Description of SStoRM v1

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1 Introduction

SStorm stands for the Solar STOrm Radiation Model. SStoRM lets you create and analyze solar particle events (SPEs).

2 Create the SPE

2.1 The "Energy Spectrum" Tab

To create your SPE, you must first select the energy spectrum, or fluence, of the event. The fluence of an SPE is a frequency distribution of the number of $protons/cm^2 MeV$ as a function of energy. For this program, fluence is defined by the following exponential curve:

$$Fluence(E) = K * E^{-\gamma} e^{-\frac{E}{Eo}}.$$

The energy spectrum can be set by going to the energy spectrum tab and setting K, γ, and E_0. SStoRM gives you the option of choosing any set parameters for your SPE so long as:

- γ is between 0 and 4.125.
- E_0 is between 10 and 500.
- K is larger then 0.
- E_{min} is at least 10 MeV.

Once parameters for K, γ, and E_0 are selected, you can press the calculate button to see a graph of your energy spectrum. Along with your event, the graph shows integral fluences for several historically observed SPEs.

The integral fluence is defined as:

$$\Phi_{E_{min}} = \int_{E_{min}}^{\infty} K E^{-\gamma} e^{-\frac{E}{E_0}} \, dE.$$

The integral fluence, $\Phi_{E_{min}}$, is the total number of $protons/cm^2$ during the entire event with an energy value above E_{min}. SStoRM calculates the integral fluence of all the graphed events and shows them in descending order.

Furthermore, if you know the spectral shape of your SPE (γ and E_0) and you also know the total number of protons (the integral fluence), you may instead of defining K define the integral fluence. To do this, all you have to do is click on the integral fluence value label and put in the value you want. When you hit calculate, K will be calculated automatically to match your integral fluence.

2.2 The "Time Evolution" Tab

Once you are happy with the fluence of your SPE, you can then define the flux, or time evolution, of your event. The flux of an SPE is a curve of total number of particles as a function of time, or how the SPE behaves as it progresses. For this application, fluence is defined with the following curve:

$$Flux = C\left(\frac{t}{A}\right)^{B_1} e^{-(\frac{t}{A})^{B2}} + 0.11$$

Here, 0.11 roughly represents the Galactic Cosmic Ray background radiation. It is used for display purposes only and is not used in any calculations. Similar to defining the fluence, you can define the flux of your event by selecting values for A, B_1, and B_2. You cannot set the value of C. C is instead calculated so that the Φ_{10} equals the integral time evolution flux. This is because both integrals equal the total number of $particles/cm^2$ (with energy above 10 MeV). C is therefore calculated using the formula:

$$C = \frac{\Phi_{10}}{\int_0^{\infty} (\frac{t}{A})^{B_1} e^{-(\frac{t}{A})^{B2}} \, dt \times 4\pi 3600 \times 24}.$$

This equation includes $4 * \pi$ and $3600 * 24$ to correct for 4π steradians in a sphere and $3600 * 24$ seconds in a day. This C is used in the graph on this page. It helps show the shape and relative size of your event in comparison to other historically recorded events. If you are unhappy with the intensity of the event, you can go back to the energy spectrum tab and change K or the integral flux to a desired level.

3 Analyze your SPE

3.1 The "Estimated Dose" Tab

Once you are happy with both the fluence and flux of your event, you can move on to analyze it. The estimated dose tab presents you with a table and graph of radiation doses.

These doses represent total event doses under various thickness equivalents to several parts of the body. Radiation doses are given under an aluminum shielding thickness of 0.3, 1, 5, 10, and 30 g/cm^2. Doses are given to the skin, ocular lens (eye), and bone marrow (BFO). These values were calculated with the BRYNTRN space transport program developed at NASA Langly Research Center. Radiation doses can be given in absorbed dose (in units of cGy) or dose equivalent (in units of cSv). Radiation doses can be given in free space or on the lunar surface. Doses on the lunar surface are assumed to be exactly one half of doses in free space.

3.2 The "Exercise" Tab

Once you have finished examining total doses for the event, you can try a lunar simulation. The simulation is this; an astronaut is on the moon during an SPE. He is warned that an SPE is going to happen a certain period of time before (or after) the event begins.He then packs up and enters the rover. He drives back to the base in a lightly shielded rover and he stays in the base until the end of the event. Given the information provided about the energy spectrum and time evolution of your SPE, it is possible to determine the radiation dose that this astronaut would receive, and to compare this dose to the dose of an astronaut who stayed in the base throughout the event.

To run this exercise, you must input 3 periods of time: the amount of time given to the astronaut before the event begins, the amount of time it takes him to pack up and enter the rover, and the amount of time it takes him to drive back to the base. You must also specify whether the units are in minutes or hours. You also need to select whether you want to examine dose to the skin, eye, or BFO. The buttons for selecting absorbed dose or dose equivalent from the last tab will be used to decide which type of radiation dose is used. A negative value for the amount of time before the event begins means that the astronaut is warned about the event that long after the event starts.

Once these values are entered, you can hit the calculate button. The program determines the total dose that the astronaut would receive and presents you with a graph of cumulative radiation dose as a function of time. Biological radiation limits are added to the graph if the numbers are BFO absorbed dose and legislated limits are added to the graph if the numbers are BFO dose equivalent.

3.3 The "Set Up" Button

You can also change the assumed thicknesses that the astronaut is under during the simulation by clicking on the set up button. It is assumed by default that the astronaut's space suit's thickness is $0.3g/cm^2$, the rover's thickness is $5g/cm^2$, and the base's thickness is $30g/cm^2$. This can be changed by clicking on the set up button. When you click on the set up button, you are allowed to change the thickness used during different stages of the event. This allows you a very large degree of customization in the nature of both the event and the simulation.