EUMETSAT NWC SAF
SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING

# User Manual for the "Automatic Satellite Image Interpretation – Next Generation" Processors of the NWC/GEO: Science Part

NWC/CDOP3/MTG/ZAMG/SCI/UM/ASII-NG, Issue 1.2.0

*31 March 2025*

*Applicable to*

*GEO-ASII-NG-v3.0 (NWC-049)*

*which is comprised of*

*GEO-ASII-TF-v3.0*

*GEO-ASII-GW-v2.0*

*GEO-ASII-ICE-v1.0*

**Prepared by GeoSphere Austria**

## REPORT SIGNATURE TABLE

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## DOCUMENT CHANGE RECORD

| Version | Date | Pages | CHANGE(S) |
|---|---|---|---|
| 1.0 | 13 November 2020 | 22 | First version. |
| 1.1 | 3 February 2023 | 23 | Update for ORR: New organization name and logo; inclusion of new validation reference; changes in output variables' names. |
| 1.2.0 | *31 March 2025* | 21 | Minor editorial changes and inclusion of latest validation report, for first MTG-I1 release |

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# 1. INTRODUCTION

The EUMETSAT "Satellite Application Facilities" (SAF) are dedicated centres of excellence for processing satellite data, and form an integral part of the distributed EUMETSAT Application Ground Segment (http://www.eumetsat.int). This documentation is provided by the SAF on Support to Nowcasting and Very Short Range Forecasting, NWCSAF. The main objective of NWCSAF is to provide, further develop and maintain software packages to be used for Nowcasting applications of operational meteorological satellite data by National Meteorological Services. More information can be found at the NWCSAF webpage, http://nwc-saf.eumetsat.int. This document is applicable to the NWCSAF processing package for geostationary satellites, NWC/GEO.

## 1.1 SCOPE OF THE DOCUMENT

This document is the User Manual for the "Automatic Satellite Image Interpretation – Next Generation" Product (PGE17 of the NWC/GEO software).

This document contains practical information for the daily use of the products. This document is intended for the meteorologist giving some principal information on the abilities and limitation of the product output.

## 1.2 SCOPE OF OTHER DOCUMENTS

The algorithms used in this software are described in the Algorithm Theoretical Basis Document [RD.3].

Details of input and output data format of the products are also described in the Interface Control Documents [AD.8] and [AD.9] for the External and Internal Interfaces of the NWC/GEO and in the Output Product Format Definition [AD.10].

The general architecture of the software (interface with the NWCSAF software, architecture of the PGE) is described in the Architectural Design Document [AD.6].

The product generator elements are described in the corresponding Software Component and Version Description.

Instructions how to install, configure and execute the NWC/GEO software in order to extract the Automatic Satellite Image Interpretation – Next Generation Products (PGE17) are detailed in the NWC/GEO Software User Manual.

The latest validation of the algorithms used to extract the Automatic Satellite Image Interpretation – Next Generation (PGE17) is reported in a validation report [RD.2].

## 1.3 SOFTWARE VERSION IDENTIFICATION

This document is compliant with the ASII-NG/PGE17 version of the v2025 NWC/GEO software package delivery. It was decided that the individual products assembled under the ASII-NG label should be as separated as possible in order to facilitate version control and other programme-managerial tasks. In version 2025, there are three sub-modules:

- the ASII-GW (gravity wave detection) module, v2.0,
- the ASII-ICE (in-flight ice detection) module, v1.0, and
- the ASII-TF (tropopause folding detection) module, v3.0.

## 1.4 IMPROVEMENTS FROM PREVIOUS VERSION

This is the first user manual for MTG-capable NWCSAF/GEO ASII-NG software.

## 1.5 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

See [AD.5] for a complete list of standard acronyms for the SAF project. Some specific abbreviations used herein include:

| | |
|---|---|
| **AD** | Applicable Document |
| **ASII** | Automatic Satellite Image Interpretation |
| **ASII-GW** | Gravity wave detection sub-product of ASII-NG |
| **ASII-ICE** | In-flight icing detection sub-product of ASII-NG |
| **ASII-NG** | ASII next generation |
| **ASII-TF** | Tropopause folding detection sub-product of ASII-NG |
| **ECMWF** | European Centre for Medium-range Weather Forecast |
| **EUMETSAT** | European Organisation for the Exploitation of Meteorological Satellites |
| **GSA** | GeoSphere Austria |
| **IR** | Infrared |
| **MSG** | Meteosat Second Generation |
| **MTG** | Meteosat Third Generation |
| **NWP** | Numerical Weather Prediction |
| **PGE** | Product Generation Element |
| **SAF** | Satellite Application Facility |
| **SEVIRI** | Spinning Enhanced Visible and Infrared Imager |
| **UTC** | Universal Time Coordinated |
| **WV** | Water Vapour |
| **ZAMG** | Zentralanstalt für Meteorologie und Geodynamik (Vienna), predecessor organization of GeoSphere Austria |

## 1.6 REFERENCES

### 1.6.1 Applicable documents

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X].

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred applies.

Current documentation can be found at the NWC SAF Helpdesk web: http://nwc-saf.eumetsat.int.

| Ref | Title | Code | Vers | Date |
|---|---|---|---|---|
| [AD.1] | Proposal for the Fourth Continuous Development and Operations Phase (CDOP 4) March 2022 – February 2027 | /NWC/SAF/AEMET/MGT/CDOP4Proposal | 1.0 | 12/03/2021 |
| [AD.2] | Project Plan for the NWCSAF CDOP4 phase | NWC/CDOP4/SAF/AEMET/MGT/PP | 3.0.0 | 21/10/2024 |
| [AD.3] | Configuration Management Plan for the NWCSAF | NWC/CDOP4/SAF/AEMET/MGT/CMP | 1.2.0 | 29/03/2024 |
| [AD.4] | NWCSAF Product Requirement Document | NWC/CDOP4/SAF/AEMET/MGT/PRD | 3.0.0 | 21/10/2024 |
| [AD.5] | NWCSAF CDOP 4 Service Specifications | NWC/CDOP4/SAF/AEMET/MGT/SSD | 1.0.0 | 31/10/2022 |
| [AD.6] | System and Components Requirements Document for the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/AEMET/SW/SCRD | 1.3.1 | 31/03/2025 |
| [AD.7] | Architecture Design Document for the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/AEMET/SW/ACDD | 1.3.0 | 31/03/2025 |
| [AD.8] | Interface Control Document for Internal and External Interfaces of the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/AEMET/SW/ICD/1 | 1.4.0 | 31/03/2025 |
| [AD.9] | Interface Control Document for the NWCLIB of the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/AEMET/SW/ICD/2 | 1.4.0 | 31/03/2025 |
| [AD.10] | Data Output Format for the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/AEMET/SW/DOF | 1.4.0 | 31/03/2025 |
| [AD.11] | User Manual for the NWC/GEO: Software Part | NWC/CDOP3/MTG/AEMET/SW/UM | 1.3.0 | 31/03/2025 |

***Table 1:*** *List of Applicable Documents*

### 1.6.2 Reference documents

The reference documents contain useful information related to the subject of the project. These reference documents complement the applicable ones, and can be looked up to enhance the information included in this document if it is desired. They are referenced in this document in the form [RD.X].

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred applies.

Current documentation can be found at the NWC SAF Helpdesk web: http://nwc-saf.eumetsat.int

| Ref | Title | Code | Vers | Date |
|---|---|---|---|---|
| [RD.1] | Scientific and Validation Report for the "Automatic Satellite Image Interpretation – Next Generation" Processors of the NWC/GEO | NWC/CDOP4/GEO/GSA/SCI/VR/ASII-NG | 1.0 | 31/03/25 |
| [RD.2] | Scientific and Validation Report for the "Automatic Satellite Image Interpretation – Next Generation" Processors of the NWC/GEO | NWC/CDOP3/GEO/ZAMG/SCI/VR/ASII-NG | 1.0 | 21/01/19 |
| [RD.3] | Algorithm Theoretical Basis Document for the "Automatic Satellite Image Interpretation – Next Generation" Processor of the NWC/GEO MTG-I day-1 | NWC/CDOP2/MTG/ZAMG/SCI/ATBD/ASII-NG | 1.1.1 | 31/03/25 |

***Table 2:*** *List of Referenced Documents*

# 2. DESCRIPTION OF THE NWC/GEO-ASII-NG PRODUCTS

## 2.1 GOAL OF THE ASII-NG PRODUCTS

ASII-NG/PGE17 utilizes concepts established during the development of ASII in CDOP, but based on new algorithmic components developed during CDOP-2 and CDOP-3, especially the probabilistic method of logistic regression. The new product collection differs also in its focus on only a few selected phenomena of particularly high user interest (e.g. because they represent threats for civil aviation) and in its output of probability-of-occurrence on a pixel-by-pixel basis.

In its first development stage, ASII-NG focussed on the detection of turbulence from characteristic patterns (i.e. gravity waves and tropopause folding). Algorithms based on pattern recognition methods are exploiting the image data provided by the Meteosat (or Himawari or GOES-R) satellite and are complemented by NWP data, where suitable, to give an objective analysis of regions with increased likelihood of turbulence.

The most recent addition is a sub-product concerned with the detection of in-flight icing potential. The intention is to develop more accurate and timely diagnoses of conditions leading to ice accretion on aircraft during flight.

## 2.2 DESCRIPTION OF AUTOMATIC SATELLITE INTERPRETATION – NEXT GENERATION PRODUCTS

The ASII-NG products are encoded in standard NWCSAF netCDF output files. As such, they feature many standard entries/matrices common to all NWC/GEO netCDF products; such contents are described in the NWCSAF Data Output Format Document [AD.10]. There is one file per slot per sub-product, and the output files are located by default in $SAFNWC/export/ASII; the naming follows the schematic S_NWC_ASII-*<sub-product>*_*<satellite>*_*<region>*-*<resolution>*_*YYYYMMDD*T*hhmmss*Z.nc (examples: S_NWC_ASII-GW_MSG3_global-VISIR_20150626T120000Z.nc and S_NWC_ASII-TF_MSG3_global-VISIR_20150626T120000Z.nc).

