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NWC SAF

SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING

Validation Report Document for Processors of the NWC/GEO MTG-I day1

NWC/CDOP4/MTG/MFL/SCI/VR/Cloud, Version 1.0.1

30 May 2025

Applicable to GEO-CMA-v6.0

GEO-CT-v5.0

GEO-CTTH-v5.0

GEO-CMIC-v3.0

Prepared by Météo-France/DESR/CNRM/ Centre d'Etudes en Météorologie Satellitaire

REPORT SIGNATURE TABLE

Function	Name	Signature	Date
Prepared by	Gaëlle KERDRAON Tony LEBASTARD Emmanuel FONTAINE		30 May 2025
Reviewed by	SAFNWC Project Team EUMETSAT		30 May 2025
Authorized by	Pilar Rípodas, AEMET *SAFNWC Project Manager*		30 May 2025

DOCUMENT CHANGE RECORD

Version	Date	Pages	Changes
1.0d			Draft version for ORR2 Delivered to
1.0	30th May 2025	38	Reviewed version of ORR2

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1 INTRODUCTION

The EUMETSAT "Satellite Application Facilities" (SAF) are dedicated to research and weather services 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 on the NWCSAF webpage, http://nwc-saf.eumetsat.int. This document is applicable to the NWCSAF processing package for geostationary meteorological satellites, NWC/GEO.

1.1 SCOPE OF THE DOCUMENT

This document is the cloud product validation report applicable to NWC/GEO software package v2025. This is the first validation for MTGI-1, performed for ORR2.

The MTG-I1 cloud products (GEO-CMA Cloud Mask, GEO_CT, Cloud Type, GEO-CTTH, Cloud Top Temperature and Height, and GEO-CMIC, Cloud Microphysics) have been compared against the MSG3 cloud products.

1.2 SOFTWARE VERSION IDENTIFICATION

The validation results presented in this document apply to the algorithms implemented in the release v2025 of the NWC/GEO software package (GEO-CMA-v6.0, GEO-CT-v5.0, GEO-CTTH-v5.0, GEO-CMIC-v3.0).

1.3 DEFINITIONS AND ACRONYMS

See [RD.1.] for a complete list of acronyms for the SAFNWC project.

1.4 REFERENCES

1.4.1 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 SAFNWC Helpdesk web: http://www.nwcsaf.org

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	2021/03/12
[AD.2.]	Algorithm Theoretical Basis Document for the Cloud Product Processors of the NWC/GEO MTG-I day-1	NWC/CDOP2/MTG/MFL/SCI/ATBD/Cloud	1.1.1	2021/01/31
[AD.3.]	Scientific and Validation report for the Cloud Product Precessors of the NWC/GEO	NWC/CDOP3/GEO/MFL/SCI/VR/Cloud	2.0.1	2022/02/28
[AD.4.]	Project Plan for the NWCSAF CDOP4 phase	NWC/CDOP4/SAF/AEMET/MGT/PP	3.0.0	21/10/2024
[AD.5.]	Configuration Management Plan for the NWCSAF	NWC/CDOP4/SAF/AEMET/MGT/CMP	1.2.0	29/03/2024
[AD.6.]	NWCSAF Product Requirement Document	NWC/CDOP4/SAF/AEMET/MGT/PRD	3.0.0	21/10/2024

Table 1: List of Applicable Documents

1.4.2 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 SAFNWC Helpdesk web: http://www.nwcsaf.org

Ref	Title	Code	Vers	Date
[RD.1.]	The Nowcasting SAF Glossary	NWC/CDOP3/SAF/AEMET/MGT/GLO		
[RD.2.]	Interface Control Document for the NWCLIB of the NWC/GEO MTG-I day-1	NWC/CDOP2/MTG/AEMET/SW/ICD/2	1.3.0	03/02/2023

Table 2: List of Referenced Documents

2 CLOUD PRODUCTS VALIDATION

2.1 GENERAL OBJECTIVES OF THE VALIDATION

This is not a proper validation, but a comparison of clouds properties retrieved on one hand with MSG3 observations and on the other hand with the MTG-I1. For MSG3 we used version 2021.1 of NWC/GEO and for MTG-I1 we used version v2025.

2.2 METHODOLOGY OUTLINE

ARPEGE with the 0.25° resolution at 00Z and 12Z was used as NWP fields forecast for both versions. The segments' size to remap the NWP fields is 4 by 4 pixels for MSG3 and 6 by 6 pixels for MTGI-1 i.e. 12 by12 km in both cases. The period of validation begins after the first Earth Stray Light correction in October 2024 and avoids the events of solar intrusions which occur around the equinoxes.

Below are the dates (27 days) for which the cloud products were compared with those made with MSG data:

- October 2024: 20, 21, 22, 23, 24 and 29
- November 2024: 3, 4, 5
- December 2024: 10, 11, 12, 13, 14 and 15
- January 2025: 2, 3, 4, 5, 6 and 7
- February 2025: 1, 2, 3, 4, 5 and 6

For the selected days, the cloud products of the 24-hourly slots were compared. Note that a straylight correction was applied by EUMETSAT on 6 March 2025 and further correction is likely to be applied in the future. This could slightly modify the results.

An extended validation will be performed for the next release of the software GEO (for « MTG DAY2 » date release unknow).

3 CLOUD MASK (GEO-CMA) VALIDATION

3.1 METHODOLOGY OUTLINE

The performance of cloud detection with data from the MTG-I1 satellite was evaluated in two different ways.

- The cloud mask was validated with observations from SYNOP/SHIP messages gathered over the full disk and collocated with the CMA. The POD (Probability Of Detection) and FAR (False Alarm Rate) are computed.

- The cloud masks produced with MTG-I1 data were compared with those processed with MSG3 data. Due to the different grids and resolutions, cloud masks cannot be compared pixel by pixel. A selection of homogeneous areas is performed both for MSG3 (areas of 3x3 pixels) and MTG-I1 (areas of 5x5 pixels). The center of both areas is collocated thanks to the NWCLIB tools [RD.2.]. An area is considered as cloudy (resp. clear) if 6 pixels or more are cloudy (resp. clear) for MSG3 and 17 pixels or more are cloudy (resp. clear) for MTGI-1.

3.2 VALIDATION WITH SYNOP/SHIP

From the SYNOP or SHIP data set, ground-based total cloud cover (N) and partial cloud cover from low, medium and high clouds are available. To simulate the surface observations from the satellite pixels, no attempt is made to consider the complexity of the observation, and the 49 pixels inside the satellite data target are used for the evaluation. The satellite cloudiness (in octas) is calculated in the 7x7 target centered over SYNOP station or SHIP and is equal to: NB*8/49, where NB is the number of pixels cloudy in the target.

An observation is cloudy if N from SYNOP/SHIP is strictly higher than 5 octas, clear if N is strictly lower than 3 octas. A detection is cloudy if more than 33 pixels (in the 7x7 box) are flagged cloud contaminated, clear if less than 16 pixels are cloudy. Consequently, all events with N=3,4,5 and equivalent CMA cloud covers expressed in octas are not considered in these statistics. This study relies on analysis of contingency tables and comparison of statistical scores.

POD=[h/(h+m)], is the rate of correctly detected cloud observations, i.e. targets classified as cloudy and observed cloudy. (h: hit; m: miss)

FAR=[fa/(fa+h)], is the rate of missed clear observations or false flagging of clouds, i.e. the targets classified as cloudy but observed clear sky (it expresses cloud over-detection errors). (fa: false alarm)

The CMA v2025 cloud detection reaches over MTG-I1 full disk the threshold accuracy (POD 85 % and FAR 20%) for all illuminations.

MTG-I1 v2025	POD	FAR
DAY	83.6%	4.6%
NIGHT	86.7%	8.6%
TWILIGHT	90.0%	4.5%
ALL Illuminations	85.9%	6.4%

Table 3: Probability of detection and false alarm rate for cloud detection using MTG-I1 data

Cloud masks were processed with MSG3 data over the full disk, for the same period and validated with observations from SYNOP/SHIP messages. POD and FAR have been computed. In this case, boxes of 5x5 pixels are used to determine the cloudiness.

MSG3 V2021	POD	FAR
DAY	85.5%	5.6%
NIGHT	88.1%	10.3%
TWILIGHT	91.2%	5.6%
All Illuminations	87.5%	7.7%

Table 4: Probability of detection and false alarm rate for cloud detection using MSG3 data

The probability of detection is slightly lower for MTG-I1 than for MSG3. The False alarm rate is lower for the CMA processed with MTG-I1 data than for the CMA processed with MSG3 data.

3.3 Comparison against MSG3

The cloud masks produced with MTG-I1 data were compared with the cloud masks processed with MSG3 data (See 3.1). Scores were computed, stratified by illuminations and land-sea mask.

