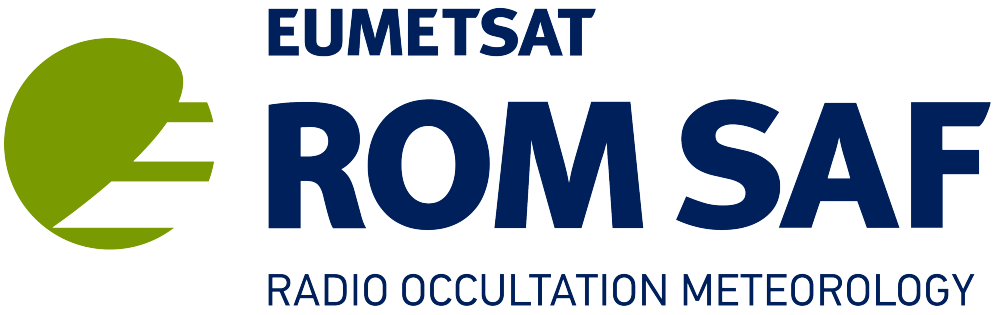

Validation Report: Offline Level 2C tropopause height products

Version 1.1

14 May 2020

ROM SAF Consortium
Danish Meteorological Institute (DMI)
European Centre for Medium-Range Weather Forecasts (ECMWF)
Institut d'Estudis Espacials de Catalunya (IEEC)
Met Office (UKMO)

Ref: SAF/ROM/DMI/REP/TPH/002

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1.0draft	16 March 2020	JKN	Version prepared for ORR12 review.
1.0	16 March 2020	JKN	Minor changes from KBL.
1.1	14 May 2020	JKN	Updated version prepared for ORR12 Closeout implementing the following: - Section 3.1.1: Ins. expl. start/end [RIDs 078, 134] - Section 3.1.1: Removed last p. [RID 079] - Fig 3.1: Removed zoomed in figure [RID 133] - Fig 3.3: Inserted caption [RID 081] - Fig 3.4: Axis expanded [RID 082, 134] - Fig 3.4: Caption and text ins. [RID 083, 134] - Section 3.2: New subsec.+fig; Metop C [RIDs 080, 133] - Exec. Sum, Chapters 4 and 6, Sec. 2.1: Metop C mentioned [RID 133] - Section 2.1: Inserted reference to CDR v1.0 validation report. - Chapter 5: Inserted “limitations” and made text more precise.

ROM SAF

The Radio Occultation Meteorology Satellite Application Facility (ROM SAF) is a decentralised processing centre under EUMETSAT which is responsible for operational processing of radio occultation (RO) data from the Metop and Metop-SG satellites and radio occultation data from other missions. The ROM SAF delivers bending angle, refractivity, temperature, pressure, humidity, and other geophysical variables in near real-time for NWP users, as well as reprocessed Climate Data Records (CDRs) and Interim Climate Data Records (ICDRs) for users requiring a higher degree of homogeneity of the RO data sets. The CDRs and ICDRs are further processed into globally gridded monthly-mean data for use in climate monitoring and climate science applications.

The ROM SAF also maintains the Radio Occultation Processing Package (ROPP) which contains software modules that aid users wishing to process, quality-control and assimilate radio occultation data from any radio occultation mission into NWP and other models.

The ROM SAF Leading Entity is the Danish Meteorological Institute (DMI), with Cooperating Entities: i) European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, United Kingdom, ii) Institut D'Estudis Espacials de Catalunya (IEEC) in Barcelona, Spain, and iii) Met Office in Exeter, United Kingdom. To get access to our products or to read more about the ROM SAF please go to: `http://www.romsaf.org`.

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List of Contents

Executive Summary

The ROM SAF Offline tropopause height product (product version v1.1) is based on data from the Metop mission, including the three satellites Metop A,B and C. These data are being processed from Level 1A (excess phase) to Level 2 (profiles of meteorological parameters) and Level 3 (latitudinal gridded monthly means).

This report documents the validation of the Level 2C dry temperature lapse rate tropopause height, product version 1.1, against ERA5. It is concluded that the product requirement target is only met in the tropics. But the latitude range, in which the service specifications can be applied, can be extended a little in comparison to the Offline v1.0 SeSp.

The report is concluded with an updated set of service specifications for the Offline v1.1 Level 2C tropopause products, which in effect are more strict than the service specifications for Offline v1.0.

1 Introduction

1.1 Purpose of document

This purpose of this validation report is to assess the Offline Level 2C dry temperature lapse rate tropopause height (DLTH), version 1.1, produced by the Radio Occultation Meteorology (ROM) Satellite Application Facility (SAF). The complete list of tropopause height (TPH) products covered by this report is provided in Table 1.1. The product requirements baseline is the PRD [AD.3], and the methods and algorithms used to calculate the products are described in [RD.5].

1.1.1 List of products being validated in this report

Table 1.1: *List of products covered by this Validation Report.*

Product ID	Product name	Product acronym	Product type	Mission	Dissemination means	Dissemination format
GRM-24	Tropopause Height	TPH	OFL	Metop Level 1A data from EUM Secretariat	web	netCDF

1.2 Applicable and Reference documents

1.2.1 Applicable documents

The following list contains documents with a direct bearing on the contents of this document.

[AD.1] CDOP-3 Proposal: Proposal for the Third Continuous Development and Operations Phase (CDOP-3); Ref: SAF/ROM/DMI/MGT/CDOP3/001 Version 1.2 of 31 March 2016, Ref: EUM/C/85/16/DOC/15, approved by the EUMETSAT Council at its 85th meeting on 28-29 June 2016.

