



PRODUCT USER MANUAL

Near real-time IASI Brescia SO₂ columns and altitude (O3M-379, O3M-431) and ash flag (O3M-381, O3M-432) HDF5

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DOCUMENT STATUS SHEET

Issue	Date	Modified items/Reason for change
1.1	15/06/2017	In section 4.3 Table 1, HEIGHT: “km” has been corrected with “m”. In section 5.1 Table “2, 7, 10, 13, 16 and 25 km” has been replaced with “7000, 10000, 13000, 16000 and 25000 m” Section 5.2.2 Data filtering has been added.
1.2	14/12/2017	Page 8, line 3, ‘Metop satellite’ replaced with ‘Metop satellites’. The sentence 'In no case the different SO2 columns (...) must be added up' was replaced by ‘Under no circumstance should the different SO2 columns (...) be added up.’
1.2	12/02/2018	Page 13, section 5.2.3, some lines describing the uncertainty characterization were added.
1.2	26/03/2018	New section 5.2.4 included to describe the conversion of altitude to pressure.
1.3	04/11/2019	Section 4.3 In Table 1, one local BUFR descriptor used by EUMETSAT was replaced by a new WMO descriptor. Section 5.1 Table 2 and section 5.2.1, although the entries from the original table for the descriptor General retrieval quality flag for SO2 were preserved, the code figures have been reassigned.
1.4	28/04/2021	Clarification was added with respect to the definition of ‘altitude’ which is above sea level (chapter 3.2, Table 1 and 2). The General retrieval quality flag for SO2 ancient and new code figures are now shown.
1.5	03/04/2023	SO ₂ altitude has now been included in the Brescia PUM.
1.6	25/01/2024	ORR Reviewer’s corrections and comments were included.
1.7	21/04/2026	New PUM for the HDF5 SO2 columns and altitude and ash flag product.

RELATED PRODUCT LIST

Product ID	Product name	Platform
O3M-379, O3M-431	IASI NRT SO2 altitude	Metop-B, Metop-C
O3M-57, O3M-377	IASI NRT total SO2	Metop-B, Metop-C
O3M-381, O3M-432	IASI NRT ash flag	Metop-B, Metop-C

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1. INTRODUCTION

1.1 Purpose and scope

This document is the Product User Manual for the HDF5 Near Real Time IASI SO₂ product including SO₂ altitude and ash flag retrieved within the context of the Satellite Application Facility on Atmospheric Composition Monitoring (AC SAF). This document gives a brief overview on the IASI Brescia retrieval algorithm and explains how to use and interpret the IASI Brescia SO₂ column and altitude product and ash flag.

This document has been written as Brescia-SO₂ v20211010 was running at EUMETSAT.

1.2 Acronyms

AC SAF: Atmospheric Composition Monitoring Satellite Application Facility

BUFR: Binary Universal Form for the Representation of meteorological data

HDF5: Hierarchical Data Format

EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites

EUMETCast: EUMETSAT multi-service data dissemination system

WMO: World Meteorological Organization

GTS: Global Telecommunication 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 Brescia SO₂ Algorithm Theoretical Basis Document SAF/AC/ULB/ATBD/002 Issue 1.3, 01/02/2021

[AD2] IASI volcanic ash flag Algorithm Theoretical Basis Document SAF/AC/ULB/ATBD/008 Issue 1.1, 14/02/2022

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

[AD4] ACSAF validation report on the EUMETSAT IASI/Metop CDR SO₂ datasets SAF/AC/AUTH/IASI/SO₂/Repro, Issue 001, 31/03/2023.

[AD5] ACSAF validation report on the ash flag (TBD)

