The EUMETSAT Network of Satellite Application Facilities

O3M SAF
Ozone and Atmospheric Chemistry Monitoring

PRODUCT USER MANUAL

Offline UV (OUV) Products

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Introduction to EUMETSAT Satellite Application Facility on Ozone and Atmospheric Chemistry Monitoring (O3M SAF)

Background

The need for atmospheric chemistry monitoring was first realized when severe loss of stratospheric ozone was detected over the Polar Regions. At the same time, increased levels of ultraviolet radiation were observed.

Ultraviolet radiation is known to be dangerous to humans and animals (causing e.g. skin cancer, cataract, immune suppression) and having harmful effects on agriculture, forests and oceanic food chain. In addition, the global warming - besides affecting the atmospheric chemistry - also enhances the ozone depletion by cooling the stratosphere. Combined, these phenomena have immense effects on the whole planet. Therefore, monitoring the chemical composition of the atmosphere is a very important duty for EUMETSAT and the world-wide scientific community.

Objectives

The main objectives of the O3M SAF are to process, archive, validate and disseminate atmospheric composition products (O_3, NO_2, SO_2, OClO, HCHO, BrO, H_2O), aerosols and surface ultraviolet radiation utilising the satellites of EUMETSAT. The majority of the O3M SAF products are based on data from the GOME-2 spectrometer onboard MetOp-A satellite.

Another important task of the O3M SAF is the research and development in radiative transfer modelling and inversion methods for obtaining long-term, high-quality atmospheric composition products from the satellite measurements.

Product families

- Near real-time Total Column (NTO)
  - O_3, NO_2, O_3Tropo, NO_2Tropo
- Near real-time Ozone Profile (NOP)
- Near real-time UV Index (NUV)
- Offline Total Column (OTO)
  - O_3, NO_2, O_3Tropo, NO_2Tropo, SO_2, BrO, H_2O, HCHO, OClO
- Offline Ozone Profile (OOP)
- Offline Surface UV (OUV)
- Aerosols (ARS)

Product timeliness and dissemination

Data products are divided in two categories depending on how quickly they are available to users:

Near real-time products are available in less than three hours after measurement. These products are disseminated via EUMETCast (NTO, NOP), GTS (NTO, NOP) or Internet (NUV).

Offline products are available in two weeks from the measurement and they are archived at the O3M SAF archives in Finnish Meteorological Institute (OOP, OUV, ARS) and German Aerospace Center (OTO).

Only products with “pre-operational” or “operational” status are disseminated. Up-to-date status of the products and ordering info is available on the O3M SAF website.

Information about the O3M SAF project, products and services: http://o3msaf.fmi.fi/

O3M SAF Helpdesk: o3msaf@fmi.fi

DOCUMENT STATUS SHEET

Issue	Date	Modified items / Reason for change
1.0	15.11.2006	Initial revision of the full document
1.1	04.05.2007	-moved algorithm description and error analysis to a separate ATBD as required by EUMETSAT -updated the file naming convention
1.2	04.04.2008	-added error fields
1.3	12.02.2009	- clarified the setting of quality flags in section 3.2.; table 3 in section 5.1.2.; tables 7 and 8 in section 5.1.4.
1.4	20.05.2013	-added vitamin D weighting products -removed SCUP-h weighting products -introduced the homogenized cover page -added the SAF introduction page -renumbered tables and figures -reformatted tables
1.5	28.06.2013	- sect. 1.2: added acronyms - sect. 1.3.2.: corrected the HDF5 link - eq. 2.2: corrected O -> O(3P) - table 2.1: swapped wavelength ranges of UVA and UVB - p. 6: a HDF5 file -> an HDF5 file - p. 9: corrected typos, changed 'produced operatively' -> 'operationally processed', 'sending e-mail' -> 'sending an email' - sect 3.2.: rephrased the list on quality flag usage

Contents

1 INTRODUCTION

1.1 Purpose and scope

This document is the user manual of the O3M SAF Offline UV product (OUV). It includes the definition of the product format. The algorithm and error analysis are described in a separate Algorithm Theoretical Basis Document [AD1].

1.2 Acronyms

ARS	Aerosol Retrieval System / Aerosol product
ATBD	Algorithm Theoretical Basis Document
AVHRR	Advanced Very High Resolution Radiometer
CIE	Commission Internationale de l'Éclairage, International Commission on Illumination
DLR	Deutsches Zentrum für Luft- und Raumfahrt, German Aerospace Center
DNA	Deoxyribonucleic acid
EUMETCast	EUMETSAT's broadcast system for environmental data
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FMI	Finnish Meteorological Institute
GOME-2	Global Ozone Monitoring Experiment-2
GTS	Global Telecommunications System
HDF	Hierarchial Data Format
Internet	International network
Metop	Meteorological Operational satellite programme
NOAA	National Oceanic and Atmospheric Administration
NOP	Near real-time Ozone Profile product
NRT	Near real-time
NTO	Near real-time Total Ozone product
NUV	Near real-time UV product
O3M SAF	Satellite Application Facility on Ozone and Atmospheric Chemistry Monitoring
OOP	Offline Ozone Profile product
OTO	Offline Total Ozone product
OUV	Offline UV product
PUM	Product User Manual
UMARF	Unified Meteorological Archiving and Retrieval Facility
UV	Ultraviolet radiation
UVI	UV Index
WHO	World Health Organization

1.3 References

1.3.1 Applicable Documents

[AD1] OUV Algorithm Theoretical Basis Document, SAF/O3M/FMI/ATBD/001, Issue 1.4, 28.6.2013.

