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Airborne Measurements Of Optical Atmospheric Properties In Northern Germany

Seibert Q. Duntley

Richard W. Johnson

Jacqueline I. Gordon

Scientific Report No. 6

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Atmospheric Optics Branch, Optical Physics Division

Prepared for

Air Force Geophysics Laboratory, Air Force Systems Command

United States Air Force, Bedford, Massachusetts 01731

[illegible] San Diego, California 92152

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Atmospheric Beam Transmittance
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Atmospheric Directional Path Reflectance
Natural Daytime Irradiance
Terrain Reflectance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents daytime atmospheric optical data collected chiefly with airborne instruments during a field expedition to northern Germany in the spring of 1973. Results from seven relatively low altitude 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 sky and terrain reflectance. Data for daytime conditions ranging from scattered clouds to completely overcast were

→ next page

20. ABSTRACT continued:

cont. derived for upward- and downward-looking paths of sight inclined at seven zenith angles (0, 75, 80, 85, 95, 100, 180 degrees) from altitudes of 1200m above ground level and lower. Data were measured in four spectral regions, as follows: Three narrow band optical filters with mean wavelengths of 478, 664, and 765 nanometers; and one broad band sensitivity representing a pseudo-photopic response with a mean wavelength of 557 nanometers.

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AIRBORNE MEASUREMENTS OF OPTICAL ATMOSPHERIC PROPERTIES IN NORTHERN GERMANY

by

Seibert Q. Duntley, Richard W. Johnson, Jacqueline I. Gordon

Visibility Laboratory
University of California, San Diego
Scripps Institution of Oceanography
San Diego, California 92152

Approved:

Seibert Q. Duntley, Director
Visibility Laboratory

Approved:

William A. Nierenberg, Director
Scripps Institution of Oceanography

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SUMMARY

This report, which describes portions of the Visibility Laboratory's Project HAVEN VIEW II* effort, was prepared under AFCRL Contract F19628-76-C-0004. The principal project task was to take daytime atmospheric optical measurements in northern Germany and, from these measurements, to determine optical properties for various upward- and downward-inclined paths of sight. These properties include the natural irradiance upon horizontal plane surfaces, scalar irradiances, total volume scattering coefficients, atmospheric beam transmittances, path radiances, directional path reflectances, and directional sky and terrain reflectances.

The field trip was made to Germany in May and June 1973. All data were recorded on one flight track between NDB Weser and Lathen near Meppen, Germany. The terrain was low lying and flat, consisting mostly of cultivated farmland interspersed with dark patches of dense woods. The daytime flight conditions for the seven low-altitude flights reported herein ranged from partial clouds to overcast.

The airborne 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 measuring upper and lower hemisphere (sky and terrain) radiances, a dual irradiometer for measuring alternately the downwelling and upwelling irradiances, an equilibrium radiance telephotometer, a variable direction path function meter and a large aperture telephotometer for nadir measurements. The meteorological instrumentation included an absolute pressure transducer, a dewpoint hygrometer, and an AN/AMQ-17 aerograph for measuring ambient temperature and pressure.

A Visibility Laboratory ground-based data station was located near one end of the flight track, near Lathen, Germany. It contained duplicate radiometric instrumentation for obtaining ground-level measurements of total scattering coefficient, upper hemisphere (sky) radiances, and downwelling irradiance. Additionally, the ground station was equipped with a contrast reduction meter for determining earth-to-space beam transmittance.

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*The project title HAVEN VIEW II 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-75-0457, Duntley, *et al.* (1975b).

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 three narrow band filters at mean wavelengths of 478, 664, and 765 nanometers and a pseudo-photopic filter with a mean wavelength of 557 nanometers.

All primary data were recorded on magnetic tapes which were returned to the Visibility Laboratory for processing at the computer facilities of the University of California, San Diego.

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LIST OF ILLUSTRATIONS

RELATED CONTRACTS AND PUBLICATIONS

Related Contracts: None

Publications:

Duntley, S. Q., 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).

Duntley, S. Q., 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).

Duntley, S. Q., 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).

Duntley, S. Q., R. W. Johnson, and J. I. Gordon, "Airborne Measurements of Optical Atmospheric Properties in Southern Illinois," AFCRL-TR-73-0422, SIO Ref. 73-24 (July 1973).

Duntley, S. Q., R. W. Johnson, and J. I. Gordon, "Airborne and Ground-Based Measurements of Optical Atmospheric Properties in Southern Illinois," AFCRL-TR-74-0298, SIO Ref. 74-25 (June 1974).

Duntley, S. Q., R. W. Johnson, and J. I. Gordon, "Airborne Measurements of Optical Atmospheric Properties in Western Washington," AFCRL-TR-75-0414, SIO Ref. 75-24 (September 1975).

Duntley, S. Q., R. W. Johnson, and J. I. Gordon, "Airborne Measurements of Optical Atmospheric Properties, Summary and Review II," AFCRL-TR-75-0457, SIO Ref. 75-26 (September 1975).

Gordon, J. I., J. L. Harris, Sr., and S. Q. Duntley, "Measuring Earth-to-Space Contrast Transmittance from Ground Stations," Appl. Opt. 12, 1317–1324 (1973).

Gordon, J. I., C. F. Edgerton, and S. Q. Duntley, "Signal-Light Nomogram," J. Opt. Soc. Am. 65, 111–118 (1975).

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.

$_k h(z,d)$	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.
$_s h(z)$	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 HAVEN VIEW II. It was conducted during May and June 1973 in northern Germany.

The HAVEN VIEW II deployment was organized to supplement the atmospheric data collected in southern Germany during the spring of 1970 under the program title HAVEN VIEW. The HAVEN VIEW II deployment to northern Germany was intended to extend the existing data bank to include atmospheres under the influence of maritime airmasses flowing over typical low land terrains. At approximately 53°N latitude the HAVEN VIEW II flight track would represent the most northern area included in the project data bank. The overall deployment plan was specified in Air Force Cambridge Research Laboratories, OPLAN 4, distributed in April, 1973.

Two of the seven missions (C-280 and C-282) presented in this report were flown in conjunction with ground-based observations conducted under the auspices of the German Institute for Atmospheric Physics at Oberpfaffenhofen. Since these two flights were made in conjunction with ground-based visual sightings, the measurements made by the airborne systems were conducted with only the pseudo-photopic spectral response. During the remaining five missions, airborne measurements were made in the four spectral regions illustrated in Fig. 1-5. A total of 19 project flights were accomplished during Project HAVEN VIEW II. Of these, 12 flights contain data of sufficient quantity and quality to warrant complete processing. The 7 flights included in this report represent those missions which were restricted to relatively low altitudes, i.e., 1000 to 1500 meters AGL. The remaining 5 high altitude flights will be presented separately at a later date.

The Visibility Laboratory maintains a continuing program of improved techniques for predicting, by calculation from physical data, the probabilities that any object can be visually detected and recognized. The program is multifaceted in that it involves the development of techniques and expertise in several different technical areas, each related to the visual detection and recognition task. Several of the major areas are, for example, measurement and analysis of typical terrain characteristics and scene reflectances, studies in the restoration of atmospherically distorted images, measurement and analysis of the optical properties of the atmosphere, and studies into the perceptual capabilities of the human visual system and its electro-optical counterparts. The joint application of the techniques perfected in each of these specialty areas results in the determination of detection probabilities. Inclusion of allowances for *a priori* information and reasoning processes of the brain enable the probabilities of recognition, classification and identification of real-world objects to be predicted.

The instrumental and computational organization for constant improvement of techniques related to optical atmospheric property documentation is summarized in Fig. 1-1, 1-2, and 1-3. These three figures illustrate the experimental interrelationships among the various pieces of project hardware, listed in rectangles at the top of each figure and discussed in Section 3, the radiometric measurements made by them, and the subsequent computational chains associated with each of the measured values. The optical properties, listed in the blocks at or near the bottom of each figure, are derived in accordance with the theoretical considerations presented in Section 2. Through an examination of these generalized flow charts, one can readily evaluate this portion of the project's flexibility and self-checking redundancies. The capability to generate equivalent optical properties from separate independent data sources, as indicated within these three figures, is the key feature in ensuring advancements in technical expertise and data quality.

This report, Scientific Report No. 6, has been prepared under Contract No. F19628-76-C-0004. It contains properties of various upward- and downward-inclined paths of sight based upon daytime atmospheric optical measurements. These properties include natural irradiance upon horizontal plane surfaces, scalar irradiance, total volume scattering coefficient, atmospheric beam transmittance, path radiance, directional path reflectance, and directional sky and terrain reflectance. The measurements were made along the flight track illustrated in Fig. 1-4, between Lathen and Oldenburg, Germany.

In addition, this report utilizes, but does not present, selected data from five sets of ground-based measurements. These measurements were made at Meppen Test Range during the same general time intervals that the aircraft was in operation along its flight track. They are restricted to ground-level scattering coefficient and earth-to-space beam transmittance.

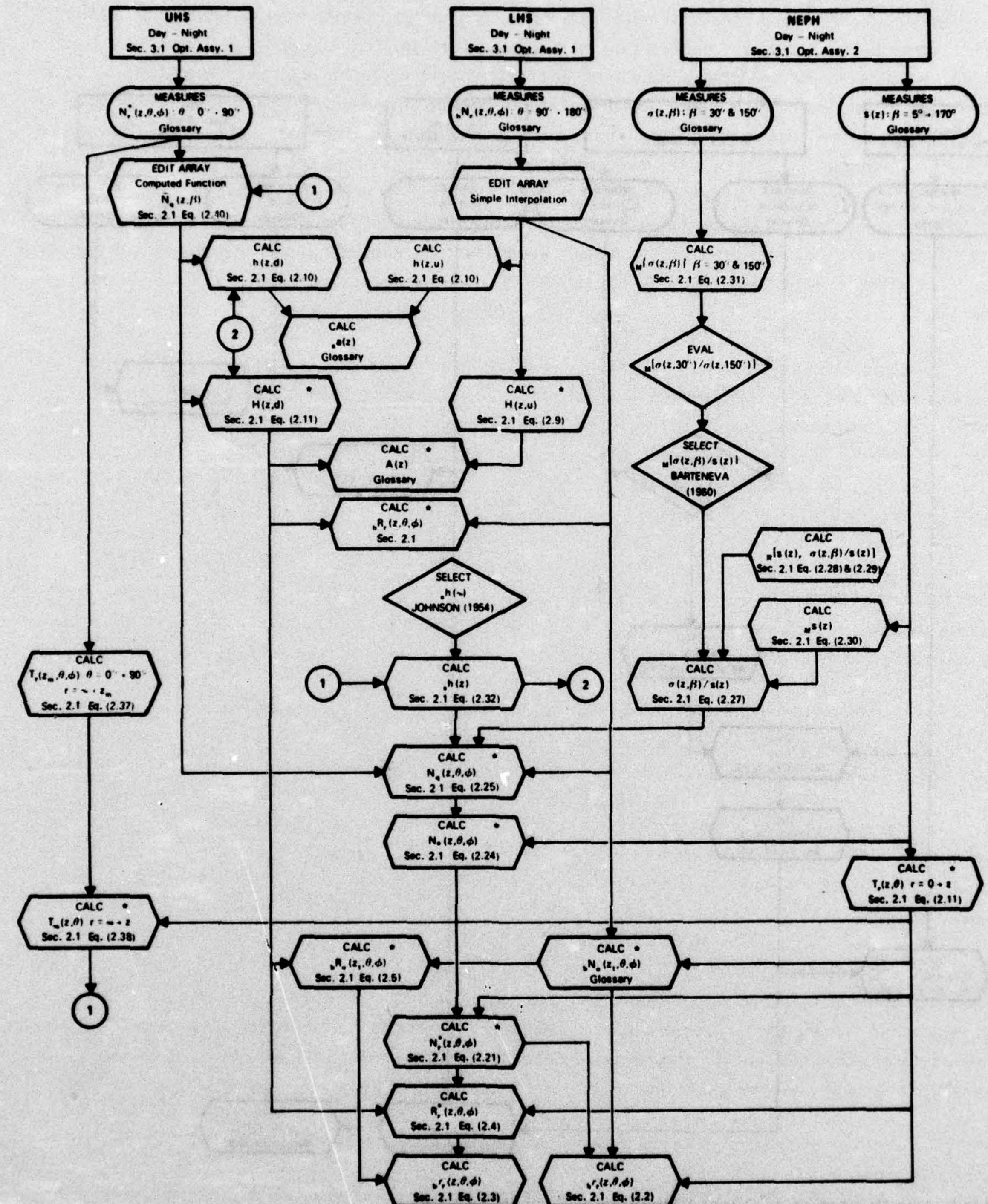
The methods used in the derivation of these optical properties are presented in Section 2 and are similar to those presented in AFCRL-54-73-0422, Duntley, *et al.* (1973). The most significant variation from earlier methods is in the derivation of optical properties for the upward path of sight.

The instrumentation, developed at the Visibility Laboratory and installed in Air Force C-130A aircraft No. 50022, is reported in detail in AFCRL-70-0137, Duntley, *et al.* (1970), AFCRL-72-0593, Duntley, *et al.* (1972c), and AFCRL-TR-75-0457, Duntley, *et al.* (1975b). A brief review of the instrumentation as used during the HAVEN VIEW II deployment is presented in Section 3.

The instrumentation used to generate the raw data upon which the reported properties are based consisted of an integrating nephelometer, two sky scanning telephotometers, a dual irradiometer, and a large aperture telephotometer on the aircraft, and an integrating nephelometer on the ground. Corroborative data were obtained using a ground-based contrast reduction meter to determine earth-to-space beam transmittances when weather permitted.

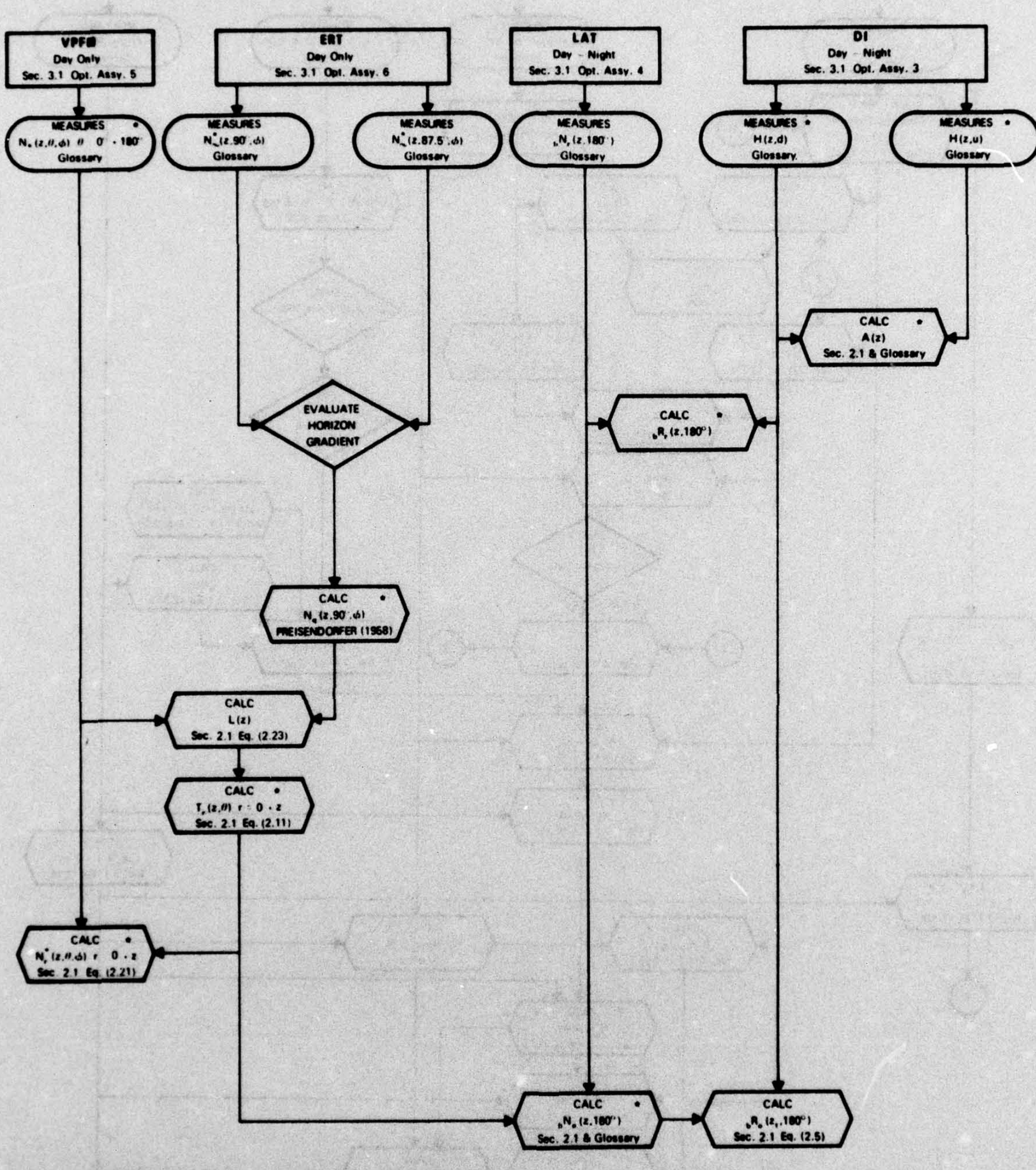
The radiometer spectral responses were standardized for the HAVEN VIEW II deployment in the manner illustrated in Fig. 1-5.

Data collection methods were similar to those reported in AFCRL-TR-74-0298, Duntley, *et al.* (1974), although all the flight profiles were conducted at relatively low altitudes. The highest straight and level altitude was approximately 1200 meters above ground level (AGL). The basic features of these stylized daytime flight profiles are summarized in Section 4.



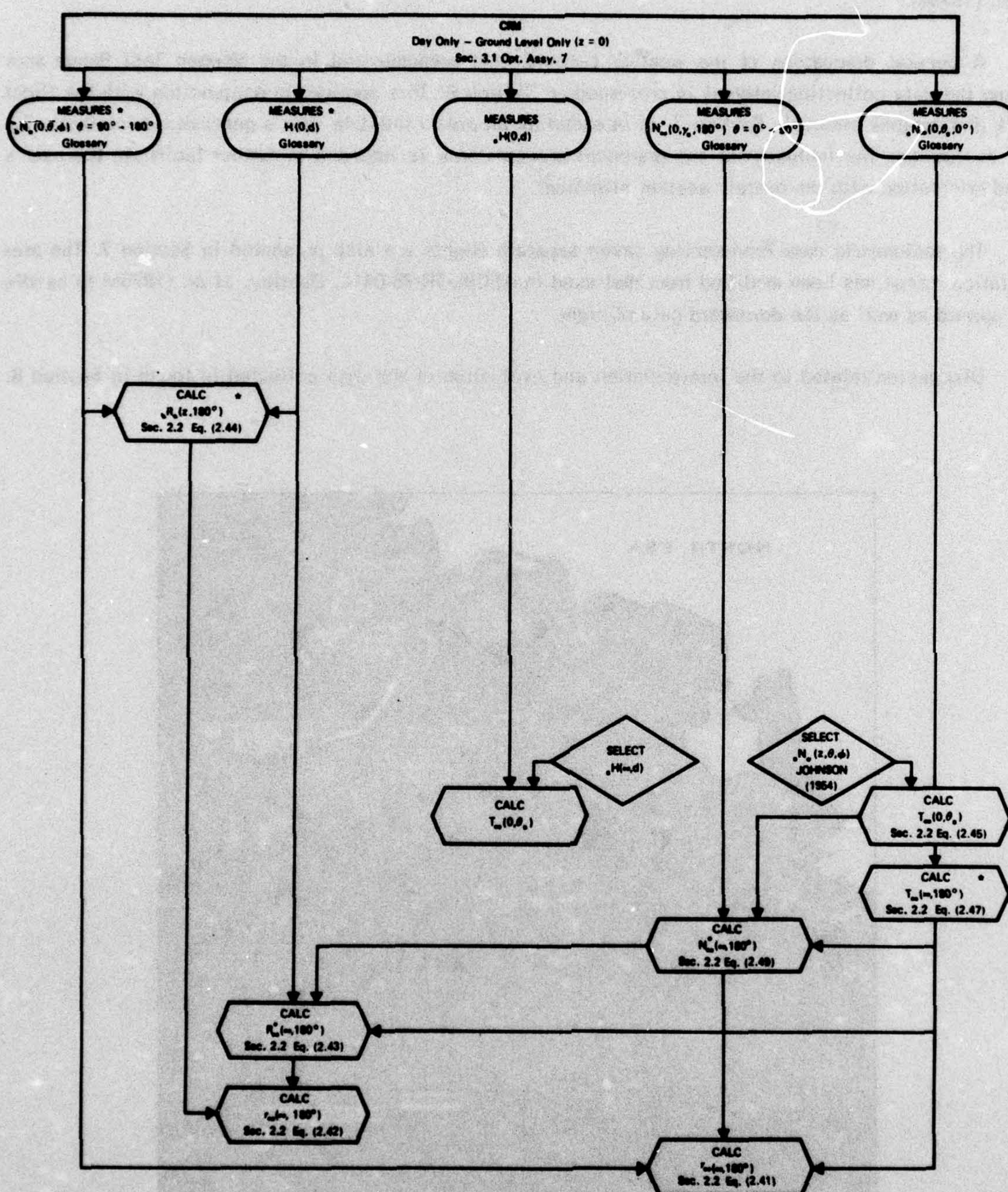
* Indicates Existence of Validation Measurement in Backup Data Sets.

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



* Indicates Utilization as Direct Validation of Computed Values.

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



* Indicates Utilization as Direct Validation of Computed Values.

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

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-TR-75-0457, Duntley, *et al.* (1975b).

A general discussion of the weather patterns that predominated in the Meppen Test Range 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 seven separate flights are also presented in Section 7. The presentation format has been modified from that used in AFCRL-TR-75-0414, Duntley, *et al.* (1975a) to handle the upward as well as the downward path of sight.

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

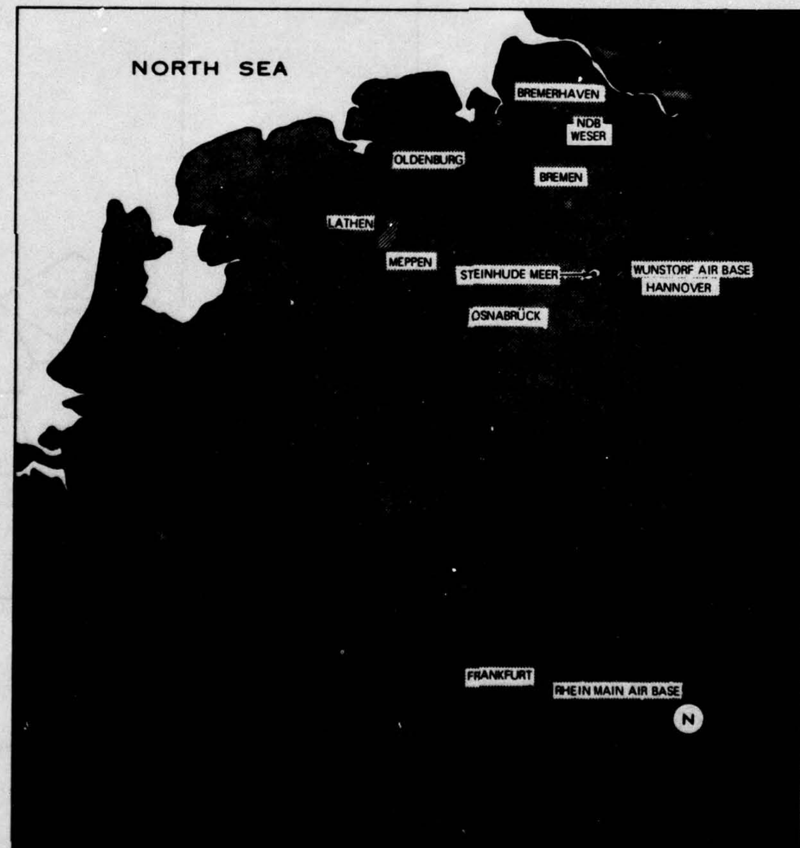


Fig. 1-4. Typical HAVEN VIEW II Flight Tracks.

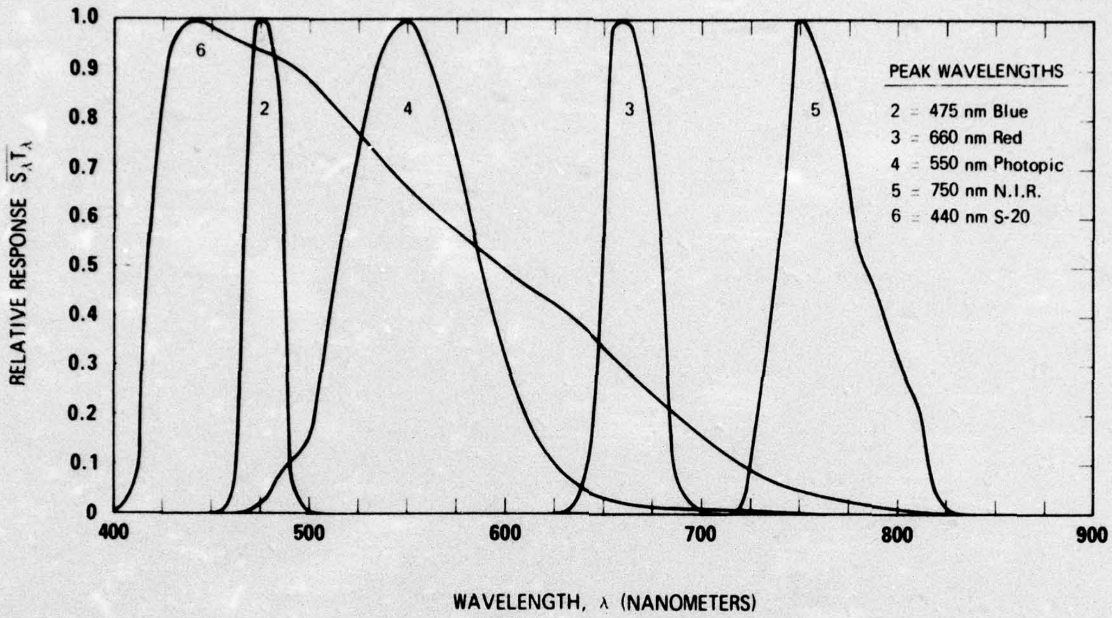


Fig. 1-5. Standard Spectral Responses – Project HAVEN VIEW II.

2. THEORY & COMPUTATIONAL PROCEDURES

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

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

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 object 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]:

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

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 for downward-looking paths of sight is

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

where $H(z_t,d)$ is the downwelling irradiance. For upward-looking paths of sight the upwelling irradiance $H(z_t,u)$ is used instead of the downwelling irradiance in Eq. 2.4.

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 upwelling 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 for downward-looking paths of sight is defined as

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

where $H(z_t,d)$ is the downwelling irradiance at the object altitude [Gordon (1964) p. 558 or Boileau and Gordon (1966) p. 805]. Note that the downwelling irradiance is used in the definition of reflectance for downward paths of sight regardless of the background surface orientation. 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.

The effective inherent background reflectance for an upward-looking path of sight is similarly

$${}_bR_o(z_t,\theta,\phi) = \pi\, {}_bN_o(z_t,\theta,\phi) / H(z_t,u) \; . \tag{2.6}$$

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† 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.

INHERENT CONTRAST

The inherent contrast of an object $C_o(z_t,\theta,\phi)$ against a background is defined as the ratio of the inherent object to background radiance minus 1:

$$C_o(z_t,\theta,\phi) \equiv {}_tN_o(z_t,\theta,\phi)/{}_bN_o(z_t,\theta,\phi) - 1 \ . \qquad (2.7)$$

Inherent contrast can also be computed from the directional reflectance of the object and background,

$$C_o(z_t,\theta,\phi) = {}_tR_o(z_t,\theta,\phi)/{}_bR_o(z_t,\theta,\phi) - 1 \ . \qquad (2.8)$$

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

$$H(z,d) = {}_sh(z)\cos\theta_s + \int_{2\pi} N(z,\theta',\phi')\cos\theta' \, d\Omega \ , \qquad (2.9)$$

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'. When the sky is fully overcast, the first term is essentially zero.

The upwelling irradiance $H(z,u)$ is computed by deleting the first term in Eq. 2.9 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:

$$h(z,d) = {}_sh(z) + \int_{2\pi} N(z,\theta',\phi') \, d\Omega \ . \qquad (2.10)$$

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. 2.10 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. 2.11. (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 total volume scattering coefficient $s(z)$. Therefore,

$$T_r(z,\theta) = \exp\left[-\sum_{i=1}^{n} \alpha(z_i)\Delta r\right] = \exp\left[-\sum_{i=1}^{n} s(z_i)\,\Delta r\right] , \tag{2.11}$$

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

$$s(o) = \frac{s(z)\rho(o)}{\rho(z)} . \tag{2.12}$$

Similarly, upward extrapolations are made to the highest reported altitude above ground level 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 maximum. For all paths of sight at zenith angles less than 85 degrees or 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. The $|\Delta z|$ used is 30 meters (98.4 feet). 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:

$$T_r(z,\theta) = T_r(z,180°)^{|\sec\theta|} . \tag{2.13}$$

For upward paths of sight for zenith angles less than 85 degrees, the beam transmittance can similarly be expressed as a function of the vertical upward transmittance $T_r(z,0°)$.

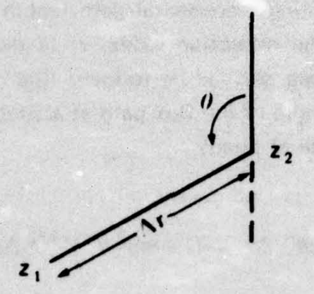

Fig. 2-1. Path Length Geometry for Steeply Inclined Paths of Sight.

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 total volume scattering coefficient:

$$L \equiv \frac{1}{\alpha(z)} = \frac{1}{s(z)} . \qquad (2.14)$$

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]

$$T_r(z,\theta) = \exp\left[-z/\bar{L}(z)\right]|\sec\theta| , \qquad (2.15)$$

where $\theta > 95°$ and path length r is between ground level and altitude z. For $\theta < 85°$, the $\bar{L}(z)$ values should be interpreted as applying to the object altitude with the sensor at ground level.

EARTH CURVATURE AND REFRACTION

For the paths of sight at zenith angles from 90 to 95 degrees, 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_1 is computed from

$$\Delta r_1 = \left\{ 1 - \left[\frac{n(z)}{n(z_1)} \frac{(\zeta + z)}{(\zeta + z_1)} \sin\theta \right]^2 \right\}^{-1/2} \Delta z . \qquad (2.16)$$

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 2.16 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):

$$\Delta r_i = \sec\theta'' \, \Delta z = (1 - \sin^2\theta'')^{-1/2} \, \Delta z \; . \tag{2.17}$$

Since $\sin x = \sin(180^\circ - x)$, the law of sines can be used to express Δr as a function of the path of sight θ:

$$\sin\theta'' = \frac{\zeta + z}{\zeta + z_i} \sin\theta \; . \tag{2.18}$$

The refraction effect is added by recourse to Snell's law, thus resulting in Eq. 2.16.

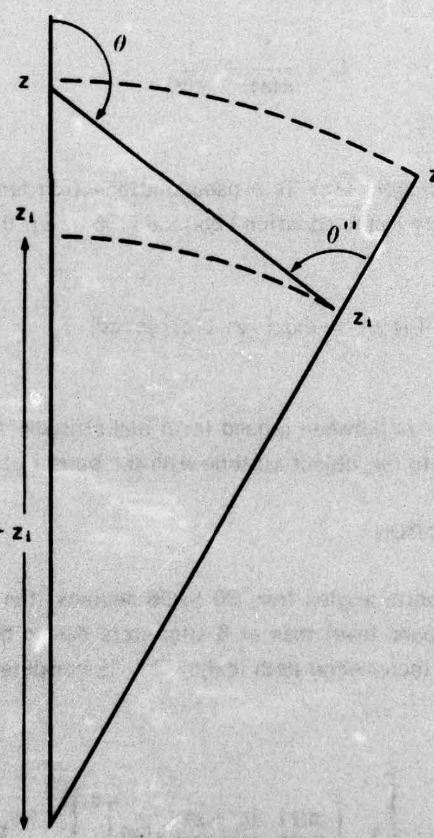

Fig. 2-2. Path Length Geometry for Grazing Paths of Sight in Refractive Spherical Atmospheres.

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

$$\left[\frac{n(z)}{n(z_1)}\right]^2 = 1 + 2[n(z) - 1]\,[1 - \rho(z_1)/\rho(z)] \ . \tag{2.19}$$

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

$$\left[\frac{n(z)}{n(z_1)}\right]^2 = 1 + 2[n(o) - 1]\left[\frac{\rho(z)}{\rho(o)} - \frac{\rho(z_1)}{\rho(o)}\right] . \tag{2.20}$$

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.

For upward-looking paths of sight from 85 to 90 degrees, the Δr for Δz = 30 meters (98.4 ft) is significantly shorter at 6 kilometers than at ground level due to the curvature of the earth. For these paths of sight the incremental path length Δr_i is computed from the same equations as for the downward path. The positions of z and z_1, and θ and θ'' should be reversed in Fig. 2-2 to illustrate the upward-looking case.

PATH RADIANCE

Path radiance $N_r^*(z,\theta,\phi)$ for the path of sight θ 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:

$$N_r^*(z,\theta,\phi) = \sum_{i=1}^{m} N_*(z_i,\theta,\phi)\, T_{ri}(z,\theta)\, \Delta r \ . \tag{2.21}$$

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]

$$N_*(z,\theta,\phi) = \lim(\Delta r \to 0)\, N^*_{\Delta r}(z,\theta,\phi)/\Delta r \ . \qquad (2.22)$$

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.* (1957), Eq. 11]

$$N_q(z,\theta,\phi) = N_*(z,\theta,\phi)\, L(z) \ . \qquad (2.23)$$

By substituting Eq. 2.14 into Eq. 2.23 and rearranging, path function is expressed as a function of the total volume scattering coefficient and the equilibrium radiance:

$$N_*(z_i,\theta,\phi) = N_q(z_i,\theta,\phi)\, s(z_i) \ . \qquad (2.24)$$

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):

$$N_q(z,\theta,\phi) = {}_s h(z)\,\frac{\sigma(z,\beta)}{s(z)} + \int_{4\pi} N(z,\theta',\phi')\,\frac{\sigma(z,\beta')}{s(z)}\, d\Omega \ , \qquad (2.25)$$

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

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'. When the sky is fully overcast, the first term in Eq. 2.25 is essentially zero. The ratio $\sigma(z,\beta')/s(z)$ is the proportional directional volume scattering function 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

$$\cos\beta' = \sin\theta \sin\phi \sin\theta' \sin\phi' + \sin\theta \cos\phi \sin\theta' \cos\phi' + \cos\theta \cos\theta' \quad . \qquad (2.26)$$

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 proportional directional volume scattering function which produces the unique equilibrium radiance associated with each path of sight.

PROPORTIONAL DIRECTIONAL VOLUME SCATTERING FUNCTION

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

$$\sigma(z,\beta')/s(z) = \left\{ {}_{R}s(z) \left[\frac{\sigma(z,\beta')}{s(z)}\right]_{R} + {}_{M}s(z) \left[\frac{\sigma(z,\beta')}{s(z)}\right]_{M} \right\} / s(z) \quad . \qquad (2.27)$$

The Rayleigh volume 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 Celsius and 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,

$${}_{R}s(z) = {}_{R}s(0)\, P(z)/[\,T(z)\ 3.516E3] \quad . \qquad (2.28)$$

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 Celsius temperature times the universal gas constant. The proportional directional volume scattering function for Rayleigh scattering ${}_{R}[\sigma(\beta)/s]$ is not a function of altitude so the parenthetical modifier is not used. It is found by

$${}_{R}[\sigma(\beta)/s] = 3(1 + f\cos^{2}\beta)/[4\pi(3 + f)] \quad , \qquad (2.29)$$

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

where f is the polarization defect factor. This factor is a function of the ratio of the weak to strong polarized component at $\beta = 90$ degrees for pure air; a ratio of 0.04 results in a factor of 0.923 [Tousey and Hulbert (1947)]. The effect of the defect factor on ${}_R\sigma(\beta)/s$ is equal to or less than 2 percent which for our purposes can be considered negligible. Therefore $f = 1$ was used in the computations.

The Mie volume scattering coefficient at measurement altitude z is the measured total volume scattering coefficient minus the Rayleigh volume scattering coefficient computed from Eq. 2.28 above:

$$ {}_M s(z) = s(z) - {}_R s(z) \ . \tag{2.30} $$

The Mie proportional directional volume scattering function ${}_M[\sigma(z,\beta)/s(z)]$ is taken from a catalog of values derived from data on photopic proportional directional volume scattering functions published by Barteneva (1960) for a range of total volume scattering coefficients typifying atmospheric conditions from near Rayleigh clarity to hazes which restricted visibilities to less than 4.8 kilometers (3 miles). Barteneva's gradual classes of proportional directional volume scattering function are used exclusively since most of the steep classes are encountered only in fog. The classes are based upon the ratio of forward- to backward-scattering coefficients. The ratio of the Mie volume scattering function at 30 and 150 degrees, ${}_M[\sigma(30°)/\sigma(150°)]$, is directly correlated with the forward- to backward-scattering ratio. 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:

$$ {}_M\sigma(\beta) = \sigma(\beta) - {}_R s(z)\, {}_R[\sigma(\beta)/s] \ . \tag{2.31} $$

SUN IRRADIANCE

Although the scanner radiance measurements include a measure of the apparent sun radiance, the sun is not always fully in the field of view. 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, $T_\infty(z,\theta_s)$:

$$ {}_s h(z) = {}_s h(\infty)\, T_\infty(z,\theta_s) \ . \tag{2.32} $$

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 Ψ at true solar distance to the radius $\bar{\Psi}$ at mean distance:

$$ {}_s h(\infty) = {}_s h(\bar{\infty}) \left(\frac{\Psi}{\bar{\Psi}} \right)^2 . \quad (2.33) $$

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.

When the sky at the highest flight altitude is clear, the transmittance from out of the atmosphere to the highest flight altitude due to scattering 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)]:

$$ N^*_{\infty}(z,\theta,\phi) = \bar{N}_q(z,\theta,\phi)\,[1 - T_{\infty}(z,\theta)] . \quad (2.34) $$

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

$$ \frac{N^*_{\infty}(z,\theta,\phi)}{N^*_{\infty}(z,\theta',\phi')} = \frac{\bar{N}_q(z,\theta,\phi) \quad [1 - T_{\infty}(z,\theta)]}{\bar{N}_q(z,\theta',\phi')\ [1 - T_{\infty}(z,\theta')]} . \quad (2.35) $$

When the scattering angle from the sun is equivalent for the two paths of sight, the equilibrium radiances are equivalent. Thus Eq. 2.35 simplifies to

$$ \frac{N^*_{\infty}(z,\theta,\phi)}{N^*_{\infty}(z,\theta',\phi')} = \frac{[1 - T_{\infty}(z,\theta)]}{[1 - T_{\infty}(z,\theta')]} . \quad (2.36) $$

Equation 2.36 can be expressed as a function of the vertical transmittance $T_{\infty}(z,0^\circ)$ and the relative optical airmass $m_{\infty}(z,\theta)/m_{\infty}(z,0^\circ)$:

$$ \frac{N^*_{\infty}(z,\theta,\phi)}{N^*_{\infty}(z,\theta',\phi')} = \frac{\left[1 - T_{\infty}(z,0^\circ)^{m_{\infty}(z,\theta)/m_{\infty}(z,0^\circ)} \right]}{\left[1 - T_{\infty}(z,0^\circ)^{m_{\infty}(z,\theta')/m_{\infty}(z,0^\circ)} \right]} . \quad (2.37) $$

Equation 2.37 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. 2.37 within a tolerance of 0.1 percent.

An error analysis of the transmittance obtained by Eq. 2.37 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 due to scattering. A validation of the sky radiance ratio method of obtaining beam transmittance was presented in Duntley, *et al.* (1972c), Section 2.1.

Atmospheric absorption acts to reduce the incoming sun irradiance but has no affect on the sky radiance relative distribution. Thus the transmittance based on sky radiance ratios is due to scattering only, and the transmittance losses due to absorption must be added as a separate factor. Tousey and Hulburt (1947) calculated a photopic transmittance of 0.977 due to absorption by ozone at the top of the atmosphere. The photopic transmittance from out of the atmosphere to the highest flight altitude is the product of the transmittance due to scattering and the transmittance due to absorption.

When the sky at the highest altitude is not completely free of clouds, the beam transmittance from space to altitude may be specified on the basis of ground-based contrast reduction meter measurements or other measurements such as downwelling irradiance measured simultaneously with sky radiance, which yield an estimate of space-to-altitude transmittance.

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

$$T_{\infty}(z,0^\circ) = T_{\infty}(z_m,0^\circ)\, T_r(z,0^\circ) \ . \qquad (2.38)$$

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

$$T_{\infty}(z,\theta_s) = T_{\infty}(z,0^\circ)^{m_{\infty}(z,\theta_s)/m_{\infty}(z,0^\circ)} \ . \qquad (2.39)$$

The relative airmass equals $\sec\theta$ for $\theta_s \leqq 70^\circ$ to an accuracy of 1 percent. Also, the relative airmass at altitudes up to 6 kilometers equals the relative airmass at sea level, $m_{\infty}(6,\theta_s)/m_{\infty}(6,0^\circ) = m_{\infty}(0,\theta_s)/m_{\infty}(0,0^\circ)$, to an accuracy of 1 percent for $\theta_s \leqq 86^\circ$. 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 each filter or the total flight is used in Eq. 2.39 as well as in computing the irradiance in Eq. 2.9 and the scattering angle β in Eq. 2.25.

SKY AND TERRAIN RADIANCE

The arrays of sky and terrain radiance measurements have missing values due to the sampling schedule and include values which are questionable due to: possible inclusion of the sun in the field of view; 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 irregularities in the angular pattern. In order to obtain a basic data array of optimum quality, these well-defined but improper values must be removed and the blank values replaced. 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. The same procedure is used for sky radiances under overcast or partial cloud.

For clear skies, 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. 2.34 as follows:

$$\bar{N}_q(z,\beta) = N_{\infty}^{*}(z,\theta,\phi)/[1 - T_{\infty}(z,\theta)] . \tag{2.40}$$

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. The questionable sky radiance measurements are then replaced using the average equilibrium radiance function and Eq. 2.34.

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°:

$${}_b\tau_{\infty}(\infty,180°) = [1 + N_{\infty}^{*}(\infty,180°)/{}_bN_o(0,180°)\,T_{\infty}(\infty,180°)]^{-1} . \tag{2.41}$$

The azimuth ϕ has been deleted from the parenthetical modifiers of the path radiance $N_{\infty}^{*}(\infty,180°)$ 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 $R^*_\infty(\infty,180°)$. Thus, Eq. 2.3 is similarly rewritten

$$ {}_b\tau_\infty(\infty,180°) = [1 + R^*_\infty(\infty,180°)/{}_bR_o(0,180°)]^{-1} \; . \tag{2.42}$$

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

$$ R^*_\infty(\infty,180°) = \pi N^*_\infty(\infty,180°)/H(0,d)\, T_\infty(\infty,180°) \; . \tag{2.43}$$

BACKGROUND REFLECTANCE

The inherent vertical background reflectance is defined as

$$ {}_bR_o(0,180°) = \pi\, {}_bN_o(0,180°)/H(0,d) \; . \tag{2.44}$$

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:

† 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).

$$T_\infty(0,\theta_s) = \frac{{}_sN_\infty(0,\theta_s,0^\circ)}{{}_sN_o(\infty,\theta_s,0^\circ)} . \tag{2.45}$$

The vertical earth-to-space beam transmittance is equal to the vertical space-to-earth beam transmittance, and therefore Eq. 2.39 can be rewritten to obtain the vertical downward transmittance from the transmittance at the angle of the sun:

$$T_\infty(\infty,180^\circ) = T_\infty(0,0^\circ) = T_\infty(0,\theta_s)^{m_\infty(0,0^\circ)/m_\infty(0,\theta_s)} . \tag{2.46}$$

For $\theta_s \leqq 70^\circ$, the inverse of the relative airmass $m_\infty(0,0^\circ)/m_\infty(0,\theta_s) = \cos\theta_s$ to an accuracy of 1 percent. Since the solar elevation angle γ_s, which equals $90^\circ - \theta_s$, is read directly off of the ground-based equipment, Eq. 2.46 is rewritten as

$$T_\infty(\infty,180^\circ) = T_\infty(0,\theta_s)^{\sin\gamma_s} . \tag{2.47}$$

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

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

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]:

$$N_\infty^*(\infty,180^\circ) = N_\infty^*(0,\theta',\phi') \left[\frac{1 - T_\infty(\infty,180^\circ)}{1 - T_\infty(0,\theta')}\right], \tag{2.48}$$

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 $T_\infty(0,\theta')$ 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 2.48 can now be rewritten as

$$N^*_\infty(\infty,180°) = N^*_\infty(0,\gamma_s,180°)\left[\frac{1 - T_\infty(\infty,180°)}{1 - T_\infty(0,\gamma_s)}\right]. \quad (2.49)$$

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

$$T_\infty(0,\gamma_s) = T_\infty(0,0°)^{\sec\gamma_s}. \quad (2.50)$$

For $\gamma_s > 70°$, the relative optical airmass from Kasten (1965) is used instead of $\sec\gamma_s$ in Eq. 2.50.

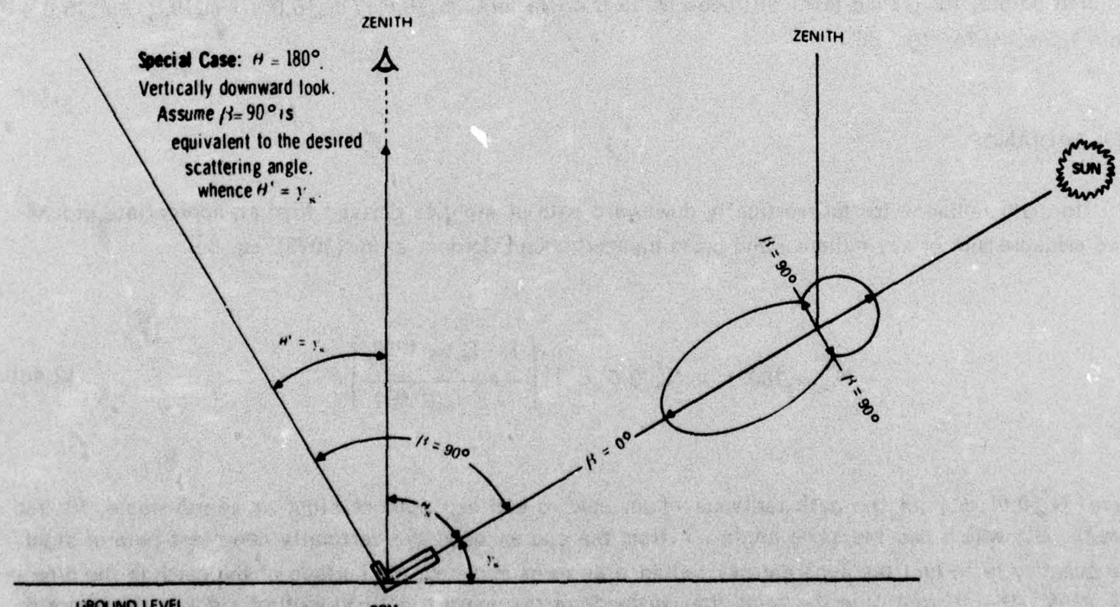

Fig. 2-3. Scattering Angle Relationships for Typical CRM Operations.

3. INSTRUMENTATION

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

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

Table 3-1

Project HAVEN VIEW II Instrumentation

I. Radiometric

   A. Multiplier Phototube (MPT) 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

3.1 RADIOMETRIC SYSTEMS

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

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

These assemblies are generally interchangeable between different radiometer systems, allowing easy field cannibalization in the event of a catastrophic failure of any assembly within a key system. For use in Project HAVEN VIEW II, these five assemblies were basically unchanged from the configurations reported in AFCRL-72-0593, Duntley, *et al.* (1972c). For reader convenience, a brief description of each optical collector assembly follows.

OPTICAL COLLECTOR ASSEMBLIES

Seven basic types of collector assemblies were used in combination with the basic detector configurations described in AFCRL-74-0298, Duntley, *et al.* (1974). The only major differences between the various radiometer systems described in this report are the differences in these seven collector assemblies. The fundamental assembly differences are summarized in the following paragraphs.

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

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

Automatic 2π Scanner (UHS and LHS) Assembly. 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 HAVEN VIEW II mission, the airborne scanners were directed in a sweep pattern which covered the full hemisphere in 180 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. The sweep pattern characteristics are more fully described in AFCRL-72-0593, Duntley, *et al.* (1972c).

Integrating Nephelometer (NEPH) Assembly. 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 (DI) Assembly. 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 on 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 (LAT) Assembly. 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.

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 in length. It is defined by the cylindrically-limited field of view of the component telephotometer and by two long cylindrical sunshades. Measurements of path function during Project HAVEN VIEW II were 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 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 ERT is basically a servo-controlled telescope. Its field of view is 1.0 degree wide and 0.2 degree 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 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 CRM consists of a standard detector and filter changing assembly, fitted with a multiple-purpose optical collector. The optical collector includes 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 4-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 HAVEN VIEW II, the meteorological systems were unchanged from the configurations reported in AFCRL-72-0593, Duntley, *et al.* (1972c).

The airborne meteorological package consisted 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 ground-based meteorological package was less extensive, consisting of only one Royco model 220 particle counter, one Bendix model 556 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) and AFCRL-72-0593, Duntley, *et al.* (1972c), no further discussion is included in this report.

3.3 CONTROL AND COMMUNICATION SYSTEMS

The basic control panels, consoles, and other support facilities listed in Table 3-1 are described fully in AFCRL-70-0137, Duntley, *et al.* (1970) and AFCRL-72-0593, Duntley, *et al.* (1972c), and the updated configurations are also reported in AFCRL-72-0593, Duntley, *et al.* (1972c).

PITCH AND ROLL INDICATOR

Prior to the HAVEN VIEW II deployment, the standard data collection flight profile included "straight and level" elements in which the aircraft was trimmed to maintain a 0-degree pitch angle. The purpose of this maneuver was to maintain a horizontal base plane for the upper and lower hemisphere scanners. There were, however, two severe shortcomings involved in this procedure. First, maintaining this flight attitude required an excessive degree of flap depression (approximately 60 degrees), which in turn caused both an exceptionally high rate of fuel consumption and a severe strain on the airframe. Second, precise orientation of the aircraft was difficult and time consuming for the pilots since there is no precision pitch indicator available on the flight console.

In order to eliminate the problems summarized above, two adjustments were made. First, mechanical shims were added to the scanner and camera mounting rings so that the base planes would be horizontal when the aircraft was in a 2½-degree nose-high attitude. Second, a digital readout was provided on the flight deck which allowed the pilot to monitor the project pitch and roll channels. This readout channel has a precision of 40 millivolts per degree and a full scale reading of 999 millivolts. Thus, to set up at 2½ degrees nose high, the pilot merely trims the aircraft until he reads +100 millivolts on the digital meter, and we are ready to go. For this slightly nose-high attitude, about only 25 degrees of flaps are normally required, which results in significant savings in fuel and the attendant increase in available data time. This procedure was initiated during the HAVEN VIEW II deployment and has proven satisfactory in all respects.

A problem, however, was discovered during post-deployment data analysis, which indicated that an erroneous biasing voltage had been within the control circuitry during the HAVEN VIEW II deployment. The trouble was traced to the visibility studies control console. Software techniques were then utilized to correct the data on the critical altitude and heading channels, and to try to more specifically locate the source of the problem. At the time of this report, the problem had been narrowed down to the filter and accessory control panels, and had been corrected.

3.4 PHOTOGRAPHIC SYSTEMS

Photographic documentation of the test environment performed simultaneously with the radiometric and meteorological measurements has always been a highly desirable adjunct to any field activity. For Project HAVEN VIEW II, this photographic capability was accomplished by the Visibility Laboratory 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, were mounted on the project aircraft (Fig. 3-1). One camera was oriented to photograph the 2π upper hemisphere and the other covered 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 HAVEN VIEW II this procedure was supplemented with a scheduled routine of site photographs using a Soligor Conversion Fisheye lens. This lens possesses almost universal adaptability to a wide variety of cameras and prime lenses. During Project HAVEN VIEW II 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 by 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 subsequent reports in this series) 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 HAVEN VIEW II 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 characteristics of the radiometer measuring circuit results in a linearity calibration curve typified in Fig. 3-3.

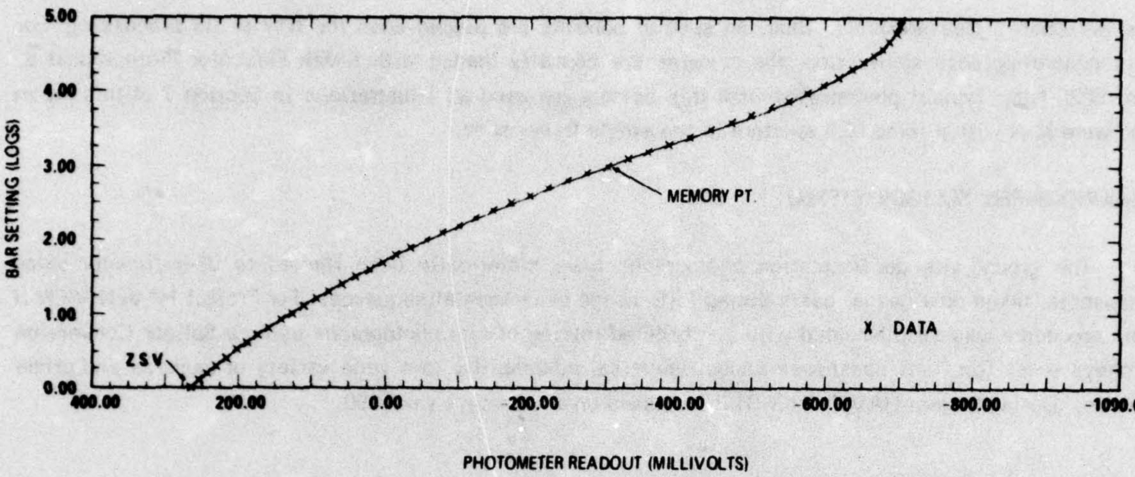

Fig. 3-3. Typical Computer-Generated Linearity Calibration Curve.

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 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 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 HAVEN VIEW II radiometer is shown in Fig. 3-4. 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.

Table 3-2

Project HAVEN VIEW II
Radiometer Calibration Constants (ZSV) and Related Fractional Standard Deviations (δ) For Daylight Flights

Radiometer Identification		Calib	Calib	Filter 2		Filter 6		Filter 4		Filter 3		Filter 5		Average %
System	MPT SN	Mode	Units	ZSV	δ%	ZSV	δ%	ZSV	δ%	ZSV	δ%	ZSV	δ%	for System
CRM/SS	9861	Out*	$w/\Omega m^2 \mu m$	2.27E + 05	1	7.67E + 03	3	6.59E + 04	1	4.38E + 05	1	4.80E + 04	2	2
CRM/E-Cap	9861	Out*	$w/m^2 \mu m$	2.49E + 06	2	7.33E + 04	3	6.31E + 05	3	3.91E + 06	2	3.95E + 05	3	3
SCAN1 Sun	10650	Out*	$w/\Omega m^2 \mu m$	8.83E + 06	1	4.80E + 05	2	3.58E + 06	1	1.92E + 07	1	3.60E + 06	1	1
SCAN1 Sky	10650	Out	$w/\Omega m^2 \mu m$	1.17E + 03	1	7.24E + 01	2	4.80E + 02	1	3.19E + 03	1	8.20E + 02	1	1
SCAN1 E-Cap	9846	Out	$w/m^2 \mu m$	1.35E + 04	1	7.08E + 02	3	4.93E + 03	1	3.05E + 04	1	7.27E + 03	1	2
SCAN3 Sun	9846	Out*	$w/\Omega m^2 \mu m$	5.04E + 06	3	2.12E + 05	1	1.64E + 06	2	1.04E + 07	3	3.77E + 06	2	2
SCAN3 Sky	9846	Out	$w/\Omega m^2 \mu m$	7.45E + 03	3	2.64E + 02	1	1.79E + 03	2	1.74E + 04	3	5.53E + 03	2	2
SCAN4 Sky	9858	Out	$w/\Omega m^2 \mu m$	1.61E + 03	2	9.[illegible]8E + 01	1	6.48E + 02	1	2.81E + 03	1	1.70E + 03	1	1
NEPH1 Σ 1	9828	Out	$w/m^2 \mu m$	1.32E – 01	3	8.08E – 03	1	6.04E – 02	4	2.52E – 01	3	1.01E + 00	2	3
NEPH1 β 1	9828	Out	$w/\Omega m^2 \mu m$	1.22E – 01	1	8.94E – 03	3	6.28E – 02	2	2.97E – 01	1	2.06E + 00	1	2
NEPH1 Σ 2	9828	Out	$w/m^2 \mu m$	1.48E – 01	4	8.10E – 03	2	6.18E – 02	4	2.61E – 01	4	1.05E + 00	2	3
NEPH1 β 2	9828	Out	$w/\Omega m^2 \mu m$	1.27E – 01	1	8.77E – 03	1	6.36E – 02	1	3.03E – 01	1	2.10E + 00	1	1
NEPH3 Σ	14509	Out	$w/m^2 \mu m$	6.16E – 02	3	3.34E – 03	0	2.88E – 02	2	8.23E – 02	2	1.05E – 01	2	2
NEPH3 β	14509	Out	$w/\Omega m^2 \mu m$	6.11E – 02	1	3.62E – 03	2	2.83E – 02	2	9.38E – 02	1	1.50E – 01	1	1
LAT1	9869	Out*	$w/\Omega m^2 \mu m$	2.37E + 03	9	3.04E + 01	2	2.62E + 02	2	5.11E + 03	5	1.75E + 02	2	4
DI Day 1	11783	Out*	$w/m^2 \mu m$	7.84E + 04	2	2.67E + 03	1	2.71E + 04	3	7.04E + 04	2	4.98E + 04	2	2
DI Day 2	11783	Out*	$w/m^2 \mu m$	1.14E + 05	4	3.95E + 03	2	4.04E + 04	1	9.95E + 04	1	6.37E + 04	1	1
ERT Day	14531	In	$w/\Omega m^2 \mu m$	5.31E + 02	6	4.41E + 01	1	2.75E + 02	1	1.63E + 03	3	2.44E + 04	2	2
VPFM	10697	Out	$w/\Omega m^2 \mu m$	4.44E + 01	1	4.24E + 00	1	2.73E + 01	1	1.08E + 02	1	3.06E + 02	2	1

* Indicates that the basic calibration was altered using the calibrated neutral density range filter Δlog.
NEPH1, use set 1 on flights C-270 to C-277, set 2 on flights C-278 to C-290.
DI, use set 1 on flights C-270 to C-282, set 2 on flights C-283 to C-290.

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. 3-4 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

ABSOLUTE CALIBRATION FOR

(21) SCAN-3 W/FIXED (9846 N) (RADIOMETER) TAKEN ON 3/28/73 (PREHAVN2) DEPLOYMENT

FILTER NO. 4 (DAY SKY 7000 DEGREES KELVIN)

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	PERCENT DIFF OF RAW AVG	AVG RAW ZSV	F1 LUM. TO RAD. WATTS/LUM.	F2 COLOR MATCH	CORRECTED ZSV
1	40	141.000	1.988E 04	8.269E-03	-167	3.188	1.276E 01	1.1	1.291E 01	1.052E-03	1.030E 00	1.409E-02
2	70	171.000	2.924E 04	5.622E-03	-221	3.358	1.282E 01	.7				
3	120	221.000	4.884E 04	3.306E-03	-299	3.586	1.298E 01	-.6				
4	200	301.000	9.060E 04	1.815E-03	-399	3.860	1.314E 01	-1.8				
5	300	401.000	1.608E 05	1.022E-03	-500	4.113	1.326E 01	-2.8				
4	200	301.000	9.060E 04	1.815E-03	-398	3.858	1.308E 01	-1.3				
3	120	221.000	4.884E 04	3.360E-03	-295	3.577	1.271E 01	1.5				
2	70	171.000	2.924E 04	5.622E-03	-220	3.354	1.269E 01	1.7				
1	40	141.000	1.988E 04	8.269E-03	-167	3.187	1.271E 01	1.5				

LINEARITY MAXIMUM = (459) APPLIED CUTOFF = (-915)
LINEARITY CALIB. END = (-915) FULL DARK = (-982) CUTOFF = (-915)

* CALCULATED LUMINANCE IN LUMENS/STERADIAN SQ.CM.

RAW ZSV STD = (2.1491E-01) FRACT. STD = (1.66) PERCENT ZSV IN WATTS SR SQ. CM. IS 1.409E-02

WITH UNIT CONVERSION FACTOR OF 127300.00000). TO CHANGE UNITS FROM (W/SR SQ.M CM)
TO (W/SR SQ.M MICRO M) THE NEW ZSV IN WATTS/SQ. M MICRO M. IS 1.79403E 03

THIS FILTER IS PSEUDO-PHOTOPIC. TO CONVERT TO TRUE PHOTOPIC STANDARD (SEE TECHNICAL MEMORANDUM AV71-0097)
FOR DAYLIGHT DATA MULTIPLY BY 72.000LUMEN-UM / WATT. PHOTOPIC ZSV IS 1.29170E 05 LUMEN/STER SQ M.
FOR NIGHT TIME LIGHTING MULTIPLY BY 68.340LUMEN-UM / WATT. PHOTOPIC ZSV IS 1.22604E 05 LUMEN/STER SQ M.
FOR NEPHELOMETER ONLY MULTIPLY BY 72.220LUMEN-UM / WATT. PHOTOPIC ZSV IS 1.29569E 05 LUMEN/STER SQ M.

MV FLUCTUATION DATA DURING EACH CALIB MEASUREMENT

SPAN ID	STD. DEV. IN MV	FRACT STD DEV IN PERCENT
1	5.123E-01	3.060E-01
2	4.787E-01	2.163E-01
3	5.164E-01	1.730E-01
4	4.472E-01	1.122E-01
5	5.164E-01	1.033E-01
4	8.165E-01	2.051E-01
3	5.000E-01	1.693E-01
2	2.500E-01	1.137E-01
1	3.416E-01	2.047E-01

CALIBRATION LAMP IDENTIFICATION

SERIAL NUMBER = 0165-4W
LAMP INTENSITY = 530.00
DISTRIBUTION TEMPERATURE = 2854
MONITOR CURRENT CHANNEL = 4

CALIBRATION TARGET DATA

REFLECTANCE OF PATH ATTENUATOR(PERCENT) = 100.0
REFLECTANCE OF CALIBRATION TARGET(PERCENT) = 96.0
DTOTAL = LAMP DISTANCE = D1 + D2. D2(CM) = 101.0
PHOTOMETER DATA CHANNEL = 1

Fig. 3-4. Typical Absolute Calibration Form.

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 in Table 3-3.

The four correction factors shown in Table 3-3 are calculated in Program SUPERCK6. Several key factors generated by Program SUPERCK6 for use with the HAVEN VIEW II data are listed in Tables 3-4 and 3-5.

