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SAM II and SAGE Data Management and Processing

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PREFACE

This report describes the data management and processing supplied by ST Systems Corporation (STX) for the SAM II and SAGE experiments under contract No. NAS1-17165 for the years 1983-1986. The report includes discussions of data validation, documentation, and scientific analysis, as well as the archival schedule met by the operational reduction of SAM II and SAGE data. The following STX employees have contributed to this contract: D. Brandl, J. C. Larsen, M. T. Osborn, M. W. Rowland, T. J. Swissler, and C. R. Trepte.

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SECTION 1 - SAM II

1.1 Introduction

ST Systems Corporation (STX) supplied software support under contract NAS1-17165 for Stratospheric Aerosol Measurement (SAM) II data management, reduction, validation, display and analysis.

The SAM II sensor is flying aboard the Earth-orbiting Nimbus 7 spacecraft and is designed to provide extinction measurements of the Antarctic and Arctic stratospheric aerosol with a vertical resolution of 1 km. The SAM II instrument consists of a single-channel sunphotometer centered at a wavelength of 1.0 μm. Data is collected during each spacecraft sunrise or sunset (approximately 14 each per day). SAM II began collecting data in October, 1978 and continues to provide excellent data after more than 8 years of operation.

A large quantity of SAM II satellite data was processed under this contract, resulting in the archival of the first seven years of SAM II data. Quality control checks revealed that the large aerosol concentrations following the April 1982 eruption of El Chichon produced errors in the processed data for the fifth year only. Algorithms were modified and the fifth year data was reprocessed. Similar checks on the fourth and other years verified the quality of these data.

Software was developed to process SAM II "quick-look" data so that SAM II data could be available within 24 hours to direct real-time scientific investigations. An extensive validation program was carried out using the Langley airborne lidar system. The first four years of SAM II data have been summarized in a series of NASA Reference Publications, covering 6 months each. Data analysis has resulted in several important studies dealing with polar stratospheric clouds, the polar vortex, the long term optical depth record in the polar regions and the effects of El Chichon.

The following section of this report is an overview of the role of ST Systems Corporation (STX) in the successful reduction and validation of the first seven years of SAM II data. In addition a list of publications and presentations supported under this contract has been included in section III.

1.2 Data Management and Processing

1.2.1 General Discussion

Goddard Space Flight Center (GSFC) combines SAM II telemetry data, spacecraft time corrections, orbital ephemeris data and solar location information on an Image Location Tape (ILT) which is sent to NASA Langley Research Center (LaRC) for science processing. A tape containing meteorological data (MET) for each event is also received from the National Oceanic and Atmospheric Administration (NOAA).

Figure 1 presents an overview of the SAM II data processing at LaRC. Data is processed by ILT, i.e. a week at a time. Weekly files of merged meteorological, ephemeris and radiance data for each event are created and saved on tape. Transmission profiles are calculated and inverted to yield profiles of aerosol extinction. Weekly files which include these profiles of aerosol extinction are also saved on tape.

SAM II processing yields two tape products which are sent to GSFC for eventual archival at the National Space Science Data Center (NSSDC). Both of these tapes contain a month of data and are created by combining and reformatting the weekly files generated during initial processing. Brief descriptions of these tapes are as follows:

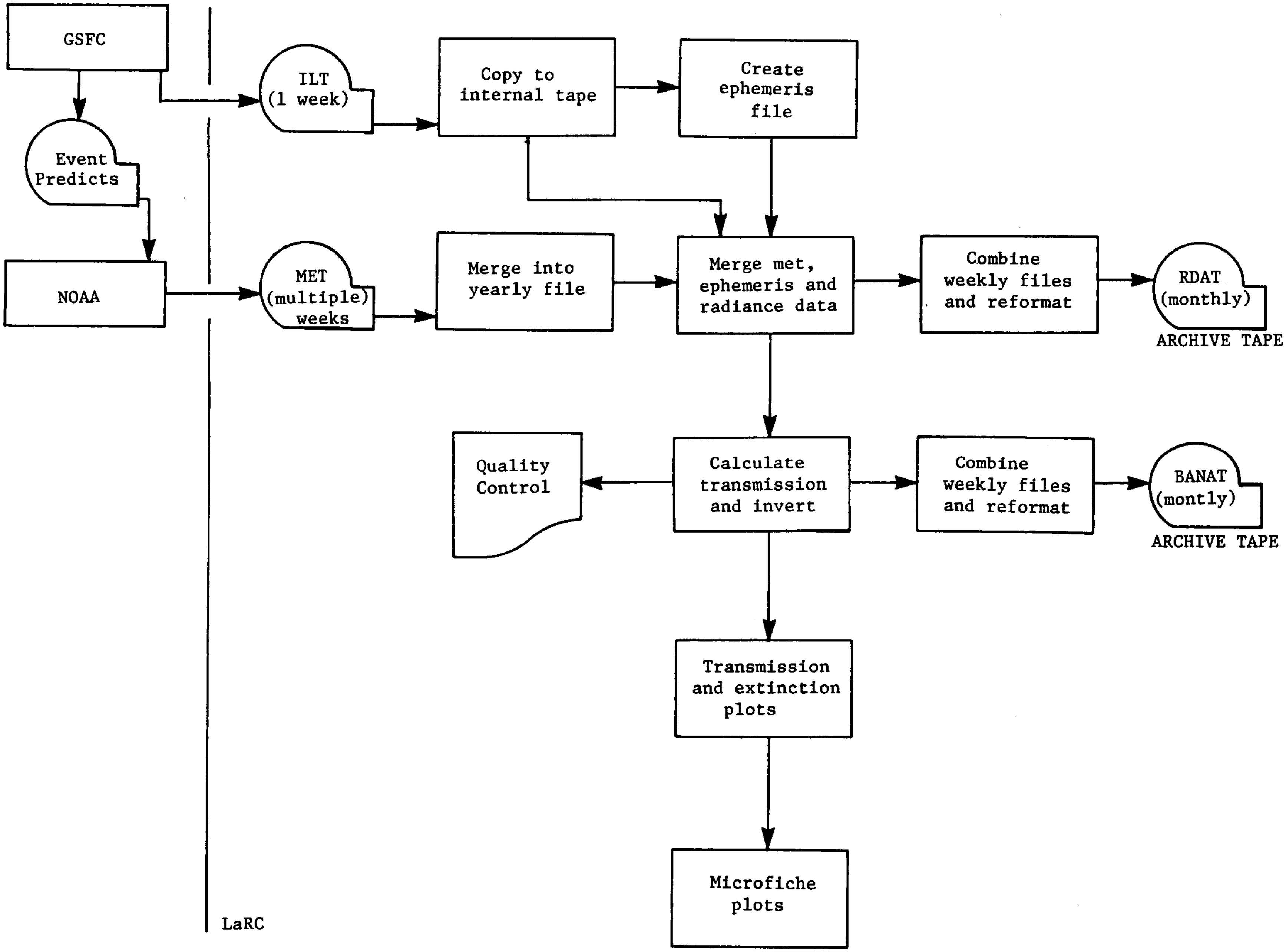


Figure 1. Flow chart of SAM II data processing.

- RDAT (Raw Data Archive Tape)

  This tape contains radiance data from each SAM II sunrise or sunset event as a function of time and tangent viewing location.

- BANAT (Beta-aerosol Number Density Archive Tape)

  This tape contains the derived aerosol extinction coefficients, atmospheric molecular extinction coefficients, and total extinction ratios as a function of altitude for each SAM II event. In addition, it also contained aerosol number density profiles and the optical models used to generate number densities from extinction coefficients for the first four years. Volcanic concentrations in year five invalidated these optical models. On advice from the SAM II Science Team the aerosol number density profiles and optical models have been deleted from year five.

Each of these tapes is described in a tape specification document supplied by NSSDC when tapes are distributed.

Two additional tape products were generated during processing of the first four years of SAM II data. MATRIX, Mapped Data Matrix Tape, contained the projected map matrices of derived SAM II parameters for plots of stereographic polar maps and cross sections of latitude (longitude) vs altitude. These tapes contained 3 months of data. PROFILE, SAM II Output Product Profiles Tape, contained the profiles of derived SAM II products and was generated monthly. Both tapes were utilized for display product processing by the Image Processing Division (IPD) at GSFC. At the request of the NASA technical representative, production of these tapes was discontinued.

Plots of transmission and extinction profiles for every SAM II event were also generated at LaRC. These plots were transferred to microfiche for archival at LaRC and are used for quality control as well as scientific investigations of the data.

1.2.2 Quality Control

During the routine processing of SAM II data, screening reports are generated to detect various raw data and processing errors. When a processing error occurs the program software is corrected. After several years of successful data reduction, processing errors are very rare. Errors in the raw data, such as operational timing errors, cannot be corrected and result in loss of the event. Occasionally, large portions of raw data are in error. This occurred recently when Goddard changed computer systems and inadvertently altered the data on the ILTs. Data dumps were obtained and we were able to help Goddard correct these problems. As mentioned in section 1.2.1, plots of all SAM II extinction profiles have been saved on microfiche. Randomly scanning these profiles provides another means of quality control.

In 1982 it was recognized that certain SAM II extinction profiles were affected by Earth Radiation Budget (ERB) calibration movements of the Nimbus 7 spacecraft. A list of these profiles have been compiled and distributed with the archived data. While screening the post El Chichon profiles, several additional anomalous extinction profiles were detected. These profiles led to the discovery that the scan altitudes were not being accurately determined following heavy stratospheric aerosol loading. In particular for the fifth year data set (November 1982-October 1983), the solar irradiance was attenuated below the detection threshold of the SAM II sensor at a height in the atmosphere that effected the sun shape-fitting techniques used to determine altitude. A new technique to determine altitude using accurate ephemeris calculations was developed and used to reprocess this data. This procedure was also applied to the fourth year data with the result the same as the initial processing. The altitude correction was only significant for the fifth year.

