GLA15 Oceans

PAD, PRD and ROSES work

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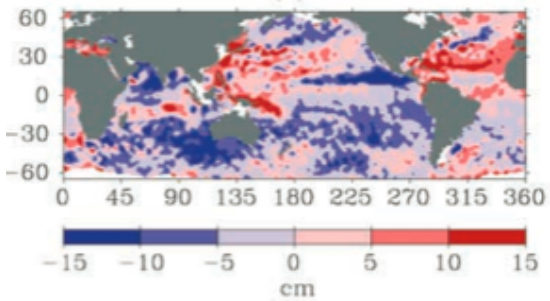
Center for Space Research
CSR
The University of Texas at Austin

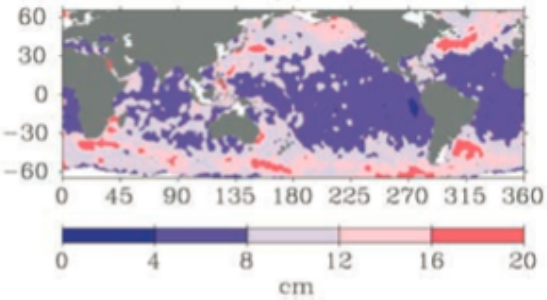
Evaluation of ICESat ocean data

GLA15 elevation



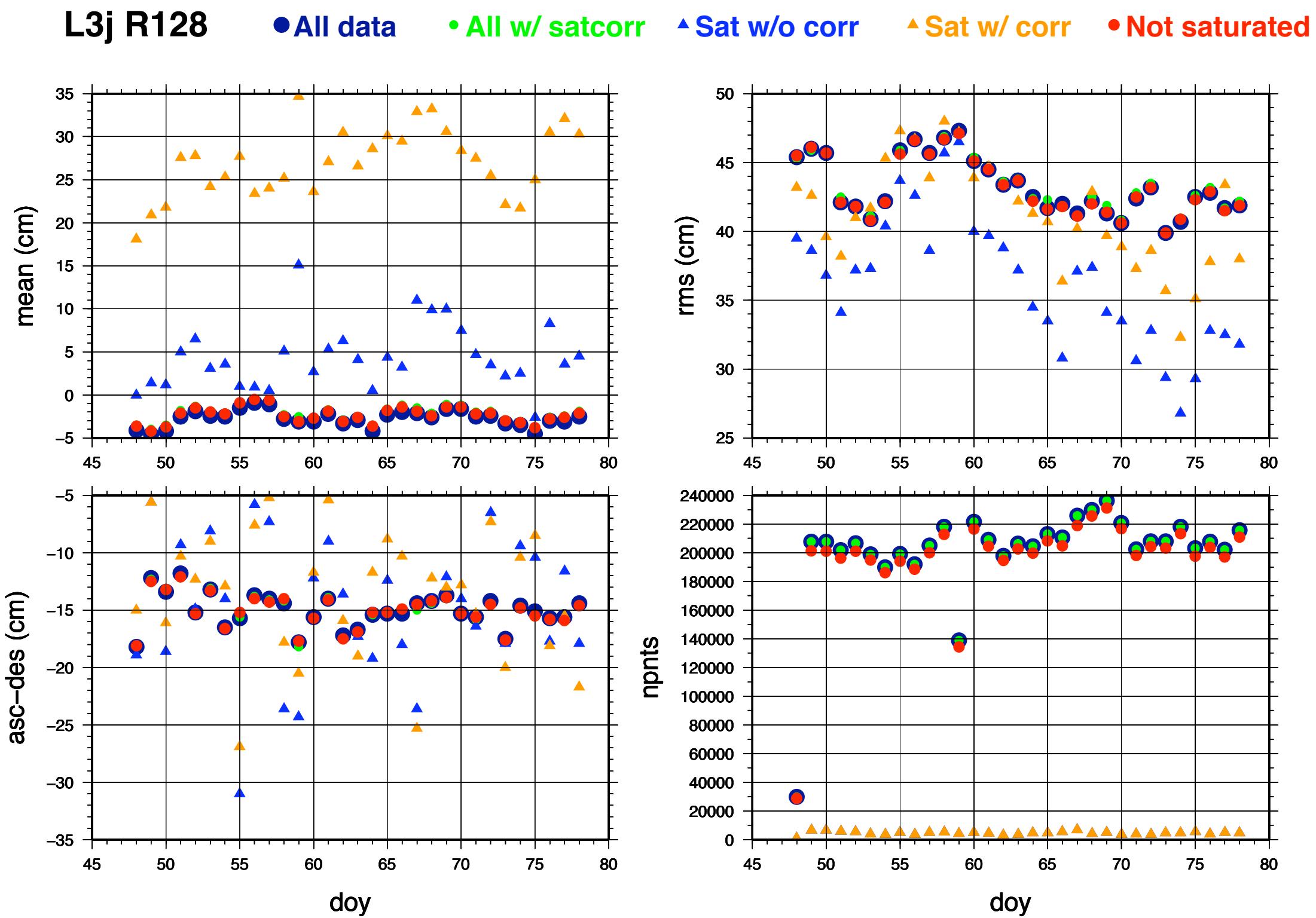
- Mean Sea Surface =

Sea Surface Anomaly

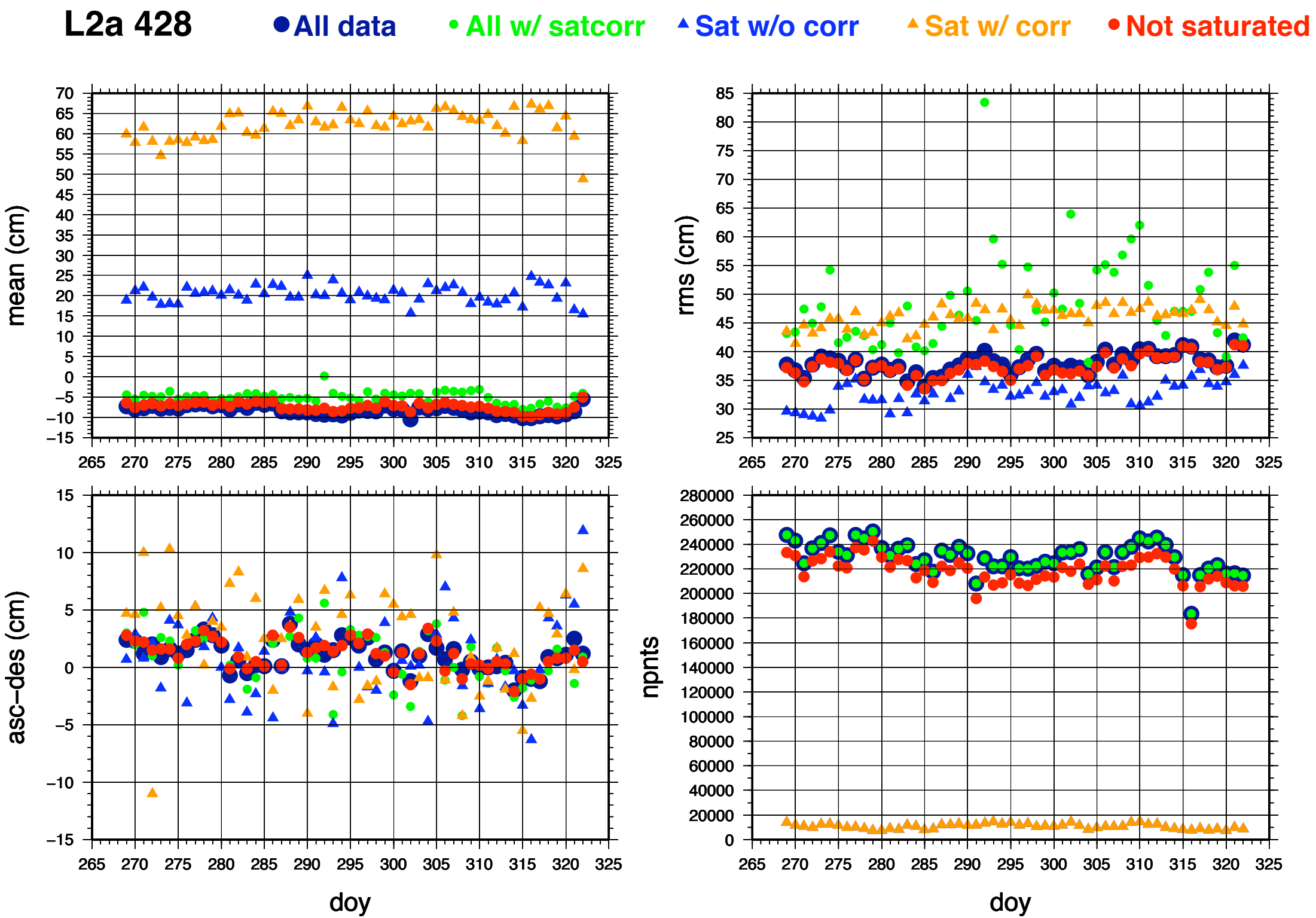


Edit criteria: within ±66º latitude, depths > 100 m,
SSA < 5 m, ICESat coelevation < 0.5º

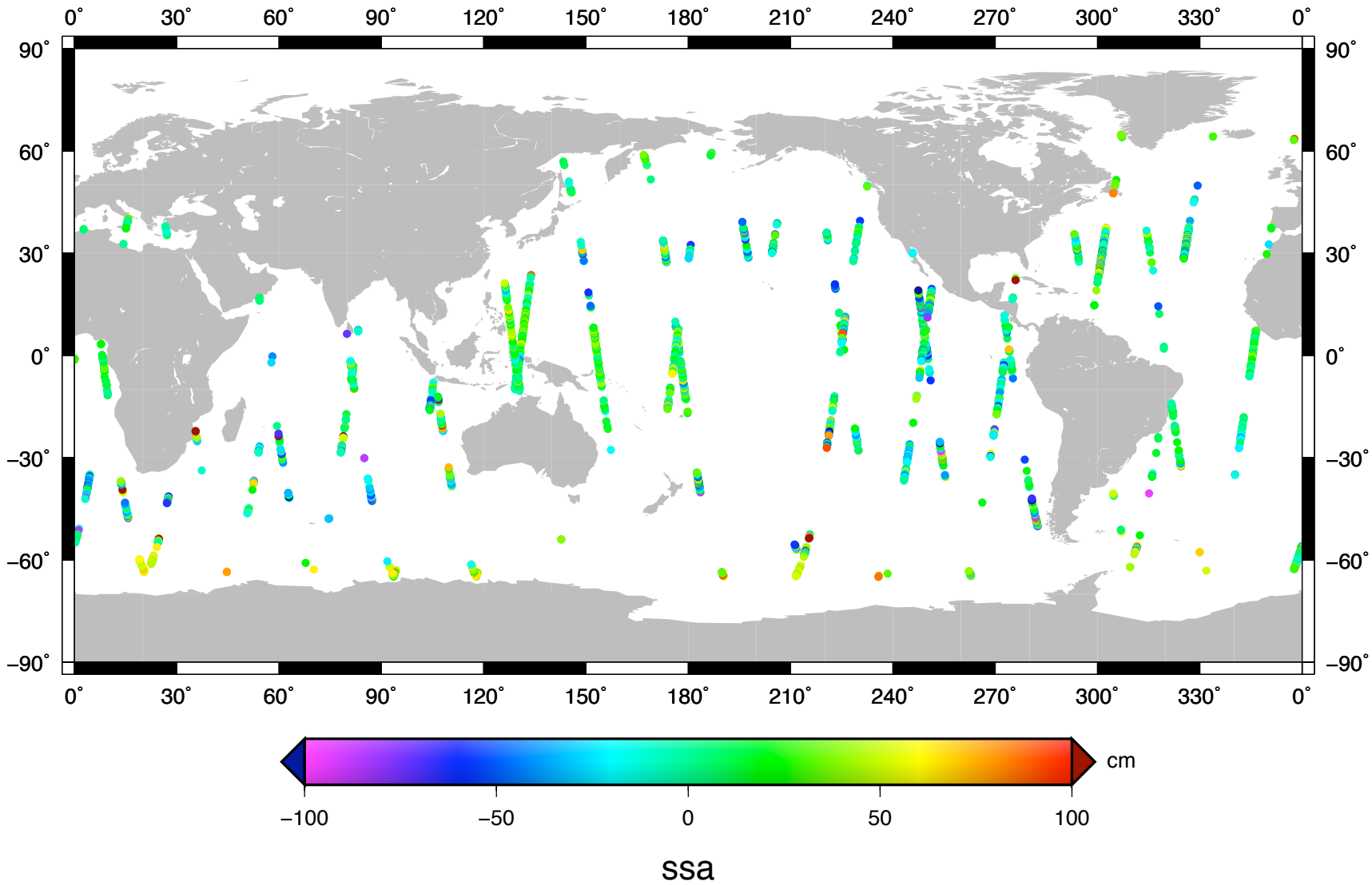
Daily, globally-averaged SSA = ocean “bias”


L3j R128
All data
All w/ satcorr
Sat w/o corr
Sat w/ corr
Not saturated
mean (cm)
rms (cm)
asc–des (cm)
npnts
doy
doy

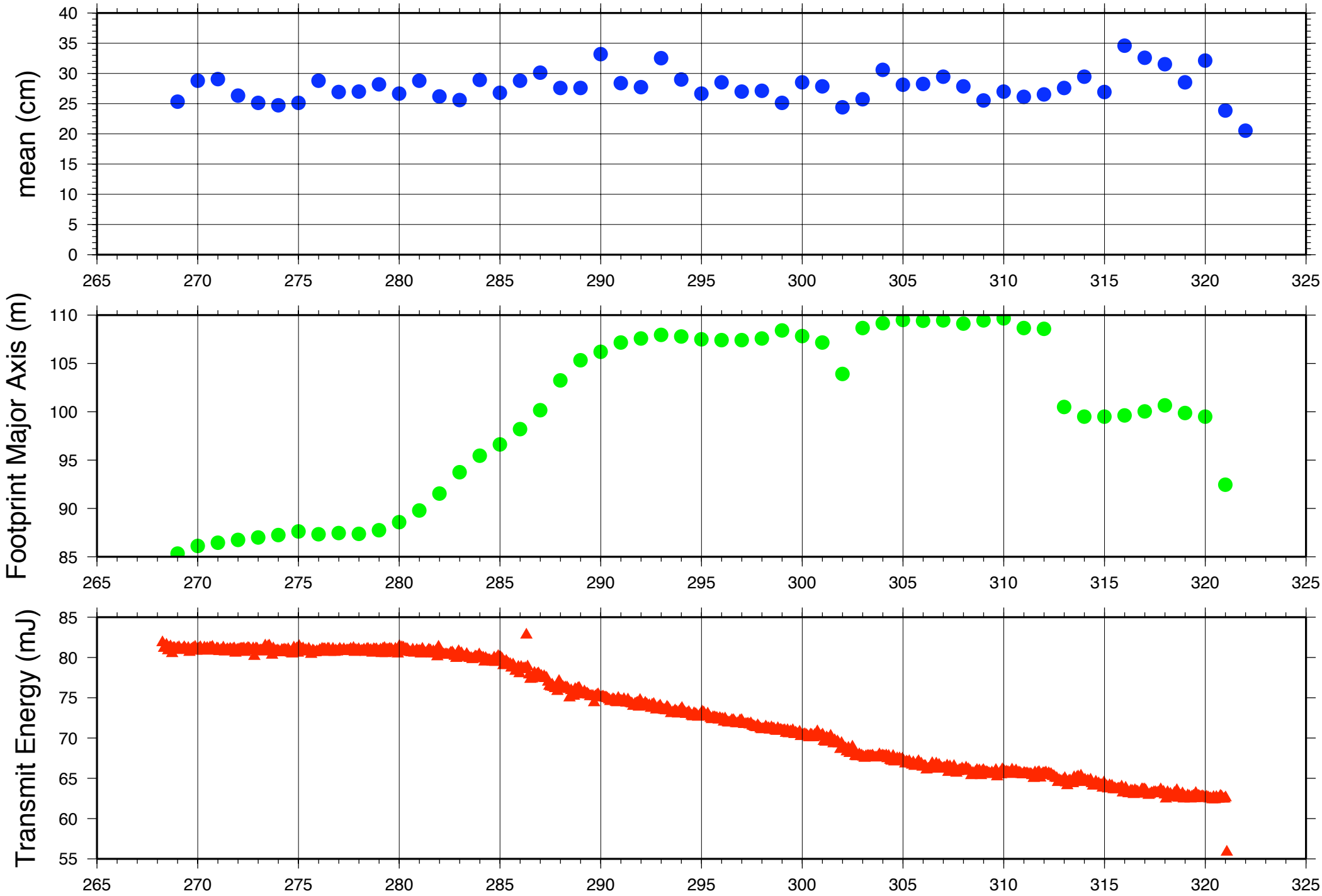
Saturation

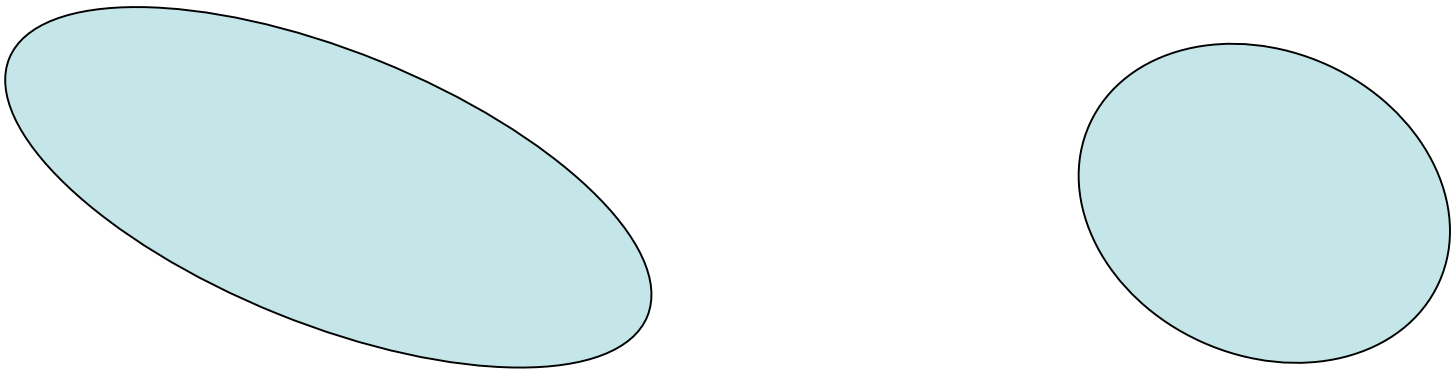

L2a 428
All data
All w/ satcorr
Sat w/o corr
Sat w/ corr
Not saturated
mean (cm)
rms (cm)
asc–des (cm)
npnts
doy
doy

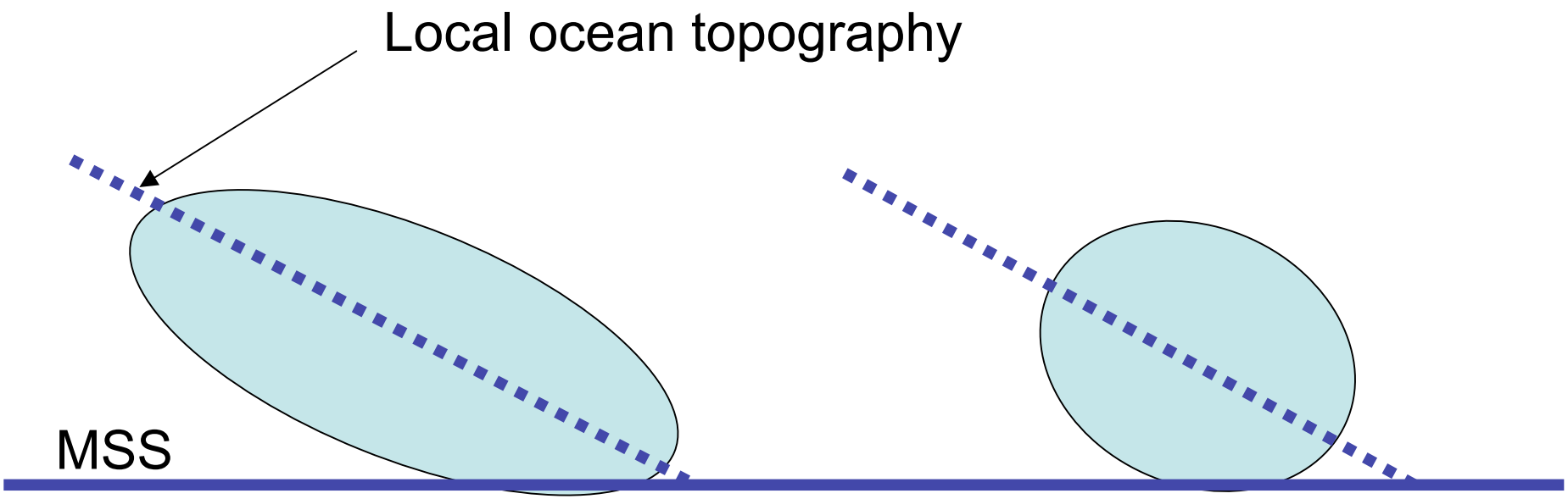
day 312, L2a R428 saturated data

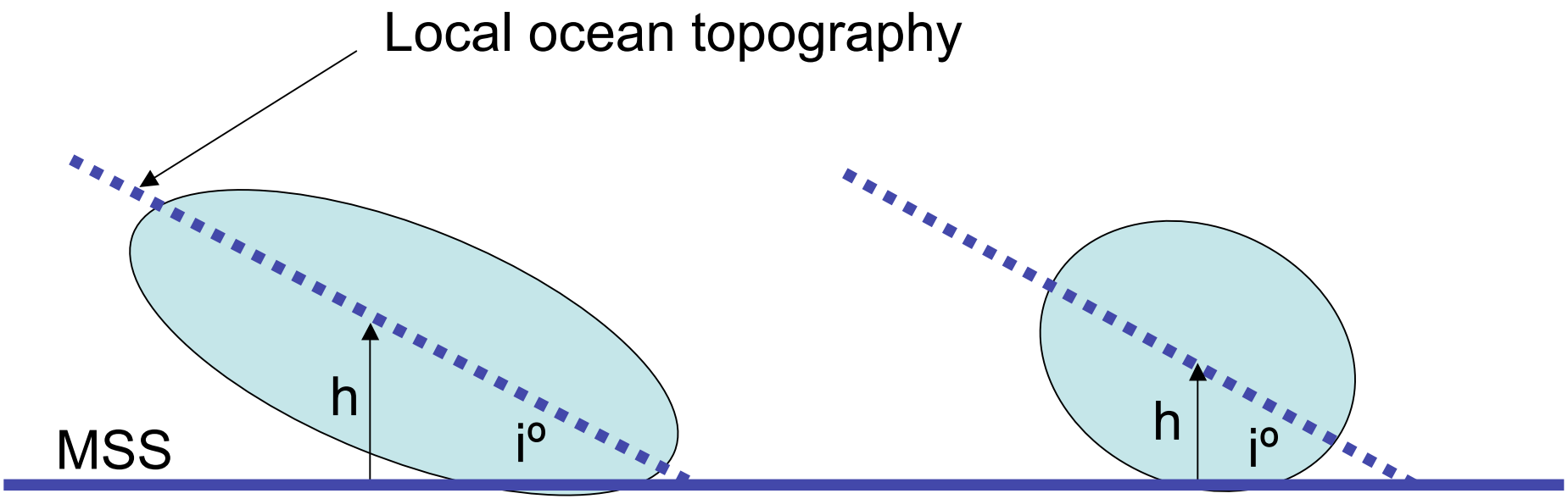


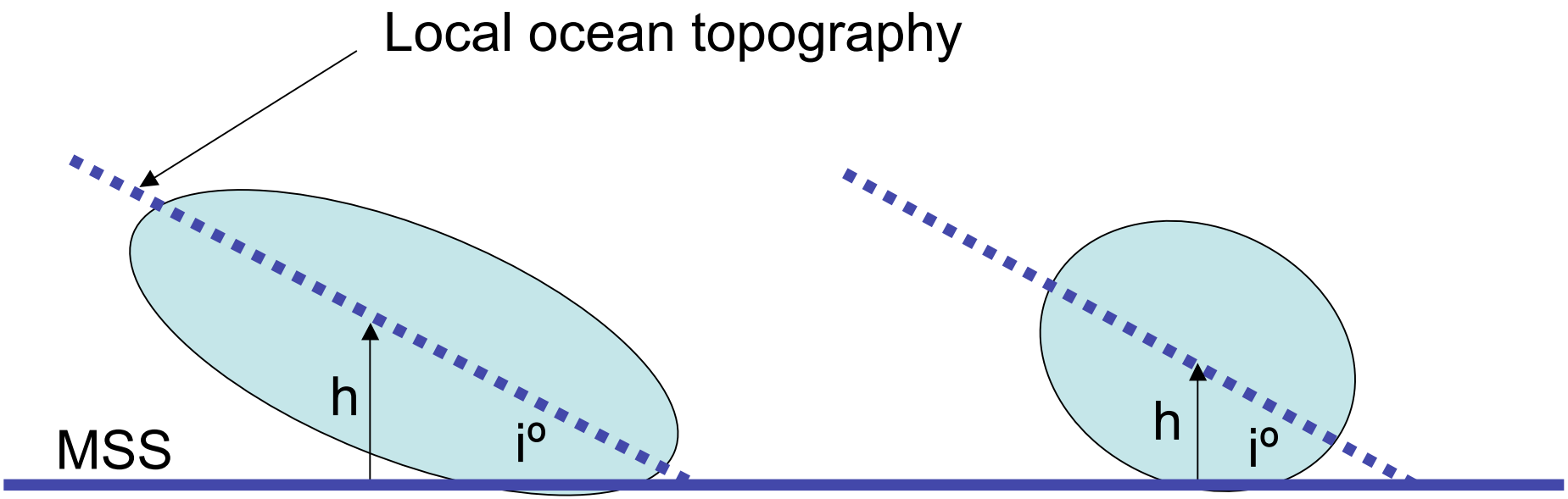
L2a 428 No sat ocean stats max gain: ● Saturated Data – Unsaturated





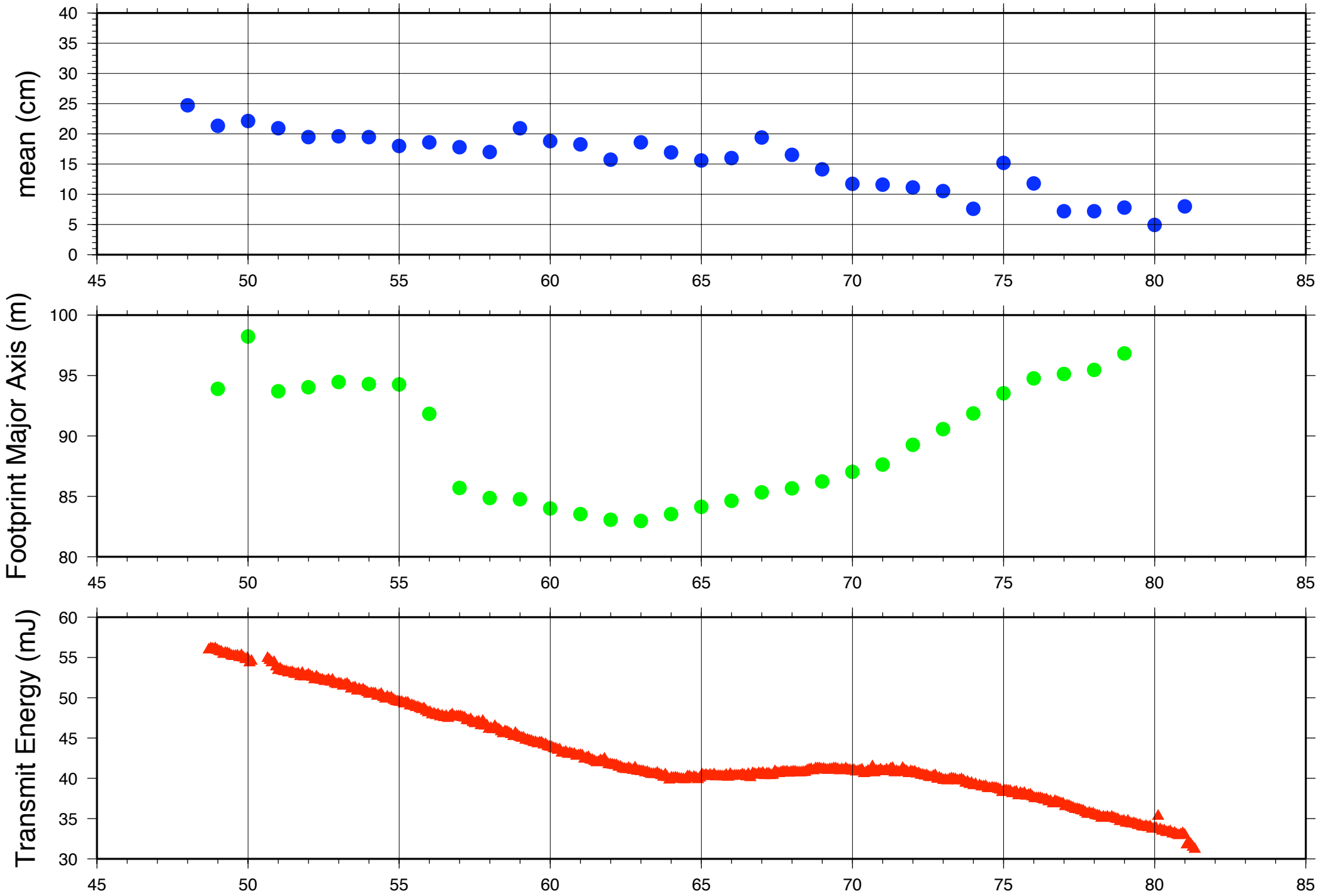

Local ocean topography
MSS


Local ocean topography
h
i°
MSS
h
i°

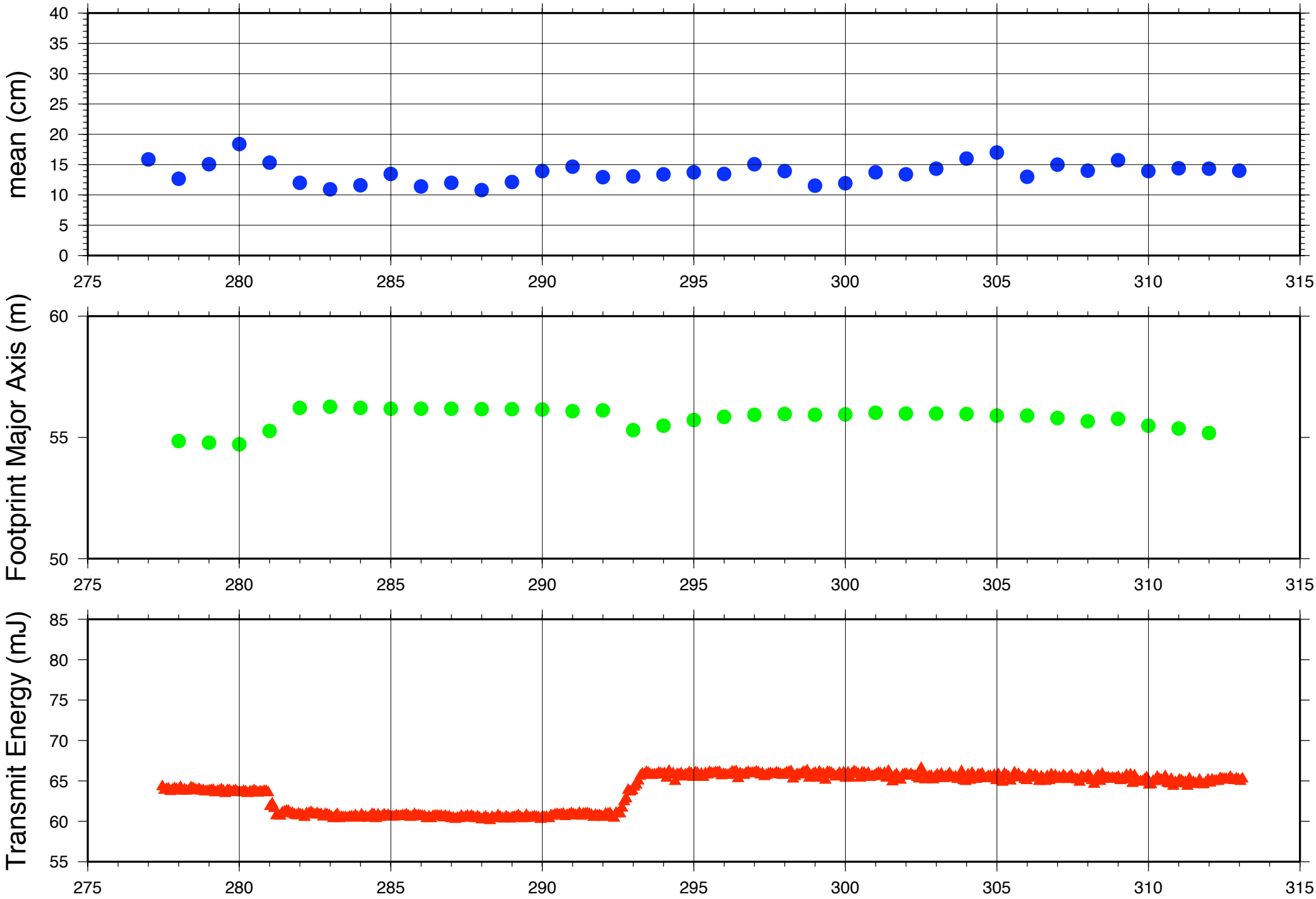


When i = 0.3º, h = 24 cm for a 90 m footprint
14 cm for a 55 m footprint

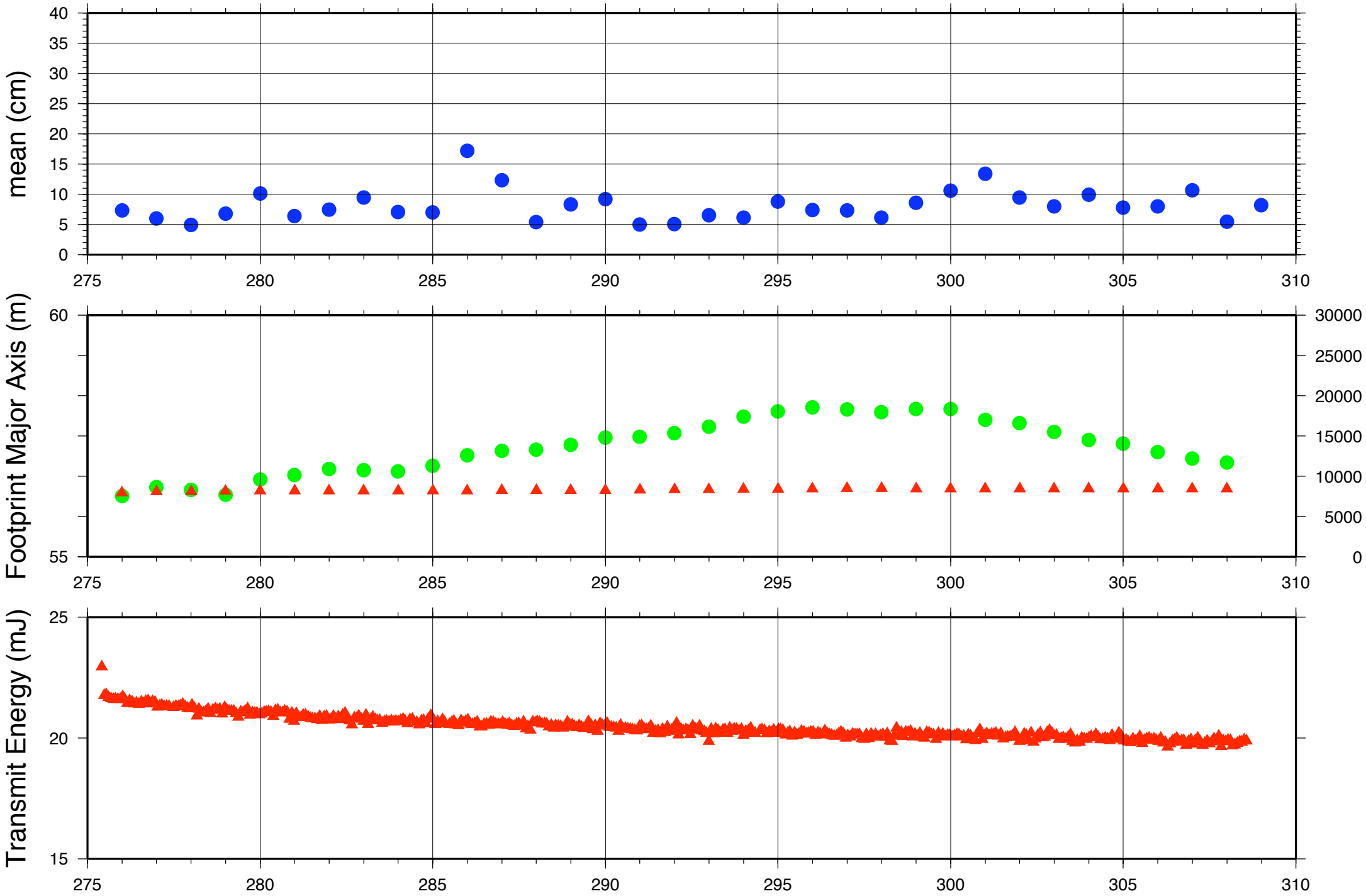
L2b 428 No sat ocean stats max gain: ● Saturated Data – Unsaturated



