LYRA degradation status after ~4800 days

IED 02 Jun, 05 Jul, 27 Jul 2023

This report is based on earlier reports, for explanations see here:
https://www.sidc.be/users/dammasch/IED_20220707_Degrad4500.pdf
https://www.sidc.be/users/dammasch/IED_20201124_Degrad4000.pdf
https://www.sidc.be/users/dammasch/IED_20180223_LyraStatus3000.pdf
It uses recent calibration campaigns between Apr 2022 and Mar 2023.

These additional campaign values are based on the latest estimates of dark currents, see here:
https://www.sidc.be/users/dammasch/IED_20230403_DarkCurrents2023.pdf

Baseline

Dark current values are extrapolated up to day #5109 (~Jan 2024). Degradation values are extrapolated up to day #5300 (~Jul 2024). These values have been introduced into the latest calibration software. It is assumed that the channels of unit 2 and unit 3 will not change significantly in the future, while the channels of unit 1 are still degrading. The previous estimate of ch1-3 may have been too pessimistic, though.

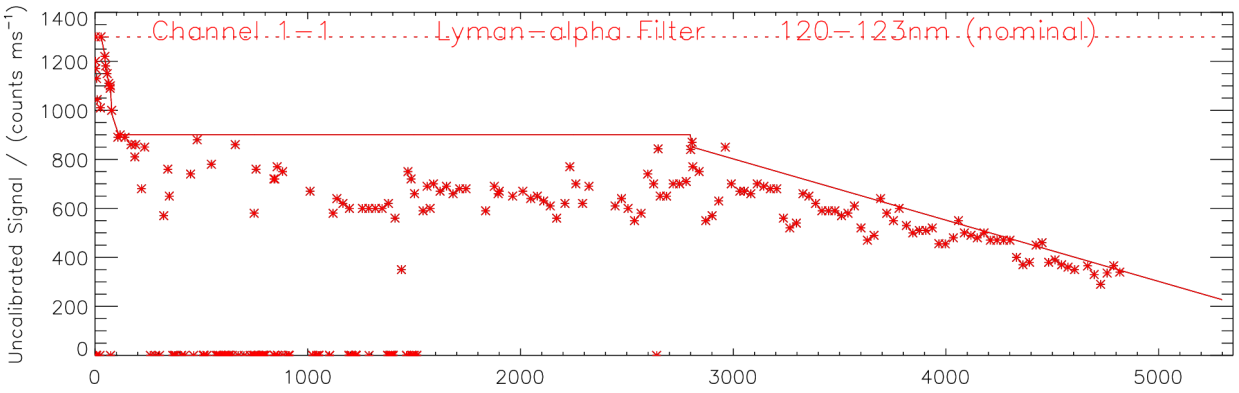
The latest calibration-software version was tested against the previous one for all three units, taking as a test case one of the most recent available full day observations. The resulting estimated jumps are caused by a mixture of dark-current and degradation updates. They are basically insignificant, except for ch1-3 due to the above-mentioned previous over-estimation of its degradation.

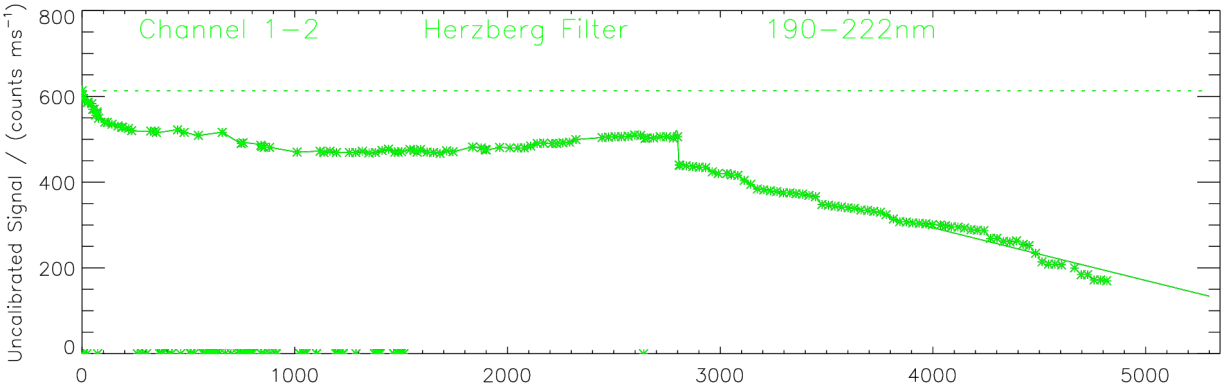
unit 1 (23 May 2023)	ch1-1: +0.8%	ch1-2: 0.0%	ch1-3: -5.0%	ch1-4: +0.2%
unit 2 (24 Jul 2023)	ch2-1: +0.01%	ch2-2: 0.0%	ch2-3: -0.08%	ch2-4: -1.3%
unit3 (11 Feb 2023)	ch3-1: +0.9%	ch3-2: +0.2%	ch3-3: -0.1%	ch3-4: -1.1%

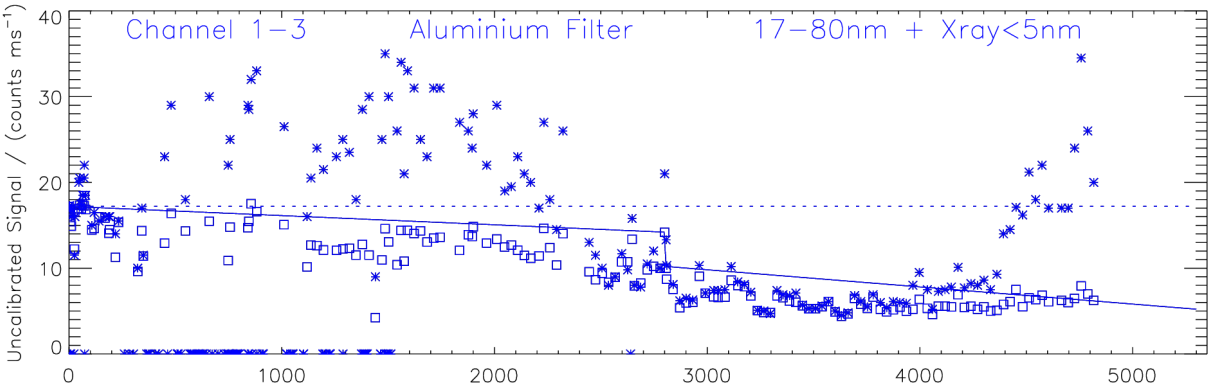
Day #4817 is 15 Mar 2023, the last campaign used here. The following table shows the current estimated degradation of the quiet-Sun signal (“baseline”) since First Light Day: Values before and after are in counts/ms, percentages show what is left from the original signal at First Light.

