昭和基地における大気光観測による極域上部中間圏領域の研究

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Study of the polar mesopause region by remote sensing of airglow in Syowa Station

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The OH Meinel band emissions are the brightest night airglow emissions in the near-infrared regions, and peak at mesopause altitudes. Since the intensity distribution in these vibration-rotation bands is quickly equalized to that determined by the local kinetic temperature, the OH rotational temperature can be derived from the spectrum of OH airglow. This technique has been widely used as a conventional and reliable method of temperature measurement in the mesopause region, especially in the middle- and low-latitude regions. However, it is known to be difficult to apply in the polar regions, because auroral emissions contaminate OH airglow spectra. There are a few examples of OH rotational temperature observations conducted in Antarctic for the purposes of studying the relationship between aurora activity and OH rotational temperature. However, highly energetic auroral electrons can reach altitudes just below the mesopause (~90 km) and can cause heating of the neutral atmosphere at that altitude. There are virtually no previous reports that show a quantitative relationship between auroral precipitations and OH rotational temperature.

A fast high-resolution spectrometer designed specifically to observe the spectrum of the OH vibrational-rotational band in the auroral zone has been developed during 7th term Antarctic core research project of NIPR. The OH 8-4 band around the 950-nm wavelength region in the nightglow spectrum was selected as the most suitable vibration-rotation band for observation in polar regions, based on Arctic survey observations. Its suitability lies in the fact that it is less susceptible to contamination from strong auroral emission. The new spectrometer comprises a fast optical system, a transmission grating and a CCD camera. The instrument was installed in the Optical Building at Syowa Station in February, 2008 by the 49th Japanese Antarctic Research Expedition.

The total dataset consists of observations over 153 nights during the 2008 austral winter season at Syowa Station as first year observation. The dataset shows both short-term (several minutes) and long-term (seasonal) variations. Typical temperature trends (high in winter and low in summer) in the polar mesopause region are also evident. These trends are very similar to those observed at the Davis Station which is located at nearly the same latitude as the Syowa Station. In addition to the seasonal trend, large-scale heating and cooling is seen over a period of several days. Short-term variations which relate to auroral activity can also be observed. Only six nights of data was found to be suitable, in terms of weather conditions and auroral activity, to study the relationship between auroral precipitations and OH airglow variations. In particular, a significant increase in the rotational temperature and a decrease in the airglow intensity related to auroral activity were identified on the night of March 27-28, 2008, but no such variations were seen on other nights. The horizontal magnetic-field disturbance on the night of March 27-28 was the largest observed during the entire winter, and cosmic radio noise absorption was also very strong. These facts indicate that a large flux of high-energy auroral particles precipitated during this night. It is suggested that the observed variations in the OH rotational temperature and airglow intensity were caused by a lowering of the average airglow altitude as a result of OH depletion in the upper part of the layer where high-energy auroral particles can reach.

Although in normal auroral activity there are no auroral effects, this study reveals the occurrence of rapid fluctuations related to very high auroral activity or hard particle precipitation in the polar mesopause region. To clarify a mechanism of the phenomena, a simultaneous observation which can derive vertical profiles of background temperature around the mesopause region is strongly desired. This will be realized by development of a resonance scatter lidar system in 8th term Antarctic core research project of NIPR