EUMETSAT AC SAF ATMOSPHERIC COMPOSITION MONITORING

PRODUCT USER MANUAL

IASI Dust Optical Depth at 10µm

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DOCUMENT STATUS SHEET

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1.0	06/02/2025	First version of the Dust PUM produced for the back-up dissemination of the product in demonstrational mode. Not reviewed.

RELATED PRODUCT LIST

Product ID	Product name	Platform
O3M-372, O3M-430	IASI NRT Dust	Metop-B, Metop-C

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1. INTRODUCTION

1.1 Purpose and scope

This document is the Product User Manual for the IASI Dust product retrieved within the context of the Satellite Application Facility on Atmospheric Composition Monitoring (AC SAF). This document gives a brief overview on the IASI Dust retrieval algorithm and explains how to use and interpret the IASI Dust product.

1.2 Acronyms

AC SAF: Atmospheric Composition Monitoring Satellite Application Facility
EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites
EUMETCast: EUMETSAT multi-service data dissemination system
IASI: Infrared Atmospheric Sounding Interferometer
ULB: Université libre de Bruxelles
LATMOS: Laboratoire Atmosphères, Observations Spatiales

1.3 Applicable and reference documents

1.3.1 Applicable documents

[AD1] IASI Dust Algorithm Theoretical Basis Document SAF/AC/ULB/Dust_ATBD Issue 1.2, 10/12/2024

[AD2] IASI Dust Product Specification, Requirement and Assessment SAF/AC/ULB/ Dust_PSRA Issue 1.1, 24/02/2022

[AD3] Product Requirements Document SAF/AC/FMI/RQ/PRD/001 Issue 2.2, 20/12/2023

1.3.2 Reference documents

[RD1] Hilton, F.; August, T.; Barnet, C.; Bouchard, A.; Camy-Peyret, C.; Clarisse, L.; Clerbaux, C.; Coheur, P.-F.; Collard, A.; Crevoisier, C.; Dufour, G.; Edwards, D.; Faijan, F.; Fourrié, N.; Gambacorta, A.; Gauguin, S.; Guidard, V.; Hurtmans, D.; Illingworth, S.; Jacquinet-Husson, N.; Kerzenmacher, T.; Klaes, D.; Lavanant, L.; Masiello, G.; Matricardi, M.; McNally, T.; Newman, S.; Pavelin, E.; Péquignot, E.; Phulpin, T.; Remedios, J.; Schlüssel, P.; Serio, C.; Strow, L.; Taylor, J.; Tobin, D.; Uspensky, A. and Zhou, D.: Hyperspectral Earth Observation with IASI. *Bull. Am. Meteorol. Soc., 93(3),* 347-370, doi: 10.1175/BAMS-D-11-00027.1, 2012.

[RD2] Camy-Peyret, C. & Eyre, J. The IASI Science Plan. Technical report, A Report From The IASI Sounding Science Working Group, 1998.

[RD3] Clerbaux, C.; Boynard, A.; Clarisse, L.; George, M.; Hadji-Lazaro, J.; Herbin, H.; Hurtmans, D.; Pommier, M.; Razavi, A.; Turquety, S.; Wespes, C. & Coheur, P. F. Monitoring of atmospheric composition using the thermal infrared IASI/MetOp sounder. *Atmos. Chem. Phys*., 9(16):6041-6054, 2009.

[RD4] Clarisse, L., Clerbaux, C., Franco, B., Hadji-Lazaro, J., Whitburn, S., Kopp, A., Hurtmans, D., & Coheur, P.-F. A decadal data set of global atmospheric dust retrieved from IASI satellite measurements. *J. Geophys. Res.: Atm.*, *124*. https://doi.org/10.1029/2018JD029701, 2019

[RD5] Whitburn, S., Damme, M. V., Clarisse, L., Bauduin, S., Heald, C. L., Hadji-Lazaro, J., & Coheur, P.-F. A flexible and robust neural network IASI-NH3 retrieval algorithm. *J. Geophys. Res.: Atm.*, *121*. https://doi.org/10.1002/2016JD024828, 2016

[RD6] EUMETCast Dissemination facility : https://user.eumetsat.int/news-events/news/ac-saf-iasi-dust-product-on-eumet-cast

2. 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 threats 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, NH3), 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 tropospheric 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 tropospheric 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