[AD.2] CDOP-3 Cooperation Agreement: Agreement between EUMETSAT and DMI on the Third Continuous Development and Operations Phase (CDOP-3) of the Radio Occultation Meteorology Satellite Applications Facility (ROM SAF), Ref. EUM/C/85/16/DOC/19, approved by the EUMETSAT Council and signed at its 86th meeting on 7 December 2016.

[AD.3] ROM SAF Product Requirements Document,
Ref. SAF/ROM/DMI/MGT/PRD/001.

1.2.2 Reference Documents

The following documents provide supplementary or background information, and could be helpful in conjunction with this document:

[RD.1] ROM SAF, Algorithm Theoretical Baseline Document: Level 2B and 2C 1D-Var products, SAF/ROM/DMI/ALG/1DV/002, .

[RD.2] ROM SAF, The Radio Occultation Processing Package (ROPP) Applications Module User Guide, SAF/ROM/METO/UG/ROPP/005, .

[RD.3] ROM SAF, Validation Report: Reprocessed Level 2C tropopause height products(Short title: Validation Report: Reprocessed tropopause products), SAF/ROM-/DMI/REP/TPH/001, 2018.

[RD.4] ROM SAF, Algorithm Theoretical Baseline Document: Level 2A dry temperature profiles., Ref. SAF/ROM/DMI/ALG/TDRY/001, Version 2.0, 2020.

[RD.5] ROM SAF, Algorithm Theoretical Baseline Document: Level 2C Tropopause Height, SAF/ROM/DMI/RQ/REP/002, version 2.0, 2020.

[RD.6] Schmidt, T., Beta testing of ROPP 7.0, ROM SAF VS Report 22, DMI, 2013.

[RD.7] WMO, *Definition of the tropopause*, Bull. 6, World Meteorological Organisation, Geneva, 1957.

1.3 Acronyms and abbreviations

1D-Var	1 Dimensional Variational Retrieval
1DV	Name of the 1D-Var implementation at DMI
ATBD	Algorithm Baseline Document
BG	Background
CDR1	ROM SAF Climate Data Record version 1.
CHAMP	Challenging Mini–Satellite Payload
COSMIC	Constellation Observing System for Meteorology, Ionosphere & Climate
DCTH	Dry Temperature Cold Point Tropopause Height
DCTT	Dry Temperature Cold Point Tropopause Temperature
DLTH	Dry Temperature Lapse Rate Tropopause Height
DLTT	Dry Temperature Lapse Rate Tropopause Temperature
DMI	Danish Meteorological Institute
ECMWF	European Centre for Medium-Range Weather Forecasts
ECMWF(OPER)	ECMWF operational system
ERA-I	ERA-Interim (global atmospheric reanalysis)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FA	Federated Activity
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite Systems (generic name for GPS, GLONASS and the future GALILEO)
GPL	General Public Licence (GNU)
GPS	Global Positioning System (US)
GRAS	GNSS Receiver for Atmospheric Sounding (onboard Metop)
IFS	Integrated Forecasting System
LEO	Low Earth Orbiter
Metop	Meteorological Operational polar satellites (EUMETSAT)
NRT	Near Real Time
NWP	Numerical Weather Prediction
PCD	Product Confidence Data
Q/C	Quality Control
RO	Radio Occultation
ROM SAF	The EUMETSAT Satellite Application Facility responsible for operational processing of radio occultation data from the Metop satellites. Members are DMI (leader), UKMO, ECMWF and IEEC.
ROPP	Radio Occultation Processing Package
SAF	Satellite Application Facility (EUMETSAT)
SeSp	Service Specifications
TBD	To Be Determined
TP	Tangent Point
TPH	Tropopause Height
TPT	Tropopause Temperature
UKMO	United Kingdom Meteorological Office
UT1	Universal Time-1 (proportional to the rotation angle of the Earth)
UTC	Universal Time Coordinated

VAR	Variational analysis; 1D, 2D, 3D or 4D versions (NWP data assimilation technique)
VT	Valid or Verification Time
WMO	World Meteorological Organization

1.4 Definitions

RO data products from the Metop and Metop-SG satellites and RO data from other missions are grouped in *data levels* (Level 0, 1, 2, or 3) and *product types* (NRT, offline, CDR, or ICDR). The data levels and product types are defined below[1]. The lists of variables should not be considered as the complete contents of a given data level, and not all data may be contained in a given data level.

Data levels:

Level 0: Raw sounding, tracking and ancillary data, and other GNSS data before clock correction and reconstruction;

Level 1A: Reconstructed full resolution excess phases, total phases, pseudo ranges, SNRs, orbit information, I, Q values, NCO (carrier) phases, navigation bits, and quality information;

Level 1B: Bending angles and impact parameters, tangent point location, and quality information;

Level 2: Refractivity, geopotential height, "dry" temperature profiles (Level 2A), pressure, temperature, specific humidity profiles (Level 2B), surface pressure, tropopause height, planetary boundary layer height (Level 2C), ECMWF model level coefficients (Level 2D), quality information;

Level 3: Gridded or resampled data, that are processed from Level 1 or 2 data, and that are provided as, e.g., daily, monthly, or seasonal means on a spatiotemporal grid, including metadata, uncertainties and quality information.