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., Hurtmans, D., Clerbaux, C., Hadji-Lazaro, J., Ngadi, Y. and Coheur, P. F.: Retrieval of sulphur dioxide from the infrared atmospheric sounding interferometer (IASI), *Atmos. Meas. Tech.*, 5, 581-594, doi:10.5194/amt-5-581-2012, 2012.
- [RD5] Carn, S.A., Clarisse, L., Prata, A.J.: Multi-decadal satellite measurements of global volcanic degassing, *Journal of Volcanology and Geothermal Research*, 311, 99-134, <http://dx.doi.org/10.1016>, 2016.
- [RD6] Clarisse, L., Coheur, P.-F., Theys, N., Hurtmans, D., and Clerbaux, C.: The 2011 Nabro eruption, a SO₂ plume height analysis using IASI measurements, *Atmos. Chem. Phys.*, 14, 3095-3111, doi:10.5194/acp-14-3095-2014, 2014.
- [RD7] Clarisse, L. & Prata, F. Volcanic ash: methods of observation and monitoring, Chapter 11 In Mackie, S., Cashman, K., Ricketts, H., Rust, A. & Watson, M. (Eds.) *Infrared sounding of volcanic ash*, pp 189-215. Elsevier, doi: 10.1016/B978-0-08-100405-0.00017-3, 2016.
- [RD8] EUMETCast Dissemination facility <https://user.eumetsat.int/data-access/eumetcast-europe>

2. IASI LEVEL 2 NRT BRESCIA SO₂ HDF5 DESCRIPTION

2.1 HDF5 file name convention

The names of the IASI Level 2 SO₂ products distributed on EUMETCast follow this example:

W_XX-EUMETSAT- Darmstadt,SOUNDING+SATELLITE,METOP*+IASI_C_EUM*letter*_
 yyyyymmddhhmmss_nnnnn_ACSAF_BRESCIA_l2.h5

where:

<i>yyyyymmdd</i>	the UTC year, month, day of the data start sensing time
<i>hhmmss</i>	the UTC hour, minute, second of the data start sensing time
<i>nnnnn</i>	the orbit number
<i>*</i>	B, C
<i>letter</i>	P for operational (Metop B), R for secondary or redundant (Metop C)

2.2 HDF5 file size estimate

The size of the output may vary and is on average 18 M per day for a number of 480 files per instrument.

2.3 Content of the HDF5 file with respect to the BUFR PDU file

In this table, the new HDF5 file variables are given with the equivalent BUFR variables. The Brescia SO₂ product is provided in the 7 last fields (in bold).

Molecule prefixes are removed in HDF5 files to reduce file size (One molecule - One file) e.g.: **SO₂_ALTITUDE** -> **ALTITUDE**.

Table 1: Data descriptors of IASI Level 2 SO₂ BUFR file with equivalent HDF5 variables and supplemental data including ash flag.

#	BUFR DATA DESCRIPTOR		NAME USED HEREAFTER in the PUM	EQUIVALENT HDF5 VARIABLE
0	0-0- 1007	SATELLITE IDENTIFIER		
1	0-0- 1031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE		
2	0-25- 060	SOFTWARE IDENTIFICATION		
3	0-0- 2019	SATELLITE INSTRUMENTS		
4	0-0- 2020	SATELLITE CLASSIFICATION		

5	0-0-4001	YEAR		/location/date
6	0-0-4002	MONTH		
7	0-0-4003	DAY		
8	0-0-4004	HOUR		/location/time
9	0-0-4005	MINUTE		
10	0-0-4006	SECOND		
11	0-0-5040	ORBIT NUMBER		/location/orbit
12	2-0-1133			
13	0-0-5041	SCAN LINE NUMBER		/location/scanline
14	2-0-1000			
15	0-0-5001	LATITUDE (HIGH ACCURACY)		/location/latitude
16	0-0-6001	LONGITUDE (HIGH ACCURACY)		/location:longitude
17	0-0-5043	FIELD OF VIEW NUMBER		1
18	0-0-7024	SATELLITE ZENITH ANGLE		
19	0-0-5021	BEARING OR AZIMUTH		
20	0-0-7025	SOLAR ZENITH ANGLE		
21	0-0-5022	SOLAR AZIMUTH		
22	0-0-7007	HEIGHT		/location/surface altitude
23	0-4-0068	GENERAL RETRIEVAL QUALITY FLAG FOR SO ₂	SO2_QFLAG	/fitted/diagnostics/QFLAG
24	0-0-7002	HEIGHT OR ALTITUDE	SO2_ALTITUDE (altitude of the plume)	/fitted/SO2/ALTITUDE
25	0-1-5045	SULFUR DIOXIDE	SO2_COL (total column)	/fitted/SO2/COL
26	0-1-2080	BRIGHTNESS TEMPERATURE REAL PART	SO2_BT_DIFFERENCE	/fitted/SO2/DBT

