Revisiting IASI – MODIS TEB Comparisons

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As always, thanks to MCST for their support in these studies

Where we left off in May 2011

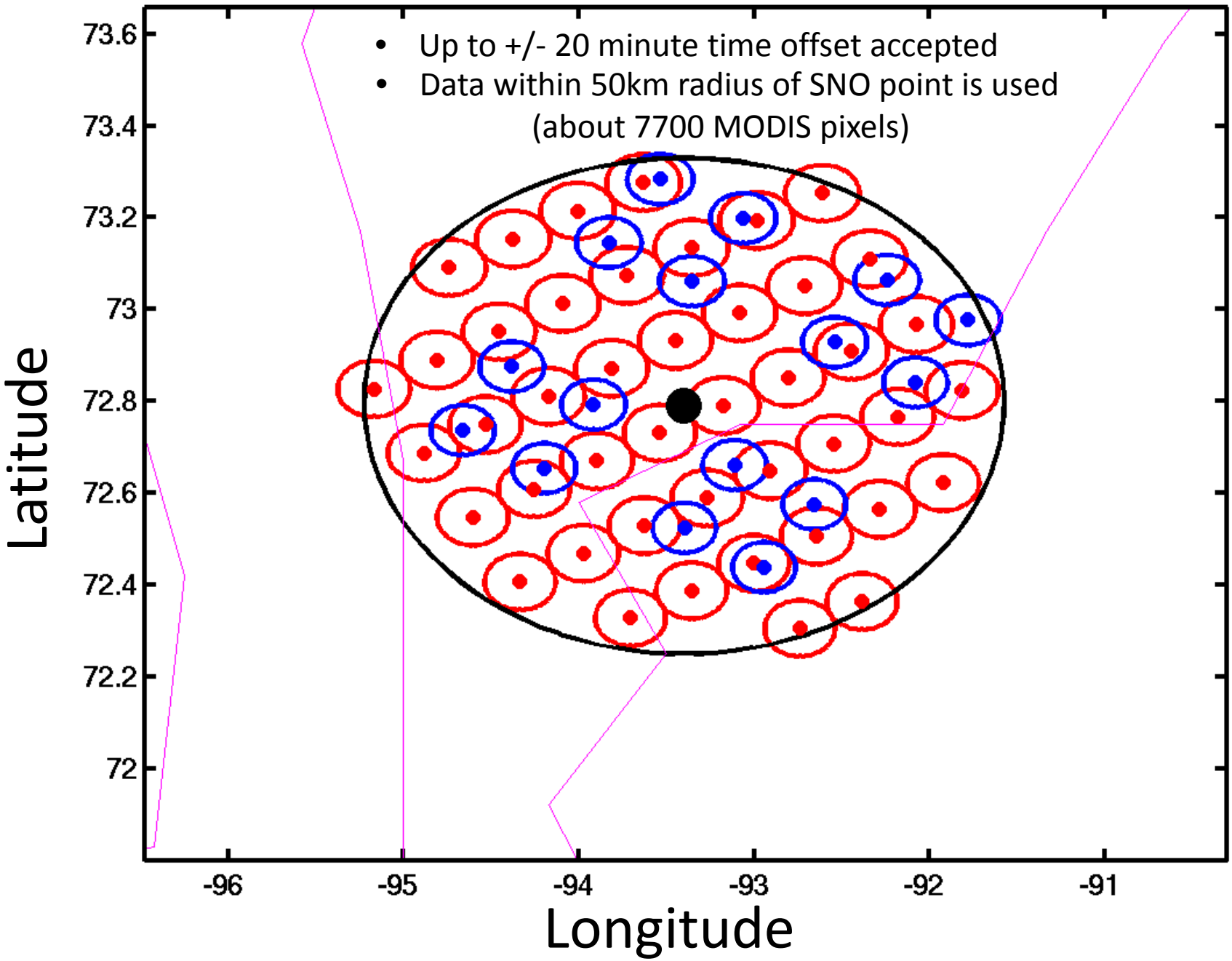
- ***Using IASI-MODIS comparisons, it was shown that Terra cold scene calibration appeared to be highly biased for many thermal bands.***
- ***Recommendation: test new offset coefficients for Terra Bands 20 – 30 in attempt to explain Terra cold scene behavior.***

- In response, MCST advised setting A0=0 for all Terra thermal bands in C6.
- To review impact of this approach, MCST provided a special LUT to allow Wisconsin to process L1B with A0=0 including an adjustment of A0 to minimize mirror side differences.
- Wisconsin compared the processed L1B against IASI.

Data Set Characteristics

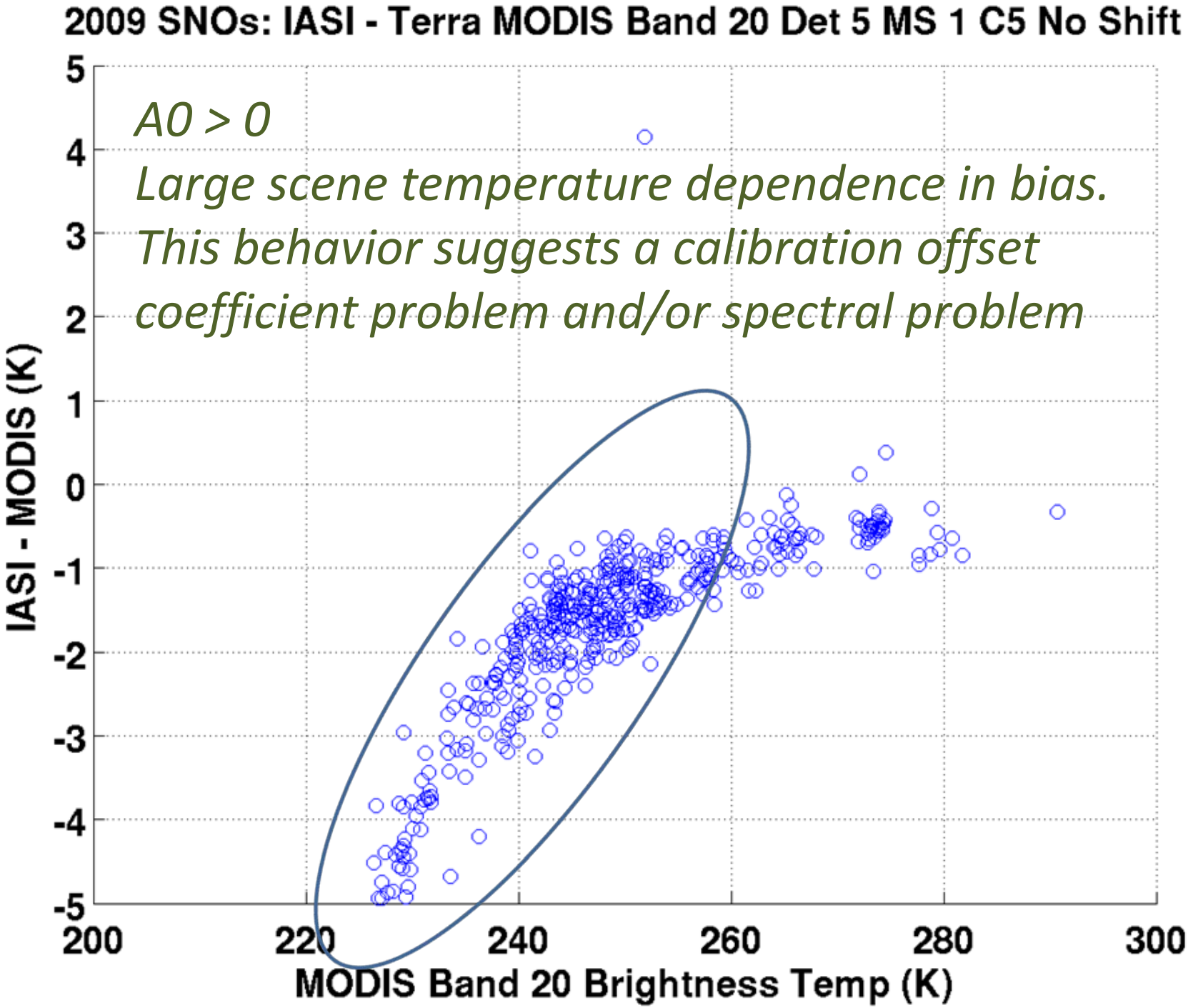
- SNOs for Year 2009 (~3600 matchups)
- Terra MODIS L1A data processed to L1B using MODISL1DB V1.7 (equivalent to Collection 6)
- Used special C6 LUT provided by MCST, with mirror side dependent updated A2 values and A0=0 for all bands.
- No spectral shifts applied to MODIS RSR
- No destriping of MODIS L1B data
- Filtering applied to remove IASI-MODIS matchups with highly structured scenes