Product types:

NRT product: Data product delivered less than: (i) 3 hours after measurement (ROM SAF Level 2 for EPS); (ii) 150 min after measurement (ROM SAF Level 2 for EPS-SG Global Mission); (iii) 125 min after measurement (ROM SAF Level 2 for EPS-SG Regional Mission);

Offline product: Data product delivered from less than 5 days to up to 6 months after measurement, depending on the requirements. The evolution of this type of product is driven by new scientific developments and subsequent product upgrades;

CDR: Climate Data Record generated from a dedicated reprocessing activity using a fixed set of processing software[2]. The data record covers an extended time period

[1] Note that the level definitions differ partly from the WMO definitions: `http://www.wmo.int/pages/prog/sat/dataandproducts_en.php`

[2] (i) GCOS 2016 Implementation Plan; (ii) `http://climatemonitoring.info/home/terminology`

of several years (with a fixed end point) and constitutes a homogeneous data record appropriate for climate usage;

ICDR: An Interim Climate Data Record (ICDR) regularly extends in time a (Fundamental or Thematic) CDR using a system having optimum consistency with and lower latency than the system used to generate the CDR[3].

1.5 Overview of this document

The document is organized as follows:

Chapter 1: Describes the purpose of the document and provides applicable and referenced documents, acronyms and definitions of product levels and types.

Chapter 2: Describes the processing context and the TPH algorithm.

Chapter 3: Contains comparisons between retrieved TPH and ERA5 TPH.

Chapter 4: Summarizes performance with respect to product requirements.

Chapter 5: Here we mention open issues related to the tropopause products.

Chapter 6: Briefly summarizes and concludes the validation.

Appendices: Repeats service specifications for the ROM SAF Offline-v1.1 TPH product.

[3] `http://climatemonitoring.info/home/terminology` (the ICDR definition was endorsed at the 9th session of the joint CEOS/CGMS Working Group Climate Meeting on 29 March 2018).

2 Background

2.1 Brief description of Offline v1.1

The ROM SAF Offline version 1.0 production was initiated in January 2018, with processing of Metop A and B beeing applied on data starting from January 1 2017. The retrieval configuration was basically inherited from the ROM SAF CDR v1.0. The tropopause algorithm is described in the ATBD [RD.5]. The ROM SAF Offline v1.0 was a reprocessing of Metop data which was meant to be subject to future algorithm updates. It was validated along with the release of ROM SAF CDR v1.0 (see [RD.3]).

By August 1 2019 the Offline v1.0 was terminated and a new processing chain, GPAC-v2.4.0.0, has been prepared for Offline v1.1 production. For Level 2C topopause height the main features of the Offline v1.1 upgrade includes use of ERA5 analysis profiles as validation reference instead of ERA-I, inclusion of Metop C data and implementation of a higher order ionospheric correction, which is not expected to have noteworthy impact on the tropopause products.

A couple of bugs regarding treatment of missing values in GPAC-v2.4.0.0 were fixed in GPAC-v2.4.0.1 which was then applied on data starting from 1 June 2019 and ending by 31 October 2019. One thing to keep in mind is that with GPAC-v2.4.0.1 the ERA5 profiles are interpolated from 3-hourly analysis fields instead of 6-hourly (GPAC-v2.4.0.0). These data are the basis of the present validation report.

2.2 Mission and time coverage

The Metop satellites, and the covered periods are given in Table 2.1

Table 2.1: *Satellites, and time periods in the ROM SAF Offline products.*

Satellite	Period
Metop-A	1 January 2017–present
Metop-B	1 January 2017–present
Metop-C	7 March 2019–present

2.3 Input data

The input Level 1A data for ROM SAF Offline products are provided by the EUMETSAT Secretariat as reprocessed Level 1A data (PPF version 4.6). The ERA5 background analysis is provided by ECMWF through the MARS archive.

2.4 Description of TPH algorithm

The ROPP tropopause tool is developed to derive the tropopause height (TPH) and tropopause temperature (TPT) according to 4 different definitions: A bending angle based, a refractivity based and two temperature based tropopause definitions. The temperature tropopause can be derived either from the WMO definition [RD.7], where TPH is defined as "the lowest level at which the lapse-rate (Λ_{WMO}) decreases to 2° C/km or less, provided that the average

lapse-rate between this level and all higher levels within 2 km does not exceed 2° C/km", or it can be derived from the cold point definition, where the TPH is defined as the altitude where temperature is at its minimum. In addition to the four mentioned methods there is also the choice of using dry temperature[1] or wet temperature[2]. In [RD.6] the different tropopause products are discussed. It was recommended to disseminate the cold point along with the WMO tropopause and not to reject double tropopause cases. The dry temperature lapse rate tropopause height (DLTH) has been chosen as the official tropopause product for ROM SAF, but the other products are disseminated as well. Seen from a scientific point of view the dry tropical and mid latitude cold point temperature is an interesting property, due to its impact on stratospheric water vapour mixing ratio. The choice of DLTH as official product is mainly pragmatic: The lapse rate tropopause is more robust than the cold point tropopause and it is defined at mid and polar latitudes. The dry temperature is suitable for the purpose because it has higher resolution than wet temperature, and it is a very good approximation of the physical temperature near the relatively dry tropopause. The DLTH tropopause calculation is done on the un-thinned dry temperature in the atm file. There is no interpolation involved, and all missions are treated the same way. Implementation details are found in [RD.2] and in [RD.5] which also contains quality control description.

[1] The "dry" variables are retrieved from the refractivity simply by ignoring the presence of water vapour. This is a valid assumption in the upper troposphere and in the stratosphere, where the "dry" variables are accurate approximations for the corresponding physical quantities. [RD.4].

[2] The "wet" temperature is retrieved through 1D-Var as described in [RD.1], combining observation and model information. The wet temperature is an accurate estimate of the physical temperature in the upper troposphere and lower stratosphere, but its vertical resolution is limited by the background model resolution.