CALIBRATION SUMMARY

The pre-HAVEN VIEW II calibration data are dated April 1973. The post-HAVEN VIEW II calibration data are dated September 1973. A review of the data related to each calibration set has led to the selection of preferred calibration constants for application to all Project HAVEN VIEW II field data. These preferred calibration constants are those presented in Table 3-2. The determinant features leading to the selection of each instrument's calibration set are discussed in in-house reference number 83 and are not repeated here.

Table 3-3

Calibration Correction Factor Summary

Factor Designator	Operational Identification	Defining Equations
F1	Luminance-to-radiance conversion	$F1 = \dfrac{\sum {}_cW_\lambda \epsilon_\lambda (\overline{S_\lambda T_\lambda}) \Delta\lambda}{680 \sum {}_cW_\lambda \epsilon_\lambda \bar{y} \Delta\lambda}$
F2	Color-matching adjustment	$F2 = \dfrac{\sum W'_\lambda (\overline{S_\lambda T_\lambda}) \Delta\lambda}{\sum W'_\lambda (S_\lambda T_\lambda) \Delta\lambda} \times \dfrac{\sum {}_cW_\lambda \epsilon_\lambda (S_\lambda T_\lambda) \Delta\lambda}{\sum {}_cW_\lambda \epsilon_\lambda (\overline{S_\lambda T_\lambda}) \Delta\lambda}$
F3	Unit conversion	$F3 = \dfrac{10^4}{\delta\lambda} = \dfrac{10^4}{\sum (\overline{S_\lambda T_\lambda}) \Delta\lambda}$
F4	Photometric reconversion	$F4 = \dfrac{680 \sum W'_\lambda \bar{y} \Delta\lambda \delta\lambda 10^{-3}}{\sum W'_\lambda (\overline{S_\lambda T_\lambda}) \Delta\lambda}$

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.*

IN-FLIGHT CROSS-CALIBRATION CHECK

The Project HAVEN VIEW II deployment incorporated the standard 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.

Table 3-4

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

Factor Designator	Spectral Filter Identification				
	Filter 2 478 nm	Filter 3 664 nm	Filter 4 557 nm	Filter 5 765 nm	Filter 6 532 nm
F1 (w/lu)	1.263E-04	7.136E-04	1.050E-03	1.561E-03	2.112E-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)	7.299 E + 01	7.222 E + 01	7.200 E + 01	7.195 E + 01	7.211 E + 01	6.834 E + 01

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 UHS, LHS, and ERT filter 4 (pseudo-photopic) 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. During the HAVEN VIEW II deployment there was an undetected error in the flight crew's check list which resulted in slightly anomolous X-CAL data. Due to an erroneous instruction, the three radiometers (UHS, LHS, and ERT) were not aimed along parallel lines of sight. During flight C-273 the UHS and LHS fields of view only partially overlapped, and the ERT field of view was approximately 1.5 degrees above their common area. During the remainder of the flights, the UHS and ERT fields of view were properly aligned, but the LHS field of view was 5 degrees below them. Thus, the relatively systematic offsets illustrated in Table 3-6 are not completely unexpected.

Due to the anomolous control settings during the X-CAL flight sequences, and since the ERT/UHS ratios are not severe, no calibration updates were made to the HAVEN VIEW II data on the basis of the X-CAL ratios.

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 optical system attempts to duplicate are indicated as $\overline{S_\lambda T_\lambda}$.

Table 3-6

Precalibration Sun Mode Photopic X-CAL Data

Flight No.	Event	UHS/LHS	ERT/UHS	ERT/LHS
C-273	3	1.02	.78	.79
C-279	83	.63	1.03	.64
C-280	Not Available	–	–	–
C-281	3	.64	1.08	.69
C-282	3	.72	1.04	.75
C-288	3	.70	1.04	.73
C-288	75	.64	1.07	.68
C-289	3	.59	1.06	.62
C-289	75	.57	1.10	.63
$\bar{R}$ (Average less C-273)		.64	1.06	.68
$\overline{\lvert R_i - \bar{R} \rvert}$		.04	.02	.04

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/m²μm are obtained from units of watts/m² by dividing by the response area $\delta\lambda$ in appropriate units.

A summary of the response characteristics of the standards for Project HAVEN VIEW II is presented in Table 3-7. The first four columns give filter code, peak wavelength, mean wavelength, and response area. The values for inherent solar properties are in columns 5, 6, and 7 and the Rayleigh limits are in columns 8, 9, and 10. The table was produced by Program RAYLIMIT.

Table 3-7

Spectral Characteristics Summary for Project HAVEN VIEW II

Spectral Characteristics for Project HAVEN VIEW II				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	Radiance (w/Ωm²μm) 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	0.839
3	660	664	30.2	1.57E+03	2.30E+07	2.75E+07	1.86E+05	5.41E-06	0.955
5	750	765	50.4	1.23E+03	1.80E+07	2.10E+07	3.28E+05	3.08E-06	0.974
4	550	557	78.5	1.90E+03	2.78E+07	3.47E+07	8.93E+04	1.15E-05	0.907
6	440	532	183.5	1.91E+03	2.80E+07	3.55E+07	7.22E+04	1.64E-05	0.867
9	555	560	106.9	1.89E+03	2.77E+07	3.45E+07	9.22E+04	1.15E-05	0.907

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 HAVEN VIEW II is presented in Fig. 1-5 and 3-5. In Fig. 3-5, 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.

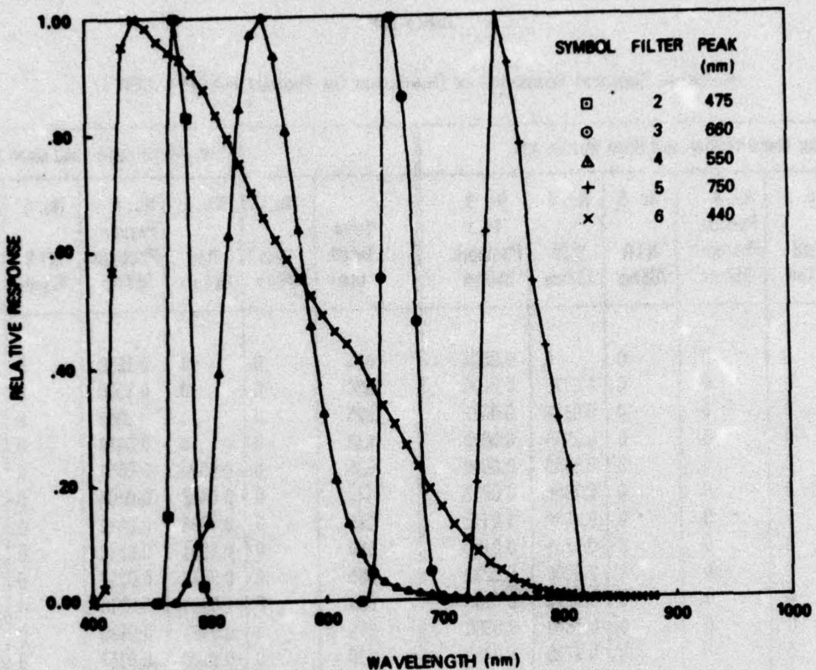

Fig. 3-5. Computer-Generated Plot of Standard Spectral Responses for Project HAVEN VIEW II.

Table 3-8

Relative Spectral Response of Standards for Project HAVEN VIEW II

Wave-length (nm)	Filter Identification and Mean Wavelength					
	No. 2 Blue 478nm	No. 3 Red 664nm	No. 4 Pseudo-Photopic 557nm	No. 5 NIR 765nm	No. 6 S-20 532nm	No. 9 True Photopic 560nm
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
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
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 HAVEN VIEW II, 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.

An illustration of our typical flight pattern, only portions of which were used for the HAVEN VIEW II mission, is shown in Fig. 4-1. In this stylized pattern, two basic elements, the straight and level (ST & LV) and the vertical profile (V-PRO), are combined to yield the total mission flight plan. A description of these two pattern elements and the calibration elements is detailed in AFCRL-72-0255, Duntley, *et al.* (1972a), modified in AFCRL-TR-75-0457, Duntley, *et al.* (1975b), and summarized in the following paragraphs.

1. Straight and Level runs (ST & LV), Mode 03 – The ST & LV runs are primarily 2π scanner runs. The measurement of upper and lower hemisphere radiance distributions has top priority. One sky mode scanner pattern (192 seconds) plus one sun mode scanner pattern (64 seconds) are run at each altitude with each of the two optical filters.

   During ST & LV runs the aircraft should maintain a fixed heading, a constant indicated airspeed of 150 knots or less, and a 2½-degree nose-high flight attitude.

2. Vertical Profile runs (V-PRO), Mode 07 – The V-PRO runs are primarily integrating nephelometer and variable path function meter runs. The measurement of the total scattering coefficient profile has top priority. Second priority is measurement of the vertical path function profile. Each V-PRO ascent or descent is made using a single filter.

   During the V-PRO runs the aircraft should maintain a fixed heading, with the sun off the left wingtip, and a flight attitude not exceeding 4 degrees nose down or 8 degrees nose up.

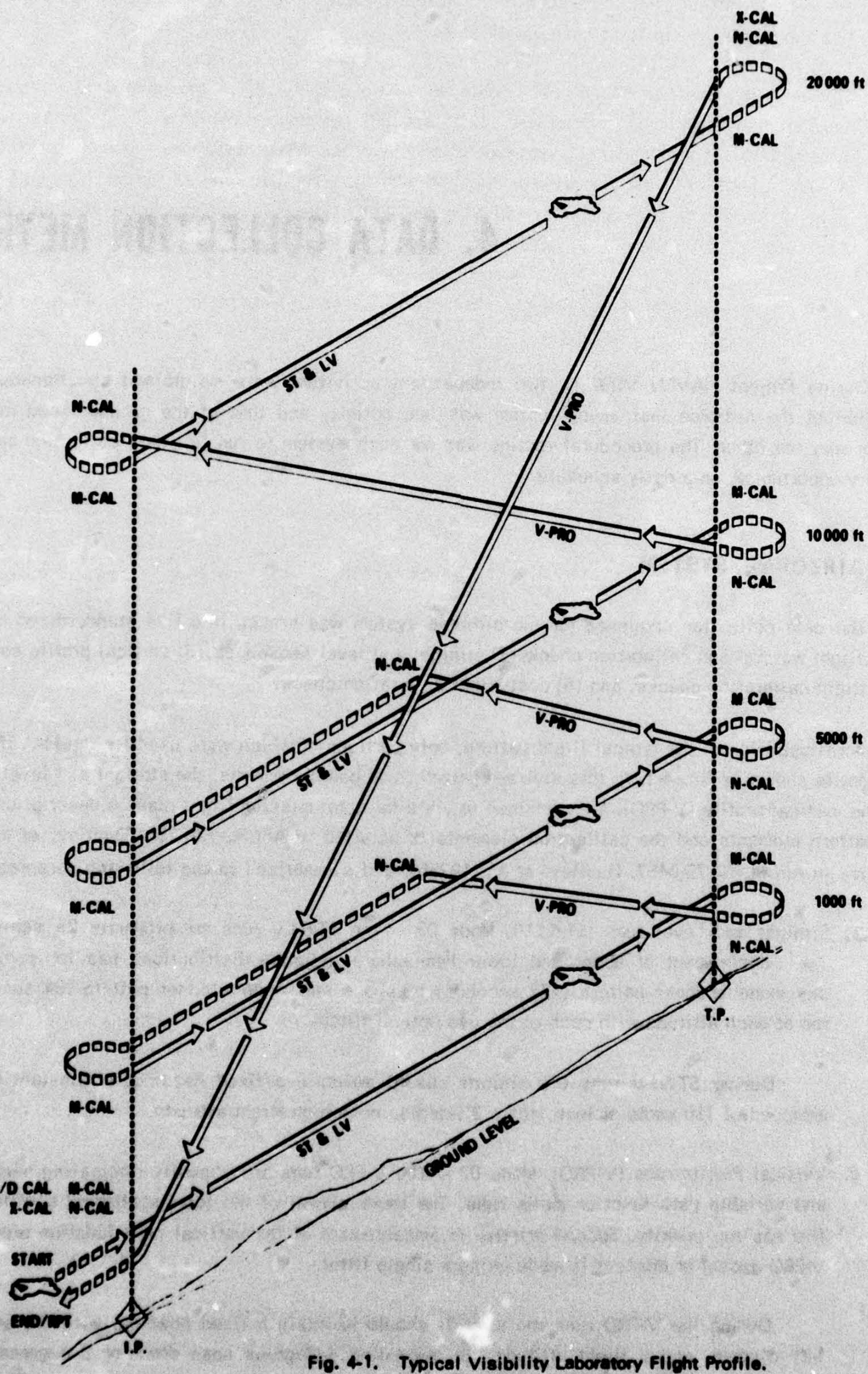

Fig. 4-1. Typical Visibility Laboratory Flight Profile.

An average rate of climb or descent of 1200 feet/minute is optimum, and airspeed is not critical, but should remain constant once established.

3. Cross-Calibration Climbs (X-CAL), Mode 08 – The X-CAL climbs are specifically designed to validate the performance of the UHS, LHS, and ERT radiometer systems. The simultaneous measurement of a common uniform segment of sky by these three radiometers has top priority. Two X-CAL climbs are associated with each standard profile, one preceding the first ST&LV run and the second following the last ST&LV run. Both sky mode and sun mode measurements are made with the UHS system.

   During the 4-minute X-CAL climb the aircraft should maintain a fixed heading, with the sun in the aft hemisphere, and a 5-degree nose-high flight attitude. The aircraft should be flown directly toward the clearest and most uniform portion of the sky as practical.

4. Calibration Blocks (A/D CAL), Mode 00, M-CAL, Mode 01, N-CAL, Mode 09 – The 32-second blocks of calibration data are inserted periodically throughout the entire data mission. They are designed to provide calibration update information to the post-flight computer processing sequences. There are 21 assorted calibration blocks associated with each (2 + 4) profile.

   During these calibration blocks there are no project-imposed requirements upon aircraft speed or attitude.

GENERAL FLIGHT PATTERN

The standard (2 + 4) profile is illustrated in Fig. 4-1. In this profile, ST&LV data runs are made using two different spectral filters at each of four altitudes. The ascent V-PRO is made using the first of the two filters, and the descent V-PRO is made using the second. After the descent V-PRO, the entire sequence is repeated using a second pair of filters.

The idealized flight profile would result in all ground tracks falling on a single line running between the Initial Point (I.P.) and the Turning Point (T.P.). See Fig. 4-1. In practice, the ST&LV elements are actually stacked in a slab of atmosphere approximately 30 miles long, 0.5 mile wide, and 4 miles high.

Periodically, in response to specialized data requirements or weather conditions, supplementary flight patterns are added to the mission profile. For HAVEN VIEW II, a pattern made up of an AVIZ (1 + 2) special descent, i.e., one spectral filter at each of two altitudes was used on five of the seven flights discussed in this report. The other two, C-273 and C-281 used an AVIZ (2 + 2) profile, i.e., two spectral filters at each of two altitudes. Both the (1+2) and (2+2) profiles are generally considered low altitude profiles, and are normally used on flights performed under a full overcast or low cloud deck.

The seven flights discussed in this report are all low altitude flights made under cloudy and overcast conditions. They were purposely chosen from the larger HAVEN VIEW II data bank to illustrate the cloudy, hazy, and overcast conditions which are typical of the real worlds' weather patterns.

At the conclusion of each mission, the radiometric data which were recorded and stored on magnetic tape were returned to the Visibility 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 ground-level data 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.

The ground-based data collection during Project HAVEN VIEW II was accomplished through the use of a fully instrumented truck van in a manner similar to that reported in AFCRL-72-0593, Duntley, *et al.* (1972c). The ground data log and experimental procedure were revised, prior to the HAVEN VIEW II deployment, to reflect a format more similar to the airborne log, and to include a more extensive preliminary check list.

The optimum procedure for the ground station is to complete at least one standardized data sequence during the interval that the aircraft is operating overhead, and to continue consecutive sequences until the aircraft leaves the area.

The standard ground-based sequence was built around three basic and readily interchangeable patchboard arrays designed for automatic 20-channel data logging:

1. The CRM Board, primarily for solar transmissometer data
2. The UHS Board, primarily for sky and solar surround data
3. The LHS Board, primarily for terrain reflectance data

Integrating nephelometer and downwelling irradiometer measurements are made and recorded continuously throughout all three of the basic patchboard sequences listed above.

HAVEN VIEW II GROUND-BASED DATA COLLECTION SEQUENCE

Ground-based data were collected in a fixed pattern on a repetitive basis during each designated data day. The standardized sequence consisted of the radiometric measurements as listed below:

1. Contrast Reduction Meter (CRM) Measurements
   - Total Downwelling Irradiance
   - Solar Disk Radiance
   - Shadow Intensity
   - Sky Radiance @ $\beta = 90$ degrees

2. Upper Hemisphere Scanner Measurements
Sky Radiances @ $2\pi\Omega$

3. Lower Hemisphere Scanner Measurements
Terrain Radiances @ $2\pi\Omega$

4. CRM Measurements listed in step 1.

Integrating nephelometer (NEPH) and downwelling irradiometer measurements were made and recorded continuously throughout all three of the basic sequences listed above, and constitute an additional data sequence of primary importance.

Project HAVEN VIEW II was not conceived as being a "fair weather" deployment even though the standard data sequence was organized to document this optimum condition should it occur. Thus, the majority of data sequences are not totally complete, but reflect through their ommisions, the transient and highly dynamic weather conditions encountered. Since the CRM data requires a clear unobscured sun, it is in short supply from this deployment. Conversely, since the NEPH data is independent of the environmental conditions, it is relatively abundant.

5. DATA PROCESSING

As in any reasonably complex, multi-input sampled data system, there is a large amount of data handling required before the scientific analyst ever sees the package. The degree of data processing sophistication utilized during this contract interval is illustrated in Fig. 5-1 and 5-2. In these generalized flow charts, the basic functional steps used in the data processing of the raw field data are clearly specified. They do not illustrate, however, all of the miscellaneous routines used for data base management and special diagnostic purposes. A more complete description of each phase of the processing sequence is contained in AFCRL-72-0255, AFCRL-72-0593, Duntley, *et al.* (1972a and c), and AFCRL-TR-75-0457, Duntley, *et al.* (1975b).

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 42-channel 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.

Several major improvements to the airborne data processing procedure have been implemented during the interval since AFCRL-72-0593, Duntley, *et al.* (1972c). The insertion of the programs summarized below into the general data processing schedule is illustrated in Fig. 5-1. These programs, and the increased diagnostic capabilities that their usage has enabled, have materially improved the quality of the upper hemisphere radiance maps, and thus the quality of all subsequently computed optical properties.

PROGRAM FLTDOC

Program FLTDOC was developed to help speed up the turnaround time required for preliminary evaluation of field data, and to provide a display to aid in the evaluation of the automatic sorting of the recorded raw data from each flight element. This program displays both tabularly and graphically each of the major flight elements (ST & LV and V-PRO) based upon the recorded identification codes, altitude, filter, and magnetic heading information. These displays permit quick classification of the flight data segments into sets which are processable and correspond to the parts of the "standard profile" described in Section 4. This early classification of the flight data permits very selective processing which insures that the analyst is provided with both an adequate representation of the flight's overall data quality and the ability to exercise close control of processing economies.

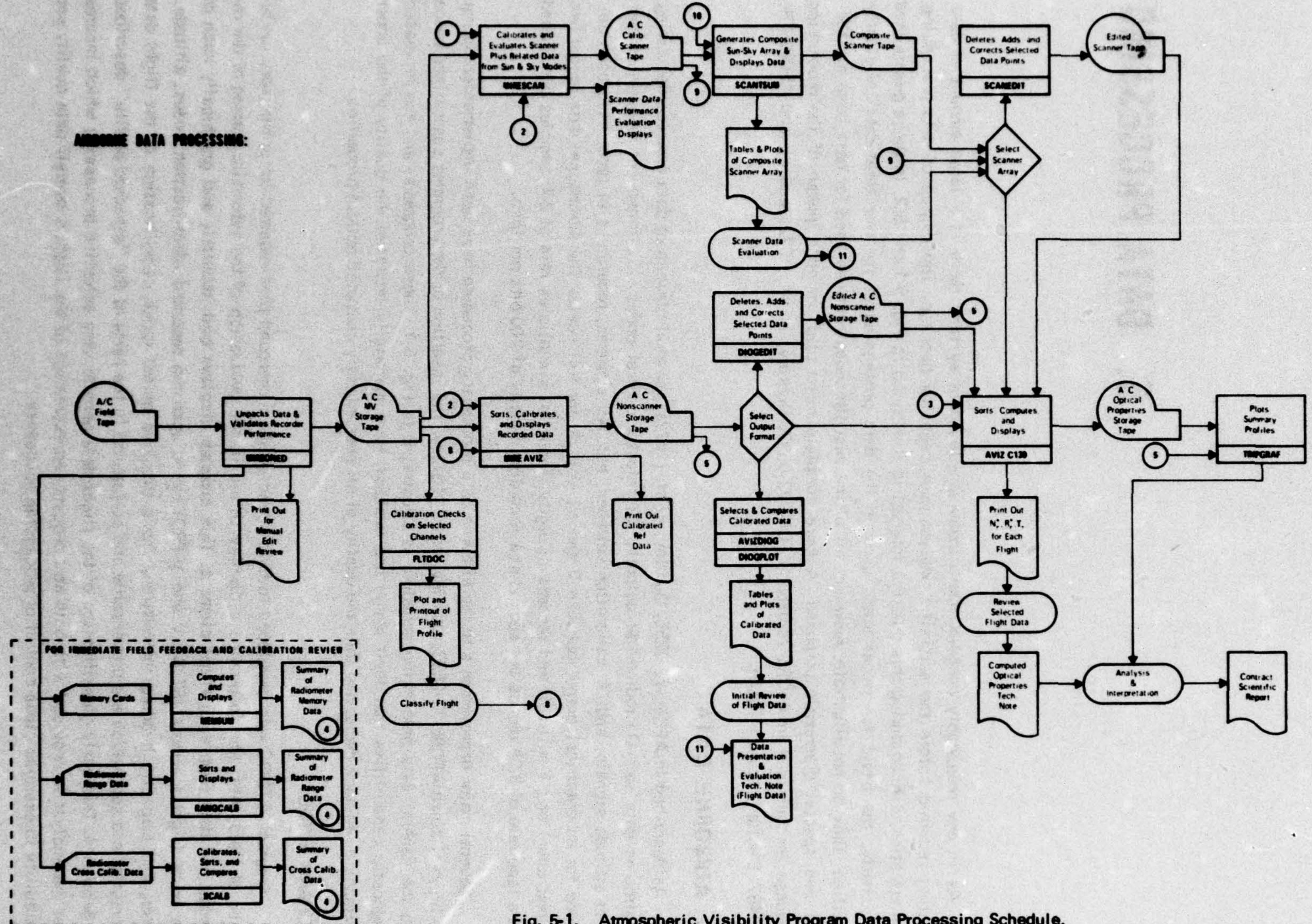

Fig. 5-1. Atmospheric Visibility Program Data Processing Schedule.

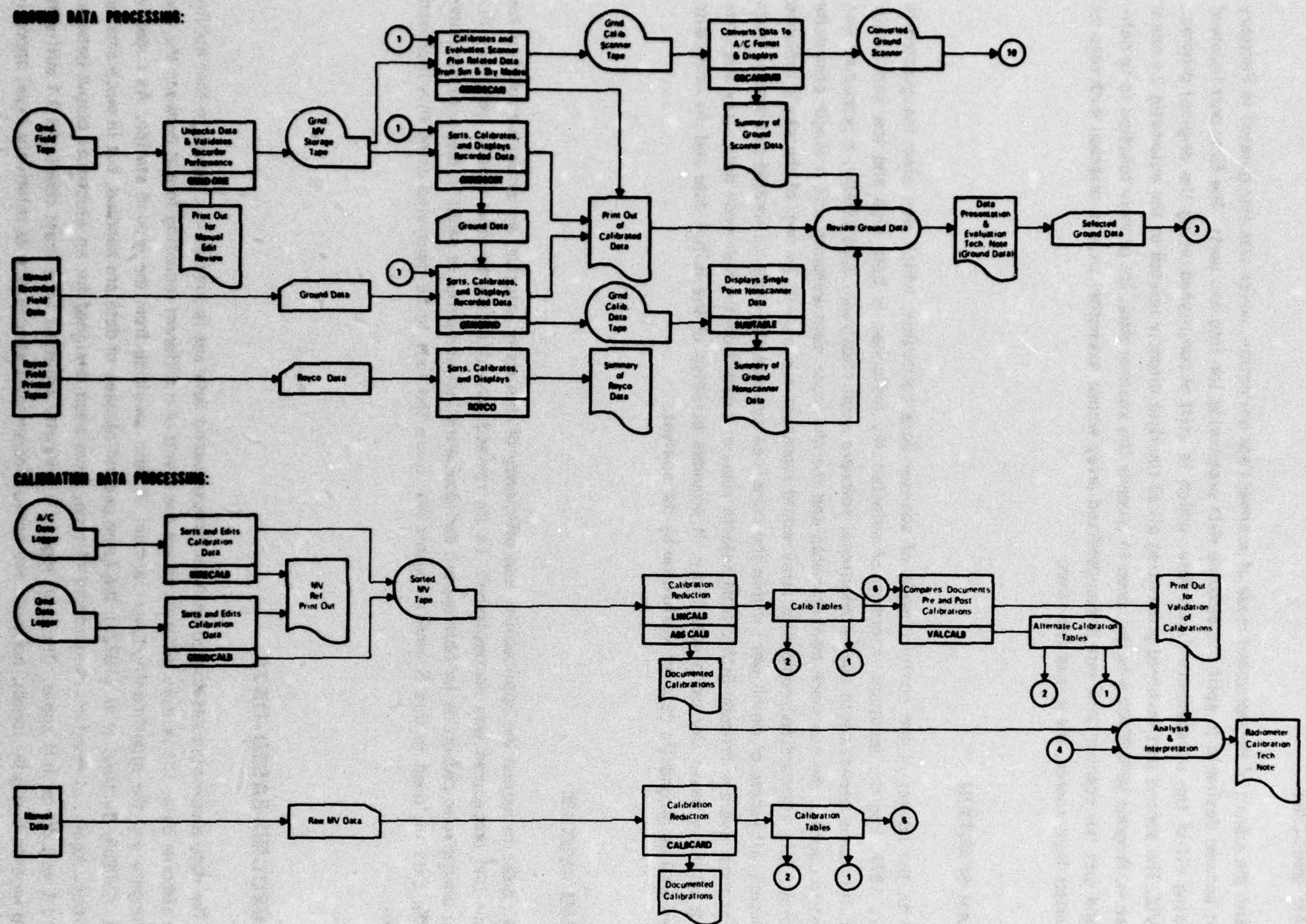

Fig. 5-2. Atmospheric Visibility Program Data Processing Schedule.

PROGRAM MIRESCAN

With the advent of the nonspiral mode of scanner data collection, which was inaugurated in February 1972, it became desirable to split the airborne data processing job into two parts. The first part involved processing all of the nonscanner-related data, which is still accomplished using the original program, MIREAVIZ. The second part involved processing all of the data directly related to the automatic 2π scanner system. Program MIRESCAN was designed to process the scanner data. Its primary function is to calibrate and sort the scanner data into a standardized array whose azimuthal axis is oriented with respect to the major light source, the sun or the moon.

PROGRAM SCANTSUM

With the advent of the sun/sky mode of scanner data collection, which was also inaugurated in February 1972, and the resultant recording of selected sky radiances in both high and low sensitivity ranges, it became necessary to devise additional software sophistications. Specifically, a procedure was required to combine the sun mode measurements and the sky mode measurements into a single composite data array. This standardized composite array would represent a complete 2π map of the sky's radiance distribution, all points of which were within the combined sun and sky mode calibrated radiometric span of the scanner system. Program SCANTSUM selects measured data from the sun mode data array and combines it with the basic sky mode data array. It provides displays of the initial data and the composite data, as well as diagnostic data for evaluation by the analyst.

PROGRAM AVIZC130

In order to extend the applicability and efficiency of this major program, an extensive redefinition of terms and procedures was accomplished. In its revised form this program now readily computes the optical atmospheric properties for both upward and downward inclined paths of sight in the same computer run. The data included in this Scientific Report No. 6 are the first to be generated using this improved routine.

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 relatively slow, approximately eight samples per second.

Since the ground-based automatic 2π scanner system is operationally equivalent to the airborne, a similar data processing update was required to efficiently handle the sun/sky mode data from the ground-based upper hemisphere scanner. Consequently, Programs GRNDSCAN and GSCANSUM were developed to convert the ground scanner data, which are recorded at a much slower rate than the airborne data, into a format compatible with the airborne data processing routines. Subsequent to conversion, Program SCANT-SUM can now be used to generate the composite array of ground-based sun and sky radiance data in the same manner as it does for the airborne data. Thus, in subsequent computational routines, data arrays from either airborne or ground-based upper hemisphere scanner systems can be used interchangeably.

The insertion of the programs discussed above into the general data processing schedule is illustrated in Fig. 5-2.

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 recorded on tape in an effort to eliminate the human bias and are 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. For final processing, the data are sorted and stored in set fashion.

Programs LINCALB and ABSCALB perform the data reduction of all raw radiometer calibration data which have been recorded on magnetic tapes, and Program CALBCARD performs the same function on manually recorded data. These programs generate "standard radiometer calibration" card decks which are used in the documentation and comparison modes of Program VALCALB. The documentation and comparison mode outputs are used to describe the quality of each pre-deployment and post-deployment set of calibration data generated, and to aid in the selection of the preferred calibration data which are ultimately applied to the field measurements.

Since many of the radiometer systems can be calibrated and used in either a high or low sensitivity range, a procedure is required to adjust the calibration constants whenever a field measurement is made in a different mode from that used during calibration. Program VALCALB handles this procedure by generating an "alternate radiometer calibration" card deck which has the high/low sensitivity range change for each radiometer built in. Thus field data from any radiometer can be correctly processed regardless of which sensitivity range was actually used by merely specifying the "standard" or "alternate" calibration card deck.

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. To simplify future retrieval, the data tape numbers, the in-house descriptions of the data, and the computed properties reported herein have been summarized in Table 5-1.

Table 5-1

Processed Data Library Tapes

HAVEN VIEW II Flight No.	MIREAVIZ Tape No. 338G File No.	MIRESCAN Tape No. 324G File No.	Data Presentation No.	AVIZC130 Tape No. 323G File No.	Computed Properties No.
C-273	1	1	87	1	94
C-279	2	2	88	2	95
C-280	3	3	89	3	96
C-281	4	4	90	4	97
C-282	5	5	86	5	93
C-288	6	6	91	6	98
C-289	7	7	92	7	99

Since the ground-based automatic 2π scanner system is operationally equivalent to the airborne, a similar data processing update was required to efficiently handle the sun/sky mode data from the ground-based upper hemisphere scanner. Consequently, Programs GRNDSCAN and GSCANSUM were developed to convert the ground scanner data, which are recorded at a much slower rate than the airborne data, into a format compatible with the airborne data processing routines. Subsequent to conversion, Program SCANT-SUM can now be used to generate the composite array of ground-based sun and sky radiance data in the same manner as it does for the airborne data. Thus, in subsequent computational routines, data arrays from either airborne or ground-based upper hemisphere scanner systems can be used interchangeably.

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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, National Meteorological Center. The charts were obtained from the National Climatic Center in Asheville. Portions of these charts have been reproduced as figures 6-1. The surface charts were for 6-hour intervals and the 500-millibar charts were for 0000 GMT and 1200 GMT. Also utilized were radiosonde data from Meppen.

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. Tabular data of the hourly observations were not available.

During the period of deployment the weather conditions were far from optimum. Most of the days when flights were conducted were partly cloudy to overcast, often with several layers of clouds. This season was chosen to coincide with HAVEN VIEW I when similar conditions were present.

During the period 9 May to 15 June 1973, there was a series of frontal passages. In early June there was a series of occlusions which moved through Britain and into France and dissipated accompanied by widespread precipitation. While these fronts did not pass Meppen, their effects precluded operations. In addition, there were days when the marine flow from the North Sea brought low clouds and fog over the operating area.

Also included in this section are graphical representations of ambient temperature measured during each reported data flight (Fig. 6-2). The temperatures were measured continuously by an AN/AMQ-17 aerograph system described briefly in AFCRL-70-0137, 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 data were measured; i.e., the temperature profile identified with the Filter 4A symbol was taken during the same time interval as the Filter 4A radiometric measurements; the temperatures coded as Filter 4B were taken simultaneously with the Filter 4B radiometric measurements, etc. Meppen, the radiosonde site, was located at the western end of the flight track. Superimposed on each graph are the radiosonde temperatures for 700 and 1300 GMT as recorded at Meppen. There were no radiosonde data available for 3 June 1973 for Flight C-279.

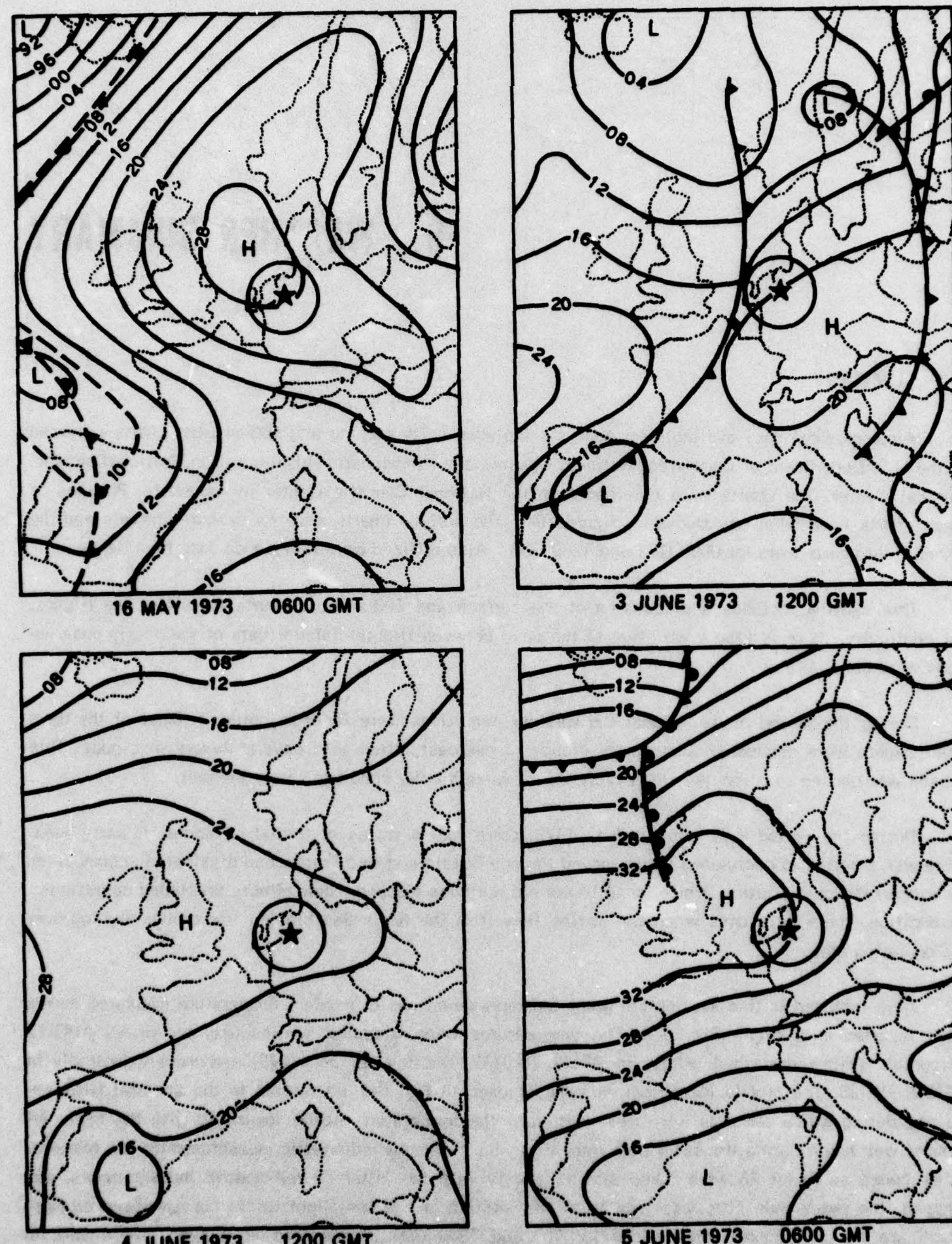
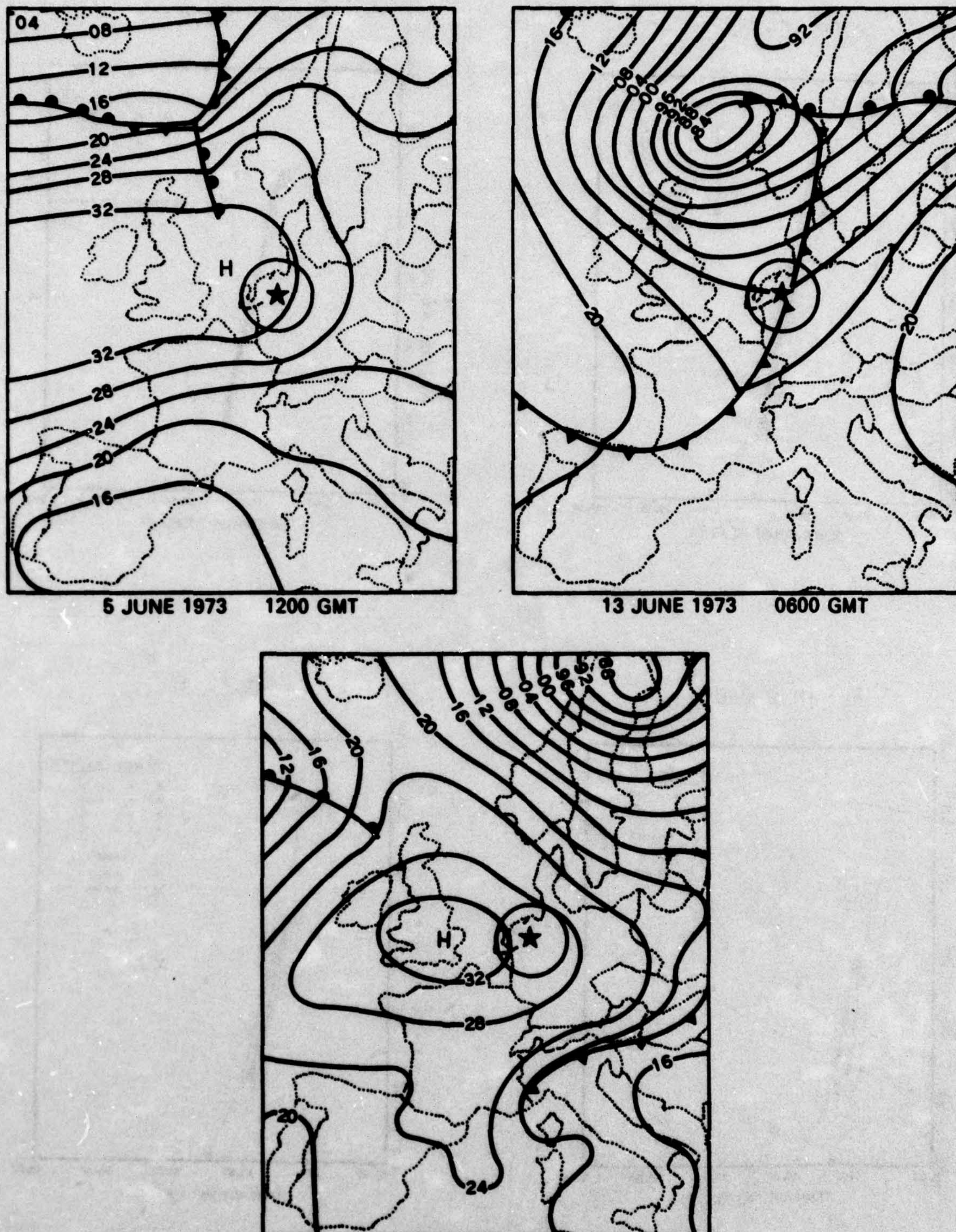


Fig. 6-1a. Synoptic Charts of Meppen Area During Project HAVEN VIEW II.



5 JUNE 1973 1200 GMT

13 JUNE 1973 0600 GMT

14 JUNE 1975 1200 GMT

Fig. 6-1b. Synoptic Charts of Meppen Area During Project HAVEN VIEW II.

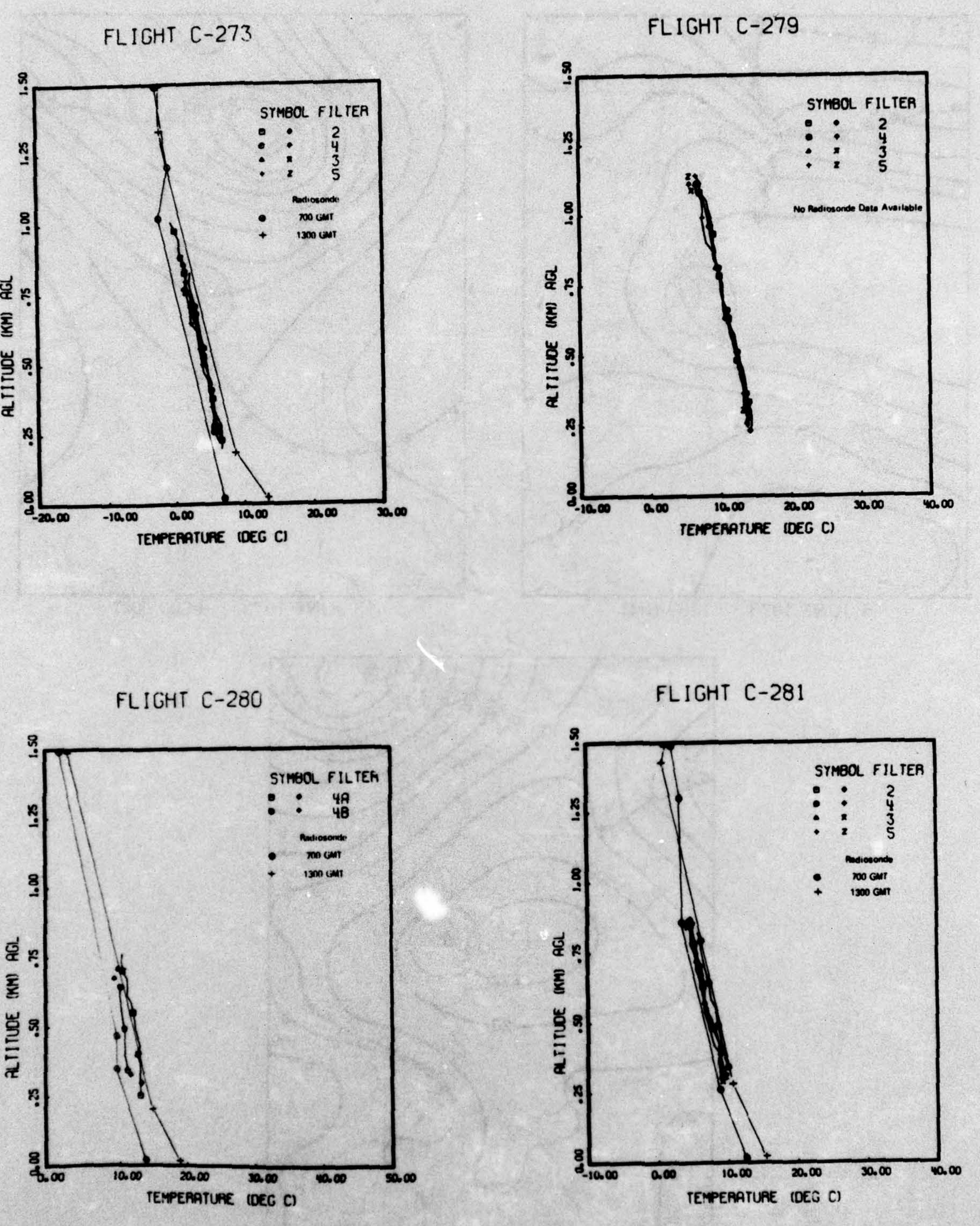


Fig. 6-2a. Temperature Versus Altitude for Seven Project HAVEN VIEW II Flights.

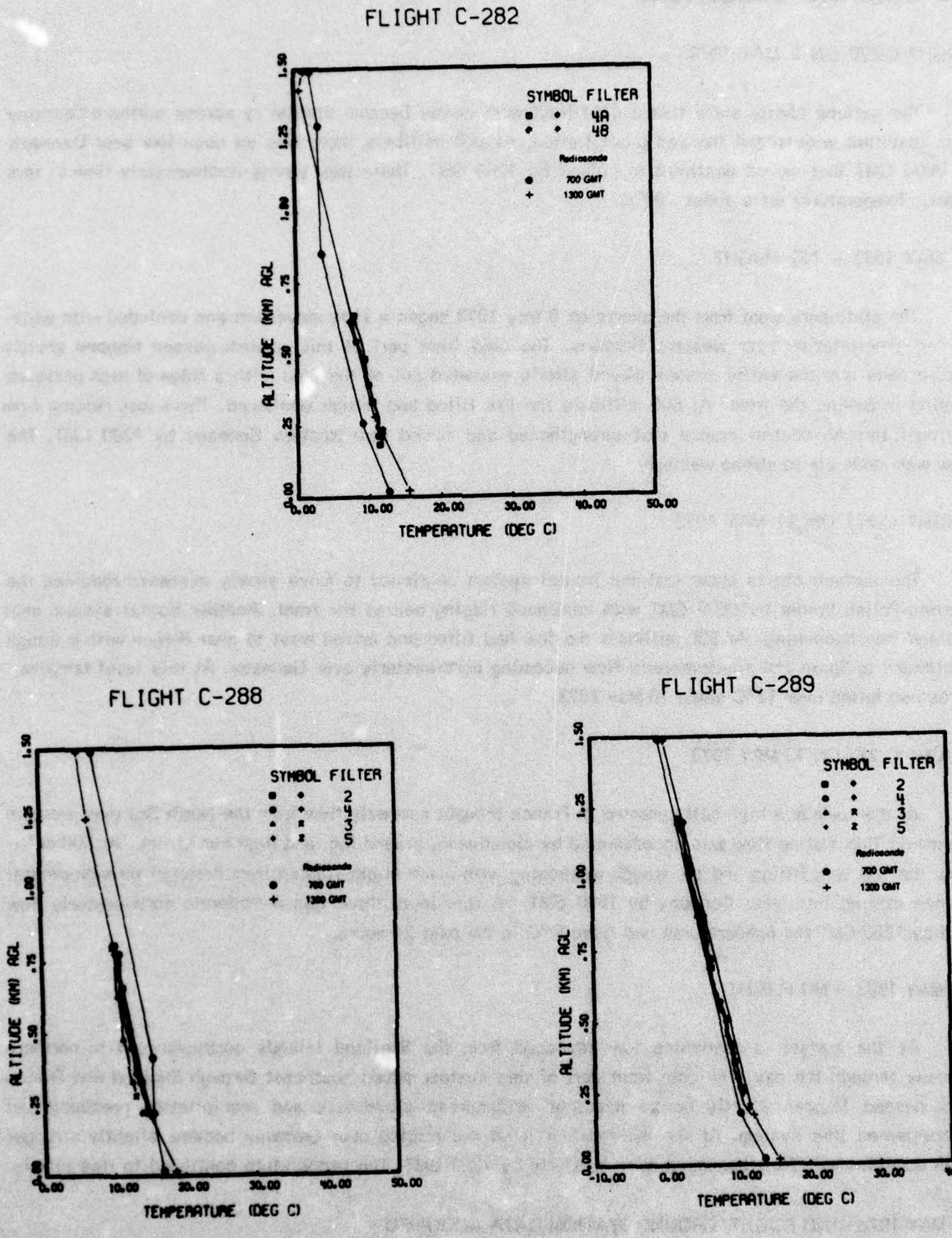


Fig. 6-2b. Temperature Versus Altitude for Seven Project HAVEN VIEW II Flights.

6.2 SYNOPTIC CONDITIONS

FLIGHT C-270 ON 9 MAY 1973

The surface charts show that a cold front with waves became stationary across northern Germany with resultant widespread fog and precipitation. At 500 millibars there was an open low over Denmark at 0000 GMT that moved eastward to Poland by 1200 GMT. There was strong northwesterly flow at this level. Temperatures were about −20°C.

10 MAY 1973 – NO FLIGHT

The stationary front from the charts on 9 May 1973 began a slow movement and occluded with widespread precipitation over western Germany. The cold front part of this system passed Meppen shortly before noon and the entire system moved slowly eastward out of the area with a ridge of high pressure moving in behind the front. At 500 millibars the low filled and trough weakened. There was ridging from Portugal through central France that strengthened and moved into western Germany by 1200 GMT. The flow was moderate to strong westerly.

FLIGHT C-271 ON 11 MAY 1973

The surface charts show that the frontal system continued to move slowly eastward reaching the German-Polish border by 0600 GMT with continued ridging behind the front. Another frontal system near Iceland was deepening. At 500 millibars the low had filled and moved west to near Bergen with a trough southward to Spain and southwesterly flow becoming northwesterly over Germany. At this level temperatures had fallen over 12°C since 10 May 1973.

FLIGHT C-272 ON 12 MAY 1973

At the surface a high cell centered in France brought northerly flow from the North Sea over western Germany. This marine flow was accompanied by cloudiness, ground fog, and high humidities. At 500 millibars the low was filling and the trough weakening with some slight ridging from Portugal through central France moving into west Germany by 1200 GMT. At this level there was a moderate northwesterly flow and by 1200 GMT the temperatures had risen 9°C in the past 24 hours.

13 MAY 1973 – NO FLIGHT

At the surface a deepening low advanced from the Shetland Islands northeastward to northern Norway through the day. The cold front part of this system moved southeast through England and France and passed Meppen shortly before midnight. Widespread cloudiness and precipitation preceded and accompanied this system. At the 500-millibar level the ridging over Germany became slightly stronger with northwesterly flow becoming more westerly by 1200 GMT. The temperature continued to rise slowly.

14 MAY 1973 – NO FLIGHT, GROUND STATION DATA ACQUIRED

The cold front that passed Meppen shortly before midnight continued its southeasterly movement throughout the day. As the front moved southward ridging from a high in Ireland extended eastward to northern Germany. With the maritime flow came low clouds and precipitation. At 500 millibars the ridge weakened slightly but strong westerly flow continued over western Germany.

15 MAY 1973 – NO FLIGHT, GROUND STATION DATA ACQUIRED

At the surface a 1031-millibar high was centered near Galway with ridging into northern Germany at 0000 GMT. This high center moved east through the day with Meppen in the southeast quadrant of the cell. A deepening low was centered south of Iceland with associated frontal system. By 1800 GMT a stationary front extended from Bordeaux to Bucharest.

At 500 millibars a trough appeared from Scandanavia southward to Germany with strong westnorthwesterly flow. By 1200 GMT there was ridging from Ireland to Iceland.

FLIGHT C-273 ON 16 MAY 1973

The surface charts show high pressure over most of western Europe except the Iberian peninsula. By 1800 GMT the high began to move northeasterly. The Atlantic storm has progressed eastward with an occlusion through extreme southwestern France and northeastern Spain extending to Mallorca and Algiers. At 500 millibars there was a closed low in the Baltic Sea and ridging from Britain to Spain. Through the day both the ridge and trough became more pronounced. There was a moderately strong northwesterly flow over Germany. The temperature rose 3.6°C from 0000 to 1200 GMT.

FLIGHT C-274 ON 17 MAY 1973

At the surface the high continued to move slowly eastward. Because of the slow movement of the high, the occlusion also moved slowly until 1800 GMT when it was along a line from London to Venice. At 500 millibars there was a ridge from France to the North Sea that weakened and moved to a line from Italy to the North Sea by 1200 GMT. There was also a trough from the Baltic to the Adriatic that showed little movement but lessened in intensity through the day. The flow was light to moderate northerly. The temperature continued to rise through the day at this level.

18 MAY 1973 – NO FLIGHT, GROUND STATION DATA ACQUIRED

At the surface there was little movement of the occlusion because a ridge continued to block. This ridge extended from Sweden through northern Germany. Through the day the front became stationary and the ridge weakened. There was southerly flow over northwestern Germany. At 1800 GMT there was a deepening low 350 miles west of the Iberian peninsula and a low centered in northeastern France. At 500 millibars there was a ridge from Italy into southern Germany, a high in the North Sea and a low in Latvia. North Germany was in a col with weak gradient. There was little change through the day except that the temperature began to fall.

19 MAY 1973 – NO FLIGHT

During the day an occlusion moved through Portugal into western Spain. Over the Meppen area the flow shifted from southerly to easterly. At 500 millibars the ridges weakened and the lows began to merge. There was a moderate westerly flow. At 1200 GMT there was a low in the North Sea and another west of France.

20 MAY 1973 – NO FLIGHT

The occlusion continued to move northeastward from Spain through France and into the English Channel where it weakened. Ahead of the front there was widespread fog and precipitation in western Germany. At 500 millibars the low in the North Sea has merged with the one in the Atlantic. There was southerly flow over Germany.

21 MAY 1973 – NO FLIGHT, GROUND STATION DATA ACQUIRED

The front has disappeared from the surface chart and there was a weak southerly flow over Germany with weak gradients. A low centered 200 miles southwest of Ireland became stationary and filled. At 500 millibars the Atlantic low moved eastnortheastward and was centered southwest of Ireland. There was light southerly flow over Germany.

22 MAY 1973 – NO FLIGHT

The occlusion was restored to the surface charts and moved from the eastern border of Portugal eastward to a position along the Paris-Lyon-Barcelona line at 1800 GMT. This front was accompanied by thunderstorms in the northern portions. There was a weak gradient and easterly flow over Germany. At 500 millibars the Atlantic low remained stationary and filled slightly. The flow was southwesterly becoming westerly over Germany. Temperatures were slightly lower.

23 MAY 1973 – NO FLIGHT

The occlusion continued to move eastward through Germany during the day, passing Meppen around 0000 GMT. Widespread low cloudiness continued with the maritime flow from the North Sea. At 500 millibars there was ridging from Italy to the North Sea that moved eastward to a position from the Baltic to the Adriatic by 1200 GMT. The flow over Germany was moderate southwesterly.

24 MAY 1973 – NO FLIGHT

At the surface a 1024-millibar high in central Portugal caused ridging over most of western Europe. The center of the high moved to near Paris by 1800 GMT. There was an open low in the North Sea north of the Netherlands. Meppen was in westerly flow which brought maritime air from the North Sea and widespread precipitation. At 500 millibars there was a low in the North Sea with a weak trough southeastward through Germany. The flow shifted from weak southwesterly to weak northwesterly.

25 MAY 1973 – NO FLIGHT

At the surface an occlusion in the Atlantic continued to move eastward towards Portugal. A 1028-millibar high moved from Paris to The Hague during the day. This high cell dominated western Europe. At 500 millibars there was ridging over western Europe with northwesterly flow over Germany.

FLIGHT C-275 ON 26 MAY 1973

On the 0000 GMT surface chart a 1029-millibar high centered near Meppen was blocking eastward movement of the front in the Atlantic. By 0600 GMT the high began to move slowly eastward and the cold front moved to western Spain by 1200 GMT and to central Spain by 1800 GMT. After noon Meppen was in the southwestern quadrant of the high. At 500 millibars there was a ridge from Morocco to Scandanavia which built slightly through the day. The flow over Germany was northwest changing to northerly.

FLIGHT C-276 ON 27 MAY 1973

A dissipating occlusion moved through southern Britain and France on the morning surface charts. Meppen remained on the back side of the high in southeasterly flow. At 500 millibars there was little change in position or intensity of the ridge that extended from Scandanavia to Morocco. A blocking low in Romania prevented movement. The Meppen area was in northerly flow. Temperatures aloft rose through the day.

FLIGHT C-277 ON 28 MAY 1973

On the surface charts a high was centered near Copenhagen with Meppen on the southwestern quadrant. During the day the high began to weaken slightly. At 500 millibars there was a slight weakening of the ridge and a weakening of the gradient with resulting weak southerly flow over northwest Germany.

FLIGHT C-278 ON 29 MAY 1974

An occlusion moved through Ireland and Britain into western France accompanied by widespread cloudiness and precipitation. Meppen remained in southerly flow in advance of the front but low clouds commenced in the forenoon. At 500 millibars the stationary ridge weakened slightly with the Meppen area still in moderate southerly flow.

30 MAY 1973 – NO FLIGHT

On the 0000 GMT surface chart the occlusion was near Meppen. Through the day this system moved slowly eastward and dissipated. By 1800 GMT another occlusion was approaching the French coast. Widespread precipitation accompanied both of the occlusions. At 500 millibars there was a gradual weakening of the ridge with a slow eastward movement. At 1200 GMT the axis of the ridge was on a line from the Baltic to Italy. There was southerly flow over Germany.

31 MAY 1973 – NO FLIGHT

On the surface charts an occlusion moved from a line in northwestern France to northern Spain eastward passing Meppen shortly before 1800 GMT. Widespread precipitation preceded and accompanied this front. By 1800 GMT there was wave development in Portugal on the cold frontal portion of this same storm. At 500 millibars there was a deepening trough off France and Spain. There was also a high in the Baltic that moved very slowly eastward through the period. There was strong southwesterly flow over northwest Germany.

1 JUNE 1973 – NO FLIGHT

Precipitation continued after the passage of the occlusion as shown on the surface charts. There was little change in the position or intensity of the cold frontal portion of the storm. Wave development continued and by 1800 GMT the position of the front was along a line Berlin-Saarbrucken-Dijon-Gibraltar. A new occlusion was approaching Ireland. At 500 millibars a trough from Scotland to Spain moved slowly eastward. Also, a ridge from the Baltic to the Adriatic moved eastward slowly. Over northwestern Germany there was a strong northerly flow.

2 JUNE 1973 – NO FLIGHT

The surface charts show that precipitation and fog continued in western Germany with the cold front moving very slowly and becoming diffuse through the day. A new occlusion was located on a north-south axis through central Britain at 0600 GMT. The occlusion moved eastward and a cold front with waves moved into eastern England. By 1800 GMT the cold front was becoming diffuse. At 500 millibars there was a trough from Britain to Portugal which filled slowly and retreated westward through the day. There was also a ridge from Italy to the Baltic that weakened through the day. Over northwestern Germany there was southsouthwesterly flow.

FLIGHT C-279 ON 3 JUNE 1973

On the 0000 GMT surface chart a diffuse cold front extended along the London-Le Harve-La Rochelle line and there was a weak low in southern Germany. This front moved eastward and became more diffuse through the day disappearing completely from the 1800 GMT chart. At 500 millibars there was a low southeast of Iceland with a trough extending through Ireland and west of Portugal. The low moved slowly eastward and filled slightly with the axis of the trough moving to a line from Scotland to Gibraltar on the 1200 GMT chart. There was a ridge from the Adriatic to the eastern Baltic which built and moved slowly east into western Russia. The flow over northern Germany was moderate to strong southwesterly.

FLIGHT C-280 ON 4 JUNE 1973

The surface charts show that western Europe was in a col early in the day. By the 1200 GMT chart there was ridging over France and Germany from a high in the Atlantic. At 500 millibars the low and trough from the charts on the third were stationary and filling. The high ridge was also stationary and was blocking eastward movement of the trough. Flow over northwestern Germany was moderate southwesterly.

FLIGHT C-281 AND C-282 ON 5 JUNE 1973

The surface charts show that ridging over France and West Germany became stronger through the day. At 500 millibars the trough still remained stationary and continued to fill. The high also remained stationary but began to weaken. A breakoff low in Spain deepened through the day. By 1200 GMT the trough had moved to a position over northern France and Germany and continued to fill. The flow over northern Germany was west to northwest.

FLIGHT C-283 ON 6 JUNE 1973

High centered near London dominated western Europe and diminished slightly in size through the day and the center moved to Ireland. At 500 millibars there was little change in the Spanish low until 1200 GMT when it began to deepen. There was a trough from the Baltic through Germany and Poland with moderate northerly flow over northwestern Germany. There was also a high centered off Ireland and a closed low over East Germany by 1200 GMT. Temperatures were 4 degrees warmer than on 5 June 1973 at this level.

FLIGHT C-284 ON 7 JUNE 1973

The high centered in Ireland dominated western Europe and began to show signs of weakening on the 1800 GMT chart. A low in western Spain deepened through the day. At 500 millibars the low in East Germany began to deepen and drift southwest. The high remained over Ireland. There was strong northeasterly flow over western Germany.

FLIGHT C-285 ON 8 JUNE 1973

The low in Spain filled throughout the day and the ridge began to slowly withdraw from western Europe. At 500 millibars the low that was in Germany moved southwest to Switzerland. There was a moderate northeasterly flow. The flight was aborted because of a low overcast cloud deck.

9 JUNE 1973 – NO FLIGHT

The ridge of high pressure remained over western Europe and showed signs of weakening. On the 1200 GMT chart there was a low centered near the Faroe Islands with an associated frontal system extending southwest. By 1800 GMT the low had deepened and an occlusion extended from ship "M" to the Orkney Islands, then southwest as a cold front through northern Scotland and across the Atlantic. In the warm air mass ahead of the front there were low clouds and fog in northern Germany. At 500 millibars there was a trough from Poland through Italy and ridging from France into Germany. The flow was moderate northerly.

10 JUNE 1973 – NO FLIGHT

The surface low continued to deepen as it moved eastward to the Scandanavian peninsula. The frontal system associated with the low moved southeastward and passed Meppen shortly before noon. Low clouds and precipitation preceded and accompanied the front. At 500 millibars there was a filling low north of Iceland with a trough from Scandanavia to the Adriatic. There was another low west of Gibraltar. Over northern Germany there was strong westnorthwesterly flow.

FLIGHT C-286 ON 11 JUNE 1973

The surface charts show ridging building over France and Germany throughout the day. At 500 millibars a low moved east along the Arctic circle to off the coast of Norway. Another low was centered near Gibraltar and a col off France. There was a strong westnorthwesterly flow.

FLIGHT C-287 ON 12 JUNE 1973

The surface charts show a ridge from the Atlantic northeastward through France and into Poland. A low centered near the Faroe Islands deepened throughout the day. The frontal system associated with this low moved southeastward through the British Isles and Ireland and reached Meppen about midnight. Ahead of the front in northwestern Germany there was some ground fog and scattered clouds. At 500 millibars the low off Norway and the low in Spain filled throughout the day. There was a high in southern Poland that moved slowly eastward. There was moderate westerly flow.

FLIGHT C-288 ON 13 JUNE 1973

On the surface charts the cold front that passed Meppen shortly before midnight moved slowly southeastward and became diffuse. Behind the front, ridging moved in over France and Germany. At 500 millibars the low moved into Finland. There was a high in southern Poland that began to move slowly eastward. By 1200 GMT there was a deepening low off Bergen. The flow was moderate to strong southwesterly.

FLIGHT C-289 ON 14 JUNE 1973

On the surface charts there was a high centered south of Ireland that moved eastward to near The Hague by 1800 GMT. A ridge was building over France and Germany. With increasing flow from the northwest at all levels moisture was brought in from the North Sea and caused increasing cloudiness throughout the day. At 500 millibars there was a ridge of high from the Iberian peninsula across France to Poland and eastern Russia. The flow was strong northwesterly.

