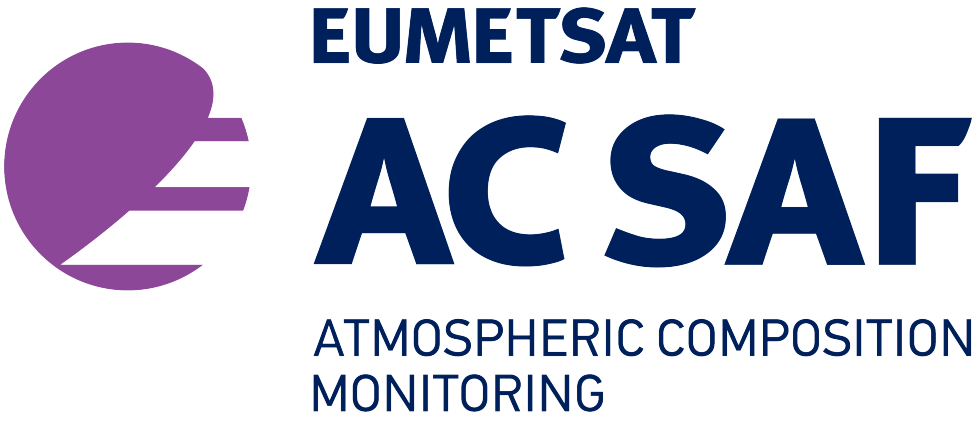

PRODUCT USER MANUAL

Offline UV Products v2

(IDs: O3M-450 - O3M-464)

and

Data Record R1

(IDs: O3M-138 - O3M-152)

Prepared by: Jukka Kujanpää Finnish Meteorological Institute

Introduction to EUMETSAT Satellite Application Facility on Atmospheric Composition monitoring (AC SAF)

Background

The monitoring of atmospheric chemistry is essential due to several human caused changes in the atmosphere, like global warming, loss of stratospheric ozone, increasing UV radiation, and pollution. Furthermore, the monitoring is used to react to the threads caused by the natural hazards as well as follow the effects of the international protocols.

Therefore, monitoring the chemical composition and radiation of the atmosphere is a very important duty for EUMETSAT and the target is to provide information for policy makers, scientists and general public.

Objectives

The main objectives of the AC SAF is to process, archive, validate and disseminate atmospheric composition products (O_3, NO_2, SO_2, BrO, HCHO, H_2O, OClO, CO, NH_3), aerosol products and surface ultraviolet radiation products utilising the satellites of EUMETSAT. The majority of the AC SAF products are based on data from the GOME-2 and IASI instruments onboard Metop satellites.

Another important task besides the near real-time (NRT) and offline data dissemination is the provision of long-term, high-quality atmospheric composition products resulting from reprocessing activities.

Product categories, timeliness and dissemination

NRT products are available in less than three hours after measurement. These products are disseminated via EUMETCast, WMO GTS or internet.

- Near real-time trace gas columns (total and troposheric O_3 and NO_2, total SO_2, total HCHO, CO) and high resolution ozone profiles
- Near real-time absorbing aerosol indexes from main science channels and polarization measurement detectors
- Near real-time UV indexes, clear-sky and cloud-corrected

Offline products are available within two weeks after measurement and disseminated via dedicated web services at EUMETSAT and AC SAF.

- Offline trace gas columns (total and troposheric O_3 and NO_2, total SO_2, total BrO, total HCHO, total H_2O) and high-resolution ozone profiles
- Offline absorbing aerosol indexes from main science channels and polarization measurement detectors
- Offline surface UV, daily doses and daily maximum values with several weighting functions

Data records are available after reprocessing activities from the EUMETSAT Data Centre and/or the AC SAF archives.

- Data records generated in reprocessing
- Lambertian-equivalent reflectivity
- Total OClO

Users can access the AC SAF offline products and data records (free of charge) by registering at the AC SAF web site.