3 Validation

The validation consists of a comparison of the retrieved DLTH to the ERA5 analysis DLTH.

3.1 Comparison to ERA5 analysis

The ERA5 analysis dry temperature is calculated for each RO profile by first applying the forward model to the model state i.e. calculating the refractivity on the same levels as the observation and then calculating the dry temperature in same way as it is done for an observed RO profile [RD.4]. Hereafter the DLTH is calculated according to the WMO definition [RD.7] from the ERA5 analysis dry temperature.

3.1.1 Zonal coverage

The purpose of this section is to reiterate conclusions, including a plot Figure 3.1, from the CDR-v1.0 validation, to explain why we do not apply service specs outside the tropics. The latitude dependence of the dry temperature lapse rate tropopause was examined in a previous validaton report [RD.3], where ECMWF(OPER) dry temperature lapse rate tropopause height was used as reference. Both ECMWF(OPER) and ERA5 has 137 vertical levels, so it is expected that the representation of the tropopause is very similar in the two models.

It was concluded that it was only meaningful to define service specifications for a narrow ±15 deg tropical latitude band. The reason for this is that multiple tropopause situations and steep horizontal gradients, especially at mid latitudes, leads to very large differences between model based and observation based tropopause height estimates. There is no need to repeat this rationale for Offline v1.1, but we repeat Figure 3.10 from [RD.3] here, in Figure 3.1, where standard deviation and mean difference between Metop and ECMWF(OPER) tropopause hight is shown as function of latitude.

There is a substantial violation of the PRD standard deviation target value of 1 km, especially in the transition between tropics and subtropics. The high resolution retrieved dry temperature has a tendency to cause the algorithm to find the lower tropopause a lttle more often, than is the case for the coarser model dry temperature. Outside the tropics the standard deviation is dominated by outliers. Keeping this in mind, we will restrict the Offline v1.1 SeSp range to a tropical band, but allow the latitude band width to be broadened, based on the time series plotd in section 3.2.

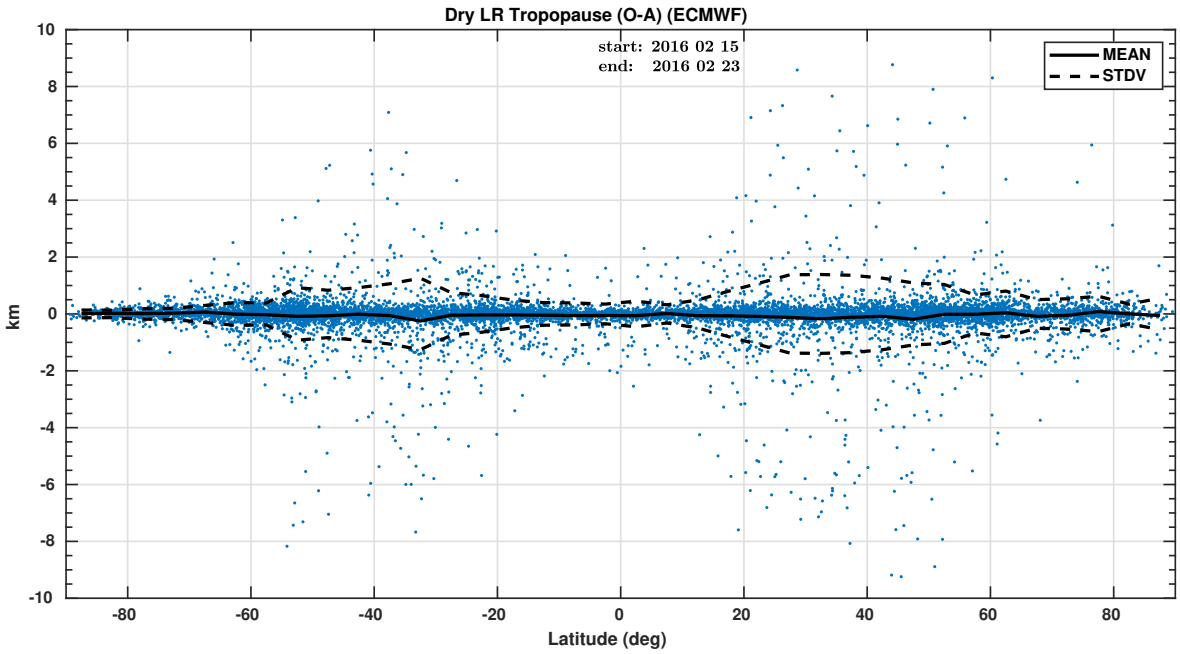

Figure 3.1: *Metop A/B: Standard deviation and Mean of retrieved dry temperature lapse rate tropopause height minus ECMWF (137 Levels) operational analysis dry temperature lapse rate tropopause height as function of latitude.*

3.2 Time series plots

In Figure 3.2 standard deviations of three Offline v1.0 and Offline v1.1 tropopause products (based on refractivity, cold-point and dry lapse rate), are plotted with reference to the ERA-I and ERA5 analysis DLTH. The three tropopause definitions seem to lie more apart from each other in Offline v1.1 versus ERA5, than in Offline v1.0 versus ERA-I, but at the same time the dry temperature lapse rate tropopause is also closest to the model in the Offline v1.1 versus ERA5 case.