27	1-0-2000	Delayed repetition for next 2		
28	0-3-1001	DELAYED DESCRIPTOR REPLICATION FACTOR	number of altitudes*=5	
29	0-0-7007	HEIGHT*	altitudes in m of the 5 plume levels	"Altitudes" attribute of /fitted/SO2/COL_AT_ALTITUDES
30	0-1-5045	SO₂ COL ALTITUDE (columns at NLSO ₂ different altitudes*)	SO₂_COL_AT_ALTITUDES*	/fitted/SO2/COL_AT_ALTITUDES
		Supplemental		
	N/A	Diagnostics on the retrieval		/fitted/diagnostics/BDIV
	N/A	Ash flag	Flag to indicate presence of ashes	/fitted/Ashes/Presence Flag
	N/A	Pressure at retrieved altitude (hPa)		/fitted/SO2/PRESSURE
	N/A	Pressures at predefined altitudes (hPa)		/fitted/SO2/P_AT_ALTITUDES

* altitude is above sea level

1 Structured data so no need

3. THE BRESCIA NRT SO₂ PRODUCT

3.1 Product description

The Brescia SO₂ product includes several variables, described in Table 1 (bold) and in Table 2. Here we describe the outputs of the algorithms.

The retrieval scheme includes two algorithms. The first algorithm, for the sounding of SO₂ above ~5 km altitude, includes as main features a wide applicable total column range (over 4 orders of magnitude, from 0.5 to 5000 dobson units), a low theoretical uncertainty (3-5 %) and near real time applicability. The output consists of 5 different hypothetical SO₂ columns, which depend on assumed a priori SO₂ plume altitudes (for this version at 7, 10, 13, 16 and 25 km), and is meant to be used with auxiliary altitude data. A typical use-case is where a user will have an estimate of the SO₂ altitude (provided by e.g. a model or third party measurements), and in that case, the user can interpolate the 5 SO₂ columns to this estimate to obtain a single SO₂ column. The different SO₂ columns must under no circumstances be added together.

Information on the SO₂ altitude can also be retrieved directly from the IASI measurements, and this is what the second algorithm aims at. This product has its applications in its own right. In addition, an interpolated SO₂ column (from the first algorithm), at the retrieved SO₂ altitude (from the second algorithm) is also provided. If the user has no information on the SO₂ altitude and is interested in the SO₂ column, it is recommended that this interpolated SO₂ column product is used.

All IASI SO₂ altitudes are above sea level.

The product contains also a flag to indicate the presence of ashes.

Table 2: Description and units of Brescia SO₂ product available in the IASI L2 SO₂ HDF5 files

Name		Description	Units
QFLAG	Low nibble	SO ₂ Plume presence certitude (and hence altitude marking) (e.g. bits 3 and 4): 4: LOW 8: MEDIUM or 12: HIGH	NA
	High nibble	Columns indicator: (e.g. bits 5->7) SO ₂ _FIXED = 16 Columns at selected altitudes (partially) filled SO ₂ _EVAL = 32 Column at plume altitude successfully evaluated	
		QFLAG= 0 (missing value)	
COL_AT_ALTITUDES		SO ₂ column at an estimated altitude** provided by the corresponding 'attribute'.	DU*

dBt		SO ₂ Brightness temperature difference	K
ALTITUDE		Retrieved plume altitude**	km
COL		SO ₂ column at the retrieved plume altitude. The SO ₂ _COL relates to a total column, so it represents the concentration of SO ₂ below and around the plume altitude.	DU*
PRESSURE		Pressure at retrieved altitude	hPa
P_AT_ALTITUDES		Pressures at predefined altitudes	hPa
ASH FLAG		Presence of ashes. Bit field: 0 = Super weak 1 = Weak 2 = Strict	NA

*1 DU=2.69 x 10¹⁶ molecules /cm²

** altitude is above sea level

In Table 2 QFLAG is a single code assessing the presence of an SO₂ plume following the retrieval error flag BDIV, as described in Table 3 below. QFLAG is a Brescia SO₂ output, see Section 3.1.

Table 3: Potential processing and input errors in Brescia SO₂ (BDIV). Note that bits have been reassigned with new WMO descriptor bits.

