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EUMETSAT RO Processing:

- Metop-C Update
- Occultation Predictions
- Reprocessing

RO Team @ EUMETSAT

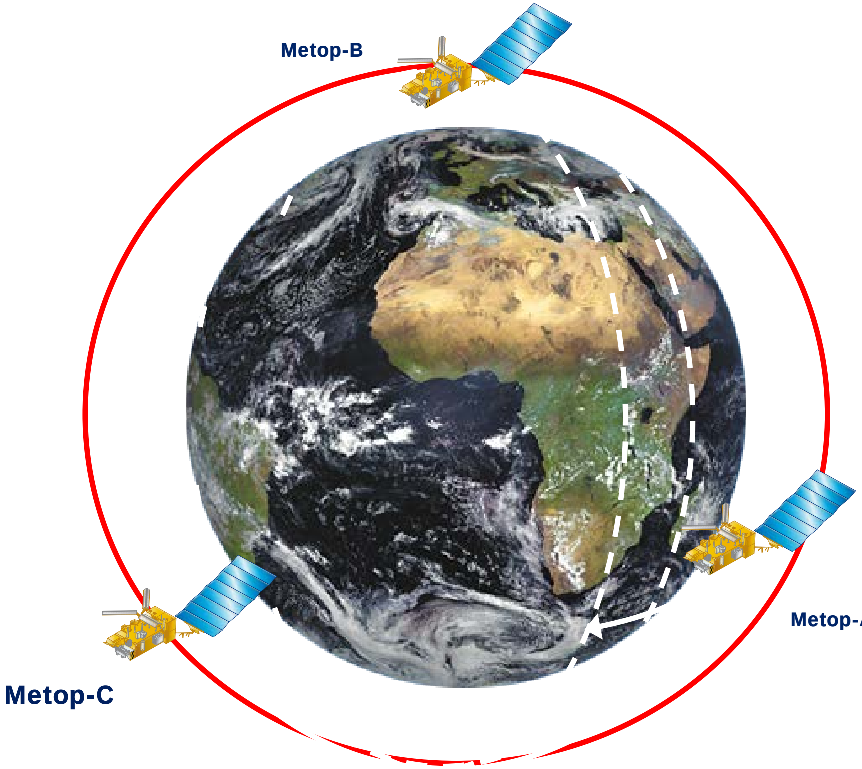
Metop-C: “Constellation” now complete

- **Metop-C**
  - **Launch 7 November 2018**
  - **Will become prime satellite after commissioning (Q3/2019)**
  - **Transition to EPS-SG**

- **Metop-B**
  - **Present prime satellite**
  - **Will become secondary satellite**

- **Metop-A**
  - **Additional operational capacity, but in drifting orbit**
  - Planned to be used for testing RO ionosphere sounding
  - Until end of life/de-orbiting, 2021/early 22

Tri-star configuration (during commissioning, TBC after)



Sun-Synchronous Orbits, 14 Orbits / day
Nominal Inclination 98.7 degrees (North = 90 degree)
Nominal Local Time of Descending Nodes (LTDN) 9h30

Slide by M. Luger / R. Evans, EUMETSAT, modified

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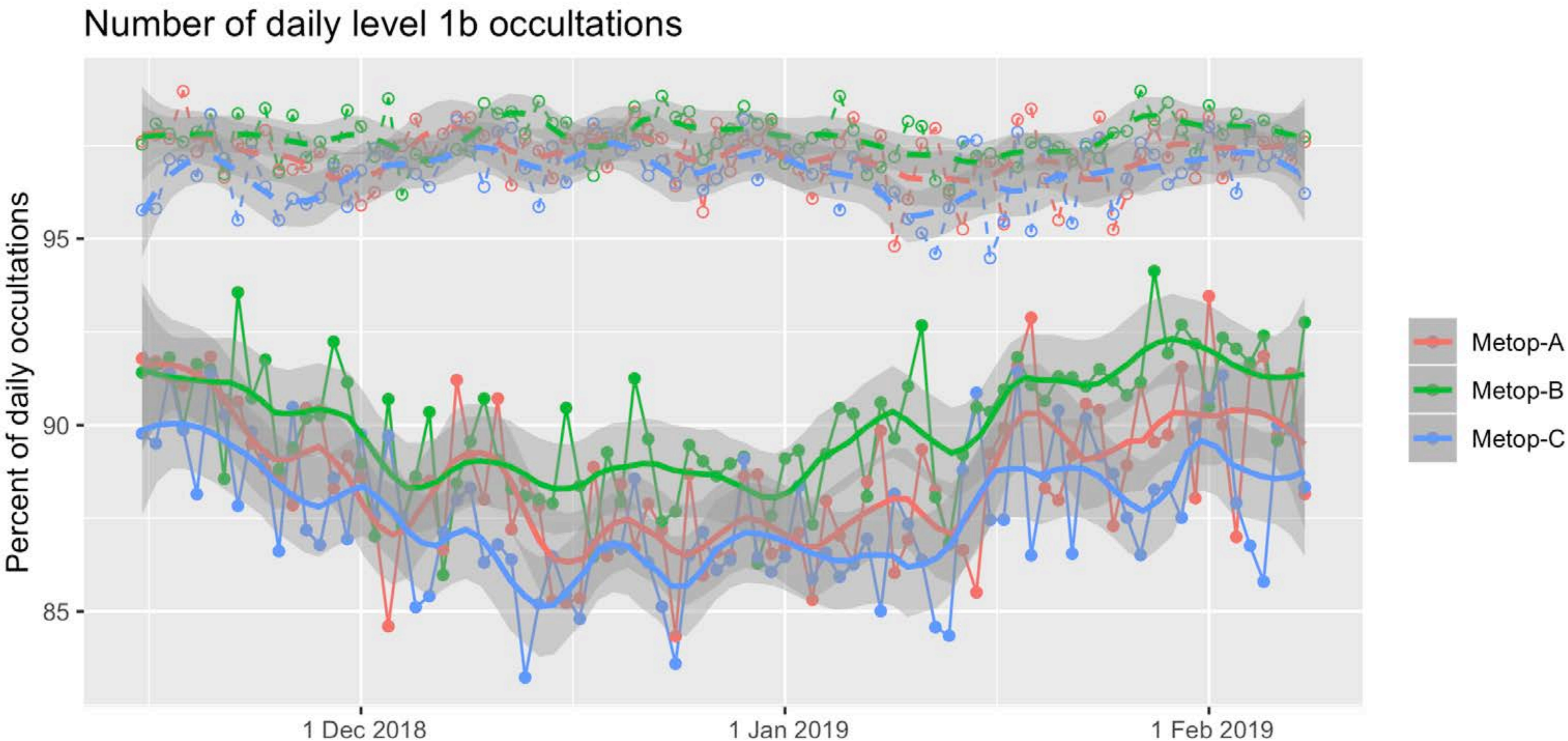
Metop-C: Occultation Numbers (Feb 2019)



