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A case study on generation mechanisms of a sporadic sodium layer during a night of high auroral activity

TAKAHASHI, Toru[1*] ; NOZAWA, Satonori[1] ; TSUDA, Takuo[2] ; OGAWA, Yasunobu[3] ; SAITO, Norihito[4] ; HIDEMORI, Takehiro[1] ; KAWAHARA, Takuya[5] ; HALL, Chris[6] ; FUJIWARA, Hitoshi[7] ; BREKKE, Asgeir[8] ; TSUTSUMI, Masaki[3] ; WADA, Satoshi[4] ; KAWABATA, Tetsuya[1] ; OYAMA, Shin-ichiro[1] ; FUJII, Ryoichi[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]The University of Electro-Communications, [3]National Institute of Polar Research, [4]RIKEN Center for Advanced Photonics, RIKEN, [5]Faculty of Engineering, Shinshu University, [6]Tromso Geophysical Observatory, The Arctic University of Tromso,, [7]Faculty of Science and Technology, Seikei University, [8]Faculty of Science, The Arctic University of Tromso, Tromso, Norway

Generation mechanisms of sporadic sodium layers (SSLs) have been discussed for more than three decade. Proposed mechanisms are as follows: *Es* layer, chemical reaction enhancement due to a background temperature variation, gravity waves, meteor deposition, and aurora particle spattering. However there are few studies that evaluate these mechanisms quantitatively based on observational data. In this study, we have quantitatively evaluated generation mechanisms of a SSL based on observational data obtained by multiple instruments at a high latitude station: Ramfjordmoen, Tromso, Norway (69.6^{o}N, 19.2^{o}E).

The sodium LIDAR observed an SSL at 2118 UT on 22 January 2012. The SSL was observed for 18 min with a maximum sodium density of about 1.9x10^{10} m^{-3} at 93 km with a 1.1 km thickness. The EISCAT UHF radar observed a sporadic *E* layer (*Es* layer) above 90 km from 2000 to 2300 UT. After 2000 UT, the Es layer gradually descended and reached 94 km at 2118 UT when the SSL appeared at the same altitude. In this event, considering the abundance of sodium ions (10% or less), the Es layer could provide only about 21% or less of the sodium atoms to the SSL. We have investigated a temporal development of the normal sodium ion layer with consideration of chemical reactions and the effect of the (south-westward) electric field using observational values of the neutral temperature, electron density, horizontal neutral wind, and electric field. This calculation has shown that those processes, including contributions of the *Es* layer, would provide about 88% sodium atoms of the SSL. Effects of meteor absorption and auroral particle spattering appear to be less important. Therefore, we have concluded that the major source of the SSL was sodium ions in a normal sodium ion layer. Two processes-namely the downward transportation of sodium ions from a normal sodium ion layer due to the electric field, and the additional supply of sodium ions from the *Es* layer under relatively high electron density conditions (i.e., in the *Es* layer)-played a major role in generating the SSL in this event. Furthermore, we have found that the SSL was located in a lower temperature region, and that the temperature inside the SSL did not show any remarkable temperature enhancements.

Keywords: Sporadic sodium layer, sodium lidar, polar region, aurora, MLT