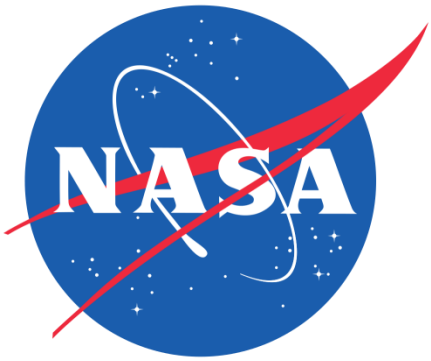

National Aeronautics and Space Administration
Langley Research Center

Stratospheric Aerosol and Gas Experiment on the International Space Station (SAGE III/ISS)

Data Products User's Guide

Version 2.0

October 2018

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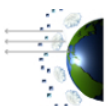


Change Record

Issue	Date	Sections Affected	Description
Version 1.0	Oct 2017	All	Baseline
Version 1.1	Dec 2017	Product Content and Formats, Appendices	Lunar information added
Version 2.0	Oct 2018	All	New data format

Contents

Acronyms and Abbreviations

ASDC	Atmospheric Sciences Data Center
ATBD	Algorithm Theoretical Basis Document
CCD	Charge-Coupled Device
Ch	Channel
EFOV	Effective Field of View
EOS	Earth Observing System
ETOS	Elapsed Time on Station
EVA	Extravehicular Activity
FOV	Field of View
GAMS	Gas and Aerosol Measurement Sensor
GMAO	Global Modeling and Assimilation Office
HDF	Hierarchical Data Format
IFOV	Instantaneous Field of View
InGaAs	Indium Gallium Arsenide
IR	Infrared
ISS	International Space Station
LOS	Line of Sight
MERRA-2	Modern-Era Retrospective analysis for Research and Applications, Version 2
QA	Quality Assurance
SAGE	Stratospheric Aerosol and Gas Experiment
SAM	Stratospheric Aerosol Measurement
SCF	Science Computing Facility
SP	Slant Path

Information for using the SAGE III/ISS Data Product User's Guide

This Data Products User's Guide (Version 2.0) provides a general description of the measurement technique, instrument, mission, and sampling coverage. Additional information on these topics or details on the retrieval algorithms are provided at the websites specified below. This document also provides information on the CCD pixel assignments used for the retrieval algorithms. These assignments and the periods they represent are described in Appendix A. Instructions for accessing the SAGE III/ISS Data Product files are also provided, with detailed descriptions of their content and format given in Appendices B, C, and D.

Reference Material	Website Location
SAGE III Algorithm Theoretical Basis Documents	https://eospso.gsfc.nasa.gov/atbd-category/50
SAGE III/ISS Mission Web Site	https://sage.nasa.gov/

Introduction

The Stratospheric Aerosol and Gas Experiment on the International Space Station (SAGE III/ISS) is an extension of the successful SAM II, SAGE I, SAGE II, and SAGE III Meteor-3M satellite experiments and is designed to acquire measurements of aerosols and gases in the stratosphere and upper troposphere [1]. These measurements are needed to enhance our understanding of natural and human-derived atmospheric processes. The experiment is a component of NASA's Earth Observing System (EOS) and is mounted on the ISS. The mission is managed by NASA's Langley Research Center.

The design for the SAGE III instruments included some advances which permit measurement of additional wavelengths over SAGE II. These added measurement capabilities resulted in

- improved aerosol characterization
- improved gaseous retrievals of O_3, H_2O, and NO_2
- extended vertical range of measurements
- self-calibration of the instrument, independent of external data
- expanded sampling coverage

Measurement Technique

The SAGE III instrument measures the attenuation of solar radiation resulting from the scattering and absorption by atmospheric constituents in the Earth's atmosphere as the spacecraft observes a sunrise or sunset event.

The viewing geometry of the satellite and the radiant target (Sun) during an occultation is illustrated in Figure 1. Measurement opportunities occur when the satellite ascends or descends from behind the Earth. Measurement begins when the instrument acquires the radiant target and uses a scanning mirror to scan the target image across the instrument field-of-view (FOV) aperture. A measurement is considered to occur at the point along the line of sight from the instrument to the target that comes closest to the Earth's surface (i.e., the subtangent point). The altitude of that point above the Earth's surface is commonly referred to as the tangent altitude.

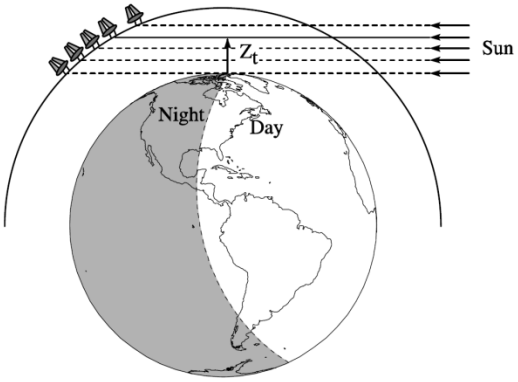
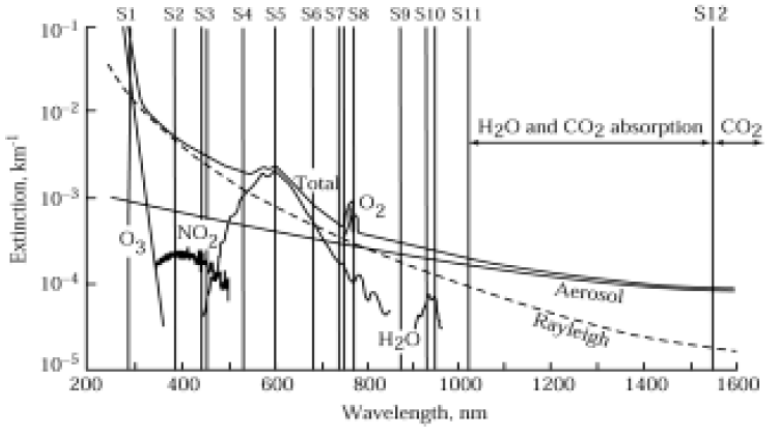


Figure 1. Occultation Geometry

The use of a scanning mirror provides multiple samples at each tangent altitude that are combined to construct transmission profiles from the Earth's surface (or cloud top) to an altitude of 100 km. Above this altitude, irradiance measurements are acquired between 100 and 300 km to characterize the instrument's performance across its wavelength range. This information is used to calibrate the instrument for each solar occultation event. By using this procedure, SAGE III data are relatively unaffected by changes in the instrument characteristics over the lifetime of the mission. A general description of the solar occultation measurement technique is provided by McCormick et al., 1979 [2].

The atmospheric extinction at any point along the line-of-sight typically includes contributions from aerosols and several gas



Ch #	Start-End WL (nm)	Target Species
01	284-296	O_3
02	382-387	Aerosol
03	433-451	NO_2/Aerosol
04	518-523	Aerosol
05	560-623	O_3/Aerosol
06	673-678	Aerosol
07	753-758	Aerosol
08	758-771	O_2
09	867-872	Aerosol
10	920-970	H_2O
11	1019-1025	Aerosol
12	1530-1560	Aerosol

Figure 2. Principal Extinction Contributions at 18 km
Vertical lines (S1-S12) denote spectral bands measured during solar events by SAGE III.

constituents. Figure 2 illustrates the principal extinction contributions for an altitude of 18 km. Both aerosol and molecular (Rayleigh) scattering contribute to extinction at all wavelengths. Ozone has strong absorption in the Hartley-Huggins band in the ultraviolet region of the spectrum and in the Chappius band in the visible spectrum. NO2 absorbs between 350 and 600 nm. Water vapor has absorption lines throughout the visible spectrum, with an additional strong band near 940 nm. Although they are not depicted in this figure, NO3 has absorption features between 500 and 650 nm, and OClO has a strong band between 380 and 400 nm.

Instrument Description and Operation

The design of the SAGE III sensor relies heavily upon the flight-proven designs used in the SAM II and SAGE I and II instruments. The SAGE III sensor assembly is illustrated in Figure 3. It consists of a pointing subsystem, an imaging subsystem, and a spectrometer. The pointing subsystem uses a scan mirror to acquire radiant energy from either the Sun or the Moon by vertically scanning across the target's image. The imaging subsystem produces a focused image of the target at the focal plane where the science aperture is located. The aperture defines the instrument's instantaneous field of view (IFOV). A removable neutral-density filter is located along the optical path of this subsystem. The filter is inserted into the optical path to attenuate the solar signal by approximately a factor of 106 and is removed for lunar measurements.

The spectrometer is located behind the science aperture and uses an 809 × 10 pixel CCD array to measure target radiation. The solar radiance between 280 and 1040 nm is measured with a spectral resolution of 1 to 2 nm along the 809 pixel array. An additional InGaAs infrared (IR) photodiode measures light near 1550 nm with a bandwidth of 30 nm for near infrared aerosol extinction measurements. This spectral coverage permits the measurement of multiple absorption features of each gaseous species and multiwavelength measurements of broadband extinction by aerosols. Because of limitations in the telemetry bandwidth, only 87 pixel groups (86 from the CCD and 1 from the photodiode) are transmitted from the satellite.

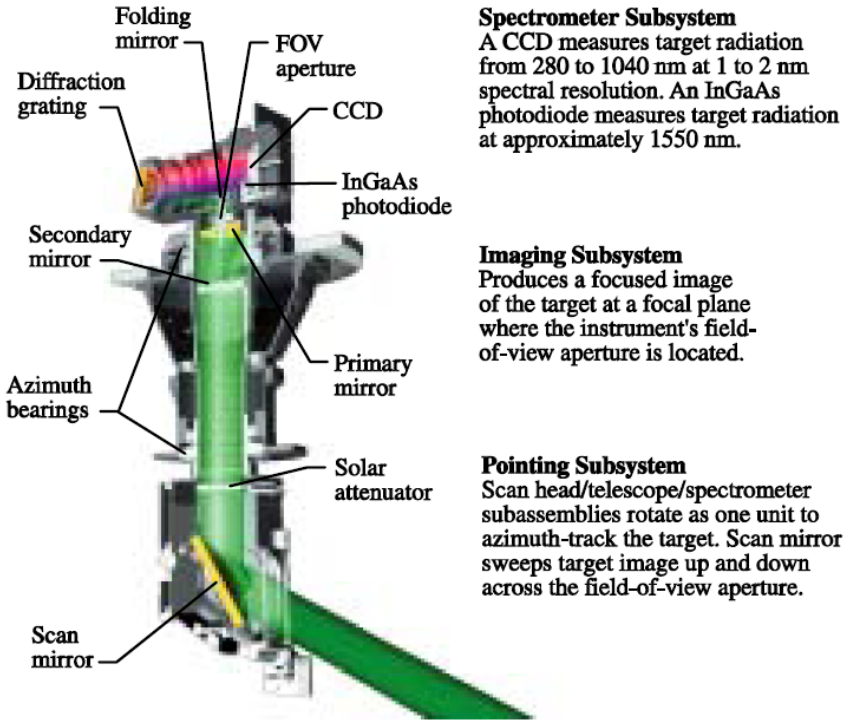


Figure 3. SAGE III Sensor Subsystems

These pixel groups are divided among 12 channels for solar observations and 3 channels for lunar observations. One of the features of the SAGE III/ISS instrument is the ability to reassign CCD pixels among these channels during flight to optimize instrument and retrieval performance. A listing of the different pixel assignments is provided in Appendix A.

As noted above, the CCD has 10 pixels for each of the 809 wavelength segments. The number of pixels utilized, consequently, defines the effective field of view (EFOV). For solar measurements, 3 of the pixels are averaged at 64 samples per second, which results in an EFOV of 30 arc seconds in the vertical and 1.5 arc minutes in the horizontal. This sampling translates to a vertical resolution of 0.5 km and a horizontal resolution of 1.5 km at the tangent point location.

For lunar measurements, the measurement integration time is increased, the sample rate is decreased to 16 samples per second, and the EFOV is widened to include all 10 elements of the CCD to improve the measurement's signal-to-noise ratio. The increased integration time and slower sample rate result in an increase in the EFOV to 1 arc minute in the vertical (or 1 km at the tangent point). The use of all 10 pixels increases the horizontal view to 5 arc minutes (or 5 km at the tangent point).