Recently the entire SAM II data set was screened for bad profiles by plotting extinction isopleths on a daily basis as a function of altitude and longitude. These plots have been compiled, organized in bindings, labelled, and delivered to the Aerosol Research Branch (ARB) at NASA-LaRC. Individual profiles which are not consistent with adjacent profiles can be easily identified when plotted in this form. Suspicious profiles are then checked against microfiche plots of extinction and transmission. A list of anomalous profiles was generated for each of the first 7 years of SAM II data and this list is included as Appendix A of this report.

1.2.3 Archival Schedule

SAM II RDAT and BANAT tapes were sent to GSFC for archival at NSSDC according to the schedule in Table 1.

1.2.4 Quick-look Program

The SAM II quick-look program was developed to rapidly process data in support of real-time scientific investigations. This reduction method was designed to rely on just the actual satellite data. Predicted satellite location and model meteorological conditions were provided by the data reduction programs. From data collection to data interpretation, the period of elapsed time could range from six to twenty-four hours. The quick-look program was used in several instances to provide near real-time guidance to correlative measurement aircraft.

Table 1: SAM II Data Archival Schedule

Data Coverage	Date Sent: RDATs	Date Sent: BANATs
Year 1 (November 1978-October 1979)	December 1980	May 1981
Year 2 (November 1979-October 1980)	November 1981	November 1981
Year 3 (November 1980-October 1981)	March 1982	May 1982
Year 4 (November 1981-October 1982)	May 1983	May 1983
Year 5 (November 1982-October 1983)	May 1984	May 1984*
Year 6 (November 1983-October 1984)	January 1986	January 1986
Year 7 (November 1984-October 1985)	June 1986	June 1986

*Removed from archives (see 1.2.2). This data has been reprocessed and upon approval of the SAM II Project Scientist, Dr. M. P. McCormick, will be forwarded by ARB to the archival center.

1.3 Data Validation

SAM II was validated by a series of coordinated experiments using a variety of sensors. Table 2 lists these major correlative experiments.

Work under this contract was confined mainly to SAM II validation using the Langley airborne lidar system. The airborne lidar system, developed especially as a correlative sensor for satellite experiments, has four main advantages: 1) it can obtain data above cloud tops; 2) it can fly to satellite sensing locations; 3) it can sample a path similar to that viewed by the satellite; and 4) the data has good vertical resolution.

The airborne lidar data was analyzed using the method described by Russell et al. (1979). Profiles of aerosol backscatter coefficient (1/km-sr) vs altitude at wavelength $\lambda = 0.6943\ \mu m$ were obtained. To compare these profiles with the $\lambda = 1.0\ \mu m$ extinction (1/km) profiles measured by SAM II, aerosol optical models were constructed. Dustsonde data, either coincident or modeled, were used to constrain these models and provide a method to convert

Table 2: SAM II Correlative Experiments

Site	Date	Sensor: Lidar	Dustsonde	SAGE	Others
Sondrestrom, Greenland	November 22-25, 1978	X	X		X
Poker Flat, Alaska	July 16-19, 1979	X	X	X	X
Frobisher Bay Canada	December 14, 1980	X			
Sondrestrom, Greenland	January 29 & 31, 1983 February 2, 1983	X			
Sondrestrom, Greenland	January 21, 23, 24, 1984	X			

backscatter coefficient to extinction during routine data processing. Comparisons obtained between SAM II and lidar-derived extinction profiles, with associated error bars, for the 1978 Sondrestrom, Greenland and 1979 Poker Flat, Alaska experiments have been described in Russell, et al. (1981a) and Russell, et al. (1984). All of the correlative experiments taken together provide convincing evidence for the validity of SAM II extinction measurements.

1.4 Documentation

A series of reference reports (Table 3) was prepared by ST Systems Corp. (STX) and published by NASA to present large amounts of atmospheric data collected by the SAM II satellite experiment in a convenient, ready-to-use visual format. The intent of these reports was to provide an overview of the observed data to facilitate use in atmospheric and climatic studies. A brief summary was given describing the aerosol distribution in both polar regions for the period encompassed by each report, however, no detailed analysis or geophysical explanation of the data was provided. The SAM II reference publications were organized into separate volumes containing 6 months of measured aerosol data beginning from the launch of the Nimbus 7 spacecraft in October 1978.

Since the incremental change in latitude between successive measurement locations is small, the averages taken over a period of a week represent zonal averages within a narrow latitude band. Consequently, the data was averaged temporally to reduce the quantity of SAM II data into a managable form for presentation. Aerosol extinction profiles, with corresponding NOAA temperature profiles, were separated into sunrise or sunset events before averaging over a period of a week. Typically, more than 90 individual profiles were included in the averaging process. These profiles were displayed in the reference publication with information about the variability of the averages provided by standard deviation and depicted as horizontal error bars. Vertical cross sections of the 1 μm aerosol extinction for a 1 day period were shown as a function of longitude. The utility of these plots was to indicate the finer structure of the aerosol distribution and show when the zonal average is a poor representation of the observed data (i.e., inside and outside the stratospheric polar vortex). Only a single day was selected for presentation for each weekly period. The stratospheric aerosol optical depth value was determined from the SAM II data and averaged in a similar manner.

During the 4 year period covered by this contract, 6 SAM II reference publications were prepared, assembled, and submitted for publication. Table 3 lists the volumes and the periods included by each report.

Table 3: SAM II Reference Publications

Reference Publication	Volume	Coverage
RP 1081 (December 1981)	I	October 1978 - April 1979
RP 1088 (March 1982)	II	April 1979 - October 1979
RP 1106 (June 1983)	III	October 1979 - April 1980
RP 1107 (June 1983)	IV	April 1980 - October 1980
RP 1140 (May 1985)	V	October 1980 - April 1981
RP 1141 (May 1985)	VI	April 1981 - October 1981
RP 1164 (August 1986)	VII	October 1981 - April 1982
RP 1165 (August 1986)	VIII	April 1982 - October 1982

1.5 Data Analysis

Over the period covered by this contract, a number of studies using SAM II data were performed to further our understanding of the stratospheric aerosol distribution. Since the scope of these studies encompassed a wide range of topics, the following discussion summarizes some of the results revealed by SAM II observations.

Figure 2 shows the 1.0 μm stratospheric optical depth record obtained in both polar regions for a 7 year period (McCormick and Trepte, 1986a). The weekly averaged data show that the overall yearly values in the two polar regions are influenced by seasonal variations and controlled by volcanic perturbations. During this period (late 1978 through October 1985), the Arctic region experienced the effects of a number of eruptions, most of which occurred in the northern hemisphere. The eruption of El Chichon in April 1982, however, created the largest enhancement in optical depth recorded in both hemispheres, with peak optical depth values of 5.5×10^{-2} in the Arctic region and 2.0×10^{-2} in the Antarctic region. Both are felt to be conservative values because of instrument limitations at such high aerosol loadings, with a more representative estimate of approximately 0.11 for the

