

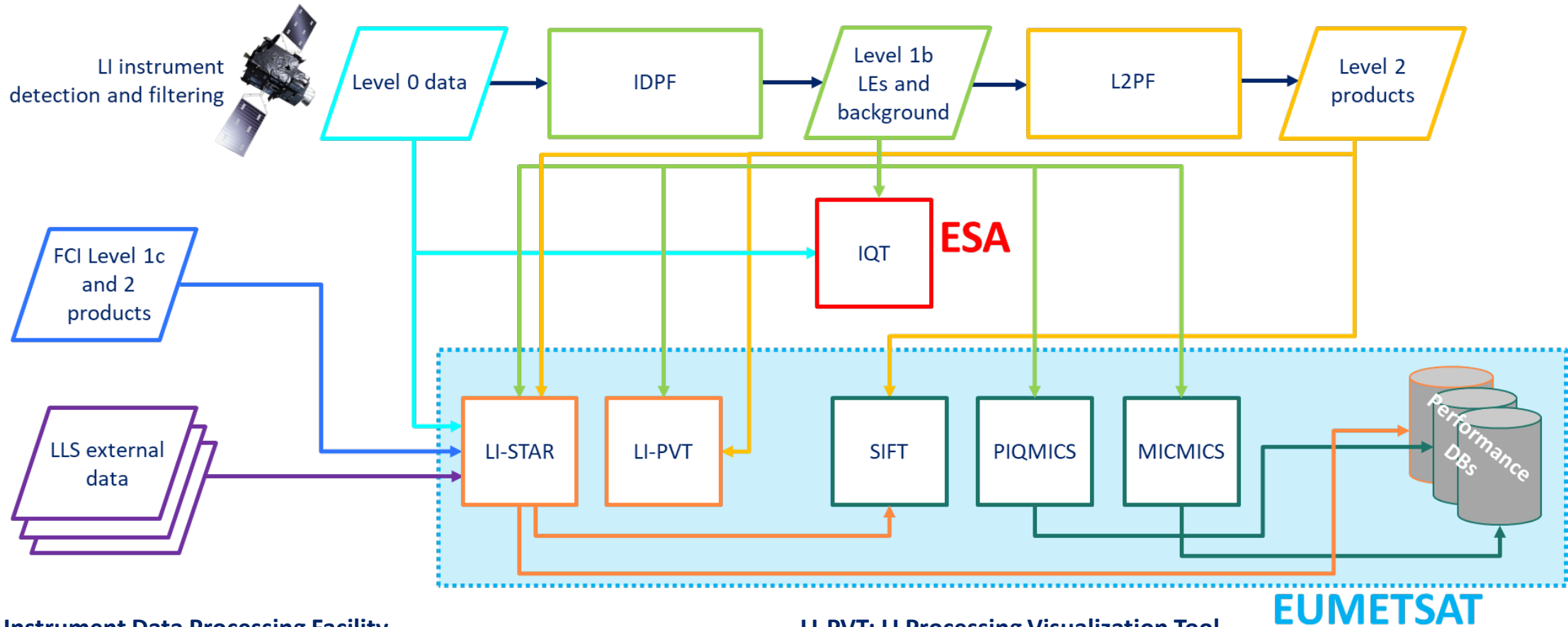
# LI-STAR Implementation Status (focus on Level 0 and Level 1b)

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# Introduction: LI-STAR



**IDPF:** Instrument Data Processing Facility

**L2PF:** Level 2 Processing Facility

**LEs:** Lightning Events (i.e., LI pixel-based measurements)

**IQT:** Image Quality Tool

**LLS:** Lightning Location System

**LI-PVT:** LI Processing Visualization Tool

**LI-STAR:** LI STATistics and Reporting

**PIQMICS:** Performance Image Quality Monitoring and Characterization System

**MICMICS:** Mission Integrated Calibration Monitoring Inter-Calibration System

**SIFT:** Satellite Information Familiarization Tool (<https://sift.ssec.wisc.edu/>)

**EUMETSAT**

# Introduction: Level 0 monitoring

The LI Science Team has been tasked to develop functionalities for the monitoring of Level 0.

We are currently focusing on four main points:

- Monitoring of the background at Level 0
- Processing of MVW content
- Monitoring of DT content
- Monitoring of on-board DT rates and voltages, currents and temperatures

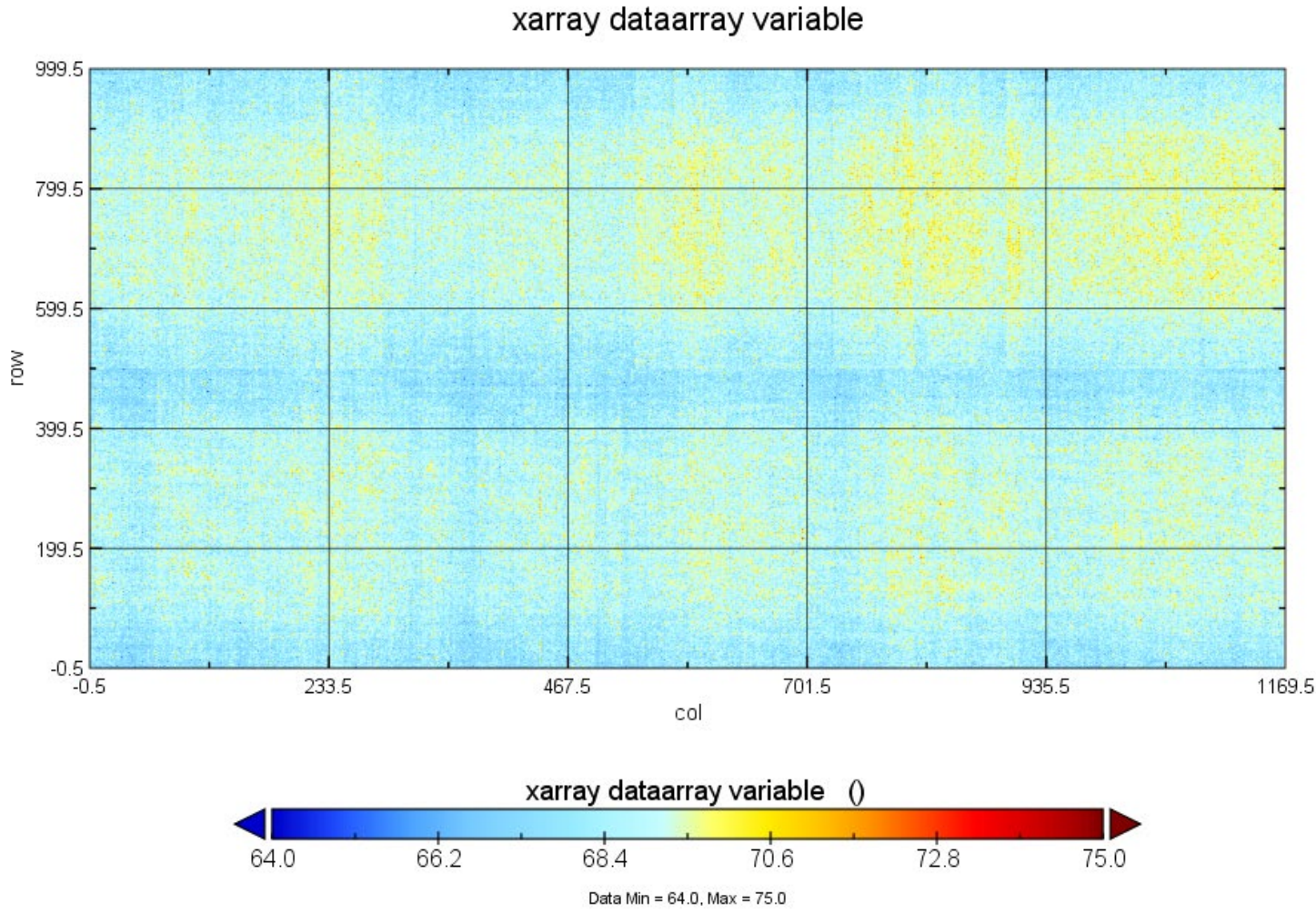
Three readers have been developed:

- Level 0 BCK reader
- Level 0 MVW reader
- Level 0 DT rates reader

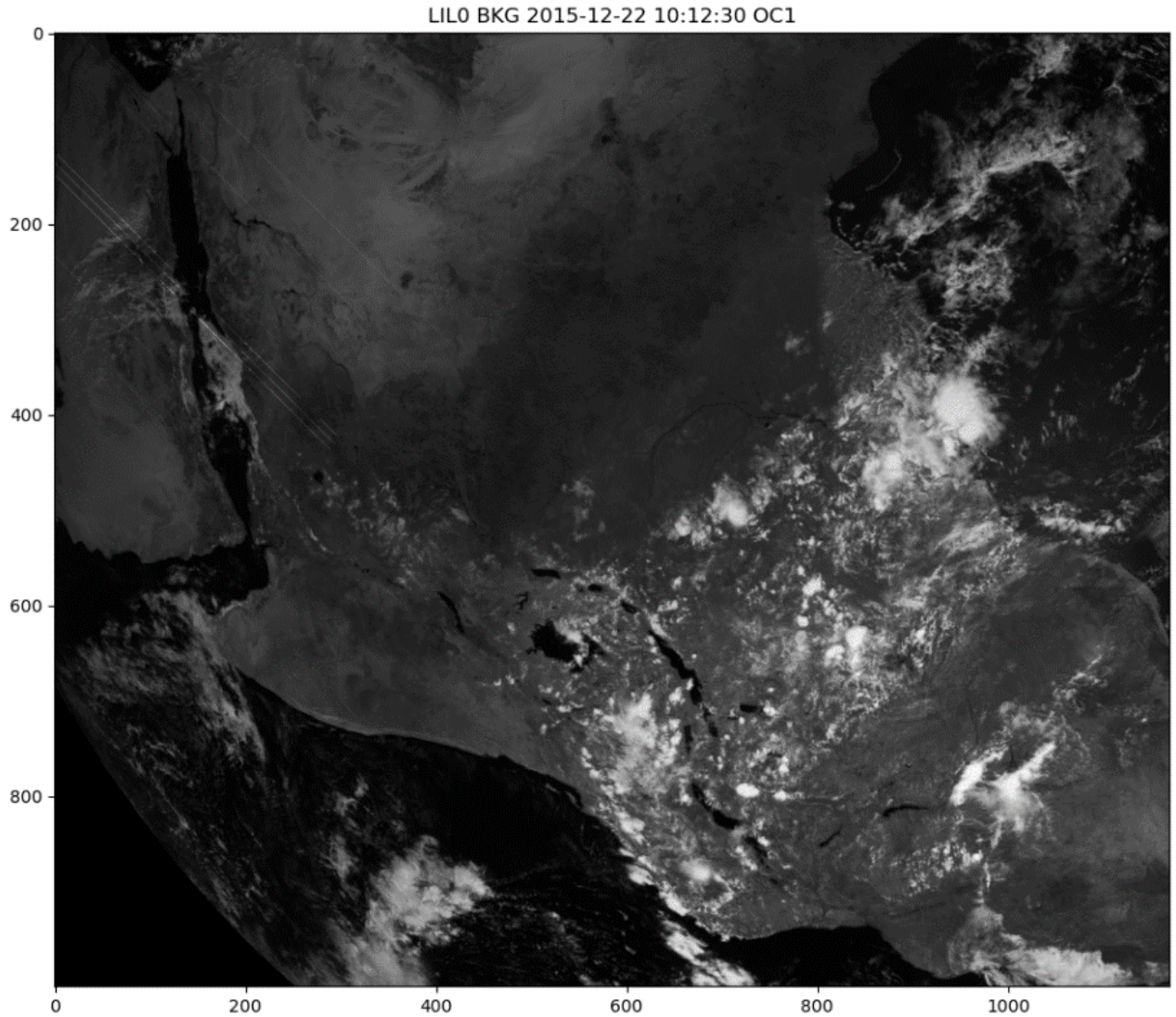
All readers are capable of handling both Level 0 binary files and continuous streams.

- SVT data (LI real data) – System Verification Testing, LI in the cleanroom (July 2022).
- PDG data – simulated LIL0 data.

# Level 0 BCK from SVT data (LI real data)



# Level 0 BCK from PDG (simulated data)



# DN histogram and pixel-based investigation

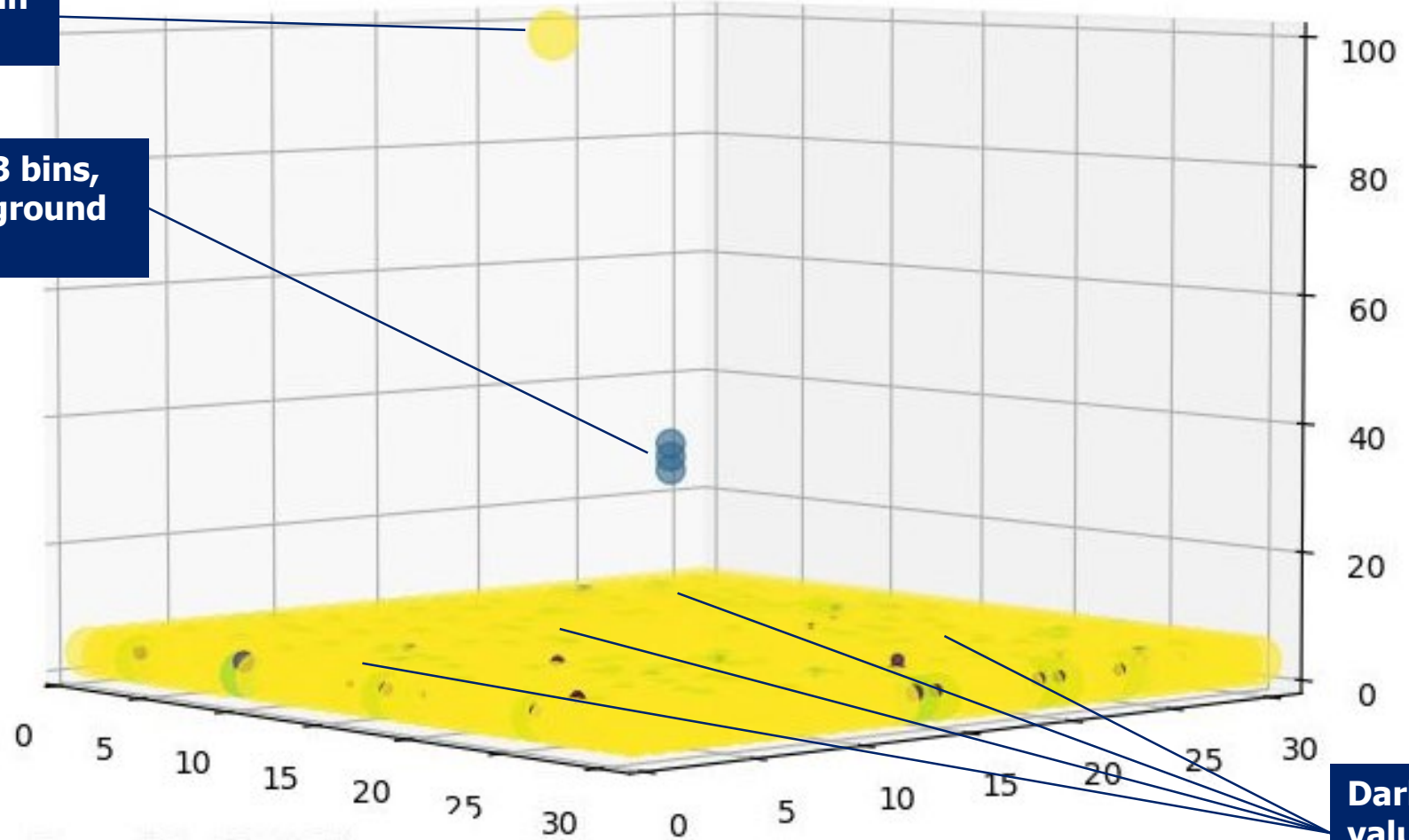
1. LI L0 background builder, i.e., extraction of 10x13 windows and composition of OC images
2. DN histogram creation, i.e., population of the DN histogram following the specifications in LI-20
3. RTS/SAT detection, analysis of night-time information to spot pixels affected by RTS noise or saturation.
4. The functionality is complemented by visualization routines for visual inspection of the DN histograms

# DN histogram and pixel-based investigation

DN histogram (start=20151222, hour=01, OC=3)

SAT pixel – all values in bin 100

RTS pixel – values in 3 bins, well above dark background level



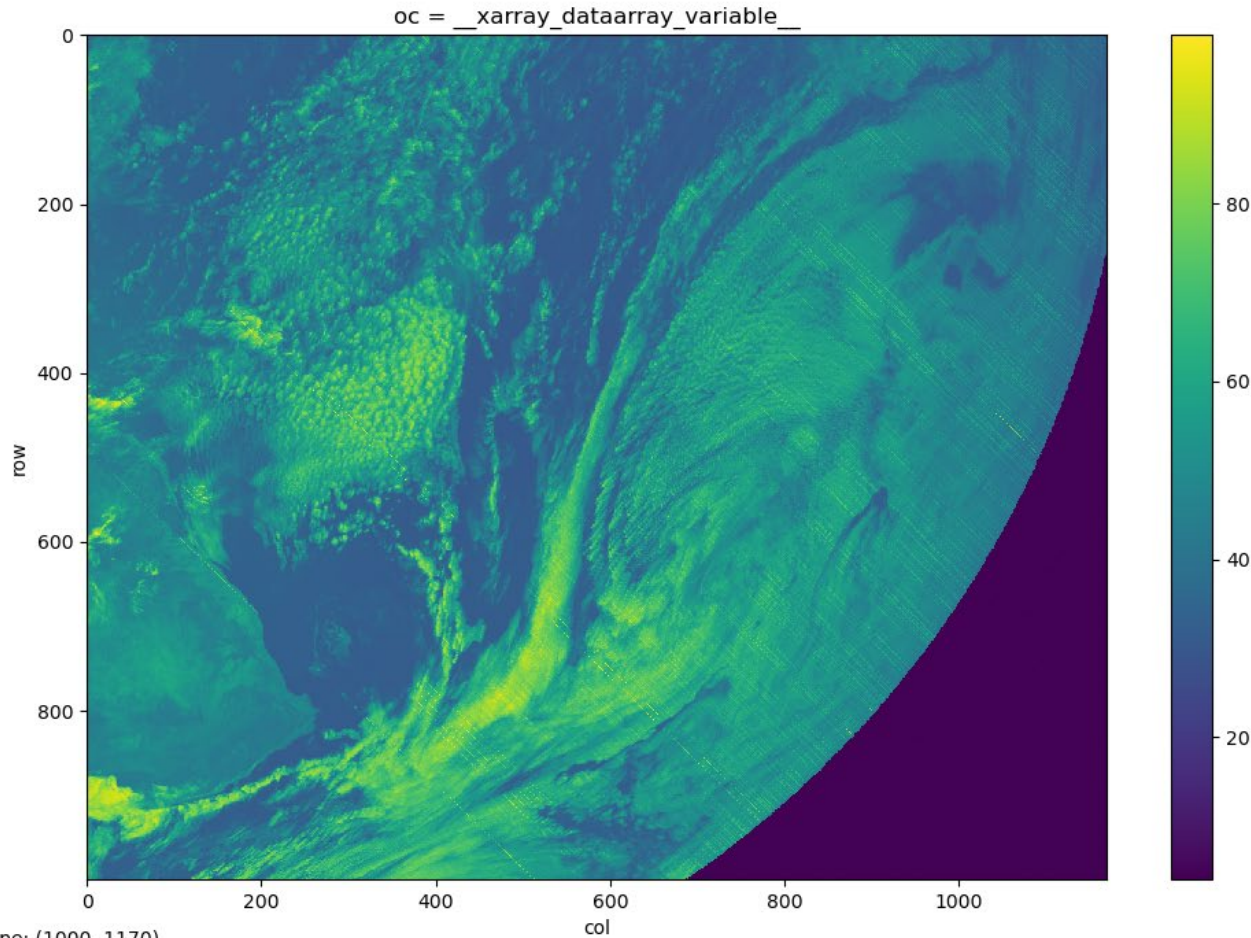
Dark background values in the low bins.

Shape: (31, 31, 100)  
Total of bin counts: 228718

```
SAT_locs_2015122201_OC1.csv — Kate
File Edit View Projects Bookmarks Sessions Tools Settings Help
SAT_locs_2015122201_OC1.csv
RTS_locs_2015122201_OC4.csv
1 row,col
2 0,0
3 100,100
4 250,250
5 333,600
6 486,733
7 495,982
8 625,100
9 666,300
10 870,870
11 922,922
12 990,990
13 993,200
14
```

# DN histogram and pixel-based investigation

DN histogram (start=20151222, hour=09, OC=2, method=amax)



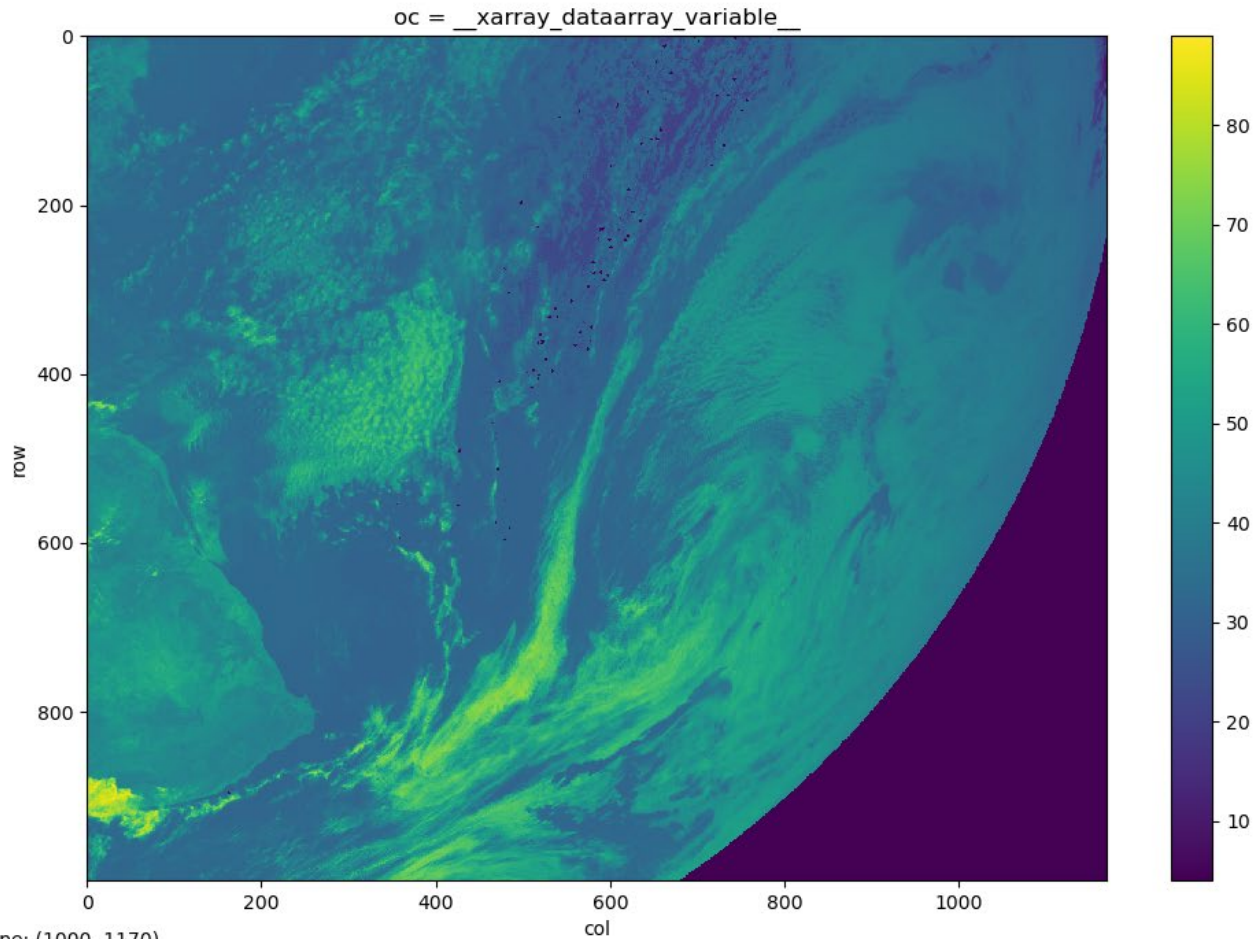
Shape: (1000, 1170)  
Total of bin counts: 50700728

- For each pixel, the ID of the highest bin with  $>0$  count, i.e. 100 would suggest saturation at DN=4095.
- High values reflect at least one high DN count in this pixel (clouds).
- Low values are pixels completely without high DN values (oceans, deep space).



# DN histogram and pixel-based investigation

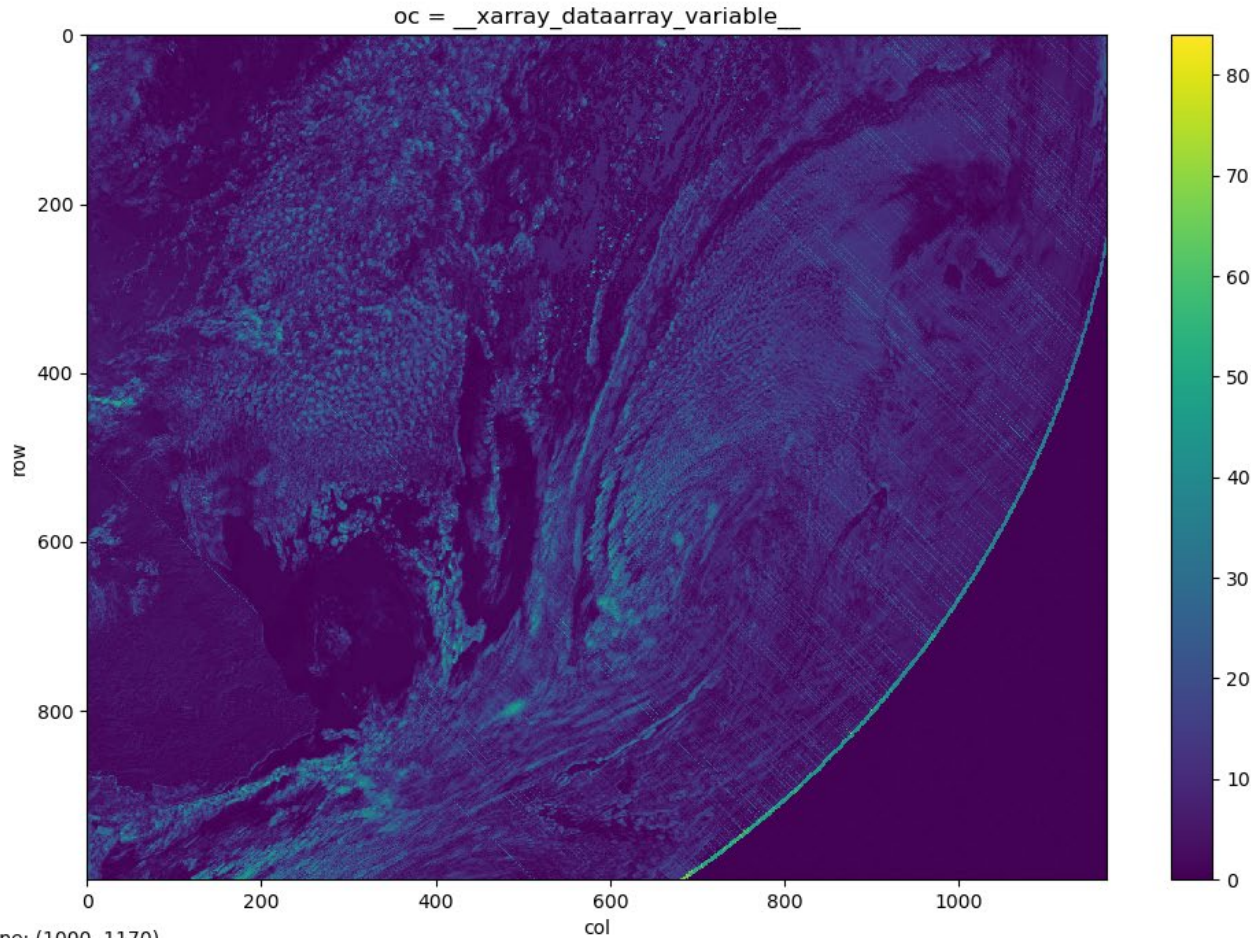
DN histogram (start=20151222, hour=09, OC=2, method=amin)



- For each pixel, the ID of the lowest bin with  $>0$  count, i.e. 1 would suggest at least one DN=0 count.
- High values are pixels with continuously high DN counts, no low values (clouds).
- Low values are pixels with at least one low DN count (oceans, deep space).

