CCMC Validation and R2O transition tools: ISWA, CAMEL and Scoreboards

M. Leila Mays, Joycelyn Jones & CCMC Team

9 June 2022

CCMC Workshop 2022

Validation at CCMC: Evaluating Model Performance

- Benchmarks current model performance. Traces progress over time.
- Validation to improve scientific understanding
  - Science-based metrics
  - CCMC leadership in community challenges/campaigns at GEM, CEDAR, SHINE, ISWAT
- Validation to determine R2O transition suitability
  - Operationally relevant metrics to test forecast value
  - CCMC validation collaborations with SWPC (ENLIL, SWMF, WSA, ADAPT)
- What to validate: focus on Essential Space Environment Quantities (ESEQs)
  - Linked to impacts or passed between domains
  - Derived from observational data and model outputs
  - Track the metrics of the ESEQs over time.
  - Use ESEQs to create benchmarks, multi-model comparisons, scorecards.

Modes:

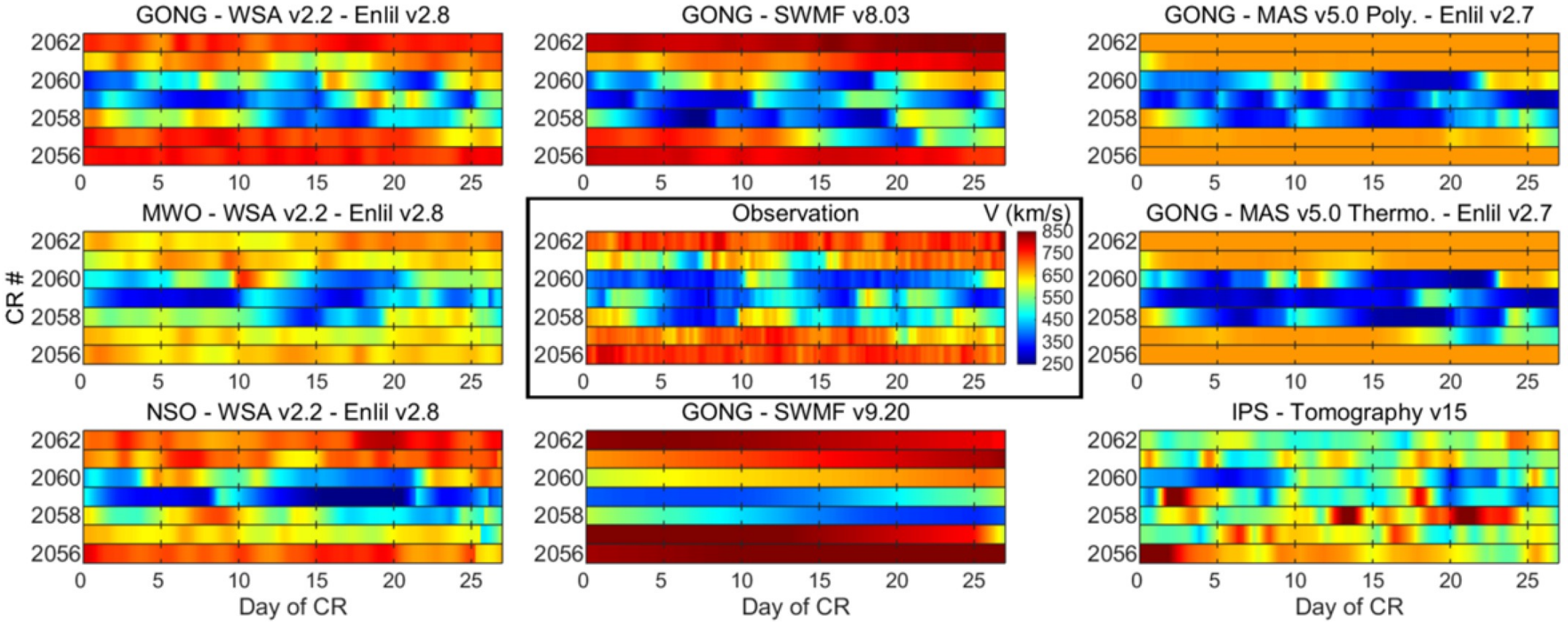
- Historical validation of historical model runs
- Historical validation of real-time forecasts (CCMC community scoreboards)
- Simulated (as-if) real-time forecast validation
- Real-time forecast validation

Validation: Important Elements

- Community involvement and coordination, including operations
  - Community agreement on metrics selection and validation approach
  - Community definition of Essential Space Environment Quantities
  - COSPAR ISWAT teams
- Preparation of observations and their uncertainties
  - Involving data experts on validation teams
  - Some observations are actually techniques/models themselves
- Care in comparing models
  - Validation studies with different designs cannot be directly compared
- Transparency and collaboration in validation studies
  - Providing data and necessary details – how were forecasts were constructed? How was validation performed?
  - CCMC CAMEL tool

Example: Validation Study using CCMC Runs-on-Request

Jian et al. (2015) *Space Weather:* solar wind speed at Ulysses

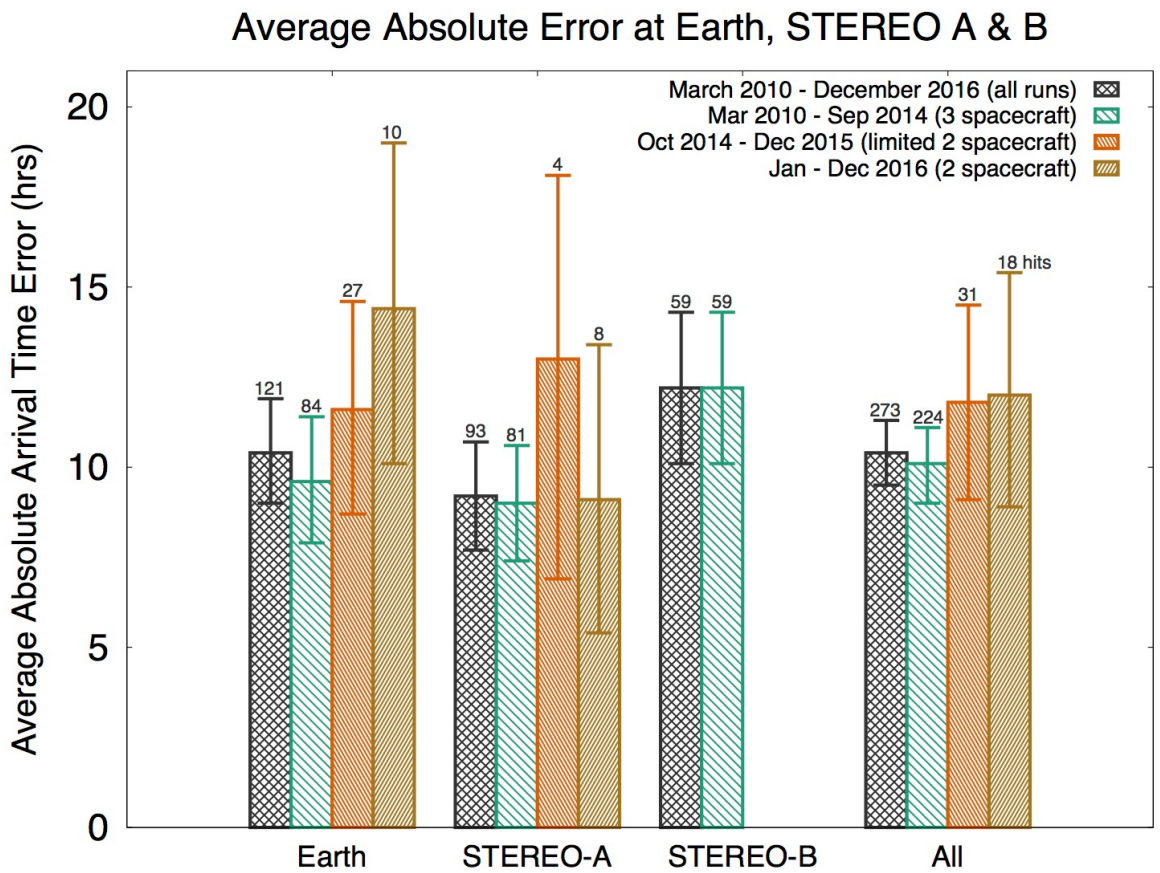


Examples: Validation Studies of CME Arrival Time Error using:

CCMC Real-Time Runs

Wold et al. (2018) *JSWSC*, for WSA-ENLIL+Cone:

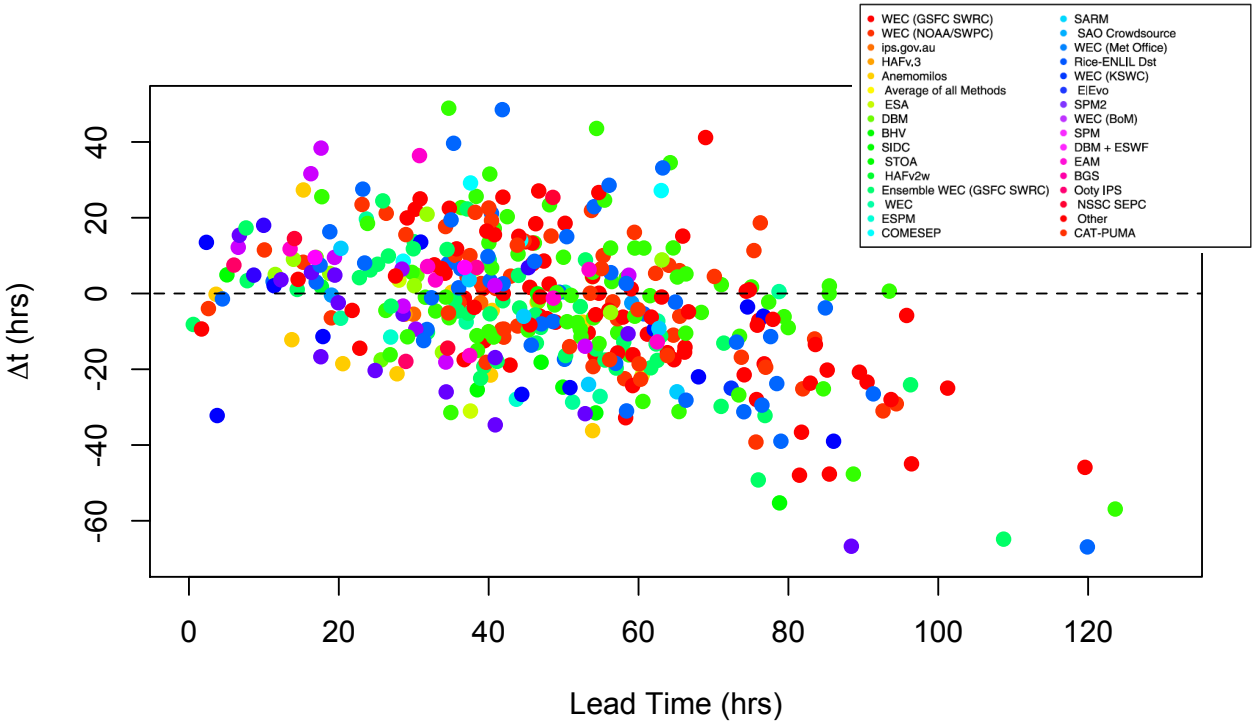
- 10.4 ± 0.9 hours error
- 1.7 hour error increase with single coronagraph



CCMC Scoreboards

Riley et al. (2018) *Space Weather*:

- First comprehensive analysis of CME scoreboard data
- 13 hours error (scoreboard average)
- ±20 hours standard deviation



Community Challenges

https://ccmc.gsfc.nasa.gov/challenges/

Solar / Heliosphere

SHINE/ISWAT/ESWW SEP Model Validation Challenge

2018 - Present

SHINE Challenge

2011 - 2014

Magnetosphere

GEM ULF Wave Modeling Challenge

2014 - 2019

GEM Dayside Kinetics Challenge

2016

GEM Mid-Tail Modeling Challenge

2014 - 2016

GEM Magnetopause Challenge

2008, 2015

GEM Global Magnetosphere Metrics Challenge

2008 - 2010

GEM Baseline Model Comparison Challenge

2009

Ionosphere

CEDAR GRAND Challenge SAPS Focus Study

2016 - 2017

CEDAR Electrodynamics Thermosphere Ionosphere (CETI) Challenge

2009 - 2014

CEDAR GRAND Challenge Problems Related to Ionospheric Models and Observations

2011 - 2014

Ionosphere / Magnetosphere

GEM-CEDAR Modeling Challenge

2014 - 2017

GEM-CEDAR Ionospheric Conductance Challenge

2016

Coordinated Community Effort:

International Forum on Space Weather Capabilities Assessment

SOLAR
CCMC facilitator(s): P. Macneice

- Solar Flare Prediction (Leads: S. Murray, M. Georgoulis, S. Bloomfield, K.D. Leka
  Scoreboard Leads: S. Murray, M.L Mays) SSA-0,SSA-6
- Coronal & Solar Wind Structure
  Coronal & SW Structure; Ambient SW; Coronal Hole Boundaries
  (Leads: P. Macneice, L. Jian) SSA-?
- 3D CME kinematics and topology (Leads: B.Thompson, C.Moestl, D.Barnes)
- Solar Indices and Irradiance (Leads: J. Klenzing, C. Henney, K. Muglach) SSA-0

GEOSPACE: Geomagnetic Environment
CCMC facilitator(s): L.Rastaetter

- Ground Magnetic Perturbations: dBdt, delta-B, GICs, FACs
  (Leads: D. Welling, H. Opgenoorth, C. Ngwira) SSA-1
- Geomagnetic Indices (Leads: M. Liemohn) SSA-1
- Magnetopause location and geosync. orbit crossing
  (Leads: Y. Collado-Vega, S. Merkin) SSA-1

HELIOSPHERE
CCMC facilitator(s): M.L. Mays, A. Taktakishvili, P. Macneice

- CME Arrival Time (Leads: C. Verbeke, M.L. Mays, A. Taktakishvili) SSA-1
- IMF Bz at L1 (Leads: N. Savani, P. Riley) SSA-1
- SEPs (Leads: I.G. Richardson. P. Quinn, M. Marsh, M.L. Mays
  Scoreboard Leads: M. Dierckxsens, M. Marsh) SSA-3,SSA-6

GEOSPACE: Auroral Region
CCMC facilitator(s): M.Kuznetsova

- Auroral precipitation and high latitude i
  (Leads: R. Robinson, Y. Zhang, B. Kosar)

RADIATION and PLASMA EFFECTS Scope of work
CCMC facilitator(s): Y. Zheng, M. Kuznetsova

- Surface Charging *few eV - keV electrons, plasma density*
  (Leads: J. Minow, D. Pitchford, N. Ganushkina) SSA-6
- Internal Charging *keV–MeV electrons*
  (Leads: P. O'Brien, Y. Shprits) SSA-6
- Single Event Effects *MeV–GeV-TeV protons, ions*
  (Leads: M. Xapsos, J. Mazur, P. Jiggens) SSA-3,SSA-6
- Total Ionizing Dose *keV–MeV electrons, keV–GeV protons,ions*
  (Leads: I. Jun, T. Guild, M. Xapsos) SSA-6
- Radiation effects for aviation (Leads: K. Tobiska, M. Meier) SSA-6

IONOSPHERE
CCMC facilitator(s): J. Shim, M. Kuznetsova

- Neutral Density and Orbit Determination at LEO
  (Leads: S. Solomon, T. Fuller-Rowell, S. Bruinsma, E. Sutton) SSA-2
- Global & Regional TEC (Leads: L. Scherliess, R. Calfas) SSA-4
- Ionosphere Plasma Density: NmF2/foF2, hmF2, TEC
  (Leads: I. Tsagouri, M. Angling, J. Shim) SSA-5
- Ionosphere Scintillation (Leads: E. Yizengaw) SSA-5

Forum working teams focused on different **evaluation topics**.

Cross-team interactions.

The COSPAR ISWAT initiative is a global hub for collaborations addressing challenges across the field of space weather.

S: Space weather origins at the Sun	H: Heliosphere variability	G: Coupled geospace system	Impacts
S1: Long-term solar variability	H1: Heliospheric magnetic field and solar wind	G1: Geomagnetic environment	Climate
S2: Ambient solar magnetic field, heating and spectral irradiance	H2: CME structure, evolution and propagation through heliosphere	G2a: Atmosphere variability	Electric power systems/GICs
S3: Solar eruptions	H3: Radiation environment in heliosphere	G2b: Ionosphere variability	Satellite/debris drag
	H4: Space weather at other planets/planetary bodies	G3: Near-Earth radiation and plasma environment	Navigation/ Communications
			(Aero)space assets functions
			Human Exploration

Overarching Activities:
Assessment Information Architecture Data Utilization Education/Outreach

Each Cluster has at least one team on predictive capabilities assessment with CCMC involvement

Game-Changing Partnerships

Utilizing Shared Proving Grounds

- NASA/CCMC-NOAA/SWPC on R2O2R transition pipeline
  - Utilized shared cloud environment to promote secure and convenient collaboration between operational and research teams.
  - Initially set up to mirror the operational environment as closely as possible.
  - Ongoing project: Implementation and Evaluation of Modeling Suite for ICAO
  - Bi-weekly tag-ups

T. Tsui, C. Didigu

- NASA CCMC-SRAG on Integrated Solar Energetic Proton (ISEP) project
  - Identify and evaluate new models
  - Develop tailored ISEP Alert/Warning Scoreboard Software
  - Implement these capabilities within CCMC as a non-operational prototype
  - Transition capabilities to M2M office for prototyping by M2M analysts and support of NASA SRAG (NASA in-house R2O2R pipeline)
  - CCMC and SRAG work as one team, weekly tag-ups, coordinated hiring

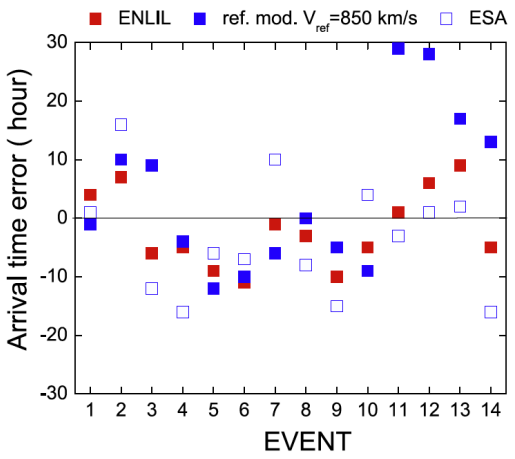
L. Mays, J. Jones

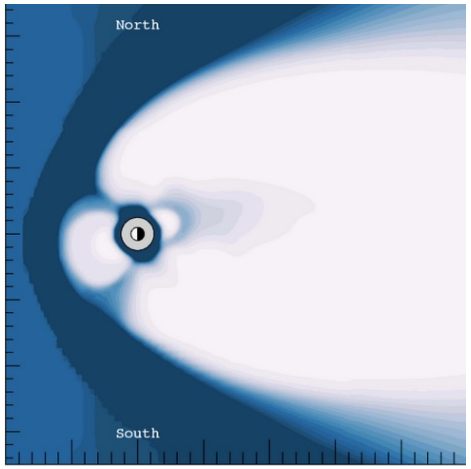
CCMC & NOAA SWPC Collaborations

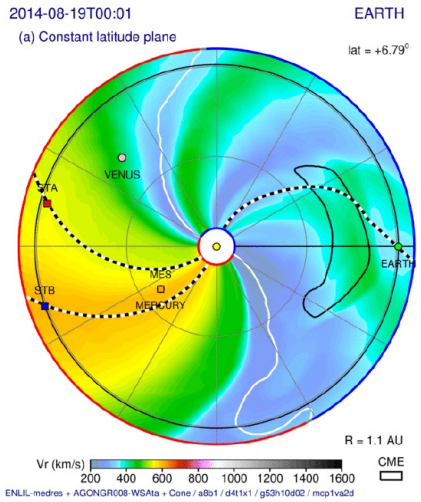
- 20-year partnership since CCMC establishment.

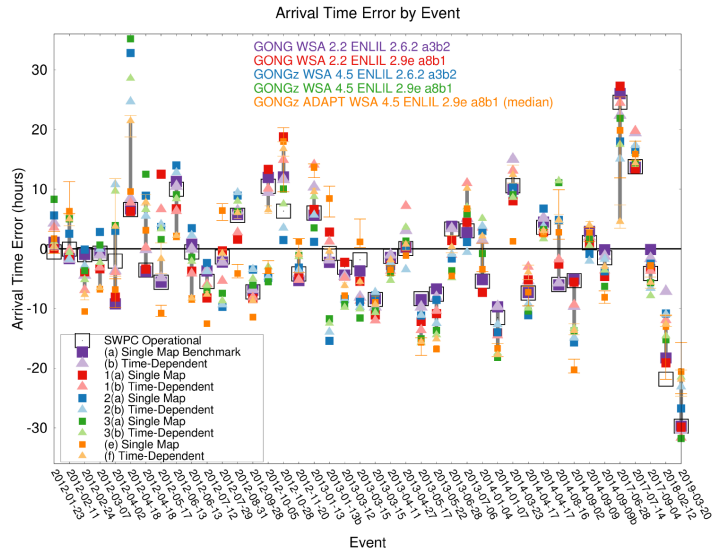
Major successes:

- Demonstrated potential of Enlil for operational forecasting (2006 - 2009)
- Geospace model transition to operations at NOAA/SWPC (2013 - 2015)
- NASA-NOAA space weather MOU on space weather modeling capabilities: MOU Annex to validate model upgrades (2017 - 2020)