SAGE III/ISS Mission

The SAGE III/ISS mission is a joint research experiment between NASA, the European Space Agency (ESA), Thales Alenia Space-

Italia (TAS-I), Ball Aerospace & Technologies Corp. (BATC), and Hampton University [3]. The instrument was launched as part of a resupply mission to the ISS on February 19, 2017. The ISS travels in a Low-Earth orbit at an altitude of 330-435 km at an inclination of 51.6°. With these orbital parameters, solar occultation measurement opportunities cover a large range of latitudes (between 60° S and 60° N). Solar observations are limited by beta angles in the range of -40° to +40°. Nominal sampling coverage for this mission is shown in Figure 4.

Additionally, observations are limited by ISS component obstructions, visiting vehicles, ISS maneuvers, and extravehicular activity (EVA, i.e. spacewalks). Lastly, onboard ISS activities occasionally cause vibrations that make observations difficult or impossible.

Data Products and Availability

A list of the profile measurements contained in the science data products produced for the SAGE III/ISS mission is provided in Table 1. The reporting resolution for all species is 0.5 km. These data products, with attendant metadata, are archived and available in either HDF5 or binary format from the Atmospheric Science Data Center (ASDC).

Most data products are organized into individual solar or lunar events. This data retrieval system allows the user to select

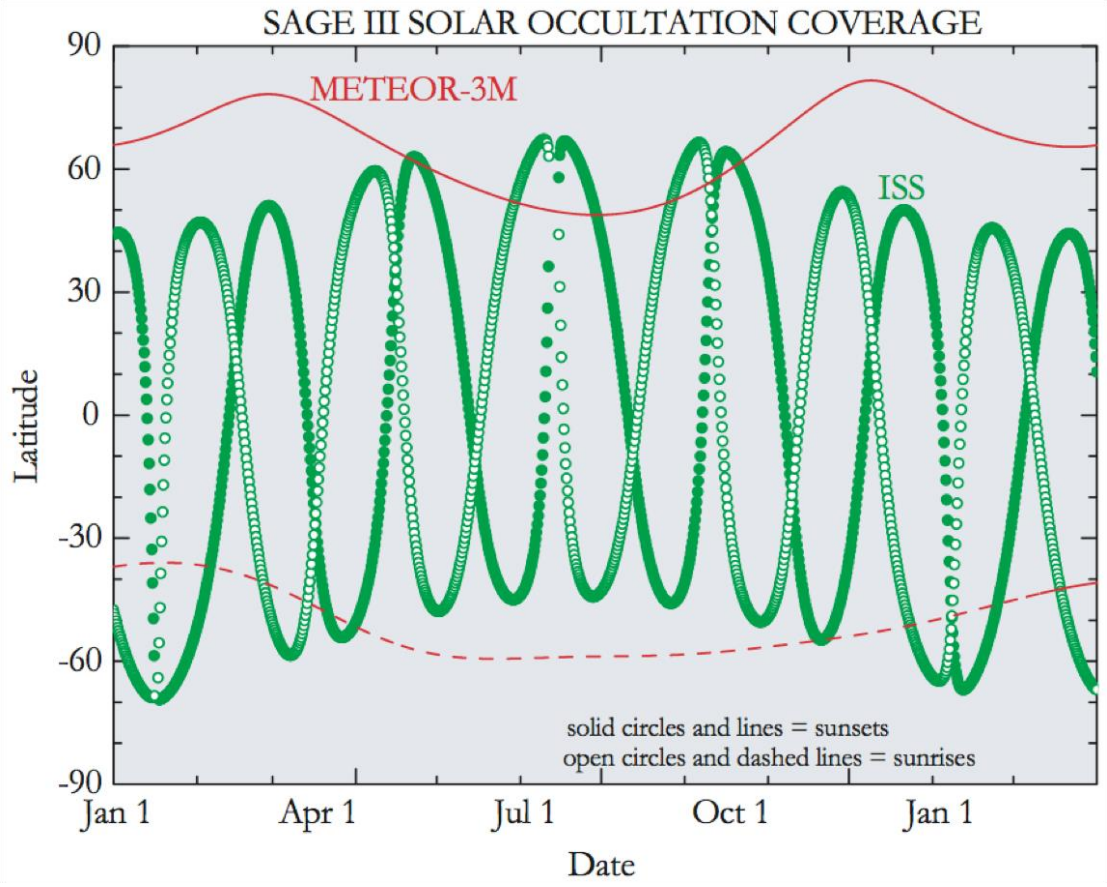


Figure 4. Nominal SAGE III/ISS Coverage Compared to SAGE III Meteor-3M Coverage

Table 1. SAGE III Measurement Inventory

Reported Measurement	Status*	Units	Vertical Range	Expected Precision	Product Residence
Transmission Slant Path Transmission	Provisional	none	0 - 100 km	0.05%	Level 1B Transmission
Aerosol (@ 9 wavelength bands) Extinction Coefficient	Provisional	km^{-1}	0 - 45 km	5%	Level 2 Solar
Ozone (MLR) Concentration	Provisional	cm^{-3}	0 - 100 km	10%	Level 2 Solar
Ozone (AO3) Concentration	Provisional	cm^{-3}	0 - 100 km	10%	Level 2 Solar
Ozone (Mesospheric) Concentration	Beta	cm^{-3}	0 - 100 km	10%	Level 2 Solar
NO_2 Concentration	Provisional	cm^{-3}	0 - 100 km	10%	Level 2 Solar
Water Vapor Concentration	Beta	cm^{-3}	0-60 km	10%	Level 2 Solar
Ozone Concentration	Provisional	cm^{-3}	0 -100 km	10%	Level 2 Lunar
NO_3 Concentration	Research	cm^{-3}	0 - 100 km	10%	Level 2 Lunar

* Release Status Definitions
Provisional – These data are partially validated and improvements are continuing; quality may not be optimal since validation and quality assurance are ongoing.
Research – Suitable for validation, potentially usable for science and publication. Users cautioned.
Beta – Products intended to enable users to gain familiarity with the parameters and the data. Comment to the SAGE III team is appreciated.

Level 1B and Level 2 products based on specified periods of time and measurement locations. SAGE III/ISS product files may be requested through the ASDC at any time.

Product Content and Formats

This section provides a description of the content and format for the HDF-EOS5 and binary Level 1B and Level 2 data products. The data formats for all binary product files are listed in detail in Appendices B, C, and D. This section also provides a description of the file-naming convention.

Reader software for SAGE III/ISS product files is available for download from the ASDC website. These readers are currently available for the IDL and Python programming languages. Due to changes in data format, readers for SAGE III products prior to version 5.1 are not compatible with later data releases.

Level 1B Transmission Product

Note: Transmission profiles currently use two different values for "fill". One is the large fill value defined in the product file (~3.4E38) to

indicate missing data, the other is a small fill value (=1E-12) to indicate the calculated transmission value was zero or negative.

The Level 1B Transmission product contains the SAGE III/ISS atmospheric slant path transmission profiles at 87 spectral channels, as listed in Appendix B. The profiles are skewed vertically and extend from sea level to an altitude of 100 km in 0.5 km intervals. The standard deviation of the binned transmission data is also provided for each reported altitude and channel. These datasets have been geolocated and normalized against exoatmospheric solar measurements to produce slant path transmission profiles. Algorithm retrievals outlined in the Algorithm Theoretical Basis Document (ATBD) are used to reduce and invert this data into the Level 2 products listed in Appendix C. The Level 1B product is only available for solar measurements.

In the construction of the transmission profiles, atmospheric density information is used to correct for refraction effects. This information is derived from temperature profiles interpolated to the location and time of each SAGE III/ISS event from global gridded meteorological analyses provided by NASA GMAO's MERRA-2. These data sets extend from the surface to a pressure-altitude of 0.1 hPa (~65 km). Above this altitude, climatological temperature data are used from GRAM95. The composite temperature profile information is included in the Level 1B data product.

Level 2 Solar Species Products

The Level 2 Solar Species products are produced from the Level 1B Transmission profiles by using algorithms described in the ATBD. Gas absorption data sources are identified in Appendix E. A description of the Level 2 Solar Species format is provided in Appendix C. This section discusses the content of the Level 2 Solar Species organized by species. Each species includes information on its relative uncertainty. Species are reported in profiles on a geometric altitude coordinate system with a vertical resolution of 0.5 km. Diurnal corrections are not applied to the retrieved constituent values.

Aerosol

Profiles of aerosol extinction at 9 wavelengths are provided from the surface or opaque cloud top to an altitude of 45 km, where the contribution due to aerosols becomes negligible at all wavelengths. In practice, the lower altitude of an aerosol extinction profile may be limited by the dynamic range of the detector and a high, integrated slant path optical depth. This detection limit occurs near a slant path optical depth of about 8, which translates to a column optical depth of approximately 0.02.

Two additional aerosol products are provided and Rayleigh extinction cross section at the center wavelength of each aerosol channel. Stratospheric optical depth values are only provided for profiles that extend below the altitude of the tropopause.

Nitrogen Dioxide

Profiles of nitrogen dioxide are provided in units of concentration over the altitude range 0 to 100 km. These profile measurements are derived from the multiple linear regression retrieval algorithm as described in the ATBD.

Ozone

Three different profiles of ozone are provided in units of concentration over the altitude range 0 to 100 km. One profile is based upon measurements made at short wavelengths in the Hartley-Huggins band (denoted Mesospheric Ozone), a second profile is based upon measurements made at visible wavelengths in the Chappius band (denoted

MLR Ozone), and a third profile is obtained using a similar approach utilized to process SAGE II data (denoted AO3 Ozone). Please note that the Mesospheric Ozone product is currently in a beta state (see Table 1).

Water Vapor

Profiles of water vapor are provided in units of concentration over the altitude range 0 to 60 km. The water vapor products are retrieved by using a nonlinear least-squares approach from the solar occultation measurements of slant path transmission. This data product is currently in a beta state (see Table 1).

Level 2 Lunar Species Products

The retrieval of constituent profiles from irradiance measurements acquired during lunar occultation events are more complex than those employed for solar events because they account for the spatial non-uniformity of the surface albedo of the moon and the much lower measurement signal. One important difference between the solar and lunar retrieval techniques is the absence of a Level 1B slant path transmission profile product for lunar occultation retrievals, a consequence of not being able to determine limb-darkening curves with sufficient accuracy to calibrate each lunar occultation event. The inaccuracies in the registration of the limb-darkening curve arise from small uncertainties in the pointing knowledge of the instrument in the presence of large variations in albedo across the lunar surface.

As a result of these challenges, the retrieval of lunar Level 2 products uses a different approach than is used for solar. A multiple linear regression is performed on the spectrum of relative optical depth for each packet, with the species absorption cross sections evaluated as the independent variables. Gas absorption data sources are identified in Appendix E. The resulting slant-path column densities are then bin-averaged, onion peeled, and reported on a geometric coordinate system with a vertical resolution of 0.5 km to maintain grid spacing compatibility with the solar Level 2 products. The tangent height registration of data for lunar profiles is accomplished by two methods, an ephemeris-based calculation and a comparison to a forward model of the oxygen A-band. The offset between the two methods is reported in the product.

A description of the content of these products is provided below and organized by species. Each product includes information on its relative uncertainty and a data quality assurance flag set.

A description of the lunar data product format and content is provided in Appendix D.

Ozone

Profiles of ozone are provided in units of concentration from 0 to 100 km. Profile measurements are derived from the multiple linear regression retrieval algorithm used for GAMS described in Reference [4].

Nitrogen Trioxide

Profiles of nitrogen trioxide are provided in units of concentration from 0 to 100 km. Profile measurements are derived from the multiple linear regression retrieval algorithm used for GAMS described in Reference [4]. This data product is currently in a research state (see Table 1).

File-Naming Convention

Following is a list of products and the file-naming convention for each product that shall be generated by SAGE III/ISS SCF processing.

- **L1B Solar Transmission Binary Products:** g3b.tb.{xxxxxxXXvzz.zz}

- **L1B Solar Transmission HDF Products:** g3b.t.{xxxxxxXXvzz.zz}
- **Level 2 Solar Binary Products:** g3b.sspb.{xxxxxxXXvzz.zz}
- **Level 2 Solar HDF Products:** g3b.ssp.{xxxxxxXXvzz.zz}
- **Level 2 Lunar Binary Products:** g3b.lspb.{xxxxxxXXvzz.zz}
- **Level 2 Lunar HDF Products:** g3b.lsp.{xxxxxxXXvzz.zz}
- **where:**

b	Binary
t	Level 1B Transmission
ssp	Level 2 Solar Species
{xxxxxxXX}	Event ID (6 digit orbit number, 2 digit event type: where 10 = sunrise, 20 = sunset, 30 = moonrise, 40 = moonset)
{vzz.zz}	Data Product Version Number

Example: g3b.tb.00645120v05.10

Refers to a transmission binary file for SAGE III/ISS captured during a sunset for orbit 6361 and released as a product of SCF Data Product Version 05.10

Example: g3b.ssp.00645110v05.10

Refers to a solar HDF5 file for SAGE III/ISS captured during a sunrise for orbit 6451 and released as a product of SCF Data Product Version 05.10

Quality Assurance Bit Flags

SAGE III Data Products are reviewed prior to their release. Profiles have values reported only for those species and altitudes where there is confidence in the ability of the algorithms to produce representative products. Each file contains bit flags that convey information about processing decisions to the user.

