

WORLD DATA CENTER A for Meteorology

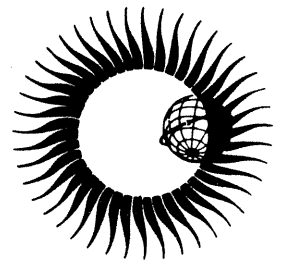
and

WORLD DATA CENTER A for Solar-Terrestrial Physics

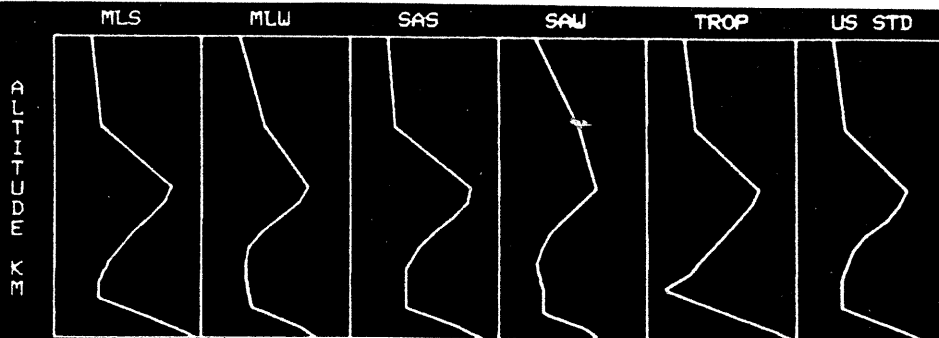


**ATMOSPHERIC HANDBOOK
Atmospheric Data Tables
Available on Computer Tape**

July 1984



**NATIONAL CLIMATIC DATA CENTER
NATIONAL GEOPHYSICAL DATA CENTER**



WORLD DATA CENTER A
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, D.C. 20418 USA

World Data Center A consists of the Coordination Office
and the following eight Subcenters:

COORDINATION OFFICE

World Data Center A
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, D.C. 20418 USA
[Telephone: (202) 334-3359]

GLACIOLOGY (Snow and Ice)

World Data Center A: Glaciology
(Snow and Ice)
Cooperative Inst. for Research in
Environmental Sciences
University of Colorado
Boulder, Colorado 80309 USA
Telephone: (303) 492-5171

MARINE GEOLOGY AND GEOPHYSICS

(Gravity, Magnetism, Bathymetry,
Seismic Profiles, Marine Sediment,
and Rock Analyses):

World Data Center A for Marine
Geology and Geophysics
NOAA, E/GC3
325 Broadway
Boulder, Colorado 80303 USA
Telephone: (303) 497-6487

METEOROLOGY (and Nuclear Radiation)

World Data Center A: Meteorology
National Climatic Data Center
NOAA, E/CC
Federal Building
Asheville, North Carolina 28801 USA
Telephone: (704) 259-0682

OCEANOGRAPHY

World Data Center A: Oceanography
National Oceanographic Data Center
NOAA, E/OC
2001 Wisconsin Avenue, NW
Page Bldg. 1, Rm. 414
Washington, D.C. 20235 USA
Telephone: (202) 634-7510

ROCKETS AND SATELLITES

World Data Center A: Rockets and
Satellites
Goddard Space Flight Center
Code 601
Greenbelt, Maryland 20771 USA
Telephone: (301) 344-6695

ROTATION OF THE EARTH

World Data Center A: Rotation
of the Earth
U.S. Naval Observatory
Washington, D.C. 20390 USA
Telephone: (202) 254-4547

**SOLAR-TERRESTRIAL PHYSICS (Solar and
Interplanetary Phenomena, Ionospheric
Phenomena, Flare-Associated Events,
Geomagnetic Variations, Aurora,
Cosmic Rays, Airglow):**

World Data Center A
for Solar-Terrestrial Physics
NOAA, E/GC2
325 Broadway
Boulder, Colorado 80303 USA
Telephone: (303) 497-6323

**SOLID-EARTH GEOPHYSICS (Seismology,
Tsunamis, Gravimetry, Earth Tides,
Recent Movements of the Earth's
Crust, Magnetic Measurements,
Paleomagnetism and Archeomagnetism,
Volcanology, Geothermics):**

World Data Center A
for Solid-Earth Geophysics
NOAA, E/GC1
325 Broadway
Boulder, Colorado 80303 USA
Telephone: (303) 497-6521

World Data Centers conduct international exchange of geophysical observations in accordance with the principles set forth by the International Council of Scientific Unions. WDC-A is established in the United States under the auspices of the National Academy of Sciences. Communications regarding data interchange matters in general and World Data Center A as a whole should be addressed to World Data Center A, Coordination Office (see address above). Inquiries and communications concerning data in specific disciplines should be addressed to the appropriate subcenter listed above.

**WORLD DATA CENTER A
for
Meteorology**

and



**WORLD DATA CENTER A
for
Solar-Terrestrial Physics**

REPORT UAG-89

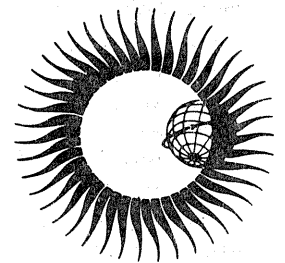
**ATMOSPHERIC HANDBOOK
Atmospheric Data Tables
Available on Computer Tape**

by

V.E. Derr

**NOAA Environmental Research Laboratories
325 Broadway
Boulder, Colorado 80303 USA**

July 1984



**U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
Boulder, Colorado, USA 80303**

DESCRIPTION OF WORLD DATA CENTERS

World Data Centers conduct international exchange of geophysical observations in accordance with the principles set forth by the International Council of Scientific Unions (ICSU). They were established in 1957 by the International Geophysical Year Committee (CSAGI) as part of the fundamental international planning for the IGY program to collect data from the numerous and widespread IGY observational programs and to make such data readily accessible to interested scientists and scholars for an indefinite period of time. WDC-A was established in the U.S.A.; WDC-B in the U.S.S.R.; and WDC-C in Western Europe, Australia, and Japan. This new system for exchanging geophysical data was found to be very effective, and the operations of the World Data Centers were extended by ICSU on a continuing basis to other international programs; the WDC's were under the supervision of the Comité International de Géophysique (CIG) for the period 1960 to 1967 and are now supervised by the ICSU Panel on World Data Centres.

The current plans for continued international exchange of geophysical data through the World Data Centers are set forth in the *Fourth Consolidated Guide to International Data Exchange through the World Data Centres*, issued by the ICSU Panel on World Data Centres. These plans are broadly similar to those adopted under ICSU auspices for the IGY and subsequent international programs.

Functions and Responsibilities of WDC's

The World Data Centers collect data and publications for the following disciplines: Meteorology; Oceanography; Rockets and Satellites; Solar-Terrestrial Physics disciplines (Solar and Interplanetary Phenomena, Ionospheric Phenomena, Flare-Associated Events, Geomagnetic Phenomena, Aurora, Cosmic Rays, Airglow); Solid Earth Geophysics disciplines (Seismology, Tsunamis, Gravimetry, Earth Tides, Recent Movements of the Earth's Crust, Rotation of the Earth, Magnetic Measurements, Paleomagnetism and Archemagnetism, Volcanology, Geothermics), and Marine Geology and Geophysics. In planning for the various scientific programs, decisions on data exchange were made by the scientific community through the international scientific unions and committees. In each discipline, the specialists themselves determined the nature and form of data exchange, based on their needs as research workers. Thus, the type and amount of data in the WDC's differ from discipline to discipline.

The objects of establishing several World Data Centers for collecting observational data were: (1) to insure against loss of data by the catastrophic destruction of a single center, (2) to meet the geographical convenience of, and provide easy communication for workers in different parts of the world. Each WDC is responsible for: (1) endeavoring to collect a complete set of data in the field or discipline for which it is responsible, (2) safe-keeping of the incoming data, (3) correct copying and reproduction of data, maintaining adequate standards of clarity and durability, (4) supplying copies to other WDC's of data not received directly, (5) preparation of catalogs of all data in its charge, and (6) making data in the WDC's available to the scientific community. The WDC's conduct their operation at no expense to ICSU or to the ICSU family of unions and committees.

World Data Center A

World Data Center A, for which the National Academy of Sciences through the Geophysics Research Board and its Committee on Data Interchange and Data Centers has overall responsibility, consists of the WDC-A Coordination Office and seven subcenters at scientific institutions in various parts of the United States. The GRB periodically reviews the activities of WDC-A and has conducted several studies on the effectiveness of the WDC system. As a result of these reviews and studies, some of the subcenters of WDC-A have been relocated so that they could more effectively serve the scientific community. The addresses of the WDC-A subcenters and Coordination Office are given inside the front cover.

The data received by WDC-A have been made available to the scientific community in various ways: (1) reports containing data and results of experiments have been compiled, published, and widely distributed; (2) synoptic-type data on cards, microfilm, or tables are available for use at the subcenters and for loan to scientists; (3) copies of data and reports are provided upon request.

CONTENTS

NOTE: Tape file name (in capitals) and number are given in brackets following section names. See Appendix B for a description of these files.

| | Page |
|---|------|
| 1. INTRODUCTION [INTRO, 1] | 1 |
| 2. DATA DESCRIPTIONS [DATADESCRIP, 3] | 2 |
| 2.1 ATTENUATION COEFFICIENTS | 2 |
| 2.1.1 Atmospheric Absorption and Scattering vs. Altitude | |
| 2.1.2 Attenuation and Scattering vs. Wavelength for Water | |
| 2.2 STANDARD ATMOSPHERES | 2 |
| 2.3 CLOUD DROP SIZE DISTRIBUTIONS: Water and Ice Particles | 3 |
| 2.4 SOLAR SPECTRAL IRRADIANCE | 4 |
| 2.5 SKY SPECTRAL RADIANCE | 5 |
| 2.6 RAYLEIGH COEFFICIENTS: Air | 5 |
| 2.7 REFRACTIVE INDICES | 5 |
| 2.7.1 Aerosols | |
| 2.7.1.1 ADP (Ammonium Dihydrogen Phosphate) | |
| 2.7.1.2 Aerosol, Synthetic | |
| 2.7.1.3 Ammonium Sulphate | |
| 2.7.1.4 Barium Fluoride | |
| 2.7.1.5 Cadmium Sulfide | |
| 2.7.1.6 Calcite | |
| 2.7.1.7 Calcium Fluoride | |
| 2.7.1.8 Dust | |
| 2.7.1.9 Fly Ash (No data files.) | |
| 2.7.1.10 Germanium | |
| 2.7.1.11 Glass | |
| 2.7.1.12 Graphite | |
| 2.7.1.13 Gypsum | |
| 2.7.1.14 KDP (Potassium Dihydrogen Phosphate) | |
| 2.7.1.15 Mascagnite | |
| 2.7.1.16 Molybdenite | |
| 2.7.1.17 Polystyrene Latex | |
| 2.7.1.18 Quartz | |
| 2.7.1.19 Salt | |
| 2.7.1.20 Sapphire | |
| 2.7.1.21 Silica | |
| 2.7.1.22 Silicon | |
| 2.7.1.23 Sodium Nitrate | |
| 2.7.1.24 Zinc Sulfide | |
| 2.7.2 Air | |
| 2.7.3 Ice (includes optical, infrared, and microwave regions) | |
| 2.7.4 Liquid Water (includes optical, infrared, and microwave regions, pure water, and water from oceans, lakes, and other sources) | |
| 2.8 RELATIVE REFLECTANCE: Ice, Water | 14 |
| 3. DATA FILE AND COMPUTER TAPE INFORMATION | 15 |
| 3.1 GUIDE [GUIDE, 4] | 15 |
| 3.1.1 Introduction to Tape Organization | |
| 3.1.2 Data File Structure | |
| 3.1.3 Deciphering File Names | |
| 3.1.4 Unit Notation | |
| 3.1.5 Significant Figures | |
| 3.1.6 Computer Programs: ATTENCOEF and MICRO | |
| 3.1.7 Data Retrieval Example | |
| 3.1.8 Data Table Examples | |

| | Page |
|---|--------------------------|
| 3.2 DATA FILE FORMATS [FORMATS, 5] | 18 |
| 3.2.1 Attenuation Coefficients | |
| 3.2.1.1 Atmospheric | |
| 3.2.1.2 Water | |
| 3.2.2 Standard Atmospheres | |
| 3.2.3 Cloud Drop Size Distributions | |
| 3.2.4 Solar Spectral Irradiance | |
| 3.2.5 Sky Spectral Radiance | |
| 3.2.6 Rayleigh Coefficients: Air | |
| 3.2.7 Refractive Indices | |
| 3.2.7.1 Aerosols | |
| 3.2.7.2 Air | |
| 3.2.7.3 Ice (includes microwave region) | |
| 3.2.7.4 Liquid H ₂ O (includes microwave region) | |
| 3.2.8 Relative Reflectance: Ice, H ₂ O | |
| 4. ACKNOWLEDGMENTS [THANKS, 6] | 22 |
| 5. REFERENCES [REF, 7] | |
| APPENDIX A: List of Files on Atmospheric Handbook Computer Tape, Listed by File Number [LISTFILE0, tape files 0 and 8] | 27 |
| APPENDIX B: Computer Tape File Descriptions [FILEXDESCRIP, 9] | 28 |
| APPENDIX C: FORTRAN Code for Program ATTENCOEF (and Related Subroutines): Atmospheric Absorption and Scattering Coefficients [APPENDIXC, 218] | 29 |
| APPENDIX D: FORTRAN Code for Program MICRO (and Related Subroutines): Select Ice and Water Refractive Indices in the Microwave Region [APPENDIXD, 219] | 41 |
| APPENDIX E: List of Useful Atmospheric Constants and Conversion [FACTS, 220] | See Inside Back Cover |

ATMOSPHERIC HANDBOOK: ATMOSPHERIC DATA TABLES AVAILABLE ON COMPUTER TAPE

by

V.E. Derr
NOAA Environmental Research Laboratories
NOAA/R/E
325 Broadway
Boulder, Colorado 80303, USA

ABSTRACT: Atmospheric data tables stored on computer tape and available for public use are described in this catalog/manual. These data are largely taken from results published in scientific journals. Data areas cover attenuation coefficients for the atmosphere and H₂O, atmospheric parameters for 1962 standard atmospheres, cloud drop size distributions for water and ice spheres, solar spectral irradiance, sky spectral radiance, Rayleigh mass and volume scattering coefficients and scattering cross section for air, the relative reflectance of ice and saline environmental waters, and refractive indices for liquid water, ice, air, and various atmospheric aerosols. Information in the report includes descriptions of the data (summarized from journal abstracts), information on the range and units of the data parameters, the FORTRAN format statements used to create the data files, and two FORTRAN programs for retrieving select data.

1. INTRODUCTION [INTRO, 1]

During the course of a number of years of work in atmospheric spectroscopy, I compiled several very useful tables of atmospheric data from the literature, and stored these data on computer disk and tape for ready access during theoretical calculations. Often, colleagues borrowed copies of these data, and some provided me with additional data. Invariably they suggested that it might be useful for fellow workers to have access to the data in a user-friendly format accessible by a computer. I resisted these urgings for a long time because the burden of selecting the "best" values, and the most useful and relevant material and assuring the accuracy of the values quoted, is intolerably large for one person aided by even a very competent part-time student. To do the job fully requires a critical review and fine judgement to distinguish between the many published sources of such data. For example, there are at least a dozen tables of refractive indices of water, many of which don't agree. To sit in Solomon-like judgement on these discrepancies requires the devotion of several full careers. These considerations, until recently, blocked any thoughts of publishing this material, and I confined its use to calculations of my own and those of colleagues aware of the pitfalls.

There is, however, a better way, by publishing this "Atmospheric Handbook: Atmospheric Data Tables Available on Computer Tape" as a compromise between fully verified and uncertain values. We make every effort to ensure the faithfulness of the tables to the source and to avoid degradation of interpolated values. If more than one source appears authoritative, both are quoted. Under this compromise, the researcher is advised to use the values cautiously, but by and large a very valuable set of data is provided for researchers in atmospheric radiation. The accuracy of the data can be determined only by reference to the source.

The Atmospheric Handbook exists in two forms: as a bound, paper report and as a computer tape. The report serves as a descriptive catalog/manual for the computer tape; it does not contain complete copies of the atmospheric data tables. Information in the report ranges from descriptions of the data in the tables, summarized from scientific journal abstracts, to information on the range and units of the data parameters, to the FORTRAN format statements used to create the data files. The computer tape version of the Handbook contains all information in the bound report, as well as the data tables themselves. Currently, two programs for accessing certain kinds of data are available in the report as well as on the tape. The computer tape is available through the National Environmental Satellite, Data, and Information Service (NESDIS). There is a charge for copying the tape.

| | | |
|----------------------------------|---------------------------------|-------------------------------|
| | Direct Requests To | Direct Questions To: |
| National Geophysical Data Center | Climatological Services Section | Dr. Vernon Derr |
| NOAA/NESDIS E/GC2 | National Climatic Data Center | NOAA/R/E |
| 325 Broadway | NOAA/NESDIS E/CC423 | 325 Broadway |
| Boulder, CO 80303, USA | Federal Building | Boulder, CO 80303, USA |
| | Asheville, NC 22801, USA | |
| (303) 497-6136; FTS: 320-6136 | (704) 259-0682; FTS: 672-0682 | (303) 497-6000; FTS: 320-6000 |

Because a future edition of the handbook is planned, I invite interested users to refer me to any additional data that may be included, and of course note any errors found. Suggestions on more useful formats are welcome. Any definitive reviews of the tables that appear in the literature will be used to discriminate between sources and eliminate less accurate versions.

2. DATA DESCRIPTIONS [DATADESCRIP, 3]

This section contains brief descriptions of the sources for data found in the Handbook. Each description is preceded by a definition of the data file variables and their ranges and units, as well as a list of the file names (in capital letters).

2.1 ATTENUATION COEFFICIENTS

2.1.1

Atmospheric Absorption (km^{-1}) and Scattering (cm^{-1}) vs. Altitude (0 to 85 km)
ATTENHT, AERXCLR, AERXHAZ, MIDLATSUM, MIDLATWIN, SUBARCSUM, SUBARCWIN, TROPIC (all accessed by Program ATTENCOEF)

The tables contain values of attenuation coefficients as a function of altitude for five atmospheric and two aerosol models from McClatchey et al. (1972). The altitude range is 0 to 85 km and the radiation wavelength is 0.6943 micrometers. Numerical values for the coefficients were computed and then logarithmically interpolated for each atmospheric layer. The aerosol attenuation coefficients are identical for all geographical and seasonal models. If the total attenuation (G) is required, the four coefficients can be summed: $G = \text{molecular absorption} + \text{molecular scattering} + \text{aerosol absorption} + \text{aerosol scattering}$. The tables are accessed by program ATTENCOEF.

2.1.2

Attenuation (m^{-1}) and Scattering (m^{-1}) vs. Wavelength (3.75E-7 to 8E-7 meters) for Water
H2OXAITENSCAT

Jerlov (1968) collected the observed attenuation coefficients of Clarke and James (1939) and the theoretical scattering coefficients of LeGrand (1939) for pure water in the range 3.75E-7 to 8E-7 meters. In their experiments Clarke and James found no palpable differences between the attenuances of distilled water and ocean water, and therefore the values for distilled water can be used when attenuation coefficients for salt water are needed.

2.2 STANDARD ATMOSPHERES

Pressure (mb), Temperature (K), and Number Densities (mols cm^{-3}) vs. Altitude (0 to 100 km) of
 H_2O , CO_2 , O_3 , N_2O , CO , CH_4 , O_2 , and N_2
MLS, MLW, SAS, SAW, TROPICAL, USXSTAN

These tables are taken from the Air Force Geophysics Lab computer code for FSCDAIM, Gallery et al. (1981). Data were originally derived from McClatchey et al. (1972). They originate from "Handbook of Geophysics and Space Environments" (Valley, 1965). The six profiles consist of the pressure, temperature, and number densities of H_2O , CO_2 , O_3 , N_2O , CO , CH_4 , O_2 , and N_2 vs. altitude for the following atmospheric types: Tropical (15 deg. N.), Midlatitude Summer (45 deg. N., July), Midlatitude Winter (45 deg. N., January), Subarctic Summer (60 deg. N., July), Subarctic Winter (60 deg. N., January), and the 1962 U.S. Standard Atmosphere.

A draft version of a section of the report on FSCDAIM states:

"The water vapor density for the 1962 Standard corresponds to relative humidities of approximately 50% for altitudes up to 10 km, whereas the relative humidity values for the other models tend to decrease with altitude from approximately 80% at sea level to approximately 30% at 10 km. Above 12 km the water vapor number densities of all models but the 1962 Standard are identical and represent volume mixing ratios which reach a minimum of about 6.5 ppmv at 17 km, increase to 30 ppmv at 30 km, then decrease to 10 ppmv at 50 km. For all models, the gases CO_2 , N_2O , CO , CH_4 , O_2 , and N_2 are considered uniformly mixed with volume mixing ratios of 330, 0.28, 0.075, 1.6, 1.095E05, and 7.905E05 ppmv respectively."

In correspondence with us, W.O. Gallery of AFGL commented that the data on which these profiles are based are old. The report continues:

"The stratospheric water vapor concentrations for the six profiles are now known to be too large by a factor of 5 at 30 km. The models may still be considered representative of their respective conditions up to about 50 km for temperature, up to 30 km for ozone densities, and up to the tropopause (approximately 15 km in the Tropics to 8 km in the Arctic) for water vapor."

Two useful recent reports are WMO (1982) and M. Smith (1982). The U.S. Standard Atmosphere for 1976 updates the 1962 Standard for temperature above 50 km and provides revised estimates for the surface concentrations of what was previously termed the "uniformly mixed gases". New values for the volume mixing ratios of CO_2 , N_2O , CO , and CH_4 are 322, 0.27, 0.19, and 1.60 ppmv respectively. The 1976 Standard gives equations for the computation of the number density of individual species. When updated tables are released by AFGL, we plan to incorporate them into the Handbook.

2.3 CLOUD DROP SIZE DISTRIBUTIONS

NOTE: All cloud files contain the number density of drops or ice particles per unit interval ($m^{-3} m^{-1}$). The number density (m^{-3}) in the interval is given by multiplying the number density per unit interval ($m^{-3} m^{-1}$) by the absolute difference between the beginning and ending radius (m).

2.3.1

Number Density of Drops ($m^{-3} m^{-1}$) vs. Radius (meters)
CLOUD1 to CLOUD8

Carrier et al. (1967) presented theoretical scattering parameters for eight different water cloud models at 4.88E-7, 6.94E-7, 1.06E-6, 4E-6, and 1.06E-5 meter radiations. These wavelengths, excluding 4E-6, correspond to the monochromatic wavelengths of operationally significant lasers. The authors presented representative cloud drop size distributions and concentrations for major water cloud types, assuming spherical water droplets only, and calculated the optical extinction coefficients for each model using the exact Mie theory. Consequently the calculated optical properties are accurate only for the cloud models used. We calculated data values in the CLOUD1 - 8 tables from both tabular and graphed data in Carrier et al. (1965, 1967).

Carrier gives these figures for the concentrations of the drop size distributions:

| Type | File Name | Concentration (number/cm ³) |
|---------------------|-----------|--|
| ----- | ----- | ----- |
| Stratus I | CLOUD1 | 464 (458) |
| Stratocumulus | CLOUD2 | 350 (370) |
| Fairweather Cumulus | CLOUD3 | 300 (157)* |
| Stratus II | CLOUD4 | 260 (260) |
| Cumulonimbus | CLOUD5 | 72 (63) |
| Cumulus Congestus | CLOUD6 | 207 (198) |
| Nimbostratus | CLOUD7 | 330 (326) |
| Altostratus | CLOUD8 | 450 (461) |

*The numbers in parentheses represent the results of calculations we performed on histograms derived from Carrier's figures. The concentration for Fairweather Cumulus, CLOUD3, is different enough that we suggest taking our value as correct for the data as presented.

2.3.2

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius (1.5E-6 to 7.5E-5 meters)
CLOUD9

Schickel (1975) took samplings from fifty-six 1980 publications on droplet distributions of water clouds. CLOUD9 is a sampling for ice fog.

2.3.3

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius (1E-6 to 5E-5 meters (CLOUD10) and 5E-5 to 5E-4 meters (CLOUD11))
CLOUD10 and CLOUD11

Heymsfield (1975) studied the growth of the ice phase in cirrus uncinus and cirrostratus clouds through aircraft measurements of cloud particle spectra at different altitudes. The temperature range was -14 to -46 degrees. CLOUD10 and CLOUD11 are taken from data for particle spectra taken near the top of a cirrostratus deck. The cirrostratus clouds sampled had their nucleation regions near the top of the clouds; crystals sedimented and grew from this source region near the top to near the base, and then evaporated to the base. The crystal concentrations were about 0.2 cm^{-3} , with 0.01 cm^{-3} longer than 100 micrometers. The mean length of crystals larger than 100 micrometers ranged between 0.2 and 0.5 mm. The ice water content ranged between 0.01 and 0.16 g m^{-3} .

2.3.4

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius (3E-6 to 1.33E-5 meters)
CLOUD12

Heymsfield and Jahnsen (1974) sampled thin, nearly invisible tropopause cirrus layers by aircraft over the continental United States and Pacific Ocean. In the data set used, samplings took place in a thin cirrus layer between 55,000 and 52,000 ft topped at the tropopause, near the Marshall Islands in the Pacific in December of 1973. There were no clouds below this level. There was a double tropopause, one at 55,000 ft and a weak one between 53,000 and 54,000 ft. The ice water content increased from the cloud top at the tropopause to 300 feet below the tropopause, decreased to 54,000 ft, increased in the second tropopause to 53,500 ft, and evaporated below. The "source" region of the ice crystals was at the cloud top where there were high concentrations of small crystals; there was a secondary source region at 53,800 ft. An SRI lidar also indicated two cloud layers, one topped at 55,000 ft, the other at 53,800 ft.

2.3.5

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($3.97E-7$ to $3.97E-5$ meters)
CLOUD13

CLOUD13 contains ice size distributions for cirrus clouds at 13.3 km as reported by Kraus and Barnes (1976b). The freezing level was between 4.6 and 4.9 km, and tropopause was at approximately 15.5 km.

2.3.6

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($3.97E-7$ to $2E-4$ meters)
CLOUD14

CLOUD14 contains the ice size distributions for cirrus clouds at 12.5 km. They represent Kraus and Barnes's (1976a) best estimate of the worst case situation along their missile trajectory. The freezing level was near 4.9 km, and the tropopause was at 15.8 km.

2.3.7

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($3.97E-7$ to $1.58E-4$ meters)
CLOUD15

Barnes (1977) reported ice size distributions for cirrus clouds at approximately 15 km.

2.3.8

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($8.05E-6$ to $5.64E-4$ meters)
CLOUD16

CLOUD16 was taken from Glass and Varley's (1978) report of data collected during a morning flight through a layer of thin cirrus in December 1977 by AFGL cloud physics research aircraft over northern Arizona and New Mexico. The aircraft flew at an altitude of approximately 7 km MSL and the ambient temperature was -25 degrees C. The 500-mb synoptic chart on this day indicated a weakening ridge pattern over this region.

