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ACOSS ELEVEN (ACTIVE CONTROL OF SPACE STRUCTURES)

Thomas H. Brooks
David Anding

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In analysis and simulation of Space-based Surveillance System Performance, a key variable is the scene/sensor interaction, under subcontract to CSDL, Photon Research Associates has developed a software package capable of generating and manipulating terrestrial scene data sets as a function of major surveillance system and mission parameters. This report documents the details of this simulation, called Genessis, which has now been incorporated into the Draper Integrated Simulations.

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ACKNOWLEDGMENT

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1.0 INTRODUCTION

In support of the Draper Integrated Simulations, Photon Research Associates has developed a computer code capable of generating and manipulating terrestrial scenes as a function of major surveillance system and mission parameters. This code (called GENESSIS) has the capability to interface with the Defense Mapping Agency (DMA) data base of terrestrial scenes as the source of scene input data. Consequently, the code is able to simulate any scene for which DMA data exists.

Because of the desirability to have a functioning code as soon as possible, the code is being developed in two phases (each phase spanning approximately one calendar year). The first phase has provided a functional synthetic scene simulation computer code, although this first-phase code has some limitations. In particular, some of the higher-order phenomena controlling scene radiance (e.g., cloud shadowing) have been neglected, some of the phenomenological treatments utilize simplifying approximations, and the input data base is limited to five terrestrial scenes and two cloud representations. The plan is to eliminate these restrictions during subsequent phases.

This report presents the status of the GENESSIS code at the end of the first phase effort and presents instructions for its use. Code architecture, I/O functions, user operational procedures, and test case outputs are each presented and discussed.

2.0 CODE ARCHITECTURE

The GENESSIS scene simulation is based upon a point-by-point algorithm, a single cycle of which consists of collecting (and in some instances, computing) inputs specific to a single point on the scene, calculating the apparent radiance of that point from the collected inputs, and finally weighting and assigning the calculated radiance to the appropriate pixel in the observer's field of view. If the density of points is large enough, the scene will be properly sampled and the radiances computed by repeated point calculations can be combined to produce an accurate pixel radiance map of the scene. The parameters of these radiance grid points are computed from the three-dimensional scene itself.

Scene data consists of discrete altitude, material type pair specified at regular intervals on a planar rectangular grid. Continuous s. aces are produced from the discrete scene data using a bi-cubic spline fi ng technique. Point data can be computed from these surfaces at any de .l spatial resolution.

The computed apparent radiances consist of four terms comb. .' lditively. These are reflected solar, thermal emission, reflected skys.....e and path radiance. The respective calculational procedures are discussed in Section 3.4. Each major calculational operation is performed with a separate software module. The atmospheric, geometric and radiance modules have stand-alone capabilities, but are normally executed in sequence to produce a final result.

The simulations' primary output is an N x M viewer-perspective pixel apparent radiance map. Diagnostic output is also available to check proper code execution.

2.1 Modules

The GENESSIS code is comprised of six (6) modules (subroutine packages) each with a single specific task. These are geometric, atmospheric, heat transfer, radiance, image and ephemeris. These are combined into three major modules each with stand-alone capabilities. Modular stand-alone capabilities allow flexibility of operation while maintaining a simplicity of structure, user interaction and memory requirements.

The geometric module performs shadowing and the viewer perspective projection of the scene. Its output is required by the radiance module.

The atmospheric module supplies atmospheric parameters required by the radiance module. It is run least often since its output covers a wide range of solar and observer geometries.

The radiance module produces a viewer perspective pixel apparent scene radiance map from information supplied by the atmospheric and geometric modules. It calls upon the heat transfer and image modules to produce,

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respectively, surface temperatures and viewer image. The heat transfer module currently does not have a stand-alone capability. Both the geometric and radiance modules utilize the ephemeris module.

With the exception of the ephemeris module, these packages are discussed in detail in Sections 3.1-3.5. The ephemeris module computes the altitude-azimuth position of the sun for any specific time, date and observer location. A published user's manual exists for this package.* See Appendix 1 for excerpts of this manual.

2.2 Module Interaction

A flow diagram of the GENESSIS architecture is given in Figure 1 which details module interaction and hierarchy. Although the ephemeris, heat transfer and image modules have stand-alone capabilities, they currently require interaction with other major modules. Plans exist to investigate increases in efficiency and flexibility potentially available by separating these modules. This will be done during Phase II of the contract. Figure 2 details the I/O-module interaction. In this figure GENESSIS is shown as having three major components.

2.3 User Inputs/Control

User inputs are categorized according to purpose. These are geometric, sensor and atmospheric. The elements of these are:

A. Geometric Inputs

    1. The date and time of the simulation, used to compute the position of the sun,

    2. The latitude and longitude of the viewer subsatellite point,

    3. The observer altitude in kilometers.

B. Sensor Inputs

    1. The vertical and horizontal angular field of view,

    2. Focal plane rotation in degrees,

    3. The vertical and horizontal spatial resolution in meters.

C. Atmospheric Inputs

    1. Atmospheric model (six LOWTRAN standard atmospheres),

    2. Aerosol model,

    3. Haze model,

    4. Visibility in kilometers.

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*Solar Ephemeris Algorithm, W. Wilson. Visibility Laboratory, Scripps Institution of Oceanography, UCSD. SIO Ref. 80-13, July 1980, La Jolla, CA.
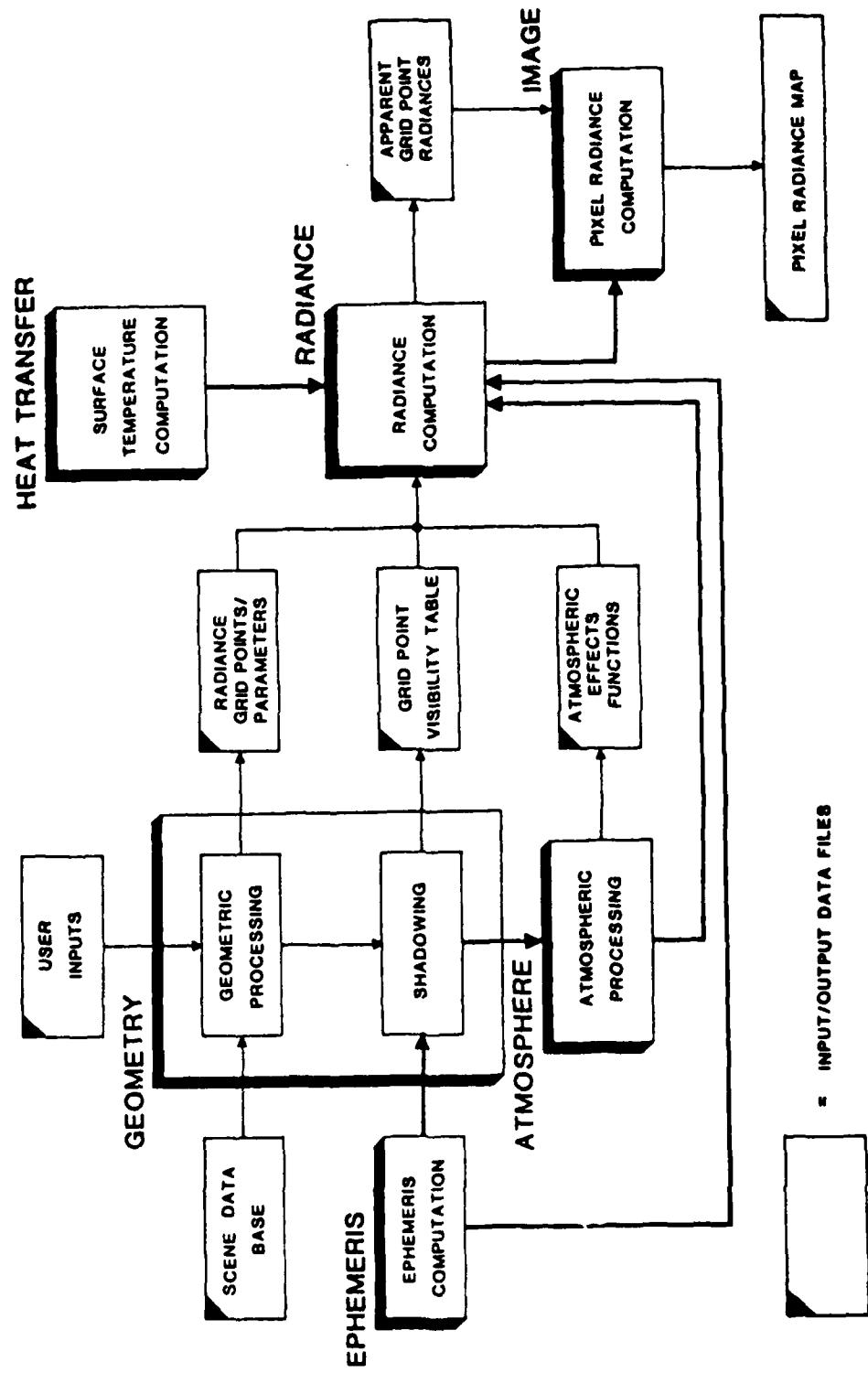
Figure 1. GENESSIS Architecture

4
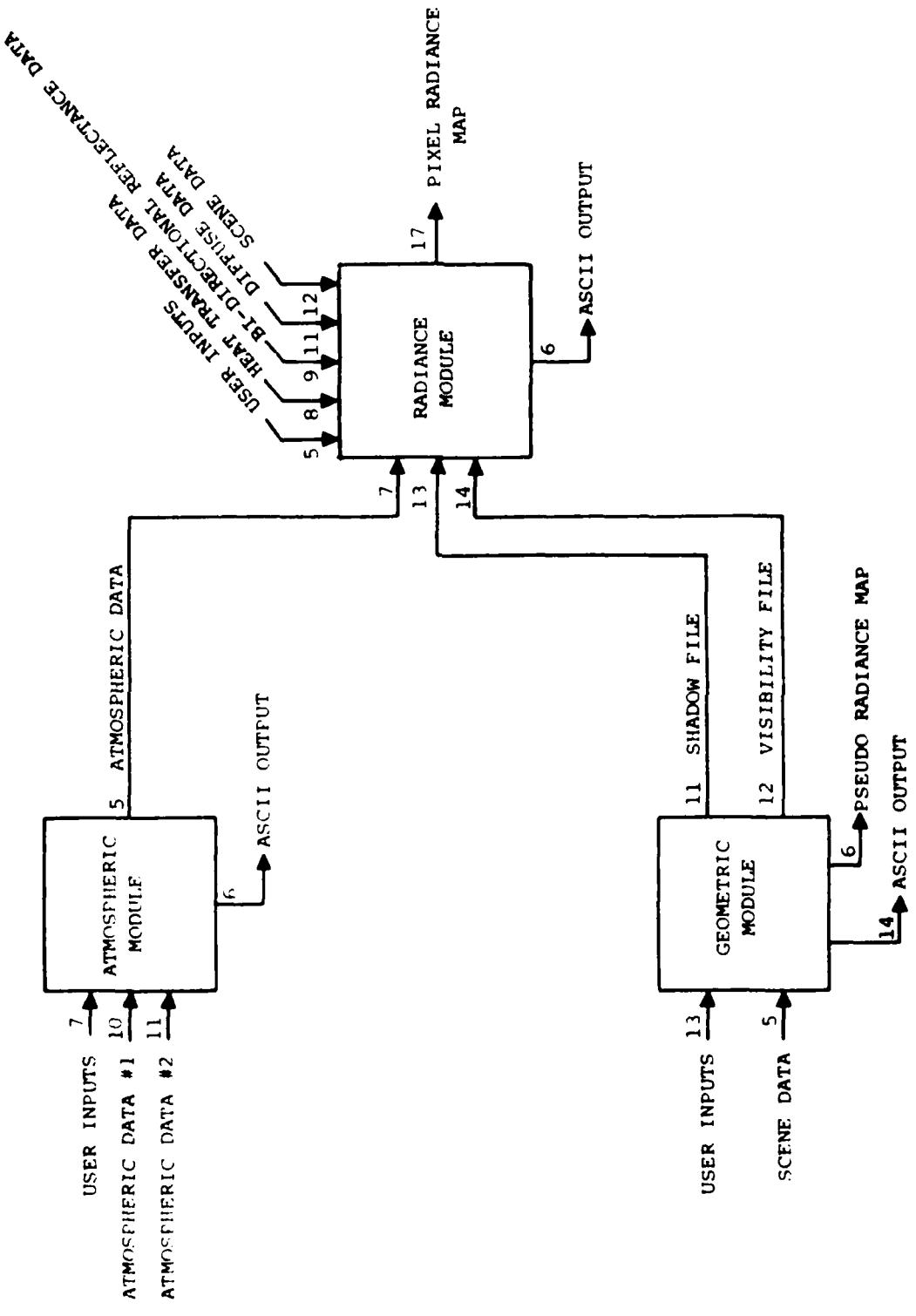
Figure 2. Overall Input/Output File Interaction. Numbers are Fortran
Unit Numbers. See Section 6 for More Detail

See Section 6 for a detailed discussion of the user specified inputs.

2.4 Scene Data Base Inputs

Scene data inputs consist of the altitude, material type pairs plus thermal, atmospheric and reflectance data. The elements of these inputs are:

1. Material thermal properties (solar absorptance, thermal emittance, thermal conductance and thermal mass) required by the heat transfer module,

2. Material in-band diffuse reflectance,

3. Cloud in-band bi-directional reflectance,

4. Surface level atmospheric properties (temperature, wind speed and humidity).

A detailed discussion of the scene data base is given in Section 4.

3.0 MODULE DESCRIPTION

3.1 Atmospheric Module

The atmospheric module performs a parametric analysis of a selected standard atmosphere which is primarily a function of spectral bandpass and observer altitude. Four in-band parameters are computed. These are reflected solar, reflected skyshine, path radiance and path transmission.

The reflected components are apparent values, having been attenuated spectrally along the observer's line-of-sight path. Path transmission and path radiance are computed for the path from the surface to the observer. For the reflected components, the atmospheric module calculates spectrally for the path from source to surface to observer. The spectral data are then integrated over wavelength to produce a single in-band value for the entire path.

In order to reduce the long-term costs associated with the computation of atmospheric parameters, and to provide the necessary computational flexibility, it is desirable to have the atmospheric parameters functionally related to altitude. Early investigations showed that these parameters could be represented by polynomials over the altitude range from 0 to 10 km.

Parameters are calculated parametrically for a series of zenith angles and altitudes. At each altitude a polynomial fit versus air mass is computed and stored for reflected solar, path transmission and path radiance. For skyshine, polynomial fits are stored as a function of altitude only. From this data base, polynomial fits versus altitude for each of the four atmospheric parameters are produced for any given solar and observer position.

Since the reflected solar component is also a function of the solar zenith angle, an additional series of cases and curve fits are required to completely describe this parameter.

The coefficients of these curve fits are written to file for use by the radiance module. This output file covers all observer and solar zenith angles and need not be remade unless the bandpass, model atmosphere, observer altitude or atmospheric conditions are changed. Curve fit diagnostics are generated in order to monitor the quality of the polynomial fits.

The atmospheric module utilizes a PRA developed code which is based on LOWTRAN that properly computes reflective or "bent path" atmospheric values.

Figure 3 is a flow diagram of the atmospheric module. Figures 4-7 illustrate sample atmospheric module outputs for the following conditions:

Atmosphere:	Subarctic Summer
Observer Altitude:	100 km
Observer Zenith Angle:	0 degs

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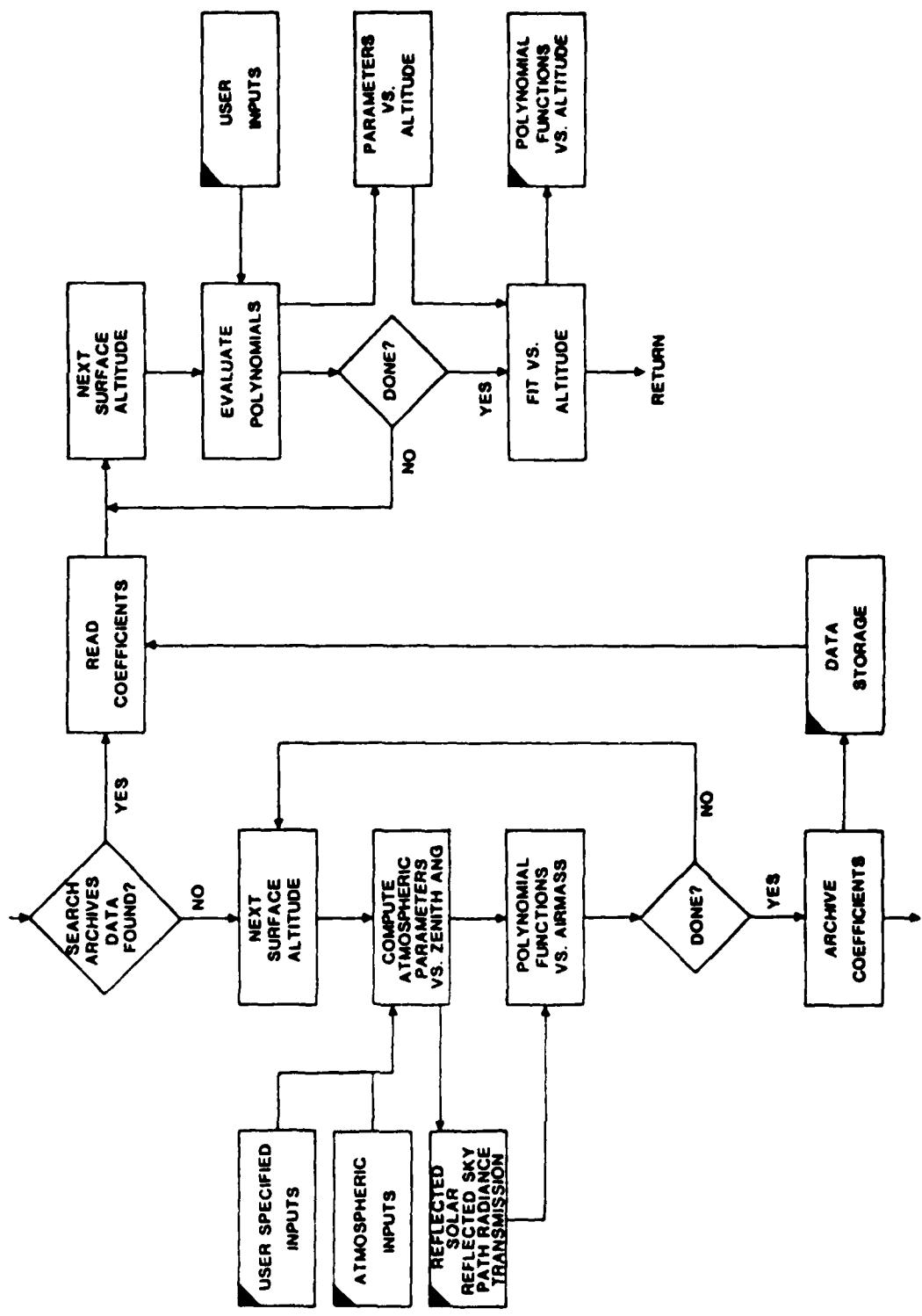
Figure 3. Atmospheric Module
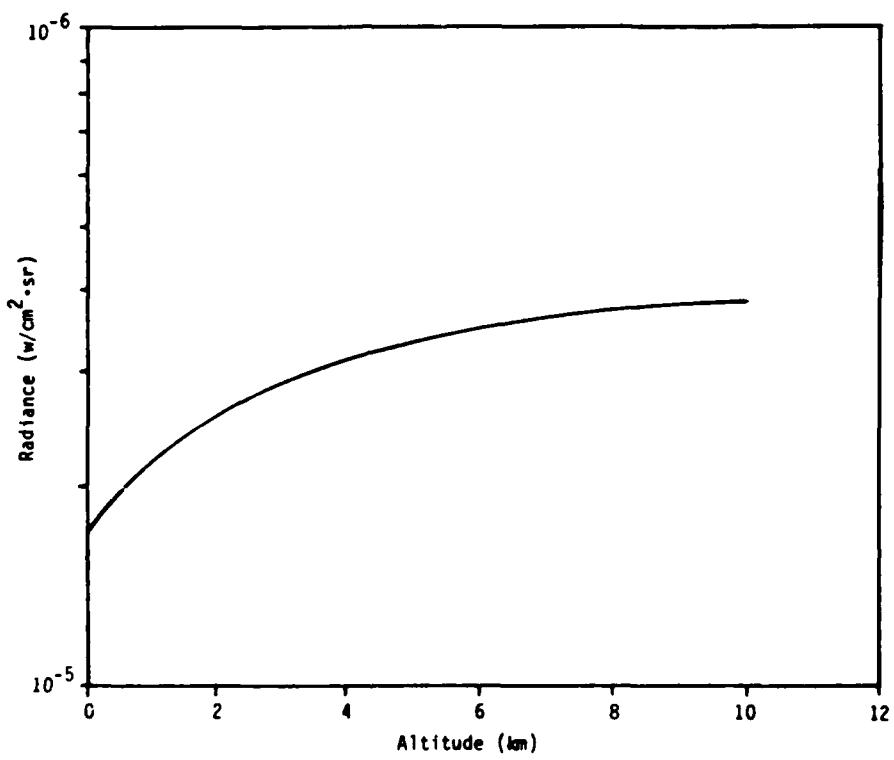
Figure 4. Apparent Reflected Solar Radiance
Versus Altitude

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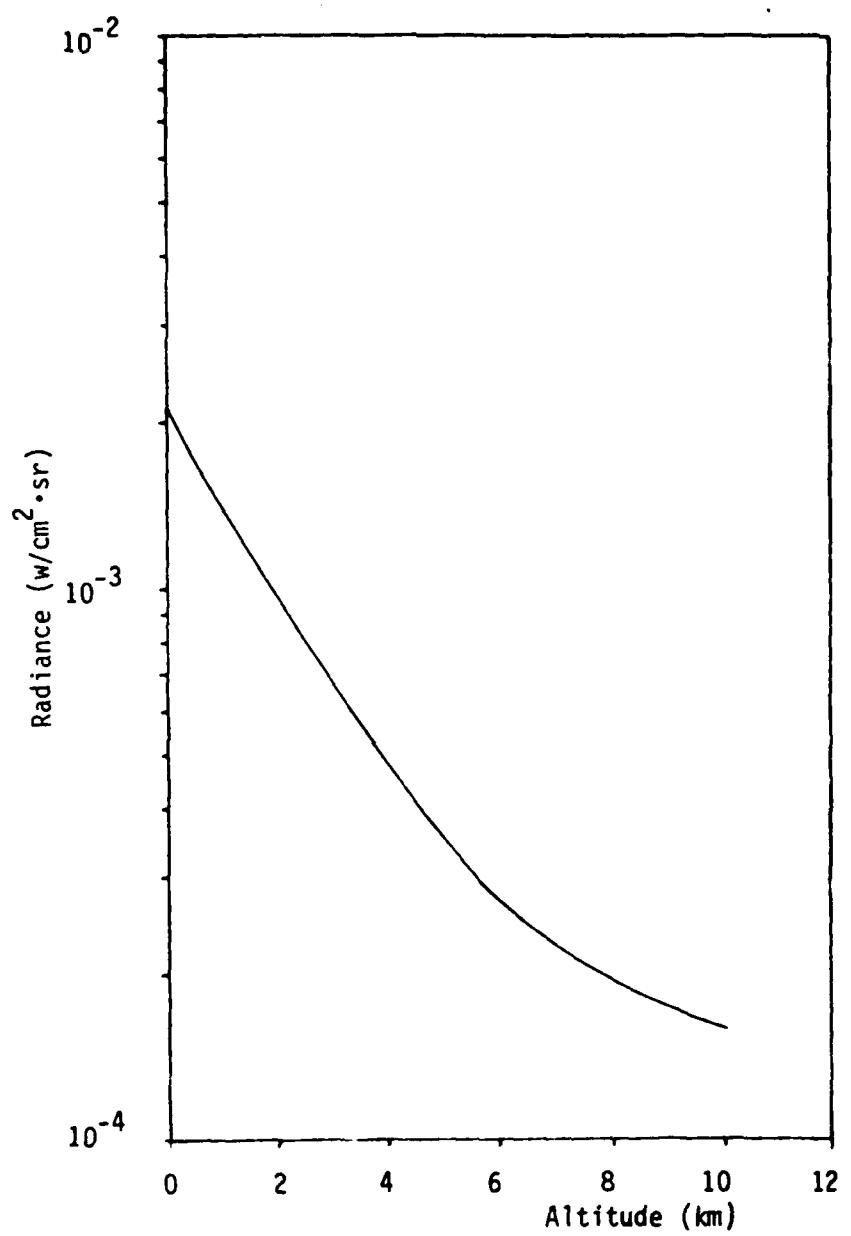
Figure 5.   Skyshine Apparent Radiance
Versus Altitude
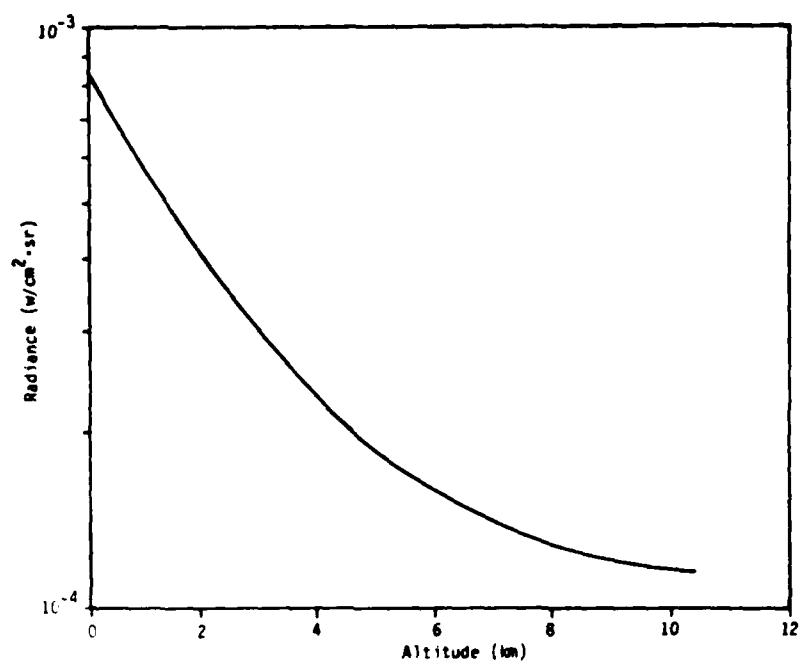
Figure 6.   Path Radiance Versus Altitude (Km)
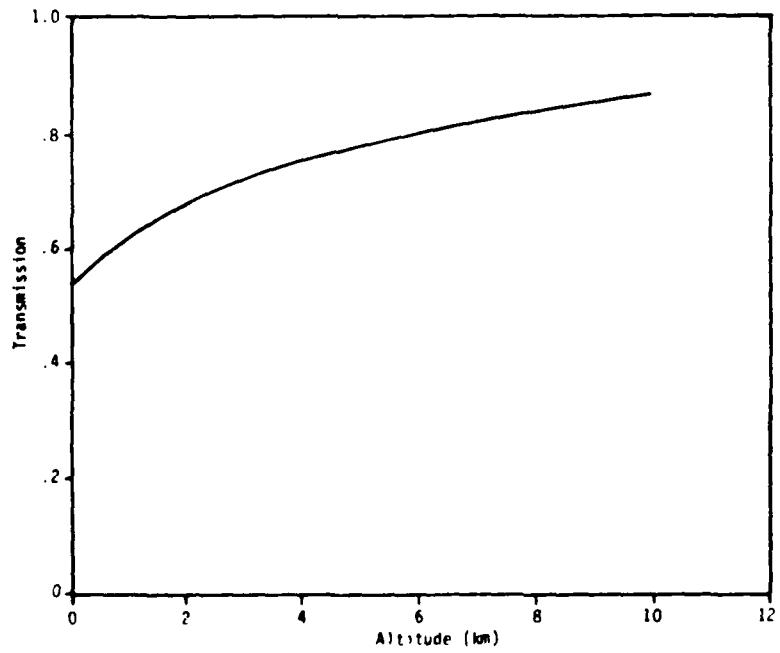
Figure 7.   Path Transmission Versus Altitude

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Sun Zenith Angle: 64 degs

Band: 7.5-12.0 μm

3.2 Geometry

The geometric module supplies information regarding the visibility, orientation and projection of scene radiance grid points. It creates a high resolution altitude map by bi-cubic spline interpolation on a DMA data base. For each interpolated point it provides the following information:

- Point in shadow or in sun,

- Point visible or not,

- Geometric information such as altitude, normal vector, direction cosines to the sun and to the observer,

- Material type.

All geometric calculations are based on an earth-centered Cartesian coordinate system.

Surfaces and normal vectors are produced from the scene data using the bi-cubic spline fitting technique. In the event grid points are required at a higher resolution than the scene input data, they are generated from the spline-fit produced surfaces. The interpolation forms a bi-cubic patch for each grid rectangle in the data base. This rectangle is evenly divided into a sub-grid of predetermined size. The bi-cubic spline is evaluated at each of these sub-grid points. For more detailed information, see: A. R. Forrest, "On Coons' and Other Methods for the Representation of Curved Surfaces," Computer Graphics and Image Processing (1972) 1 (pp 341-359).

The visibility and shadowing of each grid point is determined using a hidden line masking technique. This is done by slicing the high-resolution data base along grid-lines, so that these slices are approximately perpendicular to the line of sight. A point is visible if the line of sight from the sensor to the point does not intersect an intervening surface. The same criterion is used for the shadowing determination. The scene is processed twice, once for the observer and once for the sun.

