

# RO Present Status and Future Plans

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# Outline

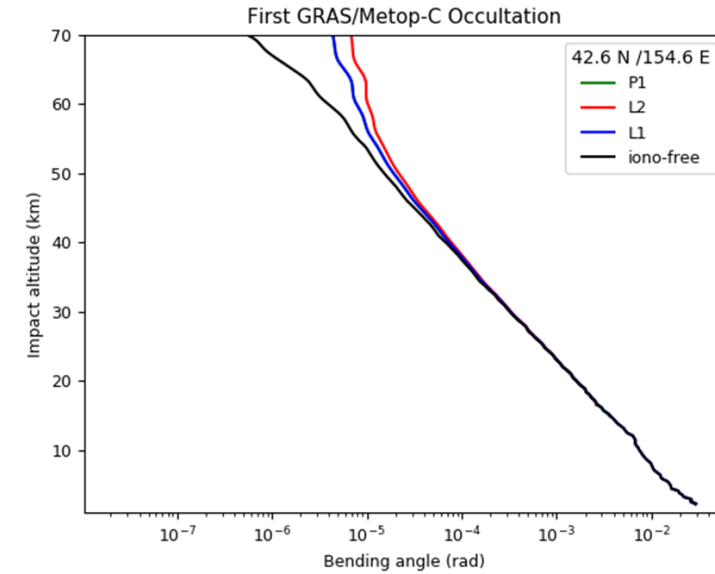
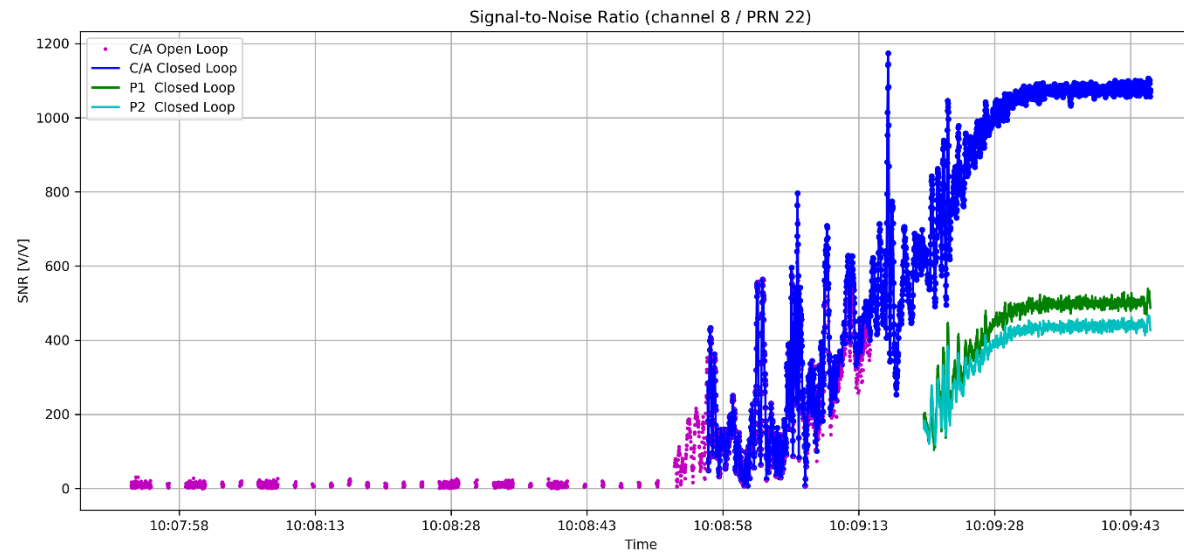
- Metop-C
- Updates to the GRAS processing
- EPS-SG and Sentinel-6/Jason-CS
- Commercial RO data



