

Search for a coincident meteor detection between Mini-EUSO and ground-based observations

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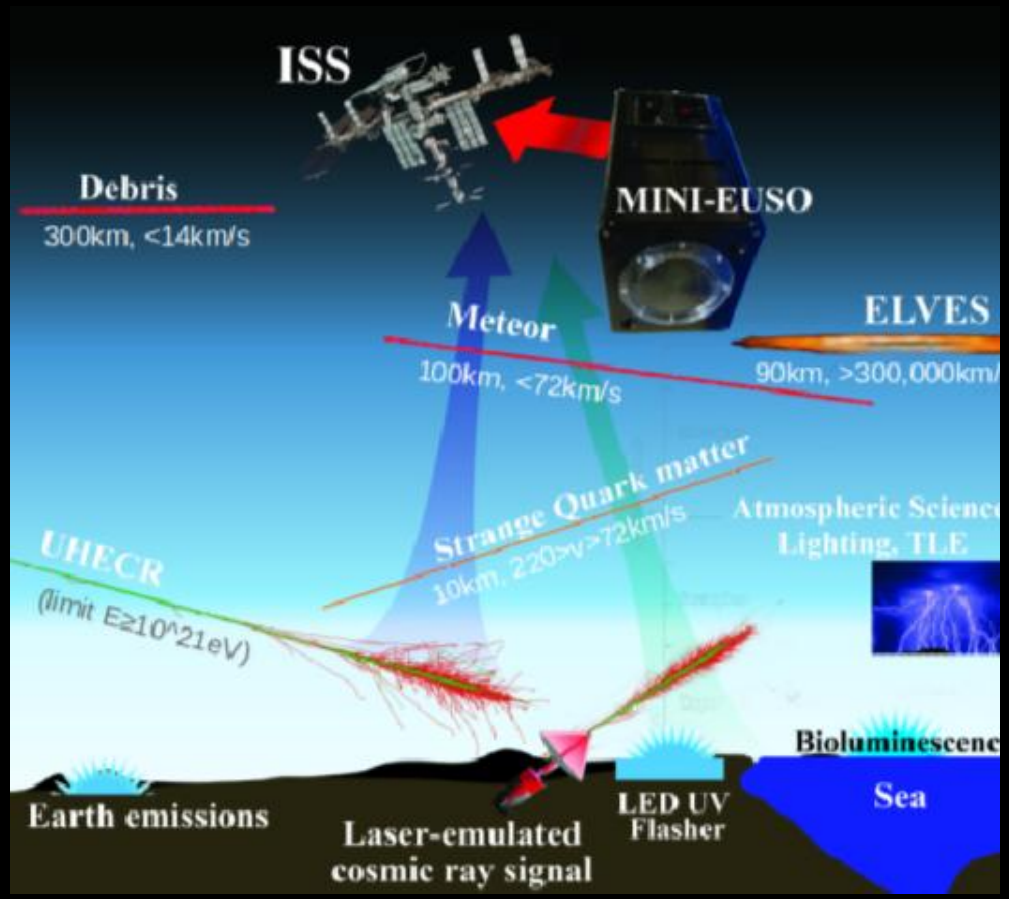
on behalf of the JEM-EUSO Collaboration