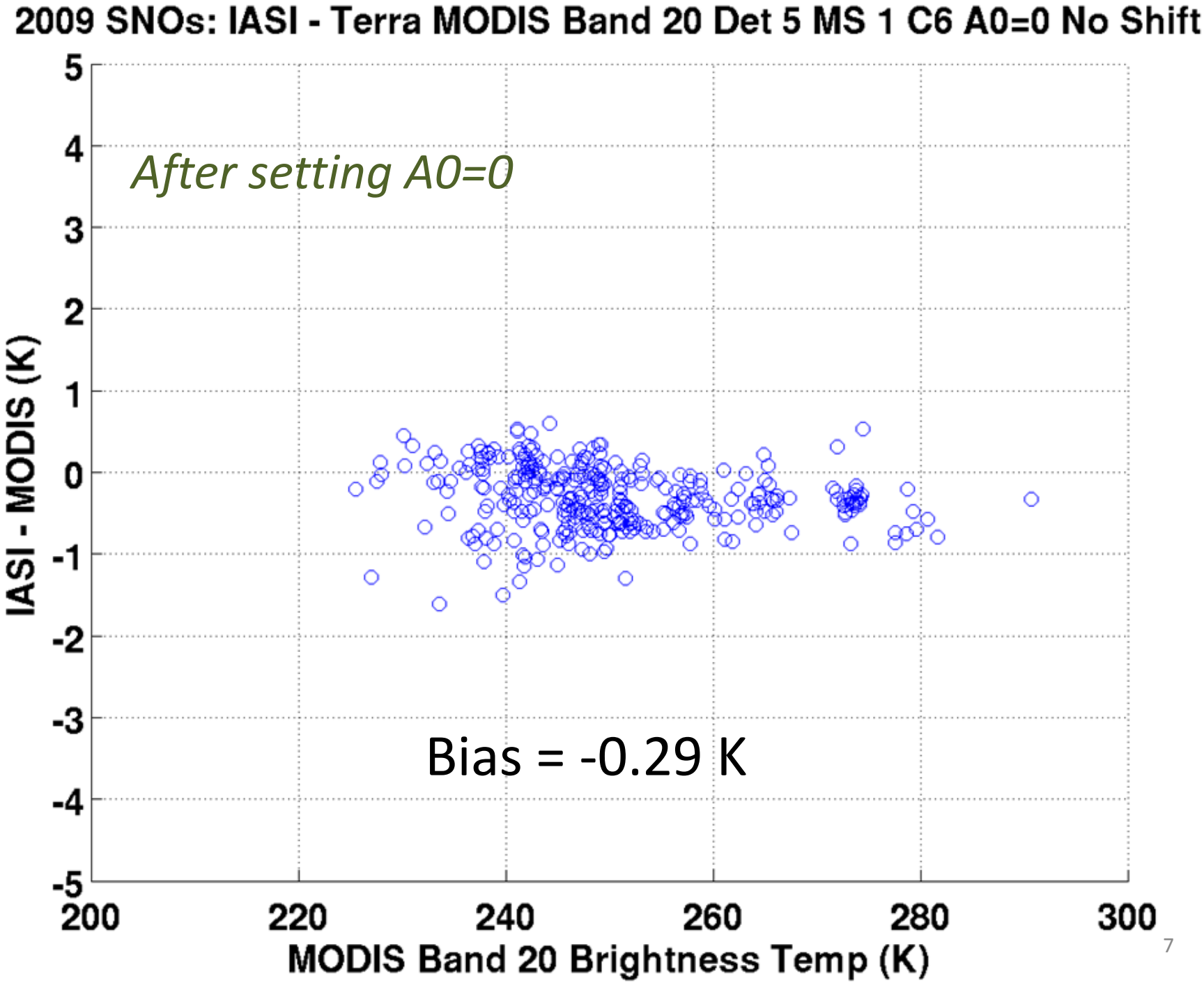
SNO Representation

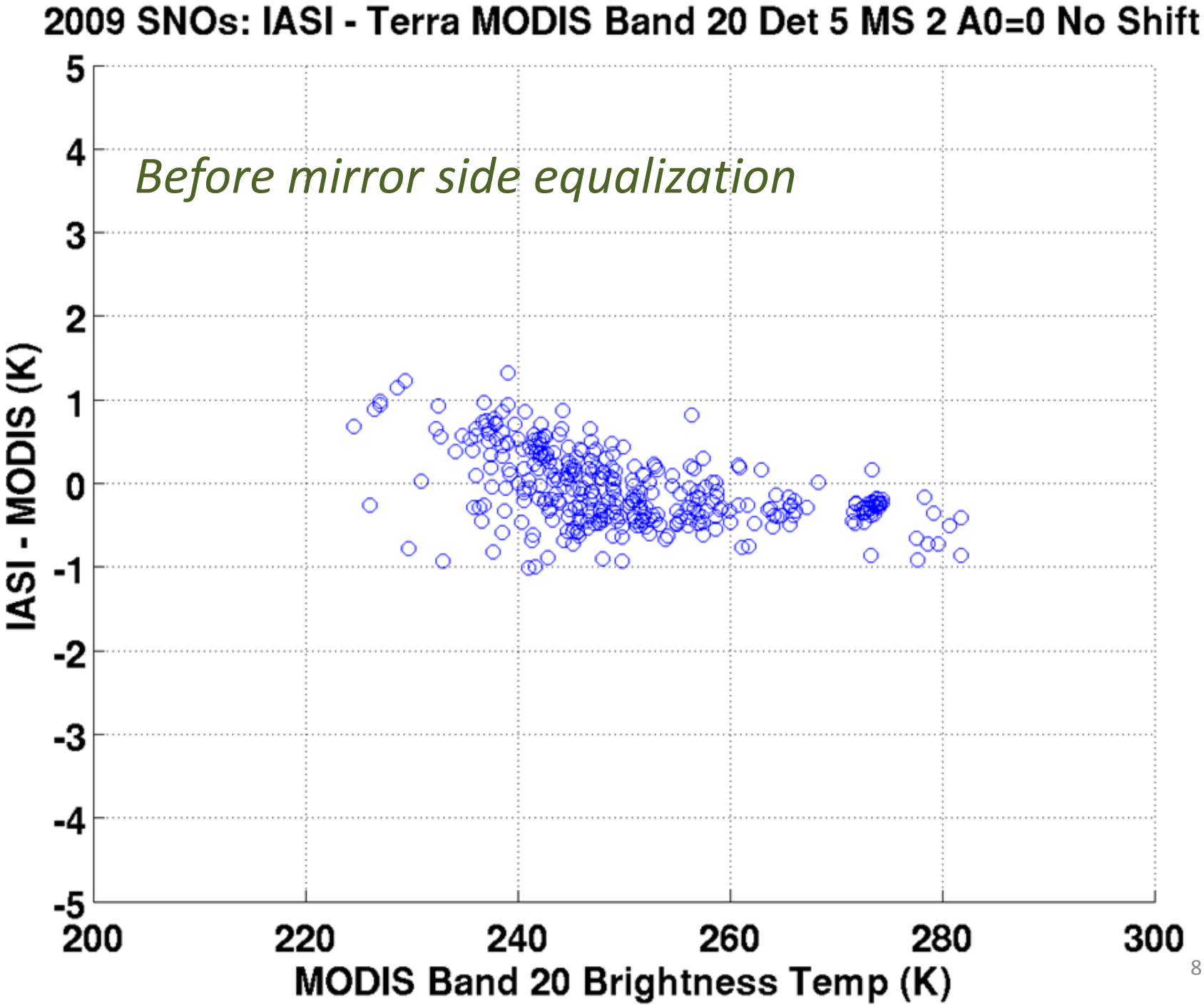


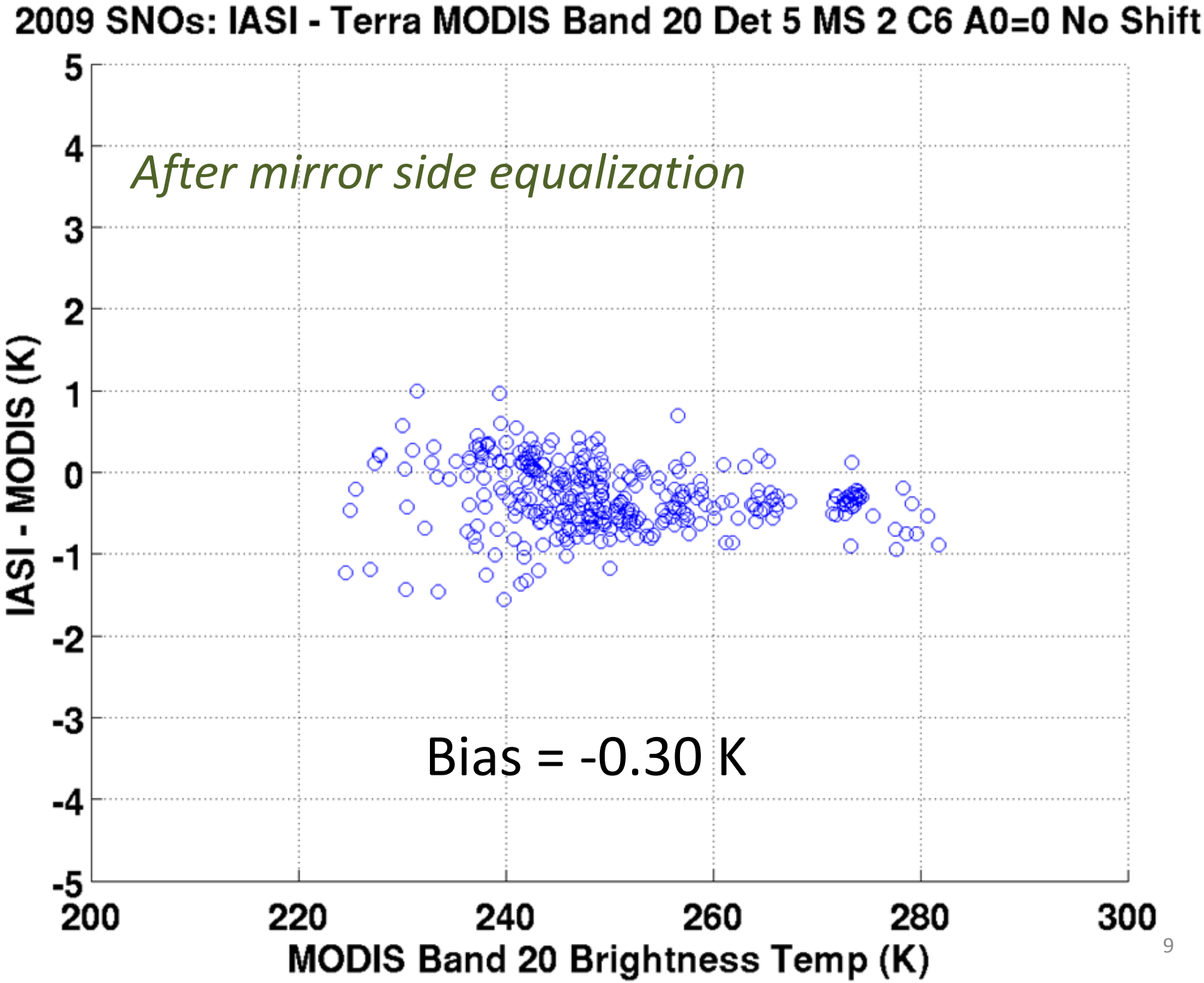
IASI – MODIS TEB Comparisons: MWIR (20-25) and PV LWIR (27-30) Bands