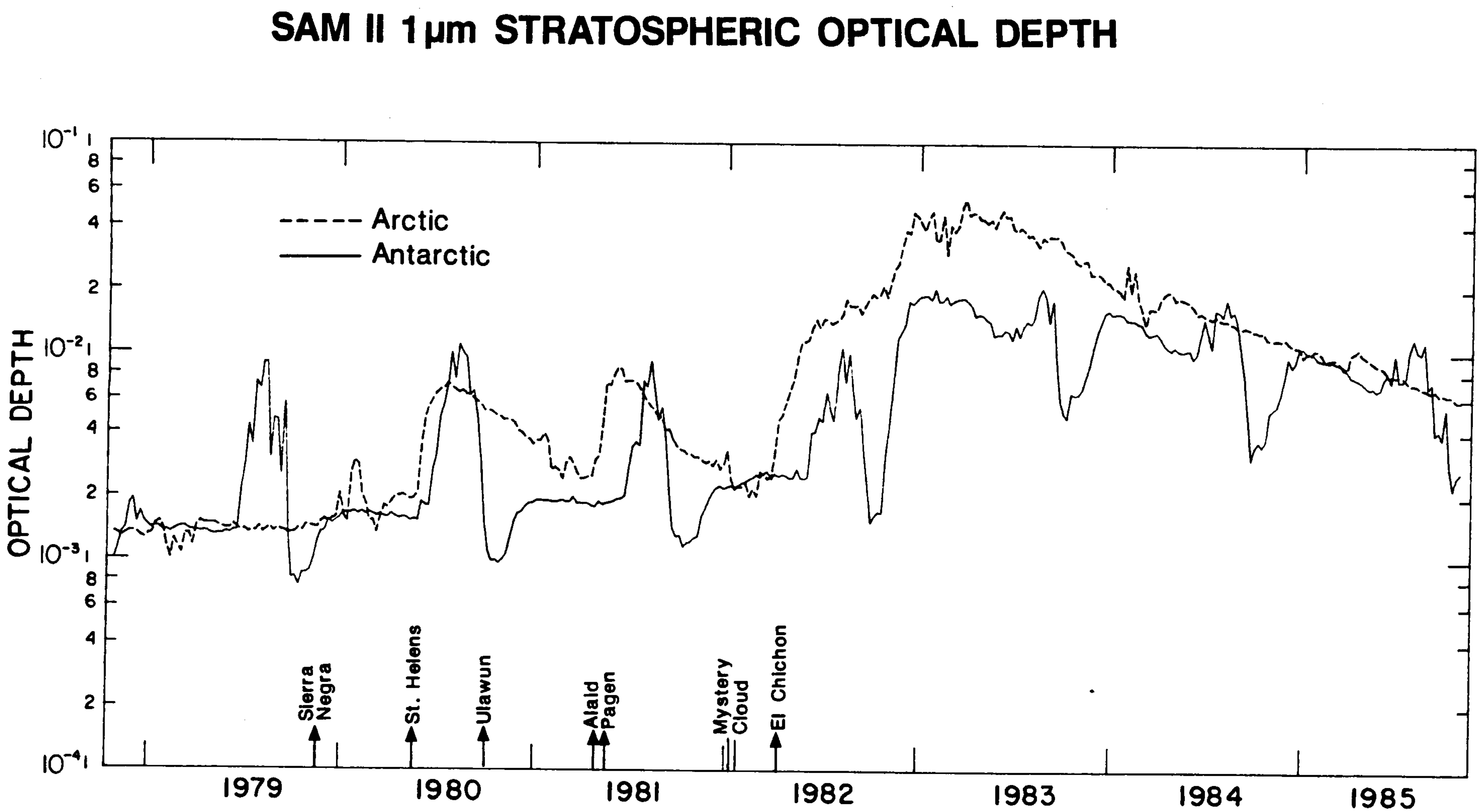


Figure 2. Weekly averaged SAM II stratospheric aerosol optical depth observations at a wavelength of 1 μm from October 1978 through October 1985. The solid line represents observations made in the southern hemisphere polar region and the dashed line represents observations made in the northern hemisphere polar region. Optical depth is calculated from 2 km above the tropopause upwards except during periods of heavy loading when measurements were not obtainable down to this altitude.

Arctic region and 2.6×10^{-2} for the Antarctic region.

Correlation of the optical depth record with a similar record of 50 mb temperatures, shown in Figure 3, indicates periodic intervals when enhancements in aerosol extinction produce as much as an order of magnitude higher optical depth values than observed during the previous summer season. These episodes are due to the formation of PSC's which themselves are a manifestation of the microphysical growth of the background sulfuric-acid aerosol particles during periods with mean temperatures <195 K. Analysis of the SAM II data shows that Antarctic PSC's are present for periods of about 3 months, from June until early September. Further investigation reveals a vertical variation of high aerosol optical properties (inferred to be PSC's) during this same interval for each year. This variation is believed to be due in part to particle sedimentation, particle evaporation, and subsidence. Recent theories employing PSC formation to help explain the ozone hole during the austral spring must account for the observed behavior of these measurements (McCormick and Trepte, 1986b). Arctic PSC's are also observed in each Arctic winter, but are much less frequent due to the warmer conditions present in the average northern winter stratosphere. Synoptic analysis of the SAM II observations reveals a non-zonal structure in aerosol properties during the winter hemisphere, especially in the Arctic region where planetary wave activity is pronounced.

Another recurring feature in the SAM II data (Figure 2) is the depression in optical depth observed in late September and early October in the southern hemisphere immediately following the disappearance of PSC's at the latitudes measured by SAM II. It is believed that this relative minima is produced by the loss of aerosols within the vortex by both gravitational settling of the PSC ice particles during the coldest segment of winter and the general

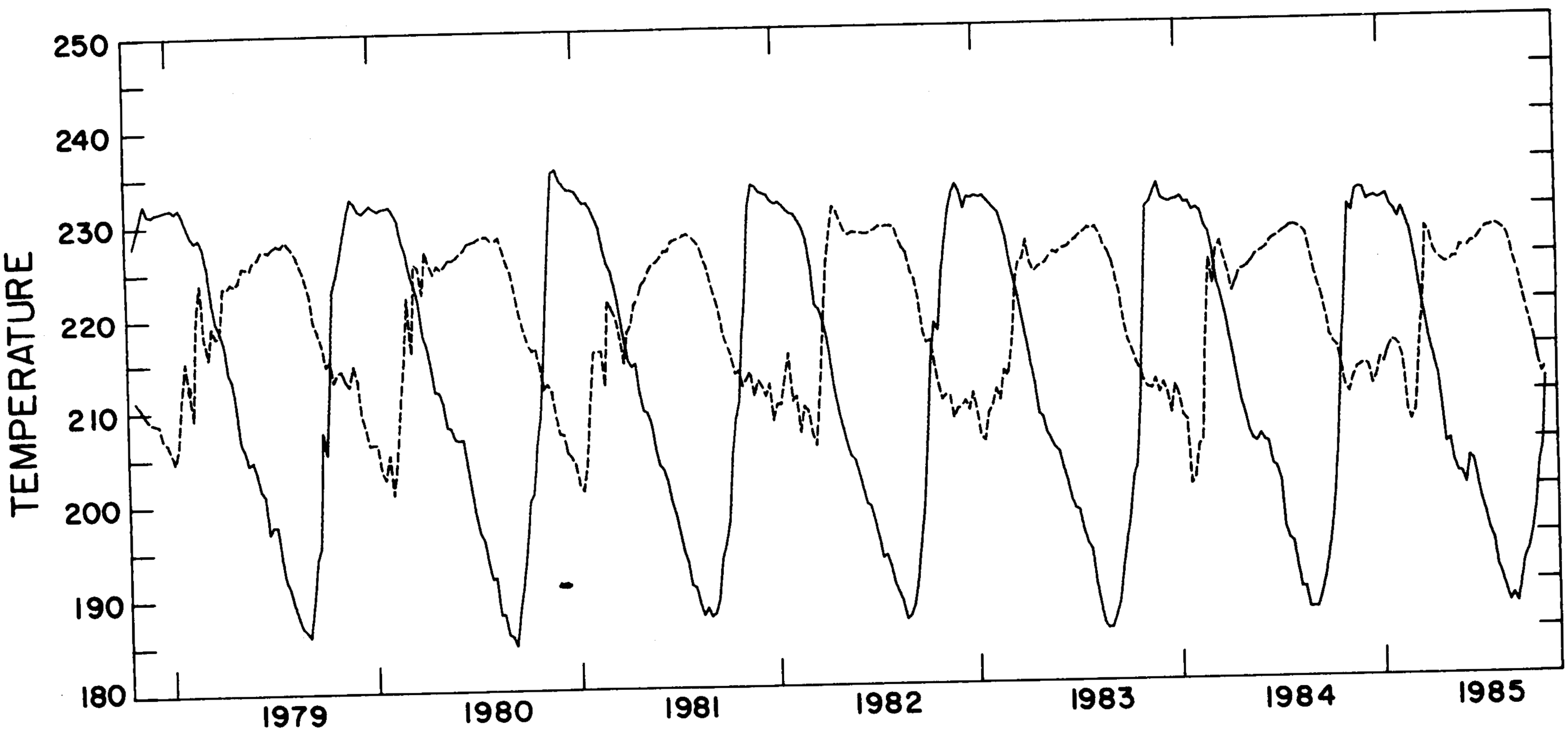


Figure 3. Weekly averaged 50 mb temperatures obtained from NMC analysis at the location of each SAM II observation. The solid line is for the southern hemisphere measurements and the dashed line the northern hemisphere measurements.

subsidence of air induced by the mean diabatic circulation. This behavior was elucidated in a study (McCormick et al., 1983) of the aerosol distribution for a winter season in the northern hemisphere polar region. It was found that within the polar vortex, a systematic lowering of aerosols inside the vortex created a strong gradient in aerosol properties across the polar night jet stream. Air parcels within the vortex remained relatively isolated from transport on the anticyclonic side of the jet stream until the vortex disappeared in late March. The lowering of aerosols inside the vortex is inferred to be caused by the descending branch of the mean diabatic circulation at high latitudes (Kent et al., 1985). A similar process should be present in the southern hemisphere as indicated by circulation calculations (Trepte, 1986). Therefore, changes in the aerosol structure that took place within the vortex by these processes are maintained until the vortex breaks up, usually about November when increases in aerosol optical depth are observed as aerosol from lower latitudes move into these higher latitudes.

The impact of volcanic eruptions as seen in Figure 2 is much more apparent in the northern high latitudes, partly because of the greater number of eruptions that occurred in the northern hemisphere during this period and partly because of the favorable seasonal circulation patterns following these eruptions. With the eruption of El Chichon, optical depth values in the Arctic latitudes were conservatively about 40 times greater than the near background observations in 1978.

1.6 Concluding Remarks

The contract period has seen the successful management, reduction, validation and archival of the fourth, sixth, and seventh years of SAM II data. The fifth year of SAM II data, which was most heavily contaminated by stratospheric aerosol loading from El Chichon, has been reprocessed. The fourth year data was also reprocessed with no change from the initial processing. Altitude corrections resulting from large volcanic concentrations were significant only for the fifth year data set. In addition, transmission and extinction profiles for every SAM II event have been plotted and saved on microfiche. The first four years of SAM II data have been summarized in a series of NASA Reference Publications. A number of studies using SAM II data were performed to further our understanding of the stratospheric aerosol distribution (Section 3).

SECTION 2 - SAGE

2.1 Introduction

ST Systems Corporation (STX) supplied software support under contract NAS1-17165 for the Stratospheric Aerosol and Gas Experiment (SAGE) data management, reduction, validation, display and analysis.

SAGE was launched February 18, 1979 on a dedicated Applications Explorer Mission (AEM-B) satellite. The SAGE orbit, selected to complement SAM II geographical coverage, allowed for collecting measurements, with some seasonal variation, between 72°N and 72°S. The SAGE instrument was a four-channel sun photometer centered at the wavelengths: 0.385 μm, 0.45 μm, 0.60 μm and 1.0 μm. The radiances obtained were mathematically inverted to yield profiles of ozone and NO_2 concentration and aerosol extinction (1.0 μm and 0.45 μm). Up until July 1979, data was collected during each spacecraft sunrise and sunset (approximately 15 each per day). At that time sunrise measurements were discontinued because of a problem with the spacecraft batteries. SAGE ceased taking measurements in November 1981.