Event Condition QA Flags (Solar Events)

A binary bit in this 32-bit integer is set to "1" when the following event conditions occur:

Bit 0 – Nadir pointing by the hexapod platform could not be achieved.

Bit 1 – Instrument contamination door was closed.

Bit 2 – Packet-time assignments were questionable.

Bit 3 – Large ISS vibrational disturbances were detected when collecting exoatmospheric data.

Bit 4 – Obstruction of the target by an ISS element was detected when collecting exoatmospheric data.

Bit 5 – Nominal CCD pixel-wavelength assignments were used (no exoatmospheric calibration).

Bit 6 – The sun was obstructed by the moon.

Event Condition QA Flags (Lunar Events)

A binary bit in this 32-bit integer is set to "1" when the following event conditions occur:

Bit 0 – Nadir pointing by the hexapod platform could not be achieved.

Bit 1 – Instrument contamination door was closed.

Bit 2 – Packet-time assignments were questionable.

Bit 3 – Large ISS vibrational disturbances were detected when collecting exoatmospheric data.

Bit 4 – Nominal CCD pixel-wavelength assignments were used (no exoatmospheric calibration).

Altitude Dependent QA Flags

Each altitude bin is assigned a 32-bit integer. A binary bit in an integer is set to "1" when the following conditions occur:

Bit 0 – Large ISS vibrational disturbances were detected when collecting data for this altitude bin.

Retrieved Profile QA Flags

The profile bit flags associated with retrieved vertical profiles are all defined in the same way. The lowest four bits (0-3) form an integer value indicating the smoothing kernel used for that shell, and the values are defined as follows:

0	No smoothing
1	1-2-1 smoothing
2	1-2-3-2-1 smoothing
3	5pt boxcar average
4	7pt boxcar average
5	9pt boxcar average
6	11pt boxcar average
7-15	Spare

Bit 4 being set indicates that the retrieved slant-path profile value was negative.

Bit 5 being set indicates that the retrieved slant-path profile value contained 'fill' data.

Bit 6 indicates that the shell was given the 'fill' value in the smoothing process because the shell was outside of the altitude window selected for smoothing. The module selects the largest block of acceptable points in the profile for smoothing, and then places 'fill' in the remaining shells.

References

[1] W. Chu and R. Veiga, "SAGE III/EOS," *SPIE, vol. 3501,* pp. 52-60, September 1998.

[2] M. P. McCormick, P. Hamill, T. J. Pepin, W. P. Chu and T. Swissler, "Satellite Studies of the Stratospheric Aerosol," *BAMS, vol 60,* pp. 1038-1046, September 1979.

[3] L. Szatkowski, O. Bradley Jr, L. Mauldin III, M. Wusk, W. Chu, L. Farwell II and P. Galeone, "Stratospheric Aerosol and Gas Experiment III (SAGE III) Mission aboard the International Space Station," *SPIE, vol.3756,* pp. 164-169, July 1999.

[4] M. Pitts, L. Thomason, J. Zawodny, B. Wenny, J. Livingston, P. Russell, J.-H. Yee, W. Swartz and R. Shetter, "Ozone observations by the Gas and Aerosol Measurement Sensor during SOLVE II," *Atmos. Chem. Phys.*, no. 6, pp. 2695-2709, 2006.

[5] K. Bogumil, J. Orphal, T. Homann, S. Voigt, P. Spietz, O. Fleischmann, A. Vogel, M. Hartmann, H. Bovensmann, J. Frerick and J. Burrows, "Measurements of molecular absorption spectra with the SCIAMACHY pre-flight model: instrument characterization and reference data for atmospheric remote-sensing in the 230–2380 nm region," *Journal of Photochemistry and Photobiology A: Chemistry*, vol. 157, no. 2-3, pp. 167-184, 2003.

[6] R. Yokelson, J. Burkholder, R. Fox, R. Talukdar and A. Ravishankara, "Temperature Dependence of the NO3 Absorption Spectrum," *Journal of Physical Chemistry*, vol. 98, pp. 13144-13150, 1994.

[7] L. Rothman, D. Jacquemart, A. Barbe, D. Benner, M. Birk, L. Brown and others, "The HITRAN 2004 molecular spectroscopic database," *Journal of Quantitative Spectroscopy & Radiative Transfer,* vol. 96, pp. 139-204, 2005.

[8] G. Greenblatt, J. Orlando, J. Burkholder and A. Ravishankara, "Absorption Measurements of Oxygen Between 330 and 1140 nm," *Journal of Geophysical Research,* vol. 95, pp. 18577-18582, 1990.

[9] A. Bucholtz, "Rayleigh-scattering calculations for the terrestrial atmosphere," *Applied Optics,* vol. 34, pp. 2765-2773, 1995.

Appendix A. SAGE III/ISS Nominal CCD Pixel Assignments

Table A1. Nominal CCD Assignments for Solar Data Collection (CCD Table Version 4)

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
1	3	281.39	3	282.32	281.85	Mesospheric O3	
2	4	282.32	11	289.77	286.04	Mesospheric O3	8-pixel sum
3	12	289.77	18	296.33	293.05	Mesospheric O3	7-pixel sum
4	110	381.77	114	386.48	384.12	Aerosol Ch. 1/Rayleigh Ext.	5-pixel average
5	164	432.66	164	433.6	433.13	NO2 Gas	
6	165	433.6	165	434.54	434.07	NO2 Gas	
7	166	434.54	166	435.48	435.01	NO2 Gas	
8	167	435.48	167	436.42	435.95	NO2 Gas	
9	168	436.42	168	437.36	436.89	NO2 Gas	
10	169	437.36	169	438.3	437.83	NO2 Gas	
11	170	438.3	170	439.24	438.77	NO2 Gas	
12	171	439.24	171	440.18	439.71	NO2 Gas	
13	172	440.18	172	441.12	440.65	NO2 Gas	
14	173	441.12	173	442.06	441.59	NO2 Gas	
15	174	442.06	174	443	442.53	NO2 Gas	
16	175	443	175	443.94	443.47	NO2 Gas	
17	176	443.94	176	444.88	444.41	NO2 Gas	
18	177	444.88	177	445.82	445.35	NO2 Gas	
19	178	445.82	178	446.76	446.29	NO2 Gas	
20	179	446.76	179	447.7	447.23	Aerosol Channel 2 / NO2 Gas	
21	180	447.7	180	448.64	448.17	Aerosol Channel 2 / NO2 Gas	
22	181	448.64	181	449.58	449.11	Aerosol Channel 2 / NO2 Gas	
23	182	449.58	182	450.52	450.05	Aerosol Channel 2 / NO2 Gas	
24	255	518.18	259	522.9	520.54	Aerosol Channel 3	5-pixel average
25	300	560.66	302	563.49	562.08	O3 Gas	3-pixel sum
26	307	567.27	309	570.1	568.68	O3 Gas	3-pixel sum
27	314	573.87	316	576.7	575.29	O3 Gas	3-pixel sum
28	321	580.48	323	583.31	581.89	O3 Gas	3-pixel sum

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
29	328	587.08	330	589.91	588.5	O3 Gas	3-pixel sum
30	335	593.68	337	596.51	595.1	O3 Gas	3-pixel sum
31	342	600.29	344	603.11	601.7	Aerosol Channel 4 / O3 Gas	3-pixel sum
32	349	606.89	351	609.71	608.3	O3 Gas	3-pixel sum
33	356	613.49	358	616.31	614.9	O3 Gas	3-pixel sum
34	363	620.08	365	622.91	621.5	O3 Gas	3-pixel sum
35	420	673.76	424	678.47	676.12	Aerosol Channel 5	5-pixel average
36	505	753.61	509	758.3	755.96	Aerosol Channel 6	5-pixel average
37	510	758.3	510	759.24	758.77	O2 A-Band	
38	511	759.24	511	760.18	759.71	O2 A-Band	
39	512	760.18	512	761.11	760.64	O2 A-Band	
40	513	761.11	513	762.05	761.58	O2 A-Band	
41	514	762.05	514	762.99	762.52	O2 A-Band	
42	515	762.99	515	763.93	763.46	O2 A-Band	
43	516	763.93	516	764.86	764.39	O2 A-Band	
44	517	764.86	517	765.8	765.33	O2 A-Band	
45	518	765.8	518	766.74	766.27	O2 A-Band	
46	519	766.74	519	767.67	767.21	O2 A-Band	
47	520	767.67	520	768.61	768.14	O2 A-Band	
48	521	768.61	521	769.55	769.08	O2 A-Band	
49	522	769.55	522	770.49	770.02	O2 A-Band	
50	523	770.49	523	771.42	770.95	O2 A-Band	
51	626	866.79	630	871.45	869.12	Aerosol Channel 7	5-pixel average
52	683	919.9	683	920.83	920.36	Water Vapor	
53	697	932.92	697	933.85	933.39	Water Vapor	
54	698	933.85	698	934.78	934.32	Water Vapor	
55	699	934.78	699	935.71	935.25	Water Vapor	
56	700	935.71	700	936.64	936.18	Water Vapor	

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
57	701	936.64	701	937.57	937.11	Water Vapor	
58	702	937.57	702	938.5	938.04	Water Vapor	
59	703	938.5	703	939.43	938.97	Water Vapor	
60	704	939.43	704	940.36	939.9	Water Vapor	
61	705	940.36	705	941.29	940.83	Water Vapor	
62	706	941.29	706	942.22	941.76	Water Vapor	
63	707	942.22	707	943.15	942.69	Water Vapor	
64	708	943.15	708	944.08	943.62	Water Vapor	
65	709	944.08	709	945.01	944.55	Water Vapor	
66	710	945.01	710	945.94	945.48	Water Vapor	
67	711	945.94	711	946.87	946.41	Water Vapor	
68	712	946.87	712	947.8	947.34	Water Vapor	
69	713	947.8	713	948.73	948.27	Water Vapor	
70	714	948.73	714	949.66	949.2	Water Vapor	
71	715	949.66	715	950.59	950.13	Water Vapor	
72	716	950.59	716	951.52	951.06	Water Vapor	
73	717	951.52	717	952.45	951.99	Water Vapor	
74	718	952.45	718	953.38	952.91	Water Vapor	
75	719	953.38	719	954.31	953.84	Water Vapor	
76	720	954.31	720	955.24	954.77	Water Vapor	
77	721	955.24	721	956.17	955.7	Water Vapor	
78	722	956.17	722	957.1	956.63	Water Vapor	
79	723	957.1	723	958.03	957.56	Water Vapor	
80	738	971.03	738	971.96	971.5	Water Vapor	
81	790	1019.29	790	1020.22	1019.75	Aerosol Channel 8	
82	791	1020.22	791	1021.14	1020.68	Aerosol Channel 8	
83	792	1021.14	792	1022.07	1021.61	Aerosol Channel 8	
84	793	1022.07	793	1023	1022.54	Aerosol Channel 8	
85	794	1023	794	1023.93	1023.46	Aerosol Channel 8	
86	795	1023.93	795	1024.85	1024.39	Aerosol Channel 8	

Table A2. Nominal CCD Assignments for Lunar Data Collection (CCD Table Version 2)