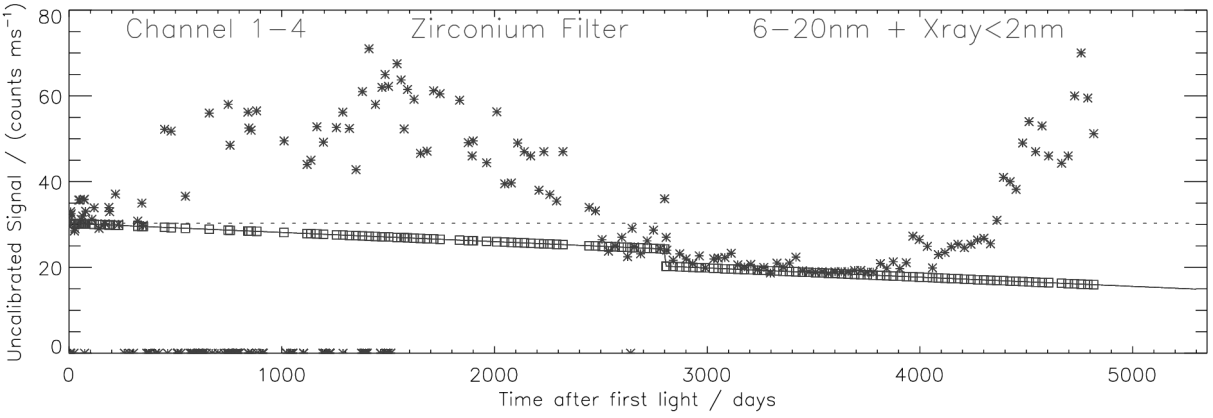
ch1-1	1300.0 -> 347.8	27%
ch1-2	613.4 -> 193.2	31%
ch1-3	17.2 -> 6.2	36%
ch1-4	30.3 -> 16.0	53%
ch2-1	492.0 -> (2.5)	<1%
ch2-2	703.5 -> (1.5)	<1%
ch2-3	16.6 -> 0.1	<1%
ch2-4	37.5 -> 4.7	13%
ch3-1	920.0 -> 455.0	49%
ch3-3	545.5 -> 1.0	<1%
ch3-3	273.6 -> 17.0	6%
ch3-4	30.0 -> 11.5	38%

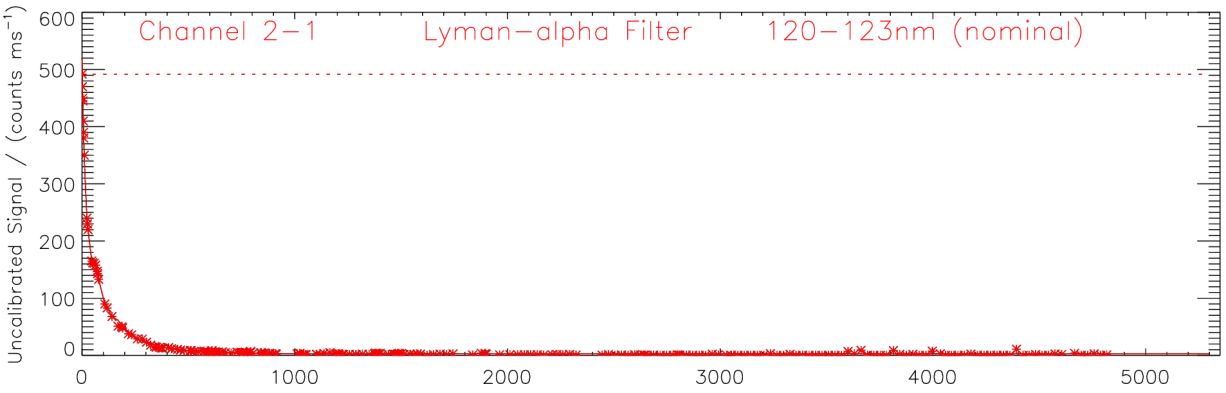
The figures on the following three pages show the development for units 1, 2, and 3.

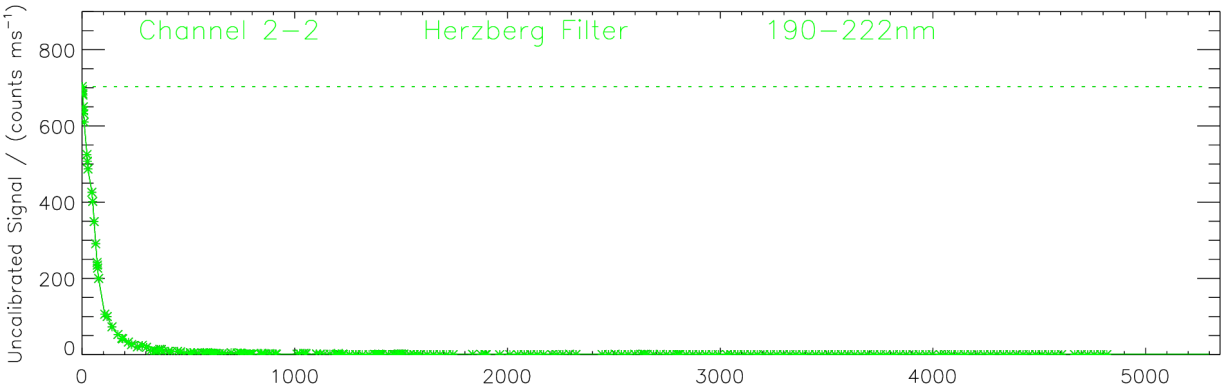

Channel 1-1 Lyman-alpha Filter 120-123nm (nominal)
Uncalibrated Signal / (counts ms^{-1})
0
200
400
600
800
1000
1200
1400
0
1000
2000
3000
4000
5000

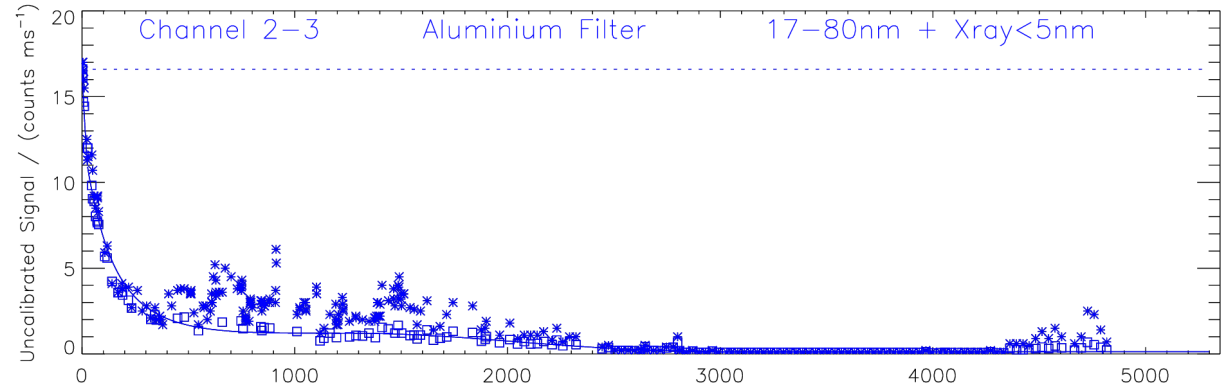

Channel 1-2 Herzberg Filter 190-222nm
Uncalibrated Signal / (counts ms^{-1})
0
200
400
600
800
0
1000
2000
3000
4000
5000

