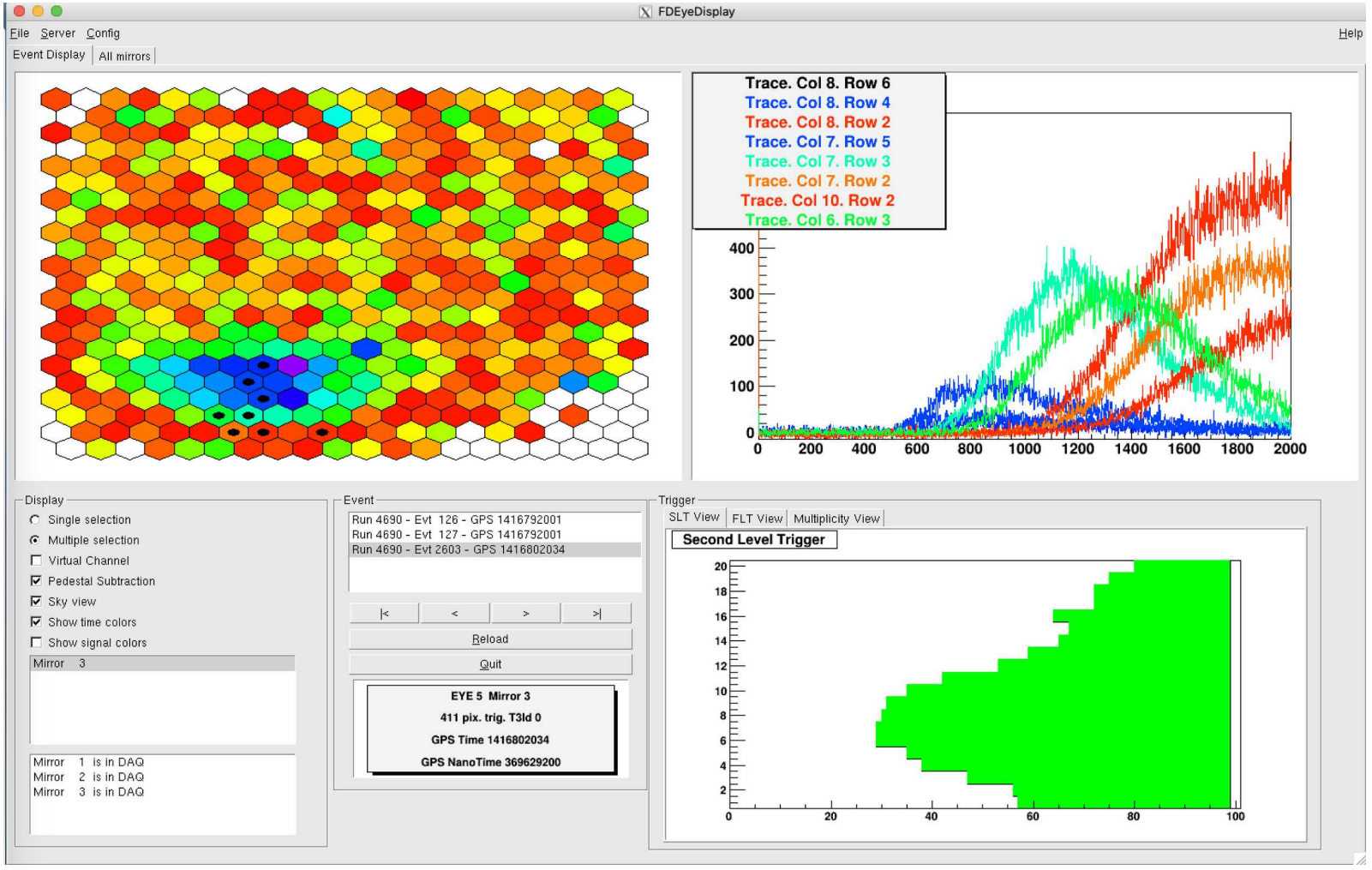
ELVES and SPRITES in Auger

R.Mussa (INFN Torino)

- First Sprites seen by both TLE cams
- SpriteFinder.py : searching SPRITES with DBSCAN
- ELVES paper status

SPRITE*ELVES on Nov28: 1st seen by both TLEcams

2024-11-28 04:06:56.369629200 1416802034 HEAT-3down … and LL-3!



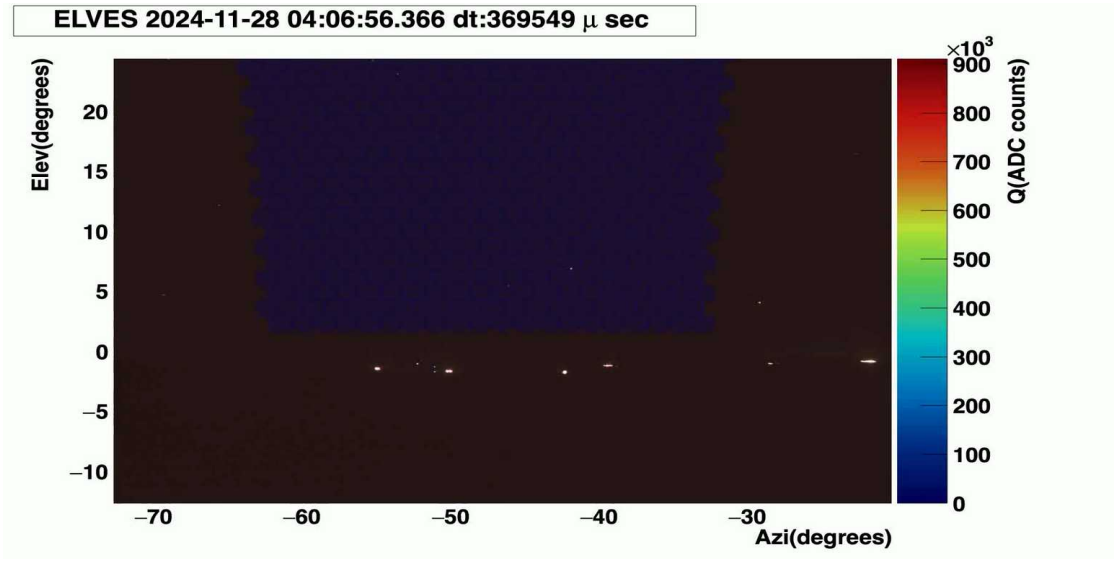
2024-11-28 04:06:56.369629200 GPS:1416802034 HEAT-3down

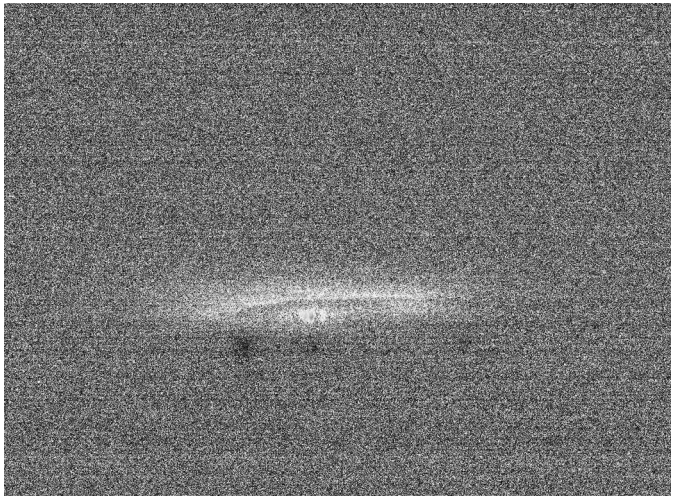
ZWO time 529-589 ms
T(ZWO)-T(FD)=189±30ms

2024-11-28 04:06:56.369629200 GPS:1416802034 HEAT-3down

ZWO time 529-589 ms
T(ZWO)-T(FD)=189±30ms

GPS:1416802034 HEAT-3down animation





- Only 1 page recorded

- ZWO Image difference show a ring which looks like an ELVES! surprising at such large distance

- Event also seen by LL

EVT1416802034_LL

2024-11-28 04:06:56

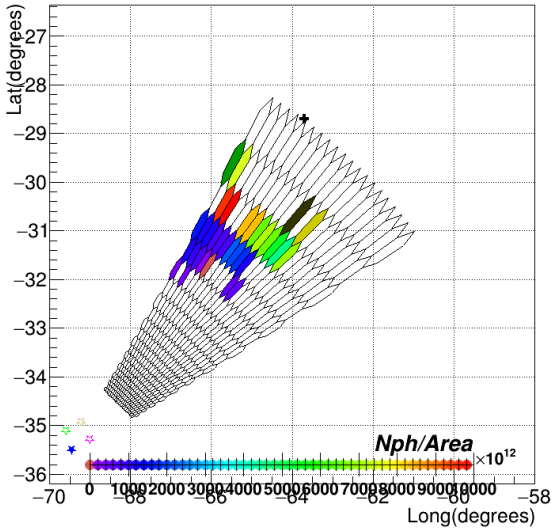
$\Delta T \sim 120\ \mu s$

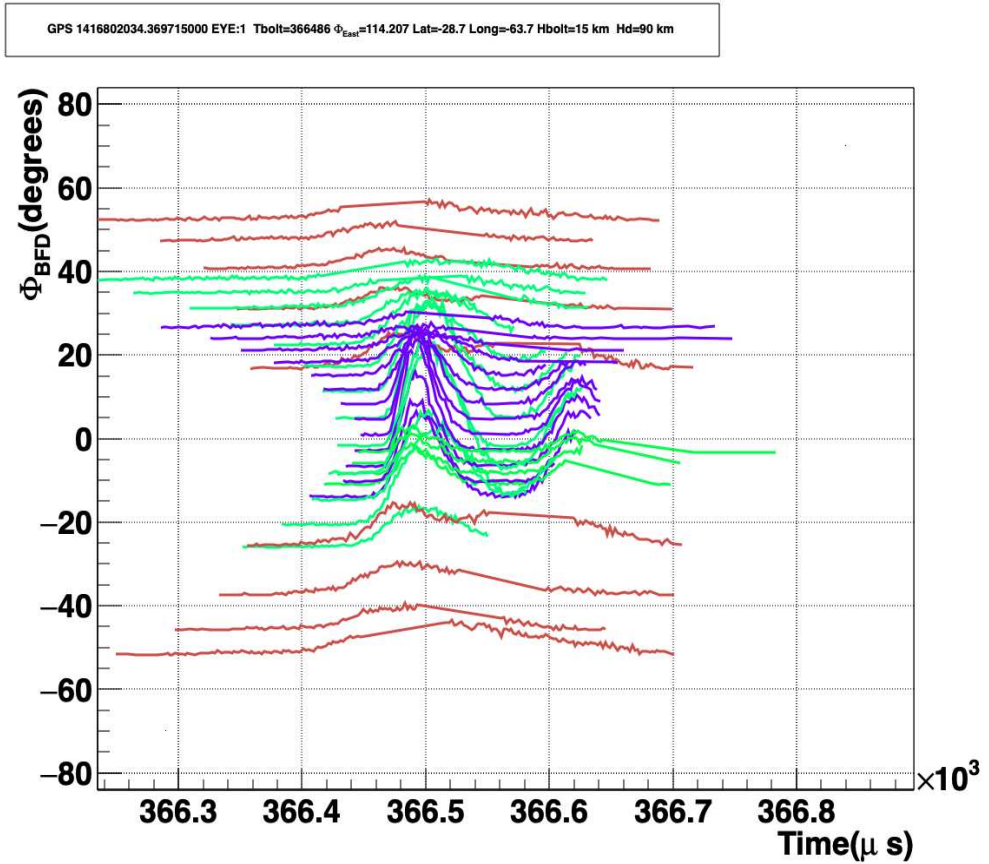
BEFD: ~1000 km!