JEM-EUSO Program



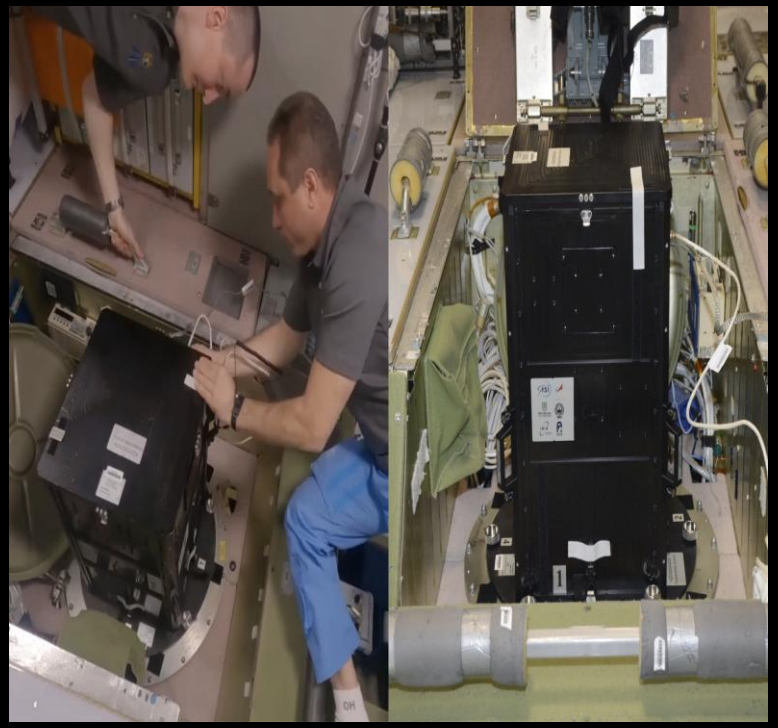
https://www.jemeuso.org/

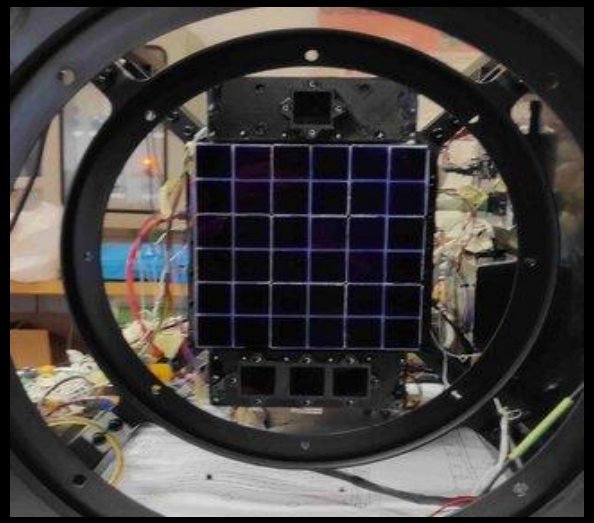


Mini-EUSO

Multiwavelength Imaging New Instrument for the Extreme Universe Space Observatory

On the ISS in the Zvezda module since August 2019





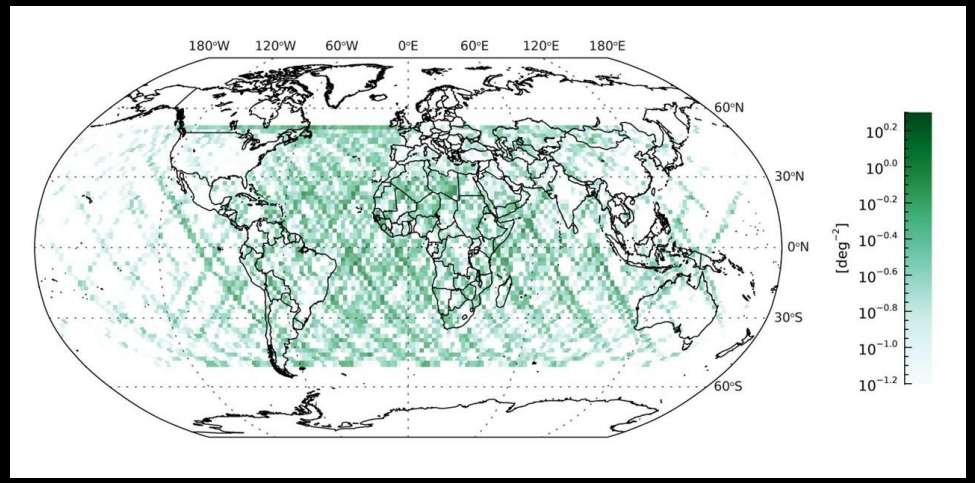
- Detector: 36 x 36 x 62 cm^3
- Two Fresnel lenses (25 cm of diameter)
- The light focuses on 36 multi-anode photomultiplier tubes (MAPMTs)
- Focal surface: 2304 pixels
- Field of view: 44°x 44°
- Spatial resolution for altitude 100 km : ~4.7 km/pixel
- Bandwidth: 290 – 430 nm

Performs data acquisition in single-photon counting mode.
Gate Time Unit (GTU) :
D1 = 2.5 µs for UHECRs
D2 = 320 µs for slower lightnings
D3 = 40.96 ms for meteors, space debris
D3 is continuously record data

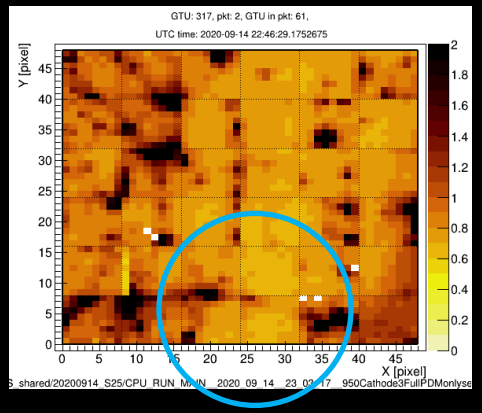
Laura Marcelli, et al. Mini-EUSO Experiment. In Proceedings of 38th International Cosmic Ray Conference — PoS(ICRC2023), volume 444, page 001, 2023.

