EUMETSAT

Product User Guide – IASI level2 TS, T,Q release 1

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1 Introduction

1.1 Purpose and Scope

The purpose of this document is to provide users with detailed information about the release 1 of the reprocessed Metop-A and –B Infrared Atmospheric Sounding Interferometer (IASI) level 2 (L2) temperature and humidity profiles together with the surface temperature and the total column water vapour.

The reprocessed "all-sky" IASI temperature and humidity profiles data record (release 1) relies on the latest algorithms available at the time of the reprocessing (Version 6.5.4, 12/2019) of the operational EUMETSAT algorithm (August, 2017; EUMETSAT, 2020b) and consists of the outputs of the statistical retrieval module Piece Wise Linear Regression (PWLR3) only. This release contains data for IASI-A from the 10th of July 2007 until the 31st December 2018 and IASI-B from 20th February 2013 until 31st December 2018.

The purposes of the reprocessing of the Level 2 IASI temperature and humidity profiles are to provide a homogeneous Thematic Climate Data Record throughout the time period that is of sufficient quality for user applications using the best, latest processor version in operations at that time.

For IASI-A, the release 1 of the fundamental climate data record (FCDR) reprocessed IASI L1c (EUMETSAT, 2019) was used as input up to December 2016. After that date for IASI-A, and for the entire period for IASI-B, the L1c products from the operational near real time processing were used to generate this L2 data record. IASI-A reprocessing was only needed for the early period where major changes happened. IASA-A reprocessed data before 2017 and IASI-A operational data from 2017 used the same version of the software to generate the data making the IASI-A L1c series fully homogeneous. IASI-B L1c data was not reprocessed because the operational L1c data are stable and homogeneous and there have been no major changes potentially affecting the CDR throughout IASI-B period. The two dataset are fully consistent for the generation of the level 2 product.

This guide provides:
1. Specifications of the data record;
2. Scientific overview on the generation and definition of the data record;
3. Characteristics and limitations of the product, to inform and guide the users in applying best-suited data selection for their specific applications;
4. Technical details on the format and the ordering of the data record, as well as information on the mechanisms to provide feedback.

1.2 Document Structure

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1.3 Reference documents

August, T.: The EUMETSAT operational IASI L2 products and services, from Global to Regional, Darmstadt, https://cimss.ssec.wisc.edu/itwg/itsc/itsc21/program/1december/1600_11.01_EUM_IASI_L2___ITSC-21____August.pdf, 2017.

ECMWF: ECMWF L137 model level definitions, ECMWF https://www.ecmwf.int/en/forecasts/documentation-and-support/137-model-levels, last access: 10 December 2020, 2014.

EUMETSAT: AMSU-A Level 1 Product Generation Specification, https://www-cdn.eumetsat.int/files/2020-04/pdf_ten_990005-eps-amsal1-pgs.pdf, 2016a.

EUMETSAT: MHS Level 1 Product Generation Specification, https://www-cdn.eumetsat.int/files/2020-04/pdf_ten_990006-eps-mhs-l1-pgs.pdf, 2016b.

EUMETSAT: IASI Level 2 product guide, https://www-cdn.eumetsat.int/files/2020-07/IASI%20Level%202_%20Product%20Guide.pdf, 2017.

EUMETSAT: Validation Report – IASI-A Level 1c FCDR release 1, https://www.eumetsat.int/media/47452, 2019.

EUMETSAT: EUMETSAT data policy, https://www.eumetsat.int/media/45173, 2020a.

EUMETSAT: IASI Level 2: Product Generation Specification, https://www-cdn.eumetsat.int/files/2020-12/IASI%20Level%202_%20Product%20Generation%20Specification.pdf, 2020b.

EUMETSAT: MTG-IRS L2 ATBD, https://www-cdn.eumetsat.int/files/2020-06/pdf_mtg_irs_l2_atbd.pdf, 2020c.

Hilton, F., Armante, R., August, T., Barnet, C., Bouchard, A., Camy-Peyret, C., Capelle, V., Clarisse, L., Clerbaux, C., Coheur, P.-F., Collard, A., Crevoisier, C., Dufour, G., Edwards, D., Faijan, F., Fourrié, N., Gambacorta, A., Goldberg, M., Guidard, V., Hurtmans, D., Illingworth, S., Jacquinet-Husson, N., Kerzenmacher, T., Klaes, D., Lavanant, L., Masiello, G., Matricardi, M., McNally, A., Newman, S., Pavelin, E., Payan, S., Péquignot, E., Peyridieu, S., Phulpin, T., Remedios, J., Schlüssel, P., Serio, C., Strow, L., Stubenrauch, C., Taylor, J., Tobin, D., Wolf, W. and Zhou, D.: Hyperspectral Earth Observation from IASI: Five Years of Accomplishments, Bull. Am. Meteorol. Soc., 93(3), 347–370, https://doi.org/10.1175/BAMS-D-11-00027.1, 2012.

1.4 Acronyms and Abbreviations

The table below lists acronyms and abbreviations used in this document:

Acronym	Meaning
AMSU-A	Advanced Microwave Sounding Unit-A
ATBD	Algorithm Theoretical Baseline Document
AVHRR	Advanced Very High Resolution Radiometer
CDR	Climate Data Record
DOI	Digital Object Identifier
EARS	EUMETSAT Advanced Retransmission Service
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA	European Reanalysis
EPS	EUMETSAT Polar System
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
IASI	Infrared Atmospheric Sounding Interferometer
IFOV	Instantaneous Field of View
IGRA	Integrated Global Radiosonde Archive
IIS	Integrated Imaging Subsystem
IRON	Infra-Red ONly
ITCZ	Inter-Tropical Convergence zone
L1c	Level 1c
L2	Level 2
Metop	Meteorological operational satellite
MHS	Microwave Humidity Sounder
MWIR	Micro-Wave Infra-Red
NOAA	National Oceanic and Atmospheric Administration
OmC	Observation minus Calculation
PPF	Product Processing Facility
PWLR[3]	Piece Wise Linear Regression
TCDR	Thematic Climate Data Record

2 Background

2.1 The IASI Instrument

The Infrared Atmospheric Sounding Interferometer (IASI) is composed of a Fourier transform spectrometer and an associated Integrated Imaging Subsystem (IIS) (Hilton et al., 2012). The Fourier transform spectrometer provides infrared spectra with high spectral resolution between 645 and 2760 cm^{-1} (3.6 µm to 15.5 µm). The IIS consists of a broadband radiometer with a high spatial resolution. However, the IIS information is only used for co-registration with the Advanced Very High Resolution Radiometer (AVHRR). Three IASI instruments are mounted on the Metop satellite series. Metop-A was launched in 2006, Metop-B in 2012 and Metop-C, the last of the series, was launch in 2018.

The IASI instrument observes the Earth up to a viewing angle of 48.3 degrees on either side of the satellite track (Figure 1), thus achieving a nearly daily global coverage. For each view, the instrument analyses an atmospheric cell of about 3.3 degrees x 3.3 degrees, or 50 km x 50 km at nadir. Each cell is analysed simultaneously by a 2 x 2 array of detectors. This geometrical arrangement, together with the step-by-step scanning mode, gives IASI a field of view that can be combined with the other instruments on the platform. The pixel diameter of 12 kilometres at nadir is a trade-off between radiometric performance and likelihood of acquiring measurements in clear-sky, which was originally the prime scope of the mission.

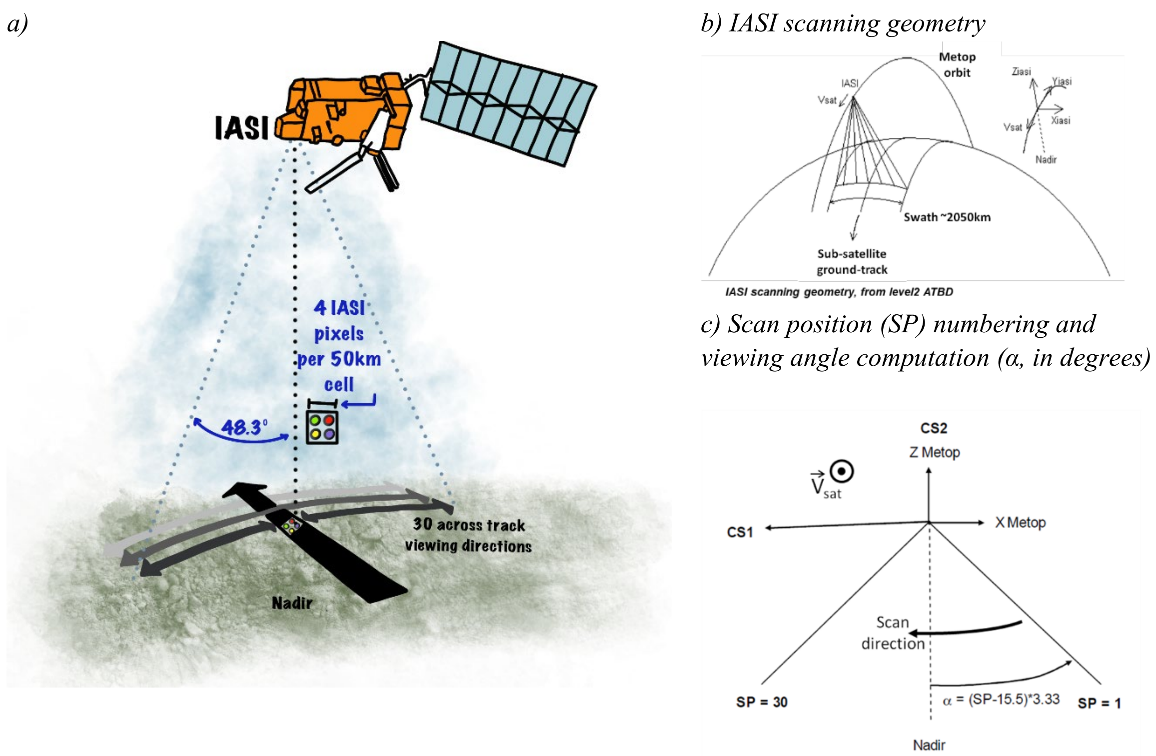


Figure 1: *a) Idealised view of IASI sensing system. b) and c) IASI geometry from level 2* (EUMETSAT, 2020b).

2.2 The AMSU-A and MHS microwave instruments

The retrieval of humidity and temperature profiles uses the infrared measurements of IASI in synergy with the microwave measurements from the Microwave Humidity Sounder (MHS) (EUMETSAT, 2016b) and the Advanced Microwave Sounding Unit-A (AMSU-A) (EUMETSAT, 2016a) that are all flying on the Metop platform. The microwave instruments provide complementary information from the bottom of the atmosphere in cloudy pixels, where IASI cannot get any signal (Figure 2). The footprint geometry of the three instruments used in the retrieval is shown on Figure 3.

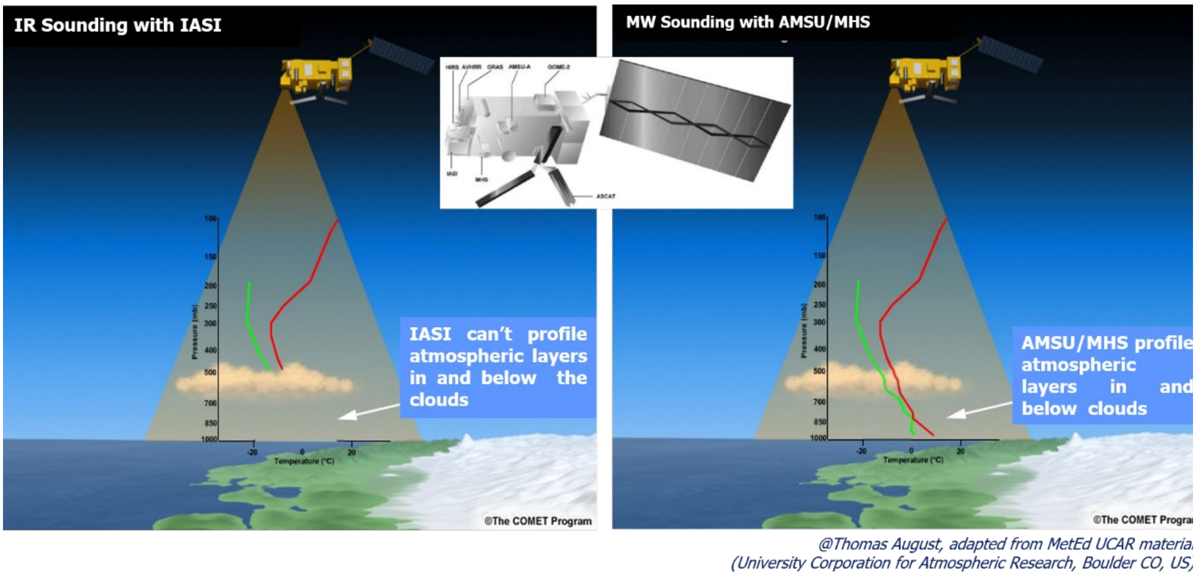


Figure 2: *Synergy between infrared (IASI) and microwave (MHS and AMSU-A) instruments.*

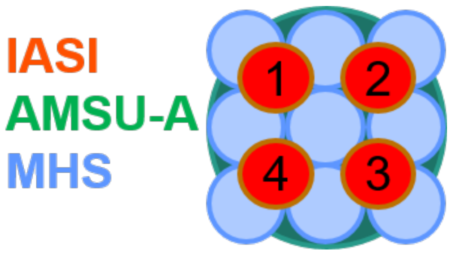


Figure 3: *Idealised view of the IASI footprint geometry with the associated AMSU-A, MHS footprints. Each IASI field of view is composed of 4 IASI pixels, each IASI pixel diameter is approximatively 12km at nadir.*

2.3 The PWLR[3] algorithm

EUMETSAT produces several operational IASI Level 2 products coming from different algorithms as shown in Figure 4.

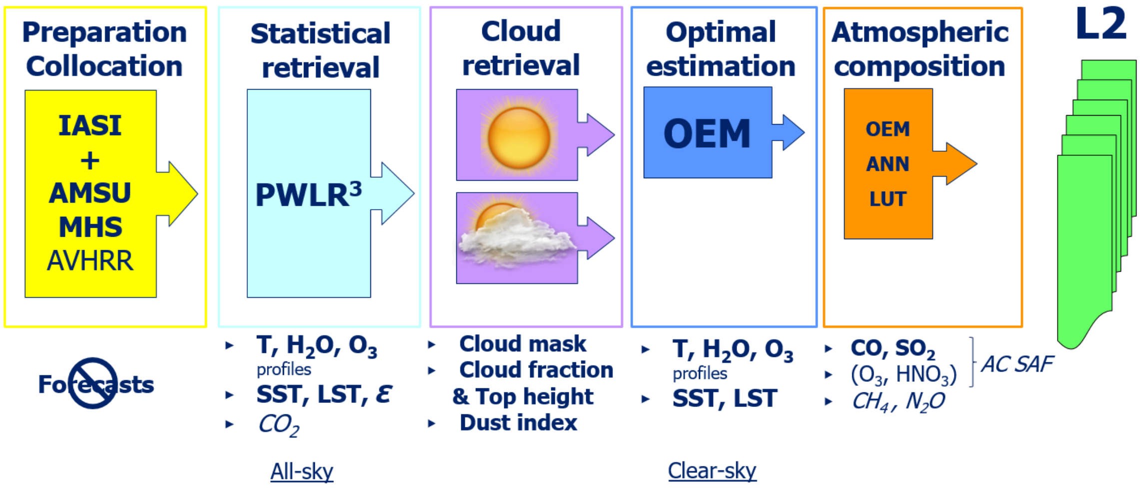


***Figure 4**: Overall picture of the operational EUMETSAT IASI level2 atmospheric product.*

The climate data record is generated using the Piece-Wise Linear Regression (PWLR^3). It is a fast and accurate statistical "all sky" retrieval scheme that uses a synergy between microwave and IR measurements from the polar satellite Metop. The input products of this algorithm are the IASI L1C, the AMSU-A L1B and the MHS L1B. The algorithm provides, for each retrieval, an associated quality indicator.

The PWLR^3 is a machine learning algorithm trained with real satellite observations paired with best correlative representation of the Earth system. For this TCDR reprocessing, it includes four surface parameters (surface pressure, surface air temperature, surface air dew point temperature, and surface skin temperature) as well as the atmospheric profiles of temperature and humidity. In addition, the algorithm also provides a cloud indicator (the predicted Observation-Calculation in window channels) and an uncertainty estimate for each product.

The training set used for the algorithm in this reprocessing is composed of the ERA-5 reanalysis for temperature, humidity and ozone, provided at 137 model levels. It uses 96 days of sensing data, 4 days (1st, 8th, 15th and 22nd) of each month for 2 years in 2015 and 2016. In total, the training set is made up of more than 120 million IASI fields of view. The algorithm defines different observation classes based on the IASI observations and on auxiliary information (e.g. surface type and elevation). Then, for each observation class, a linear regression is performed from the IASI/AMSU-A/MHS observation to retrieve the required geophysical parameters. The vertical profiles are retrieved on 138 levels, reflecting the 137 hybrid levels from the ERA-5 L137 grid plus the surface air level.

Depending on the availability of the microwave inputs, the PWLR^3 retrieval works in two different modes using two different sets of coefficients. The nominal mode is called MWIR (for "Micro-Wave Infra-Red") and is using both the IASI and the microwave data from AMSU-A and MHS. If the microwave data are not available (e.g. because of calibration issues or instrument failure, etc.), the retrieval is then done with the IASI data alone. This mode is called IRON (for Infra-Red Only) and provides retrievals of the same quality as the MWIR mode in clear sky condition. For cloudy pixels, the IRON mode provides retrievals with a slightly lower yield and quality as compared to the MWIR mode.

3 Data record overview

General	Data record name	IASI-A and –B climate data record of all sky temperature and humidity profiles release 1
	Data record digital identifier	10.15770/EUM_SEC_CLM_0027
	Data record short description	Reprocessed TCDR level 2 IASI-A and –B temperature and humidity profiles plus surface temperature, total column water vapour and associated quality indicators retrieved using the PWLR[3] algorithm
	Record type	Thematic Climate Data Record
	Period covered	**IASI-A**: 10 July 2007 – 31 December 2018 **IASI-B**: 20 February 2013 – 31 December 2018
	Content	IASI level 2 temperature and humidity profiles, surface temperature and total column water vapour
Instrument	Instrument name	Infrared Atmospheric Sounding Interferometer (IASI)
	Instrument description	The Infrared Atmospheric Sounding Interferometer (IASI) is one of the instruments flying on Metop-A, B and C. The IASI L1c product contains infrared radiance spectra at 0.25 cm^{-1} sampling. The level 1c product has for each pixel 8461 spectral samples covering the range between 645 cm^{-1} and 2760 cm^{-1}.
	Input data	IASI level 1c MHS AMSU-A AVHRR
	Output data	IASI level 2, temperature and humidity profiles, surface temperature and total column water vapour plus some associated quality indicators and processing flags.
	Format	The products are provided in NetCDF4
Access	EUMETSAT Data Centre	The data set is available from EUMETSAT Data Centre (https://eoportal.eumetsat.int/)
	Delivery	• ftp push • online pull
Coverage	Spatial	• global • each pixel (IFOV) has a ground resolution of 12 km at nadir
	Temporal	~100 minutes per orbit, 14 orbits per day

4 Product definition

This section provides summary information on file-size, file content, file formats, and file-names for the IASI-A and –B IASI "all-sky" temperature and humidity release 1 CDR.

4.1 Physical definition

The temperature (in K) and the specific humidity, also called atmospheric water vapour, (in kg/kg) are provided on the 137 hybrid sigma pressure levels of the ECMWF L137 grid (Figure 5, (ECMWF, 2014)). These levels follow the terrain near the surface and provide a smooth transition to pressure levels at higher altitude. The CDR contains also the 2-meter air surface temperature (in K) and humidity (in kg.kg) as well as the total column water-vapour content (TCWV, in mm). The TCWV is computed after integration of the atmospheric water-vapour profile. There are several associated quality indicators and flags to help the user filtering the data.