# Chronology and instrument configuration

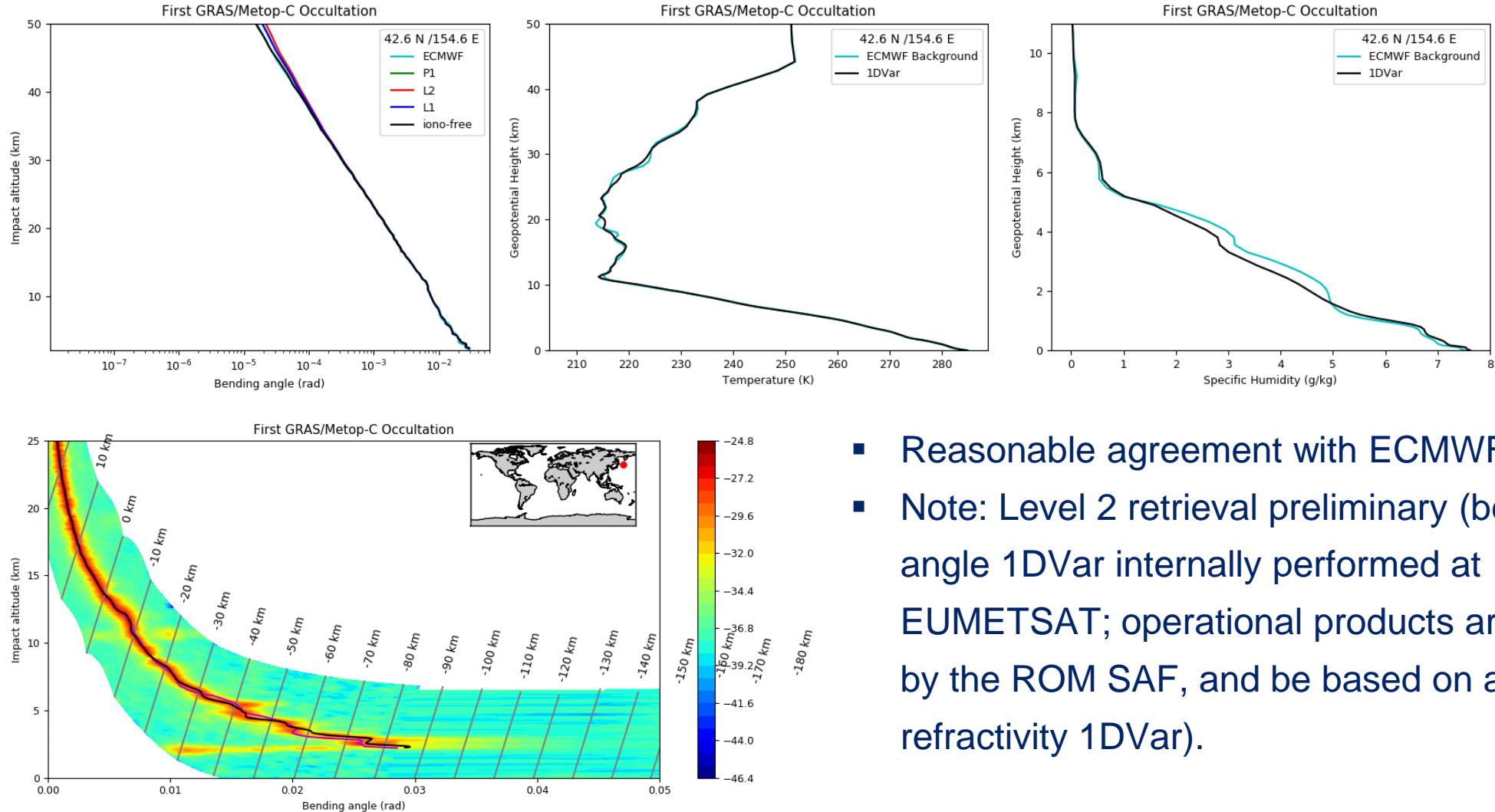
- 7 Nov 2018:
  - Launch
- 12 Nov:
  - 09:28 UTC: USO switch-on
- 13 Nov:
  - 10:04:27 UTC: Navigation mode
  - 10:05:27 UTC: Occultation mode
  - 10:07:52 UTC: First occultation
- No interruption since then, no instrument anomalies.
- GOBS v1.11,  $SLTA_{RS} = -15$  km,  $SLTA_{track} = -300$  km (as for Metop-A and -B);

