The EUMETSAT Network of Satellite Application Facilities

GRAS SAF
GRAS Meteorology

EUMETSAT Satellite Application Facility on GRAS Meteorology

Report on the Third GRAS SAF User Survey

Version 1.1

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

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1. Introduction

1.1 Purpose of document

From December 2009 to February 2010 the GRAS SAF project conducted a web based user survey, hereinafter US3. This report documents the results and conclusions of the survey. The purpose of US3 was to get user feedback in general and, more specifically, on reception and use of the GRAS SAF products that had become operational since the last survey. An additional aim was to get ideas and input regarding future products, relevant for the CDOP2 phase.
A summary of the main results can be found in Chapter 2.2.

1.2 Applicable & Reference documents

1.2.1 Applicable documents

The following documents have a direct bearing on the contents of this document.

[AD.1] Proposal for a Continuous Development and Operations Phase.
Ref: SAF/GRAS/DMI/MGT/CDOP/001 Version 1.3 of 19 July 2006,
as approved by Council in EUM/C/60/06/DOC/08 on 30 November 2006
[AD.2] SAF for GRAS Meteorology: CDOP Co-operation Agreement
Ref: EUMETSAT Council document C/60/06/DOC/09 (Annex V)
[AD.3] GRAS SAF Product Requirements Document. Ref: SAF/GRAS/METO/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]

1.3 Definitions, Acronyms, Abbreviations & Initialisms

The data products from the GRAS receiver are grouped in *levels* and are either *NRT, Offline or Climate* products:

NRT product: Product delivered less than three hours after measurement.
Offline product: Enhanced product delivered less than 30 days after measurement.
Climate product: Gridded monthly zonal means of Offline products and other RO data.

Level 0 data: Raw GRAS sounding, tracking and ancillary data, ground site observations, GNSS and METOP ancillary data, among others, after restoration of the chronological data sequence for each instrument, i.e. after demultiplexing of the data by instrument, removal of any data overlap due to the data dump procedure, and relevant quality checks. Raw instrument data information (telemetry packets) is maintained during this process. Delivered by EPS/CGS.
Level 1a data: Phase delays, SNR, a.o., METOP, GNSS and ground site instrument data in full resolution with radiometric and geometric (i.e. earth location) calibration applied. NRT products delivered by EPS/CGS, Offline products delivered by GRAS SAF.
Level 1b data: Bending angles and impact parameters, calibrated, earth located and quality controlled, with doppler shifts and the needed ancillary, engineering and auxiliary data (including a subset of Level 1a data). NRT products delivered by EPS/CGS, Offline products delivered by GRAS SAF.
Level 2 products: Refractivity, pressure, temperature, and humidity profiles, time, earth location, quality information, and background temperature/humidity profiles, spatially and temporally sub-

sampled from the Level 1b data. Also includes selected Level 1b parameters like bending angle and impact parameter plus POD and support information. Delivered by GRAS SAF.

BUFR	Binary Universal Form for the Representation of meteorological data (WMO)
CDOP	Continuous Development and Operational Phase (SAFs)
CGS	Core Ground Segment (EUMETSAT)
CHAMP	CHallenging Mini-satellite Payload (Germany)
COSMIC	Constellation Observing System for Meteorology Ionosphere and Climate (USA/Taiwan)
DMI	Danish Meteorological Institute (GRAS SAF Host)
ECMWF	European Centre for Medium-range Weather Forecasts
EPS	European Polar System (EUMETSAT)
ESA	European Space Agency
EUMETcast	EUMETSAT NRT dissemination service via commercial digital video broadcast technology
EUMETSAT	EUropean organisation for the exploitation of METeorological SATellites (Darmstadt, Germany)
GNSS	Global Navigation Satellite System (generic GPS/GLONASS/Galileo)
GRAS	GNSS Receiver for Atmospheric Sounding (METOP)
GTS	Global Telecommunications System (WMO)
IEEC	Institut d'Estudis Espacials de Catalunya
MetO	Met Office (of the UK)
METOP	METeorological OPerational satellite (EUMETSAT)
netCDF	network Common Data Form (Unidata)
NWP	Numerical Weather Prediction
NRT	Near-Real Time
PFS	Product Format Specification (Level 1b data from GCS)
POD	Precision Orbit Determination
RMDCN	Regional Meteorological Data Communications Network (Europe)
RO	Radio Occultation
ROPP	Radio Occultation Processing Package
SAF	Satellite Application Facility (EUMETSAT)
UCAR	University Center for Atmospheric Research (Boulder, CO, USA)
WMO	World Meteorological Organisation

2. Summary

2.1 Background

The third GRAS SAF User Survey (US3) was launched on December 15 2009, where 574 emails where sent out to recipients around the world. The list of recipients was put together from various lists of current and former GRAS SAF users and collaborators, NWP and climate researchers, conference and workshop participants, etc. Naturally, not all email addresses were up-to-date and the initial string of emails generated more than 130 error messages and a few responses from persons indicating e.g. that they had now retired or were working on unrelated topics. After cleaning and correcting the original list, an additional 19 emails were sent out in the following days and in the beginning of January 2010. The cleaned list of recipients eventually contained 457 relevant names. By January 15, 45 answers had been received, and on this day a reminder email was sent to all those on the cleaned list, who had not responded yet. This spurred a lot of additional answers, and by February 8 a total of 78 genuine answers had been received, equalling 17%. The GRAS SAF considers this answer rate a success, bearing in mind the very diverse group of people targeted.

Previous GRAS SAF user surveys were held in the end of 2002 (US1) and in the beginning of 2006 (US2), with the latter being a climate product-oriented survey. The purpose of US3 was to get user feedback in general and, more specifically, on reception and use of the GRAS SAF products that had become operational since the last survey. An additional aim was to get ideas and input regarding future products, relevant for the CDOP2 phase.

