Overview of ROM SAF activities

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ROM SAF team

Danish Meteorological Institute

Contents

- EUMETSAT
- ROM SAF CDOP-3
- GPAC (GNSS Processing and Archiving Center)
- ROM SAF Climate Data Records v1.0
- Looking towards ROM SAF CDOP-4

EUMETSAT SAF's

EUMETSAT

European Center for Operational Meteorological Satellites, Darmstadt, Germany

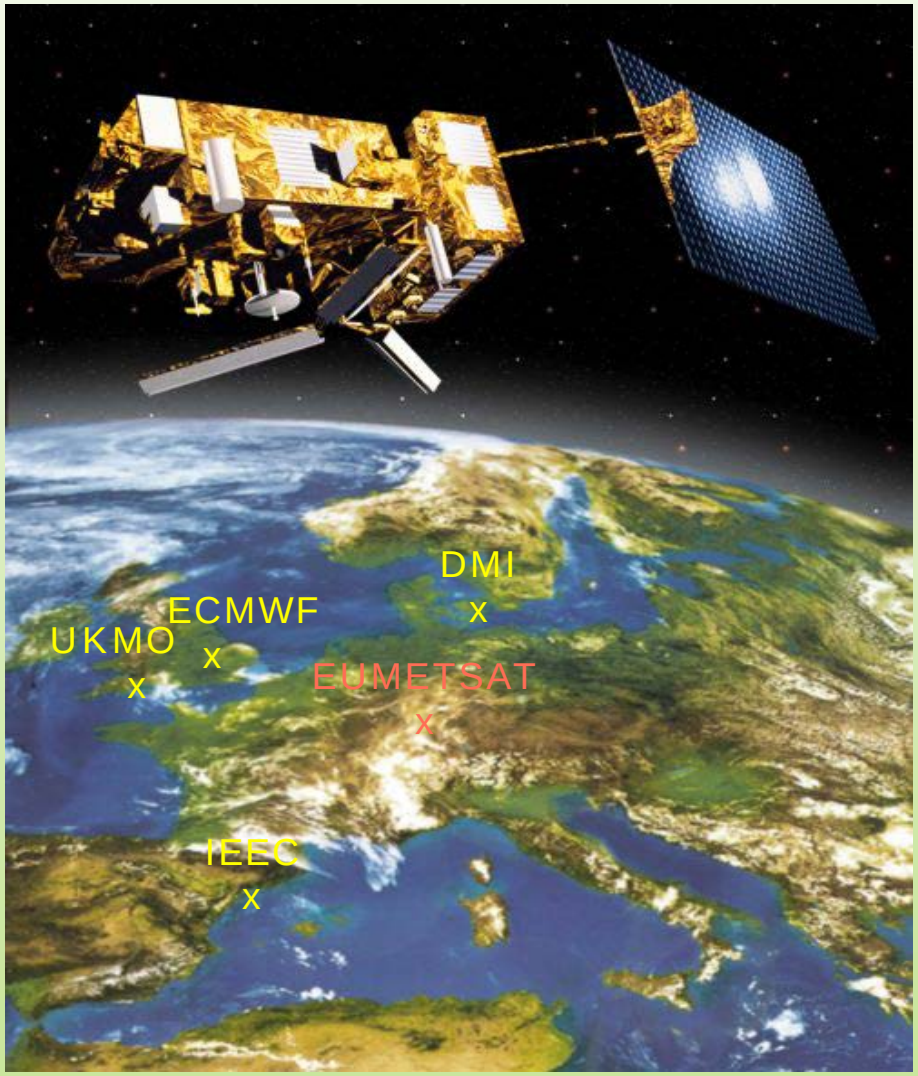
SAF's

Satellite Applications Facilities are decentralized operational processing centers of EUMETSAT, located in member countries

Radio Occultation Meteorology SAF (ROM SAF) Objectives

- To develop, produce, disseminate, and archive operational products
- Commitments related to EUMETSAT missions and other missions
- Current EUMETSAT mission: EPS/Metop
- Future EUMETSAT missions: EPS-SG, Jason-CS/Sentinel-6 (with NOAA)

ROM SAF Consortium



Leading Entity:

(DMI, Copenhagen, DK)

Cooperating Entities:

(ECMWF, Reading, UK)

(Institute d'Estudis Espacials de Catalunya, IEEC, Barcelona, Spain)

(Met Office, Exeter, UK)

ROM SAF CDOP-3 Objectives

CDOP-3

- 3rd Continuous Development and Operations Phase (2017-2022)

Overall theme

- Radio Occultation Meteorology

Objectives

- To develop, produce, disseminate, and archive operational RO products
- To support NWP (global and regional “EARS” area)
- To support climate monitoring
- To support space weather monitoring

ROM SAF CDOP-3 Activities

Main activities

- Produce radio occultation products for EUMETSAT and other missions
- Develop new products for EPS-SG: “Day 2” ionosphere products
- Products and software for NWP, climate applications, and space weather
- Regular releases of ROPP with new features and routines
- NRT monitoring website using NWP data
- Generation of Climate Data Records through reprocessing

GPAC Four Processing Modes

Near real-time (NRT):

- Based on EUMETSAT Secretariat Metop Level 1B data (bending angles)
- Delivered less than 3 hours after measurement (for EPS system)

Offline:

- Based on EUMETSAT Secretariat Metop Level 1A data (excess phases)
- Delivered from less than 5 days to up to 6 months after measurements
- Evolution is driven by new scientific developments and subsequent product upgrades

Climate Data Record (CDR):

- Based on EUMETSAT Secretariat reprocessed Metop Level 1A data (excess phases)
- CDR v1.0 also based on UCAR CDAAC reprocessed/post-processed excess phases
- Generated approximately every other year (CDR v2.0, v3.0, …)

Interim Climate Data Record (ICDR):

- Based on EUMETSAT Secretariat Metop Level 1A data (excess phases)
- Extending the latest CDR in time, having optimum consistency with and lower latency than the system used to generate the CDR