# DN histogram and pixel-based investigation

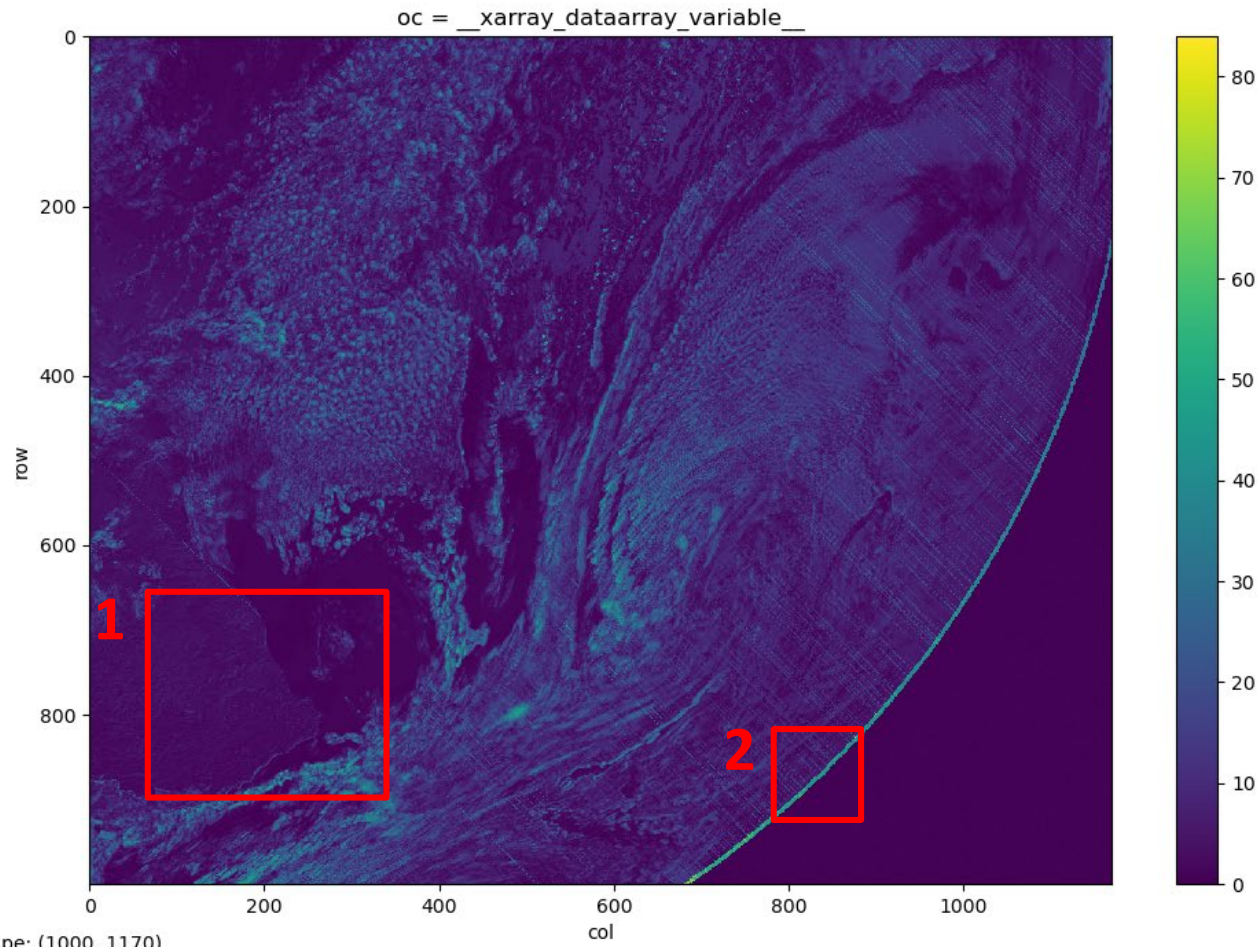
DN histogram (start=20151222, hour=09, OC=2, method=var)



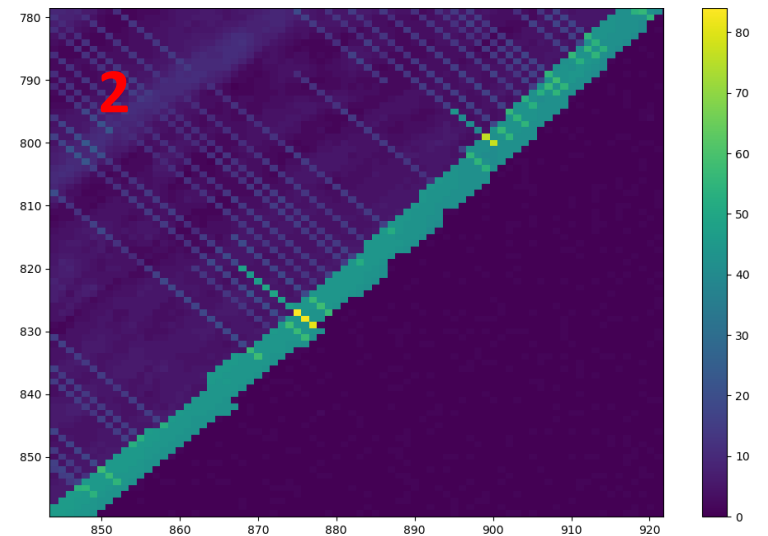
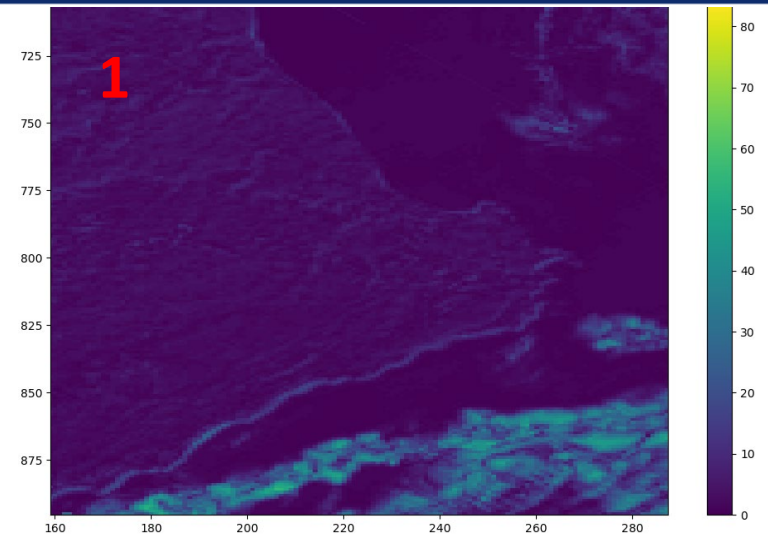
- The difference between *amax* and *amin* per pixel, i.e.  $var=amax-amin$ .
- High value – the pixel sometimes exhibited high and sometimes low DN (clouds and artefacts, possibly jitter).
- Low value – the pixel exhibited stable DN through the BKG images (deep space, oceans, also land).

# DN histogram and pixel-based investigation

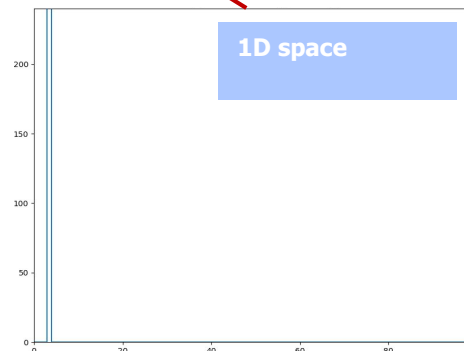
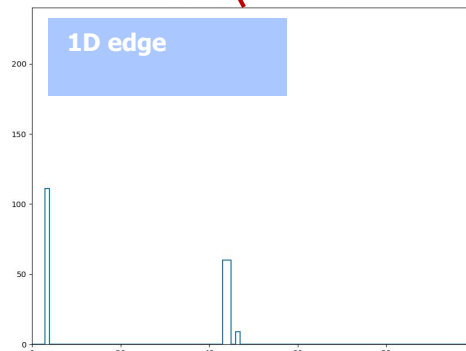
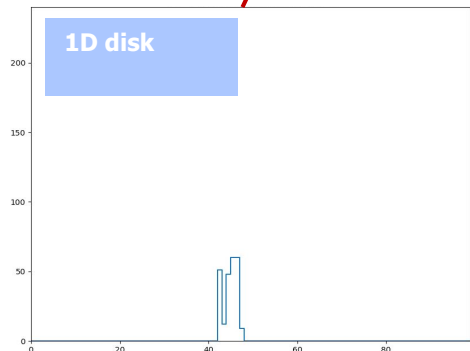
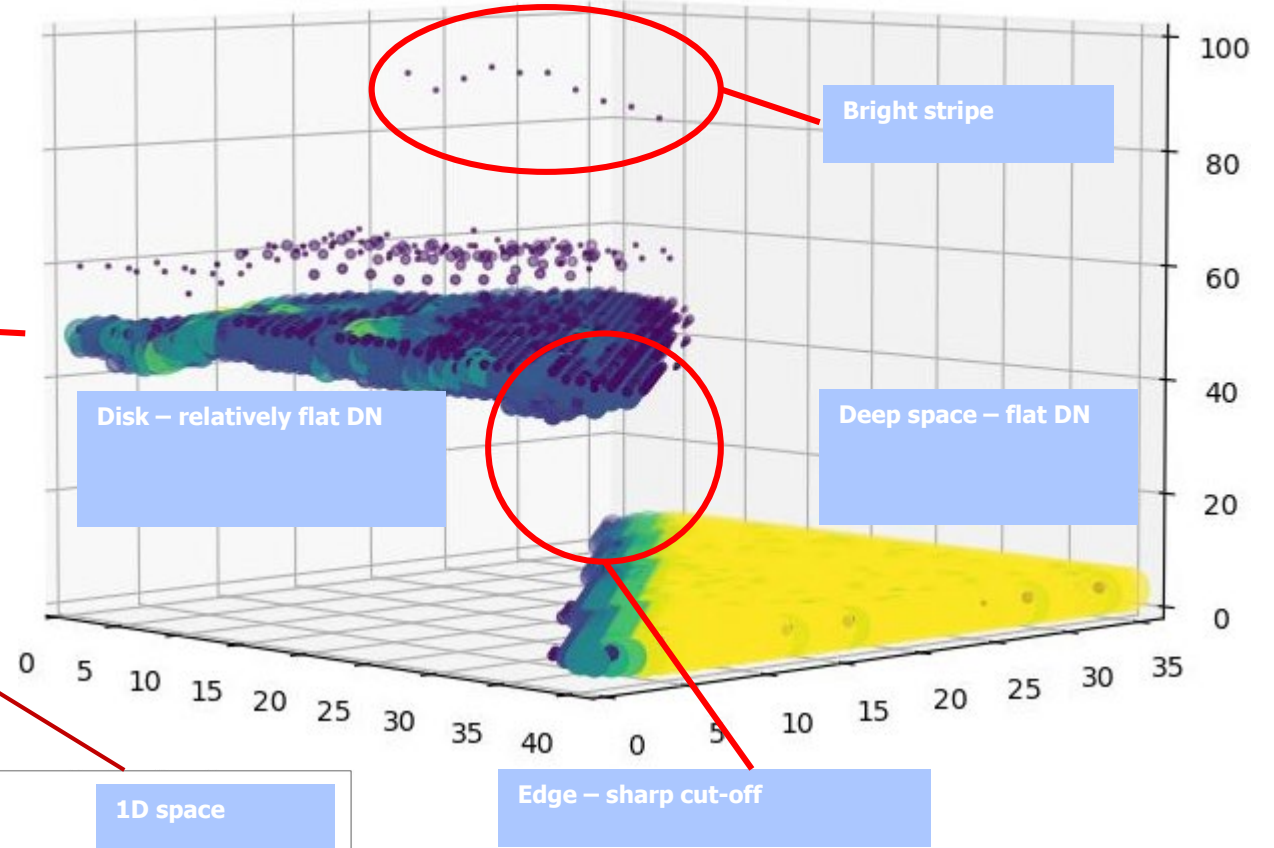
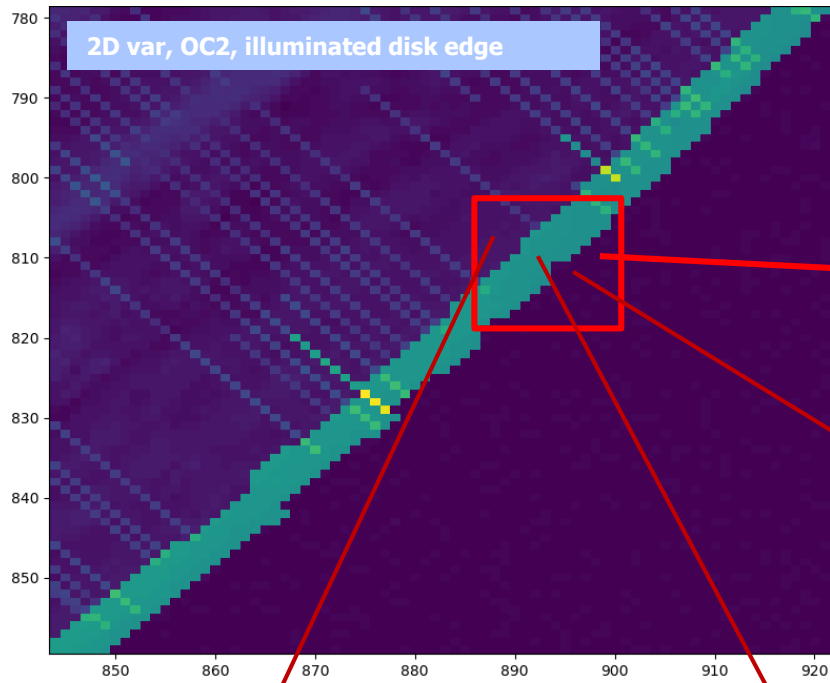
DN histogram (start=20151222, hour=09, OC=2, method=var)



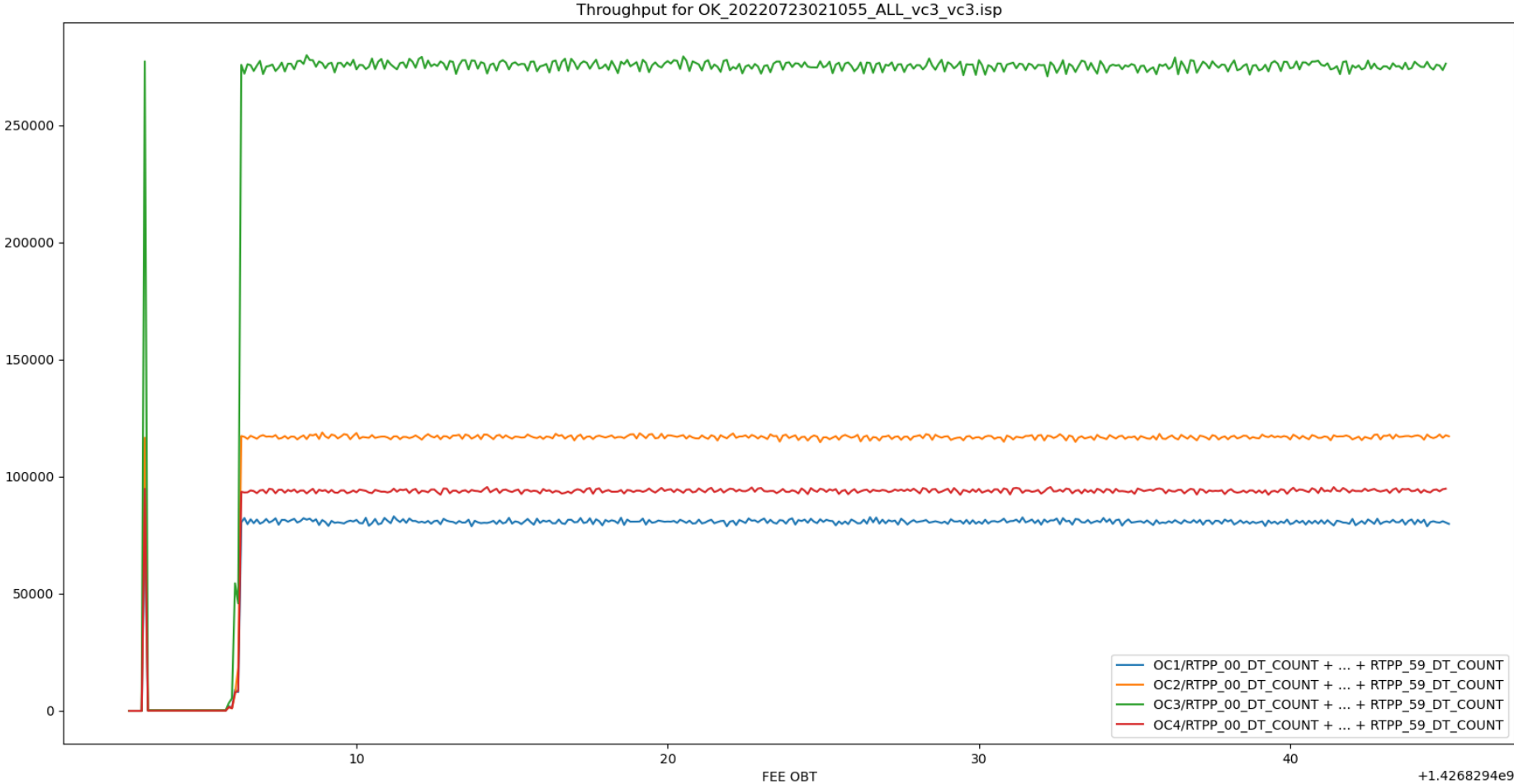
Shape: (1000, 1170)  
Total of bin counts: 8795150



# Combined usage of 1D, 2D and 3D visualization



# Monitoring of on-board DT rates in SVT data (LI real data)



# Monitoring of on-board DT rates

Reduction of the data rate

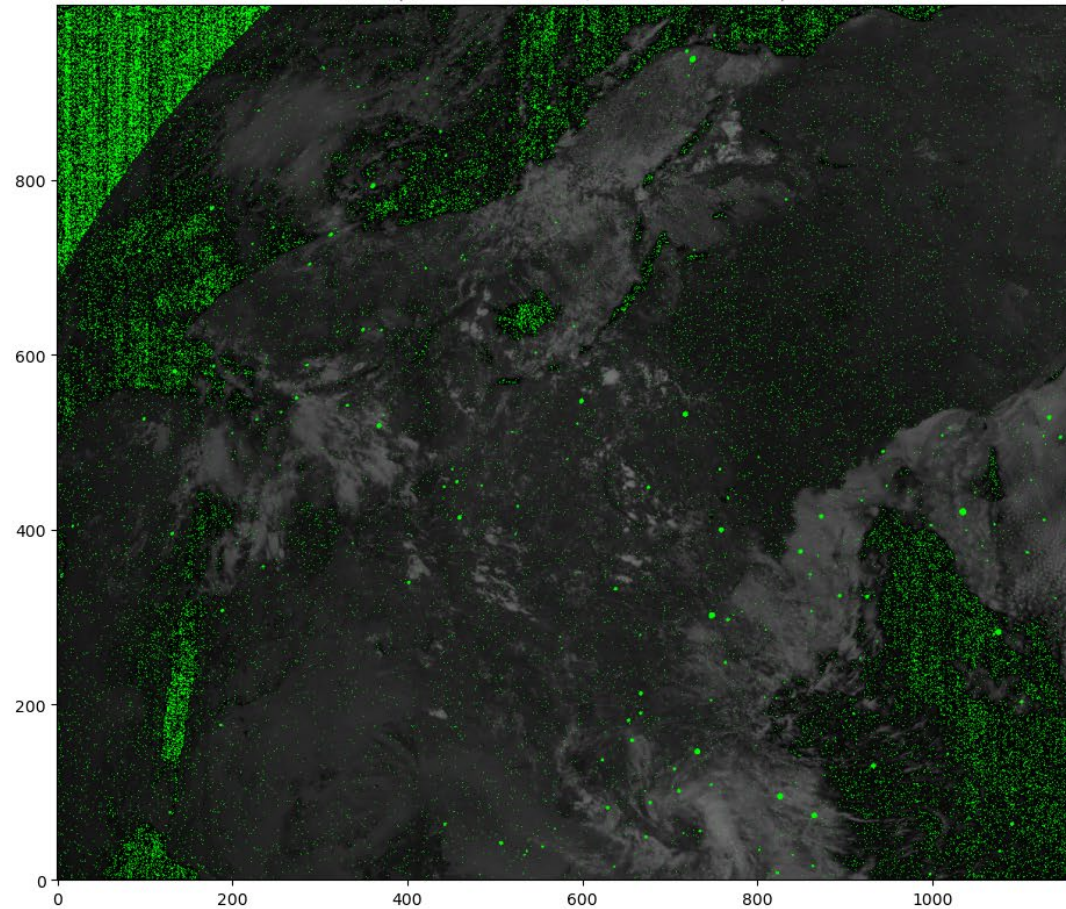


# Monitoring of DT content

Example of Level 0 DTs overlapped to the Level 0 BCK image.

The LI Science Team is working on the direct comparison between this image produced at Level 0, and the same image produced from Level 1b products.

The OBT to UTC conversion is crucial for this exercise.



# Accessing the MVW

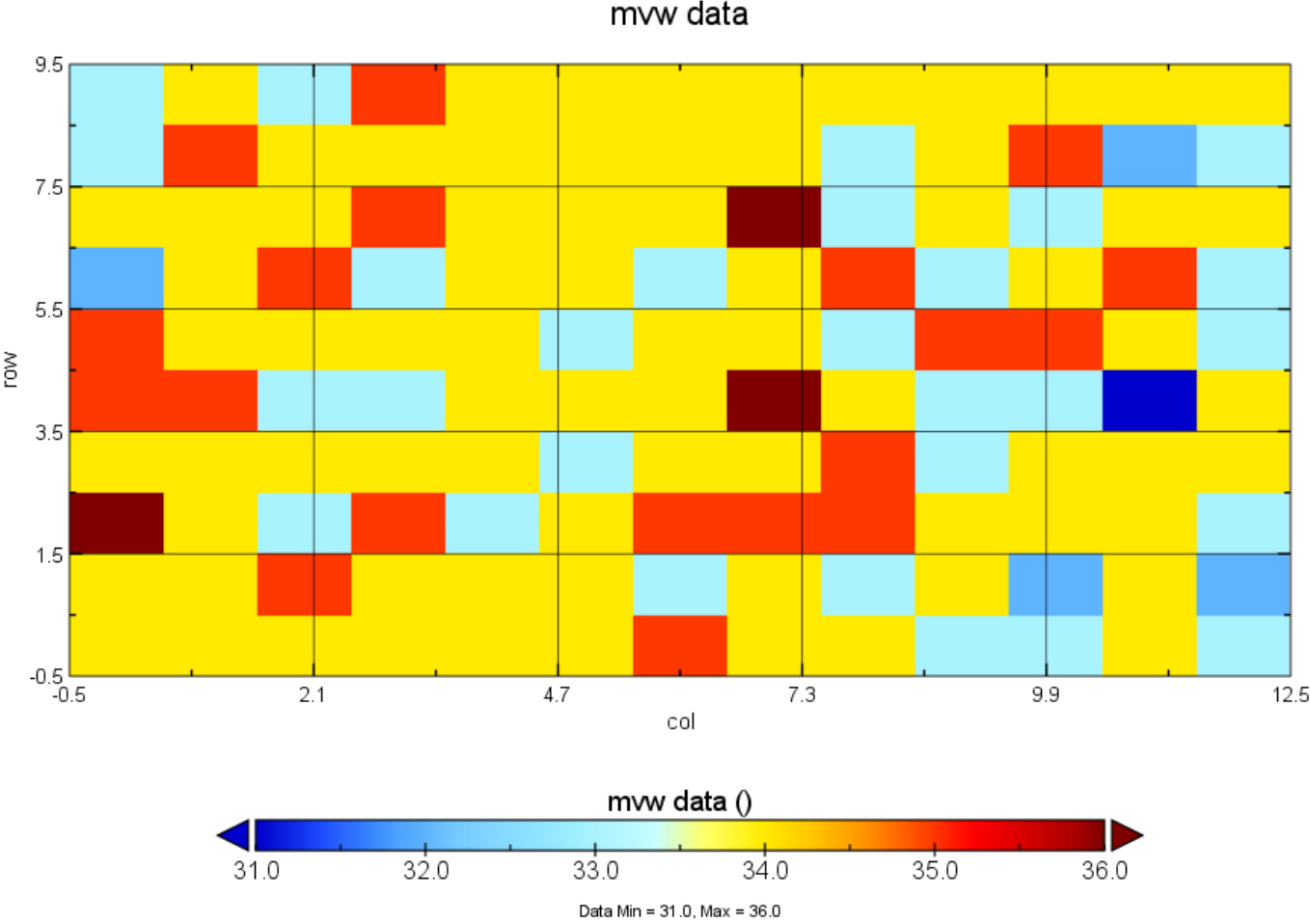
The LI Level 0 MVW builder:

- gets as input raw binary LI Level 0 MVW data (files or streams)
- gathers all data packets (i.e. 10x13 pixel windows of DNs, an *expected* 3800 per OC with a fixed ASIC, start row, start column)
- assembles LI Level 0 MVW images and saves them in netCDFs file (one per background repeat cycle)
- The algorithms for the processing of the MVW will be soon implemented.

