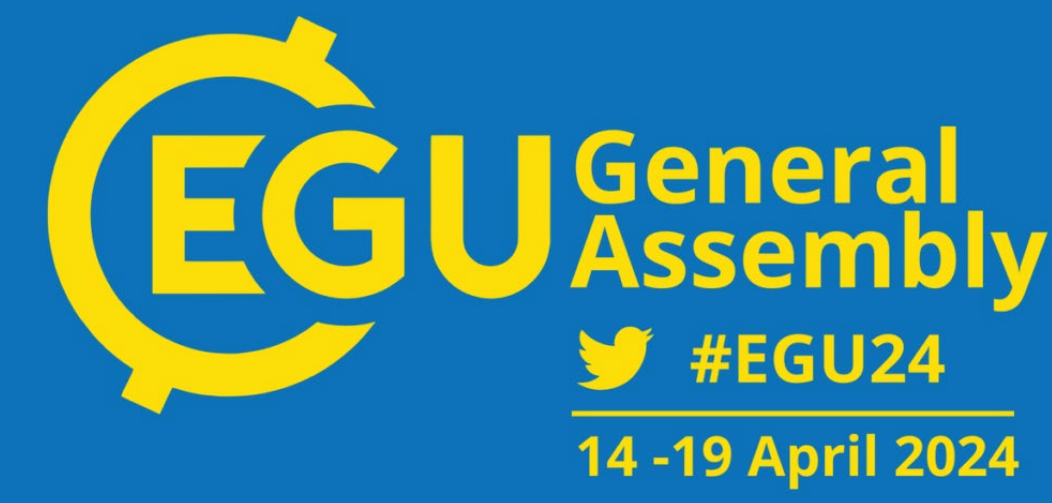




The SERPENTINE Project Data Center



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Abstract

Since its start in 2021, the Solar Energetic Particle Analysis Platform for the Inner Heliosphere (SERPENTINE) Project funded by EU H2020 program is using multi-spacecraft observations to investigate the origin of Solar Energetic Particles (SEPs) and providing new tools and datasets for the heliophysics community. SERPENTINE distributes new catalogues covering past and recent multipoint observations of SEP events, as well as their associated coronal mass ejections (CMEs) and interplanetary (IP) shocks. New SEP-related high-level data products from BepiColombo and Solar Orbiter missions, with added scientific value will be also provided in the near future. In this work, we summarize the structure, contents, and functionalities of the SERPENTINE Project Data Center, a web-based interface providing open access to the various catalogues and high-level data products resulting from the project.

1. Motivation (the SERPENTINE project)

- Science target: large **widespread SEP events**
 - Science goals: understanding SEP **acceleration and transport**
 - Causes of widespread SEP events
 - Shock acceleration in the corona and the interplanetary medium
 - Role of shocks in electron acceleration. Relative flare vs shock contributions
 - Method: **multipoint observations** in the inner heliosphere
 - Historical (Helios mission)
 - Solar cycle 25 (Solar Orbiter, PSP, BepiColombo, STEREO,...)
 - Technical goals:
 - Provide an **analysis and model visualization platform**
 - Produce and distribute catalogs**
 - Produce and deliver high-level datasets**
- Publicly distributed (Project Data Center)**

2. The Project Data Center (PDC) website

- Server hosted by University of Alcalá, providing SERPENTINE catalogs and high-level datasets
- Public access, no registration required
- User friendly web interface with search, filtering and download capabilities
- URL: <https://data.serpentine-h2020.eu/>