RO Missions Commitments

Mission	NRT	Offline	CDR (reprocessing)	ICDR
Metop	X	X	X	X
Metop-SG	X	X	X	X
Jason-CS (Sentinel-6)		X	X	X
COSMIC		X	X	
COSMIC-2a		X	X	X (TBD)
CHAMP			X	
GRACE			X	
GPS/MET			X	
FY-3/GNOS			X	X (TBD)
TSX, TDX, …			X (TBD)	
PAZ			X (TBD)	
…				

Processing of RO Data from Level 1A

L1B (bending angle) processing:

- Based on ROPP_PP wave optics algorithm
- Ionosphere correction from linear combination of L1 and L2 bending angles
- Statistical optimization based on fitting to BAROCLIM background climatology

L2A (refractivity) processing:

- Based on ROPP_PP Abel inversion

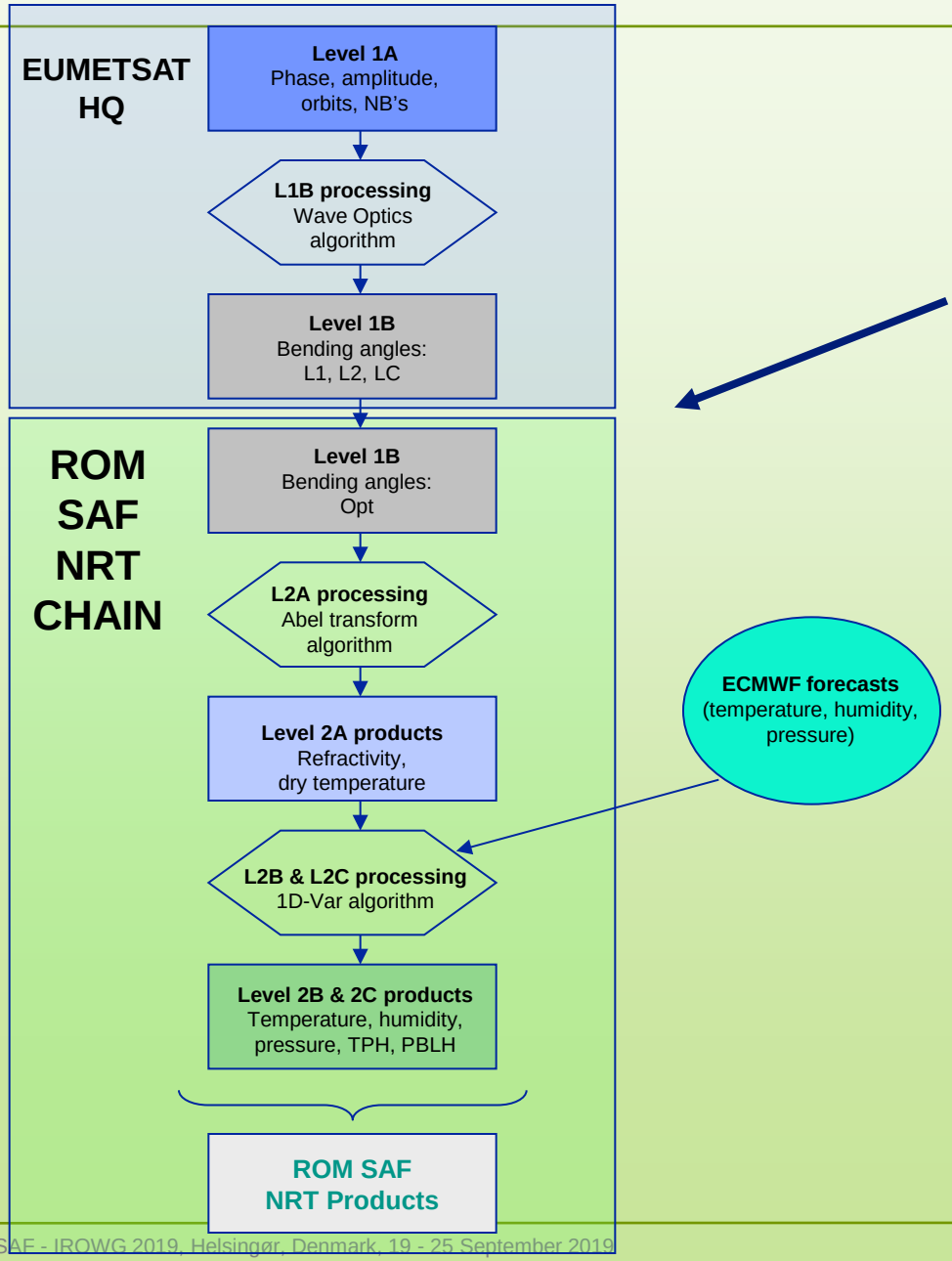
L2B (1D-Var) processing:

- Based on ROPP_1DVAR 1D-Var algorithm
- Using ECMWF background and L2A refractivity observations as input

L3 (gridding) processing:

- Based on ROMCLIM package (*non-public package*)
- Gridding of Level 1B, 2A, 2B, and other L2 variables (TPH, PBLH, geopotential height, dry temperature and pressure)
- Zonal latitude bands, Monthly mean climatologies