LILO_MVW_0000.nc	LILO_MVW_0000.nc	Local File
acquisition_time	acquisition time	2D
asic	asic	1D
asic_col	asic col	1D
asic_row	asic row	1D
mvw_data	mvw data	2D
oc_col	oc col	1D
oc_row	oc row	1D



# Accessing the MVW from SVT (real LI data)



# Conclusions on Level 0 monitoring

The LI-STAR functionalities devoted to:

- Monitoring of the background at Level 0,
- Processing of MVW content,
- Monitoring of DT content, and
- Monitoring of on-board DT rates

have been secured. Such functionalities have been tested on both PDG data and real (SVT) data.

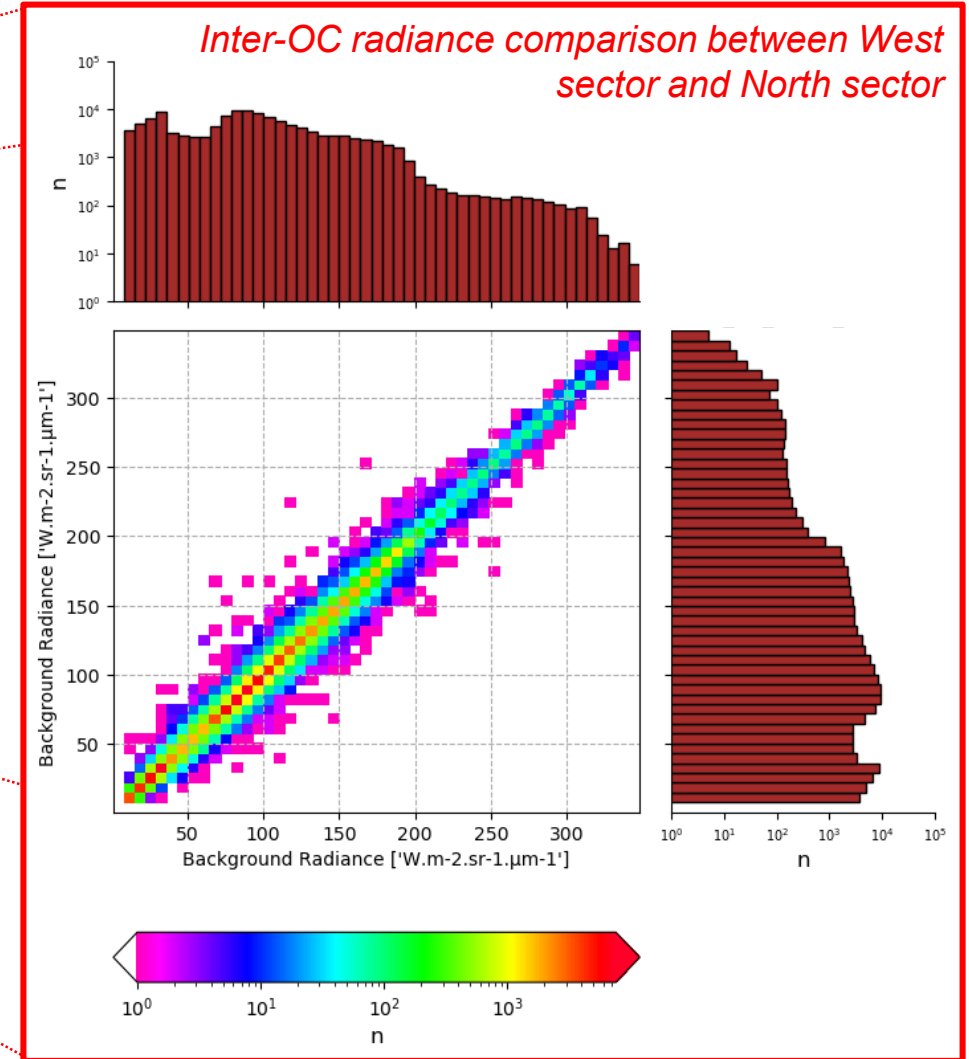
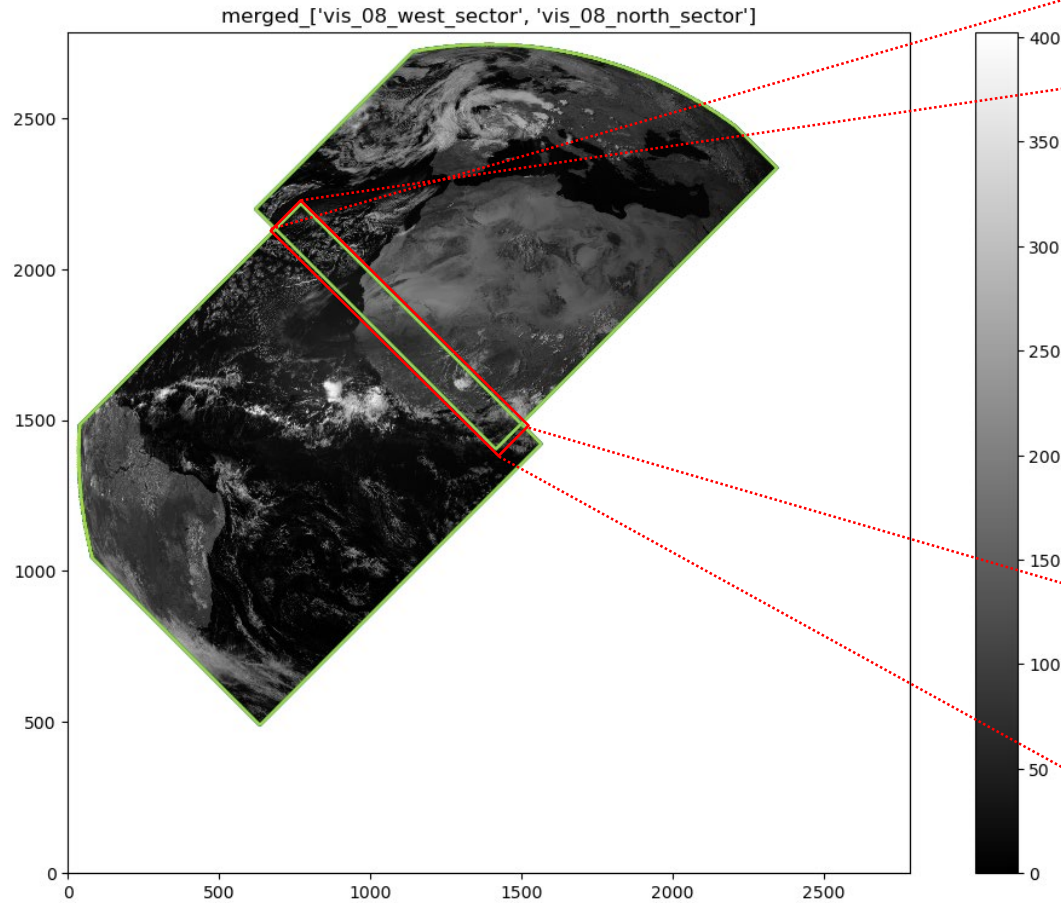
We are working on the correct conversion OBT → UTC to enable the direct comparison between LI Level 0 and Level 1b monitoring functionalities, i.e., synchronized variation of the DT rate.

The monitoring of LI Level 0 data will be critical for the beginning of the LI Commissioning. In fact, the IDPF-I is supposed to secure Level 0 archiving for the beginning of the Commissioning.

# Introduction: Level 1b monitoring

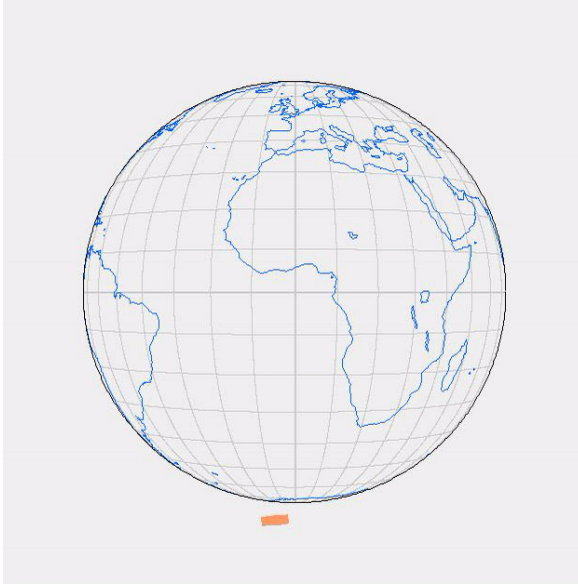
- Since 2021, the LI Science Team has been focusing on the development of LI-STAR functionalities for monitoring LI Level 1b data.
- Such functionalities cover the following performances:
  - ✓ Radiometric performances (BCK)
  - ✓ Coverage (BCK)
  - ✓ Processing performances, i.e., impact of Level 1b filtering steps
  - Detection performances at Level 1b:
    - ✓ Gridded approach for the assessment of detection performances at Level 1b
    - ✓ Monitoring simultaneous detections within overlap regions
- In the last few months we had the possibility of processing the first 6h long dataset produced in house of with IQT processing facility

# Radiometric statistics between LI OC overlapping areas



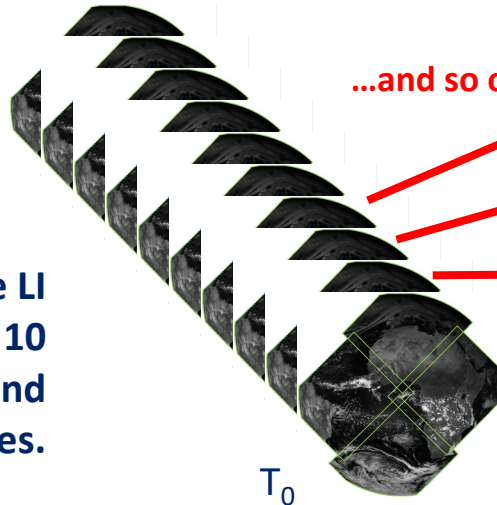
# Radiometric stats between LI and FCI vis\_08 channel

FCI full disk scan  
takes 10 minutes



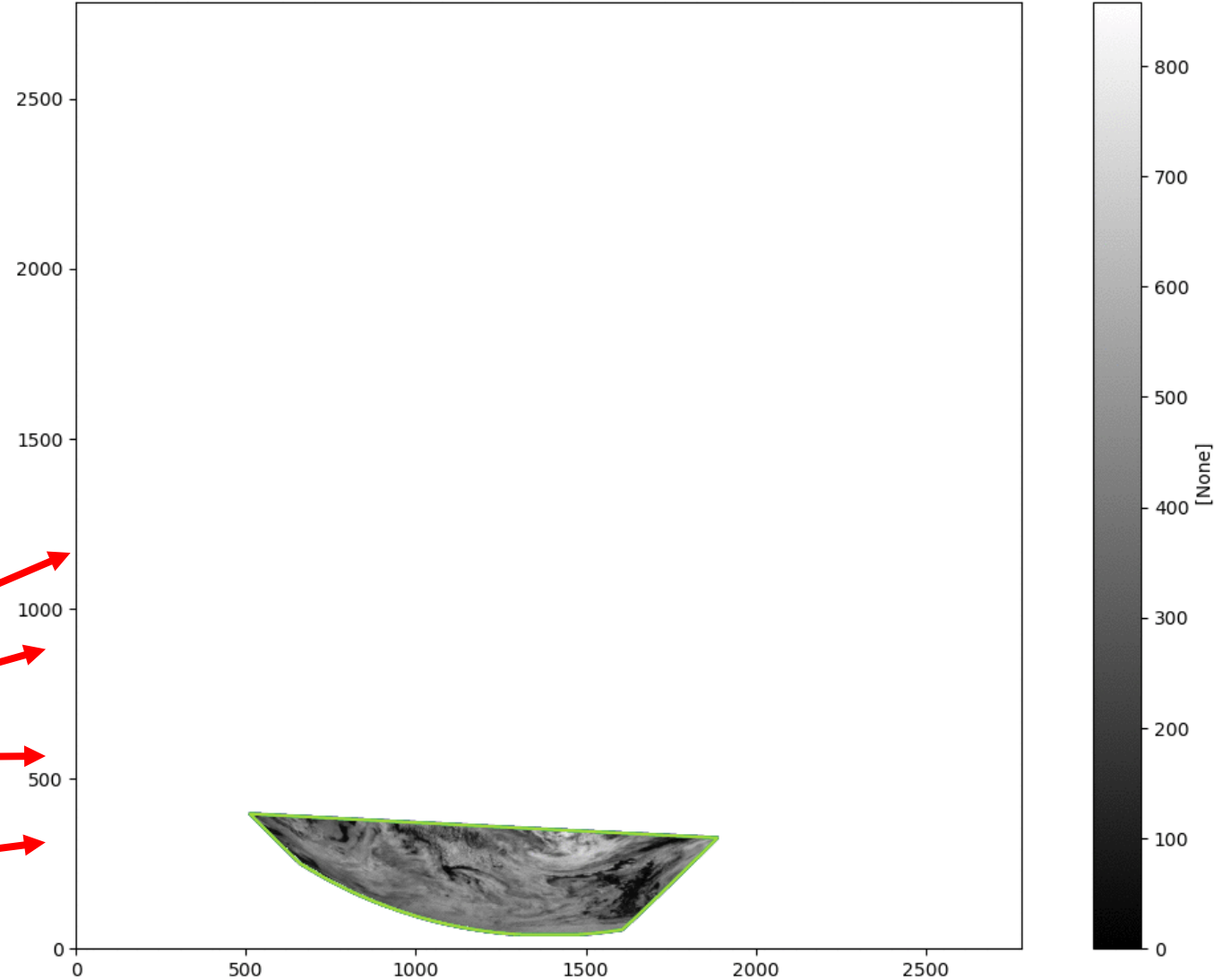
$T_0 + 10 \text{ min}$

Meanwhile LI  
takes at least 10  
background images.

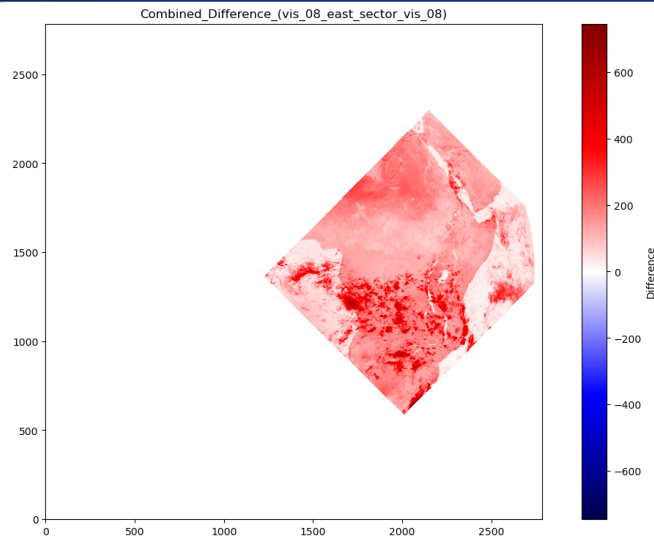
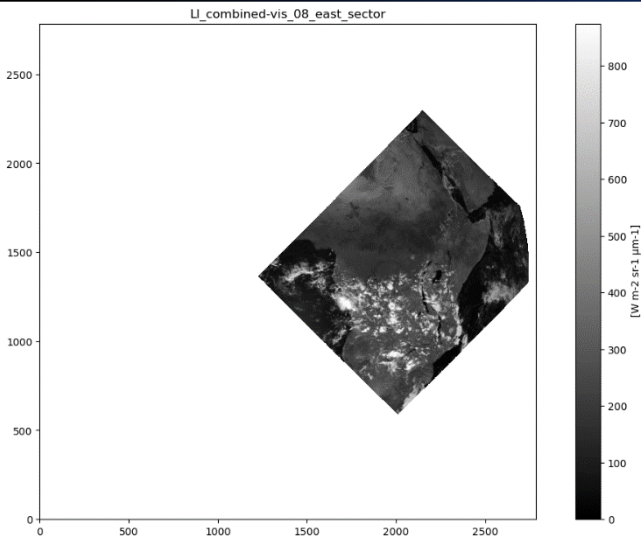


...and so on

LI\_combined\_FOV

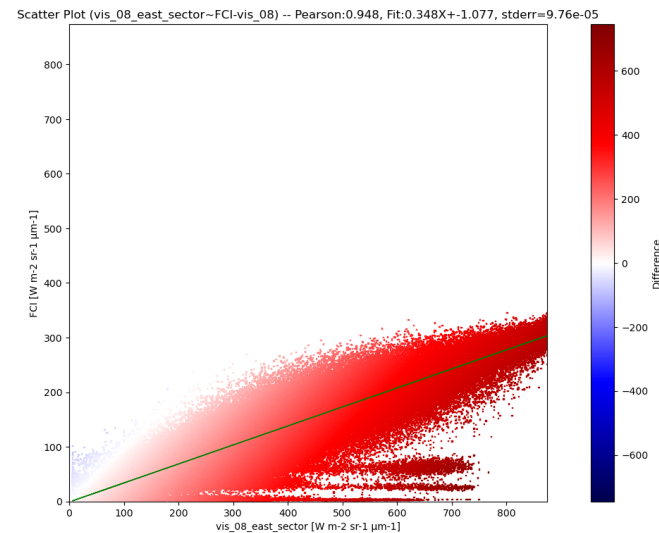
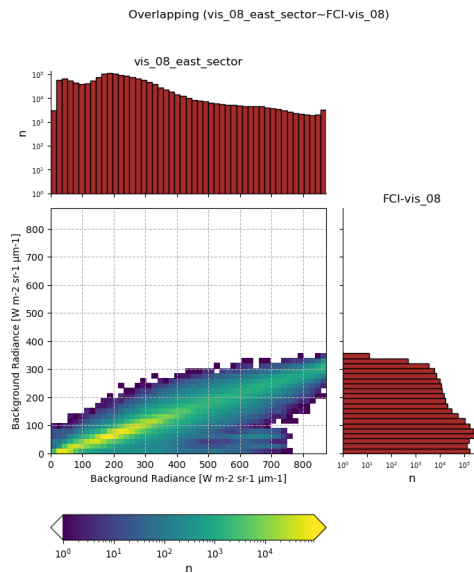


# Radiometric statistics between LI and FCI



An example of deriving radiometric comparison stats between LI OC3 composite and FCI.

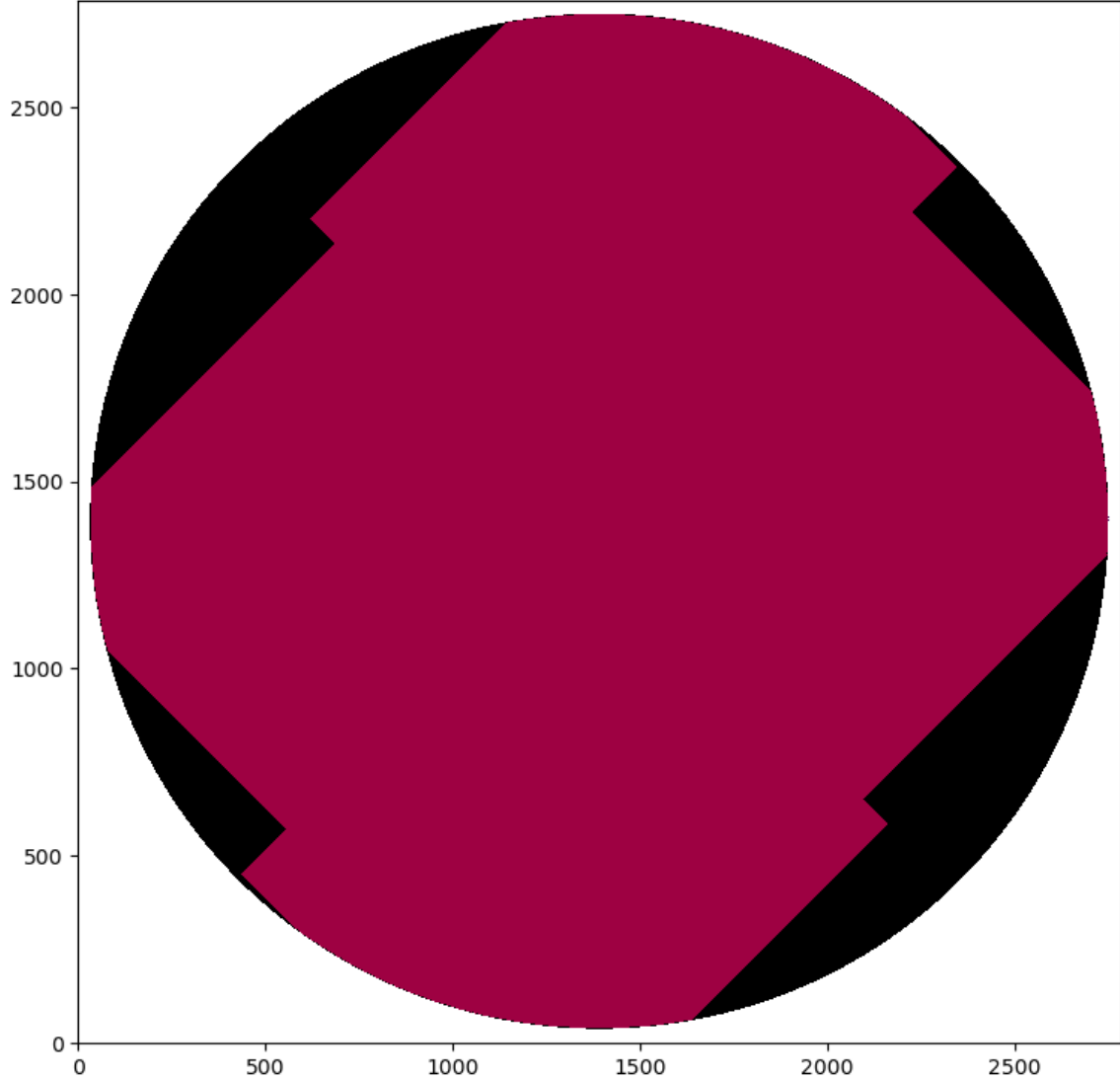
Known issues with LI background test data clearly affect the correlation with FCI on the sample plots.



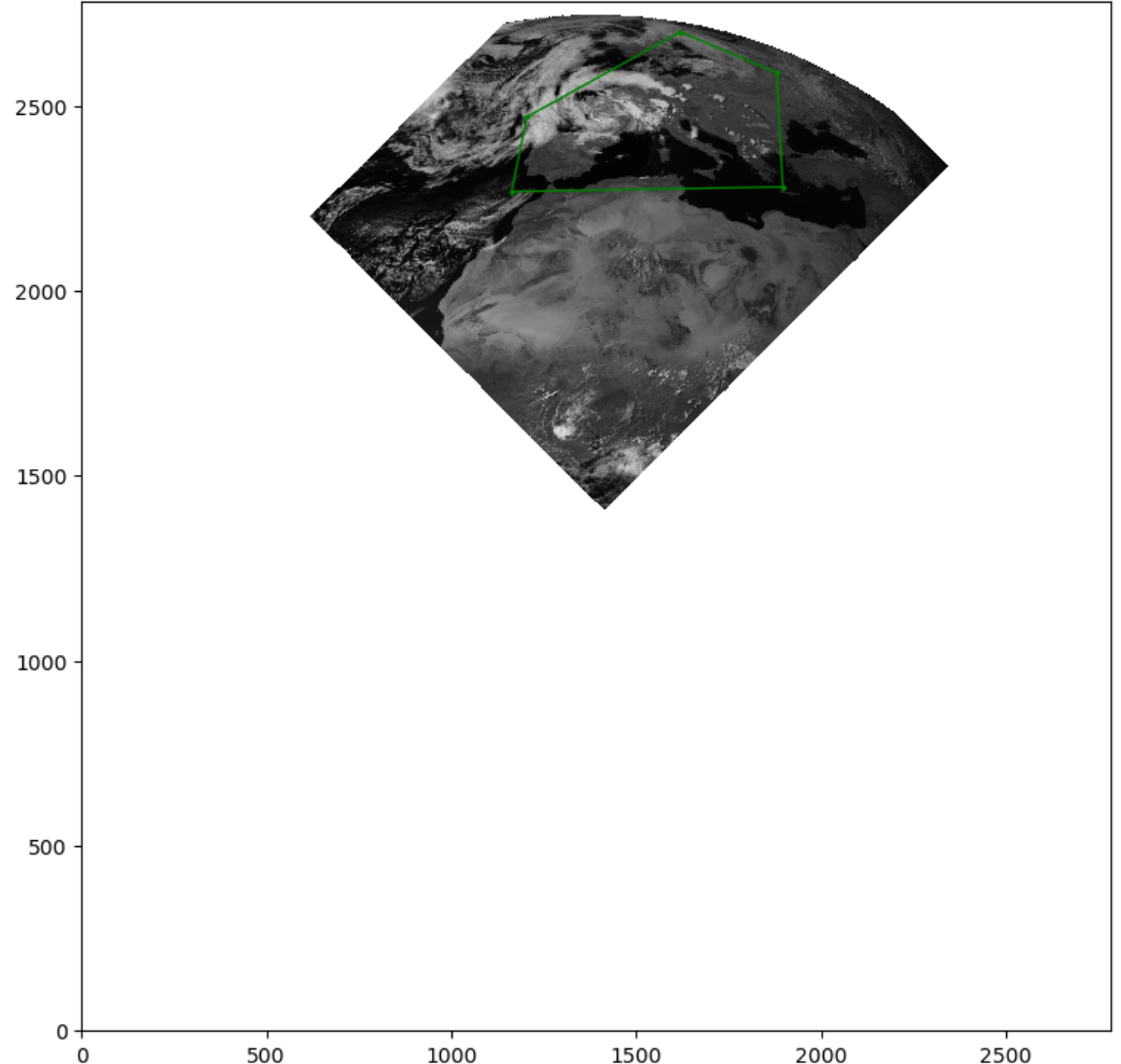
The correlation coefficient between the two together with the slope of the best fit line can be computed for each FCI repeat cycle to continuously monitor the agreement between FCI VIS08 channel and LI background image radiances.

