

Significant solar proton events: solar cycles 19-23

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Solar proton events pose a possible hazard to both man and equipment in space. Of particular concern are those events having a significant fluence at high energies. We now have a solar proton database identifying events where the > 10 MeV flux exceeded 10 protons $(\text{cm}^2\text{-sec-ster})^{-1}$ for the past five solar cycles (i.e. 1954-2006). Using this database we have determined the total solar proton fluence above both 10 and 30 MeV and the number of discrete events that occurred each cycle. We have found the following:

- (1) the number of discrete events in cycles 19-22 (1954-1995) were essentially the same;
- (2) the two solar cycles at the beginning of the space era, cycles 20 and 21 (1965-1985) were relatively benign with respect to solar proton fluence;
- (3) cycles 19 and 22, bracketing solar cycles 20 and 21 were somewhat similar with respect to solar proton fluence, and
- (4) solar cycle 23 (1995-present) has been the most active cycle since 1954.

Our study has also shown that both the number of discrete events and the total fluence can be associated with a relatively small number of solar active regions with each region producing several large events (i.e. sequences of activity). This is particularly true with solar cosmic ray events (GLEs). Of the 69 GLEs between 1942 and 2006, 15 active regions have been associated with 36 individual relativistic solar proton increases. We have also found that the emissions from some of these very productive regions are somewhat consistent from event to event. Recent studies of historic events, particularly the geophysical phenomena from late August to early September 1859 (i.e. the Carrington event period) indicate that these sequences of activity have occurred in the distant past. The ability to identify unique characteristics associated with these solar regions would be beneficial for future exploration of space.