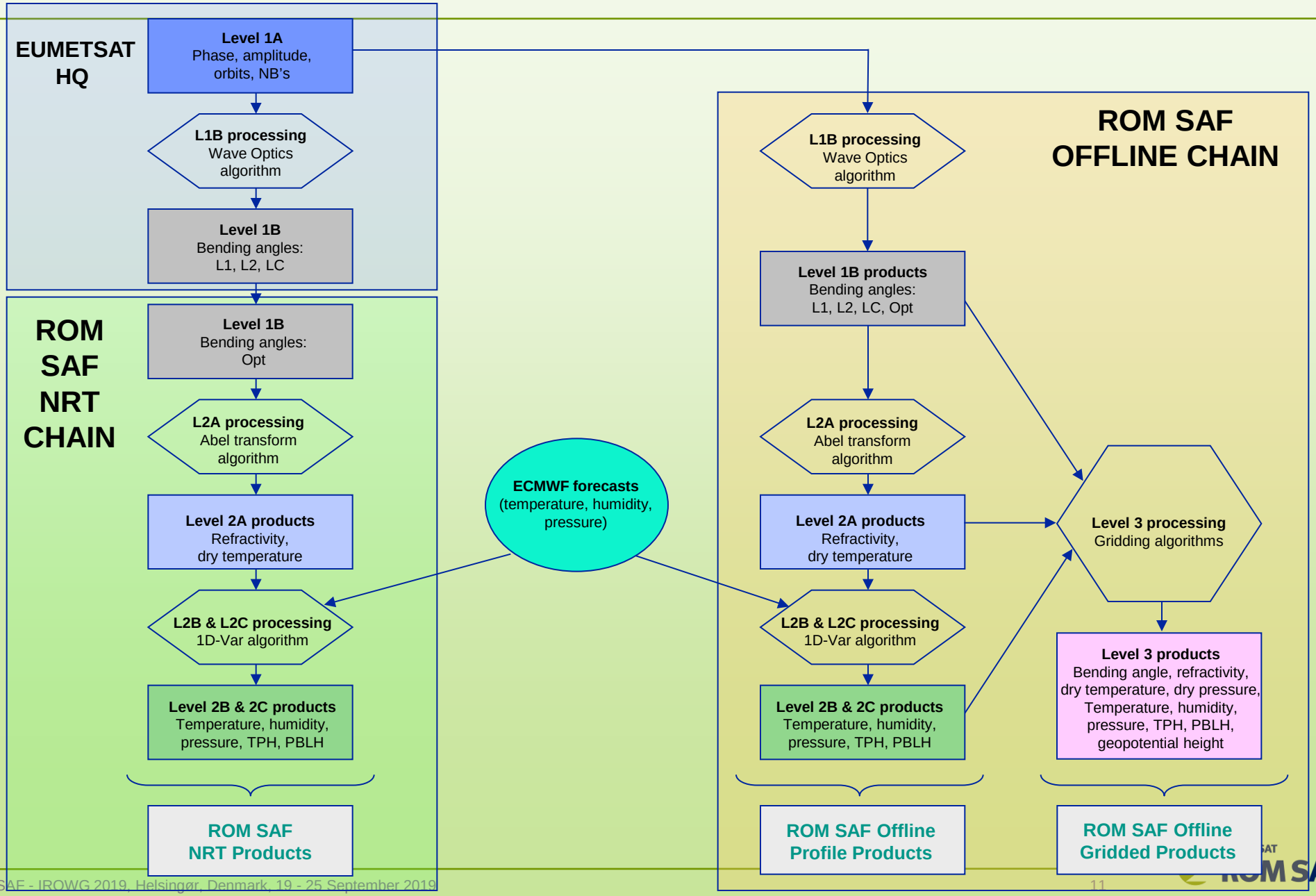
EUMETSAT HQ and ROM SAF NRT Processing



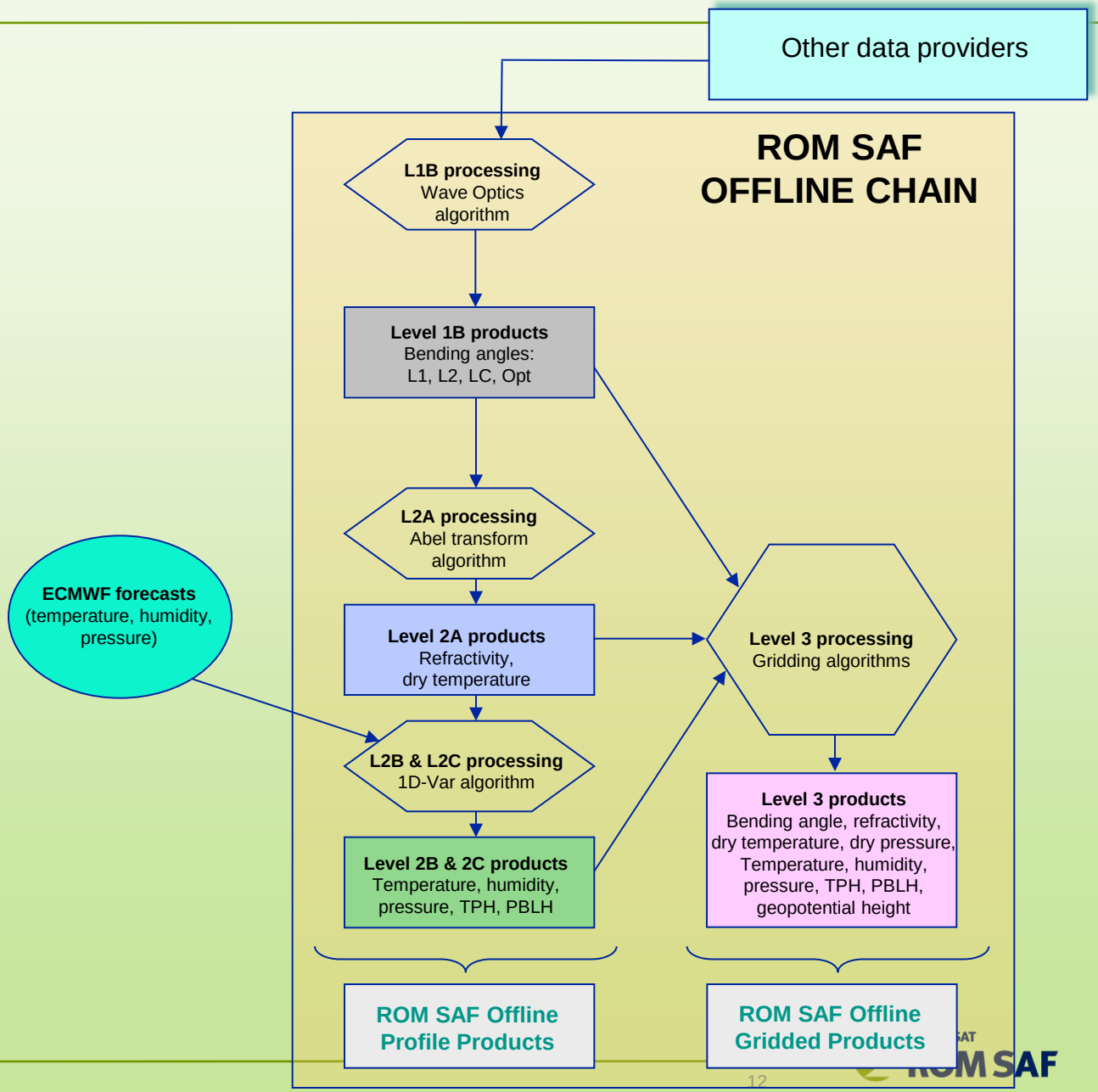
Coordination between EUMETSAT HQ and ROM SAF

