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AIRBORNE MEASUREMENTS OF OPTICAL ATMOSPHERIC PROPERTIES IN SOUTHERN ILLINOIS

by

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ABSTRACT

This report presents daytime atmospheric optical data collected chiefly with airborne instruments during a field expedition to southern Illinois in the summer of 1971. Results from five flights are presented. The data include the natural irradiance upon horizontal plane surfaces, scalar irradiances, total volume scattering coefficients, atmospheric beam transmittances, path radiances, directional path reflectances, and directional terrain reflectances. Data for sunlight conditions were derived for downward-looking paths of sight inclined at six zenith angles (95, 100, 105, 120, 150, and 180 degrees) from altitudes of 3000 meters above ground level and lower in three spectral regions, as follows: two narrow band optical filters with mean wavelengths of 478 and 664 nanometers; and one broad band sensitivity representing the photopic response with a mean wavelength of 557 nanometers.

SUMMARY

This report, which describes the Visibility Laboratory's Project METRO effort, was prepared under AFCRL Contract F19628-73-C-0013. The principal project task was to take daytime atmospheric optical measurements in southern Illinois and, from these measurements, to determine optical properties for various downward-inclined paths of sight. These properties include the natural irradiance upon horizontal plane surfaces, scalar irradiances, total volume scattering coefficients, atmospheric beam transmittances, directional path reflectances, directional terrain reflectances, and path radiances.

The field trip was made to Illinois during August 1971. Data were recorded on several flight tracks located in the area surrounding St. Louis, Missouri. The typical terrains were either rolling wooded hills or flat cultivated farmland.

The radiometric 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 pressure. Unfortunately, the dewpoint hygrometer failed to perform adequately, as did the AN/AMQ-17 pressure channel, and the data were not recoverable.

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 two narrow band filters at mean wavelengths of 478 and 664 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 Visibility Laboratory ground-based data station was located at Scott Air Force Base. It contained effectively duplicate instrumentation for obtaining optical data. In addition, it also employed a contrast reduction meter for measuring earth-to-space beam transmittance and path radiance.

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LIST OF ILLUSTRATIONS

RELATED CONTRACTS AND PUBLICATIONS

Related Contracts: None

Publications:

S. Q. Duntley, R. W. Johnson, and J. I. Gordon, "Airborne Measurements of Optical Atmospheric Properties in Southern Germany," AFCRL-72-0255, SIO Ref. 72-64 (July 1972)

S. Q. Duntley, R. W. Johnson, and J. I. Gordon, "Airborne and Ground-Based Measurements of Optical Atmospheric Properties in Central New Mexico," AFCRL-72-0461, SIO Ref. 72-71 (September 1972)

S. Q. Duntley, R. W. Johnson, and J. I. Gordon, "Airborne Measurements of Optical Atmospheric Properties, Summary and Review," AFCRL-72-0593, SIO Ref. 72-82 (November 1972)

J. I. Gordon, J. L. Harris, Sr., and S. Q. Duntley, "Measuring Earth-to-Space Contrast Transmittance from Ground Stations," Appl. Opt. **12**, 1317 – 1324

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 $A(z) \equiv H(z,u)/H(z,d)$.

${}_sA(z)$ — Scalar albedo at altitude z, defined by the equation ${}_sA(z) \equiv h(z,u)/h(z,d)$.

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

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

${}_sN_\infty(0,\theta_s,0°)$ — Apparent radiance of the center of the solar disk as determined at ground-level altitude from the end of path of sight of length ∞ from out of the atmosphere to ground at zenith angle of the sun θ_s.

${}_tN_o(z_t,\theta,\phi)$ — 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.
$\bar{N}_q(z,\theta,\phi)$	Effective equilibrium radiance for a path of sight from out of the atmosphere to altitude z in the direction specified by zenith angle θ and azimuth ϕ. This property may be defined by the equation $$\bar{N}_q(z,\theta,\phi) \equiv N_\infty^*(z,\theta,\phi)/[1 - T_\infty(z,\theta)] \ .$$ This property may also be denoted as a function of angle from light source (sun or moon) β, i.e., $\bar{N}_q(z,\beta)$.
$N_*(z,\theta,\phi)$	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.
$N_\infty^*(0,\gamma_s,180°)$	Sky radiance at a scattering angle of 90° from the sun. Also the path radiance for the path of sight of length ∞ from out of the atmosphere to ground-level altitude at a zenith angle equal to the solar elevation angle γ_s.
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.
$R_q(z,\theta,\phi)$	Equilibrium reflectance is defined as $R_q(z,\theta,\phi) \equiv N_q(z,\theta,\phi)\, \pi/H(z,d)$.

$R_r^*(z,\theta,\phi)$ — 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/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.

${}_M s(z)$ — Total volume scattering coefficient for Mie scattering at altitude z.

${}_R s(z)$ — 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.

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

${}_c W_\lambda$ — Spectral emittance of calibration source.

W'_λ — Spectral emittance of anticipated field scene.

$\bar{y}$ — 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 the 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.

γ_s — Elevation angle of the sun. The solar elevation angle is the complement of the sun zenith angle, $\gamma_s = 90° - \theta_s$.

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. 2.13 and 2.15 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 $\bar{\lambda} \equiv \Sigma\lambda(\overline{S_\lambda T_\lambda})\,\Delta\lambda/\delta\lambda$.

$\rho(z)$ — 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

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

$_b\tau_r(z,\theta,\phi)$ 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.

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.

Ψ Angular solar radius at true earth-to-sun distance.

$\bar{\Psi}$ Angular solar radius at mean solar distance.

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 METRO*. It was conducted during August 1971 in the area surrounding St. Louis, Missouri. The overall operation of this project was coordinated as a part of Air Force Cambridge Research Laboratory's Project 7621.

The METRO deployment was planned for the St. Louis area in August for several reasons. The turbid character of the heavy summer atmosphere in the vicinity of a densely urbanized population center was not available in our existing data bank. Since this class of atmosphere is typical of many modern environments, we felt it should be documented as promptly as possible. The Metropolitan Meteorological Experiment (METROMEX), Changnon *et al.* (1971), was being coordinated for the St. Louis area during the same summer interval, and the availability of a broad spectrum of coordinated measurements was an attractive inducement to participate. Not incidentally, Scott Air Force Base offered excellent support facilities for the project aircraft and ground-based data station.

The measurements obtained and the computations related to their use are examples of the Visibility Laboratory's continuing development of improved techniques for predicting, by calculation from physical data, the probabilities with which any object can be visually detected and recognized. The instrumental and computational organization for pursuing the development of these improved techniques is illustrated in Figures 1-1, 1-2, and 1-3. These three figures illustrate the experimental inter-relationships between the various pieces of project hardware, discussed in Section 3, the radiometric measurements made by them, and the subsequent computational chains accomplished in accordance with the theoretical considerations of Section 2. Through an examination of these generalized flow charts one can readily evaluate the experimental program's flexibility and self-checking redundancies. The capability to generate equivalent optical properties from separate and independent data sources, indicated in these figures, is the key feature in ensuring advancements in technical expertise and data quality.

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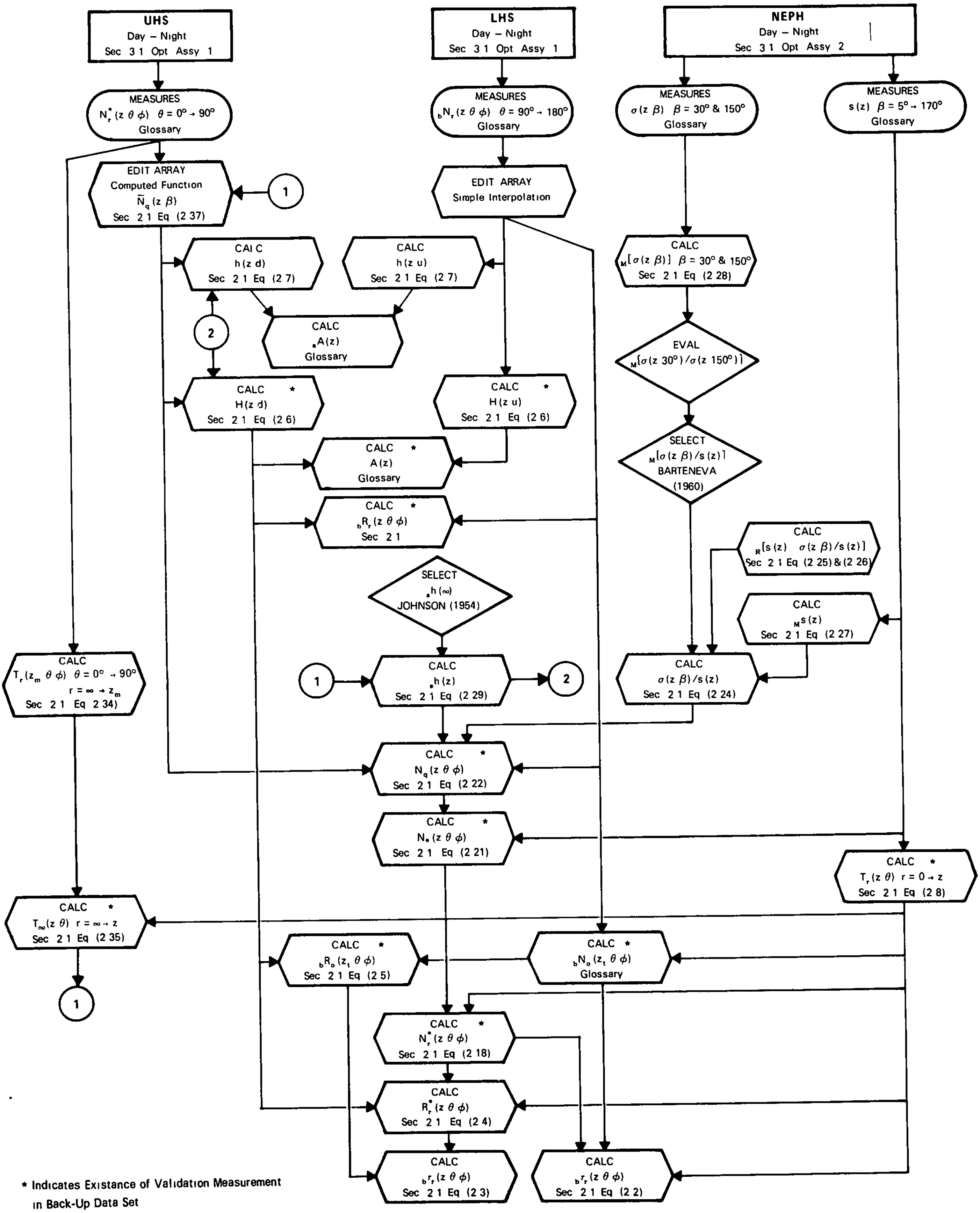
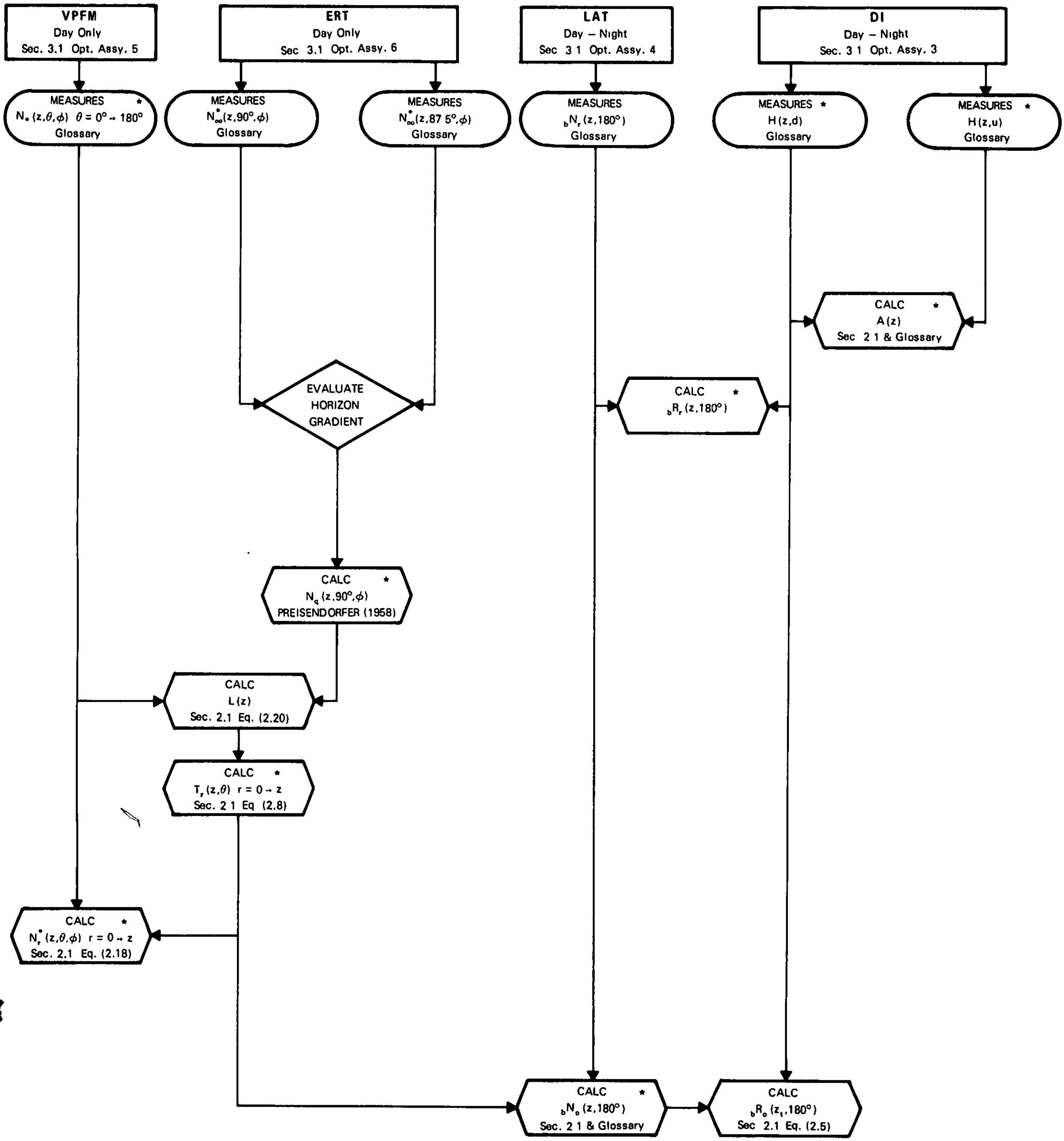
* The project title METRO has been assigned to this activity for procedural identification only and is not necessarily utilized or recognized by agencies or organizations outside the Visibility Laboratory. The relationship between this activity and other similar activities conducted by the Visibility Laboratory is well-illustrated in AFCRL-72-0593, "Airborne Measurements of Optical Atmospheric Properties, Summary and Review," Duntley *et al.* (1972c).



* Indicates Existance of Validation Measurement in Back-Up Data Set

Fig. 1-1. Computations From Basic Airborne Data.

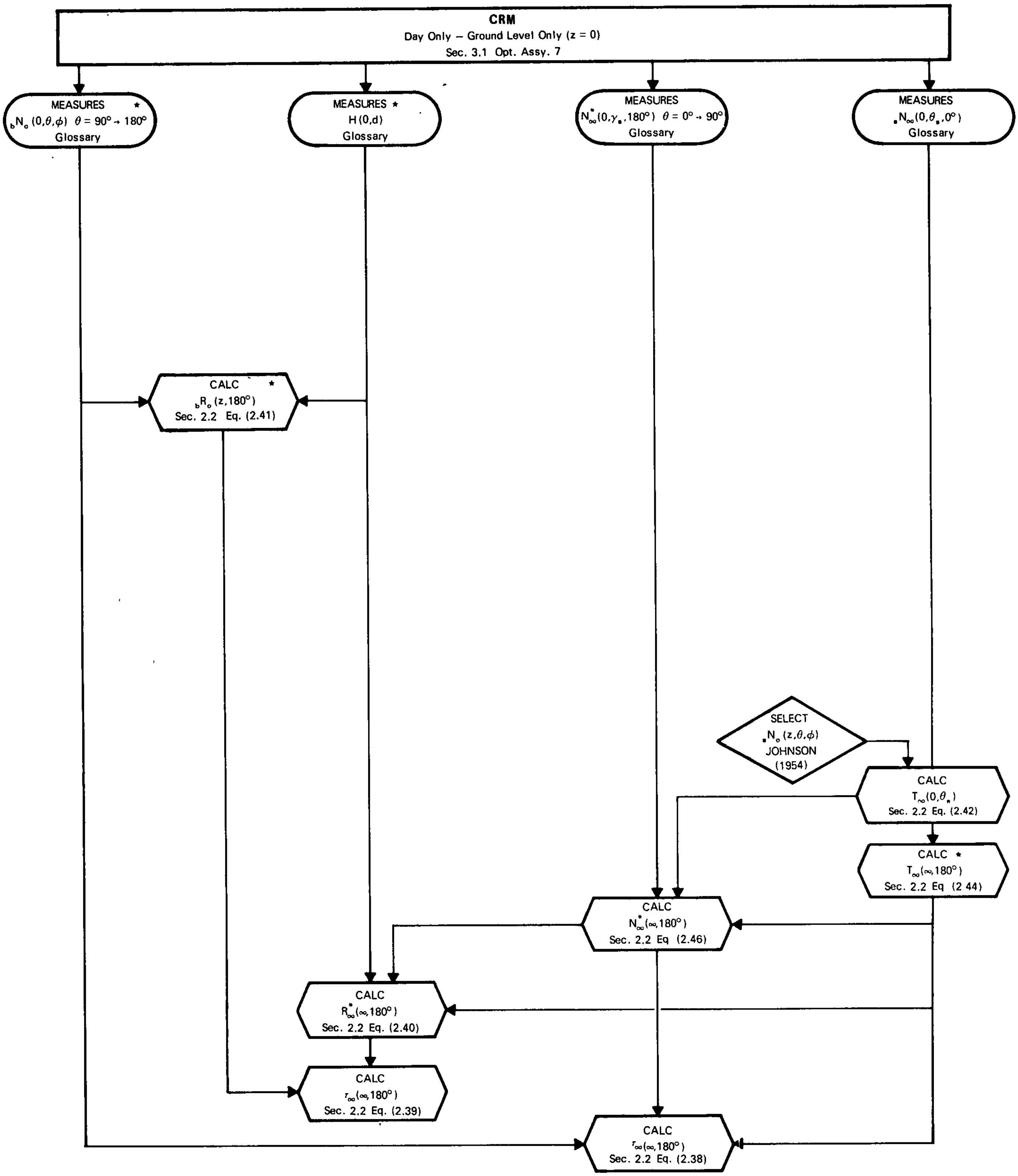
COMPUTATIONS FROM BACK-UP AIRBORNE DATA



* Indicates Utilization as Direct Validation of Computed Values.

Fig. 1-2. Computations From Backup Airborne Data.

COMPUTATIONS FROM SPECIALIZED GROUND DATA



* Indicates Utilization as Direct Validation of Computed Values.

Fig. 1-3. Computations From Specialized Ground Data.

This present report has been prepared under Contract No. F19628-73-C-0013. It contains the optical properties of various downward-inclined paths of sight based on daytime atmospheric optical measurements made along the flight tracks illustrated in Figure 1-4. These properties include natural irradiance upon horizontal plane surfaces, scalar irradiance, total volume scattering coefficient, beam transmittance, path radiance, directional path reflectance, and directional background reflectance.

The methods used in the derivation of these optical properties are discussed in Section 2 and are similar to those presented in AFCRL-72-0255 and -0461, Duntley *et al.* (1972a and b). The most significant variation from earlier methods is in the computation of beam transmittance. For the data contained in this report, beam transmittance values for the path interval from space to the highest flight altitude are determined from sky radiance ratios in a manner suggested by Kushpil' and Petrova (1971).

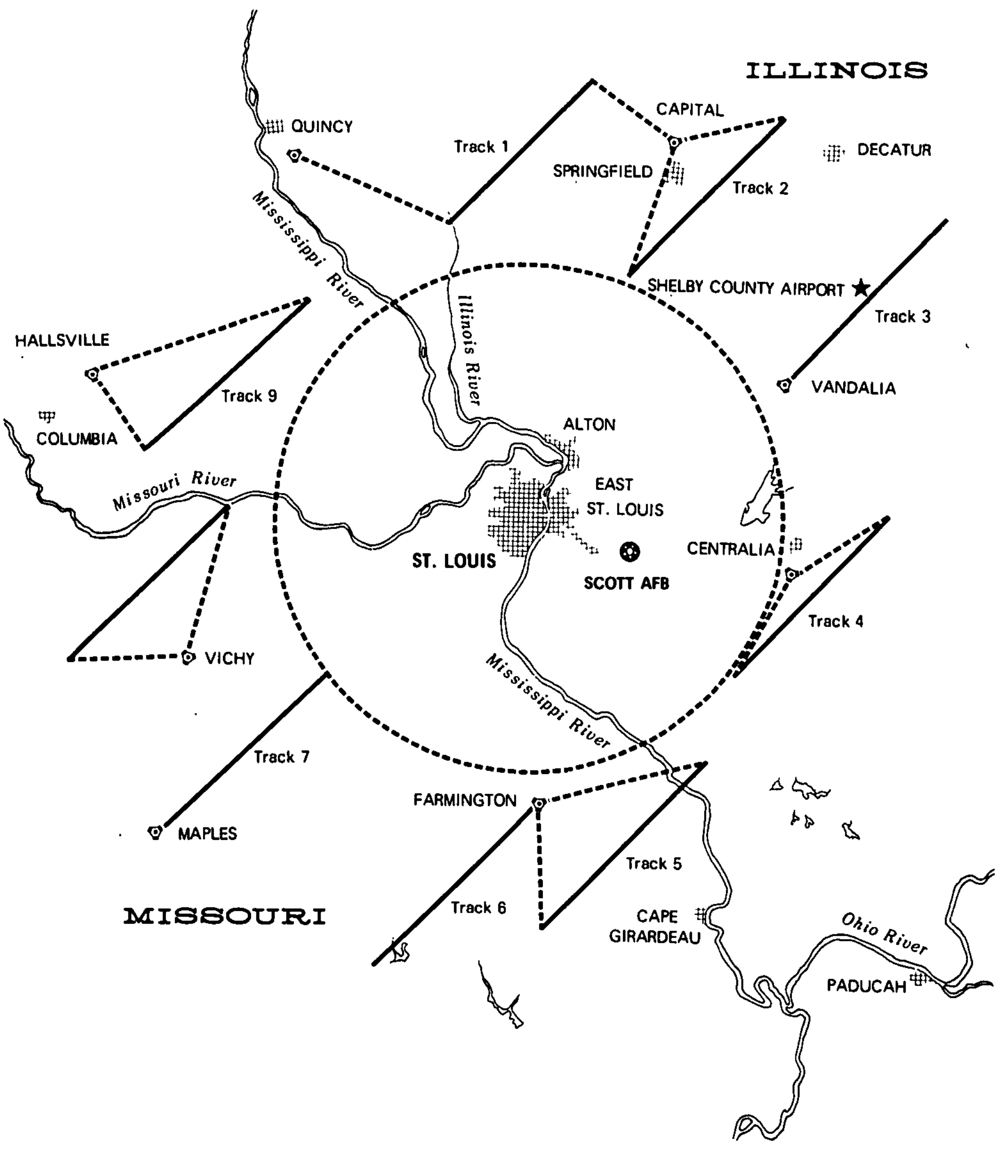


Fig. 1-4. Typical METRO Flight Tracks.

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 that 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 a ground-level value of the total volume scattering coefficient. Additionally, a ground-based contrast reduction meter was used as described in AFCRL-72-0461, Duntley *et al.* (1972b) for the determination of earth-to-space beam transmittance. The radiometer spectral responses were standardized for the METRO deployment in the manner illustrated in Figure 1-5. A brief review of the instrumentation utilized during the METRO deployment is presented in Section 3.

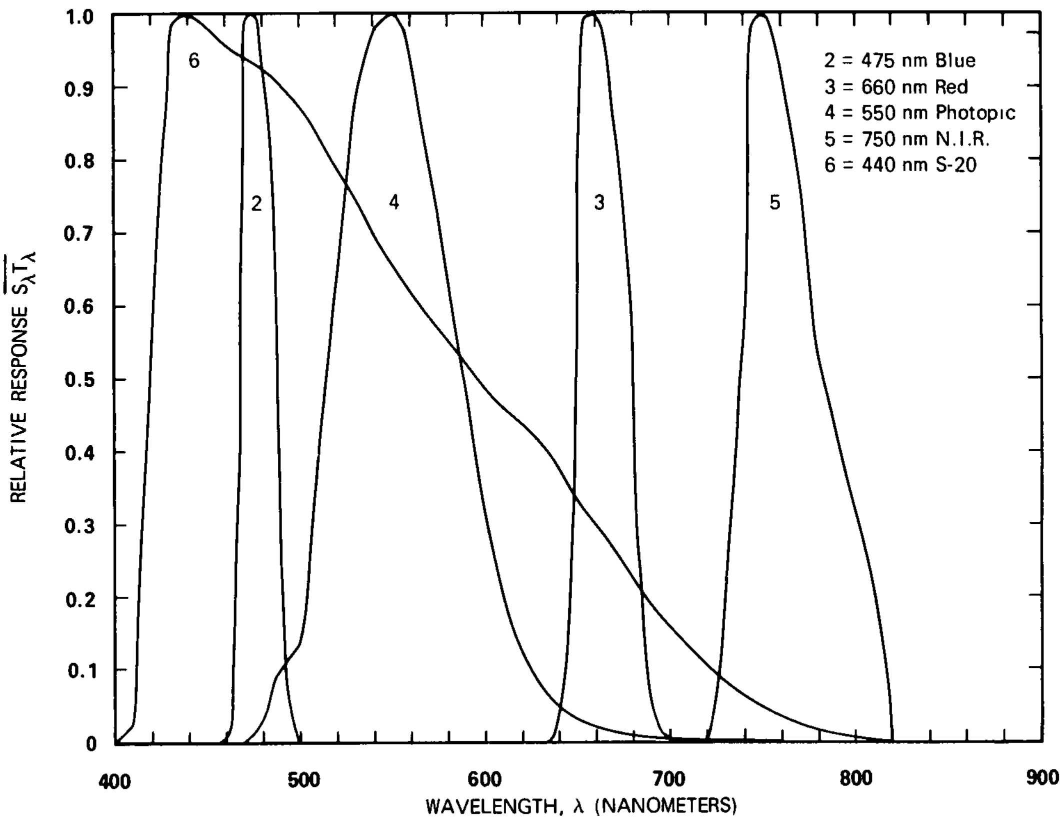


Fig. 1-5. Standard Spectral Responses – Project METRO.

Data collection methods are similar to those reported in AFCRL-72-0461, Duntley *et al.* (1972b). The typical flight profile illustrated in Figure 4-1 was modified to contain only three straight and level altitudes, with the highest at 10 000 feet (3050 meters) above ground level. All project METRO data flights were daytime flights. The basic features of these stylized flight profiles are summarized in Section 4.

The computer techniques used for processing the data included in this report are summarized in Section 5. They are, in general, the same as the techniques reported in AFCRL-72-0593, Duntley *et al.* (1972c).

A general discussion of the weather patterns that predominated in the St. Louis area during the data collection interval is presented in Section 6. This section, in conjunction with the flight track photographs shown in Section 7, is intended as an aid to the data user's generalized interpretation and evaluation. The inclusion of the graphical presentations is intended to further facilitate the user's rapid orientation with the overall weather situation.

The radiometric data representing five separate flights and containing eight separate profiles are presented in Section 7. The presentation format resembles that used in AFCRL-72-0461, Duntley *et al.* (1972b).

Discussion related to the interpretation and evaluation of the data herein is found in Section 8.

2. THEORY

2.1 CONTRAST TRANSMITTANCE IN THE TROPOSPHERE

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 $C_o(z_t,\theta,\phi)$:

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

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):

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

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.

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.

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 extrapolated to ground level were used to obtain the terrain reflectances reported here for each flight.

DOWNWELLING AND UPWELLING IRRADIANCE

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

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

where ${}_sh(z)$ is the sun scalar irradiance at altitude z, θ_s is the sun zenith angle, and $N(z,\theta',\phi')$ is the sky radiance at direction θ',ϕ'.

† 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.

The upwelling irradiance $H(z,u)$ is computed by deleting the first term in Eq. 2.6 and 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 $H(z,u)/H(z,d)$.

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

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

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 without the first term. 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).

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 passbands of the measurements, e.g., from smoke, dust, or smog, the attenuation coefficient $\alpha(z)$ is equivalent to the scattering coefficient $s(z)$. Therefore,

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

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 $\rho(z)$:

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

Similarly, upward extrapolations are made to the highest reported 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 from the U. S. Standard Atmosphere (1962). The density at each altitude is obtained by truncated Chebyshev expansion using the coefficients for the atmosphere between 0 and 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:

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

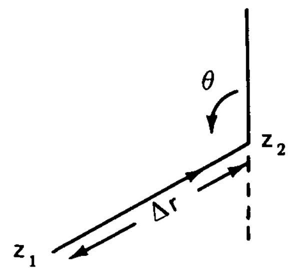


Fig. 2-1. Path Length Geometry for Steeply Inclined Paths of Sight.

ATTENUATION LENGTH

The attenuation length $L(z)$ is defined as the reciprocal of the atmospheric attenuation coefficient $\alpha(z)$. Therefore, when there is no significant absorption, it is also equivalent to the reciprocal of the atmospheric scattering coefficient:

$$L = \frac{1}{\alpha(z)} = \frac{1}{s(z)} . \tag{2.11}$$

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)

$$T_r(z,\theta) = \exp\left[-z/\bar{L}(z)\right] \sec\theta, \tag{2.12}$$

where $\theta > 95°$.

For the paths of sight at 90 to 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

$$\Delta r_i = \left\{ 1 - \left[\frac{n(z)}{n(z_i)} \; \frac{(\zeta + z)}{(\zeta + z_i)} \; \sin\theta \right]^2 \right\}^{-1/2} \Delta z \; . \tag{2.13}$$

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 2-13 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 Fig. 2-2 for the relationship of θ and θ'' for the downward path of sight):

$$\Delta r_i = \sec\theta'' \, \Delta z = (1 - \sin^2\theta'')^{-1/2} \, \Delta z \; . \tag{2.14}$$

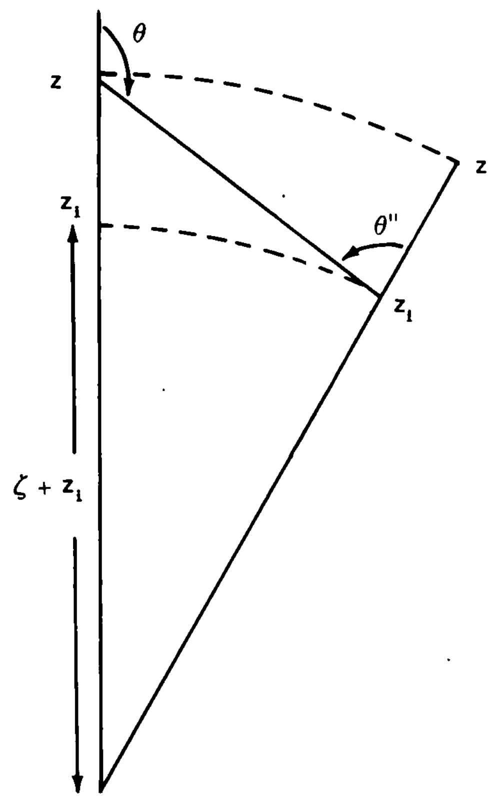


Fig. 2-2. Path Length Geometry for Grazing Paths of Sight in Refractive Spherical Atmospheres.

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:

$$\sin\theta'' = \frac{\zeta + z}{\zeta + z_i} \sin\theta \ . \tag{2.15}$$

The refraction effect is added by recourse to Snell's law, thus resulting in Eq. 2.13.

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

$$\left[\frac{n(z)}{n(z_i)}\right]^2 = 1 + 2[n(z) - 1][1 - \rho(z_i)/\rho(z)] \ . \tag{2.16}$$

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

$$\left[\frac{n(z)}{n(z_i)}\right]^2 = 1 + 2[n(o) - 1]\left[\frac{\rho(z)}{\rho(o)} - \frac{\rho(z_i)}{\rho(o)}\right] . \tag{2.17}$$

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 degrees centigrade. The maximum error in using the Δr based on 700 nanometers for wavelengths of 478 to 770 nanometers is 0.2 percent.

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:

$$N_r^*(z,\theta,\phi) = \sum_{i=1}^{m} N_*(z_i,\theta,\phi)\, T_{ri}(z,\theta)\, \Delta r \ . \tag{2.18}$$

Refer to Duntley *et al.* (1957) Eq. 17 on p. 502.

PATH FUNCTION

Image-forming light is lost by scattering and absorption in each elementary segment of the path of sight, and contrast-reducing path radiance is generated by the scattering of the ambient light which reaches the segment from all directions. The quantitative description of this scattered component of path-segment radiance involves a quantity called the "path function", $N_*(z,\theta,\phi)$. The "path function" depends upon the directional distribution of the lighting on the segment due to its surroundings. It can be operationally defined in terms of the (limiting) ratio of the path radiance associated with a short path to the path length by the relation (Duntley *et al.* (1957) p. 501)

$$N_*(z,\theta,\phi) = \lim(\Delta r \to 0)\; N^*_{\Delta r}(z,\theta,\phi)/\Delta r \; . \tag{2.19}$$

In experimental practice, the path length Δr should be sufficiently short so that no change in the ratio can be detected if Δr is made shorter.

In lieu of a direct measurement of path function, it may be derived from related quantities. Path function, attenuation length and equilibrium radiance are related by (Duntley *et al.* (1967) Eq. 11)

$$N_q(z,\theta,\phi) = N_*(z,\theta,\phi)\; L(z) \; . \tag{2.20}$$

By substituting Eq. 2.11 into Eq. 2.20 and rearranging, path function is expressed as a function of the total scattering coefficient and the equilibrium radiance:

$$N_*(z_i,\theta,\phi) = N_q(z_i,\theta,\phi)\; s(z_i) \; . \tag{2.21}$$

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. Equilibrium radiance is interpolated rather than path function since the equilibrium radiance is relatively invariant with altitude, whereas path function is sensitive to changes in aerosol scattering as well as the lighting distribution. To compute the equilibrium radiance the following equation is used (refer to Gordon (1969), Eq. 16* on p. 16):

---

* Equation 16 applies equally well to real and model atmospheres.

$$N_q(z,\theta,\phi) = {}_s h(z)\,\frac{\sigma(z,\beta)}{s(z)} + \int_{4\pi} N(z,\theta',\phi')\,\frac{\sigma(z,\beta')}{s(z)}\,d\Omega\,, \tag{2.22}$$

where ${}_s h(z)$ is the scalar irradiance of the sun (or full moon), β is the angle between the sun and the path of sight, and $N(z,\theta',\phi')$ is the apparent radiance of the sky 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

$$\cos\beta' = \sin\theta \sin\phi \sin\theta' \sin\phi' + \sin\theta \cos\phi \sin\theta' \cos\phi' + \cos\theta \cos\theta' \tag{2.23}$$

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.

PROPORTIONAL DIRECTIONAL SCATTERING COEFFICIENT

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

$$\sigma(z,\beta')/s(z) = \left\{ {}_R s(z)\ {}_R\!\left[\frac{\sigma(z,\beta')}{s(z)}\right] + {}_M s(z)\ {}_M\!\left[\frac{\sigma(z,\beta')}{s(z)}\right] \right\} / s(z)\ . \tag{2.24}$$

The Rayleigh scattering coefficient ${}_R s(z)$ for each passband is based upon monochromatic values of Rayleigh volume scattering coefficient computed using the Penndorf (1957) Eq. 14 for 15 degrees centigrade 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,

$$ {}_R s(z) = {}_R s(0)\, P(z)/[T(z)\ 3.516E3]\ , \tag{2.25}$$

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 degrees centigrade 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

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

$$ {}_R[\sigma(\beta)/s] = (1 + \cos^2\beta)3/(16\pi) \; . \tag{2.26} $$

The Mie scattering coefficient at measurement altitude z is the measured scattering coefficient minus the Rayleigh coefficient computed from Eq. 2.25 above:

$$ {}_M s(z) = s(z) - {}_R s(z) \; . \tag{2.27} $$

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:

$$ {}_M\sigma(\beta) = \sigma(\beta) - {}_R s(z) \; {}_R[\sigma(\beta)/s] \; . \tag{2.28} $$

SUN IRRADIANCE

Although the scanner radiance measurements include a measure of the apparent sun radiance, that value is beyond the calibrated span of the instrument. Therefore, the sun irradiance used in the computations of the irradiance and the equilibrium radiance is based upon the sun irradiance out of the atmosphere ${}_s h(\infty)$ for the appropriate broadband filter and the beam transmittance from out of the atmosphere to altitude z, $T_\infty(z,\theta_s)$:

$$ {}_s h(z) = {}_s h(\infty) \, T_\infty(z,\theta_s) \; . \tag{2.29} $$

The sun irradiance values for mean solar distance ${}_s h(\bar{\infty})$ are computed from spectral sun irradiance from Johnson (1954). The sun irradiance at true solar distance ${}_s h(\infty)$ is equal to the irradiance at mean distance times the square of the ratio of the angular solar radius at true solar distance Ψ to the radius at mean distance $\bar{\Psi}$:

$$ {}_s h(\infty) = {}_s h(\bar{\infty}) \left(\frac{\Psi}{\bar{\Psi}}\right)^2 \; . \tag{2.30} $$

The angular solar radius at mean solar distance is 16.016 minutes of arc. The radii at true distance are obtained from the ephemeris for the appropriate date.

The transmittance from out of the atmosphere to the highest flight altitude is computed from the ratio of sky radiances at equivalent scattering angles from the sun. This method stems from the suggested nomographic method of Kushpil' and Petrova (1971) for obtaining beam transmittance from sky radiance ratios at equivalent scattering angles from the sun. Kushpil' and Petrova do not give equations for the sky radiance ratio as a function of beam transmittance, but such an equation is derived in the following paragraph.

A sky radiance is a path radiance from out of the atmosphere to the altitude of measurement $N^*_\infty(z,\theta,\phi)$. On clear days with no absorption, we have found the sky radiance to be a function of an effective equilibrium radiance $\bar{N}_q$ and the beam transmittance (Gordon *et al.* (1963), Gordon (1969), and Gordon *et al.* (1973)):

$$N^*_\infty(z,\theta,\phi) = \bar{N}_q(z,\theta,\phi)\,[1 - T_\infty(z,\theta)] \ . \tag{2.31}$$

Thus the ratio of two sky radiances, at angles θ and θ', would be

$$\frac{N^*_\infty(z,\theta,\phi)}{N^*_\infty(z,\theta',\phi')} = \frac{\bar{N}_q(z,\theta,\phi)}{\bar{N}_q(z,\theta',\phi')}\;\frac{[1 - T_\infty(z,\theta)]}{[1 - T_\infty(z,\theta')]} \ . \tag{2.32}$$

When the scattering angle from the sun is equivalent for the two paths of sight, the equilibrium radiances are equivalent. Thus Eq. 2.32 simplifies to

$$\frac{N^*_\infty(z,\theta,\phi)}{N^*_\infty(z,\theta',\phi')} = \frac{[1 - T_\infty(z,\theta)]}{[1 - T_\infty(z,\theta')]} \ . \tag{2.33}$$

Equation 2.33 can be expressed as a function of the vertical transmittance $T(z,0^\circ)$ and the relative optical airmass $m_\infty(z,\theta)/m_\infty(z,0^\circ)$:

$$\frac{N^*_\infty(z,\theta,\phi)}{N^*_\infty(z,\theta',\phi')} = \frac{\left[1 - T_\infty(z,0^\circ)^{m_\infty(z,\theta)/m_\infty(z,0^\circ)}\right]}{\left[1 - T_\infty(z,0^\circ)^{m_\infty(z,\theta')/m_\infty(z,0^\circ)}\right]} \tag{2.34}$$

Equation 2.34 cannot be directly solved for the vertical transmittance, but by using iterative means, which is a simple task with a computer, a vertical transmittance is obtained which provides a solution to Eq. 2.34 within a tolerance of 0.1 percent.

An error analysis of the transmittance obtained by Eq. 2.34 indicates that the precision error difference of the two radiances is generally multiplied by a factor of between 1 and 2 for many zenith angle combinations. Thus, a series of measurements is used and the transmittances are averaged to enhance the reliability of the resultant transmittance. A validation of the sky radiance ratio method of obtaining beam transmittance was presented in Duntley *et al.* (1972c) Section 2.1.

The transmittance for the lower flight altitudes is the product of the transmittance from out of the atmosphere to the highest altitude $T_\infty(z_m,0°)$ and the transmittance between the two flight altitudes $T_r(z,0°)$:

$$T_\infty(z,0°) = T_\infty(z_m,0°)\,T_r(z,0°)\ . \qquad (2.35)$$

The conversion from vertical transmittance to transmittance at the zenith angle of the sun is made using the relative airmass $m_\infty(z,\theta_s)/m_\infty(z,0°)$:

$$T_\infty(z,\theta_s) = T_\infty(z,0°)^{m_\infty(z,\theta_s)/m_\infty(z,0°)}\ . \qquad (2.36)$$

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, $m_\infty(6,\theta_s)/m_\infty(6,0°) = m_\infty(0,\theta_s)/m_\infty(0,0°)$, 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°.

The sun zenith angle θ_s changes during the flight interval. In order to reduce this source of variability in the resultant data, an average sun zenith angle for the flight is used in Eq. 2.36 as well as in computing the irradiance in Eq. 2.6 and the scattering angle β in Eq. 2.22.

SKY AND TERRAIN RADIANCE

The measurements of sky and terrain radiance include values which are questionable due to: slow phototube decay after sensing high radiances; portions of the airplane such as tail or propellers extending into path of sight; values above or below the calibrated range of the sensor; and premature ending of the spiral angular pattern. In order to obtain a basic data array of optimum quality, these well-defined but improper values must be removed. To do this, the upper and lower hemisphere data arrays are handled separately, and in the following manner.

Since the terrain radiances have a relatively narrow range, questionable values are simply replaced by interpolations between adjacent valid data points.

In order to evaluate and replace the questionable sky radiance measurements, the effective equilibrium radiance as a function of angle from sun β is established on the basis of the sky radiance measurements $N_\infty^*(z,\theta,\phi)$ of known validity. The effective equilibrium radiance $\bar{N}_q$ is computed by rearranging Eq. 2.31 as follows:

$$\bar{N}_q(z,\beta) = N_\infty^*(z,\theta,\phi)/[1 - T_\infty(z,\theta)] \ . \tag{2.37}$$

An average effective equilibrium radiance for each 5 degrees of β is then calculated and the proportional standard deviation from that average function established. The value of the average effective equilibrium radiance at $\beta = 0°$ is determined using Barteneva's method of assuming log $\bar{N}_q(\beta)$ linear with $\cos\beta$ for small values of β. All sky radiance measurements including the questionable measurements are tested to see if the $\bar{N}_q(\beta)$ resulting from use of Eq. 2.37 is within three standard deviations of the average equilibrium radiance function. All sky radiance values not meeting that test are replaced using the average equilibrium radiance function and Eq. 2.31.

2.2 GROUND-BASED MEASUREMENTS OF VERTICAL EARTH-TO-SPACE CONTRAST TRANSMITTANCE

The earth-to-space contrast transmittance for the vertical path of sight is found by rewriting Eq. 2.2 in terms of the earth-to-space path length ∞ and the vertical downward path of sight at zenith angle 180°:

$$_b\tau_\infty(0,180°) = [1 + N_\infty^*(0,180°)/_bN_o(0,180°)\,T_\infty(0,180°)]^{-1} \ . \tag{2.38}$$

The azimuth ϕ has been deleted from the parenthetical modifiers of the path radiance $N_\infty^*(0,180°)$ and the inherent background radiance $_bN_o(0,180°)$ since ϕ is undefined when the path of sight is vertically downward.

DIRECTIONAL PATH REFLECTANCE

An alternate form for obtaining contrast transmittance is by use of the vertical path reflectance $R_\infty^*(0,180°)$. Thus, Eq. 2.3 is similarly rewritten,

$$_b\tau_\infty(0,180°) = [1 + R_\infty^*(0,180°)/_bR_o(0,180°)]^{-1} \ . \tag{2.39}$$

Ground-based data are often presented in the form of vertical path reflectance for convenient use in obtaining contrast transmittance. The path reflectance may be used with the directional reflectance of various backgrounds which are smaller in extent but different from the heterogeneous background which contributes to the path radiance and downwelling irradiance H(0,d). The vertical path reflectance is defined by

$$R_\infty^*(\infty,180°) = \pi N_\infty^*(\infty,180°)/H(0,d)\,T_\infty(\infty,180°). \tag{2.40}$$

BACKGROUND REFLECTANCE

The inherent vertical background reflectance is defined as

$$ {}_bR_o(0,180°) = \pi\, {}_bN_o(0,180°)/H(0,d) \; . \tag{2.41} $$

Terrain radiances ${}_bN_o(z,\theta,\phi)$ are measured directly by orienting a contrast reduction meter (CRM) telescope toward the ground.

DOWNWELLING IRRADIANCE

Total downwelling irradiance $H(z,d)$ is measured directly by orienting a 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.

BEAM TRANSMITTANCE

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 from the inherent solar radiance† ${}_sN_o(\infty,\theta_s,0°)$ by the following equation:

$$ T_\infty(0,\theta_s) = \frac{{}_sN_\infty(0,\theta_s,0°)}{{}_sN_o(\infty,\theta_s,0°)} \; . \tag{2.42} $$

The vertical earth-to-space beam transmittance is equal to the vertical space-to-earth beam transmittance, and therefore Eq. 2.36 can be rewritten to obtain the vertical downward transmittance from the transmittance at the angle of the sun:

$$ T_\infty(0,180°) = T_\infty(0,0°) = T_\infty(0,\theta_s)^{m_\infty(0,0°)/m_\infty(0,\theta_s)} \; , \tag{2.43} $$

For $\theta_s \leqq 70°$, the inverse of the relative airmass $m_\infty(0,0°)/m_\infty(0,\theta_s) = \cos\theta_s$ to an accuracy of 1 percent. Since the solar elevation angle γ_s, which equals $90° - \theta_s$, is read directly off of the ground-based equipment, Eq. 2-43 is rewritten as

$$ T_\infty(\infty,180°) = T_\infty(0,\theta_s)^{\sin\gamma_s} \; . \tag{2.44} $$

This eliminates the need for ephemeris or tabular data in the field in reducing data for $\theta_s \leqq 70°$.

---

† 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).

For $\theta_s > 70°$, the sea level relative airmass values $m_\infty(0,\theta_s)/m_\infty(0,0°)$ from Kasten (1965) are used. As noted before, for ground-level altitudes up to 6 kilometers, $m_\infty(6,\theta_s)/m_\infty(6,0°) = m_\infty(0,\theta_s)/m_\infty(0,0°)$ within 1 percent for $\theta_s \leqq 86°$.

PATH RADIANCE

The path radiance for the vertically downward path of sight is derived from an appropriate ground-based measurement of sky radiance and beam transmittance (Gordon *et al.* (1973) Eq. 8):

$$N^*_\infty(\infty,180°) = N^*_\infty(0,\theta',\phi') \left[\frac{1 - T_\infty(\infty,180°)}{1 - T_\infty(0,\theta')}\right], \tag{2.45}$$

where $N^*_\infty(0,\theta',\phi')$ is the path radiance of an upward-inclined path of sight at zenith angle θ' and azimuth ϕ', which has the same angle β from the sun as does the vertically downward path of sight. This quantity is in fact the apparent sky radiance as measured from the surface of the earth in the direction θ', ϕ'. The $T_\infty(0,\phi')$ is the beam transmittance of the upward-inclined path of sight in the direction θ', ϕ'.

The scattering at 90 degrees from the sun is assumed to be reasonably 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 γ_s, and ϕ' becomes 180°. See Fig. 2-3. The CRM illustrated in Fig. 3-2 is built to mechanically insure that the sky radiance is measured at a 90-degree angle from the sun. Equation 2.45 can now be rewritten as

$$N^*_\infty(\infty,180°) = N^*_\infty(0,\gamma_s,180°) \left[\frac{1 - T_\infty(\infty,180°)}{1 - T_\infty(0,\gamma_s)}\right]. \tag{2.46}$$

When $\gamma_s \leqq 70°$, the transmittance for the upward inclined path at θ' is

$$T_\infty(0,\gamma_s) = T_\infty(0,0°)^{\sec\gamma_s} . \tag{2.47}$$

For $\gamma_s > 70°$, the relative optical airmass from Kasten (1965) is used instead of $\sec\gamma_s$ in Eq. 2.47.

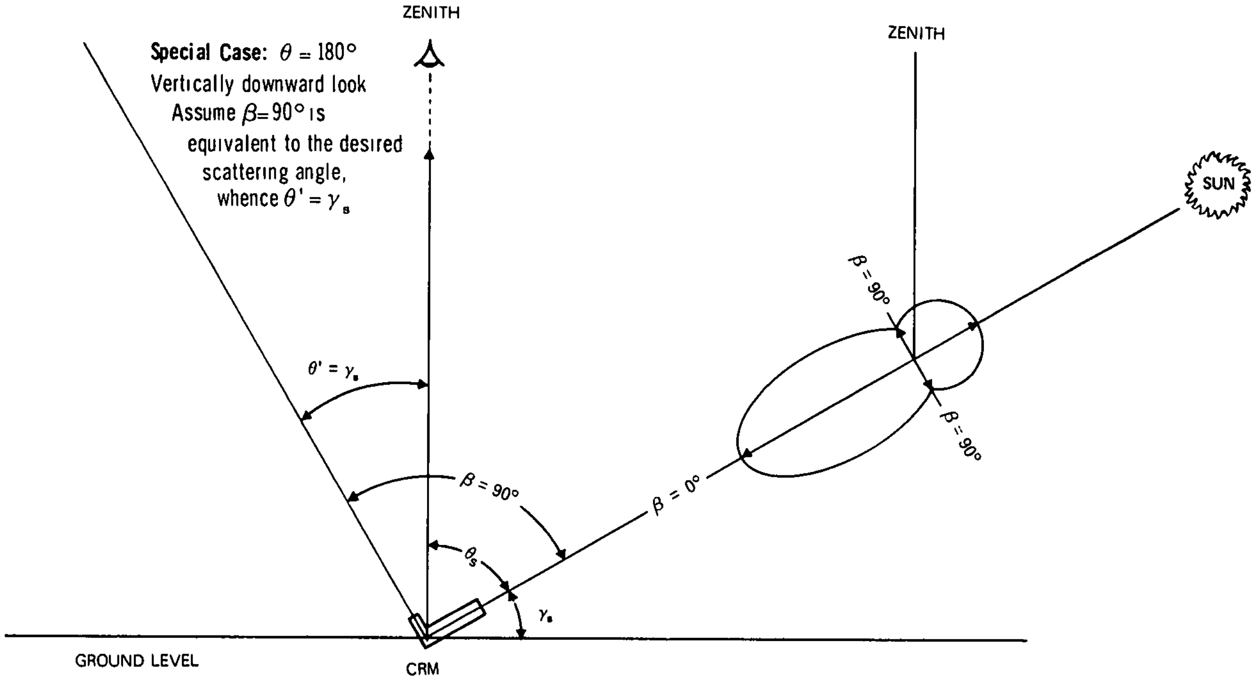


Fig. 2-3. Scattering Angle Relationships for Typical CRM Operations.

3. INSTRUMENTATION

The scientific instrumentation utilized for the Project METRO task was basically the same as that reported in AFCRL-72-0593, Duntley *et al.* (1972c).

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

Table 3-1. Project METRO 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

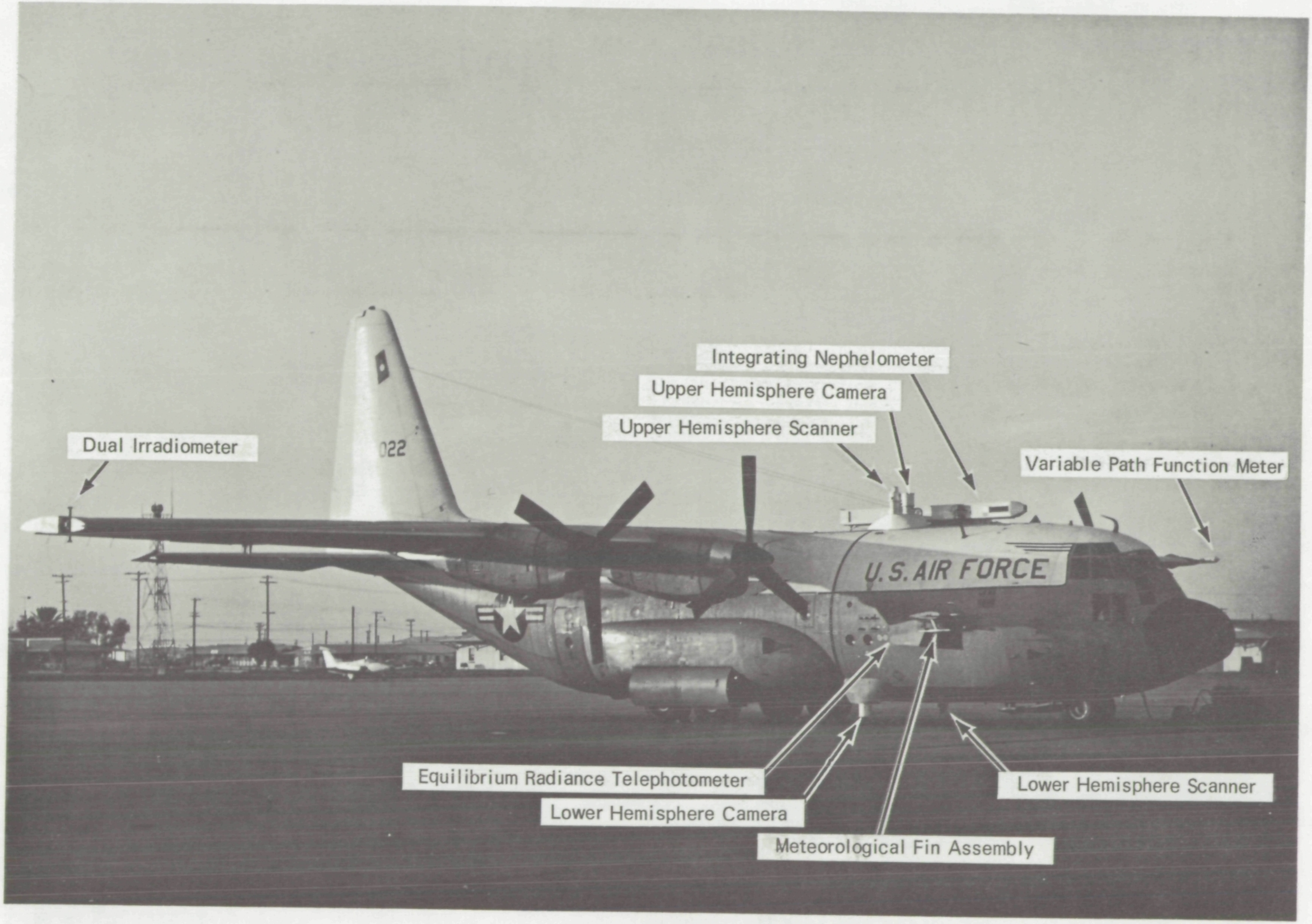


Fig. 3-1. C-130 Airborne Instrument System.

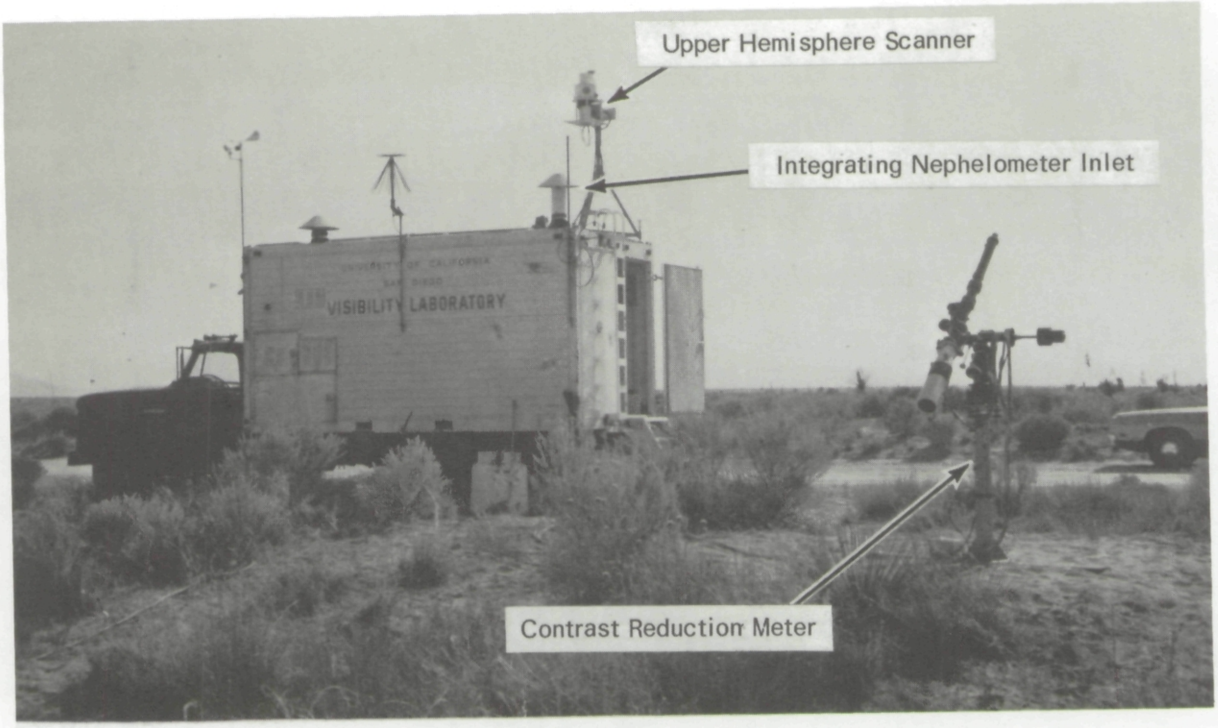


Fig. 3-2. Ground-Based Instrument System.

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 relatively 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 14-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 METRO, the multiplier phototube assemblies are unchanged from the configuration reported in AFCRL-72-0461, Duntley *et al.* (1972b).

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 METRO, the temperature control housing assemblies are unchanged from the configuration reported in AFCRL-72-0461, Duntley *et al.* (1972b).

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.

For use in Project METRO, 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.

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 Fig. 3-3.

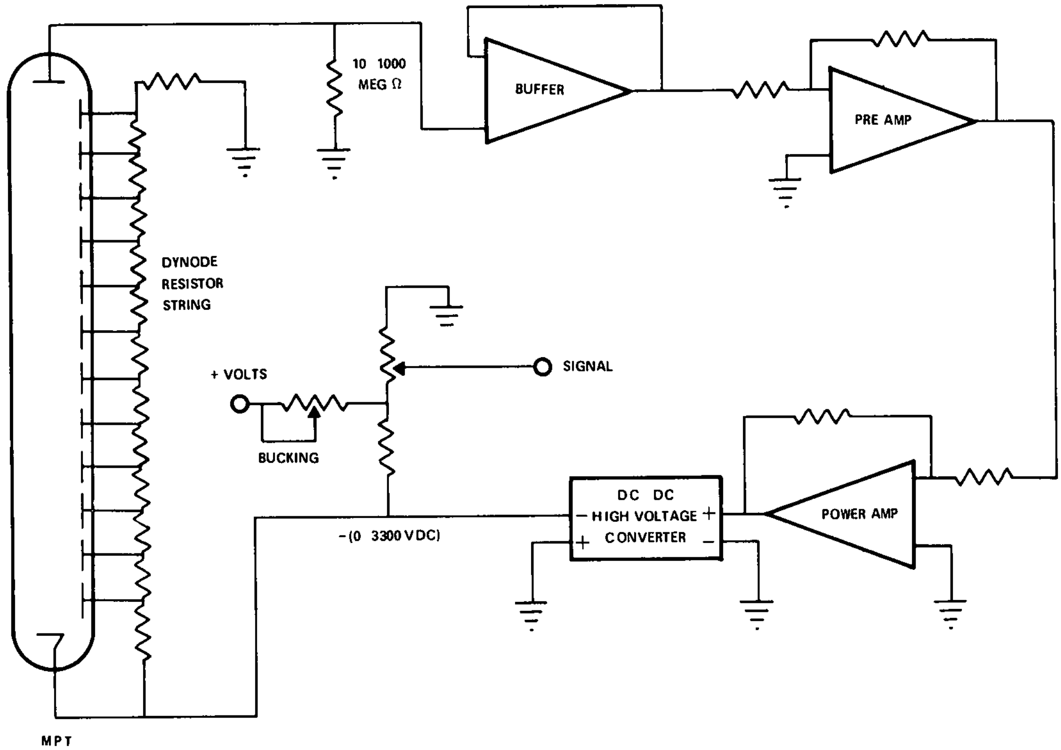


Fig. 3-3. Typical Visibility Laboratory Model 5 Photometer Circuit.

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.

For use in Project METRO, radiometer measuring circuits and the ten slide photometer modules are unchanged from the configuration reported in AFCRL-72-0461, Duntley *et al.* (1972b).

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 Assembly (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 discussed below were described in Duntley *et al.*, AFCRL-70-0137 (1970) and AFCRL-72-0255 (1972a). The last two items were discussed in AFCRL-72-0461, Duntley *et al.* (1972b). For more comprehensive information regarding the characteristics of these devices the reader is referred to these readily available sources.

Automatic 2π Scanner Assembly (UHS and LHS). This collector assembly is essentially a small telescope that can be directed to optically scan any point within a 2π steradian field of view. The telescope itself has a 5-degree field of view. For the METRO mission, the airborne scanners were directed in a spiral pattern which covered the full hemisphere in 160 seconds. The output is converted to an array of radiance values at selected azimuth and elevation angles, such that Δ azimuth = 6° and Δ elevation = 5° between adjacent array elements.

Integrating Nephelometer Assembly (NEPH). In order to measure and evaluate the total scattering coefficient of typical real aerosols, the Visibility Laboratory has devised and built an instrument referred to as an integrating nephelometer. This device measures the radiant flux scattered from the well-defined flux beam of a high-intensity projector. The scattered flux is collected through three different optical channels: two telescopes oriented to collect the flux scattered in the $\beta = 30°$ and $\beta = 150°$ directions, and one irradiometer assembly oriented to collect the flux scattered between the scattering angles of $\beta = 5°$ and $\beta = 170°$. From these measurements, the directional scattering functions $\sigma(30)$ and $\sigma(150)$ and the total volume scattering coefficient s may be derived.

Dual Irradiometer Assembly (DI). The dual irradiometer assembly is a two channel irradiometer. It has two optical input channels but only one optical output. A rotating prism subassembly allows the system operator to select either input channel for optical coupling with the output channel, while simultaneously occulting the other. The resultant time-sharing of a single detector assembly yields a device optimized for ratio type measurements.

The flat plate diffuse collector surfaces used in this assembly are mechanically corrected to yield a cosine collection characteristic within ±2 percent for all angles of incidence between 0 and 80 degrees.

The dual irradiometer assembly is mounted in the aircraft wingtip so that the flat plate collectors are horizontal. In this configuration the upper channel receives radiant flux from the entire hemisphere above the aircraft, and the lower channel receives radiant flux from the entire hemisphere below the aircraft. These measurements of downwelling and upwelling irradiance can be used both in the calculation of directional terrain reflectances and in intersystem data validation checks.