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
1	106	378.18	106	379.13	378.65	O3, NO2, NO3, and OCIO are measured using science pixel 1 through science pixel 91.	Science pixel 1 through science pixel 294 contain single CCD pixels.
2	107	379.13	107	380.07	379.6		
3	108	380.07	108	381.01	380.54		
4	109	381.01	109	381.95	381.48		
5	110	381.95	110	382.9	382.42		
6	111	382.9	111	383.84	383.37		
7	112	383.84	112	384.78	384.31		
8	113	384.78	113	385.72	385.25		
9	114	385.72	114	386.66	386.19		
10	115	386.66	115	387.6	387.13		
11	116	387.6	116	388.54	388.07		
12	117	388.54	117	389.48	389.01		
13	118	389.48	118	390.42	389.95		
14	119	390.42	119	391.36	390.89		
15	120	391.36	120	392.3	391.83		
16	121	392.3	121	393.24	392.77		
17	122	393.24	122	394.17	393.71		
18	123	394.17	123	395.11	394.64		
19	124	395.11	124	396.05	395.58		
20	125	396.05	125	396.99	396.52		
21	126	396.99	126	397.93	397.46		
22	127	397.93	127	398.87	398.4		
23	128	398.87	128	399.81	399.34		
24	129	399.81	129	400.75	400.28		
25	130	400.75	130	401.69	401.22		
26	131	401.69	131	402.63	402.16		
27	132	402.63	132	403.57	403.1		
28	133	403.57	133	404.52	404.05		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
29	134	404.52	134	405.46	404.99	O3, NO2, NO3, and OCIO are measured using science pixel 1 through science pixel 91.	Science pixel 1 through science pixel 294 contain single CCD pixels.
30	145	414.87	145	415.82	415.35		
31	146	415.82	146	416.76	416.29		
32	147	416.76	147	417.7	417.23		
33	148	417.7	148	418.64	418.17		
34	149	418.64	149	419.59	419.12		
35	150	419.59	150	420.53	420.06		
36	151	420.53	151	421.47	421		
37	152	421.47	152	422.42	421.94		
38	153	422.42	153	423.36	422.89		
39	154	423.36	154	424.3	423.83		
40	155	424.3	155	425.25	424.77		
41	156	425.25	156	426.19	425.72		
42	157	426.19	157	427.13	426.66		
43	158	427.13	158	428.07	427.6		
44	159	428.07	159	429.02	428.55		
45	160	429.02	160	429.96	429.49		
46	161	429.96	161	430.9	430.43		
47	162	430.9	162	431.85	431.37		
48	163	431.85	163	432.79	432.32		
49	164	432.79	164	433.73	433.26		
50	165	433.73	165	434.67	434.2		
51	166	434.67	166	435.62	435.14		
52	167	435.62	167	436.56	436.09		
53	168	436.56	168	437.5	437.03		
54	169	437.5	169	438.44	437.97		
55	170	438.44	170	439.38	438.91		
56	171	439.38	171	440.33	439.85		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
57	172	440.33	172	441.27	440.8	O3, NO2, NO3, and OCIO are measured using science pixel 1 through science pixel 91.	Science pixel 1 through science pixel 294 contain single CCD pixels.
58	173	441.27	173	442.21	441.74		
59	174	442.21	174	443.15	442.68		
60	175	443.15	175	444.09	443.62		
61	176	444.09	176	445.03	444.56		
62	177	445.03	177	445.97	445.5		
63	178	445.97	178	446.91	446.44		
64	179	446.91	179	447.85	447.38		
65	180	447.85	180	448.79	448.32		
66	181	448.79	181	449.74	449.26		
67	182	449.74	182	450.68	450.21		
68	183	450.68	183	451.62	451.15		
69	184	451.62	184	452.56	452.09		
70	185	452.56	185	453.5	453.03		
71	186	453.5	186	454.44	453.97		
72	187	454.44	187	455.38	454.91		
73	188	455.38	188	456.32	455.85		
74	189	456.32	189	457.26	456.79		
75	190	457.26	190	458.2	457.73		
76	191	458.2	191	459.14	458.67		
77	192	459.14	192	460.08	459.61		
78	193	460.08	193	461.02	460.55		
79	194	461.02	194	461.97	461.5		
80	195	461.97	195	462.91	462.44		
81	196	462.91	196	463.85	463.38		
82	197	463.85	197	464.79	464.32		
83	198	464.79	198	465.74	465.27		
84	199	465.74	199	466.68	466.21		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
85	200	466.68	200	467.63	467.16	O3, NO2, NO3, and OCIO are measured using science pixel 1 through science pixel 91.	Science pixel 1 through science pixel 294 contain single CCD pixels.
86	201	467.63	201	468.57	468.1		
87	202	468.57	202	469.52	469.05		
88	203	469.52	203	470.47	469.99		
89	204	470.47	204	471.42	470.94		
90	205	471.42	205	472.36	471.89		
91	206	472.36	206	473.32	472.84		
92	207	473.32	207	474.27	473.79	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	
93	208	474.27	208	475.22	474.74		
94	209	475.22	209	476.17	475.7		
95	210	476.17	210	477.13	476.65		
96	211	477.13	211	478.09	477.61		
97	212	478.09	212	479.05	478.57		
98	213	479.05	213	480.01	479.53		
99	214	480.01	214	480.97	480.49		
100	215	480.97	215	481.94	481.45		
101	216	481.94	216	482.9	482.42		
102	217	482.9	217	483.87	483.39		
103	218	483.87	218	484.84	484.36		
104	219	484.84	219	485.82	485.33		
105	220	485.82	220	486.8	486.31		
106	221	486.8	221	487.78	487.29		
107	222	487.78	222	488.76	488.27		
108	223	488.76	223	489.75	489.25		
109	234	498.42	234	499.37	498.89		
110	235	499.37	235	500.31	499.84		
111	236	500.31	236	501.26	500.79		
112	237	501.26	237	502.21	501.73		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
113	238	502.21	238	503.15	502.68	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
114	239	503.15	239	504.1	503.62		
115	240	504.1	240	505.04	504.57		
116	241	505.04	241	505.99	505.52		
117	242	505.99	242	506.93	506.46		
118	243	506.93	243	507.88	507.41		
119	244	507.88	244	508.82	508.35		
120	245	508.82	245	509.77	509.3		
121	246	509.77	246	510.72	510.24		
122	247	510.72	247	511.66	511.19		
123	248	511.66	248	512.61	512.13		
124	249	512.61	249	513.55	513.08		
125	250	513.55	250	514.5	514.02		
126	251	514.5	251	515.44	514.97		
127	252	515.44	252	516.38	515.91		
128	253	516.38	253	517.33	516.86		
129	254	517.33	254	518.27	517.8		
130	255	518.27	255	519.22	518.75		
131	256	519.22	256	520.16	519.69		
132	257	520.16	257	521.11	520.64		
133	258	521.11	258	522.05	521.58		
134	259	522.05	259	523	522.52		
135	260	523	260	523.94	523.47		
136	261	523.94	261	524.88	524.41		
137	262	524.88	262	525.83	525.36		
138	263	525.83	263	526.77	526.3		
139	264	526.77	264	527.72	527.24		
140	265	527.72	265	528.66	528.19		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
141	266	528.66	266	529.6	529.13	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
142	267	529.6	267	530.55	530.08		
143	268	530.55	268	531.49	531.02		
144	269	531.49	269	532.44	531.96		
145	270	532.44	270	533.38	532.91		
146	271	533.38	271	534.32	533.85		
147	272	534.32	272	535.27	534.79		
148	273	535.27	273	536.21	535.74		
149	274	536.21	274	537.15	536.68		
150	275	537.15	275	538.1	537.62		
151	276	538.1	276	539.04	538.57		
152	277	539.04	277	539.98	539.51		
153	278	539.98	278	540.93	540.45		
154	279	540.93	279	541.87	541.4		
155	280	541.87	280	542.81	542.34		
156	281	542.81	281	543.76	543.28		
157	282	543.76	282	544.7	544.23		
158	283	544.7	283	545.64	545.17		
159	284	545.64	284	546.59	546.11		
160	285	546.59	285	547.53	547.06		
161	286	547.53	286	548.47	548		
162	293	554.13	293	555.07	554.6		
163	294	555.07	294	556.01	555.54		
164	295	556.01	295	556.96	556.49		
165	296	556.96	296	557.9	557.43		
166	297	557.9	297	558.84	558.37		
167	298	558.84	298	559.79	559.31		
168	299	559.79	299	560.73	560.26		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
169	300	560.73	300	561.67	561.2	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
170	301	561.67	301	562.61	562.14		
171	302	562.61	302	563.56	563.09		
172	303	563.56	303	564.5	564.03		
173	304	564.5	304	565.44	564.97		
174	305	565.44	305	566.38	565.91		
175	306	566.38	306	567.33	566.86		
176	307	567.33	307	568.27	567.8		
177	308	568.27	308	569.21	568.74		
178	309	569.21	309	570.16	569.68		
179	310	570.16	310	571.1	570.63		
180	311	571.1	311	572.04	571.57		
181	312	572.04	312	572.98	572.51		
182	313	572.98	313	573.93	573.45		
183	314	573.93	314	574.87	574.4		
184	315	574.87	315	575.81	575.34		
185	316	575.81	316	576.75	576.28		
186	317	576.75	317	577.7	577.22		
187	318	577.7	318	578.64	578.17		
188	319	578.64	319	579.58	579.11		
189	320	579.58	320	580.52	580.05		
190	321	580.52	321	581.47	581		
191	322	581.47	322	582.41	581.94		
192	323	582.41	323	583.35	582.88		
193	324	583.35	324	584.29	583.82		
194	325	584.29	325	585.24	584.77		
195	326	585.24	326	586.18	585.71		
196	327	586.18	327	587.12	586.65		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
197	328	587.12	328	588.06	587.59	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
198	329	588.06	329	589.01	588.54		
199	330	589.01	330	589.95	589.48		
200	331	589.95	331	590.89	590.42		
201	332	590.89	332	591.84	591.36		
202	333	591.84	333	592.78	592.31		
203	334	592.78	334	593.72	593.25		
204	335	593.72	335	594.66	594.19		
205	336	594.66	336	595.61	595.13		
206	337	595.61	337	596.55	596.08		
207	338	596.55	338	597.49	597.02		
208	339	597.49	339	598.43	597.96		
209	340	598.43	340	599.38	598.91		
210	341	599.38	341	600.32	599.85		
211	342	600.32	342	601.26	600.79		
212	343	601.26	343	602.21	601.73		
213	344	602.21	344	603.15	602.68		
214	345	603.15	345	604.09	603.62		
215	346	604.09	346	605.03	604.56		
216	347	605.03	347	605.98	605.5		
217	348	605.98	348	606.92	606.45		
218	349	606.92	349	607.86	607.39		
219	350	607.86	350	608.8	608.33		
220	351	608.8	351	609.75	609.28		
221	352	609.75	352	610.69	610.22		
222	353	610.69	353	611.63	611.16		
223	354	611.63	354	612.58	612.1		
224	355	612.58	355	613.52	613.05		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
225	356	613.52	356	614.46	613.99	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
226	357	614.46	357	615.4	614.93		
227	358	615.4	358	616.35	615.88		
228	359	616.35	359	617.29	616.82		
229	360	617.29	360	618.23	617.76		
230	361	618.23	361	619.18	618.7		
231	362	619.18	362	620.12	619.65		
232	363	620.12	363	621.06	620.59		
233	364	621.06	364	622.01	621.53		
234	365	622.01	365	622.95	622.48		
235	366	622.95	366	623.89	623.42		
236	367	623.89	367	624.83	624.36		
237	368	624.83	368	625.78	625.31		
238	369	625.78	369	626.72	626.25		
239	370	626.72	370	627.66	627.19		
240	371	627.66	371	628.61	628.13		
241	372	628.61	372	629.55	629.08		
242	373	629.55	373	630.49	630.02		
243	374	630.49	374	631.44	630.96		
244	375	631.44	375	632.38	631.91		
245	376	632.38	376	633.32	632.85		
246	377	633.32	377	634.26	633.79		
247	378	634.26	378	635.21	634.74		
248	379	635.21	379	636.15	635.68		
249	380	636.15	380	637.09	636.62		
250	381	637.09	381	638.04	637.57		
251	382	638.04	382	638.98	638.51		
252	383	638.98	383	639.92	639.45		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
253	384	639.92	384	640.87	640.39	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
254	385	640.87	385	641.81	641.34		
255	386	641.81	386	642.75	642.28		
256	387	642.75	387	643.7	643.22		
257	388	643.7	388	644.64	644.17		
258	389	644.64	389	645.58	645.11		
259	390	645.58	390	646.52	646.05		
260	391	646.52	391	647.47	647		
261	392	647.47	392	648.41	647.94		
262	393	648.41	393	649.35	648.88		
263	394	649.35	394	650.3	649.83		
264	395	650.3	395	651.24	650.77		
265	396	651.24	396	652.18	651.71		
266	397	652.18	397	653.13	652.65		
267	398	653.13	398	654.07	653.6		
268	399	654.07	399	655.01	654.54		
269	400	655.01	400	655.96	655.48		
270	401	655.96	401	656.9	656.43		
271	402	656.9	402	657.84	657.37		
272	403	657.84	403	658.79	658.31		
273	404	658.79	404	659.73	659.26		
274	405	659.73	405	660.67	660.2		
275	406	660.67	406	661.61	661.14		
276	407	661.61	407	662.56	662.09		
277	408	662.56	408	663.5	663.03		
278	409	663.5	409	664.44	663.97		
279	410	664.44	410	665.39	664.91		
280	411	665.39	411	666.33	665.86		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
281	412	666.33	412	667.27	666.8	O3, NO2, and NO3, are measured using science pixel 92 through science pixel 294.	Science pixel 1 through science pixel 294 contain single CCD pixels.
282	413	667.27	413	668.22	667.74		
283	414	668.22	414	669.16	668.69		
284	415	669.16	415	670.1	669.63		
285	416	670.1	416	671.04	670.57		
286	417	671.04	417	671.99	671.52		
287	418	671.99	418	672.93	672.46		
288	419	672.93	419	673.87	673.4		
289	420	673.87	420	674.82	674.34		
290	421	674.82	421	675.76	675.29		
291	422	675.76	422	676.7	676.23		
292	423	676.7	423	677.64	677.17		
293	424	677.64	424	678.59	678.12		
294	425	678.59	425	679.53	679.06		
295	426	679.53	426	680.47	680	O2 B-band science pixels 295 through 313 are not currently utilized.	
296	427	680.47	427	681.41	680.94		
297	428	681.41	428	682.36	681.89		
298	429	682.36	429	683.3	682.83		
299	430	683.3	430	684.24	683.77		
300	431	684.24	431	685.19	684.71		
301	432	685.19	432	686.13	685.66		
302	433	686.13	433	687.07	686.6		
303	434	687.07	434	688.01	687.54		
304	435	688.01	435	688.95	688.48		
305	436	688.95	436	689.9	689.43		
306	437	689.9	437	690.84	690.37		
307	438	690.84	438	691.78	691.31		
308	439	691.78	439	692.72	692.25		