The third year SAGE satellite data was processed under this contract, resulting in the archival of all three years of SAGE data. Subsequently, it was learned that the NOAA supplied meteorological data used in the processing was in error above 10 mb. All three years of SAGE data were recomputed using a NOAA supplied temperature bias correction and rearchived.

An extensive aerosol validation program was carried out using the Langley airborne lidar system. SAGE ozone data was validated through comparisons with numerous ECC and MAST balloonsondes, chemiluminescent rocketsondes, and optical rocketsondes. The SAGE aerosol data has been summarized in a series of 3 NASA Reference Publications (NASA RP 1144, 1149 and 1173). The SAGE ozone and NO_2 data will be summarized by NASA-LaRC in a similar series of Reference Publications. Data analysis has examined the transport phenomena of aerosols and dynamically controlled ozone.

The following section of this report is an overview of the role of ST Systems Corporation (STX) in the successful reduction and validation of the SAGE data. In addition a list of publications and presentations supported under this contract has been included in section III.

2.2 Data Management and Processing

2.2.1 General Discussion

GSFC combined and reformatted SAGE telemetry data for each day to create an experimenter tape (EXP) which was sent to LaRC for instrument "housekeeping" checks and science processing. GSFC also supplied a weekly tape of ephemeris information (EPH). A tape containing meteorological data (MET) for each event was received from NOAA.

Figure 4 presents an overview of the SAGE data processing at LaRC. Each experimenter tape was copied onto an internal tape at the LaRC computer center. Then 4-day files of merged meteorological, ephemeris and radiance data for each event (MERDATs) were created and saved on tape. Transmission profiles were calculated and inverted to yield profiles of extinction at all 4 wavelengths. Files which included these extinction profiles for each 4-day period were also saved on tape.

SAGE processing yielded three tape products: MERDAT and PROFILE tapes, which were sent for archival at NSSDC, and OZONE tapes, which were sent to the World Ozone Data Center (WODC). MERDAT tapes, were generated during initial processing. PROFILE tapes, which contain a month of data, were created by combining and reformatting the 4-day files of inverted data generated during

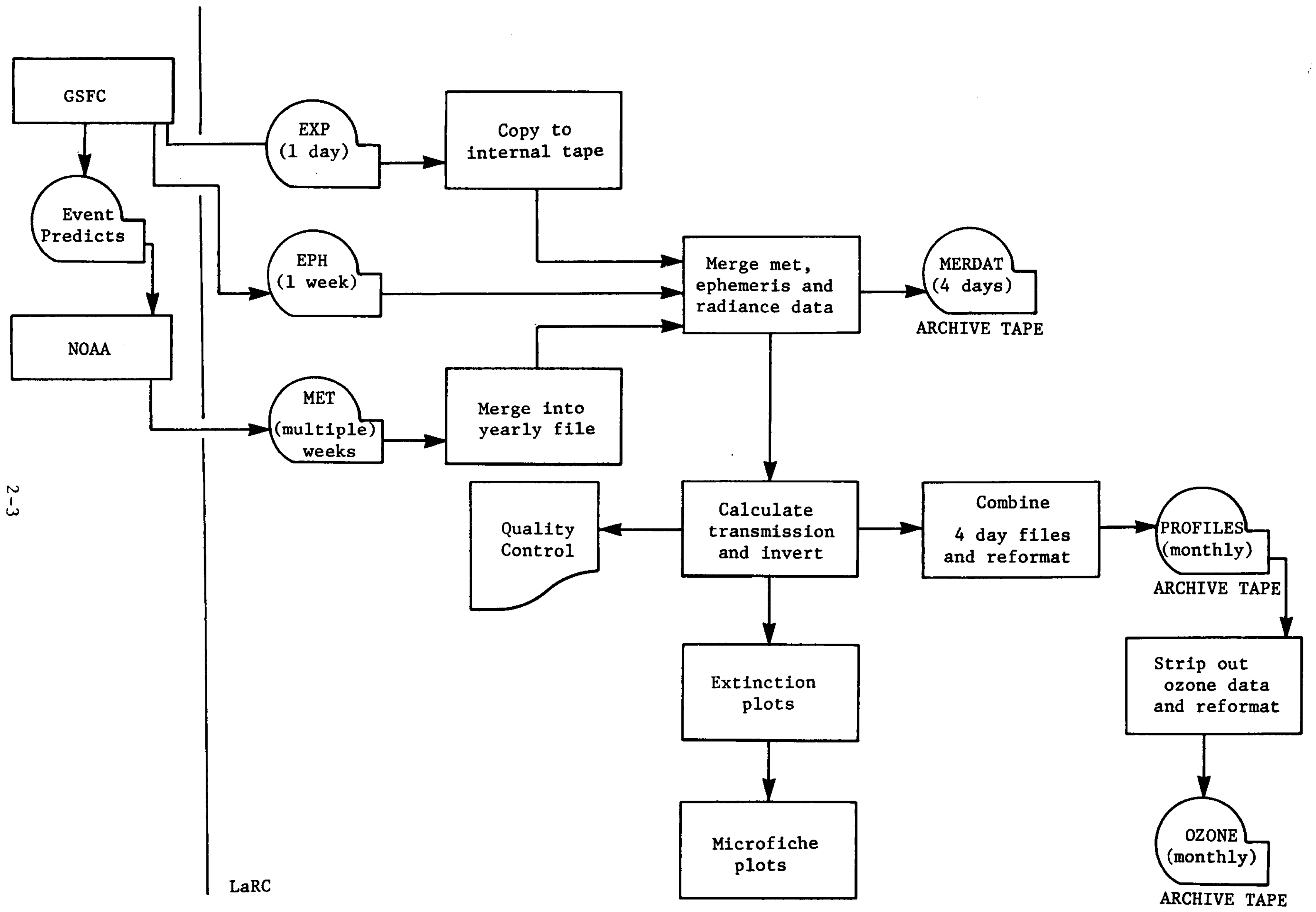


Figure 4. Flow chart of SAGE data processing.

initial processing. OZONE tapes also contain a month of data and were created by stripping out and reformatting the ozone data on the PROFILE tapes. Brief descriptions of these tapes are as follows:

- MERDAT (Meteorological Ephemeris Radiance Data Archive Tape)

  This tape contains meteorological, ephemeris and slow-scan radiance data for each SAGE sunrise or sunset event.

- PROFILE Tape

  This tape contains processed SAGE data including profiles of aerosol, ozone, and NO_2 extinction, ozone and NO_2 number density, 1.0 μm extinction ratio, and ozone and NO_2 volume mixing ratio, along with corresponding estimates of error at each altitude.

- OZONE Tape

  This tape contains only the SAGE ozone data which was contained on the PROFILE tape.

PROFILE tapes were generated at LaRC and distributed to all Science Team members and other interested scientists under this contract. The Profile Data User's Guide, written to describe the data on the PROFILE tape, has been included in Appendix B.

Plots of extinction profiles at the four SAGE wavelengths for every SAGE event were also generated at LaRC. These plots were transferred to microfiche for archival at LaRC and are used for quality control as well as scientific investigations of the data.

2.2.2 Quality Control

During the routine processing of SAGE data, screening reports were generated to detect various raw data and processing errors. When a processing error occurred, the program software was corrected. Errors in the raw data, such as timing errors, could not be corrected and resulted in the loss of an event. As mentioned in section 2.2.1, plots of all SAGE extinction profiles have been saved on microfiche. Randomly scanning these profiles provided another means of quality control.

2.2.3 Archival Schedule

SAGE MERDAT and PROFILE tapes were sent to NSSDC and SAGE OZONE tapes were sent to WODC according to the schedule in Table 3.

Table 3: SAGE Data Archival Schedule

	Data Sent		
Data Coverage	MERDATS	Profile Tapes	Ozone Tapes
Year 1 (February - December 1979)	May 1981	June 1982*	January 1983**
Year 2 (January - December 1980)	October 1981	December 1982*	January 1983**
Year 3 (January - November 1981)	March 1983	June 1983*	**

*In August 1984 SAGE data was recomputed using the NOAA temperature bias correction. All three years of SAGE PROFILE tapes were rearchived in March 1985.

**The third year OZONE tapes had not been sent when the temperature bias correction became available. The data has been reprocessed and upon approval of the SAGE Project Scientist, Dr. M. P. McCormick, will be forwarded by ARB (NASA-LaRC) to the archival center.

2.3 Data Validation

2.3.1 Aerosol Validation

SAGE aerosol data was validated by a series of coordinated experiments using a variety of sensors. Table 4 lists these major correlative experiments.

Table 4: SAGE Aerosol Correlative Experiments

Site	Date	Sensor			
		Lidar	Dustsonde	SAM II	Others
Palestine, Texas	March 12-13, 1979	X	X		X
Wallops Island, Virginia	April 5, 1979	X			X
Natal, Brazil	April 12-14, 1979	X	X		X
Poker Flat, Alaska	July 16-19, 1979	X	X	X	X
Wallops Island, Virginia	October 31-November 2, 1979	X			X
Wallops Island, Virginia	May 27-28, 1980	X			
Portland, Oregon	September 19-20, 1980	X			
Plattsburg, New York	December 9-10, 1980	X			X

Aerosol validation under this contract was confined mainly to comparisons between SAGE and the airborne lidar system. The airborne lidar data was analyzed using the method described by Russell et al. (1979). Profiles of aerosol backscatter coefficient (1/km-sr) vs. altitude at wavelengths $\lambda = 1.06\ \mu m$ and $\lambda = 0.6943\ \mu m$ were obtained. To compare these profiles with the $\lambda = 1.0\ \mu m$ and $\lambda = 0.45\ \mu m$ extinction (1/km) profiles measured by SAGE, aerosol optical models were constructed (Russell et al., 1981b). Dustsonde data, either coincident or modeled, were used to constrain these models and provide a method to convert backscatter coefficient to extinction during routine data processing. Comparisons obtained between SAGE and lidar-derived extinction profiles, with associated error bars, for the 1979 Poker Flat, Alaska experiment were described in Russell, et al. (1984). All of the correlative experiments taken together provided convincing evidence for the validity of SAGE extinction measurements.