[AD2] O3M SAF Product Requirements Document, SAF/O3M/FMI/RQ/PRD/001, Issue 1.3, 16.5.2013.

[AD3] UMARF to SAFs ICD, EUM/UMA/ICD/004, Issue 3.13, 14 Feb 2007.

[AD4] UMARF SAF Metadata Definition, EUM/UMA/TEN/030, Issue 1.7, 09 Feb 2007.

1.3.2 Reference Documents

[RD1] Global Solar UV Index: A Practical Guide, WHO, 2002, ISBN 92 4 159007 6, Annex C, http://www.who.int/uv/publications/en/GlobalUVI.pdf

[RD2] McKinlay A.F and Diffey B.L., *CIE Research Note*, 6(1), 1987

[RD3] Setlow R.B., *Proc. Nat. Acad. Sci. USA.*, 71, 3363-3366, 1974.

[RD4] Caldwell, M.M. "Solar UV Irradiation and the Growth and Development of Higher Plants", pages 131-177 in Giese A.G (ed.) *Photophysiology*, vol 6. Academic Press, New York, 1971

[RD5] CIE, 2006. Action spectrum for the production of previtamin D3 in human skin. Technical Report 174. International Commission on Illumination.

[RD6] Kinne S. (2007): Towards an observation-tied AOD climatology, presentation in AT2 Aerosol Workshop, Bremen, June 2007.

[RD7] Tanskanen, A., (2004) Lambertian surface albedo climatology at 360 nm from TOMS data using moving time-window technique. *Proc. XX Quadrennial Ozone Symposium*, 1-8 June, Kos, Greece., pp 1159-1160.

[RD8] HDF5 File Format Specification, http://www.hdfgroup.org/HDF5/doc/H5.format.html

[RD9] Herman, J.R., and E. Celarier, "Earth surface reflectivity climatology at 340-380 nm from TOMS data." *J. Geophys. Res.*, 102, 28,003-28,011, 1997.

2 Product overview

The O3M SAF offline surface UV product is derived from the measurements of the operational polar orbiting Metop and NOAA satellites. The product contains the most important quantities of the Sun's radiation that can be harmful to life and materials on the Earth. These quantities include daily doses and maximum dose rates of integrated UV-B and UV-A radiation together with values obtained by different biological weighting functions, the solar noon UV index [RD1], and quality control flags. In addition, photolysis frequencies for photodissosiation of ozone and nitrogen dioxide are given for air quality applications. The product is calculated in a 0.5 degree regular grid and stored in an HDF5 file. The contents of the product file are listed in section 5. An example of the daily erythemal dose product is shown in figure 2.1 below.

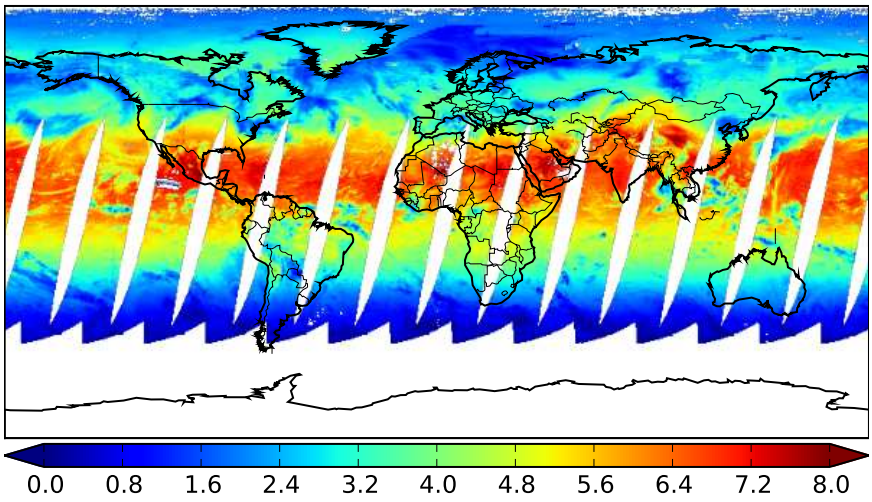

Figure 2.1: An example product field. Erythemal (CIE) daily dose [kJ/m2] on 12 May 2008. The global coverage is limited by the swath of GOME-2 instrument, leaving stripes at low latitudes. The polar night and large solar zenith angles limit the coverage at the winter pole.

The biological weighting functions (also known as action spectra) model responses of different biological entities to UV radiation. The currently applied functions are plotted in figure 2.2 (left) and a short description of their meaning is given in table 2.1.