Science Pixel Group	CCD Start Pixel	Start Wavelength (nm)	CCD End Pixel	End Wavelength (nm)	Centerline Wavelength (nm)	Measured Parameter	Comment
309	440	692.72	440	693.67	693.19	O2 B-band science pixels 295 through 313 are not currently utilized.	
310	441	693.67	441	694.61	694.14		
311	442	694.61	442	695.55	695.08		
312	443	695.55	443	696.49	696.02		
313	444	696.49	444	697.43	696.96		
314	506	754.73	507	756.6	755.67	O2 A-band science pixels 314 through 338 are used for altitude registration.	2-pixel average
315	508	756.6	509	758.47	757.54		2-pixel average
316	510	758.47	510	759.41	758.94		
317	511	759.41	511	760.34	759.87		
318	512	760.34	512	761.27	760.81		
319	513	761.27	513	762.21	761.74		
320	514	762.21	514	763.14	762.68		
321	515	763.14	515	764.08	763.61		
322	516	764.08	516	765.01	764.54		
323	517	765.01	517	765.94	765.48		
324	518	765.94	518	766.88	766.41		
325	519	766.88	519	767.81	767.34		
326	520	767.81	520	768.74	768.28		
327	521	768.74	521	769.68	769.21		
328	522	769.68	522	770.61	770.14		
329	523	770.61	523	771.54	771.07		
330	524	771.54	524	772.47	772.01		
331	525	772.47	525	773.4	772.94		
332	526	773.4	526	774.33	773.87		
333	527	774.33	527	775.27	774.8		
334	528	775.27	528	776.2	775.73		
335	529	776.2	529	777.13	776.66		
336	530	777.13	530	778.06	777.59		
337	531	778.06	531	778.99	778.52		
338	532	778.99	532	779.92	779.45		

Appendix B. SAGE III/ISS Level 1B Solar Transmission Products

Table B1. Binary File Format Sheet: SAGE III/ISS Level 1B Solar Transmission Product

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
0	0	1	I4	0	3	Event ID	**Event Identification**	
1	1	1	I4	4	7	YYYYMMDD		
2	2	1	R4	8	11	Year Fraction		
3	3	1	R4	12	15	Subtangent Latitude at 20 km		
4	4	1	R4	16	19	Subtangent Longitude at 20 km		
5	5	1	I4	20	23	HHMMSS		
6	6	1	I4	24	27	Integer	**Fill Values**	
7	7	1	R4	28	31	Floating Point		
8	8	1	I4	32	35	Mission ID	**Version Identification**	
9	9	1	R4	36	39	Definitive Orbit Processing		
10	10	1	I4	40	43	CCD Table		
11	11	1	R4	44	47	Level 0		
12	12	1	R4	48	51	Software Processing		
13	13	1	R4	52	55	Data Product		
14	14	1	R4	56	59	Spectroscopic Database		
15	15	1	R4	60	63	GRAM 95		
16	16	1	R4	64	67	Meteorological Data		
17	17	1	R4	68	71	Altitude Grid Spacing	**Data Grid Parameters**	km
18	18	1	I4	72	75	Number of Transmission Profiles		
19	19	1	I4	76	79	Number of Ground Track Points		
20	20	1	I4	80	83	Number of Pressure Surfaces		
21	21	1	I4	84	87	Number of CCD Pixel Groups		
22	22	1	I4	88	91	Number of Altitudes		
23	23	1	I4	92	95	Spacecraft-Referenced (1:Sunrise, 2:Sunset)	**Event Type**	
24	24	1	I4	96	99	Earth-Referenced (1:Sunrise, 2:Sunset)		
25	25	1	R4	100	103	Solar Beta Angle		deg
26	26	1	I4	104	107	Aurora Contamination (0:N/A, 1:T, 2:F)		
27	27	1	I4	108	111	Ephemeris Source (5:GPS)		

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
28	38	11	I4	112	155	Date	**Ground Track-Indexed**	
39	49	11	I4	156	199	Time	**Data (for 11 tangent**	
50	60	11	R4	200	243	Subtangent Latitude	**altitudes: 0km to**	deg
61	71	11	R4	244	287	Subtangent Longitude	**100km at 10km**	deg
72	82	11	R4	288	331	Ray Direction at Subtangent	**intervals)**	deg
83	93	11	R4	332	375	Spacecraft Latitude		deg
94	104	11	R4	376	419	Spacecraft Longitude		deg
105	115	11	R4	420	463	Spacecraft Altitude		km
116	315	200	R4	464	1263	Geometric Altitude	**Altitude-Indexed Data**	km
316	515	200	R4	1264	2063	Geopotential Altitude		km
516	715	200	R4	2064	2863	Pressure		hPa
716	915	200	R4	2864	3663	Pressure Uncertainty		hPa
916	1115	200	R4	3664	4463	Temperature		K
1116	1315	200	R4	4464	5263	Temperature Uncertainty		K
1316	1515	200	R4	5264	6063	Neutral Density		cm^{-3}
1516	1715	200	R4	6064	6863	Neutral Density Uncertainty		cm^{-3}
1716	1915	200	I4	6864	7663	Met Source (0:GRAM 95, 2:MERRA-2)		
1916	1916	1	R4	7664	7667	Tropopause Temperature	**Derived Tropopause**	K
1917	1917	1	R4	7668	7671	Tropopause Altitude		km
1918	1918	1	R4	7672	7675	Tropopause Pressure		hPa
1919	1960	42	R4	7676	7843	Pressure	**Pressure Surface-**	hPa
1961	2002	42	R4	7844	8011	Temperature	**Indexed Data**	K
2003	2044	42	R4	8012	8179	Temperature Uncertainty		K
2045	2086	42	R4	8180	8347	Altitude		km
2087	2087	1	I4	8348	8351	Met Source (0:GRAM95,2:MERRA-2)		
2088	2088	1	R4	8352	8355	CCD Temperature	**Instrument Condition**	°C
2089	2089	1	R4	8356	8359	Spectrometer Zenith Temperature		°C
2090	2090	1	R4	8360	8363	CCD Temperature Departure From Nominal		°C
2091	2091	1	I4	8364	8367	Ephemeris QA (0:Missing Data, 1:Nominal, 2:Interpolation Performed, 3:Questionable Data)	**Quality Assurance Information (See documentation for**	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
2092	2092	1	R4	8368	8371	Wavelength Calibration Shift	**QA flag definitions)**	nm
2093	2093	1	R4	8372	8375	Wavelength Calibration Stretch		nm/pixel
2094	2094	1	I4	8376	8379	Event Condition QA Flags		
2095	2294	200	I4	8380	9179	Altitude Dependent QA Flags		
2295	2380	86	I4	9180	9523	Beginning Pixel Number	**CCD Pixel Group**	
2381	2466	86	I4	9524	9867	End Pixel Number	**Definitions**	
2467	2552	86	R4	9868	10211	Pixel Group Center Wavelengths		nm
2553	2638	86	R4	10212	10555	Pixel Group Half-Bandwidth		nm
2639	2838	200	R4	10556	11355	Transmission: Pin Diode	**Transmission Profiles**	
2839	3038	200	R4	11356	12155	Transmission Uncertainty: Pin Diode		
3039	3238	200	I4	12156	12955	Retrieved Profile QA Flags: Pin Diode		
3239	3438	200	R4	12956	13755	Transmission: Pixel Group 1		
3439	3638	200	R4	13756	14555	Transmission Uncertainty: Pixel Group 1		
3639	3838	200	I4	14556	15355	Retrieved Profile QA Flags: Pixel Group 1		
3839	4038	200	R4	15356	16155	Transmission: Pixel Group 2		
4039	4238	200	R4	16156	16955	Transmission Uncertainty: Pixel Group 2		
4239	4438	200	I4	16956	17755	Retrieved Profile QA Flags: Pixel Group 2		
4439	4638	200	R4	17756	18555	Transmission: Pixel Group 3		
4639	4838	200	R4	18556	19355	Transmission Uncertainty: Pixel Group 3		
4839	5038	200	I4	19356	20155	Retrieved Profile QA Flags: Pixel Group 3		
5039	5238	200	R4	20156	20955	Transmission: Pixel Group 4		
5239	5438	200	R4	20956	21755	Transmission Uncertainty: Pixel Group 4		
5439	5638	200	I4	21756	22555	Retrieved Profile QA Flags: Pixel Group 4		
5639	5838	200	R4	22556	23355	Transmission: Pixel Group 5		
5839	6038	200	R4	23356	24155	Transmission Uncertainty: Pixel Group 5		
6039	6238	200	I4	24156	24955	Retrieved Profile QA Flags: Pixel Group 5		
6239	6438	200	R4	24956	25755	Transmission: Pixel Group 6		
6439	6638	200	R4	25756	26555	Transmission Uncertainty: Pixel Group 6		
6639	6838	200	I4	26556	27355	Retrieved Profile QA Flags: Pixel Group 6		
6839	7038	200	R4	27356	28155	Transmission: Pixel Group 7		
7039	7238	200	R4	28156	28955	Transmission Uncertainty: Pixel Group 7		