Shadowing and visibility information are stored in intermediate files. During the radiance calculation, these files are used to decide if the interpolated points are visible and whether they receive solar illumination. Points not visible to the observer are ignored. Points not seen by the sun are in shadow and are treated accordingly by the radiance module. The hidden line masking technique is illustrated in Figures 8-10. Projection of each point into the observer's image plane completes the primary tasks of the geometric module. The module is diagrammed in Figure 11.
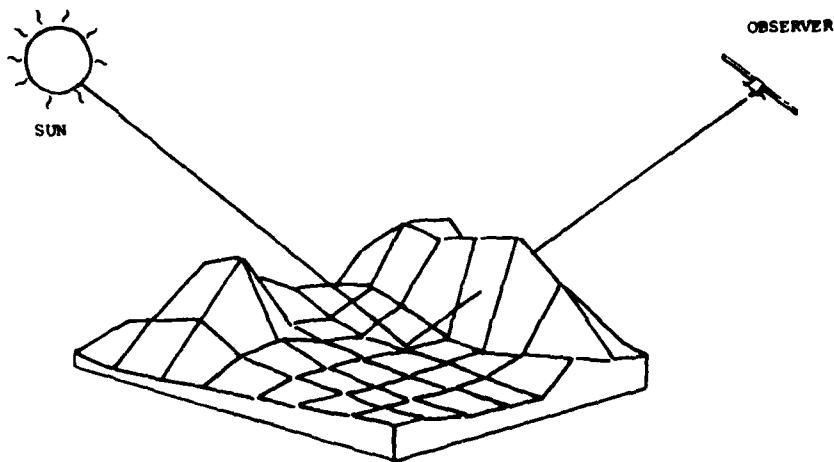
Figure 8. Schematic Demonstration of Geometric Module Procedure. Grid is the Interpolated Scene Data Base, i.e., "Radiance Grid Points". Example is for Radiance Point (I,J) which is Not Visible by the Observer but Illuminated by the Sun

SCENE IS SLICED ALONG GRID LINES IN ONE OF TWO DIRECTIONS. A RADIANCE POINT IS VISIBLE IF AND ONLY IF THERE IS A CLEAR LINE OF SIGHT FROM THE OBSERVER TO POINT. IN THIS EXAMPLE, THE POINT IS NOT VISIBLE.
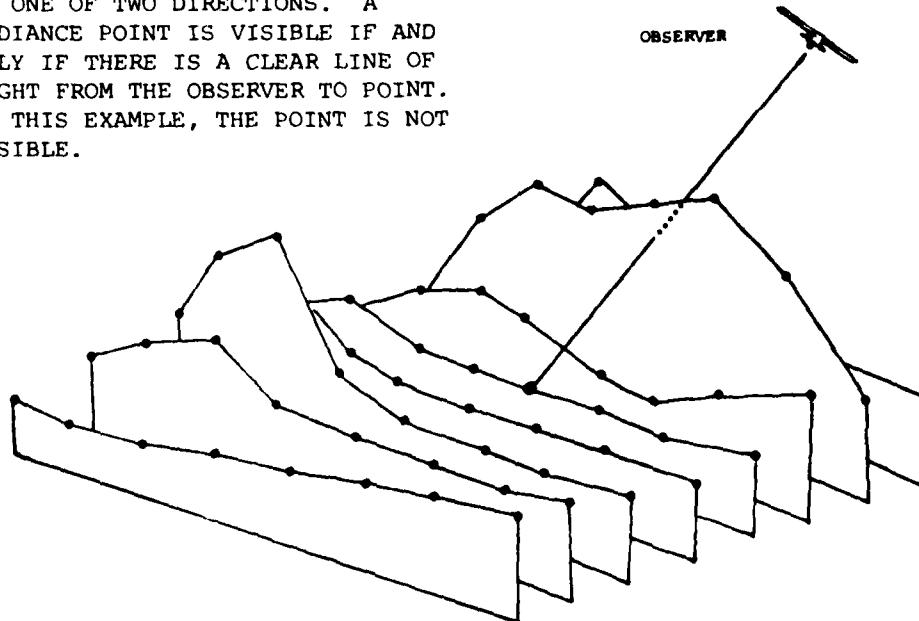
Figure 9. Example of Hidden Line Masking Technique Used to Determine Visibility of Radiance Grid Point (I,J). Scene Sliced for Observer

A RADIANCE POINT IS ILLUMINATED
BY THE SUN IF THERE IS A CLEAR
LINE OF SIGHT FROM THE SUN TO THE
POINT. IN THIS EXAMPLE THE POINT
IS ILLUMINATED BY THE SUN.
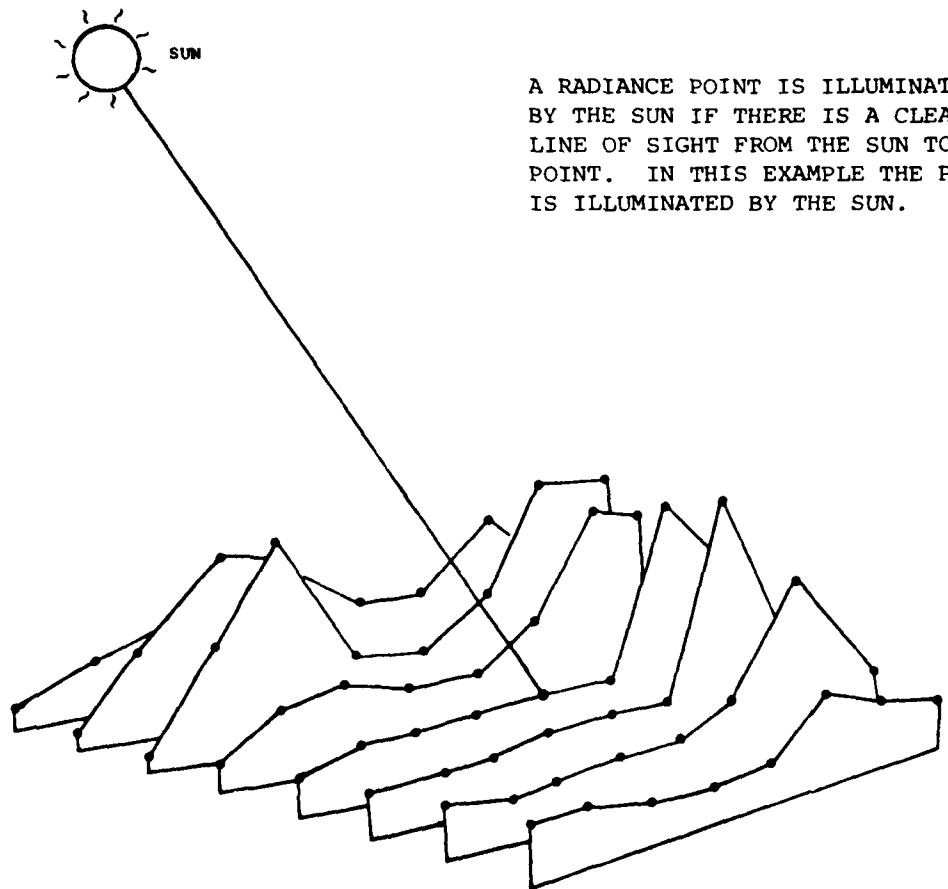
Figure 10. Example of Hidden Line Masking Technique
Used to Determine Shadowing of Point (I,J)
Scene Sliced for Sun
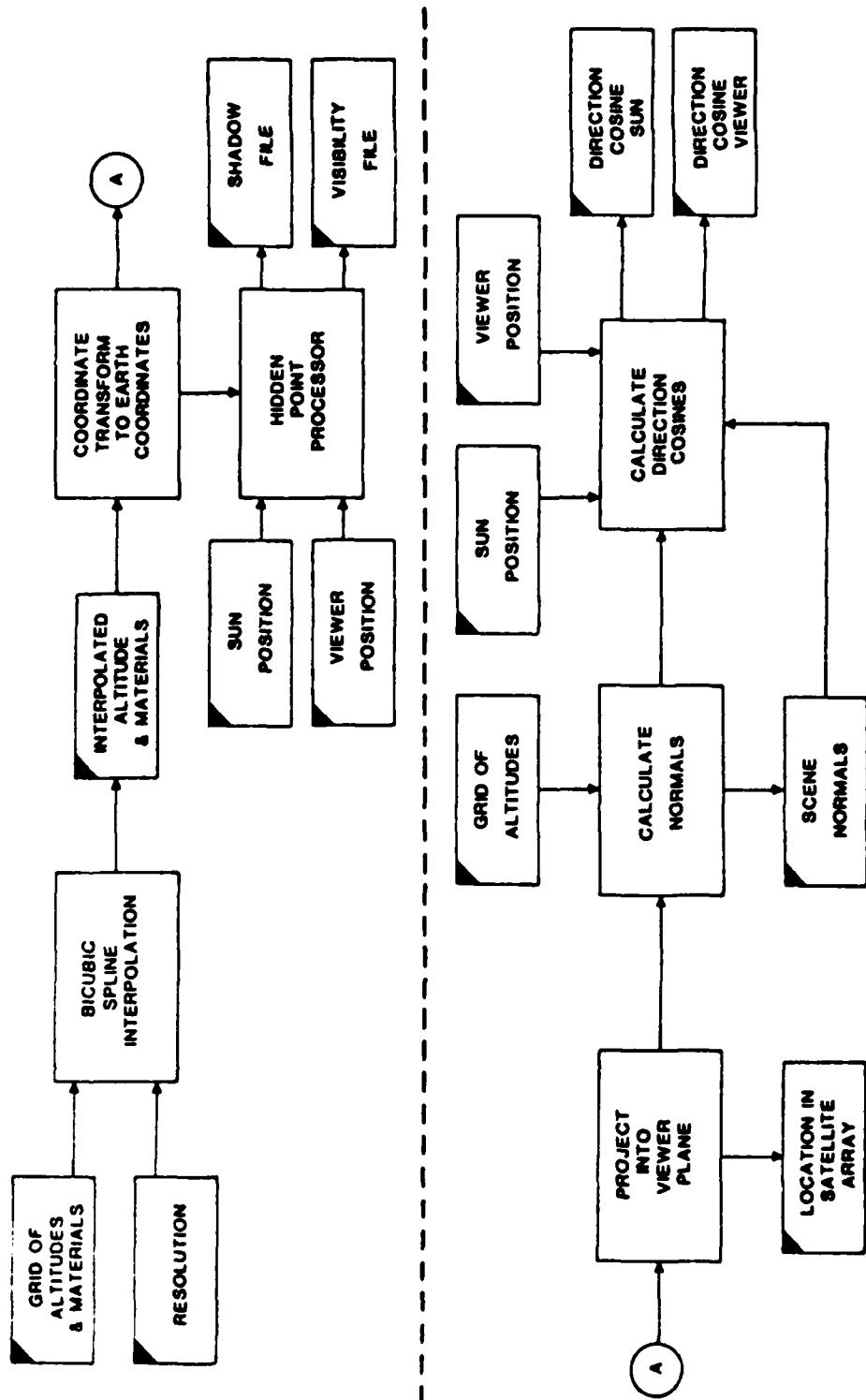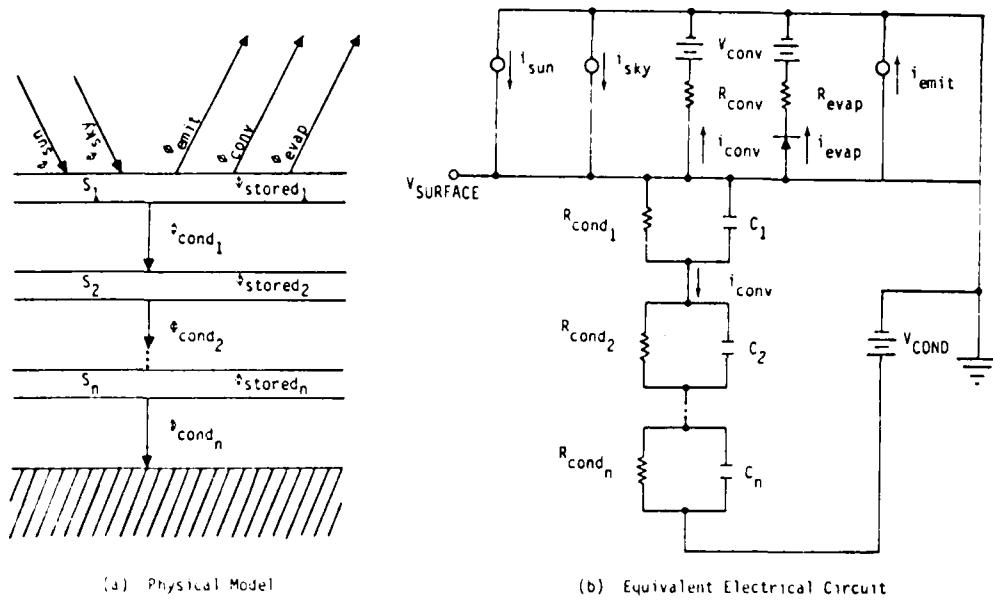
Figure 11. Geometric Module

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3.3 Heat Transfer

Surface temperature is determined by the energy fluxes and thermal prop-
erties of the surface. The fluxes considered in the model are those resulting
from solar irradiance, sky irradiance, convection to the air, self-emitted
radiation, latent heat flux due to evaporation of surface moisture,* and the
distributed flux through the material to a substrate. The heat balance solu-
tion of the dynamic surface temperature employs two simplifying assumptions.
These are that the lateral heat flux at the surface is zero, and that the
distributed heat flux to the substrate can be calculated using n discrete
layers, the lowest of which is adjacent to a diurnally constant subsurface.
The result and physical model and its equivalent electrical circuit are given
in Figure 12.

(a) Physical Model   (b) Equivalent Electrical Circuit

FLUX DEFINITION

ϕ_{sun}	= solar irradiance	ϕ_{evap}	= surface evaporation
ϕ_{sky}	= sky irradiance	ϕ_{stored}	= layer stored
ϕ_{emit}	= emission	ϕ_{conv}	= air convection
		ϕ_{cond}	= substrate conduction

Figure 12. Surface Temperature Heat Balance Model.

_____

*For GENESSIS I heat transfer due to evaporation is neglected, i.e.,
ϕ_{evap} = 0.

The heat balance equation for the physical model is

$$\phi_{sun} + \phi_{sky} + \phi_{stored} = \phi_{conv} + \phi_{evap} + \phi_{emit} + \phi_{cond} \tag{1}$$

All fluxes are in units of W/m^2 and all vary with time. Each of these fluxes is expressed as follows.

The solar irradiance flux, ϕ_{sun}, is calculated by

$$\phi_{sun} = \alpha(s) E_{sun}(h,t) \cos\zeta(t) \tag{2}$$

where

$\alpha(s)$ is the effective solar absorptance,

$\zeta_{(t)}$ is the time dependent angle between the vector to the sun and the surface normal vector, and

$E_{sun}(h,t)$ is the time dependent total solar irradiance at the surface.

The solar irradiance at the surface is given by

$$E_{sun}(h,t) = E_{sun,\Psi_o}(h) \cdot f(\Psi(t)) \tag{3}$$

where $E_{sun,\Psi_o}(h)$ is the zenith total solar irradiance as a function of surface altitude, h, and $f(\Psi(t))$ is a factor to correct for increasing atmospheric attenuation with increasing time variant solar zenith angle $\Psi(t)$.

The sky irradiance flux, ϕ_{sky}, is computed from the Idso-Jackson formula

$$\phi_{sky} = \alpha(L)\sigma T_a^4 \left\{ 1 - .261 \exp \left[-7.77 \times 10^4 (273 - T_a)^2 \right] \right\} \tag{4}$$

where

σ is the Stephan-Boltzmann constant, $5.6687 \times 10^{-8} W/m^2 \cdot {}^\circ K$,

T_a is the ambient air temperature, and

$\alpha(L)$ is the effective thermal absorptance.

The convective flux to the atmosphere is computed by

$$\phi_{conv} = \rho cDW(T - T_a) \tag{5}$$

where

     is the ambient air density,

c   is the specific heat of dry air,

D   is the drag coefficient, empirically determined from ground truth data ranging from 0.002 to 0.01 depending upon the material,

W   is the wind speed factor, equal to $1+V_w$ where V_w is the wind speed in m/sec, and

T   is the surface temperature.

The latent heat flux is computed by

$$\Phi_{evap} = 0.622\rho DWe(v-v_a)/P_a \qquad (6)$$

where

e   is the latent heat of evaporation,

v   is the water vapor pressure at the surface,

v_a is the water vapor pressure of the air, and

P_a is the atmospheric pressure.

If v_a is larger than v, Φ_{evap} is set equal to zero.

The emitted flux is computed by

$$\Phi_{emit} = \epsilon(L)\ \sigma\ T^4 \qquad (7)$$

where $\epsilon(L)$ is the effective thermal emittance, set equal to $\alpha(L)$ in Equation (4).

The conductance flux to the substrate is computed by

$$\Phi_{cond} = g\ (T-T_s)$$

where g is the conductance to the substrate, equal to $\ell_s \cdot K$ where ℓ_s is the depth at which the soil is diurnally constant and K is the soil conductivity, and T_s is the substrate temperature.

The stored flux in the surface layer is computed by

$$\Phi_{stored} = \ell_o C\ \ T(t+\Delta t) - T(t)\ \ /\Delta t \qquad (8)$$

where

ℓ_o is the layer thickness,

C   is the heat capacity of the surface material, and

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ΔT   is the time increment.

The solution for the surface temperature T is achieved using an inter-active method wherein the surface temperature is initially chosen as the ambient air temperature at midnight, and the heat balance equation is itera-tively evaluated in time increments Δt (usually set equal to 30 minutes). This iteration is continued until successive diurnal cycles match, commonly occurring within three days.

This procedure is used to produce a data base for selected materials within the scene. The data base consists of temperature and four indepen-dent variables. All independent variables are varied over a sufficient range so as to bracket all conditions that may be encountered in the scene. These independent variables are:

1.   Peak solar irradiance,

2.   Air-surface convective flux,

3.   Substrate-surface conductive flux, and

4.   Time.

The data base is compressed using a technique by which only the j most informative time points are retained of the i that were calculated. This results in a significant reduction in size of the data base (i usually 48, j/i usually 1/6) with little reduction in accuracy. The stored data base consists of four values of solar irradiances, four values of convective flux, three values of conductive flux and eight values of solar elevation angle (radians).

The heat transfer module contains data for 9 materials of the 14 total materials within GENESSIS I (see Appendix 2). The 14 materials are:

GENESSIS Material Numbers	Material
1*	Water
2*	Forest (Broadleaf)
3	Irrigated Low Vegetation
4	Scrub
5	Urban Commercial
6	Sand
7*	Ice
8	Rock
9	Soil
10	Grass
11*	Clouds
12	Asphalt
13	Urban Residential
14*	Forest (Pine)

---

*Heat transfer calculations are not performed on materials 1, 2, 7, 11 and 14.

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Surface temperatures for the 5 remaining materials (i.e., 1, 2, 7, 11 and 14) are set equal to the local ambient air temperature.* Ambient air temperature varies with altitude and is computed from the user specified sea level air temperature and the atmospheric lapse rate. The lapse rate is approximately linear for each of the six standard model atmospheres between 0-10 km. The least-squares lapse rates used by GENESSIS I are given in Figures 13-18.

To perform a GENESSIS execution the user must specify the local air temperature and the subsoil temperature. Monthly mean temperatures are good first-order approximations to the subsoil temperature. These data are given in Tables 1-4 for each of the five generic scenes provided with GENESSIS I.

3.4 Radiance Module

The radiance module computes observer apparent pixel radiances from the viewer-perspective shadow files created by the geometric module. If it is visible, an apparent radiance is computed for each of the grid points generated by the geometric modules' bi-cubic spline fit to the scene data. Pixel radiances are computed from these individually calculated grid point radiances. The apparent radiance of a specific grid point is composed of four terms combined additively. These include reflected solar, thermal emission, reflected skyshine and path radiance.

3.4.1 Reflected Solar

The apparent reflected solar component is

$$N_{solar} = \rho \, \Phi_{solar}(h) \cos \Theta$$

where

ρ = surface in-band diffuse reflectance (bi-directional reflectance for clouds),

$\Phi_{solar}(h)$ = computed fit to apparent reflected solar versus altitude (supplied by atmospheric module),

h = surface altitude in km, and

Θ = local sun zenith angle (the angle between the vector to the sun and the surface normal).

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* For ice, the temperature cannot exceed 0°C.
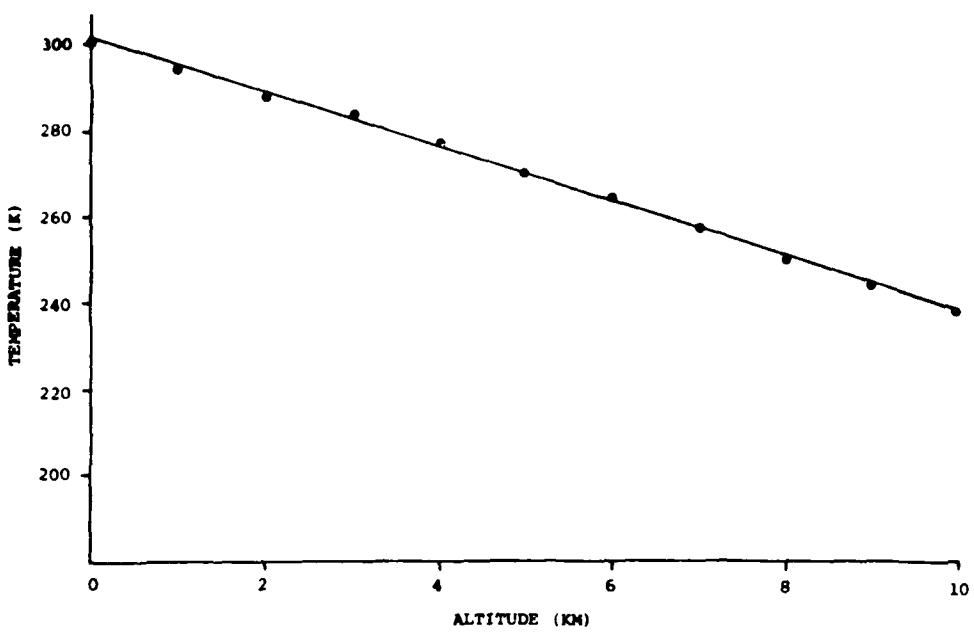
Figure 13. Tropical Model Atmosphere Lapse Rate
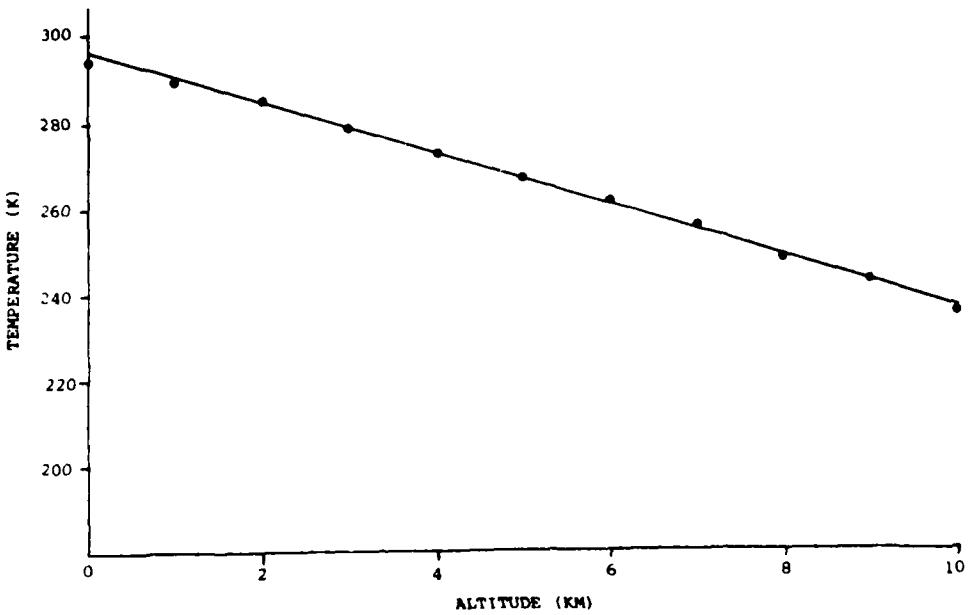
Figure 14. Midlatitude Summer Model Atmosphere Lapse Rate

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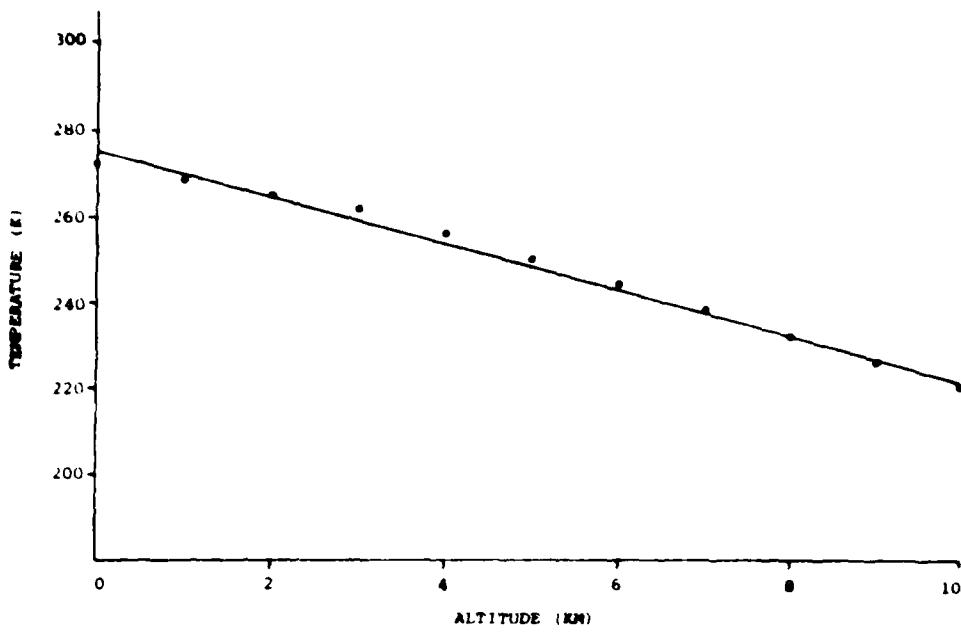
Figure 15. Midlatitude Winter Model Atmosphere Lapse Rate
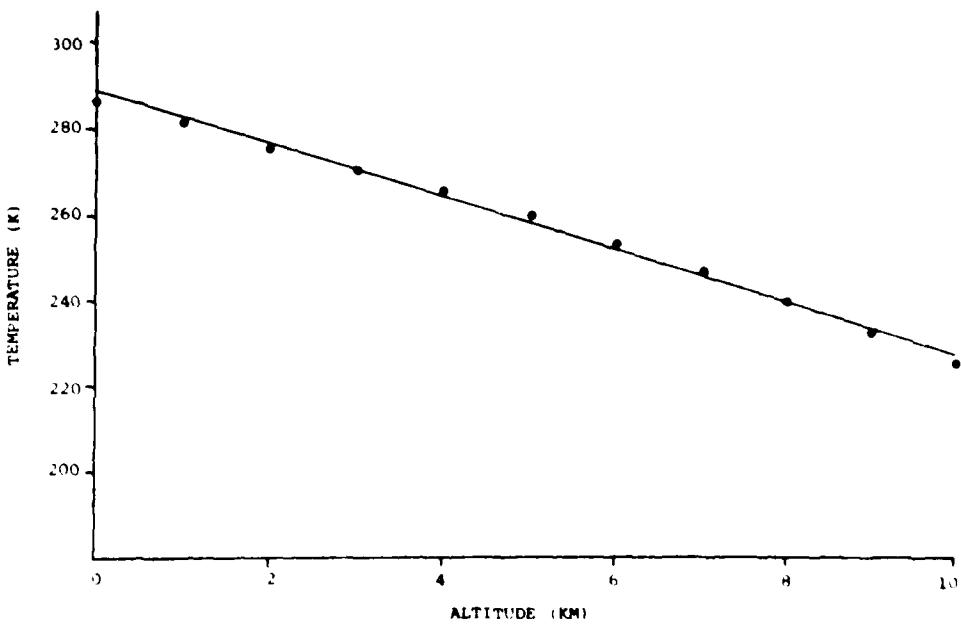
Figure 16. Subarctic Summer Model Atmosphere Lapse Rate
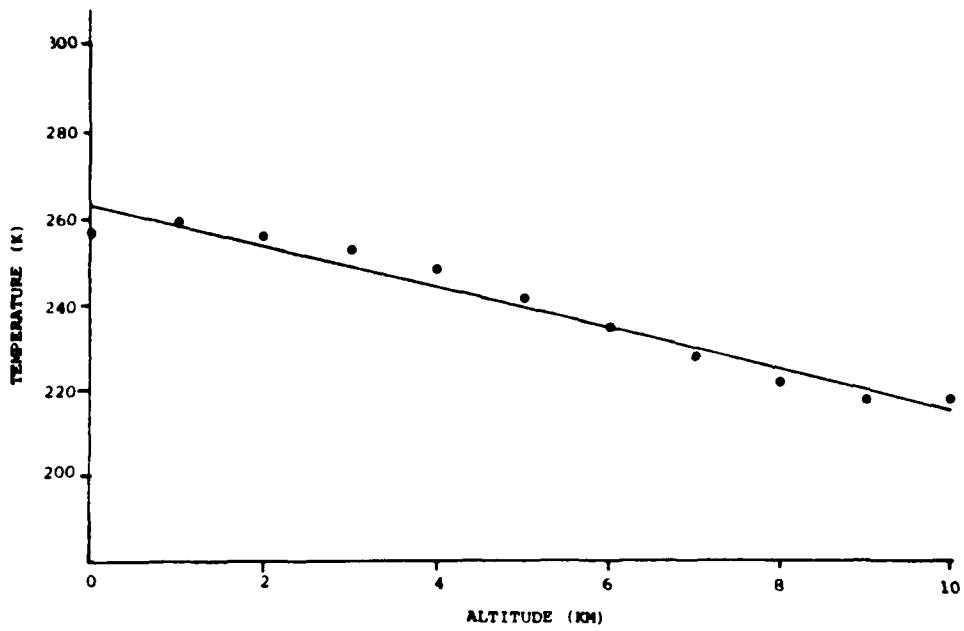
Figure 17. Subarctic Winter Model Atmosphere Lapse Rate
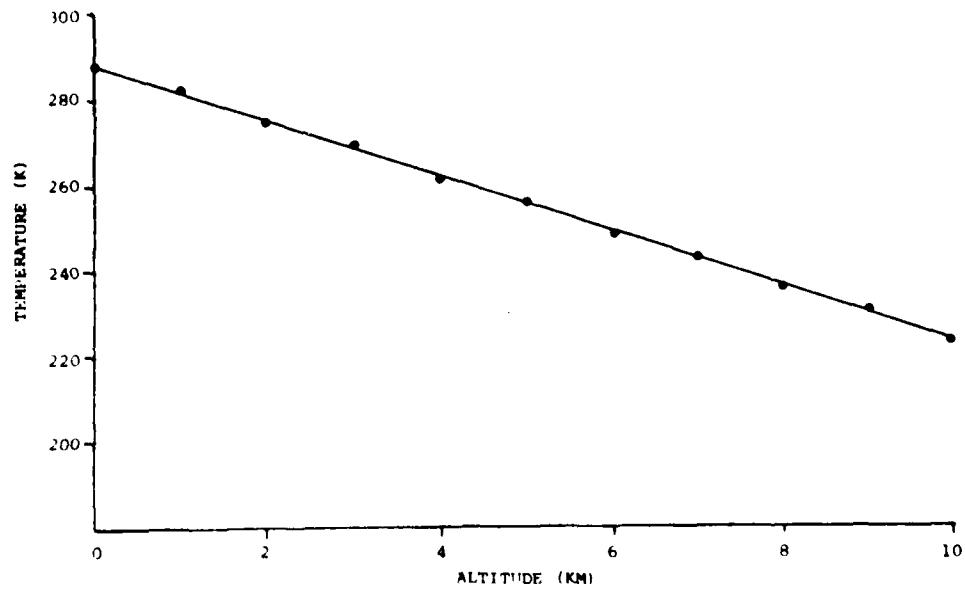
Figure 18. U.S. Standard 76 Model Atmosphere Lapse Rate

Table 1. Sea Level Air Temperature Data for
Brooks Range Scene.

Month	Temp (K)	Variance
1	260.5	33.9
2	260.2	36.0
3	262.7	41.6
4	266.2	38.2
5	270.7	31.9
6	275.2	23.9
7	277.8	22.2
8	276.9	21.8
9	274.2	21.2
10	269.6	27.0
11	265.4	30.8
12	262.6	30.0

Table 2. Sea Level Air Temperature Data for
Arctic Tundra Scene.

Month	Temp (K)	Variance
1	258.4	54.0
2	260.5	54.9
3	268.5	39.8
4	276.4	52.3
5	283.5	46.4
6	288.9	39.6
7	292.5	28.4
8	290.1	29.8
9	284.6	38.8
10	276.2	40.0
11	268.0	48.5
12	262.8	46.4

Table 3. Sea Level Air Temperature Data for
          Central Europe Scene.

Month	Temp (K)	Variance
1	278.2	20.5
2	277.7	18.7
3	279.5	17.8
4	280.9	16.2
5	283.3	14.2
6	286.0	13.2
7	287.9	12.3
8	287.9	11.3
9	286.4	11.7
10	284.3	14.2
11	280.4	18.6
12	278.9	17.2

Table 4. Sea Level Air Temperature Data for
          Middle East and California Coast Scenes.

Month	Temp (K)	Variance
1	286.6	37.1
2	287.6	39.3
3	290.3	34.7
4	293.1	38.1
5	296.8	35.6
6	298.9	33.6
7	299.7	33.4
8	299.6	33.4
9	298.0	42.5
10	295.5	39.5
11	291.7	39.2
12	287.2	37.4

3.4.2 _Thermal Emission_

The thermal emission component is given by

$$N_{thermal} = \varepsilon \, \tau(h) \int_{\lambda_1}^{\lambda_2} N(\lambda, T_s) d\lambda$$

where

ε = surface emissivity,

ρ = surface in-band diffuse reflectance $(1-\varepsilon)$,

$\tau(h)$ = computed fit to path transmission versus altitude (supplied by the atmospheric module),

h = surface altitude in km,

λ_1, λ_2 = beginning and ending band wavelengths in μm,

$N(\lambda, T_s)$ = Planck function, and

T_s = equilibrium surface temperature in Kelvins (supplied by the heat transfer module).

3.4.3 Reflected Skyshine

The apparent reflected skyshine component is given by

$$N_{sky} = \rho \, \phi_{sky}(h)$$

where

ρ = surface in-band diffuse reflectance,

$\phi_{sky}(h)$ = computed fit to apparent reflected skyshine versus altitude (supplied by the atmospheric module), and

h = surface altitude in km.

3.4.4 Path Radiance

Path radiance is given by

$$N_{path} = \phi_{path}(h)$$

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where

Φ_{path} (h) = computed fit to path radiance versus altitude (supplied by the atmospheric module), and

h = surface altitude in km.

The total apparent surface radiance returned by the radiance module for a single grid point is

$$N(i) = N_{sol}(i) + N_{sky}(i) + N_{emis}(i) + N_{path}(i)$$

where

N = total apparent grid point radiance $(w/cm^2/sr)$,

N_{sol} = apparent reflected solar radiance $(w/cm^2/sr)$,

N_{sky} = apparent reflected skyshine radiance $(w/cm^2/sr)$,

N_{emis} = apparent thermal radiance $(w/cm^2/sr)$, and

N_{path} = observer's path radiance $(w/cm^2/sr)$ per the ith grid point.

Two additional calculations are made by the radiance module. These are the total (over all wavelengths) solar and skyshine irradiances required by the heat transfer module.

The total surface solar irradiance was approximated utilizing LOWTRAN 5 path transmissions computed spectrally at 20 cm^{-1} resolution in the 0.25 to 4.0 μm region (nearly 99% of the sun's total exoatmospheric irradiance is emitted between 0.25 and 4.0 μm) and a blackbody the size, distance and effective temperature of the sun. Exoatmospheric irradiance is attenuated spectrally and integrated over wavelength to yield the total surface solar irradiance.

