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Evaluation of three different methods to estimate turbulent energy dissipation rate from the radar measurements with MAARSY

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Although atmospheric turbulence is an important dynamical process with implications for atmospheric energy and momentum budget and a well-known threat to the safety of aviation, it is far from being fully quantified or understood. Compared with in-situ techniques, radars can continuously measure turbulence over a large altitude range. In this study, we present turbulence measurements with the MAARSY MST radar which employs an active phased array with 433 linearly polarized Yagi antennas and provides continuous wind measurements (3-D wind fields), radar echo power, and spectral widths. One of the 'traditional' methods to estimate turbulence from radar observations is the spectral width method. I.e., spectral widths are converted to the energy dissipation rate ε after the removal of the broadening components due to the finite beam width of the radar. Another method is to determine the characteristic wavenumbers of the vertical wind velocity spectra and estimate ε using well-established theory (here called vertical wind spectra method). Furthermore, we introduce a new method to determien ε from the product of the vertical shear of horizontal wind and the corresponding vertical flux of horizontal momentum (here called wind method). After validating the radar-estimated results with the simultaneous in-situ measurements of ε with radiosondes, we give a preliminary climatology of atmospheric turbulence in the UTLS regions from radar measurements with MAARSY during the periods of 2010–2013. It shows a variability of about 5 orders of magnitude inherent in the dissipation rates between 10-7 and 10-2 W/kg. ε-values from three different methods are compared. The distributions of the ε values show an encouraging agreement, although the vertical wind spectra method only gives mean values for the entire altitude range with one-day resolution and hence smaller variability. Our results show that the energy dissipation rates derived from different radar products (i.e. spectral width, vertical wind velocity, as well as horizontal and vertical wind velocity, respectively) agree reasonably well. This finding provides encouraging support for the reliability of turbulence estimates with radar.