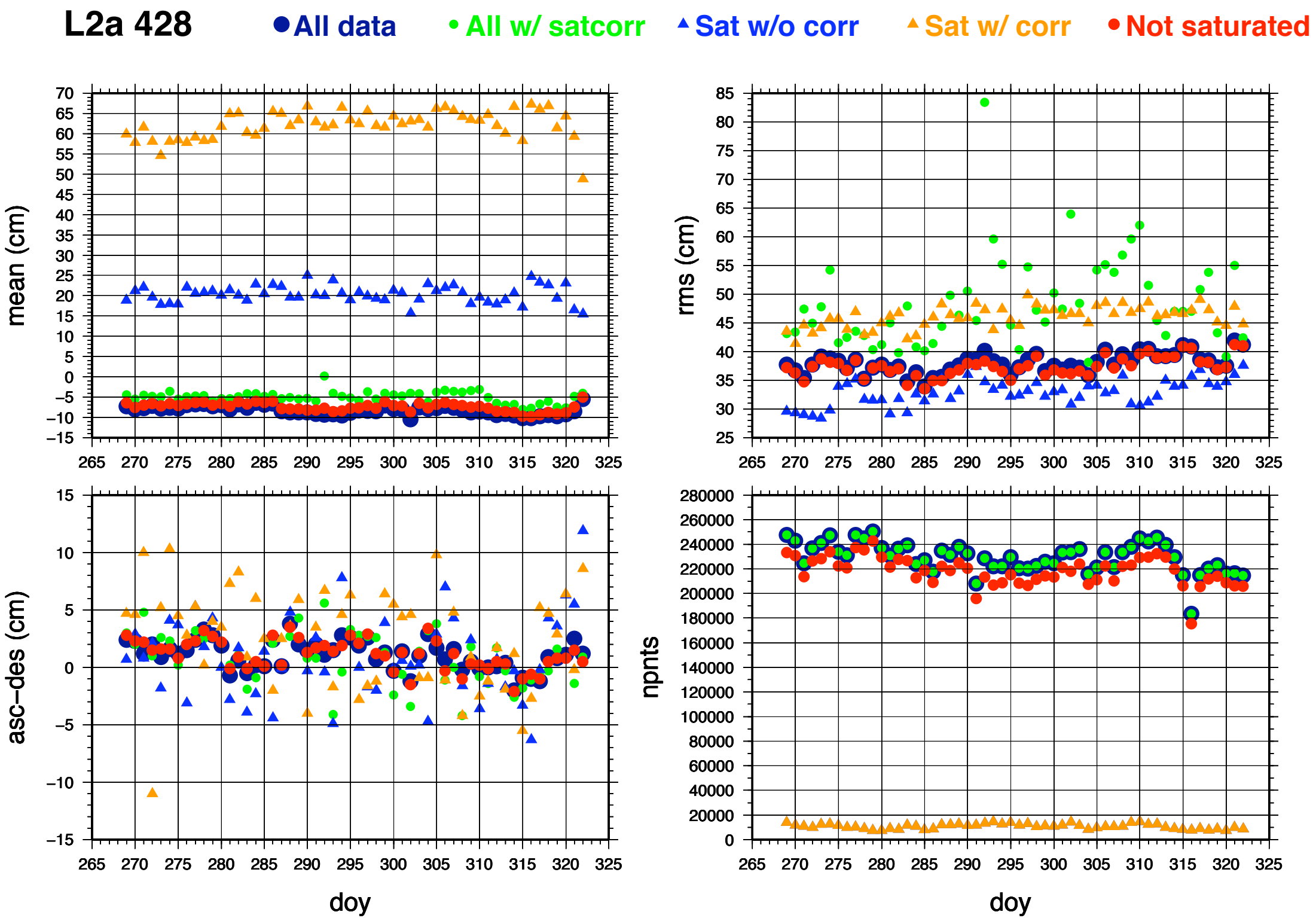
L3a 428 No sat ocean stats max gain: ● Saturated Data – Unsaturated

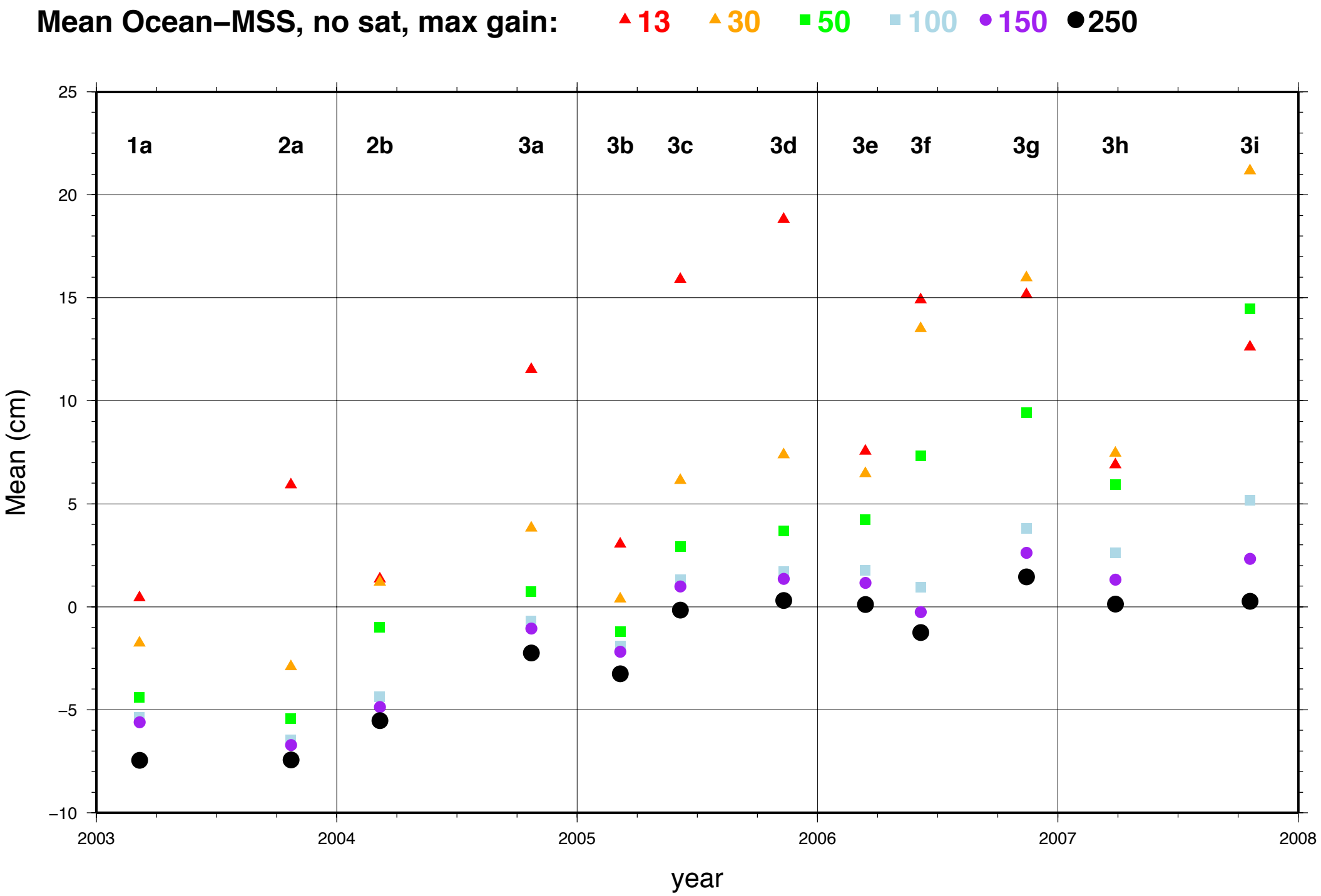


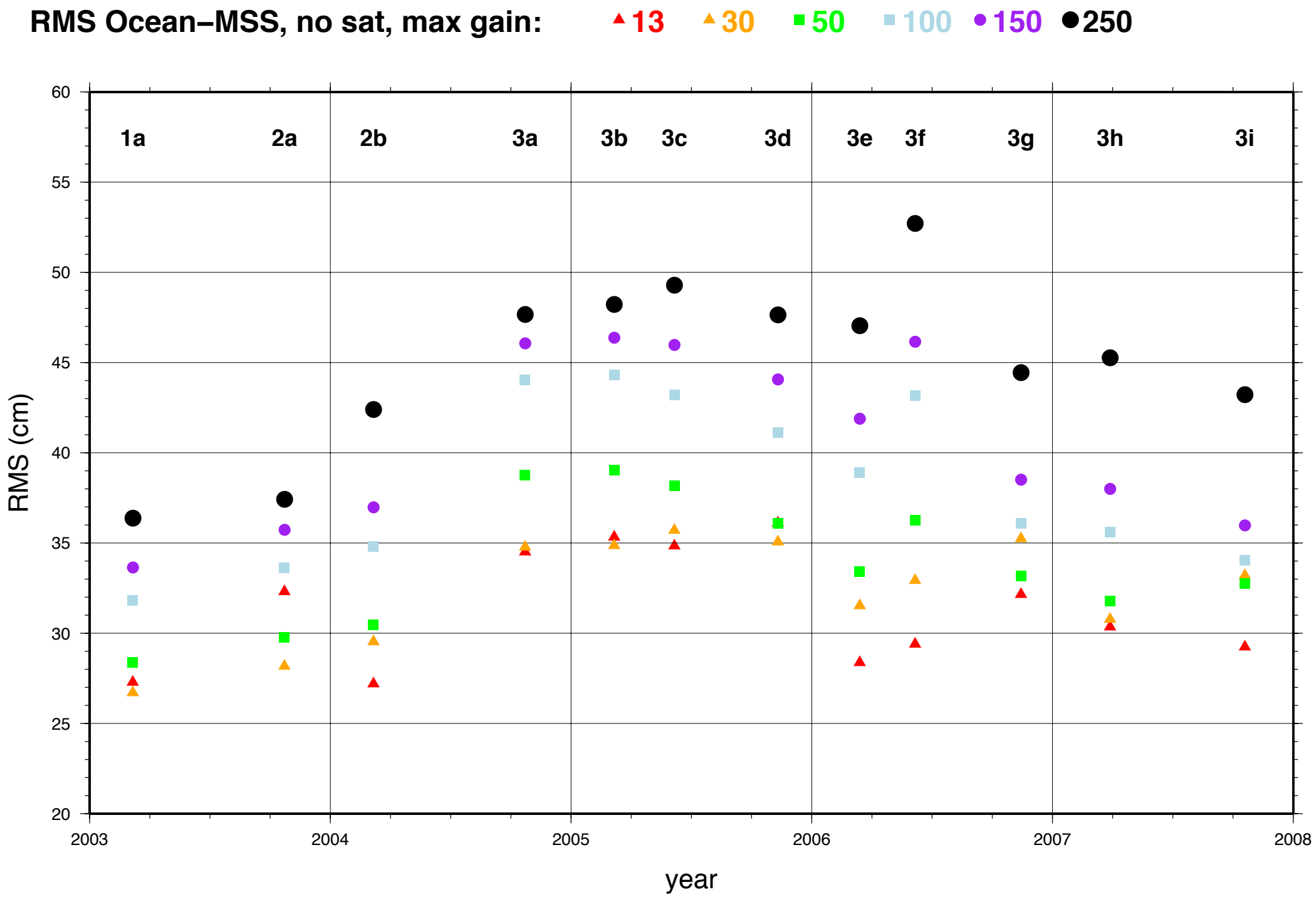
L3i 428 No sat ocean stats max gain: ● Saturated Data – Unsaturated

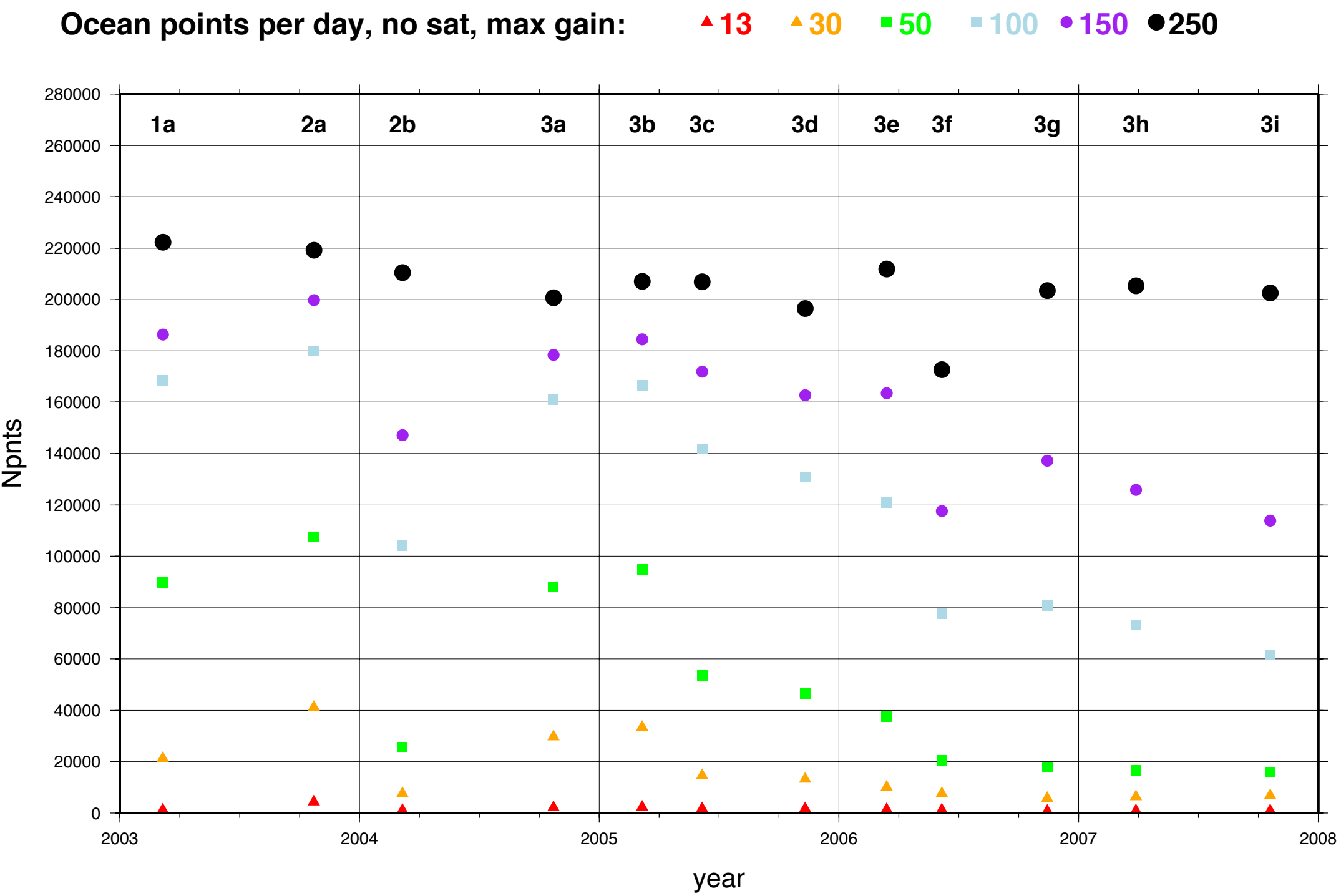


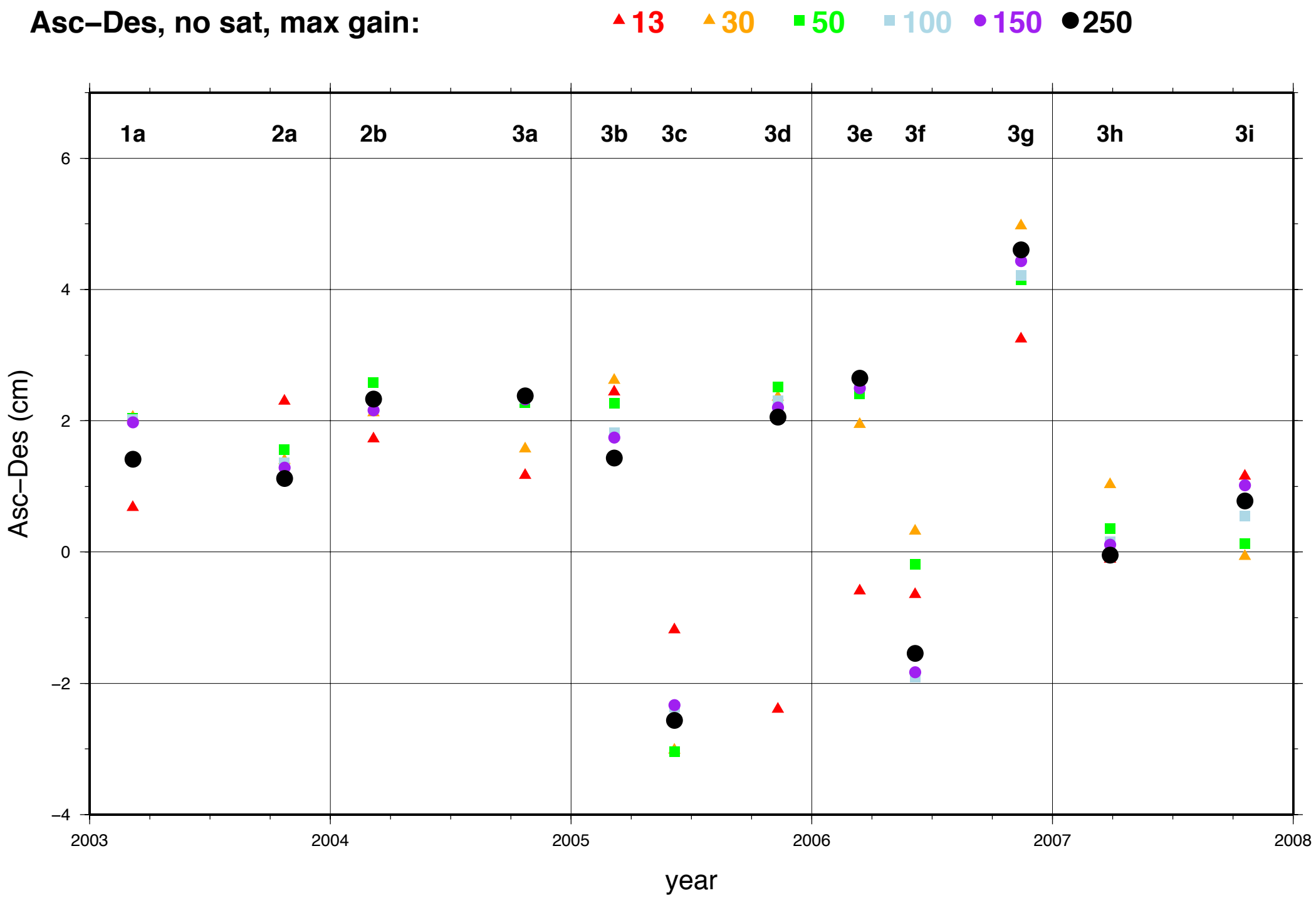
Ocean Bias

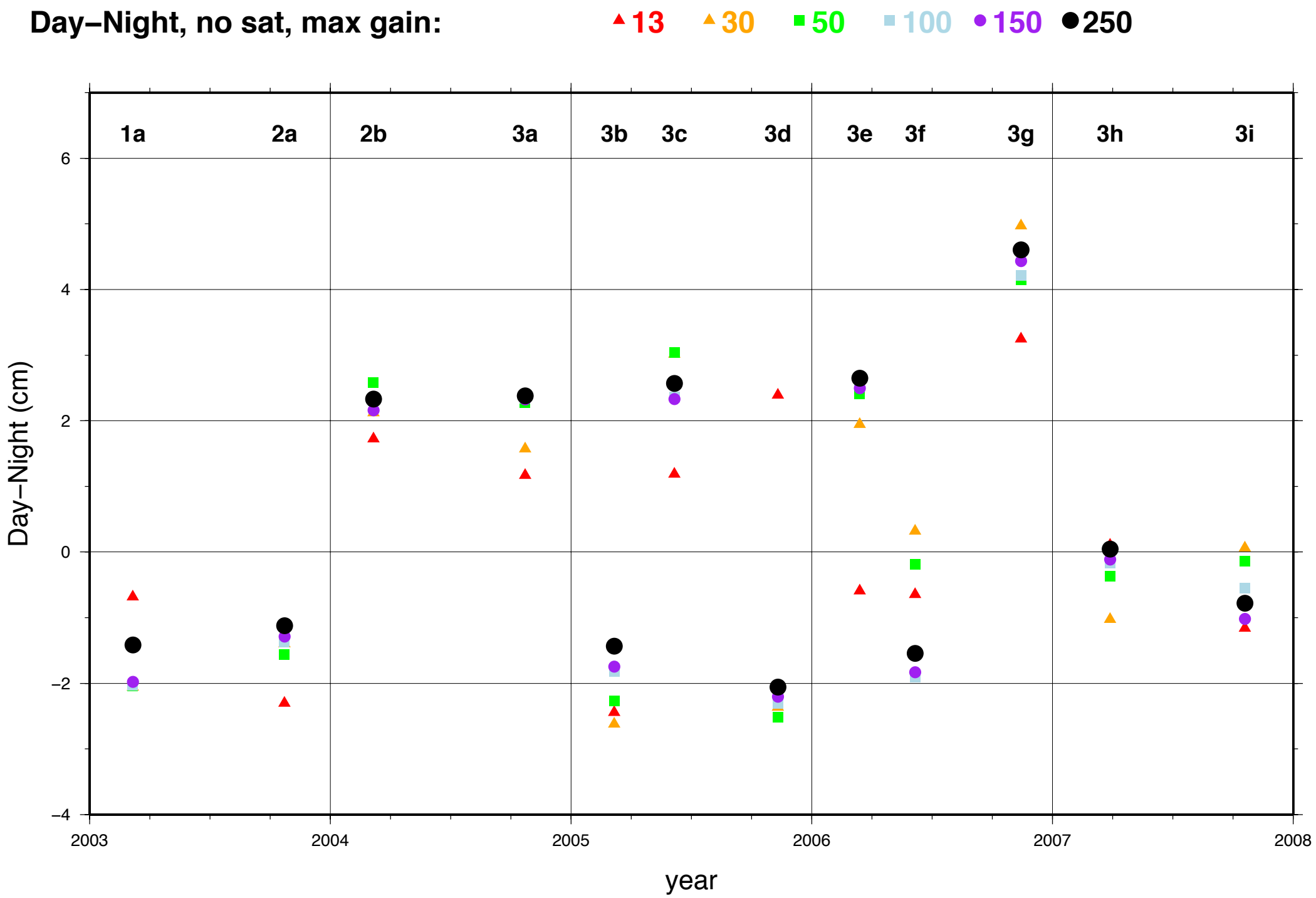

L2a 428
All data
All w/ satcorr
Sat w/o corr
Sat w/ corr
Not saturated
mean (cm)
rms (cm)
asc–des (cm)
npnts
doy
doy

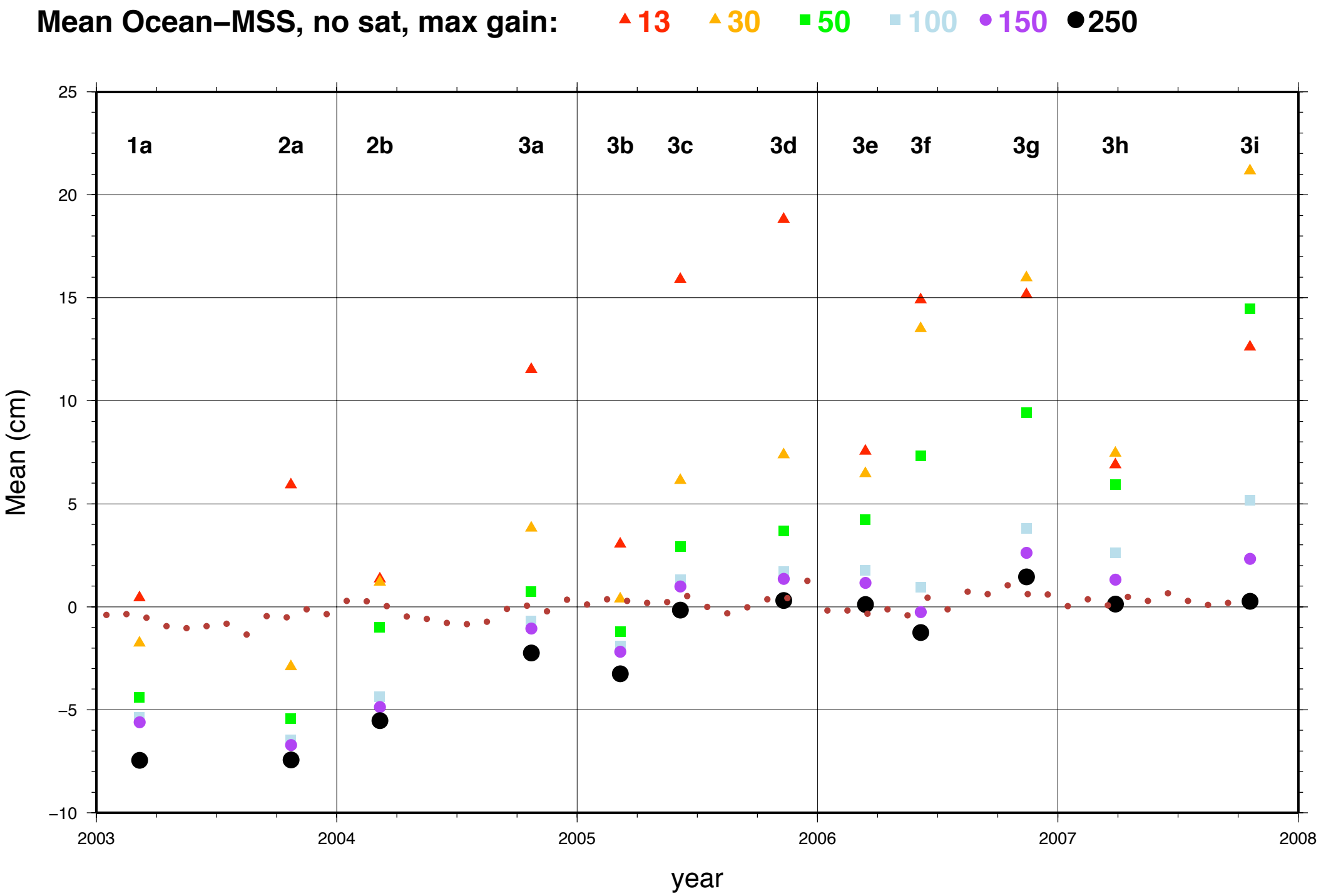

Mean Ocean–MSS, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Mean (cm)
year
25
20
15
10
5
0
−5
−10
2003
2004
2005
2006
2007
2008


RMS Ocean–MSS, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
RMS (cm)
60
55
50
45
40
35
30
25
20
2003
2004
2005
2006
2007
2008
year