More information about the AC SAF project, products and services: `https://acsaf.org/`
AC SAF Helpdesk: helpdesk@acsaf.org
Twitter: `https://twitter.com/Atmospheric_SAF`

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
2.0	30.11.2018	- bumped version to 2.0 for new 2.x products - p. 2: updated SAF introduction - sect. 1.3: updated references - sect 2.: updated text and figs 2.1 and 2.2, and table 2.1. - sect. 3.: updated text - sect. 4. updated text and fig. 4.1. - sect. 5. - update text and figs. 5.2. and 5.3., and tables 5.2., 5.4. and 5.6.
2.1	17.05.2019	- table 2.1: added the following sentence required by the SG: The DNA damage UV product corresponds to the UV damage on pure DNA, dissolved in liquid, following Setlow et al. 1974. It is to be noted that it can not directly be interpreted as DNA damage in living tissues, e.g. human skin.

Contents

1 INTRODUCTION

1.1 Purpose and scope

This document is the user manual for the AC SAF Offline UV product (OUV) version 2 and the Data Record R1. 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 2.1, 15.1.2018.

[AD2] AC SAF Product Requirements Document, SAF/AC/FMI/RQ/PRD/001, Issue 1.3, 27.6.2018.

[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] Commission Internationale de l'Eclairage, "Erythema Reference Action Spectrum and Standard Erythema Dose." CIE S007E-1998. CIE Central Bureau, Vienna, Austria, 1998.

[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.

[RD8] HDF5 File Format Specification, `https://www.hdfgroup.org`

2 Product overview

The AC 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.

The two GOME-2 instruments aboard Metop-A (GOME-2A) and Metop-B (GOME-2B) satellites have been operated in tandem since 15 July 2013. During the tandem operation, the GOME-2B measures in the full swath width mode of 1920 km while the GOME-2A measures in the reduced swath mode of 960 km. The version 2 OUV products described in the current document benefit from this mode of operation by filling in the low latitude gaps in the global maps left by the GOME-2B with the data from the GOME-2A. Examples of the solar noon UV index product are shown in figure 2.1 below.

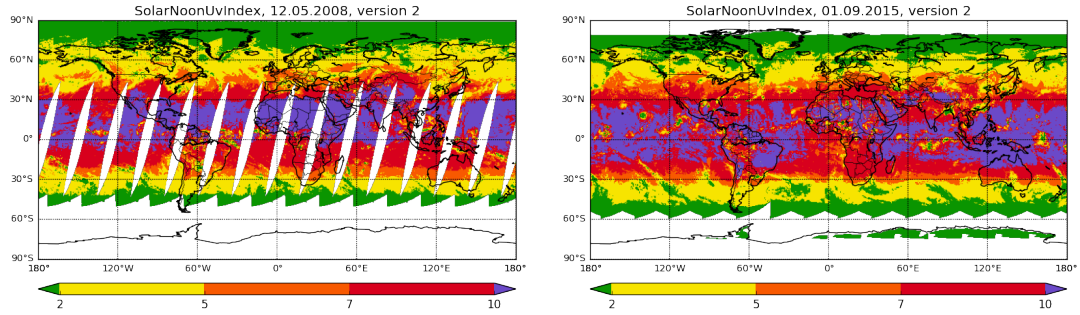

Figure 2.1: Example product fields. Left: solar noon UV index on 12 May 2008 when only Metop-A was operational. The global coverage is limited by the swath of the GOME-2A instrument (operated in the full swath mode of 1920 km during this time period), leaving stripes at low latitudes. The polar night and excessively large solar zenith angles limit the coverage at the winter pole. Right: the same product on 1 September 2015 showing the effect of GOME-2 tandem operation. The GOME-2B ozone data are used with top priority while the GOME-2A data are used with secondary priority to fill in the low latitude gaps left by GOME-2B. In the tandem operation mode, the nominal swath widths are 1920 km and 960 km for GOME-2B and GOME-2A, respectively.

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.

