Statistical study of Sporadic Sodium Layer (SSL) observed at the high latitude station at Tromsø

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Based on about 3,000 hours of sodium density data obtained with the Tromsø (69.6ºN, 19.2ºE) sodium LIDAR (*Nozawa et al.*, 2014; *Kawahara et al.*, 2017) over 7 winter seasons (October-March) between 2012 and 2018, we have identified about 40 events of Sporadic Sodium Layer (SSL) in the polar mesosphere and lower thermosphere (MLT) region (80-110 km). In general, a SSL is a thin sodium layer (about 1-2 km) with high sodium density (usually factor of 2 or higher than that of a background normal layer), and its life time is about a few minutes to a few hours (*Cox and Plane*, 1998; *Clemesha et al.*, 1999; *Batista et al.*, 1991).

Analyzing the datasets with temporal and height resolutions of 3 min and 500 m, respectively, we have identified about 40 SSL events over the seven winter seasons. Figure 1 shows temporal variation of sodium density for the night of January 15, 2014. A SSL appeared around 22 UT at 96 km, and lasted for (longer than) 2 hours. During the 2 hour interval, the peak density of the SSL increased, in genral, with time and the peak density height decended as time went.

Based on the ~40 events, we have investigated an occurrence rate of SSL as well as necessary conditions for a SSL to form in the polar MLT region. SSLs appeared for shorter than about 5 % of the overall observational time, indicating it is a rare event. Auroral electron precipitation as well as advent of a sporadic E (Es) layer would be necessary conditions to form a SSL at high latitudes. The five point observations enabled us to determine whether or not an observed SSL was in-situ generated or was advected. Most SSLs show feature of advection (systematic and similar temporal variations of sodium density), indicating associated sharp rise of sodium density, whose mechanism cannot be yet understood well in the previous published papers, can be explained with an advection effect (cf. *Tusda et al.*, 2015).

Observational results can be summarized as follows:
(1) Most observed SSLs are probably advected, (2) Ionization due to auroral particle precipitation would be one of necessary conditions at high latitudes, (3) Sporadic *E* (*Es*) layers are almost always associated, so coexistence of the *Es* layer is also one of necessary conditions, and (4) A clear local time dependence of advent time of the SSLs is found, suggesting the ion convection in the polar F-region and/or the semidiurnal tide would play an important role. We will overview these observational results and would address a generation mechanism of SSL.

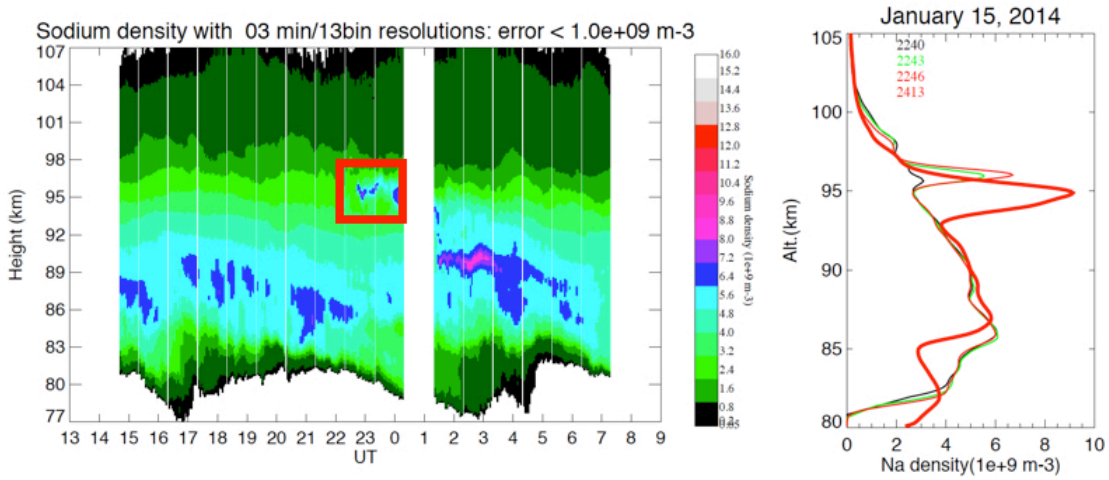

Figure 1. Left: Variation of sodium density observed at Tromso betwee 14 UT on January 15, 2014 and about 07 UT on January 16, 2014. A SSL was observed between 22 and 24 UT around 95 km (indicated by red square). Right: Temporal variation of altitude profiles of sodium density at 2240, 2243, 2246, and 2414 UT on January 15, 2014.

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