



# Confined vs. eruptive M-class solar flares (e-poster)

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# Contents

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- Methodology
- Analyses
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## Methodology: Data

<https://www.swpc.noaa.gov/products/goes-x-ray-flux>

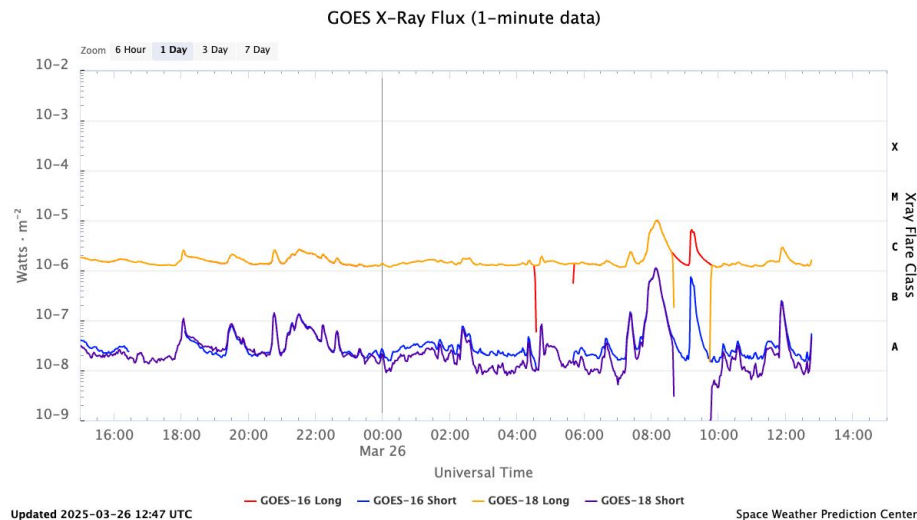
<ftp://ftp.swpc.noaa.gov/pub/warehouse/>

Based on M-class SF list:  
Miteva & Samwel (2022)

<https://www.mdpi.com/2218-1997/8/1/39>

# Aim

- Quantitative differences between confined, eruptive and the entire M-class SF population
- SCs 23 and 24



# Methodology: Event selection

all M-class SFs: 2177

<https://catalogs.astro.bas.bg/index.php/flares/m-class/>

## Confined (upper limit)

- “No associated CMEs”: 989 (SC23: 640; SC24: 349)
- No SEPs
- Few type IIs (~1%)

## Eruptive (lower limit)

- with identified CMEs: 889

### CATALOGS OF SOLAR ENERGETIC PROTONS AND SPACE WEATHER EVENTS

AIM

PROTON EVENTS

SXR FLARES

RADIO BURSTS

GEOMAGNETIC STORMS

TYPE II BURSTS

## M-class

**Acknowledgement:** This catalog is published in [Miteva and Samwel \(2022\)](#) as an [online material](#). The work is supported by the SCOSTEP/PRESTO 2020 project ‘On the relationship between major space weather phenomena in solar cycles 23 and 24’.

### Abbreviations used:

dg: data gap

nd: no data

nr: not reported

sm: from <https://www.solarmonitor.org/>

u: uncertain

v: visual

Open Access

Article

Catalog of all M-class SFs in SC23+24

## M-Class Solar Flares in Solar Cycles 23 and 24: Properties and Space Weather Relevance

by [Rositsa Miteva](#) <sup>1,\*</sup>  and [Susan W. Samwel](#) <sup>2</sup> 

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<sup>2</sup> National Research Institute of Astronomy and Geophysics (NRIAG), Helwan EG-11421, Egypt