# LI full disk and EUM coverage

px\_disk=5783270, px\_LI=4938577, px\_LI\_in\_disk=4938577, LI\_coverage=85.39 %

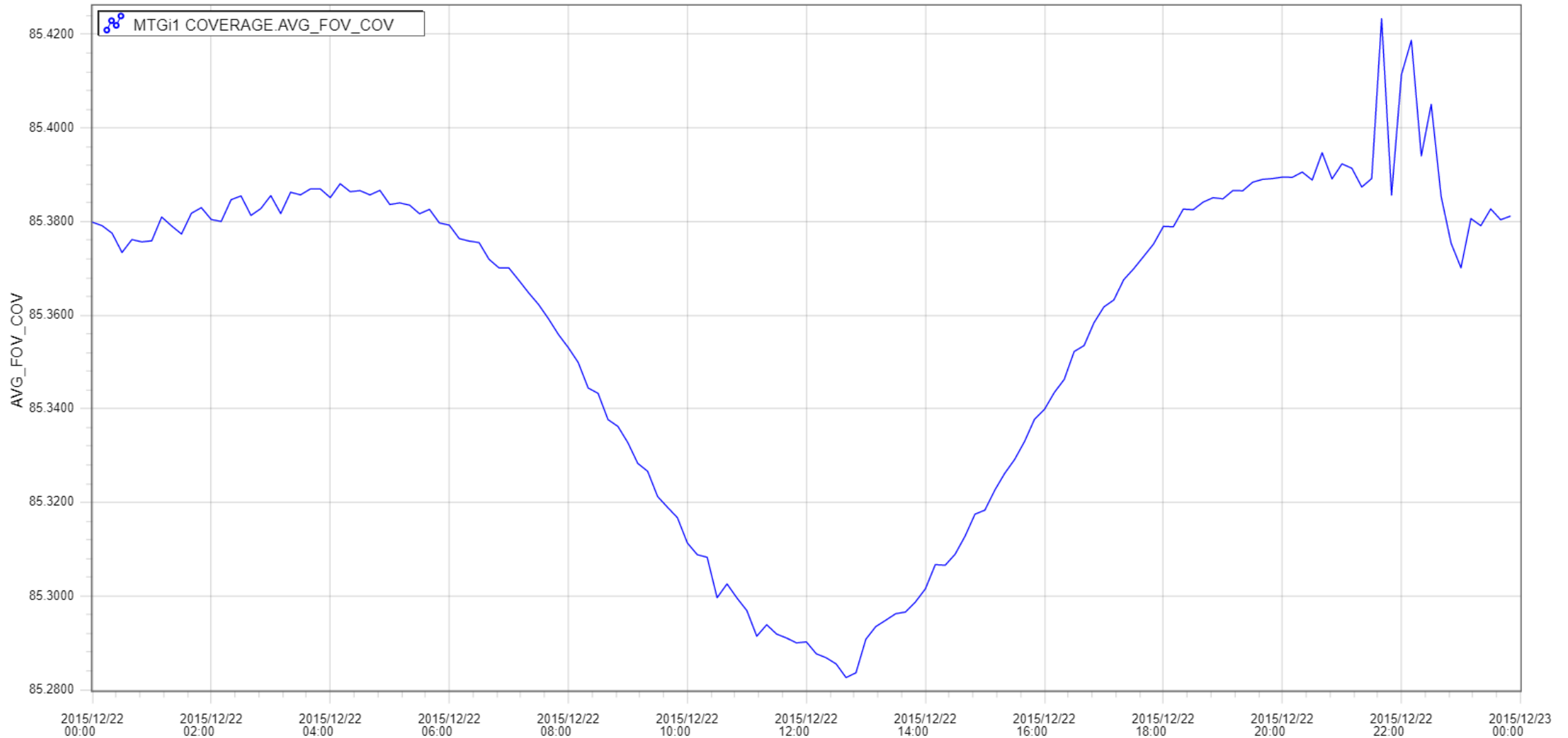


LI coverage: Consortium Countries. Boundaries:['OK', 'OK', 'OK', 'OK', 'OK']



# LI full disk coverage

Plot MTGi1 COVERAGE.AVG\_FOV\_COV for 2015-12-22 to 2015-12-23





# Monitoring detection performances at Level 1b

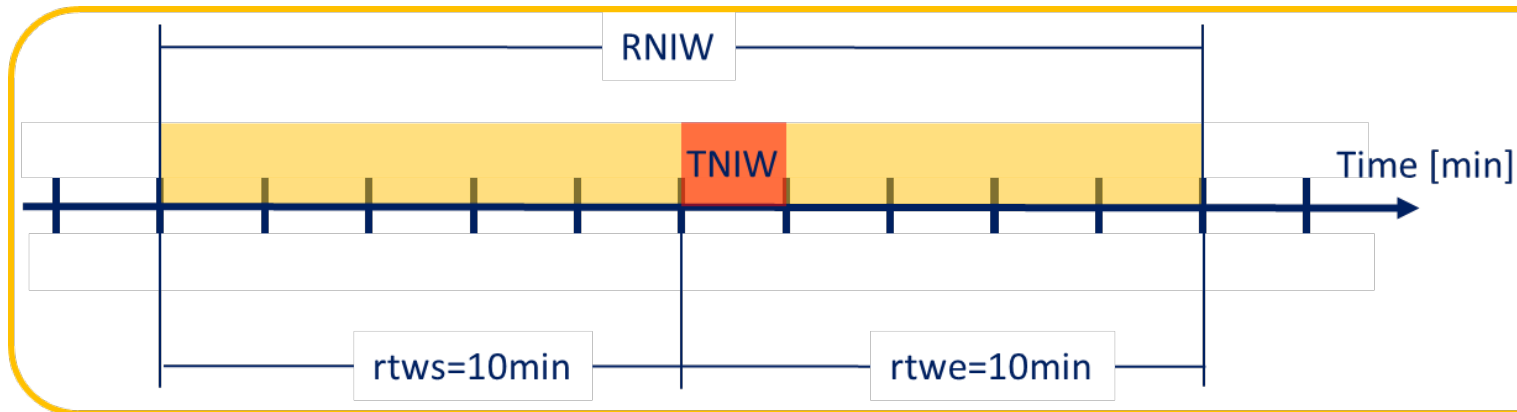
The LI Science Team is planning to adopt a gridded approach for both FAR and DE assessments at Level 1b.

This is suitable for handling the large number of events at Level 1b without direct matching between the LI and the reference system.

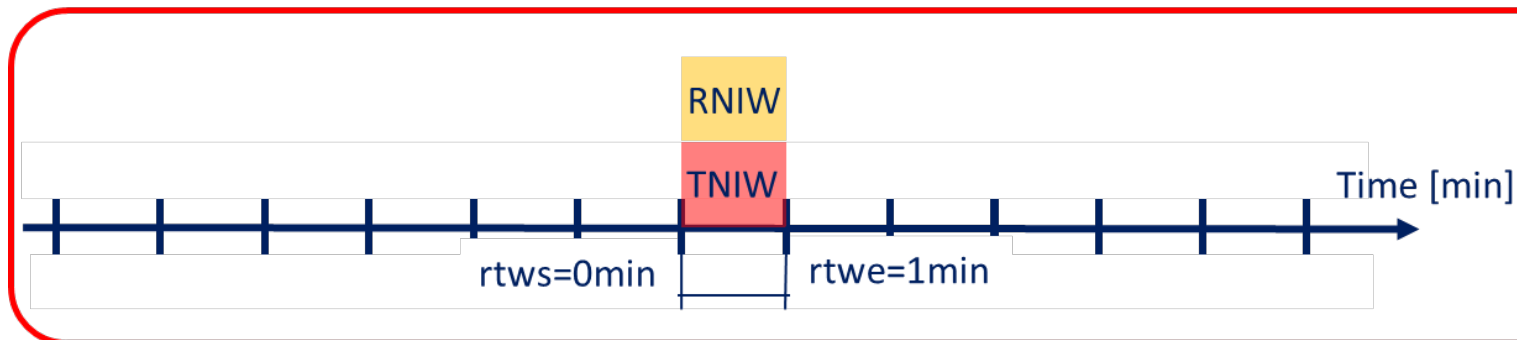
- Direct matching won't be feasible as 10k DTs/s is ~1 billion LEs per day.
- The gridded DE functionality is a faster alternative for evaluating LI DE. Effectively, this is a storm area DE.

# Monitoring detection performances at Level 1b

- Test network integration window (TNIW)
- Reference network integration window (RNIW):
  - rtws* RNIW starts so many minutes before TNIW start.
  - rtwe* RNIW ends so many minutes after TNIW start.

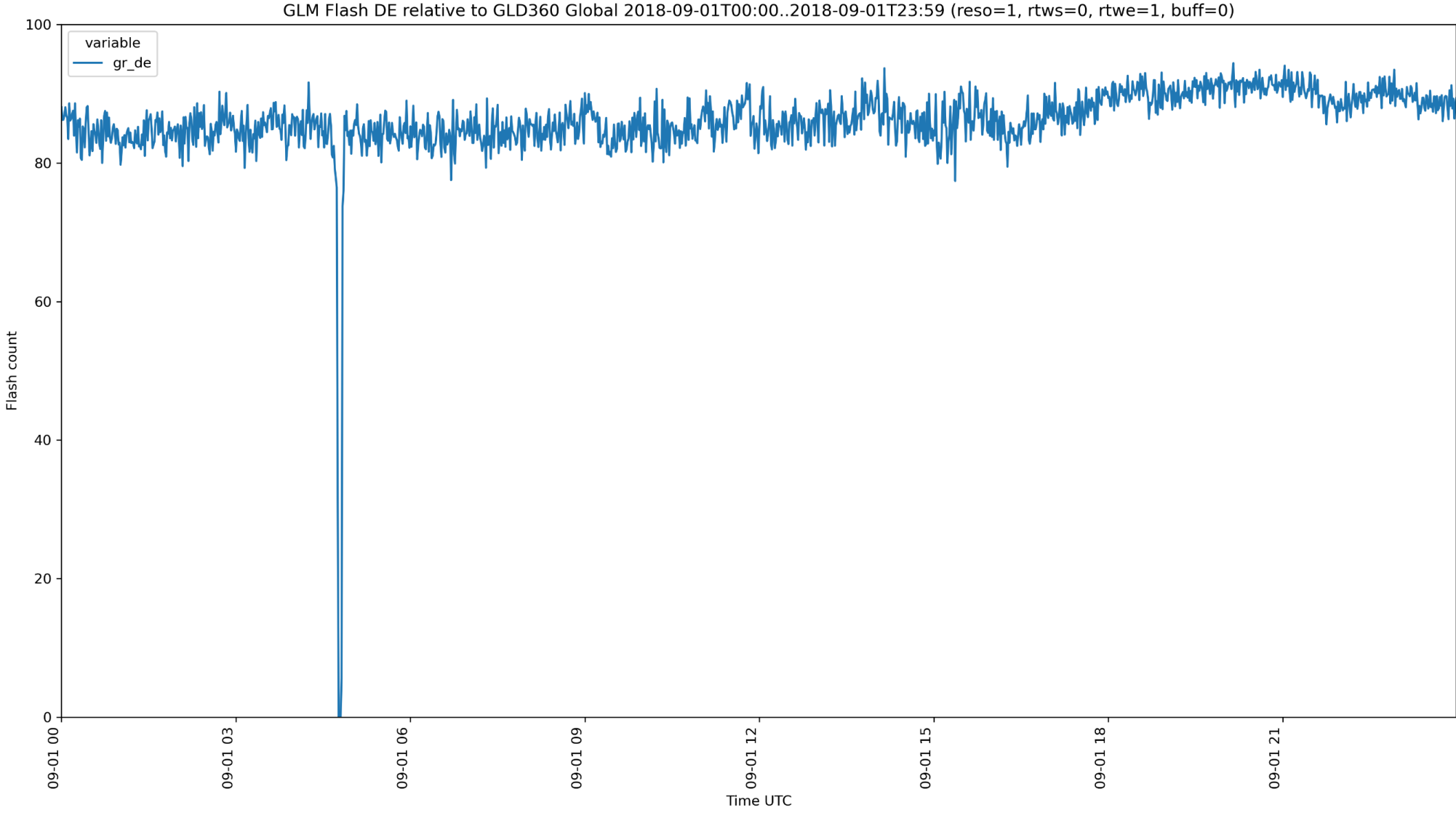


For FAR we want as long as practical RNIW as we want to ensure that even weaker storms show up on the reference network grid.



For DE we TNIW and RNIW to be equal so that both represent lightning activity during exactly the same time period.

# Monitoring detection performances at Level 1b

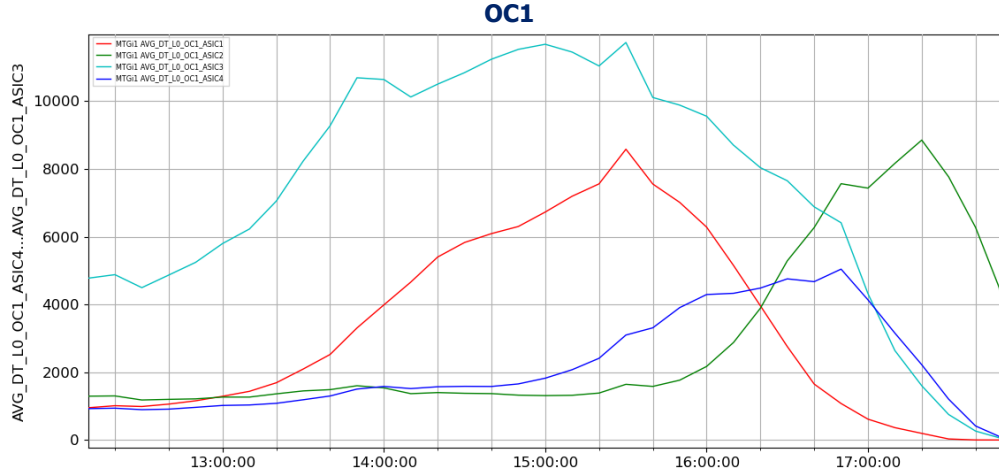


# Monitoring detection performances at Level 1b

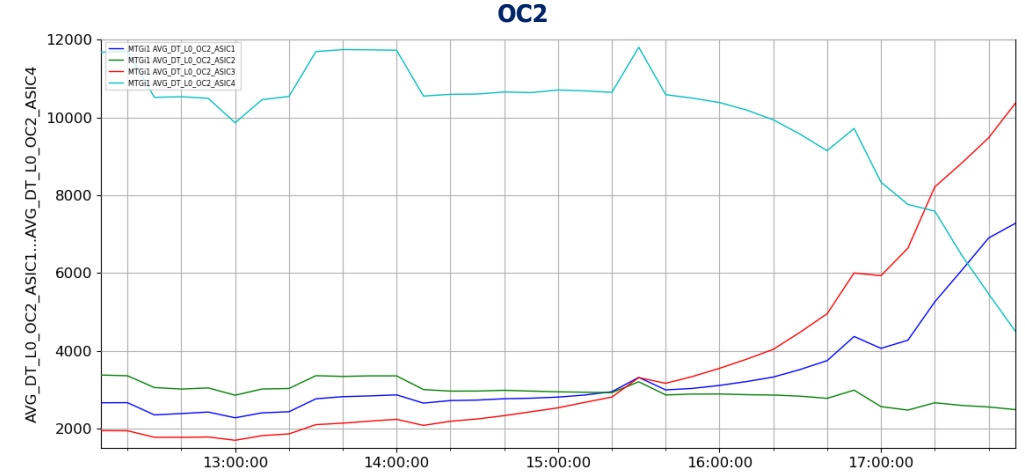
- The LI Science Team is currently giving priority to the implementation and testing (and securing) of the gridded approach for DE computation and monitoring of the detections in overlap regions.
- There is the possibility of implementing the more refined approach that relies on matching also at Level 1b.
  - CONS: This is not a trivial task and it is computationally heavy
  - PROS: It can give us a DE measure that is “directly” comparable to the DE at Level 2 (group to stroke)
  - PROS: It could be used for location accuracy by means of DTs not groups or flashes for which average lat/lon are employed (one could focus on a subset of data around Nadir).

# Monitoring DT rates per OC and ASIC through time at Level 0

MTG11 DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00

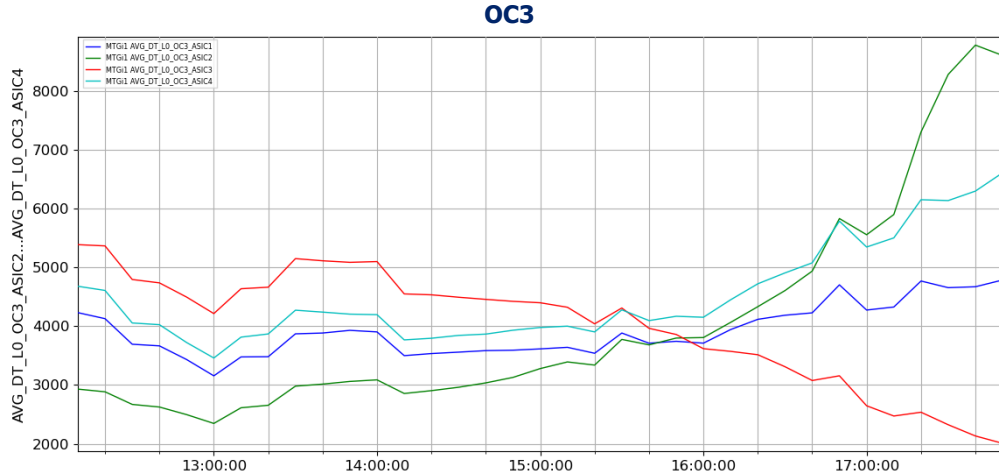


MTG11 DT\_RATES.AVG\_DT\_L0\_OC2\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC2\_ASIC4 for 2015-12-22 from 12:05 to 18:00

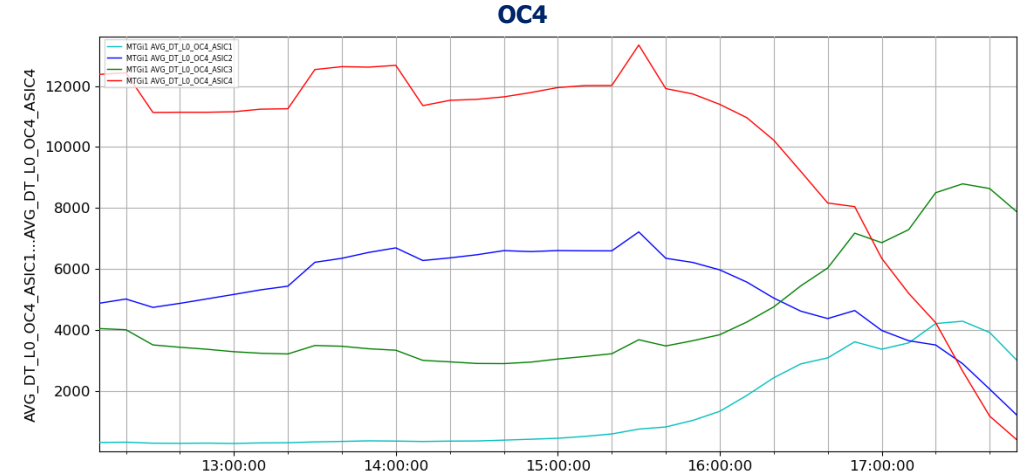


**IQTv3.5.1 6 hours!**

MTG11 DT\_RATES.AVG\_DT\_L0\_OC3\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC3\_ASIC4 for 2015-12-22 from 12:05 to 18:00

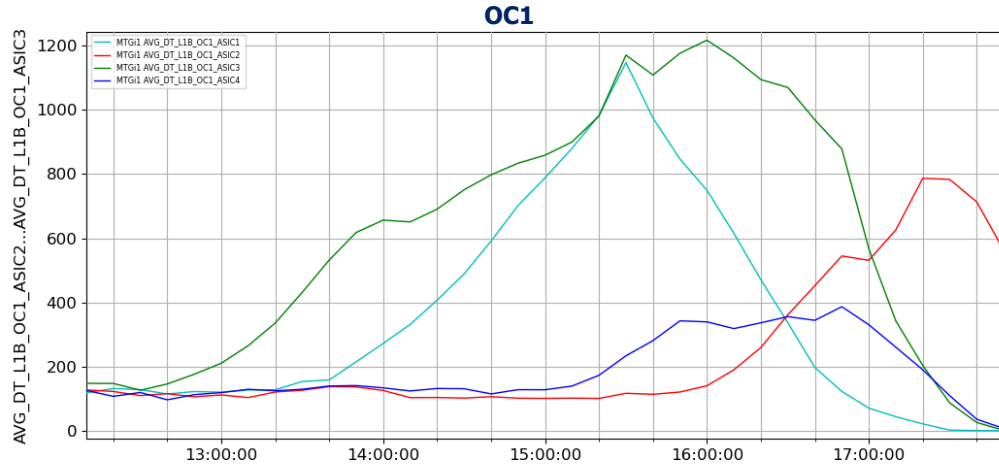


MTG11 DT\_RATES.AVG\_DT\_L0\_OC4\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC4\_ASIC4 for 2015-12-22 from 12:05 to 18:00

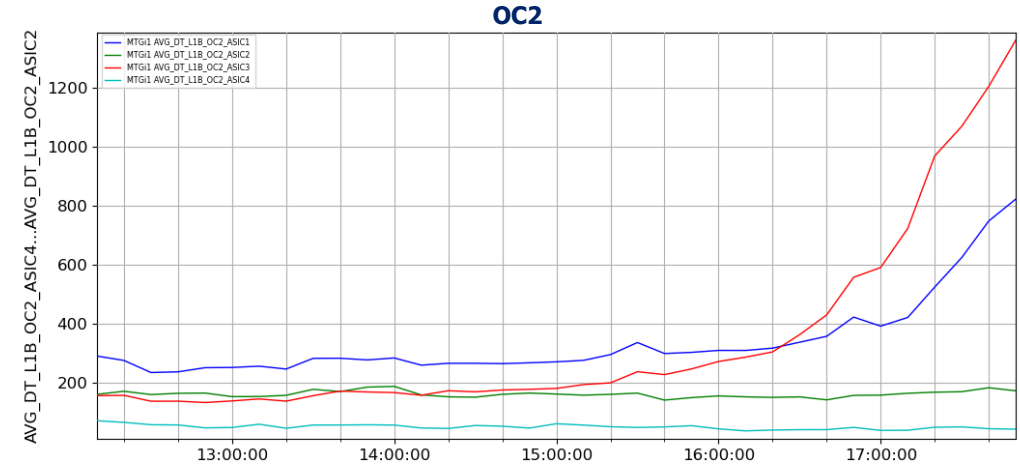


# Monitoring DT rates per OC and ASIC through time at Level 1b

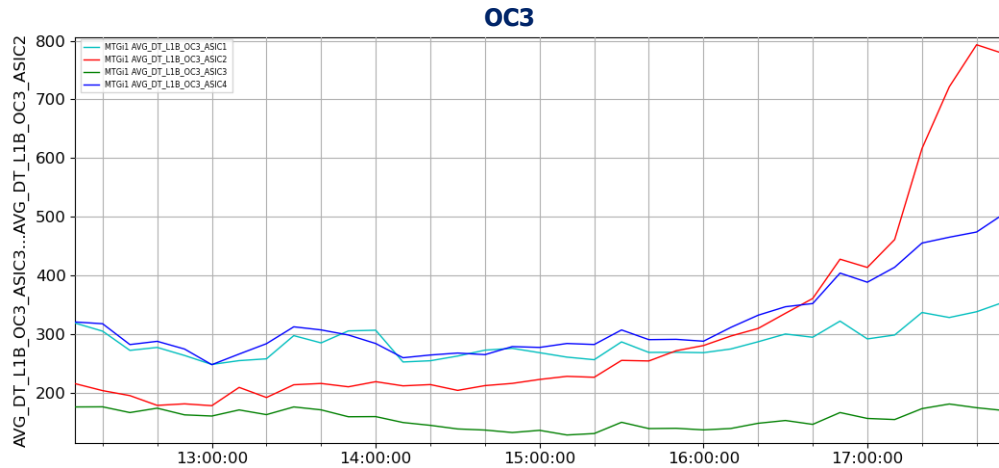
MTG1 DT\_RATES.AVG\_DT\_L1B\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L1B\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00



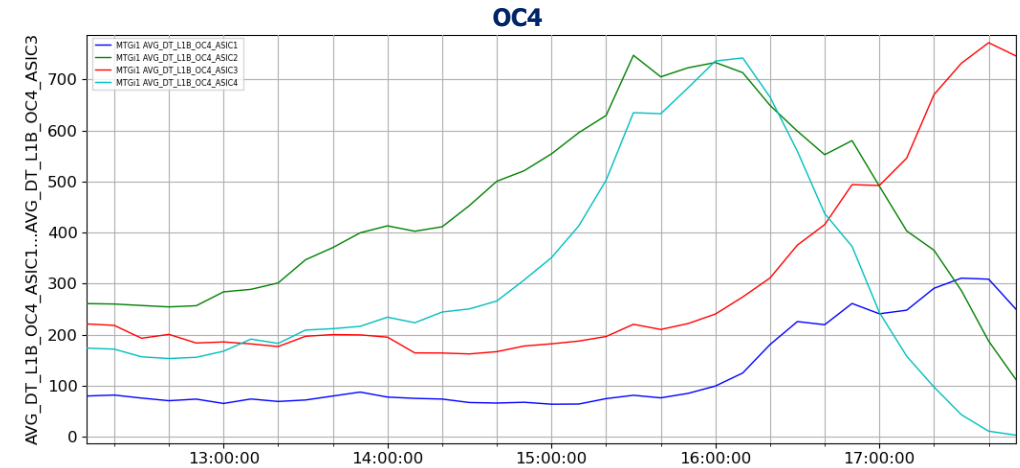
MTG1 DT\_RATES.AVG\_DT\_L1B\_OC2\_ASIC1...DT\_RATES.AVG\_DT\_L1B\_OC2\_ASIC4 for 2015-12-22 from 12:05 to 18:00