2.3.9

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($1E-6$ to $8.6E-4$ meters)
CLOUD17

Varley and Brooks (1978) reported data from a February 1978 cirrus sampling flight in Albuquerque, New Mexico, aimed at acquiring information on the typical type and concentration of ice particles in cirrus clouds.

2.3.10

Number Density of Ice Particles ($m^{-3} m^{-1}$) vs. Radius ($1E-6$ to $3.1E-5$ meters)
CLOUD18

CLOUD18 is a cirrus cloud distribution synthesized from several sources by Dr. Vernon Derr of NOAA/ERL to be a small particle distribution (<31 micrometers) for test purposes.

2.4 SOLAR SPECTRAL IRRADIANCE*

2.4.1

Solar Spectral Irradiance ($watts m^{-2} m^{-1}$) vs. Wavelength ($1.27E-7$ to $1E-4$ meters)
FLUX1

Thekaekara (1972) presented results of experiments made by NASA Goddard Space Flight Center on the solar constant and solar spectrum from a research aircraft at 11.6 km. In the wavelength range $3E-7$ to $1.5E-5$ meters these values were based mainly on measurements made from the research aircraft. The instruments used were a Perkin-Elmer model 112 spectrometer with a lithium-based fluoride window, a Leiss double quartz prism monochromator, a filter radiometer, a polarization type interferometer and, for the infrared range beyond 4 micrometers, a Michelson type interferometer. In the wavelength range $3E-7$ to $2.6E-6$ meters an independent set of data is available from the Eppley-JPL measurements, made with a filter radiometer during several series of flights. The wavelength range covered is $1.2E-7$ to $1E-4$ meters. Thekaekara writes, "...the spectral irradiance is determined in narrow wavelength ranges and the integral energy is computed to give the solar constant. The solar constant...is the energy due to the sun incident on unit area exposed normally to the sun's rays at the average sun-earth distance in the absence of the earth's atmosphere. The solar spectral irradiance is the distribution of this energy as a function of wavelength."

The data in FLUX1 are reprinted from Thekaekara (1972) with permission from Photonics Spectra, copyright holder.

*NGDC holds NIMBUS and SMM satellite solar irradiance data.

2.4.2

Solar Spectral Irradiance (watts $m^{-2} m^{-1}$) vs. Wavelength (2.5E-10 to 1.95E-2 meters)
FLUX2

From Smith and Gottlieb (1974), the tables in FLUX2 represent solar irradiance data as derived from various sources by the authors, in the wavelength range 2.5E-10 to 1.95E-2 meters. Smith and Gottlieb used the formula

$$H = \pi [(r^2)/(R^2)]F = 6.80 \times (10^{-5})F$$

to derive the solar irradiance (the solar flux at 1 AU) from the total solar flux, where H is the solar irradiance, F is the total solar flux, r is the radius of the sun, and R is 1 AU. "AU" is defined as "Astronomical Unit", the mean distance from the earth to the sun, where 1 AU = 1.49E11 meters.

The data in FLUX2 are reproduced from Smith and Gottlieb (1974) with permission from D. Reidel Publishing, copyright holder.

2.5 SKY SPECTRAL RADIANCE

NOTE: Sky spectral radiance is the power falling on area A per unit optical aperture (steradians), per unit wavelength range.

Sky Spectral Radiance (watts $m^{-2} m^{-1}$) vs. Wavelength (3.1E-7 to 7.2E-7 meters)
SKYBACL0, SKYBACSL

SKYBACSL and SKYBACL0 are files of the spectral radiance of the sky at sea level and at 10,000 feet. Walter Clark (1969) designed, built, and calibrated a spectrophotometer that was used at sea level and carried in an aircraft to collect the data. The data are for the wavelength region 3.1E-7 to 7.2E-7 meters. Clark reports that error computations of sky luminance using the root mean square method resulted in 6.5% to 11.5% error depending upon the signal amplitudes, and thus the spectral radiance absolute accuracy probably varies between 13% and 16%.

2.6 RAYLEIGH COEFFICIENTS, AIR

Mass Scattering Coefficient ($m^2 kg^{-2}$), Volume Scattering Coefficient (m^{-1}), and Scattering Cross Section (m^2) vs. Wavelength (2E-7 to 2E-5 meters) for Air
MASSXSCAT, VOLXSCAT, RAYXSCATCROSS

Penndorf (1957) calculated the real refractive indices of standard air based on Edlen's formula for the wavelength range 2E-7 to 2E-5 meters (2.7.2). Computations of the Rayleigh scattering cross sections and mass and volume scattering coefficients were tabulated in the same range. Standard air is defined as dry air containing 0.03% CO₂ by volume at normal pressure 760 mm Hg (=1013.25 mb) and having an air temperature of 15 degrees C. When calculating the refractive indices Penndorf made allowances for the influence of temperature and pressure. Penndorf used a standard textbook formula in figuring the Rayleigh scattering coefficient, and advised that its accuracy is correct to about +/- 10%; his computations for the coefficient can be considered correct to four figures. Refer to the original article for complete discussions of all formulas used.

2.7 REFRACTIVE INDICES

NOTE: In instances where one experiment resulted in data for more than one substance, only one data description is given. It contains parenthesized numerical references to the location of the data for other substances. The aerosol indices are alphabetized according to substance, and then listed according to the file name prefixes "RF", "RFI", or "RFC", in that order. The particular substance, wavelength range (meters), and refractive index type (real, imaginary, or complex, all dimensionless) are as indicated preceding the filenames.

2.7.1 Aerosols

2.7.1.1 ADP (Ammonium Dihydrogen Phosphate)

Real Refractive Index vs. Wavelength (2E-7 to 2E-6 meters)
RFXADPO, RFXADPE

Zernike (1964) measured the real refractive indices of ammonium dihydrogen phosphate (ADP) and potassium dihydrogen phosphate (KDP, 2.7.1.14) in air at wavelengths between 2E-7 and 2E-6 meters, at temperatures ranging from 24.6 to 24.9 degrees C. The accuracy of the indices is +/- 3E-5 or better. Zernike measured the indices using the method of known incidence used by F. Rydberg (1828) and Tilton et al. (1949). The ADP and KDP prisms had angles of approximately 61.5 and 60 degrees respectively. Zernike also included the real refractive indices of fused silica (2.7.1.21) for ten wavelengths between 3.65E-7 and 5.78E-7 meters.

2.7.1.2 Aerosol, Synthetic

Complex Refractive Index vs. Wavelength (4E-7 to 1.5E-5 meters)
RFCXSYNAER

Ivlev and Popova (1973) studied the optical constants of sulfates, silicates, nitrates, metal oxides, and minerals containing the cation $[\text{NH}_4]$ in the wavelength range 4E-7 to 1.5E-5 meters. Missing data on the complex indices were calculated by the Kramers-Kronig method from the transmission and reflectance spectra.

The authors collected and analyzed data on the optical constants and other optical characteristics of minerals that are present in the materials of atmospheric aerosols, and the variations of these characteristics on transition from one mineral of a given class to another, within the given wavelength region. On the basis of available observational data on the chemical composition of aerosol particles in the surface layer of the atmosphere, a model was constructed for the matter of the atmospheric-aerosol dispersed phase, and effective values of the complex index were calculated assuming the absence of free water. It was assumed that all the chemical compounds are uniformly distributed in the material of aerosol particles of different sizes. The refractive index values can be recommended for calculations of the optical characteristics of dry atmospheric aerosols.

2.7.1.3 Ammonium Sulphate

2.7.1.3.1

Complex Refractive Index vs. Wavelength (9.3E-6 to 9.5E-6 meters)
RFCXAMSP1 to RFCXAMSP3

Jennings (1981) applied an "attenuated total reflectance" goniometric system to the measurement of complex refractive indices of aerosol constituents at CO_2 laser wavelengths. He demonstrated the reliability of the system through a comparison of his experimental and previously reported values. Jennings chose water (2.7.4.4) and ammonium sulphate solutions for these checks. Water was triply distilled, and any ammonia or carbon dioxide was removed. The final sample was stored under argon. Ammonium sulphate solutions were prepared from finely ground ammonium sulphate powder, and their molality was determined gravimetrically. Our data files are for the three molalities 1.6, 2.4, and 3.2, (as indicated by the first line of the individual files). Polystyrene latex particles (2.7.1.17) with mean diameter 9.1E-8 meters were used in suspensions ranging from 5% to 20% by weight. These percentages correspond to the percentage values in the first line of each data file. From these suspension values, Jennings used the Maxwell Garnet mixture rule and an extrapolation scheme to derive the refractive index (file RFCXPLTX1).

2.7.1.3.2

Complex Refractive Index vs. Wavelength (4.05E-7 to 4E-5 meters)
RFCXAMSP4

Toon et al. (1976) reviewed techniques for finding optical constants and assessed their accuracy. From these sources they compiled the optical constants of sodium chloride (2.7.1.19) and aluminum oxide (2.7.1.20.5) in the wavelength ranges 2E-7 to 1E-4 and 2E-7 to 3E-4 meters respectively. The constants of ammonium sulphate were derived partly from values quoted and partly from their own measurements, for the wavelength range 4.05E-7 to 4E-5 meters.

2.7.1.4 Barium Fluoride

Real Refractive Index vs. Wavelength (4.05E-7 to 7.7E-7 meters)
RFXBARF1 to RFXBARF3

Malitson (1964) presented data from a 1944 National Bureau of Standards experiment on the real refractive indices of barium fluoride for nine visible wavelengths in the range 4.05E-7 to 7.68E-7 meters at 15, 35, and 55 degrees C. The uncertainty of these index measurements was estimated at 3E-6. Malitson included data from a 1958 experiment in which he determined values for the real refractive index of a commercially grown barium fluoride prism with refracting angle near 61 degrees. Measurements were made at temperatures near 25 degrees C for 46 calibrated wavelengths of various emission sources and absorption bands from 2.66E-7 meters in the ultraviolet to 1.03E-5 meters in the infrared. Malitson claims that an average absolute residual of 1.9E-5 indicates that values for the index may be interpolated to five decimal places.

2.7.1.5 Cadmium Sulfide

2.7.1.5.1

Real Refractive Index vs. Wavelength (5.12E-7 to 1.4E-6 meters)
RFXCDS10, RFXCDS1E

Bieniewski and Czyzak (1963) reported their experimental data for the real refractive index, ordinary and extraordinary rays, of zinc (2.7.1.24.1) and cadmium sulfide in the wavelength range 3.6E-7 to 1.4E-6 meters (ZnS) and 5.12E-7 to 1.4E-6 meters (CdS).

2.7.1.5.2

Real Refractive Index vs. Wavelength (5.5E-7 to 1.4E-6 meters)
RFXCDS20, RFXCDS2E

Czyzak et al. (1957) determined the real refractive index of single synthetic zinc sulfide (2.7.1.24.2, ordinary ray) and cadmium sulfide crystals (ordinary and extraordinary rays) in the wavelength range 4.4E-7 to 1.4E-6 meters (ZnS) and 5.5E-7 to 1.4E-6 meters (CdS). The prisms used were cut to angles between 10 and 15 degrees.

2.7.1.6 Calcite

Complex Refractive Index vs. Wavelength (2E-7 to 6E-6 meters)
RFXCALCE, RFXCALCO

Ivlev and Popova (1974) examined the optical constants of various chemical compounds constituting the atmospheric aerosol including calcite, graphite (2.7.1.12), gypsum (2.7.1.13), mscagnite (2.7.1.15), quartz (2.7.1.18.5), sapphire (2.7.1.20.4), and sodium nitrate (2.7.1.23). In the original data tables, Ivlev and Popova left large gaps between data entries (which correspond to "-1" in the Handbook tables), with no directions for proper interpretation. With the exception of three entries for the real index of graphite at 1.1E-6, 1.2E-6, and 1.9E-6 meters, for which the authors entered "?", there are at least two ways in which to interpret the gaps: 1) values were out of range; 2) values did not change from the last entry before the gap, until the next cited index. Additionally, the authors seemingly distinguished between the value of " 10^{-X} ", where X is any integer, and " 1×10^{-X} " with the same value for X; we chose not to draw a distinction between the two representations.

The data in RFXCALCE and any other associated data files are reproduced from Ivlev and Popova (1972) with permission from Plenum Publishing Corporation, copyright holder.

2.7.1.7 Calcium Fluoride

Real Refractive Index vs. Wavelength (4.05E-7 to 7.68E-7 meters)
RFXCAF1 to RFXCAF3

Malitson (1963) reproduced real refractive index data from experiments done at the National Bureau of Standards in 1944. The indices were determined for two samples of synthetic fluorite prisms for nine visible wavelengths (4.05E-7 to 7.68E-7 meters) at temperatures of 15, 35, and 55 degrees C. Malitson states that the real refractive index values of both prisms were averaged. The values were taken from previously published reports by Stockberger and Early (1944) and Stockberger (1949). Malitson states that the uncertainty of these index measurements is estimated at 2E-6.

2.7.1.8 Dust

2.7.1.8.1

Imaginary Refractive Index vs. Wavelength (3E-7 to 1.7E-6 meters)
RFXDUST1 to RFXDUST10

Lindberg et al. (1976) determined the imaginary part of the complex refractive index for dust samples from the Panama Canal Zone, Germany, France, Denmark, the Netherlands, Great Britain, Israel, and various locations in the United States in the wavelength range 3E-7 to 1.7E-6 meters. The samples were collected by air filtration using ultra-thin cellulose membranes. Their values for the imaginary index are dependent on the assumption that the specific gravity of the particulate matter is 2.2. The authors claim their values for the index are an underestimate by some amount less than a factor of 2.

Transmission spectroscopy examination of each sample led to the following profiles of sample composition: samples from Europe were often dominated by ammonium sulphate and some strong spectrally broad absorber such as free carbon which led to a relatively high imaginary index in the visible spectrum. Samples from less populated desert areas in the U.S. and Israel showed the presence of silicate clay minerals, quartz, calcite, and gypsum, and proportionately less ammonium sulfate and carbon. Samples from industrial or high population density areas had a significantly higher imaginary index than those from more remote desert locations. This presumably was because urban samples contained more free carbon from various man-made combustion sources, whereas desert areas had a stronger soil component which tended to reduce the overall imaginary index.

2.7.1.8.2

Complex Refractive Index vs. Wavelength (3E-7 to 1.7E-6 meters)
RFXDUST1 to RFXDUST3

These tables (Lindberg, 1977) contain imaginary index data from experiments at White Sands Missile Range in New Mexico in the wavelength range 3E-7 to 1.7E-6 meters. Dust from three geographic locations was measured by diffuse reflectance methods. The dry material as collected on cellulose ester membrane filters was dissolved in acetone and centrifuged to recover the particulate matter. The tables contain infrared laser line imaginary index measurements Lindberg obtained using a spectrophone technique.

Lindberg suggests 1.55 as a reasonable estimate for the real refractive index in the 3E-6 to 5E-6 meter region. However the silicate absorption band near the 10E-6 meter region makes both parts of the index strongly wave dependent. (As an example of this, Lindberg suggests an examination of the index values in Peterson & Weinman - see 2.7.1.18.4: "Quartz": RFCXQUAL+).

2.7.1.9 Fly Ash

2.7.1.9.1

No data files.

In September 1970 (Grams et al., 1972) the National Center for Atmospheric Research (NCAR) obtained data on the vertical distribution of particulate material over Boulder, Colorado. Particles from a layer of matter at approximately 13 km differed from normal tropospheric particles. NCAR assumed the particles were fly ash created by forest fires in California during the previous week. Assuming the real part of the refractive index to be 1.55, the imaginary part was estimated at 0.044 +/- 0.001. An analysis of errors due to the expected statistical variability of the number of particles counted and the combined instrumental and measurement errors led to an estimate of approximately 40% error. By considering that the error results in a factor of 1.4 uncertainty, the error in the measurement of the imaginary index is 0.011.

2.7.1.9.2

No data files.

P.B. Russell et al. (1974) measured the angular variation and size distribution of the intensity of light scattered from a collimated beam by airborne soil particles 1.5 meters above the ground. From their measurements they derived an estimate of the complex index of refraction of the soil particles. For the real refractive index, the value 1.525 was taken as representative. By applying Mie scatter theory to each of the observed distributions of particle size, the expected angular variation of the intensity of the scattered light was calculated for a fixed value of the real index and a wide range of values of the imaginary index. For each set of simultaneous measurements the representative value for the imaginary index was taken to be that value which provided the best fit to the experimental data. The upper limit of the value of the imaginary index for the airborne soil particles studied was determined to be 0.005 with an overall uncertainty factor of 2.3.

2.7.1.9.3

No data files.

Wyatt (1980) examined several hundred single fly ash particles. More than 40 particles were suspended in a controlled high humidity environment to permit detailed light scattering measurement. Computerized analyses of the light scattering data from six typical ash particles showed considerable refractive index variation from particle to particle. Refractive indices, both real and complex, were observed spanning the range 1.48 to 1.57 (real) and 0 to 0.1 (imaginary). The accuracy of the values was +/- 0.01 for the real parts and +/- 0.002 for the imaginary.

2.7.1.10 Germanium

2.7.1.10.1

Real Refractive Index vs. Wavelength (2.55E-6 to 1.24E-5 meters)
RFXGERM1 to RFXGERM4

Icenogle et al. (1976) examined the real refractive indices of silicon (2.7.1.22.1, 2.55E-6 to 1.03E-5 wavelength meters) and germanium (2.55E-6 to 1.24E-5 wavelength meters). They stated their errors to be about +/-6E-4 for germanium and +/-3E-4 for silicon. The indices for germanium were taken at temperatures of 297, 275, 204, and 94 kelvins. The indices for silicon were taken at 296, 275, 202, and 104 kelvins.

2.7.1.10.2

Real Refractive Index vs. Wavelength (2.06E-6 to 1.65E-5 meters)
RFXGERM5

Salzburg and Villa (1957) determined data for the infrared real refractive index for single crystal germanium, silicon (2.7.1.22.2), and modified selenium glass (2.7.11.2), at about 27 degrees C. The respective wavelength ranges are 2.06E-6 to 1.6E-5, 1.36E-6 to 1.1E-5, and 1.01E-6 to 1.1E-5, all in meters. They estimate their accuracy of the index measurements to be +/-2 in the fourth decimal place.

2.7.1.11 Glass

2.7.1.11.1

Real Refractive Index vs. Wavelength (3.65E-7 to 2.6E-6 meters)
RFXGLASS1 to RFXGLASS17

Kingslake and Conrady (1937) measured the real refractive indices of 17 different types of 60-degree prism Bausch & Lomb and Parra-Mantois optical glass, in the wavelength range 3.65E-7 to 2.6E-6 meters. They cite their indices as correct to five or six in the fifth decimal place.

NOTE: The Kingslake article contained only the data for glasses 1 through 11. The remainder of the Kingslake-Conrady data was reprinted by Herzberger (1942), where we obtained it. Note that Dr. Herzberger found some minor errors in the far red and near infrared region of the spectrum. These errors resulted from Kingslake's use of some early and slightly inaccurate data on the temperature coefficient of the refractive index of rock salt in calibrating the wavelength scale of his refractometer.

2.7.1.11.2

Real Refractive Index vs. Wavelength (1.01E-6 to 1.1E-5 meters)
RFXGLASS18, RFXGLASS19

See 2.7.1.10.2: "Germanium": RFXGERM5.

2.7.1.11.3

Real Refractive Index vs. Wavelength (5.77E-7 to 1.19E-5 meters)
RFXGLASS20

Rodney et al. (1958) determined the real refractive indices of an arsenic trisulfide prism with refracting angle of 25 degrees in the wavelength range 5.77E-7 to 1.19E-5 meters. The sample was measured at temperatures near 19, 25, and 31 degrees C. The averaged thermal coefficients of the refractive index were used to reduce all data to 25 degrees C.

2.7.1.11.4

Complex Refractive Index vs. Wavelength (4.8E-7 to 6.9E-7 meters)
RFXGLASS1

The data represent the refractive indices for Corning Glass code 0080/0081 glass in the wavelength range 4.8E-7 to 6.9E-7, as taken from correspondence with Herbert Hoover of Corning Glass Works in Corning, New York. Hoover suggests the best guess for the real refractive index at 6.943E-7 meters is 1.505 +/- 0.003. The large uncertainty allows for the fact that normal variations in manufacturing are occasionally this large. In case the index must be known closer than 0.001, consideration must be given the state of annealing, because rapidly cooled glass has a lower index than well-annealed glass.

Hoover estimates an absorption coefficient for code 0080 glass (having about 0.04% total iron) of 0.14 cm⁻¹ in determining refractive indices. He proposes this as a safe upper bound. It should be noted that a substantially clear glass with dissolved iron as a colorant has a smaller spectral absorption coefficient near the middle of the wavelength range (5.5E-7 to 6E-7). Hoover advises if for your use you cannot assume a constant absorption coefficient over the 4.8E-7 to 6.943E-7 meter range, you can make a second approximation by assuming equal values at each end and a value one-half as large at 5.75E-7, and interpolating on a smooth curve through the three points for other values. Since we used the figures derived from an absorption coefficient of 0.14 cm⁻¹ for 6.943E-7, all of the other estimates represent upper bounds.

2.7.1.12 Graphite

Complex Refractive Index vs. Wavelength (2.5E-7 to 6E-6 meters)
RFXGRAPH

See 2.7.1.6: "Calcite".

2.7.1.13 Gypsum

Complex Refractive Index vs. Wavelength (2E-7 to 6E-6 meters)
RFXGYPS

See 2.7.1.6: "Calcite".

2.7.1.14 KDP (Potassium Dihydrogen Phosphate)

Real Refractive Index vs. Wavelength (2E-7 to 2E-6 meters)
RFXKDPO, RFXKDPE

See 2.7.1.1: "ADP".

2.7.1.15 Mascagnite

Complex Refractive Index vs. Wavelength (2E-7 to 2E-6 meters)
RFXMASCAG

See 2.7.1.6: "Calcite".

2.7.1.16 Molybdenite

Complex Refractive Index vs. Wavelength (3.3E-4 to 5E-4 meters)
RFCXMOLYB

Meyer (1926) gave the averaged results of experiments which determined the complex refractive index of molybdenite for nine wavelengths in the range 3.3E-4 to 5E-4 meters. Observations were made at various angles of incidence for the same wavelength, (65, 70, and 76 degrees) and averaged. Meyer reported that individual observations varied about 5% from the average.

2.7.1.17 Polystyrene Latex

Complex Refractive Index vs. Wavelength (9.3E-6 to 1.06E-5 meters)
RFCXPLTX1 to RFCXPLTX5

See 2.7.1.3.1: "Ammonium Sulphate": RFCXAMSP1.

2.7.1.18 Quartz

2.7.1.18.1

Real Refractive Index vs. Wavelength (4.96E-5 to 4.95E-4 meters)
RFXQUA10, RFXQUALE

Russell and Bell (1967) obtained the real refractive index of crystal quartz in the wavelength range 4.96E-5 to 4.95E-4 meters, with the asymmetric Fourier-Transform method. The extrapolated, zero-frequency real refractive indices are 2.1062 (ordinary), and 2.1538 (extraordinary) with an experimental uncertainty of +/- 0.001.

The total, estimated probable error in the measured values contained in the data table is +/- 0.001, except at frequencies less than 25 cm⁻¹ and greater than 175 cm⁻¹, where, the authors claim, the error can be somewhat greater.

2.7.1.18.2

Real Refractive Index vs. Wavelength (1.6E-4 to 3.49E-3 meters)
RFXQUA2

Laikin (1961) measured the real refractive index of a 30-degree synthetic quartz prism for the ordinary ray, in the wavelength range 1.6E-4 to 3.49E-3 meters, at 47 degrees F. The indices were corrected to air. Laikin reported the accuracy of the indices good to 6E-5.

2.7.1.18.3

Real Refractive Index vs. Wavelength (1.44E-7 to 2.31E-7 meters)
RFXQUA30, RFXQUA3E

Chandrasekharan and Damany (1968) reported the measurements of the ordinary and extraordinary real refractive indices of synthetic quartz in the vacuum ultraviolet in the wavelength range 1.44E-7 to 2.31E-7 meters as deduced from the determination of the orders of interference fringes in a thin parallel plate. The ordinary and extraordinary channeled spectra were obtained by interference in transmission and recorded at room temperature. The authors estimate the absolute error in the indices to be less than 0.001.

2.7.1.18.4

Complex Refractive Index vs. Wavelength (7.68E-7 to 3.6E-5 meters)
RFCXQUA10, RFCXQUALE

Peterson and Weinman (1969) tabulated the complex indices of quartz in the wavelength range 7.7E-7 to 3.6E-5 meters. An ensemble of spherical dust particles was utilized in conjunction with Mie theory to determine the extinction coefficient and other optical properties. The data in Peterson and Weinman were originally collected by Spitzer and Kleinman (1961) at a temperature of 24 degrees C. Wavelengths shorter than 5E-6 meters were compiled by D.E. Gray (1963).

2.7.1.18.5

Complex Refractive Index vs. Wavelength (5E-7 to 6E-6 meters)
RFCXQUA20, RFCXQUA2E

See 2.7.1.6: "Calcite".

2.7.1.18.6

Complex Refractive Index vs. Wavelength (1E-7 to 1.65E-7 meters)
RFCXQUA3, RFCXQUA4

Lamy (1977) gave the near-normal incidence reflectance measurements (complex) of crystal and fused quartz (ordinary ray) in the 1E-7 to 1.65E-7 meter wavelength interval.

2.7.1.19 Salt

Complex Refractive Index vs. Wavelength (2E-7 to 1E-4 meters)
RFCXSALT

See 2.7.1.3.2: "Ammonium Sulphate": RFCXAMSP4.

2.7.1.20 Sapphire

2.7.1.20.1

Real Refractive Index vs. Wavelength (2.54E-7 to 6.91E-7 meters)
RFXSAPPH10, RFXSAPPH1E

Jeppeson (1958) measured the ordinary and extraordinary real refractive indices for synthetic sapphire at 24 degrees C in the wavelength range 2.54E-7 to 6.91E-7 meters. He reports that between 4E-7 and 6.9E-7 meters the measurements are good to about four parts in the fifth decimal place. This error increases towards the violet.

2.7.1.20.2

Real Refractive Index vs. Wavelength (2.65E-7 to 5.58E-6 meters)
RFXSAPPH2

Malitson (1962) measured the real refractive index of a synthetic sapphire prism, with reflecting angle near 40 degrees, at 46 wavelengths from 2.65E-7 to 5.58E-6 meters at controlled room temperatures near 24 degrees C.

2.7.1.20.3

Real Refractive Index vs. Wavelength (RFXSAPPH3: 2.65E-7 to 4.25E-6, RFXSAPPH4 - 6: 4.05E-7 to 7.07E-7 meters)
RFXSAPPH3 to RFXSAPPH6

Malitson et al. (1958) collected data on the real refractive indices of a synthetic sapphire prism, for the ordinary ray. The indices in the ultraviolet and infrared (2.65E-7 to 4.26E-6 meters) were measured at controlled room temperatures near 19 and 24 degrees C. In the visible region (4.05E-7 to 7.07E-7 meters) measurements were made at three temperatures near 17, 24, and 31 degrees C.

2.7.1.20.4

Complex Refractive Index vs. Wavelength (2E-7 to 6E-6 meters)
RFCXSAPPH1

See 2.7.1.6: "Calcite".