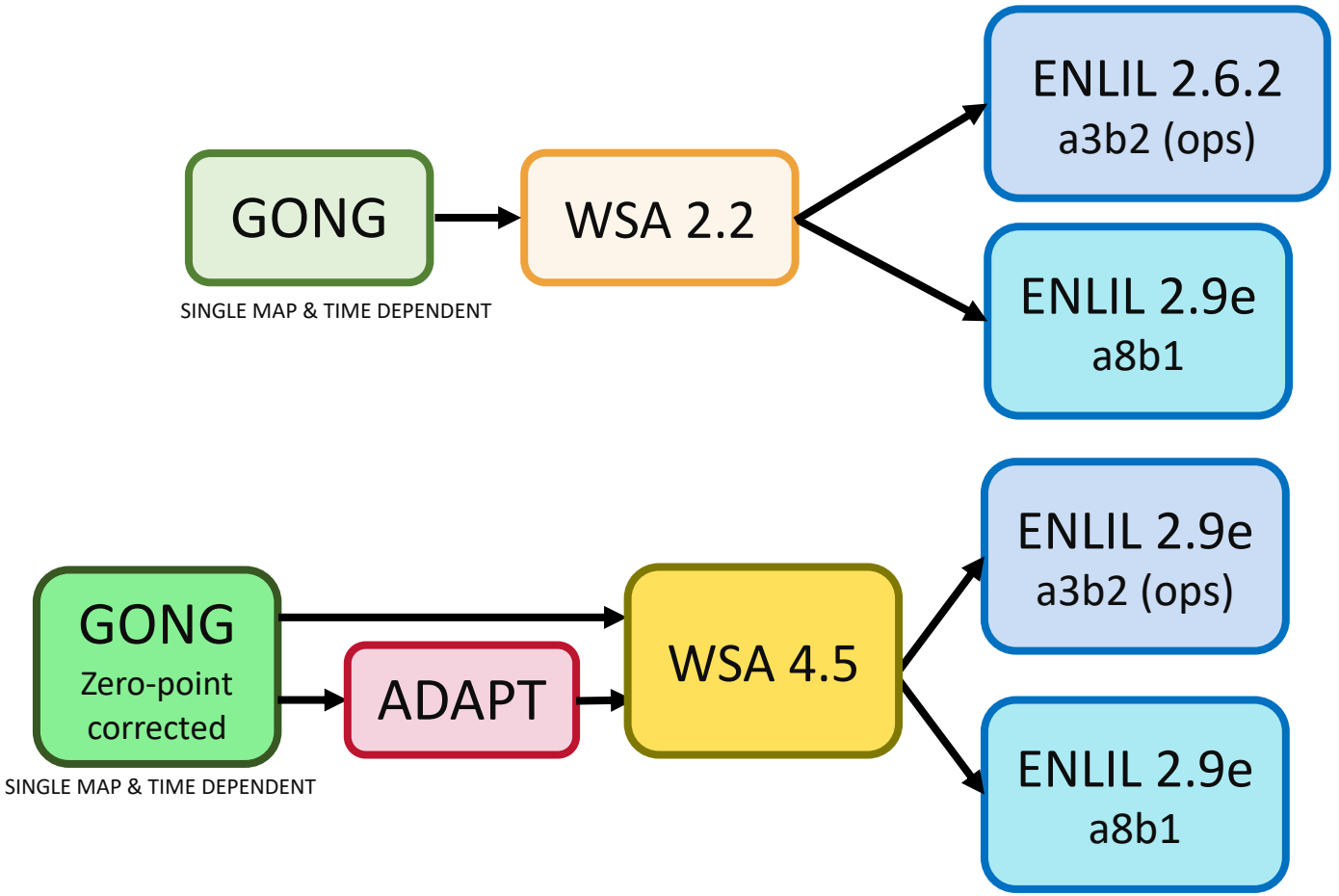




NOAA SWPC / CCMC MOU Annex
CME Arrival Time

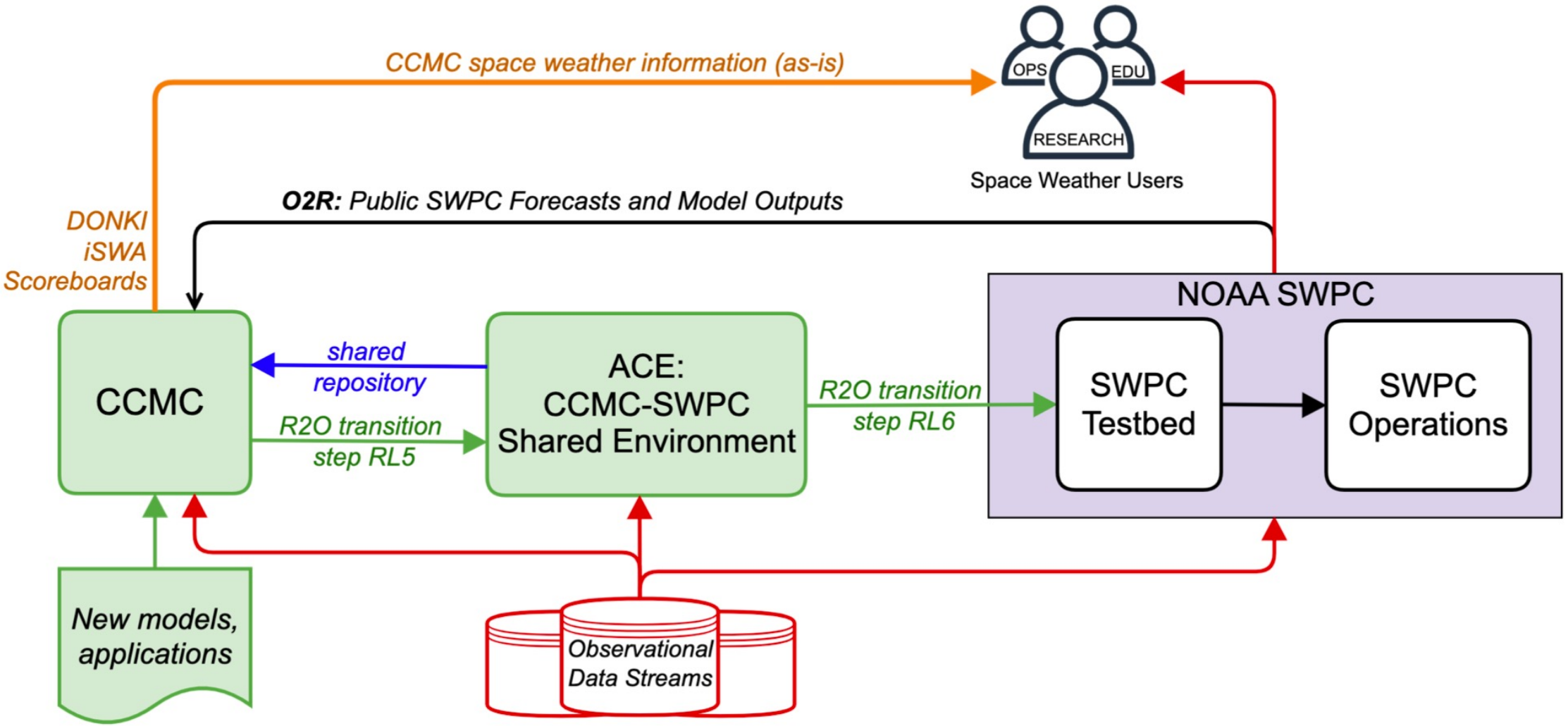
- Tested if model upgrades improve CME arrival time prediction
- CCMC performed and analyzed over 1200 simulations
- **Result:** ADAPT and time-dependent driven simulations decrease CME arrival times errors by 6 hours for GONG zero-point corrected inputs.
- Final report was delivered in May 2020

CCMC performed over 1200 simulation variations:



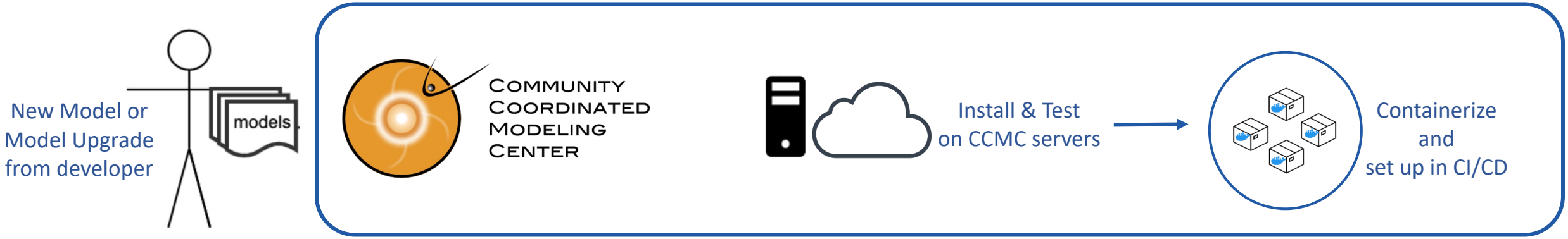
https://ccmc.gsfc.nasa.gov/annex/

CCMC-SWPC R2O2R Pipeline



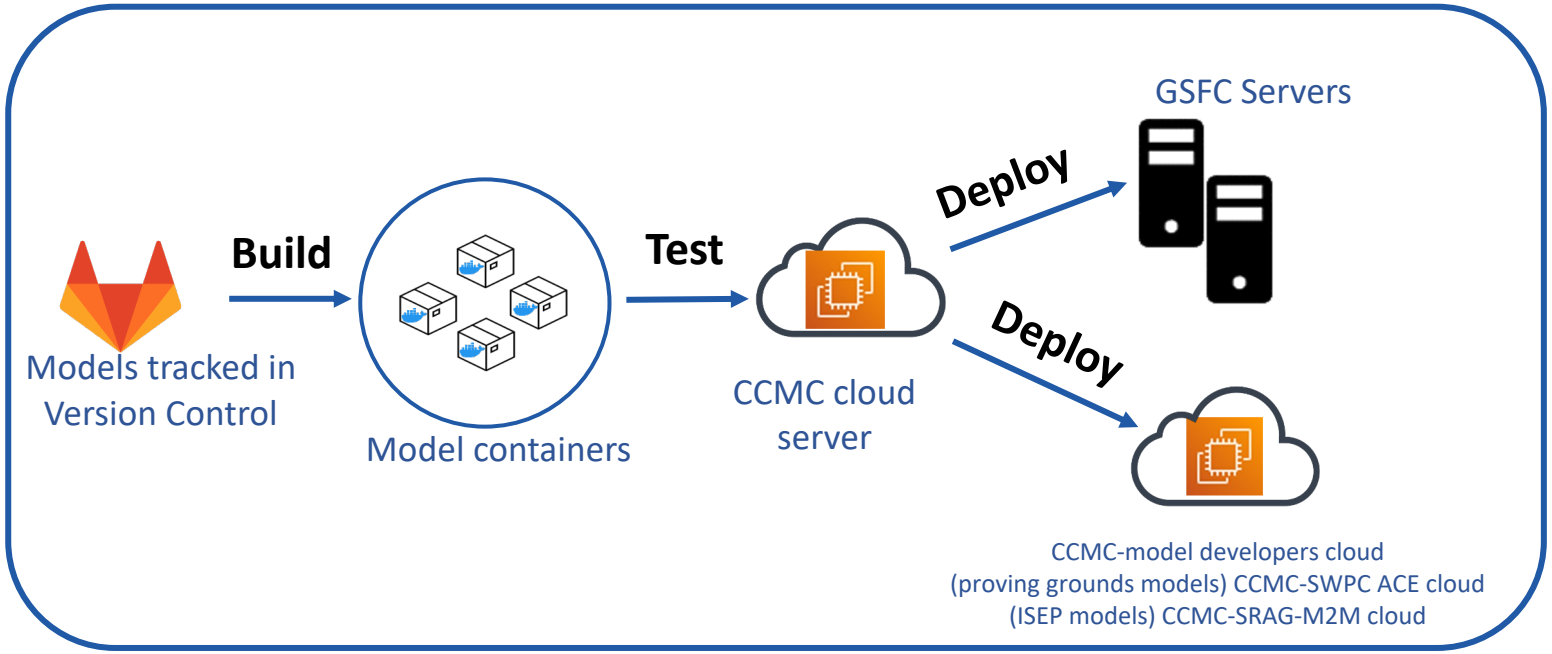
Research to Operations (R2O) at CCMC:
Real-Time Model onboarding and synchronization

Real-time/Continuous Run Model onboarding:



Continuous Integration and Deployment (CI/CD) System at CCMC:

CI/CD is a software development practice that enforces the automation of building, testing, and deployment of software.



Lead:
Chinwe
Didigu

Validation & R2O: CCMC community scoreboards

Leads: **Trinity College Dublin** (S. Murray), **ROB** (J. Andries)

Leads: **NASA SRAG**, **CCMC** (L. Mays), **BIRA-IASB** (M. Dierckxsens), **GSFC** (I. Richardson)

Leads: **CCMC** (L. Mays), **UK Met Office**

Leads: **PredSci** (P. Riley), **University of Reading** (M. Owens)

- Scoreboards collect forecasts from the community before event is observed
- Allows a consistent **real-time** comparison of various operational and research forecasts.

https://ccmc.gsfc.nasa.gov/scoreboards/

SEP Scoreboard

https://ccmc.gsfc.nasa.gov/challenges/sep.php

- Planning for the SEP Scoreboard started in 2016 - led by Mark Dierckxsens, Ian Richardson, Mike Marsh, and Leila Mays

- Builds upon the flare scoreboard and CME arrival time scoreboard
- Automated system: CCMC runs the models or model developers can routinely upload their predictions to an anonymous ftp.
- Forecast data is parsed and stored in a database which is accessible to anyone via an API

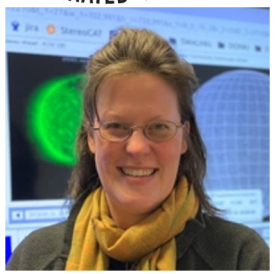
SEP Scoreboard: CCMC R2O Collaboration with NASA Johnson Space Center SRAG

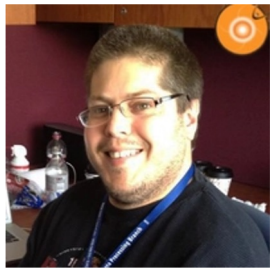
- 2018: Beginning of ISEP project between CCMC and NASA Space Radiation Analysis Group (SRAG) to transition research Solar Energetic Particle models along the R2O pipeline.
- Project goals:
  - identify, transition, and evaluate new models (R2O)
  - develop software tailored for SRAG
  - implement these capabilities within CCMC as a prototype.
- CCMC has transitioned 6+ real-time models and built the SEP Scoreboard application
- The Scoreboard is already in use by SRAG for ISS support, and will be used for Artemis support by SRAG and M2M

https://ccmc.gsfc.nasa.gov/scoreboards/sep/

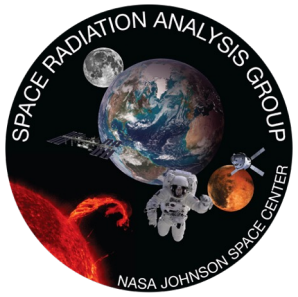
CCMC Staff focused on R2O/ISEP/ACE Proving Grounds/Real-time Runs

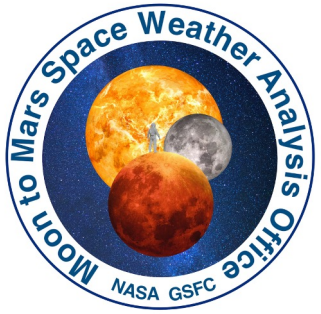
- **Masha Kuznetsova** (CCMC Director)
- **Leila Mays** (CCMC Deputy, CCMC ISEP project lead, CCMC Helio/SEP Scientist)
- **Joycelyn Jones** (Scoreboard Software Developer)
- **Chinwe Didigu** (Real-time Runs Software Developer, ACE, ISEP)
- **Aleksandre Taktakishvili (**CCMC Solar/Helio Scientist, ISEP)
- **Tina Tsui** (CCMC Cloud Infrastructure and Model Onboarding Lead)
- **Peter MacNeice** (CCMC Solar/Helio Scientist, ISEP connectivity models)
- **Chiu Wiegand** (CCMC Lead Software Developer, iSWA, DONKI)
- **Rick Mullinix** (CCMC Software Developer, iSWA, Flare Scoreboard)
- **Claudio Corti** (CCMC Helio/SEP Scientist)
- **Chris Light** (CCMC Helio/SEP Scientist)
- **Yihua Zheng** (CCMC Radiation/Inner Magnetosphere Scientist)
- **CCMC Sys Admin team** (Poly Manessis, Corey Bettenhausen, Sarabjit Bakshi, Kiran Patel)
- Consulting from **GSFC SMCE** Science Managed Cloud Environment staff





CCMC Collaborations with SRAG and M2M Staff for the ISEP project





SRAG (ISEP project)

- Eddie Semones (SRAG lead)
- Kerry Lee (SRAG operations lead)
- Janet Barzilla (ISEP project lead, Console operator)
- Steve Johnson (Console Operator, SEP models)
- Katie Whitman (Validation Lead)
- Tilaye Asfaw (MagPy lead)
- Phil Quinn (Console Operator, SEP models)
- Clayton Allison (SEP models)
- Ricky Egeland (Console Operator, SEP models)
- Michael Cook (Console Operator)

M2M (ISEP project)

- Yari Collado-Vega (M2M Director)
- Anna Chulaki (Deputy)
- Michelangelo Romano
- Mary Keenan
- Bob Loper
- Carina Alden
- Mary Aronne
- Mattie Anastopulos
- Chris Stubenrauch
- Cloud Consultant

NASA Langley (ISEP project)

- Chris Mertens (Radiation models)

SEP Models in the Community

Continuous/ Probabilistic

AFRL SFS
ASPECS/FORSPEF
GSU
MAG4 (Falconer)
SPRINTS
SWPC
UK Met Office

Physics based

WSA-ENLIL+EPREM (Odstricil, UNH)
ZEUS+iPATH (Li)
SWMF+iPATH (Li, Jin)
PARADISE (EUHFORIA)
WSA-ENLIL+SEPMOD (Luhmann)
SPARX (Dalla, Marsh)
STAT: MAS+EPREM (PSI and UNH)
SWMF M-FLAMPA (UMich)
Zhang Model (FIT)

Solar Event Triggered

Flare:
AFRL SFS
COMESEP SEPForecast (BIRA)
SPARX (Dalla, Marsh)

Flare and/or CME:
COMESEP SEPForecast
ASPECS/FORSPEF (NOA)
GSU
SOLPENCO (Arans)

Flare and proton intensity:
UMASEP (Núñez)
Boubrahimi model

Electron intensity:
HESPERIA REleASE

CME:
SEPSTER, SEPSTER2D (Richardson, Bruno)
MLSO K-Cor (St. Cyr)

Flare, Radio, H-alpha:
SWPC PPM

Flare, Radio:
ESPERTA (Laurenza)

Model in ROR /onboarding

Continuous/RT Runs - SEP Scoreboard

More in Katie's talk in this session *and her paper: Whitman et al. 2022 Adv Space Res - SEP models review paper recently submitted to COSPAR Roadmap special issue.*

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 timeseries of the probability of a threshold crossing
- Continuous intensity timeseries
- Peak intensity for event
- Peak intensity over the next x hours
- Threshold crossing

SEP Scoreboard Displays

Displays have been built for multiple forecast types:

Probability app:

- probability heat map and time series (MAG4, SWPC, *ASPECS, GSU, SPRINTS*)
  https://sep.ccmc.gsfc.nasa.gov/probability/

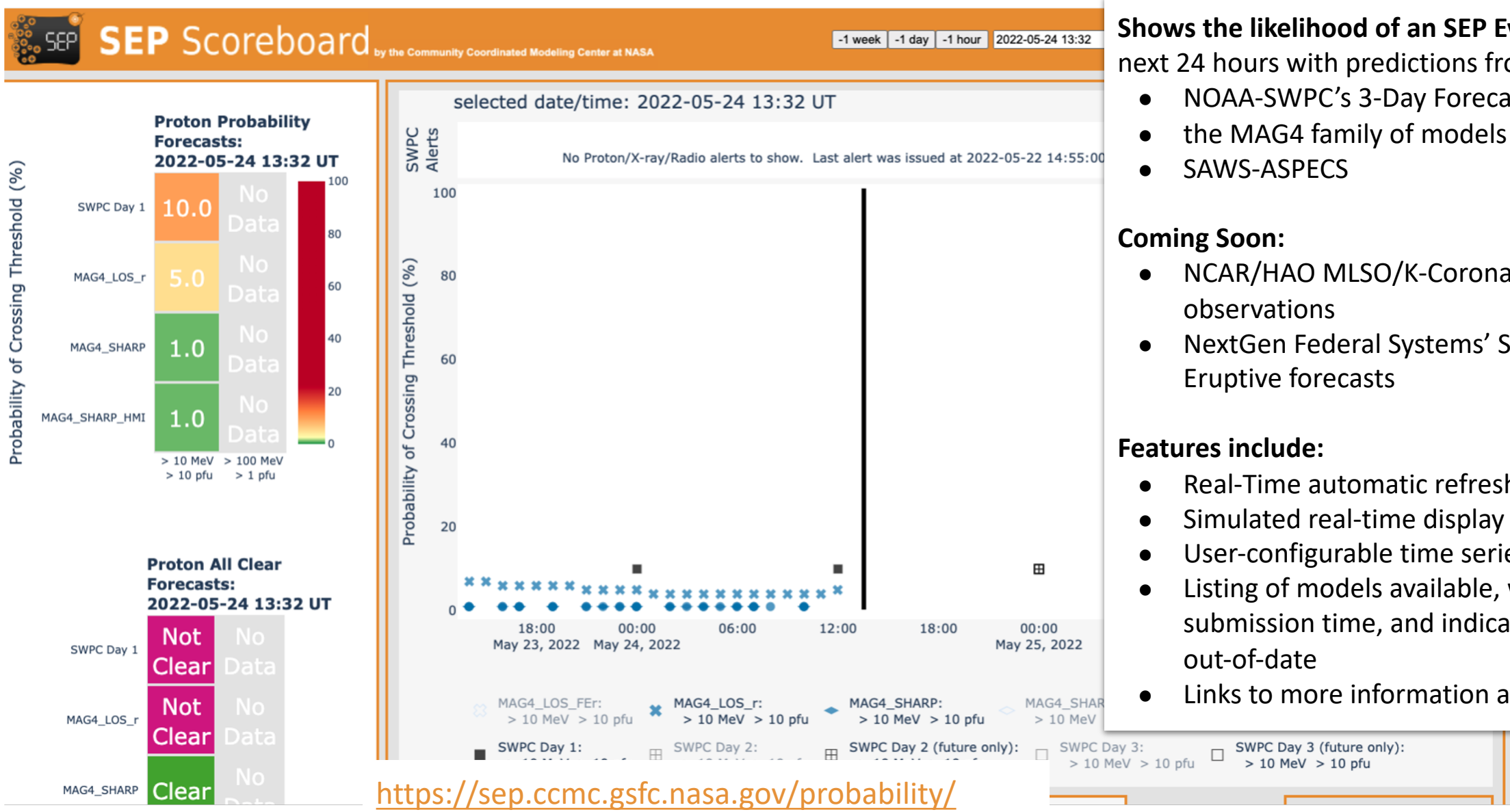
Intensity app:

- intensity heat map (SEPSTER, UMASEP, SEPMOD, *STAT, ASPECS, iPATH*)
- intensity time series (REleASE, SEPMOD, UMASEP, *STAT, ASPECS, iPATH*)
  https://sep.ccmc.gsfc.nasa.gov/intensity/

All Clear app:

- all clear forecast heat map (all models)
  https://sep.ccmc.gsfc.nasa.gov/allclear/

SEP Scoreboard: Probability App



https://sep.ccmc.gsfc.nasa.gov/probability/

Shows the likelihood of an SEP Event within the next 24 hours with predictions from