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
7239	7438	200	I4	28956	29755	Retrieved Profile QA Flags: Pixel Group 7	
7439	7638	200	R4	29756	30555	Transmission: Pixel Group 8	
7639	7838	200	R4	30556	31355	Transmission Uncertainty: Pixel Group 8	
7839	8038	200	I4	31356	32155	Retrieved Profile QA Flags: Pixel Group 8	
8039	8238	200	R4	32156	32955	Transmission: Pixel Group 9	
8239	8438	200	R4	32956	33755	Transmission Uncertainty: Pixel Group 9	
8439	8638	200	I4	33756	34555	Retrieved Profile QA Flags: Pixel Group 9	
8639	8838	200	R4	34556	35355	Transmission: Pixel Group 10	
8839	9038	200	R4	35356	36155	Transmission Uncertainty: Pixel Group 10	
9039	9238	200	I4	36156	36955	Retrieved Profile QA Flags: Pixel Group 10	
9239	9438	200	R4	36956	37755	Transmission: Pixel Group 11	
9439	9638	200	R4	37756	38555	Transmission Uncertainty: Pixel Group 11	
9639	9838	200	I4	38556	39355	Retrieved Profile QA Flags: Pixel Group 11	
9839	10038	200	R4	39356	40155	Transmission: Pixel Group 12	
10039	10238	200	R4	40156	40955	Transmission Uncertainty: Pixel Group 12	
10239	10438	200	I4	40956	41755	Retrieved Profile QA Flags: Pixel Group 12	
10439	10638	200	R4	41756	42555	Transmission: Pixel Group 13	
10639	10838	200	R4	42556	43355	Transmission Uncertainty: Pixel Group 13	
10839	11038	200	I4	43356	44155	Retrieved Profile QA Flags: Pixel Group 13	
11039	11238	200	R4	44156	44955	Transmission: Pixel Group 14	
11239	11438	200	R4	44956	45755	Transmission Uncertainty: Pixel Group 14	
11439	11638	200	I4	45756	46555	Retrieved Profile QA Flags: Pixel Group 14	
11639	11838	200	R4	46556	47355	Transmission: Pixel Group 15	
11839	12038	200	R4	47356	48155	Transmission Uncertainty: Pixel Group 15	
12039	12238	200	I4	48156	48955	Retrieved Profile QA Flags: Pixel Group 15	
12239	12438	200	R4	48956	49755	Transmission: Pixel Group 16	
12439	12638	200	R4	49756	50555	Transmission Uncertainty: Pixel Group 16	
12639	12838	200	I4	50556	51355	Retrieved Profile QA Flags: Pixel Group 16	
12839	13038	200	R4	51356	52155	Transmission: Pixel Group 17	
13039	13238	200	R4	52156	52955	Transmission Uncertainty: Pixel Group 17	
13239	13438	200	I4	52956	53755	Retrieved Profile QA Flags: Pixel Group 17	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
13439	13638	200	R4	53756	54555	Transmission: Pixel Group 18	
13639	13838	200	R4	54556	55355	Transmission Uncertainty: Pixel Group 18	
13839	14038	200	I4	55356	56155	Retrieved Profile QA Flags: Pixel Group 18	
14039	14238	200	R4	56156	56955	Transmission: Pixel Group 19	
14239	14438	200	R4	56956	57755	Transmission Uncertainty: Pixel Group 19	
14439	14638	200	I4	57756	58555	Retrieved Profile QA Flags: Pixel Group 19	
14639	14838	200	R4	58556	59355	Transmission: Pixel Group 20	
14839	15038	200	R4	59356	60155	Transmission Uncertainty: Pixel Group 20	
15039	15238	200	I4	60156	60955	Retrieved Profile QA Flags: Pixel Group 20	
15239	15438	200	R4	60956	61755	Transmission: Pixel Group 21	
15439	15638	200	R4	61756	62555	Transmission Uncertainty: Pixel Group 21	
15639	15838	200	I4	62556	63355	Retrieved Profile QA Flags: Pixel Group 21	
15839	16038	200	R4	63356	64155	Transmission: Pixel Group 22	
16039	16238	200	R4	64156	64955	Transmission Uncertainty: Pixel Group 22	
16239	16438	200	I4	64956	65755	Retrieved Profile QA Flags: Pixel Group 22	
16439	16638	200	R4	65756	66555	Transmission: Pixel Group 23	
16639	16838	200	R4	66556	67355	Transmission Uncertainty: Pixel Group 23	
16839	17038	200	I4	67356	68155	Retrieved Profile QA Flags: Pixel Group 23	
17039	17238	200	R4	68156	68955	Transmission: Pixel Group 24	
17239	17438	200	R4	68956	69755	Transmission Uncertainty: Pixel Group 24	
17439	17638	200	I4	69756	70555	Retrieved Profile QA Flags: Pixel Group 24	
17639	17838	200	R4	70556	71355	Transmission: Pixel Group 25	
17839	18038	200	R4	71356	72155	Transmission Uncertainty: Pixel Group 25	
18039	18238	200	I4	72156	72955	Retrieved Profile QA Flags: Pixel Group 25	
18239	18438	200	R4	72956	73755	Transmission: Pixel Group 26	
18439	18638	200	R4	73756	74555	Transmission Uncertainty: Pixel Group 26	
18639	18838	200	I4	74556	75355	Retrieved Profile QA Flags: Pixel Group 26	
18839	19038	200	R4	75356	76155	Transmission: Pixel Group 27	
19039	19238	200	R4	76156	76955	Transmission Uncertainty: Pixel Group 27	
19239	19438	200	I4	76956	77755	Retrieved Profile QA Flags: Pixel Group 27	
19439	19638	200	R4	77756	78555	Transmission: Pixel Group 28	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
19639	19838	200	R4	78556	79355	Transmission Uncertainty: Pixel Group 28	
19839	20038	200	I4	79356	80155	Retrieved Profile QA Flags: Pixel Group 28	
20039	20238	200	R4	80156	80955	Transmission: Pixel Group 29	
20239	20438	200	R4	80956	81755	Transmission Uncertainty: Pixel Group 29	
20439	20638	200	I4	81756	82555	Retrieved Profile QA Flags: Pixel Group 29	
20639	20838	200	R4	82556	83355	Transmission: Pixel Group 30	
20839	21038	200	R4	83356	84155	Transmission Uncertainty: Pixel Group 30	
21039	21238	200	I4	84156	84955	Retrieved Profile QA Flags: Pixel Group 30	
21239	21438	200	R4	84956	85755	Transmission: Pixel Group 31	
21439	21638	200	R4	85756	86555	Transmission Uncertainty: Pixel Group 31	
21639	21838	200	I4	86556	87355	Retrieved Profile QA Flags: Pixel Group 31	
21839	22038	200	R4	87356	88155	Transmission: Pixel Group 32	
22039	22238	200	R4	88156	88955	Transmission Uncertainty: Pixel Group 32	
22239	22438	200	I4	88956	89755	Retrieved Profile QA Flags: Pixel Group 32	
22439	22638	200	R4	89756	90555	Transmission: Pixel Group 33	
22639	22838	200	R4	90556	91355	Transmission Uncertainty: Pixel Group 33	
22839	23038	200	I4	91356	92155	Retrieved Profile QA Flags: Pixel Group 33	
23039	23238	200	R4	92156	92955	Transmission: Pixel Group 34	
23239	23438	200	R4	92956	93755	Transmission Uncertainty: Pixel Group 34	
23439	23638	200	I4	93756	94555	Retrieved Profile QA Flags: Pixel Group 34	
23639	23838	200	R4	94556	95355	Transmission: Pixel Group 35	
23839	24038	200	R4	95356	96155	Transmission Uncertainty: Pixel Group 35	
24039	24238	200	I4	96156	96955	Retrieved Profile QA Flags: Pixel Group 35	
24239	24438	200	R4	96956	97755	Transmission: Pixel Group 36	
24439	24638	200	R4	97756	98555	Transmission Uncertainty: Pixel Group 36	
24639	24838	200	I4	98556	99355	Retrieved Profile QA Flags: Pixel Group 36	
24839	25038	200	R4	99356	100155	Transmission: Pixel Group 37	
25039	25238	200	R4	100156	100955	Transmission Uncertainty: Pixel Group 37	
25239	25438	200	I4	100956	101755	Retrieved Profile QA Flags: Pixel Group 37	
25439	25638	200	R4	101756	102555	Transmission: Pixel Group 38	
25639	25838	200	R4	102556	103355	Transmission Uncertainty: Pixel Group 38	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
25839	26038	200	I4	103356	104155	Retrieved Profile QA Flags: Pixel Group 38	
26039	26238	200	R4	104156	104955	Transmission: Pixel Group 39	
26239	26438	200	R4	104956	105755	Transmission Uncertainty: Pixel Group 39	
26439	26638	200	I4	105756	106555	Retrieved Profile QA Flags: Pixel Group 39	
26639	26838	200	R4	106556	107355	Transmission: Pixel Group 40	
26839	27038	200	R4	107356	108155	Transmission Uncertainty: Pixel Group 40	
27039	27238	200	I4	108156	108955	Retrieved Profile QA Flags: Pixel Group 40	
27239	27438	200	R4	108956	109755	Transmission: Pixel Group 41	
27439	27638	200	R4	109756	110555	Transmission Uncertainty: Pixel Group 41	
27639	27838	200	I4	110556	111355	Retrieved Profile QA Flags: Pixel Group 41	
27839	28038	200	R4	111356	112155	Transmission: Pixel Group 42	
28039	28238	200	R4	112156	112955	Transmission Uncertainty: Pixel Group 42	
28239	28438	200	I4	112956	113755	Retrieved Profile QA Flags: Pixel Group 42	
28439	28638	200	R4	113756	114555	Transmission: Pixel Group 43	
28639	28838	200	R4	114556	115355	Transmission Uncertainty: Pixel Group 43	
28839	29038	200	I4	115356	116155	Retrieved Profile QA Flags: Pixel Group 43	
29039	29238	200	R4	116156	116955	Transmission: Pixel Group 44	
29239	29438	200	R4	116956	117755	Transmission Uncertainty: Pixel Group 44	
29439	29638	200	I4	117756	118555	Retrieved Profile QA Flags: Pixel Group 44	
29639	29838	200	R4	118556	119355	Transmission: Pixel Group 45	
29839	30038	200	R4	119356	120155	Transmission Uncertainty: Pixel Group 45	
30039	30238	200	I4	120156	120955	Retrieved Profile QA Flags: Pixel Group 45	
30239	30438	200	R4	120956	121755	Transmission: Pixel Group 46	
30439	30638	200	R4	121756	122555	Transmission Uncertainty: Pixel Group 46	
30639	30838	200	I4	122556	123355	Retrieved Profile QA Flags: Pixel Group 46	
30839	31038	200	R4	123356	124155	Transmission: Pixel Group 47	
31039	31238	200	R4	124156	124955	Transmission Uncertainty: Pixel Group 47	
31239	31438	200	I4	124956	125755	Retrieved Profile QA Flags: Pixel Group 47	
31439	31638	200	R4	125756	126555	Transmission: Pixel Group 48	
31639	31838	200	R4	126556	127355	Transmission Uncertainty: Pixel Group 48	
31839	32038	200	I4	127356	128155	Retrieved Profile QA Flags: Pixel Group 48	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
32039	32238	200	R4	128156	128955	Transmission: Pixel Group 49	
32239	32438	200	R4	128956	129755	Transmission Uncertainty: Pixel Group 49	
32439	32638	200	I4	129756	130555	Retrieved Profile QA Flags: Pixel Group 49	
32639	32838	200	R4	130556	131355	Transmission: Pixel Group 50	
32839	33038	200	R4	131356	132155	Transmission Uncertainty: Pixel Group 50	
33039	33238	200	I4	132156	132955	Retrieved Profile QA Flags: Pixel Group 50	
33239	33438	200	R4	132956	133755	Transmission: Pixel Group 51	
33439	33638	200	R4	133756	134555	Transmission Uncertainty: Pixel Group 51	
33639	33838	200	I4	134556	135355	Retrieved Profile QA Flags: Pixel Group 51	
33839	34038	200	R4	135356	136155	Transmission: Pixel Group 52	
34039	34238	200	R4	136156	136955	Transmission Uncertainty: Pixel Group 52	
34239	34438	200	I4	136956	137755	Retrieved Profile QA Flags: Pixel Group 52	
34439	34638	200	R4	137756	138555	Transmission: Pixel Group 53	
34639	34838	200	R4	138556	139355	Transmission Uncertainty: Pixel Group 53	
34839	35038	200	I4	139356	140155	Retrieved Profile QA Flags: Pixel Group 53	
35039	35238	200	R4	140156	140955	Transmission: Pixel Group 54	
35239	35438	200	R4	140956	141755	Transmission Uncertainty: Pixel Group 54	
35439	35638	200	I4	141756	142555	Retrieved Profile QA Flags: Pixel Group 54	
35639	35838	200	R4	142556	143355	Transmission: Pixel Group 55	
35839	36038	200	R4	143356	144155	Transmission Uncertainty: Pixel Group 55	
36039	36238	200	I4	144156	144955	Retrieved Profile QA Flags: Pixel Group 55	
36239	36438	200	R4	144956	145755	Transmission: Pixel Group 56	
36439	36638	200	R4	145756	146555	Transmission Uncertainty: Pixel Group 56	
36639	36838	200	I4	146556	147355	Retrieved Profile QA Flags: Pixel Group 56	
36839	37038	200	R4	147356	148155	Transmission: Pixel Group 57	
37039	37238	200	R4	148156	148955	Transmission Uncertainty: Pixel Group 57	
37239	37438	200	I4	148956	149755	Retrieved Profile QA Flags: Pixel Group 57	
37439	37638	200	R4	149756	150555	Transmission: Pixel Group 58	
37639	37838	200	R4	150556	151355	Transmission Uncertainty: Pixel Group 58	
37839	38038	200	I4	151356	152155	Retrieved Profile QA Flags: Pixel Group 58	
38039	38238	200	R4	152156	152955	Transmission: Pixel Group 59	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
38239	38438	200	R4	152956	153755	Transmission Uncertainty: Pixel Group 59	
38439	38638	200	I4	153756	154555	Retrieved Profile QA Flags: Pixel Group 59	
38639	38838	200	R4	154556	155355	Transmission: Pixel Group 60	
38839	39038	200	R4	155356	156155	Transmission Uncertainty: Pixel Group 60	
39039	39238	200	I4	156156	156955	Retrieved Profile QA Flags: Pixel Group 60	
39239	39438	200	R4	156956	157755	Transmission: Pixel Group 61	
39439	39638	200	R4	157756	158555	Transmission Uncertainty: Pixel Group 61	
39639	39838	200	I4	158556	159355	Retrieved Profile QA Flags: Pixel Group 61	
39839	40038	200	R4	159356	160155	Transmission: Pixel Group 62	
40039	40238	200	R4	160156	160955	Transmission Uncertainty: Pixel Group 62	
40239	40438	200	I4	160956	161755	Retrieved Profile QA Flags: Pixel Group 62	
40439	40638	200	R4	161756	162555	Transmission: Pixel Group 63	
40639	40838	200	R4	162556	163355	Transmission Uncertainty: Pixel Group 63	
40839	41038	200	I4	163356	164155	Retrieved Profile QA Flags: Pixel Group 63	
41039	41238	200	R4	164156	164955	Transmission: Pixel Group 64	
41239	41438	200	R4	164956	165755	Transmission Uncertainty: Pixel Group 64	
41439	41638	200	I4	165756	166555	Retrieved Profile QA Flags: Pixel Group 64	
41639	41838	200	R4	166556	167355	Transmission: Pixel Group 65	
41839	42038	200	R4	167356	168155	Transmission Uncertainty: Pixel Group 65	
42039	42238	200	I4	168156	168955	Retrieved Profile QA Flags: Pixel Group 65	
42239	42438	200	R4	168956	169755	Transmission: Pixel Group 66	
42439	42638	200	R4	169756	170555	Transmission Uncertainty: Pixel Group 66	
42639	42838	200	I4	170556	171355	Retrieved Profile QA Flags: Pixel Group 66	
42839	43038	200	R4	171356	172155	Transmission: Pixel Group 67	
43039	43238	200	R4	172156	172955	Transmission Uncertainty: Pixel Group 67	
43239	43438	200	I4	172956	173755	Retrieved Profile QA Flags: Pixel Group 67	
43439	43638	200	R4	173756	174555	Transmission: Pixel Group 68	
43639	43838	200	R4	174556	175355	Transmission Uncertainty: Pixel Group 68	
43839	44038	200	I4	175356	176155	Retrieved Profile QA Flags: Pixel Group 68	
44039	44238	200	R4	176156	176955	Transmission: Pixel Group 69	
44239	44438	200	R4	176956	177755	Transmission Uncertainty: Pixel Group 69	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
44439	44638	200	I4	177756	178555	Retrieved Profile QA Flags: Pixel Group 69	
44639	44838	200	R4	178556	179355	Transmission: Pixel Group 70	
44839	45038	200	R4	179356	180155	Transmission Uncertainty: Pixel Group 70	
45039	45238	200	I4	180156	180955	Retrieved Profile QA Flags: Pixel Group 70	
45239	45438	200	R4	180956	181755	Transmission: Pixel Group 71	
45439	45638	200	R4	181756	182555	Transmission Uncertainty: Pixel Group 71	
45639	45838	200	I4	182556	183355	Retrieved Profile QA Flags: Pixel Group 71	
45839	46038	200	R4	183356	184155	Transmission: Pixel Group 72	
46039	46238	200	R4	184156	184955	Transmission Uncertainty: Pixel Group 72	
46239	46438	200	I4	184956	185755	Retrieved Profile QA Flags: Pixel Group 72	
46439	46638	200	R4	185756	186555	Transmission: Pixel Group 73	
46639	46838	200	R4	186556	187355	Transmission Uncertainty: Pixel Group 73	
46839	47038	200	I4	187356	188155	Retrieved Profile QA Flags: Pixel Group 73	
47039	47238	200	R4	188156	188955	Transmission: Pixel Group 74	
47239	47438	200	R4	188956	189755	Transmission Uncertainty: Pixel Group 74	
47439	47638	200	I4	189756	190555	Retrieved Profile QA Flags: Pixel Group 74	
47639	47838	200	R4	190556	191355	Transmission: Pixel Group 75	
47839	48038	200	R4	191356	192155	Transmission Uncertainty: Pixel Group 75	
48039	48238	200	I4	192156	192955	Retrieved Profile QA Flags: Pixel Group 75	
48239	48438	200	R4	192956	193755	Transmission: Pixel Group 76	
48439	48638	200	R4	193756	194555	Transmission Uncertainty: Pixel Group 76	
48639	48838	200	I4	194556	195355	Retrieved Profile QA Flags: Pixel Group 76	
48839	49038	200	R4	195356	196155	Transmission: Pixel Group 77	
49039	49238	200	R4	196156	196955	Transmission Uncertainty: Pixel Group 77	
49239	49438	200	I4	196956	197755	Retrieved Profile QA Flags: Pixel Group 77	
49439	49638	200	R4	197756	198555	Transmission: Pixel Group 78	
49639	49838	200	R4	198556	199355	Transmission Uncertainty: Pixel Group 78	
49839	50038	200	I4	199356	200155	Retrieved Profile QA Flags: Pixel Group 78	
50039	50238	200	R4	200156	200955	Transmission: Pixel Group 79	
50239	50438	200	R4	200956	201755	Transmission Uncertainty: Pixel Group 79	
50439	50638	200	I4	201756	202555	Retrieved Profile QA Flags: Pixel Group 79	