Name	Value	Bit	WMO bit	Description	Comment
General					
AMP_ERROR	1	0	1	An error has been detected	
Origin					
AMP_L1	2	1	2	Message from L1	
AMP_L2	4	2	3	Message from L2	
AMP_ANC	8	3	4	Message from ancillary data	
AMP_FIT	16	4	5	Message from fitting procedure	
Input content					
AMP_QUALFLAG	256	8	7	Quality flag	Either bad L1 (qFlag) or L2 (F IASI Bad) flag raised
AMP_LINREG_L2	512	9	8	Level 2 “from linear regression” (F_Qual), report a pixel where L2 are not retrieved from EUM L2	
AMP_EMPTY	1024	10	9	Empty field or data	Indicate missing T or humidity level(s) in the vertical profile
AMP_INCOMPLETE	2048	11	10	Missing surface pressure value	
AMP_RADFILTER	4096	12	11	Radiance filtering	Not used in this context

AMP_POLES	8192	13	12	Polar regions	Not used in this context
AMP_NIGHT	16384	14	13	Location in the night	Not used in this context
AMP_NEGZO	32768	15	14	Negative altitude	Surface below m.s.l.
AMP_COVERAGE	65536	16	15	Cloud covered scene	
AMP_SEA	131072	17	16	Scene above the sea	Not used so far
AMP_DESERT	262144	18	17	Scene above desert	
AMP_TSKIN	524288	19	18	Skin temperature	N/A
AMP_TDIFF	1048576	20	19	Skin temperature differential	N/A
AMP_CONTRAST	2097152	21	20	Spectral line contrast too weak	N/A
Fitting					
AMP_ITERATIONS	4194304	22	21	Maximum number of iterations exceeded	N/A
AMP_NEGPC	8388608	23	22	Negative partial columns	N/A
AMP_CONDITION	16777216	24	23	Matrix ill conditioned	N/A
AMP_DIVERGED	33554432	25	24	Fit diverged	N/A
AMP_GSL	67108864	26	25	Error in gsl usage	N/A
AMP_BIAS	134217728	27	26	Residuals “biased”	N/A
AMP_SLOPE	268435456	28	27	Residuals “sloped”	N/A
AMP_RMS	536870912	29	28	Residuals rms large	N/A
AMP_AVK	1073741824	30	29	Weird averaging kernels	N/A
AMP_ICE	2147483648	31	30	Ice presence detected	N/A

3.2 Using the product

3.2.1 Quality flags

All retrieved SO₂ columns are considered best quality retrievals and can be used.

Strictly speaking, QFLAG is not a quality insurance flag. Instead, it provides information on the certainty of presence of a SO₂ plume and/or the presence of a SO₂ column value in the appropriate fields.

For example: if QFLAG indicates the presence of a MEDIUM plume then either the SO₂_FIXED and/or SO₂/EVAL could be filled depending on L2 availability.

Regarding QFLAG, it is composed of 2 nibbles (each nibble is half-a-byte, i.e. 4 bits). The low nibble is composed of the 4 less significant bits of a byte; and the high nibble, from the most significant 4 bits. If high nibble is set then low nibble should be set. Reciprocal is not true. Since the high nibble indicates the presence of retrieved columns, if it is not 0 then there is obviously a plume detected, and hence the lowest nibble is set (e.g. not 0). Conversely, detection of a plume does not guarantee a retrieval.

The ash flag, a completely independent flag from SO₂, indicates observations with an apparent spectral signature due to volcanic ash. The level of detection confidence ranges from 0 (low) to 2 (high). In case of large ash loadings, the retrieved SO₂ columns can be biased low or high. More information on the ash flag can be found in the ATBD [AD2] and in section 3.2.5 below.

3.2.2 SO₂ data filtering

First, we recommend identifying the observations for which $\text{so2_bt_difference} > 1\text{K}$. These are the most reliable. Around these observations, data for which $0.4\text{K} \leq \text{so2_bt_difference} \leq 1\text{K}$ are also reliable. See Figure 1 for an example.

In cases where large amounts of SO₂ are present, IASI L2 temperature and water vapour profiles can be missing and the Brescia algorithm then uses ECMWF forecast fields to provide an SO₂ retrieval (Note that BDIV contains already a flag indicating if a linear regression was used to provide the T, q profiles: AMP_LINREG_L2).