Total diffuse sky irradiance is computed from a pressure compensated Idso-Jackson formulation.

Functional relations between solar and diffuse sky irradiance and altitude are computed off-line and are stored as data for each of the six standard atmospheres. The radiance module is diagrammed in Figure 19. Figures 20, 21 illustrate the functional relation between solar and diffuse sky irradiances and altitude.

Diffuse reflectance data for 11 of the 14 materials are given in Table 5. For any user-specified spectral band an average value is calculated by GENESSIS. Reflectance data for urban (commercial and residential) are composites of asphalt, irrigated low vegetation and forest. Reflectance data for clouds are bidirectional data and are given in Appendix 2.
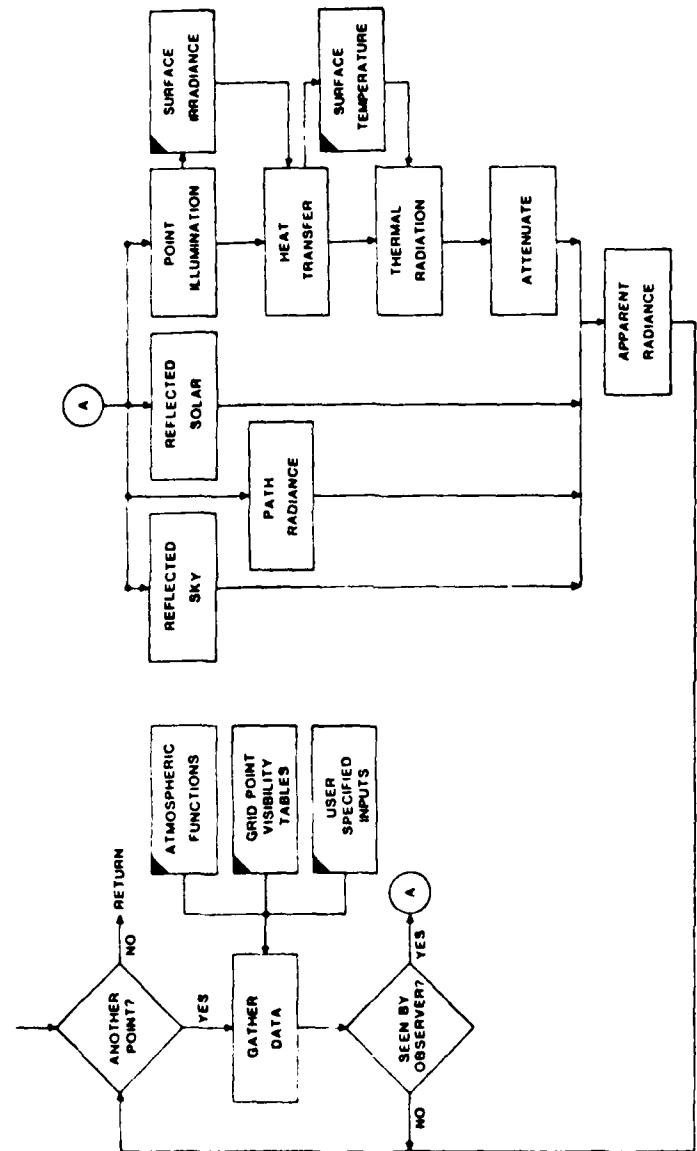
Figure 19.   Radiance Module

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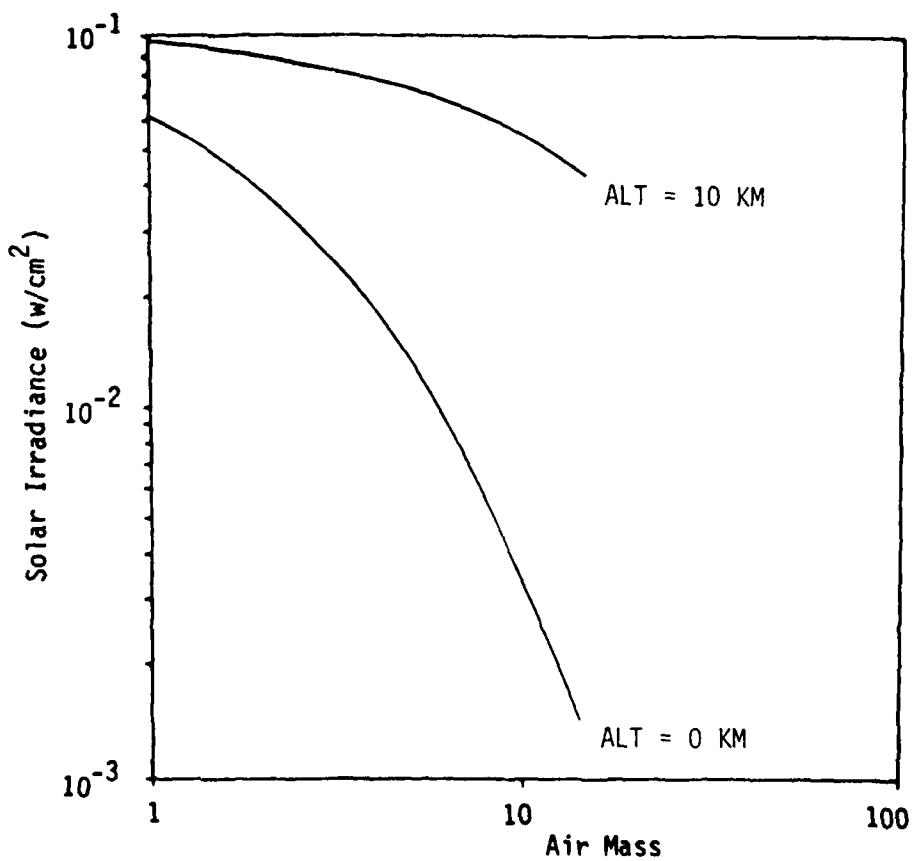
Figure 20. Solar Irradiance Versus Air Mass for Standard
Atmosphere Computed at 20 cm^{-1} Resolution
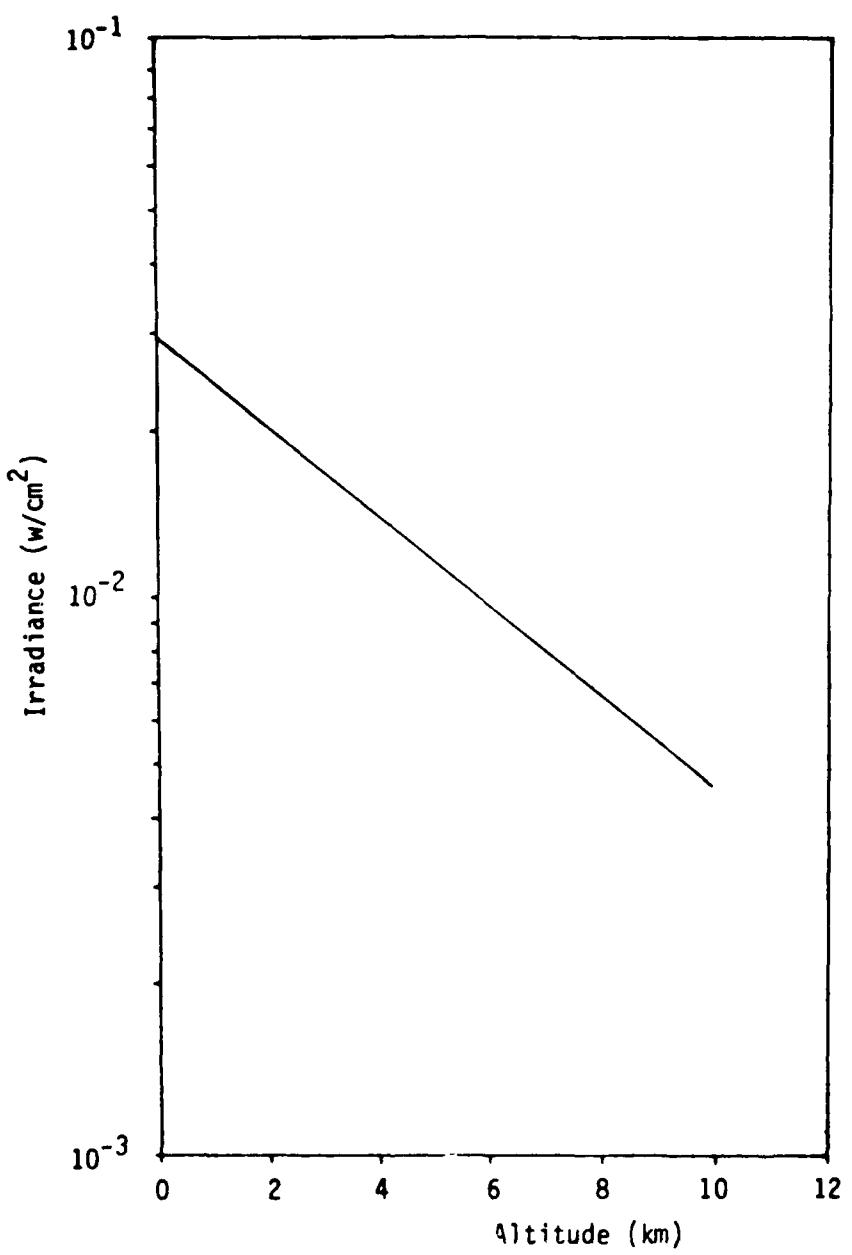
Figure 21.   Pressure Compensated Idso-Jackson Total
Diffuse Sky Irradiance Versus Altitude
for U.S. Standard Atmosphere

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Table 5. Spectral Reflectance of Terrestrial Materials (%)

GENESSIS NUMBER	MATERIAL	WAVELENGTH (μm)																								
		.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.0	12.0	13.0	14.0	15.0
1	WATER[1]	1	3	2.5	2	1.9	1.8	1.5	1.2	2	1.8	1.6	1.7	1.6	1.8	1.6	1.7	1.6	1.5	1.3	1.0	0.8	1.2	2.5	3.5	4.5
2	FOREST (BROADLEAF)[2]	10	7	10	10	12	13	15	13	8	9	2	8	8	8	8	8	8	10	16	9	8	8	7	8	10
3	VEGETATION (Low Irrigated)[2]	2	2	2	3	4	2	2	4	4	3	2	2	2	2	2	2	2	2	2	3	4	3	2	1	1
4	SCRUB[3]	28	4	16	13	17	17	13	5	4	4	4	5	4	4	3	2	2	2	1	1	2	5	5	2	2
6	SAND[1]	56	30	55	35	35	5	13	20	10	10	10	10	10	10	10	10	10	10	5	8	2	2	2	2	2
7	ICE[4]	1	5.0	3.0	2	1.5	1.2	1.6	1.0	1.0	1.0	1.6	1.0	1.0	1.0	1.6	1.0	1.0	1.0	0.8	0.7	2	4	5.5	5.5	5.0
8	ROCK[5]	5	10	8	12	18	7	5	7	8	5	4	5	4	4	3	5	11	13	14	12	5	3	2	2	2
9	SOIL[2]	36	3	8	15	14	13	10	9	10	7	4	6	4	3	2	4	3	4	5	4	3	2	2	1	1
10	GRASS (DRY MEADOW)[2]	35	8	11	20	26	25	25	9	10	7	4	4	6	4	4	5	6	8	15	15	13	10	9		
12	ASPHALT[1]	40	15	8	25	40	50	40	10	9	10	10	10	10	10	10	10	10	15	15	10	13	10	10		
14	FOREST (FINE)[3]	3	2	3	5	10	9	10	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1

REFERENCES

1. The Infrared Handbook, Environmental Research Institute of Michigan, Ann Arbor, MI, 1978.

2. Target Signature Analysis Center: Data Compilation, Infrared and Optical Sensor Laboratory, University of Michigan, Ann Arbor, MI, 1967.

3. The NASA Earth Resources Spectral Information System: Data Compilation, Infrared and Optical Sensor Laboratory, University of Michigan, Ann Arbor, MI, 1971.

4. Infrared Optical Properties of Water and Ice, International Journal of the Solar System, Vol. 8, 1968.

5. Infrared Reflectance Spectrum of Igneous Rocks, Journal of the Optical Society of America, Vol. 56, No. 5, 1966.

3.5 Imaging

A mean pixel radiance is computed for each pixel in the observer's image plane from the weighted sum of grid point apparent radiances projected into that pixel. That is,

$$\overline{N}_j = \frac{\sum\limits_{i=1}^{n} W_i N_i}{\sum\limits_{i=1}^{n} W_i}$$

where

$\overline{N}_j$ = mean apparent radiance of pixel j ,

n = number of radiance points projected into pixel j ,

W_i = weighting factor (equal $\cos \Theta_i$),

Θ_i = angle between surface normal and vector to sun, and

N_i = apparent radiance of grid point, and

i = denotes the individual grid points seen by the jth pixel.

The geometric module supplies both surface normal and projected grid point position in the observer's image plane. This produces an N x M viewer-perspective pixel apparent radiance map. The image module is diagrammed in Figure 22.

3.6 Code Structure Diagrams

Structure diagrams for the geometric, atmospheric and radiance modules are given in Figures 23-25. These diagrams depict the relationship between code subroutines and their heirarchy.
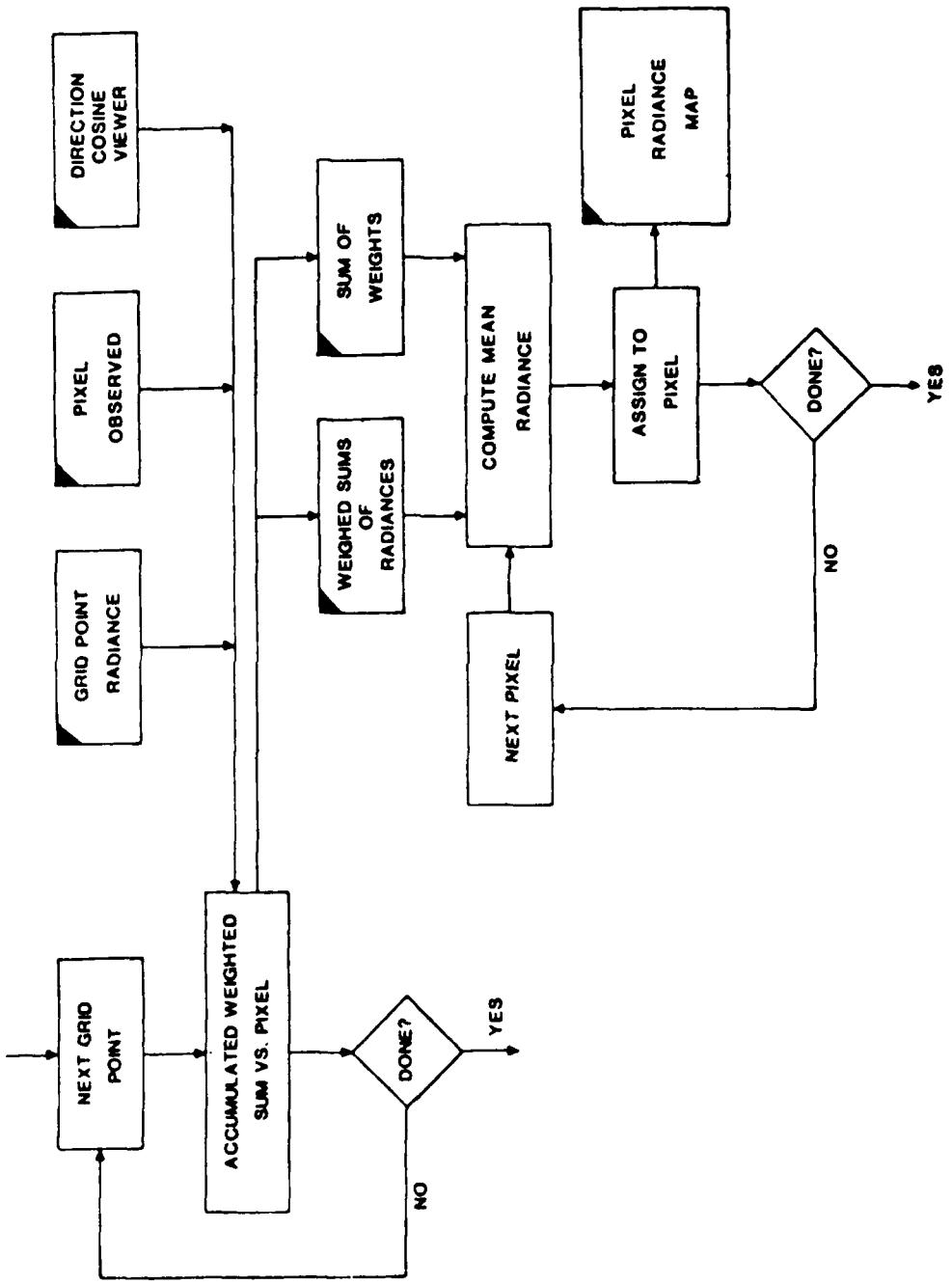
Figure 22. Image Module

Figure 23. Structure Diagram

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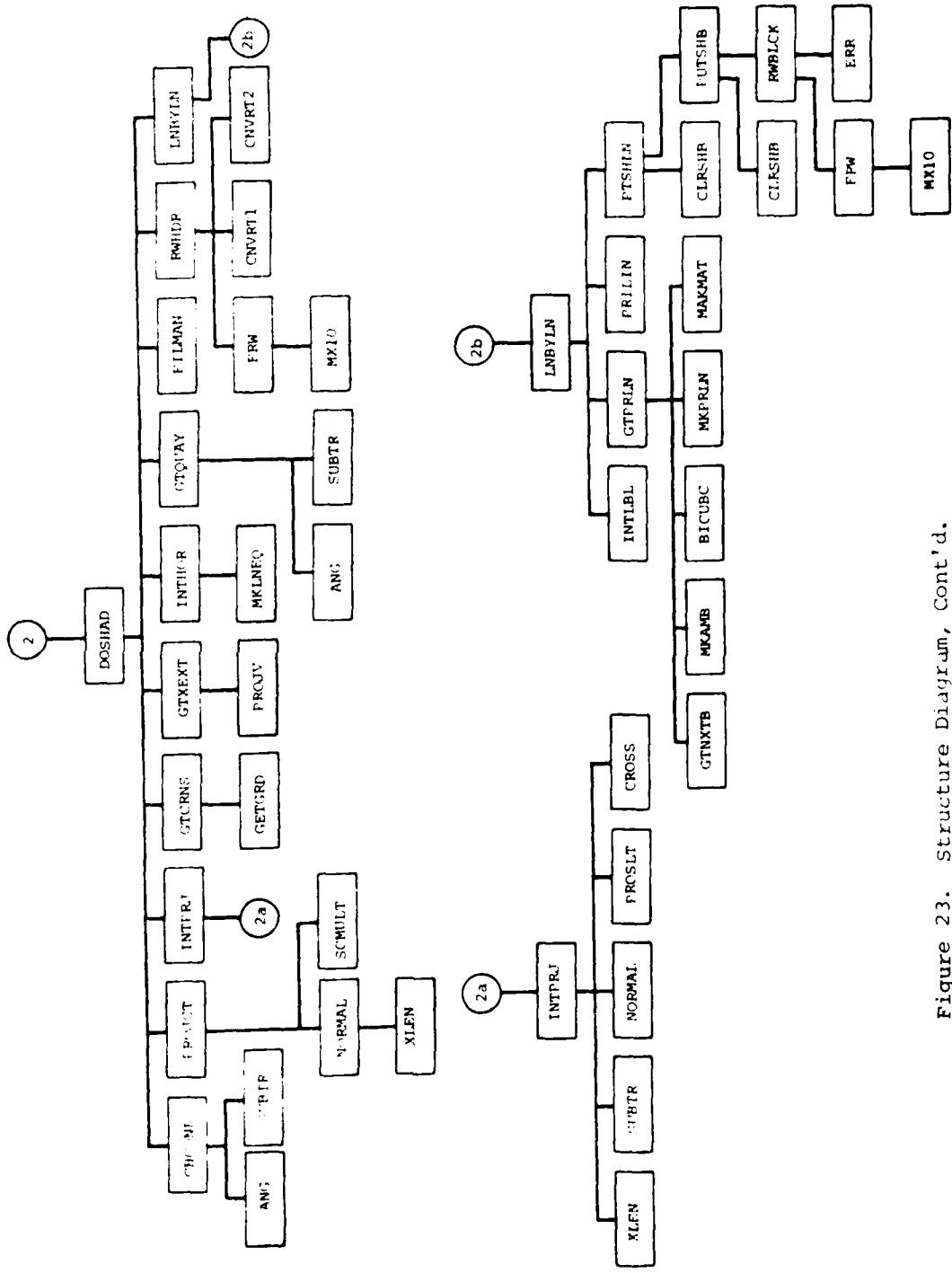
Figure 23. Structure Diagram, Cont'd.

Figure 23. Structure Diagram, Cont'd.

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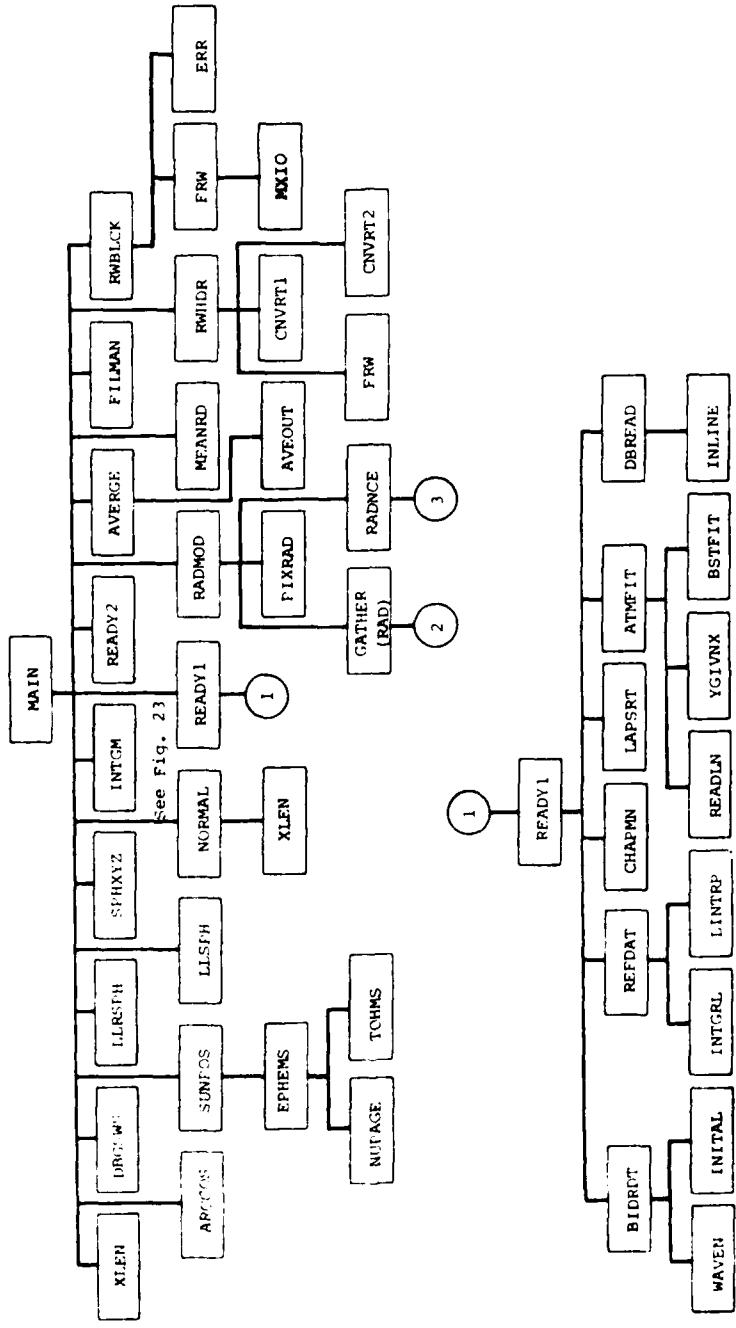
Figure 24. Radiance Module Structure Diagram
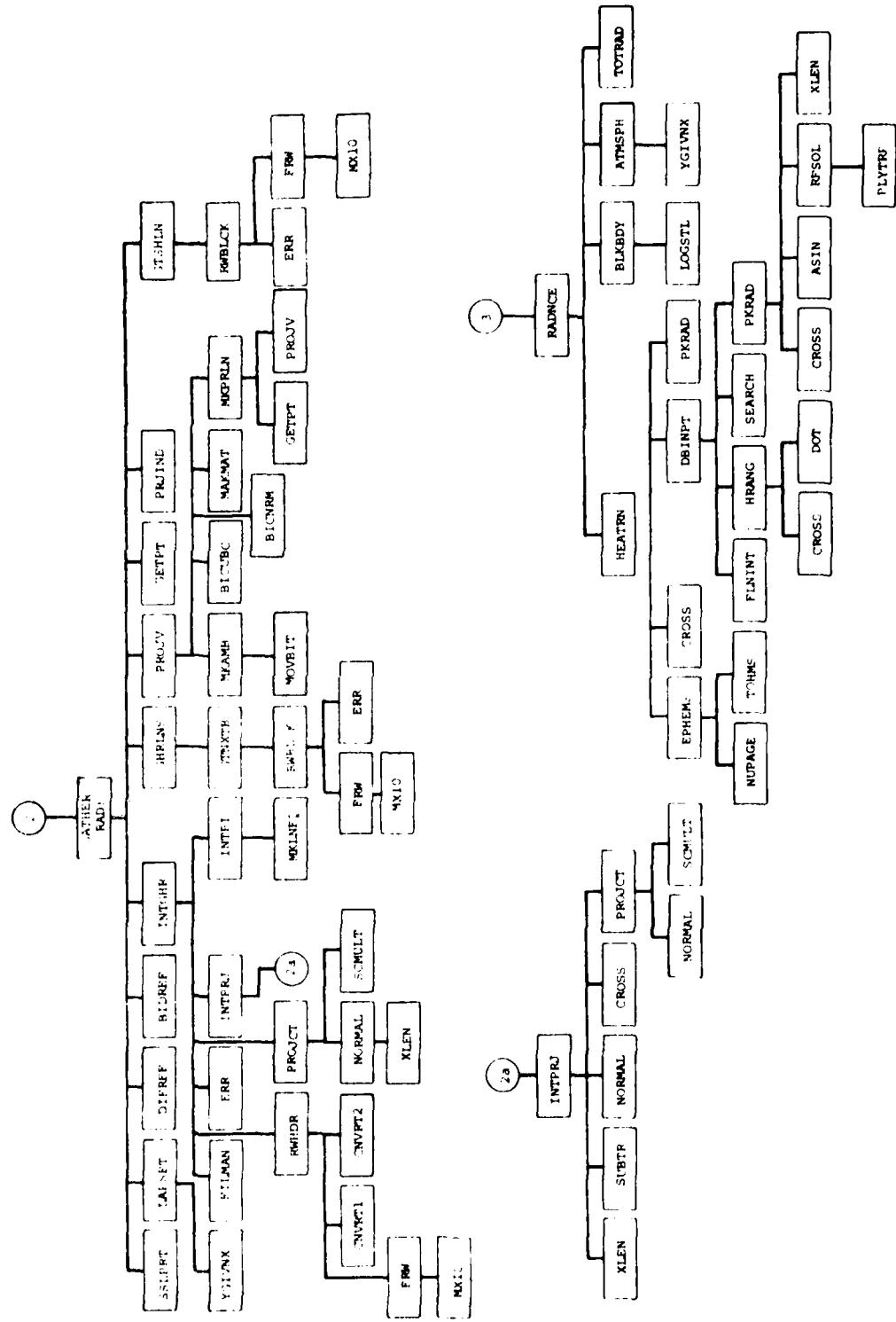
Figure 24. Radiance Module Structure Diagram, Cont'd
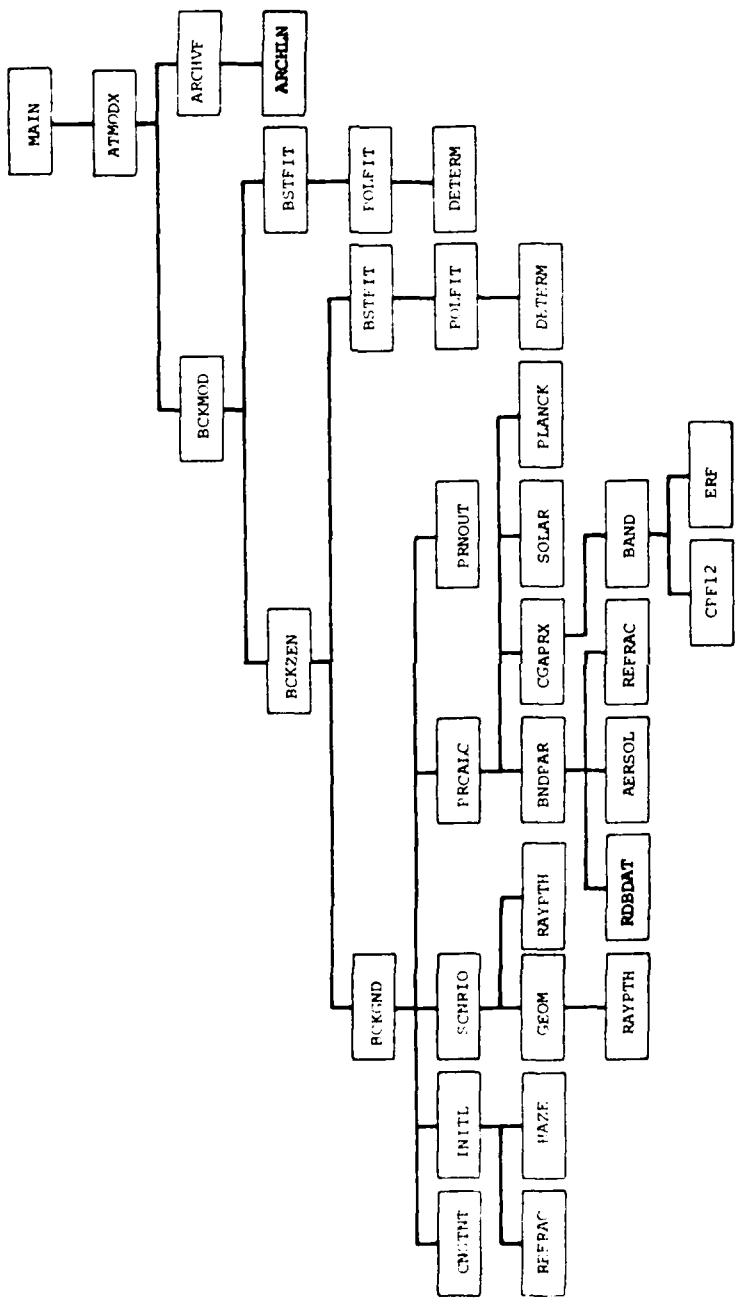
Figure 25. Atmospheric Module Structure Diagram

4.0 SCENE DATA BASES

4.1 Overview

There are five terrain data bases. Each was extracted from Defense Mapping Agency (DMA) data. The five scenes are: the California coast, the Brooks Range Mountains of Alaska, arctic tundra, Middle East, and Central Europe. All scenes were registered with Landsat data to produce complete representation of the ground cover for each point.

In addition to the five ground scenes, two cloud scenes are included. These represent a low and high altitude cloud, both with a minimum altitude of 1100 meters.

Each scene represents an area approximately forty kilometers square. DMA data is recorded at uniform angular resolution; scenes at different latitudes therefore have different spatial resolution.

4.2 File Structure

Each scene is composed of two parts: the header and the data.

Header. The header is 1024 16-bit words long. It contains the following information about the scene: the number of columns and number of rows of data, the scene center (in longitude and latitude), the scene center in X,Y,Z coordinates, the altitude scaling factors, and the spacing in kilometers between the data points in the X and Y direction. All floating-point information has been converted to an integer representation and is reconstructed by the software.

Data. The data points directly follow the header. There are (# columns) times (# rows) data points in each scene. Each data point is a 16-bit interger (binary) value and has two parts: the lower twelve bits represent the altitude of that point and the upper (left) four bits represent the material type assigned to that point. The scene is written in a row-wise format. The first row is the northernmost row.

5.0 SOFTWARE LIMITATIONS, MODEL CONSTRAINTS AND PRECAUTIONS

The following is a list of limitations, constraints, and precautions which the GENESSIS user may find useful.

1. Input scene data base is currently limited to approximately 512 x 512 grid points because of computer size restrictions.

2. Output 2-D radiance map is limited to 512 x 512 pixels.

3. Data base currently limited to 14 material types.

4. Scene and/or cloud altitudes limited to 0-10 km.

5. Observer/solar zenith angles limited to 0-86 degrees due to LOWTRAN anomalies at large zenith angles.

6. Model atmospheres limited to the six standard AFGL models.

7. The atmospheric, geometric and radiance modules have some inputs in common. These must be self consistent for any single run.

8. Cloud scene shadowing is currently not handled. Cloud/scene radiance maps must be overlaid to produce a scene which contains clouds. Cloud image pixels which do not contain cloud are assigned zero radiance to facilitate this.

