Data Analysis and Software in Heliophysics (DASH)

Exploring the validation results of ASPECS within ADVISOR

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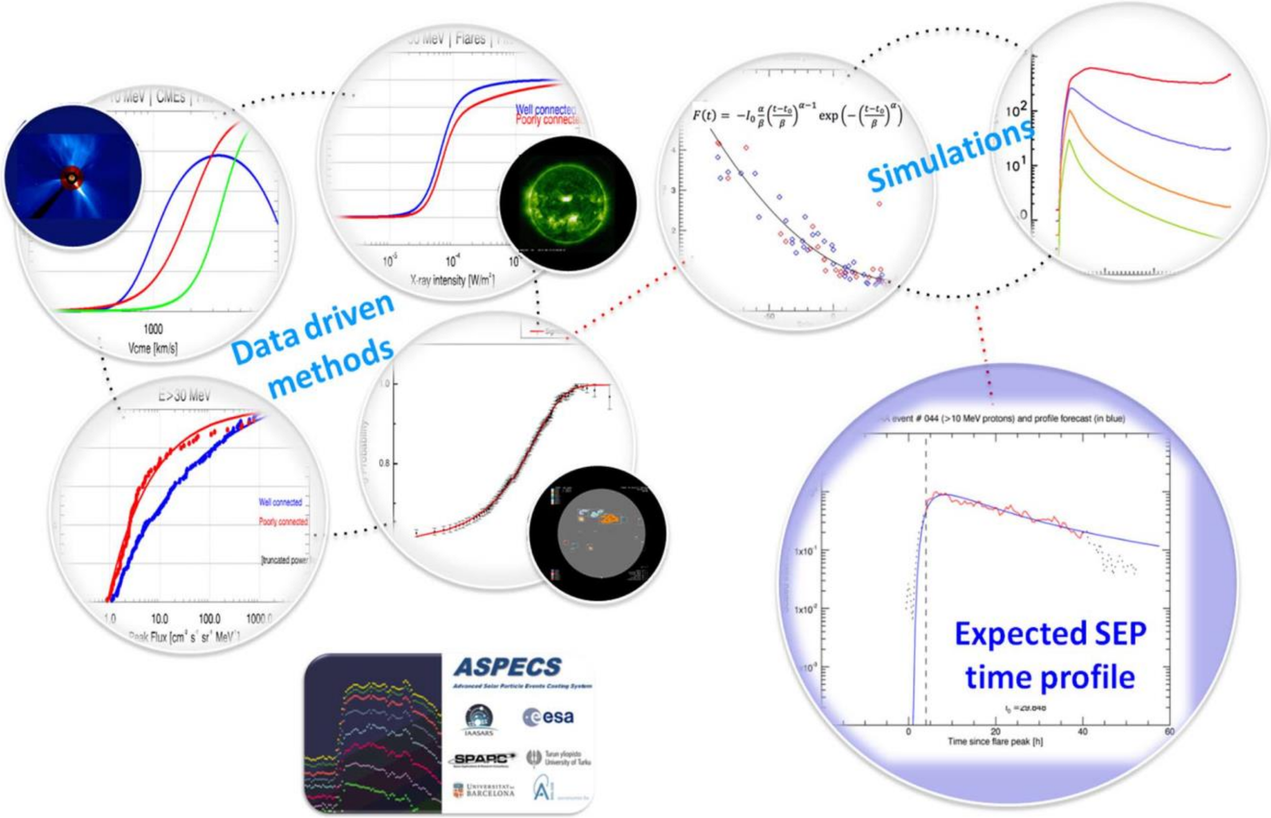
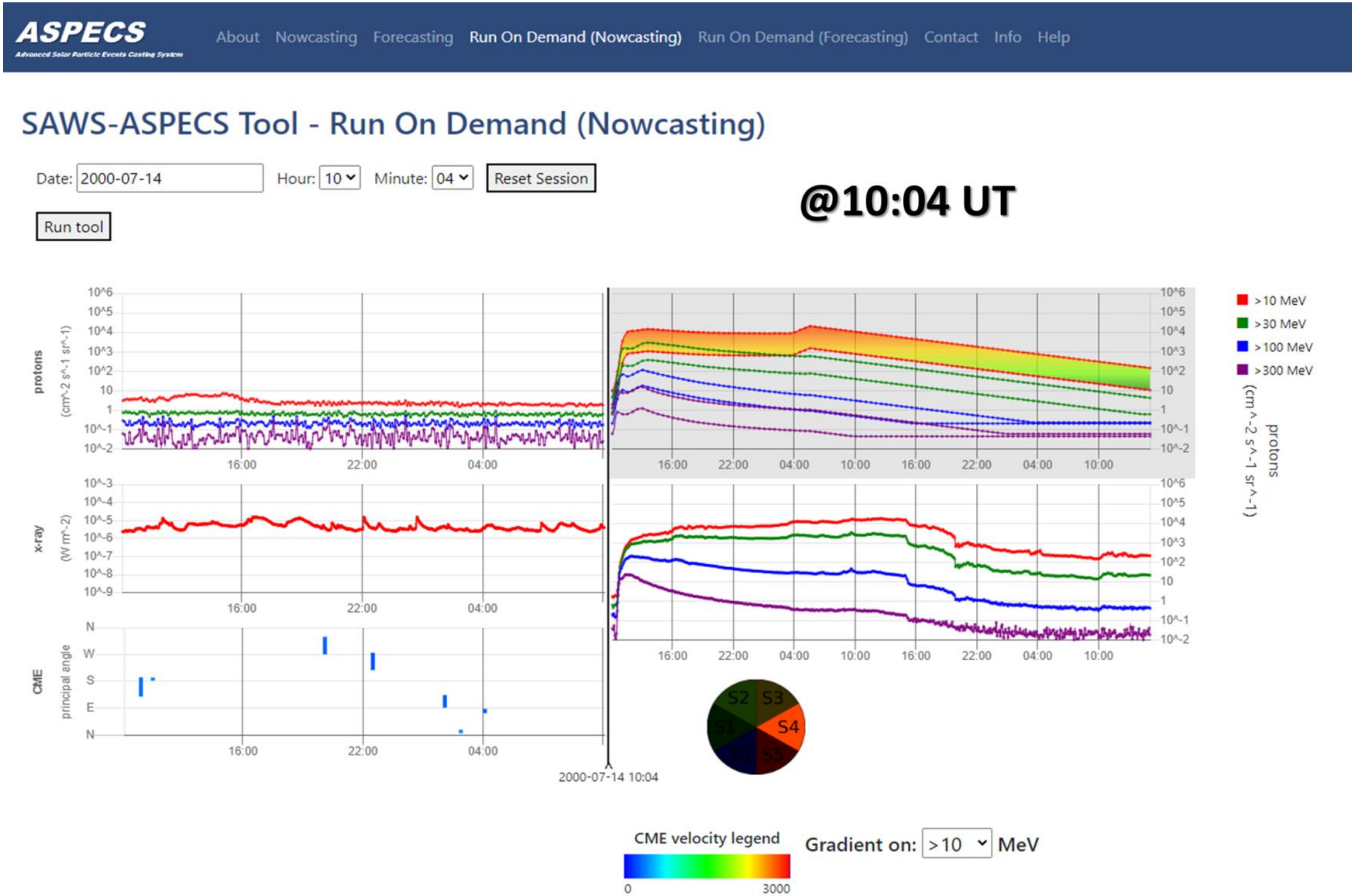
The ASPECS tool