Large Aperture Telescope Assembly (LAT). This telescope assembly is used in the radiometer system which functions as a backup system for measuring very low flux levels. The airborne telescope assembly has a 5-degree circular field of view and an objective lens 6.2 centimeters in diameter. With this larger collection aperture, flux levels significantly lower than the detection threshold of the 2π scanner assembly can be reached and adequately measured. This system was not deployed during Project METRO.

Variable Path Function Meter (VPFM). The variable path function meter is a radiometer and shroud assembly designed to measure the radiant flux scattered by a small, well-defined volume of aerosol into a given direction when illuminated from all directions. The scattering volume is 1.27 centimeters in diameter and 22.9 centimeters long. It is defined by the cylindrically-limited field of view of the component telephotometer and by two long cylindrical sunshades. Measurements of path function can be made at zenith angles between 0 and 180 degrees at azimuths corresponding to the aircraft heading.

Equilibrium Radiance Telephotometer (ERT). The concept of equilibrium radiance is defined and discussed in Duntley *et al.* (1957). In the special case of a horizontal path of sight which is optically uniform in terms of both the composition of the aerosol and its lighting, the equilibrium radiance is equal to the horizon radiance. It is this horizon radiance which is measured by the ERT.

The optical collector assembly is basically a servo-controlled telescope. Its field of view is 1.0 degrees wide and 0.2 degrees high. The ERT is oriented with a horizontal path of sight and with the wide dimension of the field of view parallel to the horizon. This orientation is maintained by use of a vertical reference gyro. 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.

Contrast Reduction Meter (CRM). The contrast reduction meter consists of a standard detector and filter changing assembly, fitted with a multiple purpose optical collector.

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

The optical collectors include a cosine collector for measuring the downwelling irradiance; a telescope with a 5-degree field of view for measuring sky and terrain radiances; and a pinhole Gershun tube with a 2-minute field of view for measuring solar disk radiances.

3.2 METEOROLOGICAL SYSTEMS

All of the meteorological systems utilized in this project were purchased items. The operating characteristics of each are available in the appropriate manufacturer's brochures. For use in Project METRO, the meteorological systems are unchanged from the configurations reported in AFCRL-72-0461, Duntley *et al.* (1972b).

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. The Cambridge system did not perform adequately during Project METRO and thus no dewpoint data are available. Also, the AN/AMQ-17 pressure channel failed, resulting in the backup Bourns channel being used for altitude determinations.

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 Fig. 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 AFCRL-72-0255, Duntley *et al.* (1972a), 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 updated configurations, reported in AFCRL-72-0593, Duntley *et al.* (1972c), 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 METRO, this photographic capability was accomplished through the use of two 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 (Fig. 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 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 35 millimeter color snapshots, taken on a casual basis during lulls in the experimental sequences. For Project METRO 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 METRO it was used on a Yashica, Lynx 1000.

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 first by 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 1972a,b,c) 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 METRO 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 Fig. 3-4.

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.

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 ±2 percent. Table 3-2 illustrates the quality of typical calibration

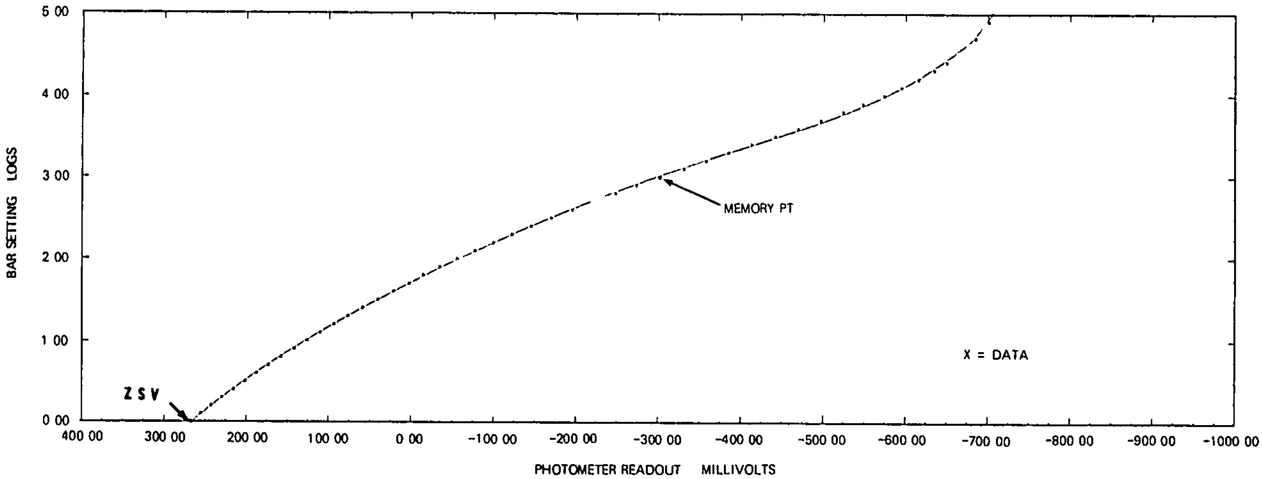


Fig. 3-4. Typical Computer-Generated Linearity Calibration Curve.

Table 3-2

Project METRO

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

Radiometer Ident		Calib	Calib	Filter 2		Filter 3		Filter 4		Filter 5		Filter 6		Average %
System	MPT SN	Mode	Units	ZSV	δ%	ZSV	δ%	ZSV	δ%	ZSV	δ%	ZSV	δ%	for System
SCAN3	9846	Night*	$w/\Omega m^2 \mu m$	9 43E+04	±1	1 27E+05	±1	4 40E+04	±1	2 48E+05	±2	4 81E+03	±1	±1
SCAN4	9858	Night*	$w/\Omega m^2 \mu m$	9 09E+03	±1	1 35E+04	±1	4 63E+03	±1	2 56E+04	±2	4 97E+02	±1	±1

NEPH1-Σ	9828	Night	$w/m^2 \mu m$	1 47E-01	±3	2 66E-01	±3	6 88E-02	±3	1 01E+00	±2	8 97E-03	±1	±2
NEPH1-β	9828	Night	$w/\Omega m^2 \mu m$	1 58E-01	±1	3 67E-01	±1	8 09E-02	±1	2 70E+00	±4	1 08E-02	±1	±2

D I 1	11783	Night*	$w/m^2 \mu m$	6 72E+04	±3	6 34E+04	±3	2 46E+04	±2	4 94E+04	±2	2 82E+03	±2	±2
LAT 1	9869	N/A	–	–		–		–		–		–		

VPFM	14531	Night	$w/\Omega m^2 \mu m$	2 31E+01	±1	7 14E+01	±1	6 95E+00	±1	1 40E+03	±4	9 61E-01	±1	±1
ERT	10697	Night*	$w/\Omega m^2 \mu m$	8 47E+02	±1	1 69E+03	±1	4 62E+02	±1	1 39E+03	±3	9 31E+01	±1	±1

NEPH3-Σ	14509	Night	$w/m^2 \mu m$	6 90E-02	±3	8 69E-02	±4	3 45E-02	±5	1 07E-01	±2	3 60E-03	±2	±3
NEPH3-β	14509	Night	$w/\Omega m^2 \mu m$	6 68E-02	±1	9 23E-02	±1	3 15E-02	±2	1 52E-01	±1	3 82E-03	±1	±1

CRM/SS	9861	Night*	$w/\Omega m^2 \mu m$	1 78E+04	±1	3 13E+04	±1	3 89E+03	±1	2 09E+03	±1	3 69E+02	±1	±1
CRM/E	9861	Night*	$w/m^2 \mu m$	1 97E+05	±2	2 85E+05	±2	3 86E+04	±1	1 74E+04	±2	3 56E+03	±1	±2
CRM/STD	9861	* * *	$w/\Omega m^2 \mu m$	1 88E+09	±1	3 65E+09	±1	7 46E+08	±1	2 53E+08	±1	4 08E+07	±1	±1

SCAN1	10650	Night*	$w/\Omega m^2 \mu m$	2 96E+05	±1	3 84E+05	±1	1 26E+05	±1	1 93E+05	±2	1 21E+04	±1	±1

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

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

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.

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.

A typical data sheet for the absolute calibration of a Project METRO radiometer is shown in Fig. 3-5. 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 FOR CRM/SS NITE 1178 (9861 NS) DATE = 11OCT71 FOR SET POST MET FILTER NO. 2 DAY SKY 7000 DEG

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	8.701E-06	-403	3.311	1.780E-02	1.771E-02	1.304E-04	9.765E-01	2.256E-06
2	70	234.000	5.476E 04	6.613E-06	-443	3.427	1.768E-02				
3	120	284.000	8.066E 04	4.490E-06	-501	3.592	1.754E-02				
4	200	364.000	1.325E 05	2.733E-06	-578	3.809	1.762E-02				
5	300	464.000	2.153E 05	1.682E-06	-652	4.025	1.780E-02				
4	200	364.000	1.325E 05	2.733E-06	-578	3.810	1.763E-02				
3	120	284.000	8.066E 04	4.490E-06	-503	3.597	1.777E-02				
2	70	234.000	5.476E 04	6.613E-06	-443	3.429	1.774E-02				
1	40	204.000	4.162E 04	8.701E-06	-403	3.311	1.782E-02				

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

CORRECTED ZERO SCALE VALUE IS 2.2557E-06 WATTS/STERADIAN SQ. CM.

TO CHNGE POSTLOC3 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 1.13484E 00 WATTS/STER. SQ M MICRO M.

STANDARD DEVIATION = 9.9628E-05

FRACTIONAL STANDARD DEVIATION = .56 PERCENT

COMPONENTS OF FILTER FACTORS F1 AND F2 ARE
680YBARSUM= 2.6874E 07 WESTSTD= 3.5050E 03 WSTSTD= 4.1000E 06 WESTINST= 3.6930E 03 WSTINST= 4.4240E 06

CALIBRATION LAMP IDENTIFICATION
SERIAL NUMBER = VLA0201
LUMINOUS INTENSITY = 23.70
DISTRIBUTION TEMPERATURE = 2854

IF MILLIVOLT DATA IS LESS THAN THE END OF RULE CUTOFF = -765.0 IGNORE DATA

Fig. 3-5. Typical Absolute Calibration Form.

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 CORRECTION FACTORS

Several calibration correction factors are used with the calibration data illustrated in Fig. 3-5 to generate the calibration constants listed in Table 3-2. In general, the factors are used at will to convert radiometric units into photometric units and reconvert them, and to adjust the value of measurements taken with an instrument having a nearly standard spectral response to the value that would have been obtained using the exact standard spectral response specified in Section 3.6.

These correction factors are discussed at length in AFCRL-70-0137 and AFCRL-72-0461, Duntley *et al.* (1970 and 1972b). Thus, they are only summarized here as Table 3-3.

Table 3-3

Calibration Correction Factor Summary

Factor Designator	Operational Identification	Defining Equations
F1	luminance-to-radiance conversion (lumens to watts)	$F1 = \dfrac{\Sigma\, {}_cW_\lambda \epsilon_\lambda (\overline{S_\lambda T_\lambda})\, \Delta\lambda}{680\, \Sigma\, {}_cW_\lambda \epsilon_\lambda \bar{y}\, \Delta\lambda}$
F2	color-matching adjustment (dimensionless)	$F2 = \dfrac{\Sigma\, W'_\lambda (\overline{S_\lambda T_\lambda})\, \Delta\lambda}{\Sigma\, W'_\lambda (S_\lambda T_\lambda)\, \Delta\lambda} \times \dfrac{\Sigma\, {}_cW_\lambda \epsilon_\lambda (S_\lambda T_\lambda)\, \Delta\lambda}{\Sigma\, {}_cW_\lambda \epsilon_\lambda (\overline{S_\lambda T_\lambda})\, \Delta\lambda}$
F3	unit conversion (watts/cm² to watts/m²μm)	$F3 = \dfrac{10^4}{\delta\lambda} = \dfrac{10^4}{\Sigma (\overline{S_\lambda T_\lambda})\, \Delta\lambda}$
F4	photometric reconversion (watts/m²μm to lu/m²)	$F4 = \dfrac{680\, \Sigma\, W'_\lambda \bar{y}\, \Delta\lambda\, \delta\lambda\, 10^{-3}}{\Sigma\, W'_\lambda (\overline{S_\lambda T_\lambda})\, \Delta\lambda}$

Where ${}_cW_\lambda$ = the known spectral emittance of the standard lamp used as a calibration source.

W'_λ = the approximate spectral emittance of the field scene anticipated for later measurement.

The four correction factors shown in Table 3-3 are calculated in Program SUPERCK6. This program is described by in-house Technical Note No. 37. Several key factors generated by Program SUPERCK6 for use with the METRO data are listed in Tables 3-4 and 3-5.

Table 3-4

Luminance-to-Radiance Conversion Factor, ${}_cW_\lambda$ = 2854°K

	Spectral Filter Identification				
Factor Designator	Filter 2 478 nm	Filter 3 664 nm	Filter 4 557 nm	Filter 5 765 nm	Filter 6 532 nm
F1 (w/lu)	1.306 E–04	6.958 E–04	1.052 E–03	1.492 E–03	2.111 E–03

Table 3-5

Radiance-to-Luminance Reconversion Factors, F4,
for Selected Typical Distribution Temperatures

Factor Designator	Distribution Temperature of Typical Data Scenes					
	4000°K	5500°K	7000°K	10 000°K	20 000°K	Night Sky
F4 (luμm/w)	7.299E+01	7.222E+01	7.200E+01	7.195E+01	7.211E+01	6.834E+01

CALIBRATION SUMMARY

The radiometric calibration data applicable to the Project METRO deployment have been presented and evaluated in in-house Technical Note No. 68.

The pre-METRO calibration data are dated June–August 1971. The post-METRO calibration data are dated September–October 1971. A review of the data related to each calibration set has led to the selection of preferred calibration constants for application to all Project METRO field data. These preferred calibration constants are those presented in Table 3-2. The determinant features leading to the selection of each calibration set are discussed in in-house Technical Note No. 68 and are not repeated here.

IN-FLIGHT CROSS-CALIBRATION CHECK

The Project METRO deployment was the first major series of data flights which incorporated the cross-calibration (X-CAL) data sequence. During this routine the automatic 2π scanners (UHS and LHS) and the equilibrium radiance telephotometer (ERT) are manually directed to look dead ahead and parallel to the aircraft flight axis. The aircraft is put into a nose-high climb attitude and it maintains this condition while the three forward-looking telephotometers simultaneously measure the radiance of the sky directly ahead of the aircraft.

By aiming the aircraft at a reasonably uniform portion of the sky in a direction away from the sun, one obtains a data set representing the simultaneous in-flight measurement of a common scene by three different radiometer systems. These data are automatically processed to validate or, if necessary, to evaluate a potential update of the system calibration constants prior to final data processing.

A summary of the upper and lower hemisphere scanner cross-calibration data is presented in Table 3-6. These ratios are not corrected or adjusted and thus represent direct in-flight absolute radiance measurements. The ratios indicate a moderate spectral mismatch between the two scanners, illustrated by the drift from 0.95 in the blue filter to 0.86 in the red. They also indicate a moderate mismatch in absolute level, i.e., all average values are less than 1.0. However, since this was an initial attempt at this flight procedure and since a major portion of the ratios fall within our anticipated ±5 percent overall accuracy for each system, no calibration updates were made to the METRO data on the basis of the X-CAL ratios.

Table 3-6

UHS/LHS Radiance Ratios from X-CAL Sequences

Flight No.	Average Radiance Ratio: UHS/LHS		
	Filter 2 (Blue)	Filter 4 (Pseudo-Photopic)	Filter 3 (Red)
C-180	0.82	0.77	0.75
C-181	0.81	0.83	0.80
C-182A & B	1.02	0.95	0.91
C-183A & B	1.12	0.93	0.91
C-185A & B	0.94	0.82	0.74
C-186A & B	0.91	0.88	0.86
C-187A & B	0.96	0.94	0.91
C-188A & B	0.95	0.91	0.88
Overall	0.95	0.89	0.86

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 attempts to duplicate 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".

MEAN WAVELENGTH

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

$$\bar{\lambda} = \frac{\sum_0^\infty \lambda \overline{S_\lambda T_\lambda}\, \Delta\lambda}{\sum_0^\infty \overline{S_\lambda T_\lambda}\, \Delta\lambda} .$$

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 normalized relative spectral response curve. It is equal to the width of the passband of a rectangular filter of equivalent area; hence, it is designated as $\delta\lambda$ and defined by $\delta\lambda = \Sigma(\overline{S_\lambda T_\lambda})\,\Delta\lambda$. 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 METRO 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 the Rayleigh limits in the final column are described in the Visibility Laboratory in-house Technical Note No. 36. The table was produced by Program RAYLIMIT.

Table 3-7

Spectral Characteristics Summary for Project METRO

Spectral Characteristics for Project METRO				Inherent Sun Properties (Johnson)			Rayleigh Atmosphere Properties (15°C)		
Filter Code No	Peak Wavelength (nm)	Mean Wavelength (nm)	Response Area (nm)	Irradiance (w/m²μm)	Radiance (w/Ωm²μm) 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
5	750	765	50 4	1 23E+03	1 80E+07	2 10E+07	3 28E+05	3 08E-06	974
4	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
9	555	560	106 9	1 89E+03	2 77E+07	3 45E+07	9 22E+04	1 15E-05	907

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. 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 of the standards used in Project METRO is presented in Fig. 1-5 and 3-6. In Fig. 3-6, which is the computer-generated plot from Program RAYLIMIT, 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 3-8, from Program RAYLIMIT.

Fig. 3-6

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

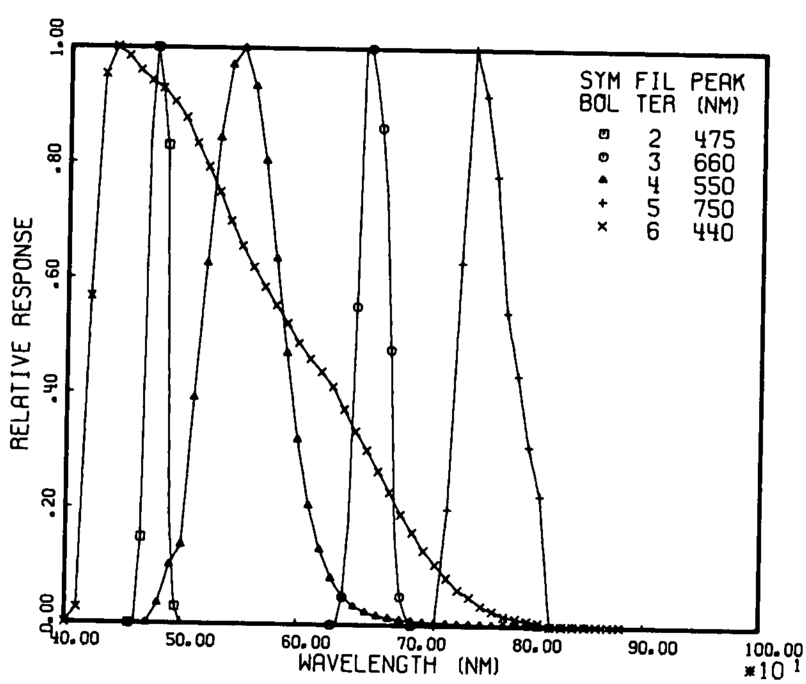


Table 3-8

Relative Spectral Response of Standards for Project METRO

	Filter Identification and Mean Wavelength					
Wavelength (nm)	Filter 2 Blue 478 nm	Filter 3 Red 664 nm	Filter 4 Pseudo-Photopic 557 nm	Filter 5 NIR 765 nm	Filter 6 S-20 532 nm	Filter 9 True Photopic 560 nm
400	0	0	0	0	0	0.0004
405	0	0	0	0	0.0129	0.0006
410	0	0	0	0	0.0258	0.0012
415	0	0	0	0	0.2969	0.0022
420	0	0	0	0	0.5680	0.0040
425	0	0	0	0	0.7605	0.0073
430	0	0	0	0	0.9530	0.0116
435	0	0	0	0	0.9765	0.0168
440	0	0	0	0	1.0000	0.0230
445	0	0	0	0	0.9920	0.0298
450	0	0	0	0	0.9840	0.0380
455	0	0	0	0	0.9720	0.0480
460	0.0070	0	0	0	0.9600	0.0600
465	0.1487	0	0	0	0.9510	0.0739
470	0.8481	0	0	0	0.9420	0.0910
475	1.0000	0	0.0172	0	0.9355	0.1126
480	0.9329	0	0.0343	0	0.9290	0.1390
485	0.8304	0	0.0677	0	0.9175	0.1693
490	0.1790	0	0.1010	0	0.9060	0.2080
495	0.0292	0	0.1185	0	0.8920	0.2586
500	0	0	0.1360	0	0.8780	0.3230
505	0	0	0.2635	0	0.8560	0.4073
510	0	0	0.3910	0	0.8340	0.5030
515	0	0	0.5085	0	0.8135	0.6082
520	0	0	0.6260	0	0.7930	0.7100
525	0	0	0.7345	0	0.7715	0.7932
530	0	0	0.8430	0	0.7500	0.8620
535	0	0	0.9065	0	0.7250	0.9149
540	0	0	0.9700	0	0.7000	0.9540
545	0	0	0.9850	0	0.6785	0.9803
550	0	0	1.0000	0	0.6570	0.9950
555	0	0	0.9665	0	0.6385	1.0002
560	0	0	0.9330	0	0.6200	0.9950

Table 3-8 (cont.)

Relative Spectral Response of Standards for Project METRO

Filter Identification and Mean Wavelength

Wavelength (nm)	Filter 2 Blue 478 nm	Filter 3 Red 664 nm	Filter 4 Pseudo-Photopic 557 nm	Filter 5 NIR 765 nm	Filter 6 S-20 532 nm	Filter 9 True Photopic 560 nm
565	0	0	0.8685	0	0.6030	0.9786
570	0	0	0.8040	0	0.5860	0.9520
575	0	0	0.7195	0	0.5700	0.9154
580	0	0	0.6350	0	0.5540	0.8700
585	0	0	0.5525	0	0.5385	0.8163
590	0	0	0.4700	0	0.5230	0.7570
595	0	0	0.3950	0	0.5060	0.6949
600	0	0	0.3200	0	0.4890	0.6310
605	0	0	0.2630	0	0.4750	0.5668
610	0	0	0.2060	0	0.4610	0.5030
615	0	0	0.1680	0	0.4500	0.4412
620	0	0	0.1300	0	0.4390	0.3810
625	0	0	0.1055	0	0.4260	0.3210
630	0	0	0.0810	0	0.4130	0.2650
635	0	0.0020	0.0657	0	0.3935	0.2170
640	0	0.0486	0.0504	0	0.3740	0.1750
645	0	0.1798	0.0411	0	0.3545	0.1382
650	0	0.5531	0.0318	0	0.3350	0.1070
655	0	0.9948	0.0268	0	0.3190	0.0816
660	0	1.0000	0.0218	0	0.3030	0.0610
665	0	0.9421	0.0188	0	0.2845	0.0446
670	0	0.8625	0.0157	0	0.2660	0.0320
675	0	0.7482	0.0139	0	0.2480	0.0232
680	0	0.4774	0.0120	0	0.2300	0.0170
685	0	0.1585	0.0105	0	0.2105	0.0119
690	0	0.0495	0.0090	0	0.1910	0.0082
695	0	0.0166	0.0080	0	0.1755	0.0057
700	0	0	0.0070	0	0.1600	0.0041
705	0	0	0.0061	0	0.1445	0.0029
710	0	0	0.0053	0	0.1290	0.0021
715	0	0	0.0048	0	0.1170	0.0015
720	0	0	0.0042	0	0.1050	0.0010
725	0	0	0.0038	0.1005	0.0938	0.0007

Table 3-8 (cont.)

Relative Spectral Response of Standards for Project METRO

	Filter Identification and Mean Wavelength					
Wavelength (nm)	Filter 2 Blue 478 nm	Filter 3 Red 664 nm	Filter 4 Pseudo-Photopic 557 nm	Filter 5 NIR 765 nm	Filter 6 S-20 532 nm	Filter 9 True Photopic 560 nm
730	0	0	0.0033	0.2010	0.0826	0.0005
735	0	0	0.0030	0.4155	0.0723	0.0004
740	0	0	0.0026	0.6300	0.0619	0.0003
745	0	0	0.0025	0.8150	0.0558	0.0002
750	0	0	0.0023	1.0000	0.0497	0.0001
755	0	0	0.0020	0.9595	0.0416	0.0001
760	0	0	0.0018	0.9190	0.0335	0.0001
765	0	0	0.0017	0.8495	0.0292	0
770	0	0	0.0016	0.7800	0.0249	0
775	0	0	0.0014	0.6620	0.0206	0
780	0	0	0.0013	0.5440	0.0162	0
785	0	0	0.0012	0.4890	0.0144	0
790	0	0	0.0012	0.4340	0.0125	0
795	0	0	0.0012	0.3720	0.0107	0
800	0	0	0.0011	0.3100	0.0088	0
805	0	0	0.0005	0.2675	0.0075	0
810	0	0	0	0.2250	0.0062	0
815	0	0	0	0.1125	0.0031	0
820	0	0	0	0	0	0

4. DATA COLLECTION METHODS

During Project METRO, two independent activities were maintained simultaneously. The operation of the airborne instrument system was one activity and that of the ground-based instrument system was the other. The procedural routine was for each system to run full data collection sequences at every opportunity, on a daily schedule.

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) and AFCRL-72-0593, Duntley *et al.* (1972c). During each data collection flight, the aircraft flew a predetermined pattern within the specified test area. An illustration of a typical flight pattern is shown in Fig. 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. These two primary elements are summarized in the following paragraphs.

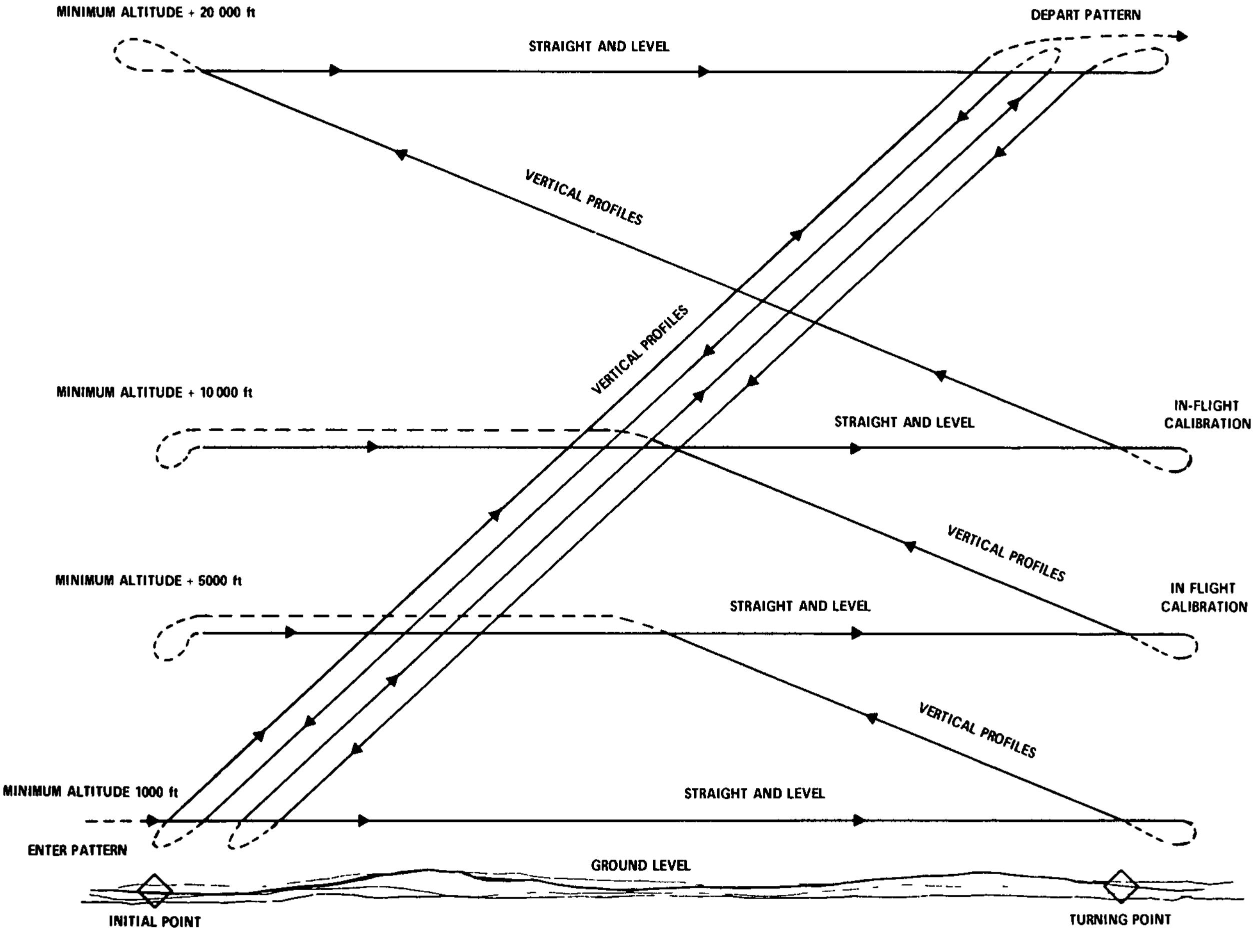


Fig. 4-1. Typical Visibility Laboratory Flight Profile.

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 Fig. 1-4. 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.

For Project METRO the typical flight profile illustrated in Fig. 4-1 was modified to include only three straight and level sequences. These three straight and levels were run at indicated altitudes of 1500, 5500, and 9500 feet above mean sea level (460, 1680, and 2900 meters MSL).

However, in order to sample the optical atmospheric properties both upwind and downwind of the city during the same flight, dual missions were flown. That is, a three filter/three level profile was run on a track upwind of the city, and then the aircraft ferried directly to a downwind track, where the same three filter/three level profile was repeated. The total elapsed flight time for these dual missions was approximately 5 hours, and they were scheduled to occur between 0930 and 1430 hours local civil time.

DATA COLLECTION SEQUENCE

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. Third, the ground system serves as a spare parts and repair facility for the entire air/ground operation. In the event of a catastrophic 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.

During Project METRO, the basic function of the ground station was to establish a data baseline against which the upwind and downwind airborne data could be judged. Thus, the ground station was left in one location, at Scott Air Force Base, during the entire deployment.

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.

Ground-based data were collected in a fixed pattern on a repetitive basis during each designated data day. The Project METRO 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, Duntley *et al.* (1970), and thus is not repeated here.

1. Nephelometer Set, Σ, $\beta 30$, $\beta 150$
2. 2π Scanner Set, Vertical Plane Scan
3. Nephelometer Set, Σ only
4. Contrast Reduction Meter Set
5. Nephelometer Set, Σ, $\beta 30$, $\beta 150$
6. 2π Scanner Set, Upper Hemisphere Scan

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.

5. DATA PROCESSING

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 METRO data is illustrated in Fig. 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 AFCRL-72-0255, Duntley *et al.* (1972a), and AFCRL-72-0593, Duntley *et al.* (1972c).

5.1 AIRBORNE DATA

As described in AFCRL-72-0255, Duntley *et al.* (1972a), 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.

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 AFCRL-72-0255, Duntley *et al.* (1972a), 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 approximately only eight samples per second.

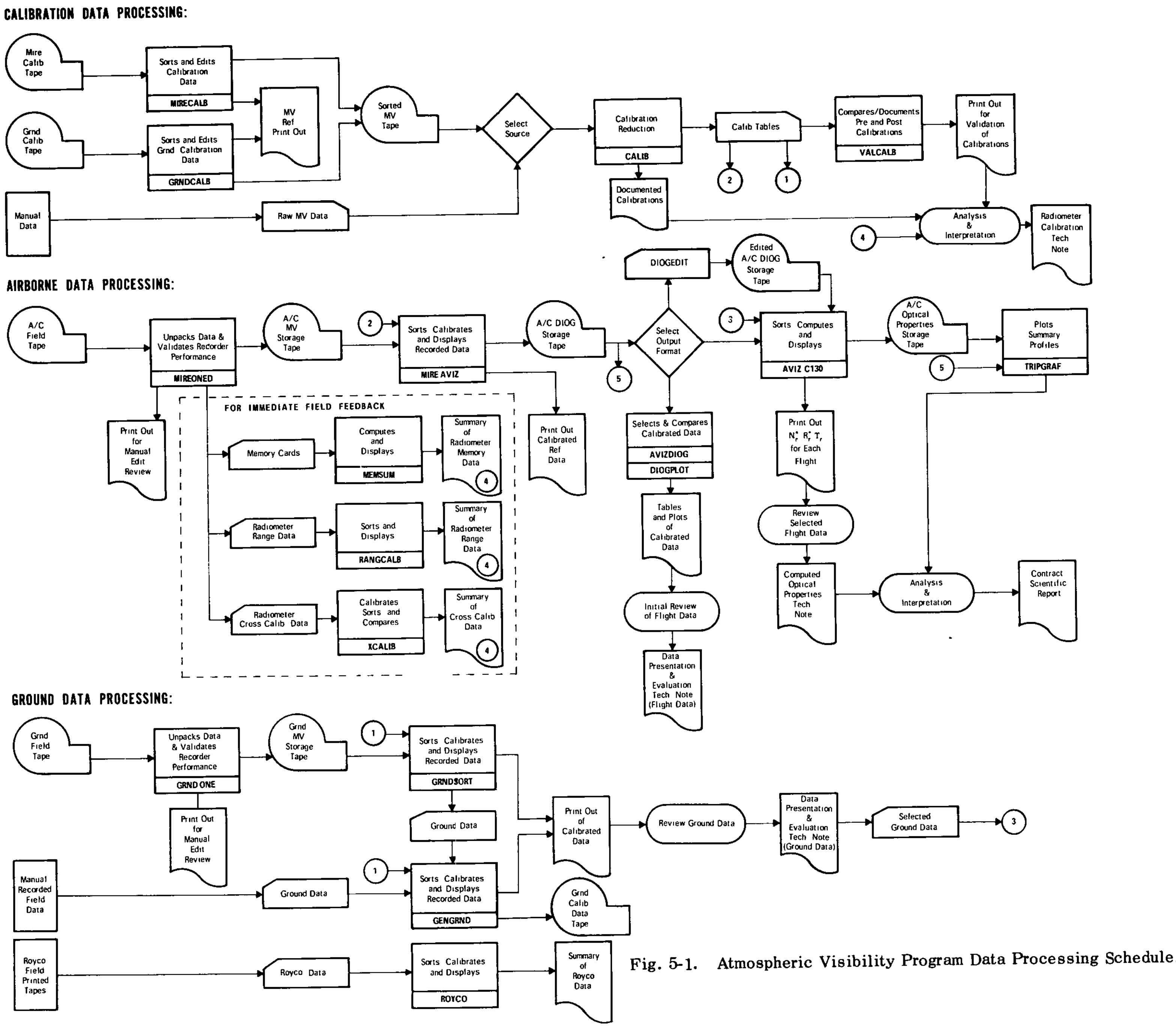


Fig. 5-1. Atmospheric Visibility Program Data Processing Schedule.

Since the recording format for the ground-based radiometer data is not as highly stylized as is the airborne format, efficient processing is best achieved by converting to card format. This conversion is accomplished by Program GRNDSORT. See Fig. 5-1. The insertion of manually recorded peripheral data into the basic data deck is also optimized through the use of this card format.

The punched card format is established to accept data from any radiometer system, plus selected identification and control information. Each radiometer measurement in each spectral band is recorded on a separate card along with the value of its "memory" reading and identification code. This one-card format was selected for conciseness and to facilitate maximum flexibility within the processing procedures.

As illustrated in Fig. 5-1, the card data are processed by the generalized program GENGRND. This program is suitable for use with all ground-based radiometer systems, i.e., CRM, UHS, and NEPH. It not only sorts and calibrates the input data, but also performs selected computations from among those illustrated in Section 2.2.

The results from Program GENGRND are available both as printer output for use in preliminary data evaluation and as a storage tape for use in further automatic data processing and manipulation.

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 an initial procedure, these data go through Program MIRECALB or GRNDCALB, according to the recording system used, to verify the electrical quality of the radiometer data and associated monitored parameters. The data are sorted and stored in set fashion for final 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, was used to generate printout for direct insertion into in-house Technical Note No. 68, Project METRO Radiometer Calibrations. 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 and is the source of the preferred calibration data illustrated in Table 3-2.

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 in-house Technical Notes describing the data and the computed properties reported herein are summarized in Table 5-1 to simplify future retrieval.

Table 5-1

Processed Data Tapes, Data Presentation Technical Notes, and Computed Properties Technical Notes

METRO Flight No.	MIREAVIZ* Tape No. VL-301D File No.	Data Presentation Technical Note No.	AVIZC130** Tape No. VL-346D File No.	Computed Properties Technical Note No.
C-180	19	60	11	78
C-181	2	61	6	73
C-182A	4	62	2	74
C-182B	14	62	1	74
C-183A	16	63	9	79
C-183B	7	63	* * *	79
C-185A	6	64	10	80
C-185B	8	64	* * *	80
C-186A	9	65	3	75
C-186B	10	65	7	75
C-187A	11	66	8	76
C-187B	12	66	* * *	76
C-188A	17	67	-4	77
C-188B	18	67	5	77

* Duplicate of VL-384   * * Duplicate of VL-371C   * * * No AVIZC130 Output Tape

6. WEATHER SUMMARY

6.1 SUMMARY

Meteorological data available for analysis included daily surface and 500-millibar charts prepared by the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service. The surface charts were for 7:00 A.M., E.S.T. (1200 GMT). Portions of these charts have been copied and are presented as Fig. 6-1. The 500-millibar charts were also for 7:00 A.M., E.S.T. (1200 GMT). Also utilized were the 3-hourly facsimile charts issued by the National Meteorological Center and obtained from the Lindbergh Field NOAA office. The 500-millibar facsimile charts were for 0000 GMT and 1200 GMT daily. Used but not described were various other facsimile charts. Also available for days when the flights were conducted were the hourly and special reports made by the weather office at Scott Air Force Base.

This section includes a discussion of the surface and 500-millibar charts for all of the flights. For continuity, there is also a narrative of the days between flights. Listed in tabular form are the hourly and special reports made by the observers at Scott Air Force Base. The meteorological data taken by the Visibility Laboratory ground station (located on the base) are in agreement with these observations.

Also included in Section 6 are graphical representations of ambient temperature profiles measured during each data flight (Fig. 6-2). These temperatures are measured continuously by an AN/AMQ-17 aerograph system described briefly in Duntley *et al.* (1970) and more completely in USNAF TP-133. The profile identification symbols used in Fig. 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 that the Filter 2 radiometric measurements were being made; the temperatures coded as Filter 3 were taken simultaneously with the Filter 3 radiometric measurements, etc. Users should be aware that these temperature profiles represent conditions appropriate to a specific flight track which may be from 50 to 100 miles away from the ground site at Scott Air Force Base.

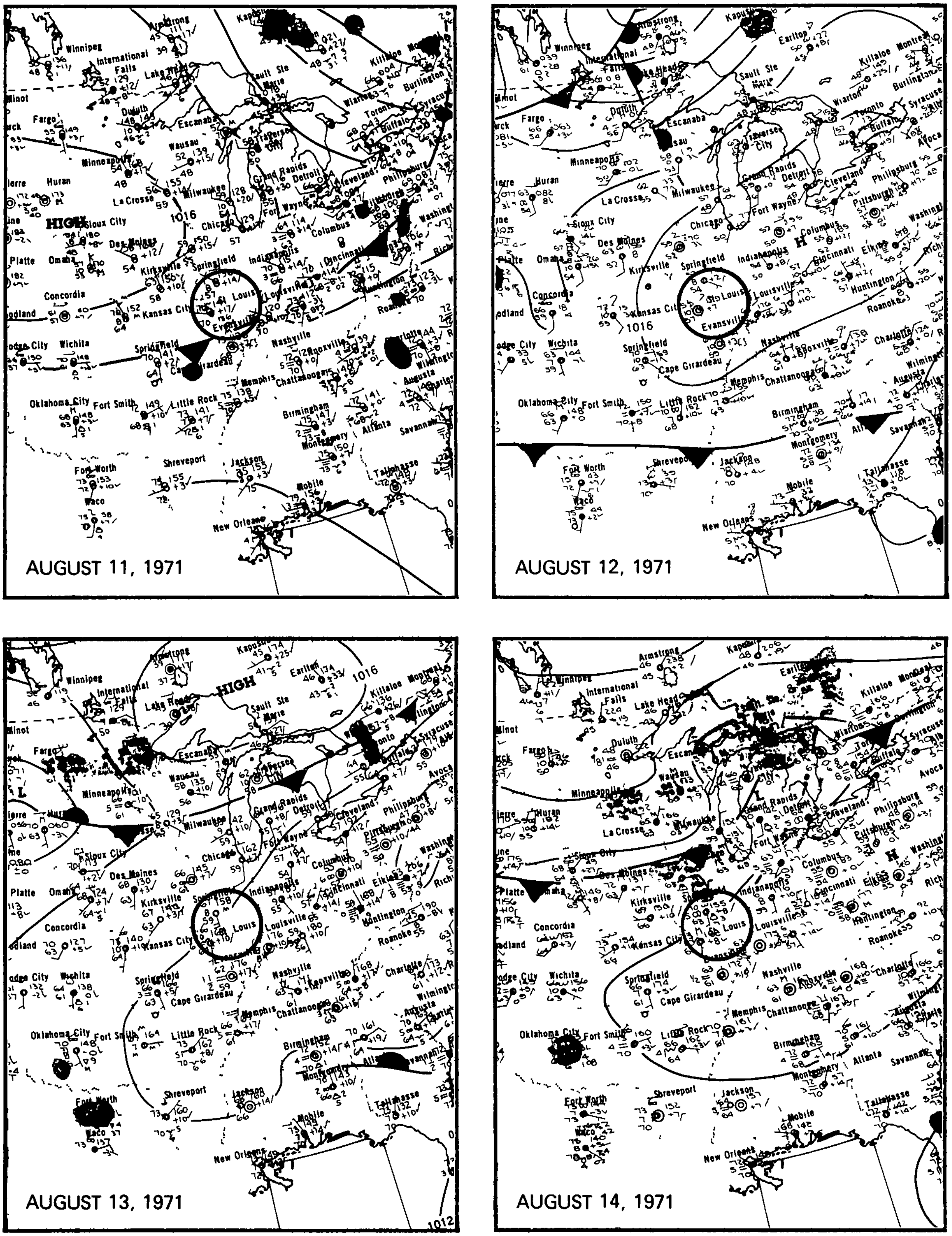


Fig. 6-1. Synoptic Charts of St. Louis Area During Project METRO.

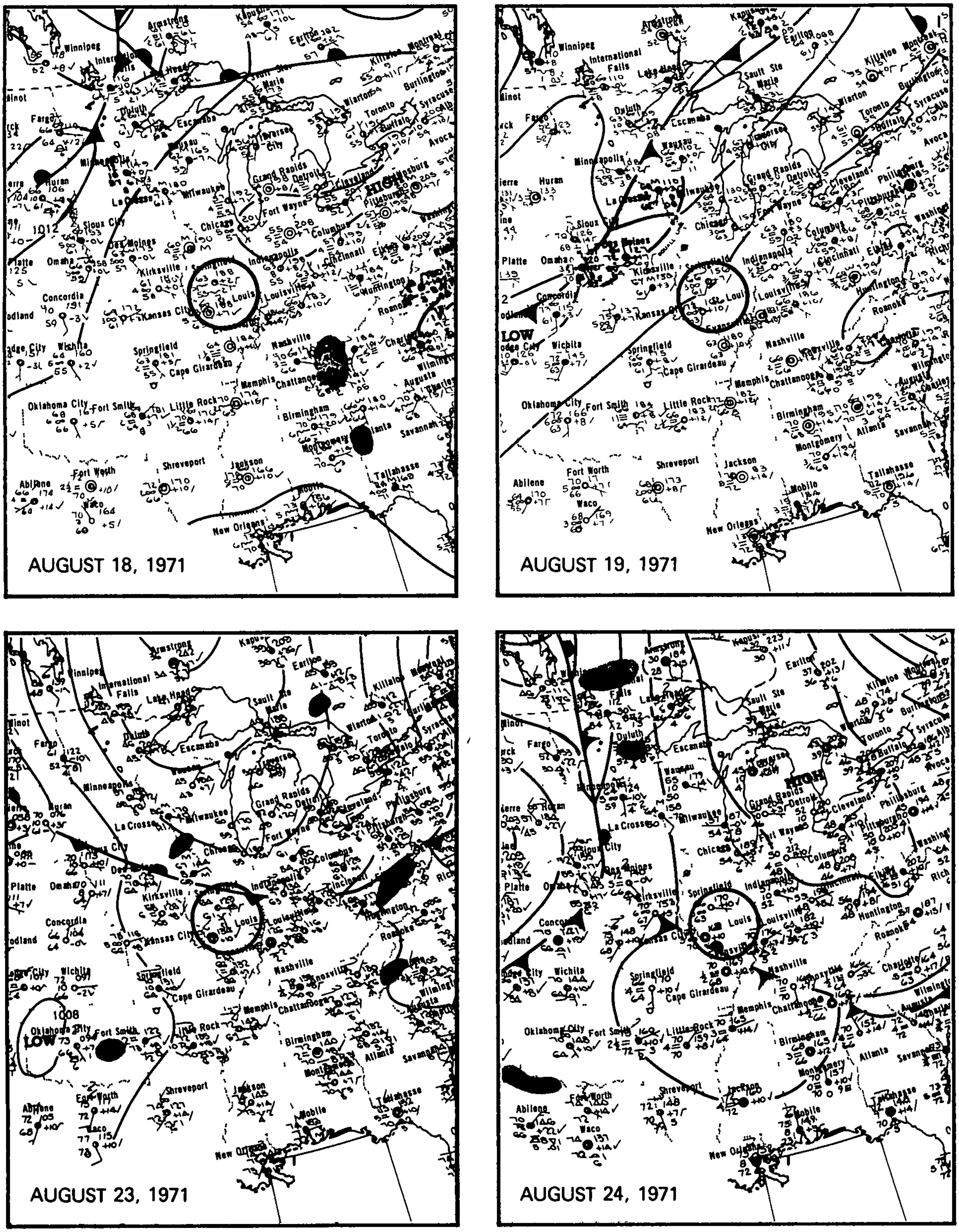


Fig. 6-1 (cont.). Synoptic Charts of St. Louis Area During Project METRO.

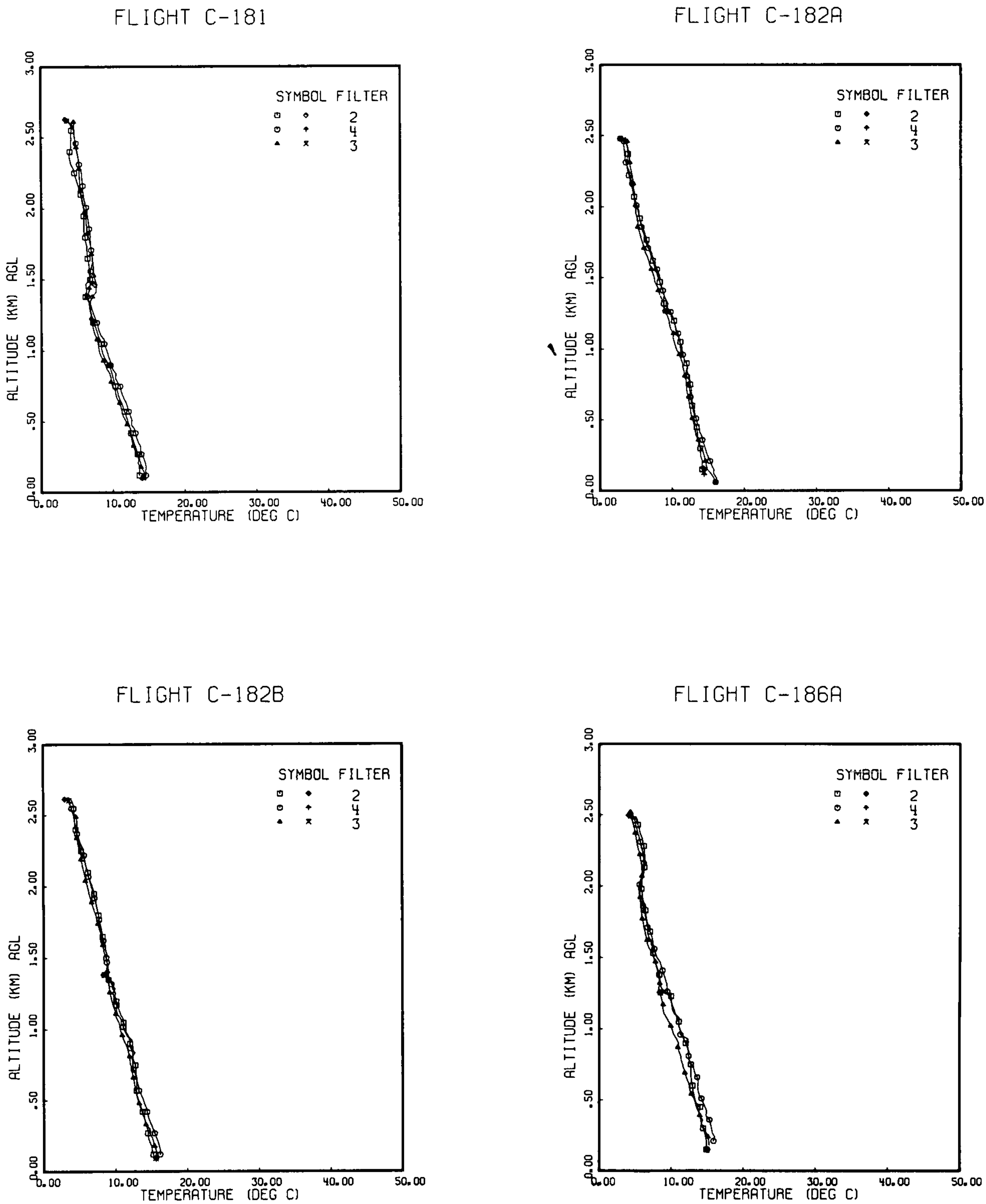


Fig. 6-2. Temperature Versus Altitude for Eight Project METRO Flights.

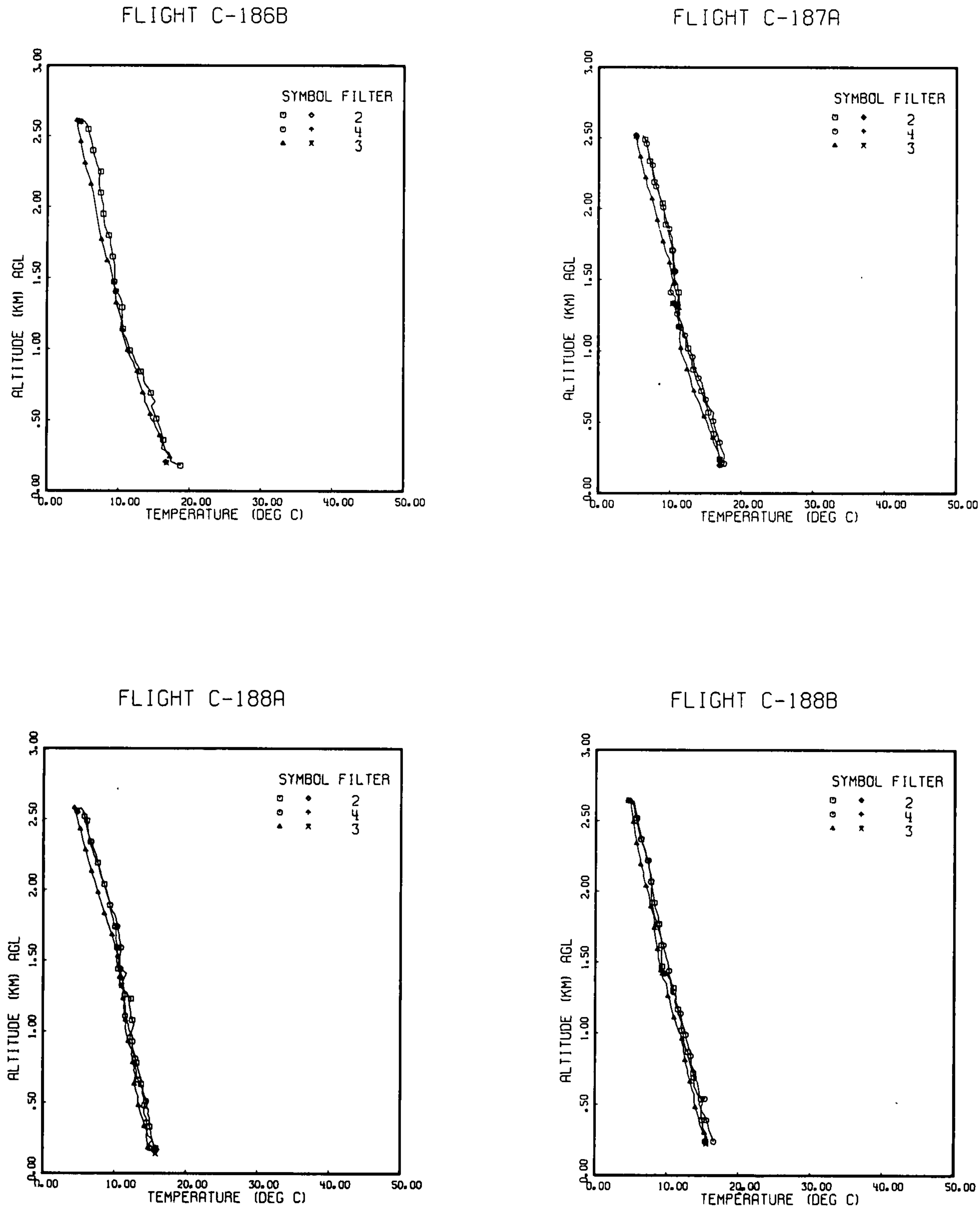


Fig. 6-2 (cont). Temperature Versus Altitude for Eight Project METRO Flights.

6.2 SYNOPTIC CONDITIONS

During the period of deployment there were a few weak frontal passages which did little to alleviate the high temperatures and deposited very little precipitation. For the most part the synoptic situation was typically summer with weak gradients both at the surface and aloft.

FLIGHT C-180 ON 11 AUGUST 1971

The surface synoptic chart shows that there was a cold frontal passage accompanied by thundershowers at about 0600 GMT. By 2100 GMT the front had moved to a line from Altoona to Bowling Green, then to northern Arkansas and Oklahoma, where it became stationary. A weak high existed over the middle half of the country with St. Louis on the leading edge. The 500-millibar chart shows a trough from Hudson Bay southward to Illinois. There was a low over the Texas Panhandle. Moderate westerly winds were present.

FLIGHT C-181 ON 12 AUGUST 1971

There is a weak circulation indicated on the surface chart. The flight area was on the rear of a weak high which had a center in Ohio. A slow-moving cold front was present in the Dakotas. At 500 millibars there was a trough from Ontario to Virginia with slight ridging over Indiana. The gradient was very weak.

FLIGHT C-182A ON 13 AUGUST 1971

The surface chart shows a weak circulation with St. Louis on the back side of a high. A cold front with waves extended through the central Great Lakes, La Crosse, and Dodge City, then northwestward into British Columbia. There was a tropical depression off the Carolinas. At 500 millibars there was a very weak gradient over the United States with the tropical depression off the Carolinas showing at this level.

FLIGHT C-182B ON 13 AUGUST 1971

The surface chart shows that the tropical depression off the Carolinas had caused the front in the Dakotas to become stationary. There was a weak 1008-millibar low in eastern South Dakota but the general circulation was very weak. At 500 millibars there was a very weak gradient over the United States with the tropical depression off the Carolinas showing at this level.

FLIGHT C-183A AND B ON 14 AUGUST 1971

The surface chart shows that St. Louis was still on the rear of a high with its center near Pittsburgh. There was a cold front through Detroit, Davenport, and southern Nebraska which extended northwestward to British Columbia. Tropical storm "Beth" was off the Virginia coast. At 500 millibars there was a high area over Wyoming, Utah, Nevada, and California. Elsewhere there were very weak gradients.

15 AUGUST 1971 – NO FLIGHT

The cold front that had been on the map for the past few days showed little movement on this date. Because of the blocking action of tropical storm "Beth," the front became stationary and dissipated. There was a ridge of high pressure from north of the Great Lakes to Texas.

FLIGHT C-184 ON 16 AUGUST 1971 – NO DATA

The surface chart shows that high pressure covered most of the nation. The 1026-millibar center of the eastern high was located in central Michigan. There was a tropical depression over western Florida. At 500 millibars there was a high covering the western two-thirds of the nation with the St. Louis area on the leading edge, in the northeastern quarter.

17 AUGUST 1971 – NO FLIGHT

High pressure was maintained over the eastern half of the nation with a 1024-millibar center at Fort Wayne, Indiana. The gradient was weak.

FLIGHTS C-185A AND B ON 18 AUGUST 1971

The surface synoptic chart shows an extremely weak gradient. A low was centered in eastern South Dakota with a cold front extending southwestward. At 500 millibars there was a high extending from Illinois to Texas and westward to California. There was another area of high along and off the east coast extending from New Jersey to Florida. The flow over the St. Louis area was moderate northeasterly.

FLIGHTS C-186A AND B ON 19 AUGUST 1971

The surface chart shows an extremely weak gradient. There was a low centered in Nevada and a slow-moving cold front along the line Minneapolis/Omaha/Trinidad. At 500 millibars there was a high over most of the country except for a weak trough over the Carolinas. The gradient was very weak.

20 AUGUST 1971 – NO FLIGHT

There was an extremely weak gradient with a slow-moving cold front along the Chicago/Ottumwa line from which it became a stationary front to Trinidad, Colorado.

21 AUGUST 1971 – NO FLIGHT

There was a high cell off the coast of Florida and Georgia with a ridge covering the southern states as far west as Texas. There was a small low cell in western Kansas. A slow-moving cold front lay just south of the Great Lakes through southern Minnesota, North Dakota, and into Saskatchewan.

22 AUGUST 1971 – NO FLIGHT

The gradient was very weak. This map shows a typical summer situation with little definition. There was a stationary front from Pennsylvania to the Great Lakes which became a wave in the northeast corner of North Dakota.

FLIGHTS C-187A AND B ON 23 AUGUST 1971

The surface chart shows a cold front extending south-southwestward from Maine to the DelMarVa* peninsula then westward to Evansville and northwestward to Springfield and Keokuk to a low in central North Dakota. At 500 millibars there was a high centered near Topeka and a trough from Ontario to Virginia. The gradient shows moderate northeasterly winds over the region.

FLIGHT C-188A ON 24 AUGUST 1971

The surface chart shows a stationary front over St. Louis. There was a weak high over Michigan with a weak ridge extending southwestward to Arkansas. The general circulation was weak. At 500 millibars there was a high covering the western two-thirds of the United States and in general all of the U. S., except the northeast where there were low values and strong winds. There was a closed high over the Great Plains.

FLIGHT C-188B ON 24 AUGUST 1971

The surface chart shows the stationary front over the region beginning to move northward as a warm front. There was a weak high over Michigan with a ridge extending southwestward to Arkansas. The general circulation was weak. At 500 millibars there was no change from the morning flight.

6.3 TABULAR SUMMARY AND GLOSSARY

A summary of the daily meteorological observations taken at Scott Air Force Base 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 Scott data were reported in local standard time (LST) but have been changed to central daylight time (CDT) to coincide with ground and flight logs.

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* Indicates the Delaware/Maryland/Virginia peninsula between the Delaware and Chesapeake Bays.

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); light (when suffixed)
- -- Very light (when suffixed)
- -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
- V Immediately following numerical value indicates a varying ceiling (also used with varying visibility)
- W Indefinite
- / Height of cirriform nonceiling layer unknown

RELATIVE HUMIDITY (RH)

Reported in percent and computed from temperature and dewpoint.

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.

