster about the curve for 'unobscured sun'. These airborne irradiances are computed from the upper hemisphere scanner radiances. There are three areas of uncertainty which can contribute to the error in the integration result: one, the sun irradiance is dependent upon the estimate of the transmittance from space to the highest flight altitude; two, the sun zenith angle used in the cosine weighting of the sun irradiance is that of the highest sky radiance recorded for the upper hemisphere, which tends to be larger than the theoretical sun zenith angle; and three, the sky radiances in the aureole, the area immediately surrounding the sun, are poorly defined. Steps are being taken to develop new processing methods to reduce the errors in these three areas. In addition, a new method of measuring the aureole irradiances is being developed.

The graphs of downwelling irradiance versus altitude indicate a general increase of irradiance with decreases in sun zenith angle, the small sun zenith angles being at the higher altitudes. Also, when Filter 4 irradiances are larger than those for the other three filters, the Filter 4 sun zenith angle is on the order of 10 degrees smaller. As noted before, the Filter 4 data were taken in a separate sequence either before or after all the data for Filters 2, 5, and 3.

The data for Filters 2, 5, and 3 were taken almost simultaneously. The irradiance for Filter 5 is generally higher than for Filter 3, as expected. The irradiance for Filter 2 is consistently lower than that for Filter 5; this may possibly be due to the low transmittances estimated for Filter 2 (see Section 8.2).

Directional Reflectance of Terrain. The tables of directional reflectance of the background (terrain) presented with each flight are derived from data obtained with the lower hemisphere scanner at the lowest flight altitude. This instrument is a telephotometer with a 5-degree field of view. The tabular values of reflectance, therefore, relate to an average radiance throughout that field of view. It is completely possible that no specific part of the terrain has that value of reflectance. Almost certainly, objects of interest will be located on a background having a different reflectance than that tabulated for the terrain. That is why ground-based measurements of directional reflectance of backgrounds are also made during the flight interval — to help provide appropriate values for generating contrast transmittance for a given problem. The effect of background reflectance on the contrast transmittance is not a trivial one. Care should be used in selecting the appropriate value for application to specific problems.

Summary Table 8-1 presents airborne data on directional reflectance of the terrain for the nadir path of sight. This summary is ordered by sun zenith angle and is presented for conceptual purposes. For the nadir path of sight at the lowest altitude of all the flights, 568 meters, a 5-degree field would cover a circle 50 meters in diameter; whereas at the lowest altitude for Filter 4 for Flight C-152, 798 meters, a 5-degree field would cover a circle 70 meters in diameter. In addition, the nadir value is the average of the values obtained during one azimuth revolution of the scanner (5 seconds). At the low altitude flight speeds of 151 to 165 knots, the distance covered in 5 seconds is 390 to 425 meters. Thus, the tabulated nadir reflectances relate to an average radiance in an area between 50 by 440 or 70 by 495 meters in size.

The inconsistency of the reflectance filter to filter and flight to flight is a direct function of the patchiness of the terrain as illustrated in Figures 7-1 through 7-4. The values always lie within the range of values measured by the contrast reduction meter during the series of flights. This range is indicated in the last row of data in Table 8-1. The high value for the range is taken from Table 7-5, the nadir reflectance of sand. The low value for the range is taken from the reflectances of the scattered brush in Table 7-7.

Equilibrium Radiance. Equilibrium radiance Eq. 2.18 is obtained by using an integrative method. An advantage of this method is the ability to handle highly variable data, variable in the sense of changing flux levels due to real changes occurring in space and/or time during the flight. Although the terrain over which a data flight takes place is chosen for its consistency of terrain appearance, specific features vary in position relative to the aircraft as it flies the track. Anomalies in the sky lighting distribution occur due to subtle changes in the weather. The sun zenith angle increases or decreases in varying degrees due to variations in procedure times. These local occurrences contribute to the variability of the overall flux level and directional radiance pattern, and these two properties define the equilibrium radiance. The values of equilibrium radiance derived using the integrative method are directly descriptive of the real conditions encountered and measured during the flight.

Table 8-1

Nadir Terrain Reflectances based on Airborne Scanners
Over Desert Sand with Low Scattered Brush

Date 1970	Flight No.	Altitude (meters) AGL	Sun Zenith Angle	Nadir Reflectance			
				Filter 2	Filter 5	Filter 3	Filter 4
26 Oct	C-152	798	48	-	-	-	0.17
28 Oct	C-154	700	48	-	-	-	0.23
4 Nov	C-158	568	49	-	-	-	0.14
3 Nov	C-157	647	49	0.07	0.10	0.11	-
30 Oct	C-155	660	50	0.09	0.10	0.13	-
3 Nov	C-157	652	52	-	-	-	0.16
26 Oct	C-152	751	58	0.14	0.30	0.28	-
4 Nov	C-158	601	61	0.04	0.13	0.16	-
30 Oct	C-155	722	61	-	-	-	0.19
28 Oct	C-154	647	63	0.14	0.14	0.22	-
24 Oct	C-151	736	68	0.13	0.13	0.26	-
23 Oct to 3 Nov CRM		0	46 to 54	.03 to .19	.06 to .34	.04 to .40	.13 to .50

Under comparatively stable conditions, equilibrium radiance tends to be relatively invariant with altitude. Several atmospheric models are based upon this tendency [Duntley (1948) and Gordon (1969)]. However, for the six ATOM flights, the equilibrium radiance was a more erratic quantity. The standard deviation with altitude had a range from less than 1 to 50 percent, with the nadir path of sight often having standard deviations in the middle of that range. To illustrate this, the equilibrium radiance for the Flight C-151 photopic response (Filter 5) is graphed in Figure 8-4 for the nadir path of sight. Flight C-151 was one of the more optically stable flights in terms of consistency in irradiance and total scattering coefficient, but the standard deviation for the nadir path equilibrium radiance varied from 23 to 26 percent for the three filters (Filter 5 standard deviation is 24 percent). Thus, the atmospheric models cited above appear inapplicable to the ATOM flights.