2.2 Main Results and Findings

The 78 users who have responded to this survey can be categorized as 45 climate users and 34 NWP users, with 20 of them overlapping. 13 users are mostly dealing with instruments and operations, and 6 work in “other fields”, these being mostly atmosphere/ionosphere researchers.
Below the main finding(s) for each of the questions are given. Apart from the detailed results (answers divided by user type) given in Chapter 3, it is also well-worth studying the text answers given to many of the questions, this input is listed below each relevant question.
The GRAS SAF Team members have online access to each individual answer, and are contacting a number of those users who provided negative (but constructive) feedback, thereby trying to understand and, if possible, correct errors or misunderstandings.

Main results and findings for each question:

User characteristics:

2: There is a distinct demand for Offline products.

RO profile products:

3: Use of GRM-01 is still sparse, but many plan to use it.

4: The users obtain GRM-01 through all the possible methods, but EUMETCast is the least used.

5: A majority plan to use GRM-02, -03, -04, and -05, and those not planning to use them mostly indicate they will use BA and/or refractivity only - as expected. Only very few indicate they will not use any of the products at all.

The ROPP software package:

6, 7, 8: Many users have obtained the different ROPP modules and evaluated them, but still only a few are using them operationally.

9: All the listed operating systems and compilers are being/will be used for ROPP testing and operations, although Linux is by far the preferred OS.

10: Of those users who have installed ROPP, most indicated the installation went smoothly or they solved problems themselves - only one user indicated that the help received through the Helpdesk was unsatisfactory.

User services:

11: A majority finds the Helpdesk “important” or “useful”.

12, 13: Those users already using these services find the monitoring pages and notification services “useful” and nobody finds them “not useful”, many plan to use them in the future.

Climate products:

14: A large majority is interested in using the future climate products.

15: All climate products have potential future users, not only BA and N.

16: Monthly to seasonal climate products have the greatest interest.

17: Only few users would not use climate products *with* uncertainty estimates.

18: A majority would like (or would perhaps like) multi-mission (merged) climate products, a small (but not insignificant) fraction prefer single-mission products.

Expert background and interest:

19: Approximately twice as many users find that the BUFR format is meeting their needs, as not. Most users, however, have not answered or have selected “N/A”

20: A large majority will use the BA product together with the refractivity product. Only a few will use BA only.

21: All the possible product levels are interesting for the users, with a fairly even distribution of answers.

22 Approximately twice as many users prefer the COSMIC-approach as the 1DVar-approach, both regarding NWP and Climate.

3. Detailed Results

Below are all results of the survey with number of persons having selected the individual possibility for answers. For the original questionnaire, see Appendix A.
Question 1 was used to label each user as “Oper”, “Clim”, “NWP”, “other”, or “Both” (see the question below for details). This makes it possible to gain more information from the answers to the rest of the questions, as can be seen in the table for each individual question.

1. How would you best describe your interests in RO data?

NWP and meteorology [NWP]	14
climate research and atmospheric sciences [Clim]	25
both NWP and climate [Both]	20
instruments, engineering and operations [Oper]	13
other sciences [other]	6

Text field for ”other sciences”:

- *atmospheric dynamics, atmospheric waves*
- *Ionosphere study*
- *Ionospheric scintillation and density*
- *Characterizing the atmosphere for infrared remote sensing studies*
- *oceanography*
- *ionosphere*
- *GNSS positioning*
- *All the above incl. other science: solid earth geophysics, geodesy*
- *Climate, Atmospheric sciences and Instruments*

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2. Which RO product type(s) do you use/plan to use?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Offline	**60**	8	20	17	10	5
Climate	**36**	2	17	14	2	1
NRT	**36**	13	5	11	5	2
No plans	**2**	0	1	0	1	0

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3. Have you obtained the GRAS SAF NRT Refractivity product (GRM-01)?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
no	**42**	3	18	12	4	5
no, but plan to	**25**	5	6	5	8	1
yes, and used	**8**	3	1	3	1	0
yes, but not used	**3**	3	0	0	0	0

Text field for ”yes, and used”:

- *NWP*
- *Atmospheric water vapour research*

- *ROPP software validation*
- *radiosonde data comparision*
- *Operational NWP*
- *Assimilation into NWP*
- *research atmospheric refraction for kinematic modes applications requiring meter precision.*
- *tests for future assimilation*

Text field for ”yes, but not used”:
- *we are interested in retrieval products, since we are a small group*
- *lack of personal resources*

Text field for ”no, but plan to”:
- *for real time weather forecast and/or verification*
- *ionospheric analysis*
- *NWP, validation*
- *do some researches for RO method*
- *validation of tomographic model*
- *presently I am working on deriving refrractive profile from Raw data and yet the chain is not established*
- *data assimilation*
- *Improved quality control of RO data in future reanalysis (once it has caught-up with real-time)*
- *comparison of different products and UTLS relating work*
- *atmospheric research*
- *climate research*
- *comparison with EG/OPS*
- *COSMIC GRAS comparison*
- *NWP*
- *We may use this for evaluation of future instrument design*

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4. If you have obtained the GRM-01 product, how did you get it?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
GTS	**8**	6	0	2	0	0
UMARF	**6**	2	3	1	0	0
Archive	**13**	3	4	2	4	0
EUMETCast	**2**	2	0	0	0	0
(not answered)	**54**	4	20	15	9	6

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5. Do you plan to use the soon-to-be-available GRAS SAF NRT Temperature, Humidity, and Pressure products (GRM-02, -03, -04, -05)?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
no, because…	**30**	9	9	5	4	3
yes, for…	**43**	4	15	14	9	1
(not answered)	**5**	1	1	1	0	2

Text field for ”yes, for”:
- *Model validation*
- *my research on atmospheric waves*