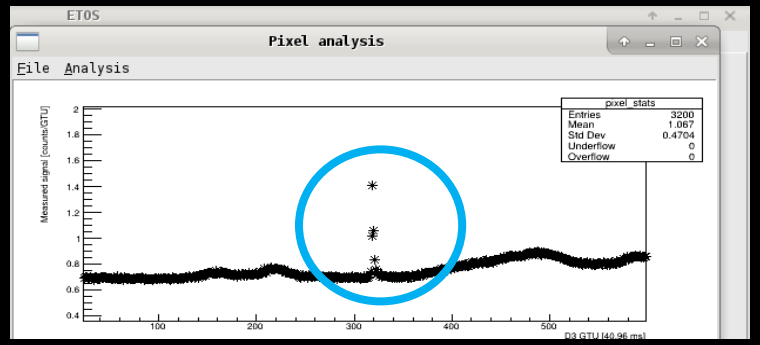
Mini-EUSO meteors

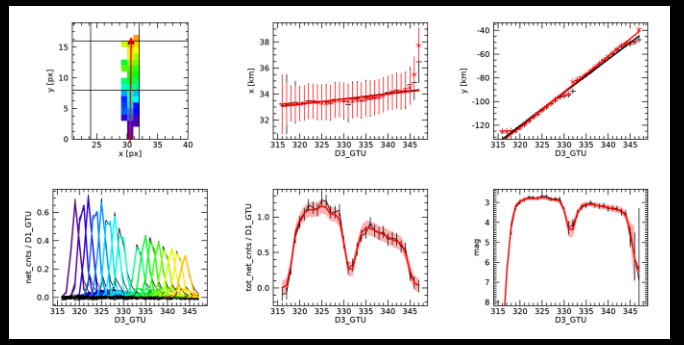
- Mini-EUSO is the first systematic meteor observation from space
- 24k meteor events were detected by the Mini-EUSO telescope in the data sessions n.05-44 (November 2019 to August 2021) for a total observation time of approximately 6 days with a limiting absolute magnitude of +6.
- ETOS (EUSO To Screen) is a visualization tool of Mini-EUSO data
- These are the result of meteor tracking algorithm on one meteor, session 25, root file 2020_09_14__23_03_17 at GTU 317 that start triggered from pixel (30, 0)



Dario Barghini, et al. Observation of meteors from space with the Mini-EUSO detector on board the International Space Station. Astronomy Astrophysics, 2024.