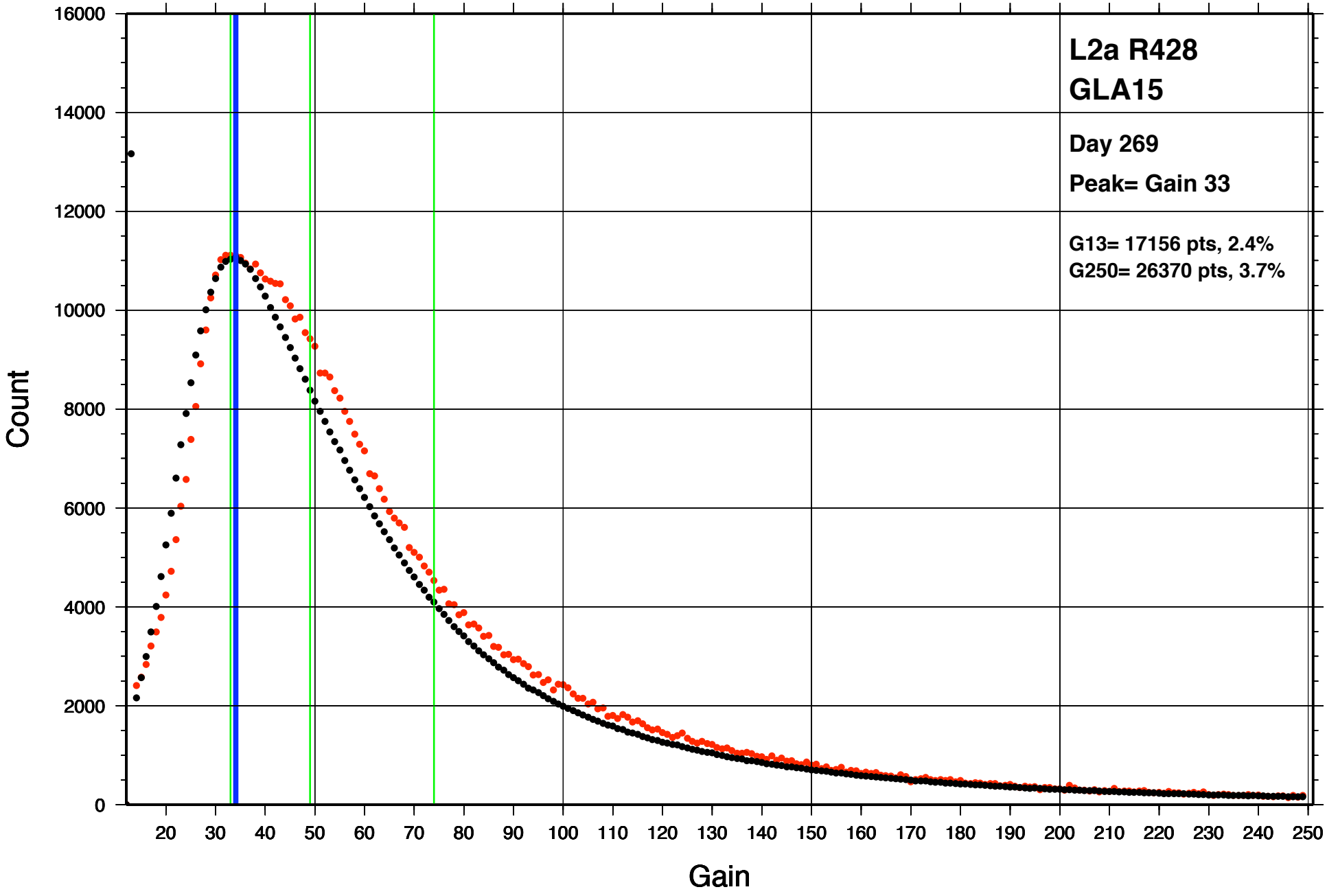

Ocean points per day, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Npnts
year
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2003
2004
2005
2006
2007
2008

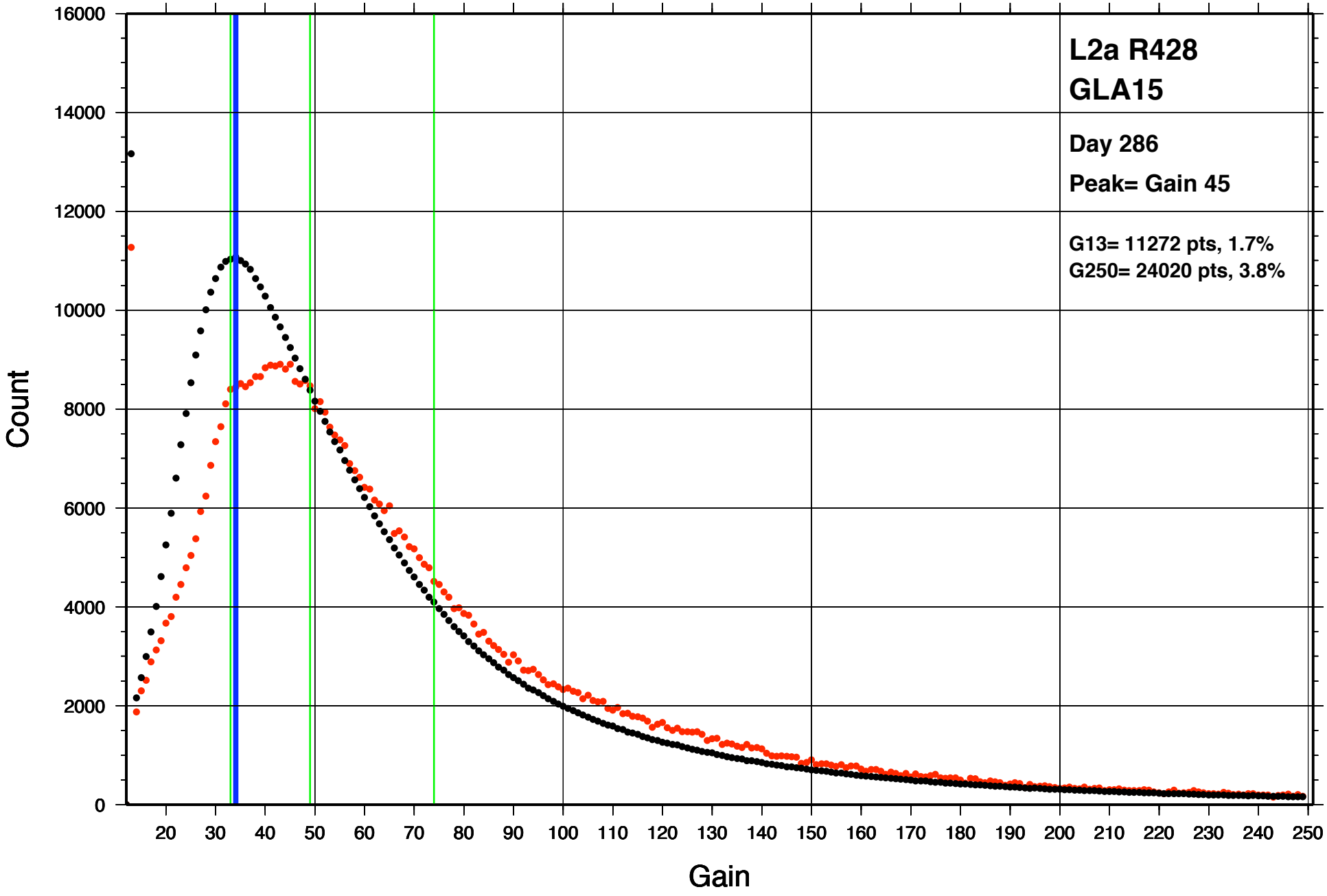

Asc−Des, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Asc−Des (cm)
2003
2004
2005
2006
2007
2008
year

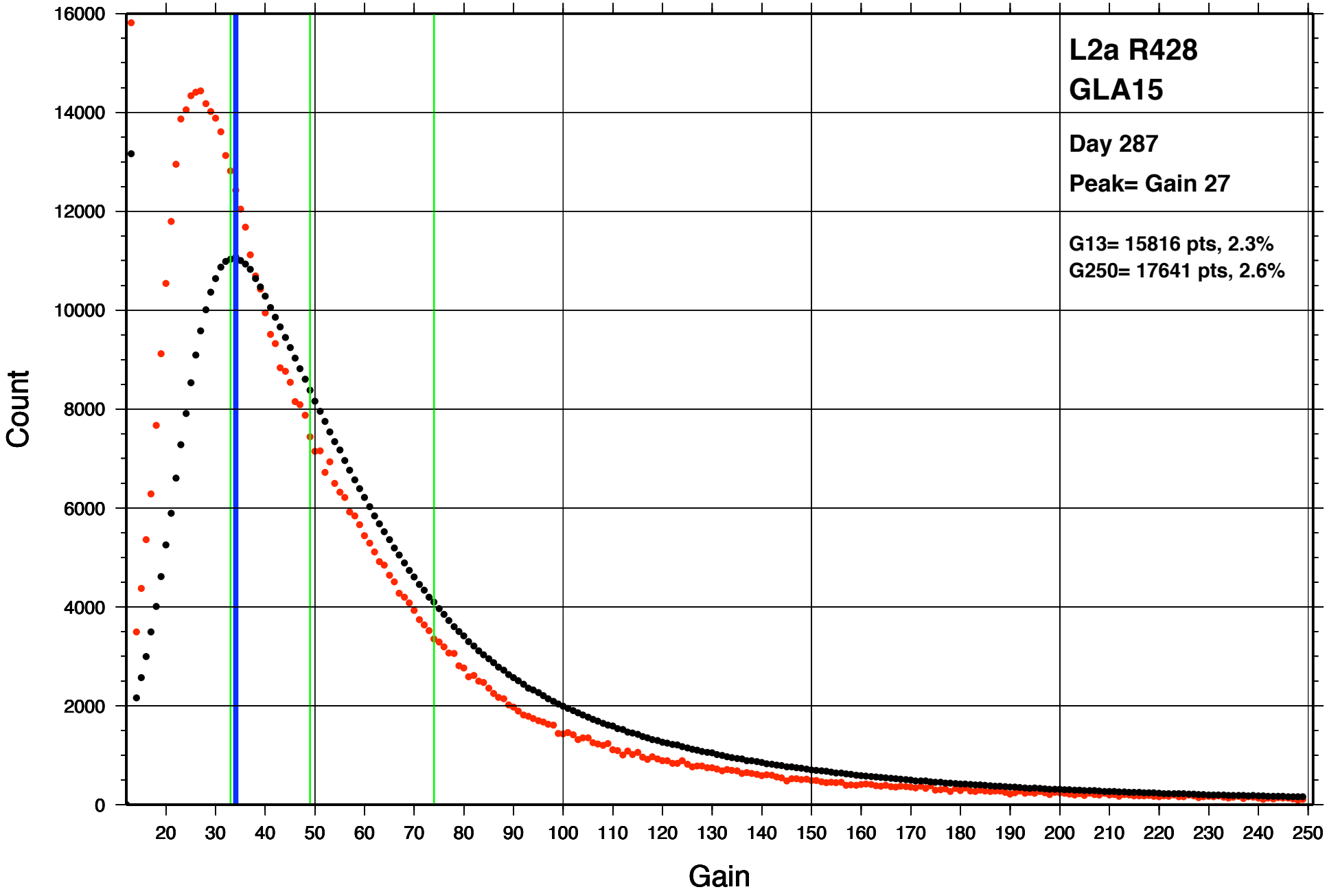

Day–Night, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Day–Night (cm)
2003
2004
2005
2006
2007
2008
year

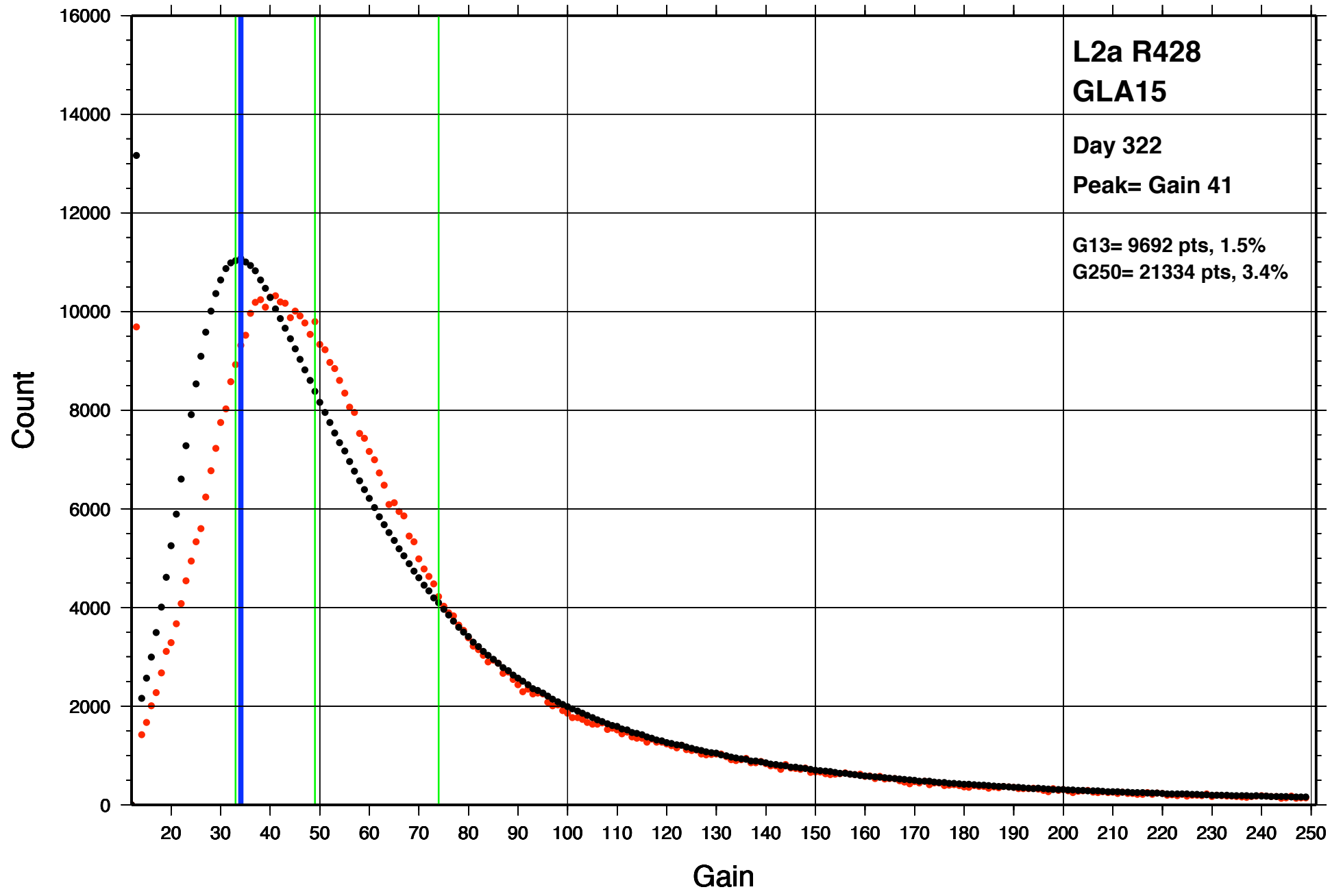

Mean Ocean–MSS, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Mean (cm)
year
25
20
15
10
5
0
−5
−10
2003
2004
2005
2006
2007
2008

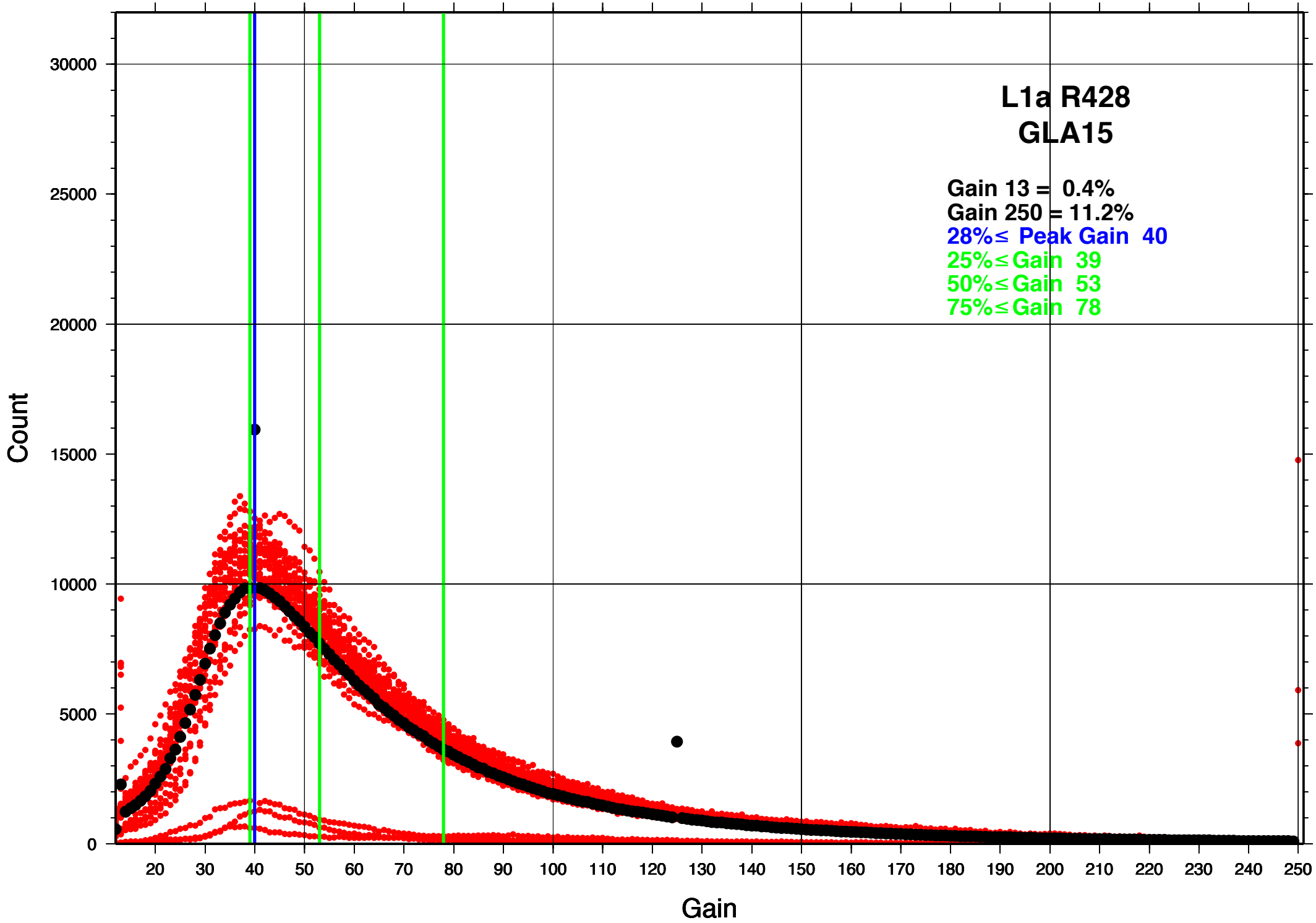
Gain


L2a R428
GLA15
Day 269
Peak= Gain 33
G13= 17156 pts, 2.4%
G250= 26370 pts, 3.7%
Count
Gain
0
2000
4000
6000
8000
10000
12000
14000
16000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L2a R428
GLA15
Day 286
Peak= Gain 45
G13= 11272 pts, 1.7%
G250= 24020 pts, 3.8%
Count
Gain
0
2000
4000
6000
8000
10000
12000
14000
16000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L2a R428
GLA15
Day 287
Peak= Gain 27
G13= 15816 pts, 2.3%
G250= 17641 pts, 2.6%
Count
Gain
0
2000
4000
6000
8000
10000
12000
14000
16000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L2a R428
GLA15
Day 322
Peak= Gain 41
G13= 9692 pts, 1.5%
G250= 21334 pts, 3.4%
Count
Gain
0
2000
4000
6000
8000
10000
12000
14000
16000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L1a R428
GLA15
Gain 13 = 0.4%
Gain 250 = 11.2%
28%≤ Peak Gain 40
25%≤Gain 39
50%≤Gain 53
75%≤Gain 78
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
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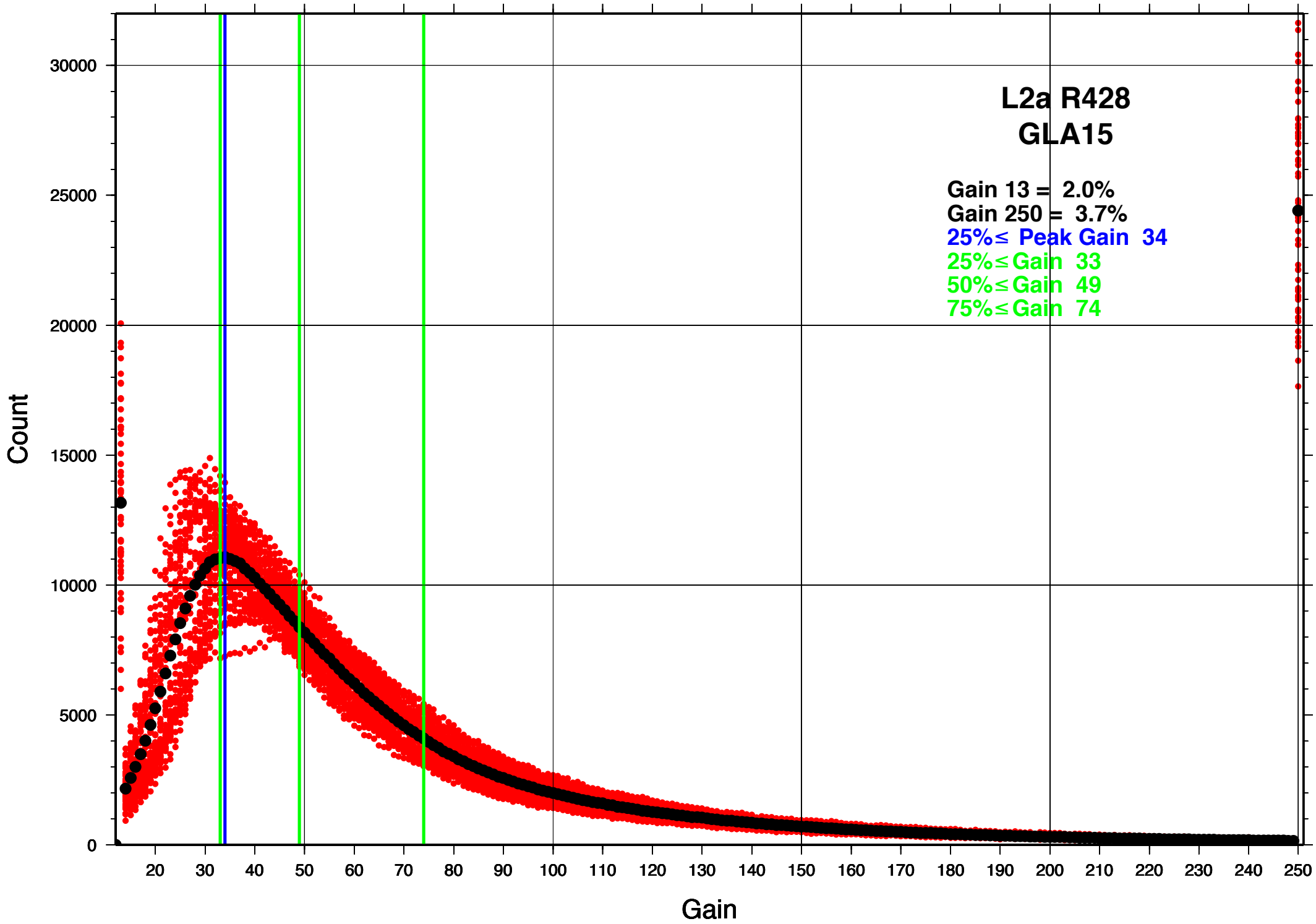
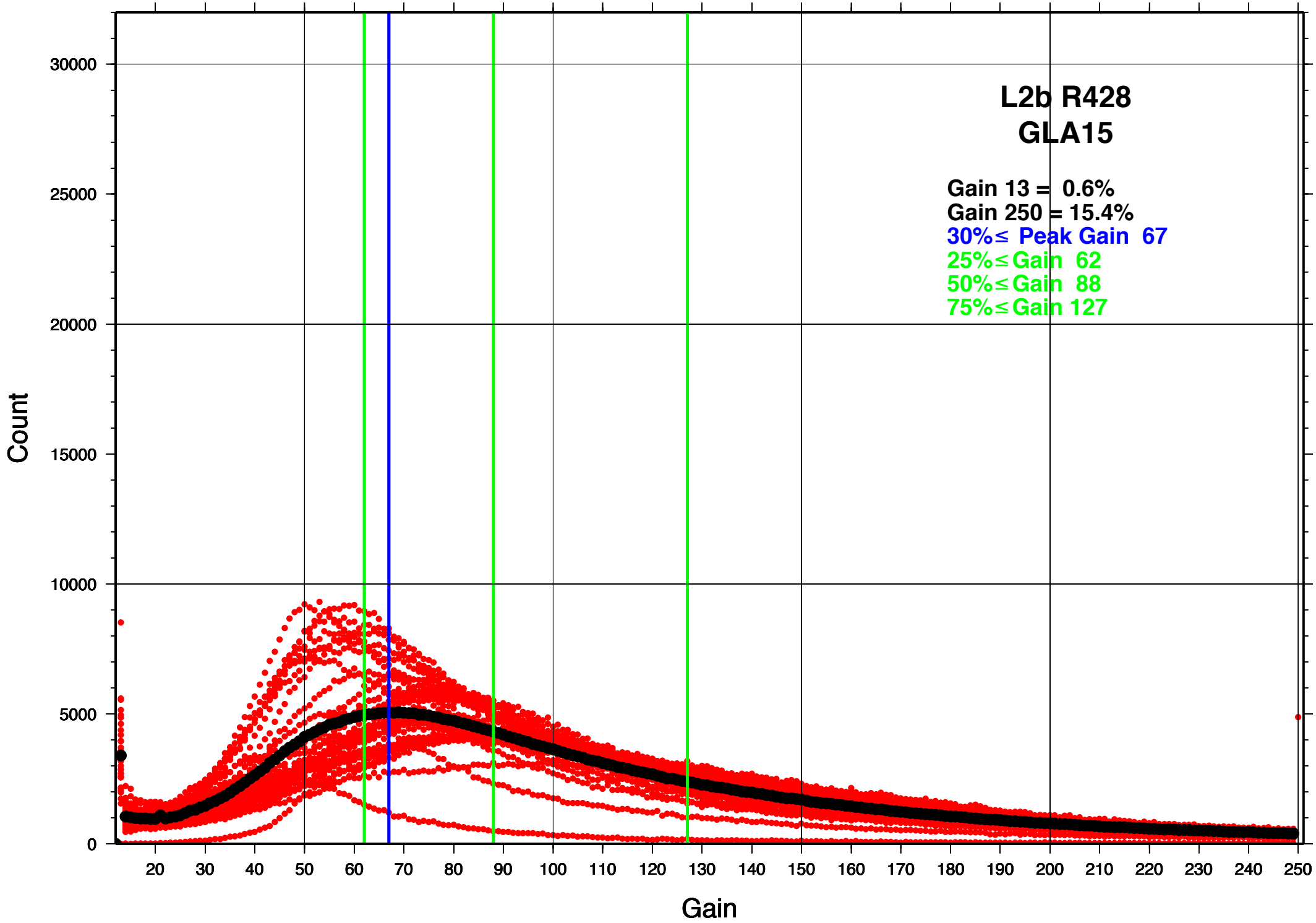
180
190
200
210
220
230
240
250


L2a R428
GLA15
Gain 13 = 2.0%
Gain 250 = 3.7%
25%≤ Peak Gain 34
25%≤Gain 33
50%≤Gain 49
75%≤Gain 74
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L2b R428
GLA15
Gain 13 = 0.6%
Gain 250 = 15.4%
30%≤ Peak Gain 67
25%≤Gain 62
50%≤Gain 88
75%≤Gain 127
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
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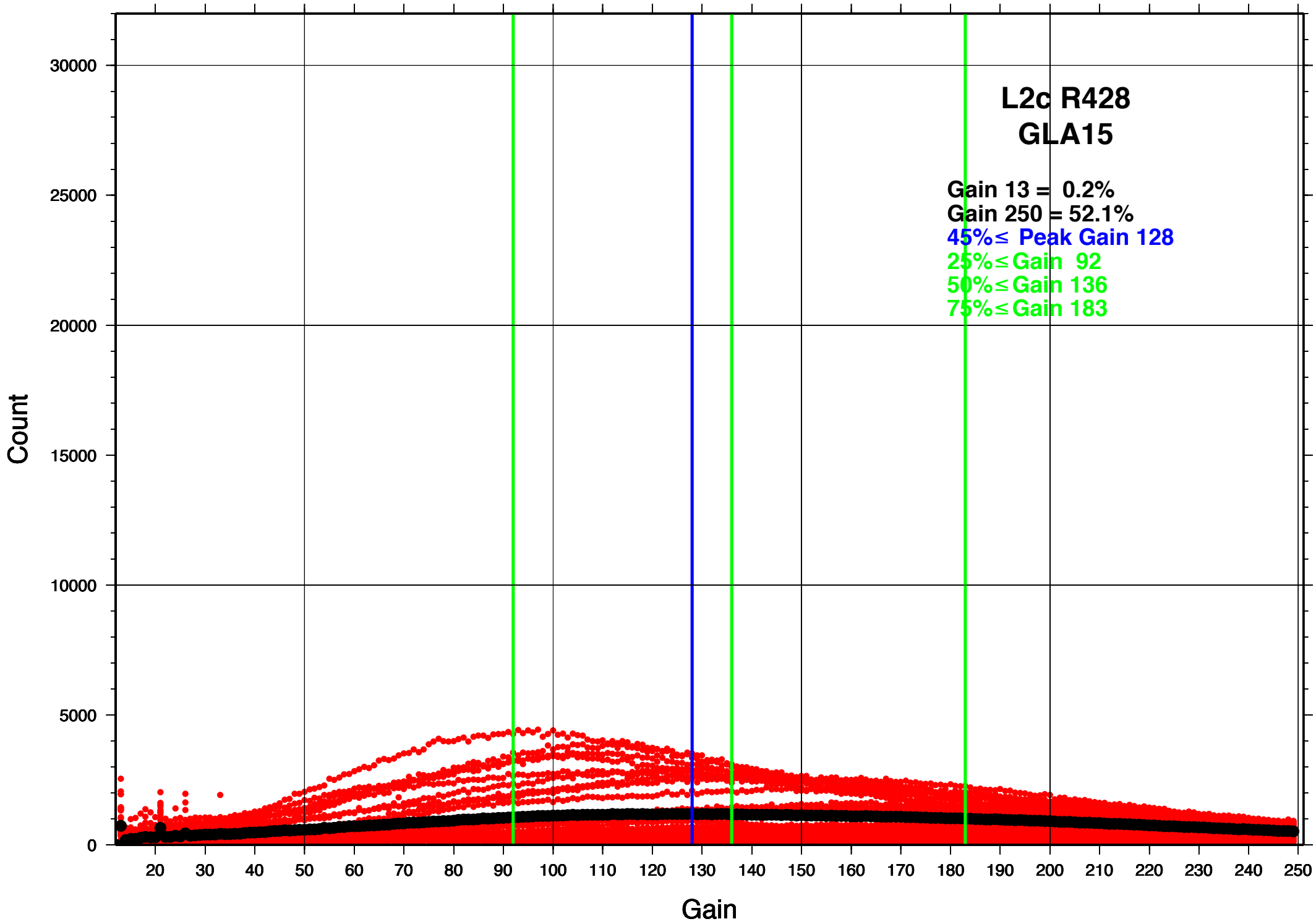
180
190
200
210
220
230
240
250