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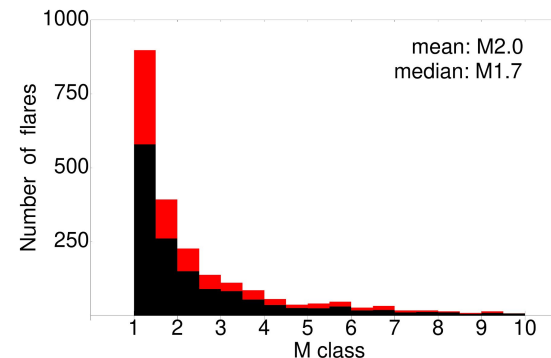
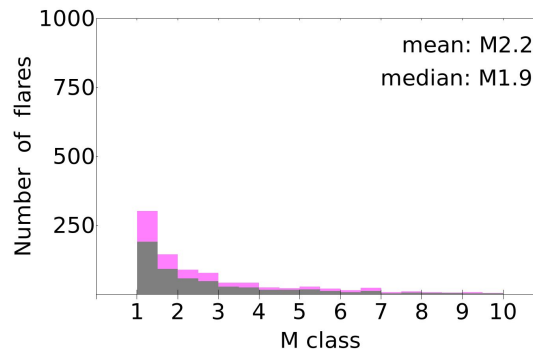
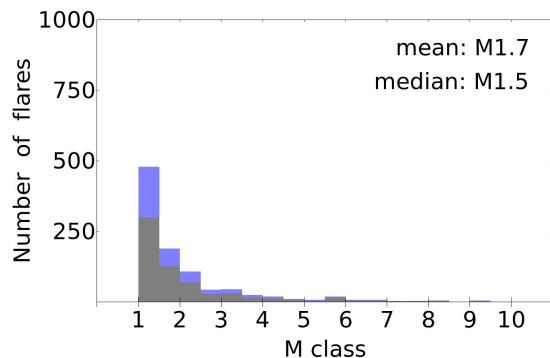
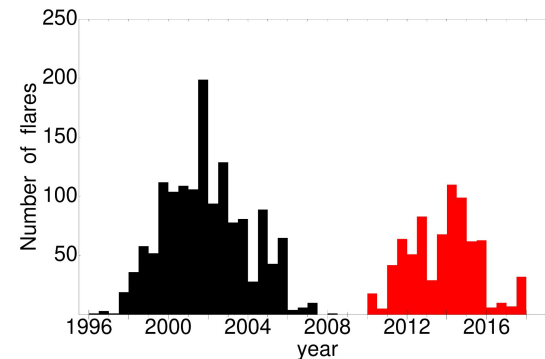
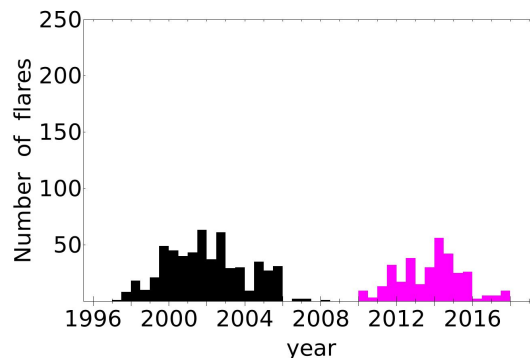
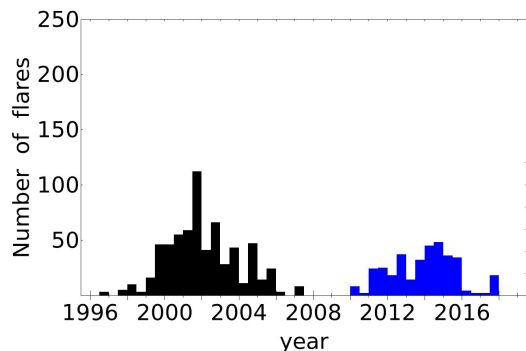
*Universe* **2022**, *8*(1), 39; <https://doi.org/10.3390/universe8010039>

## Confined M-class SFs

## Eruptive M-class SFs

## All M-class SFs

<https://www.mdpi.com/2218-1997/8/1/39>



# Confined vs. eruptive vs. All M-class SFs (sunspot area)

**Table 1.** Mean/median values for the different M-class samples and parameters, respectively. For completeness, we add the values for the entire sample of M-class flares (denoted with ‘All’) from [Miteva and Samwel, 2022]. The number of SFs in each time period are given in a bold font.