In cases where the surface_z data is missing, we recommend using the variable ‘height’, which is the average surface elevation of each IASI pixel computed by EUMETSAT using a Digital Elevation Model (DEM).

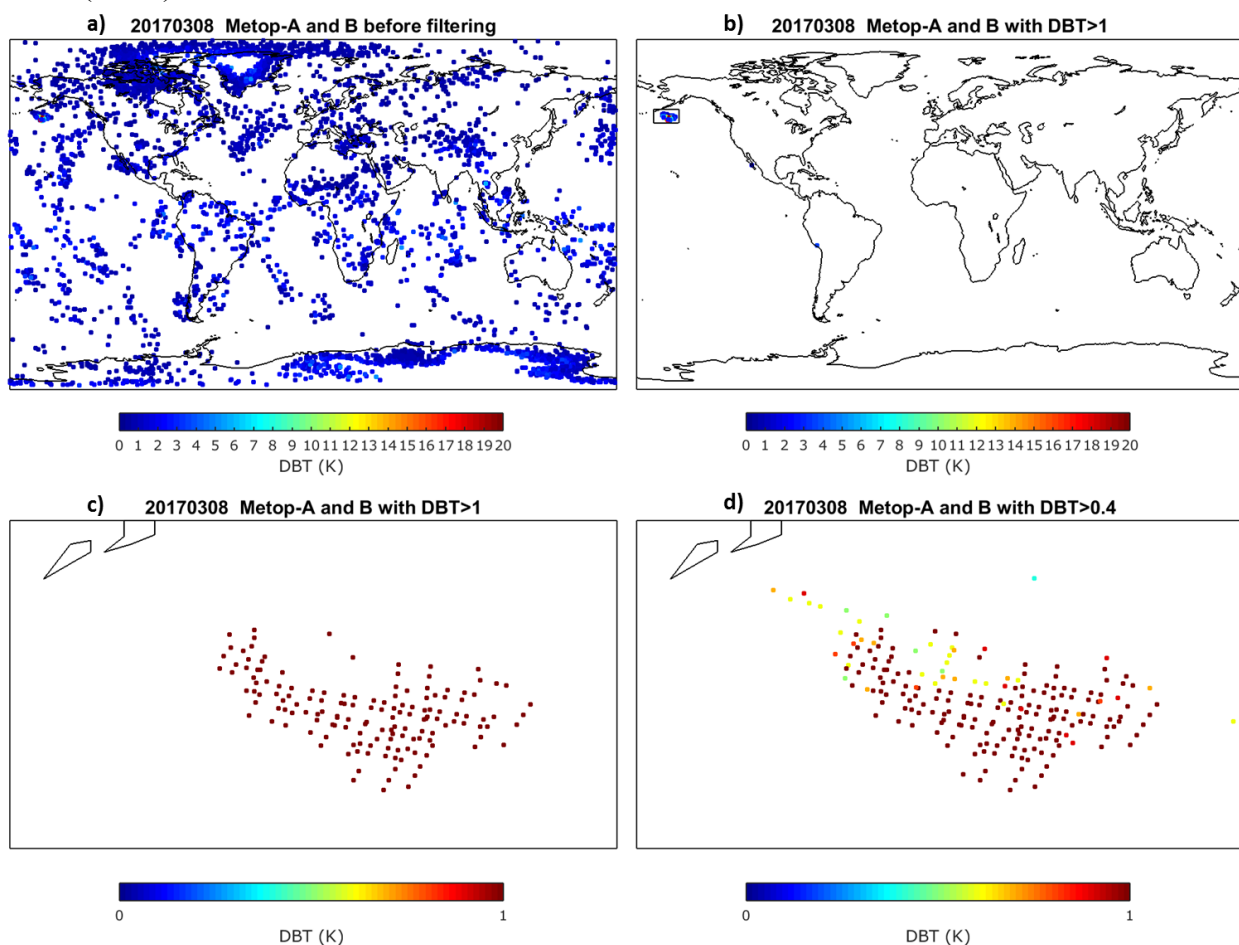


Figure 1: Filtering example using so2_bt_difference (DBT) for 8 March 2017: (a) all Metop-A and B retrievals where SO₂ is detected, (b) only pixels with DBT > 1, (c) zoom in the Alaska Gulf (rectangle in subplot b), (d) in the neighborhood of pixels with DBT > 1, one can consider pixels with DBT > 0.4.