2.7.1.20.5

Complex Refractive Index vs. Wavelength (RFCXSAPPH20: 2E-7 to 3.3E-4, RFCXSAPPH2E: 9E-6 to 3.3E-4 meters)
RFCXSAPPH20, RFCXSAPPH2E

See 2.7.1.3.2: "Ammonium Sulphate": RFCXAMSP4.

2.7.1.21 Silica

Real Refractive Index vs. Wavelength (3.65E-7 to 1.53E-6 meters)
RFXSILICA

See 2.7.1.1: "ADP".

2.7.1.22 Silicon

2.7.1.22.1

Real Refractive Index vs. Wavelength (2.55E-6 to 1.03E-5 meters)
RFXSILIC1 to RFXSILIC4

See 2.7.1.10.1: "Germanium": RFXGERM1.

2.7.1.22.2

Real Refractive Index vs. Wavelength (1.36E-6 to 1.1E-5 meters)
RFXSILIC5

See 2.7.1.10.2: "Germanium": RFXGERM5.

2.7.1.23 Sodium Nitrate

Real Refractive Index vs. Wavelength (4E-7 to 7E-7 meters)
RFXSODNITO, RFXSODNITE

See 2.7.1.6: "Calcite".

2.7.1.24 Zinc Sulfide

2.7.1.24.1

Real Refractive Index vs. Wavelength (3.6E-7 to 1.4E-6 meters)
RFXZNS10, RFXZNS1E

See 2.7.1.5.1: "Cadmium Sulfide": RFXCDS1+.

2.7.1.24.2

Real Refractive Index vs. Wavelength (4.4E-7 to 1.4E-6 meters)
RFXZNS2

See 2.7.1.5.2: "Cadmium Sulfide": RFXCDS2+.

2.7.2 Air

Real Refractive Index vs. Wavelength (2E-7 to 2E-5 meters)
RFXAIR+ (N30,N15,0,15,30)

See 2.6: Rayleigh Coefficients, Air.

2.7.3 Ice

2.7.3.1

Complex Refractive Index vs. Wavelength (9.5E-7 to 1.52E-4 meters)
RFXICE1

Irvine and Pollack (1968) critically reviewed existing literature on the absorption coefficient and reflectivity of water (2.7.4.5) and ice in the infrared, and chose best values for the complex index of refraction for wavelengths in the range 9.5E-7 to 1.5E-4 meters.

2.7.3.2

Complex Refractive Index vs. Wavelength (2E-6 to 3.3E-5 meters)
RFXICE2

Schaaf and Williams (1973) measured the normal-incidence spectral absolute reflectance of ice at -7 degrees C in the wavelength range 2E-6 to 3.3E-5 meters (2.8.1). They employed a Kramers-Kronig phase-shift analysis of the measured spectral reflectance to provide values of the real and imaginary parts of the refractive index.

2.7.3.3

Complex Refractive Index vs. Wavelength (1.25E-6 to 3.3E-4 meters)
RFXICE3

Bertie et al. (1969) measured the absorbance of several samples of Ice Ih at 100 K in the wavelength range 1.25E-6 to 3E-4 meters, and scaled it to that of a particular film of unknown thickness. They obtained the complex index, permittivity, and the normal incidence reflectivity from the absorptivity and from Kramers-Kronig relations.

2.7.3.4

Complex Refractive Index vs. Wavelength for Ice, Microwave Range. See 3.2.7.3: "Data File Formats" for wavelength ranges.
RFICEM+ (N50,N30,N10,0) (accessed by program MICRO)
(Note that additional microwave ice refractive index data were acquired after the completion of program MICR0, and thus are not available to the user through the program. See 2.7.3.6.)

Program MICRO handles microwave refractive indices for water and ice as a function of wavelength at different temperatures, using data taken from the following sources:

Ryde and Ryde (1945) found values for the complex refractive index of ice in the millimeter and microwave region using a combination of the Debye formula and constants taken from Saxton (1945) and Dunsmuir and Lamb (1945).

Lane and Saxton (1952) measured the refractive index of water at 6.2 micrometers, 1.24 cm, and 3.21 cm over the temperature range -10 to 50 degrees C. They used the Debye formula, as well as a method based on the fact that the rate of attenuation of radio frequency energy along a wave guide filled with the liquid is dependent upon both the absorption coefficient and the refractive index when the guide is operated near to cut-off conditions. The authors believe their measurements to be accurate to about +/- 1%.

Collie et al. (1948) measured the dielectric constant and loss angle of water and heavy water at widely separated wavelengths in the region of anomalous dispersion. In addition to the Debye formula, they used a method involving the observation of the attenuation in transmission through wave guides of differing cross-sectional dimensions containing the liquid.

The data taken from Collie et al. (1948) are reproduced with permission from the Institute of Physics, copyright holder.

Deirmendjian (1963) calculated the complex index for water and ice at two temperatures by means of the Debye formula.

2.7.3.5

Complex Refractive Index vs. Wavelength (4.43E-8 to 1.67E-4 meters)
RFCXICE4

Warren (1984) compiled the optical constants of Ice Ih for temperatures within 60 degrees of the melting point in the wavelength range 4.43E-8 to 1.67E-4 meters. The imaginary part of the complex index of refraction is obtained from measurements of spectral absorption coefficients; the real part is computed to be consistent with the imaginary part by use of known dispersion relations.

Warren states that the compilation of the imaginary part requires subjective interpolation in the near ultraviolet and microwave, a temperature correction in the far-infrared, and a choice between two conflicting sources in the near-infrared.

Warren advises that for intermediate wavelengths not given in the table one should interpolate the real index linearly in the log of the wavelength and the log of the imaginary index linearly in the log of the wavelength.

2.7.3.6

Complex Refractive Index vs. Wavelength (1.67E-4 to 8.6 meters)
RFCXICE5 to RFCXICE8

Warren (1984) found the complex refractive indices of Ice Ih for four temperatures: -1, -5, -20, and -60 degrees C, in the wavelength range 1.67E-4 to 8.6 meters. For intermediate wavelengths Warren advises interpolating the real index linearly in the log of the wavelength, the log of the imaginary index linearly in the log of the wavelength, the real index linearly in the temperature, and the log of the imaginary index linearly in the temperature. See also 2.7.3.5.

2.7.4 Liquid Water

2.7.4.1

Complex Refractive Index vs. Wavelength (5.46E-7 to 2.53E-5 meters)
RFCXH201

Data in this table were compiled from various experiments by Zuev et al. (1974) in the 5E-7 to 2.53E-5 meter wavelength interval for pure water at 18 to 20 degrees C. In the original data tables, Zuev left gaps between numerous data entries; in preparing RFCXH201, a cubic interpolation routine was used to approximate these missing data values. In the event that finer accuracy is needed, the real refractive indices at the following wavenumbers (cm⁻¹) should be modified using the measured real indices of the wavenumbers that bound these ranges with a more precise interpolation method: 18100-17550, 17200-16700, 16450-16350, 16200-16000, 15800-15700, 15500-15100, 14900, 14600, 14300, 14100, 13850-13550, 13300-13150, 12900-12650, 12400-12150, 11950, 11700, 11450, 11200, 10900, 10650, 10350, 10100, 9800, 9500, 9190, 8900, 8600, 8320, 8060, 7800, 7540, 7275, 7100, 6660, 6470, 6200, 5880, 5635, 5602, 5376, 5277, 5165, 5040, 4938, 4830, 4746, 4646, 4546, 4446, 4346, 4296, 4196, 4146. For example, if greater accuracy is needed in a wavenumber range including 18100-17550, take the wavenumbers preceding 18100 and

following 17550, 18300 and 17400, and use them and any other neighboring measured values not included in the above list of ranges in the interpolation method of your choice. The real refractive indexes at wavenumbers in the above ranges were calculated using cubic interpolation.

The data in RFCXH201 are reproduced from Zuev et al. with permission of Keter Publishing House Ltd., copyright holder.

2.7.4.2

Complex Refractive Index vs. Wavelength (2E-7 to 2E-4 meters)
RFCXH202

Hale and Querry (1973) determined extinction coefficients for water at 25 degrees C through a broad spectral region by manually smoothing a point-by-point graph of extinction coefficients vs. wavelength, that was plotted for data obtained from a review of the scientific literature on the optical constants of water. Where data in the vacuum UV and soft X-ray regions were not available, they postulated absorption bands representing extinction coefficients. A subtractive Kramers-Kronig analysis of the combined postulated and smoothed portions of the extinction coefficient spectrum provided the index of refraction for the spectral wavelength region 2E-7 to 2E-4 meters.

2.7.4.3

Complex Refractive Index vs. Wavelength (2E-6 to 1E-3 meters)
RFCXH203

Downing and Williams (1975) compiled values for the optical constants of liquid H₂O from current studies. Their values were based primarily on a study by Robertson et al. (1971) which measured Lambert absorption coefficients, and a Rusk et al. (1971) experiment measuring spectral reflectance at near normal incidence. They used the work of Palmer and Williams (1974) in the near infrared and the work of National Physical Labs in the extreme infrared (100 to 20 cm⁻¹). They determined real and imaginary indices in other regions using Fresnel's equation and Kramers-Kronig analysis. All the data were obtained for liquid H₂O at 27 degrees C in the wavelength range 2E-6 to 1E-3 meters.

2.7.4.4

Complex Refractive Index vs. Wavelength (9.6E-6 to 1.05E-5 meters)
RFCXH204

See 2.7.1.3.1: "Aerosols": Ammonium Sulphate: RFCXAMSP1.

2.7.4.5

Complex Refractive Index vs. Wavelength (2E-7 to 2E-4 meters)
RFCXH205

See 2.7.3.1: "Ice": RFCXICE1.

2.7.4.6

Complex Refractive Index vs. Wavelength (2E-6 to 2E-5 meters)
RFCXH206 to RFCXH2011

By using distilled water as the standard reflection, Querry et al. (1977) measured the relative specular reflectance spectra in the 2E-6 to 2E-5 meter wavelength region of the infrared for surface water samples collected from San Francisco Bay, the Pacific and Atlantic Oceans, the Great Salt Lake (Utah), the Dead Sea (Israel), and an effluent phosphate mine in central Florida (2.8.2). They compiled spectral values for the complex refractive index for each water sample by applying a Kramers-Kronig analysis to the relative reflectance spectra. For a chemical analysis of the monatomic and polyatomic ions of the natural waters, refer to the original article.

2.7.4.7

Complex Refractive Index vs. Wavelength for water in the microwave range. See 3.2.7.4: "Data File Formats" for wavelength ranges.
RFH20M+ (N8,0,10,18,20,30,40,50,60,75) (accessed by program MICRO)

See 2.7.3.4: "Ice": RFICEM+ (microwave ice files).

2.8 RELATIVE REFLECTANCE: ICE, WATER

2.8.1

Relative Reflectance (dimensionless) vs. Wavelength (2E-6 to 3.3E-5 meters) for Ice
RRXICE1

See 2.7.3.2: "Ice": RFCXICE2.

2.8.2

Relative Reflectance (dimensionless) vs. Wavelength (2E-6 to 2E-5 meters) for Water
RRXH201 - 6

See 2.7.4.6: "Liquid Water": RFCXH206.

3. DATA FILE AND COMPUTER TAPE INFORMATION

3.1 GUIDE [GUIDE, 4]

3.1.1 Introduction to Tape Organization

A single data set is referred to as a data file. Each separate data file comprises one computer tape file. Sections of informational text such as the data descriptions and data file and computer tape information, are also divided into distinct computer tape files.

Section 2, the Data Description (tape file 3) contains brief descriptions of each atmospheric area covered by the Handbook data files: definition of data file variables, ranges, and units, listing of data file names, and description of data source. Section 3.1, the Guide, (tape file 4) gives general user notes and technical information needed to access or understand the computer tape, data files, and computer programs. Section 3.2, Data File Formats (tape file 5), summarizes technical information on each data file in tabular form: data file variable definitions, units, and ranges in the order in which they appear on each line of a given data file, FORTRAN format statements used to create the data files, temperature, source, and computer tape file number. Appendix A (tape file 0) contains a list of all data files on the Handbook tape along with their corresponding tape file numbers. Appendix B (tape file 9) briefly describes the contents of single or groups of files on the tape. The computer programs for retrieving attenuation coefficient data and microwave refractive index data are located in tape files 171-187 and 188-217 respectively.

There are numerous cross references throughout the Handbook between section name and number and tape file name and number, both at the beginning of a section and within the text. In general, the tape file name (in capital letters) and number are given in brackets following a section name.

A typical use of the Atmospheric Handbook might entail three steps:

(1) Find the area of interest in the table of contents. Look up and read about your topic in the data description, section 2. Take note of the pertinent file name(s).

(2) Read through the Guide until any general technical questions you may have are answered and you are familiar with the data file formats, notation, and composition. Look up the specific format, parameter, and tape file number information on your desired files in Data File Formats.

(3) Load the file(s) from the tape onto your disk.

3.1.2 Data File Structure

Each tape file corresponds to a single data file. In general, sections of files are grouped according to atmospheric area. All tape files contain no more than 80 characters per line.

Numerical values in the data files are arranged in increasing order, where applicable. Data values of "-1" indicate the value was not given in the original source. The first line of all data files, except those associated with programs ATTENCOEF and MICRO, is informational text, in most cases identifying the data type, substance, and source. Precaution should be taken to read over or delete this line when accessing disk files after they have been loaded from the tape.

3.1.3 Deciphering File Names

File names consist of capital letters, numbers, and the delimiter "X". The "X" is used as one might use a period to visually, or logically, break up the parts of information used in naming files. Within the informational text of the Handbook, three types of abbreviating methods are used to refer to sets of data files with similar names. A "+" following a file name and preceding a parenthesized set of numbers indicates an alphanumeric extension; it is not part of the actual file name; e.g., "FIL+(1A,2,3)" refers to three files, "FIL1A", "FIL2", and "FIL3". A "+" following a file name not followed by a parenthesized set of numbers indicates an alphanumeric extension of some type; the specific type isn't pertinent in the given context. A file name ending in the character set "E,O", such as "FILE,O", actually refers to two separate data files, "FILE" with data for the Extraordinary ray, and "FILO" with data for the Ordinary. An entry such as "FIL1 - 4" refers to four distinct files; the dash is not part of the actual data file name.

On some computer systems the length of the file names as given will be too long. All data file names are intended only as suggestions. At the time of loading a file from the tape onto disk, the naming of the file is at the discretion of the user.

The refractive index data file name prefixes "RF", "RFI", and "RFC" refer to real, imaginary, and complex refractive index data sets, respectively.

3.1.4 Unit Notation

All Handbook data files are uniformly in Systeme Internationale Units ("MKS": Meters, Kilograms, Seconds) with the exception of: the attenuation coefficient data files, for which altitude is measured in

kilometers, and absorption and scattering are measured per kilometer; and the standard atmosphere data files for which altitude, pressure, temperature, and density are measured in kilometers, millibars, kelvins, and molecules per cubic centimeter, respectively.

A double asterisk, "**", stands for "raised to the power of", e.g., "m**-3 m**-1" means "per meter cubed per meter". In a numerical context, the letter "E" refers to exponent, e.g., "2.5E-3" means "2.5 x 10⁻³", where "x" is multiplication.

3.1.5 Significant Figures

In instances where our data sources reported an error estimate for their experiments, this estimate was included in the data description. Our refractive index and relative reflectance data have six digits after the decimal. This large number of significant figures was implemented to ensure sufficient space for increased accuracy in the event of interpolation on small computer systems. In most cases the refractive index data are good to 3 or 4 decimal places. Generally, Handbook data with 4 digits after the decimal can be considered significant to 2 to 3 places, unless otherwise specified. The original source should be consulted by those to whom the accuracy precision is important. The number of figures quoted in the tables is not a good guide to significance.

3.1.6 Computer Programs: ATTENCOEF (files 171-187) and MICRO (files 178, 188-217)

Program ATTENCOEF gives the attenuation coefficients as a function of altitude for five atmospheric and two aerosol models. The altitude range is 0 to 85 kilometers, and wavelength = 0.6943 micrometers. Program MICRO gives the refractive indices for select water and ice data in the microwave region. Both programs were written following standard FORTRAN 77 guidelines; however some Data General FORTRAN V options were used. The drivers of both programs list all non-standard FORTRAN characteristics; for easy identification their occurrences within the program are delimited by a "C" in column one followed by a series of "+" signs. Additionally, non-standard format codes are listed by their statement label in the comment section at the beginning of each subroutine. Make sure to load all the files belonging to a program from the tape, or the programs won't run. Additional ice refractive index data for the microwave region, located in files 222-225, were acquired after the completion of program MICRO, and thus are not available to the user through the program.

Program ATTENCOEF will request the following information:

(1) ATTENCOEF retrieves attenuation and scattering coefficients using user-entered parameters for atmospheric and aerosol types, and altitude. Do you want to enter each set of these three parameters individually, or multiply into an array? The maximum length for this array is 100.

(2) Would you like your results typed to the screen, sent to a diskfile, or both? When either of the diskfile options are used, input is sent to one standard diskfile. Care should be taken to rename this file before subsequent runs of the program occur.

(3) What atmospheric type: tropical, midlatitude summer, midlatitude winter, subarctic summer, or subarctic winter?

(4) What altitude(s) in the 0.0 to 85.0 km range?

(5) What aerosol type: clear or hazy?

(6) You may be asked to make a choice between the coefficients nearest the altitude requested or the values derived from using a linear interpolation which approximates these coefficients by using available heights.

(7) If (in response to question 1) you have been entering data parameters singly, after you receive the attenuation coefficients requested you may a) continue, using a different altitude, b) continue, using a different atmosphere, c) continue, but transfer to array entry mode, or d) terminate. If already in array entry mode, once your data parameter array has been exhausted, you may either start over in the entry mode of your choice or terminate.

Program MICRO will request the following information:

(1) Would you like your results typed to the screen, sent to a diskfile, or both? If either of the diskfile options are used, output is sent to one standard file. Care should be taken to rename this file before subsequent runs of the program occur.

(2) Do you want refractive indices for water or ice?

(3) The refractive indices are separated according to temperature and then sorted by wavelength. Do you want to request each temperature individually, or enter multiple temperatures into an array? Temperatures are in degrees C.

(4) You will be shown the entire data file for each temperature requested. If using the diskfile option, you may have this entire file sent to disk. You will be asked if you would like interpolations between any of the wavelengths shown. These wavelengths must be entered in meters. Because of the sparseness of data in the microwave region, interpolation may not be accurate.

(5) If you have been entering temperatures singly, you have the choice to repeat step 4 with another temperature. Otherwise, you have the choice to repeat steps 2-4 or to terminate.

The effort to make these programs easily adapted by computer systems other than the one it was written on resulted in cumbersome interactive user-input formats. Special care must be taken to enter data exactly as specified in the programs' main routines.

The parameter lists for subroutine and function statements and calls in programs ATTENCOEF and MICRO were based on specifications as described in "A Technique for Making FORTRAN Programs More Readable" (J. Tant Priestley, NOAA, Wave Propagation Laboratory, unpublished). All parameter lists are divided into, and conform exactly with, the following categories: inputs, inputs/outputs, outputs. Priestley defines these categories:

(1) Input - arguments that transmit information into the subprogram but whose values remain unchanged on output.

(2) Input/Output - arguments used to transmit information both into and out of the subprogram, plus any other arguments that do not fit into categories 1 or 3.

(3) Output - arguments that transmit information out of the subprogram but no information into the subprogram; their values on input are irrelevant.

To distinguish between the three argument categories when referencing subprograms, the arguments are ordered according to category, and the categories separated by spaces. Priestley gives the following rules to ensure an unambiguous and uniform use of spaces: inputs are followed by a space, inputs/outputs are bracketed by spaces, and outputs are preceded by a space. Any double spaces are merged into a single space. Note that it is each category, not each individual argument, that is delimited by a space.

Consult the main routines of each program for examples and additional useful information.

3.1.7 Data Retrieval Example

"I have briefly read the Handbook Guide. I would like some microwave refractive index data for ice. How do I find it?"

Looking at the Contents, note that section 2.7.3 contains the description of data for the refractive indices of ice in the optical, infrared, and microwave regions, and section 3.2.7.3 contains the data file format information. In 2.7.3 read about the sources of the data. Notice that there are two sets of microwave data, one which is handled by program MICRO. In 3.2.7.3, the entry key explains the data files' variables and their units, and the format key shows the FORTRAN format statements used to create the files. Check the wavelength and temperature ranges that the data files cover, and note the data tape file numbers. Then turn back to the Guide to read the section on using program MICRO, which will retrieve select data. The final step is to load the desired files from the tape onto your disk.

3.1.8 Data Table Examples

File Name, Entry Key, and Range information was taken from "Data File Formats" (section 3.2) and is not part of the data file. The first line of the data file contains identifying information in capital letters.

Example 1:

File Name: RFXQUA2

Entry Key: Sequence #, Wavelength(m), wavenumber (cm⁻¹), Real Refractive Index (dimensionless)

Range: 1.6E-4 to 3.49E-3 meters

REFRACTIVE INDICES: SYNTHETIC QUARTZ, 47 DEGREES F. (LAIKIN)

| | | | |
|----|--------------|--------------|--------------|
| 1 | 1.596060E-04 | 6.265430E 01 | 1.760350E 00 |
| 2 | 1.616580E-04 | 6.185900E 01 | 1.750650E 00 |
| 3 | 1.644390E-04 | 6.081282E 01 | 1.738620E 00 |
| 4 | 1.647690E-04 | 6.069102E 01 | 1.737310E 00 |
| 5 | 1.651790E-04 | 6.054040E 01 | 1.735740E 00 |
| 6 | 1.849500E-04 | 5.406880E 01 | 1.677210E 00 |
| 7 | 1.942300E-04 | 5.148540E 01 | 1.659060E 00 |
| 8 | 2.378320E-04 | 4.204660E 01 | 1.608930E 00 |
| 9 | 2.536520E-04 | 3.942413E 01 | 1.598390E 00 |
| 10 | 2.652040E-04 | 3.770683E 01 | 1.592110E 00 |

(etc.)

Example 2:

File Name: MLS

Entry Key: Sequence #, Altitude (km), Pressure (mb), Temp. (K), Density (mols cm⁻³) for H₂O, CO₂, O₃, N₂O, CO, CH₄, O₂, N₂

Range: 0 to 100 km

STANDARD ATMOSPHERE - MIDLATITUDE SUMMER

| | | | | | | |
|---|-----|------------|------------|------------|------------|------------|
| 1 | .0 | 1.0130E 03 | 2.9400E 02 | 4.6810E 17 | 8.0840E 15 | 7.5300E 11 |
| | | 6.8590E 12 | 1.8370E 12 | 3.9190E 13 | 5.1320E 18 | 1.9130E 19 |
| 2 | 1.0 | 9.0200E 02 | 2.9000E 02 | 3.1100E 17 | 7.3340E 15 | 7.5300E 11 |
| | | 6.2230E 12 | 1.6670E 12 | 3.5560E 13 | 4.6560E 18 | 1.7360E 19 |
| 3 | 2.0 | 8.0200E 02 | 2.8500E 02 | 1.9730E 17 | 6.6630E 15 | 7.5300E 11 |
| | | 5.6540E 12 | 1.5140E 12 | 3.2310E 13 | 4.2300E 18 | 1.5770E 19 |
| 4 | 3.0 | 7.1000E 02 | 2.7900E 02 | 1.1030E 17 | 6.0480E 15 | 7.7810E 11 |
| | | 5.1320E 12 | 1.3750E 12 | 2.9320E 13 | 3.8400E 18 | 1.4310E 19 |
| 5 | 4.0 | 6.2800E 02 | 2.7300E 02 | 6.3530E 16 | 5.4790E 15 | 8.0320E 11 |
| | | 4.6490E 12 | 1.2450E 12 | 2.6570E 13 | 3.4780E 18 | 1.2970E 19 |

(etc.)

3.2 DATA FILE FORMATS [FORMATS, 5]

This section contains technical information on each data file in tabular form: data file variable definitions, units, and ranges, Data General FORTRAN V format statement used to create the file(s), temperature, source, and computer tape file number. We have used scientific notation here in keeping with the style and format of our data files.

Entry Key:

The entry key contains explanations of the variables and their units in the order in which they appear in the data files. A double asterisk, "**", stands for "raised to the power of"; e.g., "m**⁻³ m**⁻¹" means "per meter cubed per meter".

Format:

The format section contains the Data General FORTRAN V format code used to generate a given data file. The scale factor "P" changes the location of the decimal point in the external representation of a real number, with respect to its internal value. The format is "nP", where n is an integer constant that specifies the number of positions you want to move the decimal point to the right.

3.2.1: Attenuation Coefficients

3.2.1.1: Atmospheric Attenuation Coefficients (program ATTENCOEF)

Entry Key: With the exception of ATTENHT, which is a file of altitude (km), the entries are: absorption (km⁻¹), and scattering (km⁻¹). These values are in a one-to-one correspondence with the altitudes in file ATTENHT.

Format: ATTENHT - [F4.1], all others [2(2X,1PE11.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|-------------|-------|-----------------------------|
| ATTENHT | 0 - 85 (km) | ---- | McClatchey et al.(1972)/180 |
| AERXCLR | " | ---- | "/ 181 |
| AERXHAZ | " | ---- | "/ 182 |
| MIDLATSUM | " | ---- | "/ 183 |
| MIDLATWIN | " | ---- | "/ 184 |
| SUBARCSUM | " | ---- | "/ 185 |
| SUBARCWIN | " | ---- | "/ 186 |
| TROPIC | " | ---- | "/ 187 |

3.2.1.2: Attenuation and Scattering: Water

Entry Key: sequence #, wavelength (m), attenuation (m^{-1}), scattering (m^{-1})

Format: [I5,3(2X,1PE10.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|---------------|----------------|-------|------------------------|
| H2OXATTENSCAT | 3.75E-7 - 8E-7 | ---- | Jerlov (1968)/10 |

3.2.2: Standard Atmospheres

Entry Key: sequence #, altitude (km), pressure (mb), temp. (K), density ($mols\ cm^{-3}$) for H₂O, CO₂, O₃, N₂O, CO, CH₄, O₂, N₂.