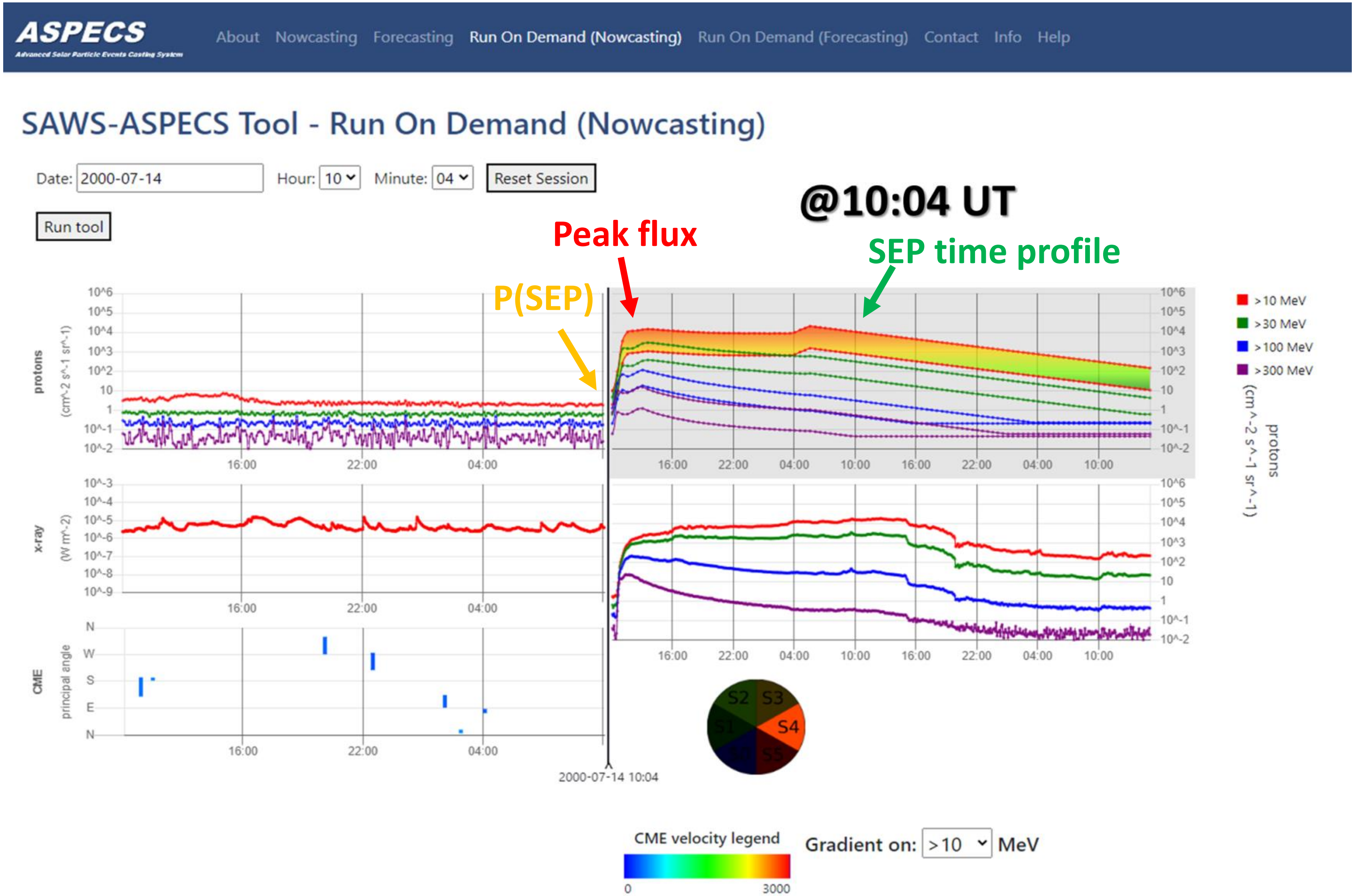
ASPECS - **A**dvanced **S**olar **P**article **E**vents **C**asting **S**ystem



The ASPECS tool

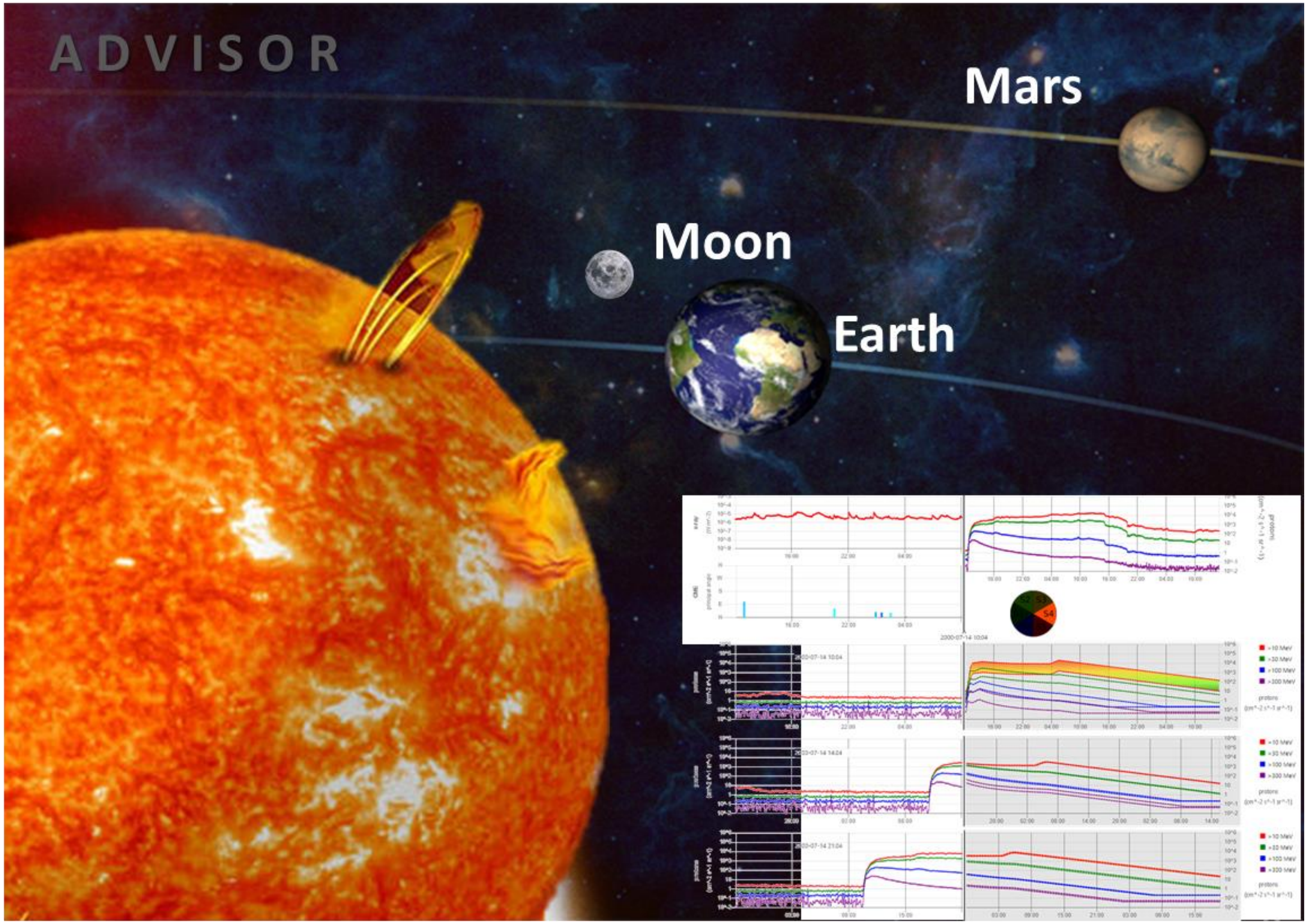


The ASPECS tool



The ADVISOR project

ADVISOR - OptimizAtion, DeliVery & Installation of the ASPECS tOol for Space WeatheR research within ISEP