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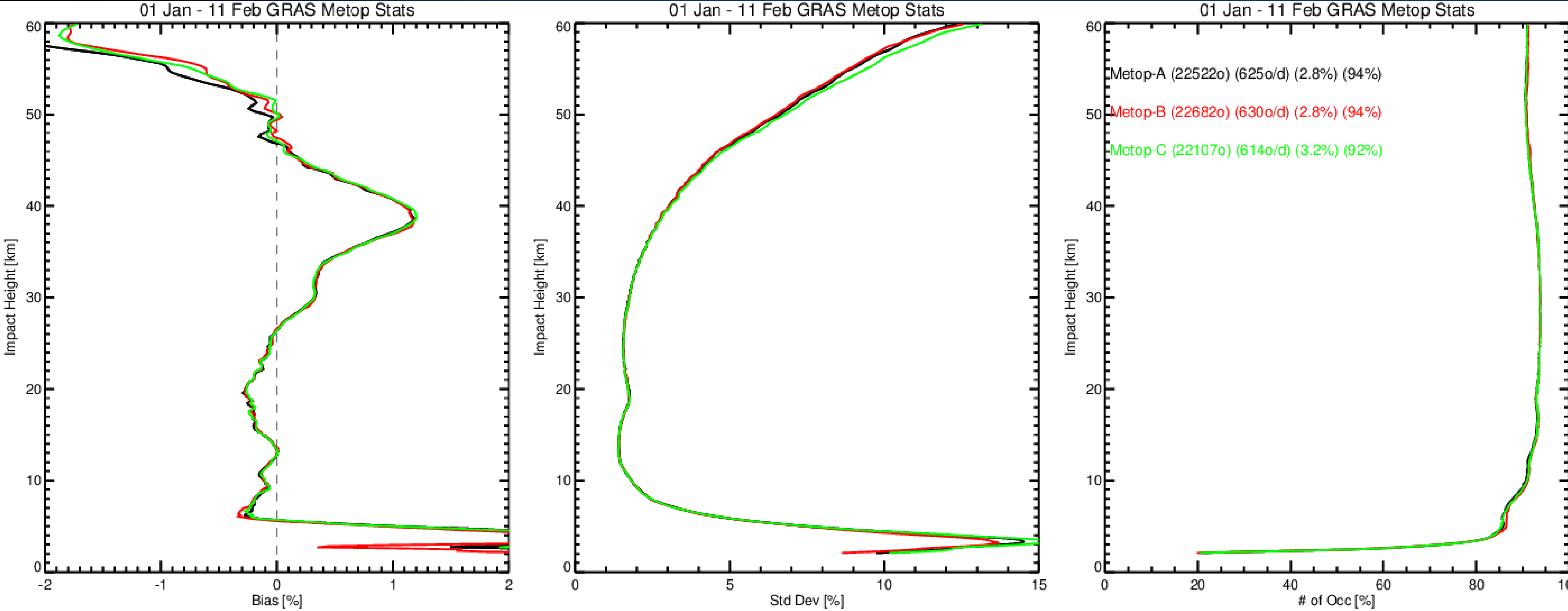
Metop-C: Statistics Against ECMWF Forecasts



Also looking at other results, seems that:

- the failure rate is mostly higher for mid-latitudes for Metop-C data
- the noise is higher at alts > 40km for all latitude bands for Metop-C
- regarding setting/rising, the increased noise higher up is more pronounced for setting.

Occultation Prediction

Background:

- since June 2017, provided as "best effort / semi-operational" service; see also: link.
- provided for all Metop, GRAS instruments (thus now including Metop-C)

