Vertical fine structure and time evolution of plasma irregularities in the E_s layer, observed by a high resolution Ca^+ lidar

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The vertical fine structures and the time evolution of plasma irregularities in the sporadic *E* (E_s) layer were observed via calcium ion (Ca^+) density measurements using a resonance scattering lidar with a high time-height resolution (5 s and 15 m) at Tachikawa (35.7°N, 139.4°E) on December 24, 2014. The observation successfully provided clearer fine structures of plasma irregularities, such as quasi-sinusoidal variation, localized clumps, "cats-eye" structures, and twist structures, in the sporadic Ca^+ (Ca^+_s) layers at around 100 km altitude. These fine structures suggested that the Kelvin-Helmholtz (K-H) instabilities occurred in the neutral atmosphere whose density changed temporarily or spatially. The maximum Ca^+ density in the Ca^+_s layer was two orders of magnitude smaller than the maximum electron density estimated from the critical frequency (f_oE_s) observed by the ionosonde at Kokubunji (35.7°N, 139.5°E) simultaneously. The correlation showed a strong positive correlation with a coefficient of 0.91. These results suggest that Ca^+ contributes forming the E_s layer as well as major metallic ions Fe^+ and Mg^+ in the lower thermosphere. Moreover, the formation of a new Ca^+_s layer at 110 km and the upward motions of the Ca^+_s layers at 100 km and 110 km were observed just after the sunrise time at the conjugation point and before the local sunrise. Although the presence or absence of a causal relationship with the sunrise time was not clear, a possible explanation for the formation and the upward motions of the Ca^+_s layers was the occurrence of strong eastward winds at around 100 km, rather than the enhancement of the eastward electric field.