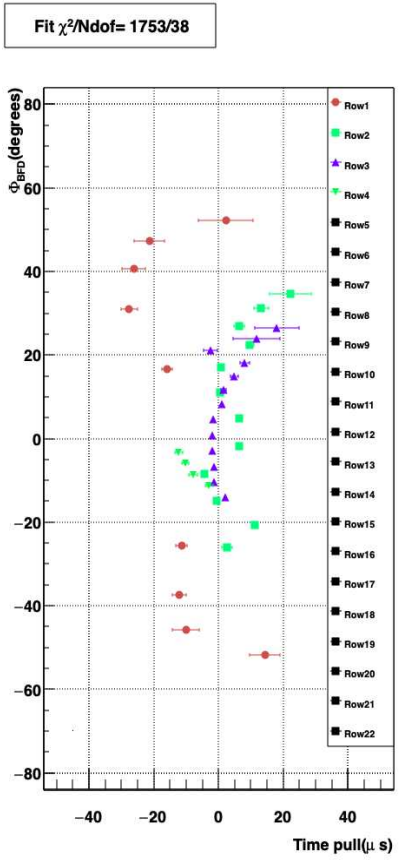
Long=-63.7

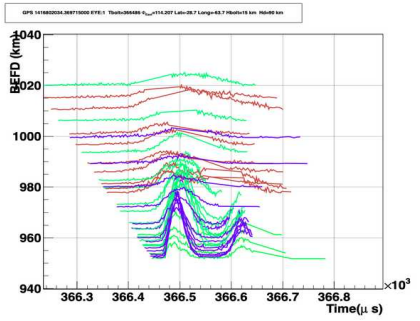
Lat=-28.7

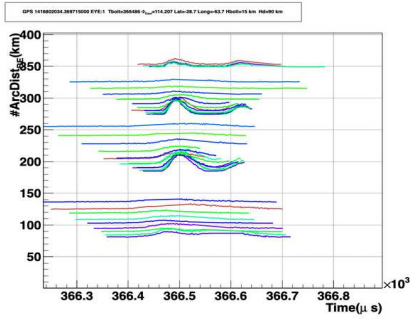
Hd=90 km

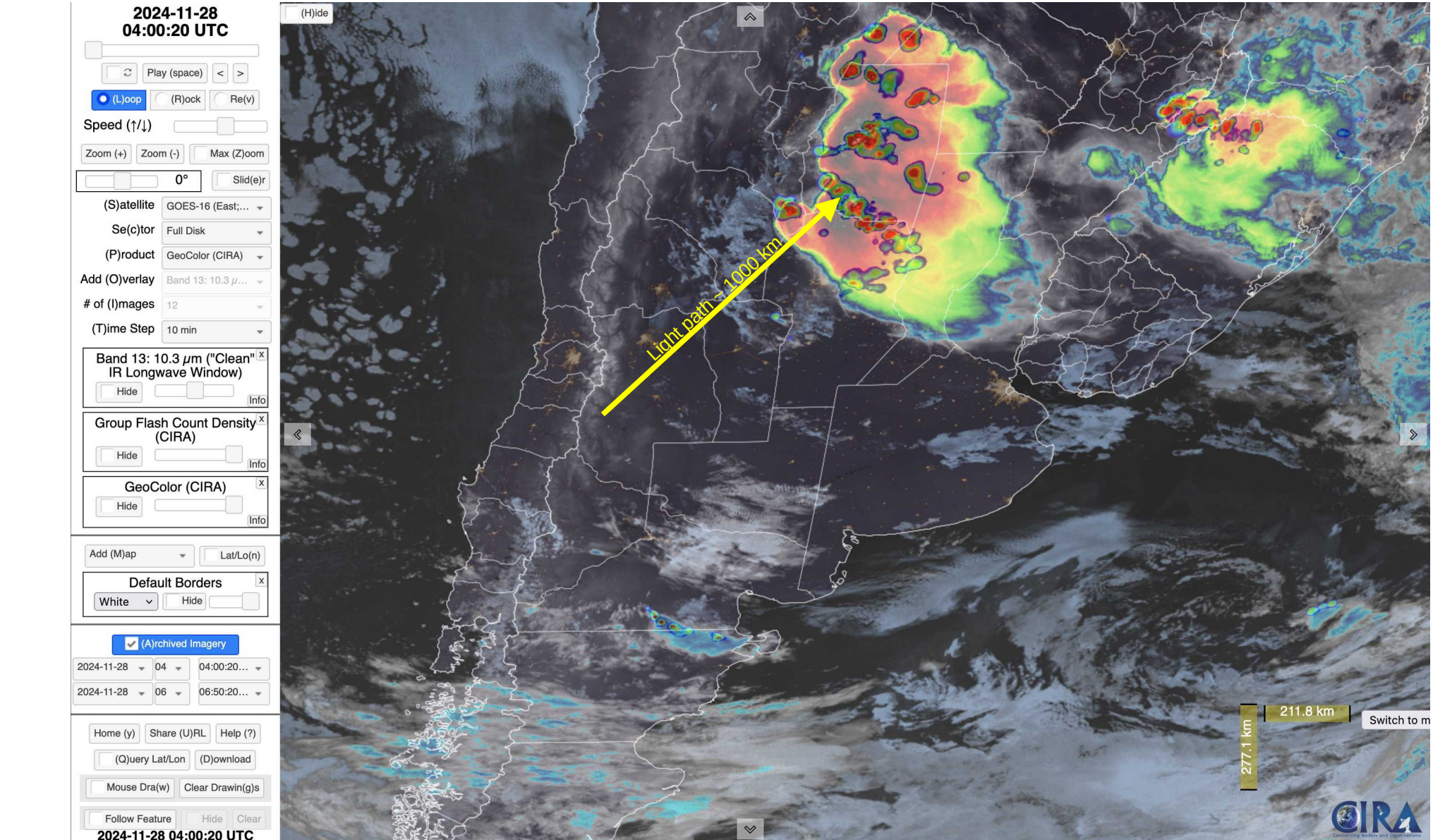




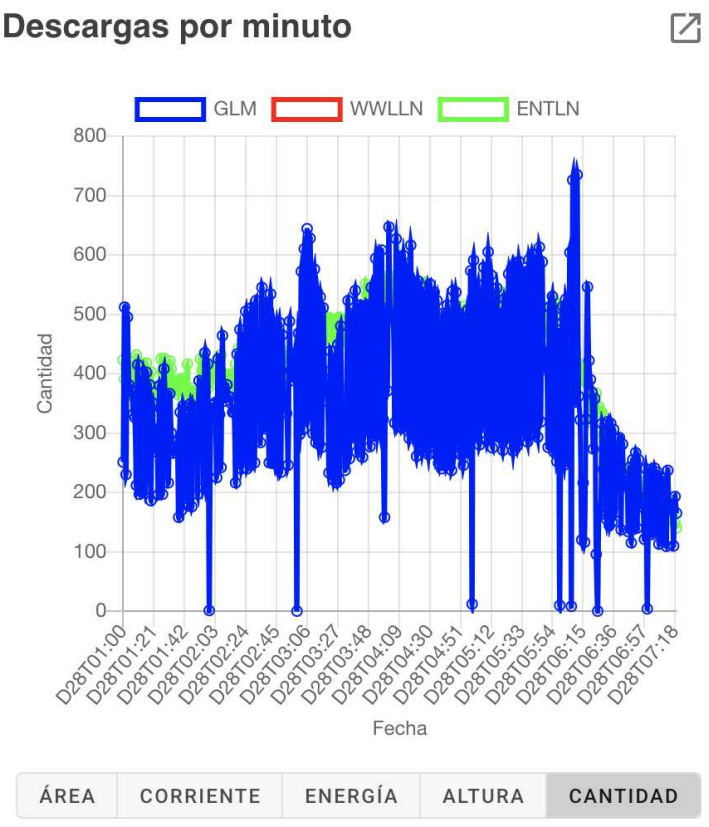


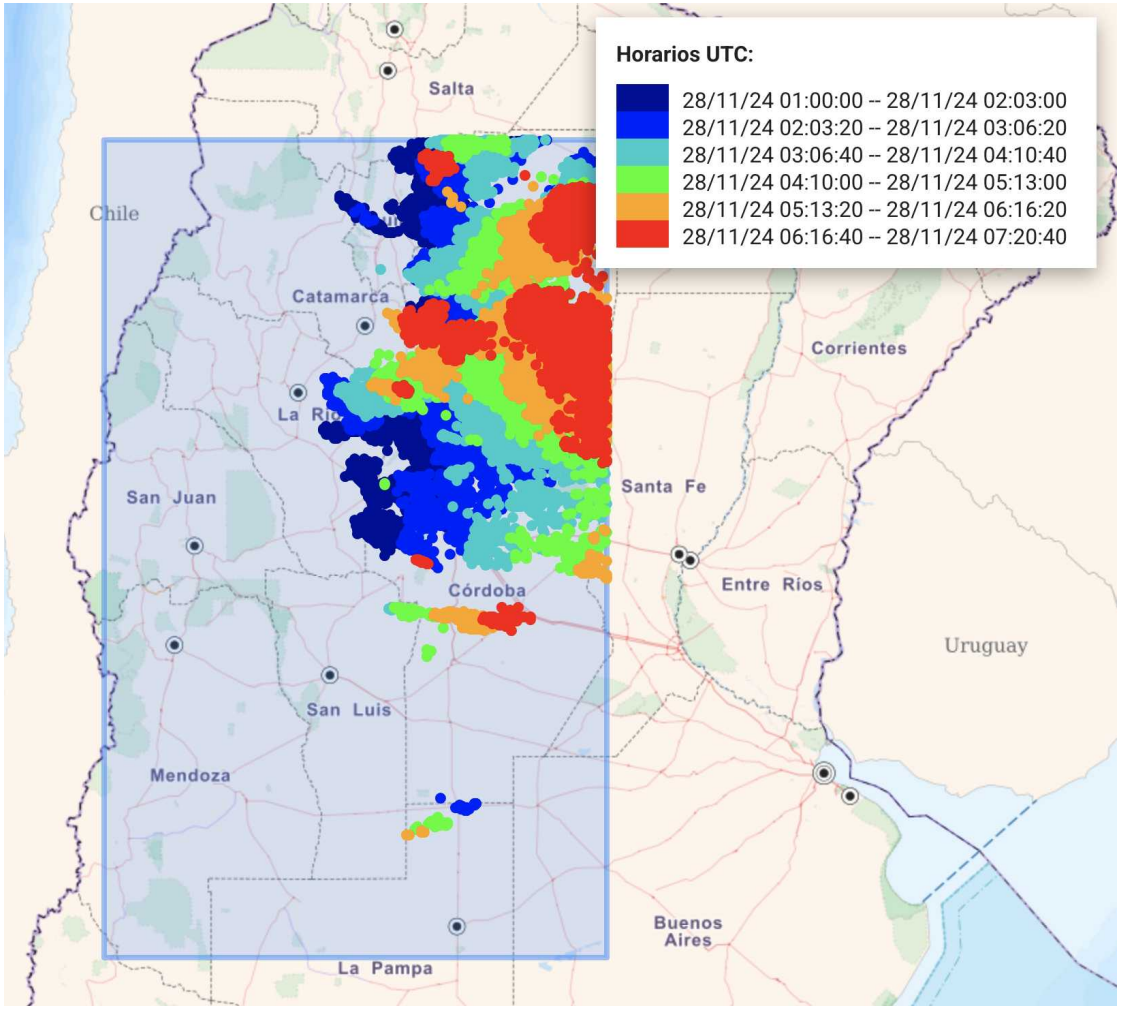





2024-11-28
04:00:20 UTC
Play (space)
(L)oop
(R)ock
Re(v)
Speed (↑/↓)
Zoom (+)
Zoom (-)
Max (Z)oom
0°
Slid(e)r
(S)atellite
GOES-16 (East;...
Se(c)tor
Full Disk
(P)roduct
GeoColor (CIRA)
Add (O)verlay
Band 13: 10.3 μ...
of (I)mages
12
(T)ime Step
10 min
Band 13: 10.3 μm ("Clean" IR Longwave Window)
Hide
Info
Group Flash Count Density (CIRA)
Hide
Info
GeoColor (CIRA)
Hide
Info
Add (M)ap
Lat/Lo(n)
Default Borders
White
Hide
(A)rchived Imagery
2024-11-28
04
04:00:20...
2024-11-28
06
06:50:20...
Home (y)
Share (U)RL
Help (?)
(Q)uery Lat/Lon
(D)ownload
Mouse Dra(w)
Clear Drawin(g)s
Follow Feature
Hide
Clear
2024-11-28 04:00:20 UTC
(H)ide
Light path ~ 1000 km
211.8 km
277.1 km
Switch to m
CIRA

GeoRayos DB info
(from G.Nicora)





Sprite Search using DBscan

The Challenge:

We started operating the ZWO camera in the Nov-Dec shift

Nov.28 : first ELVES-Sprite event detected by FD*ZWO*Sony

ZWO data rate : ~7GB in 10 min, 42 GB/h , ~250 GB /night

Not all Sprites come after one ELVES:

how can we design an unbiased trigger?

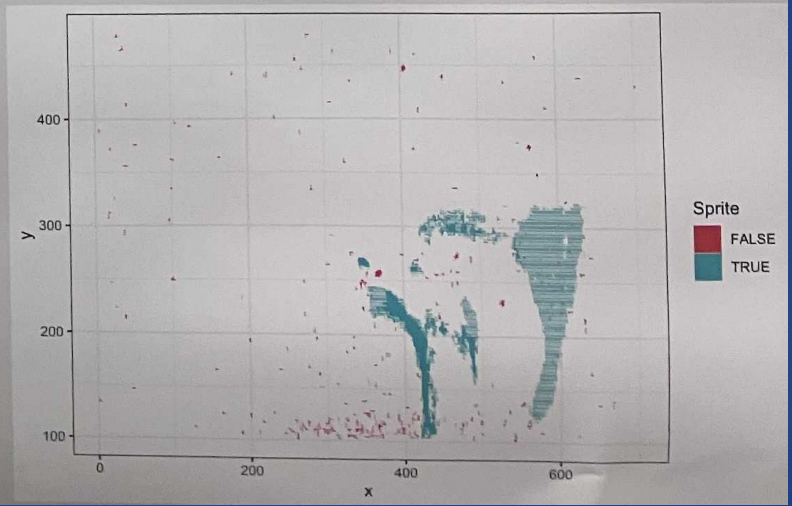
Sprite finder software from John Ortberg

Automated Sprite Detection & Characterization

In addition to the phantom high speed camera, we also operate a 30 FPS camcorder. Its much wider field of view has the ability to capture many more events than the phantom camera as we leave it operating throughout most of the night.

We analyze each frame using the DBSCAN algorithm (Density Based Spatial Clustering of Applications with Noise) on pixels above background, and developed our own algorithm to filter out pixels brightened by conventional flashes or stars.

In addition to maximizing the number of sprite events we can identify and use in analysis, this also allows us to automatically characterize the width, height, and area of each sprite in the 2-D projection available to us.



