Statistical study of atmospheric stability in the polar upper mesosphere and lower thermosphere above Tromsø by using sodium LIDAR data

Sakiho Maeda[1], Satonori Nozawa[1], Takuya Kawahara[2], Norihito Saito[3], Satoshi Wada[3], Takuo Tsuda[4], Toru Takahashi[5,6], Tetsuya Kawabata[1] and Chris Hall[7]

[1]*Institute for Space-Earth Environmental Research, Nagoya University*

[2] *Faculty of Engineering, Shinshu University*

[3]*RIKEN Center for Advanced Photonics, RIKEN*

[4]*Department of Communication Engineering and Informatics, The University of Electro-Communications*

[5]*Electronic Navigation Research Institute*

[6]*Department of Physics, University of Oslo*

[7]*UiT The Arctic University of Norway*

We will report characteristics of the atmospheric stability in the winter polar upper Mesosphere and Lower Thermosphere (MLT) region (80-105 km) above Tromsø (69.6°N, 19.2°E) based on sodium LIDAR data. We have analyzed temperature and velocity data (6 min and 1 km resolutions) obtained over 8 seasons from October 2012 to March 2019 (about 2500 hour measurements of 237 nights). We have evaluated both the static (convective) and dynamic (shear) instabilities using the square of Brunt–Väisälä frequency (N^2) and Richardson number (R_i), respectively. Furthermore, we have calculated probabilities of the instabilities defined as the percentage of an occurrence rate of unstable regions over the time interval. The probabilities of the static and dynamic instability are shown as $P(N^2 < 0)$ and $P(0 < R_i < 0.25)$, respectively.

We have found that $P(N^2 < 0)$ varies from a maximum value of 21 % to a minimum value of 1 %, while $P(0 < R_i < 0.25)$ varies from a maximum value of 14 % to a minimum value of 2 % in the altitude region between 85 km to 95 km. These probabilities do not show any prominent monthly variations from October to March, rather day-to-day variabilities are prominent. Figure 1 shows an averaged altitude variation of the probabilities: $P(N^2 < 0)$ at around 90 km altitude is lower than those at around 80 km and 100 km, indicating the static instability was less likely to occur at around 90 km than above and below. There is a weak correlation between $P(0 < R_i < 0.25)$ and the semidiurnal tidal amplitude, while no prominent correlation between $P(N^2 < 0)$ and the semidiurnal tidal amplitude is found. In addition, correlations with the solar activity and the aurora activity were investigated by using the F10.7 index and K index. The correlation coefficients were low in the both cases, suggesting these effects on atmospheric instability were not dominant.

Based on these observational results, we will present the characteristics of the atmospheric stabilities in the polar winter MLT region above Tromsø. Furthermore, the results will be compared with those in mid- and low-latitude.

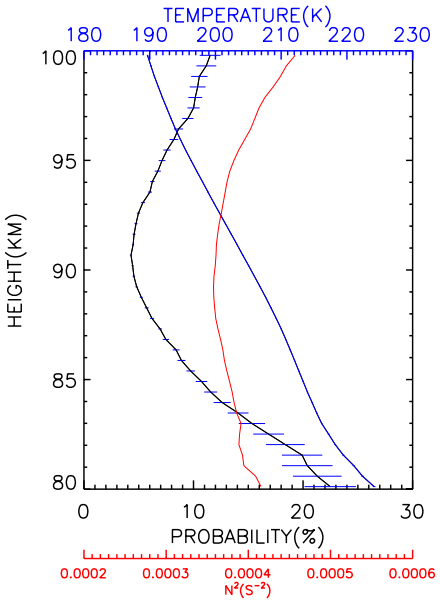

Figure 1. altitude profiles of $P(N^2 < 0)$ (black line), averaged temperature (blue line), and averaged N^2 (red line)