

Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

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Intermittent turbulence on time scales of a few minutes to 1 h is often observed in the nocturnal boundary layers. Previous observations were limited to one location (Yokoyama et al. 1981), or to homogeneous topographies within hundreds of square meters (Sun et al. 2015). The regional characteristics of these wavelike motions are unclear in metropolitan areas or in heterogeneous rural-urban areas that can be characterized by different surface conditions. Fujibe (2018) showed the climatological features of surface air temperature variations using 1 min data of the Automated Meteorological Data Acquisition System (AMeDAS) in Japan at horizontal intervals of approximately 17 km. In the Tokyo special wards, 1 min temperature and wind data have been recorded by the Air Pollution Monitoring Systems (APMS) at horizontal intervals of approximately 4.7 km. Therefore, these data can be used to analyze the characteristics of temperature and wind variations on time scales of 1 h or less and expected to investigate the regional characteristics of the variations in this area. The purpose of this study is to elucidate the temporal variations of temperature and wind and their regional characteristics over the Tokyo metropolitan area.

One-minute temperature, wind direction, and wind speed data from November 2016 to February 2017 obtained from the 44 APMS stations were used in this study. Additionally, the hourly wind speed, wind direction, cloud amounts, and precipitation data at the Tokyo District Meteorological Observatory (Kitanomaru) were used. We selected 17 clear and weak wind nights over the observation period using observational data at Kitanomaru by the same process as Nakajima et al. (2018).

The periodic variations of temperature and wind developed at several observational stations in several clear and weak winds nights. Especially, the periodic variations clearly developed on January 11-12, 2017. The winds and temperature fluctuated periodically in the western part of the Tokyo special wards from January 11 23:00 to 02:00 JST. The cycles of the variations were estimated as 20-50 mins from the wavelet analysis and were 5-10 times longer than that of the Brunt-Vaisala oscillation. This ratio agrees with the previous observational results (Yokoyama et al. 1981). On the contrary, the periodic variations were unclear in the central of the Tokyo special wards area such as Chiyoda ward.

In order to examine the regional characteristics of temporal variation of temperature, 20-50 mins band-pass filter was used to the temperature time series from 18:00 to 06:00 JST in each clear and weak wind night. The amplitudes of the band-passed filtered temperature variations in the non-urban area tended to be larger than 0.2°C. However, the amplitudes in the urban area tended to be smaller than those in a non-urban area.

The difference of the temporal variations between the urban area and the non-urban area implies that the difference of the atmospheric stability between the urban area and the non-urban area. Over a non-urban area at nighttime, ground-based inversion layer grows. However, over an urban area, the atmospheric stability tends to be near neutral (Oke et al. 2017). Small turbulence might produce a large temperature variation under a strong inversion layer, whereas the amplitude is expected to be small under a weak inversion layer (Fujibe 2018). Therefore, the smaller amplitude over urban area might develop under near neutral atmospheric stability.

Keywords: boundary layer, temperature variation, wind variation