Spritefinder.py

```
for file1 in filelist:
    f2 = filelist.index(file1)+1
    if (f2<np.size(filelist,axis=None)):
        file2 = filelist[f2]
        im1 = Image.open(file1).convert('L')
        im2 = Image.open(file2).convert('L')
        box = (0,0,4144,YMIN)  #YMIN=1860 horizon
        im1c = im1.crop(box)
        im2c = im2.crop(box)
        img1a = np.array(im1c)
        img2a = np.array(im2c)
        diff = 255-(img2a-img1a-13)
        diffT = np.transpose(diff)
        diffTF = np.fliplr(diffT)
        X = np.argwhere(diffTF>220)
        db = DBSCAN(eps=4.9, min_samples=60).fit(X)
        labels = db.labels_
        n_clusters_ = len(set(labels)) - (1 if -1 in labels else 0)
        n_noise_ = list(labels).count(-1)
        counts = np.bincount(labels[labels>=0])
        n_cnt_  = sum(1 for x in counts if x > 120)
        if ((n_clusters_>0) & (n_cnt_>0)):
                                    YES: SAVE IMAGE
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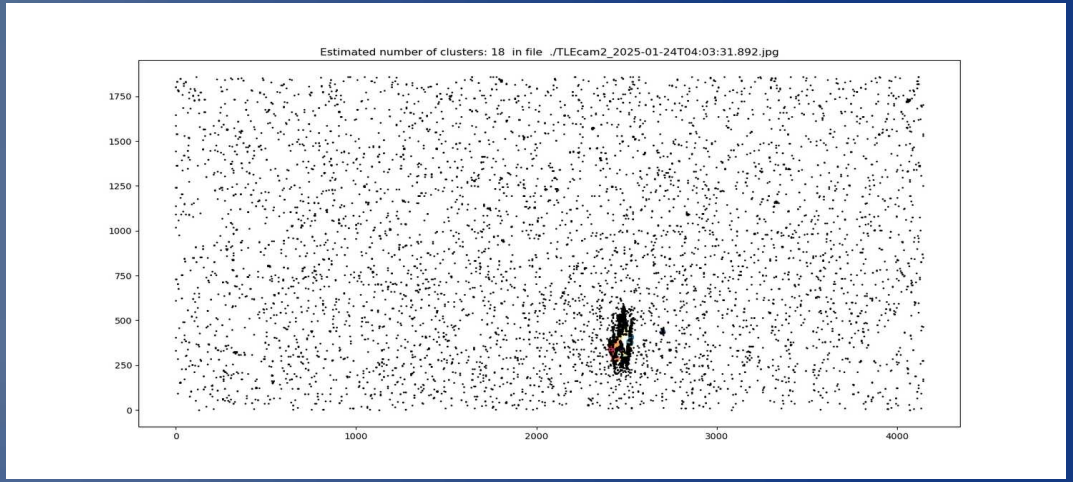

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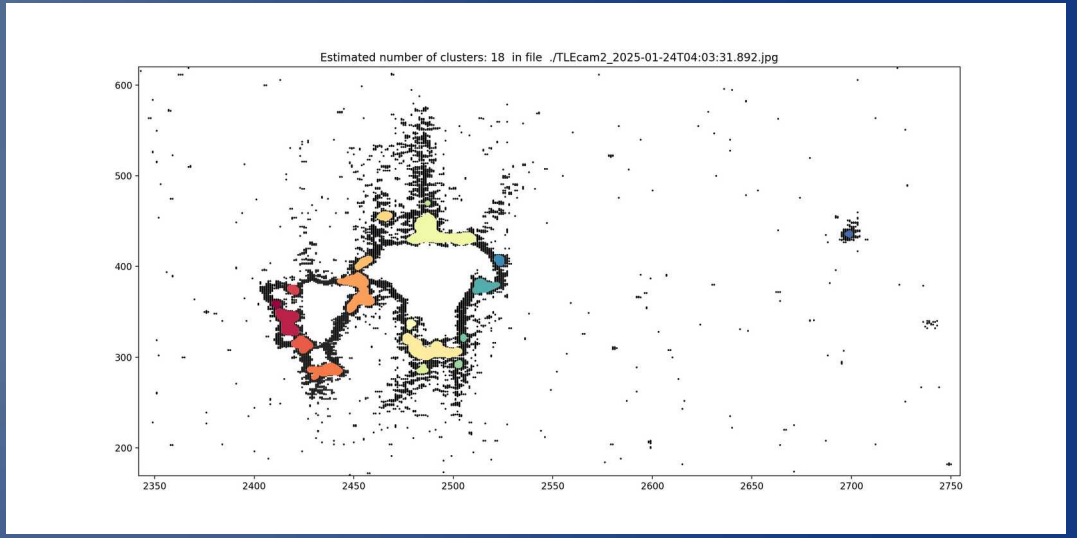

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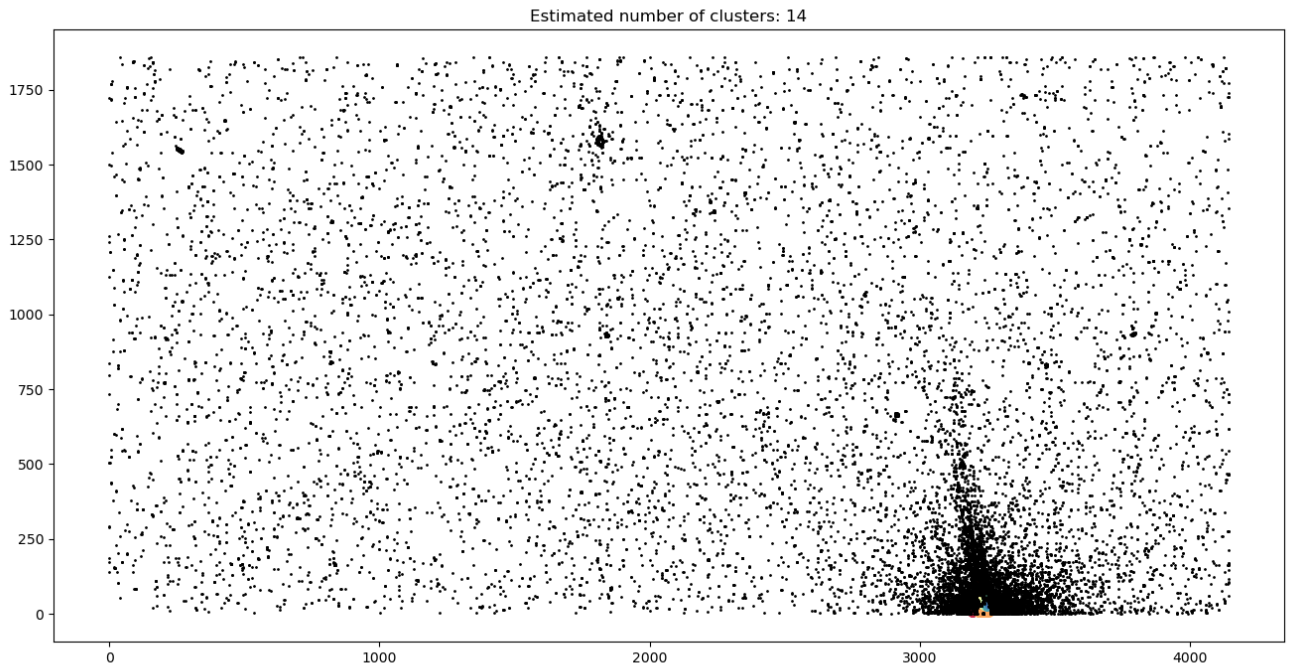
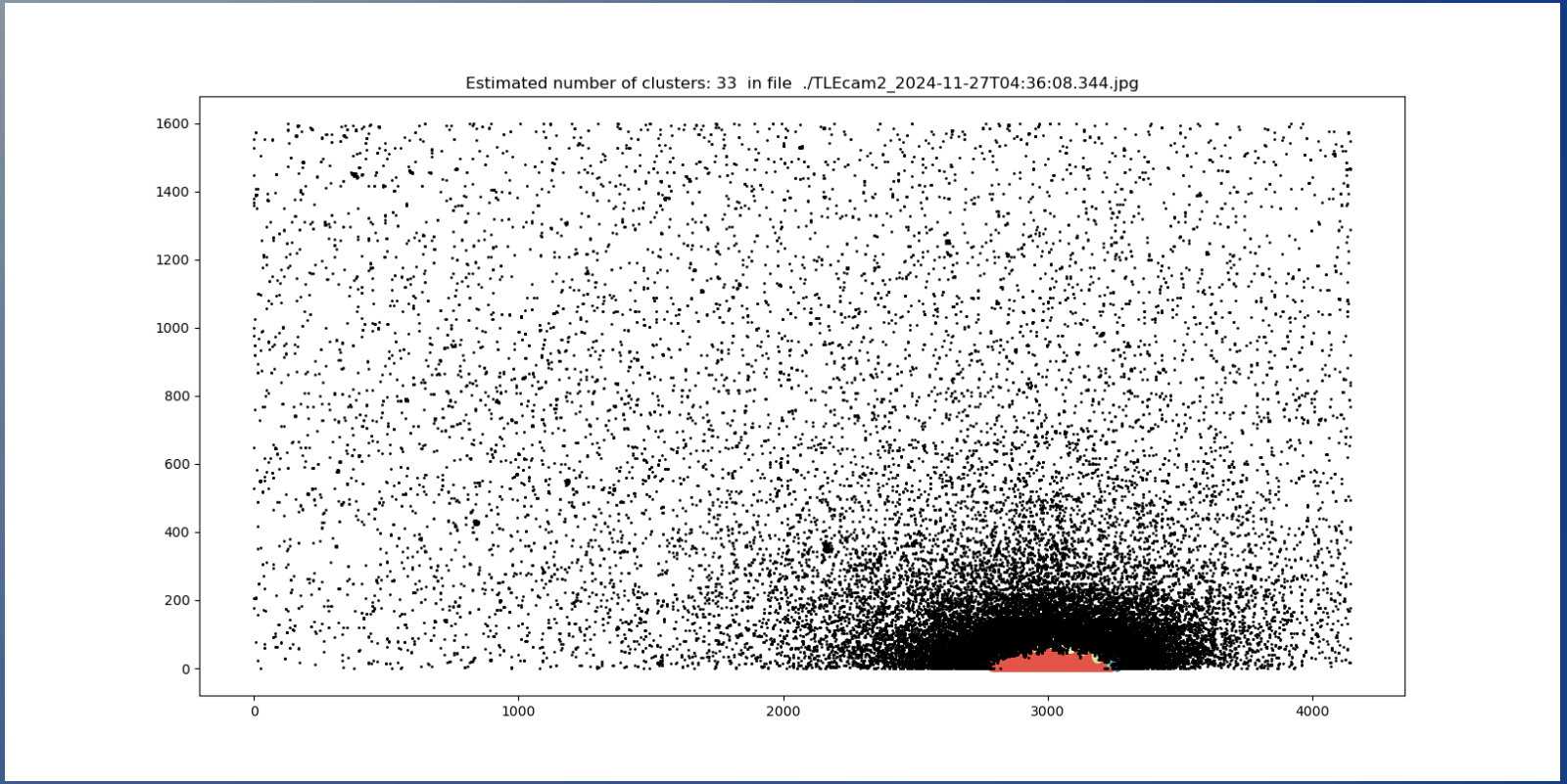
Spritefinder.py : remaining noise



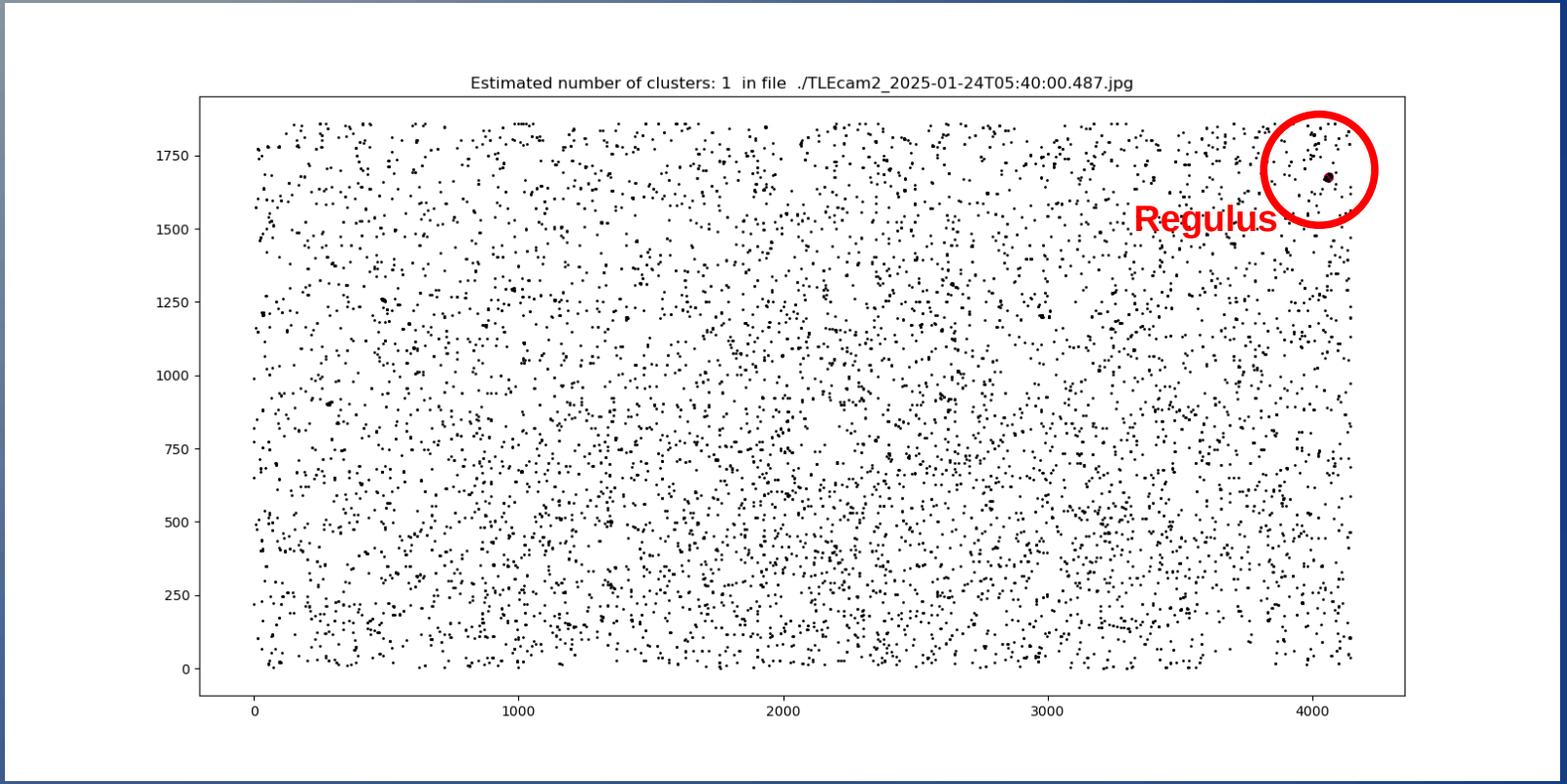
Some car/truck headlights on Ruta40 ...

Spritefinder.py : remaining noise



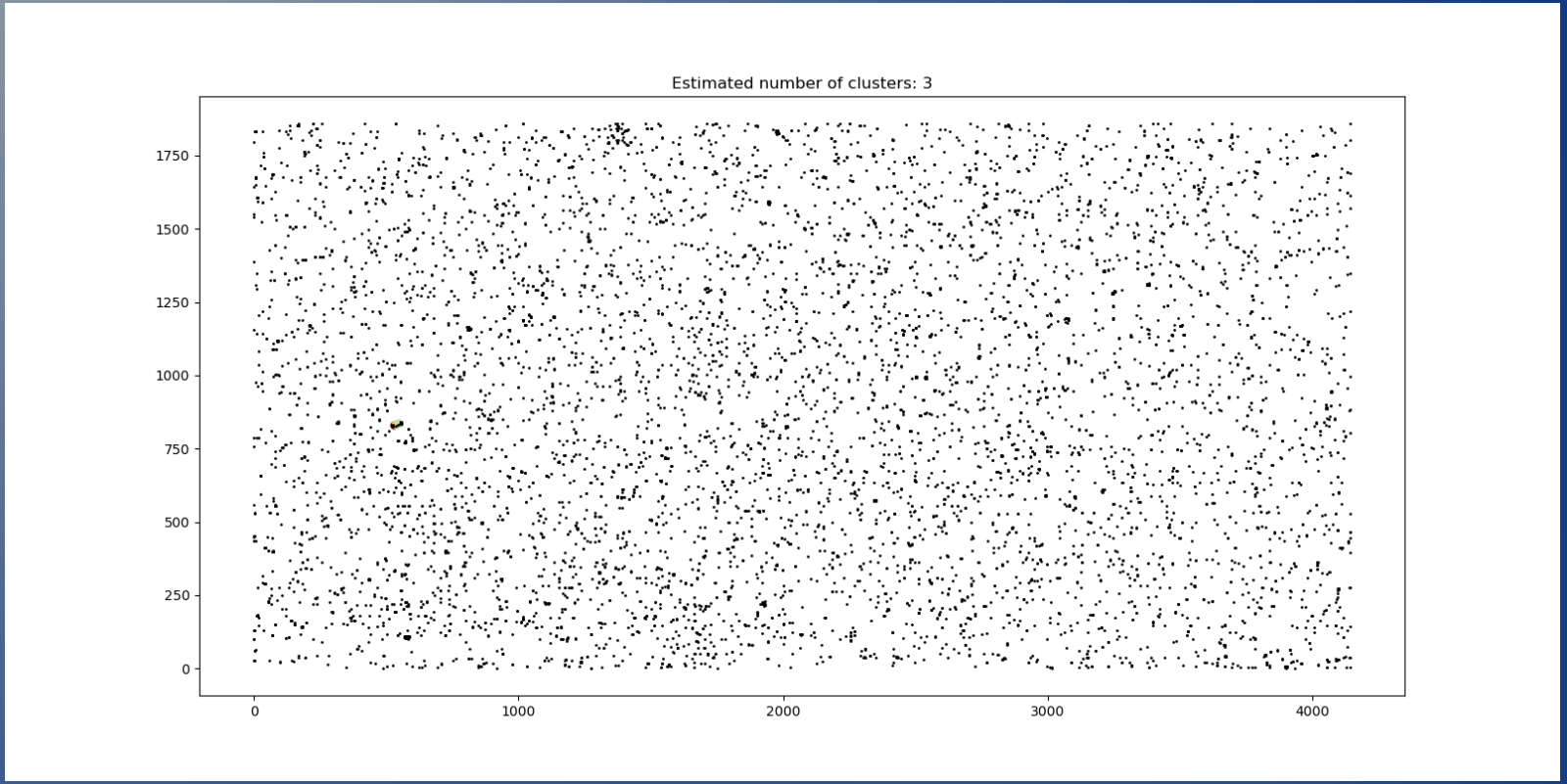
Strong lightning (Rayleigh scattering far above the cloud)

Spritefinder.py : remaining noise



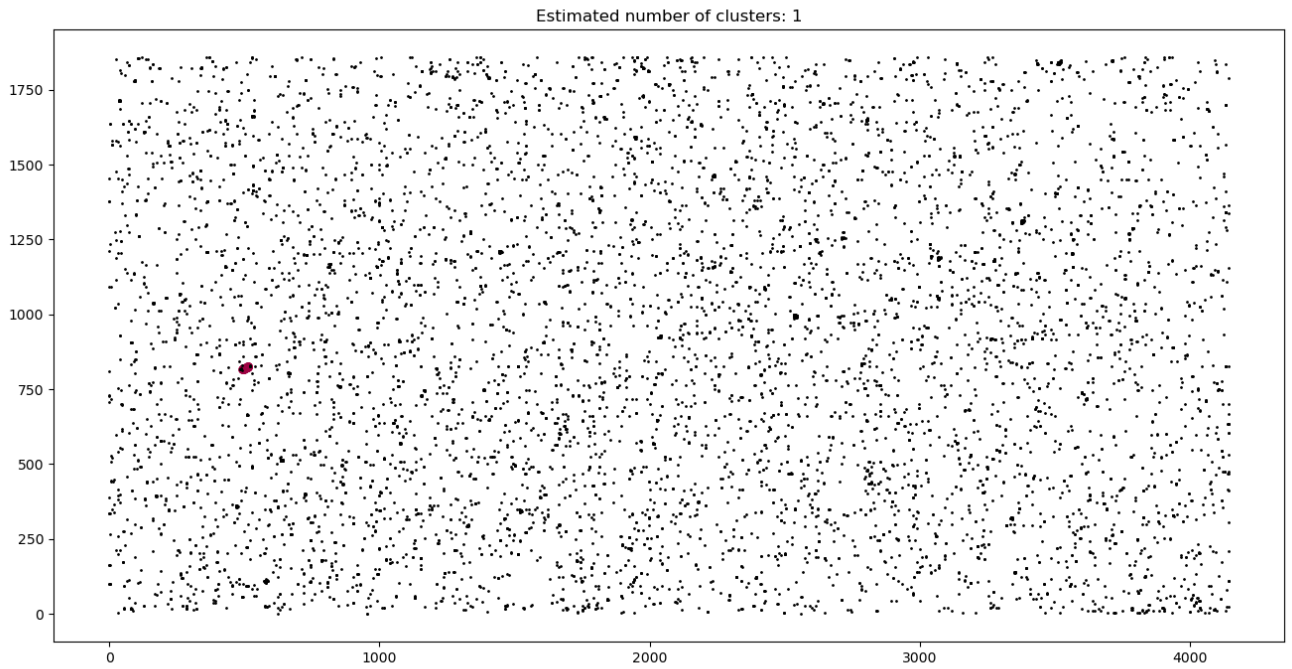
Bright stars ...

Spritefinder.py : remaining noise



Meteors ...

Spritefinder.py : remaining noise



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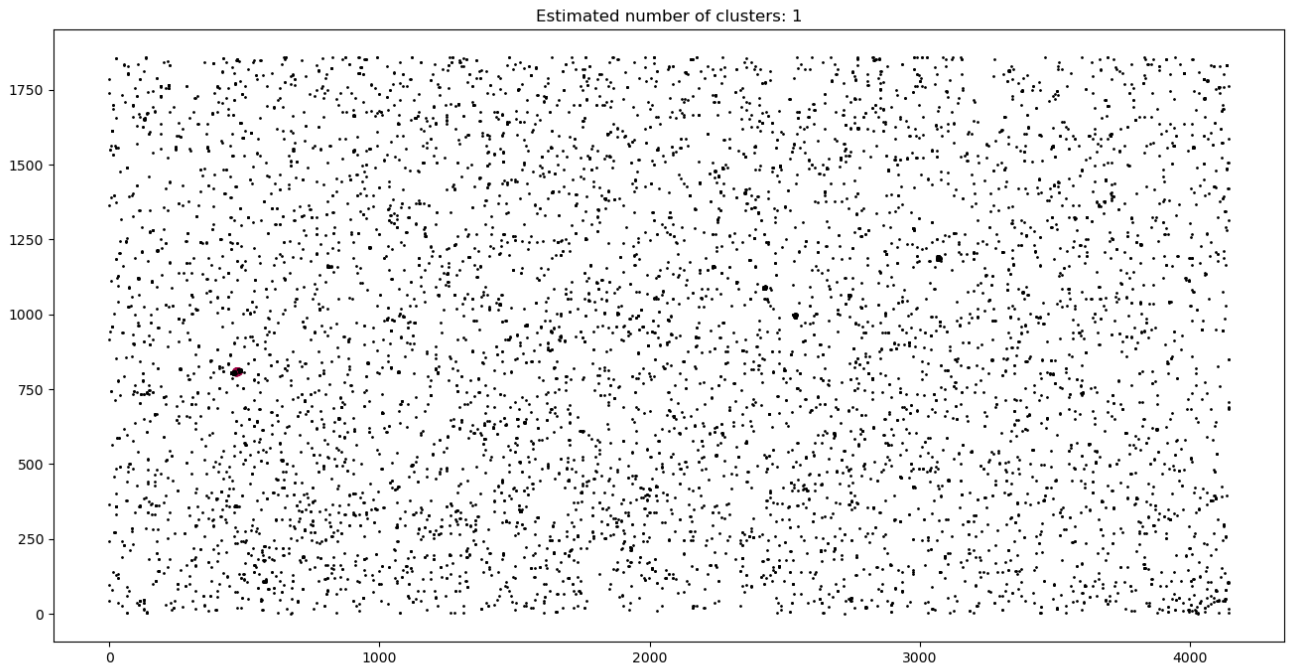

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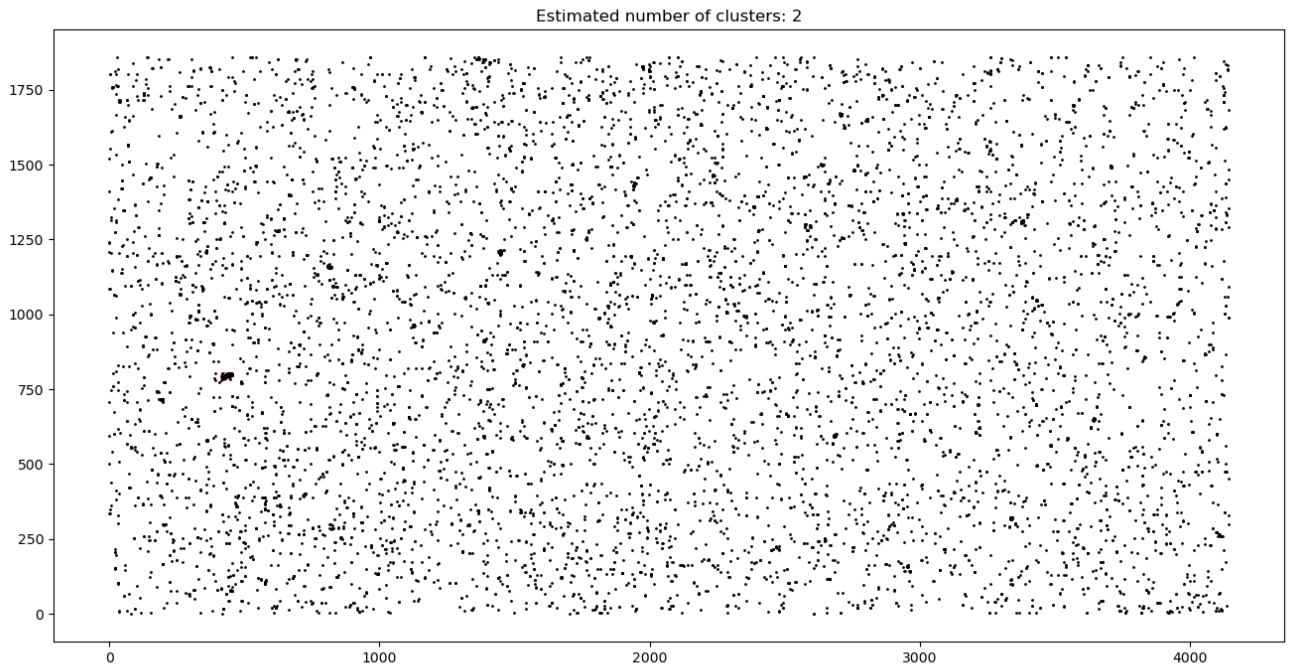