Top menu provides links to catalogs and data

Additional information and plots provided by clicking event ID codes

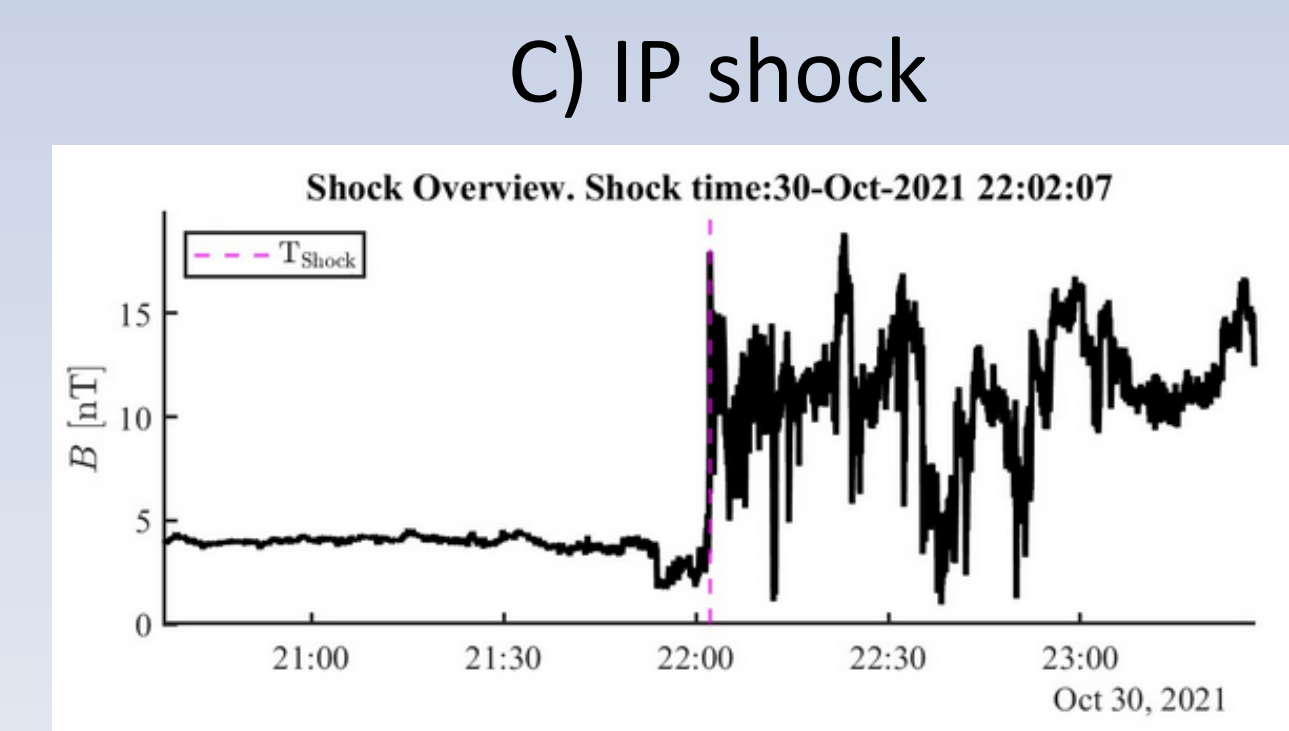