LAND NIGHT	MSG3 Clear	MSG3 Cloudy
MTG-I1 clear	99.3%	6%
MTG-I1 Cloudy	0.7%	94%

Table 5: Comparison of CMA/MTG-I1 against CMA/MSG3, over land, during nighttime

LAND DAY	MSG3 Clear	MSG3 Cloudy
MTG-I1 Clear	99.5%	6.3%
MTG-I1 Cloudy	0.5%	93.7%

Table 6: Comparison of CMA/MTG-I1 against CMA/MSG3, over land, during daytime

LAND TWILIGHT	MSG3 Clear	MSG3 Cloudy
MTG-I1 Clear	99.1%	6.5%
MTG-I1 Cloudy	0.9%	93.5%

Table 7: Comparison of CMA/MTG-I1 against CMA/MSG3, over land, during twilight

SEA NIGHT	MSG3 Clear	MSG3 Cloudy
MTG-I1 Clear	99.5%	3.4%
MTG-I1 Cloudy	0.5%	93.6%

Table 8: Comparison of CMA/MTG-I1 against CMA/MSG3, over sea, during nighttime

SEA DAY	MSG3 Clear	MSG3 Cloudy
MTG-I1 Clear	96.5%	1.8%
MTG-I1 Cloudy	3.5%	98.2%

Table 9: Comparison of CMA/MTG-I1 against CMA/MSG3, over sea, during daytime

SEA TWILIGHT	MSG3 Clear	MSG3 Cloudy
MTG-I1 Clear	98.4%	2.6%
MTG-I1 Cloudy	1.6%	97.4%

Table 10: Comparison of CMA/MTG-I1 against CMA/MSG3, over sea, during twilight

3.4 CONCLUSION FOR THE CLOUD DETECTION

When the detection is validated against SYNOP/SHIP messages, the CMA v2025 cloud detection reaches over MTG-I1 full disk the threshold accuracy (POD 85 % and FAR 20%) for all illuminations.

The cloud masks from MSG3 and MTG-I1 were also compared. There is a good agreement between the two versions using MSG3 data and MTG-I1 data for cloud detection over land.

However, version 2025 used for MTG-I1 data detects slightly less clouds over land than the version using MSG3 data, whatever the illumination. Over sea, the agreement between the two versions is very good, whatever the illumination.

4 CLOUD TYPE (GEO-CT) VALIDATION

4.1 METHODOLOGY OUTLINE

A selection of homogeneous areas is performed both for MSG3 (areas of 3x3 pixels) and MTG-I1 (areas of 5x5 pixels). The centers of both areas are collocated thanks to the NWCLIB tools.
A cloud type is associated with an area if 6 pixels or more have the same cloud type for MSG3 and 17 pixels or more for MTG-I1.

The viewing angles are limited to a maximum of 70 degrees. Contingency tables and statistical scores are then computed. They are associated with changes in illumination (day, night, twilight) and terrain (sea, land).

4.2 COMPARISON AGAINST MSG3

A visual comparison of cloud types from MTG-I1 and MSG3 shows a good agreement. However, there are some differences which were analyzed by comparing the cloud classifications systematically (See 4.1). Confusion matrixes have been calculated, stratified by illuminations and terrain. The probability of having a cloud type from MTG-I1 data, matching the cloud type from MSG3 data was calculated.

The different cloud types are:

- 5: very low clouds
- 6: low clouds
- 7: medium clouds
- 8: high opaque clouds
- 9: very high opaque clouds
- 10: fractional clouds
- 11: high semi-transparent thin clouds
- 12: high semi-transparent moderately thick clouds
- 13: high semi-transparent thick clouds
- 14: high semi-transparent clouds above low or medium clouds (during daytime only)
- 15: high semi-transparent cloud above snow/ice

The class 15, " high semi-transparent cloud above snow/ice" is not included in the comparison. This class was not active for MSG. The channel 1.38 microns is needed to classify these semi-transparent clouds and is not available with MSG/SEVIRI.

4.2.1 Overland during nighttime

For opaque clouds (very low, low, medium, high and very high clouds) the agreement between the classifications processed with MTG-I1 data and the one processed with MSG3 data is good. The differences concern the fractional clouds and the semi-transparent clouds.

- 19.5% of semi-transparent thin clouds (CT=11) from MSG3 CT are classified fractional clouds (CT=10) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 3.9µm) and the FCI channels (10.5µm and 3.8µm)
- 14.7% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)
- We suppose that due to better spatial resolution of MTG-I1 data, 13.5% of fractional clouds (CT=10) from MSG3 CT are classified low clouds (CT=6) using MTG-I1 data.

Cloud Type		**MSG**								
		5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
MTG	**5**	96.0	0	0	0	0	0	0	0	0
	6	3.8	98.7	0.4	0	0	13.5	0	1.1	0
	7	0	1.0	99.0	0.4	0	0.4	0	1.3	0
	8	0	0	0.3	99.2	0.9	0	0	0	14.7
	9	0	0	0	0	99.0	0	0	0	2.1
	10	0	0	0	0	0	83.7	19.5	0	0
	11	0	0	0	0	0	0.4	73.8	0	0
	12	0	0	0	0	0	0	0.4	96.8	2.9
	13	0	0	0	0	0	0	0	0	80.3.

Table 11: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 over land during nighttime

4.2.2 Overland during daytime

Cloud Type		**MSG**									
		5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
MTG	**5**	97.5	0	0	0	0	27.6	0.8	0	0	0
	6	1.8	97.6	0.5	0	0	2.4	8.4	0	0	1.9
	7	0	0.8	98.7	0	0	0	0	0	0	1.9
	8	0	0	0.5	99.1	0.8	0	0	0	14.1	0
	9	0	0	0	0	99.1	0	0	0	2.8	0
	10	0	0	0	0	0	23.2	0.7	0	0	0

	11	0	0.5	0	0	0	45.8	89.8	1.5	0	0
	12	0	0.5	0	0	0	0.4	0.8	55.3	1.2	0.6
	13	0	0	0	0	0	0	0	0.7	79.9	0
	14	0	0	0	0	0	0.6	0.7	42.1	2.0	95.0

Table 12: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 over land during daytime

There is a good agreement for the detection of opaque clouds (very low, low, medium, high and very high clouds), between the classifications processed with MTG-I1 data and the one processed with MSG3. Besides, the differences concern the detection of fractional clouds and the semi-transparent clouds.

- 45.8% of fractional clouds (CT=10) from MSG3 CT are classified thin semi-transparent clouds (CT=11) using MTG-I1 data, with the use of the new channel 1.38 µm. Also, we assume that due to the better spatial resolution of MTG-I1 data, 27.6% of fractional clouds (CT=10) from MSG3 CT are classified very low clouds (CT=5) using MTG-I1 data.

- 14.1% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)

- 42.1% of semi-transparent moderately thick clouds (CT=12) from MSG3 CT are classified semi-transparent above low or medium clouds (CT=14) using MTG-I1 data. In both cases, they are semi-transparent clouds.

4.2.3 Overland during twilight

For opaque clouds, ranging from very low to very high altitudes, the classifications derived from MTG-I1 data align well with those from MSG3 data. However, discrepancies between the two classifications are noted in the fractional and semi-transparent cloud categories.

- 33.5% of semi-transparent thin clouds (CT=11) from MSG3 CT are classified fractional clouds (CT=10) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 3.9µm) and the FCI channels (10.5µm and 3.8µm)

- 12.3% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)

Cloud Type		MSG								
		5	6	7	8	9	10	11	12	13
MTG	5	95.0	0	0	0	0	0	0	0	0
	6	4.5	96.0	0.6	0	0	0.4	0	0.9	0
	7	0	1.0	97.9	0.4	0	0	0	1.0	0
	8	0	0	0.6	98.9	0.8	0	0	0	12.3
	9	0	0	0	0	99.1	0	0	0	2.6
	10	0.5	0	0	0	0	95.0	33.5	0	0
	11	0	0	0	0	0	2.1	62.9	0	0
	12	0	2.6	2.8	0	0	2.4	3.2	96.8	2.9
	13	0	0	0	0.4	0	0	0	0.4	82.1

Table 13: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 over land during twilight

4.2.4 Over sea during nighttime

Cloud Type		MSG								
		5	6	7	8	9	10	11	12	13
MTG	5	97.4	0	0	0	0	1.4	1.0	0	0
	6	1.0	99.3	0.7	0	0	8.1	0	0	2.1
	7	0	0	98.1	0.7	0	0	0	1.8	0
	8	0	0	0.9	98.1	3.8	0	0	0.5	20.5
	9	0	0	0	1.0	96.1	0	0	0	2.1
	10	1.5	0	0	0	0	87.2	17.9	0	0
	11	0	0	0	0	0	3.0	76.7	1.8	0
	12	0	0	0	0	0	0	4.3	92.9	5.6
	13	0	0	0	0	0	0	0	0.4	71.8

Table 14: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 over sea during nighttime

The conclusion on the agreement of detection of opaque clouds (very low, low, medium, high and very high clouds) between MTG-I1 and MSG3 during nighttime is the same as for the detection of opaque clouds during daytime and twilight. The differences concern the fractional clouds and the semi-transparent clouds.