- Coordinated reviews (e.g. for Metop-C)
- Agree on issues and priorities
- Regular telecons

ROM SAF NRT and Offline Processing Overview



ROM SAF Offline Processing Overview



GNSS Processing and Archiving Center (GPAC)

GPAC 0.4.2 (current NRT code – operational since 2016-10-13)
- Based on OCC code;
- Takes in data in new formats (and WO) from EUMETSAT;
- Adjustments to QC settings in light of the WO data analysis;

GPAC 0.4.3 (next NRT upgrade – TBD)
- New B-matrix for 1D-Var (TBD);
- Possible adjustments to QC settings after EUM fixes (PPF 4.7);

GPAC 2.3.1 (previous offline code)
- Same as 2.3.0, but with ROPP 9.0;

GPAC 2.3.2 (current offline code)
- Same as 2.3.1, but with option to run ICDR;

GPAC 2.4.0
- Kappa-correction; transition to use ERA5

GPAC 3.0.0 (NRT and offline in one code)

Plan (Q2 2019):

Boxes indicate only approximate scheduling

	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020
NRT	**GPAC 0.4.2** + Metop-C	GPAC 0.4.3 => (TBD)	NRT code based on offline code; use ROPP PP	TBD upgrade to QC settings after EUM PPF 4.7	
Offline	Metop-A, B, C; **GPAC 2.3.1**	kappa-correction; ERA5 (TBD); **GPAC 2.4.0**	COSMIC-2 in offline (level 3); **GPAC 3.0.0**		GPAC 4.0.0 => EPS-SG
Reprocessing & ICDR	**GPAC 2.3.2**; ICDR for Metop-A, B, C	ICDR; no kappa-correction; ERA5	ICDR continued with same algorithms as in reprocessing #1		reprocessing #2 Metop; COSMIC; COSMIC-2; etc...

Climate Data Records v1.0

CDR v1.0 data records:

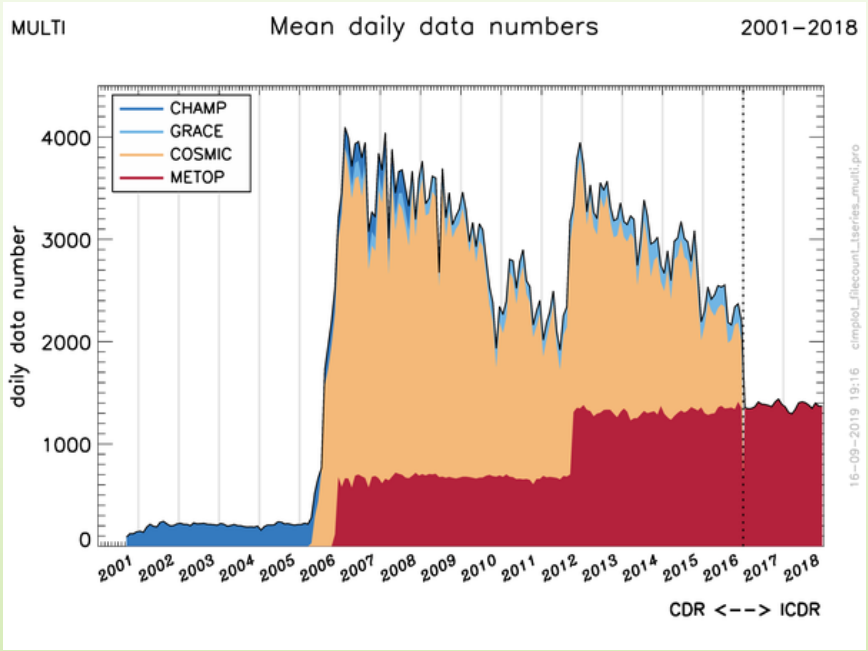
GRM-29-R1: **Metop-A and B** (2006–2016)

GRM-30-R1: **COSMIC** (2006–2016)

GRM-32-R1: **CHAMP** (2001–2008)

GRM-33-R1: **GRACE** (2007–2016)

GRM-28-R1: **Multi-mission** (2001–2016)



Interim CDR v1.0 data records:

GRM-29-I1: **Metop-A and B** (2017 – present)

Contents:

- Bending angles (Level 1B), Refractivity and dry temperature (Level 2A)
- Temperature, humidity, pressure (L2B), Surface pressure, tropopause height (L 2C)
- Gridded data of all variables, including geopotential height (Level 3)
- In total: 16 RO data records per mission

Users of ROM SAF CDRs

CDR v1.0 bending angle data records used in **reanalyses:**

- Two ROM SAF reanalyses (released 13 September 2019)
- Copernicus regional reanalyses over Baltic, Greenlandic (“CARRA”) and European regions
- Australian reanalysis