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
50639	50838	200	R4	202556	203355	Transmission: Pixel Group 80	
50839	51038	200	R4	203356	204155	Transmission Uncertainty: Pixel Group 80	
51039	51238	200	I4	204156	204955	Retrieved Profile QA Flags: Pixel Group 80	
51239	51438	200	R4	204956	205755	Transmission: Pixel Group 81	
51439	51638	200	R4	205756	206555	Transmission Uncertainty: Pixel Group 81	
51639	51838	200	I4	206556	207355	Retrieved Profile QA Flags: Pixel Group 81	
51839	52038	200	R4	207356	208155	Transmission: Pixel Group 82	
52039	52238	200	R4	208156	208955	Transmission Uncertainty: Pixel Group 82	
52239	52438	200	I4	208956	209755	Retrieved Profile QA Flags: Pixel Group 82	
52439	52638	200	R4	209756	210555	Transmission: Pixel Group 83	
52639	52838	200	R4	210556	211355	Transmission Uncertainty: Pixel Group 83	
52839	53038	200	I4	211356	212155	Retrieved Profile QA Flags: Pixel Group 83	
53039	53238	200	R4	212156	212955	Transmission: Pixel Group 84	
53239	53438	200	R4	212956	213755	Transmission Uncertainty: Pixel Group 84	
53439	53638	200	I4	213756	214555	Retrieved Profile QA Flags: Pixel Group 84	
53639	53838	200	R4	214556	215355	Transmission: Pixel Group 85	
53839	54038	200	R4	215356	216155	Transmission Uncertainty: Pixel Group 85	
54039	54238	200	I4	216156	216955	Retrieved Profile QA Flags: Pixel Group 85	
54239	54438	200	R4	216956	217755	Transmission: Pixel Group 86	
54439	54638	200	R4	217756	218555	Transmission Uncertainty: Pixel Group 86	
54639	54838	200	I4	218556	219355	Retrieved Profile QA Flags: Pixel Group 86	

Appendix C. SAGE III/ISS Level 2 Solar Species Products

Table C1. Binary File Format Sheet: SAGE III/ISS Level 2 Solar Species Product

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
0	0	1	I4	0	3	Event Identification Tag	**Event Identification**	
1	1	1	I4	4	7	YYYYMMDD		
2	2	1	R4	8	11	Year Fraction		
3	3	1	R4	12	15	Subtangent Latitude at 20km		
4	4	1	R4	16	19	Subtangent Longitude at 20km		
5	5	1	I4	20	23	HHMMSS		
6	6	1	I4	24	27	Integer	**Fill Values**	
7	7	1	R4	28	31	Floating Point		
8	8	1	I4	32	35	Mission ID	**Version Identification**	
9	9	1	R4	36	39	Definitive Orbit Processing		
10	10	1	I4	40	43	CCD Table		
11	11	1	R4	44	47	Level 0		
12	12	1	R4	48	51	Software Processing		
13	13	1	R4	52	55	Data Product		
14	14	1	R4	56	59	Spectroscopic Database		
15	15	1	R4	60	63	GRAM 95		
16	16	1	R4	64	67	Meteorological Data		
17	17	1	R4	68	71	Altitude Grid Spacing	**Data Grid Parameters**	km
18	18	1	I4	72	75	Number of Altitudes		
19	19	1	I4	76	79	Number of Pressure Surfaces		
20	20	1	I4	80	83	Number of Aerosol Channels		
21	21	1	I4	84	87	Number of Ground Track Points		
22	22	1	I4	88	91	Number of Aerosol Altitudes		
23	23	1	I4	92	95	Spacecraft-Referenced (1:Sunrise, 2:Sunset)	**Event Type**	
24	24	1	I4	96	99	Earth-Referenced (1:Sunrise, 2:Sunset)		
25	25	1	R4	100	103	Solar Beta Angle		deg
26	26	1	I4	104	107	Aurora Contamination (0:N/A, 1:T, 2:F)		
27	27	1	I4	108	111	Ephemeris Source (5:GPS)		

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
28	38	11	I4	112	155	Date	**Ground Track-Indexed**	
39	49	11	I4	156	199	Time	**Data (for 11 tangent**	
50	60	11	R4	200	243	Subtangent Latitude	**altitudes: 0km to**	deg
61	71	11	R4	244	287	Subtangent Longitude	**100km at 10km)**	deg
72	82	11	R4	288	331	Ray Direction at Subtangent		deg
83	93	11	R4	332	375	Spacecraft Latitude		deg
94	104	11	R4	376	419	Spacecraft Longitude		deg
105	115	11	R4	420	463	Spacecraft Altitude		km
116	315	200	I4	464	1263	Homogeneity Flags (0:N/A, 1:Inhomogeneous, 2:Homogeneous)	**Altitude-Indexed Data**	
316	515	200	R4	1264	2063	Geometric Altitude		km
516	715	200	R4	2064	2863	Geopotential Altitude		km
716	915	200	R4	2864	3663	Temperature		K
916	1115	200	R4	3664	4463	Temperature Uncertainty		K
1116	1315	200	R4	4464	5263	Pressure		hPa
1316	1515	200	R4	5264	6063	Pressure Uncertainty		hPa
1516	1715	200	R4	6064	6863	Neutral Density		cm^{-3}
1716	1915	200	R4	6864	7663	Neutral Density Uncertainty		cm^{-3}
1916	2115	200	I4	7664	8463	Met Source (0:GRAM 95, 2:MERRA-2)		
2116	2116	1	R4	8464	8467	Tropopause Temperature	**Derived Tropopause**	K
2117	2117	1	R4	8468	8471	Tropopause Altitude		km
2118	2118	1	R4	8472	8475	Tropopause Pressure		hPa
2119	2160	42	R4	8476	8643	Pressure	**Pressure Surface-Indexed**	hPa
2161	2202	42	R4	8644	8811	Temperature	**Data**	K
2203	2244	42	R4	8812	8979	Temperature Uncertainty		K
2245	2286	42	R4	8980	9147	Altitude		km
2287	2287	1	I4	9148	9151	Met Source (0:GRAM95, 2:MERRA-2)		
2288	2288	1	R4	9152	9155	CCD Temperature	**Instrument Condition**	°C
2289	2289	1	R4	9156	9159	Spectrometer Zenith Temperature		°C
2290	2290	1	R4	9160	9163	CCD Temperature Departure From Nominal		°C

