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

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We will report atmospheric stability in the polar upper Mesosphere and Lower Thermosphere (MLT) region (80-105 km) above Tromsø, Norway (69.6˚N, 19.2˚E) based on 2500 hours of sodium LIDAR data.

We have analyzed temperature and velocity data (6 min and 0.5 km resolutions) obtained over 8 seasons from October 2012 to March 2019 (about 2500 hour measurements of 237 nights). We have evaluated both static (convective) instability and dynamic (shear) instability using the square of Brunt–Väisälä frequency (N^2) and Richardson number (R_i), respectively. Furthermore, we have calculated the instability probability defined as the percentage of an occurrence rate of unstable regions over the time interval. The probabilities of static instability and dynamic instability are shown as $P(N^2 < 0)$ and $P(0 < R_i < 1/4)$, respectively. The temperature data and wind data are used to calculate N and wind shear (dv/dz), respectively.

We have found that $P(N^2 < 0)$ varies from a maximum of 20.6 % to a minimum of 0.5 %, and $P(0 < R_i < 1/4)$ varies from a maximum of 14 % to a minimum of 1.6% in the altitude region between 85 km to 95 km. $P(N^2 < 0)$ tends to be larger than $P(0 < R_i < 1/4)$. These probabilities do not show any obvious monthly variations from October to March, rather day-to-day variabilities are prominent. As shown in Figure 1, over the entire period, $P(N^2 < 0)$ at around 90 km altitude tends to be lower than those at around 80 km and 100 km: the static instability was less likely to occur at around 90 km. There is a weak correlation between $P(0 < R_i < 1/4)$ and the semidiurnal tidal amplitude, but no correlation between $P(N^2 < 0)$ and the semidiurnal tidal amplitude is found.

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-latitude.

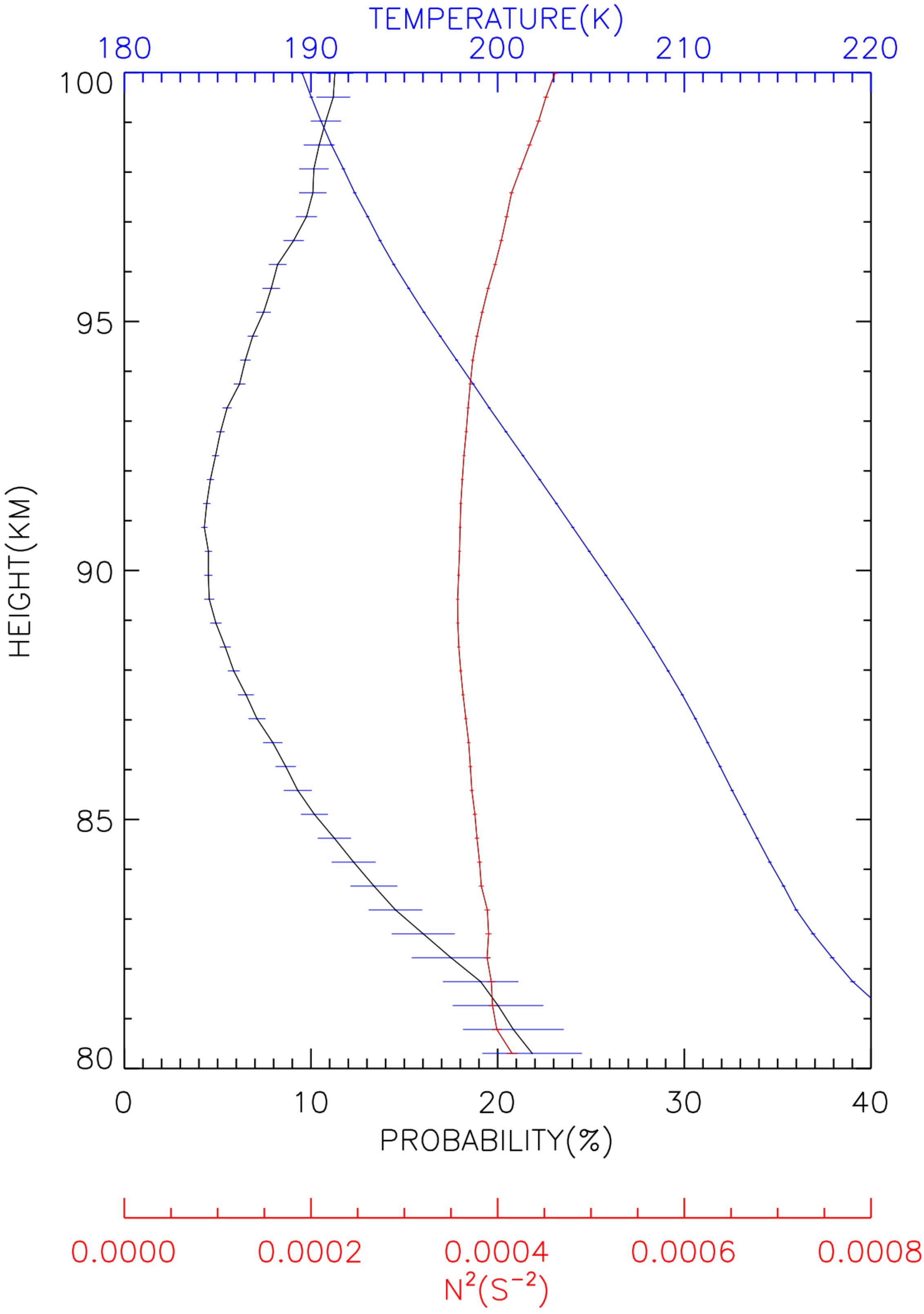

Figure 1. Height profiles of P($N^2 < 0$) (black line), averaged temperature (blue line) and N^2 (red line) associated with error bars (horizontal lines at each data point) from 80 to 100 km.