L2c R428
GLA15
Gain 13 = 0.2%
Gain 250 = 52.1%
45%≤ Peak Gain 128
25%≤Gain 92
50%≤Gain 136
75%≤Gain 183
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
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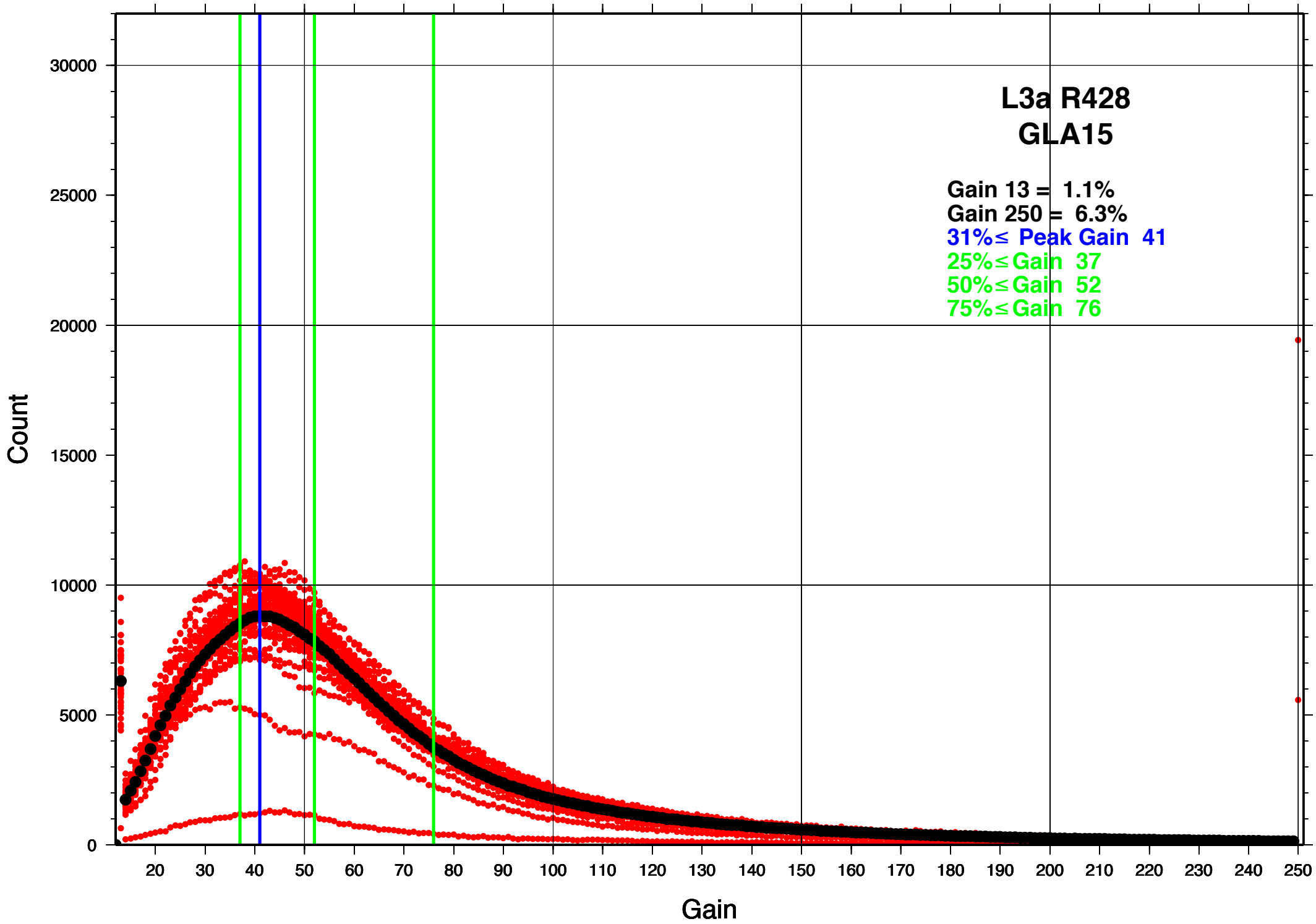
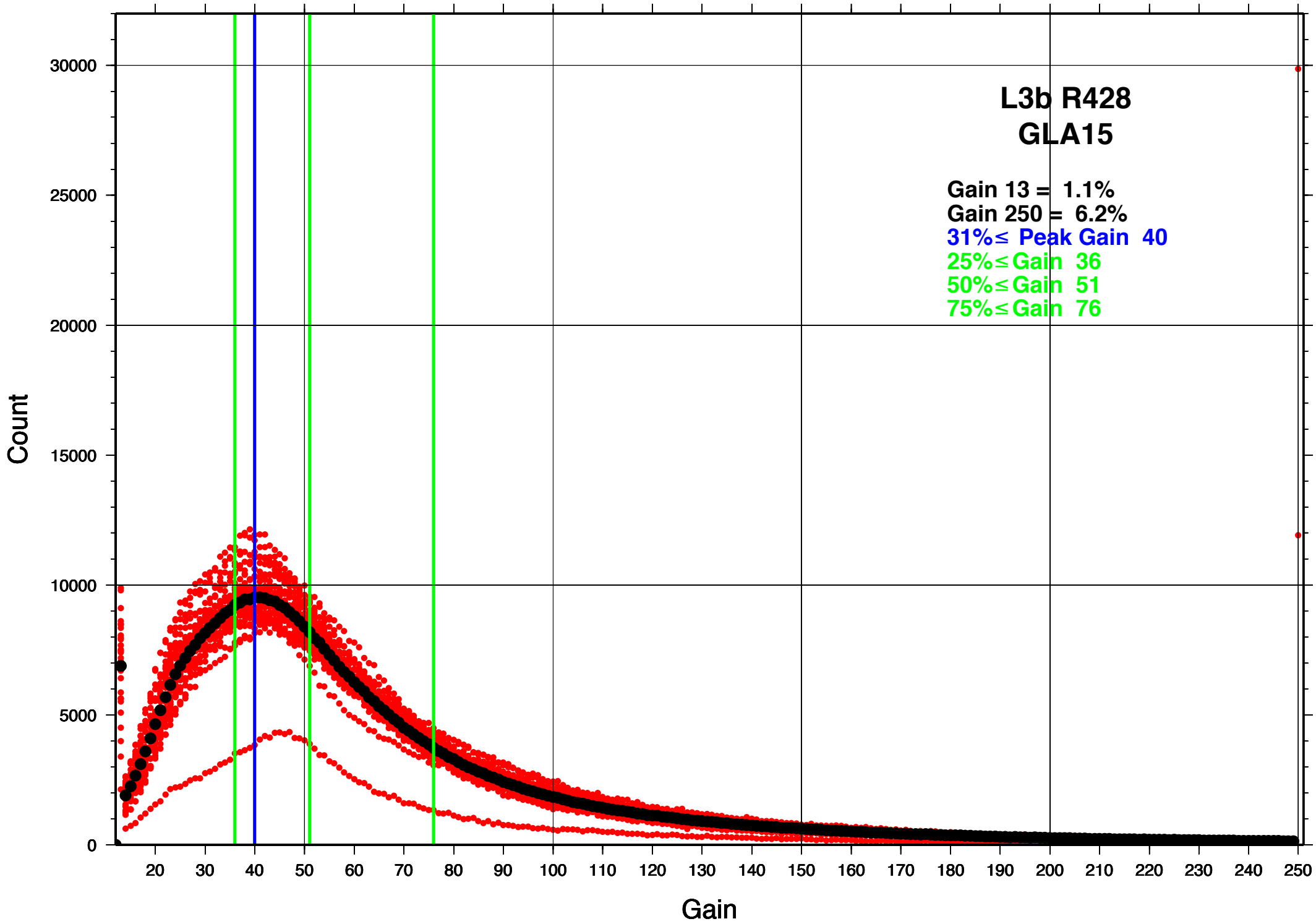
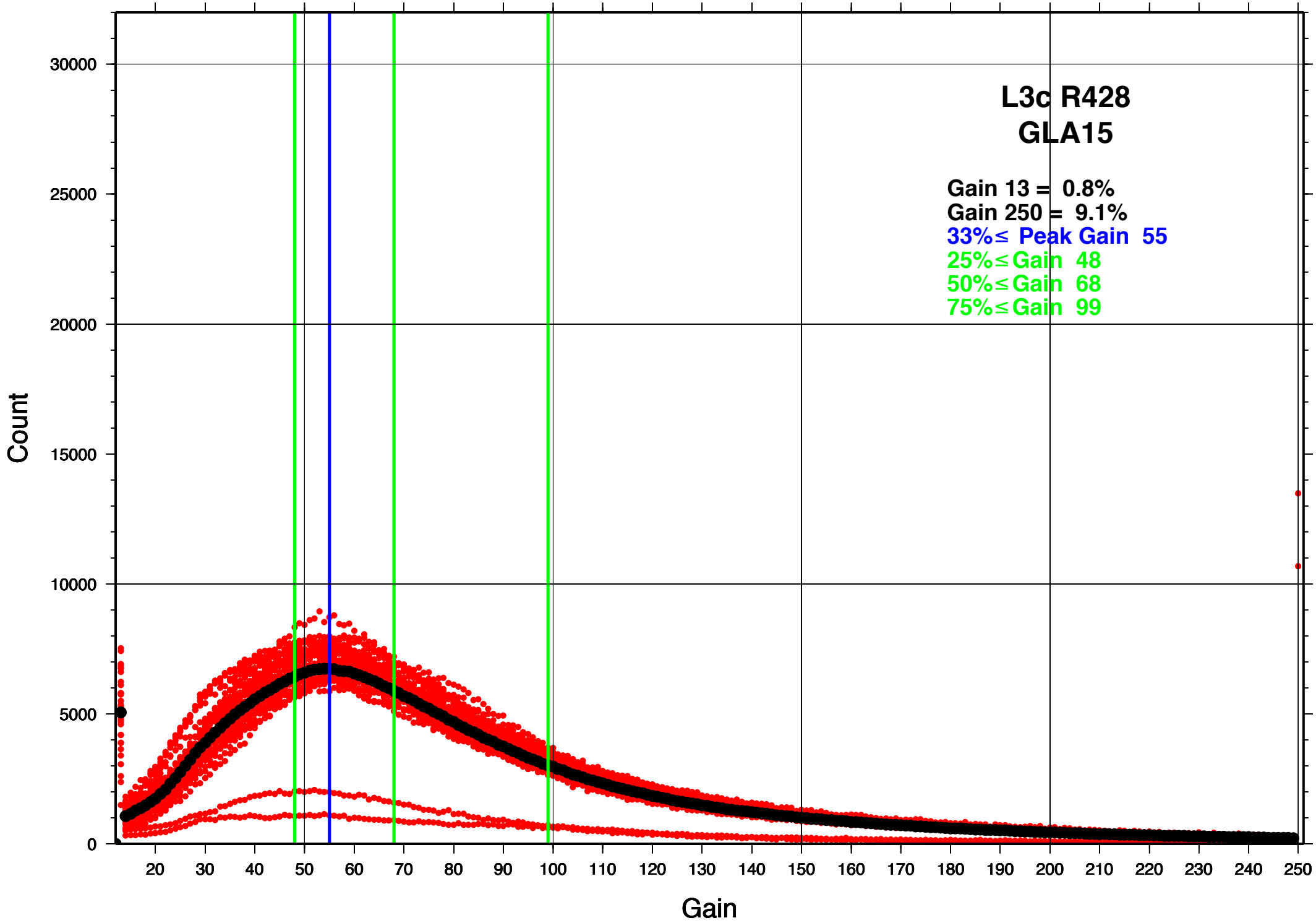
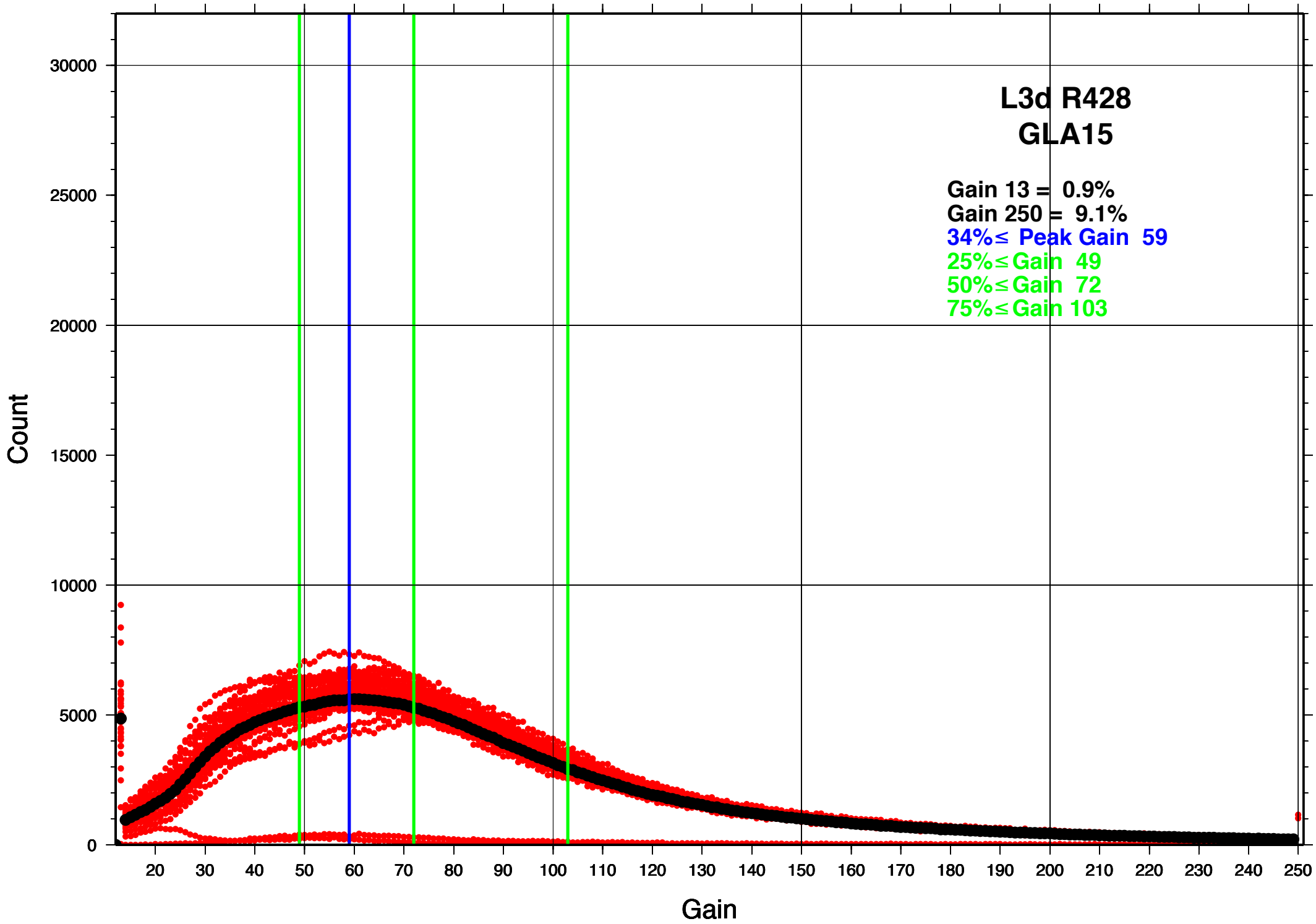
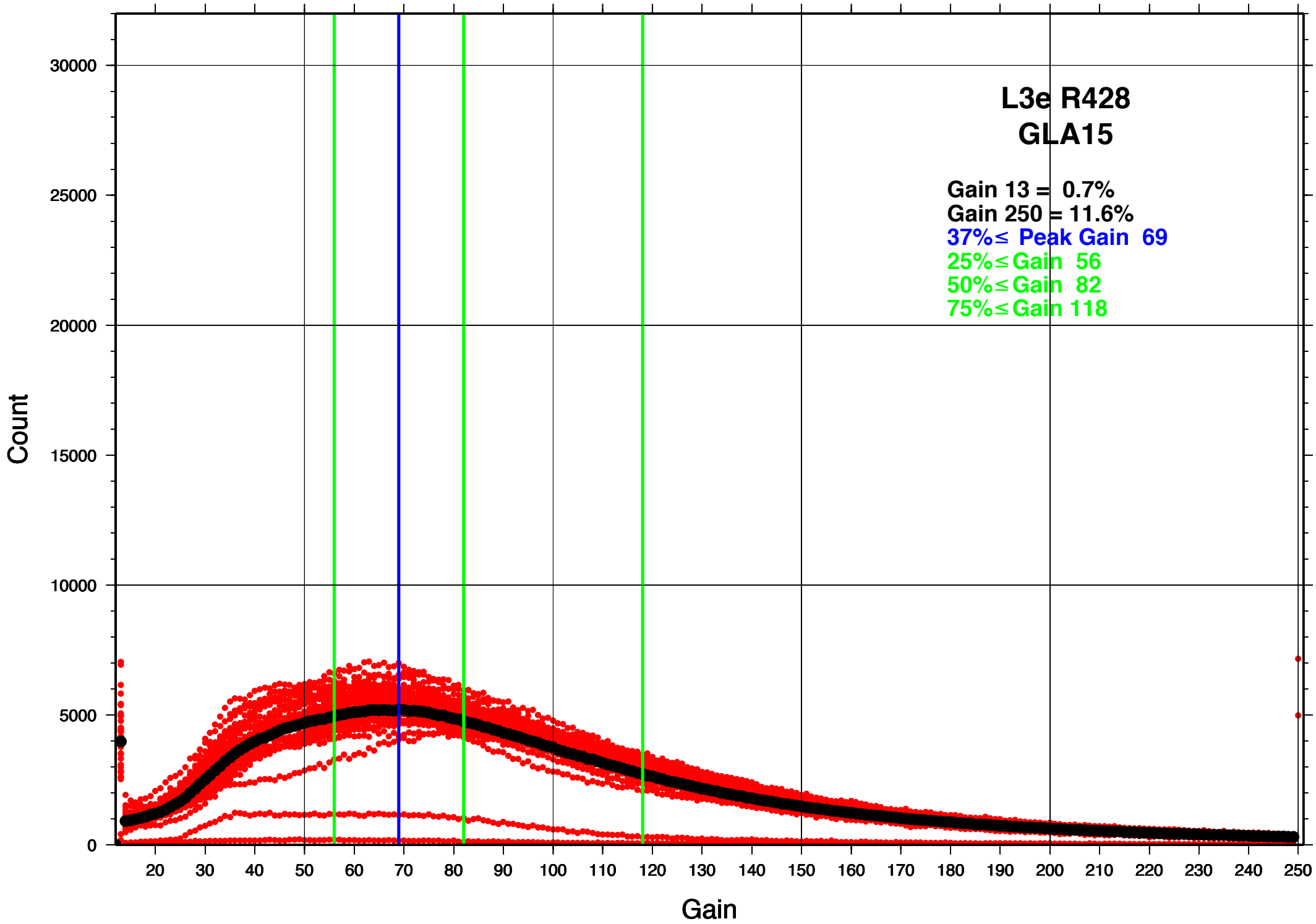
190
200
210
220
230
240
250

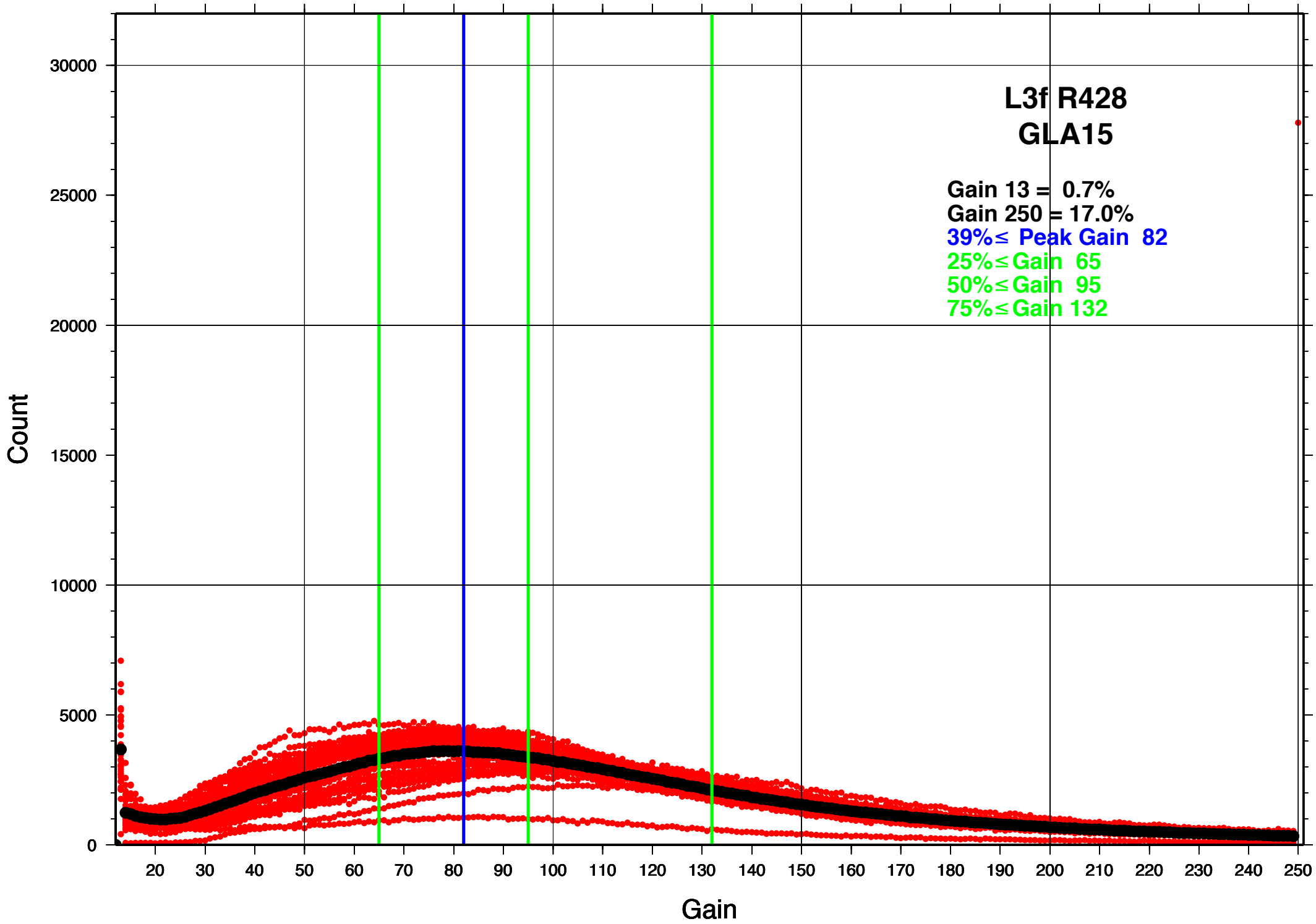

L3a R428
GLA15
Gain 13 = 1.1%
Gain 250 = 6.3%
31%≤ Peak Gain 41
25%≤Gain 37
50%≤Gain 52
75%≤Gain 76
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

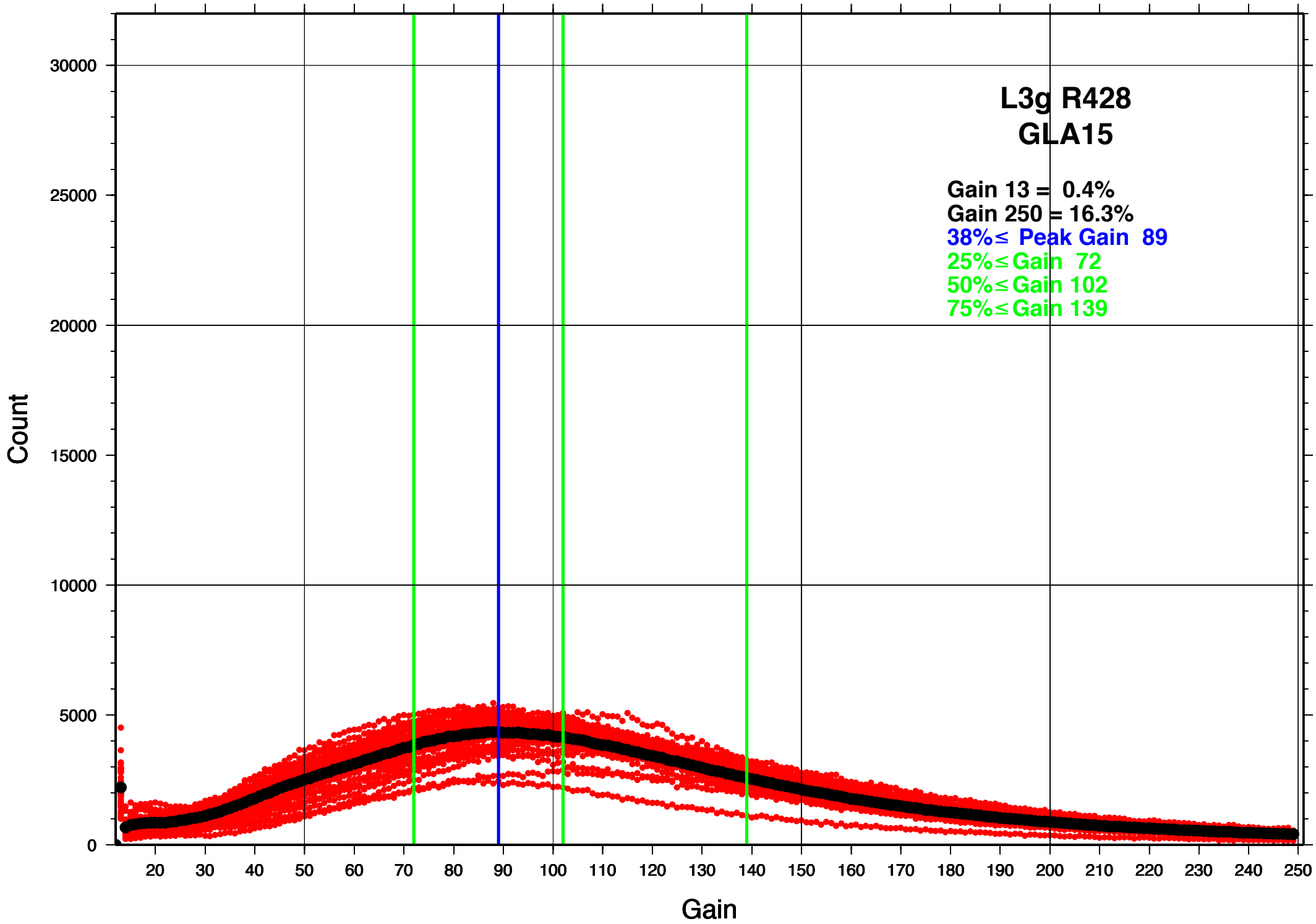

L3b R428
GLA15
Gain 13 = 1.1%
Gain 250 = 6.2%
31%≤ Peak Gain 40
25%≤Gain 36
50%≤Gain 51
75%≤Gain 76
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

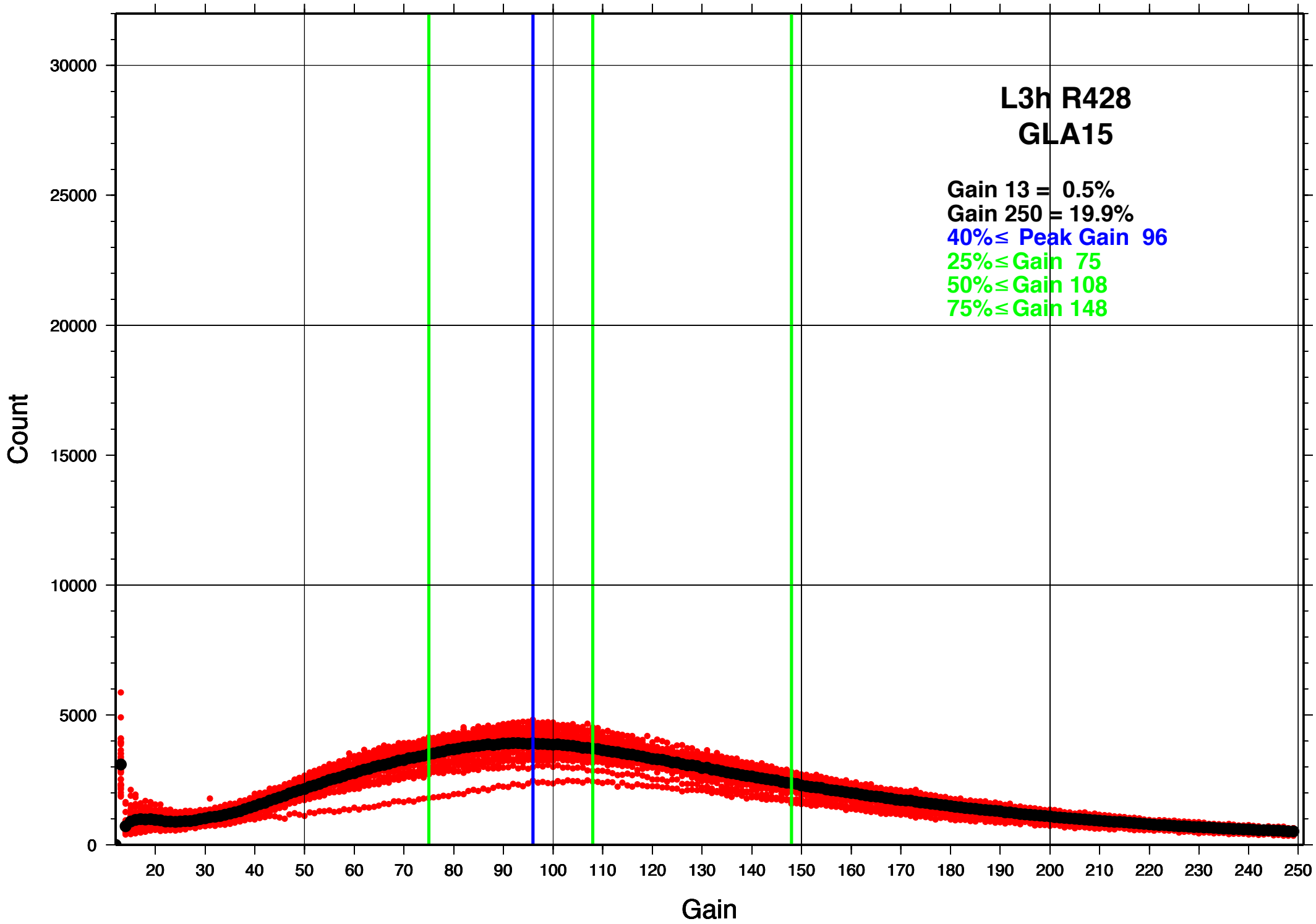

L3c R428
GLA15
Gain 13 = 0.8%
Gain 250 = 9.1%
33%≤ Peak Gain 55
25%≤Gain 48
50%≤Gain 68
75%≤Gain 99
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

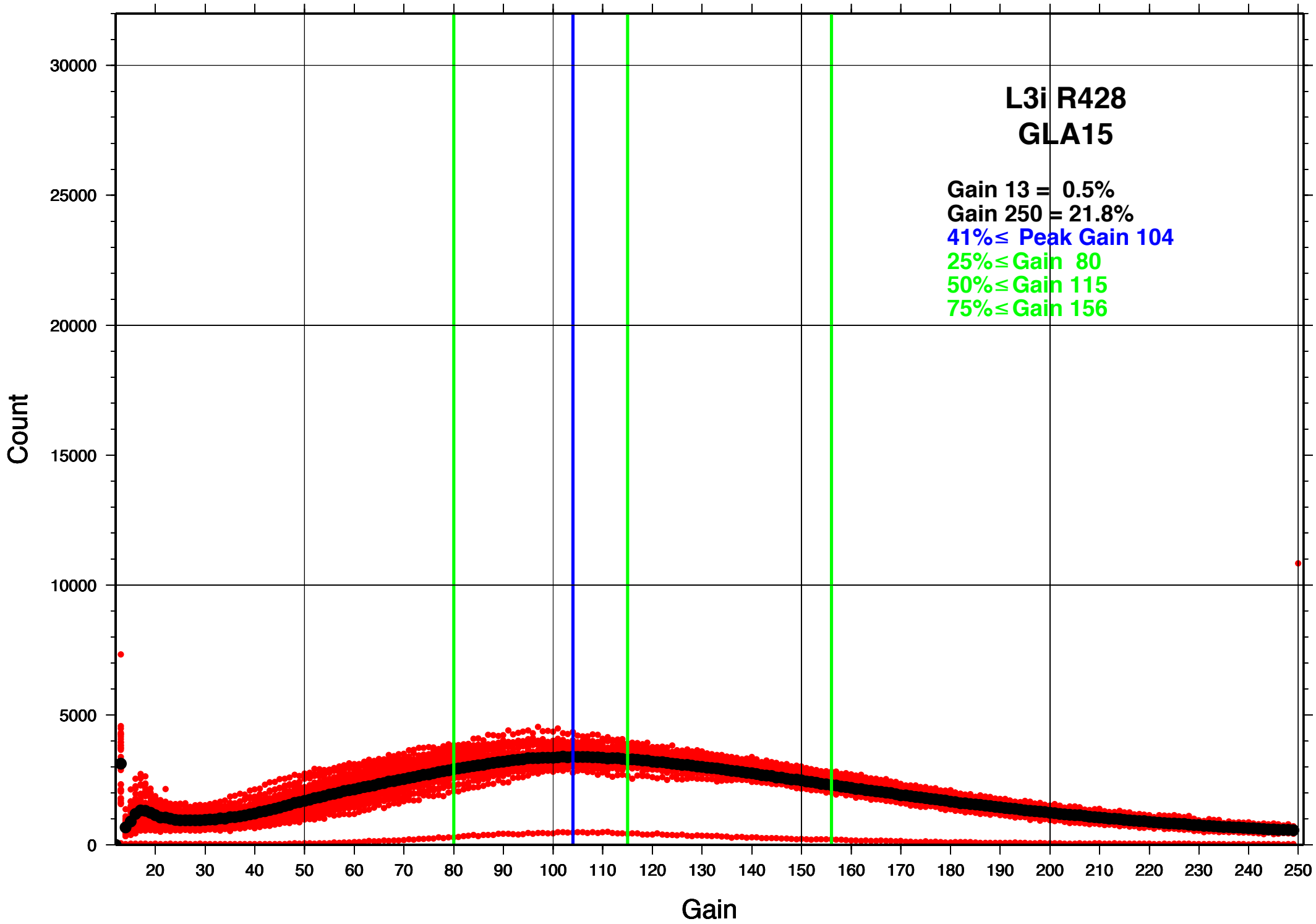

L3d R428
GLA15
Gain 13 = 0.9%
Gain 250 = 9.1%
34%≤ Peak Gain 59
25%≤Gain 49
50%≤Gain 72
75%≤Gain 103
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

