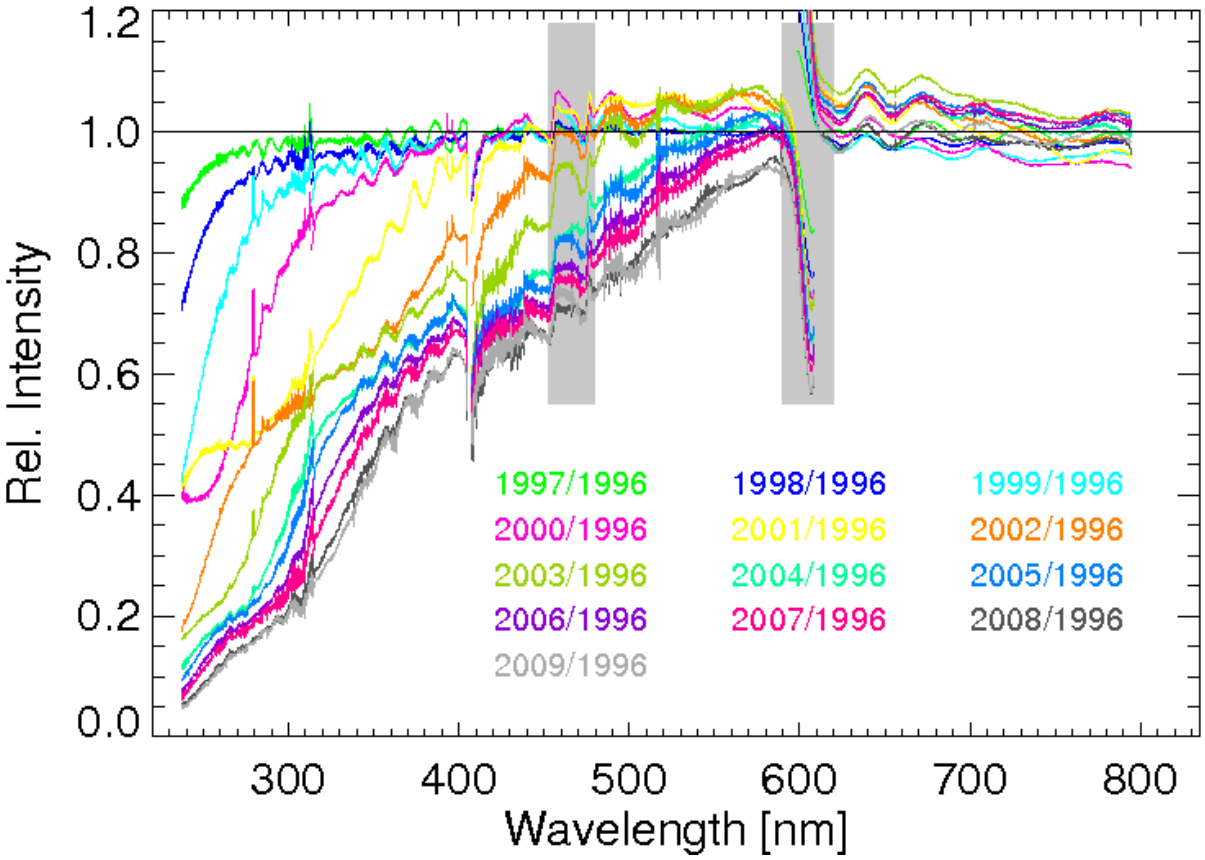
Product Specification Document for GOME Level 1 Products: Radiances/Irradiances and Cloud Properties

(GOME/ERS-2)



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Document Change Log

Issue	Rev	Date	Section	Description of Change
1/A		30.09.94	all	Completely new
2/A		11.09.95	all	Minor corrections
			appendix	Product formats were moved
				from ISD to PSD
3/A		04.04.96	all	Minor corrections
			appendix	Changes in Level 1 and Level 2 Data Product formats
3/B		30.07.96	all	Minor corrections
3/C		30.09.96	all	Minor corrections
3/D		15.05.00	2, 3.4	CD label and exclusion of level 2 products from L1 CDs,
			3.3	Geolocation gaps closed
			appendix	Correction of the byte positon on the FCD fields (table 5)
4/A		10.04.02	appendix	minor changes in ICFA and AMF index flags (tables 18, 20)
4/B		15.12.04	1	new product file name convention and updated ftp server
			3	level 2 data format updated.
			A.2	table 12 to 17 byte positions updated.
				table 17, content changed starting with field 7.
				tables 18 and 21 from previous issues remove
			A.4	table 38 and 39, byte positions updated.
				table 42, content changed starting with field 12.
			appendix	typo on the “integation time” field of table 11 on page 31
5/A		16.03.09	appendix New fields are marked yellow	Cloud records added. BOA angles and surface height added to geolocation records. Fixed : Product Format Version in SPH1 was always short instead of ASCII
				Level-2 part removed

Table of Contents

1 Introduction

1.1 Purpose and Scope

At its meeting in June 1990, the ESA Council approved the satellite project which followed the first European Remote Sensing Satellite (ERS–1). This new satellite (ERS–2), is intended to provide data continuity between ERS–1 and the European polar platforms. Its launch was performed on April, 21st 1995.

In addition to the mission objectives of ERS–1, ERS–2 is intended to make a significant contribution to atmospheric chemistry. Thus, in addition to the instruments on ERS–1 (AMI, ATSR, RA, PRARE, etc.), it also carries the Global Ozone Monitoring Experiment (GOME). This instrument is intended to measure a range of atmospheric trace constituents both in the troposphere and in the stratosphere.

GOME is a nadir–viewing spectrometer which in its normal mode scans across–track in three steps. The field of view of each steep may be varied in size from 40 km x 40 km to320 km x 40 km – a total of five options. The default mode with the largest footprint (three steps with a total coverage of 960 km x 40 km) provides global coverage at the equator within 3 days.

GOME demonstrates the feasibility of using the differential optical absorption technique (DOAS) to ob- serve trace constituents including ozone. Existing nadir–viewing instruments such as SBUV exploit the fact that the height at which solar radiation is back–scattered by the atmosphere varies with wavelength. However, this approach depends on an accurate radiometric calibration.

Besides the on–line components at the ground stations and the Mission Management and Control Center (MMCC) the GOME Data Processor (GDP) system is the operational NRT and off–line ground segment for GOME. It incorporates a Level 0-to-1 processing chain, the complete GOME data archive, a trace gas total column retrieval process (Level 1-to-2), and a value added processing chain for the generation of higher–level products.

This document describes in detail the official GOME Level 1 products generated operationally with GDP. The GOME Level 2 products are described in a separated document.

1.2 References and Documents

The following documents are referenced in this specification:

[A1]Interface Specification Document of the GDP, ER–IS–DLR–GO–0004, Issue 2, 11.9.95
[A2]GOME Level 0-to-1 Algorithms Description, ER–TN–DLR–GO–0022, Issue 5/B, 21.12.2001
[A3]GOME Level 1-to-2 Algorithm Theoretical Basis Document, ERSE–DTEX–EOPG–TN–04–0007, Issue 1/A, 15.12.2004
[A4]Product User Manual for GOME Total Columns of Ozone, Minor Trace Gases and Cloud Properties DLR/GOME/PUM/01
[A5]Delta validation report for ERS–2 GOME Data Processor upgrade to version 4.0, ESA Technical Note ERSE–CLVL–EOPG–TN–04–0001, Issue 1.0, December 2004
[A6]IECF to PAF Interface Specifications, ER–IS–EPO–GE–0102, Issue 3.0, 29.1.90
[A7]GOME Science Packet Description, ER–TN–ESA–GO–0096, Issue 2, 29.8.1991
[A8]Products Naming Standard Convention, PGSI-GSEG-EOPG-TN-06-0001

The following documents are applicable for this specification:

[A9]System Requirements Document of the GOME Data Processing, ER–SR–DLR–GO–0020, Issue 1/B, 15.10.93
[A10]Functional Software Requirements of the GOME Data Processor (Level 1), ER–SR– DLR–GO–0008, Issue 1/B, 15.10.93
[A11]Functional Software Requirements of the GOME Data Processor (Level 2), ER–SR– DLR–GO–0009, Issue 1/B, 15.10.93
[A12]Architectural Design Document of the GDP, ER–AD–DLR–GO–0021, Issue 1, 11.4.94
[A13]Architectural Design Document of the GDP (Level 1), ER–AD–DLR–GO–0011, Issue 1, 11.4.94
[A14]Architectural Design Document of the GDP (Level 2), ER–AD–DLR–GO–0012, Issue 1, 11.4.94
[A15]ESA Software Engineering Standards, ESA PSS–05–0, Issue 2, Feb. 1991
[A16]LRDPF Re–Host – Interface Specification, RH–IC–SPT–SY–0001, Issue 1/2, 15.12.93
[A17]GOME Requirements Specification, ER–RS–ESA–GO–0001, Issue 1, 5.7.1991
[A18]GOME Command Description, ER–TN–ESA–GO–0171, Issue1, 10.9.91

1.3 Abbreviations and Acronyms

A list of about all abbreviations and acronyms which are used throughout the specification is given below:

AD	Architectural Design
AMF	Air Mass Factor
AO	Announcement of Opportunity
BBM	Bread Board Model
BDDN	Broadband Data Distribution Network
BSDF	Bi–directional Scattering Distribution Function
BU	Binary Units
CEOS	Committee on Earth Observation Satellites
CDR–DP	Critical Design Review Data Package
DFD	Deutsches Fernerkundungsdatenzentrum
DLR	Deutsche Zentrum für Luft- und Raumfahrt
DOAS	Differential Optical Absorption Spectroscopy
DSR	Data Set Record
EGOC	Extracted GOME Calibration Data ERS European Remote Sensing Satellite
ESA	European Space Agency
FTP	File Transfer Protocol
GDP	GOME Data Processor
GVC	Ghost Vertical Column
GOME	Global Ozone Monitoring Experiment
ICFA	Initial Cloud Fitting Algorithm
IMF	Institut für Methodik der Fernerkundung
ISD	Interface Specification Document
ISIS	Intelligentes Satellitenbild Informationsystem
MMCC	Mission Management Control Centre
MPH	Main Product Header
OCRA	Optical Cloud Recognition Algorithm
PMD	Polarisation Measurement Device
PSD	Product Specification Document
ROCINN	Retrieval of Cloud Information using Neural Networks
SBUV	Solar Backscatter Ultra–Violet
SPH	Specific Product Header
UTC	Universal Time Coordinated
VCD	Vertical Column Density

1.4 Overview

The present document is divided into the following sections:

Products Overview
This section gives a short overview about the products of GDP

Level 1 Radiance/Irradiance Product
This section gives a detailed description of the Level 1 Product

Detailed Product Formats
This appendix gives a detailed bit–by–bit description of the specified products and their extraction formats

2 Products Overview

GOME Level 1 and Level 2 products are distributed to the users via ftp server (off–line and near–real–time products).