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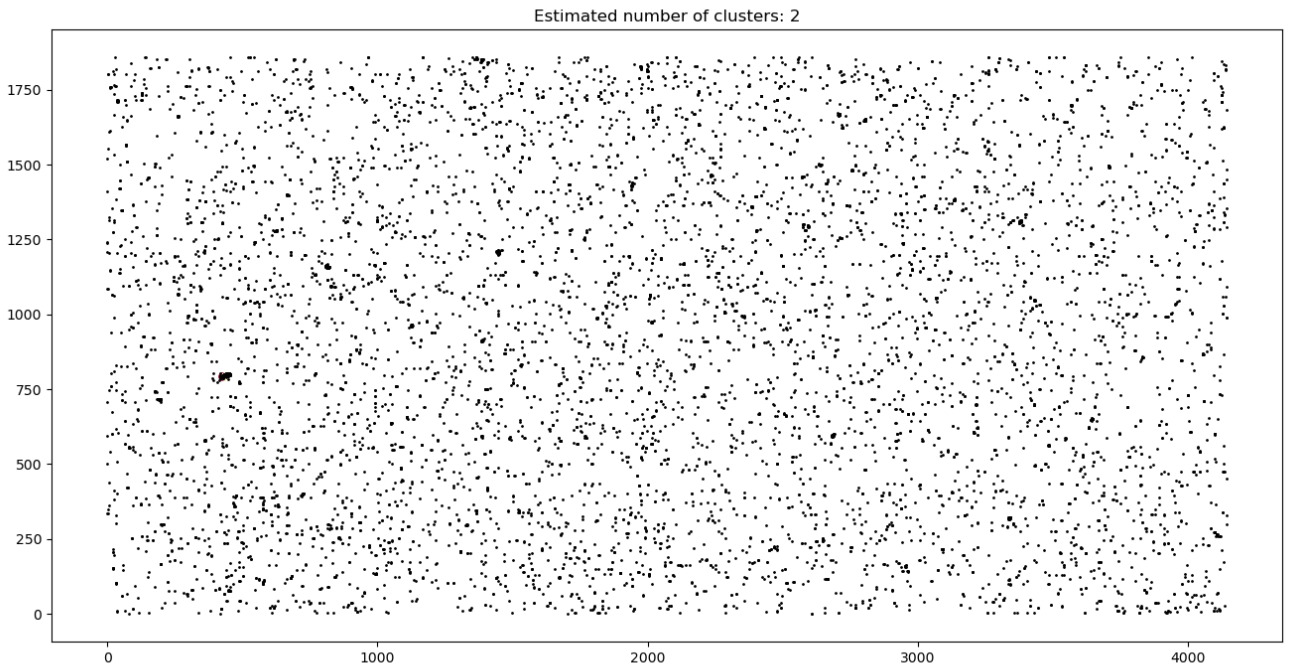
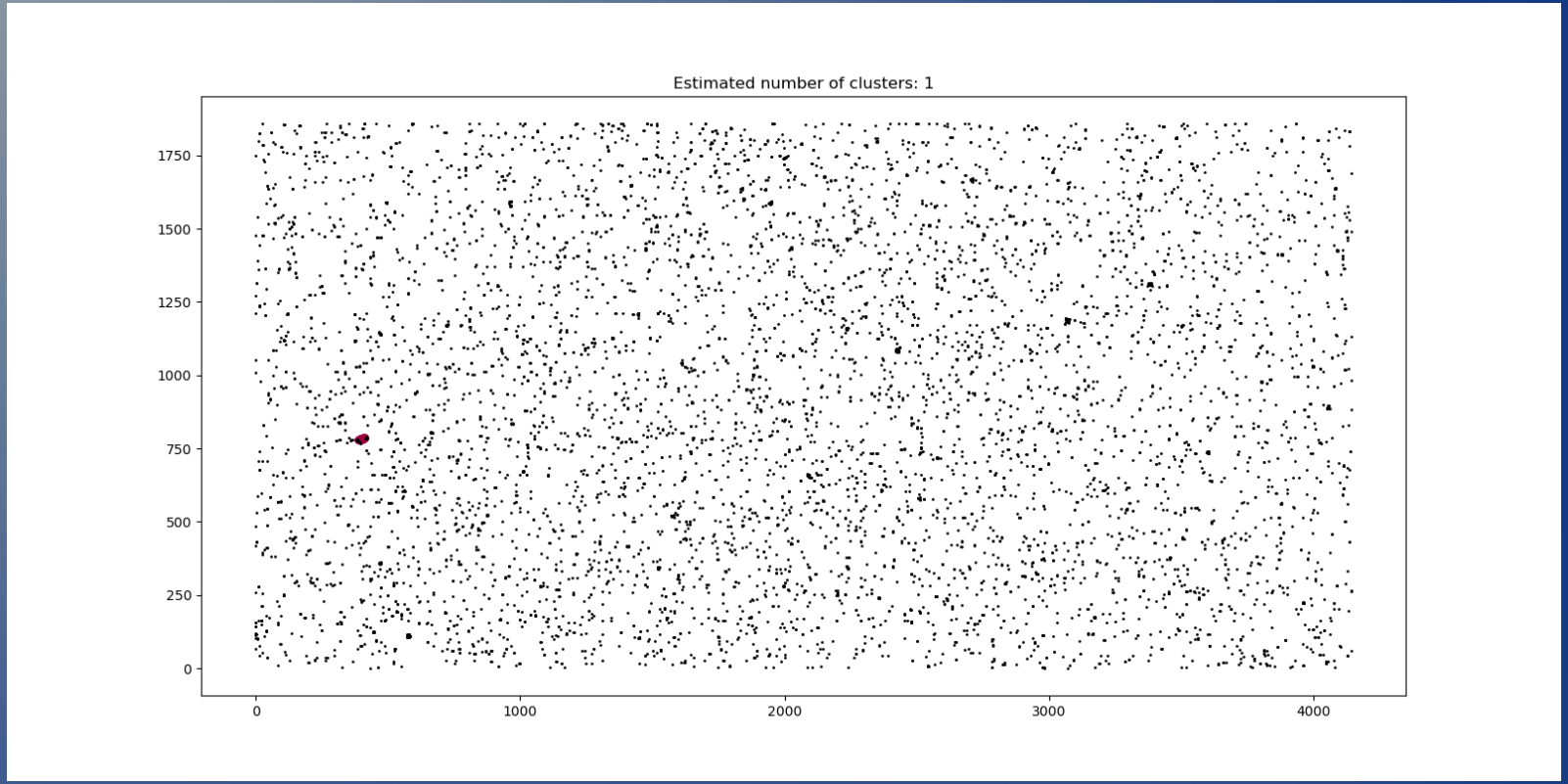


Meteors ...

Spritefinder.py : remaining noise



Meteors ...

Spritefinder.py : remaining noise

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Meteors ...

30 Sprites on Nov.28,2024

1416797064.503	1416799563.973	1416801568.141,203,269
1416797190.206	1416799765.289	1416801607.225
1416797238.626,693	1416800055.180	1416801940.277
1416797329.686	1416800193.936	1416802034.529
1416797606.157	1416800235.313	1416802521.491,621,813
1416798003.568,660	1416800283.048,114	1416803450.286
1416798012.419	1416800302.263	1416804184.466
1416798483.912	1416800661.845,913,974	1416804537.024
1416798771.218	1416801234.465	1416804995.643
1416799075.042	1416801406.200,391	1416805827.844

30 Sprites on Nov.28,2024...from > 850 km

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1416797329.686	1416800193.936	**1416802034.529 (ELVES)**
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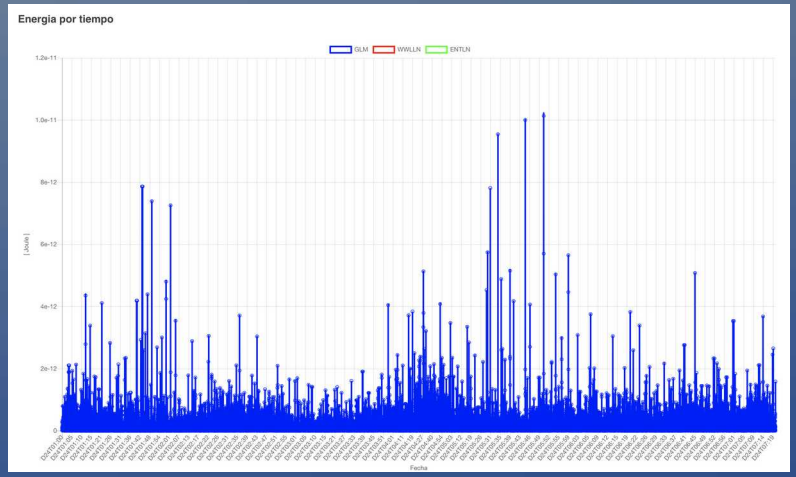
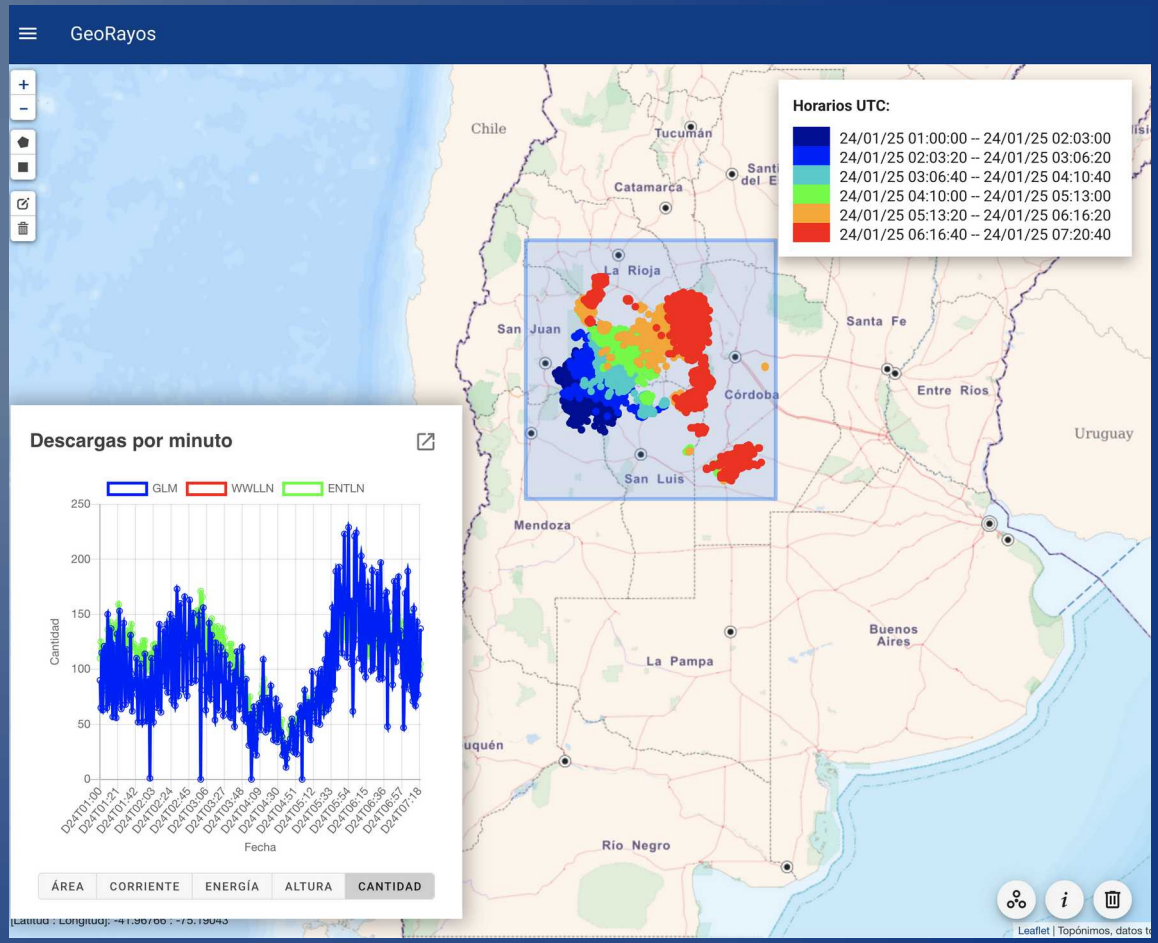
1416797606.157	1416800235.313	1416802521.491,621,813
1416798003.568,660	1416800283.048,114	1416803450.286
1416798012.419	1416800302.263	1416804184.466
1416798483.912	1416800661.845,913,974	1416804537.024
1416798771.218	1416801234.465	1416804995.643
1416799075.042	1416801406.200,391	1416805827.844

>80 Sprites on Jan 24,2025





>80 Sprites on Jan 24,2025

1421725127.876	1421726478.221	1421728147.717	1421732128.693
1421725255.413	1421726629.892	1421729096.853	1421732410.800
1421725362.602	1421726786.247	1421729411.030	1421732475.778
1421725362.802	1421726836.740	1421731386.565	1421732715.278
1421725362.866	1421726852.255	1421731386.629	1421732715.541
1421725695.576	1421726921.276	1421731540.254	1421732799.997