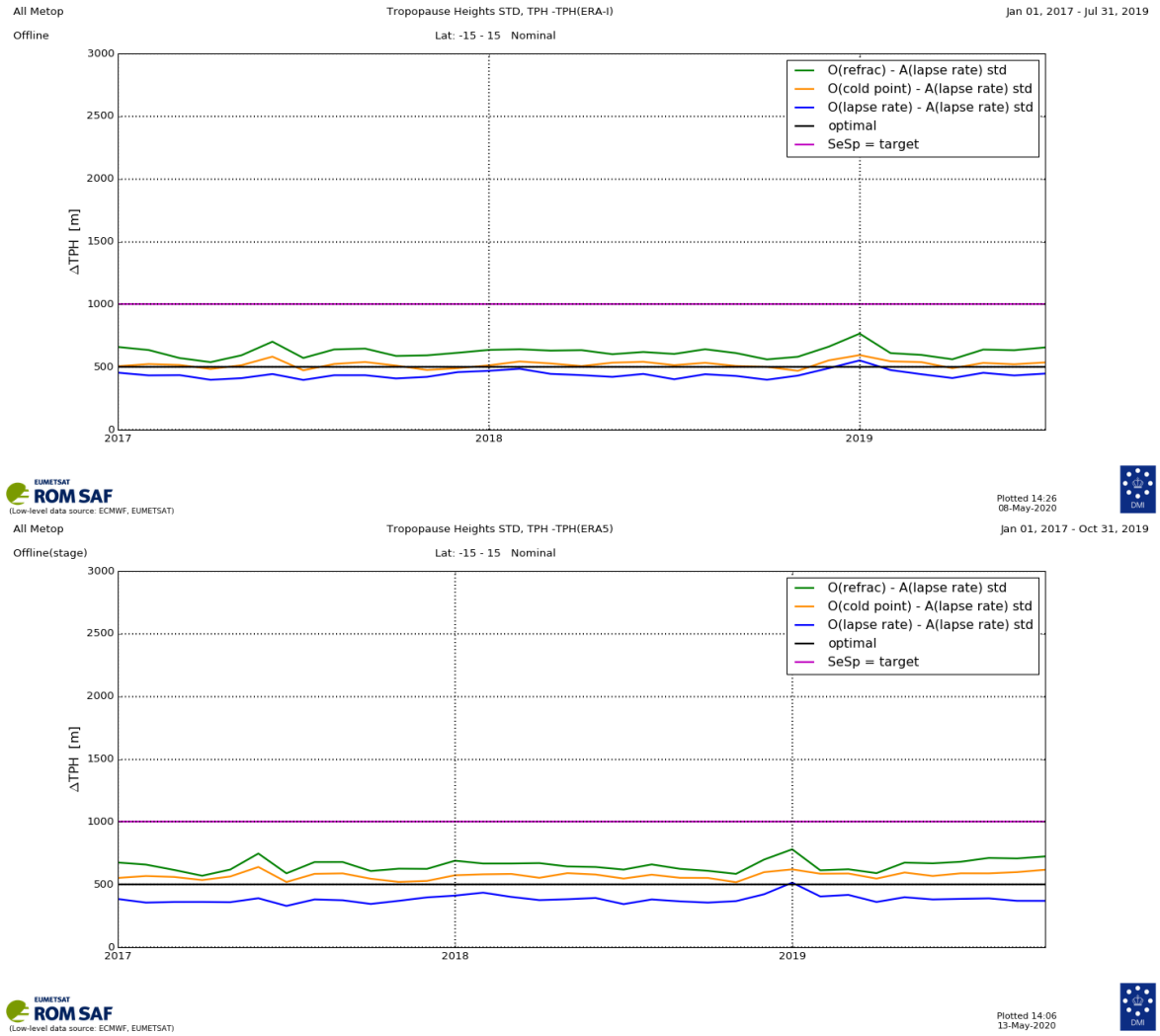

Figure 3.2: *Standard deviation of refractivity based (green), cold-point (yellow) and dry lapse rate (dark blue) tropopause versus reanalysis, averaged over the tropical ± 15 deg latitude band. Top: Offline 1.0 - Era-I, Bottom: Offline 1.1 - ERA5. The plot also shows product requirements, (black and cyan) and current service specification (magenta hidden under cyan lines)*

In figure 3.3 the same comparison is made for a ±30 deg latitude band for Offline v1.0, Offline v1.1 and Offline v1.1. During 34 month the standard deviation of the DLTH minus ERA5 does not come near 1000 m once. Therefore it seems adequate to relax the range where the SeSp is applied to a ±30 deg band. There is however no justification for expanding the band further. In figure 3.4 it is clearly seen that outside the tropics the DLTH - ERA5 standard deviation even exceeds the 2 km product requirement threshold.