- 17.9% of semi-transparent thin clouds (CT=11) from MSG3 CT are classified fractional clouds (CT=10) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 3.9µm) and the FCI channels (10.5µm and 3.9µm)

- 20.5% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)

- better spatial resolution of MTG-I1 data might be responsible for a better classification of low clouds: 8.1% of fractional clouds (CT=10) from MSG3 CT are classified low clouds (CT=6) using MTG-I1 data

4.2.5 Over sea during daytime

Cloud Type		MSG									
		5	6	7	8	9	10	11	12	13	14
MTG	5	95.4	0	0	0	0	1.7	0	0	0	0
	6	1.4	98.0	0.7	0	0	0	1.6	0	0	2.3
	7	0	0.7	98.0	0.5	0	0	0	0	0	1.6
	8	0	0	1.1	98.9	4.1	0	0	0	21.1	0
	9	0	0	0	0	95.9	0	0	0	1.3	0
	10	3.2	0	0	0	0	76.1	1.3	0	0	0
	11	0	1.1	0	0	0	18.9	95.1	6.1	0	2.4
	12	0	0	0	0	0	0	0.6	79.3	1.2	0
	13	0	0	0	0	0	0	0	0.7	71.7	0
	14	0	0	0	0	0	0	1.3	13.3	4.3	92.7

Table 15: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 overseas during daytime

Cloud classifications from MTG-I1 and MSG3 observations agree for opaque clouds (very low, low, medium, high and very high clouds). As before, the differences concern the fractional clouds and the semi-transparent clouds.

- 18.9% of fractional clouds (CT=10) from MSG3 CT are classified thin semi-transparent clouds (CT=11) using MTG-I1 data, thanks to the use of the new channel 1.38 µm. (See Figure 2)

- 21.1% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)
- 13.3% of semi-transparent moderately thick clouds (CT=12) from MSG3 CT are classified semi-transparent above low or medium clouds (CT=14) using MTG-I1 data. In both cases, they are semi-transparent clouds.

4.2.6 Over sea during twilight

As for former sections, the conclusion for cloud classification with MTG-I1 and MSG3 agree for opaque clouds (very low, low, medium, high and very high clouds) but differences can be noted for fractional clouds and the semi-transparent clouds.

- 28.7% of semi-transparent thin clouds (CT=11) from MSG3 CT are classified fractional clouds (CT=10) using MTG-I1 data. This is due to the different central wavelength between the SEVIRI channels (10.8µm and 3.9µm) and the FCI channels (10.5µm and 3.8µm)
- 19.2% of semi-transparent thick clouds (CT=13) from MSG3 CT are classified high opaque clouds (CT=8) using MTG-I1 data.This is due to the different central wavelength between the SEVIRI channels (10.8µm and 12.0µm) and the FCI channels (10.5µm and 12.3µm)

Cloud Type		**MSG**								
		5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
MTG	**5**	95.6	0.5	0	0	0	0.4	0	0	0
	6	1.2	98.6	0.9	0	0	0.4	0	1.7	0
	7	0	0.5	97.8	0.7	0	0	0	1.2	0
	8	0	0	0.9	98.8	4.9	0	0	0	19.2
	9	0	0	0	0	95.0	0	0	0	1.7
	10	3.2	0	0	0	0	97.3	28.7	1.4	0
	11	0	0	0	0	0	1.3	66.7	0.8	0
	12	0	0	0	0	0	0.6	4.4	93.7	5.7
	13	0	0	0	0	0	0	0	0	73.3

Table 16: Confusion matrix: comparison of CT/MSG3 against CT/MTG-I1 over sea during nighttime

4.3 CONCLUSION FOR THE CLOUD DETECTION AND CLASSIFICATION

Cloud classifications processed with MTG-I1 data and cloud classifications processed with MSG3 data were compared. A visual comparison of cloud types from MTG-I1 and MSG3 shows a good agreement (see Figure 1). However, there are some differences which were analyzed.

For opaque clouds, the agreement is very good, for all terrain and illuminations.

Some differences were highlighted between fractional and semi-transparent clouds classifications, and between opaque high clouds and semi-transparent thick clouds. Semi-transparent thick clouds class and high opaque clouds class are considered to be adjacent classes, and it can be difficult to determine if a cloud is high opaque or semitransparent thick cloud, without independant observations. This different classification is due to the different central wavelength between the SEVIRI channels (10.8 micron and 12.0 microns) and the FCI channels (10.5 microns and 12.3 microns).

In all conditions and taking as references Cloud Type from MSG3, the Cloud Type from MTG-I1 reaches the Optimal accuracy for the opaque high clouds and for the low clouds. It reaches the threshold accuracy and sometime the target accuracy for the semi-transparent clouds. (See Table 17)

The new EarthCare mission has just started at the time of writing and arrives too late to be used to tune and validate the algorithm of this first version for MTG-I1. However, L2 products from this mission will be used to perform a second tuning of the algorithm after a deeper analyse, and an extended validation for the next version “MTG Day-2".

MTG-I1 v2025	Low clouds	Semi-transparent	High clouds
Optimal accuracy	90.0%	90.0%	90.0%
Target accuracy	70.0%	70.0%	70.0%
Threshold accuracy	50.0%	50.0%	50.0%

Table 17: Product Requirement Table for classification ([AD.6])

4.4 EXAMPLES OF CLOUD TYPES IMPROVEMENTS WITH MTG-I1 DATA

The 2 cloud classifications derived from MTG-I1/FCI and MSG3/SEVIRI data are very similar (See figure1). Note that off the coast of south America, an area of clouds classified as fractional clouds by MSG3 was classified as thin semi-transparent clouds using data from MTG-I1/FCI, thanks to the use of the 1.38 micron channel. (See Figure 2)

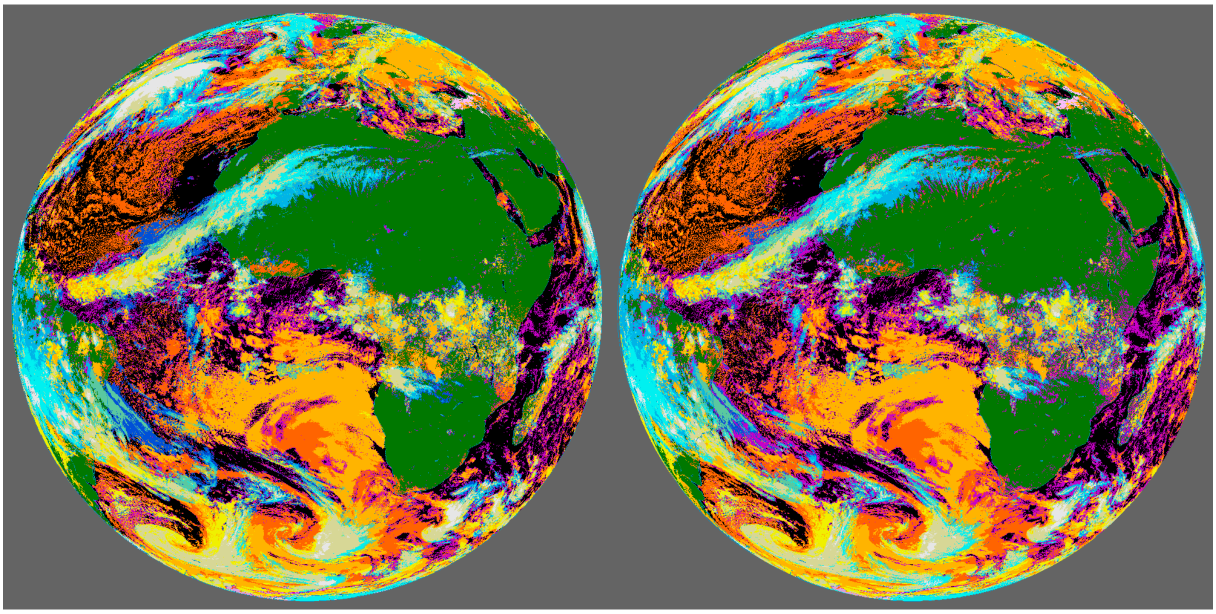

Figure 1: on the left CT for MTG-I1 valid for 20241203 09UTC and on the right CT for MSG3 valid for 20241203 09UTC.