CDR v1.0 data records used in **international collaborations:**

- SCOPE-CM RO-CLIM
- ROtrends
- IPCC AR6 contribution (First order draft)

CDR v1.0 humidity data records brokered for **Copernicus**:

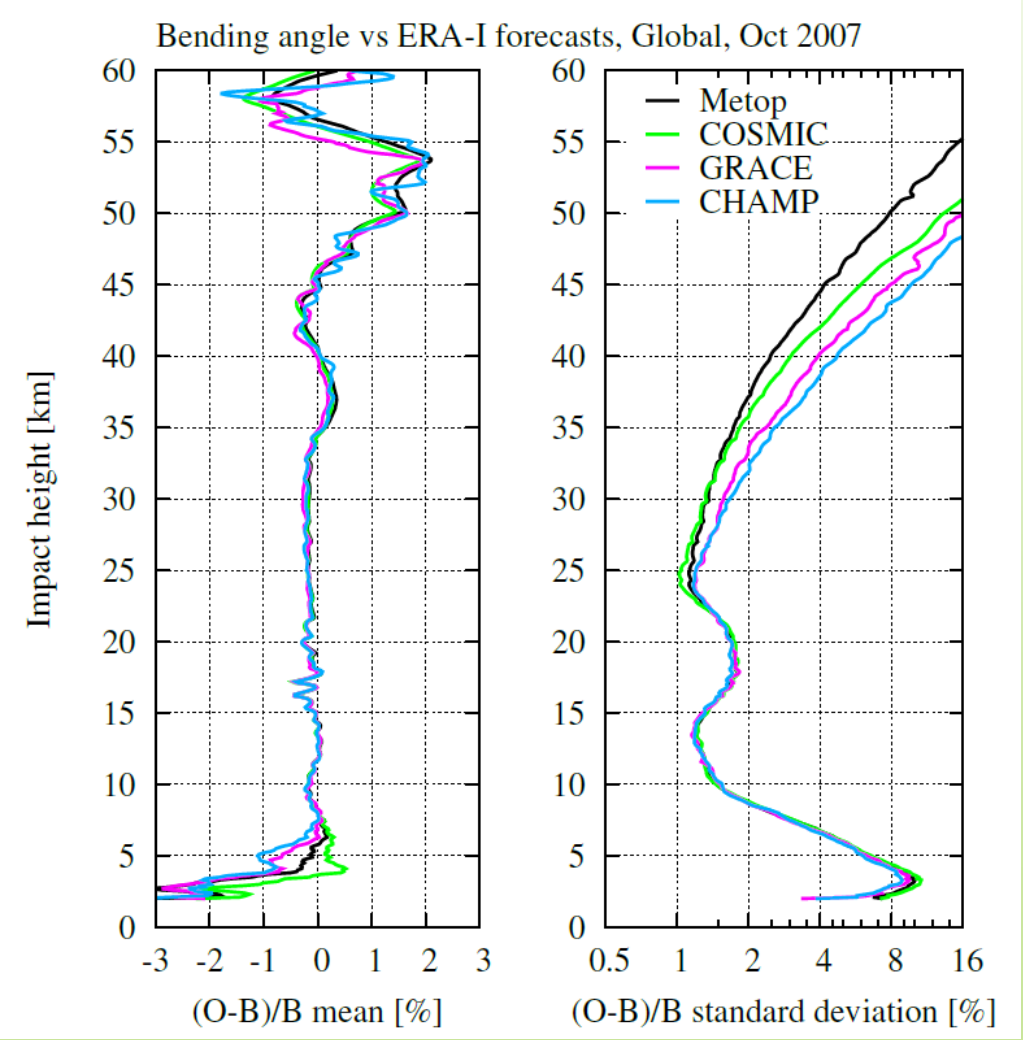
- C3S Climate data store

The Next ROM SAF Climate Data Records

- The next reprocessing activity is planned for 2020, followed by release of the ROM SAF CDR version 2 (CDR v2.0).
- CDR v2.0 could also include COSMIC-2A, GNOS, and GPS/MET (and others); Depends, amongst other things, on availability of Level 1A input data.
- In between CDR v1.0 and CDR v2.0, we provide the ROM SAF Interim Climate Data Record (Metop only), based on the same algorithms as CDR v1.0.
- At the outset, the ROM SAF offline data and ICDR v1.0 are identical, but over time the offline algorithms will evolve. The ICDR algorithms will not change (but note, we will have to transition to use ERA5 for 1D-Var when ERA-I is terminated, and an assessment of the impact of this transition is ongoing).

