Current and Future Observations of Solar Flares for Space Exploration

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There are, on average, one M-class (moderate) solar flare every two days and one X-class (extreme) flare per month as determined from a survey of GOES X-ray flares by Howard Garcia. However, several flares often occur over a period of a few days as associated with a large active region on the Sun. For example, there were 44 M-class flares and 11 X-class flares during the ~2 week period of 18 October 2003 to 5 November 2003. These large flares have a sizeable and immediate effect on the ionosphere and thus can disrupt communications at Earth and Mars. Furthermore, the hardest X-ray radiation from the flares can penetrate a couple millimeters of material and pose a threat to humans in space and can corrupt data from sensitive detectors. The solar (full-disk) irradiance measurements are commonly used for monitoring flare events, and solar imaging of flares, such as from SOHO, TRACE, RHESSI, Solar-B, and SDO, is the more likely avenue in developing forecast tools for flares. The current measurements of the flare X-ray and ultraviolet (full-disk) irradiance include those from GOES, SOHO, TIMED, and SORCE satellites. The GOES solar X-ray observations since 1970s are used as the standard to classify the flares into the various levels of A, B, C, M, and X. The TIMED flare observations are providing full spectral coverage from 0.1 nm to 192 nm but with only 3% duty cycle, and one of their results is that the variations from the large flares are about the same magnitude as the solar cycle variation. In addition, the recent SORCE flare observations indicate that the GOES 0.1-0.8 nm flare irradiance needs to be scaled by a factor of about 100 for the total solar irradiance (TSI) flares; whereas, most earlier estimates for the total flare energy from the GOES measurements are a scaling factor of about 10. New flare irradiance observations are also planned for the future NOAA GOES spacecraft and from the NASA SDO mission with a time cadence of 10 seconds. These Earth-based measurements are designed for Earth (and lunar) space weather research and can be used for about half the year for Mars research and exploration, but a more ideal approach for Mars studies is to make solar measurements at Mars. These current and future flare irradiance observations are presented along with their importance for space weather research and in operations for space exploration.