- NOAA-SWPC's 3-Day Forecast
- the MAG4 family of models
- SAWS-ASPECS

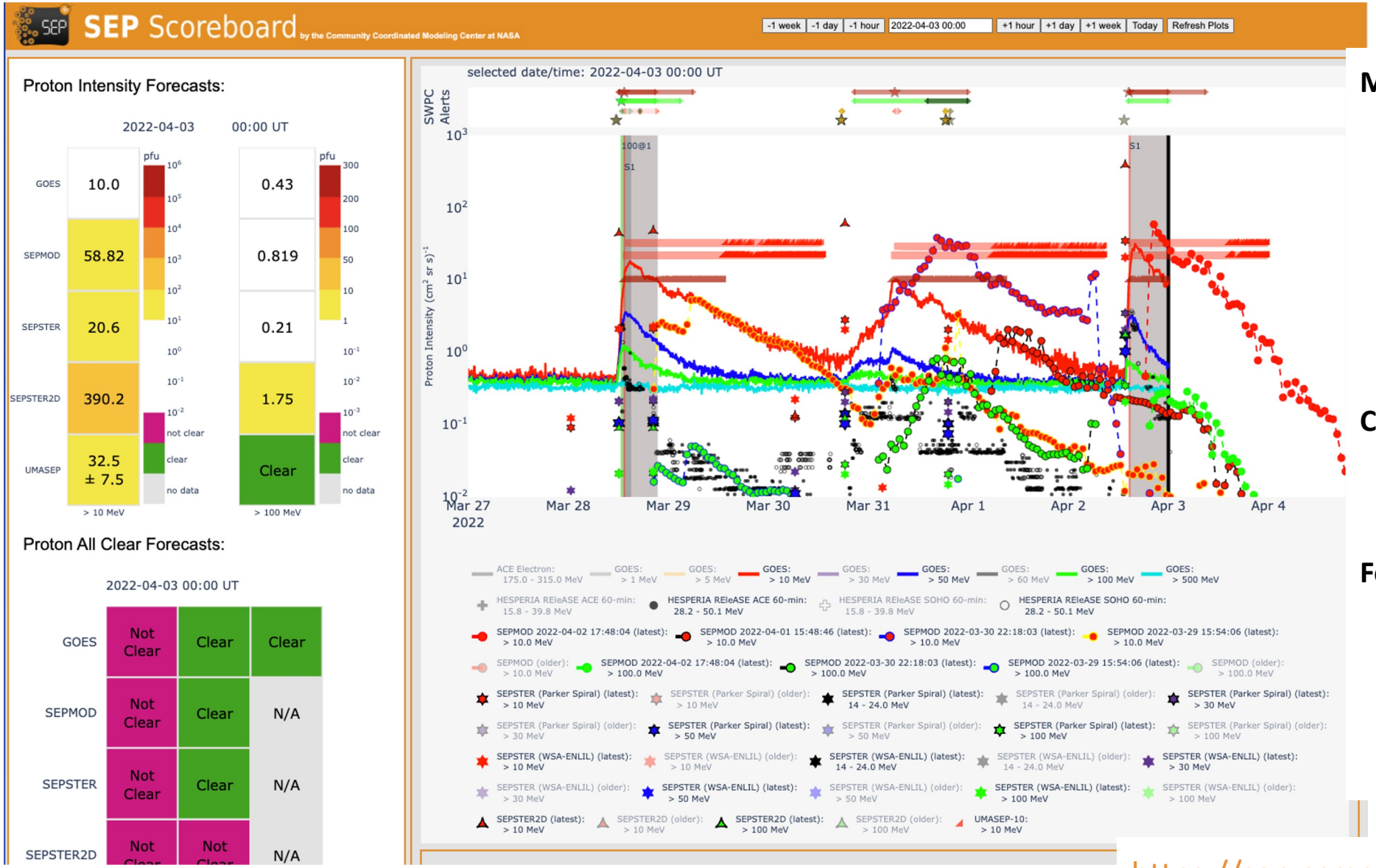
Coming Soon:

- NCAR/HAO MLSO/K-Coronagraph observations
- NextGen Federal Systems' SPRINTS Post-Eruptive forecasts

Features include:

- Real-Time automatic refreshing
- Simulated real-time display for past events
- User-configurable time series
- Listing of models available, with their last submission time, and indication if the data is out-of-date
- Links to more information about the models

SEP Scoreboard: Intensity App



Models shown include:

- SEPSTER
- HESPERIA REleASE
- UMASEP
- STAT
- SEPSTER2D
- WSA-ENLIL+SEPMOD
- SAWS-ASPECS

Coming Soon:

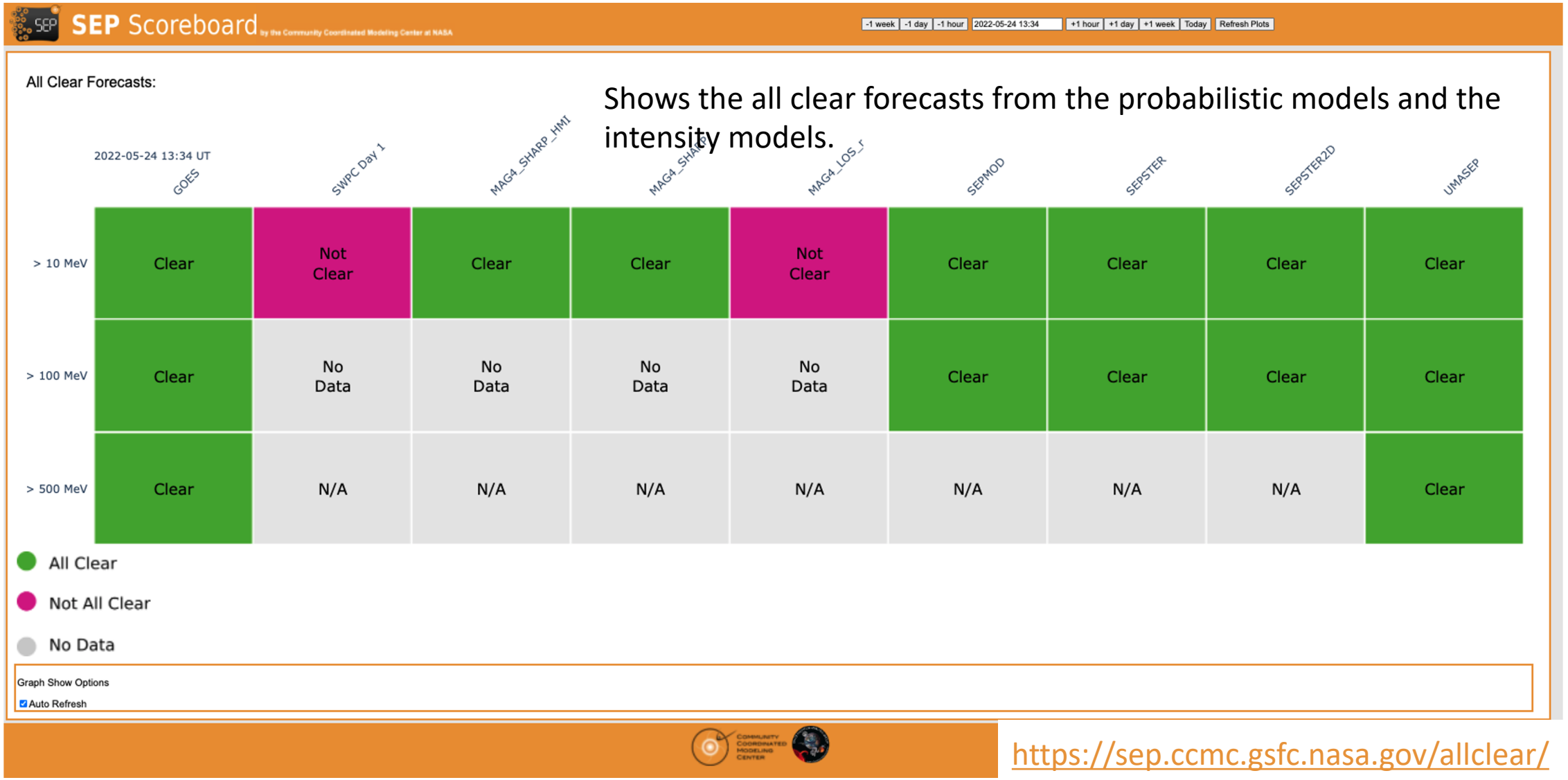
- NCAR/HAO MLSO/K-Coronagraph observations

Features include:

- Probability scoreboard features, plus
- Links to input data for some models' forecasts
- More user controls

https://sep.ccmc.gsfc.nasa.gov/intensity/

SEP Scoreboard: All Clear App

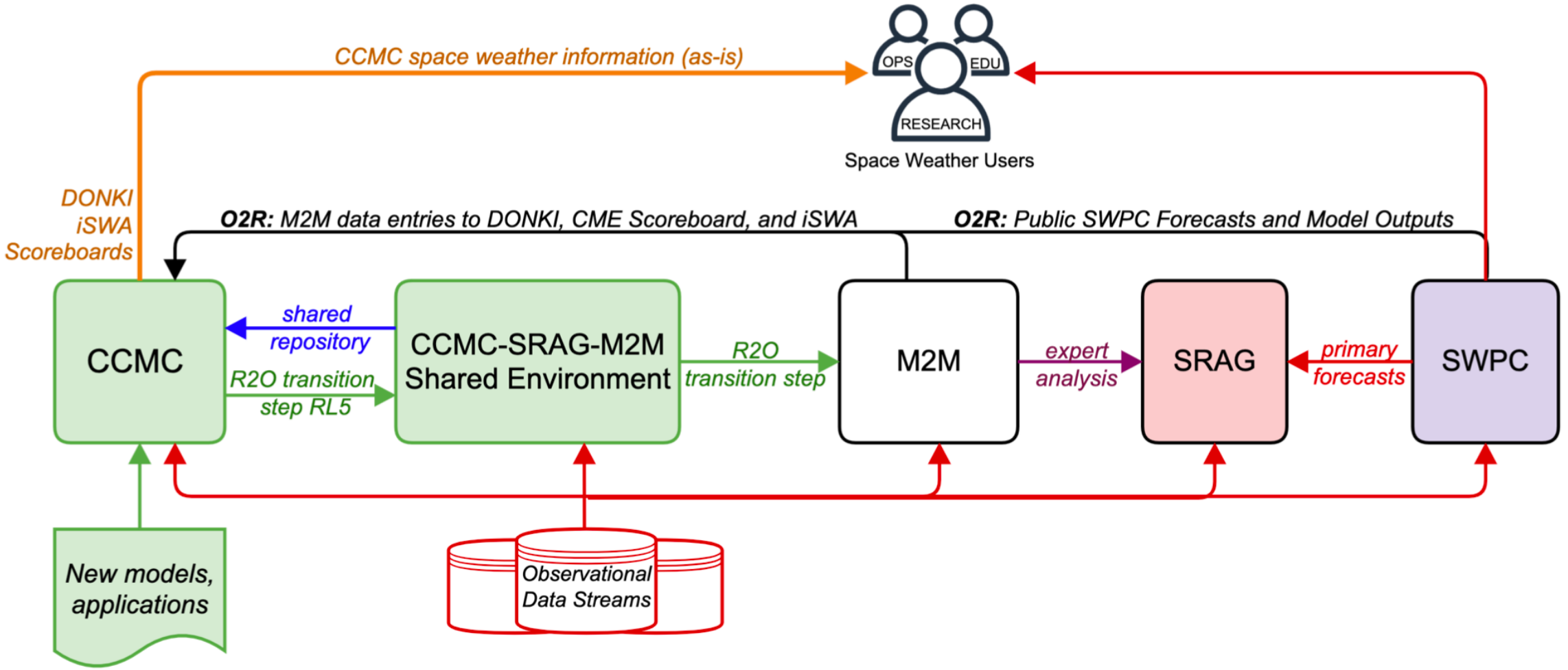


Shows the all clear forecasts from the probabilistic models and the intensity models.

https://sep.ccmc.gsfc.nasa.gov/allclear/

NASA in-house R2O2R Pipeline:

CCMC support of human exploration



Summary: SEP Scoreboard

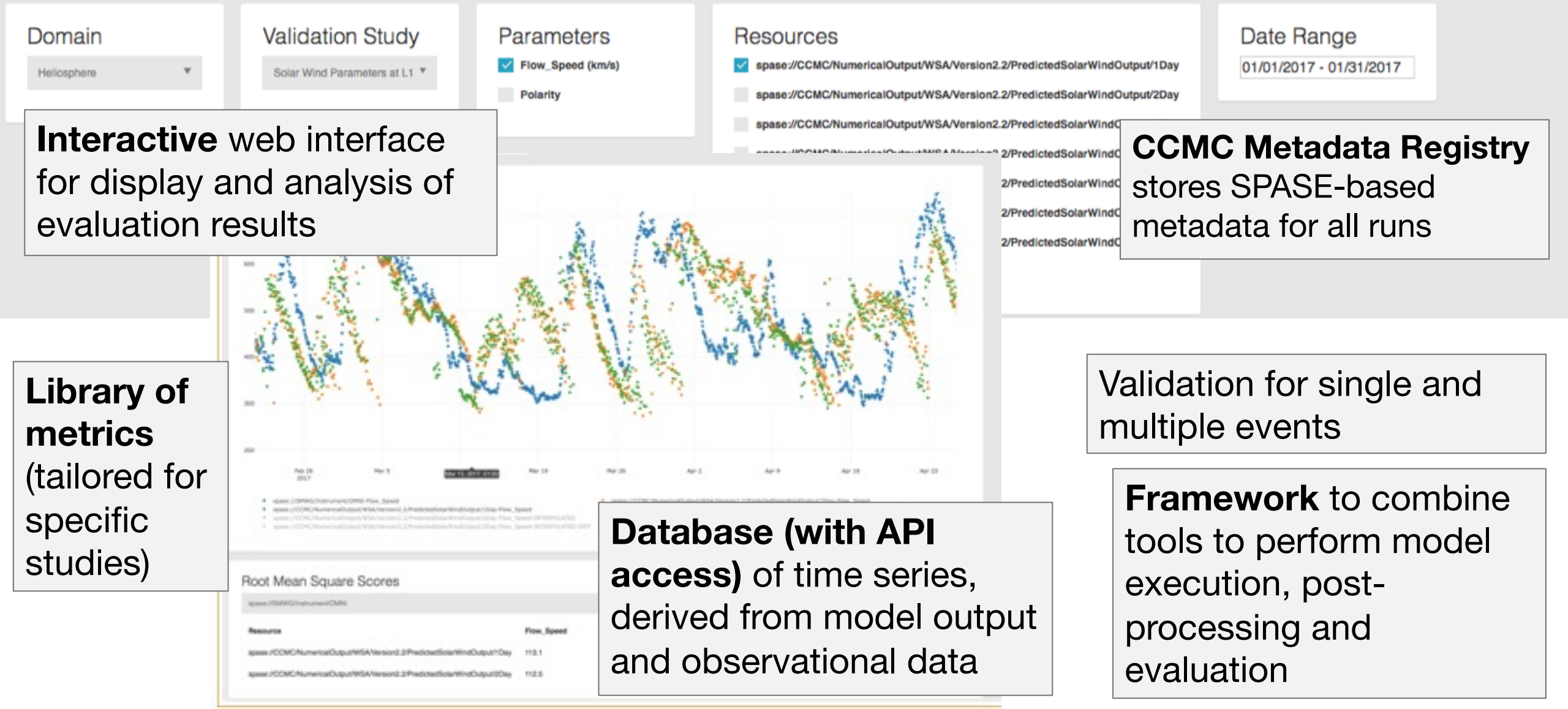
https://ccmc.gsfc.nasa.gov/scoreboards/sep/

- 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 are available publicly on the web
- 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 ISWAT SEP Validation Team activities

Comprehensive Assessment of Models and Events based on Library tools

CAMEL
Comprehensive Assessment of Models and Events based on Library tools

https://ccmc.gsfc.nasa.gov/camel



Interactive web interface for display and analysis of evaluation results

CCMC Metadata Registry stores SPASE-based metadata for all runs

Library of metrics (tailored for specific studies)

Database (with API access) of time series, derived from model output and observational data

Validation for single and multiple events

Framework to combine tools to perform model execution, post-processing and evaluation

Thank you
&
feel free to contact me with questions!

m.leila.mays@nasa.gov

Supplemental slides

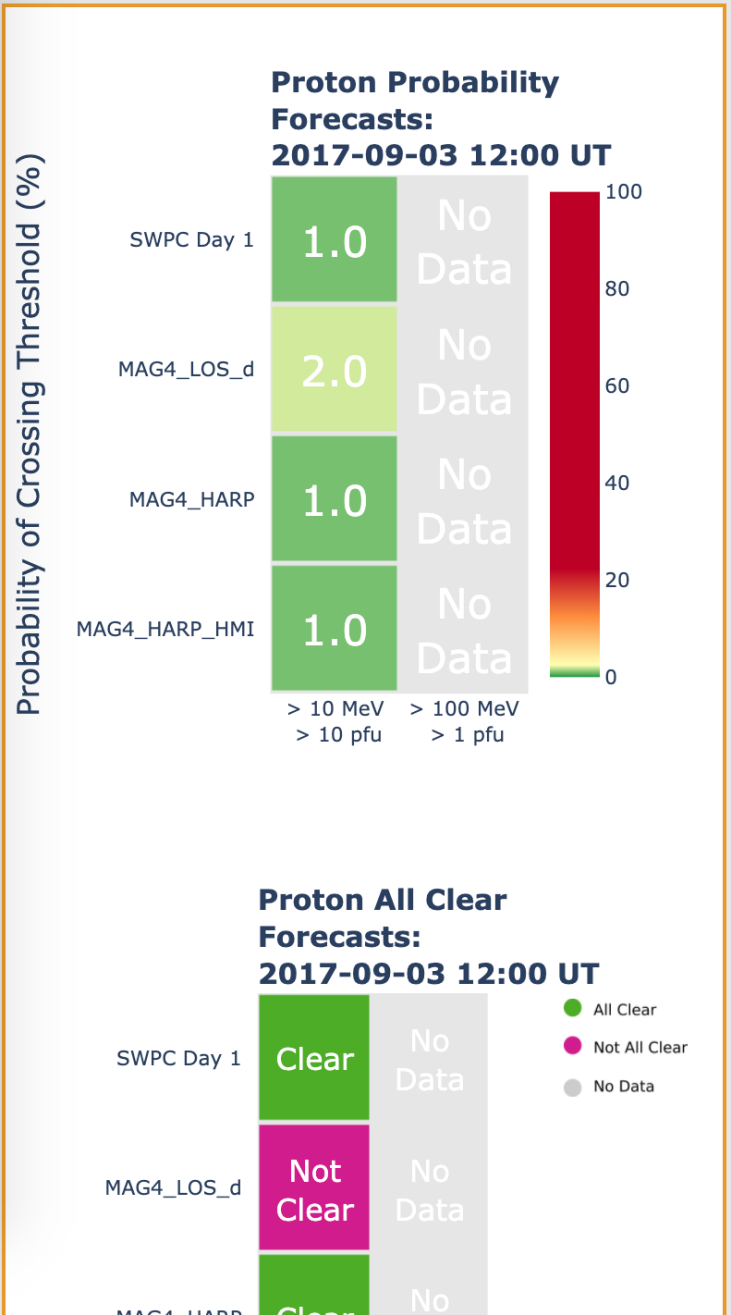
Demo Screenshots: Probability Time Series

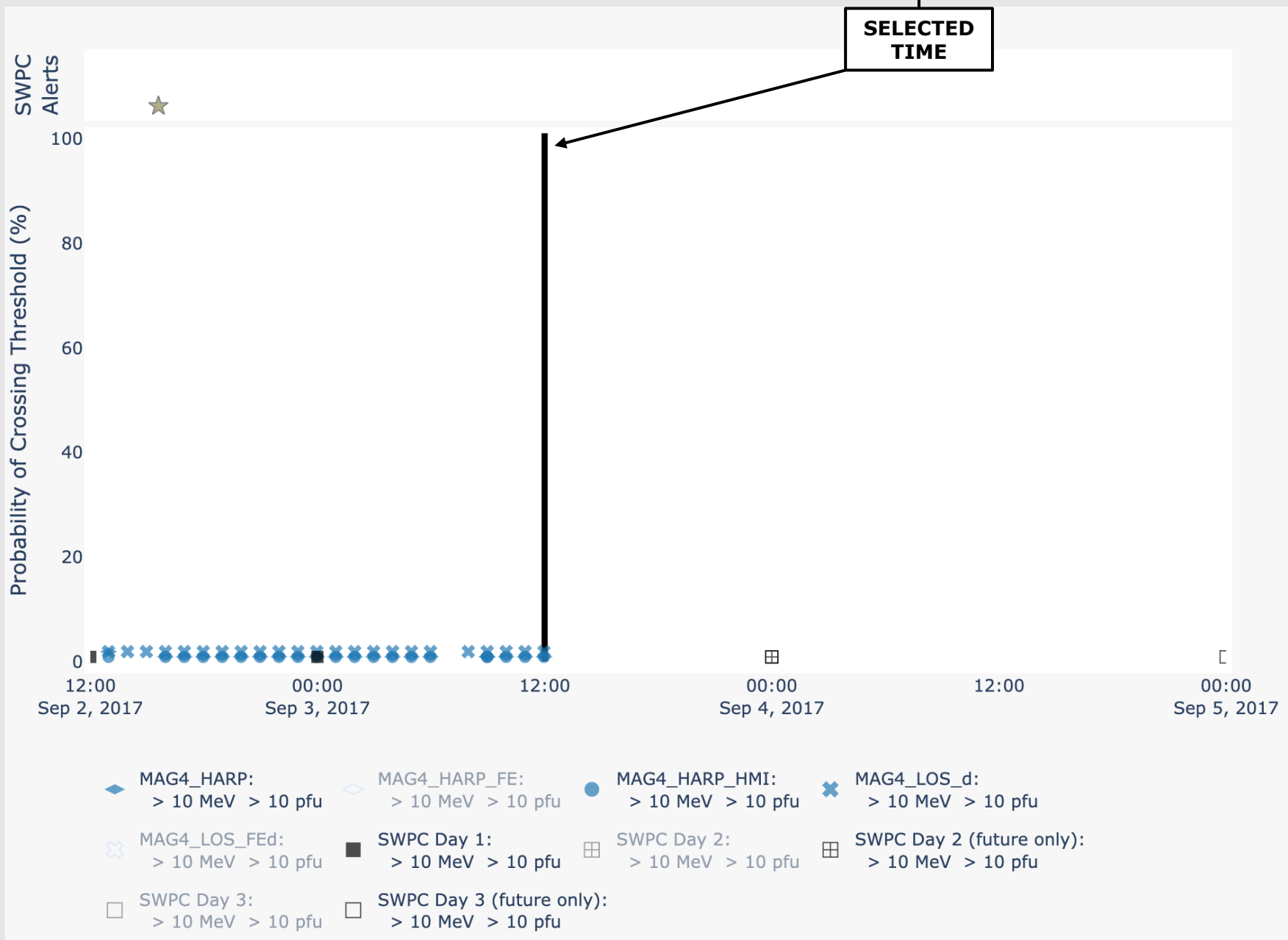
SEP Scoreboard *Demo: Probability heat map and time series*

-1 week | -1 day | -1 hour | 2017-09-03 12:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