2.1 Level 1 Radiance/Irradiance Product

Off–line Level 1 data products from the regular ground stations are available at the D–PAF NAS FTP–server: ftp-ops-dp.eo.esa.int.

The data is organized in directories as follows:

products/level_1/YYYY/MM/DD

where YYYY is the year, MM the month, DD the day.

Due to the large interest on the GOME sun and moon measurements on their own, these measurements are being included in the Level 1 Data Product as described in Section 3.

2.2 NRT Product

GOME Level 1 and Level 2 near–real–time data products are also available at the D–PAF NAS FTP–server: ftp–ops.dp.eo.esa.int
The NRT data is organized as the off–line data, but under the directory nrt_products.

2.3 Filename Convention

The filename indicates among others the UTC validity date and time of the product as defined in A8 as well as the corresponding orbit number. The file name is composed as follows:

MMNN_TTTTTTTTTT_YYYYMMDDTHHMMSS_YYYYMMDDTHHMMSS_FFF_OOOOOO_XXXX.EEEE

MMNN	Satellite Name und Mission Number
TTTTTTTTTT	File Type (10 uppercaseletters,digits,underscores)
YYYYMMDDTHHMMSS	<Validity Start/Stop>
FFF	Originating Facility
OOOOOO	Absolute Orbit at <Validity Start>, no leading zeros
XXXX	checksum calculated with CRC-16
.EEEE	Extension. Up to 4 characters.

Example :

ER02_GOM_GOM_1P_19950629T222935_19950629T232550_DPA_1000_9D67.DLR

2.4 Product Ordering

GOME Level 1 and Level 2 products are generated at DLR on behalf of ESA. For ordering/registration please contact:

EO Help Desk
ESA ESRIN
Via Galileo Galilei, I–00044 Frascati, Italy
Phone: +39 06 94180 777
Fax: +39 06 94180 272
E–mail: eohelp@esa.int
Web Site: http://earth.esa.int

2.5 Value Added Products

Information about GOME, degradation files as well as value added products are available at WDC-RSAT server at DLR:

Web Site: http://wdc.dlr.de/sensors/gome

3 Level 1 Radiance/Irradiance Product

3.1 Definition

The Level 1 Data product includes a header, fixed calibration data, ground–pixel specific calibration parameters and GOME science data in ten spectral bands. With the different integration times, these bands (six spectrum bands, because channel 1 and 2 are divided into two electronically independent bands; three 'straylight' bands; one 'blind' band) are handled as separate logical units of data. The header includes reference to input data, processing software and pre–flight data versions, time correlation, and orbital information. The fixed calibration data includes leakage current, and noise characteristics, spectral, and radiometric calibration parameters, sun reference spectra, and polarization sensitivity parameters. The pixel specific calibration parameters include geolocation information, eight fractional polarization values, and header information retained from the Level 0
Data. Using the included calibration data, the ADC readings of the diode arrays in the individual band data records may be converted to geolocated, spectrally and radiometrically calibrated radiances, including the correction for polarization, leakage current and straylight. This may be accomplished by an extraction program being part of a Level 1 Data product.

3.2 Description

3.2.1 Input

To generate GOME Level 1 Data products the following inputs are required:

GOME extracted product files (EGOC) from Level 0 Tapes or directly from the receiving ground stations, as described in [A1]. At least one EGOC product file (covering 1 orbit) is re- quired to make up one Level 1 Data product.

Restituted orbit information of the covered time period. The main product headers (MPH) of an extracted product file (EGOC) include state vectors of a predicted orbit. This orbit information may be used whenever the Restituted Orbit file of the requested period is not available. In this case the accuracies of the geolocation information and the sun reference spectrum are reduced.

Pre–flight calibration data. Conversion to Engineering Units: Polynomial coefficients of analog data package measurements and other semantic explanations of the data package content; Correction for Straylight: Center pixels of ghost columns, their efficiencies and defocussing; Radiometric Calibration: Bi–directional scattering distribution function of the diffuser in the calibration unit, Instrument response function, Polarization characteristic of the calibration unit; Polarisation Correction: Polarisation sensitivity per pixel, Correction factor for the polarisation sensitivity per pixel to correct for the various scan mirror positions, Wavelength dependency of the PMDs, the PMD ratios.

In–flight calibration data (Leakage current correction, Pixel–to–pixel gain information,

Spectral calibration parameters, Sun reference spectra measurements).

3.2.2 Algorithms

The algorithms which are used to generate Level 1 Data products are listed below. A detailed description of these algorithms may be found in A2 and A3.

Conversion to Engineering Units
Correction for Leakage Current and Determination of Noise
Correction for pixel–to–pixel gain
Correction for Straylight
Spectral Calibration
Radiometric Calibration
Polarisation Correction
Quality Flagging and Determination of Errors
Cloud Retrieval

3.2.3 Output

The extraction program of the Level 1 Data product generates the following output::
Geolocation Information for a 1.5 seconds pixel (independent of the actual integration time)

– UTC Date & Time of Pixel at end of integration time, point {C} from figure 2
– 3 Solar Zenith and Azimuth Angles at Satellite w.r.t North
– 3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t North
– 3 Solar Zenith and Azimuth Angles at Satellite w.r.t Spacecraft
– 3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t Spacecraft
– 3 Line–of–Sight Zenith and Azimuth Angles at Bottom of Atmosphere w.r.t North
– Satellite Geodetic Height w.r.t. CEM–6 ellipsoid and Earth Radius of Curvature in the across track direction. Both values are given at point {B} from figure 2
– 4 Corner Coordinates of Ground Pixel (Lat., Long.) at points {1, 2, 3, 4} from figure 2
– Center Coordinate of Ground Pixel at point {5} from figure 2

Cloud parameters

– Cloudfraction
– Cloudtopalbedo
– Cloudtopheight
– Cloudopticalthickness
– Cloudtoppressure
– Cloudtype

PMD Data normalized to PMD measurements of Sun

Earth–, Sun– and Moon–shine Spectrum Data

– Wavelength
– Solar Irradiance
– Earth–/Moon–shine Radiance
– Associated Errors
– Flags indicating quality of measurement

The geolocation information of a Ground Pixel is represented graphically in the following figures 1 to 4.

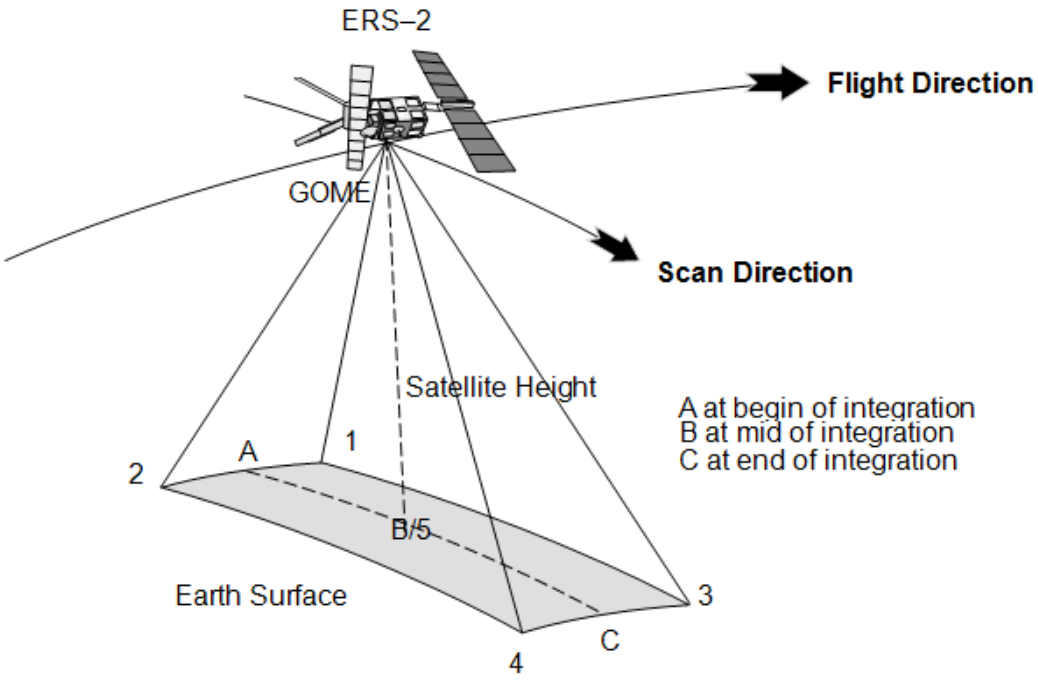

Figure 1: Ground Pixel

The Zenith angles are given at points {A, B, C} from Figure 1. Those angles are defined w.r.t. North, w.r.t. Spacecraft (S/C) and w.r.t. bottom of atmosphere as shown in Figure 2, a side view of Sun, GOME and Earth.