- *real time numerical prediction with nudging data assimilation*
- *gaining temperature*
- **Might* use them for studies of convection*
- *validation*
- *Data Assimilation*
- *do some researches and compare the data with cosmic data*
- *Validation*
- *validation of tomographic model*
- *Analysis of tropospheric and stratospheric water vapour research*
- *validation and comparision*
- *comparison with ground-based data*
- *atmospheric sciences*
- *ROPP software validation*
- *data assimilation in PSAS system*
- *occultation product validation and tropopause climate research*
- *comparison of different products*
- *Validation of WMO-GCOS-GRUAN profiles of T, q*
- *validation*
- *Model evaluations and comparing with other observations*
- *Validation against our own product*
- *awareness as a research tool for atmos sciences and NWP*
- *atmospheric research*
- *NWP*
- *meteorology*
- *1. validation of similar products*
- *Regional model evaluation and NWP experiments*
- *comparison with EG/OPS*
- *improving positioning accuracy*
- *COSMIC GRAS comparison*
- *RO research*
- *I am a team leader and do not assess the data directly, but my team members do so.*
- *Climate and weather studies*
- *atmospheric science researches*
- *ocean and climate research*
- *We may use this for evaluation of future instrument design*

Text field for ”no, because”:

- *My longer term plans involve using these products to evaluate climate models.*
- *For the time being we want to retain control of the refractivity to temperature retrieval. Details do matter for us.*
- *Only planned to use N.*
- *I do not need real time data for my experiements*
- *I'm interested in optimally processed profiles.*
- *assimilation of bending angles is prioritised*
- *More interested in products close to raw measurements for data assimilation.*
- *For the moment I'm intersested in offline products for comparisons with correspondent products derived by other RO missions*
- *I do not plan to use the Near-Real Time (NRT) products at the moment*
- *I do not plan to use the Near-Real Time (NRT) products at the moment*
- *Assimilating refractivity - no operatonal requirement for T,q,P*
- *Our work will focus on using Bending Angle and Refractivity*
- *I use bending angle*
- *We are using rawer products*

- *I primarily use RO climatologies (profiles) of derived atmospheric parameters processed at Wegener Center*
- *No NRT requirement*
- *no time to actually work with these issues*
- *no need yet*
- *prefer to use refractivity and bending angle*
- *I'm perfer to use electron density profiles*
- *Prefer refractivity*
- *no interest at the moment*
- *But may be later as fits eventual research projects*
- *they are the retrieved data mixed with the information from other data.*
- *we assimilate bending angles and we use refractivity as a quality control*

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6. Which modules from the software package ROPP have you downloaded?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
none	**44**	9	12	11	7	5
UTILS	**20**	3	6	7	4	0
IO	**22**	4	7	7	4	0
PP	**22**	3	8	7	4	0
FM	**23**	3	7	8	5	0
1DVAR	**28**	4	9	9	6	0
(not answered)	**2**	0	1	0	0	1

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7. Which ROPP modules have you evaluated?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
none	**55**	10	17	14	9	5
UTILS	**10**	2	2	3	2	1
IO	**11**	3	2	3	2	1
PP	**9**	2	2	3	2	0
FM	**11**	2	4	4	1	0
1DVAR	**8**	3	1	2	2	0
(not answered)	**6**	0	3	2	1	0

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8. Which ROPP modules do you use in your operational system? If you use any, for which application do you use it, and are there already positive impacts/visible benefits?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
None, but intend to	**32**	8	5	11	5	3
None, and no intention	**24**	4	10	5	4	1
UTILS:	**4**	0	2	1	1	0
IO:	**4**	0	2	1	1	0
PP:	**3**	0	1	1	1	0
FM:	**8**	2	3	3	0	0
1DVAR:	**7**	1	3	2	1	0
(not answered)	**9**	0	4	1	2	2

Text field for ”ROPP_UTILS”:

- *For decoding the our operational products to bufr.*
- *Use in offline validation (not operationally)*

Text field for ”ROPP_IO”:

- *For decoding the our operational products to bufr.*
- *Use in offline validation (not operationally)*

Text field for ”ROPP_PP”:

- *Use in offline validation (not operationally)*

Text field for ”ROPP_FM”:

- *Use in offline validation (not operationally)*
- *If the ROPP observation operators are in the IFS, then we do use a part of ROPP_FM already in the ERA-Interim reanalysis (but we didn't have to download ROPP)*
- *4DVAR*
- *For off-line calculations rather than in an operational system*
- *Bending angle operators*
- *Since our code is the same as IFS, we use a part of the ROPP code for the observation operator used to assimilate bending angles*

Text field for ”ROPP_1DVAR”:

- *Use in offline validation (not operationally)*
- *It is useful for research of water vapor retrieval with RO measurements*
- *Pre-4DVAR QC*
- *currently ongoing implementation, not evaluated yet*
- *evaluation /testeing is currently ongoing*
- *evaluation still in progress*

Text field for ”none, but intend to”:

- *We plan on installing some ROPP inversion code for comparison with CDAAC*
- *ROPP_UTILS, ROPP_IO*
- *I want to use ROPP_PP in processing FengYun-3C satellite in 2012.*
- *because the operational system error, so i intend to use one or more modules in the future*
- *My team members would use certain modules in the future.*
- *ROPP_UTILS, ROPP_PP*
- *May be in the future as fits eventual research projects*

Text field for ”none, and no intention”:

- *I am interested in climate products*

- *I might use it, but currently don't know what ROPP does*
- *I am a research meteorologist*
- *I do not run an operational system*
- *we are interested only in retrieval products*
- *I'm only interested in ready-to-use products*
- *we use Michael Gorbunovs version of bending angle forward operator*
- *I only do basic research*
- *we do not have an operational system*
- *We already have needed software but might consider evaluate ROPP in the future*
- *I primarily use RO climatologies (profiles) of derived atmospheric parameters processed at Wegener Center*
- *we do not provide operational services*
- *see question 5*
- *no current need*
- *The GPS data are processed by a collaborator into a format I use*
- *use CDAAC*
- *we have own tools (some routine for BUFR conversion are used)*

9.

