Scoreboard

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Planning for the SEP Scoreboard started in 2016 (led by BIRA-IASB, GSFC, UK Met Office)

Builds upon the flare scoreboard and CME arrival time scoreboard

Automated system; model developers can routinely upload their predictions to an anonymous ftp. Forecast data will be parsed and stored in a database which is accessible to anyone via an API

SEP forecasts can be roughly divided into three categories:

- Continuous/Probabilistic
- Solar Event Triggered
- Non Near Real-Time

The SEP scoreboard will focus on real-time forecasts (first and second categories) and will collect: proton intensity profile, threshold crossing probability, onset time, and duration.

The SEP scoreboard is part of the ISWAT SEP Validation Team that also focuses historical comparisons, particularly for those physics-based models in the third category that are not ready or relevant for real-time modeling.

https://ccmc.gsfc.nasa.gov/challenges/sep.php
Flare:
AFRL PPS
COMSESEP SEPForecast (BIRA)
FORSPEF (NOA)
SPARX (Dalla, Marsh)

CME:
SEPSTER (Richardson)
St. Cyr (Mauna Loa CME)

Flare and CME:
COMSESEP SEPForecast
FORSPEF (NOA)
SOLPENCO (Arans)

Flare and proton intensity:
UMASEP (Núñez)
Bouhrahimi model

Electron intensity:
HESPERIA REleASE

Flare, Radio, H-alpha:
SWPC PPM

Flare, Radio:
ESPERTA (Laurenza)

Radio:
AER SEP Model (Winter)
In 2018 CCMC started a 3 year project (ISEP) with NASA Space Radiation Analysis Group to **transition 6 research Solar Energetic Particle models to operations**: including MAG4, UMASEP, RELeASE, SEPSTER, SEPMOD, STAT

These **models were chosen by SRAG** based on their operational requirements including

- Can it run in real-time?
- Is the input data available in near real-time?
- Some degree of documented performance

Models transitioned, and **SEP Scoreboard displays** built by CCMC will be used operationally by SRAG for human missions beyond LEO starting in 2022.
For different energy ranges/thresholds models may forecast:

- Continuous probability timeseries of threshold crossing
- Continuous intensity timeseries
- Peak intensity for event
- Peak intensity with the next x hours
- and others

SEP Scoreboard Goals

- Uniform JSON input format and scoreboard displays so multiple models can be viewed and compared together
- Displays should be easy for space weather operators to understand and take action on, but contain all necessary information

SEP Forecast Types

For different energy ranges/thresholds models may forecast:

- Continuous probability timeseries of threshold crossing
- Continuous intensity timeseries
- Peak intensity for event
- Peak intensity with the next x hours
- and others
Proton Energy Range Predictions by Model

- **MAG4**: >10 MeV
- **REleASE**: 15.8–39.8 MeV, 28.2–50.1 MeV
- **SEPSTER** (Richardson):
  - 14-24 MeV; expanded to >10 MeV and >100 MeV by proxy
- **SEPMOD**: 10-100 MeV; expanded to 1 GeV
  - custom differential/integral channels possible
- **STAT**: 1-2 GeV
  - custom differential/integral channels possible
  - including >10 MeV, > 50MeV, >100 MeV
- **UMASEP**: >10 MeV, >100 MeV, >500 MeV
Display will be built for multiple forecast types/stages

- **(A)** probability heat map and time series (MAG4, SWPC)
- **(B)** peak intensity heat map (SEPSTER, UMASEP, REleASE, SEPMOD)
  - SEPSTER peak intensity is for entire event not including ESP
  - UMASEP peak intensity is for the next 1, 3, 7 hours
  - REleASE peak intensity is for next 30, 60, 90 min; derive from the timeseries
  - SEPMOD peak derived from the timeseries
- **(C)** intensity time series (REleASE, SEPMOD, UMASEP, STAT) – coming in 2020
  - REleASE time series: next 30, 60, 90 min
  - UMASEP timeseries: next 1, 3, 7 hours
  - SEPMOD timeseries: next 7 days
- **(D)** all-clear forecast time series: MAG4, UMASEP, REleASE, SEPSTER, SEPMOD, STAT – coming in 2021
Demo Screenshots
Demo – simulated real-time mode (mock-up):