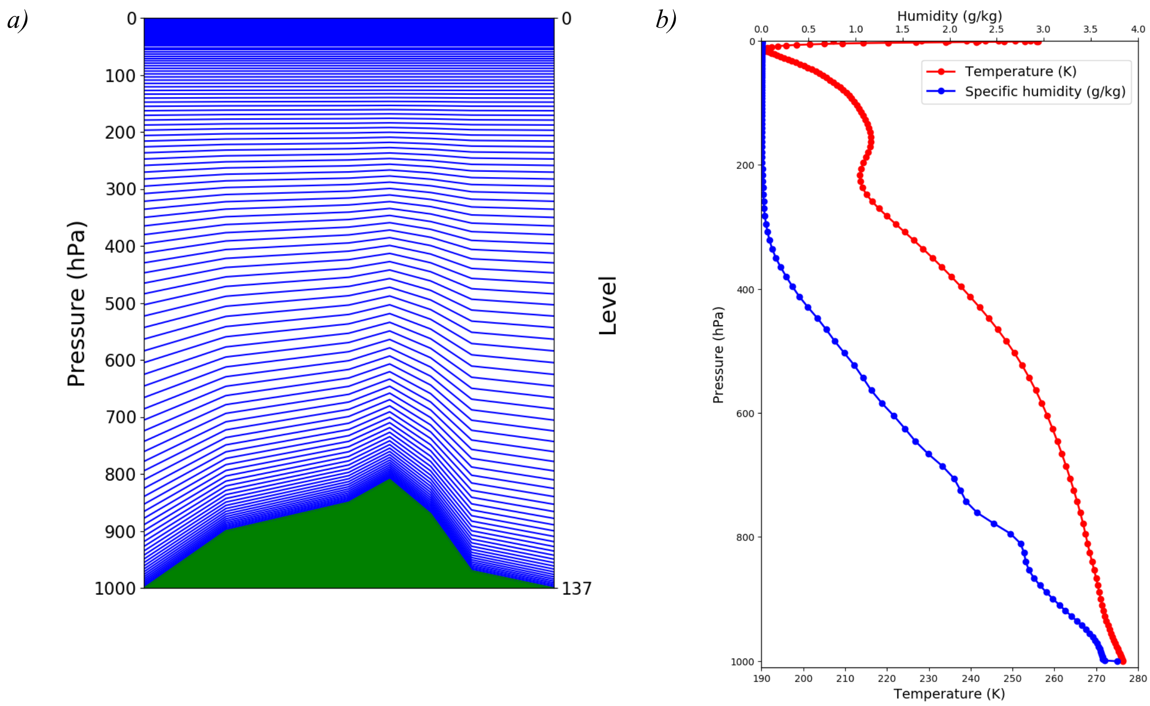


Figure 5: *a) 137 hybrid sigma pressure levels and b) an example of a temperature and humidity atmospheric profile at one particular location.*

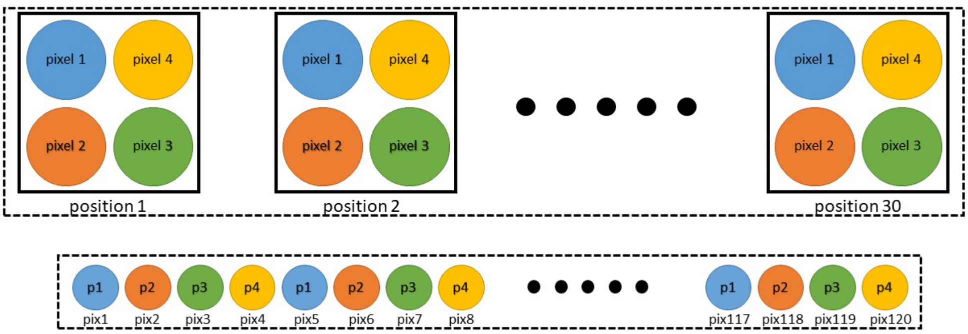


***Figure 6**: Idealised view of a pixel for each orbit scan line.*

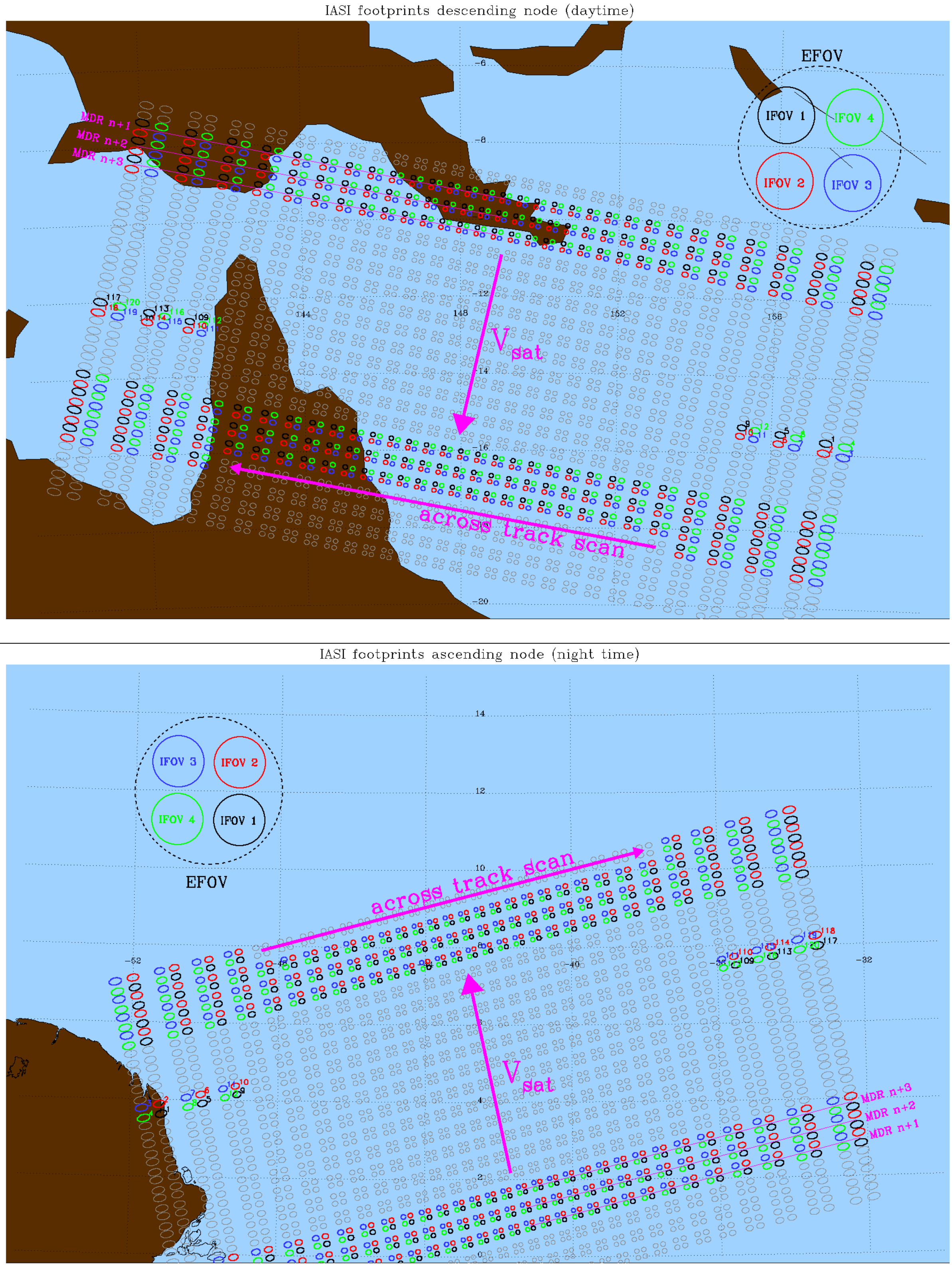


***Figure** 7: Example of location of IASI individual pixels for a descending orbit (top) and ascending orbit (bottom), note grey pixels are not coloured for clarity reasons, otherwise have the same content as the coloured pixels. Figures from: IASI_PW3_02_M02_20190126230859Z_20190126231154Z*

The data are provided in orbits. Each orbit file contains a similar number of scan lines. The scan starts on the left side with respect to the flight direction of the spacecraft (Figure 7). Each scan line has 30 measuring positions with four pixels (IFOV) each, leading to 120 pixels on each scan line (Figure 6). Each pixel is about 12 km size at nadir. More information can be found in (EUMETSAT, 2017).

4.2 Data files content and organisation

Each file contains data from one full IASI dump (Svalbard to Svalbard). Each line contains 120 pixels. Each orbit contains data acquired during the ascending and descending node for the satellite.
Everyday has about 14 orbits, which allows an almost complete coverage of the Earth twice a day (Figure 8).

4.2.1 Time

The time of each line can be computed using the two variables *SensingTime_day* and *SensingTime_msec*. For each line, these two variables provide respectively the sensing date (in days since the 01/01/2000) and the sensing time in the sensing date (in milliseconds). An example of sensing time computation code is presented in the Table 1. A variable *SensingTime* has been added giving the time in milliseconds since the 1st of January 1970.

Table 1: *Extraction of a python script computing the time for each line.*

```
Compute the time:
timed = get_var(nc,'SensingTime_day',0)
times = get_var(nc,'SensingTime_msec',0)
td    = np.array(timed)
ts    = np.array(times)
r     = datetime.timedelta(milliseconds=np.float(ts[index]))
ref   = datetime.datetime(2000,1,1,0,0,0,0)+
        datetime.timedelta(float(td[index]))+r
```

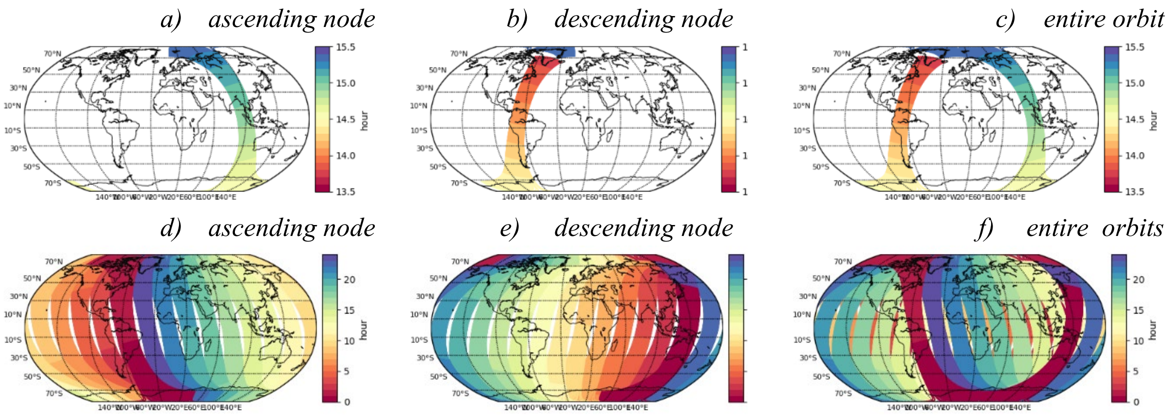


Figure 8: *Example of the acquisition time (in hours) on the 1st of January 2008.*

4.2.2 Geolocation and geometry

Geolocation and geometry information for each IASI pixel are available. Geolocation is stored in the variables *Latitude* and *Longitude* while the geometry angles can be found in the four variables *SatAzimuth* (Satellite Azimuth angle), *SatZenith* (Satellite Zenith angle), *SunAzimuth* (Solar Azimuth angle) and *SunZenith* (Solar Zenith angle).

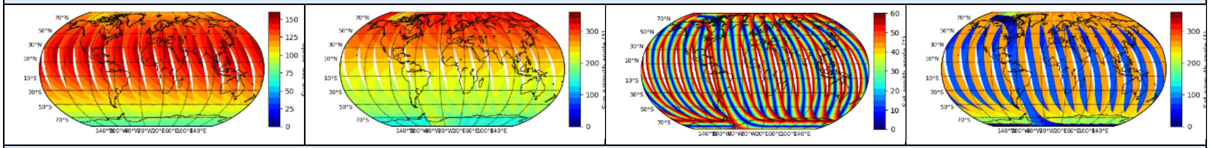
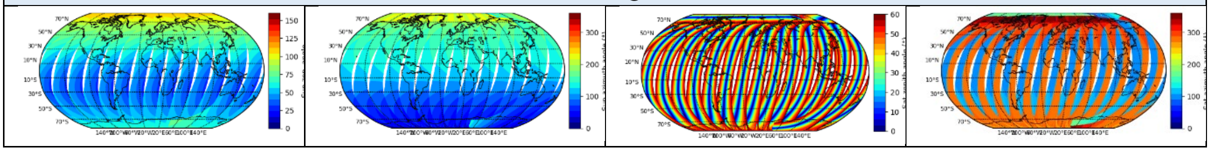
Solar zenith angle	Solar azimuth angle	Satellite zenith angle	Satellite azimuth angle
Ascending node			
			
Descending node			
			

Figure 9: *IASI-A solar and satellite zenith and azimuth angles for ascending and descending part of the orbit for the 1^{st} of January 2008.*

4.2.3 Vertical grid

For each pixel, the pressure grid associated to the atmospheric profile products (temperature and humidity) is stored in the variable *P*. The units is hPa. The variable contains the 137 pressure levels of the grid. The 138^{th} level stores the PWLR[3] retrieval of the surface pressure used to build the 137 hybrid levels of the pressure grid and is equivalent to the 2m values. The ECMWF L137 pressure grid is described in (ECMWF, 2014).

The variable *QP* stores the uncertainty estimate of the surface pressure (in hPa).

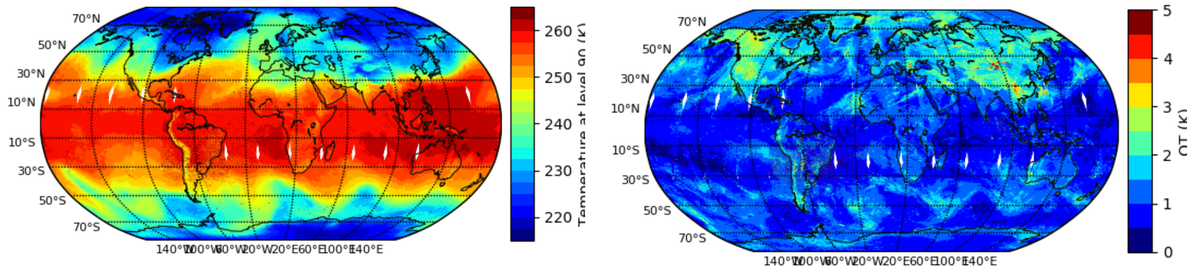
4.3 Variables

The CDR contains "all-sky" retrievals of temperature and specific humidity profiles as well as the surface temperature and the total column water vapour. Temperature and humidity associated quality indicators are also part of the product (see 4.4.1).

4.3.1 Atmospheric Temperature

The atmospheric temperature retrieval is stored in the variable *T*. The variable contains the 137 levels of the temperature profile, the last element (level 138) being the surface air temperature at 2 meters. The unit is in Kelvin (K).

The atmospheric temperature retrieval is provided with an uncertainty estimate, representative of the product precision in the lower troposphere, which is stored in the variable *QT*. The users can rely on this indicator to tailor data selection for their applications, depending on their requirements. A temperature retrieval with a quality indicator higher than 4 K is considered highly defective and is rejected in the near-real time operational IASI L2 processing.



a) Atmospheric Temperature (level 90) b) Atmospheric Temperature Quality Indicator

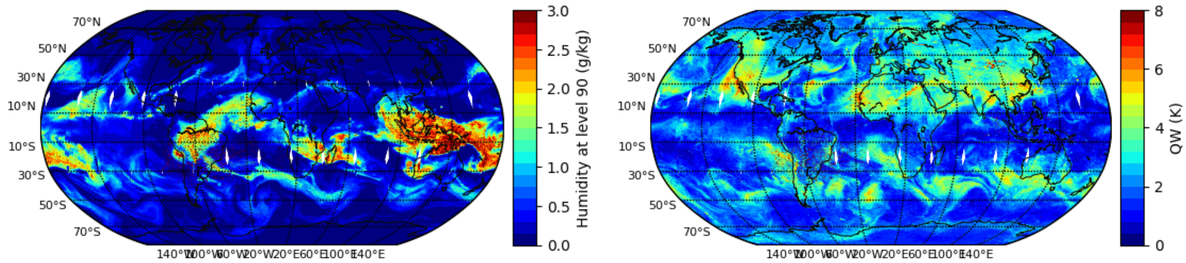
Figure 10: *Example of daily maps of a) Atmospheric Temperature (level #90, see Figure 5a, about 400hPa) and b) Quality Indicator of the Atmospheric Temperature [Metop-A 2008/01/01]*

4.3.2 Atmospheric Water Vapour

The atmospheric water vapour retrieval is stored in the variable *W*. The variable contains the 137 levels of the water vapour profile, the last element being the surface air water vapour content. The unit is kg/kg.

Similarly to temperature, the atmospheric water vapour retrievals are provided with associated uncertainty estimate, representative of the product precision in the lower troposphere, which is stored in the variable *QW*. The uncertainties are expressed in dew point temperature, in Kelvin (K). This water vapour uncertainty estimate can be used to select the retrievals with the quality required by the users for their applications. A water vapour retrieval with a quality indicator higher than 12 K is considered highly defective and is rejected in the near-real time operational IASI L2 processing.

The variable *WC* contains the water vapour total column. It corresponds to the integration of the 137 levels of the water vapour profile. It is provided in mm (which is equivalent to total column in kg/m^2).



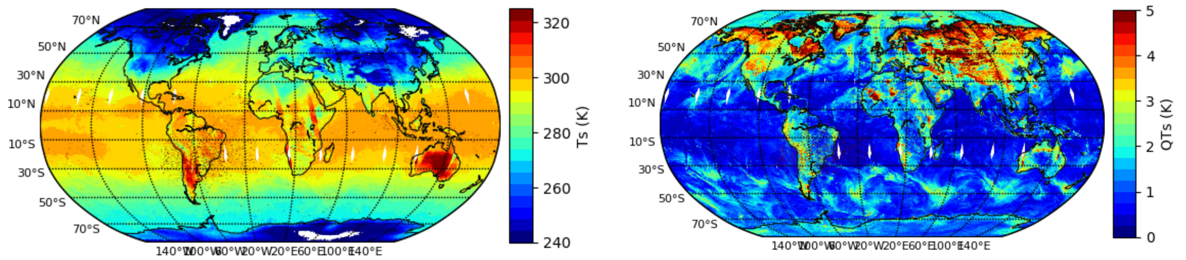
a) Atmospheric Humidity (level 90) b) Atmospheric Humidity Quality Indicator

Figure 11: *Example of daily maps of a) Atmospheric Humidity (level #90, see Figure 5a, about 400hPa) and b) Quality Indicator of the Atmospheric Humidity [Metop-A 2008/01/01]*

4.3.3 Surface Temperature

The surface temperature retrieval is stored in the variable *Ts*. The unit is Kelvin (K).

The surface temperature retrieval is provided with associated uncertainty estimate, which can be found in the variable *QTs*. This temperature uncertainty estimate can be used to select the retrievals with the quality required by the users for their applications. A surface temperature retrieval with a quality indicator higher than 5 K is considered highly defective and is rejected in the near-real time operational IASI L2 processing.



a) Surface Temperature

b) Surface Temperature Quality Indicator

***Figure 12:** Example of daily maps of a) Surface Temperature and b) Quality Indicator of the Surface Temperature [Metop-A 2008/01/01]*

4.4 Processing flags and quality information

Some additional variables providing information about the quality and the availability of the IASI L2 inputs and processing are available.

4.4.1 Uncertainty estimates

Each retrieved quantity is provided with a quality indicator (QI), which relates to corresponding retrieval uncertainty estimates. It is stored in the variables *QT*, *QW* and *QTs* for atmospheric temperature, atmospheric humidity and skin surface temperature, respectively.

Like the retrieved quantities themselves, the uncertainty estimates are also derived by regression from the measurements. In the training phase, a first regression is performed between the satellite observations and the geophysical quantities of the training set. A second regression is then performed to infer the absolute difference between the training set and the retrieved geophysical quantities resulting from the first training.

In the case of atmospheric profiles, the quality indicators reflects the average of the predicted uncertainties at the surface air level and in the mid-troposphere. They are provided in K for temperature and for humidity (dew Point). The quality indicator for surface temperature QTs provides a direct uncertainty estimate of the surface skin temperature, in Kelvin. The full description of the QIs calculation can be found in (EUMETSAT, 2020c), section 3.6.2.4.

Figure 13 illustrates the significance of the quality indicator for temperature profiles retrieved in the IRON (left) and MWIR (right) modes as assessed against radiosondes. It also illustrates the yield in both retrieval modes for different quality ranges: black (<0.75 K) – blue (0.75-1 K) – green (1-1.5 K) – yellow (1.5-2 K) -red (>2 K) bar histograms. Better retrievals are usually achieved for cloud-free pixels. A temperature retrieval with a quality indicator higher than 4 K is considered highly defective and is rejected in the near-real time operational IASI L2 processing.

These statistics were obtained with the IASI L2 operational products and with IR-only retrievals especially generated for the purpose of this sensitivity study (the present TCDR nominally exploits the MWIR synergy). They were generated with the same algorithm version as used for this climate dataset.

The figure is meant as an information to the users of how to use the quality indicator in this IASI L2 TCDR in relation to the desired yield and precision range.

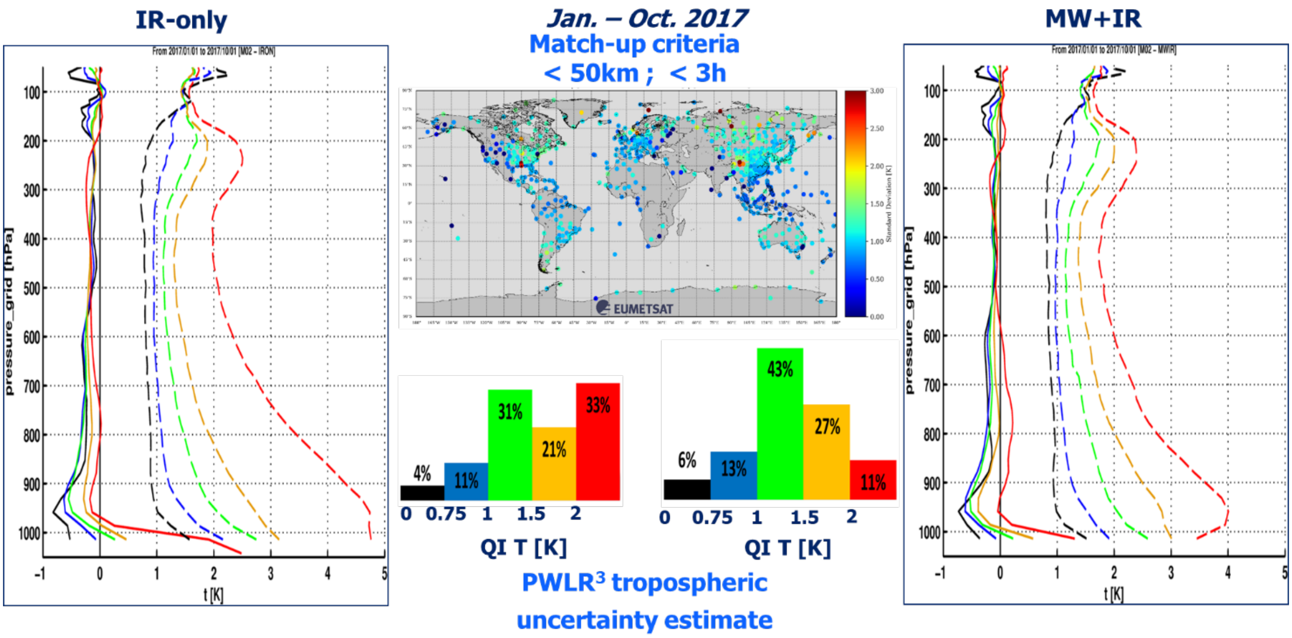


Figure 13: *Temperature retrieval yield and precision in the IRON and MWIR modes stratified against the quality indicator (uncertainty estimate), assessed through 2017 with radiosonde measurement pre-processed in the NOAA Integrated Global Radiosonde Archive (IGRA). Solid lines are the bias and dash lines are the standard deviations. The colours represent data for several QI T ranges.*

4.4.2 FLG_IASIBAD

The flag *flg_iasibad* provides information about the availability and quality of the IASI L1C data. It is described in the Table 2.

Table 2: *FLG_IASIBAD Enumeration Key*

Value	*Meaning*
0	The IASI measurements and side information are available and of good quality for L2 processing
1	The IASI L1c products are of degraded quality according to IASI L1c flags, no L2 processing.
2	Quality control indicates that the IASI L1c data are of degraded quality (not indicated by the IASI L1c flags), no L2 processing.

4.4.3 FLG_AMSUBAD

The flag *flg_amsubad* provides information about the availability and quality of the AMSU-A L1B data. It is described in the Table 3.

Table 3: *FLG_AMSUBAD Enumeration Key*

Value	*Meaning*
0	The expected AMSU-A measurements are available, of good quality and collocated with IASI for processing.
1	AMSU-A data are available but of degraded quality (according to AMSU-A L1 flags or QC tests) and not used for processing.
2	No coincident (time and space) AMSU-A measurements available for processing.

4.4.4 FLG_MHSBAD

The flag *flg_mhsbad* provides information about the availability and quality of the MHS L1B data. It is described in the Table 4.

Table 4: *FLG_MHSBAD Enumeration Key*

Value	*Meaning*
0	The expected MHS measurements are available, of good quality and collocated with IASI for processing.
1	MHS data are available but of degraded quality (according to MHS L1 flags or QC tests) and not used for processing.
2	No coincident (time and space) MHS measurements available for processing.

4.4.5 FLG_INITIA

The flag *flg_initia* indicates the measurements used in PWLR[3] retrieval and hence the PWLR[3] retrieval mode that has been used for the processing of this pixel (see section 2.3). It is described in Table 5. Most commonly used are Infra-Red Only (IRON), with bit 1 set to 1, translating to a 1 and Micro-Wave Infra-Red (MWIR), with bits 1 to 3 set to 1, translating to a bit value of 7.

Table 5: *Bitfield enumeration FLG_INITIA*

Bit number and Value	*Meaning*
0 (all Bits set to 0)	Default value, no PWLR[3] retrieval
Bit 1 = 1	IASI included
Bit 2 = 1	AMSU-A included
Bit 3 = 1	MHS included
Bit 4-8	Spare

4.4.6 OmC: Observation minus Calculation

The variable *OmC* provides the PWLR[3] prediction of the IASI observation-calculation assuming clear-sky in selected window channels (Figure 14a). This variable relates to the cloud signal and can be used as a first order cloud filtering. Retrievals with an *OmC* value between -1 K and 1 K have a high probability to be clear pixels. The full description of OmC calculation can be found in (EUMETSAT, 2020c) section 3.6.2.3.

4.5 Auxiliary information

Additional auxiliary information are provided and described in the following sections.

4.5.1 AVHRR L1B Cloud Fraction

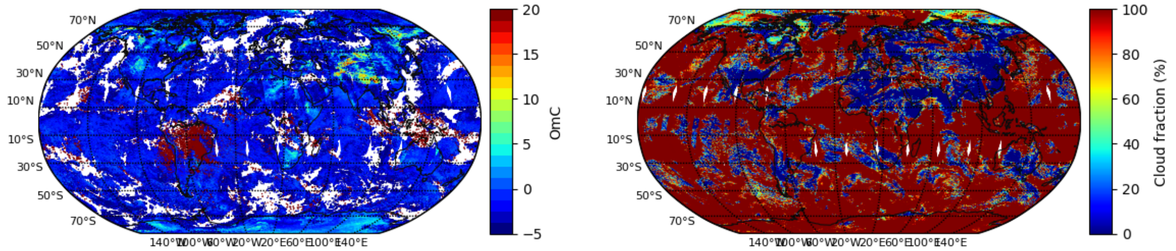
The variable *CloudFraction* provides the cloud mask coming from the AVHRR L1B cloud mask integrated within the IASI field of view. It is a direct copy from the information provided in the IASI L1C products. It varies between 0% (clear) and 100% (fully cloudy).

4.5.2 Elevation

The variables *Height* and *HeightStd* respectively provide the mean and the standard deviation of the elevation within the IASI field of view, in meters.

4.5.3 Land Fraction

The variable *LandFraction* provides the ratio of land surface in the IASI field of view. It varies between 0% (water only) and 100% (land only)



a) Obs minus Calc (OmC) b) AVHRR Cloud fraction

Figure 14: *Example of daily maps of a) Observation minus Calculation and b) AVHRR Cloud fraction [Metop-A 2008/01/01]*

4.6 Period coverage

The data record covers the periods listed in Table 6**Error! Reference source not found.**.

Table 6: Temporal coverage of the IASI L2 climate data record per satellite.

Satellite	Start Date	End Date
Metop-A – IASI	10.07.2007	31.12.2018
Metop-B – IASI	20.02.2013	31.12.2018

A detailed list of missing input data is available in the Appendix. Table 7 lists the number of days with missing orbits per instruments.

Table 7: *Number of days with missing orbits per satellite and instrument*

Instrument	Days with missing orbits
IASI – Metop-A	138
IASI – Metop-B	42
AMSU-A – Metop-A	47
AMSU-A – Metop-B	5
MHS – Metop-A	108
MHS – Metop-B	8

Figure 15 shows the average global surface temperature retrieved in MWIR mode per day (green dots) for IASI on Metop-A from 2007 to end 2017. In addition, the percentage of missing data (no MWIR nor IRON retrieval available) is given in red. Most of the time, data are not available when the IASI instrument is performing maintenance activities (calibration, decontamination etc.). From the 26 of March to 22 of May 2014, the PWLR[3] had to run in IRON mode because of an outage of the MHS instrument.

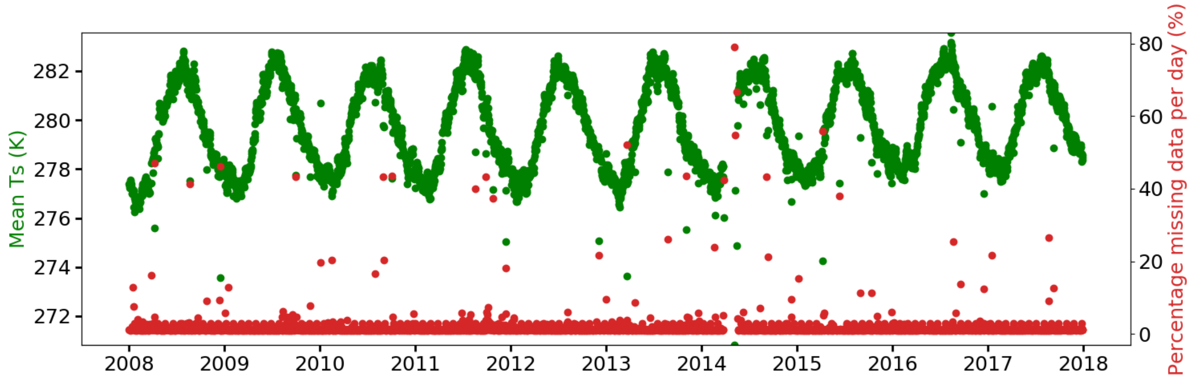


Figure 15: *Example of a global IASI-A daily averaged surface temperature (K) in green. Red dots represent the percentage of missing data for a specific day. Ts is obtained using PWRL[3].*

The daily averaged global profiles in MWIR mode over the entire period is shown in Figure 16 for IASI-A and Figure 17 for IASI-B, displaying the temperature and humidity profiles respectively.