9. Calculations are limited to 2.5-13.0 µm.

10. Scene data bases currently limited to the five generic ground scenes and two generic cloud scenes supplied.

11. The image module currently weights path radiance which should be an unweighted component of the apparent radiance. The error introduced is small. This will be corrected in Phase II.

12. Surface level atmospheric parameters are applied uniformly over the scene. They are not spatially variable.

6.0 USER SPECIFIED INPUTS

6.1 Atmospheric Module

Card 1) IATM, ALT, WLB, WLE (I3, 3F10.3)

    IATM   - Standard LOWTRAN Model Atmosphere.

                1 - Tropical
                2 - Midlatitude Summer
                3 - Midlatitude Winter
                4 - Subarctic Summer
                5 - Subarctic Winter
                6 - U. S. Standard 76

    ALT   - Observer altitude in km.

    WLB, WLE - Beginning and ending bandpass
                wavelengths in microns.

Card 2) IAERO1, IAERO2, IHAZE, IUPPER, M1, M2, M3, VIS (7I3, F10.3)

    IAERO1   - Selects the boundary layer
               (0-2 km) aerosol model.

               0, 1 - Rural
               2 - Urban
               3 - Maritime
               4 - Tropospheric
               5 - Advection Fog (default vis <0.20)
               6 - Radiation Fog (default 0.20 < vis < 1.00)

               Note: If 1 < vis < 2, the light fog option
                      is used with IAERO1.

    IAERO2   - Selects the stratospheric (~10-35 km)
               aerosol model.

               0, 1 - Background
               2 - Aged Volcanic
               3 - Fresh Volcanic
               4 - Meteoric Dust

    IHAZE   - Selects the upper atmospheric
               (2-100 km) haze model.

               0, 1 - Background
               2 - Moderate Volcanic
               3 - High Volcanic
               4 - Extreme Volcanic

IUPPER   - Allows modification of haze model in upper atmosphere (>35 km).

     0, 1 - Normal (model selected by IHAZE unchanged)

     2 - Extreme Upper (selects extreme upper atmospheric haze model)

M1, M2, M3   - The parameters M1, M2 and M3 can each take integer values between 0 and 6 and are used to modify or supplement the altitude profiles of temperature and pressure, water vapor, and ozone respectively, for any given atmospheric model specified by IATM.

     M1 = 1 selectes the TROPICAL temperature and pressure altitude profiles.

     = 2 selects the MIDLATITUDE SUMMER temperature and pressure altitude profiles.

     = 6 selects the 1962 U.S. STANDARD temperature and pressure altitude profiles.

     M2 = 1 selects the TROPICAL water vapor altitude profile.

     = 2 selects the MIDLATITUDE SUMMER water vapor altitude profile.

     = 6 selects the 1962 U.S. STANDARD water vapor altitude profile.

     M3 = 1 selects the TROPICAL ozone altitude profile.

     = 2 selects the MIDLATITUDE SUMMER ozone altitude profile.

     = 6 selects the 1962 U.S. STANDARD ozone altitude profile.

     For most applications, M1=M2=M3=0; the profiles selected by IATM are unaltered.

VIS   - Meterological range km. Override for the boundary layer haze model.

     See Figure 26 for details of the aerosol models used.
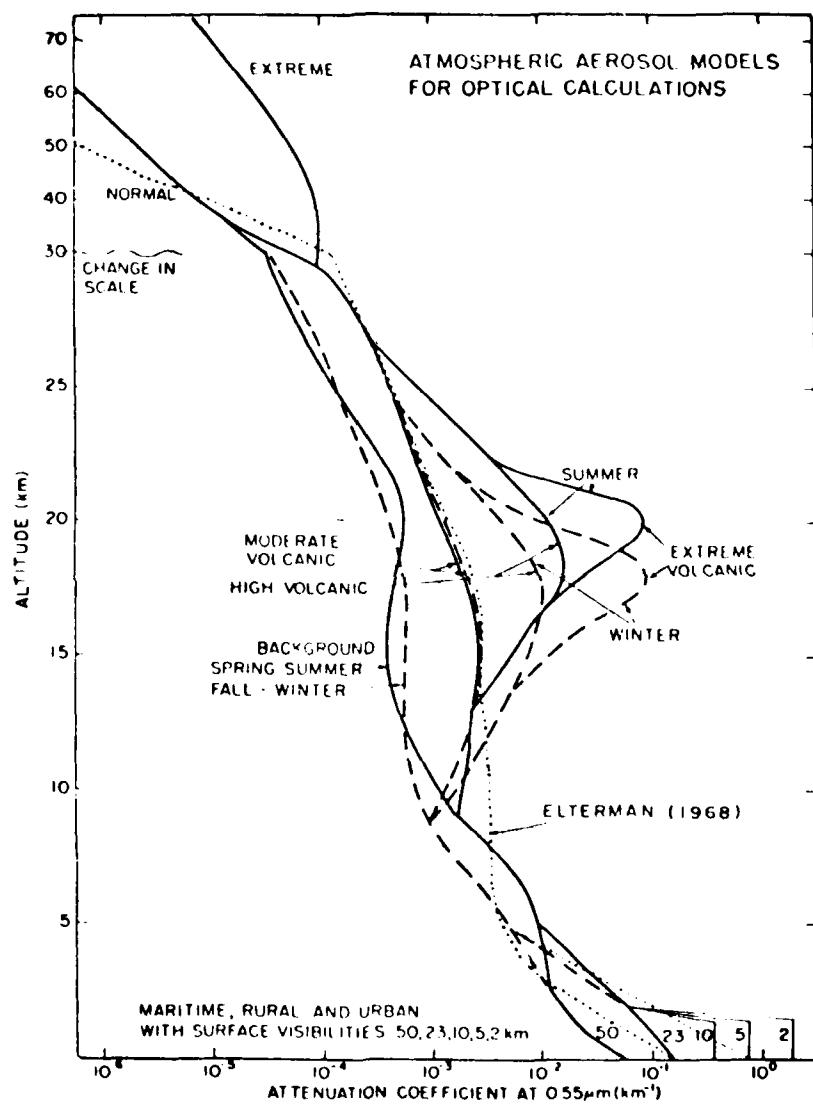
Figure 26. Atmospheric Aerosol Models Used By
the Atmospheric Module

FILE UNITS

Fortran Unit	Read, Write or Read/Write	ASCII or Binary	File
5	W	A	Output data base. Contains co-efficients of polynomial curve fits to atmospheric values.
6	W	A	ASCII output file. Run time diagnostics of curve fitting process.
7	R	A	User specified input file.
10	R	B	Atmospheric data base File 1.
11	R	B	Atmospheric data base File 2. This is a temporary work file.

6.2 Geometric Module

Card 1)   (ISW(I), I-1, 4C) (40I2)

           ISW   - Array of switches for debugging purposes.

                              ($\emptyset$ - Off, 1 - On)

Card 2)   DBG (A1)   - Debug switch (ASCII 'T' or 'F').

Card 3)   CLDMIN (F7.3)   - Minimum altitude of clouds in cloud file (km).

Card 4)   (SCXUSR(I), I=1,3) (3E14.6)   - User Specified Scene Center.

           SCXUSR(1)   - Altitude (km).

           SCXUSR(2)   - Longitude: (DEG) - West, + East

           SCXUSR(3)   - Latitude: (DEG) + North, - South

Card 5)   IDAY, IMONTH, IYEAR, TIME (3I5, F8.2)

           IDAY, IMONTH, IYEAR   - The day, month and year of the calculation. Enter as MM, DD, YYYY.

           TIME   - Time of run, GMT, (HHMM.SS).

Card 6)   (OBSRLL(I), I=1,3) (3E14.6)   – Observer position.

        OBSRLL(1)   – Altitude (km)

        OBSRLL(2)   – Longitude: (DEG) – West, + East

        OBSRLL(3)   – Latitude: (DEG) – South, + North

Card 7)   NCOLS, NROWS (2I4)

        NCOLS   – Number of columns in satellite image.

        NROWS   – Number of rows in satellite image.

Card 8)   XRESA, YRESA (2E14.6)

        XRESA   – Angular size of one pixel in the satellite image, in the horizontal direction (radians).

        YRESA   – Angular size of one pixel in the satellite image, in the vertical direction (radians).

FILE UNITS

Fortran Unit	Read, Write or Read/Write	ASCII or Binary	File
5	R	B	Scene data base.
6	W	B	Pseudo radiance used to display visible image produced.
11	W	B	Shadow file.
12	W	B	Visibility file.
13	R	A	User specified input list.
14	W	A	ASCII echo of inputs list.

6.3 Radiance Module

Card 1)   IATM, IMONTH, IDAY, IYEAR, TIME (4I5, F10.2)

        IATM   – Standard LOWTRAN Model Atmosphere.

                        1 – Tropical
                        2 – Midlatitude Summer
                        3 – Midlatitude Winter
                        4 – Subarctic Summer

5 - Subarctic Winter
                    6 - U.S. Standard 76

                    The atmosphere selected must be the
                    same as that in the atmospheric data
                    base file selected.

        IMONTH, IDAY, IYEAR   - The month, day and year of
                                   the calculation. Enter as
                                   MM, DD, YYYY.

        TIME   - Time in hours (GMT) of calcu-
                                   lation (24 hour clock, HHMM.SS).

Card 2) WLB, WLE, ALT, LONG, LAT (5F10.2)

        WLB, WLE   - Beginning and ending bandpass wave-
                           lengths in microns. These inputs
                           must be the same as those in the
                           atmospheric data base file select·d.

        ALT   - Observer altitude in km.

        LONG, LAT   - Longitude and latitude of observer's
                           NADIR point (sub-satellite point) in
                           degrees.

                           Longitude: - West, + East
                           Latitude: - South, + North

Card 3) SCNALT, SCNLNG, SCNLAT (5F10.2)

        SCNALT   - Scene stare point (scene center)
                           altitude in km.

        SCNLNG, SCNLAT   - Scene stare point (scene center)
                           longitude and latitude in degrees.

                           Longitude: - West, + East
                           Latitude: - South, + North

                           These values override the default values
                           read from the scene header.

Card 4) NCOL, NROW (2I5)

        NCOL, NROW   - Number of columns and rows in observer's
                           apparent radiance pixel map. These are
                           used to determine the scene F.O.V. extent
                           (see Card 6 below).

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Card 5) TAIR, TSSL (5F10.2)

        TAIR   - Sea level air temperature in degrees K. This is a 24 hr. diurnal average air temperature.

        TSSL   - Temperature of the sub-soil layer. The temperature of that layer of sub-soil which does not vary with the diurnal cycle of air temperature. In general, the mean monthly air temperature is a good first approximation to the sub-soil temperature (see pgs. 24-25).

Card 6) XRES, YRES (5F10.2)

        XRES, YRES   - The angular extent of one pixel in the observer's field of view in radians in the X (vertical) and Y (horizontal) directions. The total field of view is then NCOL * XRES by NROW * YRES.

FILE UNITS

Fortran Unit	Read, Write or Read/Write	ASCII or Binary	File
5	R	A	User input file.
6	W	A	ASCII output file. Run time diagnostics and statistics are written here.
7	R	A	Atmospheric data base file generated by the atmospheric module.
8	R	A	Heat transfer data base.
9	R	A	Monte Carlo cloud bi-directional reflectance data.
11	R	A	Spectral material diffuse reflectance data.
12	R	B	Scene data base.
13	R	B	Shadow file generated by geometric module.
14	R	B	Visibility file generated by geometric module.
17	W	B	Pixel apparent radiance file.

APPENDIX 1

Solar Ephemeris Module User Manual

A detailed description of the algorithm is given here, extracted verbatim* from W. Wilson, "Solar Ephemeris Algorith," University of California Visibility Laboratory, La Jolla, CA, July 1980.

This section describes the algorithm itself in terms of its logical flow and various equations and tables used.

All values computed are in degrees and fractions of degrees. For printing purposes, many times values are first converted to the form $xx^{\circ}\,xx'\,xx''$ or $xx^{h}\,xx^{m}\,xx^{s}$. The function routine which does this is called TOHMS.

3.1. STEPS

STEP 1 Compute $p23 = T$, fraction of century from 1900 JAN $0^{d}\,12^{h}$ *ET*

This routine first computes the number of days since 1900 JAN $0^{d}\,12^{h}$ *ET*. The algorithm used yields a value of 694038.5 for this date. Thus, this value is subtracted to yield the actual number of days. Because the algorithm does not take proper account of the leap year century years (*i.e.* 1800,1900) additional days need to be added for these and preceeding years. To the number of whole days the standard local time (in days) and the observer's longitude is added to get the correct time; $p22 = d$ since 1900 JAN $0^{d}\,12^{h}$ *ET*. This is then divided by 36525, the number of days in a century, to obtain the fraction of century, $p23$. Thus,

$$p23 = T = \frac{p22}{36525}.$$ (28)

---

* Used with permission.

STEP 2(a) Compute the mean longitude of sun referenced to mean equinox of date - $p24 = L$

$$p24 = L = 279°69668 + 0°98564\ 73354 \cdot p22 + 3°03 \cdot 10^{-4} \cdot p23^2 \tag{29}$$

Note that all values are converted to the range of 0-360° by using the function $mod(x,360)$, which is defined as the remainder of the division $\frac{x}{360}$.

STEP 2(b) Mean anomaly of sun - $p25 = M$.

$$p25 = M = 358°47583 + 0°98560\ 02670 \cdot p22 - 0°00015 \cdot p23^2 \tag{30}$$
$$- 3° \cdot 10^{-6} \cdot p23^3 .$$

STEP 2(c) Eccentricity - $p26 = e$

$$p26 = e = 0.01675104 - 4.18 \cdot 10^{-5} \cdot p23 - 1.26 \cdot 10^{-7} \cdot p23^2 \tag{31}$$

STEP 3 Compute eccentric anomaly - $p13 = E$ from

$$M = E - e \cdot \sin E , \tag{32}$$

or

$$p25 = p13 - p26 \cdot \sin(p13) .$$

This transcendental equation is solved for $p13$ by successive approximation. When the change in $p13$ is smaller than 10^{-8}, iteration is stopped.

STEP 4 Compute true anomaly - $p27 = V$ from

$$V = 2 \cdot \tan^{-1}\left[\frac{\sqrt{1+e}}{\sqrt{1-e}} \tan\left(\frac{E}{2}\right) \right] , \tag{33}$$

if

$$sign(V) \neq sign(E); \text{ Then } V = V + 180° , \tag{34}$$

if

$$V < 0; \quad \text{Then} \quad V = V + 360°.$$ (35)

or

$$p27 = 2 \cdot \tan^{-1}\left[\frac{\sqrt{1 + p26}}{\sqrt{1 - p26}} \ \tan\left(\frac{p13}{2}\right) \right],$$

or if

$$sign(p27) \ \# \ sign(p13), \quad \text{Then} \quad p27 = p27 + 180°.$$

or if

$$p27 < 0, \quad \text{Then} \quad p27 = p27 + 360°.$$

STEP 5(a) Compute radius vector - R

$$R = 1.0 - e \cdot \cos(E).$$ (36)

or

$$R = 1.0 - p26 \cdot \cos(p13)$$

STEP 5(b) Compute aberration - $p29 = \Delta\lambda_4$

$$p29 = \Delta\lambda_4 = \frac{-20.47}{R} \cdot \frac{1°}{3600''}$$ (37)

STEP 5(c) Compute mean obliquity - $p43 = \epsilon_m$

$$p43 = \epsilon_m = 23.452294 - 0°.0130125 \ p23 - 1°.64 \ 10^{-6} \ p23 + 5°.03 \cdot 10^{-7} \cdot p23^3.$$ (38)

STEP 5(d) Compute mean ascension - $p45 = \alpha_m$

$$p45 = \alpha_m = 279.6909832 + 0°.98564734 \ p22 + 3.8708 \ 10^{-4} \cdot p23^2$$ (39)

1-4

STEP 6   In this step all perturbations due to the moon are computed.

The variable $p8$ controls the degree of approximation of the algorithm. If $p8 < 2$, the perturbations due to the moon are included in the algorithm.

These require the initial computation of four quantities which are:

moon's mean anomaly - $p28 = l$
moon's mean elongation - $p30 = D$
moon's longitude of ascending mode - $p31 = \Omega$
moon's mean longitude - $p32 = \gamma$.

Note that $D = \gamma - L$ where $L =$ mean longitude of sun.

$$p28 = l = 296°.104608 + 1325 \cdot 360° \cdot p23 + 198°.8491083 \cdot p23 \qquad (40)$$
$$+ 0°.00919167p23^2 + 1°.4388 \cdot 10^{-5} \cdot p23^3$$

$$p30 = D = 350°.737486 + 1236 \cdot 360° \cdot p23 + 307°.1142167 \cdot p23 \qquad (41)$$
$$- 1°.436 \cdot 10^{-3} \cdot p23^2$$

$$p31 = \Omega = 259°.183275 - 5 \cdot 360° \cdot p23 - 134°.14200 \cdot p23 \qquad (42)$$
$$+ 2°.0778 \cdot 10^{-3} \cdot p23^2$$

$$p32 = \gamma = 270°.434164 + 1336 \cdot 360° \cdot p23 + 370°.8831417 \cdot p23 \qquad (43)$$
$$- 1°.1333 \times 10^{-3} \cdot p23^2 \ .$$

The perturbation of the earth's orbit due to the mass of the moon is $p33 = \Delta\lambda$,

$$\text{where } p33 = 6".454 \sin D \qquad (44)$$
$$+ 0".013 \sin 3D$$
$$+ 0".177 \sin (D+l)$$
$$- 0".424 \sin (D-l)$$
$$+ 0".039 \sin (3D-l)$$
$$- 0".064 \sin (D+M)$$
$$+ 0".172 \sin (D-M)$$

Note that $D = p30$, $l = p28$, $M = p25$.

The moon also causes nutation of the solar longitude, $\Delta\psi$, and obliquity of the ecliptic, $\Delta\epsilon$. As mentioned earlier, this nutation is in terms of a power series with up to 60 terms. Table 3 has a listing

1-5

Table 3.

Series Terms for Nutation

Period (days)	l	M	F	D	Ω	Longitude Coefficient of sine argument		Obliquity Coefficient of cosine argument	
6798					+1	−172327	−173.7T	+92100	+9.1T
3399					+2	+ 2088	+ 0.2T	− 904	+0.4T
1305	−2		+2		+1	+ 45		− 24	
1095	+2		−2			+ 10			
6786		−2	+2	−2	+1	− 4		+ 2	
1616	−2		+2		+2	− 3		+ 2	
3233	+1	−1		−1		− 2			
183			+2	−2	+2	− 12729	− 1.3T	+ 5522	−2.9T
365		+1				+ 1261	− 3.1T		
122		+1	+2	−2	+2	− 497	+ 1.2T	+ 216	−0.6T
365		−1	+2	−2	+2	+ 214	− 0.5T	− 93	+0.3T
178			+2	−2	+1	+ 124	+ 0.1T	− 66	
206	+2			−2		+ 45			
173			+2	−2		− 21			
183		+2				+ 16	− 0.1T		
386		+1			+1	− 15		+ 8	
91		+2	+2	−2	+2	− 15	+ 0.1T	+ 7	
347		−1			+1	− 10		+ 5	
200	−2			+2	+1	− 5		+ 3	
347		−1	+2	−1	+1	− 5		+ 3	
212	+2			−2	+1	+ 4		− 2	
120		+1	+2	−2	+1	+ 3		− 2	
412	+1			−1		− 3			
137			+2		+2	− 2037	− 0.2T	+ 884	
27.6	+1					+ 675	+ 0.1T		
136			+2		+1	− 342	− 0.4T	+ 183	
91	+1		+2		+2	− 261		+ 113	−0.1T
318	+1			−2		− 149			
271	−1		+2		+2	+ 114		− 50	
148				+2		+ 60			
277	+1				+1	+ 58		− 31	
274	−1				+1	− 57		+ 30	
96	−1		+2	+2	+2	− 52		+ 22	
91	+1		+2		+1	− 44		+ 23	
71			+2	+2	+2	− 32		+ 14	
138	+2					+ 28			
239	+1		+2	−2	+2	+ 26		− 11	
69	+2		+2		+2	− 26		+ 11	
136			+2			+ 25			
270	−1		+2		+1	+ 19		− 10	
320	−1			+2	+1	+ 14		− 7	
317	+1			−2	+1	− 13		+ 7	
95	−1		+2	+2	+1	+ 9		+ 5	
348	+1	+1		−2		− 7			
132		+1	+2		+2	+ 7		− 3	
96	+1			+2		+ 6			
148				+2	+1	− 6		+ 3	
142		−1	+2		+2	− 6		+ 3	
56	+1		+2	+2	+2	− 6		+ 3	
128	+2		+2	−2	+2	+ 6		− 2	
147				−2	+1	− 5		+ 3	
71			+2	+2	+1	− 5		+ 3	
239	+1		+2	−2	+1	+ 5		− 3	
295				+1		− 4			
154		+1		−2		− 4			
298	+1	−1				+ 4			
269	+1		−2			+ 4			
69	+2		+2		+1	− 4		+ 2	
91	+1		+2			+ 3			
256	+1	+1				− 3			
94	+1	−1	+2		+2	− 3			
137	−2				+1	− 2			
326	−1		+2	−2	+1	− 2			
138	+2				+1	+ 2			
98	−1	−1	+2	+2	+2	− 2			
72		−1	+2	+2	+2	− 2			
278	+1				+2	− 2			
89	+1	+1	+2		+2	+ 2			
55	+3		+2		+2	− 2			

Note: T is the fraction of century coefficient defined in the text.

of the terms of this power series. The form of each term in the series is

$$S \cdot \sin(al + bM + cF + dD + e\Omega) \quad (45)$$

for nutation in longitude, and

$$S \cdot \cos(al + bM + cF + dD + e\Omega) \quad (46)$$

for obliquity, where $F = L - \Omega$.

The algorithm as presently implemented uses only 5 terms for longitude and 4 terms for obliquity. If a higher degree of accuracy is desired more terms may be added. The terms presently used are in bold face in Table 3.

The nutation in longitude is $p34 = \Delta\psi$.

The nutation in obliquity is $p35 = \Delta\epsilon$.

The moon also has a perturbation effect on the solar latitude. For the accuracy of the present algorithm, this effect is negligible. For illustrative purposes, however, the perturbation effect is computed in the event higher degrees of accuracy are required.

The moon's mean argument of latitude, $p63$, is first computed by

$$p63 = 11°.250889 + 1342 \cdot 360° \cdot p23 + 82°.02515 \cdot p23 \quad (47)$$
$$+ 0°.003211 \cdot p23^2 .$$

Then the perturbation of latitude due to the moon is

$$\Delta\beta = 0''.576 \sin (p63) \quad (48)$$
$$+ 0''.016 \sin (p63 + l)$$
$$- 0''.047 \sin (p63 - l)$$
$$+ 0''.021 \sin (p63 - 2 (l - \Omega)) .$$

STEP 7 In this step perturbations due to the planets are computed. The variable $p8$ again controls the degree of approximation. If $p8 < 1$, the planetary perturbations are included.

The inequalities of the long period in the mean longitude, δL, caused by the planetary masses are computed from

$$p36 = \delta L = 0''.266 \sin (31.8° + 119° \cdot p23) \quad (49)$$
$$+ (1''.882 - 0''.016 \cdot p23) \sin (57°.24 + 150°.27 \cdot p23)$$
$$+ 0''.202 \sin (315°.0 + 893°.3 \cdot p23)$$
$$+ 1''.089 \cdot p23^2$$
$$+ 6''.4 \sin(231°.19 + 20°.2 \cdot p23) .$$

The other perturbations due to the planets all require the mean anomalies of each planet which are as follows:

VENUS:

$$p37 = 212°.603222 + 162 \cdot 360° \cdot p23 + 197°.803875 \cdot p23 \tag{50}$$
$$+ 1°.286 \cdot 10^{-3} \cdot p23^2$$

MARS:

$$p38 = 319°.529022 + 53 \cdot 360° \cdot p23 + 59°.8592194 \cdot p23 \tag{51}$$
$$+1°.8083 \cdot 10^{-4} \cdot p23^2$$

JUPITER:

$$p39 = 225°.3225 + 8 \cdot 360° \cdot p23 + 154°.583 \cdot p23 \tag{52}$$

SATURN:

$$p40 = 175°.613 + 3 \cdot 360° \cdot p23 + 141°.794 \cdot p23 . \tag{53}$$

The perturbations due to each planet may be computed by using the mean anomalies and the coefficients from Tables 4-7. The coefficients in Tables 4-7 are given in the form of j, i, S, and K. A single term has the form

$$S \cdot \cos(K - jg' - iM) , \tag{54}$$

where g' is the mean anomaly of the planet and M the mean anomaly of the sun.

Only the coefficients in bold face in the tables are used in the present algorithm. These coefficients account for most of the perturbations in longitude. Further discussion of this point is made later.

The perturbation of latitude by the planets is also negligible for the present purposes. However, if needed, a type of latitude correction may be made similar to the longitude correction. Table 8 gives the required coefficients.

Table 4.
Perturbations by VENUS

i	i	s	K
-1	+0	075	296 6
	1	4.838	299 6.1
	2	074	207 9
	3	009	249
-2	+0	003	162
	1	116	148 9
	2	5.526	148 18.8
	3	2.497	315 56.6
	4	044	311 4
-3	+2	013	176
	3	.666	177.71
	4	1.559	345 15.2
	5	1.024	318.15
	6	017	315
-4	+3	003	198
	4	210	206 2
	5	144	195 4
	6	152	343 8
	7	006	322
-5	+5	084	235 6
	6	037	221 8
	7	123	195 3
	8	154	359 6
-6	+6	038	264 1
	7	014	253
	8	010	230
	9	014	12
-7	+7	020	294
	8	006	279
	9	003	288
-8	+8	011	322
	12	042	259 2
	14	032	48 8
-9	+9	006	351
-10	+10	003	18

Table 6.
Perturbations by JUPITER

j	i	s	K
+1	-3	003	198
	-2	163	198 6
	-1	7.208	179 31.9
	0	2.600	263 13.0
	+1	073	276 3
+2	-3	069	80 8
	-2	2.731	87 8.7
	-1	1.010	109 29.6
	-0	073	252 6
+3	-4	005	158
	-3	164	170 5
	-2	.556	82.65
	-1	210	98 5
+4	-4	016	259
	-3	044	168 2
	-2	080	77 7
	-1	021	93
+5	-4	005	259
	-3	00?	164
	-2	009	71

Table 5.
Perturbations by MARS

j	i	s	K
+1	-2	006	218
	-1	.273	217.7
	0	048	260 3
+2	-3	041	346 0
	-2	2.043	343 53.3
	-1	1.770	280 24.1
	0	028	148
+3	-4	004	284
	-3	129	294 2
	-2	.425	330.88
	-1	008	7
+4	-4	034	71 0
	-3	.500	105.18
	-2	.585	344.06
	-1	009	325
+5	-5	007	172
	-4	085	54 6
	-3	204	100 8
	-2	003	18
+6	-5	020	186
	-4	154	227 4
	-3	101	96 3
+7	-6	006	301
	-5	049	176 5
	-4	106	222 7
+8	-7	003	72
	-6	010	307
	-5	052	348 9
	-4	021	215 2
+9	-7	004	57
	-6	028	298
	-5	062	346 0
+10	-7	005	68
	-6	019	111
	-5	005	338
+11	-7	017	59
	-6	044	105 9
+12	-7	006	232
+13	-8	013	184
	-7	045	227 8
+15	-9	021	309
+17	-10	004	243
	-9	026	113

Table 7.
Perturbations by SATURN

j	i	s	K
+1	-2	011	105
	-1	.419	100.58
	0	.320	269.46
	+1	008	270
+2	-2	108	290 6
	-1	112	293 6
	0	017	277
+3	-2	021	289
	-1	017	291
+4	-2	001	288

Table 8.
Latitude Perturbations by VENUS

j	i	s	K
-1	+0	029	145
	1	005	323
	2	.092	93.7
	3	007	262
-2	+1	023	173
	2	.012	149
	3	.067	123.0
	4	014	111
-3	+2	014	201
	3	008	187
	4	.210	151.8
	5	007	153
	6	004	296
-4	+3	006	232
	5	031	1 8
	6	012	180
-5	+6	009	27
	7	019	18
-6	+5	006	288
	7	004	57
	8	004	57
-8	+12	010	61

Latitude Perturbations By MARS

j	i	s	K
+2	-2	008	90
	0	008	346
+4	-3	007	188

Latitude Perturbations By JUPITER

j	i	s	K
+1	-2	007	180
	-1	017	273
	0	016	180
	+1	023	268
+2	-1	.166	265.5
+3	-2	006	171
	-1	018	267

Latitude Perturbations By SATURN

j	i	s	K
+1	-1	006	260
	+1	006	280

STEP 8(a) Computation of precession - $p42$

The precession is defined as the distance the equinox has moved from the beginning of the year. The *rate of precession, p,* is

$$p = 50''.2564 + 0''.0222 \cdot p23 . \tag{55}$$

Thus the precession is,

$$p42 = p \cdot (time \; since \; beginning \; of \; year) . \tag{56}$$

STEP 8(b) Computation of apparent (true) longitude - $p41 = \lambda$

The apparent longitude of the sun is the solar longitude measured from the mean equinox of date apparent at the earth's surface, ignoring refraction. Thus

$$\lambda = (V - M) + L + \Delta\lambda_4 + \delta L + \Delta\lambda + \Delta\psi , \tag{57}$$

or

$$p41 = (p27 - p25) + p24 + p29 + p33 + p36 + p34 .$$

STEP 8(c) Computation of obliquity $p75 = \epsilon$

$$\epsilon = \epsilon_m + \Delta\epsilon . \tag{58}$$

or

$$p75 = p43 + p35 .$$

STEP 8(d) Computation of apparent right ascension - $p44 = \alpha$

From equation 5)

$$\alpha = \tan^{-1}(\tan\lambda \cdot \cos \epsilon) . \tag{59}$$

if

$$sign \; \alpha \; \# \; sign \; \lambda \; ; \; the \; \alpha = \alpha + 180° . \tag{60}$$

if

$$\alpha < 0 \; Then \; \alpha = \alpha + 360° ,$$

or

$$p44 = \tan^{-1}(\tan(p41) \cdot \cos(p43)) .$$

if

$$sign \, (p44) \; \# \; sign \, (p41) , \; Then \; p44 = p44 - 180° .$$

or if
$$p44 < 0 \quad \text{Then} \quad p44 = p44 + 360°.$$

STEP 8(e) Computation of equation of time - $p46 = Eq. T.$

$$Eq. \ T = \alpha_m - \alpha, \tag{61}$$

if
$$Eq. \ T > 180°; \quad \text{Then} \quad Eq. \ T = Eq. \ T - 360°, \tag{62}$$

or
$$p46 = p45 - p44,$$

or if
$$p46 > 180°; \quad \text{Then} \quad p46 = p46 - 360°.$$

STEP 8(f) Computation of hour angle - $p48 = h_m$

From Eq. (26)

$$p48 = p21 \cdot 360 + 15 \cdot int\left[\frac{7.5 + p20}{15}\right] \cdot sign \ (p2) - p20 - 180 \tag{63}$$

where $p21$ = local standard time in fractions of days

$p20$ = absolute value of longitude

$p2$ = longitude.

STEP 8(g) Computation of local apparent hour angle - $p49 = h_s$

$$h_s = Eq. \ T + h_m \tag{64}$$

or
$$p49 = p46 + p48$$

STEP 8(h) Computation of declination - $p47 = \delta_s$ from Eq. (1)

$$\delta_s = \sin^{-1}\left[\cos\beta\sin\lambda\sin\epsilon + \sin\beta\cos\epsilon\right]. \tag{65}$$

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$$p47 = \sin^{-1}\left[\cos(p60)\sin(p41)\sin(p75) + \sin(p60)\cos(p75)\right].$$

STEP 8(i) Computation of zenith angle - Z from Eq. (7)

$$Z = \cos^{-1}\left[\sin\delta_s\sin\phi + \cos\delta_s\cos\phi\cos h_s\right],\tag{66}$$

or

$$Z = \cos^{-1}\left[\sin(p47)\sin(p19) + \cos(p47)\cos(p19)\cos(p49)\right],$$

where $p19 =$ latitude of observer.

STEP 8(j) Computation of azimuth - A from Eq. (8)

$$A = \cos^{-1}\left[\frac{\sin\delta_s\cos\phi - \cos\delta_s\sin\phi\cos h_s}{\sin Z}\right]\tag{67}$$

if

$$sign\left[\frac{-\cos\delta_s\sin h_s}{\sin Z}\right] \# sign(A); \text{ Then } A = 360 - A,\tag{68}$$

or

$$A = \cos^{-1}\left[\frac{\sin(p47)\cos(p19) - \cos(p47)\sin(p19)\cos(p49)}{\sin Z}\right],$$

or if

$$sign\left[\frac{-\cos(p47)\sin(p49)}{\sin Z}\right] \# sign(A); \text{ Then } A = 360 - A.$$

The longitude tabulated in the Nautical Almanac is the apparent longitude minus the sum of the aberration and the nutation of longitude. Therefore, the tabulated quantity is

$$\lambda - (\Delta\lambda_A + \Delta\psi),\tag{69}$$

or

$$p41 - (p29 + p34).$$

3.2. ALGORITHM ACCURACY

The accuracy of the solar ephemeris algorithm depends ultimately on the number of terms used for the perturbation effects. In order to give some insight into the degree of accuracy achievable, this section will explore the effect of the various component parts on the final result.