2.3.2. Ozone Validation

A comprehensive series of correlative experiments was conducted during 1979-1980 at five fixed sites between $6^{o}S$ and $65^{o}N$ to test the validity of SAGE ozone data. The intercomparisons included data taken with electrochemical ozone (ECC) balloonsondes and chemiluminescent and optical rocketsondes. Table 5 lists these correlative experiments. Under this contract, comparisons were made between SAGE and each of the 17 ECC balloonsondes, 3 chemiluminescent rocketsondes and 2 optical rocketsondes. Ozone volume mixing ratio was the parameter chosen for comparison. The average mean absolute difference over all these comparisons was 10.4%. A more detailed description of these comparisons is found in McCormick, et al. (1984).

A similar series of correlative measurements was conducted from European stations during the same period. Comparisons between SAGE and each of 30 balloon ozonesondes yielded an average mean absolute difference of 8.8%. A

Table 5: SAGE Ozone Correlative Experiments

Site	Date	ECC Balloon	Sensor Optical Rocket	Chemical Rocket
Palestine, Texas	March 13, 1979	X(2)		
Palestine, Texas	April 5, 1979	X		
Wallops Island, Virginia	April 5, 1979	X(2)	X	
Palestine, Texas	April 6, 1979	X(2)		
Primrose Lake, Canada	May 3, 1979	X		
Poker Flat, Alaska	July 16, 1979	X(2)		X
Poker Flat, Alaska	July 17, 1979	X		X
Poker Flat, Alaska	July 19, 1979	X(2)		
Wallops Island, Virginia	August 22, 1979	X(2)		
Wallops Island, Virginia	November 1, 1979	X	X(2)	
Natal, Brazil	February 19, 1980	X		

more detailed description of these comparisons is found in Reiter and McCormick (1982). Considering the difference in vertical resolution, experimental errors, and ozone time and space gradients, the agreement between SAGE ozone data and both sets of correlative measurements was considered very good.

2.3.3 NO_2 Validation

Extremely low values of NO_2 measured by the SAGE instrument inside the southern vortex were recently investigated. NO_2 extinction versus altitude was derived using an onion peel occultation retrieval from SAGE slant path transmittance in the 0.385 μm and 0.45 μm channels for several days. The inferred extinction was found to be very sensitive to temperature as a result of the Rayleigh scattering correction in both channels. It was concluded that the extremely low values of NO_2 may be due to temperature uncertainties.

2.4 Documentation

A series of reference documents were prepared by ST Systems Corporation (STX) to present SAGE aerosol and gaseous data in a convenient and ready-to-use visual format. These reports are organized into 2 separate series: one containing aerosol data and the other containing O_3 and NO_2 observations. Each report spans a single calendar year for 1979, 1980, and 1981. The intent of these publications is to provide a broad overview of the measured parameters without giving a detailed geophysical explanation of the observations.

Unlike the SAM II experiment, the SAGE spacecraft had orbital characteristics which permitted the instrument to sample a larger latitude range. This additional coverage required the data to be presented in a manner representative of the geophysical distribution. Consequently, the data was presented by zonal averages instead of weekly averages. A table and series of figures was given to indicate the latitude of measurement as a function of time. In general, the SAGE sunrise or sunset data were presented separately by latitude sweeps. A sweep is defined as the set of data obtained during a maximum-to-maximum (north-to-south or south-to-north) latitudinal measurement sequence. Specifically, for the SAGE Aerosol Reference Publication results consist of: (1) tables of extinction and temperature as a function of altitude, (2) plots of average extinction and temperature profiles, (3) daily vertical cross sections of extinction as a function of longitude (4) plots of zonally averaged extinction and temperature per sweep, (5) tables of seasonally averaged extinction and temperature data, (6) plots of seasonally averaged extinction and temperature, and (7) tables of stratospheric optical depth per sweep at various latitudes and longitudes. To date, NASA RP 1144 for 1979 and NASA RP 1149 for 1980 SAGE aerosol measurements have been published. The Reference Publication for Volume III of the SAGE aerosol (NASA RP 1173) has been accepted and will be published in early 1987.

For the SAGE Gas Reference Publications, the results consist of (1) tables of concentration, mixing ratio, and temperature, (2) plots of average concentration, mixing ratio, and temperature profiles, (3) plots of zonally averaged concentration, mixing ratio, and temperature per sweep, (4) tables and plots of seasonally averaged concentrations, and mixing ratio, and (5) tables of integrated column O_3 and NO_2 per sweep at various latitudes and longitudes. The first SAGE Gas Reference Publication has been submitted to NASA for acceptance.

2.5 Data Analysis

Analysis of SAGE data during this contract period has focused on transport phenomena in the stratosphere. These studies examined the poleward movement of aerosols and dynamically controlled ozone. The injection of volcanic material into the stratosphere facilitates the tracking of air masses latitudinally. Under periods of strong planetary wave activity, rapid poleward transport of enhanced aerosols was observed along zonal mean isentropic surfaces, as seen a month after the eruption of Sierra Negra in November 1979. During periods of little planetary wave activity (i.e. summer), the SAGE data showed that the redistribution of volcanic debris remained confined to narrow bands in latitude. Unlike the meridional structure of aerosols which were transported poleward rapidly, the near-background or aged aerosol distribution exhibited a structure with contours intersecting zonal mean potential temperature surfaces. It is believed that this behavior reflects the diabatic processes present in the meridional circulation. Information obtained from these analyses was used to support more detailed investigations using SAM II data of vertical transport in polar regions (i.e., Kent et al., 1985).

Other evidence of vertical air motion was inferred from measurements of anomalously high aerosol extinction values in the lowest layers of the tropical tropopause. It is widely accepted that the rising branch of the diabatic circulation is located in the tropics, but the mechanism by which tropospheric air enters the stratosphere is not clear. Overshooting thunderstorms may be a conduit for vertical transport. However, these convective cells must be located in regions with low enough tropopause temperatures to preserve the arid conditions of the stratosphere. A study examined the occurrence of high aerosol extinction episodes not associated with volcanic eruptions and found that the greatest frequency of these ´clouds´ is located in convectively active regions and varies geographically with season. Furthermore, these regions had tropopause temperatures consistent with the observed frost point of the lower stratosphere (Trepte, 1983).

2.6 Concluding Remarks

This contract has seen the successful management, reduction, validation and archival of all SAGE data. In addition extinction profiles, at each of the 4 SAGE wavelengths, for every SAGE event have been plotted and saved on microfiche. The SAGE aerosol data have been summarized in a series of NASA Reference Publications. The SAGE gas data have been similarly organized and will be published by LaRC in RP's. Data analysis has focused on transport phenomena in the stratosphere.

SECTION 3 - PUBLICATIONS/PRESENTATIONS

ST Systems Corporation (STX) employees participated in the writing of several papers during the contract period. The following list includes the most significant of these, plus a few selected earlier publications.

Kent, G. S., Trepte, C. R.*, Farrukh, U. O., McCormick, M. P.: Variation in the Stratospheric Aerosol Associated with North Cyclonic Polar Vortex as Measured by the SAM II Satellite Sensor. J. Atmos. Sci., 42, 14, July 1985.

McCormick, M. P.: SAGE Aerosol Measurements, Volume I - February 21, 1979 - December 31, 1979. NASA RP 1144, October 1985.

McCormick, M. P.: SAGE Aerosol Measurements, Volume II - January 1, 1980 - December 31, 1980. NASA RP 1149, January 1986.

McCormick, M. P.: SAGE Aerosol Measurements, Volume III - January 1, 1981 - November 18, 1981. NASA RP 1173, February 1987.

McCormick, M. P.: SAM II Measurements of the Polar Stratospheric Aerosol. Vol. I - October 1978 to April 1979. NASA RP 1081, December 1981.

McCormick, M. P., and Brandl, David*: SAM II Measurements of the Polar Stratospheric Aerosol. Vol. III - October 1979 to April 1980. NASA RP 1106, June 1983.

*Denotes ST Systems Corporation (STX) employee.

McCormick, M. P., and Brandl, David*: SAM II Measurements of the Polar Stratospheric Aerosol. Vol. IV - April 1980 to October 1980. NASA RP 1107, June 1983.

McCormick, M. P., and Brandl, David*: SAM II Measurements of the Polar Stratospheric Aerosol. Volume V - October 1980 to April 1981. NASA RP 1140, May 1985.

McCormick, M. P., and Brandl, David*: SAM II Measurements of the Polar Stratospheric Aerosol. Volume VI - April 1981 to October 1981. NASA RP 1141, May 1985.

McCormick, M. P., and Brandl, David*: SAM II Measurements of the Polar Stratospheric Aerosol. Volume VII - October 1981 to April 1982. NASA RP 1164, August 1986.

McCormick, M. P., and Brandl, David*: SAM II Measurements of Polar Stratospheric Aerosol. Volume VIII - April 1982 to October 1982. NASA RP 1165, August 1986.

McCormick, M. P., and Larsen, J. C.*: Antarctic Springtime Measurements of Ozone, Nitrogen Dioxide, and Aerosol Extinction by SAM II, SAGE and SAGE II, Geophys. Res. Lett., 13, pp. 1280-1283, 1986.