# First GRAS/Metop-C Occultation



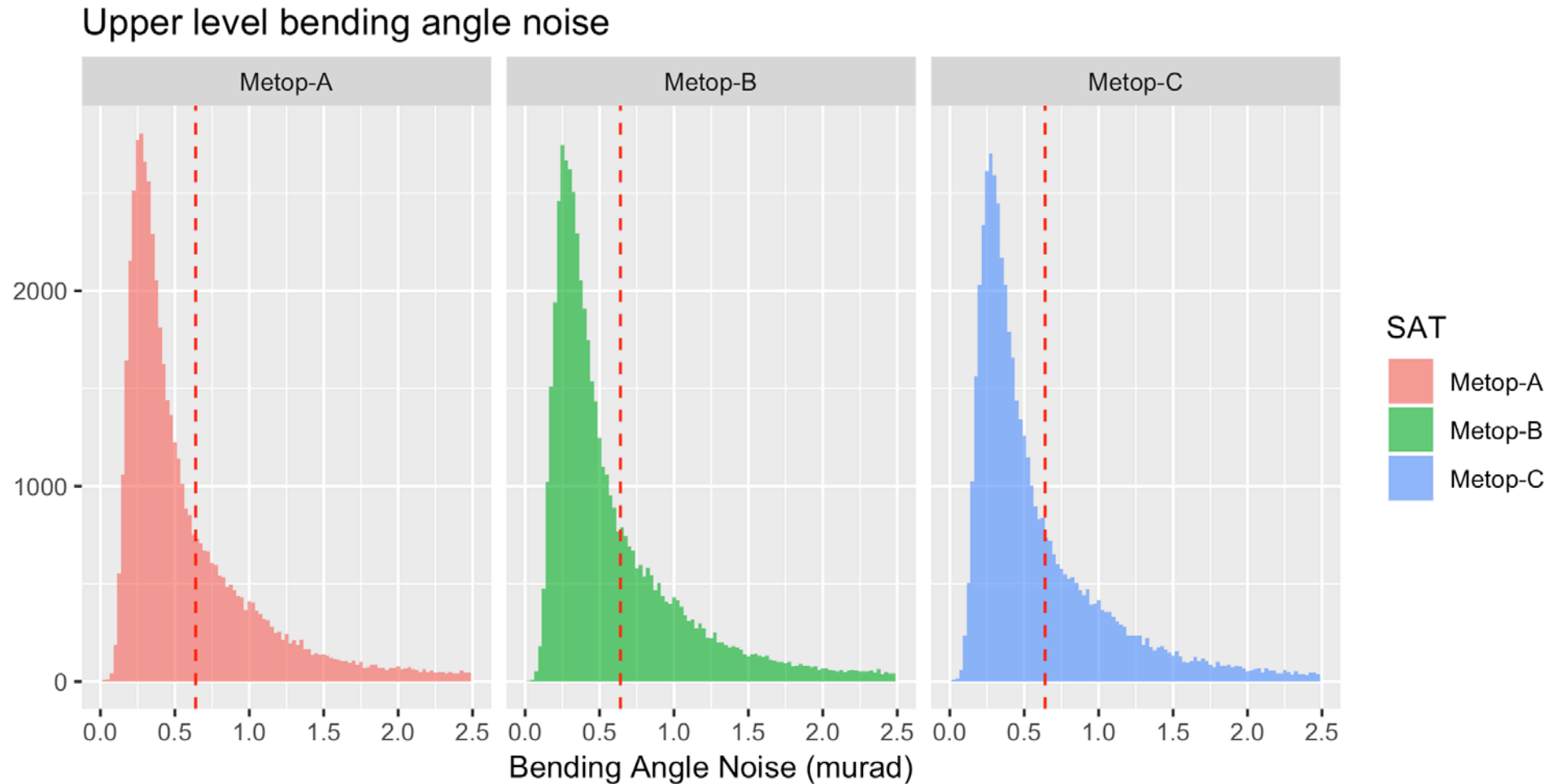
- First occultation (rising) on 13 Nov. 2018 shortly after 10:07 UTC
- Typical GRAS behaviour in Earth shadow with repeated attempts to track the signal
- Note excellent SNR at high altitudes ( $> 1000$  V/V)
- Tropopause signature around 12 km, penetration towards the ground

