Seasonal variation of Thorpe scale and energy dissipation rate derived from radiosonde observations at Syowa Station in the Antarctic

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The energy dissipation rate is a fundamental parameter describing atmospheric turbulence. Clayson and Kantha (2008) and following studies showed that radiosondes with a vertical resolution of several meters can detect at least partially overturning structures. Energy dissipation rates were estimated utilizing these radiosonde data based on Thorpe's method (1977) which is commonly used for oceanic turbulence parameters. However, energy dissipation rate in the Antarctic region has not been reported. We conducted balloon observations at Syowa Station (69°S, 40°E) using high-resolution radiosondes called Meisei Temperature Reference sondes (MTR) on 29 July and 30 December 2016 simultaneously with standard radiosondes, which is basically the same as used for twice-daily operational radiosonde observation. The vertical profiles of temperature are obtained at a sampling frequency of 16Hz (dz~30cm) by MTR. Based on the ultra-high-resolution data by MTR and moderately high-resolution data by standard radiosondes, vertical profiles of Thorpe scale (L_T) and energy dissipation rates (ε) are examined and compared.

It is shown that overturning events identified by the standard sondes accords well with the ones by the MTR in the troposphere while the standard sondes tend to slightly underestimate the frequency of overturning events in the lower stratosphere. The values of L_T and ε were comparable for both radiosonde observations, indicating that operational radiosonde observation data can be used for estimation of these turbulence parameters. Next, the seasonal variation of L_T and ε are derived from twice-daily operational radiosonde observations over 6 years. It is interesting that the annual mean vertical profile of L_T (ε) ranges from 200m (5×10^{-4} m^2 s^{-3}) to 300m (1.5×10^{-3} m^2 s^{-3}) in the troposphere, and has a peak around the tropopause. The results for the troposphere indicate that (i) the peaks of L_T and ε around the tropopause are seen in all seasons and that (ii) monthly mean L_T and ε below an altitude of 6 km have slightly larger values in the austral summer than in the austral winter. Finally yet importantly, ε increases with height in the stratosphere, which is particularly noticeable in the austral winter.

References

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