McCormick, M. P., Steele, Helen M.*, and Hamill, Patrick*: SAM II Measurement of the Polar Stratospheric Aerosol. Vol. II - April 1979 to October 1979. NASA RP 1088, March 1982.

McCormick, M. P., Steele, H. M.*, Hamill, P.*, Chu, W. P., and Swissler, T. J.*: Polar Stratospheric Cloud Sightings by SAM II. J. Atmos. Sci., 39, 6, pp. 1387-1397, 1982.

McCormick, M. P., Swissler, T. J.*, Hilsenrath, E., Krueger, A. J., and Osborn, M. T.*: Satellite and Correlative Measurements of Stratospheric Ozone: Comparison of Measurements Made by SAGE, ECC Balloons, Chemiluminescent, and Optical Rocketsondes. J. Geophys. Res., 89, D4, pp. 5315-5320, June 30, 1984.

McCormick, M. P. and Trepte, C. R.*: Polar Stratospheric Optical Depth Observed by the SAM II Satellite Instrument Between 1978 and 1985. J. Geophys. Res., (accepted, 1987).

McCormick, M. P., and Trepte, C. R.*: SAM II Measurements of Antarctic PSC's and Aerosols. Geophys. Res. Lett., 13, pp. 1276-1279, 1986.

McCormick, M. P., Trepte, C. R.*, and Kent, G. S.: Spatial Changes in the Stratospheric Aerosol Associated with the North Polar Vortex. Geophys. Res. Lett., 10, pp. 941-944, 1983.

Reiter, R., and McCormick, M. P.: SAGE-European Ozonesonde Comparison. Nature, 300, 5890, pp. 337-339, 1982.

Russell, P. B., McCormick, M. P., and Swissler, T. J.*: Validation of Aerosol Measurements by the Satellite Sensors SAM II and SAGE. Adv. Space Res., 2, 5, pp. 123-126, 1983.

Russell, P. B., McCormick, M. P., Swissler, T. J.*, Chu, W. P., Livingston, J. M., Fuller, W. H., Jr., Rosen, J. M., Hofmann, D. J., McMaster, L. R., Woods, D. C., and Pepin, T. J.: Satellite and Correlative Measurements of the Stratospheric Aerosol II: Comparison of Measurements Made by SAM II, Dustsondes and an Airborne Lidar. J. Atmos. Sci., 38, 6, pp. 1295-1312, 1981a.

Russell, P. B., McCormick, M. P., Swissler, T. J.*, McMaster, L. R., Rosen, J. M. and Hofmann, D. J.: Satellite and Correlative Measurements of the Stratospheric Aerosol III: Comparison of Measurements by SAM II, SAGE, Dustsondes, Filters, Impactors and Lidar. J. Atmos. Sci., 41, 11, pp. 1791-1800, 1984.

Russell, P. B., Swissler, T. J.*, and McCormick, M. P.: Methodology for Error Analysis and Simulation of Lidar Aerosol Measurements. Appl. Opt., 18, pp. 3783-3797, 1979.

Russell, P. B., Swissler, T. J.*, McCormick, M. P., Chu, W. P., Livingston, J. M., and Pepin, T. J.: Satellite and Correlative Measurements of the Stratospheric Aerosol I: An Optical Model for Data Conversions. J. Atmos. Sci., 38, 6, pp. 1279-1294, 1981b.

Steele, H. M.*, Hamill, P.*, McCormick, M. P., and Swissler, T. J.*: The Formation of Polar Stratospheric Clouds. J. Atmos. Sci., 40, 8, pp. 2055-2067, 1983.

Trepte, C. R.*: Variation in Polar Stratospheric Aerosol During the Southern Winter of 1984. Presented at Sixth Conference on Atmospheric Radiation of the Meteorological Society, Williamsburg, Virginia, May 13-16, 1986.

Trepte, C. R.* and McCormick, M. P.: Observations of Cirrus in the Lower Tropical Stratosphere. Am. Meteorol. Soc. 4th Conference on the Meteorology of the Upper Atmosphere, Boston, Massachusetts, March 22-25, 1983.

APPENDIX A

SAM II QUALITY CONTROL

SAMII QUALITY CONTROL

Anomolous extinction profiles have recently been found in the SAMII data set covering the period from the middle of 1982 through 1983. While some of these profiles exhibit the high extinctions characteristic of ERB calibrations, the remainder of the questionable profiles appear to be related to problems with determining the correct scan altitude during periods of heavy stratospheric aerosol loading. To determine the extent of the problem the entire SAMII data base has been screened for bad profiles by plotting extinction isopleths on a daily basis as a function of altitude and longitude. Individual profiles which are not consistent with adjacent profiles(either in time or longitude) can be easily identified when plotted in this form. Suspicious profiles are then checked against the microfiche plots of extinction and transmission. Although this visual screening process is somewhat subjective we are primarily concerned with those profiles which are obviously incorrect. Instances where the profiles are questionable but it was not possible to reach a definite conclusion are also listed in the following tables. The user should inspect these profiles and decide whether or not they are suitable to be included in the particular study being undertaken. The anomolous profiles have been categorized in the tables as follows:

CAUSE

E ERB calibration. Delete all of these profiles.

E+ Extinction profile is similar to that for an ERB calibration but the profile shape suggests there are additional problems. Delete all of these profiles.

SP Sun spots. These appear to be a problem only from 20 to 30km and above. Whether or not these profiles should be deleted depends on how the SAMII data is being used. Only the worst cases have been listed in the tables. There are many more profiles remaining in the data base which are slightly perturbed by sun spots.

ADB Altitude determination is bad. The qualifier (described below) determines whether the profile should be deleted.

? Cause unknown. Qualifier determines whether the profile should be deleted.

QUALIFIER

D Delete profile from consideration.

? End user must decide whether or not to delete profile.

Astericks following the orbit numbers in the following tables indicate those profiles which have been identified previously as perturbed by an ERB calibration. Days for which no profiles are available are listed at the end of each yearly table. These tables will be updated as new data is processed or old data reprocessed.

Jack Larsen

Last revision 9/15/85

Data screened through 5/5/84

Last revision 3/06/86

Data screened through 5/4/85,Week 341

Last revision 5/23/86

Data screened through 10/26/85,Week 366

1978

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
253	NOV/11	3/315	1	ADB(D)
490*	NOV/28	6/332	0	E
797*	DEC/20	9/354	1	E

1979

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
1073	JAN/09	12/009	0	SP
1552*	FEB/13	17/044	0	E
1766	MAR/01	19/060	1	ADB(D)
1773*	MAR/01	19/060	0	E
1987	MAR/17	21/076	1	ADB(D)
2105*	MAR/25	23/084	0	E
2105*	MAR/25	23/084	1	E
2568*	APR/28	27/118	0	E
2568*	APR/28	27/118	1	E
2836	MAY/17	30/137	0	ADB(D)
2928*	MAY/24	31/144	0	E
3259*	JUN/17	34/168	0	E
3259*	JUN/17	34/168	1	E
3591*	JUL/11	38/192	0	E
3591*	JUL/11	38/192	1	E
3923*	AUG/04	41/216	0	E
4254*	AUG/28	45/240	0	E
4586*	SEP/21	48/264	0	E
4586*	SEP/21	48/264	1	E
4691	SEP/28	49/271	0	SP
5097*	OCT/28	54/301	1	E
5130	OCT/30	54/303	1	?(?) NO FICHE
5249*	NOV/08	55/312	1	E
5560*	NOV/30	58/334	1	E
5581*	DEC/02	59/336	0	E
5915*	DEC/26	62/360	0	E

1980

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
6224	JAN/17	65/017	0	ADB(D)
6244*	JAN/19	65/019	0	E
6264	JAN/20	66/020	1	ADB(D)
6576*	FEB/12	69/043	0	E
6696	FEB/20	70/051	1	E
7085	MAR/19	74/079	0	ADB(D)
7239*	MAR/31	76/091	0	E
7571*	APR/24	79/115	0	E
7866	MAY/15	82/136	0	ADB(D)
7903*	MAY/18	83/139	0	E
8278	JUN/14	86/166	1	SP
8340	JUN/18	87/170	1	SP
8567*	JUL/05	89/187	1	E
8567*	JUL/05	89/187	0	E
8897*	JUL/29	93/211	1	E
9280	AUG/25	97/238	1	SP
9295	AUG/26	97/239	0	SP
9561*	SEP/15	100/259	0	E
9892*	OCT/09	103/283	0	E
9954	OCT/13	104/287	0	SP
10225*	NOV/02	107/307	1	E
10887*	DEC/20	113/355	1	E

NO MET DATA FOR THE FOLLOWING DAYS
MARCH 5,6,7,8,9
AUGUST 10,11
DECEMBER 15,16

1981

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
11219*	JAN/13	117/013	0	E
11549*	FEB/05	120/036	0	E
11549*	FEB/05	120/036	1	E
11882*	MAR/01	124/060	0	E
11882*	MAR/02	124/061	1	E
12214*	MAR/26	127/085	0	E
12878*	MAY/13	134/133	0	E
13210*	JUN/06	137/157	1	E
13873*	JUL/24	144/205	1	E
14205*	AUG/17	148/229	0	E
14264	AUG/21	148/233	1	SP
14291	AUG/23	149/235	1	SP
14536*	SEP/10	151/253	0	E
14868*	OCT/04	155/277	0	E
15021	OCT/15	156/288	1	SP
15200	OCT/28	158/301	0	E NO FICHE
15533*	NOV/21	161/325	0	E
15658	NOV/30	163/334	0	ADB(D)
15788	DEC/09	164/343	0	SP+ADB(D)
15863*	DEC/15	165/349	0	E
14291	AUG/23	149/235	0	SP