Which operating system was/will be used for ROPP testing?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Linux	**37**	7	11	6	8	5
Unix	**12**	3	4	4	1	0
OS X	**4**	0	3	0	0	1
other	**4**	0	0	3	1	0
CygWin	**19**	0	8	6	3	2

Which compiler was/will be used for ROPP testing?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Portland	**9**	3	1	2	2	1
GFortran	**21**	1	7	5	7	1
G95	**11**	3	1	4	2	1
Intel	**22**	4	9	5	4	0
other	**6**	2	0	3	1	0
SUN	**4**	1	2	0	1	0
NAG	**6**	0	3	2	1	0

Which operating system was/will be used for ROPP operations (where applicable)?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Linux	**32**	6	9	5	8	4
OS X	**2**	0	1	0	0	1
other	**7**	2	0	4	1	0
CygWin	**13**	0	6	4	3	0
Unix	**12**	1	4	5	2	0

Which compiler was/will be used for ROPP operations (where applicable)?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Portland	**9**	5	1	1	1	1
GFortran	**17**	0	7	3	6	1
Intel	**18**	2	8	5	3	0
other	**10**	3	0	5	2	0
G95	**10**	2	2	4	2	0
NAG	**5**	0	3	1	1	0
SUN	**4**	0	3	0	1	0

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
(not answered)	**21**	5	8	5	2	1

Text field for ”other operating system for testing”:

- *We are phasing out non-linux unix in all front ends*
- *n/a (see above)*
- *never used*
- *MAC*
- *Not aware of the answer at this stage.*

Text field for ”other compiler for testing”:

- *Portland is our standard compiler. Others only for cross-check.*
- *n/a*
- *AIX xlf compiler*
- *C*
- *matlab*
- *never used*
- *varies*
- *XLF90*
- *IBM SP*
- *Lahey lf95*
- *Not aware of the answer at this stage.*
- *Fortran*
- *Pathscale*

Text field for ”other operating system for operations”:

- *n/a*
- *As said, this is not operaional, but offline validation in a semi-operational setup.*
- *none, we used ropp_io only for a study*

- *never used*
- *MAC*
- *IBM*
- *Not aware of the answer at this stage.*

Text field for "other compiler for operations":

- *n/a*
- *IBM SGI, IBM AIX*
- *none*
- *C*
- *matlab*
- *IBM XL Fortran compiler (IBM Power 6)*
- *never used*
- *IBM HPC Fortran*
- *IBM*
- *xlf90*
- *IBM xlf*
- *Not aware of the answer at this stage.*
- *Pathscale*

---

10. Did the installation/testing of ROPP go smoothly or were there any problems?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
not applicaple	**39**	7	11	10	7	4
solved myself	**9**	2	4	0	3	0
Helpdesk not satisfactory	**1**	0	0	0	1	0
smoothly	**9**	2	2	3	1	1
Helpdesk satisfactory	**3**	0	1	2	0	0
(not answered)	**17**	3	7	5	1	1

Text field for "Wrote to Helpdesk but not satisfactory":

- *but I could not install to more system and yet not interacted with Helpdesk*

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11. How important is the GRAS SAF Helpdesk function for your use of RO data and ROPP?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
unimportant	**32**	7	11	5	7	2
useful	**9**	2	3	1	1	2
important	**29**	5	10	8	5	1
(not answered)	**8**	0	1	6	0	1

---

12. Have you used the GRAS SAF NRT Monitoring Page?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
yes, useful	**15**	4	2	6	2	1
yes, but not useful	**0**	0	0	0	0	0
plan to use	**33**	5	9	9	8	2
no	**27**	5	14	2	3	3
(not answered)	**3**	0	0	3	0	0

Text field for ”Yes, and I found it useful”:

- *We keep an eye on it for the COSMIC results*
- *Quick overview of performance & comparison vs our own checks.*
- *I can also monitor our (GRACE) RO products.*
- *All instrument monitored, several NWP centers covered, matches provided, etc.*
- *One gets a sense of the available tracks and refractivity ranges*
- *it allows comparison with our own monitoring statistics*
- *It provides monitoring of several different RO missions*
- *is possible to access operational information of the system.*
- *It enables to check whether changes seen at receiving end come from the data or problem at our end.*
- *Comprehensive info all-in-one-place*
- *I compare ECMWF and Met Office statistics*
- *to compare statistics and number of profiles available*
- *interesting plots of the occultations*

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13. Are you using the GRAS SAF NRT User Notification Service (mailgroup)?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
no	**34**	5	12	6	6	5
no, but plan to	**26**	5	10	5	5	1
yes, and in addition…	**1**	1	0	0	0	0
yes, useful	**14**	3	3	6	2	0
yes, but not useful	**0**	0	0	0	0	0
(not answered)	**3**	0	0	3	0	0

Text field for ”yes, useful”:

- *general info on the processing*
- *it keeps me informed of latest data availability*
- *it let know the new version of ROPP package as soon as possible*
- *I typically get an explanation for missing data and other GRAS events.*
- *Keep informed about anomolies*
- *notification of upcoming upgrades, etc*
- *to note interruptions of service, etc*
- *I could receive message in time.*
- *to know when and why data are degraded*

Text field for ”yes, and in addition…”:

- *Provided information is good to know. However for nearly all events there is nothing we can do operationally.*

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14. Are you interested in using climate products based on RO data (the future GRAS SAF products GRM-17, -18, -19, -20, -21)? The RO climate products will necessarily be of short duration at the start of operations, but will have global coverage.