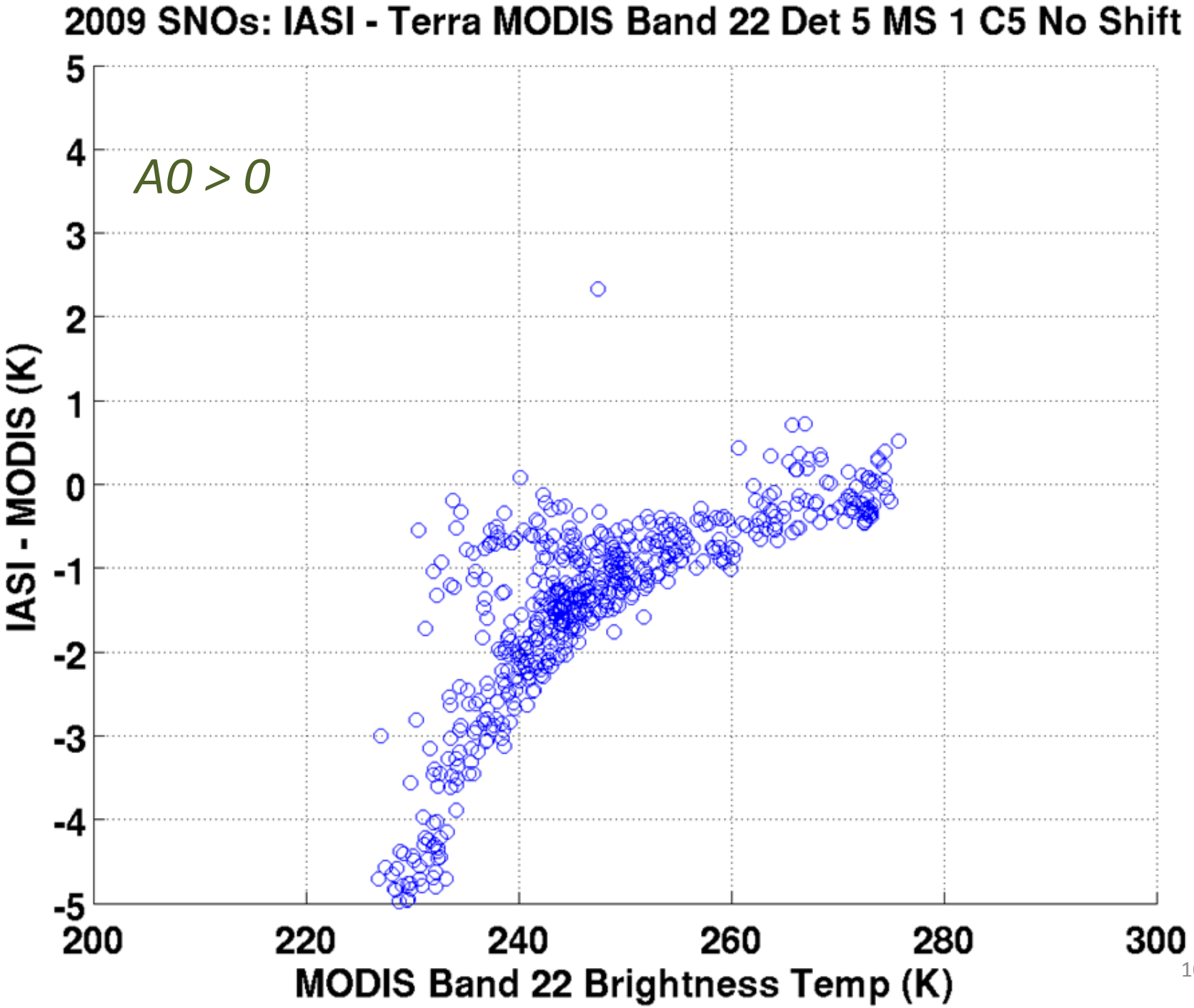
- Using C6 LUT greatly reduces bias between Terra MODIS and IASI at the cold scenes for all bands. Mirror sides match closely.
- Several atmospheric bands (e.g. 24, 27, 28, 30) still show scene temperature dependence in bias.
- Brings Terra MODIS much more in family with Aqua MODIS performance (Not shown).

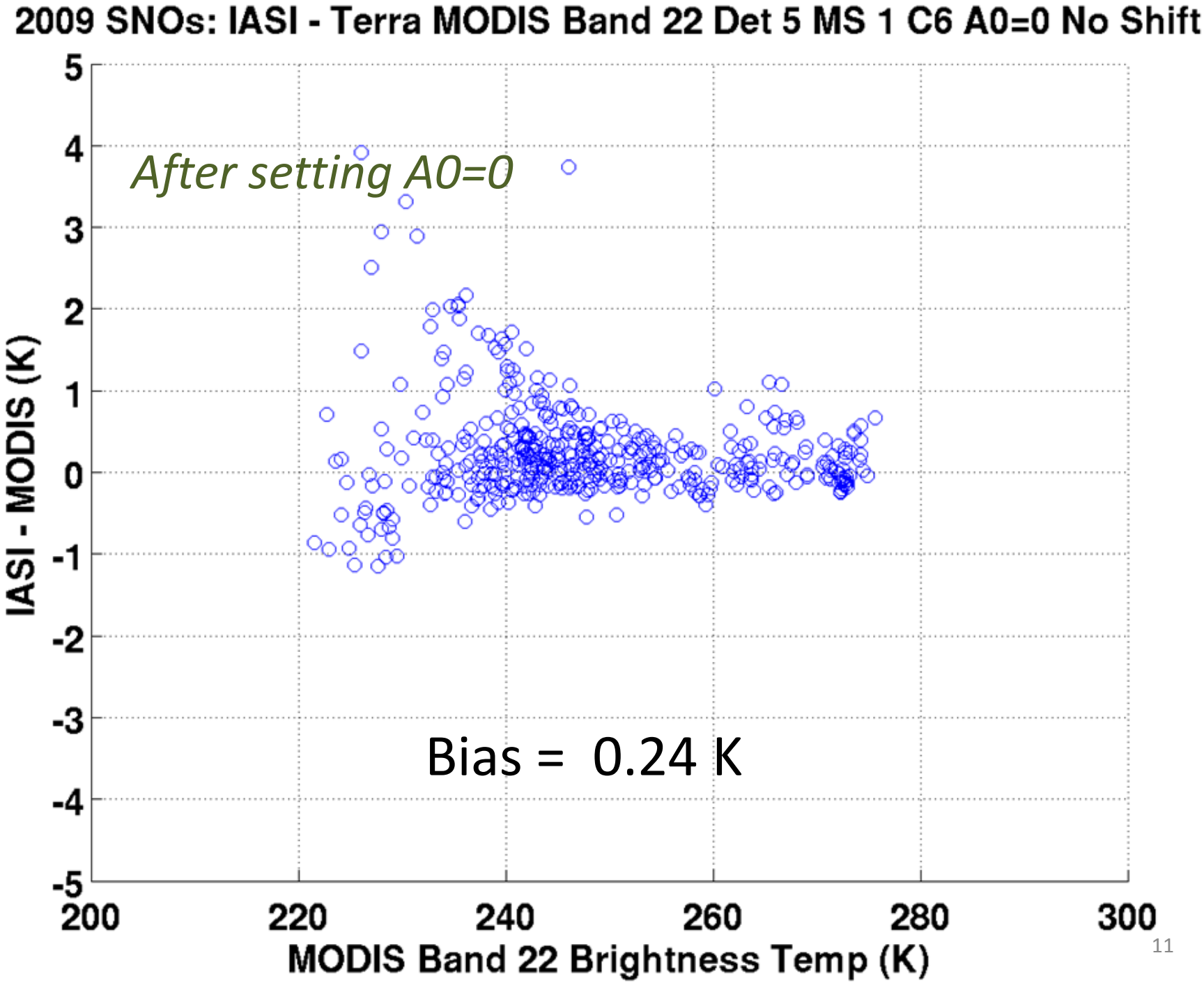

2009 SNOs: IASI - Terra MODIS Band 20 Det 5 MS 1 C5 No Shift
A0 > 0
Large scene temperature dependence in bias.
This behavior suggests a calibration offset coefficient problem and/or spectral problem
IASI - MODIS (K)
MODIS Band 20 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

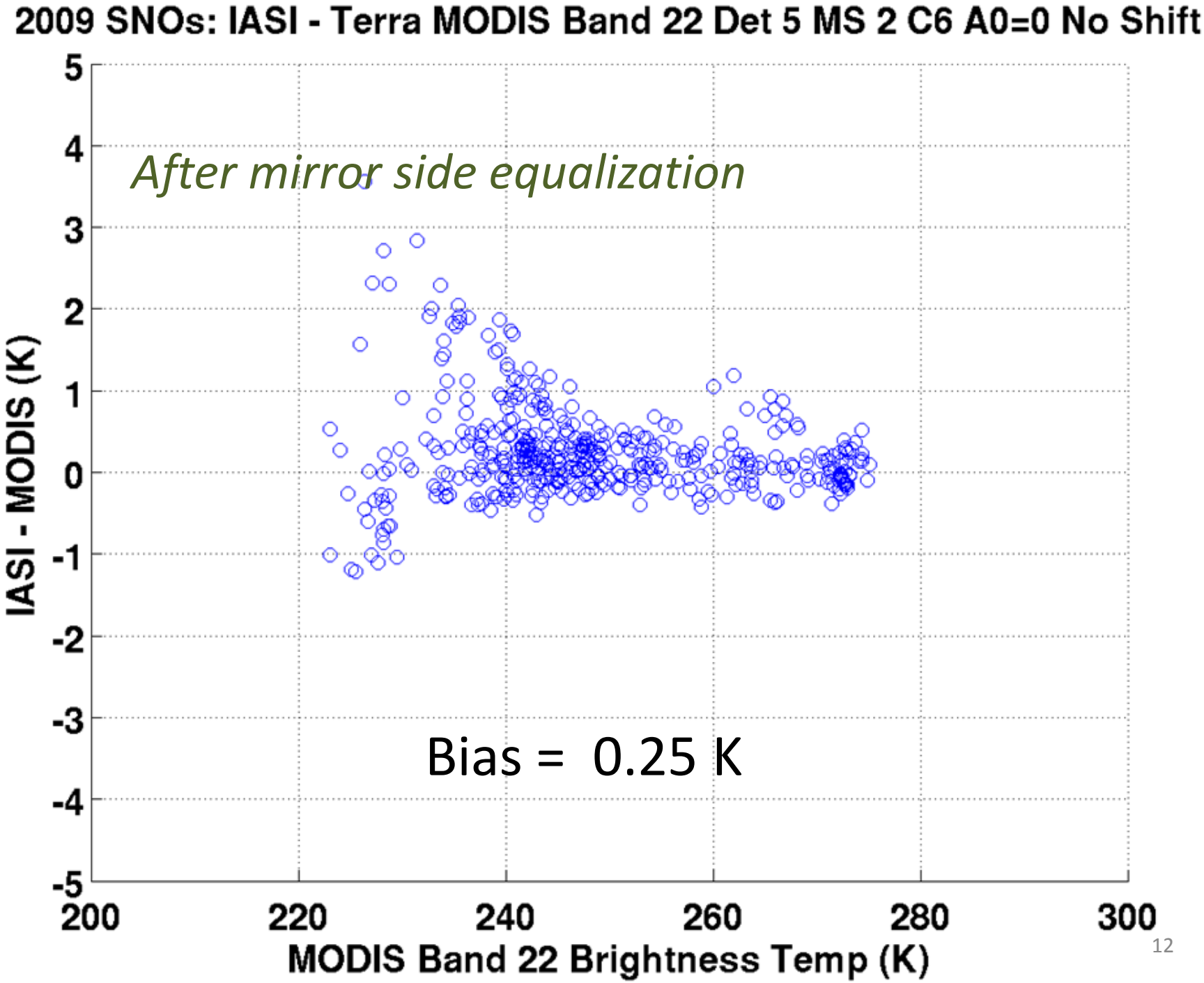

2009 SNOs: IASI - Terra MODIS Band 20 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = -0.29 K
IASI - MODIS (K)
MODIS Band 20 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

