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Reanalysis of upper tropospheric humidity data of the MOZAIC programme for the period 1994 to 2009

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Water vapour plays a dominant role in the atmospheric energy budget and greenhouse effect. It is one of the key drivers for atmospheric transport and has a strong influence on the oxidative capacity of the atmosphere. Therefore, it takes a key position in the description of climate, chemistry and their interactions. Due to a range of small-scale dynamical and microphysical processes, the abundance of upper tropospheric humidity (UTH) is highly variable on spatial and temporal scales that cannot be resolved, neither by the global radiosondes network nor by satellites.

Data with high spatial and temporal resolution for relative humidity are provided by the in-situ measurements aboard civil passenger aircraft from the MOZAIC/IAGOS-project (www.iagos.org) since 1994. The data set emerging from this long-term observation programme builds the backbone of climatologies and trend analyses of UTH. First analyses of MOZAIC measurements for the period 1994 to 1999 showed that the upper troposphere (9 to 13 km altitude, which corresponds to the aircraft cruise level) is much wetter than reflected in the model analyses of the ECMWF (European Centre for Medium Range Weather Forecast). The MOZAIC data has also demonstrated that ice supersaturation is often large enough to let contrails develop into cirrus but not large enough to let cirrus clouds form naturally.

In our study, the MOZAIC data set on relative humidity (RH) was reanalysed for the period 1994 to 2009. Previous analyses of probability distribution functions (PDF) of UTH data from MOZAIC observations from the year 2000 and later indicated a bias towards higher RH values. As a result, the PDF of UTH exhibits a maximum at RH over ice (RH_ice) of approx. 130% instead of the maximum at 100% RH_ice observed in the period 1994 to 1999. Since this bias towards higher RH_ice values is in contradiction to physical understanding and to observations made inside equilibrated cirrus clouds, an in-depth reanalysis of the MOZAIC data set was conducted. During this effort an error in the laboratory calibrations applied from year 2000 on was found, whereas the data of the period from 1994 to 1999 were found to be correct. The complete data set for the period 1994 to 2009 was reanalysed with the corrected calibration factors. As a result, the PDF of the corrected data set exhibit their maximum at 100% RH_ice, in agreement with PDF of RH_ice presented in the literature. Applied correction schemes and a revised error analysis are presented along with the PDF of RH_ice for various regions of the global upper troposphere/lowermost stratosphere.