Apart from the standard fields, the netCDF file holds the following ASII-NG-specific fields:

- (ASII-TF) "asiitf_prob": derived probability for occurrence of tropopause folding; for each pixel a value between 0 and 100%, with failure to derive it at a certain pixel indicated by code 255.
- (ASII-TF) "asiitf_status_flag": giving more details on reasons why "asii_t_prob" could not be derived at a certain pixel. 0=everything OK, probability computed; otherwise:
    - bit 1 set: problem in "stripe in WV6.2"
    - bit 2 set: problem in "(gradient in) WV6.2"
    - bit 3 set: problem in "gradient of the difference image IR9.7-IR10.8"
    - bit 4 set: problem in "shear vorticity" (NWP parameter)
    - bit 5 set: problem in "wind speed" (NWP parameter)
    - bit 6 set: problem in "tropopause from specific humidity" (NWP parameter that may require model levels in great height)
- (ASII-GW) asiigw_pal; (ASII-TF) asiitf_pal: turquoise (0)-to-red (100%) palette
- (ASII-GW) "asiigw_wv_prob", "asiigw_ir_prob": derived probability for presence of gravity wave in the WV and IR channel, respectively; for each pixel a value between 0 and 100%, with failure to derive it at a certain pixel indicated by code 255.

- (ASII-GW) "asiigw_status_flag": giving more details on reasons why "asiigw_*_prob" could not be derived at a certain pixel. 0=everything OK, probability computed; otherwise:
    - bit 1 set: not a valid WV7.3 pixel
    - bit 2 set: pixel filtered by temperature threshold in WV7.3
    - bit 3 set: not a valid IR10.8/10.5/11.2 pixel
    - bit 4 set: pixel filtered by temperature threshold in IR10.8/10.5/11.2
- (ASII-GW) "asiigw_wv_continuity", "asiigw_ir_continuity": indicating the number of slots a gravity wave probability > 0% has been obtained at the pixel in the WV and IR channel, respectively, without interruption (currently testing up to 7 preceding analyses in $SAFNWC/export/ASII; i.e. 8 being the maximum number, 1 meaning that it appeared for the first time in the current analysis).
- (ASII-ICE) "asiiice_sc_mask": flag indicating the probability of icing due to supercooled water droplets and an indication on its strength. Possible values are 0 (no icing), 1 (unknown), 2 (low probability of light icing), 3 (medium probability of light icing), 4 (high probability of light icing), 5 (high probability of medium-or-greater icing).
- (ASII-ICE) "asiiice_haic_mask": flag indicating whether icing due to high-altitude ice crystals is likely or not. Possible values are 0 (no icing), 2 (icing), 255 (product outage). Code 1 is reserved for "unknown" (to be coherent with the "asiiice_sc_mask") but currently not used.
- (ASII-ICE) "asiiice_status_flag": giving more details on the certainty about the presence of high-altitude ice crystals and reasons why "asiiice_sc_mask" could not be derived at a certain pixel:
    - bit 1 set: CMIC values of indicated high-altitude ice crystals even meet the more demanding thresholds of RDT-CW (for which icing is an attribute assigned to the convective cells)
    - bit 2 set: outage of NWC/GEO CTTH input
    - bit 3 set: outage of NWC/GEO CMIC input
- (ASII-ICE) "asiiice_sc_mask_pal", "asiiice_haic_mask_pal": colour palettes for icing flags

The common processing conditions and quality flags (described in [AD.10]) for these products bear the names asiigw_conditions/asiitf_conditions/asiiice_conditions and asiigw_quality/asiitf_quality/asiiice_quality.

The "product completeness" field in the netCDF file derives from the number of processed pixels divided by the total number of pixels (a baseline effect is to be expected if the processing region has space pixels in it). For the "product quality" of ASII-GW, a value of 1 is assigned to all pixels where all tests could be carried out. If this is not possible (typically at the edge of the domain), the quality should be lower – as the computational effort to determine the degree of incompleteness should be saved, the "average reduced quality" of 0.5 is assigned to such pixels; the netCDF variable then is computed as the average over all non-space pixels. Under normal circumstances, this is merely a function of region geometry and should therefore be a constant for a given region. For ASII-TF and ASII-ICE, no viable strategy has been devised so far to derive a global product quality figure which would provide additional value over the information contained in "asiitf_status_flag"/"asiiice_status_flag" (the major conceptual difference to ASII-GW being that the products are completely suspended at any pixel where one ingredient is missing; nevertheless, as the NWCSAF netCDF model requires the figure, it is currently arbitrarily set to 100%).

# 3. IMPLEMENTATION OF THE ASII-NG PGES

## 3.1 NWC/GEO SOFTWARE PACKAGE INSTALLATION AND PREPARATION

ASII-NG is extracted by PGE17 of the NWC/GEO software package. Detailed information on how to run this software package is available in the "Software User Manual for the NWC/GEO application".

The implementation of the ASII-NG software follows the general implementation of components of the NWC/GEO software (see the software part of the Users Manual of the NWC/GEO software for more details).