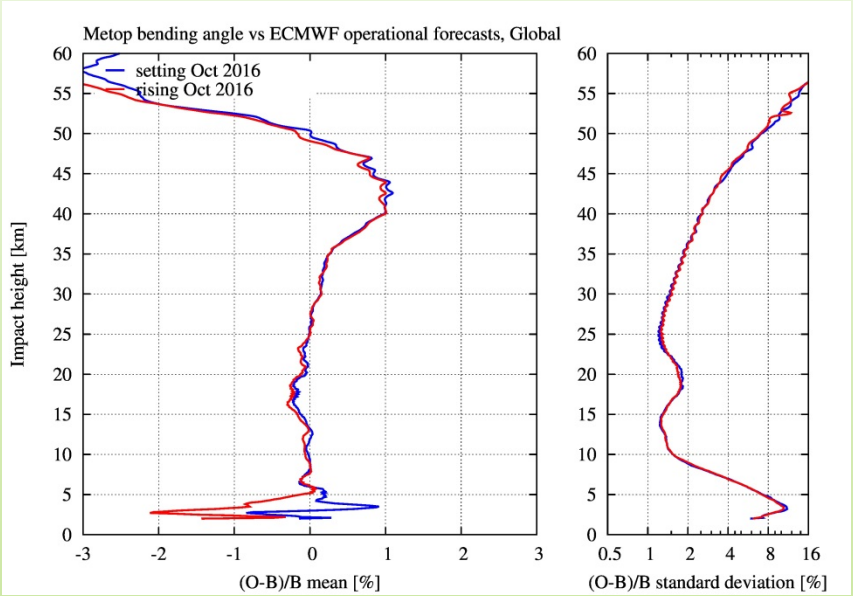
Bending Angle Statistics for CDR v1.0

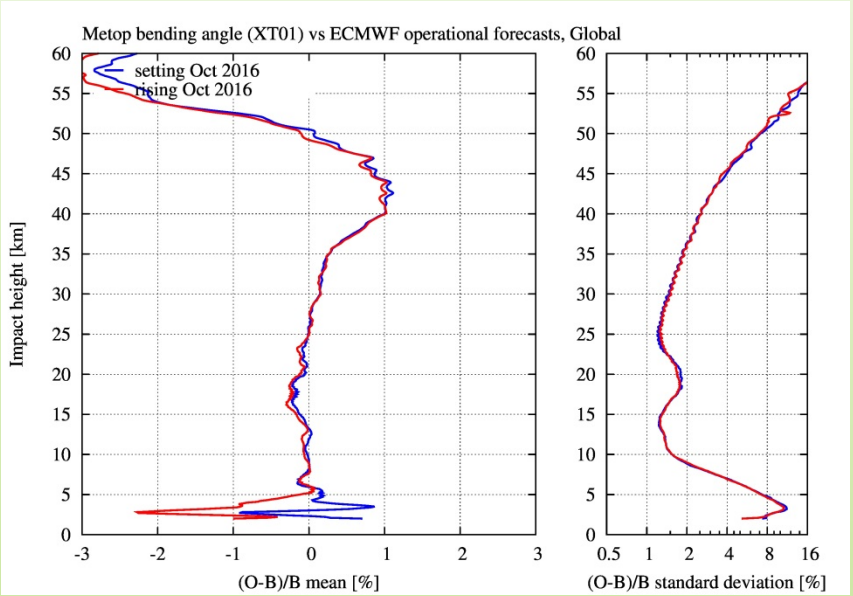
CDR v1.0: Monthly global profile statistics of bending angle for different missions



Presentation by Stig Syndergaard (DMI ROM SAF)

Title: Implementation and results of the kappa residual ionospheric correction in ROM SAF processing



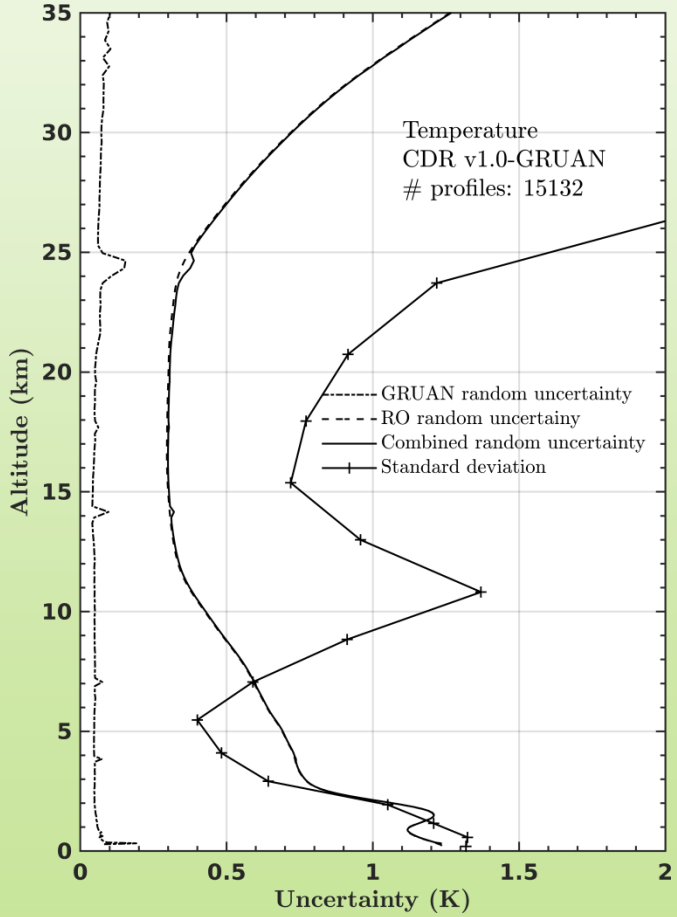


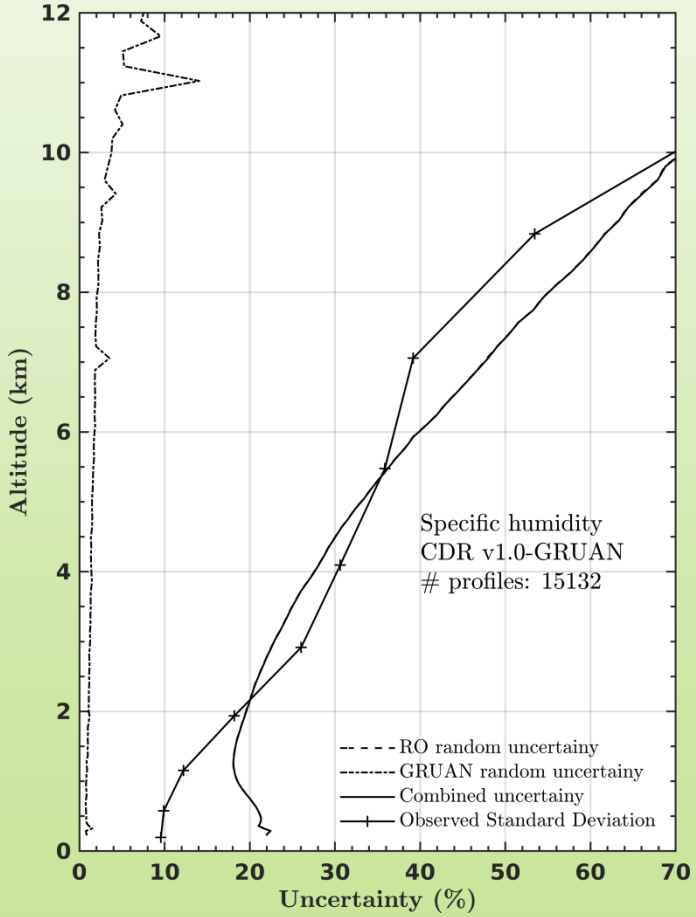
October 2016 as example

Kappa-correction can be seen as a subtle change in the (O-B)/B mean

Presentation by Johannes K. Nielsen (DMI ROM SAF)