MTG1 DT\_RATES.AVG\_DT\_L1B\_OC3\_ASIC1...DT\_RATES.AVG\_DT\_L1B\_OC3\_ASIC4 for 2015-12-22 from 12:05 to 18:00



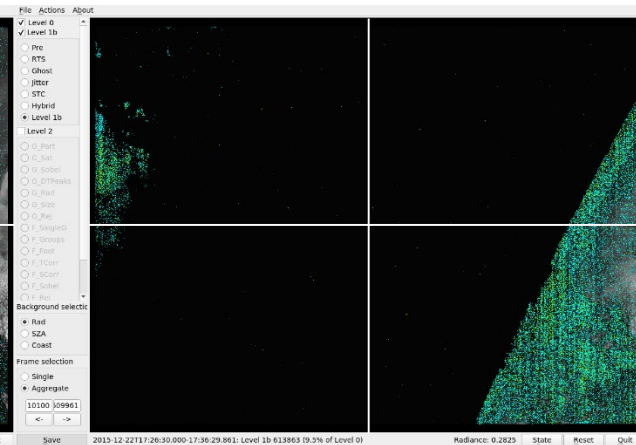
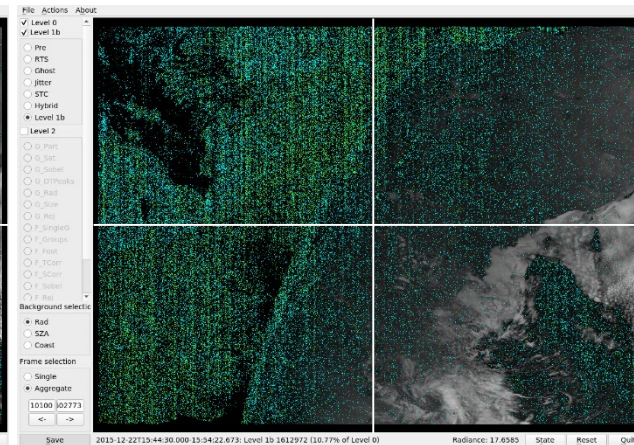
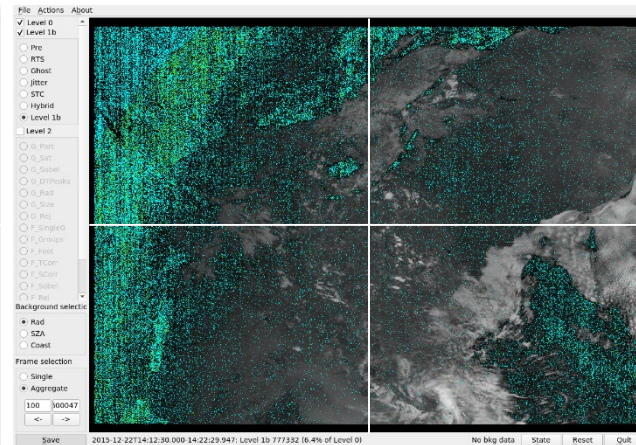
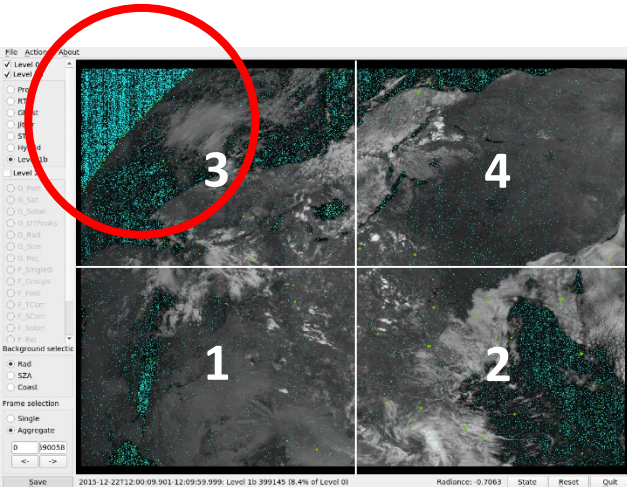
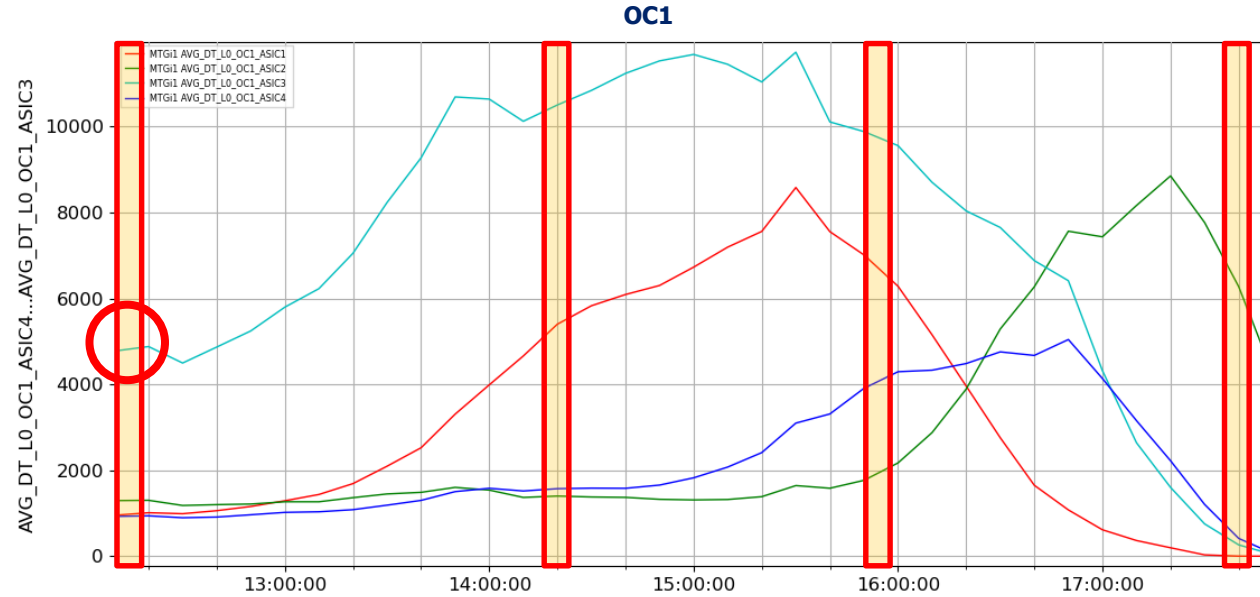
MTG1 DT\_RATES.AVG\_DT\_L1B\_OC4\_ASIC1...DT\_RATES.AVG\_DT\_L1B\_OC4\_ASIC4 for 2015-12-22 from 12:05 to 18:00



# Interpretation with the aid of LI-PVT

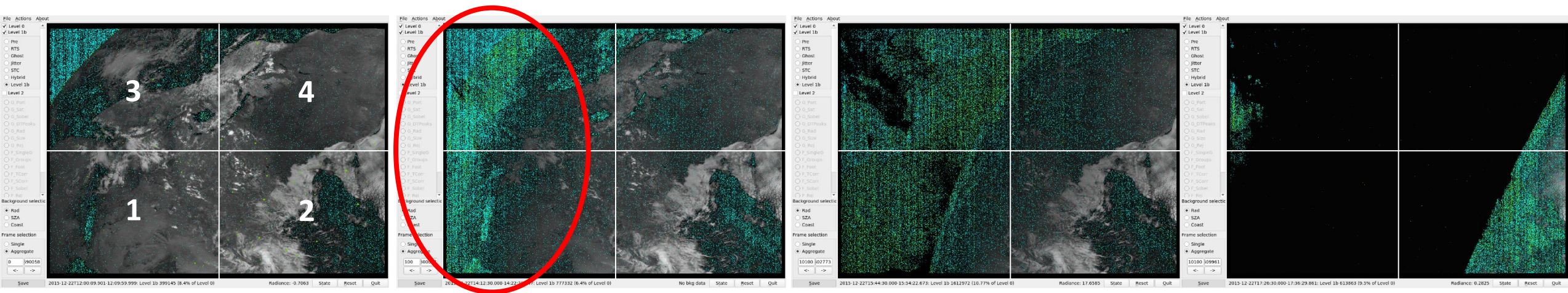
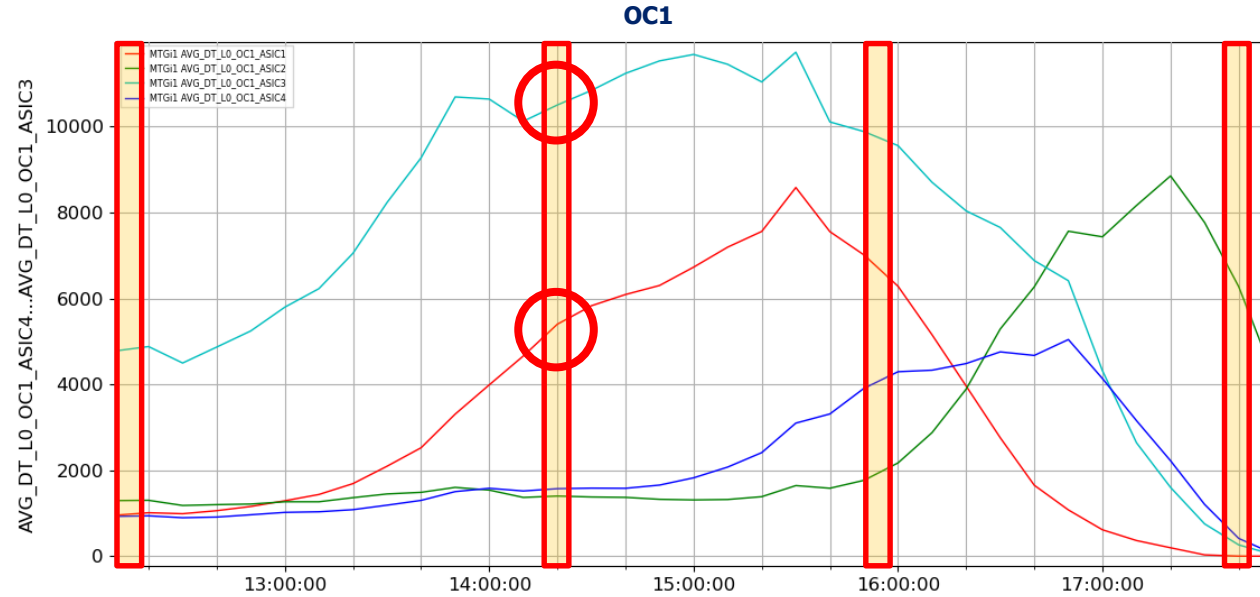
The combination of time sequence and spatial distribution is crucial for both validating the tools and understanding what the instrument is detecting and where!

MTG1 DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00



# Interpretation with the aid of LI-PVT

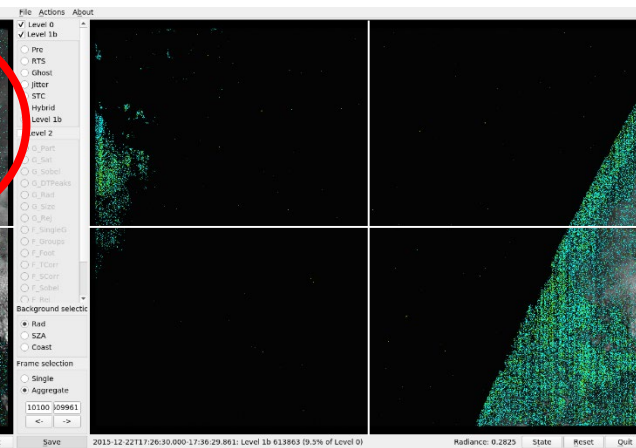
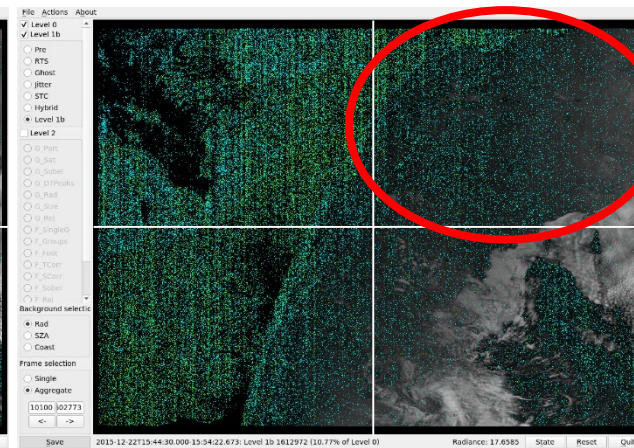
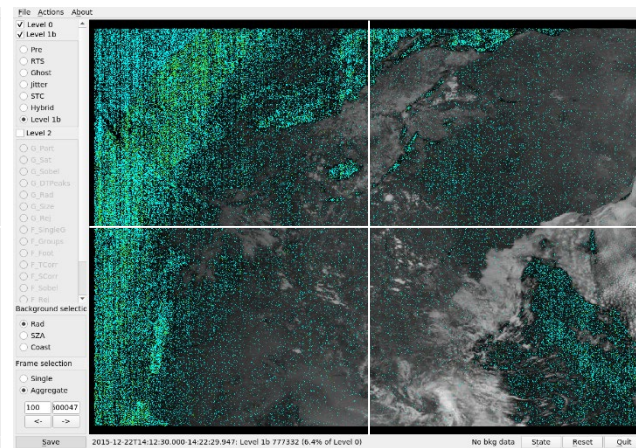
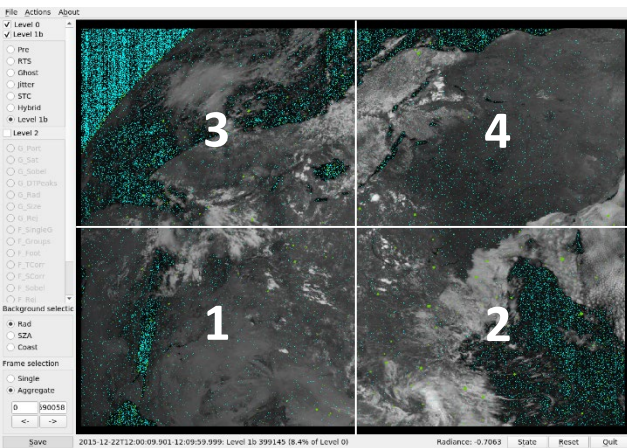
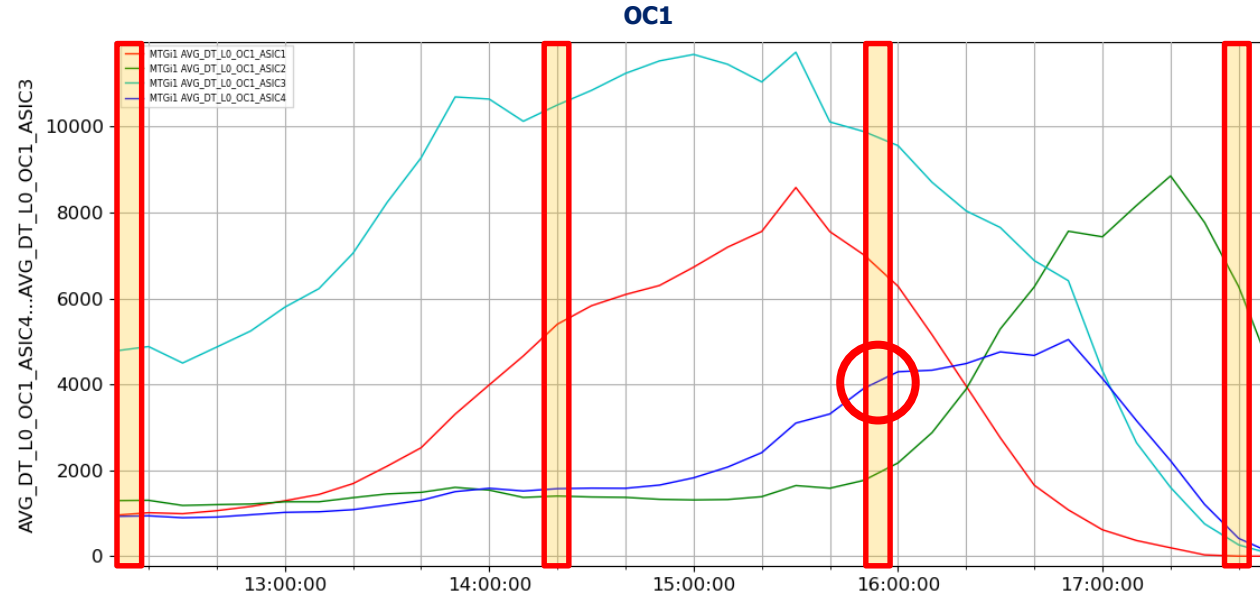
MTG1 DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00





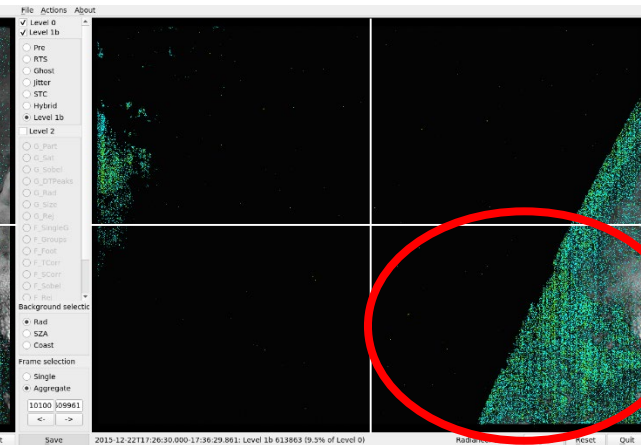
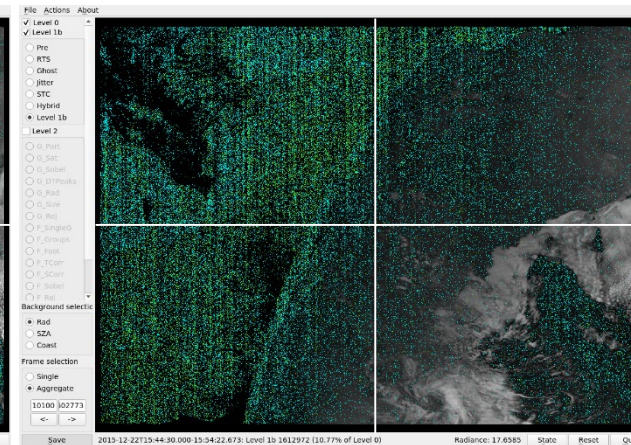
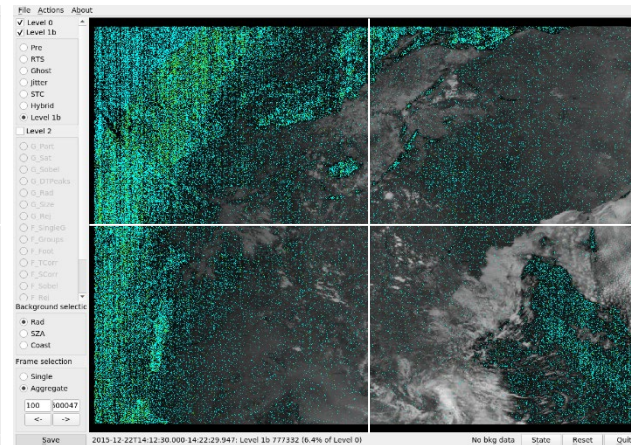
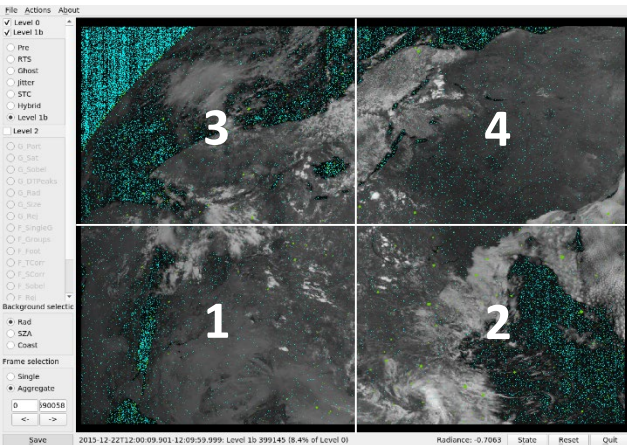
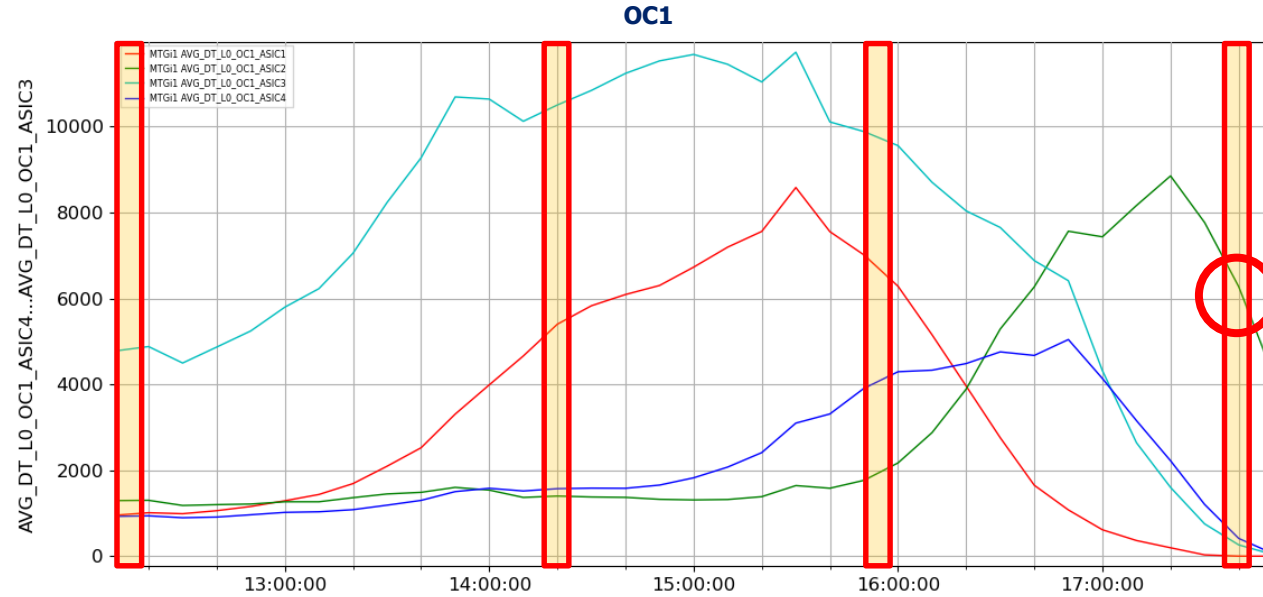
# Interpretation with the aid of LI-PVT

MTG1 DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00



# Interpretation with the aid of LI-PVT

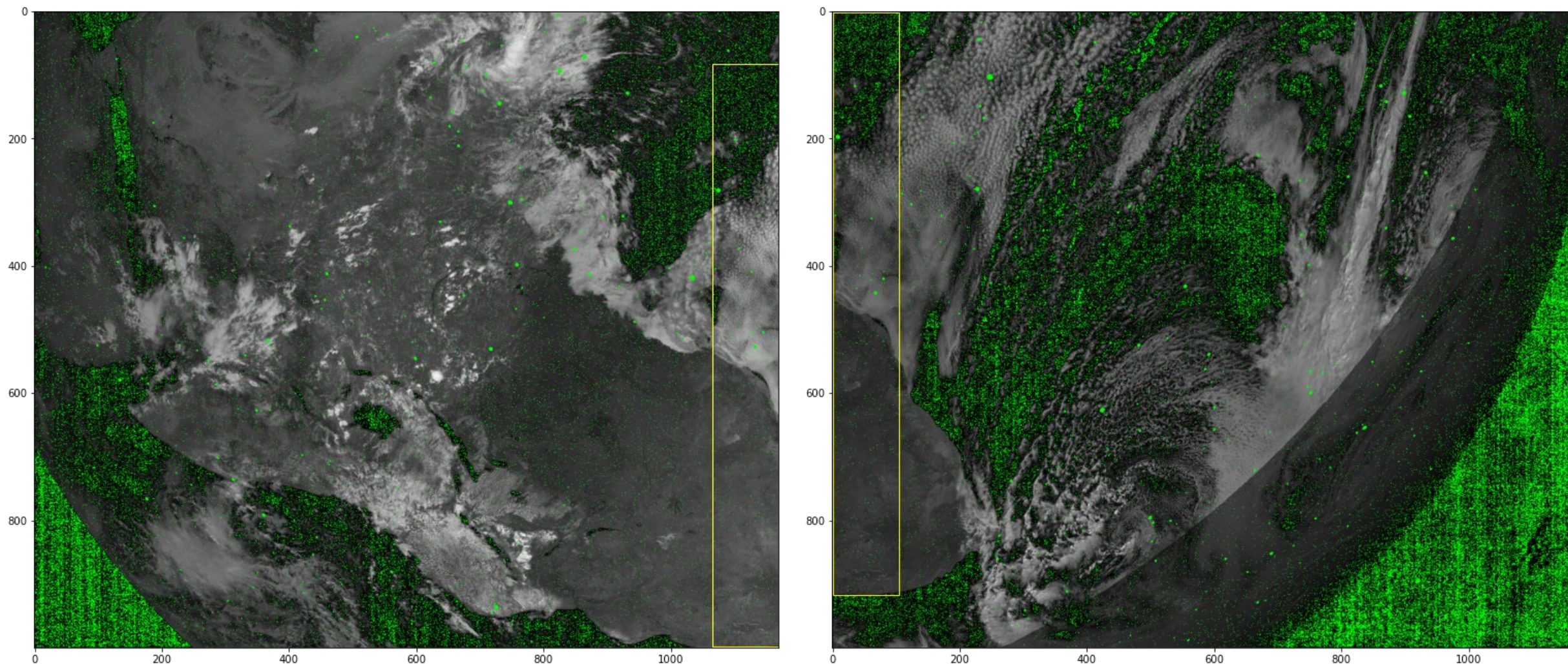
MTG1 DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC1...DT\_RATES.AVG\_DT\_L0\_OC1\_ASIC4 for 2015-12-22 from 12:05 to 18:00



# Monitoring matching detections in overlap regions

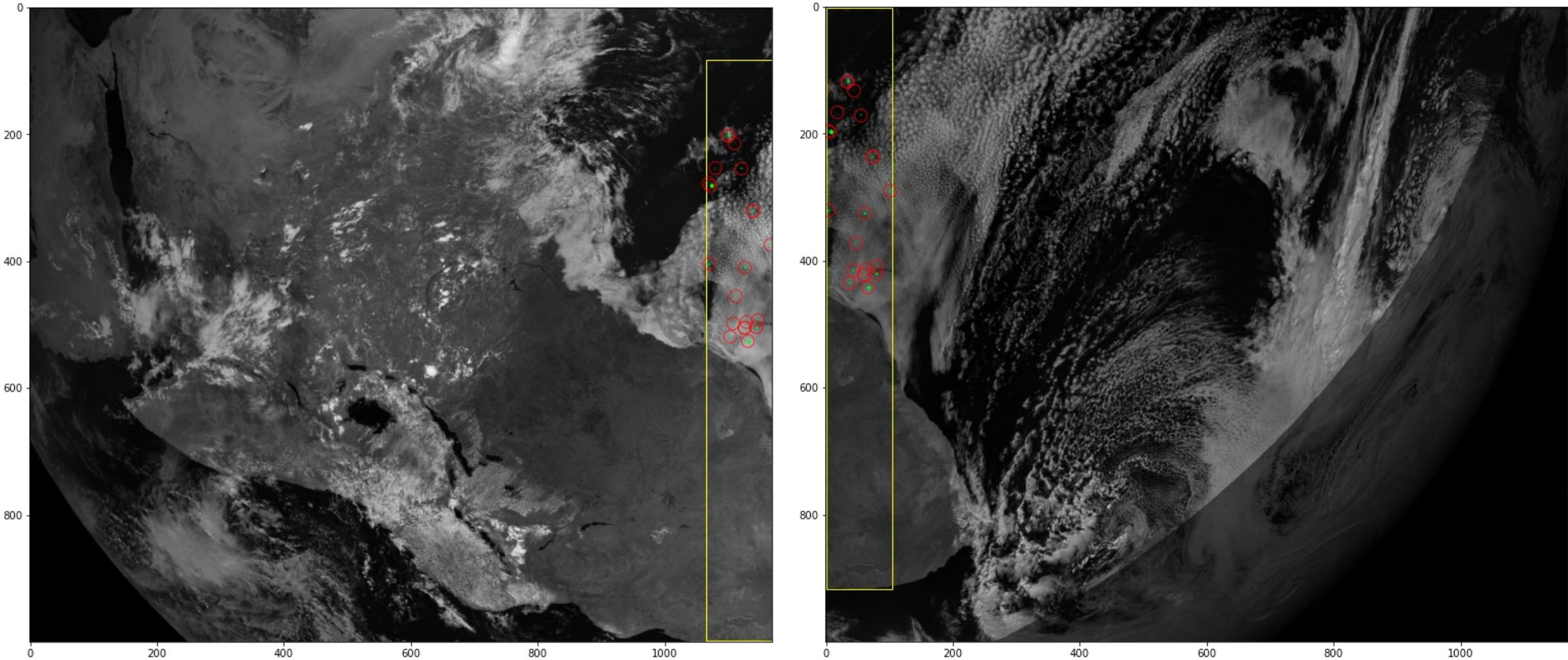
- Measuring the impact on matching detections in overlap regions between OCs, i.e., a measurement of impact of the Level 1b filtering.
- Start from matching detections within the overlap regions at Level 0. The results are computed as # of matching clusters (i.e., collections of events). Such matching clusters are regarded to be generated by pulses.
- We apply the Level 1b filtering and study the reduction of information wrt Level 0. This shows the reduction of the number of Level 0 matching clusters.