Basically, the following steps are needed to run the ASII-NG software:

1. Create or update configuration files (system, region, model and run configuration files) according to their format (see the Interface Control Document ICD/1 [AD.8]). Files are situated in $SAFNWC/config.
2. Algorithm configuration files are situated in the directories $SAFNWC/import/Aux_data/ASII<*sub-product*>. These PGE17 input files are provided with the software package, installed together with it, and are not foreseen for modification by users.
3. Ensure that the remapped NWP data have been made available in the DATABUF directory "$SAFNWC/tmp/NWP" (only needed by ASII-TF at the time being).
4. Ensure that the satellite image files in the format required by NWC/GEO are available in the directory $SAFNWC/import/Sat_data/.

Then, the processing of ASII-NG is automatically monitored by the task manager (see the Software Users Manual for the Task Manager of the NWC/GEO software).

Submitting GEO-ASII-NG, v2025 in stand-alone mode, not using the task manager:

- Ensure that pre-requirements listed under items 1-4 are fulfilled.
- The ASII-GW executable GEO-ASII-GW-v20 can be called as follows (from the directory where it is situated, which normally should be $SAFNWC/bin):

  GEO-ASII-GW-v20 <YYYYMMDDThhmmssZ> <region_conf_file> <model_conf_file>

  Example:

  GEO-ASII-GW-v20 20200229T120000Z test_asii.cfg safnwc_ASII-GW.cfm
- The ASII-TF production follows an analogous scheme:

  GEO-ASII-TF-v30 <YYYYMMDDThhmmssZ> <region_conf_file> <model_conf_file>

  Example:

  GEO-ASII-TF-v30 20200229T120000Z test_asii.cfg safnwc_ASII-TF.cfm
- And the ASII-ICE in its first version:

  GEO-ASII-ICE-v10 <YYYYMMDDThhmmssZ> <region_conf_file> <model_conf_file>

  Example:

  GEO-ASII-ICE-v10 20200229T120000Z test_asii.cfg safnwc_ASII-ICE.cfm

## 3.2 NWC/GEO-ASII-NG DIAGNOSTIC ERRORS

The following table shows the whole list of errors and warnings that can appear during the execution of the NWC/GEO-ASII-NG PGEs, the reasons causing these errors and warnings, and the way the NWC SAF user can try to solve them. In any case, if the errors or warnings persist, the NWC SAF Helpdesk should be contacted.

| Code (E/W) | Message | Comment | Recovery action |
|---|---|---|---|
| E | "Usage: %s YYYYMMDDThhmmssZ <region_conf_file> <model_conf_file>" | Error when launching an ASII-NG PGE | Check instruction for launching the concerned PGEs |
| E | All messages related to NWCLIB time handling functions: NwcTimeSetStr, NwcTimeSetT | Time input when launching PGE may be wrong. | Check the slot time input when launching PGE. |
| E | All messages including the following strings:<br>"memory allocation"<br>"allocation error"<br>"Unable to allocate"<br>"Error allocating"<br>"not allocated"<br>"cannot be allocated" | Problem of memory allocation | Check memory |
| E | All messages containing the following string:<br>"ERROR when opening" | Problem to open an existing file or to create a new file. | Check permission and disk space on the directory.<br>Check presence of the requested file. The recovery actions depends on the type of file:<br>- for missing configuration files, copy them from delivered SW;<br>- for missing file to be input by user: check why they are missing; for new file, check permission/disk space on the directory. |
| E | All messages containing the strings:<br>"mod(el)_conf(iguration)_file"<br>"PRODIO_CONF_FILE"<br>"CONF_FILE_ERROR"<br>"couldn't find all parameters for…" | Problem when looking for configuration file or reading a key from it. | Check corresponding configuration file for presence and content.<br>If needed, copy them from delivered SW. |
| E | All messages containing the strings:<br>"OUTPUT_PRODUCT…ERROR"<br>"Error initiating/writing/finalizing…"<br>"Error in module Write…"<br>"coding failed" | Problem to send output to file. | Check permission and disk space on the output directories. |
| E | All messages (and knock-on messages) related to<br>• NWCLIB initialization functions: NwcRegionSet, NwcCFRead, NwcSatInit<br>• NWCLIB Reading function NwcSatReadBand<br>• NWCLIB numerical function NwcNavGetLatLon | | Consult NWCLIB-specific documentation |
| E | "Error in reading the supplementary input" | Refers to land-sea mask | Check correct installation of NWCSAF land-sea auxiliary data |
| E | "Error in reading the Gabor filter aux file" | Refers to auxiliary ASII-GW input | Check correct installation of NWCSAF auxiliary data |
| E | Messages containing the term "NWP" | Problem with NWP configuration file or remapped NWP data | Depending on the exact message, check NWP configuration file or completeness of remapped NWP data (ASII-TF) or NWP GRIB file (ASII). |

| Code (E/W) | Message | Comment | Recovery action |
|---|---|---|---|
| E | Messages stating in which part / which subroutine the problem occurred | Introduced mainly to facilitate debugging activities by the developers | Such messages should have been preceded by another error message (in most cases on memory allocation) → see the recovery actions under these categories |

***Table 3:*** *List of possible errors reported by the ASII-NG PGEs of vMTG-I day-1.*

# 4. INPUTS AND CONFIGURABLE PARAMETERS FOR THE ASII PRODUCT GENERATION ELEMENTS

## 4.1 ASII-TF

### 4.1.1 List of inputs

- IR image, channel 9.7, current slot
- IR image, channel 10.8, current slot.
- WV image, channel 6.2, current slot
- NWP data (temperature, relative humidity, wind)

### 4.1.2 Configurable parameters

N/A in NWC/GEO v2025.