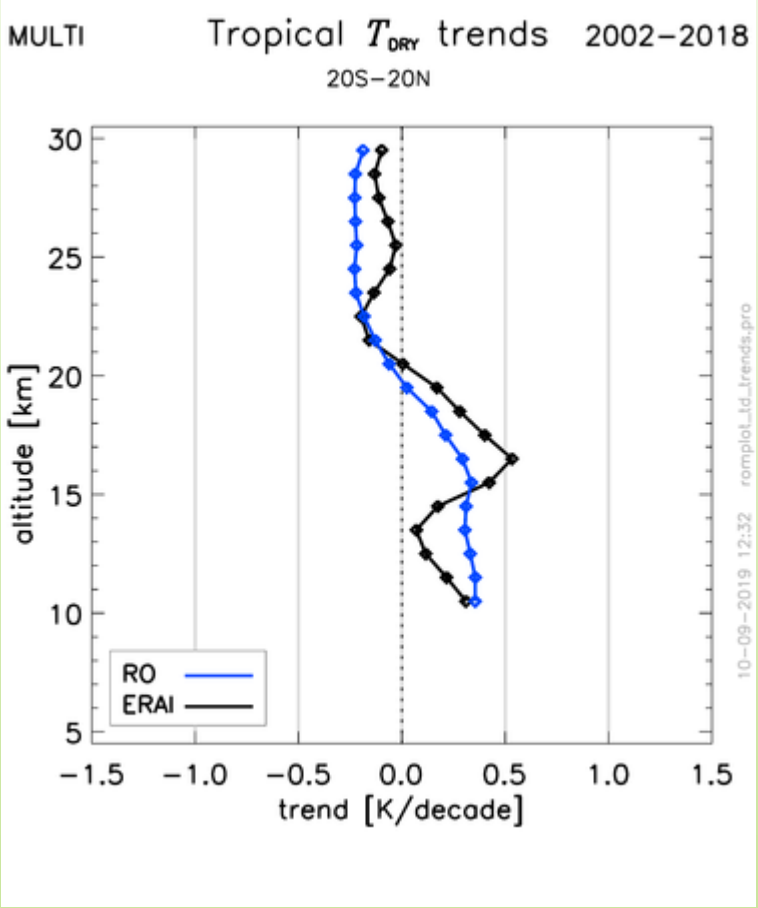
Title: Uncertainty of temperature, humidity and pressure profiles from the first ROM SAF Climate Data Record

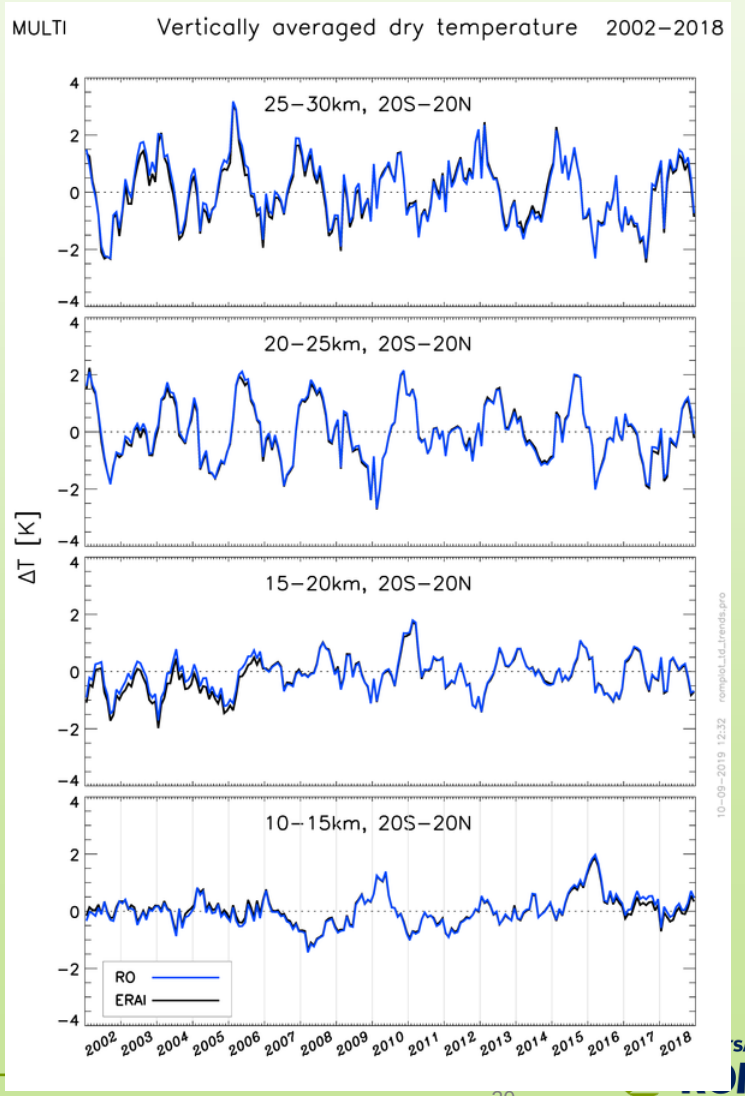




Presentation by Hans Gleisner (DMI ROM SAF)

Title: The ROM SAF RO climate data record: validation and inter-mission consistency





Tropical temperature anomaly trends, 2002-2018, from ROM SAF (blue) and from ERA-Interim (black).