Format: [I5,2X,F7.1,5(2X,1PE10.4)] (lines with sequence #)
[14X,5(2X,1PE10.4)] (lines without sequence #)

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|--------------|-------|----------------------------|
| MLS | 0 - 100 (km) | ---- | Program FSCDATM (1981)/ 11 |
| MLW | " | ---- | "/ 12 |
| SAS | " | ---- | "/ 13 |
| SAW | " | ---- | "/ 14 |
| TROPICAL | " | ---- | "/ 15 |
| USXSTAN | " | ---- | "/ 16 |

3.2.3: Cloud Drop Size Distributions

Entry Key: sequence #, number density of drops or ice particles ($m^{-3}\ m^{-1}$), beginning radius (m), ending radius (m)

Format: [I5,3(2X,1PE10.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|-------------------|-------|--------------------------------|
| CLOUD1 | 1E-7 - 1.6E-5 | ---- | Carrier et al. (1965, 1967)/17 |
| CLOUD2 | 1E-7 - 1.07E-5 | ---- | "/ 18 |
| CLOUD3 | 1E-7 - 1E-5 | ---- | "/ 19 |
| CLOUD4 | 1E-7 - 2E-5 | ---- | "/ 20 |
| CLOUD5 | 1E-7 - 3E-5 | ---- | "/ 21 |
| CLOUD6 | 1E-7 - 1.6E-5 | ---- | "/ 22 |
| CLOUD7 | 1E-7 - 2E-5 | ---- | "/ 23 |
| CLOUD8 | 1E-7 - 1.3E-5 | ---- | "/ 24 |
| CLOUD9 | 1.5E-6 - 7.5E-5 | ---- | Schickel (1975)/25 |
| CLOUD10 | 1E-6 - 5E-5 | ---- | Heymsfield (1975)/ 26 |
| CLOUD11 | 5E-5 - 5E-4 | ---- | "/ 27 |
| CLOUD12 | 3E-6 - 1.3E-5 | ---- | Heymsfield & Jahnsen (1974)/28 |
| CLOUD13 | 3.97E-7 - 3.97E-5 | ---- | Kraus & Barnes (1976b)/29 |
| CLOUD14 | 3.97E-7 - 2E-4 | ---- | Kraus & Barnes (1976a)/30 |
| CLOUD15 | 3.97E-7 - 1.58E-4 | ---- | Barnes (1977)/ 31 |
| CLOUD16 | 8.05E-6 - 5.64E-4 | ---- | Glass & Varley (1978)/32 |
| CLOUD17 | 1E-6 - 8.6E-4 | ---- | Varley & Brooks (1978)/33 |
| CLOUD18 | 1E-6 - 3.1E-5 | ---- | 34 |

3.2.4: Solar Spectral Irradiance

Entry Key: sequence #, wavelength (m), solar spectral irradiance (watts m⁻² m⁻¹)

Format: [I5,2(2X,1PE11.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|-------------------|-------|-----------------------------|
| FLUX1 | 1.2E-7 - 1E-4 | ---- | Thekaekara (1972)/ 35 |
| FLUX2 | 2.5E-10 - 1.95E-2 | ---- | Smith & Gottlieb (1974)/ 36 |

3.2.5: Sky Spectral Radiance

Entry Key: sequence #, wavelength (m), spectral radiance (watts m⁻² m⁻¹)

NOTE: This quantity is spectral radiance density: watts per square meter, per meter of wavelength.

Format: [I5,2(2X,1PE11.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|-----------------|-------|------------------------|
| SKYBACSL | 3.1E-7 - 7.2E-7 | ---- | Clark (1969)/37 |
| SKYBAC10 | " | ---- | "/ 38 |

3.2.6: Rayleigh Coefficients: Air

Entry Key: MASSXSCAT - sequence #, wavelength (m), mass scattering coefficient (m² kg⁻¹)
 : VOLXSCAT - sequence #, wavelength (m), volume scattering coefficient (m⁻¹)
 : RAYXSCATCROSS - sequence #, wavelength (m), scattering cross section (m²)

Format : [I5,2(2X,1PE10.4)]

| File Name | Range | Temp. | Source/ Tape File # |
|---------------|-------------|-------|------------------------|
| MASSXSCAT | 2E-7 - 2E-5 | 0°C | Penndorf (1957)/39 |
| VOLXSCAT | " | " | "/ 40 |
| RAYXSCATCROSS | " | " | "/ 41 |

3.2.7 Refractive Indices: Aerosols, Air, Ice, Liquid H₂O (in alphabetic order)

NOTE: The file name prefixes "RF", "RFI", and "RFC" refer to real, imaginary, and complex refractive index files, respectively, with the exception of the microwave files used by program MICRO, which contain complex data. Aerosol files are divided into these three data types, and then listed alphabetically within these categories.

File names preceded by "***" indicate they are the microwave refractive index files, used in program MICRO; these asterisks are not part of the file name.

Entry Key: RF+ files: sequence #, wavelength (m), wavenumber (cm⁻¹), real refractive index
 : RFI+ files: sequence #, wavelength (m), wavenumber (cm⁻¹), imaginary refractive index
 : RFC+ files: sequence #, wavelength (m), wavenumber (cm⁻¹), real refractive index, imaginary refractive index
 : MICRO files: sequence #, wavelength (m), real refractive index, imaginary refractive index, source (real index), source (imaginary index)

Format: RF and RFI files: [I5,3(2X,1PE13.6)]
 : RFC files: [I5,4(2X,1PE13.6)]
 : Microwave files: [I5,3(2X,1PE13.6),2(5X,A2)]

| File Name | Range | Temp. | Source/ Tape File # |
|-----------|-------|-------|------------------------|
|-----------|-------|-------|------------------------|

3.2.7.1: Aerosols

| | | | |
|----------------|-------------------|------------------------|--|
| RFXADPE,O | 2E-7 - 2E-6 | 24°C | Zernike (1964)/42, 43 |
| RFXBARF1 - 3 | 4.05E-7 - 7.68E-7 | 15,35,55°C | Malitson (1964)/49 - 51 |
| RFXBARF4 | 2.65E-7 - 1.03E-5 | 25°C | "/ 52 |
| RFXCAF1 - 3 | 4.05E-7 - 7.68E-7 | 15,35,55°C | Malitson (1963)/59 - 61 |
| RFXCDS1E,O | 5.12E-7 - 1.4E-6 | ---- | Bieniewski & Czyzak (1963)/53, 54 |
| RFXCDS2E,O | 5.5E-7 - 1.4E-6 | ---- | Czyzak et al. (1957)/ 55, 56 |
| RFXGERM1 - 4 | 2.55E-6 - 1.24E-5 | 297,275, 204, 94 K | Icenogle et al. (1976)/75 - 78 |
| RFXGERM5 | 2.06E-6 - 1.6E-5 | 27°C | Salzburg & Villa (1957)/ 79 |
| RFXGLASS1 - 17 | 3.65E-7 - 2.6E-6 | ---- | Kingslake & Conrady (1937)/80 - 96 |
| RFXGLASS18,19 | 1.01E-6 - 1.1E-5 | 27°C | Salzburg & Villa (1957)/ 97, 98 |
| RFXGLASS20 | 5.77E-7 - 1.19E-5 | 25°C | Rodney et al. (1958)/ 99 |
| RFXKDPE,O | 2E-7 - 2E-6 | 24°C | Zernike (1964)/103, 104 |
| RFXQUALE,O | 4.96E-5 - 4.95E-4 | ---- | Russell & Bell (1967)/ 112, 113 |
| RFXQUA2 | 1.6E-4 - 3.49E-3 | 47°F | Laikin (1961)/114 |
| RFXQUA3E,O | 1.44E-7 - 2.31E-7 | ---- | Chandrasekharan & Damany (1968)/115, 116 |
| RFXSAPPH1E,O | 2.54E-7 - 6.91E-7 | 24°C | Jeppeson (1958)/124, 125 |
| RFXSAPPH2 | 2.65E-7 - 5.58E-6 | 24°C | Malitson (1962)/126 |
| RFXSAPPH3 | 2.65E-7 - 4.25E-6 | 19°C | Malitson et al. (1958)/ 127 |
| RFXSAPPH4 - 6 | 4.05E-7 - 7.07E-7 | 17,24,31°C | "/ 128-130 |
| RFXSILIC1 - 4 | 2.55E-6 - 1.03E-5 | 296,275, 202, 104 K | Icenogle et al. (1976)/135 - 138 |
| RFXSILIC5 | 1.36E-6 - 1.1E-5 | 26°C | Salzburg & Villa (1957)/139 |
| RFXSILICA | 3.65E-7 - 1.53E-6 | ---- | Zernike (1964)/134 |
| RFXSODNITE,O | 4E-7 - 7E-7 | ---- | Ivlev & Popova (1974)/ 140, 141 |
| RFXZNS1E,O | 3.6E-7 - 1.4E-6 | ---- | Bieniewski & Czyzak (1963)/142, 143 |
| RFXZNS2 | 4.4E-7 - 1.4E-6 | ---- | Czyzak et al. (1957)/ 144 |
| RFIXDUST1 - 10 | 3E-7 - 1.7E-6 | ---- | Lindberg et al. (1976)/62 - 71 |
| RFCXAMSP1 - 3 | 9.3E-6 - 9.5E-6 | 24°C | Jennings (1981)/45 - 47 |
| RFCXAMSP4 | 4.05E-7 - 4E-5 | ---- | Toon et al. (1976)/ 48 |
| RFCXCALCE,O | 2E-7 - 6E-6 | ---- | Ivlev & Popova (1974)/ 57,58 |
| RFCXDUST1 - 3 | 3E-7 - 1.7E-6 | ---- | Lindberg (1977)/72 - 74 |
| RFCXGLASS1 | 4.8E-7 - 6.9E-7 | ---- | Hoover/ 100 |
| RFCXGRAPH | 2.5E-7 - 6E-6 | ---- | Ivlev & Popova (1974)/ 101 |
| RFCXGYPS | 2E-7 - 6E-6 | ---- | "/ 102 |
| RFCXMASCAG | " | ---- | "/ 105 |
| RFCXMOLYB | 3.3E-4 - 5E-4 | ---- | Meyer (1926)/106 |
| RFCXPLTX1 - 5 | 9.3E-6 - 1.06E-5 | 24°C | Jennings (1981)/107 - 111 |
| RFCXQUALE,O | 7.68E-7 - 3.6E-5 | " | Peterson & Weinman (1969)/117, 118 |
| RFCXQUA2E,O | 5E-7 - 6E-6 | ---- | Ivlev & Popova (1974)/119, 120 |
| RFCXQUA3,4 | 1E-7 - 1.65E-7 | ---- | Lamy (1977)/121, 122 |
| RFCXSALT | 2E-7 - 1E-4 | ---- | Toon et al. (1976)/ 123 |
| RFCXSAPPH1 | 2E-7 - 6E-6 | ---- | Ivlev & Popova (1974)/131 |
| RFCXSAPPH2E | 9E-6 - 3.3E-4 | ---- | Toon et al. (1976)/ 132 |
| RFCXSAPPH2O | 2E-7 - 3.3E-4 | ---- | "/ 133 |
| RFCXSYNAER | 4E-7 - 1.5E-5 | ---- | Ivlev & Popova (1973)/ 44 |

3.2.7.2 Air

| | | | |
|-----------|-------------|-------|----------------------|
| RFXAIRN30 | 2E-7 - 2E-5 | -30°C | Penndorf (1957)/ 145 |
| RFXAIRN15 | " | -15°C | "/ 146 |
| RFXAIR0 | " | 0°C | "/ 147 |
| RFXAIR15 | " | 15°C | "/ 148 |
| RFXAIR30 | " | 30°C | "/ 149 |

3.2.7.3 Ice

| | | | |
|--------------|-------------------|-------|-------------------------------|
| RFCXICE1 | 9.5E-7 - 1.52E-4 | ---- | Irvine & Pollack (1968)/ 150 |
| RFCXICE2 | 2E-6 - 3.3E-5 | -7°C | Schaaf & Williams (1973)/ 151 |
| RFCXICE3 | 1.25E-6 - 3.3E-4 | 100 K | Bertie et al. (1969)/152 |
| RFCXICE4 | 4.43E-8 - 1.67E-4 | -7°C | Warren (1984)/ 221 |
| RFCXICE5 | 1.67E-4 - 8.6 | -1°C | " 222 |
| RFCXICE6 | " | -5°C | " 223 |
| RFCXICE7 | " | -20°C | " 224 |
| RFCXICE8 | " | -60°C | " 225 |
| ** RFICEMN50 | 3E-2 - 1E-1 | -50°C | Ryde & Ryde (1945)/ 204 |
| ** RFICEMN30 | " | -30°C | "/ 205 |
| ** RFICEMN10 | " | -10°C | "/ 206 |
| ** RFICEM0 | " | 0°C | "/ 207 |

| File Name | Range | Temp. | Source/ Tape File # |
|---------------------------------|-------------------|---------|--|
| 3.2.7.4 Liquid H ₂ O | | | |
| RFCXH201 | 5.46E-7 - 2.53E-5 | 18-20°C | Zuev et al. (1974)/ 153 |
| RFCXH202 | 2E-7 - 2E-4 | 25°C | Hale & Querry (1973)/ 154 |
| RFCXH203 | 2E-6 - 1E-3 | 27°C | Downing & Williams (1975)/ 155 |
| RFCXH204 | 9.6E-6 - 1.05E-5 | 24°C | Jennings (1981)/ 156 |
| RFCXH205 | 2E-7 - 2E-4 | ---- | Irvine & Pollack (1968)/157 |
| RFCXH206 | 2E-6 - 2E-5 | 300 K | Querry et al. (1977)/ 158 |
| RFCXH207 | " | " | "/ 159 |
| RFCXH208 | " | " | "/ 160 |
| RFCXH209 | " | " | "/ 161 |
| RFCXH2010 | " | " | "/ 162 |
| RFCXH2011 | " | " | "/ 163 |
| ** RFH2OMN8 | 6.2E-3 - 3.21E-2 | -8°C | Lane & Saxton (1952)/ 208 |
| ** RFH2OM0 | 5E-3 - 1E-1 | 0°C | Ryde & Ryde (1945); Lane & Saxton (1952); Collie et al. (1948); Deimendjian (1963)/ 209 |
| ** RFH2OM10 | 1E-3 - 1E-1 | 10°C | "/ 210 |
| ** RFH2OM18 | 5E-3 - 1E-1 | 18°C | Ryde & Ryde (1945)/ 211 |
| ** RFH2OM20 | " | 20°C | Ryde & Ryde (1945); Lane & Saxton (1952); Collie et al. (1948)/ 212 |
| ** RFH2OM30 | " | 30°C | "/ 213 |
| ** RFH2OM40 | " | 40°C | "/ 214 |
| ** RFH2OM50 | 6.2E-3 - 1E-1 | 50°C | Lane & Saxton (1952); Collie et al. (1948)/ 215 |
| ** RFH2OM60 | 1.27E-2 - 1E-1 | 60°C | Collie et al. (1948)/ 216 |
| ** RFH2OM75 | " | 75°C | "/ 217 |

3.2.8 Relative Reflectance: Ice, H₂O

Entry Key: sequence #, wavelength (m), relative reflectance
 Format: [I5,2(2X,1PE13.6)]

| File Name | Range | Temp. | Source/ Tape File # |
|-------------|---------------|-------|---------------------------------------|
| RRXH201 - 6 | 2E-6 - 2E-5 | ---- | Querry et al. (1977)/ 165 - 170 |
| RRXICE1 | 2E-6 - 3.3E-5 | -7°C | Schaaf & Williams (1973)/ 164 |

4. ACKNOWLEDGMENTS [THANKS, 6]

Much gratitude is owed to Margot Ackley for her professional aid in giving the project a firm basis and a good start. Without a succession of devoted students, Kris Yoshida, Karen Umemoto, and Denise Nagode, the effort would have foundered. The editing talents of Lindsay Murdock of NOAA and Helen Coffey of NESDIS contributed to a grammatically intact publication. Above all, hard and intelligent work by Suchi Psarakos brought the project to a conclusion. Much of the compilation was made while the author was in Wave Propagation Laboratory, ERL/NOAA, Boulder, Colorado. A great deal of the data was collected at the Air Force Geophysical Laboratory, Hanscom Field, Massachusetts, by many researchers, too numerous to mention.

5. REFERENCES [REF, 7]

- BARNES, A.A., Jr. 1977 Weather Document for TDV-1, Sixty Day Report, AFGL, Bedford, MA, Table G, July 15, 1977.
- BERTIE, J.E., H.T. LABBE, 1969 Journal of Chemical Physics, 50, No. 10, pp. 4501-4520.
and E. WHALLEY
- BIENIEWSKI, T.M., and 1963 Journal of the Optical Society of America, pp. 496-497,
S.J. CZYZAK April 1963.
- CARRIER, L.W., G.A. CATO, 1965 Final Report - Laser Systems Study, Part III: Effect of
and K.J. VON ESSON Clouds. Prepared for U.S. Naval Ordnance Labs by Xerox
Electro Optical Systems, Corona, California, Contract N123
(62738) 34515A(X), EOS report 4440 - Final III.
- CARRIER, L.W., G.A. CATO, 1967 Applied Optics, 6, No. 7, pp. 1209-1216.
and K.J. VON ESSON
- CHANDRASEKHARAN, V., and 1968 Applied Optics, 7, No. 4, pp. 687-688.
H. DAMANY
- CLARK, W.M. 1969 S.P.I.E. Journal, 7, pp. 40-45.
- CLARKE, G.L., and 1939 Journal of the Optical Society of America, 29, pp. 43-55.
H.R. JAMES
- COLLIE, C.H., J.B. HASTED, 1948 Physical Society: 60, 71, 145.
and D.M. RITSON
- CZYZAK, S.J., W.M. BAKER, 1957 Journal of the Optical Society of America, 47, No. 3, pp. 240-243.
R.C. CRANE, and J.B. HOWE
- DEIRMENDJIAN, D. 1963 "Complete Microwave Scattering and Extinction Properties of
Polydispersed Cloud and Rain Elements", The Rand Corporation.
- DOWNING, H.D., and 1975 Journal of Geophysical Res., 80, No. 12, pp. 1656-1661.
D. WILLIAMS
- DUNSMUIR, R., and J. LAMB 1945 "The Dielectric Properties of Ice at Wavelengths of Three and
Nine Centimeters", Manchester University, Dept. #61.
- GALLERY, W.O., F.X. KNEIZYS, 1981 Computer code for FCSDATM by Gallery, Kneizys, and Clough,
and S.A. CLOUGH AFGL, Optical Physics, Hanscom AFB, Bedford, MA.
- GLASS, M. and 1978 "Observations of Cirrus Particle Characteristics Occurring
D.J. VARLEY with Halos", AMS preprint, Cloud Physics and Atmospheric
Electricity Conference, Issaquah, WA, July 31-August 4, 1978,
pp. 1-3.
- GRAMS, G.W., 1972 Journal of the Atmospheric Sciences, 29, pp. 900-905.
I.H. BLIFFORD, JR., B.G.
SCHUSTER and J.J. DE LUISI
- GRAY, D.E. 1963 American Institute of Physics Handbook, 2nd ed.,
McGraw-Hill, NY.
- HALE, G.M., and 1973 Applied Optics, 12, No. 3, pp. 555-563.
M.R. QUERRY
- HERZBERGER, M. 1942 Journal of the Optical Society of America, 32, pp. 70-77.
- HEYMSFIELD, A.J. 1975 Journal of the Atmospheric Sciences, 32, pp. 709-808.
- HEYMSFIELD, A.J., and 1974 "Microstructure of Tropopause Cirrus Layers", AMS preprint,
L.J. JAHNSEN Sixth Conference on Aerospace and Aeronautical Meteorology,
El Paso, TX, pp. 43-48.
- ICENOGLLE, H.W., 1976 Applied Optics, 15, No. 10, pp. 2348-2351.
B.C. PLATT, and
W.L. WOLFE
- IRVINE, W.M., and 1968 Icarus, 8, pp. 324-360.
J.B. POLLACK

- IVLEV, L.S., and S.I. POPOVA 1974 Russian: Izvestiya Vysshikh Uchebnykh Zavendenii. Fizika, 15, No. 5, pp. 91-97, May 1972; English: Soviet Physics Journal, pp. 703-707, May 15, 1974.
- IVLEV, L.S., and S.I. POPOVA 1973 Russian: Akademiia Nauk, SSSR. Izvestiya Serii Fizika Atmosfery i Okeana, 9, No. 10, pp. 1034-1043; English: Atmospheric and Oceanic Physics, 9, No. 10, pp.587-590, 1973.
- JENNINGS, S.C. 1981 Journal of the Optical Society of America, 71, No. 8, pp. 923-927.
- JEPPESON, M.A. 1958 Journal of the Optical Society of America, 48, No. 9, pp. 629-632.
- JERLOV, N.G. 1968 Optical Oceanography, p. 51, Elsevier Publishing Co., NY.
- KINGSLAKE, R., and H.G. CONRADY 1937 Journal of the Optical Society of America, 27, pp. 257-262.
- KRAUS, M.J., and A.A. BARNES, Jr. 1976a Weather documentation for SIM-11W, Sixty Day Report, AFGL, Bedford, MA, Table G, September 13.
- KRAUS, M.J., and A.A. BARNES, Jr. 1976b Weather documentation for SAMAST/MINT, Sixty Day Report, AFGL, Bedford, MA, Table G, October 18.
- LAIKIN, M. 1961 Journal of the Optical Society of America, 51, p. 238.
- LAMY, P. 1977 Applied Optics, 16, No. 8, August.
- LANE, J.A., and J.A. SAXTON 1952 Royal Society: A, 213, 400.
- LEGRAND, Y. 1939 Ann. Inst. Oceanog., 19, pp. 393-436.
- LINDBERG, J.D., J.B. GILLESPIE, and B. HINDS 1976 "Measurements of the Imaginary Refractive Indices of Atmospheric Particulate Matter from a Variety of Geographic Locations", Proceedings of the Symposium on Radiation in the Atmosphere, Garmisch-Partenkirchen FRG, 19-28 August 1976, H.J. Bolle, ed., Science Press.
- LINDBERG, J.D. 1977 Data tables were taken from correspondence with Lindberg, taken by him from various reports of experiments performed in 1977 at the Atmospheric Sciences Laboratory in White Sands, NM, by Lindberg and S.A. Schleusener.
- MALITSON, I.H., F. MURPHY, Jr., and W.S. RODNEY 1958 Journal of the Optical Society of America, 48, pp. 72-73.
- MALITSON, I.H. 1962 Journal of the Optical Society of America, 52, No. 12, pp. 1377-1379.
- MALITSON, I.H. 1963 Applied Optics, 2, No. 11, pp. 1103-1107.
- MALITSON, I.H. 1964 Journal of the Optical Society of America, 54, No. 5, pp. 628-632.
- McCLATCHEY, R.A., R.W. FENN, J.E.A. SELBY, F.E. VOLZ, and J.S. GARING 1972 Optical Properties of the Atmosphere, 3rd ed., p. 19, AFGL-72-0497.
- MEYER, A. 1926 Journal of the Optical Society of America, 13, pp. 557-560.
- PALMER, K.F., D. WILLIAMS, and M.R. QUERRY 1974 Journal of the Optical Society of America, 64, p. 1107.
- PENNDORF, R. 1957 Journal of the Optical Society of America, 47, No. 2, pp. 176-182.
- PETERSON, J.T., and J.A. WEINMAN 1969 Journal of Geophysical Res., 74, No. 28, pp. 6947-6952.
- QUERRY, M.R., W.E. HOLLAND, R.C. WARING, L.M. EARLS, and M.D. QUERRY 1977 Journal of Geophysical Res., 82, No. 9, pp. 1425-1433. In addition to the data given in the article, Marvin Querry was extremely helpful in supplying us with a supplementary set of the original unabridged data values.

| | | |
|--|------|--|
| ROBERTSON, C.W., and D. WILLIAMS | 1971 | <u>Journal of the Optical Society of America</u> , <u>61</u> , p. 1316. |
| RODNEY, W., I.H. MALITSON, and T. KING | 1958 | <u>Journal of the Optical Society of America</u> , <u>48</u> , No. 9, pp. 633-636. |
| RUSK, A.N., D. WILLIAMS, and M.R. QUERRY | 1971 | <u>Journal of the Optical Society of America</u> , <u>61</u> , p. 895. |
| RUSSELL, E., and E.E. BELL | 1967 | <u>Journal of the Optical Society of America</u> , <u>57</u> , No. 3, pp. 341-348. |
| RUSSELL, P.B., G.W. GRAMS, I.H. BLIFFORD, Jr., and D.A. GILLETTE | 1974 | <u>Journal of Applied Meteorology</u> , <u>13</u> , p. 459. |
| RYDBERG, F. | 1828 | <u>Poggendorfs Ann.</u> , <u>14</u> , 45. |
| RYDE, D., and J.W. RYDE | 1945 | "Attenuation of Centimetre and Millimetre Waves by Rain, Hail, Fogs, and Clouds", Research Labs of General Electric Company, Ltd., Wembley, England. |
| SALZBERG, C.D., and J.J. VILLA | 1957 | <u>Journal of the Optical Society of America</u> , <u>47</u> , No. 3, pp. 244-246. |
| SAXTON, J.A. | 1945 | "The Dielectric Properties of Water at Wavelengths from 2mm to 10cm and Over the Temperature Range 0 degrees C to 40 degrees C", N.P.I., Paper no. R.R.B./C.115. |
| SCHAAF, J.W., and D. WILLIAMS | 1973 | <u>Journal of the Optical Society of America</u> , <u>63</u> , No. 6, pp. 726-732. We appended the data from the article with additional data which J.W. Schaaf furnished for us. These data and information discussing pessimistic and optimistic uncertainty estimates can be found in the doctoral dissertation of J.W. Schaaf, Kansas State University (1973). |
| SCHICKEL, K.P. | 1975 | "Sampling of Droplet Distributions From Water Clouds", Deutsche Forschungs-Und Versuchsanstalt fur Luft-Und Raumfahrt, Institut fur Physik der Atmosphere, Oberpfaffenhofen, West Germany, November 25. |
| SMITH, E.V.P., and D.M. GOTTLIEB | 1974 | <u>Space Science Review</u> , <u>16</u> , pp. 771-802. |
| SMITH, M.A.H. | 1982 | "Compilation of Atmospheric Gas Concentration Profiles from 0 to 50 km", NASA-TM-83289. |
| SPITZER, W.G., and D.A. KLEINMAN | 1961 | <u>Physical Review</u> , <u>121</u> , pp. 1324-1335. |
| STOCKBERGER, D.C. | 1949 | <u>Journal of the Optical Society of America</u> , <u>39</u> , p. 731. |
| STOCKBERGER, D.C., and M. EARLY | 1944 | "Artificial Fluorite", O.S.R.D., Rept. No. 4690. |
| THEKAEKARA, M.P. | 1972 | <u>Photonics Spectra</u> , <u>6</u> , No. 3, pp. 32-35. |
| TILTON, L.W., E.K. PLYLER, and R.E. STEPHENS | 1949 | <u>J. Res. Natl. Bur. Std., U.S.</u> , <u>43</u> , 81. |
| TOON, O.B., B.N. KHARE and J.B. POLLACK | 1976 | <u>Journal of Geophysical Res.</u> , <u>81</u> , No. 33, pp. 5733-5748. |
| VALLEY, S.L., ed. | 1965 | <u>Handbook of Geophysics and Space Environments</u> , AFGL. |
| VARLEY, D.J., and D.M. BROOKS | 1978 | "Cirrus Particle Distribution Study, Part 2", AFGL-TR-78-0248. |
| WARREN, S.G. | 1984 | <u>Applied Optics</u> , <u>23</u> , pp. 1206-1225. |
| WMO | 1982 | "The Stratosphere 1981 Theory and Measurement", Global Ozone Research and Monitoring Project, Report 11. |
| WYATT, P.J. | 1980 | <u>Applied Optics</u> , <u>19</u> , No. 6, pp. 975-983. |

- ZERNIKE, F., Jr. 1964 Journal of the Optical Society of America, 54, No. 10, p. 1215.
- ZUEV, V.E. 1974 Propagation of Visible and Infrared Radiation in the Atmosphere, p. 371, John Wiley & Sons, NY, 1974.

