Cuts effectiveness on POLA-X muon rates

Ombretta Pinazza

meeting analisi EEE 15/3/2024

WG: F. Nozzoli, L. Ghezzer, O. Pinazza

Data

Original data from
/home/eee/analisi/polarRates/outPOLA-0x.root
(rates per minute)

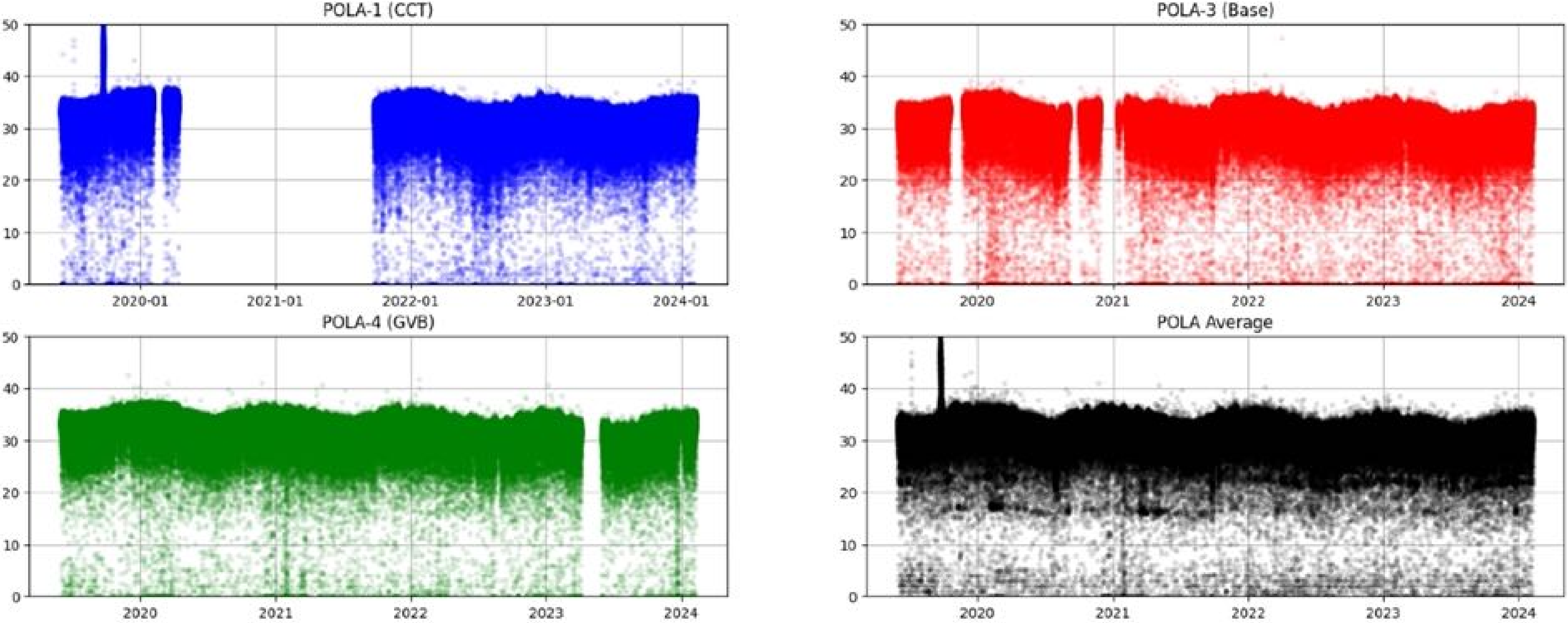
1/6/2019 – 8/2/2024, total minutes 2466751

CUTS (applied in this order):
- status = 0
- pressure available and in [700, 1100 mbar]
- rate min = 20.0 Hz
- temp max = 40.0
- rateRaw/rate/r1/r2 max diff = 3 Hz
- effiency min = 0.8

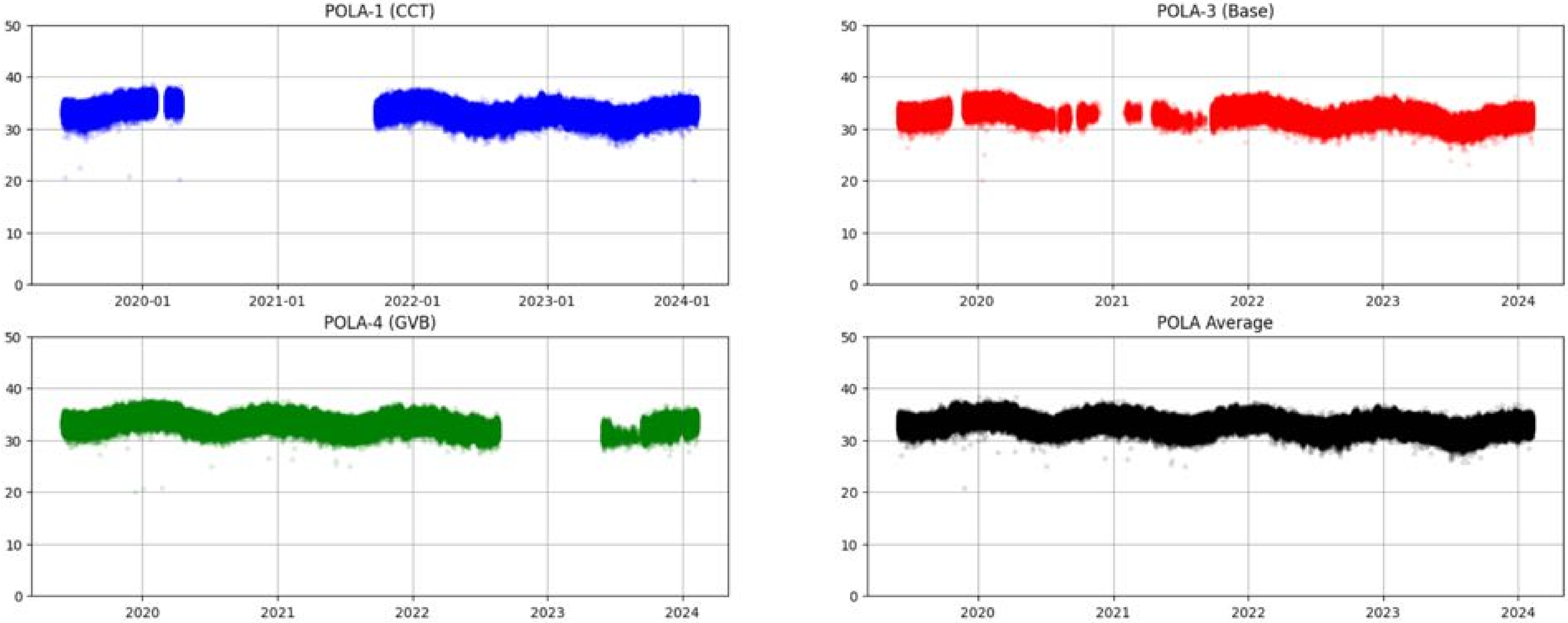
Grazie Franco Riggi per gli spunti di riflessione riguardo i tagli e la stima degli errori sistematici

	POLA-1	POLA-3	POLA-4	POLA-A
Before NyA	284006	399949	30302	
Total events	1563120 (63.4%)	2144281 (86.9%)	2224597 (90.2%)	2622029
Valid events	1224238 (78.3%)	1135197 (52.9%)	1347099 (60.6 %)	2365818
Excluded events	338882 (21.7%)	1009084 (47.1%)	877498 (39.4 %)	
- status	277179 (17.7%)	358374 (16.7%)	644398 (29.0 %)	
- pressure	91 (<0.0%)	143 (<0.0%)	64 (<0.0 %)	
- temp	19115 (1.2%)	335595 (15.7%)	44182 (2.0 %)	
- diff	37691 (2.4%)	37334 (1.7%)	28816 (1.3 %)	
- Low rate	69 (<0.0%)	398 (<0.0%)	239 (<0.0 %)	
- efficiency	4737 (0.3%)	277240 (12.9%)	159799 (7.2 %)	

Raw rates (no cuts)

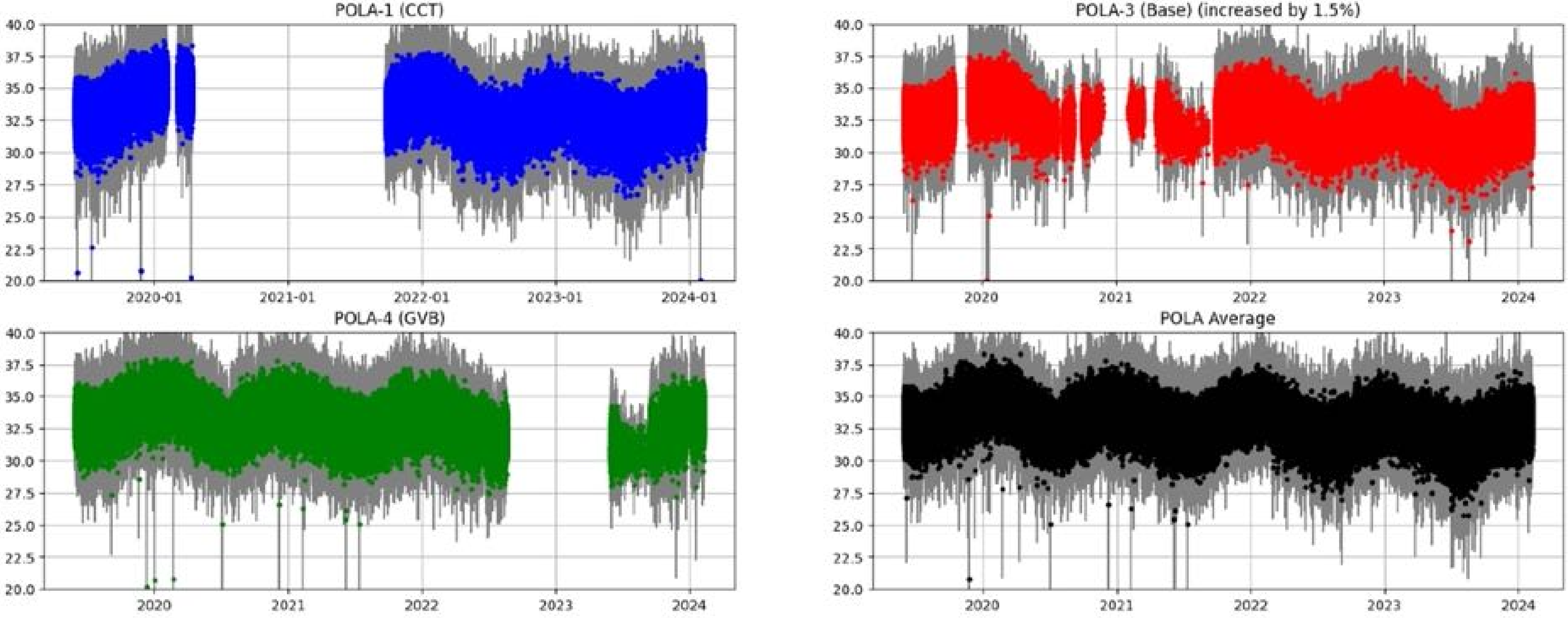


With cuts


POLA-1 (CCT)
50
40
30
20
10
0
2020-01
2021-01
2022-01
2023-01
2024-01
POLA-3 (Base)
2020
2021
2022
2023
2024
POLA-4 (GVB)
POLA Average

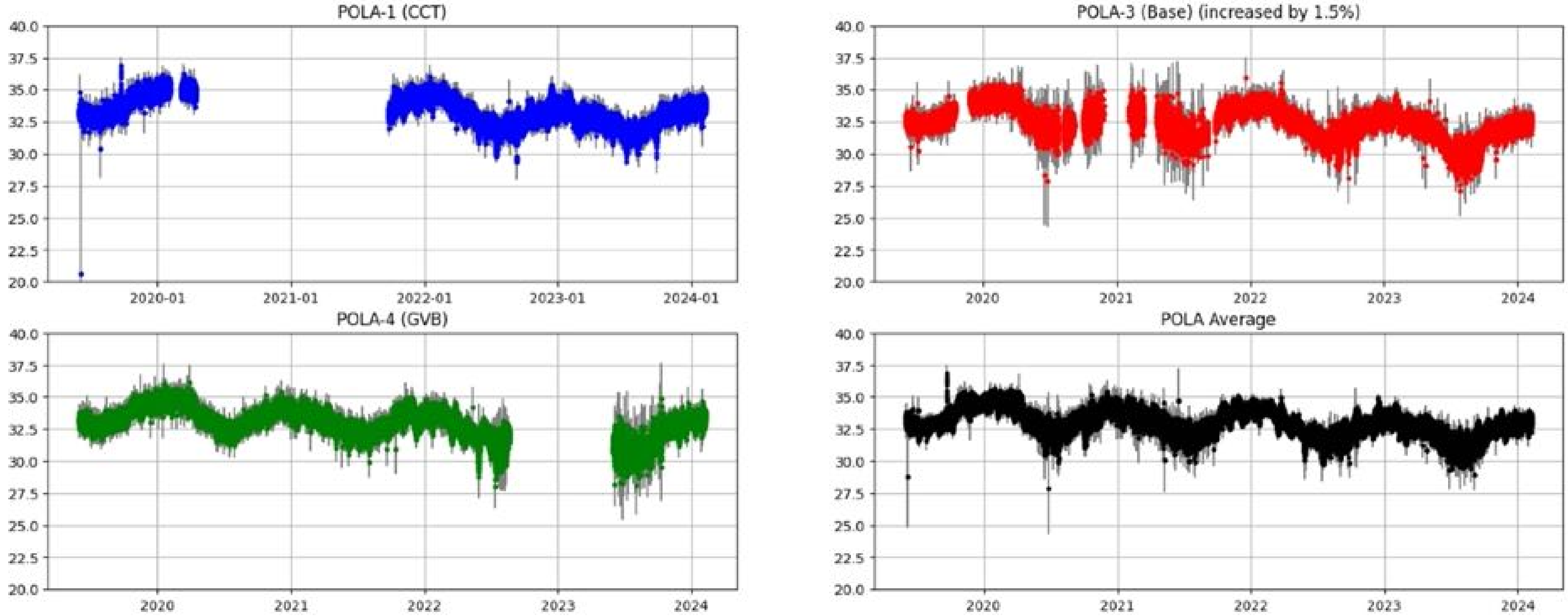
With cuts

- zooming, with error bars (statistical errors)