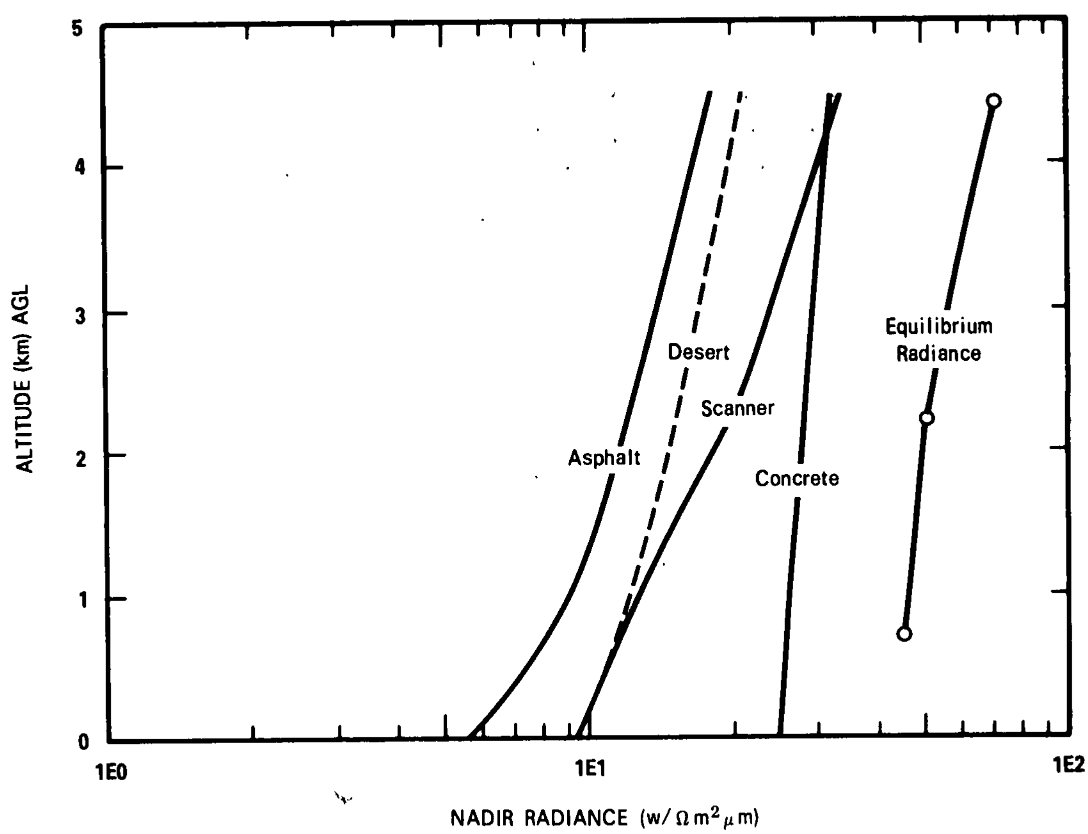


Fig. 8-4. Equilibrium and Apparent Radiance for Flight C-151 Filter 5 (Photopic) for the Nadir Path of Sight.

There is a certain amount of consistency, however, in the equilibrium reflectance for the lowest altitude for the nadir path of sight. Equilibrium reflectance R_q is derived from the equilibrium radiance and the downwelling irradiance:

$$R_q(z,\theta,\phi) = N_q(z,\theta,\phi)\ \pi/H(z,d)\ . \tag{8.1}$$

Since the apparent radiance of a terrain, background, or object tends to approach the equilibrium radiance, a look at the equilibrium reflectance at the lowest altitude will tell us whether a terrain will increase or decrease in radiance with altitude, at least initially. The nadir equilibrium reflectances for the six flights are given in Table 8-2. There is a slight correlation of the equilibrium reflectance with sun zenith angle for all but Filter 4. There is also a rough overall consistency with the reflectances in a range of 0.24 to 0.52. All the nadir terrain reflectances (Table 8-1) are lower than the equilibrium reflectances for the same day, and, therefore, the apparent terrain radiance will increase with altitude, at least at the lower altitudes.

Table 8-2

Nadir Equilibrium Reflectance at Lowest Altitude

Date 1970	Flight No.	Altitude (meters) AGL	Sun Zenith Angle	Nadir Equilibrium Reflectance			
				Filter 2	Filter 5	Filter 3	Filter 4
26 Oct	C-152	798	48	-	-	-	0.30
28 Oct	C-154	700	48	-	-	-	0.35
4 Nov	C-158	568	49	-	-	-	0.24
3 Nov	C-157	647	49	0.28	0.29	0.26	-
30 Oct	C-155	660	50	0.33	0.32	0.31	-
3 Nov	C-157	652	52	-	-	-	0.25
26 Oct	C-152	751	58	0.40	0.47	0.45	-
4 Nov	C-158	601	61	0.29	0.34	0.34	-
30 Oct	C-155	722	61	-	-	-	0.32
28 Oct	C-154	647	63	0.42	0.41	0.45	-
24 Oct	C-151	736	68	0.48	0.49	0.52	-

Another general observation that can be made is that the equilibrium reflectance usually increased for the longer slant paths (as the zenith angles approached 90 degrees).

Path Radiance. The path radiance is calculated from the values of equilibrium radiance for a given path of sight by means of Eq. 2.16 and 2.17. Thus, the path radiance combines the values of equilibrium radiance from each of the several altitudes. The required path radiance is essentially a scattered radiance in a given path at any one instant. The derived value, however, represents an averaging of the light conditions present during the entire flight (the use of integral Eq. 2.16 and 2.17 effectively combines the variable data into a crude average of the prevalent condition). The averaging, however, is progressive. The lowest altitude value is derived solely from the low altitude data, whereas at the highest altitude, all the data are averaged. Thus, the path radiances represent neither the clearest nor the cloudiest portion of a flight, but a crude combination of the various segments.

The derived path radiances are relatively smooth functions in comparison to the equilibrium radiances due to the averaging process of the integration in Eq. 2.16. For simultaneous data, path radiance would be expected to decrease with increasing wavelength. The representative graphs of path radiance in Section 7.3 indicate that this held for all flights but Flight C-154 at zenith angles 180 and 120 degrees.

The path radiance enters into the equation for contrast transmittance, Eq. 2.2, into the equation for directional path reflectance, Eq. 2.4, and into the equation for computing apparent radiance, Eq. 7.2. By rearranging Eq. 7.2, we obtain an equation for predicting the inherent radiance of the terrain at ground level ${}_bN_o(0,\theta,\phi)$ from the apparent radiance at the lowest flight altitude, the derived path radiance, and the beam transmittance:

$$ {}_bN_o(0,\theta,\phi) = [\,{}_bN_r(z,\theta,\phi) - N_r^*(z,\theta,\phi)]/T_r(z,\theta) \; . \qquad (8.2)$$

The resultant inherent radiance for the nadir path of sight for Flight C-151 Filter 5 (photopic) is 9.4 $w/\Omega m^2 \mu m$. Then using Eq. 2.5, we obtain a reflectance of 0.101. This reflectance is indicative of the desert sand with scattered brush underlying the flight track. The measured scanner radiances and the extrapolated ground value are graphed in Figure 8-4 and labeled as "scanner".