3.2.3 SO₂ column, altitude and uncertainty characterization

In the current version, the altitude of the SO₂ plume is given (SO₂_ALTITUDE), as well as the SO₂ corresponding column (SO₂_COL). If the user has no information on the SO₂ altitude and is interested in the SO₂ column, the user should use this interpolated SO₂ column product (SO₂_COL).

If the user has an estimate of the SO₂ altitude (provided by e.g. a model or third party measurements), the user can use the 5 SO₂ columns (SO2_COL_AT_ALTITUDES) in order to pick the proper SO₂ column or do the interpolation to estimate his/her own single SO₂ column.

Careful, under no circumstance should the different SO₂ columns (at 7, 10, 13, 16 and 25 km) be added up. Only one SO₂ column must be used for one location. Examples of applications can be found in [RD5] and [RD6].

A characterization of how the uncertainty in the assumed altitude translates to an uncertainty in the final column can be obtained using the variance formula:

$$\sigma_{SO_2} = \frac{\partial SO_2}{\partial alt} \sigma_{alt} \quad (1)$$

Here, σ_{alt} is the uncertainty on the altitude (user provided, e.g. 1 km) the derivative of the SO₂ column with respect to altitude $\left(\frac{\partial SO_2}{\partial alt}\right)$ can be calculated numerically from the 5 SO₂ columns. This uncertainty can be relatively small for high altitudes (e.g. 10-20% around the tropopause, see Figure 7 in [RD4]), while for lower altitudes can reach over 100%.

3.2.4 Altitude-pressure conversion

The pressure at the retrieved altitude is given in the field 'PRESSURE' and the pressures at predefined altitudes are given in the field 'P_AT_ALTITUDES'.

3.2.5 Ash flag post-processing and example

The output of the ash flag algorithm consists, on a daily basis of quite a few (false) low confidence detections. A cleaner map can be obtained by employing spatial context. The postprocessing involved in this process is left to the user as: (1) It involves arbitrary thresholds that may need to be finetuned for best results and (2) the processing of the algorithm in near-real-time at EUMETSAT is performed on a product dissemination unit (PDU) basis, while the postprocessing involves looking at spectra from nearby PDU's (including from other orbits). It is therefore best applied once all the spectra of a given region are available (ascending and descending orbit separately).

Below we describe one possible way of postprocessing. For convenience, we call low, mid, high confidence detections respectively cat3, cat2 and cat1.

1. Keep all cat1 and cat2 detection, label all cat3 detections as *possible* low confident detections
2. For each cat1 detection, consider all pixels in a 20°×20° box.
3. If the latitude is below 66° in absolute value proceed as follows:
 - a. If at least three cat2 are found in the box, all cat3 detections are confirmed
 - b. If not, confirm only the cat3 detections in a box of 2°×2° around the cat1 detection
4. If the latitude is above 66° in absolute value
 - a. If at least five cat1 are found in the box, all cat3 detections are confirmed
 - b. If not, confirm only the cat3 detections in a box of 2°×2° around the cat1 detection

An example of the unified detection method, with postprocessing is presented in Figure 2.