Presentation by other ROM SAF team members

Haixia Lyu (Ionosphere products developments)
- Two methods of electron density retrieval from truncated ionospheric radio occultation data (Monday)

Estel Cardellach (IEEC Local Manager)
- Polarimetric GNSS RO aboard the PAZ satellite: status of the ROHP-PAZ experiment (Monday)

Neill Bowler (NRT Monitoring)
- Revised observation uncertainties for bending angle assimilation (Tuesday)

Sean Healy (Science Coordinator):
- The use of GPS-RO at ECMWF (Tuesday)
- The ROM SAF reanalyses (P24)

ROM SAF Visiting Scientists
- 14 VS candidates present at this workshop (3 ongoing VS activities)

ROM SAF Collaboration with Wegener Center

CDOP-3 Federate Activity:

- Collaboration through the Austrian ATROMSAF1 project with Wegener Center, Graz University, Graz, Austria
- Objective is to improve Wegener Center and ROM SAF CDRs through assessment of structural uncertainty for different product levels

  → Veronika Proschek and Marc Schwärz (P18)
- Wegener Center application for continued collaboration through the ATROMSAF2 project with the objective to strengthen validation of RO climate data records

“35 Years of SAF Development and Operations”

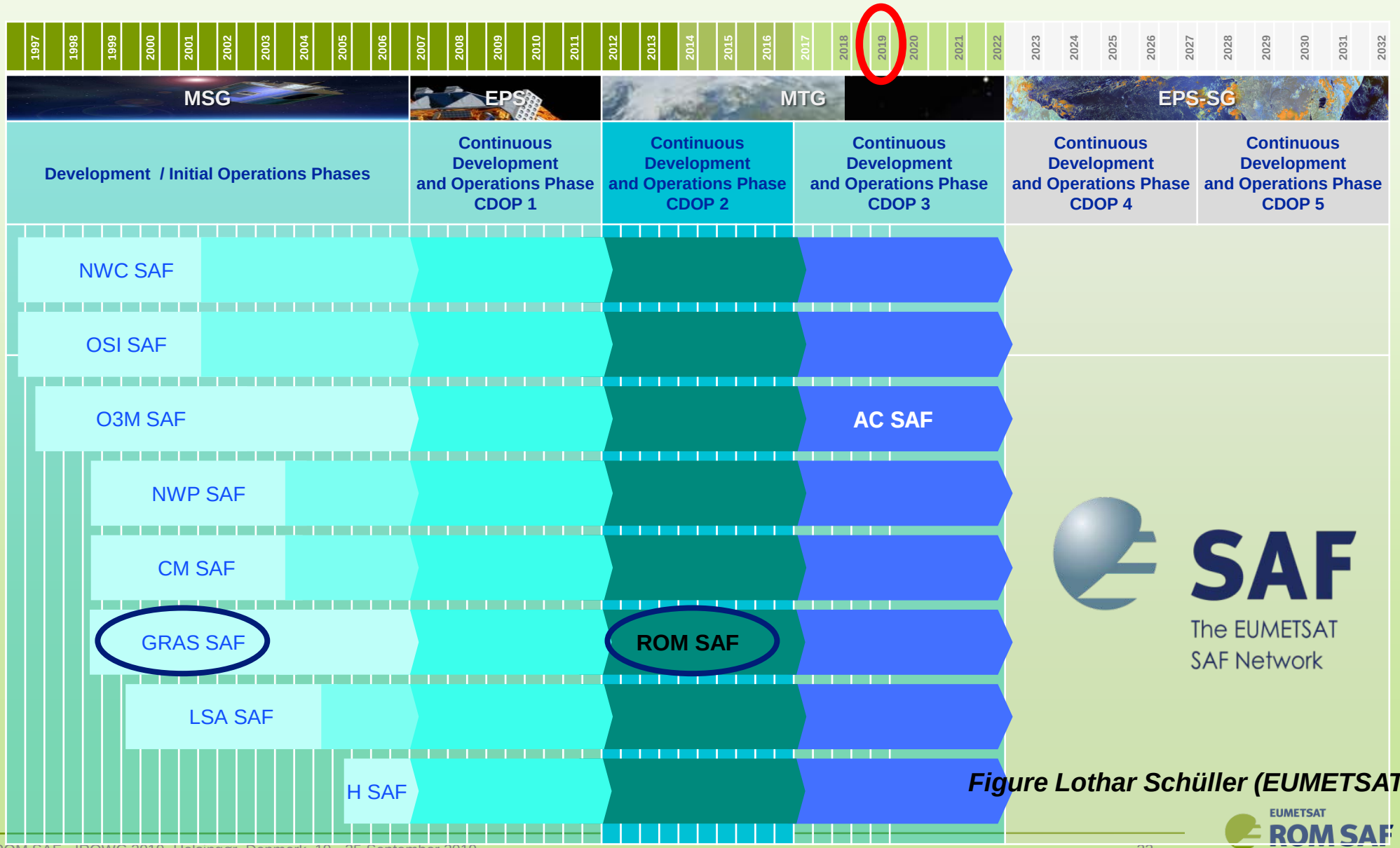


Figure Lothar Schüller (EUMETSAT)

Looking towards CDOP-4 (2022-2027)

Overall theme

- Radio Occultation Meteorology

Objective

- Operational processing center for development, production, dissemination and archiving of radio occultation (RO) products from EUMETSAT missions and other RO missions

Focus areas

- To support **NWP**
- To support **climate monitoring**
- To support **space weather monitoring**

CDOP-4 Work Driven by User Input

User interaction

- Close interactions with users regarding RO data and applications
- **Recommendations** from 6th ROM SAF User Workshop
- **Recommendations** from 7th IROWG Workshop
- Take into account requests from Copernicus services
- Respond to requests from SCOPE-CM
- Close interactions with other RO processing centers regarding intercomparison of RO quality

Fin