Validation of PREDICCS Using LRO/CRaTER Observations During Three Major Solar Events in 2012.
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Introduction: PREDICCS (Predictions of Radiation from REleASE, EMMREM, and Data Incorporating the CRaTER, COSTEP and other SEP measurements, http://prediccs.sr.unh.edu) is an online system that utilizes data from various satellites in conjunction with numerical models such as the Earth-Moon-Mars Radiation Environment Module (EMMREM) to produce a near-real-time characterization of the radiation environment of the inner heliosphere. PREDICCS offers the community a valuable tool in forecasting events and improving risk assessment models for future space missions, providing up to date predictions for dose rate, dose equivalent rates and particle flux data at Earth, Moon and Mars. We present a comparison between lunar dose rates and accumulated doses predicted by the PREDICCS system with those measured by the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument aboard the Lunar Reconnaissance Orbiter (LRO) spacecraft during three major solar events in 2012 (See Figures 1 and 2) [Joyce et al., submitted, 2012]. We also plot the dose rate measured by the microdosimeter aboard LRO for comparison, as well as additional PREDICCS dose rates for different levels of shielding, which demonstrate how advanced knowledge of events may be used to reduce radiation exposure to astronauts. In addition, we demonstrate a method for computing the modulation potential at the Moon from CRaTER-observed GCR dose rates using a PREDICCS data product based on the Badhwar and O'Neill GCR model [1]. Using this method, we compute the modulation potential throughout the duration of the LRO mission and plot it, along with the GCR dose rate as measured by CRaTER, against the mean sunspot number as measured by the SIDC to show how it varies with the solar cycle (Figure 3).

Results: We find that the dose rates and accumulated doses predicted by PREDICCS and measured by CRaTER during the three solar events are in good agreement and differ by at most 40 percent. From this, we conclude that PREDICCS offers a credible characterization of the lunar radiation environment. This study offers the first long-term validation of radiation models such as EMMREM using in-situ measurements and demonstrates how valuable PREDICCS should become in future efforts in risk assessment and in the study of radiation in the inner heliosphere. This study also demonstrates typical dose rates and accumulated doses associated with large solar events. We also show the long-term evolution of the modulation potential at the Moon calculated using the Badhwar- O'Neill GCR model. These methods may prove to be useful in future studies of GCRs since the modulation potential can be scaled to different locations in the heliosphere [2].

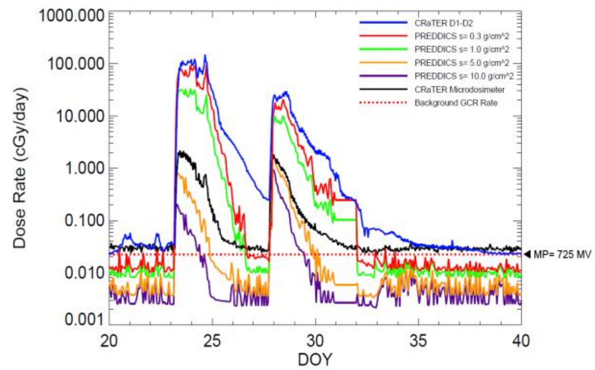

Figure 1: Dose rates measured by CRaTER (blue) vs. those predicted by PREDICCS for various levels of shielding during the January 2012 solar event. The 0.3 g/cm^2 shielded PREDICCS dose rate (red) offers the closest comparison to the level of shielding seen by CRaTER.

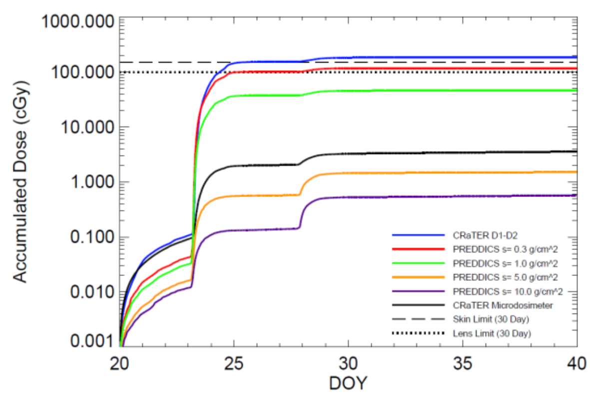

Figure 2: Doses accumulated during January 2012 event for CRaTER and PREDICCS. The dashed and dotted lines indicate the NASA 30-day exposure limits for skin and eye.

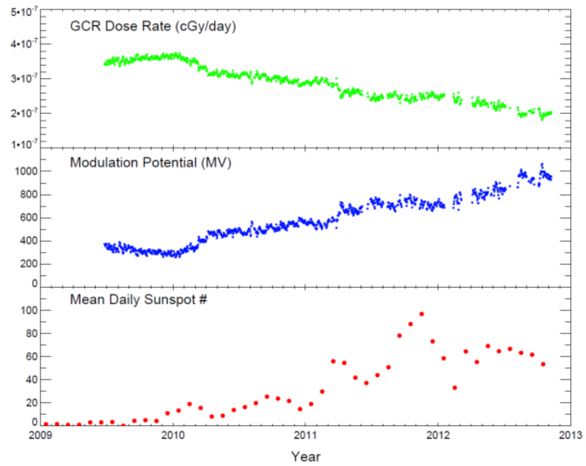

Figure 3: CRaTER-measured GCR dose rate, computed modulation potential and sunspot number during LRO mission.

References: [1] O'Neill P. M. (2006) Adv. Space Res., 37, 1727. [2] Schwadron N. A. (2010) Space Weather, 8, S00E02.