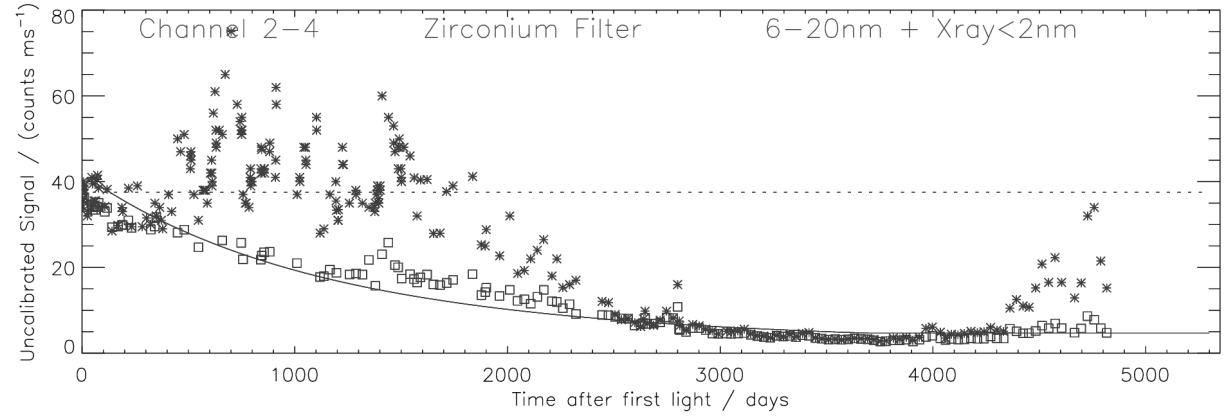

Channel 1-3 Aluminium Filter 17-80nm + Xray<5nm
Uncalibrated Signal / (counts ms^{-1})
0
10
20
30
40
0
1000
2000
3000
4000
5000

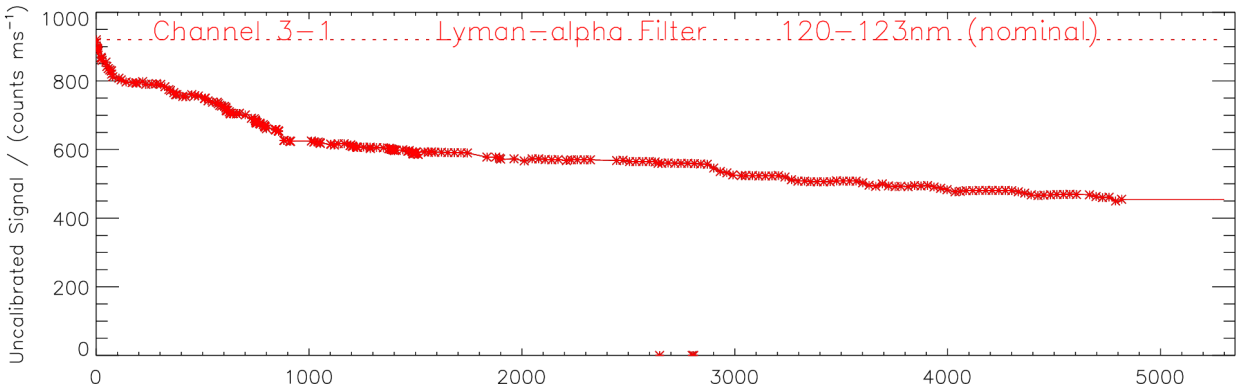

Channel 1-4 Zirconium Filter 6-20nm + Xray<2nm
Uncalibrated Signal / (counts ms^{-1})
0
20
40
60
80
0
1000
2000
3000
4000
5000
Time after first light / days

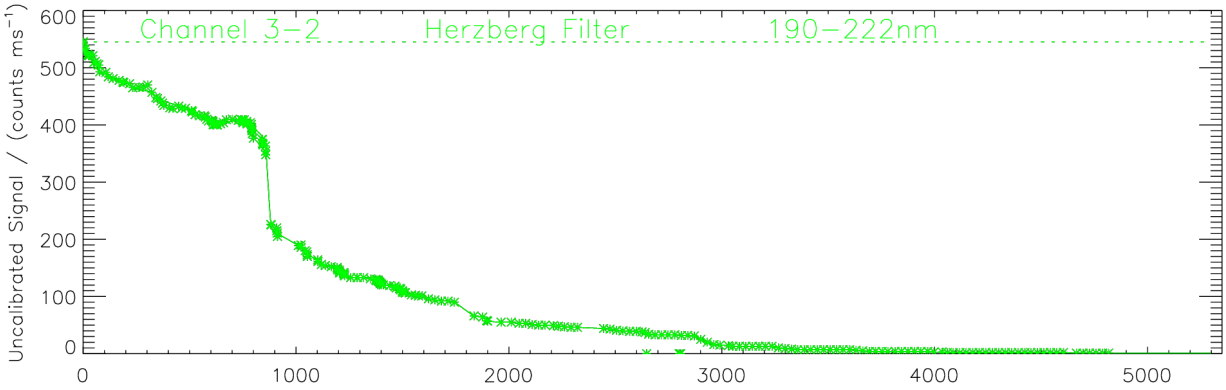

Channel 2-1
Lyman-alpha Filter
120-123nm (nominal)
Uncalibrated Signal / (counts ms^{-1})
0
100
200
300
400
500
600
0
1000
2000
3000
4000
5000

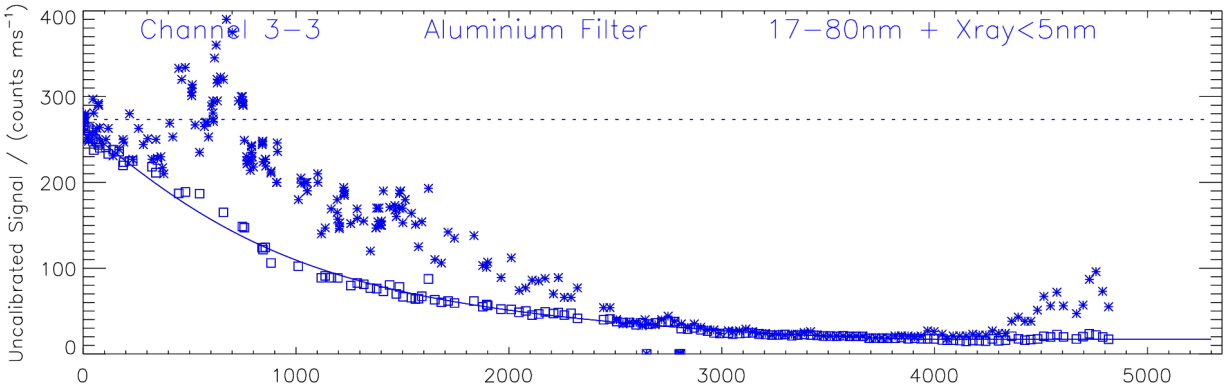

Channel 2-2
Herzberg Filter
190-222nm
Uncalibrated Signal / (counts ms^{-1})
0
200
400
600
800
0
1000
2000
3000
4000
5000

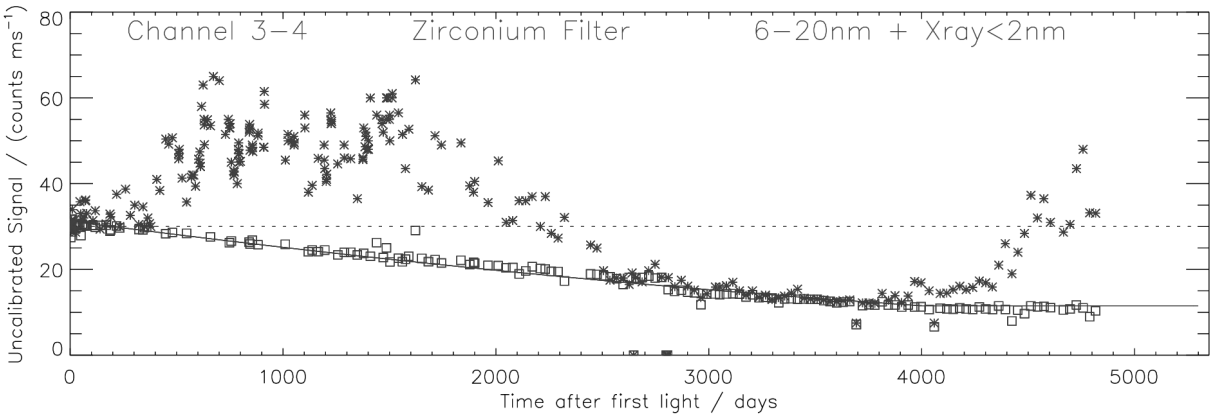

Channel 2-3
Aluminium Filter
17-80nm + Xray<5nm
Uncalibrated Signal / (counts ms^{-1})
0
5
10
15
20
0
1000
2000
3000
4000
5000


