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# Extensive atmospheric cosmic-ray-shower simulations in the South Atlantic Magnetic Anomaly for aeronautical applications

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In the last few decades, the development of aircraft with higher maximum cruising altitude and greater autonomy, as well as a significant increase of air traffic, has increased the problem of controlling the ionizing radiation dose level received by pilots, aircrew and aircraft electronics, and has begun to worry radioprotection and flight safety organizations. The study of the effects of atmospheric cosmic radiation on avionics, aircrew and embedded systems detectors requires a detailed description of the radiation field incident on the aircraft, especially neutrons, protons and alphas. Using simulations based on the Monte Carlo codes Geant4 and MCNPX, this work aimed to develop a virtual environment that allows the simulation of the transport of cosmic radiation incident on large and complex systems, such as clouds, aircraft, on ground monitoring stations, embedded detectors, electronic devices of the aircrafts etc., in the atmosphere from ground level up to 100 km, and considering the effects of Earth's magnetic field. In order to do so, the transport of the primary cosmic radiation (PCR) and secondary particles through the atmosphere subjected to the Earth's magnetic field were modeled. Methodologies were also developed to model the primary cosmic source incident in the atmosphere and to obtain the fluence rate and angular distribution of the cosmic-ray-induced particles as a function of altitude. The results obtained from simulations were compared to experimental data taken at ground level and flight altitude, for different geographic regions and dates, evaluating the (adequability) adecuacy of the physics models used to estimate the cosmic radiation transport in the atmosphere for energies above 20 MeV. Analyses were also performed of the influence of the Earth's magnetic field using the Geant4 code as well as simplified analytical calculations, and concluded that their influence starts to be significant for altitudes above 40 km. As a product of this work, a virtual environment was developed that corresponds to a fraction of the terrestrial atmosphere up to 100 km altitude in a region of 50 km in diameter, which describes the fluence, composition, energy spectrum and angular distribution of the cosmic-ray-induced particles in the atmosphere as a function of altitude and space weather variables. This platform models the primary cosmic radiation independently of external software, as the intensity of the PCR can be modulated using neutron counting from an on-ground neutron monitoring station, making the virtual platform standalone.

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