For conceptual purposes, we have computed the apparent nadir radiances for three types of backgrounds appropriate to Flight C-151 Filter 5 (photopic) using Eq. 7.2. The three backgrounds chosen are: a desert area with brush having a reflectance of 0.101 (the derived inherent terrain reflectance for the flight), oily asphalt with a film of dirt having a reflectance of 0.061, and aged white concrete with a reflectance of 0.266. The latter two photopic reflectances are from Table 3-2 of Gordon (1964). The radiances for these three backgrounds are graphed in Figure 8-4 The asphalt and concrete illustrate surfaces often used for roads.

The predicted desert radiances closely follow the scanner radiances at the lower altitudes and are lower than the scanner at the upper altitudes. The high scanner radiance is probably due to an overall increase in flux level with the smaller sun zenith angle at the high altitude. The calculated value for the desert shows the influence of the lower flux levels at the lower altitudes.

Note how the background radiances tend to approach the equilibrium radiances. All the radiances increase with altitude since they are always less than the equilibrium radiance and tend to approach it.

Contrast Transmittance. The contrast transmittance can be expressed as the beam transmittance times the ratio of the inherent to apparent background radiance:

$$ {}_b\tau_r(z,\theta,\phi) = T_r(z,\theta)\; {}_bN_o(0,\theta,\phi)/{}_bN_r(z,\theta,\phi) \; . \qquad (8.3)$$

Thus, the contrast transmittance is a direct function of the background and the manner in which the background radiance changes with altitude. The contrast transmittance for a background lower in reflectance than the equilibrium reflectance will always be smaller than the beam transmittance. This is illustrated in Figure 8-5 by the asphalt, desert, and concrete backgrounds for the nadir path of sight for Flight C-151 Filter 5 (photopic). This is true because the ratio of inherent to apparent background radiance will always be less than 1 (since apparent radiance increases with altitude as shown in Figure 8-4). On the other hand, the contrast transmittance for a background higher in reflectance than the equilibrium reflectance will have a contrast transmittance greater than the beam transmittance.

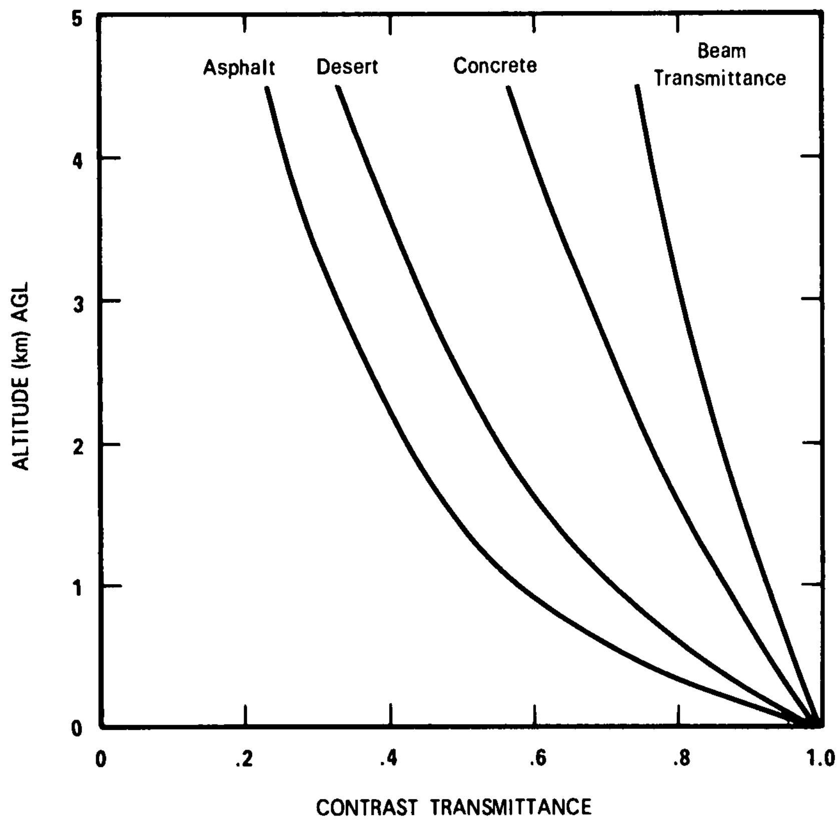


Fig. 8-5. Beam Transmittance and Contrast Transmittance for Flight C-151 Filter 5 (Photopic) Nadir Path of Sight.

The above example emphasizes the importance of selecting the appropriate background reflectances for computing valid contrast transmittance values. Photopic reflectances of backgrounds are available for clear days with moderately high suns in Gordon (1964) and Gordon and Church (1966).

DIRECTIONAL PATH REFLECTANCE

Using the data from the two scanners to obtain both the path radiance $N_r^*(z,\theta,\phi)$ and the downwelling irradiance $H(z,d)$ adds to the reliability of the path reflectance $R_r^*(z,\theta,\phi)$ since these two quantities are ratioed in Eq. 2.4 to obtain path reflectance. In this way, any absolute error in the calibration of the scanners or in the estimate of space to altitude transmittance is effectively minimized. Also, since both the path radiance and the downwelling irradiance are obtained by integration of a large number of radiance measurements, precision errors tend to cancel or average out.

For simultaneous data, the directional path reflectance should decrease with wavelength. All flights but Flight C-155 show this regularity in the representative graphs of path reflectance in Section 7.3. Flight C-155 shows Filter 2, 5, and 3 in the expected order, but Filter 4 is at times out of order. It is advisable to use the data for flights other than C-155 in any problem requiring filter comparisons.

8.2 GROUND-BASED DATA

RADIOMETRIC DATA

Since some of the data to be evaluated are derived, it seems logical to discuss the primary values first and the derived quantities later. With this in mind, the data will be discussed in the following order:

Total Volume Scattering Coefficient

Beam Transmittance

Irradiance

Terrain Reflectance

Path Radiance

Path Reflectance

Total Volume Scattering Coefficient. The ground-level total volume scattering coefficient values are reasonable and they could not always have been predicted from the airborne values measured at the lowest flight altitude. Hence, they represent a unique and necessary part of the measured optical properties describing the atmosphere during each flight.

The visibility "VV" reports in Section 6.3 from Stallion during each flight can be compared to the photopic total volume scattering coefficient s (Filter 5) by assuming no absorption. The visibility distance is considered to be roughly comparable to a 5 percent contrast transmittance range; thus, when "s" and "VV" are in similar units,

$$s = \frac{3}{VV} . \tag{8.4}$$

Values of scattering coefficient s computed from the reported estimated visibilities are presented in Table 8-3, Column 5. The measured values of s for Filter 5 are given in Column 4. The visibilities calculated from the measured s values are compared with the reported estimated visibilities in Columns 6 and 7.