APPENDIX A: List of Files on Atmospheric Handbook Computer Tape
 [LISTFILE0, tape files 0 and 8]

The following list is the linear layout of the files on the Atmospheric Handbook computer tape. Each tape file corresponds to a single data file. Sections of files are grouped according to atmospheric area; an explanation of the grouping breakdown is located in APPENDIX B, tape file 9, "FILEXDESCRIP". All tape files contain 80 characters per line. For further information, see section 3.1, tape file 4, "GUIDE".

| Tape File Number | File Name | Tape File Number | File Name | Tape File Number | File Name | Tape File Number | File Name |
|------------------|----------------|------------------|------------|------------------|-------------|------------------|-----------|
| 0 | LISTFILE0 | 63 | RFXDUST2 | 126 | RFXSAPPH2 | 189 | DAT |
| 1 | INTRO | 64 | RFXDUST3 | 127 | RFXSAPPH3 | 190 | H2OPEN |
| 2 | CONTENTS | 65 | RFXDUST4 | 128 | RFXSAPPH4 | 191 | H2OTEMP |
| 3 | DATADESCRIP | 66 | RFXDUST5 | 129 | RFXSAPPH5 | 192 | HEADER |
| 4 | GUIDE | 67 | RFXDUST6 | 130 | RFXSAPPH6 | 193 | ICEOPEN |
| 5 | FORMATS | 68 | RFXDUST7 | 131 | RFCXSAPPH1 | 194 | ICETEMP |
| 6 | THANKS | 69 | RFXDUST8 | 132 | RFCXSAPPH2E | 195 | INTERP |
| 7 | REF | 70 | RFXDUST9 | 133 | RFCXSAPPH2O | 196 | INTVEC |
| 8 | LISTFILE0 | 71 | RFXDUST10 | 134 | RFXSILICA | 197 | KEY |
| 9 | FILEXDESCRIP | 72 | RFCXDUST1 | 135 | RFXSILIC1 | 198 | RD |
| 10 | H2OXATTENSACAT | 73 | RFCXDUST2 | 136 | RFXSILIC2 | 199 | READANS |
| 11 | MLS | 74 | RFCXDUST3 | 137 | RFXSILIC3 | 200 | RFPRINT |
| 12 | MLW | 75 | RFXGERM1 | 138 | RFXSILIC4 | 201 | SUBHDR |
| 13 | SAS | 76 | RFXGERM2 | 139 | RFXSILIC5 | 202 | TEMPCHK |
| 14 | SAW | 77 | RFXGERM3 | 140 | RFXSODNITE | 203 | VECTOR |
| 15 | TROPICAL | 78 | RFXGERM4 | 141 | RFXSODNITO | 204 | RFICEMN50 |
| 16 | USXSTAN | 79 | RFXGERM5 | 142 | RFXZNS1E | 205 | RFICEMN30 |
| 17 | CLOUD1 | 80 | RFXGLASS1 | 143 | RFXZNS1O | 206 | RFICEMN10 |
| 18 | CLOUD2 | 81 | RFXGLASS2 | 144 | RFXZNS2 | 207 | RFICEM0 |
| 19 | CLOUD3 | 82 | RFXGLASS3 | 145 | RFXAIRN30 | 208 | RFH2OMN8 |
| 20 | CLOUD4 | 83 | RFXGLASS4 | 146 | RFXAIRN15 | 209 | RFH2OM0 |
| 21 | CLOUD5 | 84 | RFXGLASS5 | 147 | RFXAIR0 | 210 | RFH2OM10 |
| 22 | CLOUD6 | 85 | RFXGLASS6 | 148 | RFXAIR15 | 211 | RFH2OM18 |
| 23 | CLOUD7 | 86 | RFXGLASS7 | 149 | RFXAIR30 | 212 | RFH2OM20 |
| 24 | CLOUD8 | 87 | RFXGLASS8 | 150 | RFCXICE1 | 213 | RFH2OM30 |
| 25 | CLOUD9 | 88 | RFXGLASS9 | 151 | RFCXICE2 | 214 | RFH2OM40 |
| 26 | CLOUD10 | 89 | RFXGLASS10 | 152 | RFCXICE3 | 215 | RFH2OM50 |
| 27 | CLOUD11 | 90 | RFXGLASS11 | 153 | RFCXH201 | 216 | RFH2OM60 |
| 28 | CLOUD12 | 91 | RFXGLASS12 | 154 | RFCXH202 | 217 | RFH2OM75 |
| 29 | CLOUD13 | 92 | RFXGLASS13 | 155 | RFCXH203 | 218 | APPENDIXC |
| 30 | CLOUD14 | 93 | RFXGLASS14 | 156 | RFCXH204 | 219 | APPENDIXD |
| 31 | CLOUD15 | 94 | RFXGLASS15 | 157 | RFCXH205 | 220 | FACTS |
| 32 | CLOUD16 | 95 | RFXGLASS16 | 158 | RFCXH206 | 221 | RFCXICE4 |
| 33 | CLOUD17 | 96 | RFXGLASS17 | 159 | RFCXH207 | 222 | RFCXICE5 |
| 34 | CLOUD18 | 97 | RFXGLASS18 | 160 | RFCXH208 | 223 | RFCXICE6 |
| 35 | FLUX1 | 98 | RFXGLASS19 | 161 | RFCXH209 | 224 | RFCXICE7 |
| 36 | FLUX2 | 99 | RFXGLASS20 | 162 | RFCXH2010 | 225 | RFCXICE8 |
| 37 | SKYBACSL | 100 | RFCXGLASS1 | 163 | RFCXH2011 | | |
| 38 | SKYBAC10 | 101 | RFCXGRAH | 164 | RRXICE1 | | |
| 39 | MASSXSCAT | 102 | RFCXGYPS | 165 | RRXH201 | | |
| 40 | VOLXSCAT | 103 | RFXKDPE | 166 | RRXH202 | | |
| 41 | RAYXSCATCROSS | 104 | RFXKDPO | 167 | RRXH203 | | |
| 42 | RFXADPE | 105 | RFCXMASCAG | 168 | RRXH204 | | |
| 43 | RFXADPO | 106 | RFCXMOLYB | 169 | RRXH205 | | |
| 44 | RFCXSNAER | 107 | RFCXPLTX1 | 170 | RRXH206 | | |
| 45 | RFCXAMSP1 | 108 | RFCXPLTX2 | 171 | ATTENCOEF | | |
| 46 | RFCXAMSP2 | 109 | RFCXPLTX3 | 172 | AERRD | | |
| 47 | RFCXAMSP3 | 110 | RFCXPLTX4 | 173 | ATMRD | | |
| 48 | RFCXAMSP4 | 111 | RFCXPLTX5 | 174 | ATTEN | | |
| 49 | RFXBARF1 | 112 | RFXQUALE | 175 | BUILDVEC | | |
| 50 | RFXBARF2 | 113 | RFXQUA10 | 176 | ERCHK | | |
| 51 | RFXBARF3 | 114 | RFXQUA2 | 177 | INPT | | |
| 52 | RFXBARF4 | 115 | RFXQUA3E | 178 | LINTERP | | |
| 53 | RFXCDS1E | 116 | RFXQUA3O | 179 | NEAR | | |
| 54 | RFXCDS1O | 117 | RFCXQUALE | 180 | ATTENHT | | |
| 55 | RFXCDS2E | 118 | RFCXQUA10 | 181 | AERXCLR | | |
| 56 | RFXCDS2O | 119 | RFCXQUA2E | 182 | AERXHAZ | | |
| 57 | RFCXCALCE | 120 | RFCXQUA2O | 183 | MIDLATSUM | | |
| 58 | RFCXCALCO | 121 | RFCXQUA3 | 184 | MIDLATWIN | | |
| 59 | RFXCAF1 | 122 | RFCXQUA4 | 185 | SUBARCSUM | | |
| 60 | RFXCAF2 | 123 | RFCXSALT | 186 | SUBARCWIN | | |
| 61 | RFXCAF3 | 124 | RFXSAPPH1E | 187 | TROPIC | | |
| 62 | RFXDUST1 | 125 | RFXSAPPH1O | 188 | MICRO | | |

APPENDIX B: Computer Tape File Descriptions [FILEXDESCRIP, 9]

This section briefly describes the contents of single or groups of files on the Atmospheric Handbook computer tape, as listed in APPENDIX A, tape file 0, "LISTFILE0".

| Tape File Number | Description |
|------------------|--|
| 0: | "LISTFILE0" - List of all data files on Atmospheric Handbook tape and corresponding tape file number. Each file corresponds to a singular data file. Sections of files are grouped according to atmospheric area. (NOTE: When printed as a bound document, file 0 should not be considered part of the text, and should therefore not be printed. File 0 exists solely as an aid for someone using the Atmospheric Handbook in tape format, to enable easy initial identification of the tape and its contents.) |
| 1: | "INTRO" - Introduction to the evolution, present aims, and future prospects of the Atmospheric Handbook. |
| 2: | "CONTENTS" - Table of contents of the Atmospheric Handbook. |
| 3: | "DATADESCRIP" - A brief description of each atmospheric area covered by the Handbook data files: definition of data file variables, ranges, and units, listing of file names, and description of data source. |
| 4: | "GUIDE" - General user notes and technical information needed to access/understand the computer tape, data files, and computer programs: Introduction to Tape Organization, Data File Structure, Deciphering File Names, Unit Notation, Significant Figures, Computer Programs: ATTENCOEF and MICRO, Data Retrieval Example, Data File Examples. |
| 5: | "FORMATS" - Technical information on each data file in tabular form: data file variable definitions, units, and ranges, FORTRAN format statements used to create the file(s), temperature, source, and computer tape file number. |
| 6: | "THANKS" - Acknowledgments. |
| 7: | "REF" - A list of all references cited in file 3. |
| 8: | "LISTFILE0" - See file 0. |
| 9: | "FILEXDESCRIP" - Brief description of files listed in file 0. |
| 10: | Attenuation Coefficients, H ₂ O |
| 11- 16: | Standard Atmospheres |
| 17-34: | Cloud Drop Size Distributions |
| 35-36: | Solar Spectral Irradiance |
| 37-38: | Sky Spectral Radiance |
| 39-41: | Rayleigh Air Coefficients |
| 42-144: | Refractive Indices, Aerosols |
| 145-149: | Refractive Indices, Air |
| 150-152: | Refractive Indices, Ice (does not include microwave files). See also files 221-225. |
| 153-163: | Refractive Indices, Liquid H ₂ O (does not include microwave files) |
| 164-170: | Relative Reflectance: Ice, H ₂ O |
| 171-187: | Attenuation Coefficients, Atmospheric; Program ATTENCOEF |
| 188-217: | Select Refractive Indices for H ₂ O and Ice, microwave; Program MICRO. (Note that file 178 is used by both ATTENCOEF and MICRO and thus should be loaded with both file sets). Additional microwave ice refractive index data, located in files 222-225, were acquired after the completion of program MICRO, and thus are not available to the user through the program. |
| 218-219: | "APPENDIXC" and "APPENDIXD" - Programs ATTENCOEF and MICRO. These two files were made by appending files 171-187 and 188-217. The individual program and subroutine files should be loaded as needed to run the programs; tape files 218 and 219 should be printed as needed for casual reference or interest, as when compiling an Atmospheric Handbook reference manual. |
| 220: | "FACTS" - A list of useful atmospheric constants and conversions. |
| 221-225: | Refractive Indices, Ice (includes some data for microwave wavelengths) |

APPENDIX C: FORTRAN Code for Program ATTENCOEF (and Related Subroutines): Atmospheric Absorption and Scattering Coefficients [APPENDIXC, 218]

```
C#####
C      PROGRAM ATTENCOEF
C      -----
```

C----- Program ATTENCOEF gives the attenuation coefficients as a
 C----- function of altitude for 5 atmospheric and 2 aerosol models.
 C----- The altitude range is 0 - 85 km, and wavelength = 0.6943 microns.

C----- The following list describes all non-standard FORTRAN
 C----- characteristics in the Handbook programs. For easy access,
 C----- their occurrences within the routines are marked by a "C" in
 C----- column one, followed by a series of plus signs: '+'. Format
 C----- statements in which non-standard format codes appear are listed
 C----- in the comment section 'Non-standard Format Codes'.

C----- General Suggestions for Improvement: Due to the need to
 C----- standardize the programs, it was necessary to format inter-
 C----- active input. This often presents awkward restrictions for
 C----- the user. It is advised that, if available, free-formatted reads
 C----- be implemented to handle numerical input. In addition, the
 C----- use of one standard output filename for all program runs is
 C----- impractical and potentially hazardous. Although the 'A'
 C----- attribute will provide protection against overwriting on
 C----- some systems, it is only meant as a temporary alternative.
 C----- It is advisable that something such as string formatting
 C----- be used to allow character input, in particular, for the
 C----- interactive naming of output files.
 C----- Additionally, individual users should implement precautions
 C----- against careless user inputting, such as illegal characters.
 C----- The program contains only minor precautions. The user should
 C----- beware that some systems accept entry of a carriage return or a
 C----- mathematical sign character (+,-) or decimal as if a zero had
 C----- been entered.

C----- Non-standard FORTRAN options:
 C----- -----

C----- STATIC: The STATIC option places all non-COMMON variables and
 C----- arrays in a fixed area in memory, rather than on the run-time
 C----- stack. It initializes all static variables to zero at load time,
 C----- unless you data-initialize them. You may retrieve the values of
 C----- static variables within a subprogram upon re-entry to the
 C----- subprogram for the second and subsequent times.

C----- OPEN, CLOSE, and REWIND: Although the purpose of these
 C----- input/output statements is obvious, their implementation
 C----- may differ from system to system. The 'OPEN' statement used
 C----- with the 'ATT=A' option specifies that appending is to be
 C----- performed onto the file associated with the channel opened.
 C----- This protects against overwriting the previous contents of the
 C----- file, if any existed. REWIND repositions the record pointer to
 C----- the beginning of the specified file.

C----- 'P' and 'Z' format code: The scale factor 'P' changes the
 C----- location of the decimal point in the external representation
 C----- of a real number, with respect to its internal value. The
 C----- format is 'nP', where 'n' is an integer constant that specifies
 C----- the number of positions you want to move the decimal point to
 C----- the right. 'Z' format code suppresses the newline character
 C----- on output of the current record. It is represented internally,
 C----- and as it is used to build many of the Handbook output files,
 C----- its presence should be considered if any of these files are
 C----- edited.

C----- Non-Standard Format Codes (statement labels): 554
 C----- -----

C----- User options:
 C----- -----

C----- entry modes: single or array entry
 C----- print to screen and/or diskfile
 C----- linear interpolation or closest values at unavailable
 C----- data points

C----- Output:
 C----- -----

C----- Output diskfile 'ATTENOUT'; should be renamed after each run

```

C----- File unit #s:
C-----
C----- 0: aerosol
C----- 1: atmospheric model
C----- 2: diskfile
C----- 11: terminal
C-----
C----- Data Files Used
C-----
C----- AERXCLR,AERXHAZ,ATTENHT,MIDLATSUM,MIDLATWIN,SUBARCSUM,
C----- SUBARCWIN,TROPIC
C----- Subroutines:
C-----
C----- AERRD: opens and reads aerosol file
C----- ATMRD: opens and reads atmosphere files
C----- ATTEN: writes coefficients to output
C----- BUILDVEC: creates a user-entered array of data information
C----- ERCHK: user error check function
C----- INPT: interactively prepares variables entered singly
C-----         for input to ATTEN
C----- LINTERP: linear interpolation function
C----- NEAR: finds the value closest to the user-entered height
C----- Variables:
C-----
C----- Logical
C----- ANSR,ERCHK: check for user input error
C----- DATSET: determines entry mode
C----- INTERP: determines whether interpolation is used
C----- OPEN2: determines if output file is open for writing
C----- SCREEN,DISK: determine if text has been written to screen
C-----         and/or disk
C----- Integer:
C----- ATM: user-entered atmosphere model
C----- OUT: user print option

```

```

C      Suchi Psarakos
C      N.O.A.A.
C      325 Broadway
C      R/E/WP2
C      Boulder, Colorado 80303

```

```

C      Please direct questions to Dr. Vernon Derr, (303) 497-6002,
C      or Suchi Psarakos, (303) 497-5361.

```

```

C#####

```

```

C+++++++

```

```

      STATIC OPEN2,SCREEN,DISK

```

```

C+++++++

```

```

      INTEGER ATTENOUT
      INTEGER ATM, ANS, OUT
      LOGICAL ANSR, ERCHK, DATSET, INTERP, OPEN2, SCREEN, DISK

```

```

      OPEN2 = .FALSE.
      SCREEN = .FALSE.
      DISK = .FALSE.

```

```

C----- entry mode?
9      WRITE (11,550)
10     WRITE (11,552)
100    READ (11, 525,ERR=10)  ANS
      ANSR = ERCHK (ANS )
      IF (ANSR) GOTO 100
      IF (ANS .EQ. 0) DATSET = .FALSE.
      IF (ANS .EQ. 1) DATSET = .TRUE.

```

```

C----- print option?
125   WRITE (11,554)
126   WRITE (11,556)
      READ (11, 525, ERR = 126) ANS

      IF ((ANS .NE. 0) .AND. (ANS .NE. 1) .AND.
$      (ANS .NE. 2)) GOTO 126

```

```

      OUT = ANS
      IF ((OUT .EQ. 1) .OR. (OUT .EQ. 2)) .AND. (.NOT.OPEN2)) GOTO 225
      GOTO 250

```

```

C----- open output file
C+++++++
225 OPEN 2, "ATTENOUT", ATT="A"
C+++++++
OPEN2 = .TRUE.

C----- write heading to output
250 IF ((SCREEN).AND.(DISK)) GOTO 450
IF ((.NOT.SCREEN).AND.(.NOT.DISK).AND.(OUT.EQ.2)) GOTO 255
IF (.NOT.DISK) GOTO 252
IF ((OUT.EQ.0).OR.(OUT.EQ.2)) GOTO 255
252 IF ((OUT.EQ.1).OR.(OUT.EQ.2)) GOTO 260
255 IF (SCREEN) GOTO 450
SCREEN=.TRUE.
WRITE (11,575)
IF (OUT.NE.2) GOTO 450
260 IF (DISK) GOTO 450
DISK=.TRUE.
WRITE (2,575)

450 IF (.NOT. DATSET) GOTO 501

C----- interpolation?
WRITE (11,560)
475 WRITE (11,552)

500 READ (11, 525,ERR=475) ANS
ANSR = ERCHK (ANS )
IF (ANSR) GOTO 500

IF (ANS .EQ. 0) INTERP = .TRUE.
IF (ANS .EQ. 1) INTERP = .FALSE.
GOTO 502

501 INTERP = .FALSE.

C----- call to ATTEN
IF (.NOT.(DATSET)) CALL ATTEN (ATM,ALT,AER,DATSET,INTERP, OUT )
C----- call to BUILDVEC
502 IF (DATSET) CALL BUILDVEC (DATSET,INTERP, OUT )

C----- continue program?
IF (OUT .EQ. 10) GOTO 505
IF (OUT .EQ. 11) GOTO 506

C----- terminate
IF (OPEN2) WRITE (11, 650)
STOP

C----- continue
505 DATSET = .TRUE.
GOTO 125

506 GOTO 9

525 FORMAT (I1)
550 FORMAT (/ "WILL YOU BE ENTERING DATA SINGLY (0) ,"/
$ " OR AS A SET (1) ?")
552 FORMAT (/ "ENTER 0 OR 1")
554 FORMAT (/ "PRINT OPTION: "/3X, "0: RESULTS TO SCREEN ONLY"
$ /3X, "1: RESULTS TO DISKFILE"/3X, "2: RESULTS TO BOTH", Z,
$ " SCREEN AND DISKFILE")
556 FORMAT (/ "ENTER 0,1, OR 2")
560 FORMAT (/ "IF USER-SPECIFIED HEIGHT FALLS AT THE MIDPOINT"/
$ " BETWEEN TWO DATA VALUES, THE PROGRAM INTERPOLATES"/
$ " LINEARLY. IN OTHER CASES, DO YOU WANT INTERPOLATION (0)"/
$ " OR DO YOU WANT THE COEFFICIENTS AT THE NEAREST"/
$ " AVAILABLE HEIGHT (1) ?")
575 FORMAT ("ATTENUATION COEFFICIENTS AS A FUNCTION OF ALTITUDE",
$ /T15, "LAMBDA = 0.6943 MICRONS", /
$ "Source: 'Optical Properties of the Atmosphere', "/3X, "McClatchey,"
$ " Fenn, Selby, Volz, Garing, (1971)."/T8, "K+M = MOLECULAR ABSORPTION",
$ /T8, "S+M = MOLECULAR SCATTERING", /T8, "K+A = AEROSOL ABSORPTION",
$ /T8, "S+A = AEROSOL SCATTERING", //
$ / "VALUES OF ZERO INDICATE A COEFFICIENT LESS THAN E-06",
$ / "***** PRECEDE INTERPOLATED VALUES")
650 FORMAT ("CHECK 'ATTENOUT' FOR OUTPUT. REMEMBER TO RENAME THIS FILE.")
END

```

SUBROUTINE AERRD (AER, AERABS,AERSCAT)

C----- Opens and reads one of the two aerosol files.
C----- The files contain absorption and scattering
C----- coefficients for aerosols as a function of altitude
C----- in the range 0 - 85 km.

C----- Non-standard Format Code (statement labels): 263

DIMENSION AERABS(33), AERSCAT(33)
INTEGER AER

C----- open AER

C+++++

IF (AER .EQ. 0) OPEN 0, "AERXCLR", ERR = 250
IF (AER .EQ. 1) OPEN 0, "AERXHAZ", ERR = 260

C+++++

C----- read AER

DO 60 I = 1, 33
READ (0,263) AERABS(I), AERSCAT(I)

60 CONTINUE

C+++++

CLOSE 0

C+++++

RETURN

250 WRITE (11, 261)

STOP

260 WRITE (11, 262)

STOP

261 FORMAT (/"ERROR OPENING AERXCLR")

262 FORMAT (/"ERROR OPENING AERXHAZ")

263 FORMAT (2 (2X,1PE11.4))

END

SUBROUTINE AIMRD (ATM, RABS,SCAT)

C----- Opens and reads the 5 atmospheric model files.
 C----- The files contain absorption and scattering
 C----- coefficients as a function of altitude in the
 C----- range 0 - 85 km.

C----- Non-standard Format Code (statement label): 245

DIMENSION RABS(33), SCAT(33)
 INTEGER ATM

C----- open ATM file

C+++++

IF (ATM .EQ. 1) OPEN 1, "TROPIC", ERR = 200
 IF (ATM .EQ. 2) OPEN 1, "MIDLATSUM", ERR = 210
 IF (ATM .EQ. 3) OPEN 1, "MIDLATWIN", ERR = 220
 IF (ATM .EQ. 4) OPEN 1, "SUBARCSUM", ERR = 230
 IF (ATM .EQ. 5) OPEN 1, "SUBARCWIN", ERR = 240

C+++++

C----- read ATM file

DO 35 I = 1, 33
 READ (1,245) RABS(I), SCAT(I)
 35 CONTINUE

C+++++

CLOSE 1

C+++++

RETURN

200 WRITE (11,250)

STOP

210 WRITE (11,252)

STOP

220 WRITE (11,254)

STOP

230 WRITE (11,256)

STOP

240 WRITE (11,258)

STOP

245 FORMAT (2 (2X,1PE11.4))

250 FORMAT (/ "ERROR OPENING TROPIC")

252 FORMAT (/ "ERROR OPENING MIDLATSUM")

254 FORMAT (/ "ERROR OPENING MIDLATWIN")

256 FORMAT (/ "ERROR OPENING SUBARCSUM")

258 FORMAT (/ "ERROR OPENING SUBARCWIN")

END

SUBROUTINE ATTEN (ATM,ALT,AER,DATSET,INTERP, OUT)

C----- ATTEN is called by ATTENCOEF and BUILDVEC. It calls INPT,ATMRD,
 C----- AERRD,NEAR, and LINTERP. Does all writing to output files.
 C----- Contains choice for user to start over and enter a new entry mode.