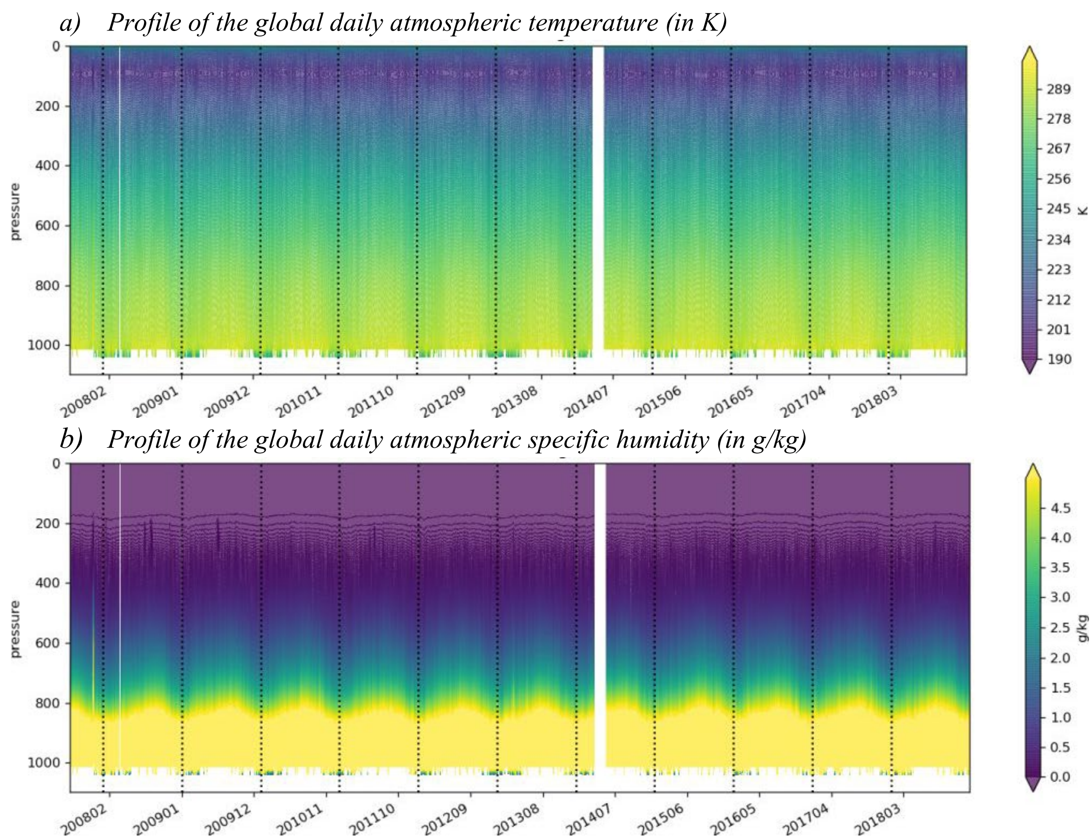
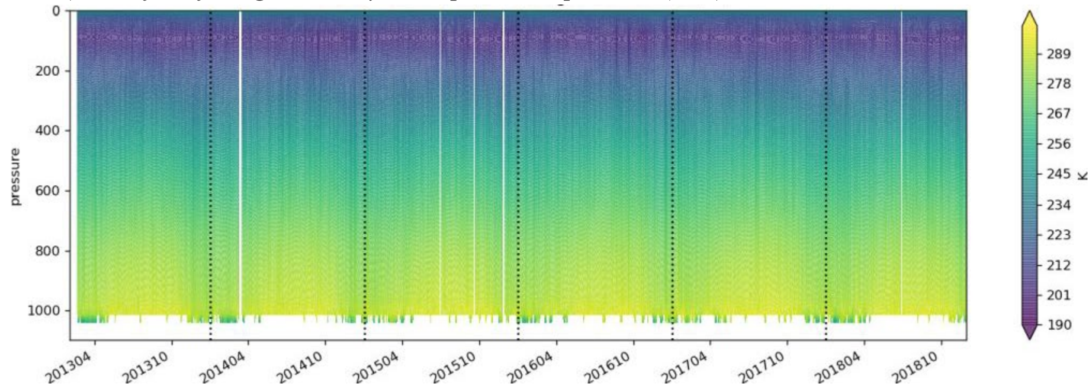


Figure 16: *Hovmoeller plots of IASI-A temperature and specific humidity profiles, global daily average over the entire CDR range.*

a) Profile of the global daily atmospheric temperature (in K)



b) Profile of the global daily atmospheric specific humidity (in g/kg)

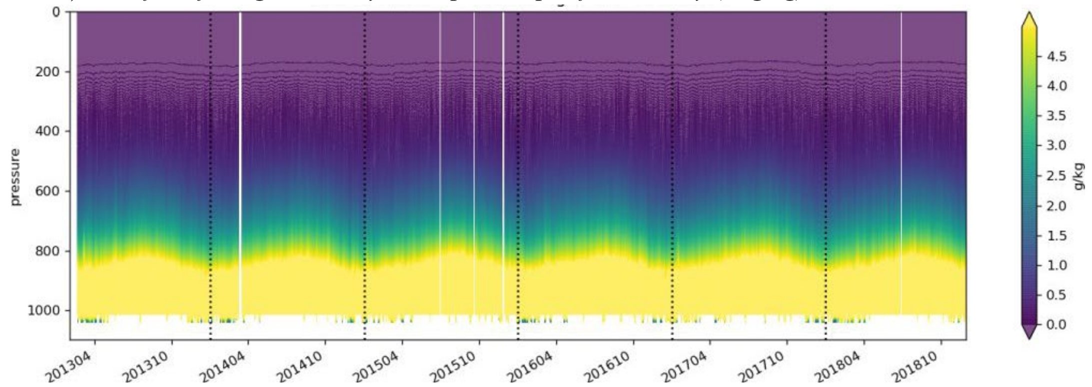


Figure 17: *Hovmoeller plots of IASI-B temperature and specific humidity profiles, global daily over the entire CDR range*

4.7 List of parameters available in the product

This section describes the files content.

4.7.1 Global attributes

Table 8: *Global attributes of each file*

Name	Description
`title`	IASI climate data record of temperature and humidity profiles retrieved using the all sky PWLR3 algorithm.
`creation_time`	File creation date as of yyyy-mm-ddThh:mm:ssZ
`creator_email`	ops@eumetsat.int
`creator_url`	www.eumetsat.int
`id`	DOI: 10.15770/EUM_SEC_CLM_0027
`institution`	EUMETSAT
`source`	Observational satellite observation: IASI + AMSU-A and MHS as input
`history`	Release 1
`references`	DOI: 10.15770/EUM_SEC_CLM_0027
`summary`	This is the first release of the all-sky temperature and humidity profiles climate data record and their associated quality parameters. This data record was processed using the operational EUMETSAT algorithm v6.5.4. It corresponds to the EARS-IASI L2 data. Each file contains one full IASI orbit (Svalbard to Svalbard).
`comment`	The input to the product is the IASI level 1C reprocessed product (doi:10.15770/EUM_SEC_CLM_001) for IASI on Metop-A (until January 2017) and the operational IASI level 1C product for IASI on Metop-B and for Metop-A after January 2017. Reprocessed and operational L1C inputs are homogeneous as produced with the same software version.
`instrument`	IASI
`platform`	Metop-A (or Metop-B)
`keywords`	IASI, level 2, profiles, temperature, specific humidity, atmospheric water vapour, surface temperature, water-vapour total column
`processing_level`	2
`processing_algorithm_version`	6.5.4
`product_version`	Release 1
`sensing_start_time`	yyyy-mm-ddThh:mm:ssZ
`sensing_stop_time`	yyyy-mm-ddThh:mm:ssZ
`cdr_start_time`	2007-07-10T07:23:58Z for Metop-A data 2013-02-20T03:56:55Z for Metop-B data first date of Metop-A or –B reprocessed data
`cdr_end_time`	2018-12-31T23:24 :00Z Metop-A 2018-12-31T22:47 :55Z Metop-B last date of Metop-A or –B reprocessed data
`processing_mode`	R
`disposition_mode`	O
`no_scalines`	Number of scanline in the orbit
`Conventions`	CF-1.9

4.7.2 Variables

There are 26 variables stored in the NetCDF file. They are listed in Table 9.

