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Numerical Study of the Proton Flux Response in the South Atlantic Anomaly during a Geomagnetic Storm

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Abstract

The South Atlantic Anomaly (SAA) is considered as a serious source of radiation for Low Earth Orbit (LEO) satellite missions and human operations. Since the radiation environment depends on the particle behavior, the objective of this study is to analyze numerically the variations of the proton flux inside the South Atlantic Anomaly (SAA) during geomagnetic storm, and to assess the corresponding radiation environment for a selected LEO mission.

In this research, we have developed a relativistic three-dimensional test particle simulation code using Tao-Chan-Brizard guiding center model in order to calculate the proton trajectories in a time-varying magnetic field background provided by Tsyganenko model TS05 in addition to the corresponding inductive electric field solved by Biot-Savart Law. The main input parameters to the model were the dynamic pressure and the velocity of the solar wind, the Interplanetary Magnetic Field (IMF) transversal components, the geodipole tilting angle, and the *Dst* index, related to the geomagnetic storm event of 15 May 2015, while the main output variables examined in this study were the maximum proton flux value, and the corresponding area of the SAA calculated below a selected proton flux threshold and altitude.

It was found that the proton flux in the SAA was intensified during the storm main phase and was significantly decreased afterward. Computed results were compared with observations at both altitudes 400 and 800 km.

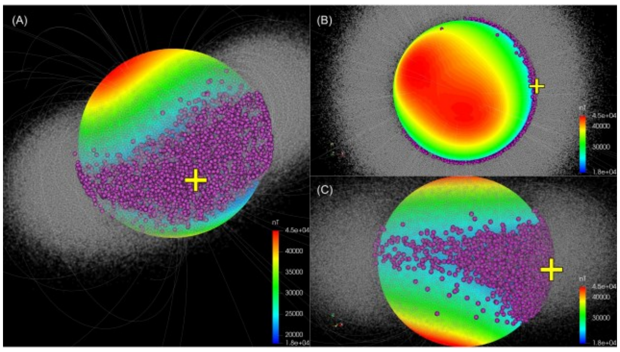

Figure 1: This figure shows three different views ((A) general, (B) top, and (C) side views) of the inner radiation belt simulation. The color indicates the magnetic field strength at 1.1 Re (≈ 640 km altitude). It can be detected visually the SAA (blue shaded area), and also the precipitated protons (magenta). The yellow cross in the panels locates the SAA center.

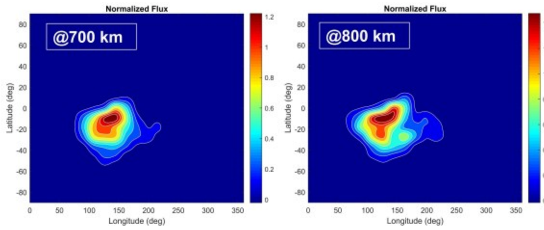

Figure 2: This figure illustrates the altitude effect on the SAA.

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