The visibilities reported by Stallion remained constant throughout each day as well as throughout the entire period of the field expedition. The ground station-measured scattering coefficient values better reflect the descriptive report of the varying haze conditions at the ground station.

Beam Transmittance. The space-to-earth vertical beam transmittance values as measured by the contrast reduction meter increased with wavelength, as expected, for Filters 2, 6, 5, and 3. Filter 4 (with a mean wavelength of 765 nanometers and a response area of 50 nanometers) is located in a portion of the spectrum dominated by the Fraunhoffer (A) oxygen absorption bands at 759.4 and 762.1 nanometers. See

Figure 8-6 taken from Tarrant's spectrum in Henderson (1970). Thus, the transmittance for Filter 4 is a product of the transmittance due to scattering and the transmittance due to absorption by 0_2. The vertical space-to-earth transmittance due to 0_2 absorption is probably on the order of 85 percent for Filter 4, sufficient to reduce the total transmittance to less than the transmittance for Filter 3.

Table 8-3

Measured Photopic (Filter 5) Total Volume Scattering Coefficients
s Compared with Reported Visibility Estimates, VV

Flight No.	Date 1970	Ground Station Report	Ground Station Measured s (per m)	Stallion Calculated s (per m)	Ground Station Calculated Visibility (miles)	Stallion Reported Visibility (miles)
C-152	26 Oct	light haze	6.90E-5	4.66E-5	27	40
C-154	28 Oct	thin haze	6.66E-5	4.66E-5	28	40
C-155	30 Oct	very dry, clear	6.66E-5	4.66E-5	28	40
C-156	2 Nov	moderate haze	7.92E-5	4.66E-5	24	40
C-157	3 Nov	moderate haze	8.45E-5	4.66E-5	22	40
C-158	4 Nov	(not reported)	8.64E-5	4.66E-5	22	40

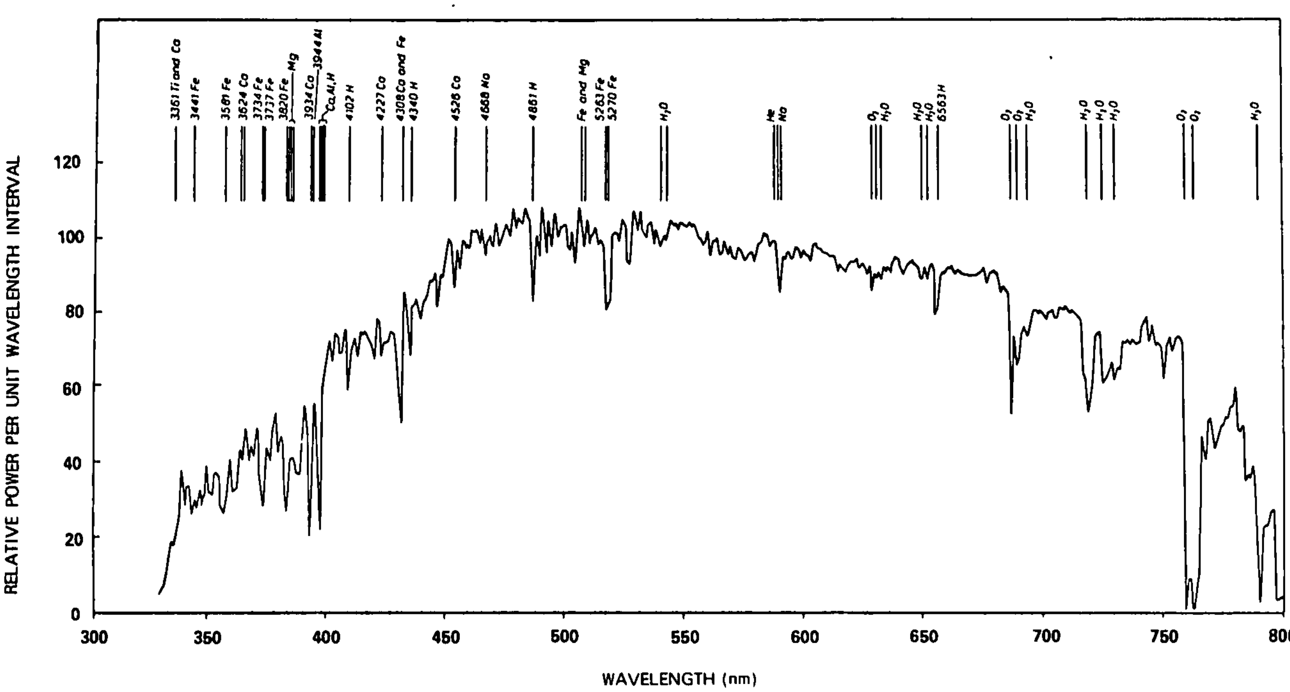


Fig. 8-6. Recorded Spectrum for a South-Facing Observation, CCT 5500 K.
Absorption Bands are identified [Tarrant in Henderson (1970)].

Beam transmittance from space to 4.5 kilometers AGL $T_\infty(4.5,0°)$ can be calculated from the space-to-earth beam transmittance $T_\infty(0,0°)$, which is measured by the contrast reduction meter, and from the beam transmittance from 4.5 kilometers AGL to ground $T_{4.5}(0,0°)$, which is computed from the airborne nephelometer values and tabulated in Section 7.3:

$$T_\infty(4.5,0°) = T_\infty(0,0°)/T_{4.5}(0,0°) \,. \tag{8.5}$$

These values are presented in Columns 3 through 6 in Table 8-4. Also tabulated in Table 8-4 are the values for Rayleigh vertical beam transmittance from space to 4.5 kilometers AGL (6 kilometers above sea level). The calculated values of $T_\infty(4.5,0°)$ are always less than the Rayleigh transmittance, thus indicating that the airborne nephelometer data and the contrast reduction meter transmittance data, when used jointly to derive $T_\infty(4.5,0°)$, yield reasonable values. The spectral irregularities of $T_\infty(4.5,0°)$ for Filters 2, 5, and 3 are trivial, on the order of 3 percent, which is below the magnitude of the precision error for the individual measurements.