Table 6-1

STANDARD METEOROLOGICAL DATA SHEET
11 August 1971

Data Source: Scott Air Force Base
Flight No. C-180 Track 1

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 89°51' W – El. + 463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	40⦶ E80 ⦷250 ⦷	10		72	64	72	33	04	CuAcCi	0.9	
0756	1256	40⦶ E80 ⦷330 ⦷	15		73	64	69	35	07	CuAcCi	0.9	
0855	1355	40⦶ 80 ⦶300-⊕	15		74	60	58	36	07	CuAcCi	1.0	
0956	1456	40⦶ 300-⦷	15		76	57	52	36	07	CuCi	0.8	
1056	1556	300-⦷	15		80	54	41	26	06	Ci	0.8	
1157	1657	300 ⦶	15		84	57	40	35	06	Ci	0.1	
1257	1757	300 ⦶	15		83	56	42	01	07	Ci	0.1	Cu East South & West, Wind 330 V 050
1359	1859	300 ⦶	12		83	54	37	01	07+18	Ci	0.1	Cu All Quadrants, Wind 340 V 040
1456	1956	50 ⦶	12		85	55	36	33	07	Ci	0.2	Wind 300 V 360
1555	2055	50 ⦶	12		84	55	37	36	10	Cu	0.1	
1655	2155	50 ⦶	15		84	54	35	35	14+20	Cu	0.1	Wind 330 V 030
1755	2255	300-⦶	15		82	53	37	36	12+17	Ci	0.3	Cu Northeast to Southwest & West to Northwest, Wind 340 V 030
1855	2355	300-⦷	15		79	55	44	01	07	Cs	0.7	
1955	0055	300-⦷	15		75	54	48	02	03	Cs	0.7	

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
12 August 1971

Data Source Scott Air Force Base
Flight No C-181 Track 3

Field Site Scott Air Force Base
Lat 33°38' N – Long 89°51' W – El +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp (°F)	Dew-point (°F)	Rel Hum (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0658	1158	250-⦶	6	GF H	57	52	84	00	00	Ci	0 3	
0755	1255	250-⦶	6	GF H	63	56	78	00	00	Ci	0 3	
0855	1355	250-⦶	8		68	55	63	12	05	Ci	0 2	Haze All Quadrants, Wind Direction Variable
0955	1455	250-⦶	12		73	55	53	15	05	Ci	0 2	Haze All Quadrants, Wind Direction Variable
1055	1555	250-⦷	20		76	54	46	15	08	Cs	0 9	Wind Direction Variable
1155	1655	250-⦷	20		80	53	39	15	06	Cs	0 9	Wind 050 V 240
1255	1755	250-⊕	20		80	52	38	16	06	Cs	1 0	Wind 060 V 240
1358	1858	250-⦷	20		81	51	36	18	06	Cs	0 7	Wind 070 V 250
1455	1955	250-⦶	20		84	50	31	18	06	Ci	0 4	Wind Direction Variable
1556	2056	250-⦶	20		85	50	30	16	02	Ci	0 3	Wind Variable
1657	2157	250-⦶	20		84	52	33	18	04	Ci	0 1	Wind Variable
1756	2256	250-⦶	20		84	53	34	19	05	Ci	0 1	Wind Variable

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
13 August 1971

Data Source: Scott Air Force Base
Flight No. C-182A & B Tracks 7 and 3

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 89°51' W – El. +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	E110 ⦷ 250 ⦷	10		66	58	80	15	02	AcCi	0.8	
0755	1255	E110 ⊕	8		68	59	73	17	03	Ac	1.0	Thin Spots in Overcast
0855	1355	R130 ⦷	8		74	60	61	19	09	Ac	0.8	Cloud Tops 14500
0957	1457	130 ⦶	10		78	61	56	19	07	Ac	0.4	
1055	1555	○	10		81	63	54	21	05		0	Wind Direction Variable
1155	1655	○	10		84	63	53	17	05		0	Wind Direction Variable
1256	1756	○	12		87	64	46	16	09		0	Wind 130 V 240, Cu Forming and Dissipating Overhead and North
1355	1855	○	12		89	64	44	21	03		0	Cu West to North, Wind Direction Variable
1455	1955	○	12		89	63	42	15	07		0	Cu All Quadrants, Wind 120 V 260
1558	2058	50 ⦶	12		90	62	39	18	07	Cu	0.1	Wind 150 V 200
1657	2158	○	12		91	62	38	15	08		0	Wind 120 V 210, Cu North and South
1757	2257	○	12		88	62	42	17	08		0	Wind 100 V 180

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
14 August 1971

Data Source Scott Air Force Base
Flight No C-183A & B Tracks 7 and 4

Field Site Scott Air Force Base
Lat 33°38' N – Long 89°51' W – El +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp (°F)	Dew-point (°F)	Rel Hum (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0658	1155	E35 ⦷	5	GF H	69	60	72	00	00	Cu	0 6	Moderate Cu All Quadrants
0759	1259	35 ⦶	6	GF	72	62	70	18	04	Cu	0 5	
0857	1357	35 ⦶	8		79	63	58	18	04	Cu	0 2	Haze All Quadrants
0957	1457	35 ⦶ 150 ⦶	8		83	64	53	24	06	CuAc	0 2	Haze All Quadrants
1057	1557	50 ⦶ 100 ⦶	8		85	65	51	23	05	CuAc	0.5	Cb 25 Northwest – 25 North, Movement Unknown, Haze All Quadrants
1157	1657	50 ⦶ 250– ⦷	12		87	63	44	21	05	CuCi	0 8	Cb 25 Northwest – 25 North, Movement Unknown, Wind Direction Variable
1257	1757	50 ⦶ R70 ⦷ 310 ⦷	12		80	65	60	03	17G23	CbAcCi	0.9	Cb All Quadrants Moving South
1310	1810	50 ⦶ E70 ⦷ 310 ⦷	12	T				01	12G24	CbAcCi	0 9	T Northwest Moving South, Occasional Lightning Cloud to Ground Northwest
1322	1822	50 ⦶ E70 ⦷ 310 ⦷	8	T RW–				36	20G26	CbAcCi	0 9	T Overhead Moving South, Occasional Lightning Cloud to Ground North to Northwest
1357	1857	50 ⦶ E70 ⊕	8	T RW–	71	65	81	36	05	CbAc	1 0	Thunder Overhead and West Moving South, Occasional Lightning Cloud to Ground Southwest to West
1403	1903	50 ⦶ E70 ⊕	12	T RW– –				09	02			Thunder Overhead and West Moving South, Occasional Lightning Cloud to Ground All Quadrants, Wind Direction Variable
1448	1948	50 ⦶ E70 ⦷ 310 ⦷	12	RW– –				28	03			T Ended 1447 Moved South, Wind Direction Variable

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
16 August 1971

Data Source: Scott Air Force Base
Flight No. C-184 Tracks 3 and 7

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 89°51' W – El. +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	E80 ⦷	2	GF H	65	61	86	01	06	Ac	0.7	
0707	1207	E80 ⦷	1-1/4	GF H				01	06			Visibility West-North 1
0744	1244	80 ⦶	1-1/2	GF H				01	06			
0756	1256	80 ⦶	1-3/4	GF H	66	62	87	02	07	Ac	0.2	
0819	1319	80 ⦶	3	H GF				02	05			
0857	1357	80 ⦶	5	H	70	62	75	03	06			
0957	1457	6 ⦶	5	H	74	63	68	01	06	Cu	0.3	
1030	1530	M6 ⦷	5	H				04	06			10 South Top Overcast 20
1057	1557	M8 ⦷	5	H	75	62	64	35	08		0.7	⦷V⦶
1128	1628	8 ⦶	5	H				01	02			
1155	1655	8 ⦶	6	H	77	64	64	36	10		0.2	Wind 340 V 030

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
18 August 1971

Data Source: Scott Air Force Base
Flight No. C-185A & B Tracks 7 and 3

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 89°51' W – El. +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0658	1158	200 ⦶	5	GF H	62	58	86	00	00	Cs	0.2	
0757	1257	60 ⦶ 200 ⦶	4	H GF	66	59	78	00	00	AcCs	0.3	
0858	1358	200–⦶	4	H	72	60	66	11	01	Cs	0.7	Ac North
0958	1458	200–⦶	5	H	77	62	60	15	02	Cs	0.9	Wind Direction Variable
1057	1557	○	5	H	81	62	52	18	02		0	In-Flight Visibility 3, Wind Direction Variable
1155	1655	40 ⦶	6	H	84	57	40	29	06	Cu	0.1	Wind Direction Variable
1256	1756	40 ⦶	6	H	85	55	37	23	09	Cu	0.1	Wind Direction Variable
1355	1855	40 ⦶	6	H	86	56	36	25	04	Cu	0.1	Wind Direction Variable
1455	1955	45 ⦶	6	H	88	55	32	19	08	Cu	0.1	Wind 070 V 250
1558	2058	○	6	H	88	56	34	18	04	Sc	0	Sc All Quadrants
1655	2155	○	5	H	88	57	35	17	09	Sc	0	Sc All Quadrants

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
19 August 1971

Data Source: Scott Air Force Base
Flight No. C-186A & B Tracks 7 and 3

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 81°51' W – El. +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	-X	3	GF H	63	58	83	19	01	Fog	0.3	Visibility North-East-Southeast 1-1/4
0755	1255	-X	3	GF H	67	60	78	19	03	Fog	0.3	
0855	1355	-X	4	GF H	76	61	59	22	06	Fog	0.2	In-Flight Visibility 1
0956	1456	-X	4	H	81	63	54	22	09	Haze	0.1	
1056	1556	○	5	H	86	63	46	22	09		0	Wind 180 V 280
1155	1655	○	6	H	89	65	45	23	08		0	Wind 140 V 290
1255	1755	○	6	H	93	65	40	23	09		0	Wind 150 V 280
1355	1855	○	7		94	60	32	23	12		0	Wind 160 V 270
1458	1958	○	8		94	61	34	23	10		0	Wind 180 V 310
1555	2055	40 ⦶	10		95	60	32	23	06	Cu	0.1	Haze All Quadrants, Wind 200 V 280
1655	2155	○	10		94	61	34	25	07G20		0	Wind 210 V 280, Haze All Quadrants, Cu All Quadrants, Moderate Cu South and Northwest

Table 6-1 (cont)

STANDARD METEOROLOGICAL DATA SHEET
23 August 1971

Data Source Scott Air Force Base
Flight No C-187A & B Tracks 7 and 4

Field Site Scott Air Force Base
Lat 33°38' N – Long 87°51' W – El +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp (°F)	Dew point (°F)	Rel Hum (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	-X320-⦷	1-1/4	H	70	65	84	00	00	Ci	0 8	
0711	1211	-X320-⦷	1-1/2	GF H				23	02			Visibility Northwest 2
0742	1242	320-⊕	2	GF H				22	02			Visibility Northwest 2-1/2
0757	1257	320-⦷	2 1/2	H	73	67	81	24	05	Cs	0 9	
0827	1327	320-⦷	3	H				24	06			
0855	1355	300-⦷	4	H	79	70	74	24	05	Cs	0 7	
0955	1455	300-⦶	5	H	85	69	58	26	05	Cs	0 7	Wind Direction Variable
1055	1555		6	H	90	67	46	31	07	Cs	0 1	Wind 250 V 340
1155	1655	○	12		91	67	46	34	03		0	Few Cu All Quads, Thin Ci North, Wind Direction Variable
1257	1757	○	15		89	66	47	36	05		0	Cu South-West ○ V ⦶ , Wind Direction Variable
1355	1855	40 ⦶	12		93	65	40	03	03	Cu	0 1	Wind Direction Variable
1455	1955	40 ⦶ 300- ⦶	12		93	65	40	03	05	CuCi	0 3	Wind Direction Variable
1555	2055	40 ⦶ 300-⦷	12		94	64	38	06	02	CuCi	0 6	Wind Direction Variable
1656	2156	40 ⦶ 100 ⦶ 300-⦷	12		93	63	37	03	03	CuAcCi	0 7	

Table 6-1 (cont.)

STANDARD METEOROLOGICAL DATA SHEET
24 August 1971

Data Source: Scott Air Force Base
Flight No. C-188A & B Tracks 9 and 4

Field Site: Scott Air Force Base
Lat. 33°38' N – Long. 89°51' W – El. +463 ft

Time CDT	Time GMT	Sky and Ceiling (Hundreds of Feet)	Visibility (miles)	Weather and Obstructions To Vision	Temp. (°F)	Dew-point (°F)	Rel. Hum. (%)	Wind Direction (00-36)	Wind Speed (Kt)	Cloud Type	Total Sky Cover	REMARKS
0655	1155	O	5	H GF	68	64	87	00	00		0	
0755	1255	O	5	H GF	72	66	81	00	00		0	
0855	1355	O	5	H GF	76	68	76	18	02		0	
0955	1455	O	6	H	83	70	65	22	05		0	Wind Direction Variable
1055	1555	O	7		86	69	57	21	04		0	Wind Direction Variable, Haze All Quadrants
1155	1655	O	15		89	66	46	27	05G10		0	Wind Direction Variable
1255	1755	O	15		92	63	38	21	07		0	Cu East Southeast, Wind 190 V 300
1355	1855	O	15		94	61	34	21	07		0	Wind 190 V 270
1455	1955	O	15		95	59	23	08			0	Thin Ci North, Wind 180 V 280
1555	2055	O	15		94	65	18	10			0	Ci North, Wind 100 V 260

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 relationship between the optical properties of the atmosphere and the meteorological specifications of that atmosphere.

During the METRO deployment, the airmass characteristics were not well-defined. Despite the passage of a few weak fronts, there were no changes apparent in the airmass character but they were rather diffuse. Thus, there are no clear-cut comparisons by airmass discrimination that can realistically be made, as in Edgerton (1967). Consequently, the METRO 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 11 and 24 August 1971, eight flights resulting in 14 data profiles were made in southern Illinois and eastern Missouri. A ninth flight, C-184, was attempted, but bad weather caused the flight to be terminated without obtaining any data. Included in this report are eight selected data profiles from five flights.

The flights were conducted in the vicinity of St. Louis, Missouri in order to conveniently sample the optical properties both upwind and downwind of a major inland city. (See Fig. 1-4). Only five of the nine designated track locations surrounding the city were used during the field trip. The latitude and longitude coordinates, average elevation above sea level, location relative to St. Louis, and basic terrain description for each of these five flight tracks are given in Table 7-1.

PHOTOGRAPHIC DOCUMENTATION

The sky and terrain conditions encountered during each of the eight data flights were documented photographically during each straight and level flight sequence. These documentary photographs were made simultaneously with the measurements of sky and terrain radiance at each of the three designated altitudes.

Photographs illustrating sky and terrain conditions during each of the 14 data collection profiles have been examined and classified with respect to discernible cloud conditions. A summary of these general cloud descriptions is presented in Table 7-2. There are six profiles for which the pictures show skies

Table 7-1

Location and Description of METRO Flight Tracks

Track	Site Reference	Latitude (N)	Longitude (W)	Ground Elevation (m)	Flights	Direction from St. Louis	Terrain Description
1	Quincy/ Capitol	39.9°	90.3°	192	180	N	Cultivated farm area
3	Vandalia	39.4°	88.8°	183	181,182B,185B, 186B	NE	Flat, highly cultivated farmland with multiple small fields
4	Centralia	38.4°	89.1°	153	183B,187B,188B	ESE	Flat, highly cultivated farmland and small bodies of water
7	Maples	37.8°	91.5°	305	182A,183A,185A, 186A,187A	SW	Heavily wooded, rolling hills
9	Hallsville	39.1°	91.6°	244	188A	NW	Cultivated farm area with small fields and woodlands

clear at all altitudes except for a few horizon clouds, and with no clouds appearing in the lower hemisphere. They are flight profiles C-181, C-182B, C-186B, C-187A, C-188A, and C-188B. There are five profiles for which the pictures show only slightly heavier cloud conditions. They are flight profiles C-180, C-182A, C-183A, C-185A, and C-186A. Pictures for these five profiles show skies clear at the top altitude, but with scattered clouds appearing in the lower hemisphere. Thus, at the lower altitudes these five profiles would show skies containing scattered clouds in addition to the horizon clouds. Photographs from the three remaining flight profiles illustrate cloud conditions so severe or unstable that these profiles have been rejected for further processing except for scattering coefficient, equivalent attenuation length, and beam transmittance.

Photographs illustrating typical sky and terrain conditions during four of the data collection profiles are shown in Fig. 7-1 and 7-2. In each instance, the picture on the left represents the sky (upper hemisphere) as seen through a 180-degree lens, and the picture on the right represents the terrain (lower hemisphere). The photographs are taken from both the highest and lowest flight altitudes for each of the two flight profiles.

The photographs representing flight profile C-188B illustrate cloud conditions typical for those six profiles having clear skies at all altitudes. Those representing C-182A illustrate cloud conditions typical for the five profiles having clear skies at only the top altitude. The photographs representing flight profiles C-188A and C-182B are included so that the terrain characteristics for all four reported flight tracks are illustrated.

Table 7-2

Summary of Hemispherical Pictures in Terms of Presence of Clouds

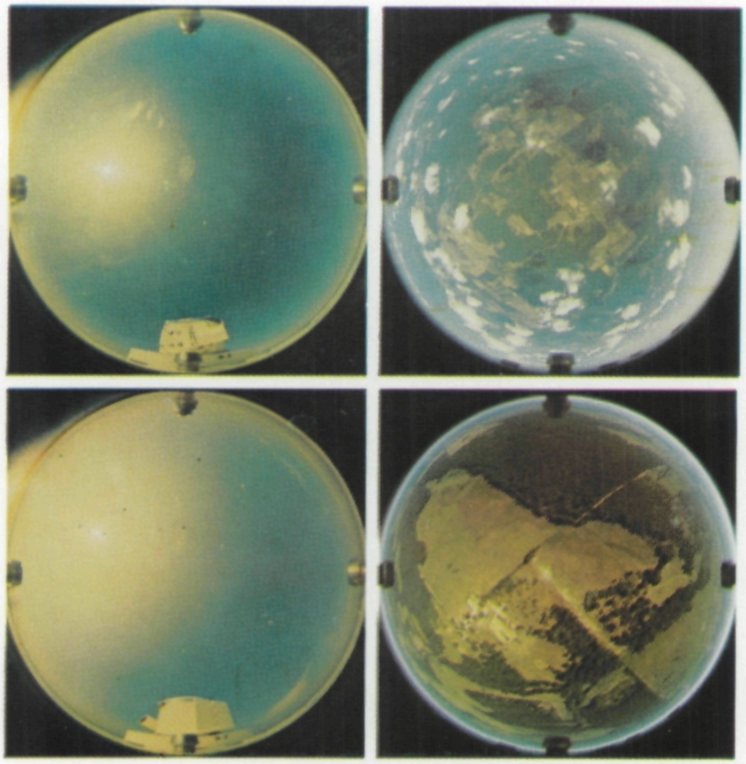
Flight No.	Upper Hemisphere			Lower Hemisphere		
	Low Altitude	Middle Altitude	High Altitude	Low Altitude	Middle Altitude	High Altitude
C-180	scattered clouds	some clouds *	clear	clear	clear	clear
C-181	small horizon clouds	small horizon clouds	clear	clear	clear	clear
C-182A	horizon clouds	some clouds **	clear	clear	few clouds	scattered clouds
C-182B	clear	clear	clear	clear	clear	clear
C-183A	horizon clouds	horizon clouds	horizon clouds	clear	clear	few scattered clouds
C-183B	scattered clouds, sun clear	cloud deck above		clear	few clouds	
C-185A	some horizon clouds	clear	clear	clear	clear	scattered heavy clouds
C-185B	scattered clouds	scattered clouds	clear	clear	clear	scattered clouds
C-186A	clear	some clouds †	clear	clear	clear	scattered clouds
C-186B	clear	some horizon clouds	clear	clear	clear	clear
C-187A	scattered horizon clouds	clear	clear	clear	clear	clear
C-187B	scattered clouds	scattered clouds		clear	clear	
C-188A	clear	clear	clear	clear	clear	clear
C-188B	clear	clear	clear	clear	clear	clear

* Two pictures show clear, and in one picture a large cloud obscures the sun, but all UHS data indicate sun unobscured.

** One picture is clear, one shows horizon clouds, and one has a large cloud deck. Again, all UHS data indicate sun unobscured.

† One picture is clear, one shows horizon clouds, and one looks overcast, but again, all UHS data indicate sun unobscured.

FLIGHT C-182A

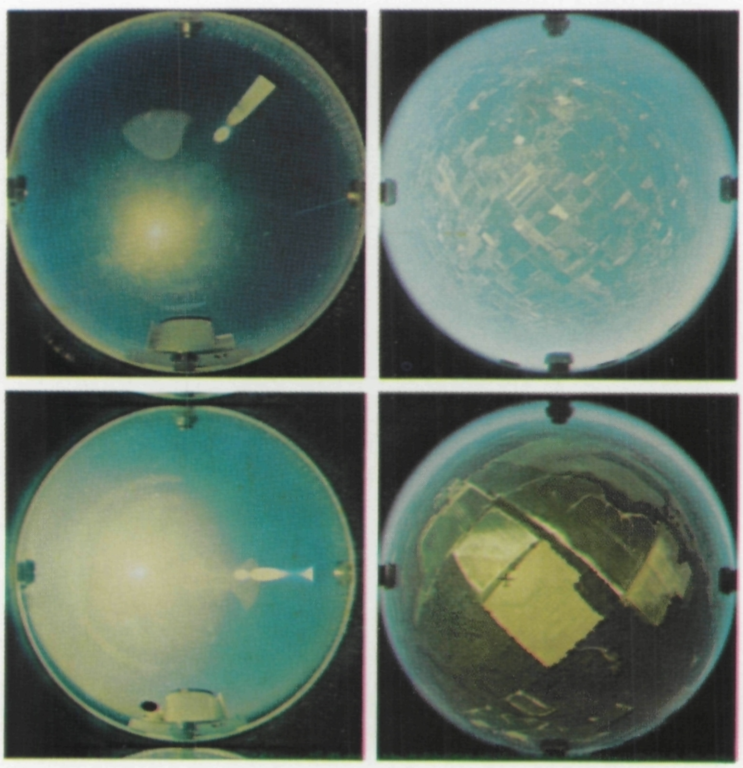


Upper and Lower Hemisphere
2477m AGL 1601 GMT Track 7.

Upper and Lower Hemisphere
134m AGL 1512 GMT Track 7.

Fig. 7-1. Typical Sky and Terrain Photographs for Flight C-182.

FLIGHT C-182B



Upper and Lower Hemisphere
2611m AGL 1814 GMT Track 3.

Upper and Lower Hemisphere
92m AGL 1726 GMT Track 3.

FLIGHT C-188A

Upper and Lower Hemisphere
2555m AGL 1426 GMT Track 9.

Upper and Lower Hemisphere
154m AGL 1343 GMT Track 9.

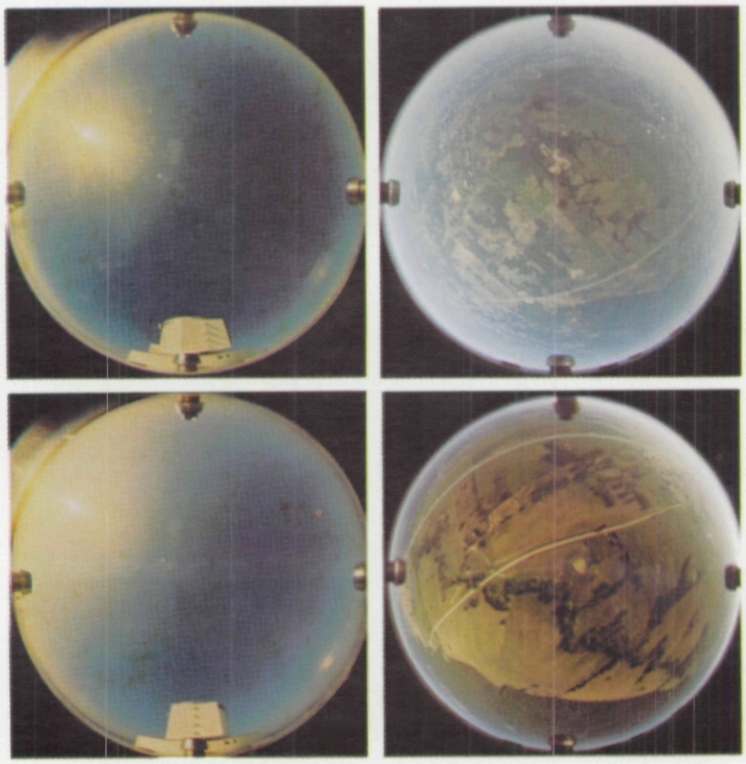


Fig. 7-2. Typical Sky and Terrain Photographs for Flight C-188.

FLIGHT C-188B

Upper and Lower Hemisphere
2641m AGL 1621 GMT Track 4.

Upper and Lower Hemisphere
235m AGL 1542 GMT Track 4.

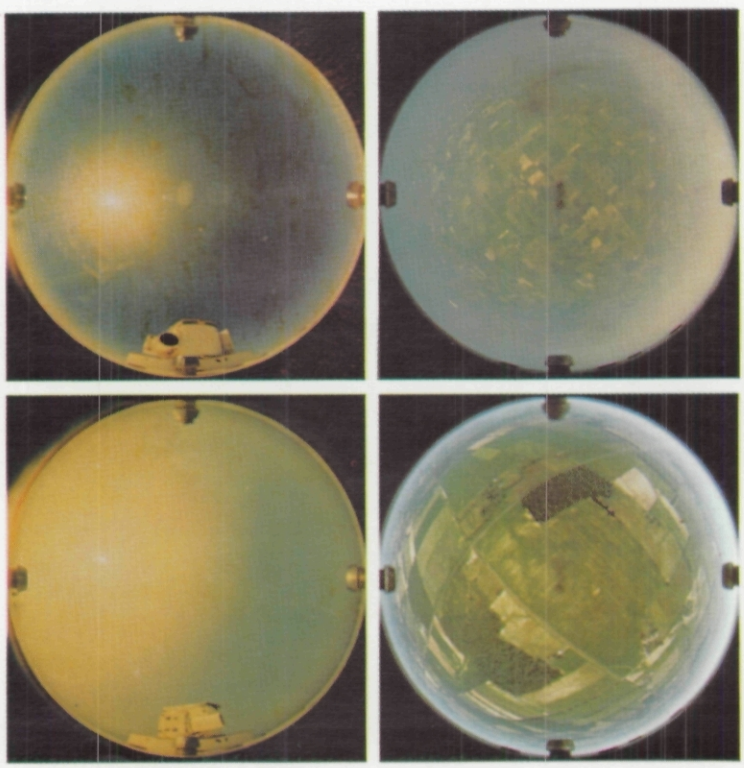


Table 7-3 contains a summary of pertinent descriptive information for the 14 flight profiles for which radiometric data were collected. The flight numbers are sequential. The times under the Total Time of Data-Taking column are Greenwich mean time (GMT) and local civil time (LCT). LCT is local daylight savings time which is equal to GMT-5. The sun zenith angles are tabulated for the time when sky radiance data-taking began, at the time of sun transit (minimum sun zenith angle), and at the conclusion of the sky radiance data-taking. The average sun zenith angles in Col. 12 were used in Eq. 2.6, 2.22, and 2.36 during the calculations leading to the derivation of path radiance and path reflectance. The maximum flight altitude is noted in Column 13.

Table 7-3

METRO Flight Data Summary

		Total Time of Data-Taking						Sun Zenith Angle (degrees)				Maximum Flight Altitude
Flight No.	Date (1971)	GMT	LCT	GMT	LCT	Track	Filters	Start	Transit	End	Average	(meters AGL)
C-180	11 August	1933	1433	2321	1821	1	2,3,4	31.1	–	51.9	40.5	5064
C-181	12 August	1901	1401	2040	1540	3	2,3,4	28.0	–	35.7	31.6	2627
C-182A	13 August	1511	1011	1640	1140	7	2,3,4	45.7	–	35.7	40.6	2490
C-182B	13 August	1726	1226	1856	1356	3	2,3,4	25.6	24.6	25.1	25.0	2615
C-183A	14 August	1502	1002	1635	1135	7	2,3,4	47.5	–	37.8	42.6	2550
C-183B	14 August	1731	1231	1848	1348	4	2,3,4	24.8	24.0	24.0	24.3	2550
C-185A	18 August	1522	1022	1700	1200	7	2,3,4	44.6	–	35.2	39.8	2550
C-185B	18 August	1746	1246	1913	1413	3	2,3,4	26.3	26.2	28.0	26.8	2640
C-186A	19 August	1543	1043	1707	1207	7	2,3,4	41.0	–	32.9	36.8	2520
C-186B	19 August	1751	1251	1857	1357	3	2,3	26.6	26.5	28.4	27.2	2610
C-187A	23 August	1742	1242	1900	1400	7	2,3,4	27.0	26.4	26.8	26.6	2520
C-187B	23 August	1942	1442	2024	1524	4	2,3,4	35.5	–	39.8	37.6	1440
C-188A	24 August	1339	839	1501	1001	9	2,3,4	65.4	–	55.8	60.6	2580
C-188B	24 August	1539	1039	1658	1158	4	2,3,4	41.3	–	34.4	37.7	2643

Radiometric data for five flights representing eight separate profiles are presented tabularly and graphically in Section 7.3 in sets by flight number. The eight profiles consist of the six with nearly clear skies, C-181, C-182B, C-186B, C-187A, C-188A, and C-188B, plus C-182A and C-186A, included to complete three double sets. A detailed description and report of weather characteristics are given as the introductory page of each data set.

The beam transmittance is extrapolated from space to the highest altitude of flight as described in Section 2.1. 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 eight flight profiles in Table 7-4.

Table 7-4

Vertical Beam Transmittance, Space to Sensor and Space to Ground

Flight No.	Date (1971)	Sensor Altitude (meters AGL)	Space-to-Sensor Beam Transmittance			Space-to-Ground Beam Transmittance		
			Filter 2	Filter 4	Filter 3	Filter 2	Filter 4	Filter 3
C-181	12 August	3000	0.881	0.899	0.914	0.584	0.659	0.745
C-182A	13 August	3000	0.883	0.924	0.945	0.566	0.680	0.776
C-182B	13 August	3000	0.829	0.782	0.923	0.486	0.511	0.722
C-186A	19 August	3000	0.869	0.900	0.953	0.368	0.495	0.582
C-186B	19 August	3000	0.863	–	0.938	0.420	–	0.717
C-187A	23 August	3000	0.873	0.925	0.970	0.612	0.716	0.818
C-188A	24 August	3000	0.873	0.888	0.878	0.648	0.725	0.758
C-188B	24 August	3000	0.836	0.893	0.886	0.333	0.483	0.576

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 directional 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.

Irradiance. The downwelling irradiances $H(z,d)$ and upwelling irradiances $H(z,u)$, albedos $H(z,u)/H(z,d)$, scalar irradiances ${}_{s}h(z)$, ${}_{k}h(z,d)$, $h(z,u)$, 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 three tables of irradiance for each flight, one table for each optical filter. The dimensions and units for the irradiances are "$wm^{-2}\mu m^{-1}$". Albedos are, of course, dimensionless.

The irradiances for Filter Code Number 4 can be converted to illuminance values in units of lumens per square meter by multiplying each irradiance by the factor 72.0 luμm/w.

Directional Reflectance of Background. The directional background reflectance ${}_{b}R_{o}(z,\theta,\phi)$ is tabulated by zenith angle in three columns for the three 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 ${}_{b}R_{o}(0,\theta,\phi)$ and the downwelling irradiance $H(z_t,d)$:

$$ {}_{b}N_{o}(z_t,\theta,\phi) = \frac{1}{\pi}\, {}_{b}R_{o}(z_t,\theta,\phi)\, H(z_t,d) \,. \qquad (7.1)$$

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 4 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 three columns for the three 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 six zenith angles from 95 to 180 degrees. There are three 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 six zenith angles from 95 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 three 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 4 may be converted to path luminance values with units of lu/Ωm² by multiplying the radiance by the factor 72.0 luμm/w.

Directional Path Reflectance from Ground to Altitude. Directional path reflectance $R_r^*(z,\theta,\phi)$ is also tabulated for the downward-looking slant paths of sight, between ground and the altitude shown, for the six zenith angles from 95 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 three 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:

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

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 measurements and the sun irradiance 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 equivalent attenuation length $\bar{L}(z)$ is a pseudo-attenuation length which, when combined with its altitude z, can be used directly in Eq. 2.12 to compute beam transmittance. 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 three 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 three 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) unless otherwise specified. The flight log entries have two altitudes specified: (1) the altitude of flight in meters AGL at the time of the observation and (2) the estimated altitude in feet mean sea level (MSL) of the observed cloud or haze feature.

FLIGHT C-181 – 12 AUGUST 1971 – TRACK 3 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon. At the beginning of data-taking, the sky was covered with thin broken cirrus clouds which decreased to 0.3 coverage by the end of data-taking. The flight was conducted over multiple small fields northeast of St. Louis. The typical terrain was flat, highly cultivated farmland. Data-taking started at 1901 GMT (1401 CDT) and continued until 2040 GMT (1540 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 28.0 degrees at the beginning and 35.7 degrees at the end. The maximum altitude for the flight was 2627 meters. Average elevation of terrain along this track was 183 meters.

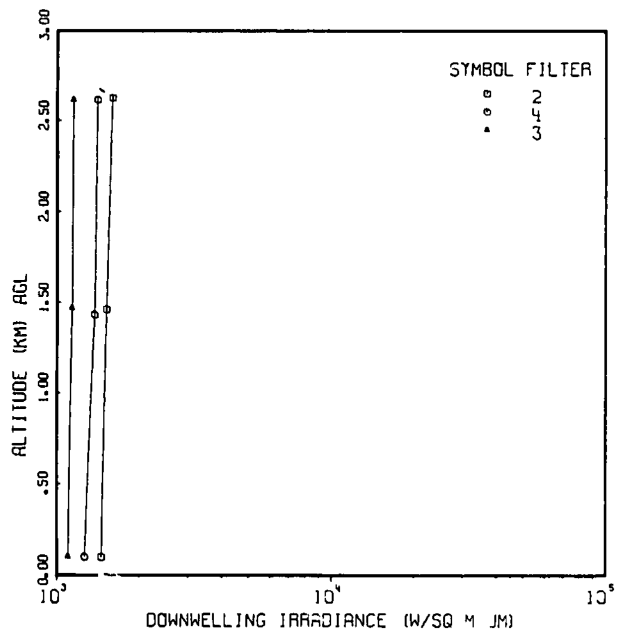
> At the beginning of data-taking, Scott Air Force Base was reporting 0.7 thin broken cirrostratus clouds at 25 000 feet (7500 meters), with 20-mile (32-kilometer) visibility.
>
> The ground station located at Scott, 70 miles (110 kilometers) from the center of the flight path, recorded hot, clear, some high cirrus.
>
> During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Moderate haze with tops at 5500 feet (MSL) (1650 meters). No clouds overhead, 10-mile (16-kilometer) slant range visibility at the end of the mission.
>
> At the end of data-taking, Scott was reporting 0.3 cirrus at 25 000 feet (7500 meters). The visibility was reported as 20 miles (32 kilometers).

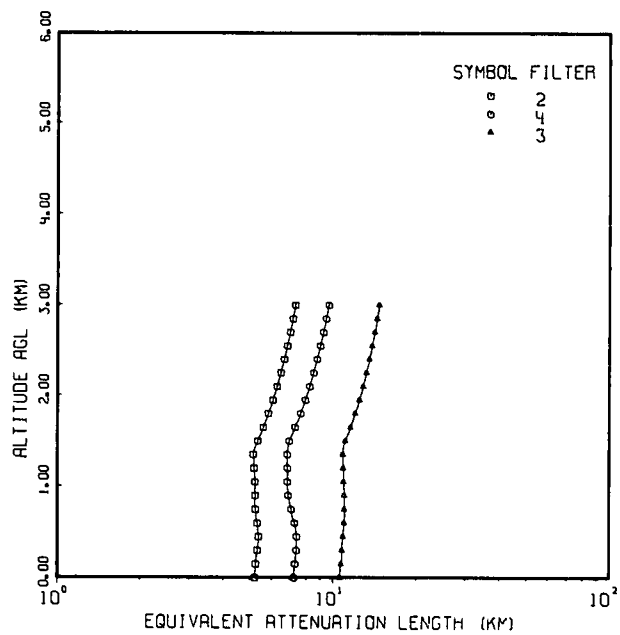
The surface synoptic chart shows a weak circulation. The area was on the rear of a weak high which had a center in Ohio. A slow-moving cold front was in the Dakotas.

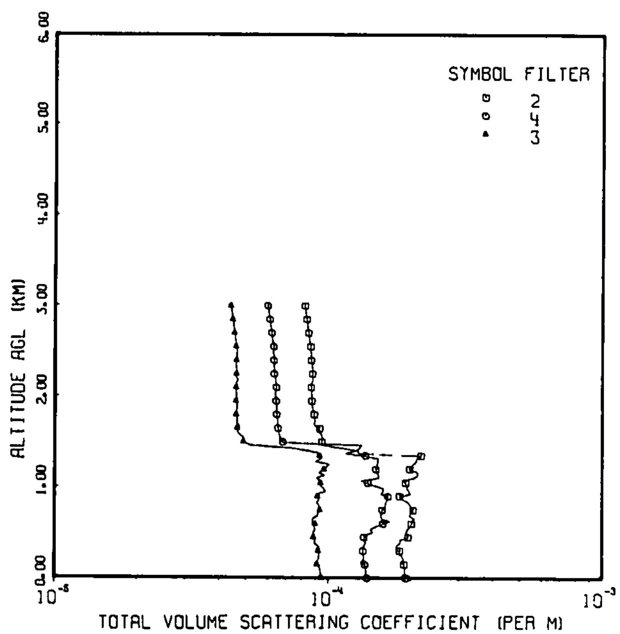
At 500 millibars there was a trough from Ontario to Virginia with slight ridging over Indiana. The gradient was very weak.

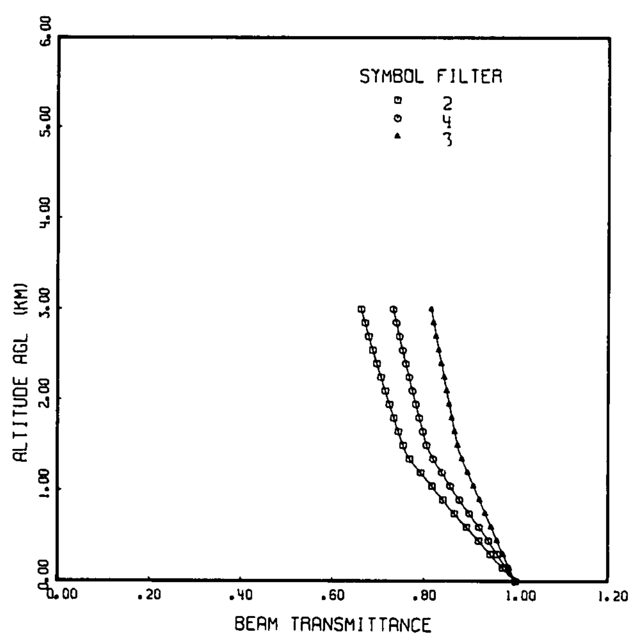
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-181









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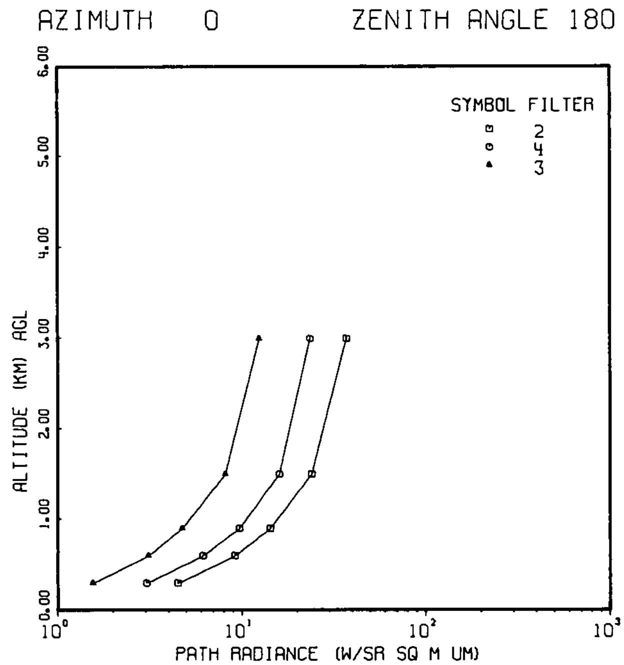

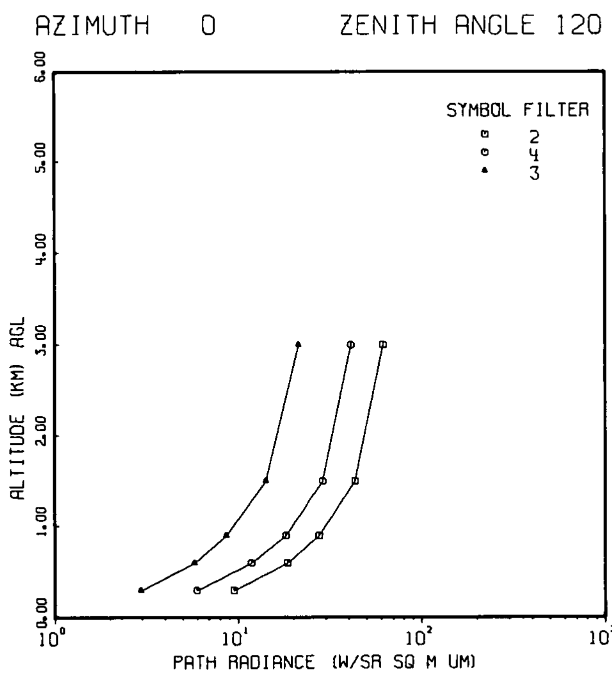

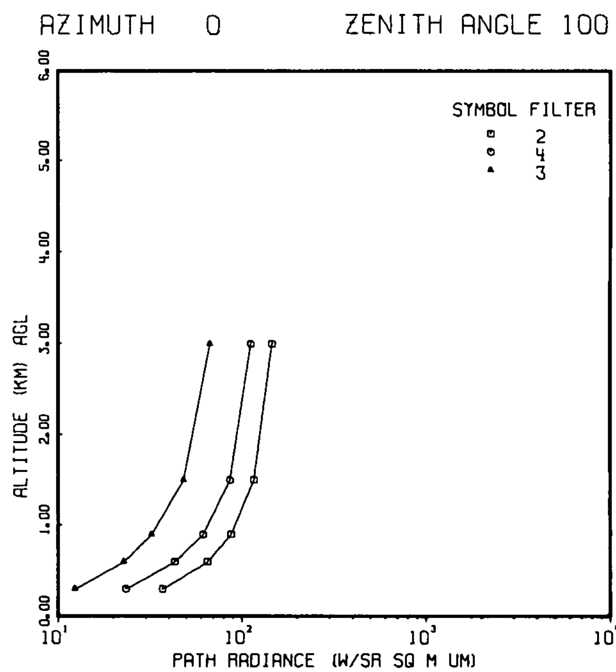

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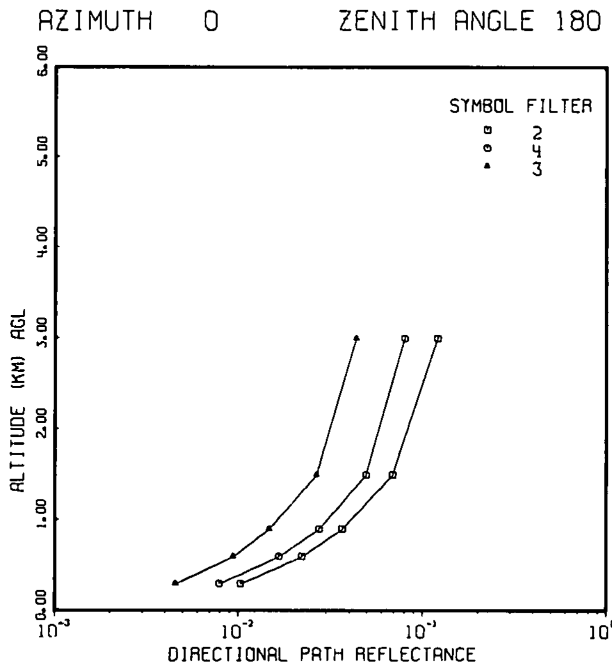
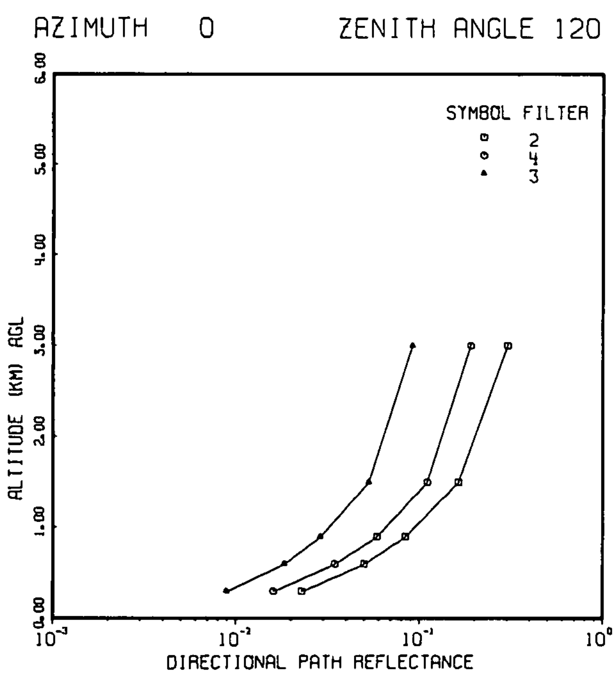
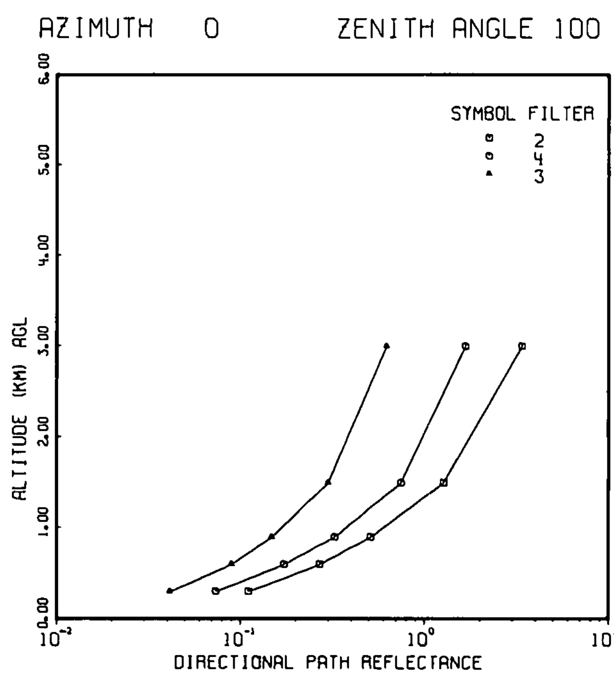






FLIGHT NO. C-181
IRRADIANCE

(JOB 5032 DATE 03/05/73)

FLIGHT NO.C-181 FILTER NO. 2 SUN ZENITH ANGLE 31.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
100	1.46E 03	6.06E 01	.042	1.13E 03	8.68E 02	1.50E 02	2.15E 03	.075
1464	1.52E 03	1.15E 02	.076	1.54E 03	4.72E 02	2.99E 02	2.31E 03	.149
2627	1.59E 03	1.26E 02	.079	1.73E 03	4.33E 02	3.48E 02	2.52E 03	.161

FLIGHT NO.C-181 FILTER NO. 4 SUN ZENITH ANGLE 31.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
101	1.27E 03	8.20E 01	.065	1.15E 03	5.19E 02	1.76E 02	1.85E 03	.105
1435	1.37E 03	1.08E 02	.079	1.45E 03	3.05E 02	2.63E 02	2.02E 03	.150
2617	1.41E 03	1.16E 02	.082	1.59E 03	2.85E 02	2.97E 02	2.17E 03	.158

FLIGHT NO.C-181 FILTER NO. 3 SUN ZENITH ANGLE 31.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
103	1.10E 03	5.10E 01	.046	1.09E 03	2.90E 02	1.07E 02	1.49E 03	.077
1471	1.13E 03	7.03E 01	.062	1.27E 03	1.27E 02	1.64E 02	1.56E 03	.118
2617	1.15E 03	6.84E 01	.060	1.35E 03	1.23E 02	1.72E 02	1.64E 03	.117

FLIGHT NO. C-181
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5032 CATE 03/05/73)

FLIGHT NO. C-181
AZIMUTH OF PATH OF SIGHT = C
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0981	.0913	.0572
100	.0573	.0767	.C508
105	.0487	.0697	.0468
120	.0322	.0286	.0306
150	.0152	.0917	.0418
180	.0376	.0655	.0664

FLIGHT NO. C-181
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0855	.0934	.0508
100	.0505	.0852	.0447
105	.0444	.0666	.0412
120	.0409	.0522	.0368
150	.0182	.0502	.0451
180	.0376	.0655	.C664

FLIGHT NO. C-181
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0911	.1008	.0772
100	.0606	.0888	.0613
105	.0739	.0803	.0499
120	.0954	.0813	.0417
150	.0372	.1056	.0619
180	.0376	.0655	.C664

FLIGHT NO. C-181
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0896	.0902	.0571
100	.0385	.0773	.0514
105	.0707	.0755	.0563
120	.0534	.0605	.0487
150	.0312	.0731	.0463
180	.0376	.0655	.0664

FLIGHT NO. C-181
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5032 CATE 03/05/73)
DATE 81271 FLIGHT NO. C-181 GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	9.53E-05	6.61E-05	4.88E-05
1560	9.43E-05	6.66E-05	4.86E-05
1590	9.42E-05	6.58E-05	4.69E-05
1620	9.08E-05	6.56E-05	4.63E-05
1650	9.25E-05	6.52E-05	4.62E-05
1680	8.90E-05	6.51E-05	4.71E-05
1710	8.85E-05	6.49E-05	4.60E-05
1740	8.93E-05	6.49E-05	4.61E-05
1770	8.85E-05	6.47E-05	4.61E-05
1800	8.84E-05	6.44E-05	4.59E-05
1830	8.84E-05	6.44E-05	4.57E-05
1860	8.74E-05	6.43E-05	4.60E-05
1890	8.71E-05	6.45E-05	4.62E-05
1920	8.65E-05	6.41E-05	4.61E-05
1950	8.66E-05	6.41E-05	4.58E-05
1980	8.66E-05	6.41E-05	4.61E-05
2010	8.66E-05	6.38E-05	4.59E-05
2040	8.65E-05	6.37E-05	4.59E-05
2070	8.63E-05	6.39E-05	4.58E-05
2100	8.60E-05	6.41E-05	4.59E-05
2130	8.62E-05	6.43E-05	4.60E-05
2160	8.65E-05	6.40E-05	4.58E-05
2190	8.76E-05	6.36E-05	4.66E-05
2220	8.67E-05	6.37E-05	4.58E-05
2250	8.69E-05	6.30E-05	4.60E-05
2280	8.74E-05	6.32E-05	4.60E-05
2310	8.72E-05	6.32E-05	4.60E-05
2340	8.68E-05	6.30E-05	4.57E-05
2370	8.67E-05	6.30E-05	4.57E-05
2400	8.62E-05	6.28E-05	4.60E-05
2430	8.63E-05	6.30E-05	4.59E-05
2460	8.61E-05	6.28E-05	4.60E-05
2490	8.60E-05	6.25E-05	4.60E-05
2520	8.52E-05	6.26E-05	4.61E-05
2550	8.58E-05	6.27E-05	4.58E-05
2580	8.56E-05	6.30E-05	4.57E-05
2610	8.50E-05	6.22E-05	4.56E-05
2640	8.47E-05	6.20E-05	4.55E-05
2670	8.44E-05	6.18E-05	4.53E-05
2700	8.42E-05	6.16E-05	4.52E-05
2730	8.39E-05	6.14E-05	4.51E-05
2760	8.36E-05	6.12E-05	4.49E-05
2790	8.34E-05	6.11E-05	4.48E-05
2820	8.31E-05	6.09E-05	4.46E-05
2850	8.29E-05	6.07E-05	4.45E-05
2880	8.26E-05	6.05E-05	4.44E-05
2910	8.23E-05	6.03E-05	4.42E-05
2940	8.21E-05	6.01E-05	4.41E-05
2970	8.18E-05	5.99E-05	4.39E-05
3000	8.16E-05	5.97E-05	4.38E-05
FIRST DATA ALT	120	120	90
LAST DATA ALT	2610	2610	2610

FLIGHT NO. C-181
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5032 DATE 03/05/73)
DATE 81271 FLIGHT NO. C-181 GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
0	1.92E-04	1.39E-04	9.44E-05
30	1.91E-04	1.38E-04	9.40E-05
60	1.91E-04	1.37E-04	9.37E-05
90	1.90E-04	1.37E-04	9.35E-05
120	1.90E-04	1.37E-04	9.28E-05
150	1.89E-04	1.36E-04	9.10E-05
180	1.86E-04	1.32E-04	9.04E-05
210	1.89E-04	1.35E-04	9.25E-05
240	1.87E-04	1.35E-04	9.24E-05
270	1.82E-04	1.34E-04	9.28E-05
300	1.82E-04	1.34E-04	9.20E-05
330	1.77E-04	1.33E-04	9.26E-05
360	1.78E-04	1.35E-04	9.18E-05
390	1.83E-04	1.36E-04	8.88E-05
420	1.83E-04	1.36E-04	8.93E-05
450	1.95E-04	1.35E-04	8.82E-05
480	1.94E-04	1.39E-04	8.85E-05
510	1.92E-04	1.45E-04	8.80E-05
540	1.94E-04	1.42E-04	8.94E-05
570	1.99E-04	1.48E-04	8.87E-05
600	2.01E-04	1.58E-04	8.94E-05
630	2.04E-04	1.68E-04	8.75E-05
660	2.07E-04	1.56E-04	8.77E-05
690	1.99E-04	1.56E-04	9.10E-05
720	1.99E-04	1.56E-04	9.17E-05
750	2.04E-04	1.57E-04	9.30E-05
780	2.00E-04	1.61E-04	9.27E-05
810	1.99E-04	1.62E-04	9.19E-05
840	1.95E-04	1.63E-04	9.07E-05
870	1.87E-04	1.64E-04	9.22E-05
900	1.82E-04	1.65E-04	9.11E-05
930	2.00E-04	1.55E-04	9.27E-05
960	1.97E-04	1.58E-04	9.76E-05
990	1.93E-04	1.59E-04	9.61E-05
1020	1.94E-04	1.49E-04	9.35E-05
1050	1.91E-04	1.39E-04	9.36E-05
1080	1.89E-04	1.31E-04	9.28E-05
1110	2.05E-04	1.53E-04	9.02E-05
1140	2.12E-04	1.52E-04	9.70E-05
1170	2.11E-04	1.50E-04	9.21E-05
1200	1.98E-04	1.49E-04	9.63E-05
1230	2.01E-04	1.51E-04	9.82E-05
1260	2.05E-04	1.51E-04	1.01E-04
1290	2.09E-04	1.51E-04	8.93E-05
1320	2.10E-04	1.52E-04	9.41E-05
1350	2.18E-04	1.36E-04	9.28E-05
1380	1.29E-04	1.15E-04	9.12E-05
1410	1.28E-04	1.27E-04	8.42E-05
1440	1.12E-04	1.30E-04	7.28E-05
1470	9.55E-05	1.32E-04	5.18E-05
1500	9.45E-05	6.79E-05	4.88E-05

FLIGHT NO. C-181
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5032 DATE 03/05/73)

FLIGHT NO. C-181 FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.22E-01	7.22E-01	8.04E-01	8.93E-01	9.37E-01	9.45E-01
600	2.71E-01	5.22E-01	6.46E-01	7.98E-01	8.78E-01	8.93E-01
900	1.36E-01	3.70E-01	5.13E-01	7.08E-01	8.19E-01	8.42E-01
1500	3.77E-02	1.98E-01	3.37E-01	5.69E-01	7.22E-01	7.55E-01
3000	7.54E-03	9.34E-02	2.04E-01	4.39E-01	6.22E-01	6.63E-01

FLIGHT NO. C-181 FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.26E-01	7.91E-01	8.54E-01	9.22E-01	9.54E-01	9.60E-01
600	3.86E-01	6.21E-01	7.27E-01	8.48E-01	9.09E-01	9.21E-01
900	2.20E-01	4.71E-01	6.03E-01	7.70E-01	8.60E-01	8.77E-01
1500	8.06E-02	2.88E-01	4.33E-01	6.49E-01	7.79E-01	8.05E-01
3000	2.48E-02	1.66E-01	3.00E-01	5.37E-01	6.98E-01	7.32E-01

FLIGHT NO. C-181 FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.26E-01	8.52E-01	8.98E-01	9.46E-01	9.68E-01	9.73E-01
600	5.32E-01	7.30E-01	8.10E-01	8.96E-01	9.39E-01	9.47E-01
900	3.88E-01	6.24E-01	7.29E-01	8.49E-01	9.10E-01	9.21E-01
1500	2.07E-01	4.58E-01	5.92E-01	7.63E-01	8.55E-01	8.73E-01
3000	8.86E-02	3.08E-01	4.54E-01	6.65E-01	7.90E-01	8.15E-01

FLIGHT NO. C-181
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5032 DATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-181 FILTER NO. 2
RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.58E 01	3.71E 01	2.33E 01	9.48E 00	4.57E 00	4.51E 00
600	1.16E 02	6.53E 01	4.31E 01	1.85E 01	9.25E 00	9.21E 00
900	1.39E 02	8.78E 01	6.07E 01	2.76E 01	1.43E 01	1.43E 01
1500	1.61E 02	1.17E 02	8.66E 01	4.34E 01	2.37E 01	2.42E 01
3000	1.87E 02	1.47E 02	1.14E 02	6.19E 01	3.54E 01	3.72E 01

FLIGHT NO. C-181 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.02E 01	2.35E 01	1.46E 01	5.96E 00	3.00E 00	3.04E 00
600	8.30E 01	4.33E 01	2.80E 01	1.18E 01	6.05E 00	6.17E 00
900	1.07E 02	6.18E 01	4.14E 01	1.83E 01	9.50E 00	9.74E 00
1500	1.30E 02	8.67E 01	6.14E 01	2.89E 01	1.55E 01	1.61E 01
3000	1.56E 02	1.12E 02	8.27E 01	4.13E 01	2.26E 01	2.36E 01

FLIGHT NO. C-181 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.79E 01	1.24E 01	7.54E 00	2.95E 00	1.47E 00	1.55E 00
600	4.78E 01	2.29E 01	1.43E 01	5.78E 00	2.92E 00	3.11E 00
900	6.31E 01	3.25E 01	2.08E 01	8.64E 00	4.44E 00	4.76E 00
1500	8.35E 01	4.84E 01	3.23E 01	1.42E 01	7.52E 00	8.18E 00
3000	1.05E 02	6.74E 01	4.64E 01	2.15E 01	1.15E 01	1.25E 01

FLIGHT NO. C-181
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5032 DATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-181 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.07E 01	2.67E 01	1.79E 01	8.65E 00	4.93E 00	4.51E 00
600	7.79E 01	4.72E 01	3.32E 01	1.70E 01	1.00E 01	9.21E 00
900	9.40E 01	6.39E 01	4.71E 01	2.54E 01	1.55E 01	1.43E 01
1500	1.09E 02	8.59E 01	6.79E 01	4.02E 01	2.58E 01	2.42E 01
3000	1.24E 02	1.06E 02	8.93E 01	5.77E 01	3.92E 01	3.72E 01

FLIGHT NO. C-181 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.25E 01	1.66E 01	1.11E 01	5.50E 00	3.30E 00	3.04E 00
600	5.33E 01	3.05E 01	2.12E 01	1.09E 01	6.67E 00	6.17E 00
900	6.78E 01	4.33E 01	3.13E 01	1.69E 01	1.05E 01	9.74E 00
1500	8.14E 01	6.01E 01	4.63E 01	2.68E 01	1.73E 01	1.61E 01
3000	9.36E 01	7.56E 01	6.12E 01	3.79E 01	2.52E 01	2.36E 01

FLIGHT NO. C-181 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.66E 01	8.17E 00	5.43E 00	2.70E 00	1.67E 00	1.55E 00
600	2.84E 01	1.52E 01	1.03E 01	5.28E 00	3.32E 00	3.11E 00
900	3.74E 01	2.15E 01	1.50E 01	7.89E 00	5.05E 00	4.76E 00
1500	4.94E 01	3.20E 01	2.34E 01	1.30E 01	8.58E 00	8.18E 00
3000	5.91E 01	4.29E 01	3.29E 01	1.93E 01	1.31E 01	1.25E 01

FLIGHT NO. C-181
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5032 DATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-181 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.84E 01	2.67E 01	1.86E 01	1.00E 01	6.24E 00	4.51E 00
600	7.51E 01	4.75E 01	3.48E 01	1.99E 01	1.28E 01	9.21E 00
900	9.15E 01	6.47E 01	4.97E 01	3.00E 01	2.01E 01	1.43E 01
1500	1.08E 02	8.82E 01	7.27E 01	4.80E 01	3.42E 01	2.42E 01
3000	1.30E 02	1.15E 02	1.00E 02	7.30E 01	5.54E 01	3.72E 01

FLIGHT NO. C-181 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.07E 01	1.65E 01	1.16E 01	6.46E 00	4.24E 00	3.04E 00
600	5.07E 01	3.05E 01	2.22E 01	1.29E 01	8.59E 00	6.17E 00
900	6.51E 01	4.36E 01	3.31E 01	2.00E 01	1.36E 01	9.74E 00
1500	7.94E 01	6.13E 01	4.94E 01	3.20E 01	2.23E 01	1.61E 01
3000	9.41E 01	7.93E 01	6.72E 01	4.68E 01	3.36E 01	2.36E 01

FLIGHT NO. C-181 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.57E 01	8.23E 00	5.78E 00	3.30E 00	2.26E 00	1.55E 00
600	2.72E 01	1.54E 01	1.11E 01	6.53E 00	4.57E 00	3.11E 00
900	3.61E 01	2.19E 01	1.62E 01	9.85E 00	7.06E 00	4.76E 00
1500	4.87E 01	3.32E 01	2.57E 01	1.65E 01	1.23E 01	8.18E 00
3000	5.89E 01	4.53E 01	3.68E 01	2.52E 01	1.92E 01	1.25E 01

FLIGHT NO. C-181
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5032 CATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-181 FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.13E 01	2.71E 01	1.82E 01	8.82E 00	5.05E 00	4.51E 00
600	7.84E 01	4.76E 01	3.35E 01	1.72E 01	1.02E 01	9.21E 00
900	9.40E 01	6.40E 01	4.72E 01	2.56E 01	1.57E 01	1.43E 01
1500	1.08E 02	8.51E 01	6.74E 01	4.01E 01	2.60E 01	2.42E 01
3000	1.22E 02	1.05E 02	8.80E 01	5.72E 01	3.93E 01	3.72E 01

FLIGHT NO. C-181 FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.24E 01	1.67E 01	1.12E 01	5.61E 00	3.37E 00	3.04E 00
600	5.29E 01	3.04E 01	2.12E 01	1.11E 01	6.80E 00	6.17E 00
900	6.71E 01	4.30E 01	3.12E 01	1.70E 01	1.07E 01	9.74E 00
1500	7.96E 01	5.90E 01	4.56E 01	2.67E 01	1.74E 01	1.61E 01
3000	9.21E 01	7.44E 01	6.03E 01	3.77E 01	2.54E 01	2.36E 01

FLIGHT NO. C-181 FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.68E 01	8.26E 00	5.48E 00	2.71E 00	1.68E 00	1.55E 00
600	2.87E 01	1.53E 01	1.04E 01	5.31E 00	3.34E 00	3.11E 00
900	3.77E 01	2.16E 01	1.51E 01	7.93E 00	5.08E 00	4.76E 00
1500	4.96E 01	3.21E 01	2.35E 01	1.30E 01	8.62E 00	8.18E 00
3000	5.90E 01	4.29E 01	3.29E 01	1.94E 01	1.31E 01	1.25E 01

FLIGHT NO. C-181
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5032 DATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-181 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	3.13E-01	1.11E-01	6.26E-02	2.29E-02	1.05E-02	1.03E-02
600	9.22E-01	2.70E-01	1.44E-01	5.01E-02	2.27E-02	2.22E-02
900	2.21E 00	5.11E-01	2.55E-01	8.41E-02	3.75E-02	3.67E-02
1500	9.19E 00	1.27E 00	5.54E-01	1.64E-01	7.06E-02	6.90E-02
3000	5.34E 01	3.38E 00	1.20E 00	3.04E-01	1.23E-01	1.21E-01

FLIGHT NO. C-181 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	1.99E-01	7.36E-02	4.25E-02	1.60E-02	7.79E-03	7.87E-03
600	5.34E-01	1.73E-01	9.55E-02	3.46E-02	1.65E-02	1.66E-02
900	1.20E 00	3.26E-01	1.70E-01	5.88E-02	2.74E-02	2.76E-02
1500	4.02E 00	7.48E-01	3.52E-01	1.11E-01	4.95E-02	4.95E-02
3000	1.56E 01	1.68E 00	6.83E-01	1.91E-01	8.05E-02	8.00E-02

FLIGHT NO. C-181 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	1.09E-01	4.14E-02	2.40E-02	8.90E-03	4.32E-03	4.55E-03
600	2.56E-01	8.96E-02	5.05E-02	1.84E-02	8.88E-03	9.38E-03
900	4.64E-01	1.48E-01	8.14E-02	2.90E-02	1.39E-02	1.47E-02
1500	1.15E 00	3.01E-01	1.56E-01	5.32E-02	2.51E-02	2.67E-02
3000	3.37E 00	6.23E-01	2.92E-01	9.21E-02	4.15E-02	4.38E-02

FLIGHT NO. C-181
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5032 CATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-181 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	2.C9E-01	7.97E-02	4.80E-02	2.09E-02	1.13E-02	1.03E-02
600	6.19E-01	1.95E-01	1.11E-01	4.59E-02	2.46E-02	2.22E-02
900	1.49E 00	3.72E-01	1.98E-01	7.74E-02	4.07E-02	3.67E-02
1500	6.25E 00	9.37E-01	4.35E-01	1.52E-01	7.70E-02	6.90E-02
3000	3.54E 01	2.45E 00	9.44E-01	2.83E-01	1.36E-01	1.21E-01

FLIGHT NO. C-181 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.29E-01	5.21E-02	3.23E-02	1.48E-02	8.57E-03	7.87E-03
600	3.43E-01	1.22E-01	7.24E-02	3.20E-02	1.82E-02	1.66E-02
900	7.63E-01	2.28E-01	1.29E-01	5.44E-02	3.03E-02	2.76E-02
1500	2.51E 00	5.19E-01	2.65E-01	1.03E-01	5.50E-02	4.95E-02
3000	9.35E 00	1.13E 00	5.06E-01	1.75E-01	8.96E-02	8.00E-02

FLIGHT NO. C-181 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	6.50E-02	2.74E-02	1.72E-02	8.13E-03	4.91E-03	4.55E-03
600	1.52E-01	5.92E-02	3.64E-02	1.68E-02	1.01E-02	9.38E-03
900	2.75E-01	9.82E-02	5.87E-02	2.65E-02	1.58E-02	1.47E-02
1500	6.83E-01	1.99E-01	1.13E-01	4.86E-02	2.86E-02	2.67E-02
3000	1.90E 00	3.97E-01	2.07E-01	8.27E-02	4.71E-02	4.38E-02

FLIGHT NO. C-181
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5032 DATE 03/05/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-181 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.00E-01	7.96E-02	4.99E-02	2.42E-02	1.44E-02	1.03E-02
600	5.97E-01	1.96E-01	1.16E-01	5.37E-02	3.15E-02	2.22E-02
900	1.45E 00	3.77E-01	2.09E-01	9.12E-02	5.28E-02	3.67E-02
1500	6.19E 00	9.62E-01	4.65E-01	1.82E-01	1.02E-01	6.90E-02
3000	3.70E 01	2.65E 00	1.06E 00	3.59E-01	1.92E-01	1.21E-01

FLIGHT NO. C-181 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.22E-01	5.18E-02	3.37E-02	1.74E-02	1.10E-02	7.87E-03
600	3.26E-01	1.22E-01	7.59E-02	3.77E-02	2.34E-02	1.66E-02
900	7.33E-01	2.30E-01	1.36E-01	6.45E-02	3.91E-02	2.76E-02
1500	2.45E 00	5.29E-01	2.83E-01	1.23E-01	7.12E-02	4.95E-02
3000	9.40E 00	1.18E 00	5.55E-01	2.16E-01	1.19E-01	8.00E-02

FLIGHT NO. C-181 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.17E-02	2.75E-02	1.84E-02	9.97E-03	6.66E-03	4.55E-03
600	1.46E-01	6.01E-02	3.91E-02	2.08E-02	1.39E-02	9.38E-03
900	2.66E-01	1.00E-01	6.36E-02	3.31E-02	2.21E-02	1.47E-02
1500	6.72E-01	2.07E-01	1.24E-01	6.16E-02	4.11E-02	2.67E-02
3000	1.90E 00	4.19E-01	2.31E-01	1.08E-01	6.93E-02	4.38E-02

FLIGHT NO. C-181
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5032 CATE 03/C5/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-181 FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDB

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	2.12E-01	8.07E-02	4.87E-02	2.13E-02	1.16E-02	1.03E-02
600	6.23E-C1	1.97E-01	1.12E-01	4.65E-02	2.50E-02	2.22E-02
900	1.49E C0	3.73E-01	1.98E-01	7.80E-02	4.13E-02	3.67E-02
1500	6.17E C0	9.28E-01	4.31E-01	1.52E-01	7.75E-02	6.90E-02
3000	3.47E 01	2.41E 00	9.30E-01	2.81E-01	1.36E-01	1.21E-01

FLIGHT NO. C-181 FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.29E-01	5.23E-02	3.25E-02	1.51E-02	8.78E-03	7.87E-03
600	3.41E-01	1.22E-01	7.25E-02	3.24E-02	1.86E-02	1.66E-02
900	7.55E-01	2.26E-01	1.28E-01	5.48E-02	3.08E-02	2.76E-02
1500	2.45E 00	5.09E-01	2.61E-01	1.02E-01	5.56E-02	4.95E-02
3000	9.21E 00	1.11E 00	4.99E-01	1.75E-01	9.03E-02	8.00E-02

FLIGHT NO. C-181 FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.58E-02	2.77E-02	1.74E-02	8.18E-03	4.94E-03	4.55E-03
600	1.54E-01	5.98E-02	3.67E-02	1.69E-02	1.01E-02	9.38E-03
900	2.77E-C1	9.89E-02	5.91E-02	2.66E-02	1.59E-02	1.47E-02
1500	6.85E-01	2.C0E-01	1.13E-01	4.88E-02	2.87E-02	2.67E-02
3000	1.90E 00	3.97E-01	2.07E-01	8.31E-02	4.75E-02	4.38E-02

FLIGHT C-182A – 13 AUGUST 1971 – TRACK 7 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit morning. At the beginning of data-taking, the sky was covered with 0.4 altocumulus clouds which dissipated by the end of data-taking. The flight was conducted over rolling hills southwest of St. Louis. The typical terrain was heavily wooded. The data-taking started at 1511 GMT (1011 CDT) and continued until 1640 GMT (1140 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 45.7 degrees at the beginning and 35.7 degrees at the end. The maximum altitude for the flight was 2490 meters. Average elevation of the terrain on this track was 305 meters.