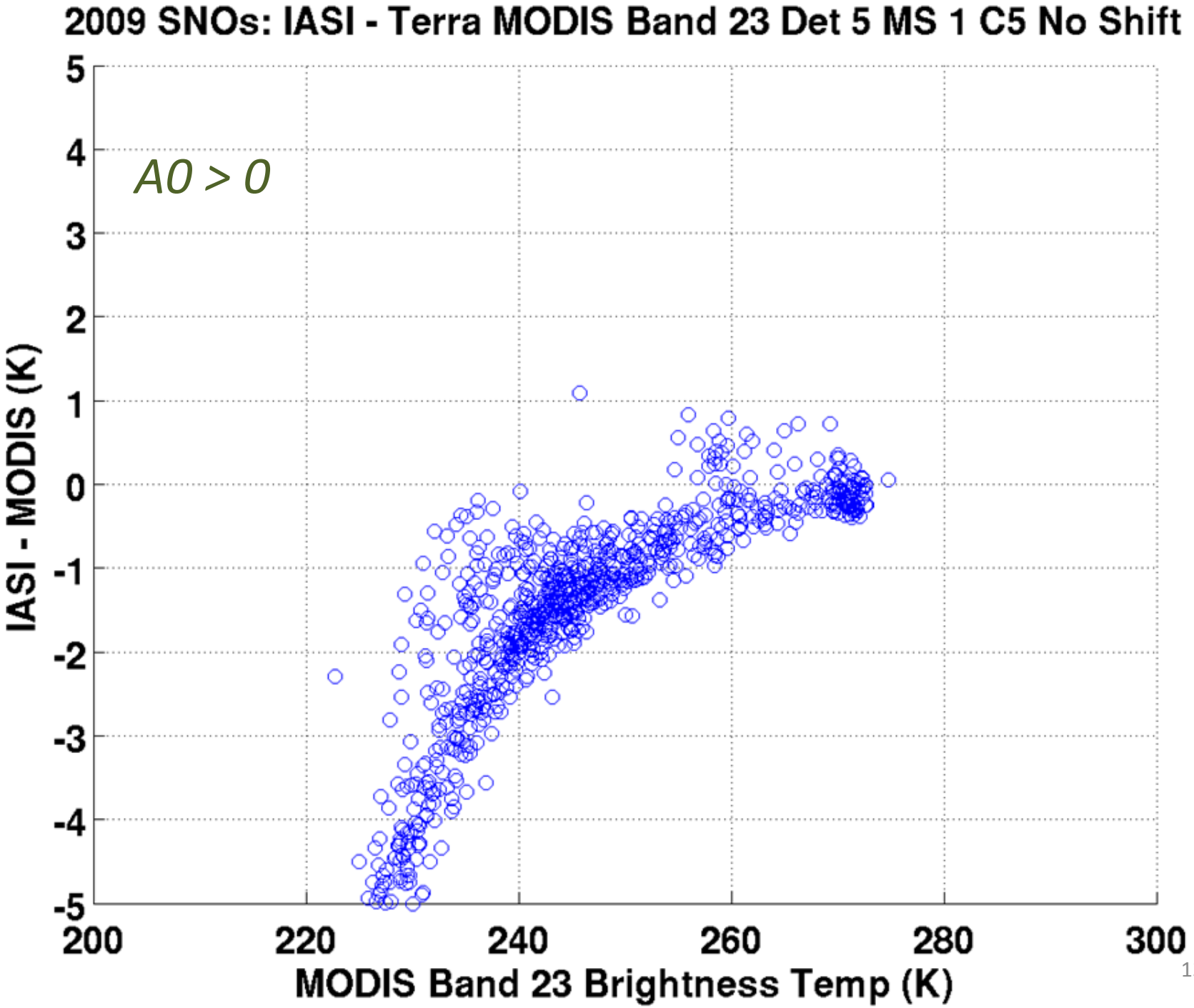

2009 SNOs: IASI - Terra MODIS Band 20 Det 5 MS 2 A0=0 No Shift
Before mirror side equalization
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 20 Brightness Temp (K)

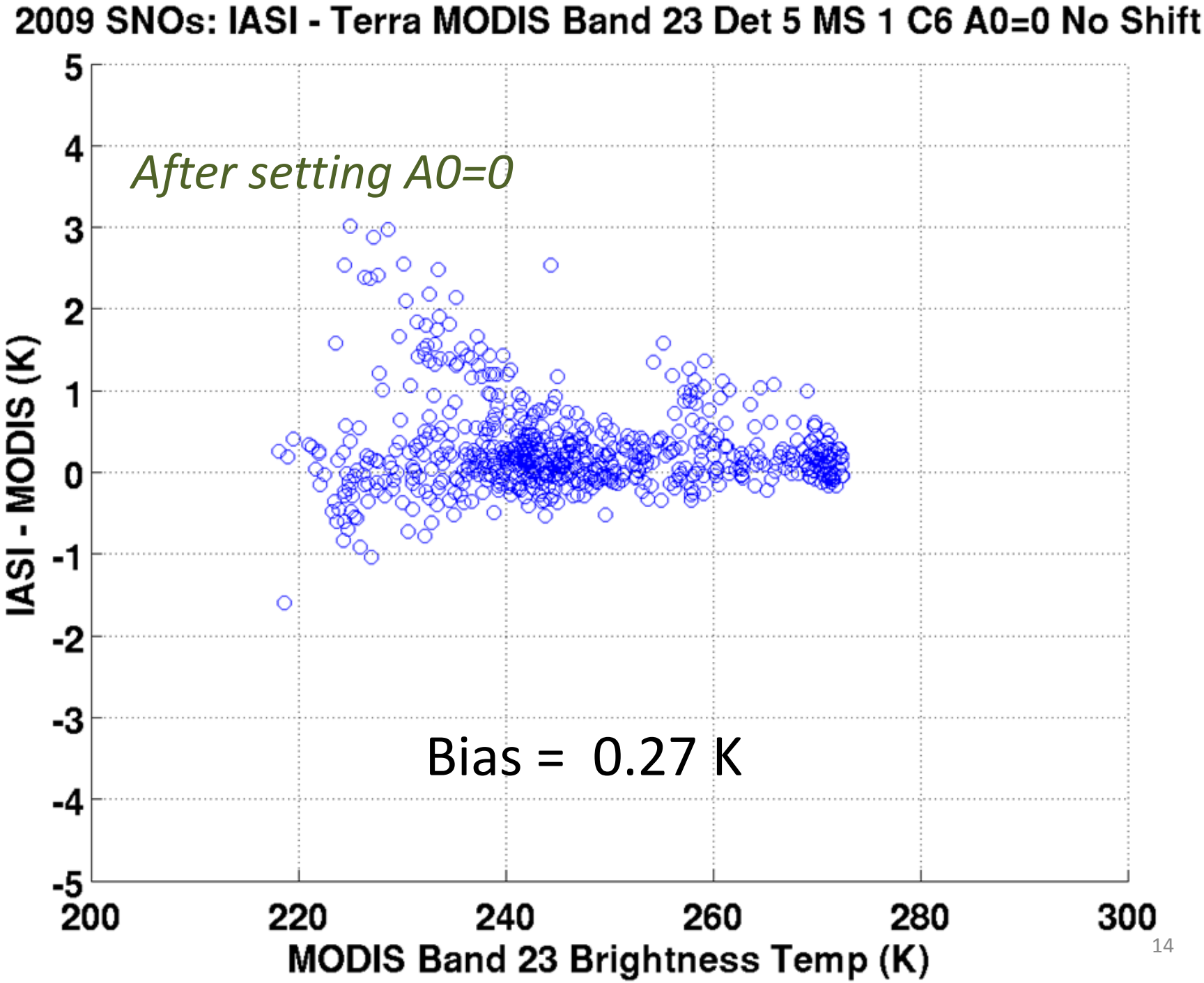

2009 SNOs: IASI - Terra MODIS Band 20 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.30 K
IASI - MODIS (K)
MODIS Band 20 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