1421725695.649	1421727706.544	1421731540.318	1421733292.325
1421725814.398	1421727783.156	1421731758.492	1421733292.390
1421725890.073	1421727806.944	1421731836.987	1421733462.835
1421726126.850	1421727874.389	1421731896.052	1421733559.946
1421726160.271	1421727892.522	1421731896.116	1421733560.216
1421726202.288	1421727949.474	1421731896.183	1421733674.945
1421726310.985	1421728000.223	1421732035.275	1421733771.034
1421726311.055	1421728147.648	1421732053.544	1421733771.909

ELVES trigger in CO-6
GPSms= 316.208
ENTLN : +CG, 99kA
GPSms= 316.214

>80 Sprites on Jan 24,2025

1421719354.637	1421725255.413	1421727783.156	1421732053.544
1421719354.705	1421725362.602	1421727806.944	1421732128.693
1421719354.770	1421725362.802	1421727874.389	1421732410.800
1421719444.767	1421725362.866	1421727892.522	1421732475.778
1421719444.834	1421725695.576	1421727949.474	1421732715.278
1421719563.804	1421725695.649	1421728000.223	1421732715.541
1421719563.876	1421725814.398	1421728147.648	1421732799.997
1421719564.215	1421725890.073	1421728147.717	1421733060.238
1421719661.923	1421726126.850	1421729096.853	1421733060.303
1421719738.588	1421726160.271	1421729411.030	1421733060.372
1421719964.723	1421726202.288	1421731386.565	1421733292.325
1421720253.391	1421726310.985	1421731386.629	1421733292.390
1421720253.459	1421726311.055	1421731540.254	1421733462.835
1421720577.735	1421726478.221	1421731540.318	1421733559.946
1421721328.288	1421726629.892	1421731758.492	1421733560.216
1421721389.103	1421726786.247	1421731836.987	1421733674.945
1421721389.172	1421726836.740	1421731896.052	1421733771.034
1421722135.998	1421726852.255	1421731896.116	1421733771.909
1421722136.068	1421726921.276	1421731896.183	1421733967.865
1421725127.876	1421727706.544	1421732035.275	1421733967.930

>80 Sprites on Jan 24,2025

1421719354.637	1421725255.413	1421727783.156	1421732053.544