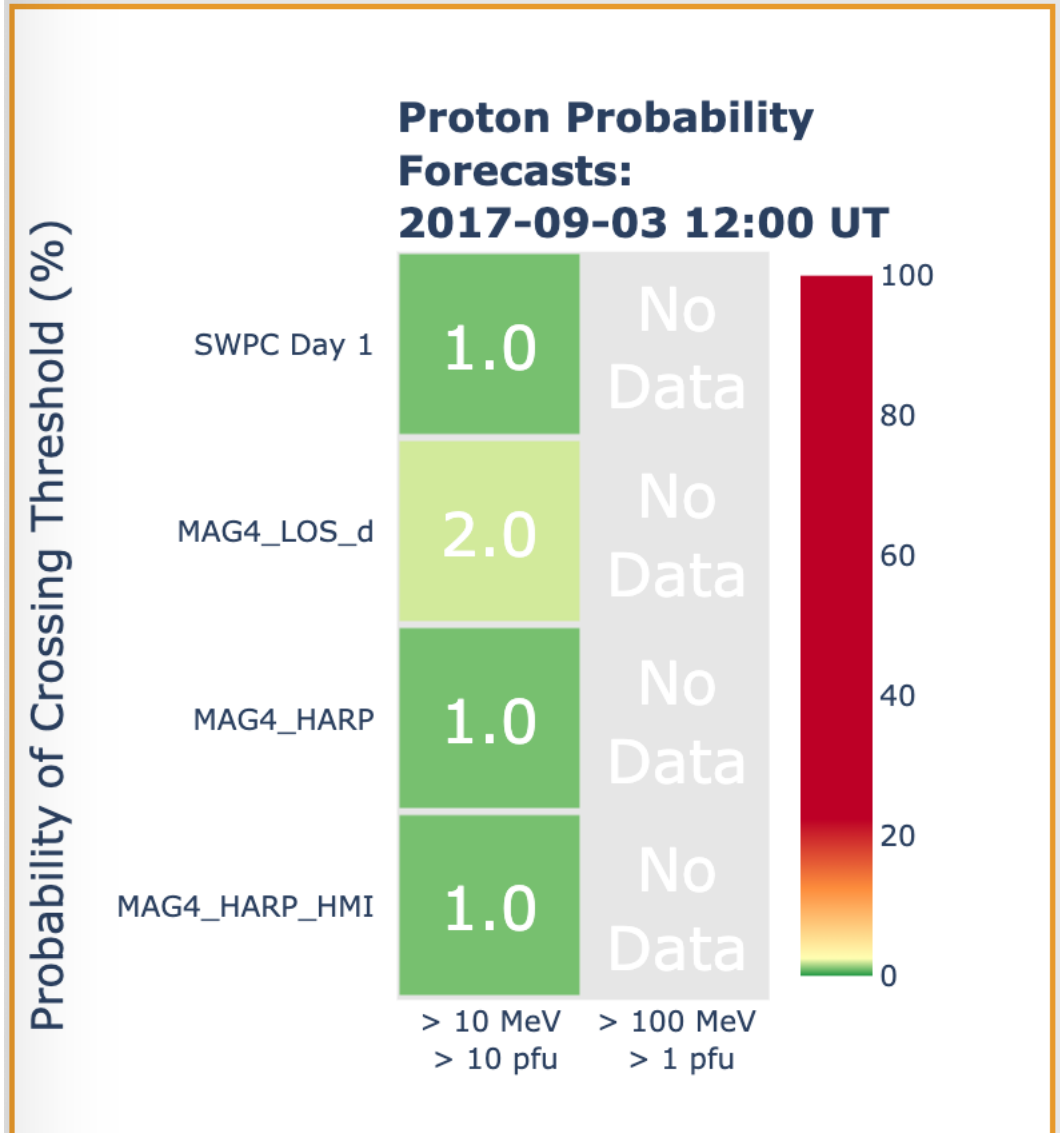
SELECTED TIME

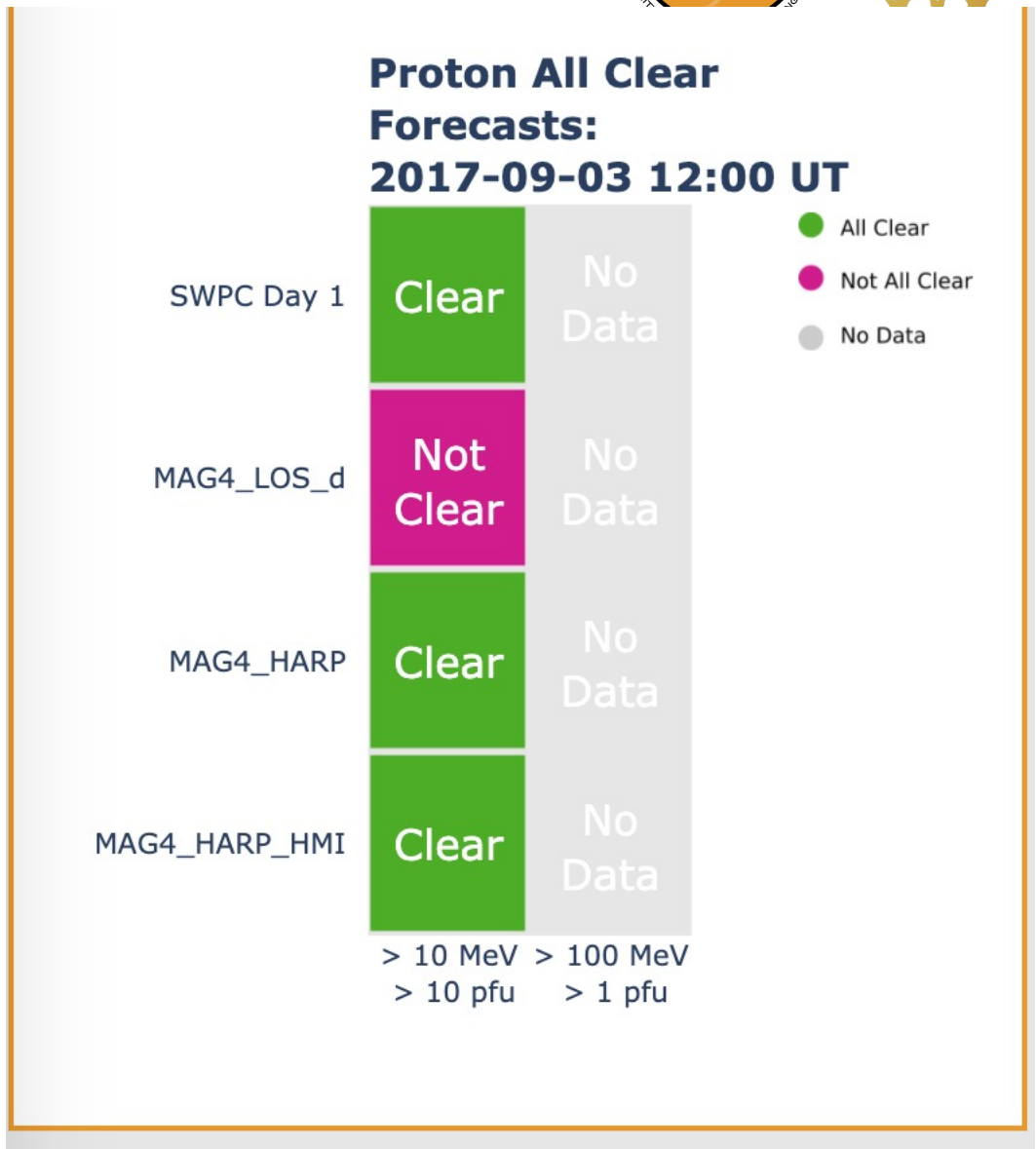




SEP Scoreboard

Demo: all clear display



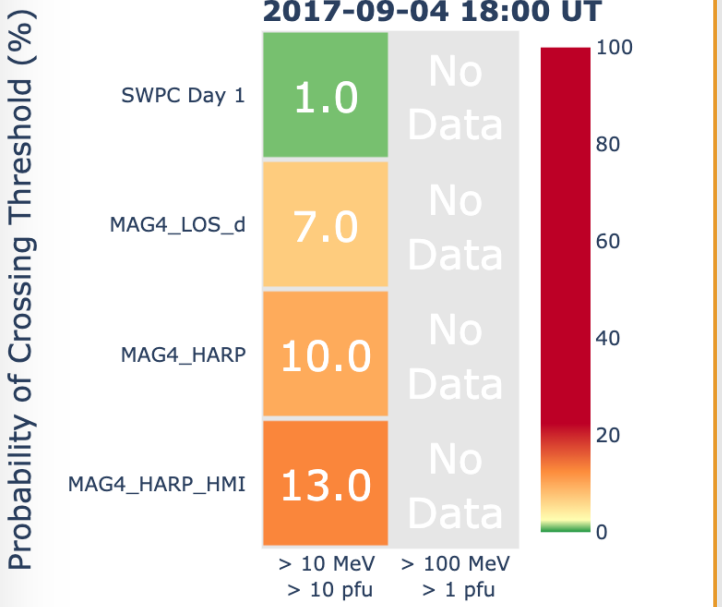


SEP Scoreboard

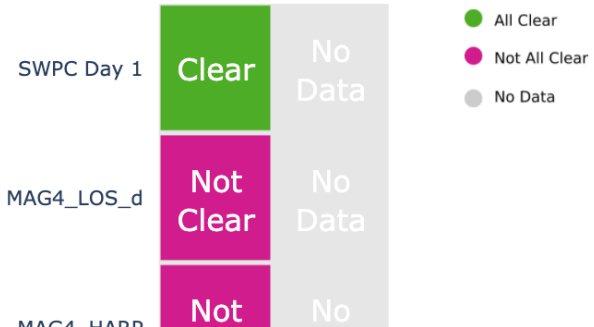
-1 week | -1 day | -1 hour | 2017-09-04 18:00 | +1 hour | +1 day | +1 week | Today

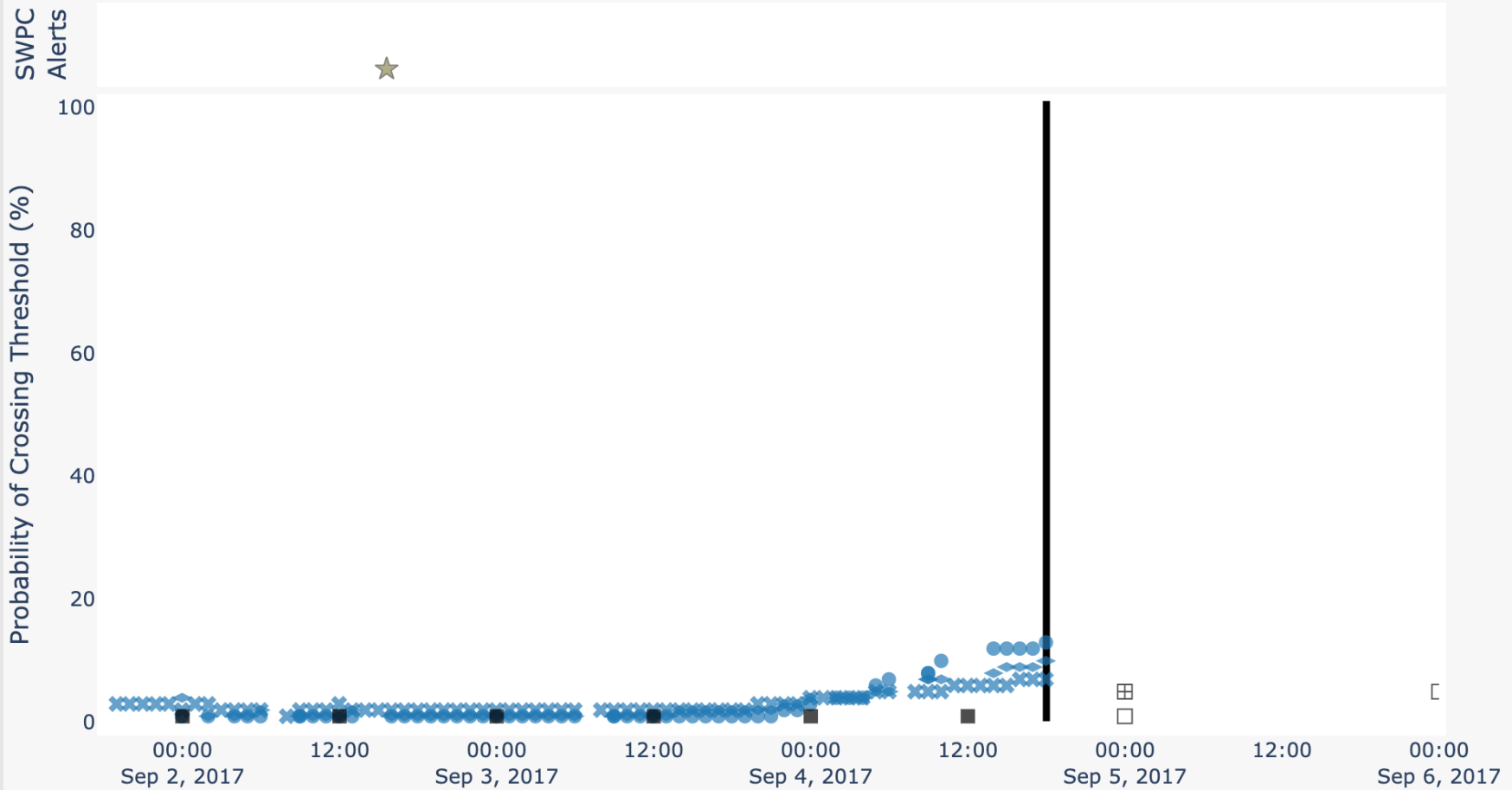
Refresh Plots

Proton Probability Forecasts: 2017-09-04 18:00 UT

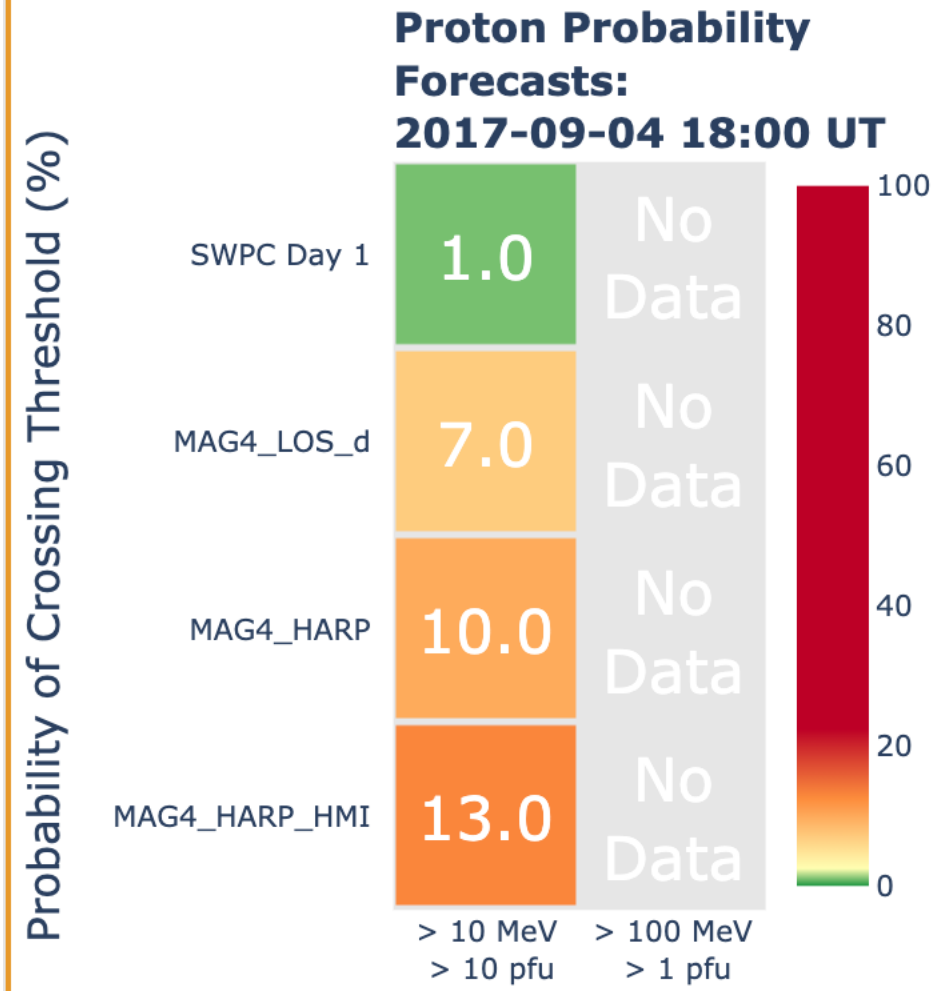


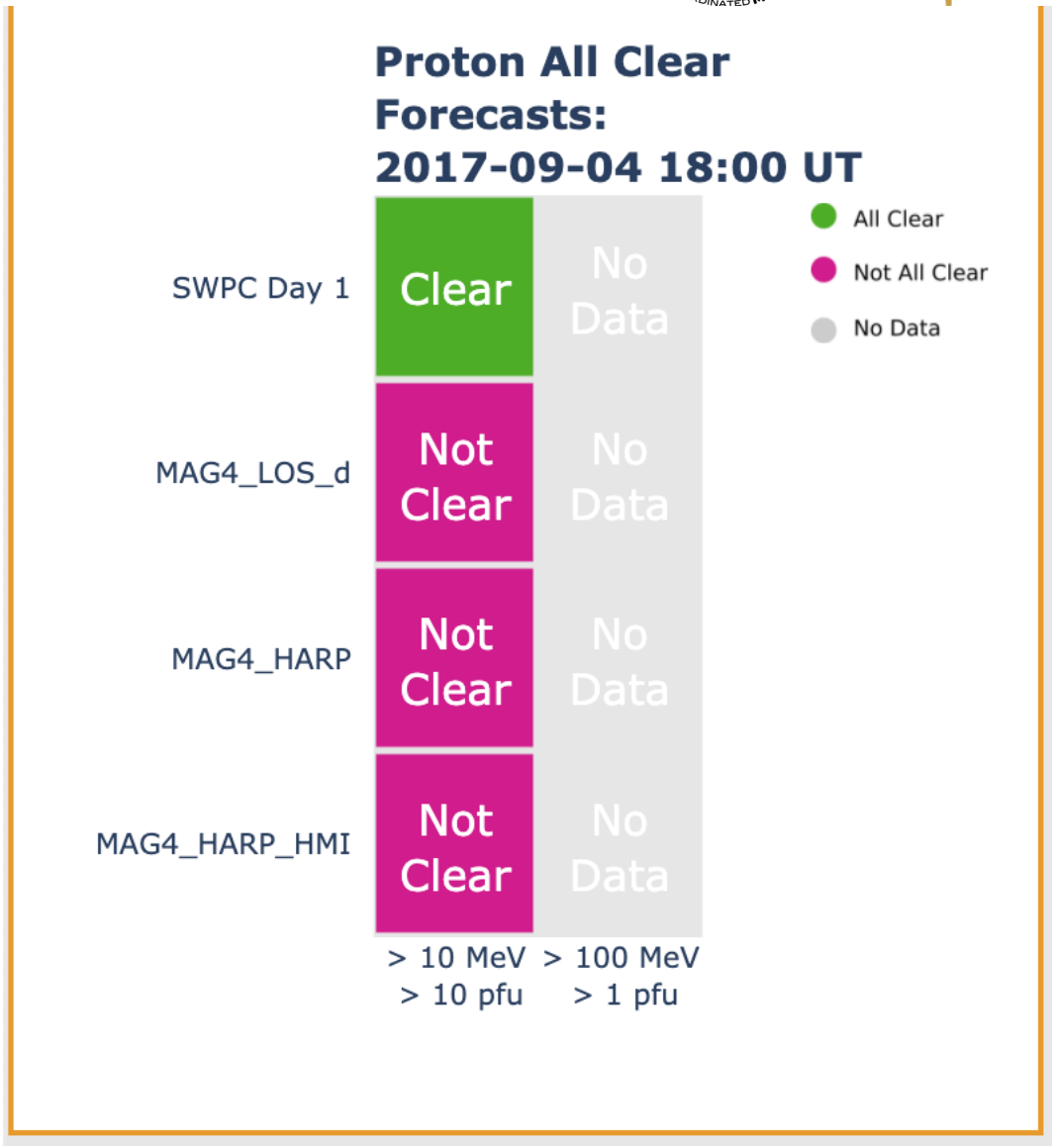
Proton All Clear Forecasts: 2017-09-04 18:00 UT





SEP Scoreboard





SEP Scoreboard

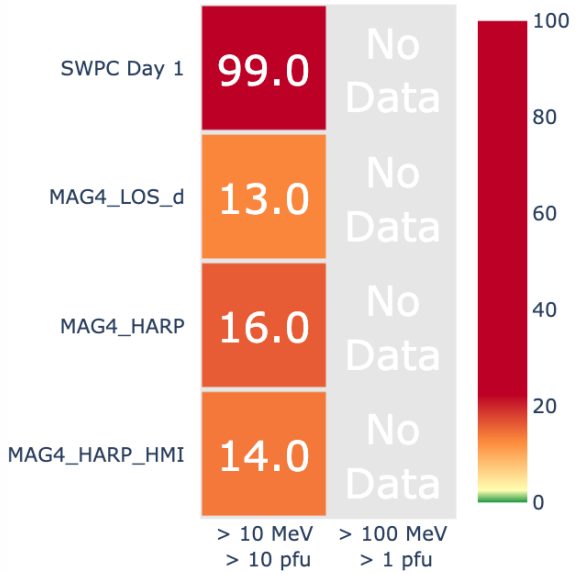
red line:
S1 event onset
(>10 MeV first exceeds 10pfu)

-1 week | -1 day | -1 hour | 2017-09-06 12:00 | +1 hour | +1 day | +1 week | Today

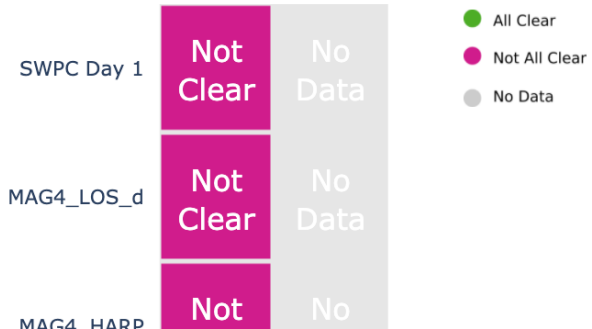
Refresh Plots

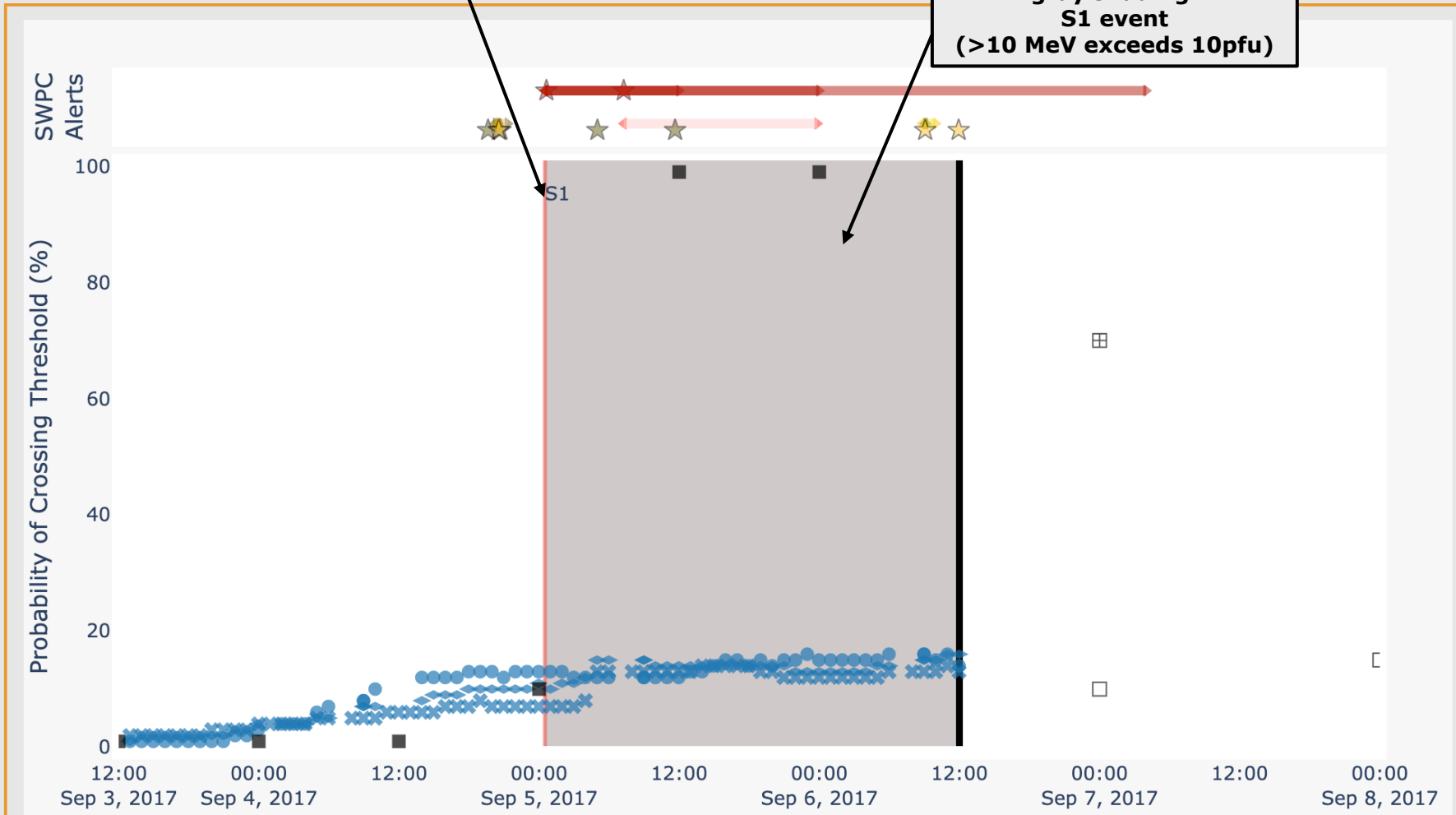
gray shading:
S1 event
(>10 MeV exceeds 10pfu)