FLIGHT C-290 ON 15 JUNE 1973

There was little change on the surface charts. The high drifted slowly eastward and moisture from the North Sea at all levels caused widespread cloudiness over northwestern Germany. At 500 millibars ridging continued together with strong to moderate northwesterly flow.

7. DATA PRESENTATION

7.1 AIRBORNE DATA AND FLIGHT SUMMARY

Between 9 May and 15 June 1973, 21 flights were made in northern Germany. Twelve of these flights contain usable data profiles. Seven are low altitude flights, below overcast or scattered clouds; data for these flights are reported herein. The remaining five flight profiles are for high altitude; data for these flights have not yet been processed.

The seven flights were conducted in northern Germany on a flight track between Lathan and Oldenburg (see Fig. 1-4). The center of the flight track was 7°45' E longitude, 53°02' N latitude, 20 meters mean sea level. The terrain beneath the flight track was low lying and flat, mostly cultivated farmlands interspersed with dark patches of dense woods.

PHOTOGRAPHIC DOCUMENTATION

Sky and terrain conditions encountered during the data flights were documented photographically during each straight and level flight sequence, at each of two designated altitudes per filter. On sunlit days the documentary photographs were taken simultaneously with the measurements made by the upper hemisphere scanner in the sun mode. On overcast days the photographs were taken simultaneously with the measurements of sky and terrain radiance.

The photographs illustrating sky and terrain conditions during each of the seven flights have been examined and classified with respect to discernible cloud conditions. A summary of these general cloud and terrain descriptions is presented in Table 7-1.

There are three flights for which the pictures show scattered clouds or a broken cloud deck above the highest flight altitude, but with the sun unobscured during significant portions of each flight. There are four flights with predominantly full overcast at all or most altitudes.

Photographs illustrating typical sky and terrain conditions during two of the seven flights reported herein are shown in Fig. 7-1. 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 were taken from only low altitude on Flight C-288 and from both the high and low flight altitudes for each of the four flight profiles on Flight C-289. The pictures representing flight profile C-288, filter 4, illustrate the full overcast condition. The pictures representing Flight C-289, filter 4, indicate the scattered to broken clouds with unobscured sun.

Table 7-1

Summary of Hemispherical Pictures

Flight No.	General Description of Pictures for Flight	Filter	Upper Hemisphere		Lower Hemisphere	
			Low Altitude	High Altitude	Low Altitude	High Altitude
C-273	Broken cloud deck changing to scattered clouds	4	Broken deck	Scattered on horizon	Mostly under shadow, fields	Scattered shadow, fields
		5	Scattered clouds	Scattered on horizon	–	Broken shadow, fields
		2	Scattered on horizon	Scattered clouds overhead	Some shadow near horizon, fields	Broken shadow, fields
		3	More clouds on horizon	Scattered clouds	Less shadow near horizon, fields	Scattered shadow, fields
C-279**	Overcast	2	–	–	–	–
		3	Thick overcast	Thin overcast	Clear*, fields	Hazy, fields
C-280**	Overcast	4A	Overcast	Overcast	Clear, fields with small patches of woods	Haze, fields
		4B	–	–	–	–
C-281**	Overcast	4	Overcast	Overcast	Clear, fields	Hazy, fields
		5	–	–	–	–
C.282**	Thin overcast changing to scattered clouds	4A	Thin overcast, sun spot visible	Scattered clouds, sun behind thick cloud	Clear, fields	Nearly complete shadow, fields
		4B	Scattered clouds, sun behind thick cloud	Scattered clouds, sun behind clouds	Broken shadows, fields	Scattered shadow, fields
C-288	Slightly broken cloud deck changing to full overcast	4	Slightly broken cloud deck	–	Clear, fields	–
		5	Overcast (multilayer)	–	Clear, fields	–
		2	Overcast	–	Clear, fields	–
		3	Overcast	–	Clear, fields	–
C-289	Overcast changing to broken or scattered clouds	2	Broken clouds	Overcast	Mostly shadow, fields	Mostly shadow, fields
		3	Scattered clouds	Broken clouds	Mostly clear, fields	Half shadow, fields
		4	Scattered clouds	Broken clouds	Mostly clear, fields	Some shadow, fields
		5	Scattered clouds	Scattered clouds	A little shadow, fields	Scattered shadow, fields

*In lower hemisphere, the term "clear" means there are no distinct, well-defined cloud shadows.

**Upper hemisphere lens cover contaminated making it difficult to distinguish a clear sky from a high thin overcast.

RADIOMETRIC DOCUMENTATION

Table 7-2 contains a summary of pertinent descriptive information on the seven flights for which radiometric data are reported herein. The flight numbers are sequential. The times under the total time of data-taking column are Greenwith mean time (GMT) and local civil time (LCT). The LCT is equal to GMT+1. 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 column 11 were used in Eq. 2.9, 2.25, and 2.39 during the calculations leading to the derivation of path radiance and path reflectance. The maximum flight altitude is noted in column 12 and the maximum computed sensor or object altitude in column 13.

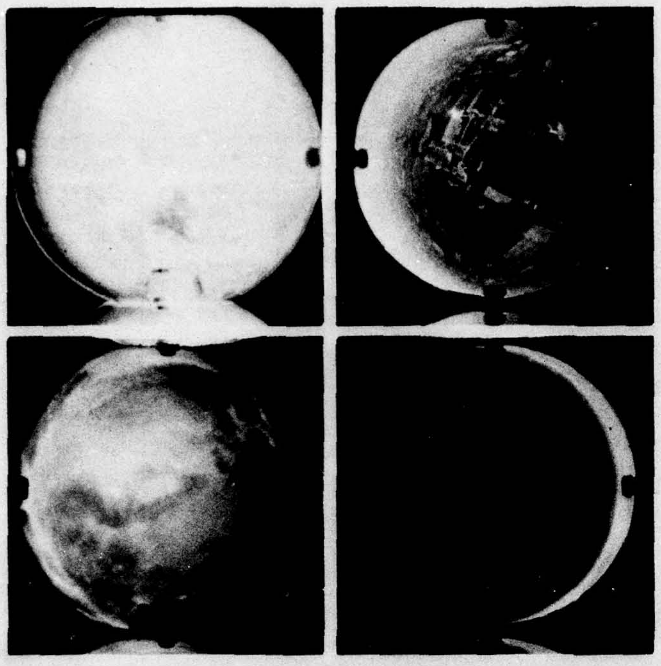
Table 7-2

Flight Data Summary

		Total Time of Data Taking					Sun Zenith Angle (degrees)					
		Start		End								
Flight No.	Date (1973)	GMT	LCT	GMT	LCT	Filter	Start	Transit	End	Average	Maximum Flight Altitude (meters AGL)	Maximum Sensor or Object Altitude (meters AGL)
C-273	16 May	758	858	833	944	4,5	52.1	–	48.4	50.3	840	1050
		844	944	922	1022	2,3	45.9	–	42.3	44.1	1020	1050
C-279	3 June	1108	1208	1120	1220	2	30.9	–	30.7	30.8	1116	1200
		1140	1240	1152	1252	3	30.8	–	31.1	30.9	1110	1200
C-280	4 June	1616	1716	1628	1728	4A	61.7	–	63.3	62.5	750	750
		1736	1836	1744	1844	4B	73.6	–	74.6	74.1	673	750
C-281	5 June	855	955	923	1023	4,5	41.9	–	39.3	40.6	863	900
C-282	5 June	1618	1718	1629	1729	4A	61.8	–	63.4	62.6	610	600
		1705	1805	1716	1816	4B	68.8	–	70.3	69.6	613	600
C-288	13 June	1150	1250	1158	1258	4	30.1	–	30.3	30.2	808	900
		1211	1311	1219	1319	5	30.9	–	31.3	31.1	810	900
		1234	1334	1243	1343	2	32.3	–	32.9	32.6	810	900
		1255	1355	1304	1404	3	34.0	–	34.7	34.4	800	900
C-289	14 June	1245	1345	1258	1358	2	33.1	–	34.1	33.6	1200	1200
		1314	1414	1325	1425	3	35.8	–	36.9	36.4	1200	1200
		1341	1441	1354	1454	4	38.9		40.4	39.6	1200	1200
		1405	1505	1419	1519	5	41.9	–	43.6	42.7	1211	1200

Radiometric data for the seven flights are presented tabularly and graphically in Section 7.3 in sets by flight number. A detailed description and report of weather characteristics are given as the introductory page of each data set.

Four of the seven flights (C-279, C-280, C-281, and C-288) were under partial or complete overcast so that the sun was not visible through the clouds during most of these flights. During the remaining three flights (C-273, C-282, and C-289) the sun was generally unobscured but space-to-altitude transmittance could not be obtained from sky radiance ratios as described in Section 2.1 due to the presence of scattered clouds. It was possible to obtain estimates of space-to-altitude beam transmittance from the average of the measured values of downwelling irradiance minus computed sky irradiance for all three flights. On one of the three flights (C-273), there were also available earth-to-space transmittance values based upon ground-based contrast reduction meter measurements coupled with airborne total scattering coefficient values. Since these transmittance values were reasonably comparable to those obtained from the irradiometer, the irradiometer-based values averaged for each filter were used for all three flights. However, since the measurements of downwelling irradiance during each straight and level flight element exhibited a considerable variance in range, it should be remembered that the beam transmittance used for each flight represents that of an intermediate lighting condition.

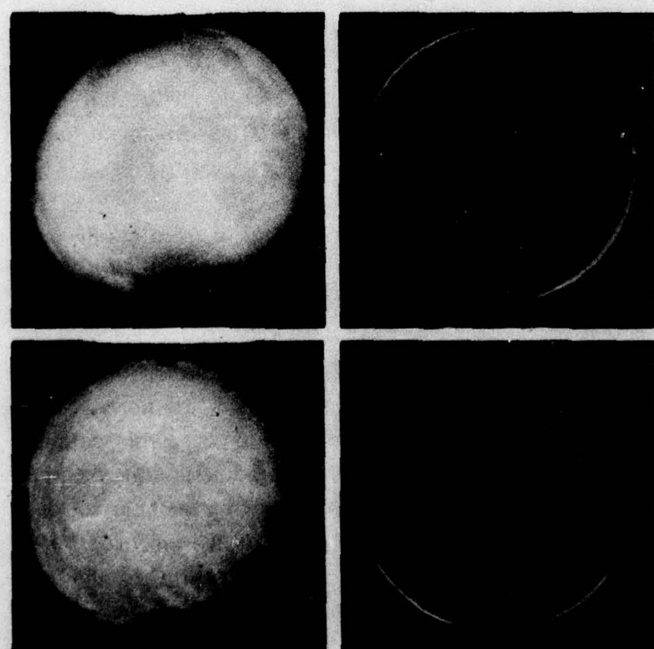


FLIGHT C-288

Filter 4
Upper and Lower Hemisphere
324 m AGL 1157 GMT

Filter 5
Upper and Lower Hemisphere
225 m AGL 1218 GMT

Fig. 7-1. Typical Sky and Terrain Photographs for Flight C-288.



FLIGHT C-288

Filter 2
Upper and Lower Hemisphere
222 m AGL 1242 GMT

Filter 3
Upper and Lower Hemisphere
280 m AGL 1303 GMT

FLIGHT C-289
Filter 4

Upper and Lower Hemisphere
1180m AGL 1345 GMT

Upper and Lower Hemisphere
237m AGL 1357 GMT

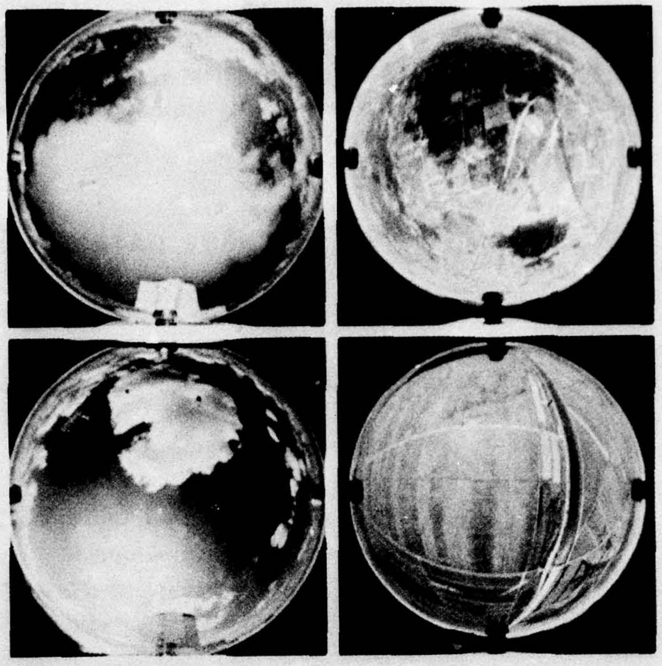
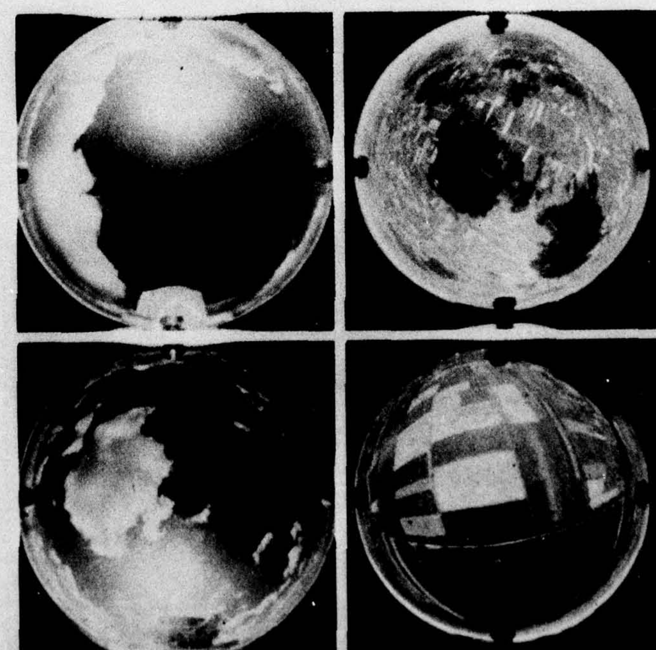


Fig. 7-2. Typical Sky and Terrain Photographs for Flight C-289.

FLIGHT C-289
Filter 5

Upper and Lower Hemisphere
1216m AGL 1409 GMT

Upper and Lower Hemisphere
211m AGL 1422 GMT



These values of space-to-altitude transmittance are not included in the standard sets of data tables by flight. These values 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 three flights in Table 7-3.

7.2 DESCRIPTION OF AIRBORNE DATA TABLES AND GRAPHS

DATA TABLES

Data are presented in tables of:

- Total Volume Scattering Coefficient
- Irradiance
- Directional Reflectance (Sky or Terrain)
- Equivalent Attenuation Length
- Beam Transmittance Between Ground and Altitude
- Path Radiance Between Ground and Altitude
- Directional Path Reflectance Between Ground and Altitude

Each optical property is tabulated in the tables as a function of altitude above ground level. The data are further divided by optical filters which are given in order of increasing wavelength. The tables of directional reflectance (sky or terrain), path radiance, and directional path reflectance are presented in four tables for four azimuths with respect to the sun of 0°, 90°, 180°, and 270°.

Table 7-3

Vertical Beam Transmittance, Space to Altitude and Space to Ground

		Space-to-Altitude Beam Transmittance					Space-to-Ground Beam Transmittance			
Flight No.	Date (1973)	Altitude (meters)	Filter 2	Filter 4	Filter 3	Filter 5	Filter 2	Filter 4	Filter 3	Filter 5
C-273	16 May	1050	.470	.466	.517	.530	.431	.435	.494	.509
C-282A	5 June	600		.489				.461		
C-282B	5 June	600		.489				.461		
C-289	14 June	1200	.541	.723	.518	.645	.482	.664	.486	.616

The tables have been divided into three categories depending upon the meaning of the altitude in the tables. First are those variables tabulated by measurement altitude: total volume scattering coefficient and irradiance. Second are those variables tabulated by object altitude for each path of sight: irradiance and directional sky or terrain reflectance. Third are the variables tabulated by object or sensor altitude depending on whether the path of sight is upward or downward: equivalent attenuation length, beam transmittance, path radiance, and path reflectance.

CATEGORY I: MEASUREMENT ALTITUDE

Total Volume Scattering Coefficient. The total volume scattering coefficient s(z) is tabulated by measurement altitude in two to four columns for the optical filters. The altitude is given in meters, above ground level, at 30 meter (98.4 foot) increments. The measurement 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 airborne data measurements.

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

Irradiance. The downwelling irradiances H(z,d) and upwelling irradiances H(z,u), albedos H(z,u)/H(z,d), scalar irradiances $_s h(z,d)$, $_k h(z,d)$, h(z,u), and h(z), and scalar albedos h(z,u)/h(z,d) are presented in columnar form as a function of measurement 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 and from the sun irradiance.

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

The irradiances for filter code number 4 can be converted to illuminance values in units of lu/m^2 by multiplying each irradiance by the factor 72.0 luμm/w.

CATEGORY II: OBJECT ALTITUDE

There are five object altitudes for the upward paths of sight $\theta < 90°$ at various altitudes above ground level. The object altitude for the downward path of sight $\theta > 90°$ is ground level or 0 meters.

Irradiance. The irradiance at the object altitude appropriate to the paths of sight 0° to 180° is tabulated for each filter at the top of the page containing directional sky or terrain reflectance. One column contains the upwelling irradiance appropriate for upward paths of sight at five object altitudes above ground level. These irradiances have been linearly interpolated between the measurement altitudes and assumed not to change above the highest measurement altitude or below the lowest measurement altitude. The second column contains the downwelling irradiance for ground level which has been assumed to be equivalent to the downwelling irradiance at the lowest altitude of measurement. 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].

Directional Reflectance (Sky or Terrain). The directional reflectances were computed from the irradiance presented above and the sky or terrain radiance at the object altitude. The sky radiances at the object altitudes were linearly interpolated between the measurement altitudes and assumed not to change above the highest measurement altitude or below the lowest altitude of measurement. The inherent terrain radiance for ground level was assumed equivalent to the measurement taken at the lowest flight altitude for each filter.

The directional sky or terrain reflectances are tabulated as a function of object altitude for the seven paths of sight 0 to 180 degrees. There are two to four sets of tables, one set for each spectral filter. Each set is listed on a single page which contains four tables, one for each of the four cardinal azimuths from the sun 0, 90, 180, and 270 degrees. Reflectance is dimensionless.

Effective sky reflectance is an odd concept since the sky radiance is not solely a function of the upwelling irradiance. However, it is a useful computational convenience for obtaining inherent contrast for nonself radiant objects viewed against the sky background using Eq. 2.8.

It should be stressed again that the sky and terrain reflectances presented in this section are typical of the average sky or terrain along the flight path. The upper and lower hemisphere scanners have 5-degree circular fields 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 object. This will not necessarily be the same as the average reflectance of the surrounding general area.

Inherent and Apparent Radiance. Inherent and apparent sky and terrain radiance are not included in these tables. The inherent radiance of the object or background for the upward path of sight $N_o(z_t,\theta,\phi)$ would be computed from the directional reflectance of the object, sky, or other background $R_o(z_t,\theta,\phi)$ and the upwelling irradiance at the object altitude $H(z_t,u)$ (from the preceding table):

$$N_o(z_t,\theta,\phi) = \frac{1}{\pi} R_o(z_t,\theta,\phi) H(z_t,u) \ . \tag{7.1}$$

The apparent object or background radiance at the sensor altitude $z=0$ can be computed as follows for the upward-looking path of sight,

$$N_r(0,\theta,\phi) = N_o(z_t,\theta,\phi)\, T_r(0,\theta) + N_r^*(0,\theta,\phi) \ , \tag{7.2}$$

where the beam transmittance $T_r(0,\theta)$ and path radiance $N_r^*(0,\theta,\phi)$ for the appropriate object altitudes z_t are given in the tables to be described later.

For the downward-looking path of sight, the inherent radiance of the terrain at $z_t = 0$ $N_o(0,\theta,\phi)$ immediately surrounding the object may be computed from the directional reflectance of the terrain $R_o(0,\theta,\phi)$ and the downwelling irradiance $H(0,d)$ (from the preceding table)

$$N_o(0,\theta,\phi) = \frac{1}{\pi} R_o(0,\theta,\phi)\, H(0,d) \quad . \qquad (7.3)$$

Also, the apparent terrain radiance $N_r(z,\theta,\phi)$ at the sensor altitude z can be computed as follows:

$$N_r(z,\theta,\phi) = N_o(0,\theta,\phi)\, T_r(z,\theta) + N_r^*(z,\theta,\phi) \quad . \qquad (7.4)$$

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

The terrain radiances for filter 4 may be converted to luminance values in units of $lu/\Omega m^2$ by multiplying the radiance by the factor 72.0 $lu\mu m/w$.

CATEGORY III: OBJECT OR SENSOR ALTITUDE

These variables are tabulated by object or sensor altitude depending upon whether the path of sight is upward or downward. For upward paths of sight $\theta < 90°$ the sensor is at ground level and the altitudes shown in the table are the object altitudes. For the downward paths of sight $\theta > 90°$, the object is at ground level and the altitudes in the table are the sensor altitudes.

Equivalent Attenuation Length. 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. 2.15 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 $\bar{L}(z)$ is tabulated by altitude for the path of sight between ground and the altitude shown in two to four columns for the optical filters. The altitude is given in meters, above ground level, at 30-meter (98.4-foot) increments. The measurement unit for the equivalent attenuation length is "km."

Beam Transmittance Between Ground and Altitude. The atmospheric beam transmittance $T_r(z,\theta)$ is tabulated for the paths of sight between ground and the altitude shown, for the seven zenith angles from 0 to 180 degrees. There are two or more 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 Between Ground and Altitude. Path radiance $N_r^*(z,\theta,\phi)$ is tabulated for the paths of sight, between the ground and the altitude shown, for the seven zenith angles from 0 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 two to four sets of data tables, one set for each of the spectral filters. Each set is listed on a single sheet and contains four tables, one for each of the four cardinal azimuths from the sun 0, 90, 180, and 270 degrees. The 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 $lu/\Omega m^2$ by multiplying the radiance by the factor 72.0 $lu\mu m/w$.

Directional Path Reflectance Between Ground and Altitude. Directional path reflectance $R_r^*(z,\theta,\phi)$ is also tabulated for the paths of sight, between ground and the altitude shown, for the seven zenith angles from 0 to 180 degrees. The directional path reflectance is computed from the previously derived values of path radiance, beam transmittance and the irradiance at the object altitude. The upwelling irradiance is used for upward paths of sight $\theta < 90°$ and the total downwelling irradiance is used for downward paths of sight $\theta > 90°$.

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

The path reflectance tables for the upward paths of sight are used for computing contrast transmittance against either a sky or a nonsky background. For instance, the contrast transmittance for a marking on an aircraft is dependant on the reflectance of the background airplane surface which surrounds the marking not on the sky surrounding the aircraft.

Contrast Transmittance. Contrast transmittance ${}_b\tau_t(z,\theta,\phi)$ is not tabulated. This optical property is a function of the directional background reflectance against which an object is viewed. The directional sky and terrain 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 cloudy sky or terrain. If, however, 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:

$$ {}_b\tau_r(z,\theta,\phi) = \left\{1 + [R_r^*(z,\theta,\phi)/{}_bR_o(z_t,\theta,\phi)]\right\}^{-1} . \qquad (7.5) $$

DATA GRAPHS

Data are also presented in graphs of:

- Total Volume Scattering Coefficient
- Downwelling Irradiance
- Equivalent Attenuation Length, Between Ground and Altitude
- Vertical Beam Transmittance, Between Ground and Altitude
- Path Radiance, Between Ground and Altitude
- Directional Path Reflectance, Between Ground and Altitude

Total Volume 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 every fifth data point, or at 150-meter intervals. These same data were tabulated in the total scattering coefficient table.

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

Equivalent Attenuation Length. 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 Between Ground and 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, Between Ground and Altitude. The path radiance $N_r^*(z,\theta,\phi)$ is graphed for upward and downward-looking paths between ground and the altitude shown. Each graph is for one path of sight for the two to four optical filters. The first graph is for the vertical upward path of sight, the second and third are for zenith angles 80 and 100 degrees, in the azimuth of the sun, and the fourth is for the vertical downward path of sight. These are data selected from the path radiance tables.

Directional Path Reflectance Between Ground and Altitude. The directional path reflectance $R_r^*(z,\theta,\phi)$ is also graphed for upward and downward-looking paths between ground and the altitude shown. Each graph is for one path of sight and two to four optical filters. The first graph is for the vertical upward path of sight; the second and third are for zenith angles 80 and 100 degrees, in the azimuth of the sun, and the fourth is for the vertically downward path of sight. 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 terrain, in particular, should be rounded off to 2 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 scattering coefficient and/or 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 meters AGL of the observed cloud or haze feature.

FLIGHT C-273 – 16 May 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit morning with a broken layer of low clouds changing to scattered clouds. The flight was conducted over low lying flat terrain consisting mostly of cultivated farmland interspersed with dark patches of dense woods. The data-taking started at 0758 GMT and continued until 0922 GMT. The sun zenith angle during sky radiance data-taking was 52.1 degrees at the beginning and 42.3 degrees at the end. The maximum altitude for the flight was 1020 meters. The average elevation of the terrain was 20 meters.

Near the beginning of data-taking the ground station reported cumulus cloud buildup and some blue sky (0.5). There was cumulus cloud cover through most of the package with many holds to wait for a clear sun.

At the radiosonde station in Meppen the 0700 GMT report was 0.9 cumulus and stratocumulus with bases 300 to 599 meters. At 1300 GMT this station recorded 0.4 cumulus at 1000 to 1499 meters.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
0758	160	Clear air, scattered to broken overhead. Flight run under scattered to overcast between ground and 750 meters.

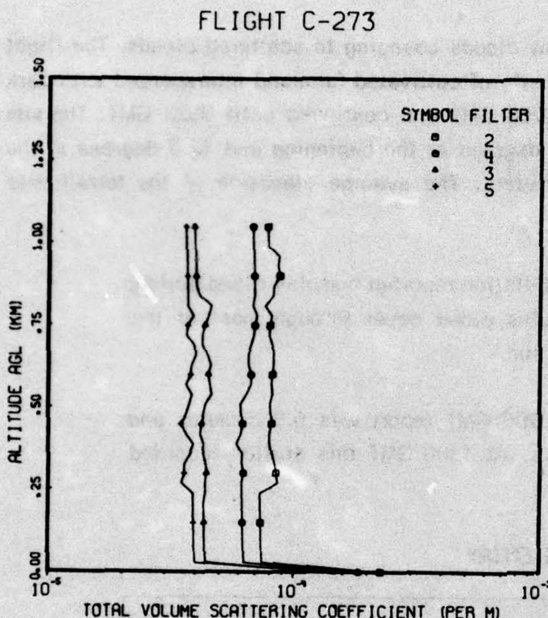
Note: Flight elevations in approximate feet MSL have been converted to approximate meters AGL.

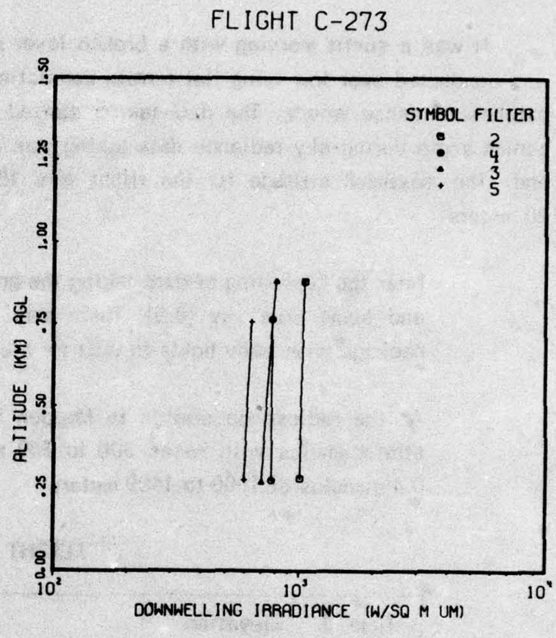
On the surface charts there was high pressure over most of Europe except the Iberian peninsula. By 1800 GMT the high began to move northeasterly. A storm in the Atlantic progressed eastward with an occlusion through extreme southwestern France and northeastern Spain extending to Mallorca and Algiers.

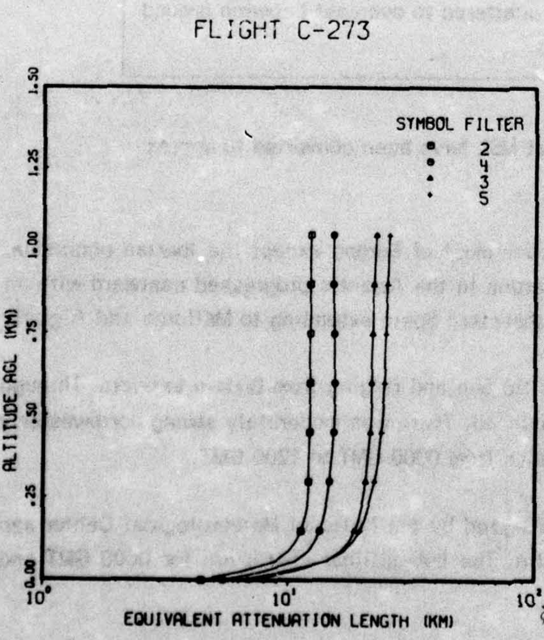
At 500 millibars there was a closed low in the Baltic Sea and ridging from Britain to Spain. Through the day both the trough and the ridge became more pronounced. There was moderately strong northwesterly flow over Germany. Temperatures rose 3.6 degrees Celsius from 0000 GMT to 1200 GMT.

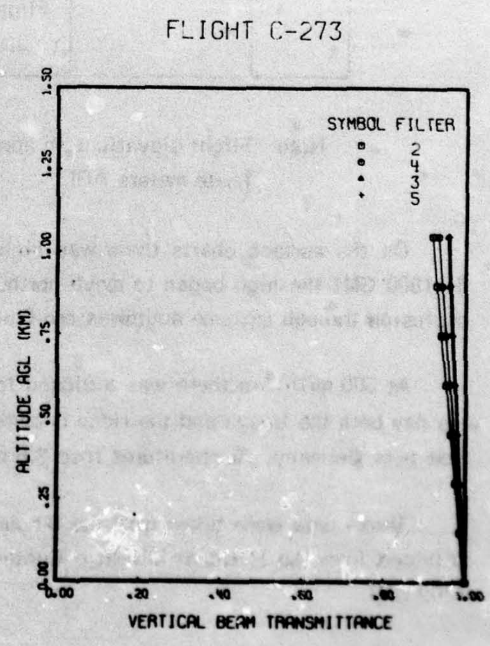
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT.

FLIGHT NO. C-273









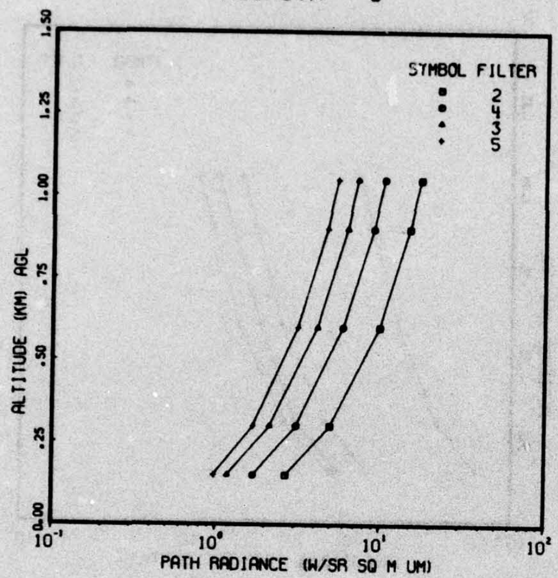
AD-A035 571 SCRIPPS INSTITUTION OF OCEANOGRAPHY SAN DIEGO CALIF --ETC F/G 4/1
AIRBORNE MEASUREMENTS OF OPTICAL ATMOSPHERIC PROPERTIES IN NORT--ETC(U)
SEP 76 S Q DUNTLEY, R W JOHNSON, J I GORDON F19628-76-C-0004

UNCLASSIFIED SIO-REF-76-17 AFGL-TR-76-0188 NL

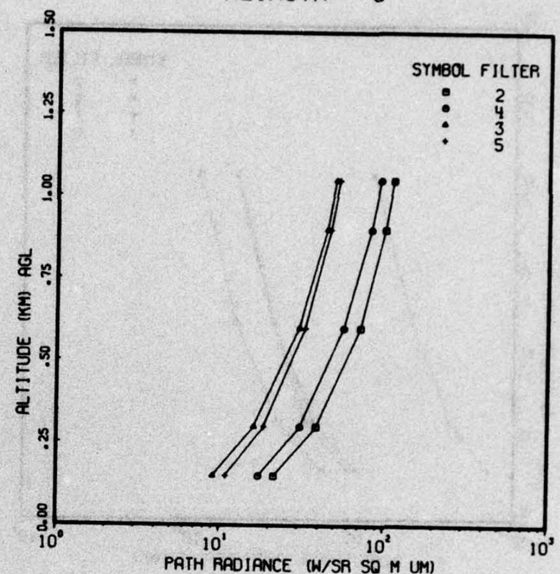
2 OF 3
AD
A035571

FLIGHT NO. C-273

FLIGHT C-273 ZENITH ANGLE 0
AZIMUTH 0



FLIGHT C-273 ZENITH ANGLE 80
AZIMUTH 0



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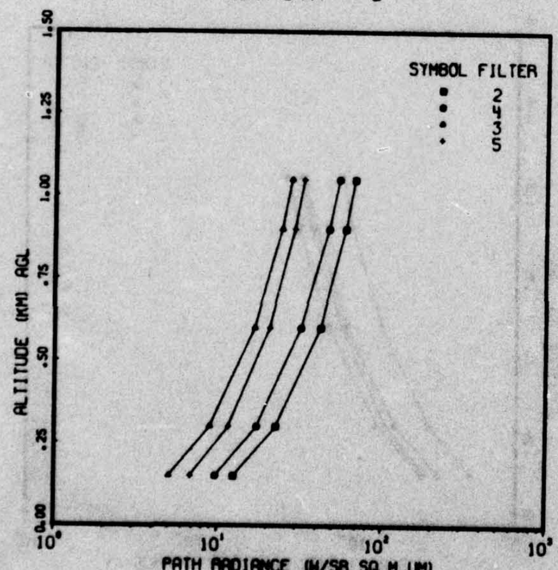
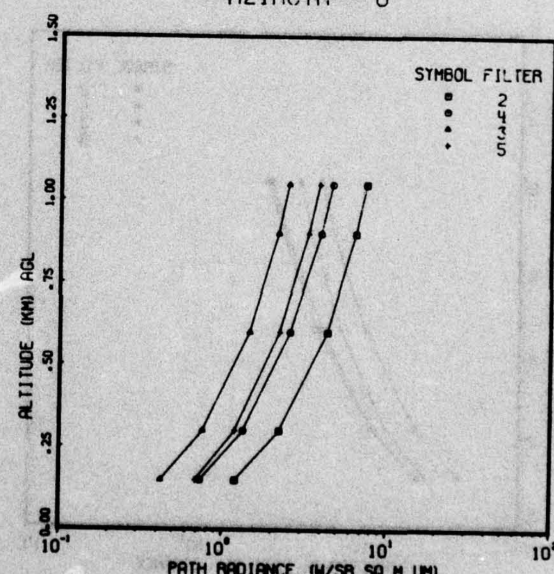
AZIMUTH 0

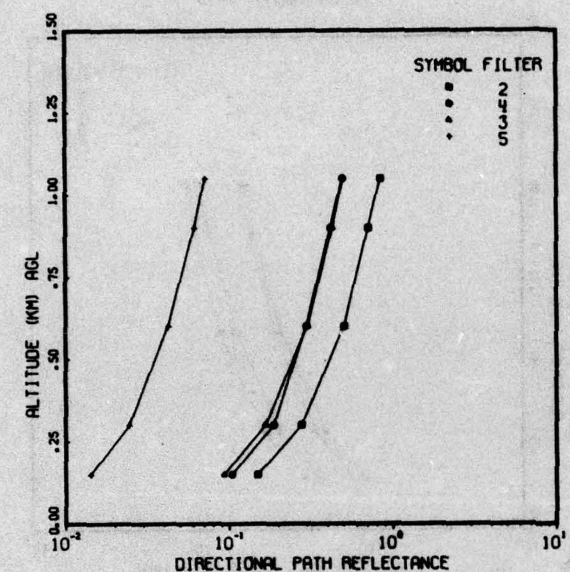


FLIGHT C-273 ZENITH ANGLE 180
AZIMUTH 0

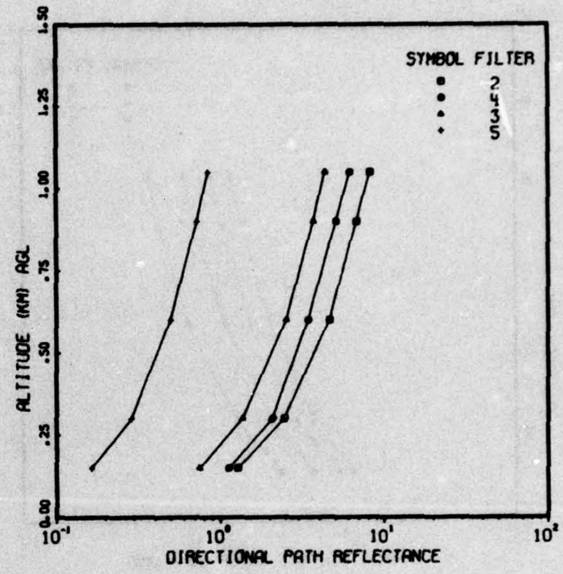


FLIGHT NO. C-273

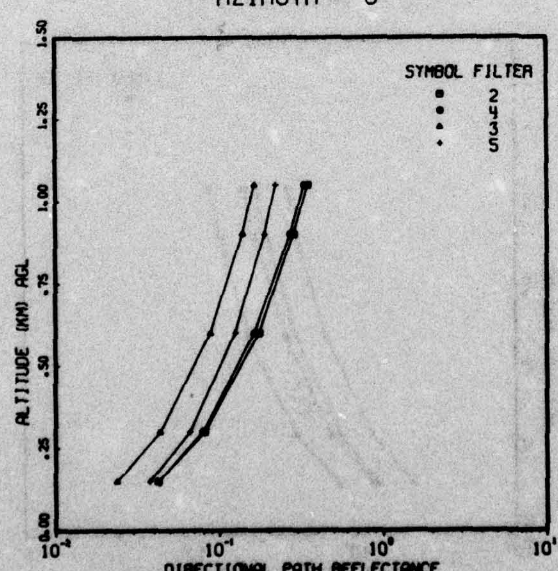
FLIGHT C-273 ZENITH ANGLE 0
AZIMUTH 0



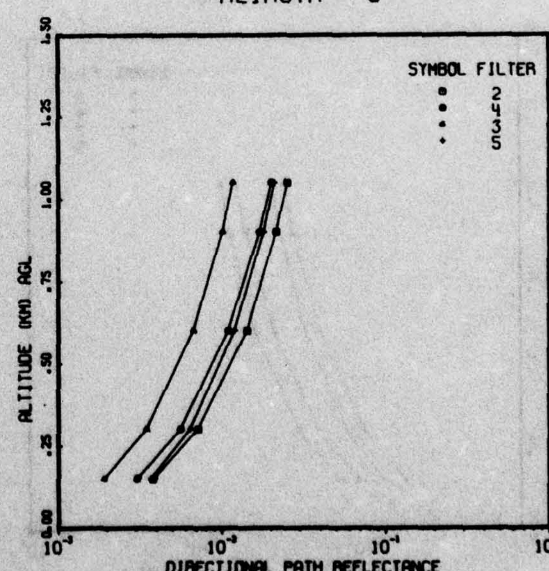
FLIGHT C-273 ZENITH ANGLE 80
AZIMUTH 0



FLIGHT C-273 ZENITH ANGLE 100
AZIMUTH 0



FLIGHT C-273 ZENITH ANGLE 180
AZIMUTH 0



FLIGHT NO. C-273
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5683 DATE 06/09/76)
DATE 51673 FLIGHT NO. C-273 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3	5
0	2.26E-04	1.84E-04	1.46E-04	1.59E-04
30	7.42E-05	6.26E-05	4.37E-05	3.96E-05
60	7.40E-05	6.25E-05	4.36E-05	3.95E-05
90	7.38E-05	6.23E-05	4.35E-05	3.94E-05
120	7.36E-05	6.22E-05	4.34E-05	3.93E-05
150	7.34E-05	6.20E-05	4.33E-05	3.92E-05
180	7.32E-05	6.18E-05	4.32E-05	3.91E-05
210	7.31E-05	6.17E-05	4.31E-05	3.90E-05
240	7.29E-05	6.15E-05	4.37E-05	3.89E-05
270	8.59E-05	6.14E-05	4.37E-05	3.49E-05
300	8.46E-05	6.24E-05	4.41E-05	3.58E-05
330	8.32E-05	6.13E-05	4.38E-05	3.59E-05
360	8.12E-05	6.16E-05	4.27E-05	3.79E-05
390	7.95E-05	5.86E-05	4.30E-05	3.90E-05
420	7.95E-05	6.10E-05	4.16E-05	3.65E-05
450	8.11E-05	6.19E-05	4.21E-05	3.47E-05
480	8.07E-05	6.12E-05	4.30E-05	3.65E-05
510	8.00E-05	6.08E-05	4.38E-05	3.76E-05
540	8.19E-05	6.40E-05	4.63E-05	3.85E-05
570	8.12E-05	6.70E-05	4.54E-05	3.64E-05
600	8.18E-05	6.70E-05	4.49E-05	3.79E-05
630	8.26E-05	6.54E-05	4.59E-05	3.82E-05
660	8.25E-05	6.50E-05	4.43E-05	3.98E-05
690	8.19E-05	6.69E-05	4.24E-05	3.95E-05
720	7.94E-05	6.88E-05	4.24E-05	3.66E-05
750	7.97E-05	6.93E-05	4.34E-05	3.69E-05
780	8.11E-05	7.07E-05	4.49E-05	3.89E-05
810	7.62E-05	6.79E-05	4.60E-05	3.69E-05
840	8.21E-05	6.90E-05	4.11E-05	3.68E-05
870	8.25E-05	6.88E-05	3.98E-05	3.67E-05
900	8.71E-05	6.86E-05	3.97E-05	3.66E-05
930	8.54E-05	6.84E-05	3.96E-05	3.65E-05
960	8.65E-05	6.82E-05	3.94E-05	3.64E-05
990	7.84E-05	6.80E-05	3.93E-05	3.62E-05
1020	7.80E-05	6.77E-05	3.92E-05	3.61E-05
1050	7.77E-05	6.75E-05	3.91E-05	3.60E-05
FIRST DATA ALT	240	270	210	240
LAST DATA ALT	1020	840	870	810

FLIGHT NO. C-273
IRRADIANCE

(JOB 5683 DATE 06/09/76)

FLIGHT NO.C-273 FILTER NO. 2 SUN ZENITH ANGLE 44.1

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
282	1.00E 03	5.68E 01	.057	6.71E 02	1.05E 03	1.52E 02	1.87E 03	.089
882	1.05E 03	7.05E 01	.067	7.15E 02	1.03E 03	2.31E 02	1.98E 03	.132

FLIGHT NO.C-273 FILTER NO. 4 SUN ZENITH ANGLE 50.3

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
275	7.67E 02	5.14E 01	.067	5.21E 02	8.92E 02	1.36E 02	1.55E 03	.096
766	7.78E 02	7.12E 01	.091	5.49E 02	8.99E 02	2.06E 02	1.65E 03	.142

FLIGHT NO.C-273 FILTER NO. 3 SUN ZENITH ANGLE 44.1

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
269	6.98E 02	4.01E 01	.057	5.66E 02	5.62E 02	9.96E 01	1.25E 03	.087
881	8.04E 02	4.71E 01	.059	6.09E 02	6.80E 02	1.29E 02	1.42E 03	.101

FLIGHT NO.C-273 FILTER NO. 5 SUN ZENITH ANGLE 50.3

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
276	5.94E 02	2.17E 02	.365	4.27E 02	6.93E 02	4.71E 02	1.59E 03	.420
759	6.41E 02	2.48E 02	.387	4.39E 02	7.10E 02	5.25E 02	1.67E 03	.457

FLIGHT NO. C-273 SPECTRAL FILTER NO. 2
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5683 DATE 06/09/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-273 FILTER NO. = 2 SUN ZENITH ANGLE 44.1

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		1.00E 03
150	5.08E 01	
300	5.72E 01	
600	6.41E 01	
900	7.05E 01	
1050	7.05E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2263	.1043	.0461
150	3.5437	23.2100	20.2728	15.6436			
300	3.4936	22.6696	20.0818	15.6894			
600	2.7531	14.6802	17.2592	16.3675			
900	2.1881	8.5827	15.1050	16.8850			
1050	2.1881	8.5827	15.1050	16.8850			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1862	.0863	.0461
150	3.5437	7.3798	6.5128	5.8811			
300	3.4936	7.3192	6.5090	5.8887			
600	2.7531	6.4240	6.4524	6.0004			
900	2.1881	5.7408	6.4092	6.0857			
1050	2.1881	5.7408	6.4092	6.0857			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1961	.0665	.0461
150	3.5437	7.3288	6.0521	5.5449			
300	3.4936	7.2192	5.9925	5.4961			
600	2.7531	5.5985	5.1124	4.7751			
900	2.1881	4.3615	4.4407	4.2248			
1050	2.1881	4.3615	4.4407	4.2248			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1219	.0964	.0461
150	3.5437	5.5945	6.4048	6.0522			
300	3.4936	5.5425	6.3545	6.0188			
600	2.7531	4.7738	5.6229	5.5246			
900	2.1881	4.1871	5.0645	5.1475			
1050	2.1881	4.1871	5.0645	5.1475			

FLIGHT NO. C-273 SPECTRAL FILTER NO. 4
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5683 DATE 06/09/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-273 FILTER NO. = 4 SUN ZENITH ANGLE 50.3

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		7.67E 02
150	5.14E 01	
300	5.24E 01	
600	6.45E 01	
900	7.12E 01	
1050	7.12E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1060	.1214	.0401
150	2.0777	21.2580	19.0881	13.2814			
300	2.2383	20.6343	19.3454	13.3390			
600	3.7751	14.6666	21.8068	13.8901			
900	4.4015	12.2343	22.8100	14.1147			
1050	4.4015	12.2343	22.8100	14.1147			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1335	.0835	.0401
150	2.0777	5.7478	6.3495	5.2019			
300	2.2383	5.6103	6.2497	5.1530			
600	3.7751	4.2944	5.2950	4.6852			
900	4.4015	3.7581	4.9058	4.4945			
1050	4.4015	3.7581	4.9058	4.4945			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1449	.1569	.0401
150	2.0777	6.5881	6.0480	5.5896			
300	2.2383	6.3697	5.9910	5.5643			
600	3.7751	4.3569	5.4457	5.3222			
900	4.4015	3.5365	5.2234	5.2236			
1050	4.4015	3.5369	5.2234	5.2236			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1514	.0750	.0401
150	2.0777	6.5407	7.1587	6.4200			
300	2.2383	6.3649	7.0276	6.3581			
600	3.7751	4.6836	5.7734	5.7656			
900	4.4015	3.9983	5.2682	5.5242			
1050	4.4015	3.9983	5.2682	5.5242			

FLIGHT NO. C-273 SPECTRAL FILTER NO. 3
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5683 DATE 06/09/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-273 FILTER NO. = 3 SUN ZENITH ANGLE 44.1

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		6.98E 02
150	4.01E 01	
300	4.04E 01	
600	4.39E 01	
900	4./1E 01	
1050	4./1E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1406	.0718	.0621
150	2.7768	11.1709	15.4983	16.1715			
300	2.9769	11.1705	15.5840	16.0335			
600	4.7448	11.1673	16.3410	14.8147			
900	6.1644	11.1646	16.9488	13.8359			
1050	6.1644	11.1646	16.9488	13.8359			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0898	.0875	.0621
150	2.7768	5.4195	5.2539	5.5574			
300	2.9769	5.2606	5.1035	5.5174			
600	4.7448	3.8573	3.7752	5.1638			
900	6.1644	2.7305	2.7086	4.8798			
1050	6.1644	2.7305	2.7086	4.8798			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1472	.0894	.0621
150	2.7768	5.3804	5.1793	4.8642			
300	2.9769	5.2957	5.1661	4.8761			
600	4.7448	4.5473	5.0497	4.9806			
900	6.1644	3.9464	4.9562	5.0645			
1050	6.1644	3.9464	4.9562	5.0645			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0767	.0784	.0621
150	2.7768	8.5144	7.1282	5.9056			
300	2.9769	8.2790	7.0313	5.8779			
600	4.7448	6.1995	6.2467	5.6339			
900	6.1644	4.5296	5.6166	5.4379			
1050	6.1644	4.5296	5.6166	5.4379			

FLIGHT NO. C-273 SPECTRAL FILTER NO. 5
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5683 DATE 06/09/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-273 FILTER NO. = 5 SUN ZENITH ANGLE 50.3

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		5.94E 02
150	2.17E 02	
300	2.19E 02	
600	2.38E 02	
900	2.48E 02	
1050	2.48E 02	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3183	.1807	.3158
150	.1491	4.4699	3.8336	3.2739			
300	.1509	4.3307	3.7670	3.2498			
600	.1707	2.7428	3.0078	2.9751			
900	.1800	2.0007	2.6530	2.8467			
1050	.1800	2.0007	2.6530	2.8467			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3648	.3518	.3158
150	.1491	1.0409	1.0421	1.4479			
300	.1509	1.0697	1.0415	1.4236			
600	.1707	1.3981	1.0347	1.1468			
900	.1800	1.5515	1.0315	1.0175			
1050	.1800	1.5515	1.0315	1.0175			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3908	.5996	.3158
150	.1491	1.6303	1.3574	1.4195			
300	.1509	1.6024	1.3065	1.3926			
600	.1707	1.2838	.7263	1.0851			
900	.1800	1.1349	.4551	.9415			
1050	.1800	1.1349	.4551	.9415			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.4857	.5728	.3158
150	.1491	.6813	.5778	1.0810			
300	.1509	.7154	.6144	1.0794			
600	.1707	1.1049	1.0321	1.0603			
900	.1800	1.2868	1.2272	1.0513			
1050	.1800	1.2868	1.2272	1.0513			

FLIGHT NO. C-273
EQUIVALENT ATTENUATION LENGTH

(JOB 5683 DATE 06/09/76)
DATE 51673 FLIGHT NO. C-273 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 2	4	3	5
0	4.42E 00	5.43E 00	6.85E 00	6.29E 00
30	6.66E 00	8.11E 00	1.05E 01	1.01E 01
60	8.92E 00	1.08E 01	1.44E 01	1.44E 01
90	1.01E 01	1.21E 01	1.65E 01	1.68E 01
120	1.08E 01	1.29E 01	1.77E 01	1.84E 01
150	1.12E 01	1.34E 01	1.86E 01	1.95E 01
180	1.16E 01	1.38E 01	1.92E 01	2.03E 01
210	1.18E 01	1.41E 01	1.97E 01	2.09E 01
240	1.20E 01	1.43E 01	2.01E 01	2.14E 01
270	1.21E 01	1.45E 01	2.03E 01	2.19E 01
300	1.21E 01	1.47E 01	2.06E 01	2.24E 01
330	1.20E 01	1.48E 01	2.07E 01	2.28E 01
360	1.21E 01	1.49E 01	2.09E 01	2.31E 01
390	1.21E 01	1.50E 01	2.11E 01	2.33E 01
420	1.21E 01	1.51E 01	2.13E 01	2.35E 01
450	1.21E 01	1.52E 01	2.14E 01	2.38E 01
480	1.22E 01	1.53E 01	2.15E 01	2.40E 01
510	1.22E 01	1.53E 01	2.16E 01	2.42E 01
540	1.22E 01	1.54E 01	2.17E 01	2.43E 01
570	1.22E 01	1.54E 01	2.17E 01	2.44E 01
600	1.22E 01	1.53E 01	2.17E 01	2.45E 01
630	1.22E 01	1.53E 01	2.17E 01	2.46E 01
660	1.22E 01	1.53E 01	2.17E 01	2.46E 01
690	1.22E 01	1.53E 01	2.18E 01	2.46E 01
720	1.22E 01	1.53E 01	2.18E 01	2.47E 01
750	1.22E 01	1.53E 01	2.19E 01	2.48E 01
780	1.22E 01	1.52E 01	2.19E 01	2.49E 01
810	1.22E 01	1.52E 01	2.19E 01	2.49E 01
840	1.22E 01	1.52E 01	2.20E 01	2.50E 01
870	1.22E 01	1.52E 01	2.20E 01	2.51E 01
900	1.22E 01	1.51E 01	2.21E 01	2.51E 01
930	1.22E 01	1.51E 01	2.22E 01	2.52E 01
960	1.22E 01	1.51E 01	2.23E 01	2.53E 01
990	1.22E 01	1.51E 01	2.24E 01	2.53E 01
1020	1.22E 01	1.51E 01	2.25E 01	2.54E 01
1050	1.22E 01	1.51E 01	2.26E 01	2.54E 01

FLIGHT NO. C-273

BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. 2

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.87E-01	9.50E-01	9.26E-01	8.58E-01	8.58E-01	9.26E-01	9.87E-01
300	9.75E-01	9.08E-01	8.67E-01	7.52E-01	7.51E-01	8.67E-01	9.75E-01
600	9.52E-01	8.27E-01	7.53E-01	5.70E-01	5.67E-01	7.53E-01	9.52E-01
900	9.29E-01	7.53E-01	6.55E-01	4.33E-01	4.27E-01	6.55E-01	9.29E-01
1050	9.18E-01	7.18E-01	6.10E-01	3.76E-01	3.70E-01	6.10E-01	9.18E-01

FLIGHT NO. C-273 FILTER NO. 4

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.89E-01	9.58E-01	9.38E-01	8.80E-01	8.79E-01	9.38E-01	9.39E-01
300	9.80E-01	9.24E-01	8.89E-01	7.91E-01	7.90E-01	8.89E-01	9.80E-01
600	9.62E-01	8.60E-01	7.98E-01	6.40E-01	6.37E-01	7.98E-01	9.62E-01
900	9.42E-01	7.95E-01	7.10E-01	5.08E-01	5.02E-01	7.10E-01	9.42E-01
1050	9.33E-01	7.64E-01	6.69E-01	4.53E-01	4.46E-01	6.69E-01	9.33E-01

FLIGHT NO. C-273 FILTER NO. 3

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.92E-01	9.69E-01	9.55E-01	9.12E-01	9.11E-01	9.55E-01	9.92E-01
300	9.86E-01	9.45E-01	9.19E-01	8.46E-01	8.45E-01	9.19E-01	9.86E-01
600	9.73E-01	8.99E-01	8.53E-01	7.29E-01	7.27E-01	8.53E-01	9.73E-01
900	9.60E-01	8.55E-01	7.91E-01	6.29E-01	6.25E-01	7.91E-01	9.60E-01
1050	9.55E-01	8.35E-01	7.65E-01	5.89E-01	5.83E-01	7.65E-01	9.55E-01

FLIGHT NO. C-273 FILTER NO. 5

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.92E-01	9.71E-01	9.57E-01	9.15E-01	9.15E-01	9.57E-01	9.92E-01
300	9.87E-01	9.50E-01	9.26E-01	8.58E-01	8.57E-01	9.26E-01	9.87E-01
600	9.76E-01	9.10E-01	8.68E-01	7.56E-01	7.54E-01	8.68E-01	9.76E-01
900	9.65E-01	8.71E-01	8.14E-01	6.65E-01	6.61E-01	8.14E-01	9.65E-01
1050	9.60E-01	8.53E-01	7.89E-01	6.25E-01	6.20E-01	7.89E-01	9.60E-01

FLIGHT NO. C-273 SPECTRAL FILTER NO. 2
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 2 SUN ZENITH ANGLE 44.1

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.67E 00	1.65E 01	2.14E 01	3.57E 01	2.75E 01	1.25E 01	1.19E 00
300	4.94E 00	3.00E 01	3.85E 01	6.23E 01	4.80E 01	2.25E 01	2.21E 00
600	9.82E 00	5.67E 01	7.12E 01	1.08E 02	8.37E 01	4.20E 01	4.32E 00
900	1.48E 01	8.10E 01	9.97E 01	1.43E 02	1.12E 02	5.96E 01	6.38E 00
1050	1.74E 01	9.24E 01	1.13E 02	1.57E 02	1.23E 02	6.77E 01	7.40E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.67E 00	6.24E 00	8.87E 00	1.64E 01	1.54E 01	7.60E 00	1.19E 00
300	4.94E 00	1.14E 01	1.60E 01	2.86E 01	2.69E 01	1.37E 01	2.21E 00
600	9.82E 00	2.18E 01	2.99E 01	5.02E 01	4.72E 01	2.57E 01	4.32E 00
900	1.48E 01	3.17E 01	4.27E 01	6.72E 01	6.37E 01	3.67E 01	6.38E 00
1050	1.74E 01	3.65E 01	4.86E 01	7.44E 01	7.07E 01	4.18E 01	7.40E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.67E 00	5.87E 00	8.65E 00	1.66E 01	1.67E 01	8.71E 00	1.19E 00
300	4.94E 00	1.07E 01	1.56E 01	2.90E 01	2.92E 01	1.57E 01	2.21E 00
600	9.82E 00	2.02E 01	2.88E 01	5.02E 01	5.09E 01	2.90E 01	4.32E 00
900	1.48E 01	2.89E 01	4.04E 01	6.63E 01	6.73E 01	4.07E 01	6.38E 00
1050	1.74E 01	3.30E 01	4.56E 01	7.29E 01	7.41E 01	4.59E 01	7.40E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.67E 00	6.30E 00	8.92E 00	1.64E 01	1.54E 01	7.58E 00	1.18E 00
300	4.94E 00	1.15E 01	1.61E 01	2.87E 01	2.68E 01	1.37E 01	2.18E 00
600	9.82E 00	2.18E 01	2.99E 01	5.01E 01	4.69E 01	2.55E 01	4.28E 00
900	1.48E 01	3.15E 01	4.23E 01	6.66E 01	6.28E 01	3.63E 01	6.35E 00
1050	1.74E 01	3.60E 01	4.79E 01	7.35E 01	6.95E 01	4.12E 01	7.39E 00

FLIGHT NO. C-273 SPECTRAL FILTER NO. 4
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 4 SUN ZENITH ANGLE 50.3

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.69E 00	1.35E 01	1.72E 01	2.90E 01	2.21E 01	9.67E 00	7.31E-01
300	3.07E 00	2.43E 01	3.07E 01	5.04E 01	3.83E 01	1.72E 01	1.33E 00
600	5.87E 00	4.52E 01	5.63E 01	8.78E 01	6.71E 01	3.19E 01	2.56E 00
900	8.96E 00	6.69E 01	8.19E 01	1.22E 02	9.40E 01	4.71E 01	3.92E 00
1050	1.05E 01	7.72E 01	9.37E 01	1.36E 02	1.05E 02	5.42E 01	4.60E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.69E 00	4.46E 00	6.31E 00	1.16E 01	1.08E 01	5.29E 00	7.31E-01
300	3.07E 00	8.01E 00	1.12E 01	2.02E 01	1.87E 01	9.35E 00	1.33E 00
600	5.87E 00	1.49E 01	2.07E 01	3.53E 01	3.28E 01	1.73E 01	2.56E 00
900	8.96E 00	2.22E 01	3.02E 01	4.90E 01	4.59E 01	2.55E 01	3.92E 00
1050	1.05E 01	2.57E 01	3.46E 01	5.48E 01	5.15E 01	2.93E 01	4.60E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.69E 00	3.90E 00	5.79E 00	1.13E 01	1.16E 01	5.91E 00	7.31E-01
300	3.07E 00	7.01E 00	1.03E 01	1.95E 01	2.00E 01	1.05E 01	1.33E 00
600	5.87E 00	1.30E 01	1.89E 01	3.40E 01	3.50E 01	1.94E 01	2.56E 00
900	8.96E 00	1.93E 01	2.75E 01	4.71E 01	4.88E 01	2.84E 01	3.92E 00
1050	1.05E 01	2.23E 01	3.15E 01	5.26E 01	5.45E 01	3.25E 01	4.60E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.69E 00	4.24E 00	6.06E 00	1.13E 01	1.06E 01	5.20E 00	7.31E-01
300	3.07E 00	7.62E 00	1.08E 01	1.96E 01	1.84E 01	9.26E 00	1.33E 00
600	5.87E 00	1.43E 01	1.99E 01	3.43E 01	3.24E 01	1.72E 01	2.56E 00
900	8.96E 00	2.13E 01	2.92E 01	4.78E 01	4.56E 01	2.55E 01	3.92E 00
1050	1.05E 01	2.46E 01	3.35E 01	5.35E 01	5.13E 01	2.93E 01	4.60E 00

FLIGHT NO. C-273 SPECTRAL FILTER NO. 3
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 3 SUN ZENITH ANGLE 44.1

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.18E 00	7.09E 00	9.07E 00	1.50E 01	1.14E 01	5.03E 00	4.19E-01
300	2.12E 00	1.27E 01	1.61E 01	2.61E 01	1.98E 01	8.93E 00	7.35E-01
600	4.10E 00	2.40E 01	3.01E 01	4.70E 01	3.57E 01	1.67E 01	1.44E 00
900	6.20E 00	3.55E 01	4.40E 01	6.61E 01	5.05E 01	2.44E 01	2.15E 00
1050	7.18E 00	4.08E 01	5.02E 01	7.41E 01	5.68E 01	2.79E 01	2.48E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.18E 00	2.43E 00	3.44E 00	6.41E 00	5.95E 00	2.87E 00	4.19E-01
300	2.12E 00	4.34E 00	6.11E 00	1.12E 01	1.04E 01	5.10E 00	7.55E-01
600	4.10E 00	8.17E 00	1.14E 01	2.00E 01	1.85E 01	9.47E 00	1.44E 00
900	6.20E 00	1.20E 01	1.65E 01	2.79E 01	2.60E 01	1.38E 01	2.15E 00
1050	7.18E 00	1.37E 01	1.87E 01	3.12E 01	2.92E 01	1.57E 01	2.48E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.18E 00	2.08E 00	3.02E 00	5.88E 00	6.07E 00	3.08E 00	4.19E-01
300	2.12E 00	3.71E 00	5.36E 00	1.02E 01	1.06E 01	5.47E 00	7.55E-01
600	4.10E 00	6.86E 00	9.87E 00	1.82E 01	1.88E 01	1.01E 01	1.44E 00
900	6.20E 00	9.93E 00	1.41E 01	2.51E 01	2.62E 01	1.46E 01	2.15E 00
1050	7.18E 00	1.11E 01	1.60E 01	2.80E 01	2.93E 01	1.66E 01	2.48E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.18E 00	2.47E 00	3.51E 00	6.38E 00	5.98E 00	2.84E 00	4.19E-01
300	2.12E 00	4.40E 00	6.22E 00	1.11E 01	1.03E 01	5.09E 00	7.55E-01
600	4.10E 00	8.19E 00	1.14E 01	1.97E 01	1.83E 01	9.33E 00	1.44E 00
900	6.20E 00	1.17E 01	1.61E 01	2.72E 01	2.54E 01	1.39E 01	2.15E 00
1050	7.18E 00	1.32E 01	1.82E 01	3.03E 01	2.03E 01	1.53E 01	2.48E 00