Table 8-4

Vertical Transmittance Space to 4.5 km $T_\infty(4.5,0°)$ as Calculated from Ground-Based Contrast Reduction Meter and Airborne Nephelometer Data, and as Estimated from High Altitude Nephelometer Values

Flight No.	Date 1970	Calculated Transmittance $T_\infty(4.5,0°)^*$ Filter 2	Filter 5	Filter 3	Filter 4	Estimated Transmittance $T_\infty(4.5,0°)^{**}$ Filter 2	Filter 5	Filter 3	Filter 4
C-151	24 Oct	0.88	0.90	0.88	-	0.55	0.65	0.69	-
C-152	26 Oct	0.88	0.85	0.86	0.75	0.56	0.62	0.71	0.73
C-154	28 Oct	0.82	0.82	0.84	0.76	0.58	0.67	0.71	0.78
C-155	30 Oct	0.82	0.85	0.83	0.78	0.57	0.64	0.70	0.74
C-157	3 Nov	0.74	0 76	0.77	0.70	0.67	0.76	0.81	0.88
Rayleigh Transmittance		0.92	0.96	0.98	0.99				

* Calculated transmittance from measured values of s and $T_\infty(0,0°)$.

** Estimated transmittance from measured values of s(4.5) and the scale height at 4.5 km.

The apparent sun radiance values used to compute the airborne irradiance, equilibrium radiance, and, hence, path radiance, use an estimate of space to 4.5 kilometers AGL beam transmittance $T_\infty(4.5,0°)$ from equations in Section 2.10. This estimate is based upon two assumptions:

1. There is no absorption.
2. The aerosol composition at the highest flight altitude pertains (except in density) to all altitudes above 4.5 kilometers.

The estimated values of transmittance based on these two assumptions and the total scattering coefficient measured at the highest flight altitude are presented in Columns 7 through 10 in Table 8-4.

The applicability of the two assumptions can be ascertained by comparing the estimates with the calculated values in Columns 3 through 6. To aid in this evaluation, the transmittance estimates have been divided by the transmittance as calculated from the contrast reduction meter and the airborne nephelometer data. These ratios are given in Table 8-5.

Table 8-5

Ratio of Estimated to Calculated Beam Transmittance Space to 4.5 km

Flight No.	Date 1970	Transmittance Ratio, $T_{(est.)}/T_{(calc.)}$ Filter 2	Filter 5	Filter 3	Filter 4
C-151	24 Oct	0.63	0.72	0.78	-
C-152	26 Oct	0.63	0.74	0.82	0.97
C-154	28 Oct	0.70	0.82	0.86	1.02
C-155	30 Oct	0.69	0.76	0.85	0.96
C-157	3 Nov	0.90	1.01	1.05	1.26

$T_{(est.)}$: from measured s(4.5) and scale height at 4.5 km.

$T_{(calc.)}$: from measured s data and measured $T_{\infty}(0,0°)$.

Since assumption (1) will hold for Filters 2, 5, and 3, we will examine those ratios first. They indicate that assumption (2) is reasonable for Flight C-157 but not for Flights C-151, C-152, C-154, and C-155. For Filter 4 (for which there is absorption) if assumption (2) holds, the ratio would be greater than 1 since the airborne estimate is the estimated transmittance due to scattering only. Again, this is true for Flight C-157, indicating the aerosol does not change above 4.5 kilometers during this flight. The ratios for Filter 4 for the other four flights (all near 1) indicate that the error in the scattering estimate due to the inapplicability of assumption (2) is about the same order of magnitude, but of opposite sign, as the error due to assuming no absorption. Thus, the ratios for all four filters indicate that assumption (2) holds for Flight C-157, but that for the other four flights the aerosol changes in character to a clearer one above 4.5 kilometers AGL.

These general observations are borne out by most of the flight descriptions. The descriptions for Flights C-151, C-154, and C-155 indicate that at the maximum flight altitude the aircraft was still in a haze layer; whereas for Flight C-157 at the maximum altitude, the haze was below.

These same general observations are also consistent with the graphs of total scattering coefficient in Section 7.3 and in Figure 8-2. These figures indicate that Flight C-157 at 4.5 kilometers AGL is above the primary haze layer (a clear haze top occurs at about 2.5 kilometers AGL), thus it is not unreasonable to assume an unchanging aerosol above 4.5 kilometers AGL. For Flights C-154 and C-155 there is no haze top indicated in the scattering coefficient data; thus, a top to the primary haze layer might be expected above 4.5 kilometers AGL. For Flights C-151 and C-152 a slight haze top shows up at 1 to 1.5 kilometers in the figures, but Figure 8-2 indicates that the haze above 1.5 kilometers is about the same strength as in the primary haze layer for the other four flights. Thus, for Flights C-151, C-152, C-154, and C-155 the transmittance estimates for $T_\infty(4.5,0°)$ for Filters 2, 5, and 3 are too low.

It is recommended that, on future flights, contrast reduction meter transmittance values be considered high priority measurements and that, whenever possible, the transmittance from space to the highest flight altitude be based upon the value calculated from the contrast reduction meter and the airborne nephelometer values, rather than estimated using the equations in Section 2.10.

Irradiance. The ground-level downwelling irradiance for the photopic Filter 5 can be compared to the ground level values of Brown (1952). The illuminance values of Brown for unobscured sun and average cloud conditions have been converted to irradiance units and are presented as solid curves in Figure 8-7. The downwelling irradiances for Filter 5 as measured with the contrast reduction meter are depicted as separate data points. They compare well to the unobscured sun values of Brown.

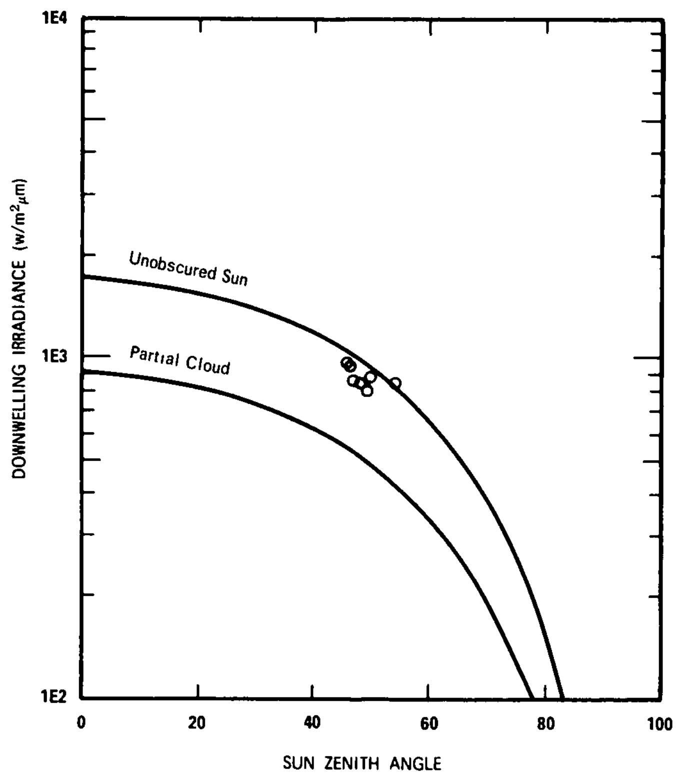


Fig. 8-7. Ground-Level Downwelling Irradiance for Filter 5 (Pseudo-Photopic) as Compared to Brown (1952).