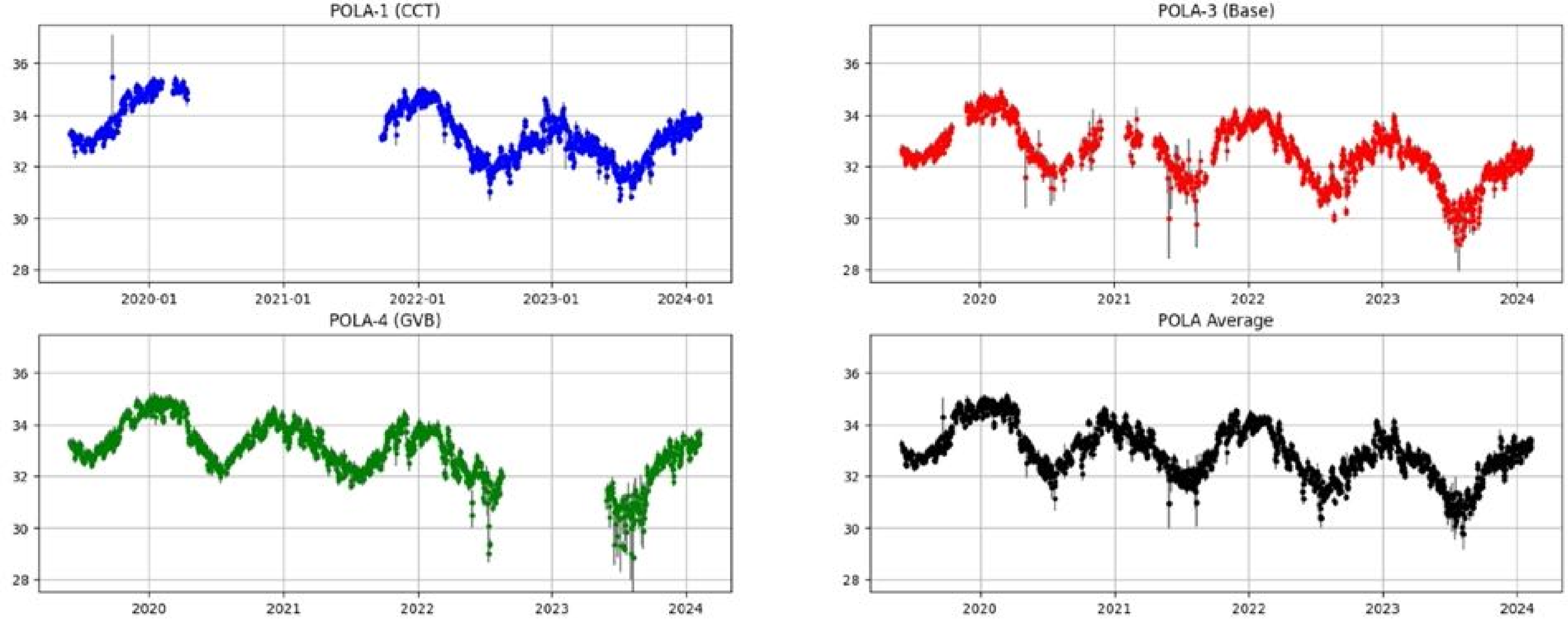
With cuts

- resampling 15min



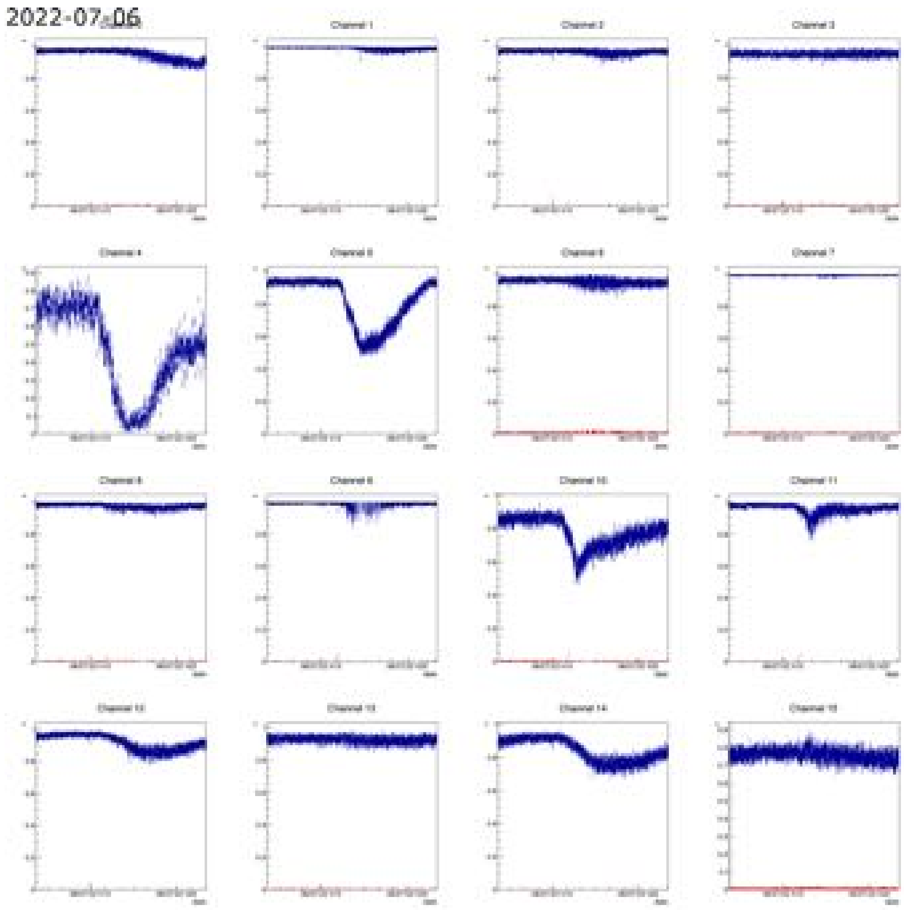
With cuts, resampling 1d

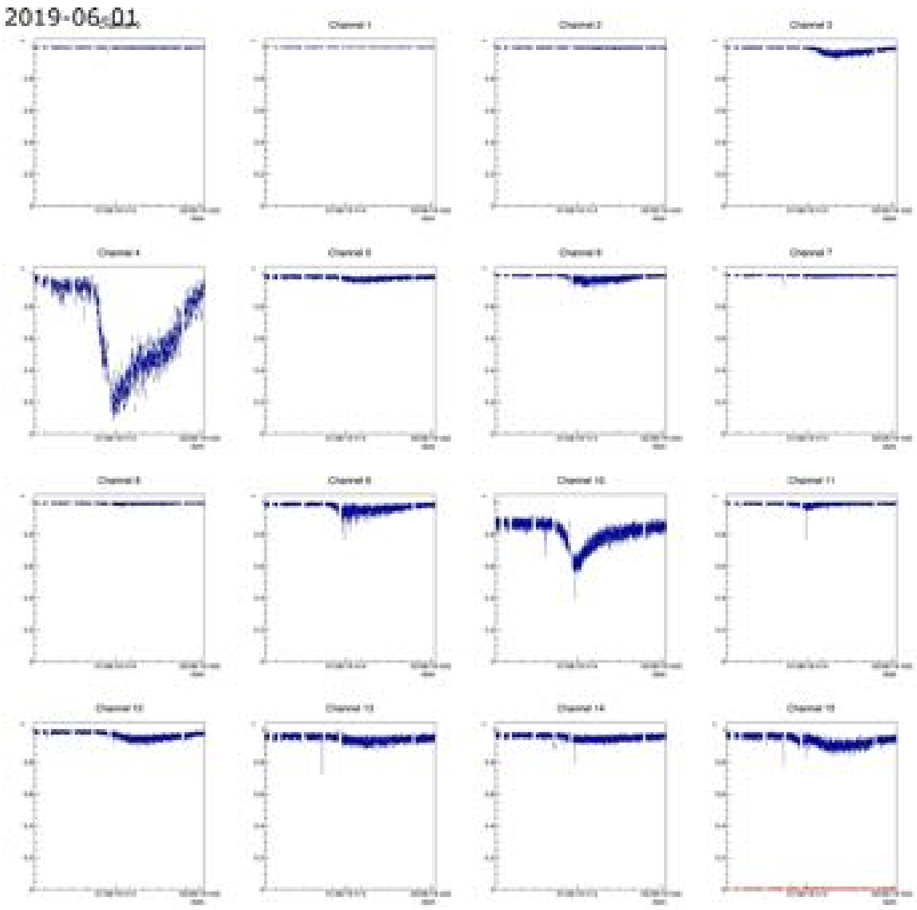
- resampling 1day, and zooming



Efficiency

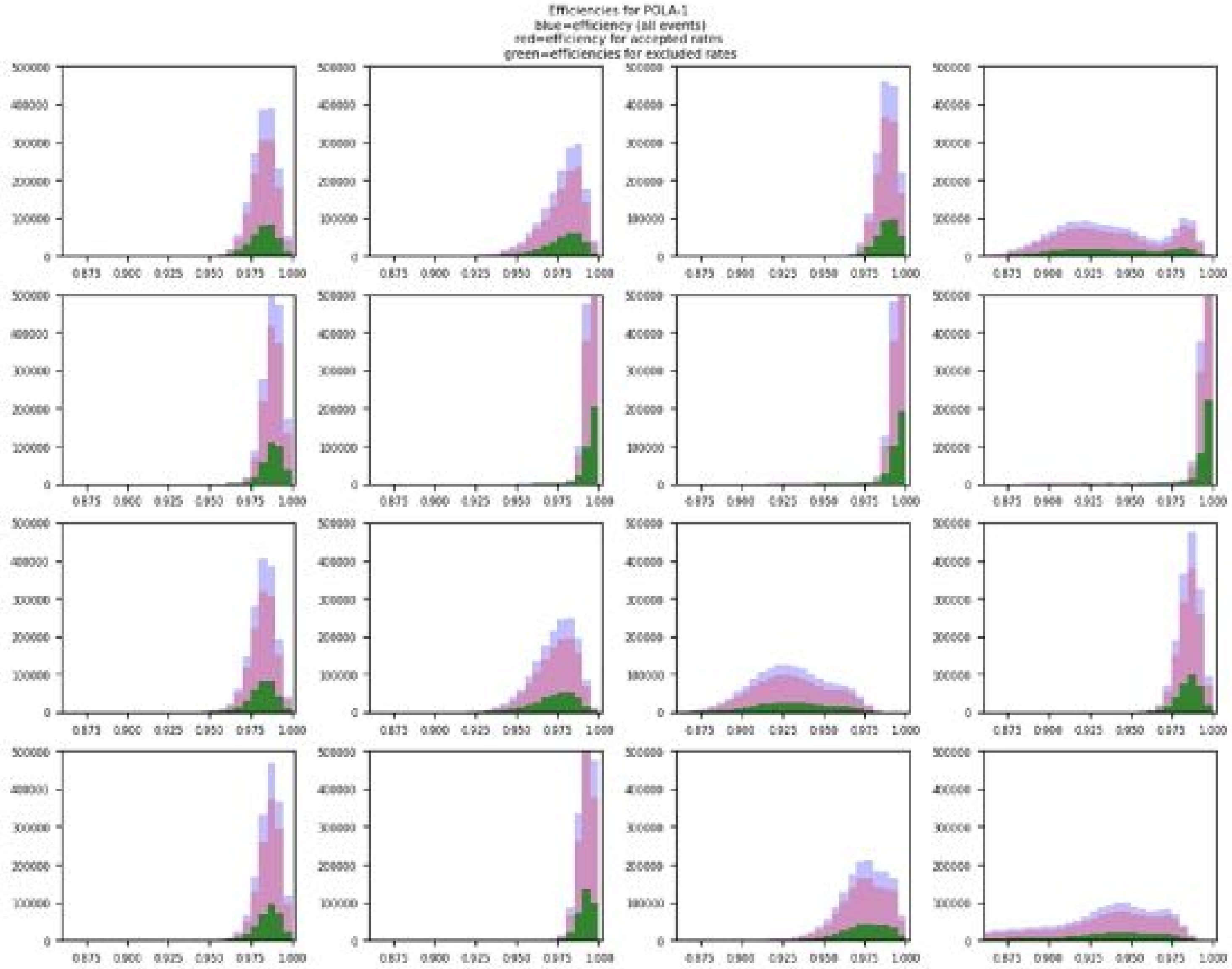
Efficiency index corresponds to SiPM index



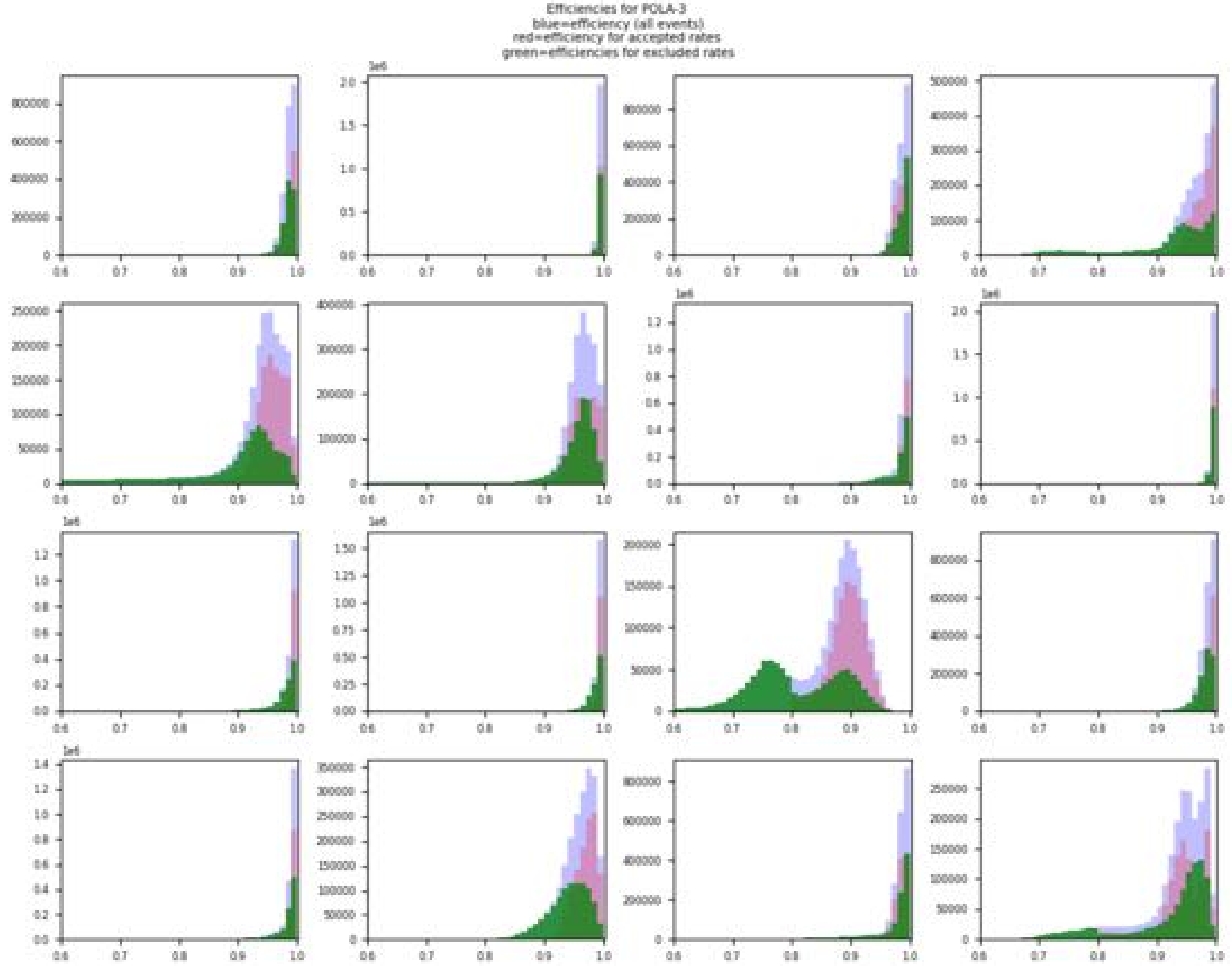


Example: POLA-3 efficiency in time

Efficiency POLA-1 after cuts

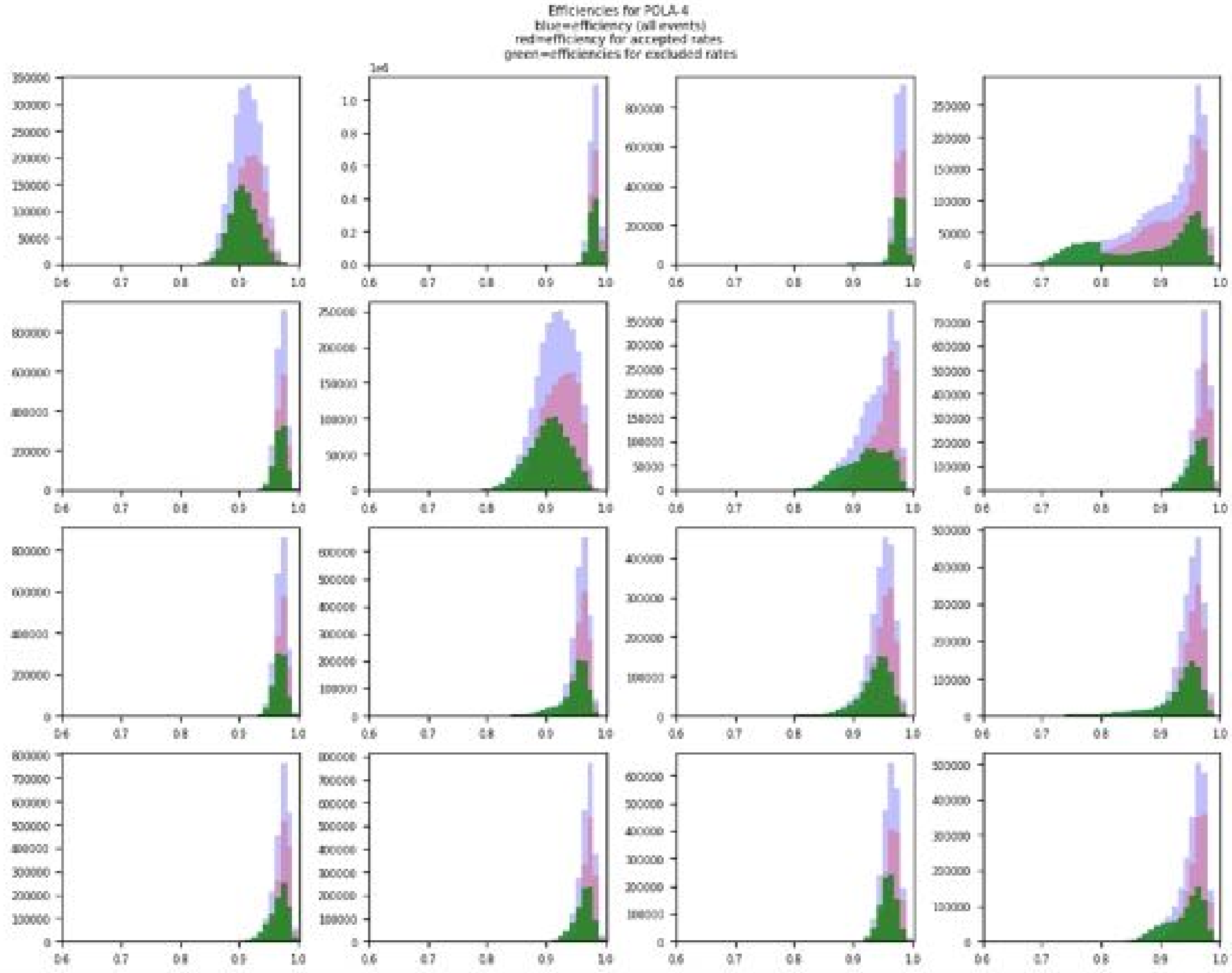


POLA-3



Efficiencies for POLA-3
blue=efficiency (all events)
red=efficiency for accepted rates
green=efficiencies for excluded rates