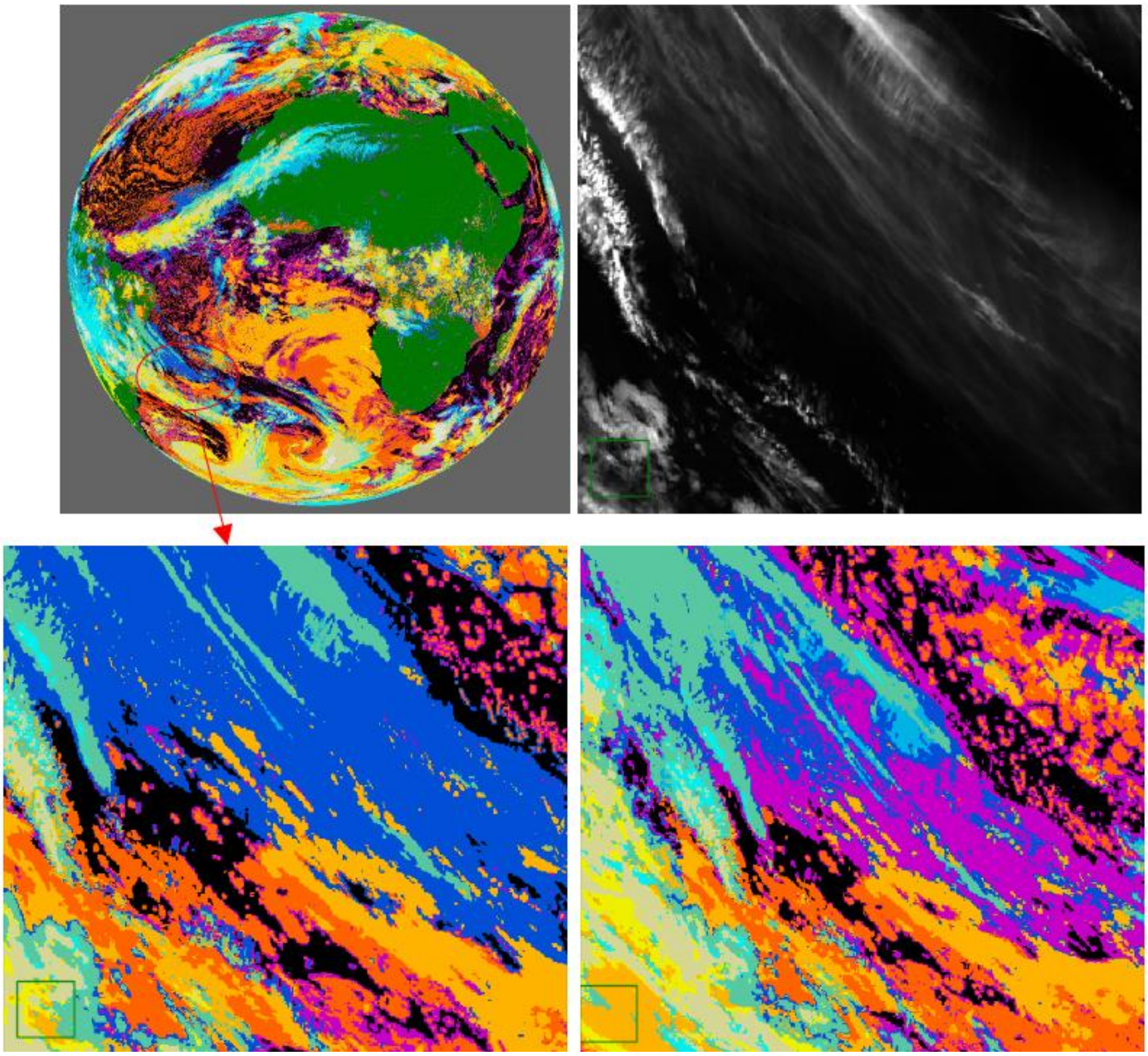

Figure 2: Top left: CT from MTG-I1 valid for 20241203 09UTC. Top right: Zoom on the "cirrus" channel 1.38 microns. Bottom: Zoom on the same area, where thin semi-transparent clouds are better classified (deep blue) using the "cirrus" channel available with MTG-I1/FCI data (on the left) than using MSG3 data, where these clouds are classified as fractional clouds (purple, on the right).

18Detection of very low clouds over land in nighttime is also improved when using MTG-I1/FCI data. Figure 3 illustrates this improved detection over Brittany on 29 November 2024 at 00UTC. The SYNOP messages from Brest, Nantes and Rennes indicate 8 octas of low clouds.

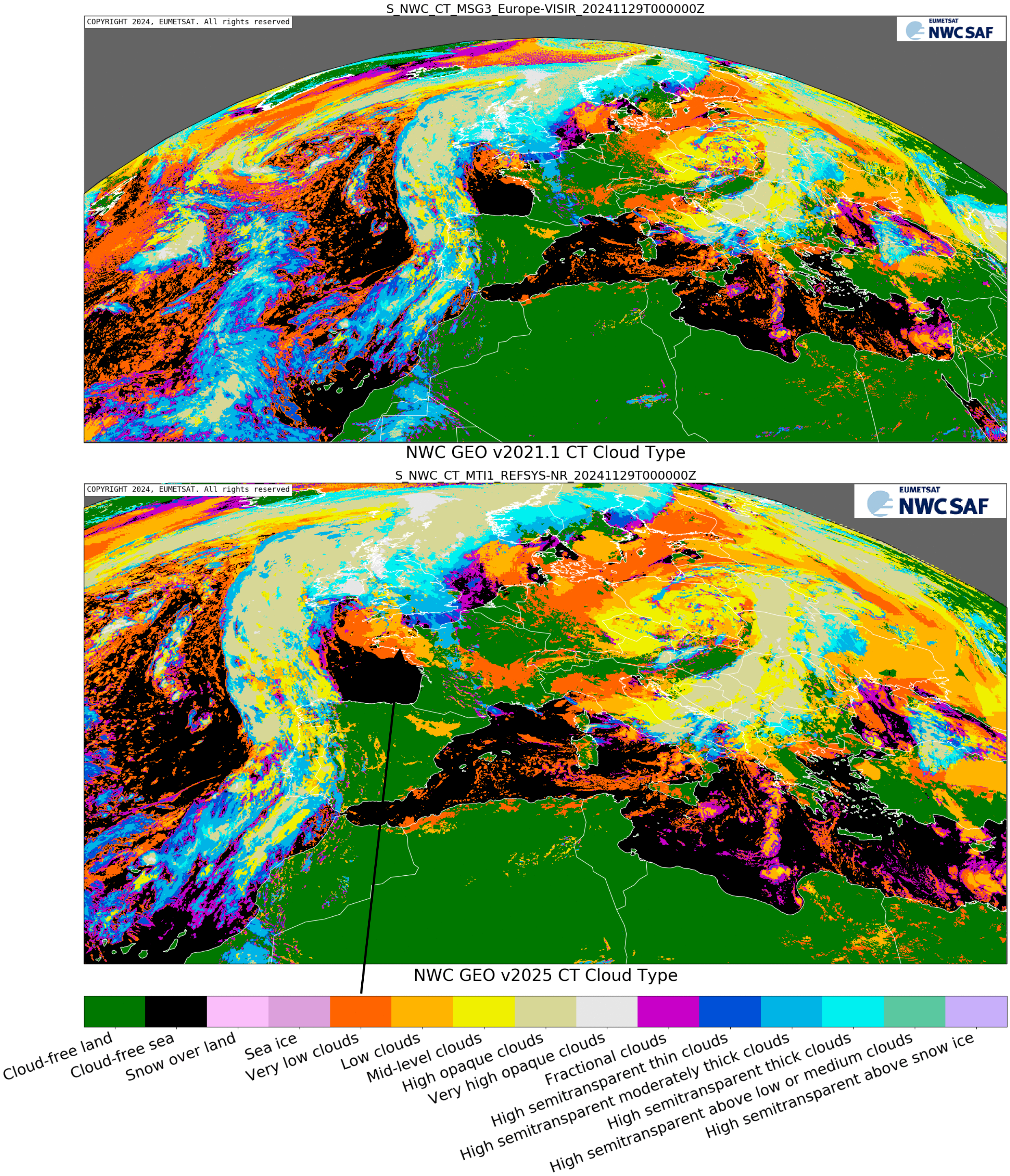

Figure 3: Top: Cloud classification from MSG3 valid for 20241129 at 00UTC.Detections of very low clouds are missing over Brittany. Bottom: Cloud Classification from MTG-I1 for the same slot. The very low clouds are detected (orange) over Brittany. (Illustrations from NWCSAF website)

5 CLOUD TOP TEMPERATURE AND HEIGHT (GEO-CTTH) VALIDATION

5.1 METHODOLOGY OUTLINE

Cloud top altitude and temperature are deduced directly from the pressure estimated by the CTTH algorithm and the NWP vertical profiles. As the NWP model used with MTG-I1 and MSG3 is the same, we have chosen here to show the comparison only in terms of cloud top altitudes.

The MTG-I1 and MSG3 data are not at the same horizontal resolution (2 km vs 3 km at nadir). For comparison purposes, cloud top altitudes estimated from MTG-I1 are first oversampled on a 1x1 km2 grid and then averaged on 3x3 km2 boxes, matching perfectly with the geometry of MSG3 pixels.

As shown above, there may be some differences in cloud typing (CT) between MTG-I1 and MSG3. CT is used as input to the CTTH algorithm, helping to choose the method for restitution. However, the aim here being simply to compare the performance of the CTTH algorithm, only pixels for which the CT are homogeneous and identical with MTG-I1 and MSG3 within the 3x3 km2 boxes are retained.

Contingency tables and statistical scores are computed for the period described in 2.1 and presented separately for opaque and semi-transparent clouds.

5.2 COMPARISON AGAINST MSG3

5.2.1 Opaque clouds

In this section, we compare cloud top altitude retrievals from MSG3 and MTG-I1 for opaque clouds.

The cloud top distributions of MTG-I1 and MSG3 presented in Figure 4 are centered on the first bisector (y=x), meaning that differences are close to 0 on average. This is confirmed by the distribution of differences displayed in Figure 5.

The mean bias of MTG-I1 compared to MSG3 is very low (-15 m). The first and last deciles of differences are around ±300 m and first and last percentiles are around ±1100 m.

The large differences sometimes observed are partially linked to the different methods used in the algorithm. If we restrict the selection of pixels to those for which the same CTTH restitution method has been used for both MTG-I1 and MSG3, the size of the dataset is reduced by 14% and the dispersion is significantly reduced (Figure 6 and Figure 7).

The mean bias of MTG-I1 compared to MSG3 is still very low (-10 m), and the first and last deciles drop to around ±200 m and first and last percentiles decrease to roughly ±700 m.