1421719354.705	1421725362.602	1421727806.944	1421732128.693
1421719354.770	1421725362.802	1421727874.389	1421732410.800
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>80 Sprites on Jan 24,2025 SONY animation

>80 Sprites on Jan 24,2025 ZWO animation

Problems and Prospects

The timing of TLEcams is based on PC unixtime and time tags are 150-200 ms later than FD times .

A GPS antenna is available at APF, we'll try to use it and get better synchronisation

SONY resolution is still limited by the limits of remote operation

ZWO sensitivity is higher in the red and allow detection of fainter TLEs
Nevertheless, color balance is not very natural

Dbscan takes about 15' to process 10' and this prevents ontime sparsification, but can be run the day after .

Georayos DB can be used in real time to adjust the horizon threshold and avoid close lightning, we'll work on this with G.Nicora

During March FD shift I will do more field tests

Status of the JGR paper

Submitted by Adriana on Jan.27

Reply on Jan.31:

Dear Dr. Vásquez Ramírez:

Thank you for submitting your manuscript to Journal of Geophysical Research - Space Physics. Based on my own reading of the manuscript, the science area of the manuscript does not belong to space physics. I am declining your manuscript for publication in Journal of Geophysical Research - Space Physics.

Thank you for your interest in Space Physics. Sincerely, Paul Song (Editor)

Reply by Adriana on Jan.31:

Dear Dr. Song,

Thank you for reviewing our manuscript. We would like to better understand the scope concern, as our study follows a similar approach to previous works published in the Journal of Geophysical Research - Space Physics. For example, Newsome and Inan (2010) present ground-based observations of elves doublets, discussing their occurrence within the Ionosphere and Upper Atmosphere category (https://doi.org/10.1029/2009JA014834). Our manuscript follows a comparable approach, reporting multi-peak elves from different storms detected by our ground-based instrument and analyzing their origin.