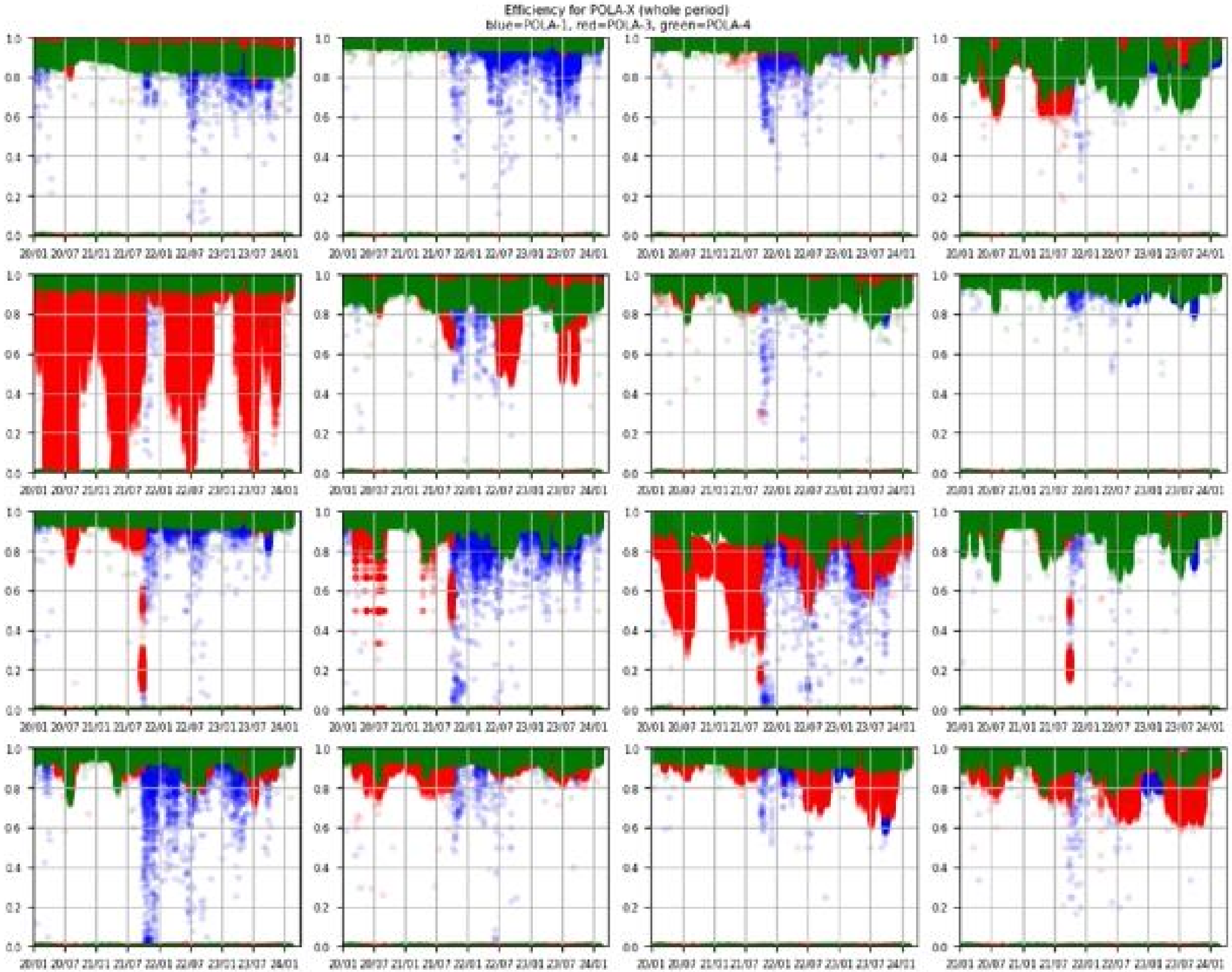
POLA-4



Efficiencies for POLA-4
blue=efficiency (all events)
red=efficiency for accepted rates
green=efficiencies for excluded rates

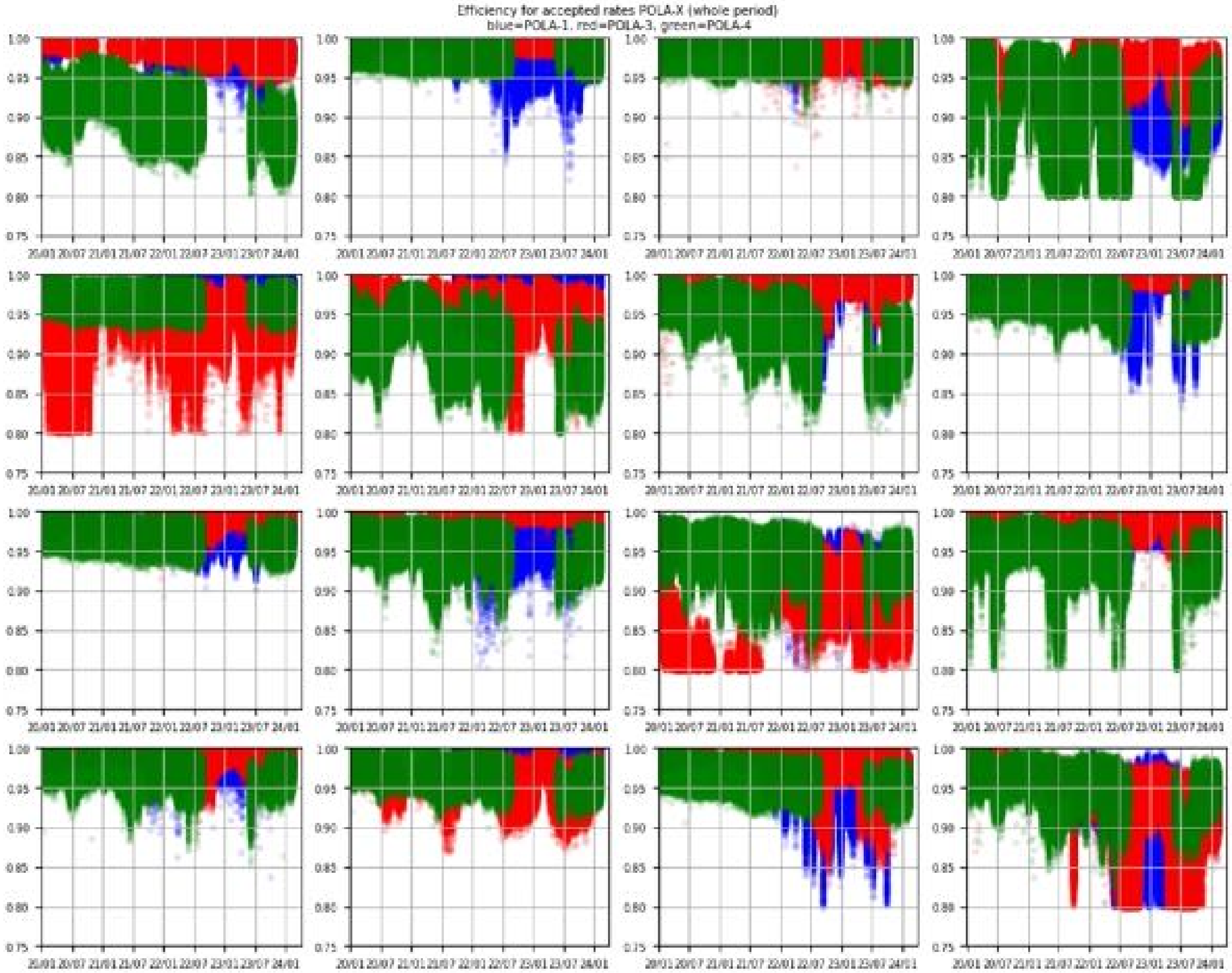
Time trend

- all rates



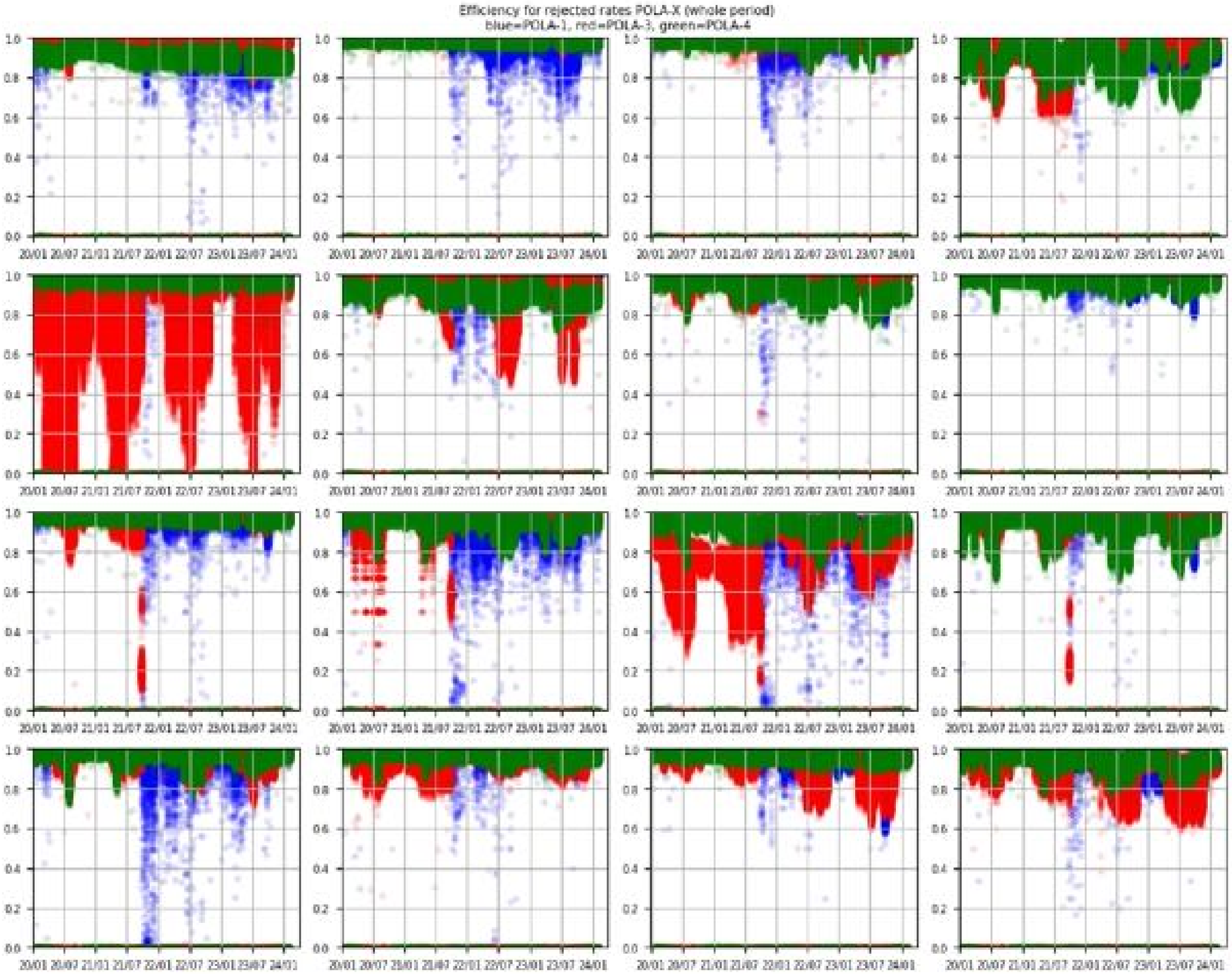
Time trend

- accepted rates (y-axis adapted to specific range)
- $eff_{min} \geq 0.8$

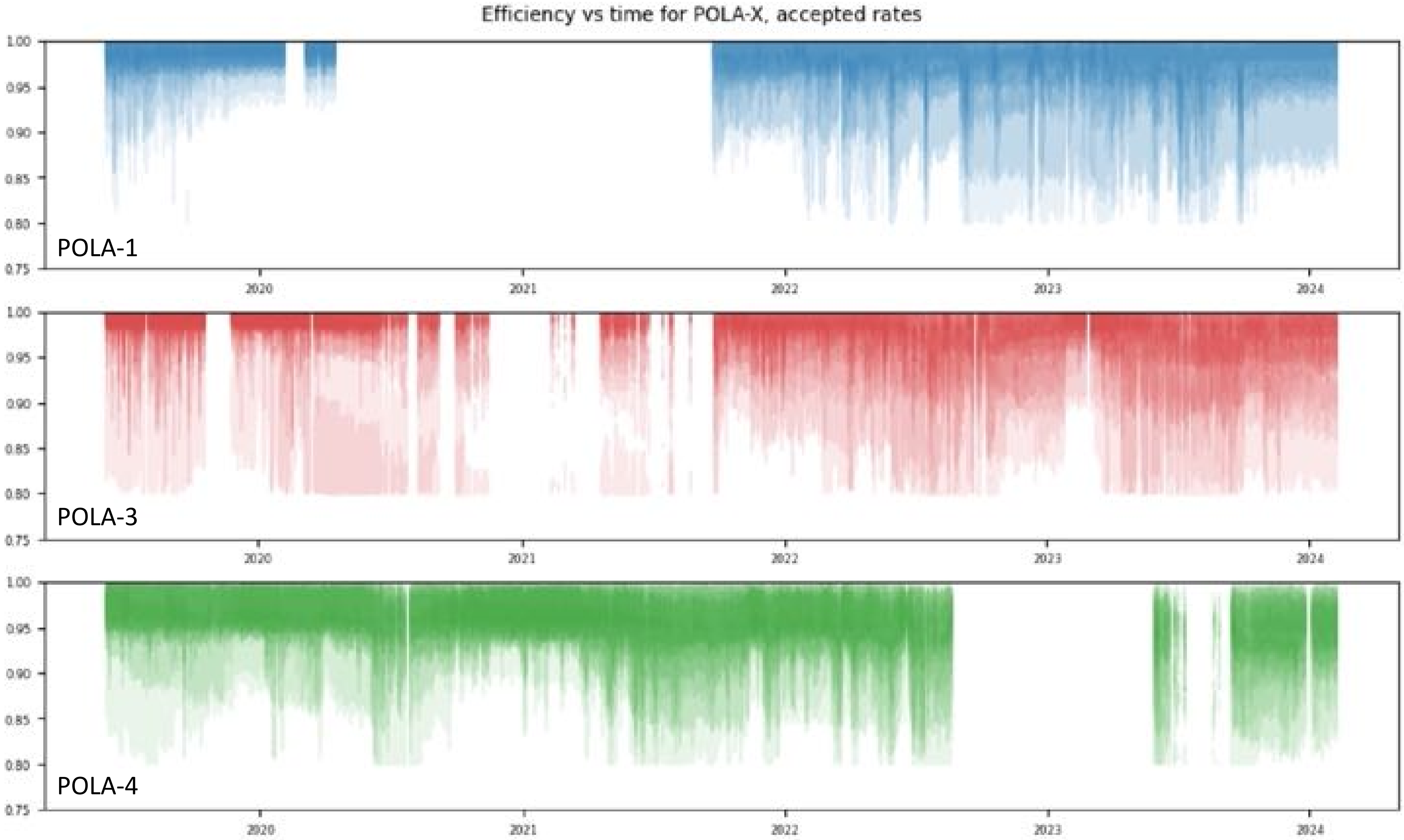


Time trend

- rejected rates

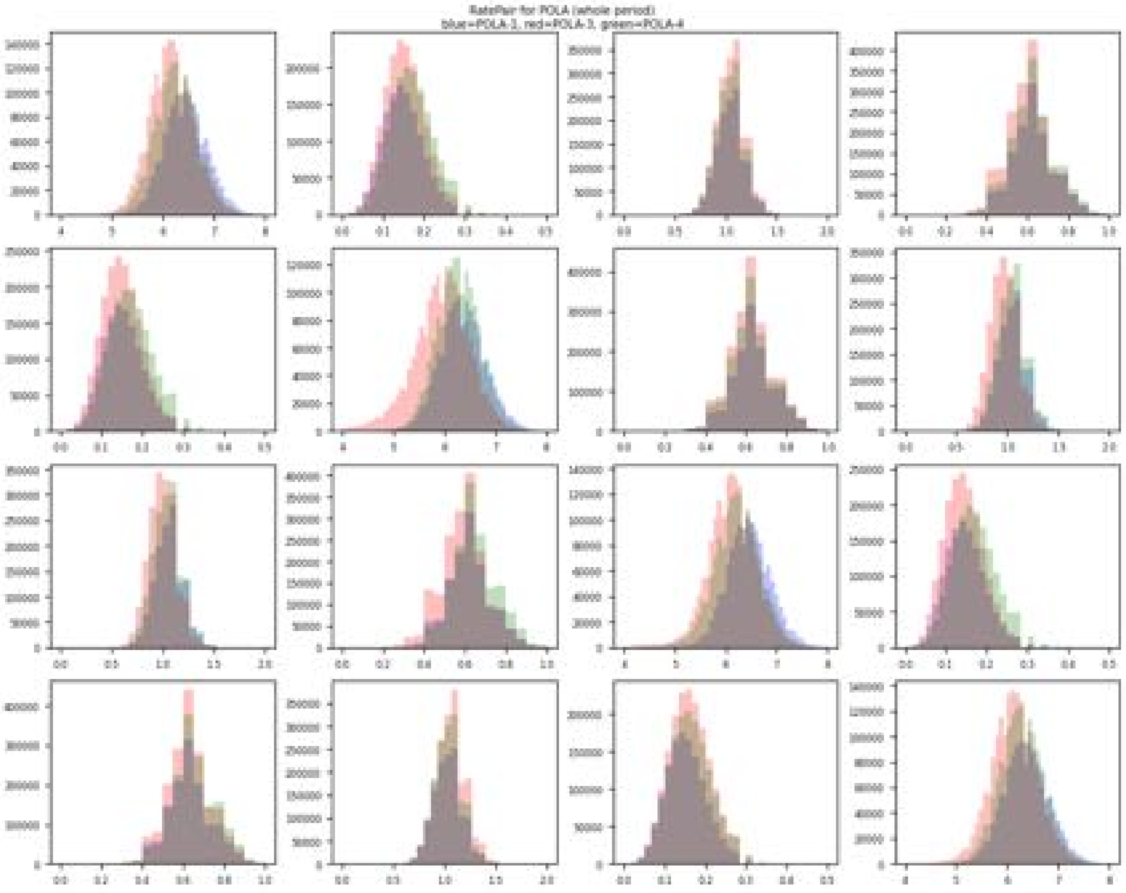


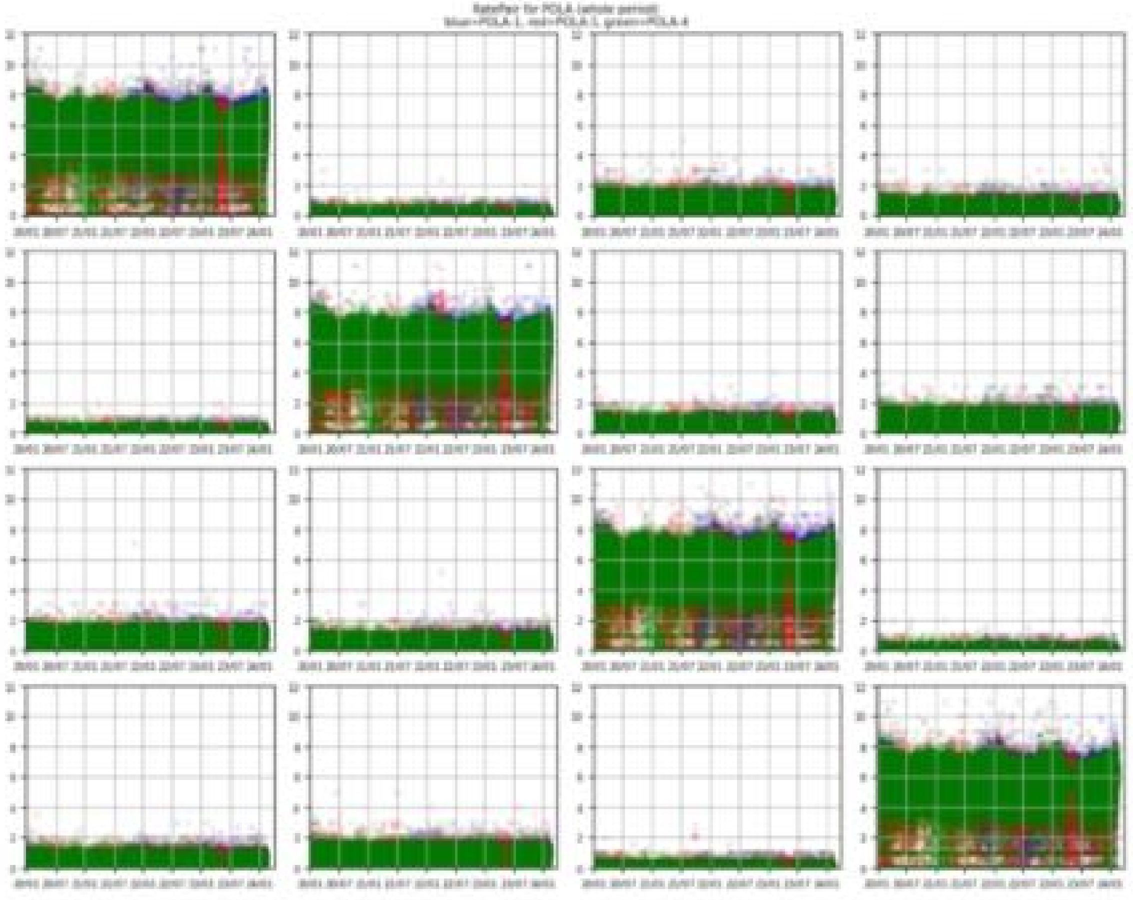
Time trend



Efficiency vs time for POLA-X, accepted rates
1.00
0.95
0.90
0.85
0.80
0.75
POLA-1
POLA-3
POLA-4
2020
2021
2022
2023
2024