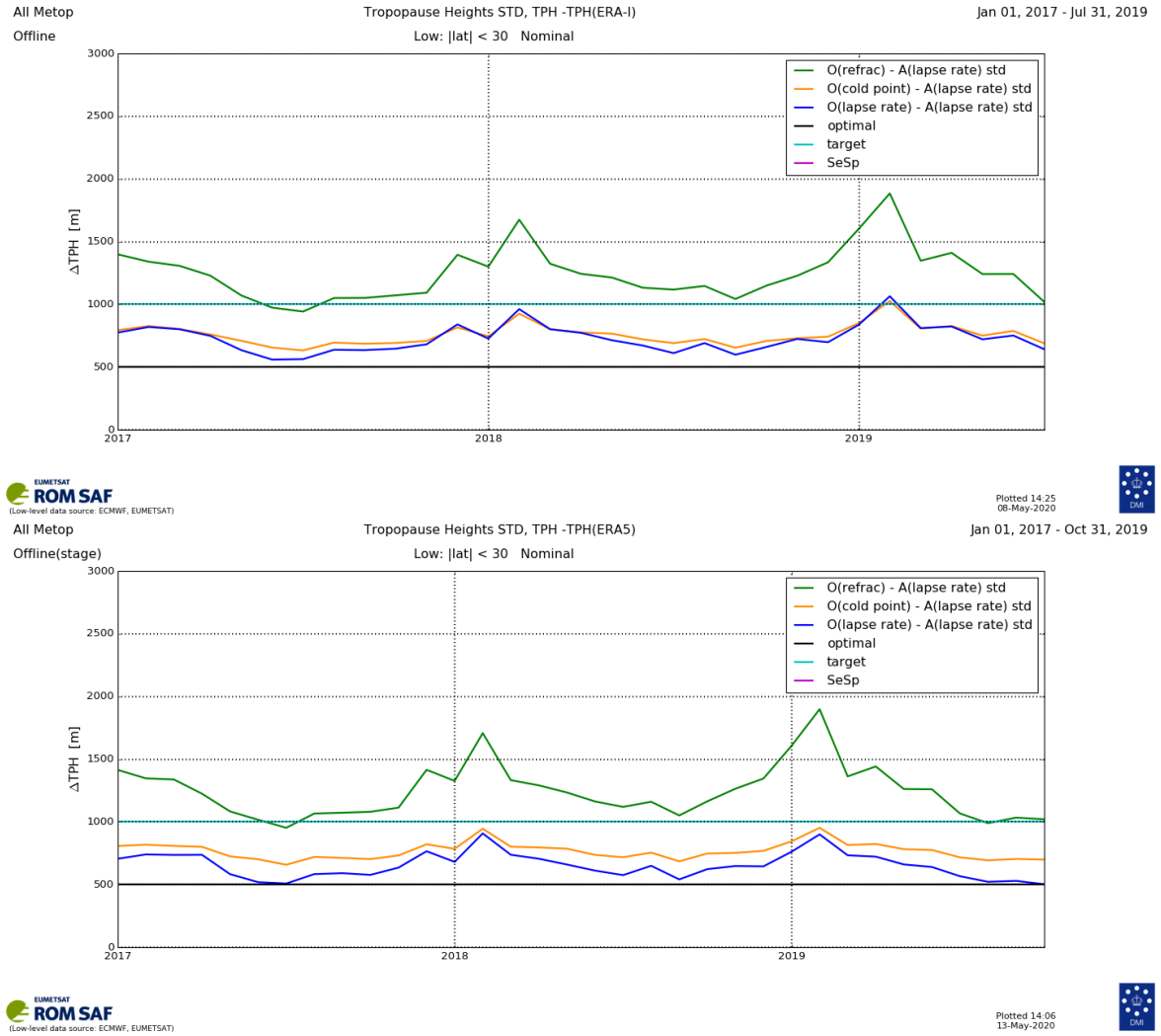

Figure 3.3: *Standard deviation of refractivity based (green), cold-point (yellow) and dry lapse rate (dark blue) tropopause versus reanalysis, averaged over the tropical ± 30 deg latitude band. Top: Offline 1.0 - Era-I, Bottom: Offline 1.1 - ERA5. The plot also shows product requirements, (black and cyan) and current service specification (magenta hidden under cyan lines)*