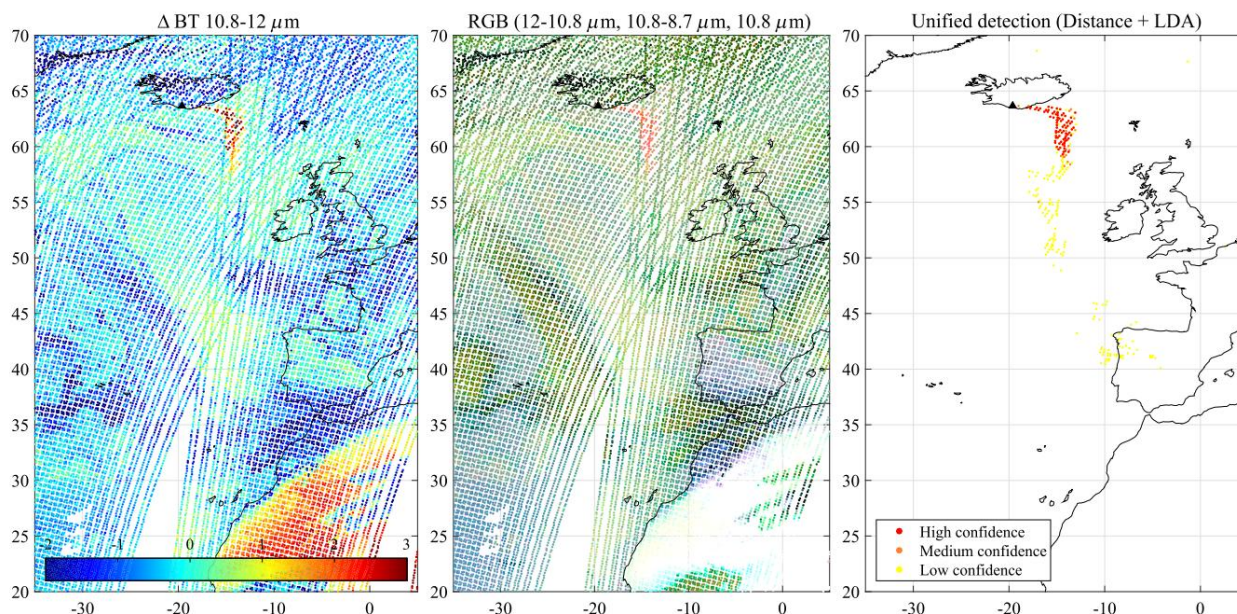


Figure 1: Comparison of the RA/DBT method, the RGB imaging technique, and the unified detection methods for a plume of Eyjafjallajökull on May 6, 2010, as seen with IASI (morning overpass) [RD7].

3.3 Product requirements

The product requirements are given in terms of threshold, target and optimal values in Table 3 below. This information is given in the Product Requirements Document [AD3]. The product performance is given in the Validation Report of this product.

Table 3: Brescia product requirements for SO₂ column, SO₂ altitude and ash flag.

		Error*			Spatial resolution	Spatial coverage	NRT
		Threshold	Target	Optimal			
SO₂ Total column	Below 10km	200%	100%	50%	IASI pixel	Global	<3h
	Above 10 km	100%	35%	20%	IASI pixel	Global	<3h
SO₂ altitude	Below 10km	<3km	<2km	<1km	IASI pixel	Global	<3h
	Above 10 km	<6km	<4km	<2km	IASI pixel	Global	<3h
Ash flag		On average less than 1 false alert/day for high confidence detections	On average less than 1 false alert/month for high confidence detections	No false alerts for high confidence detections	IASI pixel	Global	<3h

*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).

3.4 Validation of the product

The validation of the IASI SO₂ altitude product is performed by AUTH and BIRA. The ‘IASI SO₂ CDR and SO₂ altitude validation report’ [AD4] reports the validation of this product and possible processing errors as well as abnormal behavior are noticed and checked.

The validation of the IASI ash flag product is performed by DWD. The IASI ash flag validation report [AD5] reports the validation of this product and also provides recommendations for users.

3.5 Product dissemination and archiving

3.5.1 Near real time Product dissemination

The IASI Level 2 products are disseminated to users in near real-time through EUMETCast [RD8] with a time lapse of two hours from sensing to delivery. The data are disseminated in HDF5 format. A description of the IASI SO₂ Level 2 HDF5 content is given in Section 2.3.

3.5.2 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 or EPS format. Visibility of EPS products to the users is 6 hours after sensing (start) time.