## 4.2 ASII-GW

### 4.2.1 List of inputs

- WV image, channel 7.3, current slot
- IR image, channel 10.8, current slot

### 4.2.2 Configurable parameters

The configurable parameters can be found at the end of the model configuration file for ASII-GW:

| Keyword(s) | Description | Type | Possible Value(s) |
|---|---|---|---|
| IR<br>WV | Decide whether the IR10.8 and/or WV7.3 analysis are used. | chain of characters | YES or NO<br>(the software interprets any expression with a "Y" or "y" in it as a "Yes".) |

## 4.3 ASII-ICE

### 4.3.1 List of inputs

- NWC/GEO CTTH product, current slot
- NWC/GEO CMIC product, current slot

### 4.3.2 Configurable parameters

N/A in NWC/GEO v2025.

# 5. SUMMARY OF AUTOMATIC SATELLITE IMAGE INTERPRETATION – NEXT GENERATION (ASII-NG) VALIDATION RESULTS

## 5.1 ASII-GW

The ASII-NG gravity wave detection sub-product ASII-GW directs the meteorologist in a time-saving manner to those areas where gravity waves can be seen. Recent advances that help eliminating cases of incorrectly flagged areas of marine stratocumulus (especially disturbing during the cold season) and allow to offer an IR10.8 analysis in ASII-GW v2.0 (v1.0 was based on WV7.3 only) are documented in Jann (2019). Applicability of the detection algorithm to higher-resolution imagery of the most recent sensors was verified in He et al. (2020). Given the similarity to the HIMAWARI sensor used there, the latter study prepared well for MTG FCI, so that the adequate performance in the latest validation on actual FCI data ([RD.1]) could be anticipated.

## 5.2 ASII-TF

The ASII-NG tropopause fold detection sub-product is tuned to detect stronger variations of the tropopause height. Validation of the indicated tropopause fold positions by the ASII-TF product has been done against pilot reports (PIREP) and IASI derived tropopause heights [RD.2].

Visual inspection of the ASII-TF output with IASI-derived tropopause gradients showed a fairly good consistency regarding the position of the tropopause folds. The ASII-TF product showed even more details than the sounding data, and it also seems to be more sensitive to smaller height variations.

When comparing the ASII-TF output against PIREPs, only turbulence reports from higher atmospheric levels have been considered. Here, turbulence experienced by aircrafts is mainly caused by wind shear at jet level. Strong wind bands at around 300 hPa are often found near tropopause folds. This geographical connection has been used to examine the relation between the position of the observed turbulence and the location of the tropopause fold. The obtained results show that most turbulence reports (87%) are issued within or close to tropopause folds identified by the ASII-TF product, when turbulence originates from wind shear.

Although tropopause folds are good indicators for the position of jet streaks, tropopause folds alone are not sufficient to trigger turbulence. Hence, in case the ASII-TF product is intended to be used as turbulence warning tool, factors like vertical and/or horizontal wind shear should also be considered by the forecaster.

## 5.3 ASII-ICE

In its first version, the in-flight icing product simply implements (and thus makes them available as a data set to the NWC/GEO community) two approaches (Smith et al., 2012; de Laat et al. 2017) with proven value and associated validation campaigns.

# 6. WELL-KNOWN PROBLEMS AND RECOMMENDATION FOR USE

These products are aimed to be part of the inputs for decision making by meteorologists, yet cannot be used as stand-alone automatic warning tools.

The ASII-TF and ASII-GW products are satellite products searching for features favourable for turbulence but NOT the turbulence itself. As CAT by definition is a clear-air phenomenon; there may be areas of turbulence which cannot be detected by any remote-sensing tool. Therefore, the absence of signals in satellite imagery does not preclude the presence of CAT. In other words, even assuming the detection algorithms are working perfectly, the detection rate of CAT will never reach 1.

As computation of tropopause heights is one ingredient of ASII-TF, it is recommended that NWP data are provided up to the 50 hPa level to ensure that the tropopause is captured (on the other hand, it was found for the GFS model that the humidity fields in layers above 30 hPa are not dependable. Random fluctuations with often unrealistic increases at high levels accidentally satisfy the tropopause criteria. In order to avoid such erroneous signals, the ASII-TF software simply omits NWP input from layers with <30hPa pressure, as the tropopause should be located in lower layers anyway).

Although the NWCSAF software package can be processed at any region of the disc, the focus of tuning and validation was on Europe and the neighbouring sea areas (although the validation exercise for ASII-GW v2.0 included visits to areas on the whole disc including the southern hemisphere [RD.2]; Jann(2019)). The higher resolution of Himawari/GOES-R/MTG-FCI means that gravity waves with smaller wavelengths can be inspected. Given the typical scale of tropospheric gravity waves, this should have a positive impact on detectability. Still, for geometrical reasons, one must accept that gravity waves near the edge of the disc are not resolved or, in general terms, that the detection rate has an irremediable dependence on the satellite zenith angle.

