Statistical study of solar activiy and seasonal dependence of semidiurnal tide in the polar lower Thermosphere on quiet days using EISCAT radar data

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Atmospheric gravity waves, atmospheric tidal waves, and planetary waves propagate upward in the polar MLT region, and play an important role in the dynamics there. Solar irradicance and solar wind energy is injected from above. Therefore, it can be said that the polar MLT region is a unique region. Understanding of the Polar MLT region is important for the vertical atmosphere coupling as well as magnetosphere-ionosphere-thermosphere coupling. In the polar lower thermosphere, the semidiurnal tide becomes dominant in the atmospheric dynamics with its strong amplitude (say 50-100 m/s) (see Nozawa and Brekke, 1999a; Wu et al., 2003, etc.). Amplitude variation of the semidiurnal tide have a great influence on vertical propagation of gravity wave and atmospheric stability near the mesopause (Zhao et al., 2003). Many studies have been conducted on semidiurnal tide (Murphy et al., 2006; Aso, 2007, etc.), however our understanding of this has not yet been sufficient. For example, understanding of altitude variations of the amplitude and phase of the semidiurnal tide from the mesosphere to the lower thermosphere is still insufficient. More observations are needed for further understanding of the variation. In previous studies in terms of neutral wind variation using EISCAT radar (Brekke, Nozawa, and Sparr, 1994; Nozawa and Brekke, 1995; Nozawa and Brekke, 1999a,b), dependence of season, geomagnetic disturbance, and solar activity for tidal wave are presented. However, the three factors could not be separated because of shortage of data. The purpose of this study is to reveal the variations of the semidiurnal tide with season, geomagnetic disturbance, and solar activity.

The averaged neutral wind velocities were calculated with 6 minutes and 3 km of temporal resolution and spatial resolution, respectively, for several categories (season, geomagnetic disturbance, and solar actibity), and then tidal components were derived. The number of data in geomagnetically quiet time ($Kp \leq 3$) was 46 days in summer and 144 days in winter during the observation period from November 1986 to February 2019. F10.7 index was used to classify wind data into three categories of 75 or less, 75 to 150, and 150 or more.

Figure 1 shows seasonal comparison of semidiurnal tidal amplitude for each solar activities. The open circles show summer and the solid circles shows winter, respectively. From the results, it was found some characteristics of season and solar activity for semidiurnal tide. Results of solar activity and seasonal variations are summarized as follows;

(1) In the northward direction, the amplitude of semidiurnal tide is stronger in summer than in winter, indicating that there is seasonal dependence under the condition of $F10.7 \leq 150$. On the other hand, the seasonal dependence could not be seen and the amplitudes of summer are similar to amplitudes of winter under the condition of $F10.7 \geq 150$. (2) In the eastern direction, as the solar activity increases, the altitude at which seasonal dependence appears descend, and seasonal dependence can be seen at all observational altitudes (say 93 - 120km) under the condition of $F10.7 \geq 150$. (3) The phase variations of semidiurnal tide about 1 hour in summer and about 2 hours in winter.

SSWs occurred relatively often during the observationnal period. The number of data in the same month when a SSW onset occurred is 36 days out of 60 days the observation data under the conditions of winter, $Kp \leq 3$ and $F10.7 \leq 75$. Comparisons of the amplitudes were conducted to evaluate effects of SSWs. Figure 2 shows altitude variations of the amplitude under conditions of winter, $Kp \leq 3$ and $F10.7 \leq 75$. Dot lines shows the amplitude profile that includes the influence of SSW, and the solid line shows the amplitude profile that excludes the influence of SSW. From this result, it found that SSW has the effect of increasing the amplitude of semidirnal tide.

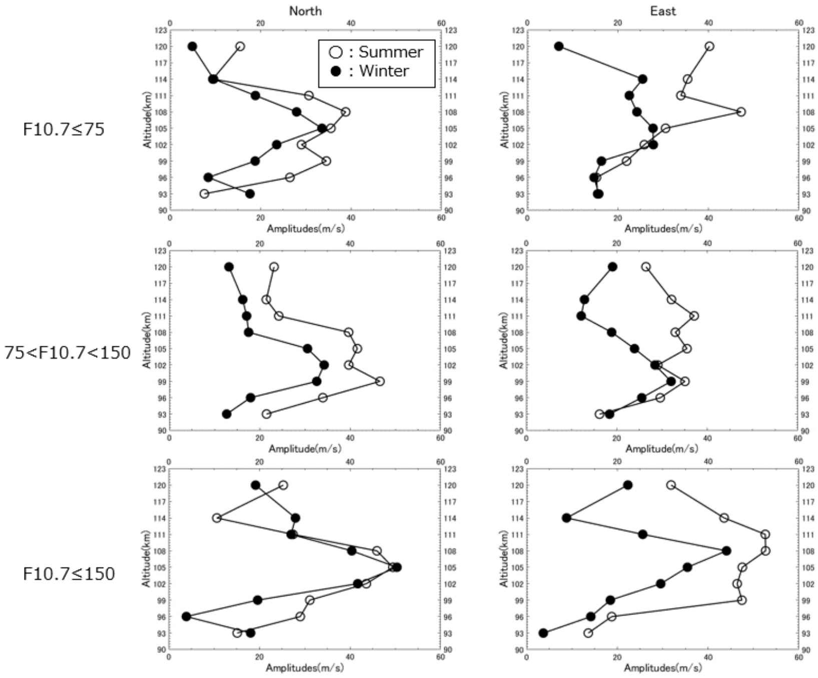

Figure 1. Height variations of semidiurnal tidal amplitude

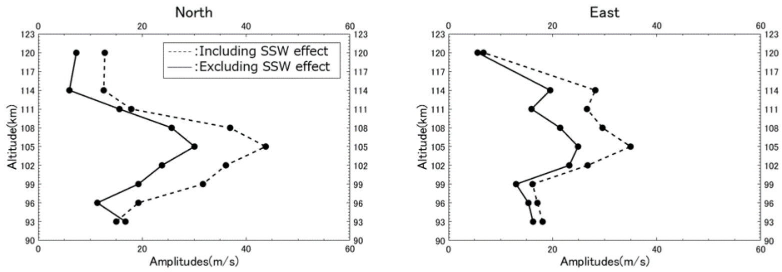

Figure 2. Height variations of Amplitude of semidiurnal tide for solar acitivity in winter.

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