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A Dynamical Atmospheric Ionizing Radiation (AIR) Model for Epidemiological Studies: New Developments

G. DE ANGELIS[1,2,3], J.M. CLEM[4], P. GOLDHAGEN[5], S. BLATTNIG[3], and J.W. WILSON[3]

[1]*Istituto Superiore di Sanita', Rome, I-00161, Italy*
[2]*Old Dominion University, Norfolk VA, 23529, USA*
[3]*NASA Langley Research Center, Hampton VA, 23681, USA*
[4]*Bartol Research Institute, University of Delaware, Newark DE, 19716, USA*
[5]*Environm. Meas. Laboratory, Department of Homeland Security, New York NY, 10014, USA*

A new Atmospheric Ionizing Radiation (AIR) model is in development to compute particle spectra and dosimetric quantities all throughout the Earth's atmosphere for radiation dose evaluation of current aircrew member doses as well as in epidemiological studies targeted to atmospheric flight personnel such as civilian airlines crewmembers. The model will allow computing values for biologically relevant parameters, e.g. dose equivalent and effective dose, for individual flights from 1945. Each flight is described by its actual three-dimensional flight profile, i.e. geographic coordinates and altitudes varying with time. The incoming particles are filtered with a fully angular dependent geomagnetic cut-off rigidity model, as a function of latitude, longitude, arrival direction, altitude and time. The propagation of cosmic rays through the Earth's atmosphere has been calculated using the Monte Carlo transport code FLUKA with several novel auxiliary methods. Solar-modulated primary cosmic ray spectra were determined through an analysis of simultaneous proton and helium measurements made on spacecraft or high-altitude balloon flights, and generated within the rigidity range of 0.5 GV - 20 TV, uniform in $\cos^2\theta$. For a given location, primaries above the effective angle-dependent geomagnetic cut-off rigidity and re-entrant albedo protons are transported through the atmosphere. Helium ions are initially transported with a separate transport code called HEAVY interfacing with FLUKA to provide interaction starting points for each nucleon originating from a helium nucleus. The new FLUKA code with heavy ion transport will be later used in this effort, and some new deterministic transport techniques will be shown. Calculated cosmic-ray neutron spectra and consequent dosimetric quantities for locations with a wide range of altitude and geomagnetic cut-off will be presented and compared to measurements made on high-altitude aircraft and on the ground. Particle fluxes are transformed into dose-related quantities and then integrated all along the flight path to obtain the overall flight dose. Preliminary validations of the particle transport technique, the flight route profile analysis, the epidemiological interface and the new angular dependent geomagnetic cut-off rigidity model will be also described.

Keywords: Radiation; Earth; atmosphere; modeling; technique; aircraft.