Details by
George Vasalos

Today @16:30

Validation

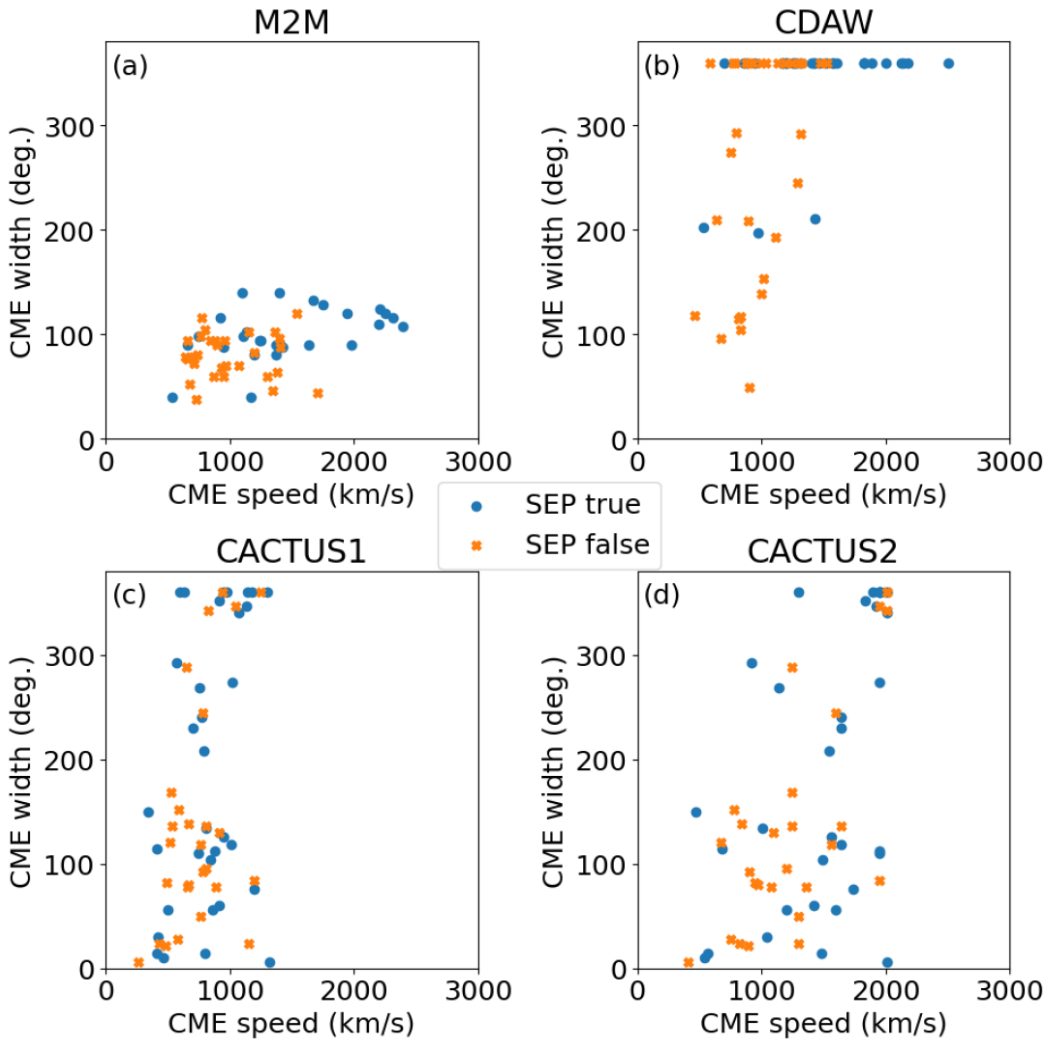
- The **SEP** Model **Val**idation Working Meeting (**SEPVAL**) sample

flare_date	flare_longitude	flare_magnitude	flare_class	cme_m2m_date	cme_m2m_speed	cme_m2m_width	cme_donki_date	cme_donki_speed	cme_donki_width	cme_soho_date	cme_soho_speed	cme_soho_width	cme_cactus1_date
2011-03-07 19:43:00	48	0.000037	M3.7	N/A	N/A	N/A	2011-03-07 20:00:00	1980	90	2011-03-07 20:00:00	2125	360	2011-03-07 20:12:00
2023-02-25 18:40:00	42	0.000063	M6.3	N/A	N/A	N/A	2023-02-25 19:24:05	920	116	2023-02-25 19:24:05	1170	360	2023-02-25 20:00:00
2014-02-25 00:41:00	-77	0.00049	X4.9	N/A	N/A	N/A	2014-02-25 01:25:00	1670	132	2014-02-25 01:25:00	2147	360	2014-02-25 01:25:00
N/A	N/A	N/A	N/A	N/A	N/A	N/A	2015-10-29 02:36:00	535	40	2015-10-29 02:36:00	530	202	2015-10-29 02:24:00
2017-09-10 15:35:00	88	0.00082	X8.2	2017-09-10 16:00:00	2314	116	N/A	N/A	N/A	2017-09-10 16:00:00	3163	360	2017-09-10 16:48:00
2017-09-04 20:28:00	16	0.000055	M5.5	N/A	N/A	N/A	N/A	N/A	N/A	2017-09-04 20:36:00	1418	360	2017-09-04 20:48:00
2012-03-07 01:05:00	-27	0.00013	X1.3	N/A	N/A	N/A	N/A	N/A	N/A	2012-03-07 01:30:24	1825	360	2012-03-07 01:25:00
2013-05-22 12:30:00	75	0.00005	M5.0	2013-05-22 13:25:00	1756	128	N/A	N/A	N/A	2013-05-22 13:25:00	1466	360	2013-05-22 14:00:00
2012-01-23 03:38:00	20	0.000087	M8.7	N/A	N/A	N/A	2012-01-23 04:00:00	2211	124	2012-01-23 04:00:00	2175	360	2012-01-23 04:24:00
2012-07-06 23:01:00	50	0.00011	X1.1	N/A	N/A	N/A	2012-07-06 23:24:00	1200	80	2012-07-06 23:24:00	1828	360	2012-07-06 23:48:00
2012-09-27 23:36:00	26	0.0000037	C3.7	2012-09-28 00:12:00	1252	94	N/A	N/A	N/A	2012-09-28 00:12:00	947	360	2012-09-28 00:12:00
2012-05-17 01:25:00	89	0.000051	M5.1	N/A	N/A	N/A	N/A	N/A	N/A	2012-05-17 01:48:00	1582	360	2012-05-17 02:12:00
2012-03-13 16:21:00	59	0.000079	M7.9	N/A	N/A	N/A	2012-03-13 17:36:00	2250	120	2012-03-13 17:36:00	1884	360	2012-03-13 17:36:00
2017-07-14 01:07:00	33	0.000024	M2.4	N/A	N/A	N/A	2017-07-14 01:25:00	750	98	2017-07-14 01:25:00	1200	360	2017-07-14 01:36:00
2021-05-28 22:19:00	68	0.0000094	C9.4	2021-05-28 23:12:00	949	88	N/A	N/A	N/A	2021-05-28 23:12:00	971	197	2021-05-28 23:12:00
N/A	N/A	N/A	N/A	2014-01-06 08:00:00	1138	102	N/A	N/A	N/A	2014-01-06 08:00:00	1402	360	2014-01-06 08:00:00
2014-09-10 17:21:00	-5	0.00016	X1.6	N/A	N/A	N/A	2014-09-10 18:00:00	1400	90	2014-09-10 18:00:00	1267	360	2014-09-10 18:00:00
2017-09-06 11:53:00	34	0.00093	X9.3	2017-09-06 12:24:00	1636	90	N/A	N/A	N/A	2017-09-06 12:24:00	1571	360	2017-09-06 12:12:00
2012-01-27 17:37:00	90	0.00018	X1.8	N/A	N/A	N/A	2012-01-27 18:27:00	2200	110	2012-01-27 18:27:00	2508	360	2012-01-27 18:48:00
2014-04-18 12:31:00	29	0.000073	M7.3	2014-04-18 13:25:00	1244	94	N/A	N/A	N/A	2014-04-18 13:25:00	1203	360	2014-04-18 13:25:00
2022-04-02 12:56:00	61	0.000039	M3.9	N/A	N/A	N/A	2022-04-02 13:36:00	1370	90	2022-04-02 13:36:00	1433	360	2022-04-02 13:36:00
2011-08-09 07:48:00	69	0.00069	X6.9	N/A	N/A	N/A	2011-08-09 08:12:00	1175	40	2011-08-09 08:12:00	1610	360	2011-08-09 08:24:00
2014-01-07 18:04:00	11	0.00012	X1.2	N/A	N/A	N/A	N/A	N/A	N/A	2014-01-07 18:24:00	1830	360	2014-01-07 18:36:00
2022-08-27 01:52:00	62	0.000048	M4.8	N/A	N/A	N/A	2022-08-27 02:24:00	1372	80	2022-08-27 02:24:00	1284	360	2022-08-27 02:24:00
N/A	N/A	N/A	N/A	2012-07-23 02:36:00	2395	108	N/A	N/A	N/A	2012-07-23 02:36:00	2003	360	2012-07-23 02:36:00
2011-08-04 03:41:00	39	0.000093	M9.3	N/A	N/A	N/A	2011-08-04 04:12:00	1950	120	2011-08-04 04:12:00	1315	360	2011-08-04 04:12:00
2022-01-20 05:41:00	76	0.000055	M5.5	N/A	N/A	N/A	2022-01-20 06:12:00	1426	88	2022-01-20 06:12:00	1431	211	2022-01-20 06:12:00
2022-03-28 10:58:00	1	0.00004	M4.0	N/A	N/A	N/A	2022-03-28 12:00:00	662	90	2022-03-28 12:00:00	702	360	2022-03-28 12:00:00
2012-07-12 15:37:00	2	0.00014	X1.4	N/A	N/A	N/A	2012-07-12 16:48:00	1400	140	2012-07-12 16:48:00	885	360	2012-07-12 15:24:00
2021-10-28 15:17:00	4	0.0001	X1.0	N/A	N/A	N/A	2021-10-28 15:48:00	1109	98	2021-10-28 15:48:00	1519	360	2021-10-28 16:00:00
2011-06-07 06:16:00	53	0.000025	M2.5	N/A	N/A	N/A	2011-06-07 06:49:00	1400	92	2011-06-07 06:49:00	1255	360	2011-06-07 10:20:00
2013-09-29 21:43:00	33	0.0000012	C1.2	N/A	N/A	N/A	2013-09-29 22:12:00	1100	140	2013-09-29 22:12:00	1179	360	2013-09-29 22:24:00
2013-04-11 06:55:00	-12	0.000065	M6.5	N/A	N/A	N/A	N/A	N/A	N/A	2013-04-11 07:24:00	861	360	2013-04-11 07:36:00

33 SEP events + 30 Non SEP events = 63 Predictions from the tool

"Different" CME catalogues (i.e. CDAW, DONKI, M2M, CACTUS) |inputs

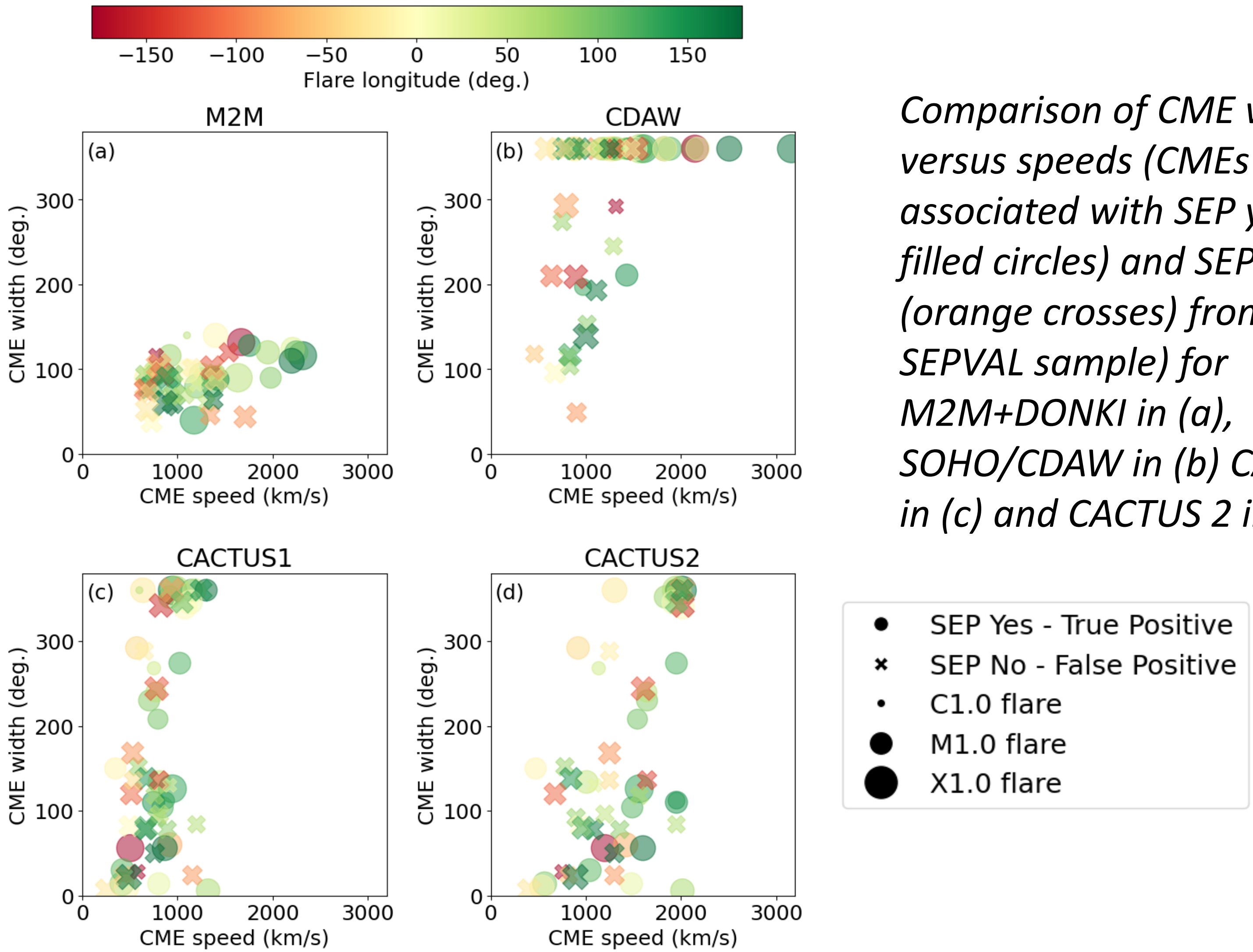
The SEPVAL sample



Comparison of CME widths versus speeds (CMEs associated with SEP yes (blue filled circles) and SEP no (orange crosses) from the SEPVAL sample) for M2M+DONKI in (a), SOHO/CDAW in (b) CACTUS 1 in (c) and CACTUS 2 in (d).

Papaioannou et al., *SW*, (**2024**)
to be submitted

The SEPVAL sample



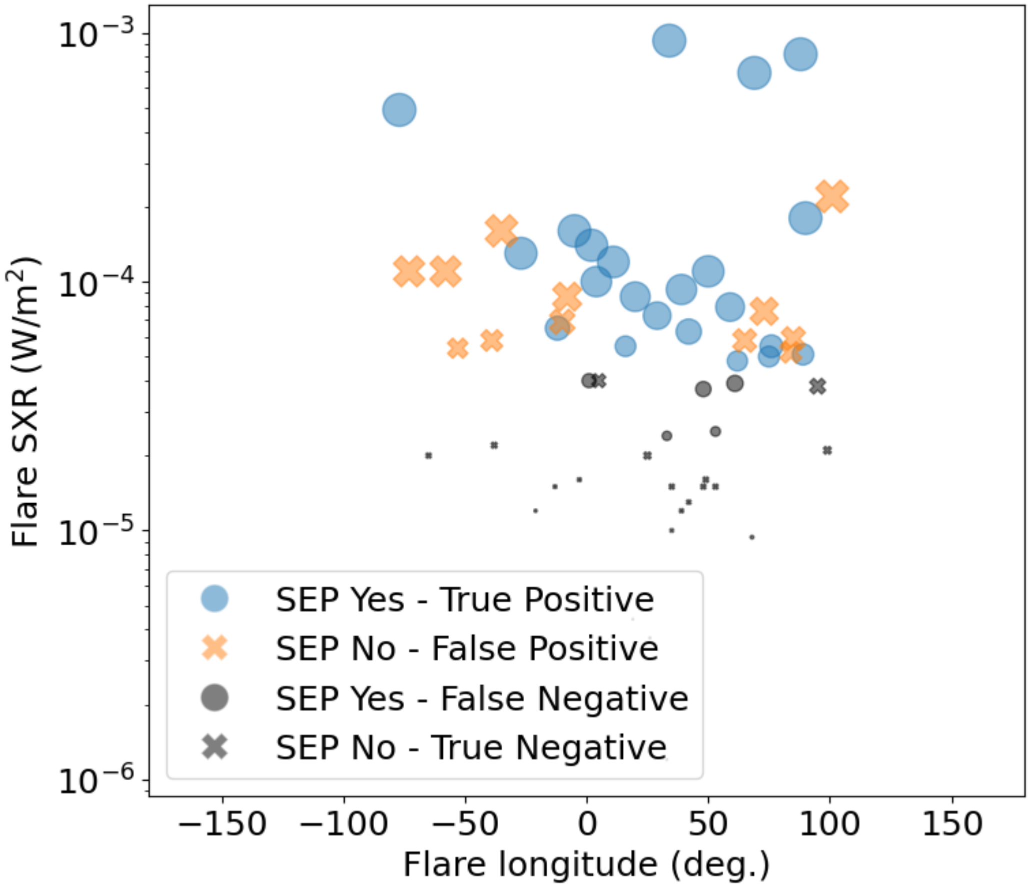
Comparison of CME widths versus speeds (CMEs associated with SEP yes (blue filled circles) and SEP no (orange crosses) from the SEPVAL sample) for M2M+DONKI in (a), SOHO/CDAW in (b) CACTUS 1 in (c) and CACTUS 2 in (d).