At the beginning of data-taking, Scott Air Force Base was reporting 0.4 altocumulus at 13 000 feet (3900 meters), with 8-mile (12.8-kilometer) visibility.

The ground station located at Scott, 85 miles (137 kilometers) from the center of the flight path, recorded clear with moderate to heavy haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
1510	-	Light to moderate haze, no clouds overhead
1535	1270	Clear above with scattered cumulus below
1553	2290	Moderate to heavy haze
1604	-	Scattered cumulus below, light smoke from wood kiln and brush fire

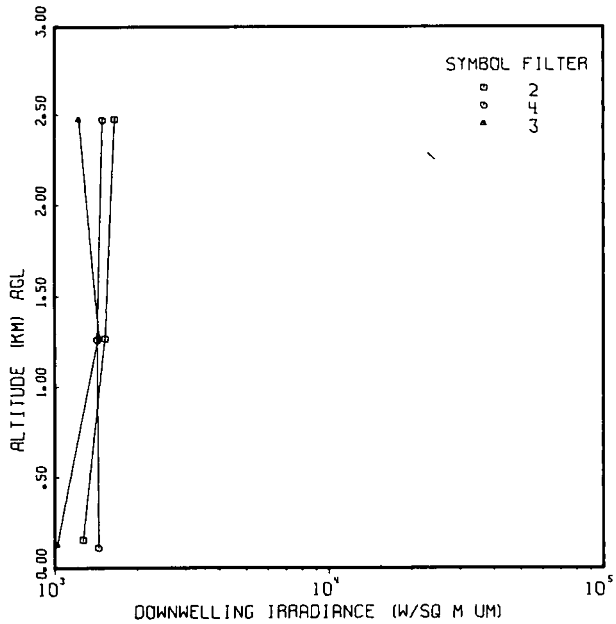
At the end of data-taking, Scott was reporting clear skies. The visibility was 10 miles (16 kilometers).

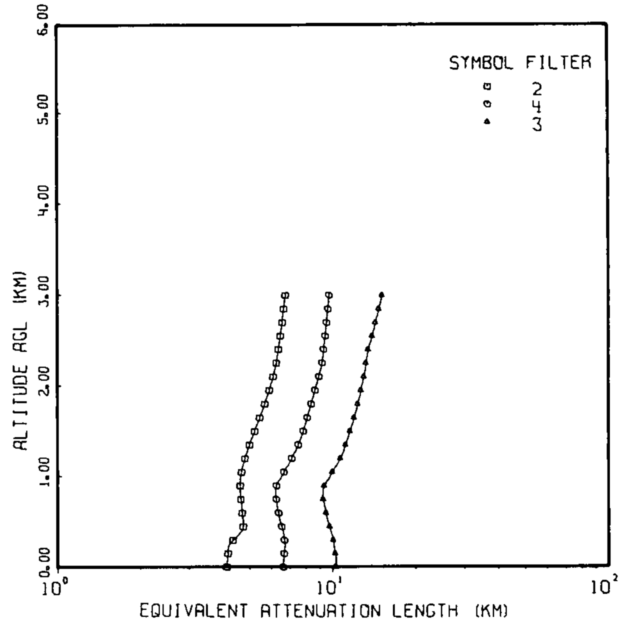
The surface synoptic chart shows a weak circulation with St. Louis on the back side of a high. A cold front with waves extended through the central Great Lakes, La Crosse, and Dodge City, then northwestward into British Columbia. There was a tropical depression off the Carolinas.

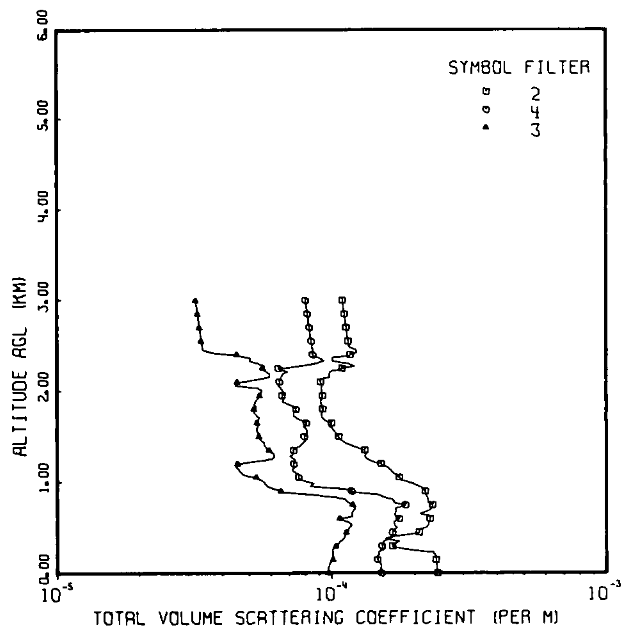
At 500 millibars there was a very weak gradient over the United States with the tropical depression off the Carolinas showing at this level.

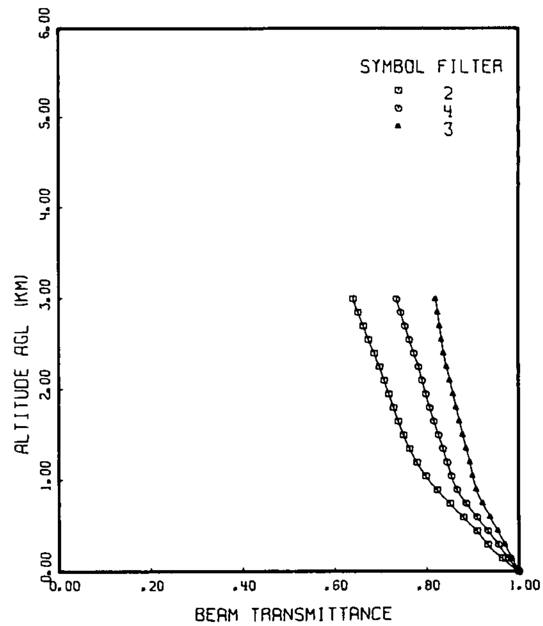
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-182A

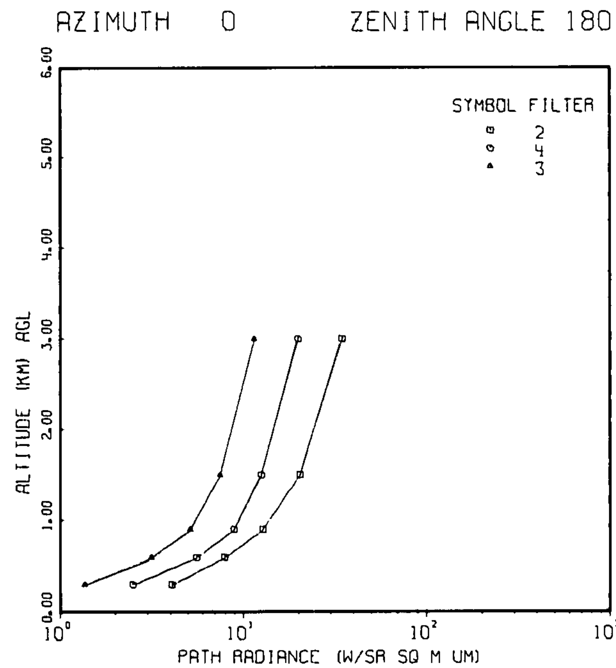


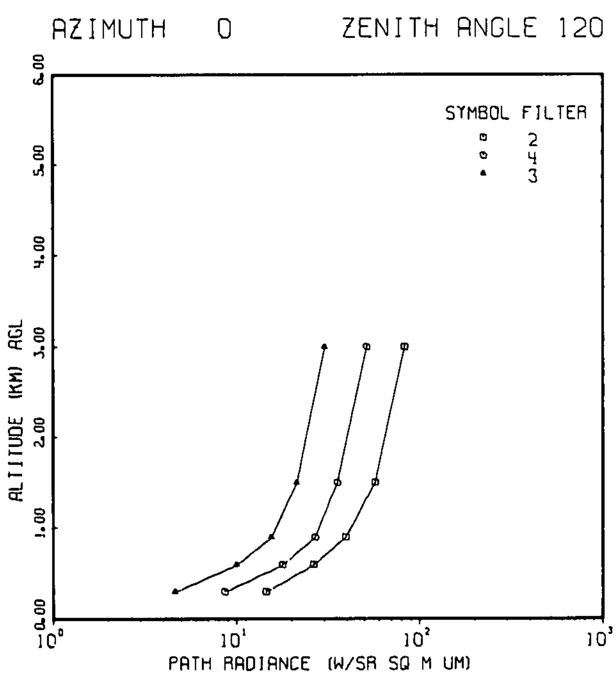


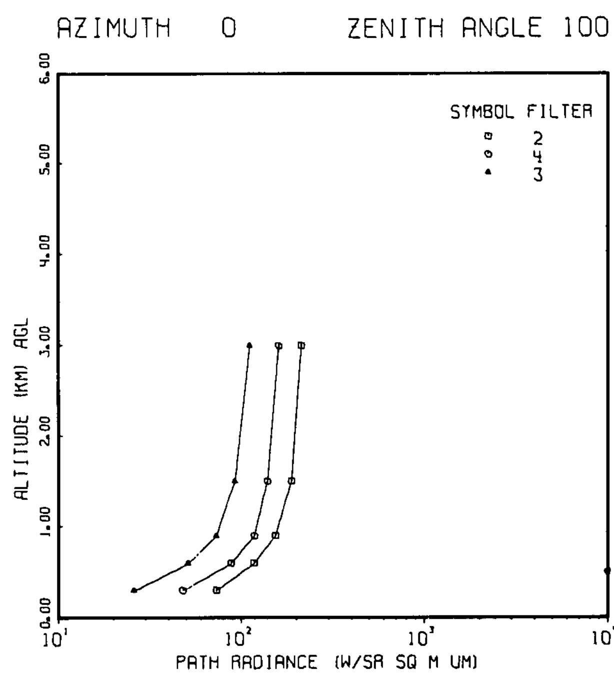




FLIGHT NO. C-182A

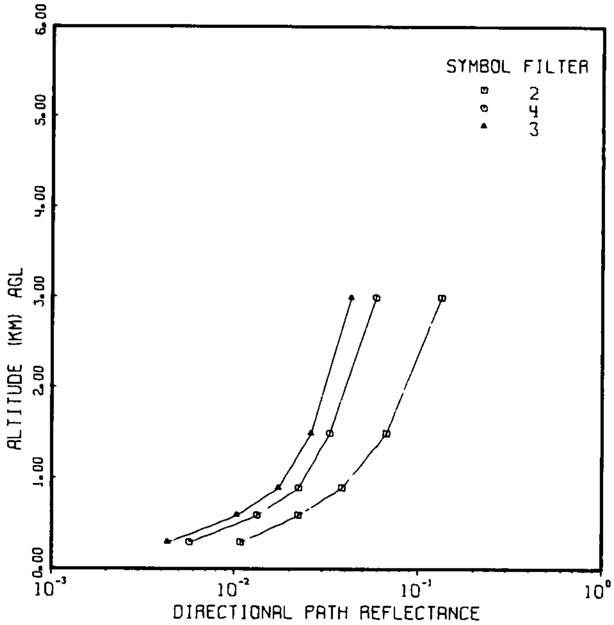




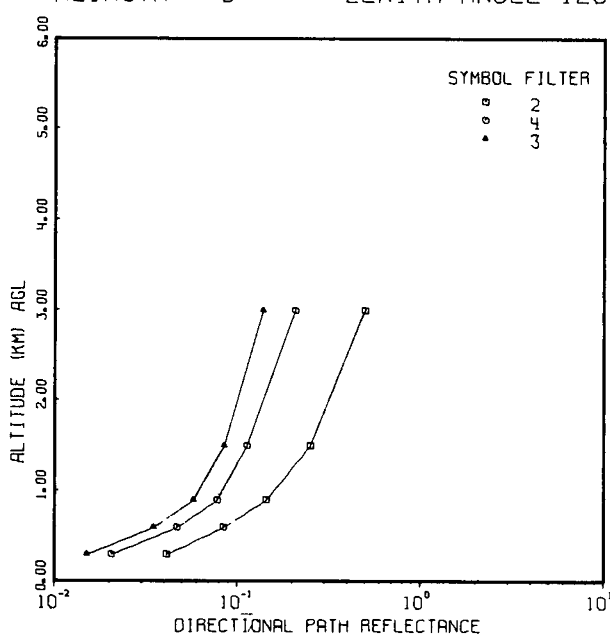


FLIGHT NO. C-182A

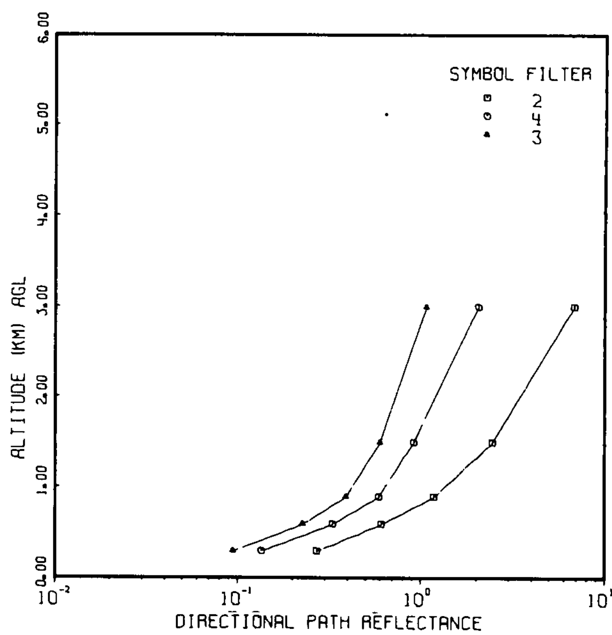
AZIMUTH 0 ZENITH ANGLE 180



AZIMUTH 0 ZENITH ANGLE 120



FLIGHT C-182A ZENITH ANGLE 100
AZIMUTH 0



FLIGHT NO. C-182A
IRRADIANCE

(JOB 5226 DATE 04/12/73)

FLIGHT NO.C-182A FILTER NO. 2 SUN ZENITH ANGLE 40.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
158	1.27E 03	5.15E 01	.041	1.04E 03	1.11E 03	1.54E 02	2.30E 03	.072
1269	1.53E 03	1.12E 02	.073	1.39E 03	9.66E 02	3.42E 02	2.69E 03	.145
2478	1.66E 03	1.65E 02	.099	1.64E 03	7.37E 02	4.55E 02	2.83E 03	.191

FLIGHT NO.C-182A FILTER NO. 4 SUN ZENITH ANGLE 40.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
114	1.44E 03	4.99E 01	.035	1.14E 03	1.20E 03	1.35E 02	2.47E 03	.058
1261	1.43E 03	9.86E 01	.069	1.40E 03	7.35E 02	2.83E 02	2.42E 03	.133
2475	1.50E 03	1.32E 02	.088	1.58E 03	4.80E 02	3.64E 02	2.42E 03	.177

FLIGHT NO.C-182A FILTER NO. 3 SUN ZENITH ANGLE 40.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
129	1.02E 03	4.87E 01	.048	1.11E 03	5.20E 02	1.13E 02	1.75E 03	.069
1281	1.45E 03	7.46E 01	.052	1.28E 03	8.23E 02	1.99E 02	2.30E 03	.095
2478	1.22E 03	9.68E 01	.079	1.39E 03	2.47E 02	2.53E 02	1.89E 03	.154

FLIGHT NO. C-182A
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5226 DATE 04/12/73)

FLIGHT NO. C-182A
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.3671	.1622	.1450
100	.0952	.0756	.0784
105	.0665	.0518	.0541
120	.0319	.0283	.0258
150	.0464	.0189	.0150
180	.0153	.0573	.0500

FLIGHT NO. C-182A
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1686	.0680	.0610
100	.0546	.0587	.0515
105	.0480	.0496	.0509
120	.0230	.0305	.0220
150	.0484	.0239	.0263
180	.0153	.0573	.0500

FLIGHT NO. C-182A
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0696	.0713	.0735
100	.0689	.0602	.0860
105	.0617	.0568	.0705
120	.0712	.0512	.0766
150	.0640	.0392	.0564
180	.0153	.0573	.0500

FLIGHT NO. C-182A
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0733	.0795	.0657
100	.0635	.0538	.0559
105	.0451	.0439	.0649
120	.0343	.0352	.0295
150	.0414	.0257	.0550
180	.0153	.0573	.0500

FLIGHT NO. C-182A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5226 DATE 04/12/73)
DATE 81371 FLIGHT NO. C-182A GROUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
0	2.43E-04	1.51E-04	9.76E-05
30	2.41E-04	1.51E-04	9.71E-05
60	2.41E-04	1.50E-04	9.68E-05
90	2.40E-04	1.51E-04	9.76E-05
120	2.40E-04	1.50E-04	9.84E-05
150	2.39E-04	1.47E-04	1.01E-04
180	2.39E-04	1.45E-04	1.01E-04
210	2.38E-04	1.49E-04	1.00E-04
240	2.34E-04	1.48E-04	1.01E-04
270	1.90E-04	1.55E-04	1.00E-04
300	1.66E-04	1.52E-04	1.04E-04
330	1.70E-04	1.55E-04	1.06E-04
360	1.77E-04	1.54E-04	1.08E-04
390	1.56E-04	1.63E-04	1.11E-04
420	1.73E-04	1.67E-04	1.12E-04
450	2.08E-04	1.66E-04	1.13E-04
480	2.07E-04	1.70E-04	1.15E-04
510	2.20E-04	1.74E-04	1.16E-04
540	2.25E-04	1.69E-04	1.18E-04
570	2.26E-04	1.68E-04	1.15E-04
600	2.28E-04	1.76E-04	1.07E-04
630	2.28E-04	1.70E-04	1.19E-04
660	2.09E-04	1.69E-04	1.18E-04
690	2.24E-04	1.72E-04	1.19E-04
720	2.32E-04	1.70E-04	1.22E-04
750	2.33E-04	1.86E-04	1.20E-04
780	2.24E-04	1.68E-04	1.15E-04
810	2.24E-04	1.67E-04	1.13E-04
840	2.23E-04	1.55E-04	1.03E-04
870	2.20E-04	1.47E-04	8.44E-05
900	2.18E-04	1.18E-04	6.54E-05
930	2.15E-04	1.11E-04	6.17E-05
960	2.07E-04	8.33E-05	5.82E-05
990	1.97E-04	8.64E-05	5.73E-05
1020	1.83E-04	7.90E-05	5.59E-05
1050	1.76E-04	7.58E-05	5.33E-05
1080	1.71E-04	7.61E-05	4.83E-05
1110	1.67E-04	7.40E-05	4.66E-05
1140	1.64E-04	7.18E-05	4.60E-05
1170	1.59E-04	7.30E-05	4.47E-05
1200	1.51E-04	7.28E-05	4.54E-05
1230	1.41E-04	7.38E-05	5.13E-05
1260	1.34E-04	7.33E-05	6.08E-05
1290	1.32E-04	7.04E-05	6.18E-05
1320	1.34E-04	7.26E-05	6.14E-05
1350	1.32E-04	7.28E-05	5.94E-05
1380	1.25E-04	7.49E-05	5.80E-05
1410	1.17E-04	7.71E-05	5.68E-05
1440	1.11E-04	7.91E-05	5.68E-05
1470	1.08E-04	8.04E-05	5.51E-05
1500	1.06E-04	7.95E-05	5.45E-05

FLIGHT NO. C-182A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5226 DATE 04/12/73)
DATE 81371 FLIGHT NO. C-182A GROUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	1.04E-04	8.14E-05	5.47E-05
1560	1.03E-04	8.17E-05	5.36E-05
1590	1.01E-04	8.10E-05	5.32E-05
1620	9.81E-05	7.88E-05	5.40E-05
1650	1.00E-04	8.10E-05	5.36E-05
1680	9.51E-05	7.79E-05	5.39E-05
1710	9.25E-05	7.46E-05	5.49E-05
1740	9.20E-05	7.29E-05	5.34E-05
1770	9.20E-05	7.27E-05	5.22E-05
1800	9.30E-05	7.43E-05	5.23E-05
1830	9.20E-05	7.30E-05	5.31E-05
1860	9.18E-05	7.00E-05	5.24E-05
1890	9.13E-05	6.62E-05	5.28E-05
1920	9.19E-05	6.70E-05	5.37E-05
1950	9.25E-05	6.61E-05	5.48E-05
1980	9.20E-05	6.82E-05	5.51E-05
2010	9.21E-05	6.65E-05	5.59E-05
2040	9.18E-05	6.54E-05	5.40E-05
2070	9.22E-05	6.40E-05	4.45E-05
2100	9.13E-05	6.47E-05	4.54E-05
2130	9.05E-05	6.53E-05	5.25E-05
2160	9.86E-05	6.56E-05	5.94E-05
2190	9.81E-05	6.62E-05	5.96E-05
2220	9.86E-05	6.93E-05	5.78E-05
2250	1.10E-04	6.41E-05	5.62E-05
2280	1.22E-04	7.64E-05	5.71E-05
2310	1.14E-04	8.77E-05	5.41E-05
2340	1.00E-04	9.42E-05	5.02E-05
2370	1.01E-04	9.03E-05	5.06E-05
2400	1.17E-04	8.56E-05	4.53E-05
2430	1.24E-04	8.47E-05	3.66E-05
2460	1.23E-04	8.60E-05	3.39E-05
2490	1.16E-04	8.49E-05	3.38E-05
2520	1.15E-04	8.47E-05	3.37E-05
2550	1.15E-04	8.44E-05	3.36E-05
2580	1.15E-04	8.42E-05	3.35E-05
2610	1.14E-04	8.39E-05	3.34E-05
2640	1.14E-04	8.36E-05	3.33E-05
2670	1.14E-04	8.34E-05	3.31E-05
2700	1.13E-04	8.31E-05	3.30E-05
2730	1.13E-04	8.28E-05	3.29E-05
2760	1.12E-04	8.26E-05	3.28E-05
2790	1.12E-04	8.23E-05	3.27E-05
2820	1.12E-04	8.21E-05	3.26E-05
2850	1.11E-04	8.18E-05	3.25E-05
2880	1.11E-04	8.16E-05	3.24E-05
2910	1.11E-04	8.13E-05	3.23E-05
2940	1.10E-04	8.10E-05	3.22E-05
2970	1.10E-04	8.08E-05	3.21E-05
3000	1.10E-04	8.05E-05	3.20E-05
FIRST DATA ALT	150	60	60
LAST DATA ALT	2490	2490	2460

FLIGHT NO. C-182A
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5226 DATE 04/12/73)

FLIGHT NO. C-182A FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.51E-01	6.71E-01	7.65E-01	8.71E-01	9.23E-01	9.33E-01
600	2.29E-01	4.79E-01	6.10E-01	7.74E-01	8.63E-01	8.80E-01
900	1.05E-01	3.25E-01	4.71E-01	6.77E-01	7.98E-01	8.23E-01
1500	3.50E-02	1.91E-01	3.29E-01	5.63E-01	7.17E-01	7.50E-01
3000	5.15E-03	7.75E-02	1.80E-01	4.11E-01	5.99E-01	6.41E-01

FLIGHT NO. C-182A FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.96E-01	7.72E-01	8.41E-01	9.14E-01	9.49E-01	9.56E-01
600	3.36E-01	5.81E-01	6.94E-01	8.28E-01	8.97E-01	9.10E-01
900	1.89E-01	4.36E-01	5.73E-01	7.50E-01	8.47E-01	8.66E-01
1500	1.08E-01	3.32E-01	4.78E-01	6.82E-01	8.02E-01	8.26E-01
3000	2.61E-02	1.70E-01	3.05E-01	5.41E-01	7.01E-01	7.35E-01

FLIGHT NO. C-182A FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.10E-01	8.42E-01	8.91E-01	9.42E-01	9.66E-01	9.71E-01
600	4.81E-01	6.94E-01	7.83E-01	8.81E-01	9.29E-01	9.39E-01
900	3.28E-01	5.74E-01	6.89E-01	8.25E-01	8.95E-01	9.08E-01
1500	2.21E-01	4.75E-01	6.07E-01	7.72E-01	8.61E-01	8.79E-01
3000	9.57E-02	3.21E-01	4.66E-01	6.74E-01	7.96E-01	8.21E-01

FLIGHT NO. C-182A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-182A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.51E 02	7.33E 01	4.31E 01	1.45E 01	4.91E 00	4.07E 00
600	2.11E 02	1.18E 02	7.30E 01	2.64E 01	9.37E 00	7.93E 00
900	2.45E 02	1.54E 02	1.02E 02	3.95E 01	1.48E 01	1.28E 01
1500	2.65E 02	1.89E 02	1.33E 02	5.72E 01	2.31E 01	2.04E 01
3000	2.60E 02	2.13E 02	1.66E 02	8.29E 01	3.77E 01	3.47E 01

FLIGHT NO. C-182A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.07E 02	4.79E 01	2.70E 01	8.62E 00	2.85E 00	2.49E 00
600	1.72E 02	8.80E 01	5.25E 01	1.79E 01	6.26E 00	5.55E 00
900	2.06E 02	1.18E 02	7.41E 01	2.69E 01	9.93E 00	8.92E 00
1500	2.22E 02	1.39E 02	9.18E 01	3.56E 01	1.38E 01	1.26E 01
3000	2.10E 02	1.60E 02	1.16E 02	5.16E 01	2.17E 01	2.00E 01

FLIGHT NO. C-182A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.01E 01	2.59E 01	1.43E 01	4.63E 00	1.58E 00	1.37E 00
600	1.08E 02	5.14E 01	2.96E 01	1.00E 01	3.59E 00	3.15E 00
900	1.42E 02	7.32E 01	4.39E 01	1.55E 01	5.79E 00	5.15E 00
1500	1.68E 02	9.27E 01	5.78E 01	2.14E 01	8.32E 00	7.50E 00
3000	1.71E 02	1.12E 02	7.48E 01	3.05E 01	1.26E 01	1.16E 01

FLIGHT NO. C-182A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-182A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.43E 01	3.42E 01	2.24E 01	9.90E 00	4.85E 00	4.07E 00
600	9.28E 01	5.66E 01	3.90E 01	1.84E 01	9.35E 00	7.93E 00
900	1.12E 02	7.70E 01	5.59E 01	2.82E 01	1.49E 01	1.28E 01
1500	1.30E 02	9.96E 01	7.68E 01	4.22E 01	2.34E 01	2.04E 01
3000	1.44E 02	1.25E 02	1.04E 02	6.48E 01	3.90E 01	3.47E 01

FLIGHT NO. C-182A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.39E 01	2.16E 01	1.37E 01	5.86E 00	2.86E 00	2.49E 00
600	7.34E 01	4.12E 01	2.75E 01	1.25E 01	6.32E 00	5.55E 00
900	9.17E 01	5.75E 01	4.00E 01	1.92E 01	1.01E 01	8.92E 00
1500	1.04E 02	7.10E 01	5.15E 01	2.61E 01	1.41E 01	1.26E 01
3000	1.09E 02	8.88E 01	7.03E 01	3.97E 01	2.23E 01	2.00E 01

FLIGHT NO. C-182A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.09E 01	1.02E 01	6.53E 00	2.97E 00	1.58E 00	1.37E 00
600	3.91E 01	2.09E 01	1.39E 01	6.60E 00	3.61E 00	3.15E 00
900	5.33E 01	3.08E 01	2.11E 01	1.04E 01	5.85E 00	5.15E 00
1500	6.59E 01	4.07E 01	2.87E 01	1.47E 01	8.47E 00	7.50E 00
3000	7.39E 01	5.30E 01	3.97E 01	2.18E 01	1.29E 01	1.16E 01

FLIGHT NO. C-182A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-182A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.20E 01	2.93E 01	2.04E 01	1.09E 01	5.74E 00	4.07E 00
600	7.76E 01	4.98E 01	3.64E 01	2.05E 01	1.12E 01	7.93E 00
900	9.78E 01	7.01E 01	5.37E 01	3.19E 01	1.81E 01	1.28E 01
1500	1.19E 02	9.48E 01	7.66E 01	4.86E 01	2.88E 01	2.04E 01
3000	1.38E 02	1.24E 02	1.08E 02	7.54E 01	4.81E 01	3.47E 01

FLIGHT NO. C-182A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.60E 01	1.91E 01	1.31E 01	6.89E 00	3.63E 00	2.49E 00
600	6.11E 01	3.68E 01	2.64E 01	1.47E 01	8.04E 00	5.55E 00
900	7.76E 01	5.20E 01	3.88E 01	2.26E 01	1.28E 01	8.92E 00
1500	8.99E 01	6.52E 01	5.04E 01	3.06E 01	1.80E 01	1.26E 01
3000	9.59E 01	8.18E 01	6.82E 01	4.54E 01	2.81E 01	2.00E 01

FLIGHT NO. C-182A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.82E 01	9.49E 00	6.56E 00	3.61E 00	1.95E 00	1.37E 00
600	3.49E 01	1.99E 01	1.42E 01	8.04E 00	4.49E 00	3.15E 00
900	4.86E 01	2.99E 01	2.19E 01	1.28E 01	7.33E 00	5.15E 00
1500	6.17E 01	4.04E 01	3.02E 01	1.81E 01	1.07E 01	7.50E 00
3000	6.90E 01	5.23E 01	4.14E 01	2.64E 01	1.63E 01	1.16E 01

FLIGHT NO. C-182A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-182A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.47E 01	2.95E 01	1.96E 01	9.21E 00	4.81E 00	4.07E 00
600	8.03E 01	4.94E 01	3.46E 01	1.72E 01	9.28E 00	7.93E 00
900	9.90E 01	6.84E 01	5.03E 01	2.67E 01	1.49E 01	1.28E 01
1500	1.18E 02	9.05E 01	7.05E 01	4.02E 01	2.34E 01	2.04E 01
3000	1.36E 02	1.17E 02	9.82E 01	6.23E 01	3.88E 01	3.47E 01

FLIGHT NO. C-182A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.78E 01	1.90E 01	1.24E 01	5.65E 00	2.94E 00	2.49E 00
600	6.32E 01	3.63E 01	2.47E 01	1.20E 01	6.47E 00	5.55E 00
900	7.89E 01	5.05E 01	3.60E 01	1.84E 01	1.03E 01	8.92E 00
1500	8.96E 01	6.24E 01	4.62E 01	2.49E 01	1.43E 01	1.26E 01
3000	9.60E 01	7.86E 01	6.30E 01	3.75E 01	2.26E 01	2.00E 01

FLIGHT NO. C-182A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.97E 01	9.71E 00	6.33E 00	2.97E 00	1.58E 00	1.37E 00
600	3.77E 01	2.02E 01	1.36E 01	6.57E 00	3.59E 00	3.15E 00
900	5.23E 01	3.03E 01	2.08E 01	1.04E 01	5.80E 00	5.15E 00
1500	6.59E 01	4.05E 01	2.86E 01	1.46E 01	8.36E 00	7.50E 00
3000	7.24E 01	5.20E 01	3.90E 01	2.15E 01	1.27E 01	1.16E 01

FLIGHT NO. C-182A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-182A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.31E-01	2.70E-01	1.39E-01	4.13E-02	1.32E-02	1.08E-02
600	2.29E 00	6.08E-01	2.96E-01	8.43E-02	2.69E-02	2.23E-02
900	5.79E 00	1.17E 00	5.34E-01	1.45E-01	4.60E-02	3.86E-02
1500	1.87E 01	2.45E 00	1.00E 00	2.52E-01	7.96E-02	6.74E-02
3000	1.25E 02	6.81E 00	2.28E 00	4.99E-01	1.56E-01	1.34E-01

FLIGHT NO. C-182A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.91E-01	1.35E-01	7.00E-02	2.05E-02	6.53E-03	5.68E-03
600	1.11E 00	3.30E-01	1.64E-01	4.70E-02	1.52E-02	1.33E-02
900	2.38E 00	5.88E-01	2.81E-01	7.82E-02	2.55E-02	2.24E-02
1500	4.49E 00	9.11E-01	4.18E-01	1.13E-01	3.75E-02	3.31E-02
3000	1.75E 01	2.05E 00	8.30E-01	2.08E-01	6.74E-02	5.91E-02

FLIGHT NO. C-182A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.60E-01	9.45E-02	4.95E-02	1.51E-02	5.04E-03	4.32E-03
600	6.91E-01	2.27E-01	1.16E-01	3.50E-02	1.19E-02	1.03E-02
900	1.33E 00	3.92E-01	1.96E-01	5.79E-02	1.99E-02	1.74E-02
1500	2.32E 00	6.00E-01	2.93E-01	8.53E-02	2.97E-02	2.62E-02
3000	5.48E 00	1.07E 00	4.93E-01	1.39E-01	4.88E-02	4.33E-02

FLIGHT NO. C-182A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-182A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	3.53E-01	1.26E-01	7.24E-02	2.81E-02	1.30E-02	1.08E-02
600	1.01E 00	2.92E-01	1.58E-01	5.88E-02	2.68E-02	2.23E-02
900	2.65E 00	5.86E-01	2.94E-01	1.03E-01	4.63E-02	3.86E-02
1500	9.17E 00	1.29E 00	5.78E-01	1.86E-01	8.09E-02	6.74E-02
3000	6.92E 01	3.99E 00	1.44E 00	3.90E-01	1.61E-01	1.34E-01

FLIGHT NO. C-182A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	1.60E-01	6.10E-02	3.55E-02	1.39E-02	6.56E-03	5.68E-03
600	4.75E-01	1.55E-01	8.61E-02	3.28E-02	1.53E-02	1.33E-02
900	1.06E 00	2.87E-01	1.52E-01	5.58E-02	2.59E-02	2.24E-02
1500	2.11E 00	4.65E-01	2.35E-01	8.32E-02	3.82E-02	3.31E-02
3000	9.11E 00	1.14E 00	5.02E-01	1.60E-01	6.93E-02	5.91E-02

FLIGHT NO. C-182A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	9.07E-02	3.71E-02	2.25E-02	9.69E-03	5.02E-03	4.32E-03
600	2.50E-01	9.25E-02	5.46E-02	2.30E-02	1.19E-02	1.03E-02
900	5.00E-01	1.65E-01	9.43E-02	3.89E-02	2.01E-02	1.74E-02
1500	9.14E-01	2.64E-01	1.46E-01	5.87E-02	3.02E-02	2.62E-02
3000	2.37E 00	5.08E-01	2.62E-01	9.96E-02	4.99E-02	4.33E-02

FLIGHT NO. C-182A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-182A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.85E-01	1.08E-01	6.60E-02	3.09E-02	1.54E-02	1.08E-02
600	8.41E-01	2.58E-01	1.48E-01	6.54E-02	3.21E-02	2.23E-02
900	2.31E 00	5.34E-01	2.83E-01	1.17E-01	5.60E-02	3.86E-02
1500	8.43E 00	1.23E 00	5.76E-01	2.14E-01	9.92E-02	6.74E-02
3000	6.64E 01	3.96E 00	1.48E 00	4.54E-01	1.99E-01	1.34E-01

FLIGHT NO. C-182A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.31E-01	5.38E-02	3.38E-02	1.64E-02	8.32E-03	5.68E-03
600	3.95E-01	1.38E-01	8.28E-02	3.86E-02	1.95E-02	1.33E-02
900	8.93E-01	2.59E-01	1.47E-01	6.57E-02	3.30E-02	2.24E-02
1500	1.82E 00	4.27E-01	2.30E-01	9.77E-02	4.88E-02	3.31E-02
3000	8.00E 00	1.05E 00	4.87E-01	1.83E-01	8.74E-02	5.91E-02

FLIGHT NO. C-182A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.87E-02	3.46E-02	2.26E-02	1.18E-02	6.21E-03	4.32E-03
600	2.23E-01	8.81E-02	5.56E-02	2.81E-02	1.49E-02	1.03E-02
900	4.56E-01	1.60E-01	9.75E-02	4.76E-02	2.52E-02	1.74E-02
1500	8.56E-01	2.61E-01	1.53E-01	7.20E-02	3.80E-02	2.62E-02
3000	2.22E 00	5.02E-01	2.73E-01	1.21E-01	6.31E-02	4.33E-02

FLIGHT NO. C-182A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5226 DATE 04/12/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-182A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.00E-01	1.09E-01	6.35E-02	2.62E-02	1.29E-02	1.08E-02
600	8.70E-01	2.56E-01	1.40E-01	5.51E-02	2.66E-02	2.23E-02
900	2.34E 00	5.21E-01	2.65E-01	9.75E-02	4.61E-02	3.86E-02
1500	8.33E 00	1.17E 00	5.30E-01	1.77E-01	8.07E-02	6.74E-02
3000	6.55E 01	3.74E 00	1.35E 00	3.75E-01	1.61E-01	1.34E-01

FLIGHT NO. C-182A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.38E-01	5.36E-02	3.20E-02	1.34E-02	6.73E-03	5.68E-03
600	4.08E-01	1.36E-01	7.74E-02	3.15E-02	1.57E-02	1.33E-02
900	9.08E-01	2.52E-01	1.36E-01	5.35E-02	2.64E-02	2.24E-02
1500	1.81E 00	4.08E-01	2.10E-01	7.95E-02	3.89E-02	3.31E-02
3000	8.01E 00	1.00E 00	4.50E-01	1.51E-01	7.01E-02	5.91E-02

FLIGHT NO. C-182A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.55E-02	3.54E-02	2.18E-02	9.67E-03	5.01E-03	4.32E-03
600	2.40E-01	8.96E-02	5.34E-02	2.29E-02	1.19E-02	1.03E-02
900	4.90E-01	1.62E-01	9.30E-02	3.87E-02	1.99E-02	1.74E-02
1500	9.14E-01	2.62E-01	1.45E-01	5.82E-02	2.98E-02	2.62E-02
3000	2.32E 00	4.99E-01	2.57E-01	9.82E-02	4.91E-02	4.33E-02

FLIGHT C-182B—13 AUGUST 1971—TRACK 3—DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon. At the beginning and throughout the data-taking there were no clouds. The flight was conducted over multiple small fields northeast of St. Louis. The typical terrain was flat, highly cultivated farmland. The data-taking started at 1726 GMT (1226 CDT) and continued until 1856 GMT (1356 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 25.6 degrees at the beginning and 25.0 degrees at the end. The maximum altitude for the flight was 2615 meters. Average elevation of terrain on this track was 183 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 10-mile (16-kilometer) visibility.

The ground station located at Scott, 70 miles (110 kilometers) from the center of the flight path, recorded clear, moderate to heavy haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
–	–	Moderate to heavy haze, haze layer at about 6000 ft (1830 m) MSL
–	–	Haze appears heavier on Track 3 than on Track 7
1718	270	Heavy haze, no clouds above
1738	1470	Moderate to heavy haze, clear overhead
1755	1470	Estimated 10-mile (16-kilometer) slant range visibility
1814	2670	Estimated top of haze 10500 ft (3200 m) MSL
1831	2670	Very hazy

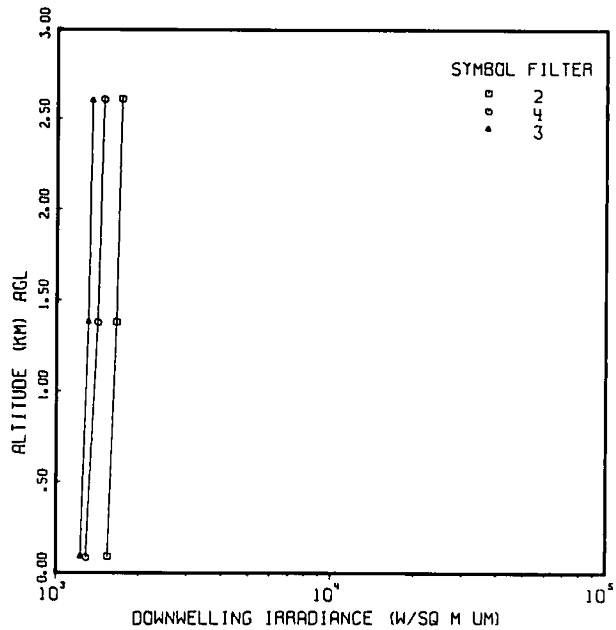
At the end of data-taking, Scott was reporting clear skies with 12-mile (19-kilometer) visibility. There were some cumulus clouds in the west to north quadrants.

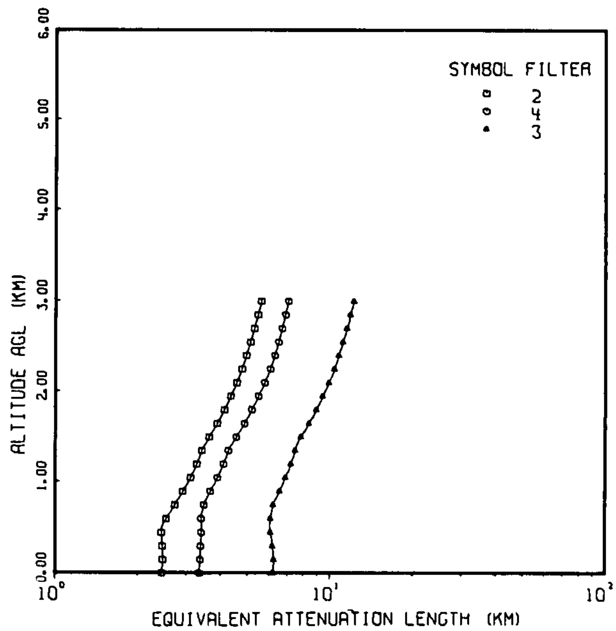
The surface synoptic chart shows that the tropical depression off the Carolinas had caused the front in the Dakotas to become stationary. There was a 1008-millibar low in eastern South Dakota but the general circulation was very weak.

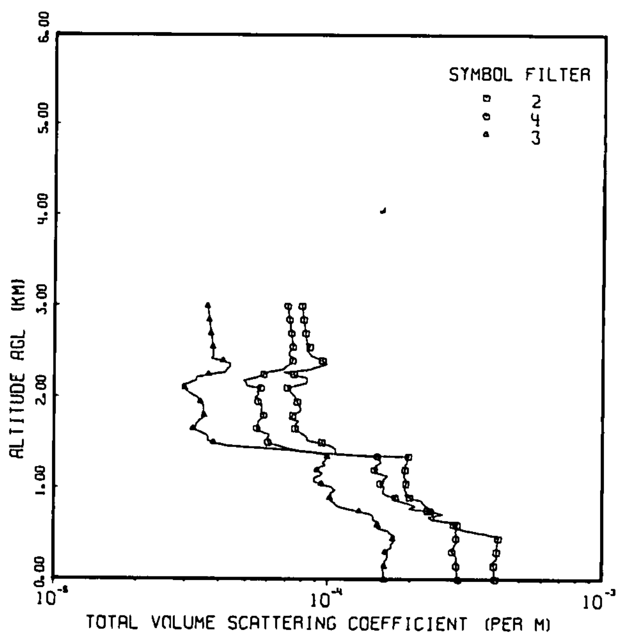
At 500-millibars there was a very weak gradient over the United States with the tropical depression off the Carolinas showing at this level.

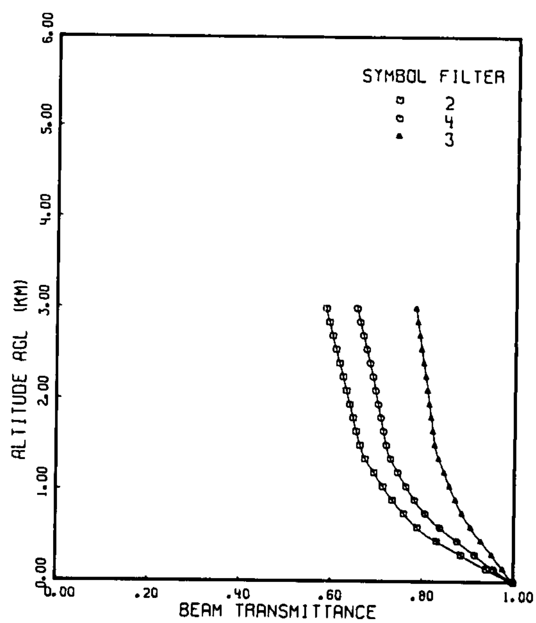
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindberg Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-182B

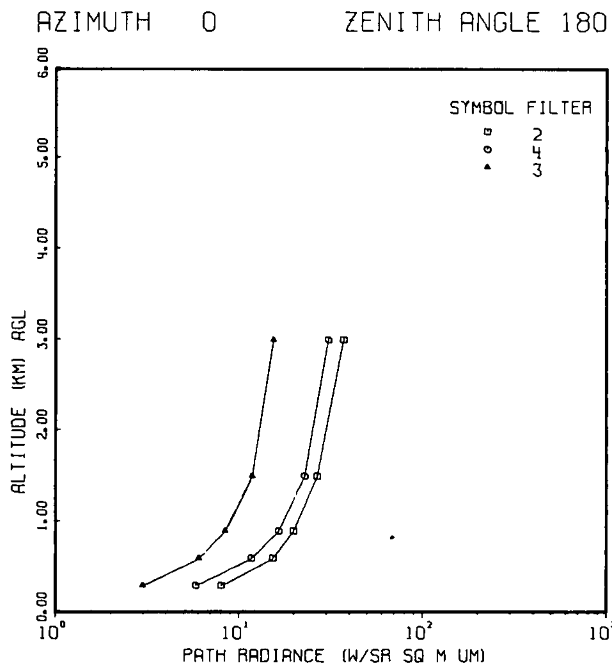


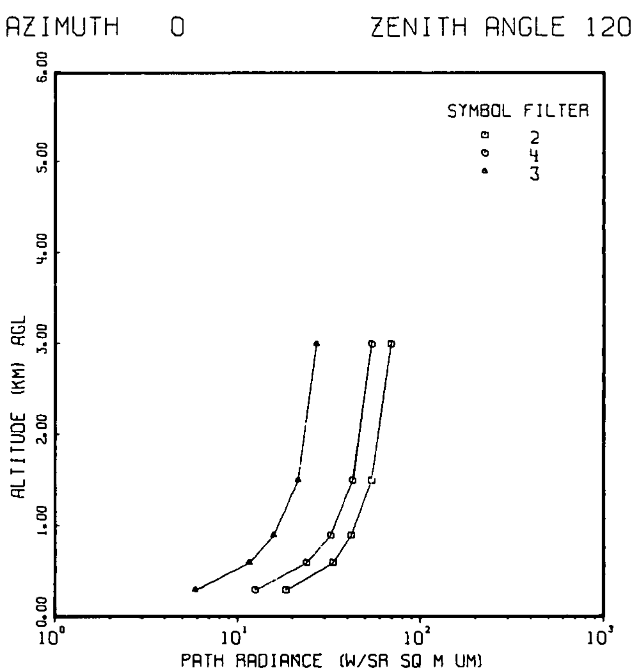


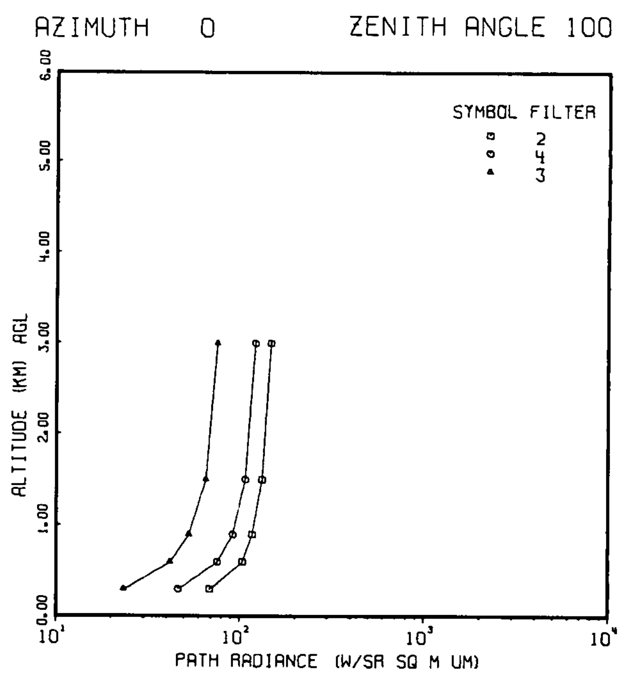




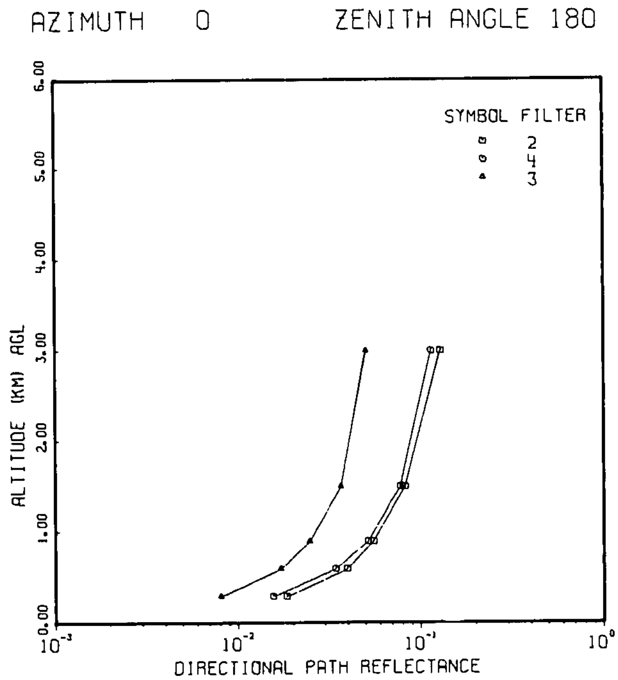
FLIGHT NO. 182B

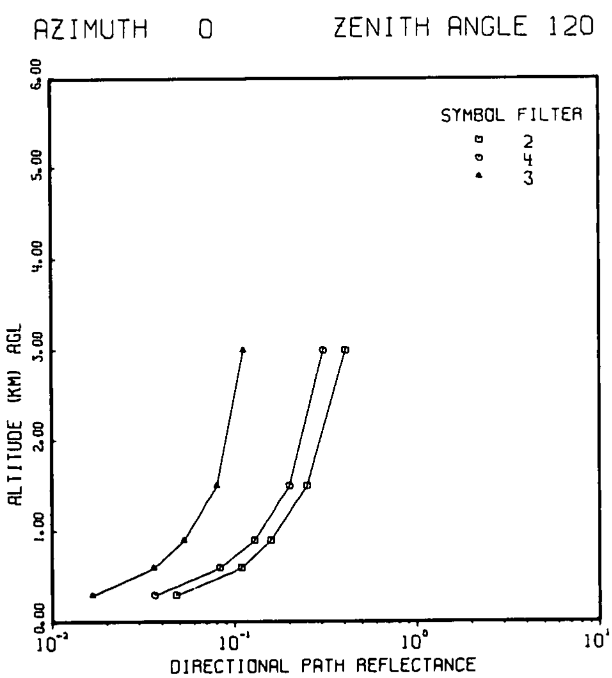


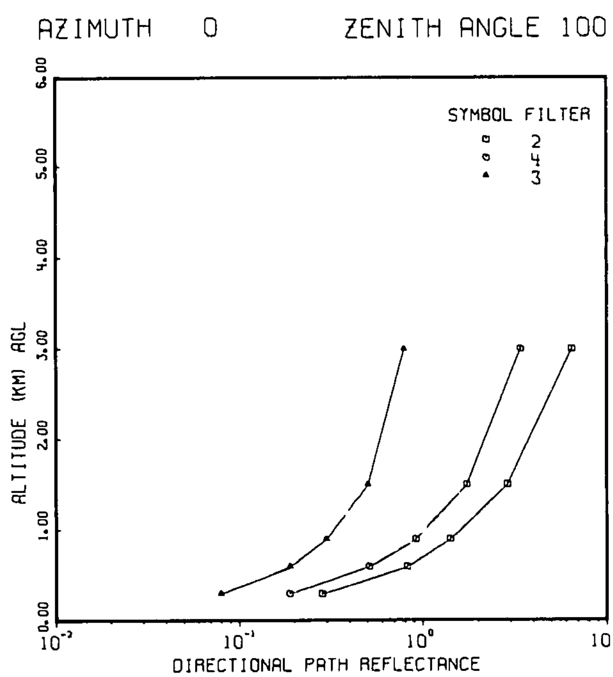




FLIGHT NO. C-182B







FLIGHT NO. C-182B
IRRADIANCE

(JOB 5097 CATE 04/09/73)

FLIGHT NO.C-182B FILTER NO. 2 SUN ZENITH ANGLE 25.0

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
94	1.54E 03	6.79E 01	.044	9.81E 02	1.15E 03	1.74E 02	2.30E 03	.082
1384	1.65E 03	1.57E 02	.095	1.46E 03	6.57E 02	4.11E 02	2.53E 03	.194
2615	1.72E 03	1.85E 02	.107	1.64E 03	5.16E 02	4.75E 02	2.63E 03	.220

FLIGHT NO.C-182B FILTER NO. 4 SUN ZENITH ANGLE 25.0

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
88	1.29E 03	9.78E 01	.076	9.10E 02	8.46E 02	2.11E 02	1.97E 03	.120
1381	1.41E 03	1.47E 02	.104	1.26E 03	5.19E 02	3.70E 02	2.15E 03	.209
2613	1.48E 03	1.63E 02	.110	1.37E 03	4.75E 02	4.07E 02	2.25E 03	.221

FLIGHT NO.C-182B FILTER NO. 3 SUN ZENITH ANGLE 25.0

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
93	1.23E 03	5.33E 01	.043	1.09E 03	4.76E 02	1.18E 02	1.68E 03	.076
1384	1.30E 03	9.18E 01	.070	1.31E 03	2.45E 02	2.25E 02	1.78E 03	.145
2606	1.34E 03	1.00E 02	.075	1.38E 03	1.98E 02	2.49E 02	1.83E 03	.158

FLIGHT NO. C-182B
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5097 DATE 04/09/73)

FLIGHT NO. C-182B
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1383	.1369	.0871
100	.1033	.1040	.0667
105	.0749	.0719	.056C
120	.0405	.0472	.0508
150	.0200	.9507	.0346
180	.0597	.0566	.131C

FLIGHT NO. C-182B
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1227	.1351	.0620
100	.0726	.1002	.0538
105	.0482	.0821	.0425
120	.0411	.0483	.0393
150	.0275	.0777	.0344
180	.0597	.0566	.1310

FLIGHT NO. C-182B
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0927	.1132	.0610
100	.0737	.0918	.0505
105	.0673	.0804	.0447
120	.0400	.0651	.0601
150	.0330	.1811	.0429
180	.0597	.0566	.131C

FLIGHT NO. C-182B
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1023	.1155	.0705
100	.0640	.0842	.0502
105	.0525	.0794	.0507
120	.0396	.0672	.0426
150	.0301	.1076	.0322
180	.0597	.0566	.1310

FLIGHT NO. C-182B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5097 DATE 04/09/73)
DATE 81371 FLIGHT NO. C-182B GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE	TOTAL VOLUME SCATTERING COEFFICIENT (PER M)		
(M)	FILTERS 2	4	3
0	4.08E-04	2.99E-04	1.61E-04
30	4.06E-04	2.98E-04	1.60E-04
60	4.05E-04	2.97E-04	1.60E-04
90	4.04E-04	2.96E-04	1.59E-04
120	4.03E-04	2.95E-04	1.59E-04
150	4.04E-04	2.94E-04	1.61E-04
180	3.98E-04	2.97E-04	1.61E-04
210	4.07E-04	2.93E-04	1.62E-04
240	4.15E-04	2.96E-04	1.65E-04
270	4.10E-04	2.93E-04	1.66E-04
300	4.13E-04	2.85E-04	1.62E-04
330	4.15E-04	2.82E-04	1.67E-04
360	4.16E-04	2.90E-04	1.71E-04
390	4.15E-04	2.91E-04	1.70E-04
420	4.19E-04	2.97E-04	1.74E-04
450	4.19E-04	2.95E-04	1.73E-04
480	4.09E-04	2.95E-04	1.75E-04
510	3.72E-04	2.95E-04	1.69E-04
540	3.24E-04	2.93E-04	1.65E-04
570	2.91E-04	2.98E-04	1.51E-04
600	2.87E-04	2.97E-04	1.52E-04
630	2.83E-04	2.95E-04	1.52E-04
660	2.43E-04	2.41E-04	1.46E-04
690	2.44E-04	2.33E-04	1.46E-04
720	2.42E-04	2.63E-04	1.44E-04
750	2.31E-04	2.37E-04	1.30E-04
780	2.34E-04	1.97E-04	1.17E-04
810	2.29E-04	2.08E-04	1.08E-04
840	2.21E-04	1.96E-04	1.06E-04
870	2.19E-04	1.80E-04	1.03E-04
900	1.99E-04	1.77E-04	1.01E-04
930	1.91E-04	1.63E-04	1.03E-04
960	1.94E-04	1.58E-04	1.02E-04
990	1.91E-04	1.59E-04	1.07E-04
1020	1.91E-04	1.61E-04	1.03E-04
1050	1.92E-04	1.55E-04	9.48E-05
1080	1.94E-04	1.60E-04	8.88E-05
1110	1.92E-04	1.60E-04	8.84E-05
1140	1.89E-04	1.65E-04	9.20E-05
1170	1.91E-04	1.51E-04	9.55E-05
1200	1.91E-04	1.48E-04	9.13E-05
1230	1.92E-04	1.51E-04	9.32E-05
1260	1.91E-04	1.50E-04	9.81E-05
1290	1.95E-04	1.57E-04	9.53E-05
1320	1.95E-04	1.54E-04	9.82E-05
1350	1.97E-04	1.51E-04	9.95E-05
1380	1.07E-04	1.14E-04	9.70E-05
1410	1.06E-04	8.18E-05	8.47E-05
1440	1.07E-04	7.22E-05	6.39E-05
1470	1.02E-04	6.66E-05	4.30E-05
1500	9.48E-05	6.03E-05	3.81E-05