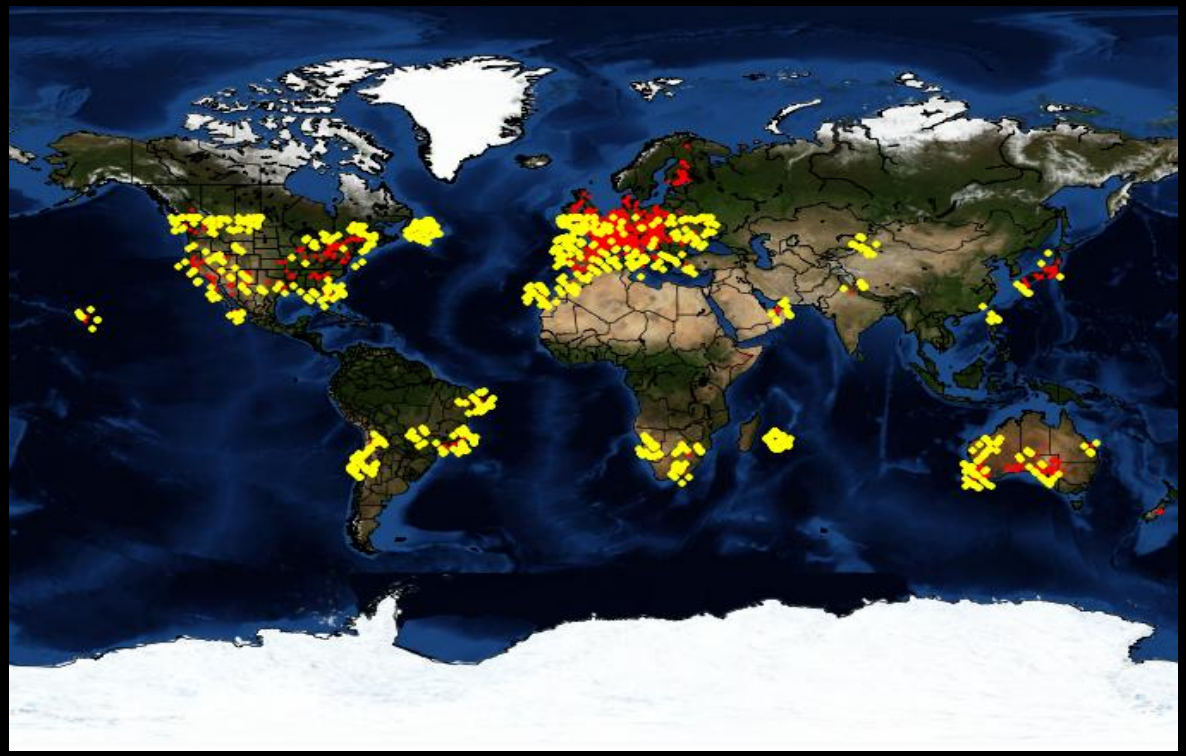


Mini-EUSO meteors and ground-based stations

- A list of ground-based operating meteor and fireball networks which contains stations name, latitude, and longitude (created by Dario Barghini, 2021)
- Mini-EUSO meteor data sessions n.05-44 (from November 2019 to August 2021)
- Mini-EUSO meteors detected near ground-based stations that :

$$\left|lat_{MEe} - lat_{gbs}\right| \leq 3°$$

$$\left|lon_{MEe} - lon_{gbs}\right| \leq 3°$$



- : 820 ground-based stations from the list
- : 770 meteors events detected by Mini-EUSO

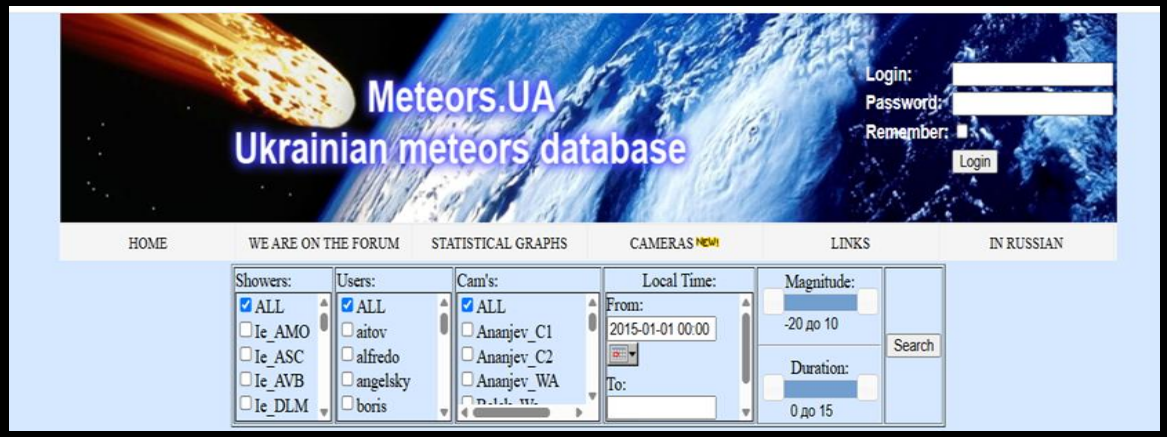
I. Meteor ground-based networks











- https://fireball.fripon.org/list_multiple.php
- https://ceres.ta3.sk/iaumdcdb//home/PDA/SNMv3
- https://globalmeteornetwork.org/data/traj_summary_data/
- https://meteornews.net/edmond/
- https://meteors.com.ua/

I. Cross-check of the meteor events

- Applied selection criteria in comparing meteor events between Mini-EUSO and each ground-based data