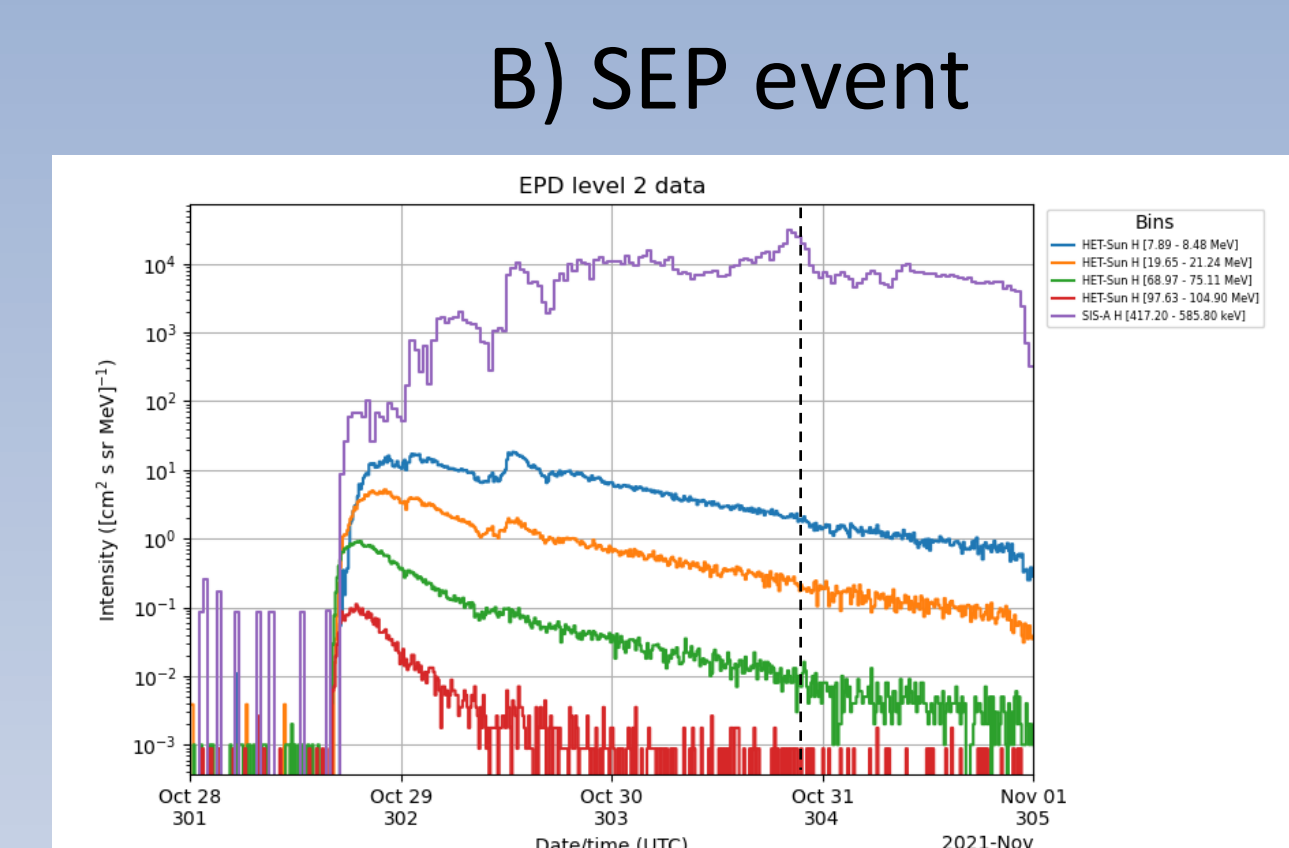
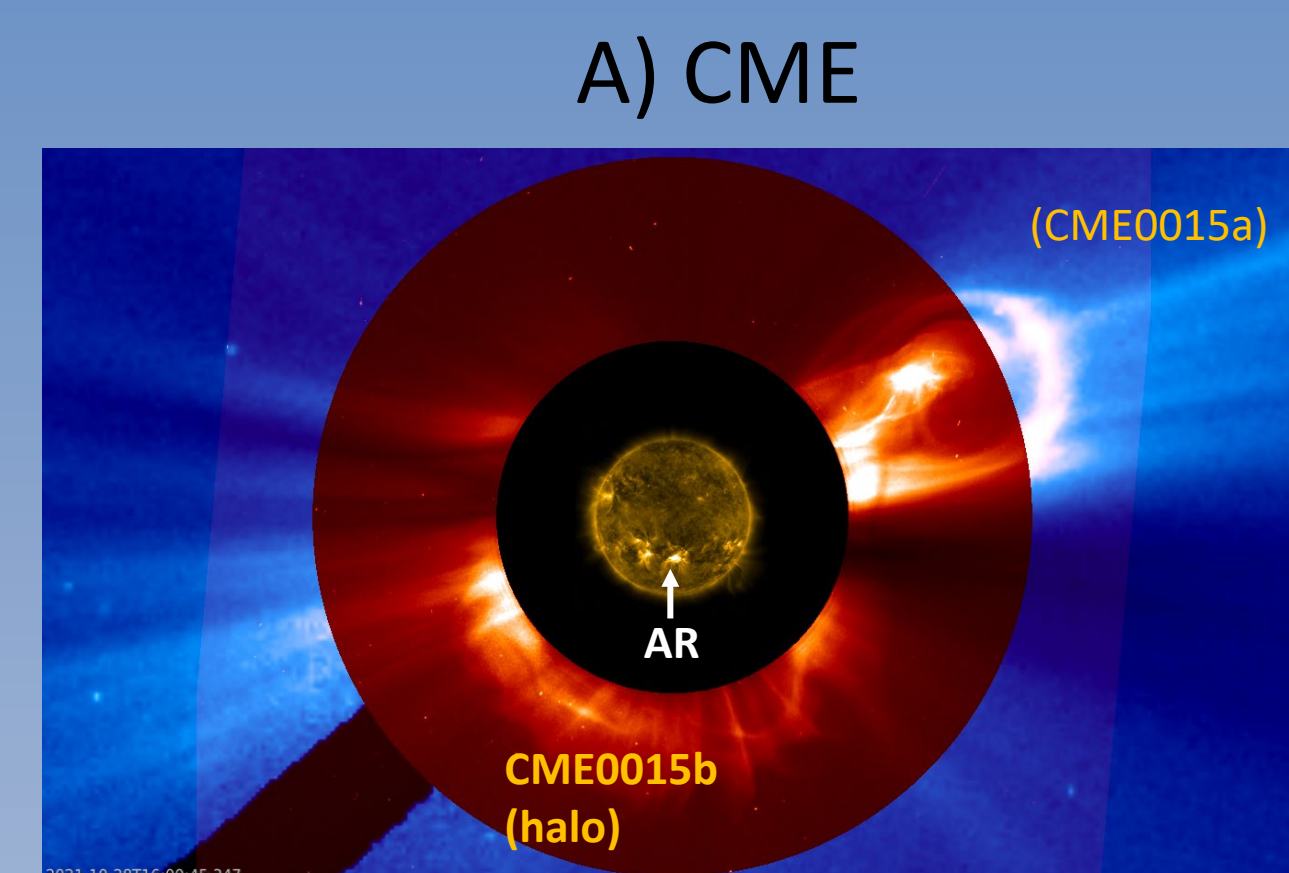
Catalogs presented in tabular format