3. IASI DUST RETRIEVAL ALGORITHM

3.1 IASI instrument

IASI is an infrared Fourier transform spectrometer developed jointly by CNES (the French spatial agency) with support of the scientific community (for a review see [RD1]), and by EUMETSAT. IASI is mounted on-board the European polar-orbiting Metop satellites with the primary objective to improve numerical weather predictions, by measuring tropospheric temperature and humidity with high horizontal resolution and sampling, with 1 km vertical resolution, and with respectively 1 K and 10% accuracy [RD2]. IASI also contributes to atmospheric composition measurements for climate and chemistry applications [RD3]. To reach these two objectives, IASI measures the infrared radiation of the Earth's surface and of the atmosphere between 645 and 2760 cm^{-1} at nadir and along a 2200 km swath perpendicular to the satellite track. A total of 120 views are collected over the swath, divided as 30 arrays of 4 individual Field-of-views (FOVs) varying in size from 36 $\times\pi$ km^2 at nadir (circular 12 km diameter pixel) to 10 x 20 x π km^2 at the larger viewing angle (ellipse-shaped FOV at the end of the swath). IASI offers in this standard observing mode global coverage twice daily, with overpass times at around 9:30 and 21:30 mean local solar time. The very good spatial and temporal sampling of IASI is complemented by fairly high spectral and radiometric performances: the calibrated level 1C radiances are at 0.5 cm^{-1} apodized spectral resolution (the instrument achieves a 2 cm optical path difference), with an apodized noise that ranges below 2500 cm^{-1} between 0.1 and 0.2 K for a reference blackbody at 280 K [RD1].

3.2 Dust algorithm overview

The algorithm is based on (1) a sensitive hyperspectral dust index (R) and (2) the conversion of this index to dust optical depth (DOD) at 10 μm. The dust index is derived from a Jacobian, encompassing a typical infrared dust signature and a covariance matrix, derived from spectra without observable quantities of dust. The conversion to optical depths (ODs) relies on a neural network (NN), trained from a database of synthetic spectra, a CALIPSO dust climatology and IASI L2 meteorological data (pressure, temperature, humidity profiles). The NN output is a conversion ratio (CR) by which the R value should be multiplied to get DOD, that is DOD = R x CR. The algorithm description is given in the Dust ATBD [AD1] and in [RD4].

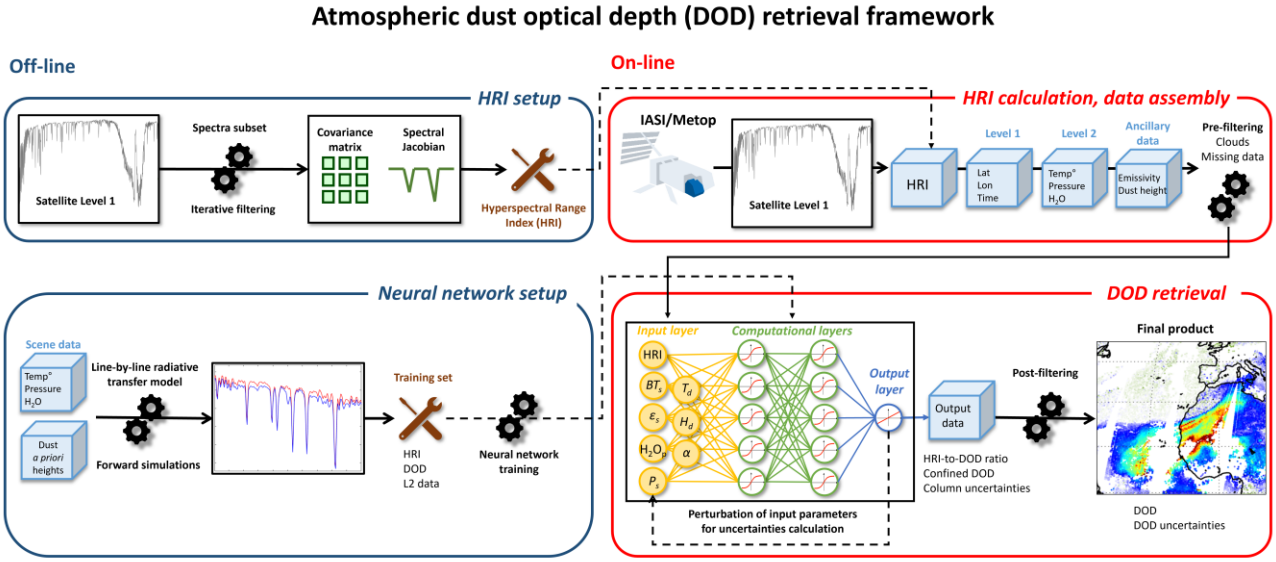

Figure 1: Flowchart showing the IASI atmospheric dust optical depth retrieval framework.