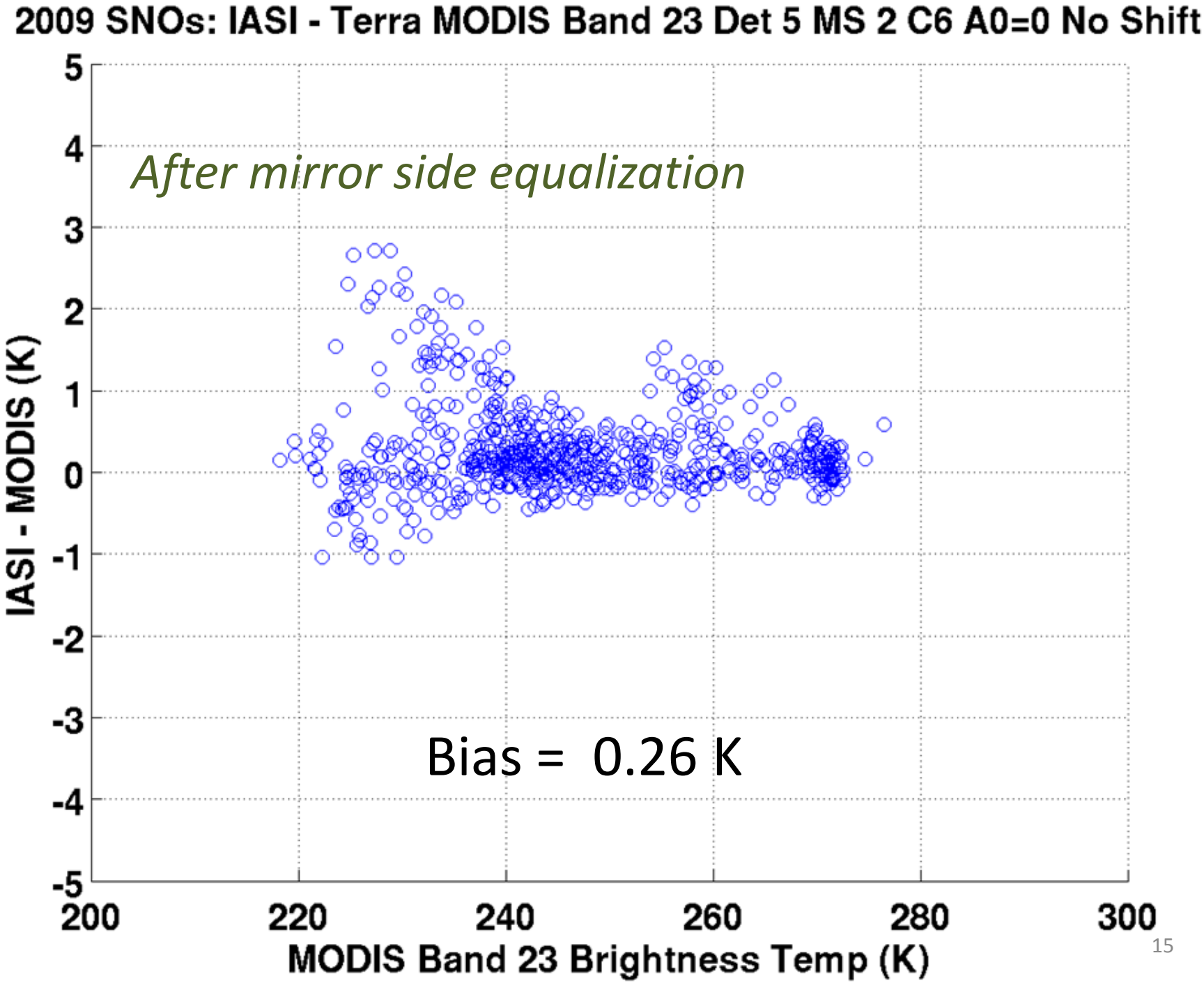

2009 SNOs: IASI - Terra MODIS Band 22 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 22 Brightness Temp (K)

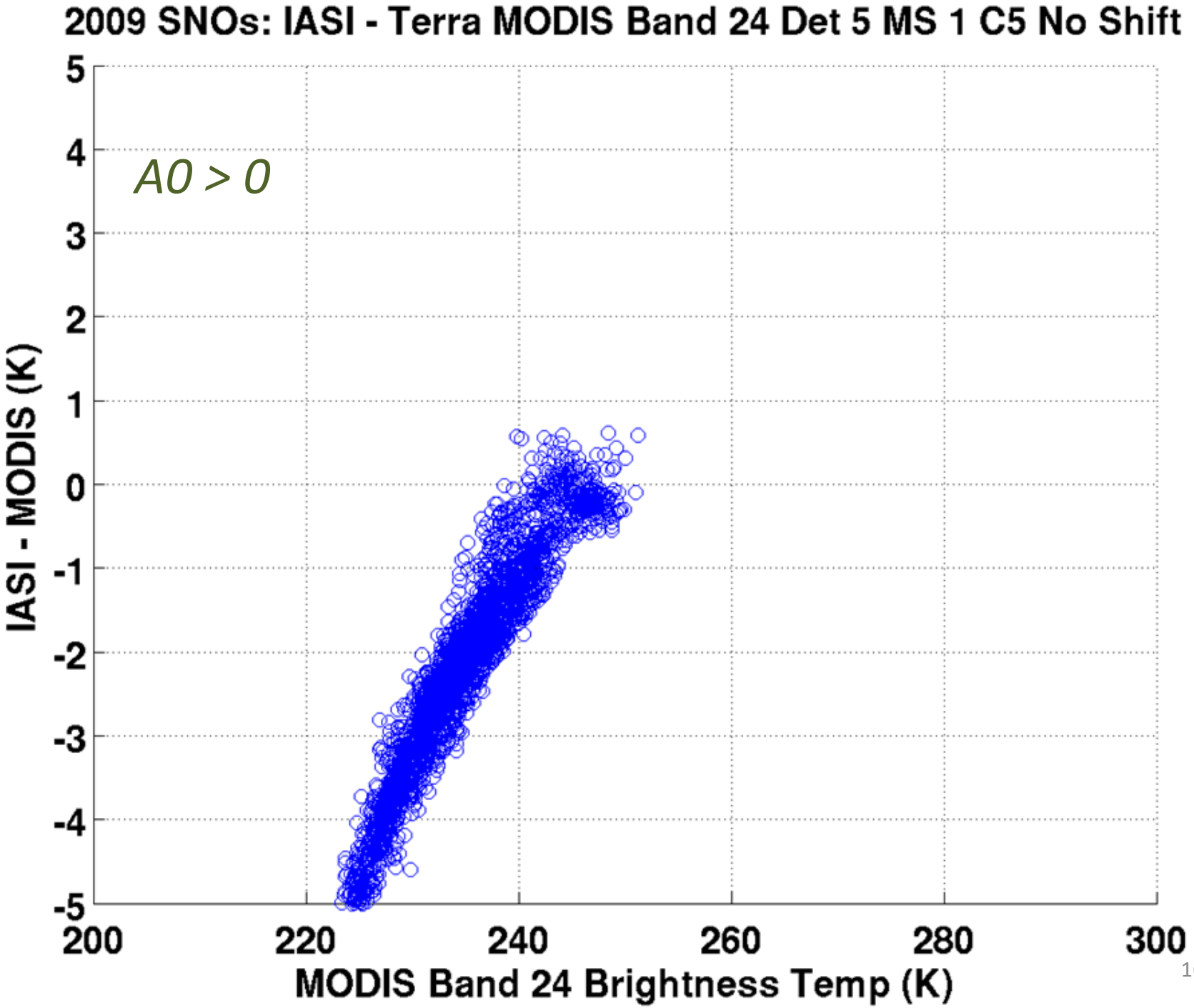

2009 SNOs: IASI - Terra MODIS Band 22 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.24 K
IASI - MODIS (K)
MODIS Band 22 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

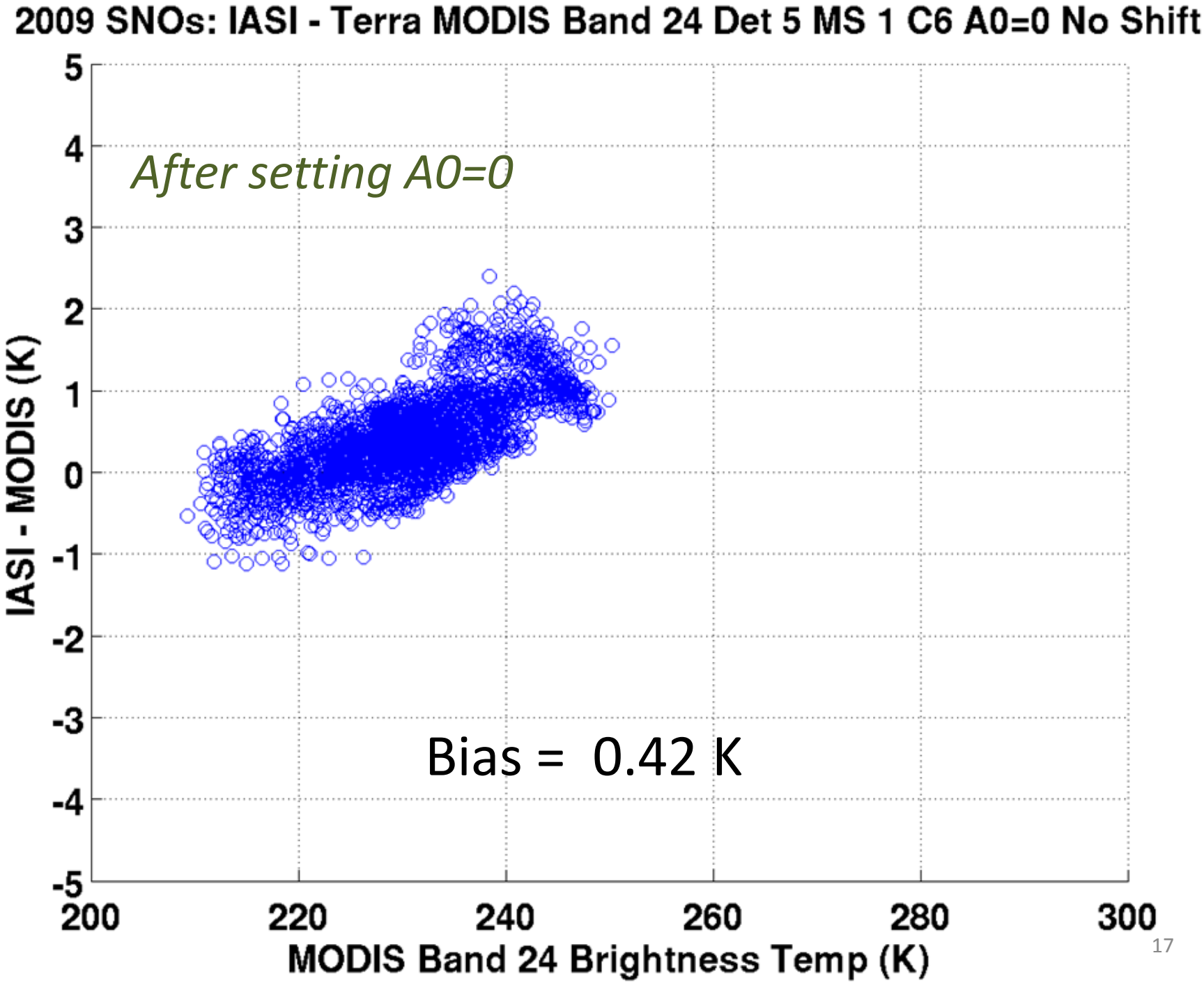

2009 SNOs: IASI - Terra MODIS Band 22 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.25 K
IASI - MODIS (K)
MODIS Band 22 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