Channel 2-4
Zirconium Filter
6-20nm + Xray<2nm
Uncalibrated Signal / (counts ms^{-1})
0
20
40
60
80
0
1000
2000
3000
4000
5000
Time after first light / days


Channel 3-1 Lyman-alpha Filter 120-123nm (nominal)
Uncalibrated Signal / (counts ms^{-1})
0
200
400
600
800
1000
0
1000
2000
3000
4000
5000

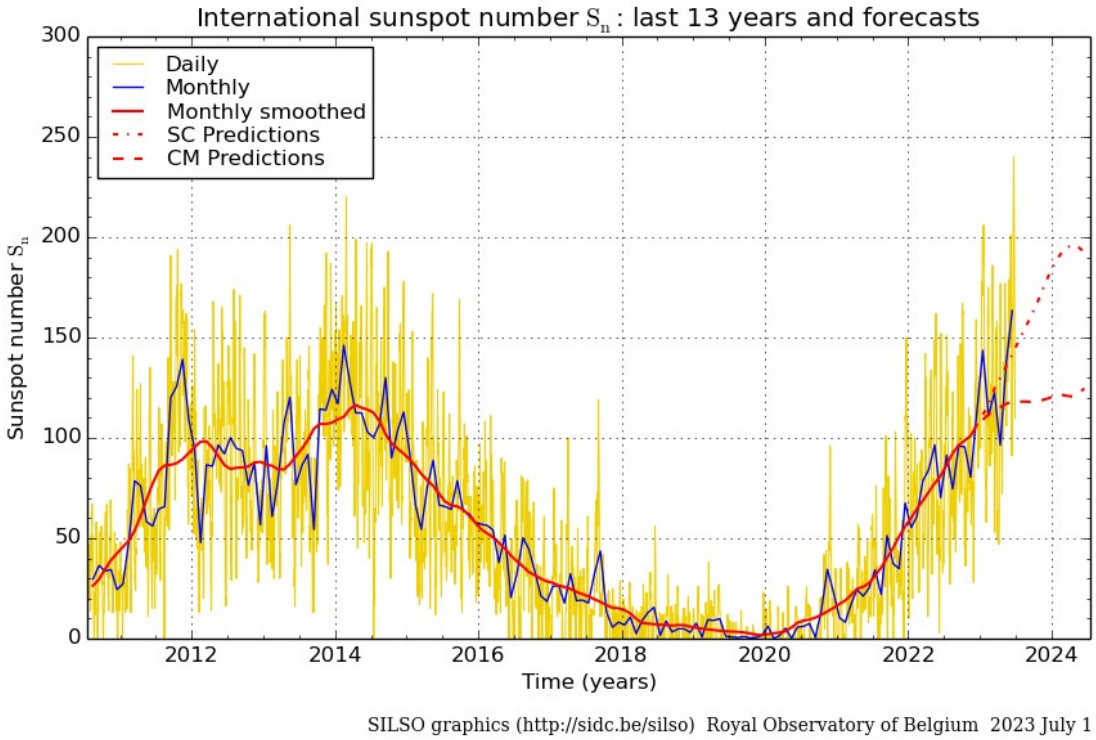

Channel 3-2 Herzberg Filter 190-222nm
Uncalibrated Signal / (counts ms^{-1})
0
100
200
300
400
500
600
0
1000
2000
3000
4000
5000


Channel 3-3 Aluminium Filter 17-80nm + Xray<5nm
Uncalibrated Signal / (counts ms^{-1})
0
100
200
300
400
0
1000
2000
3000
4000
5000


Channel 3-4 Zirconium Filter 6-20nm + Xray<2nm
Uncalibrated Signal / (counts ms^{-1})
0
20
40
60
80
0
1000
2000
3000
4000
5000
Time after first light / days

Active-region signal

The following two pages show the development of the active-region signal for channel 3 and channel 4 of all three units. For ch1-3, ch1-4, ch2-4, and ch3-4, which are less degraded, the development shows a similar structure as the development of the sunspot numbers, see SILSO figure below.

