ATMOSPHERIC COMPOSITION MONITORING

PRODUCT USER MANUAL

European High-resolution Surface UV Radiation Product (EUV)

(ID: AC-611)

and

European High-resolution Surface UV Radiation Data Record (EDR) Release 1

(ID: AC-617.1)

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

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1.0draft	01.06.2024	Initial revision of the full document

Contents

1 INTRODUCTION

1.1 Purpose and scope

This document is the user manual for the AC SAF European High-resolution Surface UV Radiation Product product (EUV) and the first release of the corresponding data record. 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

AC SAF	Satellite Application Facility on Atmospheric Composition Monitoring
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
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
Metop	Meteorological Operational satellite programme
MVIRI	Meteosat Visible and Infrared Imager
NOAA	National Oceanic and Atmospheric Administration
NRT	Near real-time
NTO	Near real-time Total Ozone product
OTO	Offline Total Ozone product
OUV	Offline UV product
PUM	Product User Manual
SEVIRI	Spinning Enhanced Visible and Infrared Imager
UV	Ultraviolet radiation
UVI	UV Index
WHO	World Health Organization

1.3 References

1.3.1 Applicable Documents

[AD1] TBA

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] Meirink, J. F. and Roebeling, R. A. and Stammes, P.: Inter-calibration of polar imager solar channels using SEVIRI, Atmos. Meas. Tech., 6, 2495–2508, `https://doi.org/10.5194/amt-6-2495-2013`, 2013.

[RD4] NetCDF4 File Format Specification, `https://www.unidata.ucar.edu/software/netcdf/index.html`

[RD5] CF Metadata Conventions, `https://cfconventions.org`

2 Product overview

The key factors affecting the surface UV radiation are ozone, clouds, aerosols, surface albedo and altitude. The European surface UV radiation product (EUV) covers Europe and combines total column ozone measurements from the GOME-2 instrument on the polar orbiting Metop satellites with cloud optical depth retrievals from optical imagers onboard the geostationary Meteosat satellites. The product contains the UV index ([RD1], [RD2]), its uncertainty estimate and quality control flags. It is calculated in the spatial and temporal resolution of the cloud imager. Figure 2.1 shows an example product. The product is processed in a realtime stream (Sect. 2.1) and also a data record from past data is produced (Sect. 2.2).

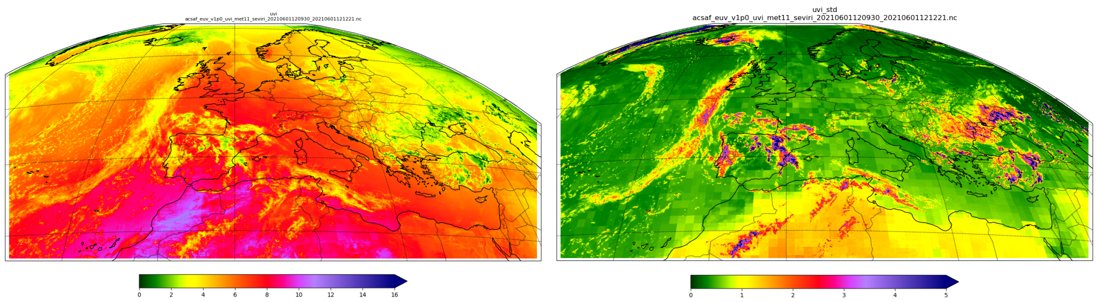

Figure 2.1: Example UVI product on 1.6.2021 around 12:10 UTC from Meteosat-11 SEVIRI data (left) and its uncertainty estimate (right).

2.1 Realtime product

Total ozone is obtained from the AC SAF total column ozone product, generated by the German Aerospace Center (DLR) from the measurements of the GOME-2 instruments onboard Metop satellites. A total ozone map is gridded from the total ozone products.