RatePair after cuts

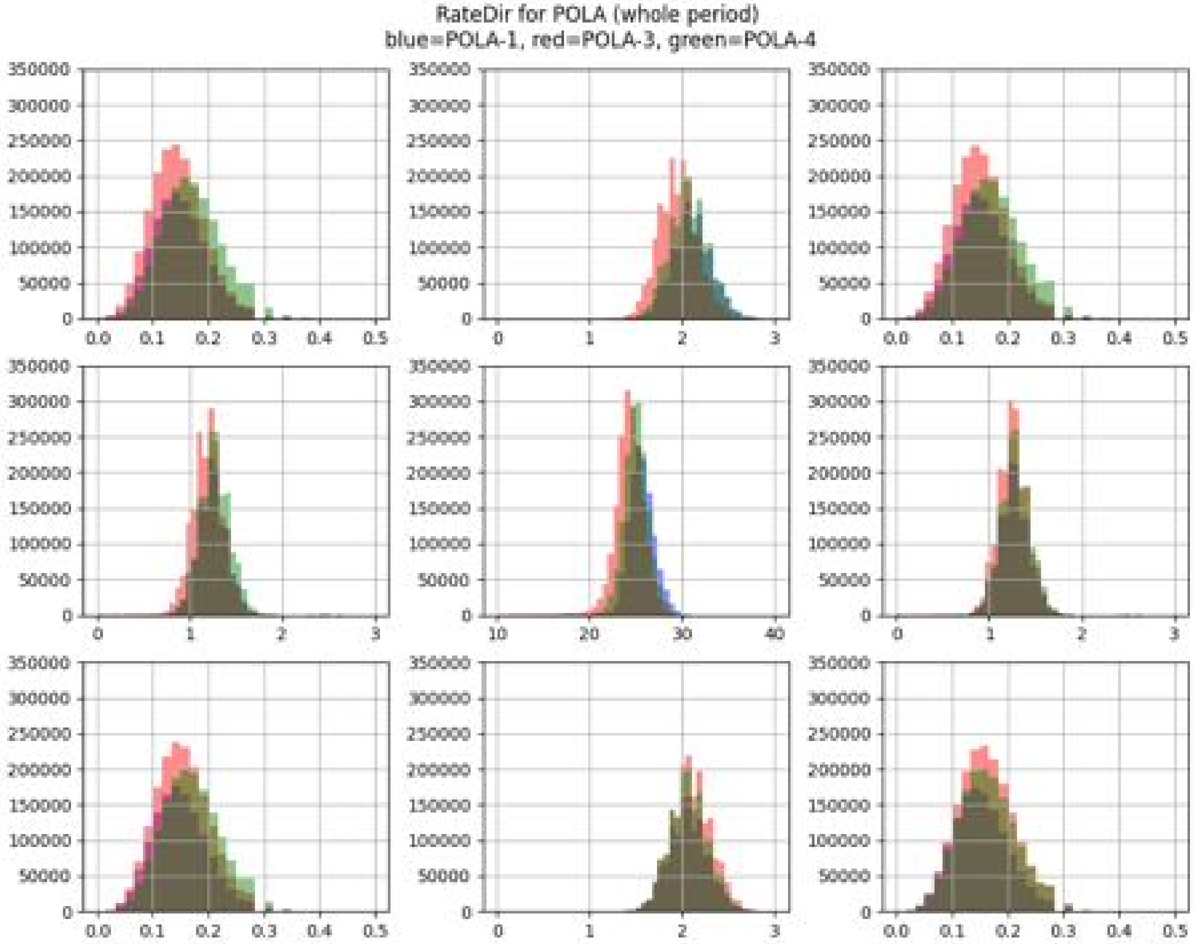


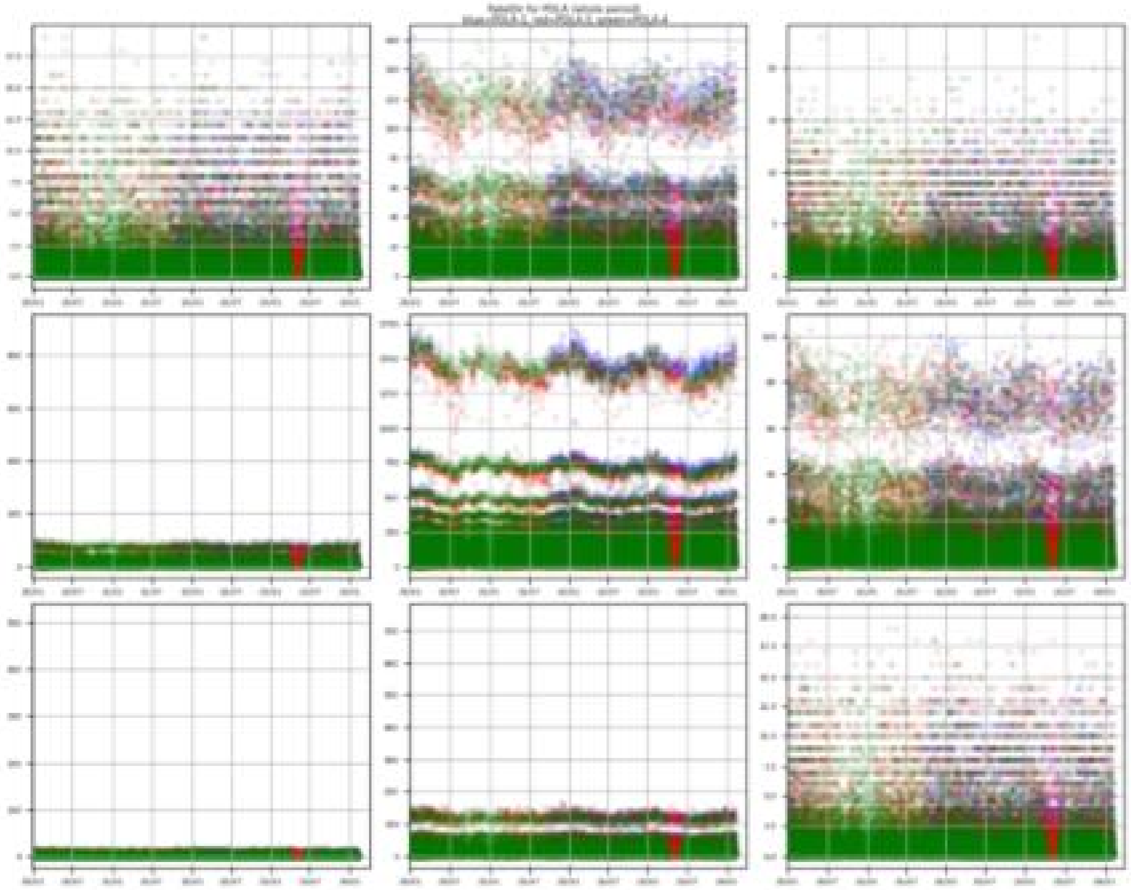


rate of a TOP-BOTTOM tiles pair

- 0,5,10,15 (diagonals): overlapping tiles
- 2,7,8,13: (?) tiles with long side in common
- 3,6,9,12: (?) tiles with short side in common
- 1,4,11,14: (?) tiles in opposite position

RateDir after cuts



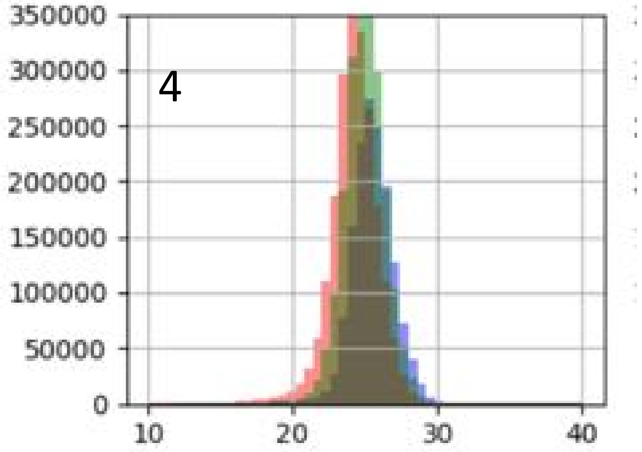


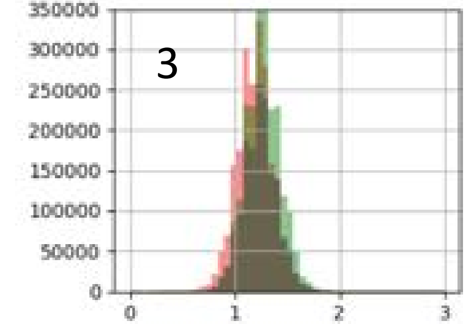
Direction mapping

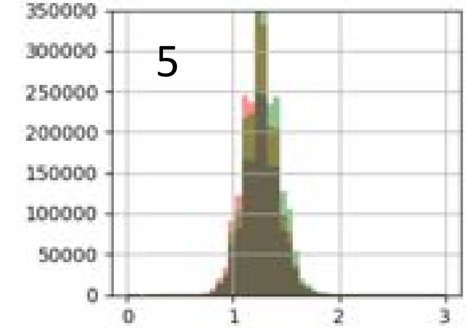
6	7	8
3	4	5
0	1	2

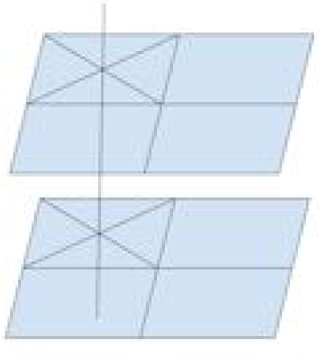
n. Casella	Passaggio di muoni	combinazioni possibili	angolo di incidenza θ
4	perpendicolare	4	$(26,8731 \pm 26,8731)^\circ$
1 e 7	verticale (sul lato corto)	2 (4 in tutto)	$(61,1892 \pm 8,6745)^\circ$
3 e 5	orizzontale (sul lato lungo)	2 (4 in tutto)	$(69,8637 \pm 6,4000)^\circ$
0, 2, 6, 8	diagonale	1 (4 in tutto)	$(73,0338 \pm 5,469)^\circ$

(tesi Bellagamba) Tabella 3.1: *Legenda per lettura matrice*

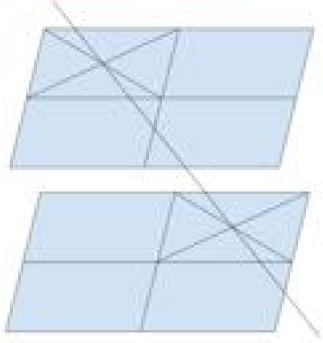




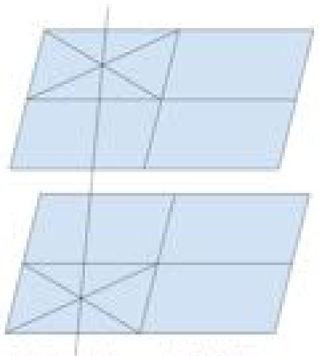




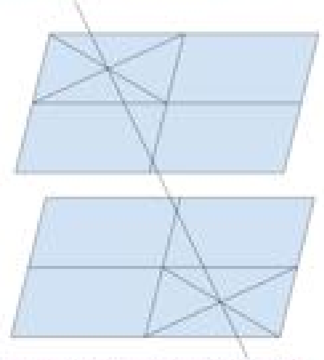
Configurazione ortogonale (4)



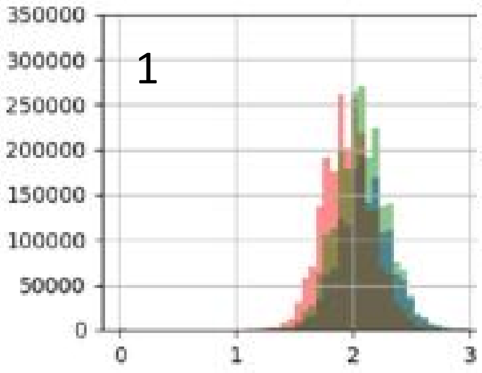
Configurazione orizzontale (3, 5)

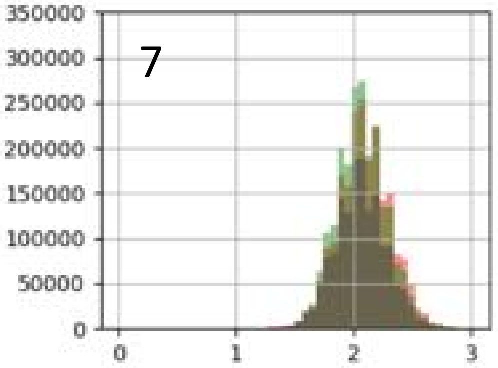


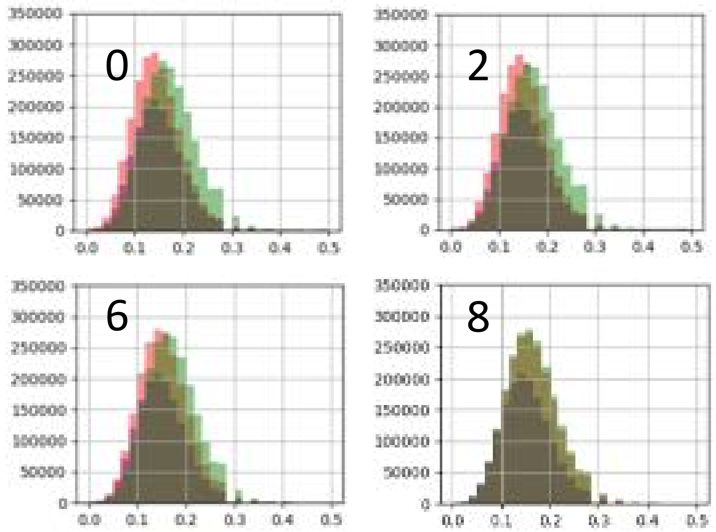
Configurazione verticale (1, 7)



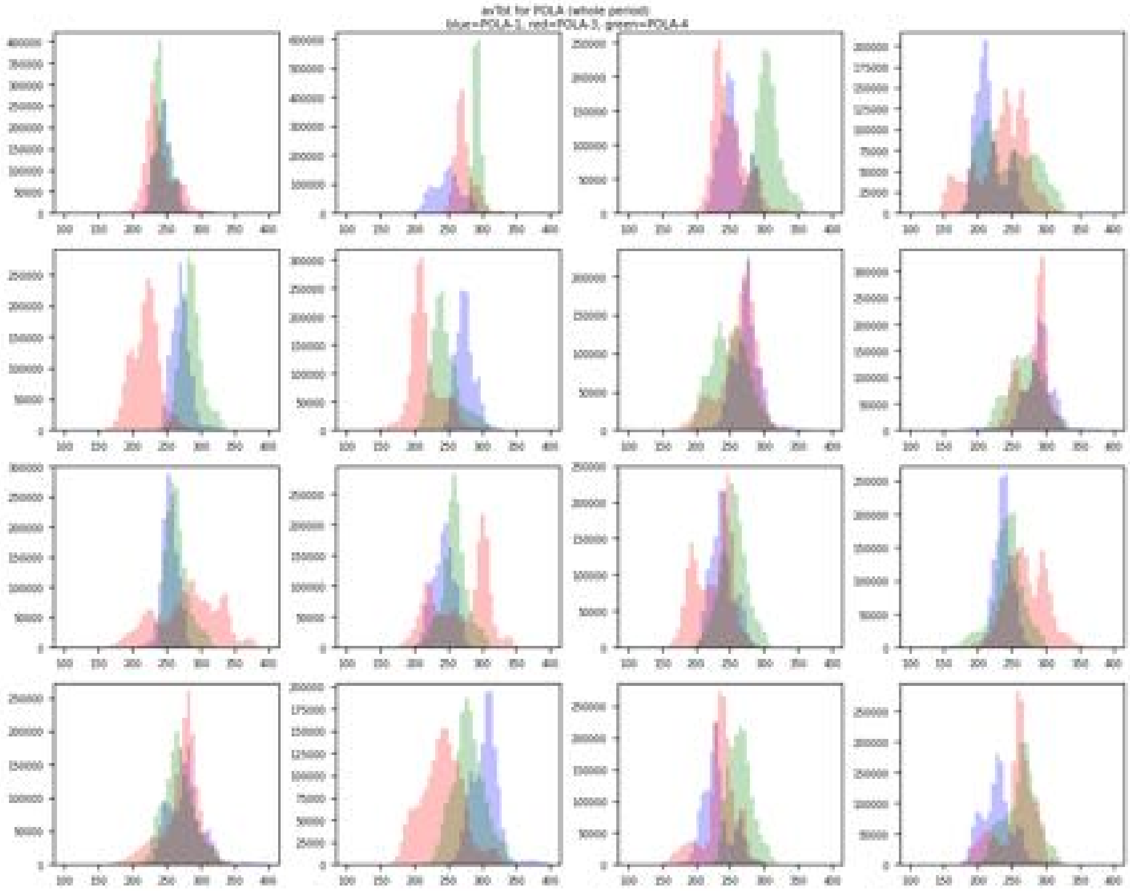
Configurazione diagonale (0, 2, 6, 8)

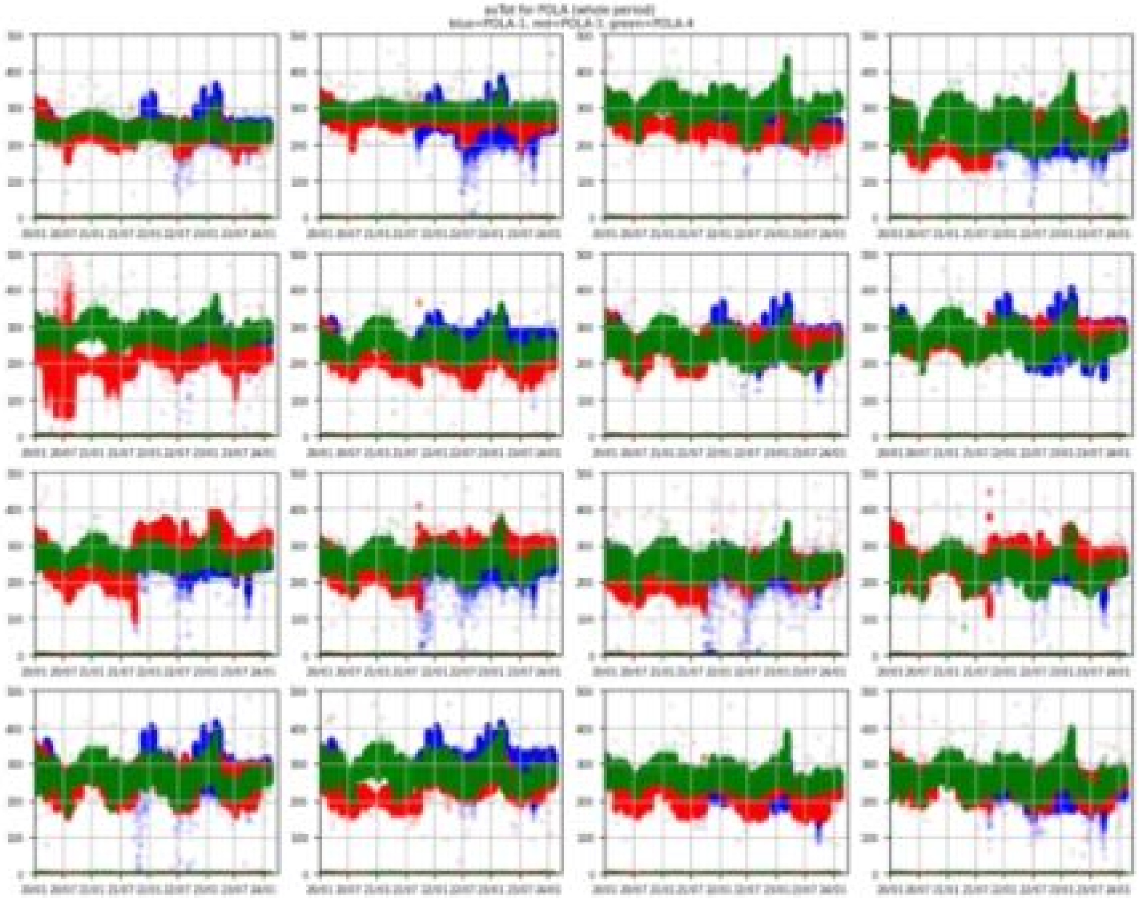




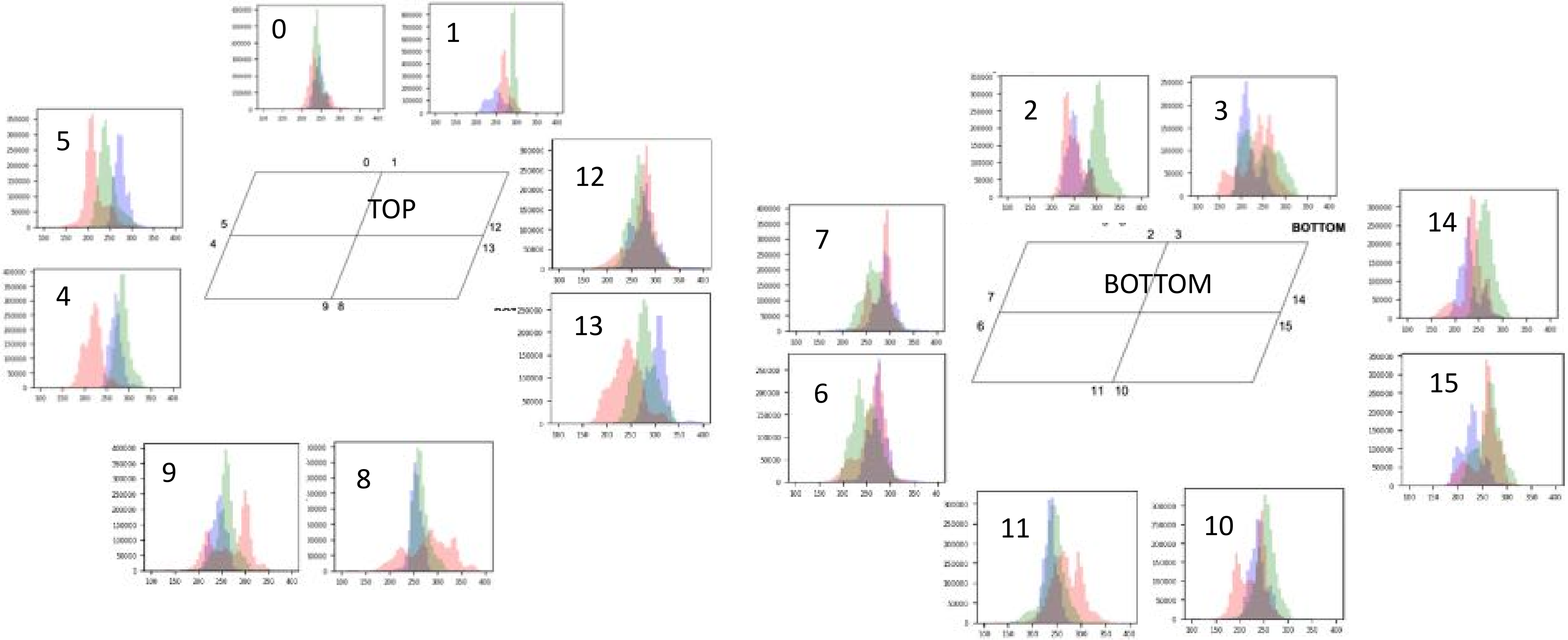


avToT after cuts



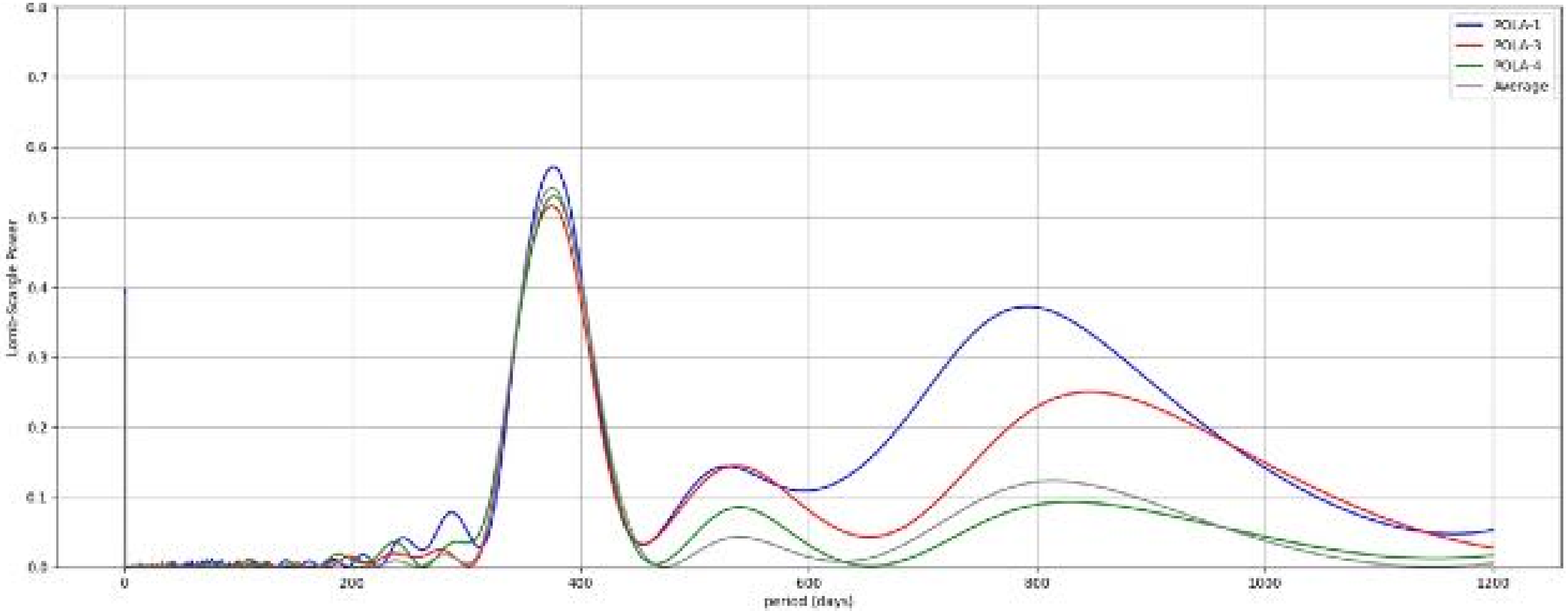


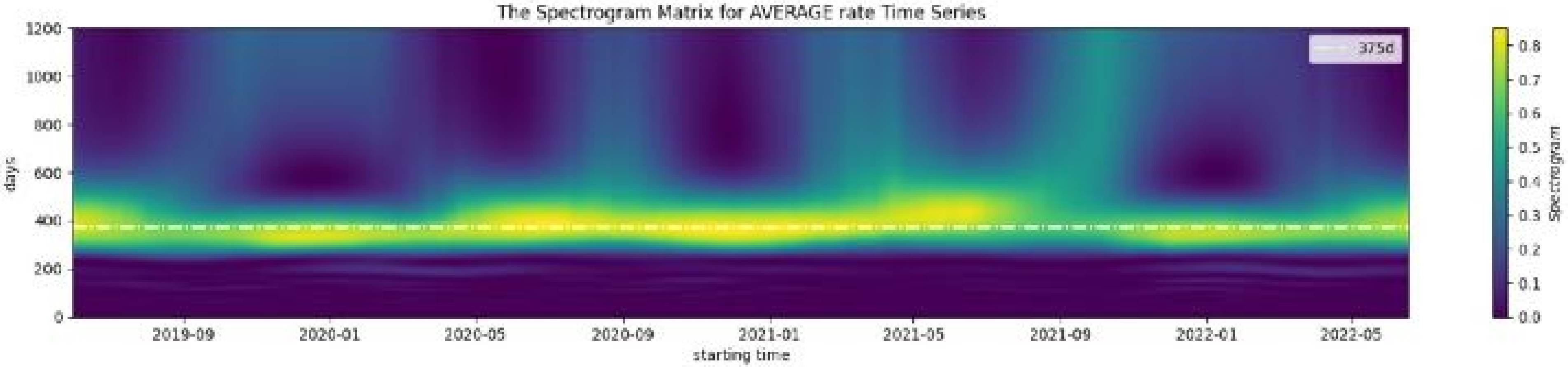
avToT index corresponds to SiPM index



Periodogram after cuts

Peaks POLA-1:	376.3	792.0	528.5	287.2
Peaks POLA-3:	374.9	847.0	536.7	277.1
Peaks POLA-4:	376.7	829.6	539.4	292.1
Peaks POLA-A:	375.3	814.9	539.1	322.4





Conclusions (on cuts)

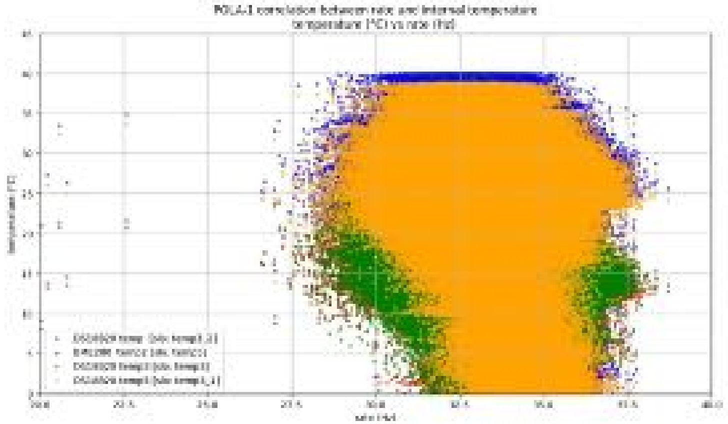
- important cuts based on status flag, internal temperature and efficiency
- mapping of parameters is complex
- how shall we estimate systematic errors

Correlation between rate and temperature

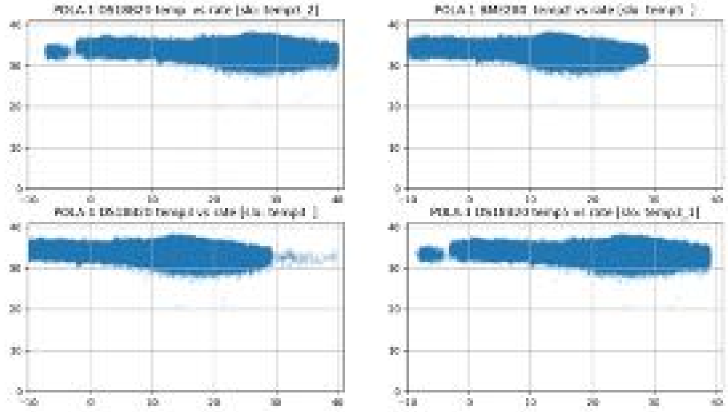
Correlation between rate and internal temperature

