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Radiosounding HARMonization (RHARM): a new algorithm for the harmonization of temperature, humidity and wind radiosounding time series and estimation of uncertainties

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Observational records have a key role when assessing long-term changes in our climate. However, these are these are often influenced by residual non-climatic factors which may lead to incorrect conclusions about the current state and evolution of the climate and may lead to biases if assimilated within a reanalysis system. Therefore, it is important to detect and adjust systematic inhomogeneities in the observation time series and quantify measurement uncertainties in the historical data where traceability cannot be properly established.

In the frame of the Copernicus Climate Change Service (C3S), a novel approach, named RHARM (Radiosounding HARMonization), has been developed to provide a harmonized dataset of temperature, humidity and wind profiles along with an estimation of the related uncertainties for a substantial subset of radiosounding stations globally (656 stations) among those available from the Integrated Global Radiosonde Archive (IGRA).

The RHARM approach has been applied to daily (0000 and 1200 UTC) radiosonde data on 16 standard pressure levels (from 1000 to 10 hPa) from 1978 onward.

Each historical radiosounding time series is harmonized using two different types of adjustments:
1. The most recent period of the records when modern radiosonde models have been in operation at each station (typically starting between 2006 and 2010 but varying on a station-by-station basis) are corrected using reference datasets from the GCOS Reference Upper Air Network (GRUAN) and the 2010 WMO/CIMO radiosonde intercomparison.
2. The remaining historical data are scanned to identify structural breaks due to prolonged systematic effects in the measurements at each mandatory pressure level using the CUmulative SUMming (CUSUM) method test. Then, an adjustment for each time interval between each pair of structural breaks is calculated to reduce the systematic effects.

Along with the adjustments, corresponding uncertainties are also estimated accordingly taking advantage of GRUAN time series for the uncertainty validation.

Beyond the algorithm, RHARM algorithm, the presented work also summarises decadal trends and anomalies calculated at different latitudes and at global scale using the source data provided by IGRA, the data harmonized using RHARM and the ECWMF ERA-Interim/ERA5 reanalysis data. Results will be framed in the context of the other existing homogenized radiosounding datasets provided through the C3S. An analysis aiming to independently identify the benefit of the adjustments obtained using reference datasets versus the CUSUM method will be also discussed.

Future developments of the C3S work (under C3S 311a Lot3) will consider the elaboration of a second version of RHARM, named RHARMRE (Radiosonde HARMonization using REanalysis) using the same approach as RHARM with a few key changes to adapt the algorithm to enable the use of ECWMF reanalysis as the background reference time series for the adjustment of systematic effects.