$$\left|t_{MEe} - t_{gbe}\right| \leq 1\,min$$

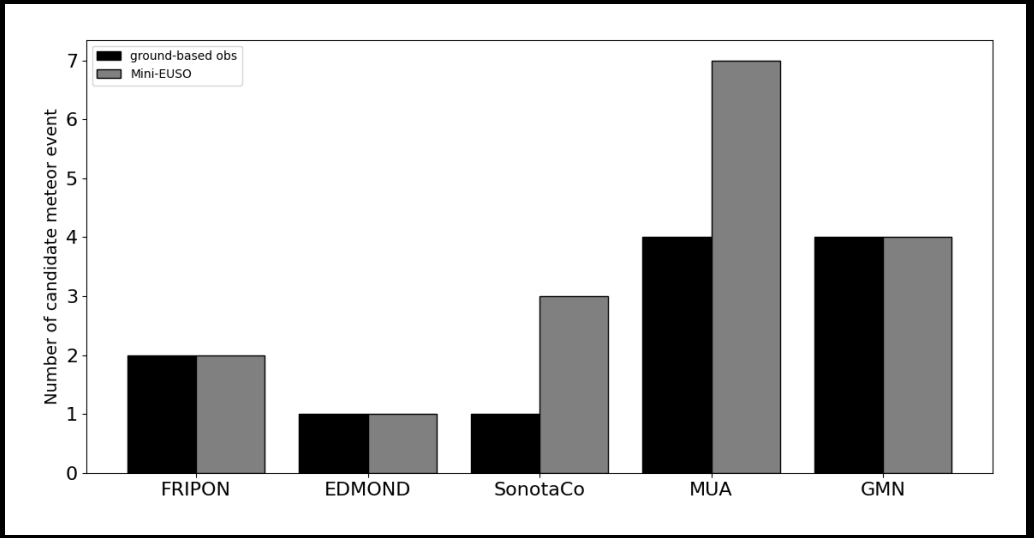
$$\left|lat_{MEe} - lat_{gbe}\right| \leq 3°$$

$$\left|lon_{MEe} - lon_{gbe}\right| \leq 3°$$

- Inspected the physics parameters to cross-check the possibility of being the same event

"No coincident meteor detections were found using this approach."

With : t : time of detection in UTC
lat : latitude of detection in degree
lon : t : latitude of detection in degree



	Mini-EUSO	EDMOND
Identifier	2019_12_31__03_56_47 GTU 377	Version 516 # 35326
Magnitude	0.69	- 0.89
Duration (s)	0.69	0.24
Latitude (°)	46.39	43.94
Longitude (°)	8.73	12.07
Horizontal speed (km/s)	17.1	54.3

II. Search for meteor candidate events using ETOS

One(s) meteor event detected by ground-based stations was observed by Mini-EUSO but not triggered ?

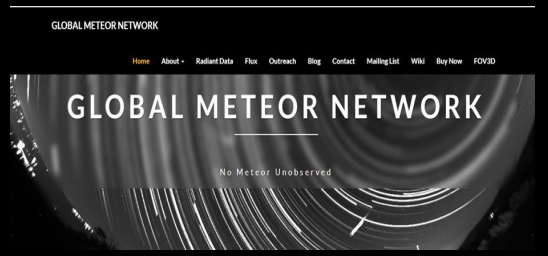
- Applied selection criteria in comparing each ground-based data with the Mini-EUSO time and position :

$$\left|t_{ME} - t_{gbe}\right| \leq 1\,min$$

$$\left|lat_{ME} - lat_{gbe}\right| \leq 3°$$

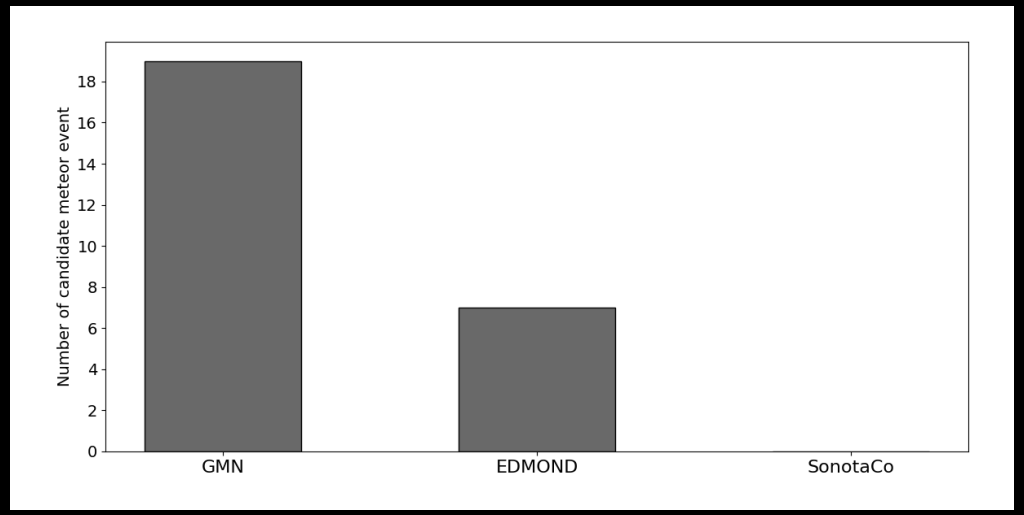
$$\left|lon_{ME} - lon_{gbe}\right| \leq 3°$$

- Calculate each pixel position of the Mini-EUSO for each meteor possible candidate (start and end position based on each meteor event duration).