As a consequence of the limited capabilities of sensors on geostationary satellites to scan inner-cloud microphysical processes, the icing products necessarily describe the situation only near the cloud-top level. (As is also fairly evident in the northern parts of **Figure 4** below,) the detection of in-flight icing is currently confined to daylight hours as there is no Meteosat cloud microphysics product for the nighttime.

# 7. EXAMPLES OF PRODUCT VISUALISATIONS

The ASII-NG output files are in netCDF format, a widespread standard for which several handy visualization and data extraction tools exist. As an example, **Figure 1** features a tool called "HDF Explorer" (which, despite of its name, can also be used to quickly look into NWCSAF netCDF files).

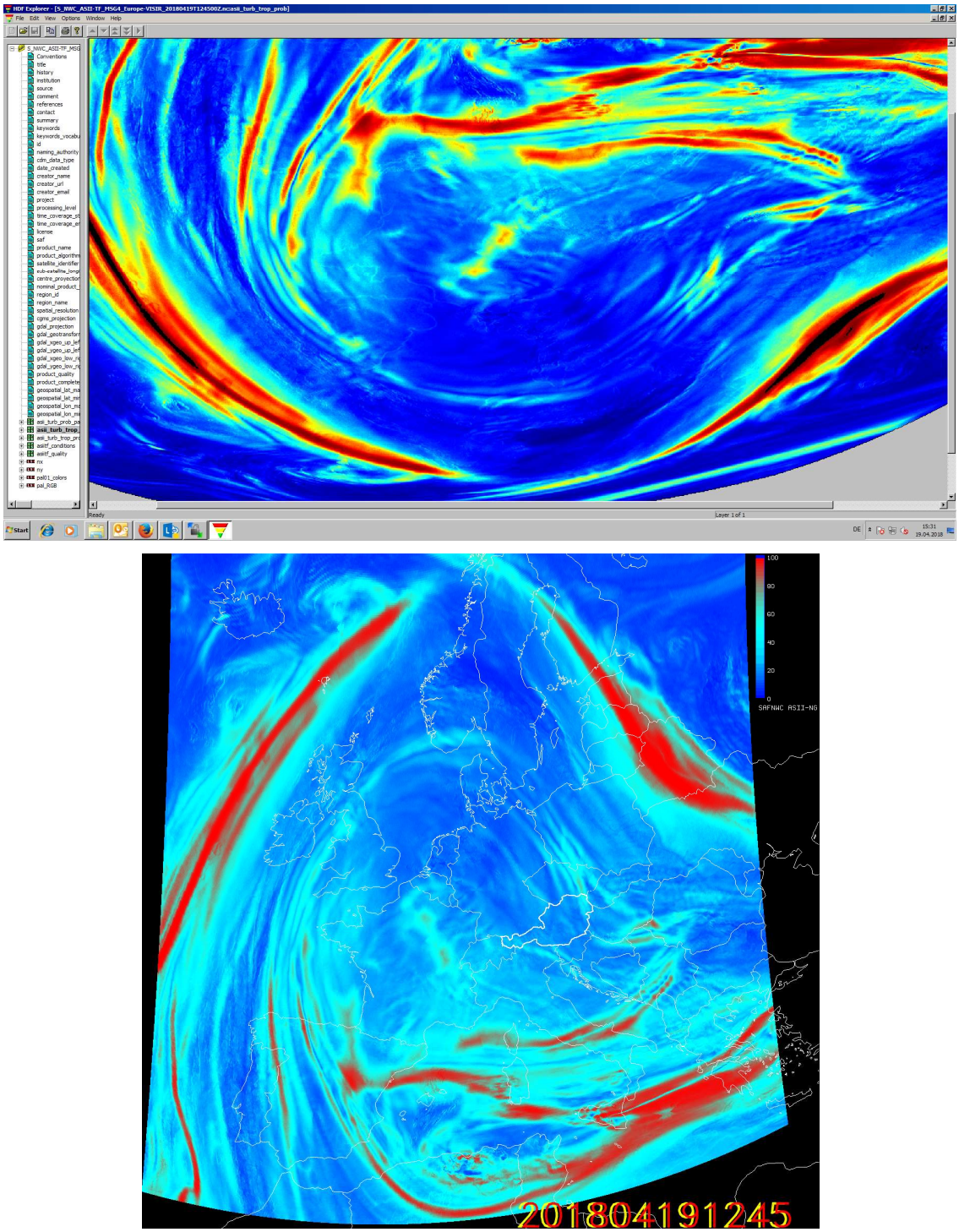


***Figure 1:*** *Example quicklook displays of ASII-TF's "probability of occurrence of tropopause folding" for 19 April 2018, 1245 UTC. Upper panel: as shown in the "HDF Explorer" (a simple viewer that does not interpret/add geographical information); lower panel: as shown on the GSA monitoring website using the default colour palette included in the output file.*