# First GRAS/Metop-C Occultation



- Reasonable agreement with ECMWF
- Note: Level 2 retrieval preliminary (bending angle 1DVar internally performed at EUMETSAT; operational products are provided by the ROM SAF, and be based on a refractivity 1DVar).

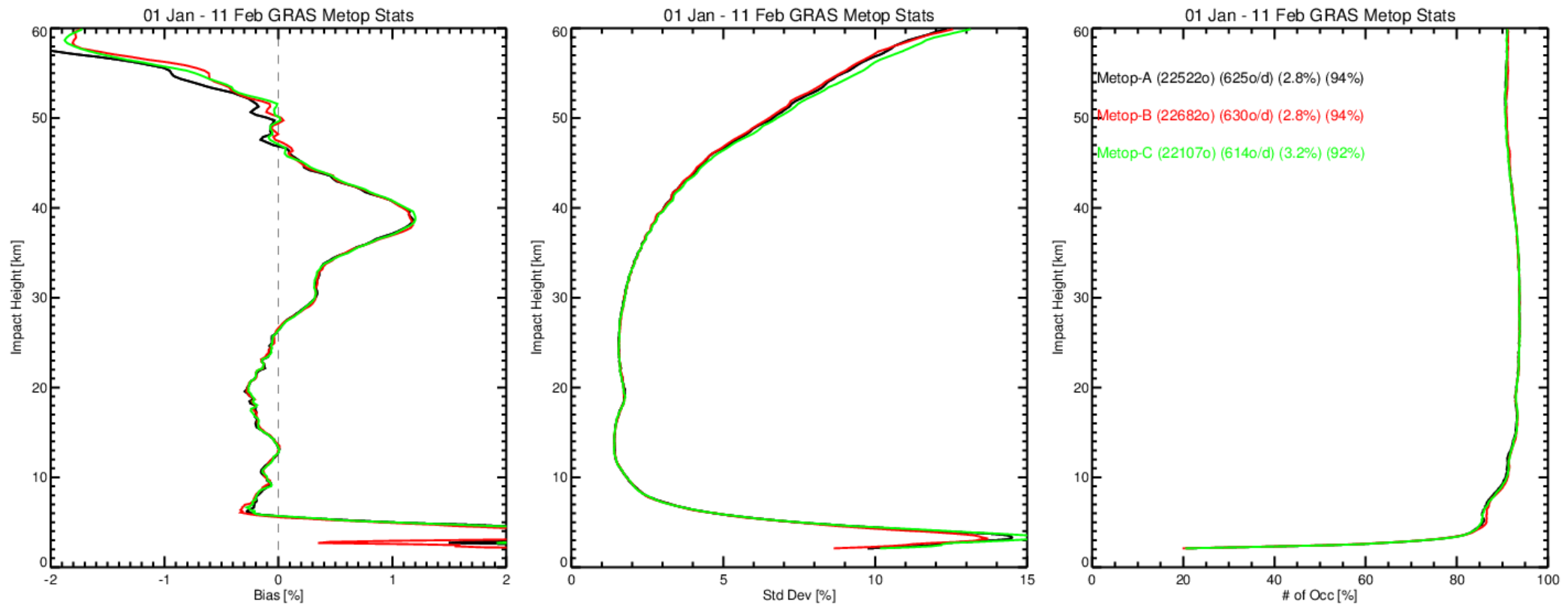
# Upper Level Bending Angle Noise (Nov '18 – Feb '19)