Table 9: *Content of the CDR files. One file per orbit. nlin is the number of scan lines per orbit. Second dimension is the number of pixels per line and third dimension is the number of vertical levels.*

Variable short name	Description	Dimension	Long name	Fill value	Range	Units
P	Pressure grid [137 atmospheric levels + surface pressure]	[nlin,**120**,**138**]	Pressure	3.4028235e+38	[0; 1150]	hPa
Ps	Surface pressure	[nlin,**120**]	Surface Pressure	3.4028235e+38	[0; 1150]	hPa
Ts	Surface temperature	[nlin,**120**]	Surface temperature (FG_SURFACE_TEMPERAURE)	3.4028235e+38	[100;400]	K
T	Temperature profile [137 atmospheric levels + surface air (2m)]	[nlin,**120**,**138**]	Temperature profile (FG_ATMOSPHERIC_TEMPERATURE)	3.4028235e+38	[100;400]	K
WC	Water-vapour total column	[nlin,**120**]	Total column water vapour (FG_ INTEGRATED_WATER_VAPOUR)	3.4028235e+38	[0;300]	mm (corresponds to kg/m^2)
W	Atmospheric water-vapour profile [137 atmospheric levels + surface air (2m)]	[nlin,**120**,**138**]	Atmospheric water vapour profile (FG_ATMOSPHERIC_WATER_VAPOUR)	3.4028235e+38	[0,1]	kg/kg
QP	Quality indicator for surface pressure (~uncertainties in hPa)	[nlin,**120**]	Quality indicator for the surface pressure	3.4028235e+38	[0,1000]	hPa

Variable short name	Description	Dimension	Long name	Fill value	Range	Units
QTs	Quality indicator for skin surface temperature (~uncertainties in K)	[nlin,**120**]	Quality indicator for surface temperature (FG_QI_SURFACE_TEMPERATURE)	3.4028235e+38	[0;400]	K
QT	Quality indicator for temperature (~uncertainty estimates of surface air temperature in K)	[nlin,**120**]	Quality indicator for temperature (FG_QI_ATMOSPHERIC_TEMPERATURE)	3.4028235e+38	[0;400]	K
QW	Quality indicator for water-vapour (~uncertainty estimates of surface air water-vapour, for humidity expressed in Dew point temperature)	[nlin,**120**]	Quality indicator for water vapour (FG_QI_ATMOSPHERIC_WATER_VAPOUR)	3.4028235e+38	[0,300]	K
FLG_IASIBAD	Availability and quality of IASI L1 measurements 0=The IASI measurements and side information are available and of good quality for L2 processing 1=The IASI L1c products are of degraded quality according to IASI L1c flags, no L2 processing 2=Quality control indicates that the IASI L1c data are of degraded quality (not indicated by the IASI L1c flags), no L2 processing	[nlin,**120**]	IASI quality flag	3.4028235e+38	[0;2]	N/A
FLG_AMSUBAD	0=The expected AMSU-A measurements are available, of good quality and	[nlin,**30**]	AMSU-A quality flag	3.4028235e+38	[0;2]	N/A

Variable short name	Description	Dimension	Long name	Fill value	Range	Units
	collocated with IASI for processing 1=AMSU-A data are available but of degraded quality (according to AMSU-A L1 flags or QC tests) and not used for processing 2=No coincident (time and space) AMSU-A measurements available for processing					
FLG_MHSBAD	0=The expected MHS measurements are available, of good quality and collocated with IASI for processing. 1=MHS data are available but of degraded quality (according to MHS L1 flags or QC tests) and not used for processing 2=No coincident (time and space) MHS measurements available for processing	[nlin,**120**]	MHS quality flag	3.4028235e+38	[0;2]	N/A
FLG_INITIA	Bit field indicates the measurements used in the PWLR3 retrieval. 0 (all Bits set to 0) = Default value, no PWLR3 retrieval Bit 1 = 1 IASI included Bit 2 = 1 AMSU-A included Bit 3 = 1 MHS included	[nlin]	Measurement used for FG retrieval	3.4028235e+38	[0; 7]	N/A
OmC	Cloud signal (radiative impact of cloud). Predicted	[nlin,**120**]	OBS minus CALC parameter	3.4028235e+38	[-200; 100]	K

Variable short name	Description	Dimension	Long name	Fill value	Range	Units
	OBS-CALC assuming clear-sky [K] averaged over a few selected window channel					
Latitude	Latitude of the pixel centre	[nlin,**120**]	Latitude	3.4028235e+38	[-90; 90] N>0	degrees
Longitude	Longitude of the pixel centre	[nlin,**120**]	Longitude	3.4028235e+38	[-180; 180] E>0	degrees
SatAzimuth	Satellite azimuth angle	[nlin,**120**]	Satellite azimuth angle	3.4028235e+38	[0; 360]	degrees
SatZenith	Satellite zenith angle	[nlin,**120**]	Satellite zenith angle	3.4028235e+38	[0; 90]	degrees
SunAzimuth	Solar azimuth angle	[nlin,**120**]	Solar azimuth angle	3.4028235e+38	[0; 360]	degrees
SunZenith	Solar zenith angle	[nlin,**120**]	Solar zenith angle	3.4028235e+38	[0; 180]	degrees
SensingTime_day	Sensing date, day since 01 January 2000	[nlin]	Sensing date in days since 1st January 2000	3.4028235e+38	[2747; 6939]	day since 1/1/2000
SensingTime_msec	Sensing time in milliseconds in the sensing date	[nlin]	Sensing time in milliseconds in the sensing date	3.4028235e+38	[0; 8,64e+7]	milliseconds
SensingTime	Sensing time in milliseconds since the 1st of January 2000	[nlin]	Sensing time of the scanline in milliseconds since 1st January 2000	3.4028235e+38	[189388800000; 631152000000]	milliseconds
Height	average surface elevation within the field of view	[nlin,**120**]	Surface elevation (SURFACE_Z)	3.4028235e+38	[0; 10000]	meters
HeightStd	stddev of the elevation within the field of view	[nlin***120**]	Standard deviation of the surface elevation (STD_SURFACE_Z)	3.4028235e+38	[0,10000]	meters

Variable short name	Description	Dimension	Long name	Fill value	Range	Units
LandFraction	land fraction as computed with AVHRR collocated data (copied across from IASI L1C)	[nlin,**120**]	Land fraction	3.4028235e+38	[0; 100]	%
CloudFraction	integrated cloud fraction from AVHRR	[nlin,**120**]	AVHRR cloud fraction	3.4028235e+38	[0; 100]	%

4.8 Data and file name format description

Reprocessed files can be identified by their filenames for which the processing mode is set to ***R***. A reprocessed IASI level 2 filename follows the convention:

Table 10: *IASI filename description*

Convention	<instrument>_<product_type>_<processing_level>_<satellite>_<sensingstart>_<sensing_stop>_<processing_mode>_<disposition_mode>_<processing_time>_<reprocessing_baseline>
Product name	IASI_PW3_02_M02_20160130110852Z_20160130124756Z_R_O_20180216145847Z_0100.nc

4.9 Product generated

The reprocessing was done by EUMETSAT, using IASI L2 PPF version 6.5.4.

4.10 Format

The data record is produced and archived in NetCDF format.

5 Product validation summary

The present IASI L2 CDR (Release-1) consists of IASI-A and -B temperature and humidity profiles and surface parameters reprocessed for the period July 2007 to December 2018. The reprocessing was done using the IASI Level-2 PPF version 6.5.4. The IASI L1c data, used as input for this CDR, are homogeneous throughout the entire period as IASI L1c are retrieved using the same software version (IASI-A L1c for the earlier period until January 2017).

The three main purposes of the reprocessing of the level-2 IASI temperature and humidity profiles are to provide a dataset to the user community:

- of suitable quality for scientific studies;
- using the best and most up-to-date version of the operational algorithm;
- homogeneous and consistent throughout the time series.

This report demonstrates that both points were achieved. Comparison to radiosonde measurements pre-processed in the NOAA/IGRA project and ERA-Interim reanalysis outputs have been used to analyse the quality of the IASI temperature and humidity profiles.

The temperature and humidity profiles retrieved using IASI flying on board Metop-A (IASI-A) and Metop-B (IASI-B) show very similar performance when compared to other measurements and reanalysis outputs. However, systematic deviations between IASI-A and -B appear mainly for ascending nodes over land and for cloudy situations. The cause for this difference is not fully understood, and it requires further study before the next reprocessing.

The precision of global averaged temperature profiles lies within 1 K for most of the troposphere, which is consistent with the requirements expressed in the EUMETSAT polar system end-users requirements document (EUMETSAT, 2017). Near the surface, the precision is slightly less, because of the reduced sensitivity and vertical resolution inherent to passive infrared sounding, especially when the thermal contrast between atmospheric layers and surface is low.

The precision of the humidity profiles in the lower troposphere typically varies between 1 to 1.5 g/kg depending on the actual moisture content and with seasonal and regional variations. The bias towards radiosondes shows negative values of up to 0.25 g/kg near the surface, turning to a same magnitude positive bias in the mid troposphere. The absolute errors are smaller in drier atmospheres, and vice versa. Best retrievals are usually achieved for cloud-free pixels, but the joint use of IASI with microwave observations enables useful retrievals in most cloudy scenes as well. A small bias of up to a few tenth of Kelvin is possible outside of the training period of the retrieval algorithm (2015 and 2016).

The profile retrievals are supplied with quality indicators, representative of the products uncertainty estimates in the lower troposphere, which can be used for quality control and data selection depending on the yield and precision required by the user's applications.

The validation against radiosondes shows in particular:

- A long-term and very stable agreement with the IGRA data;
- Only minor seasonal differences;

- The overall temperature and humidity bias are small throughout the whole atmosphere (lower than 0.25g/kg for humidity and 1K for temperature);
- Trends in the differences throughout the time series are not visible neither for temperature nor for humidity.

The comparison against ERA-Interim shows in particular:

- A stable time series without significant changes but slight trends in the differences for temperature or humidity;
- An overall temperature bias well below 0.5K and a standard deviation around 1K throughout the troposphere;
- The humidity difference peaks near the boundary layer with values just below 0.5g/kg. Measurements in the high stratosphere strongly differ between IASI and ERA-Interim. IASI is much colder and dryer than the model but, at this atmospheric level, the bias can come either from the model or from the satellite measurement.
- IASI retrieves less humidity compared to ERA-Interim but this could be an artefact as no screening for clouds in ERA-Interim data was performed and only cloud free IASI pixel used;
- Some regions show a constant positive or negative bias in humidity and temperature, but overall the pattern of the bias distribution is changing over time;
- Regional structure of the difference behave distinctly depending of the height of the atmosphere and the season. Closer to the surface sea/land influences dominate. Higher up in the atmosphere, large-scale dynamics have more influence, e.g. the ITCZ.
- At some vertical levels, a small trend in the temperature bias can be observed outside of the training period of the retrieval algorithm (2015 and 2016). This could be due to the training set not being fully representative of the entire period as concerns the CO_2 signal, which is strongly entangled with the temperature information in the spectral measurements. The effect is small, of a couple of tenth of a Kelvin throughout the whole period. It is part of ongoing work on a future algorithm version to confirm and study this more in details.

6 Product ordering

Access to the data record is granted to all users without charge but accepting the EUMETSAT Data Policy provided in (EUMETSAT, 2020a) and the corresponding EUMETSAT webpage: *https://www.eumetsat.int/website/home/AboutUs/WhoWeAre/LegalFramework/DataPolicy/index.html*. To access data, you need to register with the EUMETSAT Data Centre. When registered, you can order the data through a written request send to EUMETSAT's helpdesk.

