## Comparison of reference upper-air GRUAN and homogenized RHARM data with GNSS-RO

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The study of thermodynamical variables, such as temperature and relative humidity in the upper troposphere/lower stratosphere (UT/LS), is one of the key elements for understanding climate change. Several studies estimated trends both regionally and globally in the UT/LS, using both satellite and ground-based data and different measurement techniques. However, the accuracy and spatial-temporal coverage of measurements can significantly affect trend estimates. This work investigates the consistency of temperature and humidity measurements by comparing upper-air data from three sources: GRUAN (Global Climate Observing System (GCOS) Reference Upper-Air Network), RHARM (Radiosounding HARMonization), and GNSS-RO (Global Navigation Satellite System - Radio Occultation) from COSMIC and METOP B-C missions.

RHARM, a bias-adjusted radiosounding dataset based on IGRA and processed mimicking the GRUAN data processing, includes uncertainty estimates and covers ~700 stations worldwide. For this study, a subset of 100 long-term stations, since 2006, was selected for comparison. GNSS-RO data were collocated using a 200 km / 3 h criterion and interpolated at mandatory pressure levels (850-10 hPa). Comparisons were performed across latitude bands: mid-latitudes (NH), polar regions (NP), and tropics (TR).

Results show that RHARM profiles exhibit smaller biases compared to GRUAN (up to 0.1 K), while IGRA shows larger discrepancies (up to 0.25 K). GNSS-RO data, when compared to RHARM, reveal temperature biases up to 0.3 K and relative humidity biases up to 12% in tropical regions. RHARM consistently shows better agreement with GRUAN than IGRA, especially in the UT/LS region. This dual comparison allows assessing the performance of satellite-based profiles both against reference and homogenized ground-based observations.

These findings highlight the importance of homogenized radiosounding datasets for climate applications and support the integration of GNSS-RO data into global monitoring frameworks. Future work will extend the analysis to all RHARM stations and explore seasonal and latitudinal variability.

**Keywords: upper-air climatology, radiosounding homogenization, GNSS-RO validation.**