Data filtering, sorting and download controls

Catalog interconnection: associated events in different catalogs linked by unique ID codes

3. SERPENTINE Catalogs

Example: 28 Oct 2021 SEP event (Catalog ID SEP-C25-0015)



Event catalogs generated by SERPENTINE and currently available in the PDC:

- Historical SEP events (Helios)
- Solar cycle 25 SEP events
- Historical interplanetary shocks (Helios)
- Solar cycle 25 IP shocks
- Solar cycle 25 CMEs and coronal shocks

CME catalog

Summarizes CME multipoint observations and provides 3D reconstruction parameters

ID	Date [UTC]	Observations	GCS reconstruction										Associated SEPs	Comments	
			Spacecraft	Start time [UTC]	Pos speed [km/s]	Acceleration [m/s ²]	Angular width [deg]	Position angle [deg]	Time [h:m:s]	Height [R _☉]	Half angle [deg]	Aspect ratio			Latitude, longitude [lon/lat]
CME-0015b	2021-10-28	LASCO/C2	15:48:05	1519	-6.1	360	241	15:20	4.44	12.6	0.22	25.71, 97.5	28.47	SEP-C25-0015	
		STA/COR2	15:53:30	924	-7.2	121	241	15:50	5.04	12.6	0.22	25.71, 97.5	32.14		
CME-0015a	2021-10-28	LASCO/C2	13:25:45	420	11.5	91	314	16:20	6.12	13.25	0.19	24.8, 103.13	26.63	SEP-C25-0015	
		STA/COR2	13:23:29	207	—	27	64	16:50	7.44	10.8	0.2	24.8, 103.13	26.63		

