Origin of pre-seismic whistler wave intensity attenuation - Comparison between DEMETER satellite and global lightning data -

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The intensity decrease of VLF electromagnetic waves around 1.7 kHz observed by DEMETER satellite within 4 hours before 4.8 mainshock of global earthquakes (EQs) within 550 km epicentral distance (537 earthquakes in total) was statistically found by Němec et al. [Geophys. Res. Lett., 2008; J. Geophys. Res.. 2009] and Píša et al. [J. Geophys. Res., 2013]. Our analysis also showed that the statistical comparison between the whistler wave data observed by the DEMETER and the lightning location data provided by World-Wide Lightning Location Network (WWLLN), we found that the intensity decrease was caused by not only change of earth-ionosphere cut-off frequency (i.e., approximately 1.7 kHz) but also absorption of whistler waves due to D-region electron density increase. In addition, we found the statistical correlation between the intensity decrease and EQ occurrences. Thus, one can expect that an in-situ monitoring of VLF electromagnetic waves on the satellite will provide the EQ prediction. In particular, the intensive whistler wave can be observed by nano-satellite, which also provides the practical precursor monitoring for the EQ prediction.

There are 289 orbits in the condition that a sub-satellite point existed within epicentral 330 km distance within 4 hours before the mainshock of $M \geq 4.8$ EQ during nighttime. In particular, 30 orbits were highly correlated with more than 0.8 correlation coefficient to the staking curves (i.e. model curve). Here we termed the 30 orbits EQ-related orbits. For the comparison, control 30 orbits similar to the 30 EQ-related orbits in the condition such as location, season, and geomagnetic activity are selected.

In order to investigate the correlation between the VLF intensity decrease and EQs, we evaluated the anomaly appearance rate (AAR) and EQ occurrence rate (EOR). First of all, we modeled the decrease of average of the EQ-related orbits and defined this variation as an anomaly. The AAR is defined by the number of EQs with the anomaly divided by the total number of EQs, while the EOR is the number of the anomaly which preceded EQs within the lead-time interval ΔT (i.e. 4 hours) divided by the total number of the anomaly. Note that the AAR and EOR are equivalent to the alarm rate and success rate in earthquake prediction study. Our results showed cross lines of the AAR and EOR versus correlation coefficients between the model anomaly and the observed data. Although EOR is not large so far, the cross lines of EOR and AAR means the positive correlation between the EQ occurrence and the VLF intensity decrease. As the low EOR originates from the identification criteria of the VLF intensity decrease, i.e., only the technical issue, future investigation is expected to be large EOR.