UPDATED TIME-DEPENDENT MODELS FOR THE MARS RADIATION ENVIRONMENT.

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Introduction: The radiation protection is one of the two NASA highest concerns priorities [1]. In view of manned missions targeted to Mars [2], for which radiation exposure is one of the greatest challenges [3], it is fundamental to determine particle fluxes and doses at any time and at any location and elevation on and around Mars [4]. With this goal in mind, models of radiation environment induced by Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE) on Mars have been developed [5]. The work is described [6] as models of incoming cosmic ray [7-9] and solar events [5-6] primary particles rescaled for Mars conditions then transported through the atmosphere down to the surface, with topography and backscattering taken into account, then through the subsurface layers, with volatile content and backscattering taken into account, eventually again through the atmosphere, and interacting with some targets described as material layers. The atmosphere structure has been modeled in a time-dependent way [10-11], the atmospheric chemical and isotopic composition over results from Viking Landers [12-13]. The surface topography has been reconstructed with a model based on Mars Orbiter Laser Altimeter (MOLA) data at various scales [14]. Mars regolith has been modeled based on orbiter and lander spacecraft data from which an average composition has been derived [4-6]. The subsurface volatile inventory (e.g. CO_2 ice, H_2O ice), both in regolith and in the seasonal and perennial polar caps, has been modeled vs. location and time [15-16]. Models for both incoming GCR and SPE particles have been rescaled at Mars conditions [4-6]. Preliminary models [4] have been updated and extended to the whole planet [6] and are not any longer limited to the surface.

Results: Particle transport computations were performed with a deterministic (HZETRN) code [17] adapted for planetary surfaces geometry and human body dose evaluations [4]. Fluxes and spectra for most kinds of particles, namely protons, neutrons, alpha particles, heavy ions, pions, muons etc., have been obtained. Neutrons show a much higher energy tail than for any atmosphereless bodies [4]. Results have been obtained for different surface compositions: only at the latitudes closer to the equator the soil is mostly silicatic regolith, whereas for northern or southern locations a suitable mixture, with variable ice concentration with time, of ices of water and carbon dioxide needs to be used [4-6]. Results have been calculated for different locations and atmospheric properties models [4-6]. The results differ from those from other models obtained with different assumptions for the Martian atmosphere and surface structure and composition and computational techniques [18-19]. This model will be soon tested against spacecraft data (e.g. LIULIN-PHOBOS onboard the RKA PHOBOS-GRUNT spacecraft, IRAS onboard the ESA EXOMARS spacecraft).

Conclusions: Models for the radiation environment to be found on the planet Mars have been developed. Primary particles rescaled for Mars conditions are transported through the Martian atmosphere, with temporal properties modeled with variable timescales, down to the surface, and back, with altitude and surface backscattering patterns taken into account. The Mars Radition Environment Model will be tested with the data from spacecraft instruments in the future.

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