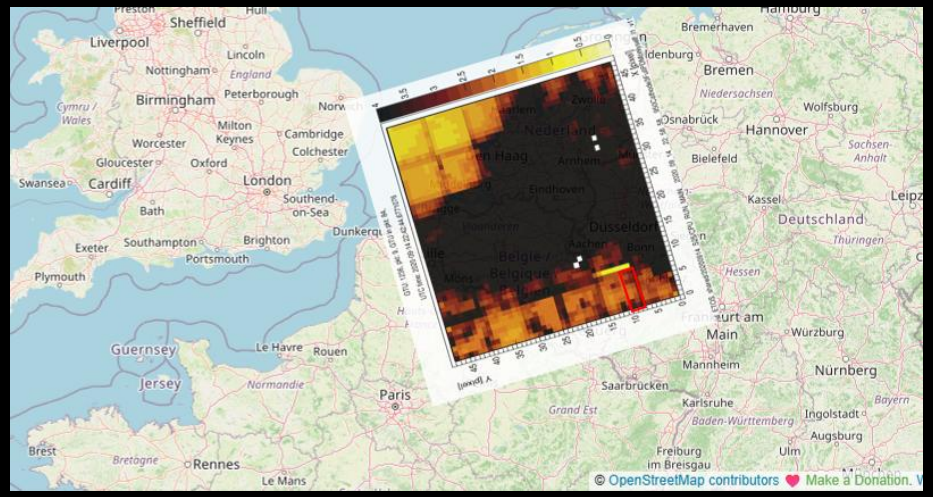


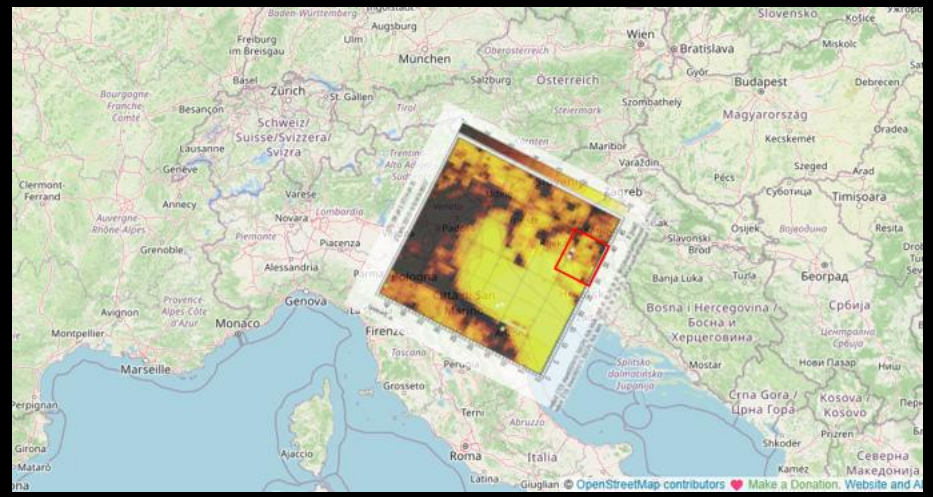
EDMOND meteor news

SonotaCo Network Japan



II. Search for meteor candidate events using ETOS



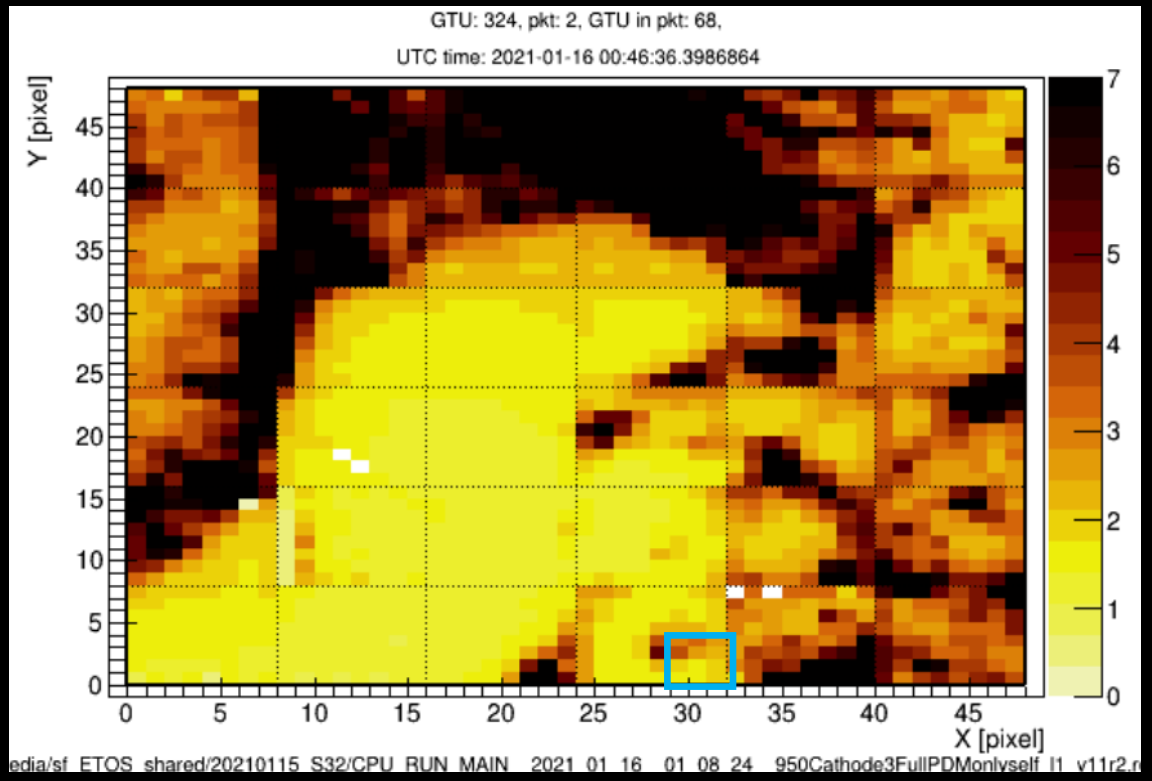


Map data from OpenStreetMap

GMN meteor event : 20200914225138_l2rOF
Detected at 14 September 2020 near Bütgenbach, Belgium with mag 1.89
From the pixel position, the meteor event should appear in pixels (4,8) and (4,9), but we found no meteor event detected by Mini-EUSO.
The meteor event happened in between two PMTs.