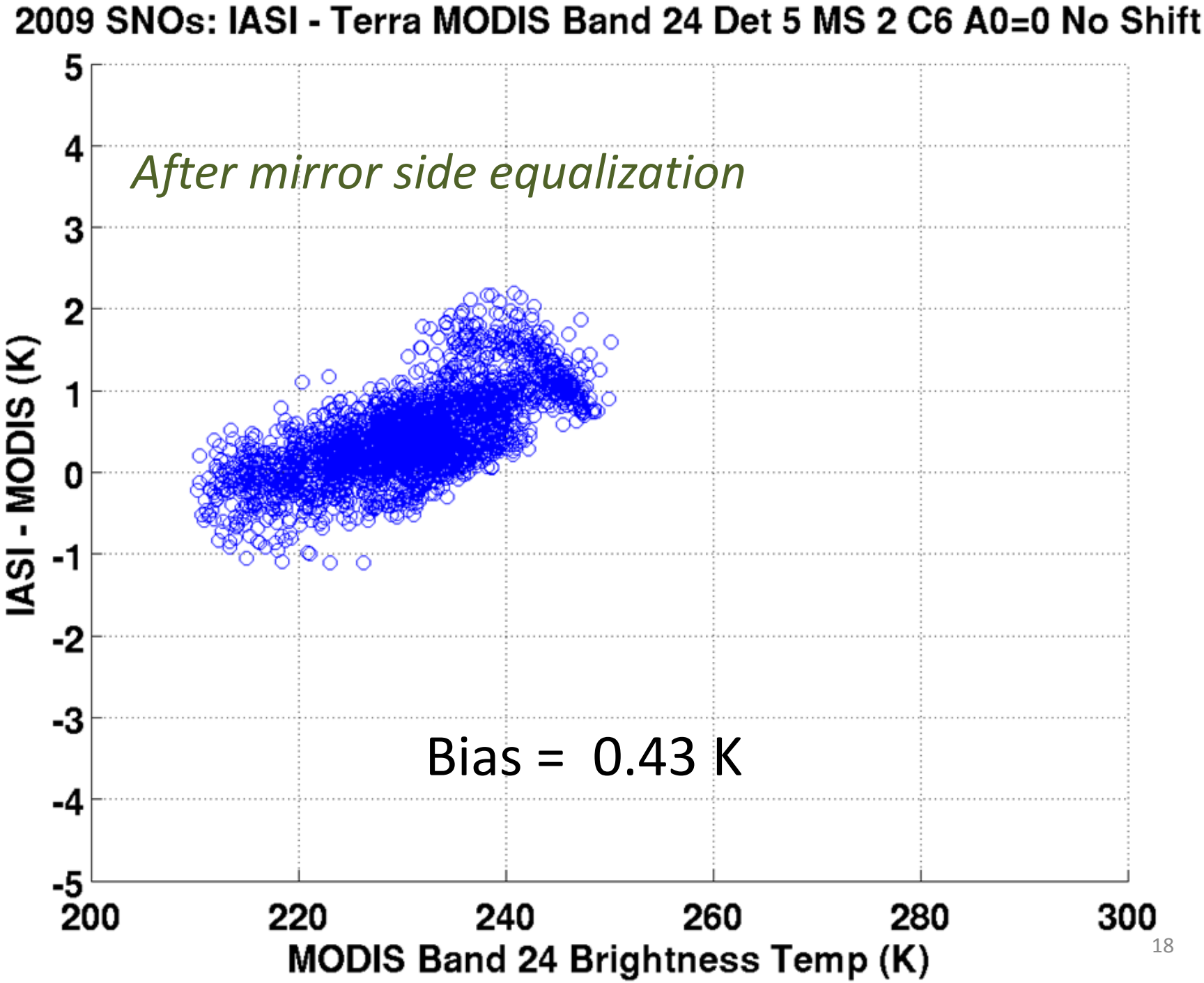

2009 SNOs: IASI - Terra MODIS Band 23 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 23 Brightness Temp (K)

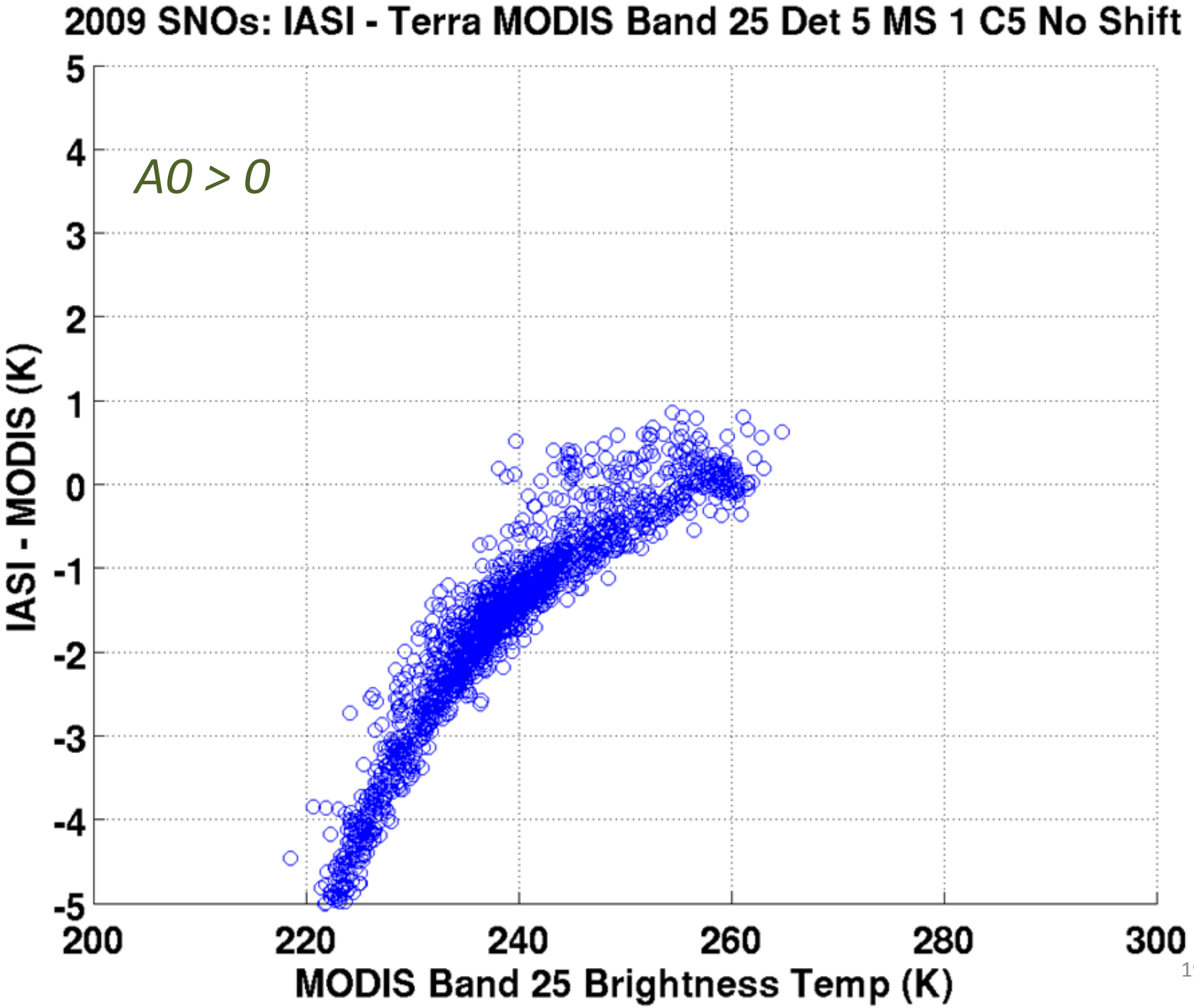

2009 SNOs: IASI - Terra MODIS Band 23 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.27 K
IASI - MODIS (K)
MODIS Band 23 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

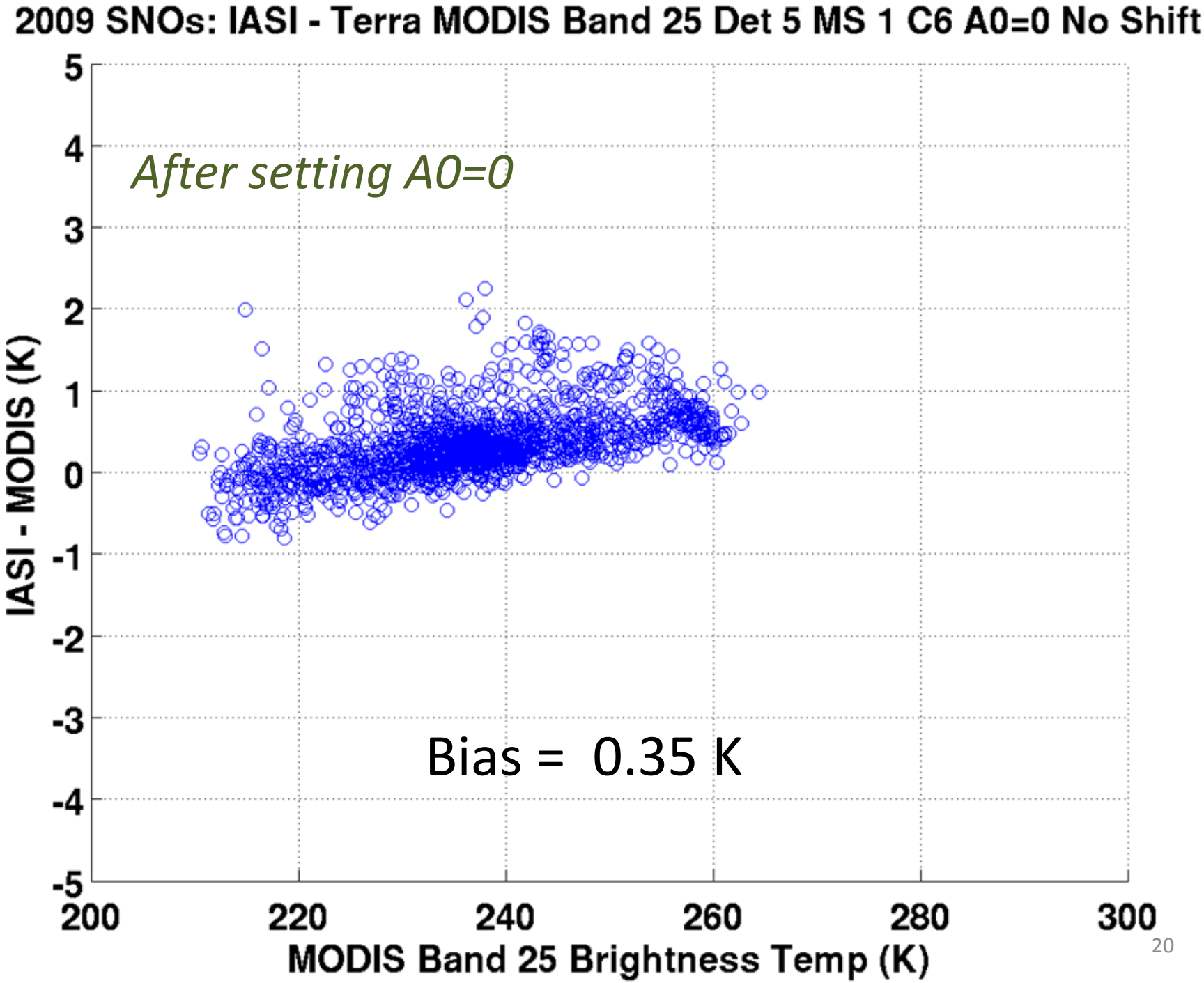

2009 SNOs: IASI - Terra MODIS Band 23 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.26 K
IASI - MODIS (K)
MODIS Band 23 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