For opaque clouds, the threshold accuracy is fixed to 1000 m, and the target accuracy to 750 m. The target was reached in the previous version of the software with MSG3 compared to the CALIOP lidar measurements (bias of –460 m). Assuming that the performance of MSG3 during this study is identical to that of the previous validation and considering that the mean bias between MTG-I1 and MSG3 is very low, MTG-I1 would likely meet this requirement too. It is not possible to conclude concerning the requirement about the standard deviation (2000 m for the accuracy threshold).

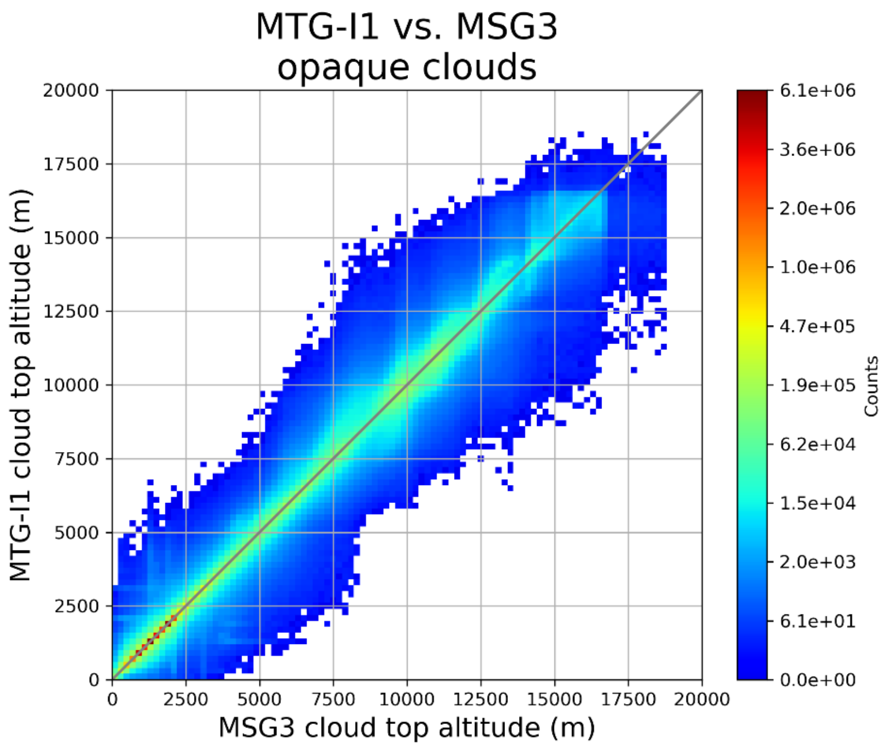

Figure 4: Distribution of opaque cloud top altitudes from MTG-I1 versus MSG3 for pixels with the same cloud type (CT).

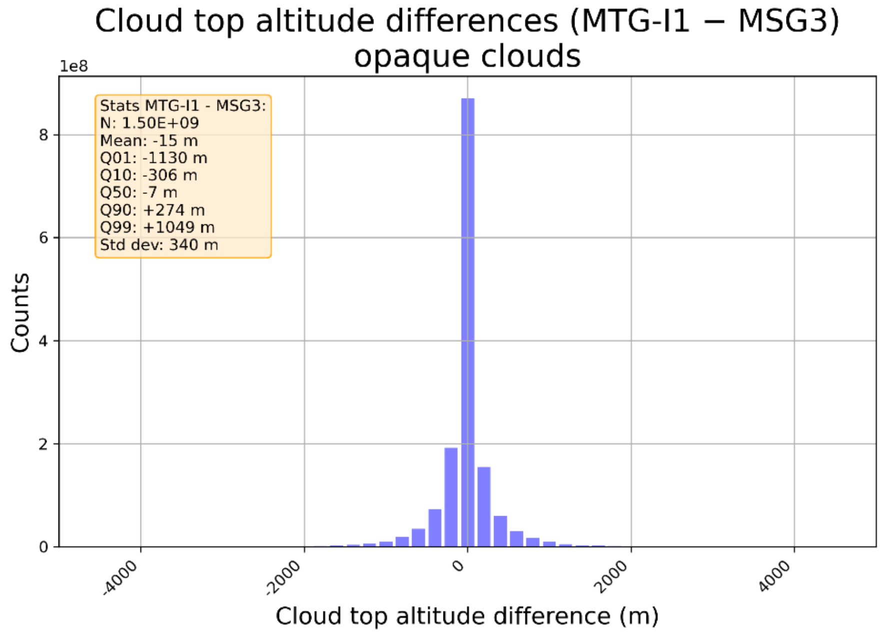

Figure 5: Distribution of opaque cloud top altitudes differences between MTG-I1 and MSG3 for pixels with the same cloud type (CT).

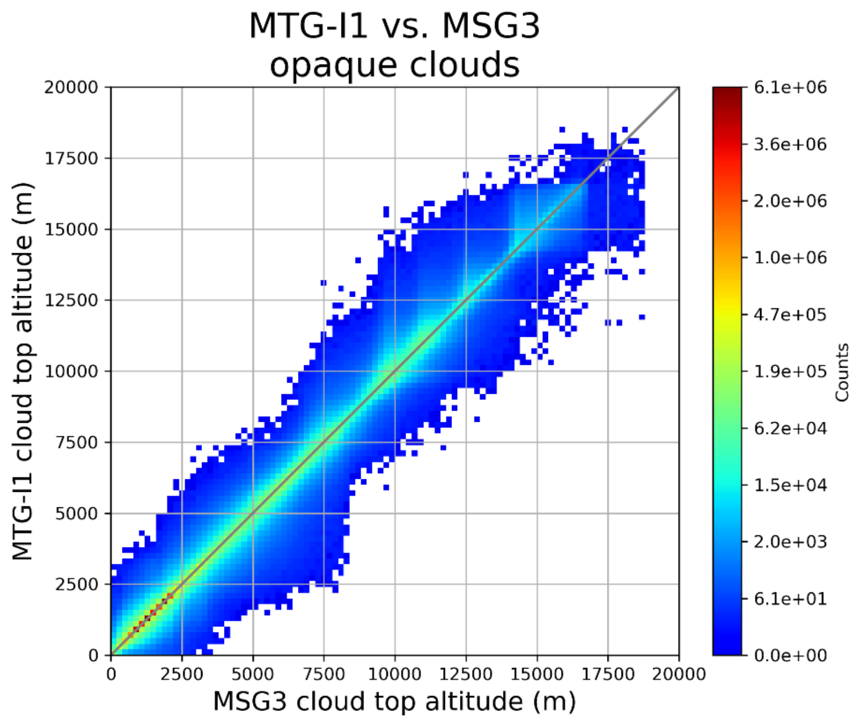

Figure 6: Distribution of opaque cloud top altitudes from MTG-I1 versus MSG3 for pixels with the same cloud type (CT) and processed with the same CTTH method.

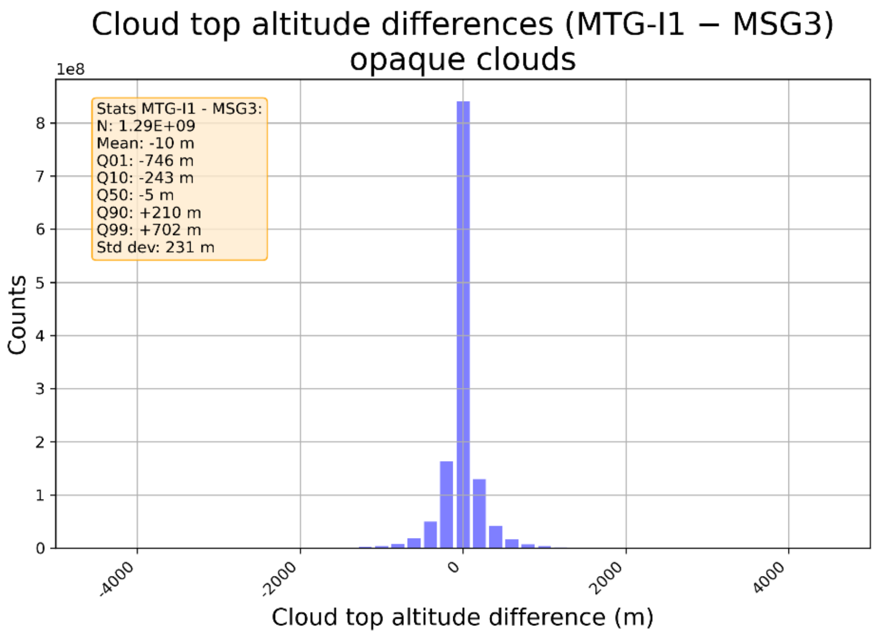

Figure 7: Distribution of opaque cloud top altitudes differences between MTG-I1 and MSG3 for pixels with the same cloud type (CT) and processed with the same CTTH method.

5.2.2 Semi-transparent clouds

In this section, we compare cloud top altitude retrievals from MSG3 and MTG-I1 for semi-transparent clouds.

The cloud top distributions of MTG-I1 and MSG3 presented in Figure 8 are centered on the first bisector (y=x), meaning that differences are close to 0 on average. However, the dispersion is much greater than with opaque clouds. This is confirmed by the distribution of differences displayed in Figure 9.