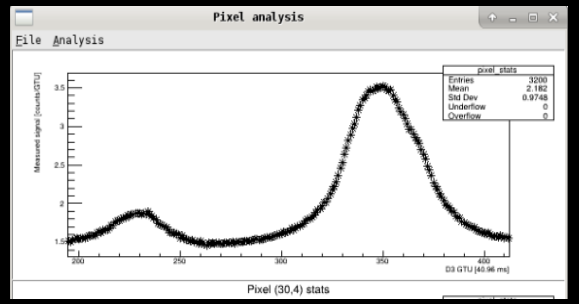
GMN meteor event : 20210116005819_MgI67
Detected at 16 January 2021 near Lopar, Croatia with mag 3.06
From the pixel position, the meteor event should appear between pixels (30,0) and (32,5), but we found no meteor event detected by Mini-EUSO.

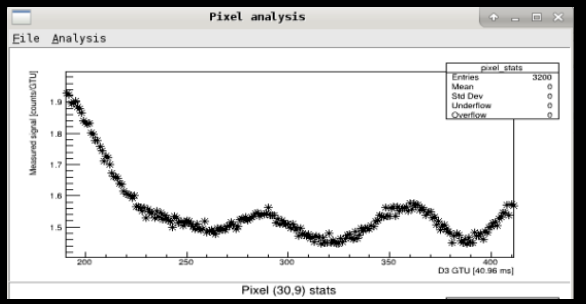
II. Search for meteor candidate events using ETOS

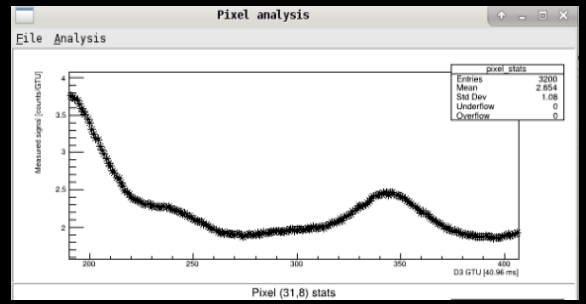


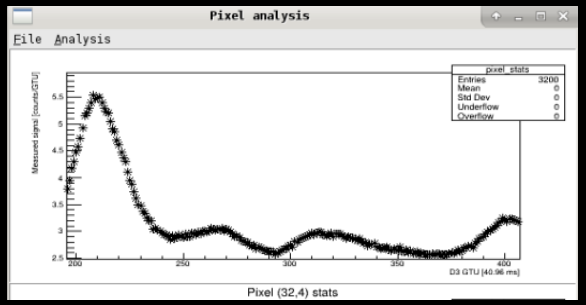
between pixel (30,0) to pixel (32,5)