The photolysis frequencies $j_{O(^1D)}$ and j_{NO_2} are the rate constants of the following two key reactions in the chemistry of the troposphere:

$$O_3 + h\nu(\lambda < 320nm) \rightarrow O(^1D) + O_2, \quad \frac{d[O(^1D)]}{dt} = j_{O(^1D)}[O_3] \tag{2.1}$$

$$NO_2 + h\nu(\lambda < 420nm) \rightarrow NO + O(^3P), \quad -\frac{d[NO_2]}{dt} = j_{NO_2}[NO_2] \tag{2.2}$$

Absorption cross sections of ozone and nitrogen dioxide, and the quantum yields of the two reactions are shown in figure 2.2 (right). The photolysis frequencies are currently given only at the surface level.

Table 2.1: Description of the biological weighting functions used in the OUV product.

Weighting function	Ref.	Integration wavelength range [nm]	Description
CIE	[RD2]	290 - 400	Measures the reddening of the skin due to sunburn. Also known as the erythemal weighting function. Used for UV index.
DNA	[RD3]	290 - 400	Measures the ability of UV irradiance to cause damage to unprotected DNA.
Plant	[RD4]	290 - 400	Measures the generalized response of plants to UV irradiance.
UVB	-	290 - 315	Integrated UVB radiation
UVA	-	315 - 400	Integrated UVA radiation
Vitamin D	[RD5]	290 - 330	production of previtamin D3 in human skin

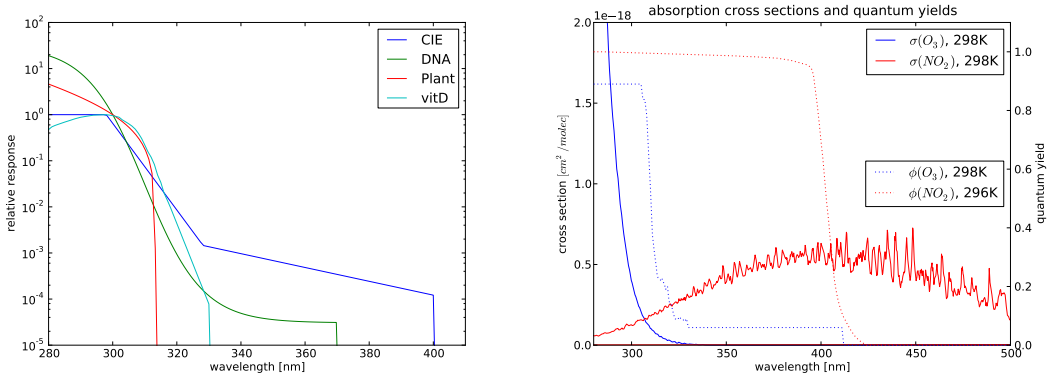

Figure 2.2: Left: the biological weighting functions: CIE (blue), DNA (green), Plant (red) and vitamin D (cyan). Right: cross-sections (solid line) and quantum yields (dotted line) for ozone (blue) and NO_2 (red).

The key factors affecting the surface UV radiation are ozone, clouds, aerosols and surface albedo. The total ozone is obtained from the O3M SAF near real time total column ozone product (NTO). This product is made by German Aerospace Center (DLR) and disseminated via the EUMETCast broadcasting system. It is derived from the measurements of the GOME-2 instrument onboard Metop satellites.

The cloud optical depth is estimated from AVHRR channel 1 (visible) reflectances. AVHRR is also onboard the Metop satellites. The sampling of the diurnal cloud cycle is improved by using additional AVHRR data from the NOAA satellites, available through the data exchange between EUMETSAT and NOAA. Because Metop is on a morning orbit and NOAA satellite on the afternoon orbit, at least two samples of the diurnal cycle can be obtained globally (fig. 2.3). More overpasses are available at high latitudes where the instrument swaths overlap for consecutive orbits. This sampling scheme provides a sufficient compromise between the global coverage and sampling of the diurnal cycle. Moreover, the processing data flow can be kept relatively simple because both the Metop and NOAA AVHRR data are available through EUMETCast. The aerosol optical depth is currently taken from a climatology [RD6], and the surface albedo from the climatologies of Tanskanen [RD7] and Herman *et al.* [RD9].

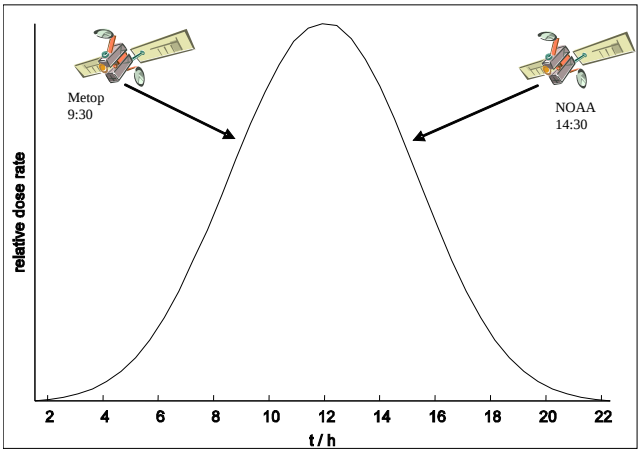

Figure 2.3: The diurnal cycle of UV dose rate (clear-sky case shown for clarity) together with the sampling achieved by Metop and NOAA AVHRR measurements. The sampling of the diurnal cycle is improved at high latitudes where the instrument swaths overlap for consecutive orbits.