FLIGHT NO. C-182B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5097 DATE 04/09/73)
DATE 81371 FLIGHT NO. C-182B GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	8.35E-05	6.07E-05	3.60E-05
1560	8.35E-05	6.01E-05	3.64E-05
1590	8.13E-05	6.08E-05	3.58E-05
1620	7.83E-05	5.71E-05	3.40E-05
1650	7.55E-05	5.47E-05	3.21E-05
1680	7.62E-05	5.57E-05	3.29E-05
1710	7.60E-05	5.54E-05	3.31E-05
1740	7.81E-05	5.55E-05	3.36E-05
1770	7.17E-05	5.73E-05	3.48E-05
1800	7.41E-05	5.80E-05	3.53E-05
1830	7.66E-05	5.72E-05	3.47E-05
1860	7.92E-05	5.68E-05	3.52E-05
1890	7.93E-05	5.71E-05	3.51E-05
1920	7.79E-05	5.71E-05	3.50E-05
1950	7.71E-05	5.54E-05	3.42E-05
1980	7.59E-05	5.54E-05	3.37E-05
2010	7.57E-05	5.39E-05	3.29E-05
2040	7.39E-05	5.57E-05	3.16E-05
2070	7.25E-05	5.50E-05	3.06E-05
2100	7.08E-05	5.65E-05	2.99E-05
2130	7.57E-05	5.01E-05	2.93E-05
2160	8.27E-05	5.00E-05	3.11E-05
2190	8.36E-05	4.88E-05	3.30E-05
2220	8.34E-05	5.41E-05	3.30E-05
2250	7.47E-05	5.81E-05	3.65E-05
2280	6.86E-05	6.05E-05	4.19E-05
2310	8.51E-05	6.79E-05	4.26E-05
2340	9.11E-05	7.01E-05	4.38E-05
2370	9.88E-05	7.20E-05	4.39E-05
2400	9.51E-05	7.40E-05	4.13E-05
2430	9.13E-05	7.41E-05	3.72E-05
2460	8.62E-05	7.19E-05	3.80E-05
2490	8.49E-05	7.14E-05	3.81E-05
2520	8.26E-05	7.28E-05	3.80E-05
2550	8.52E-05	7.41E-05	3.78E-05
2580	8.27E-05	7.47E-05	3.77E-05
2610	8.31E-05	7.38E-05	3.76E-05
2640	8.28E-05	7.35E-05	3.75E-05
2670	8.26E-05	7.33E-05	3.74E-05
2700	8.23E-05	7.31E-05	3.72E-05
2730	8.21E-05	7.28E-05	3.71E-05
2760	8.18E-05	7.26E-05	3.70E-05
2790	8.16E-05	7.24E-05	3.69E-05
2820	8.13E-05	7.22E-05	3.68E-05
2850	8.10E-05	7.19E-05	3.67E-05
2880	8.08E-05	7.17E-05	3.66E-05
2910	8.05E-05	7.15E-05	3.64E-05
2940	8.03E-05	7.13E-05	3.63E-05
2970	8.00E-05	7.10E-05	3.62E-05
3000	7.98E-05	7.08E-05	3.61E-05
FIRST DATA ALT	120	120	120
LAST DATA ALT	2610	2610	2490

FLIGHT NO. C-182B
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5097 DATE 04/09/73)

FLIGHT NO. C-182B FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	2.46E-01	4.96E-01	6.24E-01	7.84E-01	8.69E-01	8.85E-01
600	6.51E-02	2.56E-01	4.01E-01	6.23E-01	7.61E-01	7.89E-01
900	2.81E-02	1.69E-01	3.04E-01	5.40E-01	7.00E-01	7.35E-01
1500	8.17E-03	9.33E-02	2.04E-01	4.39E-01	6.21E-01	6.62E-01
3000	1.73E-03	4.64E-02	1.28E-01	3.44E-01	5.40E-01	5.87E-01

FLIGHT NO. C-182B FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	3.61E-01	6.01E-01	7.10E-01	8.38E-01	9.03E-01	9.15E-01
600	1.31E-01	3.62E-01	5.06E-01	7.03E-01	8.16E-01	8.38E-01
900	5.87E-02	2.44E-01	3.88E-01	6.13E-01	7.54E-01	7.83E-01
1500	2.16E-02	1.51E-01	2.81E-01	5.18E-01	6.84E-01	7.20E-01
3000	6.35E-03	8.68E-02	1.94E-01	4.28E-01	6.13E-01	6.54E-01

FLIGHT NO. C-182B FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	5.73E-01	7.57E-01	8.29E-01	9.08E-01	9.46E-01	9.53E-01
600	3.20E-01	5.67E-01	6.83E-01	8.21E-01	8.92E-01	9.06E-01
900	2.05E-01	4.54E-01	5.89E-01	7.60E-01	8.54E-01	8.72E-01
1500	1.08E-01	3.32E-01	4.78E-01	6.82E-01	8.02E-01	8.26E-01
3000	5.38E-02	2.44E-01	3.88E-01	6.12E-01	7.53E-01	7.83E-01

FLIGHT NO. C-182B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5097 CATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-182B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.20E 02	6.89E 01	4.48E 01	1.84E 01	8.36E 00	8.03E 00
600	1.49E 02	1.03E 02	7.31E 01	3.33E 01	1.59E 01	1.53E 01
900	1.56E 02	1.17E 02	8.66E 01	4.19E 01	2.06E 01	1.99E 01
1500	1.62E 02	1.32E 02	1.03E 02	5.40E 01	2.77E 01	2.67E 01
3000	1.72E 02	1.47E 02	1.20E 02	6.90E 01	3.79E 01	3.71E 01

FLIGHT NO. C-182B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.60E 01	4.62E 01	2.96E 01	1.25E 01	6.37E 00	5.82E 00
600	1.18E 02	7.57E 01	5.20E 01	2.39E 01	1.26E 01	1.17E 01
900	1.29E 02	9.17E 01	6.61E 01	3.23E 01	1.75E 01	1.65E 01
1500	1.38E 02	1.07E 02	8.11E 01	4.25E 01	2.38E 01	2.28E 01
3000	1.47E 02	1.21E 02	9.60E 01	5.40E 01	3.14E 01	3.07E 01

FLIGHT NO. C-182B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.71E 01	2.34E 01	1.45E 01	5.88E 00	2.87E 00	2.99E 00
600	7.49E 01	4.19E 01	2.71E 01	1.16E 01	5.82E 00	6.07E 00
900	8.76E 01	5.30E 01	3.54E 01	1.57E 01	8.07E 00	8.43E 00
1500	9.83E 01	6.54E 01	4.56E 01	2.14E 01	1.13E 01	1.18E 01
3000	1.04E 02	7.53E 01	5.45E 01	2.70E 01	1.47E 01	1.55E 01

FLIGHT NO. C-182B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5097 CATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-182B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	8.46E 01	5.08E 01	3.49E 01	1.65E 01	8.78E 00	8.03E 00
600	1.06E 02	7.69E 01	5.75E 01	3.00E 01	1.67E 01	1.53E 01
900	1.12E 02	8.78E 01	6.85E 01	3.78E 01	2.15E 01	1.99E 01
1500	1.18E 02	1.00E 02	8.24E 01	4.90E 01	2.89E 01	2.67E 01
3000	1.29E 02	1.15E 02	9.86E 01	6.38E 01	4.00E 01	3.71E 01

FLIGHT NO. C-182B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	6.22E 01	3.50E 01	2.37E 01	1.12E 01	6.27E 00	5.82E 00
600	8.53E 01	5.75E 01	4.18E 01	2.16E 01	1.26E 01	1.17E 01
900	9.39E 01	6.99E 01	5.33E 01	2.94E 01	1.77E 01	1.65E 01
1500	1.01E 02	8.22E 01	6.59E 01	3.90E 01	2.44E 01	2.28E 01
3000	1.09E 02	9.37E 01	7.88E 01	5.01E 01	3.27E 01	3.07E 01

FLIGHT NO. C-182B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	3.13E 01	1.62E 01	1.08E 01	5.23E 00	3.13E 00	2.99E 00
600	4.94E 01	2.90E 01	2.03E 01	1.03E 01	6.34E 00	6.07E 00
900	5.76E 01	3.69E 01	2.66E 01	1.41E 01	8.78E 00	8.43E 00
1500	6.48E 01	4.58E 01	3.44E 01	1.92E 01	1.23E 01	1.18E 01
3000	7.03E 01	5.35E 01	4.17E 01	2.44E 01	1.60E 01	1.55E 01

FLIGHT NO. C-182B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5097 DATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-182B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.16E 01	4.49E 01	3.20E 01	1.70E 01	1.05E 01	8.03E 00
600	9.02E 01	6.82E 01	5.28E 01	3.07E 01	1.98E 01	1.53E 01
900	9.60E 01	7.82E 01	6.31E 01	3.86E 01	2.56E 01	1.99E 01
1500	1.03E 02	9.01E 01	7.62E 01	4.99E 01	3.41E 01	2.67E 01
3000	1.19E 02	1.07E 02	9.42E 01	6.63E 01	4.72E 01	3.71E 01

FLIGHT NO. C-182B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.17E 01	3.05E 01	2.16E 01	1.16E 01	7.45E 00	5.82E 00
600	7.25E 01	5.10E 01	3.86E 01	2.25E 01	1.50E 01	1.17E 01
900	8.14E 01	6.30E 01	4.99E 01	3.08E 01	2.10E 01	1.65E 01
1500	9.05E 01	7.57E 01	6.27E 01	4.13E 01	2.90E 01	2.28E 01
3000	1.00E 02	8.87E 01	7.66E 01	5.38E 01	3.88E 01	3.07E 01

FLIGHT NO. C-182B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.69E 01	1.47E 01	1.03E 01	5.80E 00	3.95E 00	2.99E 00
600	4.27E 01	2.66E 01	1.94E 01	1.15E 01	8.00E 00	6.07E 00
900	5.01E 01	3.38E 01	2.55E 01	1.56E 01	1.11E 01	8.43E 00
1500	5.70E 01	4.23E 01	3.32E 01	2.13E 01	1.55E 01	1.18E 01
3000	6.30E 01	5.01E 01	4.07E 01	2.72E 01	2.02E 01	1.55E 01

FLIGHT NO. C-182B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5097 DATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-182B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.92E 01	4.78E 01	3.31E 01	1.59E 01	8.74E 00	8.03E 00
600	9.94E 01	7.26E 01	5.45E 01	2.90E 01	1.66E 01	1.53E 01
900	1.05E 02	8.31E 01	6.51E 01	3.66E 01	2.15E 01	1.99E 01
1500	1.13E 02	9.55E 01	7.86E 01	4.75E 01	2.89E 01	2.67E 01
3000	1.25E 02	1.10E 02	9.48E 01	6.19E 01	3.99E 01	3.71E 01

FLIGHT NO. C-182B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.80E 01	3.30E 01	2.25E 01	1.11E 01	6.38E 00	5.82E 00
600	8.02E 01	5.44E 01	3.99E 01	2.13E 01	1.28E 01	1.17E 01
900	8.90E 01	6.65E 01	5.11E 01	2.89E 01	1.79E 01	1.65E 01
1500	9.71E 01	7.88E 01	6.35E 01	3.84E 01	2.47E 01	2.28E 01
3000	1.05E 02	9.07E 01	7.64E 01	4.93E 01	3.30E 01	3.07E 01

FLIGHT NO. C-182B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.05E 01	1.58E 01	1.06E 01	5.15E 00	3.13E 00	2.99E 00
600	4.83E 01	2.84E 01	1.99E 01	1.02E 01	6.36E 00	6.07E 00
900	5.65E 01	3.62E 01	2.61E 01	1.39E 01	8.84E 00	8.43E 00
1500	6.38E 01	4.51E 01	3.40E 01	1.91E 01	1.24E 01	1.18E 01
3000	6.87E 01	5.24E 01	4.11E 01	2.43E 01	1.62E 01	1.55E 01

FLIGHT NO. C-182B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5097 CATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-182B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TC ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	9.93E-01	2.83E-01	1.46E-01	4.78E-02	1.96E-02	1.85E-02
600	4.65E 00	8.24E-01	3.72E-01	1.09E-01	4.25E-02	3.96E-02
900	1.13E 01	1.41E 00	5.81E-01	1.58E-01	5.98E-02	5.51E-02
1500	4.05E 01	2.89E 00	1.03E 00	2.51E-01	9.07E-02	8.22E-02
3000	2.02E 02	6.47E 00	1.92E 00	4.08E-01	1.43E-01	1.29E-01

FLIGHT NO. C-182B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	5.82E-01	1.88E-01	1.02E-01	3.64E-02	1.72E-02	1.55E-02
600	2.19E 00	5.10E-01	2.51E-01	8.30E-02	3.78E-02	3.42E-02
900	5.36E 00	9.18E-01	4.16E-01	1.29E-01	5.68E-02	5.15E-02
1500	1.56E 01	1.74E 00	7.06E-01	2.01E-01	8.50E-02	7.75E-02
3000	5.65E 01	3.41E 00	1.21E 00	3.08E-01	1.25E-01	1.14E-01

FLIGHT NO. C-182B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	2.10E-01	7.92E-02	4.47E-02	1.66E-02	7.78E-03	8.04E-03
600	5.98E-01	1.89E-01	1.02E-01	3.61E-02	1.67E-02	1.72E-02
900	1.10E 00	2.99E-01	1.54E-01	5.30E-02	2.42E-02	2.48E-02
1500	2.34E 00	5.04E-01	2.44E-01	8.04E-02	3.61E-02	3.67E-02
3000	4.96E 00	7.92E-01	3.60E-01	1.13E-01	5.01E-02	5.06E-02

FLIGHT NO. C-182B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5097 CATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-182B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.00E-01	2.09E-01	1.14E-01	4.29E-02	2.06E-02	1.85E-02
600	3.31E 00	6.12E-01	2.92E-01	9.80E-02	4.46E-02	3.96E-02
900	8.09E 00	1.06E 00	4.59E-01	1.43E-01	6.27E-02	5.51E-02
1500	2.95E 01	2.19E 00	8.24E-01	2.27E-01	9.47E-02	8.22E-02
3000	1.51E 02	5.02E 00	1.57E 00	3.77E-01	1.51E-01	1.29E-01

FLIGHT NO. C-182B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.21E-01	1.42E-01	8.14E-02	3.27E-02	1.70E-02	1.55E-02
600	1.59E 00	3.88E-01	2.02E-01	7.51E-02	3.78E-02	3.42E-02
900	3.91E 00	7.00E-01	3.36E-01	1.17E-01	5.74E-02	5.15E-02
1500	1.15E 01	1.33E 00	5.74E-01	1.84E-01	8.72E-02	7.75E-02
3000	4.18E 01	2.64E 00	9.92E-01	2.86E-01	1.30E-01	1.14E-01

FLIGHT NO. C-182B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.40E-01	5.47E-02	3.33E-02	1.47E-02	8.47E-03	8.04E-03
600	3.94E-01	1.31E-01	7.60E-02	3.22E-02	1.82E-02	1.72E-02
900	7.21E-01	2.08E-01	1.16E-01	4.73E-02	2.63E-02	2.48E-02
1500	1.54E 00	3.53E-01	1.85E-01	7.20E-02	3.93E-02	3.67E-02
3000	3.35E 00	5.62E-01	2.75E-01	1.02E-01	5.45E-02	5.06E-02

FLIGHT NO. C-182B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5097 DATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-182B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	5.93E-01	1.84E-01	1.04E-01	4.41E-02	2.46E-02	1.85E-02
600	2.82E 00	5.43E-01	2.69E-01	1.00E-01	5.31E-02	3.96E-02
900	6.96E 00	9.41E-01	4.23E-01	1.46E-01	7.43E-02	5.51E-02
1500	2.58E 01	1.97E 00	7.62E-01	2.32E-01	1.12E-01	8.22E-02
3000	1.40E 02	4.71E 00	1.50E 00	3.92E-01	1.78E-01	1.29E-01

FLIGHT NO. C-182B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	3.50E-01	1.24E-01	7.42E-02	3.38E-02	2.01E-02	1.55E-02
600	1.35E 00	3.44E-01	1.86E-01	7.82E-02	4.48E-02	3.42E-02
900	3.38E 00	6.30E-01	3.14E-01	1.23E-01	6.80E-02	5.15E-02
1500	1.02E 01	1.23E 00	5.46E-01	1.95E-01	1.03E-01	7.75E-02
3000	3.86E 01	2.50E 00	9.65E-01	3.07E-01	1.55E-01	1.14E-01

FLIGHT NO. C-182B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	1.20E-01	4.98E-02	3.18E-02	1.64E-02	1.07E-02	8.04E-03
600	3.42E-01	1.20E-01	7.28E-02	3.58E-02	2.30E-02	1.72E-02
900	6.27E-01	1.91E-01	1.11E-01	5.25E-02	3.33E-02	2.48E-02
1500	1.36E 00	3.26E-01	1.78E-01	7.99E-02	4.96E-02	3.67E-02
3000	3.00E 00	5.26E-01	2.69E-01	1.14E-01	6.88E-02	5.06E-02

FLIGHT NO. C-182B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5097 DATE 04/09/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-182B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	6.56E-01	1.96E-01	1.08E-01	4.14E-02	2.05E-02	1.85E-02
600	3.11E 00	5.78E-01	2.77E-01	9.48E-02	4.45E-02	3.96E-02
900	7.64E 00	1.00E 00	4.37E-01	1.38E-01	6.26E-02	5.51E-02
1500	2.81E 01	2.08E 00	7.86E-01	2.20E-01	9.49E-02	8.22E-02
3000	1.47E 02	4.84E 00	1.51E 00	3.66E-01	1.51E-01	1.29E-01

FLIGHT NO. C-182B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	3.92E-01	1.34E-01	7.75E-02	3.22E-02	1.73E-02	1.55E-02
600	1.50E 00	3.67E-01	1.93E-01	7.39E-02	3.83E-02	3.42E-02
900	3.70E 00	6.66E-01	3.22E-01	1.15E-01	5.81E-02	5.15E-02
1500	1.10E 01	1.28E 00	5.53E-01	1.81E-01	8.81E-02	7.75E-02
3000	4.06E 01	2.55E 00	9.62E-01	2.81E-01	1.31E-01	1.14E-01

FLIGHT NO. C-182B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	1.36E-01	5.34E-02	3.26E-02	1.45E-02	8.48E-03	8.04E-03
600	3.86E-01	1.29E-01	7.46E-02	3.19E-02	1.83E-02	1.72E-02
900	7.06E-01	2.04E-01	1.14E-01	4.69E-02	2.65E-02	2.48E-02
1500	1.52E 00	3.48E-01	1.82E-01	7.17E-02	3.97E-02	3.67E-02
3000	3.27E 00	5.51E-01	2.71E-01	1.02E-01	5.52E-02	5.06E-02

FLIGHT C-186A – 19 AUGUST 1971 – TRACK 7 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit morning. There were no clouds during the flight reported by Scott Air Force Base, which is southeast of the city. The flight was conducted over rolling hills southwest of St. Louis. The typical terrain was heavily wooded. The data-taking started at 1543 GMT (1043 CDT) and continued until 1707 GMT (1207 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 41.0 degrees at the beginning and 32.9 degrees at the end. The maximum altitude for the flight was 2520 meters. Average terrain elevation along this track was 305 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 5-mile (8-kilometer) visibility in haze.

The ground station located at Scott, 85 miles (137 kilometers) from the center of the flight path, recorded clear with moderate haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
1617	1645	Haze top at 6500 ft (1980 m) MSL, some clouds broken to scattered below and to the south

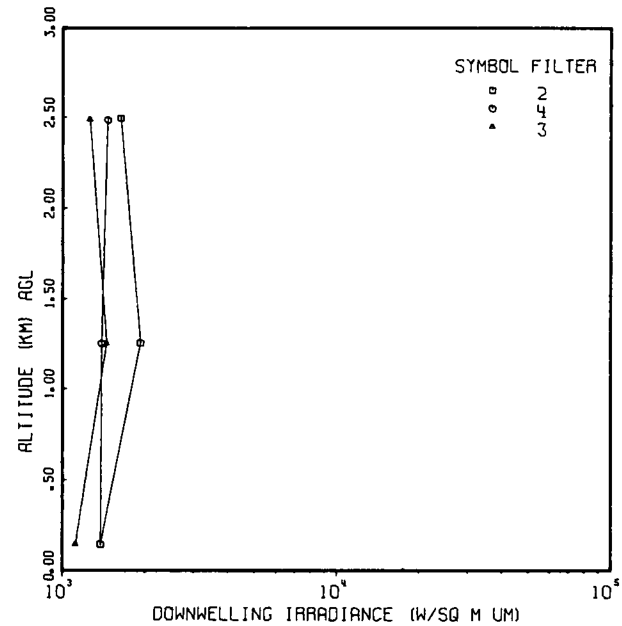
At the end of data-taking, Scott was reporting clear skies with 6-mile (9.6-kilometer) visibility in haze.

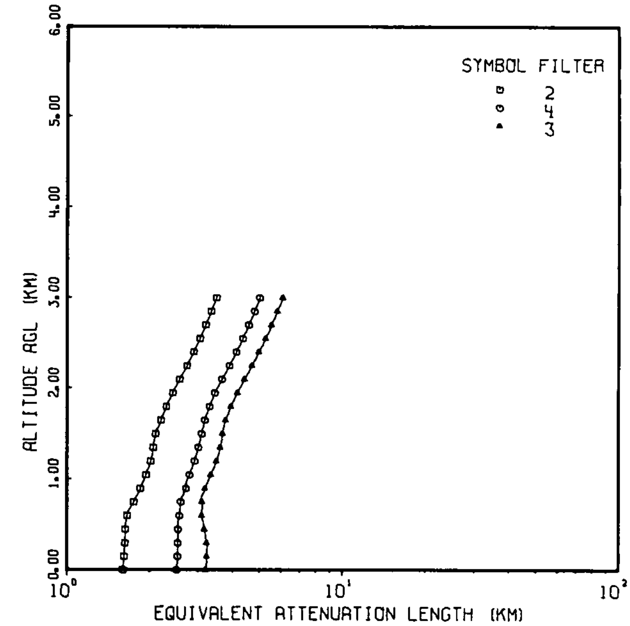
The surface synoptic chart shows an extremely weak gradient. There was a low centered in Nevada and a slow-moving cold front along the line Minneapolis/Omaha/Trinidad.

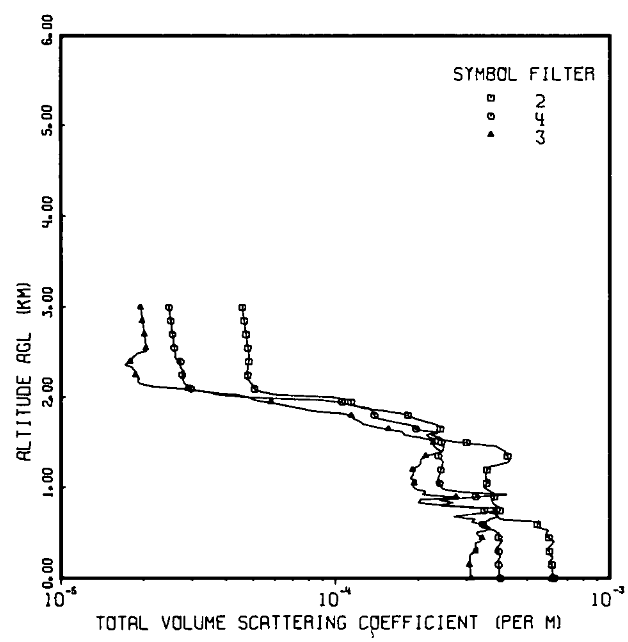
At 500 millibars there was high over most of the country except for a weak trough over Tennessee. There was a high center off Florida and the Carolinas. The gradient was very weak.

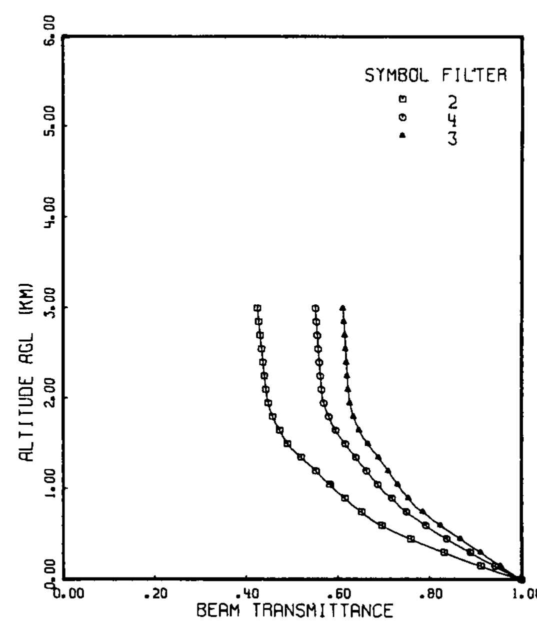
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-186A

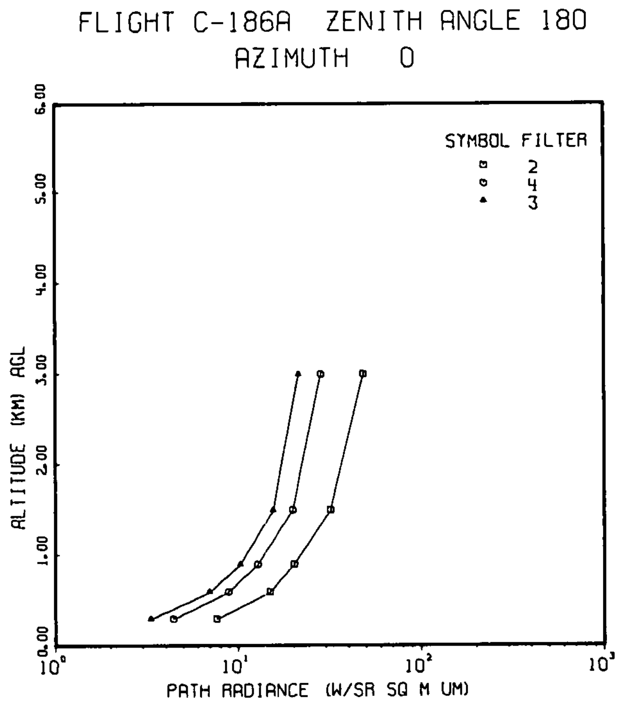


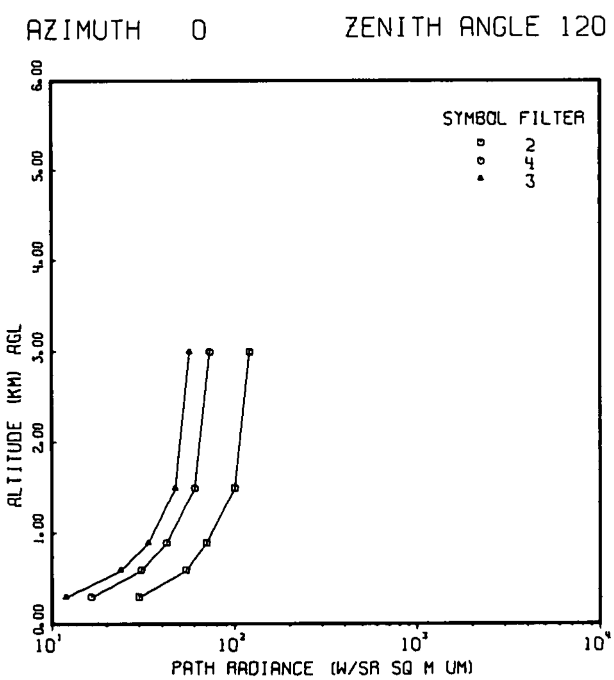


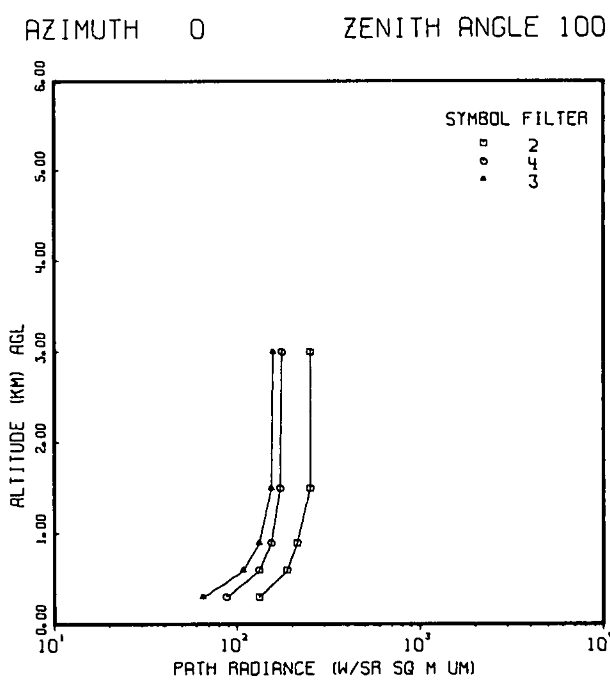




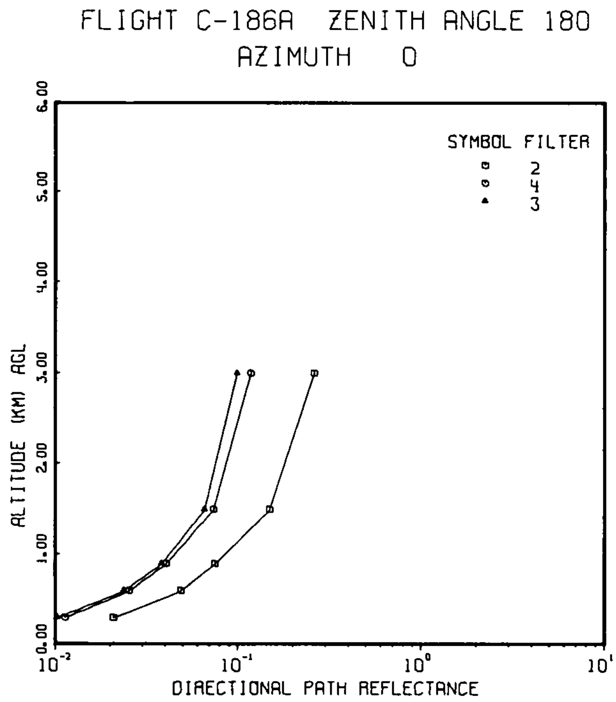
FLIGHT NO. C-186A

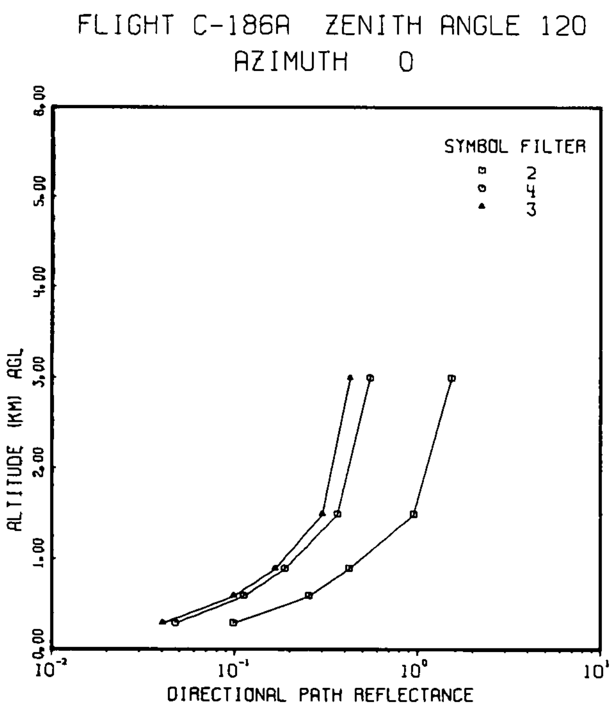


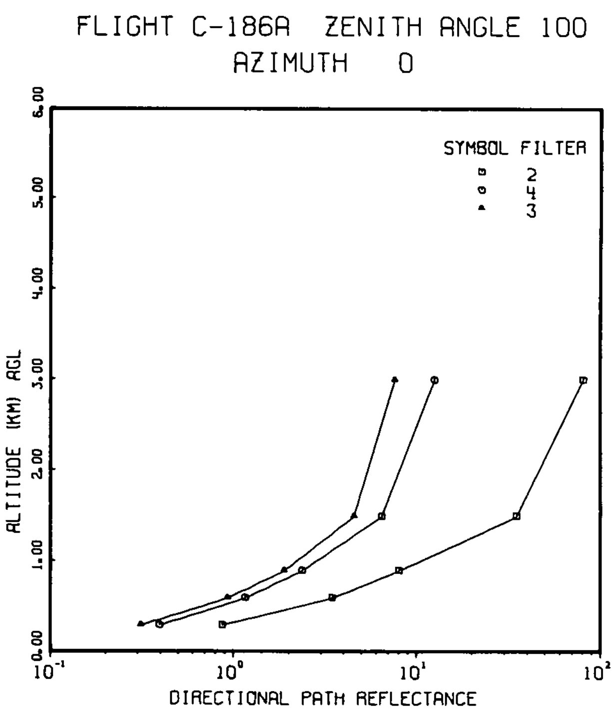




FLIGHT NO. C-186A







FLIGHT NO. C-186A
IRRADIANCE

(JOB 5359 CATE 04/18/73)

FLIGHT NO.C-186A FILTER NO. 2 SUN ZENITH ANGLE 36.8

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DCWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
147	1.38E 03	7.01E 01	.051	6.75E 02	1.58E 03	2.09E 02	2.46E 03	.093
1255	1.93E 03	1.66E 02	.086	1.30E 03	1.68E 03	4.93E 02	3.47E 03	.166
2496	1.63E 03	3.80E 02	.234	1.70E 03	5.38E 02	8.30E 02	3.07E 03	.370

FLIGHT NO.C-186A FILTER NO. 4 SUN ZENITH ANGLE 36.8

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
148	1.38E 03	7.23E 01	.053	8.32E 02	1.34E 03	2.03E 02	2.37E 03	.094
1254	1.39E 03	1.53E 02	.110	1.32E 03	6.65E 02	4.16E 02	2.40E 03	.210
2487	1.46E 03	1.73E 02	.118	1.60E 03	3.10E 02	4.48E 02	2.36E 03	.235

FLIGHT NO.C-186A FILTER NU. 3 SUN ZENITH ANGLE 36.8

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
148	1.12E 03	5.38E 01	.048	8.26E 02	9.33E 02	1.49E 02	1.91E 03	.085
1254	1.45E 03	1.08E 02	.075	1.21E 03	9.57E 02	2.96E 02	2.47E 03	.136
2491	1.26E 03	1.71E 02	.136	1.42E 03	1.59E 02	4.23E 02	2.01E 03	.267

FLIGHT NO. C-186A
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5359 CATE 04/18/73)

FLIGHT NO. C-186A
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.3178	.2811	.2911
100	.1948	.1816	.1419
105	.1440	.1240	.0850
120	.0555	.0547	.0399
150	.0534	.0293	.0396
180	.0237	.0555	.0317

FLIGHT NO. C-186A
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1657	.1267	.1145
100	.0933	.0999	.0948
105	.0723	.0845	.0842
120	.0589	.0393	.0505
150	.0510	.0330	.0345
180	.0237	.0555	.0317

FLIGHT NO. C-186A
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1115	.1065	.0842
100	.0873	.0850	.0655
105	.0700	.0683	.0806
120	.0453	.0555	.0390
150	.0644	.0494	.0564
180	.0237	.0555	.0317

FLIGHT NO. C-186A
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1298	.1396	.1109
100	.1001	.1018	.0897
105	.0682	.0806	.0779
120	.0462	.0510	.0344
150	.0564	.0528	.0479
180	.0237	.0555	.0317

FLIGHT NO. C-186A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5359 DATE 04/18/73)
DATE 81971 FLIGHT NO. C-186A GRCUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING CCEFFICIENT (PER M) FILTERS 2	4	3
0	6.25E-04	3.99E-04	3.13F-04
30	6.21E-04	3.97E-04	3.11E-04
60	6.20E-04	3.96E-04	3.10E-04
90	6.18E-04	3.95E-04	3.10E-04
120	6.17E-04	3.94E-04	3.09E-04
150	6.15E-04	3.93E-04	3.08E-04
180	6.08E-04	3.92E-04	3.07E-04
210	6.09E-04	3.91E-04	3.09E-04
240	6.21E-04	3.97E-04	3.08E-04
270	6.02E-04	3.96E-04	3.11E-04
300	6.02E-04	3.93E-04	3.24E-04
330	5.97E-04	3.85E-04	3.32E-04
360	6.04E-04	3.92E-04	3.24E-04
390	6.18E-04	3.97E-04	3.23E-04
420	6.27E-04	4.05E-04	3.38E-04
450	6.00E-04	3.93E-04	3.43E-04
480	5.92E-04	3.96E-04	3.31E-04
510	5.85E-04	3.93E-04	3.27E-04
540	5.98E-04	3.77E-04	3.57E-04
570	5.44E-04	3.42E-04	3.65E-04
600	5.45E-04	3.45E-04	3.44E-04
630	5.56E-04	3.55E-04	3.13E-04
660	4.01E-04	3.64E-04	3.23E-04
690	3.88E-04	3.93E-04	2.71E-04
720	3.86E-04	3.81E-04	3.27E-04
750	3.98E-04	3.49E-04	3.83E-04
780	3.97E-04	3.46E-04	3.76E-04
810	3.86E-04	2.41E-04	2.55E-04
840	3.73E-04	2.69E-04	2.01E-04
870	3.72E-04	2.40E-04	2.04E-04
900	3.79E-04	3.25E-04	2.76E-04
930	3.82E-04	4.22E-04	2.08E-04
960	3.71E-04	2.87E-04	2.14E-04
990	3.57E-04	2.47E-04	1.97E-04
1020	3.46E-04	2.42E-04	1.92E-04
1050	3.55E-04	2.40E-04	1.94E-04
1080	3.66E-04	2.35E-04	1.98E-04
1110	3.53E-04	2.37E-04	1.87E-04
1140	3.52E-04	2.39E-04	1.91E-04
1170	3.54E-04	2.41E-04	1.93E-04
1200	3.57E-04	2.42E-04	1.91E-04
1230	3.62E-04	2.44E-04	1.97E-04
1260	3.95E-04	2.46E-04	2.04E-04
1290	4.29E-04	2.47E-04	2.05E-04
1320	4.31E-04	2.43E-04	2.05E-04
1350	4.24E-04	2.37E-04	2.14E-04
1380	4.20E-04	2.38E-04	2.29E-04
1410	4.16E-04	2.47E-04	2.44E-04
1440	3.99E-04	2.48E-04	2.34E-04
1470	3.83E-04	2.48E-04	2.27E-04
1500	3.01E-04	2.43E-04	2.28E-04

FLIGHT NO. C-186A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5359 CATE 04/18/73)
DATE 81971 FLIGHT NO. C-186A GRCUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	2.49E-04	2.45E-04	2.22E-04
1560	2.22E-04	2.41E-04	2.03E-04
1590	2.14E-04	2.22E-04	1.78E-04
1620	2.39E-04	2.38E-04	1.76E-04
1650	2.41E-04	1.97E-04	1.56E-04
1680	2.43E-04	1.94E-04	1.38E-04
1710	2.31E-04	1.81E-04	1.27E-04
1740	2.11E-04	1.60E-04	1.22E-04
1770	1.97E-04	1.44E-04	1.17E-04
1800	1.84E-04	1.39E-04	1.14E-04
1830	1.73E-04	1.38E-04	1.05E-04
1860	1.49E-04	1.36E-04	8.16E-05
1890	1.26E-04	1.31E-04	7.36E-05
1920	1.16E-04	1.15E-04	6.56E-05
1950	1.14E-04	1.06E-04	5.84E-05
1980	1.13E-04	8.86E-05	5.07E-05
2010	9.82E-05	4.97E-05	4.83E-05
2040	6.07E-05	3.73E-05	4.36E-05
2070	5.43E-05	3.43E-05	3.42E-05
2100	5.07E-05	2.97E-05	2.90E-05
2130	5.02E-05	2.92E-05	2.15E-05
2160	4.96E-05	2.82E-05	1.93E-05
2190	4.86E-05	2.78E-05	1.90E-05
2220	4.73E-05	2.76E-05	1.94E-05
2250	4.79E-05	2.75E-05	1.87E-05
2280	4.74E-05	2.82E-05	1.88E-05
2310	4.79E-05	2.78E-05	1.84E-05
2340	4.79E-05	2.72E-05	1.81E-05
2370	4.79E-05	2.70E-05	1.71E-05
2400	4.83E-05	2.72E-05	1.79E-05
2430	4.82E-05	2.63E-05	1.81E-05
2460	4.82E-05	2.59E-05	1.85E-05
2490	4.82E-05	2.60E-05	1.89E-05
2520	4.80E-05	2.59E-05	2.05E-05
2550	4.79E-05	2.58E-05	2.04E-05
2580	4.77E-05	2.57E-05	2.03E-05
2610	4.76E-05	2.57E-05	2.03E-05
2640	4.74E-05	2.56E-05	2.02E-05
2670	4.73E-05	2.55E-05	2.02E-05
2700	4.72E-05	2.54E-05	2.01E-05
2730	4.70E-05	2.53E-05	2.00E-05
2760	4.69E-05	2.53E-05	2.00E-05
2790	4.67E-05	2.52E-05	1.99E-05
2820	4.66E-05	2.51E-05	1.98E-05
2850	4.64E-05	2.50E-05	1.98E-05
2880	4.63E-05	2.49E-05	1.97E-05
2910	4.61E-05	2.49E-05	1.97E-05
2940	4.60E-05	2.48E-05	1.96E-05
2970	4.58E-05	2.47E-05	1.95E-05
3000	4.57E-05	2.46E-05	1.95E-05
FIRST DATA ALT	150	210	180
LAST DATA ALT	2490	2490	2520

FLIGHT NO. C-186A
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5359 DATE 04/18/73)

FLIGHT NO. C-186A FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.20E-01	3.46E-01	4.91E-01	6.92E-01	8.08E-01	8.32E-01
600	1.53E-02	1.24E-01	2.46E-01	4.84E-01	6.58E-01	6.96E-01
900	3.59E-03	6.09E-02	1.53E-01	3.78E-01	5.70E-01	6.15E-01
1500	2.44E-04	1.64E-02	6.34E-02	2.40E-01	4.39E-01	4.90E-01
3000	3.50E-05	7.10E-03	3.62E-02	1.79E-01	3.71E-01	4.24E-01

FLIGHT NO. C-186A FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.56E-01	5.06E-01	6.33E-01	7.89E-01	8.72E-01	8.88E-01
600	6.73E-02	2.60E-01	4.05E-01	6.26E-01	7.63E-01	7.91E-01
900	2.14E-02	1.48E-01	2.77E-01	5.15E-01	6.82E-01	7.17E-01
1500	3.49E-03	6.11E-02	1.53E-01	3.79E-01	5.71E-01	6.15E-01
3000	8.01E-04	3.21E-02	9.96E-02	3.03E-01	5.02E-01	5.50E-01

FLIGHT NO. C-186A FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.43E-01	5.85E-01	6.98E-01	8.30E-01	8.98E-01	9.11E-01
600	1.06E-01	3.27E-01	4.72E-01	6.78E-01	7.99E-01	8.23E-01
900	3.78E-02	1.96E-01	3.35E-01	5.68E-01	7.21E-01	7.53E-01
1500	8.59E-03	9.52E-02	2.06E-01	4.42E-01	6.24E-01	6.65E-01
3000	2.76E-03	5.84E-02	1.49E-01	3.73E-01	5.66E-01	6.11E-01

FLIGHT NO. C-186A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5359 CATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-186A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.21E 02	1.32E 02	8.48E 01	2.99E 01	9.82E 00	7.63E 00
600	2.61E 02	1.88E 02	1.34E 02	5.43E 01	1.90E 01	1.49E 01
900	2.79E 02	2.14E 02	1.60E 02	7.02E 01	2.56E 01	2.02E 01
1500	3.06E 02	2.52E 02	2.00E 02	1.00E 02	3.96E 01	3.20E 01
3000	2.80E 02	2.52E 02	2.13E 02	1.21E 02	5.57E 01	4.86E 01

FLIGHT NO. C-186A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.70E 02	8.77E 01	5.26E 01	1.64E 01	5.02E 00	4.41E 00
600	2.08E 02	1.33E 02	8.72E 01	3.09E 01	1.02E 01	8.84E 00
900	2.15E 02	1.54E 02	1.08E 02	4.26E 01	1.48E 01	1.28E 01
1500	2.12E 02	1.73E 02	1.32E 02	6.06E 01	2.32E 01	1.99E 01
3000	2.02E 02	1.76E 02	1.43E 02	7.33E 01	3.17E 01	2.85E 01

FLIGHT NO. C-186A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.33E 02	6.52E 01	3.86E 01	1.20E 01	3.80E 00	3.32E 00
600	1.80E 02	1.08E 02	6.95E 01	2.39E 01	3.03E 00	6.99E 00
900	1.96E 02	1.32E 02	9.01E 01	3.37E 01	1.19E 01	1.03E 01
1500	2.04E 02	1.55E 02	1.13E 02	4.75E 01	1.79E 01	1.56E 01
3000	1.91E 02	1.58E 02	1.22E 02	5.69E 01	2.38E 01	2.15E 01

FLIGHT NO. C-186A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5359 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-186A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.06E 02	6.90E 01	4.77E 01	2.11E 01	9.52E 00	7.63E 00
600	1.30E 02	1.01E 02	7.74E 01	3.90E 01	1.85E 01	1.49E 01
900	1.43E 02	1.18E 02	9.44E 01	5.11E 01	2.49E 01	2.02E 01
1500	1.69E 02	1.47E 02	1.25E 02	7.53E 01	3.89E 01	3.20E 01
3000	1.79E 02	1.63E 02	1.44E 02	9.59E 01	5.59E 01	4.86E 01

FLIGHT NO. C-186A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.20E 01	4.12E 01	2.70E 01	1.11E 01	4.87E 00	4.41E 00
600	9.24E 01	6.47E 01	4.63E 01	2.13E 01	9.82E 00	8.84E 00
900	1.00E 02	7.83E 01	5.96E 01	2.98E 01	1.43E 01	1.28E 01
1500	1.11E 02	9.50E 01	7.80E 01	4.39E 01	2.25E 01	1.99E 01
3000	1.20E 02	1.07E 02	9.15E 01	5.65E 01	3.18E 01	2.85E 01

FLIGHT NO. C-186A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.40E 01	2.95E 01	1.91E 01	7.93E 00	3.69E 00	3.32E 00
600	7.89E 01	5.18E 01	3.62E 01	1.63E 01	7.81E 00	6.99E 00
900	9.20E 01	6.69E 01	4.91E 01	2.36E 01	1.16E 01	1.03E 01
1500	1.08E 02	8.55E 01	6.65E 01	3.47E 01	1.77E 01	1.56E 01
3000	1.10E 02	9.40E 01	7.68E 01	4.37E 01	2.41E 01	2.15E 01

FLIGHT NO. C-186A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5359 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-186A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.74E 01	5.25E 01	3.80E 01	1.96E 01	1.05E 01	7.63E 00
600	9.72E 01	7.85E 01	6.26E 01	3.63E 01	2.03E 01	1.49E 01
900	1.09E 02	9.28E 01	7.72E 01	4.77E 01	2.74E 01	2.02E 01
1500	1.36E 02	1.21E 02	1.05E 02	7.16E 01	4.31E 01	3.20E 01
3000	1.66E 02	1.49E 02	1.34E 02	9.81E 01	6.58E 01	4.86E 01

FLIGHT NO. C-186A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.11E 01	3.11E 01	2.18E 01	1.11E 01	5.90E 00	4.41E 00
600	6.60E 01	4.90E 01	3.74E 01	2.10E 01	1.17E 01	8.84E 00
900	7.22E 01	5.94E 01	4.80E 01	2.92E 01	1.69E 01	1.28E 01
1500	8.25E 01	7.35E 01	6.36E 01	4.27E 01	2.61E 01	1.99E 01
3000	1.04E 02	9.18E 01	8.10E 01	5.78E 01	3.79E 01	2.85E 01

FLIGHT NO. C-186A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.69E 01	2.18E 01	1.54E 01	7.89E 00	4.35E 00	3.32E 00
600	5.41E 01	3.82E 01	2.88E 01	1.59E 01	9.10E 00	6.99E 00
900	6.33E 01	4.91E 01	3.87E 01	2.27E 01	1.33E 01	1.03E 01
1500	7.65E 01	6.35E 01	5.24E 01	3.30E 01	2.03E 01	1.56E 01
3000	8.84E 01	7.60E 01	6.49E 01	4.40E 01	2.94E 01	2.15E 01

FLIGHT NO. C-186A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5359 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-186A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.21E 01	6.00E 01	4.18E 01	1.93E 01	9.46E 00	7.63E 00
600	1.15E 02	8.97E 01	6.88E 01	3.58E 01	1.83E 01	1.49E 01
900	1.29E 02	1.06E 02	8.49E 01	4.72E 01	2.46E 01	2.02E 01
1500	1.57E 02	1.36E 02	1.15E 02	7.03E 01	3.82E 01	3.20E 01
3000	1.69E 02	1.53E 02	1.35E 02	9.07E 01	5.53E 01	4.86E 01

FLIGHT NO. C-186A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.46E 01	3.73E 01	2.47E 01	1.07E 01	5.18E 00	4.41E 00
600	8.14E 01	5.76E 01	4.17E 01	2.03E 01	1.03E 01	8.84E 00
900	8.68E 01	6.86E 01	5.29E 01	2.81E 01	1.49E 01	1.28E 01
1500	9.34E 01	8.14E 01	6.79E 01	4.08E 01	2.31E 01	1.99E 01
3000	1.06E 02	9.38E 01	8.10E 01	5.27E 01	3.22E 01	2.85E 01

FLIGHT NO. C-186A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.48E 01	2.49E 01	1.65E 01	7.25E 00	3.72E 00	3.32E 00
600	6.51E 01	4.35E 01	3.10E 01	1.48E 01	7.86E 00	6.99E 00
900	7.56E 01	5.59E 01	4.18E 01	2.14E 01	1.16E 01	1.03E 01
1500	8.89E 01	7.13E 01	5.63E 01	3.13E 01	1.77E 01	1.56E 01
3000	9.38E 01	7.97E 01	6.58E 01	3.95E 01	2.38E 01	2.15E 01

FLIGHT NO. C-186A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5359 CATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-186A FILTER NO. 2
DIRECTICNAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	4.20E 00	8.70E-01	3.94E-01	9.86E-02	2.77E-02	2.09E-02
600	3.89E 01	3.46E 00	1.24E 00	2.56E-01	6.59E-02	4.89E-02
900	1.77E 02	8.02E 00	2.38E 00	4.23E-01	1.02E-01	7.49E-02
1500	2.86E C3	3.50E 01	7.20E 00	9.52E-01	2.06E-01	1.49E-01
3000	1.83E 04	8.09E 01	1.34E 01	1.53E 00	3.42E-01	2.61E-01

FLIGHT NO. C-186A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.51E 00	3.96E-01	1.90E-01	4.75E-02	1.31E-02	1.13E-02
600	7.05E 00	1.16E 00	4.91E-01	1.13E-01	3.03E-02	2.55E-02
900	2.28E 01	2.38E 00	8.91E-01	1.89E-01	4.96E-02	4.07E-02
1500	1.39E 02	6.46E 00	1.97E 00	3.65E-01	9.25E-02	7.37E-02
3000	5.75E 02	1.25E 01	3.27E 00	5.52E-01	1.44E-01	1.18E-01

FLIGHT NO. C-186A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.09E 00	3.13E-01	1.56E-01	4.05E-02	1.19E-02	1.02E-02
600	4.76E 00	9.32E-01	4.14E-01	9.91E-02	2.83E-02	2.38E-02
900	1.46E 01	1.90E 00	7.56E-01	1.67E-01	4.62E-02	3.84E-02
1500	6.69E 01	4.56E 00	1.53E 00	3.02E-01	8.07E-02	6.59E-02
3000	1.94E 02	7.60E 00	2.30E 00	4.29E-01	1.18E-01	9.91E-02

FLIGHT NO. C-186A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5359 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-186A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.02E 00	4.55E-01	2.22E-01	6.96E-02	2.68E-02	2.09E-02
600	1.94E 01	1.86E 00	7.15E-01	1.84E-01	6.41E-02	4.89E-02
900	9.09E 01	4.42E 00	1.41E 00	3.08E-01	9.96E-02	7.49E-02
1500	1.58E 03	2.05E 01	4.48E 00	7.15E-01	2.02E-01	1.49E-01
3000	1.17E 04	5.24E 01	9.09E 00	1.22E 00	3.44E-01	2.61E-01

FLIGHT NO. C-186A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.41E-01	1.86E-01	9.72E-02	3.20E-02	1.27E-02	1.13E-02
600	3.13E 00	5.67E-01	2.61E-01	7.74E-02	2.93E-02	2.55E-02
900	1.07E 01	1.21E 00	4.90E-01	1.32E-01	4.79E-02	4.07E-02
1500	7.22E 01	3.55E 00	1.16E 00	2.65E-01	8.99E-02	7.37E-02
3000	3.42E 02	7.59E 00	2.10E 00	4.25E-01	1.44E-01	1.18E-01

FLIGHT NO. C-186A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.42E-01	1.42E-01	7.71E-02	2.68E-02	1.15E-02	1.02E-02
600	2.08E 00	4.46E-01	2.16E-01	6.76E-02	2.75E-02	2.38E-02
900	6.84E 00	9.59E-01	4.12E-01	1.17E-01	4.51E-02	3.84E-02
1500	3.54E 01	2.53E 00	9.06E-01	2.21E-01	7.95E-02	6.59E-02
3000	1.12E 02	4.53E 00	1.45E 00	3.30E-01	1.20E-01	9.91E-02

FLIGHT NO. C-186A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5359 CATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-186A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.47E 00	3.46E-01	1.77E-01	6.45E-02	2.95E-02	2.09E-02
600	1.45E 01	1.44E 00	5.79E-01	1.71E-01	7.03E-02	4.89E-02
900	6.93E 01	3.47E 00	1.15E 00	2.88E-01	1.09E-01	7.49E-02
1500	1.27E 03	1.68E C1	3.79E 00	6.80E-01	2.24E-01	1.49E-01
3000	1.08E 04	4.78E 01	8.42E 00	1.25E 00	4.05E-01	2.61E-01

FLIGHT NO. C-186A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.55E-01	1.40E-01	7.86E-02	3.21E-02	1.54E-02	1.13E-02
600	2.24E 00	4.29E-01	2.10E-01	7.66E-02	3.50E-02	2.55E-02
900	7.69E 00	9.16E-01	3.95E-01	1.29E-01	5.65E-02	4.07E-02
1500	5.38E 01	2.74E 00	9.45E-01	2.57E-01	1.04E-01	7.37E-02
3000	2.96E 02	6.51E 00	1.86E 00	4.35E-01	1.72E-01	1.18E-01

FLIGHT NO. C-186A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	3.C2E-01	1.05E-01	6.18E-02	2.67E-02	1.36E-02	1.02E-02
600	1.43E 00	3.28E-01	1.71E-01	6.61E-02	3.20E-02	2.38E-02
900	4.71E C0	7.04E-01	3.25E-01	1.12E-01	5.19E-02	3.84E-02
1500	2.50E 01	1.87E 00	7.14E-01	2.10E-01	9.15E-02	6.59E-02
3000	8.99E 01	3.68E 00	1.23E 00	3.32E-01	1.46E-01	9.91E-02

FLIGHT NO. C-186A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5359 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-186A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.75E 00	3.95E-01	1.94E-01	6.34E-02	2.67E-02	2.09E-02
600	1.72E 01	1.65E 00	6.36E-01	1.69E-01	6.34E-02	4.89E-02
900	8.19E 01	3.97E 00	1.27E 00	2.84E-01	9.83E-02	7.49E-02
1500	1.47E 03	1.88E 01	4.12E 00	6.68E-01	1.99E-01	1.49E-01
3000	1.10E 04	4.91E 01	8.49E 00	1.15E 00	3.40E-01	2.61E-01

FLIGHT NO. C-186A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.75E-01	1.68E-01	8.88E-02	3.09E-02	1.35E-02	1.13E-02
600	2.76E 00	5.05E-01	2.35E-01	7.37E-02	3.09E-02	2.55E-02
900	9.24E 00	1.06E 00	4.35E-01	1.24E-01	4.99E-02	4.07E-02
1500	6.09E 01	3.04E 00	1.01E 00	2.45E-01	9.22E-02	7.37E-02
3000	3.03E 02	6.66E 00	1.86E 00	3.96E-01	1.46E-01	1.18E-01

FLIGHT NO. C-186A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.67E-01	1.20E-01	6.63E-02	2.45E-02	1.16E-02	1.02E-02
600	1.72E 00	3.75E-01	1.84E-01	6.15E-02	2.77E-02	2.38E-02
900	5.62E 00	8.02E-01	3.51E-01	1.06E-01	4.53E-02	3.84E-02
1500	2.91E 01	2.10E 00	7.67E-01	1.99E-01	7.95E-02	6.59E-02
3000	9.55E 01	3.84E 00	1.24E 00	2.98E-01	1.18E-01	9.91E-02

FLIGHT C-186B – 19 AUGUST 1971 – TRACK 3 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon. Clear skies were reported for the period of the flight. The flight was conducted over multiple small fields northeast of St. Louis. The typical terrain was flat, highly cultivated farmland. The data-taking started at 1751 GMT (1251 CDT) and continued until 1857 GMT (1357 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 26.5 degrees at the beginning and 27.2 degrees at the end. The maximum altitude for the flight was 2610 meters. Average terrain elevation along this track was 183 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 6-mile (9.6-kilometer) visibility in haze.

The ground station located at Scott, 70 miles (110 kilometers) from the center of the flight path, recorded clear with moderate haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
–	–	Much clearer than Flight C-186A
–	–	Light haze, no clouds overhead
1803	1493	Light to moderate haze at 5500 ft (1680 m) MSL
1817	1493	Moderate to heavy haze at 5500 ft (1680 m) MSL, no clouds
1836	2713	Moderate to heavy haze below 9500 ft (2900 m) MSL, clear above with scattered clouds to the north

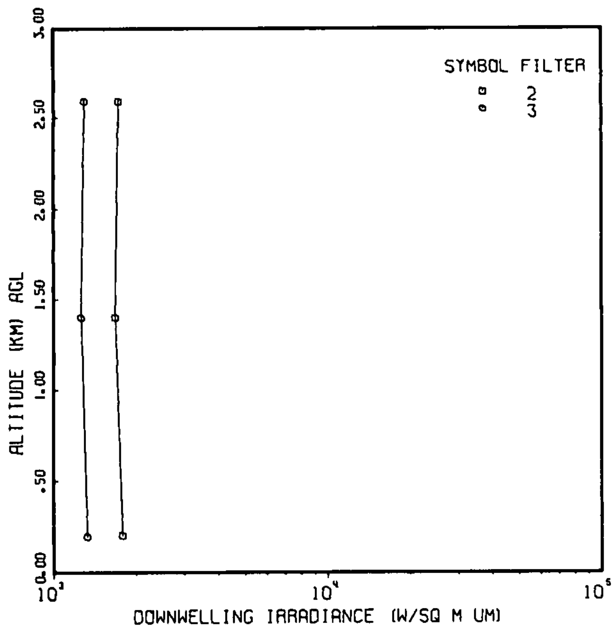
At the end of data-taking, Scott was reporting clear skies with 7-mile (11.2-kilometer) visibility.

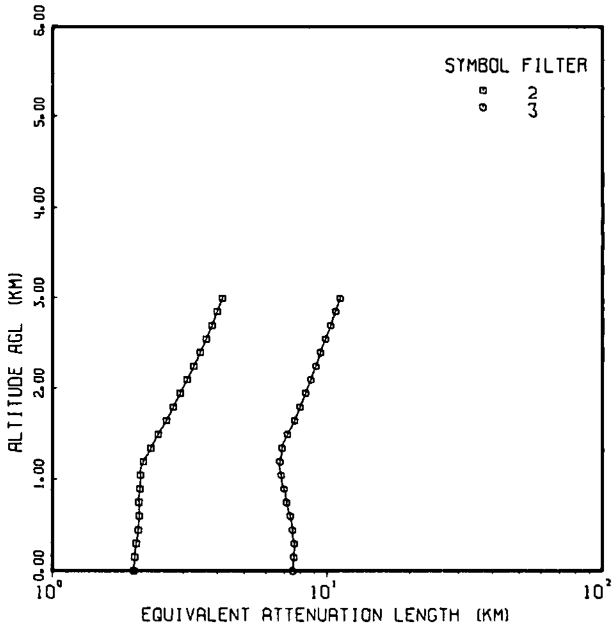
The surface synoptic chart shows an extremely weak gradient. There was a low centered in Nevada and a slow-moving cold front along the line Minneapolis/Omaha/Trinidad.

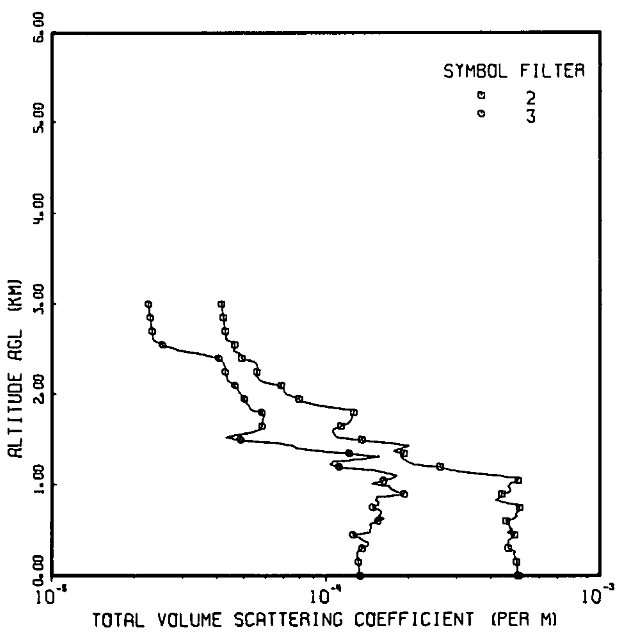
At 500 millibars there was a high over most of the country except for a weak trough over Tennessee. There was a high center off Florida and the Carolinas. The gradient was very weak.