C----- Non-standard Format Code (statement label): 7100,7200,9140,9145,9146

C----- Variables
 C----- data arrays
 C----- molecular data:
 C----- RABS: absorption
 C----- SCAT: scattering
 C----- aerosol:
 C----- AERABS: absorption
 C----- AERSCAR: scattering
 C----- logical
 C----- ATM2,AER2,HEIGHT: determine structural positions
 C----- in the program as well as whether informational text
 C----- has been printed; prevent unnecessary printing
 C----- real
 C----- ALT: user entered altitude
 C----- ABS1,ABS2,HT1,HT2,SCAT1,SCAT2: output
 C----- LINTERP: linear interpolation function
 C----- integer
 C----- AERSL: current aerosol model
 C----- NEAR: function, returns the index of ALT in HT, or the
 C----- index to the next closest value
 C----- OLDAIM: current atmospheric model
 C----- OUT: print option, multi-usage variable;
 C----- within ATTEN, its value may change:
 C----- = 10: return to driver, enter array mode
 C----- = 11: return to driver with option for new entry mode
 C----- UNIT: current output unit #

DIMENSION HT(33), RABS(33), SCAT(33), AERABS(33), AERSCAT(33)

LOGICAL AER2, ATM2, INTERP, DATSET,HEIGHT,
 \$ ANSR,ERCHK

C+++++
 STATIC OLDAIM,AERSL/-1/,HT,HEIGHT/.FALSE./,ATM2/.TRUE./

C+++++

INTEGER OLDAIM,ATM, AER, AERSL, OUT,NEAR, ANS,UNIT
 REAL ALT,HT1,HT2,ABS1,ABS2,SCAT1,SCAT2,LINTERP

C----- user finished?
 IF (OUT .LT. 0) GOTO 1120

IF (HEIGHT) GOTO 19

C----- open/read height file
 C+++++
 OPEN 1, "ATTENHT", ERR = 3
 C+++++
 GOTO 4
 3 WRITE (11,5000)
 STOP
 4 DO 5 I = 1, 33
 READ (1,4600) HT(I)
 5 CONTINUE
 HEIGHT = .TRUE.
 C+++++
 CLOSE 1
 C+++++

19 IF (.NOT. DATSET) CALL INPT (DATSET,ATM2, ATM,ALT,AER)
 IF (ATM.EQ.0) GOTO 1120
 IF (OLDAIM .NE. ATM) CALL ATMRD (ATM, RABS,SCAT)
 IF (OLDAIM .NE. ATM) GOTO 21
 IF (OLDAIM .EQ. ATM) ATM2 = .FALSE.
 GOTO 22
 21 ATM2 = .TRUE.
 22 OLDAIM = ATM

```

30     IF (AERSL .NE. AER) CALL AERRD (AER, AERABS,AERSCAT)
      IF ((ATM2) .OR. (AERSL .NE. AER)) GOTO 31
      IF ((.NOT. ATM2) .OR. (AERSL .EQ. AER)) AER2 = .FALSE.
      GOTO 32
31     AER2 = .TRUE.
32     AERSL = AER

C----- call to NEAR
      J = NEAR (ALT,HT,DATSET,INTERP )

      IF ((OUT .EQ. 0) .OR. (OUT .EQ. 2)) GOTO 84
82     IF ((OUT .EQ. 1) .OR. ((OUT .EQ. 2) .AND.
      $   (UNIT .EQ. 11))) UNIT = 2
      GOTO 85

84     UNIT = 11

85     IF (ATM2) GOTO 90
      IF ((.NOT. ATM2) .AND. (AER2)) GOTO 91
      IF ((.NOT. ATM2) .AND. (.NOT. AER2)) GOTO 95

C----- atmosphere model
90     WRITE ( UNIT, 7100)

      IF (ATM .EQ. 1) WRITE (UNIT, 9100)
      IF (ATM .EQ. 2) WRITE (UNIT, 9105)
      IF (ATM .EQ. 3) WRITE (UNIT, 9110)
      IF (ATM .EQ. 4) WRITE (UNIT, 9115)
      IF (ATM .EQ. 5) WRITE (UNIT,9120)

      GOTO 92
91     IF ((DATSET) .OR. ((.NOT.DATSET) .AND. (UNIT.EQ.2)))
      $   WRITE (UNIT, 7000)

C----- aerosol
92     WRITE (UNIT, 7200)
      IF (AER .EQ. 0) WRITE (UNIT, 9125)
      IF (AER .EQ. 1) WRITE (UNIT, 9130)

C----- column headings
      WRITE (UNIT, 9135)

C----- if j not negative, don't interpolate
95     IF (J .GE. 0) GOTO 140

      IF ((OUT .EQ. 2) .AND. (UNIT .EQ. 2)) GOTO 139
      J = ABS (J)
      HT1 = HT(J)
      HT2 = HT(J+1)
C----- call to LINTERP
      ABS1 = LINTERP (HT1,HT2,RABS(J),RABS(J+1),ALT )
      SCAT1 = LINTERP (HT1,HT2,SCAT(J),SCAT(J+1),ALT )
      ABS2 = LINTERP (HT1,HT2,AERABS(J),AERABS(J+1),ALT )
      SCAT2 = LINTERP (HT1,HT2,AERSCAT(J),AERSCAT(J+1),ALT )

C----- write interpolated coefficients
139    WRITE (UNIT, 9140)
      WRITE (UNIT,9145) ALT,ABS1,SCAT1,ABS2,SCAT2
      IF ((.NOT.DATSET) .AND. (OUT .EQ. 1)) WRITE (11,5100)
      J = -J
      GOTO 141

C----- write coefficients
140    WRITE (UNIT, 9146) HT(J),RABS(J), SCAT(J), AERABS(J), AERSCAT(J)
      IF ((.NOT.DATSET) .AND. (OUT .EQ. 1)) WRITE (11,5100)

C----- check output option - writing done?
141    IF ((OUT .EQ. 2) .AND. (UNIT .EQ. 11)) GOTO 82

      IF (DATSET) GOTO 1100

C----- another height?
      WRITE (11,5400)
143    WRITE (11,5200)
145    READ (11,4800,ERR=143) ANS
      ANSR = ERCHK (ANS )
      IF (ANSR) GOTO 145

```

```

C----- no
IF (ANS .EQ. 0) GOTO 154
C----- yes
ATM2 = .FALSE.
CALL INPT (DATSET,ATM2, ATM,ALT,AER)
GOTO 30
C----- another atm?
154 WRITE (11,5600)
155 WRITE (11,5200)
156 READ (11,4800,ERR=155) ANS
ANSR = ERCHK (ANS )
IF (ANSR) GOTO 156
C----- no
IF (ANS .EQ. 0) GOTO 1000
C----- yes
ATM2 = .TRUE.
GOTO 19
C----- start over? (from single entry mode)
1000 WRITE (11,5800)
1001 WRITE (11,5200)
1002 READ (11, 4800,ERR = 1001) ANS
ANSR = ERCHK (ANS )
IF (ANSR) GOTO 1002

C----- no
IF (ANS .EQ. 0) GOTO 1200
C----- yes
OLDATM = 0
ATM2 = .TRUE.
AERSL = -1
OUT = 10
RETURN

1100 RETURN
C----- start over? (from array entry mode)
1120 WRITE (11,6000)
1130 WRITE (11,5200)
1140 READ (11, 4800,ERR = 1130) ANS
ANSR = ERCHK (ANS )
IF (ANSR) GOTO 1140
C----- no
IF (ANS .EQ. 0) GOTO 1200
C----- yes
OLDATM = 0
ATM2 = .TRUE.
AERSL = -1
IF (OUT .EQ. -10) OUT = 0
IF (OUT .LT. 0) OUT = ABS(OUT )
OUT = 11
RETURN

C----- terminate
1200 RETURN

4600 FORMAT (F4.1)
4800 FORMAT (I1)
5000 FORMAT (/ "ERROR OPENING ATTENHT" )
5100 FORMAT (/ "COMPLETED" )
5200 FORMAT (/ "ENTER 0 OR 1" )
5400 FORMAT (/ "WOULD YOU LIKE ANOTHER HEIGHT? (0=NO, 1=YES)" )
5600 FORMAT (/ "WOULD YOU LIKE A DIFFERENT ATMOSPHERE? (0=NO, 1=YES)" )
5800 FORMAT (/ "WOULD YOU LIKE TO CONTINUE, BUT ENTER"/
$ "YOUR DATA INTO AN ARRAY? (0=NO, 1=YES)" )
6000 FORMAT (/ "WOULD YOU LIKE TO START OVER? (0=NO, 1=YES)" )
7000 FORMAT ( )
7100 FORMAT (/ "ATMOSPHERE:" ,Z)
7200 FORMAT ("AEROSOL:" ,Z)
9100 FORMAT ("TROPICAL")
9105 FORMAT ("MIDLATITUDE SUMMER")
9110 FORMAT ("MIDLATITUDE WINTER")
9115 FORMAT ("SUBARCTIC SUMMER")
9120 FORMAT ("SUBARCTIC WINTER")
9125 FORMAT ("CLEAR"/)
9130 FORMAT ("HAZY"/)
9135 FORMAT (4X,"HT(KM)",4X,"K+M(KM**-1)",4X,"S+M(KM**-1)",
$ 4X,"K+A(KM**-1)",4X,"S+A(KM**-1)",/)
9140 FORMAT ("***",Z)
9145 FORMAT (2X,F5.2,4(5X,1PE10.2))
9146 FORMAT (5X,F5.2,4(5X,1PE10.2))
END

```

SUBROUTINE BUILDVEC (DATSET,OUT,INTERP)

C----- When DATSET is true, BUILDVEC is called by ATTEN to
 C----- create the user-entered array. BUILDVEC calls INPT
 C----- and ATTEN. The maximum array size is 50.

C----- WARNING: If the user does not enter at least one value
 C----- the array, the program terminates immediately.

INTEGER ATMVEC(50), AERVEC(50)
 DIMENSION ALTVEC (50)
 INTEGER ATM, AER, VECSIZ, OUT
 REAL ALT
 LOGICAL ATM2,DATSET, INTERP

ATM2 = .FALSE.

C----- entry specifications
 WRITE (11,310)

C----- create array
 DO 100 K = 1, VECSIZ
 75 READ (11,312, ERR = 80) ATM
 IF (ATM.EQ.0) GOTO 110
 76 READ (11, 313, ERR=85) ALT
 77 READ (11, 312, ERR=90) AER

C----- call to INPT
 C----- Note that when INPT is called from BUILDVEC, all variables
 C----- in the parameter list are input variables.

CALL INPT (DATSET,ATM2,ATM,ALT,AER)
 ATMVEC(K) = ATM
 ALTVEC(K) = ALT
 AERVEC(K) = AER
 WRITE (11,315)
 GOTO 100
 80 WRITE (11,320)
 GOTO 75
 85 WRITE (11, 321)
 GOTO 76
 90 WRITE (11, 322)
 GOTO 77

100 CONTINUE
 GOTO 199

110 IF (K.EQ.1) GOTO 111
 VECSIZ = K - 1
 GOTO 199
 111 WRITE (11,400)
 STOP

C----- call to ATTEN
 199 DO 200 K = 1,VECSIZ
 CALL ATTEN (ATMVEC(K),ALTVEC(K),AERVEC(K),DATSET,INTERP, OUT)
 200 CONTINUE

IF (OUT.EQ.1) WRITE (11, 330)
 C----- prepare for termination
 IF (OUT .EQ. 0) GOTO 250
 IF (OUT .NE. 0) OUT = -OUT
 GOTO 300

250 OUT = -10
 300 CALL ATTEN (ATM,ALT,AER,DATSET,INTERP, OUT)
 RETURN

310 FORMAT (/"ATMOSPHERIC MODELS ARE:"/3X,"1 - TROPICAL"/3X,
 \$ "2 - MIDLATITUDE SUMMER"/3X,"3 - MIDLATITUDE WINTER"/3X,
 \$ "4 - SUBARCTIC SUMMER"/3X,"5 - SUBARCTIC WINTER"//
 \$ "ENTER: 1. # OF ATMOSPHERIC MODEL (1-5)"/7X,
 \$ "2. ALTITUDE IN km (0.0 - 85.0)"/11X,
 \$ "AN ALTITUDE OTHER THAN ZERO THAT IS A WHOLE NUMBER"/11X,
 \$ "MUST BE ENTERED WITH A DECIMAL, E.G. '12' WOULD BE"/11X,
 \$ "ENTERED AS '12.0'."/7X,
 \$ "3. AEROSOL TYPE - CLEAR (0) OR HAZY (1)"//
 \$ "ENTER EACH VALUE ON A SEPARATE LINE. AFTER THE THIRD"/
 \$ "VALUE IN EACH SET HAS BEEN ENTERED, WAIT FOR THE"/
 \$ "PROMPT, '\$', THEN CONTINUE."//
 \$ "WHEN YOU WISH TO STOP ENTERING VALUES, ENTER A ZERO"/
 \$ "AFTER YOU RECEIVE THE PROMPT.")

```

312   FORMAT (I1)
313   FORMAT (F5.2)
315   FORMAT ("$$")
320   FORMAT (/ "RE-ENTER ATMOSPHERE")
321   FORMAT ("RE-ENTER ALTITUDE")
322   FORMAT ("RE-ENTER AEROSOL")
330   FORMAT (/ "COMPLETED")
400   FORMAT ("ERROR: THERE MUST BE AT LEAST ONE SET OF VALID "/
$     "ENTRIES IN THIS ARRAY. PROGRAM TERMINATED")
      END

```

FUNCTION ERCHK (ANS)

```

C----- Checks for errors in user answers. In general,
C----- 0 = NO and 1 = YES.
C----- Note that on some systems inputting '+', '-', or '.' is
C----- identical to inputting a zero.

```

```

LOGICAL ERCHK
INTEGER ANS

```

```

IF ((ANS .NE. 0) .AND. (ANS .NE. 1)) GOTO 10
ERCHK = .FALSE.
RETURN

```

```

10   ERCHK = .TRUE.
      WRITE (11, 20)
      RETURN
20   FORMAT (/ "INCORRECT ENTRY. ENTER 0 OR 1")

      END

```

SUBROUTINE INPT (DATSET,ATM2, ATM,ALT,AER)

C----- INPT is called by BUILDVEC to check for user input error,
 C----- and by ATTEN to obtain the ATM, ALT, and AER from the user
 C----- when the program is in single entry mode.
 C----- Note that when INPT is called from within BUILDVEC, 'ATM,ALT,
 C----- AER' are input variables; when called from within ATTEN, these
 C----- variables are output variables.

LOGICAL ATM2,DATSET
 INTEGER ATM, AER
 REAL ALT

IF (DATSET) GOTO 15
 IF (.NOT. ATM2) GOTO 350

WRITE (11, 420)

C----- input atmospheric type

WRITE (11, 425)

14 READ (11, 410, ERR=20) ATM

15 IF ((ATM .NE. 1).AND.(ATM .NE. 2)
 \$.AND.(ATM .NE. 3).AND.(ATM .NE. 4)
 \$.AND.(ATM .NE. 5)) GOTO 20
 GOTO 30

20 WRITE (11, 430)
 GOTO 14

30 IF (DATSET) GOTO 352

C----- input altitude

350 WRITE (11, 435)

351 READ (11, 415, ERR = 355) ALT

352 IF ((ALT .GT. 85.0) .OR. (ALT .LT. 0.0)) GOTO 355
 IF (DATSET) GOTO 402
 GOTO 400

355 WRITE (11, 440)
 GOTO 351

C----- input aerosol

400 WRITE (11, 445)

401 READ (11, 410,ERR=400) AER

402 IF ((AER .NE. 0).AND.(AER .NE. 1)) GOTO 403

RETURN

403 WRITE (11, 450)
 GOTO 401

410 FORMAT (I1)

415 FORMAT (F5.2)

420 FORMAT (/"ATMOSPHERIC MODELS ARE:"/7X,"1 - TROPICAL"/7X,
 \$ "2 - MIDLATITUDE SUMMER"/7X,"3 - MIDLATITUDE WINTER"/7X,
 \$ "4 - SUBARCTIC SUMMER"/7X,"5 - SUBARCTIC WINTER"/7X,
 \$ "5 - SUBARCTIC WINTER"/7X,")

425 FORMAT (/"ENTER THE NUMBER OF THE ATMOSPHERE YOU WOULD LIKE")

430 FORMAT (/"RE-ENTER ATMOSPHERIC MODEL")

435 FORMAT (/"ENTER ALTITUDE IN km (0.0 - 85.0)"/7X,
 \$ "AN ALTITUDE OTHER THAN ZERO THAT IS A WHOLE NUMBER"/7X,
 \$ "MUST BE ENTERED WITH A DECIMAL, E.G. '12' WOULD BE"/7X,
 \$ "ENTERED AS '12.0'")

440 FORMAT (/"RE-ENTER ALTITUDE (0.0 TO 85.0)")

445 FORMAT (/"AEROSOL: CLEAR (0) OR HAZY (1)? ENTER 0 OR 1")

450 FORMAT (/"RE-ENTER AEROSOL: CLEAR (0) OR HAZY (1)?")

END

FUNCTION LINTERP (DAT1,DAT2,RES1,RES2,X)

C----- DAT and RES correspond to 'data' and 'result', and
C----- constitute an ordered pair. X is the known value for
C----- which a Y is needed. LINTERP determines Y by linear
C----- interpolation.

REAL DAT1,DAT2,RES1,RES2,X,LINTERP

Y = ((X - DAT1) * (RES2 - RES1)/(DAT2 - DAT1)) + RES1
LINTERP = Y

RETURN
END

FUNCTION NEAR (ALT,HT,DATSET,INTERP)

C----- NEAR searches for the value equal or closest to ALT
C----- in the array HT. HT is sorted in increasing order. In
C----- the case of an exact match, NEAR returns the index of
C----- the value in HT. If a match does not exist and
C----- the user has asked for interpolation, NEAR
C----- returns the negative index of the value in HT
C----- which is closest to ALT. If interpolation is not
C----- requested, the positive index is returned, and the
C----- program outputs the coefficients at that closest
C----- value. If ALT is the midpoint between 2 HT values,
C----- a negative index is returned, and the program interpolates.
C----- If the user is in single entry mode, NEAR offers a
C----- choice between interpolation or the coefficients at
C----- the closest value. If the user is entering data as
C----- an array, this choice is made earlier in the driver ATTENCOEF.

DIMENSION HT(33)
INTEGER ANS,NEAR
LOGICAL ANSR,ERCHK,INTERP, DATSET

C----- search for ALT in HT
DO 10 I = 1, 32
 IF ((HT(I) .LT. ALT) .AND. (HT(I+1) .GT. ALT)) GOTO 20
 IF (HT(I) .EQ. ALT) GOTO 36
10 CONTINUE

20 IF (INTERP) GOTO 50
 IF ((ALT - HT(I)) .LT. (HT(I+1) - ALT)) GOTO 30
 IF ((ALT - HT(I)) .EQ. (HT(I+1) - ALT)) GOTO 50
 IF ((ALT - HT(I)) .GT. (HT(I+1) - ALT)) GOTO 21

21 IF (DATSET) GOTO 26
 WRITE (11,45) HT(I+1)
24 WRITE (11, 70)
25 READ (11, 40, ERR = 24) ANS
 ANSR = ERCHK(ANS)
 IF (ANSR) GOTO 25
 IF (ANS .EQ. 0) GOTO 50
26 NEAR = I+1
 GOTO 60

30 IF (DATSET) GOTO 36
 WRITE (11, 45) HT(I)
31 WRITE (11, 70)
34 READ (11, 40,ERR=31) ANS
 ANSR = ERCHK(ANS)
 IF (ANSR) GOTO 34
 IF (ANS .EQ. 0) GOTO 50
36 NEAR = I
 GOTO 60

40 FORMAT (I1)
45 FORMAT ("THE CLOSEST HT IN KM IS ",F4.1)
50 NEAR = -I
60 RETURN
70 FORMAT ("DO YOU WANT AN INTERPOLATION (0) OR THE "/
\$ "COEFFICIENTS (1) AT THIS VALUE? ENTER 0 OR 1")
END

APPENDIX D: FORTRAN Code for Program Micro (and Related Subroutines): Ice and Water Refractive Indices
in the Microwave Region [APPENDIXD,219]

C#####

C----- Program MICRO

C-----

C----- Program MICRO gives the refractive indices for ice
C----- and water in the microwave region.

C----- The following list describes all non-standard FORTRAN
C----- characteristics in the Handbook programs. For easy access,
C----- their occurrences within the routines are marked by a "C"
C----- in column one, followed by a series of signs: '+'. Format
C----- statements in which non-standard format codes appear are
C----- listed in the comment section, 'Non-standard Format Codes'.

C----- General Suggestions for Improvement: Due to the need to
C----- standardize the programs, it was necessary to format inter-
C----- active input. This often presents awkward restrictions for
C----- the user. It is advised that, if available, free-formatted reads
C----- be implemented to handle numerical input. In addition, the
C----- use of one standard output filename for all program runs is
C----- impractical and potentially hazardous. Although the 'A'
C----- attribute will provide protection against overwriting on
C----- some systems, it is only meant as a temporary alternative.
C----- It is advisable that something such as string formatting
C----- be used to allow character input, in particular, for the
C----- interactive naming of output files.
C----- Additionally, individual users should implement precautions
C----- against careless user inputting, such as illegal characters. The
C----- program contains only minor precautions. The user should beware
C----- that some systems accept entry of a carriage return or a
C----- mathematical sign character (+,-) or decimal as if a zero had
C----- been entered.

C----- Non-standard FORTRAN options:

C-----

C----- STATIC: The STATIC option places all non-COMMON variables and
C----- arrays in a fixed area in memory, rather than on the run-time
C----- stack. It initializes all static variables to zero at load time,
C----- unless you data-initialize them. You may retrieve the values of
C----- static variables within a subprogram upon re-entry to the
C----- subprogram for the second and subsequent times.

C----- OPEN, CLOSE, and REWIND: Although the purpose of these
C----- input/output statements is obvious, their implementation
C----- may differ from system to system. The 'OPEN' statement used
C----- with the 'ATT=A' option specifies that appending is to be
C----- performed onto the file associated the the channel opened.
C----- This protects against overwriting the previous contents of the
C----- file, if any existed. REWIND repositions the record pointer to
C----- the beginning of the specified file.

C----- 'P' and 'Z' format code: The scale factor 'P' changes the
C----- location of the decimal point in the external representation
C----- of a real number, with respect to its internal value. The
C----- format is 'nP', where 'n' is an integer constant that specifies
C----- the number of positions you want to move the decimal point to
C----- the right. 'Z' format code suppresses the newline character
C----- on output of the current record. It is represented internally,
C----- and as it is used to build many of the Handbook output files,
C----- its presence should be considered if any of these files are
C----- edited.

C----- Non-Standard Format Codes (statement numbers): 90

C-----

```

C----- Special Input Format Procedures:
C-----
C----- When entering wavelength data, use exponential notation
C----- of the form "digit'E'exponent", where
C-----   : 'digit' is any number. The number must include
C-----   a decimal and must occupy 4 spaces;
C-----   : 'E' is the letter 'E';
C-----   : 'exponent' is a signed or unsigned integer constant.
C-----   'exp' must occupy 2 spaces.
C----- EXAMPLES:      NUMBER          YOU ENTER
C-----                -----          -
C-----                2E6             2.00E06
C-----                2E-6            2.00E-6
C-----                275E-8           275.E-8, 2.75E-6, etc.

C----- User Options
C-----
C----- - desired temperatures entered singly or as an array
C----- - print output to screen and/or diskfile

C----- Output - output diskfile named "MICOUT"; should be renamed after each run
C-----

C----- File unit #s
C-----
C----- 1: data file (h2o or ice)
C----- 2: diskfile
C----- 11: terminal

C----- Data Files used:
C-----
C----- RFICEMN50,RFICEMN30,RFICEMN10,RFICEM0,RFH2OMN8,RFH2OM0,
C----- RFH2OM10,RFH2OM18,RFH2OM20,RFH2OM30,RFH2OM40,RFH2OM50,
C----- RFH2OM60,RFH2OM75

C----- Subroutines
C-----
C----- DAT: reads indices data into arrays
C----- H2OPEN: opens h2o data file
C----- H2OTEMP: checks temperature validity
C----- HEADER: prints informational header
C----- ICEOPEN: opens ice data file
C----- ICETEMP: checks temperature validity
C----- INTERP: uses linear interpolation to build
C----- output arrays
C----- INTVEC: builds a user-entered integer array
C----- KEY: prints variable key
C----- LINTERP: two-point linear interpolation
C----- RD: transfers a data array to output
C----- READANS: checks user answers for error
C----- RFPRI: prints output arrays
C----- SUBHDR: prints substance and temperature
C----- TEMPCHK: checks temperature array for errors
C----- VECTOR: builds user-entered real array

C----- Arrays
C-----
C----- Input
C----- DATIMAG: imaginary index data
C----- DATREAL: real index data
C----- DATVEC: wavelength data
C----- MICFIL: character array; used to transfer
C----- data arrays to output
C----- TEM: temperature

C----- Output
C----- IMAG: imaginary indices (in general, interpolated)
C----- LAM: wavelength
C----- RFREAL: real indices (in general, interpolated)

C----- Variables
C-----
C----- Logical
C----- CHK: used in checking temperature validity
C----- DATSET: indicates whether temps. are being
C----- entered singly or as an array
C----- H2O,ICE: indicate current substance
C----- OPEN2: indicates whether unit 2 is open

```

```

C----- Integer
C-----   ANS: user answer
C-----   DATSIZ: length of current data array
C-----   MICOUT: output filename
C-----   LAMLEN: length of user wavelength array
C-----   OUT: indicates print option
C-----   TEMP: temperature
C-----   TEMPLEN: length of temperature array

```

```

C      Suchi Psarakos
C      N.O.A.A.
C      325 Broadway
C      R/E/WP2
C      Boulder, Colorado 80303

```

```

C      Please direct questions to Dr. Vernon Derr, (303) 497-6002,
C      or Suchi Psarakos, (303) 497-5361.

```

```

C#####

```

```

          LOGICAL OPEN2,H2O,ICE,DATSET,CHK,H2OTEMP,ICETEMP
          DIMENSION MICFIL(29),DATVEC(23),
$          DATREAL(23),DATIMAG(23),RFREAL(50)
          INTEGER ANS,OUT,TEMPLEN,TEMP,LAMLEN,DATSIZ,TEM(50),MICOUT
          REAL LAM(50),IMAG(50)

```

```

C----- initialize
          CALL HEADER (0 )
          WRITE (11, 98)
          OPEN2=.FALSE.

```

```

C----- print option
          WRITE (11,90)
          WRITE (11,91)

```

```

5          READ (11,95,ERR=8) ANS
          IF ((ANS.NE.0).AND.(ANS.NE.1).AND.(ANS.NE.2)) GOTO 8
          OUT = ANS
          IF ((OUT.EQ.1).OR.(OUT.EQ.2).AND.(.NOT.OPEN2)) GOTO 6
          GOTO 9

```

```

C----- name for output file?

```

```

C+++++
6          OPEN 2, "MICOUT", ATT="A"

```

```

C+++++
          OPEN2 = .TRUE.
          IF ((OUT.EQ.1).OR.(OUT.EQ.2)) CALL HEADER (1)
          GOTO 9

```

```

C----- incorrect entry
8          WRITE (11,94)
          WRITE (11,91)
          GOTO 5

```

```

C----- substance?

```

```

9          WRITE (11,100)
          WRITE (11,125)
          CALL READANS (ANS )
          IF (ANS.EQ.0) GOTO 20

```

```

C----- ice
          ICE = .TRUE.
          H2O = .FALSE.
          GOTO 30

```

```

C----- h2o
20         H2O=.TRUE.
          ICE=.FALSE.

```

```

C----- entry mode?