- Consistently low noise figures in upper level (60 – 80 km) bending angle noise



# Statistics Against ECMWF (Jan & Feb 2019; Tropics)

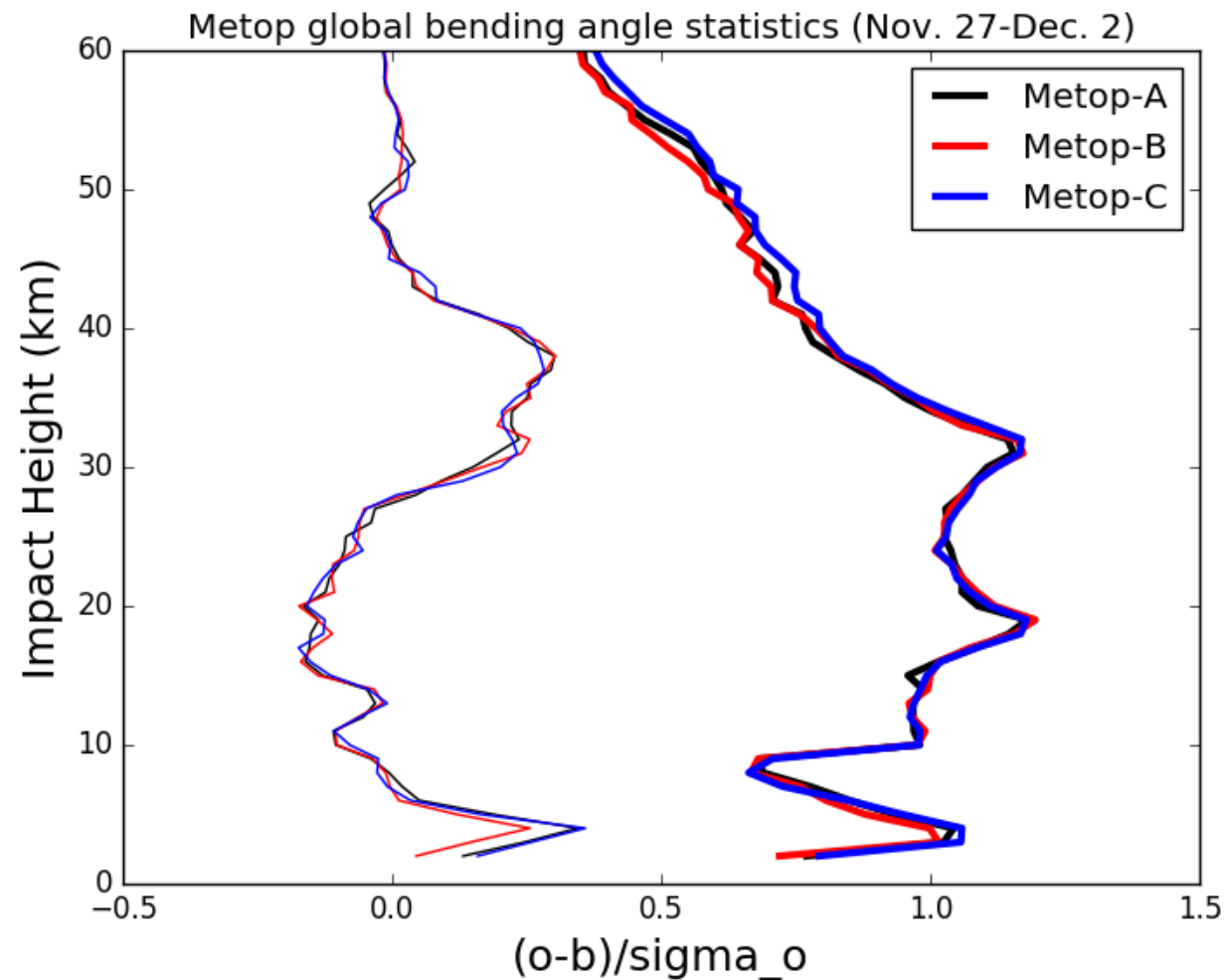


- Metop's are consistent...
- Also looking at other results, it seems that Metop-C noise is slightly higher at altitudes > 40km for all latitude bands

# ECMWF / ROM SAF Assessment (Nov 2018)

Sean Healy (email on 6 December):

- “Remarkable consistency - fantastic work guys!”
- “The plan here is to put the metop-c in the operational system passively next week. I will start assimilation experiments ASAP.”