POLA-1

temperature vs rate

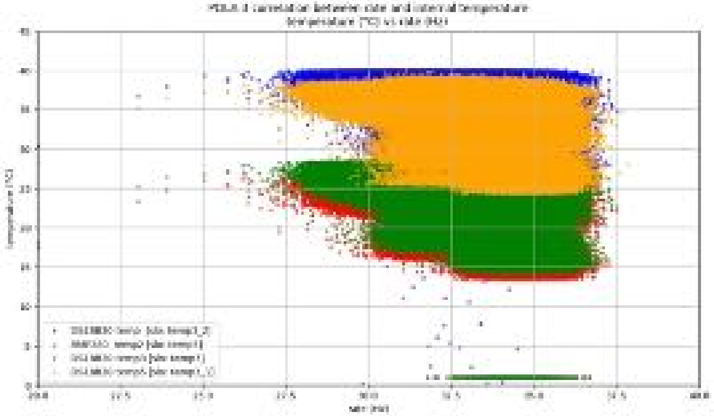


rate vs temperature

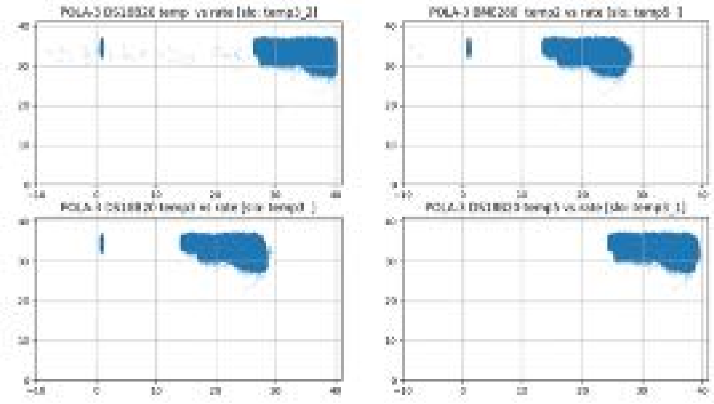


POLA-3

temperature vs rate

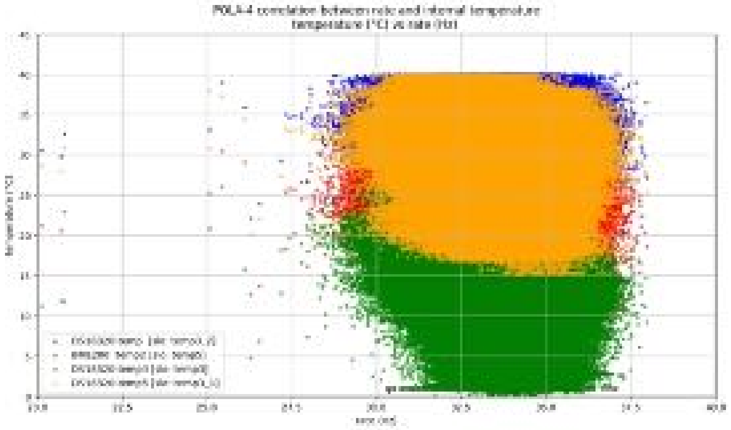


rate vs temperature

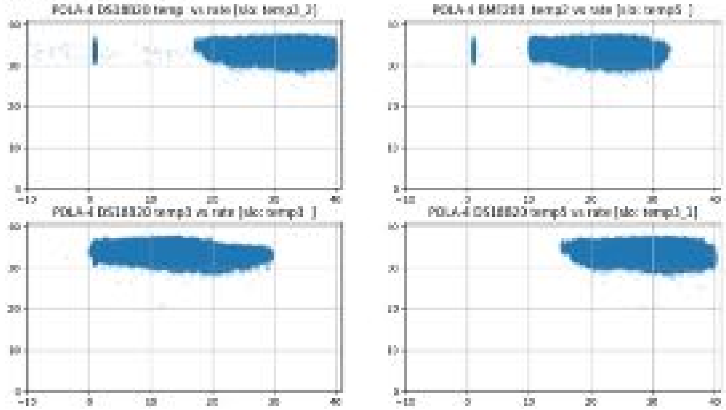


POLA-4

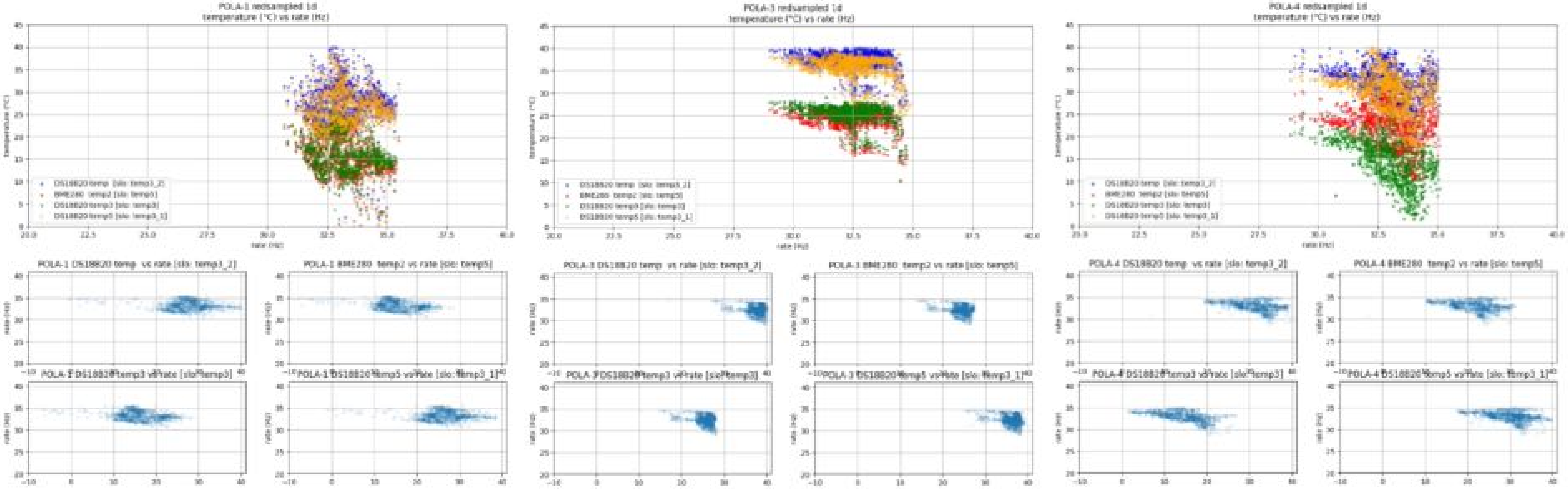
temperature vs rate



rate vs temperature

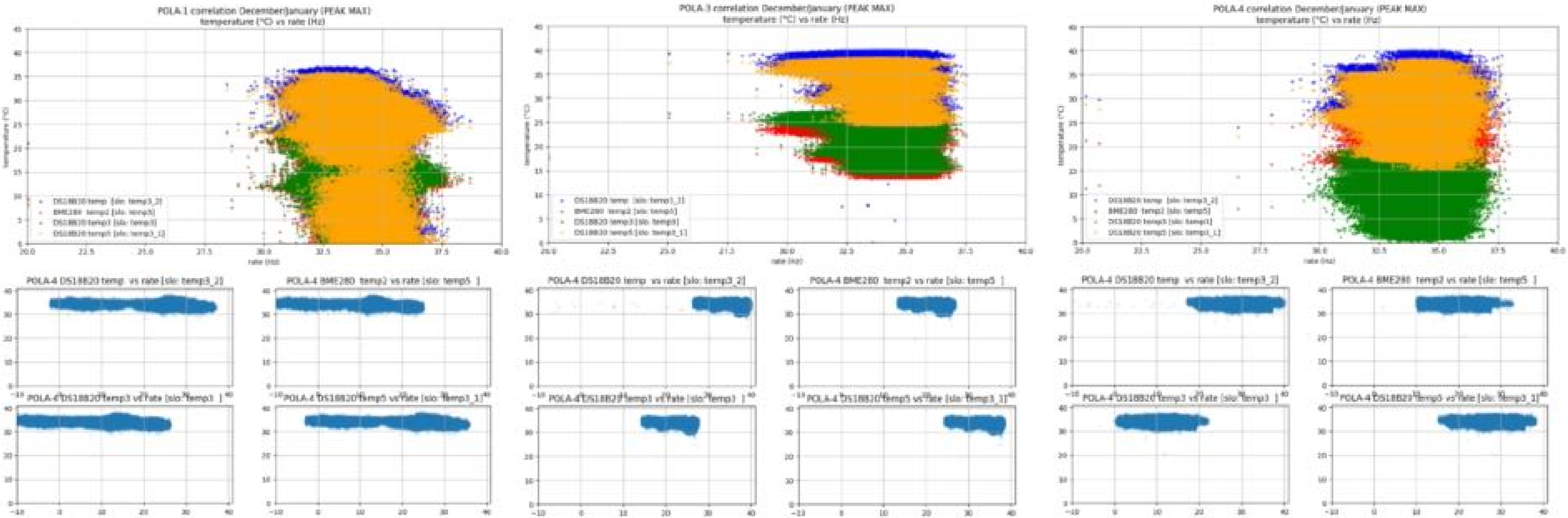


Correlation between rate and internal temperature overall period - resampling over 1d



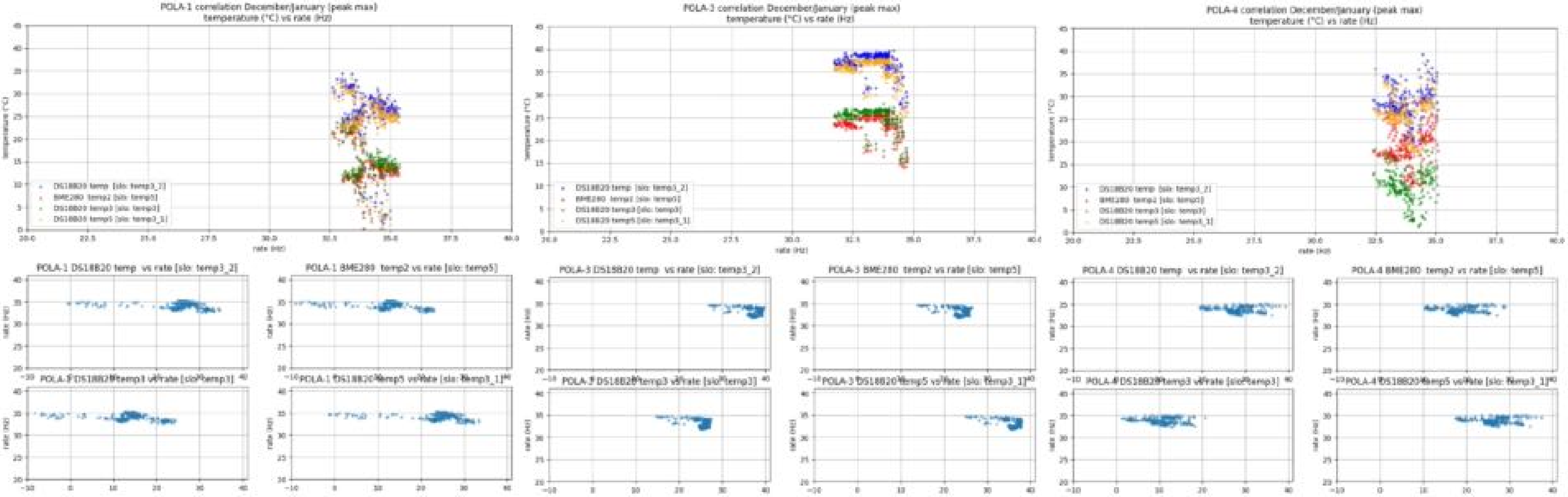
Correlation between rate and internal temperature

December/January = PEAK MAX



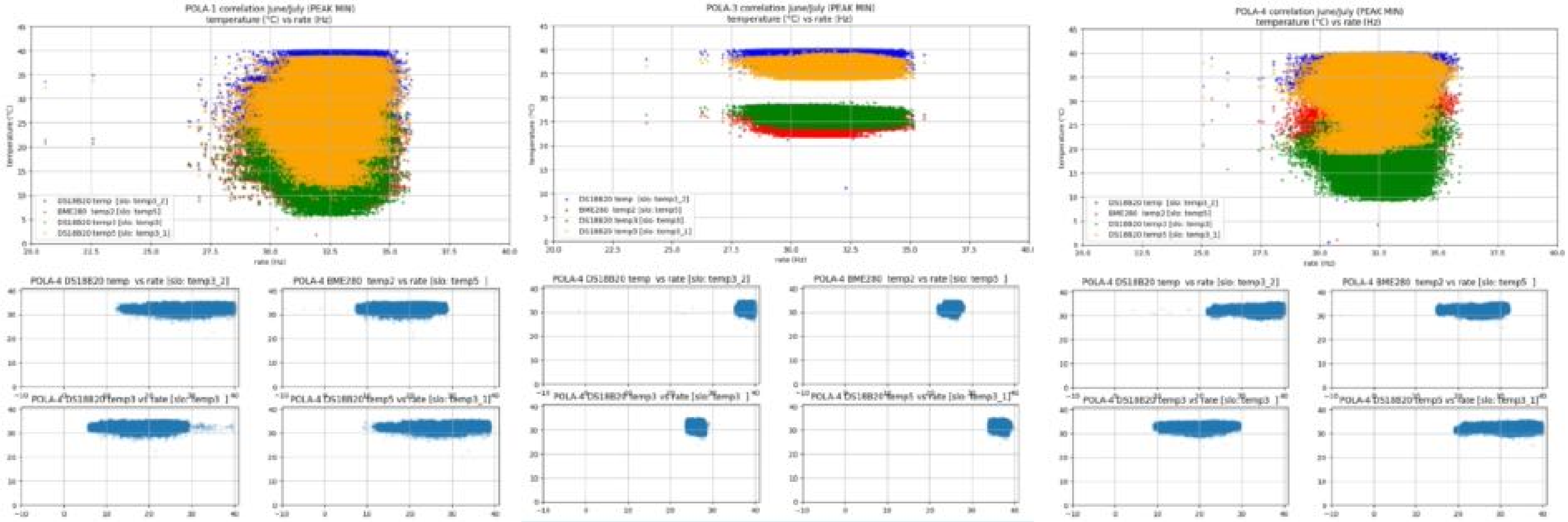
Correlation between rate and internal temperature (1d)

December/January = PEAK MAX



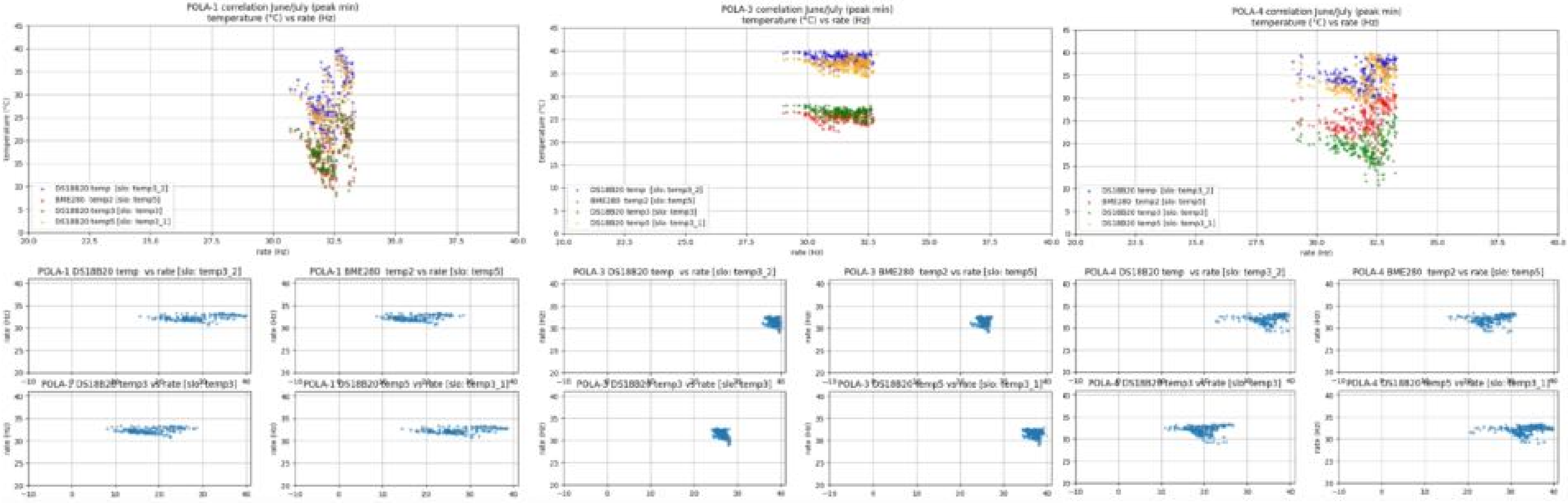
Correlation between rate and internal temperature

June/July = PEAK MIN



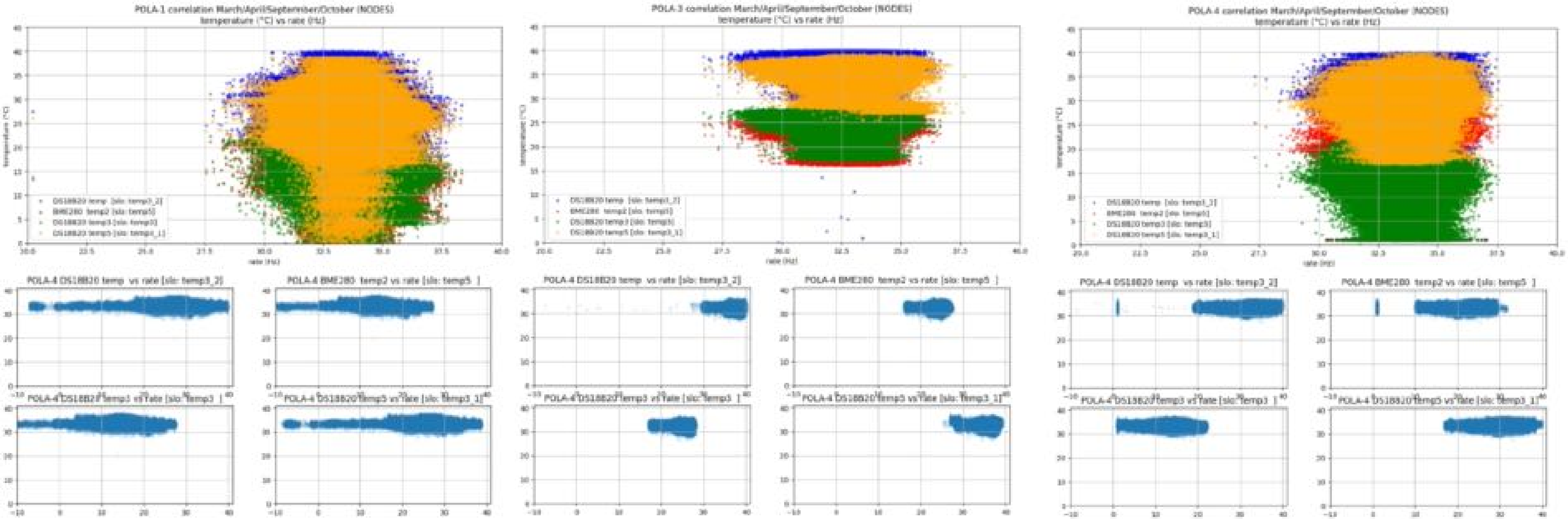
Correlation between rate and internal temperature (1d)