```

```

30         WRITE (11,225)
          WRITE (11,125)
          CALL READANS (ANS )
          IF (ANS.EQ.0) GOTO 40

```

```

C----- data set

```

```

          DATSET=.TRUE.
          WRITE (11, 150)
          IF (H2O) WRITE (11, 175)
          IF (ICE) WRITE (11, 200)
          WRITE (11,1000)
          CALL INTVEC (H2O, TEMPLEN, TEM)
          IF (TEMPLEN.LT.0) GOTO 89
          CALL TEMPCHK (TEM,TEMPLEN,ICE )

```

```

C----- begin DO
      DO 72 I=1,TEMPLEN
          TEMP=TEM(I)
          GOTO 47

C----- single entry mode
40      DATSET=.FALSE.
C----- enter temperature
41      WRITE (11,150)
          IF (ICE) GOTO 43
          WRITE (11, 175)
          WRITE (11, 1000)
42      READ (11, 96, ERR=46) TEMP
          CHK=H2OTEMP(TEMP )
          GOTO 45
43      WRITE (11, 200)
          WRITE (11, 1000)
44      READ (11, 97, ERR=46) TEMP
          CHK=ICETEMP(TEMP )
45      IF (.NOT.CHK) GOTO 46
          GOTO 47
46      WRITE (11,1001)
          IF (H2O) GOTO 42
          GOTO 44

47      IF (ICE) CALL ICEOPEN (TEMP )
          IF (H2O) CALL H2OPEN (TEMP )
          CALL SUBHDR (-OUT,TEMP,ICE )
          CALL KEY (0 )
          CALL RD (11, MICFIL)

C----- save values?
      IF (OUT.EQ.0) GOTO 50
      WRITE (11,1100)
      WRITE (11,125)
      CALL READANS (ANS )
      IF (ANS.EQ.0) GOTO 50
      CALL SUBHDR (1,TEMP,ICE )
      CALL KEY (1 )
      CALL RD (2, MICFIL)
      WRITE (2,999)

C----- interpolation?
50      WRITE (11,1200)
          WRITE (11,125)
          CALL READANS (ANS )
          IF (ANS.EQ.1) GOTO 68
C+++++
      CLOSE 1
C+++++
          IF (DATSET) GOTO 70
          GOTO 69

C----- yes; create wavelength array,prepare data
C----- array,interpolate
68      IF (ANS.EQ.1) WRITE (11,1300)
          CALL VECTOR ( LAMLEN, LAM)
          IF (LAMLEN.LT.0) GOTO 89
          CALL DAT ( DATVEC,DATREAL,DATIMAG,DATSIZ)
          CALL INTERP (LAM,LAMLEN,DATVEC,DATREAL,DATIMAG,
      $      DATSIZ, RFREAL,IMAG)
          CALL SUBHDR (OUT,TEMP,ICE )
          CALL KEY (OUT )
          CALL RFPRT (LAM,LAMLEN,RFREAL,IMAG,OUT )
          IF (OUT.EQ.1) WRITE (11,250)
          IF (DATSET) GOTO 70

C----- another temp?
69      WRITE (11,1400)
          WRITE (11,125)
          CALL READANS (ANS )
          IF (ANS.EQ.0) GOTO 74
          GOTO 41
C----- end DO
70      WRITE (11,999)
72      CONTINUE

```

```

C----- different substance?
74  WRITE (11,1500)
    WRITE (11,125)
    CALL READANS (ANS )
    IF (ANS.EQ.0) GOTO 89
    GOTO 9

89  IF ((OUT.EQ.1).OR.(OUT.EQ.2)) WRITE (11,1600)
    STOP

90  FORMAT (/"PRINT OPTION:"/3X,"0: RESULTS TO SCREEN ONLY"
    $      /3X,"1: RESULTS TO DISKFILE"/3X,"2: RESULTS TO BOTH",Z,
    $      " SCREEN AND DISKFILE"/)
91  FORMAT ("ENTER 0, 1, OR 2")
94  FORMAT ("INCORRECT ENTRY")
95  FORMAT (I1)
96  FORMAT (I2)
97  FORMAT (I3)
98  FORMAT ("USE EXPONENTIAL NOTATION OF THE FORM 'digit'E'exponent'"/
    $      "WHERE"/7X,
    $      ": 'digit' IS ANY NUMBER. THE NUMBER MUST INCLUDE"/10X,
    $      "A DECIMAL AND MUST OCCUPY 4 SPACES"/7X,
    $      ": 'E' IS THE LETTER 'E'"/7X,
    $      ": 'exponent' IS A SIGNED OR UNSIGNED INTEGER CONSTANT."/10X,
    $      "'exp' MUST OCCUPY 2 SPACES."//
    $      "EXAMPLES:      NUMBER      YOU ENTER"/
    $      "      -----      -----"/
    $      "      2E6          2.00E06"/
    $      "      2E-6         2.00E-6"/
    $      "      275E-8       275.E-8, 2.75E-6"/)
100  FORMAT (/"REFRACTIVE INDICES FOR WATER (0) OR ICE (1)?")
125  FORMAT ("ENTER 0 OR 1")
150  FORMAT (/"AVAILABLE TEMPERATURES (degrees C):"/)
175  FORMAT ("8"/"0"/"10"/"18"/"20"/"30"/"40"/"50"/"60"/
    $      "75"/)
200  FORMAT ("50"/"30"/"10"/"0"/)
225  FORMAT (/"WILL YOU BE ENTERING TEMPERATURES SINGLY (0)"/
    $      "OR INTO AN ARRAY (1)?")
250  FORMAT ("COMPLETED")
999  FORMAT ()
1000  FORMAT (/"ENTER TEMPERATURE (C):")
1001  FORMAT ("RE-ENTER TEMPERATURE")
1100  FORMAT (/"DO YOU WANT THIS FILE SENT TO DISK? (0=NO, 1=YES)")
1200  FORMAT (/"DO YOU WANT ANY INTERPOLATIONS? (0=NO, 1=YES)")
1300  FORMAT (/"ENTER WAVELENGTH (meters):")
1400  FORMAT (/"WOULD YOU LIKE ANOTHER TEMPERATURE? (0=NO,1=YES)")
1500  FORMAT (/"WOULD YOU LIKE A DIFFERENT SUBSTANCE? (0=NO,1=YES)")
1600  FORMAT (/"CHECK 'MICOUT' FOR OUTPUT. REMEMBER TO RENAME THIS FILE.")
    END

```

```
SUBROUTINE DAT ( DATVEC,DATREAL,DATIMAG,DATSIZ)
```

```
C----- Reads values from data file into arrays
```

```
C----- Non-standard Format Code (statement number): 23
```

```
C----- Parameter list
```

```
C----- output - real
```

```
C----- DATIMAG,DATREAL,DATVEC: imaginary,real, and
```

```
C----- wavelength data arrays
```

```
C----- output - integer
```

```
C----- DATSIZ: data array length
```

```
    DIMENSION DATVEC(23),DATREAL(23),DATIMAG(23)
```

```
    INTEGER DATSIZ
```

```
    DO 10 I=1,23
```

```
        READ (1,23,ERR=21,END=20) DATVEC(I),DATREAL(I),
```

```
        $    DATIMAG(I)
```

```
        DATSIZ = DATSIZ+1
```

```
10    CONTINUE
```

```
C+++++
```

```
20    CLOSE 1
```

```
C+++++
```

```
    DATSIZ=I-1
```

```
    RETURN
```

```
21    WRITE (11,22)
```

```
22    FORMAT ("ERR READING DATFILE")
```

```
23    FORMAT (5X,3(2X,1PE13.6))
```

```
    STOP
```

```
    END
```

SUBROUTINE H2OPEN (TEMP)

C----- opens h2o data file

INTEGER TEMP

C+++++

```

IF (TEMP.EQ. - 8) OPEN 1,"RFH2OMN",ERR=1000
IF (TEMP.EQ.  0) OPEN 1,"RFH2OM0",ERR=1500
IF (TEMP.EQ. 10) OPEN 1,"RFH2OM10",ERR=2000
IF (TEMP.EQ. 18) OPEN 1,"RFH2OM18",ERR=2500
IF (TEMP.EQ. 20) OPEN 1,"RFH2OM20",ERR=3000
IF (TEMP.EQ. 30) OPEN 1,"RFH2OM30",ERR=3500
IF (TEMP.EQ. 40) OPEN 1,"RFH2OM40",ERR=4000
IF (TEMP.EQ. 50) OPEN 1,"RFH2OM50",ERR=4500
IF (TEMP.EQ. 60) OPEN 1,"RFH2OM60",ERR=5000
IF (TEMP.EQ. 75) OPEN 1,"RFH2OM75",ERR=5500

```

C+++++

RETURN

```

1000  WRITE (11,1001)
      STOP
1500  WRITE (11,1501)
      STOP
2000  WRITE (11,2001)
      STOP
2500  WRITE (11,2501)
      STOP
3000  WRITE (11,3001)
      STOP
3500  WRITE (11,3501)
      STOP
4000  WRITE (11,4001)
      STOP
4500  WRITE (11,4501)
      STOP
5000  WRITE (11,5001)
      STOP
5500  WRITE (11,5501)
      STOP

```

```

1001  FORMAT ("ERR OPENING RFH2OMN8")
1501  FORMAT ("ERR OPENING RFH2OM0")
2001  FORMAT ("ERR OPENING RFH2OM10")
2501  FORMAT ("ERR OPENING RFH2OM18")
3001  FORMAT ("ERR OPENING RFH2OM20")
3501  FORMAT ("ERR OPENING RFH2OM30")
4001  FORMAT ("ERR OPENING RFH2OM40")
4501  FORMAT ("ERR OPENING RFH2OM50")
5001  FORMAT ("ERR OPENING RFH2OM60")
5501  FORMAT ("ERR OPENING RFH2OM75")
      END

```

FUNCTION H2OTEMP (T)

C----- Checks a user-requested h2o temperature for validity

```

LOGICAL H2OTEMP
INTEGER T

H2OTEMP=.TRUE.
IF ( (T.NE.-8).AND.(T.NE.0).AND.(T.NE.10).AND.
$ (T.NE.18).AND.(T.NE.20).AND.(T.NE.30).AND.
$ (T.NE.40).AND.(T.NE.50).AND.(T.NE.60).AND.
$ (T.NE.75)) H2OTEMP=.FALSE.
RETURN
END

```

SUBROUTINE HEADER (OUT)

C----- Prints informational header

C----- Parameter list
C----- input - integer
C----- OUT: print entry option

INTEGER OUT,UNIT

```

IF (OUT.EQ.0) UNIT=11
IF (OUT.EQ.1) UNIT=2
WRITE (UNIT,100)
WRITE (UNIT,200)
WRITE (UNIT,300)
WRITE (UNIT,400)
WRITE (UNIT,500)

```

RETURN

```

100  FORMAT ("REFRACTIVE INDICES: MICROWAVE"// "SOURCES:"/
$     "1:RYDE,D. AND J.W. RYDE"// "2:LANE,J.A. AND",
$     " J.A. SAXTON"// "4:COLLIE, C.H., J.B. HASTED, AND",
$     " D.M. RITSON"// "5:DEIRMENDJIAN, D."/)
200  FORMAT ("-ALPHANUMERIC COLUMNS SHOW SOURCE (REAL)"/3X,"AND",
$     " SOURCE (IMAGINARY)")
300  FORMAT ("-NUMBERS ALONE REFER TO SOURCE AND"/
$     3X,"INDICATE EXPERIMENTAL VALUES"// "-A' REFERS TO VALUES",
$     " CALCULATED WITH THE DEBYE FORMULA")
400  FORMAT ("-***' CORRESPONDS TO INTERPOLATED VALUES")
500  FORMAT ("-N=REAL, K=IMAGINARY"//)
END

```

SUBROUTINE ICEOPEN (TEMP)

C----- opens ice data file

INTEGER TEMP

C+++++

IF (TEMP.EQ. -50) OPEN 1, "RFICEMN50",ERR=1000
IF (TEMP.EQ. -30) OPEN 1, "RFICEMN30",ERR=2000
IF (TEMP.EQ. -10) OPEN 1, "RFICEMN10",ERR=3000
IF (TEMP.EQ. 0) OPEN 1, "RFICEM0",ERR=4000

C+++++

RETURN

1000 WRITE (11,1001)

STOP

2000 WRITE (11,2001)

STOP

3000 WRITE (11,3001)

STOP

4000 WRITE (11,4001)

STOP

1001 FORMAT ("ERR OPENING RFICEMN50")

2001 FORMAT ("ERR OPENING RFICEMN30")

3001 FORMAT ("ERR OPENING RFICEMN10")

4001 FORMAT ("ERR OPENING RFICEM0")

END

FUNCTION ICETEMP (T)

C----- Checks user-requested ice temperatures for validity

LOGICAL ICETEMP

INTEGER T

ICETEMP=.TRUE.

IF ((T.NE.-50).AND.(T.NE.-30).AND.(T.NE.-10)

\$.AND.(T.NE.0)) ICETEMP=.FALSE.

RETURN

END

```

SUBROUTINE INTERP (VEC,VECSIZ,DATVEC,DATREAL,
$   DATIMAG,DATSIZ, RFREAL,IMAG)

```

```

C----- Matches appropriate two neighboring values in the
C----- available data wavelength array,DATVEC, to the requested
C----- wavelengths in VEC. Calls function INTERP. In the case
C----- of a user-request which outlies the endpoint values
C----- in DATVEC, the routine substitutes the indices of the
C----- appropriate endpoint. The DATVEC array is increasing.

```

```

C----- Note: Some data arrays have multiple indices for
C----- a given wavelength (due to more than one source).
C----- The arrays have been arranged such that either the
C----- most recent source or the experimental (rather
C----- than predicted) values come first.

```

```

C----- Parameter list
C-----   input - real
C-----   DATIMAG, DATREAL, DATVEC: imaginary,real,
C-----   wavelength data arrays
C-----   VEC: user-entered wavelength array
C-----   input - integer
C-----   VECSIZ, DATSIZ: length of VEC and DATVEC
C-----   output - real
C-----   IMAG, RFREAL: output imaginary and real arrays

```

```

DIMENSION VEC(VECSIZ), DATVEC(DATSIZ),DATREAL(DATSIZ),
$   DATIMAG(DATSIZ), RFREAL(VECSIZ)
REAL IMAG(VECSIZ),LINTERP
INTEGER VECSIZ, DATSIZ

```

```

DO 100 I=1,VECSIZ
  DO 15 J=1,(DATSIZ-1)

```

```

C----- user wavelength out of range
      IF (DATVEC(J).EQ.VEC(I)) GOTO 25
      IF ((DATVEC(1).GT.VEC(I)).OR.
$       DATVEC(DATSIZ).LT.VEC(I)) GOTO 30
      IF ((DATVEC(J).LT.VEC(I)).AND.
$       (DATVEC(J+1).GT.VEC(I))) GOTO 20

```

```

15    CONTINUE
C----- call to INTERP
20    RFREAL(I)=LINTERP(DATVEC(J),DATVEC(J+1),DATREAL(J),
$     DATREAL(J+1),VEC(I))
      IMAG(I)=LINTERP(DATVEC(J),DATVEC(J+1),DATIMAG(J),
$     DATIMAG(J+1),VEC(I))

```

```

C----- mark interpolated values for future id.
      VEC(I) = -VEC(I)
      GOTO 100

```

```

25    RFREAL(I)=DATREAL(J)
      IMAG(I)=DATIMAG(J)
      GOTO 100

```

```

30    IF ((J.NE.1).AND.(DATVEC(DATSIZ).EQ.DATVEC(DATSIZ-1))) GOTO 40

```

```

C----- substitute endpoint indices for user request
      IF (DATVEC(DATSIZ).LT.VEC(I)) J=DATSIZ
32    VEC(I)=DATVEC(J)
      RFREAL(I)=DATREAL(J)
      IMAG(I)=DATIMAG(J)
      GOTO 100

```

```

C----- multiple values for a given wavelength; position
C----- 'J' at most reliable source

```

```

40    J=DATSIZ-1
41    IF (DATVEC(J).EQ.DATVEC(J-1)) GOTO 42
      GOTO 32
42    J=J-1
      GOTO 41

```

```

100   CONTINUE

```

```

      RETURN
      END

```

SUBROUTINE INTVEC (H2O, LEN, VEC)

C----- Creates a user-entered integer array; max. length
 C----- = 50. Input session is terminated upon entry of a
 C----- '99'.
 C----- Note: The program stops if there is not at least one
 C----- value entered into the array.

C----- Non-standard Format Code (statement number): 1100, 1200

C----- Parameter list
 C----- Input - logical
 C----- H2O: specifies which substance is being used
 C----- Input/Output - integer
 C----- LEN: length of the array
 C----- Output - integer
 C----- VEC: integer array

INTEGER VEC(50)
 INTEGER LEN
 LOGICAL H2O

C----- entry procedure
 WRITE (11,1000)

C----- build vector
 DO 15 I=1,50

WRITE (11,1200)
 10 IF (H2O) READ (11, 900, ERR=11) VEC(I)
 IF (.NOT.H2O) READ (11, 920, ERR=11) VEC(I)
 IF ((VEC(I).EQ.99).OR.(VEC(I).EQ.990)) GOTO 20
 GOTO 15
 11 WRITE (11,1100)
 GOTO 10

15 CONTINUE
 GOTO 21

C----- check array length for error; return
 20 IF (I.EQ.1) GOTO 22

LEN = I-1
 RETURN

21 LEN=I
 RETURN

22 WRITE (11,1300)
 LEN=-1
 RETURN

900 FORMAT (I2)

920 FORMAT (I3)

1000 FORMAT ("ENTER EACH VALUE IN CORRECT UNIT, WAIT FOR"/
 \$ "PROMPT ':', THEN CONTINUE. TYPE '99' WHEN FINISHED."/)

1100 FORMAT ("INCORRECT ENTRY. PLEASE RE-ENTER"/":",Z)

1200 FORMAT (":",Z)

1300 FORMAT ("ERROR: YOU MUST HAVE AT LEAST ONE VALUE"/
 \$ "IN THIS ARRAY. PROGRAM TERMINATED.")

END

SUBROUTINE KEY (OUT)

C----- Prints a variable key for output

C----- Parameter list

C----- input - integer

C----- OUT: print entry option

INTEGER UNIT,OUT

IF ((OUT.EQ.0).OR.(OUT.EQ.2)) GOTO 10

GOTO 15

10 UNIT =11

GOTO 20

15 UNIT = 2

20 WRITE (UNIT,100)

IF ((OUT.EQ.2).AND.(UNIT.EQ.11)) GOTO 15

RETURN

100 FORMAT (11X,"LAM (m)",14X,"N",14X,"K",3X,"S(N)",

§ 3X,"S(K)"/)

END

FUNCTION LINTERP (DAT1,DAT2,RES1,RES2,X)

C----- 2 point linear interpolation

C----- DAT and RES correspond to 'data' and 'result',; and

C----- constitute an ordered pair. X is the known value for

C----- which a Y is needed. LINTERP determines Y by linear

C----- interpolation.

REAL DAT1,DAT2,RES1,RES2,X,LINTERP,Y

Y = ((X - DAT1) * (RES2 - RES1)/(DAT2 - DAT1)) + RES1

LINTERP = Y

RETURN

END

SUBROUTINE RD (UNIT, MICFIL)

C----- Transfers a data array to output
C----- Non-standard Format Code (statement number): 5000
C Note that the use of 'A' format code is system dependent.
C Depending on the system, it will have to be modified
C according to the form 'xAy', where 'x' is a repetition
C count, and 'y' represents the number of characters you
C want read in per computer word (note that the characters
C will be left-justified, and padded with blanks).

C----- Parameter list
C----- input - integer
C----- UNIT: the device to which the data file
C----- will be written
C----- output
C----- MICFIL: array used to transfer one
C----- of the data arrays to output, line by line

DIMENSION MICFIL (29)
INTEGER UNIT

10 READ (1,5000,END=20) (MICFIL(I), I=1,29)
WRITE (UNIT,5000) (MICFIL(I), I=2,29)
GOTO 10

C+++++
20 REWIND 1
C+++++
RETURN

5000 FORMAT (6X,29A2)
END

SUBROUTINE READANS (ANS)

```

C----- checks user answers for error

      INTEGER ANS

      GOTO 10
5      WRITE (11,100)
10     READ (11,110,ERR=5) ANS
      IF ((ANS.NE.0).AND.(ANS.NE.1)) GOTO 5

      RETURN
100    FORMAT ("INCORRECT ENTRY. ENTER 0 OR 1")
110    FORMAT (I1)
      END
  
```

SUBROUTINE RFPRINT (LAM,LEN,RFREAL,IMAG,OUT)

```

C----- Prints wavelength, real, and imaginary arrays
C----- to output. Interpolated values have been marked as
C----- negative in the wavelength array.

C----- Non-standard Format Code (statement number): 100, 200, 300

C----- Parameter list
C-----   input - real
C-----   IMAG,LAM,RFREAL: imaginary, wavelength, and real
C-----   arrays
C-----   input - integer
C-----   LEN: length of output arrays
C-----   OUT: indicates print option
  
```

```

      REAL LAM(LEN),RFREAL(LEN),IMAG(LEN)
      INTEGER LEN,OUT,UNIT

      DO 10 I=1,LEN
        IF ((OUT.EQ.0).OR.(OUT.EQ.2)) GOTO 5
        GOTO 6
5       UNIT=11
        GOTO 7
6       UNIT=2
        IF (LAM(I).GE.0) GOTO 8
        WRITE (UNIT,100)
        LAM(I)=ABS(LAM(I))
        WRITE (UNIT,300) LAM(I),RFREAL(I),IMAG(I)
        IF ((OUT.EQ.2).AND.(UNIT.EQ.11)) LAM(I)=-LAM(I)
        GOTO 9
8       WRITE (UNIT,200) LAM(I),RFREAL(I),IMAG(I)
9       IF ((OUT.EQ.2).AND.(UNIT.EQ.11)) GOTO 6
10      CONTINUE

      RETURN

100    FORMAT ("**",Z)
200    FORMAT (3X,3(2X,1PE13.6),2(3X,"-----"))
300    FORMAT (1X,3(2X,1PE13.6),2(3X,"-----"))
      END
  
```

SUBROUTINE SUBHDR (OUT,TEMP,ICE)

C----- Prints current substance and temperature to output
 C----- Non-standard Format Code (statement number): 100, 200
 C----- Parameter list
 C----- input - logical
 C----- ICE: indicates current substance
 C----- input - integer
 C----- OUT: indicates print option
 C----- TEMP: temperature

LOGICAL ICE
 INTEGER OUT,TEMP

```

      IF (OUT.LT.0) GOTO 10
      IF ((OUT.EQ.0).OR.(OUT.EQ.2)) GOTO 10
      GOTO 20
10     UNIT = 11
      GOTO 40
20     UNIT=2
      IF (ICE) GOTO 90

      WRITE (UNIT,100)
      IF (TEMP.EQ.-8) WRITE (UNIT,300)
      IF (TEMP.EQ. 0) WRITE (UNIT,400)
      IF (TEMP.EQ. 10) WRITE (UNIT,500)
      IF (TEMP.EQ. 18) WRITE (UNIT,550)
      IF (TEMP.EQ. 20) WRITE (UNIT,600)
      IF (TEMP.EQ. 30) WRITE (UNIT,700)
      IF (TEMP.EQ. 40) WRITE (UNIT,800)
      IF (TEMP.EQ. 50) WRITE (UNIT,900)
      IF (TEMP.EQ. 60) WRITE (UNIT,1000)
      IF (TEMP.EQ. 75) WRITE (UNIT,1100)
      GOTO 91

90     WRITE (UNIT,200)
      IF (TEMP.EQ.-50) WRITE (UNIT,1200)
      IF (TEMP.EQ.-30) WRITE (UNIT,1300)
      IF (TEMP.EQ.-10) WRITE (UNIT,1400)
      IF (TEMP.EQ.0) WRITE (UNIT,400)

91     IF ((OUT.EQ.2).AND.(UNIT.EQ.11)) GOTO 20

      RETURN

100    FORMAT (/"SUBSTANCE: H2O",3X,"TEMP: ",Z)
200    FORMAT (/"SUBSTANCE: ICE",3X,"TEMP: ",Z)
300    FORMAT ("-8"/)
400    FORMAT ("0"/)
500    FORMAT ("10"/)
550    FORMAT ("18"/)
600    FORMAT ("20"/)
700    FORMAT ("30"/)
800    FORMAT ("40"/)
900    FORMAT ("50"/)
1000   FORMAT ("60"/)
1100   FORMAT ("75"/)
1200   FORMAT ("-50"/)
1300   FORMAT ("-30"/)
1400   FORMAT ("-10"/)

```

END

SUBROUTINE TEMPCHK (TEMP,TEMPLEN,ICE)

C----- Checks user-entered temperature array for validity.

C----- Calls H2OTEMP or ICETEMP.

C----- Non-standard Format Code (statement label): 110

C----- Parameter list

C----- input - logical

C----- ICE: indicates current substance

C----- input - integer

C----- TEMP: temperature array

C----- TEMPLEN: length of TEMP array

LOGICAL ICE,CHK,H2OTEMP,ICETEMP,MESS
 INTEGER TEMP(TEMPLEN),T,TEMPLEN,NEWT

MESS=.FALSE.

DO 20 I=1,TEMPLEN

T=TEMP(I)

C----- check for valid temperature

IF (.NOT.ICE) CHK=H2OTEMP(T)

IF (ICE) CHK=ICETEMP(T)

C----- invalid

IF (.NOT.CHK) GOTO 10

GOTO 20

C----- re-enter correction

10 IF (.NOT.MESS) WRITE (11,100)

MESS=.TRUE.

11 WRITE (11,110) T

12 IF (.NOT.ICE) READ (11,130,ERR=15) NEWT

IF (ICE) READ (11,135,ERR=15) NEWT

IF ((.NOT.ICE).AND.(NEWT.EQ.99)).OR.

\$ ((ICE).AND.(NEWT.EQ.99))

\$ GOTO 14

C----- check correction

IF (.NOT.ICE) CHK=H2OTEMP(NEWT)

IF (ICE) CHK=ICETEMP(NEWT)

C----- invalid

IF (.NOT.CHK) GOTO 15

TEMP(I)=NEWT

GOTO 20

C----- reprint available temperatures

14 WRITE (11,150)

IF (.NOT.ICE) WRITE (11,175)

IF (ICE) WRITE (11,200)

GOTO 11

15 WRITE (11,120)

GOTO 12

20 CONTINUE

RETURN

100 FORMAT (/"INVALID ENTRIES:"/"NOTE: IF YOU NEED TO SEE THE"/

\$ "LISTING OF AVAILABLE TEMPERATURES, TYPE '99' INSTEAD"/

\$ "OF THE CORRECTED VALUE"/)

110 FORMAT (I3,2X,"CORRECTION: ",Z)

120 FORMAT ("RE-ENTER")

130 FORMAT (I2)

135 FORMAT (I3)

150 FORMAT ("AVAILABLE TEMPERATURES (degrees C):"/)

175 FORMAT (" -8"/"0"/"10"/"18"/"20"/"30"/"40"/"50"/"60"/

\$ "75"/)

200 FORMAT (" -50"/" -30"/" -10"/"0"/)

END

SUBROUTINE VECTOR (LEN, VEC)

C----- Creates a user-entered array of exponents; max. length = 50.
 C----- Input session is terminated upon entry of '-1'.
 C----- Note: the program stops if there is not at least one
 C----- value entered into the array.
 C----- Non-standard Format Code (statement label): 1100, 1200
 C----- Parameter list
 C----- input/output - integer
 C----- LEN: length of array
 C----- output - real
 C----- VEC: real array

```

    DIMENSION VEC(50)
    INTEGER LEN

C----- entry procedure
    WRITE (11, 950)
    WRITE (11,1000)
C----- build vector
    DO 15 I=1,50
        WRITE (11,1200)
10      READ (11, 900, ERR= 11) VEC(I)
        IF (VEC(I).LT.0) GOTO 20
        GOTO 15
11      WRITE (11,1100)
        GOTO 10
15      CONTINUE
        GOTO 21
C----- check array length for error; return
20      IF (I.EQ.1) GOTO 22
        LEN = I-1
        RETURN
21      LEN=I
        RETURN
22      WRITE (11,1300)
        LEN=-1
        RETURN

900    FORMAT (E7.2)
950    FORMAT ("USE EXPONENTIAL NOTATION OF THE FORM 'digit'E'exponent'"/
  $      "WHERE THE ENTIRE EXPRESSION OCCUPIES 7 SPACES"/)
1000   $  FORMAT ("ENTER EACH VALUE IN CORRECT UNIT, WAIT FOR"/
  $      "PROMPT ':', THEN CONTINUE. TYPE '-1' WHEN FINISHED."/)
1100   $  FORMAT ("INCORRECT ENTRY. PLEASE RE-ENTER"/":",Z)
1200   $  FORMAT (":",Z)
1300   $  FORMAT ("ERROR: YOU MUST HAVE AT LEAST ONE VALUE"/
  $      "THIS ARRAY. PROGRAM TERMINATED")
    END
  
```

UAG SERIES OF REPORTS

Fewer than four UAG Reports are published at irregular intervals each year. Copies of these publications may be purchased through the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2) 325 Broadway, Boulder, Colorado 80303, USA. A \$4.00 handling charge per order will be added to single-copy price, if any, listed below. Please note, too, that some reports are available on microfiche only. Orders must include check or money order payable in U.S. currency to Commerce, NOAA/NGDC.