# External validation

We got feedback from

- Sean Healy (ECWMF)
- Neill Bowler (MetOffice)
- Stig Syndergaard and Joe Nielsen (DMI)
- Dominique Raspaud (Meteo France)
- Harald Anlauf (DWD)
- Hui Shao and Shu-Pen Ho (NOAA/JCSDA)
- Mi Liao (CMA)

Thank you!

# Evolution of the GRAS processing

- We (eventually) introduced wave optics processing in late 2017; there are still issues in the operational GRAS processing. Examples:
  - Non-physical oscillations in GRAS bending angle profiles at altitudes above 40 km (inconsistent L1 and L2 filtering)
  - Non-physical spikes in tropospheric retrievals (filtering issues and impact multipath)
  - Different biases for rising and setting occultations (~ 1-2%)
- Also considering empirical error estimates based on signal spectra (there's a poster on that; we'd like your feedback)
- Addressed by a new GRAS processor release later this year
- Data evaluation and validation primarily by the ROM SAF, but let us know if you're interested.

# Other

- Reprocessing of GRAS data from 2006 until 2018 has been completed; a new round will start early 2020 and also include CHAMP, GRACE and COSMIC data
- Analysis of reprocessed data: Axel's talk on tomorrow
  
- In early 2020, we will run a test campaign extending GRAS measurements of Metop-A into the ionosphere (up to 500 km, similar to EPS-SG)
- Might implement limited ionospheric capability in all GRAS receivers in the future
- We are looking into multi-mission topside TEC from EUMETSAT satellites carrying space-borne GPS receivers; see Riccardo's talk on Monday.

# Metop-A

- Planned to be operated until 2021 before being de-orbited
- Will drift out of the nominal orbit plane
- End-of-life technology test campaign(s), e.g. GRAS extension into the ionosphere
  
- So far, Metops were operated in a Tristar configuration
- Will change to a Trident configuration