4. IASI LEVEL 2 DAILY DUST PRODUCT

4.1 NetCDF file name convention

The names of the IASI Level 2 Dust products distributed on EUMETCast follow this example:
S-AC_IASI_Dust_L2_yyyymmdd_METOP*_ULB-LATMOS_90.nc

where:

yyyymmdd	the UTC year, month, day of the data start sensing time
*	B or C

4.2 NetCDF file size estimate

The output is one file per day per instrument and is on average 4.8 MB.

4.3 Content of the NetCDF file

This table describes variables included in the IASI Level 2 Daily Dust NetCDF files.

Table 1: Variables name and description

Variables name in NEtCDF file	**Variables description**
time	UTC observation time in days since 1970-01-01 00:00:00 UTC
time_in_second	UTC observation time in seconds since 2007-01-01 00:00:00 UTC
hour	UTC observation hour of the day
minute	UTC observation minute of the hour
second	UTC observation second of the minute
AMPM	AM/PM flag based on local time; 0 for AM data, A for PM data
latitude	latitude of ground pixel center
longitude	longitude of ground pixel center
orbit_number	Metop orbit number
scanline_number	scanline number in the Metop orbit
pixel_number	pixel number in the current scanline; between 1 and 120
ifov_number	field of view number in the 2x2 observation matrix; between 1 and 4

Dust_z	altitude of dust plume in kilometer; this altitude is extracted from a monthly climatology of dust altitudes built from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation 5-km Aerosol Layer product (v4.10) for all available data in the period 2006-2016 (see section 4.1 of [RD4]).
Dust_OD	dust plume optical depth at 10 µm, without unit
Dust_Err	estimated error on dust plume optical depth at 10 µm, without unit
general quality flag	retrieval general quality flag; 0 = unreliable and should in most cases be removed/filtered out, 1 = all the rest. This is the result of the postfilter as explained in section 4.3 of [RD4].

5. THE DUST PRODUCT

5.1 Product description

The Dust product includes several variables, described in Table 1 and in Table 2. The principal product is a Dust plume optical depth and an estimated error on this optical depth, together with the climatological altitude of the dust plume. A 1°x1° monthly climatology of dust altitudes was built from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation 5-km Aerosol Layer product (v4.10) for all available data in the period 2006-2016 [RD4].
The estimated error is given by the total uncertainty. It is calculated by propagation of the uncertainty of the different input parameters of the NN, augmented with a (conservative) 10% uncertainty to take into account errors in the NN [RD5]. The total uncertainty is estimated in absolute terms and is always positive, being obtained from the sum of the squares of the different contributions [RD4].

Table 2: Description and units of the Dust product available in the IASI L2 Dust NetCDF files

Name	Description	Units
Dust_OD	Dust plume optical depth	unitless
Dust_Err	Estimated error on dust plume optical depth	unitless
Dust_Z	Climatological altitude of dust plume	km
general_quality_flag	General quality flag	unitless

5.2 Using the product

5.2.1 General quality flag

general_quality_flag = 0 if:

- Dust_OD < -0.1 or hyperspectral dust index (R, see section 3.2) < -3
- conversion ratio (CR, see section 3.2) > 0.15
- Dust_Err > 0.15 and (Dust_Err/Dust_OD)*100 > 50%

general_quality_flag = 1 for all the rest.

5.2.2 Data filtering

We recommend to filter out data for which the associated general quality flag is zero.

5.3 Product requirements

The product requirements are given in terms of threshold, target and optimal values in Table 5 below. This information is taken from the Dust product specification, requirement and assessment document [AD2] and is also given in the Product Requirements Document [AD3].

Table 5: Dust product requirements.

		Error*			Spatial resolution	Spatial coverage	
		Threshold	Target	Optimal			
Dust O.D.		RE < 150 % or AE < 0.2	RE < 75 % or AE < 0.05	RE < 25 % or AE < 0.01	IASI pixel	Global	

*difference of quantity value obtained by measurement and true value of the quantity intended to be measured, as defined by CEOS/ISO:19159 (ISO/TS 19159-1:2014(en), Geographic information - Calibration and validation of remote sensing imagery sensors and data — Part 1: Optical sensors).

5.4 Product dissemination and archiving

5.4.1 Daily Product dissemination

The IASI Level 2 products are disseminated to users every day through EUMETCast [RD6]. The daily data delivered in the morning corresponds to the data from the day before. The data are disseminated in NetCDF format. A description of the IASI Daily Dust Level 2 NetCDF content is given in Section 4.3.

5.4.2 Archive retrieval

The IASI Level 2 products available from the EUMETSAT Data Centre are archived as full orbits. The products in the EUMETSAT Data Centre are available in NetCDF format.