Summary for Session #19
SEP Modeling Challenge: Research to Operations

Organized by Katie Whitman and Ian Richardson
Thursday August 8, 2019
Session Focus and Discussion

• Brought together SEP modelers, observers, NASA space radiation operators, and NOAA space weather forecasters

• Discussed:
  - What is needed from SEP models to support human space exploration? A variety of models desired to support operational needs.
  - Need for All Clear models to predict yes/no SEP event in next 24 hours.
  - Details around determining skill of forecasters and prediction efficiency. Exactly what do you count as hit or miss? How do you define an event?
  - No operational coronagraph with high cadence and low latency causes forecasters to “fly blind”. Can be 6+ hours after CME before data arrives.
  - Nearly all physics-based time profile models suffer from unknown seed population and solar wind models that start 20 Rsun from the solar corona.
### Contributing Models and Speakers

**Scene Setters:** Phil Quinn (NASA JSC SRAG) and Hazel Bain (CU Boulder CIRES/NOAA SWPC)

<table>
<thead>
<tr>
<th>Model</th>
<th>Author</th>
<th>Model Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENLIL+SEPMOD</td>
<td>Luhmann, Lee (Berkeley)</td>
<td>Physics-based: Time Profile</td>
</tr>
<tr>
<td>AFRL PPS and ADEPT</td>
<td>White, Kahler (AFRL)</td>
<td>Empirical: Onset, Peak Flux, Time profile</td>
</tr>
<tr>
<td>ENLIL+EPREM</td>
<td>Schwadron, Poduval (UNH)</td>
<td>Physics-based: Time Profile</td>
</tr>
<tr>
<td>STAT (MAS + EPREM)</td>
<td>Linker (PSI)</td>
<td>Physics-based: Time Profile</td>
</tr>
<tr>
<td>iPATH</td>
<td>Li (UAH)</td>
<td>Physics-based: Time Profile</td>
</tr>
<tr>
<td>SEPSTER</td>
<td>Richardson (U Maryland, GSFC)</td>
<td>Empirical: Peak Flux</td>
</tr>
<tr>
<td>UMASEP</td>
<td>Núñez (University of Malaga)</td>
<td>Empirical: Onset flux profile over 7 – 11 hours</td>
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<tr>
<td>ESPERTA</td>
<td>Laurenza (INAF)</td>
<td>Empirical: SEP Storm Class (≥S1, ≥S2)</td>
</tr>
<tr>
<td>SEP Electron Transport</td>
<td>Du Toit Strauss (NWU)</td>
<td>Physics-based, Poster</td>
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Operational Thresholds and Actions for Crew Safety During EVAs

Solar Proton Event (SPE)

- Defined by GOES measurements when
  \[ \geq 10 \text{ MeV protons} \geq 10 \text{ pfu}. \]
- Important during EVAs where crew is outside of spacecraft shielding.
- SRAG console operator predicts dose based on GOES proton flux and spacecraft location then gives a recommendation to Surgeon.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Upcoming EVA</th>
<th>EVA in Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Dose &lt; Action Level</td>
<td>Delay up to 2 days</td>
<td>Continue but do not add tasks</td>
</tr>
<tr>
<td>Predicted Dose &gt; Action Level</td>
<td>Delay up to 14 days</td>
<td>Continue and expedite tasks</td>
</tr>
<tr>
<td>Predicted Dose Rate &gt; High Dose Rate Limits</td>
<td>Reschedule</td>
<td>Expedite by deleting tasks</td>
</tr>
<tr>
<td>Predicted Dose &gt; Joint Exposure Limits</td>
<td>Reschedule</td>
<td>Terminate</td>
</tr>
</tbody>
</table>

Source: Phil Quinn (NASA JSC SRAG)
Operational Thresholds and Actions for Crew Safety During IVAs

Energetic Solar Proton Event (ESPE)

- Defined by GOES measurements when $\geq 100$ MeV protons $\geq 1$ pfu.
- Important during IVAs since higher energy protons can penetrate the lower shielded areas of the spacecraft.
- If threshold is crossed, SRAG console operator alerts the FCT.
- SRAG console operators remains on console for the entire event duration.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 100$ MeV protons $\geq 1$ pfu</td>
<td>Inform crew to avoid lower shielded areas</td>
</tr>
<tr>
<td>$\geq 100$ MeV protons $\geq 100$ pfu</td>
<td>Inform crew to stay in higher shielded areas</td>
</tr>
</tbody>
</table>

Source: Phil Quinn (NASA JSC SRAG)
Future SEP Forecasting Requirements

When?
Increase forecast lead time. Particularly for prompt events.

How big?
Improved forecasts of peak intensity.

How long?
Event duration

Time
Intensity profiles

Low False Alarm Rate

Forecast issued 30 mins – 3 hrs after onset

>C 10 MeV
>C 100 MeV
>C 500 MeV

Courtesy: Hazel Bain (CU Boulder CIRES/NOAA SWPC)
May 17, 2012 Predictions – Preliminary Results

SHINE 2019

>10 MeV Flux Profile

ENLIL+ SEPMOD
2.5 hour resolution

Operational threshold
Data Model

ENLIL+ SEPMOD
6 hour resolution

>100 MeV Flux Profile

ENLIL+ SEPMOD
2.5 hour resolution

ENLIL+ SEPMOD
6 hour resolution

ENLIL+ EPREM
6 hour resolution
Peak Flux Data – Model Comparison
May 17, 2012

>10 MeV Peak Flux

>100 MeV Peak Flux
Session Discussion:
Have to do better than choosing a single magnetic field line.