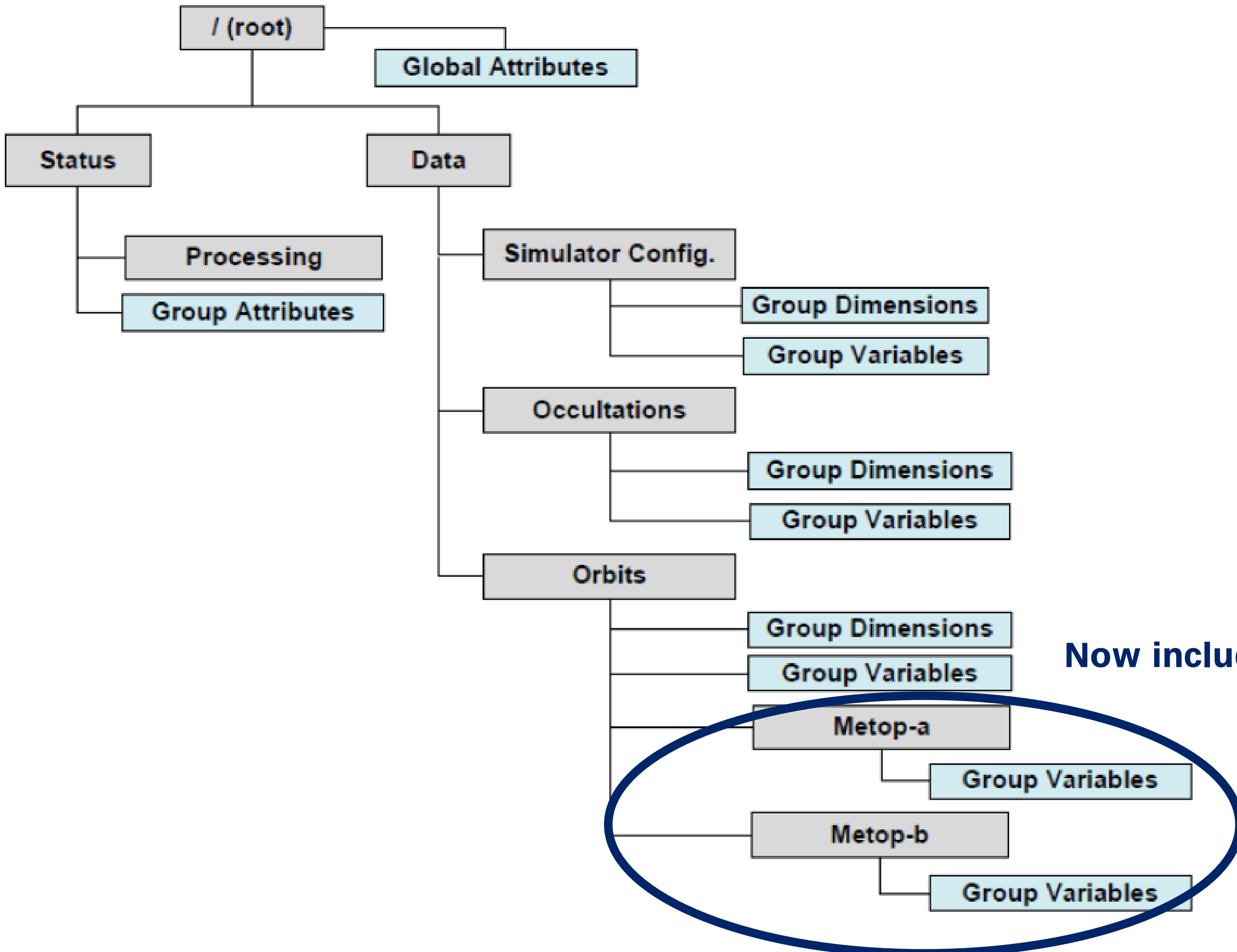
Status:

- providing all possible occultations over the next 14 days, plus the sub satellite points
- daily generation, usually provided within first 6h of the day
- generally 80+% are actually observed by GRAS instrument
- sonde station / occultation / overpass match information send to GRUAN stations

Next Steps:

- identified more robust environment within EUM infrastructure, working on way forward for implementation
- work on improved prediction quality indicator:
  - identifying cause for GRAS failures and flag those, err on the side of caution
  - removing very short occultations (are currently marked with quality = 0 already)
  - include GNSS ~~and scheduled LEO maneuver~~ (and campaigns) where possible
  - provide information on better setting occultation quality
  - further analysis instrument vs. predictions to understand limitations
  - further analyze the actual GRAS data quality vs. the prediction
- within GSN to RSN transition, identified also short GNSS clock gaps as cause for not processed occultations, mitigation options are investigated
- use of simulations to evaluate instrument performance
- use for operational monitoring of EPS-SG performance (RO instrument, RSN provider)