- UAG- 1 IQSY NIGHT AIRGLOW DATA, by L.L. Smith, F.E. Roach, and J.M. McKennan, ESSA Aeronomy Laboratory Boulder, CO, July 1968, 305 pp, \$1.75.
- UAG- 2 A REEVALUATION OF SOLAR FLARES, 1964-1966, by Helen W. Dodson and E. Ruth Hedeman, McMath-Hulbert Observatory, University of Michigan, Pontiac, MI, August 1968, 28 pp.
- UAG- 3 OBSERVATIONS OF JUPITER'S SPORADIC RADIO EMISSION IN THE RANGE 7.6-41 MHZ, 6 JULY 1966 THROUGH 8 SEPTEMBER 1968, by James W. Warwick and George A. Dulk, University of Colorado, Boulder, CO, October 1968, 35 pp.
- UAG- 4 ABBREVIATED CALENDAR RECORD 1966-1967, by J. Virginia Lincoln, Hope I. Leighton and Dorothy K. Kropp, ESSA now NOAA, Aeronomy and Space Data Center, Boulder, CO, January 1969, 170 pp, \$1.25.
- UAG- 5 DATA ON SOLAR EVENT OF MAY 23, 1967, AND ITS GEOPHYSICAL EFFECTS, compiled by J. Virginia Lincoln, World Data Center A, Upper Atmosphere Geophysics, ESSA now NOAA, Boulder, CO, February 1969, 120 pp.
- UAG- 6 INTERNATIONAL GEOPHYSICAL CALENDARS 1957-1969, by A.H. Shapley and J. Virginia Lincoln, ESSA Research Laboratories, now NOAA, Boulder, CO, March 1969, 25 pp.
- UAG- 7 OBSERVATIONS OF THE SOLAR ELECTRON CORONA: FEBRUARY 1964 - JANUARY 1968, by Richard T. Hansen, High Altitude Observatory, NCAR, Boulder, CO, and Kamuela, HI, October 1969, 12 pp.
- UAG- 8 DATA ON SOLAR-GEOPHYSICAL ACTIVITY OCTOBER 24 - NOVEMBER 6, 1968, Parts 1 and 2, compiled by J. Virginia Lincoln, World Data Center A, Upper Atmosphere Geophysics, ESSA now NOAA, Boulder, CO, March 1970, 312 pp, \$1.75 (includes Parts 1 and 2).
- UAG- 9 DATA ON COSMIC RAY EVENT OF NOVEMBER 18, 1968, AND ASSOCIATED PHENOMENA, compiled by J. Virginia Lincoln, World Data Center A, Upper Atmosphere Geophysics, ESSA now NOAA, Boulder, CO, April 1970, 109 pp.
- UAG-10 ATLAS OF IONOGRAMS, edited by A.H. Shapley, ESSA Research Laboratories now NOAA, Boulder, CO, May 1970, 243 pp, \$1.50.
- UAG-12 SOLAR-GEOPHYSICAL ACTIVITY ASSOCIATED WITH THE MAJOR GEOMAGNETIC STORM OF MARCH 8, 1970, Parts 1, 2 and 3, compiled by J. Virginia Lincoln and Dale B. Bucknam, World Data Center A, Upper Atmosphere Geophysics, ESSA now NOAA, Boulder, CO, April 1971, 466 pp, \$3.00 (includes Parts 1-3).
- UAG-13 DATA ON THE SOLAR PROTON EVENT OF NOVEMBER 2, 1969, THROUGH THE GEOMAGNETIC STORM OF NOVEMBER 8-10, 1969, compiled by Dale B. Bucknam and J. Virginia Lincoln, World Data Center A, Upper Atmosphere Geophysics, ESSA now NOAA, Boulder, CO, May 1971, 76 pp.
- UAG-14 AN EXPERIMENTAL, COMPREHENSIVE FLARE INDEX AND ITS DERIVATION FOR 'MAJOR' FLARES, 1955-1969, by Helen W. Dodson and E. Ruth Hedeman, McMath-Hulbert Observatory, University of Michigan, Pontiac, MI, July 1971, 25 pp.
- UAG-16 TEMPORAL DEVELOPMENT OF THE GEOPHYSICAL DISTRIBUTION OF AURORAL ABSORPTION FOR 30 SUBSTORM EVENTS IN EACH OF IQSY (1964-65) AND IASY (1960), by F.T. Berkey, University of Alaska, Fairbanks, AK; V.M. Driatskiy, Arctic and Antarctic Research Institute, Leningrad, USSR; K. Henriksen, Auroral Observatory, Tromso, Norway; D.H. Jelly, Communications Research Center, Ottawa, Canada; T.I. Shchuka, Arctic and Antarctic Research Institute, Leningrad, USSR; A. Theander, Kiruna Geophysical Observatory, Kiruna, Sweden; and J. Yliniemi, University of Oulu, Oulu, Finland, September 1971, 131 pp, \$1.50 (microfiche only).
- UAG-17 IONOSPHERIC DRIFT VELOCITY MEASUREMENTS AT JICAMARCA, PERU (JULY 1967 - MARCH 1970), by Ben B. Balsley, NOAA Aeronomy Laboratory, Boulder, CO, and Ronald F. Woodman, Jicamarca Radar Observatory, Instituto Geofisico del Peru, Lima, Peru, October 1971, 45 pp, \$1.50 (microfiche only).
- UAG-18 A STUDY OF POLAR CAP AND AURORAL ZONE MAGNETIC VARIATIONS, by K. Kawasaki and S.-I. Akasofu, University of Alaska, Fairbanks, AK, June 1972, 21 pp.
- UAG-19 REEVALUATION OF SOLAR FLARES 1967, by Helen W. Dodson and E. Ruth Hedeman, McMath-Hulbert Observatory, University of Michigan, Pontiac, MI, and Marta Rovira de Miceli, San Miguel Observatory, Argentina, June 1972, 15 pp.

UAG SERIES OF REPORTS (Continued)

- UAG-21 PRELIMINARY COMPILATION OF DATA FOR RETROSPECTIVE WORLD INTERVAL JULY 26 - AUGUST 14, 1972, by J. Virginia Lincoln and Hope I. Leighton, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, November 1972, 128 pp.
- UAG-22 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES (AE) FOR 1970, by Joe Haskell Allen, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, November 1972, 146 pp.
- UAG-23 U.R.S.I. HANDBOOK OF IONOGRAM INTERPRETATION AND REDUCTION, Second Edition, November 1972, edited by W.R. Piggott, Radio and Space Research Station, Slough, UK, and K. Rawer, Arbeitsgruppe fur Physikalische Weltraumforschung, Freiburg, GFR, November 1972, 324 pp, \$1.75.
- UAG-23A U.R.S.I. HANDBOOK OF IONOGRAM INTERPRETATION AND REDUCTION, Second Edition, Revision of Chapters 1-4, edited by W.R. Piggott, Radio and Space Research Station, Slough, UK, and K. Rawer, Arbeitsgruppe fur Physikalische Weltraumforschung, Freiburg, GFR, November 1972, 135 pp, \$2.14.
- UAG-24 DATA ON SOLAR-GEOPHYSICAL ACTIVITY ASSOCIATED WITH THE MAJOR GROUND LEVEL COSMIC RAY EVENTS OF 24 JANUARY AND 1 SEPTEMBER 1971, Parts 1 and 2, compiled by Helen E. Coffey and J. Virginia Lincoln, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, December 1972, 462 pp, \$2.00 (includes Parts 1 and 2).
- UAG-25 OBSERVATIONS OF JUPITER'S SPORADIC RADIO EMISSION IN THE RANGE 7.6-41 MHZ, 9 SEPTEMBER 1968 THROUGH 9 DECEMBER 1971, by James W. Warwick, George A. Dulk and David G. Swann, University of Colorado, Boulder, CO, February 1973, 35 pp.
- UAG-26 DATA COMPILATION FOR THE MAGNETOSPHERICALLY QUIET PERIODS FEBRUARY 19-23 AND NOVEMBER 29 - DECEMBER 3, 1970, compiled by Helen E. Coffey and J. Virginia Lincoln, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, May 1973, 129 pp.
- UAG-27 HIGH SPEED STREAMS IN THE SOLAR WIND, by D.S. Intriligator, University of Southern California, Los Angeles, CA, June 1973, 16 pp.
- UAG-28 COLLECTED DATA REPORTS ON AUGUST 1972 SOLAR-TERRESTRIAL EVENTS, Parts 1, 2 and 3, edited by Helen E. Coffey, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, July 1973, 932 pp, \$4.50.
- UAG-29 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1968, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, October 1973, 148 pp.
- UAG-30 CATALOGUE OF DATA ON SOLAR-TERRESTRIAL PHYSICS, prepared by NOAA Environmental Data Service, Boulder, CO, October 1973, 317 pp, \$1.75. Supersedes catalogs UAG-11, 15 and 20.
- UAG-31 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1969, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, February 1974, 142 pp.
- UAG-32 SYNOPTIC RADIO MAPS OF THE SUN AT 3.3 MM FOR THE YEARS 1967-1969, by Earle B. Mayfield, Kennon P. White III, and Fred I. Shimabukuro, Aerospace Corp., El Segundo, CA, April 1974, 26 pp.
- UAG-33 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(10) FOR 1967, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, May 1974, 142 pp.
- UAG-34 ABSORPTION DATA FOR THE IGY/IGC AND IQSY, compiled and edited by A.H. Shapley, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO; W.R. Piggott, Appleton Laboratory, Slough, UK; and K. Rawer, Arbeitsgruppe fur Physikalische Weltraumforschung, Freiburg, GFR, June 1974, 381 pp, \$2.00.
- UAG-36 AN ATLAS OF EXTREME ULTRAVIOLET FLASHES OF SOLAR FLARES OBSERVED VIA SUDDEN FREQUENCY DEVIATIONS DURING THE ATM-SKYLAB MISSIONS, by R.F. Donnelly and E.L. Berger, NOAA Space Environment Laboratory; Lt. J.D. Busman, NOAA Commissioned Corps; B. Henson, NASA Marshall Space Flight Center; T.B. Jones, University of Leicester, UK; G.M. Lerfald, NOAA Wave Propagation Laboratory; K. Najita, University of Hawaii; W.M. Retallack, NOAA Space Environment Laboratory and W.J. Wagner, Sacramento Peak Observatory, October 1974, 95 pp.
- UAG-37 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(10) FOR 1966, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, December 1974, 142 pp.
- UAG-38 MASTER STATION LIST FOR SOLAR-TERRESTRIAL PHYSICS DATA AT WDC-A FOR SOLAR-TERRESTRIAL PHYSICS, by R.W. Buhmann, World Data Center A for Solar-Terrestrial Physics, Boulder, CO; Juan D. Roederer, University of Denver, Denver, CO; and M.A. Shea and D.F. Smart, Air Force Cambridge Research Laboratories, Hanscom AFB, MA, December 1974, 110 pp, \$1.60.

UAG SERIES OF REPORTS (Continued)

- UAG-39 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1971, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, February 1975, 144 pp, \$2.05.
- UAG-40 H-ALPHA SYNOPTIC CHARTS OF SOLAR ACTIVITY FOR THE PERIOD OF SKYLAB OBSERVATIONS, MAY 1973 - MARCH 1974, by Patrick S. McIntosh, NOAA Space Environment Laboratory, Boulder, CO, February 1975, 32 pp.
- UAG-41 H-ALPHA SYNOPTIC CHARTS OF SOLAR ACTIVITY DURING THE FIRST YEAR OF SOLAR CYCLE 20 OCTOBER 1964 - AUGUST 1965, by Patrick S. McIntosh, NOAA Space Environment Laboratory, Boulder, CO, and Jerome T. Nolte, American Science and Engineering, Inc., Cambridge, MA, March 1975, 25 pp.
- UAG-42 OBSERVATIONS OF JUPITER'S SPORADIC RADIO EMISSION IN THE RANGE 7.6-80 MHZ, 10 DECEMBER 1971 THROUGH 21 MARCH 1975, by James W. Warwick, George A. Dulk and Anthony C. Riddle, University of Colorado, Boulder, CO, April 1975, 49 pp.
- UAG-43 CATALOG OF OBSERVATION TIMES OF GROUND-BASED SKYLAB-COORDINATED SOLAR OBSERVING PROGRAMS, compiled by Helen E. Coffey, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, May 1975, 159 pp, \$3.00.
- UAG-44 SYNOPTIC MAPS OF SOLAR 9.1 CM MICROWAVE EMISSION FROM JUNE 1962 TO AUGUST 1973, by Werner Graf and Ronald N. Bracewell, Stanford University, Stanford, CA, May 1975, 183 pp, \$2.55.
- UAG-45 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1972, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, May 1975, 144 pp, \$1.50 (microfiche only).
- UAG-46 INTERPLANETARY MAGNETIC FIELD DATA 1963-1964, by Joseph H. King, National Space Science Data Center, NASA Goddard Space Flight Center, Greenbelt, MD, June 1975, 382 pp, \$1.95.
- UAG-47 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1973, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, June 1975, 144 pp, \$1.50 (microfiche only).
- UAG-48A SYNOPTIC OBSERVATIONS OF THE SOLAR CORONA DURING CARRINGTON ROTATIONS 1580-1596 (11 OCTOBER 1971 - 15 JANUARY 1973), [Re-issue of UAG-48 with quality images], by R.A. Howard, M.J. Koomen, D.J. Michels, R. Tousey, C.R. Detwiler, D.E. Roberts, R.T. Seal, and J.D. Whitney, U.S. Naval Research Laboratory, Washington, DC; and R.T. Hansen and S.F. Hansen, C.J. Garcia and E. Yasukawa, High Altitude Observatory, NCAR, Boulder, CO, February 1976, 200 pp, \$4.27. Supersedes UAG-48.
- UAG-50 HIGH-LATITUDE SUPPLEMENT TO THE URSI HANDBOOK ON IONOGRAM INTERPRETATION AND REDUCTION, edited by W.R. Piggott, British Antarctic Survey, c/o Appleton Laboratory, Slough, UK, October 1975, 294 pp, \$4.00.
- UAG-51 SYNOPTIC MAPS OF SOLAR CORONAL HOLE BOUNDARIES DERIVED FROM HE II 304A SPECTROHELIOGRAMS FROM THE MANNED SKYLAB MISSIONS, by J.D. Bohlin and D.M. Rübstein, U.S. Naval Research Laboratory, Washington, DC, November 1975, 30 pp.
- UAG-52 EXPERIMENTAL COMPREHENSIVE SOLAR FLARE INDICES FOR CERTAIN FLARES, 1970-1974, by Helen W. Dodson and E. Ruth Hedeman, McMath-Hulbert Observatory, University of Michigan, Pontiac, MI, November 1975, 27 pp.
- UAG-53 DESCRIPTION AND CATALOG OF IONOSPHERIC F-REGION DATA, JICAMARCA RADIO OBSERVATORY (NOVEMBER 1966 - APRIL 1969), by W.L. Clark and T.E. Van Zandt, NOAA Aeronomy Laboratory, Boulder, CO, and J.P. McClure, University of Texas at Dallas, Dallas, TX, April 1976, 10 pp.
- UAG-55 EQUIVALENT IONOSPHERIC CURRENT REPRESENTATIONS BY A NEW METHOD, ILLUSTRATED FOR 8-9 NOVEMBER 1969 MAGNETIC DISTURBANCES, by Y. Kamide, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO; H.W. Kroehl, Data Studies Division, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO; M. Kanamitsu, Advanced Study Program, National Center for Atmospheric Research, Boulder, CO; Joe Haskell Allen, Data Studies Division, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO; and S.-I. Akasofu, Geophysical Institute, University of Alaska, Fairbanks, AK, April 1976, 91 pp, \$1.50 (microfiche only).
- UAG-56 ISO-INTENSITY CONTOURS OF GROUND MAGNETIC H PERTURBATIONS FOR THE DECEMBER 16-18, 1971, GEOMAGNETIC STORM, Y. Kamide, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, April 1976, 37 pp, \$1.39.
- UAG-57 MANUAL ON IONOSPHERIC ABSORPTION MEASUREMENTS, edited by K. Rawer, Institut für Physikalische Weltraumforschung, Freiburg, GFR, June 1976, 302 pp, \$4.27.

UAG SERIES OF REPORTS (Continued)

- UAG-58 AT56 RADIO BEACON ELECTRON CONTENT MEASUREMENTS AT BOULDER, JULY 1974 - MAY 1975, by R.B. Fritz, NOAA Space Environment Laboratory, Boulder, CO, September 1976, 61 pp.
- UAG-59 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11) FOR 1974, by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, December 1976, 144 pp, \$2.16.
- UAG-60 GEOMAGNETIC DATA FOR JANUARY 1976 [AE(7) INDICES AND STACKED MAGNETOGRAMS], by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, July 1977, 57 pp.
- UAG-61 COLLECTED DATA REPORTS FOR STIP INTERVAL II 20 MARCH - 5 MAY 1976, edited by Helen E. Coffey and John A. McKinnon, World Data Center A for Solar-Terrestrial Physics, Boulder, CO, August 1977, 313 pp, \$2.95.
- UAG-62 GEOMAGNETIC DATA FOR FEBRUARY 1976 [AE(7) INDICES AND STACKED MAGNETOGRAMS], by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, September 1977, 55 pp.
- UAG-63 GEOMAGNETIC DATA FOR MARCH 1976 [AE(7) INDICES AND STACKED MAGNETOGRAMS], by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, September 1977, 57 pp.
- UAG-64 GEOMAGNETIC DATA FOR APRIL 1976 [AE(8) INDICES AND STACKED MAGNETOGRAMS], by Joe Haskell Allen, Carl C. Abston and Leslie D. Morris, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO, February 1978, 55 pp.
- UAG-65 THE INFORMATION EXPLOSION AND ITS CONSEQUENCES FOR DATA ACQUISITION, DOCUMENTATION, PROCESSING, by G.K. Hartmann, Max-Planck-Institut fur Aeronomie, Lindau, GFR, May 1978, 36 pp.
- UAG-66 SYNOPTIC RADIO MAPS OF THE SUN AT 3.3 MM 1970-1973, by Earle B. Mayfield and Fred I. Shimabukuro, Aerospace Corp., El Segundo, CA, May 1978, 30 pp.
- UAG-67 IONOSPHERIC D-REGION PROFILE DATA BASE, A COLLECTION OF COMPUTER-ACCESSIBLE EXPERIMENTAL PROFILES OF THE D AND LOWER E REGIONS, by L.F. McNamara, Ionospheric Prediction Service, Sydney, Australia, August 1978, 30 pp, \$1.50 (microfiche only).
- UAG-68 A COMPARATIVE STUDY OF METHODS OF ELECTRON DENSITY PROFILE ANALYSIS, by L.F. McNamara, Ionospheric Prediction Service, Sydney, Australia, August 1978, 30 pp, \$1.50 (microfiche only).
- UAG-69 SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES. THEIR RELATION TO THE UNDISTURBED D REGION, by L.F. McNamara, Ionospheric Prediction Service, Sydney, Australia, October 1978, 50 pp, \$1.50 (microfiche only).
- UAG-70 ANNOTATED ATLAS OF H-ALPHA SYNOPTIC CHARTS FOR SOLAR CYCLE 20 (1964-1974) CARRINGTON SOLAR ROTATIONS 1487-1616, by Patrick S. McIntosh, NOAA Space Environment Laboratory, Boulder, CO, February 1979, 327 pp, \$3.50.
- UAG-71 MAGNETIC POTENTIAL PLOTS OVER THE NORTHERN HEMISPHERE FOR 26-28 MARCH 1976, A.D. Richmond, NOAA Space Environment Laboratory, Boulder, CO; H.W. Kroehl, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO; M.A. Henning, Lockheed Missiles and Space Co., Aurora, CO; and Y. Kamide, Kyoto Sangyo University, Kyoto, Japan, April 1979, 118 pp, \$1.50.
- UAG-72 ENERGY RELEASE IN SOLAR FLARES, PROCEEDINGS OF THE WORKSHOP ON ENERGY RELEASE IN FLARES, 26 FEBRUARY - 1 MARCH 1979, CAMBRIDGE, MASSACHUSETTS, U.S.A., edited by David M. Rust, American Science and Engineering, Inc., Cambridge, MA; and A. Gordon Emslie, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, July 1979, 68 pp, \$1.50 (microfiche only).
- UAG-73 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(11-12) FOR JANUARY - JUNE 1975, by Joe Haskell Allen, Carl C. Abston, J.E. Salazar and J.A. McKinnon, National Geophysical and Solar-Terrestrial Data Center, NOAA, Boulder, CO, August 1979, 114 pp, \$1.75 (microfiche only).
- UAG-74 AT5-6 RADIO BEACON ELECTRON CONTENT MEASUREMENTS AT OOTACAMUND, INDIA, OCTOBER - JULY 1976, by S.D. Bouwer, K. Davies, R.F. Donnelly, R.N. Grubb, J.E. Jones and J.H. Taylor, NOAA Space Environment Laboratory, Boulder, CO; and R.G. Rastogi, M.R. Deshpande, H. Chandra and G. Sethia, Physical Research Laboratory, Ahmedabad, India, March 1980, 58 pp, \$2.50.
- UAG-75 THE ALASKA IMS MERIDIAN CHAIN: MAGNETIC VARIATIONS FOR 9 MARCH - 27 APRIL 1978, by H.W. Kroehl and G.P. Kosinski, National Geophysical and Solar-Terrestrial Data Center, Boulder, CO; S.-I. Akasofu, G.J. Romick, C.E. Campbell and G.K. Corrick, University of Alaska, Fairbanks, AK; and C.E. Hornback and A.M. Gray, NOAA Space Environment Laboratory, Boulder, CO, June 1980, 107 pp, \$3.00.

UAG SERIES OF REPORTS (Continued)

- UAG-76 AURORAL ELECTROJET MAGNETIC ACTIVITY INDICES AE(12) FOR JULY - DECEMBER 1975, by Joe Haskell Allen, Carl C. Abston, J.E. Salazar and J.A. McKinnon, National Geophysical and Solar-Terrestrial Data Center, NOAA, Boulder, CO, August 1980, 116 pp, \$2.50.
- UAG-77 SYNOPTIC SOLAR MAGNETIC FIELD MAPS FOR THE INTERVAL INCLUDING CARRINGTON ROTATIONS 1601-1680, MAY 5, 1973 - APRIL 26, 1979, by J. Harvey, B. Gillespie, P. Miedaner and C. Slaughter, Kitt Peak National Observatory, Tucson, AZ, August 1980, 66 pp, \$2.50.
- UAG-78 THE EQUATORIAL LATITUDE OF AURORAL ACTIVITY DURING 1972-1977, by N.R. Sheeley, Jr. and R.A. Howard, E.O. Hulbert Center for Space Research, U.S. Naval Research Laboratory, Washington, DC and B.S. Dandekar, Air Force Geophysics Laboratory, Hanscom AFB, MA, October 1980, 61 pp, \$3.00.
- UAG-79 SOLAR OBSERVATIONS DURING SKYLAB, APRIL 1973 - FEBRUARY 1974, I. CORONAL X-RAY STRUCTURE, II. SOLAR FLARE ACTIVITY, by J.M. Hanson, University of Michigan, Ann Arbor, MI; and E.C. Roelof and R.E. Gold, The Johns Hopkins University, Laurel, MD, December 1980, 43 pp, \$2.50.
- UAG-80 EXPERIMENTAL COMPREHENSIVE SOLAR FLARE INDICES FOR 'MAJOR' AND CERTAIN LESSER FLARES, 1975-1979, compiled by Helen W. Dodson and E. Ruth Hedeman, The Johns Hopkins University, Laurel, MD, July 1981, 33 pp, \$2.00.
- UAG-81 EVOLUTIONARY CHARTS OF SOLAR ACTIVITY (CALCIUM PLAGES) AS FUNCTIONS OF HELIOGRAPHIC LONGITUDE AND TIME, 1964-1979, by E. Ruth Hedeman, Helen W. Dodson and Edmond C. Roelof, The Johns Hopkins University, Laurel, MD, August 1981, 103 pp, \$4.00.
- UAG-82 INTERNATIONAL REFERENCE IONOSPHERE - IRI 79, edited by J. Virginia Lincoln and Raymond O. Conkright, National Geophysical and Solar-Terrestrial Data Center, NOAA, Boulder, CO, November 1981, 243 pp, \$4.50.
- UAG-83 SOLAR-GEOPHYSICAL ACTIVITY REPORTS FOR SEPTEMBER 7-24, 1977 AND NOVEMBER 22, 1977, Parts 1 and 2, compiled by John A. McKinnon and J. Virginia Lincoln, World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, CO, February 1982, 553 pp, \$10.00.
- UAG-84 CATALOG OF AURORAL RADIO ABSORPTION DURING 1976-1979 AT ABISKO, SWEDEN, by J.K. Hargreaves, C.M. Taylor and J.M. Penman, Environmental Sciences Department, University of Lancaster, Lancaster, UK, July 1982, 69 pp, \$3.00.
- UAG-85 CATALOG OF IONOSPHERE VERTICAL SOUNDINGS DATA, edited by Raymond O. Conkright and H. Irene Brophy, National Geophysical Data Center, NOAA, Boulder, CO, July 1982, 107 pp, \$3.50. Supersedes UAG-54.
- UAG-86 INTERNATIONAL CATALOG OF GEOMAGNETIC DATA, compiled by J.H. Allen and C.C. Abston, National Geophysical Data Center, NOAA, Boulder, CO; E.P. Kharin and N.E. Papitashvili, Academy of Sciences of the USSR, World Data Center B2, Moscow, USSR; and V.O. Papitashvili, IZMIRAN, Moscow Region, USSR, November 1982, 191 pp, \$4.00. Supersedes UAG-35 and 49.
- UAG-87 CHANGES IN THE GLOBAL ELECTRIC FIELDS AND CURRENTS FOR MARCH 17-19, 1978, FROM SIX IMS MERIDIAN CHAINS OF MAGNETOMETERS, by Y. Kamide, Kyoto Sangyo University, Kyoto, Japan; H.W. Kroehl, National Geophysical Data Center, NOAA, Boulder, CO; and A.D. Richmond, NOAA Space Environment Laboratory, Boulder, CO, November 1982, 102 pp, \$3.50.
- UAG-88 NUMERICAL MODELING OF IONOSPHERIC PARAMETERS FROM GLOBAL IMS MAGNETOMETER DATA FOR THE CDAW-6 INTERVALS, by Y. Kamide, Kyoto Sangyo University, Kyoto, Japan; H.W. Kroehl, National Geophysical Data Center, NOAA, Boulder, CO; and B.A. Hausman, National Geophysical Data Center, NOAA, Boulder, CO, November 1983, 197 pp, \$4.00.
- UAG-89 ATMOSPHERIC HANDBOOK: ATMOSPHERIC DATA TABLES AVAILABLE ON COMPUTER TAPE, by V.E. Derr, NOAA Environmental Research Laboratories, Boulder, CO, July 1984, 56 pp.
- UAG-90 EXPERIENCE WITH PROPOSED IMPROVEMENTS OF THE INTERNATIONAL REFERENCE IONOSPHERE (IRI): CONTRIBUTED PAPERS, MAINLY FROM THE URSI-COSPAR WORKSHOP HELD IN BUDAPEST IN 1980, edited by K. Rawer, University of Freiburg, Federal Republic of Germany, and C.M. Minnis, former Secretary General of URSI, Brussels, Belgium, May 1984, 233 pp, \$6.00.