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Theoretical modeling for ENA investigations at Earth

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Theoretical modeling of ENA essentially involves modeling of the 3-dimensional distribution of “seed” ions. Solving kinetic equation of the ions trapped in Earth’s magnetosphere [1], we have calculated evolution of the phase space density of the ions with energy between keV and hundreds of keV ranges. The ions are transported by the convection electric field with its intensity depending on solar wind and IMF conditions under the assumptions that the first second invariants are conserved. The primary output of the simulation is the 4-dimenaional equatorial phase space density, which can be easily mapped to the directional differential number flux at off-equator. We employed the Chamberlain type model for the H distribution and MSIS-E90 for the O distribution. ENA emission is usually strongest at the lowest altitude where the ambient neutral density is the highest. The lowest altitude of the ENA calculation was set to be 1200 km because contribution from secondary products due to the stripping, ionization and excitation collision was neglected. We are still under constraint to make the assumption that there is no emission at altitudes less than 1200 km and there is no secondary emission because of limited computer resources. Therefore, we avoid focusing on the ENA emission from the near-limb region. In spite of the assumption, some of features are found to agree well with the IMAGE/HENA observation. A noticeable feature is the global morphology of the ENA emission, especially the post-midnight enhancement of the ENA emission during large storms [2]. When the magnetosphere is self-consistently coupled with the ionosphere in terms of conservation of electric currents, our simulations show that the peak of ENA emission is rotated toward the morning side due to the enhanced shielding electric field. The degree of the rotation depends on the intensity of the convection electric field, the ionospheric conductivity and the plasma sheet density as well. ENA observations together with theoretical modeling are shown to be powerful tools for investigating not only the global morphology of the magnetospheric ions, but also the complicated physical processes connecting from the solar wind to the ionosphere.

References

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