Probability of SEP Occurrence

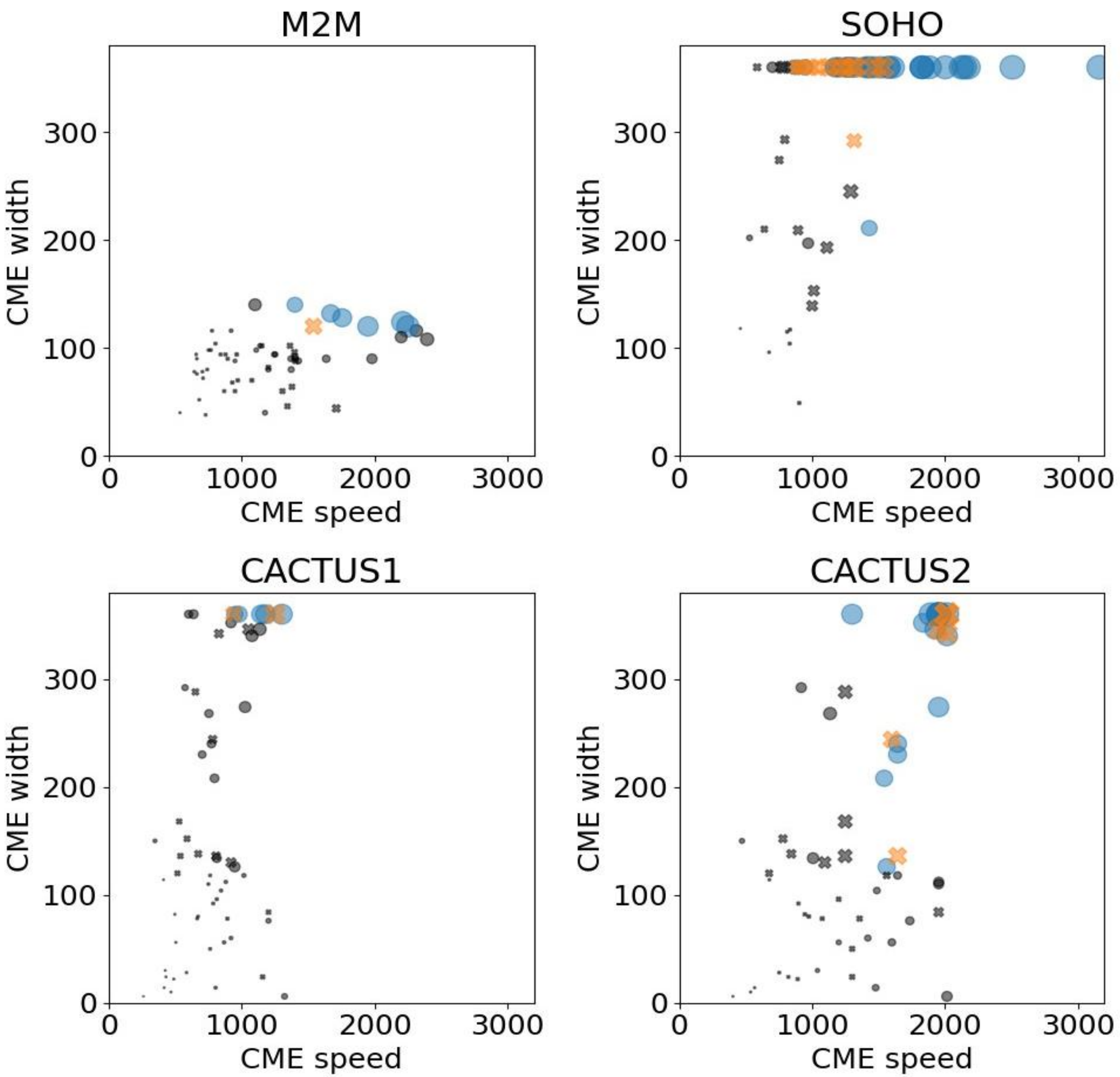
P(SEP) E>10 MeV

Flare input

P(SEP) obtained from PROSPER for the flare input



Probability of SEP Occurrence



P(SEP) E>10 MeV

CME input

P(SEP) obtained from PROSPER for the CME input overplayed on a parametric space of CME width vs CME speed from M2M+DONKI in (a), SOHO/CDAW in (b) CACTUS 1 in (c) and CACTUS 2 in (d). Colors = high SEP prob. Black = low SEP prob. Size is a function of the P(SEP).

Metrics

	#Events	TP	FP	TN	FN	%POD	%FAR	%PC	%HSS	%TSS
flare_probabilities	60	22	12	18	8	73	35	66	33	33
flare_50cl	60	22	12	18	8	73	35	66	33	33
flare_90cl	60	22	12	18	8	73	35	66	33	33
cme_m2m_probabilities	58	6	1	29	22	21	14	60	18	18
cme_soho_probabilities	63	30	13	17	3	90	30	74	48	47
cme_cactus1_probabilities	60	5	2	25	28	15	28	50	7	7
cme_cactus2_probabilities	60	15	6	21	18	45	28	60	22	23
flare_cme_m2m_probabilities	55	19	11	19	6	76	36	69	38	39
flare_cme_m2m_50cl	55	18	7	23	7	72	28	74	48	48
flare_cme_m2m_90cl	55	18	10	20	7	72	35	69	38	38
flare_cme_soho_probabilities	60	27	21	9	3	90	43	60	20	20
flare_cme_soho_50cl	60	26	16	14	4	86	38	66	33	33
flare_cme_soho_90cl	60	27	18	12	3	90	40	65	30	30
flare_cme_cactus1_probabilities	57	24	9	18	6	80	27	73	46	46
flare_cme_cactus1_50cl	57	18	6	21	12	60	25	68	37	37
flare_cme_cactus1_90cl	57	21	7	20	9	70	25	71	43	44
flare_cme_cactus2_probabilities	57	27	11	16	3	90	28	75	50	49
flare_cme_cactus2_50cl	57	25	7	20	5	83	21	78	57	57
flare_cme_cactus2_90cl	57	26	10	17	4	86	27	75	50	49

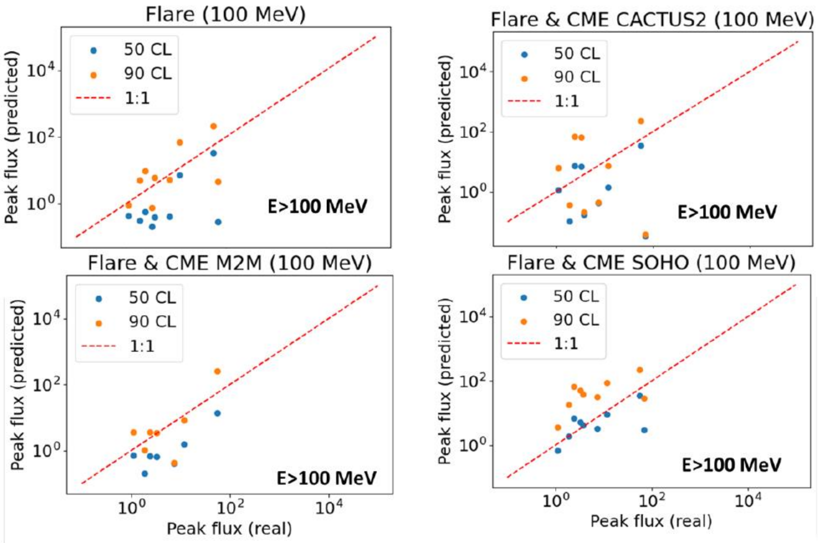
P(SEP) E>10 MeV

Summary heatmap that depicts ASPECS flavors at each row, number of events, elements of the contingency table and corresponding metrics at each of the columns.

Flare input
POD=73% FAR=35%

Flare+CME (CACTUS 2) input
POD=90% FAR=28%

Peak flux



Scatter plots of predicted vs observed peak proton fluxes for E>100 MeV SEPs. The red dashed line is the dichotomous. The predictions of the peak flux at a 90% CL are depicted with orange dots, while those at 50% CL with blue dots.

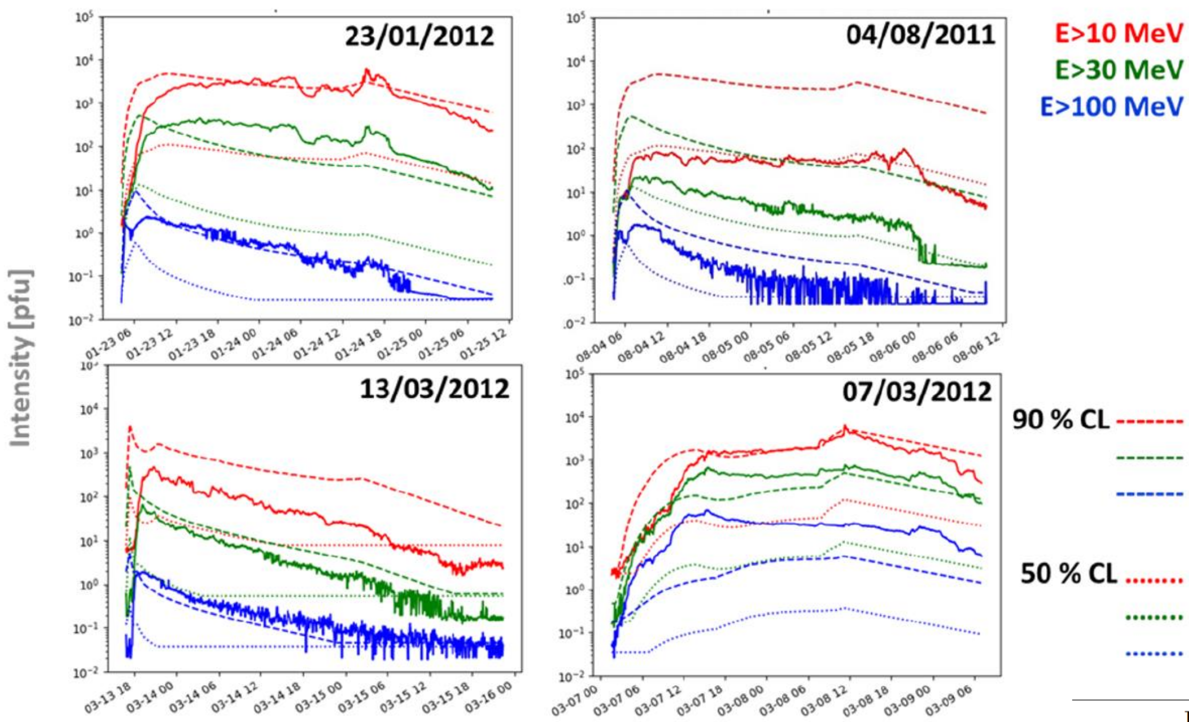
Strongest cc
Flare+CME input

P(SEP) E>100 MeV

A correlation coefficient heatmap that depicts the obtained Pearson cc obtained from the comparison of the observed versus the predicted peak fluxes at E>10 MeV and E>100 MeV. For each energy, there are three columns: (a) PROSPER, (b) 24hrs and (c) 48 hrs.

	Correlation with Observed Peak Flux (10 MeV)			Correlation with Observed Peak Flux (100 MeV)		
	PROSPER	24h	48h	PROSPER	24h	48h
Observed	1	1	1	1	1	1
Flare 50%	0.011	0.015	0.027	0.3	0.36	0.36
Flare 90%	0.041	0.023	0.061	0.29	0.35	0.35
Flare & M2M 50%	0.44	0.47	0.47	0.99	0.99	0.99
Flare & M2M 90%	0.55	0.58	0.58	0.99	0.98	0.98
Flare & CDAW 50%	0.078	0.05	0.13	0.3	0.37	0.39
Flare & CDAW 90%	0.12	0.048	0.2	0.3	0.36	0.39
Flare & CACTUS1 50%	0.36	0.4	0.41	0.93	0.53	0.53
Flare & CACTUS1 90%	0.43	0.47	0.48	0.91	0.5	0.5
Flare & CACTUS2 50%	0.25	0.27	0.28	0.93	0.51	0.51
Flare & CACTUS2 90%	0.24	0.28	0.28	0.89	0.47	0.47

SEP time profile



Predicted SEP time profiles against data for the SEP events that took place on 23/01/2012, 04/08/2011, 13/03/2012 and 07/03/2012

What is the best metric to use?

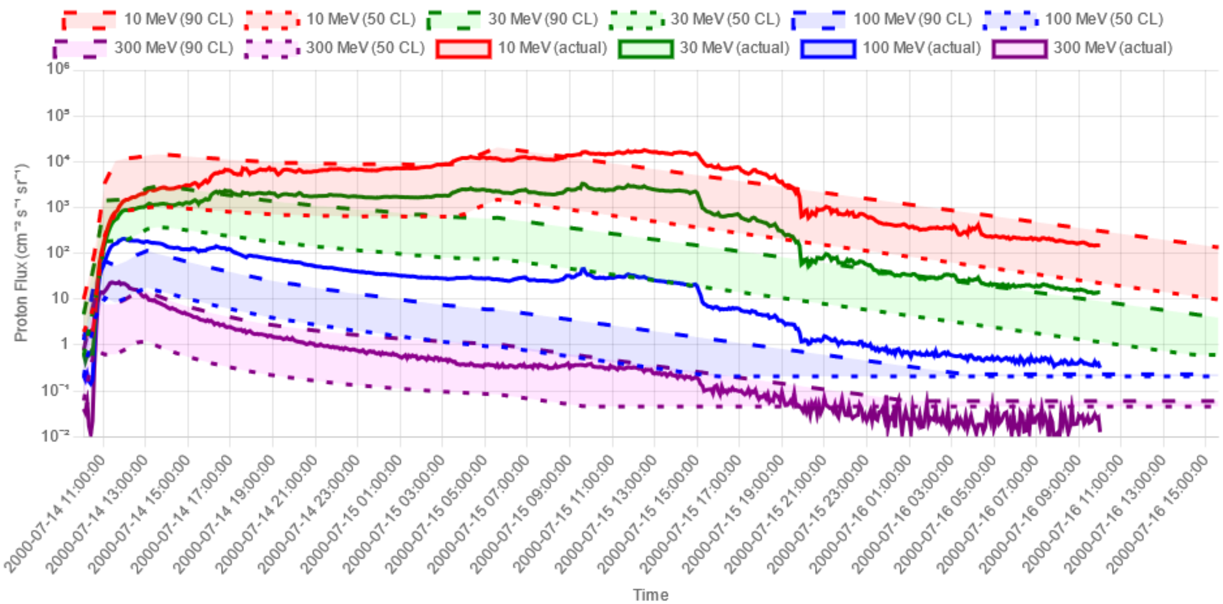
	23/01/2012				04/08/2011			
	E>10 MeV		E>100 MeV		E>10 MeV		E>100 MeV	
CL (%)	(50%)	(90%)	(50%)	(90%)	(50%)	(90%)	(50%)	(90%)
cc	0.57	0.57	0.65	0.70	0.78	0.78	0.74	0.77
RMSLE	3.39	0.97	0.46	0.27	0.51	4.08	0.25	0.39
MAPE	0.94	2.87	0.71	0.63	0.62	66.18	0.52	2.53

	13/03/2012				07/03/2012			
	E>10 MeV		E>100 MeV		E>10 MeV		E>100 MeV	
CL (%)	(50%)	(90%)	(50%)	(90%)	(50%)	(90%)	(50%)	(90%)
cc	0.43	0.51	0.12	0.30	0.89	0.89	0.40	0.42
RMSLE	1.49	2.27	0.30	0.23	3.16	0.97	2.97	1.87
MAPE	1.09	17.30	0.70	2.16	0.90	1.77	0.98	0.87