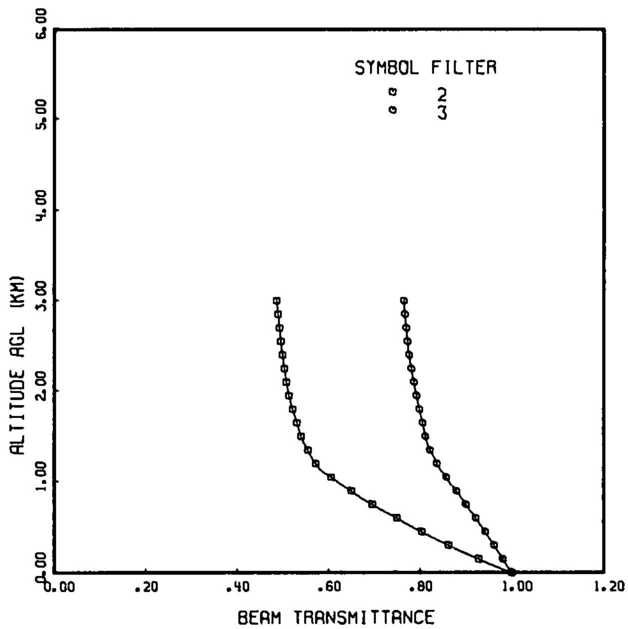
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-186B

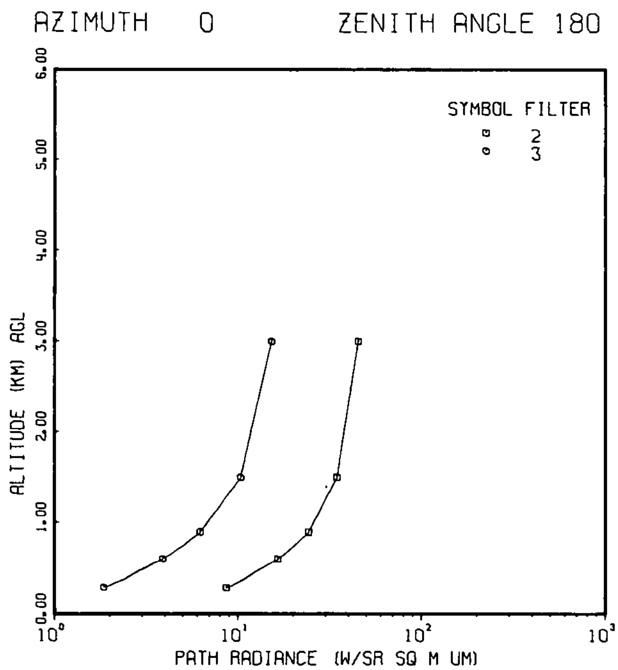


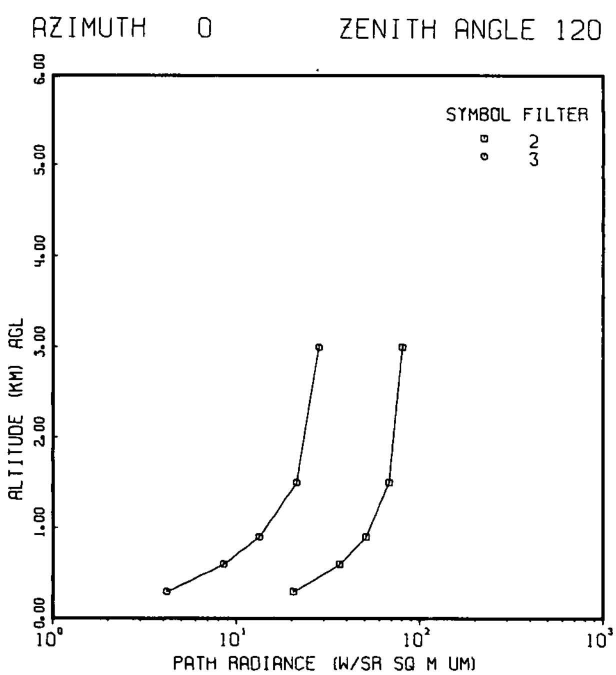


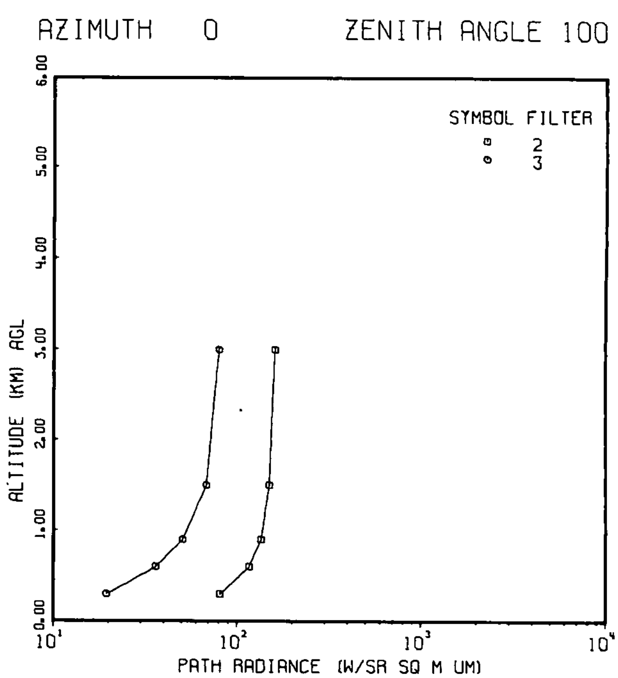




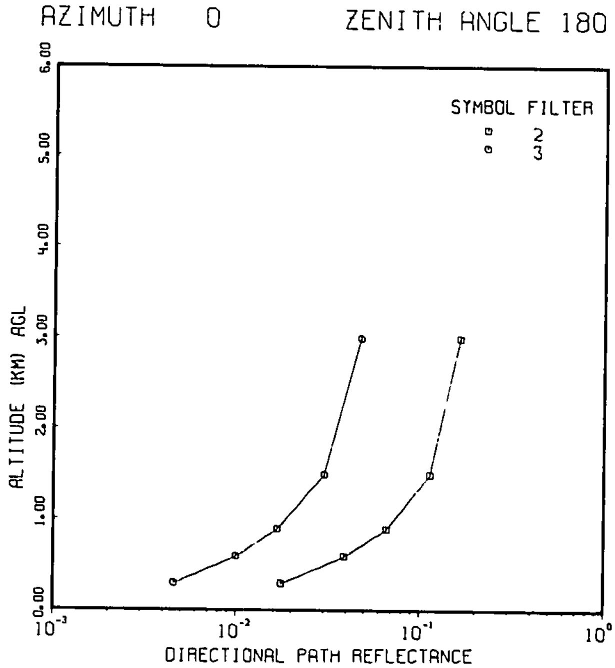
FLIGHT NO. C-186B

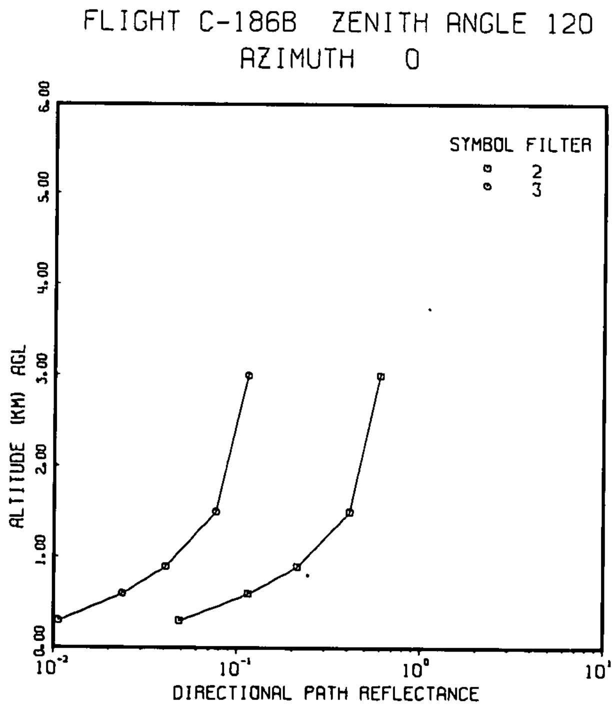


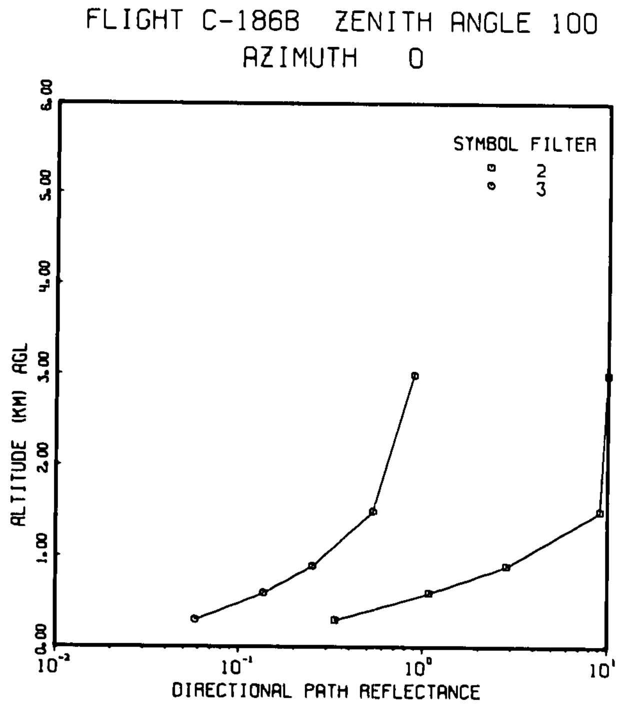




FLIGHT NO. C-186B







FLIGHT NO. C-186B
IRRADIANCE

(JOB 5111 DATE 03/07/73)

FLIGHT NO.C-186B FILTER NO. 2 SUN ZENITH ANGLE 27.2

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
205	1.79E 03	8.34E 01	.047	8.86E 02	1.57E 03	2.18E 02	2.68E 03	.089
1401	1.68E 03	1.67E 02	.100	1.55E 03	6.32E 02	4.38E 02	2.62E 03	.201
2600	1.73E 03	1.90E 02	.110	1.74E 03	4.77E 02	4.90E 02	2.70E 03	.221

FLIGHT NO.C-186B FILTER NO. 3 SUN ZENITH ANGLE 27.2

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
199	1.33E 03	7.29E 01	.055	1.09E 03	6.46E 02	1.62E 02	1.90E 03	.093
1402	1.26E 03	1.02E 02	.081	1.32E 03	1.87E 02	2.53E 02	1.76E 03	.168
2601	1.30E 03	1.08E 02	.083	1.41E 03	1.40E 02	2.71E 02	1.82E 03	.175

FLIGHT NO. C-186B
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5111 DATE 03/07/73)

FLIGHT NO. C-186B
AZIMUTH OF PATH OF SIGHT = .0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	3
95	.1429	.1386
100	.1015	.0921
105	.0834	.0701
120	.0385	.0514
150	.0384	.0477
180	.0310	.0412

FLIGHT NO. C-186B
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	3
95	.1393	.0914
100	.0949	.0690
105	.0649	.0615
120	.0365	.0378
150	.0251	.0332
180	.0310	.0412

FLIGHT NO. C-186B
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	3
95	.1046	.0710
100	.0829	.0689
105	.0671	.0690
120	.0419	.0469
150	.0477	.0966
180	.0310	.0412

FLIGHT NO. C-186B
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	3
95	.1074	.0881
100	.0800	.0658
105	.0627	.0567
120	.0298	.0420
150	.0406	.0851
180	.0310	.0412

FLIGHT NO. C-186B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5111 DATE 03/07/73)
DATE 81971 FLIGHT NO. C-186B GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	3
0	5.04E-04	1.33E-04
30	5.02E-04	1.32E-04
60	5.00E-04	1.32E-04
90	4.99E-04	1.32E-04
120	4.98E-04	1.31E-04
150	4.97E-04	1.31E-04
180	4.95E-04	1.31E-04
210	4.89E-04	1.30E-04
240	4.86E-04	1.30E-04
270	4.90E-04	1.31E-04
300	4.63E-04	1.35E-04
330	4.63E-04	1.42E-04
360	4.63E-04	1.43E-04
390	4.62E-04	1.37E-04
420	4.80E-04	1.33E-04
450	4.88E-04	1.25E-04
480	4.57E-04	1.45E-04
510	4.80E-04	1.45E-04
540	4.69E-04	1.46E-04
570	4.63E-04	1.45E-04
600	4.56E-04	1.55E-04
630	4.85E-04	1.63E-04
660	4.97E-04	1.55E-04
690	4.94E-04	1.59E-04
720	5.08E-04	1.58E-04
750	5.08E-04	1.48E-04
780	4.94E-04	1.55E-04
810	4.46E-04	1.56E-04
840	4.15E-04	1.51E-04
870	4.35E-04	1.54E-04
900	4.39E-04	1.93E-04
930	4.72E-04	1.81E-04
960	4.71E-04	1.72E-04
990	4.61E-04	1.70E-04
1020	4.71E-04	1.47E-04
1050	5.03E-04	1.62E-04
1080	4.93E-04	1.75E-04
1110	4.22E-04	1.82E-04
1140	3.34E-04	1.63E-04
1170	2.85E-04	1.48E-04
1200	2.61E-04	1.11E-04
1230	2.10E-04	1.03E-04
1260	2.00E-04	1.06E-04
1290	1.92E-04	1.31E-04
1320	1.88E-04	1.57E-04
1350	1.92E-04	1.21E-04
1380	1.75E-04	9.39E-05
1410	1.89E-04	7.82E-05
1440	2.02E-04	7.50E-05
1470	1.73E-04	6.61E-05
1500	1.35E-04	4.86E-05

FLIGHT NO. C-186B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5111 DATE 03/07/73)
DATE 81971 FLIGHT NO. C-186B GROUND LEVEL ALTITUDE (M)= 183

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	3
1530	1.10E-04	4.29E-05
1560	1.08E-04	4.78E-05
1590	1.05E-04	5.40E-05
1620	1.06E-04	5.77E-05
1650	1.13E-04	5.83E-05
1680	1.20E-04	5.88E-05
1710	1.22E-04	5.83E-05
1740	1.24E-04	5.89E-05
1770	1.24E-04	5.95E-05
1800	1.26E-04	5.82E-05
1830	1.27E-04	5.33E-05
1860	1.06E-04	5.26E-05
1890	9.17E-05	5.18E-05
1920	8.31E-05	5.10E-05
1950	7.94E-05	5.03E-05
1980	7.59E-05	4.95E-05
2010	7.12E-05	4.87E-05
2040	7.02E-05	4.80E-05
2070	6.97E-05	4.72E-05
2100	6.84E-05	4.64E-05
2130	6.12E-05	4.51E-05
2160	5.72E-05	4.38E-05
2190	5.64E-05	4.34E-05
2220	5.50E-05	4.31E-05
2250	5.58E-05	4.28E-05
2280	5.62E-05	4.30E-05
2310	5.61E-05	4.28E-05
2340	5.58E-05	4.24E-05
2370	5.44E-05	4.18E-05
2400	4.92E-05	4.05E-05
2430	4.90E-05	3.73E-05
2460	4.84E-05	3.40E-05
2490	4.57E-05	2.92E-05
2520	4.64E-05	2.74E-05
2550	4.63E-05	2.53E-05
2580	4.59E-05	2.43E-05
2610	4.32E-05	2.34E-05
2640	4.31E-05	2.33E-05
2670	4.29E-05	2.32E-05
2700	4.28E-05	2.32E-05
2730	4.27E-05	2.31E-05
2760	4.25E-05	2.30E-05
2790	4.24E-05	2.30E-05
2820	4.23E-05	2.29E-05
2850	4.21E-05	2.28E-05
2880	4.20E-05	2.27E-05
2910	4.19E-05	2.27E-05
2940	4.17E-05	2.26E-05
2970	4.16E-05	2.25E-05
3000	4.15E-05	2.25E-05
FIRST DATA ALT	180	210
LAST DATA ALT	2610	2610

FLIGHT NO. C-186B
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5111 DATE 03/07/73)

FLIGHT NO. C-186B FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	1.82E-01	4.26E-01	5.64E-01	7.44E-01	8.43E-01	8.62E-01
600	3.58E-02	1.90E-01	3.28E-01	5.61E-01	7.17E-01	7.49E-01
900	6.86E-03	8.38E-02	1.89E-01	4.23E-01	6.08E-01	6.50E-01
1500	7.62E-04	2.88E-02	9.26E-02	2.92E-01	4.91E-01	5.40E-01
3000	1.83E-04	1.58E-02	6.18E-02	2.37E-01	4.35E-01	4.87E-01

FLIGHT NO. C-186B FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	6.35E-01	7.97E-01	8.59E-01	9.24E-01	9.56E-01	9.61E-01
600	3.90E-01	6.25E-01	7.30E-01	8.49E-01	9.10E-01	9.22E-01
900	2.26E-01	4.76E-01	6.08E-01	7.73E-01	8.62E-01	8.79E-01
1500	8.81E-02	3.01E-01	4.47E-01	6.59E-01	7.86E-01	8.12E-01
3000	4.09E-02	2.13E-01	3.54E-01	5.85E-01	7.33E-01	7.65E-01

FLIGHT NO. C-186B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-186B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.39E 02	8.09E 01	5.22E 01	2.05E 01	9.26E 00	8.65E 00
600	1.63E 02	1.16E 02	8.27E 01	3.66E 01	1.75E 01	1.65E 01
900	1.70E 02	1.35E 02	1.03E 02	5.10E 01	2.56E 01	2.43E 01
1500	1.74E 02	1.49E 02	1.23E 02	6.81E 01	3.62E 01	3.47E 01
3000	1.85E 02	1.60E 02	1.35E 02	8.06E 01	4.57E 01	4.53E 01

FLIGHT NO. C-186B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.30E 01	1.95E 01	1.15E 01	4.16E 00	1.94E 00	1.86E 00
600	7.07E 01	3.61E 01	2.23E 01	8.52E 00	4.05E 00	3.89E 00
900	8.82E 01	5.06E 01	3.28E 01	1.33E 01	6.48E 00	6.23E 00
1500	1.02E 02	6.82E 01	4.75E 01	2.13E 01	1.07E 01	1.04E 01
3000	1.11E 02	7.98E 01	5.82E 01	2.82E 01	1.51E 01	1.53E 01

FLIGHT NO. C-186B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-186B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.73E 01	5.99E 01	4.08E 01	1.81E 01	9.16E 00	8.65E 00
600	1.14E 02	8.64E 01	6.48E 01	3.26E 01	1.74E 01	1.65E 01
900	1.19E 02	1.00E 02	8.11E 01	4.56E 01	2.57E 01	2.43E 01
1500	1.23E 02	1.11E 02	9.65E 01	6.12E 01	3.68E 01	3.47E 01
3000	1.37E 02	1.24E 02	1.10E 02	7.41E 01	4.76E 01	4.53E 01

FLIGHT NO. C-186B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.56E 01	1.24E 01	7.86E 00	3.37E 00	1.84E 00	1.86E 00
600	4.23E 01	2.31E 01	1.54E 01	6.99E 00	3.89E 00	3.89E 00
900	5.33E 01	3.28E 01	2.28E 01	1.11E 01	6.30E 00	6.23E 00
1500	6.25E 01	4.50E 01	3.37E 01	1.81E 01	1.07E 01	1.04E 01
3000	7.19E 01	5.51E 01	4.31E 01	2.49E 01	1.57E 01	1.53E 01

FLIGHT NO. C-186B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-186B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.56E 01	4.89E 01	3.49E 01	1.80E 01	1.04E 01	8.65E 00
600	9.16E 01	7.19E 01	5.62E 01	3.24E 01	1.98E 01	1.65E 01
900	9.88E 01	8.58E 01	7.18E 01	4.55E 01	2.93E 01	2.43E 01
1500	1.07E 02	9.90E 01	8.79E 01	6.15E 01	4.20E 01	3.47E 01
3000	1.33E 02	1.19E 02	1.07E 02	7.85E 01	5.72E 01	4.53E 01

FLIGHT NO. C-186B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.95E 01	1.01E 01	6.77E 00	3.43E 00	2.21E 00	1.86E 00
600	3.29E 01	1.91E 01	1.34E 01	7.13E 00	4.69E 00	3.89E 00
900	4.27E 01	2.77E 01	2.02E 01	1.13E 01	7.63E 00	6.23E 00
1500	5.28E 01	3.94E 01	3.07E 01	1.86E 01	1.30E 01	1.04E 01
3000	6.71E 01	5.20E 01	4.20E 01	2.73E 01	2.04E 01	1.53E 01

FLIGHT NO. C-186B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-186B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.45E 01	5.26E 01	3.63E 01	1.69E 01	9.26E 00	8.65E 00
600	1.01E 02	7.69E 01	5.83E 01	3.04E 01	1.76E 01	1.65E 01
900	1.08E 02	9.10E 01	7.40E 01	4.28E 01	2.59E 01	2.43E 01
1500	1.16E 02	1.04E 02	8.98E 01	5.80E 01	3.68E 01	3.47E 01
3000	1.33E 02	1.18E 02	1.04E 02	7.12E 01	4.77E 01	4.53E 01

FLIGHT NO. C-186B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.39E 01	1.17E 01	7.57E 00	3.47E 00	2.11E 00	1.86E 00
600	3.96E 01	2.19E 01	1.48E 01	7.13E 00	4.38E 00	3.89E 00
900	5.01E 01	3.11E 01	2.20E 01	1.12E 01	6.97E 00	6.23E 00
1500	5.93E 01	4.28E 01	3.24E 01	1.81E 01	1.15E 01	1.04E 01
3000	6.94E 01	5.31E 01	4.17E 01	2.47E 01	1.65E 01	1.53E 01

FLIGHT NO. C-186B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-186B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.34E 00	3.34E-01	1.63E-01	4.84E-02	1.93E-02	1.77E-02
600	8.02E 00	1.08E 00	4.44E-01	1.15E-01	4.30E-02	3.87E-02
900	4.35E 01	2.84E 00	9.61E-01	2.12E-01	7.42E-02	6.59E-02
1500	4.03E 02	9.13E 00	2.33E 00	4.11E-01	1.30E-01	1.13E-01
3000	1.79E 03	1.79E 01	3.85E 00	5.99E-01	1.85E-01	1.64E-01

FLIGHT NO. C-186B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.60E-01	5.78E-02	3.17E-02	1.06E-02	4.79E-03	4.57E-03
600	4.28E-01	1.37E-01	7.22E-02	2.37E-02	1.05E-02	9.97E-03
900	9.25E-01	2.51E-01	1.27E-01	4.08E-02	1.78E-02	1.67E-02
1500	2.73E 00	5.36E-01	2.51E-01	7.65E-02	3.23E-02	3.02E-02
3000	6.40E 00	8.85E-01	3.88E-01	1.14E-01	4.86E-02	4.72E-02

FLIGHT NO. C-186B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-186B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.42E-01	2.48E-01	1.27E-01	4.29E-02	1.91E-02	1.77E-02
600	5.63E 00	8.01E-01	3.48E-01	1.02E-01	4.28E-02	3.87E-02
900	3.06E 01	2.11E 00	7.54E-01	1.90E-01	7.44E-02	6.59E-02
1500	2.84E 02	6.80E 00	1.83E 00	3.69E-01	1.32E-01	1.13E-01
3000	1.32E 03	1.38E 01	3.12E 00	5.51E-01	1.93E-01	1.64E-01

FLIGHT NO. C-186B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.53E-02	3.68E-02	2.16E-02	8.63E-03	4.55E-03	4.57E-03
600	2.56E-01	8.75E-02	4.97E-02	1.94E-02	1.01E-02	9.97E-03
900	5.59E-01	1.63E-01	8.87E-02	3.39E-02	1.73E-02	1.67E-02
1500	1.68E 00	3.54E-01	1.79E-01	6.51E-02	3.21E-02	3.02E-02
3000	4.16E 00	6.11E-01	2.87E-01	1.01E-01	5.05E-02	4.72E-02

FLIGHT NO. C-186B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-186B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.32E-01	2.02E-01	1.09E-01	4.25E-02	2.18E-02	1.77E-02
600	4.51E 00	6.67E-01	3.02E-01	1.02E-01	4.87E-02	3.87E-02
900	2.53E 01	1.80E 00	6.67E-01	1.90E-01	8.48E-02	6.59E-02
1500	2.48E 02	6.05E 00	1.67E 00	3.71E-01	1.50E-01	1.13E-01
3000	1.28E 03	1.32E 01	3.03E 00	5.83E-01	2.31E-01	1.64E-01

FLIGHT NO. C-186B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.24E-02	2.98E-02	1.86E-02	8.77E-03	5.48E-03	4.57E-03
600	1.99E-01	7.22E-02	4.34E-02	1.98E-02	1.22E-02	9.97E-03
900	4.47E-01	1.37E-01	7.86E-02	3.47E-02	2.09E-02	1.67E-02
1500	1.42E 00	3.10E-01	1.62E-01	6.69E-02	3.90E-02	3.02E-02
3000	3.88E 00	5.77E-01	2.80E-01	1.10E-01	6.58E-02	4.72E-02

FLIGHT NO. C-186B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5111 DATE 03/07/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-186B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.18E-01	2.17E-01	1.13E-01	3.99E-02	1.93E-02	1.77E-02
600	4.99E 00	7.14E-01	3.13E-01	9.54E-02	4.32E-02	3.87E-02
900	2.77E 01	1.91E 00	6.88E-01	1.78E-01	7.49E-02	6.59E-02
1500	2.67E 02	6.33E 00	1.71E 00	3.50E-01	1.32E-01	1.13E-01
3000	1.28E 03	1.32E 01	2.97E 00	5.29E-01	1.93E-01	1.64E-01

FLIGHT NO. C-186B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.87E-02	3.48E-02	2.08E-02	8.87E-03	5.21E-03	4.57E-03
600	2.40E-01	8.29E-02	4.78E-02	1.98E-02	1.14E-02	9.97E-03
900	5.25E-01	1.54E-01	8.53E-02	3.43E-02	1.91E-02	1.67E-02
1500	1.59E 00	3.37E-01	1.71E-01	6.48E-02	3.45E-02	3.02E-02
3000	4.01E 00	5.89E-01	2.78E-01	1.00E-01	5.30E-02	4.72E-02

FLIGHT C-187A – 23 AUGUST 1971 – TRACK 7 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon. There were some scattered towering cumulus clouds during the period of the flight. The flight was conducted over rolling hills southwest of St. Louis. The typical terrain was heavily wooded. The data-taking started at 1742 GMT (1242 CDT) and continued until 1900 GMT (1400 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 27.0 degrees at the beginning and 26.8 degrees at the end. The maximum altitude for the flight was 2520 meters. Average terrain elevation along this track was 305 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 12-mile (19-kilometer) visibility. There were towering cumulus clouds south through west horizons.

The ground station located at Scott, 85 miles (137 kilometers) from the center of the flight path, recorded scattered small cumulus and moderate haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
–	–	Light to moderate haze with top at approximately 6000 ft (1800 m) MSL, clear blue sky above
1745	235	Light to moderate haze at 1800 ft (550 m) MSL, clear overhead
1746	–	Thin scattered cloud deck high to the south
1804	1370	Running on top fringe of haze at 5500 ft (1680 m) MSL, scattered clouds on horizon
1824	2590	At 9500 ft (2900 m) MSL, haze and scattered clouds below, clear above
1839	1524	Passing light to moderate haze layer at 6000 ft (1830 m) MSL

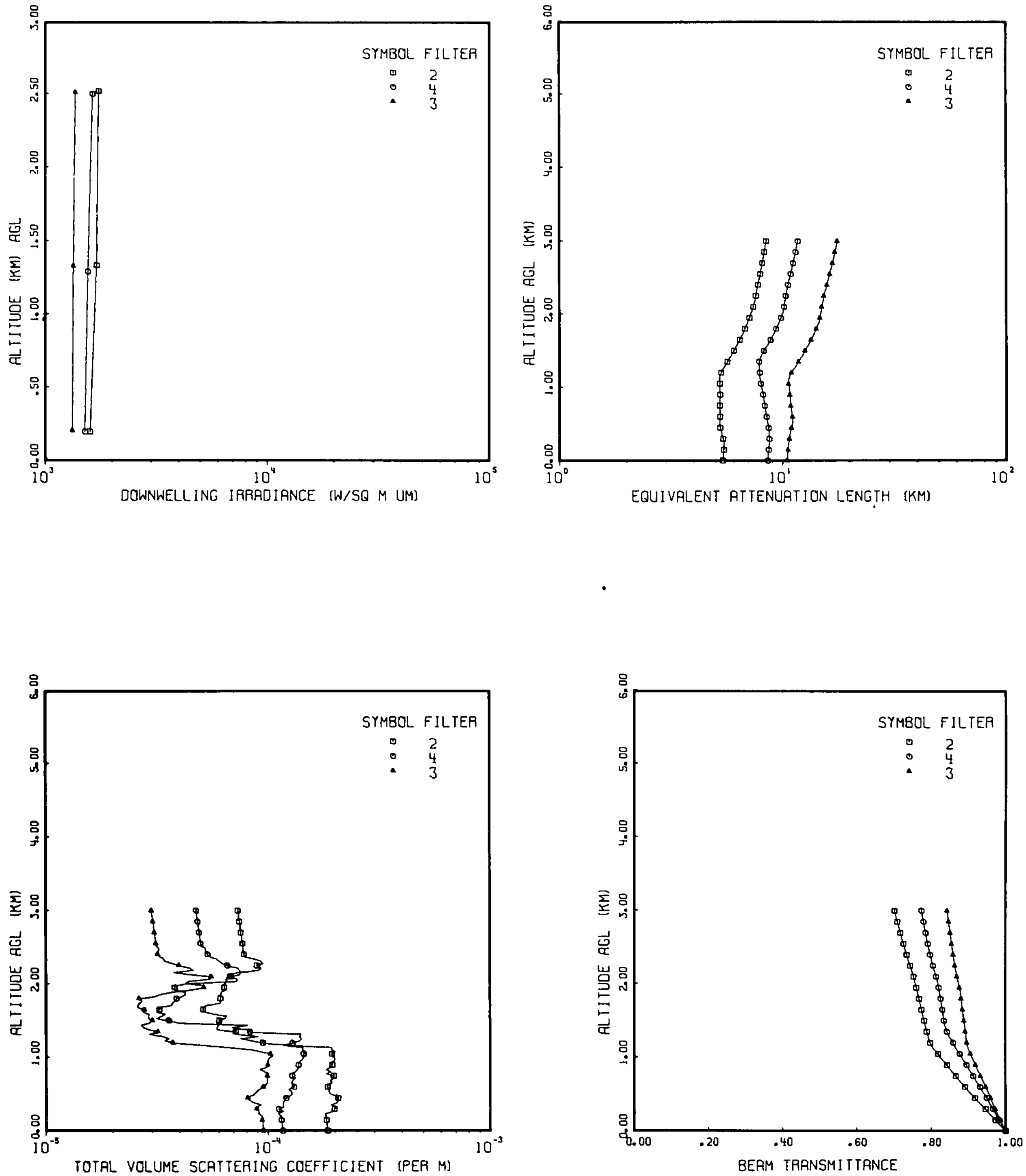
At the end of data-taking, Scott was reporting 0.1 cumulus at 4000 feet (1200 meters) and 12-mile (19-kilometer) visibility.

The surface synoptic chart shows a cold front extending south-southwestward from Maine to the DelMarVa peninsula, then westward to Evansville and northwestward to Springfield and Keokuk to a low in central North Dakota.

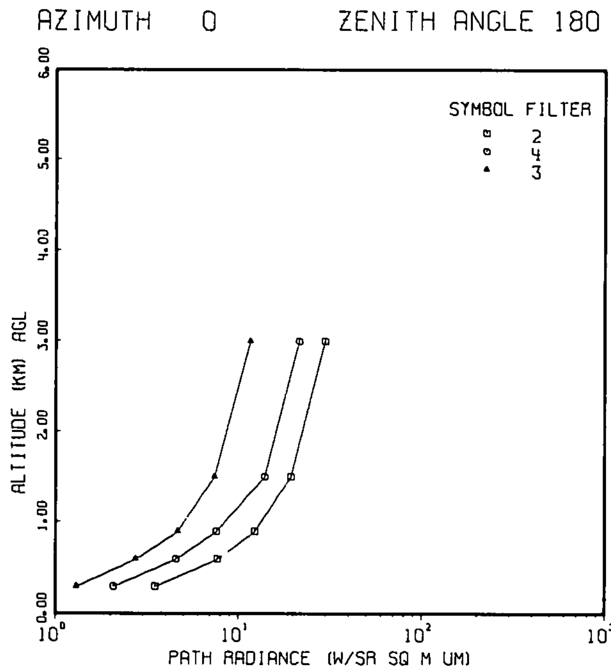
At 500 millibars there was a high centered near Topeka and a trough from Ontario to Virginia. The gradient shows moderate northeasterly winds over the region.

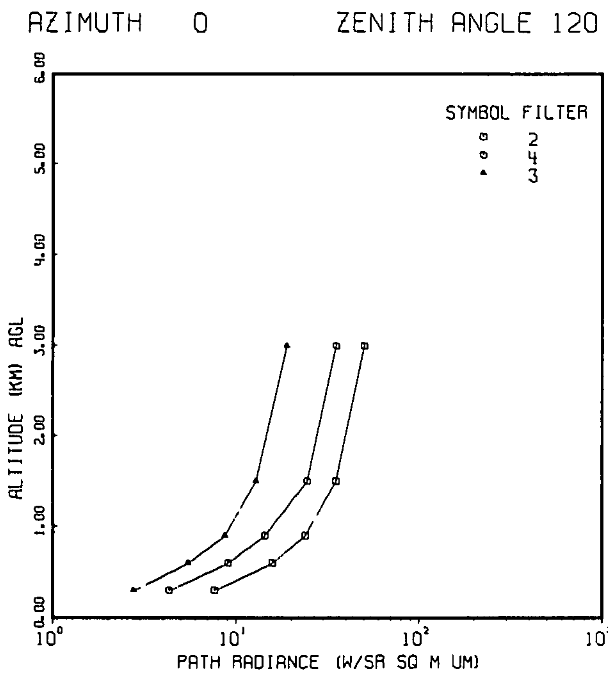
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

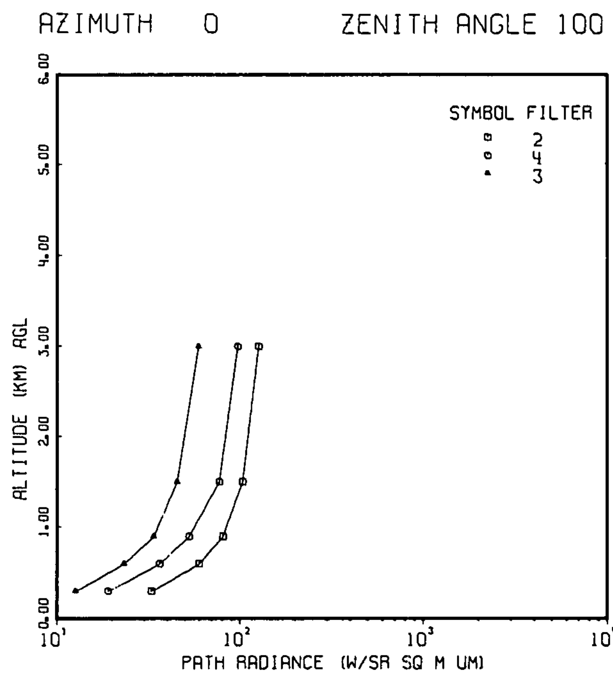
FLIGHT NO. C-187A



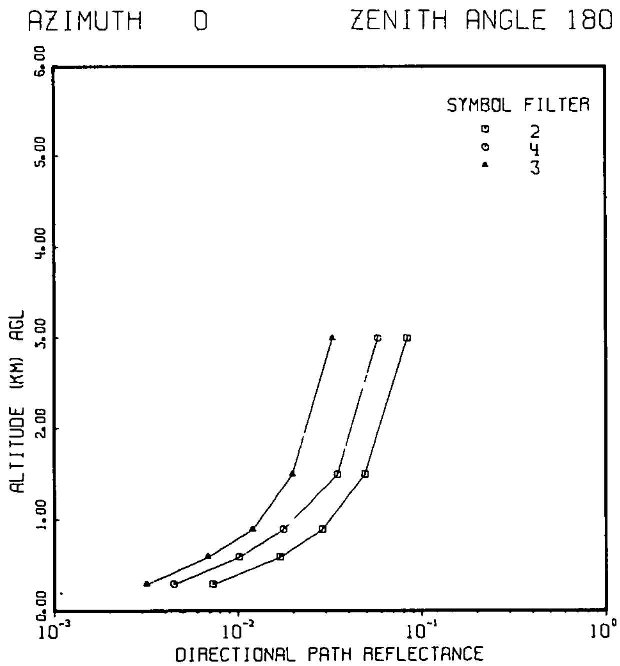
FLIGHT NO. C-187A

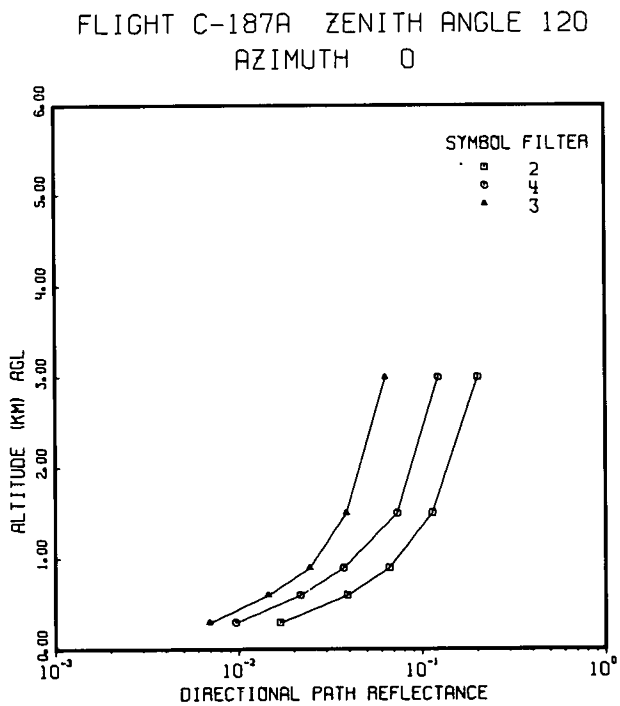


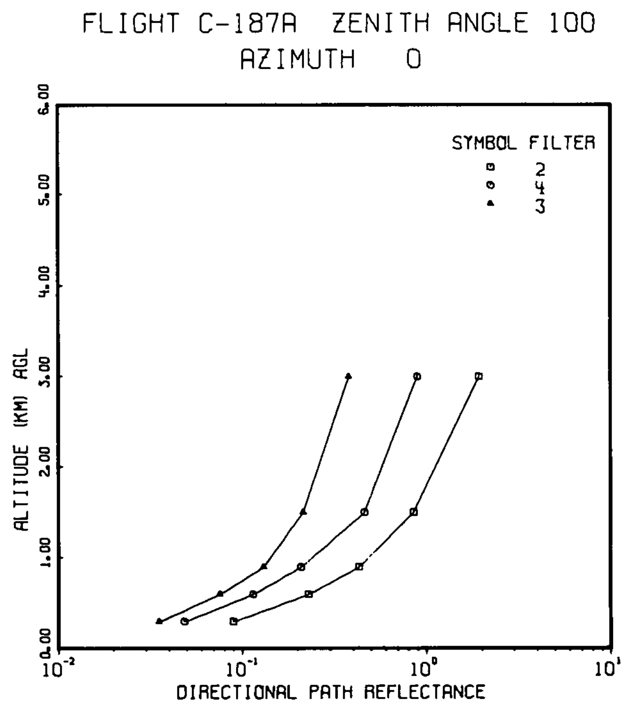




FLIGHT NO. C-187A







FLIGHT NO. C-187A
IRRADIANCE

(JOB 5196 DATE 03/11/73)

FLIGHT NO.C-187A FILTER NO. 2 SUN ZENITH ANGLE 26.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
199	1.59E 03	5.19E 01	.033	1.26E 03	8.72E 02	1.29E 02	2.26E 03	.060
1333	1.70E 03	1.04E 02	.061	1.58E 03	6.03E 02	2.70E 02	2.45E 03	.124
2520	1.74E 03	1.19E 02	.068	1.73E 03	4.70E 02	3.23E 02	2.52E 03	.147

FLIGHT NO.C-187A FILTER NO. 4 SUN ZENITH ANGLE 26.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
197	1.51E 03	6.20E 01	.041	1.31E 03	6.29E 02	1.35E 02	2.08E 03	.069
1290	1.56E 03	8.93E 01	.057	1.54E 03	3.87E 02	2.28E 02	2.15E 03	.119
2502	1.63E 03	1.08E 02	.066	1.66E 03	3.38E 02	2.75E 02	2.27E 03	.138

FLIGHT NO.C-187A FILTER NO. 3 SUN ZENITH ANGLE 26.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
205	1.32E 03	4.99E 01	.038	1.25E 03	3.89E 02	1.16E 02	1.76E 03	.071
1329	1.34E 03	7.77E 01	.058	1.39E 03	1.90E 02	1.72E 02	1.76E 03	.109
2512	1.37E 03	7.41E 01	.054	1.46E 03	1.47E 02	1.77E 02	1.79E 03	.110

FLIGHT NO. C-187A
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5196 DATE 03/11/73)

FLIGHT NO. C-187A
AZIMUTH OF PATH OF SIGHT = 0
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0697	.0850	.0476
100	.0393	.0516	.0402
105	.0321	.0395	.0439
120	.0388	.0302	.0239
150	.0568	.0313	.0164
180	.0167	.0404	.0540

FLIGHT NO. C-187A
AZIMUTH OF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0382	.0536	.0385
100	.0317	.0434	.0435
105	.0314	.0374	.0352
120	.0396	.0326	.0297
150	.0158	.0325	.0197
180	.0167	.0404	.0540

FLIGHT NO. C-187A
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.0557	.0627	.0643
100	.0494	.0579	.0492
105	.0459	.0540	.0409
120	.0387	.0521	.0824
150	.0710	.0555	.0371
180	.0167	.0404	.0540

FLIGHT NO. C-187A
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1501	.0579	.0895
100	.0675	.0463	.0493
105	.0333	.0403	.0418
120	.0277	.0342	.0415
150	.0666	.0386	.0264
180	.0167	.0404	.0540

FLIGHT NO. C-187A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5196 DATE 03/11/73)
DATE 82371 FLIGHT NO. C-187A GROUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
0	1.85E-04	1.17E-04	9.55E-05
30	1.84E-04	1.16E-04	9.50E-05
60	1.84E-04	1.16E-04	9.48E-05
90	1.83E-04	1.15E-04	9.46E-05
120	1.83E-04	1.15E-04	9.43E-05
150	1.83E-04	1.15E-04	9.41E-05
180	1.82E-04	1.15E-04	9.38E-05
210	1.82E-04	1.14E-04	9.36E-05
240	1.81E-04	1.11E-04	9.03E-05
270	1.95E-04	1.18E-04	9.07E-05
300	1.99E-04	1.12E-04	8.87E-05
330	2.02E-04	1.18E-04	9.03E-05
360	1.91E-04	1.17E-04	9.34E-05
390	2.05E-04	1.17E-04	8.55E-05
420	2.06E-04	1.18E-04	8.23E-05
450	2.07E-04	1.21E-04	8.09E-05
480	2.01E-04	1.26E-04	8.43E-05
510	1.90E-04	1.28E-04	8.76E-05
540	1.88E-04	1.27E-04	8.89E-05
570	1.89E-04	1.23E-04	9.20E-05
600	1.85E-04	1.31E-04	9.51E-05
630	1.85E-04	1.30E-04	9.83E-05
660	1.95E-04	1.27E-04	9.90E-05
690	1.90E-04	1.29E-04	9.94E-05
720	1.97E-04	1.33E-04	9.92E-05
750	1.97E-04	1.28E-04	9.92E-05
780	1.82E-04	1.29E-04	1.00E-04
810	1.92E-04	1.33E-04	9.63E-05
840	1.81E-04	1.35E-04	9.15E-05
870	1.92E-04	1.38E-04	9.90E-05
900	1.94E-04	1.37E-04	9.97E-05
930	1.89E-04	1.37E-04	9.99E-05
960	1.99E-04	1.40E-04	9.98E-05
990	2.00E-04	1.44E-04	1.01E-04
1020	1.93E-04	1.45E-04	1.05E-04
1050	1.94E-04	1.45E-04	1.02E-04
1080	2.01E-04	1.48E-04	9.27E-05
1110	1.94E-04	1.43E-04	8.33E-05
1140	1.92E-04	1.43E-04	6.57E-05
1170	1.27E-04	1.18E-04	5.02E-05
1200	9.48E-05	1.29E-04	3.73E-05
1230	8.43E-05	1.38E-04	3.41E-05
1260	7.50E-05	1.41E-04	3.58E-05
1290	9.03E-05	1.38E-04	3.32E-05
1320	7.19E-05	1.40E-04	2.91E-05
1350	7.14E-05	8.28E-05	3.19E-05
1380	5.88E-05	8.05E-05	2.91E-05
1410	5.91E-05	6.88E-05	2.74E-05
1440	6.00E-05	8.11E-05	2.68E-05
1470	6.05E-05	3.99E-05	2.92E-05
1500	6.03E-05	3.58E-05	3.01E-05

FLIGHT NO. C-187A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5196 DATE 03/11/73)
DATE 82371 FLIGHT NO. C-187A GROUND LEVEL ALTITUDE (M)= 305

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	6.38E-05	3.15E-05	2.89E-05
1560	6.51E-05	3.30E-05	2.89E-05
1590	5.73E-05	3.45E-05	2.91E-05
1620	5.15E-05	3.15E-05	2.73E-05
1650	5.10E-05	3.24E-05	2.78E-05
1680	5.14E-05	3.27E-05	2.58E-05
1710	5.31E-05	3.68E-05	2.58E-05
1740	6.10E-05	3.71E-05	2.65E-05
1770	6.11E-05	3.82E-05	2.71E-05
1800	6.11E-05	3.88E-05	2.63E-05
1830	6.10E-05	4.09E-05	3.08E-05
1860	6.11E-05	4.26E-05	3.30E-05
1890	6.18E-05	4.22E-05	3.71E-05
1920	6.45E-05	3.82E-05	4.48E-05
1950	6.36E-05	3.79E-05	5.15E-05
1980	6.35E-05	3.84E-05	5.10E-05
2010	6.41E-05	4.38E-05	4.27E-05
2040	6.55E-05	7.24E-05	4.42E-05
2070	6.47E-05	7.26E-05	5.52E-05
2100	6.79E-05	6.73E-05	5.56E-05
2130	6.68E-05	7.49E-05	4.49E-05
2160	7.39E-05	7.52E-05	3.76E-05
2190	9.11E-05	7.44E-05	4.62E-05
2220	9.34E-05	7.32E-05	4.43E-05
2250	8.93E-05	6.57E-05	3.98E-05
2280	9.56E-05	6.23E-05	3.71E-05
2310	9.34E-05	6.06E-05	3.44E-05
2340	8.78E-05	5.90E-05	3.39E-05
2370	7.90E-05	5.50E-05	3.28E-05
2400	7.81E-05	5.35E-05	3.18E-05
2430	7.76E-05	5.31E-05	3.15E-05
2460	7.73E-05	5.24E-05	3.24E-05
2490	7.73E-05	5.24E-05	3.22E-05
2520	7.71E-05	5.00E-05	3.14E-05
2550	7.68E-05	4.99E-05	3.13E-05
2580	7.66E-05	4.97E-05	3.12E-05
2610	7.63E-05	4.96E-05	3.11E-05
2640	7.61E-05	4.94E-05	3.10E-05
2670	7.59E-05	4.92E-05	3.09E-05
2700	7.56E-05	4.91E-05	3.08E-05
2730	7.54E-05	4.89E-05	3.08E-05
2760	7.52E-05	4.88E-05	3.07E-05
2790	7.49E-05	4.86E-05	3.06E-05
2820	7.47E-05	4.85E-05	3.05E-05
2850	7.45E-05	4.83E-05	3.04E-05
2880	7.42E-05	4.82E-05	3.03E-05
2910	7.40E-05	4.80E-05	3.02E-05
2940	7.38E-05	4.79E-05	3.01E-05
2970	7.35E-05	4.77E-05	3.00E-05
3000	7.33E-05	4.76E-05	2.99E-05
FIRST DATA ALT	240	210	210
LAST DATA ALT	2490	2520	2520

FLIGHT NO. C-187A
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5196 DATE 03/11/73)

FLIGHT NO. C-187A FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE.

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.28E-01	7.26E-01	8.07E-01	8.95E-01	9.38E-01	9.46E-01
600	2.67E-01	5.17E-01	6.42E-01	7.95E-01	8.76E-01	8.92E-01
900	1.37E-01	3.72E-01	5.15E-01	7.09E-01	8.20E-01	8.42E-01
1500	5.56E-02	2.40E-01	3.84E-01	6.09E-01	7.51E-01	7.80E-01
3000	1.47E-02	1.30E-01	2.54E-01	4.92E-01	6.64E-01	7.01E-01

FLIGHT NO. C-187A FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.73E-01	8.20E-01	8.75E-01	9.33E-01	9.61E-01	9.66E-01
600	4.41E-01	6.65E-01	7.60E-01	8.68E-01	9.21E-01	9.32E-01
900	2.79E-01	5.30E-01	6.53E-01	8.02E-01	8.80E-01	8.95E-01
1500	1.20E-01	3.51E-01	4.95E-01	6.95E-01	8.10E-01	8.34E-01
3000	4.76E-02	2.28E-01	3.71E-01	5.99E-01	7.44E-01	7.74E-01

FLIGHT NO. C-187A FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.25E-01	8.51E-01	8.97E-01	9.46E-01	9.68E-01	9.72E-01
600	5.34E-01	7.31E-01	8.11E-01	8.97E-01	9.39E-01	9.47E-01
900	3.80E-01	6.18E-01	7.24E-01	8.46E-01	9.08E-01	9.20E-01
1500	2.50E-01	5.04E-01	6.31E-01	7.88E-01	8.72E-01	8.88E-01
3000	1.31E-01	3.74E-01	5.17E-01	7.11E-01	8.21E-01	8.43E-01

FLIGHT NO. C-187A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-187A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.88E 01	3.28E 01	1.99E 01	7.61E 00	3.64E 00	3.49E 00
600	1.08E 02	5.98E 01	3.84E 01	1.57E 01	7.86E 00	7.67E 00
900	1.30E 02	8.07E 01	5.44E 01	2.39E 01	1.24E 01	1.23E 01
1500	1.49E 02	1.03E 02	7.39E 01	3.52E 01	1.92E 01	1.94E 01
3000	1.64E 02	1.27E 02	9.64E 01	5.03E 01	2.88E 01	2.97E 01

FLIGHT NO. C-187A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.21E 01	1.90E 01	1.14E 01	4.30E 00	2.06E 00	2.07E 00
600	7.24E 01	3.64E 01	2.26E 01	9.00E 00	4.45E 00	4.54E 00
900	9.51E 01	5.27E 01	3.40E 01	1.43E 01	7.35E 00	7.58E 00
1500	1.21E 02	7.72E 01	5.31E 01	2.44E 01	1.33E 01	1.39E 01
3000	1.37E 02	9.75E 01	7.08E 01	3.52E 01	2.00E 01	2.14E 01

FLIGHT NO. C-187A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.87E 01	1.26E 01	7.46E 00	2.75E 00	1.25E 00	1.30E 00
600	4.86E 01	2.32E 01	1.41E 01	5.46E 00	2.59E 00	2.74E 00
900	6.52E 01	3.39E 01	2.13E 01	8.69E 00	4.33E 00	4.66E 00
1500	7.99E 01	4.54E 01	2.96E 01	1.29E 01	6.76E 00	7.40E 00
3000	9.43E 01	5.96E 01	4.07E 01	1.90E 01	1.05E 01	1.16E 01

FLIGHT NO. C-187A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-187A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.56E 01	2.30E 01	1.49E 01	6.73E 00	3.74E 00	3.49E 00
600	7.28E 01	4.26E 01	2.91E 01	1.41E 01	8.17E 00	7.67E 00
900	8.94E 01	5.86E 01	4.20E 01	2.17E 01	1.31E 01	1.23E 01
1500	1.05E 02	7.70E 01	5.85E 01	3.26E 01	2.06E 01	1.94E 01
3000	1.17E 02	9.57E 01	7.75E 01	4.73E 01	3.13E 01	2.97E 01

FLIGHT NO. C-187A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.65E 01	1.29E 01	8.29E 00	3.81E 00	2.17E 00	2.07E 00
600	4.65E 01	2.51E 01	1.68E 01	8.10E 00	4.76E 00	4.54E 00
900	6.25E 01	3.71E 01	2.58E 01	1.31E 01	7.96E 00	7.58E 00
1500	8.24E 01	5.61E 01	4.15E 01	2.29E 01	1.46E 01	1.39E 01
3000	9.63E 01	7.26E 01	5.65E 01	3.33E 01	2.23E 01	2.14E 01

FLIGHT NO. C-187A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.67E 01	8.01E 00	5.20E 00	2.47E 00	1.37E 00	1.30E 00
600	2.89E 01	1.50E 01	1.00E 01	4.93E 00	2.84E 00	2.74E 00
900	3.99E 01	2.25E 01	1.55E 01	7.92E 00	4.78E 00	4.66E 00
1500	5.08E 01	3.11E 01	2.21E 01	1.18E 01	7.50E 00	7.40E 00
3000	6.19E 01	4.20E 01	3.12E 01	1.76E 01	1.17E 01	1.16E 01

FLIGHT NO. C-187A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-187A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.03E 01	2.16E 01	1.47E 01	7.54E 00	4.59E 00	3.49E 00
600	6.56E 01	4.06E 01	2.91E 01	1.59E 01	1.01E 01	7.67E 00
900	8.23E 01	5.66E 01	4.25E 01	2.47E 01	1.61E 01	1.23E 01
1500	9.96E 01	7.60E 01	6.00E 01	3.73E 01	2.53E 01	1.94E 01
3000	1.14E 02	9.68E 01	8.12E 01	5.48E 01	3.87E 01	2.97E 01

FLIGHT NO. C-187A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.34E 01	1.21E 01	8.24E 00	4.36E 00	2.77E 00	2.07E 00
600	4.18E 01	2.39E 01	1.69E 01	9.33E 00	6.06E 00	4.54E 00
900	5.73E 01	3.60E 01	2.63E 01	1.52E 01	1.01E 01	7.58E 00
1500	7.84E 01	5.60E 01	4.33E 01	2.69E 01	1.85E 01	1.39E 01
3000	9.37E 01	7.37E 01	5.98E 01	3.98E 01	2.90E 01	2.14E 01

FLIGHT NO. C-187A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.46E 01	7.55E 00	5.20E 00	2.84E 00	1.78E 00	1.30E 00
600	2.56E 01	1.43E 01	1.01E 01	5.75E 00	3.76E 00	2.74E 00
900	3.61E 01	2.17E 01	1.58E 01	9.35E 00	6.45E 00	4.66E 00
1500	4.69E 01	3.04E 01	2.29E 01	1.42E 01	1.03E 01	7.40E 00
3000	5.82E 01	4.17E 01	3.26E 01	2.13E 01	1.64E 01	1.16E 01

FLIGHT NO. C-187A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-187A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.54E 01	2.34E 01	1.54E 01	7.00E 00	3.85E 00	3.49E 00
600	7.25E 01	4.33E 01	2.99E 01	1.46E 01	8.41E 00	7.67E 00
900	8.91E 01	5.93E 01	4.30E 01	2.24E 01	1.34E 01	1.23E 01
1500	1.05E 02	7.76E 01	5.94E 01	3.35E 01	2.11E 01	1.94E 01
3000	1.17E 02	9.64E 01	7.85E 01	4.84E 01	3.20E 01	2.97E 01

FLIGHT NO. C-187A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.55E 01	1.25E 01	8.16E 00	3.89E 00	2.26E 00	2.07E 00
600	4.48E 01	2.44E 01	1.65E 01	8.24E 00	4.93E 00	4.54E 00
900	6.04E 01	3.62E 01	2.54E 01	1.33E 01	8.18E 00	7.58E 00
1500	8.03E 01	5.50E 01	4.10E 01	2.31E 01	1.49E 01	1.39E 01
3000	9.47E 01	7.16E 01	5.60E 01	3.35E 01	2.26E 01	2.14E 01

FLIGHT NO. C-187A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.67E 01	8.11E 00	5.31E 00	2.51E 00	1.39E 00	1.30E 00
600	2.88E 01	1.52E 01	1.02E 01	5.02E 00	2.90E 00	2.74E 00
900	3.97E 01	2.26E 01	1.57E 01	8.06E 00	4.90E 00	4.66E 00
1500	5.04E 01	3.12E 01	2.23E 01	1.21E 01	7.73E 00	7.40E 00
3000	6.07E 01	4.16E 01	3.11E 01	1.78E 01	1.20E 01	1.16E 01

FLIGHT NO. C-187A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-187A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.57E-01	8.91E-02	4.87E-02	1.68E-02	7.66E-03	7.28E-03
600	7.99E-01	2.28E-01	1.18E-01	3.90E-02	1.77E-02	1.70E-02
900	1.87E 00	4.28E-01	2.08E-01	6.63E-02	2.98E-02	2.88E-02
1500	5.27E 00	8.50E-01	3.79E-01	1.14E-01	5.04E-02	4.90E-02
3000	2.19E 01	1.93E 00	7.49E-01	2.02E-01	8.56E-02	8.34E-02

FLIGHT NO. C-187A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.30E-01	4.83E-02	2.70E-02	9.60E-03	4.46E-03	4.47E-03
600	3.42E-01	1.14E-01	6.19E-02	2.16E-02	1.01E-02	1.02E-02
900	7.10E-01	2.07E-01	1.09E-01	3.72E-02	1.74E-02	1.76E-02
1500	2.09E 00	4.59E-01	2.24E-01	7.33E-02	3.41E-02	3.48E-02
3000	6.00E 00	8.89E-01	3.97E-01	1.23E-01	5.61E-02	5.77E-02

FLIGHT NO. C-187A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.40E-02	3.52E-02	1.97E-02	6.91E-03	3.07E-03	3.18E-03
600	2.16E-01	7.54E-02	4.14E-02	1.45E-02	6.55E-03	6.87E-03
900	4.08E-01	1.30E-01	6.99E-02	2.44E-02	1.13E-02	1.20E-02
1500	7.60E-01	2.14E-01	1.11E-01	3.87E-02	1.84E-02	1.98E-02
3000	1.70E 00	3.78E-01	1.87E-01	6.35E-02	3.03E-02	3.28E-02

FLIGHT NO. C-187A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-187A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.70E-01	6.25E-02	3.63E-02	1.48E-02	7.85E-03	7.28E-03
600	5.38E-01	1.63E-01	8.94E-02	3.50E-02	1.84E-02	1.70E-02
900	1.28E 00	3.10E-01	1.61E-01	6.04E-02	3.14E-02	2.88E-02
1500	3.73E 00	6.33E-01	3.00E-01	1.06E-01	5.39E-02	4.90E-02
3000	1.56E 01	1.46E 00	6.02E-01	1.90E-01	9.30E-02	8.34E-02

FLIGHT NO. C-187A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.22E-02	3.27E-02	1.97E-02	8.51E-03	4.70E-03	4.47E-03
600	2.20E-01	7.85E-02	4.59E-02	1.94E-02	1.08E-02	1.02E-02
900	4.67E-01	1.46E-01	8.23E-02	3.40E-02	1.88E-02	1.76E-02
1500	1.43E 00	3.34E-01	1.75E-01	6.86E-02	3.76E-02	3.48E-02
3000	4.21E 00	6.62E-01	3.17E-01	1.16E-01	6.24E-02	5.77E-02

FLIGHT NO. C-187A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.46E-02	2.23E-02	1.38E-02	6.20E-03	3.35E-03	3.18E-03
600	1.28E-01	4.88E-02	2.94E-02	1.31E-02	7.19E-03	6.87E-03
900	2.50E-01	8.65E-02	5.08E-02	2.22E-02	1.25E-02	1.20E-02
1500	4.83E-01	1.47E-01	8.33E-02	3.56E-02	2.04E-02	1.98E-02
3000	1.12E 00	2.66E-01	1.43E-01	5.88E-02	3.39E-02	3.28E-02

FLIGHT NO. C-187A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-187A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.50E-01	5.87E-02	3.59E-02	1.66E-02	9.66E-03	7.28E-03
600	4.85E-01	1.55E-01	8.93E-02	3.95E-02	2.26E-02	1.70E-02
900	1.18E 00	3.00E-01	1.63E-01	6.86E-02	3.87E-02	2.88E-02
1500	3.53E 00	6.24E-01	3.08E-01	1.21E-01	6.65E-02	4.90E-02
3000	1.53E 01	1.47E 00	6.30E-01	2.20E-01	1.15E-01	8.34E-02

FLIGHT NO. C-187A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.24E-02	3.07E-02	1.96E-02	9.72E-03	6.00E-03	4.47E-03
600	1.97E-01	7.49E-02	4.62E-02	2.24E-02	1.37E-02	1.02E-02
900	4.28E-01	1.41E-01	8.40E-02	3.95E-02	2.39E-02	1.76E-02
1500	1.36E 00	3.33E-01	1.82E-01	8.07E-02	4.77E-02	3.48E-02
3000	4.10E 00	6.72E-01	3.36E-01	1.38E-01	8.12E-02	5.77E-02

FLIGHT NO. C-187A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.78E-02	2.11E-02	1.38E-02	7.14E-03	4.36E-03	3.18E-03
600	1.14E-01	4.64E-02	2.97E-02	1.52E-02	9.52E-03	6.87E-03
900	2.25E-01	8.34E-02	5.18E-02	2.62E-02	1.69E-02	1.20E-02
1500	4.46E-01	1.44E-01	8.60E-02	4.27E-02	2.81E-02	1.98E-02
3000	1.05E 00	2.64E-01	1.49E-01	7.12E-02	4.73E-02	3.28E-02

FLIGHT NO. C-187A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5196 DATE 03/11/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-187A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.69E-01	6.36E-02	3.75E-02	1.54E-02	8.09E-03	7.28E-03
600	5.37E-01	1.65E-01	9.19E-02	3.63E-02	1.89E-02	1.70E-02
900	1.28E 00	3.14E-01	1.65E-01	6.23E-02	3.23E-02	2.88E-02
1500	3.71E 00	6.38E-01	3.05E-01	1.08E-01	5.54E-02	4.90E-02
3000	1.57E 01	1.47E 00	6.10E-01	1.94E-01	9.49E-02	8.34E-02

FLIGHT NO. C-187A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.89E-02	3.18E-02	1.94E-02	8.69E-03	4.90E-03	4.47E-03
600	2.12E-01	7.64E-02	4.52E-02	1.98E-02	1.11E-02	1.02E-02
900	4.51E-01	1.42E-01	8.11E-02	3.45E-02	1.94E-02	1.76E-02
1500	1.39E 00	3.27E-01	1.73E-01	6.91E-02	3.83E-02	3.48E-02
3000	4.14E 00	6.53E-01	3.14E-01	1.17E-01	6.34E-02	5.77E-02

FLIGHT NO. C-187A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.46E-02	2.26E-02	1.40E-02	6.29E-03	3.40E-03	3.18E-03
600	1.28E-01	4.92E-02	2.99E-02	1.33E-02	7.34E-03	6.87E-03
900	2.48E-01	8.70E-02	5.15E-02	2.26E-02	1.28E-02	1.20E-02
1500	4.80E-01	1.47E-01	8.41E-02	3.64E-02	2.11E-02	1.98E-02
3000	1.10E 00	2.64E-01	1.43E-01	5.94E-02	3.47E-02	3.28E-02

FLIGHT C-188A – 24 AUGUST 1971 – TRACK 9 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit morning. This flight was conducted under clear skies. There was ground fog and haze at the beginning of the data-taking and haze at the end. The flight was conducted over small fields northwest of St. Louis. The typical terrain was cultivated farms and woodlands. The data-taking started at 1339 GMT (0839 CDT) and continued until 1501 GMT (1001 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 65.4 degrees at the beginning and 55.8 degrees at the end. The maximum altitude for the flight was 2580 meters. Average terrain elevation on this track was 244 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 5-mile (8-kilometer) visibility in haze and ground fog.

The ground station located at Scott, 86 miles (138 kilometers) from the center of the flight path, recorded clear with moderate haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
–	–	Moderate to heavy haze, blue sky overhead with no clouds
1342	213	Moderate to heavy haze at 1500 ft (460 m) MSL, clear above
1401	1432	Moderate to heavy haze at 5500 ft (1670 m) MSL, clear overhead

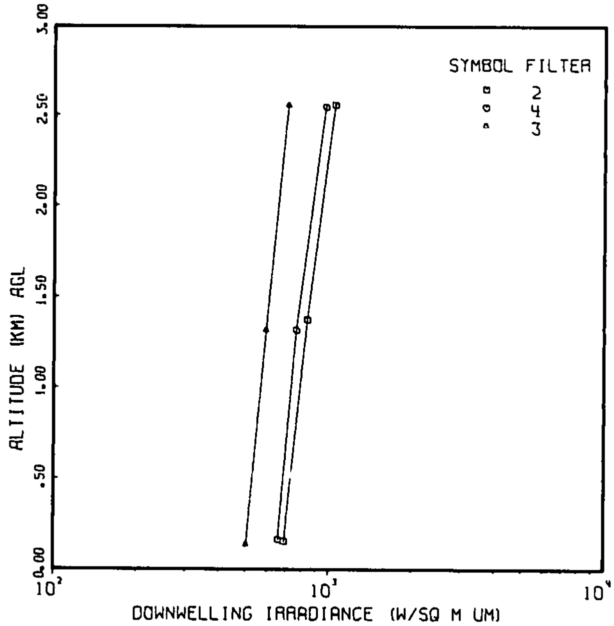
At the end of data-taking, Scott was reporting clear skies with a visibility of 6 miles (9.6 kilometers) in haze.