| Parameter                        | Confined   | Eruptive   | All         |
|----------------------------------|------------|------------|-------------|
| <b>SCs 23+24</b>                 | <b>989</b> | <b>889</b> | <b>2177</b> |
| class                            | M1.7/M1.5  | M2.2/M1.9  | M2.0/M1.7   |
| rise time (min)                  | 13/9       | 20/13      | 16/10       |
| decline time (min)               | 11/8       | 17/10      | 13/8        |
| sunspot area ( $\mu\text{hem}$ ) | 608/420    | 420/260    | 523/340     |
| latitude (degrees)               | S04/S09    | S01/S04    | S02/S07     |
| <b>SC23</b>                      | <b>640</b> | <b>562</b> | <b>1428</b> |
| class                            | M1.8/M1.5  | M2.2/M1.9  | M2.0/M1.7   |
| rise time (min)                  | 14/9       | 20/13      | 16/11       |
| decline time (min)               | 11/8       | 17/10      | 14/9        |
| sunspot area ( $\mu\text{hem}$ ) | 610/423    | 426/250    | 527/330     |
| latitude (degrees)               | S03/S08    | N01/N02    | S01/S05     |
| <b>SC24</b>                      | <b>349</b> | <b>327</b> | <b>749</b>  |
| class                            | M1.7/M1.4  | M2.2/M2.0  | M1.9/M1.6   |
| rise time (min)                  | 12/8       | 20/13      | 16/10       |
| decline time (min)               | 13/8       | 20/13      | 16/10       |
| sunspot area ( $\mu\text{hem}$ ) | 604/370    | 411/270    | 515/330     |
| latitude (degrees)               | S05/S12    | S02/S09    | S04/S10     |

# Confined vs. eruptive vs. All M-class SFs (sunspot type)

**Table 2.** Number of sunspots according to their Hale type (reported $\pm$ uncertain), identified as the origin of confined vs. eruptive M-class SFs. For completeness, we add the values for the entire sample of M-class flares (denoted with ‘All’) from [Miteva and Samwel, 2022]. In parenthesis are given the values (in percentage) normalized to the respective sample size, after rounding.

| Hale type                     | Confined                   | Eruptive                   | All                         |
|-------------------------------|----------------------------|----------------------------|-----------------------------|
| <b>SCs 23+24</b>              | <b>989</b>                 | <b>889</b>                 | <b>2177</b>                 |
| $\alpha$                      | 29 $\pm$ 20 (3 $\pm$ 2%)   | 37 $\pm$ 25 (4 $\pm$ 3 %)  | 76 $\pm$ 50 (3 $\pm$ 2%)    |
| $\beta$                       | 226 $\pm$ 39 (23 $\pm$ 4%) | 253 $\pm$ 56 (28 $\pm$ 6%) | 546 $\pm$ 109 (25 $\pm$ 5%) |
| $\gamma$                      | 6                          | –                          | 6                           |
| $\beta$ - $\gamma$            | 210 $\pm$ 11 (21 $\pm$ 1%) | 177 $\pm$ 10 (20 $\pm$ 1%) | 459 $\pm$ 22 (21 $\pm$ 1%)  |
| $\beta$ - $\delta$            | 23 (2%)                    | 24 (3%)                    | 48 (2%)                     |