1982

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
16195*	JAN/08	168/008	0	E
16195*	JAN/08	168/008	1	E
16306	JAN/16	169/016	0	SP+ADB(D)
16858*	FEB/25	175/056	0	E
16858*	FEB/25	175/056	1	E
17156	MAR/18	178/077	0	E+ADB(D)
17190*	MAR/21	179/080	0	E
17190*	MAR/21	179/080	1	E
17521*	APR/14	182/104	1	E
17853*	MAY/08	185/128	1	E
18185*	JUN/01	189/152	0	E
18185*	JUN/01	189/152	1	E
18517*	JUN/25	192/176	0	E
18517*	JUN/25	192/176	1	E
18595	JUN/30	193/181	0	ADB(D)
18678	JUL/06	194/187	0	ADB(D)
18848*	JUL/19	196/200	0	E
18848*	JUL/19	196/200	1	E
19110	AUG/07	198/219	1	?(D)
19118	AUG/07	198/219	0	SP+ADB(?)
19512*	SEP/05	203/248	0	E
19512*	SEP/05	203/248	1	E
19649	SEP/15	204/258	1	ADB(D)
19844*	SEP/29	206/272	0	E
19844*	SEP/29	206/272	1	E
19852	SEP/29	206/272	1	ADB(D)
20553	NOV/19	213/323	0	ADB(D)
20629	NOV/24	214/328	0	ADB(D)
20643	NOV/25	214/329	1	E
20679	NOV/28	215/332	0	ADB(D)
20684	NOV/28	215/332	1	E
20753	DEC/03	215/337	1	E
20796	DEC/06	216/340	1	SP
20804	DEC/07	216/341	1	ADB(D)
20851	DEC/10	216/344	1	?(?)
20892	DEC/13	217/347	0	ADB(D)
21001	DEC/21	218/355	0	ADB(?)
21016	DEC/22	218/356	0	ADB(D)
21065	DEC/26	219/360	1	ADB(D)
21011	DEC/22	218/356	0	ADB(D)
21123	DEC/30	219/364	0	ADB(D)
21137	DEC/31	219/365	0	ADB(D)

NO MET DATA FOR THE FOLLOWING DAYS

JANUARY 17,18

JULY 13,14,27,28,29,30

AUGUST 12,13

1983

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
21178	JAN/03	220/003	0	ADB(D)
21220	JAN/06	220/006	0	ADB(D)
21245	JAN/08	220/008	0	ADB(D)
21416	JAN/20	222/020	0	ADB(D)
21417	JAN/20	222/020	0	ADB(D)
21834*	FEB/20	227/051	1	E
21918	FEB/26	227/057	0	ADB(D)
22436	APR/04	233/094	0	ADB(D)
22444	APR/05	233/095	1	ADB(D)
22757	APR/27	236/117	0	ADB(D)
22839	MAY/03	237/123	1	E
22860	MAY/05	237/125	0	ADB(D)
23037	MAY/18	239/138	1	ADB(D)
23052	MAY/19	239/139	0	ADB(?)
23298	JUN/05	242/156	0	SP
23369	JUN/11	242/162	0	SP
23516	JUN/21	244/172	1	E+?(D)
23723	JUL/06	246/187	0	ADB(D)
23831	JUL/14	247/195	1	ADB(D)
23876	JUL/17	248/198	0	ADB(?)
23985	JUL/25	249/206	0	E
24292	AUG/16	252/228	0	SP+ADB(D)
24394	AUG/24	253/236	1	ADB(D)
24695	SEP/15	256/258	1	ADB(D)
25060	OCT/11	260/284	1	ADB(D)
25712	NOV/27	267/331	0	ADB(D)
25834	DEC/06	268/340	0	ADB(D)
26176	DEC/31	271/365	0	ADB(D)

1984

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
26821	FEB/15	278/046	1	E
27152	MAR/10	281/070	1	E
27474	APR/03	285/094	1	E
27811	APR/27	288/118	1	SP
28894	JUL/14	299/196	0	ADB(D)
30064	OCT/07	312/281	1	ADB(D)
30093	OCT/09	312/283	0	ADB(D)
30257	OCT/21	314/295	0	ADB(D)
30420	NOV/02	315/307	0	E
30792	NOV/29	319/334	1	E

1985

ORBIT NUMBER	MONTH/DAY	WEEK/DOY	0-SR(S) 1-SS(N)	CAUSE
31684	FEB/01	328/032	0	E
32021	FEB/25	332/056	0	E
33210	MAY/23	344/143	1	ADB(D)
33491	JUN/12	347/163	1	SP
33760	JUL/01	350/182	0	?(D)
33925	JUL/13	351/194	0	ADB(D)
33981	JUL/17	352/198	0	ADB(D)
33995	JUL/18	352/199	0	ADB(D)
34051	JUL/22	353/203	0	ADB(D)
34078	JUL/24	353/205	0	ADB(D)
34578	AUG/29	358/241	1	ADB(D)

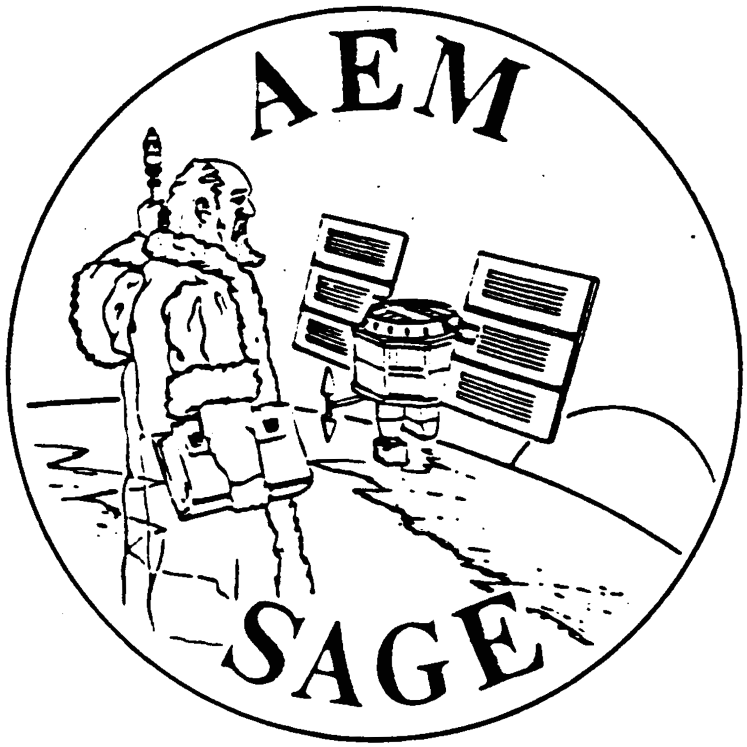
FOLLOWING DAYS HAVE NO EVENTS
JULY 2
MAY 27,28,29,30,31

APPENDIX B

SAGE PROFILE DATA USER´S GUIDE

APPLICATIONS EXPLORER MISSION (AEM 2)

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT (SAGE)



PROFILE DATA USER'S GUIDE

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PREFACE

The SAGE Profile tapes have been revised as of August 1, 1984 to incorporate zonal mean temperature corrections above 10 mb described by Gelman et al. (1983). Temperature and density values have been changed to reflect these corrections as well as the values of NO_2 extinction and the mixing ratios of NO_2 and O_3.

In addition to allow for a comparison of this data set with other studies defined on a pressure coordinate system, the revised profile tape contains a new array consisting of the pressure (mb) values associated with the extinction altitudes.

APPLICATIONS EXPLORER MISSION (AEM-2)

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT (SAGE)

DATA USER'S GUIDE

Description of Experiment

SAGE is a radiometer that measures the extinction of solar radiation traversing the Earth's limb during spacecraft sunrise and sunset in four wavelength bands centered at 0.385, 0.45, 0.60, and 1.0 μm. The four-channel extinction data are combined with spacecraft ephemeris and a local atmospheric density profile and then numerically inverted to yield vertical profiles of aerosol extinction at 1.0 and 0.45 μm and O_3 and NO_2 concentration. Details of the inversion process are discussed in "Inversions of Stratospheric Aerosol and Gaseous Constituents From Spacecraft Solar Extinction Data in the 0.38 - 1.0 μm Wavelength Region" by W. P. Chu and M. P. McCormick, Appl. Opt., 18, 1404-1413, 1979.

Spatial and Temporal Coverage

SAGE was launched February 18, 1979, aboard the AEM-2 spacecraft. The AEM-2 orbital geometry was such that SAGE sunrise and sunset observations were made every 96 minutes, i.e. every 24^{o} longitude. Spacecraft power subsystem problems four months after launch, however, essentially limited data collection thereafter to sunsets only and eventually forced termination of all data collection after November 18, 1981. Latitude coverage of the data, with some seasonal variation, extends from 72°N to 72°S. (This latitude coverage complements the 64°-80°N and 64°S-80°S coverage of the Nimbus 7/SAM II stratospheric aerosol sensor data, also archived at NSSDC.)

Data Products

1. SAGE radiance, spacecraft ephemeris, and NOAA correlative meteorological data are merged and recorded on Meteorological Ephemeris Radiance Data Archive Tapes (MERDAT) for archival at NSSDC.

2. Processed SAGE data including aerosol, O_3, and NO_2 extinction profiles; O_3 and NO_2 number density profiles; 1.0 μm extinction ratio and O_3 and NO_2 volume mixing ratio profiles; along with corresponding estimates of error at each altitude are recorded on PROFILE tapes for archival at NSSDC and the World Ozone Data Center (WODC). Each PROFILE contains a months time span of data. (A detailed PROFILE tape specification is enclosed.)

