Global spatio-temporal development of magnetospheric ELF/VLF waves based on ground-satellite observation and RAM simulation

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The magnetospheric ELF/VLF waves are plasma waves generated by energetic electrons from several keV to tens of keV with temperature anisotropy at magnetospheric equatorial plane of the inner magnetosphere. These ELF/VLF waves with frequencies lower than local half-gyro frequency (lower-band) can propagate to the ground along geomagnetic field lines. It is also known that the ELF/VLF waves interact with electrons drifting longitudinally in the inner magnetosphere, and help accelerating accelerate them to relativistic energies. It is important to know the spatial-scale of magnetospheric ELF/VLF waves to estimate the amount of generated relativistic electrons.

Takeshita et al. [submitted to JGR 2019] statistically investigated the longitudinal extent of the magnetospheric ELF/VLF waves using six ground-based stations for two months, and showed the typical extent of the ELF/VLF waves as ˜80 degrees in longitude. On the other hand, Jordanova et al. [JGR, 2010] investigated the global distribution of linear growth rate of whistler mode chorus waves using global ring current-atmosphere interactions model (RAM), and showed that the region of large linear growth rate can extend ˜180 degrees in longitude during the geomagnetic storm of 22 April 2001.

In this study we investigate the spatio-temporal distribution of the source region of magnetospheric ELF/VLF waves using three methods, (A) wave observation using ground based stations and satellites, (B) proxy of ELF/VLF waves using precipitating electrons observed by POES/MetOP, and (C) linear growth rate calculated by RAM simulation during the geomagnetic storm period from 26-30 March 2017.

(A) Wave observations are investigated using ground based observations at Athabasca (ATH; 54.7N, 246.4E, MLAT: 61.3N), Kapuskasing (KAP; 49.4N, 277.8E, MLAT: 58.7N), Kannuslehto (KAN: 67.7N, 26.3E, MLAT: 64.5N) and satellite-based observations by ERG with an apogee in the pre-dawn sector and RBSP-A and RBSP-B with an apogee in the post-dusk sector.

(B) proxy of ELF/VLF waves were estimated by precipitating electrons observed by POES/MetOP satellites [e.g. Li et al. 2013, Chen et al. 2014]

(C) Global distribution of linear growth rate of ELF/VLF waves obtained by the RAM simulation [Jordanova et al. 2012]. The self-consistent magnetic field and the Volland-Stern electric field are used as ambient magnetic and electric fields. The night-side boundary conditions are determined from plasma sheet flux measurements by LANL geosynchronous spacecraft.

We compared the global distribution of magnetospheric ELF/VLF waves deduced from these three methods. We found that the magnetospheric ELF/VLF waves with an extent from 0 MLT to 12 MLT associated with substorm onset were observed by three methods. In this presentation, we will also report comparison with another geomagnetic storm event during 19-24 Nov 2017. Seven ground based stations are were operated during this event, so that we can estimate spatio-temporal development of waves in more detail.