FLIGHT NO. C-273 SPECTRAL FILTER NO. 5
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 5 SUN ZENITH ANGLE 50.3

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)

AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.75E-01	8.38E 00	1.08E 01	1.87E 01	1.48E 01	6.79E 00	6.85E-01
300	1.69E 00	1.44E 01	1.85E 01	3.15E 01	2.50E 01	1.16E 01	1.19E 00
600	3.14E 00	2.58E 01	3.28E 01	5.40E 01	4.31E 01	2.06E 01	2.20E 00
900	4.69E 00	3.69E 01	4.64E 01	7.42E 01	5.94E 01	2.92E 01	3.29E 00
1050	5.44E 00	4.21E 01	5.27E 01	8.30E 01	6.65E 01	3.31E 01	3.82E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)

AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.75E-01	3.10E 00	4.55E 00	8.79E 00	8.55E 00	4.26E 00	6.85E-01
300	1.69E 00	5.32E 00	7.70E 00	1.48E 01	1.44E 01	7.28E 00	1.19E 00
600	3.14E 00	9.53E 00	1.30E 01	2.54E 01	2.49E 01	1.30E 01	2.20E 00
900	4.69E 00	1.36E 01	1.99E 01	3.48E 01	3.46E 01	1.88E 01	3.29E 00
1050	5.44E 00	1.56E 01	2.22E 01	3.89E 01	3.89E 01	2.15E 01	3.82E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)

AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.75E-01	2.97E 00	4.50E 00	9.02E 00	9.53E 00	5.00E 00	6.85E-01
300	1.69E 00	5.10E 00	7.69E 00	1.52E 01	1.61E 01	8.55E 00	1.19E 00
600	3.14E 00	9.12E 00	1.36E 01	2.60E 01	2.77E 01	1.51E 01	2.20E 00
900	4.09E 00	1.31E 01	1.93E 01	3.57E 01	3.82E 01	2.15E 01	3.29E 00
1050	5.44E 00	1.49E 01	2.19E 01	3.99E 01	4.27E 01	2.43E 01	3.82E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)

AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.75E-01	3.12E 00	4.59E 00	8.90E 00	8.84E 00	4.51E 00	6.85E-01
300	1.09E 00	5.37E 00	7.89E 00	1.50E 01	1.49E 01	7.71E 00	1.19E 00
600	3.14E 00	9.60E 00	1.39E 01	2.57E 01	2.57E 01	1.37E 01	2.20E 00
900	4.09E 00	1.37E 01	1.97E 01	3.52E 01	3.54E 01	1.93E 01	3.29E 00
1050	5.44E 00	1.57E 01	2.24E 01	3.94E 01	3.96E 01	2.20E 01	3.82E 00

FLIGHT NO. C-273 SPECTRAL FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 2 SUN ZENITH ANGLE 44.1

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.50E-01	9.58E-01	1.20E 00	2.30E 00	1.01E-01	4.23E-02	3.79E-03
300	2.78E-01	1.81E 00	2.44E 00	4.55E 00	2.00E-01	8.15E-02	7.09E-03
600	5.06E-01	3.36E 00	4.64E 00	9.30E 00	4.63E-01	1.75E-01	1.42E-02
900	7.12E-01	4.80E 00	6.79E 00	1.47E 01	8.20E-01	2.85E-01	2.15E-02
1050	8.45E-01	5.74E 00	8.23E 00	1.86E 01	1.05E 00	3.48E-01	2.53E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.50E-01	3.63E-01	5.29E-01	1.06E 00	5.63E-02	2.57E-02	3.79E-03
300	2.78E-01	6.87E-01	1.01E 00	2.09E 00	1.12E-01	4.95E-02	7.09E-03
600	5.06E-01	1.29E 00	1.99E 00	4.32E 00	2.61E-01	1.07E-01	1.42E-02
900	7.12E-01	1.88E 00	2.90E 00	6.93E 00	4.68E-01	1.76E-01	2.15E-02
1050	8.45E-01	2.27E 00	3.59E 00	8.80E 00	5.99E-01	2.15E-01	2.53E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.50E-01	3.42E-01	5.17E-01	1.07E 00	6.11E-02	2.95E-02	3.79E-03
300	2.78E-01	6.46E-01	9.80E-01	2.11E 00	1.22E-01	5.68E-02	7.09E-03
600	5.06E-01	1.20E 00	1.80E 00	4.32E 00	2.81E-01	1.21E-01	1.42E-02
900	7.12E-01	1.71E 00	2.75E 00	6.83E 00	4.94E-01	1.95E-01	2.15E-02
1050	8.45E-01	2.05E 00	3.33E 00	8.63E 00	6.28E-01	2.36E-01	2.53E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.50E-01	3.67E-01	5.33E-01	1.06E 00	5.62E-02	2.56E-02	3.74E-03
300	2.78E-01	6.94E-01	1.02E 00	2.09E 00	1.12E-01	4.94E-02	7.00E-03
600	5.06E-01	1.29E 00	1.99E 00	4.30E 00	2.59E-01	1.06E-01	1.41E-02
900	7.12E-01	1.86E 00	2.80E 00	6.86E 00	4.61E-01	1.74E-01	2.14E-02
1050	8.45E-01	2.24E 00	3.50E 00	8.70E 00	5.89E-01	2.12E-01	2.52E-02

FLIGHT NO. C-273 SPECTRAL FILTER NO. 4

DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 4 SUN ZENITH ANGLE 50.3

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	8.63E-01	1.12E 00	2.02E 00	1.03E-01	4.23E-02	3.03E-03
300	1.08E-01	1.58E 00	2.07E 00	3.81E 00	1.98E-01	7.94E-02	5.57E-03
600	2.97E-01	2.56E 00	3.43E 00	6.69E 00	4.32E-01	1.64E-01	1.09E-02
900	4.20E-01	3.72E 00	5.09E 00	1.06E 01	7.66E-01	2.72E-01	1.70E-02
1050	4.96E-01	4.46E 00	6.18E 00	1.32E 01	9.68E-01	3.32E-01	2.02E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	2.84E-01	4.11E-01	8.09E-01	5.03E-02	2.29E-02	3.03E-03
300	1.08E-01	5.19E-01	7.58E-01	1.53E 00	9.70E-02	4.31E-02	5.57E-03
600	2.97E-01	8.47E-01	1.26E 00	2.69E 00	2.11E-01	8.86E-02	1.09E-02
900	4.20E-01	1.24E 00	1.88E 00	4.26E 00	3.74E-01	1.47E-01	1.70E-02
1050	4.96E-01	1.48E 00	2.28E 00	5.34E 00	4.73E-01	1.79E-01	2.02E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	2.49E-01	3.77E-01	7.82E-01	5.39E-02	2.58E-02	3.03E-03
300	1.08E-01	4.55E-01	6.95E-01	1.48E 00	1.04E-01	4.85E-02	5.57E-03
600	2.97E-01	7.39E-01	1.15E 00	2.59E 00	2.25E-01	9.93E-02	1.09E-02
900	4.20E-01	1.07E 00	1.71E 00	4.09E 00	3.97E-01	1.64E-01	1.70E-02
1050	4.96E-01	1.29E 00	2.08E 00	5.13E 00	5.01E-01	1.99E-01	2.02E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	2.71E-01	3.95E-01	7.83E-01	4.95E-02	2.27E-02	3.03E-03
300	1.08E-01	4.94E-01	7.28E-01	1.48E 00	9.54E-02	4.27E-02	5.57E-03
600	2.97E-01	8.08E-01	1.21E 00	2.61E 00	2.08E-01	8.81E-02	1.09E-02
900	4.20E-01	1.18E 00	1.81E 00	4.15E 00	3.72E-01	1.47E-01	1.70E-02
1050	4.96E-01	1.42E 00	2.21E 00	5.21E 00	4.71E-01	1.79E-01	2.02E-02

FLIGHT NO. C-273 SPECTRAL FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 3 SUN ZENITH ANGLE 44.1

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.31E-02	5.74E-01	7.45E-01	1.29E 00	5.62E-02	2.37E-02	1.90E-03
300	1.08E-01	1.04E 00	1.36E 00	2.40E 00	1.05E-01	4.37E-02	3.45E-03
600	3.02E-01	1.91E 00	2.53E 00	4.61E 00	2.21E-01	8.81E-02	6.68E-03
900	4.31E-01	2.77E 00	3.70E 00	7.00E 00	3.64E-01	1.39E-01	1.01E-02
·1050	5.02E-01	3.25E 00	4.37E 00	8.39E 00	4.39E-01	1.64E-01	1.17E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.31E-02	1.97E-01	2.83E-01	5.51E-01	2.94E-02	1.35E-02	1.90E-03
300	1.08E-01	3.57E-01	5.17E-01	1.03E 00	5.51E-02	2.49E-02	3.45E-03
600	3.02E-01	6.51E-01	9.54E-01	1.96E 00	1.15E-01	5.00E-02	6.68E-03
900	4.31E-01	9.35E-01	1.39E 00	2.95E 00	1.87E-01	7.83E-02	1.01E-02
1050	5.02E-01	1.09E 00	1.63E 00	3.53E 00	2.25E-01	9.21E-02	1.17E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.31E-02	1.68E-01	2.48E-01	5.06E-01	3.00E-02	1.45E-02	1.90E-03
300	1.08E-01	3.05E-01	4.53E-01	9.41E-01	5.62E-02	2.68E-02	3.45E-03
600	3.02E-01	5.46E-01	8.28E-01	1.79E 00	1.17E-01	5.35E-02	6.68E-03
900	4.31E-01	7.67E-01	1.19E 00	2.66E 00	1.89E-01	8.33E-02	1.01E-02
1050	5.02E-01	8.88E-01	1.39E 00	3.17E 00	2.26E-01	9.79E-02	1.17E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.31E-02	2.00E-01	2.88E-01	5.49E-01	2.91E-02	1.34E-02	1.90E-03
300	1.08E-01	3.62E-01	5.26E-01	1.02E 00	5.46E-02	2.47E-02	3.45E-03
600	3.02E-01	6.49E-01	9.55E-01	1.93E 00	1.13E-01	4.93E-02	6.68E-03
900	4.31E-01	9.11E-01	1.34E 00	2.88E 00	1.83E-01	7.65E-02	1.01E-02
1050	5.02E-01	1.06E 00	1.58E 00	3.43E 00	2.18E-01	8.98E-02	1.17E-02

FLIGHT NO. C-273 SPECTRAL FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5683 DATE 06/09/76)

FLIGHT NO. C-273 FILTER NO. = 5 SUN ZENITH ANGLE 50.3

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E-02	1.25E-01	1.64E-01	2.96E-01	8.57E-02	3.76E-02	3.65E-03
300	2.46E-02	2.18E-01	2.87E-01	5.28E-01	1.54E-01	6.63E-02	6.36E-03
600	4.25E-02	3.75E-01	4.99E-01	9.45E-01	3.02E-01	1.25E-01	1.19E-02
900	6.17E-02	5.37E-01	7.24E-01	1.41E 00	4.75E-01	1.89E-01	1.81E-02
1050	7.19E-02	6.26E-01	8.47E-01	1.68E 00	5.67E-01	2.22E-01	2.11E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E-02	4.62E-02	6.89E-02	1.39E-01	4.94E-02	2.35E-02	3.65E-03
300	2.46E-02	8.06E-02	1.21E-01	2.48E-01	8.86E-02	4.16E-02	6.36E-03
600	4.25E-02	1.38E-01	2.10E-01	4.43E-01	1.75E-01	7.95E-02	1.19E-02
900	6.17E-02	1.99E-01	3.04E-01	6.64E-01	2.77E-01	1.22E-01	1.81E-02
1050	7.19E-02	2.31E-01	3.56E-01	7.89E-01	3.32E-01	1.44E-01	2.11E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E-02	4.42E-02	6.81E-02	1.43E-01	5.51E-02	2.76E-02	3.65E-03
300	2.46E-02	7.72E-02	1.19E-01	2.54E-01	9.91E-02	4.88E-02	6.36E-03
600	4.25E-02	1.33E-01	2.07E-01	4.55E-01	1.94E-01	9.22E-02	1.19E-02
900	6.17E-02	1.90E-01	3.01E-01	6.81E-01	3.05E-01	1.39E-01	1.81E-02
1050	7.19E-02	2.21E-01	3.52E-01	8.10E-01	3.65E-01	1.63E-01	2.11E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E-02	4.66E-02	6.95E-02	1.41E-01	5.11E-02	2.49E-02	3.65E-03
300	2.46E-02	8.12E-02	1.22E-01	2.51E-01	9.19E-02	4.40E-02	6.36E-03
600	4.25E-02	1.40E-01	2.12E-01	4.49E-01	1.80E-01	8.32E-02	1.19E-02
900	6.17E-02	2.00E-01	3.07E-01	6.72E-01	2.83E-01	1.26E-01	1.81E-02
1050	7.19E-02	2.33E-01	3.59E-01	7.99E-01	3.38E-01	1.47E-01	2.11E-02

FLIGHT C-279 – 3 June 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was an overcast afternoon. The flight was conducted under the cloud deck over low lying flat terrain consisting mostly of cultivated farmlan's interspersed with dark patches of dense woods. The data-taking started at 1108 GMT and continued until 1152 GMT. The sun zenith angle during sky radiance data-taking was 30.9 degrees at the beginning, 30.7 degrees at transit, and 31.1 degrees at the end. The maximum flight altitude was 1116 meters. The average elevation of the terrain was 20 meters.

At the beginning of data-taking the ground station reported generally solid cumulus overcast with sun breaking through only for 1 to 2 minutes. By 1400 GMT the ground station was recording 0.5 cloud cover.

Data were not available from the radiosonde station.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
1109	1050	Solid overcast deck.
1112	1050	Under broken to full overcast, moderate to heavy haze. Temperature at 1050 meters was +2.8°C.

Note: Flight elevations in approximate feet MSL have been converted to approximate meters AGL.

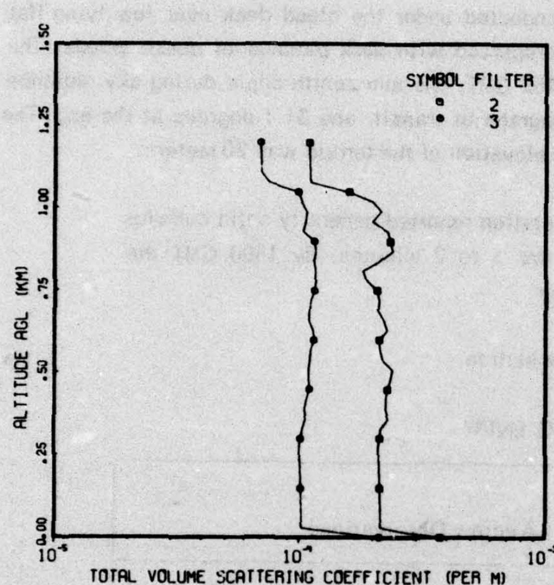
The surface charts show that a diffuse cold front west of the area moved eastward slowly but disappeared from the charts before passing Meppen. Ahead of the front the Meppen area was in southwesterly flow.

At 500 millibars there was a low southeast of Iceland with a trough through Ireland and west of Portugal. The low moved slowly east and filled slightly with the axis of the trough moving to a line from Scotland to Gibraltar on the 1200 GMT chart. There was a ridge from the Adriatic to the eastern Baltic which built and moved slowly eastward. The flow over northern Germany was moderate to strong southwesterly.

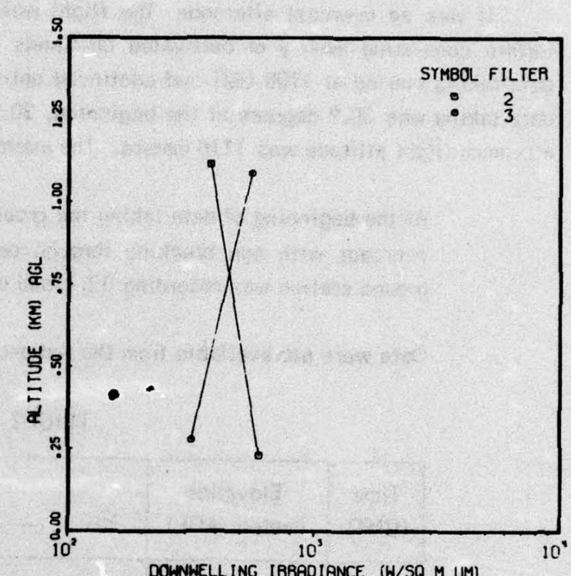
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-279

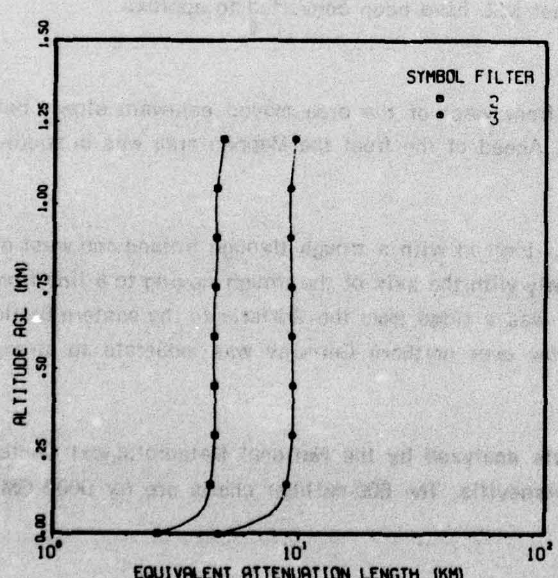
FLIGHT C-279



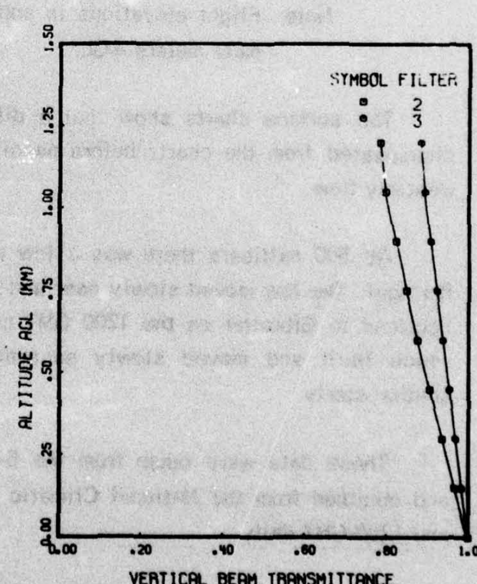
FLIGHT C-279



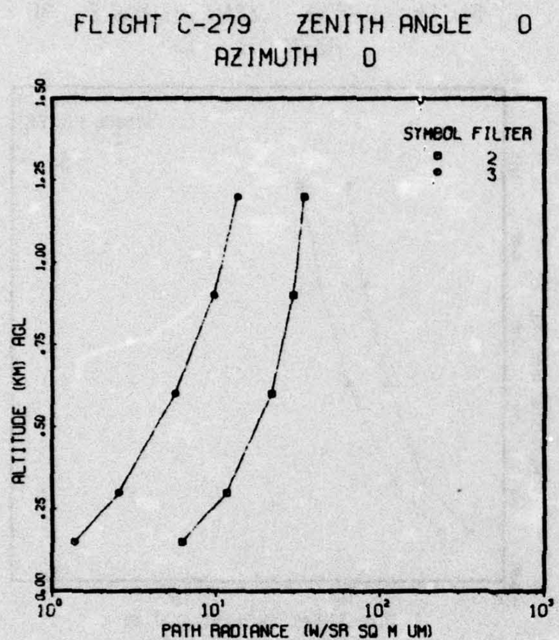
FLIGHT C-279

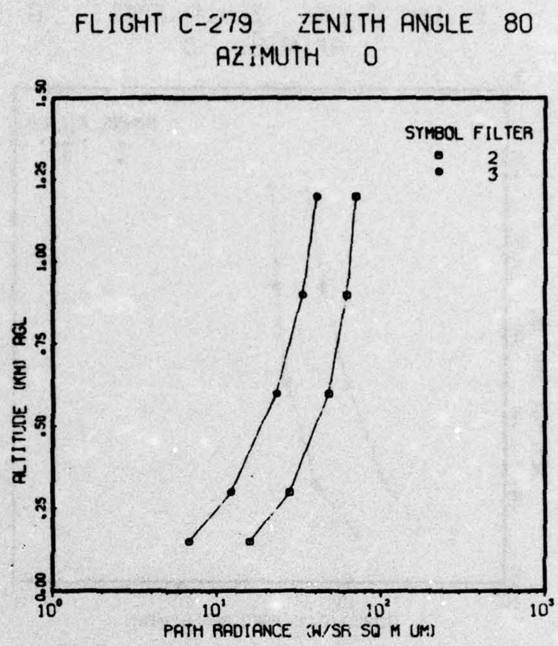


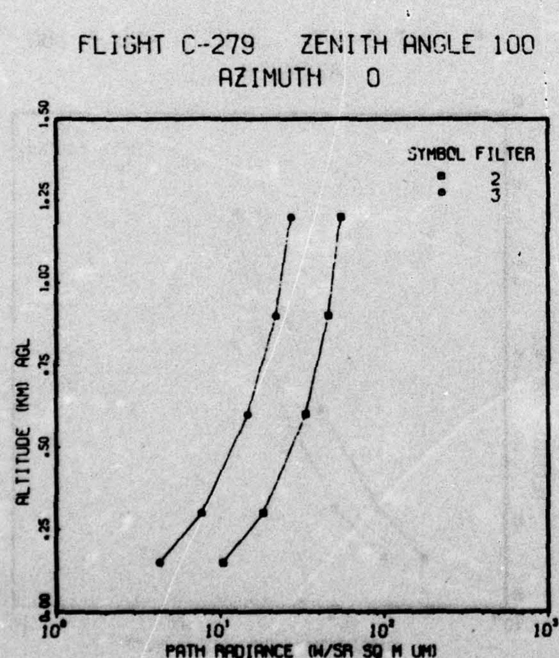
FLIGHT C-279

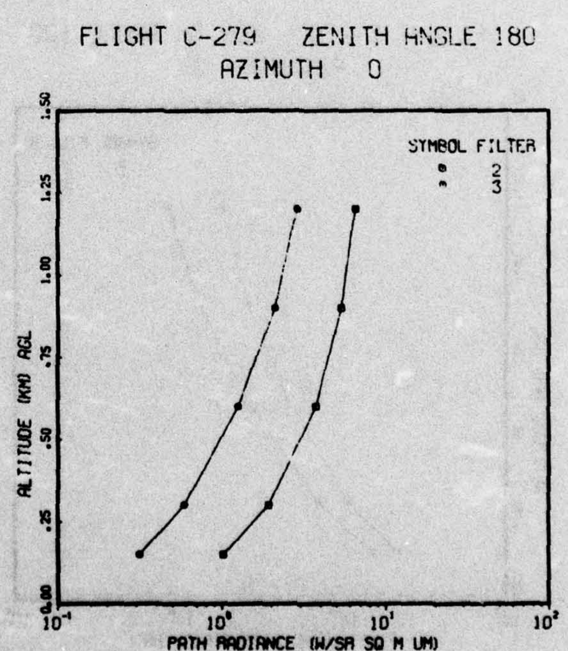


FLIGHT NO. C-279



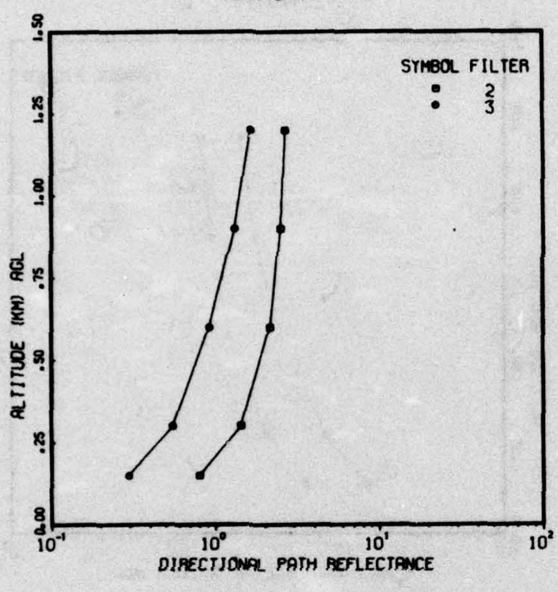




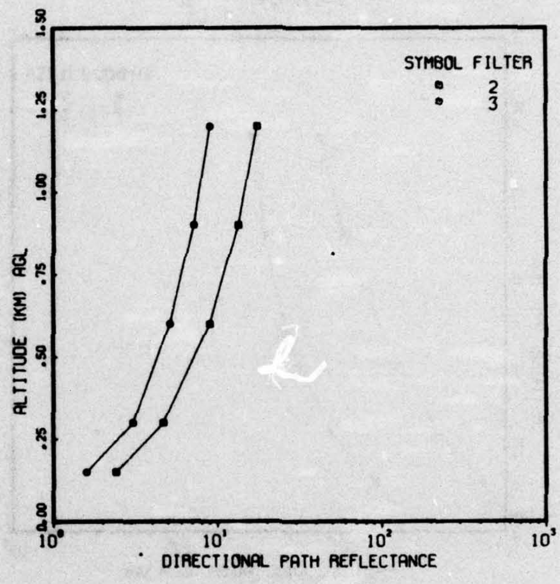


FLIGHT NO. C-279

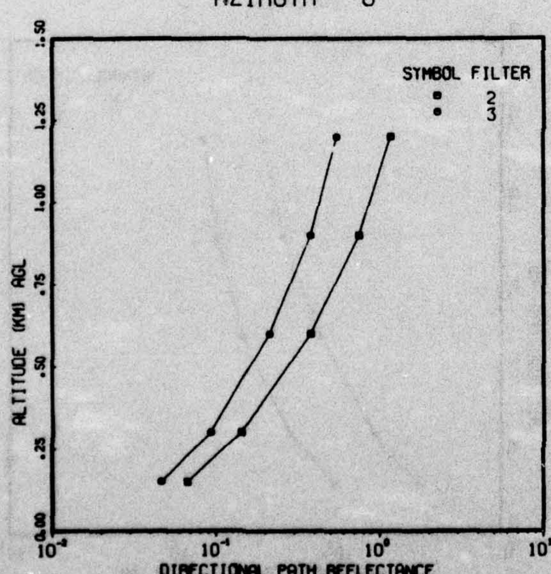
FLIGHT C-279 ZENITH ANGLE 0
AZIMUTH 0



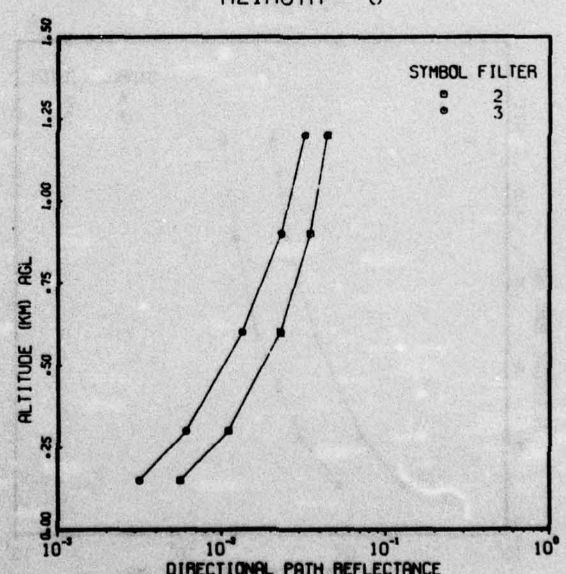
FLIGHT C-279 ZENITH ANGLE 80
AZIMUTH 0



FLIGHT C-279 ZENITH ANGLE 100
AZIMUTH 0



FLIGHT C-279 ZENITH ANGLE 180
AZIMUTH 0



FLIGHT NO. C-279
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5599 DATE 06/15/76)
DATE 69373 FLIGHT NO. C-279 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	3
0	3.75E-04	2.12E-04
30	2.14E-04	1.02E-04
60	2.14E-04	1.02E-04
90	2.13E-04	1.02E-04
120	2.12E-04	1.01E-04
150	2.12E-04	1.01E-04
180	2.11E-04	1.01E-04
210	2.11E-04	1.01E-04
240	2.10E-04	1.00E-04
270	2.10E-04	1.00E-04
300	2.13E-04	1.01E-04
330	2.15E-04	1.03E-04
360	2.30E-04	1.06E-04
390	2.24E-04	1.05E-04
420	2.24E-04	1.07E-04
450	2.28E-04	1.10E-04
480	2.34E-04	1.09E-04
510	2.39E-04	1.09E-04
540	2.18E-04	1.10E-04
570	2.12E-04	1.11E-04
600	2.11E-04	1.14E-04
630	2.28E-04	1.14E-04
660	2.21E-04	1.09E-04
690	2.09E-04	1.10E-04
720	2.10E-04	1.11E-04
750	2.06E-04	1.15E-04
780	1.87E-04	1.16E-04
810	1.81E-04	1.16E-04
840	2.12E-04	1.15E-04
870	2.39E-04	1.17E-04
900	2.34E-04	1.15E-04
930	2.29E-04	1.03E-04
960	1.98E-04	1.06E-04
990	2.15E-04	1.07E-04
1020	1.98E-04	1.02E-04
1050	1.58E-04	9.83E-05
1080	1.10E-04	7.45E-05
1110	1.10E-04	6.96E-05
1140	1.09E-04	6.94E-05
1170	1.09E-04	6.92E-05
1200	1.09E-04	6.90E-05
FIRST DATA ALT	270	270
LAST DATA ALT	1080	1110

FLIGHT NO. C-279
IRRADIANCE

(JOB 5599 DATE 06/15/76)

FLIGHT NO.C-279 FILTER NO. 2 SUN ZENITH ANGLE 30.8

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
231	5.94E 02	2.52E 01	.042	5.40E-01	9.55E 02	7.48E 01	1.03E 03	.078
1116	3.78E 02	5.16E 01	.136	6.67E-01	7.57E 02	1.91E 02	9.48E 02	.252

FLIGHT NO.C-279 FILTER NO. 3 SUN ZENITH ANGLE 30.9

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
278	3.18E 02	1.47E 01	.046	4.39E-01	5.61E 02	4.27E 01	6.04E 02	.076
1088	5.58E 02	2.90E 01	.052	4.86E-01	8.64E 02	8.74E 01	9.52E 02	.101

FLIGHT NO. C-279 SPECTRAL FILTER NO. 2
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5599 DATE 06/15/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-279 FILTER NO. = 2 SUN ZENITH ANGLE 30.8

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		5.94E 02
150	2.52E 01	
300	2.72E 01	
600	3.62E 01	
900	4.51E 01	
1200	5.16E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1704	.0935	.0147
150	11.3662	12.6559	11.0010	11.0213			
300	11.1128	13.0613	11.3590	10.8306			
600	10.3464	14.2869	12.4414	10.2542			
900	9.8843	15.0260	13.0940	9.9066			
1200	9.6510	15.3991	13.4235	9.7311			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1117	.0728	.0147
150	11.3662	7.9105	6.9286	6.2610			
300	11.1128	7.5191	6.6994	6.0705			
600	10.3464	6.3360	6.0065	5.4945			
900	9.8843	5.6226	5.5887	5.1471			
1200	9.6510	5.2624	5.3777	4.9718			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1326	.0846	.0147
150	11.3662	7.8142	7.3175	6.6642			
300	11.1128	7.8490	7.2732	6.4950			
600	10.3464	7.9542	7.1395	5.9834			
900	9.8843	8.0176	7.0588	5.6749			
1200	9.6510	8.0496	7.0181	5.5191			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2087	.1036	.0147
150	11.3662	12.2853	10.3681	9.6441			
300	11.1128	12.2734	10.1281	9.0564			
600	10.3464	12.2375	9.4023	7.2797			
900	9.8843	12.2159	8.9647	6.2084			
1200	9.6510	12.2050	8.7438	5.6675			

FLIGHT NO. C-279 SPECTRAL FILTER NO. 3
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5599 DATE 06/15/76)
AVIZPRNT (JOB 3686 DATE 06/18/76)

FLIGHT NO. C-279 FILTER NO. = 3 SUN ZENITH ANGLE 30.9

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		3.18E 02
150	1.47E 01	
300	1.51E 01	
600	2.04E 01	
900	2.57E 01	
1200	2.90E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1835	.0887	.0095
150	7.2620	37.9305	29.8507	18.9019			
300	7.7824	36.5214	28.9598	18.3603			
600	12.8921	22.6859	20.2130	13.0433			
900	15.8876	14.5752	15.0854	9.9262			
1200	17.2055	11.0067	12.8294	8.5348			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0706	.0505	.0095
150	7.2620	8.5754	9.5254	6.7024			
300	7.7824	8.4193	9.3527	6.5767			
600	12.8921	6.8758	7.6568	5.3427			
900	15.8876	5.9715	6.6626	4.6193			
1200	17.2055	5.5736	6.2252	4.3010			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1610	.0749	.0095
150	7.2620	7.9817	8.4574	7.0535			
300	7.7824	7.9041	8.2434	6.9492			
600	12.8921	7.1422	6.1425	5.9249			
900	15.8876	6.6955	4.9109	5.3244			
1200	17.2055	6.4990	4.3690	5.0602			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2674	.1554	.0095
150	7.2620	25.3533	19.5740	14.0715			
300	7.7824	24.8015	19.1856	13.7754			
600	12.8921	19.3833	15.3718	10.8679			
900	15.8876	16.2071	13.1361	9.1634			
1200	17.2055	14.8096	12.1524	8.4135			

FLIGHT NO. C-279
EQUIVALENT ATTENUATION LENGTH

(JOB 5599 DATE 06/15/76)
DATE 60373 FLIGHT NO. C-279 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 2	3
0	2.67E 00	4.72E 00
30	3.40E 00	6.37E 00
60	3.93E 00	7.72E 00
90	4.16E 00	8.32E 00
120	4.28E 00	8.66E 00
150	4.36E 00	8.88E 00
180	4.42E 00	9.03E 00
210	4.46E 00	9.15E 00
240	4.49E 00	9.25E 00
270	4.52E 00	9.32E 00
300	4.54E 00	9.38E 00
330	4.55E 00	9.42E 00
360	4.55E 00	9.43E 00
390	4.54E 00	9.43E 00
420	4.53E 00	9.43E 00
450	4.53E 00	9.42E 00
480	4.51E 00	9.40E 00
510	4.49E 00	9.39E 00
540	4.49E 00	9.37E 00
570	4.50E 00	9.36E 00
600	4.51E 00	9.33E 00
630	4.51E 00	9.30E 00
660	4.51E 00	9.29E 00
690	4.51E 00	9.28E 00
720	4.52E 00	9.27E 00
750	4.53E 00	9.25E 00
780	4.55E 00	9.23E 00
810	4.58E 00	9.21E 00
840	4.60E 00	9.18E 00
870	4.59E 00	9.17E 00
900	4.58E 00	9.15E 00
930	4.57E 00	9.15E 00
960	4.57E 00	9.16E 00
990	4.58E 00	9.17E 00
1020	4.59E 00	9.18E 00
1050	4.61E 00	9.20E 00
1080	4.66E 00	9.25E 00
1110	4.72E 00	9.34E 00
1140	4.79E 00	9.42E 00
1170	4.84E 00	9.51E 00
1200	4.90E 00	9.59E 00

FLIGHT NO. C-279
BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5599 DATE 06/15/76)

FLIGHT NO. C-279 FILTER NO. 2
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.66E-01	8.76E-01	8.20E-01	6.74E-01	6.73E-01	8.20E-01	9.66E-01
300	9.36E-01	7.75E-01	6.84E-01	4.70E-01	4.68E-01	6.84E-01	9.36E-01
600	8.75E-01	5.98E-01	4.65E-01	2.19E-01	2.15E-01	4.65E-01	8.75E-01
900	8.22E-01	4.68E-01	3.22E-01	1.07E-01	1.03E-01	3.22E-01	8.22E-01
1200	7.83E-01	3.88E-01	2.44E-01	6.19E-02	5.83E-02	2.44E-01	7.83E-01

FLIGHT NO. C-279 FILTER NO. 3
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.83E-01	9.37E-01	9.07E-01	8.24E-01	8.24E-01	9.07E-01	9.83E-01
300	9.69E-01	8.84E-01	8.32E-01	6.93E-01	6.92E-01	8.32E-01	9.69E-01
600	9.38E-01	7.90E-01	6.91E-01	4.80E-01	4.76E-01	6.91E-01	9.38E-01
900	9.06E-01	6.84E-01	5.67E-01	3.26E-01	3.20E-01	5.67E-01	9.06E-01
1200	8.82E-01	6.17E-01	4.86E-01	2.41E-01	2.34E-01	4.86E-01	8.82E-01

FLIGHT NO. C-279 SPECTRAL FILTER NO. 2
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5599 DATE 06/15/76)

FLIGHT NO. C-279 FILTER NO. = 2 SUN ZENITH ANGLE 30.8

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.18E 00	1.20E 01	1.57E 01	2.58E 01	2.13E 01	1.04E 01	1.02E 00
300	1.17E 01	2.17E 01	2.78E 01	4.21E 01	3.48E 01	1.83E 01	1.93E 00
600	2.18E 01	3.92E 01	4.79E 01	6.33E 01	5.47E 01	3.32E 01	3.77E 00
900	2.97E 01	5.26E 01	6.19E 01	7.37E 01	6.82E 01	4.56E 01	5.39E 00
1200	3.46E 01	6.11E 01	7.00E 01	7.82E 01	7.69E 01	5.43E 01	6.56E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.18E 00	1.16E 01	1.48E 01	2.49E 01	2.01E 01	9.75E 00	1.02E 00
300	1.17E 01	2.10E 01	2.61E 01	4.06E 01	3.26E 01	1.72E 01	1.93E 00
600	2.18E 01	3.72E 01	4.42E 01	5.98E 01	4.89E 01	2.99E 01	3.77E 00
900	2.97E 01	4.86E 01	5.60E 01	6.84E 01	5.76E 01	3.91E 01	5.39E 00
1200	3.46E 01	5.53E 01	6.24E 01	7.18E 01	6.21E 01	4.49E 01	6.36E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.18E 00	9.41E 00	1.25E 01	2.07E 01	1.77E 01	8.83E 00	1.02E 00
300	1.17E 01	1.71E 01	2.20E 01	3.38E 01	2.89E 01	1.56E 01	1.93E 00
600	2.18E 01	3.09E 01	3.79E 01	5.06E 01	4.47E 01	2.77E 01	3.77E 00
900	2.97E 01	4.14E 01	4.88E 01	5.88E 01	5.47E 01	3.74E 01	5.39E 00
1200	3.46E 01	4.51E 01	5.52E 01	6.22E 01	6.08E 01	4.39E 01	6.56E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.18E 00	1.21E 01	1.64E 01	2.68E 01	2.22E 01	1.08E 01	1.02E 00
300	1.17E 01	2.19E 01	2.88E 01	4.36E 01	3.60E 01	1.90E 01	1.92E 00
600	2.18E 01	3.90E 01	4.87E 01	6.45E 01	5.40E 01	3.30E 01	3.75E 00
900	2.97E 01	5.16E 01	6.17E 01	7.40E 01	6.35E 01	4.31E 01	5.38E 00
1200	3.46E 01	5.93E 01	6.88E 01	7.79E 01	6.83E 01	4.93E 01	6.55E 00

FLIGHT NO. C-279 SPECTRAL FILTER NO. 3
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5599 DATE 06/15/76)

FLIGHT NO. C-279 FILTER NO. = 3 SUN ZENITH ANGLE 30.9

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.36E 00	5.01E 00	6.73E 00	1.16E 01	9.36E 00	4.26E 00	3.14E-01
300	2.56E 00	9.21E 00	1.22E 01	2.01E 01	1.63E 01	7.74E 00	5.91E-01
600	5.62E 00	1.79E 01	2.30E 01	3.48E 01	2.85E 01	1.48E 01	1.26E 00
900	9.73E 00	2.67E 01	3.33E 01	4.64E 01	3.90E 01	2.18E 01	2.12E 00
1200	1.35E 01	3.34E 01	4.05E 01	5.32E 01	4.60E 01	2.71E 01	2.89E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.36E 00	2.50E 00	3.40E 00	5.98E 00	5.25E 00	2.52E 00	3.14E-01
300	2.56E 00	4.61E 00	6.17E 00	1.04E 01	9.13E 00	4.58E 00	5.91E-01
600	5.62E 00	9.43E 00	1.22E 01	1.88E 01	1.70E 01	9.18E 00	1.26E 00
900	9.73E 00	1.50E 01	1.88E 01	2.64E 01	2.52E 01	1.45E 01	2.12E 00
1200	1.35E 01	1.97E 01	2.39E 01	3.13E 01	3.16E 01	1.90E 01	2.89E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.36E 00	2.55E 00	3.54E 00	6.33E 00	5.71E 00	2.77E 00	3.14E-01
300	2.56E 00	4.69E 00	6.42E 00	1.10E 01	9.93E 00	5.03E 00	5.91E-01
600	5.62E 00	9.49E 00	1.25E 01	1.97E 01	1.83E 01	9.98E 00	1.26E 00
900	9.73E 00	1.48E 01	1.90E 01	2.73E 01	2.67E 01	1.56E 01	2.12E 00
1200	1.35E 01	1.91E 01	2.39E 01	3.22E 01	3.31E 01	2.02E 01	2.89E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.36E 00	4.33E 00	5.93E 00	1.04E 01	8.70E 00	4.03E 00	3.14E-01
300	2.56E 00	7.96E 00	1.08E 01	1.81E 01	1.51E 01	7.32E 00	5.91E-01
600	5.62E 00	1.54E 01	2.02E 01	3.12E 01	2.64E 01	1.39E 01	1.26E 00
900	9.73E 00	2.27E 01	2.89E 01	4.13E 01	3.60E 01	2.05E 01	2.12E 00
1200	1.35E 01	2.81E 01	3.51E 01	4.73E 01	4.22E 01	2.54E 01	2.89E 00

FLIGHT NO. C-279 SPECTRAL FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5599 DATE 06/15/76)

FLIGHT NO. C-279 FILTER NO. = 2 SUN ZENITH ANGLE 30.8

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.99E-01	1.71E 00	2.40E 00	4.78E 00	1.67E-01	6.68E-02	5.59E-03
300	1.44E 00	3.23E 00	4.69E 00	1.04E 01	3.93E-01	1.42E-01	1.09E-02
600	2.17E 00	5.70E 00	8.99E 00	2.51E 01	1.34E 00	3.77E-01	2.27E-02
900	2.52E 00	7.83E 00	1.34E 01	4.81E 01	3.51E 00	7.47E-01	3.47E-02
1200	2.69E 00	9.58E 00	1.75E 01	7.69E 01	4.98E 00	1.18E 00	4.43E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.99E-01	1.66E 00	2.26E 00	4.62E 00	1.57E-01	6.28E-02	5.59E-03
300	1.44E 00	3.14E 00	4.41E 00	9.98E 00	3.68E-01	1.33E-01	1.09E-02
600	2.17E 00	5.40E 00	8.27E 00	2.37E 01	1.20E 00	3.40E-01	2.27E-02
900	2.52E 00	7.23E 00	1.21E 01	4.46E 01	2.96E 00	6.42E-01	3.47E-02
1200	2.69E 00	8.67E 00	1.56E 01	7.06E 01	5.63E 00	9.72E-01	4.43E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.99E-01	1.34E 00	1.90E 00	3.84E 00	1.39E-01	5.69E-02	5.59E-03
300	1.44E 00	2.54E 00	3.71E 00	8.31E 00	3.27E-01	1.21E-01	1.09E-02
600	2.17E 00	4.48E 00	7.08E 00	2.01E 01	1.10E 00	3.16E-01	2.27E-02
900	2.52E 00	6.16E 00	1.05E 01	3.84E 01	2.81E 00	6.13E-01	3.47E-02
1200	2.69E 00	7.55E 00	1.38E 01	6.12E 01	5.52E 00	9.49E-01	4.43E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.99E-01	1.72E 00	2.49E 00	4.96E 00	1.74E-01	6.96E-02	5.56E-03
300	1.44E 00	3.26E 00	4.86E 00	1.07E 01	4.07E-01	1.47E-01	1.08E-02
600	2.17E 00	5.67E 00	9.11E 00	2.56E 01	1.33E 00	3.75E-01	2.26E-02
900	2.52E 00	7.68E 00	1.33E 01	4.83E 01	3.26E 00	7.06E-01	3.46E-02
1200	2.69E 00	9.30E 00	1.72E 01	7.66E 01	6.20E 00	1.07E 00	4.42E-02

FLIGHT NO. C-279 SPECTRAL FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5599 DATE 06/15/76)

FLIGHT NO. C-279 FILTER NO. = 3 SUN ZENITH ANGLE 30.9

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.96E-01	1.14E 00	1.59E 00	3.00E 00	1.12E-01	4.64E-02	3.16E-03
300	5.50E-01	2.17E 00	3.06E 00	6.05E 00	2.32E-01	9.19E-02	6.03E-03
600	9.24E-01	3.54E 00	5.14E 00	1.12E 01	5.92E-01	2.11E-01	1.33E-02
900	1.31E 00	4.78E 00	7.17E 00	1.74E 01	1.20E 00	3.79E-01	2.31E-02
1200	1.66E 00	5.86E 00	9.01E 00	2.39E 01	1.94E 00	5.50E-01	3.24E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.96E-01	5.72E-01	8.02E-01	1.55E 00	6.29E-02	2.75E-02	3.16E-03
300	5.50E-01	1.09E 00	1.55E 00	3.13E 00	1.30E-01	5.44E-02	6.03E-03
600	9.24E-01	1.86E 00	2.73E 00	6.05E 00	3.52E-01	1.31E-01	1.33E-02
900	1.31E 00	2.69E 00	4.05E 00	9.89E 00	7.78E-01	2.53E-01	2.31E-02
1200	1.66E 00	3.45E 00	5.32E 00	1.40E 01	1.34E 00	3.85E-01	3.24E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.96E-01	5.82E-01	8.34E-01	1.65E 00	6.85E-02	3.02E-02	3.16E-03
300	5.50E-01	1.11E 00	1.61E 00	3.32E 00	1.42E-01	5.97E-02	6.03E-03
600	9.24E-01	1.87E 00	2.80E 00	6.34E 00	3.79E-01	1.43E-01	1.33E-02
900	1.31E 00	2.64E 00	4.09E 00	1.02E 01	8.23E-01	2.71E-01	2.31E-02
1200	1.66E 00	3.35E 00	5.32E 00	1.44E 01	1.40E 00	4.10E-01	3.24E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.96E-01	9.59E-01	1.40E 00	2.69E 00	1.04E-01	4.39E-02	3.16E-03
300	5.50E-01	1.88E 00	2.70E 00	5.43E 00	2.16E-01	8.69E-02	6.03E-03
600	9.24E-01	3.04E 00	4.50E 00	1.00E 01	5.48E-01	1.99E-01	1.33E-02
900	1.31E 00	4.06E 00	6.23E 00	1.55E 01	1.11E 00	3.57E-01	2.31E-02
1200	1.66E 00	4.94E 00	7.80E 00	2.12E 01	1.78E 00	5.15E-01	3.24E-02

FLIGHT C-280 – 4 June 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was an overcast afternoon. The flight was conducted under the cloud deck over low lying flat terrain consisting mostly of cultivated farm lands interspersed with dark patches of dense woods. The data-taking started at 1616 GMT and continued until 1744 GMT. The sun zenith angle during sky radiance data-taking was 61.7 degrees at the beginning and 74.6 degrees at the end. The maximum altitude for the flight was 750 meters. The average elevation of the terrain was 20 meters.

At the beginning of data-taking the ground station recorded generally overcast with clear sun on the western horizon.

The radiosonde station at Meppen reported 0.2 to 0.3 cumulus cloud with considerable development and 0.1 cirrus cloud. The height of the cumulus was 1500 to 1999 meters.

FLIGHT LOG ENTRY

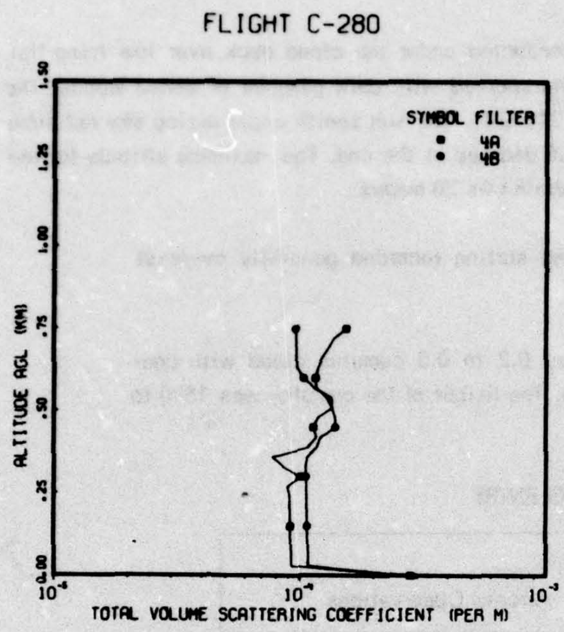
Time (GMT)	Elevation (meters AGL)	Aircrew Observations
		Full overcast above, moderate to heavy haze.

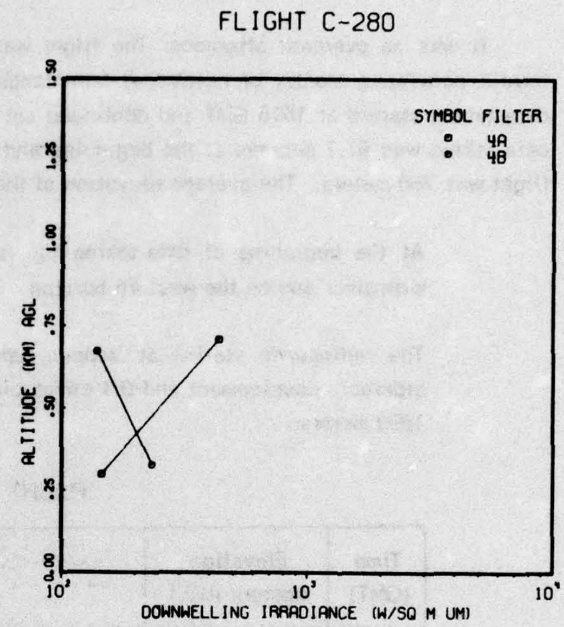
The afternoon surface charts show ridging over France and Germany from a high in the Atlantic. Above 800 millibars there is considerably more moisture than shown for the morning radiosonde.

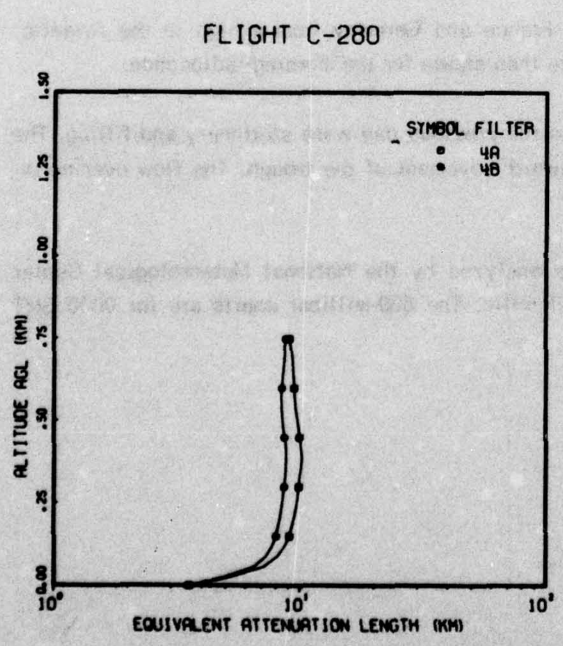
At 500 millibars both the low and the trough from the previous day were stationary and filling. The high ridge was also stationary and was blocking eastward movement of the trough. The flow over northwestern Germany was moderate southwesterly.

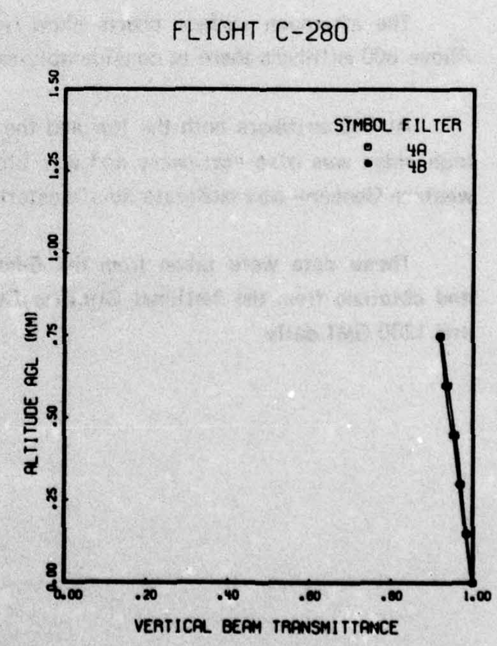
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-280



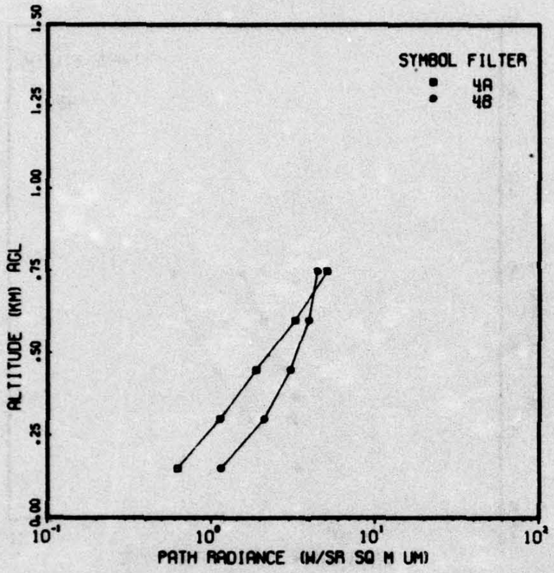




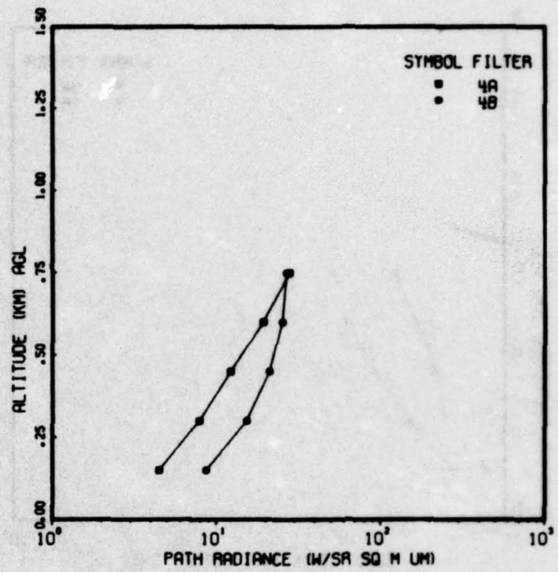


FLIGHT NO. C-280

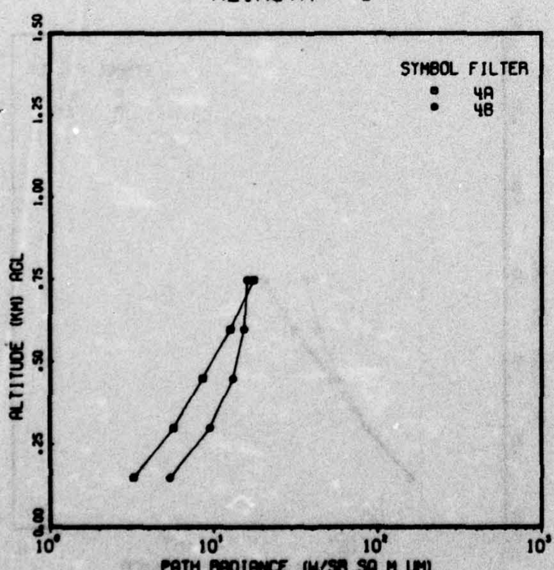
FLIGHT C-280 ZENITH ANGLE 0
AZIMUTH 0



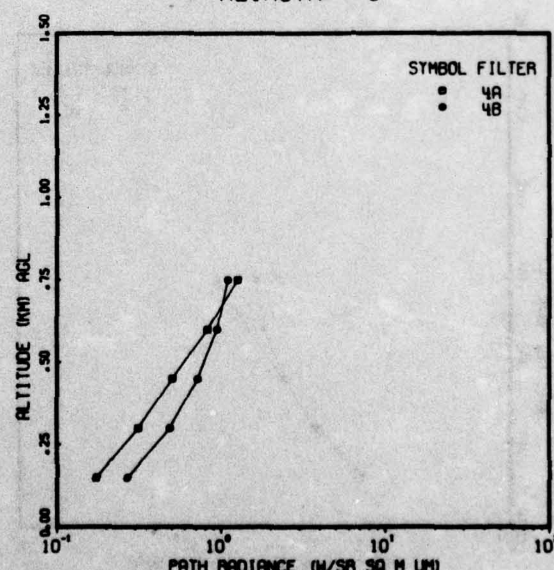
FLIGHT C-280 ZENITH ANGLE 80
AZIMUTH 0



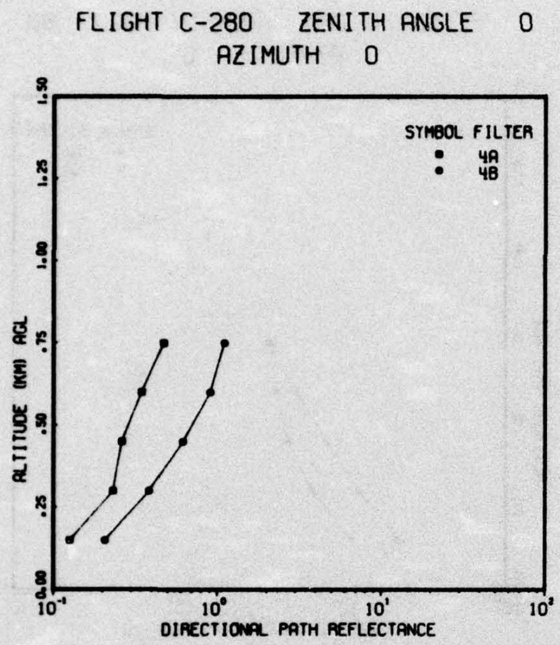
FLIGHT C-280 ZENITH ANGLE 100
AZIMUTH 0

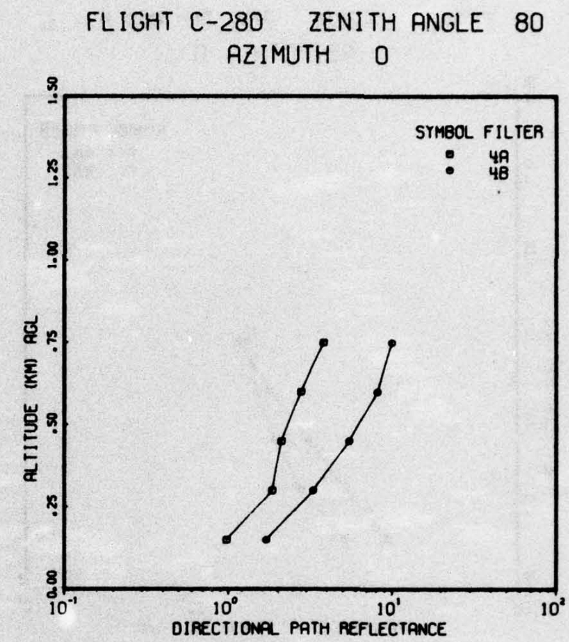


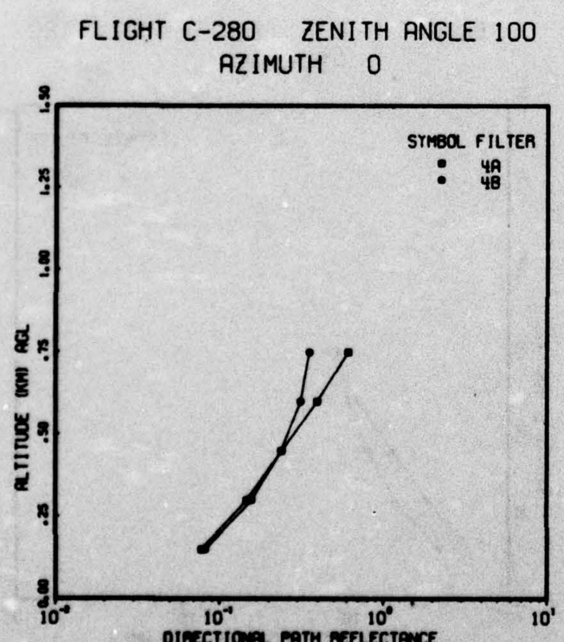
FLIGHT C-280 ZENITH ANGLE 180
AZIMUTH 0

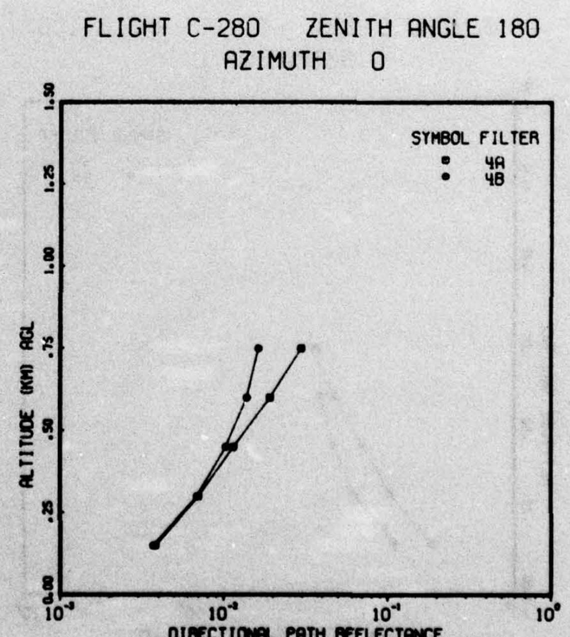


FLIGHT NO. C-280









FLIGHT NO. C-280
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5608 DATE 06/16/76)
DATE 60473 FLIGHT NO. C-280 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 4A	4B
0	2.81E-04	2.86E-04
30	9.23E-05	1,08E-04
60	9.21E-05	1,08E-04
90	9.18E-05	1,07E-04
120	9.16E-05	1,07E-04
150	9.14E-05	1,07E-04
180	9.12E-05	1,07E-04
210	9.09E-05	1,06E-04
240	9.07E-05	1,06E-04
270	8.90E-05	1,06E-04
300	1.00E-04	1,06E-04
330	8.58E-05	1,05E-04
360	7.71E-05	1,07E-04
390	1.08E-04	1,17E-04
420	1.17E-04	1,22E-04
450	1.13E-04	1,39E-04
480	1.18E-04	1,39E-04
510	1.35E-04	1,35E-04
540	1.28E-04	1,34E-04
570	1.17E-04	1,14E-04
600	1.15E-04	1,03E-04
630	1.18E-04	9,69E-05
660	1.23E-04	9,67E-05
690	1.31E-04	9,64E-05
720	1.38E-04	9,61E-05
750	1.54E-04	9,58E-05
FIRST DATA ALT	240	330
LAST DATA ALT	750	630

FLIGHT NO. C-280
IRRADIANCE

(JOB 5608 DATE 06/16/76)

FLIGHT NO.C-280 FILTER NO. 4A SUN ZENITH ANGLE 62.5

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
299	1.45E 02	1.57E 01	.108	5.60E-04	3.34E 02	5.99E 01	3.94E 02	.179
709	4.36E 02	3.68E 01	.084	6.21E-04	7.93E 02	9.55E 01	8.88E 02	.120

