O3M SAF

Ozone and Atmospheric Chemistry Monitoring

PRODUCT USER MANUAL

Near real-time UV (NUV) products

Version 3.3

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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 is 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)
1.1O_3, NO_2, O_3Tropo, NO_2Tropo
Near real-time Ozone Profile (NOP)
Near real-time UV Index (NUV)
Offline Total Column (OTO)
1.2O_3, NO_2, O_3Tropo, NO_2Tropo, SO_2, BrO, H_2O, HCHO, OClO
Offline Ozone Profile (OOP)
Offline Surface UV (OUV)
Aerosols (ARS)
HIRS Total Ozone (HTO)

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, HTO) 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	02.05.2007	1st version
1.1	10.10.2007	Revised according to ORRA RID
1.2	27.03.2008	Minor changes.
1.3	21.11.2008	Updated sections 1 and 4. NUV version number added to section
1.4	02.06.2010	Introduction to EUM SAF page included Section 3 updated
1.5	17.02.2012	Version for ORR of NUV/CLOUD
1.6	12.03.2012	Updated according to ORR RIDs
1.7	27.05.2013	Version for Metop-B ORR Minor changes in Sect. 2 and 3

1. INTRODUCTION

1.1 Purpose and scope

This document is the user manual of the Near Real UV index (NUV) product. It includes the product format description while the algorithm is described in a separate Algorithm Theoretical Basis Document.

1.2 References

1.2.1 Applicable documents

O3M SAF Algorithm Theoretical Basis Document for NUV, SAF/O3M/DMI/ATBD/001, Issue 1.7, 27.05.2013

1.2.2 References documents

WMO, Report of the meeting of experts on UV-B measurements, data quality and standardization of UV-indices. Global Atmospheric Watch report no. 95, 1994

1.2.3 Acronyms

FMI	Danish Meteorological Institute
ATO	Assimilate Total Ozone
ECMWF	European Centre for Medium-Range Weather Forecasts
ATBD	Algorithm Theoretical Basis Document

2. PRODUCT OVERVIEW

The O3M SAF Near Real Time UV product is clear sky UV-fields (NUV/CLEAR), i.e. the UV-index (WMO, 1994), and the UV index corrected for the expected cloud cover (NUV/CLOUD). The UV clear sky index is derived from the GOME-2 assimilated total ozone (ATO) as the only dynamical input. Climatological parameters are used for all other atmospheric input data as well as surface albedo. The cloud cover corrected UV fields are produced from the NUV/CLEAR using the fractional cloud cover forecast from ECMWF. The UV fields are calculated in the same grid size as the input ATO field, with a sub-pixel altitude correction resolution of 0.25° x 0.25°.A global and several regional colour coded maps are produced. Special user requested sub-products are also being produced.

Both NUV/CLEAR and NUV/CLOUD are valid for conditions at local noon, or rather at minimum solar zenith angle, thus reflecting the maximal UV index to be expected for the current day.

In the case that ATO is either not available at the time of processing (02:00 UT) or the ATO is corrupted, the NUV processor choose to use ECMWF assimilated total ozone instead. If this input data is not available either calculations will be based upon a total ozone climatology. The type of input ozone date is clearly marked in the product.

For a limited period ATO from GOME-2 instruments onboard both theMetop-A and Metop-B satellite may be available, the product output will contain information on which instrument has been used.

The accuracy of the derived UV index is calculated using the ATO error field as input and assumed accuracies for all other parameters. All accuracies involved in the calculations are listed in a file included in the NUV product. See also the ATBD

2.1 Processing and dissemination

ATO is produced at KNMI and delivered to DMI each night and the NUV processor is started at 02:30 UT and produce the output UV fields, based upon the available ozone data, as described above. The NUV product is ready for dissemination no later than 03:00 UT and can be distributed to end users via ftp or e-mail, and to the NUV web page (http://uv-saf.dmi.dk). The ftp and e-mail service can be ordered via the NUV web page on the O3M SAF page http://o3saf.fmi.fi.

At request the output can be customized for special user requirements, contact information is found on the NUV web page.

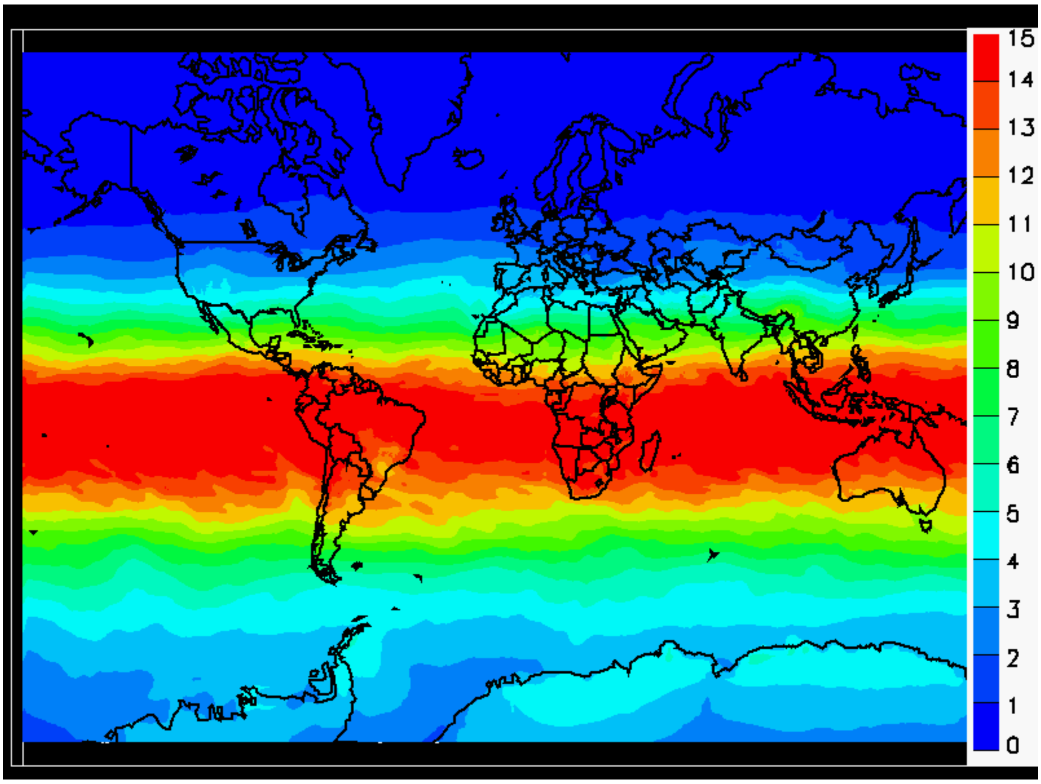
3. PRODUCT FILE FORMAT

The daily output of the NRT UVI processor presented at the NUV web page (http://uv-saf.dmi.dk) consists of a number of contour maps of UV-index for pre-selected locations, two files containing additional information and a “standard” HTML-page for quick access to the maps and files. On-line quality control data is also presented daily.

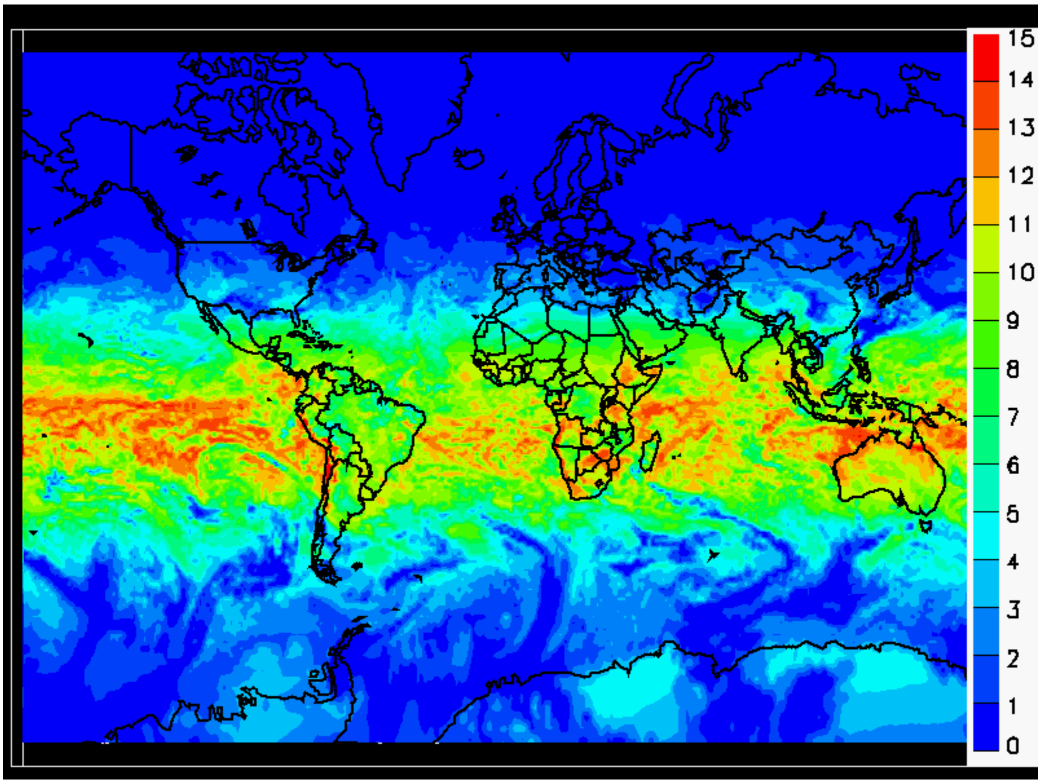
- The maps are saved as PNG (Portable Network Graphics) files, which takes up approximately 0.5 Mbyte of disk space. The maps are named after their centre location and date of production.
- The global UV map is also produced in kml format for access via Google Earth.
- The ASCII file “Errors.txt” contains estimated accuracies of the maps. For each map the average, minimum and maximum error of the UV-index are listed. The input errors/accuracies of the various parameters are listed at the end of the file.
- The HTML file “INFO.html” contains a short general information on UV-index and the NUV processor.

As mentioned in section 2.1 users may request the full daily output, parts of it or customized maps and list of locations etc. These special requests are delivered to end users either directly or via special web pages.

The NUV web page presents the daily NUV/CLEAR product:



And the NUV/CLOUD product:



Example of the content of the 'Error.txt' file

```
UVI maps produced at Mon Mar 12 04:07:14 2012
Based on assimilated GOME (Metop-A) input for 20120312 at UT=12:00
Internal precisions calculated on the basis of the GOME input error field

AVERAGE INTERNAL PRECISION OF THE UVI-FIELDS

       MAP      AVERAGE ERROR  ERROR IN %   AVERAGE UVI
--------------------------------------------------------
         Europe       0.21       6.79       3.11
         Africa       0.77       6.57      11.81
           Asia       0.46       6.52       6.91
      Australia       0.74       6.35      11.71
  North-America       0.36       6.73       5.38
  South-America       0.75       6.41      11.69
     Antarctica       0.05       6.62       0.80
        Arctica       0.01       5.94       0.13
          World      0.466      6.508      7.102
--------------------------------------------------------
Calculated on the basis of the following input errors:
                SZA:         0.017 [deg]
             Albedo:         0.050
          Dayofyear:         0.000 [days]
                AOD:         0.100
           Altitude:         0.100 [m]
 Average Ozone error:        9.121 DU
```

APPENDIX: DESCRIPTION OF ATO

Assimilation of Total ozone

The assimilation of total ozone ATO service will be based on the GOME-2 ozone processing chain that is provided by the KNMI. The system is based on: 1) NTO ozone columns; 2) Medium-range meteorological analyses and forecasts of the ECMWF. Pre-processing of this meteo data is required to match form and resolution for the TM chemistry-transport model; 3) The ozone column data assimilation model TM3DAM. One 9-day assimilation/forecast run will be performed around 2 am, directly after completion of the ECMWF medium-range weather forecast.

Product description	
Summary	Daily ozone analyses and 9-day ozone assimilation / forecast of the global total ozone field
Product properties	
Parameter(s)	- Daily ozone analysis based on GOME-2 ozone observations - Ozone forecasts for days 0 to 9
Accuracy	2 dimensional field of accuracy is provided as part of the product (typically 3%)
Geometric resolution	2D, 1 degree latitude by 1.5 degree longitude
Grid / projection	Latitude-longitude grid, various projections possible
Spatial coverage	Global
Temporal coverage	Hourly fields
Data format	HDF4 and ASCII
availability	Operational implementation based on GOME-2 ozone measurements since April 2007.
Production process	
Method/algorithm	TM3DAM chemistry-transport model driven by ECMWF medium-range forecast wind, pressure and temperature fields.
Model / assimilation	TM3DAM data assimilation approach.

reference	Eskes et al, Q. J. R. Meteorol. Soc., 129, 1663-1681 (2003) Eskes, Atmos. Chem. Phys., 2, 271-278 (2002)
Quality standards	
Production	- Routine monitoring of production chain during working hours; - Monitoring of ozone observations and model forecast quality by means of observation-minus-forecast (OmF) reports. Quality screening to reject bad retrievals and outliers.
Product	- Retrospective analysis of performance - Study of OmF reports, fine tuning of two-dimensional analysis precision distributions that are part of the product.
Validation	- Intercomparison of the TM3DAM analyses (2D, 3D) with ground-based observations (Brewer, Dobson, DOAS, SAOZ, ozone sondes, lidar etc..) - Study of OmF statistics: bias, rms as a function of relevant parameters in the assimilation model and retrieval.
Input data	
EO data	GOME-2 level 2 NTO data in HDF5 format
Other data	Meteorological medium-range forecast data of ECMWF
Optional or other specific properties (if applicable)	
Historical archive	Archive of global ozone analyses and forecasts since April 2007
Offline/NRT	Once per day (Offline for reanalysis runs)
Visualization standards	Images in gif format provided for northern hemisphere, southern hemisphere and globe. Data sets: HDF4
Underlying primary user requirement(s)	
Key requirement	Reliable forecasts for UV forecast processing
Originator(s)	KNMI, DMI

Table -1: Characteristics of the ozone assimilation product

Total Ozone Assimilation/Forecast Service

System overview

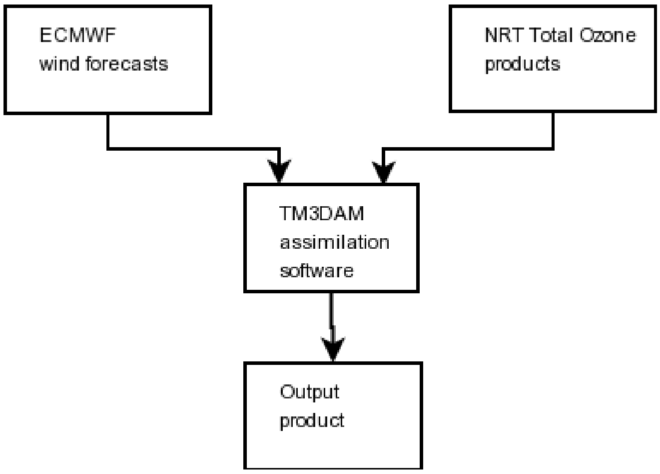


Figure -1: Overview of the Total Ozone assimilation process

The diagram summarizes the ozone assimilation/forecasting process. The different elements are:

Input data: This consists of GOME-2 level-2 data and the 10-day medium-range meteorological forecast of ECMWF.

Processor: The ozone columns are used by the TM3DAM assimilation software to provide an analysis of the present global ozone distribution, and subsequently an ozone forecast run is performed.

Output data: This consists of an analysis of the global ozone distribution (O3AN) and a 9-day ozone forecast (O3FC).

Storage, internet: The data base of ozone products is linked to the TEMIS website (www.temis.nl) ozone internet service. Dynamical web pages provide users with the most recent ozone products.

Technical requirements

External interface(s)

or NRT processing direct transfer of GOME-2 data from EUMETCast is provided. The KNMI has direct access to ECMWF forecast meteo. Pre-processing software is running operationally on the ECMWF hardware. This converts ECMWF forecast fields (temperature, pressure, vorticity, divergence) to a resolution and form suitable for the TM model. These pre-processed meteorological fields are subsequently transferred to the KNMI by ftp.

Verification and quality control

he main source of information for quality control is the observation-minus-forecast statistics (OmF) produced by the TM3DAM analysis system. This mechanism allows detection of sudden changes in the data quality and provides error estimates for the total ozone retrieval as well as the model performance. A quality screening is implemented to reject unrealistic ozone retrievals which will not influence the analyses. The forecast continuity is guarded by a routine monitoring of forecast production chain during working hours. The overall performance of the ozone forecasting system is studied by a-posteriori comparison of the forecast with the corresponding verifying analyses. The analyses uncertainty is reported as a two-dimensional field, part of the analysis product.

Hardware

The meteorological preprocessing runs on machines at ECMWF.

The TM3DAM assimilation runs on the O3MSAF computer at KNMI.

The TM3DAM ozone assimilation and forecast

The ozone chemistry-transport model

The ozone forecasts are based on a tracer-transport and assimilation model called TM3DAM. The modelling of the transport, chemistry and the aspects of the ozone data assimilation are described in detail in a recent paper [Eskes et al, 2003]. Here we will only provide a brief overview of the model set-up.

The three-dimensional advection of ozone is described by the flux-based second order moments scheme of Prather. The model is driven by 6-hourly meteorological fields (forecasts of wind, surface pressure, and temperature) and follows the latest ECMWF vertical layer definition, operational from the end of 1999 until the present. The 60 ECMWF hybrid layers between 0.1 hPa and the surface have been reduced to 44 in TM3DAM by removing 16 layers in the lower and middle troposphere. The horizontal resolution of the model version used in this study is 2 by 3 degree.

Ozone chemistry in the stratosphere is described by two parametrizations. One consists of a linearization of the gas-phase chemistry with respect to production and loss, the ozone amount, temperature and UV radiation. A second parametrization scheme accounts for heterogeneous ozone loss. This scheme introduces a three-dimensional chlorine activation tracer which is formed when the temperature drops below the critical temperature of polar stratospheric cloud formation. Ozone breakdown occurs in the presence of the activation tracer, depending on the presence of sunlight. The rate of ozone decrease is described by an exponential decay, with a rate proportional to the amount of cold tracer and a minimal decay time of 12 days. The cold tracer is deactivated with a time scale of 10 days in the Southern hemisphere when light is present.

Ozone assimilation and ozone forecasts

The total ozone data are assimilated in TM3DAM by applying a parameterized Kalman filter technique. In this approach the forecast error covariance matrix is written as a product of a time independent correlation matrix and a time-dependent diagonal variance. The various parameters in the approach are fixed and are based on the forecast minus observation statistics accumulated over the period of one year (2000). This approach produces detailed and realistic time- and space-dependent forecast error distributions.

On average the root-mean-square difference between new GOME-1 or SCIAMACHY observations and the short range model forecast (between 1 and 3 days) is small: about 9 Dobson Units (DU), or roughly 3%. The bias between the model and the GOME-1 columns is in general smaller than 1%.

The quantitative performance of the ozone forecasts was reported recently [Eskes et al., 2002]. Medium range stratospheric ozone forecasts can be produced for a forecast period similar to 500 hPa geopotential height anomaly forecasts: the anomaly correlation in the extratropics crosses the value of 0.6 after about 6-7 days with the present set-up. In the tropics the anomaly statistics are worse, and possible reasons for this have been identified. Special events such as ozone mini-holes and the South Pole ozone hole development can be forecasted successfully at least 4-5 days in advance.

Post-processing

Post-processing consists of several aspects:

• Quality checks: The OmF statistics will be inspected in order to quantify errors in either the retrieval of the ozone columns or the TM3DAM model.

• Monitoring: The forecast continuity is guarded by a routine monitoring of forecast production chain during working hours. OmF monitoring is performed to detect changes in the analysis / forecast.

• Image processing: After completion of the forecast run images (and possibly additional data formats) are produced for the TEMIS internet ozone service.

• Dynamical web page generation: The TEMIS ozone service web page is automatically updated directly after completion of the analysis/forecast runs

References

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