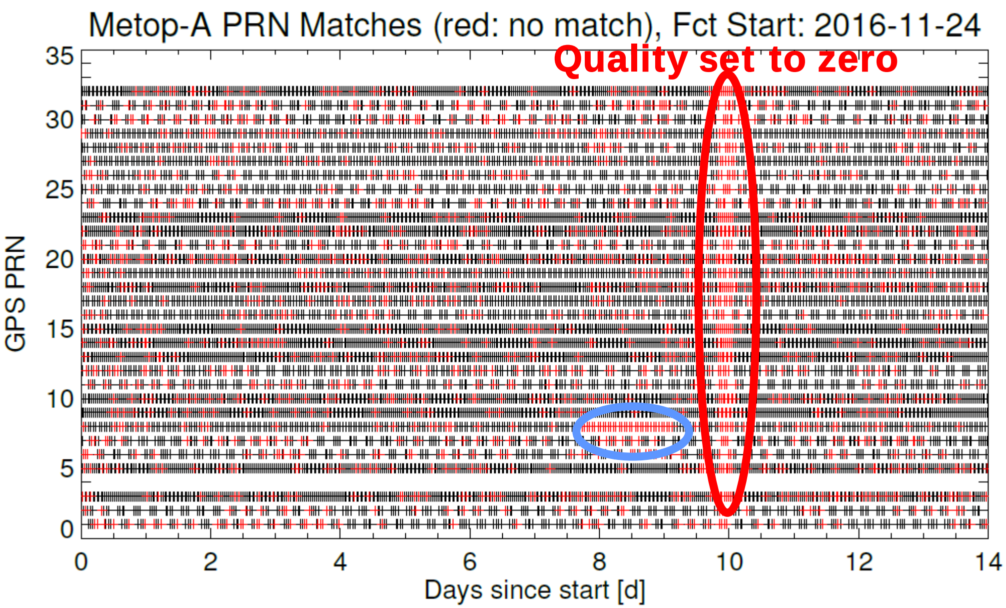
Occultation Prediction: Format

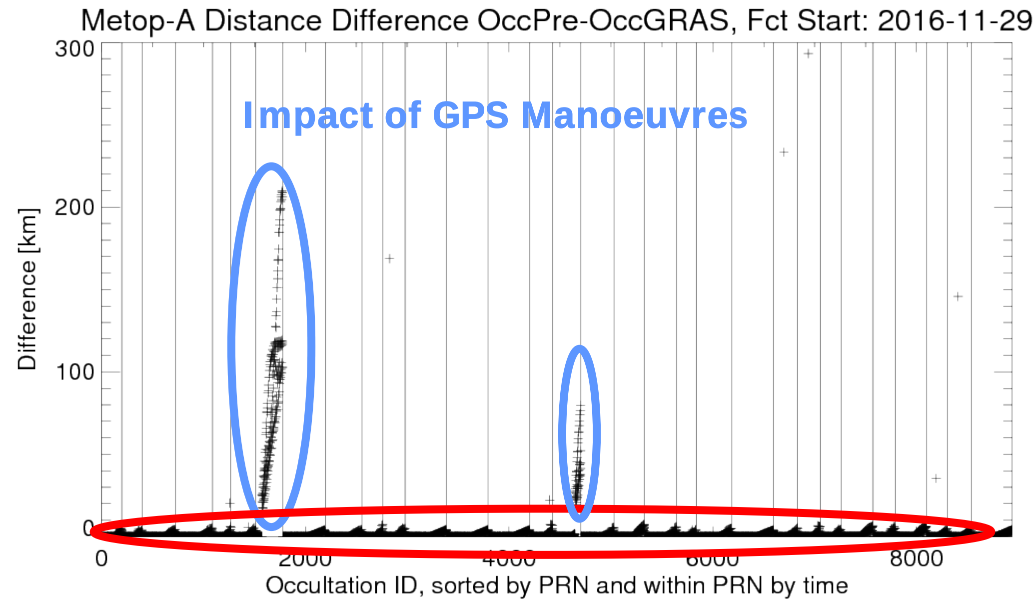


Now includes Metop-C

Fig. 2.1: Overall netCDF data group structure of EPS Level 1C file example, assuming Metop-A and -B orbits are covered.

Occultation Prediction: Reminder





GNSS Data Outage (NANU) due to Manoeuvre

Metop Data Outage due to Manoeuvre

Impact of LEO Manoeuvre

(left) Example of GPS occultation prediction matches against GRAS observations over the 14 day prediction period (on average about 85% or predicted also observed by GRAS);

(right) generally high accuracy in reference position prediction achieved, but LEO and GPS maneuvers impact the predicted occultation location accuracy; small LEO maneuver impact (on day 9) visible for each GPS satellite towards the end of prediction period (small ripples); large impact of GPS PRN 08 and 17 visible for these GPS satellites.