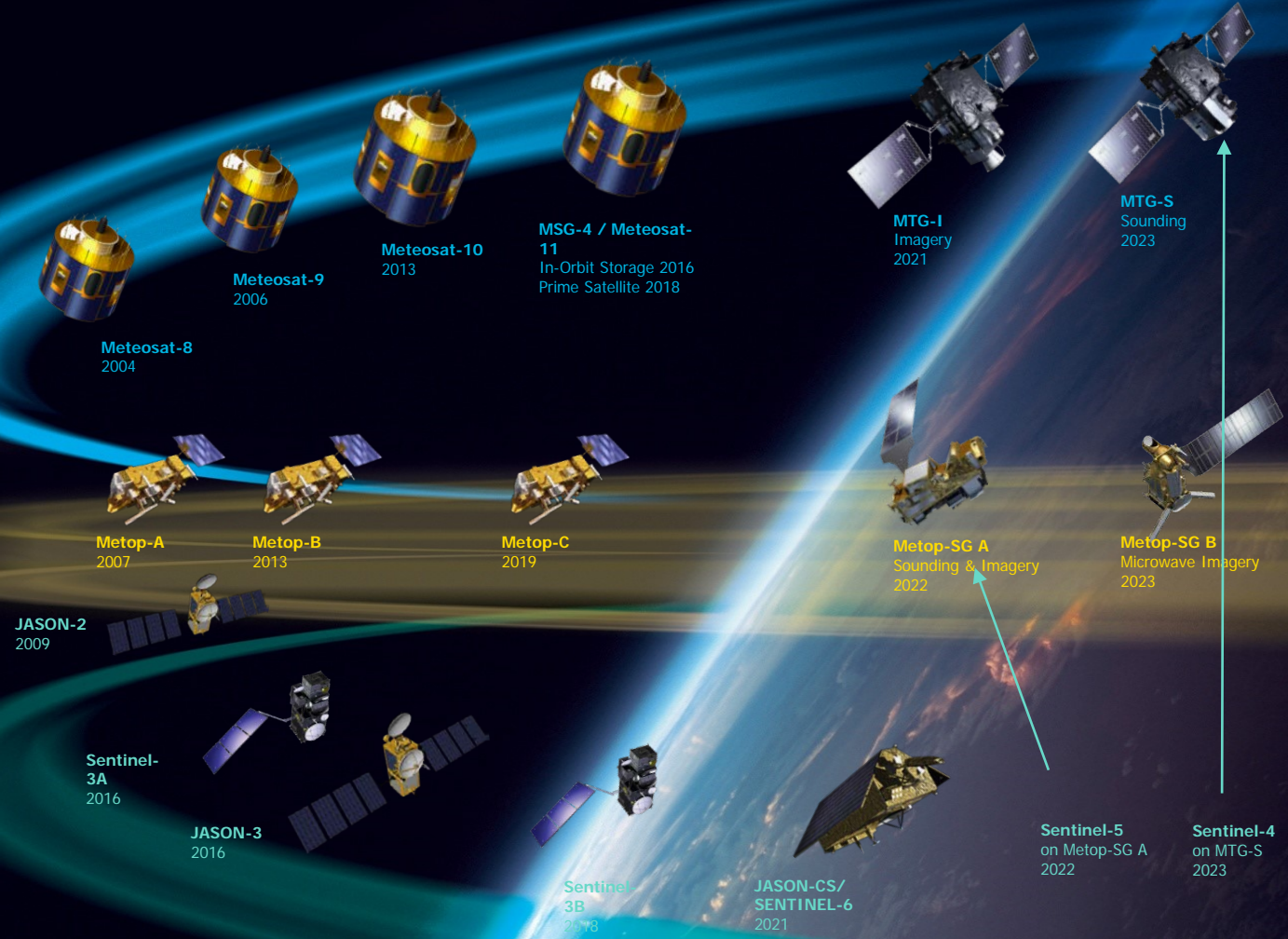
# EUMETSAT missions – current and future

## Geostationary Programmes

## Mandatory Programmes

## Polar Programmes

## Optional and Third Party Programmes (incl. Copernicus)



# EUMETSAT RO missions – future

## EPS-SG:

- GRAS-2 (Anders' talk later today)
- Improved tropospheric open loop tracking
- Ionosphere (up to 500 km)
- Constellations: GPS, Galileo, Beidou (likely), QZSS (possibly)
- Current launch dates: November 2022 (Sat A) and 2023 (Sat B)