2.2 Data record

The data record covers the time period 19.1.2004 - 31.12.2023, with an extension up to 11.5.2024 to catch up the realtime processing. The main differences to the realtime processing version are:

- SEVIRI native files are used instead of HRIT files.
- The Meirink-2013 calibration coefficients [RD3] are used for SEVIRI 0.6 μm channel instead of EUMETSAT operational coefficients.
- ERA-5 total ozone in a 0.25 degree x 0.25 degree grid is used instad of GOME-2 total ozone map.

3 Processing, archiving and dissemination

3.1 Processing

The EUV product is operationally processed as an AC SAF offline product 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 very short, less than 15 minutes.

The AC SAF near real time total column ozone product (NTO) is produced by the German Aerospace Center (DLR). It is sent to the EUMETCast uplink station, where it is broadcasted via telecommunication satellites. The SEVIRI HRIT files are sent to EUMETCast from the EUMETSAT Headquaters. The NTO and SEVIRI products are received at FMI. The EUMETCast satellite service is backed up with the corresponding Terrestrial service. The offline version of the AC SAF total ozone product (OTO) can be accessed from the DLR ftp server for any backlog processing.

The data record is generated at the EUMETSAT side of European Weather Cloud (EWC) with a fast access to the past SEVIRI level 1b native data in the EUMETSAT Data Store. The processing data flows are depicted in figure 3.1 below.

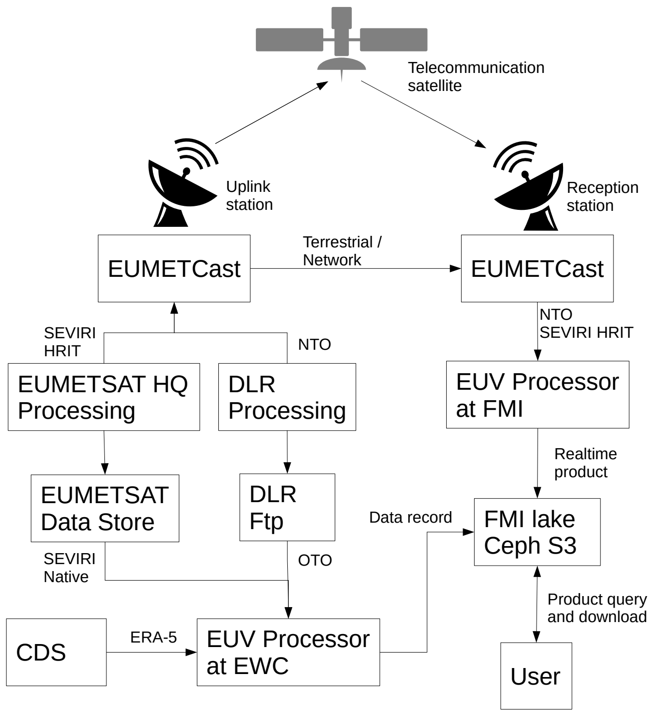

Figure 3.1: EUV processing and product ordering data flow.

3.2 Archiving and dissemination

The product files are archived and available from the FMI Ceph S3 system. They can be accessed with a suitable program, for example *rclone* available at `https://rclone.org`. First, a configuration file (Fig. 3.2) has to be created. The large volume data are stored in multiple S3 buckets as shown in Figure 3.3. The NetCDF4 objects are stored in daily gzipped tar archive files, and the UVI bucket also contains daily mp4 videos (Fig. 3.4). The *eumetsat-acsaf-euv* bucket contains smaller volume data as shown in Figure 3.5. The data can also be accessed with a web browser by entering the URL in format:

https://<bucketname>.lake.fmi.fi/index.html

for example:

https://eumetsat-acsaf-euv.lake.fmi.fi/index.html

```
[fmi-lake-acsaf-ro]
type = s3
provider = Ceph
access_key_id = <ask from helpdesk>
secret_access_key = <ask from helpdesk>
endpoint = https://lake.fmi.fi
```