Proton Probability Forecasts: 2017-09-06 12:00 UT



Proton All Clear Forecasts: 2017-09-06 12:00 UT





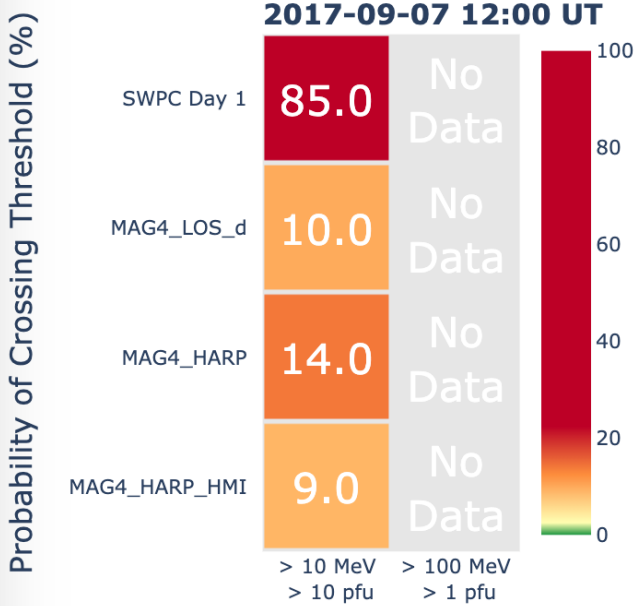
MAG4_HARP: > 10 MeV > 10 pfu
MAG4_HARP_FE: > 10 MeV > 10 pfu
MAG4_HARP_HMI: > 10 MeV > 10 pfu
MAG4_LOS_d: > 10 MeV > 10 pfu
MAG4_LOS_FEd: > 10 MeV > 10 pfu
SWPC Day 1: > 10 MeV > 10 pfu
SWPC Day 2: > 10 MeV > 10 pfu
SWPC Day 2 (future only): > 10 MeV > 10 pfu
SWPC Day 3: > 10 MeV > 10 pfu
SWPC Day 3 (future only): > 10 MeV > 10 pfu

SEP Scoreboard

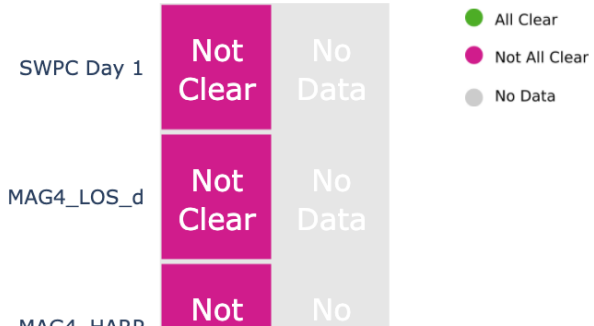
-1 week | -1 day | -1 hour | 2017-09-07 12:00 | +1 hour | +1 day | +1 week | Today

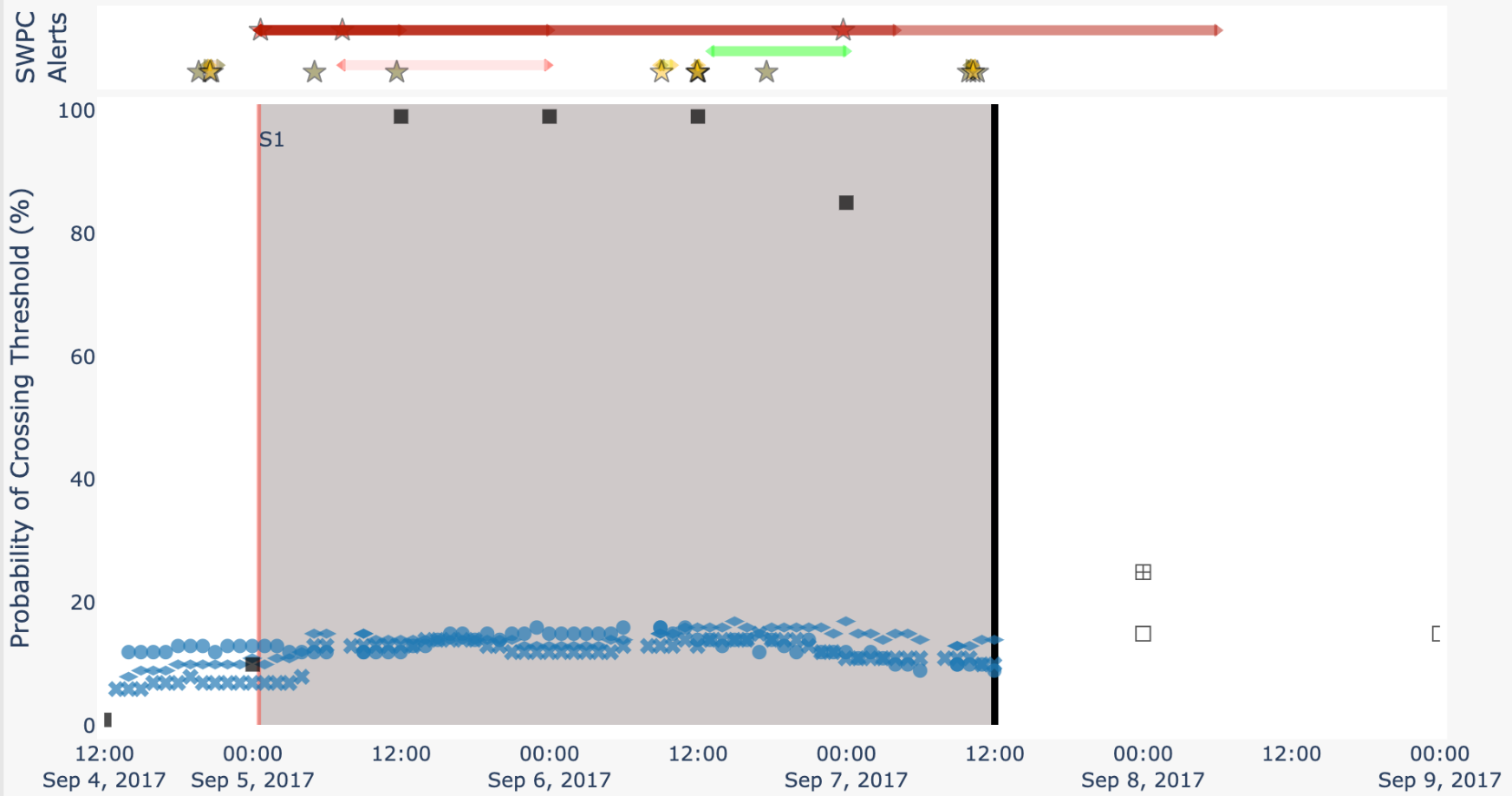
Refresh Plots

Proton Probability Forecasts: 2017-09-07 12:00 UT



Proton All Clear Forecasts: 2017-09-07 12:00 UT





MAG4_HARP: > 10 MeV > 10 pfu

MAG4_HARP_FE: > 10 MeV > 10 pfu

MAG4_HARP_HMI: > 10 MeV > 10 pfu

MAG4_LOS_d: > 10 MeV > 10 pfu

MAG4_LOS_FEd: > 10 MeV > 10 pfu

SWPC Day 1: > 10 MeV > 10 pfu

SWPC Day 2: > 10 MeV > 10 pfu

SWPC Day 2 (future only): > 10 MeV > 10 pfu

SWPC Day 3: > 10 MeV > 10 pfu

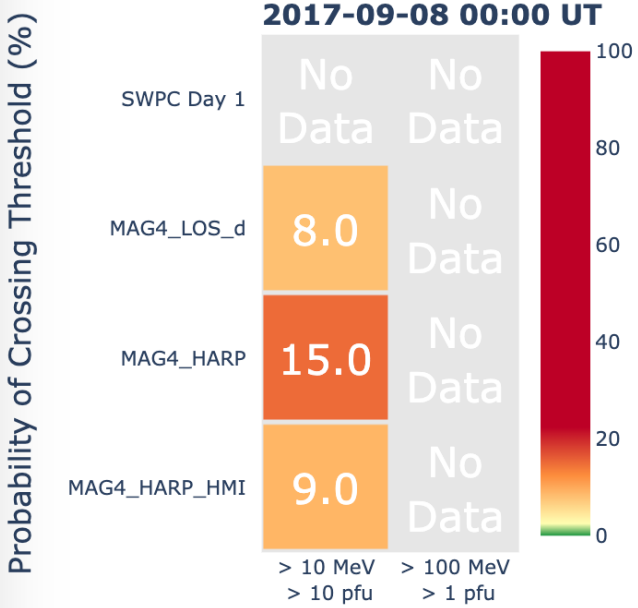
SWPC Day 3 (future only): > 10 MeV > 10 pfu

SEP Scoreboard

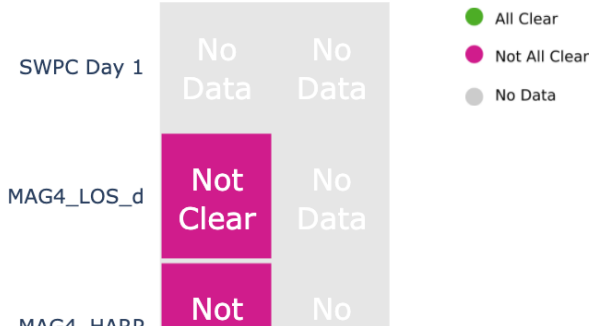
-1 week | -1 day | -1 hour | 2017-09-08 00:00 | +1 hour | +1 day | +1 week | Today

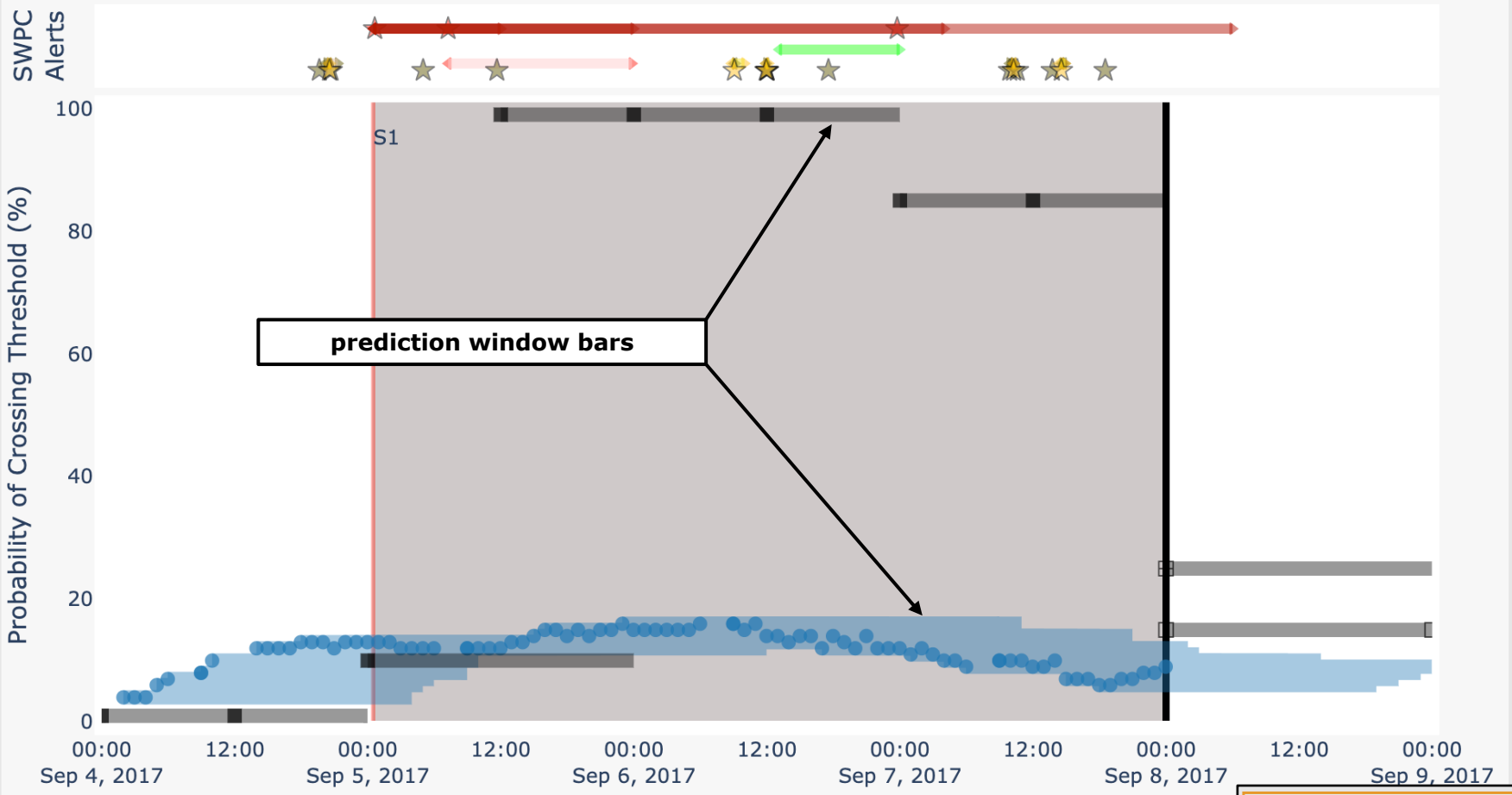
Refresh Plots

Proton Probability Forecasts: 2017-09-08 00:00 UT



Proton All Clear Forecasts: 2017-09-08 00:00 UT





MAG4_HARP: > 10 MeV > 10 pfu

MAG4_HARP_FE: > 10 MeV > 10 pfu

MAG4_HARP_HMI: > 10 MeV > 10 pfu

MAG4_LOS_d: > 10 MeV > 10 pfu

MAG4_LOS_FEd: > 10 MeV > 10 pfu

SWPC Day 1: > 10 MeV > 10 pfu

SWPC Day 2: > 10 MeV > 10 pfu

SWPC Day 2 (future onl > 10 MeV > 10 pfu

SWPC Day 3: > 10 MeV > 10 pfu

SWPC Day 3 (future only): > 10 MeV > 10 pfu

Graph Show Options

- [ ] Auto Refresh
- [x] Prediction Window Bars
- [ ] Model Family as One
- [ ] Forecast Probability Error Bars

Range of X Axis

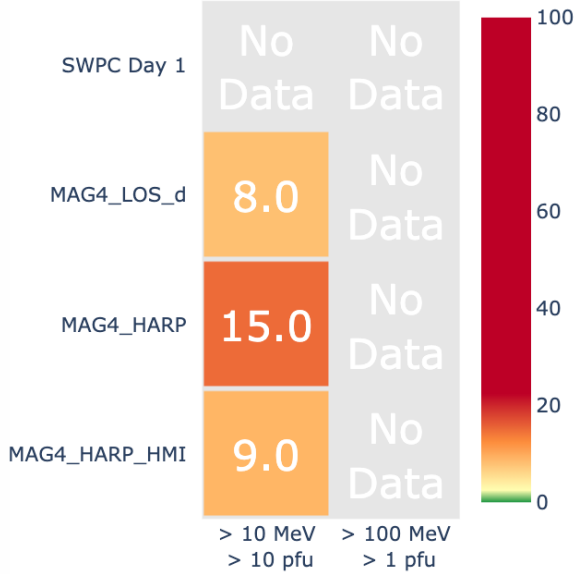
4 days of data

SEP Scoreboard

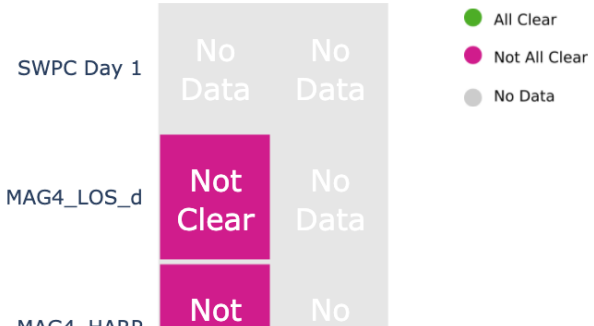
-1 week | -1 day | -1 hour | 2017-09-08 00:00 | +1 hour | +1 day | +1 week | Today

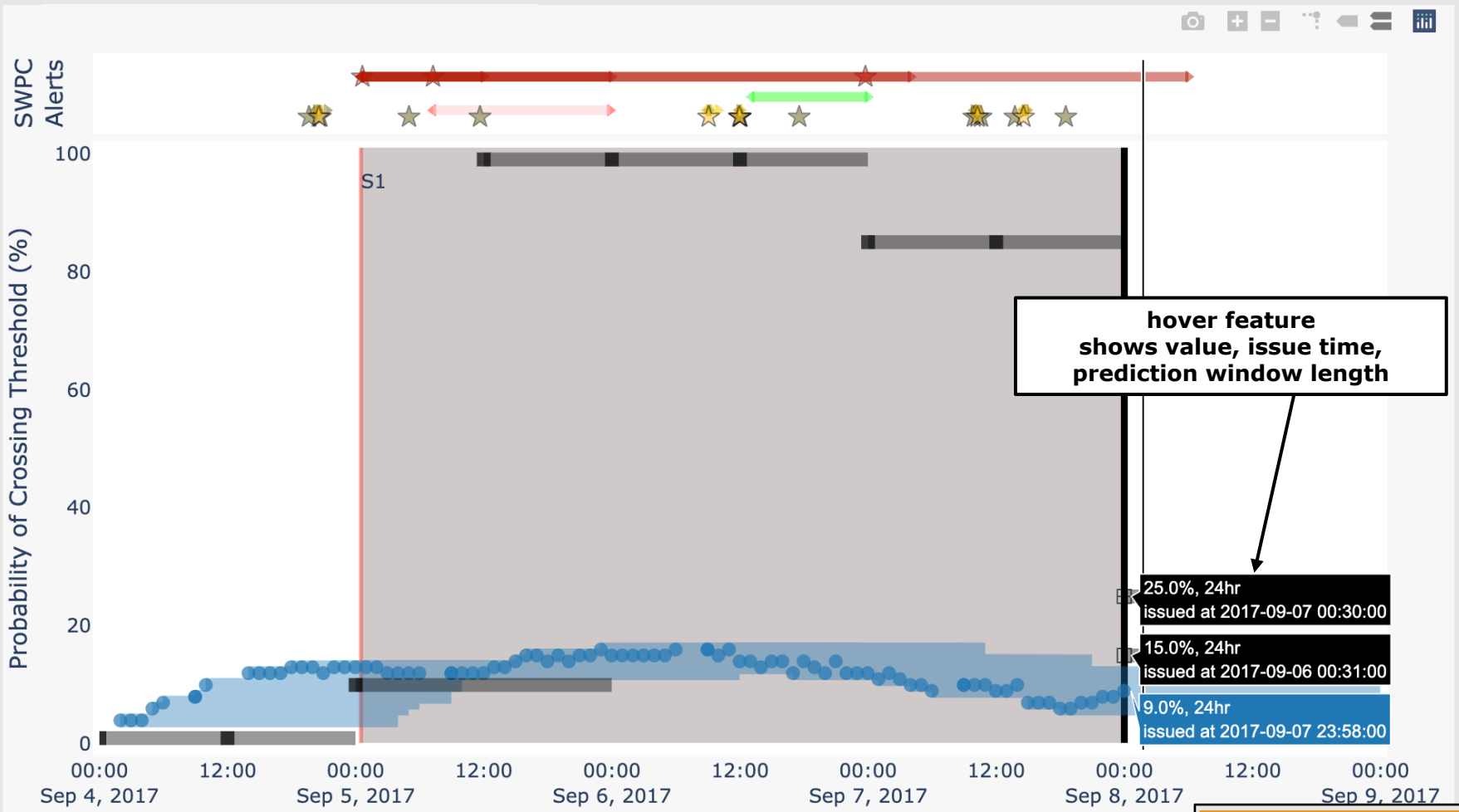
Refresh Plots

Proton Probability Forecasts: 2017-09-08 00:00 UT



Proton All Clear Forecasts: 2017-09-08 00:00 UT





MAG4_HARP: > 10 MeV > 10 pfu

MAG4_HARP_FE: > 10 MeV > 10 pfu

MAG4_HARP_HMI: > 10 MeV > 10 pfu

MAG4_LOS_d: > 10 MeV > 10 pfu

MAG4_LOS_FEd: > 10 MeV > 10 pfu

SWPC Day 1: > 10 MeV > 10 pfu

SWPC Day 2: > 10 MeV > 10 pfu

SWPC Day 2 (future onl > 10 MeV > 10 pfu

SWPC Day 3: > 10 MeV > 10 pfu

SWPC Day 3 (future only): > 10 MeV > 10 pfu

Graph Show Options

- [ ] Auto Refresh
- [x] Prediction Window Bars
- [ ] Model Family as One
- [ ] Forecast Probability Error Bars

Range of X Axis

4 days of data

Preview

SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-08 01:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Probability Forecasts: 2017-09-08 01:00 UT

Probability of Crossing Threshold (%)

	> 10 MeV > 10 pfu	> 100 MeV > 1 pfu
SWPC Day 1	99.0	No Data
MAG4_LOS_d	8.0	No Data
MAG4_HARP	14.0	No Data
MAG4_HARP_HMI	8.0	No Data

100 80 60 40 20 0

Proton All Clear Forecasts: 2017-09-08 01:00 UT

SWPC Day 1	Not Clear	No Data
MAG4_LOS_d	Not Clear	No Data
	Not	No

Graph Show Options

- [ ] Auto Refresh
- [ ] Prediction Window Bars
- [x] Model Family as One
- [ ] Forecast Probability Error Bars

Range of X Axis

4 days of data

SWPC Alerts

S1

model family feature: uses same symbol for all model variations

Probability of Crossing Threshold (%)