Given this precedent, I would appreciate clarification on why our manuscript falls outside the journal's scope.

I look forward to your response.

Reply by Editor on Feb.3:

Thank you for your message requesting clarification of the scope of JGR-SP.

The scope of the journal is given in the AGU website:
“Journal of Geophysical Research: Space Physics publishes original research articles on the broad field of space physics, including aeronomy, magnetospheric physics, planetary atmospheres, ionospheres and magnetospheres, solar and interplanetary physics, cosmic rays, and heliospheric physics.”

Other than planetary (not including terrestrial, which has its own journal) atmospheres, the common topic is ionized particles interacting with electromagnetic fields. This includes electromagnetic waves propagating in plasma and ionization that forms plasma. My understanding of your manuscript concerns propagation of electromagnetic waves propagating in the terrestrial atmosphere and reflecting at the ionosphere. In this case, if the propagation speed were determined by plasma waves from which electron density can be derived or the waves modified the properties of the ionosphere e.g., by ionization, I would consider the work belonging to the journal.

Thank you for mentioning Newsome and Inan’s 2010 paper. It presented a large observation facility including PIPER (which measures precipitation electrons) and VLF wave receivers, both precipitation electrons and VLF waves are common topics in space physics belonging to JGR-Space Physics.

Please let me know if I misjudged your manuscript or if you have further questions.