SEP event catalog

Provides comprehensive observational SEP information from multiple spacecraft

ID	Spacecraft	Channel	Event date [UTC]	Event time [UTC]	Flare location [lon/lat]	Flare distance [AU]	SEP peak time [UTC]	SEP peak flux [p/cm ² /sr/MeV/h]	SEP peak time [UTC]	SEP peak flux [p/cm ² /sr/MeV/h]	SEP peak time [UTC]	SEP peak flux [p/cm ² /sr/MeV/h]	SEP peak time [UTC]	SEP peak flux [p/cm ² /sr/MeV/h]	Comments						
STEREO-A	STEREO-A	EPD	2021-10-28	10:13:00	E1	0.96	10:13:00	1.3e-01	10:13:00	1.3e-01	10:13:00	1.3e-01	10:13:00	1.3e-01	SEP-C25-0015						
																10:13:00	1.3e-01	10:13:00	1.3e-01	10:13:00	1.3e-01
																10:13:00	1.3e-01	10:13:00	1.3e-01	10:13:00	1.3e-01
																10:13:00	1.3e-01	10:13:00	1.3e-01	10:13:00	1.3e-01

IP shock catalog

Provides comprehensive shock observations by multiple spacecraft, including derived shock parameters

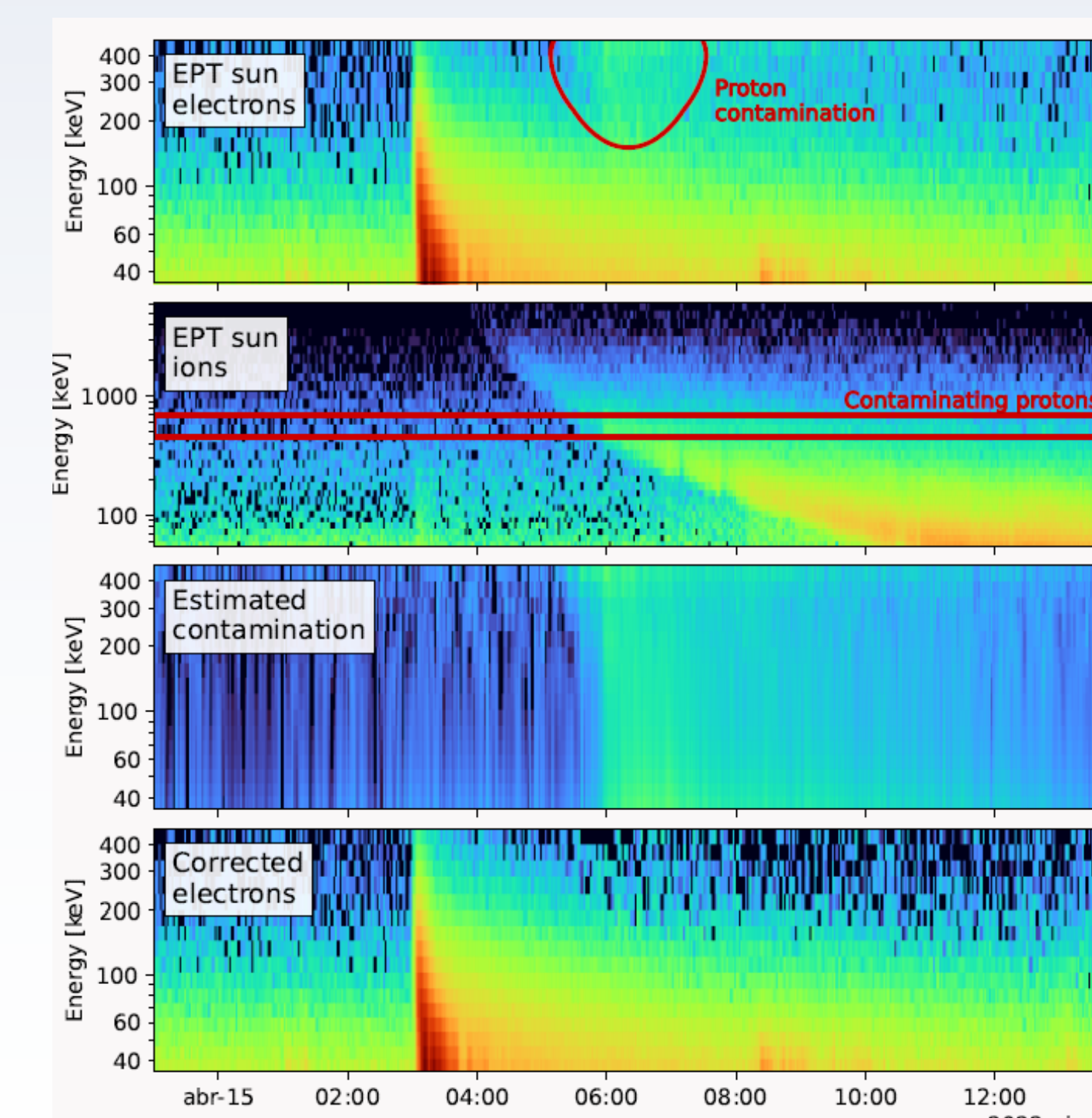
ID	Spacecraft	Date [UTC]	Time [UTC]	Radial distance [AU]	Shock normal angle [deg]	B _z /B _r	B _θ /B _r	Shock speed [km/s]	M _A	M _B	DB/B	Associated SEP events	Comments	
STEREO-2021103012	STEREO A	2021-10-30	12:22:00	0.96	(0.41, -0.26, -0.87)	1.25	4.98	33.11	289	0.81	—	SEP-C25-0015	Very clear plasma and magnetic field increases	
SHK-2021103002	Solar Orbiter	2021-10-30	22:02:07	0.82	(0.73, 0.01, -0.68)	4.3	3.1	44	398	7.6	4.7	0.61964	SEP-C25-0015	Strong shock
WIND-2021103109	Wind	2021-10-31	09:33:19	1.00	(-0.72, -0.53, -0.46)	2.3	2.5	58	376	2.8	2.3	—	SEP-C25-0015	Strongly disturbed medium around Oct 30 - Good alignment with SoL - 31 Oct shock also at SoL