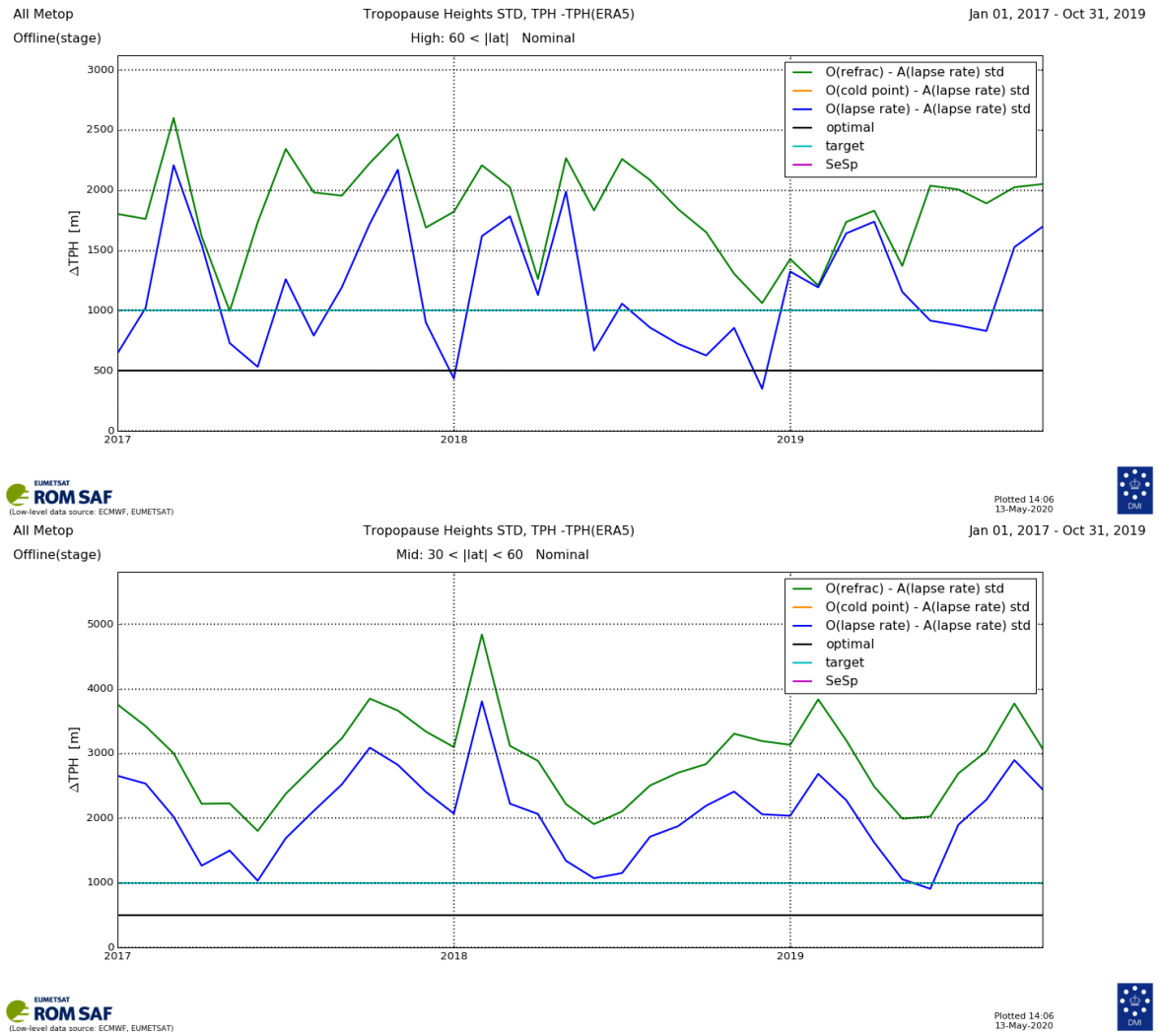

Figure 3.4: *Standard deviation of dry temperature lapse rate tropopause height (blue), and refractivity tropopause (green) for polar (upper panel) and mid latitudes (lower panel). The cold point tropopause and the service specifications, mentioned in the legend, are absent in the plot because they do not apply outside the tropics.*

Figure 3.4 is included to show that outside the tropics the DLTH - ERA5 standard deviation even exceeds the 2 km product requirement threshold. This is why no SeSp criteria are defined outside the tropics.

Performance of Metop C

In figure 3.5 the standard deviations of three Offline v1.1 tropopause products (based on refractivity, cold-point and dry lapse rate), are plotted with reference to the ERA5 analysis DLTH. There is no noticeable difference in between the dry temperature lapse rate tropopause of three Metop (A,B and C) satellites. It is concluded that the performance of Metop C is indistinguishable from that of Metop A and Metop B in terms of S-A monthly standard deviation.