For our specific requirements, the value of major concern is the apparent zenith angle Z. This value, computed from Eq. (7), is a function of declination δ_s, observer latitude ϕ and solar hour angle h_s. Thus

$$\cos Z = \sin\delta_s \sin\phi + \cos\delta_s \cos\phi \cos h . \tag{70}$$

We also know

$$h_s = h_m + Eq. \ T = h_m + \alpha_m - \alpha , \tag{71}$$

or, combining known quantities,

$$h_s = LMT - \alpha - \Lambda + C . \tag{72}$$

Thus taking derivatives and assuming the maximum possible error for each component, one obtains

$$\Delta Z \approx \Delta\delta_s + \Delta\alpha + \Delta LMT + \Delta\Lambda + \Delta\phi . \tag{73}$$

It should be noted that the maximum possible error will not occur simultaneously for each of the components. Thus the maximum error $\Delta\Lambda$ will occur when $\phi = 0$, while the maximum error $\Delta\delta_s$ will occur when $\phi = 0$, $\delta_s = 0$ but $h_s = 0°$ or $90°$. By doing the analysis in this manner however, the relative *importance* of each component is illustrated.

The present requirements for the algorithm have been to compute ΔZ to within $0°.1$ or $6'$. If this error is then divided proportionaly among the five components, each must have maximum errors of $0°.02$ or $72''$.

3.2.1. Latitude and Longitude

Since $0°.02$ of latitude is 1.2 nautical miles, this fixes the required latitude determination. A longitude increment of $0.°02$, in terms of surface distance is given by

$$\frac{0°.02}{\cos\phi} . \tag{74}$$

However, the maximum error $\Delta\Lambda$ is proportional to $\cos\phi$, so that again a determination of Λ to within 1.2 nautical miles will give the requisite accuracy.

3.2.2. Time

A change in arc degrees of $0°.02$ in zenith angle is equivalent to 4.8 seconds of time. Again, this is proportional to $\cos\phi$, so that at higher latitudes this requirement is relaxed.

3.2.3. Declination

Declination is computed using Eq. (4). Thus,

$$\sin\delta_s = \sin\lambda \cdot \sin\epsilon , \tag{75}$$

and therefore

$$\Delta\delta_s = \left[\frac{\sin\lambda\cos\epsilon}{\cos\delta_s}\right]\Delta\epsilon + \left[\frac{\cos\lambda\sin\epsilon}{\cos\delta_s}\right]\Delta\lambda \ . \tag{76}$$

Since ϵ, the obliquity is on the order of $23°.5$, the maximum error for $\Delta\epsilon + \Delta\lambda$ is on the order of

$$\Delta\delta_s = \Delta\epsilon + 0.4x\Delta\lambda \ . \tag{77}$$

For $\Delta\delta_s = 0°.02$, and dividing maximum error proportionaly

$$\Delta\epsilon = 36'' \tag{78}$$

and

$$\Delta\lambda = 90'' = 1'\,30'' \ .$$

3.2.4. Right Ascension

From Eq. (5), right ascension α is computed as

$$\tan\alpha = \tan\lambda \cdot \cos\epsilon \ , \tag{79}$$

or

$$\Delta\alpha = \frac{\sec^2\lambda\cos\epsilon}{\sec^2\alpha} \cdot \Delta\lambda + \frac{\tan\lambda\sin\epsilon}{\sec^2\alpha} \cdot \Delta\epsilon \ . \tag{80}$$

Putting in values for maximum error, the relationship

$$\Delta\alpha = \Delta\lambda + 0.7 \cdot \Delta\epsilon \tag{81}$$

is obtained.

For $\Delta\alpha = 0°.02$ and dividing the maximum error proportionally,

$$\Delta\epsilon = 90'' = 1'30'' \tag{82}$$

and

$$\Delta\lambda = 36'' \ .$$

3.2.5. Obliquity and Solar Longitude

The analysis of errors due to declination and right ascension shows that in general for $\Delta Z = 0°.1$, the error in obliquity $\Delta\epsilon$ should be less than $36''$. This is also true for the error in solar longitude $\Delta\lambda$.

The major source of error in obliquity is the inclusion of the nutation of obliquity $\Delta\epsilon$. Addition of all of the coefficients for nutation of obliquity found in Table 3 gives the sum $10''.04$. If the four highest terms are summed the value $9''.94$ is obtained.

Thus the maximum possible error in obliquity is not $36''$ but on the order of $10''$. If the four largest terms for nutation of obliquity are used this reduces the maximum error to $0''.1$. Therefore the maximum error for longitude $\Delta\lambda$ may be increased to $62''$ or $72''$.

The errors in the computation of longitude are listed in Table 9 along with the corrections used in the present algorithm. The errors are computed by adding the coefficients given in Tables 3 and 4.

Table 9.

	All Corrections	Algorithm Corrections	# of Terms
Nutation of Long Δφ	19" 36	19" 03	5
Moon perturbation of long ΔΛ_m	7" 34	7" 34	7
Inequalities of Long Period δL	9" 84	9" 84	5
Perturbations of Planets			
VENUS	17" 57	16" 11	6
MARS	7" 02	5" 60	6
JUPITER	15" 65	14" 71	5
SATURN	1" 04	0" 74	2
TOTAL	77" 82	73" 37	

It can be seen from Table 9 that the maximum error $\Delta\lambda$ is about 78". This is just 16" higher than the maximum allowable error of 62" from $\Delta Z = 0°.1$. Since this is the maximum allowable error, the computation of λ without any nutation and perturbation corrections should allow Z to be computed to within 0°.1 under most conditions.

The addition of the nutation terms in the obliquity and longitude calculations using only those 9 terms used in the present algorithm will reduce the maximum allowable error in longitude to 49" which is well within the requirement.

The use of all the terms for nutation and perturbations in the present algorithm reduces the error in longitude computation on the order of 4".5. This degree of accuracy is far greater than is needed for most applications. Their inclusion has been merely an illustration of the technique required for a highly accurate solar ephemeris.

3.2.6. Sample Results

To show the accuracy of the algorithm, the ephemeris for four days have been computed and tabulated below. They are:

Table 10   1786 MAY 3, $17^h 30^m$ GMT
Table 11   1960 MAR 1, 0^h GMT
Table 12   1979 JAN 1, 0^h GMT
Table 13   1979 JUL 1, 0^h GMT

The first date was chosen because Newcomb used this date as an example as to how to use the "tables". The second date is used in the *Supplement* as an example, and the last two are merely illustrative of the accuracy for the year 1979.

For each date the computations have been made for the approximations noted in the sections above. The first uses the full algorithm, the second excludes planetary effects, while the third excludes lunar and planetary effects.

Table 10. 1786 MAY 4 5ʰ30ᵐ GMT*

	Nautical Almanac	Algorithm Full	Algorithm no planetary effects	Algorithm no lunar effects
Longitude for Mean Equinox of Date	43° 50'49".5	43° 50'51".7	43° 50'57".3	43° 50'54".6
Reduction to Apparent Longitude	-6".02	-6".11	-6".11	-20".28
Latitude for ecliptic of Date	.	-0".01	0".02	.
Precession in Longitude from 1786.0 to Date	17".06	17".22	17".22	17".22
Nutation in Longitude	14".26	14".17	14".17	.
Nutation in Obliquity	4".13	4".30	4".30	.
Obliquity of Ecliptic	25° 28'05".8	23° 28'05".8	23° 28'05".8	23° 28'01".5
Apparent Right Ascension	.	2ʰ45ᵐ31ˢ.6	2ʰ45ᵐ20ˢ.1	2ʰ45ᵐ31ˢ.0
Apparent Declination	.	16° 00'50".0	16° 00'51".8	16° 00'43".9
Radius Vector	1.0093	1.0093	1.0093	1.0093
ET of Ephemeris Transit	.	11ʰ50ᵐ30ˢ.3	11ʰ50ᵐ30ˢ.6	11ʰ56ᵐ29ˢ.6

*Note that previous to 1925 GMT was measured from Greenwich noon. Thus Newcomb computed ephemeris for 1786 May 3 17ʰ30ᵐ GMT

Table 11. 1960 MARCH 7 0ʰ GMT

	Nautical Almanac	Algorithm Full	Algorithm no planetary effects	Algorithm no lunar effects
Longitude for Mean Equinox of Date	346° 26'23".5	346° 26'24".3	346° 26'04".5	346° 26'01".9
Reduction to Apparent Longitude	-21".37	-21".45	-21".45	-20".62
Latitude for ecliptic of Date	-0".65	-0".61	-0".57	.
Precession in Longitude from 1960.0 to Date	9".04	9".01	9".01	9".01
Nutation in Longitude	-0".74	-0".82	-0".82	.
Nutation in Obliquity	-8".84	-8".89	-8".89	.
Obliquity of Ecliptic	23° 26'31".2	23° 26'31".2	23° 26'31".2	23° 26'40".0
Apparent Right Ascension	23ʰ10ᵐ04ˢ.1	23ʰ10ᵐ04ˢ.1	23ʰ10ᵐ02ˢ.9	23ʰ10ᵐ02ˢ.9
Apparent Declination	-5° 21'16".3	-5° 21'16".0	-5° 21'23".7	-5° 21'25".7
Radius Vector	.9925	.9925	.9925	.9925
ET of Ephemeris Transit	12ʰ11ᵐ05ˢ.8	12ʰ11ᵐ05ˢ.7	12ʰ11ᵐ04ˢ.5	12ʰ11ᵐ04ˢ.5

Table 12. 1979 JAN 1 0ʰ GMT

	Nautical Almanac	Algorithm Full	Algorithm no planetary effects	Algorithm no lunar effects
Longitude for Mean Equinox of Date	279° 58'14".90	279° 58'16".3	279° 58'16".7	279° 58'18".6
Reduction to Apparent Longitude	-22".86	-22".88	-22".88	-20".82
Latitude for ecliptic of Date	0".60	0".21	0".38	.
Precession in Longitude from 1979.0 to Date	+0".007	-0".03	-0".03	-0".03
Nutation in Longitude	-2".047	2".059	2".059	.
Nutation in Obliquity	-9".743	-9".724	-9".724	.
Obliquity of Ecliptic	23° 20'21".467	23° 26'21".5	23° 26'21".5	23° 26'31".3
Apparent Right Ascension	18ʰ43ᵐ21ˢ.66	18ʰ43ᵐ21ˢ.76	18ʰ43ᵐ21ˢ.8	18ʰ43ᵐ22".1
Apparent Declination	-23° 03'53".8	-23° 03'54".1	23° 03.53".9	-23° 04'03".6
Radius Vector	0.9833336	.9833	.9833	.9833
ET of Ephemeris Transit	12ʰ03ᵐ23ˢ.61	12ʰ03ᵐ23ˢ.5	12ʰ03ᵐ23ˢ.5	12ʰ03ᵐ23ˢ.8

Table 13. 1979 JUL 1 0ʰ GMT

	Nautical Almanac	Algorithm Full	Algorithm no planetary effects	Algorithm no lunar effects
Longitude for Mean Equinox of Date	98° 35'43".40	98° 35'43".4	98° 35'43".8	98° 35'42".6
Reduction to Apparent Longitude	-25".27	-25".33	-25".33	-20".13
Latitude for ecliptic of Date	+".02	".15	0".12	.
Precession in Longitude from 1979.0 to Date	-25".353	-24".88	24".88	-24".88
Nutation in Longitude	.5".119	.5".19	.5".19	.
Nutation in Obliquity	-9".271	9".25	-9".25	.
Obliquity of Ecliptic	23° 26'21".747	23° 26'21".8	23° 26'21".8	23° 26'31".0
Apparent Right Ascension	6ʰ37ᵐ23ˢ.45	6ʰ37ᵐ23ˢ.45	6ʰ37ᵐ23ˢ.5	6ʰ37ᵐ23ˢ.8
Apparent Declination	23° 09'40".0	23° 09'40".02	23° 09'40".1	23° 09'48".9
Radius Vector	1.0166819	1.0167	1.016"	1.0167
ET of Ephemeris Transit	12ʰ01ᵐ40ˢ.62	12ʰ01ᵐ40ˢ.2	12ʰ01ᵐ40ˢ.1	12ʰ01ᵐ40ˢ.6

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APPENDIX 2

GENESSIS Heat Transfer and Reflectance Data Bases

Table A2-1. Heat Transfer Data Base.[*]

```
3
4      4     3     8
0 000  220 940  '613 641  864 682  - Solar Irradiance Values
260 00  273 00  286 00   300 00   - Convective Flux Values
-60 00  0 00   60 00             - Conductive Flux Values
```

(Solar Elevation Angle (rad)

(Temperature (kelvin)

-1 560	-1 560	-1 557	1 553	1 554 ·	1 554	1 557	1 560
248 7	248 7	248 7	248 7	248 7	248 7	248 7	248 7
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
259 9	259 9	260 0	260 0	260 0	260 0	260 0	259 9
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
271 2	271 2	271 3	271 3	271 3	271 3	271 3	271 2
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
261 5	261 5	261 6	261 6	261 6	261 6	261 6	261 5
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
272 8	272 8	272 9	272 9	272 9	272 9	272 9	272 8
-1 560	-1 559	-1 557	1 553	1 554	1 554	1 557	1 560
284 2	284 2	284 2	284 2	284 2	284 2	284 2	284 2
-1 560	-1 557	1 553	1 554	1 554	1 554	1 557	1 560
274 5	274 5	274 5	274 5	274 5	274 5	274 5	274 5
-1 560	-1 557	1 553	1 554	1 556	1 556	1 557	1 560
285 8	285 8	285 8	285 8	285 8	285 0	285 8	285 8
-1 560	-1 560	-1 559	-1 557	1 553	1 554	1 557	1 560
297 2	297 2	297 2	297 2	297 2	297 2	297 2	297 2
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
288 4	288 4	288 4	288 5	288 5	288 5	288 4	288 4
-1 560	-1 559	-1 557	1 553	1 554	1 554	1 557	1 560
299 8	299 8	299 8	299 8	299 8	299 0	299 8	299 8
-1 560	-1 559	-1 559	-1 557	1 553	1 554	1 557	1 560
311 2	311 2	311 2	311 2	311 3	311 0	311 2	311 2
-1 445	-1 320	-1 226	-1 033	1 185	1 271	1 392	2 084
249 3	250 1	250 8	252 3	251 2	250 4	249 7	246 2
-1 445	-1 320	-1 226	-1 033	1 185	1 271	1 392	2 084
260 6	261 5	262 1	263 7	262 5	261 7	261 0	257 4
-1 445	-1 340	1 320	-1 226	-1 033	1 271	1 392	2 084
271 9	272 6	272 8	273 5	275 1	273 0	272 4	268 5

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[*] See P. 19 for further explanation.

-1 445	-1 320	-1 226	-1 033	1 185	1.291	1 392	2 084
262 2	263 1	263 8	265 3	264 2	263 3	262 7	259 0
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
273 5	274 2	274 4	275 1	276 8	274 7	274 0	270 1
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
284 9	285 6	285 8	286 6	288 2	285 1	285 4	281 4
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
275 1	275 8	276 0	276 7	278 4	276 3	275 6	271 7
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
286 5	287 2	287 5	288 2	289 9	287 7	287 0	283 0
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
297 9	298 7	298 9	299 6	301 4	299 2	298 4	294 2
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
289 1	289 9	290 1	290 8	272 5	290 4	289 6	285 5
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
300 6	301 3	301 5	302 3	304 0	301 8	301 1	296 8
-1 445	-1 340	-1 320	-1 226	-1 033	1.291	1 392	2 084
312 0	312 8	313 0	313 7	315 5	313 3	312 5	308 1
-1 364	-1 178	-0 962	-0 510	0 879	1.090	1 274	2 607
249 8	251 1	252 7	255 5	253 4	251 9	250 6	244 4
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
261 1	262 4	264 1	267 0	264 9	263 3	262 0	255 5
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
272 5	273 8	275 5	278 5	276 3	274 7	273 3	266 6
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
262 7	264 1	265 7	268 6	266 5	264 9	263 6	257 1
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
274 1	275 4	277 2	280 1	278 0	276 3	275 0	268 1
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
285 5	286 9	288 7	291 7	289 5	287 8	286 4	279 3
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
275 7	277 1	278 8	281 8	279 6	270 0	276 6	269 7
-1 364	-1 178	-0 962	-0 510	0 879	1 090	1 274	2 607
287 1	288 5	290 3	293 3	291 1	289 4	288 0	280 9

-1 364	-1 178	-0 962	-0 510	1 090	1 ?74	1 500	2 607
298 5	300 0	301 8	304 9	300 9	29? 5	297 7	292 0
-1 364	-1 178	-0 962	-0 510	0 879	1 070	1 274	2 607
289 7	291 1	292 9	296 0	293 7	29? 1	290 6	283 4
-1 364	-1 178	-0 962	-0 510	1 090	1 ?74	1 500	2 607
301 2	302 6	304 4	307 6	303 6	30? 1	300 3	294 6
-1 364	-1 178	-0 962	-0 510	1 090	1 ?74	1 500	2 607
312 6	314 1	316 0	319 2	315 1	313 6	311 8	305 8
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
249 7	251 3	253 4	256 8	254 3	25? 4	250 7	243 4
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
261 0	262 7	264 8	268 3	265 7	26? 0	262 1	254 4
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
272 3	274 0	276 2	279 8	277 2	275 ?	273 4	265 5
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
262 6	264 3	266 4	270 0	267 3	265 4	263 7	256 0
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
274 0	275 7	277 8	281 5	278 8	276 0	275 0	267 1
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
285 3	287 0	289 3	293 0	290 2	288 ?	286 4	278 1
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
275 6	277 3	279 4	283 1	280 4	278 4	276 7	268 6
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
286 9	288 6	290 9	294 6	291 9	28? 8	288 0	279 7
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
298 2	300 0	302 3	306 1	303 3	301 ?	299 4	290 7
-1 339	-1 121	-0 859	-0 033	0 756	1 010	1 236	3 109
289 5	291 3	293 5	297 2	294 5	29? 4	290 6	282 2
-1 339	-1 121	-0 859	-0 033	0 756	1 018	1 236	3 109
300 8	302 7	304 9	308 8	305 9	30? 9	302 0	293 3
-1 339	-1 121	-0 859	-0 033	1 018	1 ?36	1 498	3 109
312 2	314 0	316 4	320 3	315 2	313 4	311 1	304 3

```
    4
    4     4     3     8
 0 000      220 940    613 641    864 682
260 00      273 00     286 00     300 00
-60 00       0 00       60 00


  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   248 9     248 9     248 9     248 9     248 9     248 9     248 9     248 9

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   259 8     259 8     259 8     259 8     259 8     259 9     259 8     259 8

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   270 8     270 8     270 8     270 8     270 8     270 8     270 8     270 8

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   261 7     261 7     261 7     261 7     261 7     261 7     261 7     261 7

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   272 6     272 6     272 6     272 7     272 7     272 7     272 6     272 6

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   283 7     283 7     283 7     283 7     283 7     283 7     283 7     283 7

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   274 5     274 5     274 5     274 5     274 5     274 5     274 5     274 5

  -1 560    -1 559    -1 557     1 553     1 554     1 554     1 557     1 560
   285 5     285 5     285 6     285 6     285 6     285 6     285 6     285 5

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   296 7     296 7     296 7     296 7     296 7     296 7     296 7     296 7

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   288 4     288 4     288 4     288 4     288 4     288 4     288 4     288 4

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   299 5     299 5     299 6     299 6     299 6     299 6     299 6     299 5

  -1 560    -1 560    -1 557     1 553     1 554     1 554     1 557     1 560
   310 7     310 7     310 7     310 8     310 8     310 8     310 7     310 7

  -1 445    -1 320    -1 226    -1 033     1 185     1 271     1 392     2 084
   249 5     250 6     251 4     253 6     252 1     251 0     250 2     246 5

  -1 445    -1 320    -1 226    -1 033     1 185     1 271     1 392     2 084
   260 5     261 6     262 4     264 7     263 1     262 0     261 2     257 3

  -1 445    -1 320    -1 226    -1 033     1 185     1 271     1 392     2 084
   271 5     272 6     273 5     275 7     274 1     273 0     272 1     268 2
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2-5

-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
262 4	263 4	264 3	266 5	264 9	263 8	263 0	259 2
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
273 3	274 4	275 3	277 6	276 0	274 9	274 0	270 0
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
284 4	285 6	286 5	288 8	297 1	285 0	285 1	280 9
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
275 2	276 3	277 2	279 5	277 9	276 7	275 9	271 8
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
286 3	287 4	288 3	290 7	289 0	287 9	287 0	282 8
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
297 5	298 6	299 6	301 9	300 3	299 1	298 2	293 8
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
289 1	290 3	291 2	293 5	291 9	290 7	289 8	285 6
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
300 3	301 5	302 4	304 8	303 1	301 9	301 0	296 6
-1 445	-1 320	-1 226	-1 033	1 185	1 ?71	1 392	2 084
311 5	312 7	313 7	316 1	314 4	313 2	312 2	307 7
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
250 2	252 4	254 0	258 1	255 3	253 1	251 4	244 8
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
261 1	263 4	265 1	269 2	266 3	264 2	262 4	255 5
-1 364	-1 141	-0 962	-0 510	0 879	1 090	1 274	2 607
272 1	274 4	276 2	280 4	277 5	275 2	273 5	266 2
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
263 0	265 2	266 9	271 1	268 2	266 0	264 3	257 3
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
274 0	276 3	278 0	282 3	279 3	277 1	275 3	268 1
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
285 1	287 4	289 2	293 6	290 5	288 3	286 5	278 9
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
275 9	278 2	279 9	284 1	281 2	279 0	277 2	269 9
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
287 0	289 3	291 1	295 4	292 4	290 1	288 3	280 7

-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
298 2	300 6	302 4	306 8	303 7	301 4	299 6	291 6
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
289 8	292 2	294 0	298 3	295 3	293 0	291 2	283 5
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
301 0	303 4	305 2	309 7	306 6	304 3	302 4	294 5
-1 364	-1 141	-0 962	-0 510	0 879	1 070	1 274	2 607
312 2	314 7	316 5	321 0	317 9	315 5	313 7	305 4
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
249 8	252 7	254 9	260 1	256 5	253 7	251 5	243 5
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
260 8	263 7	265 9	271 2	267 5	264 7	262 5	254 2
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
271 7	274 7	277 0	282 3	278 6	275 8	273 5	264 8
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
262 6	265 6	267 8	273 0	269 4	266 6	264 3	256 0
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
273 6	276 6	278 8	284 2	280 4	277 6	275 3	266 7
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
284 6	287 6	289 9	295 3	291 5	288 7	286 3	277 3
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
275 4	278 4	280 7	286 0	282 3	279 5	277 2	268 5
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
286 4	289 5	291 7	297 2	293 4	290 5	288 2	279 2
-1 339	-1 077	-0 859	0 033	0 756	1 010	1 236	3 109
297 4	300 5	302 8	308 4	304 5	301 6	299 2	289 9
-1 339	-1 077	-0 859	-0 023	0 756	1 010	1 236	3 109
289 2	292 3	294 6	300 0	276 2	293 4	291 0	282 0
-1 339	-1 077	-0 859	-0 033	0 756	1 018	1 236	3 109
300 2	303 4	305 7	311 2	307 4	304 4	302 0	292 7
-1 339	-1 077	-0 859	0 033	0 756	1 010	1 236	3 109
311 2	314 4	316 7	322 3	318 4	315 5	313 0	303 4

2-7

```
     5
     4      4      3      8
  0 000   270 940   613 641   864 682
260 00   273 00    286 00    300 00
-60 00    0 00      60 00
```

-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
250 0	250 0	250 0	250 0	250 0	250 0	250 0	250 0
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
259 7	259 7	259 7	259 7	259 7	259 7	259 7	259 7
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
269 5	269 5	269 5	269 5	269 5	269 5	269 5	269 5
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
262 6	262 6	262 6	262 7	262 7	262 7	262 7	262 6
-1 560	-1 560	-1 560	-1 557	1 553	1 554	1 557	1 560
272 4	272 4	272 4	272 4	272 4	272 4	272 4	272 4
-1 560	-1 559	-1 557	1 553	1 554	1 556	1 557	1 560
282 4	282 4	282 4	282 4	282 4	282 4	282 4	282 4
-1 560	-1 559	-1 559	-1 557	1 553	1 554	1 557	1 560
275 3	275 4	275 4	275 4	275 4	275 4	275 4	275 4
-1 560	-1 559	-1 559	-1 557	1 553	1 554	1 557	1 560
285 3	285 3	285 3	285 3	285 3	285 3	285 3	285 3
-1 560	-1 560	-1 557	1 553	1 554	1 556	1 557	1 560
295 4	295 4	295 4	295 4	275 4	295 4	295 4	295 4
-1 560	-1 560	-1 559	-1 557	1 553	1 554	1 557	1 560
289 2	289 2	289 2	289 2	289 2	289 2	289 2	289 2
-1 560	-1 560	-1 557	1 553	1 554	1 554	1 557	1 560
299 3	299 3	299 3	299 3	299 3	299 3	299 3	299 3
-1 560	-1 560	-1 557	1 553	1 554	1 556	1 557	1 560
309 4	309 4	309 5	309 5	309 5	309 5	309 5	309 4
-1 445	-1 320	-1 226	-1 033	1 185	1 272	1 392	2 084
251 6	251 9	252 9	255 7	253 7	252 7	251 4	247 8
-1 445	-1 320	-1 226	1 033	1 185	1 272	1 392	2 084
260 4	261 7	262 7	265 6	263 6	261 6	261 2	257 5
-1 445	-1 320	-1 226	-1 033	1 185	1 272	1 392	2 084
270 2	271 5	272 6	275 5	273 4	271 4	271 0	267 2

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 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 263 3     264 6     265 6     268 5      266 5    265 5     264 1     260 4

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 273 1     274 4     275 5     278 4      276 4    275 3     273 9     270 1

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 283 1     284 4     285 5     288 5      286 4    285 3     283 9     279 9

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 276 1     277 4     278 4     28? 3      279 3    278 3     276 9     273 0

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 286 0     287 4     288 5     291 4      289 3    288 3     286 9     282 8

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 296 2     297 5     298 6     301 6      299 5    298 4     297 0     292 7

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 290 0     291 3     292 4     295 3      293 3    292 ?     290 8     286 7

 -1 445    -1 320    -1 226    -1 033     1 185    1 ??1     1 392     2 084
 300 1     301 4     302 6     305 5      303 4    30? 0     300 9     296 6

 -1 445    -1 320    -1 226    -1 033     1 185    1 ???     1 392     2 084
 310 2     311 6     312 7     315 7      313 6    31? 5     311 1     306 7

 -1 364    -1 141    -0 962    -0 510     0 879    1 070     1 274     2 607
 251 4     254 1     256 2     261 4      257 8    255 1     253 0     246 3

 -1 364    -1 141    -0 962    -0 510     0 879    1 070     1 274     2 607
 261 1     263 9     266 0     271 4      267 7    264 9     262 8     255 9

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273.2	274.4	275.4	277.9	276.1	275.1	273.8	270.3
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282.7	283.9	284.9	287.5	285.6	284.6	283.3	279.6
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275	278 4	280 7	286 0	282 3	279 5	277 2	268 5
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END
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MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

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273.1	274.4	275.5	278.4	276.4	275.3	273.9	270.1
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283.1	284.4	285.5	288.5	286.4	285.3	283.9	279.9
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276.1	277.4	278.4	281.3	279.3	278.3	276.9	273.0
-1.445	-1.320	-1.226	-1.033	1.185	1.272	1.392	2.084
286.0	287.4	288.5	291.4	289.3	288.3	286.9	282.8
-1.445	-1.320	-1.226	-1.033	1.185	1.272	1.392	2.084
296.2	297.5	298.6	301.6	299.5	298.4	297.0	292.7
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290.0	291.3	292.4	295.3	293.3	292.2	290.8	286.7
-1.445	-1.320	-1.226	-1.033	1.185	1.291	1.392	2.084
300.1	301.4	302.6	305.5	303.4	302.0	300.9	296.6
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310.2	311.6	312.7	315.7	313.6	312.5	311.1	306.7
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
251.4	254.1	256.2	261.4	257.8	255.1	293.0	246.3
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
261.1	263.9	266.0	271.4	267.7	264.9	262.8	255.9
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271.0	273.3	276.0	281.4	277.7	274.8	272.6	265.4
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
264.1	266.8	268.9	274.3	270.6	267.8	265.7	258.8
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
273.9	276.7	278.9	284.3	280.6	277.8	275.6	268.3
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
283.9	286.8	289.0	294.5	290.7	287.8	285.6	278.0
-1.364	-1.141	-0.962	-0.510	0.879	1.090	1.274	2.607
276.8	279.6	281.8	287.2	283.5	280.7	278.5	271.2
-1.364	-1.141	-0.962	0.510	0.879	1.090	1.274	2.607
286.8	289.7	291.5	297.4	293.6	290.8	288.5	280.9

-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
297.0	299.9	302.1	307.7	303.9	301.0	298.7	290.8
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
290.8	293.6	295.8	301.3	297.5	294.7	292.4	284.8
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300.9	303.8	306.1	311.6	307.8	304.7	302.6	294.7
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250.8	254.5	257.3	264.1	259.4	255.0	253.0	244.8
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260.6	264.3	267.2	274.0	269.3	265.7	262.8	254.3
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270.3	274.1	277.0	284.0	279.2	275.5	272.5	263.8
-1.339	-1.077	-0.859	-0.033	0.756	1.018	1.236	3.109
263.5	267.2	270.1	276.9	272.2	268.6	265.7	257.2
-1.339	-1.077	-0.859	-0.033	0.756	1.018	1.236	3.109
273.2	277.0	279.9	286.8	282.1	278.4	275.5	266.7
-1.339	-1.077	-0.859	-0.033	0.756	1.010	1.236	3.109
283.0	286.9	289.8	296.8	292.0	288.3	285.3	276.2
-1.339	-1.077	-0.859	-0.033	0.756	1.018	1.236	3.109
276.1	279.9	282.8	289.7	284.9	281.3	278.4	269.6
-1.339	-1.077	-0.859	-0.033	0.756	1.018	1.236	3.109
285.9	289.8	292.7	299.7	294.9	291.2	288.2	279.1
-1.339	-1.077	-0.859	-0.033	0.756	1.010	1.236	3.109
295.8	299.7	302.6	309.7	304.8	301.1	298.1	288.7
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299.7	303.6	306.5	313.6	308.7	304.7	301.9	292.5
-1.339	-1.077	-0.859	0.033	0.756	1.018	1.236	3.109
309.5	313.4	316.4	323.5	318.6	314.6	311.8	302.1

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259.8	259.8	259.8	259.8	259.8	259.9	259.8	259.8
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
270.8	270.8	270.8	270.8	270.8	270.8	270.8	270.8
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
261.7	261.7	261.7	261.7	261.7	261.7	261.7	261.7
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
272.6	272.6	272.6	272.7	272.7	272.7	272.6	272.6
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
283.7	283.7	283.7	283.7	283.7	283.7	283.7	283.7
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
274.5	274.5	274.5	274.5	274.5	274.5	274.5	274.5
-1.560	-1.559	-1.557	1.553	1.554	1.554	1.557	1.560
285.5	285.5	285.6	285.6	285.6	285.6	285.6	285.5
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
296.7	296.7	296.7	296.7	296.7	296.7	296.7	296.7
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
288.4	288.4	288.4	288.4	288.4	288.4	288.4	288.4
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	i.560
299.5	299.5	299.6	299.6	299.6	299.6	299.6	299.5
-1.560	-1.560	-1.557	1.553	1.554	1.554	1.557	1.560
310.7	310.7	310.7	310.8	310.8	310.8	310.7	310.7
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
249.5	250.6	251.4	253.6	252.1	251.0	250.2	246.5
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
260.5	261.6	262.4	264.7	263.1	262.0	261.2	257.3
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
271.5	272.6	273.5	275.7	274.1	273.0	272.1	268.2

-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
262.4	263.4	264.3	266.5	264.9	263.8	263.0	259.2
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
273.3	274.4	275.3	277.6	276.0	274.9	274.0	270.0
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
284.4	285.6	286.5	288.8	287.1	286.0	285.1	280.9
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
275.2	276.3	277.2	279.5	277.9	276.7	275.9	271.8
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
286.3	287.4	288.3	290.7	289.0	287.9	287.0	282.8
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
297.5	298.6	299.6	301.9	300.3	299.1	298.2	293.8
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
289.1	290.3	291.2	293.5	291.9	290.7	289.8	285.6
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
300.3	301.5	302.4	304.8	303.1	301.9	301.0	296.6
-1.445	-1.320	-1.226	-1.033	1.185	1.271	1.392	2.084
311.5	312.7	313.7	316.1	314.4	313.2	312.2	307.7
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
250.2	252.4	254.0	258.1	255.3	253.1	251.4	244.8
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
261.1	263.4	265.1	269.2	266.3	264.2	262.4	255.5
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
272.1	274.4	276.2	280.4	277.5	275.2	273.5	266.2
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
263.0	265.2	266.9	271.1	268.2	266.0	264.3	257.3
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
274.0	276.3	278.0	282.3	279.3	277.1	275.3	268.1
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
285.1	287.4	289.2	293.6	290.5	288.3	286.5	278.9
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
275.9	278.2	279.9	284.1	281.2	279.0	277.2	269.9
-1.364	-1.141	-0.962	-0.510	0.879	1.070	1.274	2.607
287.0	289.3	291.1	295.4	292.4	290.1	288.3	280.7

-1 364	-1 141	-0 962	-0 510	0. 879	1. 090	1. 274	2. 607
298. 2	300. 6	302 4	306 8	303. 7	301. 4	299. 6	291. 6
-1 364	-1 141	-0 962	-0 510	0. 879	1. 090	1. 274	2. 607
289 8	292. 2	294. 0	298 3	295. 3	293. 0	291. 2	283. 5
-1. 364	-1 141	-0 962	-0. 510	0. 879	1. 090	1. 274	2. 607
301 0	303 4	305. 2	309 7	306. 6	304. 3	302. 4	294 5
-1 364	-1 141	-0 962	-0 510	0. 879	1. 090	1. 274	2. 607
312 2	314. 7	316. 5	321 0	317. 9	315. 5	313. 7	305 4
-1 339	-1 077	-0 859	-0 033	0 756	1. 018	1 236	3 109
249 8	252. 7	254 9	260 1	256. 5	253. 7	251. 5	243. 5
-1 339	-1 077	-0 859	-0 033	0. 756	1. 018	1. 236	3. 109
260 8	263. 7	265. 9	271. 2	267. 5	264. 7	262. 5	254. 2
-1 339	-1 077	-0 859	-0 033	0. 756	1. 018	1. 236	3. 109
271 7	274. 7	277. 0	282. 3	278. 6	275. 8	273. 5	264. 8
-1 339	-1 077	-0. 859	-0. 033	0. 756	1. 018	1. 236	3. 109
262 6	265 6	267. 8	273 0	269. 4	266. 6	264. 3	256. 0
-1 339	-1 077	-0 859	-0 033	0. 756	1. 018	1. 236	3. 109
273 6	276 6	278 8	284 2	280 4	277. 6	275 3	266. 7
-1. 339	-1. 077	-0 859	-0. 033	0. 756	1. 018	1. 236	3. 109
284 6	287. 6	289. 9	295 3	291. 5	288. 7	286. 3	277. 3
-1 339	-1. 077	-0 859	-0 033	0. 756	1. 018	1. 236	3. 109
275 4	278. 4	280. 7	286 0	282. 3	279. 5	277 2	268 5
-1 339	-1 077	-0 859	-0 033	0. 756	1. 018	1. 236	3. 109
286 4	289. 5	291 7	297. 2	293. 4	290. 5	288 2	279. 2
-1 339	-1 077	-0 859	-0 033	0. 756	1 018	1. 236	3 109
297 4	300. 5	302 8	308 4	304. 5	301 6	299. 2	289 9
-1 339	-1 077	-0 859	-0 033	0 756	1. 018	1 236	3 109
289 2	292 3	294 6	300 0	296. 2	293. 4	291 0	282 0
-1 339	-1 077	-0 859	-0 033	0. 756	1 018	1 236	3 109
300 2	303 4	305. 7	311 2	307 4	304. 4	302 0	292. 7
-1 339	-1. 077	-0 859	-0 033	0. 756	1 018	1 236	3 109
311 2	314 4	316. 7	322 3	318 4	315. 5	313 0	303 4

APPENDIX 3

Test Cases

Two test cases are presented and described herein. They were run on a small section of the Brooks Range scene. Measured data from Daedalus exists for this scene. All GENESSIS input parameters were selected to match the conditions present at the time of Daedalus data acquisition in order that the computed results may be compared with the measured data.

A.3.1.   Test Case I - Brooks Range (Thermal Band)

A.3.1.1   Atmospheric Module

Display of input file (Fortran Unit 7) for Brooks Range thermal band.