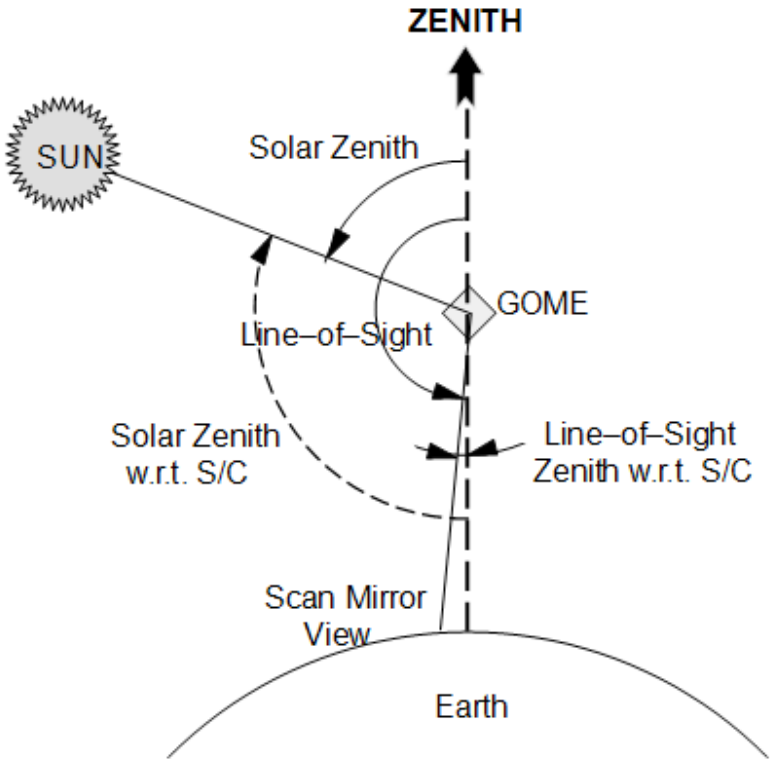

Figure 2: Zenith Angles (side view)

The Azimuth angles are given at points {A, B, C} from Figure 1. Figure 3 shows a north pole view of Earth, Sun and GOME representing Azimuth angles w.r.t. North as continuous lines, and Azimuth angles w.r.t. Spacecraft (S/C) as dotted lines. Azimuth angles are positive in orientation from Flight Direction to Scan Direction. Angles w.r.t. S/C are counted from the Flight Direction.

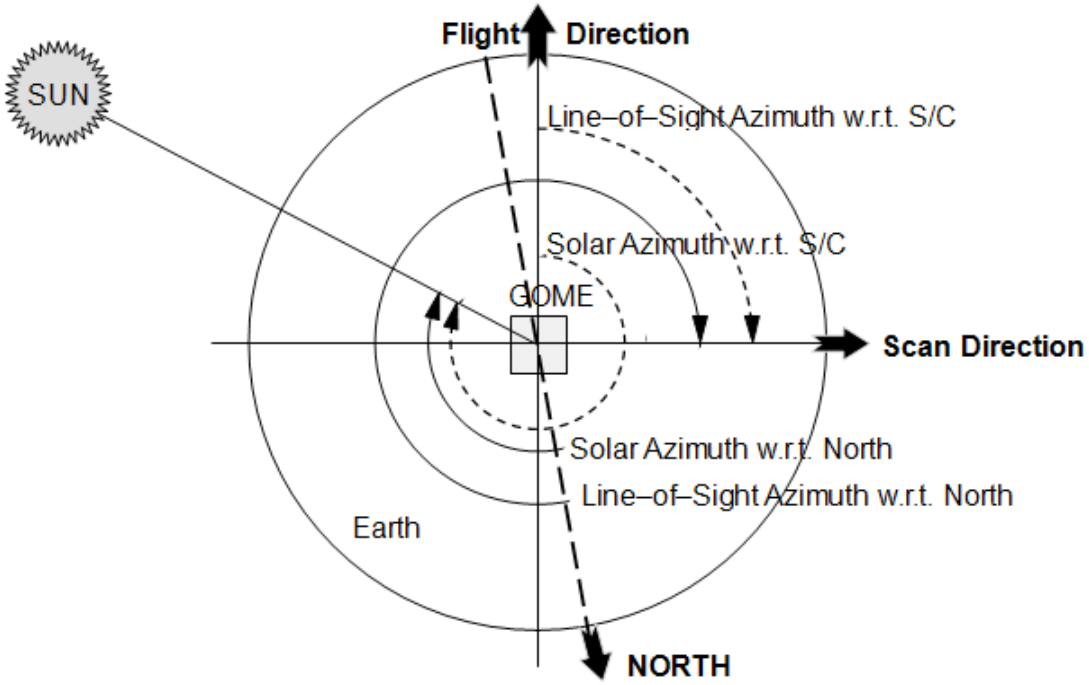

Figure 3: Zenith Angles (top view)

Direction to Scan Direction. Angles w.r.t. S/C are counted from the Flight Direction.

3.3 Specifications

Units

Angles	[degree]
Satellite Geodetic Height	[km]
Earth Radius of Curvature	[km]
Geographical Coordinates (long., lat.)	[0 to 360 degrees].[–90 to +90 degrees]
PMD Data	[–]
Wavelength	[nm]
Radiance	[photons s–1 sr–1 cm–2 nm–1] or [mW sr–1 m–2 nm–1]
Irradiance	[photons s–1 cm–2 nm–1] or [mW m–2 nm–1]
Errors	[absolute]

Geographical Coverage

Nominal: global

Depending on the scanning mode which will be used the measured ground pattern may

be different. Only the largest footprint results in global coverage at the equator after three days. (see note below on spatial resolution)

Radiometric Resolution

16 Bit

Spectral Resolution

240 – 400 nm: ~0.2 nm

400 – 790 nm: ~0.4 nm

Spatial Resolution

Nominal: 3 ground pixels across–track with 40 km along–track, 320 km across–track

GOME scans across–track in three steps. Each step has a nominal duration of 1.5 seconds. The fly-back is done within 1.5 seconds. The scanning pattern is shown in Figure 4. Depending on the scanning mode (swath width) the across–track range of one ground pixel may be: 320, 160, 120, 80 or 40 km.

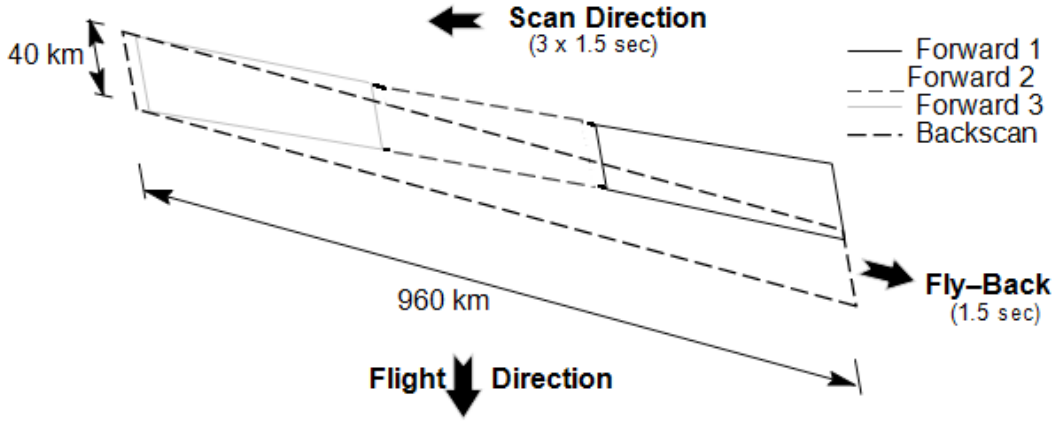

Figure 4: Scanning Pattern

Note: GOME data up to end of March 1996 have a reduced integration time (1.5 sec to 0.375 sec) to avoid saturation on the detector arrays. Only the last quarter of each ground pixel is covered by the recorded measurements using nominal mode. New sensor modes have been implemented on the GOME FS by ESA/ESTEC to overcome this problem. The 'co–adding' modes with integration time of 1.5 seconds is active since end of March 1996. A detailed description of these modes is given in [A8].

Absolute Radiometric Accuracy

GOME Level 1 data products are validated in two Geophysical Validation Campaigns, for the validation of the 240 – 400 nm wavelength region data from SOLSTICE and SSBUV have been used.. It was shown that the average deviation is ~ 3%. The deviation is time dependent due to instrument degradation.

Relative Radiometric Accuracy

< 1%

Spectral Accuracy

0.01 – 0.02 detector elements corresponding 0.002 – 0.0045 nm

Spatial Accuracy

Restituted Orbit: 60 m along–track, 15 m across–track

Predicted Orbit: 920 m along–track, 15 m across–track (whenever the restituted orbit is not available)

Sizing

Level 1 Data is calculated in granules of one orbit from an ascending node to the next. 35 orbits stored in 35 different files covering approximately a period of 3 days are logically packed to be one Level 1 Data product.

3.4 Data Availability

The Level 1 data products are available on FTP server. The extraction program gdp01_ex to yield Level 1 extracted data (ASCII) is also available on this FTP server (see Products Overview). The format of the Level 1 data product and the extraction format is described in A.1 and in A.2, respectively.