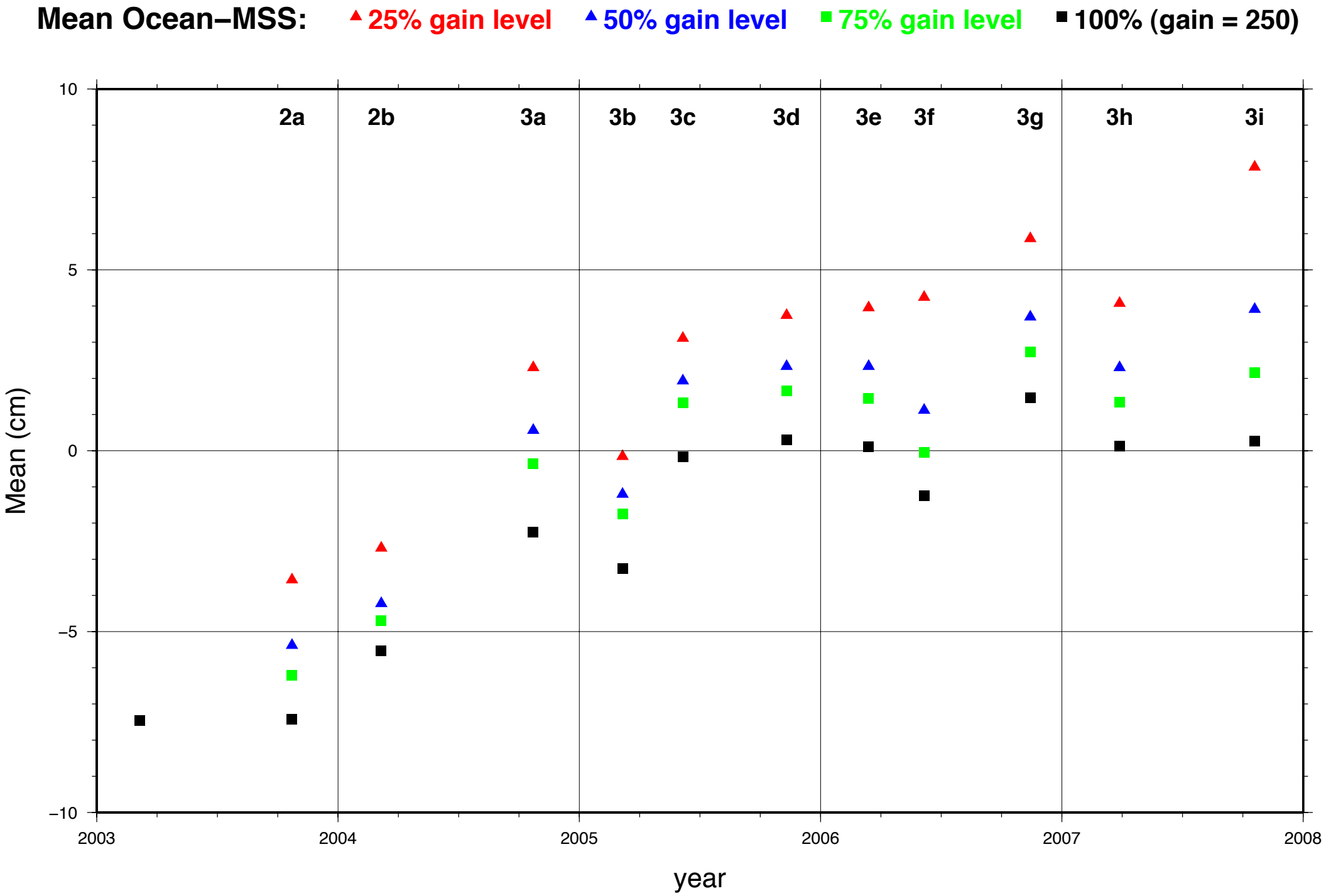

L3e R428
GLA15
Gain 13 = 0.7%
Gain 250 = 11.6%
37%≤ Peak Gain 69
25%≤Gain 56
50%≤Gain 82
75%≤Gain 118
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

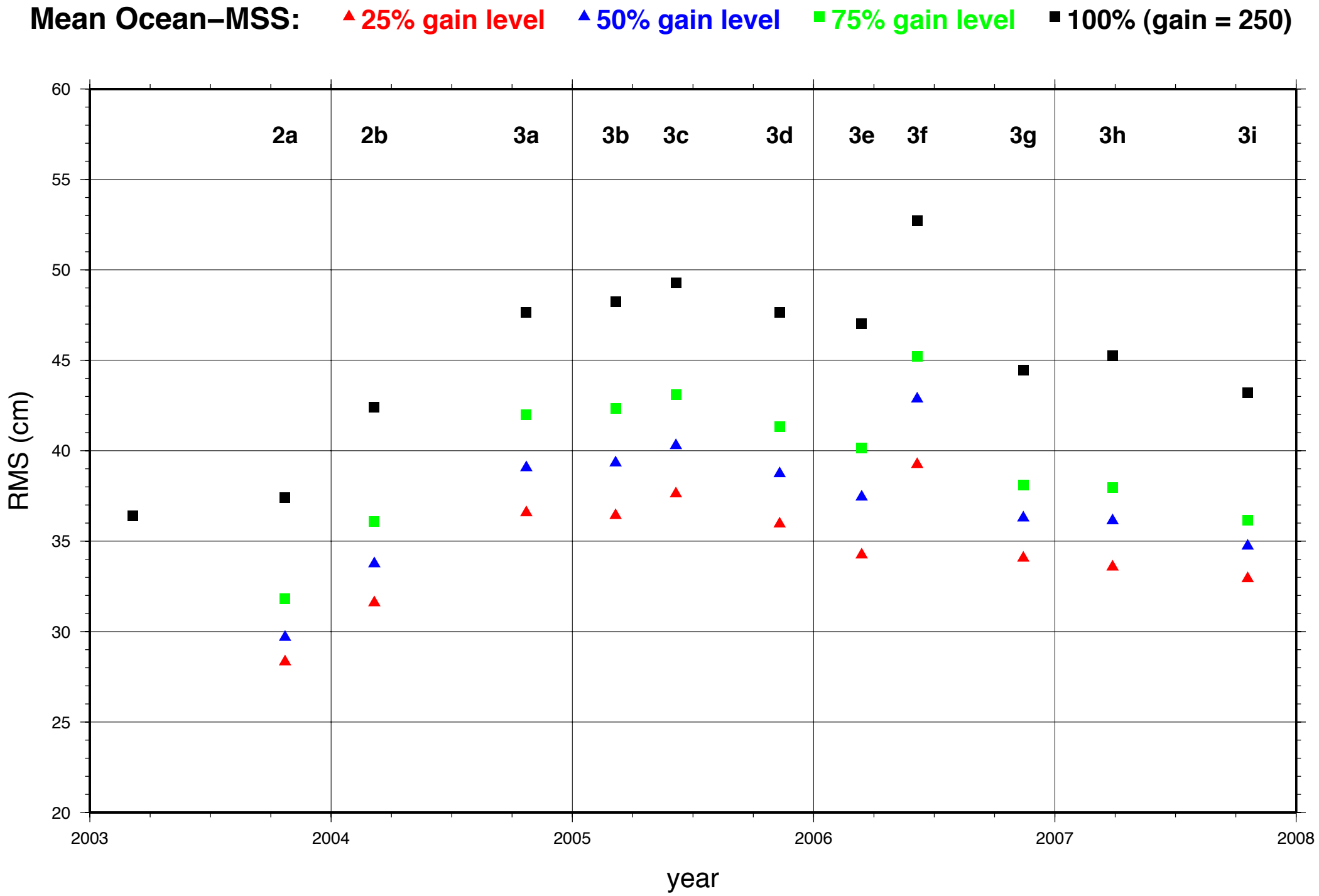

L3f R428
GLA15
Gain 13 = 0.7%
Gain 250 = 17.0%
39%≤ Peak Gain 82
25%≤Gain 65
50%≤Gain 95
75%≤Gain 132
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

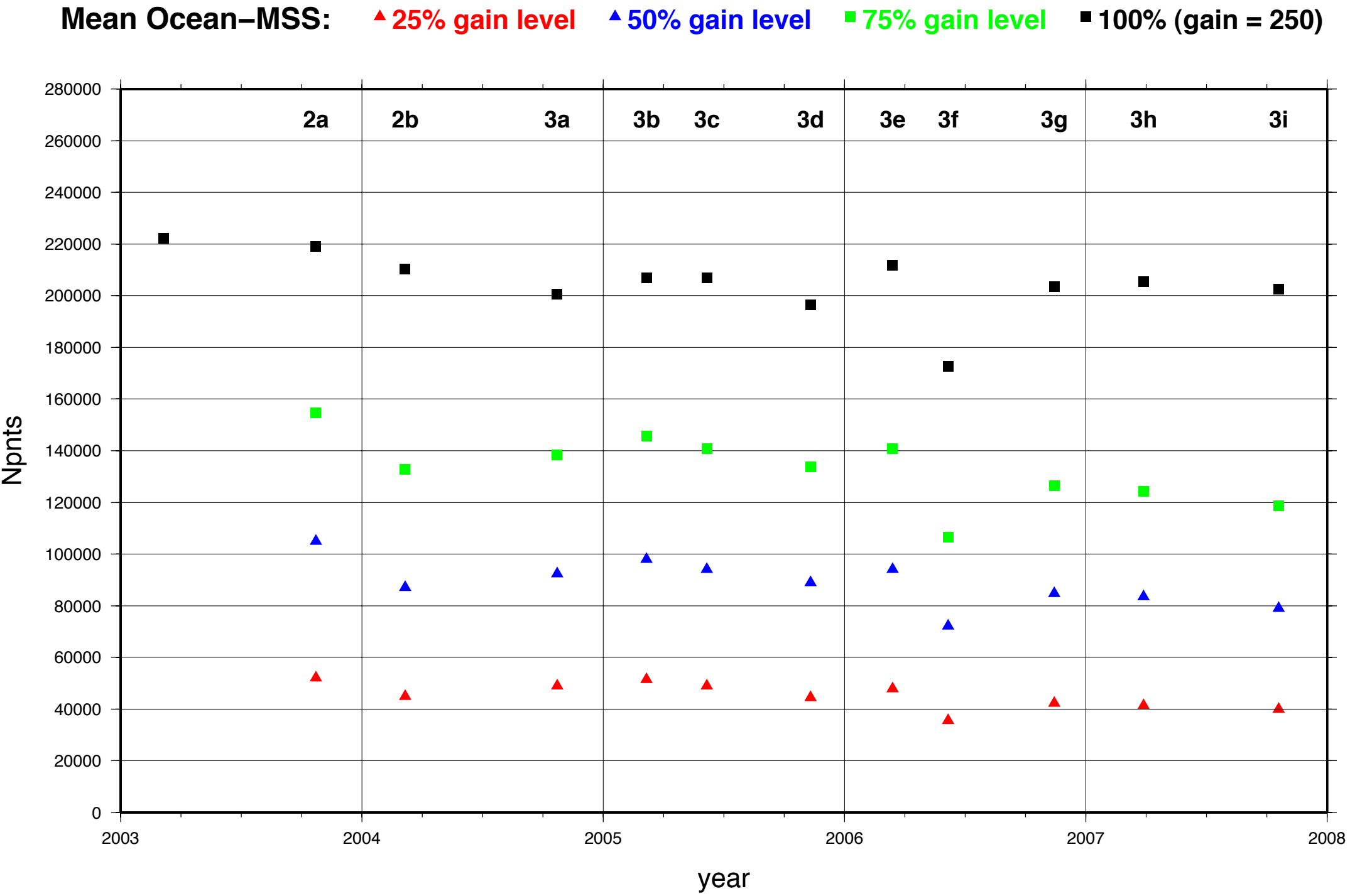

L3g R428
GLA15
Gain 13 = 0.4%
Gain 250 = 16.3%
38%≤ Peak Gain 89
25%≤Gain 72
50%≤Gain 102
75%≤Gain 139
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

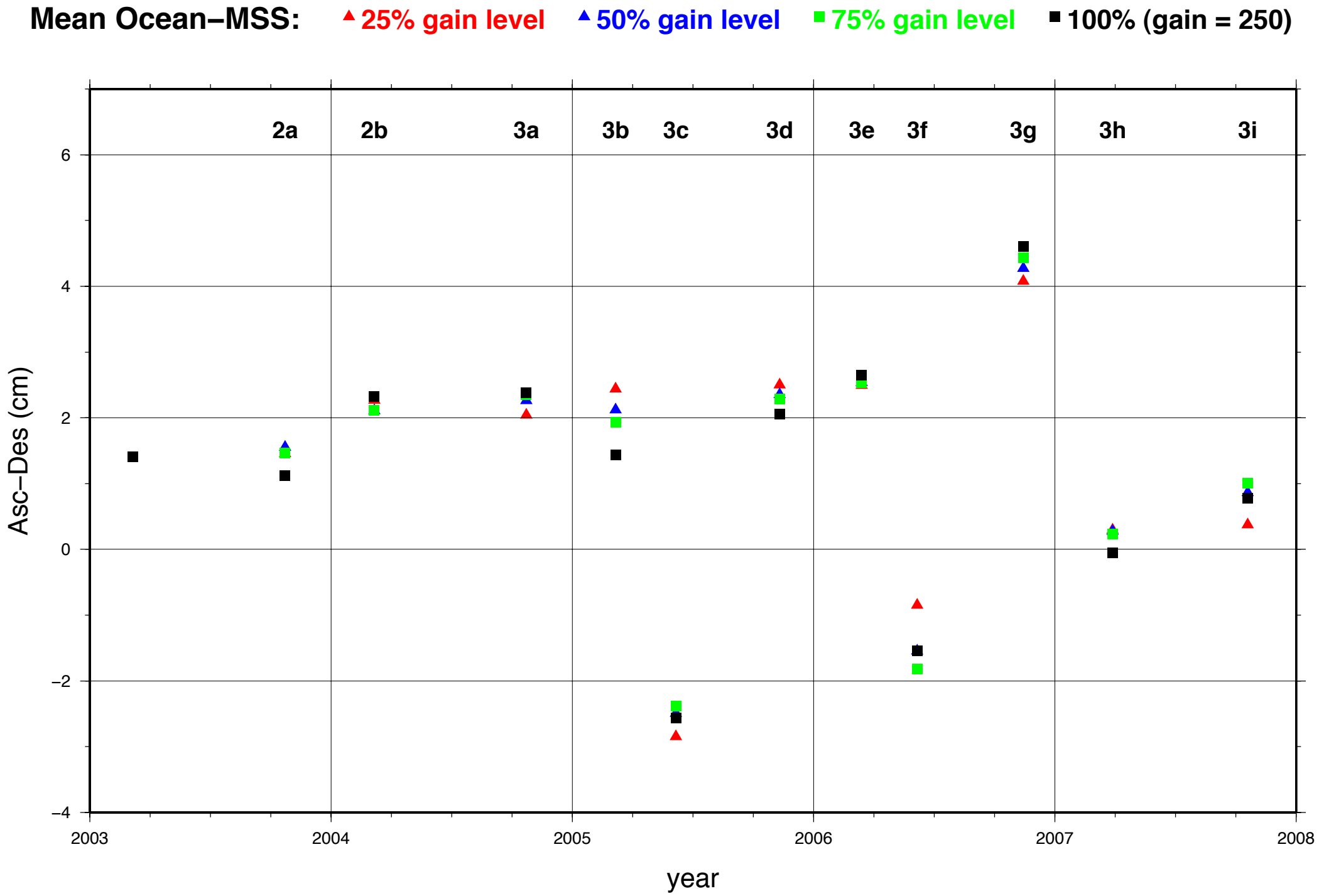

L3h R428
GLA15
Gain 13 = 0.5%
Gain 250 = 19.9%
40%≤ Peak Gain 96
25%≤Gain 75
50%≤Gain 108
75%≤Gain 148
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L3i R428
GLA15
Gain 13 = 0.5%
Gain 250 = 21.8%
41%≤ Peak Gain 104
25%≤Gain 80
50%≤Gain 115
75%≤Gain 156
Count
Gain
0
5000
10000
15000
20000
25000
30000
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

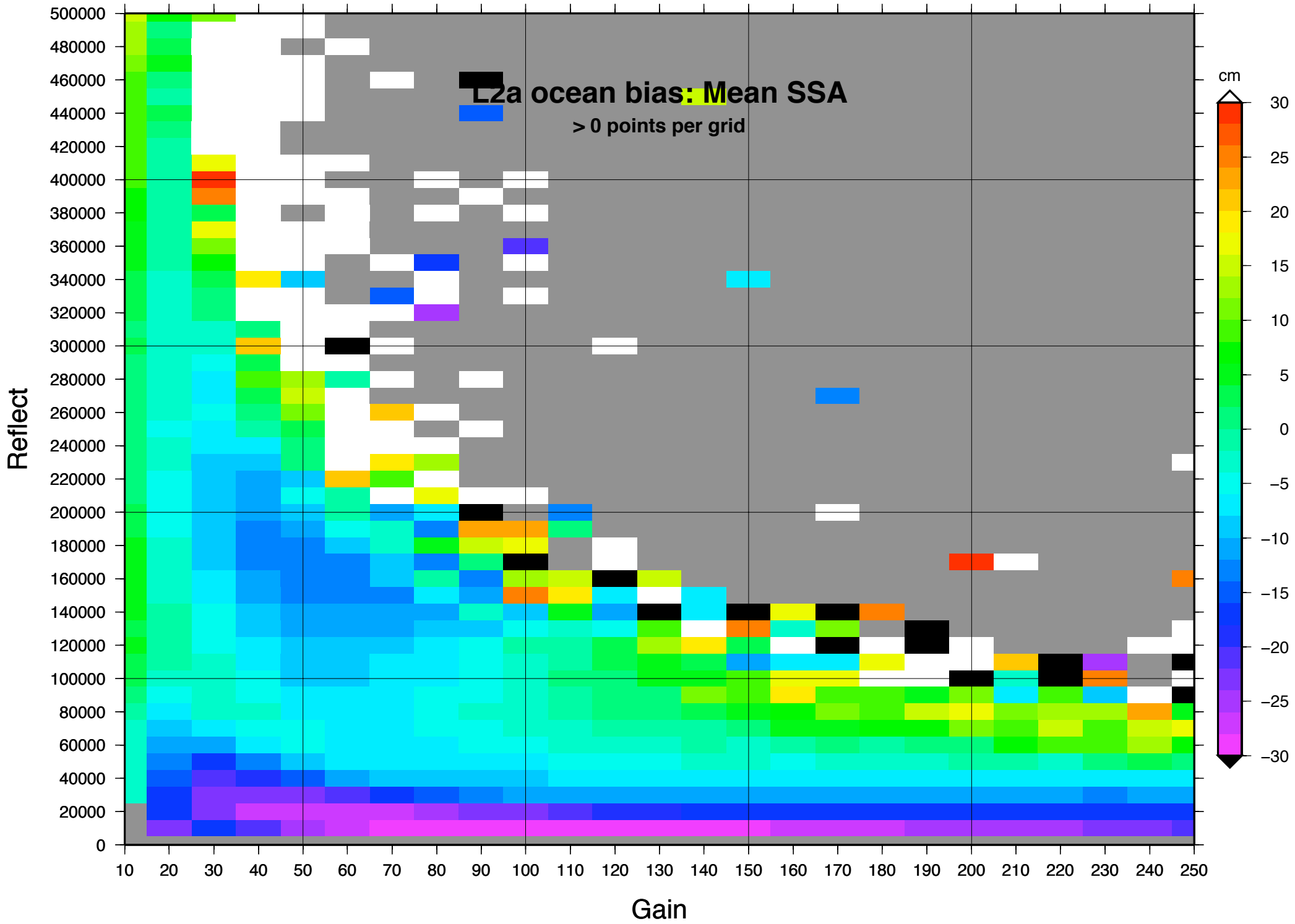

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
10
5
0
−5
−10
Mean (cm)
2003
2004
2005
2006
2007
2008
year

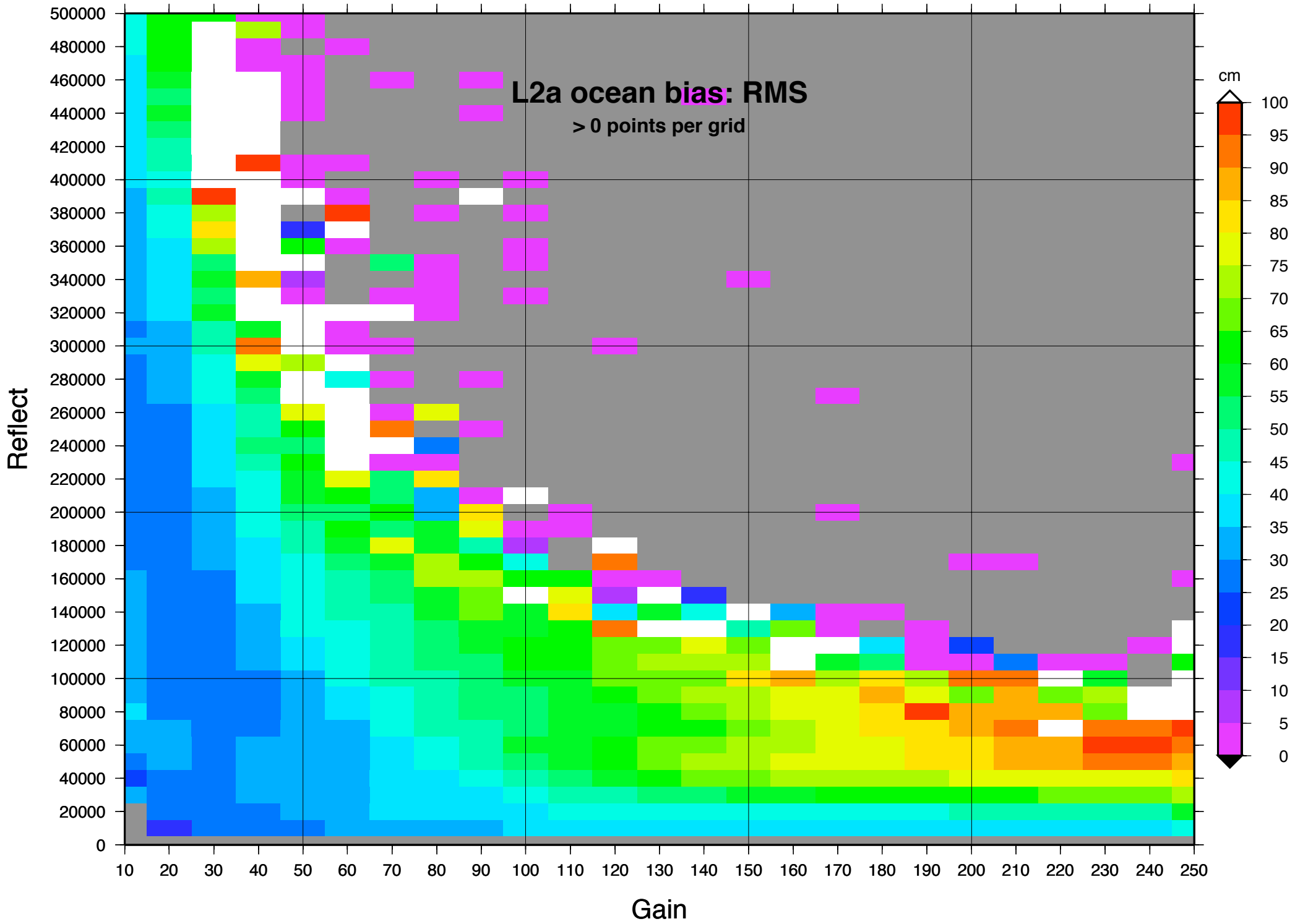

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
RMS (cm)
60
55
50
45
40
35
30
25
20
2003
2004
2005
2006
2007
2008
year

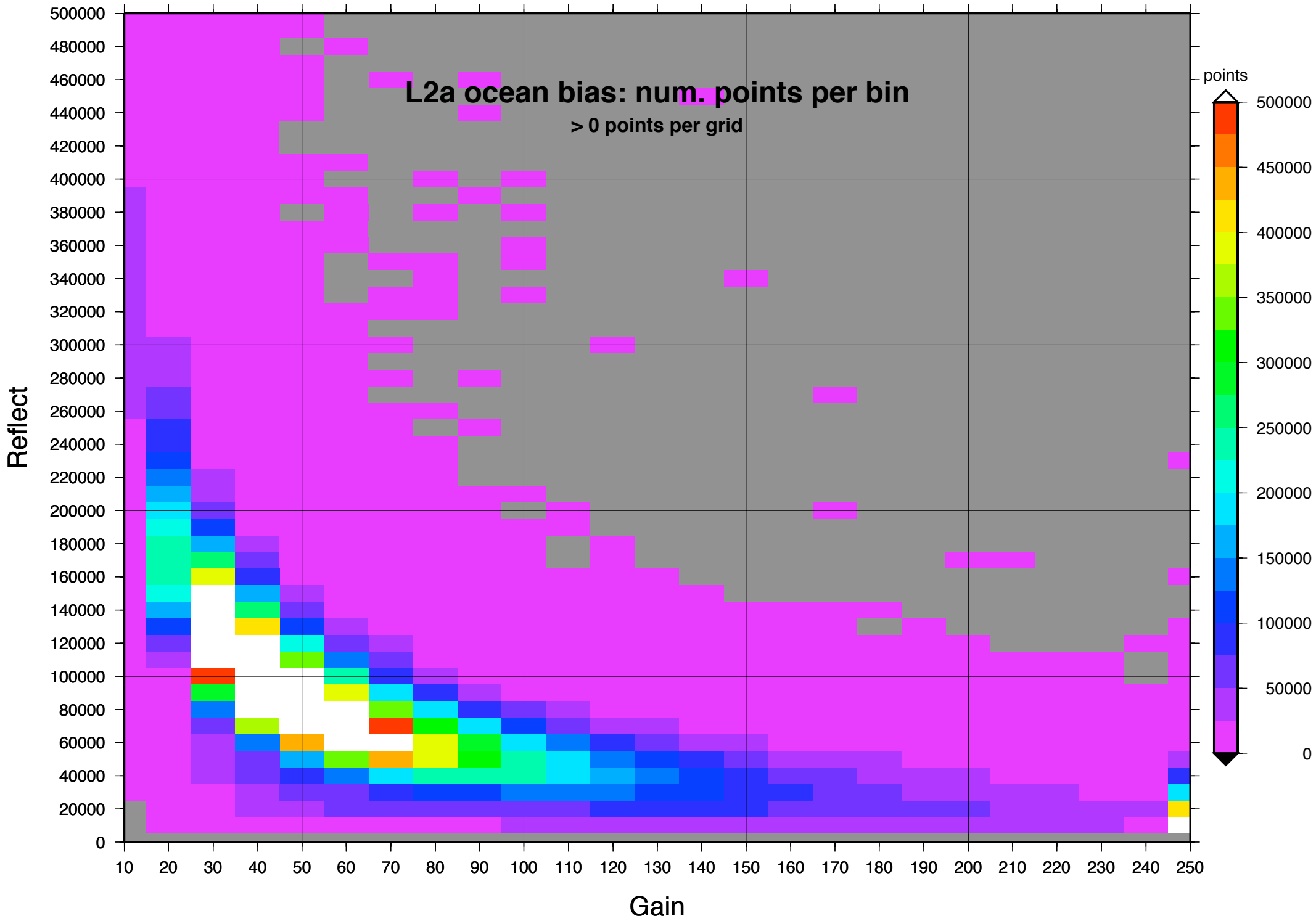

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Npnts
year
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2003
2004
2005
2006
2007
2008

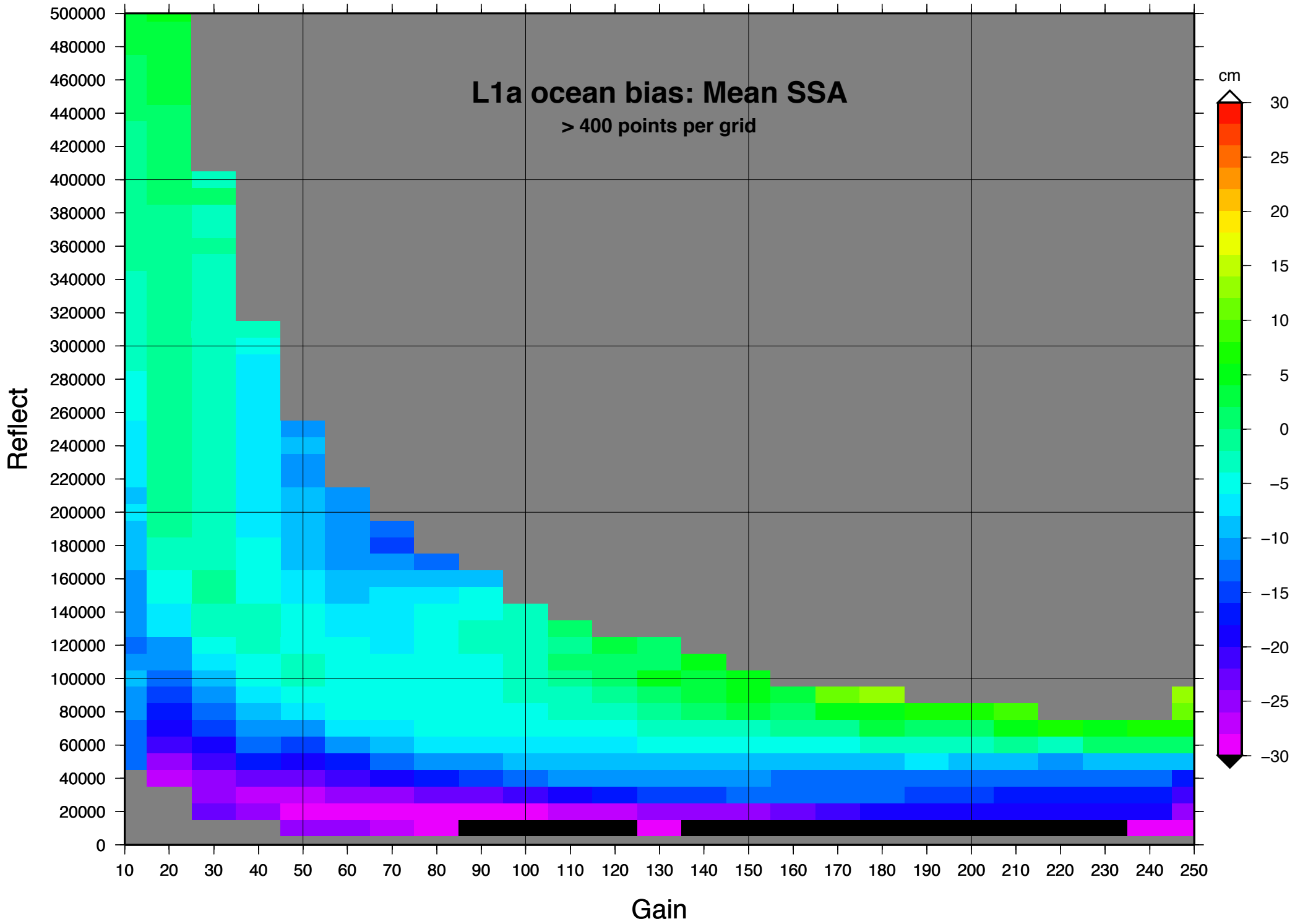

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Asc–Des (cm)
2003
2004
2005
2006
2007
2008
year

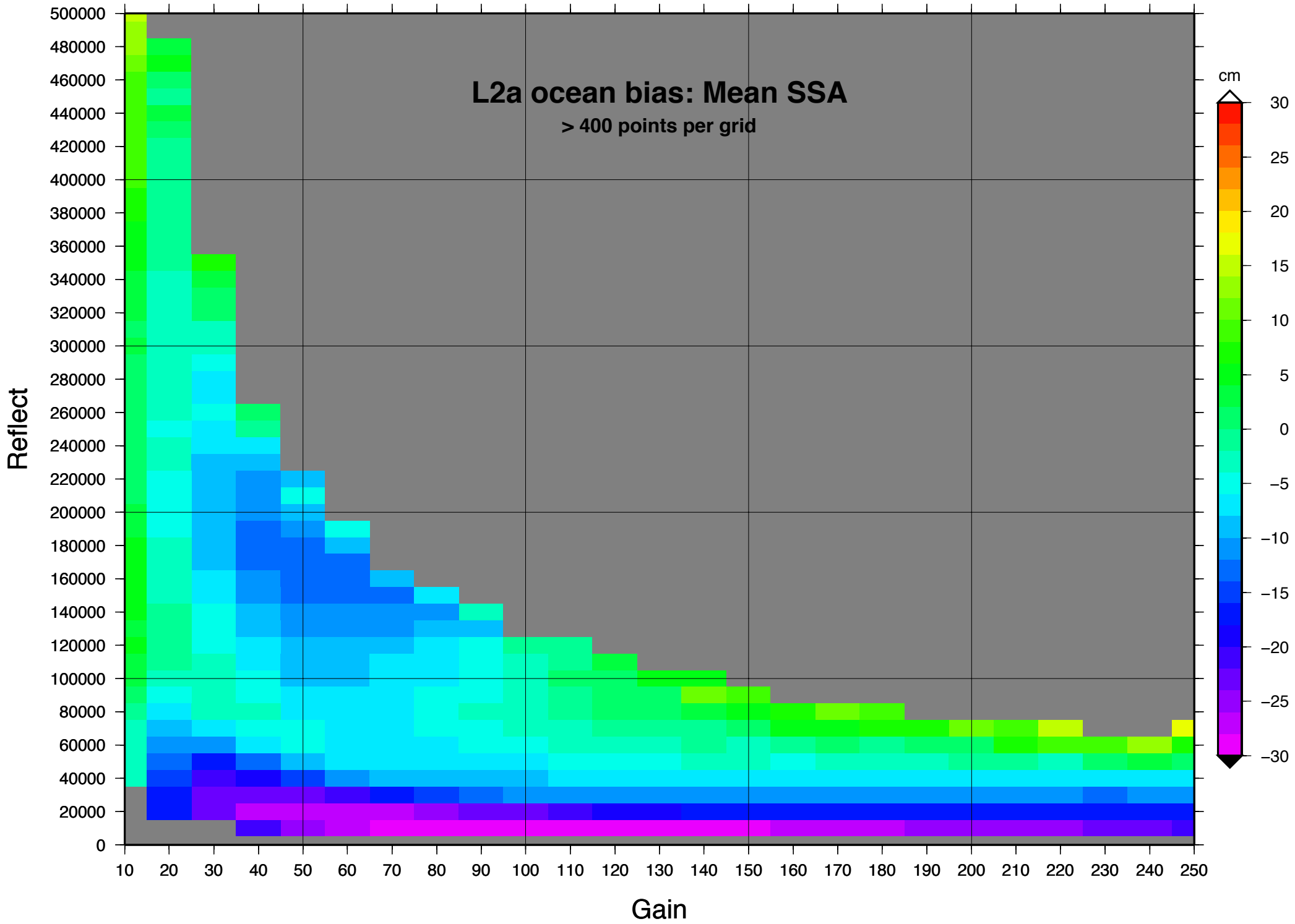
Ocean Bias as a function of Gain & Reflectivity

