高エネルギー降下粒子が Na 層に与える影響の化学モデル計算

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Chemical model calculations on Na layer variation induced by energetic particle precipitation

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Metallic atom and ion layers, such as Na/Na^+, K/K^+, Fe/Fe^+, and Ca/Ca^+ layers, exist in the mesosphere and lower thermosphere (MLT). The height range of the MLT region corresponds to the ionospheric D and E regions, and in the polar region energetic particles precipitating from the magnetosphere can often penetrate into the E region and even into the D region. Therefore, the influence of energetic particles on the metallic atom and ion layers is of interest regarding changes in atmospheric composition accompanied by auroral activity or geomagnetic activity.

There are several previous studies on energetic particle effects to Na atom. Decreases in Na density during energetic particle precipitations were reported from Na resonance scattering lidar and incoherent scatter radar observations during nighttime at high-latitudes, i.e., wintertime. Using sunlight-induced Na emission data by a low-orbit-satellite, it was revealed that Na densities were low during the geomagnetically active periods in the polar daytime, i.e., summertime, compared with those during the quiet periods. Some models based on the Na chemistry indicated that charge exchange reactions Na atoms and background ions (NO^+, $O_2{}^+$), which can be enhanced by ionization due to energetic particles, play important role in mechanism for Na densities decrease induced by the energetic particle precipitation. However, our understanding on energetic particle effects to the Na layer is still limited. In particular, more quantitative evaluations on the Na chemical processes are needed.

In this study, we have developed a numerical model to understand importance of the Na chemical processes triggered by ionization, i.e., enhancements of electron and ion densities, due to energetic particle precipitation. The model describes simply continuity equations related with Na chemical reactions. To investigate the ionization effects to the Na layer, we have perfomred two calcurations using the model. One is the case of higher electron and ion densities, i.e., the case of ionization induced by energetic particle precipitation, and the other is the case of lower electron and ion densities, i.e., the case of no ionization or no particle precipitation. Such calculations have been done in the two background conditions, which are summertime and wintertime. As the results, we have found that the calculrated Na densities in the cases of ionization were lower than those in the cases of no ionization in both summertime and wintertime. Under the winter condition, amount of Na density decrease was ˜3700 cm^{-3} at 95 km height while that under the summer condition was ˜2400 cm^{-3} at 94 km height. These summr and winter results would be fairly consistent with the previous observational results. Thus, the enhancements of electron and ion densities can induce Na density decrease through the Na chemical process. In the presentation, we will introduce our model and present the calculated results. Furtheremore, we will discuss important chemical processes and background parameters in the Na decrease due to energetic particles, based on comparisons between results in the summertime and wintertime.