The distribution of differences is slightly asymmetrical and shifted toward positive values (mean difference of +208 m). The first and last deciles of differences are around -700 and +1400 m respectively, whereas first and last percentiles exceed ±3000 m.

If we restrict the selection of pixels to those for which the same CTTH restitution method has been used for both MTG-I1 and MSG3, the size of the dataset is reduced by 42% and the dispersion is a bit reduced (Figure 10 and Figure 11).

The distribution of differences is still a bit asymmetrical and shifted toward positive values but the mean bias of MTG-I1 compared to MSG3 is more than halved (+81 m). First and last deciles are reduced by 100 to 500 m and first and last percentiles by roughly 700 m.

For semi-transparent clouds, the threshold accuracy is fixed to 2000 m, and the target accuracy to 1500 m. The target was reached in the previous version of the software with MSG3 compared to the

CALIOP lidar measurements (bias of –1260 m). Assuming that the performance of MSG3 is identical to that of the previous validation and considering that the mean bias between MTG-I1 and MSG3 is slightly positive, MTG-I1 would likely meet this requirement too, and probably better than MSG3. It is not possible to conclude concerning the requirement about the standard deviation (2000 m for the accuracy threshold).

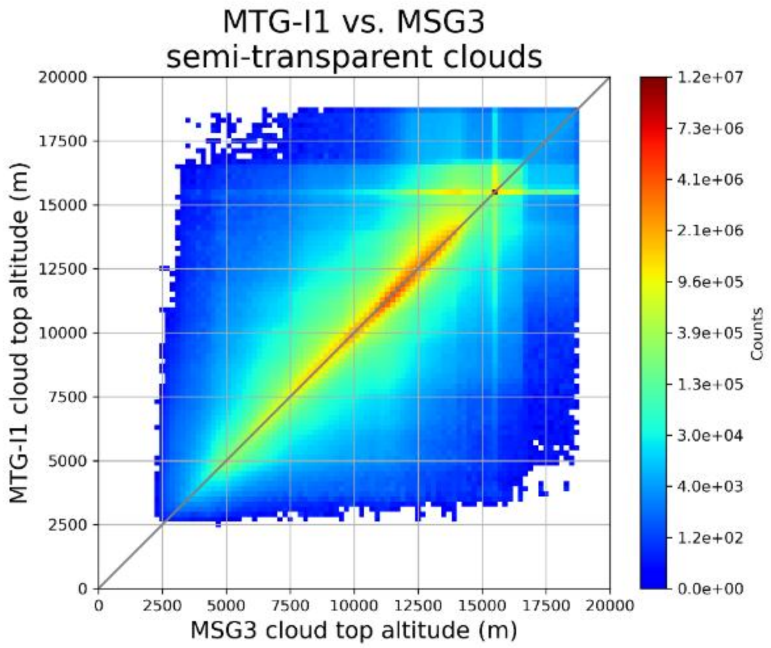

Figure 8: Distribution of semi-transparent cloud top altitudes from MTG-I1 versus MSG3 for pixels with the same cloud type (CT).

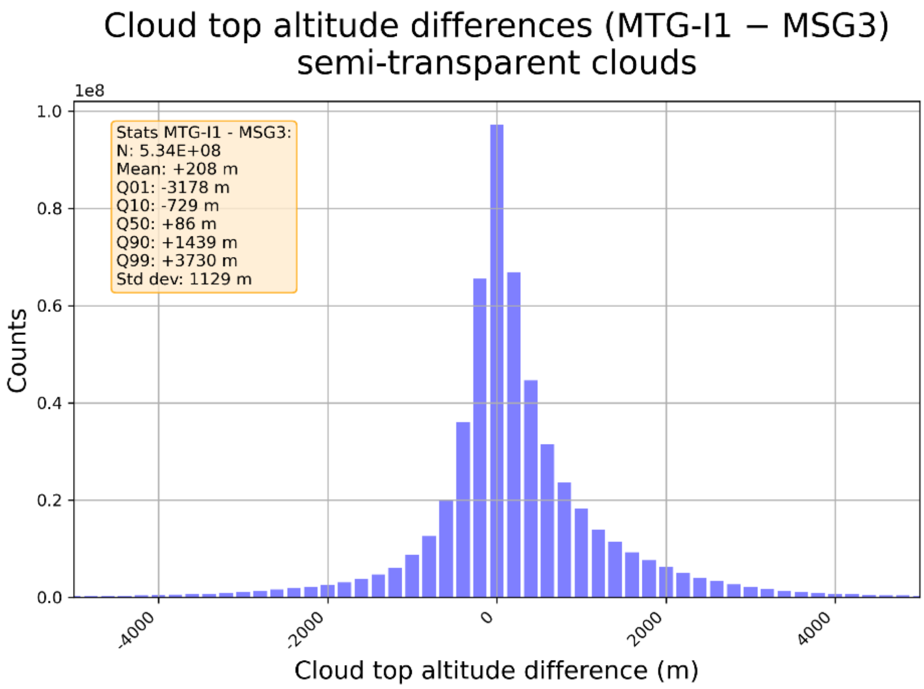

Figure 9: Distribution of semi-transparent cloud top altitudes differences between MTG-I1 and MSG3 for pixels with the same cloud type (CT).

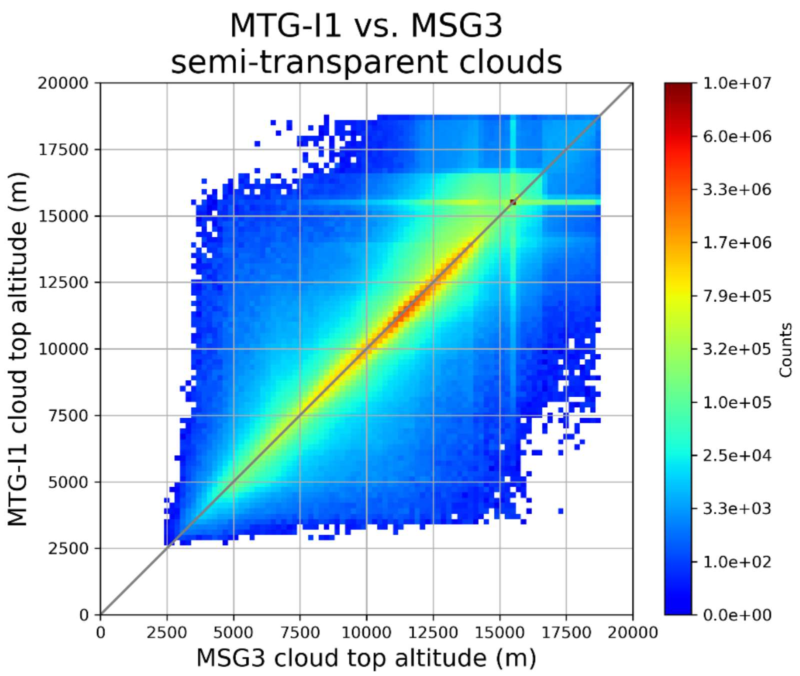

Figure 10: Distribution of semi-transparent cloud top altitudes from MTG-I1 versus MSG3 for pixels with the same cloud type (CT) and processed with the same CTTH method.

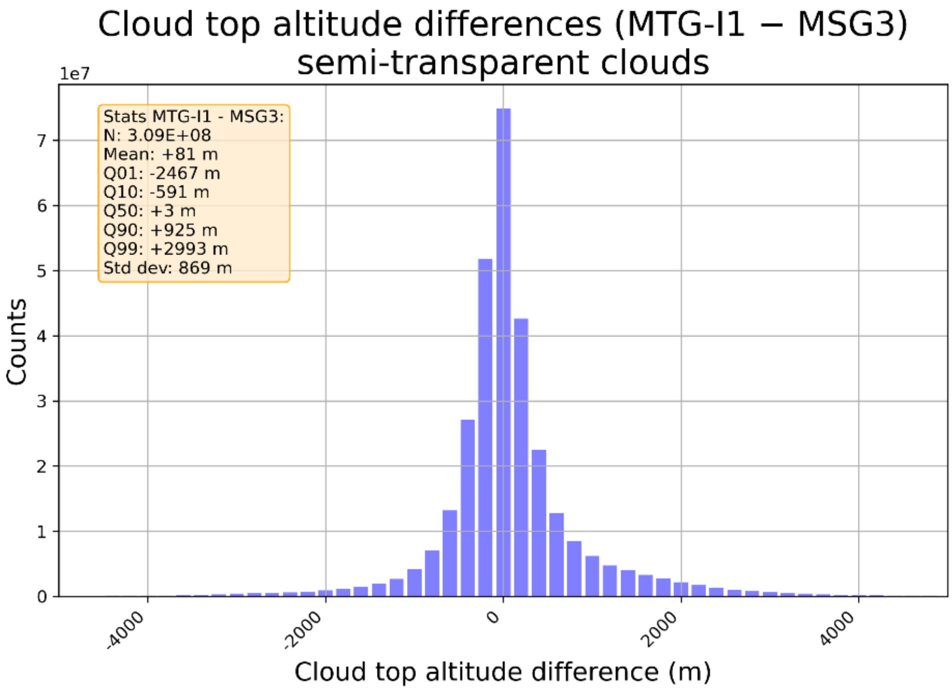

Figure 11:Distribution of semi-transparent cloud top altitudes differences between MTG-I1 and MSG3 for pixels with the same cloud type (CT) and processed with the same CTTH method.

