

On Investigating the Variation of the Radiation Dose in the Martian SubSurface due to the CO₂ Ice Thickness

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Abstract

The radiation environment at the Martian surface and near sub-surface is strongly dominated by extra-Martian radiation sources. These external sources are in themselves variable and dependant on the solar cycle. To compound this, there is a seasonal dependance on what little shielding the surface is provided by the Martian CO₂ cycle. The variation in the sub-surface radiation dose across seasons due to this cycle and the relation it has to the CO₂ ice thickness has been modelled to give the variation with latitude and depth over time.

1. Introduction

The Martian radiation environment is dominated by space-born radiation such as cosmic rays [1] due to its rarefied atmosphere and lack of global magnetic field. With a surface pressure of approximately 0.6 hpa[2], which is less than 1% of the equivalent value on Earth, the atmosphere itself poses little hindrance to cosmic radiation.

1.1. The CO₂ Cycle

Over the Martian year the already rarefied atmospheric pressure varies dramatically[2]. This variation being caused by the cycles of sublimation and solidification after and during Martian polar winters. The temperatures during the winter periods drop below the freezing point of CO₂ gas, locking away the predominant component of the Martian atmosphere into an ice layer[2][3].

As the atmospheric freezing occurs, what little shielding from cosmic radiation the atmosphere provides will decrease. However, in a polar region's winter, the deposited CO₂ ice on the surface will provide an additional layer of protection.

The formation and propagation of extensive air

showers[4], particle cascades triggered by highly energetic particles travelling through material, is dependent on the density of the local medium. While the atmosphere is much more rarefied during the winter period, the shielding from the CO₂ ice can be much greater than the atmospheric contribution. Therefore the shielding due to the Martian atmosphere and CO₂ ice shielding are both inversely dependant on the local season, but not necessarily in equal measure.

2. Modelling

The effects of seasonal CO₂ ice on the Martian Radiation environment have been modeled using the GEANT4 (GEometry AND Tracking) Simulation Toolkit[5][6][7], utilising data from both the European Mars Climate Database[8] and CREME96[9][10]. Through modeling the Martian surface and atmosphere as a segmented sphere, the total energy deposits produced by the propagation of cosmic ray induced air showers as if during solar minimum have been simulated. The data were collected to analysis the variation with latitude and depth over time with respect to the CO₂ ice layer.

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