4. SERPENTINE Level 3 data

Currently the PDC provides 1-minute averaged level 3 data for the Electron and Proton Telescope (EPT), part of the Energetic Particle Detector (EPD) suite onboard Solar Orbiter:

- Ion (31 bins) and electron (16 bins) fluxes with 1 minute cadence for 4 different looking directions.
- Including correction of ion contamination in electron data (uncorrected data also provided).
- Pitch angles (using MAG data).

Additional forthcoming level 3 data products for Solar Orbiter EPD and BepiColombo SIXS are under development and will be publicly distributed by the PDC and the ESA archives.



5. Conclusions

During the last three years, the SERPENTINE team has compiled and analyzed a vast amount of SEP-related multipoint observations. New data analysis tools and correction methods have been also developed. As a result, various SEP-related event catalogs and new high-level data products have been produced. These results are publicly available for the scientific community.

- Project website: <https://serpentine-h2020.eu/>
- Data Center website: <https://data.serpentine-h2020.eu/>
- Related SERPENTINE presentations at EGU 2024:
 - Oral: EGU24-417, EGU24-3846, EGU24-6034, EGU24-5558, EGU24-8772.
 - Poster: EGU24-2836, EGU24-6092, EGU24-6233, EGU24-6382, EGU24-7917, EGU24-10356, EGU24-10365, EGU24-15030, EGU24-15162, EGU24-16054, EGU24-16660, EGU24-18758.

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