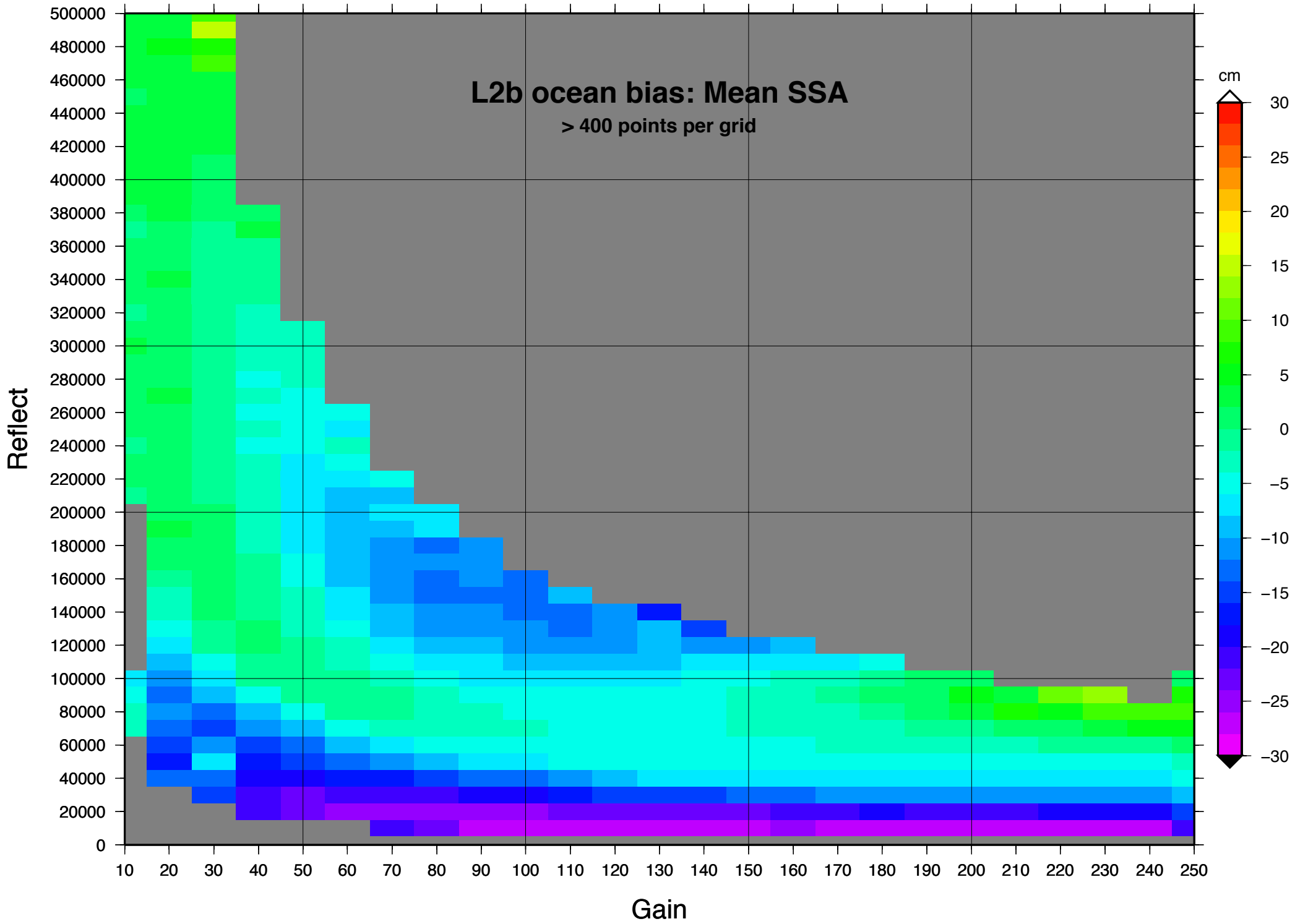

L2a ocean bias: Mean SSA
> 0 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

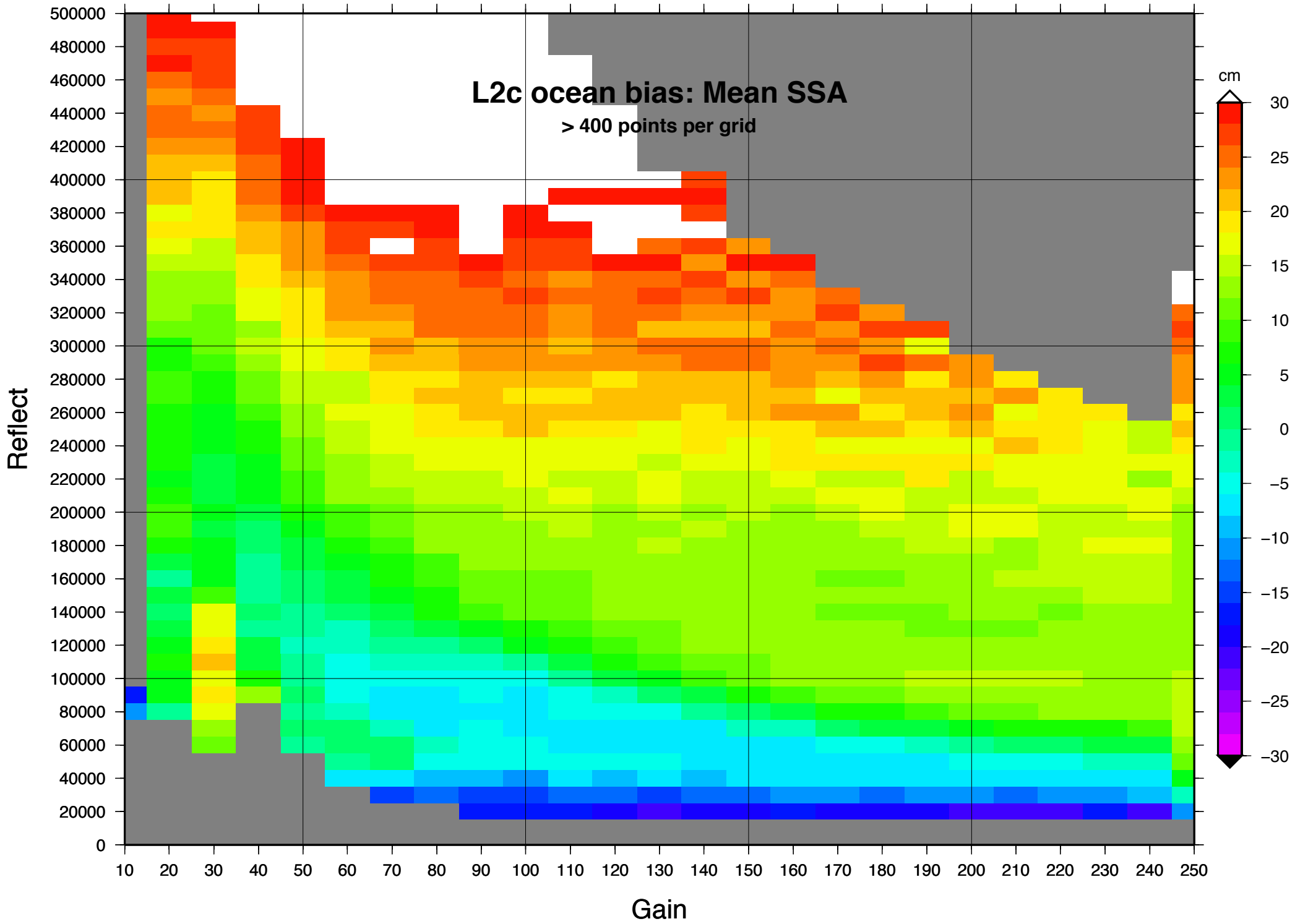

L2a ocean bias: RMS
> 0 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0


L2a ocean bias: num. points per bin
> 0 points per grid
Reflect
Gain
points
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250


L1a ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L2a ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L2b ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L2c ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
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100
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120
130
140
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170
180
190
200
210
220
230
240
250
30
25
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15
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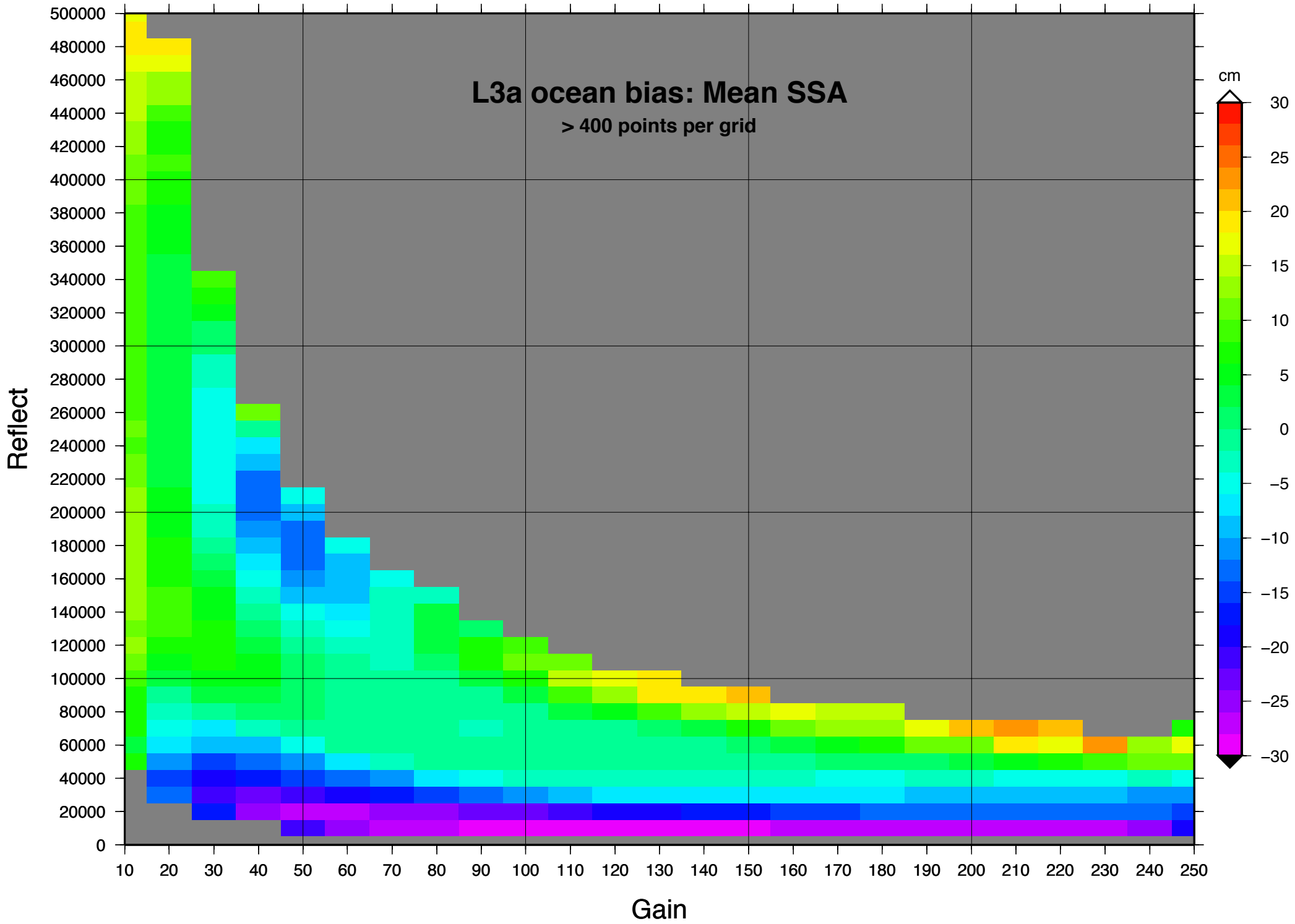
−5
−10
−15
−20
−25
−30


L3a ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
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70
80
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100
110
120
130
140
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160
170
180
190
200
210
220
230
240
250
30
25
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15
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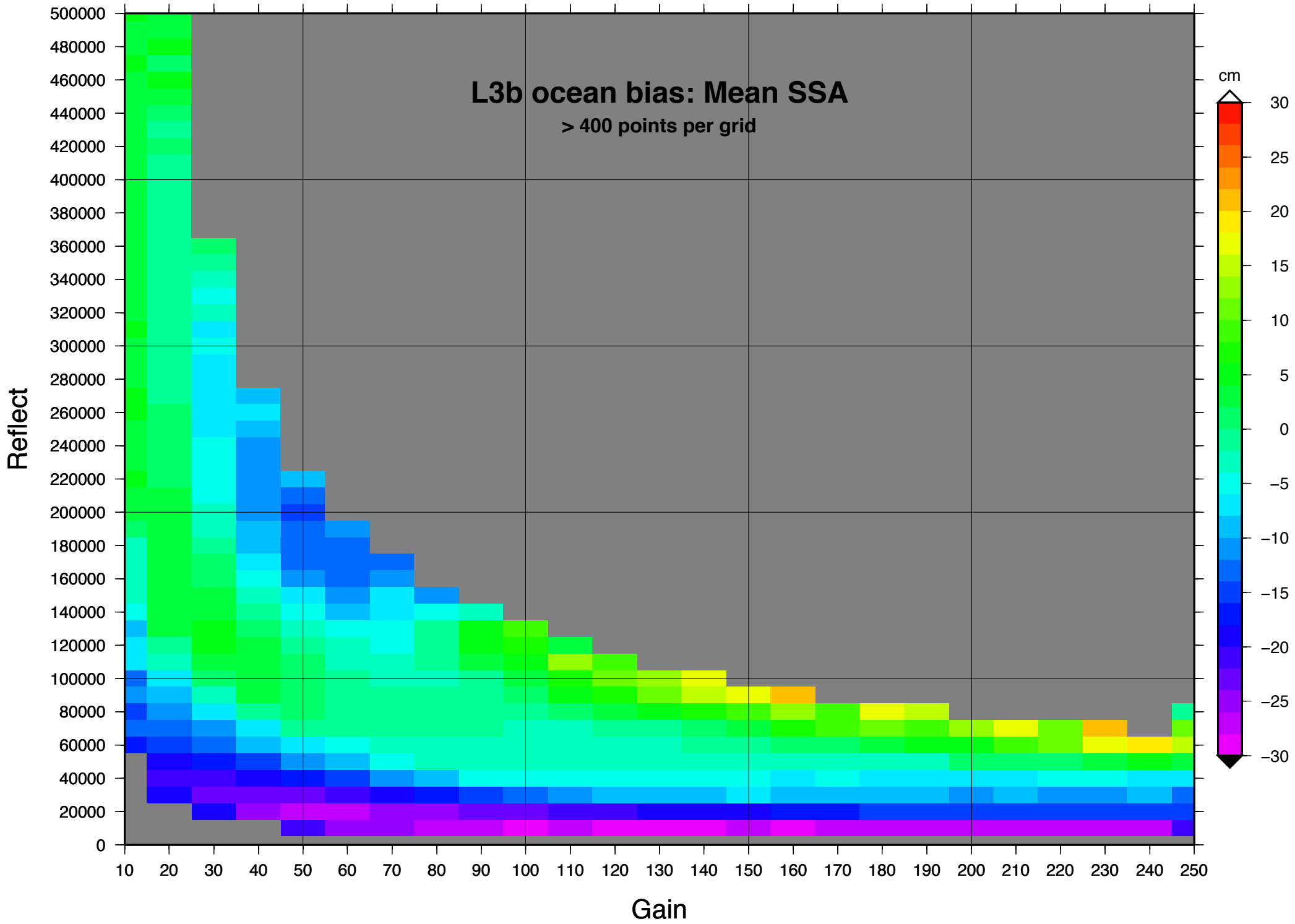
−5
−10
−15
−20
−25
−30


L3b ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
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40
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80
90
100
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120
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140
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170
180
190
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210
220
230
240
250
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25
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15
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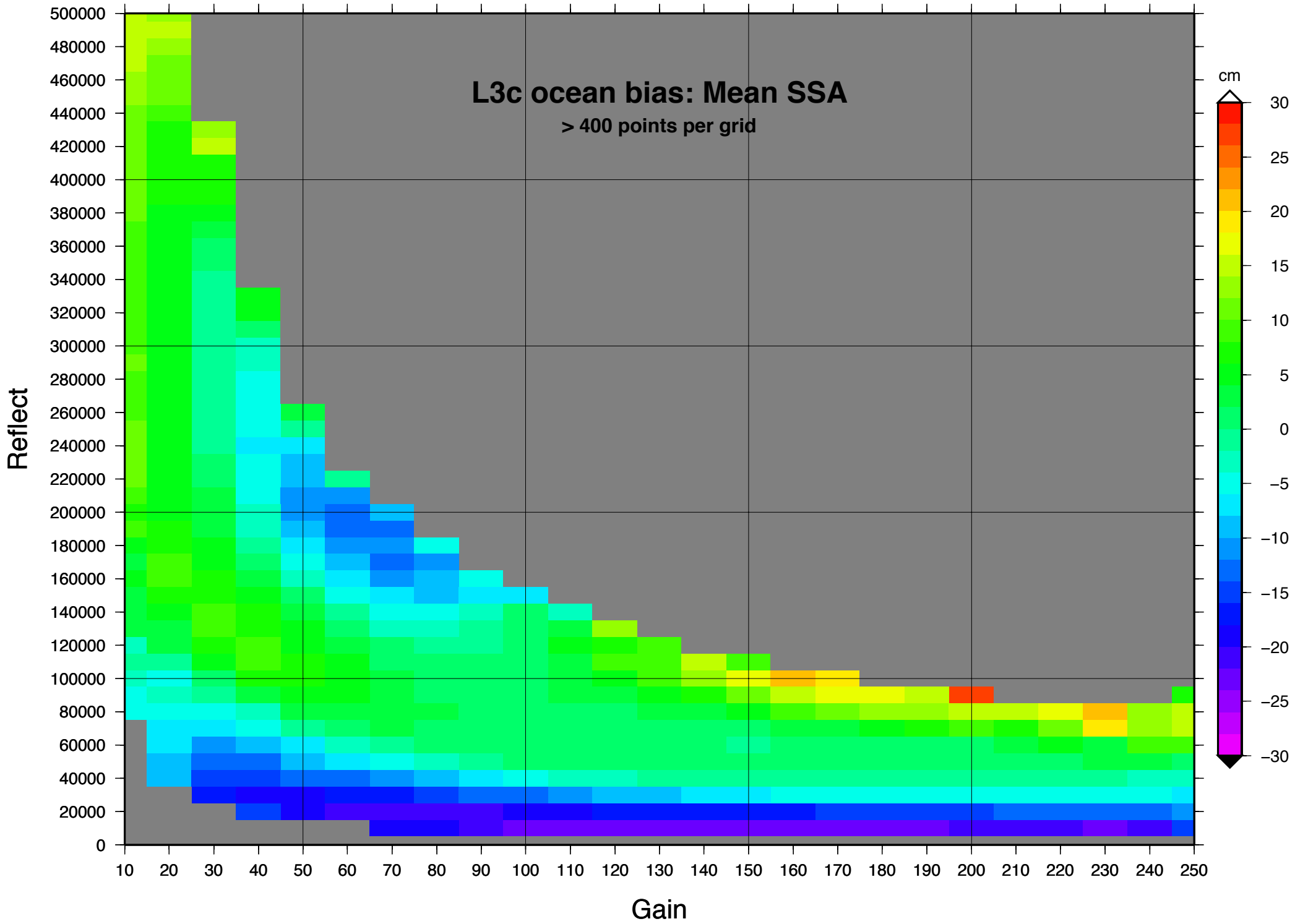
−5
−10
−15
−20
−25
−30


L3c ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
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20000
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90
100
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120
130
140
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170
180
190
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210
220
230
240
250
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25
20
15
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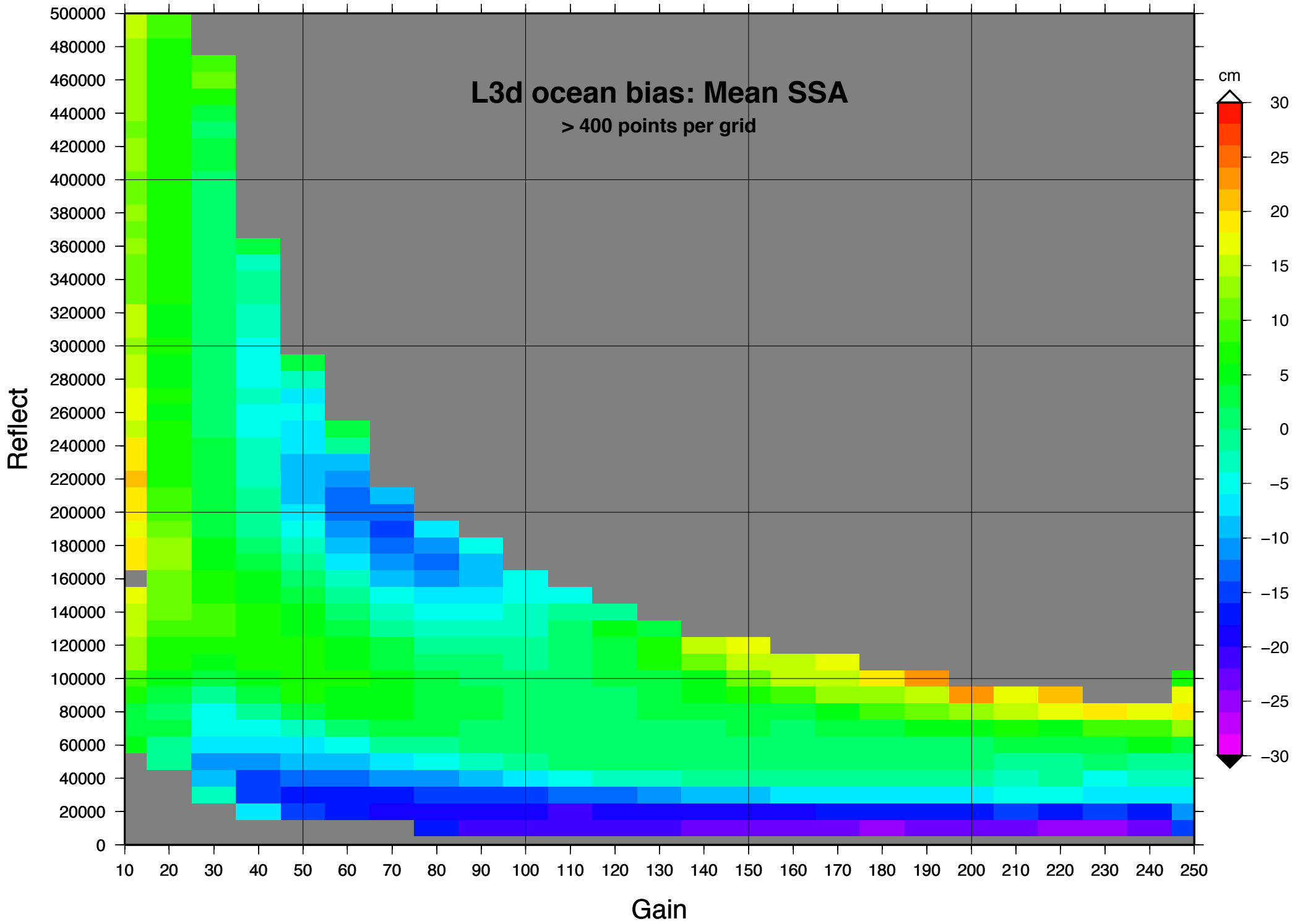
−5
−10
−15
−20
−25
−30