2017-09-03 12:00 UT Probability heat map and time series
Demo: all clear display
Demo – historical mode:
2017-09-03 12:00 UT

red line: S1 event onset
(>10 MeV first exceeds 10 pfu)

gray shading: S1 event
(>10 MeV exceeds 10 pfu)
Demo: 2017-09-04 14:00 UT
Demo – historical mode: 2017-09-04 14:00 UT
Demo – historical mode: 2017-09-04 14:00 UT

Hover feature shows value, issue time, prediction window length
Demo – historical mode: 2017-09-04 14:00 UT

uncertainty shown as y error bars
Demo – historical mode: 2017-09-04 14:00 UT

Model family feature: uses same symbol for all model variations
Demo:
2017-09-05 03:00 UT
**SEP Scoreboard**

**Proton Probability Forecasts:**
2017-09-05 03:00 UT

- **MAG4_HARP**
  - Probability of Crossing Threshold (%): 11.0
  - > 10 MeV: No Data
  - > 100 MeV: No Data

- **MAG4_HARP_HMI**
  - Probability of Crossing Threshold (%): 12.0
  - > 10 MeV: No Data
  - > 100 MeV: No Data

- **MAG4_LOS_d**
  - Probability of Crossing Threshold (%): 7.0
  - > 10 MeV: No Data
  - > 100 MeV: No Data

- **SWPC Day 1**
  - Probability of Crossing Threshold (%): 10.0
  - > 10 MeV: No Data
  - > 100 MeV: No Data

**Proton All Clear Forecasts:**
2017-09-05 03:00 UT

- **MAG4_HARP**
  - Not Clear
  - No Data

- **MAG4_HARP_HMI**
  - Not Clear
  - No Data

- **MAG4_LOS_d**
  - Not Clear
  - No Data

- **SWPC Day 1**
  - Not Clear
  - No Data

Legend:
- Green: All Clear
- Purple: Not All Clear
- Gray: No Data
Demo:
2017-09-06 00:00 UT
Demo:
2019-10-01 00:00 UT
Demo:
Peak Intensity heat map on 2017-09-04, 09-05, 09-06

Proton Peak Intensity Forecasts:

2017-09-04
20:35 UT

SEPSTER
STAT
UMASEP

Clear
No data

Clear
No data

29 ± 6

Proton Peak Intensity Forecasts:

2017-09-05
00:00 UT

SEPSTER
STAT
UMASEP

No data
No data

No data
No data

Proton Peak Intensity Forecasts:

2017-09-06
15:00 UT

SEPSTER
STAT
UMASEP

No data
No data

No data
Not Clear

2 ± 0
JSON model output schema

• Initial JSON schema developed by Mark Dierckxsens
• Continued to iterate with SRAG and model developer community to define JSON file format
• Schema covers every known SEP model in the community (for scoreboard display purposes)
• Scoreboard database design is based on the schema
• Provided detailed examples, python helper script to write out the format, script documentation, and visual schema:
  https://ccmc.gsfc.nasa.gov/challenges/sep.php#format
• Email us to get help putting your model output into the required format.
Planned SEP Scoreboard Connections

**Flare Scoreboard**

**DONKI:** CCMC’s real-time SW Event Catalog

**CME Scoreboard**
ISWAT SEP Validation Team

Team Leads: K. Whitman, P. Quinn, H. Bain, I.G. Richardson, M.L. Mays
Scoreboard Leads: M. Dierckxsens, M.L. Mays

- Began in 2017 as the “SEP Working Team”; now part of ISWAT
- Conducted 3 community campaign sessions: SHINE 2018-2019, and ESWW 2018
- Bring together SEP modelers, observers, operators and forecasters
- Inform research community operational needs
- Compare model results for operationally relevant information for 3 SEP events
- Contact us to get involved: https://www.iswat-cospar.org/h3-01

Preliminary comparisons of integral intensity time series for 5 different models for the September 2017 event (SHINE 2019 campaign)
Summary: SEP Scoreboard

- Six models are being added to the scoreboard as part of a project with NASA Space Radiation Analysis Group; all models are welcome.
- The Scoreboard displays will be available publicly on the web early in 2020: probability time series and heat map, and peak intensity heat map
- The SEP Validation Team has performed preliminary validation for 3 historical events as part of SHINE 2018-2019 and ESWW 2018 community campaigns
- Everyone in the community is welcome to participate!
  - Models that run in real-time: provide model outputs to the scoreboard via ftp
  - Models that run in historical mode/for science studies: provide results and participate in the SEP Validation Team activities

https://ccmc.gsfc.nasa.gov/challenges/sep.php
Extra slides
Schema contains necessary details!