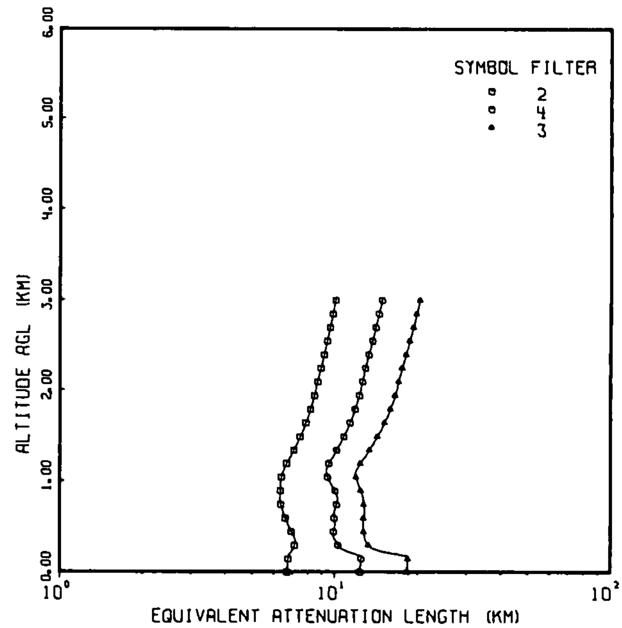
The surface synoptic chart shows a stationary front over St. Louis. There was a weak high over Michigan with a weak ridge extending southwestward to Arkansas. The general circulation was weak.

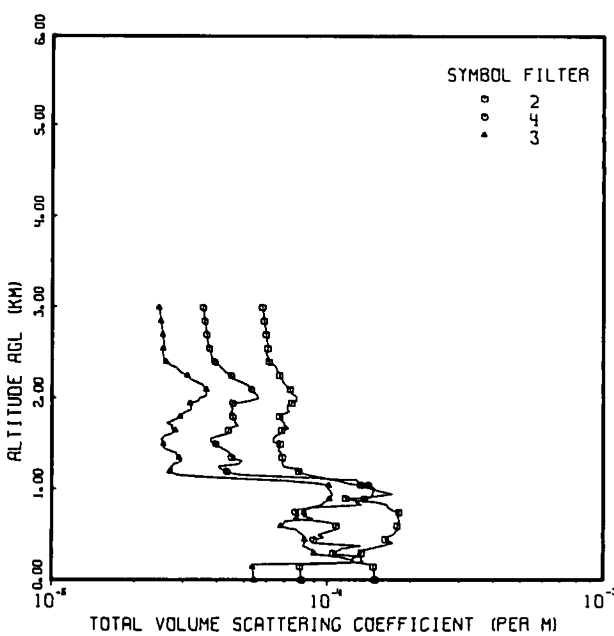
At 500 millibars there was a high covering the western two thirds of the United States and in general all of the U.S., except the northeast where there were low values and strong winds. There was a closed high over the Great Plains.

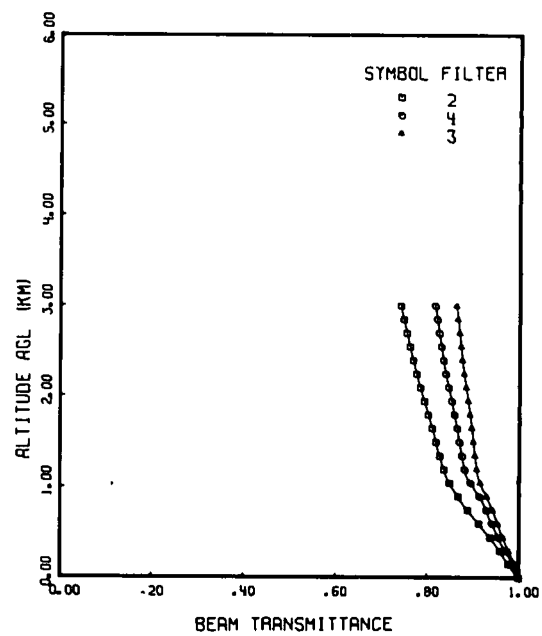
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-188A

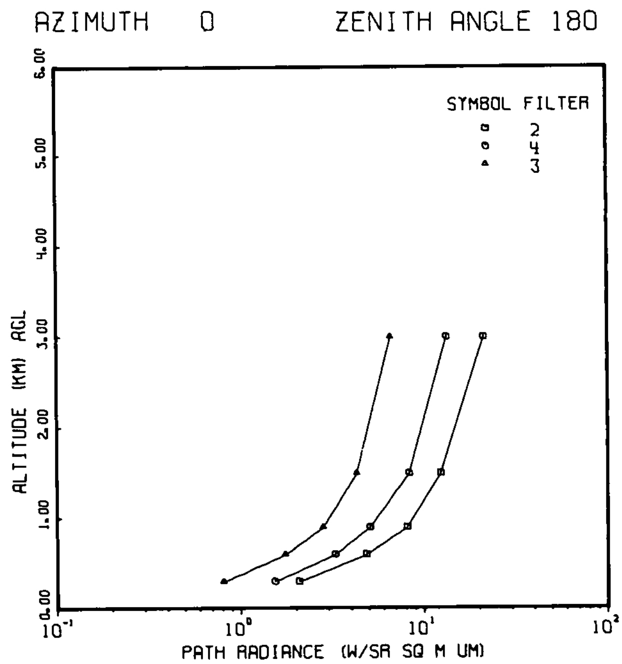


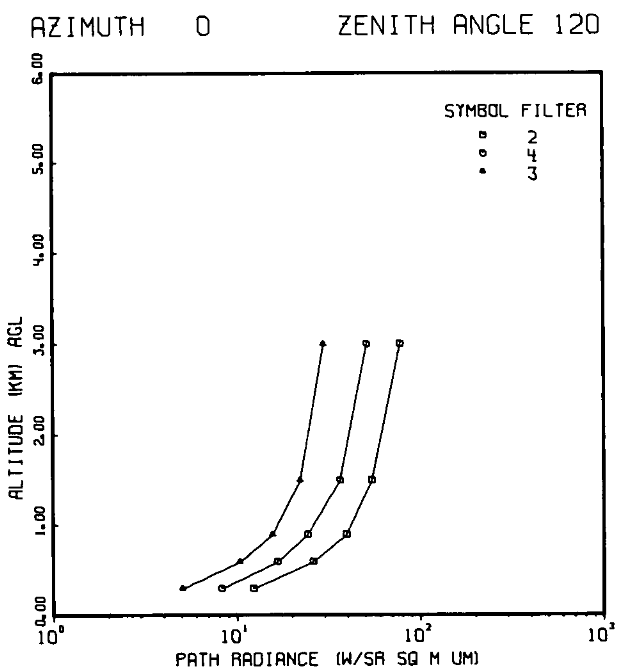


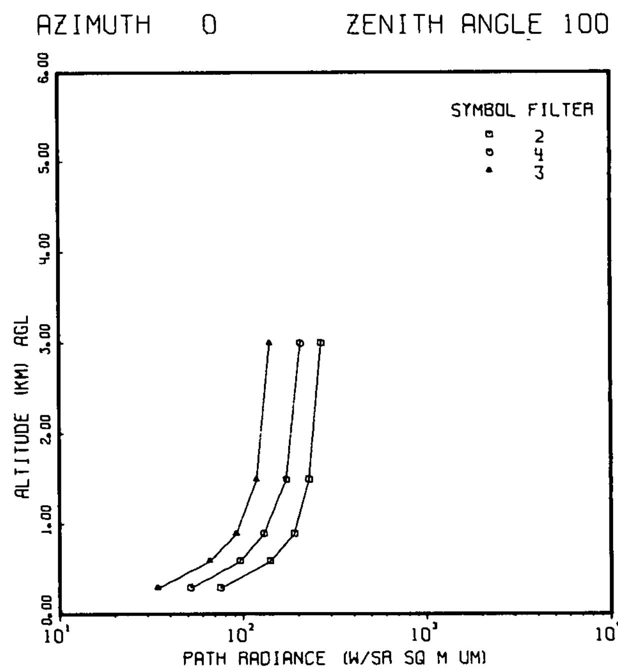




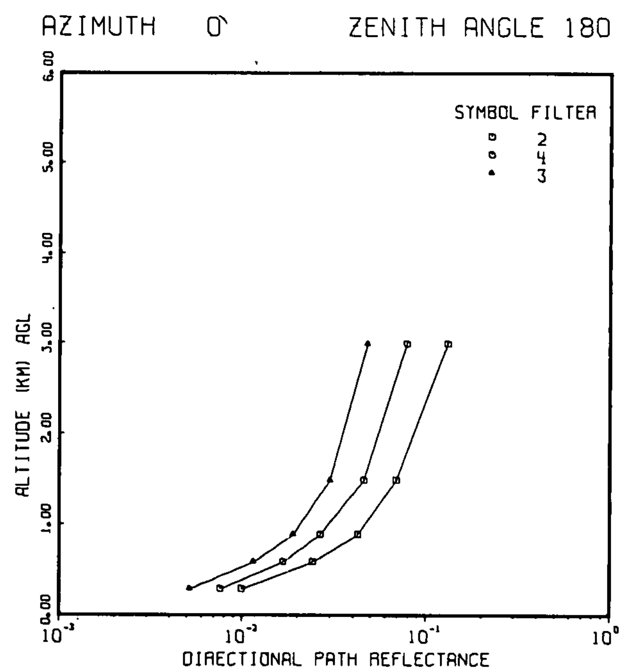
FLIGHT NO. C-188A

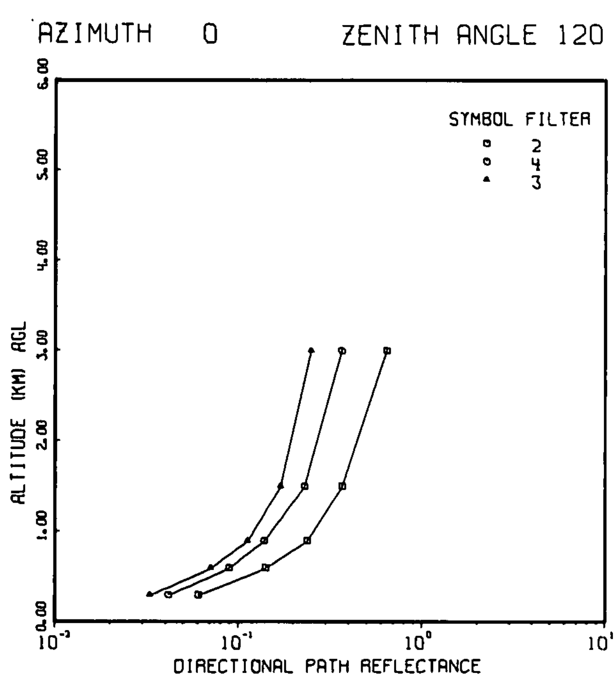


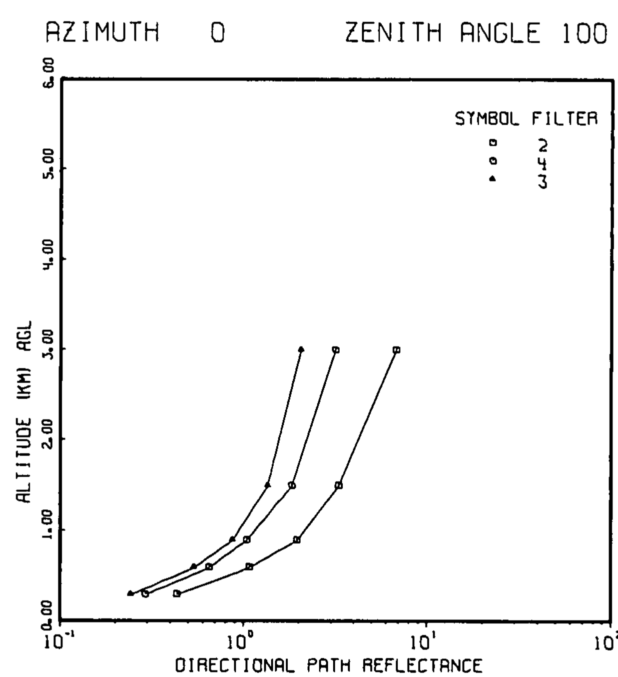




FLIGHT NO. C-188A







FLIGHT NO. C-188A
IRRADIANCE

(JOB 5385 CATE 04/18/73)

FLIGHT NO.C-188A FILTER NC. 2 SLN ZENITH ANGLE 60.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
158	6.91E 02	3.97E C1	.057	9.C7E 02	8.08E 02	1.60E 02	1.87E 03	.093
1377	8.37E 02	9.C7E 01	.1C8	1.28E 03	6.06E 02	3.22E 02	2.21E 03	.171
2559	1.05E 03	1.18E 02	.112	1.51E 03	6.06E 02	3.80E 02	2.49E 03	.180

FLIGHT NC.C-188A FILTER NC. 4 SLN ZENITH ANGLE 60.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
166	6.57E 02	6.04E 01	.C92	9.98E 02	5.96E 02	1.76E 02	1.77E 03	.110
1321	7.63E 02	9.61E C1	.126	1.27E 03	3.80E 02	2.94E 02	1.94E 03	.179
2549	9.71E 02	1.18E 02	.121	1.41E 03	4.44E 02	3.36E 02	2.19E 03	.181

FLIGHT NO.C-188A FILTER NO. 3 SLN ZENITH ANGLE 6C.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
139	5.03E 02	3.43E C1	.068	8.90E 02	3.56E 02	1.05E 02	1.35E 03	.084
1320	5.93E 02	6.11E 01	.1C3	1.07E 03	2.02E 02	1.92E 02	1.47E 03	.150
2557	7.09E 02	7.05E 01	.099	1.15E 03	1.89E 02	2.09E 02	1.55E 03	.156

FLIGHT NO. C-188A
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5385 CATE 04/18/73)

FLIGHT NO. C-188A

AZIMUTH OF PATH OF SIGHT = 0

DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.4871	.8833	.7659
100	.2577	.3377	.3276
105	.1753	.2153	.1711
120	.0750	.1075	.0587
150	.0309	.0702	.0523
180	.0168	.0647	.0646

FLIGHT NO. C-188A

AZIMUTH OF PATH OF SIGHT = 90

DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1822	.2049	.1403
100	.1017	.1361	.0960
105	.0905	.0863	.0802
120	.0491	.0723	.0920
150	.0266	.0602	.0440
180	.0168	.0647	.0646

FLIGHT NO. C-188A

AZIMUTH OF PATH OF SIGHT = 180

DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1848	.1768	.1731
100	.1204	.1452	.1400
105	.0844	.1389	.1191
120	.05C8	.1245	.1211
150	.0284	.0797	.0662
180	.0168	.0647	.0646

FLIGHT NO. C-188A

AZIMUTH OF PATH OF SIGHT = 270

DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.3676	.1437	.1334
100	.2273	.1049	.1014
105	.1375	.0902	.0768
120	.0546	.0931	.0755
150	.0370	.0708	.0563
180	.0168	.0647	.0646

FLIGHT NO. C-188A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5385 CATE 04/18/73)
DATE 82471 FLIGHT NO. C-188A GRCUND LEVEL ALTITUDE (M)= 244

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
0	1.49E-04	8.08E-05	5.46E-05
30	1.48E-04	8.04E-05	5.43E-05
60	1.48E-04	8.02E-05	5.42E-05
90	1.48E-04	8.00E-05	5.40E-05
120	1.47E-04	7.98E-05	5.39E-05
150	1.47E-04	7.96E-05	5.37E-05
180	1.46E-04	7.94E-05	5.36E-05
210	1.25E-04	1.35E-04	1.26E-04
240	1.23E-04	1.32E-04	1.21E-04
270	1.27E-04	1.33E-04	1.10E-04
300	1.33E-04	1.05E-04	8.96E-05
330	1.33E-04	1.09E-04	8.94E-05
360	1.45E-04	1.13E-04	8.53E-05
390	1.60E-04	1.32E-04	8.15E-05
420	1.73E-04	8.88E-05	8.29E-05
450	1.62E-04	8.93E-05	8.29E-05
480	1.66E-04	9.73E-05	8.17E-05
510	1.73E-04	9.25E-05	8.19E-05
540	1.77E-04	9.98E-05	7.88E-05
570	1.82E-04	1.07E-04	7.69E-05
600	1.79E-04	1.08E-04	6.80E-05
630	1.82E-04	1.10E-04	6.94E-05
660	1.82E-04	9.43E-05	7.06E-05
690	1.82E-04	7.56E-05	8.87E-05
720	1.79E-04	7.91E-05	8.18E-05
750	1.82E-04	7.66E-05	8.26E-05
780	1.72E-04	7.80E-05	8.31E-05
810	1.65E-04	8.75E-05	8.74E-05
840	1.64E-04	1.33E-04	9.50E-05
870	1.49E-04	1.26E-04	9.77E-05
900	1.17E-04	1.36E-04	1.02E-04
930	1.45E-04	1.46E-04	1.04E-04
960	1.72E-04	1.46E-04	1.05E-04
990	1.54E-04	1.47E-04	1.03E-04
1020	1.43E-04	1.49E-04	1.00E-04
1050	1.32E-04	1.42E-04	1.02E-04
1080	1.17E-04	1.30E-04	9.18E-05
1110	1.08E-04	1.28E-04	7.10E-05
1140	9.49E-05	8.75E-05	4.09E-05
1170	8.51E-05	4.92E-05	2.87E-05
1200	7.85E-05	4.31E-05	2.69E-05
1230	7.73E-05	4.13E-05	2.74E-05
1260	6.95E-05	4.03E-05	2.69E-05
1290	6.87E-05	4.75E-05	2.79E-05
1320	6.90E-05	4.91E-05	2.96E-05
1350	6.86E-05	4.49E-05	2.90E-05
1380	6.83E-05	4.46E-05	2.84E-05
1410	6.79E-05	4.42E-05	2.82E-05
1440	6.61E-05	4.26E-05	2.64E-05
1470	6.69E-05	4.08E-05	2.53E-05
1500	6.74E-05	3.93E-05	2.55E-05

FLIGHT NO. C-188A
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5385 DATE 04/18/73)
DATE 82471 FLIGHT NO. C-188A GROUND LEVEL ALTITUDE (M)= 244

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	6.35E-05	3.78E-05	2.53E-05
1560	6.37E-05	3.75E-C5	2.49E-05
1590	6.46E-05	3.95E-C5	2.55E-05
1620	6.75E-05	4.36E-05	2.71E-05
1650	6.82E-05	4.37E-05	2.81E-05
1680	7.25E-05	4.48E-05	2.71E-05
1710	7.00E-05	4.76E-05	2.75E-05
1740	6.94E-05	4.61E-C5	2.61E-05
1770	6.81E-05	4.60E-C5	2.77E-05
1800	6.70E-05	4.54E-05	2.92E-05
1830	6.90E-05	4.40E-05	2.99E-05
1860	7.28E-05	4.48E-05	3.C7E-05
1890	7.16E-05	4.54E-C5	3.23E-05
1920	7.12E-05	4.49E-05	3.20E-05
1950	7.42E-05	4.53E-C5	3.17E-05
1980	7.75E-05	5.17E-C5	3.38E-05
2010	7.75E-05	5.63E-05	3.44E-05
2040	7.64E-05	5.57E-05	3.65E-05
2070	7.33E-05	5.40E-05	3.64E-05
2100	7.32E-05	5.31E-05	3.64E-05
2130	7.18E-05	5.21E-05	3.57E-05
2160	7.01E-05	5.08E-C5	3.51E-05
2190	6.88E-05	4.84E-05	3.34E-05
2220	6.83E-05	4.57E-05	3.18E-05
2250	6.70E-05	4.48E-05	3.10E-05
2280	6.69E-05	4.33E-05	2.98E-05
2310	6.55E-05	4.21E-05	2.90E-05
2340	6.51E-05	4.12E-05	2.84E-05
2370	6.42E-05	4.04E-05	2.70E-05
2400	6.15E-05	3.89E-05	2.60E-05
2430	6.00E-05	3.83E-C5	2.54E-05
2460	6.12E-05	3.80E-05	2.54E-05
2490	5.99E-05	3.77E-05	2.52E-05
2520	6.02E-05	3.77E-05	2.51E-05
2550	6.07E-05	3.72E-05	2.53E-05
2580	6.05E-05	3.69E-05	2.55E-05
2610	6.03E-05	3.67E-05	2.54E-05
2640	6.01E-05	3.66E-05	2.54E-05
2670	5.99E-05	3.65E-05	2.53E-05
27C0	5.98E-05	3.64E-05	2.52E-05
2730	5.96E-05	3.63E-05	2.51E-05
2760	5.94E-05	3.62E-05	2.50E-05
2790	5.92E-05	3.61E-05	2.50E-05
2820	5.90E-05	3.59E-05	2.49E-05
2850	5.88E-C5	3.58E-05	2.48E-05
2880	5.86E-05	3.57E-05	2.47E-05
2910	5.85E-05	3.56E-05	2.47E-05
2940	5.83E-05	3.55E-C5	2.46E-05
2970	5.81E-05	3.54E-05	2.45E-05
3000	5.79E-05	3.53E-05	2.44E-05
FIRST DATA ALT	180	180	180
LAST DATA ALT	2550	2580	2580

FLIGHT NO. C-188A
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5385 DATE 04/18/73)

FLIGHT NO. C-188A FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.17E-01	7.85E-01	8.50E-01	9.19E-01	9.53E-01	9.59E-01
600	3.51E-01	5.93E-01	7.04E-01	8.34E-01	9.00E-01	9.13E-01
900	1.94E-01	4.42E-01	5.78E-01	7.53E-01	8.49E-01	8.68E-01
1500	9.69E-02	3.16E-01	4.61E-01	6.70E-01	7.94E-01	8.19E-01
3000	2.88E-02	1.79E-01	3.16E-01	5.50E-01	7.08E-01	7.42E-01

FLIGHT NO. C-188A FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.15E-01	8.45E-01	8.93E-01	9.43E-01	9.67E-01	9.71E-01
600	4.99E-01	7.07E-01	7.92E-01	8.86E-01	9.33E-01	9.42E-01
900	3.54E-01	5.96E-01	7.07E-01	8.36E-01	9.02E-01	9.14E-01
1500	1.97E-01	4.48E-01	5.84E-01	7.57E-01	8.51E-01	8.70E-01
3000	9.02E-02	3.12E-01	4.57E-01	6.67E-01	7.92E-01	8.17E-01

FLIGHT NO. C-188A FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.71E-01	8.78E-01	9.16E-01	9.56E-01	9.74E-01	9.78E-01
600	5.80E-01	7.62E-01	8.33E-01	9.10E-01	9.47E-01	9.54E-01
900	4.33E-01	6.59E-01	7.56E-01	8.65E-01	9.20E-01	9.30E-01
1500	2.94E-01	5.46E-01	6.67E-01	8.11E-01	8.86E-01	9.00E-01
3000	1.73E-01	4.28E-01	5.66E-01	7.45E-01	8.44E-01	8.63E-01

FLIGHT NO. C-188A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-188A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.69E 02	7.50E 01	4.15E 01	1.23E 01	3.01E 00	2.08E 00
600	2.77E 02	1.41E 02	8.19E 01	2.59E 01	6.80E 00	4.85E 00
900	3.33E 02	1.90E 02.	1.17E 02	3.95E 01	1.11E 01	8.11E 00
1500	3.59E 02	2.29E 02	1.49E 02	5.45E 01	1.65E 01	1.24E 01
3000	3.65E 02	2.68E 02	1.90E 02	7.79E 01	2.68E 01	2.14E 01

FLIGHT NO. C-188A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.21E 02	5.15E 01	2.83E 01	8.21E 00	2.11E 00	1.54E 00
600	2.06E 02	9.62E 01	5.47E 01	1.66E 01	4.43E 00	3.28E 00
900	2.58E 02	1.30E 02	7.66E 01	2.43E 01	6.75E 00	5.08E 00
1500	3.04E 02	1.72E 02	1.08E 02	3.65E 01	1.08E 01	8.35E 00
3000	3.19E 02	2.06E 02	1.37E 02	5.11E 01	1.67E 01	1.34E 01

FLIGHT NO. C-188A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.24E 01	3.42E 01	1.83E 01	5.04E 00	1.15E 00	8.05E-01
600	1.47E 02	6.56E 01	3.61E 01	1.03E 01	2.47E 00	1.75E 00
900	1.92E 02	9.20E 01	5.24E 01	1.56E 01	3.90E 00	2.82E 00
1500	2.28E 02	1.19E 02	7.06E 01	2.22E 01	5.85E 00	4.33E 00
3000	2.41E 02	1.41E 02	8.79E 01	2.98E 01	8.61E 00	6.64E 00

FLIGHT NO. C-188A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-188A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	3.62E 01	1.83E 01	1.19E 01	5.28E 00	2.51E 00	2.08E 00
600	6.41E 01	3.67E 01	2.50E 01	1.18E 01	5.81E 00	4.85E 00
900	8.38E 01	5.35E 01	3.81E 01	1.90E 01	9.67E 00	8.11E 00
1500	1.02E C2	7.12E 01	5.29E 01	2.8CE 01	1.47E 01	1.24E 01
3000	1.24E C2	9.73E 01	7.68E 01	4.44E 01	2.49E 01	2.14E 01

FLIGHT NO. C-188A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	100	105	120	150	180
300	2.44E C1	1.21E 01	7.89E 00	3.63E 00	1.81E 00	1.54E 00
600	4.36E C1	2.36E 01	1.59E 01	7.57E 00	3.86E 00	3.28E 00
900	5.76E 01	3.36E 01	2.32E 01	1.15E 01	5.96E 00	5.08E 00
1500	7.49E 01	4.85E 01	3.50E 01	1.82E 01	9.77E 00	8.35E 00
3C00	9.29E C1	6.64E C1	5.01E 01	2.77E 01	1.55E 01	1.34E 01

FLIGHT NO. C-188A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	95	1C0	105	120	150	180
300	1.30E C1	6.33E 00	4.12E 00	1.88E 00	9.38E-01	8.05E-01
600	2.44E 01	1.28E 01	8.51E 00	4.01E 00	2.04E 00	1.75E 00
900	3.39E 01	1.90E 01	1.30E 01	6.33E 00	3.29E 00	2.82E 00
15C0	4.39E C1	2.66E 01	1.87E 01	9.48E 00	5.04E 00	4.33E 00
3C00	5.46E C1	3.60E C1	2.62E 01	1.40E 01	7.67E 00	6.64E 00

FLIGHT NO. C-188A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-188A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.80E 01	2.00E 01	1.36E 01	6.52E 00	2.82E 00	2.08E 00
600	6.90E 01	4.13E 01	2.94E 01	1.50E 01	6.64E 00	4.85E 00
900	9.27E 01	6.15E 01	4.58E 01	2.47E 01	1.12E 01	8.11E 00
1500	1.16E 02	8.42E 01	6.53E 01	3.74E 01	1.73E 01	1.24E 01
3000	1.55E 02	1.25E 02	1.03E 02	6.58E 01	3.10E 01	2.14E 01

FLIGHT NO. C-188A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.49E 01	1.30E 01	9.02E 00	4.59E 00	2.10E 00	1.54E 00
600	4.53E 01	2.58E 01	1.84E 01	9.70E 00	4.51E 00	3.28E 00
900	6.12E 01	3.75E 01	2.74E 01	1.49E 01	7.02E 00	5.08E 00
1500	8.24E 01	5.56E 01	4.22E 01	2.41E 01	1.16E 01	8.35E 00
3000	1.07E 02	7.97E 01	6.31E 01	3.86E 01	1.91E 01	1.34E 01

FLIGHT NO. C-188A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.35E 01	7.00E 00	4.86E 00	2.47E 00	1.10E 00	8.05E-01
600	2.57E 01	1.43E 01	1.02E 01	5.32E 00	2.41E 00	1.75E 00
900	3.63E 01	2.16E 01	1.57E 01	8.49E 00	3.90E 00	2.82E 00
1500	4.81E 01	3.07E 01	2.29E 01	1.29E 01	6.03E 00	4.33E 00
3000	6.21E 01	4.31E 01	3.33E 01	1.98E 01	9.47E 00	6.64E 00

FLIGHT NO. C-188A
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5385 CATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-188A FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	3.61E C1	1.84E 01	1.21E 01	5.43E 00	2.55E 00	2.08E 00
600	6.31E C1	3.65E C1	2.51E 01	1.20E 01	5.87E 00	4.85E 00
900	8.16E 01	5.26E 01	3.77E 01	1.90E 01	9.72E 00	8.11E 00
1500	9.72E C1	6.88E C1	5.15E C1	2.76E 01	1.47E 01	1.24E 01
3C00	1.20E C2	9.41E 01	7.46E C1	4.37E 01	2.49E 01	2.14E 01

FLIGHT NO. C-188A FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	2.20E C1	1.1CE 01	7.30E 00	3.51E 00	1.84E 00	1.54E 00
600	3.94E 01	2.15E 01	1.47E 01	7.32E 00	3.90E 00	3.28E 00
900	5.24E 01	3.08E 01	2.16E 01	1.11E 01	6.01E 00	5.08E 00
1500	6.87E C1	4.48E 01	3.27E 01	1.76E 01	9.80E 00	8.35E 00
3C00	8.68E C1	6.22E 01	4.73E 01	2.69E 01	1.56E 01	1.34E 01

FLIGHT NO. C-188A FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.19E 01	5.85E C0	3.85E 00	1.84E 00	9.62E-01	8.05E-01
600	2.23E 01	1.18E 01	7.95E 00	3.90E 00	2.08E 00	1.75E 00
900	3.09E 01	1.75E 01	1.21E 01	6.12E 00	3.33E 00	2.82E 00
1500	4.C0E C1	2.44E 01	1.74E 01	9.10E 00	5.07E 00	4.33E 00
3000	5.04E 01	3.34E 01	2.45E 01	1.34E 01	7.69E C0	6.64E 00

FLIGHT NO. C-188A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-188A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.24E 00	4.34E-01	2.22E-01	6.07E-02	1.44E-02	9.88E-03
600	3.58E 00	1.08E 00	5.29E-01	1.41E-01	3.44E-02	2.42E-02
900	7.83E 00	1.96E 00	9.20E-01	2.39E-01	5.94E-02	4.25E-02
1500	1.68E 01	3.30E 00	1.47E 00	3.70E-01	9.46E-02	6.90E-02
3000	5.75E 01	6.79E 00	2.73E 00	6.43E-01	1.72E-01	1.31E-01

FLIGHT NO. C-188A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.08E-01	2.91E-01	1.51E-01	4.16E-02	1.04E-02	7.55E-03
600	1.97E 00	6.51E-01	3.30E-01	8.94E-02	2.27E-02	1.66E-02
900	3.48E 00	1.04E 00	5.18E-01	1.39E-01	3.58E-02	2.66E-02
1500	7.36E 00	1.84E 00	8.80E-01	2.30E-01	6.08E-02	4.59E-02
3000	1.69E 01	3.16E 00	1.43E 00	3.66E-01	1.01E-01	7.86E-02

FLIGHT NO. C-188A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.67E-01	2.43E-01	1.24E-01	3.29E-02	7.39E-03	5.14E-03
600	1.58E 00	5.38E-01	2.71E-01	7.10E-02	1.63E-02	1.15E-02
900	2.77E 00	8.72E-01	4.33E-01	1.13E-01	2.65E-02	1.90E-02
1500	4.83E 00	1.36E 00	6.62E-01	1.71E-01	4.13E-02	3.00E-02
3000	8.67E 00	2.05E 00	9.70E-01	2.50E-01	6.38E-02	4.81E-02

FLIGHT NO. C-188A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-188A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.67E-01	1.06E-01	6.35E-02	2.61E-02	1.20E-02	9.88E-03
600	8.30E-01	2.82E-01	1.62E-01	6.44E-02	2.93E-02	2.42E-02
900	1.97E 00	5.51E-01	3.00E-01	1.15E-01	5.18E-02	4.25E-02
1500	4.76E 00	1.03E 00	5.21E-01	1.90E-01	8.44E-02	6.90E-02
3000	1.96E 01	2.47E 00	1.11E 00	3.67E-01	1.60E-01	1.31E-01

FLIGHT NO. C-188A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.63E-01	6.82E-02	4.22E-02	1.84E-02	8.95E-03	7.55E-03
600	4.17E-01	1.59E-01	9.58E-02	4.08E-02	1.98E-02	1.66E-02
900	7.77E-01	2.69E-01	1.57E-01	6.56E-02	3.16E-02	2.66E-02
1500	1.81E 00	5.17E-01	2.87E-01	1.15E-01	5.48E-02	4.59E-02
3000	4.92E 00	1.02E 00	5.24E-01	1.99E-01	9.38E-02	7.86E-02

FLIGHT NO. C-188A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.06E-01	4.50E-02	2.81E-02	1.23E-02	6.02E-03	5.14E-03
600	2.63E-01	1.05E-01	6.38E-02	2.76E-02	1.35E-02	1.15E-02
900	4.90E-01	1.80E-01	1.07E-01	4.57E-02	2.23E-02	1.90E-02
1500	9.31E-01	3.04E-01	1.75E-01	7.31E-02	3.55E-02	3.00E-02
3000	1.97E 00	5.25E-01	2.90E-01	1.17E-01	5.68E-02	4.81E-02

FLIGHT NO. C-188A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5385 DATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-188A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.80E-01	1.16E-01	7.28E-02	3.23E-02	1.35E-02	9.88E-03
600	8.94E-01	3.16E-01	1.90E-01	8.18E-02	3.35E-02	2.42F-02
900	2.18E 00	6.34E-01	3.60E-01	1.49E-01	6.00E-02	4.25E-02
1500	5.44E 00	1.21E 00	6.44E-01	2.54E-01	9.92E-02	6.90E-02
3000	2.44E 01	3.17E 00	1.49E 00	5.43E-01	1.99E-01	1.31E-01

FLIGHT NO. C-188A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.66E-01	7.36E-02	4.83E-02	2.33E-02	1.04E-02	7.55E-03
600	4.34E-01	1.75E-01	1.11E-01	5.23E-02	2.31E-02	1.66E-02
900	8.26E-01	3.00E-01	1.85E-01	8.52E-02	3.72E-02	2.66E-02
1500	1.99E 00	5.93E-01	3.45E-01	1.52E-01	6.53E-02	4.59E-02
3000	5.69E 00	1.22E 00	6.59E-01	2.77E-01	1.15E-01	7.86E-02

FLIGHT NO. C-188A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.09E-01	4.98E-02	3.31E-02	1.61E-02	7.06E-03	5.14E-03
600	2.76E-01	1.17E-01	7.61E-02	3.65E-02	1.59E-02	1.15E-02
900	5.25E-01	2.05E-01	1.30E-01	6.13E-02	2.65E-02	1.90E-02
1500	1.02E 00	3.51E-01	2.15E-01	9.92E-02	4.25E-02	3.00E-02
3000	2.24E 00	6.25E-01	3.67E-01	1.66E-01	7.01E-02	4.81E-02

FLIGHT NO. C-188A
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5385 CATE 04/18/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-188A FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.66E-01	1.07E-01	6.46E-02	2.69E-02	1.22E-02	9.88E-03
600	8.18E-01	2.80E-01	1.62E-01	6.53E-02	2.96E-02	2.42E-02
900	1.92E C0	5.42E-C1	2.97E-01	1.15E-01	5.21E-02	4.25E-02
1500	4.56E 00	9.92E-01	5.08E-01	1.87E-01	8.44E-02	6.90E-02
3C00	1.88E C1	2.39E 00	1.07E C0	3.61E-01	1.60E-01	1.31E-01

FLIGHT NO. C-188A FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.47E-01	6.22E-02	3.90E-02	1.78E-02	9.08E-03	7.55E-03
600	3.77E-01	1.46E-01	8.88E-02	3.95E-02	2.00E-02	1.66E-02
900	7.07E-C1	2.47E-01	1.46E-01	6.34E-02	3.19E-02	2.66E-02
1500	1.66E 00	4.78E-01	2.68E-01	1.11E-01	5.50E-02	4.59E-02
3000	4.60E 00	9.54E-01	4.94E-01	1.93E-01	9.40E-02	7.86E-02

FLIGHT NO. C-188A FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	9.64E-02	4.16E-02	2.63E-02	1.20E-02	6.17E-03	5.14E-03
600	2.40E-01	9.65E-02	5.96E-02	2.68E-02	1.37E-02	1.15E-02
900	4.47E-01	1.66E-01	1.00E-01	4.42E-02	2.26E-02	1.90E-02
1500	8.49E-01	2.79E-01	1.63E-01	7.01E-02	3.57E-02	3.00E-02
3C00	1.81E 00	4.87E-C1	2.70E-01	1.13E-01	5.69E-02	4.81E-02

FLIGHT C 188B – 24 AUGUST 1971 – TRACK 4 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit morning. Flight terminated shortly after noon, local daylight time. There were clear skies during the period of the flight with haze in all quadrants around the horizon. The flight was conducted over cultivated farmlands eastsoutheast of St. Louis. The typical terrain was flat, highly cultivated farmlands. The data-taking started at 1539 GMT (1039 CDT) and continued until 1658 GMT (1158 CDT). The sun zenith angle during sky radiance data-taking for Filters 2, 3, and 4 was 41.3 degrees at the beginning and 34.4 degrees at the end. The maximum altitude for the flight was 2643 meters. Average terrain elevation on this track was 153 meters.

At the beginning of data-taking, Scott Air Force Base was reporting clear skies with 7-mile (11.2-kilometer) visibility. There was haze around the horizon in all quadrants.

The ground station located at Scott, 39 miles (63 kilometers) from the center of the flight path, recorded clear with moderate haze.

During the flight, the aircrew made the following observations, which have been extracted from the flight log and summarized. Metric altitudes have been added editorially.

FLIGHT LOG ENTRY

Time (GMT)	Altitude (m AGL)	Aircrew Observations
1550	1520	Very heavy haze, estimated visibility 2 miles (3.2 km), ground barely visible from 5500 ft (1870 m) MSL, heavier haze at 5500 ft than at 1500 ft (460 m) MSL
1616	2740	On top at 9500 ft (2900 m) MSL, thin cloud deck at 6000 ft (1830 m) MSL, thin clouds about 20 miles (32 km) ahead

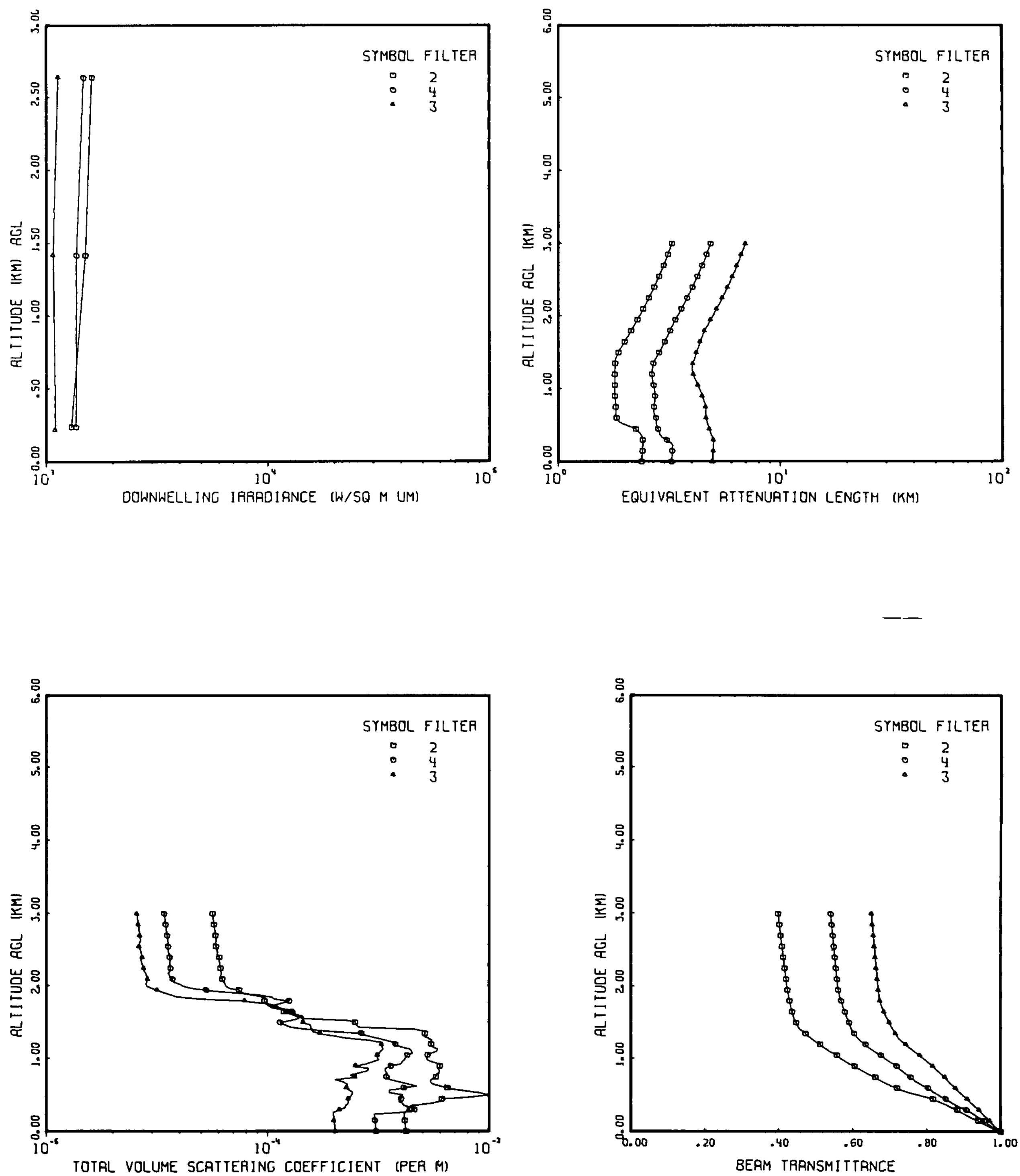
At the end of data-taking, Scott was reporting clear skies with 15-mile (24-kilometer) visibility. They also reported cumulus clouds to the eastsoutheast.

The surface synoptic chart shows the stationary front, that was over the region, beginning to move northward as a warm front. There was a weak high over Michigan with a ridge extending southwestward to Arkansas. The general circulation was weak.

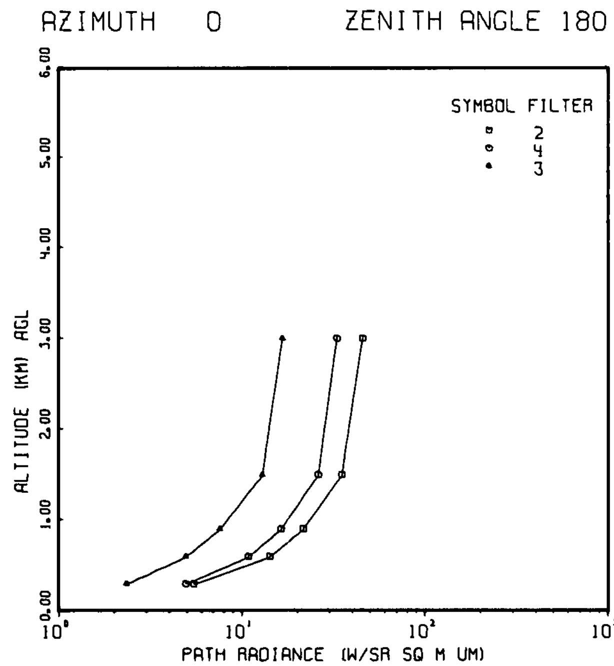
At 500 millibars there was a high covering the western two thirds of the United States and in general all of the U.S., except the northeast where there were low values and strong winds. There was a closed high over the Great Plains.

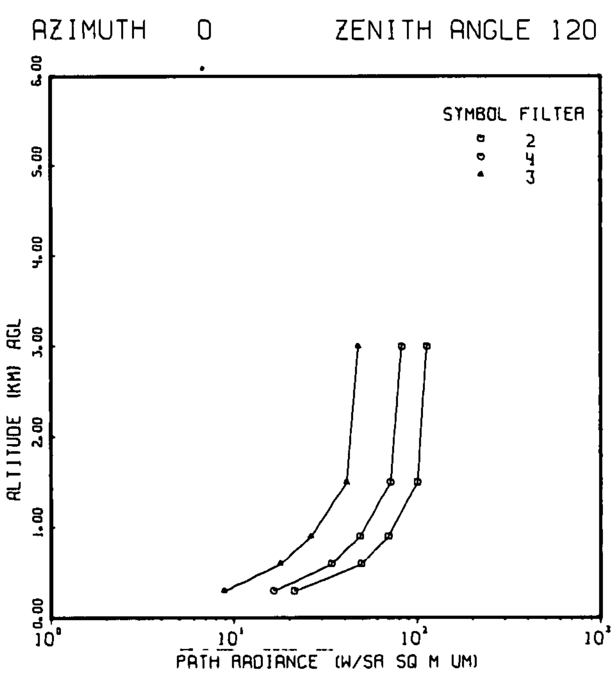
These data were taken from the 3-hourly facsimile charts issued by the NMC and obtained from Lindbergh Field NOAA office. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

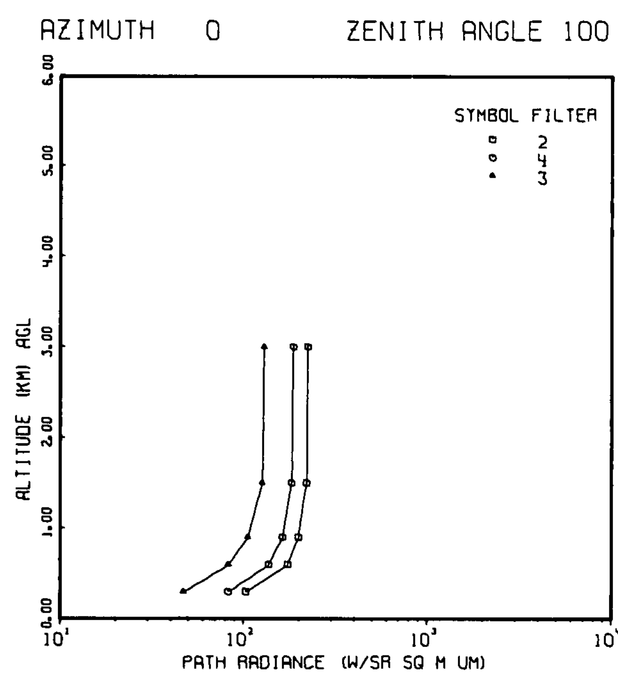
FLIGHT NO. C-188B



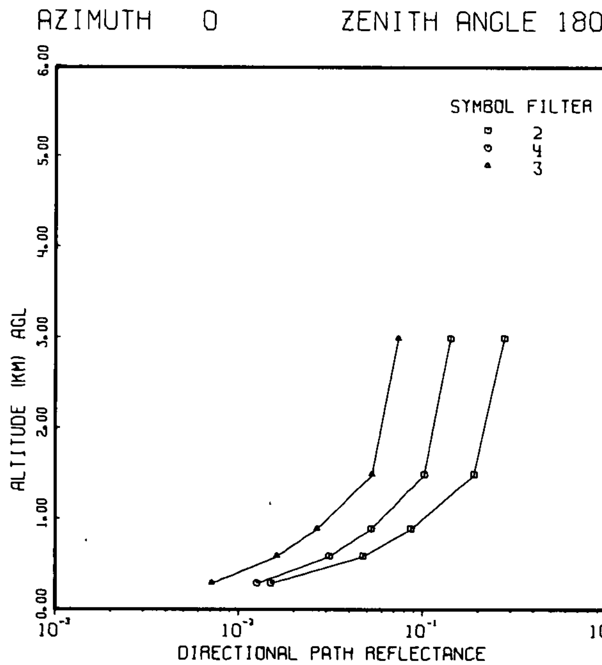
FLIGHT NO. C-188B

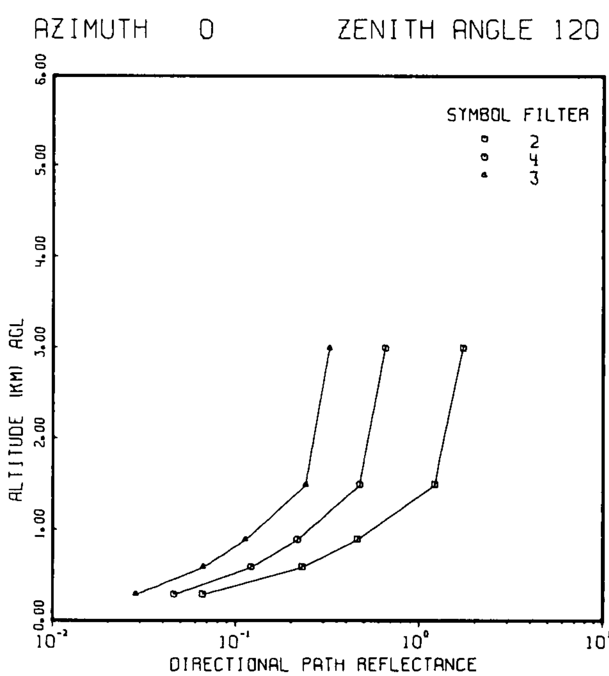


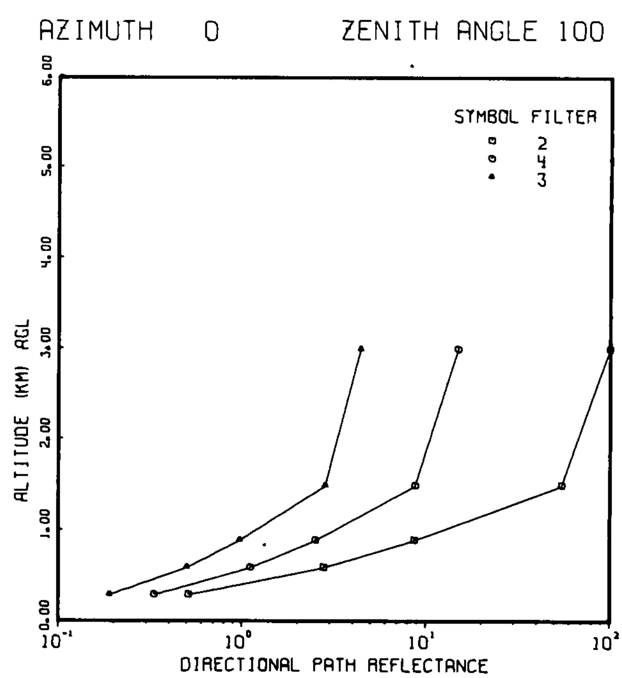




FLIGHT NO. C-188B







FLIGHT NO. C-188B
IRRADIANCE

(JOB 5439 DATE 04/19/73)

FLIGHT NO.C-188B FILTER NO. 2 SUN ZENITH ANGLE 37.7

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
241	1.30E 03	7.06E 01	.054	5.93E 02	1.57E 03	2.26E 02	2.39E 03	.105
1420	1.50E 03	2.05E 02	.136	1.40E 03	8.44E 02	5.53E 02	2.79E 03	.247
2641	1.61E 03	2.35E 02	.146	1.63E 03	6.18E 02	6.08E 02	2.85E 03	.271

FLIGHT NO.C-188B FILTER NO. 4 SUN ZENITH ANGLE 37.7

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
241	1.36E 03	9.00E 01	.066	8.13E 02	1.35E 03	2.38E 02	2.40E 03	.110
1420	1.37E 03	1.99E 02	.145	1.42E 03	5.09E 02	5.06E 02	2.44E 03	.262
2640	1.48E 03	2.23E 02	.151	1.59E 03	3.79E 02	5.50E 02	2.52E 03	.280

FLIGHT NO.C-188B FILTER NO. 3 SUN ZENITH ANGLE 37.7

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN- WELLING	UP- WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
223	1.10E 03	4.86E 01	.044	8.08E 02	9.32E 02	1.41E 02	1.88E 03	.081
1422	1.07E 03	1.22E 02	.114	1.18E 03	3.06E 02	3.26E 02	1.81E 03	.219
2643	1.13E 03	1.27E 02	.112	1.30E 03	1.60E 02	3.25E 02	1.79E 03	.222

FLIGHT NO. C-188B
DIRECTIONAL REFLECTANCE OF BACKGROUND

(JOB 5439 DATE 04/19/73)

FLIGHT NC. C-188B
AZIMUTH CF PATH OF SICHT = 0
DIRECTIONAL REFLECTANCE CF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.3774	.3077	.2583
100	.2354	.1604	.1375
105	.1400	.1141	.0929
120	.0582	.0576	.0561
150	.0302	.0558	.0468
180	.0383	.0559	.0626

FLIGHT NO. C-188B
AZIMUTH CF PATH OF SIGHT = 90
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1966	.1701	.1428
100	.1238	.1067	.0904
105	.0758	.0877	.0795
120	.0582	.0615	.0344
150	.0318	.0543	.0442
180	.0383	.0559	.0626

FLIGHT NC. C-188B
AZIMUTH OF PATH OF SIGHT = 180
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1408	.1306	.0928
100	.0987	.1059	.0907
105	.0836	.0841	.0884
120	.0549	.0547	.0388
150	.0608	.0923	.0635
180	.0383	.0559	.0626

FLIGHT NC. C-188B
AZIMUTH OF PATH OF SIGHT = 270
DIRECTIONAL REFLECTANCE OF BACKGROUND

ZENITH ANGLE	FILTERS 2	4	3
95	.1843	.1340	.1040
100	.1315	.1020	.0954
105	.0930	.0749	.0819
120	.0618	.0657	.0285
150	.0428	.0585	.0497
180	.0383	.0559	.0626

FLIGHT NO. C-188B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5439 DATE 04/19/73)
DATE 82471 FLIGHT NO. C-188B GRCUND LEVEL ALTITUDE (M)= 152

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
0	4.21E-04	3.09E-04	2.02E-04
30	4.19E-04	3.08E-04	2.01E-04
60	4.18E-04	3.07E-04	2.01E-04
90	4.17E-04	3.06E-04	2.00E-04
120	4.16E-04	3.05E-04	2.00E-04
150	4.15E-04	3.05E-04	1.99E-04
180	4.14E-04	3.04E-04	1.99E-04
210	4.13E-04	3.03E-04	1.98E-04
240	4.12E-04	3.02E-04	1.98E-04
270	4.16E-04	4.16E-04	1.97E-04
300	4.37E-04	4.61E-04	2.11E-04
330	4.38E-04	4.56E-04	2.23E-04
360	4.46E-04	4.13E-04	2.25E-04
390	5.36E-04	4.05E-04	2.31E-04
420	6.05E-04	3.89E-04	2.31E-04
450	6.10E-04	4.01E-04	2.31E-04
480	8.10E-04	4.02E-04	2.38E-04
510	1.10E-03	4.07E-04	2.40E-04
540	9.10E-04	3.53E-04	2.42E-04
570	7.62E-04	3.56E-04	2.34E-04
600	6.48E-04	4.11E-04	2.27E-04
630	6.01E-04	4.69E-04	2.28E-04
660	5.54E-04	4.26E-04	2.29E-04
690	5.42E-04	3.91E-04	2.18E-04
720	5.46E-04	3.55E-04	2.01E-04
750	5.74E-04	3.43E-04	2.48E-04
780	5.73E-04	3.42E-04	2.35E-04
810	5.96E-04	3.45E-04	2.60E-04
840	5.96E-04	3.39E-04	2.82E-04
870	5.88E-04	3.39E-04	2.85E-04
900	5.98E-04	3.60E-04	2.49E-04
930	5.95E-04	3.98E-04	2.78E-04
960	5.56E-04	4.03E-04	2.96E-04
990	5.23E-04	4.13E-04	3.18E-04
1020	5.24E-04	4.18E-04	3.12E-04
1050	5.27E-04	4.26E-04	3.13E-04
1080	5.49E-04	4.52E-04	3.20E-04
1110	5.82E-04	4.45E-04	3.24E-04
1140	5.83E-04	4.37E-04	3.33E-04
1170	5.54E-04	3.97E-04	3.28E-04
1200	5.46E-04	3.76E-04	3.27E-04
1230	5.42E-04	3.67E-04	3.23E-04
1260	5.55E-04	3.42E-04	2.86E-04
1290	5.28E-04	3.10E-04	2.27E-04
1320	5.05E-04	2.81E-04	1.99E-04
1350	5.12E-04	2.64E-04	1.72E-04
1380	5.13E-04	1.95E-04	1.59E-04
1410	4.61E-04	1.51E-04	1.59E-04
1440	2.57E-04	1.28E-04	1.56E-04
1470	2.52E-04	1.21E-04	1.56E-04
1500	2.48E-04	1.14E-04	1.45E-04

FLIGHT NO. C-188B
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5439 DATE 04/19/73)
DATE 82471 FLIGHT NO. C-188B GROUND LEVEL ALTITUDE (M)= 152

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3
1530	2.33E-04	1.25E-04	1.43E-04
1560	1.45E-04	1.38E-04	1.45E-04
1590	1.35E-04	1.39E-04	1.45E-04
1620	1.28E-04	1.34E-04	1.35E-04
1650	1.18E-04	1.29E-04	1.24E-04
1680	1.18E-04	1.21E-04	1.22E-04
1710	1.05E-04	1.13E-04	1.13E-04
1740	1.01E-04	1.04E-04	1.10E-04
1770	9.84E-05	1.15E-04	9.85E-05
1800	9.67E-05	1.25E-04	7.88E-05
1830	9.68E-05	1.08E-04	4.95E-05
1860	9.69E-05	1.04E-04	3.91E-05
1890	8.42E-05	9.14E-05	3.62E-05
1920	7.66E-05	6.89E-05	3.38E-05
1950	7.41E-05	5.27E-05	3.16E-05
1980	6.68E-05	4.49E-05	2.98E-05
2010	6.47E-05	4.15E-05	2.83E-05
2040	6.40E-05	3.98E-05	2.82E-05
2070	6.32E-05	3.73E-05	2.84E-05
2100	6.23E-05	3.72E-05	2.86E-05
2130	6.15E-05	3.63E-05	2.88E-05
2160	6.12E-05	3.60E-05	2.82E-05
2190	6.18E-05	3.54E-05	2.81E-05
2220	6.12E-05	3.61E-05	2.76E-05
2250	6.12E-05	3.64E-05	2.76E-05
2280	6.08E-05	3.61E-05	2.71E-05
2310	6.07E-05	3.62E-05	2.72E-05
2340	6.04E-05	3.61E-05	2.69E-05
2370	6.02E-05	3.63E-05	2.67E-05
2400	6.04E-05	3.60E-05	2.71E-05
2430	5.89E-05	3.59E-05	2.69E-05
2460	5.92E-05	3.59E-05	2.68E-05
2490	5.91E-05	3.54E-05	2.67E-05
2520	5.87E-05	3.54E-05	2.64E-05
2550	5.83E-05	3.55E-05	2.62E-05
2580	5.81E-05	3.54E-05	2.63E-05
2610	5.83E-05	3.56E-05	2.64E-05
2640	5.84E-05	3.53E-05	2.66E-05
2670	5.82E-05	3.52E-05	2.65E-05
2700	5.80E-05	3.51E-05	2.64E-05
2730	5.79E-05	3.49E-05	2.63E-05
2760	5.77E-05	3.48E-05	2.63E-05
2790	5.75E-05	3.47E-05	2.62E-05
2820	5.73E-05	3.46E-05	2.61E-05
2850	5.71E-05	3.45E-05	2.60E-05
2880	5.70E-05	3.44E-05	2.59E-05
2910	5.68E-05	3.43E-05	2.58E-05
2940	5.66E-05	3.42E-05	2.58E-05
2970	5.64E-05	3.41E-05	2.57E-05
3000	5.63E-05	3.40E-05	2.56E-05
FIRST DATA ALT	240	240	270
LAST DATA ALT	2640	2640	2640

FLIGHT NO. C-188B
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

(JOB 5439 DATE 04/19/73)

FLIGHT NO. C-188B FILTER NO. 2
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.37E-01	4.97E-01	6.17E-01	7.79E-01	8.65E-C1	8.82E-01
600	2.28E-02	1.51E-01	2.82E-01	5.19E-01	6.85E-01	7.20E-01
900	3.C2E-03	5.56E-02	1.44E-01	3.67E-01	5.60E-01	6.05E-01
1500	8.61E-05	9.73E-03	4.47E-02	2.CCE-01	3.95E-01	4.47E-01
3000	1.68E-05	4.97E-03	2.85E-02	1.58E-01	3.45E-01	3.98E-01

FLIGHT NO. C-188B FILTER NO. 4
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.27E-01	5.71E-01	6.87E-01	8.23E-01	8.94E-01	9.07E-01
600	8.11E-02	2.85E-01	4.31E-01	6.47E-01	7.78E-01	8.04E-01
900	2.20E-02	1.50E-01	2.80E-01	5.17E-01	6.83E-01	7.19E-01
1500	2.17E-03	4.82E-02	1.31E-01	3.49E-01	5.44E-C1	5.91E-01
3000	6.42E-04	2.88E-02	9.26E-02	2.92E-01	4.91E-01	5.40E-01

FLIGHT NO. C-188B FILTER NO. 3
BEAM TRANSMITTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.02E-01	7.08E-01	7.93E-01	8.87E-01	9.33E-01	9.42E-01
600	2.25E-01	4.75E-01	6.07E-01	7.72E-01	8.61E-01	8.79E-01
900	9.66E-02	3.12E-01	4.58E-01	6.68E-01	7.92E-01	8.17E-01
1500	1.56E-02	1.28E-01	2.51E-01	4.89E-01	6.62E-01	6.99E-01
3000	5.96E-03	8.42E-02	1.90E-01	4.23E-01	6.09E-01	6.51E-01

FLIGHT NO. C-188B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5439 CATE 04/19/73)
AZIMUTH CF PATH OF SICHT = 0

FLIGHT NO. C-188B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.90E 02	1.C3E 02	6.35E 01	2.12E 01	6.62E 00	5.47E 00
600	2.42E 02	1.74E 02	1.23E 02	4.95E 01	1.71E 01	1.42E 01
900	2.50E 02	1.99E 02	1.53E 02	6.96E 01	2.60E 01	2.17E 01
1500	2.58E C2	2.21E 02	1.85E 02	1.00E 02	4.21E 01	3.53E 01
3000	2.51E 02	2.24E 02	1.92E 02	1.13E 02	5.22E 01	4.59E 01

FLIGHT NO. C-188B FILTER NO. 4
PATH RADIANCE FRCM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.64E 02	8.24E 01	4.97E 01	1.64E 01	5.74E 00	4.93E 00
600	2.16E 02	1.37E 02	9.10E 01	3.40E 01	1.26E 01	1.09E 01
900	2.23E 02	1.63E 02	1.17E 02	4.87E 01	1.91E 01	1.64E 01
1500	2.16E C2	1.83E 02	1.44E 02	7.15E 01	3.06E 01	2.62E 01
3000	2.13E 02	1.87E 02	1.53E 02	8.24E 01	3.78E 01	3.32E 01

FLIGHT NO. C-188B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE CF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.02E 02	4.70E 01	2.76E 01	8.81E 00	2.85E 00	2.34E 00
600	1.51E 02	8.30E 01	5.19E 01	1.79E 01	6.01E 00	4.96E 00
900	1.67E 02	1.06E 02	7.04E 01	2.63E 01	9.20E 00	7.61E 00
1500	1.64E 02	1.27E 02	9.41E 01	4.12E 01	1.56E 01	1.30E 01
3000	1.57E 02	1.30E 02	1.01E 02	4.77E 01	1.94E 01	1.68E 01

FLIGHT NO. C-188B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5439 DATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 90