3 Product quality

3.1 Expected Accuracy and Validation

The target product accuracy is 20 % against ground-based UV measurements. The surface UV product is validated by a validation service. This service, also located at FMI, performs two different validation activities. Firstly, online quality monitoring compares new products with a time-series of all previously processed products to detect any degration in the product quality. These online quality monitoring plots are available at http://o3msaf.fmi.fi/uv_validation/online_quality.html. Secondly, the UV product is fully validated against quality-checked ground-based measurements. These results are provided as validation reports. The latest validation report is available on the O3M SAF web site at http://o3msaf.fmi.fi/uv_validation/latest_report.html.

3.2 Quality flags

Quality flags (table 5.6) are set during the processing to indicate degraded product quality. Figure 3.1 shows example plots of the quality flags. These quality flags should be carefully examined when using the product. In order to simplify basic quality control, three summary flags (table 5.7) have been designed: QC_MISSING, QC_LOW_QUALITY and QC_MEDIUM_QUALITY. The user is encouraged to use these summary flags as follows:

- If invalid data is to be filtered out, apply QC_MISSING. This is also achieved by excluding fill values in the data.
- If low data quality is to be filtered out, apply QC_LOW_QUALITY (it contains QC_MISSING).
- If medium quality data is to be filtered out apply QC_MEDIUM (it contains QC_LOW_QUALITY).

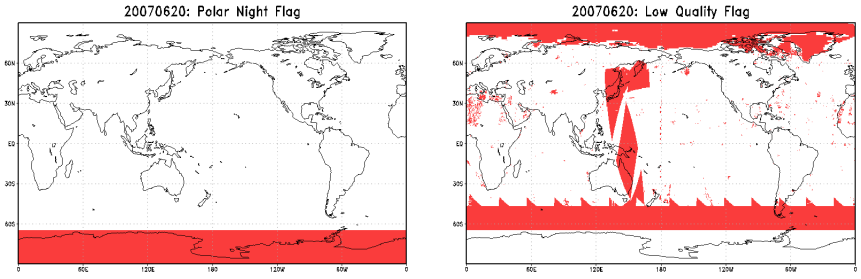

Figure 3.1: Example plots of the quality flags. The red color indicates where the flag is on. (left) The polar night flag is set when the solar zenith angle is larger than 88 degrees and (right) the low quality flag is set when it is larger than 70 degrees. The low quality flag is also set for other conditions, such as edges of ice sheets with inhomogeneous surface albedo and mountains with sloped surfaces.

3.3 Current Quality Issues

The estimation of effective cloud optical depth from the AVHRR reflectances becomes prone to errors if the solar zenith angle is larger than 70 degrees or if the surface albedo is high, and therefore the corresponding product values are flagged as of low quality. The product values are also flagged if insufficient cloud data were available for the calculation of the diurnal integral.

Climatological values are currently used for surface albedo and aerosols. The surface albedo climatology fails during snow falling and melting periods, which vary from year to year. The aerosol climatology, on the other hand, tends to underestimate the aerosol loading in the boundary layer, especially during the summer time.

4 Processing, archiving and dissemination

4.1 Processing and archiving

The offline UV product is operationally processed with a maximum delay of 15 days between the satellite measurements and the dissemination to the users. The actual delay depends on the operational computing environment and on possible delays in getting the input data from different sources. The delay is typically three days. The overall processing scheme is described below.

The input near real time total column ozone product (NTO) is produced by the German Aerospace Center (DLR). It is sent to the EUMETCast uplink station at Usingen, Germany, where it is broadcasted via telecommunication satellites (Eurobird). The NTO product is received at FMI, together with input AVHRR level 1b products both from Metop and NOAA satellites.

The output OUV product is stored in the FMI Archive, from where it can be ordered via the Eumetsat Data Centre. The processing data flow is depicted in figure 4.1 below.

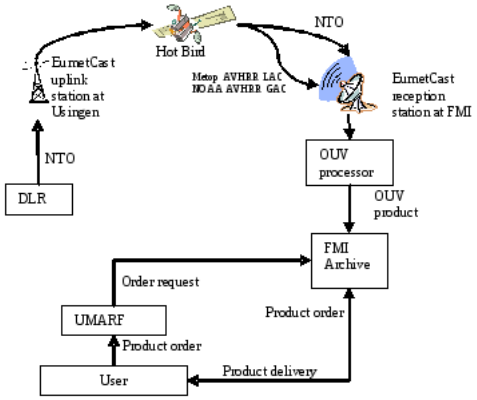

Figure 4.1: Overall processing data flow.

4.2 Product ordering

The product can be ordered from the Eumetsat Data Centre at http://www.eumetsat.int/Home/Main/DataAccess/EUMETSATDataCentre/index.htm. The product order will be transmitted to the FMI Archive, and the user will receive an e-mail containing the instructions on how to download the data files.

4.3 User services

The helpdesk can be accessed through the O3M SAF web site at http://o3msaf.fmi.fi, or by sending an email to o3msaf@fmi.fi.

5 Product file format

This section describes the HDF5 format [RD8] of the offline UV product.