FLIGHT NO.C-280 FILTER NO. 4B SUN ZENITH ANGLE 74.1

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
327	2.32E 02	1.77E 01	.076	2.41E-08	4.57E 02	5.63E 01	5.14E 02	.123
673	1.39E 02	1.38E 01	.099	2.77E-08	2.48E 02	4.20E 01	2.90E 02	.169

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4A
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5608 DATE 06/16/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-280 FILTER NO. #4A SUN ZENITH ANGLE 62.5

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		1.45E 02
150	1.57E 01	
300	1.58E 01	
450	2.35E 01	
600	3.12E 01	
750	3.68E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.6287	.3904	.0623
150	10.3918	23.1547	20.3036	22.2631			
300	10.3872	23.0590	20.2116	22.1566			
450	9.9207	13.4371	10.9620	11.4526			
600	9.6846	8.5660	6.2803	6.0348			
750	9.5751	6.3073	4.1081	3.5211			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3095	.2473	.0623
150	10.3918	3.2664	3.7783	4.7448			
300	10.3872	3.2944	3.7980	4.7503			
450	9.9207	6.1100	5.7780	5.2968			
600	9.6846	7.5351	6.7802	5.5735			
750	9.5751	8.1963	7.2452	5.7018			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.5643	.3597	.0623
150	10.3918	16.3817	14.2345	12.0478			
300	10.3872	16.3264	14.1882	12.0091			
450	9.9207	10.7684	9.5424	8.1170			
600	9.6846	7.9552	7.1909	6.1470			
750	9.5751	6.6500	6.0998	5.2330			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.5990	.4081	.0623
150	10.3918	16.2935	12.8592	12.2873			
300	10.3872	16.2481	12.8287	12.2514			
450	9.9207	11.6831	9.7593	8.6446			
600	9.6846	9.3726	8.2057	6.8191			
750	9.5751	8.3005	7.4849	5.9721			

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4B
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

·AVIZC130 (JOB 5608 DATE 06/16/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-280 FILTER NO. =4B SUN ZENITH ANGLE 74.1

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		2.32E 02
150	1./7E 01	
300	1./7E 01	
450	1.63E 01	
600	1.46E 01	
750	1.38E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.4697	.2662	.0322
150	11.2777	70.1433	30.1749	16.6546			
300	11.2777	70.1433	30.1749	16.6546			
450	11.2111	51.1560	23.1903	14.3780			
600	11.1128	23.0897	12.8659	11.0127			
750	11.0561	6.9220	6.9185	9.0741			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2544	.1470	.0322
150	11.2777	12.2993	10.2168	8.4073			
300	11.2777	12.2993	10.2168	8.4073			
450	11.2111	10.7512	9.2029	7.9819			
600	11.1128	8.4628	7.7043	7.3531			
750	11.0561	7.1446	6.8409	6.9908			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1836	.1725	.0322
150	11.2777	7.6757	6.4607	5.2922			
300	11.2777	7.6757	6.4607	5.2922			
450	11.2111	6.9220	5.8642	4.9260			
600	11.1128	5.8078	4.9824	4.3846			
750	11.0561	5.1660	4.4745	4.0728			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1795	.1399	.0322
150	11.2777	6.9242	5.2829	4.3332			
300	11.2777	6.9242	5.2829	4.3332			
450	11.2111	6.4767	5.4246	4.7339			
600	11.1128	5.8153	5.6340	5.3261			
750	11.0561	5.4342	5.7547	5.6672			

FLIGHT NO. C-280
EQUIVALENT ATTENUATION LENGTH

(JOB 5608 DATE 06/16/76)
DATE 60473 FLIGHT NO. C-280 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 4A	4B
0	3.56E 00	3.50E 00
30	5.36E 00	5.08E 00
60	7.17E 00	6.56E 00
90	8.09E 00	7.27E 00
120	8.65E 00	7.69E 00
150	9.02E 00	7.97E 00
180	9.30E 00	8.18E 00
210	9.51E 00	8.33E 00
240	9.67E 00	8.45E 00
270	9.81E 00	8.55E 00
300	9.89E 00	8.63E 00
330	9.96E 00	8.70E 00
360	1.01E 01	8.76E 00
390	1.02E 01	8.77E 00
420	1.01E 01	8.74E 00
450	9.96E 00	8.66E 00
480	9.87E 00	8.55E 00
510	9.72E 00	8.46E 00
540	9.57E 00	8.40E 00
570	9.49E 00	8.38E 00
600	9.44E 00	8.42E 00
630	9.39E 00	8.49E 00
660	9.34E 00	8.55E 00
690	9.27E 00	8.62E 00
720	9.17E 00	8.68E 00
750	9.05E 00	8.74E 00

FLIGHT NO. C-280

BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5608 DATE 06/16/76)

FLIGHT NO. C-280 FILTER NO. 4A

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.84E-01	9.38E-01	9.09E-01	8.27E-01	8.26E-01	9.09E-01	9.84E-01
300	9.70E-01	8.89E-01	8.40E-01	7.07E-01	7.05E-01	8.40E-01	9.70E-01
450	9.56E-01	8.40E-01	7.71E-01	5.97E-01	5.94E-01	7.71E-01	9.56E-01
600	9.38E-01	7.82E-01	6.93E-01	4.84E-01	4.80E-01	6.93E-01	9.38E-01
750	9.20E-01	7.26E-01	6.21E-01	3.89E-01	3.84E-01	6.21E-01	9.20E-01

FLIGHT NO. C-280 FILTER NO. 4B

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ZENITH ANGLE OF PATH OF SIGHT (DEG)

ALTITUDE M	0	75	80	85	95	100	180
150	9.81E-01	9.30E-01	8.97E-01	8.06E-01	8.06E-01	8.97E-01	9.81E-01
300	9.66E-01	8.74E-01	8.19E-01	6.72E-01	6.70E-01	8.19E-01	9.66E-01
450	9.49E-01	8.18E-01	7.41E-01	5.52E-01	5.49E-01	7.41E-01	9.49E-01
600	9.31E-01	7.59E-01	6.63E-01	4.43E-01	4.40E-01	6.63E-01	9.31E-01
750	9.18E-01	7.18E-01	6.10E-01	3.76E-01	3.71E-01	6.10E-01	9.18E-01

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4A
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 560R DATE 06/16/76)

FLIGHT NO. C-280 FILTER NO. =4A SUN ZENITH ANGLE 62.5

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.24E-01	3.11E 00	4.46E 00	8.08E 00	6.96E 00	3.25E 00	1.73E-01
300	1.13E 00	5.54E 00	7.84E 00	1.37E 01	1.18E 01	5.71E 00	3.14E-01
450	1.88E 00	8.96E 00	1.22E 01	2.00E 01	1.72E 01	8.57E 00	5.05E-01
600	3.23E 00	1.49E 01	1.92E 01	2.88E 01	2.50E 01	1.27E 01	8.30E-01
750	5.10E 00	2.28E 01	2.78E 01	3.81E 01	3.39E 01	1.76E 01	1.26E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.24E-01	1.54E 00	2.20E 00	4.05E 00	3.76E 00	1.85E 00	1.73E-01
300	1.13E 00	2.74E 00	3.87E 00	6.86E 00	6.35E 00	3.25E 00	3.14E-01
450	1.88E 00	4.53E 00	6.22E 00	1.04E 01	9.82E 00	5.13E 00	5.05E-01
600	3.23E 00	7.78E 00	1.03E 01	1.58E 01	1.57E 01	8.30E 00	8.30E-01
750	5.10E 00	1.21E 01	1.55E 01	2.20E 01	2.31E 01	1.24E 01	1.26E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.24E-01	2.78E 00	3.90E 00	6.97E 00	5.97E 00	2.80E 00	1.73E-01
300	1.13E 00	4.95E 00	6.86E 00	1.18E 01	1.01E 01	4.92E 00	3.14E-01
450	1.88E 00	7.37E 00	1.01E 01	1.66E 01	1.44E 01	7.29E 00	5.05E-01
600	3.23E 00	1.06E 01	1.42E 01	2.22E 01	1.98E 01	1.05E 01	8.30E-01
750	5.10E 00	1.42E 01	1.86E 01	2.76E 01	2.56E 01	1.42E 01	1.26E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	6.24E-01	3.40E 00	4.68E 00	8.22E 00	6.84E 00	3.17E 00	1.73E-01
300	1.13E 00	6.06E 00	8.23E 00	1.39E 01	1.16E 01	5.57E 00	3.14E-01
450	1.88E 00	8.97E 00	1.20E 01	1.95E 01	1.63E 01	8.16E 00	5.05E-01
600	3.23E 00	1.28E 01	1.68E 01	2.58E 01	2.21E 01	1.15E 01	8.30E-01
750	5.10E 00	1.69E 01	2.18E 01	3.18E 01	2.79E 01	1.52E 01	1.26E 00

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4B
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5608 DATE 06/16/76)

FLIGHT NO. C-280 FILTER NO. =4B SUN ZENITH ANGLE 74.1

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.14E 00	6.29E 00	8.62E 00	1.49E 01	1.19E 01	5.39E 00	2.68E-01
300	2.10E 00	1.13E 01	1.52E 01	2.52E 01	2.01E 01	9.53E 00	4.90E-01
450	3.05E 00	1.58E 01	2.10E 01	3.35E 01	2.62E 01	1.31E 01	7.19E-01
600	3.93E 00	1.90E 01	2.51E 01	3.88E 01	2.88E 01	1.54E 01	9.48E-01
750	4.46E 00	2.04E 01	2.67E 01	4.07E 01	2.82E 01	1.60E 01	1.10E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.14E 00	3.53E 00	4.84E 00	8.44E 00	7.09E 00	3.34E 00	2.68E-01
300	2.10E 00	6.35E 00	8.54E 00	1.43E 01	1.20E 01	5.91E 00	4.90E-01
450	3.05E 00	8.97E 00	1.19E 01	1.92E 01	1.59E 01	8.24E 00	7.19E-01
600	3.93E 00	1.12E 01	1.47E 01	2.28E 01	1.83E 01	1.01E 01	9.48E-01
750	4.46E 00	1.24E 01	1.62E 01	2.46E 01	1.90E 01	1.10E 01	1.10E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.14E 00	2.71E 00	3.73E 00	6.56E 00	5.69E 00	2.75E 00	2.68E-01
300	2.10E 00	4.86E 00	6.58E 00	1.11E 01	9.62E 00	4.85E 00	4.90E-01
450	3.05E 00	6.92E 00	9.23E 00	1.49E 01	1.28E 01	6.78E 00	7.19E-01
600	3.93E 00	8.72E 00	1.15E 01	1.78E 01	1.48E 01	8.31E 00	9.48E-01
750	4.46E 00	9.76E 00	1.27E 01	1.93E 01	1.55E 01	9.07E 00	1.10E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.14E 00	2.74E 00	3.72E 00	6.48E 00	5.56E 00	2.68E 00	2.68E-01
300	2.10E 00	4.91E 00	6.57E 00	1.10E 01	9.39E 00	4.73E 00	4.90E-01
450	3.05E 00	6.97E 00	9.20E 00	1.48E 01	1.25E 01	6.61E 00	7.19E-01
600	3.93E 00	8.78E 00	1.14E 01	1.77E 01	1.46E 01	8.15E 00	9.48E-01
750	4.46E 00	9.82E 00	1.27E 01	1.92E 01	1.53E 01	8.94E 00	1.10E 00

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4A
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5608 DATE 06/16/76)

FLIGHT NO. C-280 FILTER NO. =4A SUN ZENITH ANGLE 62.5

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.27E-01	6.63E-01	9.81E-01	1.95E 00	1.82E-01	7.73E-02	3.81E-03
300	2.32E-01	1.24E 00	1.86E 00	3.86E 00	3.61E-01	1.47E-01	7.00E-03
450	2.63E-01	1.43E 00	2.12E 00	4.49E 00	6.26E-01	2.40E-01	1.14E-02
600	3.47E-01	1.93E 00	2.79E 00	5.99E 00	1.12E 00	3.96E-01	1.91E-02
750	4.74E-01	2.68E 00	3.83E 00	8.38E 00	1.91E 00	6.12E-01	2.96E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.27E-01	3.28E-01	4.84E-01	9.80E-01	9.83E-02	4.40E-02	3.81E-03
300	2.32E-01	6.14E-01	9.18E-01	1.93E 00	1.95E-01	8.36E-02	7.00E-03
450	2.63E-01	7.22E-01	1.08E 00	2.33E 00	3.57E-01	1.44E-01	1.14E-02
600	3.47E-01	1.00E 00	1.50E 00	3.30E 00	7.07E-01	2.59E-01	1.91E-02
750	4.74E-01	1.43E 00	2.13E 00	4.83E 00	1.30E 00	4.33E-01	2.96E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.27E-01	5.93E-01	8.59E-01	1.69E 00	1.56E-01	6.67E-02	3.81E-03
300	2.32E-01	1.11E 00	1.63E 00	3.33E 00	3.09E-01	1.27E-01	7.00E-03
450	2.63E-01	1.18E 00	1.75E 00	3.72E 00	5.23E-01	2.05E-01	1.14E-02
600	3.47E-01	1.37E 00	2.06E 00	4.63E 00	8.94E-01	3.28E-01	1.91E-02
750	4.74E-01	1.67E 00	2.56E 00	6.07E 00	1.44E 00	4.94E-01	2.96E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.27E-01	7.26E-01	1.03E 00	1.99E 00	1.79E-01	7.55E-02	3.81E-03
300	2.32E-01	1.36E 00	1.95E 00	3.92E 00	3.54E-01	1.44E-01	7.00E-03
450	2.63E-01	1.43E 00	2.08E 00	4.37E 00	5.93E-01	2.29E-01	1.14E-02
600	3.47E-01	1.65E 00	2.44E 00	5.38E 00	9.94E-01	3.60E-01	1.91E-02
750	4.74E-01	1.99E 00	3.00E 00	6.99E 00	1.57E 00	5.29E-01	2.96E-02

FLIGHT NO. C-280 SPECTRAL FILTER NO. 4B
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5618 DATE 06/16/76)

FLIGHT NO. C-280 FILTER NO. =4B SUN ZENITH ANGLE 74.1

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.07E-01	1.20E 00	1.71E 00	3.28E 00	1.99E-01	8.13E-02	3.69E-03
300	3.86E-01	2.29E 00	3.31E 00	6.66E 00	4.05E-01	1.57E-01	6.87E-03
450	6.19E-01	3.72E 00	5.48E 00	1.17E 01	6.46E-01	2.39E-01	1.03E-02
600	9.08E-01	5.40E 00	8.16E 00	1.88E 01	8.87E-01	3.14E-01	1.38E-02
750	1.11E 00	6.48E 00	1.00E 01	2.47E 01	1.03E 00	3.56E-01	1.63E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.07E-01	6.74E-01	9.57E-01	1.86E 00	1.19E-01	5.04E-02	3.69E-03
300	3.86E-01	1.29E 00	1.85E 00	3.78E 00	2.42E-01	9.77E-02	6.87E-03
450	6.19E-01	2.11E 00	3.11E 00	6.70E 00	3.92E-01	1.50E-01	1.03E-02
600	9.08E-01	3.18E 00	4.78E 00	1.11E 01	5.65E-01	2.06E-01	1.38E-02
750	1.11E 00	3.96E 00	6.07E 00	1.49E 01	6.94E-01	2.43E-01	1.63E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.07E-01	5.18E-01	7.38E-01	1.45E 00	9.56E-02	4.14E-02	3.69E-03
300	3.86E-01	9.94E-01	1.43E 00	2.94E 00	1.94E-01	8.02E-02	6.87E-03
450	6.19E-01	1.53E 00	2.40E 00	5.22E 00	3.15E-01	1.24E-01	1.03E-02
600	9.08E-01	2.47E 00	3.72E 00	8.67E 00	4.57E-01	1.70E-01	1.38E-02
750	1.11E 00	3.10E 00	4.76E 00	1.17E 01	5.65E-01	2.01E-01	1.63E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.07E-01	5.23E-01	7.36E-01	1.43E 00	9.34E-02	4.03E-02	3.69E-03
300	3.86E-01	9.97E-01	1.42E 00	2.90E 00	1.90E-01	7.81E-02	6.87E-03
450	6.19E-01	1.54E 00	2.39E 00	5.16E 00	3.08E-01	1.21E-01	1.03E-02
600	9.08E-01	2.49E 00	3.71E 00	8.58E 00	4.49E-01	1.66E-01	1.38E-02
750	1.11E 00	3.12E 00	4.75E 00	1.16E 01	5.58E-01	1.98E-01	1.63E-02

FLIGHT C-281 – 5 June 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was an overcast morning. The flight was conducted over low lying flat terrain consisting mainly of cultivated farmlands interspersed with dark patches of dense woods. The data-taking started at 0855 GMT and continued until 0923 GMT. The sun zenith angle during sky radiance data-taking was 41.9 degrees at the beginning and 39.3 degrees at the end. The maximum flight altitude was 863 meters. The average elevation of the terrain was 20 meters.

Near the beginning of data-taking the ground station was reporting generally solid overcast, heavy fast moving cumulus with occasional breaks.

The radiosonde station at Meppen reported 0.4 cumulus and stratocumulus at 600 to 999 meters at 0700 GMT. By 1300 GMT they reported 0.5 stratocumulus at a height of 1000 to 1499 meters.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
0803		Above clouds, very clear and bright sun.
0820	300	Filter 3 low altitude straight and level.
		Cloud deck about 1050 to 1350 meters, clear above and clear below, visibility 20+ miles (32+kilometers).
0826		Broken to solid overcast.
0914	750	Pass through cloud at 091442 in Rev 15 of scanner.
		Low level visibility decreasing slightly through mission. Below the overcast, short profiles only.

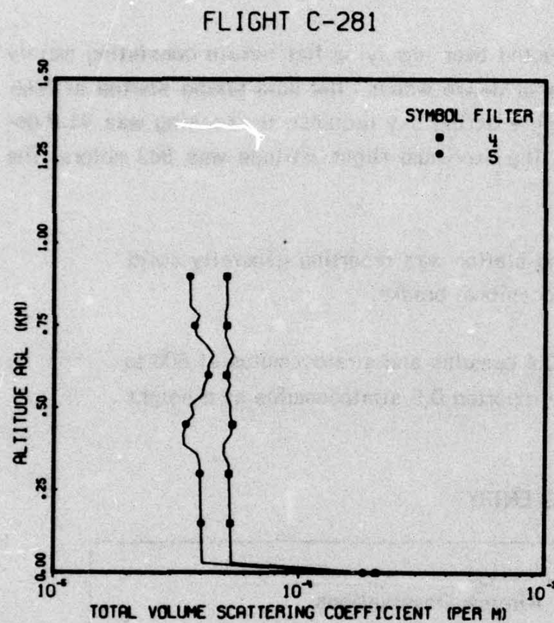
Note: Flight elevations in approximate feet MSL have been converted to approximate meters AGL.

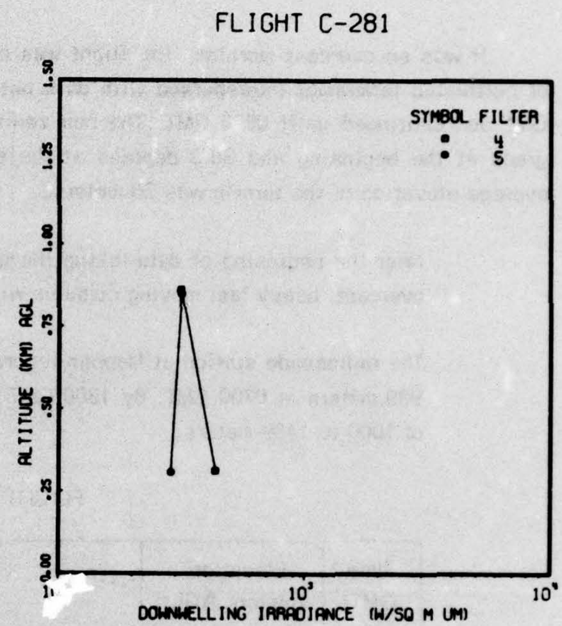
On the surface charts ridging over France and West Germany became stronger throughout the day.

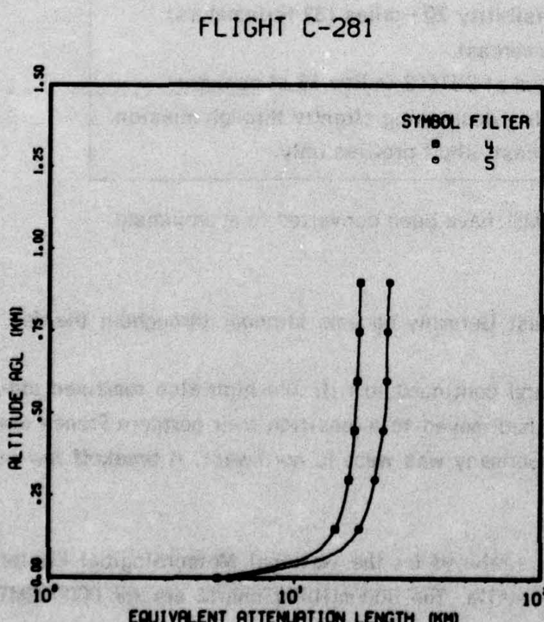
At 500 millibars the trough remained stationary and continued to fill. The high also remained stationary but began to weaken. By 1200 GMT the trough had moved to a position over northern France and Germany and continued to fill. The flow over northern Germany was west to northwest. A breakoff low in Spain deepened throughout the day.

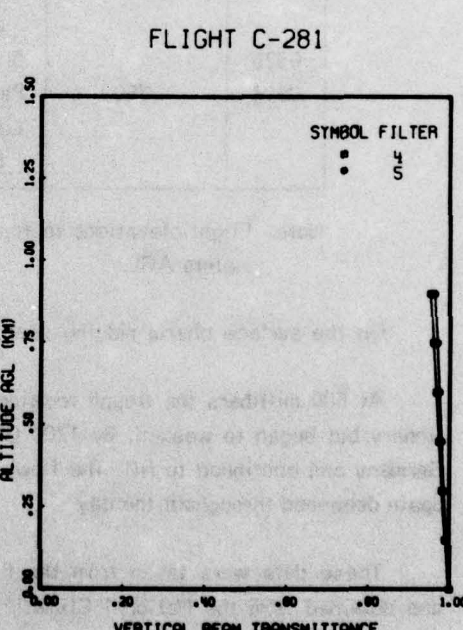
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1300 GMT daily.

FLIGHT NO. C-281



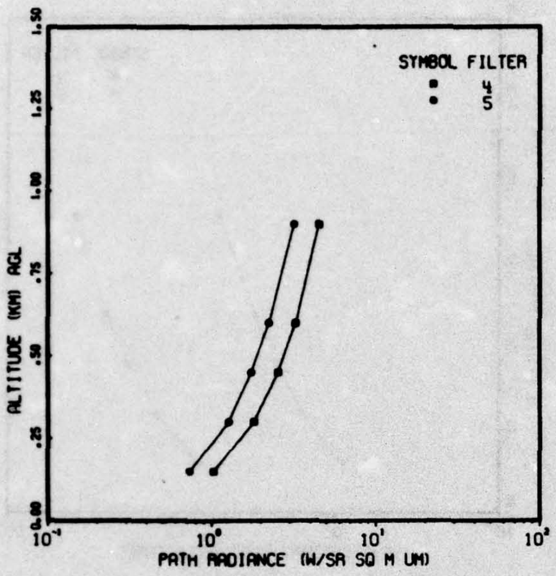




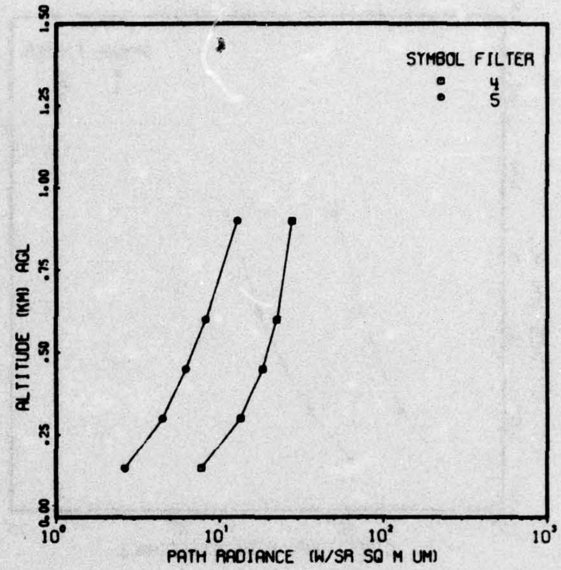


FLIGHT NO. C-281

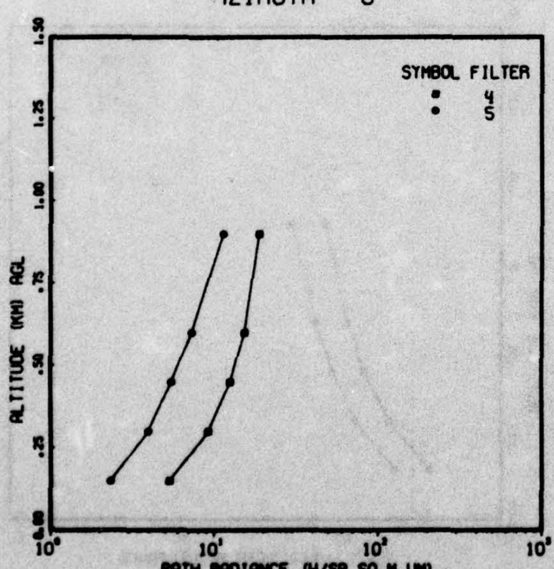
FLIGHT C-281 ZENITH ANGLE 0
AZIMUTH 0



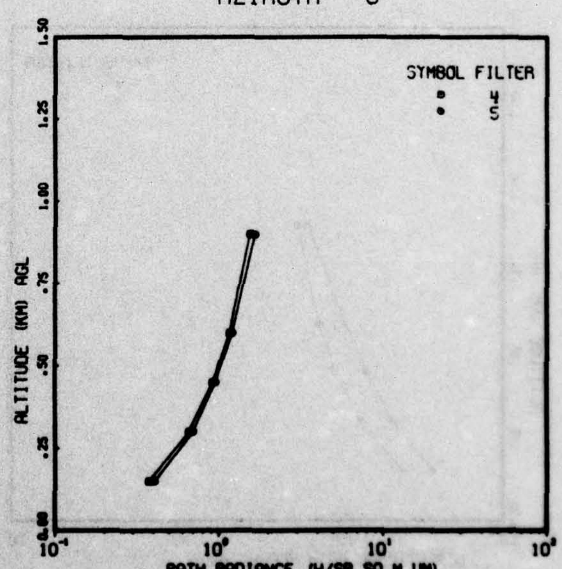
FLIGHT C-281 ZENITH ANGLE 80
AZIMUTH 0



FLIGHT C-281 ZENITH ANGLE 100
AZIMUTH 0

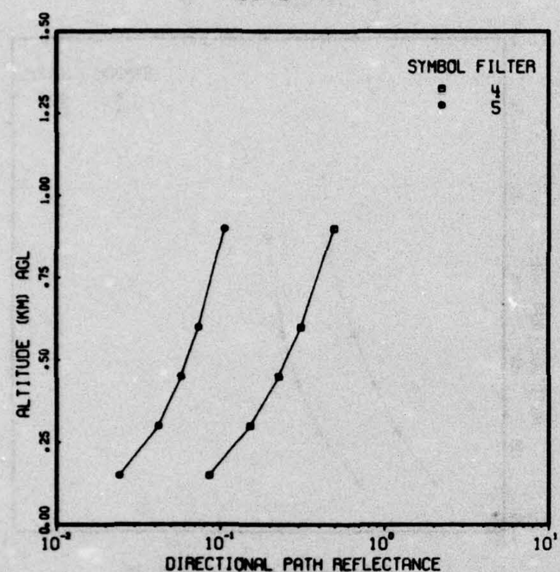


FLIGHT C-281 ZENITH ANGLE 180
AZIMUTH 0

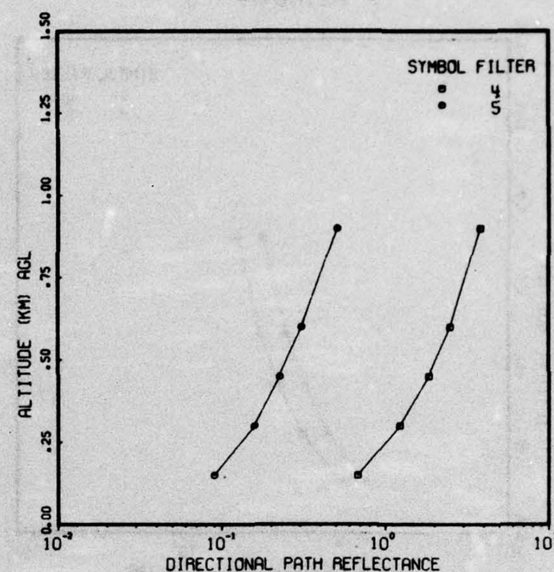


FLIGHT NO. C-281

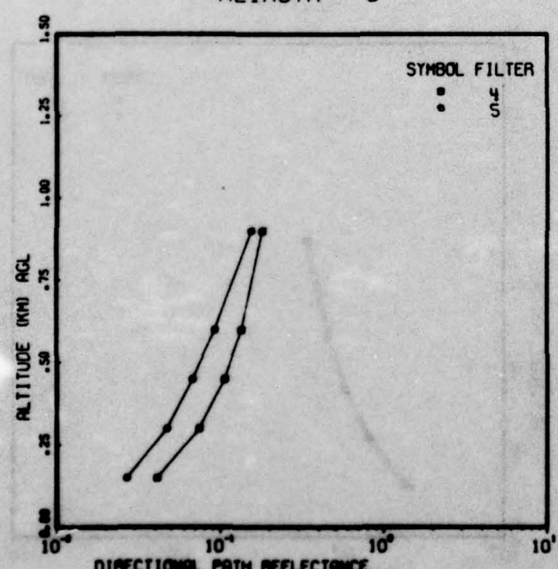
FLIGHT C-281 ZENITH ANGLE 0
AZIMUTH 0



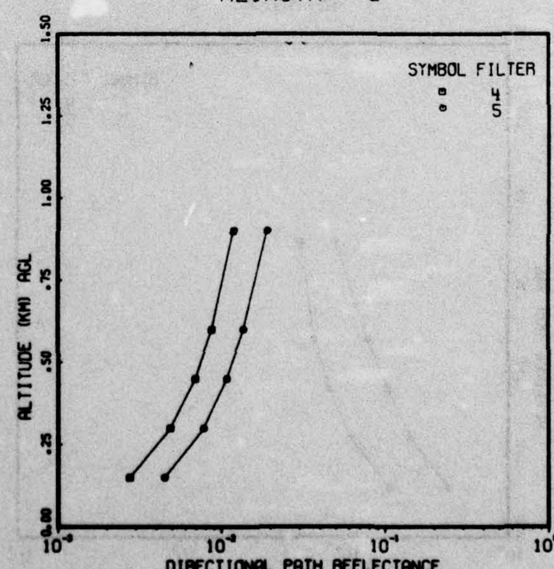
FLIGHT C-281 ZENITH ANGLE 80
AZIMUTH 0



FLIGHT C-281 ZENITH ANGLE 100
AZIMUTH 0



FLIGHT C-281 ZENITH ANGLE 180
AZIMUTH 0



FLIGHT NO. C-281
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5628 DATE 06/17/76)
DATE 60573 FLIGHT NO. C-281 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 4	5
0	2.06E-04	1.83E-04
30	5.30E-05	4.04E-05
60	5.29E-05	4.03E-05
90	5.27E-05	4.02E-05
120	5.26E-05	4.01E-05
150	5.25E-05	4.00E-05
180	5.23E-05	3.98E-05
210	5.22E-05	3.97E-05
240	5.21E-05	3.96E-05
270	5.19E-05	3.95E-05
300	5.18E-05	3.94E-05
330	5.17E-05	3.93E-05
360	4.92E-05	3.84E-05
390	4.94E-05	3.38E-05
420	5.27E-05	3.37E-05
450	5.34E-05	3.45E-05
480	5.23E-05	3.71E-05
510	5.23E-05	3.62E-05
540	5.05E-05	4.03E-05
570	5.22E-05	4.11E-05
600	5.04E-05	4.26E-05
630	5.13E-05	4.25E-05
660	5.37E-05	4.46E-05
690	5.17E-05	4.19E-05
720	4.97E-05	3.80E-05
750	5.05E-05	3.73E-05
780	4.97E-05	3.91E-05
810	5.10E-05	3.60E-05
840	5.09E-05	3.60E-05
870	5.07E-05	3.59E-05
900	5.06E-05	3.58E-05
FIRST DATA ALT	330	330
LAST DATA ALT	810	840

FLIGHT NO. C-281
IRRADIANCE

(JOB 5620 DATE 06/17/76)

FLIGHT NO.C-281 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
313	4.32E 02	3.81E 01	.088	2.01E-01	9.39E 02	1.20E 02	1.06E 03	.128
863	3.13E 02	3.04E 01	.097	2.09E-01	5.97E 02	1.03E 02	7.01E 02	.173

FLIGHT NO.C-281 FILTER NO. 5 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
308	2.86E 02	9.63E 01	.337	1.31E-01	5.22E 02	1.97E 02	7.19E 02	.378
850	3.15E 02	9.85E 01	.313	1.35E-01	6.15E 02	2.61E 02	8.76E 02	.425

FLIGHT NO. C-281 SPECTRAL FILTER NO. 4
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5620 DATE 06/17/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-281 FILTER NO. = 4 SUN ZENITH ANGLE 40.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		4.32E 02
150	3.81E 01	
300	3.81E 01	
450	3.62E 01	
600	3.41E 01	
900	3.04E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0
ZENITH ANGLE OF PATH OF SIGHT (DEG)

TARGET ALTITUDE M	0	75	80	85	95	100	180
0					.2707	.2726	.0513
150	9.8146	42.6352	32.3141	18.4892			
300	9.8146	42.6352	32.3141	18.4892			
450	11.2406	35.2270	27.1001	16.1367			
600	12.9849	26.1661	20.7228	13.2594			
900	16.6204	7.2801	7.4305	7.2620			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90
ZENITH ANGLE OF PATH OF SIGHT (DEG)

TARGET ALTITUDE M	0	75	80	85	95	100	180
0					.2235	.0952	.0513
150	9.8146	14.5080	11.5973	10.0893			
300	9.8146	14.5080	11.5973	10.0893			
450	11.2406	13.2189	11.1278	10.3381			
600	12.9849	11.6421	10.5535	10.6423			
900	16.6204	8.3556	9.3566	11.2765			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180
ZENITH ANGLE OF PATH OF SIGHT (DEG)

TARGET ALTITUDE M	0	75	80	85	95	100	180
0					.3470	.2703	.0513
150	9.8146	13.6051	13.1673	10.8167			
300	9.8146	13.6051	13.1673	10.8167			
450	11.2406	12.1381	11.6070	9.4944			
600	12.9849	10.3437	9.6986	7.8772			
900	16.6204	6.6038	5.7209	4.5062			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270
ZENITH ANGLE OF PATH OF SIGHT (DEG)

TARGET ALTITUDE M	0	75	80	85	95	100	180
0					.3039	.2462	.0513
150	9.8146	12.9328	11.2261	9.1768			
300	9.8146	12.9328	11.2261	9.1768			
450	11.2406	12.4910	10.3581	8.4449			
600	12.9849	11.9506	9.2964	7.5499			
900	16.6204	10.8243	7.0836	5.6842			

FLIGHT NO. C-281 SPECTRAL FILTER NO. 5
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5620 DATE 06/17/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-281 FILTER NO. = 5 SUN ZENITH ANGLE 40.6

TARGET ALTITUDE	IRRADIANCE (W/SQ M UM)	
	UPWELLING	DOWNWELLING
M		
0		2.86E 02
150	9.63E 01	
300	9.63E 01	
450	9.69E 01	
600	9.75E 01	
900	9.85E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
0					.6645	.5674	.5923
150	4.7459	2.0478	2.6636	3.4527			
300	4.7459	2.0478	2.6636	3.4527			
450	3.9337	2.7767	2.9222	3.2898			
600	3.0863	3.5372	3.1921	3.1198			
900	1.6974	4.7836	3.6343	2.8411			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
0					.8707	.8075	.5923
150	4.7459	3.8494	3.7165	3.0089			
300	4.7459	3.8494	3.7165	3.0089			
450	3.9337	3.9781	3.8201	3.1559			
600	3.0863	4.1124	3.9283	3.3092			
900	1.6974	4.3325	4.1055	3.5605			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
0					.4755	.4455	.5923
150	4.7459	1.5997	1.5601	2.7001			
300	4.7459	1.5997	1.5601	2.7001			
450	3.9337	1.7265	1.6614	2.5632			
600	3.0863	1.8587	1.7671	2.4203			
900	1.6974	2.0755	1.9404	2.1862			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
0					.3324	.1917	.5923
150	4.7459	3.0400	2.3105	1.8223			
300	4.7459	3.0400	2.3105	1.8223			
450	3.9337	2.7680	2.1927	1.7606			
600	3.0863	2.4843	2.0699	1.6963			
900	1.6974	2.0193	1.8686	1.5908			

FLIGHT NO. C-281
EQUIVALENT ATTENUATION LENGTH

(JOB 5620 DATE 06/17/76)
DATE 60573 FLIGHT NO. C-281 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 4	5
0	4.85E 00	5.46E 00
30	7.72E 00	8.95E 00
60	1.10E 01	1.32E 01
90	1.28E 01	1.56E 01
120	1.39E 01	1.72E 01
150	1.47E 01	1.84E 01
180	1.53E 01	1.92E 01
210	1.57E 01	1.99E 01
240	1.61E 01	2.04E 01
270	1.64E 01	2.09E 01
300	1.66E 01	2.12E 01
330	1.69E 01	2.16E 01
360	1.71E 01	2.19E 01
390	1.73E 01	2.22E 01
420	1.74E 01	2.26E 01
450	1.75E 01	2.30E 01
480	1.76E 01	2.32E 01
510	1.77E 01	2.34E 01
540	1.78E 01	2.36E 01
570	1.79E 01	2.36E 01
600	1.79E 01	2.36E 01
630	1.80E 01	2.36E 01
660	1.80E 01	2.36E 01
690	1.81E 01	2.36E 01
720	1.81E 01	2.36E 01
750	1.82E 01	2.37E 01
780	1.83E 01	2.38E 01
810	1.83E 01	2.39E 01
840	1.84E 01	2.40E 01
870	1.84E 01	2.41E 01
900	1.85E 01	2.43E 01

FLIGHT NO. C-281
BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5620 DATE 06/17/76)

FLIGHT NO. C-281 FILTER NO. 4

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	9.90E-01	9.61E-01	9.43E-01	8.90E-01	8.89E-01	9.43E-01	9.90E-01
300	9.82E-01	9.33E-01	9.01E-01	8.13E-01	8.13E-01	9.01E-01	9.82E-01
450	9.75E-01	9.05E-01	8.62E-01	7.45E-01	7.44E-01	8.62E-01	9.75E-01
600	9.67E-01	8.79E-01	8.25E-01	6.82E-01	6.80E-01	8.25E-01	9.67E-01
900	9.52E-01	8.28E-01	7.55E-01	5.74E-01	5.69E-01	7.55E-01	9.52E-01

FLIGHT NO. C-281 FILTER NO. 5

BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	9.92E-01	9.69E-01	9.54E-01	9.11E-01	9.10E-01	9.54E-01	9.92E-01
300	9.86E-01	9.47E-01	9.22E-01	8.51E-01	8.50E-01	9.22E-01	9.86E-01
450	9.81E-01	9.27E-01	8.93E-01	7.99E-01	7.98E-01	8.93E-01	9.31E-01
600	9.75E-01	9.07E-01	8.64E-01	7.48E-01	7.46E-01	8.64E-01	9.75E-01
900	9.64E-01	8.66E-01	8.08E-01	6.55E-01	6.51E-01	8.08E-01	9.64E-01

FLIGHT NO. C-281 SPECTRAL FILTER NO. 4
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5620 DATE 06/17/76)

FLIGHT NO. C-281 FILTER NO. = 4 SUN ZENITH ANGLE 40.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.03E 00	5.48E 00	7.74E 00	1.40E 01	1.17E 01	5.31E 00	3.73E-01
300	1.81E 00	9.54E 00	1.34E 01	2.36E 01	1.98E 01	9.18E 00	6.57E-01
450	2.55E 00	1.32E 01	1.83E 01	3.17E 01	2.64E 01	1.26E 01	9.21E-01
600	3.26E 00	1.62E 01	2.24E 01	3.80E 01	3.14E 01	1.53E 01	1.16E 00
900	4.53E 00	2.03E 01	2.78E 01	4.60E 01	3.64E 01	1.89E 01	1.55E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.03E 00	4.15E 00	5.80E 00	1.05E 01	9.06E 00	4.22E 00	3.73E-01
300	1.81E 00	7.22E 00	1.00E 01	1.77E 01	1.53E 01	7.29E 00	6.37E-01
450	2.55E 00	1.00E 01	1.38E 01	2.39E 01	2.06E 01	1.00E 01	9.21E-01
600	3.26E 00	1.25E 01	1.72E 01	2.92E 01	2.49E 01	1.25E 01	1.16E 00
900	4.53E 00	1.66E 01	2.24E 01	3.69E 01	3.08E 01	1.61E 01	1.55E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.03E 00	3.82E 00	5.41E 00	9.94E 00	8.91E 00	4.23E 00	3.73E-01
300	1.81E 00	6.65E 00	9.34E 00	1.68E 01	1.50E 01	7.30E 00	6.57E-01
450	2.55E 00	9.25E 00	1.29E 01	2.27E 01	2.02E 01	1.00E 01	9.21E-01
600	3.26E 00	1.16E 01	1.60E 01	2.76E 01	2.43E 01	1.23E 01	1.16E 00
900	4.53E 00	1.34E 01	2.09E 01	3.47E 01	2.92E 01	1.56E 01	1.55E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.03E 00	3.89E 00	5.43E 00	9.85E 00	8.57E 00	4.02E 00	3.73E-01
300	1.81E 00	6.76E 00	9.38E 00	1.66E 01	1.45E 01	6.93E 00	6.57E-01
450	2.55E 00	9.40E 00	1.30E 01	2.25E 01	1.95E 01	9.56E 00	9.21E-01
600	3.26E 00	1.18E 01	1.61E 01	2.74E 01	2.36E 01	1.18E 01	1.16E 00
900	4.53E 00	1.57E 01	2.12E 01	3.48E 01	2.89E 01	1.52E 01	1.55E 00

FLIGHT NO. C-281 SPECTRAL FILTER NO. 5
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5620 DATE 06/17/76)

FLIGHT NO. C-281 FILTER NO. = 5 SUN ZENITH ANGLE 40.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.36E-01	1.82E 00	2.63E 00	4.99E 00	4.76E 00	2.32E 00	4.04E-01
300	1.27E 00	3.10E 00	4.47E 00	8.34E 00	7.95E 00	3.94E 00	6.96E-01
450	1.75E 00	4.34E 00	6.21E 00	1.14E 01	1.09E 01	5.48E 00	9.53E-01
600	2.24E 00	5.81E 00	8.26E 00	1.48E 01	1.43E 01	7.30E 00	1.21E 00
900	3.20E 00	9.18E 00	1.29E 01	2.22E 01	2.18E 01	1.14E 01	1.66E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.36E-01	2.19E 00	3.16E 00	5.95E 00	5.55E 00	2.67E 00	4.04E-01
300	1.27E 00	3.74E 00	5.37E 00	9.94E 00	9.27E 00	4.54E 00	6.96E-01
450	1.75E 00	5.18E 00	7.40E 00	1.35E 01	1.26E 01	6.27E 00	9.55E-01
600	2.24E 00	6.79E 00	9.64E 00	1.72E 01	1.62E 01	8.20E 00	1.21E 00
900	3.20E 00	1.02E 01	1.44E 01	2.48E 01	2.36E 01	1.23E 01	1.66E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.36E-01	1.93E 00	2.62E 00	4.92E 00	4.63E 00	2.25E 00	4.04E-01
300	1.27E 00	3.13E 00	4.45E 00	8.21E 00	7.73E 00	3.82E 00	6.96E-01
450	1.75E 00	4.32E 00	6.12E 00	1.11E 01	1.05E 01	5.26E 00	9.35E-01
600	2.24E 00	5.53E 00	7.92E 00	1.41E 01	1.34E 01	6.84E 00	1.21E 00
900	3.20E 00	8.36E 00	1.16E 01	2.01E 01	1.92E 01	1.01E 01	1.66E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.36E-01	1.80E 00	2.57E 00	4.82E 00	4.49E 00	2.18E 00	4.04E-01
300	1.27E 00	3.08E 00	4.37E 00	8.04E 00	7.50E 00	3.70E 00	6.96E-01
450	1.75E 00	4.26E 00	6.01E 00	1.09E 01	1.01E 01	5.10E 00	9.55E-01
600	2.24E 00	5.54E 00	7.79E 00	1.38E 01	1.30E 01	6.63E 00	1.21E 00
900	3.20E 00	8.24E 00	1.14E 01	1.97E 01	1.87E 01	9.84E 00	1.36E 00

FLIGHT NO. C-281 SPECTRAL FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5620 DATE 06/17/76)

FLIGHT NO. C-281 FILTER NO. = 4 SUN ZENITH ANGLE 40.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.57E-02	4.71E-01	6.77E-01	1.30E 00	9.57E-02	4.10E-02	2.74E-03
300	1.52E-01	8.44E-01	1.22E 00	2.39E 00	1.77E-01	7.40E-02	4.86E-03
450	2.27E-01	1.26E 00	1.84E 00	3.69E 00	2.58E-01	1.06E-01	6.87E-03
600	3.11E-01	1.70E 00	2.50E 00	5.13E 00	3.36E-01	1.35E-01	8.73E-03
900	4.91E-01	2.53E 00	3.80E 00	8.28E 00	4.65E-01	1.82E-01	1.18E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.57E-02	3.56E-01	5.07E-01	9.73E-01	7.41E-02	3.25E-02	2.74E-03
300	1.52E-01	6.39E-01	9.17E-01	1.80E 00	1.37E-01	5.88E-02	4.86E-03
450	2.27E-01	9.62E-01	1.39E 00	2.79E 00	2.01E-01	8.47E-02	6.87E-03
600	3.11E-01	1.32E 00	1.92E 00	3.94E 00	2.67E-01	1.10E-01	8.73E-03
900	4.91E-01	2.06E 00	3.07E 00	6.64E 00	3.93E-01	1.55E-01	1.18E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.57E-02	3.28E-01	4.73E-01	9.22E-01	7.29E-02	3.26E-02	2.74E-03
300	1.52E-01	5.88E-01	8.55E-01	1.70E 00	1.35E-01	5.89E-02	4.86E-03
450	2.27E-01	8.97E-01	1.30E 00	2.64E 00	1.97E-01	8.46E-02	6.87E-03
600	3.11E-01	1.22E 00	1.79E 00	3.72E 00	2.60E-01	1.09E-01	8.73E-03
900	4.91E-01	1.92E 00	2.86E 00	6.24E 00	3.74E-01	1.50E-01	1.18E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.57E-02	3.33E-01	4.75E-01	9.13E-01	7.01E-02	3.10E-02	2.74E-03
300	1.52E-01	5.98E-01	8.59E-01	1.69E 00	1.29E-01	5.59E-02	4.86E-03
450	2.27E-01	9.01E-01	1.30E 00	2.62E 00	1.90E-01	8.06E-02	6.87E-03
600	3.11E-01	1.24E 00	1.80E 00	3.70E 00	2.52E-01	1.04E-01	8.73E-03
900	4.91E-01	1.95E 00	2.89E 00	6.25E 00	3.70E-01	1.47E-01	1.18E-02

FLIGHT NO. C-281 SPECTRAL FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5620 DATE 06/17/76)

FLIGHT NO. C-281 FILTER NO. = 5 SUN ZENITH ANGLE 40.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.42E-02	6.11E-02	8.99E-02	1.79E-01	5.75E-02	2.67E-02	4.48E-03
300	4.20E-02	1.07E-01	1.58E-01	3.20E-01	1.03E-01	4.70E-02	7.76E-03
450	5.78E-02	1.52E-01	2.25E-01	4.62E-01	1.50E-01	6.75E-02	1.07E-02
600	7.42E-02	2.06E-01	3.08E-01	6.39E-01	2.10E-01	9.29E-02	1.36E-02
900	1.06E-01	3.38E-01	5.08E-01	1.08E 00	3.68E-01	1.56E-01	1.90E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.42E-02	7.37E-02	1.08E-01	2.13E-01	6.71E-02	3.08E-02	4.48E-03
300	4.20E-02	1.29E-01	1.90E-01	3.81E-01	1.20E-01	5.42E-02	7.76E-03
450	5.78E-02	1.91E-01	2.69E-01	5.47E-01	1.73E-01	7.71E-02	1.07E-02
600	7.42E-02	2.41E-01	3.60E-01	7.43E-01	2.39E-01	1.04E-01	1.36E-02
900	1.06E-01	3.77E-01	5.67E-01	1.21E 00	3.99E-01	1.68E-01	1.90E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.42E-02	6.16E-02	8.95E-02	1.76E-01	5.59E-02	2.59E-02	4.48E-03
300	4.20E-02	1.08E-01	1.58E-01	3.15E-01	1.00E-01	4.56E-02	7.76E-03
450	5.78E-02	1.51E-01	2.22E-01	4.51E-01	1.44E-01	6.47E-02	1.07E-02
600	7.42E-02	2.00E-01	2.96E-01	6.09E-01	1.97E-01	8.70E-02	1.36E-02
900	1.06E-01	3.08E-01	4.60E-01	9.77E-01	3.25E-01	1.38E-01	1.90E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.42E-02	6.07E-02	8.80E-02	1.73E-01	5.42E-02	2.51E-02	4.48E-03
300	4.20E-02	1.06E-01	1.55E-01	3.08E-01	9.70E-02	4.42E-02	7.76E-03
450	5.78E-02	1.49E-01	2.18E-01	4.41E-01	1.40E-01	6.27E-02	1.07E-02
600	7.42E-02	1.97E-01	2.90E-01	5.96E-01	1.91E-01	8.44E-02	1.36E-02
900	1.06E-01	3.03E-01	4.52E-01	9.57E-01	3.15E-01	1.34E-01	1.90E-02

FLIGHT C-282 – 5 June – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon with scattered low clouds. The flight was conducted over low lying flat terrain consisting mainly of cultivated farmlands interspersed with dark patches of dense woods. The data-taking started at 1618 GMT and continued until 1716 GMT. The sun zenith angle during sky radiance data-taking was 61.8 degrees at the beginning and 70.3 degrees at the end. The maximum flight altitude was 613 meters. The average elevation of the terrain was 20 meters.

The ground station did not record any remarks concerning cloud cover.

The radiosonde station at Meppen reported 0.5 stratocumulus at 1000 to 1499 meters.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
1632	600	Scattered to broken deck above, light to moderate haze below.

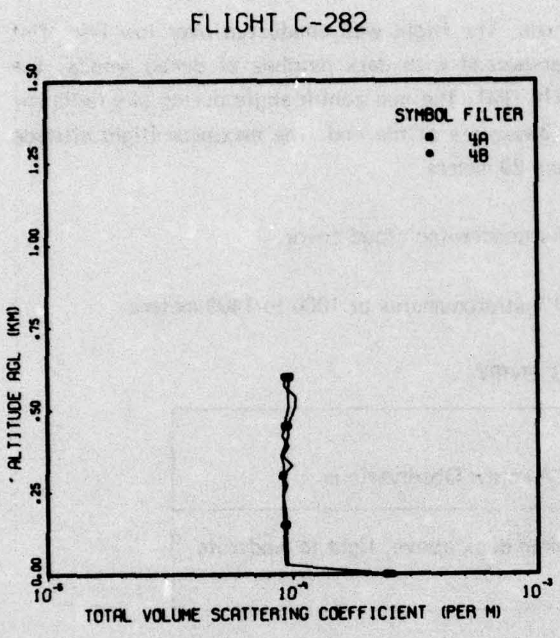
Note: Flight elevations in approximate feet MSL have been converted to approximate meters AGL.

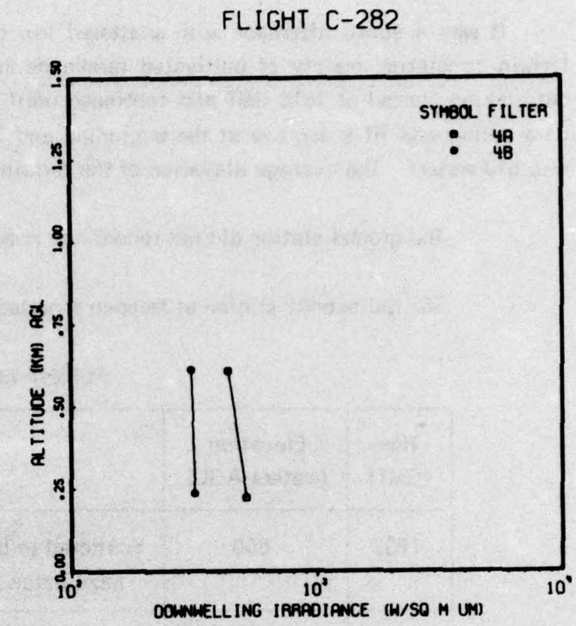
On the surface charts ridging over France and West Germany became stronger throughout the day.

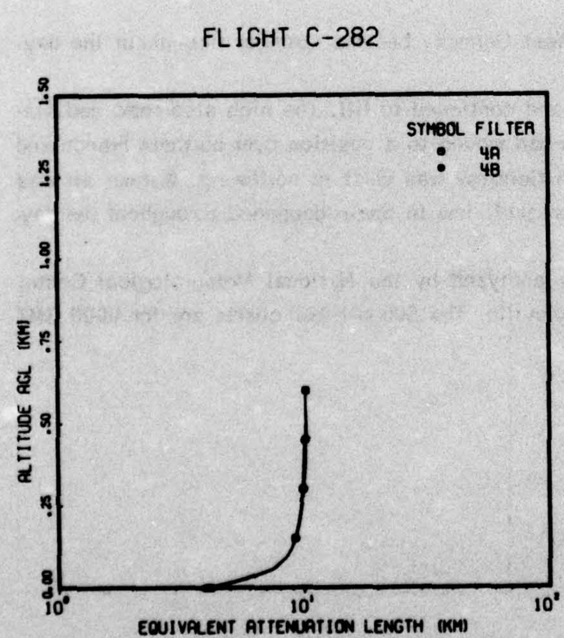
At 500 millibars the trough remained stationary and continued to fill. The high also remained stationary but began to weaken. By 1200 GMT the trough had moved to a position over northern France and Germany and continued to fill. The flow over northern Germany was west to northwest. Warmer air was moving in aloft at all levels above 2500 meters. A breakoff low in Spain deepened throughout the day.