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
2291	2291	1	I4	9164	9167	Ephemeris QA (0:Missing Data, 1:Nominal, 2:Interpolation Performed, 3:Questionable Data)	**Quality Assurance Information (See documentation for QA flag definitions)**	
2292	2292	1	R4	9168	9171	Wavelength Calibration Shift		nm
2293	2293	1	R4	9172	9175	Wavelength Calibration Stretch		nm/pixel
2294	2294	1	I4	9176	9179	Event Condition QA Flags		
2295	2494	200	I4	9180	9979	Altitude Dependent QA Flags		
2495	2694	200	R4	9980	10779	Concentration	**Composite Ozone Profiles**	cm^{-3}
2695	2894	200	R4	10780	11579	Concentration Uncertainty		cm^{-3}
2895	3094	200	I4	11580	12379	Retrieved Profile QA Flags		
3095	3294	200	R4	12380	13179	Concentration	**Mesospheric Ozone Profiles**	cm^{-3}
3295	3494	200	R4	13180	13979	Concentration Uncertainty		cm^{-3}
3495	3694	200	I4	13980	14779	Retrieved Profile QA Flags		
3695	3894	200	R4	14780	15579	Concentration	**MLR Ozone Profiles**	cm^{-3}
3895	4094	200	R4	15580	16379	Concentration Uncertainty		cm^{-3}
4095	4294	200	I4	16380	17179	Retrieved Profile QA Flags		
4295	4494	200	R4	17180	17979	Concentration	**AO3 Ozone Profiles**	cm^{-3}
4495	4694	200	R4	17980	18779	Concentration Uncertainty		cm^{-3}
4695	4894	200	I4	18780	19579	Retrieved Profile QA Flags		
4895	5094	200	R4	19580	20379	Concentration	**Water Vapor Profiles**	cm^{-3}
5095	5294	200	R4	20380	21179	Concentration Uncertainty		cm^{-3}
5295	5494	200	I4	21180	21979	Retrieved Profile QA Flags		
5495	5694	200	R4	21980	22779	Concentration	**Nitrogen Dioxide Profiles**	cm^{-3}
5695	5894	200	R4	22780	23579	Concentration Uncertainty		cm^{-3}
5895	6094	200	I4	23580	24379	Retrieved Profile QA Flags		
6095	6294	200	R4	24380	25179	Temperature	**Retrieved Meteorological Profiles**	K
6295	6494	200	R4	25180	25979	Temperature Uncertainty		K
6495	6694	200	R4	25980	26779	Pressure		hPa
6695	6894	200	R4	26780	27579	Pressure Uncertainty		hPa
6895	7094	200	I4	27580	28379	Retrieved Profile QA Flags		
7095	7103	9	R4	28380	28415	Channel Center Wavelengths	**Aerosol Profiles**	nm

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
7104	7112	9	R4	28416	28451	Channel Half-Bandwidth	nm
7113	7121	9	R4	28452	28487	Rayleigh Extinction Cross Section	cm^3/km
7122	7130	9	R4	28488	28523	Rayleigh Extinction Cross Section Uncertainty	cm^3/km
7131	7139	9	R4	28524	28559	Stratospheric Optical Depth	
7140	7148	9	R4	28560	28595	Stratospheric Optical Depth Uncertainty	
7149	7157	9	I4	28596	28631	Stratospheric Optical Depth QA Flags	
7158	7247	90	R4	28632	28991	Aerosol Extinction Channel 1	km^{-1}
7248	7337	90	R4	28992	29351	Aerosol Extinction Uncertainty Channel 1	km^{-1}
7338	7427	90	I4	29352	29711	Retrieved Profile QA Flags Channel 1	
7428	7517	90	R4	29712	30071	Aerosol Extinction Channel 2	km^{-1}
7518	7607	90	R4	30072	30431	Aerosol Extinction Uncertainty Channel 2	km^{-1}
7608	7697	90	I4	30432	30791	Retrieved Profile QA Flags Channel 2	
7698	7787	90	R4	30792	31151	Aerosol Extinction Channel 3	km^{-1}
7788	7877	90	R4	31152	31511	Aerosol Extinction Uncertainty Channel 3	km^{-1}
7878	7967	90	I4	31512	31871	Retrieved Profile QA Flags Channel 3	
7968	8057	90	R4	31872	32231	Aerosol Extinction Channel 4	km^{-1}
8058	8147	90	R4	32232	32591	Aerosol Extinction Uncertainty Channel 4	km^{-1}
8148	8237	90	I4	32592	32951	Retrieved Profile QA Flags Channel 4	
8238	8327	90	R4	32952	33311	Aerosol Extinction Channel 5	km^{-1}
8328	8417	90	R4	33312	33671	Aerosol Extinction Uncertainty Channel 5	km^{-1}
8418	8507	90	I4	33672	34031	Retrieved Profile QA Flags Channel 5	
8508	8597	90	R4	34032	34391	Aerosol Extinction Channel 6	km^{-1}
8598	8687	90	R4	34392	34751	Aerosol Extinction Uncertainty Channel 6	km^{-1}
8688	8777	90	I4	34752	35111	Retrieved Profile QA Flags Channel 6	
8778	8867	90	R4	35112	35471	Aerosol Extinction Channel 7	km^{-1}
8868	8957	90	R4	35472	35831	Aerosol Extinction Uncertainty Channel 7	km^{-1}
8958	9047	90	I4	35832	36191	Retrieved Profile QA Flags Channel 7	
9048	9137	90	R4	36192	36551	Aerosol Extinction Channel 8	km^{-1}
9138	9227	90	R4	36552	36911	Aerosol Extinction Uncertainty Channel 8	km^{-1}
9228	9317	90	I4	36912	37271	Retrieved Profile QA Flags Channel 8	
9318	9407	90	R4	37272	37631	Aerosol Extinction Channel 9	km^{-1}

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description	Units
9408	9497	90	R4	37632	37991	Aerosol Extinction Uncertainty Channel 9	km^{-1}
9498	9587	90	I4	37992	38351	Retrieved Profile QA Flags Channel 9	

Appendix D. SAGE III/ISS Level 2 Lunar Species Products

Table D1. Binary File Format Sheet: SAGE III/ISS Level 2 Lunar Species Product

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
0	0	1	I4	0	3	Event ID	**Event Identification**	
1	1	1	I4	4	7	YYYYMMDD		
2	2	1	R4	8	11	Year Fraction		
3	3	1	R4	12	15	Subtangent Latitude at 20 km		
4	4	1	R4	16	19	Subtangent Longitude at 20 km		
5	5	1	I4	20	23	HHMMSS		
6	6	1	I4	24	27	Integer	**Fill Values**	
7	7	1	R4	28	31	Floating Point		
8	8	1	I4	32	35	Mission ID	**Version Identification**	
9	9	1	R4	36	39	Definitive Orbit Processing		
10	10	1	I4	40	43	CCD Table		
11	11	1	R4	44	47	Level 0		
12	12	1	R4	48	51	Software Processing		
13	13	1	R4	52	55	Data Product		
14	14	1	R4	56	59	Spectroscopic Database		
15	15	1	R4	60	63	GRAM 95		
16	16	1	R4	64	67	Meteorological Data		
17	17	1	R4	68	71	Lunar Model		
18	18	1	R4	72	75	Lunar Albedo		
19	19	1	R4	76	79	Altitude Grid Spacing	**Data Grid Parameters**	km
20	20	1	I4	80	83	Number of Altitudes		
21	21	1	I4	84	87	Number of Pressure Surfaces		
22	22	1	I4	88	91	Number of Ground Track Points		
23	23	1	I4	92	95	Spacecraft-Referenced (3:Moonrise, 4:Moonset)	**Event Type**	
24	24	1	I4	96	99	Earth-Referenced (3: Moonrise, 4:Moonset)		
25	25	1	R4	100	103	Lunar Beta Angle		deg

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
26	26	1	R4	104	107	Lunar Phase		%
27	27	1	R4	108	111	Zenith Angle		deg
28	28	1	I4	112	115	Aurora Contamination (0:N/A, 1:T, 2:F)		
29	29	1	I4	116	119	Ephemeris Source (5:GPS)		
30	40	11	I4	120	163	Date	**Ground Track-Indexed**	
41	51	11	I4	164	207	Time	**Data (For 11 tangent**	
52	62	11	R4	208	251	Subtangent Latitude	**altitudes: 0km to 100km**	deg
63	73	11	R4	252	295	Subtangent Longitude	**at 10km intervals)**	deg
74	84	11	R4	296	339	Ray Direction at Subtangent		deg
85	95	11	R4	340	383	Spacecraft Latitude		deg
96	106	11	R4	384	427	Spacecraft Longitude		deg
107	117	11	R4	428	471	Spacecraft Altitude		km
118	317	200	R4	472	1271	Geometric Altitude	**Altitude-Indexed Data**	km
318	517	200	R4	1272	2071	Geopotential Altitude		km
518	717	200	R4	2072	2871	Temperature		K
718	917	200	R4	2872	3671	Temperature Uncertainty		K
918	1117	200	R4	3672	4471	Pressure		hPa
1118	1317	200	R4	4472	5271	Pressure Uncertainty		hPa
1318	1517	200	R4	5272	6071	Neutral Density		cm^{-3}
1518	1717	200	R4	6072	6871	Neutral Density Uncertainty		cm^{-3}
1718	1917	200	I4	6872	7671	Met Source (0:GRAM 95, 2:MERRA-2)		
1918	1918	1	R4	7672	7675	Tropopause Temperature	**Derived Tropopause**	K
1919	1919	1	R4	7676	7679	Tropopause Altitude		km
1920	1920	1	R4	7680	7683	Tropopause Pressure		hPa
1921	1962	42	R4	7684	7851	Pressure	**Pressure Surface-Indexed Data**	hPa
1963	2004	42	R4	7852	8019	Temperature		K
2005	2046	42	R4	8020	8187	Temperature Uncertainty		K
2047	2088	42	R4	8188	8355	Altitude		km
2089	2089	1	I4	8356	8359	Met Source (0:GRAM95,2:MERRA-2)		
2090	2090	1	R4	8360	8363	CCD Temperature	**Instrument Condition**	°C
2091	2091	1	R4	8364	8367	Spectrometer Zenith Temperature		°C

Field Num Start	Field Num End	Num Values	F90 Type	Start Byte	End Byte	Description		Units
2092	2092	1	R4	8368	8371	CCD Temperature Departure From Nominal		°C
2093	2093	1	I4	8372	8375	Ephemeris QA (0:Missing Data, 1:Nominal, 2:Interpolation Performed, 3:Questionable Data)	**Quality Assurance Information (See documentation for QA flag definitions)**	
2094	2094	1	R4	8376	8379	Wavelength Calibration Shift		nm
2095	2095	1	R4	8380	8383	Wavelength Calibration Stretch		nm/pixel
2096	2096	1	I4	8384	8387	Event Condition QA Flags		
2097	2296	200	I4	8388	9187	Altitude Dependent QA Flags		
2297	2496	200	I4	9188	9987	A-Band Altitude Registration QA Flags		
2497	2497	1	R4	9988	9991	A-Band Altitude Registration Offset		km
2498	2697	200	R4	9992	10791	Concentration	**Ozone**	cm^{-3}
2698	2897	200	R4	10792	11591	Concentration Uncertainty		cm^{-3}
2898	3097	200	I4	11592	12391	Retrieved Profile QA Flags		
3098	3297	200	R4	12392	13191	Concentration	**Nitrogen Dioxide**	cm^{-3}
3298	3497	200	R4	13192	13991	Concentration Uncertainty		cm^{-3}
3498	3697	200	I4	13992	14791	Retrieved Profile QA Flags		
3698	3897	200	R4	14792	15591	Concentration	**Nitrogen Trioxide**	cm^{-3}
3898	4097	200	R4	15592	16391	Concentration Uncertainty		cm^{-3}
4098	4297	200	I4	16392	17191	Retrieved Profile QA Flags		
4298	4497	200	R4	17192	17991	Concentration	**Chlorine Dioxide**	cm^{-3}
4498	4697	200	R4	17992	18791	Concentration Uncertainty		cm^{-3}
4698	4897	200	I4	18792	19591	Retrieved Profile QA Flags		

Appendix E. Reference Absorption Cross Sections for Gas Retrievals

Table E1. Absorption Spectrum Data Source by Species

Gas Species	Source
Ozone	SCIAMACHY O_3 Version 3.0, Dec. 2004 [5]
Nitrogen Dioxide	SCIAMACHY NO_2 Version 1.0, Aug. 2000 [5]
Nitrogen Trioxide	Yokelson 1994 [6]
Water Vapor	HITRAN 2004 [7]
Chlorine Dioxide	SCIAMACHY OClO Version 1.0, Aug. 2000 [5]
Dioxygen	HITRAN 2004 [7]
Tetraoxygen	Greenblatt 1990 [8]
Rayleigh-Scattering	Bucholtz 1995 [9]