5.1 File structure

The data in the HDF5 file is organized under four groups: METADATA, PRODUCT_SPECIFIC_METADATA, GRID_DESCRIPTION and GRID_PRODUCT. The file structure is shown in figure 5.1. The values in all groups are either copied from the input data or calculated by the processor. The METADATA group contains the parameters required by the

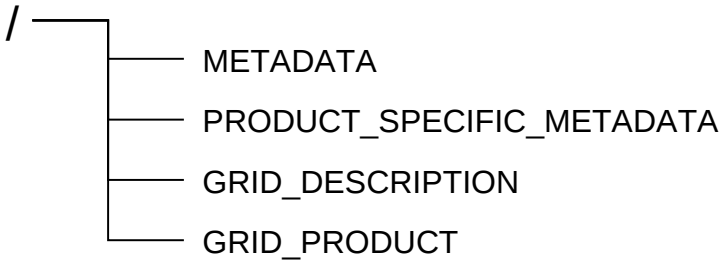

Figure 5.1: Structure of the HDF5 file.

Eumetsat Data Centre while the PRODUCT_SPECIFIC_METADATA group is used for additional information specific to this product. The product fields are stored in a regular longitude-latitude grid. The grid parameters are stored as attributes of the GRID_DESCRIPTION group whereas the product fields are stored as datasets in the GRID_PRODUCT group. The x-dimension of the grid is the longitude and the y-dimension is the latitude. The product fields are two-dimensional arrays of floating point or integer data. If a value for a grid cell cannot be calculated, a fill value is written to the array. Each array has five attributes: Title, Unit, FillValue, ValidRangeMin and ValidRangeMax. These are used to describe the contents of the array. The organization of the data is illustrated in figure 5.2.

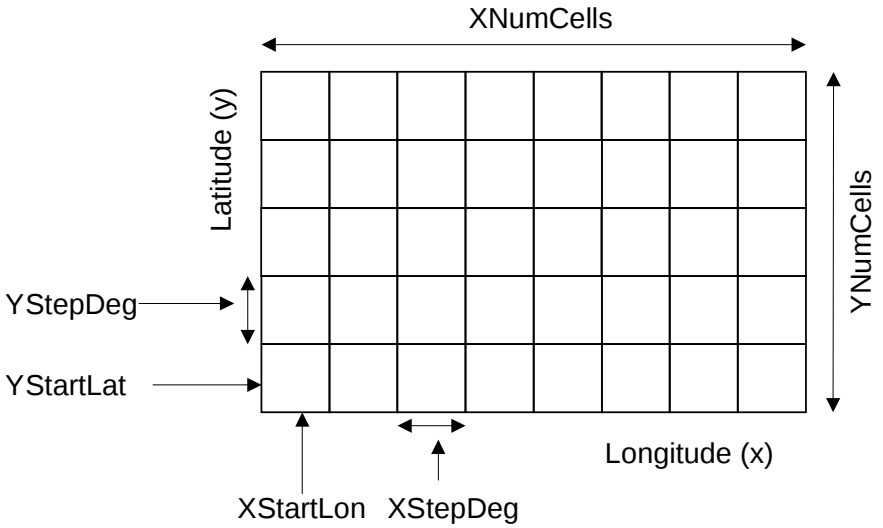

Figure 5.2: Organization of the product fields in the HDF5 file.

5.1.1 METADATA Group

The content of the METADATA group is shown in the following table. All parameters are stored as attributes of the group. The allowed values for the parameters that are required by the Eumetsat Data Centre are consistent with the requirements given in [AD4]. The allowed values given in italics mean any value of the given type (e.g. string means that the attribute can contain any string, within the size limit).

Table 5.1: METADATA group contents.

Attribute name	Data type	Description	Allowed values
SatelliteID	string	Platform identifier (mission and spacecraft the product originated from).	M01,M02,M03, N15,N16,N17,N18, N19 etc.
OrbitType	string	Orbit type of the spacecraft, indicating the coverage of the product.	LEO
InstrumentID	string	Instrument which acquired the product.	GOME,AVHR
SensingStartTime	string	UTC date and time at acquisition start of the product.	YYYY-MM-DDThh:mm:ss.ddd
SensingEndTime	string	UTC date and time at acquisition end of the product.	YYYY-MM-DDThh:mm:ss.ddd
ProcessingCentre	string	Centre that generated the data.	O3FMI
ProcessingLevel	string	Processing level applied for generation of the product.	03
ProcessingMode	string	Processing mode applied for generation of the product	N=Nominal, B=Backlogged, R=Reprocessed, V=Validation
ProcessingTime	string	UTC date and time at processing end of the product.	YYYY-MM-DDThh:mm:ss.ddd
ReferenceTime	string	Time at which the product is defined to be valid.	Same value as ProcessingTime
ProductAlgorithmVersion	string	Version of the algorithm that produced the product.	String<4>
ParentProducts	string	A list of the name of the parent products, upon which the product is based.	NTO, AVHRR_level_1b
BaseAlgorithmVersion	string	Version of the NTO product.	String<4>
ProductType	string	Abbreviated name for the product type, or rather product category.	O3MOUV
ProductFormatVersion	string	Version number of the product format (= Issue of this User Manual document)	String<4>
OverallQualityFlag	string	Overall quality flag for the product.	OK or NOK
QualityInformation	string	Several miscellaneous quality indicators for the product.	String<511>
DegradedRecordCount	int	Number of degraded product values.	Int
DegradedRecordPercentage	int	Percentage of degraded product values.	Int 0-100
MissingDataCount	int	Number of missing product values.	Int
MissingDataPercentage	int	Missing data percentage.	Int 0-100
GranuleType	string	Type description of the item.	DP
MapProjection	string	Projection used by the product	Geographic
DispositionMode	string	Disposition mode applied for generation of the product	O = Operational, P = Pre-operational

5.1.2 PRODUCT_SPECIFIC_METADATA Group

The product specific metadata are listed in the following table.