June/July = PEAK MIN



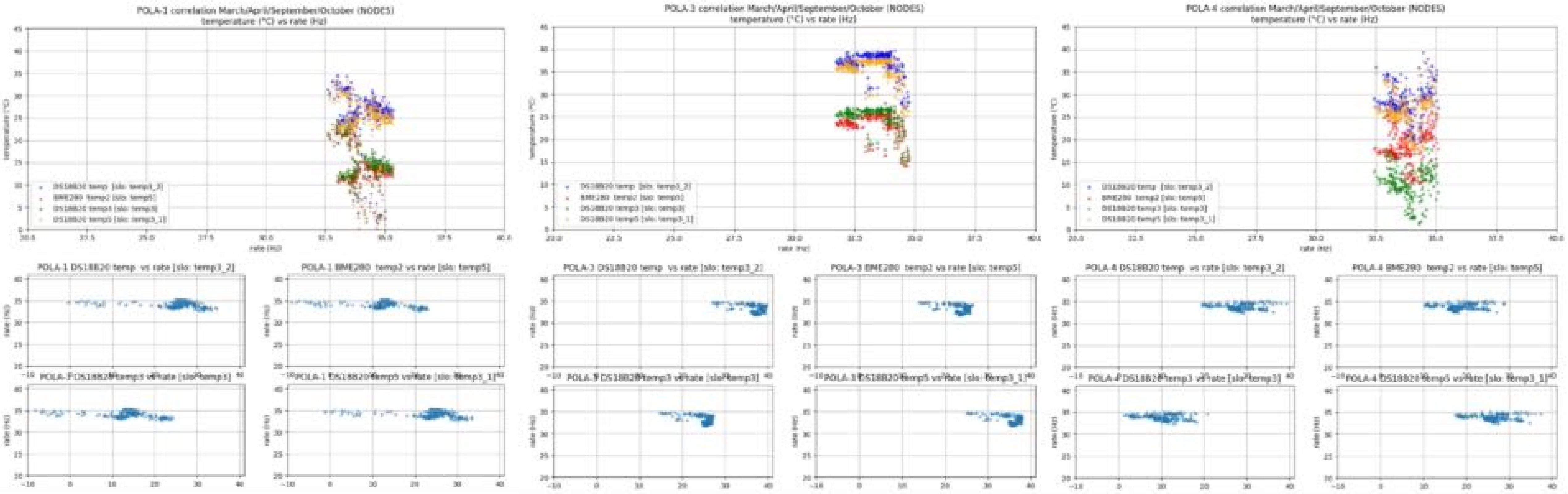
Correlation between rate and internal temperature

March/April+Sep/Oct = NODES



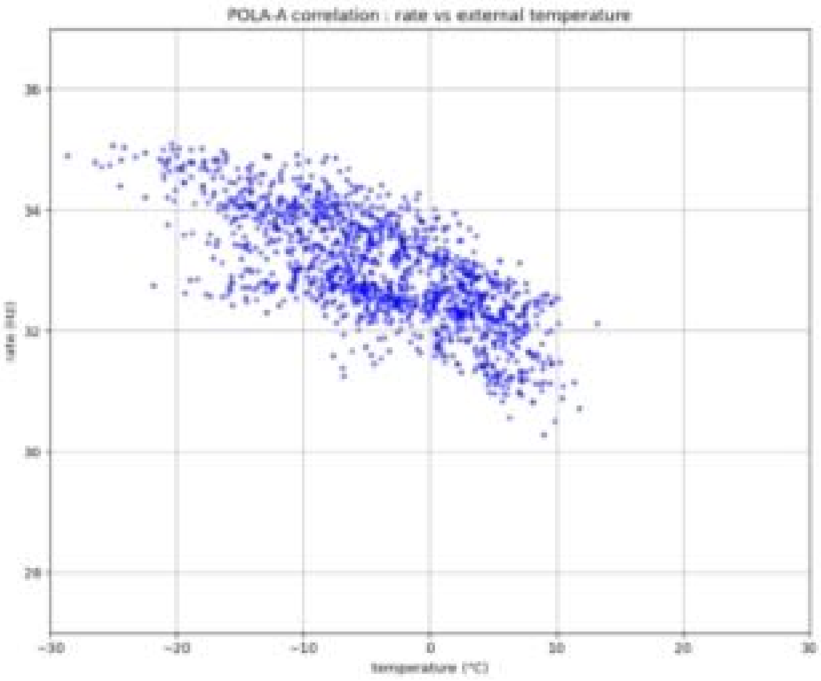
Correlation between rate and internal temperature (1d)