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
yes, as a complement	**26**	2	8	12	3	1
yes	**32**	3	15	7	5	2
no, never	**16**	8	0	0	5	3
not until it covers	**3**	1	2	0	0	0
(not answered)	**1**	0	0	1	0	0

Text field for ”yes”:

- *process studies and comparison with Met. analysis and model data*
- *We plan to detect biases between model climate and RO climate.*
- *Evaluating boundary layer variability at high vertical resolution across the globe.*
- *it can do a lot of research work*
- *validation, quality control*
- *I think so in climate study in other groups in the CPTEC-INPE*
- *validation with other data*
- *GCM*
- *data validation*
- *Climate studies and climate model evaluation*
- *Model evaluation and intercalibration*
- *evaluation against our own product*
- *data validation*
- *Climate group is interested in incorporating the data*
- *Comparison to products from other sensors to establish confidence in eiter estimates*
- *Characterizing the atmosphere*
- *Comparison and trend studies*
- *Global*
- *Regional climate studies, i.e. Antarctic, sourthen hemisphere*

Text field for ”yes, as a complement”:

- *We may download these data for comparison with our climate studies*
- *Evaluation of temperature/water vapour changes simulated by models.*
- *possibly (not familiar)*
- *studies of convection*
- *Climat eanalyses. Comparison with own investigations.*
- *Validation*
- *Water vapour validation purposes*
- *comparison with other data sets*
- *tropopause altitude height studies, boundary layer studies, trend analysis*
- *As a comparison with our monitoring system*
- *Renalysis applications*
- *trend detection, climate change detection (MetOp data as extension to other RO satellite data); evaluation of climate models*
- *Model evaluation, Atmospheric water cycle study*
- *these data could be used for chemistry-climate coupled model validation in the stratosphere*
- *We may use this for evaluation of future instrument design*

Text field for ”not until it covers”:

- *long periods (unfortunately) needed for analysing trends*

15. The RO technique gives vertical profiles of bending angles, which are processed into atmospheric refractivity and further into temperature, pressure, and humidity. Using the globally distributed RO profiles, various climate products consisting of gridded monthly zonal means can be obtained. Which climate products would you be interested in using? And for which purpose?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
BA	**37**	3	13	11	7	3
N	**39**	5	11	12	9	2
T	**43**	4	21	11	4	3
Q	**34**	4	17	7	4	2
GPH	**23**	2	13	4	2	2
none	**17**	6	2	3	4	2
(not answered)	**2**	1	0	1	0	0

Text field for ”BA”:

- *comparison with model simulations*
- *We have planned tests, but currently unsure.*
- *ionospheric refractivity*
- *determination of climate change/variabilty, comparison with own products*
- *do some bending angle errors characteristic work*
- *analysis during thunderstorm and tropical cyclones*
- *trends, quality checks, validation, PBL detection*
- *comparision and validation*
- *tropopause altitude height studies, boundary layer studies, trend analysis*
- *Monitoring, as compared with reanalysis*
- *comparisons with similar products derived by other RO observations and processing software*
- *UTLS related work*
- *validation*
- *Climate studies and climate model evaluation*
- *climate model evaluation*
- *validation*
- *assimilation into climate model*
- *trend/detection studies (MetOp data as extension to other RO satellite data)*
- *Atmospheric reseach*
- *We may use this for evaluation of future instrument design*

Text field for ”N”:

- *Comparison with CDAAC-derived climate products*
- *comparison with model simulations*
- *Immediate capability to detect biases between model climate and RO climate.*
- *anomalous propagation conditions*
- *electron density*
- *determination of climate change/variabilty, comparison with own products*
- *do some refractivity errors characteristic work*
- *analysis during thunderstorm and tropical cyclones*
- *trends, quality checks, validation, PBL detection*
- *comparison to tomographic solution*
- *comparision and validation*
- *comparison with othet systems*

- *tropopause altitude height studies, boundary layer studies, trend analysis*
- *Monitoring, as compared with reanalysis*
- *comparisons with similar products derived by other RO observations and processing software*
- *validation*
- *Climate studies and climate model evaluation*
- *evaluation against our own product*
- *validation*
- *the same as bending angle, until we transition to bending angle*
- *combination with other data*
- *trend/detection studies (MetOp data as extension to other RO satellite data)*
- *NWP*
- *Atmospheric reseach*
- *We may use this for evaluation of future instrument design*

Text field for ”T”:

- *use as an additional diagnostic for comparison with model simulations*
- *Model validation and understanding impact of deep tropical convection on TTL structure*
- *PBL mean quantities and vertical gradients to determing PBL height*
- *meteorology*
- *determination of climate change/variabilty, comparison with own products*
- *do some temperature errors characteristic work*
- *analysis during thunderstorm and tropical cyclones*
- *trends, quality checks, validation, PBL detection*
- *comparison with othet systems*
- *numerical analysis*
- *tropopause climate*
- *comparisons with similar products derived by other RO observations and processing software*
- *UTLS related work*
- *Standard T profiles for Cabauw, comparison against De Bilt*
- *validation*
- *intercalibratiobn*
- *evaluation against our own product*
- *validation*
- *comparison and combination with other data*
- *trend/detection studies (MetOp data as extension to other RO satellite data)*
- *Characterizing the atmosphere for RTE simulations*
- *Atmospheric reseach*
- *atmospheric waves study*

Text field for ”Q”:

- *as above*
- *model validation and understanding stratospheric water vapour budget*
- *PBL mean quantities and vertical gradients to determing PBL height*
- *analysis during thunderstorm and tropical cyclones*
- *trends, quality checks, validation, PBL detection*
- *comparision and validation*
- *comparison with othet systems*
- *comparisons with similar products derived by other RO observations and processing software*
- *UTLS related work*
- *Same as above for q*
- *validation*
- *intercalibration*
- *validation*
- *comparison and combination with other data*

- *MetOp trend/detection studies (data as extension to other RO satellite data), evaluation of climate models*
- *Characterizing the atmosphere for RTE simulations*
- *Atmospheric reseach*
- *these data may be useful for the same reason as in answer 14, depending on the accuracy*

Text field for "GPH":

- *determination of climate change/variabilty, comparison with own products*
- *numerical analysis*
- *comparisons with similar products derived by other RO observations and processing software*
- *smae as above for GH*
- *validation*
- *evaluation against our own product*
- *validation*
- *comparison and combination with other data*
- *trend/detection studies (MetOp data as extension to other RO satellite data)*

---

16. Which time resolutions of climate data are you most interested in?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
month	**41**	6	16	12	5	2
other	**12**	0	5	4	2	1
none	**14**	7	0	0	4	3
season	**6**	0	3	2	1	0
(not answered)	**5**	1	1	2	1	0

Text field for "other":

- *all*
- *I do both case-study analysis (where hourly/daily data are important, and climate analysis (where I am more interested in long-term (e.g. 30-year) trends are of interest*
- *individual occultation and seasonal means*
- *daily*
- *by occultation*
- *I would appreciate daily and monthly data records*
- *Some use of individual profiles too.*
- *month to year(s)*
- *same as for NWP (for the climate assimilation system)*
- *all plus daily and subdaily*
- *daily*
- *real time*
- *NRT data*
- *Individual profiles of high quality*
- *month, weekls, daily, season*

---

17. Climate data can be provided alone, or together with uncertainty estimates. Would you use uncertainty estimates if provided?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
perhaps	**13**	2	3	5	3	0
yes	**46**	4	21	12	5	4
no	**13**	5	1	1	4	2
(not answered)	**6**	3	0	2	1	0

Text field for ”perhaps”:

- *Ideally we would use the incertainty estimate but realistically it would have to be a simple field.*
- *It is not unlikely that we will create our own tailored climate products, with tailored uncertainty.*
- *for error analysis*
- *Note: Uncertainty estimates are essential for climate studies.*
- *as applicable/needed*

---

18. Several RO missions have previously provided RO profile data that can be used in the generation of climate data. Would you be interested in using climate data based on merged data from several RO missions, or would you prefer single-mission climate data sets?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
perhaps multi-mission	**24**	3	6	7	6	2
yes, multi-mission	**32**	3	15	10	3	1
no, single-mission	**13**	3	3	2	3	2
(not answered)	**9**	5	1	1	1	1

---

19. RO data from GRAS, COSMIC and GRACE-A is provided in NRT to NWP users in WMO BUFR format over the GTS. Is the content of the current BUFR template meeting your needs?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
yes	**15**	5	1	5	4	0
no	**8**	1	2	2	3	0
not applicaple	**27**	4	8	6	5	4
(not answered)	**28**	4	14	7	1	2

Text field for ”no”:

- *NetCDF format*
- *PBL altitude and possibly other relevant parameters, e.g. orbit quality.*
- *I would like to have easier extraction methods included...*
- *ray information in BUFR format too*

---

20. Are you using or will you use the GRAS Bending Angle (BA) product?

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
no	**14**	3	3	3	3	2
yes, but also refractivity	**32**	6	8	7	9	2
yes, only	**6**	2	0	4	0	0
(not answered)	**26**	3	14	6	1	2

---

21. The RO technique produces data at various levels of proximity to 'standard meteorological variables'. From the purely observational excess phase, refractivity and geophysical variables are derived with an increasing level of model-dependency. It is important for us to understand what sort of data the potential users wish to work with: geophysical variables only, or more fundamental RO observables as well.

Select the data types you could be interested in:

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
Something else	**6**	0	1	1	2	2
EP and Amp	**26**	4	7	4	9	2
Iono. corr. BA	**26**	2	7	7	9	1
Stat. opt. BA	**27**	5	7	6	8	1
Refractivity	**37**	6	10	9	11	1
Real met. obs.	**32**	5	9	9	7	2
Climate prods.	**27**	1	10	10	4	2
(not answered)	**22**	2	13	4	1	2

Text field for ”something else”:

- *In general, we are most interested in level 0 (raw binary) instrument data.*
- *the raw RO observation in rinex format.*
- *Ionosphere profiles*
- *Use of excess phase and amplitude for our own retrieval. Use of other data products for validation.*
- *For our research, the essential products are excess phase and amplitude data (including satellite orbit data), since our retrieval starts at this level. Higher level products are, however, very welcome for evaluation purposes.*
- *Raw bending angle in the future- available from EUMETSAT*
- *raw measurements data (phases) and orbit data from LEO*
- *We use RO data to understand current instrument behaviour and to optimize design of future instruments. Many of the questions above are only partly relevant in this scope.*

---

22. It is the plan that the soon-to-be-available GRAS SAF NRT temperature, humidity, and pressure products will be derived via a traditional 1Dvar approach in which the observations (refractivity) and the background (ECMWF forecast fields) are weighted according to assumed observation and background error covariances. This results in temperature, humidity, and pressure profiles that in principle can be considered an 'optimal' solution given the observations and the best available a priori knowledge that we have. However, such profiles will generally be inconsistent with the observations in that the derived temperature, humidity, and pressure does not correspond to the observed refractivity via the equation connecting these variables (e.g., the Smith-Wientraub formula). An alternative approach, currently applied to COSMIC data at CDAAC (product provided in the CDAAC wetPrf NetCDF files and BUFR

products) is to give much more weight to the observations than to the background. In this way the physical relation between the solution and the observed refractivity is preserved, and the temperature is basically the same as the so-called dry-temperature in regions where moisture is negligible. Such an approach still includes information from ECMWF fields to separate out the meteorological variables in the moist troposphere, but it seeks to minimize the influence from the ECMWF fields and it preserves the full information coming from the observations.
If you are a potential user of the GRAS SAF temperature, specific humidity, and pressure products (either for NRT or research/climate applications), please indicate your preference:[1]

A: For NWP and meteorology

	total	*NWP*	*Clim*	*Both*	*Oper*	*other*
1DVAR	**6**	0	1	4	1	0
COSMIC	**12**	4	4	1	3	0
other	**0**	0	0	0	0	0
no intention	**23**	4	5	7	3	4

B: For climate research and atmospheric sciences

	total
1DVAR	**10**
COSMIC	**22**
other	**2**
no intention	**19**

	total
(not answered)	**39**

Text field for ”NWP other”:

- *There is an error here, I cannot select A & B! I want 1DVAR for NWP.*

Text field for ”Climate other”:

- *both products (1DVar and dry temperature) should be provided.*
- *I don't know*