Occultation Prediction: Quality Indicator / Background

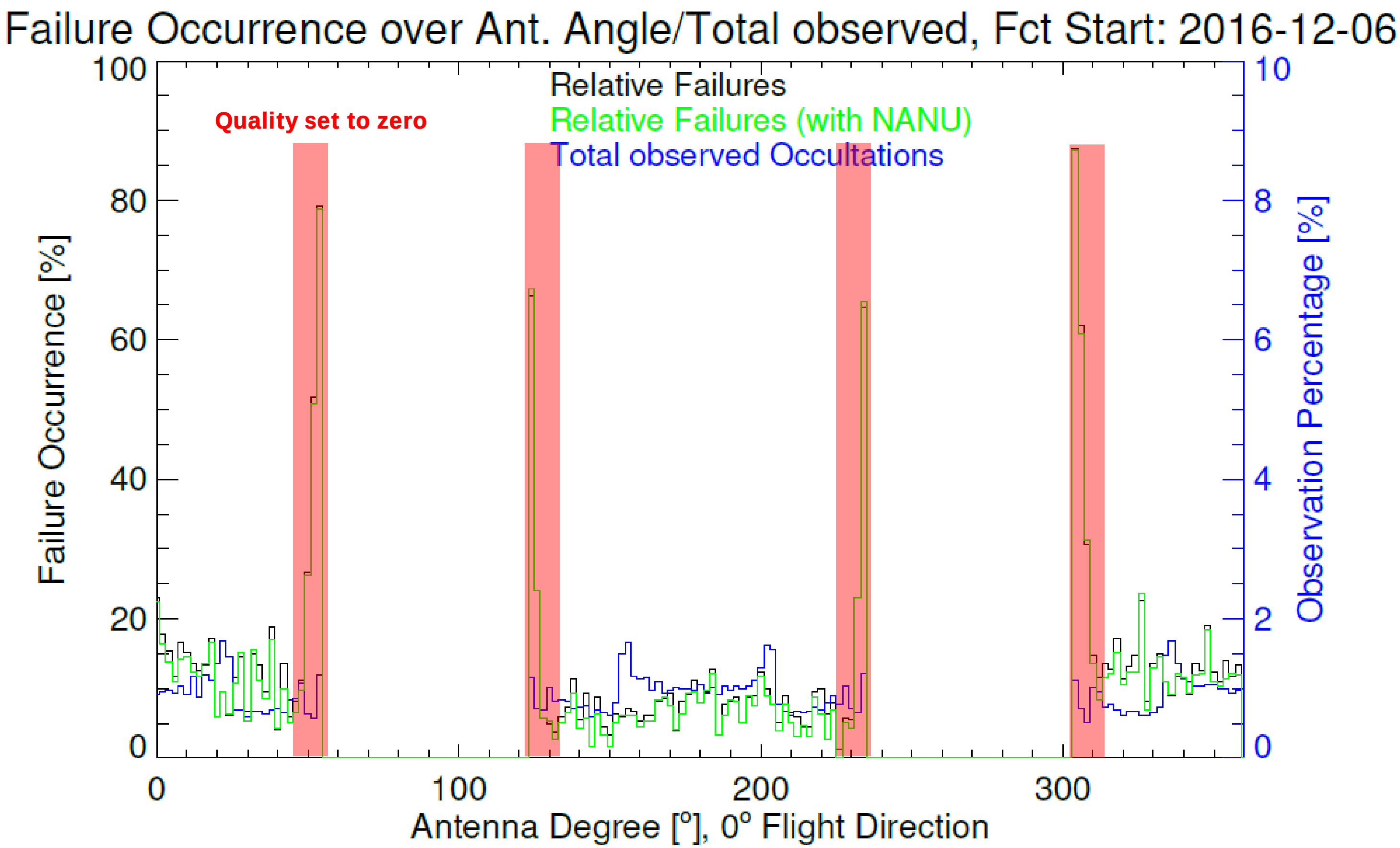
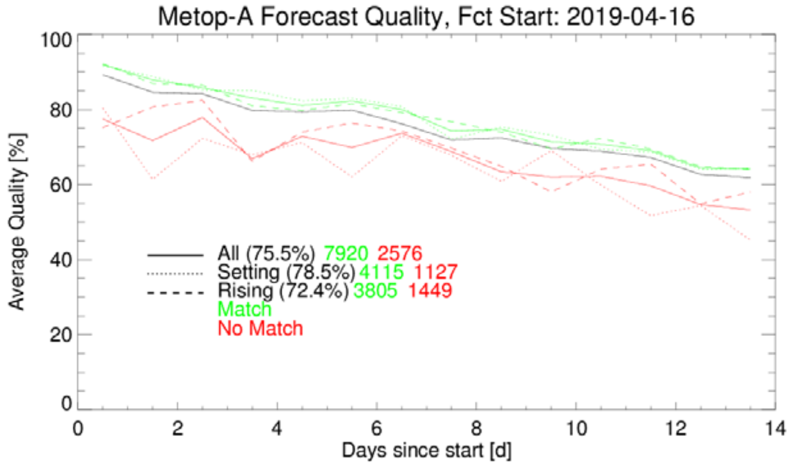
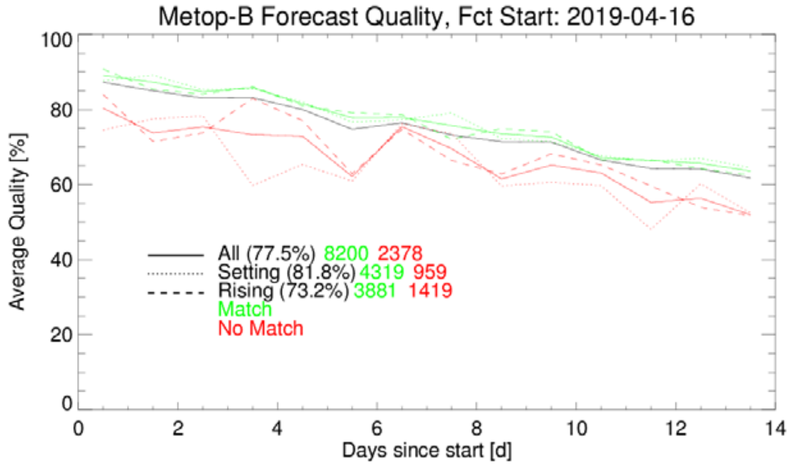


Fig. 4.6: Normalized occultation prediction failures over antenna azimuth, 0 Degrees is flight direction (rising occultations). Bin-size for all histograms is 2 Degrees, failures are shown without NANU (black) and with NANU information (green) taken into account; also shown in blue (right y-axis) is the normalized number of occultations per bin-size.

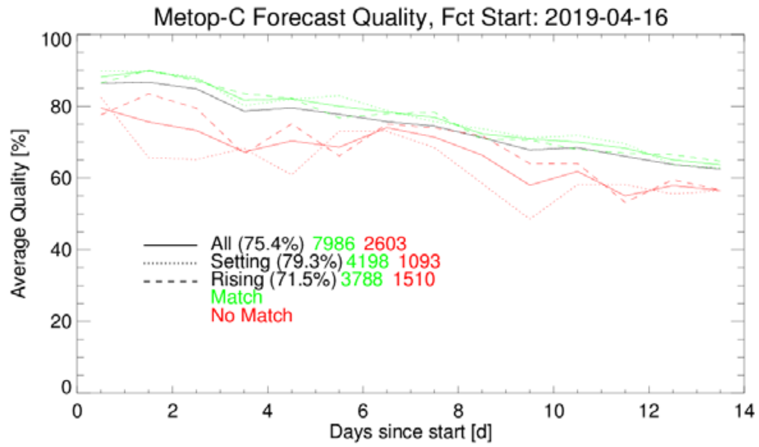
Occultation Prediction: Quality Indicator