| $\beta$ - $\gamma$ - $\delta$ | 353 $\pm$ 2 (36%)          | 224 (25%)                  | 661 $\pm$ 2 (30%)           |
| $\gamma$ - $\delta$           | 3                          | –                          | 4                           |
| no sunspots                   | –                          | 31 (3%)                    | 51 (2%)                     |
| uncertain                     | 27 (3%)                    | 50 (6%)                    | 135 (6%)                    |
| <b>SC23</b>                   | <b>640</b>                 | <b>562</b>                 | <b>1428</b>                 |
| $\alpha$                      | 26 $\pm$ 10 (4 $\pm$ 2%)   | 20 $\pm$ 17 (4 $\pm$ 3%)   | 55 $\pm$ 31 (4 $\pm$ 2%)    |
| $\beta$                       | 164 $\pm$ 24 (26 $\pm$ 4%) | 183 $\pm$ 38 (33 $\pm$ 7%) | 397 $\pm$ 70 (28 $\pm$ 5%)  |
| $\gamma$                      | 6                          | –                          | 6                           |
| $\beta$ - $\gamma$            | 135 $\pm$ 5 (21 $\pm$ 1%)  | 100 $\pm$ 4 (18 $\pm$ 1%)  | 289 $\pm$ 9 (20 $\pm$ 1%)   |
| $\beta$ - $\delta$            | 16 (2%)                    | 11 (2%)                    | 28 (2%)                     |
| $\beta$ - $\gamma$ - $\delta$ | 196 (31%)                  | 131 (23%)                  | 385 (27%)                   |
| $\gamma$ - $\delta$           | 3                          | –                          | 4                           |
| no sunspots                   | –                          | 14 (2%)                    | 22 (2%)                     |
| uncertain                     | 27 (4%)                    | 42 (7%)                    | 124 (9%)                    |
| <b>SC24</b>                   | <b>349</b>                 | <b>327</b>                 | <b>749</b>                  |
| $\alpha$                      | 3 $\pm$ 10 (1 $\pm$ 3%)    | 17 $\pm$ 8 (5 $\pm$ 2%)    | 21 $\pm$ 19 (3 $\pm$ 3%)    |
| $\beta$                       | 62 $\pm$ 15 (18 $\pm$ 4%)  | 70 $\pm$ 18 (21 $\pm$ 6%)  | 149 $\pm$ 39 (20 $\pm$ 12%) |
| $\gamma$                      | –                          | –                          | –                           |
| $\beta$ - $\gamma$            | 75 $\pm$ 6 (21 $\pm$ 2%)   | 77 $\pm$ 6 (24 $\pm$ 1%)   | 170 $\pm$ 13 (23 $\pm$ 2%)  |
| $\beta$ - $\delta$            | 7 (2%)                     | 13 (4%)                    | 20 (3%)                     |
| $\beta$ - $\gamma$ - $\delta$ | 157 $\pm$ 2 (45 $\pm$ 1%)  | 93 (28%)                   | 276 $\pm$ 2 (37%)           |
| $\gamma$ - $\delta$           | –                          | –                          | –                           |
| no sunspots                   | –                          | 17 (5%)                    | 29 (4%)                     |
| uncertain                     | –                          | 8 (2%)                     | 11 (1%)                     |