FLIGHT NO. C-188B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.21E 01	5.39E 01	3.56E 01	1.48E 01	6.39E 00	5.47E 00
600	1.20E 02	9.35E 01	7.08E 01	3.51E 01	1.65E 01	1.42E 01
900	1.28E 02	1.09E 02	8.95E 01	5.00E 01	2.50E 01	2.17E 01
1500	1.38E 02	1.27E 02	1.13E 02	7.37E 01	4.04E 01	3.53E 01
3000	1.52E 02	1.40E 02	1.26E 02	8.70E 01	5.15E 01	4.59E 01

FLIGHT NO. C-188B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	7.38E 01	4.13E 01	2.71E 01	1.17E 01	5.60E 00	4.93E 00
600	9.98E 01	7.01E 01	5.07E 01	2.45E 01	1.23E 01	1.09E 01
900	1.07E 02	8.56E 01	6.66E 01	3.54E 01	1.85E 01	1.64E 01
1500	1.11E 02	1.01E 02	8.66E 01	5.32E 01	2.96E 01	2.62E 01
3000	1.21E 02	1.10E 02	9.70E 01	6.33E 01	3,72E 01	3.32E 01

FLIGHT NO. C-188B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.28E 01	2.20E 01	1.41E 01	5.94E 00	2.77E 00	2.34E 00
600	6.50E 01	3.96E 01	2.71E 01	1.23E 01	5.84E 00	4.96E 00
900	7.40E 01	5.20E 01	3.78E 01	1.84E 01	8.96E 00	7.61E 00
1500	7.77E 01	6.63E 01	5.36E 01	2.99E 01	1.52E 01	1.30E 01
3000	8.06E 01	7.14E 01	6.00E 01	3.58E 01	1.93E 01	1.68E 01

FLIGHT NO. C-188B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5439 CATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-188B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	6.79E 01	4.18E 01	2.92E 01	1.44E 01	7.37E 00	5.47E 00
600	9.03E C1	7.33E C1	5.84E 01	3.39E 01	1.88E 01	1.42E 01
900	9.76E 01	8.69E 01	7.44E 01	4.81E 01	2.83E 01	2.17E 01
1500	1.10E 02	1.04E 02	9.52E 01	7.04E 01	4.51E 01	3.53E 01
3000	1.42E 02	1.28E 02	1.17E 02	8.93E 01	6.10E 01	4.59E 01

FLIGHT NO. C-188B FILTER NO. 4
PATH RADIANCE FROM GRCUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	5.54E 01	3.28E 01	2.30E 01	1.19E 01	6.60E 00	4.93E 00
600	7.59E 01	5.62E C1	4.31E 01	2.47E 01	1.43E 01	1.09E 01
900	8.26E 01	6.91E 01	5.67E 01	3.53E 01	2.13E 01	1.64E 01
1500	8.89E 01	8.29E 01	7.39E 01	5.20E 01	3.32E 01	2.62E 01
3000	1.C6E 02	9.68E 01	8.72E 01	6.39E 01	4.26E 01	3.32E 01

FLIGHT NO. C-188B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 95	100	105	120	150	180
300	3.12E 01	1.70E 01	1.18E 01	6.05E 00	3.22E 00	2.34E 00
600	4.73E 01	3.07E 01	2.25E 01	1.24E 01	6.80E 00	4.96E 00
900	5.41E 01	4.02E 01	3.12E 01	1.84E 01	1.04E 01	7.61E 00
1500	5.73E 01	5.12E 01	4.38E 01	2.94E 01	1.77E 01	1.30E 01
3000	6.58E 01	5.89E 01	5.16E 01	3.64E 01	2.32E 01	1.68E 01

FLIGHT NO. C-188B
PATH RADIANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 5439 DATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-188B FILTER NO. 2
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.26E 01	4.91E 01	3.30E 01	1.46E 01	6.74E 00	5.47E 00
600	1.08E 02	8.47E 01	6.51E 01	3.40E 01	1.72E 01	1.42E 01
900	1.14E 02	9.87E 01	8.18E 01	4.80E 01	2.59E 01	2.17E 01
1500	1.23E 02	1.14E 02	1.02E 02	6.95E 01	4.12E 01	3.53E 01
3000	1.43E 02	1.29E 02	1.16E 02	8.27E 01	5.22E 01	4.59E 01

FLIGHT NO. C-188B FILTER NO. 4
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	6.47E 01	3.66E 01	2.45E 01	1.13E 01	5.83E 00	4.93E 00
600	8.78E 01	6.22E 01	4.56E 01	2.34E 01	1.27E 01	1.09E 01
900	9.43E 01	7.59E 01	5.97E 01	3.35E 01	1.90E 01	1.64E 01
1500	9.90E 01	8.94E 01	7.69E 01	4.94E 01	2.98E 01	2.62E 01
3000	1.12E 02	1.00E 02	8.78E 01	5.91E 01	3.73E 01	3.32E 01

FLIGHT NO. C-188B FILTER NO. 3
PATH RADIANCE FROM GROUND TO ALTITUDE (W/SR SQ M UM)

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.77E 01	1.95E 01	1.26E 01	5.52E 00	2.73E 00	2.34E 00
600	5.69E 01	3.49E 01	2.41E 01	1.13E 01	5.78E 00	4.96E 00
900	6.42E 01	4.54E 01	3.33E 01	1.69E 01	8.88E 00	7.61E 00
1500	6.62E 01	5.67E 01	4.63E 01	2.72E 01	1.51E 01	1.30E 01
3000	7.12E 01	6.23E 01	5.25E 01	3.28E 01	1.92E 01	1.68E 01

FLIGHT NO. C-188B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 0

(JOB 5439 DATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 0

FLIGHT NO. C-188B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.94E 00	5.12E-01	2.49E-01	6.59E-02	1.85E-02	1.50E-02
600	2.56E 01	2.79E 00	1.06E 00	2.30E-01	6.03E-02	4.77E-02
900	2.00E 02	8.66E 00	2.57E 00	4.59E-01	1.12E-01	8.66E-02
1500	7.24E 03	5.48E 01	9.99E 00	1.21E 00	2.58E-01	1.91E-01
3000	3.61E 04	1.09E 02	1.63E 01	1.73E 00	3.65E-01	2.79E-01

FLIGHT NO. C-188B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	1.16E 00	3.33E-01	1.67E-01	4.60E-02	1.48E-02	1.26E-02
600	6.14E 00	1.11E 00	4.87E-01	1.21E-01	3.75E-02	3.12E-02
900	2.33E 01	2.52E 00	9.62E-01	2.17E-01	6.45E-02	5.26E-02
1500	2.29E 02	8.77E 00	2.54E 00	4.73E-01	1.30E-01	1.02E-01
3000	7.66E 02	1.49E 01	3.81E 00	6.52E-01	1.78E-01	1.42E-01

FLIGHT NO. C-188B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.81E-01	1.90E-01	9.97E-02	2.85E-02	8.76E-03	7.13E-03
600	1.93E 00	5.01E-01	2.45E-01	6.65E-02	2.00E-02	1.62E-02
900	4.96E 00	9.72E-01	4.41E-01	1.13E-01	3.33E-02	2.67E-02
1500	3.00E 01	2.85E 00	1.07E 00	2.42E-01	6.75E-02	5.33E-02
3000	7.56E 01	4.42E 00	1.52E 00	3.23E-01	9.15E-02	7.38E-02

FLIGHT NO. C-188B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 90

(JOB 5439 CATE 04/19/73)
AZIMUTH CF PATH OF SIGHT = 90

FLIGHT NO. C-188B FILTER NO. 2
DIRECTICNAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	9.39E-01	2.68E-01	1.40E-01	4.60E-02	1.78E-02	1.50E-02
600	1.27E 01	1.49E 00	6.07E-01	1.63E-01	5.81E-02	4.77E-02
900	1.02E 02	4.75E 00	1.50E 00	3.29E-01	1.C8E-01	8.66E-02
1500	3.88E 03	3.16E 01	6.11E 00	8.89E-01	2.47E-01	1.91E-01
3000	2.19E 04	6.79E 01	1.07E 01	1.33E 00	3.61E-01	2.79E-01

FLIGHT NO. C-188B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	5.21E-01	1.67E-01	9.12E-02	3.28E-02	1.45E-02	1.26E-02
600	2.84E 00	5.67E-01	2.72E-01	8.73E-02	3.65E-02	3.12E-02
900	1.12E 01	1.32E 00	5.50E-01	1.58E-01	6.26E-02	5.26E-02
1500	1.18E 02	4.84E 00	1.53E 00	3.52E-01	1.25E-01	1.02E-01
3000	4.36E 02	8.83E 00	2.42E 00	5.00E-01	1.75E-01	1.42E-01

FLIGHT NO. C-188B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.45E-01	8.90E-02	5.09E-02	1.92E-02	8.50E-03	7.13E-03
600	8.29E-01	2.39E-01	1.28E-01	4.55E-02	1.95E-02	1.62E-02
900	2.20E 00	4.77E-01	2.36E-01	7.90E-02	3.25E-02	2.67E-02
1500	1.43E 01	1.49E 00	6.12E-01	1.75E-01	6.61E-02	5.33E-02
3000	3.88E 01	2.43E 00	9.05E-01	2.42E-01	9.10E-02	7.38E-02

FLIGHT NO. C-188B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 180

(JOB 5439 CATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 180

FLIGHT NO. C-188B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	6.92E-01	2.07E-01	1.14E-01	4.48E-02	2.06E-02	1.50E-02
600	9.57E C0	1.17E 00	5.01E-01	1.58E-01	6.63E-02	4.77E-02
900	7.80E 01	3.78E 00	1.25E 00	3.17E-01	1.22E-01	8.66E-02
1500	3.08E 03	2.57E 01	5.15E C0	8.50E-01	2.76E-01	1.91E-01
3000	2.04E C4	6.20E 01	9.89E 00	1.36E 00	4.27E-01	2.79E-01

FLIGHT NO. C-188B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	3.91E-01	1.33E-01	7.73E-02	3.34E-02	1.70E-02	1.26E-02
600	2.16E 00	4.54E-01	2.31E-01	8.80E-02	4.25E-02	3.12E-02
900	8.65E 00	1.07E 00	4.68E-01	1.58E-01	7.19E-02	5.26E-02
1500	9.44E 01	3.97E 00	1.31E 00	3.44E-01	1.41E-01	1.02E-01
3C00	3.83E 02	7.74E 00	2.17E 00	5.06E-01	2.00E-01	1.42E-01

FLIGHT NO. C-188B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	1C0	105	120	150	180
300	1.78E-01	6.91E-02	4.25E-02	1.96E-02	9.90E-03	7.13E-03
600	6.04E-01	1.85E-01	1.06E-01	4.60E-02	2.27E-02	1.62E-02
900	1.60E 00	3.69E-01	1.95E-01	7.90E-02	3.78E-02	2.67E-02
1500	1.05E 01	1.15E C0	5.00E-01	1.72E-01	7.68E-02	5.33E-02
3000	3.17E 01	2.00E 00	7.78E-01	2.46E-01	1.09E-01	7.38E-02

FLIGHT NO. C-188B
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE
AZIMUTH OF PATH OF SIGHT = 270

(JOB 9439 DATE 04/19/73)
AZIMUTH OF PATH OF SIGHT = 270

FLIGHT NO. C-188B FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	8.42E-01	2.44E-01	1.29E-01	4.52E-02	1.88E-02	1.50E-02
600	1.14E 01	1.35E 00	5.59E-01	1.58E-01	6.07E-02	4.77E-02
900	9.10E 01	4.29E 00	1.37E 00	3.16E-01	1.12E-01	8.66E-02
1500	3.45E 03	2.83E 01	5.52E 00	8.39E-01	2.52E-01	1.91E-01
3000	2.05E 04	6.27E 01	9.87E 00	1.26E 00	3.66E-01	2.79E-01

FLIGHT NO. C-188B FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	4.57E-01	1.48E-01	8.22E-02	3.16E-02	1.51E-02	1.26E-02
600	2.50E 00	5.03E-01	2.44E-01	8.35E-02	3.77E-02	3.12E-02
900	9.87E 00	1.17E 00	4.92E-01	1.50E-01	6.41E-02	5.26E-02
1500	1.05E 02	4.28E 00	1.36E 00	3.27E-01	1.27E-01	1.02E-01
3000	4.03E 02	8.02E 00	2.19E 00	4.67E-01	1.75E-01	1.42E-01

FLIGHT NO. C-188B FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE FROM GROUND TO ALTITUDE

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)					
M	95	100	105	120	150	180
300	2.16E-01	7.90E-02	4.57E-02	1.78E-02	8.40E-03	7.13E-03
600	7.25E-01	2.11E-01	1.14E-01	4.21E-02	1.92E-02	1.62E-02
900	1.91E 00	4.17E-01	2.08E-01	7.26E-02	3.21E-02	2.67E-02
1500	1.21E 01	1.27E 00	5.28E-01	1.59E-01	6.56E-02	5.33E-02
3000	3.43E 01	2.12E 00	7.93E-01	2.22E-01	9.05E-02	7.38E-02

8. DATA INTERPRETATION AND EVALUATION

8.1 METEOROLOGICAL DATA

The basic discussion of meteorological conditions as presented in Section 6 and summarized with each flight description is based upon meteorological data reported for Scott Air Force Base. It should be remembered that the flight tracks were from 32 to 108 miles distant so that reports of visibility or cloud conditions at Scott Air Force Base often do not correspond to the conditions encountered during the flights.

CLOUD CONDITIONS

The airborne pictures which documented the cloud conditions during the flights were summarized in Table 7-2. These descriptions can be divided into five categories as follows:

Description	Flight Profiles
1. Upper and lower sky – clear	C-182B, C-188A, C-188B
2. Upper sky – horizon clouds; Lower sky – clear	C-181 , C-186B, C-187A
3. Upper sky – horizon clouds; Lower sky – some clouds	C-183A, C-185A
4. Upper sky – some scattered clouds; Lower sky – either clouds or clear	C-180 , C-182A, C-186A
5. Upper sky – considerable scattered clouds	C-183B, C-185B, C-187B

The sky radiance data for the flight profiles in categories 1 through 4 were sufficiently consistent so that path radiance and path reflectance could be derived, but only the nephelometer data for the flights in category 5 could be utilized. This report contains the data for the six clearest profiles, categories 1 and 2. In addition, in order to report as many double flights as possible, flight profiles for C-182A and C-186A from category 4 are included in the report, even though the pictures indicate these to have somewhat variable cloud conditions.

TEMPERATURE

The flights were conducted during August at latitudes of 37.8 to 39.9 degrees and thus can be profitably compared to the U. S. Standard Atmosphere Supplements for 30°N and 45°N latitude. To facilitate this comparison, the temperature profile (a graphical average of the temperatures measured during the vertical profile sequences) of each of the flights is superimposed on a graph of the temperature for July 30°N, July 45°N, and Spring/Fall 45°N. The temperatures for the six clear-day flight profiles plus C-182A and C-186A are depicted in Figure 8-1. The remaining flight profiles from cloud categories 3 through 5 are depicted in Figure 8-2. Note that the altitude scale is above mean sea level. The ground level altitudes ranged between 153 and 305 meters.

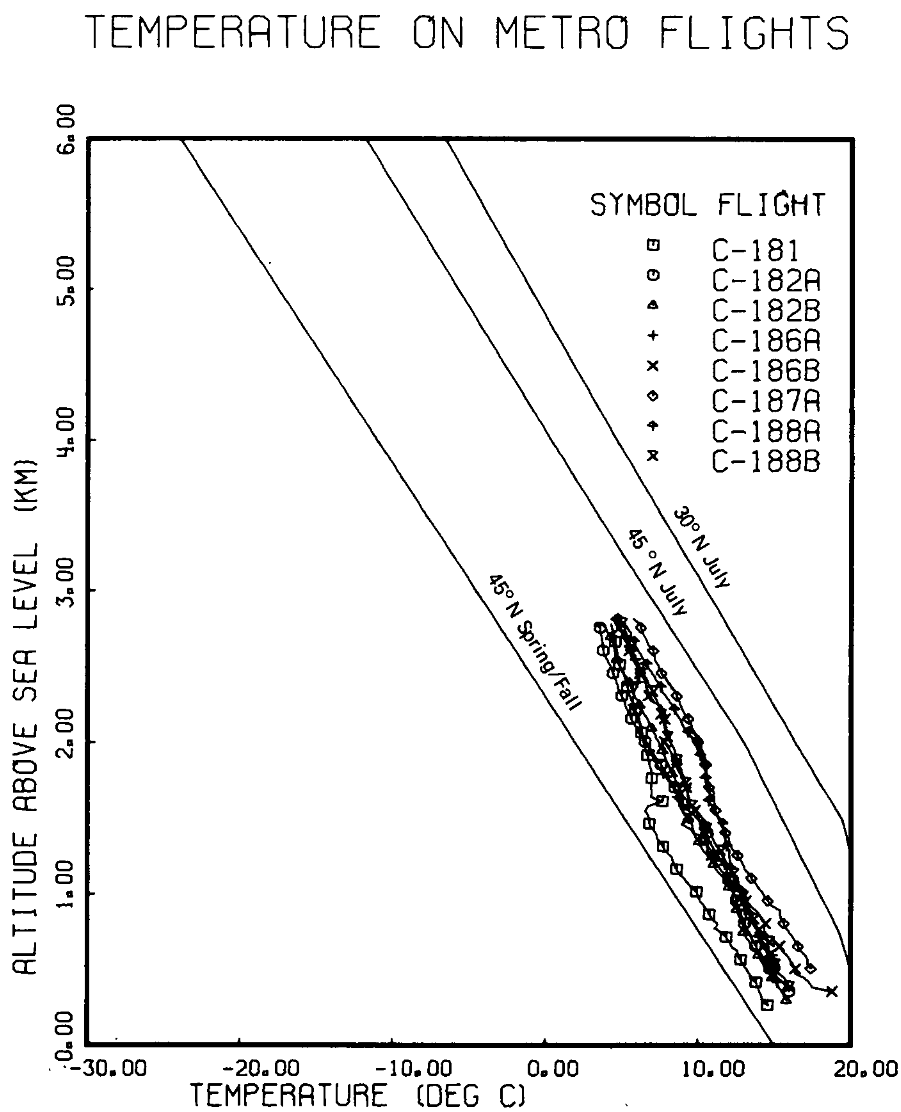


Fig. 8-1. Temperature for Six Clear Flight Profiles Plus C-182A and C-186A.

The temperatures for all the flights lie between the values for July and Spring/Fall for 45°N. There is also a general tendency toward either an inversion or a slight decrease in the lapse rate between 1 and 2 kilometers. The top of the primary haze layer also tended to lie in this altitude range.

There appears to be no significant difference in the temperature profiles for the six clear flight profiles as compared to the profiles with scattered clouds.

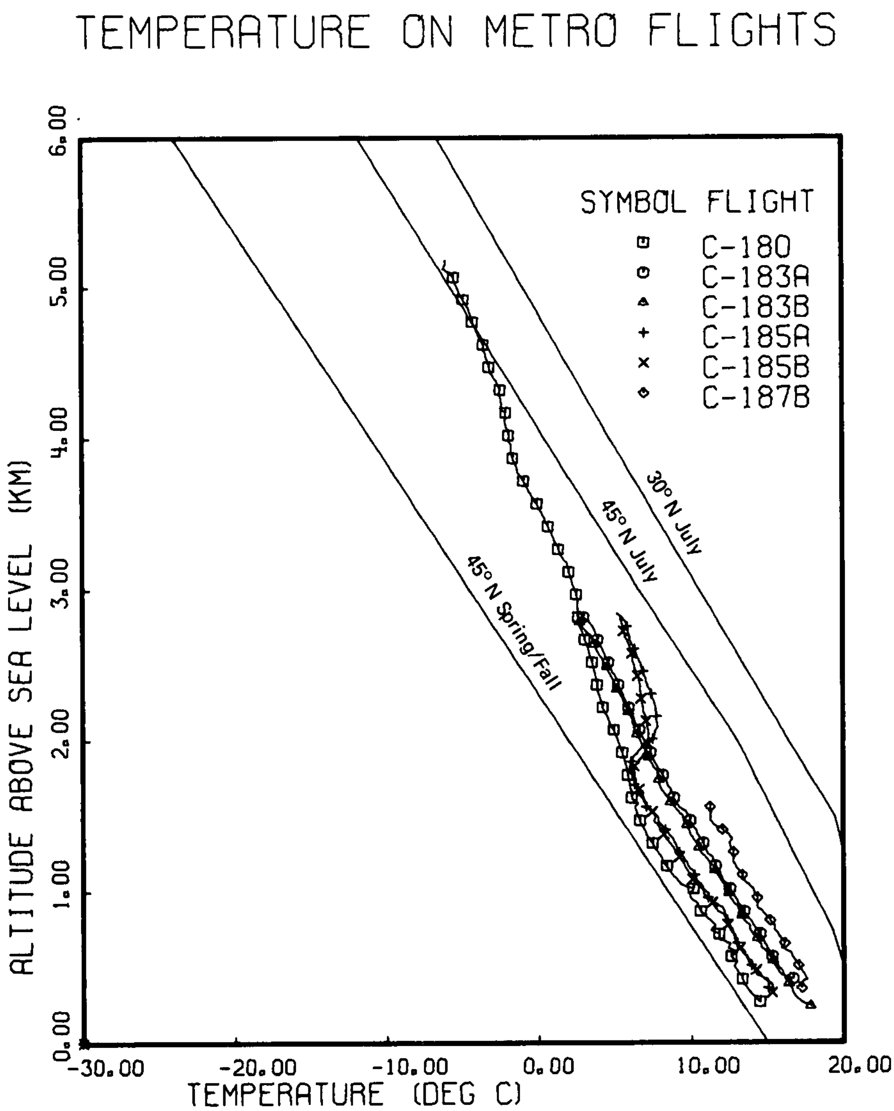


Fig. 8-2. Temperatures for Flights With Some Scattered Clouds.

8.2 RADIOMETRIC DATA

TOTAL VOLUME SCATTERING COEFFICIENT

The total volume scattering coefficients were measured during the vertical profile sequences. In all eight profiles in this report, the vertical profile data for Filter 2 were measured during the ascents made between the straight and level sequences. The vertical profiles for Filter 3 were made when descending from the highest straight and level altitude, followed by an ascent for measurements in Filter 4. Average elapsed time between the start of the first vertical profile and the end of the final vertical profile was 1 hour and 15 minutes.

Three flights with double profiles were designed to sample the optical properties upwind and downwind of the city. The ground level wind information is from Scott Air Force Base, so the implicit assumption is that the wind directions and speeds are similar over the large area surrounding St. Louis. For each of the three double flights the first portion was in the morning and upwind or crosswind of the city; the second portion of the flight was in the afternoon and downwind of the city. Flights C-182 and C-188 measured heavier haze on the downwind tracks, C-188 significantly so, but C-186 encountered slightly heavier haze on the upwind track.

During the 24 hours preceding each of the three flights, the ground-level winds at Scott Air Force Base had been reported as somewhat variable in direction. The prevailing direction had been basically consistent for C-182, but for C-186 and C-188 the prevailing direction shifted by as much as 180 degrees during the previous day. The 700-millibar (1.5 to 1.9 kilometer MSL) wind directions at Springfield, Illinois, were relatively constant in direction for the three soundings in the 36-hour period related to Flights C-182 and C-188. The prevailing wind direction at approximately 1.7 kilometers was diametrically opposed to the ground-level direction during Flight C-182 and roughly perpendicular to the ground-level direction during Flight C-188. For C-186, the 700-millibar winds before and after the flight were in roughly the same direction as the ground winds during the flight, but the 700-millibar winds the day before had been diametrically opposite. More detail spatially and chronologically in windspeed and direction near the flight tracks is necessary for a fuller understanding of the upwind/downwind haze characteristics during these flights.

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(4) > s(3). Thus, parallel curves indicate optical stability during the period of measurement. All eight profiles show small areas of instability, most often at the edge of the haze layers.

During all the flights it was possible to take airborne data down to at least 270 meters and sometimes as low as 60 meters. Thus, the low altitude total scattering profile is reasonably well-documented. The extrapolation to ground level is quite reasonable for the first six profiles, but for flight profiles C-188A and C-188B the values at low altitude from the vertical profiles were inconsistent, indicating optical instability. Thus, the extrapolations downward for these two flight profiles are based upon the total scattering coefficients measured during the low altitude straight and level sequence.

During the eight profiles, airborne data were generally taken up to 2.46 kilometers and sometimes as high as 2.64 kilometers. Extrapolations up to 3 kilometers appear reasonable for flight profiles C-181, C-186A, C-188A, and C-188B. The upward extrapolations for the remaining four profiles are somewhat questionable since those profiles indicate less optical stability around 2.5 kilometers.

In order to compare the scattering characteristics of the profiles, the total volume scattering coefficient for Filter 4 (pseudo-photopic) has been graphed in Figure 8-3. Only seven of the eight profiles are included since Filter 4 data were not taken during Flight C-186B. Although there is considerable variability in the seven profiles, all indicate haze at low altitude with clearer air above. The height of the haze layers, the sharpness of the haze edge, and the number of haze layers vary considerably. Two of the flights, C-182B and C-186B, have a denser haze below 0.5 kilometer and a second haze top around 1.4 and 1.5 kilometers. Four of the profiles, C-182A, C-182B, C-187A, and C-188A, have a small haze layer at the higher altitudes (varying between 1.8 and 2.4 kilometers) which is slightly denser than the air just below it.

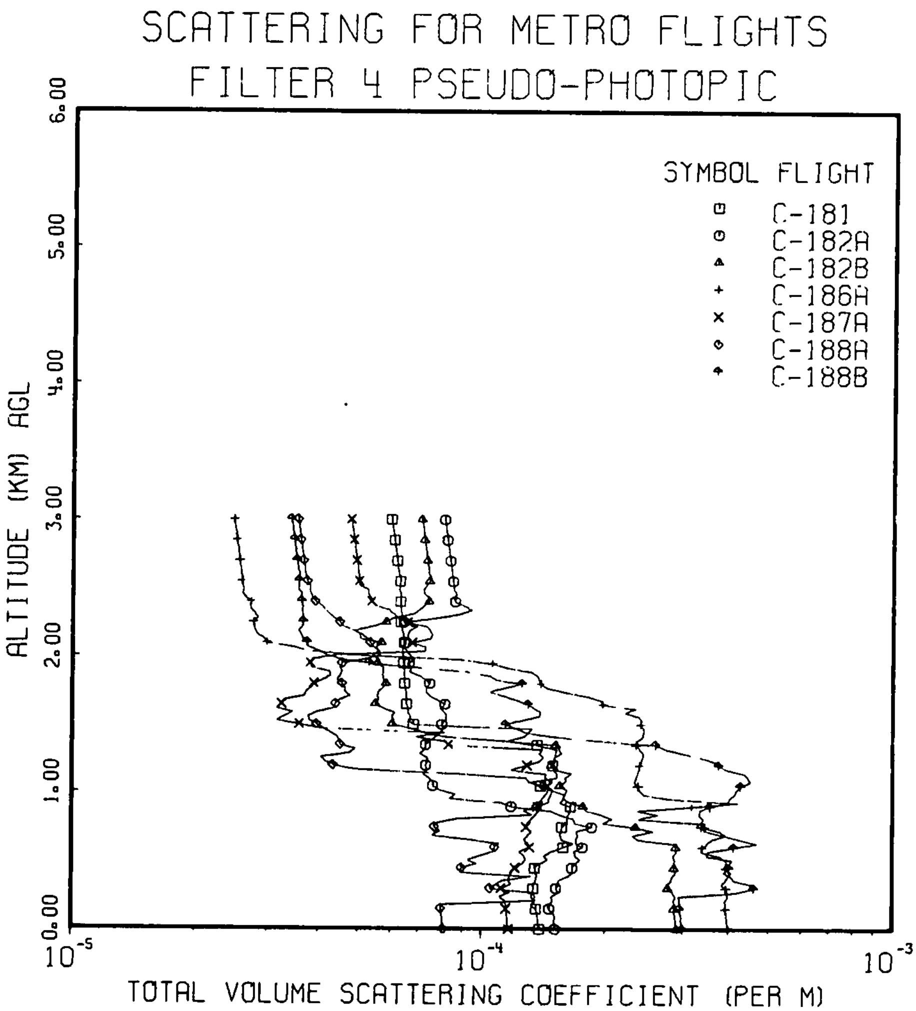


Fig. 8-3. Total Volume Scattering Coefficient for Filter 4 (Pseudo-Photopic) for Seven METRO Profiles.

A comparison of the METRO scattering coefficient data to the data from the HAVEN VIEW and ATOM field trips was presented in Section 7.3 of Duntley *et al.* (1972c). In summary, the METRO data showed a higher degree of variability over the 14-day period of the field trip than did the data for either the HAVEN VIEW or ATOM trips. All of the METRO flights have heavier haze at the lower altitudes than the ATOM flights. In comparison to the HAVEN VIEW haze at low altitude, the METRO flights have both heavier and lighter haze, and a more complicated haze structure with altitude.

EQUIVALENT ATTENUATION LENGTH AND BEAM TRANSMITTANCE

At ground level the equivalent attenuation 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 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 vary directly as the mean wavelength of the filters, i.e., $\bar{L}$(Filter 2) < $\bar{L}$(4) < $\bar{L}$(3). All of the eight profiles display this feature, indicating that the minor filter anomalies in the total scattering coefficient profiles have little effect when the total profile is summed.

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 photopic Filter 4 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 8-4. Superimposed on the same figure are the low altitude downwelling irradiance values for Filter 4 for seven profiles. The straight vertical line between the values for Filters 2 and 3 for Flight C-186B indicates the range in which the Filter 4 value would have fallen (Filter 4 was not measured on that profile). The altitudes for the lowest straight and level sequence ranged between 88 and 241 meters above ground level. The irradiances cluster about the Brown curve for unobscured sun as would be expected.

The graphs of downwelling irradiance versus altitude are generally more regular as a function of altitude and filter than data from previous field trips. This is primarily the result of the improved methods of handling the sky radiance data, of obtaining the apparent sun radiance using the transmittance from the sky radiance ratios, and of establishing an average sun zenith angle before the downwelling irradiance is computed. Five of the six profiles from the clearest sky description categories 1 and 2 are smooth as a function of altitude and filter. The greater irregularity for flight profiles C-182A and C-186A is not unexpected since these flights encountered somewhat variable cloud conditions.

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 affect 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.

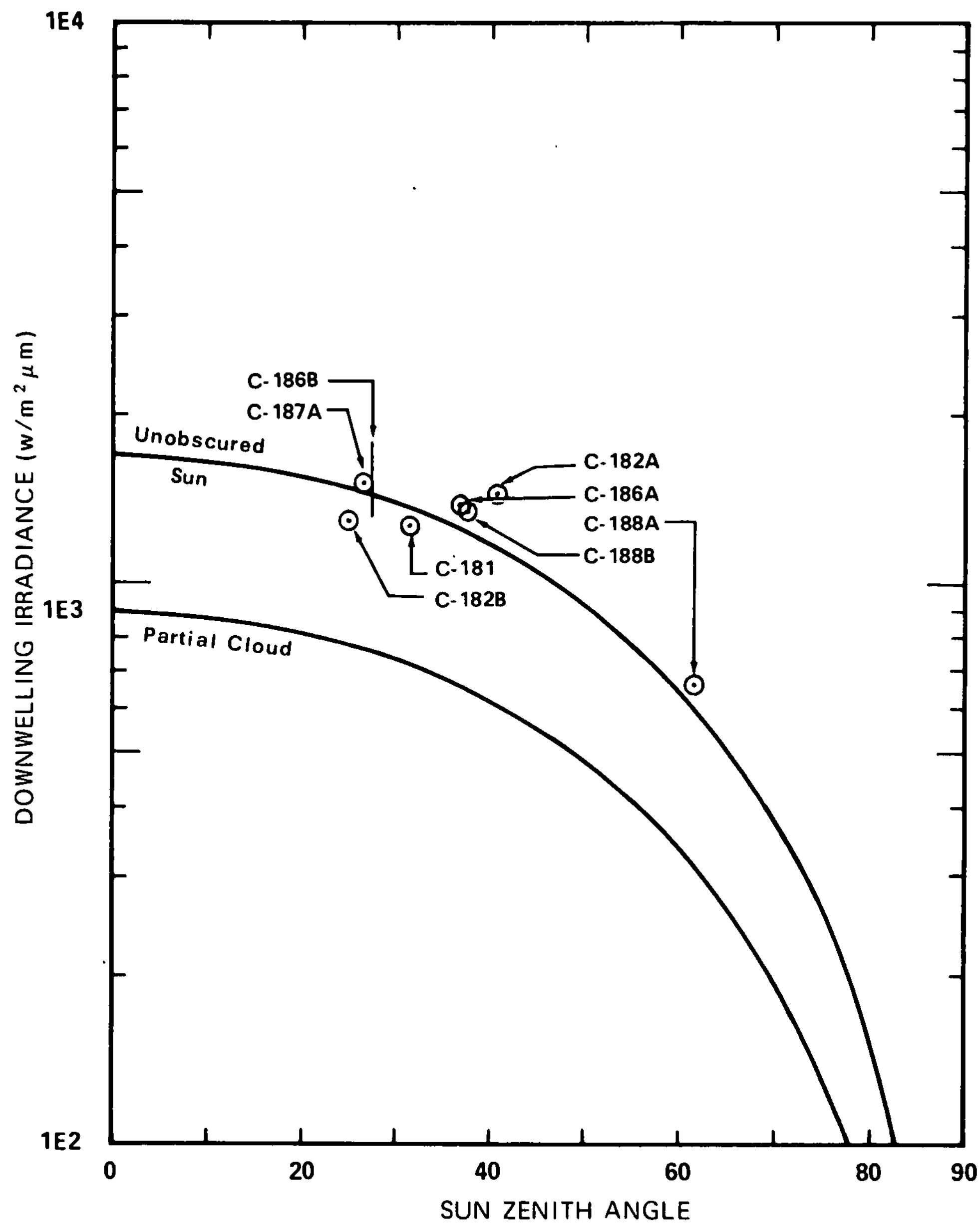


Fig. 8-4. Low Altitude Downwelling Irradiance for Filter 4 (Pseudo-Photopic) Compared to Brown (1952).

Summary Table 8-1 presents airborne data on terrain reflectance for the nadir path of sight. This summary groups the data into same or similar terrains and within each group presents the data in order by increasing sun zenith angle. For the nadir path of sight at the lowest altitude of all the flights, 92 meters, a 5-degree field would cover a circle 8 meters in diameter; whereas at the highest altitude of all the flights, 235 meters, a 5-degree field would cover a circle 20 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 159 knots, the distance covered in 5 seconds is 389 to 409 meters. Thus, the tabulated nadir reflectances relate to an average radiance in an area between 8 by 397 or 20 by 429 meters in size.

The seeming inconsistency of the reflectance filter to filter and flight to flight is probably a function of the patchiness of the terrain as illustrated in Figures 7-1 and 7-2. The reflectances are reasonable compared to the nadir reflectances of meadows, crops, and forests which are presented in Table 8-2. The range of the reflectances in Table 8-2 are indicated in the last row of data in Table 8-1.

Table 8-1

Nadir Terrain Reflectances Based on Airborne Scanner Radiances

Track	Terrain Description	Date (1971)	Flight Profile No	Average Altitude (meters AGL)	Sun Zenith Angle	Nadir Reflectance		
						Filter 2	Filter 4	Filter 3
3	Flat, highly cultivated farmland with multiple small fields	13 Aug	C-182B	92	25 0	0 060	0 057	0 131
		19 Aug	C-186B	202	27 2	0 031	–	0 041
		12 Aug	C 181	101	31 6	0 038	0 066	0 066
4	Flat, highly cultivated farmland and small bodies of water	24 Aug	C 188B	235	37 7	0 038	0 056	0 063
9	Cultivated farm area with small fields and woodlands	24 Aug	C-188A	154	60 6	0 017	0 065	0 065
7	Heavily wooded, rolling hills	23 Aug	C-187A	200	26 6	0 017	0 040	0 054
		19 Aug	C-186A	148	36 8	0 024	0 056	0 032
		13 Aug	C-182A	135	40 6	0 015	0 057	0 050
	Range of values for meadows, crops, and forests (See Table 8-2)					0 013 to 0 082	0 032 to 0 14	0 027 to 0 21

EQUILIBRIUM RADIANCE

Equilibrium radiance Eq. 2.22 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 sky radiance flux level and directional radiance pattern, and these two properties plus the apparent sun radiance 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 except for the use of an average sun zenith angle for obtaining the apparent sun radiances.

Table 8-2

Nadir Reflectances of Meadows, Crops, and Forests

Terrain Description	Sun Zenith Angle	Nadir Reflectance Filter 2 (λ = 480)	Filter 4 (Photopic)	Filter 3 (λ = 650)	Spectral Reference	Photopic Reference
Grass, thick, long, pale green, dormant, dryish	41.5	-	.088	-		Gordon (1964) Table 3.2, No. 2
Grass, lush green, closely mowed, thick lawn	40.4	-	.10	-		Gordon (1964) Table 3.2, No. 6
Turf, hillocks covered with grass, summer	45	.013	.035	.027	Krinov (1947) Object No. 70	Gordon and Church (1966) Table II
Pasture meadow at end of summer	45	.045	.082	.075	Krinov (1947) Object No. 75	Gordon and Church (1966) Table I, No. 15
Pasture meadow, beginning of autumn	45	.049	.090	.086	Krinov (1947) Object No. 81	Gordon and Church (1966) Table II
Lush meadow, lush dense grass, beginning of autumn	45	.027	.071	.040	Krinov (1947) Object No. 94	Gordon and Church (1966) Table II
Grass, dry meadow, dense, mid-summer	45	.040	.096	.067	Krinov (1947) Object No. 114	Gordon (1964) Table 3.2, No. 11
Dry meadow, sparse low grass	45	.054	.084	.090	Krinov (1947) Object No. 135	Gordon and Church (1966) Table I, No. 18
Dry meadow, more dense low grass	45	.036	.080	.074	Krinov (1947) Object No. 138	Gordon and Church (1966) Table I, No. 19
Dry meadow, sparse dry grass on hills, beginning of autumn	45	.052	.079	.11	Krinov (1947) Object No. 141	Gordon and Church (1966) Table II
Meadows, dense, low grass, beginning of fall	45	.046	.080	.075	Krinov (1947) Object No. 142	Gordon and Church (1966) Table II
Oats, spike-forming period	45	.036	.079	.032	Krinov (1947) Object No. 185	Gordon and Church (1966) Table II
Oat field, stubble	45	.059	.098	.11	Krinov (1947) Object No. 193	Gordon and Church (1966) Table II
Lentil fields, stubble	45	.048	.065	.077	Krinov (1947) Object No. 194	Gordon and Church (1966) Table II
Barley fields, stubble	45	.082	.14	.21	Krinov (1947) Object No. 195	Gordon and Church (1966) Table II
Millet, ripening	45	.024	.057	.034	Krinov (1947) Object No. 197	Gordon and Church (1966) Table II
Field, with ripe crops, buildings and roads, from air	45	.030	-	-	Krinov (1947) Object No. 228	
Field, with green crops, from air	45	.064	-	-	Krinov (1947) Object No. 229	
Pine trees, small uniformly spaced	41.5	-	.033	-		Gordon (1964) Table 3.2, No. 1
Mixed green forest, oak and pine	39.0	-	.036	-		Gordon (964) Table 3.2, No. 9
Pine forest	33.5	-	.038	-		Gordon (1964) Table 3.2, No. 10
Fir, late summer, mature forest, from air	45	.025	.032	.028	Krinov (1947) Object No. 25	Gordon and Church (1966) Table II

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 eight METRO flight profiles, the equilibrium radiance was a more erratic quantity. The standard deviation with altitude had a range from less than 1 to 84 percent, with the nadir path of sight often having standard deviations in the upper portion of that range. To illustrate this, the equilibrium radiance for the Flight C-181 photopic response (Filter 4) is graphed in Figure 8-5 for the nadir path of sight. Flight C-181 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 15 to 27 percent for the three filters (Filter 4 standard deviation was 16 percent). Thus, the atmospheric models cited above appear inapplicable to the METRO flights.

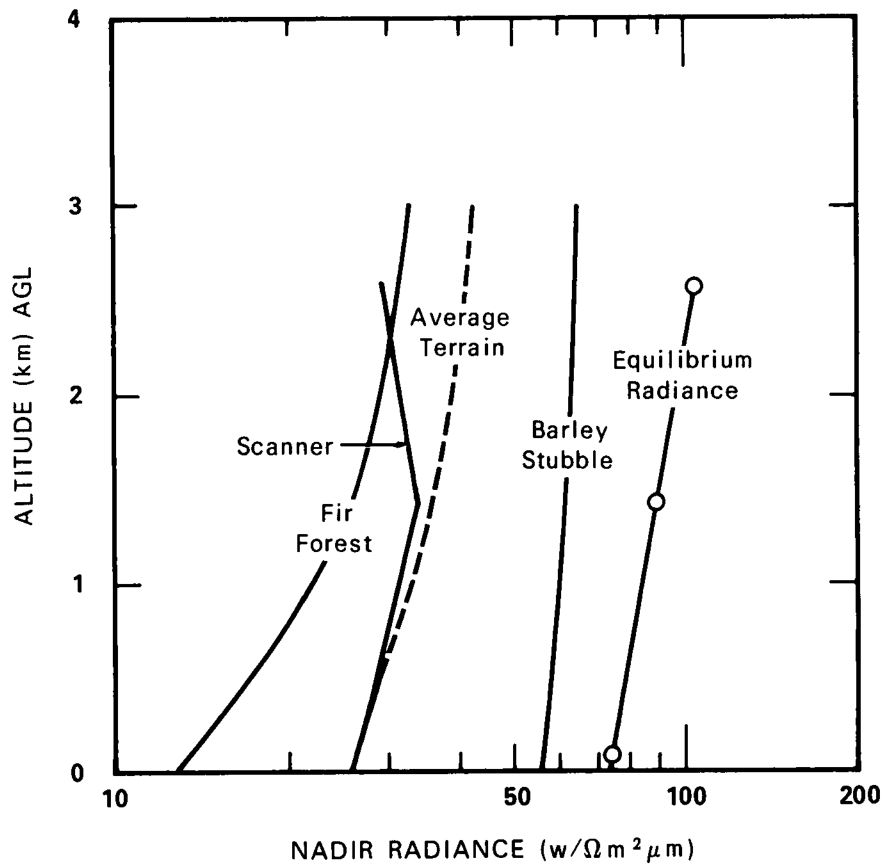


Fig. 8-5. Equilibrium and Apparent Terrain Radiance for Flight C-181 Filter 4 (photopic) for the Nadir Path of Sight.

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 eight flight profiles are given in Table 8-3 in the same groupings as for Table 8-1. There is a rough overall consistency among the reflectances in the range of 0.10 to 0.25. 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.

The METRO nadir equilibrium reflectances are very similar to the nadir equilibrium reflectances for the HAVEN VIEW field trip which was over somewhat similar terrain and also had low altitude haze. The ATOM nadir equilibrium reflectances were all higher, as might be expected over a desert and in generally clearer air.

Table 8-3

Nadir Equilibrium Reflectance at Lowest Altitude

Track	Date (1971)	Flight Profile No.	Altitude (meters AGL)	Sun Zenith Angle	Nadir Equilibrium Reflectance		
					Filter 2	Filter 4	Filter 3
3	13 Aug	C-182B	92	25.0	0.14	0.16	0.16
	19 Aug	C-186B	202	27.2	0.11	-	0.11
	12 Aug	C-181	101	31.6	0.17	0.19	0.16
4	24 Aug	C-188B	235	37.7	0.11	0.12	0.12
9	24 Aug	C-188A	154	60.6	0.23	0.25	0.22
7	23 Aug	C-187A	200	26.6	0.13	0.13	0.11
	19 Aug	C-186A	148	36.8	0.10	0.09	0.10
	13 Aug	C-182A	135	40.6	0.15	0.12	0.14

PATH RADIANCE

The path radiance is calculated from the values of equilibrium radiance for a given path of sight by means of Eq. 2.18 and 2.21. 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. 2.18 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 with altitude due to the averaging process of the integration of Eq. 2.18. 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 eight flight profiles.

The path radiances for both the ATOM and HAVEN VIEW field trips were less regular as a function of filter than for the METRO trip. The regularity of the METRO path radiances is probably the result of the improved methods of handling the sky radiance data and of obtaining apparent sun radiance using the transmittance from sky radiance ratios and an average sun zenith angle.

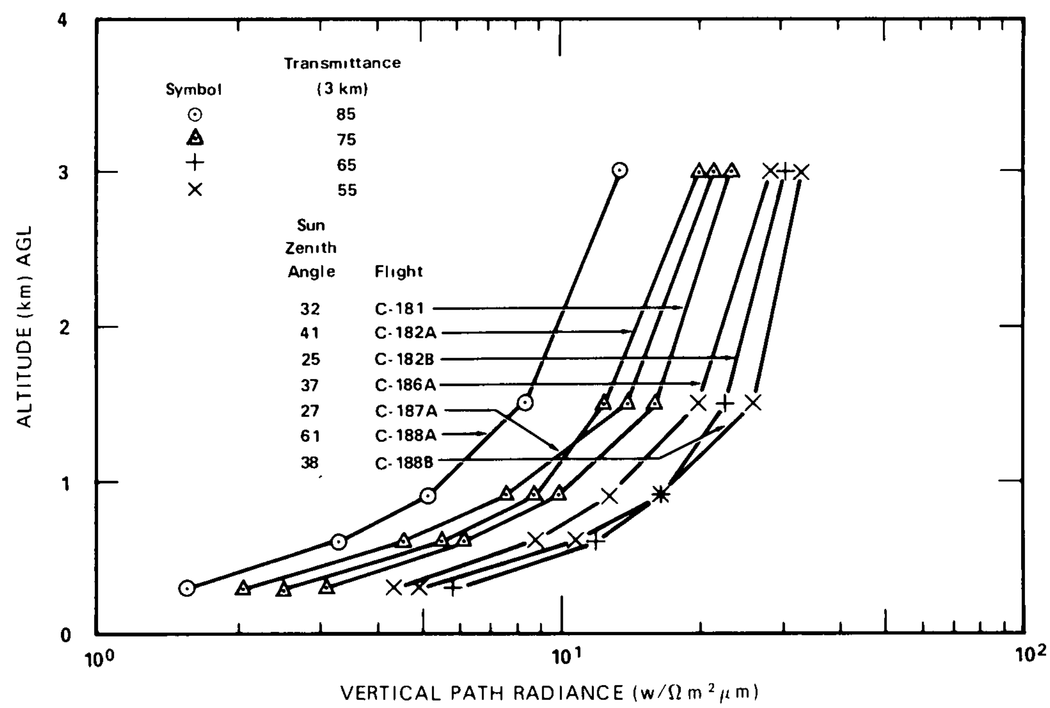


Fig. 8-6. Vertical Path Radiance for Filter 4 (pseudo-photopic) for METRO Flights.

The vertical path radiances for Filter 4 (pseudo-photopic) are graphed in Figure 8-6 for the METRO flights. Path radiance is a function of transmittance and sun zenith angle. Since the sun zenith angles for all but Flight C-188A are in a narrow range, 25 to 41 degrees, the curves are coded by the vertical beam transmittance at 3 kilometers. Each symbol represents a transmittance of ±0.05, i.e., the symbol ⊙ represents transmittances of 0.8 to 0.9 or 0.85 ±0.05. The path radiances generally are inversely related to beam transmittance and sun zenith angle.

The only METRO flight with a sun zenith angle in the same range as the ATOM data is C-188A – to 61 degrees. Since three ATOM flights, C-151, C-154, and C-158 have a sun zenith angle range including 61 degrees, the vertical path radiances for the pseudo-photopic filter for the four flights are compared graphically in Figure 8-7. All four flights have a vertical beam transmittance at 3 kilometers of 0.85 ± 0.05. The four flights are reasonably comparable in path radiance, with the METRO path radiances generally slightly higher than the ATOM path radiances. This may be due to a slightly heavier haze at the lower altitudes for C-188A, particularly at 1 kilometer and below.

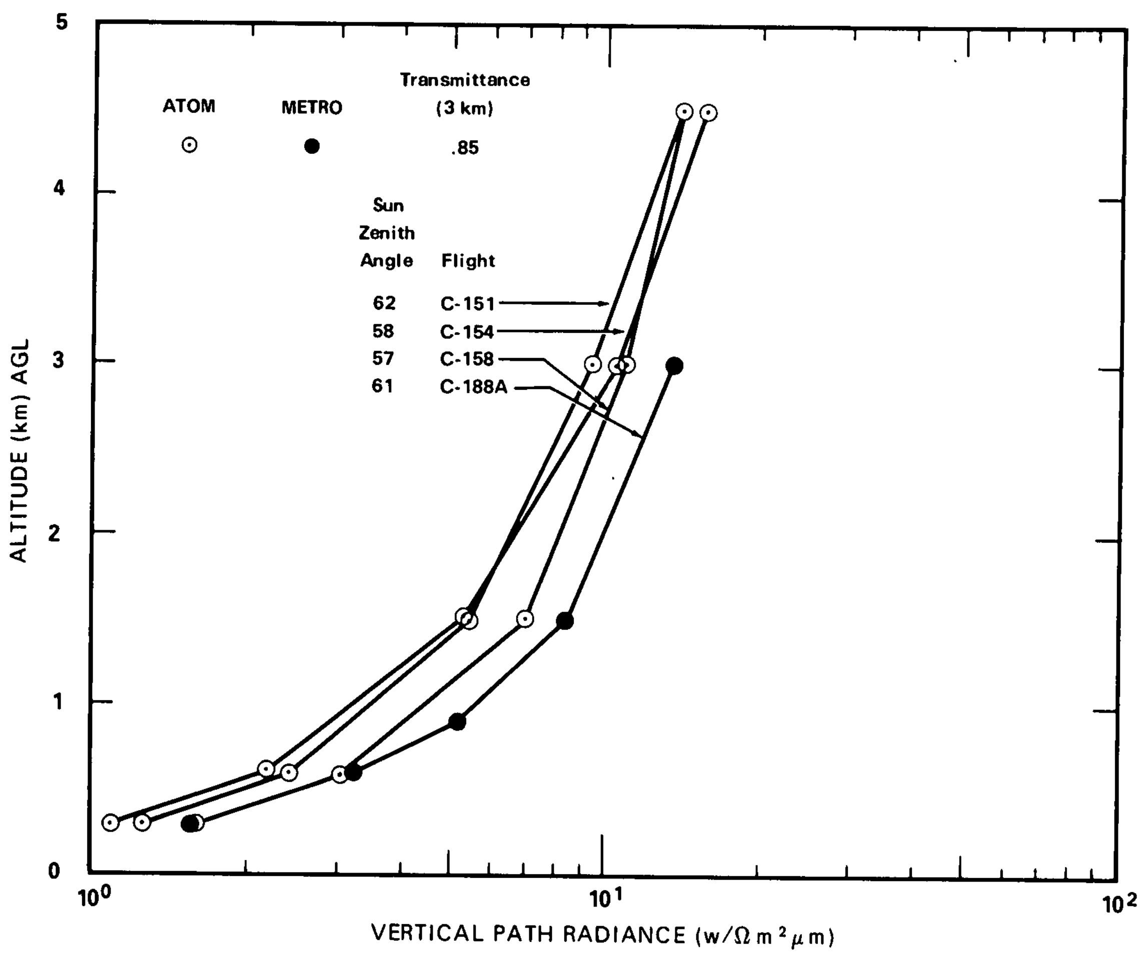


Fig. 8-7. Vertical Path Radiance for Pseudo-Photopic Filter for METRO and ATOM Flights at Comparable Sun Zenith Angles.

There are four METRO flights and two HAVEN VIEW flights with nearly comparable sun zenith angles and clear skies near the sun at the highest altitude. The vertical path radiances for the pseudo-photopic filter are presented for these flights in Figure 8-8. The path radiances for the lower transmittances of 0.55 ±0.05 are higher than for the 0.75 transmittance for both field trips. The METRO path radiances are slightly higher than the HAVEN VIEW values at roughly comparable transmittances. Inspection of the total scattering coefficient profiles indicates that either slightly heavier haze or haze extending to higher altitudes was encountered during the METRO flights as opposed to the HAVEN VIEW flights.

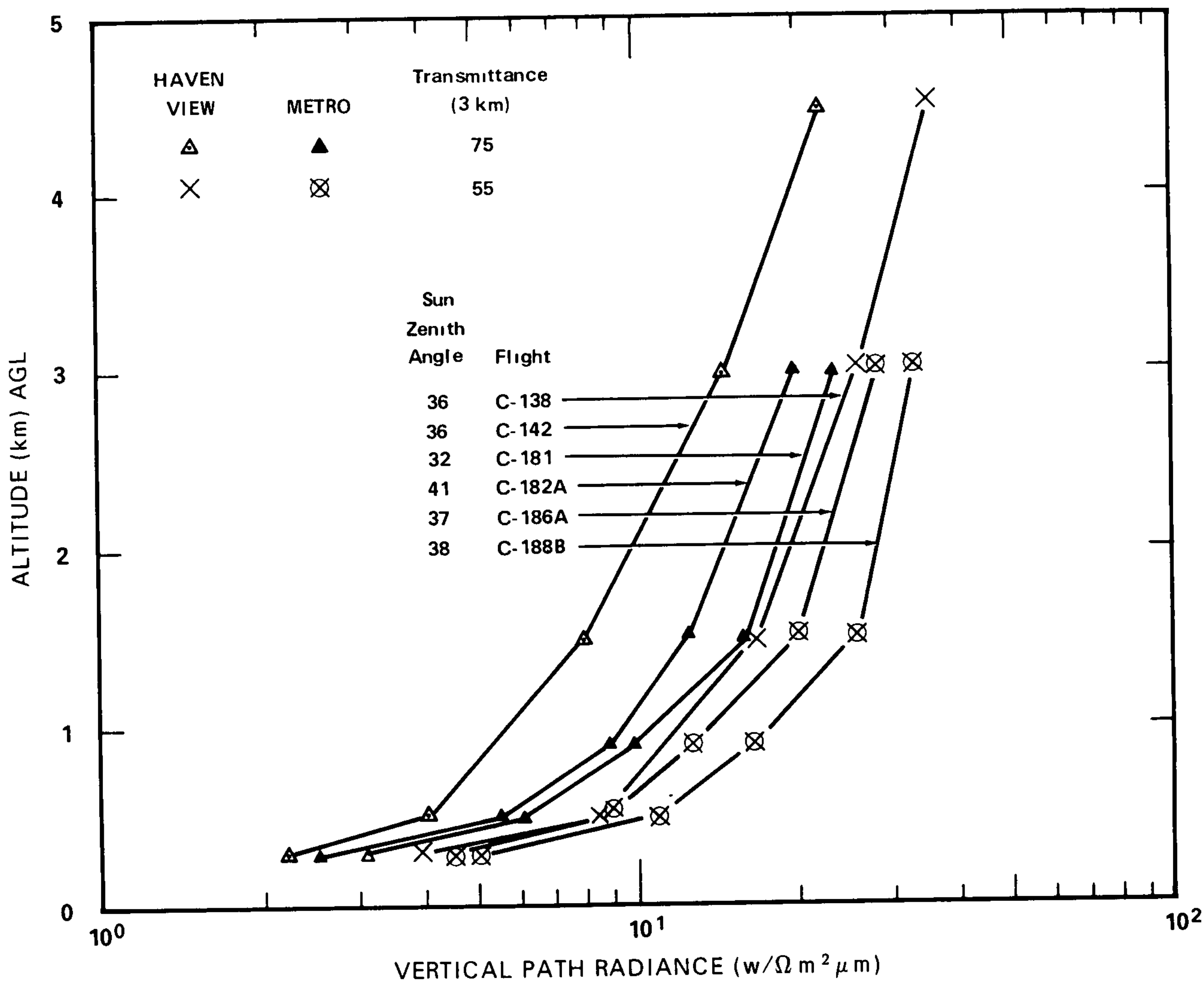


Fig. 8-8. Vertical Path Radiance Pseudo-Photopic Filter for METRO and HAVEN VIEW Flights at Comparable Sun Zenith Angles.

Path Radiance Applications. 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, the beam transmittance, and the path radiance:

$$ {}_bN_o(0,\theta,\phi) = [{}_bN_r(z,\theta,\phi) - N_r^*(z,\theta,\phi)]/T_r(z,\theta) \ . \tag{8.2}$$

The resultant inherent radiance for the nadir path of sight for Flight C-181 Filter 4 (photopic) is 25.8 $w/\Omega m^2\mu m$. Then using Eq. 2.5, we obtain a reflectance of 0.064. This reflectance is indicative of the highly cultivated farmland underlying the flight track. The measured scanner radiances and the extrapolated ground value were graphed in Figure 8-5 and labeled as "scanner".

For conceptual purposes, we have computed the apparent nadir radiances for three types of backgrounds appropriate to Flight C-181 Filter 4 (photopic) using Eq. 7.2. The three backgrounds chosen are: highly cultivated farmland having a reflectance of 0.064 (the derived inherent terrain reflectance for the flight), a fir forest in late summer having a reflectance of 0.032, and barley stubble with a reflectance of 0.14. The latter two photopic reflectances are the minimum and maximum from Table 8-2. The radiances for these three backgrounds are graphed in Figure 8-5. The fir forest and barley stubble illustrate high and low values for cultivated fields with woodlots.

The predicted farmland radiances closely follow the scanner radiances at the lower altitudes and are higher than the scanner at the upper altitudes. The low scanner radiance is possibly due to an overall decrease in flux level with the larger sun zenith angle at the high altitude. The calculated value for the farmland shows the influence of the higher flux levels at the lower altitudes.

Note how the background radiances tend to approach the equilibrium radiances. All the computed 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:

$$ {}_b\tau_r(z,\theta,\phi) = T_r(z,\theta)\ {}_bN_o(0,\theta,\phi)/{}_bN_r(z,\theta,\phi) \ . \tag{8.3}$$

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 items displayed against a background lower in reflectance than the equilibrium reflectance will always be smaller than the beam transmittance. 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 8-5. This characteristic is illustrated in Figure 8-9. 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.

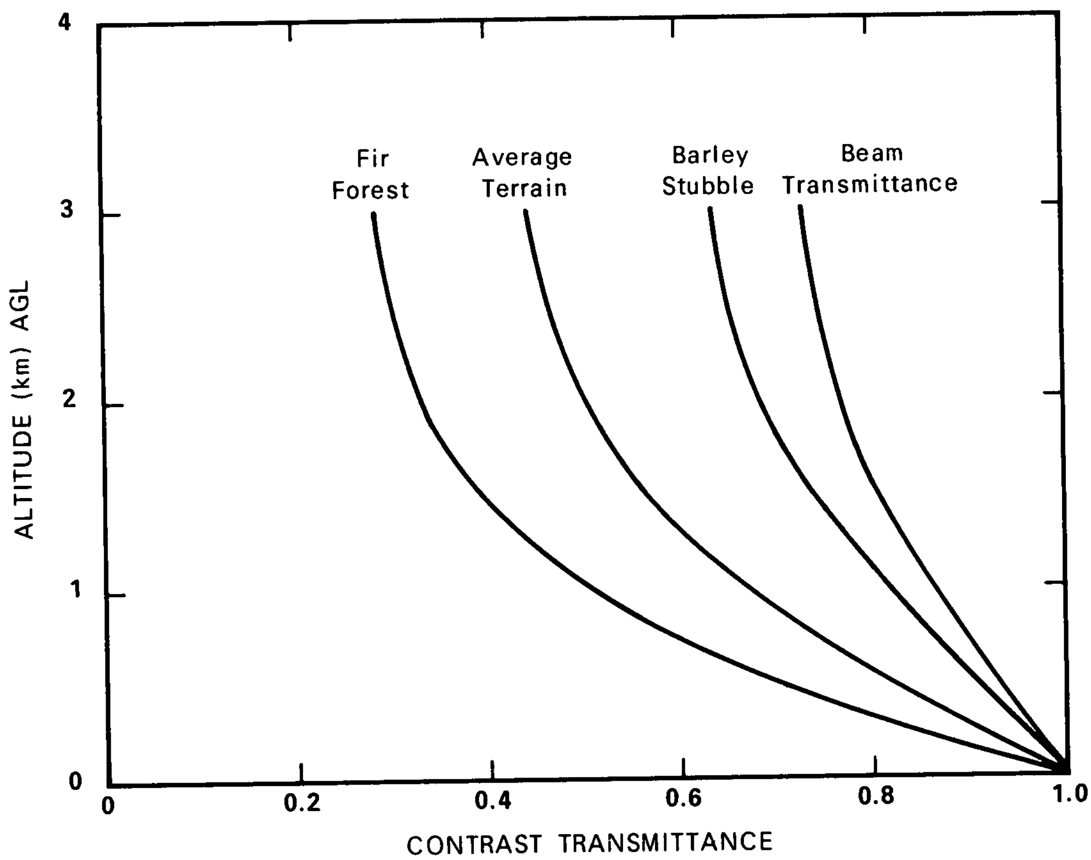


Fig. 8-9. Beam Transmittance and Contrast Transmittances for Flight C-181 Filter 4 (photopic) Nadir Path of Sight.

The above example emphasizes the importance of selecting the appropriate background reflectances for computing valid contrast transmittance values. Photopic reflectances of many 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 eight flight profiles show this regularity in the representative graphs of path reflectance in Section 7.3.

The path reflectances for both the ATOM and HAVEN VIEW field trips were less regular as a function of filter than for METRO. The regularity of the METRO path reflectances is probably the result of the improved method of handling the sky radiance data and of obtaining the apparent sun radiance using an average sun zenith angle and the transmittance from sky radiance ratios.

8.3 SUMMARY

The derived optical properties for the METRO flights are more consistent as a function of altitude and spectral filter than the values of irradiance, path radiance, and path reflectance for ATOM and HAVEN VIEW. This is the direct result of utilizing advanced methods for evaluating and handling the measured values of the lighting distribution for the upper hemisphere. First, the apparent sun radiance was separated from the sky radiance array. Then the transmittance from out of the atmosphere to the highest flight altitude was calculated from the ratio of the sky radiances at equivalent angles from the sun. That transmittance, combined with the transmittances derived from the airborne integrating nephelometer data, provided a space-to-altitude beam transmittance for each flight altitude. Next, sky radiances were evaluated as a function of angle from sun, and spurious values resulting from slow phototube decay were corrected. Finally, an average sun zenith angle for the entire flight was established and used for the computation of apparent sun radiance, irradiance, path radiance, and path reflectance. All of these computed optical properties showed consequent improvements in consistency.

These demonstrated improvements in data quality are convincing evidence that the computational techniques used are capable of producing increasingly reliable data. It is necessary that we continue to improve only the precisions and accuracies in the measurements of upper and lower hemisphere radiance distributions. Procedural updates to accomplish these ends have been devised and are currently being inserted into the field measurement routines.

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Lt. Col. John D. Morrow, navigator
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13 ABSTRACT

This report presents daytime atmospheric optical data collected chiefly with airborne instruments during a field expedition to southern Illinois in the summer of 1971. Results from five flights are presented. The data include the natural irradiance upon horizontal plane surfaces, scalar irradiances, total volume scattering coefficients, atmospheric beam transmittances, path radiances, directional path reflectances, and directional terrain reflectances. Data for sunlight conditions were derived for downward-looking paths of sight inclined at six zenith angles (95, 100, 105, 120, 150, and 180 degrees) from altitudes of 3000 meters above ground level and lower in three spectral regions, as follows: two narrow band optical filters with mean wavelengths of 478 and 664 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						
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Atmospheric Optical Properties						
Atmospheric Scattering Coefficient						
Atmospheric Beam Transmittance						
Atmospheric Contrast Transmittance						
Atmospheric Path Reflectance						
Daytime Radiance						
Daytime Irradiance						
Radiometry						
Terrain Reflectance						