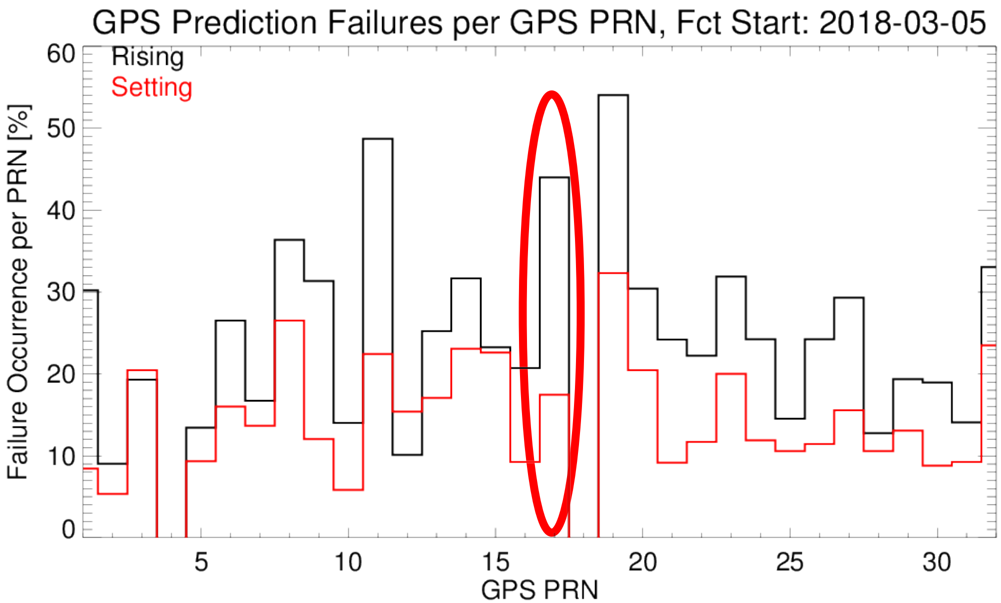
Examples of GPS current occultation prediction quality, separated for setting/rising and for those actually matched/unmatched, over the 14 day prediction. Current quality setting are based on:

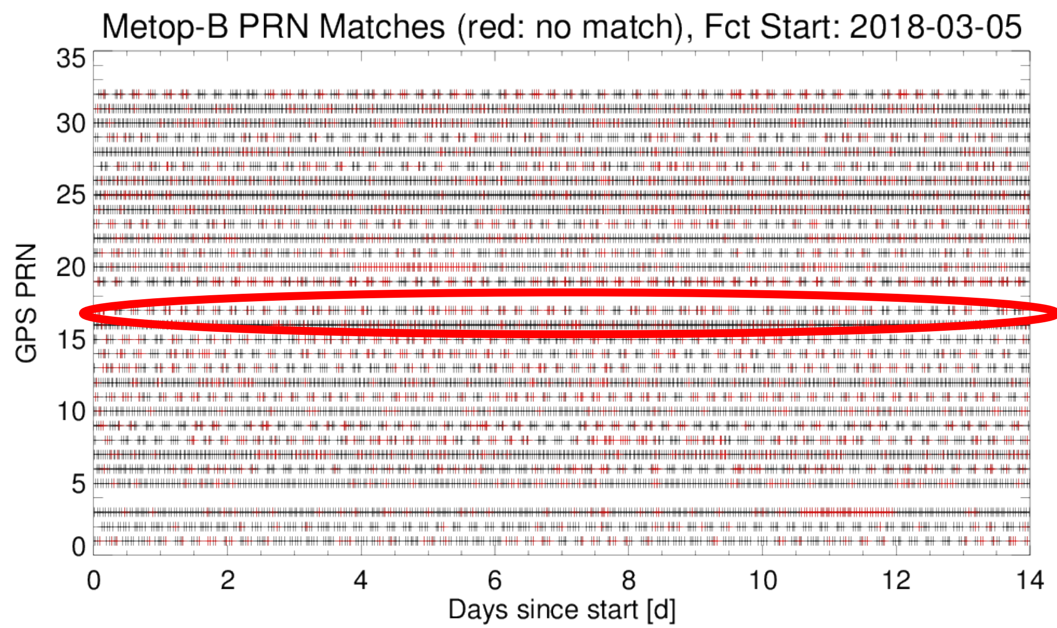
- reduced quality over time (linear, by 30% over 14 days)
- occultation is on the edge of the occultation antenna
- Note: setting/rising quality the same, though obvious that this impacts predictions
- Note also: this is an example with GPS aux data outage around day 6 (would be available in reprocessing)



Occultation Prediction: Reassessing Failures (1)

Prediction vs. actual observations separated in setting/rising and per GPS PRN (left) and failures per GPS PRN (right)





Fairly large difference between rising and setting for some satellites, e.g. PRN 17

PRN 17 also with few occultations predicted

-> indicates rising occultations more difficult to track when generally low number of predictions are made for a certain GPS satellite