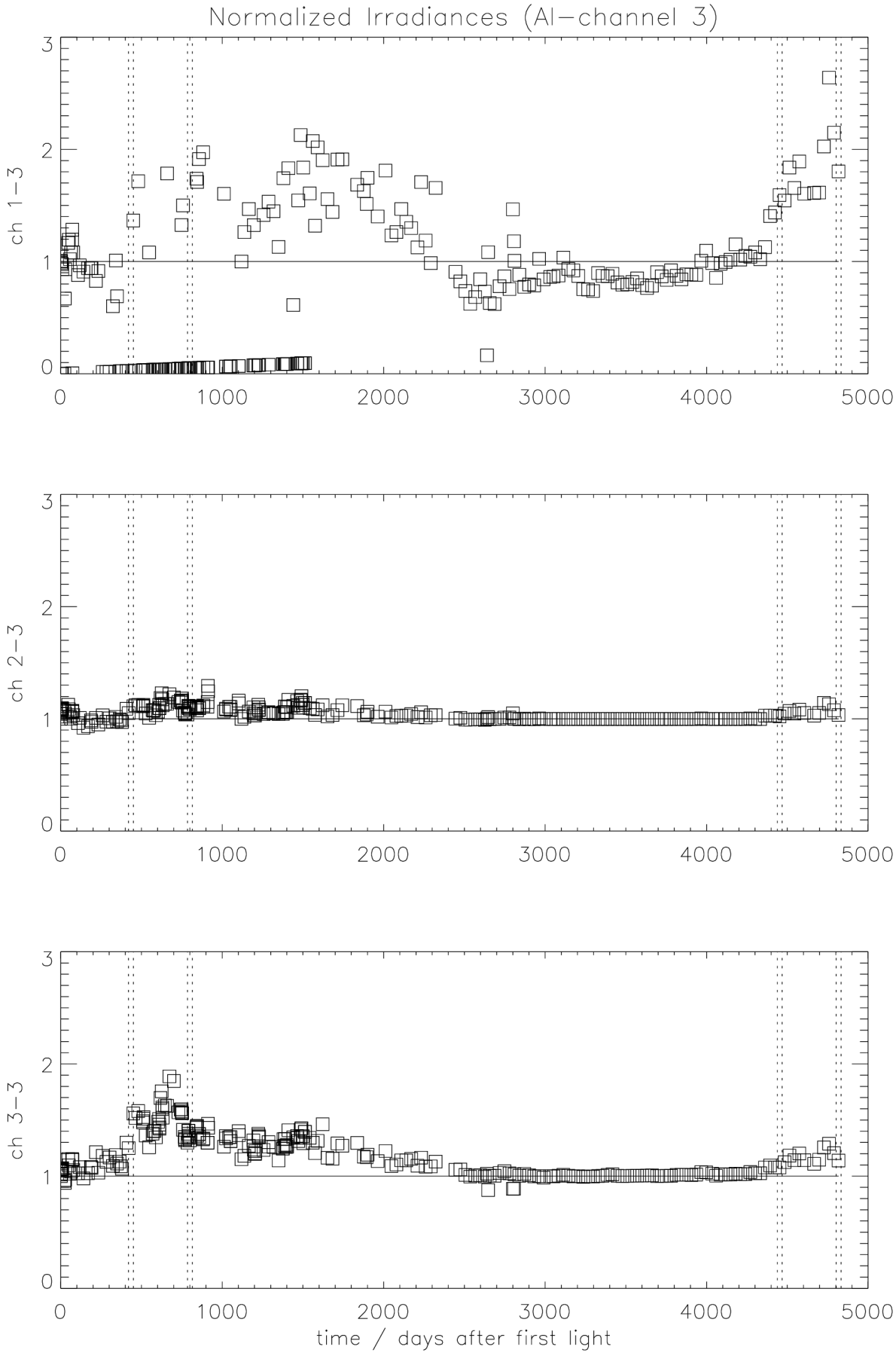


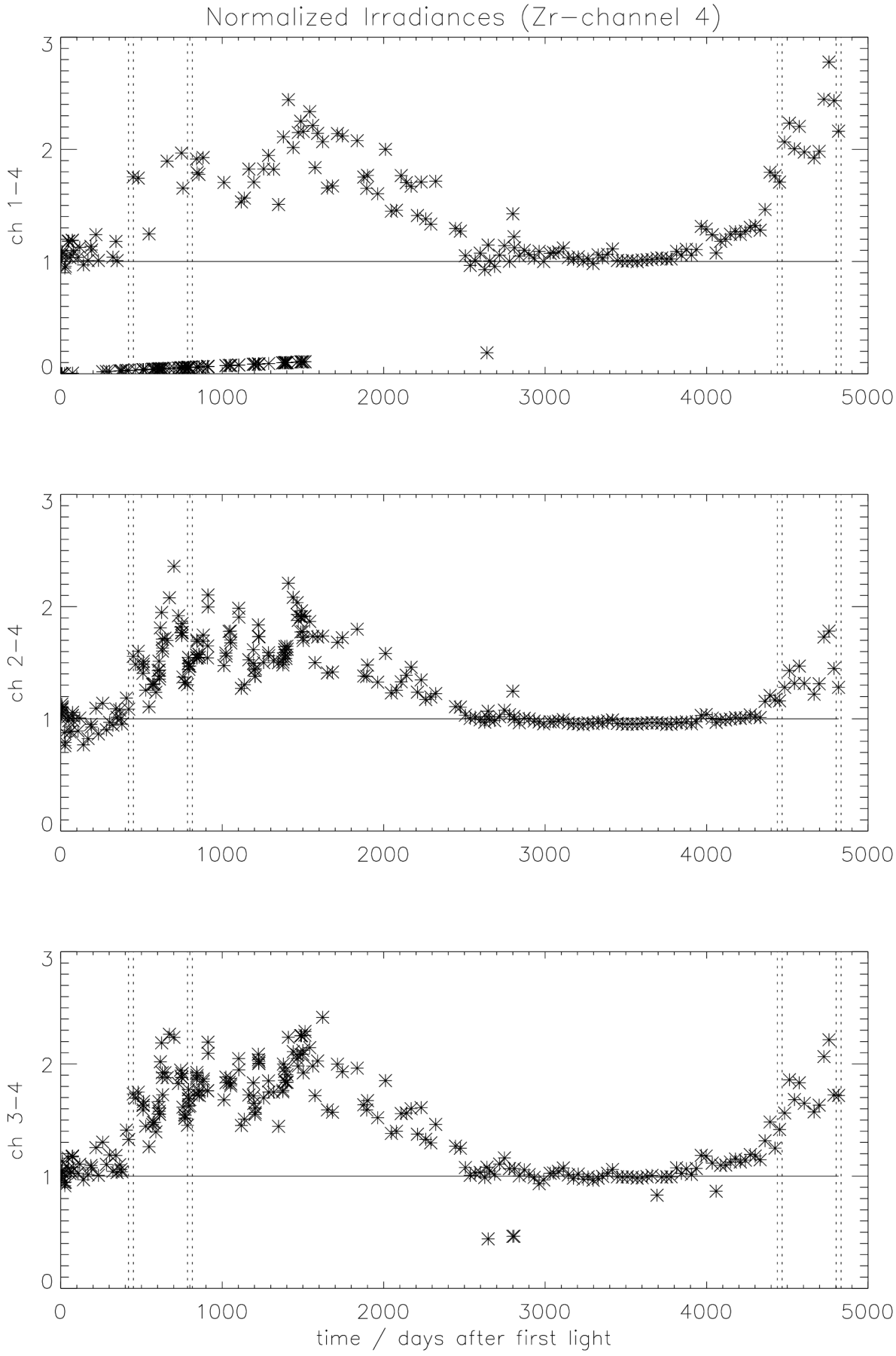
The values are observed during calibration campaigns. The estimated baseline degradation was added, and the result divided by the initial (First Light) observations.

For a correct comparison, it has to be taken into account that ch1-3 uses an MSM detector which has a long saturation time. Also, at the beginning of the mission, not many campaigns were taken with unit 1, therefore some data points during the first solar maximum phase are missing. Nevertheless, it appears that the current cycle is slightly higher than the previous one.

Ch2-3 and ch3-3 are strongly degraded, thus a comparison is more difficult.

Marked are the months March 2011 and 2012, and the months March 2022 and 2023, which represent comparable phases of solar cycles 24 and 25.


Normalized Irradiances (Al−channel 3)
ch 1−3
ch 2−3
ch 3−3
0
1
2
3
0
1000
2000
3000
4000
5000
time / days after first light


Normalized Irradiances (Zr−channel 4)
ch 1−4
ch 2−4
ch 3−4
0
1
2
3
0
1000
2000
3000
4000
5000
time / days after first light

Flare strengths

Here, the net flare strengths (flare peak minus pre-flare level) are compared for LYRA channel 3 and channel 4 vs. GOES. They are generally well correlated. For unit 2, the correlation could be calculated for all years from 2010 until 2023. The years of the solar minimum are less significant, though, because of the lack of strong flares.

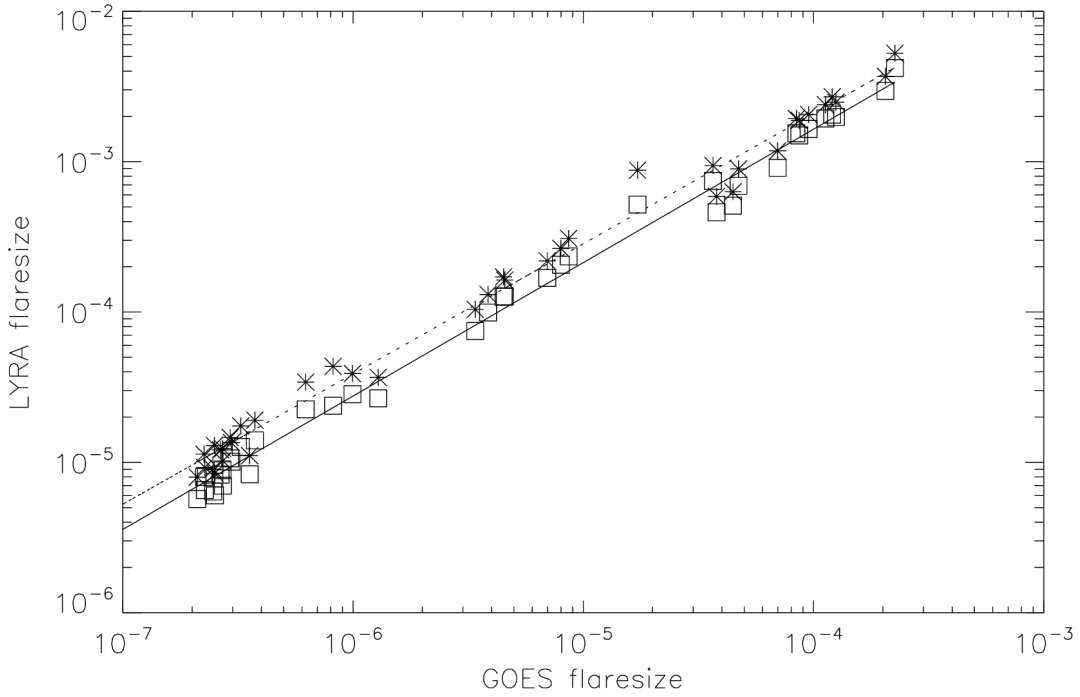
Flare campaigns with units 1 and 3 could be used to calculate the correlation for the years 2017, 2022, and 2023. The development of the flare strengths are demonstrated for C1.0 and M1.0 flares calculated for all three units.