5.3 CONCLUSION FOR CTTH

Cloud top altitudes processed both with MTG-I1 and MSG3 data were compared systematically for a selection of 27 days between October 2024 and February 2025. There is a general good agreement between both datasets.

This is particularly true for opaque clouds for which differences are centered around 0 with a rather low dispersion.

Concerning semi-transparent clouds, they tend to be slightly higher on average with MTG-I1 (+208 m) whatever the method considered for the restitution. The differences with MSG3 disperse more than with opaque clouds.

Assuming identical performances of MSG3 since the last validation made with CALIOP lidar, we can affirm that MTG-I1 CTTH reaches the target accuracy for bias both for opaque and semi-transparent clouds. It is not possible to conclude for standard deviation and we have to wait for validation data (EarthCare).

6 CLOUD MICROPHYSICS (GEO-CMIC)

6.1 METHODOLOGY OUTLINE

CMIC products are averaged over a box of 3 by 3 pixels for MTG-I1 retrievals and a box of 2 by 2 pixels for MSG3 retrievals i.e. 6 by 6 km at satellite's nadir. The following is the list of conditions in order that the average pixels for MSG3 and MTG-I1 are kept in the comparison:

- For cloud top Phase for day and night:
    - All CT (cloud types) pixels in the box must be equal or the same
- For cloud top effective radius (Reff), cloud optical thickness (COT) and liquid/ice water path (LWP/IWP):
    - All CT (cloud types) pixels in the box must be the same
    - All CMIC_phase pixels in the box must be the same
    - Satellite zenith angle < 60°

6.2 CLOUD TOP PHASE

This section focuses on the comparison of retrieved Cloud top phase (CMIC_phase) [AD.2.]. Note that for the former version of the NWC/GEO [AD.3.], only ice phase and liquid phase are validated. Hence, we do not include the "mixed phase" in this comparison.

6.2.1 All conditions

This section compares the cloud top phase (CMIC_phase) retrieved during day and night. The contingency tables are computed with the assumption that CMIC_phase from MSG3 is the reference and CMIC phase from MTG-I1 is the one whose accuracy is tested. We recall that the MSG3 CMIC_phase from NWC/GEOv2018 [AD.3.] reached over full disk the threshold accuracy (POD (60.0%/70.0%) and FAR (35%)) and even the target accuracy (POD (80.0%) and FAR (20%)).

In all conditions and taking as references CMIC_phase from MSG3, the CMIC_phase from MTG-I1 reaches the target accuracy for the detection of cloud top with liquid phase (Table 19) and ice phase (Table 20).

		MTG				
		Liquid	NOT liquid	Total	FAR [%]	POD [%]
MSG	Liquid	43,226,402	214,070	43,440,472	0.70	99.50
	NOT liquid	306,807	88,418,885	88,725,692		
	Total	43,533,209	88,632,955	132,166,164		

Table 19: Number of events counted for each condition and Contingency table for the detection of liquid clouds from MTG-I1 regarding MSG3. For day and Night Conditions.

		MTG				
		Ice	NOT Ice	Total	FAR [%]	POD[%]
MSG	Ice	84,730,937	21,835	84,752,772	3.72	99.97
	NOT Ice	3,277,448	44,135,944	47,413,392		
	Total	88,008,385	44,157,779	132,166,164		

Table 20: Number of events counted for each condition and Contingency table for the detection of ice clouds from MTG-I1 regarding MSG3. For day and Night Conditions.

6.2.2 During Night only

In this section we are focusing on CMIC_phase retrieved during the night, especially at 1h00 and 1h30 UTC, when mostly all MSG3 and MTG-I1 are in "night condition" (with pixels with satellite zenith angle smaller than 70°).

		MTG				
		Liquid	NOT liquid	Total	FAR [%]	POD [%]
MSG	Liquid	2,050,779	3,748	2,054,527	0.98	99.81
	NOT liquid	20,420	4,836,149	4,856,569		
	Total	2,071,199	4,839,897	6,911,096		

Table 21: Number of events counted for each condition and Contingency table for the detection of liquid clouds from MTG-I1 regarding MSG3. For Night Condition.

		MTG				
		Ice	NOT Ice	Total	FAR [%]	POD [%]
MSG	Ice	4,534,364	43	4,534,407	5.54	99.999
	NOT Ice	265,914	2,110,775	2,376,689		
	Total	4,800,278	2,110,818	6,911,096		

Table 22: Number of events counted for each condition and Contingency table for the detection of ice clouds from MTG-I1 regarding MSG3. For Night Condition.

During the night and taking as references CMIC_phase from MSG3, the CMIC_phase from MTG-I1 reaches the target accuracy for the detection of cloud top with liquid phase (Table 21) and ice phase (Table 22).

6.2.3 During the day

In this section we are focusing on CMIC_phase retrieved during the day, especially at 13h00 and 13h30 UTC, when mostly all MSG3 and MTG-I1 are in "day condition" (with pixels with satellite zenith angle smaller than 70°).

		MTG				
		Liquid	NOT liquid	Total	FAR [%]	POD [%]
MSG	Liquid	1,399,639	15,899	1,415,538	0.40	98.88
	NOT liquid	5,734	2,383,719	2,389,453		
	Total	1,405,373	2,399,618	3,804,991		

Table 23: Number of events counted for each condition and Contingency table for the detection of liquid clouds from MTG-I1 regarding MSG3. For day Condition.

		MTG				
		Ice	NOT Ice	Total	FAR [%]	POD [%]
MSG	Ice	2,357,063	2,343	2,359,406	1.41	99.90
	NOT Ice	33,676	1,411,909	1,445,585		
	Total	2,390,739	1,414,252	3,804,991		

Table 24: Number of events counted for each condition and Contingency table for the detection of ice clouds from MTG-I1 regarding MSG3. For day Condition.

During the day and taking as references CMIC_phase from MSG3, the CMIC_phase from MTG-I1 reaches the target accuracy for the detection of cloud top with liquid phase (Table 23) and ice phase (Table 24).

6.2.4 Conclusions on the retrieval of cloud top phase from MTGI1

We have compared the cloud top phase retrieved from MTG-I1 with the cloud top phase retrieved from MSG3 and we have focused on ice and liquid phase, excluding the mixed phase. Looking these first results, it seems that the new design of the 10.5µm channel on board MTG/FCI does not degrade the distinction of ice and liquid phase at the top of the clouds. We can notice a slight increase of the ice phase detection during night condition (Table 22) compared to day condition (Table 24).

6.3 Cloud microphysics: effective radius, optical thickness, ice and liquid water path

The two next sections compare the cloud microphysic properties retrieved with the GEO-CMIC software from MSG3 (v2021.1) and MTG-I1 (v2025). We recall that for now, cloud microphysics properties are retrieved during day only. These sections will focus on the CMIC products: CMIC_cot (cloud optical thickness in visible), CMIC_reff (cloud top effective radius), CMIC_lwp (liquid water path) and CMIC_iwp (cloud ice water path). The evaluation of these products is separated in two parts, first we focus on liquid clouds i.e. when the cloud top phase is detected as liquid. Then, we focus on ice clouds i.e. when the cloud top phase is detected as ice.

6.3.1 Liquid Clouds

The Figure 11-B shows the distribution of effective radius (CMIC_reff) retrieved from MSG3 observations versus the ones retrieved from MTG-I1 observations. This comparison is distributed along the slope "MSG=MTG" showing that retrieved effective radius are similar from both datasets i.e. MSG3 and MTG-I1. However, the Table 25 points out a median relative difference of less than -4%, making effective radius from MTGI1 slightly underestimated compared to the one retrieved from MSG3. Similar conclusions can be driven for retrieved Cloud optical thickness (COT;Figure 11-A) and Liquid water path (LWP; Figure 11-C) with median relative difference of less than -1% and -5%, respectively (Table 25: Relative difference in percentage of MTG-I1 Reff, COT and LWP regarding the one retrieved for MSG3. For liquid clouds. The differences are rounded. Note that former version of the CMIC software, only liquid water path has been validated with other retrieval techniques using passive micro-wave observations (SSMI or AMSR). In this case, validations were only performed over ocean. The liquid water path retrieved from MSG for the version 2018 (same as v2021.1) reaches the target accuracy.

Rel. Diff. Quantiles in %	10th	25th	median	50th	75th
Reff	-21	- 13	-4	8	25
COT	-28	-15	-1	20	51
LWP	-38	-23	-5	23	66

Table 25: Relative difference in percentage of MTG-I1 Reff, COT and LWP regarding the one retrieved for MSG3. For liquid clouds. The differences are rounded.