3.5 Remarks

General

The Level 1 Data product includes not directly the calibrated radiances, but the Level 0 Data values and the associated calibration parameters. This information has to be combined using a program which is also part of the Level 1 Data product. The following requirements have driven the design of the Level 1 Data product format:

– Storage space should be saved in the archive and on distribution media;

– Most of the information included in the Level 0 Data should be retained in the Level 1 Data product;

– Error values should be given on the earth–shine spectra and on the sun reference spectrum separately.

These requirements imply a format as given in appendix A.1 where no calibration data is actually applied to the spectrum data. To get calibrated radiances (Extracted Level 1 Data), the additional data processing step for the extraction of this data from a Level 1 Data product must be carried out in order to perform the application of the calibration data to the signal data and to calculate the associated errors (see format in A.3).

Geolocation

The geolocation information is given at Satellite for a 1.5 seconds pixel, independent of the actual integration time of each band.

Cloud parameters

The cloud parameters are given for a 1.5 seconds pixel, independent of the actual integration time of each band.

Variable Portions

There are several places in the product where variable portions have been used to keep the product as compact as possible. This is always done by specifying the number of records prior to records themselves. The following places are found in the product:

– Pixel specific Calibration Records

– Band Data Records

– Input Data References

– State Vectors

– Hot Pixel Occurrences

– Spectral Calibration Parameters

– Sun Reference Measurements

– Polarization Sensitivity Parameters

– Array Data Values

Indexing

To reduce redundant information and to increase flexibility in the reading of the product, an indexing scheme was used. The elements of some of the lists mentioned in the Variable Portion remark above are referred to by an index (number of the element in this list, starting with number 0) into other portions of the product. The following indices are used:

From the Pixel specific Calibration Records into

– the Band Data Records

– the Spectral Calibration Parameters

– the Polarization Sensitivity Parameters

From the Spectral Band Records into

– the Pixel specific Calibration Records

This scheme allows the sequential read by time via the Pixel specific Calibration Records with in- dices to the available (depending on the integration time) spectral bands and the corresponding spectral calibration and polarization sensitivity parameters. It also allows the sequential read of just one spectral band with indices to the Pixel specific Calibration Records which again give access to the necessary calibration data.

Hot Pixels

Individual detector pixels may be hit by high energy particles, such as protons. The worst situation

could be permanent damage to the detector pixel; this case will be identified by a zero value in the pixel–to–pixel gain array in the Fixed Calibration Data Record. Another possibility is a transient

effect whereby a detector pixel shows several abnormal (most probably very high) readouts before returning to normal operation. Such an occurrence, the so–called ”Hot Pixel”, will be identified by the Level 0-to-1 Processing and entered in this list. In the current implementation, Hot Pixel detection is done only for dark measurements.

Spectral Calibration Parameters

Depending on the temperature of the optical bench, the dispersion of the predisperser prism is different resulting in different spectral properties on the detector arrays. Using the spectral calibration lamp of the calibration unit, a set of spectral calibration parameters is calculated for each occurring temperature. Measurements with GOME BBM in the thermal–vacuum chamber at Galileo have shown that the maximum shift for a temperature difference of 60 C (–20 to +40) is below one detector pixel. To fulfill the ultimate° scientific requirement for the spectral accuracy of 1/100th of a detector pixel, it is possible to round the temperature measurements to a 1/10th of degree Celsius. Therefore, temperature steps of 0.1 C is used for the spectral calibration parameters. Measurements with the ERS–2 payload in the thermal–vacuum chamber at ESTEC have shown an orbital temperature variation of about 1 C. Therefore, about 10 sets of spectral calibration parameters are expected to be in one individual product.

There is one set of spectral calibration parameters which is valid for the sun reference measurements and their mean value. The Intensity Calibration Parameters and the Polarization Sensitivity values are interpolated to this wavelength grid.

Intensity Calibration Parameters

The Intensity Calibration Parameters are the interpolated instrument response (radiance sensitivity) function for the four detector arrays. The radiance sensitivity is dependent on the scan mirror angle. Therefore, it is necessary to include for each scan mirror angle

occurring during the time period of the product an array of radiance sensitivity values. For a nominal time-line three scan mirror angles are expected; a polar view time-line will yield in six different scan mirror angles.

Sun Reference Spectrum

The Sun Reference Spectrum is given in form of the individual sun calibration measurements (in BU), the mean value of these measurements using the Bi–directional Scattering Distribution Function (BSDF) of the diffuser and the mean values of the corresponding PMD measurements.

Polarization Sensitivity Parameters

The polarization sensitivity is also dependent on the scan mirror angle. Therefore, it is also necessary to include for each scan mirror angle occurring during time period of the product an array of polarization sensitivity values.

Level 0 Data Headers

The Level 1 Data product is the lowest level of GOME data which are delivered to a general user. Therefore, it is a good idea to retain as much information as possible of the raw data. The following information of the Level 0 Data is copied into the Level 1 Data product:

parts of the Main Product Header (MPH)

– Product Confidence Data

– UTC time when MPH was generated

– Processor software version used to generate Level 0 Data product.

parts of the Specific Product Header (SPH)

– Product Confidence Data or Padding Flag

(padding of the product DSR occurs in the event of missing frames containing GOME science data. The corresponding fields of the DSR are padded with BB hexadecimal)

– Product Confidence Data

parts of the Data Set Record (DSR)

– Primary Header

– Secondary Header

Auxiliary Data of the Science Data Packets

–

Other Outputs

With the Level 1 extraction program is possible to print some additional information like general product information, geolocation information or calibration data records. The

format of those out- puts are not given in these document because they are auxiliary outputs and most of them are selfs explanatory.

A Detailed Format Descriptions

A.1 Level 1 Radiance/Irradiance Product

The Level 1 Product file consist of the following basic elements:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	38	PIR	1-38	Product Identifier Record see Table 3
2	96	FSR1	39-134	File Structure Record see Table 2
3	292	SPH1	135-422	Specific Product Header see Table 4
4	ca. 265,102	FCD	323-265,524	Fixed Calibration Data Record see Table 5
5	Nrec*736 ca. 1,619,200	PCD	265,525-1,884,724	Pixel Specific Calibration Records see Table 7
6	Nsun*511 ca. 79,205	SMCD	1,884,725-1,963,929	Sun Specific Calibration Records see Table 8
7	Nmoon*511 ca. 1022	SMCD	1,963,930-1,964,951	Moon Specific Calibration Records see Table 8
8	ca. 15,576,000	BDR	1,964,952-17,540,952	Band Data Records see Table 9

Table 1: Level 1 Data Product Content

This yields an approximate size of 17 MB (16.73 MB for the assumptions as made below) for one Level 1 Data product which covers one complete orbit.

The File Structure Record (FSR1) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1–2	Number of SPH1 Records (always 1)
2	4	long	3–6	Length of SPH1 Record
3	2	short	7–8	Number of FCD Records (always 1)
4	4	long	9–12	Length of FCD Record
5	2	short	13–14	Number of PCD Records (Nrec, ca. 2200)
6	4	long	15–18	Length of PCD Record
7	2	short	19–20	Number of SCD Records (Nsun, ca. 155)
8	4	long	21–24	Length of SCD Record
9	2	short	25–26	Number of MCD Records (Nmoon, ca. 2)
10	4	long	27–30	Length of MCD Record
11	2	short	31–32	Spare, null
12	4	long	33–336	Spare, null
13	2	short	37–38	Number of Band 1a Data Records
14	4	long	39–42	Length of Band 1a Data Record
15	2	short	43–44	Number of Band 1b Data Records
16	4	long	45–48	Length of Band 1b Data Record
17	2	short	49–50	Number of Band 2a Data Records
18	4	long	51–54	Length of Band 2a Data Record
19	2	short	55–56	Number of Band 2b Data Records
20	4	long	57–60	Length of Band 2b Data Record
21	2	short	61–62	Number of Band 3 Data Records
22	4	long	63–66	Length of Band 3 Data Record
23	2	short	67–68	Number of Band 4 Data Records
24	4	long	69–72	Length of Band 4 Data Record
25	2	short	73–74	Number of Blind Pixel Data Records
26	4	long	75–78	Length of Blind Pixel Data Record
27	2	short	79–80	Number of Straylight 1a Data Records
28	4	long	81–84	Length of Straylight 1a Data Record
29	2	short	85–86	Number of Straylight 1b Data Records
30	4	long	87–90	Length of Straylight 1b Data Record
31	2	short	91–92	Number of Straylight 2a Data Records
32	4	long	93–96	Length of Straylight 2a Data Record

Table 2: File Structure Record Content

The Product Identifier Record (PIR) structure is given in the following table, as defined in [A6]:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	A	1–2	Satellite/Mission Identifier (E2)
2	3	A	3–5	Sensor Identifier (GOM)
3	5	A	6–10	Start Orbit Number (e.g. 05765)
4	4	A	11–14	Number of Processed Orbits (e.g. 0001)
5	2	A	15–16	Acquisition Facility Identifier (e.g. KS, if more than one station, this field is DP)
6	5	A	17–21	Product Type (LVL10)
7	1	A	22	Spare, blank
8	2	A	23–24	Processing Facility Identifier (DP)
9	8	A	25–32	Processing Date (YYYYMMDD)
10	6	A	33–38	Processing Time (hhmmss)

Table 3: Product Identifier Record

The Specific Product Header (SPH1) structure for the Level 1 Data product is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1-2	Number of Input Data References (Nref=2)
2	38*Nref= 76	PIR	1-78	Input Data Reference; see Table 3 (Product Type field: LVL0_)
3	5	A	79-83	GDP Software Version, Level 0-to-1 Processing (XX.XX)
4	5	A	84-88	Pre–flight Calibration Data Version (XX.XX)
5	2	short	89-90	Product Format Version
6	5 * 4 = 20	unsigned long	91-110	Time Correlation Information: – Orbit Number – UTC days since 1.1.1950 – UTC ms since midnight – Satellite Binary Counter – Satellite Binary Counter Period
7	2	short	111-112	GOME Science Package PMD Entry Point
8	2	short	113-114	GOME Science Package Subset Counter Entry Point
9	2	short	115-116	GOME Science Package Integration Status Entry Point
10	2	short	117-118	GOME Science Package Peltier Entry Point

