Seasonal variation of energy dissipation rate derived from radar and 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 which is commonly used for oceanic turbulence parameters. However, recent studies using oceanic microstructure observations and direct numerical simulations (DNS) pointed out that Thorpe's method tends to overestimate energy dissipation rates. VHF radar observations have been used to estimate turbulent parameters including energy dissipation rates in the free atmosphere since 1980's (e.g., Sato and Woodman, 1982; Hocking, 1983). Previous comparison of radiosonde results with radar-based estimates are based on only dozens of radiosonde observations.

In this study, the energy dissipation rates are estimated from one-year observations of the Program of the Antarctic Syowa MST/IS radar (PANSY radar; Sato et al., 2014), and compared with estimates from radiosondes. Taking the proportional constant for Thorpe's method (the ratio of Thorpe scale to Ozmidov scale) to unity, radiosonde-based estimates give similar value ranges to radar-based estimates (5×10^{-5}~1.5×10^{-3} m^2s^{-3}). Difference in median values between radiosonde- and radar-based estimates is larger in the troposphere than in the stratosphere. According to the previous DNS results, Thorpe's method approximately gives true energy dissipation rates for shear-instability-driven turbulence while it overestimates energy dissipation rates for the convective-driven turbulence. Our results suggest that turbulence due to shear instability is dominant in the stratosphere and that turbulence in the troposphere is attributed to convective process as well as shear instability.

Seasonal variation of the energy dissipation rates is also examined. It is shown that the energy dissipation rate in the lower stratosphere becomes larger in the austral winter and spring. This is likely due to seasonal variation of gravity wave activity in the stratosphere (e.g., Yoshiki and Sato, 2000).

Key words: turbulent dissipation rate, Thorpe scale, VHF radar, radiosonde

References

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