Although the order of the filters by increasing mean wavelength is 2 (478 nanometers), 6 (532 nanometers), 5 (557 nanometers), 3 (664 nanometers), and 4 (765 nanometers), the irradiances for Filter 6 consistently lie between those for Filters 5 and 3. Thus the irradiances H (filter) are in the order H(2) > H(5) > H(6) > H(3) > H(4). This inverted juxtaposition of the Filter 6 data is not unexpected, since irradiances for these same filters computed from the daytime spectral irradiance values of Buchtemann and Hohn (1970) generally show this same spectral relationship. (These computations and the resultant irradiances are described in Visibility Laboratory In-House Technical Note No. 44.)

Downwelling irradiance at low altitude and ground level should only be compared for comparable sun zenith angles. There are nine such cases summarized in ratio form in Table 8-6. The airborne irradiance values are computed using the estimated transmittance from space to the altitude of measurement (see Table 7-2 and 8-4 for space to sensor estimates) for determining the apparent sun contribution. Thus, the resultant irradiance values are dependent on the appropriateness of the transmittance estimate. The transmittance ratios in Table 8-5 are an indication of the appropriateness of the estimate. The transmittance ratios are also given in Column 7 of Table 8-6. The rough correlation between the comparability of the irradiance values (low altitude to ground) and the appropriateness of the airborne transmittance estimate is indicated in Figure 8-8, where the irradiance ratio is graphed as a function of the airborne to ground transmittance ratio.

Table 8-6

Low Altitude Airborne Irradiance Divided by Ground Level Irradiance
for Closely Comparable Sun Zenith Angles

Flight No.	Date 1970	Sun Zenith Angle		Filter	Irradiance Ratio	Transmittance Ratio
		Airborne	Ground			
C-152	26 Oct	48	46	4	0.78	0.97
C-154	28 Oct	48	47	4	0.86	1.02
C-155	30 Oct	50	48	2	0.57	0.69
C-155	30 Oct	50	48	5	0.80	0.76
C-155	30 Oct	50	48	3	0.89	0.85
C-157	3 Nov	49	49	2	0.95	0.90
C-157	3 Nov	49	49	5	1.12	1.01
C-157	3 Nov	49	49	3	1.13	1.05
C-157	3 Nov	52	49	4	1.02	1.26

The use of the transmittance from space to the highest altitude of measurement based upon measurements from the contrast reduction meter and the nephelometer, as recommended in the previous section on beam transmittance, would probably greatly enhance the validity of the resultant downwelling irradiance values.

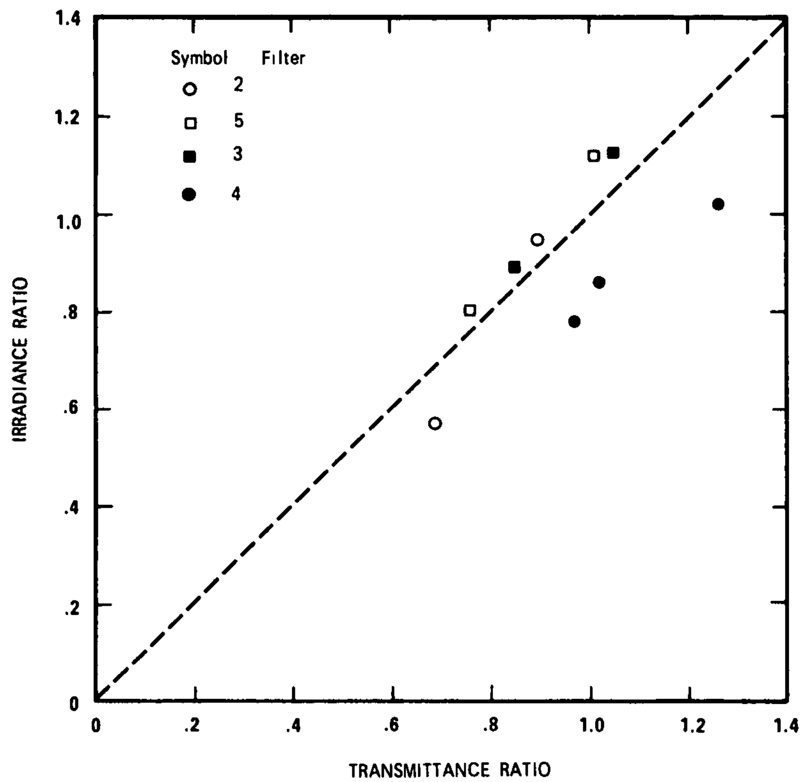


Fig. 8-8. Airborne to Ground-Level Irradiance Ratios as a Function of Airborne to Ground-Level Transmittance Ratios.

Terrain Reflectance. Nadir terrain reflectance values were derived from the contrast reduction meter measurements of terrain radiance and total downwelling irradiance. They provided a validation of the nadir reflectance values derived from the lower hemisphere scanner radiance measurements at the lowest flight altitude as described in Section 8.1.

The ground-based values of nadir reflectance for the desert sand in Table 7-5 can be compared to nadir reflectance values for other desert terrains as measured spectrally by Krinov (1947) and photopically by the Visibility Laboratory. These are presented in Table 8-7. The values in Table 8-7 are spectral values at the mean wavelength of the filter for Filters 2, 6, 3, and 4. The mean wavelength reflectance should be a close estimate for narrow band Filters 2, 3, and 4. Luminous reflectances are tabulated in Column 5 for comparison to the reflectances measured by Filter 5.

The ranges of the reflectances in Table 7-5 and Table 8-7 are tabulated in Table 8-8. They indicate that the sand measurements from the contrast reduction meter compare reasonably with the reflectances in the literature for all but Filter 6. Since Filter 6 is a broad band filter, the reflectance at mean wavelength 532 nanometers is probably not a reasonable estimate of the Filter 6 reflectance. Thus, the discrepancy in ranges for Filter 6 can be ignored.

Table 8-7

Nadir Reflectance of Desert Terrains

Terrain Description	Sun Zenith Angle	Nadir Reflectance Filter 2[a] $\bar{\lambda}$ = 478	Filter 6[a] $\bar{\lambda}$ = 532	Filter 5 Photopic	Filter 3[a] $\bar{\lambda}$ = 664	Filter 4[a] $\bar{\lambda}$ = 765	Spectral Reference	Photopic Reference
Ilyas, sparse and dry, yellowish grass on sand at end of summer, in desert	40	0.16	0.21	0.23[b]	0:27	0.30	Krinov (1947) Object No. 56	Gordon (1964) Table 3.2, No. 12
Wind-eroded place, dry, in desert	45	0.17	0.21	0.24[b]	0.34	0.34	Krinov (1947) Object No. 241	Gordon and Church (1966), Table 2
Sand dunes, with sharply-expressed microrelief, dry, no shadows, in desert	40	0.18	0.25	0.25[b]	0.30	0.50	Krinov (1947) Object No. 248	Gordon and Church (1966), Table 1, No. 26
Sand dunes, with sharply-expressed microrelief, dry, shadows right angles to mountain, in desert	40	0.20	0.28	0.29[b]	0.29	0 28	Krinov (1947) Object No. 255	Gordon (1964) Table 3.2, No. 13
Dirt, flat desert road freshly bulldozed to remove encroaching sage	42	-	-	0.23[c]	-	-		Gordon and Church (1966), Table 1 No. 32
Dirt, flat desert road freshly bulldozed to remove encroaching sage	78	-	-	0.23[c]	-	-		Boileau and Gordon (1966), Table 1, No. 6

(a) Spectral reflectance at mean wavelength $\bar{\lambda}$.

(b) Luminous directional reflectance computed from spectrophotometric data by Krinov (1947) using C.I.E. Illuminant B.

(c) Luminous directional reflectance data taken with goniophotometer at Naval Ordnance Test Station, China Lake, California.

Table 8-8

Range of Nadir Reflectances from Tables 7-5 and 8-7

	Nadir Reflectance Range Filter 2	Filter 6	Filter 5	Filter 3	Filter 4
Table 7-5, Sand	0.12 to 0.19	0.27 to 0.42	0.21 to 0.34	0.29 to 0 40	0.36 to 0.50
Table 8-7, Desert Terrains	0.16 to 0.20	0 21 to 0.28	0.23 to 0.29	0 27 to 0.34	0.28 to 0.50

Path Radiance. The earth-to-space vertical path radiance values are derived from the contrast reduction meter measurements of apparent sun radiance and sky radiance. Since path radiance is defined as the light scattered into the path of sight, it can be expected to be inversely related to the mean wavelength of the filter, as is the scattering coefficient. The derived path radiances display this expected spectral relationship.

The ground-based earth-to-space vertical path radiance values for Filter 5 (photopic) are presented graphically in Figure 8-9 as a function of sun zenith angle. The solid curve represents a graphical average of over 350 photopic earth-to-space path radiance measurements made over a period of 5 years in various geographical locations; the dashed curves are a rough estimate of the range of values (some fall beyond these dashed curves). The measurements summarized by these curves are described in Visibility Laboratory In-House Technical Note No. 5. The ground-based path radiances measured during the Fall of 1970 in central New Mexico are lower than the average but fit into the normal range of data.

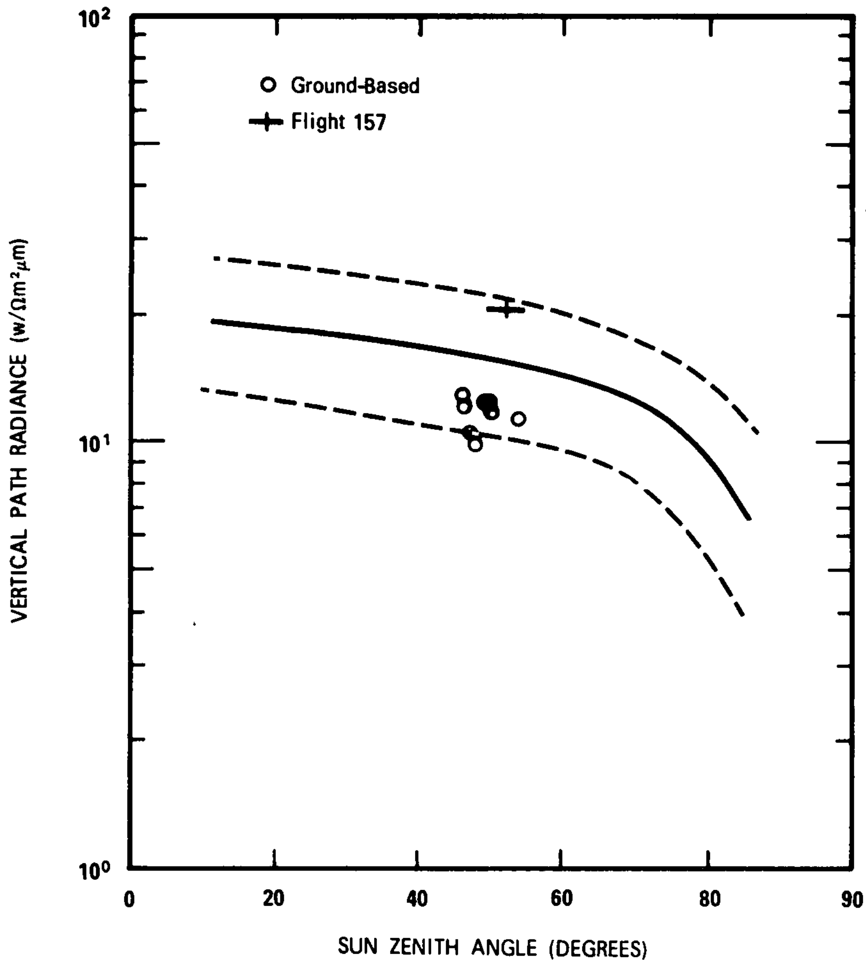


Fig. 8-9. Vertical Path Radiance for Filter 5 (Photopic) Compared to Graphical Average of Over 350 Earth-to-Space Measurements.

The airborne values of path radiance for earth to 4.5 kilometers should only be compared to the ground-based values for earth-to-space for comparable sun zenith angles and total beam transmittance values. These few cases are presented in Table 8-9. The transmittance ratio in Column 6 is the ratio of the airborne transmittance estimate space to 4.5 kilometers to the value derived from the contrast reduction meter and nephelometer values, from Table 8-5.

