Relationship between magnetic ripples observed by the Swarm satellites and lower atmospheric disturbances

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The Swarm satellites, which are the low Earth, polar orbiting satellites, observed small-amplitude (0.1–5 nT) magnetic fluctuations, so-called magnetic ripples (MRs), with period around a few tens of seconds along the satellite orbit in the topside ionosphere at middle and low latitudes. A possible generation mechanism of the MRs is as follows. (1) The atmospheric waves generated by the lower atmospheric disturbance propagate to the ionospheric layer. (2) The neutral wind perturbations caused by the atmospheric wave drive the ionospheric layer dynamo, so that Hall and Pedersen currents flow in the ionosphere. (3) Because the dynamo region is limited, directions of the dynamo electric fields in the two adjoining dynamo regions with the spatial scales of the neutral wind perturbation apart are opposite. Therefore the ionospheric currents diverge to flow along the geomagnetic field-line with much higher conductivity. (4) As an Alfvén wave with polarized electric field, the front of the current circuit propagates along the geomagnetic field-line to the conjugate point on the ionosphere. (5) The currents are closed to make an electric current circuit which is made up of the currents in the ionosphere and field-aligned currents (FACs). The MRs are the spatial structure of small-scale FACs, and we confirmed with the Swarm observations their basic characteristics to be almost the same with those obtained by the CHAMP satellite. That is, the global distribution of the averaged MR amplitudes has clear geographical, seasonal and local time dependence highly correlated with the ionospheric conductivities. We found that the averaged amplitudes of the MRs derived from the Swarm-B satellite which flies about 50 km higher altitude are slightly smaller than those of the Swarm-A and -C, suggesting that the location of origin of the MRs is below ~470 km altitude, i.e., not in the magnetosphere. From the global distribution and its characteristics, the source of the MRs has been expected to be the atmospheric waves generated by lower atmospheric disturbances including the effects of earthquakes or volcanic eruptions. The fact that the MRs appear almost always suggests that some typical meteorological phenomena are the main source of MRs. To confirm the suggestion, we tried to find the connection between the MRs and typhoons as the first step. To show the evidence which correlates the MRs with typhoons, we performed an event and a statistical analyses with track data of typhoons. The data of 54 typhoons during the period from 26 November 2013 to 31 July 2016 are used for the statistical analysis. The results show that the averaged amplitudes of the MRs during typhoon activity are, in general, except for the day side local time sector, larger than those during non-typhoon condition. The event analyses indicate amplitudes enhancement of the MRs around the typhoons, and the latitude of the enhancement moved with the typhoon. These analyses indicate that typhoons are one of the source meteorological phenomena of the MRs. From the comparison with the infrared brightness temperature data the convection activity include typhoon seems to affect the amplitude of MRs. These results indicate that the MRs are generated by the lower atmospheric waves through the ionospheric dynamo.

Keywords: Magnetic ripple, Magnetic fluctuation, Field-aligned current, Ionospheric dynamo, Acoustic gravity wave, Swarm