100 80 60 40 20 0

12:00 Sep 4, 2017 | 00:00 Sep 5, 2017 | 12:00 | 00:00 Sep 6, 2017 | 12:00 | 00:00 Sep 7, 2017 | 12:00 | 00:00 Sep 8, 2017

mag4: > 10 MeV > 10 pfu

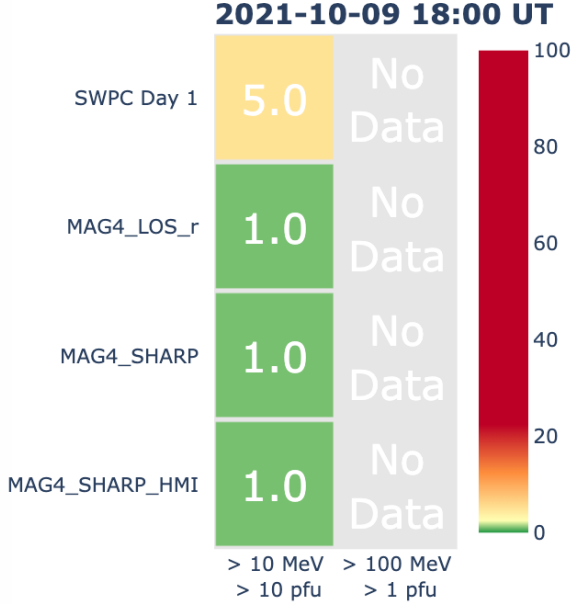
swpc: > 10 MeV > 10 pfu

SEP Scoreboard

-1 week | -1 day | -1 hour | 2021-10-09 18:00 | +1 hour | +1 day | +1 week | Tod

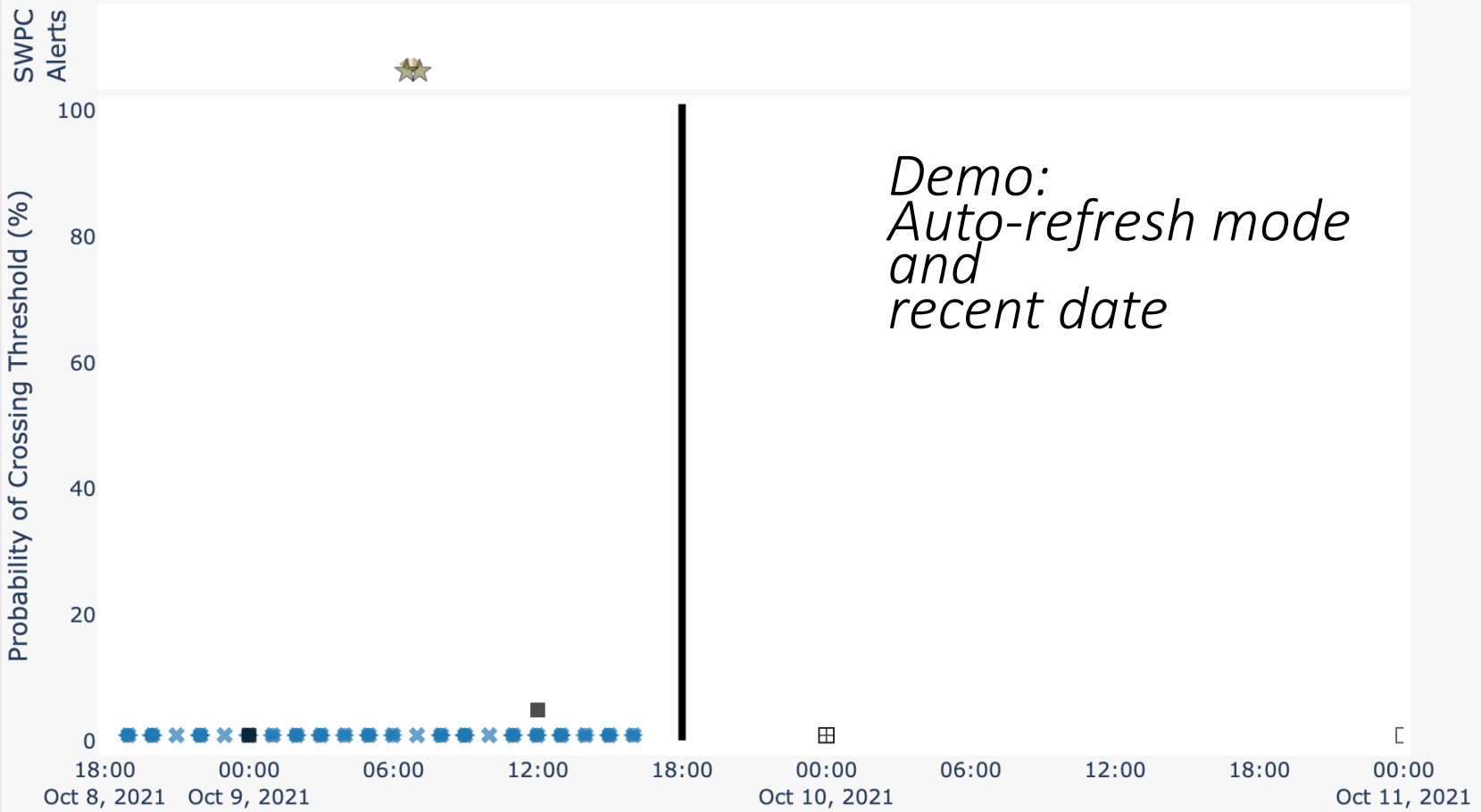
Refresh Plots

Proton Probability Forecasts: 2021-10-09 18:00 UT



Proton All Clear Forecasts: 2021-10-09 18:00 UT

selected date/time: 2021-10-09 18:00 UT



Demo Screenshots: Intensity Time Series

(shown in simulated real-time mode)

SEP Scoreboard

Demo: Intensity time series and intensity heat map

-1 week | -1 day | -1 hour | 2017-09-04 12:00 | +1 hour | +1 day | +1 week | Today | Refresh Plots

Proton Intensity Forecasts:

2017-09-04 12:00 UT

	> 10 MeV	> 100 MeV
GOES	0.1	0.03
SEPMOD	No Data	No Data
SEPSTER	No Data	No Data
SEPSTER2D	No Data	No Data
UMASEP	Clear	Clear

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}

not clear / clear / no data

Proton All Clear Forecasts:

2017-09-04 12:00 UT

GOES	Clear	Clear	N/A

selected date/time: 2017-09-04 12:00 UT

CURRENT TIME

SWPC Alerts

Proton Intensity (cm^2 sr s)$^{-1}$

10^2, 10^1, 10^0, 10^{-1}, 10^{-2}

GOES: > 10 MeV
GOES: > 100 MeV
HESPERIA REleASE ACE 30-min: 15.8 - 39.8 MeV
HESPERIA REleASE ACE 30-min: 28.2 - 50.1 MeV
HESPERIA REleASE ACE 60-min: 15.8 - 39.8 MeV
HESPERIA REleASE ACE 60-min: 28.2 - 50.1 MeV
HESPERIA REleASE ACE 90-min: 15.8 - 39.8 MeV
HESPERIA REleASE ACE 90-min: 28.2 - 50.1 MeV
HESPERIA REleASE SOHO 30-min: 15.8 - 39.8 MeV
HESPERIA REleASE SOHO 60-min: 15.8 - 39.8 MeV
HESPERIA REleASE SOHO 60-min: 28.2 - 50.1 MeV
HESPERIA REleASE SOHO 90-min: 15.8 - 39.8 MeV
HESPERIA REleASE SOHO 90-min: 28.2 - 50.1 MeV
SEPSTER (Parker Spiral): > 10.0 MeV
SEPSTER (Parker Spiral): 14.0 - 24.0 MeV
SEPSTER (Parker Spiral): > 30.0 MeV
SEPSTER (Parker Spiral): > 50.0 MeV
SEPSTER (Parker Spiral): > 100.0 MeV
SEPSTER (WSA-ENLIL): > 10.0 MeV
SEPSTER (WSA-ENLIL): 14.0 - 24.0 MeV
SEPSTER (WSA-ENLIL): > 30.0 MeV
SEPSTER (WSA-ENLIL): > 50.0 MeV
SEPSTER (WSA-ENLIL): > 100.0 MeV

12:00 Sep 2, 2017 | 18:00 | 00:00 Sep 3, 2017 | 06:00 | 12:00 | 18:00 | 00:00 Sep 4, 2017 | 06:00 | 12:00

SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-04 22:40 | +1 hour | +1 day | +1 week | Today | Refresh Plots

Proton Intensity Forecasts:

2017-09-04 22:40 UT

	> 10 MeV	> 100 MeV
GOES	0.5	0.06
SEPMOD	No Data	No Data
SEPSTER	No Data	No Data
SEPSTER2D	No Data	No Data
UMASEP	Clear	Clear

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}; not clear; clear; no data

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}; not clear; clear; no data

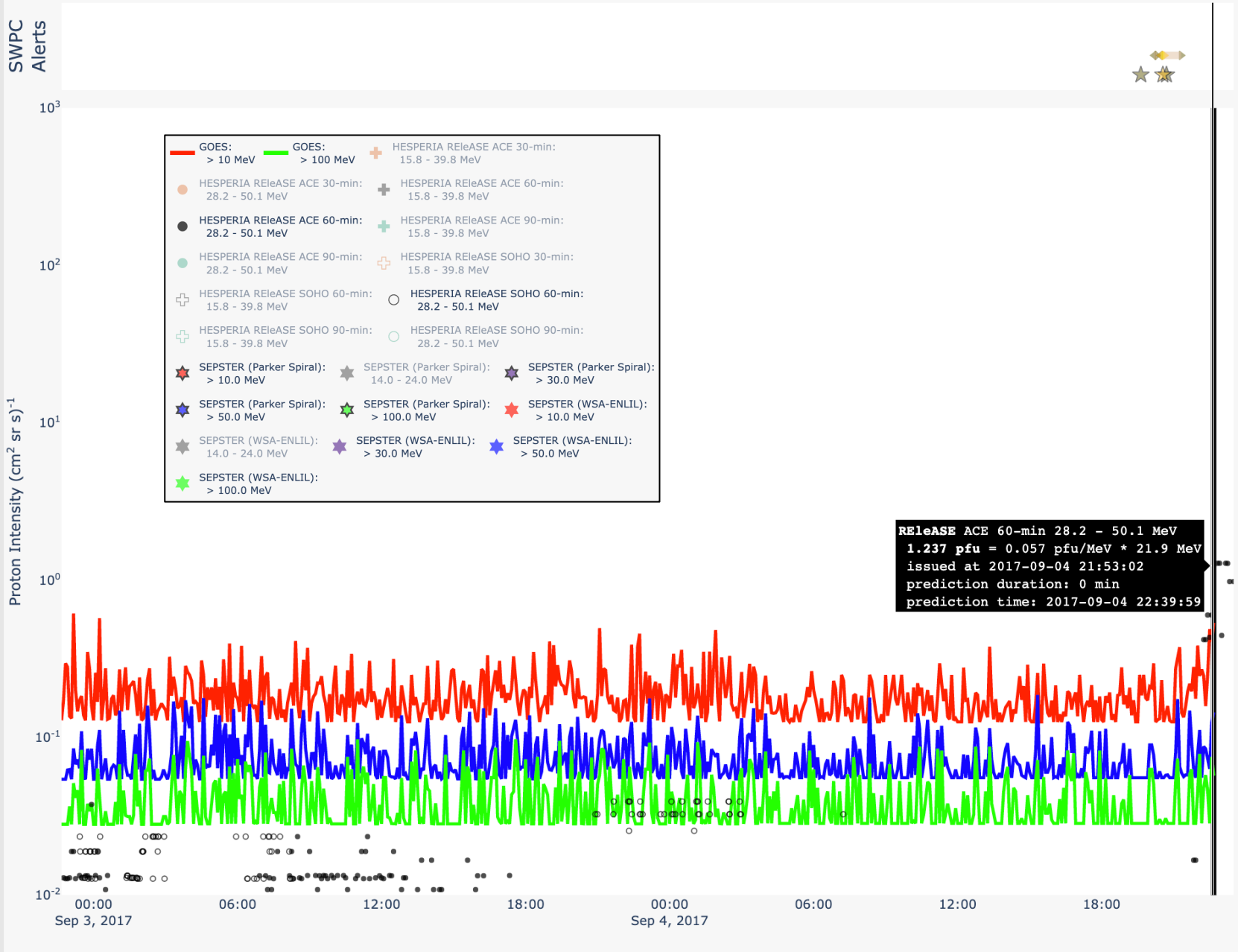
Proton All Clear Forecasts:

2017-09-04 22:40 UT

GOES	Clear	Clear	N/A
SEPMOD	No	No	N/A

selected date/time: 2017-09-04 22:40 UT

SWPC Alerts



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-05 00:15 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-05 00:15 UT

	> 10 MeV	> 100 MeV
GOES	5.4	0.07
SEPMOD	No Data	No Data
SEPSTER	14.2	0.14
SEPSTER2D	103.8	0.27
UMASEP	29.3 ± 6.7	Clear

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

ACE Electron: 175.0 - 315.0 MeV | GOES: > 10 MeV | GOES: > 30 MeV | GOES: > 50 MeV | GOES: > 100 MeV

HESPERIA REleASE ACE 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE ACE 60-min: 28.2 - 50.1 MeV

HESPERIA REleASE SOHO 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE SOHO 60-min: 28.2 - 50.1 MeV

SEPSTER (Parker Spiral): > 10.0 MeV | SEPSTER (Parker Spiral): 14.0 - 24.0 MeV | SEPSTER (Parker Spiral): > 30.0 MeV

SEPSTER (Parker Spiral): > 50.0 MeV | SEPSTER (Parker Spiral): > 100.0 MeV | SEPSTER (WSA-ENLIL): > 10.0 MeV

SEPSTER (WSA-ENLIL): 14.0 - 24.0 MeV | SEPSTER (WSA-ENLIL): > 30.0 MeV | SEPSTER (WSA-ENLIL): > 50.0 MeV

SEPSTER (WSA-ENLIL): > 100.0 MeV | SEPSTER2D: > 10.0 MeV | SEPSTER2D: > 100.0 MeV | UMASEP-10: > 10 MeV | UMASEP-30: > 30 MeV

selected date/time: 2017-09-05 00:15 UT

SWPC Alerts

Additional Information (URL) for Selected Point or All Clear Box:

https://webtools.ccmc.gsfc.nasa.gov/DONKI/view/CME/12987/-1

SEPSTER2D >10 MeV
53.69 pfu
Intensity range with uncertainty: 33.65 - 85.67999999999999 pfu
issued at 2017-09-04 23:45:00
prediction window duration: 1d 12hr
prediction window start: 2017-09-04 19:39:00
prediction window end: 2017-09-06 07:39:00

Fluence: 3956000.0 cm^-2*sr^-1
uncertainty: 1502000.0 - 2421000.0 cm^-2*sr^-1

Input CME parameters:
start time: 2017-09-04 19:39:00
speed: 710 km/s **half-width:** 25°
longitude: 26° **latitude:** -6°
time@height 21.5 Rs: 2017-09-04 23:45:00

Proton Intensity (cm^2 sr s)$^{-1}$

10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}

12:00 Sep 3, 2017 | 00:00 Sep 4, 2017 | 12:00 | 00:00 Sep 5, 2017 | 12:00 | 00:00 Sep 6, 2017

SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-05 01:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-05 01:00 UT

	> 10 MeV	> 100 MeV
GOES	11.4	0.05
SEPMOD	No Data	No Data
SEPSTER	14.2	0.14
SEPSTER2D	103.8	0.27
UMASEP	39.8 ± 9.2	Clear

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}; not cl; clear; no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}; not clear; clear; no data

ACE Electron: 175.0 - 315.0 MeV | GOES: > 10 MeV | GOES: > 30 MeV | GOES: > 50 MeV | GOES: > 100 MeV

HESPERIA REleASE ACE 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE ACE 60-min: 28.2 - 50.1 MeV

HESPERIA REleASE SOHO 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE SOHO 60-min: 28.2 - 50.1 MeV

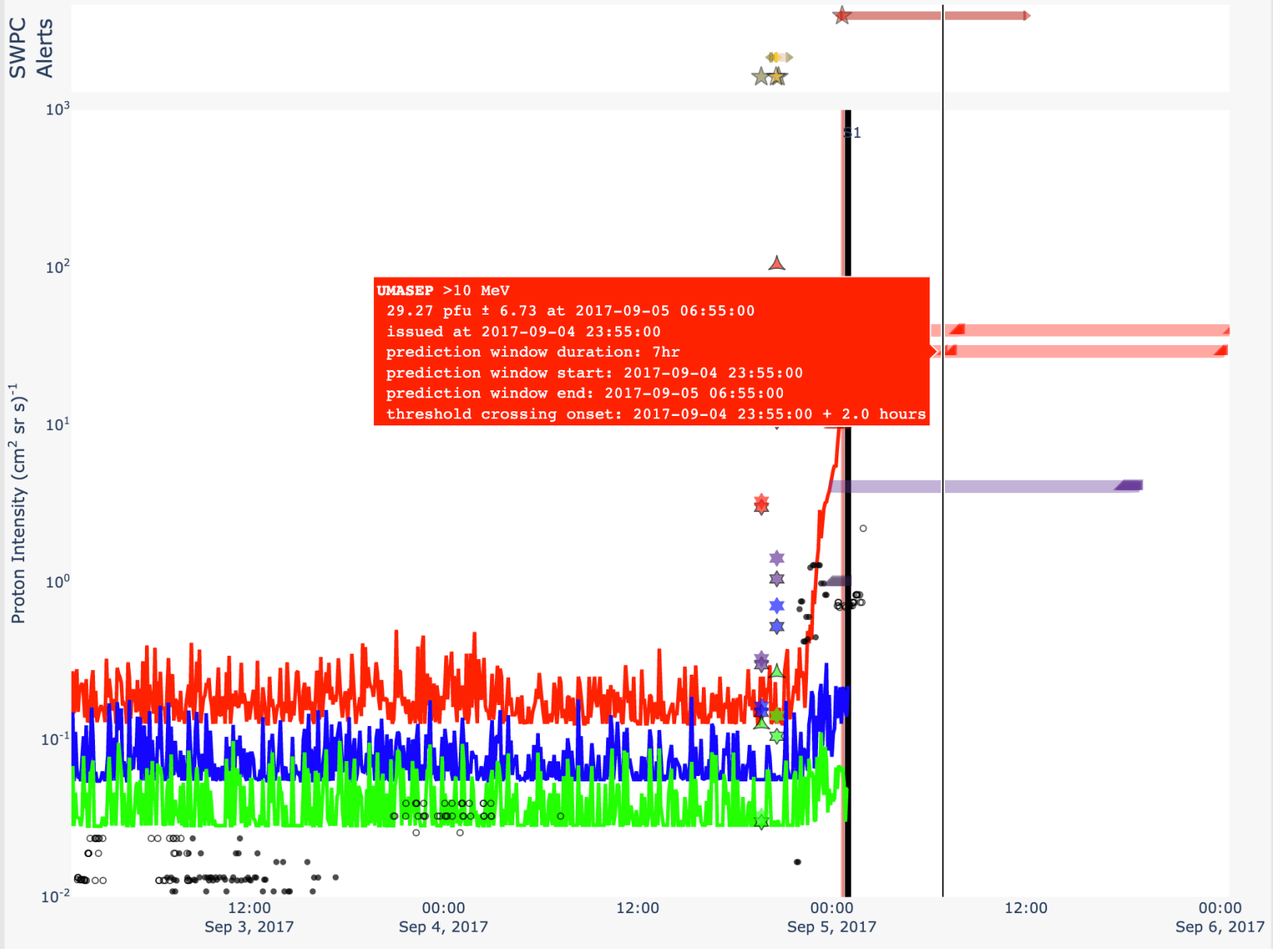
SEPSTER (Parker Spiral): > 10.0 MeV | SEPSTER (Parker Spiral): 14.0 - 24.0 MeV | SEPSTER (Parker Spiral): > 30.0 MeV

SEPSTER (Parker Spiral): > 50.0 MeV | SEPSTER (Parker Spiral): > 100.0 MeV | SEPSTER (WSA-ENLIL): > 10.0 MeV

SEPSTER (WSA-ENLIL): 14.0 - 24.0 MeV | SEPSTER (WSA-ENLIL): > 30.0 MeV | SEPSTER (WSA-ENLIL): > 50.0 MeV

SEPSTER (WSA-ENLIL): > 100.0 MeV | SEPSTER2D: > 10.0 MeV | SEPSTER2D: > 100.0 MeV | UMASEP-10: > 10 MeV | UMASEP-30: > 30 MeV

selected date/time: 2017-09-05 01:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-05 02:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-05 02:00 UT

	> 10 MeV	> 100 MeV
GOES	26.6	0.08
SEPMOD	163.8	2.765
SEPSTER	14.2	0.14
SEPSTER2D	103.8	0.27
UMASEP	39.8 ± 9.2	Clear

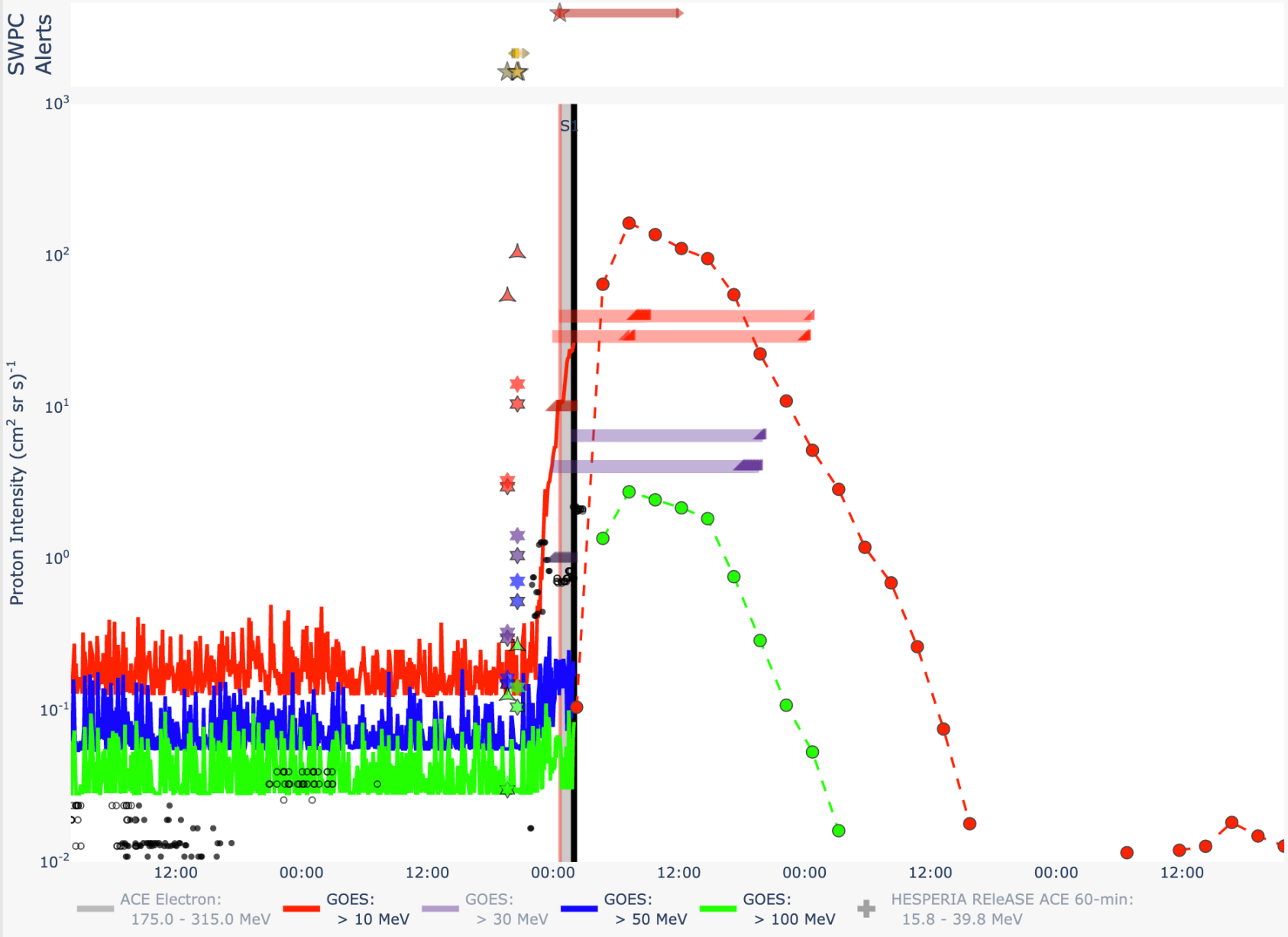
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-05 02:00 UT

selected date/time: 2017-09-05 02:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-05 02:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-05 02:00 UT