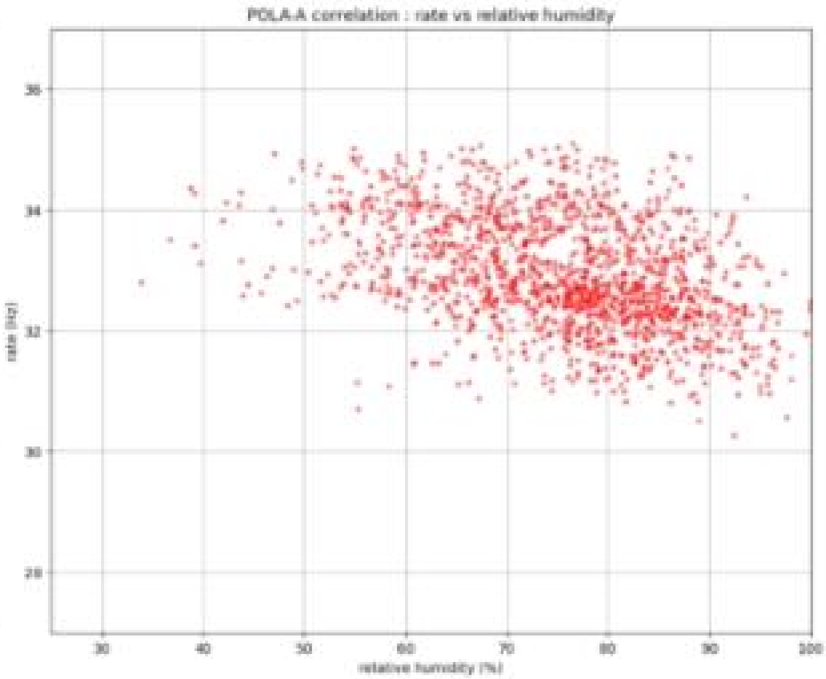
March/April+Sep/Oct = NODES

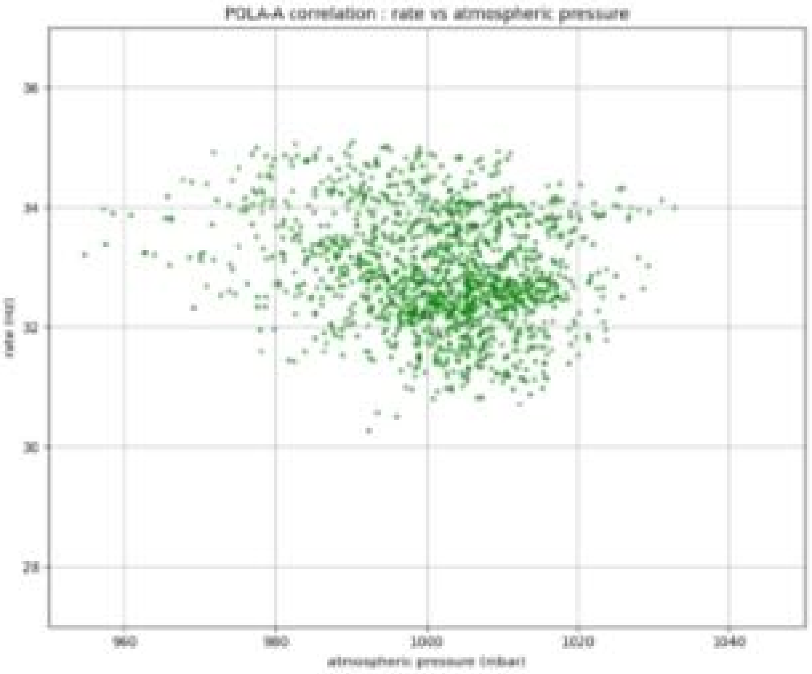


Correlation with environmental parameters

POLA-A rate, resampled for 1d; meteo data from CNR CCT 2m

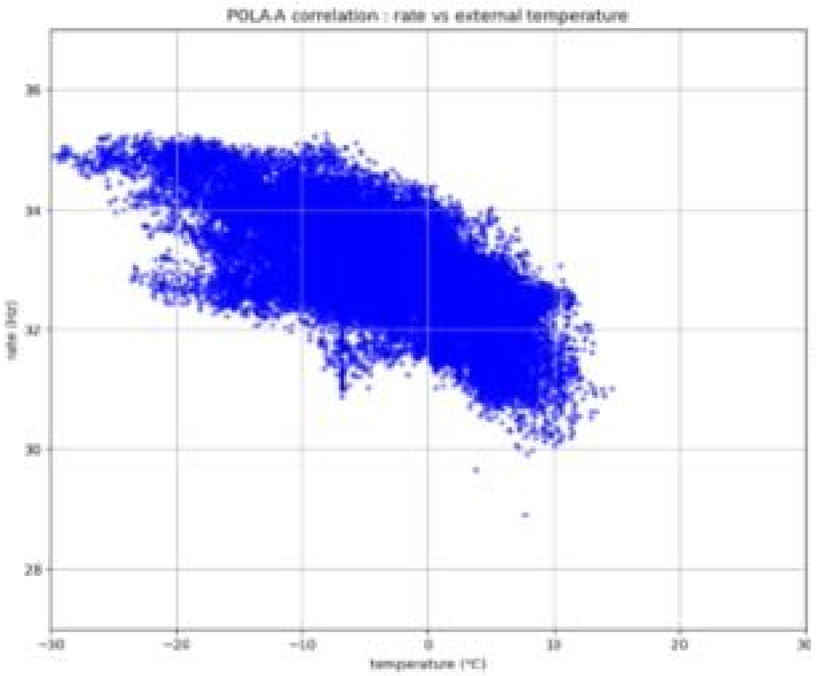


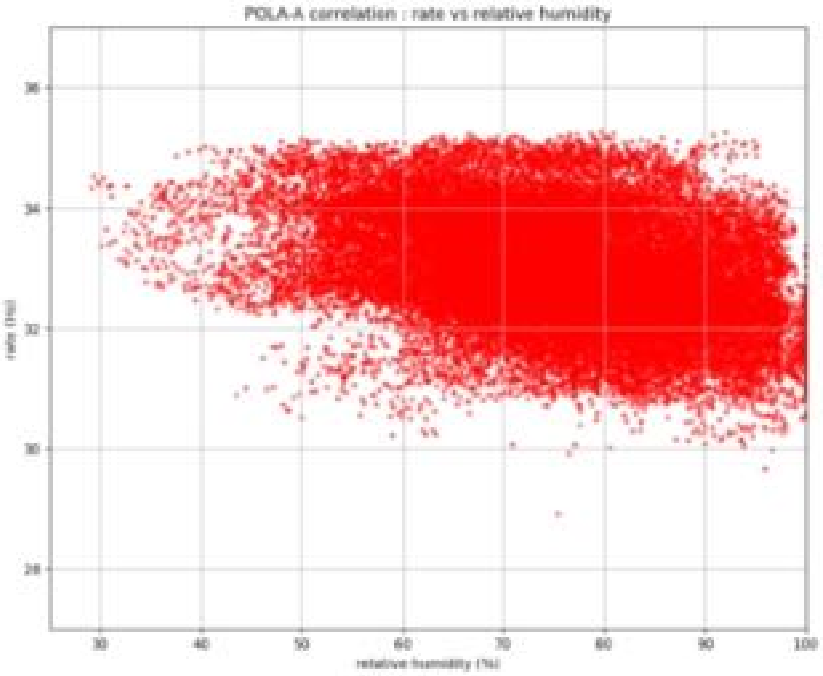


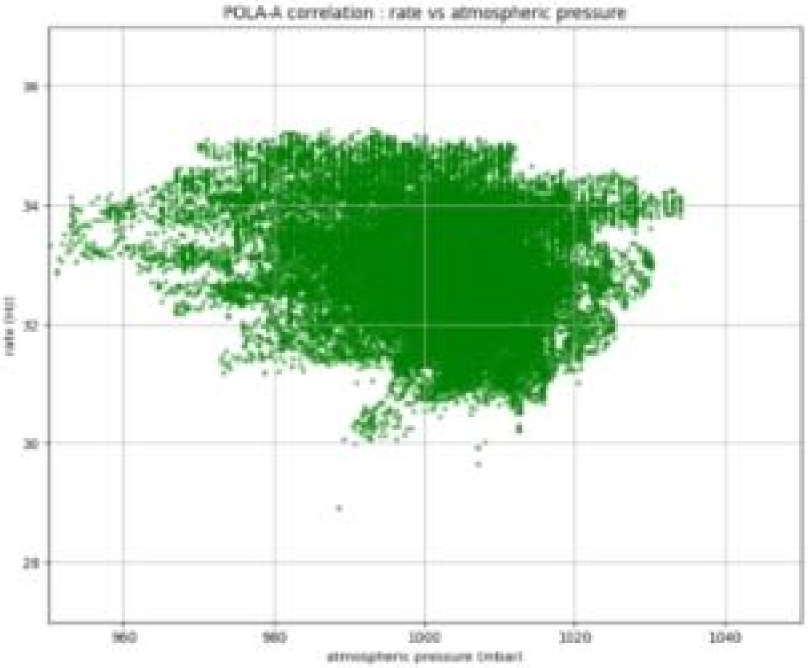


Correlation with environmental parameters

POLA-A rate, resampled for 1h; meteo data from CNR CCT 2m

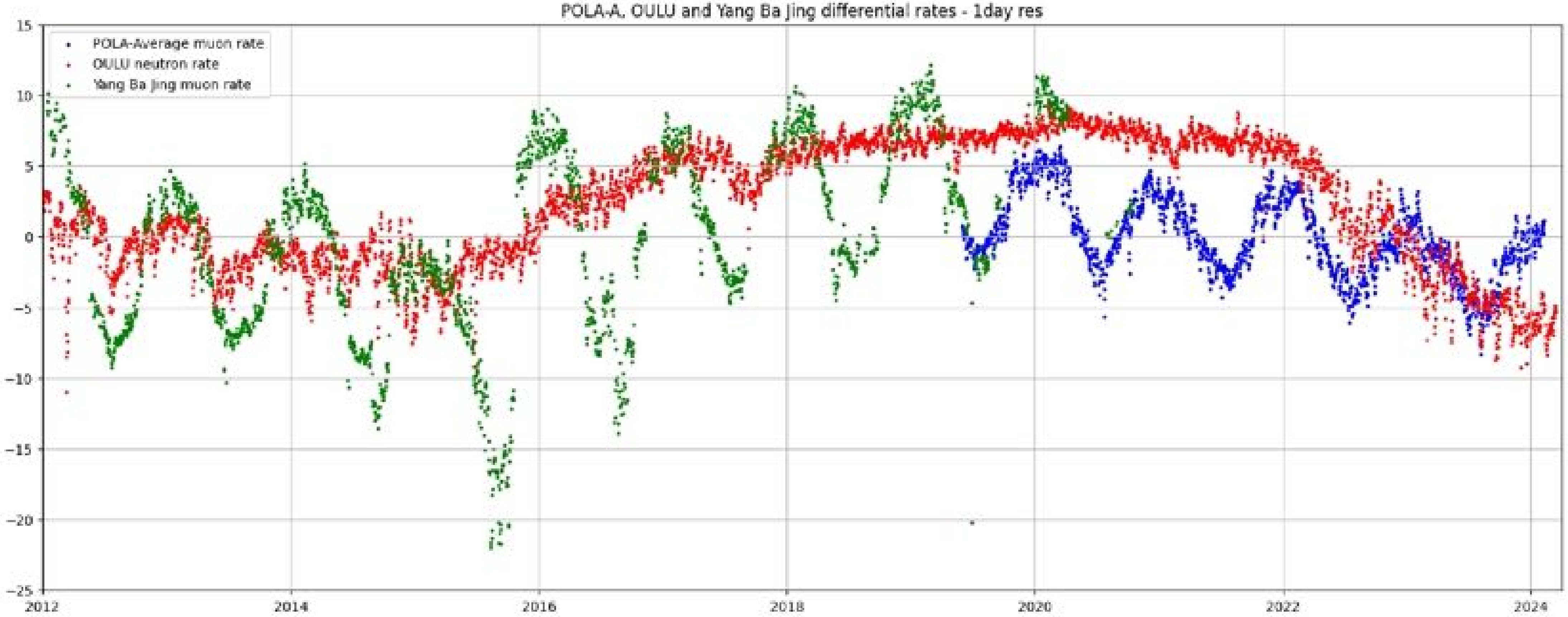




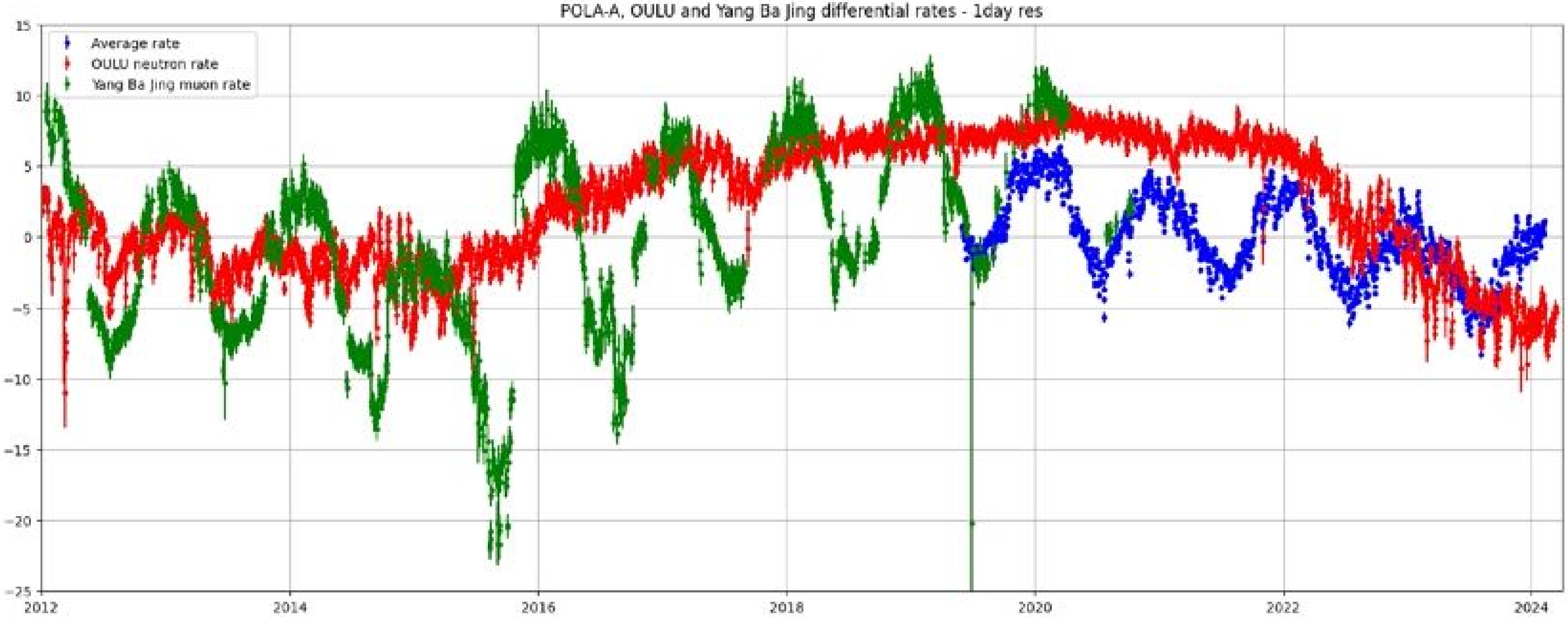


OPEN DATA

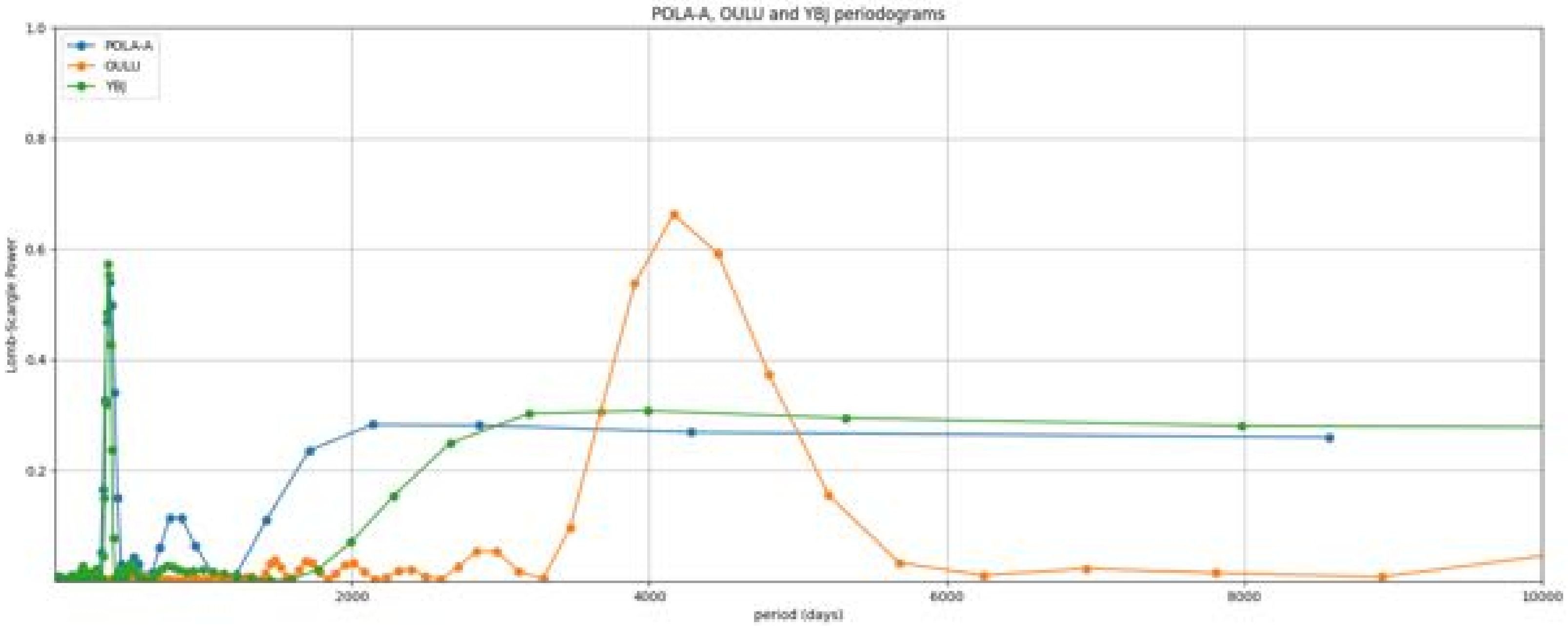
Open data : differential rates, resolution 1d

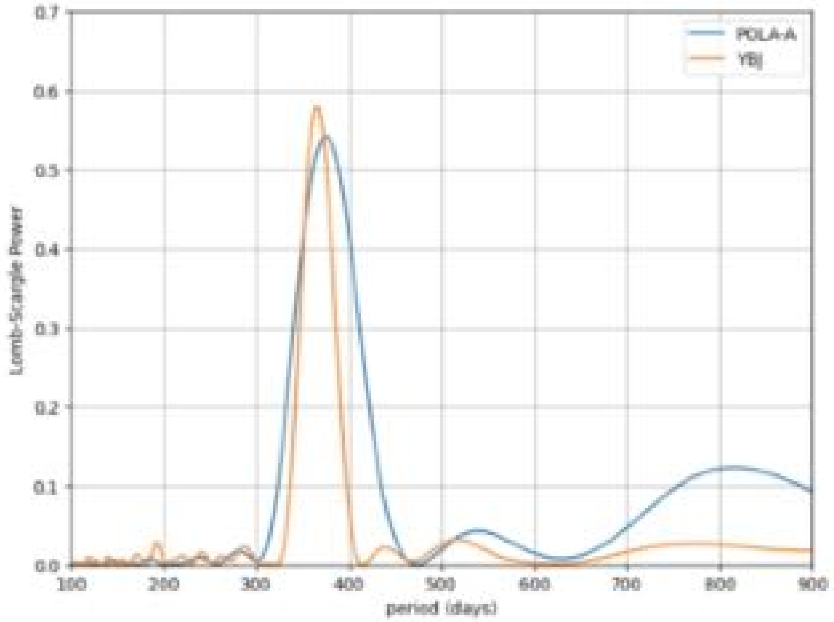


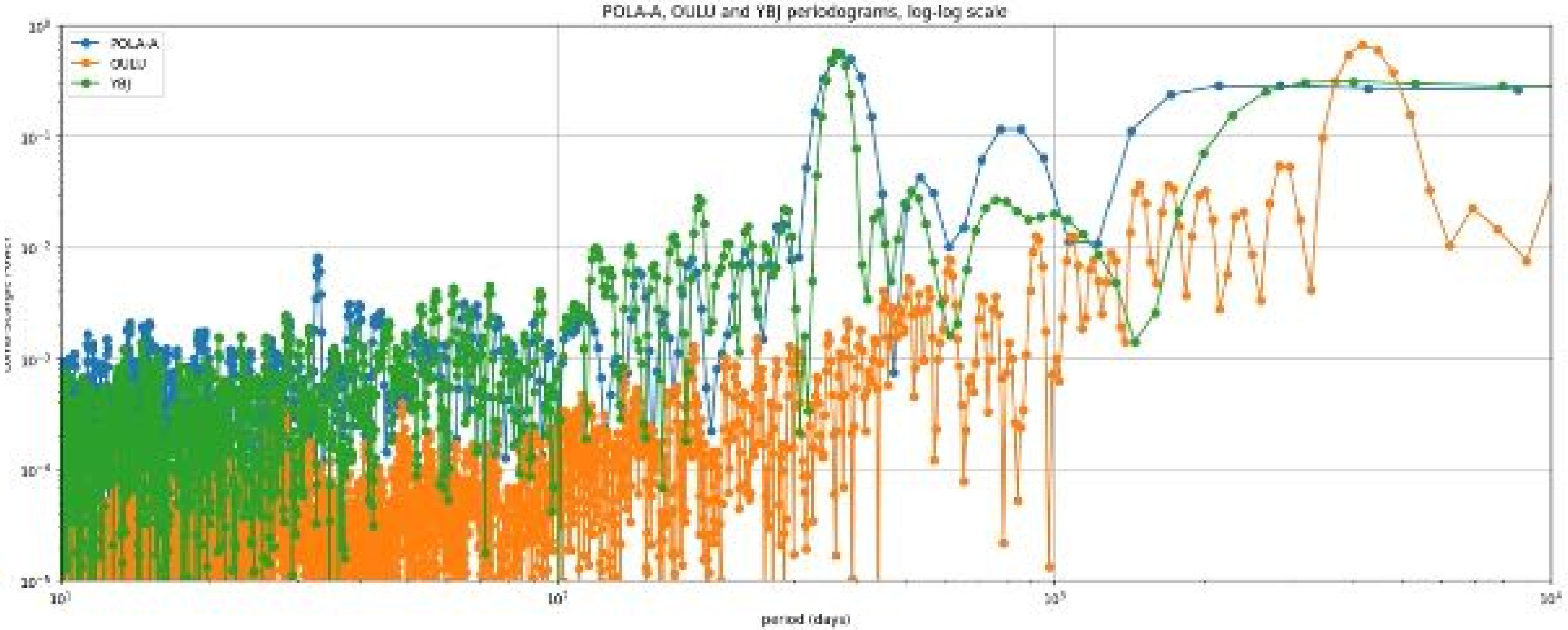
Open data: differential rates and stat error



Periodograms





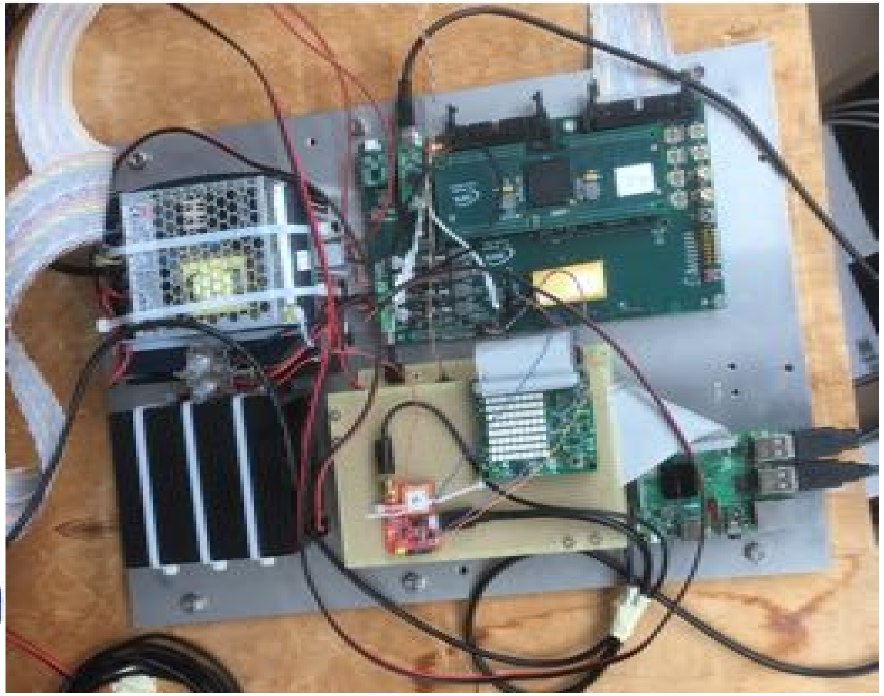


backup slides

Temperature mapping

	SenseHat		DS1820 (1-wire)			BNO055	BME280
Slo	temp1 outline1[2][1]	temp2 outline1[2][2]	temp3 outline1[1][0]	temp3_1 outline1[1][1]	temp3_2 outline1[1][2]	temp4 outline1[3][0]	temp5 outline1[4][0]
Root			temp3	temp2	temp		temp5

SenseHat can give 2 temperatures:
- from humidity sensor (slo: temp1)
- from pressure sensor (slo: temp2)

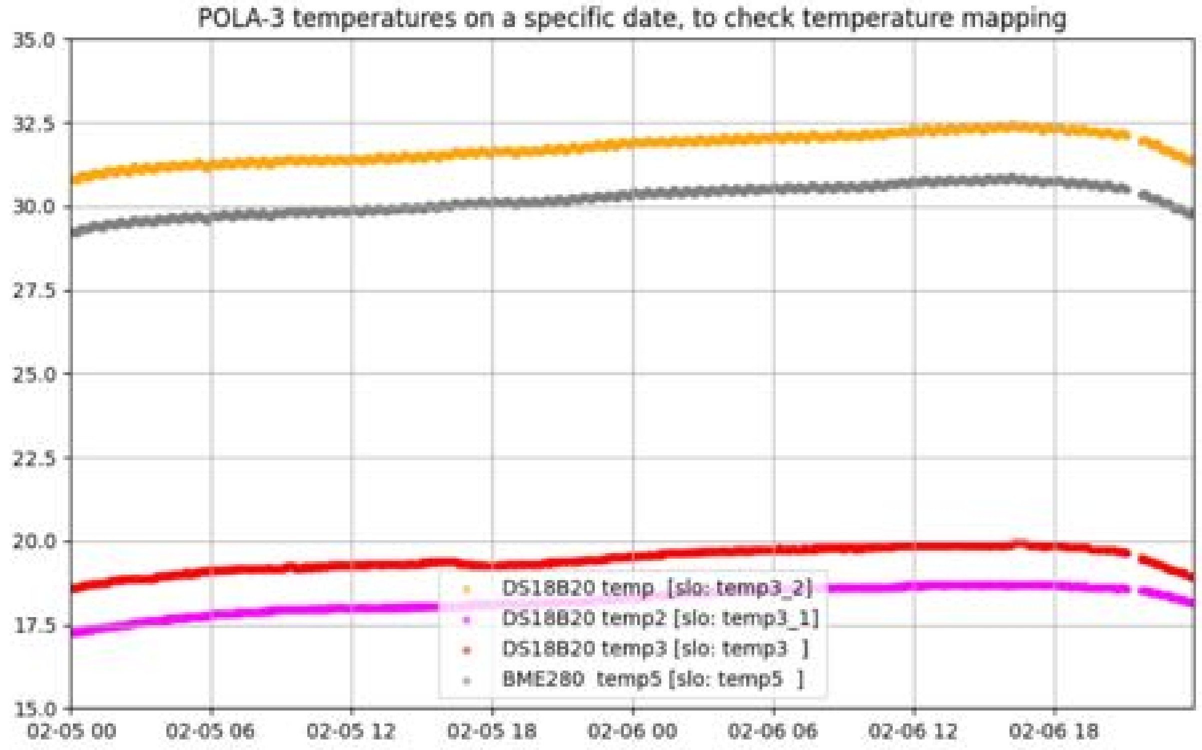


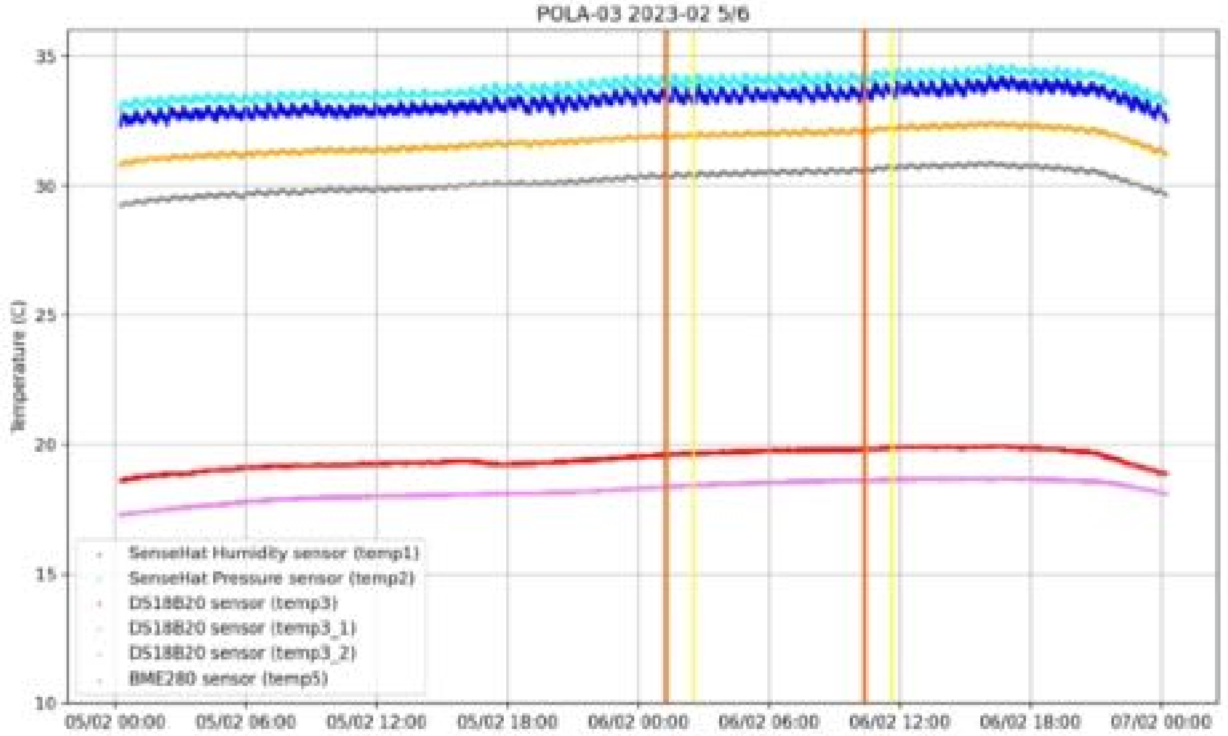
BME280
Slo: hum1,pres1,temp5
Root: (temp5,humi1,pres1) = getattr(el,"parExtra")

DS18B20 (1-wire) 3 temperatures

root	temp	temp3	temp2
Slo	temp3_2	temp3	temp3_1

How did I map root and slo temperatures





Abstract

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Annual quasiperiodicity in muon rate observed by PolarquEEEst detectors at 79°N

Since 2019, three scintillation detectors, readout by SiPM and controlled by low-cost electronics, are installed in the scientific research site in Ny Ålesund (Svalbard) at 79°N, recording muons from secondary cosmic rays. The detectors are part of the EEE Project, involving almost 100 secondary schools in Italy.
After collecting nearly 5 years of data, we are able to analyze the muon rate time series and observe an evident oscillating component with a period of about one year. Applying spectral techniques and sinusoidal fit optimization (Lomb-Scargle periodogram) we can quantify the annual component and verify its independence from environmental and experimental factors.
Finally, we compare the observed periodicity with open data provided by other muon experiments and by neutron counters from the NMDB network.