The key factors affecting the surface UV radiation are ozone, clouds, aerosols, surface albedo and altitude. The total ozone is obtained from the AC SAF total column ozone product. This product is made by German Aerospace Center (DLR) and the NRT version (NTO) is disseminated via the EUMETCast

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

Weighting function	Ref.	Integration wavelength range [nm]	Description
ERY	[RD2]	290 - 400	Erythemal weighting function. Measures the reddening of the skin due to sunburn. Used for UV index.
DNA	[RD3]	290 - 400	Measures the ability of UV irradiance to cause damage to unprotected DNA. The DNA damage UV product corresponds to the UV damage on pure DNA, dissolved in liquid, following Setlow et al. 1974. It is to be noted that it can not directly be interpreted as DNA damage in living tissues, e.g. human skin.
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

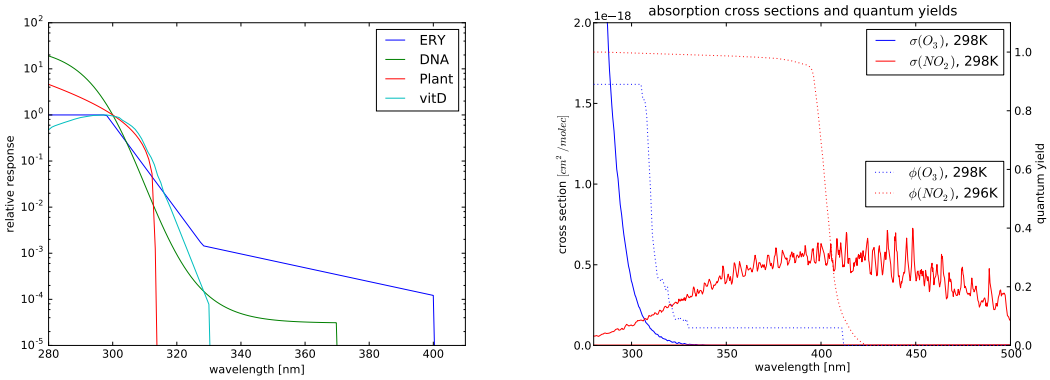

Figure 2.2: Left: the biological weighting functions: ERY (blue), DNA (green), Plant (red) and vitamin D (cyan). Right: cross-sections (solid line) and quantum yields (dotted line) for ozone (blue) and NO_2 (red).

broadcasting system (see sect. 4.1). 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 offline processing data flow can be kept relatively simple because both the Metop and NOAA AVHRR data are available through EUMETCast. The aerosol optical depth and surface albedo are obtained from MODIS data as described in the ATBD [AD1].

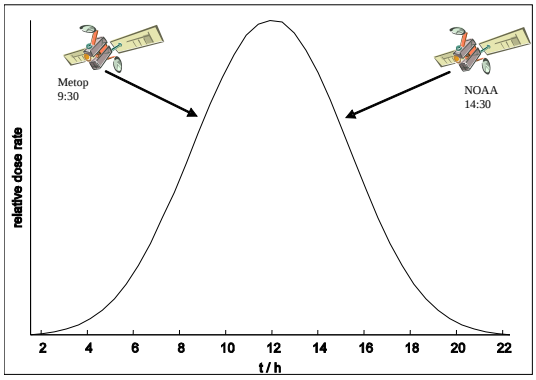

Figure 2.3: The diurnal cycle of UV dose rate (clear-sky case shown for clarity) together with the sampling achieved by Metop and NOAA AVHRR measurements. The sampling of the diurnal cycle is improved at high latitudes where the instrument swaths overlap for consecutive orbits.

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 `https://acsaf.org/uv_validation/index.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 AC SAF web site at `https://acsaf.org/uv_validation/validation_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 or exclude 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).