	> 10 MeV	> 100 MeV
GOES	26.6	0.08
SEPMOD	163.8	2.765
SEPSTER	14.2	0.14
SEPSTER2D	103.8	0.27
UMASEP	39.8 ± 9.2	Clear

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-05 02:00 UT

selected date/time: 2017-09-05 02:00 UT

SWPC Alerts

SEPMOD (DONKI) >10.0 MeV
163.8 pfu
2017-09-05 07:15:00
peak intensity max: None
peak intensity onset: 163.8 pfu
peak intensity ESP: None
issued at 2017-09-05 01:38:00

prediction window duration: 7d 0hr
start: 2017-09-04 00:00:00
end: 2017-09-11 00:02:00
threshold crossing onset: 2017-09-05 02:15:00 (0.001 pfu)

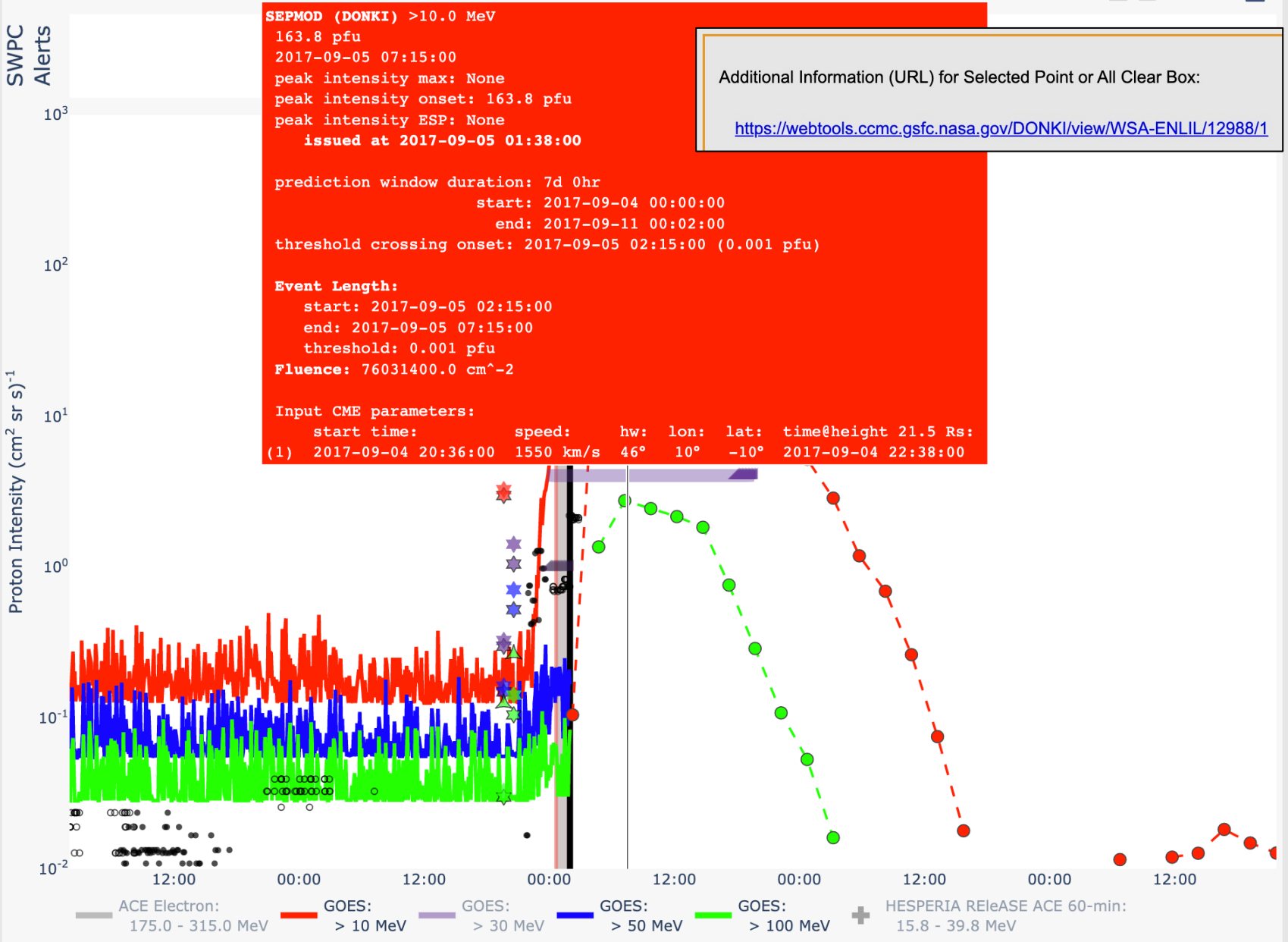
Event Length:
start: 2017-09-05 02:15:00
end: 2017-09-05 07:15:00
threshold: 0.001 pfu
Fluence: 76031400.0 cm^-2

Input CME parameters:

	start time:	speed:	hw:	lon:	lat:	time@height 21.5 Rs:
(1)	2017-09-04 20:36:00	1550 km/s	46°	10°	-10°	2017-09-04 22:38:00

Additional Information (URL) for Selected Point or All Clear Box:

https://webtools.ccmc.gsfc.nasa.gov/DONKI/view/WSA-ENLIL/12988/1



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-06 12:15 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-06 12:15 UT

	> 10 MeV	> 100 MeV
GOES	25.8	0.04
SEPMOD	40.45	0.681
SEPSTER	0.5	0.0
SEPSTER2D	103.8	No Data
UMASEP	In Event	Clear

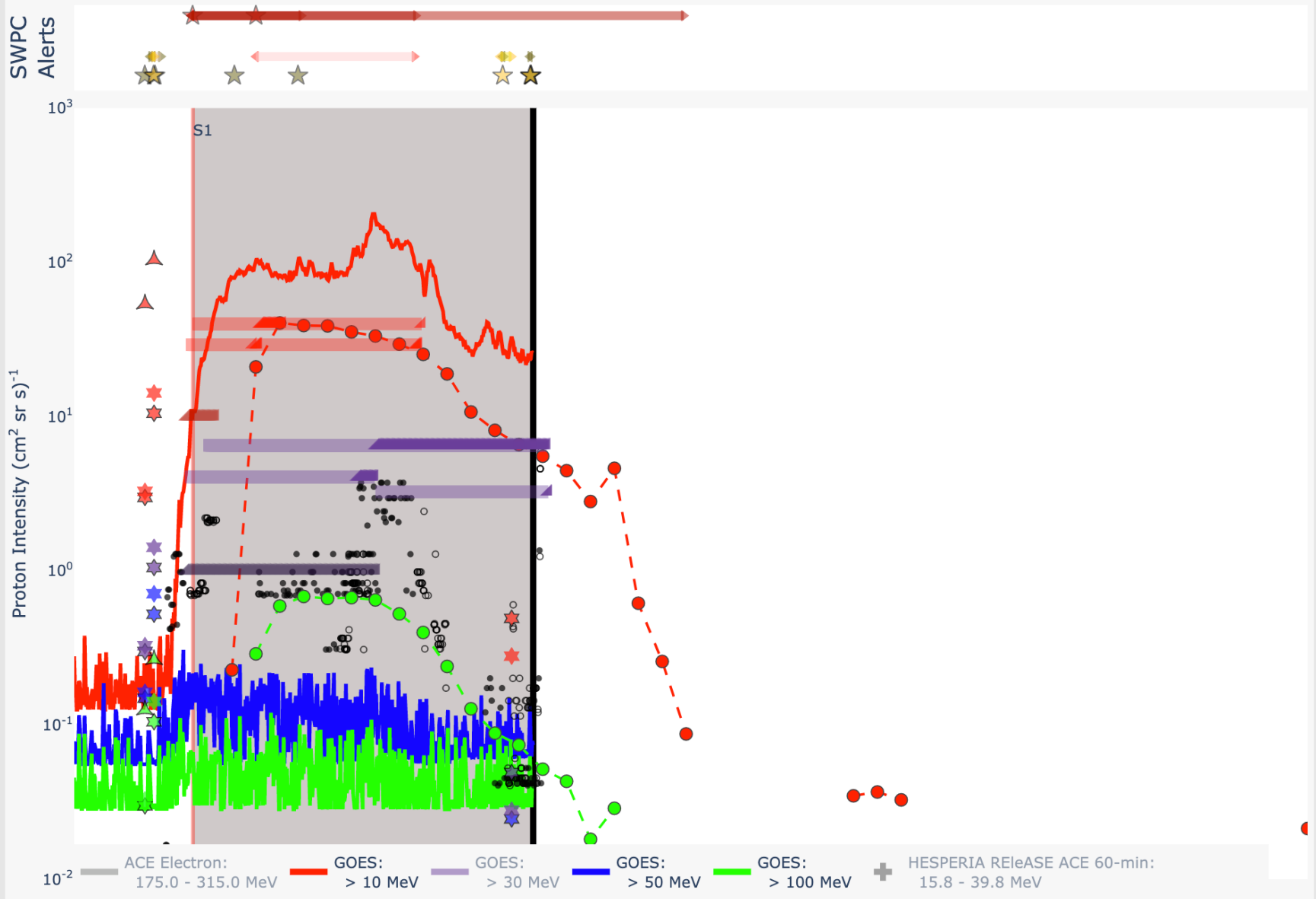
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no da

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-06 12:15 UT

selected date/time: 2017-09-06 12:15 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-07 02:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-07 02:00 UT

	> 10 MeV	> 100 MeV
GOES	174.0	0.09
SEPMOD	588.2	7.564
SEPSTER	4.4	0.04
SEPSTER2D	103.8	0.29
UMASEP	In Event	Clear

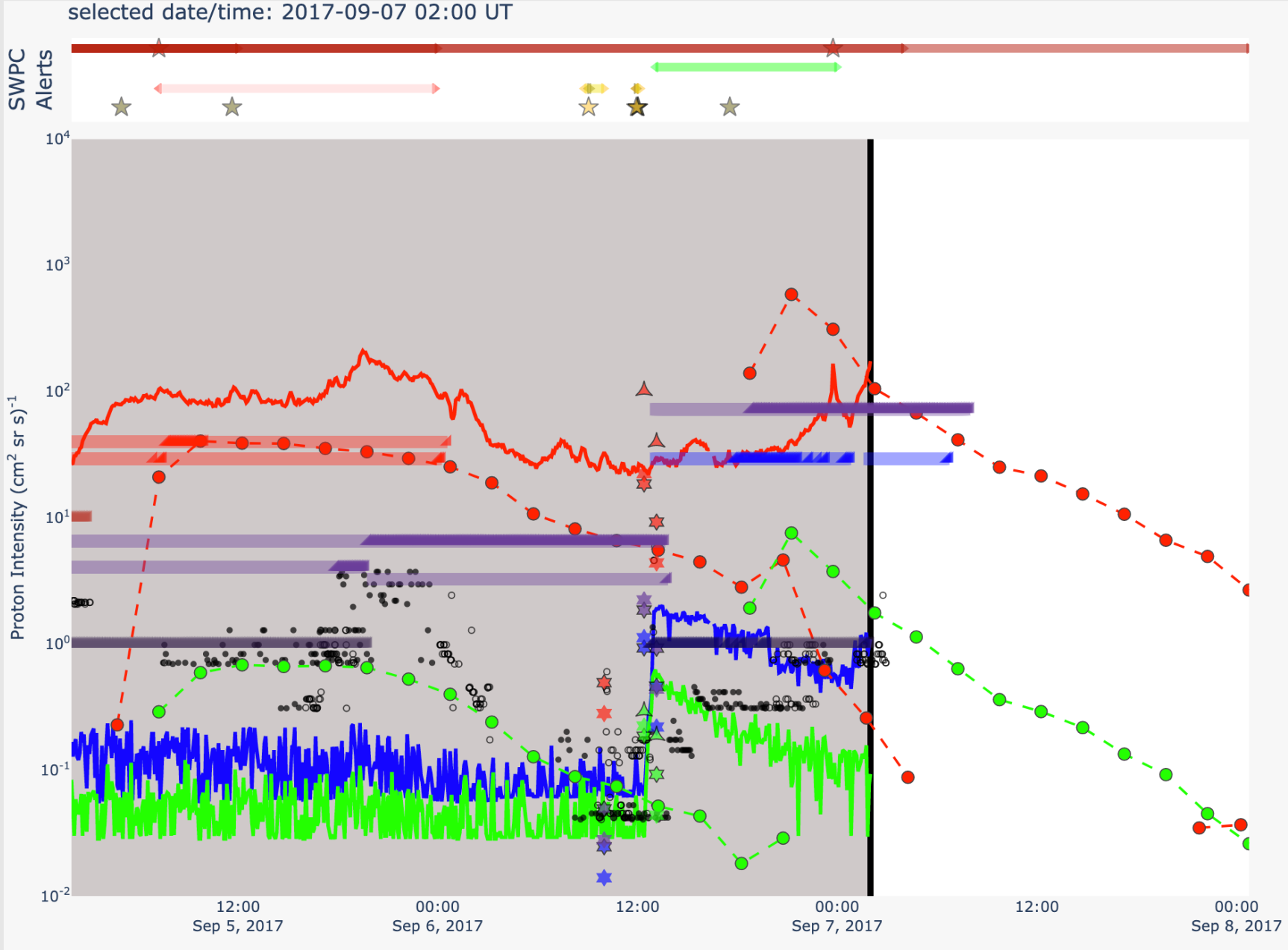
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-07 02:00 UT

selected date/time: 2017-09-07 02:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-10 16:20 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-10 16:20 UT

	> 10 MeV	> 100 MeV
GOES	1.0	0.39
SEPMOD	588.2	7.564
SEPSTER	No Data	No Data
SEPSTER2D	No Data	No Data
UMASEP	Clear	2.93 ± 0.7

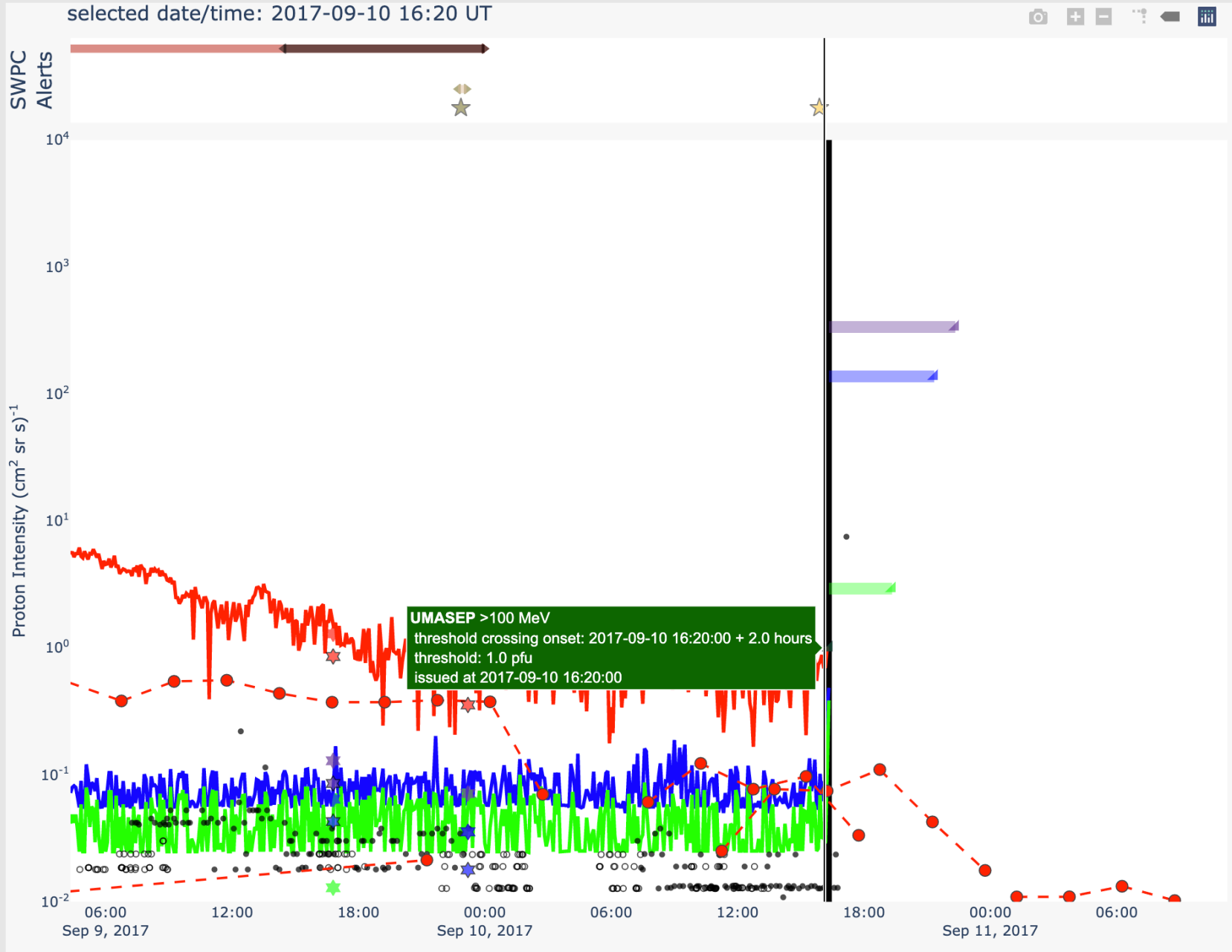
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-10 16:20 UT

selected date/time: 2017-09-10 16:20 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-10 16:31 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-10 16:31 UT

	> 10 MeV	> 100 MeV
GOES	3.3	2.52
SEPMOD	588.2	7.564
SEPSTER	No Data	No Data
SEPSTER2D	No Data	No Data
UMASEP	2210.6 ± 508.4	2.93 ± 0.7

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

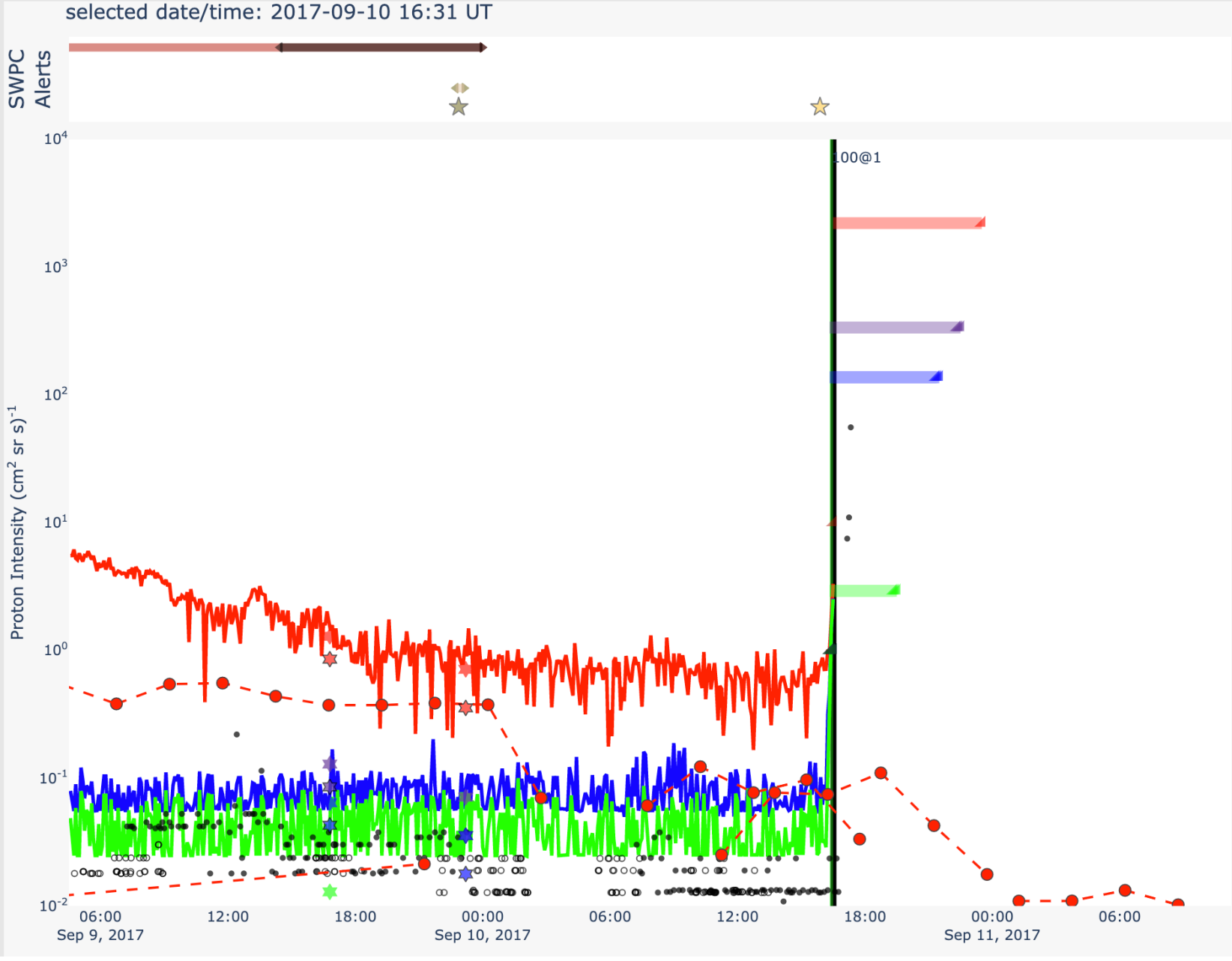
pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-10 16:31 UT

Not

selected date/time: 2017-09-10 16:31 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-10 18:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-10 18:00 UT