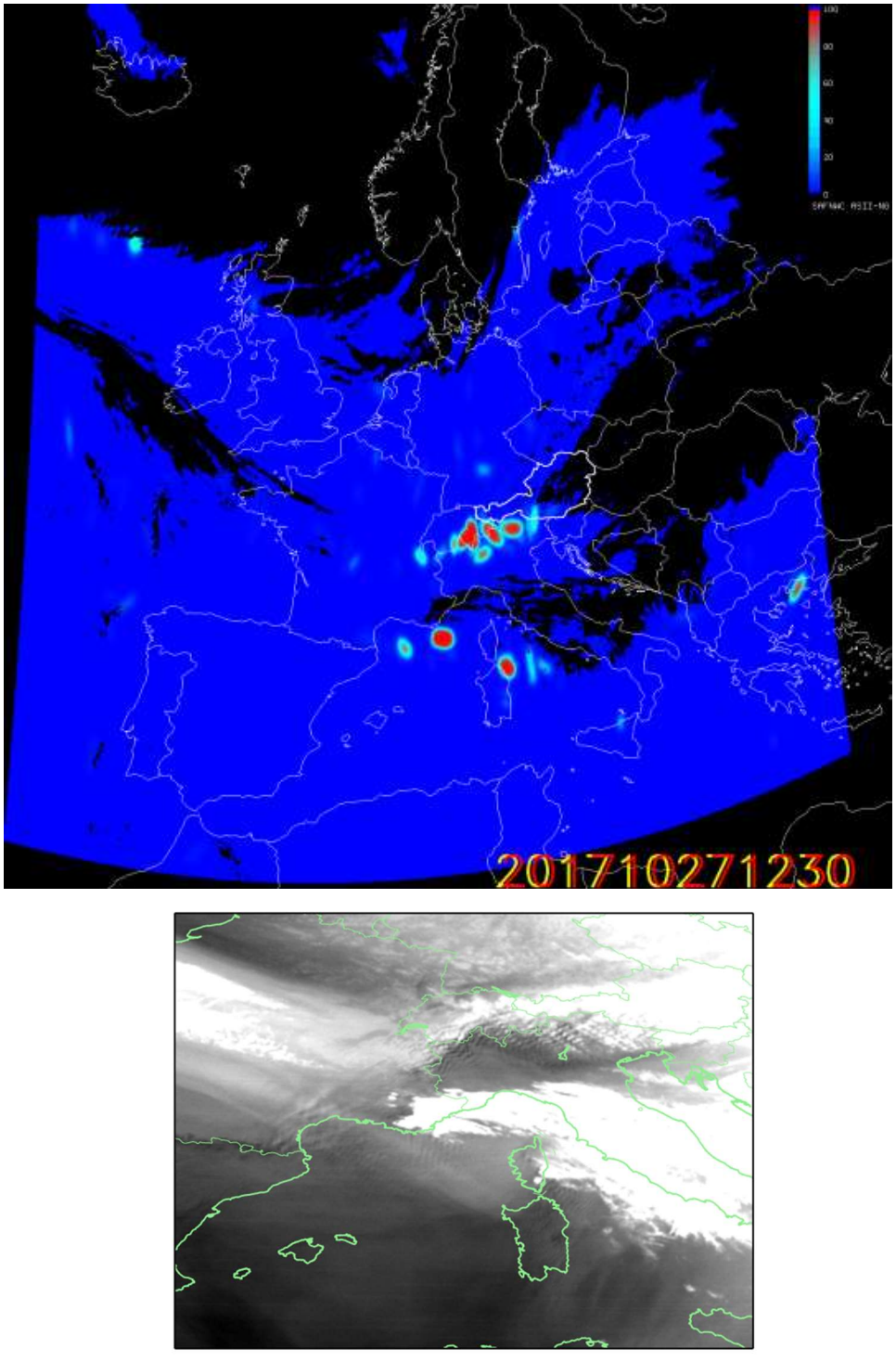


***Figure 2:*** *Case of 27 October 2017, 1230 UTC. Upper panel: The probability-of-occurrence of gravity waves, as analysed by the ASII-GW module on the basis of the WV7.3 image (the colour table runs from dark blue = 0% to red=100%; the black areas are those masked by a temperature threshold used to avoid random signals in thick clouds; this is the default colour palette, as included in the output file). Lower panel: Excerpt of the used WV7.3 image.*

Both the ASII-GW and the ASII-TF product contain a turquoise (0)-to-red (100%) palette in the field asiigw_pal/asiitf_pal of their respective netCDF output files. **Figure 1** shows the selected case also in this colouring scheme, **Figure 2** features an example ASII-GW display produced with this suggested colour table. In this figure, the WV7.3 image is added on a separate display so the product can be verified against the patterns subjectively detected in the image. As the ASII-GW product is very amenable to isoline representation, such a verification can be conveniently accomplished also within a single image, as in **Figure 3**.

The ASII-ICE product features a colour palette inspired by Smith et al. (2012), i.e. the paper presenting one of the used detection algorithms. **Figure 4** shows visualization of the two sub-products using this palette.