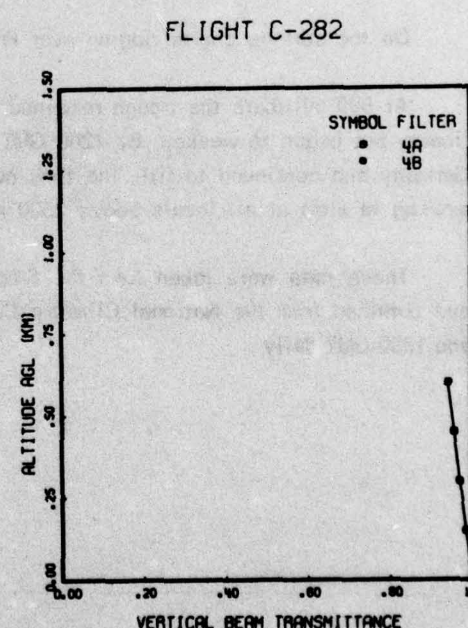
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center at Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-282



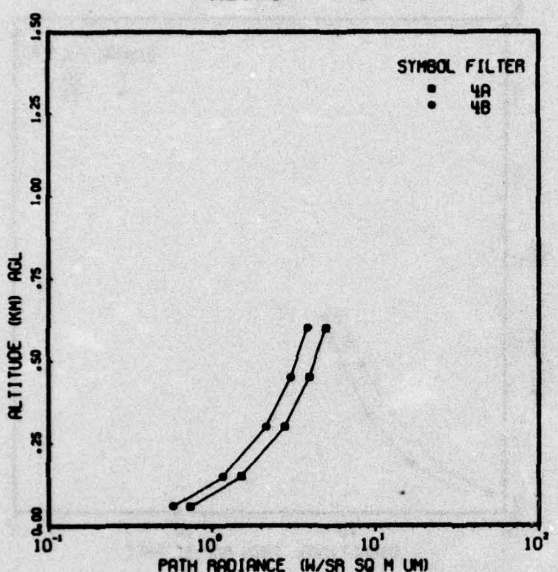




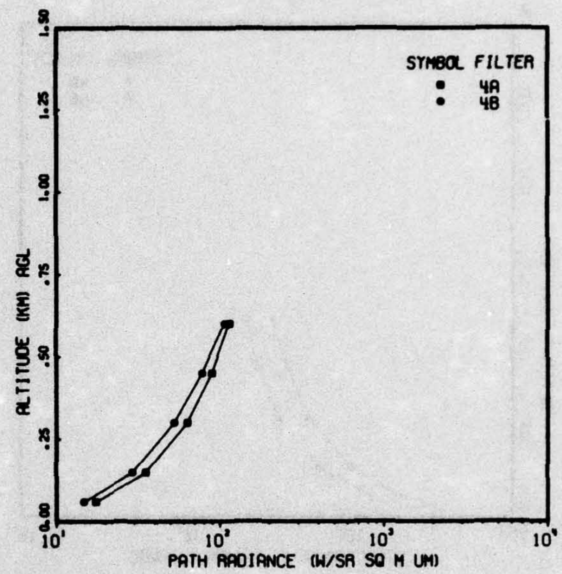


FLIGHT NO. C-282

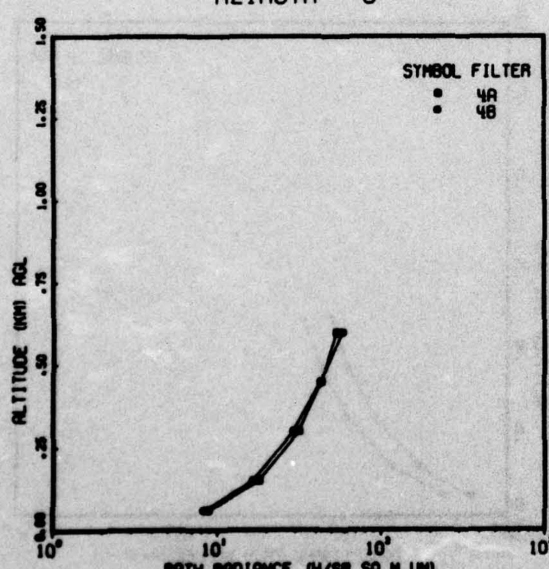
FLIGHT C-282 ZENITH ANGLE 0
AZIMUTH 0



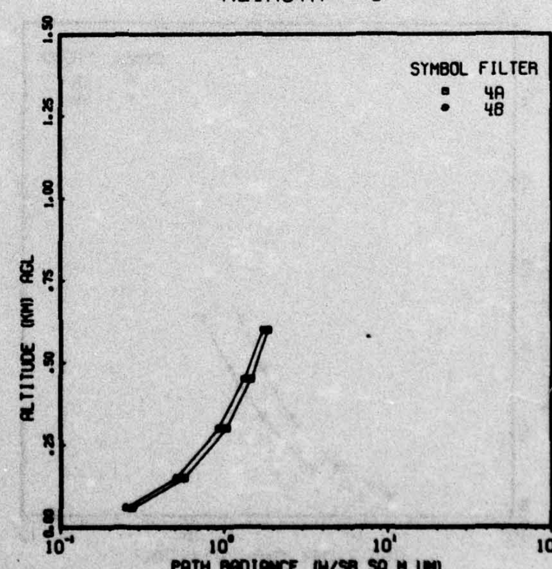
FLIGHT C-282 ZENITH ANGLE 80
AZIMUTH 0



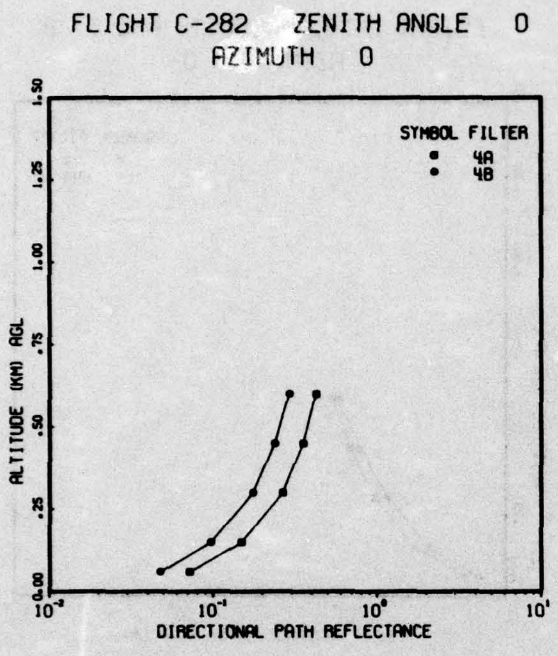
FLIGHT C-282 ZENITH ANGLE 100
AZIMUTH 0

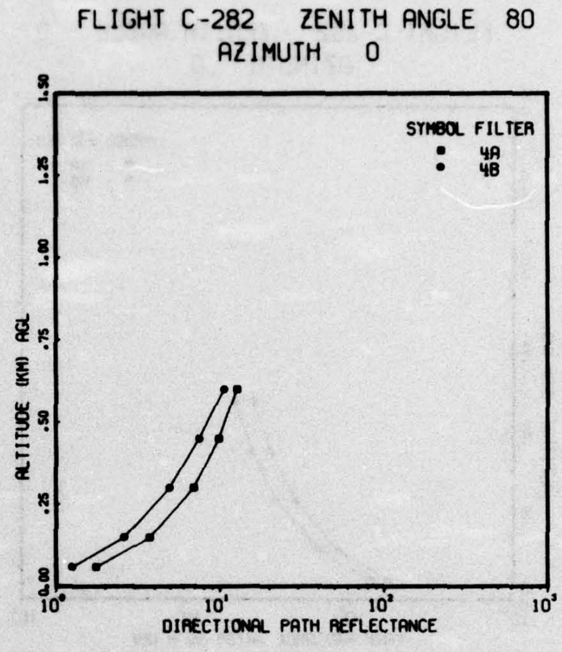


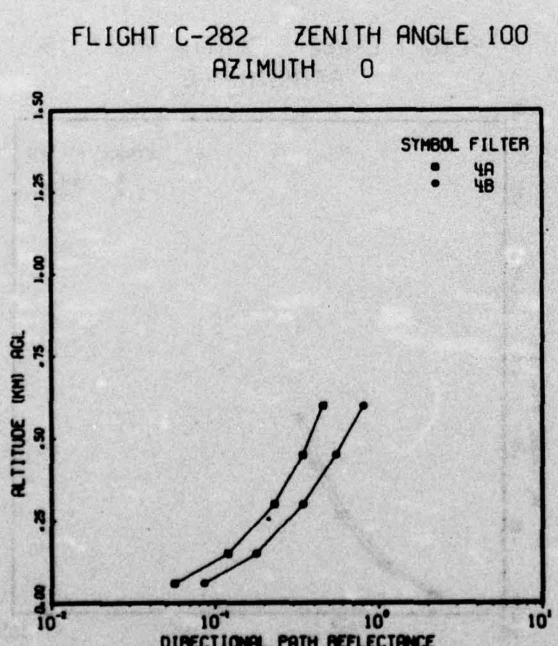
FLIGHT C-282 ZENITH ANGLE 180
AZIMUTH 0

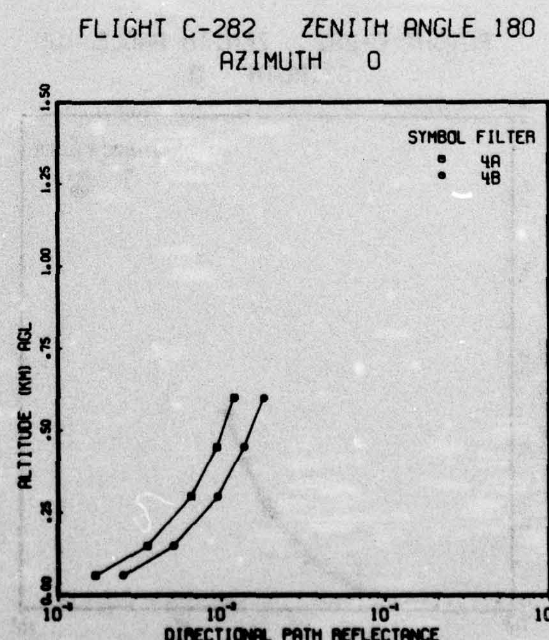


FLIGHT NO. C-282









FLIGHT NO. C-282
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5605 DATE 03/24/76)
DATE 60573 FLIGHT NO. C-282 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 4A	4B
0	2.41E-04	2.54E-04
30	9.50E-05	9.29E-05
60	9.47E-05	9.27E-05
90	9.45E-05	9.25E-05
120	9.43E-05	9.22E-05
150	9.40E-05	9.20E-05
180	9.38E-05	9.18E-05
210	9.27E-05	9.15E-05
240	9.13E-05	9.17E-05
270	9.51E-05	9.19E-05
300	9.13E-05	9.16E-05
330	9.94E-05	9.19E-05
360	9.10E-05	8.98E-05
390	9.63E-05	9.31E-05
420	9.08E-05	9.62E-05
450	9.35E-05	9.61E-05
480	9.44E-05	9.90E-05
510	9.63E-05	1.03E-04
540	9.60E-05	1.03E-04
570	9.63E-05	9.26E-05
600	9.76E-05	9.30E-05
FIRST DATA ALT	180	210
LAST DATA ALT	600	600

FLIGHT NO. C-282
IRRADIANCE

(JOB 5605 DATE 03/24/76)

FLIGHT NO.C-282 FILTER NO. 4A SUN ZENITH ANGLE 62.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
223	5.16E 02	3.26E 01	.063	3.63E 02	8.09E 02	1.23E 02	1.29E 03	.105
610	4.37E 02	3.97E 01	.091	3.93E 02	5.61E 02	1.17E 02	1.07E 03	.122

FLIGHT NO.C-282 FILTER NO. 43 SUN ZENITH ANGLE 69.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
237	3.18E 02	3.87E 01	.122	2.19E 02	6.38E 02	1.18E 02	9.75E 02	.138
613	3.09E 02	4.46E 01	.144	2.41E 02	6.62E 02	1.62E 02	1.06E 03	.179

FLIGHT NO. C-282 SPECTRAL FILTER NO. 4A
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5605 DATE 03/24/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-282 FILTER NO. =4A SUN ZENITH ANGLE 62.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		5.16E 02
60	3.26E 01	
150	3.26E 01	
300	3.40E 01	
450	3.68E 01	
600	3.95E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.9027	.2566	.0400
60	5.4366	18.9288	36.6654	50.7321			
150	5.4366	18.9288	36.6654	50.7321			
300	4.6510	16.1373	30.1126	43.0426			
450	3.2935	11.4860	18.7886	29.7542			
600	2.1245	7.4805	9.0369	18.3108			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1788	.0987	.0400
60	5.4366	10.3428	9.5655	8.1134			
150	5.4366	10.3428	9.5655	8.1134			
300	4.6510	9.0160	8.5148	7.3196			
450	3.2935	6.7232	6.6992	5.9479			
600	2.1245	4.7487	5.1356	4.7667			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2044	.1652	.0400
60	5.4366	4.8337	4.6784	5.2999			
150	5.4366	4.8337	4.6784	5.2999			
300	4.6510	4.9555	4.8143	5.0653			
450	3.2935	5.1660	5.0491	4.6599			
600	2.1245	5.3473	5.2512	4.3109			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2233	.1176	.0400
60	5.4366	11.0933	10.3550	9.2230			
150	5.4366	11.0933	10.3550	9.2230			
300	4.6510	9.1440	8.6229	8.2690			
450	3.2935	5.7754	6.1753	6.6203			
600	2.1245	2.8744	3.8952	5.2005			

FLIGHT NO. C-282 SPECTRAL FILTER NO. 4B
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5685 DATE 03/24/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-282 FILTER NO. =4B SUN ZENITH ANGLE 69.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		3.18E 02
60	3.87E 01	
150	3.87E 01	
300	3.97E 01	
450	4.20E 01	
600	4.44E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					1,0927	.6726	.0684
60	6.3740	83.7353	53,0085	45.0737			
150	6.3740	83.7353	53,0085	45.0737			
300	5.4935	90.1632	58,2578	45.4893			
450	3.5631	104.2543	69,7655	46.4005			
600	1.8368	116.8552	80,0562	47.2153			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2509	.1570	.0684
60	6.3740	4.5896	5.4221	5.7486			
150	6.3740	4.5896	5.4221	5.7486			
300	5.4935	4.4934	5.2613	5.4740			
450	3.5631	4.2826	4,9085	4.8721			
600	1.8368	4.0940	4.5931	4.3339			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.4025	.4014	.0684
60	6.3740	6.2470	6,4255	6.2846			
150	6.3740	6.2470	6,4255	6.2846			
300	5.4935	6.0167	6,2252	5.9110			
450	3.5631	5.5119	5,7859	5.0920			
600	1.8368	5.0605	5.3931	4.3596			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3109	.2599	.0684
60	6.3740	5.4094	6,2569	6.7031			
150	6.3740	5.4094	6,2569	6.7031			
300	5.4935	5.0767	5,8273	6.3184			
450	3.5631	4.3474	4,8854	5.4750			
600	1.8368	3.6951	4,0431	4.7208			

FLIGHT NO. C-282
EQUIVALENT ATTENUATION LENGTH

(JOB 5605 DATE 03/24/76)
DATE 60573 FLIGHT NO. C-282 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 4A	4B
0	4.15E 00	3.94E 00
30	5.95E 00	5.76E 00
60	7.61E 00	7.51E 00
90	8.39E 00	8.36E 00
120	8.85E 00	8.86E 00
150	9.16E 00	9.20E 00
180	9.38E 00	9.44E 00
210	9.55E 00	9.63E 00
240	9.70E 00	9.77E 00
270	9.80E 00	9.89E 00
300	9.89E 00	9.98E 00
330	9.94E 00	1.01E 01
360	9.98E 00	1.01E 01
390	1.00E 01	1.02E 01
420	1.01E 01	1.02E 01
450	1.01E 01	1.02E 01
480	1.02E 01	1.02E 01
510	1.02E 01	1.02E 01
540	1.02E 01	1.02E 01
570	1.02E 01	1.02E 01
600	1.02E 01	1.02E 01

FLIGHT NO. C-282
BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5605 DATE 03/24/76)

FLIGHT NO. C-282 FILTER NO. 4A
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	9.92E-01	9.70E-01	9.56E-01	9.14E-01	9.13E-01	9.56E-01	9.92E-01
150	9.84E-01	9.39E-01	9.10E-01	8.29E-01	8.28E-01	9.10E-01	9.84E-01
300	9.70E-01	8.89E-01	8.40E-01	7.07E-01	7.05E-01	8.40E-01	9.70E-01
450	9.57E-01	8.42E-01	7.74E-01	6.02E-01	5.99E-01	7.74E-01	9.57E-01
600	9.43E-01	7.97E-01	7.13E-01	5.11E-01	5.07E-01	7.13E-01	9.43E-01

FLIGHT NO. C-282 FILTER NO. 4B
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	9.92E-01	9.70E-01	9.55E-01	9.12E-01	9.12E-01	9.55E-01	9.92E-01
150	9.84E-01	9.39E-01	9.10E-01	8.30E-01	8.29E-01	9.10E-01	9.84E-01
300	9.70E-01	8.90E-01	8.41E-01	7.09E-01	7.08E-01	8.41E-01	9.70E-01
450	9.57E-01	8.44E-01	7.76E-01	6.05E-01	6.02E-01	7.76E-01	9.57E-01
600	9.43E-01	7.97E-01	7.13E-01	5.11E-01	5.08E-01	7.13E-01	9.43E-01

FLIGHT NO. C-282 SPECTRAL FILTER NO. 4A
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5605 DATE 03/24/76)

FLIGHT NO. C-282 FILTER NO. =4A SUN ZENITH ANGLE 62.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.35E-01	1.33E 01	1.74E 01	2.94E 01	2.09E 01	8.78E 00	2.74E-01
150	1.52E 00	2.73E 01	3.54E 01	5.81E 01	4.13E 01	1.78E 01	5.68E-01
300	2.78E 00	4.94E 01	6.30E 01	9.96E 01	7.04E 01	3.16E 01	1.04E 00
450	3.95E 00	7.14E 01	8.92E 01	1.35E 02	9.35E 01	4.34E 01	1.47E 00
600	5.01E 00	9.36E 01	1.14E 02	1.64E 02	1.11E 02	5.34E 01	1.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.35E-01	2.68E 00	3.76E 00	6.90E 00	6.06E 00	2.86E 00	2.74E-01
150	1.52E 00	5.47E 00	7.63E 00	1.36E 01	1.20E 01	5.80E 00	5.68E-01
300	2.78E 00	9.81E 00	1.39E 01	2.33E 01	2.04E 01	1.03E 01	1.04E 00
450	3.95E 00	1.36E 01	1.84E 01	3.08E 01	2.66E 01	1.40E 01	1.47E 00
600	5.01E 00	1.67E 01	2.29E 01	3.65E 01	3.09E 01	1.69E 01	1.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.35E-01	2.02E 00	2.99E 00	5.67E 00	5.54E 00	2.76E 00	2.74E-01
150	1.52E 00	4.12E 00	5.98E 00	1.12E 01	1.10E 01	5.60E 00	5.68E-01
300	2.78E 00	7.41E 00	1.06E 01	1.92E 01	1.87E 01	9.92E 00	1.04E 00
450	3.95E 00	1.04E 01	1.47E 01	2.56E 01	2.47E 01	1.37E 01	1.47E 00
600	5.01E 00	1.30E 01	1.82E 01	3.07E 01	2.93E 01	1.68E 01	1.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.35E-01	2.71E 00	3.83E 00	7.06E 00	6.25E 00	2.95E 00	2.74E-01
150	1.52E 00	5.54E 00	7.77E 00	1.40E 01	1.24E 01	5.99E 00	5.68E-01
300	2.78E 00	9.91E 00	1.37E 01	2.38E 01	2.10E 01	1.06E 01	1.04E 00
450	3.95E 00	1.36E 01	1.86E 01	3.12E 01	2.71E 01	1.42E 01	1.47E 00
600	5.01E 00	1.66E 01	2.25E 01	3.66E 01	3.09E 01	1.70E 01	1.85E 00

FLIGHT NO. C-282   SPECTRAL FILTER NO. 4B
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5605 DATE 03/24/76)

FLIGHT NO. C-282   FILTER NO. =4B   SUN ZENITH ANGLE 69.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	5.78E-01	1.05E 01	1.47E 01	2.58E 01	1.95E 01	8.20E 00	2.50E-01
150	1.17E 00	2.10E 01	2.93E 01	5.02E 01	3.78E 01	1.63E 01	5.07E-01
300	2.14E 00	3.80E 01	5.24E 01	8.64E 01	6.51E 01	2.92E 01	9.27E-01
450	3.03E 00	5.71E 01	7.77E 01	1.23E 02	9.29E 01	4.28E 01	1.33E 00
600	3.67E 00	7.95E 01	1.07E 02	1.60E 02	1.23E 02	5.82E 01	1.72E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	5.78E-01	1.86E 00	2.62E 00	4.93E 00	4.53E 00	2.18E 00	2.50E-01
150	1.17E 00	3.73E 00	5.23E 00	9.59E 00	8.83E 00	4.34E 00	5.07E-01
300	2.14E 00	6.69E 00	9.28E 00	1.64E 01	1.51E 01	7.70E 00	9.27E-01
450	3.03E 00	9.55E 00	1.31E 01	2.23E 01	2.06E 01	1.09E 01	1.33E 00
600	3.67E 00	1.24E 01	1.69E 01	2.78E 01	2.55E 01	1.39E 01	1.72E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	5.78E-01	1.94E 00	2.83E 00	5.39E 00	4.96E 00	2.45E 00	2.50E-01
150	1.17E 00	3.89E 00	5.64E 00	1.05E 01	9.66E 00	4.88E 00	5.07E-01
300	2.14E 00	6.97E 00	9.99E 00	1.79E 01	1.65E 01	8.66E 00	9.27E-01
450	3.03E 00	9.84E 00	1.40E 01	2.42E 01	2.25E 01	1.22E 01	1.33E 00
600	3.67E 00	1.26E 01	1.77E 01	2.97E 01	2.78E 01	1.56E 01	1.72E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	5.78E-01	1.97E 00	2.84E 00	5.34E 00	4.86E 00	2.31E 00	2.50E-01
150	1.17E 00	3.96E 00	5.66E 00	1.04E 01	9.45E 00	4.61E 00	5.07E-01
300	2.14E 00	7.10E 00	1.00E 01	1.77E 01	1.61E 01	8.18E 00	9.27E-01
450	3.03E 00	1.00E 01	1.40E 01	2.39E 01	2.17E 01	1.14E 01	1.33E 00
600	3.67E 00	1.29E 01	1.78E 01	2.93E 01	2.64E 01	1.45E 01	1.72E 00

FLIGHT NO. C-282 SPECTRAL FILTER NO. 4A
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5605 DATE 03/24/76)

FLIGHT NO. C-282 FILTER NO. =4A SUN ZENITH ANGLE 62.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.14E-02	1.35E 00	1.76E 00	3.10E 00	1.39E-01	5.60E-02	1.69E-03
150	1.49E-01	2.90E 00	3.74E 00	6.76E 00	3.04E-01	1.19E-01	3.52E-03
300	2.65E-01	5.13E 00	6.93E 00	1.30E 01	6.08E-01	2.29E-01	6.52E-03
450	3.53E-01	7.24E 00	9.89E 00	1.91E 01	9.51E-01	3.42E-01	9.33E-03
600	4.23E-01	9.34E 00	1.27E 01	2.56E 01	1.34E 00	4.57E-01	1.19E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.14E-02	2.66E-01	3.79E-01	7.27E-01	4.04E-02	1.82E-02	1.69E-03
150	1.49E-01	5.62E-01	8.07E-01	1.59E 00	8.82E-02	3.89E-02	3.52E-03
300	2.65E-01	1.02E 00	1.48E 00	3.04E 00	1.76E-01	7.45E-02	6.52E-03
450	3.53E-01	1.38E 00	2.04E 00	4.37E 00	2.71E-01	1.10E-01	9.33E-03
600	4.23E-01	1.67E 00	2.51E 00	5.67E 00	3.71E-01	1.45E-01	1.19E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.14E-02	2.00E-01	2.97E-01	5.98E-01	3.70E-02	1.76E-02	1.69E-03
150	1.49E-01	4.23E-01	6.33E-01	1.30E 00	8.06E-02	3.75E-02	3.52E-03
300	2.65E-01	7.69E-01	1.17E 00	2.51E 00	1.61E-01	7.20E-02	6.52E-03
450	3.53E-01	1.05E 00	1.62E 00	3.64E 00	2.51E-01	1.07E-01	9.33E-03
600	4.23E-01	1.29E 00	2.03E 00	4.78E 00	3.52E-01	1.44E-01	1.19E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
60	7.14E-02	2.69E-01	3.86E-01	7.49E-01	4.17E-02	1.88E-02	1.69E-03
150	1.49E-01	5.69E-01	8.22E-01	1.62E 00	9.10E-02	4.01E-02	3.52E-03
300	2.65E-01	1.03E 00	1.51E 00	3.11E 00	1.81E-01	7.67E-02	6.52E-03
450	3.53E-01	1.38E 00	2.05E 00	4.43E 00	2.76E-01	1.12E-01	9.33E-03
600	4.23E-01	1.66E 00	2.51E 00	5.70E 00	3.71E-01	1.45E-01	1.19E-02

FLIGHT NO. C-282 SPRCTRAL FILTER NO. 4B
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5605 DATE 03/24/76)

FLIGHT NO. C-282 FILTER NO. =4B SUN ZENITH ANGLE 69.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	4.73E-02	8.75E-01	1.25E 00	2.30E 00	2.11E-01	8.49E-02	2.49E-03
150	9.69E-02	1.82E 00	2.62E 00	4.92E 00	4.51E-01	1.77E-01	5.10E-03
300	1.75E-01	3.38E 00	4.94E 00	9.65E 00	9.09E-01	3.43E-01	9.44E-03
450	2.37E-01	5.06E 00	7.49E 00	1.52E 01	1.52E 00	5.46E-01	1.37E-02
600	2.91E-01	7.06E 00	1.06E 01	2.22E 01	2.40E 00	8.07E-01	1.81E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	4.73E-02	1.55E-01	2.23E-01	4.38E-01	4.91E-02	2.26E-02	2.49E-03
150	9.69E-02	3.22E-01	4.66E-01	9.38E-01	1.05E-01	4.72E-02	5.10E-03
300	1.75E-01	5.95E-01	8.73E-01	1.83E 00	2.11E-01	9.06E-02	9.44E-03
450	2.37E-01	8.46E-01	1.26E 00	2.76E 00	3.38E-01	1.38E-01	1.37E-02
600	2.91E-01	1.10E 00	1.68E 00	3.85E 00	4.96E-01	1.93E-01	1.81E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	4.73E-02	1.62E-01	2.41E-01	4.80E-01	5.37E-02	2.53E-02	2.49E-03
150	9.69E-02	3.36E-01	5.03E-01	1.03E 00	1.15E-01	5.30E-02	5.10E-03
300	1.75E-01	6.20E-01	9.41E-01	2.00E 00	2.31E-01	1.02E-01	9.44E-03
450	2.37E-01	8.72E-01	1.34E 00	2.99E 00	3.69E-01	1.55E-01	1.37E-02
600	2.91E-01	1.12E 00	1.76E 00	4.11E 00	5.42E-01	2.17E-01	1.81E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
60	4.73E-02	1.65E-01	2.42E-01	4.75E-01	5.27E-02	2.40E-02	2.49E-03
150	9.69E-02	3.42E-01	5.05E-01	1.02E 00	1.13E-01	5.01E-02	5.10E-03
300	1.75E-01	6.31E-01	9.45E-01	1.98E 00	2.25E-01	9.61E-02	9.44E-03
450	2.37E-01	8.90E-01	1.39E 00	2.96E 00	3.56E-01	1.46E-01	1.37E-02
600	2.91E-01	1.15E 00	1.77E 00	4.06E 00	5.15E-01	2.01E-01	1.81E-02

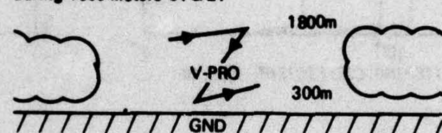
FLIGHT C-288 – 13 June 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was an overcast morning. The flight was conducted under the clouds at low altitudes over low lying flat terrain consisting mainly of cultivated farmlands interspersed with dark patches of dense woods. The data-taking started at 1150 GMT and continued until 1304 GMT. The sun zenith angle during sky radiance data-taking was 30.1 degrees at the beginning and 34.7 degrees at the end. The maximum altitude for the flight was 810 meters. The average elevation of the terrain was 20 meters.

The ground station was not in operation on this date.

The radiosonde station at Meppen reported 0.7 to 0.8 stratocumulus at 1500 to 1999 meters and haze at 0700 GMT. At 1300 GMT the report was 1.0 cumulus and stratocumulus based at 600 to 999 meters with breaks in the overcast.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
1102	300	Hazy Working in a slot in the cloud deck [see diagram below], rough at low altitude, clear with thin cirrus overhead during 1800 meters ST & LV 
		Filter 4 and 5 below the deck, slot gone.
1150	750	Under full overcast now (below deck).
1157	300	Still under broken to overcast deck.
		Under full overcast – moderate to heavy haze
		Repeat filter 2 and 3 below the deck.
1242	300	Low altitude visibility estimated 10 miles (16 kilometers), high altitude estimated 5 miles (8 kilometers).

Note: The flight log entries are listed chronologically. Those below the line refer to the part of the flight which was processed. The listed elevations are the approximate elevation of the aircraft at the time the comment was made.

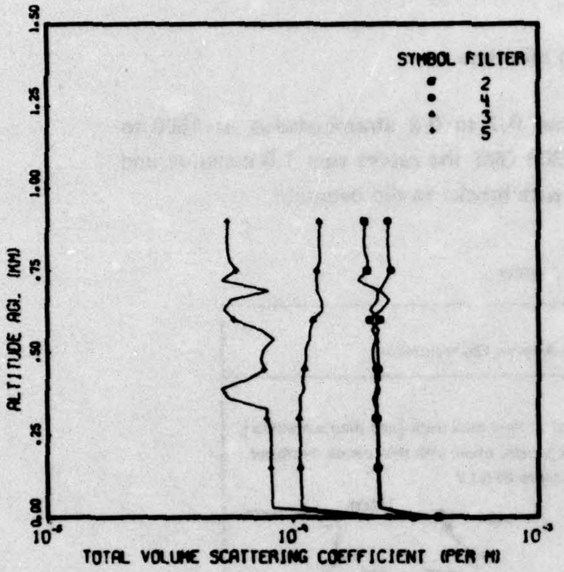
The surface charts show that the front that passed Meppen shortly before midnight moved slowly southeastward and became diffuse. Behind the front ridging moved in over France and Germany.

At 500 millibars the low moved into Finland. There was a high in southern Poland that began to move slowly eastward. By 1200 GMT there was a deepening low off Bergen. The flow was moderate to strong southwesterly.

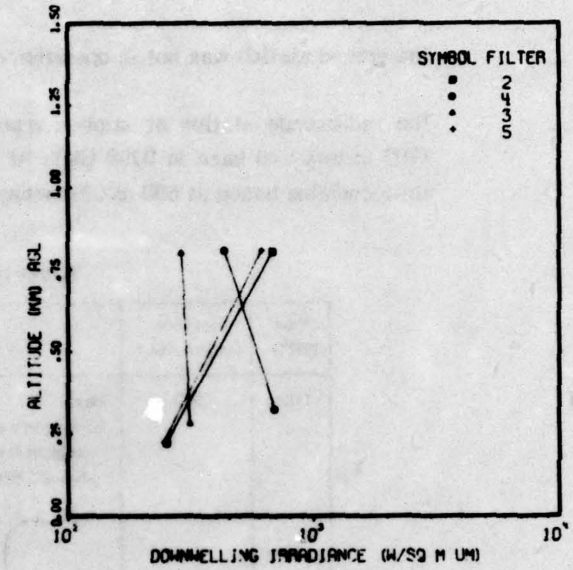
These data were taken from the 6-hourly charts analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-288

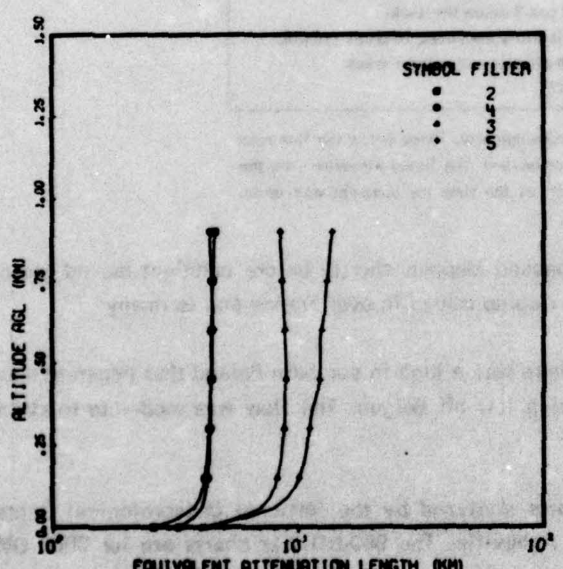
FLIGHT C-288



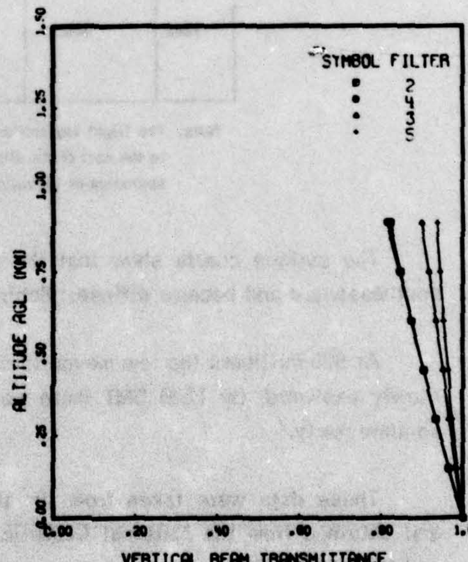
FLIGHT C-288



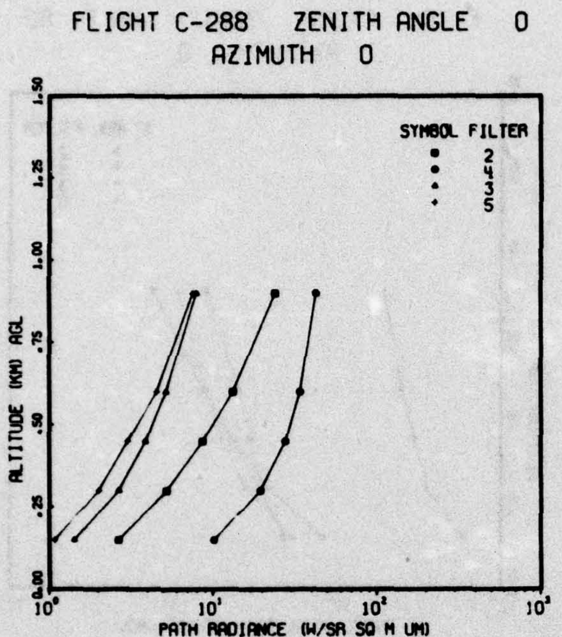
FLIGHT C-288

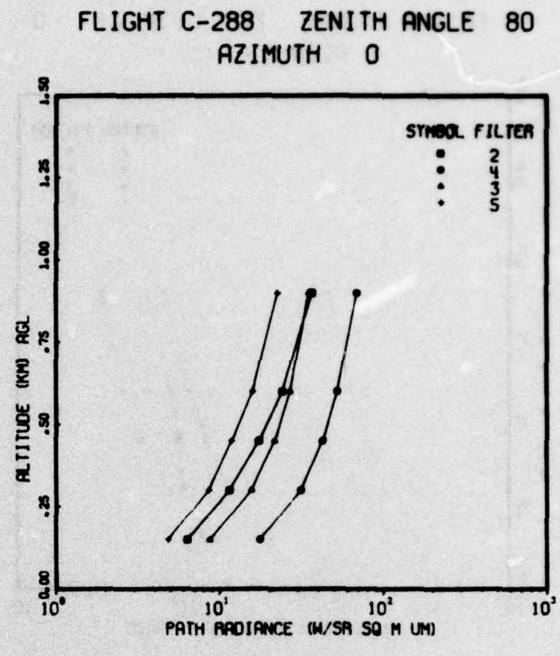


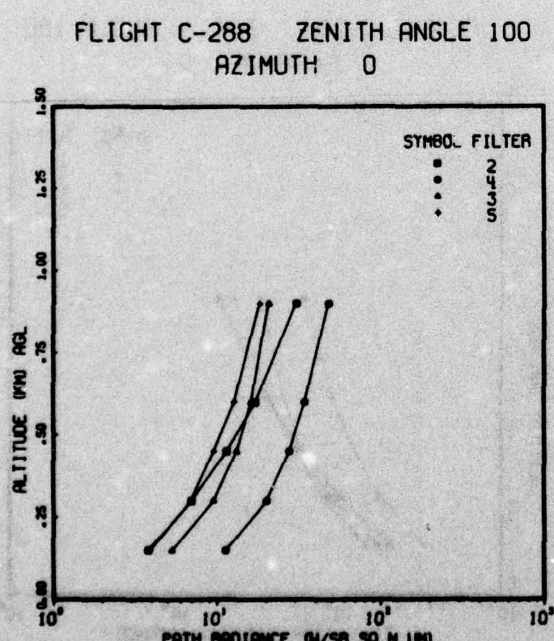
FLIGHT C-288

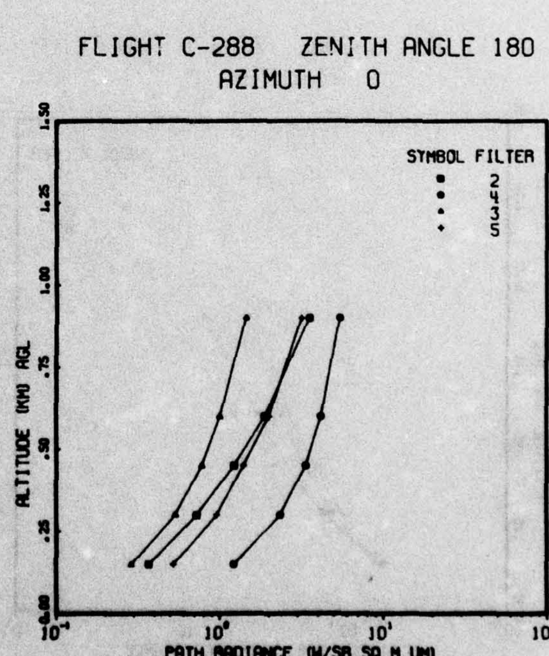


FLIGHT NO. C-288

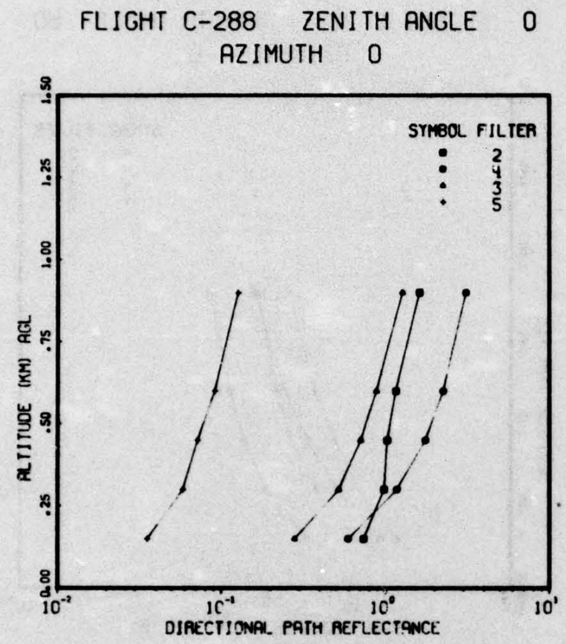


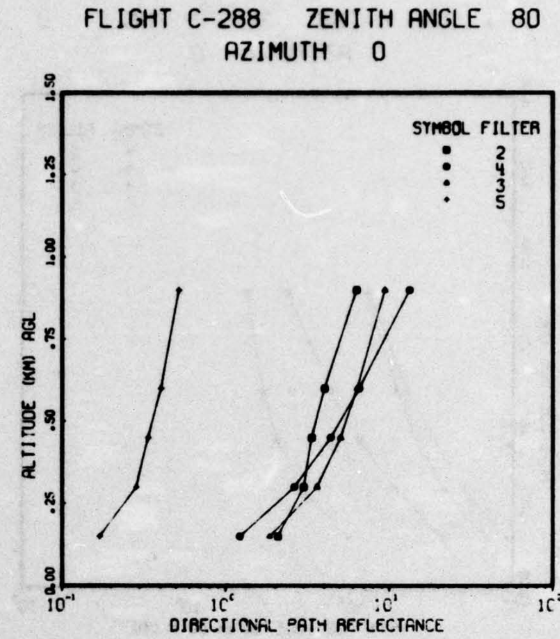


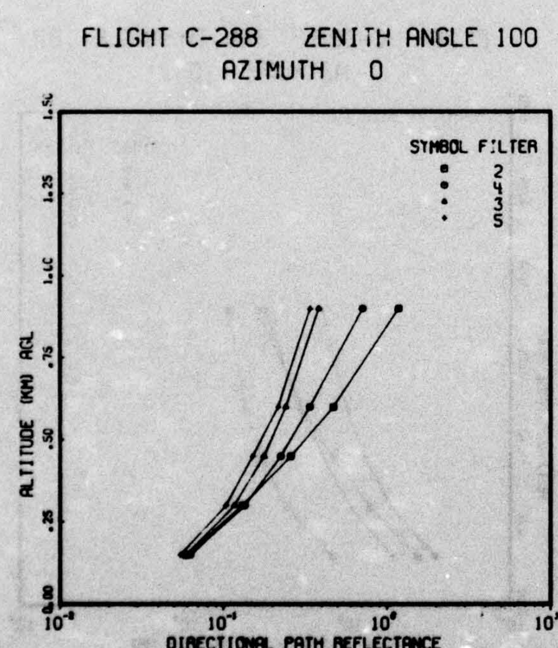


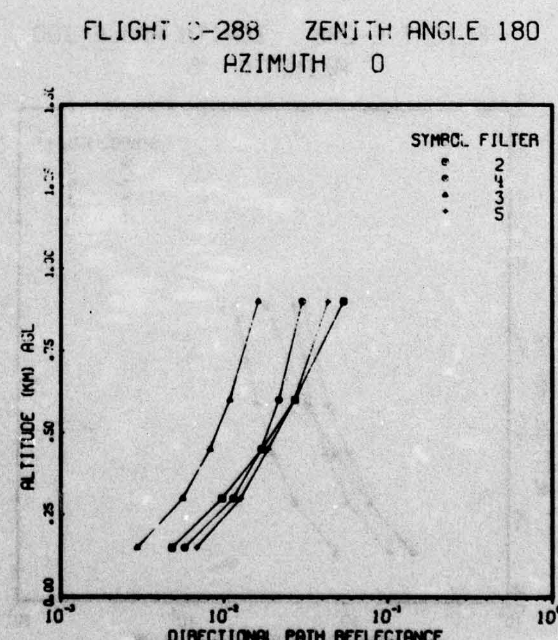


FLIGHT NO. C-288









FLIGHT NO. C-288

TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5353 DATE 04/21/76)
DATE 61373 FLIGHT NO. C-288 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3	5
0	3.89E-04	3,09E-04	2.41E-04	2,49E-04
30	2.23E-04	2,25E-04	1.08E-04	8,23E-05
60	2.23E-04	2,25E-04	1.08E-04	8,21E-05
90	2.22E-04	2,24E-04	1.08E-04	8,19E-05
120	2.22E-04	2,24E-04	1.07E-04	8,17E-05
150	2.21E-04	2,23E-04	1.07E-04	8,15E-05
180	2.21E-04	2,23E-04	1.07E-04	8,13E-05
210	2.20E-04	2,22E-04	1.07E-04	8,11E-05
240	2.19E-04	2,21E-04	1.06E-04	8,09E-05
270	2.20E-04	2,21E-04	1.06E-04	8,07E-05
300	2.17E-04	2,20E-04	1.06E-04	7,81E-05
330	2.18E-04	2,20E-04	1.08E-04	7,95E-05
360	2.13E-04	2,19E-04	1.07E-04	5,51E-05
390	2.18E-04	2,24E-04	1.11E-04	5,12E-05
420	2.23E-04	2,15E-04	1.09E-04	6,60E-05
450	2.21E-04	2,18E-04	1.11E-04	7,65E-05
480	2.22E-04	2,11E-04	1.13E-04	7,39E-05
510	2.21E-04	2,11E-04	1.13E-04	7,61E-05
540	2.20E-04	2,17E-04	1.17E-04	8,35E-05
570	2.10E-04	2,23E-04	1.18E-04	7,42E-05
600	2.26E-04	2,05E-04	1.21E-04	5,75E-05
630	2.07E-04	2,30E-04	1.32E-04	5,26E-05
660	2.20E-04	2,46E-04	1.30E-04	5,60E-05
690	2.23E-04	2,25E-04	1.25E-04	7,96E-05
720	1.83E-04	2,38E-04	1.24E-04	5,13E-05
750	2.00E-04	2,51E-04	1.25E-04	5,88E-05
780	2.02E-04	2,45E-04	1.29E-04	5,50E-05
810	1.96E-04	2,45E-04	1.29E-04	5,42E-05
840	1.95E-04	2,44E-04	1.28E-04	5,40E-05
870	1.95E-04	2,43E-04	1.28E-04	5,39E-05
900	1.94E-04	2,42E-04	1.28E-04	5,37E-05
FIRST DATA ALT	240	360	300	270
LAST DATA ALT	810	780	780	810

FLIGHT NO. C-288
IRRADIANCE

(JOB 5393 DATE 04/21/76)

FLIGHT NO.C-288 FILTER NO. 2 SUN ZENITH ANGLE 32.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
222	2.50E 02	1.17E 01	.047	4.84E-01	4.14E 02	3.76E 01	4.52E 02	.091
805	6.83E 02	5.68E 01	.083	5.63E-01	1.09E 03	1.74E 02	1.26E 03	.159

FLIGHT NO.C-288 FILTER NO. 4 SUN ZENITH ANGLE 30.2

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
324	6.93E 02	5.55E 01	.080	5.40E-01	1.08E 03	1.36E 02	1.22E 03	.126
808	4.33E 02	5.32E 01	.123	6.12E-01	8.42E 02	1.82E 02	1.03E 03	.217

FLIGHT NO.C-288 FILTER NO. 3 SUN ZENITH ANGLE 34.4

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
280	3.13E 02	1.63E 01	.052	3.25E-01	5.99E 02	5.40E 01	6.53E 02	.090
800	2.90E 02	2.18E 01	.075	3.50E-01	5.60E 02	7.12E 01	6.31E 02	.127

FLIGHT NO.C-288 FILTER NO. 5 SUN ZENITH ANGLE 31.1

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
225	2.45E 02	9.74E 01	.397	3.59E-01	4.48E 02	1.97E 02	6.45E 02	.440
809	6.17E 02	2.00E 02	.324	3.75E-01	9.74E 02	3.86E 02	1.36E 03	.396

FLIGHT NO. C-288 SPECTRAL FILTER NO. 2
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5353 DATE 04/21/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-288 FILTER NO. = 2 SUN ZENITH ANGLE 32.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		2.50E 02
150	1.17E 01	
300	1.78E 01	
450	2.94E 01	
600	4.10E 01	
900	5.08E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1556	.0901	.0304
150	24.7311	12.0540	9.6316	6.6643			
300	21.8062	9.9833	7.6427	5.6417			
450	19.5597	6.6247	6.1150	4.8563			
600	18.5857	5.6021	5.4527	4.5157			
900	17.8978	4.9799	4.9850	4.2752			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1463	.0665	.0304
150	24.7311	13.4564	13.1073	11.4422			
300	21.8062	10.0418	9.7354	8.7023			
450	19.5597	7.4191	7.1456	6.5978			
600	18.5857	6.2820	6.0227	5.6854			
900	17.8978	5.4790	5.2297	5.0410			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2905	.1112	.0304
150	24.7311	13.5569	16.4047	16.6487			
300	21.8062	10.9705	11.7814	11.3744			
450	19.5597	8.9840	8.2304	7.3294			
600	18.5857	8.1227	6.6908	5.5757			
900	17.8978	7.5144	5.6035	4.3372			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2740	.1236	.0304
150	24.7311	6.4414	7.7606	9.4605			
300	21.8062	6.8365	6.0214	7.0328			
450	19.5597	7.1400	4.6856	5.1681			
600	18.5857	7.2716	4.1064	4.3596			
900	17.8978	7.3645	3.6974	3.7886			

FLIGHT NO. C-288 SPECTRAL FILTER NO. 4
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5353 DATE 04/21/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-288 FILTER NO. = 4 SUN ZENITH ANGLE 30.2

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		6.95E 02
150	5.55E 01	
300	5.55E 01	
450	5.49E 01	
600	5.42E 01	
900	5.32E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2159	.1218	.1182
150	24.7727	6.2497	6.8174	6.6054			
300	24.7727	6.2497	6.8174	6.6054			
450	19.9187	6.7046	7.1492	6.9742			
600	13.9976	7.2594	7.5538	7.4241			
900	9.5193	8.0539	8.1332	8.0682			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1542	.0863	.1182
150	24.7727	5.7191	5.1065	4.3738			
300	24.7727	5.7191	5.1065	4.3738			
450	19.9187	6.8948	5.6837	4.6755			
600	13.9976	8.3290	6.3877	5.0436			
900	9.5193	10.3825	7.3958	5.5706			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2361	.1428	.1182
150	24.7727	8.1635	7.5764	6.0623			
300	24.7727	8.1635	7.5764	6.0623			
450	19.9187	7.8838	7.2976	6.1041			
600	13.9976	7.5427	6.9576	6.1552			
900	9.5193	7.0542	6.4707	6.2283			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2206	.1292	.1182
150	24.7727	5.4576	4.6625	4.6947			
300	24.7727	5.4576	4.6625	4.6947			
450	19.9187	5.9573	4.7958	5.1253			
600	13.9976	6.5669	4.9585	5.6506			
900	9.5193	7.4397	5.1915	6.4027			

FLIGHT NO. C-288 SPECTRAL FILTER NO. 3
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5353 DATE 04/21/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-288 FILTER NO. = 3 SUN ZENITH ANGLE 34.4

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		3.13E 02
150	1.63E 01	
300	1.65E 01	
450	1.81E 01	
600	1.97E 01	
900	2.18E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2120	.1403	.0154
150	13.2643	36.8773	32.9536	23.0521			
300	13.0888	35.5719	31.8200	22.2291			
450	11.9024	26.7457	24.1559	16.6644			
600	10.9057	19.3314	17.7177	11.9899			
900	9.8010	11.1127	10.5810	6.8082			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1417	.0959	.0154
150	13.2643	9.1655	8.6202	7.5503			
300	13.0888	9.3613	8.8104	7.6385			
450	11.9024	10.6852	10.0961	8.2351			
600	10.9057	11.7974	11.1761	8.7362			
900	9.8010	13.0302	12.3733	9.2917			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2489	.1439	.0154
150	13.2643	12.8287	10.7666	10.0035			
300	13.0888	13.0779	10.8910	9.9014			
450	11.9024	14.7625	11.7322	9.2115			
600	10.9057	16.1776	12.4388	8.6320			
900	9.8010	17.7462	13.2220	7.9896			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1960	.1295	.0154
150	13.2643	15.2080	13.5189	11.3106			
300	13.0888	15.1281	13.2939	11.0772			
450	11.9024	14.5880	11.7729	9.4992			
600	10.9057	14.1342	10.4952	8.1736			
900	9.8010	13.6313	9.0788	6.7043			

FLIGHT NO. C-288 SPECTRAL FILTER NO. 5
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5353 DATE 04/21/76)
AVIZPRNT (JOB 3636 DATE 06/18/76)

FLIGHT NO. C-288 FILTER NO. = 5 SUN ZENITH ANGLE 31.1

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		2.45E 02
150	9.74E 01	
300	1.11E 02	
450	1.37E 02	
600	1.63E 02	
900	2.00E 02	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.4933	.3695	.3108
150	2.3335	1.6489	2,2693	2.5541			
300	2,3984	1.4731	1,9282	2.1934			
450	2,4906	1.2233	1,4432	1,6803			
600	2,5530	1.0541	1,1148	1,3330			
900	2,6125	.8928	,8017	1.0018			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.3989	.3918	.3108
150	2.3335	1.5942	1,2927	1.2521			
300	2.3984	1.6156	1,3913	1.3456			
450	2,4906	1.6462	1,5316	1.4786			
600	2.5530	1.6668	1,6265	1.5686			
900	2.6125	1.6865	1,7170	1.6544			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					,2833	.2893	.3108
150	2.3335	1.2125	1,0936	1.2915			
300	2,3984	1.2931	1,2065	1,3577			
450	2,4906	1.4077	1,3670	1,4519			
600	2,5530	1.4852	1.4757	1,5156			
900	2,6125	1.5592	1,5794	1,5764			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					,5712	.4121	.3108
150	2,3335	2.1756	2,4838	2.6102			
300	2,3984	1.8861	2,1298	2.2236			
450	2,4906	1.4745	1,6262	1.6739			
600	2,5530	1.1959	1,2853	1.3017			
900	2,6125	.9302	,9602	,9468			

FLIGHT NO. C-288
EQUIVALENT ATTENUATION LENGTH

(JOB 5353 DATE 04/21/76)
DATE 61373 FLIGHT NO. C-288 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 2	4	3	5
0	2.57E 00	3.24E 00	4.15E 00	4.02E 00
30	3.27E 00	3.74E 00	5.73E 00	6.04E 00
60	3.78E 00	4.06E 00	7.08E 00	8.07E 00
90	3.99E 00	4.18E 00	7.68E 00	9.09E 00
120	4.11E 00	4.25E 00	8.03E 00	9.71E 00
150	4.18E 00	4.29E 00	8.26E 00	1.01E 01
180	4.24E 00	4.33E 00	8.43E 00	1.04E 01
210	4.28E 00	4.35E 00	8.55E 00	1.07E 01
240	4.31E 00	4.37E 00	8.65E 00	1.09E 01
270	4.34E 00	4.38E 00	8.73E 00	1.10E 01
300	4.36E 00	4.40E 00	8.79E 00	1.11E 01
330	4.38E 00	4.41E 00	8.84E 00	1.13E 01
360	4.40E 00	4.42E 00	8.88E 00	1.15E 01
390	4.42E 00	4.43E 00	8.90E 00	1.19E 01
420	4.42E 00	4.44E 00	8.92E 00	1.21E 01
450	4.43E 00	4.45E 00	8.93E 00	1.22E 01
480	4.43E 00	4.46E 00	8.93E 00	1.23E 01
510	4.44E 00	4.48E 00	8.92E 00	1.24E 01
540	4.44E 00	4.49E 00	8.91E 00	1.24E 01
570	4.45E 00	4.49E 00	8.89E 00	1.24E 01
600	4.46E 00	4.50E 00	8.86E 00	1.25E 01
630	4.47E 00	4.50E 00	8.81E 00	1.27E 01
660	4.48E 00	4.49E 00	8.75E 00	1.29E 01
690	4.48E 00	4.48E 00	8.70E 00	1.29E 01
720	4.50E 00	4.47E 00	8.67E 00	1.30E 01
750	4.52E 00	4.45E 00	8.64E 00	1.32E 01
780	4.54E 00	4.44E 00	8.61E 00	1.33E 01
810	4.55E 00	4.42E 00	8.58E 00	1.34E 01
840	4.57E 00	4.41E 00	8.55E 00	1.36E 01
870	4.59E 00	4.40E 00	8.52E 00	1.37E 01
900	4.60E 00	4.39E 00	8.49E 00	1.38E 01

FLIGHT NO. C-288
BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. 2
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.65E-01	8.71E-01	8.13E-01	6.63E-01	6.62E-01	8.13E-01	9.65E-01
300	9.33E-01	7.66E-01	6.73E-01	4.55E-01	4.53E-01	6.73E-01	9.33E-01
450	9.03E-01	6.75E-01	5.57E-01	3.13E-01	3.10E-01	5.57E-01	9.03E-01
600	8.74E-01	5.95E-01	4.61E-01	2.15E-01	2.12E-01	4.61E-01	8.74E-01
900	8.22E-01	4.70E-01	3.24E-01	1.08E-01	1.04E-01	3.24E-01	8.22E-01

FLIGHT NO. C-288 FILTER NO. 4
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.66E-01	8.74E-01	8.18E-01	6.70E-01	6.69E-01	8.18E-01	9.66E-01
300	9.34E-01	7.68E-01	6.75E-01	4.58E-01	4.56E-01	6.75E-01	9.34E-01
450	9.04E-01	6.77E-01	5.59E-01	3.15E-01	3.12E-01	5.59E-01	9.04E-01
600	8.75E-01	5.97E-01	4.64E-01	2.18E-01	2.15E-01	4.64E-01	8.75E-01
900	8.15E-01	4.53E-01	3.07E-01	9.68E-02	9.33E-02	3.07E-01	8.15E-01

FLIGHT NO. C-288 FILTER NO. 3
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.82E-01	9.32E-01	9.01E-01	8.12E-01	8.12E-01	9.01E-01	9.82E-01
300	9.66E-01	8.76E-01	8.22E-01	6.77E-01	6.75E-01	8.22E-01	9.66E-01
450	9.51E-01	8.25E-01	7.48E-01	5.62E-01	5.59E-01	7.48E-01	9.51E-01
600	9.35E-01	7.70E-01	6.77E-01	4.62E-01	4.58E-01	6.77E-01	9.35E-01
900	8.99E-01	6.64E-01	5.43E-01	2.99E-01	2.93E-01	5.43E-01	8.99E-01

FLIGHT NO. C-288 FILTER NO. 5
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.85E-01	9.44E-01	9.18E-01	8.44E-01	8.44E-01	9.18E-01	9.85E-01
300	9.73E-01	9.01E-01	8.56E-01	7.35E-01	7.34E-01	8.56E-01	9.73E-01
450	9.64E-01	8.68E-01	8.09E-01	6.57E-01	6.55E-01	8.09E-01	9.64E-01
600	9.53E-01	8.31E-01	7.59E-01	5.78E-01	5.75E-01	7.59E-01	9.53E-01
900	9.37E-01	7.78E-01	6.87E-01	4.76E-01	4.70E-01	6.87E-01	9.37E-01

FLIGHT NO. C-288 SPECTRAL FILTER NO. 2

PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 2 SUN ZENITH ANGLE 32.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.65E 00	4.92E 00	6.33E 00	1.01E 01	7.93E 00	3.81E 00	3.69E-01
300	5.18E 00	9.16E 00	1.14E 01	1.68E 01	1.35E 01	6.98E 00	7.22E-01
450	8.67E 00	1.45E 01	1.74E 01	2.33E 01	2.10E 01	1.14E 01	1.22E 00
600	1.32E 01	2.07E 01	2.41E 01	2.94E 01	3.03E 01	1.72E 01	1.88E 00
900	2.41E 01	3.38E 01	3.69E 01	3.83E 01	5.00E 01	3.04E 01	3.51E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.65E 00	5.80E 00	7.46E 00	1.19E 01	9.16E 00	4.33E 00	3.69E-01
300	5.18E 00	1.07E 01	1.34E 01	1.96E 01	1.54E 01	7.89E 00	7.22E-01
450	8.67E 00	1.64E 01	1.98E 01	2.67E 01	2.32E 01	1.26E 01	1.22E 00
600	1.32E 01	2.27E 01	2.67E 01	3.30E 01	3.25E 01	1.85E 01	1.88E 00
900	2.41E 01	3.55E 01	3.94E 01	4.20E 01	5.17E 01	3.16E 01	3.51E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.65E 00	5.67E 00	7.58E 00	1.26E 01	1.02E 01	4.87E 00	3.69E-01
300	5.18E 00	1.05E 01	1.36E 01	2.07E 01	1.70E 01	8.79E 00	7.22E-01
450	8.67E 00	1.59E 01	2.00E 01	2.78E 01	2.47E 01	1.36E 01	1.22E 00
600	1.32E 01	2.20E 01	2.67E 01	3.40E 01	3.35E 01	1.93E 01	1.88E 00
900	2.41E 01	3.42E 01	3.89E 01	4.27E 01	5.09E 01	3.16E 01	3.51E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.65E 00	4.99E 00	6.55E 00	1.08E 01	8.80E 00	4.26E 00	3.69E-01
300	5.18E 00	9.26E 00	1.18E 01	1.78E 01	1.48E 01	7.78E 00	7.22E-01
450	8.67E 00	1.44E 01	1.78E 01	2.44E 01	2.25E 01	1.25E 01	1.22E 00
600	1.32E 01	2.04E 01	2.44E 01	3.05E 01	3.18E 01	1.84E 01	1.88E 00
900	2.41E 01	3.28E 01	3.67E 01	3.93E 01	5.12E 01	3.17E 01	3.51E 00

FLIGHT NO. C-288 SPECTRAL FILTER NO. 4
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 4 SUN ZENITH ANGLE 30.2

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.01E 01	1.33E 01	1.76E 01	2.90E 01	2.35E 01	1.13E 01	1.22E 00
300	1.94E 01	2.43E 01	3.13E 01	4.76E 01	3.85E 01	2.01E 01	2.34E 00
450	2.77E 01	3.41E 01	4.27E 01	6.04E 01	4.92E 01	2.76E 01	3.35E 00
600	3.40E 01	4.27E 01	5.23E 01	6.95E 01	5.79E 01	3.45E 01	4.16E 00
900	4.28E 01	5.89E 01	6.92E 01	8.17E 01	7.28E 01	4.80E 01	5.38E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.01E 01	1.21E 01	1.58E 01	2.57E 01	2.05E 01	9.86E 00	1.22E 00
300	1.94E 01	2.22E 01	2.82E 01	4.22E 01	3.36E 01	1.76E 01	2.34E 00
450	2.77E 01	3.12E 01	3.84E 01	5.35E 01	4.26E 01	2.40E 01	3.35E 00
600	3.40E 01	3.91E 01	4.71E 01	6.14E 01	4.92E 01	2.93E 01	4.16E 00
900	4.28E 01	5.42E 01	6.21E 01	7.19E 01	5.88E 01	3.88E 01	5.38E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.01E 01	1.39E 01	1.88E 01	3.08E 01	2.43E 01	1.17E 01	1.22E 00
300	1.94E 01	2.54E 01	3.35E 01	5.05E 01	3.99E 01	2.08E 01	2.34E 00
450	2.77E 01	3.56E 01	4.55E 01	6.39E 01	5.05E 01	2.83E 01	3.35E 00
600	3.40E 01	4.44E 01	5.52E 01	7.29E 01	5.76E 01	3.44E 01	4.16E 00
900	4.28E 01	6.09E 01	7.14E 01	8.42E 01	6.65E 01	4.44E 01	5.38E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.01E 01	1.24E 01	1.64E 01	2.69E 01	2.20E 01	1.07E 01	1.22E 00
300	1.94E 01	2.27E 01	2.92E 01	4.43E 01	3.60E 01	1.90E 01	2.34E 00
450	2.77E 01	3.18E 01	3.99E 01	5.62E 01	4.61E 01	2.61E 01	3.35E 00
600	3.40E 01	3.99E 01	4.89E 01	6.47E 01	5.45E 01	3.28E 01	4.16E 00
900	4.28E 01	5.54E 01	6.49E 01	7.63E 01	6.96E 01	4.63E 01	5.38E 00

FLIGHT NO. C-288 SPECTRAL FILTER NO. 3
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 3 SUN ZENITH ANGLE 34.4

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E 00	6.42E 00	8.69E 00	1.49E 01	1.17E 01	5.30E 00	2.88E-01
300	2.65E 00	1.17E 01	1.56E 01	2.56E 01	2.02E 01	9.52E 00	5.36E-01
450	3.88E 00	1.65E 01	2.17E 01	3.42E 01	2.67E 01	1.32E 01	7.74E-01
600	5.17E 00	2.07E 01	2.69E 01	4.09E 01	3.13E 01	1.62E 01	1.00E 00
900	7.94E 00	2.79E 01	3.53E 01	5.01E 01	3.58E 01	2.07E 01	1.44E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E 00	3.57E 00	4.81E 00	8.31E 00	6.94E 00	3.26E 00	2.88E-01
300	2.65E 00	6.51E 00	8.65E 00	1.43E 01	1.19E 01	5.87E 00	5.36E-01
450	3.88E 00	9.52E 00	1.25E 01	1.97E 01	1.64E 01	8.37E 00	7.74E-01
600	5.17E 00	1.28E 01	1.65E 01	2.48E 01	2.07E 01	1.09E 01	1.00E 00
900	7.94E 00	2.03E 01	2.50E 01	3.40E 01	2.87E 01	1.61E 01	1.44E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E 00	3.86E 00	5.23E 00	9.10E 00	7.64E 00	3.60E 00	2.88E-01
300	2.65E 00	7.04E 00	9.41E 00	1.57E 01	1.31E 01	6.47E 00	5.36E-01
450	3.88E 00	1.03E 01	1.35E 01	2.15E 01	1.80E 01	9.20E 00	7.74E-01
600	5.17E 00	1.38E 01	1.78E 01	2.70E 01	2.26E 01	1.19E 01	1.00E 00
900	7.94E 00	2.18E 01	2.69E 01	3.68E 01	3.09E 01	1.74E 01	1.44E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.42E 00	4.65E 00	6.36E 00	1.09E 01	8.79E 00	4.06E 00	2.88E-01
300	2.65E 00	8.49E 00	1.14E 01	1.87E 01	1.51E 01	7.29E 00	5.36E-01
450	3.88E 00	1.22E 01	1.61E 01	2.53E 01	2.03E 01	1.02E 01	7.74E-01
600	5.17E 00	1.58E 01	2.05E 01	3.09E 01	2.47E 01	1.30E 01	1.00E 00
900	7.94E 00	2.31E 01	2.88E 01	3.99E 01	3.13E 01	1.79E 01	1.44E 00

FLIGHT NO. C-288 SPECTRAL FILTER NO. 5
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 5 SUN ZENITH ANGLE 31.1

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	1.08E 00	3.43E 00	4.83E 00	8.78E 00	7.99E 00	3.90E 00	5.21E-01
300	2.00E 00	6.16E 00	8.56E 00	1.50E 01	1.37E 01	6.91E 00	9.56E-01
450	3.02E 00	8.65E 00	1.18E 01	2.01E 01	1.84E 01	9.52E 00	1.39E 00
600	4.53E 00	1.19E 01	1.59E 01	2.60E 01	2.41E 01	1.20E 01	2.00E 00
900	7.57E 00	1.74E 01	2.26E 01	3.48E 01	3.32E 01	1.82E 01	3.14E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	1.08E 00	2.88E 00	3.99E 00	7.19E 00	6.56E 00	3.23E 00	5.21E-01
300	2.00E 00	5.22E 00	7.14E 00	1.24E 01	1.14E 01	5.70E 00	9.56E-01
450	3.02E 00	7.52E 00	1.02E 01	1.72E 01	1.60E 01	8.34E 00	1.39E 00
600	4.53E 00	1.07E 01	1.43E 01	2.31E 01	2.24E 01	1.19E 01	2.00E 00
900	7.57E 00	1.65E 01	2.16E 01	3.30E 01	3.40E 01	1.86E 01	3.14E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	1.08E 00	2.73E 00	3.81E 00	6.92E 00	6.42E 00	3.19E 00	5.21E-01
300	2.00E 00	4.92E 00	6.79E 00	1.19E 01	1.11E 01	5.70E 00	9.56E-01
450	3.02E 00	7.02E 00	9.60E 00	1.64E 01	1.55E 01	8.15E 00	1.39E 00
600	4.53E 00	9.82E 00	1.33E 01	2.18E 01	2.14E 01	1.15E 01	2.00E 00
900	7.57E 00	1.49E 01	1.98E 01	3.07E 01	3.20E 01	1.77E 01	3.14E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
150	1.08E 00	3.27E 00	4.70E 00	8.73E 00	8.22E 00	4.06E 00	5.21E-01
300	2.00E 00	5.86E 00	8.31E 00	1.49E 01	1.40E 01	7.17E 00	9.56E-01
450	3.02E 00	8.09E 00	1.13E 01	1.97E 01	1.86E 01	9.77E 00	1.39E 00
600	4.53E 00	1.08E 01	1.49E 01	2.50E 01	2.39E 01	1.29E 01	2.00E 00
900	7.57E 00	1.53E 01	2.06E 01	3.27E 01	3.19E 01	1.70E 01	3.14E 00

FLIGHT NO. C-288 SPECTRAL FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 2 SUN ZENITH ANGLE 32.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.57E-01	1.51E 00	2.09E 00	4.09E 00	1.50E-01	5.87E-02	4.79E-03
300	9.83E-01	2.11E 00	3.01E 00	6.54E 00	3.73E-01	1.30E-01	9.70E-03
450	1.03E 00	2.29E 00	3.35E 00	7.97E 00	8.47E-01	2.58E-01	1.69E-02
600	1.16E 00	2.67E 00	4.01E 00	1.05E 01	1.79E 00	4.68E-01	2.70E-02
900	1.62E 00	3.98E 00	6.28E 00	1.96E 01	6.02E 00	1.18E 00	5.35E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.57E-01	1.79E 00	2.46E 00	4.81E 00	1.73E-01	6.67E-02	4.79E-03
300	9.83E-01	2.47E 00	3.52E 00	7.63E 00	4.26E-01	1.47E-01	9.70E-03
450	1.03E 00	2.59E 00	3.81E 00	9.12E 00	9.37E-01	2.83E-01	1.69E-02
600	1.16E 00	2.95E 00	4.45E 00	1.17E 01	1.92E 00	5.02E-01	2.70E-02
900	1.62E 00	4.18E 00	6.71E 00	2.15E 01	6.22E 00	1.22E 00	5.35E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.57E-01	1.74E 00	2.50E 00	5.08E 00	1.93E-01	7.50E-02	4.79E-03
300	9.83E-01	2.41E 00	3.57E 00	8.04E 00	4.71E-01	1.64E-01	9.70E-03
450	1.03E 00	2.52E 00	3.83E 00	9.51E 00	9.99E-01	3.06E-01	1.69E-02
600	1.16E 00	2.84E 00	4.44E 00	1.21E 01	1.98E 00	5.25E-01	2.70E-02
900	1.62E 00	4.03E 00	6.63E 00	2.19E 01	6.13E 00	1.22E 00	5.35E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	7.57E-01	1.54E 00	2.16E 00	4.35E 00	1.67E-01	6.57E-02	4.79E-03
300	9.83E-01	2.14E 00	3.10E 00	6.92E 00	4.11E-01	1.45E-01	9.70E-03
450	1.03E 00	2.29E 00	3.42E 00	8.36E 00	9.12E-01	2.81E-01	1.69E-02
600	1.16E 00	2.64E 00	4.05E 00	1.09E 01	1.89E 00	5.00E-01	2.70E-02
900	1.62E 00	3.86E 00	6.26E 00	2.01E 01	6.17E 00	1.22E 00	5.35E-02

FLIGHT NO. C-288 SPECTRAL FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 4 SUN ZENITH ANGLE 30.2

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.91E-01	8.59E-01	1.21E 00	2.45E 00	1.59E-01	6.29E-02	5.71E-03
300	1.17E 00	1.79E 00	2.62E 00	5.88E 00	3.82E-01	1.35E-01	1.13E-02
450	1.75E 00	2.88E 00	4.37E 00	1.10E 01	7.15E-01	2.24E-01	1.68E-02
600	2.25E 00	4.14E 00	6.54E 00	1.85E 01	1.22E 00	3.36E-01	2.15E-02
900	3.11E 00	7.69E 00	1.33E 01	4.98E 01	3.54E 00	7.09E-01	2.99E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.91E-01	7.85E-01	1.09E 00	2.17E 00	1.39E-01	5.47E-02	5.71E-03
300	1.17E 00	1.64E 00	2.36E 00	5.21E 00	3.34E-01	1.18E-01	1.13E-02
450	1.75E 00	2.63E 00	3.93E 00	9.73E 00	6.19E-01	1.94E-01	1.68E-02
600	2.25E 00	3.79E 00	5.88E 00	1.63E 01	1.04E 00	2.86E-01	2.15E-02
900	3.11E 00	7.00E 00	1.20E 01	4.38E 01	2.86E 00	5.72E-01	2.99E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.91E-01	8.97E-01	1.30E 00	2.60E 00	1.64E-01	6.47E-02	5.71E-03
300	1.17E 00	1.87E 00	2.80E 00	6.24E 00	3.96E-01	1.40E-01	1.13E-02
450	1.75E 00	3.01E 00	4.66E 00	1.16E 01	7.33E-01	2.29E-01	1.68E-02
600	2.25E 00	4.31E 00	6.90E 00	1.94E 01	1.22E 00	3.35E-01	2.15E-02
900	3.11E 00	7.94E 00	1.37E 01	5.14E 01	3.23E 00	6.56E-01	2.99E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.91E-01	8.01E-01	1.13E 00	2.27E 00	1.49E-01	5.90E-02	5.71E-03
300	1.17E 00	1.67E 00	2.45E 00	5.46E 00	3.57E-01	1.27E-01	1.13E-02
450	1.75E 00	2.69E 00	4.08E 00	1.02E 01	6.70E-01	2.12E-01	1.68E-02
600	2.25E 00	3.87E 00	6.11E 00	1.72E 01	1.15E 00	3.20E-01	2.15E-02
900	3.11E 00	7.25E 00	1.25E 01	4.65E 01	3.38E 00	6.84E-01	2.99E-02

FLIGHT NO. C-288 SPECTRAL FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 3 SUN ZENITH ANGLE 34.4

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.79E-01	1.32E 00	1.86E 00	3.53E 00	1.45E-01	5.91E-02	2.94E-03
300	5.21E-01	2.54E 00	3.61E 00	7.19E 00	3.00E-01	1.16E-01	5.57E-03
450	7.09E-01	3.47E 00	5.03E 00	1.05E 01	4.79E-01	1.77E-01	8.18E-03
600	8.83E-01	4.30E 00	6.34E 00	1.41E 01	6.86E-01	2.41E-01	1.08E-02
900	1.27E 00	6.06E 00	9.37E 00	2.42E 01	1.22E 00	3.82E-01	1.61E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.79E-01	7.37E-01	1.03E 00	1.97E 00	8.58E-02	3.64E-02	2.94E-03
300	5.21E-01	1.41E 00	2.00E 00	4.02E 00	1.77E-01	7.17E-02	5.57E-03
450	7.09E-01	2.01E 00	2.89E 00	6.08E 00	2.94E-01	1.12E-01	8.18E-03
600	8.83E-01	2.66E 00	3.89E 00	8.58E 00	4.54E-01	1.62E-01	1.08E-02
900	1.27E 00	4.40E 00	6.65E 00	1.64E 01	9.83E-01	2.98E-01	1.61E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.79E-01	7.97E-01	1.12E 00	2.16E 00	9.46E-02	4.02E-02	2.94E-03
300	5.21E-01	1.55E 00	2.18E 00	4.40E 00	1.95E-01	7.91E-02	5.57E-03
450	7.09E-01	2.17E 00	3.14E 00	6.64E 00	3.23E-01	1.24E-01	8.18E-03
600	8.83E-01	2.87E 00	4.21E 00	9.33E 00	4.95E-01	1.77E-01	1.08E-02
900	1.27E 00	4.73E 00	7.15E 00	1.77E 01	1.06E 00	3.23E-01	1.61E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.79E-01	9.61E-01	1.36E 00	2.58E 00	1.09E-01	4.53E-02	2.94E-03
300	5.21E-01	1.84E 00	2.64E 00	5.26E 00	2.25E-01	8.92E-02	5.57E-03
450	7.09E-01	2.56E 00	3.73E 00	7.81E 00	3.65E-01	1.38E-01	8.18E-03
600	8.83E-01	3.28E 00	4.84E 00	1.07E 01	5.42E-01	1.93E-01	1.08E-02
900	1.27E 00	5.02E 00	7.65E 00	1.92E 01	1.07E 00	3.32E-01	1.61E-02

FLIGHT NO. C-288 SPECTRAL FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5353 DATE 04/21/76)

FLIGHT NO. C-288 FILTER NO. = 5 SUN ZENITH ANGLE 31.1

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.53E-02	1.17E-01	1.70E-01	3.36E-01	1.21E-01	5.44E-02	6.77E-03
300	5.84E-02	1.94E-01	2.84E-01	5.82E-01	2.39E-01	1.03E-01	1.26E-02
450	7.18E-02	2.29E-01	3.35E-01	7.03E-01	3.61E-01	1.51E-01	1.85E-02
600	9.14E-02	2.75E-01	4.03E-01	8.64E-01	5.37E-01	2.16E-01	2.68E-02
900	1.27E-01	3.52E-01	5.17E-01	1.15E 00	9.04E-01	3.39E-01	4.30E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.53E-02	9.85E-02	1.40E-01	2.75E-01	9.96E-02	4.50E-02	6.77E-03
300	5.84E-02	1.64E-01	2.37E-01	4.80E-01	1.99E-01	8.66E-02	1.26E-02
450	7.18E-02	1.99E-01	2.89E-01	5.99E-01	3.14E-01	1.32E-01	1.85E-02
600	9.14E-02	2.47E-01	3.62E-01	7.70E-01	5.00E-01	2.01E-01	2.68E-02
900	1.27E-01	3.35E-01	4.93E-01	1.09E 00	9.27E-01	3.47E-01	4.30E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.53E-02	9.31E-02	1.34E-01	2.65E-01	9.76E-02	4.45E-02	6.77E-03
300	5.84E-02	1.59E-01	2.25E-01	4.61E-01	1.94E-01	8.54E-02	1.26E-02
450	7.18E-02	1.86E-01	2.72E-01	5.71E-01	3.04E-01	1.29E-01	1.85E-02
600	9.14E-02	2.27E-01	3.37E-01	7.26E-01	4.78E-01	1.94E-01	2.68E-02
900	1.27E-01	3.00E-01	4.51E-01	1.01E 00	8.71E-01	3.30E-01	4.30E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.53E-02	1.12E-01	1.65E-01	3.34E-01	1.25E-01	5.66E-02	6.77E-03
300	5.84E-02	1.85E-01	2.76E-01	5.76E-01	2.45E-01	1.07E-01	1.26E-02
450	7.18E-02	2.14E-01	3.21E-01	6.88E-01	3.65E-01	1.55E-01	1.35E-02
600	9.14E-02	2.50E-01	3.78E-01	8.32E-01	5.33E-01	2.17E-01	2.68E-02
900	1.27E-01	3.09E-01	4.70E-01	1.08E 00	8.70E-01	3.33E-01	4.30E-02

FLIGHT C-289 – 14 June 1973 – DESCRIPTION OF FLIGHT AND WEATHER CHARACTERISTICS

It was a sunlit afternoon with a broken layer of clouds. The flight was conducted over low lying flat terrain consisting mainly of cultivated farmlands interspersed with dark patches of dense woods. The data-taking commenced at 1245 GMT and continued until 1419 GMT. The sun zenith angle during sky radiance data-taking was 33.1 degrees at the beginning and 43.6 degrees at the end. The maximum flight altitude was 1211 meters. The average elevation of the terrain was 20 meters.