	> 10 MeV	> 100 MeV
GOES	684.0	24.7
SEPMOD	588.2	7.564
SEPSTER	3590.0	35.9
SEPSTER2D	2066.0	22.24
UMASEP	2321.1 ± 533.9	2.93 ± 0.7

pfu 10^6 10^5 10^4 10^3 10^2 10^1 10^0 10^{-1} 10^{-2} not cl clear no dat

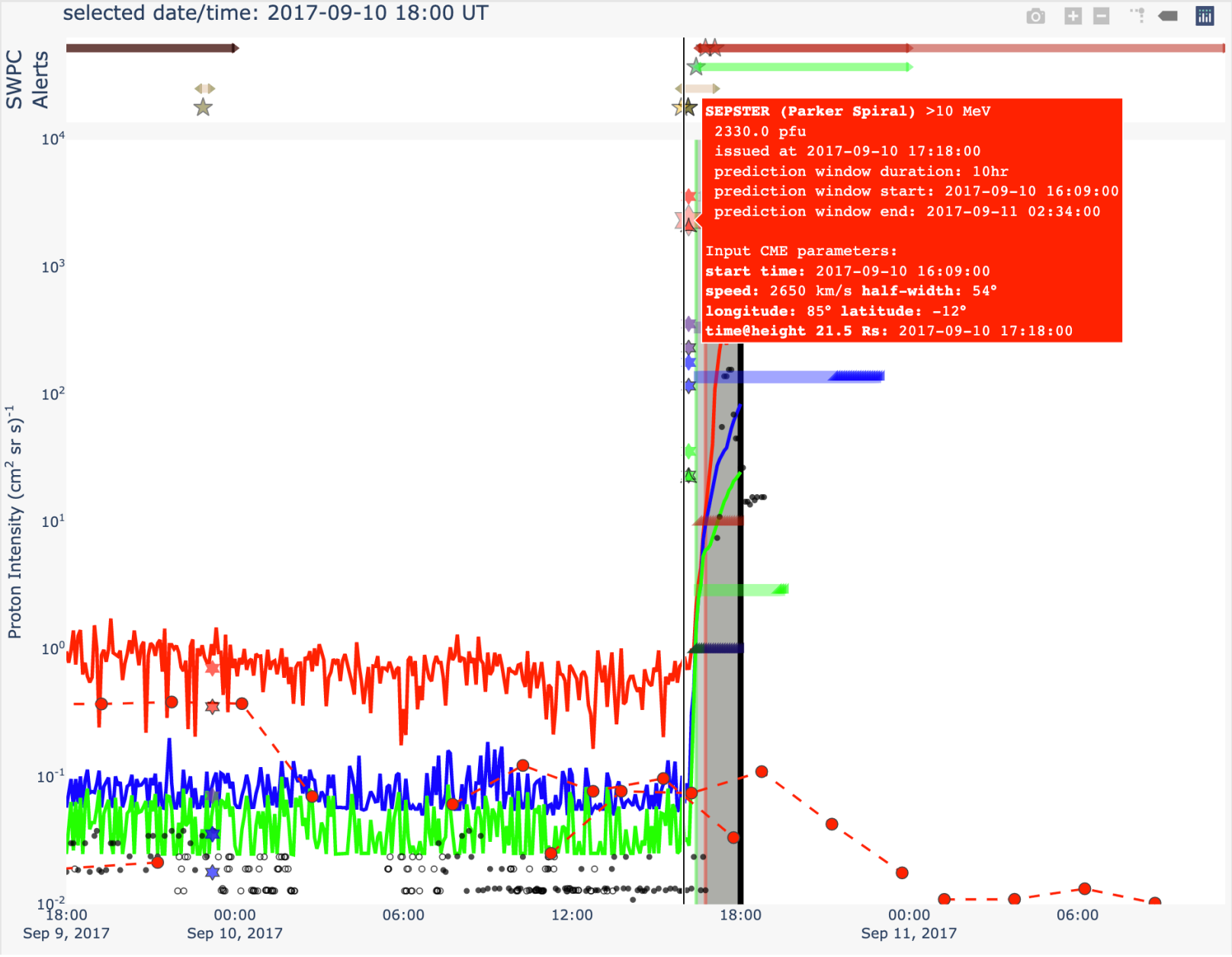
pfu 300 200 100 50 10 1 10^{-1} 10^{-2} 10^{-3} not clear clear no data

Proton All Clear Forecasts:

2017-09-10 18:00 UT

Not Not

selected date/time: 2017-09-10 18:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-10 19:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

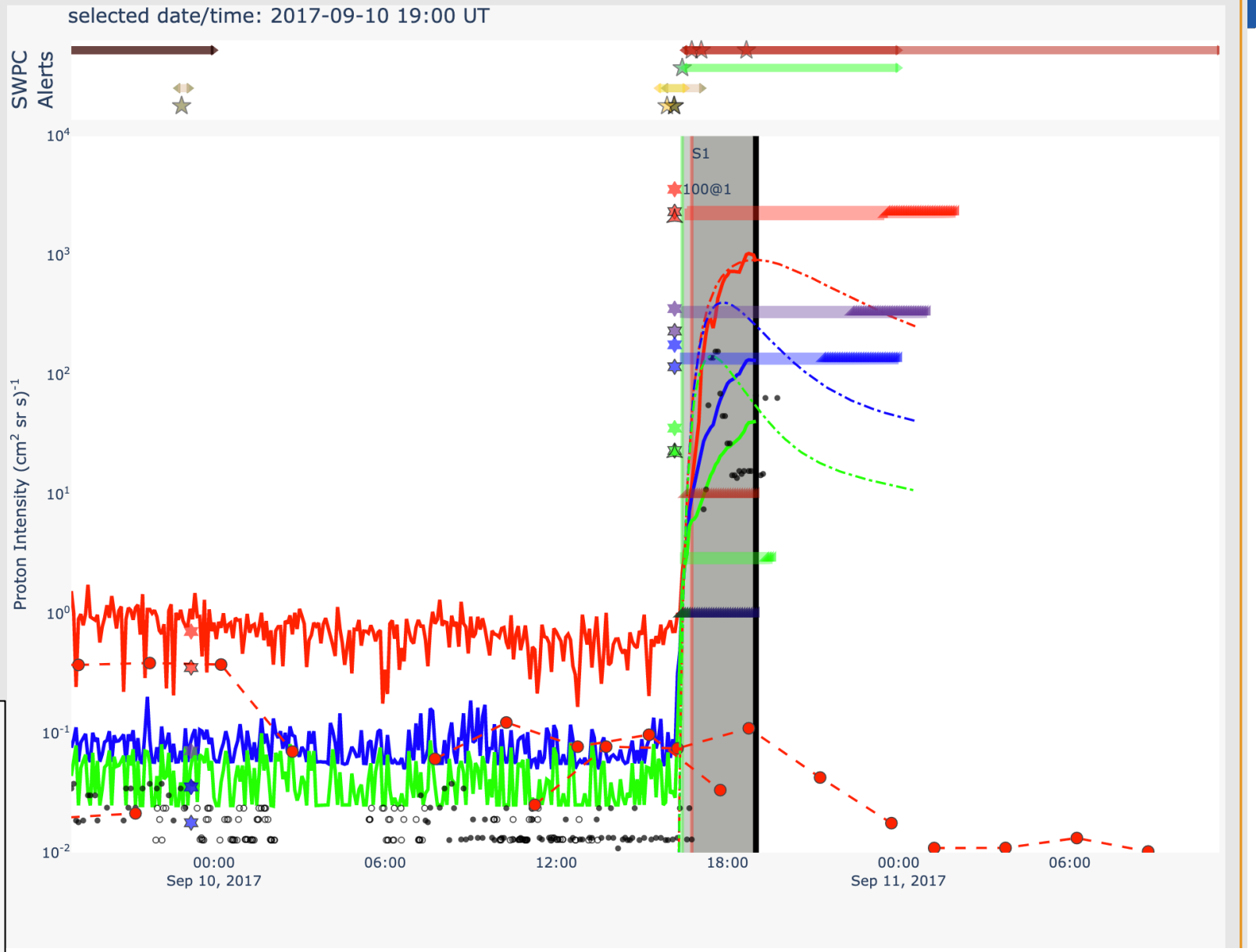
Proton Intensity Forecasts:

2017-09-10 19:00 UT

		pfu			pfu	
GOES	890.0	10^6	300	40.9	300	
SEPMOD	588.2	10^5	200	7.564	200	
SEPSTER	3590.0	10^4	100	35.9	100	
SEPSTER2D	2066.0	10^3	50	22.24	50	
UMASEP	2321.1 ± 533.9	10^2	10	2.93 ± 0.7	10	
		10^1	1		1	
		10^0	10^{-1}		10^{-1}	
		10^{-1}	10^{-2}		10^{-2}	
		10^{-2}	10^{-3}		10^{-3}	
		not cl	not clear		not clear	
		clear	clear		clear	
		no dat	no data		no data	

GOES: > 10 MeV | GOES: > 100 MeV | HESPERIA REleASE ACE 30-min: 15.8 - 39.8 MeV | HESPERIA REleASE ACE 30-min: 28.2 - 50.1 MeV | HESPERIA REleASE ACE 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE ACE 60-min: 28.2 - 50.1 MeV | HESPERIA REleASE ACE 90-min: 15.8 - 39.8 MeV | HESPERIA REleASE ACE 90-min: 28.2 - 50.1 MeV | HESPERIA REleASE SOHO 30-min: 15.8 - 39.8 MeV | HESPERIA REleASE SOHO 60-min: 15.8 - 39.8 MeV | HESPERIA REleASE SOHO 60-min: 28.2 - 50.1 MeV | HESPERIA REleASE SOHO 90-min: 15.8 - 39.8 MeV | HESPERIA REleASE SOHO 90-min: 28.2 - 50.1 MeV | SEPSTER (Parker Spiral): > 10.0 MeV | SEPSTER (Parker Spiral): 14.0 - 24.0 MeV | SEPSTER (Parker Spiral): > 30.0 MeV | SEPSTER (Parker Spiral): > 50.0 MeV | SEPSTER (Parker Spiral): > 100.0 MeV | SEPSTER (WSA-ENLIL): > 10.0 MeV | SEPSTER (WSA-ENLIL): 14.0 - 24.0 MeV | SEPSTER (WSA-ENLIL): > 30.0 MeV | SEPSTER (WSA-ENLIL): > 50.0 MeV | SEPSTER (WSA-ENLIL): > 100.0 MeV | STAT: > 10.0 MeV | STAT: > 50.0 MeV | STAT: > 100.0 MeV | UMASEP-100: > 100 MeV | UMASEP-10: > 10 MeV

selected date/time: 2017-09-10 19:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-10 20:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-10 20:00 UT

	> 10 MeV	> 100 MeV
GOES	558.0	45.7
SEPMOD	2345.0	35.4
SEPSTER	3590.0	35.9
SEPSTER2D	2066.0	22.24
UMASEP	2321.1 ± 533.9	In Event

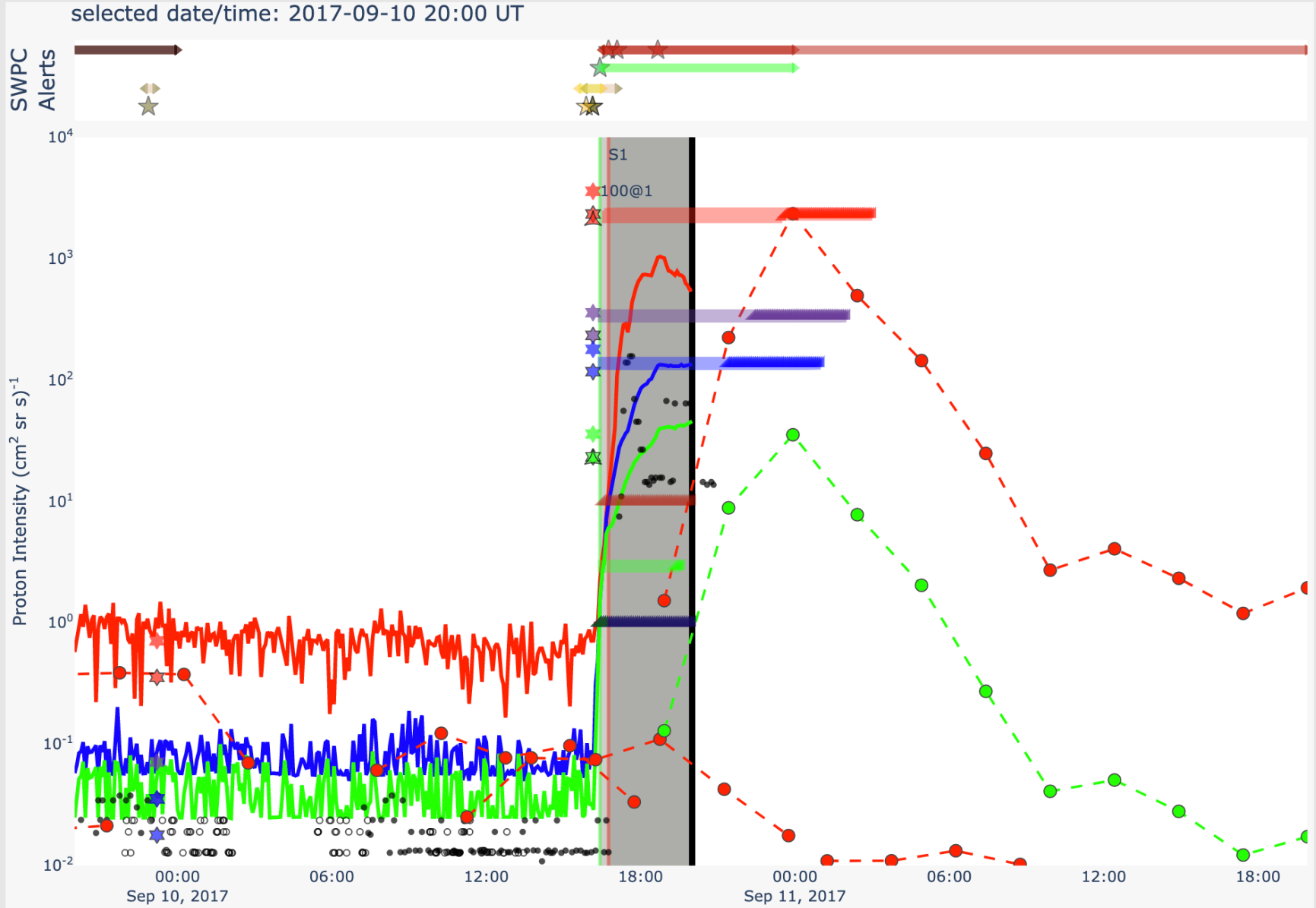
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}; not cl; clear; no da

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}; not clear; clear; no data

Proton All Clear Forecasts:

2017-09-10 20:00 UT

selected date/time: 2017-09-10 20:00 UT



SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-11 01:00 | +1 hour | +1 day | +1 week | Today

Refresh Plots

Proton Intensity Forecasts:

2017-09-11 01:00 UT

	> 10 MeV	> 100 MeV
GOES	1120.0	58.9
SEPMOD	2345.0	35.4
SEPSTER	2330.0	23.3
SEPSTER2D	2066.0	22.24
UMASEP	2321.1 ± 533.9	In Event

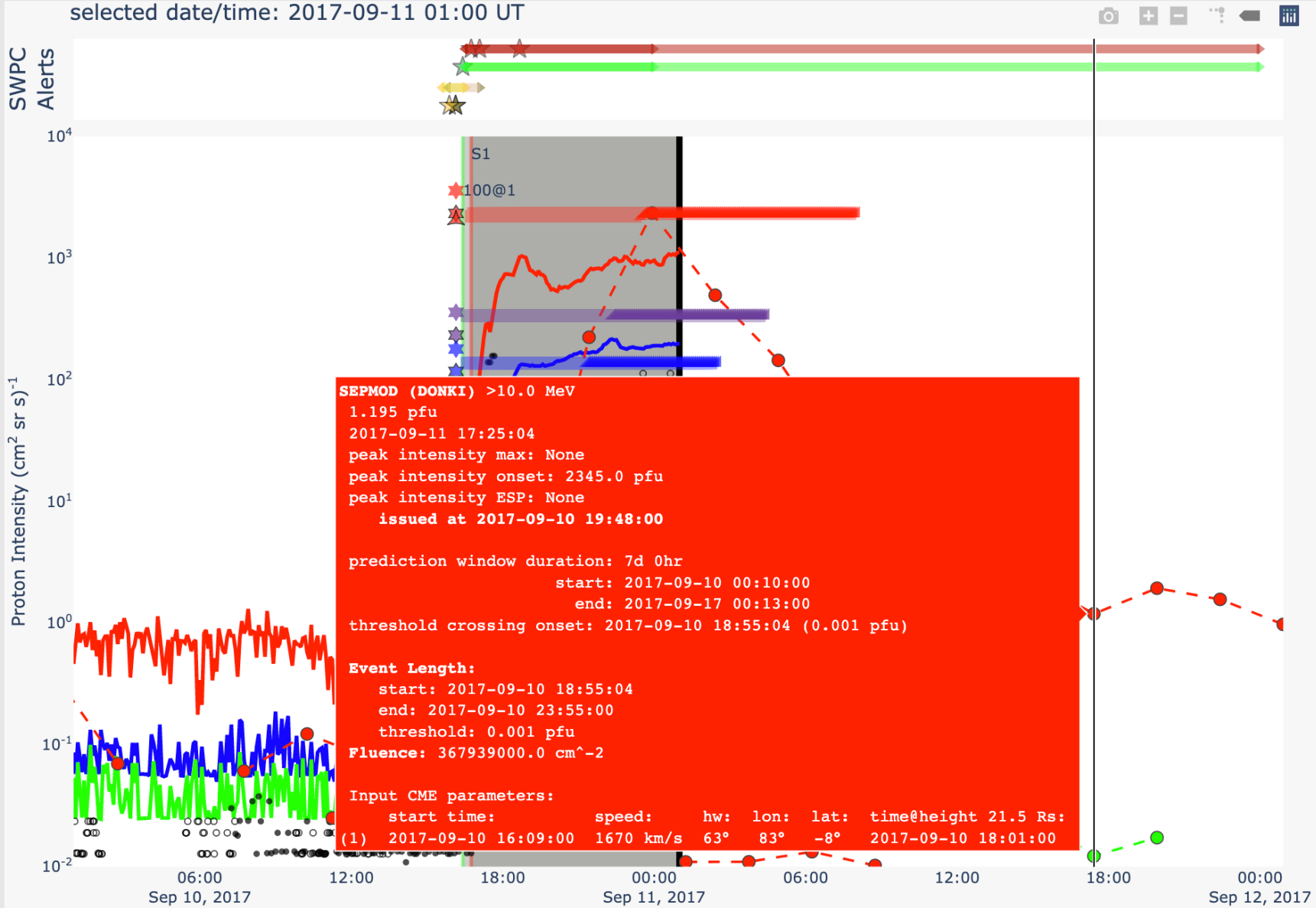
pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

2017-09-11 01:00 UT

selected date/time: 2017-09-11 01:00 UT



SEPMOD (DONKI) >10.0 MeV
1.195 pfu
2017-09-11 17:25:04
peak intensity max: None
peak intensity onset: 2345.0 pfu
peak intensity ESP: None
issued at 2017-09-10 19:48:00

prediction window duration: 7d 0hr
start: 2017-09-10 00:10:00
end: 2017-09-17 00:13:00
threshold crossing onset: 2017-09-10 18:55:04 (0.001 pfu)

Event Length:
start: 2017-09-10 18:55:04
end: 2017-09-10 23:55:00
threshold: 0.001 pfu
Fluence: 367939000.0 cm^-2

Input CME parameters:

	start time:	speed:	hw:	lon:	lat:	time@height 21.5 Rs:
(1)	2017-09-10 16:09:00	1670 km/s	63°	83°	-8°	2017-09-10 18:01:00

SEP Scoreboard

-1 week | -1 day | -1 hour | 2017-09-11 01:00 | +1 hour | +1 day | +1 week

Refresh Plots

Proton Intensity Forecasts:

2017-09-11 01:00 UT

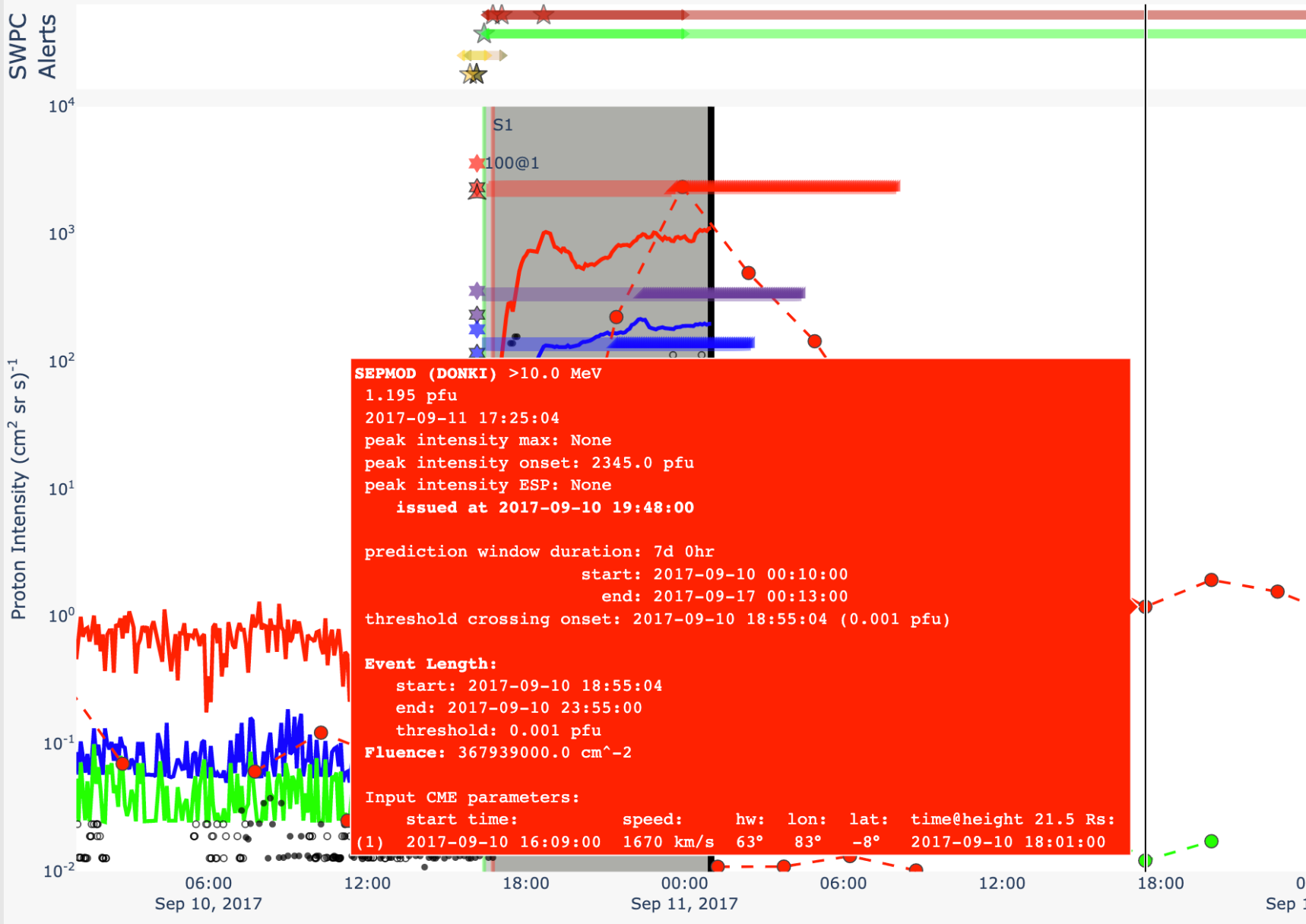
	> 10 MeV	> 100 MeV
GOES	1120.0	58.9
SEPMOD	2345.0	35.4
SEPSTER	2330.0	23.3
SEPSTER2D	2066.0	22.24
UMASEP	2321.1 ± 533.9	In Event

pfu: 10^6, 10^5, 10^4, 10^3, 10^2, 10^1, 10^0, 10^{-1}, 10^{-2}, not cl, clear, no dat

pfu: 300, 200, 100, 50, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, not clear, clear, no data

Proton All Clear Forecasts:

selected date/time: 2017-09-11 01:00 UT



SEPMOD (DONKI) >10.0 MeV
1.195 pfu
2017-09-11 17:25:04
peak intensity max: None
peak intensity onset: 2345.0 pfu
peak intensity ESP: None
issued at 2017-09-10 19:48:00

prediction window duration: 7d 0hr
start: 2017-09-10 00:10:00
end: 2017-09-17 00:13:00
threshold crossing onset: 2017-09-10 18:55:04 (0.001 pfu)

Event Length:
start: 2017-09-10 18:55:04
end: 2017-09-10 23:55:00
threshold: 0.001 pfu
Fluence: 367939000.0 cm^-2

Input CME parameters:

	start time:	speed:	hw:	lon:	lat:	time@height 21.5 Rs:
(1)	2017-09-10 16:09:00	1670 km/s	63°	83°	-8°	2017-09-10 18:01:00