[1] *Note: The questionnaire form originally contained a programming error, making it impossible to answer both question A and B. This was only discovered and corrected after the first 22 answers. Unfortunately this means that the detailed results for question B cannot be obtained, wherefore only the total numbers (which are correct) are given here.*

Appendix A

This is the original survey questionnaire which was available on www.grassaf.org

GRAS SAF User Survey 2009

THIS QUESTIONNAIRE

The GRAS SAF is part of EUMETSAT's network of Satellite Application Facilities (SAFs). The objective of the GRAS SAF is to deliver operational RO products from the GRAS instruments onboard the three Metop satellites for Numerical Weather Prediction (NWP) and climate use. A second objective is to deliver the ROPP (Radio Occultation Processing Package) software package, containing modules for processing and assimilation of RO data into NWP models.
The GRAS SAF is now in the operational phase and started delivering pre-operational products on March 25 2009. We would therefore like to determine the interest in, and use of, RO products, and whether the data are as expected by their users. Hence, this questionnaire tries to build a picture of the current, planned, and expected use of the products. Because the users of RO data are from a wide range of fields, with different types of interest and expertise, we divide the survey into three parts. You may skip the last part if you are not familiar with the RO principle.
Thank you for taking the time (about 10-20 minutes) to complete this questionnaire!

Name: *

Email Address:

Affiliation *

Current position: *

**mandatory fields*

BACKGROUND

Occultations of the radio signals from GPS satellites can provide detailed information about the atmosphere. The data consist of high-resolution vertical profiles of atmospheric quantities like temperature, pressure, specific humidity and refractivity, from (near) the surface up to the upper stratosphere. The vertical resolution is in the range 150-300 m, and radio occultation (RO) profiles have been demonstrated to contain a very high information content in the upper troposphere and lower stratosphere. Such RO data are now available from the GRAS instrument on EUMETSAT's MetOp satellite, yielding about 650 vertical atmospheric profiles per day evenly distributed across the globe, from the COSMIC satellites giving about 2000 profiles per day, and, previously, from the CHAMP satellite, which delivered about 200 profiles per day.

RO METHOD & BENEFITS

The basic principle of the RO method is that a receiver onboard a low-orbiting satellite tracks GPS signals as the transmitting satellite sets or rises behind the Earth. Due to refraction in the ionosphere and the neutral atmosphere the signal is delayed and its path bent, enabling calculation of profiles of the index of refraction (or refractivity) and subsequently temperature and humidity as a function of height. Many of the characteristics of RO data suggest them as a near-ideal resource for input to NWP models and for climate studies, particularly the global coverage, the all-weather capability, and the self-calibrated nature of the RO data. The latter property - which distinguishes RO from most other satellite observational techniques - allows for relatively easy inter-

comparison of data from different satellites and RO instruments. If you are not familiar with the RO principle, you may also want to read this short introduction.

PART 1: User characteristics

1. How would you best describe your interests in RO data:

- ☐ NWP and meteorology
- ☐ Climate research and atmospheric sciences
- ☐ Both NWP and climate
- ☐ Instruments, engineering & operations
- ☐ Other sciences, please specify:

  _____
- ☐ Not interested

2. Which RO product type(s) do you use/plan to use?
(More than one answer possible)

- ☐ The Near-Real Time (NRT) products (disseminated less than 3 hours after measuring time)
- ☐ The Offline products (optimally processed profiles available less than 30 days after measuring)
- ☐ The Climate products (gridded monthly zonal means of RO profiles)
- ☐ No plans to use RO products

PART 2: RO Profile Products

3. Have you obtained the GRAS SAF NRT Refractivity product (GRM-01)?

- ☐ Yes, and I use(d) it for:

  _____
- ☐ Yes, but I do/did not use it because:

  _____
- ☐ No, but I plan to use it for:

  _____
- ☐ No

4. If you have obtained the GRM-01 product, how did you get it?
(More than one answer possible)

- ☐ Via GTS (RMDCN)
- ☐ Via EUMETCast
- ☐ Via the GRAS SAF Product Archive

☐ (I prefer to download it via UMARF, when it becomes available there)

5. Do you plan to use the soon-to-be-available GRAS SAF NRT Temperature, Humidity, and Pressure products (GRM-02, -03, -04, -05)?

☐ Yes, and I plan to use them for:

☐ No, because:

PART 3: The ROPP Software Package

6. Which modules from the software package ROPP have you downloaded?
(More than one answer possible)

☐ ROPP_UTILS

☐ ROPP_IO

☐ ROPP_PP

☐ ROPP_FM

☐ ROPP_1DVAR

☐ None

7. Which ROPP modules have you evaluated?
(More than one answer possible)

☐ ROPP_UTILS

☐ ROPP_IO

☐ ROPP_PP

☐ ROPP_FM

☐ ROPP_1DVAR

☐ None

8. Which ROPP modules do you use in your operational system? If you use any, for which application do you use it, and are there already positive impacts/visible benefits?
(More than one answer possible)

☐ ROPP_UTILS

☐ ROPP_IO

☐ ROPP_PP

☐ ROPP_FM

☐ ROPP_1DVAR

☐ None, but I intend to use one or more modules in the future:

☐ None, and I do not intend to use ROPP in an operational system because:

9. Which operating system was/will be used for ROPP testing:

☐ Linux

☐ Unix

☐ Windows/Cygwin

☐ OS X

☐ Other (please specify):

Which compiler was/will be used for ROPP testing:

☐ Intel

☐ NAG

☐ Portland

☐ SUN

☐ GFortan

☐ G95

☐ Other (please specify):

Which operating system was/will be used for ROPP operations (where applicable):

☐ Linux

☐ Unix

☐ Windows/Cygwin

☐ OS X

☐ Other (please specify):

Which compiler was/will be used for ROPP operations (where applicable):

- ☐ Intel
- ☐ NAG
- ☐ Portland
- ☐ SUN
- ☐ GFortan
- ☐ G95
- ☐ Other (please specify):