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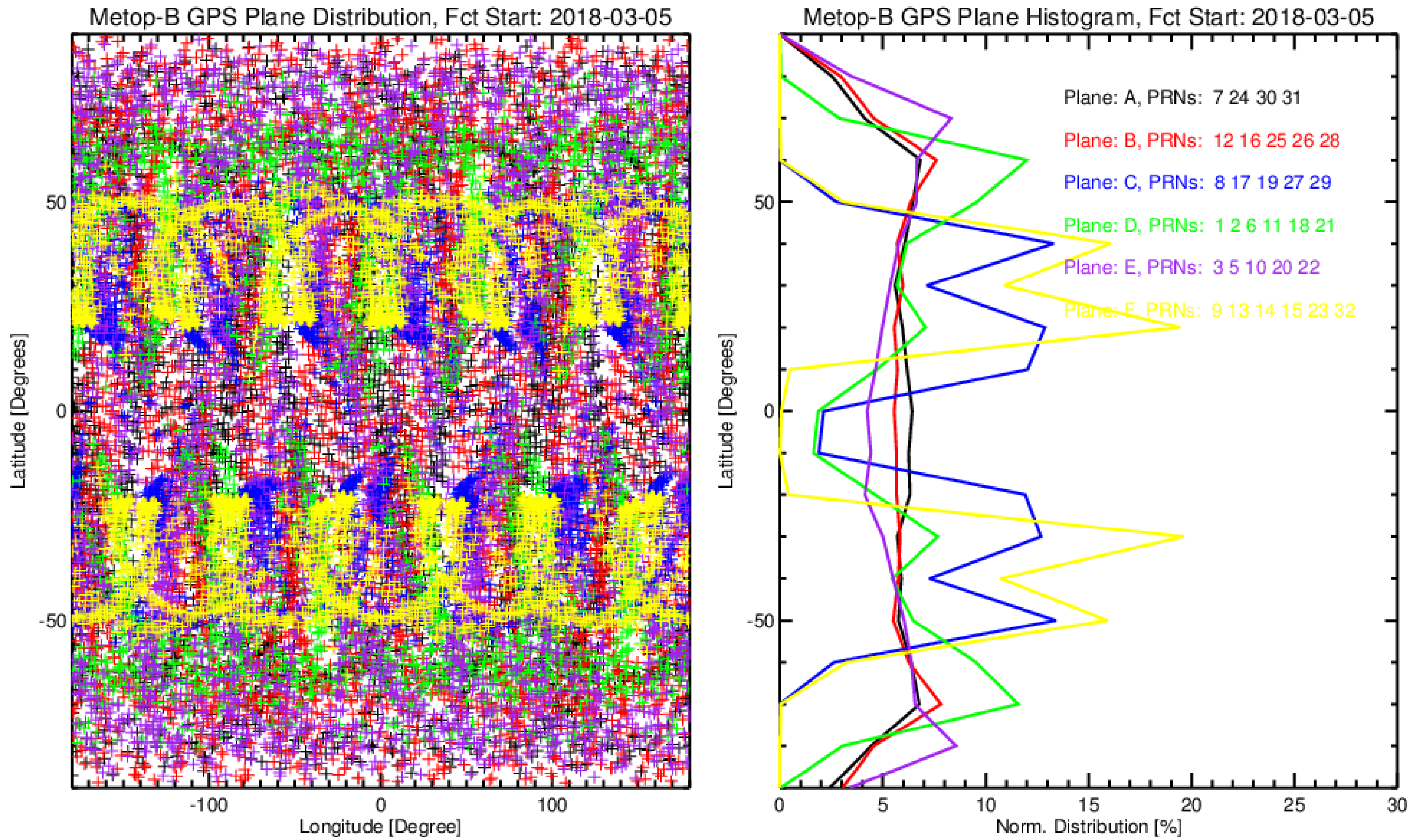
Occultation Prediction: Reassessing Failures (2)

Recent prediction vs. actual observations separated per GPS Plane over latitude and longitude (left) and histogram of predictions per GPS plane (right)

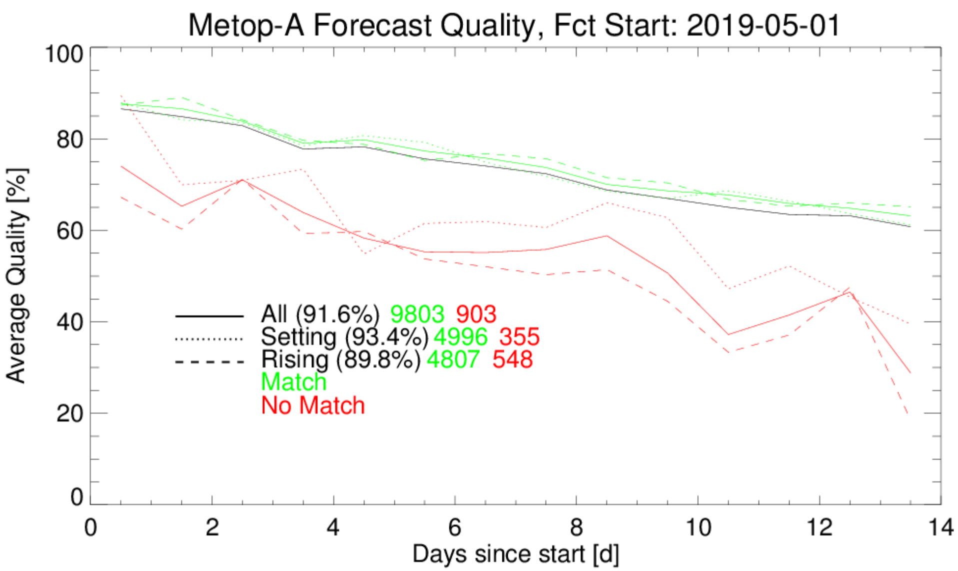


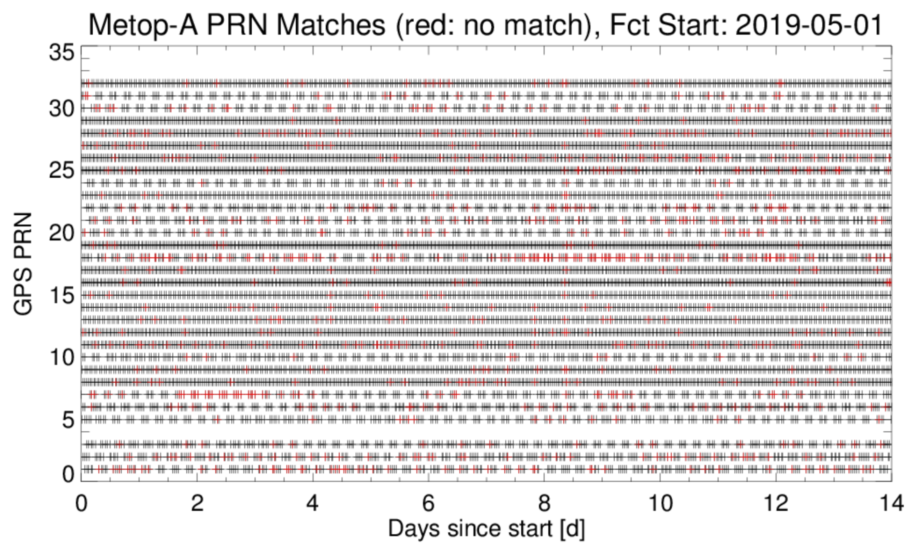
-> indicates certain GPS planes have only observations at certain latitudes, e.g. Plane F, likely due to unfavorable geometry. This can be used as additional quality indicator, flagging in particular rising occultations within this geometry.