Figure 3.2: Example *rclone* config file.

```
$ rclone lsf fmi-lake-acsaf-ro:
eumetsat-acsaf-euv/
eumetsat-acsaf-euv-realtime-erydd/
eumetsat-acsaf-euv-realtime-support-cloudod/
eumetsat-acsaf-euv-realtime-support-dynamic/
eumetsat-acsaf-euv-realtime-uvi/
eumetsat-acsaf-euv-v1p0-erydd/
eumetsat-acsaf-euv-v1p0-support-cloudod/
eumetsat-acsaf-euv-v1p0-support-dynamic/
eumetsat-acsaf-euv-v1p0-uvi/
```

Figure 3.3: Listing of S3 buckets.

```
$ rclone ls fmi-lake-acsaf-ro:eumetsat-acsaf-euv-v1p0-uvi/2023/06/01
2165741 mp4/acsaf_euv_v1p0_uvi_met10_seviri_20230601.mp4
118355712 nc/acsaf_euv_v1p0_uvi_met10_seviri_20230601.tar.gz
```

Figure 3.4: Listing of UVI objects.

```
$ rclone lsf fmi-lake-acsaf-ro:eumetsat-acsaf-euv/v1p0/
doc/
overpass/
static/
stats/
validation/
```

Figure 3.5: Contents of v1p0 directory.

3.3 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.

4 Product files

This section describes the structure of the NetCDF4 files [RD4]. The climate and forecast model (CF) conventions are applied where possible [RD5]. The product is stored in the main UV index file (sect. 4.2.1) and is accompanied with the supporting static (sect. 4.2.2), dynamic (sect. 4.2.3) and cloud optical depth (sect. 4.2.4) data files. In addition, overpass files are generated in CSV format for a pre-selected list of ground station locations (sect. 4.2.6).

4.1 File naming convention

The UVI and supporting dynamic and cloud optical depth files are named as:

acsaf_euv_<ver>_<content>_<sat>_<instr>_<start>_<end>.nc

where:

- ver: product version number, *e.g.* v1p0 for version v1.0
- content: uvi, support_dynamic or support_ cloudod
- sat: satellite acronym, *e.g.* met10 for Meteosat-10
- instr: instrument, *e.g.* seviri for SEVIRI
- start: start UTC time in format yyyymmddHHMMSS
- end: end UTC time in format yyyymmddHHMMSS

The static supporting files are named as:

acsaf_euv_support_static_<ver>_<instr>_from<startvalid>.nc

where:

- startvalid: validity start UTC time in format yyyymmddHHMMSS. The file is valid from the start time until any similarly named file with a later start time.

The erythemal daily dose files are named as:

acsaf_euv_<ver>_erydd_<sat>_<instr>_<date>.nc

where:

- date: date in format yyyymmdd

4.2 File contents and structure

4.2.1 UV index file

Figure 4.1 shows the contents of the UVI file.

Name	Long Name	Type
acsaf_euv_v1p0_uvi_met10_seviri_20240515100934_20240515101222.nc	European UV radiation product of EUMETSAT AC SAF	Local File
acquisition_time	acquisition time	Geo2D
msg_geostationary_projection	MSG geostationary projection	—
quality_flags	pixel quality flags	Geo2D
time	time	—
uvi	UV Index	Geo2D
uvi_stdev	UV Index standard deviation	Geo2D
x	projection x coordinate	1D
y	projection y coordinate	1D

Figure 4.1: Structure of the UVI file (a screenshot from Panoply).

4.2.2 Supporting static data file

Figure 4.2 shows the contents of the supporting static file.

Name	Long Name	Type
acsaf_euv_support_static_v1p0_seviri_from20171206083931.nc	acsaf_euv_support_static_v1p0_seviri_from20171206083931.nc	Local File
altitude	altitude	Geo2D
latitude	latitude	Geo2D
longitude	longitude	Geo2D
msg_geostationary_projection	MSG geostationary projection	—
time	time	—
viewing_azimuth_angle	viewing azimuth angle	Geo2D
viewing_zenith_angle	viewing zenith angle	Geo2D
x	projection x coordinate	1D
y	projection y coordinate	1D

Figure 4.2: Structure of the supporting static file.