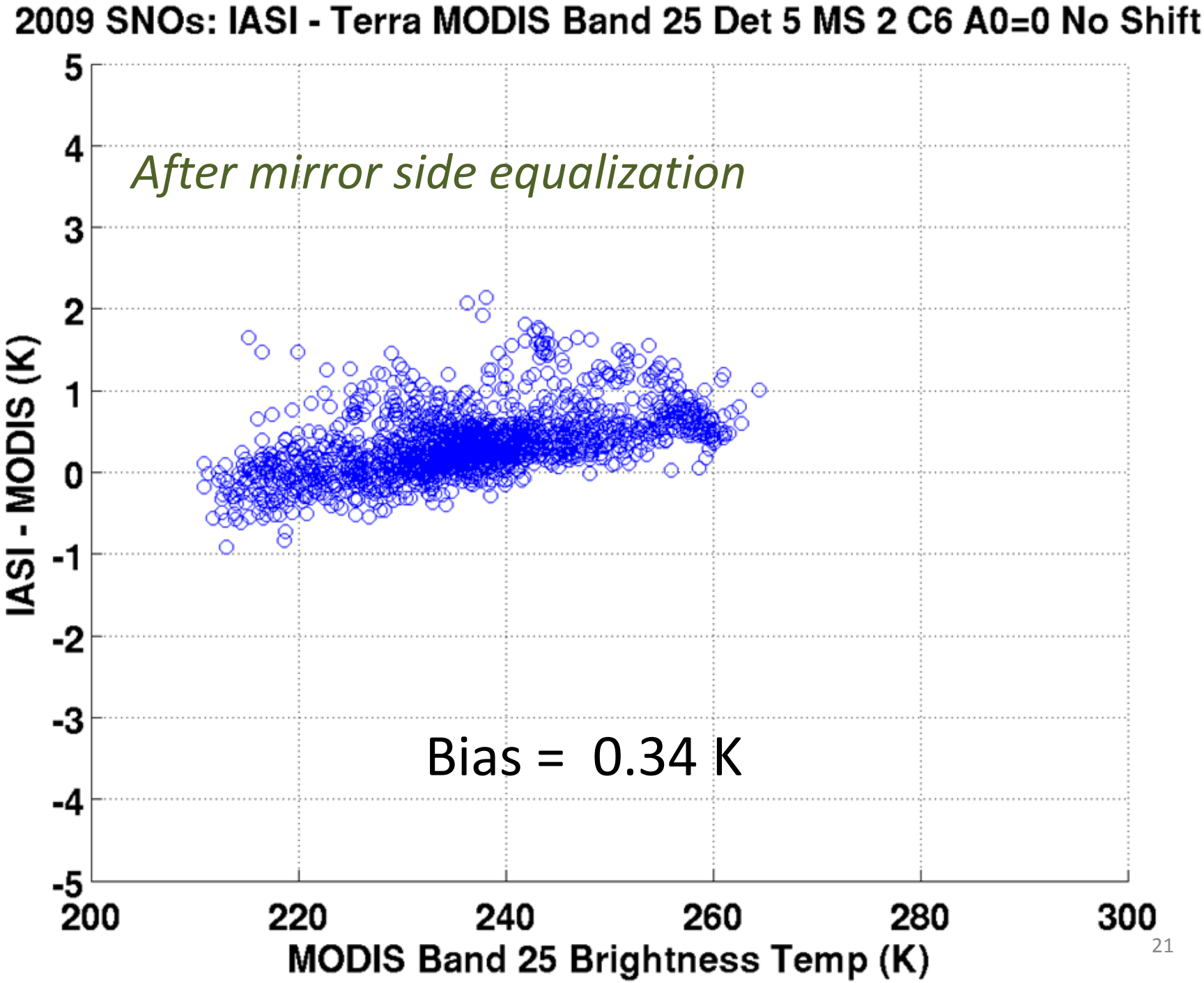

2009 SNOs: IASI - Terra MODIS Band 24 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 24 Brightness Temp (K)

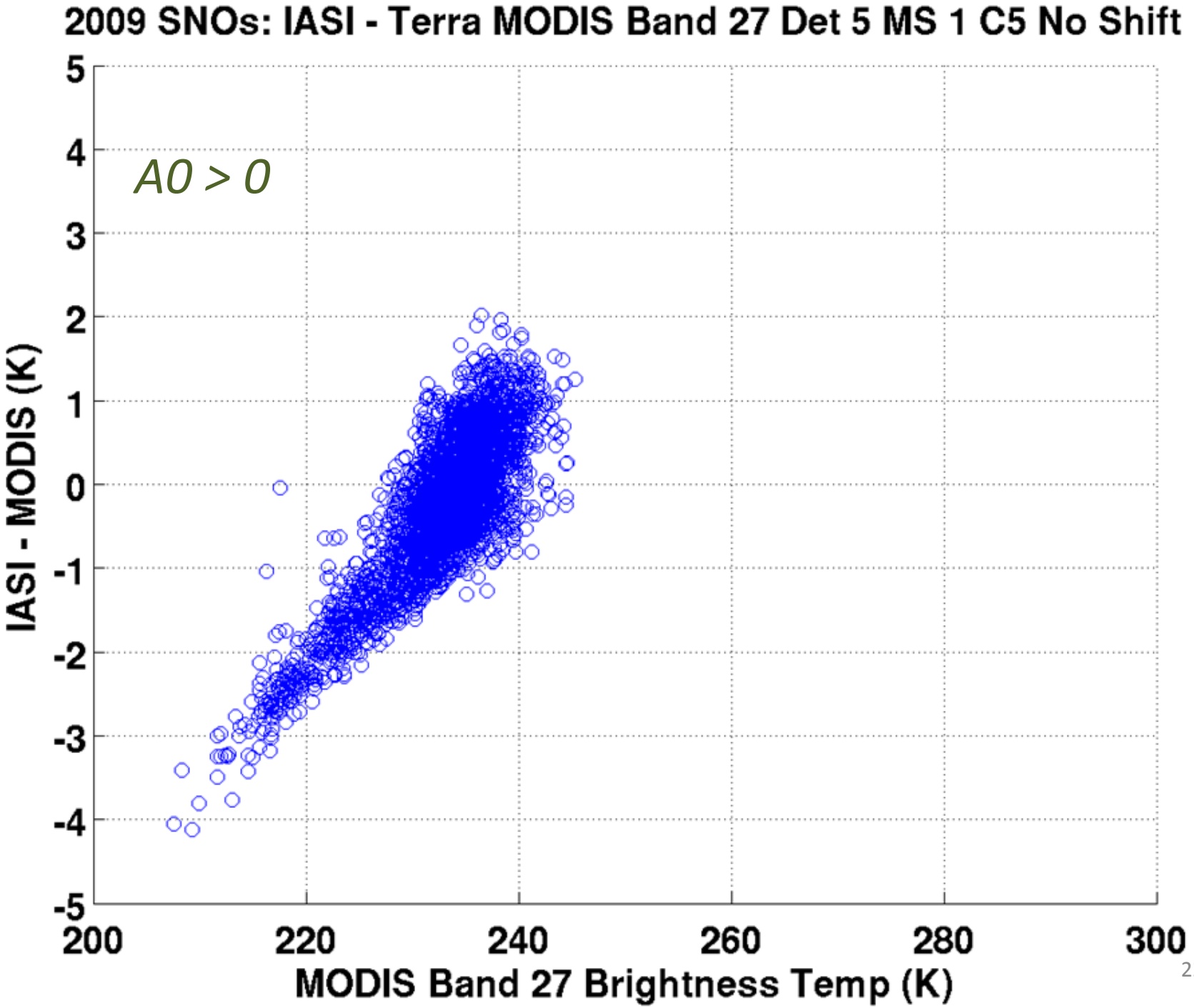

2009 SNOs: IASI - Terra MODIS Band 24 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.42 K
IASI - MODIS (K)
MODIS Band 24 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