ANNEX 1. 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 are 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 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

ANNEX 2. IASI-BRESCIA SO₂ RETRIEVAL ALGORITHM

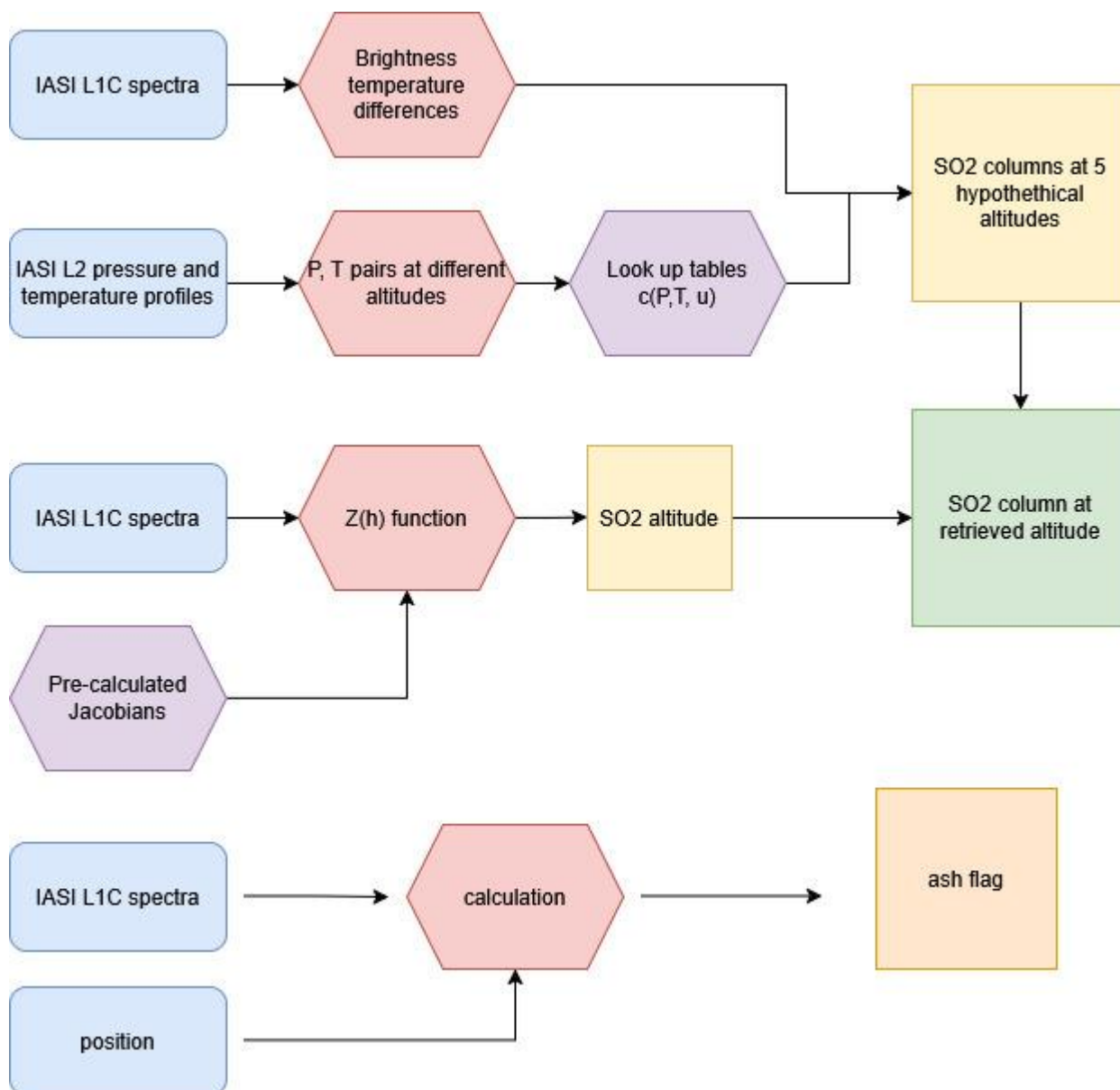
IASI instrument

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 x π km² at nadir (circular 12 km diameter pixel) to 10 x 20 x π km² 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].

Brescia overview

The principal product is a SO₂ total column, given at 5 estimated altitudes: 7, 10, 13, 16 and 25 km. This version includes retrieval of SO₂ plume altitude and the associated SO₂ total column. The ash flag algorithm is also included.

The data flow of the three algorithms and how they are linked is illustrated in Annex 2 Figure.



Annex 2 Figure: Graphic representation of the retrieval sequence of the Brescia SO₂ column and altitude, and ash flag algorithm.

The algorithm descriptions are given in the Brescia ATBD [AD1] and in [RD4], and in the ash flag ATBD [AD2].