Quality Aspects of the WEGC Multi-Satellite GPS Radio Occultation Record

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Introduction

GPS Radio Occultation (RO) is a limb sounding satellite technique providing thermodynamic atmospheric parameters since 2001. Its properties include high vertical resolution, global coverage, and high quality within the upper troposphere to the mid stratosphere. Data from different GPS RO missions can be combined to a single dataset, if processed in a consistent way. For climate applications, data consistency and quality are essential, specifically for a combined multi-satellite RO record, with several satellites providing data for the same time period. Information about distinct quality characteristics of the different satellite instruments is important for producing a homogeneous long-term multi-satellite RO record, as we demonstrate here for the WEGC RO processing version OPSv5.6 (**Fig. 1**).

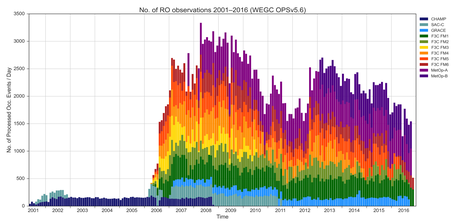

Fig. 1: Daily number of processed RO events for different satellites (different colors) as a function of time from 2001 to 2016.

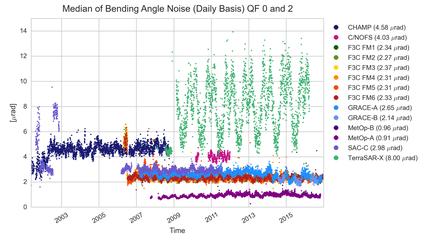

Fig. 2: Temporal evolution of daily median Bending Angle (BA) noise for all RO satellites. Total median of BA noise is shown in the legend. Only high-quality profiless areused in this statistics.

Quality aspects of single satellites

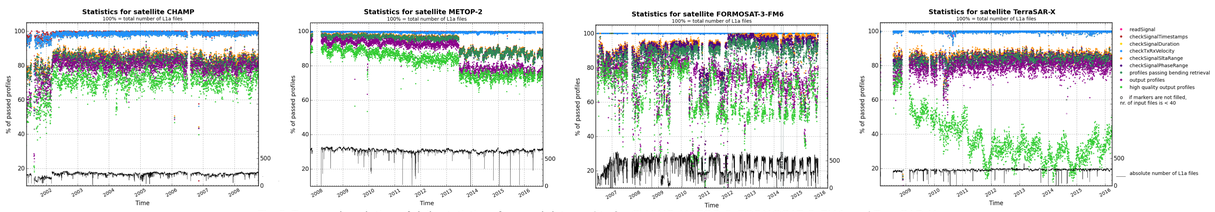

Fig. 3: Temporal evolution of daily statistics of general data quality for CHAMP, METOP-2, FORMOSAT-3-FM6, and TerraSAR-X.

based on several quality criteria the output profiles get flagged (quality flags)

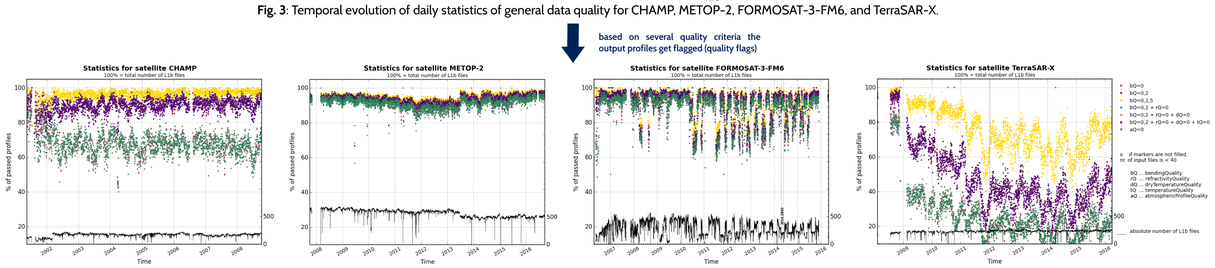

Fig. 4: Temporal evolution of daily statistics of different quality flag combinations as well as the total atmospheric profile quality for CHAMP, METOP-2, FORMOSAT-3-FM6, and TerraSAR-X.

BA quality flags reveal differences in quality levels for different satellites

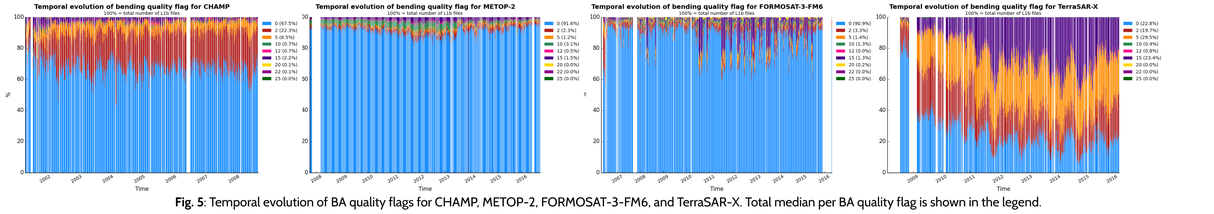

Fig. 5: Temporal evolution of BA quality flags for CHAMP, METOP-2, FORMOSAT-3-FM6, and TerraSAR-X. Total median per BA quality flag is shown in the legend.