Table 5.2: PRODUCT_SPECIFIC_METADATA group contents.

Attribute name	Data type	Unit	Description
LowSunNoonSza	float	degree	Limiting solar noon zenith angle for setting the QC_LOW_SUN quality flag.
PolarNightNoonSza	float	degree	Limiting solar noon zenith angle for setting the QC_POLAR_NIGHT quality flag.
ThickCloudsCod	float	none	Limiting cloud optical depth for setting the QC_THICK_CLOUDS quality flag.
HighAlbedoClearSky	float	none	Limiting surface albedo for setting the QC_HIGHALB_CLEARSKY quality flag.
HighAlbedoClearSkyPatm	float	atm	Limiting surface pressure for setting the QC_HIGHALB_CLEARSKY quality flag.
InhomogeneousSurfaceHeightLimit	float	m	Limiting surface height deviation for setting the QC_INHOMG_SURFACE quality flag.
InhomogeneousSurfaceAlbedoLimit	float	none	Limiting surface albedo deviation for setting the QC_INHOMG_SURFACE quality flag.

5.1.3 GRID_DESCRIPTION Group

The grid parameters are stored as attributes of the GRID_DESCRIPTION group. The attributes are given in the following table.

Table 5.3: GRID_DESCRIPTION group contents.

Attribute name	Data type	Unit	Description
XNumCells	int	N/A	Number of grid cells in the X direction
YNumCells	int	N/A	Number of grid cells in the Y direction
XStartLon	float	degree	Longitude of the centre of the first grid cell in the X direction. Longitude ranges from -180 to +180.
YStartLat	float	degree	Latitude of the centre of the first gird cell in the Y direction. Latitude ranges from -90 to +90.
XStepDeg	float	degree	Step (increment) between the grid cells in the X direction
YStepDeg	float	degree	Step (increment) between the grid cells in the Y direction

5.1.4 GRID_PRODUCT Group

The datasets in the GRID_PRODUCT group are given in the following table. The daily doses, daily maximum dose rates and their error estimates are stored for the following four different biological weightings: erythemal (“Cie”), DNA damage (“Dna”), generalized plant response (“Plant”) and vitamin D (“Vitd”), together with integrated UV-B (290-315 nm) and UV-A (315-400 nm) radiation and the solar noon UV index. In addition, the daily maximum photolysis frequencies of $O(^1D)$ formation and NO_2 photodissosiation are given. Attributes attached to all datasets in this group are listed in table 5.5. The contents of the QualityFlags and the setting of the summary flags are listed in tables 5.6 and 5.7.

Table 5.4: GRID_PRODUCT group contents.

Dataset name	Data type	Unit	Description
DailyDoseCie	float	kJ/m2	Daily UV dose, CIE weighting
DailyDoseCieLow			-low dose estimate
DailyDoseCieHigh			-high dose estimate
DailyDoseDna	float	kJ/m2	Daily UV dose, DNA damage weighting
DailyDoseDnaLow			-low dose estimate
DailyDoseDnaHigh			-high dose estimate
DailyDosePlant	float	kJ/m2	Daily UV dose, Plant response weighting
DailyDosePlantLow			-low dose estimate
DailyDosePlantHigh			-high dose estimate
DailyDoseVitd	float	kJ/m2	Daily UV dose, Vitamin D synthesis weighting
DailyDoseVitdLow			-low dose estimate
DailyDoseVitdHigh			-high dose estimate
DailyDoseUvb	float	kJ/m2	Daily UV dose, integrated UV-B (290-315 nm)
DailyDoseUvbLow			-low dose estimate
DailyDoseUvbHigh			-high dose estimate
DailyDoseUva	float	kJ/m2	Daily UV dose, integrated UV-A (315-400 nm)
DailyDoseUvaLow			-low dose estimate
DailyDoseUvaHigh			-high dose estimate
DailyMaxDoseRateCie	float	mW/m2	Daily maximum dose rate, CIE weighting
DailyMaxDoseRateCieLow			-low dose rate estimate
DailyMaxDoseRateCieHigh			-high dose rate estimate
DailyMaxDoseRateDna	float	mW/m2	Daily maximum dose rate, DNA damage weighting
DailyMaxDoseRateDnaLow			-low dose rate estimate
DailyMaxDoseRateDnaHigh			-high dose rate estimate
DailyMaxDoseRatePlant	float	mW/m2	Daily maximum dose rate, Plant response weighting
DailyMaxDoseRatePlantLow			-low dose rate estimate
DailyMaxDoseRatePlantHigh			-high dose rate estimate
DailyMaxDoseRateVitd	float	mW/m2	Daily maximum dose rate, Vitamin D synthesis weighting
DailyMaxDoseRateVitdLow			-low dose rate estimate
DailyMaxDoseRateVitdHigh			-high dose rate estimate
DailyMaxDoseRateUvb	float	mW/m2	Daily maximum dose rate, integrated UV-B (290-315 nm)
DailyMaxDoseRateUvbLow			-low dose rate estimate
DailyMaxDoseRateUvbHigh			-high dose rate estimate
DailyMaxDoseRateUva	float	mW/m2	Daily maximum dose rate, integrated UV-A (315-400 nm)
DailyMaxDoseRateUvaLow			-low dose rate estimate
DailyMaxDoseRateUvaHigh			-high dose rate estimate
DailyMaxJO1D	float	1/s	Daily maximum $j(O(^1D))$
DailyMaxJO1DLow			-low rate estimate
DailyMaxJO1DLow			-high rate estimate
DailyMaxJNO2	float	1/s	Daily maximum $j(NO_2)$
DailyMaxJNO2Low			-low rate estimate
DailyMaxJNO2Low			-high rate estimate
SolarNoonUvIndex	float	N/A	Solar noon UV index
SolarNoonUvIndexLow			-low index estimate
SolarNoonUvIndexHigh			-high index estimate
QualityFlags	int	N/A	Quality flags for the product. See table 5.6 for interpretation of the bits.