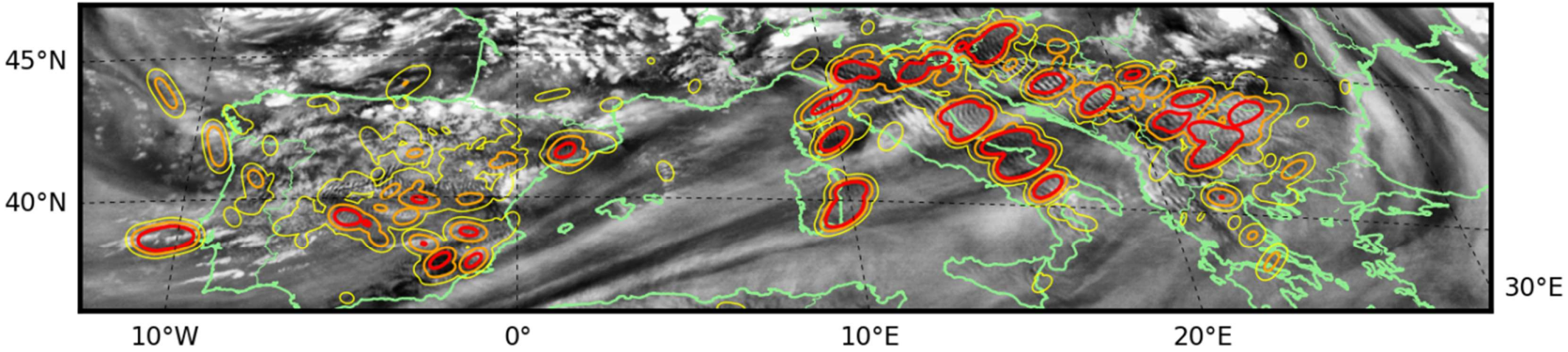


***Figure 3:*** *The WV7.3 image of 29 June 2017, 1400 UTC, over Mediterranean Europe, superimposed by the 1, 50 and 99% isolines of probability of gravity-wave occurrence, as indicated by the ASII-GW product (v2018).*

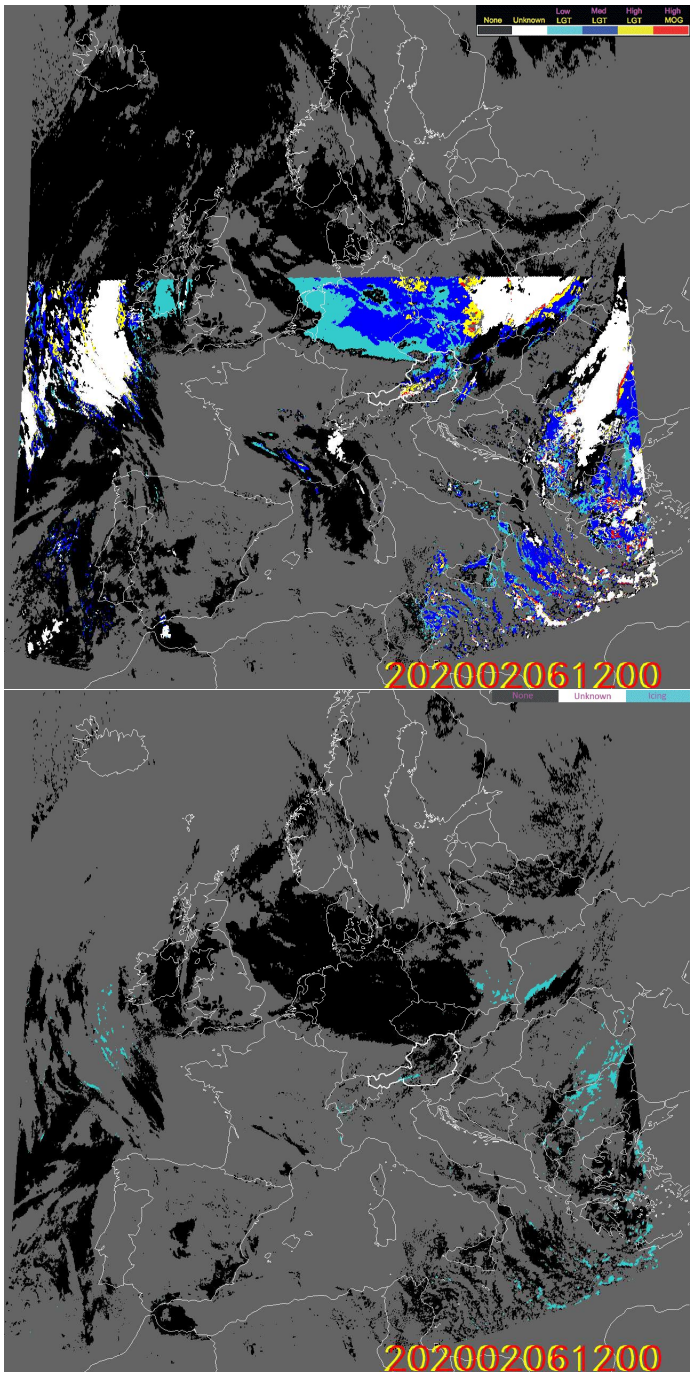


***Figure 4:*** *ASII-ICE sub-products of 6 February 2020, 1200 UTC. Upper panel: The "supercooled water droplets" categories analysed after Smith et al. (2012). Lower panel: "High-altitude ice crystals", as indicated by the method of de Laat et al. (2017).*

# 8. REFERENCES

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