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Statistical study of probability of instabilities in the polar upper mesosphere/lower thermosphere

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The aim of this study is to clarify probabilities of convective and dynamical instabilities and their variations in altitude/time in the polar upper mesosphere and lower thermosphere (80-110 km). In this study, we have used temperature data obtained with the sodium LIDAR operated at the EISCAT Tromsoe (69.6N, 19.2E) site. Between October 2010 and January 2015, there are 287 nights when their temporal data lengths are equal to or longer than 4 hours on a night. Based on the temperature data, we have calculated square of Brunt-Vaisala frequency (N^2). The time and height resolution of the temperature data used are 10 min and 1 km, respectively. Together with wind data obtained by the sodium LIDAR (after October 2012) or the co-located meteor radar (before March 2012), we have also calculated Richardson numbers (R_i) for the 287 nights. The instability probability on one night is calculated as the percentage of the number of points whose N^2 is negative for convective instability, and whose Ri falls in the range of $0 < R_i < 0.25$ for dynamical instability to the total data set over the height region for the entire night.

Studies of probabilities of instabilities around the mesopause region were made at middle/low latitudes. Zhao et al. (JASTP, 65, 219-232, 2003) analyzed 32 nights (195 hours) of data sets over 1 year between June 1998 and May 1999 obtained at Starfire Optical Range, near Albuquerque, NM (35N, 106.5W) and showed that the probabilities of static and dynamic instabilities were maximum in mid-winter. Li et al. (JGR, 110, 2004JD005097, 2005) analyzed 19 nights of data sets obtained between January 2002 and November 2003 at Maui, Hawaii (20.7N, 156.3W), and pointed out that at any given time the probability that an unstable condition was found at some altitudes in the 85-100 km range was about 90%. To the best of our knowledge, no such a study has been made for the polar upper mesosphere/lower thermosphere.

We will show probabilities of instabilities in the polar upper mesosphere and lower thermosphere, and difference of the probabilities in terms of year, month, and altitude. Furthermore, we will discuss correlations between the probabilities and amplitudes of tides/gravity waves and between the probabilities and auroral activity.

Keywords: polar upper mesosphere and lower thermosphere, convective instability, dynamical instability, sodium LIDAR, Tromsoe