```
1)   3     16.76      10.4      12.5
2)   1   1   1   1   0   0   0     23.0
```

Display of atmospheric diagnostic output file (Fortran Unit 6).
Selected standard atmosphere is represented parametrically for 5 zenith
angles and 6 altitudes. Air masses are computed using the Chapman function.

RESULTS FOR BACKGROUND ALTITUDE = 0 KM

APPARENT REFLECTED SOLAR

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
0.0	1.0	1.299E-04	8.875E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.551E-05
48.2	1.5	2.433E-05
70.8	3.0	2.117E-05
80.8	6.0	1.615E-05
86.0	12.0	8.773E-06

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0.0
DEGREE OF BEST FIT POLYNOMIAL. 4
SUM SQUARE ERROR: 1.091E-10

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
48.2	1.5	1.807E-04	8.427E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.434E-05
48.2	1.5	3.324E-05
70.8	3.0	2.027E-05
80.8	6.0	1.550E-05
86.0	12.0	8.440E-06

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.455E-10

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
70.8	3.0	3.093E-04	7.282E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.122E-05
48.2	1.5	2.031E-05
70.8	3.0	1.780E-05
80.8	6.0	1.368E-05
86.0	12.0	7.501E-06

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70.8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 1.592E-10

```
OBSERVER
ZA      AM   PATH RADIANCE  PATH TRANSMISSION
80.8    6.0  5.039E-04 5.517E-01

SOLAR
 ZA      AM      REFLECTED SOLAR
 0.0    1.0       1.624E-05
48.2    1.5       1.557E-05
70.8    3.0       1.372E-05
80.8    6.0       1.064E-05
86.0   12.0       5.902E-06
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1.355E-10


OBSERVER
ZA      AM   PATH RADIANCE  PATH TRANSMISSION
86.0   12.0  7.751E-04 2.969E-01

SOLAR
 ZA      AM    REFLECTED SOLAR
 0.0    1.0       8.858E-06
48.2    1.5       8.517E-06
70.8    3.0       7.557E-06
80.8    6.0       5.928E-06
86.0   12.0       3.348E-06
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1.455E-10


      ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

            15              1.034E-04
            45              1.368E-04
            75              3.175E-04

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL. 4
SUM SQUARE ERROR:  1.140E-12

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR  8.527E-11
```

RESULTS FOS BACKGROUND ALTITUDE = 1 KM

APPARENT REFLECTED SOLAR

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
0.0	1.0	7.282E-05	9.329E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.792E-05
48.2	1.5	2.718E-05
70.8	3.0	2.511E-05
80.8	6.0	2.156E-05
86.0	12.0	1.541E-05

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0.0
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.573E-10

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
48.2	1.5	1.023E-04	9.053E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.719E-05
48.2	1.5	2.648E-05
70.8	3.0	2.450E-05
80.8	6.0	2.107E-05
86.0	12.0	1.509E-05

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.091E-10

OBSERVER

ZA	AM	PATH RADIANCE	PATH TRANSMISSION
70.8	3.0	1.791E-04	8.325E-01

SOLAR

ZA	AM	REFLECTED SOLAR
0.0	1.0	2.517E-05
48.2	1.5	2.454E-05
70.8	3.0	2.278E-05
80.8	6.0	1.968E-05
86.0	12.0	1.416E-05

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70.8
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.110E-10

```
OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80.8    6.0 3.046E-04 7 122E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0.0    1.0       2.167E-05
48.2    1 5       2.117E-05
70.8    3.0       1.974E-05
80.8    6.0       1.715E-05
86.0   12.0       1.244E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  9.095E-11


OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86.0   12 0 5.155E-04 5.071E-01

SOLAR
 ZA!    AM     REFLECTED SOLAR
 0.0    1.0       1.556E-05
48.2    : 5       1 523E-05
70 8    3.0       1 426E-05
80.8    6.0       1.249E-05
86.0   12.0       9.172E-06
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR.  1 573E-10


     ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

          15              6 050E-05
          45              8 039E-05
          75              1 922E-04

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR.  1 222E-12

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR.  1 103E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 2 KM

APPARENT REFLECTED SOLAR

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
0.0   1.0 3.842E-05 9.618E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   2.949E-05
48.2   1.5   2.904E-05
70.8   3.0   2.777E-05
80.8   6.0   2.551E-05
86.0   12.0   2.131E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0.0
DEGREE OF BEST FIT POLYNOMIAL. 4
SUM SQUARE ERROR: 1.473E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
48.2   1.5 5.446E-05 9.456E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   2.906E-05
48.2   1.5   2.862E-05
70.8   3.0   2.739E-05
80.8   6.0   2.520E-05
86.0   12.0   2.107E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.255E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
70.8   3.0 9.692E-05 9.020E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   2.783E-05
48.2   1.5   2.744E-05
70.8   3.0   2.633E-05
80.8   6.0   2.428E-05
86.0   12.0   2.038E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70.8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   1.110E-10

```
OBSERVER
ZA     AM   PATH RADIANCE  PATH TRANSMISSION
80.8   6.0 1.685E-04 8 278E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0.0    1.0      2.565E-05
48.2    1.5      2.532E-05
70.8    3.0      2.436E-05
80.8    6.0      2.257E-05
86 0   12.0      1.904E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  8 276E-11


OBSERVER
ZA     AM   PATH RADIANCE  PATH TRANSMISSION
86.0   12.0 3.002E-04 6 904E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0.0    1.0      2.151E-05
48.2    1.5      2.126E-05
70.8    3.0      2.053E-05
80.8    6.0      1.912E-05.
86.0   12.0      1.627E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  1 455E-10


      ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

          15              3 328E-05
          45              4 445E-05
          75              1 077E-04

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR   1 094E-12

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR   1 421E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 4 KM

APPARENT REFLECTED SOLAR

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
0.0   1.0   8.949E-06 9.887E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.097E-05
48.2   1.5   3.080E-05
70.8   3.0   3.032E-05
80.8   6.0   2.945E-05
86.0   12.0   2.777E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0.0
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.373E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
48.2   1.5   1.300E-05 9.835E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.081E-05
48.2   1.5   3.065E-05
70.8   3.0   3.019E-05
80.8   6.0   2.933E-05
86.0   12.0   2.768E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR: 1.473E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
70.8   3.0   2.429E-05 9.687E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.029E-05
48.2   1.5   3.024E-05
70.8   3.0   2.981E-05
80.8   6.0   2.899E-05
86.0   12.0   2.740E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70.8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR: 1.455E-10

```
OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80.8    6.0   4.398E-05  9.426E-01

SOLAR
 ZA      AM    REFLECTED SOLAR
 0.0    1.0      2.961E-05
48.2    1.5      2.948E-05
70.8    3.0      2.908E-05
80.8    6.0      2.833E-05
86.0   12.0      2.683E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR:  1.774E-10


OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86.0   12.0   8.283E-05  8.912E-01

SOLAR
 ZA      AM    REFLECTED SOLAR
 0.0    1.0      2.805E-05
48.2    1.5      2.794E-05
70.8    3.0      2.761E-05
80.8    6.0      2.696E-05
86.0   12.0      2.563E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL.  4
SUM SQUARE ERROR:  1.692E-10


        ZENITH ANGLE     SKYSHINE (W/CM**2/SR)

            15                  8.786E-06
            45                  1.184E-05
            75                  2.964E-05


 PATH TRANSMISSION
 DEGREE OF BEST FIT POLYNOMIAL   4
 SUM SQUARE ERROR   9.663E-13

 PATH RADIANCE
 DEGREE OF BEST FIT POLYNOMIAL   4
 SUM SQUARE ERROR   1.355E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 7 KM

APPARENT REFLECTED SOLAR

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
0.0   1.0 1.186E-06 9.975E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.147E-05
48.2   1.5   3.141E-05
70.8   3.0   3.125E-05
80.8   6.0   3.093E-05
86.0   12.0   3.032E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0.0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR: 1.810E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
48.2   1.5 1.766E-06 9.963E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.143E-05
48.2   1.5   3.138E-05
70.8   3.0   3.121E-05
80.8   6.0   3.089E-05
86.0   12.0   3.029E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR: 1.055E-10

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
70.8   3.0 3.532E-06 9.926E-01

SOLAR
ZA   AM   REFLECTED SOLAR
0.0   1.0   3.132E-05
48.2   1.5   3.126E-05
70.8   3.0   3.110E-05
80.8   6.0   3.079E-05
86.0   12.0   3.020E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70.8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 9.095E-11

```
OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
80.8    6.0 6.888E-06 9 855E-01

SOLAR
  ZA      AM      REFLECTED SOLAR
  0.0    1.0       3.110E-05
 48.2    1.5       3.105E-05
 70.8    3.0       3.089E-05
 80.8    6.0       3.059E-05
 86.0   12.0       3.002E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST!FIT POLYNOMIAL  4
SUM SQUARE ERROR:  6 366E-11


OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
86.0   12.0 1.389E-05 9.709E-01

SOLAR
  ZA      AM      REFLECTED SOLAR
  0.0    1.0       3.064E-05
 48.2    1.5       3 059E-05
 70 8    3.0       3 045E-05
 80.8    6.0       3.017E-05
 86.0   12.0       2 963E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  1 473E-10


        ZENITH ANGLE    SKYSHINE  (W/CM**2/SR)

            15              1 714E-06
            45              2 337E-06
            75              6 122E-06

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR  5 258E-13

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR  1 892E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 10 KM

APPARENT REFLECTED SOLAR

OBSERVER
```
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
 0.0    1.0  5.221E-07 9 987E-01
```

SOLAR
```
 ZA      AM     REFLECTED SOLAR
 0.0    1.0       3.154E-05
48 2    1.5       3.150E-05
70 8    3.0       3.138E-05
80.8    6.0       3.115E-05
86.0   12.0       3.071E-05
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR: 1 473E-10

OBSERVER
```
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
48.2    1.5 7 821E-07 9 980E-01
```

SOLAR
```
 ZA      AM     REFLECTED SOLAR
 0.0    1.0       3.152E-05
48 2    1.5       3.148E-05
70 8    3.0       3.136E-05
80 8    6.0       3 113E-05
86.0   12 0       3 069E-05
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48.2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR: 1 573E-10

OBSERVER
```
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
70 8    3.0 1.574E-06 9 960E-01
```

SOLAR
```
 ZA      AM     REFLECTED SOLAR
 0 0    1 0       3 146E-05
48 2    1 5       3 142E-05
70 8    3.0       3.130E-05
80 8    6.0       3 107E-05
86 0   12.0       3 063E-05
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   1 091E-10

```
OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80 8    6.0 3 180E-06 9 919E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1.0      3.133E-05
48.2    1.5     3 129E-05
70 8    3.0      3.118E-05
80 8    6.0      3.095E-05
86.0    12.0     3.052E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  9 913E-11


OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86.0    12 0 6.612E-06 9 832E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0.0    1.0      3.106E-05
48.2    1.5     3 102E-05
70.8    3 0      3.091E-05
80.8    6.0      3.069E-05
86.0    12.0     3.027E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR:  1 573E-10


         ZENITH ANGLE   SKYSHINE (W/CM**2/SR)

              15              1.049E-06
              45              1.430E-06
              75              3 752E-06

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR   9 948E-13

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR   2 010E-10
 FIT OF SKYSHINE TO ALTITUDE
DEGREE OF BEST FIT POLYNOMIAL  5
SUM SQUARE ERROR   2 323E-10
```

Display of atmospheric module output database (Fortran Unit 5). **Header**
(Line 1) contains parameters used to generate the database. Lines 2-44
contain the coefficients of the polynomial curve fits to the computed
atmospheric values.

```
 1)10.40 12.50  2  2  1  1  1  1  3   3   3 23.00
 2)  6 4.0 -4 59326E 00 -7.89541E-02 -2 61340E-01   3 14837E-01 -3 46999E-01
 3)  6 4.0 -4.61362E 00 -7 62383E-02 -2 60405E-01   3.14517E-01 -3 47019E-01
 4)  6 4.0 -4 67320E 00 -7.18782E-02 -2.52246E-01   3 04209E-01 -3 41877E-01
 5)  6 4.0 -4.78952E 00 -6.62978E-02 -2 53453E-01   3 15605E-01 -3 46782E-01
 6)  6 4.0 -5 05269E 00 -6 03881E-02 -2 52162E-01   3.25010E-01 -3 48786E-01
 7)  6 4.0   8.87542E-01 -2.15883E-01 -2 02091E-01  -9 32986E-02 -4 26052E-03
 8)  6 4.0 -3.88650E 00   8 24803E-01 -4 18577E-02 -7.62313E-02  2 36430E-02
 9)  6 4.0 -4.55402E 00 -4.57499E-02 -1.43330E-01   1 63474E-01 -1.82706E-01
10)  6 4.0 -4.56554E 00 -4.46328E-02 -1 41305E-01   1.62373E-01 -1.82544E-01
11)  6 4.0 -4 59918E 00 -4 08432E-02 -1 43886E-01   1 71667E-01 -1 87517E-01
12)  6 4.0 -4.66406E 00 -3 79587E-02 -1 33861E-01   1 59578E-01 -1 80915E-01
13)  6 4.0 -4.80799E 00 -3 36733E-02 -1.34668E-01   1 70270E-01 -1.84895E-01
14)  6 4 0   9.32920E-01 -1 26791E-01 -1 76578E-01   5 78391E-02 -1 15521E-01
15)  6 4.0 -4 13776E 00   8 43565E-01 -1 43116E-02 -1 11035E-01   7 10696E-02
16)  6 4.0 -4 53032E 00 -2 66672E-02 -7 54294E-02   7 74168E-02 -9 00134E-02
17)  6 4.0 -4.53676E 00 -2 67539E-02 -7.15051E-02   7.46099E-02 -8.95482E-02
18)  6 4.0 -4.55553E 00 -2.33272E-02 -7 36055E-02   7 80294E-02 -9.05309E-02
19)  6 4.0 -4 59094E 00 -2 17035E-02 -6 90229E-02   7.72063E-02 -9 06321E-02
20)  6 4 0 -4.66727E 00 -1 96165E-02 -6.31279E-02   7 21464E-02 -8.67119E-02
21)  6 4 0   9.61813E-01 -7.16439E-02 -1.29004E-01   8 99944E-02 -1 16057E-01
22)  6 4.0 -4 41546E 00   8 64030E-01   5 07067E-01 -1.61819E-01   1 16908E-01
23)  6 4.0 -4 50912E 00 -1 05611E-02 -1 83363E-02   1.12846E-02 -2 11929E-02
24)  6 4.0 -4 51124E 00 -9 79073E-03 -2.00226E-02   1 38421E-02 -2 22447E-02
25)  6 4.0 -4 51722E 00 -8 93966E-03 -1 97966E-02   1 36947E-02 -2 18937E-02
26)  6 4.0 -4.52856E 00 -8 10631E-03 -2.02461E-02   1.72982E-02 -2 37717E-02
27)  6 4.0 -4 55204E 00 -7 07087E-03 -1.82874E-02   1.60502E-02 -2.25099E-02
28)  6 4.0   9.88674E-01 -2 13511E-02 -5 38013E-02   4.84879E-02 -5.37432E-02
29)  6 4 0 -5 04821E 00   9 10515E-01   1.14639E-01 -3 51154E-01   2 15552E-01
30)  6 4 0 -4.50207E 00 -3 43650E-03 -6 56931E-03   3 07842E-03 -6.44504E-03
31)  6 4 0 -4.50260E 00 -3 45846E-03 -6 39680E-03   2.97737E-03 -6 42083E-03
32)  6 4 0 -4.50421E 00 -3 38141E-03 -5 53514E-03   1 37477E-03 -5.49920E-03
33)  6 4.0 -4.50724E 00 -3 39597E-03 -4 37231E-03  -5.87997E-04 -4 38643E-03
34)  6 4.0 -4.51366E 00 -2 92654E-03 -6 54856E-03   3.80021E-03 -6.41356E-03
35)  6 4 0   9.97527E-01 -4 79561E-03 -1 34789E-02   1 10782E-02 -1 45320E-02
36)  6 4 0 -5 92579E 00   9 46583E-01   2 80240E-01 -5.10162E-01   2 67284E-01
37)  6 4 0 -4 50110E 00 -2 32612E-03 -5 17328E-03   2 93591E-03 -5 05607E-03
38)  6 4.0 -4.50139E 00 -2 36292E-03 -4 92426E-03   2.69867E-03 -5 00112E-03
39)  6 4.0 -4 50226E 00 -2 44486E-03 -4 27801E-03   1 76970E-03 -4 56799E-03
40)  6 4.0 -4 50402E 00 -2 20475E-03 -4 94241E-03   2 55295E-03 -4.78402E-03
41)  6 4 0 -4 50785E 00 -2 21831E-03 -4 48939E-03   1 91881E-03 -4 38155E-03
42)  6 4 0   9.98677E-01 -2 66467E-03 -6 77741E-03   5 47854E-03 -8 54138E-03
43)  6 4 0 -6 28225E 00   9 85047E-01   8 81497E-02 -1 39739E-01   8 35264E-02
44)  7 5 0 -3.26326E 00   1 36249E-01 -6 08680E 00   1 68157E 01 -2 47246E 01   1 19027E 01
```

A.3.1.2 <u>Geometric Module</u>

Display of input file (Fortran Unit 13).

```
1)   F
2)   1. 100
3)              0. E0        -149. 5E0         67. 78E0
4)       1     9 1982 2210. 00
5)         16. 76E0         -149. 5E0         67. 78E0
6)    100  100
7)          . 0025E0           . 0025E0
```

Hex display of the binary shadow map (Fortran Unit 11).

```
FFFF FFFF FFFF FFFE 0000 0000 000. 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFE 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFC 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFC 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFB0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE0 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFC 0000 C000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFC 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF 8010 C000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF7 E81F 88C0 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFF7 FC1F 0C00 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE3 FE1F 0C00 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE3 FF7E 0C00 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE3 FFF6 0800 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFC1 FFFC 0800 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFC1 FFFC 0780 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FF81 FFF8 0FFC 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FF80 FFF8 0FFC 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FF00 FFF8 0FFE 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF EF00 FFFC 0CFF 8000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FECC 7FE0 087F 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFE0 7FE0 007F 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FE38 7F28 007E 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FC1E 3E30 007F 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FC1D FE1D 003F 0000 0000 0000 0000 0000 0000
FFFF FFFF F7FF F81F DC1F 003F 0000 0000 0000 0000 0000 0000
FFFF FFFF E3FF F80F FC1F 003E 0000 0000 0000 0000 0000 0000
FFFF FFFF C1FF F00F F00E 003E 0000 0000 0000 0000 0000 0000
FFFF FFFF C1FF F00F E00F 003C 0000 0000 0000 0000 0000 0000
FFFF FFFF E0FF E807 F80F 003C 0000 0000 0000 0000 0000 0000
FFFF FFFF F87F FF97 FE07 00B8 0000 0000 0000 0000 0000 0000
FFFF FFFF FC3F FFE7 FF8E 0078 0000 0000 0000 0000 0000 0000
FFFF FFFF FEFF FFFB FFCE 01F0 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF 80F0 0000 0000 0000 0000 0018 0000
FFFF FFFF FFFF FFFF FFFF E0F0 0000 0000 0000 0000 003F 0000
FFFF FFFF FFFF FFFF FFFF F3F9 0000 0000 0000 0000 003F 0000
FFFF FFFF FFFF FFFF E7FE FF7F 8000 0000 E000 0000 0007 0000
FFFF FFFF FFFF FFFF E7FF FFFF 8000 0000 F0FF F803 FFC7 103C
FFFF FFFF FFFF FFFF 03FD FFFF E000 0000 F1FF F803 FFC7 FFFC
FFFF FFFF FFFF FFFF C3FF 7FFF F008 000F FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF C1FF FFFF F81F FFFF 9FFF FFFE FFFF FFFC
FFFF FFFF FFFF FFFF 81FE FFFF FC1F FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF 8CFF FFFF FFBF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF 80FD FFFF FFFF FFFF FFFF FFFF FFFF 07FC
FFFF FFFF 8FFF FFFF 0CFF 0FFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF 1FFF FFFF 00FF 0FFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF 1FFF FFFF 00FE 0FFF FFFF FFFF FFFF FFFF FFFF FFC0
FFFF FFFF 1FFF FFFE 007E 8FFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF E03D FFFF FFFB FFFF FFFF 9FFF FFFF FFFC
FFFF FFFF FFFF FFFF F83F FBFF FFFF FFFF FFFF 9FFF FFFF FFFC
FFFF FFFF FFFF FFFF FE3B FFFF FFFF FFFF FFBF FFFF FFFF FFFC
```

```
FFFF FFFF FFFF FFFF FFFF FFFF FFFF 7FFF FE1F FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFDF FFFF FFFF 7FFF FF1F FFFF FFFF FFFC
FFFF FFFF FFFF FFF7 FFFF F8FF FFFF 6FFF 7FFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF E1FF FFFF E7FC 3FFF FFFF FFFF FFFC
FFFF FFFF FFFF FFBF FFFF E1FF FFFF E7FE 3FFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF C1FF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF 81FF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF 81FF FFE7 FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF D9FF FFE7 FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF 0FFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC 7FFC
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFF8 03FC
FFFF FFFF FFFF FFFF EFFF 8FFF FFFF FFFF FFFF FFFF FFF8 0000
FFFF FFFF FFFF FFFF 7FFF FFFF FFFF FFFF FFFF FFFF FFF0 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFB FFFF FFFF FFFF FFF0 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFB FFFF FFFF FFFF FFE0 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFC0 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FF80 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FF00 0000
FFFF FFFF FFFF FFFF FFFF FFF7 FFFF FFFF FFFF FFFF FE00 0000
FFFF FFFF FFFF FFFF FFFF FFE0 FFFF FFFF FFFF FFFF F800 0000
FFFF FFFF 9FFF FFFF FFFF FFE0 FFFF FFFF FFFF FFFF E000 0000
FFFF FFFF 1FFF FFFF FFFF FFE0 7FFF FFFF FFFF FFFF C000 0000
FFFF FFFF 1FFF FFFF FFDF FFE0 39FF FFFF FFFF FFFF 8000 0000
FFFF FFFF 0FFF FFFF FF8F FFE0 30FF FFFF FFFF FFFF 0000 0000
FFFF FFFF 0FFF FFFF FF0F FFE0 39FF FFFF FFFF FFFF 0000 0000
FFFF FFFF F7FF FFFF FF0F FFC0 3FFF FFFF FFFF FFFF 0000 0000
FFFF FFFF F7FF FFFF FE07 FFC0 1FFF FFFF FFFF FFFF 0000 0000
FFFF FFFF FFFF FFFF FC07 FFC0 3FFF FFFF FFFF FFFE 0000 0000
FFFF FFFF FFFF FFFF F807 FFC0 FFFF FFFF FFFF FFF4 0000 0000
FFFF FFFF FFFF FFFF F403 FFC0 FFFF FFFF FFFF C180 0000 0000
FFFF FFFF FFFF FFFF FC07 FFC0 FFFF FFFF FFFC C000 0000 0000
FFFF FFFF FFFF FFFF FF7F FFC0 FFFF FFFF FFF8 C000 0000 0000
FFFF FFFF FFFF FFFF FFFF FF80 FFFF FFFF FFF0 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FF80 FFFF FFFF FF00 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FF83 FFFF FFFF F800 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FF07 FFFF FFFF F000 C000 0000 0000
FFFF FFFF FFFF FFFF FFFF FB07 FFFF FFFF E000 C000 0000 0000
FFFF FFFF FFFF FFFF FFFF FB07 FFEF FFFF C000 C000 0000 0000
FFFF FFFF FFFF FFFF FFFF F307 FFEF FFFF 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF F307 FFFF FFFE 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF E107 FFFF FFFC 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF E007 9BFF FFF0 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF C1BF BFFF FFE0 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF C1FF 0FFF FFC0 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF C1FF 1FFF FF80 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF E1FF FFFF FE00 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF F9FF FFFF FC00 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF F9FF FFFF F800 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFF0 7FFF FFFF F000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFF8 3FFF FFFF E000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFF8 3FFF FFFF E000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFF0 3FFF FFFF 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FEFF FFFF FFFF 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F43F FFFB FFFF C000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FC3F FFFF FFFE 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FC1F FFFF FFFC 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F81F A3FF FFF0 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F83E 01FF FFE0 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F07E 00FF FFC0 0000 0000 0000 0000 0004
FFFF FFFF FFFF FFFF F07E 007F FC00 0000 0000 0000 0000 003C
FFFF FFFF FFFF FFFF F03E 033F C000 0000 0000 0000 0000 003C
```

```
FFFF FFFF FFFF FFFF F000 0000 0000 0000 0000 0000 3000 0000
FFFF FFFF FFFF FFFF F000 0000 0000 0000 0000 0300 3800 0FC0
FFFF FFFF FFFF FFFF F000 0000 0000 0000 0000 0300 0000 07FC
FFFF FFFF FFFF FFFF E000 0000 0000 0000 0000 03E8 0000 03FC
FFFF FFFF FFFF FFFF E000 0000 0000 0000 0000 03FF 0103 C3FC
FFFF FFFF FFFF FFFF E000 0000 0000 0000 0000 03FF FBCF FFFC
FFFF FFFF FFFF FFFF E000 0000 0000 0000 0000 03FF FFFF FFFC
FFFF FFFF FFFF FFFF C000 0000 0000 0000 0000 03FF FFFF FFFC
FFFF FFFF FFFF FFFF C000 0000 0000 0000 0000 03FF FFFF FFFC
FFFF FFFF FFFF FFFF C000 0000 0000 0000 0000 03FF FFFF FFFC
FFFF FFFF FFFF FFFE 0000 0000 0000 0000 0000 C0FF FFFF FFFC
FFFF FFFF FFFF FFFE 0000 0000 0000 0000 0000 001F FFFF FFFC
FFFF FFFF FFFF FFFC 0000 0000 0000 0000 0000 0007 FFFF FFFC
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 1FFF FFFC
FFFF FFFF FFFF FFF8 0000 0000 0000 0000 0000 0000 0FFF FFFC
FFFF FFFF FFFF FFE1 0000 0000 0000 0000 0000 0000 0FFF FFFC
FFFF FFFF FFFF F-01 0000 0000 0000 0000 0000 0000 07FF FFFC
FFFF FFFF FFFF FFB0 0000 0000 0000 0000 0000 0000 03FF FFFC
FFFF FFFF FFFF FE00 0000 0000 0000 0000 0000 0000 00FF FFFC
FFFF FFFF FFFF BC00 0000 0000 0000 0000 0000 0000 003F FFFC
FFFF FFFF FFFF E900 0000 0000 0000 0000 0000 0000 0003 FFFC
FFFF FFFF FFFF FE00 0000 0000 0000 0000 0000 0000 0000 FFFC
FFFF FFFF FFFF FE00 0000 0000 0000 0000 0000 0000 0000 3FFC
FFFF FFFF FFFF FD80 0000 0000 0000 0000 0000 0000 0000 03FC
FFFF FFFF FFFF FD5F 0000 0000 0000 0000 0000 0000 0000 01FC
FFFF FFFF FFFF F9FF 8000 0000 0000 0000 0000 0000 0000 00FC
FFFF FFFF FFDF FAFF 0000 0000 0000 0000 0000 0000 0000 003C
FFFF FFFF FFBF F7FF 0000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFBF FFFF 8000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFBF FFFF 8000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF 4000 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF C080 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F0C0 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F0C0 0000 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F0F0 7800 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF F9F0 7800 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFE0 7E00 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFF8 7F00 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFE FF80 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FF80 0000 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF DFFF FE00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF DFFF FFFF FE00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FC00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FC00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FC00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF F9FF FC00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF F3FF FC00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FF00 0000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFD FFF7 8000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFD FFFF FFFF C000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFE 7FFF E000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFE 3FFF E000 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFF1 2FFF F800 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FDFF F800 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF F87F FC00 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FE00 FFFF FFFF F87F FFE0 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFF8 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFF8 0000 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFF8 C007 0000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFE C01F 8000 0000 0000
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFC
```

Visibility map (Fortran Unit 12). Since this test case is a nadir view, all points are visible to the observer. Therefore, the entire visibility map is composed of zeros and is not displayed.

ASCII display of a portion of the binary pseudo radiance map (Fortran Unit 6). One third of the scene (leftmost portion) is shown. Columns 1-10 are uniformly zero (the field of view extends beyond the edge of the scene) and are not included.

	11	12	13	14	15	16	17	18	19	20
51	0.0000E 00	0.6499E 00	0.6580E 00	0.6624E 00	0.6628E 00	0.6592E 00	0.6590E 00	0.6594E 00	0.6569E 00	0.6493E 00
52	0.0000E 00	0.6553E 00	0.6475E 00	0.6594E 00	0.6615E 00	0.6510E 00	0.6457E 00	0.6456E 00	0.6444E 00	0.6452E 00
53	0.0000E 00	0.6648E 00	0.6607E 00	0.6437E 00	0.6412E 00	0.6576E 00	0.6679E 00	0.6623E 00	0.6468E 00	0.6449E 00
54	0.0000E 00	0.6628E 00	0.6623E 00	0.6610E 00	0.6611E 00	0.6508E 00	0.6457E 00	0.6461E 00	0.6446E 00	0.6443E 00
55	0.0000E 00	0.6626E 00	0.6626E 00	0.6627E 00	0.6628E 00	0.6598E 00	0.6581E 00	0.6583E 00	0.6583E 00	0.6582E 00
56	0.0000E 00	0.6632E 00	0.6626E 00	0.6626E 00	0.6626E 00	0.6633E 00	0.6636E 00	0.6637E 00	0.6644E 00	0.6636E 00
57	0.0000E 00	0.6601E 00	0.6628E 00	0.6627E 00	0.6626E 00	0.6626E 00	0.6629E 00	0.6619E 00	0.6590E 00	0.6620E 00
58	0.0000E 00	0.6510E 00	0.6607E 00	0.6643E 00	0.6641E 00	0.6641E 00	0.6652E 00	0.6606E 00	0.6460E 00	0.6610E 00
59	0.0000E 00	0.6544E 00	0.6457E 00	0.6462E 00	0.6463E 00	0.6463E 00	0.6460E 00	0.6499E 00	0.6593E 00	0.6489E 00
60	0.0000E 00	0.6609E 00	0.6582E 00	0.6563E 00	0.6583E 00	0.6589E 00	0.6510E 00	0.6441E 00	0.6474E 00	0.6451E 00
61	0.0000E 00	0.6620E 00	0.6628E 00	0.6635E 00	0.6636E 00	0.6640E 00	0.6587E 00	0.6528E 00	0.6511E 00	0.6429E 00
62	0.0000E 00	0.6672E 00	0.6662E 00	0.6629E 00	0.6625E 00	0.6624E 00	0.6658E 00	0.6608E 00	0.6677E 00	0.6595E 00
63	0.0000E 00	0.6797E 00	0.6768E 00	0.6657E 00	0.6642E 00	0.6639E 00	0.6727E 00	0.6809E 00	0.6825E 00	0.7003E 00
64	0.0000E 00	0.6581E 00	0.6631E 00	0.6796E 00	0.6814E 00	0.6811E 00	0.6810E 00	0.6811E 00	0.6814E 00	0.6820E 00
65	0.0000E 00	0.6765E 00	0.6774E 00	0.6807E 00	0.6811E 00	0.6814E 00	0.6734E 00	0.6649E 00	0.6654E 00	0.6657E 00
66	0.0000E 00	0.6722E 00	0.6718E 00	0.6703E 00	0.6702E 00	0.6702E 00	0.6705E 00	0.6703E 00	0.6499E 00	0.6686E 00
67	0.0000E 00	0.6609E 00	0.6618E 00	0.6632E 00	0.6659E 00	0.6649E 00	0.6734E 00	0.6816E 00	0.6813E 00	0.6836E 00
68	0.0000E 00	0.6635E 00	0.6663E 00	0.6774E 00	0.6789E 00	0.6800E 00	0.6802E 00	0.6793E 00	0.6809E 00	0.5934E 00
69	0.0000E 00	0.6835E 00	0.6777E 00	0.6610E 00	0.6586E 00	0.6726E 00	0.6808E 00	0.6793E 00	0.6781E 00	0.6774E 00
70	0.0000E 00	0.6705E 00	0.6808E 00	0.6782E 00	0.6775E 00	0.6777E 00	0.6791E 00	0.6820E 00	0.6711E 00	0.6797E 00
71	0.0000E 00	0.6698E 00	0.6671E 00	0.6784E 00	0.6784E 00	0.6792E 00	0.6787E 00	0.6798E 00	0.6800E 00	0.6809E 00
72	0.0000E 00	0.6736E 00	0.6665E 00	0.6786E 00	0.6836E 00	0.6806E 00	0.6819E 00	0.6823E 00	0.6796E 00	0.6914E 00
73	0.0000E 00	0.6791E 00	0.6799E 00	0.6805E 00	0.6910E 00	0.6841E 00	0.6874E 00	0.6936E 00	0.6806E 00	0.6780E 00
74	0.0000E 00	0.6691E 00	0.6818E 00	0.6790E 00	0.6607E 00	0.6725E 00	0.6810E 00	0.6795E 00	0.6794E 00	0.6790E 00
75	0.0000E 00	0.6629E 00	0.6638E 00	0.6635E 00	0.6770E 00	0.6694E 00	0.6623E 00	0.6667E 00	0.6793E 00	0.6810E 00
76	0.0000E 00	0.6621E 00	0.6620E 00	0.6629E 00	0.6661E 00	0.6632E 00	0.6608E 00	0.6628E 00	0.6661E 00	0.6668E 00
77	0.0000E 00	0.6615E 00	0.6622E 00	0.6620E 00	0.6608E 00	0.6651E 00	0.6646E 00	0.6617E 00	0.6607E 00	0.6607E 00
78	0.0000E 00	0.6646E 00	0.6620E 00	0.6618E 00	0.6614E 00	0.6723E 00	0.6704E 00	0.6617E 00	0.6617E 00	0.6605E 00
79	0.0000E 00	0.6736E 00	0.6602E 00	0.6620E 00	0.6631E 00	0.6462E 00	0.6496E 00	0.6634E 00	0.6608E 00	0.6643E 00
80	0.0000E 00	0.6714E 00	0.6763E 00	0.6626E 00	0.6612E 00	0.6725E 00	0.6702E 00	0.6616E 00	0.6621E 00	0.6608E 00
81	0.0000E 00	0.6615E 00	0.6675E 00	0.6744E 00	0.6630E 00	0.6641E 00	0.6644E 00	0.6608E 00	0.6621E 00	0.6613E 00
82	0.0000E 00	0.6711E 00	0.6708E 00	0.6719E 00	0.6724E 00	0.6643E 00	0.6669E 00	0.6705E 00	0.6641E 00	0.6716E 00
83	0.0000E 00	0.6774E 00	0.6741E 00	0.6635E 00	0.6744E 00	0.6673E 00	0.6693E 00	0.6749E 00	0.6649E 00	0.6708E 00
84	0.0000E 00	0.6621E 00	0.6616E 00	0.6621E 00	0.6609E 00	0.6621E 00	0.6620E 00	0.6629E 00	0.6607E 00	0.6431E 00
85	0.0000E 00	0.6741E 00	0.6619E 00	0.6622E 00	0.6622E 00	0.6632E 00	0.6532E 00	0.6491E 00	0.6621E 00	0.6627E 00
86	0.0000E 00	0.6652E 00	0.6625E 00	0.6624E 00	0.6634E 00	0.6643E 00	0.6625E 00	0.6577E 00	0.6502E 00	0.6497E 00
87	0.0000E 00	0.6619E 00	0.6629E 00	0.6617E 00	0.6541E 00	0.6526E 00	0.6546E 00	0.6534E 00	0.6492E 00	0.6442E 00
88	0.0000E 00	0.6691E 00	0.6627E 00	0.6615E 00	0.6903E 00	0.6479E 00	0.6460E 00	0.6440E 00	0.6453E 00	0.6454E 00
89	0.0000E 00	0.6750E 00	0.6619E 00	0.6626E 00	0.6651E 00	0.6663E 00	0.6557E 00	0.6447E 00	0.6454E 00	0.6462E 00
90	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
91	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
92	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
93	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
94	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
95	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
96	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
97	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
98	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
99	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
100	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00

	21	22	23	24	25	26	27	28	29	30
1	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
2	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
3	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
4	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
5	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
6	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
7	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
8	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
9	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
10	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
11	0 5571E 00	0 6493E 00	0 6458E 00	0 6464E 00	0 6374E 00	0 6364E 00	0 6408E 00	0 6480E 00	0 6551E 00	0 6618E 00
12	0 5624E 00	0 6625E 00	0 6639E 00	0 6627E 00	0 6625E 00	0 6626E 00	0 6627E 00	0 6622E 00	0 6622E 00	0 6619E 00
13	0 6709E 00	0 6823E 00	0 6878E 00	0 6887E 00	0 7051E 00	0 7086E 00	0 7015E 00	0 6874E 00	0 6744E 00	0 6616E 00
14	0 6734E 00	0 6893E 00	0 7020E 00	0 7094E 00	0 7125E 00	0 7013E 00	0 6892E 00	0 6804E 00	0 6774E 00	0 6623E 00
15	0 6766E 00	0 6909E 00	0 7017E 00	0 7116E 00	0 7118E 00	0 7008E 00	0 6890E 00	0 6788E 00	0 6711E 00	0 6929E 00
16	0 6847E 00	0 6990E 00	0 6977E 00	0 7000E 00	0 7117E 00	0 7116E 00	0 7030E 00	0 6823E 00	0 6570E 00	0 6429E 00
17	0 6700E 00	0 6976E 00	0 7170E 00	0 7145E 00	0 7105E 00	0 6962E 00	0 6823E 00	0 6770E 00	0 6728E 00	0 6418E 00
18	0 6869E 00	0 6967E 00	0 7022E 00	0 7167E 00	0 7254E 00	0 7043E 00	0 6828E 00	0 6705E 00	0 6578E 00	0 6549E 00
19	0 6852E 00	0 6979E 00	0 7129E 00	0 7139E 00	0 7156E 00	0 6987E 00	0 6818E 00	0 6665E 00	0 6578E 00	0 6691E 00
20	0 6735E 00	0 6884E 00	0 7094E 00	0 7141E 00	0 7138E 00	0 6975E 00	0 6835E 00	0 6729E 00	0 6658E 00	0 6650E 00
21	0 6670E 00	0 6630E 00	0 6892E 00	0 7119E 00	0 7264E 00	0 6993E 00	0 6884E 00	0 6807E 00	0 6713E 00	0 6971E 00
22	0 6731E 00	0 6700E 00	0 6544E 00	0 6639E 00	0 7068E 00	0 6942E 00	0 6784E 00	0 6699E 00	0 6699E 00	0 6582E 00
23	0 6793E 00	0 6786E 00	0 6779E 00	0 6735E 00	0 6676E 00	0 6769E 00	0 6908E 00	0 6832E 00	0 6701E 00	0 6574E 00
24	0 6648E 00	0 6656E 00	0 6658E 00	0 6638E 00	0 6620E 00	0 6670E 00	0 6686E 00	0 6551E 00	0 6405E 00	0 6264E 00
25	0 6609E 00	0 6597E 00	0 6599E 00	0 6587E 00	0 6608E 00	0 6758E 00	0 6726E 00	0 6522E 00	0 6411E 00	0 6354E 00
26	0 6692E 00	0 6615E 00	0 6613E 00	0 6593E 00	0 6592E 00	0 7112E 00	0 7023E 00	0 6583E 00	0 6477E 00	0 6454E 00
27	0 6754E 00	0 6722E 00	0 6597E 00	0 6580E 00	0 6951E 00	0 4926E 00	0 5811E 00	0 6482E 00	0 6300E 00	0 6144E 00
28	0 6612E 00	0 6721E 00	0 6730E 00	0 6550E 00	0 6704E 00	0 1945E 00	0 1500E 00	0 5838E 00	0 6131E 00	0 6009E 00
29	0 6664E 00	0 6625E 00	0 6651E 00	0 6616E 00	0 6644E 00	0 5964E 00	0 2611E 00	0 2232E 00	0 6200E 00	0 6237E 00
30	0 6656E 00	0 6602E 00	0 6614E 00	0 6601E 00	0 6611E 00	0 6539E 00	0 6154E 00	0 5473E 00	0 6115E 00	0 6321E 00
31	0 6614E 00	0 6613E 00	0 6621E 00	0 6601E 00	0 6613E 00	0 6482E 00	0 6578E 00	0 6439E 00	0 6189E 00	0 6345E 00
32	0 6613E 00	0 6613E 00	0 6621E 00	0 6602E 00	0 6613E 00	0 6477E 00	0 6475E 00	0 6598E 00	0 6667E 00	0 6436E 00
33	0 6620E 00	0 6613E 00	0 6621E 00	0 6602F 00	0 6614E 00	0 6465E 00	0 6570E 00	0 6670E 00	0 6683E 00	0 6842E 00
34	0 6620E 00	0 6620E 00	0 6632E 00	0 6628E 00	0 6709E 00	0 6626E 00	0 6683E 00	0 6735E 00	0 6899E 00	0 6973E 00
35	0 6624E 00	0 6566E 00	0 6549E 00	0 6403E 00	0 2360E 00	0 5269E 00	0 6562E 00	0 6649E 00	0 6735E 00	0 6861E 00
36	0 6626E 00	0 6548E 00	0 6511E 00	0 6307E 00	0 3681E 00	0 5226E 00	0 6348E 00	0 6499E 00	0 6538E 00	0 6639E 00
37	0 6616E 00	0 6625E 00	0 6635E 00	0 6605E 00	0 6450E 00	0 5231E 00	0 6443E 00	0 6558E 00	0 6558E 00	0 6537E 00
38	0 6677E 00	0 6595E 00	0 6584E 00	0 6698E 00	0 7052E 00	0 7770E 00	0 6443E 00	0 6428E 00	0 6557E 00	0 6554E 00
39	0 6735E 00	0 6769E 00	0 6720E 00	0 6914E 00	0 7563E 00	0 7254E 00	0 6736E 00	0 6573E 00	0 6538E 00	0 6668E 00
40	0 6668E 00	0 6708E 00	0 6724E 00	0 6862E 00	0 7155E 00	0 7092E 00	0 7023E 00	0 6838E 00	0 6797E 00	0 6729E 00
41	0 6650E 00	0 6644E 00	0 6686E 00	0 6695E 00	0 6531E 00	0 6843E 00	0 7067E 00	0 7062E 00	0 6988E 00	0 6822E 00
42	0 6788E 00	0 6792E 00	0 6723E 00	0 6597E 00	0 6613E 00	0 6620E 00	0 6826E 00	0 6938E 00	0 6884E 00	0 7012E 00
43	0 6606E 00	0 6606E 00	0 6612E 00	0 6615E 00	0 6623F 00	0 6560E 00	0 6510E 00	0 6642E 00	0 6919E 00	0 6900E 00
44	0 6621E 00	0 6621E 00	0 6621E 00	0 6616E 00	0 5628E 00	0 6459E 00	0 6471E 00	0 6607E 00	0 6599E 00	0 6604E 00
45	0 6627E 00	0 6632E 00	0 6628E 00	0 6615E 00	0 6625E 00	0 6479E 00	0 5299E 00	0 6537E 00	0 6435E 00	0 6567E 00
46	0 6592E 00	0 6573E 00	0 6593E 00	0 6614E 00	0 6621E 00	0 6554E 00	0 6564E 00	0 6476E 00	0 6436E 00	0 6518E 00
47	0 6510E 00	0 6442E 00	0 6501E 00	0 6602E 00	0 6623E 00	0 6524E 00	0 6440E 00	0 6443E 00	0 6534E 00	0 6417E 00
48	0 6576E 00	0 6674E 00	0 6562E 00	0 6468E 00	0 2240E 00	0 4647E 00	0 6277E 00	0 6406E 00	0 6411E 00	0 6576E 00
49	0 6512E 00	0 6471E 00	0 6511E 00	0 6069E 00	0 1500E 00	0 5855E 00	0 6330E 00	0 6308E 00	0 6419E 00	0 6418E 00
50	0 6598E 00	0 6599E 00	0 6603E 00	0 6484E 00	0 6069E 00	0 4356E 00	0 5921E 00	0 6287E 00	0 6297E 00	0 6405E 00

	21	22	23	24	25	26	27	28	29	30
51	0 6539E 00	0 6599E 00	0 6603E 00	0 6634E 00	0 6565E 00	0 5964E 00	0 5955E 00	0 6224E 00	0 6255E 00	0 6412E 00
52	0 6442E 00	0 6430E 00	0 6493E 00	0 6592E 00	0 6979E 00	0 6632E 00	0 6390E 00	0 6152E 00	0 6300E 00	0 6408E 00
53	0 6449E 00	0 6443E 00	0 6410E 00	0 6403E 00	0 6396E 00	0 6557E 00	0 6623E 00	0 6556E 00	0 6400E 00	0 6423E 00
54	0 6432E 00	0 6518E 00	0 6599E 00	0 6593E 00	0 6564E 00	0 6591E 00	0 6569E 00	0 6627E 00	0 6698E 00	0 6570E 00
55	0 6575E 00	0 6599E 00	0 6558E 00	0 6483E 00	0 6568E 00	0 6591E 00	0 6642E 00	0 6735E 00	0 6766E 00	0 6831E 00
56	0 6636E 00	0 6626E 00	0 6584E 00	0 6536E 00	0 6569E 00	0 6572E 00	0 6670E 00	0 6765E 00	0 6787E 00	0 6938E 00
57	0 6591E 00	0 6591E 00	0 6606E 00	0 6591E 00	0 6625E 00	0 6671E 00	0 6752E 00	0 6792E 00	0 6827E 00	0 6938E 00
58	0 6494E 00	0 6505E 00	0 6545E 00	0 6469E 00	0 6769E 00	0 6952E 00	0 6979E 00	0 7022E 00	0 7160E 00	0 7133E 00
59	0 6593E 00	0 6599E 00	0 6625E 00	0 65E9E 00	0 6478E 00	0 6575E 00	0 6734E 00	0 6810E 00	0 6802E 00	0 6821E 00
60	0 6560E 00	0 6617E 00	0 6577E 00	0 6494E 00	0 6560E 00	0 6588E 00	0 6609E 00	0 6664E 00	0 6784E 00	0 6901E 00
61	0 6541E 00	0 6622E 00	0 6559E 00	0 6499E 00	0 6578E 00	0 6675E 00	0 6740E 00	0 6812E 00	0 6890E 00	0 6950E 00
62	0 6585E 00	0 6612E 00	0 6563E 00	0 6476E 00	0 6621E 00	0 6759E 00	0 6881E 00	0 6934E 00	0 6924E 00	0 6944E 00
63	0 6791E 00	0 6586E 00	0 6598E 00	0 6503E 00	0 6793E 00	0 6798E 00	0 6769E 00	0 6742E 00	0 6774E 00	0 6935E 00
64	0 6688E 00	0 6597E 00	0 6543E 00	0 6463E 00	0 6717E 00	0 6883E 00	0 6924E 00	0 6981E 00	0 7066E 00	0 6954E 00
65	0 6604E 00	0 6544E 00	0 6723E 00	0 6965E 00	0 6975E 00	0 7117E 00	0 7119E 00	0 7068E 00	0 7096E 00	0 7060E 00
66	0 6834E 00	0 6754E 00	0 6874E 00	0 7350E 00	0 7577E 00	0 7517E 00	0 7349E 00	0 7290E 00	0 7183E 00	0 7189E 00
67	0 7010E 00	0 6960E 00	0 6928E 00	0 7248E 00	0 7591E 00	0 7702E 00	0 7570E 00	0 7404E 00	0 7321E 00	0 7324E 00
68	0 6828E 00	0 6896E 00	0 6899E 00	0 6692E 00	0 6533E 00	0 7382E 00	0 7602E 00	0 7439E 00	0 7472E 00	0 7459E 00
69	0 6777E 00	0 6767E 00	0 6781E 00	0 6796E 00	0 6809E 00	0 6947E 00	0 7034E 00	0 7734E 00	0 7743E 00	0 7594E 00
70	0 6878E 00	0 6864E 00	0 6786E 00	0 6792E 00	0 6804E 00	0 6652E 00	0 6799E 00	0 7327E 00	0 7723E 00	0 7565E 00
71	0 6883E 00	0 6836E 00	0 6792E 00	0 6772F 00	0 6705E 00	0 6688E 00	0 6933E 00	0 7478E 00	0 7899E 00	0 7711E 00
72	0 6833E 00	0 6776E 00	0 6797E 00	0 6768E 00	0 6664E 00	0 6694E 00	0 7019E 00	0 7355E 00	0 7459E 00	0 7343E 00
73	0 6788E 00	0 6792E 00	0 6791E 00	0 6797E 00	0 6806E 00	0 6686E 00	0 6619E 00	0 6421E 00	0 6101E 00	0 6133E 00
74	0 6801E 00	0 6827E 00	0 6806E 00	0 6805E 00	0 6805E 00	0 6815E 00	0 6788E 00	0 6994E 00	0 7083E 00	0 6288E 00
75	0 6696E 00	0 6631E 00	0 6640E 00	0 6640E 00	0 6640E 00	0 6639E 00	0 6631E 00	0 6676E 00	0 5796E 00	0 6349E 00
76	0 6640E 00	0 6618E 00	0 6621E 00	0 6621E 00	0 6621E 00	0 6636E 00	0 6606E 00	0 4704E 00	0 1500E 00	0 6107E 00
77	0 6621E 00	0 6621E 00	0 6622E 00	0 6622E 00	0 6623E 00	0 6596E 00	0 6580E 00	0 5470E 00	0 3684E 00	0 5962E 00
78	0 6619E 00	0 6623E 00	0 6615E 00	0 6604E 00	0 6608E 00	0 6503E 00	0 6532E 00	0 6611E 00	0 6420E 00	0 6089E 00
79	0 6549E 00	0 6643E 00	0 6557E 00	0 6408E 00	0 6408E 00	0 6576E 00	0 6642E 00	0 6569E 00	0 6378E 00	0 6208E 00
80	0 6614E 00	0 6623E 00	0 6620E 00	0 6605E 00	0 6607E 00	0 6494E 00	0 6525E 00	0 6498E 00	0 6236E 00	0 6340E 00
81	0 6615E 00	0 6621E 00	0 6626E 00	0 6620E 00	0 6618E 00	0 6694E 00	0 6660E 00	0 6504E 00	0 6355E 00	0 6507E 00
82	0 6660E 00	0 6620E 00	0 6633E 00	0 6620E 00	0 6617E 00	0 6694E 00	0 6664E 00	0 6546E 00	0 6468E 00	0 6380E 00
83	0 6664E 00	0 6590E 00	0 6596E 00	0 6624E 00	0 6622E 00	0 6610E 00	0 6595E 00	0 6574E 00	0 6576E 00	0 6602E 00
84	0 6562E 00	0 6532E 00	0 6487E 00	0 6644E 00	0 6640E 00	0 6626E 00	0 6603E 00	0 6565E 00	0 6592E 00	0 6723E 00
85	0 6511E 00	0 6449E 00	0 6578E 00	0 6460E 00	0 6458E 00	0 6574E 00	0 6610E 00	0 6628E 00	0 6733E 00	0 6741E 00
86	0 6471E 00	0 6398E 00	0 6393E 00	0 6451E 00	0 6434E 00	0 6449E 00	0 6524E 00	0 6646E 00	0 6767E 00	0 6876E 00
87	0 6465E 00	0 6393E 00	0 6309E 00	0 6471E 00	0 6533E 00	0 6523E 00	0 6536E 00	0 6648E 00	0 6801E 00	0 7006E 00
88	0 6430E 00	0 6337E 00	0 6318E 00	0 6470E 00	0 6567E 00	0 6619E 00	0 6594E 00	0 6648E 00	0 6830E 00	0 7120E 00
89	0 6320E 00	0 6265E 00	0 6323E 00	0 6443E 00	0 6437E 00	0 6593E 00	0 6599E 00	0 6654E 00	0 6833E 00	0 7133E 00
90	0 0000E 00	0 6216E 00	0 6325E 00	0 6429E 00	0 6359E 00	0 6515E 00	0 6601E 00	0 6657E 00	0 6839E 00	0 7153E 00
91	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
92	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
93	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
94	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
95	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
96	0 0000E 00	0 0000E 00	0 0000E 00	0 0000F 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
97	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
98	0 0000E 00	0 0000F 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
99	0 0000E 00	0 0000F 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
100	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00

A.3.1.3. Radiance Module

Display of user specified input file (Fortran Unit 5).

```
1)     3    9    1 1981 2210.
2)        10.4       12.5      16.76     -149.5      67.70
3)         0.     -149.5      67.78
4)   100  100
5)       286.       280.
6)       0025       0025
```

Display of run time diagnostics and statistics output file (Fortran Unit 6).

ZENITH ANGLE OF SUN (DEGS):   59.4
ZENITH ANGLE OF OBSERVER (DEGS):   0.0

IN-BAND DIFFUSE REFLECTANCES
BAND (MICRONS): 10.4
            TO 12.5

MATERIAL	REFLECTANCE
1	0.01
2	0.08
3	0.03
4	0.03
5	0.09
6	0.03
7	0.03
8	0.05
9	0.03
10	0.14
12	0.10
13	0.07
14	0.02

```
RESULTS OF CURVE FITS TO
ATMOSPHERIC VALUES VS' ALTITUDE
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  0. 0 KM
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1. 592E-10
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  1. 0 KM
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1. 010E-10
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  2. 0 KM
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1. 692E-10
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  4. 0 KM
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1. 573E-10
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  7. 0 KM
DEGREE OF BEST FIT POLYNOMIAL· 4
SUM SQUARE ERROR:  1. 091E-10
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE = 10. 0 KM
DEGREE OF BEST FIT POLYNOMIAL: 4
SUM SQUARE ERROR:  1. 010E-10


REFLECTED SOLAR
DEGREE OF BEST FIT POLYNOMIAL: 5
SUM SQUARE ERROR:  2. 592E-10


PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL: 5
SUM SQUARE ERROR:  3. 112E-12


PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL: 5
SUM SQUARE ERROR:  1. 032E-09
```

APPARENT REFLECTED SOLAR (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	2 266E-07	1 921E-07	0 000E-01	4 1:9E-07

APPARENT REFLECTED SKYSHINE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	1 659E-05	2 183E-06	1 163E-05	1 960E-05

APPARENT THERMAL RADIANCE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	1 320E-03	6 264E-05	1 234E-03	1 490E-03

AGPARENT PATH RADIANCE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	8 063E-05	1 255E-05	5 364E-05	9 875E-05

SURFACE TEMPERATURE (K)

MATERIAL	MEAN	SDEV	MIN	MAX
8	2 823E 02	3 006E 00	2 779E 02	2 900E 02

APPARENT SCENE RADIANCE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	1 236E-03	2 130E-04	2 839E-04	1 464E-03

DIFFUSE OR BI-DIRECTIONAL REFLECTANCE

MATERIAL	MEAN	SDEV	MIN	MAX
8	4 707E-02	0 000E-01	4 707E-02	4 707E 02

3-25

ASCII Display of a portion of the binary radiance map output file
(Fortran Unit 17). One third of the scene (leftmost portion) is shown.
Columns 1-10 are uniformly zero (the field of view extends beyond the
edge of the scene) are are not included.

	11	12	13	14	15	16	17	18	19	20
1	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
2	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
3	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
4	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
5	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
6	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
7	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
8	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
9	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0001E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
10	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
11	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
12	0 1450E-02	0 1450E-02	0 1450E-02	0 1450E-02	0 1450E 02	0 1449E-02	0 1450E-02	0 1449E-02	0 1450E-02	0 1451E-02
13	0 0000E 00	0 1451E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1450E-02	0 1450E-02
14	0 1450E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1451E-02	0 1450E-02	0 1450E-02
15	0 0000E 00	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1450E-02	0 1450E-02	0 1450E-02	0 1450E-02	0 1450E-02
16	0 0000E 00	0 1453E-02	0 1454E-02	0 1454E-02	0 1453E-02	0 1453E-02	0 1450E-02	0 1450E-02	0 1450E-02	0 1450E-02
17	0 0000E 00	0 1452E-02	0 1454E-02	0 1453E-02	0 1450E-02	0 1453E-02	0 1454E-02	0 1453E-02	0 1450E-02	0 1450E-02
18	0 0000E 00	0 1451E-02	0 1453E-02	0 1451E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1451E-02	0 1452E-02	0 1452E-02
19	0 0000E 00	0 1452E-02	0 1453E-02	0 1452E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1453E-02	0 1453E-02
20	0 0000E 00	0 1452E-02	0 1453E-02	0 1454E-02	0 1453E-02	0 1453E-02	0 1454E-02	0 1454E-02	0 1453E-02	0 1453E-02
21	0 0000E 00	0 1449E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1453E-02	0 1453E-02
22	0 0000E 00	0 1451E-02	0 1454E-02	0 1454E-02	0 1451E 02	0 1452E-02	0 1454E-02	0 1454E-02	0 1453E-02	0 1450E-02
23	0 0000E 00	0 1450E-02	0 1451E-02	0 1451E-02	0 1453E-02	0 1454E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1453E-02
24	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02
25	0 0000E 00	0 1452E-02	0 1454E-02	0 1453E-02	0 1452E-02	0 1451E-02	0 1452E-02	0 1453E-02	0 1453E 02	0 1451E-02
26	0 0000E 00	0 1451E-02	0 1453E-02	0 1452E-02	0 1453E-02	0 1454E-02	0 1453E-02	0 1450E-02	0 1450E-02	0 1453E-02
27	0 0000E 00	0 1451E-02	0 1450E-02	0 1451E-02	0 1454E-02	0 1451E-02	0 1452E-02	0 1454E-02	0 1451E-02	0 1450E-02
28	0 0000E 00	0 1451E-02	0 1453E-02	0 1451E-02	0 1451E 02	0 1453E-02	0 1452E-02	0 1451E-02	0 1453E 02	0 1451E-02
29	0 0000E 00	0 1452E-02	0 1454E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1453E-02	0 1452E 02	0 1453E-02
30	0 0000E 00	0 1452E-02	0 1453E-02	0 1454E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1453E 02	0 1451E-02	0 1453E-02
31	0 0000E 00	0 1451E-02	0 1453E-02	0 1453E-02	0 1451E-02	0 1453E-02	0 1452E-02	0 1451E 02	0 1451E-02	0 1450E-02
32	0 0000E 00	0 1451E-02	0 1454E-02	0 1451E-02	0 1454E-02	0 1453E-02	0 1450E-02	0 1451E 02	0 1454E-02	0 1451E-02
33	0 0000E 00	0 1452E-02	0 1454E-02	0 1454E-02	0 1451F 02	0 1453E-02	0 1452E-02	0 1453E-02	0 1451E-02	0 1451E-02
34	0 0000E 00	0 1451E-02	0 1451E-02	0 1452E-02	0 1453E-02	0 1454E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02
35	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02
36	0 0000E 00	0 1453E-02	0 1454E-02	0 1454E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1450E-02
37	0 0000E 00	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1450E-02
38	0 0000E 00	0 1451E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1454E-02
39	0 0000E 00	0 1453E-02	0 1454E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1451E-02	0 1452E-02
40	0 0000E 00	0 1451E-02	0 1452E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1451E-02
41	0 0000E 00	0 1450E-02	0 1452E-02	0 1452E-02	0 1454E 02	0 1454E-02	0 1454E-02	0 1454E 02	0 1454E 02	0 1452E-02
42	0 0000E 00	0 1453E-02	0 1455E-02	0 1455E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E 02	0 1451E-02	0 1454E-02
43	0 0000E 00	0 1453E-02	0 1452E-02	0 1452E-02	0 1454E 02	0 1455E-02	0 1453E-02	0 1451E 02	0 1451E-02	0 1451E-02
44	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1452F 02	0 1453E-02	0 1452E-02	0 1451E 02	0 1451E-02	0 1451E-02
45	0 0000E 00	0 1452E-02	0 1450E-02	0 1452E-02	0 1451E 02	0 1451E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02
46	0 0000E 00	0 1452E-02	0 1449E-02	0 1451E-02	0 1451F 02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451F-02	0 1451E-02
47	0 0000E 00	0 1452E-02	0 1452E-02	0 1451F-02	0 1451F 02	0 1450E-02	0 1450E-02	0 1451E-02	0 1451E-02	0 1451E-02
48	0 0000E 00	0 1454E-02	0 1451E-02	0 1451E-02	0 1449F 02	0 1450E-02	0 1452E-02	0 1451E 02	0 1447E-02	0 1447E-02
49	0 0000E 00	0 1454E-02	0 1454E-02	0 1452E-02	0 1451C 02	0 1451F-02	0 1450E-02	0 1449E-02	0 1450E-02	0 1450E-02
50	0 0000E 00	0 1453E-02	0 1454E-02	0 1452E-02	0 1453F-02	0 1451E-02	0 1451E-02	0 1450E-02	0 1451E-02	0 1450E-02