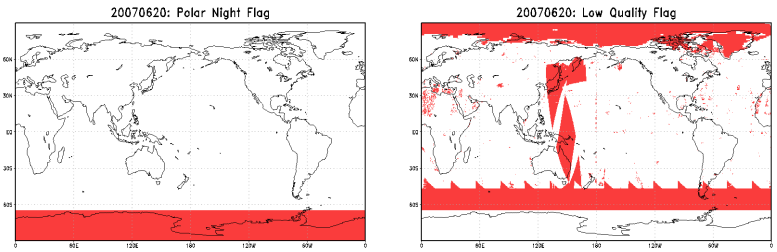

Figure 3.1: Example plots of the quality flags. The red color indicates where the flag is on. (left) The polar night flag is set when the solar zenith angle is larger than 88 degrees and (right) the low quality flag is set when it is larger than 70 degrees. The low quality flag is also set for other 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.

Uncertainty in the knowledge of surface albedo can cause problems in snow/ice melting and forming periods. In the data record, a surface albedo time-series generated from MODIS data is used as input, and therefore the UV products should well reflect the changes in the surface albedo. In the operational offline product, however, a day-of-year climatology formed of the 10-year MODIS record is used, and the product uncertainty estimates include the uncertainty in the surface albedo originating from this 10-year period. Similar approach is taken for the aerosol optical depth [AD1].

4 Processing, archiving and dissemination

4.1 Processing and archiving

The data record is generated once and stored in the FMI Archive. The offline UV product, on the other hand, 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 directly or via the Eumetsat Data Centre. The processing data flow is depicted in figure 4.1 below.

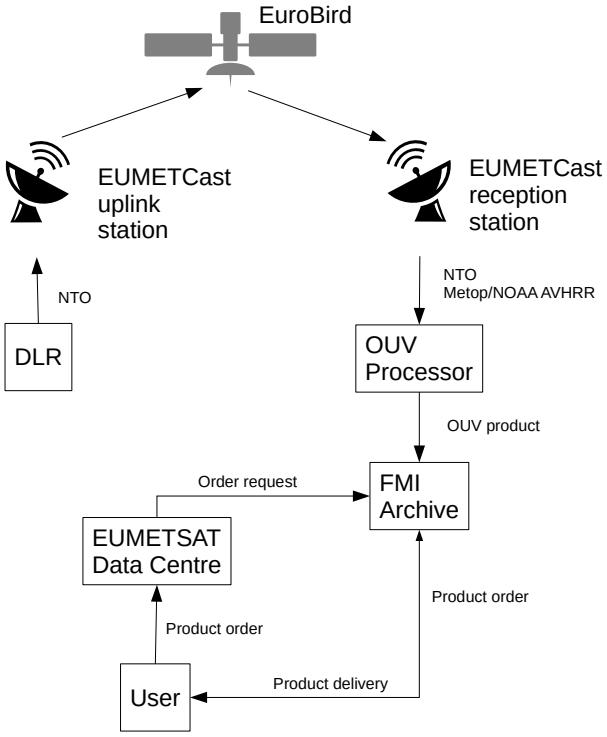

Figure 4.1: Offline processing and product ordering data flow.

4.2 Product ordering

Users can access the offline products and data records (free of charge) by registering at the AC SAF web site. Both types of products also can be ordered from the Eumetsat Data Centre available at the Earth Observation Portal `https://eoportal.eumetsat.int`. 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 AC SAF web site at `https://acsaf.org/`, or by sending an email to helpdesk@acsaf.org.

5 Product file format

This section describes the structure of product HDF5 files [RD8].

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

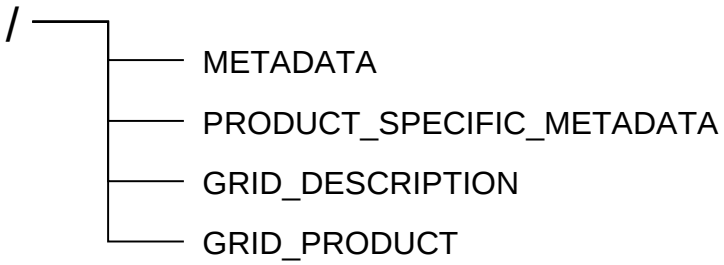

Figure 5.1: Structure of the HDF5 file.

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 0.5 degree x 0.5 degree longitude-latitude grid. Each grid cell represents an average value within the cell area. 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.

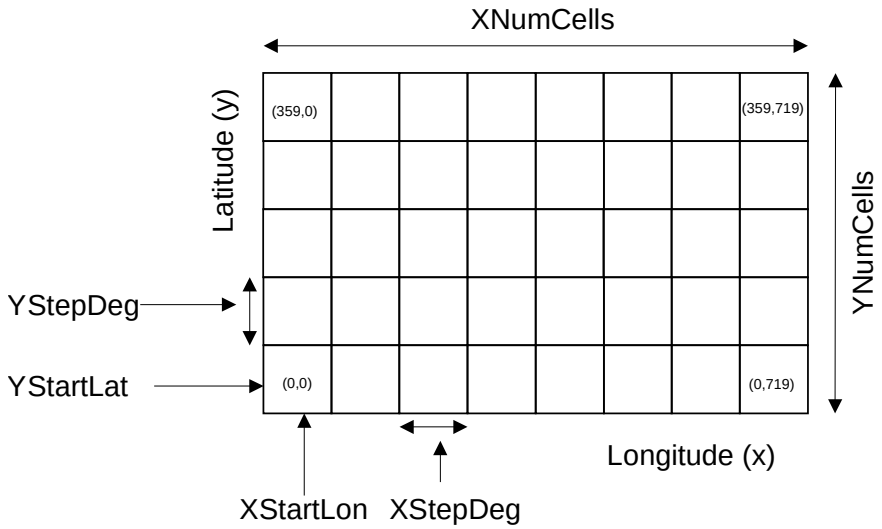

Figure 5.2: Organization of the product fields in the HDF5 file. The data array runs from South to North and West to East. The zero-based array indices of the corners are also shown.

5.1.1 METADATA Group

The content of the METADATA group is listed in table 5.1. 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).

5.1.2 PRODUCT_SPECIFIC_METADATA Group

The product specific metadata are listed in table 5.2.

5.1.3 GRID_DESCRIPTION Group

The grid parameters are stored as attributes of the GRID_DESCRIPTION group. The attributes are listed in table 5.3.

5.1.4 GRID_PRODUCT Group

The datasets in the GRID_PRODUCT group are listed in table 5.4. The daily doses, daily maximum dose rates and their error estimates are stored for the following four different biological weightings: erythemal ("Ery"), 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.

5.2 Data Types

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

5.3 File naming convention

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

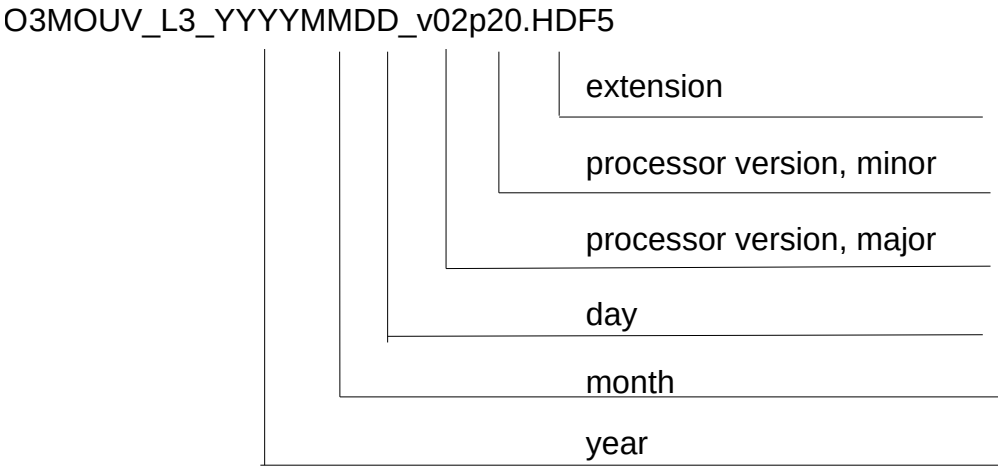

Figure 5.3: The structure of the OUV file name. The O3M prefix is maintained although the SAF was renamed from O3M to AC SAF. In the data record, the version label is replaced with a _R1 label.