10. Did the installation/testing of ROPP go smoothly or were there any problems?

- ☐ Installation and testing went smoothly
- ☐ There were one or more problems, but I solved it myself
- ☐ There were one or more problems, I wrote to the Helpdesk about it, and got a satisfactory solution
- ☐ There were one or more problems, I wrote to the Helpdesk about it, but did not get a satisfactory solution, because:
- ☐ (not applicable)

PART 4: User Services

11. How important is the GRAS SAF Helpdesk function for your use of RO data and ROPP?

- ☐ Important
- ☐ Useful, but not very important
- ☐ Unimportant/have not used it yet

12. Have you used the GRAS SAF NRT Monitoring Page?

- ☐ Yes, and I found it useful because:
- ☐ Yes, but I did not find it useful because:
- ☐ No, but I plan to use it
- ☐ No

13. Are you using the GRAS SAF NRT User Notification Service (mailgroup)?

☐ Yes, and I find it useful because:

☐ Yes, but I do not find it useful because:

☐ Yes, and additionally I would like to suggest the following:

☐ No, but I plan to sign up for it

☐ No

PART 5: Climate products

14. Are you interested in using climate products based on RO data (the future GRAS SAF products GRM-17, -18, -19, -20, -21)? The RO climate products will necessarily be of short duration at the start of operations, but will have global coverage.

☐ Yes, I could use RO climate products right from the start for this purpose:

☐ Yes, but only as a complement to other climate data. It will be used for this purpose:

☐ No, RO climate products will not be of any use to me until they cover a long time span:

☐ No, RO climate products has no interest for me

15. The RO technique gives vertical profiles of bending angles, which are processed into atmospheric refractivity and further into temperature, pressure, and humidity. Using the globally distributed RO profiles, various climate products consisting of gridded monthly zonal means can be obtained. Which climate products would you be interested in using? And for which purpose?
(More than one answer possible)

☐ Bending angles for:

☐ Refractivity for:

☐ Temperature for:

☐ Specific humidity for:

☐ Geopotential heights at fixed pressure levels for:

☐ None

16. Which time resolutions of climate data are you most interested in?

☐ Month to season

☐ Season to year

☐ Other:

☐ None

17. Climate data can be provided alone, or together with uncertainty estimates. Would you use uncertainty estimates if provided?

☐ Yes

☐ Perhaps:

☐ No

18. Several RO missions have previously provided RO profile data that can be used in the generation of climate data. Would you be interested in using climate data based on merged data from several RO missions, or would you prefer single-mission climate data sets?

☐ Yes, I would like to use climate data from multi-mission merged data sets

☐ Perhaps

☐ No, I am only interested in single-mission climate data sets

PART 6: Expert background and interest

Only for those familiar with the RO techniques. Otherwise, you may skip these questions and submit directly.

19. RO data from GRAS, COSMIC and GRACE-A is provided in NRT to NWP users in WMO BUFR format over the GTS. Is the content of the current BUFR template meeting your needs?

☐ Yes.

☐ No. I would like to see this extra information included in a potential extended BUFR template:

☐ (not applicable)

20. Are you using or will you use the GRAS Bending Angle (BA) product?

☐ Yes, and I will only use this RO product

☐ Yes, but I will also use refractivity for quality control

☐ No

21. The RO technique produces data at various levels of proximity to 'standard meteorological variables'. From the purely observational excess phase, refractivity and geophysical variables are derived with an increasing level of model-dependency. It is important for us to understand what sort of data the potential users wish to work with: geophysical variables only, or more fundamental RO observables as well.

Select the data types you could be interested in:

☐ Excess phase and amplitude.

☐ Ionosphere corrected bending angle (but not statistically optimized)

☐ Statistically optimized bending angle, somewhat dependent on assumptions about the atmosphere at higher altitudes (above ~35 km).

☐ Refractivity, somewhat dependent on assumptions about the atmosphere at higher altitudes (above ~35 km).

☐ Real meteorological observables like temperature, pressure, and specific humidity, somewhat dependent on ECMWF background fields.

☐ Processed climate data products.

☐ Something else, please specify:

22. It is the plan that the soon-to-be-available GRAS SAF NRT temperature, humidity, and pressure products will be derived via a traditional 1Dvar approach in which the observations (refractivity) and the background (ECMWF forecast fields) are weighted according to assumed observation and background error covariances. This results in temperature, humidity, and pressure profiles that in principle can be considered an 'optimal' solution given the observations and the best available a priori knowledge that we have. However, such profiles will generally be inconsistent with the observations in that the derived temperature, humidity, and pressure does not correspond to the observed refractivity via the equation connecting these variables (e.g., the Smith-Wientraub formula). An alternative approach, currently applied to COSMIC data at CDAAC (product provided in the CDAAC wetPrf NetCDF files and BUFR products) is to give much more weight to the observations than to the background. In this way the physical relation between the solution and the observed refractivity is preserved, and the temperature is basically the same as the so-called dry-temperature in regions where moisture is negligible. Such an approach still includes information from ECMWF fields to separate out the meteorological variables in the moist troposphere, but it seeks to minimize the influence from the ECMWF fields and it preserves the full information coming from the observations.
If you are a potential user of the GRAS SAF temperature, specific humidity, and pressure products (either for NRT or research/climate applications), please indicate your preference:

A: For NWP and meteorology

☐ I prefer products based on a traditional 1Dvar approach

☐ I prefer products based on an alternative approach similar to the one used for COSMIC at CDAAC

☐ I prefer products based on a different approach. Please describe shortly the approach, e.g., with a reference to a paper or other:

☐ I do not intend to use these products for NWP

B: For climate research and atmospheric sciences

☐ I prefer products based on a traditional 1Dvar approach

☐ I prefer products based on an alternative approach similar to the one used for COSMIC at CDAAC

☐ I prefer products based on a different approach. Please describe shortly the approach, e.g., with a reference to a paper or other:

☐ I do not intend to use these products for climate or atmospheric research

Send Reset