Table 5.5: Attributes for the GRID_PRODUCT group datasets.

Attribute name	Data type	Description
Title	string	Description of the dataset, e.g. “Solar noon UV index”
Unit	string	Unit of the values in the array, e.g. second
FillValue	same as the dataset	Number in the array, if actual data value is missing
ValidRangeMin	same as the dataset	Minimum allowed value for the data in the array
ValidRangeMax	same as the dataset	Maximum allowed value for the data in the array

Table 5.6: Interpretation of the QualityField. Flags have the value 1 for on and 0 for off.

Bit	Name	Description
0	QC_MISSING	Data are missing.
1	QC_LOW_QUALITY	At most low quality expected.
2	QC_MEDIUM_QUALITY	At most medium quality expected.
3	QC_INHOMOG_SURFACE	The surface UV varies too much within the grid cell because of surface inhomogenity. The flag is set if: - surface height within the grid cell deviates from the mean value more than the value InhomogeneousSurfaceHeightLimit given in the product specific metadata field. - surface albedo within the grid cell and its nearby neighbours deviates more than the value InhomogeneousSurfaceAlbedoLimit given in the product specific metadata field.
4	OC_POLAR_NIGHT	Polar night. The solar zenith angle is larger than the value PolarNightNoonSza given in the product specific metadata field.
5	QC_LOW_SUN	The Sun is too low for reliable radiative transfer modelling of surface UV. The threshold solar zenith angle is given in the LowSunNoonSza attribute of the product specific metadata field.
6	QC_OUTOFRANGE_INPUT	Out of range input data was detected, but the value could still be used in processing.
7	QC_NO_CLOUD_DATA	No cloud data were available.
8	QC_POOR_DIURNAL_CLOUDS	Poor diurnal cloud coverage. This flag is set when insufficient cloud data are available to cover the diurnal cloud cycle.
9	QC_THICK_CLOUDS	Thick clouds were observed. This flag is set when optically thick clouds are observed during the day. Saturation of the atmospheric reflectance as a function of the cloud optical depth prevents accurate estimation of the cloud optical depth, and therefore, the surface UV flux cannot be accurately determined. The threshold cloud optical depth is given in the ThickCloudsCod attribute of the product specific metadata field.
10	QC_ALB_CLIM_IN_DYN_REG	Surface albedo climatology was used in a dynamic region where albedo varies with the snow and ice cover.
11	QC_LUT_OVERFLOW	Look-up table limits were exceeded and a value was extrapolated.
12	QC_HIGHALB_CLEARSKY	Clear-sky was assumed if surface albedo was larger than the value HighAlbedoClearSky and surface pressure was smaller than the value HighAlbedoClearSkyPatm given in the product specific metadata field.
13-15	reserved for future use	
16-19	QC_OZONE_SOURCE	4 bits as an integer: source of total column ozone data. In the current version this is always 0 meaning GOME-2 total ozone (NTO or OTO)
20-23	QC_NUM_AM_COT	4 bits as an integer: number of cloud optical thickness observations in the morning, value 15 indicating 15 or more observations.
24-27	QC_NUM_PM_COT	4 bits as an integer: number of cloud optical thickness observations in the afternoon, value 15 indicating 15 or more observations.
28-31	QC_NOON_TO_COT	4 bits as an integer: minimum time in hours (rounding towards zero) between the solar noon and the nearest cloud optical thickness (COT) observation

Table 5.7: Mapping of the quality flags to summary flags.