# Monitoring detections in overlap regions



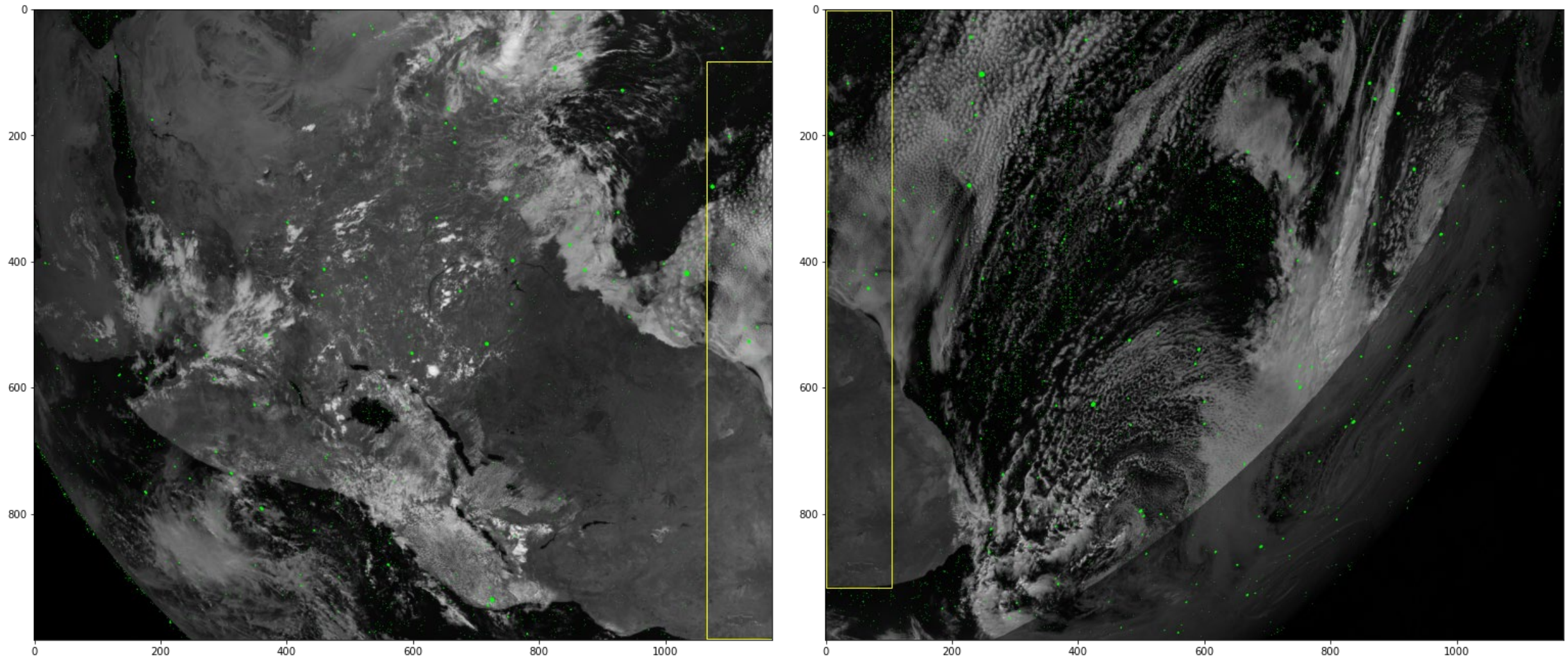
**Level 0 content**

# Monitoring detections in overlap regions



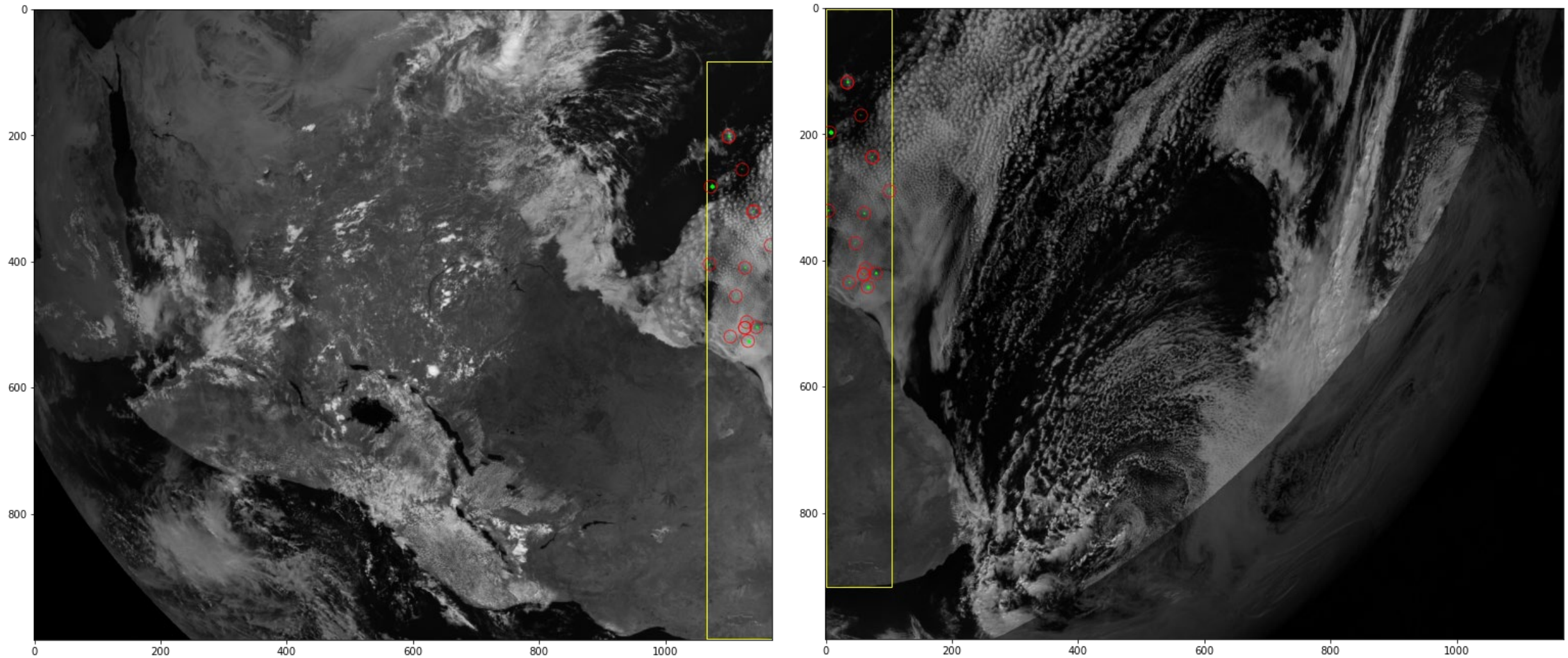
Matching clusters at Level 0 content

# Monitoring detections in overlap regions



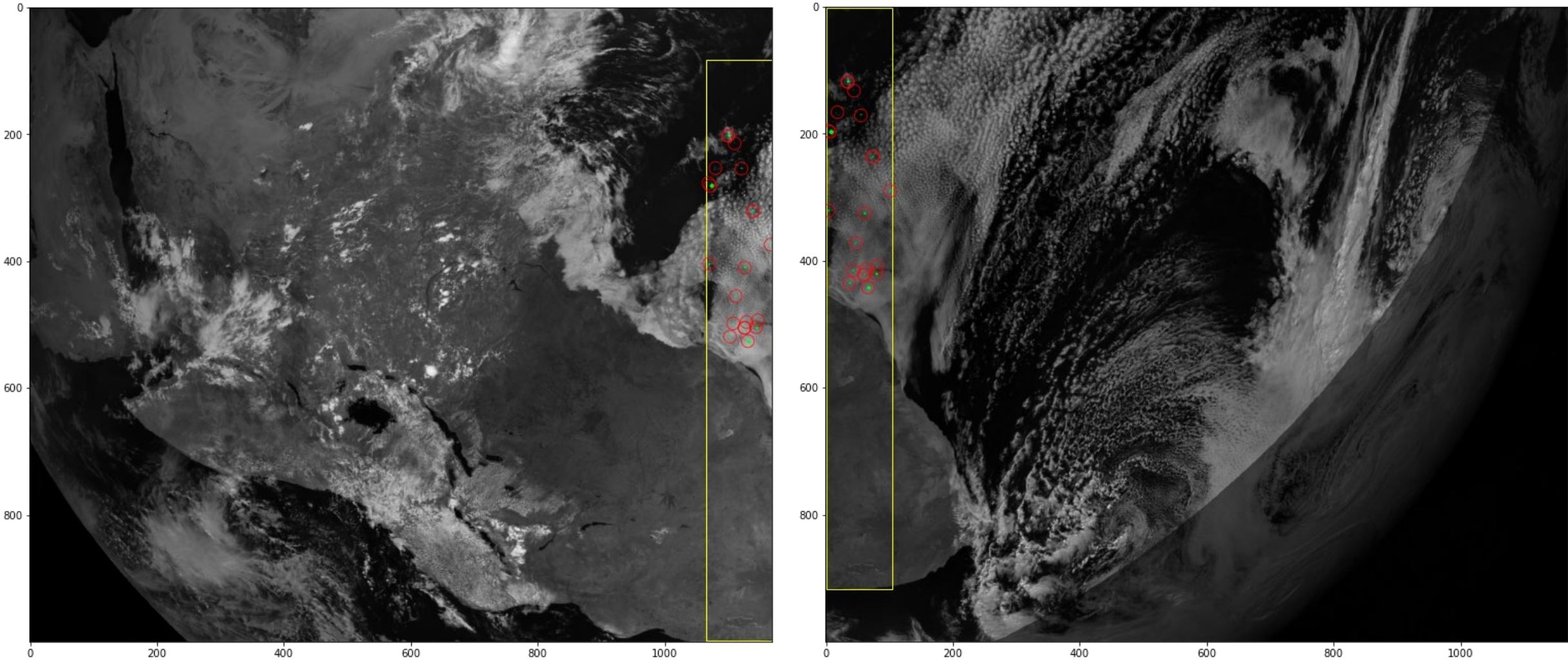
**Level 1b content**

# Monitoring detections in overlap regions



**Matching clusters at Level 1b content**

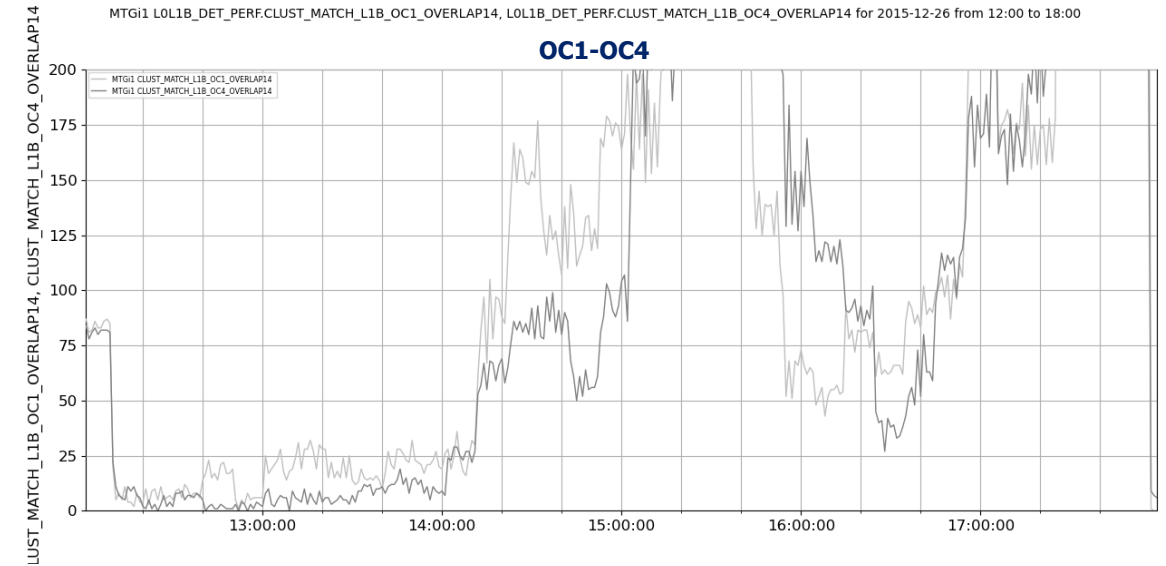
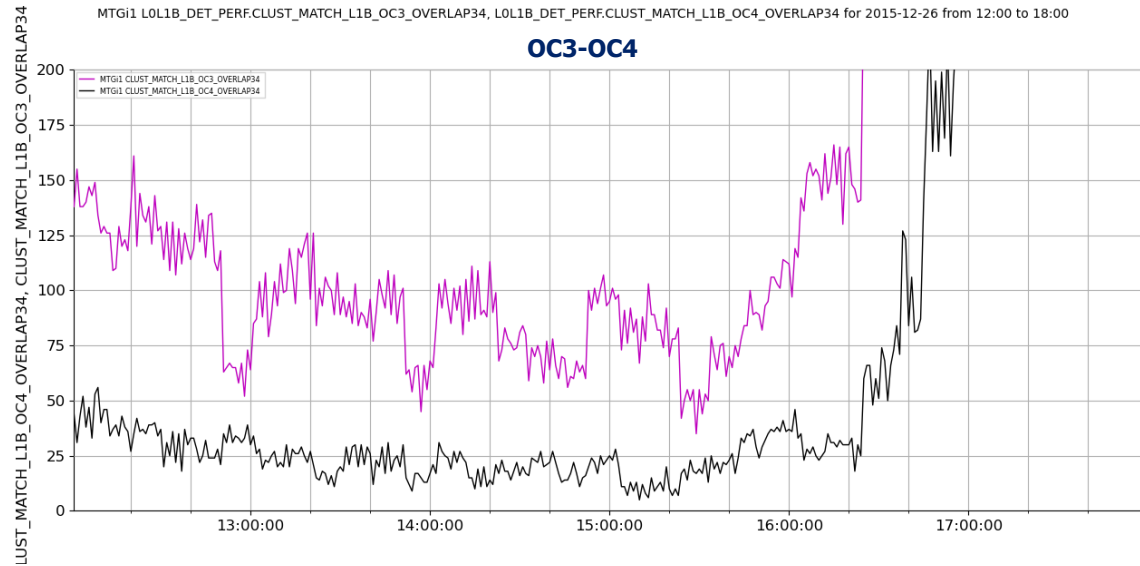
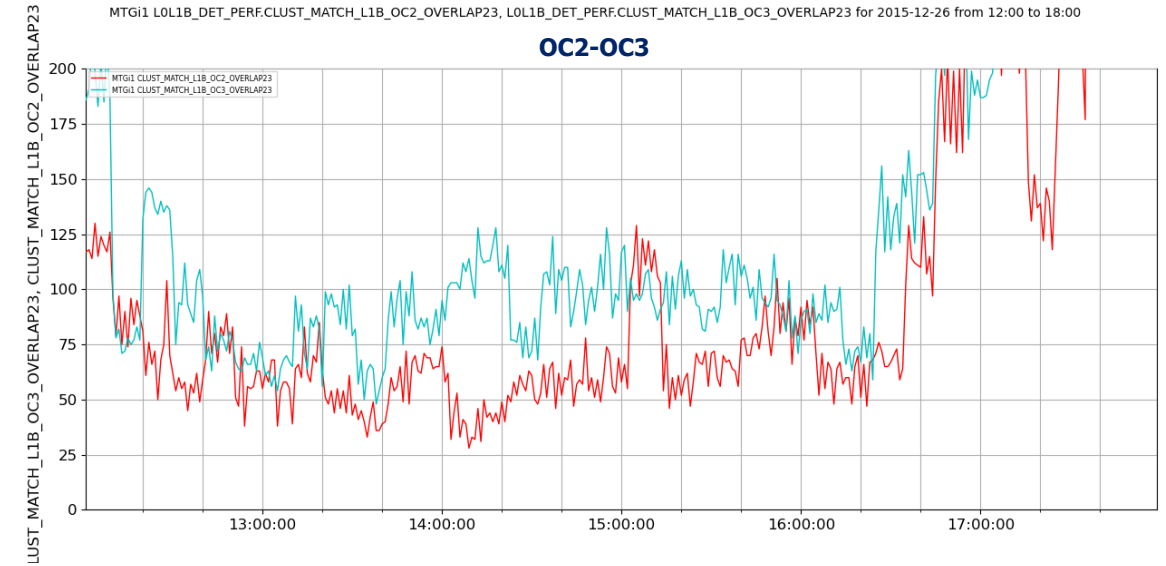
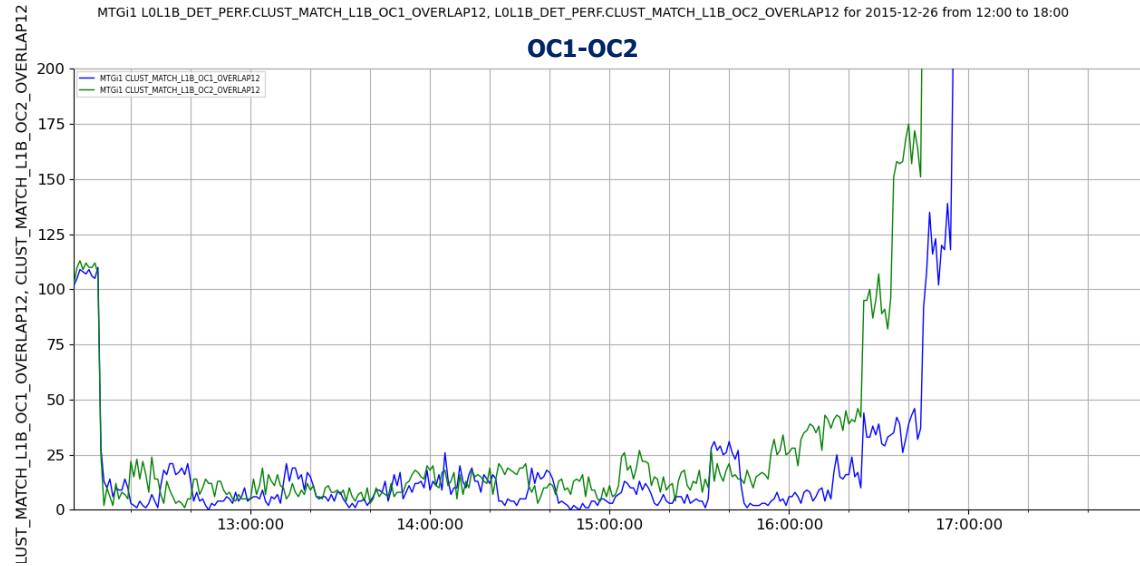
# Monitoring detections in overlap regions



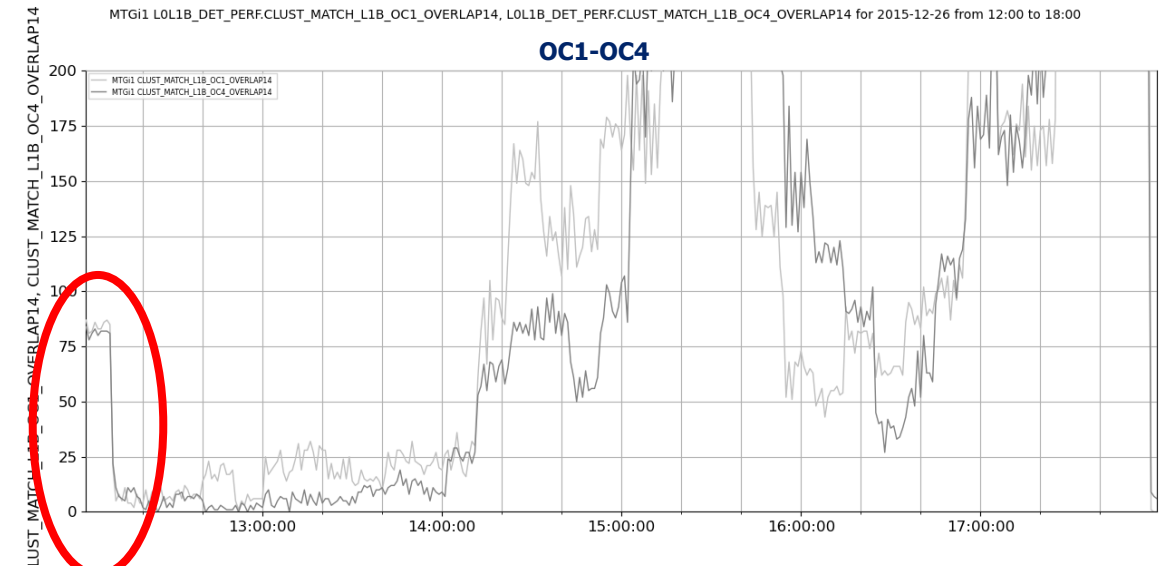
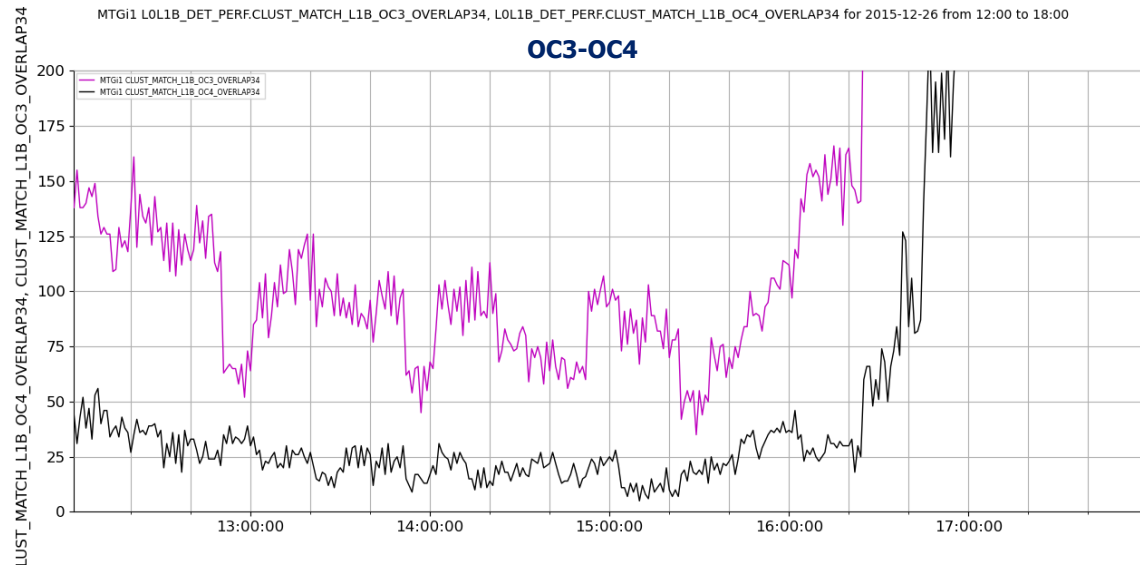
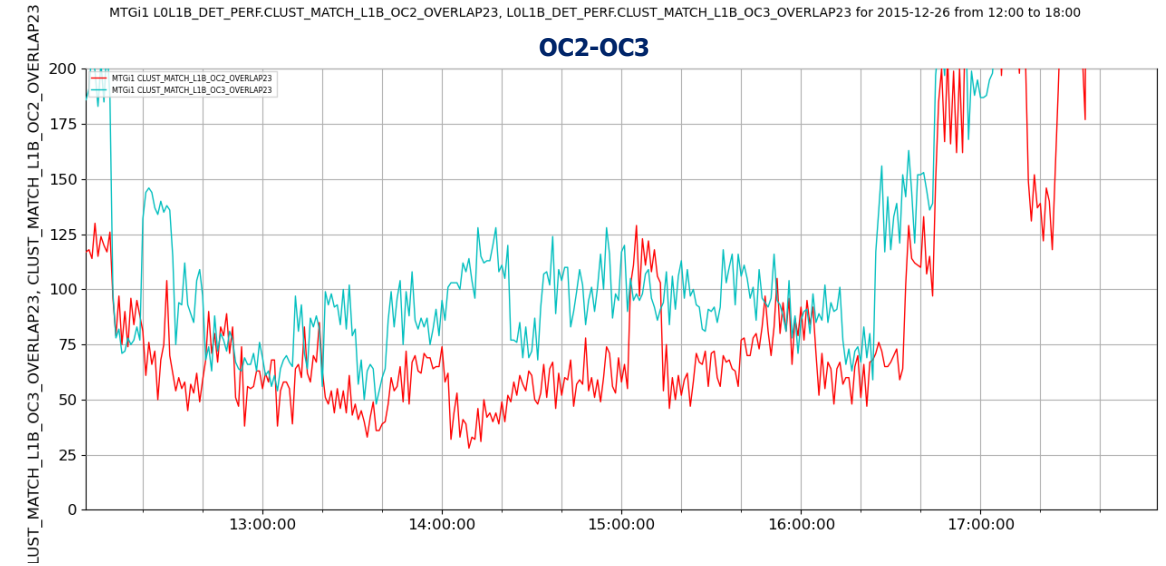
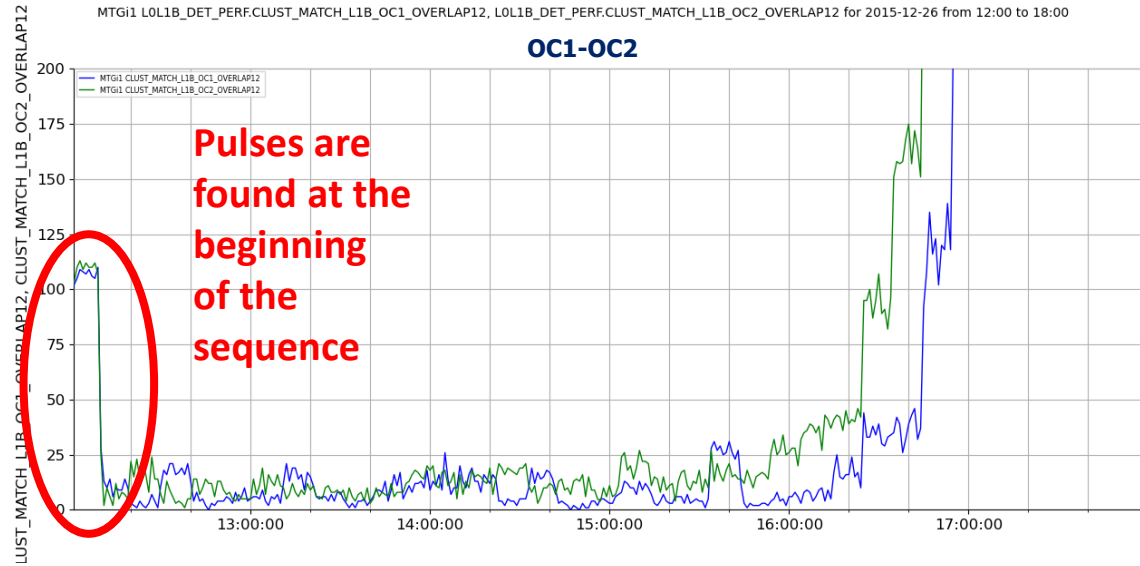
**Matching clusters at Level 0 content**



