The Lunar Radiation Environment from the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) and from Earth-Moon-Mars Radiation Environment Modules (EMMREM)

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The Cosmic Ray Telescope for the Effects of Radiation (CRaTER) is actively measuring lineal energy transfer by Galactic Cosmic Rays (GCRs) and Solar Energetic Particles (SEPs) on the Lunar Reconnaissance Orbiter (LRO) Mission, which is in a near cirular, polar lunar orbit. Major advances in physics-based numerical models of the coupled Sun-to-Earth system now provide unprecedented opportunities to predict the lunar radiation environment and to compare these predictions with CRaTER observations. The Sun is slowly emerging from a deep and prolonged solar minimum between solar cycles 23 and 24. The Galactic Cosmic Ray (GCR) levels remain at almost the highest levels ever observed during the space age, while activity has just begun to elevate as we observe some of the first Solar Energetic Particle (SEP) events from the this peculiar solar cycle 24. To date, the largest SEP event observed by CRaTER occurred on June 8, 2011 (day-of-year 157). We compare model predictions by the Earth-Moon-Mars Radiation Environment Module (EMMREM) for both dose rates from GCRs and SEPs during the June 8 event with observations from CRaTER. We demonstrate the remarkable agreement between these models and the CRaTER dose rates, which shows the accuracy of EMMREM, and its suitability for a real-time space weather system. We find further that flux levels of GCRs and their associated dose rates were likely at the highest levels in the space age very near the time that CRaTER began taking data. This maximum in GCR dose rate observed by CRaTER in mid-2009 was almost 60% higher than the previous solar maximum GCR dose rate of in 1998 in the solar minimum between cycles 22 and 23. These historic highs in GCR dose rates in the anomalously long and deep solar minimum between cycles 23 and 24 reinforce the fact that the Sun and space environment are experiencing remarkable changes.