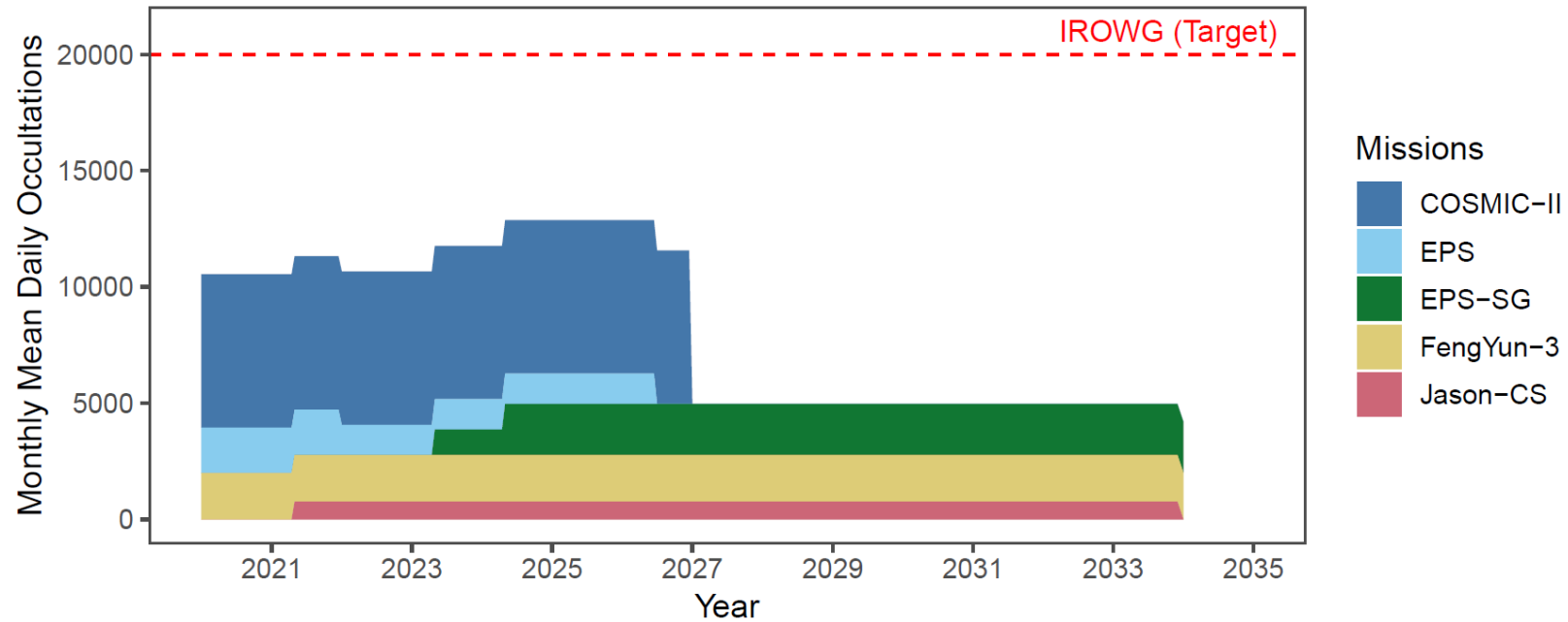
## Jason-CS/Sentinel-6:

- TriG (Chad Galley's talk this afternoon)
- Operational products by JPL/NASA
- Non-Time Critical (NTC) processing by EUMETSAT
- Current launch date: November 2020

For both missions, ROM SAF will do level 2 products and provide scientific advice and applications.

# Number of occultations from public missions

Expected Monthly Mean Daily Radio Occultation Numbers  
(WMO/OSCAR with updates)



EUMETSAT (May 2019)

- Conservative estimate: Only missions committed to operational data provision, with secured funding; assuming nominal lifetimes;
- Assuming data availability 6 months after launch.



# Assessment of Commercial RO data

- EUMETSAT has initiated a discussion with its Council on the use of RO data from commercial providers.
- EUMETSAT Council in December 2018 recognised that the value of obtaining RO data from constellations of state-of-the-art RO instruments shall be studied.
- To that purpose, Council authorised, among others, EUMETSAT:
  - To support ESA in studies aiming at assessing the scientific value of RO data provided by commercial entities – ongoing (see talk this afternoon)
  - To positively respond to NOAA offer to be an international partner involved in the NOAA Commercial Weather Data Pilot (CWDP - Phase 2) – ongoing.

# Assessment of Commercial RO data (cont'd)

For the ESA studies, this support is provided under the condition that :

- Study results could be captured in EUMETSAT's Technical Report, made available to EUMETSAT Member States and on EUMETSAT website.
- Any use of the study results produced by EUMETSAT, either in full or in part, requires EUMETSAT's prior approval.

The results of these evaluation studies will be reported to Council for discussion on possible further steps.

# Conclusions

- With the launch of Metop-C, EUMETSAT operates a 3-satellite European RO constellation;
- Data from all GRAS instruments on the Metop satellites is highly consistent.
- We are...
  - ...addressing issues in the operational wave optics processing with an upcoming release of the GRAS processing (in late 2019)
  - ...preparing for future missions with RO: EPS-SG and Jason-CS
  - ...involved in assessing the quality of RO data from the private sector with both ESA and NOAA.