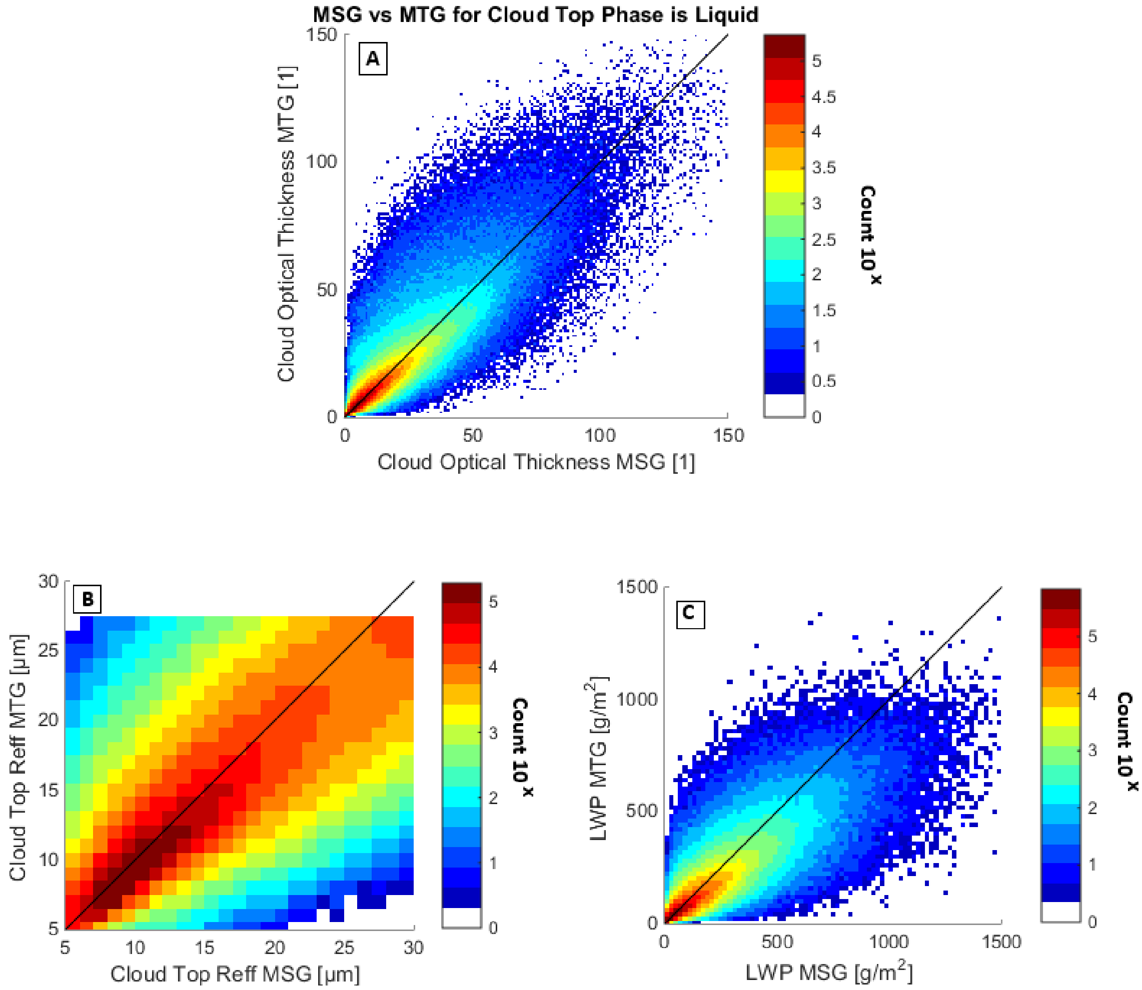

Figure 12 : A) Distributions of effective radius retrieved for MSG3 on x-axis versus effective radius retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale. B) Distributions of Cloud Optical Thickness retrieved for MSG3 on x-axis versus Cloud Optical Thickness retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale. C) Distributions of Liquid Water Path retrieved for MSG3 on x-axis versus Liquid Water Path retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale.

6.3.2 Ice Clouds

The results are similar with the section above for the comparison of microphysical parameters for ice clouds and retrieved with MTG-I1 observations on one side and MSG3 observations on the other side. Indeed, the parameters retrieved with MTG-I1 versus with MSG3, such Cloud optical thickness (Figure 13-A) , effective radius (Figure 13-B) and Ice water path (IWP ; Figure 13-C), are distributed along the line "MSG=MTG". And the Table 26 gives median relative difference of MTG-I1 regards MSG3 of about less than -4% for effective radius and less than -1% for both cloud optical thickness and Ice water path.

Rel. Diff. Quantiles in %	10th	25th	median	50th	75th
Reff	-25	- 10	-4	3	16
COT	-21	-11	-1	12	33
LWP	-24	-13	-1	12	32

Table 26: Relative differences in percentage of MTG-I1 Reff, COT and LWP regarding the one retrieved for MSG3. For ice clouds.

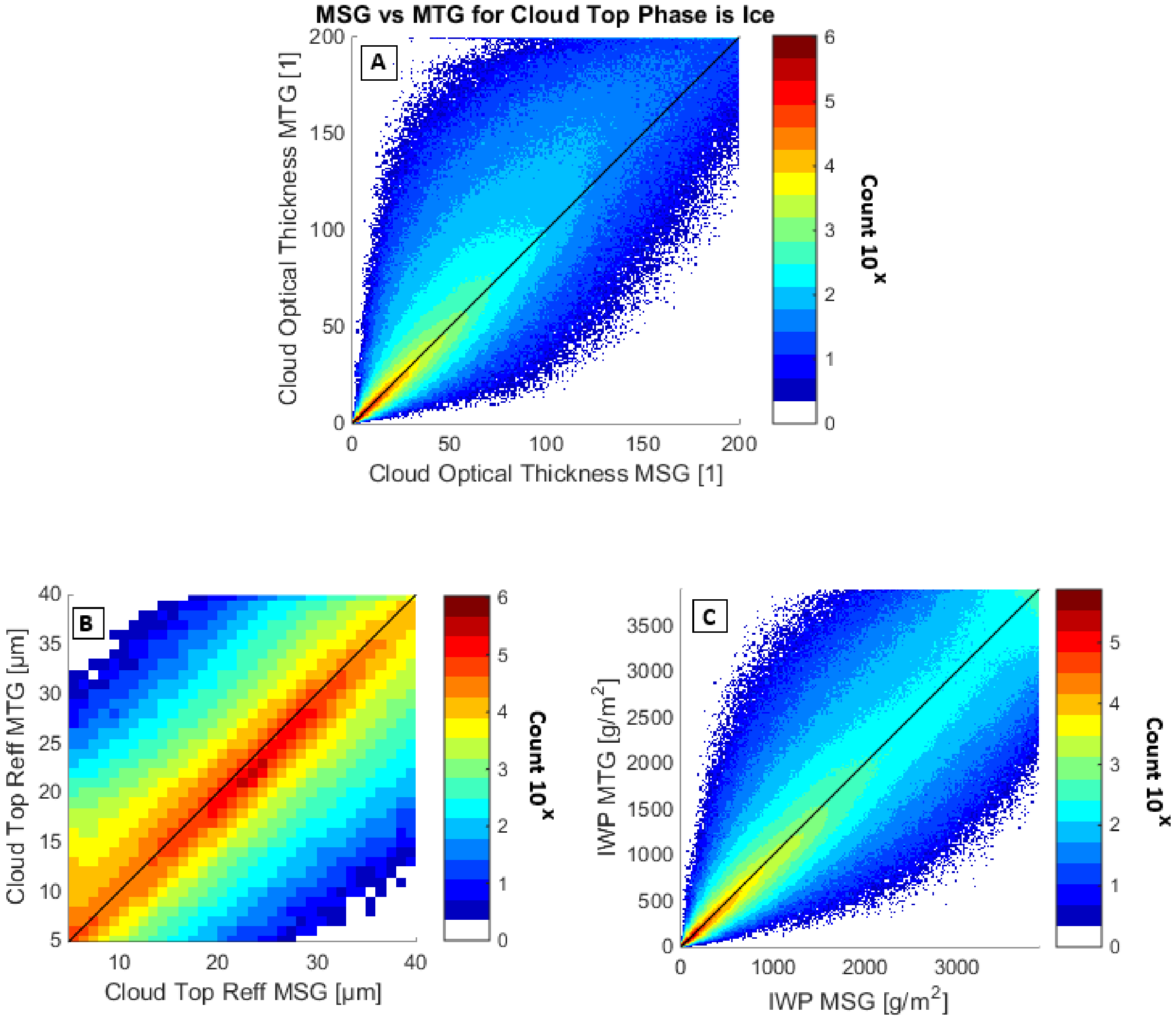

Figure 13: A) Distributions of Cloud top effective radius retrieved for MSG3 on x-axis versus Cloud top effective radius retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale. B) Distributions of Cloud Optical Thickness retrieved for MSG3 on x-axis versus Cloud Optical

Thickness retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale. C) Distributions of Ice Water Path retrieved for MSG3 on x-axis versus Ice Water Path retrieved for MTG-I1 on y axis. The color scale gives the density in logarithmic scale.

Note that when selecting the condition (i.e., a 3 by 3 pixels box with the same cloud type and cloud top phase for all pixels), the average Cloud Optical Thickness (COT) of MTG cannot reach values higher than 200. However, when examining the infrared resolution of MTG (i.e., 2 km), the COT can reach 250 in areas where deep convective clouds can be identified.

6.3.3 Conclusions on the retrieval of microphysics of liquid and ice clouds

The two previous sections show that cloud microphysics retrieved from MTG-I1 slightly underestimate (between 1% and 5%) the one retrieved from MSG3 for the full disc and centered at the longitude 0°.