The ground station was not in operation on this date.

The radiosonde station at Meppen reported 0.9 cumulus at 1000 to 1499 meters and 0.1 cirrus at 1300 GMT.

FLIGHT LOG ENTRY

Time (GMT)	Elevation (meters AGL)	Aircrew Observations
		Special descents under the cloud deck, broken to overcast.
1235		Light haze, scattered to broken deck above.
1246	1050	Broken to overcast above, approximately 6 to 8 miles (10 to 13 kilometers) visibility.
1355	300	West end begins to go scattered.

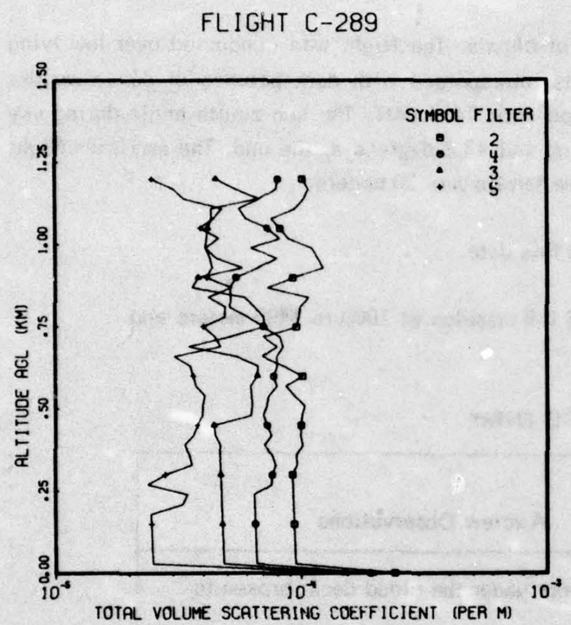
Note: Flight elevations in approximate feet MSL have been converted to approximate meters AGL.

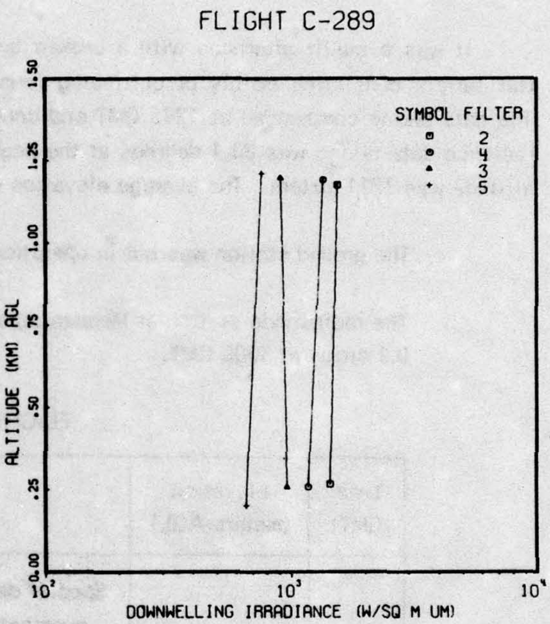
The surface charts show that a high centered south of Ireland moved eastward to near The Hague by 1800 GMT. A ridge was building over France and Germany. With increasing flow from the northwest at all levels, moisture was brought in from the North Sea and cloudiness increased throughout the day.

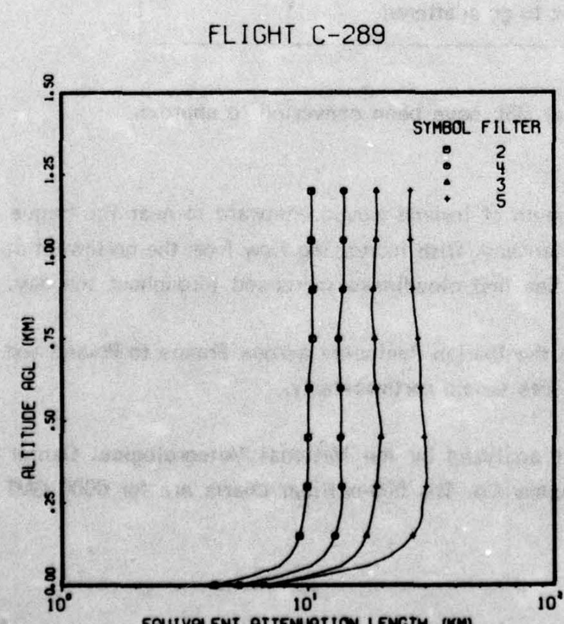
At 500 millibars there was a ridge of high from the Iberian Peninsula across France to Poland and and eastern Russia. The flow over northwest Germany was strong northwesterly.

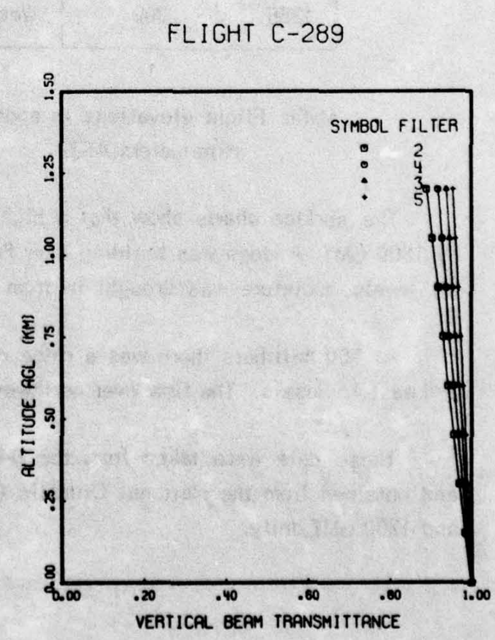
These data were taken from the 6-hourly chart analyzed by the National Meteorological Center and obtained from the National Climatic Center in Asheville. The 500-millibar charts are for 0000 GMT and 1200 GMT daily.

FLIGHT NO. C-289









AD-A035 571 SCRIPPS INSTITUTION OF OCEANOGRAPHY SAN DIEGO CALIF --ETC F/G 4/1
AIRBORNE MEASUREMENTS OF OPTICAL ATMOSPHERIC PROPERTIES IN NORT--ETC(U)
SEP 76 S Q DUNTLEY, R W JOHNSON, J I GORDON F19628-76-C-0004

UNCLASSIFIED SIO-REF-76-17 AFGL-TR-76-0188 NL

3 OF 3
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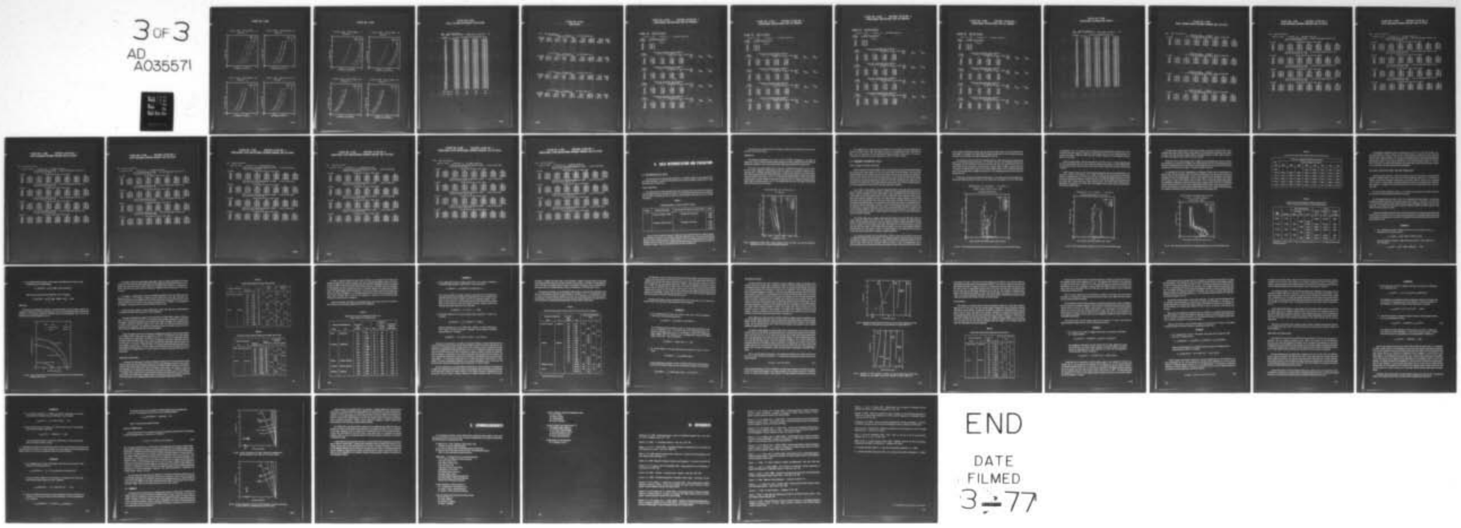
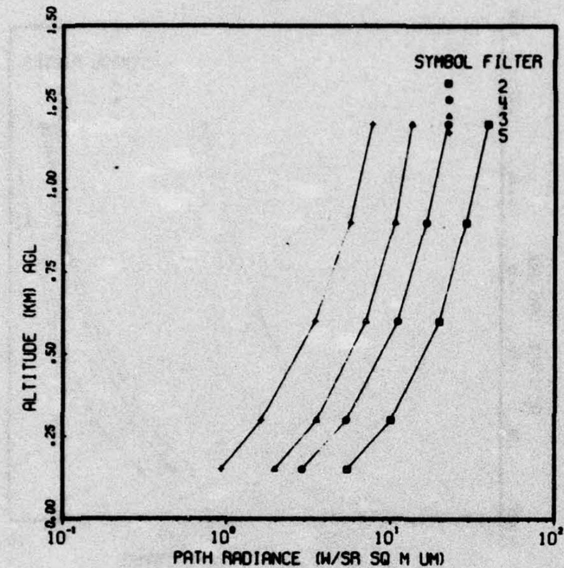
A035571



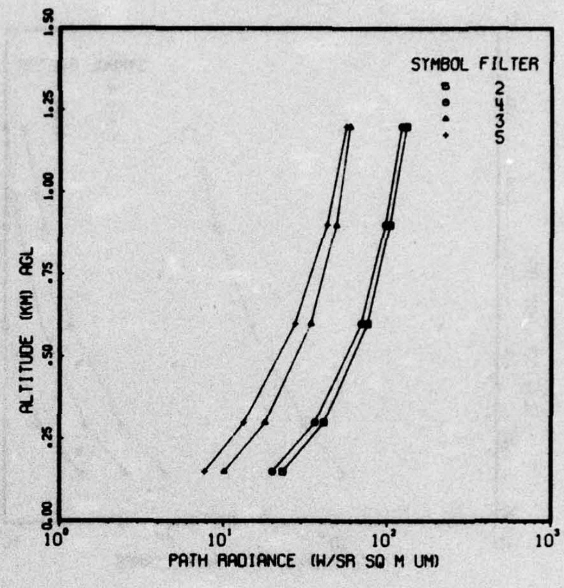
END
DATE
FILMED
3-77

FLIGHT NO. C-289

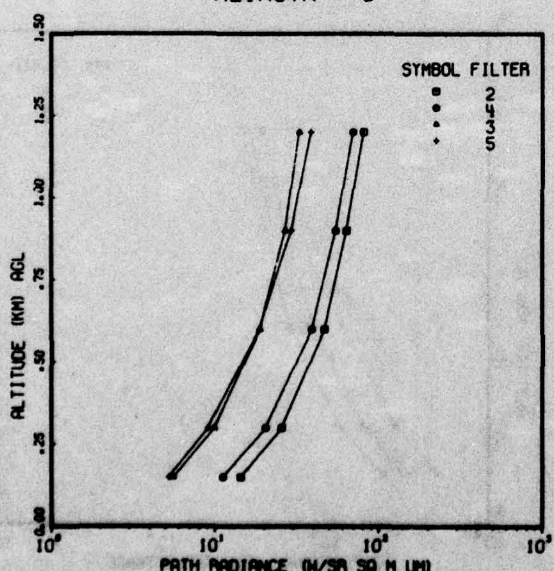
FLIGHT C-289 ZENITH ANGLE 0
AZIMUTH 0



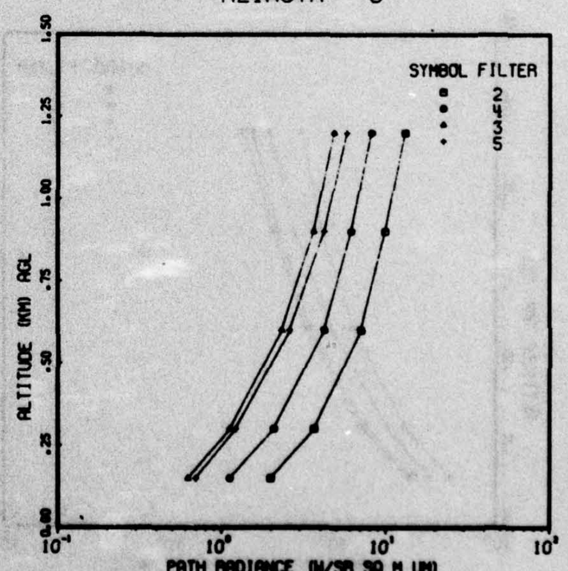
FLIGHT C-289 ZENITH ANGLE 80
AZIMUTH 0



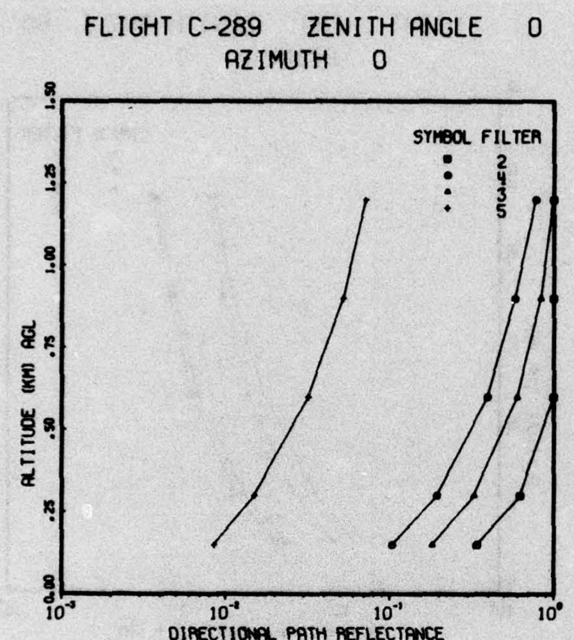
FLIGHT C-289 ZENITH ANGLE 100
AZIMUTH 0

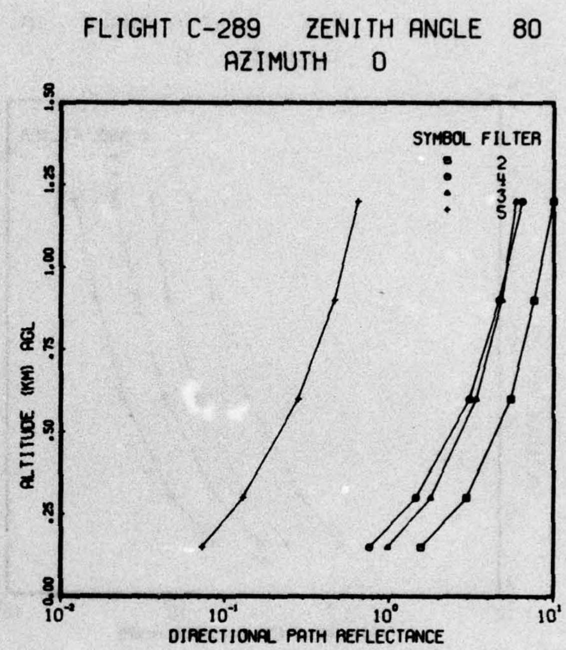


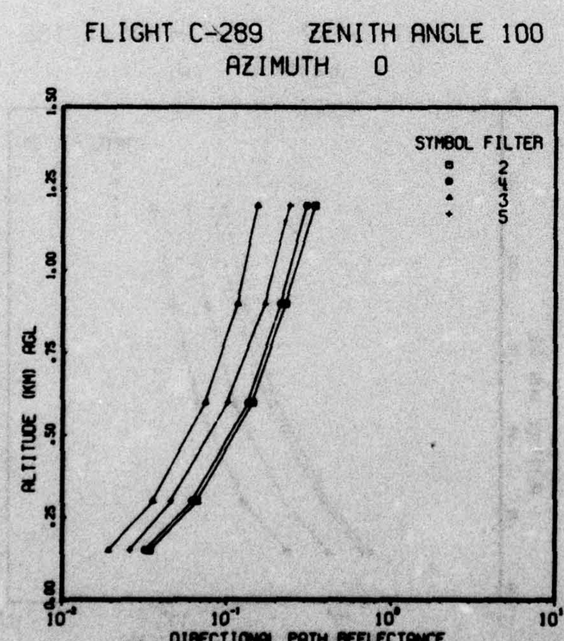
FLIGHT C-289 ZENITH ANGLE 180
AZIMUTH 0

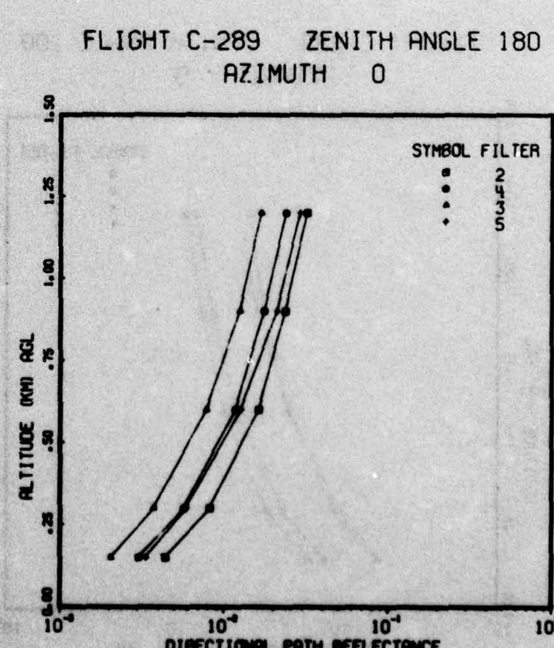


FLIGHT NO. C-289









FLIGHT NO. C-289
TOTAL VOLUME SCATTERING COEFFICIENT

(JOB 5401 DATE 05/03/76)
DATE 61473 FLIGHT NO. C-289 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	TOTAL VOLUME SCATTERING COEFFICIENT (PER M) FILTERS 2	4	3	5
0	2.40E-04	1,91E-04	1.49E-04	1,54E-04
30	9.45E-05	6,56E-05	4.82E-05	2,48E-05
60	9.42E-05	6,55E-05	4.80E-05	2,48E-05
90	9.40E-05	6,53E-05	4.79E-05	2,47E-05
120	9.37E-05	6,51E-05	4.78E-05	2,46E-05
150	9.35E-05	6,50E-05	4.77E-05	2,46E-05
180	9.33E-05	6,48E-05	4.76E-05	2,45E-05
210	9.30E-05	6,46E-05	4.74E-05	3,31E-05
240	9.28E-05	6,45E-05	4.73E-05	3,45E-05
270	9.25E-05	7,59E-05	4.72E-05	2,38E-05
300	9.23E-05	7,63E-05	4.71E-05	2,80E-05
330	9.64E-05	7,90E-05	4.69E-05	3,61E-05
360	9.58E-05	7,63E-05	4.68E-05	3,52E-05
390	1.01E-04	7,06E-05	4.67E-05	3,36E-05
420	9.92E-05	7,56E-05	4.46E-05	3,65E-05
450	9.98E-05	7,26E-05	4.41E-05	3,80E-05
480	1.01E-04	7,02E-05	6.27E-05	3,98E-05
510	1.04E-04	7,25E-05	6.34E-05	3,99E-05
540	9.38E-05	7,39E-05	6.28E-05	4,06E-05
570	8.69E-05	7,97E-05	6.24E-05	3,73E-05
600	1.01E-04	7,73E-05	6.65E-05	3,65E-05
630	8.55E-05	8,00E-05	6.68E-05	3,55E-05
660	6.95E-05	7,97E-05	5.45E-05	3,06E-05
690	8.00E-05	5,46E-05	3.50E-05	4,73E-05
720	7.03E-05	8,21E-05	5.16E-05	4,47E-05
750	9.60E-05	7,07E-05	7.09E-05	4,02E-05
780	9.82E-05	6,07E-05	7.06E-05	4,92E-05
810	9.96E-05	5,14E-05	6.47E-05	4,94E-05
840	1.07E-04	5,17E-05	5.87E-05	4,19E-05
870	7.30E-05	5,14E-05	3.61E-05	5,20E-05
900	9.26E-05	5,43E-05	3.82E-05	4,14E-05
930	1.23E-04	6,71E-05	5.77E-05	4,36E-05
960	1.17E-04	7,96E-05	4.50E-05	4,25E-05
990	1.11E-04	6,26E-05	4.08E-05	4,10E-05
1020	8.87E-05	8,19E-05	4.13E-05	4,62E-05
1050	8.23E-05	7,30E-05	4.18E-05	3,91E-05
1080	7.59E-05	5,95E-05	4.33E-05	4,44E-05
1110	9.48E-05	5,61E-05	4.32E-05	4,78E-05
1140	1.03E-04	6,78E-05	6.72E-05	3,34E-05
1170	1.08E-04	7,95E-05	5.41E-05	3,03E-05
1200	1.01E-04	8,06E-05	4.51E-05	2,47E-05
FIRST DATA ALT	300	240	390	180
LAST DATA ALT	1200	1200	1200	1200

FLIGHT NO. C-289
IRRADIANCE

(JOB 5401 DATE 05/03/76)

FLIGHT NO.C-289 FILTER NO. 2 SUN ZENITH ANGLE 33.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
267	1.44E 03	5.12E 01	.035	8.94E 02	1.22E 03	1.38E 02	2.25E 03	.065
1176	1.56E 03	7.75E 01	.050	9.90E 02	1.28E 03	2.20E 02	2.49E 03	.097

FLIGHT NO.C-289 FILTER NO. 4 SUN ZENITH ANGLE 39.6

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
258	1.13E 03	8.66E 01	.075	1.11E 03	7.26E 02	1.95E 02	2.03E 03	.106
1192	1.36E 03	9.71E 01	.071	1.21E 03	8.77E 02	2.52E 02	2.34E 03	.121

FLIGHT NO.C-289 FILTER NO. 3 SUN ZENITH ANGLE 36.4

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
257	9.63E 02	3.43E 01	.036	6.34E 02	7.90E 02	8.00E 01	1.50E 03	.056
1197	9.10E 02	4.50E 01	.050	6.73E 02	6.34E 02	1.19E 02	1.43E 03	.091

FLIGHT NO.C-289 FILTER NO. 5 SUN ZENITH ANGLE 42.7

IRRADIANCE (W/SQ M UM)

ALTITUDE (METERS)	DOWN-WELLING	UP-WELLING	ALBEDO	SCALAR SUN	SCALAR SKY	SCALAR UPWELLING	SCALAR TOTAL	SCALAR ALBEDO
281	6.57E 02	3.44E 02	.524	6.24E 02	4.68E 02	7.02E 02	1.79E 03	.643
1211	7.64E 02	3.53E 02	.462	6.57E 02	6.30E 02	6.84E 02	1.97E 03	.531

FLIGHT NO. C-289 SPECTRAL FILTER NO. 2
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5401 DATE 05/03/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-289 FILTER NO. = 2 SUN ZENITH ANGLE 33.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		1.44E 03
150	5.12E 01	
300	5.22E 01	
600	6.09E 01	
900	6.96E 01	
1200	7.75E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1122	.0614	.0201
150	17.2438	8.7736	7.9877	7.9515			
300	16.5313	8.6525	8.0365	8.0499			
600	11.1397	7.7357	8.4059	8.7945			
900	7.0930	7.0475	8.6831	9.3534			
1200	4.1704	6.5505	8.8834	9.7571			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0751	.0532	.0201
150	17.2438	11.5283	9.3647	6.9417			
300	16.5313	11.2028	9.3558	6.9598			
600	11.1397	8.7391	9.2884	7.0969			
900	7.0930	6.8899	9.2379	7.1998			
1200	4.1704	5.5544	9.2014	7.2740			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1118	.0641	.0201
150	17.2438	5.4078	6.6437	6.4910			
300	16.5313	5.4309	6.5981	6.3721			
600	11.1397	5.6060	6.2531	5.5474			
900	7.0930	5.7373	5.9941	4.9205			
1200	4.1704	5.8322	5.8071	4.4414			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1132	.0665	.0201
150	17.2438	8.9551	8.5193	7.1138			
300	16.5313	8.9829	8.4339	7.0337			
600	11.1397	8.3367	7.7875	6.4279			
900	7.0930	7.9267	7.3023	5.9732			
1200	4.1704	7.6307	6.9520	5.6448			

FLIGHT NO. C-289 SPECTRAL FILTER NO. 4
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5401 DATE 05/03/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-289 FILTER NO. = 4 SUN ZENITH ANGLE 39.6

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		1.18E 03
150	8.86E 01	
300	8.89E 01	
600	9.17E 01	
900	9.45E 01	
1200	9.71E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.2566	.0975	.0842
150	1.3600	9.6546	11.3491	9.4196			
300	1.5513	9.5046	11.3145	9.4666			
600	2.8780	8.4646	11.0746	9.7927			
900	4.1273	7.4853	10.8488	10.0997			
1200	5.2737	5.5866	10.6415	10.3814			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1097	.0708	.0842
150	1.3600	4.4202	3.9496	4.3247			
300	1.5513	4.4168	3.9835	4.3561			
600	2.8780	4.3934	4.2189	4.5743			
900	4.1273	4.3713	4.4405	4.7798			
1200	5.2737	4.3510	4.6439	4.9683			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1174	.1016	.0842
150	1.3600	2.3090	2.8622	3.4987			
300	1.5513	2.3427	2.9326	3.5465			
600	2.8780	2.5761	3.4206	3.8784			
900	4.1273	2.7959	3.8801	4.1908			
1200	5.2737	2.9976	4.3018	4.4776			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.1158	.0600	.0842
150	1.3600	3.9862	3.8616	3.8033			
300	1.5513	3.9878	3.9121	3.8024			
600	2.8780	3.9989	4.2625	3.7961			
900	4.1273	4.0095	4.5924	3.7902			
1200	5.2737	4.0193	4.8951	3.7847			

FLIGHT NO. C-289 SPECTRAL FILTER NO. 3
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5401 DATE 05/03/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-289 FILTER NO. = 3 SUN ZENITH ANGLE 36.4

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		9.63E 02
150	3.43E 01	
300	3.47E 01	
600	3.82E 01	
900	4.16E 01	
1200	4.50E 01	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0741	.0449	.0169
150	5.3554	13.2860	7.9034	7.3589			
300	5.2257	12.9077	7.9280	7.6102			
600	4.4090	10.5262	8.0830	9.1921			
900	3.7274	8.5386	8.2124	10.5123			
1200	3.1544	6.8678	8.3211	11.6221			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0584	.0650	.0169
150	5.3554	5.6641	6.7133	6.4327			
300	5.2257	5.6576	6.4733	6.3533			
600	4.4090	5.6168	4.9626	5.8536			
900	3.7274	5.5827	3.7018	5.4364			
1200	3.1544	5.5541	2.6420	5.0858			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0872	.0535	.0169
150	5.3554	8.6329	7.0574	7.3063			
300	5.2257	8.2529	6.9775	7.1947			
600	4.4090	5.8608	6.4745	6.4923			
900	3.7274	3.8644	6.0547	5.9061			
1200	3.1544	2.1862	5.7018	5.4133			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.0612	.0265	.0169
150	5.3554	7.0474	8.6294	7.6771			
300	5.2257	6.8168	8.3438	7.5727			
600	4.4090	5.3648	6.5455	6.9156			
900	3.7274	4.1531	5.0447	6.3471			
1200	3.1544	3.1344	3.7831	5.9061			

FLIGHT NO. C-289 SPECTRAL FILTER NO. 5
DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)

AVIZC130 (JOB 5401 DATE 05/03/76)
AVIZPRNT (JOB 3606 DATE 06/18/76)

FLIGHT NO. C-289 FILTER NO. = 5 SUN ZENITH ANGLE 42.7

TARGET ALTITUDE M	IRRADIANCE (W/SQ M UM) UPWELLING	DOWNWELLING
0		6.57E 02
150	3.44E 02	
300	3.45E 02	
600	3.48E 02	
900	3.51E 02	
1200	3.53E 02	

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 0

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					,5012	.4691	.0466
150	.3915	1.3418	1,5395	1.6902			
300	.3596	1.3309	1,5240	1.6964			
600	.2642	1.2982	1,4774	1.7147			
900	.1703	1.2660	1,4316	1.7327			
1200	.0778	1.2344	1,3864	1.7505			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 90

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					,4439	.5691	.0466
150	.3915	.9747	1,1459	.9963			
300	.3596	1.0040	1,1307	.9707			
600	.2642	1.0915	1,0849	.8940			
900	.1703	1.1778	1,0399	.8185			
1200	.0778	1.2626	,9956	.7442			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 180

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					.7104	.7794	.0466
150	.3915	.3474	,4495	.6095			
300	.3596	.3538	,4488	.6297			
600	.2642	.3729	,4465	.6900			
900	.1703	.3917	,4444	.7493			
1200	.0778	.4102	,4422	.8077			

DIRECTIONAL REFLECTANCE (SKY OR TERRAIN)
AZIMUTH OF PATH OF SIGHT = 270

TARGET ALTITUDE M	ZENITH ANGLE OF PATH OF SIGHT (DEG) 0	75	80	85	95	100	180
0					,3703	.3912	.0466
150	.3915	.4364	,5795	.8579			
300	.3596	.4329	,5749	.8539			
600	.2642	.4222	,5610	.8419			
900	.1703	.4118	,5473	.8300			
1200	.0778	.4014	,5338	.8184			

FLIGHT NO. C-289
EQUIVALENT ATTENUATION LENGTH

(JOB 5401 DATE 05/03/76)
DATE 61473 FLIGHT NO. C-289 GROUND LEVEL ALTITUDE (M)= 20

ALTITUDE (M)	EQUIVALENT ATTENUATION LENGTH (KM) FILTERS 2	4	3	5
0	4.17E 00	5.24E 00	6.71E 00	6.49E 00
30	5.98E 00	7.79E 00	1.01E 01	1.12E 01
60	7.65E 00	1.03E 01	1.36E 01	1.75E 01
90	8.43E 00	1.16E 01	1.54E 01	2.16E 01
120	8.90E 00	1.23E 01	1.65E 01	2.45E 01
150	9.21E 00	1.28E 01	1.72E 01	2.66E 01
180	9.43E 00	1.32E 01	1.78E 01	2.82E 01
210	9.59E 00	1.35E 01	1.82E 01	2.90E 01
240	9.73E 00	1.37E 01	1.85E 01	2.91E 01
270	9.83E 00	1.39E 01	1.87E 01	2.96E 01
300	9.92E 00	1.37E 01	1.90E 01	3.03E 01
330	9.98E 00	1.36E 01	1.92E 01	3.04E 01
360	1.00E 01	1.36E 01	1.93E 01	3.01E 01
390	1.00E 01	1.36E 01	1.95E 01	3.01E 01
420	1.00E 01	1.36E 01	1.96E 01	2.99E 01
450	1.00E 01	1.36E 01	1.98E 01	2.97E 01
480	1.00E 01	1.36E 01	1.97E 01	2.94E 01
510	1.00E 01	1.36E 01	1.94E 01	2.91E 01
540	1.00E 01	1.36E 01	1.92E 01	2.89E 01
570	1.01E 01	1.36E 01	1.90E 01	2.87E 01
600	1.01E 01	1.35E 01	1.88E 01	2.86E 01
630	1.01E 01	1.35E 01	1.86E 01	2.86E 01
660	1.02E 01	1.35E 01	1.85E 01	2.86E 01
690	1.03E 01	1.34E 01	1.86E 01	2.85E 01
720	1.04E 01	1.33E 01	1.88E 01	2.81E 01
750	1.05E 01	1.33E 01	1.86E 01	2.79E 01
780	1.05E 01	1.34E 01	1.84E 01	2.76E 01
810	1.05E 01	1.35E 01	1.83E 01	2.73E 01
840	1.04E 01	1.37E 01	1.82E 01	2.70E 01
870	1.04E 01	1.38E 01	1.83E 01	2.68E 01
900	1.05E 01	1.39E 01	1.85E 01	2.66E 01
930	1.05E 01	1.40E 01	1.85E 01	2.65E 01
960	1.04E 01	1.40E 01	1.86E 01	2.63E 01
990	1.03E 01	1.40E 01	1.87E 01	2.63E 01
1020	1.03E 01	1.40E 01	1.88E 01	2.62E 01
1050	1.03E 01	1.39E 01	1.89E 01	2.61E 01
1080	1.04E 01	1.40E 01	1.90E 01	2.60E 01
1110	1.04E 01	1.40E 01	1.91E 01	2.59E 01
1140	1.04E 01	1.41E 01	1.91E 01	2.58E 01
1170	1.04E 01	1.41E 01	1.90E 01	2.60E 01
1200	1.04E 01	1.40E 01	1.90E 01	2.61E 01

FLIGHT NO. C-289

BEAM TRANSMITTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. 2
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.84E-01	9.39E-01	9.10E-01	8.30E-01	8.29E-01	9.10E-01	9.84E-01
300	9.70E-01	8.90E-01	8.40E-01	7.07E-01	7.06E-01	8.40E-01	9.70E-01
600	9.42E-01	7.95E-01	7.10E-01	5.07E-01	5.04E-01	7.10E-01	9.42E-01
900	9.18E-01	7.18E-01	6.10E-01	3.77E-01	3.71E-01	6.10E-01	9.18E-01
1200	8.91E-01	6.39E-01	5.14E-01	2.69E-01	2.61E-01	5.14E-01	8.91E-01

FLIGHT NO. C-289 FILTER NO. 4
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.88E-01	9.56E-01	9.35E-01	8.75E-01	8.74E-01	9.35E-01	9.88E-01
300	9.78E-01	9.19E-01	8.82E-01	7.78E-01	7.77E-01	8.82E-01	9.78E-01
600	9.57E-01	8.43E-01	7.75E-01	6.03E-01	6.00E-01	7.75E-01	9.57E-01
900	9.37E-01	7.79E-01	6.89E-01	4.79E-01	4.73E-01	6.89E-01	9.37E-01
1200	9.18E-01	7.19E-01	6.11E-01	3.79E-01	3.71E-01	6.11E-01	9.18E-01

FLIGHT NO. C-289 FILTER NO. 3
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.91E-01	9.67E-01	9.51E-01	9.05E-01	9.05E-01	9.51E-01	9.91E-01
300	9.84E-01	9.41E-01	9.13E-01	8.34E-01	8.34E-01	9.13E-01	9.84E-01
600	9.69E-01	8.84E-01	8.32E-01	6.95E-01	6.92E-01	8.32E-01	9.69E-01
900	9.52E-01	8.28E-01	7.55E-01	5.74E-01	5.69E-01	7.55E-01	9.52E-01
1200	9.39E-01	7.64E-01	6.96E-01	4.89E-01	4.81E-01	6.96E-01	9.39E-01

FLIGHT NO. C-289 FILTER NO. 5
BEAM TRANSMITTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.94E-01	9.78E-01	9.68E-01	9.37E-01	9.37E-01	9.68E-01	9.94E-01
300	9.90E-01	9.62E-01	9.45E-01	8.93E-01	8.92E-01	9.45E-01	9.90E-01
600	9.79E-01	9.22E-01	8.86E-01	7.87E-01	7.85E-01	8.86E-01	9.79E-01
900	9.67E-01	8.77E-01	8.23E-01	6.80E-01	6.76E-01	8.23E-01	9.67E-01
1200	9.55E-01	8.37E-01	7.68E-01	5.94E-01	5.87E-01	7.68E-01	9.55E-01

FLIGHT NO. C-289 SPECTRAL FILTER NO. 2
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 2 SUN ZENITH ANGLE 33.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.46E 00	1.78E 01	2.31E 01	3.85E 01	3.09E 01	1.44E 01	1.99E 00
300	1.01E 01	3.22E 01	4.13E 01	6.61E 01	5.30E 01	2.56E 01	3.67E 00
600	1.98E 01	6.06E 01	7.56E 01	1.12E 02	9.02E 01	4.69E 01	7.07E 00
900	2.87E 01	8.45E 01	1.03E 02	1.44E 02	1.16E 02	6.40E 01	9.98E 00
1200	3.90E 01	1.10E 02	1.30E 02	1.70E 02	1.39E 02	8.13E 01	1.31E 01

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.46E 00	9.22E 00	1.29E 01	2.34E 01	2.19E 01	1.11E 01	1.99E 00
300	1.01E 01	1.67E 01	2.29E 01	4.01E 01	3.75E 01	1.98E 01	3.67E 00
600	1.98E 01	3.12E 01	4.18E 01	6.79E 01	6.34E 01	3.59E 01	7.07E 00
900	2.87E 01	4.33E 01	5.67E 01	8.64E 01	8.06E 01	4.82E 01	9.98E 00
1200	3.90E 01	5.59E 01	7.14E 01	1.02E 02	9.54E 01	6.02E 01	1.31E 01

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.46E 00	7.83E 00	1.15E 01	2.18E 01	2.26E 01	1.19E 01	1.99E 00
300	1.01E 01	1.41E 01	2.05E 01	3.74E 01	3.89E 01	2.13E 01	3.67E 00
600	1.98E 01	2.66E 01	3.74E 01	6.34E 01	6.57E 01	3.86E 01	7.07E 00
900	2.87E 01	3.69E 01	5.08E 01	8.08E 01	8.33E 01	5.19E 01	9.98E 00
1200	3.90E 01	4.78E 01	6.41E 01	9.55E 01	9.78E 01	6.48E 01	1.31E 01

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	5.46E 00	8.87E 00	1.24E 01	2.27E 01	2.14E 01	1.07E 01	1.99E 00
300	1.01E 01	1.60E 01	2.21E 01	3.89E 01	3.68E 01	1.91E 01	3.67E 00
600	1.98E 01	3.02E 01	4.06E 01	6.62E 01	6.25E 01	3.50E 01	7.07E 00
900	2.87E 01	4.21E 01	5.53E 01	8.47E 01	8.04E 01	4.77E 01	9.98E 00
1200	3.90E 01	5.47E 01	7.02E 01	1.01E 02	9.63E 01	6.06E 01	1.31E 01

FLIGHT NO. C-289 SPECTRAL FILTER NO. 4
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 4 SUN ZENITH ANGLE 39.6

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.89E 00	1.60E 01	1.99E 01	3.34E 01	2.55E 01	1.12E 01	1.12E 00
300	5.39E 00	2.93E 01	3.63E 01	5.90E 01	4.50E 01	2.04E 01	2.09E 00
600	1.10E 01	5.72E 01	6.95E 01	1.06E 02	8.13E 01	3.93E 01	4.22E 00
900	1.64E 01	8.10E 01	9.66E 01	1.41E 02	1.08E 02	5.50E 01	6.18E 00
1200	2.22E 01	1.04E 02	1.22E 02	1.69E 02	1.31E 02	7.01E 01	8.21E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.89E 00	5.40E 00	7.69E 00	1.43E 01	1.36E 01	6.69E 00	1.12E 00
300	5.39E 00	9.94E 00	1.40E 01	2.53E 01	2.40E 01	1.22E 01	2.09E 00
600	1.10E 01	1.95E 01	2.70E 01	4.59E 01	4.36E 01	2.35E 01	4.22E 00
900	1.64E 01	2.79E 01	3.77E 01	6.10E 01	5.83E 01	3.30E 01	6.18E 00
1200	2.22E 01	3.61E 01	4.80E 01	7.37E 01	7.11E 01	4.22E 01	8.21E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.89E 00	4.38E 00	6.58E 00	1.30E 01	1.39E 01	7.25E 00	1.12E 00
300	5.39E 00	8.06E 00	1.20E 01	2.30E 01	2.46E 01	1.32E 01	2.09E 00
600	1.10E 01	1.60E 01	2.32E 01	4.18E 01	4.48E 01	2.55E 01	4.22E 00
900	1.64E 01	2.30E 01	3.28E 01	5.59E 01	6.01E 01	3.60E 01	6.18E 00
1200	2.22E 01	3.00E 01	4.20E 01	6.80E 01	7.38E 01	4.62E 01	8.21E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	2.89E 00	5.33E 00	7.55E 00	1.40E 01	1.32E 01	6.45E 00	1.12E 00
300	5.39E 00	9.81E 00	1.38E 01	2.48E 01	2.33E 01	1.18E 01	2.09E 00
600	1.10E 01	1.95E 01	2.68E 01	4.53E 01	4.27E 01	2.29E 01	4.22E 00
900	1.64E 01	2.81E 01	3.79E 01	6.08E 01	5.79E 01	3.25E 01	6.18E 00
1200	2.22E 01	3.69E 01	4.88E 01	7.42E 01	7.17E 01	4.22E 01	8.21E 00

FLIGHT NO. C-289 SPECTRAL FILTER NO. 3
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 3 SUN ZENITH ANGLE 36.4

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.96E 00	7.97E 00	1.01E 01	1.69E 01	1.28E 01	5.60E 00	6.22E-01
300	3.55E 00	1.43E 01	1.80E 01	2.94E 01	2.22E 01	9.95E 00	1.13E 00
600	7.05E 00	2.74E 01	3.41E 01	5.32E 01	4.01E 01	1.89E 01	2.32E 00
900	1.06E 01	3.95E 01	4.85E 01	7.23E 01	5.43E 01	2.70E 01	3.65E 00
1200	1.34E 01	4.84E 01	5.88E 01	8.48E 01	6.33E 01	3.28E 01	4.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.96E 00	2.80E 00	3.87E 00	7.29E 00	6.88E 00	3.43E 00	6.22E-01
300	3.55E 00	5.01E 00	6.89E 00	1.27E 01	1.20E 01	6.10E 00	1.13E 00
600	7.05E 00	9.76E 00	1.33E 01	2.35E 01	2.22E 01	1.18E 01	2.32E 00
900	1.06E 01	1.44E 01	1.94E 01	3.27E 01	3.11E 01	1.72E 01	3.65E 00
1200	1.34E 01	1.80E 01	2.41E 01	3.93E 01	3.75E 01	2.13E 01	4.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.96E 00	2.40E 00	3.59E 00	7.08E 00	7.56E 00	3.93E 00	6.22E-01
300	3.55E 00	4.30E 00	6.40E 00	1.23E 01	1.32E 01	7.00E 00	1.13E 00
600	7.05E 00	8.49E 00	1.24E 01	2.29E 01	2.44E 01	1.37E 01	2.32E 00
900	1.06E 01	1.27E 01	1.82E 01	3.21E 01	3.43E 01	2.02E 01	3.65E 00
1200	1.34E 01	1.61E 01	2.29E 01	3.88E 01	4.16E 01	2.55E 01	4.85E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.96E 00	3.15E 00	4.40E 00	8.11E 00	7.47E 00	3.55E 00	6.22E-01
300	3.55E 00	5.64E 00	7.82E 00	1.41E 01	1.30E 01	6.31E 00	1.13E 00
600	7.05E 00	1.09E 01	1.49E 01	2.58E 01	2.38E 01	1.22E 01	2.32E 00
900	1.06E 01	1.58E 01	2.13E 01	3.56E 01	3.29E 01	1.78E 01	3.65E 00
1200	1.34E 01	1.94E 01	2.61E 01	4.22E 01	3.91E 01	2.21E 01	4.85E 00

FLIGHT NO. C-289 SPECTRAL FILTER NO. 5
PATH RADIANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 5 SUN ZENITH ANGLE 42.7

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.30E-01	5.78E 00	7.70E 00	1.36E 01	1.13E 01	5.24E 00	6.94E-01
300	1.63E 00	1.01E 01	1.34E 01	2.33E 01	1.93E 01	9.09E 00	1.22E 00
600	3.47E 00	2.09E 01	2.74E 01	4.62E 01	3.86E 01	1.87E 01	2.60E 00
900	5.64E 00	3.28E 01	4.27E 01	6.94E 01	5.83E 01	2.94E 01	4.24E 00
1200	7.69F 00	4.35E 01	5.59E 01	8.81E 01	7.44E 01	3.88E 01	5.80E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.30E-01	2.46E 00	3.67E 00	7.23E 00	7.46E 00	3.75E 00	6.94E-01
300	1.63E 00	4.30E 00	6.38E 00	1.24E 01	1.28E 01	6.50E 00	1.22E 00
600	3.47E 00	9.10E 00	1.33E 01	2.50E 01	2.56E 01	1.35E 01	2.60E 00
900	5.64E 00	1.47E 01	2.12E 01	3.82E 01	3.90E 01	2.12E 01	4.24E 00
1200	7.69E 00	1.99E 01	2.83F 01	4.91E 01	5.02E 01	2.81E 01	5.80E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.30E-01	2.17E 00	3.40E 00	7.04E 00	8.06E 00	4.29E 00	6.94E-01
300	1.63E 00	3.79E 00	5.91E 00	1.21E 01	1.38E 01	7.44E 00	1.22E 00
600	3.47F 00	8.06E 00	1.24E 01	2.43E 01	2.75E 01	1.53E 01	2.60E 00
900	5.64F 00	1.31E 01	1.97E 01	3.71E 01	4.17E 01	2.38E 01	4.24E 00
1200	7.69E 00	1.78E 01	2.64E 01	4.78E 01	5.33E 01	3.12E 01	5.80E 00

PATH RADIANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN (W/SR SQ M UM)
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	9.30E-01	2.20E 00	3.29E 00	6.54E 00	6.88E 00	3.49E 00	6.94E-01
300	1.63E 00	3.83E 00	5.72E 00	1.12E 01	1.18E 01	6.06E 00	1.22E 00
600	3.47E 00	8.10E 00	1.19E 01	2.26E 01	2.38E 01	1.26E 01	2.60E 00
900	5.64E 00	1.31E 01	1.90E 01	3.46E 01	3.64E 01	2.00E 01	4.24E 00
1200	7.69E 00	1.76E 01	2.54E 01	4.47E 01	4.78E 01	2.67E 01	5.80E 00

FLIGHT NO. C-289 SPECTRAL FILTER NO. 2
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 2 SUN ZENITH ANGLE 33.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.40E-01	1.16E 00	1.56E 00	2.85E 00	8.12E-02	3.43E-02	4.40E-03
300	6.24E-01	2.18E 00	2.95E 00	5.62E 00	1.63E-01	6.63E-02	8.23E-03
600	1.08E 00	3.93E 00	5.49E 00	1.14E 01	3.90E-01	1.44E-01	1.63E-02
900	1.41E 00	5.31E 00	7.61E 00	1.72E 01	6.80E-01	2.28E-01	2.37E-02
1200	1.77E 00	6.96E 00	1.03E 01	2.57E 01	1.15E 00	3.45E-01	3.21E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.40E-01	6.02E-01	8.69E-01	1.73E 00	5.74E-02	2.65E-02	4.40E-03
300	6.24E-01	1.13E 00	1.64E 00	3.41E 00	1.16E-01	5.12E-02	8.23E-03
600	1.08E 00	2.03E 00	3.04E 00	6.91E 00	2.74E-01	1.10E-01	1.63E-02
900	1.41E 00	2.72E 00	4.19E 00	1.04E 01	4.73E-01	1.72E-01	2.37E-02
1200	1.77E 00	3.54E 00	5.63E 00	1.54E 01	7.95E-01	2.55E-01	3.21E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.40E-01	5.11E-01	7.72E-01	1.61E 00	5.93E-02	2.85E-02	4.40E-03
300	6.24E-01	9.57E-01	1.47E 00	3.18E 00	1.20E-01	5.51E-02	8.23E-03
600	1.08E 00	1.73E 00	2.72E 00	6.45E 00	2.84E-01	1.18E-01	1.53E-02
900	1.41E 00	2.32E 00	3.76E 00	9.69E 00	4.89E-01	1.85E-01	2.37E-02
1200	1.77E 00	3.03E 00	5.06E 00	1.44E 01	8.15E-01	2.74E-01	3.21E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	3.40E-01	5.79E-01	8.35E-01	1.67E 00	5.63E-02	2.56E-02	4.40E-03
300	6.24E-01	1.08E 00	1.58E 00	3.31E 00	1.13E-01	4.94E-02	8.23E-03
600	1.08E 00	1.96E 00	2.95E 00	6.73E 00	2.70E-01	1.07E-01	1.63E-02
900	1.41E 00	2.65E 00	4.10E 00	1.02E 01	4.72E-01	1.70E-01	2.37E-02
1200	1.77E 00	3.47E 00	5.54E 00	1.52E 01	8.02E-01	2.57E-01	3.21E-02

FLIGHT NO. C-289 SPECTRAL FILTER NO. 4
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 4 SUN ZENITH ANGLE 39.6

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	5.92E-01	7.56E-01	1.35E 00	7.77E-02	3.20E-02	3.02E-03
300	1.95E-01	1.13E 00	1.45E 00	2.68E 00	1.55E-01	6.18E-02	5.69E-03
600	3.95E-01	2.33E 00	3.07E 00	6.05E 00	3.62E-01	1.35E-01	1.18E-02
900	5.82E-01	3.46E 00	4.66E 00	9.78E 00	6.10E-01	2.13E-01	1.76E-02
1200	7.81E-01	4.67E 00	6.45E 00	1.45E 01	9.44E-01	3.06E-01	2.39E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	2.01E-01	2.92E-01	5.81E-01	4.15E-02	1.91E-02	3.02E-03
300	1.95E-01	3.82E-01	5.61E-01	1.15E 00	8.26E-02	3.69E-02	5.69E-03
600	3.95E-01	7.94E-01	1.19E 00	2.61E 00	1.94E-01	8.09E-02	1.18E-02
900	5.82E-01	1.19E 00	1.82E 00	4.24E 00	3.29E-01	1.28E-01	1.76E-02
1200	7.81E-01	1.62E 00	2.54E 00	6.29E 00	5.12E-01	1.84E-01	2.39E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	1.63E-01	2.50E-01	5.26E-01	4.25E-02	2.07E-02	3.02E-03
300	1.95E-01	3.10E-01	4.81E-01	1.04E 00	8.44E-02	4.00E-02	5.69E-03
600	3.95E-01	6.49E-01	1.03E 00	2.38E 00	1.99E-01	8.80E-02	1.18E-02
900	5.82E-01	9.80E-01	1.58E 00	3.88E 00	3.39E-01	1.39E-01	1.76E-02
1200	7.81E-01	1.35E 00	2.72E 00	5.81E 00	5.31E-01	2.02E-01	2.39E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.04E-01	1.98E-01	2.87E-01	5.68E-01	4.02E-02	1.84E-02	3.02E-03
300	1.95E-01	3.77E-01	5.51E-01	1.12E 00	8.00E-02	3.56E-02	5.69E-03
600	3.95E-01	7.92E-01	1.18E 00	2.57E 00	1.90E-01	7.88E-02	1.18E-02
900	5.82E-01	1.20E 00	1.83E 00	4.22E 00	3.26E-01	1.26E-01	1.76E-02
1200	7.81E-01	1.66E 00	2.58E 00	6.33E 00	5.16E-01	1.84E-01	2.39E-02

FLIGHT NO. C-289 SPECTRAL FILTER NO. 3
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 3 SUN ZENITH ANGLE 36.4

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.62E-01	7.56E-01	9.78E-01	1.71E 00	4.61E-02	1.92E-02	2.05E-03
300	3.26E-01	1.37E 00	1.79E 00	3.19E 00	8.70E-02	3.56E-02	3.73E-03
600	5.99E-01	2.55E 00	3.37E 00	6.30E 00	1.89E-01	7.41E-02	7.32E-03
900	8.57E-01	3.59E 00	4.85E 00	9.51E 00	3.12E-01	1.16E-01	1.25E-02
1200	9.96E-01	4.31E 00	5.90E 00	1.21E 01	4.29E-01	1.54E-01	1.68E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.62E-01	2.65E-01	3.73E-01	7.39E-01	2.48E-02	1.18E-02	2.05E-03
300	3.26E-01	4.82E-01	6.83E-01	1.38E 00	4.70E-02	2.18E-02	3.73E-03
600	5.99E-01	9.69E-01	1.31E 00	2.78E 00	1.05E-01	4.61E-02	7.32E-03
900	8.57E-01	1.31E 00	1.94E 00	4.30E 00	1.78E-01	7.41E-02	1.25E-02
1200	9.96E-01	1.60E 00	2.42E 00	5.60E 00	2.54E-01	1.00E-01	1.68E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.62E-01	2.28E-01	3.46E-01	7.18E-01	2.72E-02	1.35E-02	2.05E-03
300	3.26E-01	4.14E-01	6.33E-01	1.34E 00	5.15E-02	2.50E-02	3.73E-03
600	5.99E-01	7.90E-01	1.23E 00	2.71E 00	1.15E-01	5.35E-02	7.82E-03
900	8.57E-01	1.16E 00	1.82E 00	4.22E 00	1.97E-01	8.72E-02	1.25E-02
1200	9.96E-01	1.43E 00	2.29E 00	5.53E 00	2.82E-01	1.19E-01	1.68E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN
AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	1.62E-01	2.99E-01	4.24E-01	8.21E-01	2.69E-02	1.22E-02	2.05E-03
300	3.26E-01	5.42E-01	7.75E-01	1.53E 00	5.08E-02	2.26E-02	3.73E-03
600	5.99E-01	1.01E 00	1.47E 00	3.06E 00	1.12E-01	4.77E-02	7.82E-03
900	8.57E-01	1.44E 00	2.13E 00	4.68E 00	1.89E-01	7.67E-02	1.25E-02
1200	9.96E-01	1.73E 00	-2.62E 00	6.03E 00	2.69E-01	1.04E-01	1.68E-02

FLIGHT NO. C-289 SPECTRAL FILTER NO. 5
DIRECTIONAL PATH REFLECTANCE BETWEEN GROUND AND ALTITUDE

(JOB 5401 DATE 05/03/76)

FLIGHT NO. C-289 FILTER NO. = 5 SUN ZENITH ANGLE 42.7

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 0

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.54E-03	5.39E-02	7.26E-02	1.32E-01	5.77E-02	2.59E-02	3.34E-03
300	1.50E-02	9.52E-02	1.29E-01	2.37E-01	1.04E-01	4.60E-02	5.88E-03
600	3.20E-02	2.04E-01	2.79E-01	5.30E-01	2.39E-01	1.01E-01	1.27E-02
900	5.23E-02	3.35E-01	4.69E-01	9.14E-01	4.12E-01	1.71E-01	2.10E-02
1200	7.16E-02	4.62E-01	6.40E-01	1.32E 00	6.06E-01	2.42E-01	2.91E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 90

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.54E-03	2.30E-02	3.46E-02	7.04E-02	3.01E-02	1.85E-02	3.34E-03
300	1.50E-02	4.07E-02	6.15E-02	1.26E-01	6.85E-02	3.29E-02	5.88E-03
600	3.20E-02	8.91E-02	1.36E-01	2.87E-01	1.56E-01	7.27E-02	1.27E-02
900	5.23E-02	1.50E-01	2.31E-01	5.03E-01	2.76E-01	1.23E-01	2.10E-02
1200	7.16E-02	2.11E-01	3.27E-01	7.36E-01	4.09E-01	1.75E-01	2.91E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 180

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.54E-03	2.03E-02	3.21E-02	6.86E-02	4.11E-02	2.12E-02	3.34E-03
300	1.50E-02	3.59E-02	5.70E-02	1.23E-01	7.39E-02	3.77E-02	5.88E-03
600	3.20E-02	7.89E-02	1.26E-01	2.79E-01	1.68E-01	8.24E-02	1.27E-02
900	5.23E-02	1.34E-01	2.15E-01	4.89E-01	2.95E-01	1.38E-01	2.10E-02
1200	7.16E-02	1.89E-01	3.05E-01	7.16E-01	4.34E-01	1.94E-01	2.91E-02

DIRECTIONAL PATH REFLECTANCE BETWEEN ALTITUDE= 0 AND ALTITUDE SHOWN

AZIMUTH OF PATH OF SIGHT = 270

ALTITUDE	ZENITH ANGLE OF PATH OF SIGHT (DEG)						
M	0	75	80	85	95	100	180
150	8.54E-03	2.05E-02	3.10E-02	6.36E-02	3.51E-02	1.72E-02	3.34E-03
300	1.50E-02	3.63E-02	5.51E-02	1.14E-01	6.32E-02	3.07E-02	5.88E-03
600	3.20E-02	7.93E-02	1.22E-01	2.60E-01	1.45E-01	6.81E-02	1.27E-02
900	5.23E-02	1.33E-01	2.07E-01	4.56E-01	2.57E-01	1.16E-01	2.10E-02
1200	7.16E-02	1.87E-01	2.94E-01	6.69E-01	3.83E-01	1.66E-01	2.91E-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 Meppen, Germany which is near the western end of the flight track.