GMN meteor event : 20210116005819_MgI67









pixel analysis of (30,4), (30,9), (31, 8), (32,4)

III. Expected number of meteor events in coincidence

- Detection rate of each ground-based network

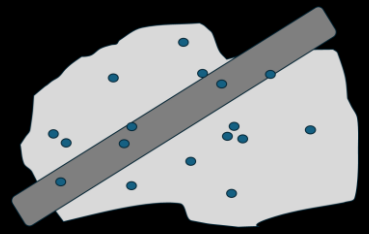
$$R_i = \frac{N_i}{T_{obs}}$$

- Maximum number detected by Mini-EUSO

$$N_{max} = R_i \times T_{ME}$$

- Expected number detected by Mini-EUSO

$$N_{ME} = N_{max} \times \frac{A_{ME}}{A_i}$$



	FRIPON	EDMOND	SonotaCo	GMN
$N_i(event)$	3,253	68,000	103,210	85,227
$T_{ME}(second)$	6,693	7,072	89	18,547
$A_i(km^2)$	2,377,492	1,939,300	435,563	10,715,367
$R_i(event/minute)$	0.006	0.130	0.200	1.630
$N_{max}(event)$	0.67	15.32	0.30	225.66

With :

R_i : detection rate

N_i : total number detected event over 3 years

T_{obs} : total minutes observation over 3 years with 8 hours of observation per day (525,600 minutes)

N_{max} : the maximum number detected by Mini-EUSO

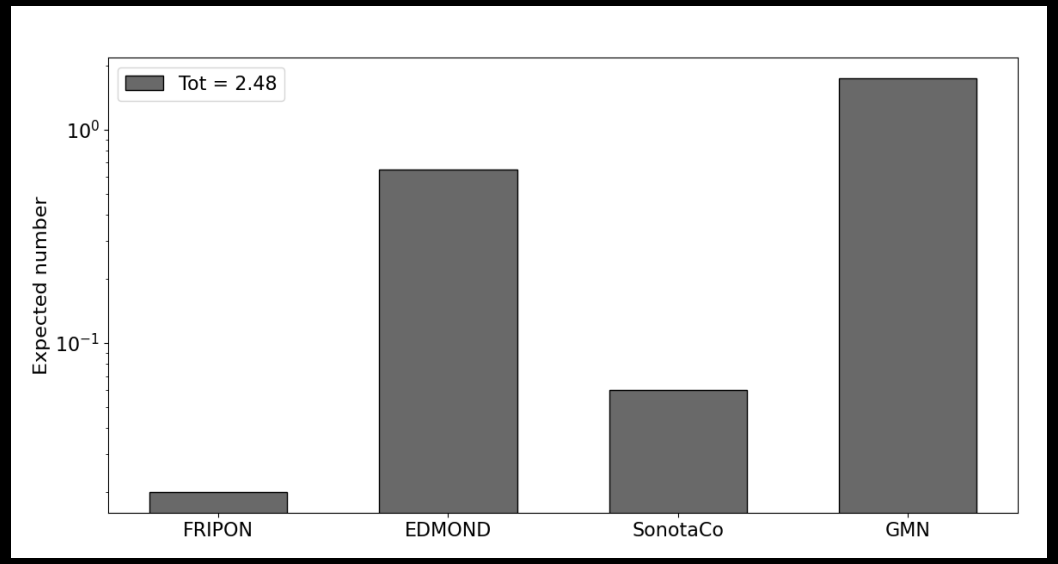
T_{ME} : total minutes Mini-EUSO near the stations

A_{ME} : area observation of Mini-EUSO near the stations

A_i : total area observation (assuming an area 200 x 200 km^2)

III. Expected number of meteor events in coincidence

Expected number of each ground-based networks



FRIPON 0.02 EDMOND 0.65
SonotaCo 0.06 GMN 1.75

Probability of detection number

$$P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

$$P(0) = 0.08$$

Using the average number λ : total event (2.48)

Conclusion

- For the moment there is no evidence of a common detection.
  It is consistent with the calculated detection rate, which is low but not zero.

- Thanks to observations carried out in the last years, the Mini-EUSO is expected to increase the exposure for meteor observations by a factor ~ 3. This might give us finally a coincidence event.

Thank you