Data Resolution and Accuracy

The data have been validated by an extensive error analysis and comparisons with correlative observations. (See "SAGE Ground Truth Plan-Correlative Measurements for the Stratospheric Aerosol and Gas Experiment on the AEM-B Satellite," edited by P. B. Russell, NASA TM-80076, 1979.) The derived 1.0 μm aerosol extinction profiles have a vertical resolution of 1 km from cloud tops to approximately 35 km with an error of $< 10^{-5}$ km^{-1} (< 5 percent at the peak); the derived 0.45 μm aerosol extinction profiles have a vertical resolution of 3 km with an error of approximately 20 percent; the derived NO_2 concentration profiles have a vertical resolution of 3 km from 20-45 km with an error of approximately 30 percent at the peak; the derived O_3 concentration profiles have a vertical resolution of 1 km from the cloud tops to an altitude of approximately 40 km with < 10 percent error at the peak. At altitudes where extinction values are $< 2 \times 10^{-5}$ km^{-1}, the O_3 concentration profile is smoothed over a 5 km interval in height. The estimated errors of the derived products are calculated based on a vertical resolution of 1 km. The horizontal resolution, i.e. integration along the viewing direction, is approximately 200 km. Additional information on the SAGE mission and the other NASA satellite observations of aerosols is available in "Satellite Studies of the Stratospheric Aerosol" by M. P. McCormick, et al., Bull. Am. Meteorol. Soc., 60, 1038-1046, 1979 and "Stratospheric Aerosol and Gas Experiment (SAGE) Satellite End-of-Life Report" by M. Enciso and C. Kucera, NASA TM 83911, 1982.

A description of the stratospheric meteorological data set which includes information about the various sources and methods of analysis of the data is given in "Mean Zonal Wind and Temperature Structure During the PMP-1 Winter Period" by M. E. Gelman et al. Adv. Space Res., 2, 159-162, 1983.

SAGE PROFILES

(AEROSOL, OZONE, AND NO_2 EXTINCTION)

USER'S GUIDE

August 1, 1984

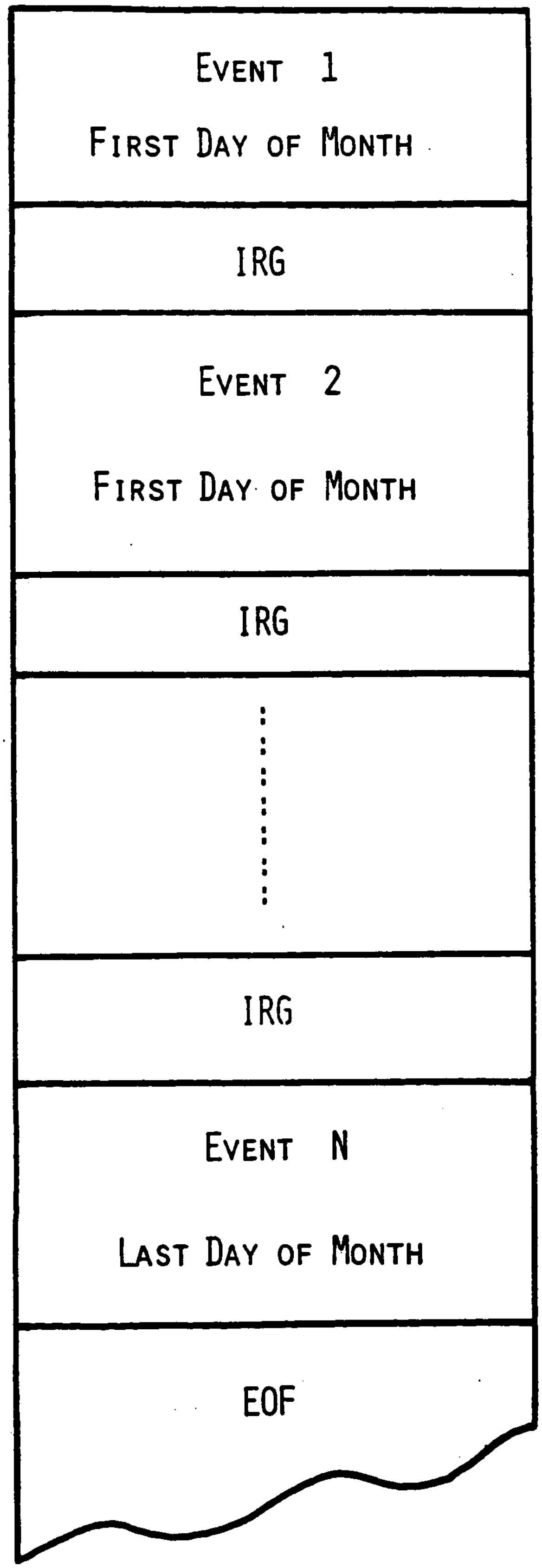
Mary Osborn

William P. Chu

PROFILES TAPE CHARACTERISTICS AND DATA ORGANIZATION

This is on 9-track, 1600 CPI, unlabeled magnetic tape in fixed length 2200 CDC word (60 bit) binary records. Each record contains the data for one SAGE event. There is one file containing all available events for a period of one month. Missing events will not be padded.

PROFILES GROSS FORMAT



PROFILES DETAIL DESCRIPTION

The first 108 CDC words of each record will contain the following:

EVENT DESCRIPTION AND METEOROLOGICAL DATA

CDC WORD #	DESCRIPTION	CDC INTERNAL FORMAT
1	Satellite Code (AEM-B)	A9
2	Instrument (SAGE)	A6
3	Year	I4
4	Month	I2
5	Day	I2
6	Hour	I2
7	Minute	I2
8	Second	I2
9	Latitude	A6
10	Longitude	A7
11	Event Type (SUNRISE or SUN SET)	A7
12	No. Events in Day	I2
13	This Event No. in Day	I2
*14-32	Temperature Deg. K or 9999.	Real
*33-51	Temp. Error Deg. K or 999.	Real
*52-70	Altitude in Meters or 99999.	Real
*71-89	Density g/m^3 or 9999. x 10^5	Real
*90-108	Density Error(Temp.Err./Temp.) or 999.	Real

*The first 18 values correspond to fixed pressure levels in millibars: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 10, 5, 2, 1 0.4. The 19th value is derived at the variable tropopause pressure.

PROFILES DETAIL DESCRIPTION (CONTINUED)

DATA PARAMETERS

Beginning CDC Word #	Length in CDC Words	Description (All CDC Floating Point Words Unless Integer Specified)
109	1	Quality Code (0. to 1.) 1.0 micron extinction
110	1	Quality Code (0. to 1.) .60 micron extinction
111	1	Quality Code (0. to 1.) .45 micron extinction
112	1	Quality Code (0. to 1.) .385 micron extinction
113	1	Index #1* Integer
114	1	Index #2** Integer
115	60*	Extinction altitudes (geometric) in km
175	60*	1.0 micron aerosol extinction km^{-1}
235	60*	.60 micron ozone extinction km^{-1}
295	60*†	.45 micron aerosol extinction km^{-1}
355	60*†	.385 micron NO_2 extinction km^{-1}
415	60*	1.0 micron aerosol extinction error km^{-1}
475	60*	.60 micron ozone extinction error km^{-1}
535	60*†	.45 micron aerosol extinction error km^{-1}
595	60*†	.385 micron NO_2 extinction error km^{-1}
655	60**	1.0 micron transmission (0. to 1.)
715	60**	.60 micron transmission (0. to 1.)
775	60**	.45 micron transmission (0. to 1.)
835	60**	.385 micron transmission (0. to 1.)
895	60**	1.0 micron optical depth error
955	60**	.60 micron optical depth error
1015	60**	.45 micron optical depth error
1075	60**	.385 micron optical depth error
1135	60**	1.0 micron Rayleigh extinction km^{-1}
1195	60**	.60 micron Rayleigh extinction km^{-1}
1255	60**	.45 micron Rayleigh extinction km^{-1}
1315	60**	.385 micron Rayleigh extinction km^{-1}
1375	60*	Ozone number density cm^{-3}
1435	60*	Ozone number density error cm^{-3}
1495	60*†	NO_2 number density cm^{-3}

DATA PARAMETERS

1555	60*†	NO_2 number density error cm^{-3}
1615	60*	Aerosol number density (zero filled)
1675	60*	Aerosol number density error (zero filled)
1735	60*	1.0 micron extinction ratio (aerosol + molecular/molecular)
1795	60*	1.0 micron extinction ratio error
1855	60*	Ozone mixing ratio (v/v)
1915	60*	Ozone mixing ratio error
1975	60*†	NO_2 mixing ratio (v/v)
2035	60*†	NO_2 mixing ratio error
2095	5	Tangent altitudes ≈10 to 50 km
2100	5	Corresponding latitudes
2105	5	Corresponding longitudes
2110	1	Event code INTEGER (0 = sunrise 1 = sunset)
2111	1	Event start time from Jan. 0 in days
2112	1	Spare
2113	60*	Pressure (mb) corresponding to extinction altitude
2173	20	Zero fill
2193	1	Spare
2194	1	Revision date (e.g. 1984.08 = August 1984)
2195	4	Spares
2199	1	Total number of words in record (2200) INTEGER
2200	1	12 bit 1's complement add checksum with end-around carry INTEGER.

* only elements 1 - Index #1 (of 60) are defined

** only elements 1 - Index #2 (of 60) are defined (zero fill)

† values below 10 km are 999. filled.

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15. Supplementary Notes

Langley Technical Monitor: L. R. McMaster

16. Abstract

This report describes the data management and processing supplied by ST Systems Corporation (STX) for the SAM II and SAGE experiments under contract No. NAS1-17165 for the years 1983-1986. The report includes discussions of data validation, documentation, and scientific analysis, as well as the archival schedule met by the operational reduction of SAM II and SAGE data. Work under this contract resulted in the archival of the first seven years of SAM II data and all three years of SAGE data. A list of publications and presentations supported under this contract has also been included.

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