Numerical simulation on the solar cycle variation of the outer radiation belt

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Since the discovery of the radiation belts in the late 1950's, many observations and theoretical studies on their time variations have been carried out. As for the long-term variation (e.g., solar cycle), however, there are few studies, and it has not been well known. We have performed analysis to investigate the energy and spatial dependence of the solar cycle variation on energetic electrons in the radiation belts, using the data set from the TIROS/NOAA satellites during the period from 1979 to 1999. It was confirmed that there exists the synchronized variation with the solar cycle in both the inner and outer radiation belts. The relativistic electron (300 keV -) flux, at the inner portion, enhanced after the solar maximum and was absent near the solar minimum. On the contrary, at the outer portion of the outer belt, the electron flux was absent in the solar maximum, and the flux increased near the solar minimum. It was also revealed that the spatial structure of the outer radiation belt changes during the solar cycle.

In order to investigate control parameters for the long-term variation of the outer belt, we have developed the numerical code on the radial diffusion expressed by the Fokker-Planck equation. The model included the effects of particle source, losses and transport, and assumed that the source exists outside the radiation belt. As the time variation of the outer boundary condition, the changes of the open/close boundary due to the polar cap potential were calculated.

To verify the effect of the variation of the particle transport efficiency, we used the time dependent diffusion coefficients parameterized by Kp index and the time independent parameters on source and losses. As the result, the model reproduced not only the solar cycle variation but also the semi-annual and recurrent variations in the inner portion of the outer belt. The model, however, could not reproduce the long-term variation of the spatial structure of the outer belt. This result suggests that the variations of the other parameters, including source and losses, are also important for long-term variation of the outer belt besides the changes of the transport efficiency.