Study of atmospheric stability in the polar lower thermosphere and upper mesosphere by using simultaneous 5-directional observations at Tromsø

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The atmospheric static stability has been evaluated by calculating the squares of Brunt-Väisälä frequency (N^2). Below the Mesopause (and above Stratopause), although the atmosphere is generally stable ($N^2 > 0$), it has a negative temperature gradient in altitude. The negative vertical gradient of the temperature can be enhanced by perturbations due to atmospheric waves such as tidal and gravity waves, resulting in the atmosphere becoming unstable ($N^2 < 0$). Since in winter the Mesopause is located around 100 km, the Mesosphere and Lower Thermosphere (MLT) region (80-105 km) sometimes become unstable as shown by *Zhao et al.* (2002), *Li et al.* (2005), and *Andrioli et al.* (2017). Until now, several studies on the atmospheric stability around the mesopause region have been reported, but none focus on the polar Mesopause region.

The sodium LIDAR operated at Tromsø (69.6°N, 19.2°E) has obtained about 4000 hours of temperature and sodium density data as well as about 3000 hours of wind data since October 2010 for nine winter seasons between ~80 and ~105 km. Using height resolved temperature data obtained for about 200 nights between October 2012 and December 2018, when five directional observations were made, we have conducted a statistical analysis and investigated the characteristics of atmospheric static instability in the polar MLT region. In this study, as a result of the statistical analysis, we have derived the static probability (shown in percentage of occurrence rate of the static unstable regions over the time interval) during the interval; it changed from a maximum value of 27% (occurring on 30 November 2013) to a minimum value of 2.6% (occurring on 16 February 2018), and 12.6% on average; the high static stability found on 16 February 2018 would be related to occurrence of a Sudden Stratospheric Warming (SSW) event (its onset occurring on 12 February, and ending on 27 February 2018). It is found that the monthly average probabilities when SSW occurred (January or February) are slightly lower than those in other months; the average probability tends to be the largest in November or December. In addition, over the entire period, the probability around 90 km altitude tended to be the lower than those above and below.

Based on these observational results, we will talk about the characteristics of the atmospheric stability in the polar winter Mesopause region above Tromsø. Furthermore, the results will be compared with those in mid-latitude.

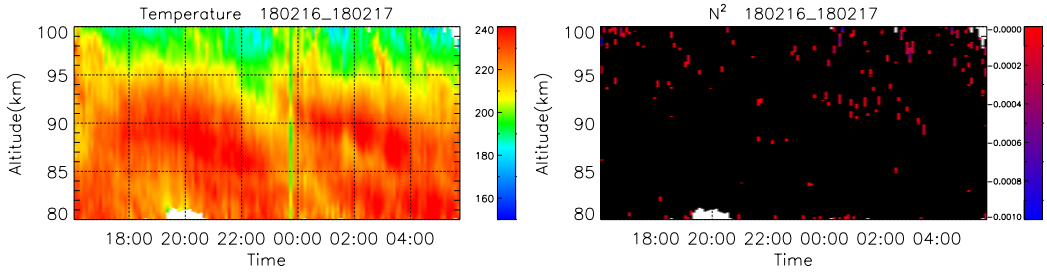

Figure 1. Altitude-time plots of temperature (left) and the squares of Brunt-Väisälä frequency (N^2) (right) derived by sodium LIDAR data on 16-17 February 2018. The stable region is shown in black, while the unstable region ($N^2 < 0$) is shown in red, purple, and blue squares.

References

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