6.1 Register with the Data Centre

Do this to register with the EUMETSAT Data Centre:

1 Register in the EUMETSAT EO-Portal (*https://eoportal.eumetsat.int/*) by clicking on the New User – Create New Account tab;
2 After finalisation of the registration process, an e-mail is sent to the e-mail address entered in the registration. Click the confirmation link in the e-mail to activate your account;
3 Login and subscribe to the Data Centre Service by going to the Service Subscription Tab and selecting Data Centre Service. Follow instructions issued from the web page to add needed information.

6.2 Order Data

The data record described in this product user guide can also be ordered via the EUMETSAT User Service Helpdesk in Darmstadt, Germany. Please send a written request to the helpdesk, email *ops@eumetsat.int,* indicating the data record that you want to order including its Digital Object Identifier (DOI) number: *10.15770/EUM_SEC_CLM_0027.*

7 Product support and feedback

For enquiries about the Metop-A and -B IASI temperature and humidity CDR described in this product user guide, please contact the EUMETSAT User Service Helpdesk by email: *ops@eumetsat.int.*

8 Product referencing

The data record described in this product user guide has a unique DOI that should be used for referencing. The product's filename provide a unique identifier for each product, which is also given in the *id* global attribute.

APPENDIX A LIST OF MISSING ORBITS

In this appendix, we list the days with missing input data. In Table 11 and Table 12, the days with the respective number of missing IASI orbits are listed. Number of missing orbits per day for AMSU-A and MHS are listed in Table 13 to Table 16.

Note that all throughout its lifetime, the IASI instrument is automatically calibrated and closely monitored. Every 29 days, the instrument is set to a *special* mode for a 4-hour duration, called external calibration mode, to achieve an in-depth monitoring of the exact same scene. No data are available to the users during these periods.

Table 11: Missing orbits per day for IASI-A

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2007-05-29	2	2008-05-11	1	2013-11-06	14
2007-06-05	1	2008-07-22	1	2013-11-07	14
2007-06-08	1	2008-07-30	1	2013-11-08	4
2007-06-13	8	2008-08-06	1	2013-11-12	3
2007-06-14	9	2008-10-23	3	2013-11-23	1
2007-06-19	3	2008-12-09	2	2014-02-18	8
2007-06-21	1	2008-12-10	14	2014-02-19	14
2007-06-24	1	2008-12-11	14	2014-02-20	14
2007-06-28	1	2008-12-12	6	2014-02-21	4
2007-06-29	1	2008-12-30	14	2014-03-26	2
2007-06-30	1	2008-12-31	14	2014-04-09	3
2007-07-03	3	2009-01-01	14	2014-05-12	1
2007-07-04	1	2009-01-02	5	2014-06-02	1
2007-07-09	1	2009-03-08	2	2014-06-10	1
2007-07-20	11	2009-06-24	1	2014-09-08	10
2007-07-21	7	2009-08-10	1	2014-09-09	14
2007-07-22	1	2009-08-26	1	2014-09-10	14
2007-08-26	1	2009-09-07	4	2014-09-11	14
2007-09-17	11	2009-09-08	4	2014-09-12	14
2007-09-18	14	2009-09-09	1	2014-09-13	8
2007-09-19	14	2009-09-11	2	2014-12-10	1
2007-09-20	7	2009-09-17	3	2015-04-09	11
2007-10-15	2	2009-09-30	10	2015-04-10	14
2007-10-29	1	2009-10-01	14	2015-04-11	14
2007-11-01	4	2009-10-02	4	2015-04-12	14
2007-11-08	5	2009-10-30	1	2015-04-13	4
2007-11-15	1	2009-11-23	1	2015-06-12	9
2007-11-16	2	2009-11-28	1	2015-07-12	1
2007-11-18	13	2010-03-19	1	2015-09-02	1
2007-11-19	14	2010-03-20	3	2015-09-12	1
2007-11-20	14	2010-08-30	11	2015-10-14	3
2007-11-21	14	2010-08-31	14	2015-10-15	1

2007-11-22	6	2010-09-01	14	2015-11-04	3
2008-01-14	1	2010-09-02	14	2016-04-15	1
2008-01-16	7	2010-09-03	14	2016-04-16	1
2008-01-17	14	2010-09-04	7	2016-07-26	1
2008-01-18	14	2010-10-05	10	2016-08-31	3
2008-01-19	4	2010-10-06	4	2016-12-03	3
2008-01-29	1	2011-07-25	1	2017-01-26	1
2008-02-04	2	2011-08-18	6	2017-01-30	1
2008-03-08	1	2011-09-28	10	2017-02-25	1
2008-03-19	2	2011-09-29	3	2017-05-13	1
2008-03-20	14	2011-10-22	1	2017-05-14	2
2008-03-21	14	2011-10-23	14	2017-08-22	8
2008-03-22	14	2011-10-24	14	2017-08-23	6
2008-03-23	14	2011-10-25	9	2017-08-28	1
2008-03-24	14	2013-03-20	10	2018-02-06	2
2008-03-25	14	2013-03-21	3	2018-06-30	1
2008-03-26	7	2013-06-17	1	2018-11-09	1
2008-04-08	10	2013-10-06	1	2018-11-10	1
2008-04-09	3	2013-11-05	10		

Table 12: Number of missing orbits per day for IASI-B

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2013-02-20	2	2014-06-21	7	2015-11-30	6
2013-03-18	1	2014-10-08	2	2016-03-16	3
2013-10-29	2	2014-10-22	3	2016-04-27	3
2013-11-05	3	2015-06-30	9	2017-09-13	3
2014-03-10	9	2015-07-01	14	2018-04-24	1
2014-03-11	14	2015-07-02	7	2018-05-23	5
2014-03-12	14	2015-10-15	2	2018-06-27	10
2014-03-13	14	2015-11-11	2	2018-06-28	14
2014-03-14	14	2015-11-12	8	2018-06-29	14
2014-03-15	14	2015-11-25	10	2018-06-30	14
2014-03-16	14	2015-11-26	14	2018-07-01	14
2014-03-17	5	2015-11-27	14	2018-07-02	4
2014-03-26	1	2015-11-28	14	2018-09-19	3
2014-06-20	7	2015-11-29	14	2018-10-31	2

Table 13: Number of missing orbits per day for AMSU-A on Metop-A

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2007-07-22	1	2008-07-30	1	2015-07-12	1
2007-08-26	1	2008-12-31	1	2015-09-02	1
2007-09-17	11	2009-03-08	1	2015-09-12	1
2007-09-18	14	2009-06-24	1	2015-10-15	1

2007-09-19	6	2009-11-23	1	2016-04-15	1
2007-10-15	2	2009-11-28	1	2016-04-16	1
2007-10-29	1	2010-03-19	1	2016-07-26	1
2007-11-15	1	2010-03-20	2	2016-12-03	3
2007-11-16	1	2011-10-22	1	2017-01-26	1
2008-01-14	1	2011-10-23	8	2017-01-30	1
2008-01-16	6	2013-06-17	1	2017-02-25	1
2008-01-17	10	2013-11-12	2	2017-05-13	1
2008-01-29	1	2014-03-26	1	2017-05-14	1
2008-03-08	1	2014-05-12	1	2017-08-28	1
2008-03-19	2	2014-06-02	1	2018-07-11	1
2008-03-20	12	2014-06-10	1	2018-11-09	1

Table 14: Number of missing orbits per day for AMSU-A on Metop-B

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2012-12-13	2	2013-10-29	2	2015-10-15	1
2013-03-18	1	2014-03-26	1		

Table 15: Number of missing orbits per day for MHS on Metop-A

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2007-07-22	1	2014-04-02	14	2014-05-10	14
2007-08-26	1	2014-04-03	14	2014-05-11	14
2007-09-17	11	2014-04-04	14	2014-05-12	14
2007-09-18	14	2014-04-05	14	2014-05-13	14
2007-09-19	5	2014-04-06	14	2014-05-14	14
2007-10-15	2	2014-04-07	14	2014-05-15	14
2007-10-29	1	2014-04-08	14	2014-05-16	14
2007-11-15	1	2014-04-09	14	2014-05-17	14
2007-11-16	1	2014-04-10	14	2014-05-18	14
2008-01-14	1	2014-04-11	14	2014-05-19	14
2008-01-16	6	2014-04-12	14	2014-05-20	14
2008-01-17	10	2014-04-14	14	2014-06-02	1
2008-01-29	1	2014-04-15	14	2014-06-10	1
2008-03-08	1	2014-04-16	14	2015-07-12	1
2008-03-19	2	2014-04-17	14	2015-07-16	1
2008-03-20	14	2014-04-18	14	2015-09-02	1
2008-03-21	14	2014-04-19	14	2015-09-12	1
2008-03-22	8	2014-04-20	14	2015-10-15	1
2008-07-30	1	2014-04-21	14	2016-04-15	1
2008-12-31	1	2014-04-22	14	2016-04-16	1

2009-03-08	1	2014-04-23	14	2016-07-26	1
2009-06-24	1	2014-04-24	14	2016-12-03	3
2009-11-23	1	2014-04-25	14	2017-01-03	1
2009-11-28	1	2014-04-26	14	2017-01-26	1
2010-03-19	1	2014-04-27	14	2017-01-30	1
2010-03-20	3	2014-04-28	14	2017-02-25	1
2011-10-22	1	2014-04-29	14	2017-05-13	1
2011-10-23	10	2014-04-30	14	2017-05-14	2
2013-06-17	1	2014-05-01	14	2017-05-22	1
2013-11-12	3	2014-05-02	14	2017-08-28	1
2014-03-26	1	2014-05-03	14	2018-07-11	1
2014-03-27	9	2014-05-04	14	2018-11-09	1
2014-03-28	14	2014-05-05	14	2018-11-10	1
2014-03-29	14	2014-05-06	14	2019-01-16	1
2014-03-30	14	2014-05-07	14	2019-03-12	2
2014-03-31	14	2014-05-08	14	2019-06-06	2
2014-04-01	14	2014-05-09	14	2019-07-30	4

Table 16: Number of missing orbits per day for MHS on Metop-B

Date	Missing orbits	Date	Missing orbits	Date	Missing orbits
2013-03-18	1	2015-09-18	13	2015-09-21	7
2013-10-29	2	2015-09-19	14	2015-10-15	2
2014-03-26	1	2015-09-20	14		