11	2	short	119-120	GOME Instrument Status_2 Entry Point
12	(2 * 3) * 4 = 24	float	121-144	PMD's Conversion Factors
13	(3 * 4 + 6 * 4) = 36	3* unsigned long 6*float	145-180	State Vectors (ESOC Supplied Restituted Orbit): – UTC days since 1.1.1950 – UTC ms since midnight – Orbit number – Position vectors (X, Y, Z) in km – Velocity vector (dx/dt, dy/dt, dz/dt) in km/s
14	(3*8 + 3*8 + 4 + 4) = 56	3*double 3*double long long	181-236	Attitude Variables – ATT Combined Effect of AOCS Mis-pointing (yaw around z, pitch around –x, roll around –y) – DATT AOCS Mispointing Rate, deg/sec, w.r.t. Nominal (yaw, pitch, roll) – IATT Attitude Flag (0 Nominal Yaw Steering Mode, 1 and 2 other pointing – Status Returned from GOME_INIT (0 Nominal, 1 and 2 No Convergence, 3 4 and 5 State Vector Outside Nominal ERS
15	(8 + 6 * 8) = 56	double 6 * double	237-292	– Modified Julian Day (MJD50) at True Ascending Node Crossing – Reference Mean Kepler State at True Ascending Node Crossing (Semi–major Axis (km), Excentricity, Inclination (deg), Right Asc. of Asc. Node (deg), Argument of Perigee (deg), Mean anomaly (deg)

Table 4: Specific Product Header Content

The Fixed Calibration Data Record (FCD) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1-2	Detector Confidence Flags: Bit 16–12: always 0 Bit 11: PMD 3 Bit 10: PMD 2 Bit 9: PMD 1 Bit 8–7: Array 4 Bit 6–5: Array 3 Bit 4–3: Array 2 Bit 2–1: Array 1 0 = detector ok 1 = detector is dead 2 = detector has dead pixels

				(arrays only)
2	10 * 6 = 60	BCR	3-62	Band Configuration Record; see Table 6 : 6 Spectral Bands 1 Blind Pixel Band 3 Straylight Bands
3	(7*4*2 + 4,096) * 4 = 16,608	float	63-16,670	Relative Error Budget on KeyData Functions
4	(3+8) * 4 = 44	float	16,671-16714	Bi–directional Scattering Distribution Function Parameters: BSDF_0, Elevation, Azimuth and Coefficients
5	4 * 4 = 16	float	16,715-16,730	Uniform straylight level
6	4*2 * (2*2 + 2*4) = 96	short – float	16,731-16,826	Symmetrical and asymmetrical ghosts characteristics
7	2	short	16,827-16,828	Width of the triangle convolution window used in straylight
8	5 * 4 = 20	float	16,829-16,848	Scale factors for Peltier induced dark signal noise correction
9	2	short	16,849-16,850	Number of Peltier filter coefficients used
10	100 * 4 = 400	float	16,851-17,250	Filter coefficients for Peltier induced dark signal noise correction
11	2	short	17,251-17,252	Number of Leakage Correction Parameter Sets (Nleak, ca. 5; Integration Time Pattern or Time Line variance during one orbit)
12	(5 + 4,096) *4 * Nleak = 82,020	float	17,253-99,272	Array Noise, 3 PMD Offsets, PMD Noise and Dark Current
13	4,096 * 4 = 16,384	float	99,273-115,656	Pixel–to–Pixel Gain
14	2	short	115,657-115,658	Number of Hot Pixel Occurrences during this Orbit (Nhot, e.g. 5, hopefully zero)
15	3 * 2 * Nhot ca. 30	short	115,659-115,688	Hot Pixel Occurrences: Record, Array, Pixel
16	2	short	115,689-115,690	Number of Spectral Calibration Parameter Sets (Nspec, ca. 10; temperature variance during one orbit is expected to be ca. 1 and the temperature is resoluted to 0.1)
17	(5 * 4 + 4)	double	115,691-	Spectral Calibration Parameters (4th

	* 8 * Nspec ca. 1,920		117,610	order polynomial) and Average Pixel Deviation for each channel
18	2	short	117,611-117,612	Index into Spectral Calibration Parameters for the following Calibration Parameters (field 15, 16 and 22) and Sun Specific Calibration Records (Table 8)
19	4,096* 4 = 16,384	float	117,613-133,996	Intensity Calibration Parameters (Interpolated Radiance Response Function)
20	4,096* 4 = 16,384	float	133,997-150,380	Sun Reference Spectrum (Mean Value)
21	4,096* 4 = 16,384	float	150,381-166,764	Relative Radiometric Precision of the Sun Reference Spectrum
22	3 * 4 = 12	float	166,765-166,776	PMD Mean Values of the Sun Reference Spectra
23	3 * 4 = 12	float	166,777-166,788	Wavelength of the PMD Mean Values of the Sun Reference Spectra
24	2 * 4 = 8	unsigned long	166,789-166,796	UTC Date & Time of the Sun Reference Spectrum
25	2	short	166,797-166,798	Number of different scan mirror angles per channel for which the pre–flight calibration parameters "Interpolated Polarisation Sensitivity" and "Radiance Response" are calculated (Nang; e.g. 12)
26	(1,024 + 1024) * 4 * Nang = 98,304	float	166,799-265,102	Interpolated Polarisation Sensitivity (Vnadir • %(co)) defined in [A2] section "Polarisation Correction" and Radiance Response (H(X,o)) defined in [A2] section "Radiometric Calibration"

Table 5: Fixed Calibration Data Content

The Band Configuration Record (BCR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1-2	Detector Array Number (1–4)
2	2	short	3-4	Start Detector of Band (0–1023)
3	2	short	5-6	End Detector of Band (0–1023)

Table 6: Band Configuration Record

The Pixel Specific Calibration Records (PCD) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	151	GLR1	1-151	Geolocation Record, see Table 10
2	48	CR1	152-200	Cloud Record, see Table 12
3	2 * 4 = 8	float	201-208	Dark Current & Noise Correction Factor
4	2	short	209-210	Index to Spectral Calibration Parameters
5	2	short	211-212	Index to Leakage Correction Parameters
6	((7 + 1) * 3 * 4 + 4) = 100	float	213-312	Polarization Parameters (7+1 fractional polarization values including the appropriate wavelength value, error and Chi, the angle of the plane of polarization) defined in # section "Polarization Correction"
7	34	MPH: 6, 7, 16	313-346	Extraction of Level 0 Data MPH: fields 6, 7, 16; see#
8	22	SPH: 5, 6 + 1 byte	347-368	Extraction of Level 0 Data SPH: fields 5, 6; see # (last byte reserved to get field even)
9	396	IHR	369-764	Instrument Header Record of the Science Data Packet; see#
10	10 * 2 = 20	short	765-784	Index to the 10 Spectral Bands -1, if the integration time of this band was not completed

Table 7: Pixel Specific Calibration Data Content

The Sun/Moon Specific Calibration Records (SMCD) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2 * 4 = 8	unsigned long	1-7	UTC Date & Time of the Sun/Moon Measurement at end of integration time
2	2 * 4 = 8	float	8-15	Sun Zenith and Azimuth Angles at Satellite w.r.t North
3	2 * 4 = 8	float	16-23	BSDF Zenith and Azimuth Angles or Moon Zenith and Azimuth Angles at Sat elite w.r.t North
4	4	float	24-27	Flag indicating if the record was used in the calculation of the Sun Reference Spectrum (Table 5 , field 20) or Illuminated Fraction of the Moon's Disk
5	2 * 4 = 8	float	28-35	Dark Current & Noise Correction Factor
6	2	short	36-37	Index to Spectral Calibration Parameters
7	2	short	38-39	Index to Leakage Correction Parameters
8	34	MPH: 6, 7, 16	40-73	Extraction of Level 0 Data MPH: fields 6, 7, 16; see[A1]
9	22	SPH: 5, 6 + 1 byte	74-95	Extraction of Level 0 Data SPH: fields 5, 6; see[A1] (last byte reserved to get field even)
10	396	IHR	96-491	Instrument Header Record of the Science Data Packet; see[A7]
11	10 * 2 = 20	short	491-511	Index to the 10 Spectral Bands –1, if the integration time of this band was not completed

Table 8: Sun/Moon Specific Calibration Data Content

The Band Data Records (BDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	284,900	REC	1-	Band 1a, Nlen=256, Iv=550 (see Table 11)
2	2,182,400	REC	...	Band 1b, Nlen=493, Iv=2200
3	52,800	REC	...	Band 2a, Nlen=9, Iv=2200
4	3,436,400	REC	...	Band 2b, Nlen=778, Iv=2200
5	4,518,800	REC	...	Band 3, Nlen=1024, Iv=2200
6	4,518,800	REC	...	Band 4, Nlen=1024, Iv=2200
7	57,200	REC	...	Blind Pixel, Nlen=49, Iv=550
8	58,300	REC	...	Straylight Pixel 1a, Nlen=50, Iv=550
9	233,200	REC	...	Straylight Pixel 1b, Nlen=50, Iv=2200
10	233,200	REC	15,576,000	Straylight Pixel 2a, Nlen=50, Iv=2200

Table 9: Band Data Records Content

The values for the number of pixels per spectral band (Nlen) are taken from Table 5 field 2 (Band Configuration Record, Nlen = End–Start + 1) and the number of integration intervals (Iv) are estimates for one orbit to calculate the expected size of one Level 1 Data product.

