

MLS-Related Scientific Publication

Scientific Theme: Climate Research

The statistical distribution law of relative humidity in the global tropopause region. Peter Spichtinger, Klaus Gierens, William Read, *Meteorol. Z.*, **11**, 83-88, 2002.
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Summary

This paper uses UARS MLS measurements of upper tropospheric humidity at the 215 hPa pressure layer to determine global statistics of relative humidity with respect to ice (RH_i). This extends, to a global scale, an earlier study using data from the Measurement of ozone by Airbus in-service aircraft (MOZAIC) project. In agreement with the earlier study, an exponential distribution of the form $f(u) = b \times \exp(-bu)$ is found, where $f(u)$ is the probability of a value of RH_i equal to u , and b is a fitted parameter. This distribution is found in the MLS data (1) for the degree of supersaturation in tropospheric ice-supersaturated regions (ISSR), (2) for RH_i itself in the lowermost stratosphere, and (3) additionally for RH_i > 20% in tropospheric subsaturated regions but with a less steep slope than in ISSRs. A break of the exponential distributions occurs at RH_i ≈ 100% for the tropospheric measurements, indicating the onset of ice formation and - in itself - providing a validation of the absolute values of RH_i from MLS. In the supersaturated region, the distribution exponent b found from MLS (for the northern hemisphere) is $b=4.6$, compared to $b=5.8$ from MOZAIC; the difference is probably due to the different spatial resolutions of the two techniques, and the different regions where the data are mainly obtained (tropics for MLS, northern mid-latitudes for MOZAIC).

An unexpected finding is that the exponential distribution extends without any sign of cloud formation far beyond values of RH_i where, according to theory, homogeneous nucleation of micrometer-sized aqueous solution droplets should commence. This is not thought to be an MLS measurement artifact. It may be that these rare events (about 0.5% of the analyzed data) occur when there is lack of aerosol particles in the MLS FOV; most occur in the tropics where aerosol could be washed out by sedimenting ice crystals, and at the edge of Antarctica where cooling of polar air during polar winter could result in high relative humidities.

This work benefits society by providing new information on processes affecting the formation of ice clouds that can affect climate.

Figure 1. The distribution of events (number of events per 1% RH_i bin) of RH_i for the MLS 215 hPa layer in the troposphere, showing the separate exponential fits for 20-80% and 100-200% regions. Note the break at RH_i ≈ 100%, where ice formation is expected. Noteworthy is the lack of change in the shape of the distribution throughout the ~100-200% range; one might expect a signature of cirrus formation at ~150% as this is approximately (at the temperatures for the 215 hPa layer) the threshold for homogeneous nucleation of micrometer-sized aqueous solution droplets. Only data where the 215 hPa layer is clearly in the troposphere (as identified by NCEP temperature profiles) have been included.

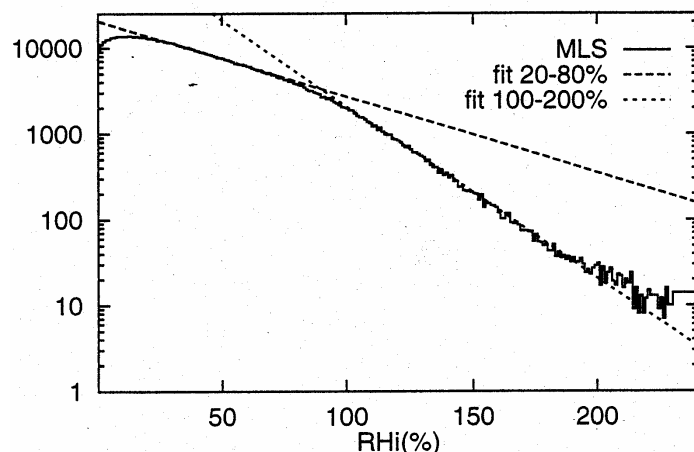


Figure 1: