An anaysis of fine structure in the summer troposphere and stratosphere based on radiosonde observations at Shigaraki, Shiga, Japan

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In order to examine characteristics of atmospheric fine structure in the troposphere and stratosphere, radiosondes were launched every 3 hours from 18:00JST 27th July,2015 to 18:00JST 28th at Shigaraki MU Observatory, Kyoto University. Vertical profiles of horizontal wind, temperature, and relative humidity were obtained at a height interval of 5 m. During the observation period, high and low pressure systems are situated in the south and north of Japan, respectively. This is a typical synoptic-scale pressure pattern in summer in Japan. The tropopause determined based on the Brunt-Vaisala frequency was located around a height of 15 km. Using these observation data, time evolution of the atmospheric boundary layer, altitude dependency of dominant vertical wavelength, and dynamic characterictics of dominant wave-like structure in the stratosphere were analyzed.
First, we examined in detail the vertical profiles of the potential temperature, the equivalent potential temperature, and water-vapor mixing ratio to see development of the atmospheric boundary layer in daytime. It is expected that these quantities are constant in the vertical as a result of strong convection in the mixing layer. The altitude up to which these quantities are constant was raised from 0.5 km to 1.2 km during the time period of 9:00-15:00LST. On the other hand, a strong inversion layer appeared in the lowermost troposphere at 3:00LST.
Second, a wavelet analysis with a box-car type mother wavelet was carried out. The wavelet spectrum for each vertical profile of temperature, zonal wind, and meridional wind was calculated, and the mean spectrum for the entire period was obtained. It was clear that dominant wavelength depends on the altitude. It is approximately 1 km and 6 km for the lower (15-25 km) and middle (25-35 km) stratosphere, respectively. Because any drastic change in the Brunt-Vaisala frequency and background winds were not observed, it is inferred that the disturbance with the long vertical wavelength in the middle stratosphere was generated in the region far from, propagated horizontally toward and reached the observatory.
Phases of the dominant wave propagate downward, suggesting that the disturbance is due to an internal gravity wave propagating energy upward. Given a working hypothesis that the wave disturbance was an internal gravity wave, a hodograph analysis was carried out. First, the background wind was obtained as a linear least square fit for the vertical profiles of zonal and meridional winds above a height of 20 km. Deviation from the background wind was analyzed as the disturbance component. The hodograph of the disturbance component was approximated by an ellipse. The intrinsic frequency was estimated from the ratio of long to short axes of the ellipse. The horizontal wavenumber was determined from the dispersion relation of the internal gravity wave, using the estimated intrinsic frequency and the vertical wavenumber directly obtained from the vertical profile. The ground-based frequency that was determined from these wave parameters and the mean wind was approximately consistent with that observed in the time series of the vertical profiles. This means that the working hypothesis was valid and that the disturbance is due to an internal gravity wave. Furthermore, using these wave parameters and the mean wind, and the propagation paths of the internal gravity wave was estimated. As a result, it was concluded that the gravity wave likely originated from the low pressure system over a northern part of Korean Peninsula.

Keywords: radiosonde observations, wavelet analysis, internal gravity waves