4.2.3 Supporting dynamic data file

Figure 4.3 shows the contents of the supporting dynamic file.

Name	Long Name	Type
acsaf_euv_v1p0_support_dynamic_met10_seviri_20240515100934_20240515101222.nc	acsaf_euv_v1p0_support_dynamic_met10_seviri_20240515100934_20240515101222.nc	Local File
aerosol_optical_depth_550nm	aerosol optical depth 550nm	Geo2D
aerosol_optical_depth_550nm_std	aerosol optical depth 550nm std	Geo2D
msg_geostationary_projection	MSG geostationary projection	—
mu_reflectance_06um	mu reflectance 06um	Geo2D
mu_reflectance_06um_std	mu reflectance 06um std	Geo2D
relative_azimuth_angle	relative azimuth angle	Geo2D
solar_azimuth_angle	solar azimuth angle	Geo2D
solar_zenith_angle	solar zenith angle	Geo2D
surface_albedo_uv	surface albedo uv	Geo2D
surface_albedo_uv_std	surface albedo uv std	Geo2D
surface_albedo_vis006	surface albedo vis006	Geo2D
surface_albedo_vis006_std	surface albedo vis006 std	Geo2D
surface_pressure	surface pressure	Geo2D
surface_pressure_std	surface pressure std	Geo2D
time	time	—
total_column_ozone	total column ozone	Geo2D
total_column_ozone_std	total column ozone std	Geo2D
total_column_water_vapour	total column water vapour	Geo2D
total_column_water_vapour_std	total column water vapour std	Geo2D
x	projection x coordinate	1D
y	projection y coordinate	1D

Figure 4.3: Structure of the supporting dynamic file.

4.2.4 Supporting cloud optical depth data file

Figure 4.4 shows the contents of the supporting cloud optical depth file.

Name	Long Name	Type
acsaf_euv_v1p0_support_cloudod_met10_seviri_20240515100934_20240515101222.nc	acsaf_euv_v1p0_support_cloudod_met10_seviri_20240515100934_20240515101222.nc	Local File
cloud_optical_depth	cloud optical depth	Geo2D
cloud_optical_depth_std	cloud optical depth std	Geo2D
msg_geostationary_projection	MSG geostationary projection	—
time	time	—
x	projection x coordinate	1D
y	projection y coordinate	1D

Figure 4.4: Structure of the supporting cloud optical depth file.

4.2.5 Erythemal daily dose file

Figure 4.5 shows the contents of the erythemal daily dose file.

Name	Long Name	Type
acsaf_euv_v1p0_erydd_met10_seviri_20240515.nc	acsaf_euv_v1p0_erydd_met10_seviri_20240515.nc	Local File
erythemal_daily_dose	erythemal daily dose	Geo2D
erythemal_daily_dose_stdev	erythemal daily dose standard deviation	Geo2D
msg_geostationary_projection	MSG geostationary projection	—
quality_flags	quality flags	Geo2D
time	time	—
x	projection x coordinate	1D
y	projection y coordinate	1D

Figure 4.5: Structure of the erythemal daily dose file.

