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Characteristics of calcium ion layer observed with resonance scattering lidar at Syowa in Antarctic

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Layers of metal ions in the mesosphere and lower-thermosphere (MLT) are produced by meteoric ablation. The meteoric metal ions have relatively long chemical life time in the MLT region and behave as plasma affected by neutral atmosphere dynamics. In the mid-latitude, the meteoric metal ions in the MLT region are generally accepted as key species for generation of sporadic E (E_s) layer in the wind shear theory. Calcium ion (Ca^+) is one of meteoric metal ion and only one ion, which can be measured its vertical profile from the ground by a lidar sounding. The close link between the E_s layer and metal ion layer has been shown also by simultaneous observations of the Ca^+ lidar and radars [Raizada et al., 2012; Ejiri et al., 2019]. Annual variation of the Ca+ vertical distribution observed at Kuhlungsborn in 1997-1998 showed existing a permanent Ca^+ layer between 90 and 100 km through the year though it was sometimes rather weak [Gerding et al., 2000]. Recently, the Whole Atmosphere Community Climate Model incorporated a large database of neutral and ion?molecule reaction kinetics of calcium (Ca) species (WACCM-Ca) simulated the seasonal Ca^+ layer globally [Plane et al., 2018]. However, the results cannot be verified well yet because observation lacks except at the mid-latitude in the northern hemisphere.
A new resonance scattering lidar system with frequency-tunable alexandrite laser was developed by the National Institute of Polar Research (NIPR) and installed at Syowa Station (69S, 40E) by the 58th Japan Antarctic Research Expedition (JARE 58). Density profiles of Ca^+ in the MLT region over Antarctic were successfully observed 6 nights in total in September and October, 2017 and 2018. The Ca^+ layers observed at Syowa showed similar altitude of peak (~94 km) and layer width (~7 km) with Kuhlungsborn (54N, 12E) in spring while Ca^+ density at Syowa seems slightly smaller than that at Kuhlungsborn. Sporadic Ca^+ (Ca^+_s) layer with higher density than several hundred cm^{-3} was not seen in our observations at Syowa in spring while the Ca^+_s layer is often observed at the mid-latitude in the northern hemisphere. Ca^+ column abundance observed at Syowa was one order smaller than that predicted by WACCM-Ca. This is qualitatively consistent with Plane et al. [2018] that WACCM-Ca tends to overestimate Ca^+ measurements made by lidar.