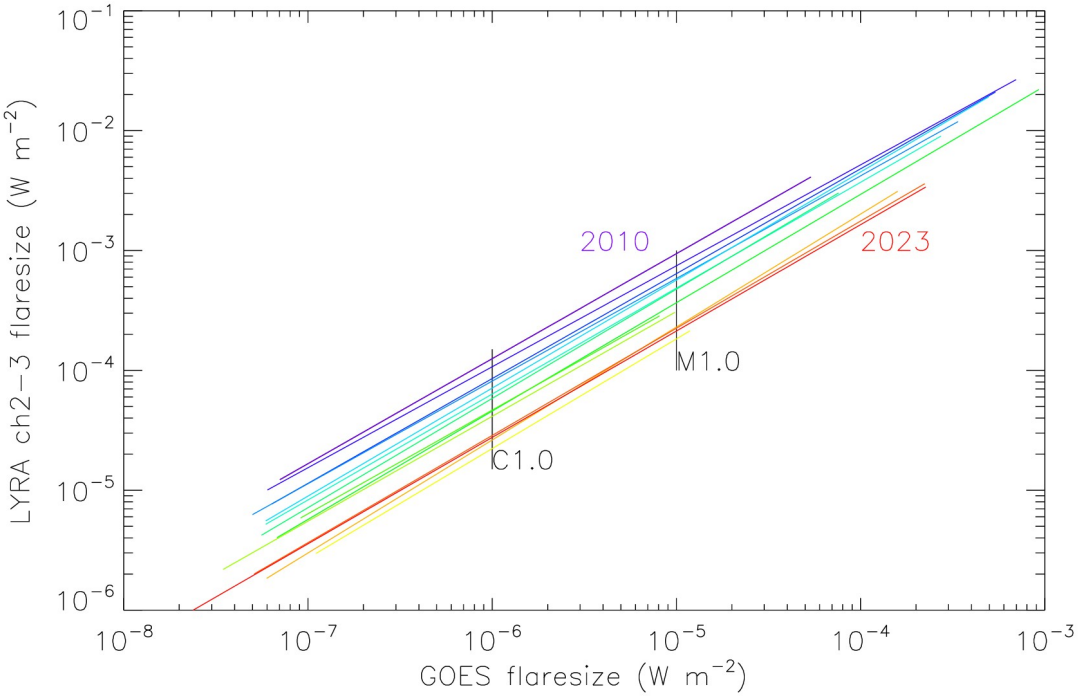
It is not certain whether it can be assumed that the resp. channels of the three units start with the same flare strength. It appears that the initial strength of ch1-4 is somewhat lower than the other two units, but it degrades slower. The initial strength of ch1-3 is rather high. Consistent with the active-region signal, unit 1 degrades slower than unit 3, which degrades slower that unit 2; the reason is most probably the number of campaigns (open cover).

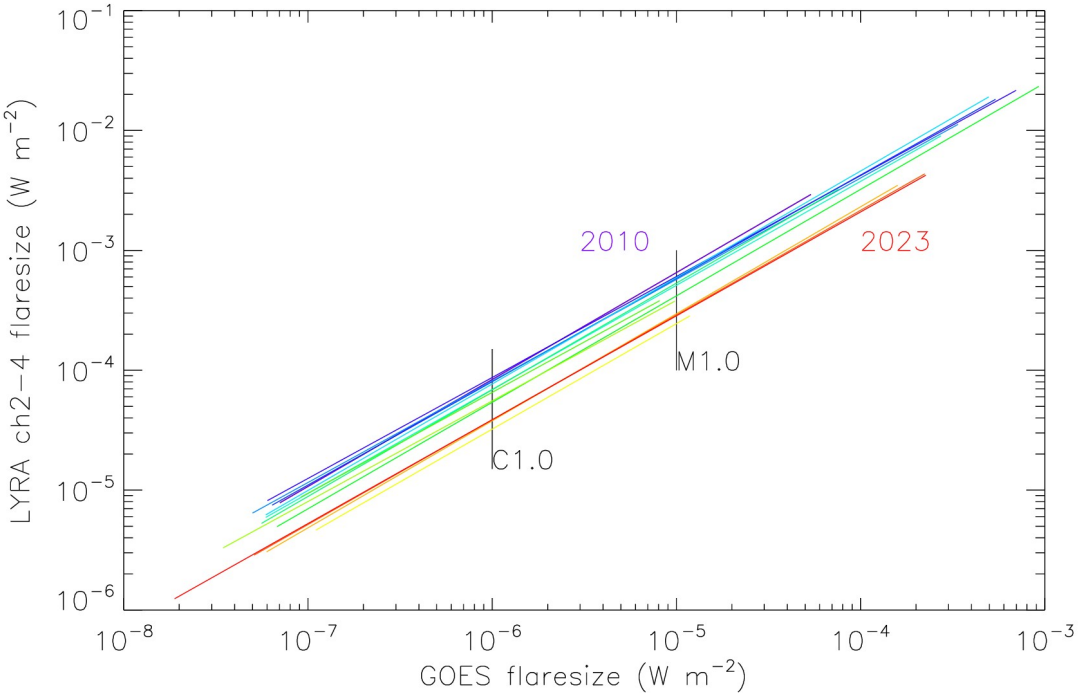
In units 2 and 3, channel 3 has degraded such that its flare response is weaker than channel 4. The reason is most probably the spectral degradation (stronger for longer wavelengths). In the less used unit 1, the response of channel 3 is still stronger than channel 4.