L3d ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
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40
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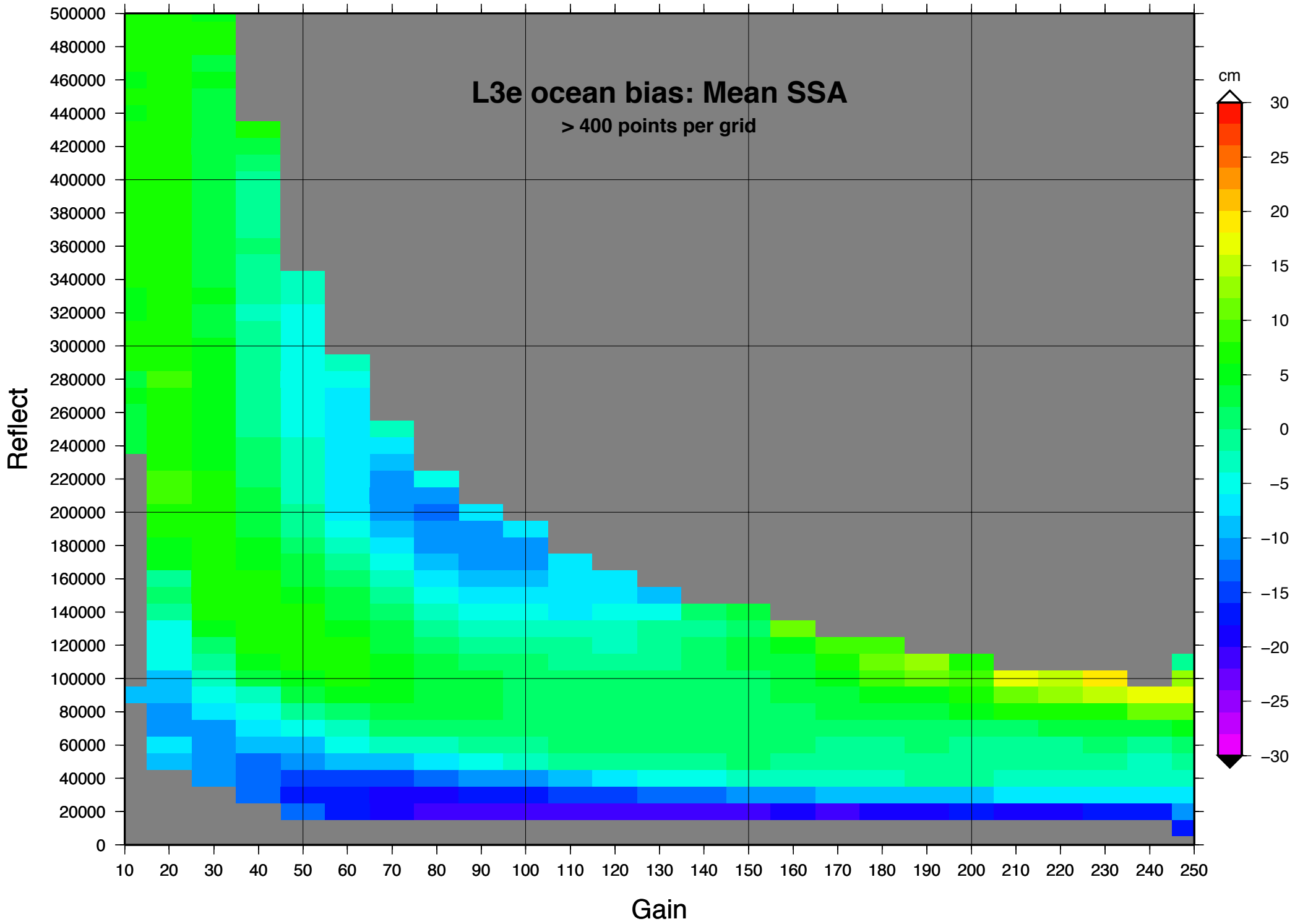
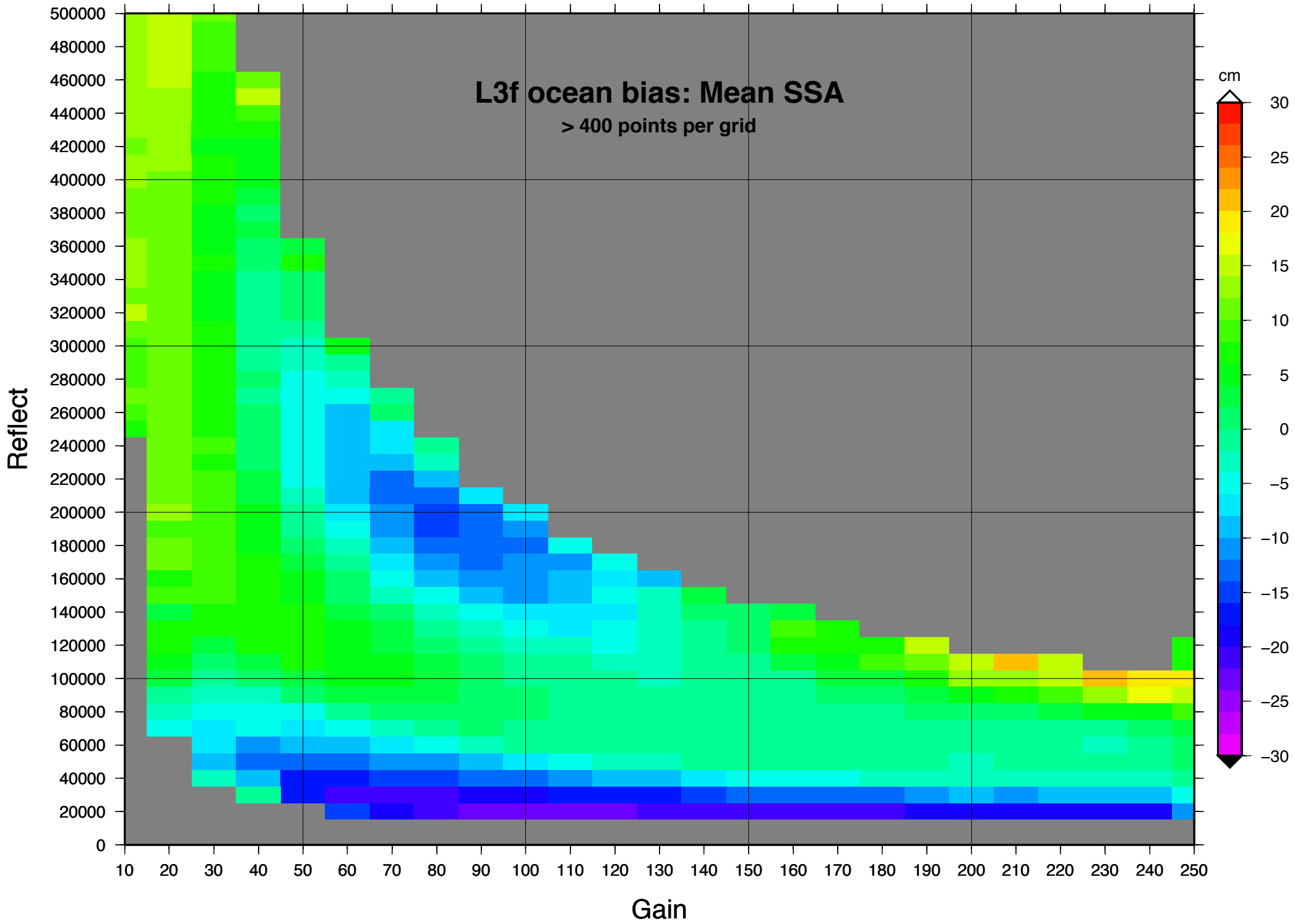
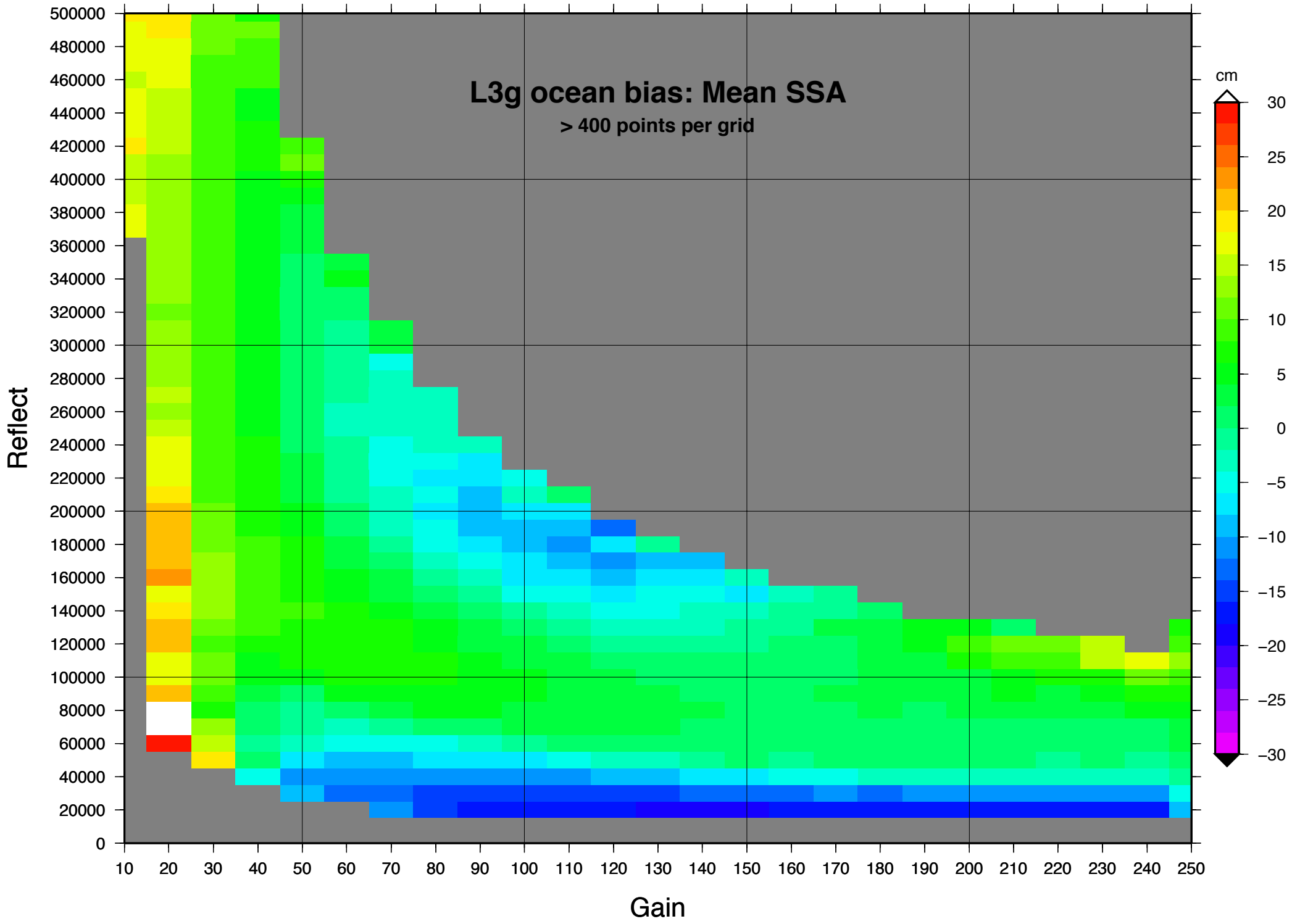
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L3e ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L3f ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L3g ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
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170
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190
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210
220
230
240
250
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25
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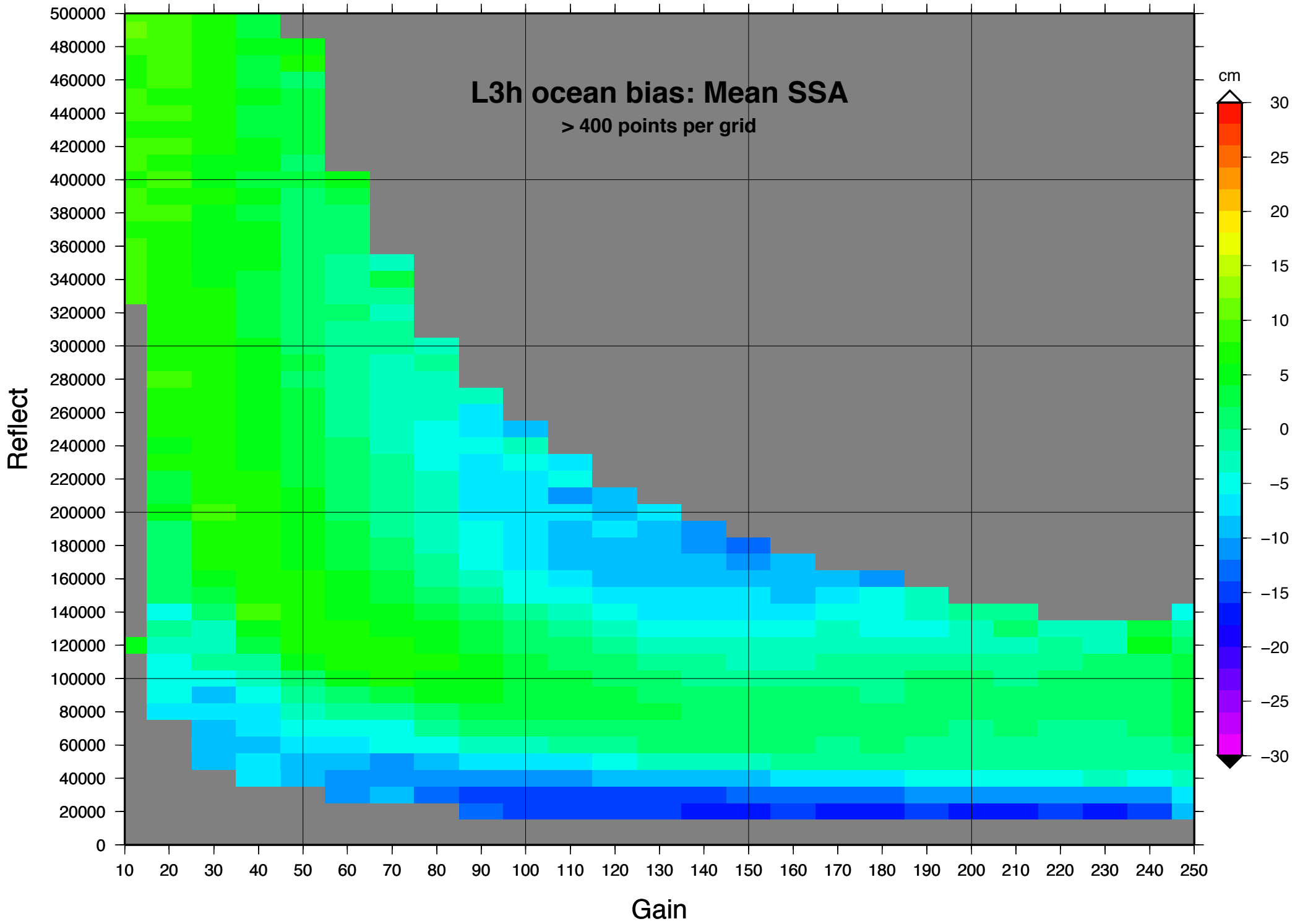
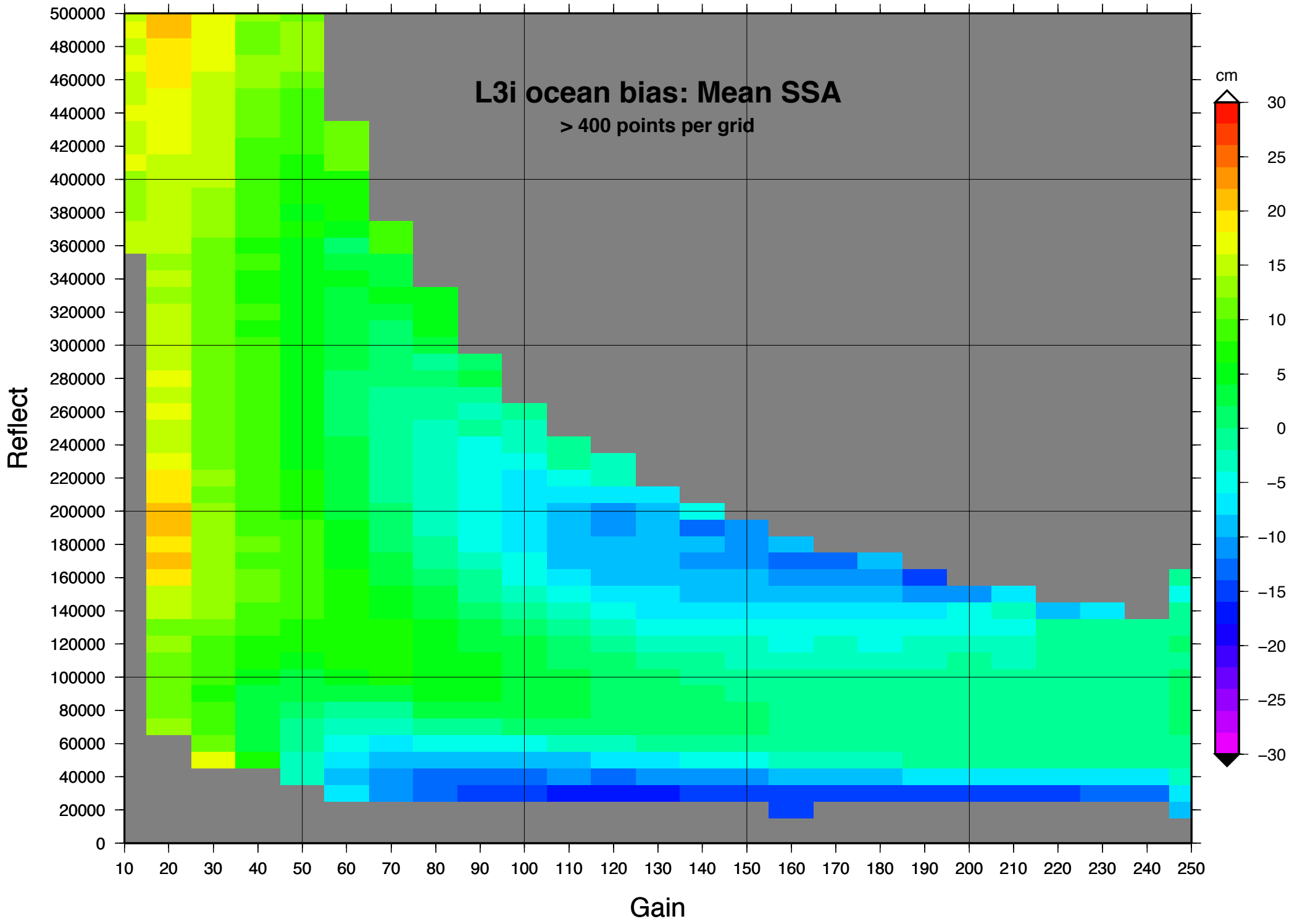
−5
−10
−15
−20
−25
−30


L3h ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30


L3i ocean bias: Mean SSA
> 400 points per grid
Reflect
Gain
cm
500000
480000
460000
440000
420000
400000
380000
360000
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
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160
170
180
190
200
210
220
230
240
250
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25
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15
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−5
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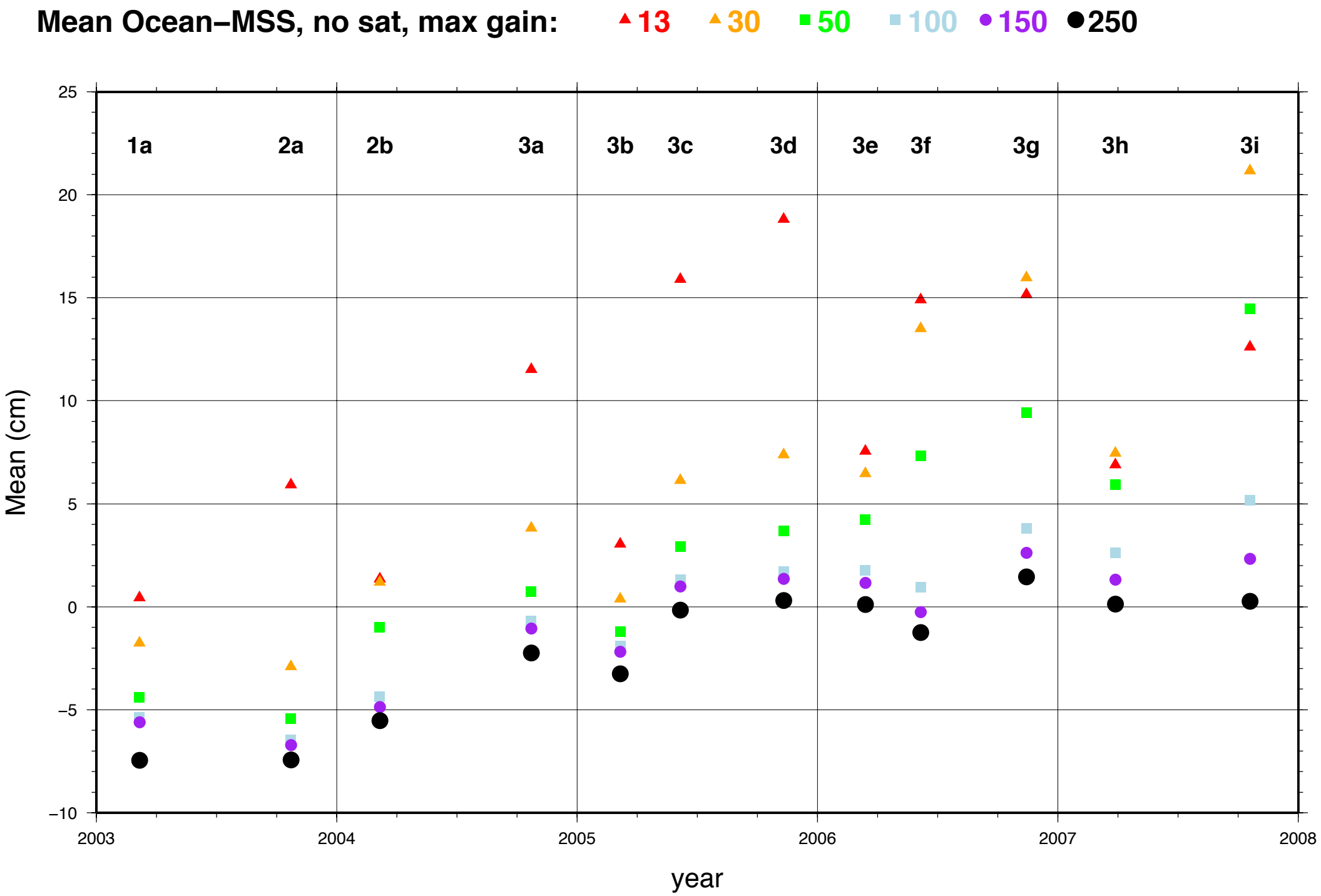
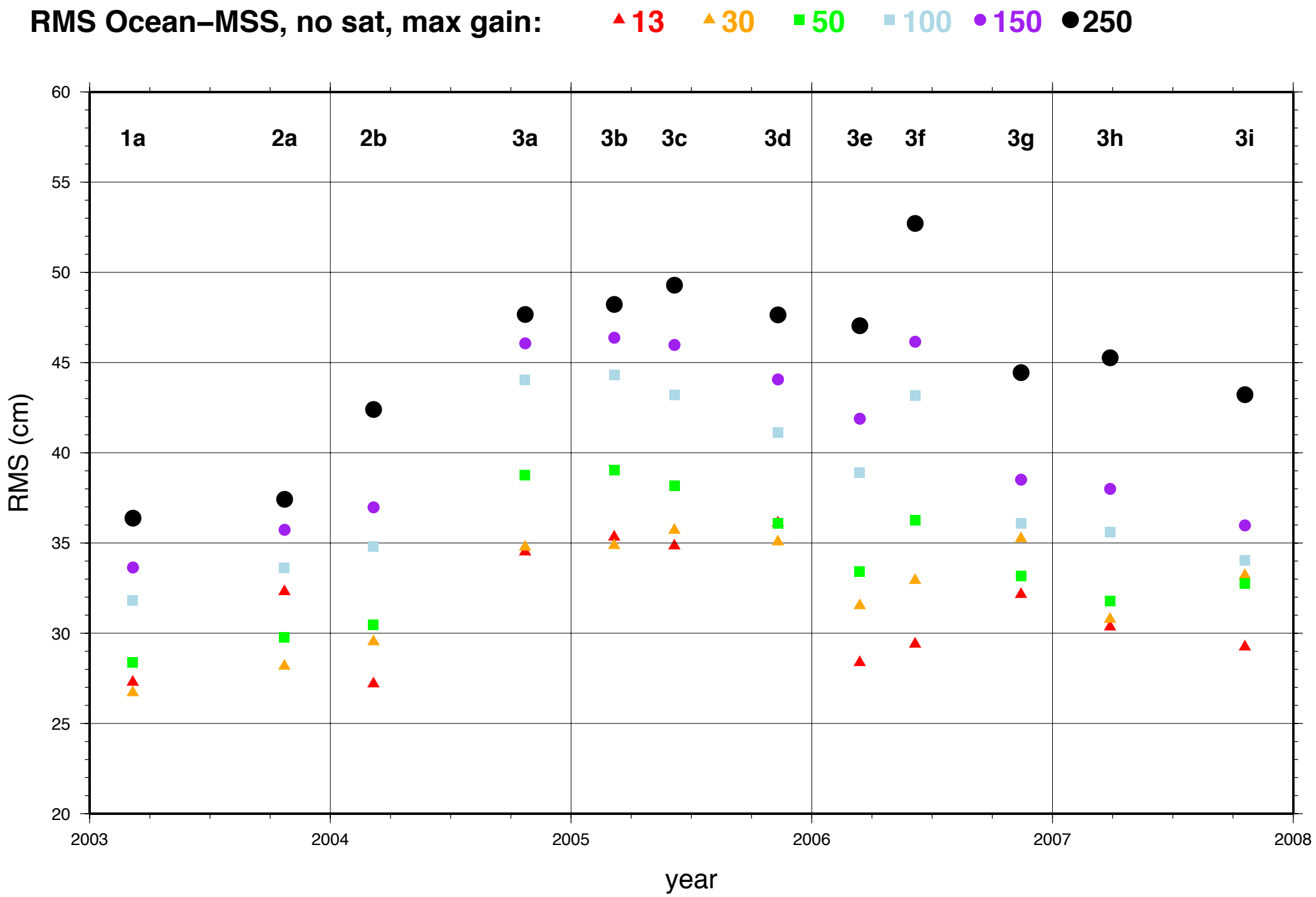
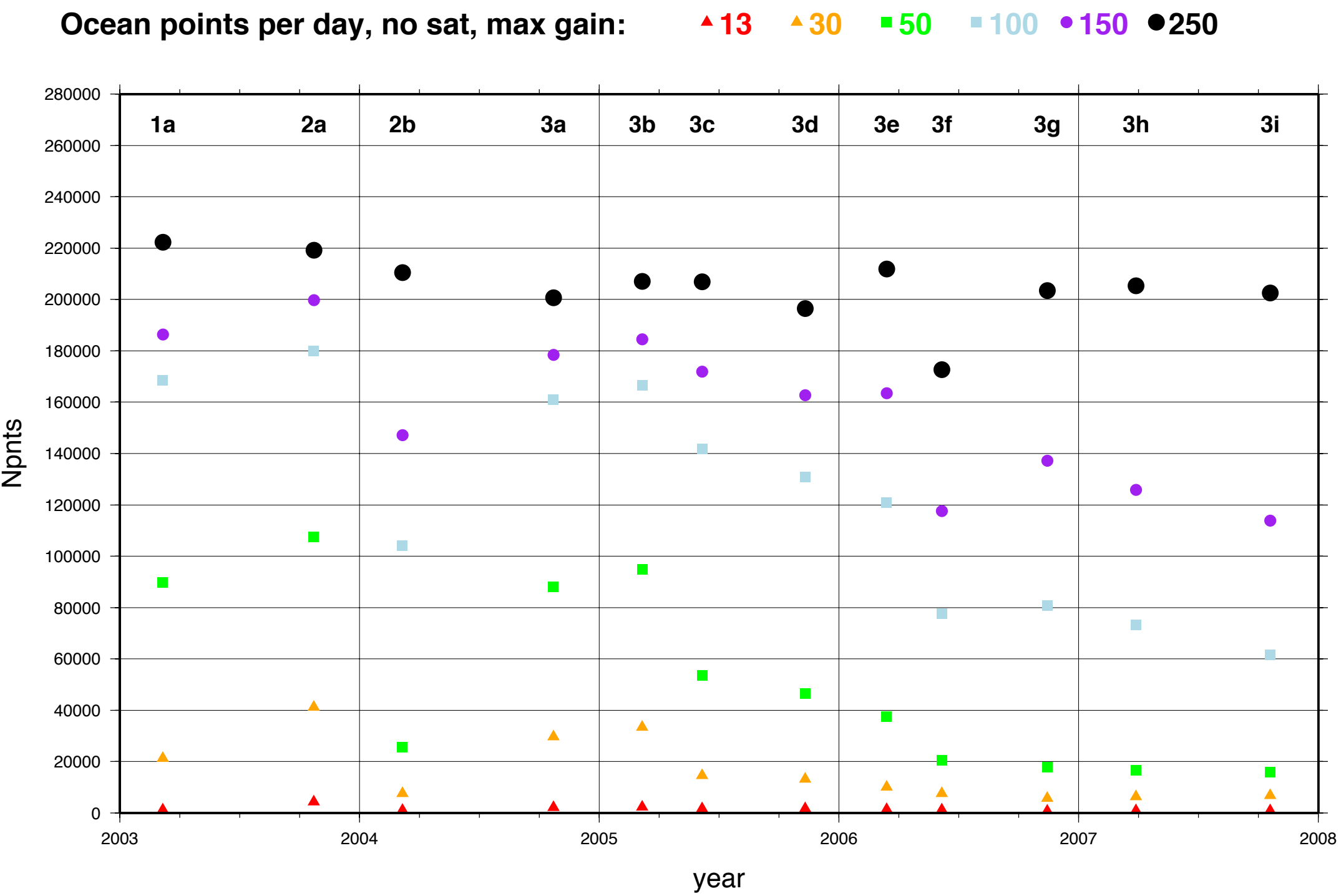
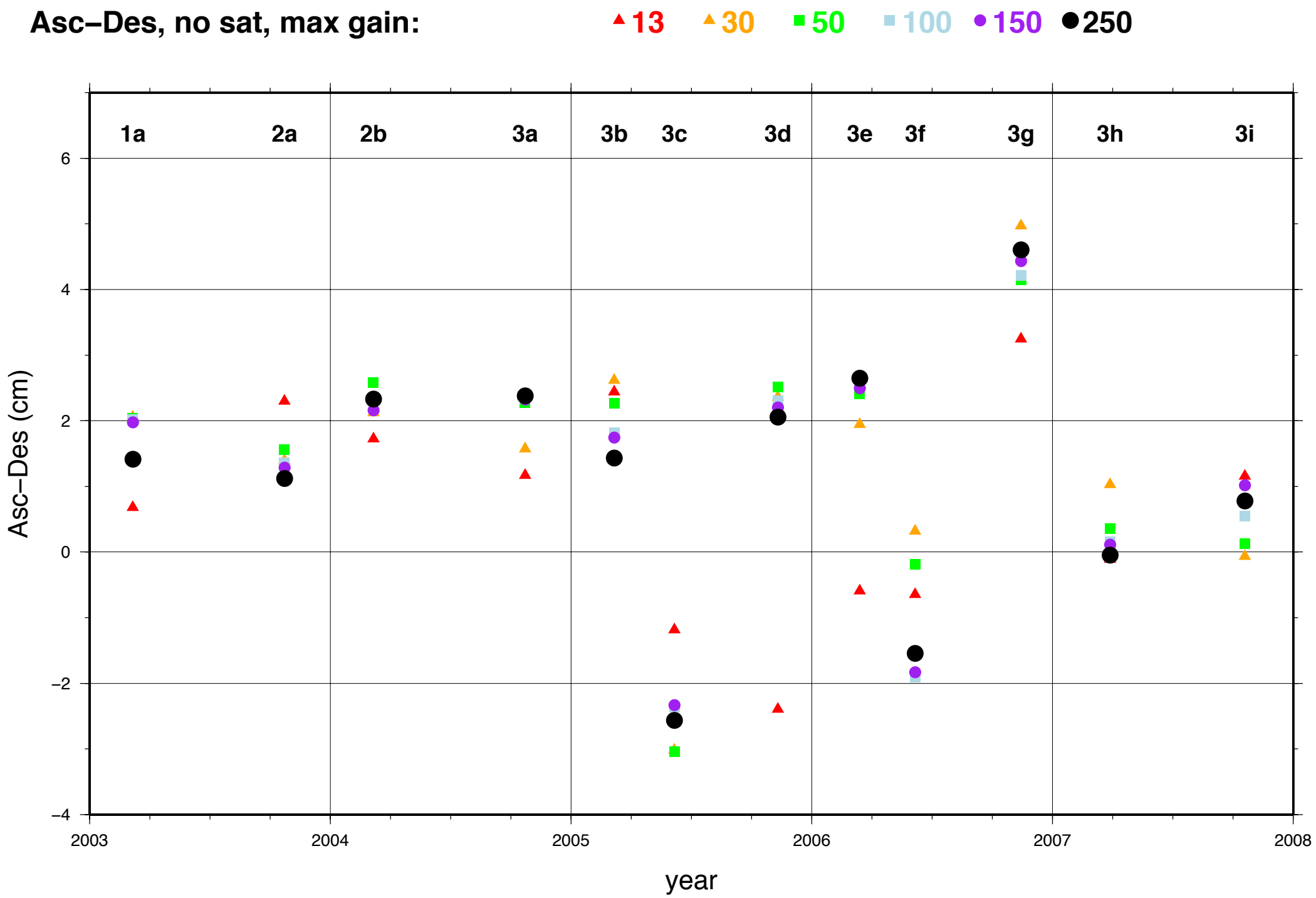
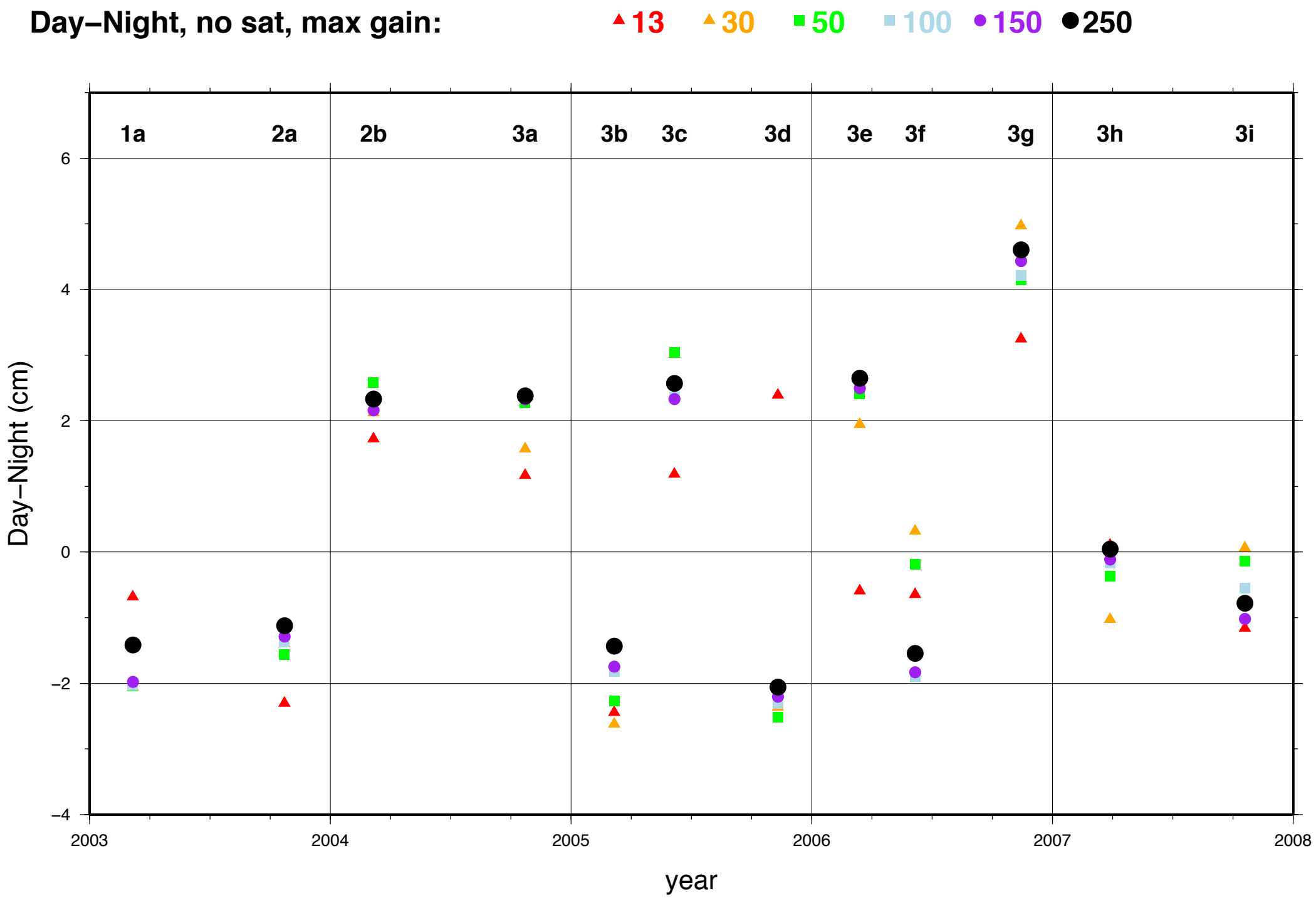
−15
−20
−25
−30

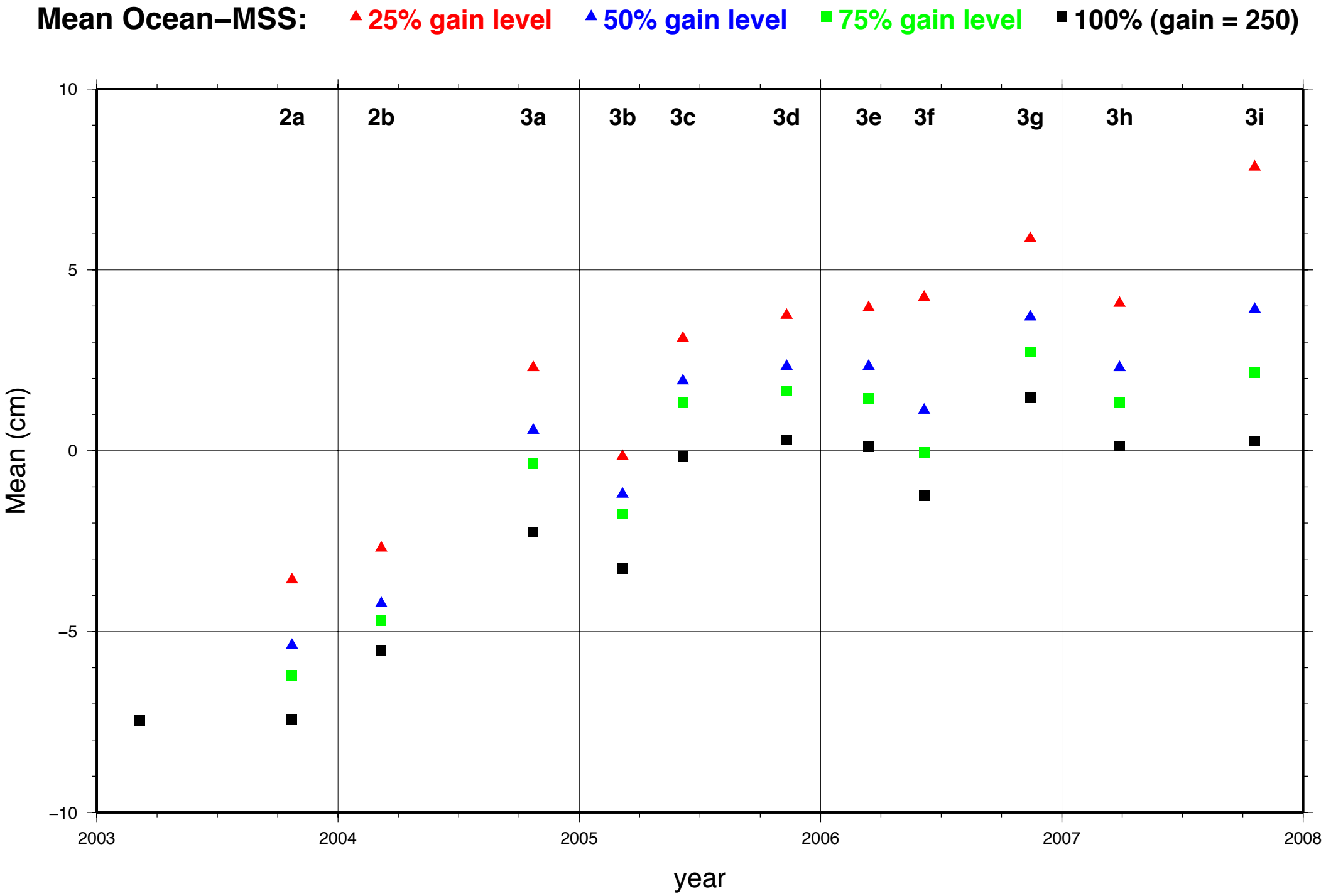

Mean Ocean–MSS, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Mean (cm)
year
25
20
15
10
5
0
−5
−10
2003
2004
2005
2006
2007
2008