The Geolocation Record (GLR1) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2 * 4 = 8	unsigned long	1-7	UTC Date & Time of the ground pixel at end of integration time
2	6 * 4 = 24	float	8-32	3 Solar Zenith and Azimuth Angles at Satellite w.r.t North for the points {A, B, C}
3	6 * 4 = 24	float	33-56	3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t North for the points {A, B, C}
4	6 * 4 = 24	float	57-80	3 Solar Zenith and Azimuth Angles at Satellite w.r.t Spacecraft for the points {A, B, C}
5	6 * 4 = 24	float	81-104	3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t North for the points {A, B, C}
6	6 * 4 = 24	float	105-128	3 Solar Zenith and Azimuth Angles at Bottom of Atmosphere w.r.t North for the points {A, B, C}
7	6 * 4 = 24	float	129-152	3 Line–of–Sight Zenith and Azimuth Angles at Bottom of Atmosphere w.r.t North for the points {A, B, C}
8	4	float	153-176	Satellite Geodetic Height at point {B}
9	4	float	177-180	Earth Radius of Curvature at point {B}
10	1	char	181	Possible Sun–glint (0 = no, 1 = yes)
11	(5 * 2 * 4) = 40	float	182-221	4 Corner and Center Coordinates (Latitude and Longitude) at points {1, 2, 3, 4 and 5} of Ground Pixel

Table 10: Geolocation Record 1 Content

The Spectral Band Record (REC) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1-2	Quality Flags: Bit 8-7: Spectral check: 0 = 8 < 0.02 px 1 = 0.02 < 8 < 0.05 px 2 = 8 > 0.05 px Bit 6-5: Saturated pixels Bit 4-3: Hot pixels Bit 2-1: Dead pixels 0 = all pixels ok 1 = less than 1% of pixels affected 2 = more than 1% of pixels affected
2	2	short	3-4	Index to Polarizations Sensitivity Parameters
3	2	short	5-6	Index to Pixel Specific Calibration Parameters Record (PCD)
4	2	unsigned short	7-8	Integration Time (one count corresponds to 93.75 ms)
5	Nlen * 2 = ca. 2048	unsigned short	9– max. 2056	Array Data Values

Table 11: Spectral Band Record Content

The Cloud Record (CR1) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	2	short	1-2	Mode (normal: 0, snow-ice: 1)
2	4	float	3-6	Surfaceheight [km]
3	4	float	7-10	Cloudfraction
4	4	float	11-14	Cloudfraction error [%]
5	4	float	15-18	Cloud-Topalbedo
6	4	float	19-22	Cloud-Topalbedo error [%]
7	4	float	23-26	Cloud-Topheight [km]
8	4	float	27-30	Cloud-Topheight error [%]
9	4	float	31-34	Cloudopticalthickness
10	4	float	35-38	Cloudopticalthickness error [%]
11	4	float	39-42	Cloud-Toppressure [hPa]
12	4	float	43-46	Cloud-Toppressure error [%]
13	2	short	47-48	Cloudtype (1:Cirrus, 2:Cirrostratus, 3: Deep convection, 4: Altocumulus, 5: Altostratus, 6: Nimbostratus, 7: Cumulus, 8: Stratocumulus, 9: Stratus)

Table 12: Cloud Record 1

A.2 Extracted Level 1 Radiance/Irradiance Product

Extracted Level 1 Product files for earthshine ground pixels have the following format:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	432	GSI1	1-432	GDP Software Identifier, see Table 22
2	38	PIR	433-470	Product Identifier, see Table 3
3	1 or 2	char	471	Line Separator; the number of bytes for this field depends on the operating system the *Extract_Level_1_Data* programme was running on (e.g. UNIX = 1, MS–DOS = 2)
4	303	ERSI	472-773	ERS Orbit Propagator Information, see Table 23
5	40	SFS	774-812	Solar Format Specification, see Table 24
6	Nchannel * (48,173 or 49,193) = 192,692	CDR	813-193,504	Channel Data Records, (Nchannel = 4), see Table 25
7	52 or 53	EFS	193,505-193,556	Earthshine Format Specification, see Table 27
8	Nground * (193,656 or 197,736) = ~405 MB	EGP	193,557-	Earthshine Ground Pixels (Nground ca. 2200), see Table 28

Table 13: Extracted Level 1 Data Content

The byte position information is given for the extraction of a complete Level 1 Data product. It is expected that for the normal case only parts (e.g. bands containing wavelength windows for the DOAS fitting) are extracted which is smaller than 405 MB.

The same format is used for Extracted Level 1 Data files for sun/moon measurements. The EFS and EGP are replaced by the corresponding SMFS (Table 27) and SMMD (Table 28).

The GDP Software Identifier (GSI1) structure for the Level 1 extraction software is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	80	A	1-80	Separator 1 (/* *\)
2	1 or 2	A	81	Line Separator, see comment in Table 13
3	80	A	82-161	Software Version (** GDP Level 0-to-1 Extracting * Version 9.99 * Copyright © DLR 1996-2004 **)
4	1 or 2	A	162	Line Separator, see comment in Table 13
5	80	A	163-242	** * Product Format Version 9 * **
6	1 or 2	A	243	Line Separator, see comment in Table 13
5	80	A	244-323	Separator 2 (* */)
6	1 or 2	A	324	Line Separator, see comment in Table 13
7	20	A	325-344	Calibration Correction (Calibrations Applied)
8	1 or 2	A	345	Line Separator, see comment in Table 13
9	82	A	346-427	Calibration Parameters Applied (Leakage FPA Fixed Straylight Normalize Polarization BSDF Intensity Unit_Conversion)
10	1 or 2	A	428	Line Separator, see comment in Table 13
11	5	A	429-433	Units of the Results (Units)
12	1 or 2	A	434	Line Separator, see comment in Table 13
13	80	A	435-514	Wavelength, Irradiance and Radiance Units (Wavelength [nm], Irradiance [photons/s.cm^2.nm], Radiance [photons/s.sr.cm^2.nm])
14	1 or 2	A	515	Line Separator, see comment in Table 13

Table 14: GDP Software Identifier

ERS Orbit Propagator Information (ERSI) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	15	A	1-15	Description (ERS_Information)
2	1 or 2	char	16	Line Separator, see comment in Table 13
3	90	A	17-106	State Vectors (ESOC Supplied Restituted Orbit): – UTC days since 1.1.1950 – UTC ms since midnight – Orbit number – Position vectors (X, Y, Z) in km – Velocity vector (dx/dt, dy/dt, dz/dt) in km/s (99999_99999999_99999_-9999.9 99999_-9999.999999_-9999.9999 99_-9.999999_-9.999999_-9.999 999)
4	1 or 2	char	107	Line Separator, see comment in Table 13
5	27	A	108-134	Attitude Variables – ATT Combined Effect of AOCS Mis-pointing (yaw around z, pitch around –x, roll around –y) – DATT AOCS Mispointing Rate, deg/sec, w.r.t. Nominal (yaw, pitch, roll) – IATT Attitude Flag (0 Nominal Yaw Steering Mode, 1 and 2 other pointing – Status Returned from GOME_INIT (0 Nominal, 1 and 2 No Convergence, 3 4 and 5 State Vector Outside Nominal ERS (9.9_9.9_9.9_9.9_9.9_9.9_9_9)
4	1 or 2	char	135	Line Separator, see comment in Table 13
5	167	A	136-302	– Modified Julian Day (MJD50) at True Ascending Node Crossing – Reference Mean Kepler State at True Ascending Node Crossing (Semi–major Axis (km), Excentricity, Inclination (deg), Right Asc. of Asc. Node (deg), Argument of Perigee (deg), Mean anomaly (deg) 7* (-9.999999999999999e-999_)
4	1 or 2	char	303	Line Separator, see comment in Table 13

Table 15: ERS Orbit Propagator Information

The Solar Format Specification (SFS) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	15	A	1-15	Description (`Solar_Spectrum_`)
2	12	A	16-27	UTC Date of Solar Spectrum (`DD-MMM-YYYY_`)
3	12	A	28-39	UTC Time of Solar Spectrum (`HH:MM:SS.mmm`)
4	1 or 2	char	40	Line Separator, see comment in Table 13

Table 16: Solar Format Specification Content

The Channel Data Record (CDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	10	A	1-10	Channel Identifier (`Channel 9_`)
3	16	A	11-26	Wavelength Range (nm) (`999.999_999.999_`)
4	4	A	27-30	Number of Detector Pixels Samples (`9999`) (Nsamp)
5	8	A	31-38	Spectral Calibration Error (`9.9999_`)
6	2	A	39-40	Spectral check (9_) 0 = e < 0.02 px 1 = 0.02 < e < 0.05 px 2 = e > 0.05 px
7	2	A	41-42	Saturated pixels (9_) [1]
8	2	A	43–44	Hot pixels (9_) [1]
9	2	A	45-46	Dead pixels (9_) [1]
10	1 or 2	A	47-48	Line Separator, see comment in Table 13
11	Nsamp * (47 or 48)	SDR	49–48,173 or 49,193	Solar Data Records, see Table 26 (e.g. Nsamp = 1024)

Table 17: Channel Data Record Content

1 : 0 = all pixels ok, 1=less than 1%, 2=more than 1% of pixels affected

The Solar Data Record (SDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	9	A	1-9	Wavelength [nm], (999.9999_)
2	12	A	10-21	Absolute Irradiance measurement [pho-tons/ nm.cm^2.s], (9.99999e-99_)
3	12	A	22-33	Absolute Irradiance measurement Error [photons/nm.cm^2.s], (9.99999e-99_)
4	12	A	34-45	Irradiance* relative response Error [–], (9.99999e-99_)
5	1	A	46	Flag, (9) (e.g. 0=Good, 1=Dead, 2=Hot, 3=Saturated, ..., 9=other errors)
6	1 or 2	A	47	Line Separator, see comment in Table 13