4.2.6 Overpass file

Figure 4.6 shows the header rows and the first data row of the overpass file in Comma Separated Values (CSV) format.

```
#Site = fmi_helsinki.kumpula
#Country = Finland
#Latitude = 60.20307 deg
#Longitude = 24.96131 deg
#OvpFormat = euv_l2ovp1
#OvpExtractorVersion = 1.0.1
#DateCreated = 2024-06-06
#MaxDistanceKm = inf
#StoreWithinMaxDistance = nearest
#
#Columns:
#datetime: date and time (UTC)
#lat: latitude at pixel centre (degree north)
#lon: longitude at pixel centre (degree east)
#dist: distance between pixel centre and site (km)
#uvi: UV index (dimensionless)
#uvistd: UV index standard deviation (dimensionless)
#cod: cloud optical depth (dimensionless)
#codstd: cloud optical depth standard deviation (dimensionless)
#r06um: reflectance at 0.6 um (dimensionless)
#r06umstd: reflectance at 0.6 um standard deviation (dimensionless)
#sp: surface pressure (hPa)
#spstd: surface pressure standard deviation (hPa)
#tco3: total column ozone (DU)
#tco3std: total column ozone standard deviation (DU)
#tcwv: total column water vapor (mm)
#tcwvstd: total column water vapor standard deviation (mm)
#albuv: surface UV albedo (dimensionless)
#albuvstd: surface UV albedo standard deviation (dimensionless)
#albvis: visible UV albedo (dimensionless)
#albvisstd: visible UV albedo standard deviation (dimensionless)
#aod550: aerosol optical depth at 550 nm (dimensionless)
#aod550std: aerosol optical depth at 550 nm standard deviation (dimensionless)
#sza: solar zenith angle (degree)
#saz: solar azimuth angle (degree)
#vza: viewing zenith angle (degree)
#vaz: viewing azimuth angle (degree)
#raa: relative azimuth angle between reflected and incoming solar beams (degree)
#satnum: Meteosat number, e.g. 10 = Meteosat-10
#procver: Processor version, e.g. 010000= 1.0.0
#qcflags: quality flags (uint16)
datetime,lat,lon,dist,uvi,uvistd,cod,codstd,r06um,r06umstd,sp,spstd,tco3,tco3std
,tcwv,tcwvstd,albuv,albuvstd,albvis,albvisstd,aod550,aod550std,sza,saz,vza,vaz,r
aa,satnum,procver,qcflags
2024-01-
01T08:24:33,60.15385,24.91927,5.939,0.010,5.760,150.000,265.860,0.783,0.008,1016
.898,10.132,311.100,5.000,0.230,1.000,0.303,0.180,0.244,0.114,0.120,0.120,86.520
,153.310,71.384,208.188,125.120,10,010005,256
```

Figure 4.6: Header rows and the first data row of the overpass file.

4.3 Usage examples

4.3.1 Plotting with Panoply

The UVI netCDF4 files can be plotted with standard tools, for example Panoply (`https://www.giss.nasa.gov/tools/panoply/`, version 5.4.1 at the time of this writing). Unfortunately, at the time of this writing, the tool does not understand the projection information stored in the *msg_geostationary_projection* variable. Therefore the latitude and longitude values have to be merged from the static file as explained in Section 4.3.2.

4.3.2 Merging the files using Python xarray

The static and other support files can be merged to the UVI files using the merge function of the xarray package (Fig. 4.7). Figure 4.8 shows a command line example.

```
import argparse
import xarray as xr

parser = argparse.ArgumentParser()
parser.add_argument('infiles', nargs='+',
                    help='names␣of␣UVI␣and␣support␣files')
parser.add_argument('outfile',
                    help='name␣of␣the␣merged␣output␣file')
args = parser.parse_args()

dsets = [xr.open_dataset(fn) for fn in args.infiles]
merged = xr.merge(dsets, compat='override', join='override' )
del merged['x']
del merged['y']
for var in merged.variables.values():
    if 'grid_mapping' in var.attrs:
        del var.attrs['grid_mapping']

merged.to_netcdf(args.outfile)
```

Figure 4.7: Listing of the EUV merging code. (Save as euv_merge.py for the example in Fig. 4.8)

```
$ python euv_merge.py acsaf_euv_v1p0_uvi_met10_seviri_20240515100934_20240515101222.nc
acsaf_euv_support_static_v1p0_seviri_from20171206083931.nc
acsaf_euv_v1p0_support_dynamic_met10_seviri_20240515100934_20240515101222.nc
acsaf_euv_v1p0_support_cloudod_met10_seviri_20240515100934_20240515101222.nc
acsaf_euv_v1p0_uvi_met10_seviri_20240515100934_20240515101222_merged.nc
```

Figure 4.8: Example of merging the EUV files. Write the command in a single line. The support dynamic and/or cloudod files are optional and can be left out.