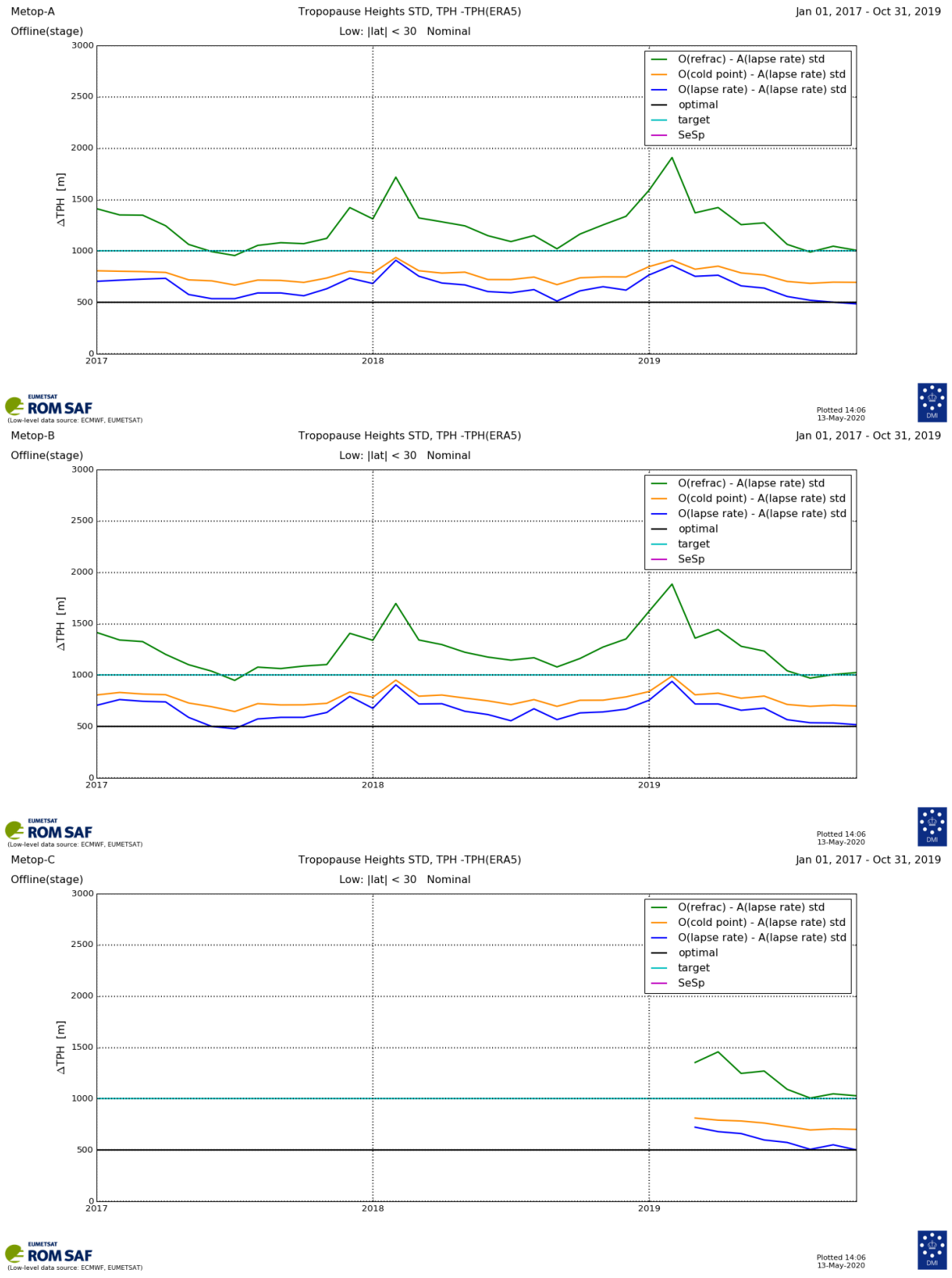

Figure 3.5: *Standard deviation of Offline 1.1 - ERA5 refractivity based (green), cold-point (yellow) and dry lapse rate (dark blue) tropopause versus reanalysis, averaged over the tropical ± 30 deg latitude band. Top: Metop A, Middle: Metop B and Bottom: Metop C Offline 1.1 - ERA5. The plot also shows product requirements, (black and cyan) and current service specification (magenta hidden under cyan lines)*

4 Compliance with Product Requirements

For the TPH product the accuracy is defined as the standard deviation of the difference of (TPH product - model analysis) where "model analysis" is the time interpolated analysis from ERA5.

The formal requirements for the ROM SAF data products are given in the Products Requirements Document [AD.3]. The requirements for the TPH product are formulated as standard deviations of the retrieved DLTH minus the ERA5 DLTH. Table 4.1 is summarizing the product requirements for the TPH-var products. The Offline 1.1 DLTH does fulfill the product requirement target in the tropics, on average within ±30 deg. It is noticed that Metop C, in particular is within the requirements. Outside the tropics the product requirement target and threshold are not met.

Table 4.1: *Threshold, Target, and Optimal accuracies for DLTH according to the PRD [AD.3]*

GRM-24			
Accuracy	Threshold	Target	Optimal
Standard deviation of Solution - Analysis	2 km	1 km	0.5 km
Verification/Validation Methods: Comparison to Re-analysis data.			
Coverage, Resolution			
Spatial Coverage	Spatial Resolution		
Global	RO resolution		

5 Open Issues and Limitations

In polar and mid latitude regions, north as well as south, there is an annual variability in the standard deviation of the retrieved DLTH minus ERA5 DLTH, which reflects an apparent ambiguity of the lapse rate tropopause definition, especially during winter. These latitude ranges are left out of the validation, while the data is still available.

Neither the ERA5 or ECMWF analysis are suitable as DLTH reference, especially in the presence of multiple tropopauses. A validation against radiosondes, e.g. the GRUAN data set is desirable.

6 Conclusions

The Offline v1.1 dry temperature lapse rate tropopause has been validated and found to be generally sound. The quality of the newly included Metop C dry temperature lapse rate tropopause height product is similar to the quality of its predecessors derived Metop A and Metop B data. The stochastic noise, standard deviation of retrieved tropopause products minus ERA5
tropopause, is stable with some annual variability, and the mean of the official DLTH product itself is stable.

The PRD target (standard deviation of retrieved tropopause minus ERA5 tropopause < 1 km) could not be reached at mid and polar latitudes. This was rationalized as a consequence of less well defined tropopause in ERA5, and as such not an issue with the Offline v1.1 product.

The service specifications SeSp was modified to be adequate for the DLTH product by only applying the (standard deviation of retrieved tropopause - ERA5 < 1 km) criterion in a latitude band between -30 and 30 degrees latitude.

Appendices

Annex I. Service Specifications ROM SAF Offline Data (v1.1)

The Service Specifications describes the commitments by the ROM SAF related to the services and products provided to the users. These commitments include a set of operational accuracy targets that should be met by the TPH product, and which are monitored regularly and documented as a part of normal operations.

The conclusion on the DLTH validation is that the SeSp should only be applied on a smaller latitude interval of ± 30 deg. This does not imply that the product is invalid outside this area. There is just not a reasonable way to compare to models at higher latitudes. If one restricts the SeSp to be applied only in the summer season at high latitudes these could also have been subject to SeSp. For simplicity this possibility has been omitted.

The latitude dependent DLTH validation may be summarized as follows: The product generally meets the PRD target (STDV≤ 1 km) in the tropics (Figure 3.3). At mid and high latitude the requirements are not obeyed.

As a consequence of the latitudinal dependence of standard deviation, guided by Figures 3.1 and 3.3, we reduce the SeSp validation latitude range to include only a narrow latitude band; 30 deg. South to 30 deg. North, and keep the 1 km threshold value. The SeSp are summarized in Table 6.1

Table 6.1: *Service specifications for the dry temperature lapse rate tropopause height*

GRM-24	Tropopause height		
Type	Offline Data Set		
Applications and Users	Climate and atmosphere researchers		
Characteristics and Methods	Dry temperature lapse rate		
Operational Satellite Input Data	Offline level 1A Metop, COSMIC, CHAMP and GRACE from EUMETSAT Secretariat and UCAR CDAAC		
Other Operational Input Data	ECMWF ERA Interim fields		
Dissemination			
Format	Means	Timeliness	
netCDF	Web	n/a	
Service Specification			
1 km			
Verification/Validation Methods	Monthly standard deviation of (Product - ERA Interim analysis) based on all nominal dry temperature lapse rate tropopause retrievals in the latitude range		
Coverage, Resolution			
Spatial Coverage	Spatial Resolution	Vertical Resolution	Temporal resolution
30 deg. south to 30 deg. north	RO resolution	scalar	RO resolution