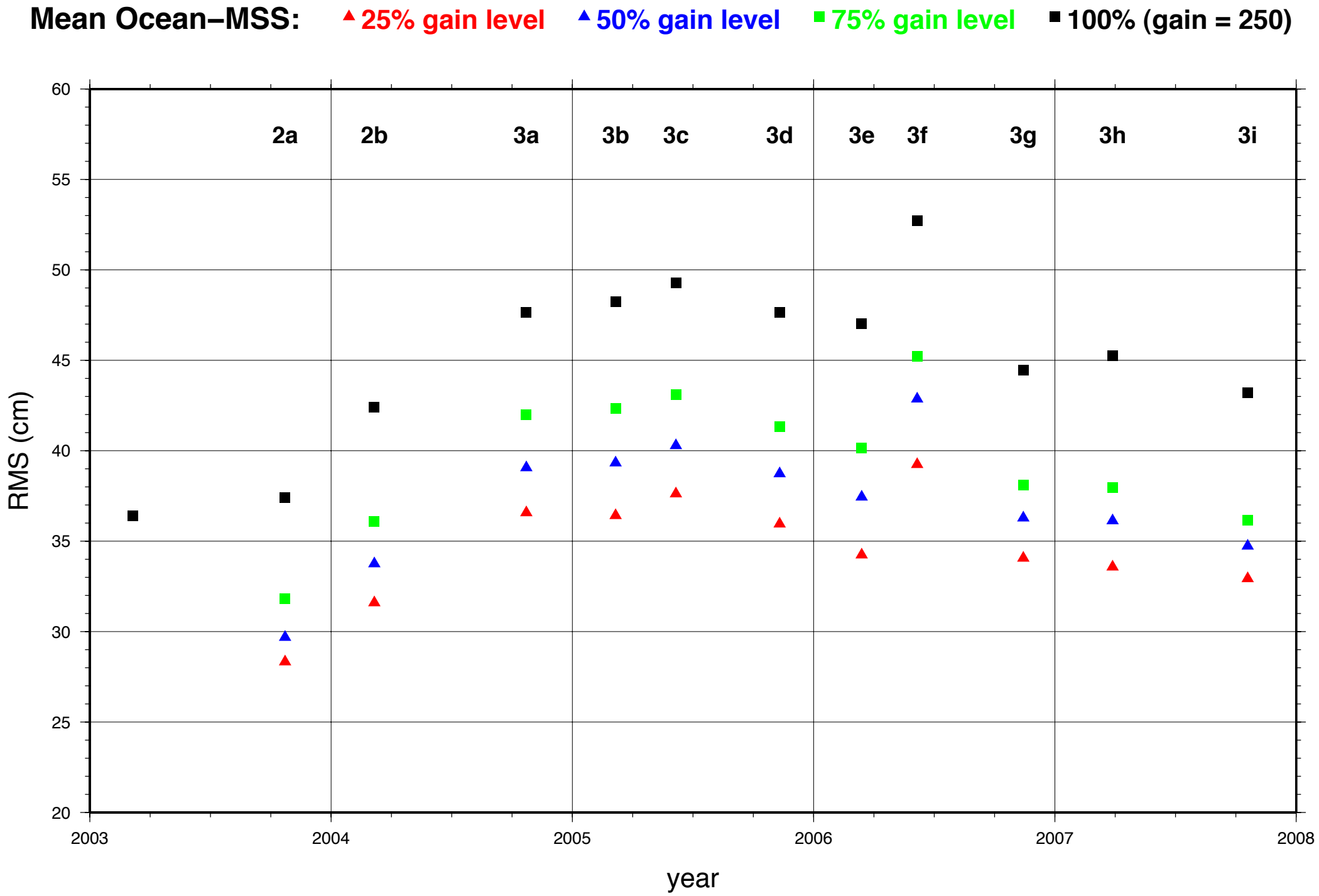

RMS Ocean–MSS, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
RMS (cm)
60
55
50
45
40
35
30
25
20
2003
2004
2005
2006
2007
2008
year

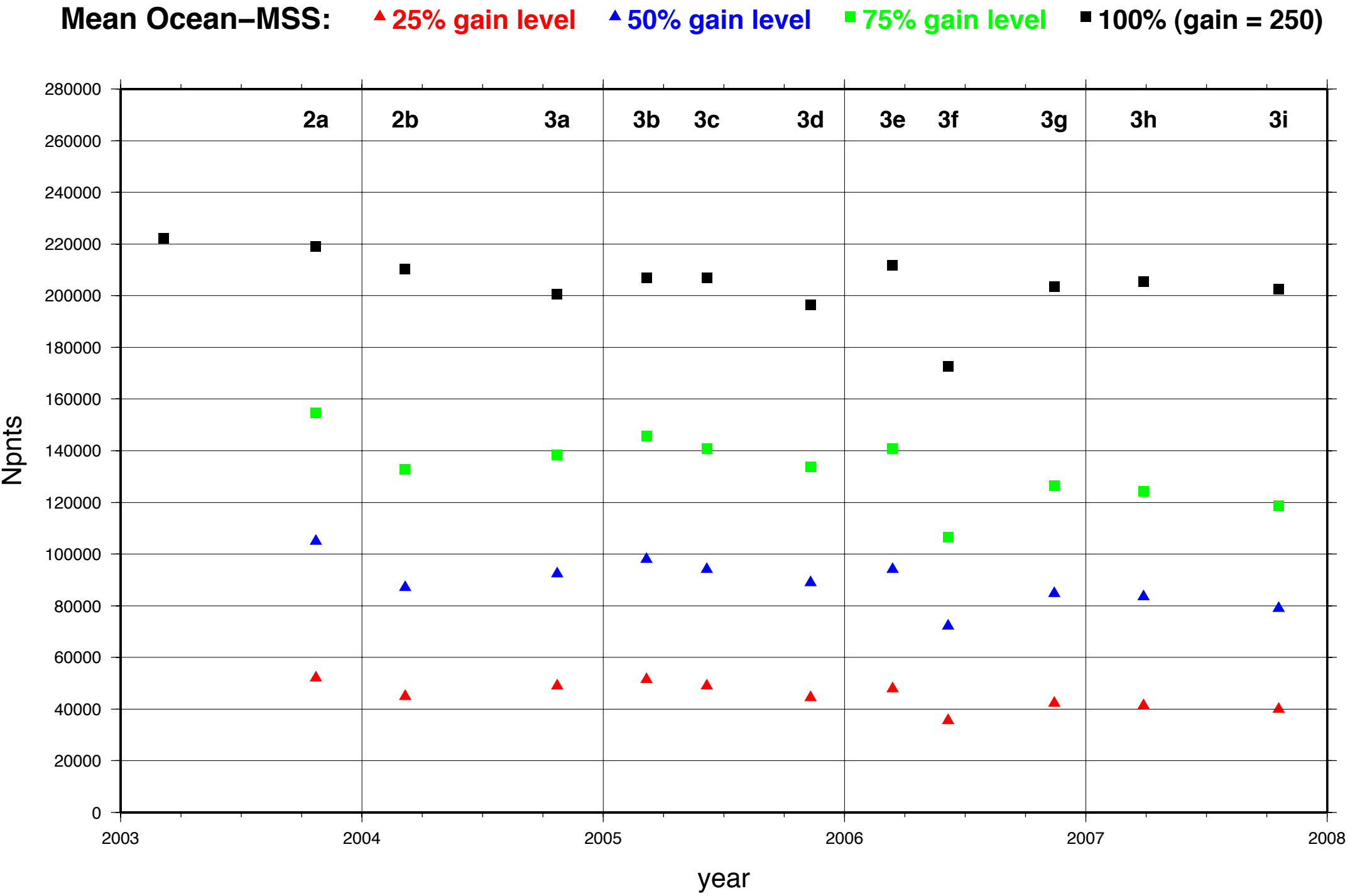

Ocean points per day, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Npnts
year
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2003
2004
2005
2006
2007
2008

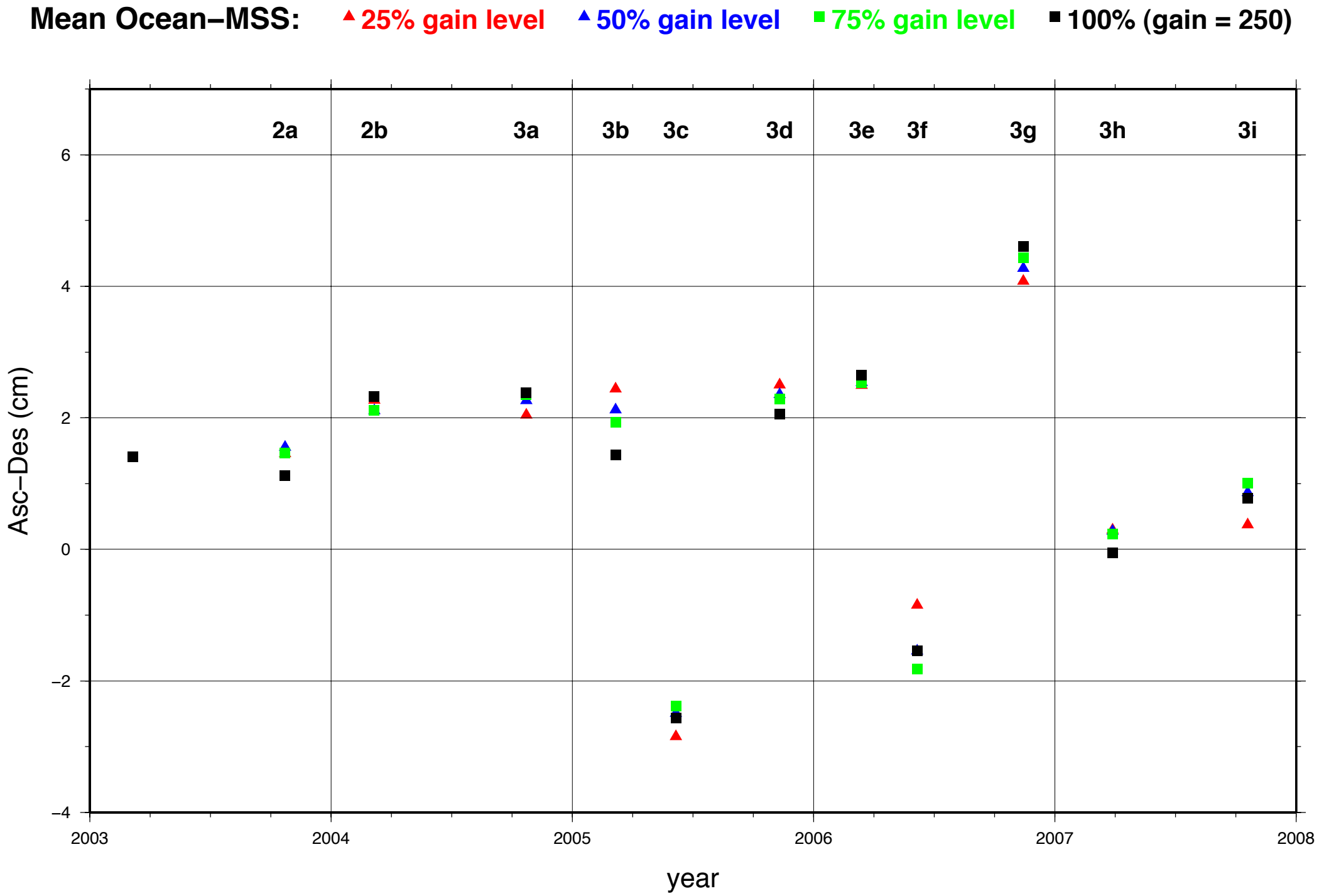

Asc−Des, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Asc−Des (cm)
2003
2004
2005
2006
2007
2008
year

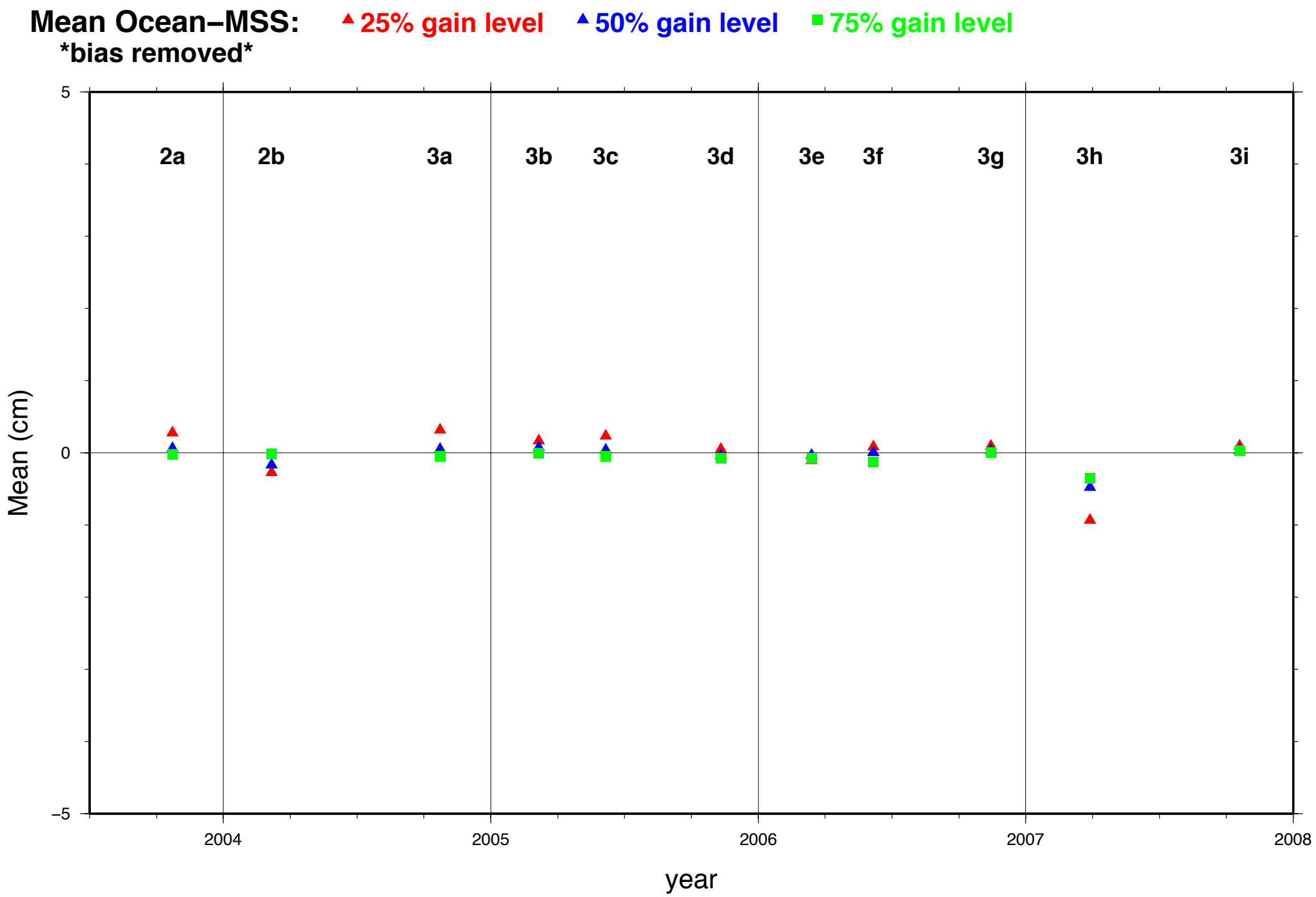

Day–Night, no sat, max gain:
13
30
50
100
150
250
1a
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Day–Night (cm)
2003
2004
2005
2006
2007
2008
year

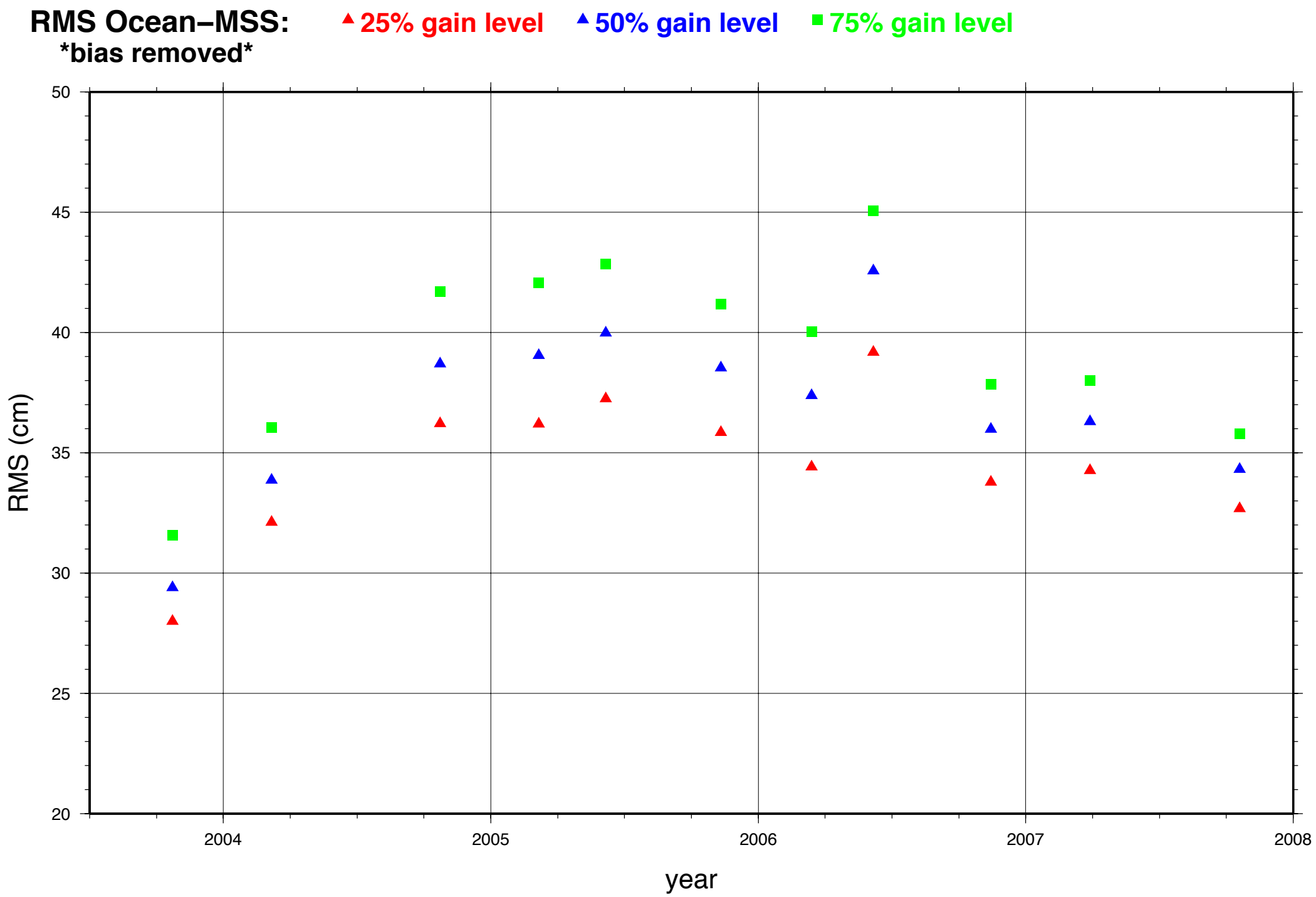

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
10
5
0
−5
−10
Mean (cm)
2003
2004
2005
2006
2007
2008
year

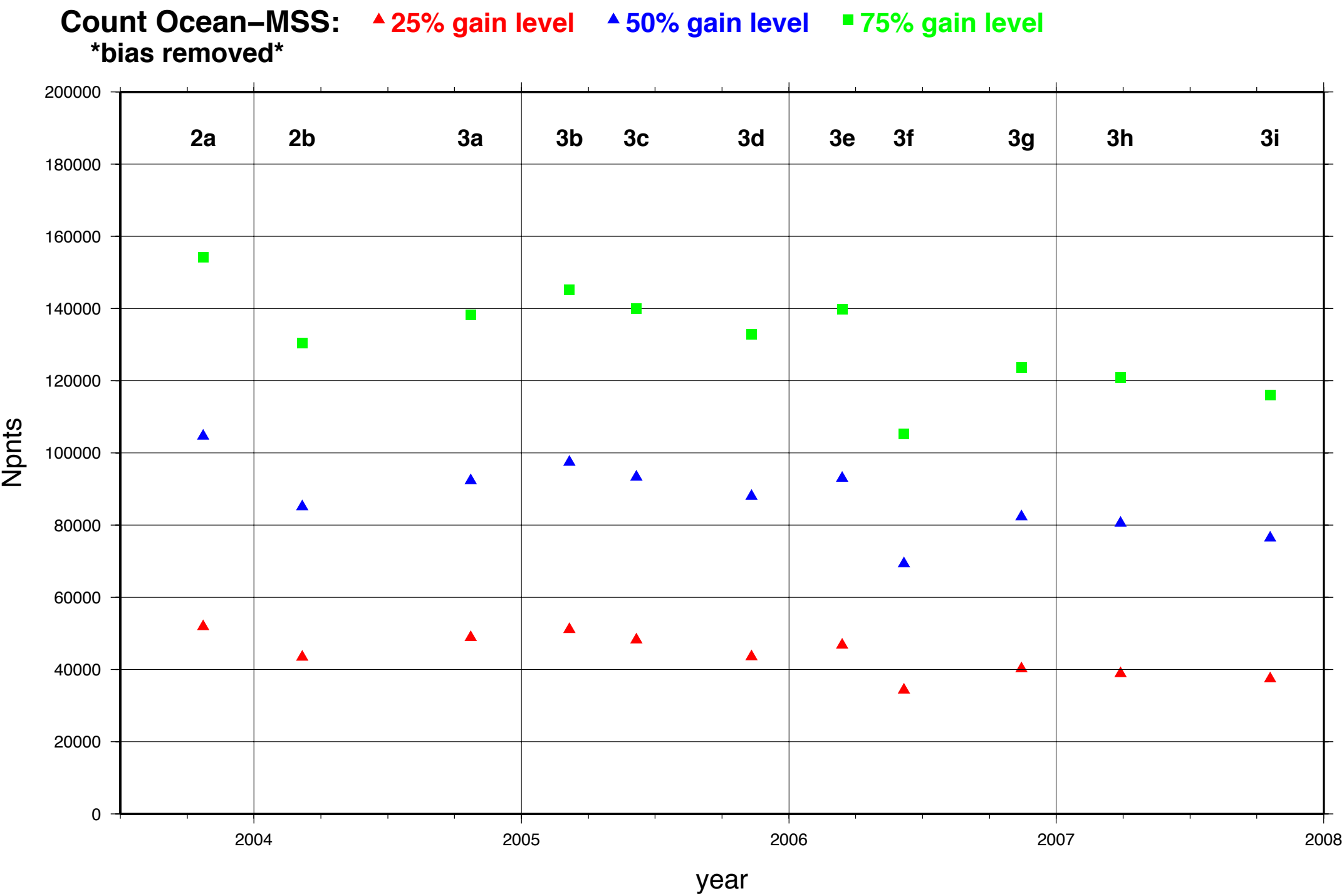

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
RMS (cm)
60
55
50
45
40
35
30
25
20
2003
2004
2005
2006
2007
2008
year

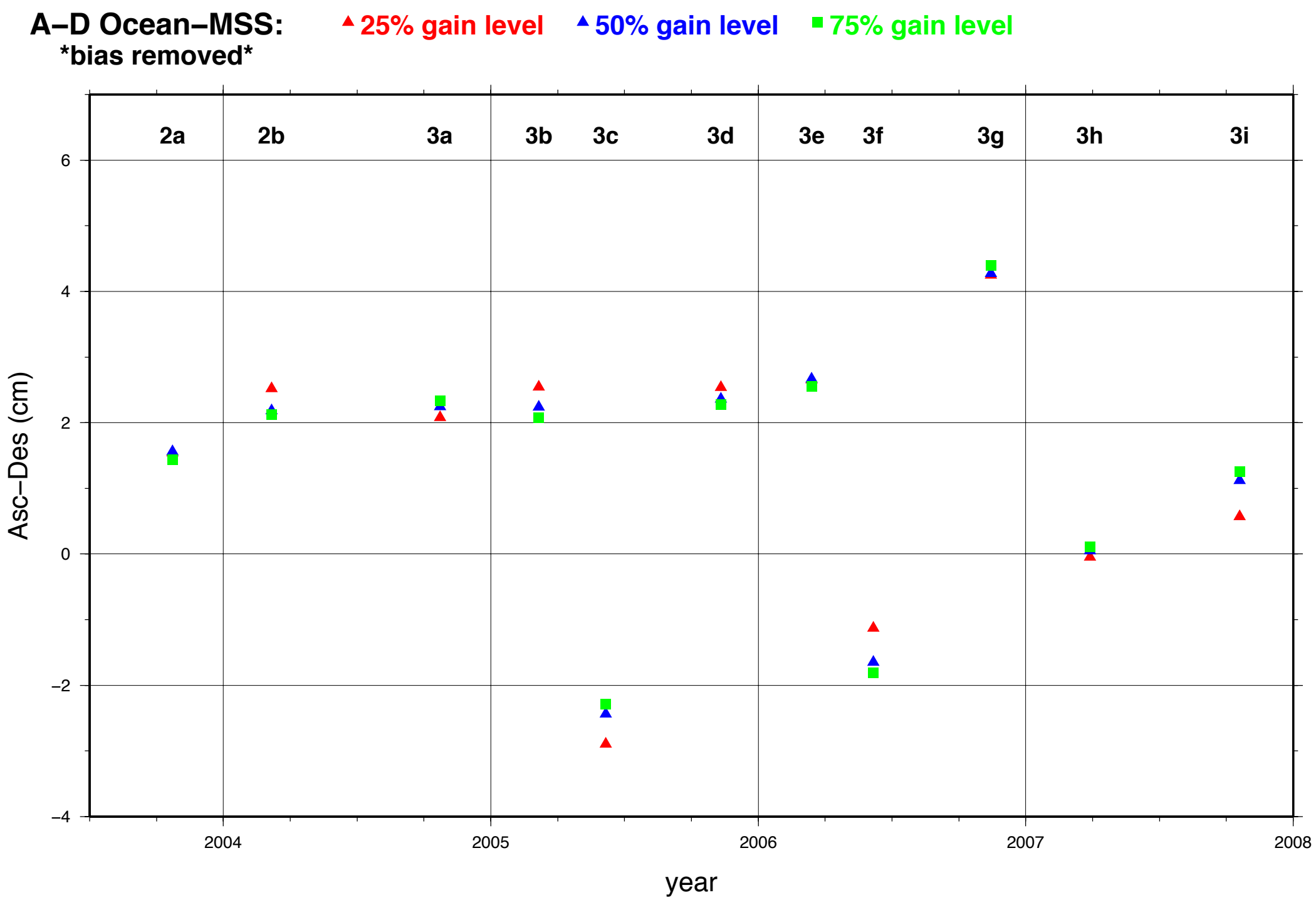

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
Npnts
year
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2003
2004
2005
2006
2007
2008

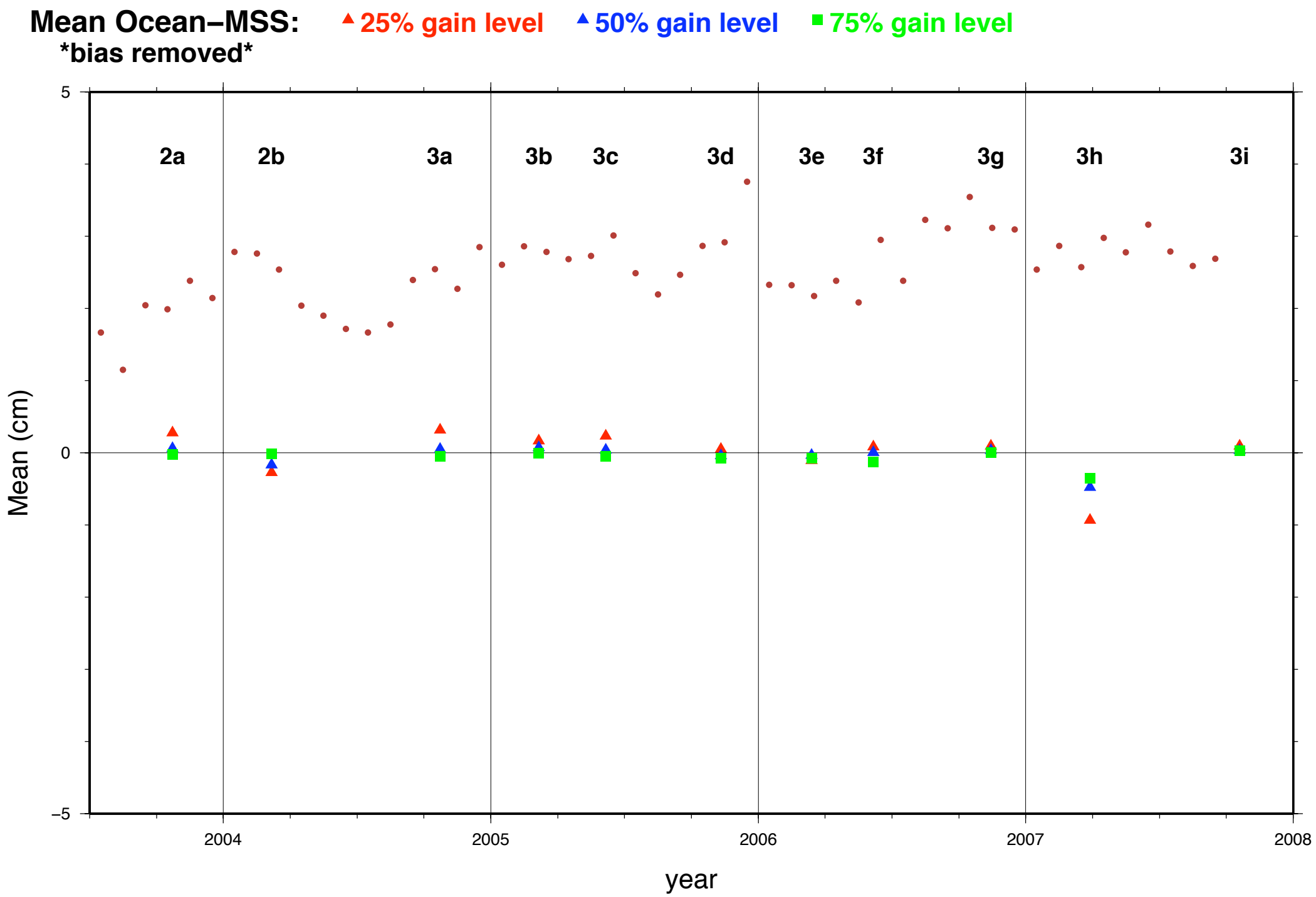

Mean Ocean–MSS:
25% gain level
50% gain level
75% gain level
100% (gain = 250)
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Asc–Des (cm)
2003
2004
2005
2006
2007
2008
year


Mean Ocean–MSS:
bias removed
25% gain level
50% gain level
75% gain level
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
5
0
−5
Mean (cm)
2004
2005
2006
2007
2008
year


RMS Ocean–MSS:
bias removed
25% gain level
50% gain level
75% gain level
RMS (cm)
50
45
40
35
30
25
20
2004
2005
2006
2007
2008
year


Count Ocean–MSS:
bias removed
25% gain level
50% gain level
75% gain level
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Npnts
2004
2005
2006
2007
2008
year


A–D Ocean–MSS:
bias removed
25% gain level
50% gain level
75% gain level
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
6
4
2
0
−2
−4
Asc–Des (cm)
2004
2005
2006
2007
2008
year


Mean Ocean–MSS:
bias removed
25% gain level
50% gain level
75% gain level
2a
2b
3a
3b
3c
3d
3e
3f
3g
3h
3i
5
0
−5
Mean (cm)
2004
2005
2006
2007
2008
year