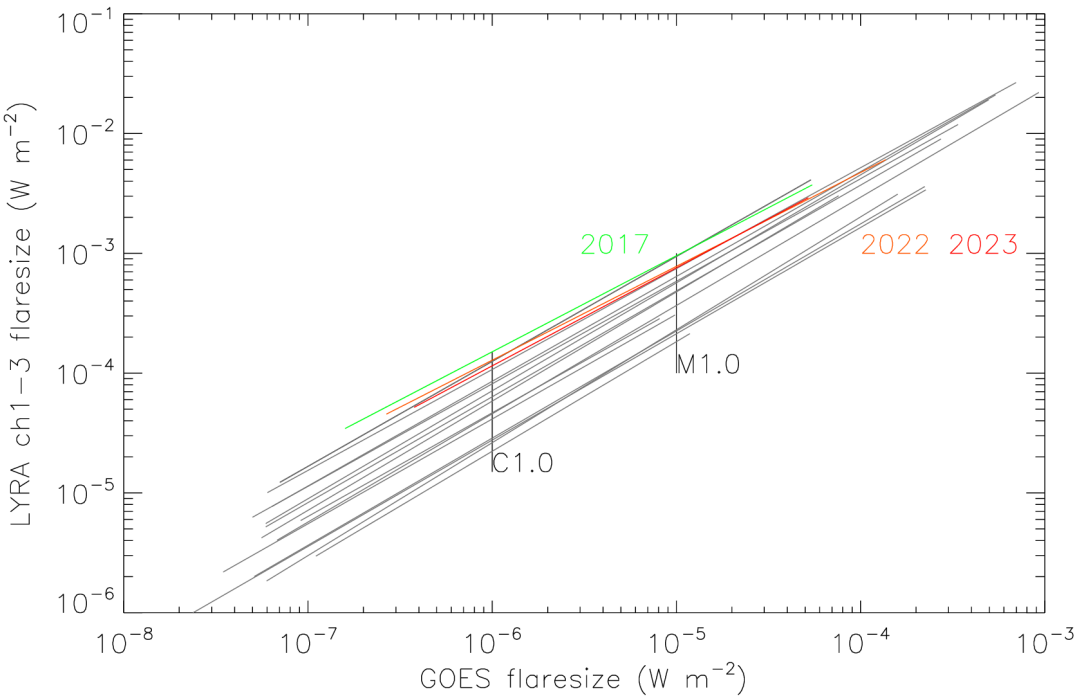
The flare strengths of unit 1 appear to slowly degrade on a high level (because only used for campaigns). The degradation of unit 2 seems to have reached a stable level. The degradation of unit 3 is still significant (open all the time during occultation period).

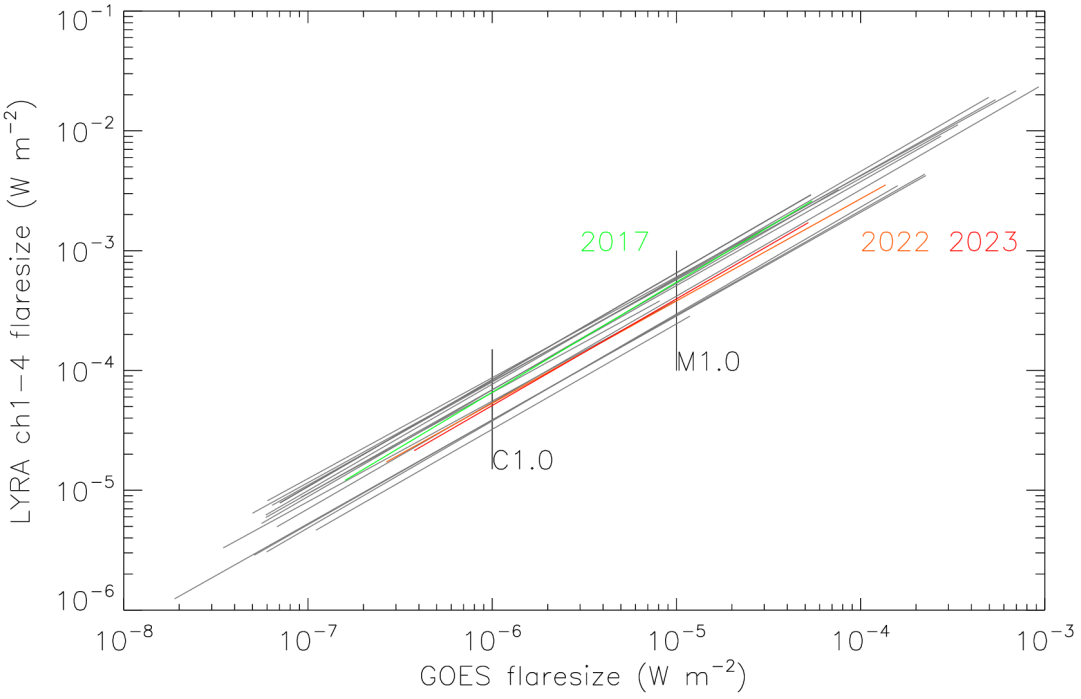
The following figure shows a typical correlation of flare strengths (unit 2 in 2023, ch2-3 represented by squares, ch2-4 by asterisks). The next pages show the development over time of this correlation for unit 2, unit 1, and unit 3 (gray lines demonstrate unit 2 for comparison), and the development over time of C1.0 and M1.0 flares.