# Discussions: Confined vs. eruptive vs. all M-class solar flares

## Sunspot magnetic field characteristics

- $\square$ - $\gamma$ - $\delta$  (8-17% more for the confined SFs, depending on SC)
- Similar fractions for the remaining sunspot configurations

## Sunspot area

- Larger area (by  $\sim 1/3$ ) for confined SFs wrt eruptive SFs

## Possible space weather implications

- The complexity of magnetic field configurations tend to suppress eruptivity
- The AR area can be used as a proxy for confinement/eruptions

# Outlook

- BAJ (in press, 2025)  
<https://astro.bas.bg/AIJ/issues/n43/RMiteva.pdf>
- Use SDO/HMI database & KSO ground-based chromospheric data for AR properties (e.g.  
<https://www.mdpi.com/2073-4433/15/8/930> )

## Acknowledgements

Bilateral project: Bulgaria-Austria <https://astro.bas.bg/project-sun/>  
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# Hale classification

<https://www.spaceweather.com/glossary/magneticclasses.html>

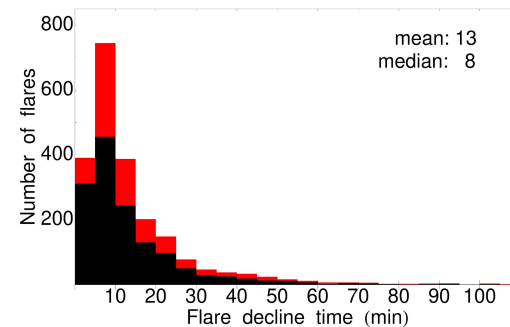
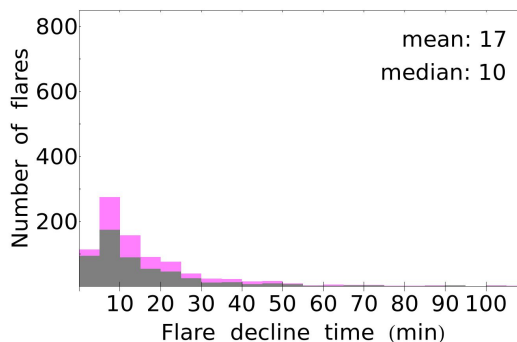
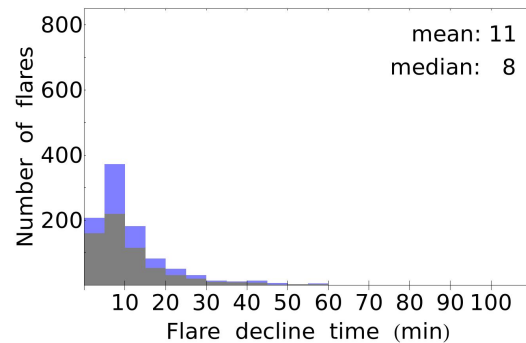
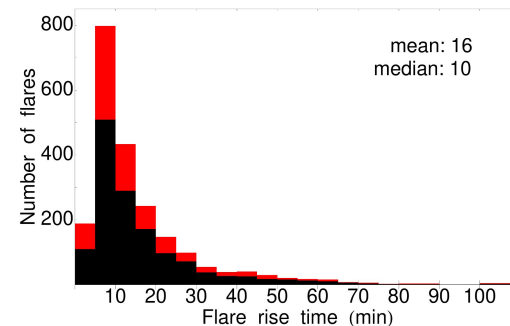
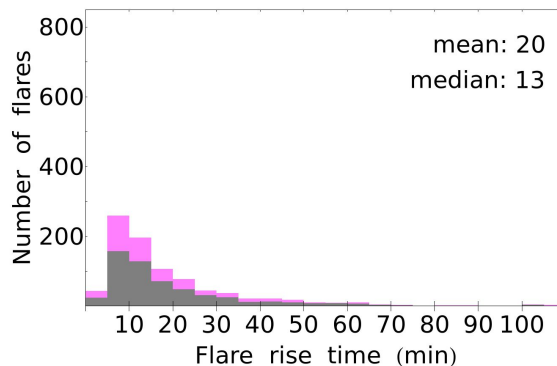
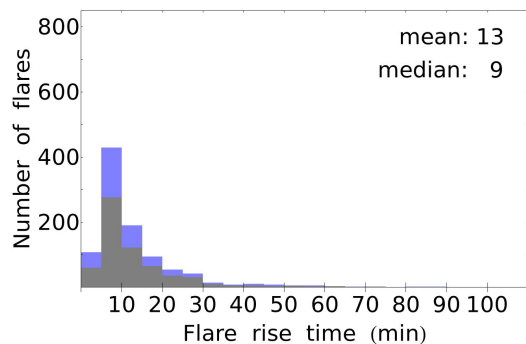
- $\alpha$ : A unipolar sunspot group.
- $\beta$ : A sunspot group having both positive and negative magnetic polarities (bipolar), with a simple and distinct division between the polarities.
- $\gamma$ : A complex active region in which the positive and negative polarities are so irregularly distributed as to prevent classification as a bipolar group.
- $\beta$ - $\gamma$ : A sunspot group that is bipolar but which is sufficiently complex that no single, continuous line can be drawn between spots of opposite polarities.
- $\delta$ : A qualifier to magnetic classes indicating that umbrae separated by less than 2 degrees within one penumbra have opposite polarity.
- $\beta$ - $\delta$ : A sunspot group of general  $\beta$  magnetic classification but containing one (or more)  $\delta$  spot(s).
- $\beta$ - $\gamma$ - $\delta$ : A sunspot group of  $\beta$ - $\gamma$  magnetic classification but containing one (or more)  $\delta$  spot(s).
- $\gamma$ - $\delta$ : A sunspot group of  $\gamma$  magnetic classification but containing one (or more) delta spot(s).

## Confined M-class SFs

## Eruptive M-class SFs

## All M-class SFs

<https://www.mdpi.com/2218-1997/8/1/39>



## Confined M-class SFs

## Eruptive M-class SFs

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