A systematic analysis of the quality aspects has been performed on the WEGC processing version OPSv5.6. Quality of the input data is checked prior to the RO retrieval, where data with bad quality get discarded. Bending Angle (BA) profiles are only calculated if a profile passes several input data quality checks. However, if the quality of the retrieved BA is not sufficient, it will not be further processed to refractivity and other atmospheric parameters. **Fig. 3** shows the temporal evolution of the general data quality, relative to the total number of input data.

Depending on the quality level of the atmospheric parameters, the profiles are marked by quality flags (QFs). **Fig. 4** illustrates the quality of the retrieved output profiles. The dominant quality control is the BA quality control. The temporal evolution of the different BA quality flags reveals variations in the data quality of the output profiles (**Fig.5**). Only profiles with BA QF = 0 or 2 are identified as high-quality profiles for most applications and will be used in further investigations. TerraSAR-X will be excluded from our current multi-satellite record based on the revealed decline in high quality data and the strongly varying BA noise (**Fig. 2**). The reason for this behavior is currently under investigation.

Consistency of multi-satellite means

The consistency of the multi-satellite climatologies is examined by comparing monthly mean temperatures of each single satellite to the satellite mean and external references. Deviations from the satellite mean reveal a considerable variance in the temperature time evolution (**Fig. 6**). The distinct feature in mid-2011 stems from large deviations of C/NOFS (outside plot scale) which only provides data for the tropics. Not considering this special sampling characteristics leads to a bias in the global mean. Accounting for the sampling error from different spatial and temporal sampling, by comparing to a „true" reference field (ECMWF), yields high consistency. However, a diverging behavior of the retrieved temperature of MetOp-A is now revealed above 25 km (**Fig. 7**).

Deviations from satellite mean

not sampling error corrected

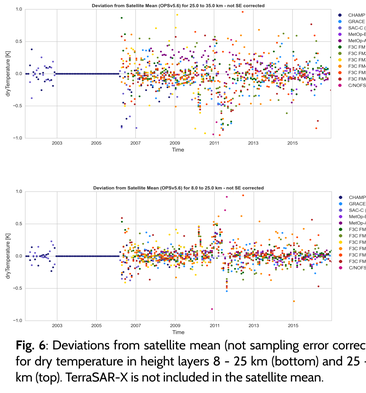

Fig. 6: Deviations from satellite mean (not sampling error corrected) for dry temperature in height layers 8 - 25 km (bottom) and 25 - 35 km (top). TerraSAR-X is not included in the satellite mean.

sampling error corrected

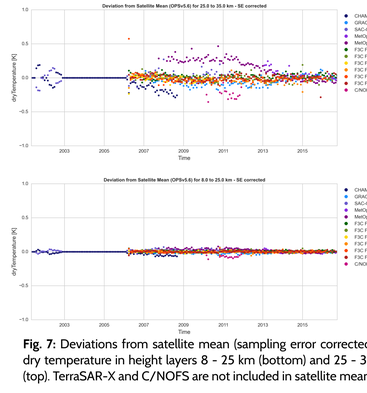

Fig. 7: Deviations from satellite mean (sampling error corrected) for dry temperature in height layers 8 - 25 km (bottom) and 25 - 35 km (top). TerraSAR-X and C/NOFS are not included in satellite mean.

Deviations from ECMWF

sampling error corrected

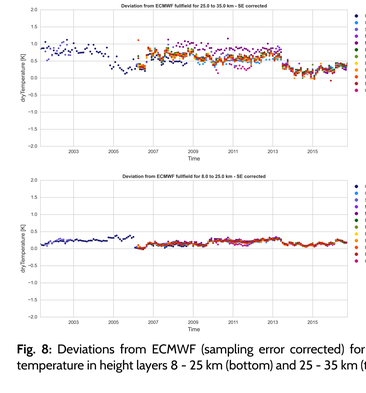

Fig. 8: Deviations from ECMWF (sampling error corrected) for dry temperature in height layers 8 - 25 km (bottom) and 25 - 35 km (top).

OPSv5.6 uses ECMWF forecasts for the high-altitude BA initialization. The deviations from this ECMWF background field reveal several jumps, e.g. in 2006 and in mid-2013 (**Fig. 8**), which result from ECMWF model changes (**Fig. 10**). The influence of the background field on the retrieved profiles varies depending on the quality of the satellite receiver. Due to the low BA noise of MetOP/Gras data they are less influenced by the background field (**Fig. 9)** and more obervational information is used above 30 km in the retrieval of atmospheric parameters.

Conclusion

Detailed knowledge of the satellite specific characteristics and data quality as well as their consistency is crucial for a combined RO dataset. Furthermore, it is essential to track the quality and influence of the background field to understand the height-dependent characteristics for establishing a homogeneous long-term RO climate record.

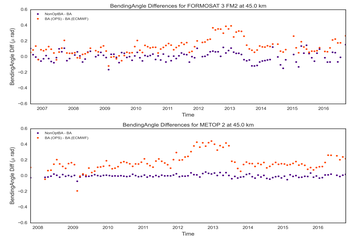

Fig. 9: Difference between OPSv5.6 non-optimized and optimized bending angle as well as between optimized bending angle (OPSv5.6) and bending angle of co-located ECMWF profiles.

Fig. 10: Differences between OPSv5.6 optimized bending angle to ERA-Interim, ECMWF and co-located ECMWF profiles. ECMWF cycle changes with significant impact are marked.

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