Table 18: Solar Data Record Content

The Earthshine Format Specification (EFS) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	20	A	1-20	Description (Earthshine_Spectrum_)
2	26	A	21-46	Time Range (99:99:99_99:99:99_)
3	5	A	47-51	Number of Ground Pixels (9999) (Nground)
4	1 or 2	char	52	Line Separator, see comment in Table 13

Table 19: Earthshine Format Specification Content

The Earthshine Ground Pixel (EGP) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	18	A	1-18	Ground Pixel Number (Ground_Pixel_9999_)
2	1	A	19-20	Number of Band Data Samples (9) (Nband)
3	2	A	21	Subset Counter (9_) ('0' to '2' forward, '3' backward)
4	1 or 2	char	22	Line Separator, see comment in Table 13
5	303-310	AGI	23-325	Geolocation Information in ASCII, see Table 21
6	116	ACI	326-441	Cloud Information in ASCII, see Table 22
7	586 or 587	PDR	442-1027	PMD Data Values of the corresponding science data packet, see Table 23
8	1 or 2	A	1028	Line Separator, see comment in Table 13
9	Nband * (48,186 or 49,206) = 192,744	BDRA	1029– 193772	Band Data Records, see Table 25 (e.g. Nband = 4)

Table 20: Earthshine Ground Pixel Content

The Geolocation Information in ASCII (AGI) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	12	A	1-12	UTC Date of Ground Pixel End (DD-MMM-YYYY_)
2	12	A	13-24	UTC Time of Ground Pixel End (HH:MM:SS.mmm)
3	1 or 2	A	25	Line Separator, see comment in Table 13
4	47	A	26-72	3 Solar Zenith and Azimuth Angles at Satellite w.r.t North for the points {A, B, C} , 3* (-999.99_-999.99_)
5	1 or 2	A	73	Line Separator, see comment in Table 13
6	47	A	74-120	3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t North for the points {A, B, C} , 3* (-999.99_-999.99_)
7	1 or 2	A	121	Line Separator, see comment in Table 13
8	47	A	122-168	3 Solar Zenith and Azimuth Angles at Satellite w.r.t Spacecraft for the points {A, B, C} , 3* (-999.99_-999.99_)
9	1 or 2	A	169	Line Separator, see comment in Table 13
10	47	A	170-216	3 Line–of–Sight Zenith and Azimuth Angles at Satellite w.r.t Spacecraft for the points {A, B, C} , 3* (-999.99_-999.99_)
11	1 or 2	A	217	Line Separator, see comment in Table 13
12	47	A	218-264	3 Solar Zenith and Azimuth Angles at Bottom of Atmosphere w.r.t North for the points {A, B, C} , 3* (-999.99_-999.99_)
13	1 or 2	A	265	Line Separator, see comment in
14	47	A	266-312	3 Line–of–Sight Zenith and Azimuth Angles at Bottom of Atmosphere w.r.t North for the points {A, B, C} , 3* (-999.99_-999.99_)
15	1 or 2	A	313	Line Separator, see comment in Table 13
16	7	A	314-320	Satellite Geodetic Height at point {B}, (999.99_)
17	8	A	321-328	Earth Radius of Curvature at point {B}, (9999.99_)
18	8	A	329-336	Surface Height [km]
19	1	A	337	Possible Sun-glint (9) 0 = no, 1 = yes
20	1 or 2	A	338	Line Separator, see comment in Table 13
21	69	A	339-407	4 Corner and Center Coordinates (Lat., Long.) at points {1, 2, 3, 4 and 5} of Ground Pixel, 5* (-99.99_999.99_)
22	1 or 2	A	408	Line Separator, see comment in Table 13

Table 21: Geolocation Information in ASCII Content

The Cloud Information structure in ASCII (ACI) is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	29	A	1-29	Description (OCRA/ROCINN Cloud Information)
2	2	A	30-31	Mode (normal: 0, snow-ice: 1)
3	1 or 2	A	32	Line Separator, see comment in Table 13
4	8	A	33-40	Cloudfraction (_-999.99)
5	8	A	41-48	Cloudfraction Error (_-999.99) [%]
6	8	A	49-56	Cloud-Topalbedo (_-999.99)
7	8	A	57-64	Cloud-Topalbedo Error (_-999.99) [%]
8	8	A	65-72	Cloud-Topheight (_-999.99) [km]
9	8	A	73-80	Cloud-Topheight Error (_-999.99) [%]
10	1 or 2	A	81	Line Separator, see comment in Table 13
11	8	A	82-89	Cloudopticalthickness (_-999.99)
12	8	A	90-97	Cloudopticalthickness Error (_-999.99) [%]
13	8	A	98-105	Cloud-Toppressure (_-999.99) [hPa]
14	8	A	106-113	Cloud-Toppressure Error (_-999.99) [%]
15	2	A	114-115	Cloud-Type (1:Cirrus, 2:Cirrostratus, 3: Deep convection, 4: Altocumulus, 5: Altostratus, 6: Nimbostratus, 7: Cumulus, 8: Stratocumulus, 9: Stratus)
16	1 or 2	A	116	Line Separator, see comment in Table 13

Table 22: Cloud Information

The PMD Data Record (PDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	9	A	1-9	PMD Flags for PMD 1, PMD 2 and PMD 3 (PMD 9 9 9) 0=Good, l=Error
2	1 or 2	A	10 or 11	Line Separator, see comment in Table 13
3	16* (36 or 37) = 576	PVDR	11-586	PMD Values Data Record, see Table 24
4	1 or 2	A	586 or 587	Line Separator, see comment in Table 13

Table 23: PMD Data Record Content

The PMD Values Data Record (PVDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	12	A	1-12	PMD 1 Data Value relative to Sun [–] (9.99999e-99_)
2	12	A	13-24	PMD 2 Data Value relative to Sun [–] (9.99999e-99_)
3	11	A	25-35	PMD 3 Data Value relative to Sun [–] (9.99999e-99)
4	1 or 2	A	36 or 37	Line Separator, see comment in Table 13

Table 24: PMD Values Data Record Content

The Band Data Record ASCII (BDRA) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	8	A	1-8	Band Identifier (Band 9a_)
2	11	A	9-19	Integration Time [s] (9999.99999_)
3	16	A	20-35	Wavelength Range (nm) (999.999_999.999_)
4	4	A	36-39	Number of Detector Pixels Samples (9999) (Nsamp)
5	8	A	40-47	Spectral Calibration Error (9.9999)
6	2	A	48-49	Spectral check (9_) 0 = e <= 0.02 px 1 = 0.02 < e <= 0.05 px 2 = e > 0.05 px
7	2	A	50-51	Saturated pixels (9_)
8	2	A	52-53	Hot pixels (9_)
9	2	A	54-55	Dead pixels (9_)
10	2	A	56-57	Reflectivity jump (9_) 0 = no jump check done or reflectivity ratio <= 1.1 1 = 1.1 <reflectivity ratio <= 1.4 2 = reflectivity ratio > 1.4
11	1 or 2	A	58-58	Line Separator, see comment in Table 13
12	Nsamp * (47 or 48)	EDR	58-48,186 or 49,206	Earthshine Data Records, see Table 26 (e.g. Nsamp = 1024)

Table 25: Band Data Record ASCII Content

The Earthshine Data Record (EDR) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	9	A	1-9	Wavelength [nm], (999.9999)
2	12	A	10-21	Absolute Radiance measurement [photons/ nm.cm^2.s.sr], (9.99999e-99_)
3	12	A	22-33	Absolute Radiance measurement Error [photons/nm.cm^2.s.sr], (9.99999e–99_)
4	12	A	34-45	Radiance* relative response Error [–], (9.99999e-99_)
5	1	A	46	Flag, (9) (e.g. 0=Good, 1=Dead, 2=Hot, 3=Saturated, ..., 9=other errors)
6	1 or 2	A	47 or 48	Line Separator, see comment in Table 13