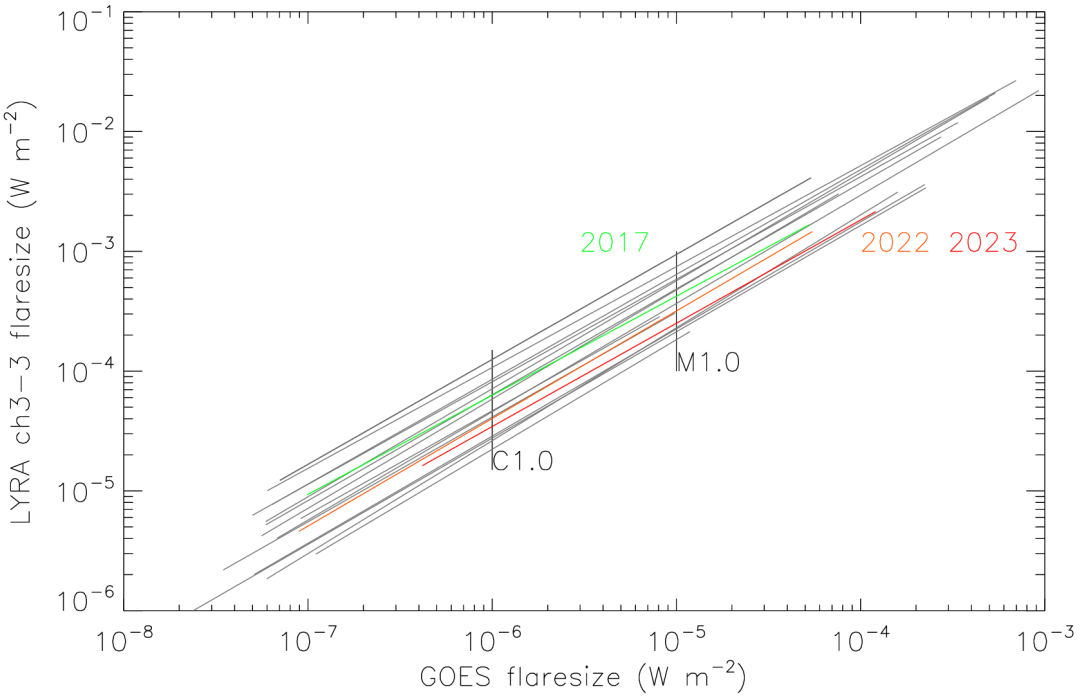


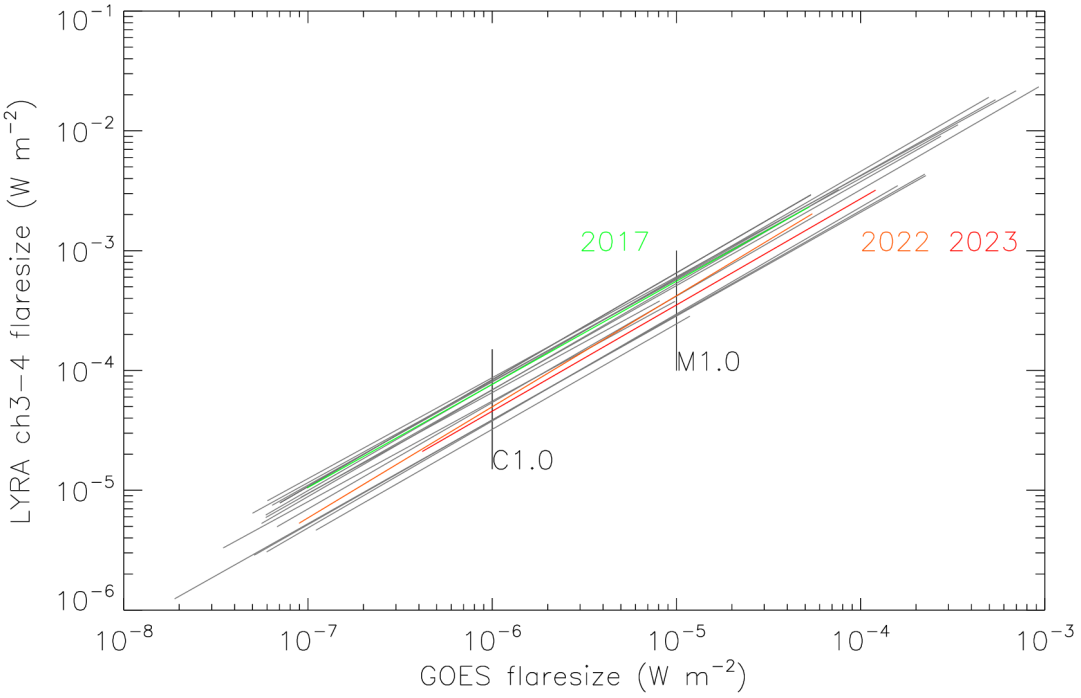

LYRA ch2−3 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2010
2023
M1.0
C1.0

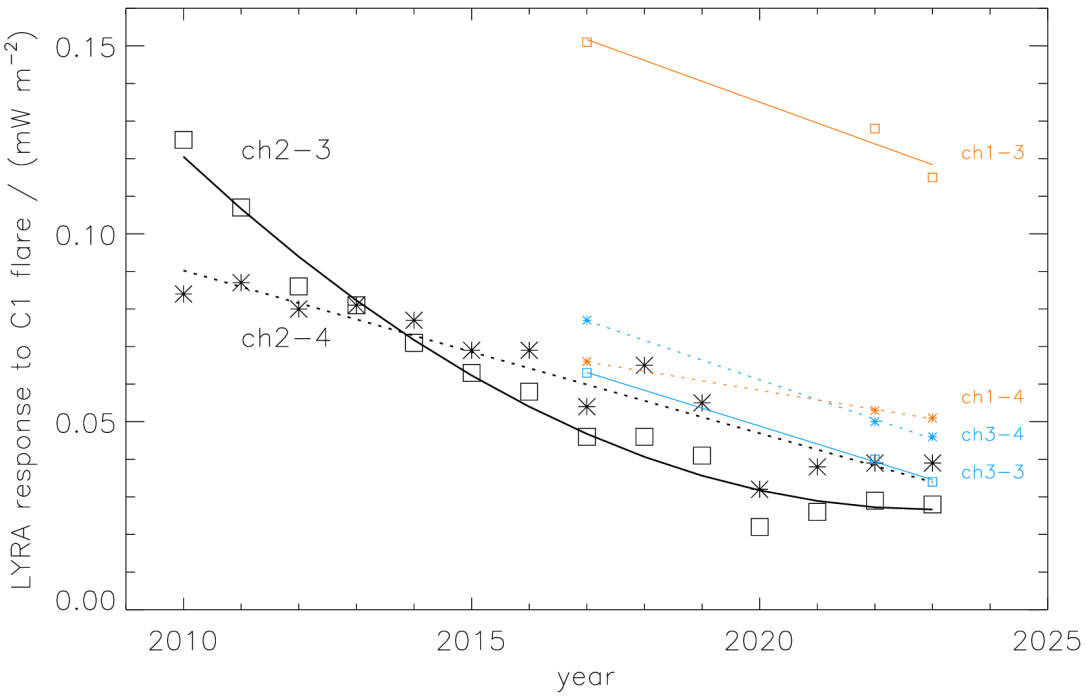

LYRA ch2−4 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2010
2023
M1.0
C1.0

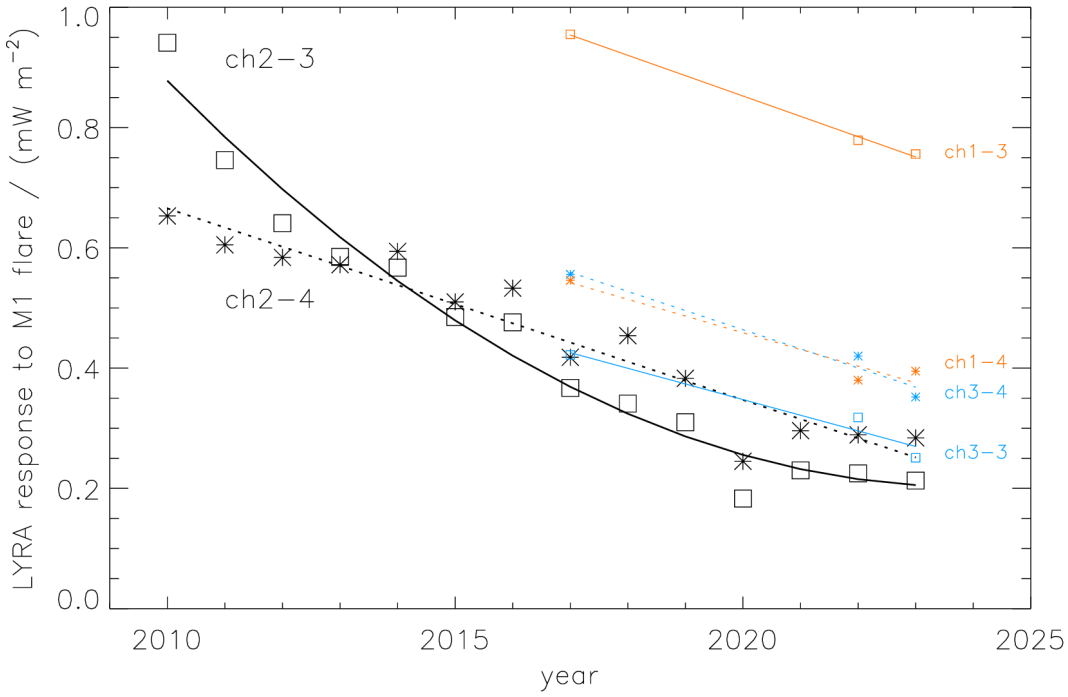

LYRA ch1−3 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2017
2022 2023
M1.0
C1.0


LYRA ch1−4 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2017
2022 2023
M1.0
C1.0


LYRA ch3−3 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2017
2022 2023
M1.0
C1.0


LYRA ch3−4 flaresize (W m^{-2})
GOES flaresize (W m^{-2})
2017
2022 2023
M1.0
C1.0


LYRA response to C1 flare / (mW m^{-2})
0.15
0.10
0.05
0.00
2010
2015
2020
2025
year
ch2−3
ch2−4
ch1−3
ch1−4
ch3−4
ch3−3


LYRA response to M1 flare / (mW m^{-2})
1.0
0.8
0.6
0.4
0.2
0.0
2010
2015
2020
2025
year
ch2−3
ch2−4
ch1−3
ch1−4
ch3−4
ch3−3