Validation toolbox

Post-Profile Prediction Graphs

Predicted Profiles



Profile Flag

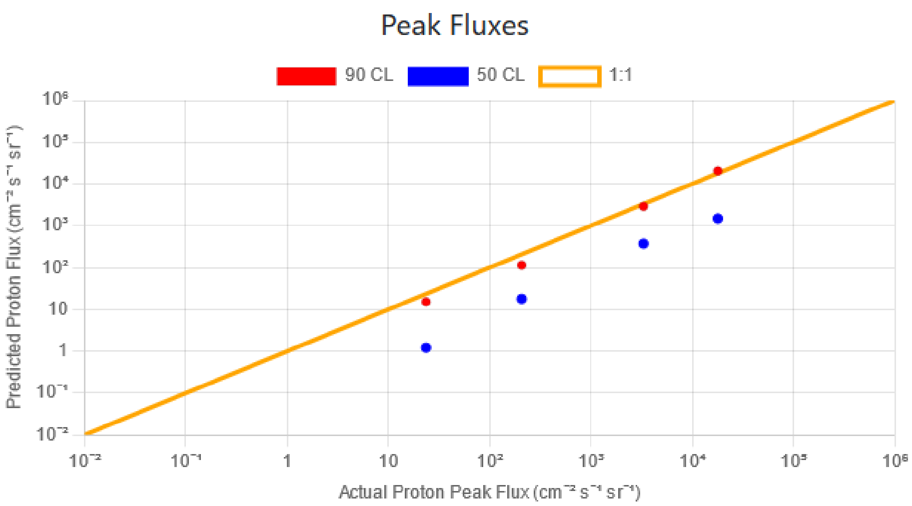
Single SEP event predicted

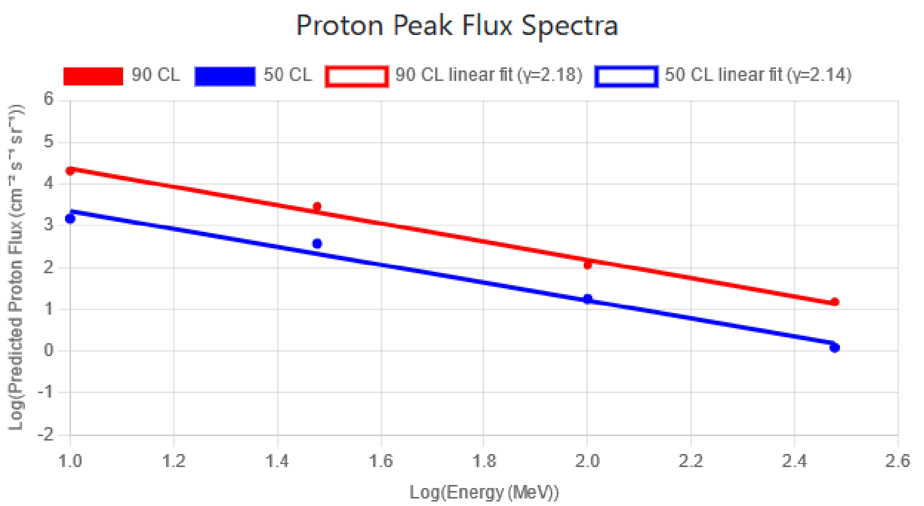
Valid until: 2000-07-14 16:03:00
Start: 2000-07-14 10:03:00, class: X5.7, longitude: 7

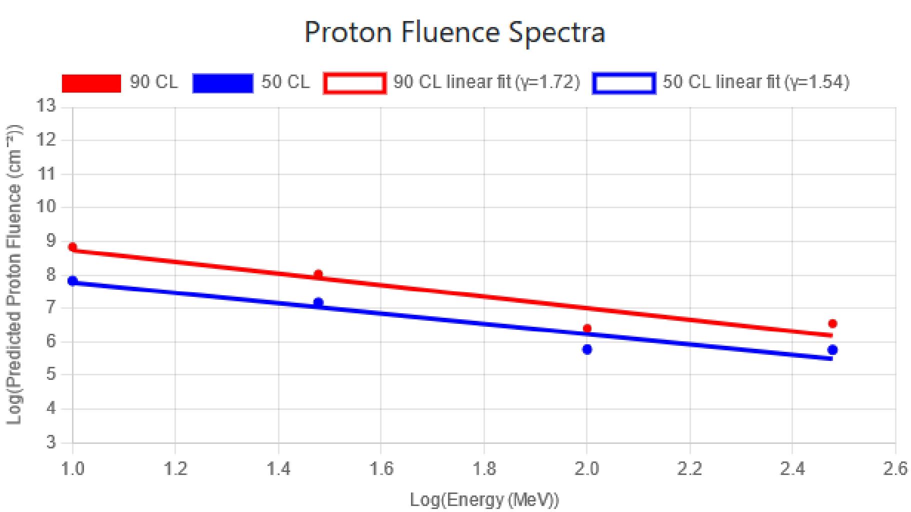
	50% CL	90% CL
E>10MeV	1575.76	21654.06
E>30MeV	374.43	2914.47
E>100MeV	17.93	114.17
E>300MeV	1.29	16.08

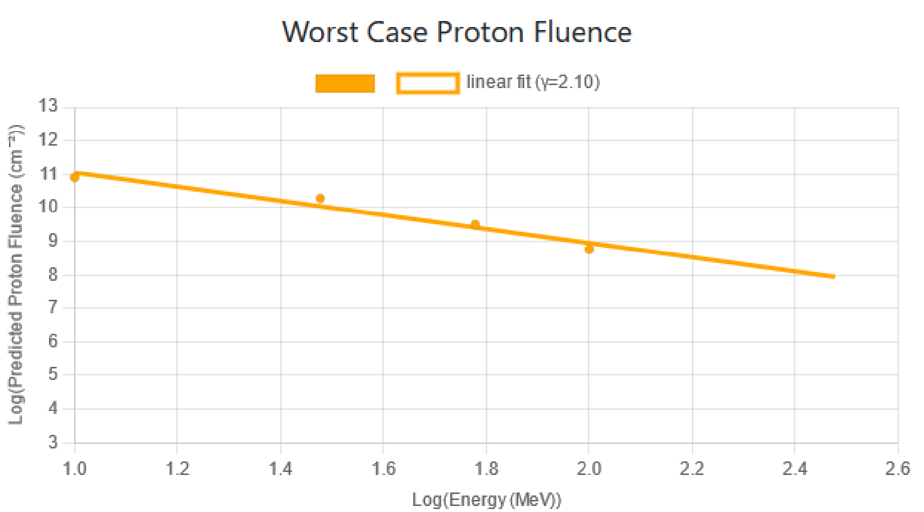
	Pearson R				RMSLE				MAPE			
	E>10 MeV	**E>30 MeV**	**E>100 MeV**	**E>300 MeV**	**E>10 MeV**	**E>30 MeV**	**E>100 MeV**	**E>300 MeV**	**E>10 MeV**	**E>30 MeV**	**E>100 MeV**	**E>300 MeV**
50% CL	0.58	0.34	0.93	0.81	2.26	2.83	2.16	0.69	0.92	0.95	0.93	0.88
90% CL	0.58	0.34	0.93	0.81	0.87	1.17	1.14	0.31	1.14	0.79	0.84	1.20

Validation toolbox









Validation toolbox

Download JSON

Intervals Indexer

2000-07-14 10:04:00
2000-07-14 10:34:00
2000-07-14 11:04:00
2000-07-14 11:34:00
2000-07-14 12:04:00
2000-07-14 12:34:00
2000-07-14 13:04:00
2000-07-14 13:34:00
2000-07-14 14:04:00

SAWS-ASPECS Validation Toolbox

Import Validation JSON

-or-

Browse... No file selected.

Visualize

Choose Validation Flavor

- (●) Time Range
- ( ) Custom Input

Time Range

Start: 2000-07-14 10:04:00

End: 2000-07-14 14:04:00

Start Validation

Conclusions & Open Questions

SEPVAL offers a common basis for SEP model developers to compare their models and concepts

ASPECS via the ADVISOR implementation offers granulation of the obtained validation results

A Validation Toolbox has been implemented allowing for external users to run the tool on demand, while predictions evolve with time

What is the best metric to use for the SEP time profile predictions ?

How to build upon SEPVAL?

How can users take advantage of the Validation Toolbox?