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

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.
AodRangeLow	float	-	lower end of aerosol optical depth range.
AodRangeHigh	float	-	higher end of aerosol optical depth range.
CodRangeLow	float	-	lower end of cloud optical depth range.
CodRangeHigh	float	-	higher end of cloud optical depth range.
OzoneRangeLow	float	DU	lower end of total ozone column range.
OzoneRangeHigh	float	DU	higher end of total ozone column range.
SurfaceAlbedoRangeLow	float	-	lower end of surface albedo range.
SurfaceAlbedoRangeHigh	float	-	higher end of surface albedo range.
SurfacePressureRangeHpaLow	float	hPa	lower end of surface pressure range.
SurfacePressureRangeHpaHigh	float	hPa	higher end of surface pressure range.
UvLutFilename	string	-	filename of the UV look-up table.
CodeDistributionVersion	string	-	version number of the processor code.

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

Table 5.4: GRID_PRODUCT group contents.

Dataset name	Data type	Unit	Description
DailyDoseEry	float	kJ/m2	Daily UV dose, erythemal weighting
DailyDoseEryError			-uncertainty estimate
DailyDoseDna	float	kJ/m2	Daily UV dose, DNA damage weighting
DailyDoseDnaError			-uncertainty estimate
DailyDosePlant	float	kJ/m2	Daily UV dose, plant response weighting
DailyDosePlantError			-uncertainty estimate
DailyDoseVitd	float	kJ/m2	Daily UV dose, vitamin D weighting
DailyDoseVitdError			-uncertainty estimate
DailyDoseUvb	float	kJ/m2	Daily UV dose, integrated UV-B
DailyDoseUvbError			-uncertainty estimate
DailyDoseUva	float	kJ/m2	Daily UV dose, integrated UV-A
DailyDoseUvaError			-uncertainty estimate
DailyMaxDoseRateEry	float	mW/m2	Daily maximum dose rate, erythemal weighting
DailyMaxDoseRateEryError			-uncertainty estimate
DailyMaxDoseRateDna	float	mW/m2	Daily maximum dose rate, DNA damage weighting
DailyMaxDoseRateDnaError			-uncertainty estimate
DailyMaxDoseRatePlant	float	mW/m2	Daily maximum dose rate, plant response weighting
DailyMaxDoseRatePlantError			-uncertainty estimate
DailyMaxDoseRateVitd	float	mW/m2	Daily maximum dose rate, vitamin D weighting
DailyMaxDoseRateVitdError			-uncertainty estimate
DailyMaxDoseRateUvb	float	mW/m2	Daily maximum dose rate, integrated UV-B
DailyMaxDoseRateUvbError			-uncertainty estimate
DailyMaxDoseRateUva	float	mW/m2	Daily maximum dose rate, integrated UV-A
DailyMaxDoseRateUvaError			-uncertainty estimate
DailyMaxJO1D	float	1/s	Daily maximum $j(O(^1D))$
DailyMaxJO1DError			-uncertainty estimate
DailyMaxJNO2	float	1/s	Daily maximum $j(NO_2)$
DailyMaxJNO2Error			-uncertainty estimate
SolarNoonUvIndex	float	N/A	Solar noon UV index
SolarNoonUvIndexError			-uncertainty 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: zero-based index of total ozone data source, as listed in the attribute to QualityFlags data field.
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

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

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 AC SAF 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

Acronym	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 AC SAF archive; provided by archive software
APPN	ParentProducts	-
APAS	Added by Archive	Product Actual Size; provided 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; provided by archive software
UUDT	N/A	Ingestion Date and Time
GGTP	GranuleType	-
UDSP	N/A	DispositionFlag, UMARF internal