Table 26: Earthshine Data Record Content

The following is an example of an extracted Level 1 Data for the earthshine ground pixels (the text in brackets and the dots are only for information and shortness, and not part of the data set).

```
/*-------------------------------------------------------------------------*\    (GSI1)
** GDP Level 0-to-1 Extracting * Version  4.00 * Copyright (c) DLR 1996-2008 **
**                        * Product Format Version 2 *                       **
\*-------------------------------------------------------------------------*/
Calibrations Applied
Leakage FPA Fixed Straylight Normalize Polarization Intensity Unit_Conversion
Units
Wavelength [nm], Irradiance [photons/s.cm^2.nm], Radiance [photons/s.sr.cm^2.nm]
E2GOM000000001KSEXTR1 DP19940506191143                                    (PIR)
ERS Information                                                           (ERSI)
16638 19672770 1319 -1404.150757 -1300.069946 6893.603516 1.473122 7.208139 1.655951
0.0 0.0 0.0 0.0 0.0 0.0 0 0
21275.537822 7159.610274 0.001146 98.553971 167.722033 89.700693 270.429902 Solar
Spectrum 19-MAY-1994 10:35:09.500                                         (SFS)
Channel 1 236.898 314.484 512 0.0315 0 0 0 0                              (SDR)
237.3802 0.00000E+00 0.00000E+00 0.00000E+00 0
237.5007 0.00000E+00 0.00000E+00 0.00000E+00 0
237.6206 0.44720E+14 0.22360E+13 0.89441E+11 0
237.7412 0.52373E+14 0.26186E+13 0.10475E+12 0
237.8616 0.45247E+14 0.22623E+13 0.90494E+11 0
.....
790.0000 0.50000E+15 0.30000E+14 0.20000E+13 0
Earthshine Spectrum 10:35:95.500 12:15:90.000 1500                        (EFS)
Ground Pixel 1 6 0                                                        (EGP)
20-MAY-1994 10:35:09.500                                                  (AGI)
42.50 205.61  42.46 205.63  42.42 205.65
10.00  90.00  19.68 90.00  -9.37 270.00
42.50 205.61  42.46 205.63  42.42 205.65
```

```
10.00  90.00  19.68 90.00  -9.37 270.00
42.50 205.61  42.46 205.63  42.42 205.65
10.00  90.00  19.68 90.00  -9.37 270.00
795.41 6395.70   0.00 0
 70.05 334.22  70.45 334.53  66.33 355.52  66.67 356.11  68.72 345.98
OCRA/ROCINN Cloud Information 1                                          (ACI)
   1.00    4.87    0.68    7.17    2.26    5.65
  25.10    7.17  762.48    5.65 9
PMD 0 0 0                                                                (PDR)
0.12345E+00 0.23456E+00 0.34567E+00
0.12345E+00 0.23456E+00 0.34567E+00
0.12345E+00 0.23456E+00 0.34567E+00
0.12345E+00 0.23456E+00 0.34567E+00
0.12345E+00 0.23456E+00 0.34567E+00
.....
0.12345E+00 0.23456E+00 0.34567E+00
Band 1a 30 236.898 268.121 255 0.0493 0 0 0 0 0                          (BDRA)
237.2598 0.00000E+00 0.00000E+00 0.00000E+00 0
237.3805 0.00000E+00 0.00000E+00 0.00000E+00 0
237.5003 0.00000E+00 0.00000E+00 0.00000E+00 0
237.6206 0.44720E+12 0.22360E+11 0.89441E+09 0
237.7413 0.52373E+12 0.26186E+11 0.10475E+10 0
....
268.1213 0.95544E+13 0.47772E+12 0.19109E+11 0
Band 4 1.5 578.602 780.266 1024 0.0331 0 0 0 0 0                         (BDRA)
...
Ground Pixel 2 1 6                                                       (EGP)
```

The Sun/Moon Format Specification (SMFS) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	16	A	1-16	Description (Sun/Moon Spectrum)
2	26	A	17-42	Time Range (99:99:99_99:99:99_)
3	5	A	43-47	Number of measurements (9999) (Nsun/ Nmoon)
4	1 or 2	char	48	Line Separator, see comment in Table 13

Table 27: Sun/Moon Format Specification Content

The Sun/Moon Measurement Data (SMMD) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	22	A	1-22	Measurement Number (Sun/Moon Measurement 9999)
2	1	A	23	Number of Band Data Samples (9) (Nband)
3	1 or 2	char	24	Line Separator, see comment in Table 13
4	42 or 43	SMGI	25-66	Sun/Moon Geolocation Information, see Table 29
5	586 or 587	PDR	67-112	PMD Data Values of the corresponding science data packet, see Table 24
6	1 or 2	A	113	Line Separator, see comment in Table 13
7	Nband * (48,186 or 49,206) =	BDRA	114— 48,308	Band Data Records, see Table 25 (e.g. Nband = 4)

Table 28: Sun/Moon Measurement Data Content

The Sun/Moon Geolocation Information (SMGI) structure is given in the following table:

Field Number	Number of Bytes	Data Type	Byte Position	Description
1	12	A	1-12	UTC Date of Measurement End (DD-MMM-YYYY)
2	12	A	13-24	UTC Time of Measurement End (HH:MM:SS.mmm)
3	1 or 2	A	25	Line Separator, see comment in Table 13
4	15	A	26-40	Solar Zenith and Azimuth Angles at Satellite w.r.t North, (-999.99 -999.99)
5	1 or 2	A	41	Line Separator, see comment in Table 13
6	15	A	42-56	BSDF Zenith and Azimuth Angles or Moon Zenith and Azimuth Angles at Satel-lite w.r.t North, (-999.99 -999.99)
7	1 or 2	A	57	Line Separator, see comment in Table 13
8	7	A	58-64	Flag indicating if the record was used in the calculation of the Sun Reference Spectrum (9) 0 = no, 1 = yes, _ = no applicable or Illuminated Fraction of the Moon's Disk (9.99999)
9	1 or 2	A	65	Line Separator, see comment in Table 13

Table 29: Sun/Moon Geolocation Information Content

The following is an example of an extracted Level 1 Data for the sum measurements (the text in brackets and the dots are only for information and shortness, not part of the data set).

```
/*-------------------------------------------------------------------------*\    (GSI1)
** GDP Level 0-to-1 Extracting * Version  4.00 * Copyright (c) DLR 1996-2008 **
**                          * Product Format Version 2 *                     **
\*-------------------------------------------------------------------------*/
 Calibrations Applied
 Leakage Fixed Straylight Normalize Polarization BSDF Intensity
 Units
 Wavelength [nm], Irradiance [mW/m^2.nm], Radiance [mW/m^2.nm.sr]
E2GOM000000001KSEXTR1 DP19940506191143                                    (PIR)
ERS Information                                                           (ERSI)
 16638 19672770 1319 -1404.150757 -1300.069946 6893.603516 1.473122 7.208139 1.655951
 0.0 0.0 0.0 0.0 0.0 0.0 0 0
21275.817266 7159.468039 0.001148 98.552360 167.996690 91.476479 268.657728
Solar Spectrum 19-MAY-1994 10:35:09.500                                   (SFS)
Channel 1 236.898 314.484 512 0.0315 0 0 0 0                              (SDR)
 237.3802 0.00000E+00 0.00000E+00 0.00000E+00 0
 237.5007 0.00000E+00 0.00000E+00 0.00000E+00 0
 237.6206 0.44720E+14 0.22360E+13 0.89441E+11 0
 237.7412 0.52373E+14 0.26186E+13 0.10475E+12 0
 237.8616 0.45247E+14 0.22623E+13 0.90494E+11 0
 .....
 790.0000 0.50000E+15 0.30000E+14 0.20000E+13 0
Sunshine Spectrum 10:35:95.500 12:15:90.000 0155                          (SMFS)
Sun Measurement 1 6                                                       (SMMD)
20-MAY-1994 10:35:09.500                                                  (SMGI)
 42.50 25.61
 34.23 34.65
0
PMD 0 0 0                                                                 (PDR)
 0.12345E+00 0.23456E+00 0.34567E+00
 0.12345E+00 0.23456E+00 0.34567E+00
 0.12345E+00 0.23456E+00 0.34567E+00
 0.12345E+00 0.23456E+00 0.34567E+00
 0.12345E+00 0.23456E+00 0.34567E+00
 .....
 0.12345E+00 0.23456E+00 0.34567E+00
Band 1a 30 236.898 268.121 255 0.0493 0 0 0 0 0                           (BDRA)
 237.2598 0.00000E+00 0.00000E+00 0.00000E+00 0
 237.3805 0.00000E+00 0.00000E+00 0.00000E+00 0
 237.5003 0.00000E+00 0.00000E+00 0.00000E+00 0
 237.6206 0.44720E+12 0.22360E+11 0.89441E+09 0
 237.7413 0.52373E+12 0.26186E+11 0.10475E+10 0
 ....
 268.1213 0.95544E+13 0.47772E+12 0.19109E+11 0
```

```
Band 4 1.5 578.602 780.266 1024 0.0331 0 0 0 0 0                    (BDRA)
...
Sun Measurement 2 6                                                 (SMMD)
```

A.3 Basic Data Representations

This appendix describes how GDP represents data in storage, specifically in the data products. This chapter is intended as a guide to programmers who wish to write their own reading modules in other languages or on other machines having a different representation of numbers.

Storage Allocation

The following table shows the storage allocation of the basic numeric data types which are used for GDP products:

Data Type	Internal Representation
char	a single 8–bit byte aligned on a byte boundary.
short	half word (two bytes or 16 bits), aligned on a two–byte boundary.
long	32 bits (four bytes or one word), aligned on a four–byte boundary.
float	32 bits (four bytes or one word), aligned on a four–byte boundary. A float has a sign bit, 8–bit exponent, and 23–bit fraction.
double	64 bits (eight bytes or two words), aligned on a double–word boundary. A double element has a sign bit, an 11–bit exponent and a 52–bit fraction.

Table 30: Data Type Storage Allocation

Data Representations

Bit numberings of any given data element used for GDP are as follows:

1.3- Bit 0 is the least significant bit of one byte;

1.3 Byte 0 is the most significant byte of a given data element.

The most significant bit of the `char`, `Short` and `long` data types is a sign bit. The `unsigned` versions of these data types use all bits for representation of the number, but do not known negative values.

`float` and `double` data elements are represented according to the ”ANSI IEEE” 754-1985 Standard.

Bits	Content
8-15	Byte 0
0-7	Byte 1

Table 31: Short Data Type Representation

Bits	Content
24-31	Byte 0
16-23	Byte 1
8-15	Byte 2
0-7	Byte 3

Table 32: Long Data Type Representation

Bits	Name	Content
31	Sign	1 if number is negative.
23-30	Exponent	Eight–bit exponent, biased by 127. Values of all zeros, and all ones, reserved.
0-22	Fraction	23–bit fraction component of normalised significand. The ”one” bit is ”hidden”.

Table 33: Float Data Type Representation

Bits	Name	Content
63	Sign	1 if number is negative.
52-62	Exponent	Eleven–bit exponent, biased by 1023. Values of all zeros, and all ones, reserved.
0-51	Fraction	52–bit fraction component of normalised significand. The ”one” bit is ”hidden”.

Table 34: Double Data Type Representation

A float and double number is represented by the form:

$$(-1)^{Sign} \quad 2^{(exponent - bias)} \quad 1.fraction$$

where ”1.fraction” is the significand and ”fraction” are the bits in the significand fraction.