Strongly enhanced plasma lines observed by the EISCAT Svalbard Radar during the International Polar Year

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The plasma line (PL) is one of the signatures in the incoherent scatter radar spectrum and appears at frequencies up- and down-shifted from the transmitted signal by a few MHz. These frequency shifts respectively correspond to the frequencies of the down- and up-going scattering Langmuir waves plus the Doppler shift caused by the bulk motion of the electron gas. Although intensity of the PL is sometimes below noise level, it is occasionally enhanced and detectable in the presence of certain nonthermal features of the electron distribution function, such as local or magnetic conjugate photoelectrons and aurorally generated suprathermal (secondary) electrons. Especially during auroral activities, PL frequency and power may drastically change both with altitude and with time as reported from several case studies [e.g., *Wickwar*, 1978; *Valladares et al.*, 1998; *Kirkwood et al.*, 1995]. In the preceding companion paper by *Ivchenko et al.* [2017], data from the European Incoherent Scatter (EISCAT) Svalbard Radar (ESR) during the International Polar Year (from March 2007 to February 2008) were analyzed for statistical occurrence of enhanced PL. In this study, we use the same data set but focus on strongly enhanced plasma lines (SPL) with intensity higher than 1000 K, and a statistical analysis with a fully-automated detection method are performed to elucidate various occurrence properties of SPLs for the first time. More than 90 percent of SPL events have a peak intensity below 210-km altitude and usually in a frequency range of 3.0-3.25 MHz. The peak intensity is most likely to appear near 3.17 MHz frequency and 160-165 km altitude. These *E* -region SPLs are attributed to 2-4 eV dip in the electron fluxes caused by excitation of vibration levels in N_2, which results in low Landau damping and strong enhancement of Langmuir waves [*Kirkwood et al.*, 1995]. Remaining several percent of SPL events have a peak intensity at altitudes higher than 210 km and in a wider frequency range, which may result from parametric decay of large-scale (small-wavenumber) Langmuir waves excited by soft electrons (~100 eV) [e.g., *Forme*,1993]. Our statistical analysis also shows the dependence of SPL occurrence rate on local time/season/Kp-index and unexpected difference in intensity and altitude between up- and down-shifted SPLs. Although these occurrence properties of SPLs are not fully explained by previously proposed theories, they are affected by combined factors such as auroral precipitation, secondary electrons, background electron density, and its small scale gradient.

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