	11	12	13	14	15	16	17	18	19	20
51	0 0000E 00	0 1490E-02	0 1491E-02	0 1493E-02	0 1452E-02	0 1491E-02	0 1491E-02	0 1491E-02	0 1490E-02	0 1448E-02
52	0 0000E 00	0 1491E-02	0 1449E-02	0 1491E-02	0 1452E-02	0 1490E-02	0 1449E-02	0 1448E-02	0 1448E-02	0 1448E-02
53	0 0000E 00	0 1453E-02	0 1453E-02	0 1449E-02	0 1451E-02	0 1491E-02	0 1453E-02	0 1491E-02	0 1448E-02	0 1448E-02
54	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1451E-02	0 1449E-02	0 1449E-02	0 1449E-02	0 1448E-02	0 1448E-02
55	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1491E-02	0 1491E-02	0 1490E-02	0 1490E-02
56	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1451E-02	0 1451E-02
57	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1451E-02	0 1451E-02	0 1491E-02	0 1491E-02
58	0 0000E 00	0 1450E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1492E-02	0 1451E-02	0 1448E-02	0 1451E-02
59	0 0000E 00	0 1449E-02	0 1449E-02	0 1449E-02	0 1449E-02	0 1449E-02	0 1449E-02	0 1449E-02	0 1448E-02	0 1448E-02
60	0 0000E 00	0 1452E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1451E-02	0 1449E-02	0 1448E-02	0 1449E-02	0 1448E-02
61	0 0000E 00	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1451E-02	0 1490E-02	0 1449E-02	0 1447E-02
62	0 0000E 00	0 1453E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1452E-02	0 1450E-02
63	0 0000E 00	0 1454E-02	0 1453E-02	0 1453E-02	0 1451E-02	0 1451E-02	0 1493E-02	0 1455E-02	0 1455E-02	0 1450E-02
64	0 0000E 00	0 1453E-02	0 1453E-02	0 1453E-02	0 1459E-02	0 1454E-02	0 1454E-02	0 1459E-02	0 1455E-02	0 1453E-02
65	0 0000E 00	0 1499E-02	0 1453E-02	0 1459E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1452E-02	0 1452E-02
66	0 0000E 00	0 1454E-02	0 1494E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1452E-02	0 1452E-02
67	0 0000E 00	0 1493E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1499E-02	0 1453E-02	0 1459E-02	0 1459E-02	0 1459E-02
68	0 0000E 00	0 1493E-02	0 1453E-02	0 1453E-02	0 1453E-02	0 1499E-02	0 1459E-02	0 1459E-02	0 1459E-02	0 1457E-02
69	0 0000E 00	0 1454E-02	0 1453E-02	0 1453E-02	0 1491E-02	0 1453E-02	0 1499E-02	0 1453E-02	0 1454E-02	0 1454E-02
70	0 0000E 00	0 1454E-02	0 1453E-02	0 1454E-02	0 1454E-02	0 1454E-02	0 1499E-02	0 1459E-02	0 1457E-02	0 1454E-02
71	0 0000E 00	0 1453E-02	0 1453E-02	0 1498E-02	0 1458E-02	0 1454E-02	0 1493E-02	0 1454E-02	0 1456E-02	0 1456E-02
72	0 0000E 00	0 1454E-02	0 1453E-02	0 1459E-02	0 1454E-02	0 1499E-02	0 1499E-02	0 1459E-02	0 1454E-02	0 1457E-02
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90	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 1452E-02	0 1449E-02	0 1449E-02	0 1449E-02
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99	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
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2	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
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8	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
9	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
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13	0 1473E-02	0 1474E-02	0 1467E-02	0 1474E-02	0 1474E-02	0 1475E-02	0 1474E-02	0 1472E-02	0 1471E-02	0 1468E-02
14	0 1473E-02	0 1474E-02	0 1464E-02	0 1474E-02	0 1471E-02	0 1474E-02	0 1474E-02	0 1472E-02	0 1471E-02	0 1468E-02
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85	0 1449E-02	0 1450E-02	0 1450E-02	0 1448E-02	0 1448E-02	0 1449E-02	0 1450E-02	0 1471E-02	0 1472E-02	0 1472E-02
86	0 1449E-02	0 1447E-02	0 1447E-02	0 1448E-02	0 1447E-02	0 1447E-02	0 1449E-02	0 1472E-02	0 1473E-02	0 1474E-02
87	0 1449E-02	0 1447E-02	0 1446E-02	0 1448E-02	0 1449E-02	0 1448E-02	0 1448E-02	0 1472E-02	0 1473E-02	0 1475E-02
88	0 1448E-02	0 1447E-02	0 1454E-02	0 1447E-02	0 1449E-02	0 1450E-02	0 1449E-02	0 1469E-02	0 1474E-02	0 1477E-02
89	0 1447E-02	0 1446E-02	0 1445E-02	0 1447E-02	0 1447E-02	0 1449E-02	0 1449E-02	0 1465E-02	0 1474E-02	0 1477E-02
90	0 1444E-02	0 1445E-02	0 1451E-02	0 1447E-02	0 1444E-02	0 1449E-02	0 1449E-02	0 1465E-02	0 1474E-02	0 1477E-02
91	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
92	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
93	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
94	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
95	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
96	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
97	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
98	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
99	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00
100	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00	0 0000E 00

A.3.2 Test Case II - Brooks Range (Solar Band)

A.3.2.1 Atmospheric Module

Display of input file (Fortran Unit 7) for Brooks Range solar reflective band.

```
1)  3      16.76      3.6        4.0
2)  1  1  1  1  0  0  0     23.0
```

Display of the atmospheric diagnostic output file (Fortran Unit 6). Selected standard atmosphere is represented parametrically for 5 zenith angles and 6 altitudes. Air masses computed using the Chapman function.

```
RESULTS FOR BACKGROUND ALTITUDE =  0 KM

 APPARENT REFLECTED SOLAR


OBSERVER
ZA     AM    PATH RADIANCE  PATH TRANSMISSION
 0 0    1 0 4 370E-07 8 695E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      3 445E-04
48 2    1 5      3 239E-04
70 8    3 0      2 718E-04
80 8    6 0      1 969E-04
86 0   12 0      1 026E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE =  0 0
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR  3 138E-11


OBSERVER
ZA     AM    PATH RADIANCE  PATH TRANSMISSION
48 2    1 5 6 145E-07 8 150E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      3 245E-04
48 2    1 5      3 059E-04
70 8    3 0      2 579E-04
80 8    6 0      1 877E-04
86 0   12 0      9 850E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR  5 070E-11


OBSERVER
ZA     AM    PATH RADIANCE  PATH TRANSMISSION
70 8    3 0 1 040E-06 6 783E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      2 733E-04
48 2    1 5      2 590E-04
70 8    3 0      2 206E-04
80 8    6 0      1 630E-04
86 0   12 0      8 711E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL  4
SUM SQUARE ERROR  6 298E-11
```

```
OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
80 8    5 0   1 110E-08  9 475E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      4 236E-04
48 2    1 5      4 214E-04
70 8    3 0      4 153E-04
80 8    6 0      4 042E-04
86 0   12 0      3 842E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   7 071E-11


OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
86 0   12 0   2 058E-08  9 019E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      4 042E-04
48 2    1 5      4 025E-04
70 8    3 0      3 975E-04
80 8    6 0      3 882E-04
86 0   12 0      3 707E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   3 683E-11


       ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

            15            3 189E-09
            45            4 286E-09
            75            1 005E-08


 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR    4 832E-13

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR    5 684E-10
 FIT OF SKYSHINE TO ALTITUDE
DEGREE OF BEST FIT POLYNOMIAL   5
SUM SQUARE ERROR    5 758E-10
```

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION80.8   6.0 1.507E-06 4.867E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   1 991E-04
48.2   1 5   1 896E-04
70.8   3 0   1 640E-04
80.8   6 0   1 239E-04
86.0   12.0   6 831E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80.8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   5 411E-11

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
86 0   12 0 2 137E-06 2 503E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1.0   1.043E-04
48.2   1.5   1 000E-04
70.8   3 0   8 814E-05
80.8   6 0   6 871E-05
86.0   12.0   3 980E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86.0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   8 026E-11

         ZENITH ANGLE   SKYSHINE (W/CM**2/SR)

              15   3 894E-07
              45   5 187E-07
              75   1 228E-06

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   7 709E-13

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 810E-10

3-31

RESULTS FOR BACKGROUND ALTITUDE = 1 KM

APPARENT REFLECTED SOLAR

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
0 0   1 0 2 427E-07 9 074E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   3 738E-04
48 2   1 5   3 579E-04
70 8   3 C   3 166E-04
80 8   6 C   2 534E-04
86 0   12 0   1 639E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   5 025E-11

OBSERVER
ZA   AM   PATH RADIANCE PATH TRANSMISSION
48 2   1 5 3 437E-07 8 677E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   3 586E-04
48 2   1 5   3 440E-04
70 8   3 0   3 053E-04
80 8   6 0   2 453E-04
86 0   12 0   1 595E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   5 957E-11

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
70 8   3 0 5 999E-07 7 635E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   3 184E-04
48 2   1 5   3 065E-04
70 8   3 0   2 744E-04
80 8   6 0   2 229E-04
86 0   12 0   1 470E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   4 729E-11

```
OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80.8    6 0 9 612E-07 6 075E-01

SOLAR
 ZA      AM     REFLECTED SOLAR
 0 0    1 0      2 564E-04
48 2    1 5      2 480E-04
70.8    3 0      2 243E-04
80.8    6 0      1 855E-04
86 0   12 0      1 254E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   5 957E-11


OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86 0   12 0 1 416E-06 3 891E-01

SOLAR
 ZA      AM     REFLECTED SOLAR
 0.0    1 0      1 665E-04
48 2    1 5      1 619E-04
70 8    3 0      1 488E-04
80.8    6.0      1 262E-04
86 0   12.0      8 868E-05
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   5 707E-11


     ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

          15               2 234E-07
          45               2 994E-07
          75               7 330E-07

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   1 013E-12

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 146E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 2 KM
APPARENT REFLECTED SOLAR

OBSERVER
ZA	AM	PATH RADIANCE	PATH TRANSMISSION
0 0	1 0	1 323E-07	9 330E-01

SOLAR
ZA	AM	REFLECTED SOLAR
0 0	1 0	3 943E-04
48 2	1 5	3 819E-04
70 8	3 0	3 493E-04
80 8	6 0	2 976E-04
86 0	12 0	2 189E-04

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 3 638E-11

OBSERVER
ZA	AM	PATH RADIANCE	PATH TRANSMISSION
48 2	1 5	1 885E-07	9 036E-01

SOLAR
ZA	AM	REFLECTED SOLAR
0 0	1 0	3 827E-04
48 2	1 5	3 712E-04
70 8	3 0	3 403E-04
80 8	6 0	2 908E-04
86 0	12 0	2 147E-04

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 7 026E-11

OBSERVER
ZA	AM	PATH RADIANCE	PATH TRANSMISSION
70 8	3 0	3 360E-07	8 242E-01

SOLAR
ZA	AM	REFLECTED SOLAR
0 0	1 0	3 514E-04
48 2	1 5	3 418E-04
70 8	3 0	3 155E-04
80 8	6 0	2 718E-04
86 0	12 0	2 029E-04

REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 5 957E-11

3-34

```
OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
80 8    6 0 5 558E-07 & 999E-01

SOLAR
 ZA      AM      REFLECTED SOLAR
 0 0    1 0      3 011E-04
48 2    1 5      2 939E-04
70 8    3 0      2 735E-04
80 8    6 0      2 387E-04
86 0   12 0      1 817E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   7 026E-11


OBSERVER
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
86 0   12 0 6 696E-07 5 118E-01

SOLAR
 ZA      AM      REFLECTED SOLAR
 0 0'   1 0      2 226E-04
48 2    1 5      2 181E-04
70 8    3 0      2 055E-04
80 8    6 0      1 829E-04
86 0   12 0      1 436E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   6 639E-11


       ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

            15                1 248E-07
            45                1 677E-07
            75                4 202E-07


 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   9 237E-13

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 519E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 4 KM

APPARENT REFLECTED SOLAR

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
0 0     1 0 3 888E-08 9 616E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
0 0     1 0      4 173E-04
48 2    1 5      4 094E-04
70 8    3 0      3 883E-04
80 8    6 0      3 530E-04
86 0    12 0     2 946E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   5 707E-11

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
48 2    1 5 5 649E-08 9 441E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
0 0     1 0      4 102E-04
48 2    1 5      4 028E-04
70 8    3 0      3 825E-04
80 8    6 0      3 483E-04
86 0    12 0     2 914E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   5 366E-11

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
70 8    3 0 1 040E-07 8 951E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
0 0     1 0      3 908E-04
48 2    1 5      3 844E-04
70 8    3 0      3 662E-04
80 8    6 0      3 350E-04
86 0    12 0     2 820E-04
```
REFLECTED SOLAR
OCSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR   5 070E-11

OBSERVER
```
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80 8    6 0  1 803E-07  6 145E-01
```

SOLAR
```
 ZA      AM      REFLECTED SOLAR
 0 0    1 0      3 574E-04
48 2    1 5      3 522E-04
70 8    3 0      3 371E-04
80 8    6 0      3 107E-04
86 0   12 0      2 643E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   3 398E-11

OBSERVER
```
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86 0   12 0  3 085E-07  6 788E-01
```

SOLAR
```
 ZA      AM      REFLECTED SOLAR
 0 0    1 0      3 000E-04
48 2    1 5      2 963E-04
70 8    3 0      2 857E-04
80 8    6 0      2 663E-04
86 0   12 0      2 305E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   8 527E-11


```
     ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

          15              3 917E-08
          45              5 265E-08
          75              1 339E-07
```

PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   1 222E-12

PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 029E-10

RESULTS FOR BACKGROUND ALTITUDE = ⎯ KM

APPARENT REFLECTED SOLAR

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
0 0   1 0 ⎯ 104E-0⁹ ⁹ 808E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   4 335E-04
48 2   1 5   4 291E-04
70 8   3 0   4 171E-04
80 8   6 0   3 966E-04
86 0   12 0   3 617E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   6 639E-11

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
48 2   1 5 1 037E-08 9 721E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   4 299E-04
48 2   1 5   4 257E-04
70 8   3 0   4 140E-04
80 8   6 0   3 941E-04
86 0   12 0   3 599E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   8 481E-11

OBSERVER
ZA   AM   PATH RADIANCE   PATH TRANSMISSION
70 8   3 0 1 938E-08 9 470E-01

SOLAR
 ZA   AM   REFLECTED SOLAR
 0 0   1 0   4 199E-04
48 2   1 5   4 160E-04
70 8   3 0   4 054E-04
80 8   6 0   3 868E-04
86 0   12 0   3 543E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   ⎯ 799E-11

```
OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
80 8     6 0 3 465E-08  9 037E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      4 020E-04
48 2    1 5      3 988E-04
70 8    3 0      3 896E-04
80 8    6 0      3 731E-04
86 0   12 0      3 434E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 80 8
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   7 412E-11


OBSERVER
ZA      AM    PATH RADIANCE  PATH TRANSMISSION
86 0    12 0 6 209E-08  8 266E-01

SOLAR
 ZA     AM     REFLECTED SOLAR
 0 0    1 0      3 692E-04
48 2    1 5      3 667E-04
70 8    3 0      3 595E-04
80 8    6 0      3 464E-04
86 0   12 0      3 216E-04
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 86 0
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 478E-11


     ZENITH ANGLE    SKYSHINE (W/CM**2/SR)

          15             7 880E-09
          45             1 059E-08
          75             2 626E-08

 PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL   4SUM SQUARE ERROR    1 350E-12

 PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL   4
SUM SQUARE ERROR   2 674E-10
```

RESULTS FOR BACKGROUND ALTITUDE = 10 KM

APPARENT REFLECTED SOLAR

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
 0 0    1 0 2 162E-09 9 900E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
 0.0    1.0       4 411E-04
48 2    1 5       4 383E-04
70 8    3 0       4 306E-04
80 8    6 0       4 175E-04
86 0   12 0       3 948E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 0 0
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 6 298E-11

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
48 2    1 5 3 147E-09 9 854E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
 0 0    1 0       4 392E-04
48 2    1 5       4 364E-04
70 8    3 0       4 290E-04
80 8    6 0       4 161E-04
86 0   12 0       3 937E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 48 2
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 5 025E-11

OBSERVER
```
ZA      AM    PATH RADIANCE   PATH TRANSMISSION
70 8    3 0 5 995E-09 9 719E-01
```

SOLAR
```
ZA      AM      REFLECTED SOLAR
 0 0    1 0       4 337E-04
48 2    1 5       4 312E-04
70 8    3 0       4 242E-04
80 8    6 0       4 120E-04
86 0   12 0       3 905E-04
```
REFLECTED SOLAR
OBSERVER ZENNITH ANGLE = 70 8
DEGREE OF BEST FIT POLYNOMIAL 4
SUM SQUARE ERROR 4 729E-11

Display of the atmospheric module output data base (Fortran Unit 5).
Header (Line 1) contains parameters used to generate the database. Lines
2-44 contain the coefficients of the polynomial curve fits to the computed
atmospheric values.

```
 1)  3  60  4 00  2  2  1  1   1  1  3   3  3 23 00
 2)  6  4  0 -3 46284E 00 -1 11549E-01 -2 61007E-01  2 24806E-01 -2 83901E-01
 3)  6  4  0 -3 48878E 00 -1 05400E-01 -2 58260E-01  2 19159E-01 -2 79991E-01
 4)  6  4  0 -3 56340E 00 -9 03640E-02 -2 71626E-01  2 51200E-01 -2 94428E-01
 5)  6  4  0 -3 70089E 00 -8 39613E-02 -2 37777E-01  2 25825E-01 -2 81483E-01
 6)  6  4  0 -3 98170E 00 -7 10444E-02 -2 19036E-01  2 20372E-01 -2 77924E-01
 7)  6  4  0  8 69542E-01 -2 60830E-01 -2 65659E-01 -8 50601E-02  5 77305E-02
 8)  6  4  0 -6 35956E 00  8 61341E-01 -9 08967E-02 -1 43050E-01  3 44700E-02
 9)  6  4  0 -3 42735E 00 -8 04749E-02 -1 69492E-01  1 26608E-01 -1 72303E-01
10)  6  4  0 -3 44540E 00 -7 53176E-02 -1 72287E-01  1 30624E-01 -1 73307E-01
11)  6  4  0 -3 49697E 00 -6 85144E-02 -1 60587E-01  1 22057E-01 -1 68979E-01
12)  6  4  0 -3 59112E 00 -5 73153E-02 -1 61956E-01  1 40772E-01 -1 75301E-01
13)  6  4  0 -3 77850E 00 -4 63821E-02 -1 48690E-01  1 47804E-01 -1 74559E-01
14)  6  4  0  9 07389E-01 -1 82809E-01 -2 39290E-01 -8 70806E-03 -2 34240E-02
15)  6  4  0 -6 61501E 00  8 62224E-01  2 60056E-02 -2 76614E-01  1 13052E-01
16)  6  4  0 -3 40422E 00 -5 92082E-02 -1 19595E-01  8 06226E-02 -1 13653E-01
17)  6  4  0 -3 41717E 00 -5 64910E-02 -1 16914E-01  7 71077E-02 -1 11416E-01
18)  6  4  0 -3 45422E 00 -5 03290E-02 -1 10285E-01  7 39641E-02 -1 09028E-01
19)  6  4  0 -3 52126E 00 -4 34176E-02 -1 03583E-01  7 46371E-02 -1 07711E-01
20)  6  4  0 -3 65249E 00 -3 67537E-02  8 60774E-02  7 05191E-02 -1 02794E-01
21)  6  4  0  9 32966E-01 -1 32491E-01 -1 98621E-01  2 39440E-02 -5 71700E-02
22)  6  4  0 -6 87859E 00  8 68891E-01  8 78490E-02 -3 49367E-01  1 60348E-01
23)  6  4  0 -3 37959E 00 -3 63487E-02 -6 37638E-02  3 43437E-02 -5 98221E-02
24)  6  4  0 -3 38702E 00 -3 39836E-02 -6 58790E-02  3 68779E-02 -6 02250E-02
25)  6  4  0 -3 40807E 00 -3 05594E-02 -6 32523E-02  3 57915E-02 -5 92027E-02
26)  6  4  0 -3 44682E 00 -2 61577E-02 -6 40165E-02  4 53933E-02 -6 30544E-02
27)  6  4  0 -3 52294E 00 -2 15654E-02 -5 45116E-02  4 78898E-02 -6 02340E-02
28)  6  4  0  9 61633E-01 -7 54867E-02 -1 45628E-01  6 43540E-02 -8 33460E-02
29)  6  4  0 -7 41026E 00  9 16719E-01  8 13844E-02 -3 54554E-01  1 92884E-01
30)  6  4  0 -3 36300E 00 -2 01413E-02 -3 14818E-02  1 22578E-02 -2 63735E-02
31)  6  4  0 -3 36662E 00 -1 85577E-02 -3 48747E-02  1 75168E-02 -2 85512E-02
32)  6  4  0'-3 37687E 00 -1 88745E-02 -2 34980E-02  2 51976E-02 -2 16529E-02
33)  6  4  0 -3 39579E 00 -1 46855E-02 -3 12327E-02  1 80983E-02 -2 87780E-02
34)  6  4  0 -3 43279E 00 -1 11985E-02 -3 24670E-02  2 65797E-02 -3 20424E-02
35)  6  4  0  9 80845E-01 -3 73178E-02 -7 66054E-02  3 85653E-02 -5 41863E-02
36)  6  4  0 -8 14853E 00  9 27078E-01  7 88673E-02 -3 07176E-01  1 73919E-01
37)  6  4  0 -3 35543E 00 -1 24087E-02 -2 09358E-02  9 43774E-03 -1 64875E-02
38)  6  4  0 -3 35734E 00 -1 24081E-02 -1 83024E-02  5 69330E-03 -1 4744BE-02
39)  6  4  0 -3 36282E 00 -1 03876E-02 -2 29223E-02  1 34728E-02 -1 81711E-02
40)  6  4  0 -3 37303E 00 -1 05441E-02 -1 31133E-02  7 46155E-04 -1 23970E-02
41)  6  4  0 -3 39343E 00 -7 94391E-03 -1 57100E-02  8 19546E-03 -1 54522E-02
42)  6  4  0  9 90024E-01 -1 96063E-02 -4 02397E-02  1 96981E-02 -3 31941E-02
43)  6  4  0 -8 66506E 00  9 04792E-01  1 72356E-01 -3 38503E-01  1 67636E-01
44)  7  5  0 -5 68091E 00  4 54502E-01 -8 34379E 00  2 11032E 01 -2 63076E 01  1 11020E 01
```

A.3.2.2 Geometric Module

Case II is also a nadir view and a new geometric run is not required.

A.3.2.3 Radiance Module

Display of user specified input file (Fortran Unit 5).

```
1)      3     9    1 1981 2210.
2)          3.6         4.0      16.76     -149.5      67.78
3)          0.      -149.5      67.78
4)    100   100
5)        286.         280.
6)      .0025       .0025
```

Display of run time diagnostics and statistics output file (Fortran Unit 6).

ZENITH ANGLE OF SUN (DEGS): 59.4
ZENITH ANGLE OF OBSERVER (DEGS):   0.0

IN-BAND DIFFUSE REFLECTANCES
BAND (MICRONS): 3.6
              TO 4.0

MATERIAL	REFLECTANCE
1	0.02
2	0.10
3	0.03
4	0.12
5	0.14
6	0.43
7	0.02
8	0.15
9	0.12
10	0.16
12	0.18
13	0.09
14	0.04

```
RESULTS OF CURVE FITS TO
ATMOSPHERIC VALUES VS' ALTITUDE
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  0. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  7. 458E-11
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  1. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  5. 707E-11
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  2. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  6. 639E-11
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  4. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  4. 729E-11
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE =  7. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  3. 683E-11
 REFLECTED SOLAR VS OBSERVER POSITION
 ALTITUDE = 10. 0 KM
DEGREE OF BEST FIT POLYNOMIAL:  4
SUM SQUARE ERROR:  4. 729E-11


REFLECTED SOLAR
DEGREE OF BEST FIT POLYNOMIAL:  5
SUM SQUARE ERROR:  1. 050E-10


PATH TRANSMISSION
DEGREE OF BEST FIT POLYNOMIAL:  5
SUM SQUARE ERROR:  2. 544E-12


PATH RADIANCE
DEGREE OF BEST FIT POLYNOMIAL:  5
SUM SQUARE ERROR:  1. 074E-09
```

APPARENT REFLECTED SOLAR (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	9.512E-06	8.062E-06	0.000E-01	1.730E-05

APPARENT REFLECTED SKYSHINE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	2.037E-07	2.911E-08	1.405E-07	2.457E-07

APPARENT THERMAL RADIANCE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	6.989E-06	1.003E-06	5.628E-06	9.850E-06

APPARENT PATH RADIANCE (W/CM**2/SR)

MATESIAL	MEAN	SDEV	MIN	MAX
8	2.658E-07	3.811E-08	1.812E-07	3.202E-07

SURFACE TEMPERATURE (K)

MATERIAL	MEAN	SDEV	MIN	MAX
8	2.823E 02	3.006E 00	2.779E 02	2.700E 02

APPARENT SCENE RADIANCE (W/CM**2/SR)

MATERIAL	MEAN	SDEV	MIN	MAX
8	1.515E-05	8.637E-06	1.354E-06	2.501E-05

DIFFUSE OR BI-DIRECTIONAL REFLECTANCE

MATERIAL	MEAN	SDEV	MIN	MAX
8	1.520E-01	0.000E-01	1.520E-01	1.520E-01

ASCII display of a portion of the binary radiance map output file
(Fortran Unit 17). One third of the scene (leftmost portion) is shown.
Columns 1-10 are uniformly zero (the field of view extends beyond the
edge of the scene) and are not included.

	11	12	13	14	15	16	17	18	19	20
51	0.0000E 00	0.2380E-04	0.2383E-04	0.2384E-04	0.2384E-04	0.2383E-04	0.2384E-04	0.2384E-04	0.2383E-04	0.2381E-04
52	0.0000E 00	0.2385E-04	0.2379E-04	0.2383E-04	0.2384E-04	0.2381E-04	0.2381E-04	0.2380E-04	0.2380E-04	0.2381E-04
53	0.0000E 00	0.2385E-04	0.2383E-04	0.2379E-04	0.2379E-04	0.2383E-04	0.2387E-04	0.2385E-04	0.2381E-04	0.2381E-04
54	0.0000E 00	0.2384E-04	0.2384E-04	0.2384E-04	0.2381E-04	0.2381E-04	0.2380E-04	0.2381E-04	0.2381E-04	0.2381E-04
55	0.0000E 00	0.2384E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2384E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2385E-04
56	0.0000E 00	0.2384E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2385E-04	0.2384E-04	0.2384E-04	0.2386E-04	0.2384E-04
57	0.0000E 00	0.2384E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2388E-04	0.2383E-04	0.2385E-04	0.2385E-04	0.2384E-04
58	0.0000E 00	0.2380E-04	0.2385E-04	0.2385E-04	0.2385E-04	0.2384E-04	0.2384E-04	0.2381E-04	0.2381E-04	0.2385E-04
59	0.0000E 00	0.2381E-04	0.2379E-04	0.2380E-04	0.2380E-04	0.2381E-04	0.2381E-04	0.2382E-04	0.2385E-04	0.2382E-04
60	0.0000E 00	0.2393E-04	0.2383E-04	0.2383E-04	0.2384E-04	0.2384E-04	0.2382E-04	0.2381E-04	0.2382E-04	0.2381E-04
61	0.0000E 00	0.2384E-04	0.2384E-04	0.2385E-04	0.2383E-04	0.2386E-04	0.2385E-04	0.2383E-04	0.2383E-04	0.2381E-04
62	0.0000E 00	0.2385E-04	0.2385E-04	0.2385E-04	0.2385E-04	0.2387E-04	0.2385E-04	0.2388E-04	0.2386E-04	0.2386E-04
63	0.0000E 00	0.2390E-04	0.2390E-04	0.2389E-04	0.2384E-04	0.2384E-04	0.2388E-04	0.2391E-04	0.2393E-04	0.2390E-04
64	0.0000E 00	0.2384E-04	0.2386E-04	0.2389E-04	0.2389E-04	0.2390E-04	0.2390E-04	0.2391E-04	0.2391E-04	0.2392E-04
65	0.0000E 00	0.2388E-04	0.2389E-04	0.2390E-04	0.2390E-04	0.2391E-04	0.2389E-04	0.2386E-04	0.2387E-04	0.2387E-04
66	0.0000E 00	0.2387E-04	0.2387E-04	0.2387E-04	0.2387E-04	0.2387E-04	0.2388E-04	0.2388E-04	0.2388E-04	0.2388E-04
67	0.0000E 00	0.2383E-04	0.2384E-04	0.2385E-04	0.2385E-04	0.2384E-04	0.2388E-04	0.2391E-04	0.2392E-04	0.2392E-04
68	0.0000E 00	0.2384E-04	0.2385E-04	0.2388E-04	0.2390E-04	0.2390E-04	0.2390E-04	0.2390E-04	0.2391E-04	0.2395E-04
69	0.0000E 00	0.2390E-04	0.2388E-04	0.2388E-04	0.2383E-04	0.2387E-04	0.2391E-04	0.2390E-04	0.2390E-04	0.2390E-04
70	0.0000E 00	0.2384E-04	0.2390E-04	0.2388E-04	0.2388E-04	0.2390E-04	0.2390E-04	0.2391E-04	0.2394E-04	0.2390E-04
71	0.0000E 00	0.2385E-04	0.2384E-04	0.2389E-04	0.2389E-04	0.2389E-04	0.2390E-04	0.2390E-04	0.2393E-04	0.2393E-04
72	0.0000E 00	0.2387E-04	0.2384E-04	0.2389E-04	0.2391E-04	0.2391E-04	0.2390E-04	0.2390E-04	0.2390E-04	0.2394E-04
73	0.0000E 00	0.2389E-04	0.2388E-04	0.2389E-04	0.2379E-04	0.2391E-04	0.2392E-04	0.2394E-04	0.2390E-04	0.2390E-04
74	0.0000E 00	0.2389E-04	0.2389E-04	0.2388E-04	0.2387E-04	0.2389E-04	0.2389E-04	0.2390E-04	0.2390E-04	0.2389E-04
75	0.0000E 00	0.2385E-04	0.2383E-04	0.2384E-04	0.2388E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2389E-04	0.2390E-04
76	0.0000E 00	0.2388E-04	0.2383E-04	0.2384E-04	0.2384E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2385E-04	0.2386E-04
77	0.0000E 00	0.2385E-04	0.2383E-04	0.2383E-04	0.2383E-04	0.2385E-04	0.2384E-04	0.2384E-04	0.2383E-04	0.2384E-04
78	0.0000E 00	0.2385E-04	0.2383E-04	0.2387E-04	0.2383E-04	0.2379E-04	0.2387E-04	0.2384E-04	0.2384E-04	0.2384E-04
79	0.0000E 00	0.2384E-04	0.2382E-04	0.2383E-04	0.2383E-04	0.2379E-04	0.2380E-04	0.2384E-04	0.2384E-04	0.2380E-04
80	0.0000E 00	0.2384E-04	0.2387E-04	0.2383E-04	0.2383E-04	0.2387E-04	0.2384E-04	0.2384E-04	0.2384E-04	0.2384E-04
81	0.0000E 00	0.2388E-04	0.2385E-04	0.2387E-04	0.2383E-04	0.2384E-04	0.2388E-04	0.2388E-04	0.2384E-04	0.2385E-04
82	0.0000E 00	0.2385E-04	0.2385E-04	0.2384E-04	0.2387E-04	0.2384E-04	0.2384E-04	0.2385E-04	0.2385E-04	0.2384E-04
83	0.0000E 00	0.2387E-04	0.2384E-04	0.2383E-04	0.2387E-04	0.2385E-04	0.2384E-04	0.2388E-04	0.2385E-04	0.2388E-04
84	0.0000E 00	0.2381E-04	0.2383E-04	0.2383E-04	0.2383E-04	0.2384E-04	0.2383E-04	0.2384E-04	0.2384E-04	0.2379E-04
85	0.0000E 00	0.2385E-04	0.2383E-04	0.2383E-04	0.2383E-04	0.2384E-04	0.2381E-04	0.2380E-04	0.2384E-04	0.2385E-04
86	0.0000E 00	0.2384E-04	0.2383E-04	0.2383E-04	0.2383E-04	0.2385E-04	0.2384E-04	0.2383E-04	0.2381E-04	0.2381E-04
87	0.0000E 00	0.2382E-04	0.2383E-04	0.2383E-04	0.2381E-04	0.2381E-04	0.2382E-04	0.2382E-04	0.2385E-04	0.2380E-04
88	0.0000E 00	0.2384E-04	0.2383E-04	0.2383E-04	0.2380E-04	0.2380E-04	0.2390E-04	0.2387E-04	0.2387E-04	0.2381E-04
89	0.0000E 00	0.2387E-04	0.2383E-04	0.2384E-04	0.2385E-04	0.2385E-04	0.2388E-04	0.2380E-04	0.2385E-04	0.2381E-04
90	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.2384E-04	0.2380E-04	0.2383E-04	0.2381E-04
91	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
92	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
93	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
94	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
95	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
96	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
97	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
98	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
99	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00
100	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00	0.0000E 00

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