Interplanetary Proton Cumulative Fluence Model Update

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Contents

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  – Model description

• Data
  – Calibration
  – >30MeV, >60MeV

• Results

• Conclusions and future work
Engineering requirements

• Integrated proton fluence over time period (months to years) at given energy

• Frequency of occurrence of particle flux above given value over time period (seconds to years) at given energy, given ion mass.

• Function of location (geo- and interplanetary space)

• Function of time (minutes to years).

• This study: update of existing model to predict integrated fluence for a given period
Aim of the study

• Prelude to SEPEM study & in line with engineering support role at ESA
  – Generate an update of existing model for solar interplanetary cumulative fluence
  – Model of the underlying probability distribution
  – Builds on the work of Feynman et al. 1985, 1991 and Rosenqvist et al. 2005

• Compare distribution of event fluences to lognormal distributions
  – Noting that the real distribution is not entirely log-normal since excess of points at low values.
  – Consequently apply fit to upper half of dataset only
  – Accumulated fluence dominated by large events for a given mission, so assumption valid.
    ➔ plots and parameters (tabulated)
Method

- Following the approach of Feynman et al. JPL-85&91
- Probability that mission fluence will exceed a certain value based on combined consideration of:
  - Distribution of SEP fluences
  - Probability of occurrence of an event

- Normal distribution used to describe the $\log_{10}$ of individual fluences
- Poisson distribution gives probability of $n$ events occurring in time $t$
- Solution via Monte Carlo simulation
- Solar cycle divided into active and inactive years as per Feynman et al.
Definition of Event

- Sensitive to:
  - Event selection criteria (flux/fluence thresholds, multiple events)
  - Identification of high activity part of cycle
  - Parameter fitting to event distribution
  - Calibration of different datasets
  - Data gaps and/or spikes
- Adopted same thresholds used by JPL-91

(Table adapted from Feynman et al. 1993)

<table>
<thead>
<tr>
<th>Proton Energy Range</th>
<th>Flux Threshold ($\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$)</th>
<th>$\Phi_{\text{min}}$ ($\text{cm}^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;10\text{MeV}$</td>
<td>1</td>
<td>$1.0 \times 10^7$</td>
</tr>
<tr>
<td>$&gt;30\text{MeV}$</td>
<td>1</td>
<td>$1.0 \times 10^6$</td>
</tr>
<tr>
<td>$&gt;60\text{MeV}$</td>
<td>1</td>
<td>$1.0 \times 10^6$</td>
</tr>
</tbody>
</table>
Availability of Data

Data coverage

GOES-10
GOES-8
GOES-7
GOES-6
IMP-8/CPME
IMP-8/GME

Feynman et al., [1993]
Feynman et al., [1990]

YEAR
Intercalibration of Datasets

Rosenqvist et al (2005) extended dataset to include data up to 2002. Intercalibration on basis of event fluence illustrated best match between GME, GOES7 and GOES8

Generates complete dataset from 1974: 2002
Model based on GME, GOES-7 and GOES-8, >10MeV
Extending model to $>30\text{MeV}$

- Best match found between GME and GOES-8 events
- Adjustment needed to merge datasets

Adjust Parameters: $l=0.024$ & $d=1.031$
log-normal distribution $>30\text{MeV}$

> 30 MeV H$^+$ — Proton Fluence Distribution
IMP8–GME & GOES8

- JPL–91 *Feynman et al.*, [1993]
- IMP8–GME & GOES8 best fit
  - Standard deviation ($\sigma$) = 1.20
  - Mean Fluence ($\mu$) = 7.42
  - Event rate ($\nu$) = 5.40
Results:
GME adjusted to GOES8

Combined dataset predicts Higher fluences for mission Lengths of 1, 2, 3, 5 and 7yrs.

GME dataset alone plotted for Comparison gives closer but Slightly lower values than JPL91

GME:GOES-8: $\mu=7.42$, $s=1.2$, $w=5.4$
JPL91: $\mu=7.00$, $s=1.10$, $w=7.22$
Results >60MeV?

• Too few events to calibrate data on the basis of event fluence.
• Correction made on the basis of flux values.
• Work ongoing…
Conclusions and next steps

- Results show higher fluence values than JPL91 at >30MeV with inclusion of GOES8 data in model
- Cumulative fluence higher for >10MeV and >30MeV fluences
- Small number of events necessitates different calibration approach from >60MeV data
- Calibration of datasets crucial in gaining accurate results.
- Next steps: include most recent GOES data in particular for higher energies & investigate performance of GME detectors over lifetime.
- SEPEM study recently started to look at developing new SEP models & investigate issue of heliocentric dependence.