CLOUD CONDITIONS

The airborne pictures which documented the cloud conditions during each flight were examined, and their general features are summarized in Table 8-1. The descriptions are divided into two categories. Since all lower sky pictures were free of clouds, the lower hemisphere characteristics are not included in that table.

Table 8-1

Airborne Hemispherical Picture and Scanner Summary

Category	Upper Sky Description	Upper Scanner Sun Radiance During Sky Mode	Flights
1	Scattered to broken clouds	Sun generally unobscured	C-273 C-282 C-289
2	Overcast to slightly broken	Sun generally obscured	C-279 C-280 C-281 C-288

Since the pictures during the category 1 flights were taken slightly after the sky radiance measurements (during the sun mode), the sky radiance data were examined to see if the sun was unobscured or obscured. The sky radiance generally indicated offscale in the sun radiance direction even though the pictures and the sun mode data often indicated clouds obscuring the sun during the later time interval. Therefore all category 1 data were handled as sunlit, with the sun unobscured.

The pictures and sky radiance data for the category 2 flights were more consistent since they were obtained in the same time interval.

TEMPERATURE

The temperature measurements were made using the AN/AMQ-17 aerograph set. The graphs of temperature in Fig. 6-2 indicate excellent agreement between the airborne temperatures and the radiosonde temperatures at Meppen in view of the time and spatial differences between the two measurements.

There were seven project flights, listed in Table 8-1, accomplished during May and June 1973 at 53.03°N. latitude. Temperature data measured during these flights can be profitably compared to equivalent data from U.S. Standard Atmosphere Supplements. To facilitate this comparison, the average temperature profile measured during each of the seven flights has been superimposed on a graph of the temperatures anticipated for late spring in Fig. 8-1. The anticipated temperature profiles are for 45° and 60°N. latitude in July, and 45°N. latitude in spring/fall as specified in the U.S. Standard Atmosphere Supplements (1966). The altitude scale in Fig. 8-1 is kilometers above mean sea level (MSL), and the ground elevation at the test site was 20 meters.

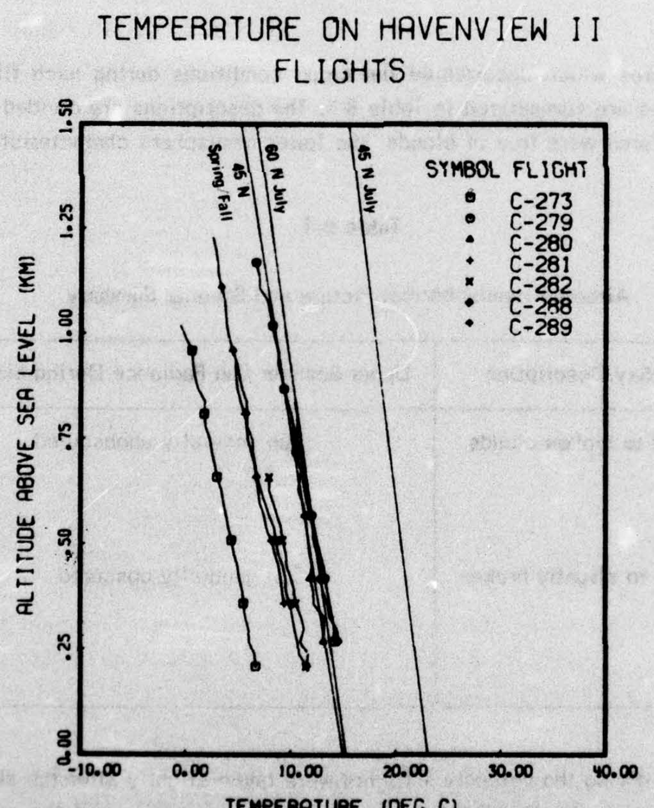


Fig. 8-1. Temperature for HAVEN VIEW II Flights Compared to 45°N. July, 60°N. July, and 45°N. Spring/Fall Temperatures from the U. S. Standard Atmosphere Supplements.

The temperatures for all the flights lie well below the curve for 45°N. July. The temperatures for three of the flights C-279, C-280, and C-288 are similar to the temperatures for 45°N. spring/fall and 60°N. July. The temperatures for the remaining four flights lie below all three curves. This is not unreasonable for late spring at a latitude intermediate to the 45°N. and 60°N. latitudes.

8.2 AIRBORNE RADIOMETRIC DATA

TOTAL VOLUME SCATTERING COEFFICIENT

General Evaluation. The data reported for total volume scattering coefficient were measured during the vertical profile flight elements. For five of the seven flights these were between the low and high altitude straight and level elements for each filter and there was an average elapsed time between the start of the first element and the end of the final element of 14 minutes. On the remaining two flights, C-273 and C-281, the data for two filters were measured during each straight and level element with the vertical profile element being between these elements for one filter and following the straight and level elements for the second filter. The average elapsed time between the start of the first measurement and end of final measurement for each filter for these two flights was 27 minutes.

On all flights it was possible to take the airborne data down to 390 meters and occasionally as low as 180 meters. To extend the profile data to ground level, the ground-based nephelometer data are normally used for interpolation. During HAVEN VIEW II, these ground-based values were always significantly greater than the low altitude values. On the other hand, total volume scattering coefficient data taken during approach to landing at the end of the flight indicated no abrupt change due to low altitude haze down to very low altitudes. Since there was no other reason to question either the airborne or the ground-based nephelometer values, it was decided that the airborne data should be extrapolated down to 30 meters AGL based on the change in density, and then the ground-based data used for 0 meters AGL. The presence of a very low altitude haze or dust layer at the ground-based instrument site might be due to the surrounding vegetation which was dissimilar from that near the landing site. This sudden shift in the values between 30 and 0 meters is readily apparent on the graphs of total volume scattering coefficient as a function of altitude.

The altitude chosen for the highest straight and level element was about 150 meters below the clouds. Observer altitudes were chosen at even 150-meter increments. Therefore the highest observer altitude for each flight was selected as no more than 150 meters above the highest altitude for the straight and level elements. The only exception was flight C-273 where one of the vertical profiles was taken more than 150 meters above all the straight and level elements. Since that total scattering coefficient profile indicates no abrupt change in value at the higher altitudes, it was assumed that the cloud was at least more than 30 meters above the highest altitude of measurement.

The extrapolation upward to the selected observer altitude is based upon the density ratios of the U.S. Standard Atmosphere (45°N. Spring/Fall). The extrapolation appears on the graphs of total scattering coefficient as a slightly slanting straight line except where there is no upward extrapolation as is the case for flight C-280, filter 4A, and flights C-282 and C-289, all filters. The extrapolations seem to follow the general trend of the data for each profile except for flights C-279 and C-280. The high altitude data for flight C-279 indicate a clearer layer just below the clouds, above a haze layer extending from low altitude to 1+ kilometers. For flight C-280, the highest altitude data for filter 4A indicate increasing haze which is not reflected in the upward extrapolation for filter 4B.

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) > s(5). Although the data were not simultaneous, the data for flights C-273 and C-281 follow this order. The data for filters 2 and 4 for flight C-288 are nearly equivalent at low altitude and in reverse order for higher altitude but there was a 45-minute time between the two data sets. For flight C-289 the order by filter is generally present but there is much overlap which is probably consistent with a less homogeneous aerosol layer and the time between data sets.

To more easily compare the scattering characteristics of the flights, the filter 4 (pseudo-photopic) total volume scattering coefficient profiles for each flight have been graphed in Fig. 8-2. Filter 4 data

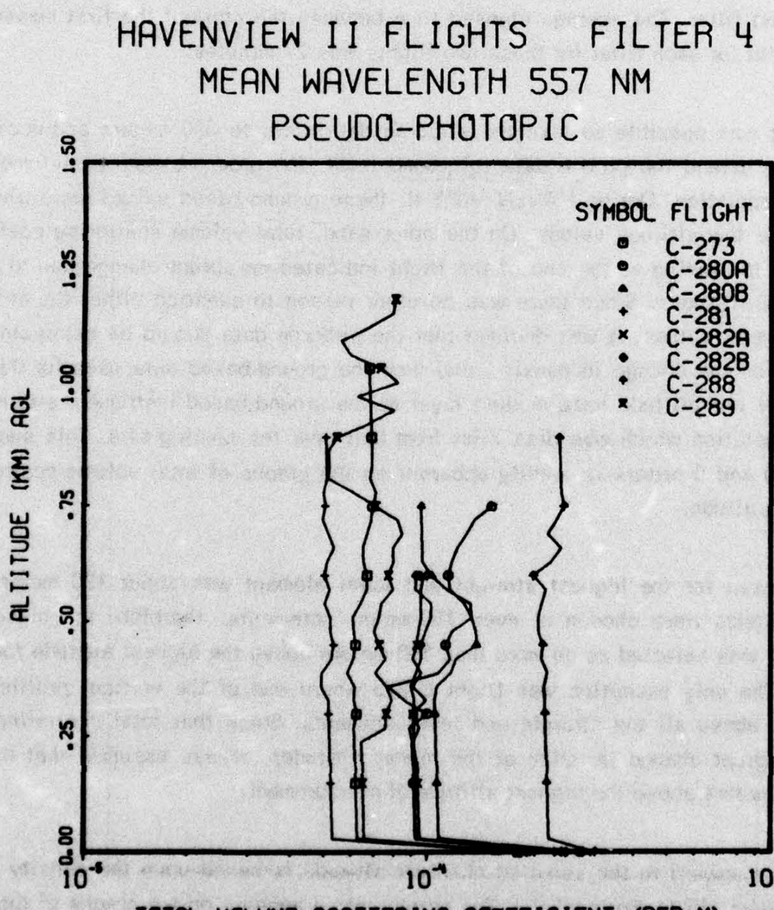


Fig. 8-2. Total Volume Scattering Coefficient for Filter 4 (Pseudo-Photopic) for Six HAVEN VIEW II Flights.

are available for only 6 of the flights. All six flights show the increased haze at ground level. Four of the flights show little structure as though all the data were taken in a fairly uniform haze layer. The remaining two flights, C-280 and C-289, show more variability indicating a less homogeneous aerosol beneath the cloud layer.

Since the seventh flight, C-279, had valid data for only filters 2 and 3, a similar composite graph for filter 2 is presented in Fig. 8-3. Filter 2 data are available for four flights. This graph indicates that the scattering for flight C-279 was similar to the values for flight C-288, with very little structure below 1 kilometer.

Similar composite graphs of total volume scattering coefficient data for the pseudo-photopic filter were given in Section 7.3 of Duntley, *et al.* (1972c). The graph for the previous field trip to southern Germany is reproduced here as Fig. 8-4. Note that the filter numbering changed between the two field trips but that the filters are identical in spectral sensitivity. Note also the change in altitude scale since the HAVEN VIEW I flights were over a larger altitude interval. The HAVEN VIEW I flights were near Memmingen from 25 May to 6 June 1970. They were 5 degrees further south but during the same general time period as HAVEN VIEW II.

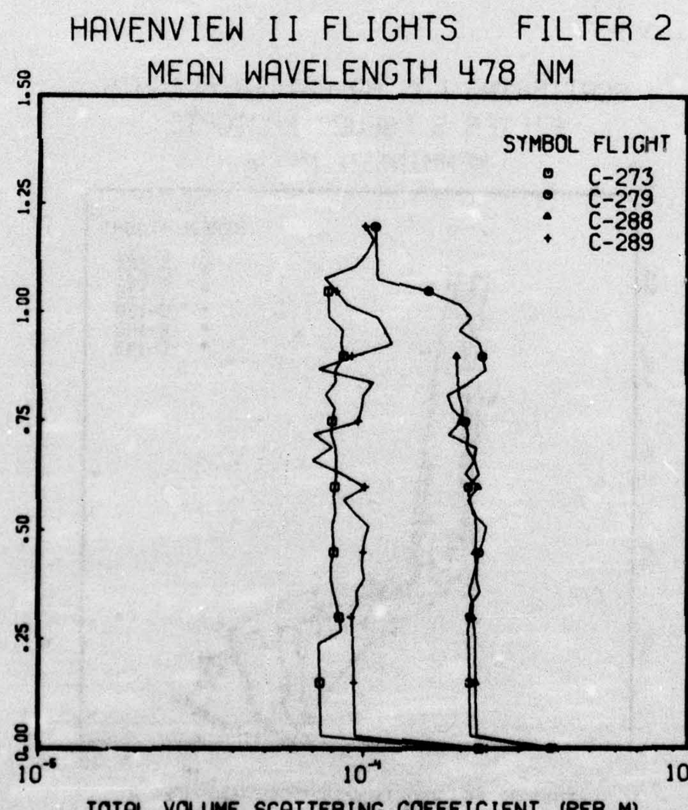


Fig. 8-3. Total Volume Scattering Coefficient for Filter 2 for Four HAVEN VIEW II Flights.

The ground-based values from the two field trips overlap in range with the HAVEN VIEW I values extending lower, and the HAVEN VIEW II values higher. On the other hand the airborne values are generally lower at the same altitudes for HAVEN VIEW II. The notable exception is flight C-288 which falls in the middle of the range for HAVEN VIEW I at the same altitudes.

Comparison to Eltro Transmissometer Data. In addition to the radiosonde data, values of transmittance measured at the ground site at Meppen over a 300-meter path with an Eltro transmissometer were available. Ground-based values of total volume scattering coefficient per meter were derived from these transmittances for the 6 days of the flights. These are presented in Table 8-2.

It is presumed that the Eltro transmissometer is photopically filtered since the transmittances are used to obtain visibility estimates. Table 8-3 provides a comparison of the total volume scattering coefficients from the Eltro transmissometer, and the values measured by the ground-based and airborne nephelometer for filter 4 pseudo-photopic. The Eltro values closest in time to the vertical profile element time are given in column 5. The airborne values in column 7 are for the lowest altitude of measurement. The ground-based nephelometer values and the Eltro values compare closely except for the 16 May data (Flight C-273) where there is no Eltro value at 0600 GMT preceding the flight. As was mentioned earlier, the low altitude airborne and the ground-based nephelometer values are not similar but both instruments were apparently operating normally, therefore both sets of data are considered valid.

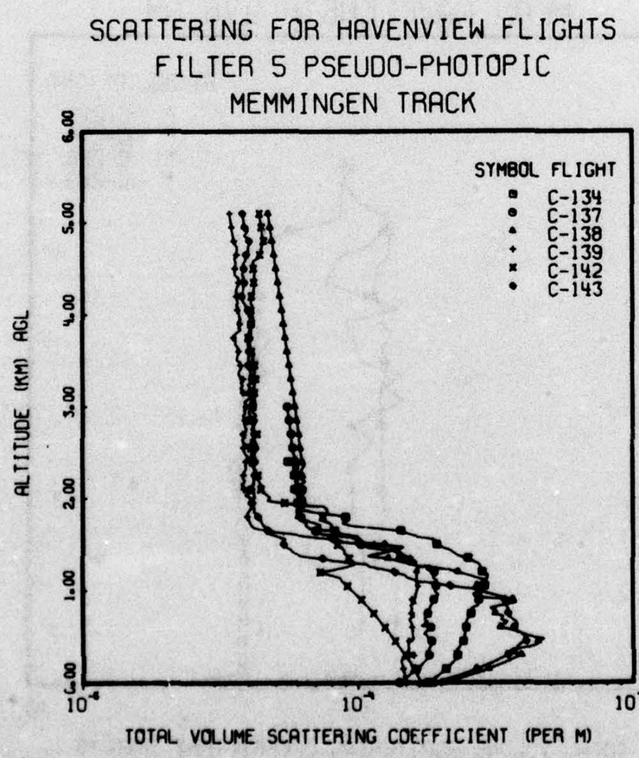


Fig. 8-4. Total Volume Scattering Coefficient for the Pseudo-Photopic Filter for Six HAVEN VIEW I Flights.

Table 8-2

Total Volume Scattering Coefficient Based Upon Eltro Transmissometer Data

Date	Total Volume Scattering Coefficient (per meter) *							
	Greenwich Meridian Time (GMT)							
1973	0000	0300	0600	0900	1200	1500	1800	2100
16 May	–	–	–	2.78E-4	2.60E-4	1.02E-4	1.02E-4	2.42E-4
3 June	5.61E-4	1.08E-3	3.33E-4	1.89E-4	2.20E-4	2.24E-4	2.13E-4	4.26E-4
4 June	1.10E-3	2.81E-3	4.83E-4	3.59E-4	2.35E-4	2.67E-4	3.14E-4	3.14E-4
5 June	7.65E-4	1.77E-2	2.42E-4	1.99E-4	2.35E-4	2.42E-4	2.60E-4	3.59E-4
13 June	1.44E-4	1.82E-3	8.28E-4	5.18E-4	2.96E-4	2.78E-4	2.06E-4	2.92E-4
14 June	3.81E-4	3.33E-4	1.89E-4	2.06E-4	2.06E-4	1.57E-4	2.06E-4	2.42E-4

Table 8-3

Comparison of Total Volume Scattering Coefficient s(per meter) from the Eltro Transmissometer and Ground and Airborne Nephelometers

Date 1973	Flight No.	Eltro Transmissometer			Filter 4		
		Time (GMT)			Ground	Airborne	V-PRO
		Before	After	$s(m^{-1})$	$s(m^{-1})$	$s(m^{-1})$	Time (GMT)
16 May	C-273	–		–	1.84E-4	6.14E-5	0810
			0900	2.78E-4			
4 June	C-280	1500		2.67E-4	2.81E-4	9.07E-5	1622
			1800	3.14E-4	2.86E-4	1.05E-5	1741
5 June	C-281	0900		1.99E-4	2.06E-4	5.17E-5	0904
			1200	2.35E-4			
5 June	C-282	1500		2.42E-4	2.41E-4	9.38E-5	1624
			1800	2.60E-4	2.54E-4	9.15E-5	1711

*** These data are in the form 5.61E-4, which is an alternate format for 5.61×10^{-4}. This computer format is used throughout this report.**

No ground-based nephelometer data were measured on either 13 or 14 June 1973. However, there were measurements of visibility made by the Eltro transmissometer on these days at times reasonably comparable with flights C-288 and C-289. Therefore, the ground-based total volume scattering coefficients used for flights C-288 and C-289 filter 4 computations are based upon these Eltro transmissometer data. Ground-based values for total scattering coefficients in the other three spectral bends, i.e., filter 2, filter 3, and filter 5, are based upon the average ratio between these coefficients and the filter 4 coefficient as determined from previous nephelometer measurements.

EQUIVALENT ATTENUATION LENGTH AND BEAM TRANSMITTANCE

Equivalent attenuation length is for the path between ground level and altitude. At ground level the equivalent attenuation length is the reciprocal of the total scattering coefficient $s(z)$. As altitude increases, the equivalent attenuation length shows *the cumulative effect of summing* $s(z)$ *from* ground level to altitude z. Large increases in equivalent attenuation length at low altitude are due to the difference between the airborne total scattering coefficient and the larger ground-based total scattering coefficient.

The vertical beam transmittance starts at 1.0 at ground level and shows the cumulative effect of the summation of the total scattering coefficient with altitude.

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., $\bar{L}(\text{Filter } 2) < \bar{L}(4) < \bar{L}(3) < \bar{L}(5)$. All the profiles except filters 2 and 4 at high altitude for flight C-288 display this feature. Thus the minor anomalies in filter order in the total volume scattering coefficient profiles for flight C-289 have little effect when the total profile is summed.

Equivalent Attenuation Length and Beam Transmittance Examples. The equivalent attenuation length table can easily be used in Eq. 2.15 to obtain beam transmittance for intermediate object altitudes and zenith angles for the upward path of sight and for intermediate sensor altitudes and zenith angles for the downward path of sight.

EXAMPLES

A. For an upward path of sight at 60-degree zenith angle, with an object altitude z_t at 1080 meters Eq. 2.15 would be written

$$T_{2160}(0,60°) = \exp\left\{[-1080\text{m}/\bar{L}(1080)] \sec 60°\right\} .$$

Using the equivalent attenuation length converted to meters for flight C-289 filter 4, Eq. 2.15 becomes

$$T_{2160}(0,60°) = \exp\left\{[-1080\text{m}/14\,000\text{m}]\,2\right\} = 0.857 .$$

B. For a downward path of sight at a zenith angle of 135 degrees from a sensor altitude of 750 meters, Eq. 2.15 would become

$$T_{1061}(750,135°) = \exp\left\{[-750m/\bar{L}(750)]\,|\sec 135°|\right\} .$$

Again using the values from flight C-289 filter 4, Eq. 2.15 becomes

$$T_{1061}(750,135°) = \exp\left\{[-750m/13300m]\,1.414\right\} = 0.923 .$$

IRRADIANCE

Downwelling. 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 downward path directional path reflectance. The low-altitude downwelling irradiance values for pseudo-photopic filter 4 for all the HAVEN VIEW II profiles are graphed in Fig. 8-5.

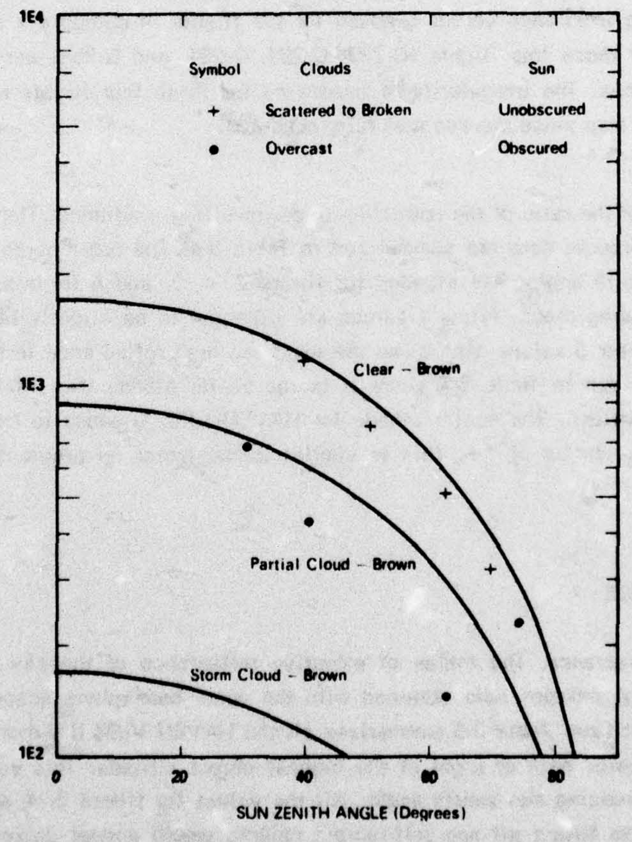


Fig. 8-5. Project HAVEN VIEW II Low Altitude Downwelling Irradiance for Filter 4 (Pseudo-Photopic) Compared to Brown (1952).

The symbols indicate the cloud categories described in Table 8-1. Since the altitudes for the lowest straight and level sequences ranged between 223 and 327 meters above ground level, they can be compared to the ground-level values of Brown (1952). The illuminance values of Brown for unobscured sun, partial cloud, and storm cloud, have been converted to irradiance units and depicted as solid curves in Fig. 8-5.

The category 1 (unobscured sun) values of downwelling irradiance tend to be slightly below the Brown clear-day curve. The category 1 flights are C-273, C-282A and B, and C-289. The space-to-low-altitude transmittance values ranged from 0.44 to 0.68 for these flights, whereas the Brown curve is most likely appropriate to the average clear-day photopic transmittance of 0.7. Therefore, it is reasonable for the category 1 irradiances to be near or below the Brown clear-day values.

The overcast data, category 2, flights C-280A and B, C-281, and C-288, have 3 values below and 1 value above the Brown partial cloud curve, which is reasonable.

The graphs of downwelling irradiance versus altitude for the HAVEN VIEW II flights in cloud category 1 are very regular due to the use of a consistent space-to-altitude transmittance for each filter. The graphs of downwelling irradiance versus altitude for the flights in category 2 are irregular because the lighting conditions for those four flights (C-279, C-280, C-281, and C-288) were variable during the straight and level sequences. The irregularity of irradiance for these four flights results from the variability of the sky radiance map since the sun was fully obscured.

Albedo. The albedo is the ratio of the upwelling to downwelling irradiance. The low altitude albedos for the HAVEN VIEW II airborne data are summarized in Table 8-4. The order given is by cloud category and by increasing sun zenith angle. The albedos for filters 2, 4, 3, and 5 lie in a reasonable range for cultivated fields with growing crops. Filter 4 values are expected to be slightly higher than the values for filters 2 and 3. The filter 5 values also show the expected high reflectance in the near infrared. The scalar albedos are also given in Table 8-4 since it is the scalar albedo that affects the path function and equilibrium radiance values. The scalar albedo for HAVEN VIEW II tends to be higher than the flat plate albedo by an average factor of 1.5. This is similar to the factor for previous field trips over cultivated areas.

DIRECTIONAL REFLECTANCE

Directional Sky Reflectance. The tables of effective reflectance of the sky presented with each flight are derived from sky radiance data obtained with the upper hemisphere scanner at each straight-and-level flight element altitude. Table 8-5 summarizes all the HAVEN VIEW II airborne data on effective sky reflectance for the zenith path of sight at the highest object altitude. This summary is in order by cloud category and by increasing sun zenith angle. All the values for filters 2, 4, and 3 are greater than 1, indicating that for these filters all non-self-radiant objects would appear darker than the sky background, that is, they would have a negative contrast. The values for filter 5 are consistently lower than for the other filters. This is probably partially due to the consistently larger albedo for filter 5.

Table 8-4

HAVEN VIEW II Albedos at the Lowest Airborne Altitude

Descriptive Characteristics: Cloud	Descriptive Characteristics: Sun	Sun Zenith Angle (Deg)	Flight	Altitude (m)	Albedo Filters 2	Albedo Filters 4	Albedo Filters 3	Albedo Filters 5	Scalar Albedo Filters 2	Scalar Albedo Filters 4	Scalar Albedo Filters 3	Scalar Albedo Filters 5
Broken to scattered	Unobscured	33.6	C-289	267	.035				.065			
		36.4	C-289	257			.036				.056	
		39.6	C-289	258		.075				.11		
		42.7	C-289	201				.52				.64
		44.1	C-273	276	.057		.057		.089		.087	
		50.3	C-273	276		.067		.36		.096		.42
		62.6	C-282A	223		.063				.11		
		69.6	C-282B	237		.12				.14		
Overcast	Obscured	30.2	C-288	324		.080				.13		
		30.8	C-279	231	.042				.078			
		30.9	C-279	278			.046				.076	
		31.1	C-288	225				.40				.44
		32.6	C-288	222	.047				.091			
		34.4	C-288	280			.052				.090	
		40.6	C-281	310		.088		.34		.13		.38
		62.5	C-280A	299		.11				.18		
		74.1	C-280B	327		.076				.12		

Table 8-5

HAVEN VIEW II Zenith Sky Effective Reflectance at Highest Object Altitude

Descriptive Characteristics: Cloud	Descriptive Characteristics: Sun	Sun Zenith Angle (Deg)	Flight	Maximum Altitude m	Zenith Sky Effective Reflectance: Filter 2	Filter 4	Filter 3	Filter 5
Broken to scattered	Unobscured	33.6	C-289	1200	4.17			
		36.4	C-289	1200			3.15	
		39.6	C-289	1200		5.27		
		42.7	C-289	1200				0.078
		44.1	C-273	1050	2.19		6.16	
		50.3	C-273	1050		4.40		0.180
		62.6	C-282A	600		2.12		
		69.6	C-282B	600		1.84		
Overcast	Obscured	30.2	C-288	900		5.52		
		30.8	C-279	1200	9.65			
		30.9	C-279	1200			17.2	
		31.1	C-288	900				2.61
		32.6	C-288	900	17.9			
		34.4	C-288	900			9.80	
		40.6	C-281	900		16.6		1.70
		62.5	C-280A	750		9.58		
		74.1	C-280B	750		11.1		

In order to determine whether the large values of effective sky reflectance for the flights with scattered to broken clouds were due to clouds at the zenith, a summary was made of effective sky reflectance for the SEEKVAL data which included both clear and cloudy data. The SEEKVAL summary is presented in Table 8-6 given in order of increasing clouds and increasing sun zenith angle in each cloud category. All the SEEKVAL data were measured using filter 4. The higher effective sky reflectances for HAVEN VIEW II are indeed probably due to the presence of clouds at the zenith, since they are all larger than the clear day values for SEEKVAL. It is not unreasonable that the clear day zenith sky effective reflectance values are greater than 1.0 since the sky radiance is a function of all of the incoming scalar irradiance, sun and sky as well as upwelling.

Upward Path Example. The effective sky reflectance tables can be used with Eq. 2.8 to obtain inherent contrast of non-self-radiant objects against the sky background.

Table 8-6

SEEKVAL Zenith Sky Effective Reflectance for Filter 4 at the Highest Straight and Level Element Altitude

Descriptive Characteristics		Sun Zenith Angle (degrees)	Flight	Filter	Maximum ST & LV Altitude (meters)	Zenith Sky Effective Reflectance
Clouds	Sun					
Clear	Unobscured	26.0	C-351	4A	763	1.27
		26.0	C-351	4B	753	1.16
		36.2	C-360B	4B	963	1.51
		44.4	C-352	4B	886	1.23
Scattered	Unobscured	47.3	C-357	4A	928	1.45
		47.3	C-360B	4A	926	1.30
		51.1	C-360A	4B	880	1.25
		63.2	C-352	4A	937	1.22
		68.7	C-360A	4A	923	1.43
		72.6	C-357	4B	909	2.21
Broken	Partially obscured	31.0	C-359	4A	717	4.14
		47.8	C-359	4B	843	1.52
Overcast	Partially obscured	26.5	C-358	4B	895	1.48
		32.3	C-358	4A	920	1.54
Overcast	Obscured	29.3	C-354	4B	973	3.72
		38.3	C-354	4A	936	2.39

EXAMPLES

A. For an upward path of sight at 0 degree zenith angle, with an object at 1200 meters the maximum object altitude for flight C-289, Eq. 2.8 would be written

$$C_o(1200,0^\circ,0^\circ) = [\,{}_tR_o(1200,0^\circ,0^\circ)/{}_bR_o(1200,0^\circ,0^\circ)] - 1 \;.$$

Let us use an aircraft as an object. Lacking a direct measure of the reflectance of unpainted aluminum under the appropriate lighting conditions, we will assume a reflectance of 0.4 for this filter 4 example. Note that the upwelling irradiance, $H(z_t,u)$, which is relatively diffuse, is used in determining the object reflectance for all upward paths of sight regardless of the object surface orientation. Using the effective sky reflectance from flight C-289 filter 4, Eq. 2.8 becomes

$$C_o(1200,0^\circ,0^\circ) = [0.4/5.27] - 1 = -0.924 \;.$$

B. The inherent radiance of the aluminum would be found by using Eq. 7.1 (see p. 7-8), as follows,

$${}_tN_o(1200,0^\circ,0^\circ) = \frac{1}{\pi}\;{}_tR_o(1200,0^\circ,0^\circ)\;\;H(1200,u) \;.$$

Using the upwelling irradiance at 1200 meters $H(1200,u)$ for flight C-289 from the filter 4 table at the top of the page of reflectance, and the aluminum reflectance assumed above, Eq. 7.1 becomes

$${}_tN_o(1200,0^\circ,0^\circ) = \frac{1}{\pi}\;0.4\,(97.1\;w/m^2\mu m) = 12.4\;w/\Omega\,m^2\mu m \;.$$

Directional Terrain Reflectance. The tables of directional reflectance of 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, and it is completely possible that no specific part of the terrain has that exact value of reflectance. In addition, objects of interest will almost certainly be located on a background having a different reflectance than that tabulated for the terrain. That is why ground-based measurements of directional reflectance of backgrounds are also made during the flight interval – to help provide appropriate values for generating contrast transmittance for a given problem. The effect of background reflectance on the contrast transmittance is not a trivial one. Care should be used in selecting the appropriate value for application to a specific problem.

Table 8-7 summarizes all the HAVEN VIEW II airborne data on terrain reflectance for the nadir path of sight. This summary presents the data in order by cloud category and by increasing sun zenith angle. For the nadir path of sight at the lowest altitude of all the flights, 223 meters, a 5-degree field of view would cover a circle 19 meters in diameter, whereas at the highest minimum altitude of all the flights, 327 meters, a 5-degree field would cover a circle 29 meters in diameter. The nadir value is the average of the values obtained during one azimuthal revolution of the scanner (10 seconds). At flight speeds of 158 to 165 knots, the average distance covered in 10 seconds is 830 meters. Thus the tabulated nadir reflectances relate to an average radiance in areas 19 by 849 meters, to 29 by 859 meters in size.

The seeming inconsistency of the reflectances flight to flight is a function of the patchiness of the terrain and the presence or absence of cloud shadows as illustrated in Fig. 7-1. The description in Table 7-1 of each terrain picture does not necessarily coincide with the reflectance since the time the picture was taken may not directly coincide with the time of the scanner nadir measurement. The general description of the terrain is cultivated farmland interspersed with dark patches of dense woods.

Table 8-7

HAVEN VIEW II Nadir Reflectances Based Upon Low Altitude Airborne Scanner Radiances

Descriptive Characteristics: Cloud	Descriptive Characteristics: Sun	Sun Zenith Angle (degrees)	Flight	Nadir Terrain Reflectance, Filters: 2	4	3	5
Broken to scattered	Unobscured	33.6	C-289	.020			
		36.4	C-289			.017	
		39.6	C-289		.084		
		42.7	C-289				.047
		44.1	C-273	.046		.062	
		50.3	C-273		.040		.316
		62.6	C-282A		.040		
		69.6	C-282B		.068		
Overcast	Obscured	30.2	C-288		.118		
		30.8	C-279	.015			
		30.9	C-279			.010	
		31.1	C-288				.311
		32.6	C-288	.030			
		34.4	C-288			.015	
		40.6	C-281		.061		.592
		62.5	C-280A		.062		
		74.1	C-280B		.032		
Meadows and crops *			Minimum	.013	.035	.027	.186
			Maximum	.082	.14	.21	.803
Forest *			Minimum	.025	.032	.028	–
			Maximum	–	.038	–	–

* See Table 8-2, Duntley *et al.* (1973

The reflectances can be compared to the nadir reflectances of meadows, crops, and forests from the literature which were presented in Table 8-2 of Duntley, *et al.* (1973). The range of those reflectances is indicated in the last four rows of data in Table 8-7 of this report. The values for filter 5 are for $\lambda = 765$ nm; they are taken from the same spectral data [Krinov (1947)] as were presented in Table 8-2 of Duntley, *et al.* (1973). The reflectance data for filters 2 and 4 lie within the range of values from the literature. However, three of the four values for filter 3 and one of the filter 5 values are lower than the range of values from the literature. The low values for filters 3 and 5 for flight C-289 may possibly be due to the presence of cloud shadows. However, the low values for filter 3 for flights C-279 and C-288 cannot be similarly accounted for and hence should be used with caution.

Downward Path Example. The terrain reflectance tables can be used with Eq. 2.8 to obtain the inherent contrast of non-self-radiant objects against the terrain background.

EXAMPLES

A. For the downward path of sight let us assume a nadir path of sight at 180 degrees zenith angle. Eq. 2.8 would be written thus

$$C_o(0,180°,0°) = [\,{}_tR_o(0,180°,0°)/{}_bR_o(0,180°,0°)] - 1 \ .$$

Let us compute the inherent contrast for filter 4 of a hard packed yellowish dirt road such as is depicted in Fig. 7-1 for flight C-289. For the surrounding fields, let us assume the reflectance equal to that of a lush meadow in autumn, 0.071 (Gordon and Church (1969) p. 796). The reflectance of dirt, hard-packed and yellowish from Gordon (1964) p. 559 is 0.243. Thus Eq. 2.8 becomes

$$C_o(0,180°,0°) = [0.243/0.071] - 1 = 2.42 \ .$$

B. The inherent radiance of the road would be found by using Eq. 7.3 (see p. 7-9), as follows

$${}_tN_o(0,180°,0°) = \frac{1}{\pi}\,{}_tR_o(0,180°,0°)\,H(0,d) \ .$$

Using the downwelling irradiance for filter 4 for flight C-289 from the irradiance table at the top of the reflectance page, with the dirt reflectance from above, Eq. 7.3 becomes

$${}_tN_o(0,180°,0°) = \frac{1}{\pi}\ 0.243\,[1180\ w/m^2\mu m] = 91.3\ w/\Omega\, m^2\mu m \ .$$

EQUILIBRIUM RADIANCE

Equilibrium radiance (Eq. 2.25) 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 occuring in space and/or time during the flight. For instance, specific features of the terrain 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, in this case the variable cloud patterns. Also, the sun zenith angle increases or decreases in varying degrees due to changes in procedural elapsed 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 a flight, except for the average sun zenith angle used for obtaining the apparent sun radiances and the assumption that beam transmittance from space to the highest altitude remains constant throughout the profile. Thus clouds, when present, contribute only to the variability of the sky irradiance at each altitude. The assumption of an unobscured sun for the cloud category 1 profiles is consistent with the real-world case when checked against the scanner sky data arrays for the ten profiles containing scattered clouds in the upper sky.

Under comparatively stable clear-day conditions, equilibrium radiance tends to be relatively invariant with altitude. Several atmospheric models are based upon this tendency [Duntley (1948) and Gordon (1969)]. The first model assumes an invariant particle-size distribution which decreases with increased altitude. The second model assumes both a clear day with no clouds and no absorption, and an invariant equilibrium radiance with altitude.

In contrast to these models, the twenty HAVEN VIEW II flight profiles have equilibrium radiance functions which vary with altitude. The standard deviation of the equilibrium radiance from the average values varied from less than 1 to 76 percent, with the nadir path of sight often having standard deviations in the upper portion of that range. The zenith equilibrium radiance for flight C-289 photopic response filter 4 has been graphed in Fig 8-6, and the nadir equilibrium radiance in Fig. 8-7. Flight C-289 was one of the more optically stable flights in terms of consistency of irradiance with altitude, and the filter 4 standard deviation for the equilibrium radiance varied from 4 to 15 percent for the various paths of sight (standard deviation for the zenith path of sight was 15 percent and for the nadir path of sight was 7 percent). But, in general, the atmospheric models cited above appear inapplicable to the HAVEN VIEW II flights.

There is a certain amount of consistency in the equilibrium reflectance for the lowest altitude of the nadir path of sight. Equilibrium reflectance R_q is derived from the equilibrium radiance and the downwelling irradiance:

$$R_q(z,\theta,\phi) = N_q(z,\theta,\phi)\pi/H(z,d) \ . \qquad (8.1)$$

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 reflectance for the twenty

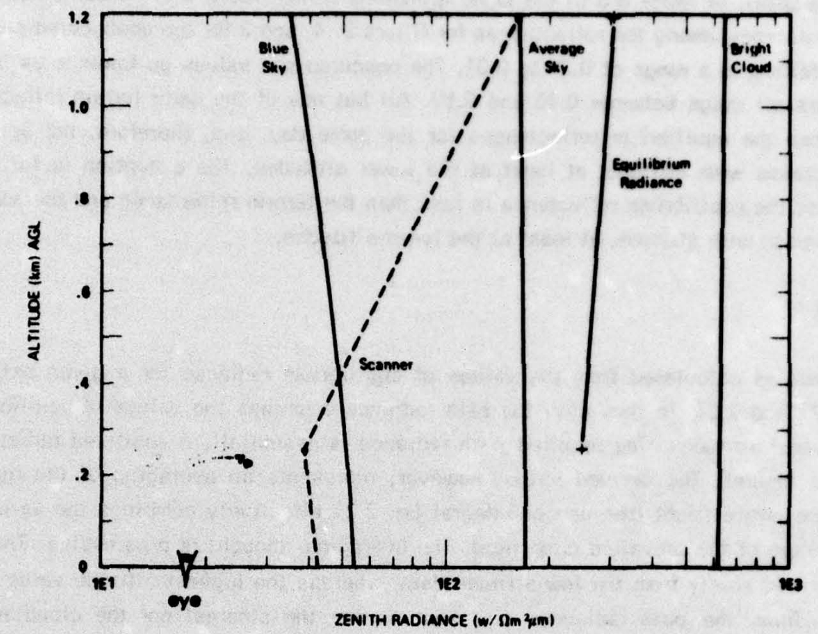


Fig. 8-6. Comparison of Zenith Equilibrium Radiance with Several Computed Apparent Zenith Sky Radiances and the Measured Scanner Zenith Radiance from Flight C-289 Filter 4.

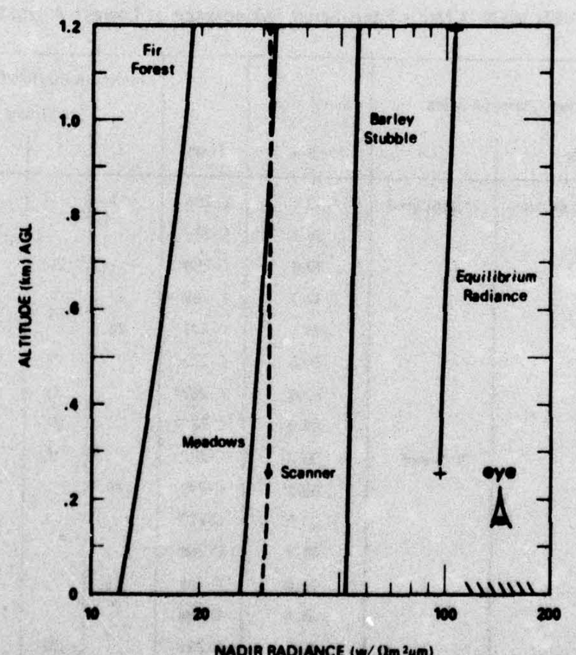


Fig. 8-7. Comparison of Nadir Equilibrium Radiance with Several Computed Apparent Nadir Terrain Radiances and the Measured Scanner Nadir Radiance from Flight C-289 Filter 4.

flight profiles are given in Table 8-8 in the same groupings as for Table 8-7. As can be seen, there is a rough overall consistency among the reflectances for filters 2, 4, and 3 for the unobscured sun flights with the reflectances falling in a range of 0.21 to 0.31. The obscured sun values go lower to as little as 0.13. The filter 5 values all range between 0.45 and 0.59. All but one of the nadir terrain reflectances (Table 8-7) 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 exception is for filter 5 flight C-281, in this case the equilibrium reflectance is less than the terrain reflectance and the apparent terrain radiance will decrease with altitude, at least at the lower altitudes.

PATH RADIANCE

Path radiance is calculated from the values of equilibrium radiance for a given path of sight by means of Eq. 2.21 and 2.24. In this way, the path radiance combines the values of equilibrium radiance from each of 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. 2.21 effectively combines the variable data into an unrefined average of the prevalent condition). The averaging, though, is progressive. The lowest altitude value is derived solely from the low-altitude data, whereas the highest altitude value is an average of all the data. Thus, the path radiances represent neither the clearest nor the cloudiest portion of a flight, but a combination of the various segments.

Table 8-8

HAVEN VIEW II Nadir Equilibrium Reflectance at Lowest Altitude

Descriptive Characteristics		Sun Zenith Angle (degrees)	Flight	Nadir Equilibrium Reflectance Filters			
Clouds	Sun			2	4	3	5
Scattered to broken	Unobscured	33.6	C-289	.27			
		36.4	C-289			.23	
		39.6	C-289		.26		
		42.7	C-289				.59
		44.1	C-273	.28		.24	
		50.3	C-273		.27		.47
		62.6	C-282A		.21		
		69.6	C-282B		.31		
Overcast	Obscured	30.2	C-288		.16		
		30.8	C-279	.16			
		30.9	C-279			.18	
		31.1	C-288				.45
		32.6	C-288	.13			
		34.4	C-288			.16	
		40.6	C-281		.27		.55
		62.5	C-280A		.23		
		74.1	C-280B		.19		

The derived path radiance profiles are relatively smooth as a function of altitude, partially due to the averaging process of the integration of Eq. 2.21. The downward path radiances for the unobscured sun flights of HAVEN VIEW II (Flights C-273, C-282, and C-289) using consistent space-to-altitude beam transmittances are similar in regularity to those of METRO and SEEKVAL field trips, all three are more regular than those for the HAVEN VIEW I and ATOM trips. This change indicates an overall improvement in data quality and data handling.

Some of the path radiance data for the obscured sun flights are less regular. This can be directly attributed to the changing sky lighting conditions during these flights as was noted concerning the down-welling irradiance graphs with altitude.

The path radiance and other related parameters are routinely evaluated using a variety of diagnostic tests. For example, one important diagnostic is that for the same downward-looking path of sight, the path radiance should be less than the apparent terrain radiance. In all cases, all the internal diagnostics indicate that the data quality has improved substantially since Project METRO. This improvement is a direct result of the current method of measuring the sky radiance near the sun, and the method for obtaining apparent sun radiance using the best of several independently determined values of space-to-high altitude beam transmittance.

Upward Path Example. The path radiance tables can be used with Eq. 7.2 (see p. 7-8) to obtain the apparent radiance at ground level of an object or background at altitude.

EXAMPLE

A. For an upward path of sight at 0 degrees zenith angle, with the object at 1200 meters, Eq. 7.2 would be written

$$N_{1200}(0,0°,0°) = N_o(1200,0°,0°)\, T_{1200}(0,0°) + N^*_{1200}(0,0°,0°) \ .$$

The appropriate transmittance and path radiance for the above equation are listed under 1200 meters, the object altitude. Using the aircraft as the object, the inherent radiance as computed earlier for flight C-289 filter 4 is 1.24E1. Then, using appropriate values from flight C-289, Eq. 7.2 becomes

$$N_{1200}(0,0°,0°) = 12.4\,(0.918) + 22.2 = 33.6\ \mathrm{w}/\Omega\,\mathrm{m}^2\mu\mathrm{m} \ .$$

Further Upward Path 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 for computing apparent radiance, Eq. 7.2. Using Eq. 7.2, we computed the apparent radiance at ground level of the sky for the zenith path of sight for flight C-289 filter 4. This apparent radiance, based upon the zenith radiance during the lowest straight and level flight element, is 42.3. The measured scanner sky radiances at the zenith and the computed apparent radiance at ground level have been graphed in Fig. 8-6 and labeled as "scanner."

Upon examining the sky radiance table for 1192 meters at the smallest zenith angle 2.5, we found that the average of 163 used as the zenith value was derived from 60 values (each 6-degree increment in azimuth). These 60 values ranged from 647 to 35.5 (in effective reflectance they ranged from 20.9 to 1.15). It is reasonable to assume that the high value is for a bright cloud and the low value for blue sky. For conceptual purposes, we have computed the apparent radiances at various altitudes based upon these two inherent sky radiances measured at 1192 meters, and a third sky radiance based upon the average of the 60 sky radiance measurements at $\theta = 2.5°$. The computed apparent radiances for these three sky values are graphed in Fig. 8-6.

The measured scanner radiance at low altitude, 258 meters, is slightly lower than the apparent blue sky radiance at that altitude which is based upon the minimum sky measurement at 1192 meters. This seeming inconsistency of the measured scanner radiance with altitude is indicative of the variability of the sky radiances, the changing cloud patterns with time as well as with space, as the airplane flew the track.

Note how all the computed sky radiances (blue sky, average sky, and bright cloud) approach the equilibrium radiance. The blue and average sky radiances increase as we approach ground level since they are less than the equilibrium radiance. The cloud radiance decreases as we approach ground level since its radiance is greater than the equilibrium radiance.

Downward Path Example. The path radiance tables can be used with Eq. 7.4 (see p. 7-9) to obtain the apparent radiance at altitude of an object or background at ground level.

EXAMPLE

A. For a downward path of sight at 180 degrees zenith angle, with the sensor at 1200 meters, Eq. 7.4 would be written

$$N_{1200}(1200,180°,0°) = N_o(0,180°,0°)\, T_{1200}(1200,180°) + N^*_{1200}(1200,180°,0°) \; .$$

Using our previous example of a hard-packed yellow dirt road as an example with filter 4 data from flight C-289, Eq. 7.4 becomes

$$N_{1200}(1200,180°,0°) = 91.3\,(0.918) + 8.21 = 92.0 \text{ w}/\Omega\, \text{m}^2\mu\text{m} \; .$$

Further Downward 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. 7.4. By rearranging Eq. 7.4, we obtain an equation for predicting the inherent radiance of the terrain at ground level $N_o(0,\theta,\phi)$ from the apparent radiance at low altitude, the beam transmittance, and the path radiance

$$N_o(0,\theta,\phi) = [N_r(z,\theta,\phi) - N^*_r(z,\theta,\phi)] / T_r(z,\theta) \; . \qquad (8.2)$$

For example, the resultant inherent radiance for the nadir path of sight for flight C-289, filter 4 (pseudo-photopic) is 30.3 $w/\Omega m^2\mu m$. Then using Eq. 2.5, we obtain a reflectance of 0.081. This reflectance is indicative of the cultivated farmland underlying much of the flight track. The measured scanner radiances and the extrapolated ground value have been graphed in Fig. 8-7 and labeled as "scanner."

For conceptual purposes, we have computed the apparent nadir radiances for three types of terrain appropriate to flight C-289, filter 4, using Eq. 7.4. The three terrains chosen were: lush meadow in autumn having a reflectance of 0.071, 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 the last four rows in Table 8-7 and illustrate high and low values from the literature for woods interspersed with meadows and cultivated fields. The computed radiances for these three terrains are graphed in Fig. 8-7.

The measured scanner radiance is slightly higher than the computed meadow radiance at low altitude and slightly lower than the computed meadow radiance at high altitude. This seeming inconsistency of the scanner radiance with altitude is indicative of the patchiness of the terrain and the presence and absence of cloud shadow beneath the flight track. Pictures taken simultaneously with the nadir measurement would be necessary before appropriate descriptions of the terrain could be made for the nadir measurement.

Note how all the computed terrain radiances increase, tending to approach the equilibrium radiance. All the computed radiances increase with altitude since they are less than the equilibrium radiance and tend to approach it.

DIRECTIONAL PATH REFLECTANCE

Using data from the two scanners to obtain both the path radiance $N_r^*(z,\theta,\phi)$ and the downwelling irradiance $H(z_t,d)$ or upwelling irradiance $H(z_t,u)$ 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 manner, 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 irradiance are obtained by integration of a large number of radiance measurements, precision errors tend to cancel or average out.

The path reflectances for the HAVEN VIEW II unobscured sun flights C-273, C-282, and C-289 were similar to those of the METRO and SEEKVAL field trips in being more regular than those for the earlier HAVEN VIEW and ATOM trips. The continuing improvement within these data sets is another indication of the improving quality of the path radiance and beam transmittance determinations. The path reflectances for the flights with obscured sun, flights C-279, C-280, C-281, and C-288 were not as regular with altitude because the lighting conditions were more variable.

Upward Path Example. The path reflectance tables can be used with Eq. 2.3 to obtain the contrast transmittance at ground level of an object against a background other than the sky. For instance, the painted markings on an aircraft would be viewed against the aircraft as background (not the sky).

EXAMPLES

A. For an upward path of sight at 0 degrees zenith angle, with the object at 1200 meters, Eq. 2.3 would be written

$$ {}_b\tau_{1200}(0,0°,0°) = \left\{1 + [R^*_{1200}(0,0°,0°)/{}_bR_o(1200,0°,0°)]\right\}^{-1} . $$

The reflectance of the unpainted aluminum surface has already been assumed to be 0.4 for filter 4. The appropriate value of path reflectance is found at the object altitude 1200 meters in the filter 4 tables for flight C-289, and Eq. 2.3 becomes

$$ {}_b\tau_{1200}(0,0°,0°) = \left\{1 + [0.781/0.4]\right\}^{-1} = 0.339 . $$

B. The final step would be to compute the apparent contrast. To obtain apparent contrast Eq. 2.1 can be transposed as follows

$$ C_{1200}(0,0°,0°) = C_o(1200,0°,0°)\ {}_b\tau_{1200}(0,0°,0°) . \qquad (8.3) $$

If we assume the diffuse reflectance of the black paint to be 0.04, its inherent contrast against the aircraft background is −0.90. Thus the apparent contrast at ground level of the black paint as seen against the aircraft background at 1200 meters is

$$ C_{1200}(0,0°,0°) = -0.90(0.339) = -0.305 . $$

Since the sky radiance during the seven HAVEN VIEW II flights was quite variable, it is reasonable to assume a range of effective sky reflectances for each given path of sight which would be consistent with the overall irradiance level and path reflectance derived for each flight. Contrast transmittance with these various effective sky reflectances as background would be computed in a manner similar to the above example. This assumes that the sky radiance area is small enough in extent so as not to appreciably effect the path reflectance and takes cognizance of the sky radiance variability illustrated in Fig. 8-6. The difficulty lies in determining reasonable effective sky reflectance values to utilize in each instance. The concept of effective sky reflectance is a new one, and as yet there is not a large body of data nor much experience in using the data now available. This is an area of inquiry which should be pursued further so that reasonable values of effective sky reflectance could be made available for clear and cloudy days for a range of values of sun zenith angle, space-to-altitude transmittance, and scalar albedo.

Additional Upward Path Example. The path reflectance tables can be used with Eq. 2.3 to obtain the contrast transmittance at ground level of an object against a background of typical skies.

EXAMPLES

A. For illustrative purposes let us compute the contrast transmittance of any object viewed against the average zenith sky at 1200 meters. Eq. 2.3 becomes

$$ {}_b\tau_{1200}(0,0°,0°) = \left\{1 + [0.781/5.27]\right\}^{-1} = .871 \ . $$

B. Now using the aircraft as the object, the inherent contrast for filter 4 was computed earlier for flight C-289 as −0.924, then

$$ C_{1200}(0,0°,0°) = -0.924(0.871) = -0.805 \ . $$

This is the apparent contrast of the aircraft at 1200 meters as viewed at ground level against the average zenith sky radiance.

Downward Path Example. The path reflectance tables can also be used with Eq. 2.3 to obtain contrast transmittance at altitude of an object at ground level as seen against various backgrounds small enough in extent so as not to have an appreciable effect on the path reflectance.

EXAMPLES

A. For a downward path of sight at 180 degrees zenith angle, with the sensor at 1200 meters, Eq. 2.3 would be written thus

$$ {}_b\tau_{1200}(1200,180°,0°) = \left\{1 + [R^*_{1200}(1200,180°,0°)/{}_bR_o(0,180°,0°)]\right\}^{-1} \ . $$

Using our previous example of the lush meadow as a background and a path reflectance value from flight C-289 for filter 4 Eq. 2.3 becomes

$$ {}_b\tau_{1200}(1200,180°,0°) = \left\{1 + [0.0239/0.071]\right\}^{-1} = 0.748 \ . $$

B. Again, a concluding step would be to compute the apparent contrast at 1200 meters of the object, in this case the yellow dirt road. Rewriting Eq. 8.3 for the downward path case, it becomes

$$ C_{1200}(1200,180°,0°) = C_o(0,180°,0°)\ {}_b\tau_{1200}(1200,180°,0°) \ . $$

The inherent contrast of the road against the meadow background was computed earlier as 2.42. Thus the apparent contrast of the road at 1200-meter altitude is

$$C_{1200}(1200, 180°, 0°) = 2.42(0.748) = 1.81 ,$$

which is a relatively high apparent contrast.

CONTRAST TRANSMITTANCE

Contrast transmittance can be expressed as the beam transmittance times the ratio of the inherent to apparent background radiance [Duntley *et al.* (1957) Eq. 7]

$$_b\tau_r(z,\theta,\phi) = T_r(z,\theta)\, _bN_o(z_t,\theta,\phi) / _bN_r(z,\theta,\phi) . \qquad (8.4)$$

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 less than the beam transmittance. This is true because the ratio of inherent to apparent background radiance is always less than 1, since apparent radiance increases with distance from the background as shown in Figs. 8-6 and 8-7. This characteristic is illustrated in Figs. 8-8 and 8-9. On the other hand, the contrast transmittance for a background higher in reflectance than the equilibrium reflectance will be greater than the beam transmittance, as is the case for the bright cloud, see Fig. 8-8. The values of contrast transmittance for the zenith path of sight using the table of effective sky reflectances with altitude for flight C-289 filter 4 are given as a dashed line in Fig. 8-8. That curve illustrates the effect of using a changing background reflectance for a contrast transmittance computation. This changing background is illustrated by the radiance labeled "scanner" in Fig. 8-6.

The discussion above emphasizes the importance of selecting the appropriate reflectance for use as background reflectance when computing valid contrast transmittance values. Photopic reflectances of many terrain backgrounds are available for clear days with moderately high suns in Gordon (1964) and Gordon and Church (1966a), for low suns in Boileau and Gordon (1966), and for overcast skies in Gordon and Church (1966b). Effective sky reflectance values are not as readily available.

8.3 SUMMARY

The derived optical properties for the downward path of sight for HAVEN VIEW II unobscured sun flights are similar to those for the SEEKVAL and METRO flights in terms of consistency as a function of altitude. The optical properties are more consistent than the equivalent values for HAVEN VIEW and ATOM. In addition, the internal diagnostics which cross-compare the various computed properties as well as the measured properties indicate a significant improvement in data quality since Project METRO. This is the direct result of utilizing advanced methods for measuring, evaluating, and handling the radiance distribution for the upper hemisphere.

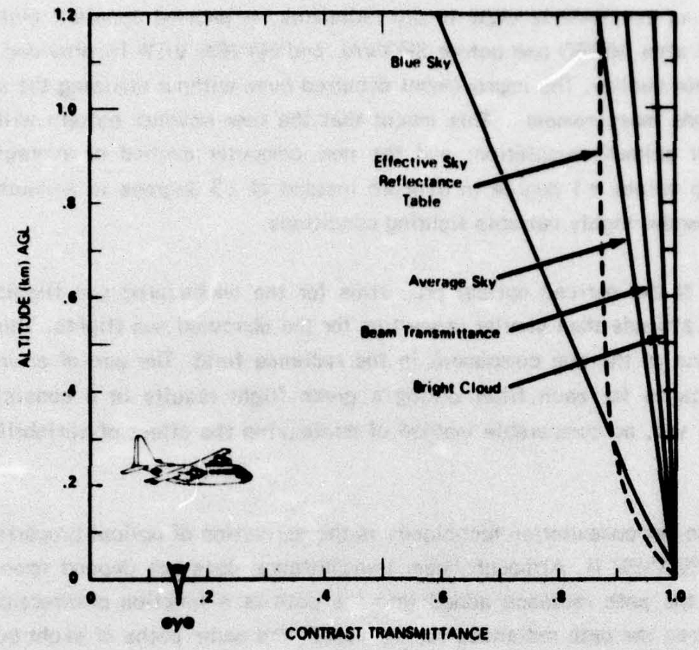


Fig. 8-8. Contrast Transmittance for Several Different Sky Backgrounds and Beam Transmittance for Flight C-289 Filter 4 Zenith Path of Sight.

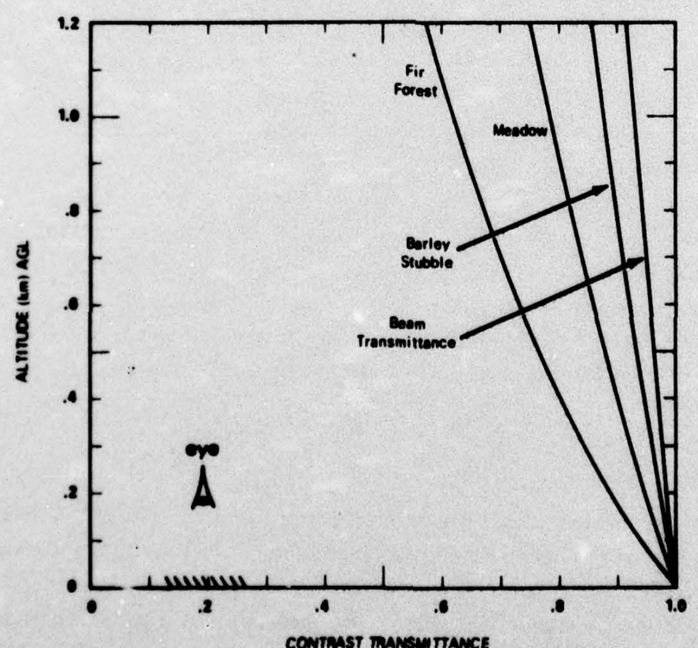


Fig. 8-9. Contrast Transmittance for Several Different Backgrounds and Beam Transmittance for Flight C-289 Filter 4 (Pseudo-Photopic) Nadir Path of Sight.

During evaluation of the HAVEN VIEW II sky radiances, it became apparent that the new scanner sweep pattern, initiated after METRO and before SEEKVAL and HAVEN VIEW II, provided a significant improvement in scanner data quality. The improvement occurred even without utilizing the solar aureole data provided by the sun-mode measurements. This meant that the new scanner pattern with 10 seconds instead of 5 seconds per azimuth resolution; and the new computer method of averaging the measured scanner radiances using values ±1 degree in azimuth instead of ±3 degrees in azimuth, yielded a high-quality data array even under highly variable lighting conditions.

For HAVEN VIEW II the derived optical properties for the unobscured sun flights were more consistent as a function of altitude than similar properties for the obscured sun flights. This is an indication of the primary importance of the sun component in the radiance field. The use of an invariant space-to-altitude beam transmittance for each filter during a given flight results in a consistent set of optical properties. There is, as yet, no comparable method of minimizing the effect of variability in the lighting in obscured sun flights.

A major addition to our computation techniques is the derivation of optical properties for the upward path of sight for HAVEN VIEW II. Although beam transmittance does not depend upon direction of flux through a given path, the path radiance added into the path is a function of direction, as can be seen by the comparison between the path radiances for the zenith and nadir paths of sight between ground and altitude. Although the equations for the upward and downward paths of sight are essentially similar, the addition of this computation to the automatic computer processing greatly increases the flexibility of our computational scheme.

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Sgt Marc Elliot, Maintenance Specialist

Visibility Laboratory, Technical Field Team:
Mr. J. Douglas Bailey, Ground Station Crew
Mr. George F. Simas, Ground Station Crew
Mr. Leonard A. Castro, Technical Flight Crew

Visibility Laboratory Data Processing and Analysis Team:
Mr. Nils R. Persson, Jr.
Ms. Janet E. Shields
Ms. Catharine F. Edgerton
Mr. Steven J. Bettinger

Visibility Laboratory, Editorial and Reproduction Team:

- Mr. John C. Brown
- Ms. Arlene C. Streed
- Mr. James Rodriguez
- Ms. Alicia G. Enriquez

Wunstorf Air Base, Flight Leaders School "S":

- Col. Naumann, Base Commander
- Lt. Col. Dreyer, Wing Commander
- Lt. Billik, Base Operations Officer
- Mr. Frenzel, Base Meteorologist
- Mr. Paulik, Base Meteorologist

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