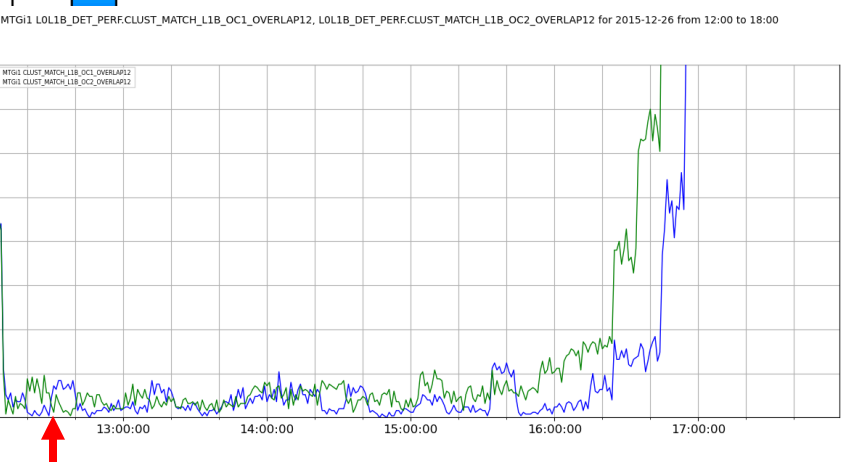
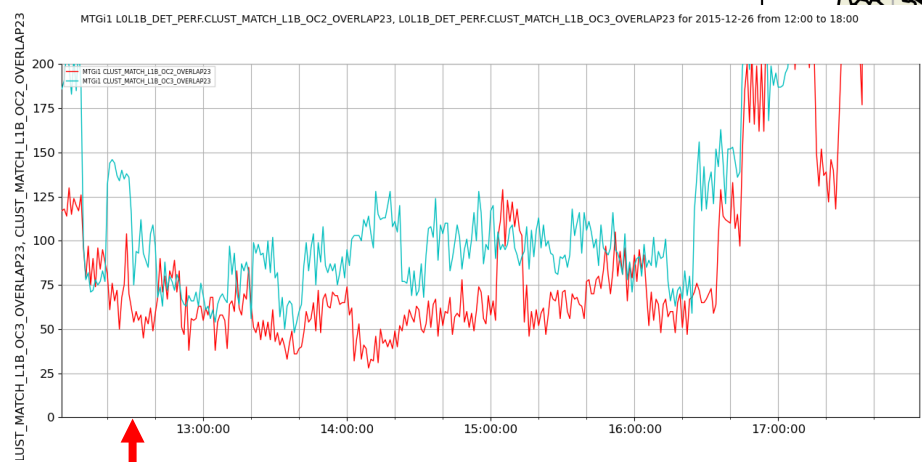
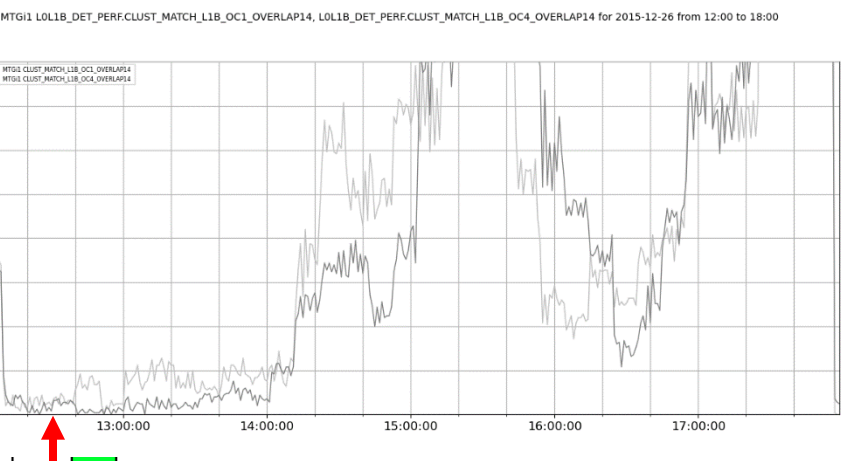
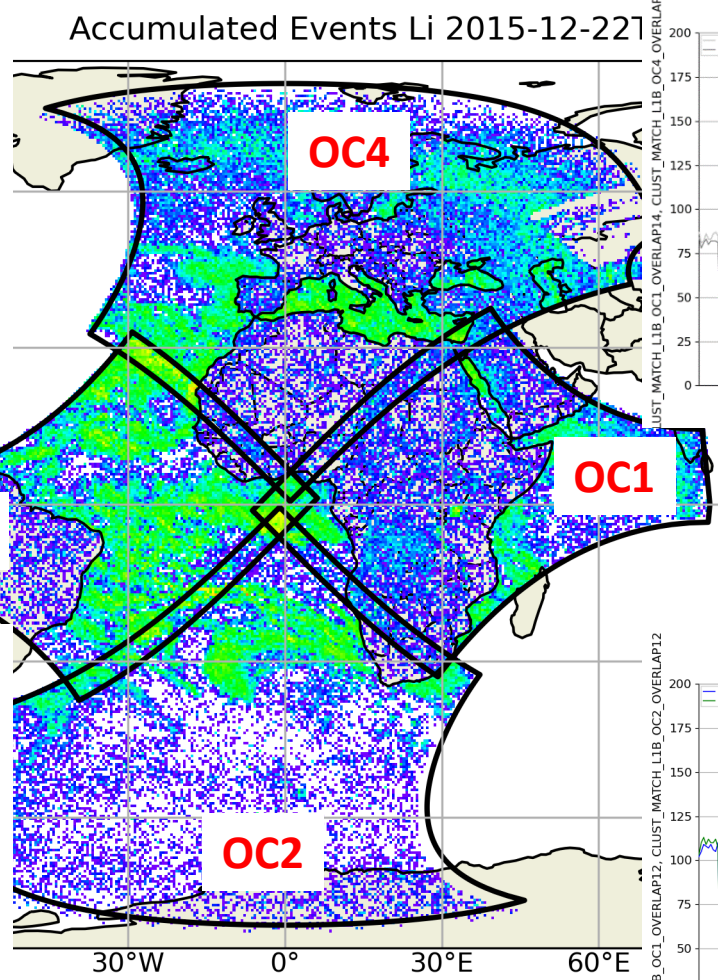
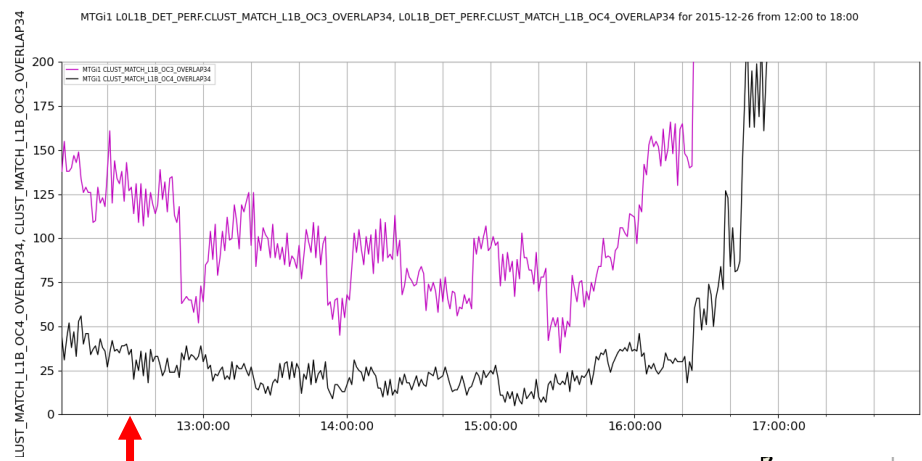
# Monitoring matching detections in overlap regions (L0 output)



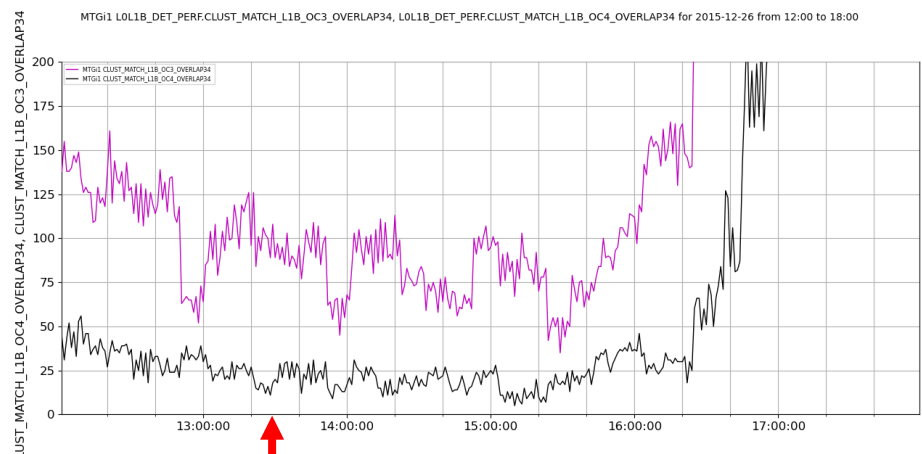
# Monitoring matching detections in overlap regions (L0 output)



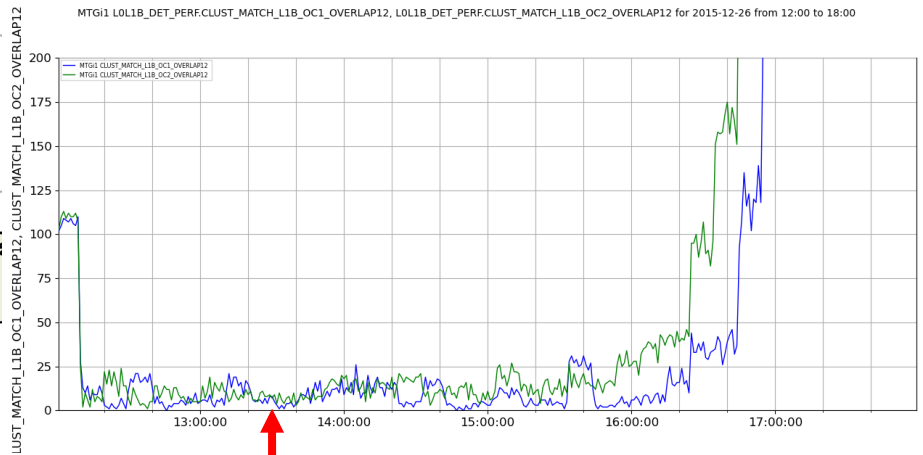
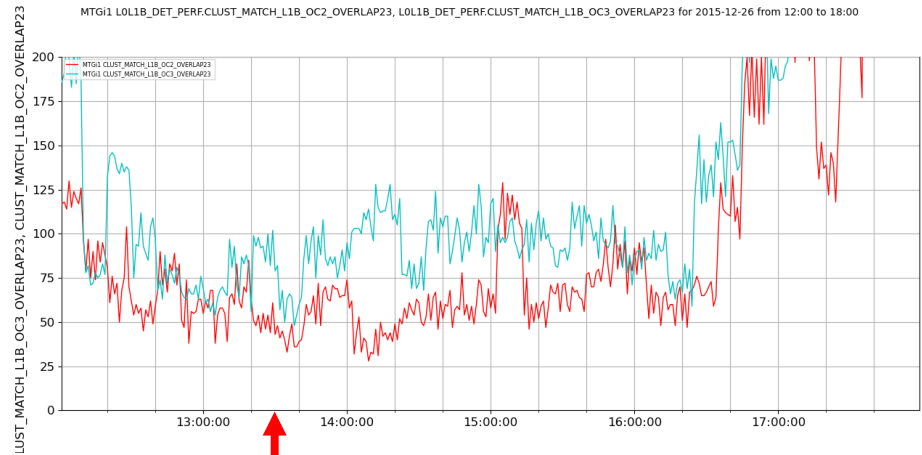
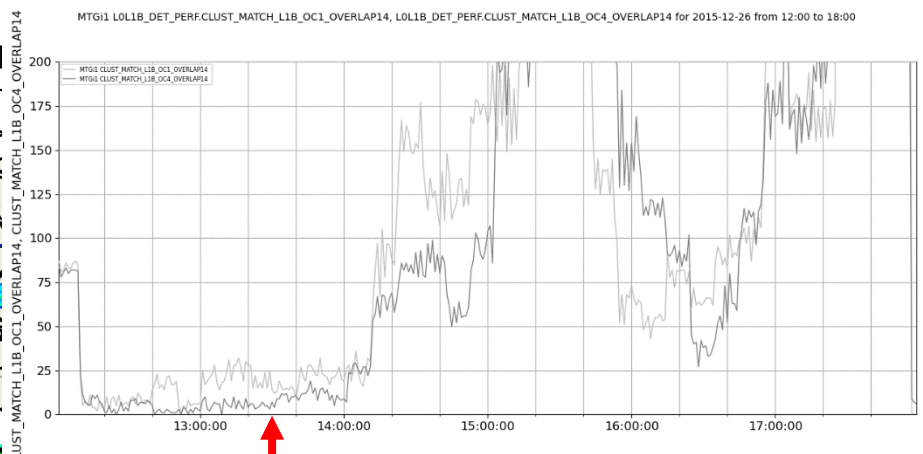
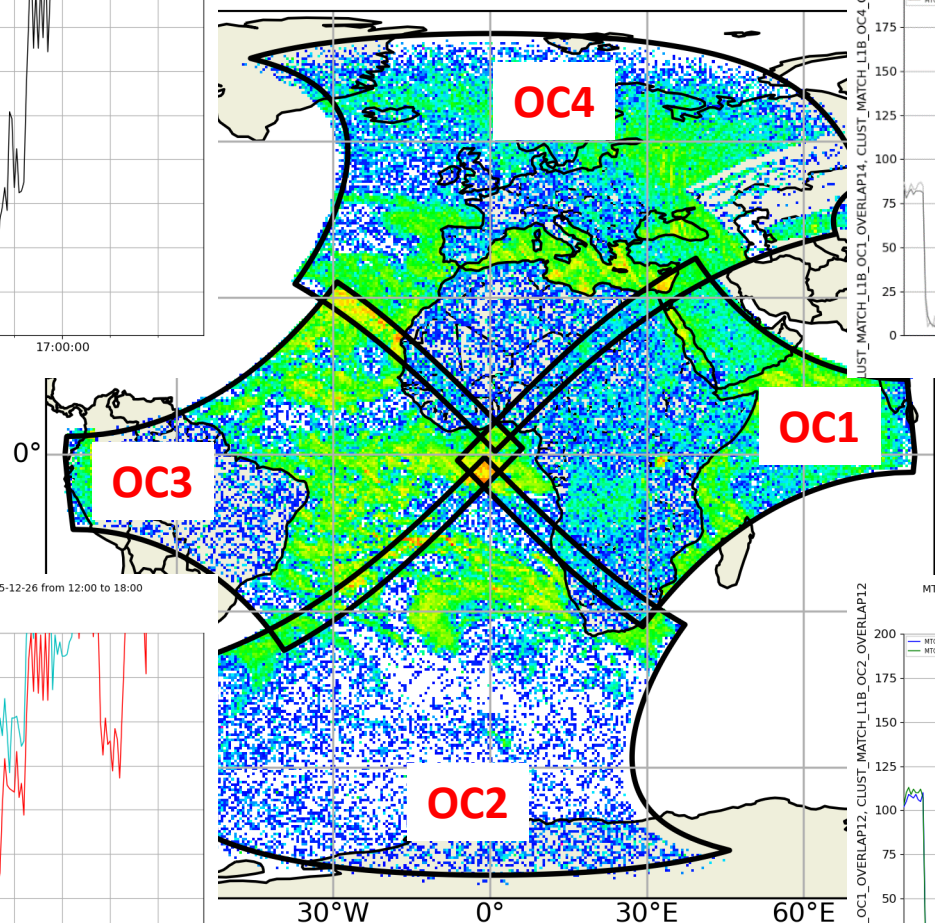
# Monitoring matching detections in overlap regions (L0 output)



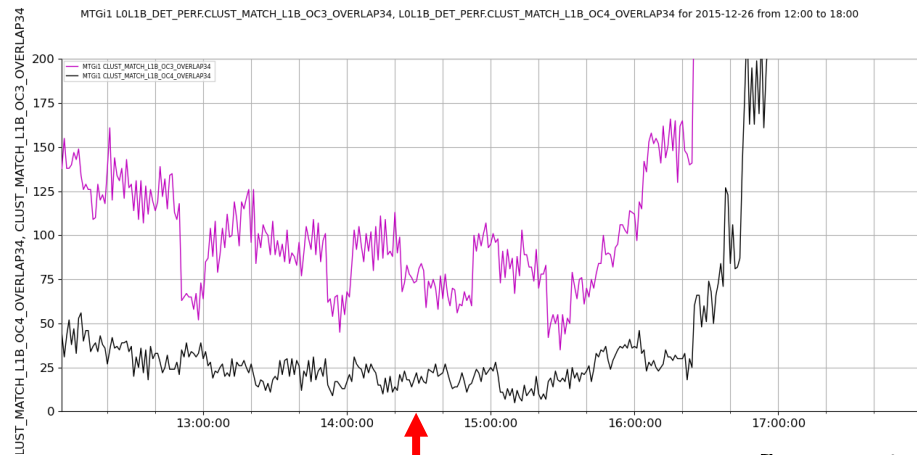
# Monitoring matching detections in overlap regions (L0 output)



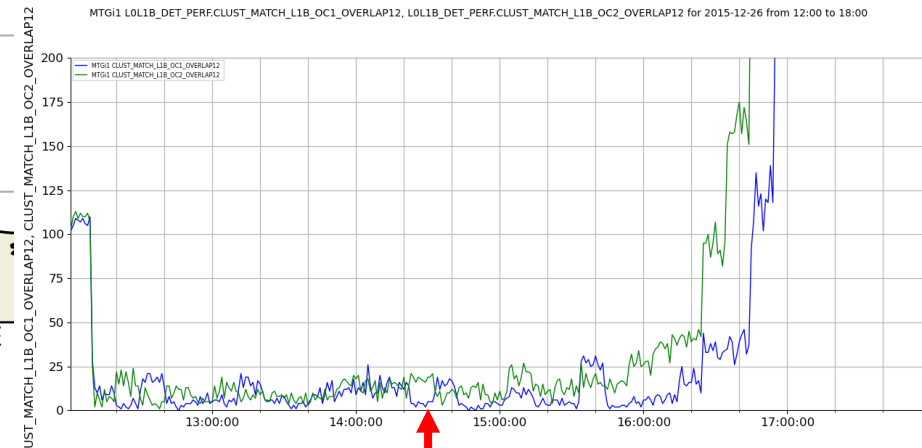
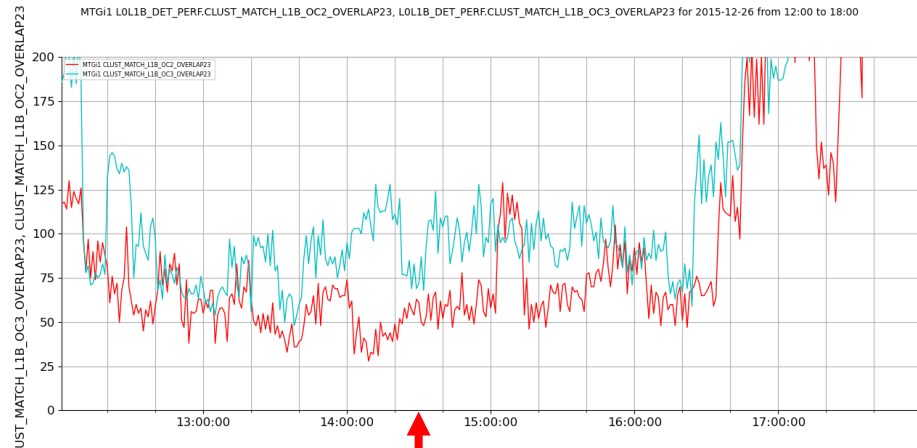
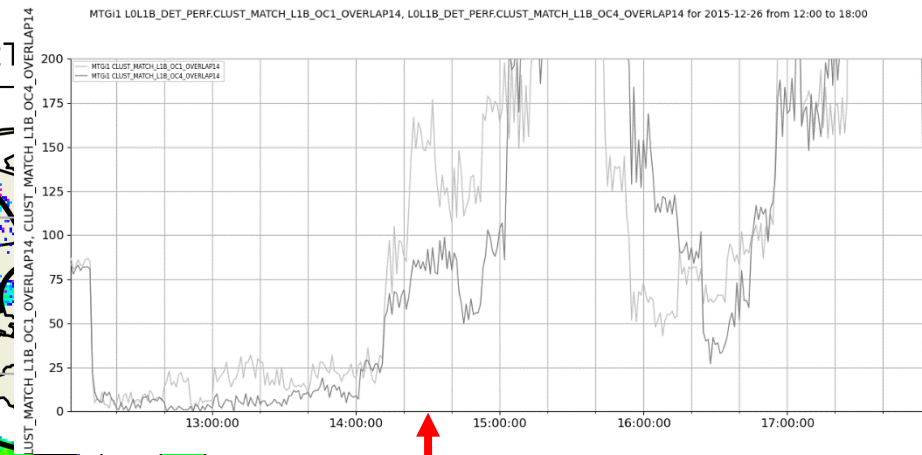
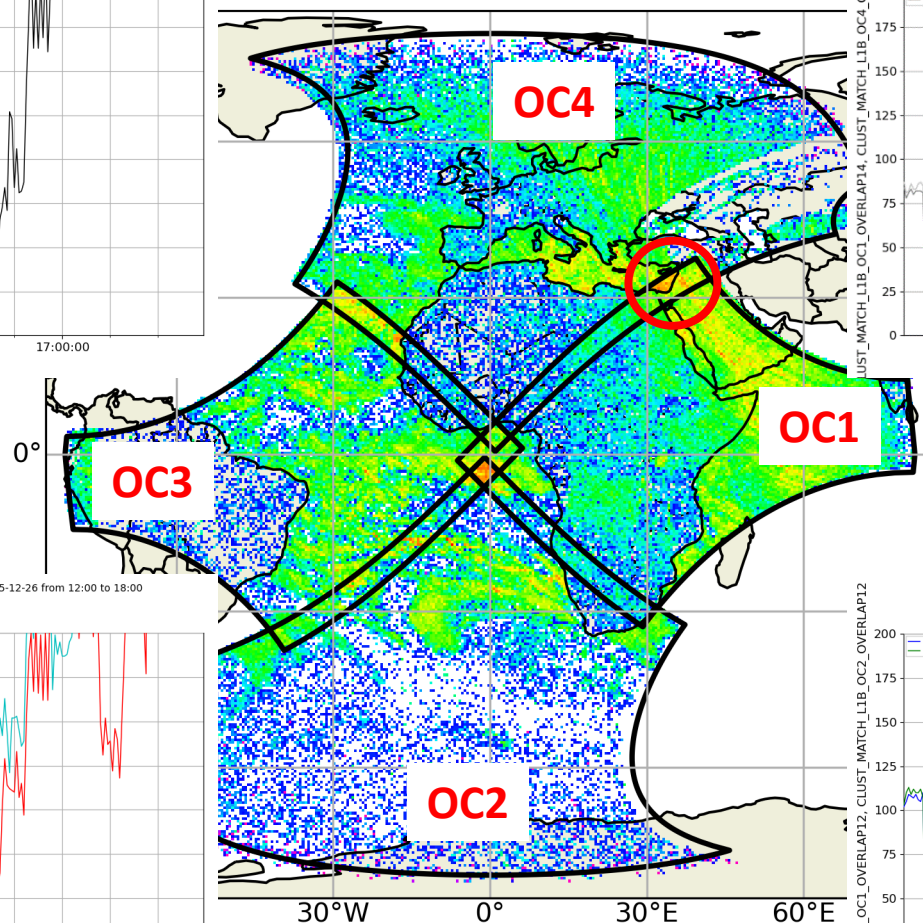
Accumulated Events Li 2015-12-22T