Occultation Prediction: Reassessing Failures (3)

Summary:

- **Geometry impacts whether an occultation is tracked by the instrument**
- **however, several other "unpredictable" factors do this too, e.g.**
  - **GPS age / reliability (partly not covered in NANUs)**
  - **NRT GNSS information unavailability (would though be available in reprocessing)**
  - **Collision avoidance maneuvers**





Old quality settings

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Occultation Prediction: Reassessing Failures (3)

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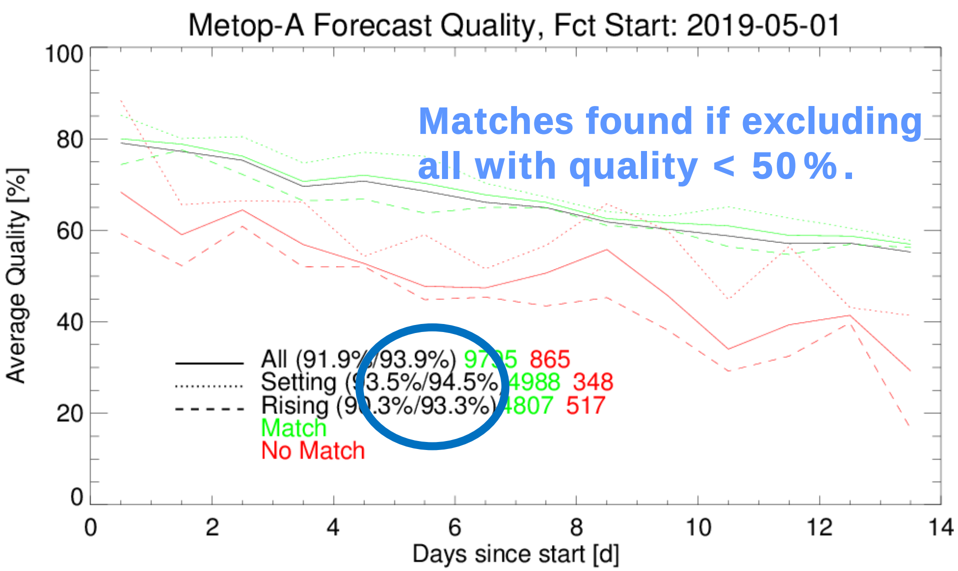

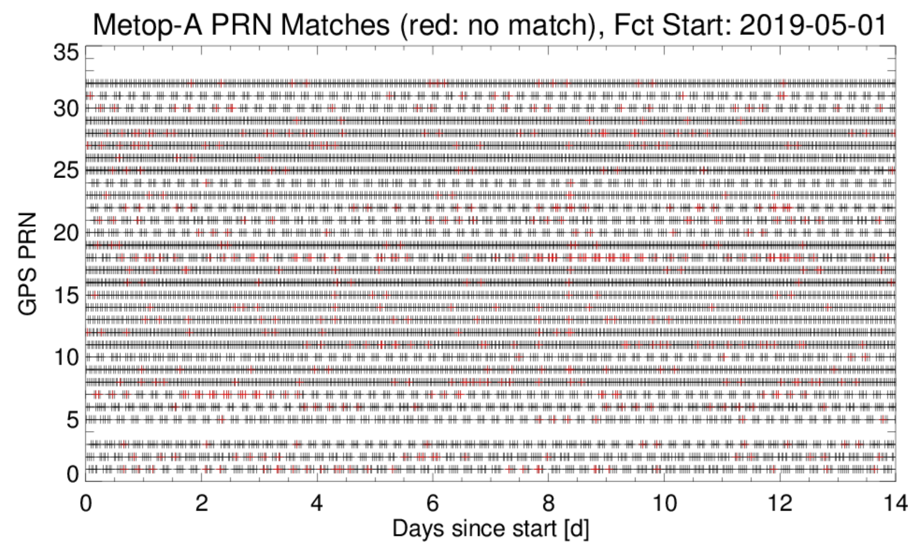

New quality settings

Overview of Reprocessing Activities

- GRAS Level 1b Bending Angle FCDR Release 1:
  - GRAS-A from launch to end 2016
  - Product User Guide, Validation Report finalized
  - to be formally released by EUMETSAT within the next months
  - used for ROM SAF CDR 1.0 GRAS reprocessing (link)
- GRAS Level 1b Bending Angle FCDR Release 2:
  - GRAS-A and -B from launch to end 2017 (same s/w as Release 1)
  - Validation Report started, no issues/discontinuities detected
  - planned release towards end 2019
- GRAS Level 1b Bending Angle FCDR Release 3:
  - GRAS-A, -B, -C from launch to end 2018/19 (updated s/w to Release 1/2)
  - planned release data Q2/2020
- RO 3rd Party Level 1b Bending Angle FCDR Release 1:
  - COSMIC/CHAMP/GRACE from launch to end lifetime or 2018/19
  - planned release date Q2/2020

Summary / Future Steps

- Metops:
  - 3 now in orbit (expected up to ~2021)
  - all show very similar performance
  - NRT GNSS orbit/clock/etc information now provided by RSN Service (GMV)
- Occultation Predictions:
  - 14 days in advance; targeting e.g. sonde launches
  - Prediction Quality Improvements:
    - err on caution; remove very short occultations; higher quality for setting occs; LEO maneuver
  - Future (possible) improvements:
    - more operational service
    - include GNSS maneuvers (no occs after maneuvers) - possible with RSN service
    - build up "history" per GNSS satellite
    - improve clock coverage of GNSS data provider (<1%)
- Reprocessing:
  - First Metop-A, 2006-2016 released, Metop-A, -B to 2017 later this year