Summary flag	Summary flag is on if any of these flags is on.
QC_MISSING	QC_POLAR_NIGHT QC_NO_CLOUD_DATA
QC_LOW_QUALITY	QC_MISSING QC_LOW_SUN QC_OUTOFRANGE_INPUT QC_LUT_OVERFLOW
QC_MEDIUM_QUALITY	QC_LOW_QUALITY QC_POOR_DIURNAL_CLOUDS QC_HIGHALB_CLEARSKY QC_INHOMOG_SURFACE QC_THICK_CLOUDS QC_ALB_CLIM_IN_DYN_REG

5.2 Data Types

The data types to be used in the HDF5 files are listed in the table 5.8 below.

Table 5.8: Data types for the HDF5 files.

Data type	HDF5 predefined data type
char	H5T_STD_I8LE
short int	H5T_STD_I16LE
int	H5T_STD_I32LE
float	H5T_IEEE_F32LE
double	H5T_IEEE_F64LE
string	Fortran: H5T_FORTRAN_S1, C: H5T_C_S1

5.3 File naming convention

The file naming convention of the OUV product is depicted in figure 5.3.

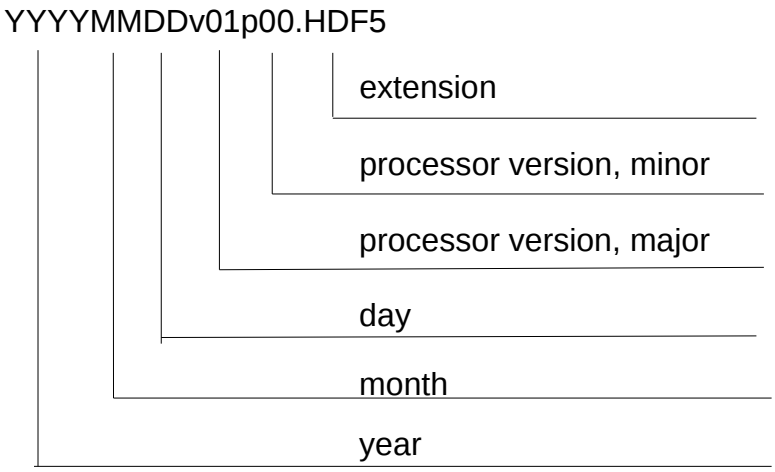

Figure 5.3: The structure of the OUV file name.

A Traceability of metadata to Eumetsat Data Centre parameters

This appendix contains details related to the interface between the catalogue of the EUMETSAT Data Centre (previously named as UMARF, this acronym is used here for clarity) and the FMI archive [AD3]. The metadata parameters [AD4] which are applicable to the O3MSAF products are stored in the HDF5 file as attributes in the Metadata group (table 5.1). The tracing of UMARF parameters to the attributes in the product file is shown in table A.1 below. The attributes can only have values which are allowed by UMARF.

Table A.1: Traceability of metadata to UMARF parameters

UMARF Short Name	Attribute Name	Notes
ASTI	SatelliteID	-
GORT	OrbitType	-
LONS	N/A	Start Orbit Number
LONE	N/A	End Orbit Number
LLAS	N/A	SubSatellitePointStartLat
LLOS	N/A	SubSatellitePointStartLon
LLAE	N/A	SubSatellitePointEndLat
LLOE	N/A	SubSatellitePointEndLon
LSVT	N/A	Ascending Node Crossing Date and Time
OCSA	N/A	Occultation Satellite ID (TBC)
OCLA	N/A	Occultation Latitude (TBC)
OCLO	N/A	Occultation Longitude (TBC)
OCTM	N/A	Occultation Date and Time (TBC)
AIID	InstrumentID	-
SMOD	N/A	InstrumentMode
SSBT	SensingStartTime	-
SSST	SensingEndTime	-
ABID	N/A	Spectral Band IDs
GNSP	N/A	Number of Spectral Bands
RRCC	N/A	ReceivingCentre
RRBT	N/A	Reception Start Date and Time
RRST	N/A	Ibid. End Date and Time
PPRC	ProcessingCentre	-
PPDT	N/A	Processing Start Date and Time
PPST	ProcessingTime	Processing End Date and Time
GPLV	ProcessingLevel	-
AVBA	BaseAlgorithmVersion	-
AVPA	ProductAlgorithmVersion	-
LMAP	Map Projection	-
LSCD	N/A	SpatialCoverageModel
APXS	N/A	PixelSize
SNIT	ReferenceTime	-
AENV	N/A	SourceEnvironment
GDMD	Disposition Mode	-
GPMD	ProcessingMode	-
APNM	ProductType	-
APNA	N/A	Unique product identifier used in the O3M SAF archive; not included in the product file, provided to UMARF by archive software
APPN	ParentProducts	-
APAS	Added by Archive	Product Actual Size; not included in the product file, provided to UMARF by archive software
GNPO	N/A	Native Pixel Order
GNPF	N/A	ProductFormatType
GNFV	ProductFormatVersion	-
QCCV	N/A	Cloud Coverage
QQOV	OverallQualityFlag	-
QQAI	QualityInformation	-
QDRC	DegradedRecordCount	-
QDRP	DegradedRecordPercentage	-
QDLC	MissingDataCount	-
QDLP	MissingDataPercentage	-
AARF	Added by Archive	Archive Facility; not included in the product file, provided to UMARF by archive software
UUDT	N/A	Ingestion Date and Time
GGTP	GranuleType	-
UDSP	N/A	DispositionFlag, UMARF internal