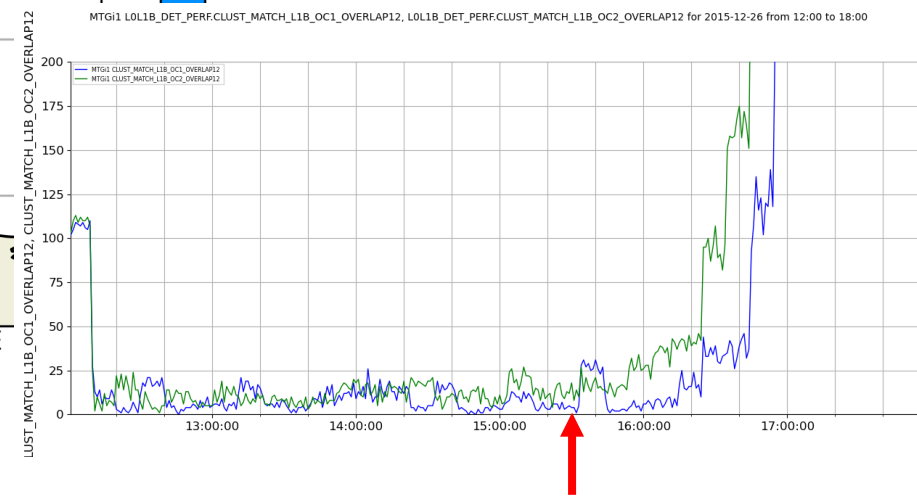
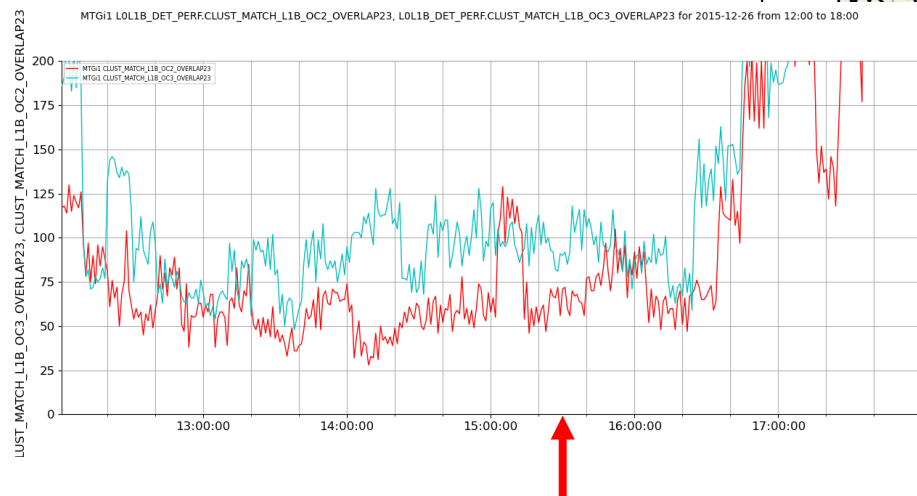
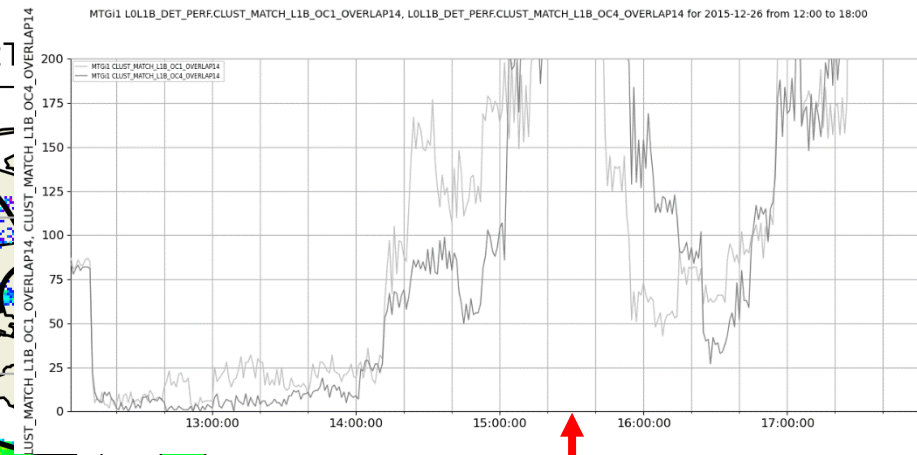
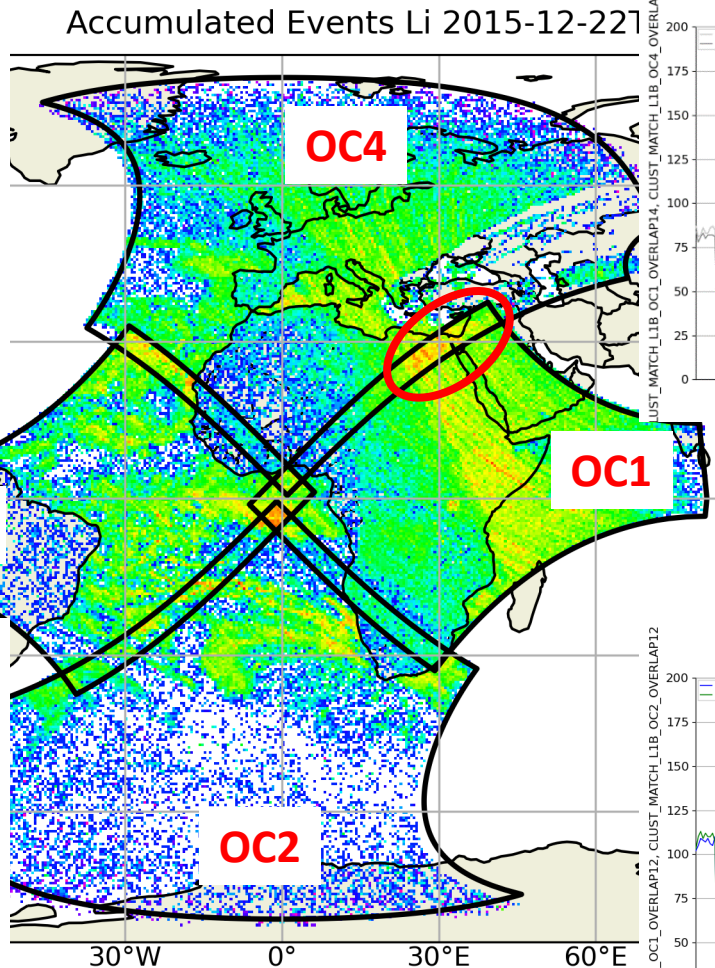
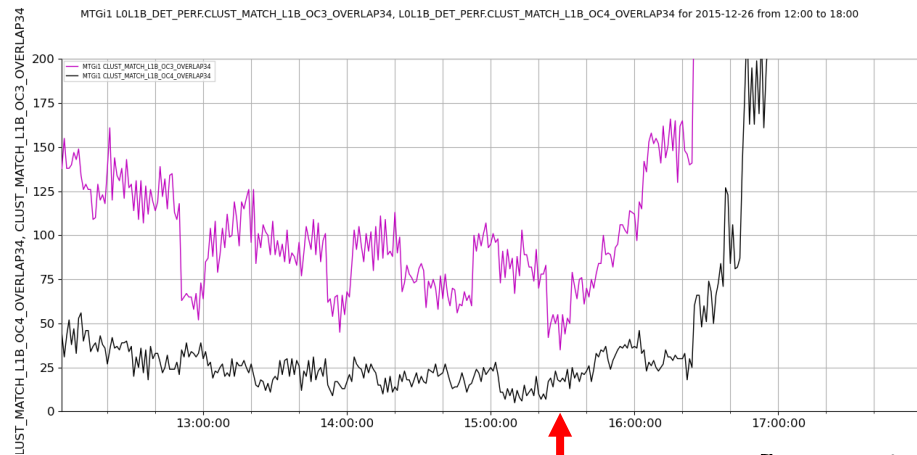
# Monitoring matching detections in overlap regions (L0 output)



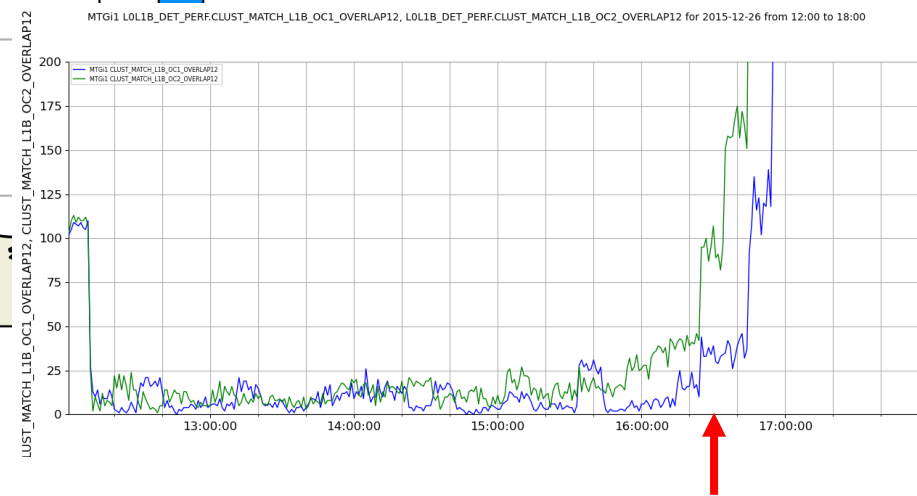
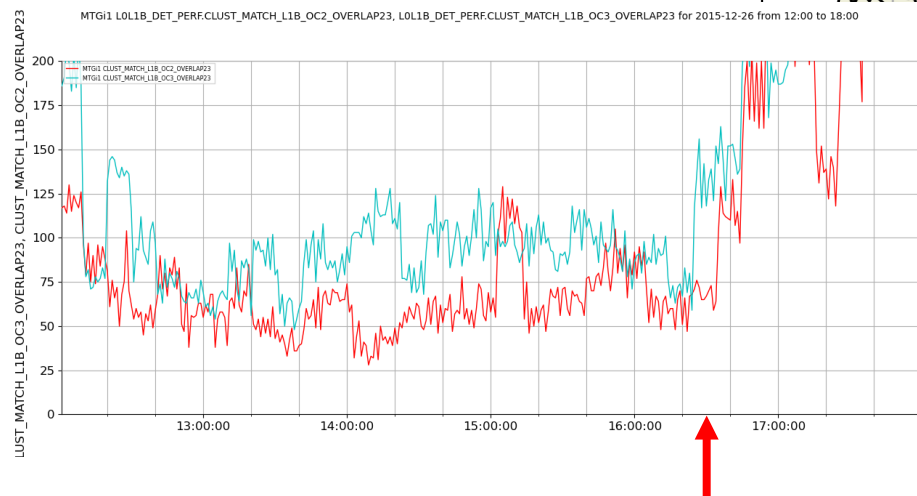
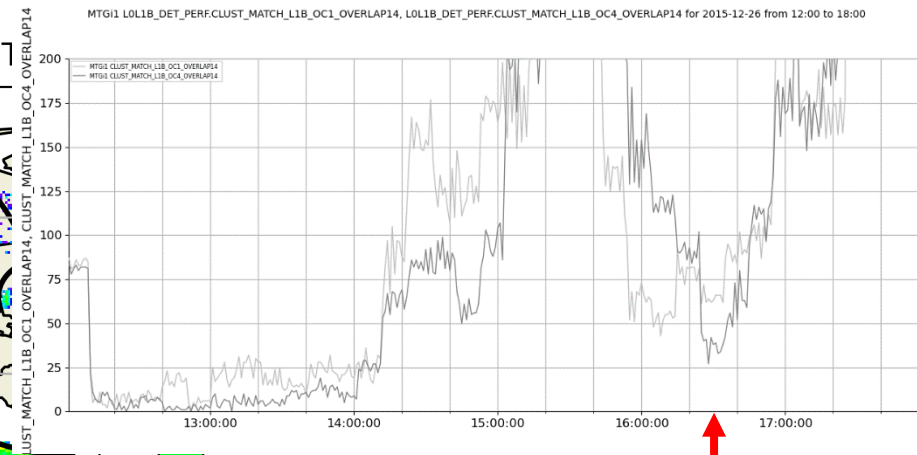
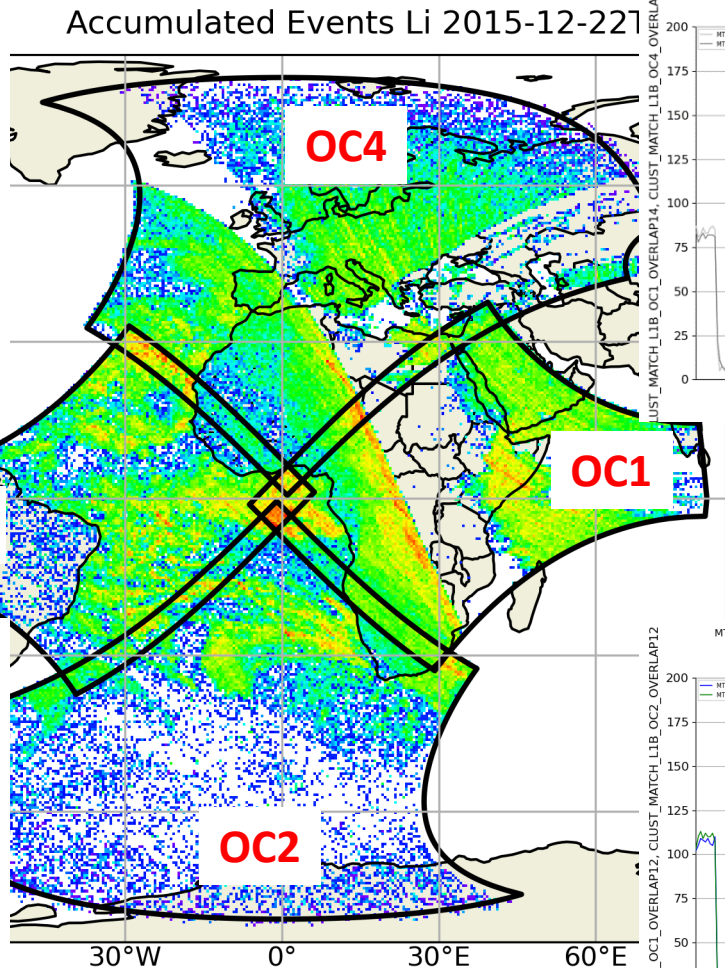
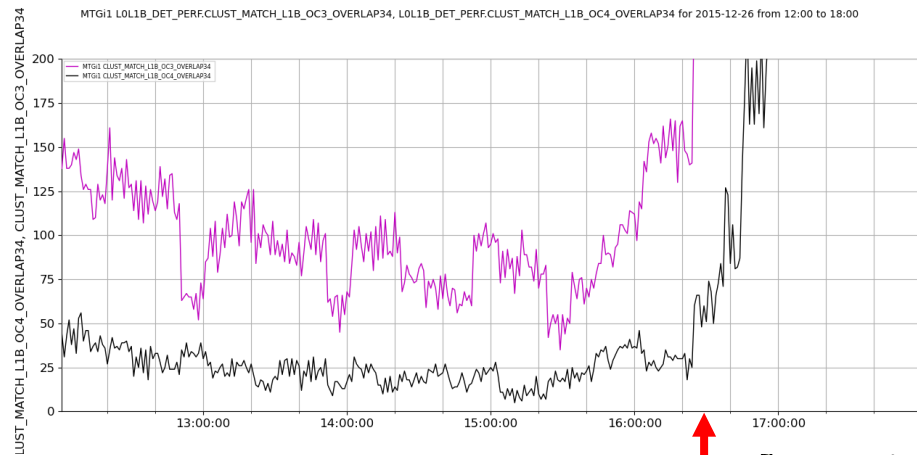
Accumulated Events Li 2015-12-22T



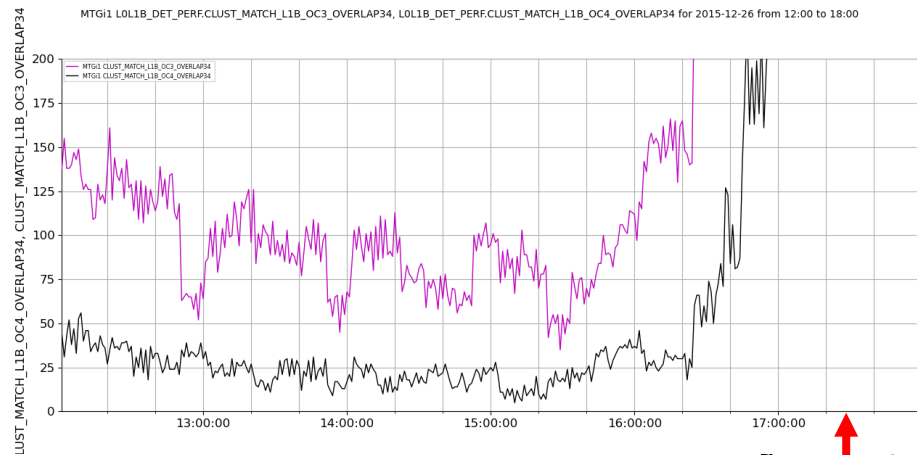
# Monitoring matching detections in overlap regions (L0 output)



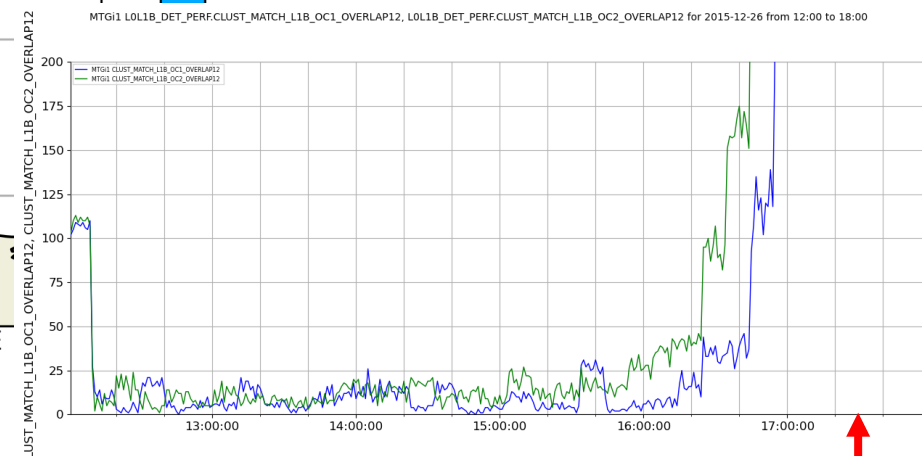
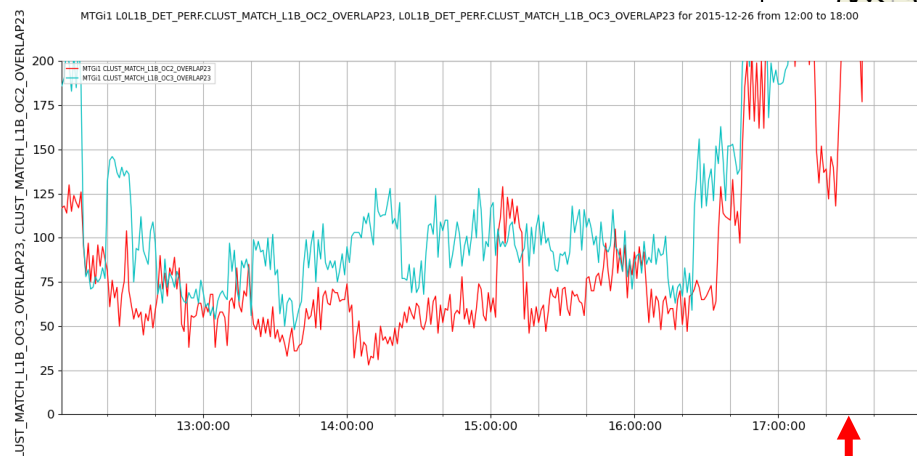
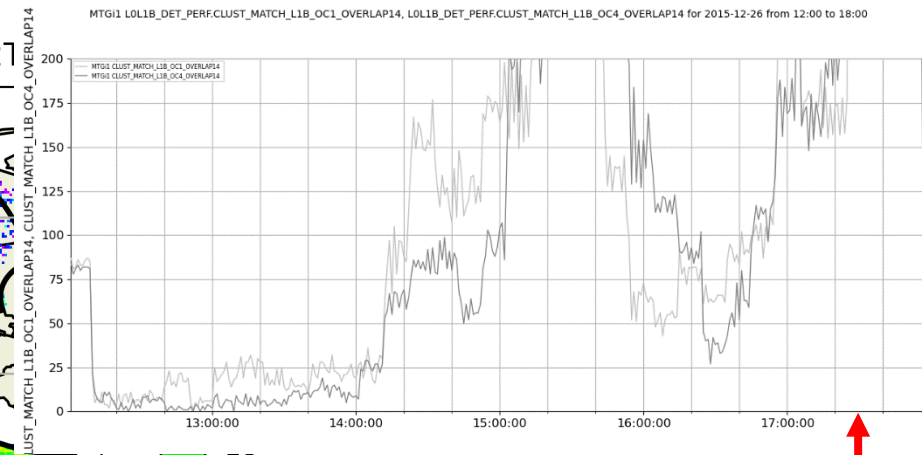
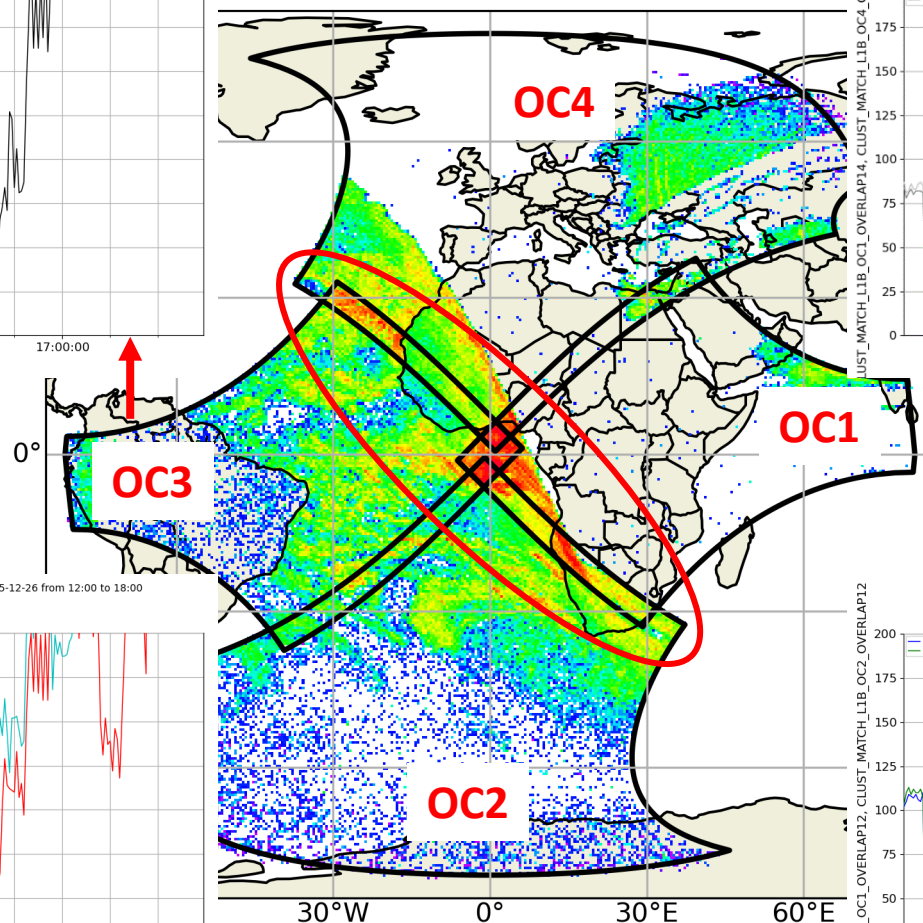
# Monitoring matching detections in overlap regions (L0 output)



# Monitoring matching detections in overlap regions (L0 output)

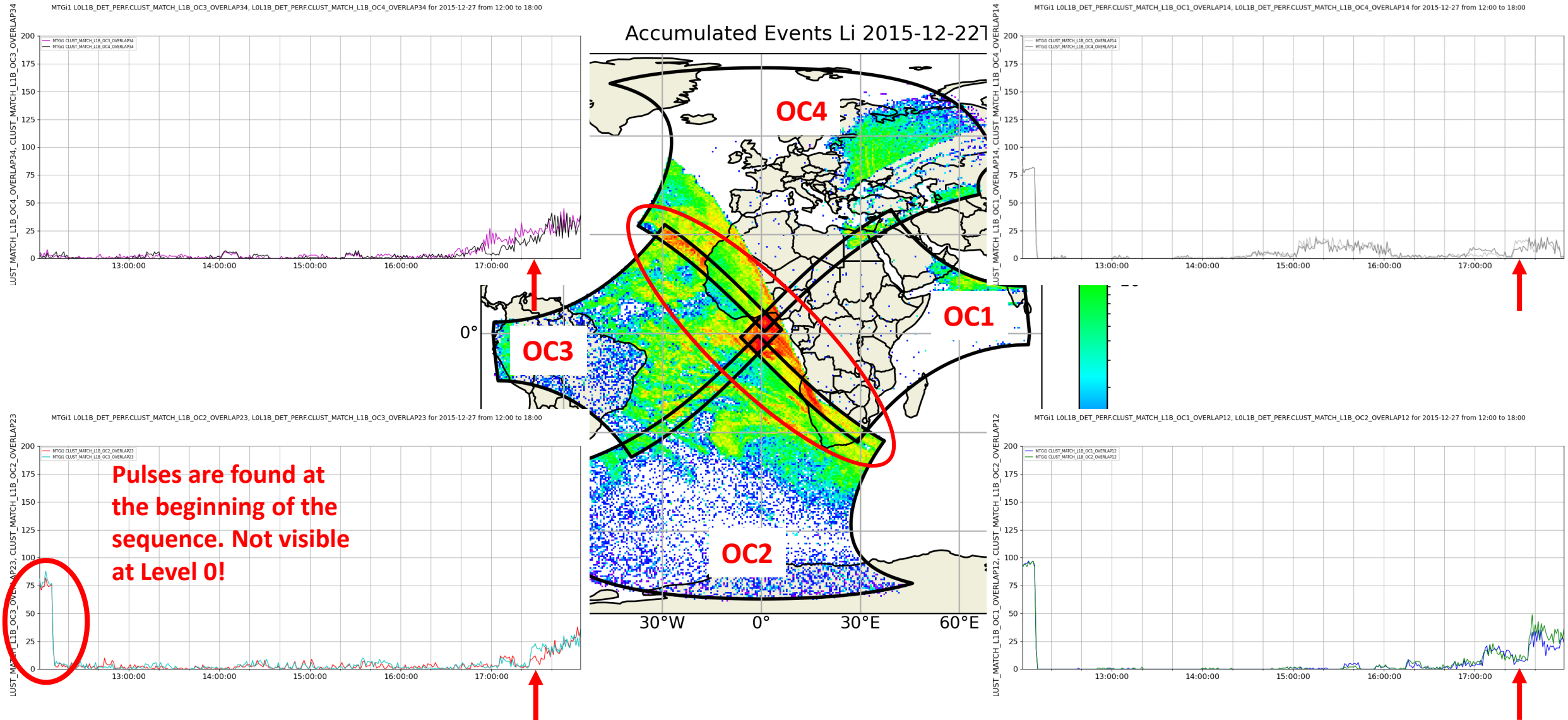


Accumulated Events Li 2015-12-22T





# Monitoring matching detections in overlap regions (test at L1B)



# Conclusions

- LI-STAR functionalities devoted to monitor Level 1b filtering performances, FAR and DE are secured and the team is now consolidating the automation of such procedure to achieve the “live” processing of the data.
- Note on the availability of the processing facilities:
  - IDPF-I is supposed to secure only Level 0 archiving for the beginning of the Commissioning.
  - Only IDPF-I v5.1.A will be able to process data as IQT v3.5 patch#3. The use of the IDPF-I v5.1.A should in Q2 2023.
  - EUMETSAT is planning to use anyway the first Level 1b data available (either from IQT or IDPF-I).