Table 8-9

Comparison of Airborne to Ground-Based Path Radiance and Path Reflectance for Similar Sun Zenith Angles and Transmittance Ratios

Flight No.	Date 1970	Filter	Sun Zenith Angle		Transmittance Ratio	Path Radiance			Path Reflectance		
			Airborne	Ground		Airborne	CRM	Ratio	Airborne	CRM	Ratio
C-152	26 Oct	4	46 to 48	46	0.97	8.44E+0	3.02E+0	2.79	7.26E-2	2.73E-2	2.66
C-154	28 Oct	4	47 to 48	47	1.02	8.75E+0	2.65E+0	3.30	6.32E-2	2.17E-2	2.91
C-157	3 Nov	2	55 to 49	49	0.90	2.38E+1	2.25E+1	1.06	1.28E-1	1.55E-1	0.83
C-157	3 Nov	5	55 to 49	49	1.01	2.05E+1	1.26E+1	1.63	9.30E-2	8.45E-2	1.10
C-157	3 Nov	3	55 to 49	49	1.05	1.12E+1	6.52E+0	1.72	5.57E-2	4.74E-2	1.18

The comparisons for Filter 4 are particularly poor. This is probably because Filter 4 spectrally contains the Fraunhoffer (A) oxygen absorption bands at 759.4 and 762.1 nanometers (see Figure 8-6). Thus, the airborne beam transmittance values for earth to 4.5 kilometers that are based solely upon scattering are too high. Also, the method of deriving path radiance from ground-based sky and sun radiance measurements is probably valid only for bandwidths where there is little or no absorption (see Gordon (1969) for implications of the no-absorption assumption). Therefore, both airborne and ground-based path radiance values for Filter 4 should be used with great caution, and the effect of absorption on the derivation methods used should be investigated.

The other three filters (2, 5, and 3) are essentially unaffected by absorption. The ratio for Filter 2 is excellent, whereas both Filters 5 and 3 show high airborne path radiances relative to the ground-based values. The airborne value for Filter 5 (Flight C-157) has also been graphed in Figure 8-9. The horizontal length of the cross indicates the sun zenith angle span during the flight. This point also lies within the normal range of values, as indicated by the dashed lines, but is above the average.

Path Reflectance. The earth-to-space vertical path reflectance values are derived from the contrast reduction meter measurements of apparent sun radiance, sky radiance, and downwelling irradiance. The derived path reflectances display an inverse relationship to the mean wavelength of the filters, as expected on the basis of previous measurements with various filters.

The ground-based earth-to-space vertical path reflectance values for Filter 5 (photopic) are presented as a function of sun zenith angle in Figure 8-10. The solid curve represents a graphical average of over 350 photopic earth-to-space vertical path reflectance values based on measurements made in various locations over a period of 5 years; the dashed curves are a rough estimate of the range of values. These curves are based on data graphs in Visibility Laboratory In-House Technical Note No. 5. The ground-based path reflectances measured in central New Mexico during the Fall of 1970 compare very well with the average curve and easily fall within the normal range of values.

The airborne path reflectances for earth to 4.5 kilometers can profitably be compared to the ground-based values for earth-to-space for comparable sun zenith angles and total beam transmittance. These cases are presented in Columns 10, 11, and 12 of Table 8-9. Again, as was the case for path radiance, the values for Filter 4 compare very poorly due to the effects of absorption on both the airborne and ground-based path reflectance values. The path reflectances for the other three filters (2,5, and 3) for Flight C-157 compare reasonably well.

The airborne value of path reflectance for the vertical path earth to 4.5 kilometers is also depicted in Figure 8-10. Although slightly higher than the ground-based values, it also lies well within the normal range of values.

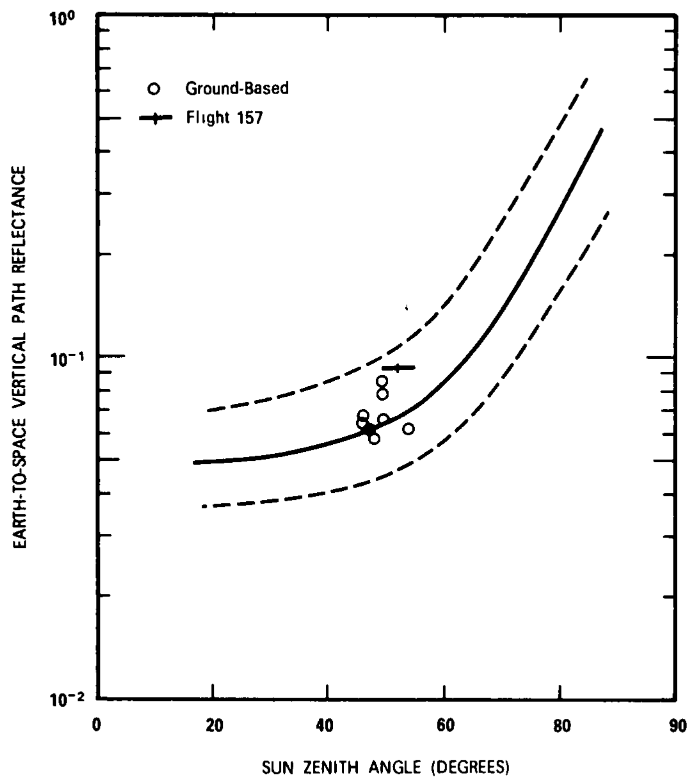


Fig. 8-10. Vertical Path Reflectance for Filter 5 (Photopic) Compared to Graphical Average of Over 350 Earth-to-Space Measurements.

RECOMMENDATION

The addition of the contrast reduction meter to the ground-based instrumentation has provided a powerful diagnostic tool for evaluating the airborne data. In the future, the ground-based beam transmittance earth-to-space should be used as a basic input to the airborne data processing procedure. It is equally as important as the ground-based nephelometer values.

Great caution should be exercised in using the data from Filter 4 because of the domination of that portion of the wavelength band by oxygen absorption.

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13 ABSTRACT

This report presents atmospheric optical data collected in the daytime chiefly with airborne instruments during a field expedition to central New Mexico in the Fall of 1970. Results from six flights are presented. The data include irradiance, directional reflectance of terrain, total volume scattering coefficients, atmospheric beam transmittance, path radiance, and directional path reflectance. Data for sunlight and overcast conditions were derived for downward-looking paths of sight inclined at seven zenith angles (93, 95, 100, 105, 120, 150, and 180 degrees) from altitudes of 4500 meters above ground level and lower in four spectral regions, as follows: three narrow band optical filters with mean wavelengths of 478, 664, and 765 nanometers; and one broad band sensitivity representing the photopic response with a mean wavelength of 557 nanometers.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE		ROLE	WT
Albedos						
Atmospheric Optics						
Atmospheric Scattering Coefficient						
Atmospheric Beam Transmittance						
Atmospheric Contrast Transmittance						
Atmospheric Path Reflectance						
Daytime Radiance						
Daytime Irradiance						
Terrain Reflectance						
Radiometry						
Atmospheric Optical Properties						