Project Details

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Project Title:
Earth-Moon-Mars Radiation Exposure Module (EMMREM)

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Summary:
We are preparing to return humans to the Moon and setting the stage for exploration to Mars and beyond. However, it is unclear if long missions outside of Low-Earth Orbit (LEO) can be accomplished with acceptable risk. The central objective of our project, the Earth-Moon-Mars Radiation Exposure Module (EMMREM), is to develop and validate a numerical module for completely characterizing time-dependent radiation exposure in the Earth-Moon-Mars and Interplanetary space environments. EMMREM provides the ability to predict radiation exposure anywhere on the surface or atmosphere of Earth, on the Moon, Mars, and in interplanetary space between Earth and Mars. EMMREM is designed for broad use by researchers to predict radiation exposure generated by almost any particle distribution incident from interplanetary space. EMMREM is developed using contemporary, state-of-the-art, physics-based particle radiation models. Beyond this, it has the capability to incorporate new models, as they become available, to give continually improved estimates of radiation hazards and effects. EMMREM is comprehensively validated in the environments where risks need to be assessed, using direct and contemporaneous measurements near Earth, at the Moon and Mars to significantly reduce uncertainties in radiation exposure. EMMREM characterizes the extremes, statistics, and variations over time of radiation exposure caused by solar energetic particles and cosmic rays. The results of EMMREM will improve risk assessment models so that future human exploration missions can be adequately planned. This makes EMMREM highly relevant to NASA's Vision for Space Exploration and Living With a Star Programs. EMMREM's highly cross-disciplinary team makes the unprecedented link from particle radiation researchers to radiation biophysics researchers and risk assessment specialists. EMMREM is a powerful tool, urgently needed to reduce uncertainties in risk assessment models. EMMREM is the missing link from Space Science to Space Exploration. EMMREM's central objective is achieved through four primary activities: 1. We develop the central EMMREM module for predicting time- dependent radiation exposure (Linear-Energy-Transfer spectra and dose-related quantities) based on existing, well-established, working codes including the BRYNTRN and HZETRN code developed at NASA Langley and the HETC-HEDS Monte Carlo code developed at Oak Ridge National Laboratory and the University of Tennessee. 2. We develop interfaces between EMMREM and energetic particle simulations using, as a test-bed, sophisticated, physics-based solar energetic particle (SEP) and cosmic ray models. Simulations and associated EMMREM radiation exposure predictions are used to characterize typical, and worst-case event scenarios, and to characterize exposure near-Earth, at the Moon, Mars and throughout the inner heliosphere over the solar cycle. 3. We develop interfaces between EMMREM and direct observations of particle radiation (SoHO, ACE, Wind, STEREO, SAMPEX, NOAA-GOES and Ulysses). The observations are used both to validate SEP and cosmic ray simulations, and as direct input to predict radiation exposure at the Earth, on the Moon, Mars and in interplanetary space environments. 4. We significantly reduce radiation exposure uncertainties through comprehensive validation in the Earth, Moon, Mars and interplanetary space environments. EMMREM is validated with previously measured LET spectra from the International Space Station (ISS) and the Space Shuttle, observations from LRO/CRaTER, MSL/RAD, MARIE on Mars Odyssey, and using an extensive database of Accelerator Beam Measurements.

Publication References:

Summary: no summary

Reference: Kozarev, K. A.; Schwadron, N. A.; Townsend, L. W.; Hatcher, R.; Desai, M.; Al-Dayeh, M.; Squier, R.; (2009), The Earth-Moon-Mars Radiation Environment Module (EMMREM): Framework and Current Developments, SPACE PLASMA PHYSICS: School of Space Plasma Physics. AIP Conference Proceedings, Volume 1121, pp. 164-168, doi: 10.1063/1.3137938

Summary: no summary

Reference:

Schwadron, N. A.; Townsend, L.; Kozarev, K.; Dayeh, M. A.; Cucinotta, F.; Desai, M.; Golightly, M.; Hassler, D.; Hatcher, R.; Kim, M.-Y.; Posner, A.; PourArsalan, M.; Spence, H. E.; Squier, R. K.; (2010), Earth-Moon-Mars Radiation Environment Module framework, Space Weather, Volume 8, Issue 10, CiteID S00E02, doi: 10.1029/2009SW000523