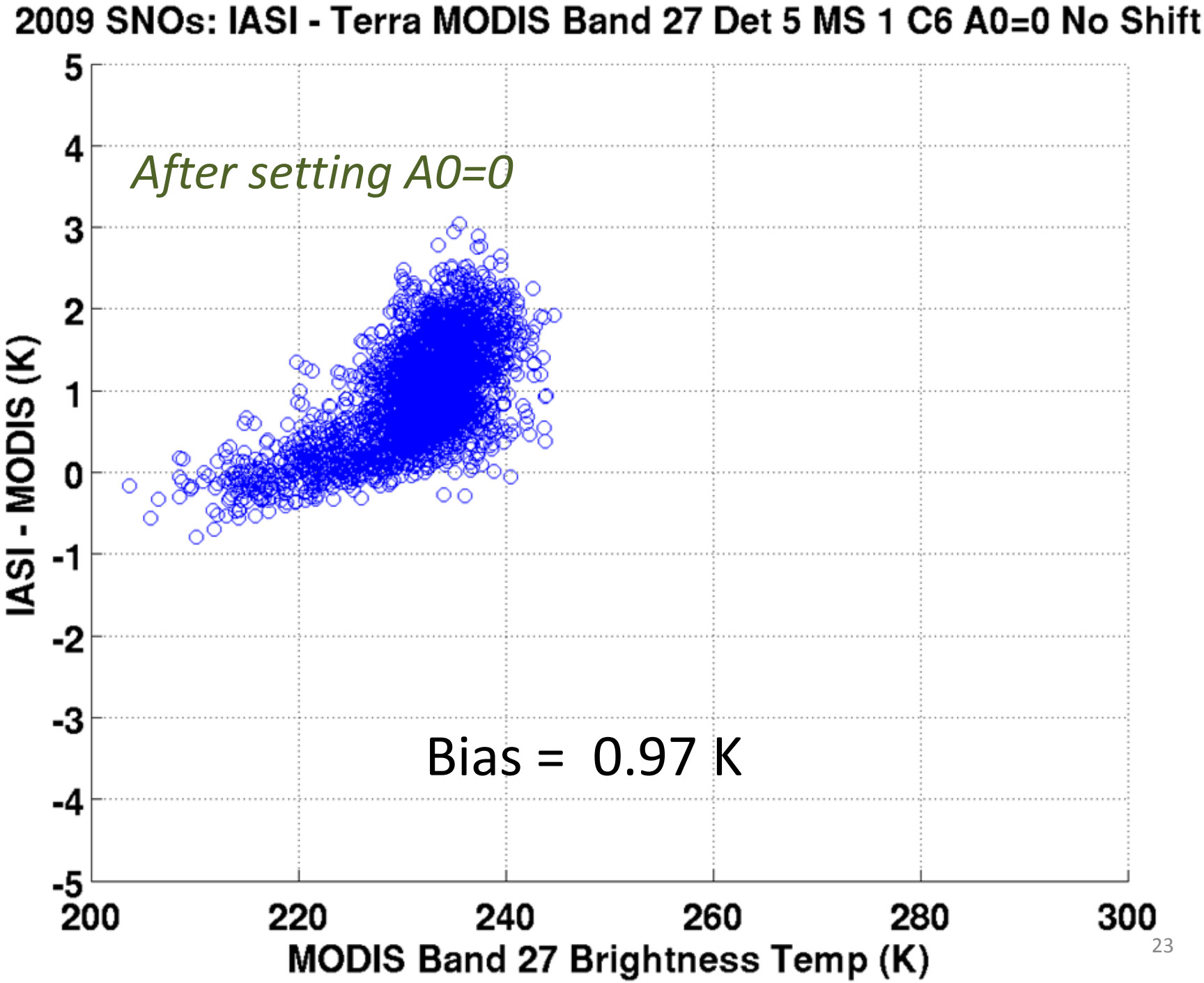

2009 SNOs: IASI - Terra MODIS Band 24 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.43 K
IASI - MODIS (K)
MODIS Band 24 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

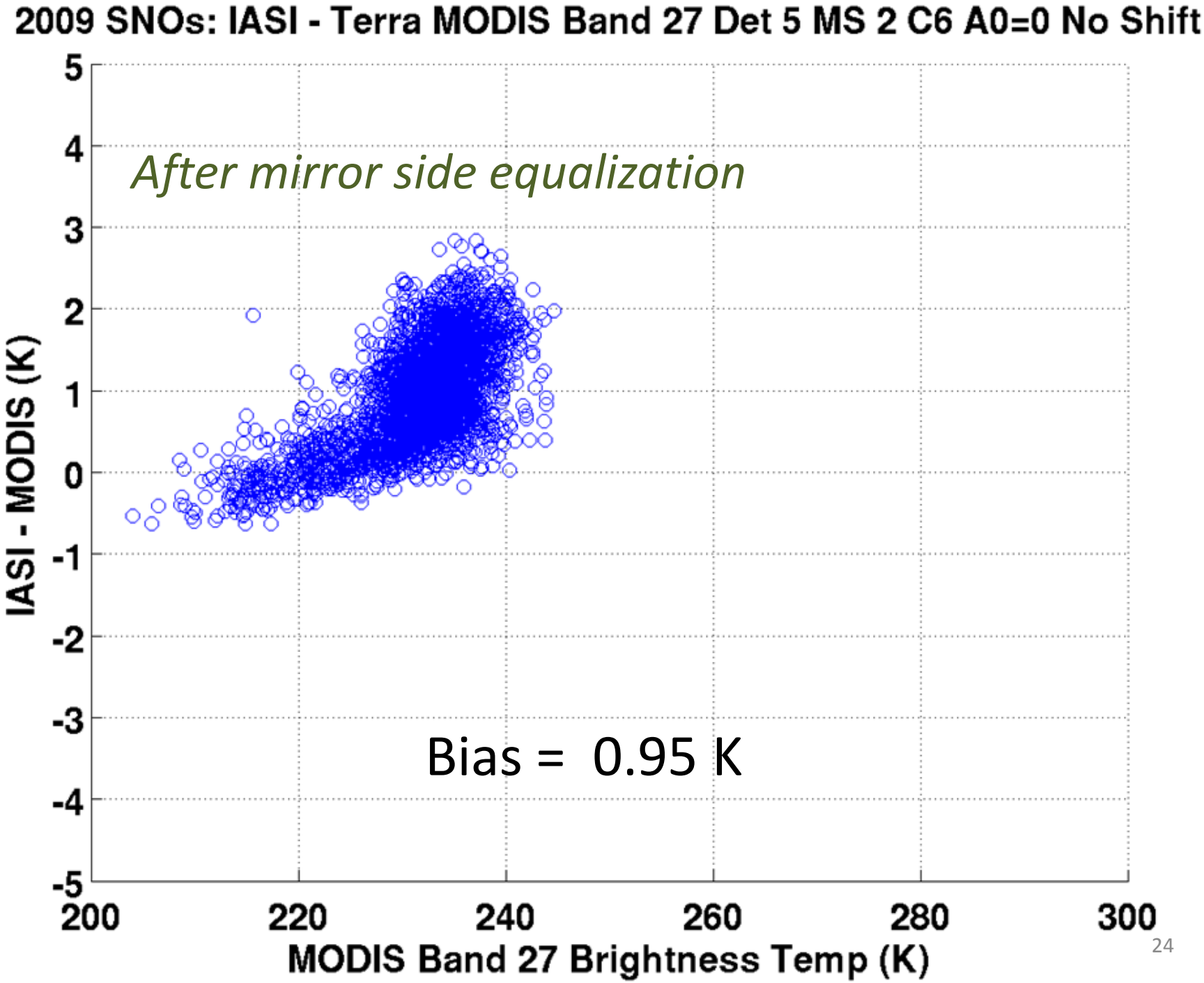

2009 SNOs: IASI - Terra MODIS Band 25 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 25 Brightness Temp (K)

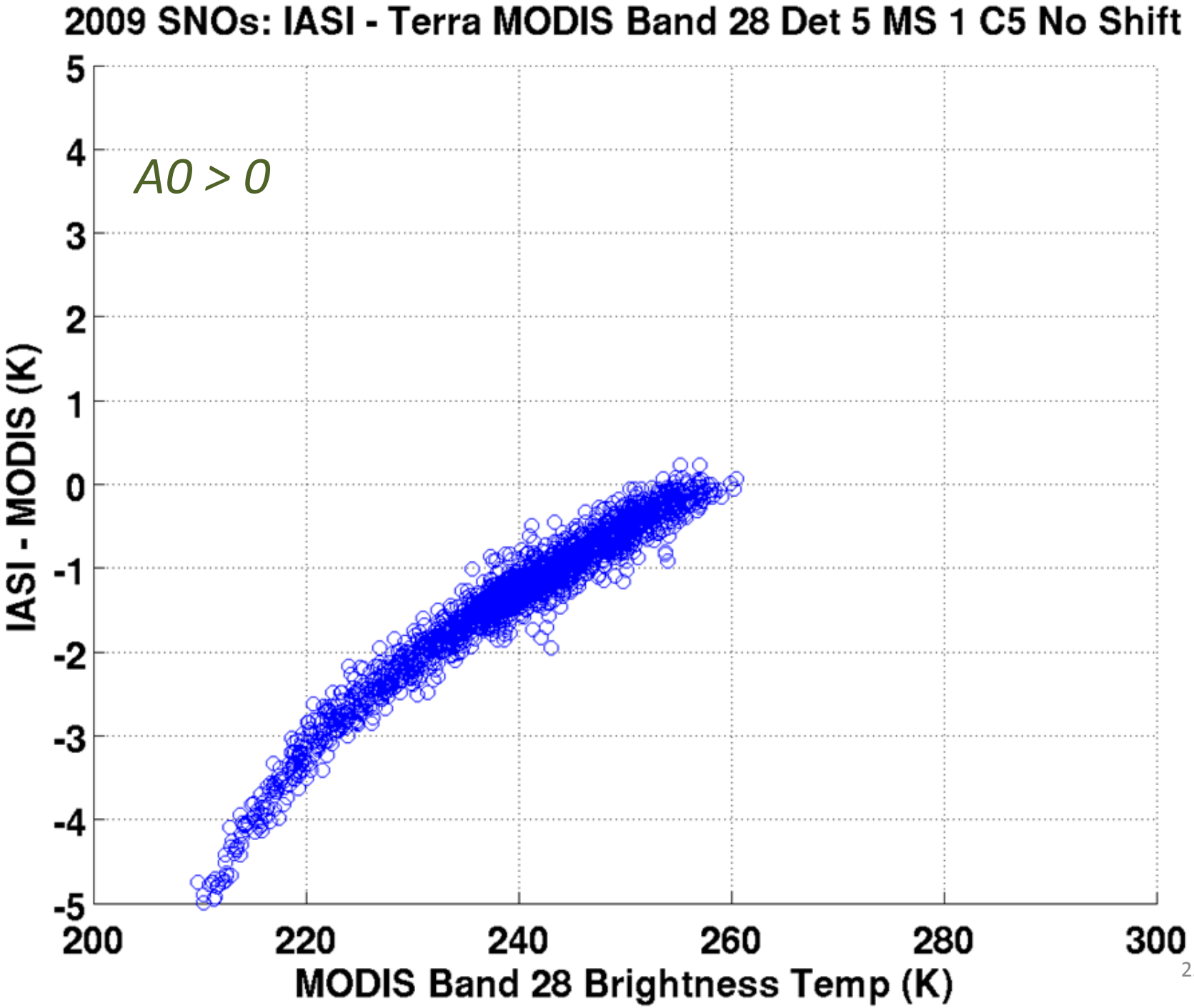

2009 SNOs: IASI - Terra MODIS Band 25 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.35 K
IASI - MODIS (K)
MODIS Band 25 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

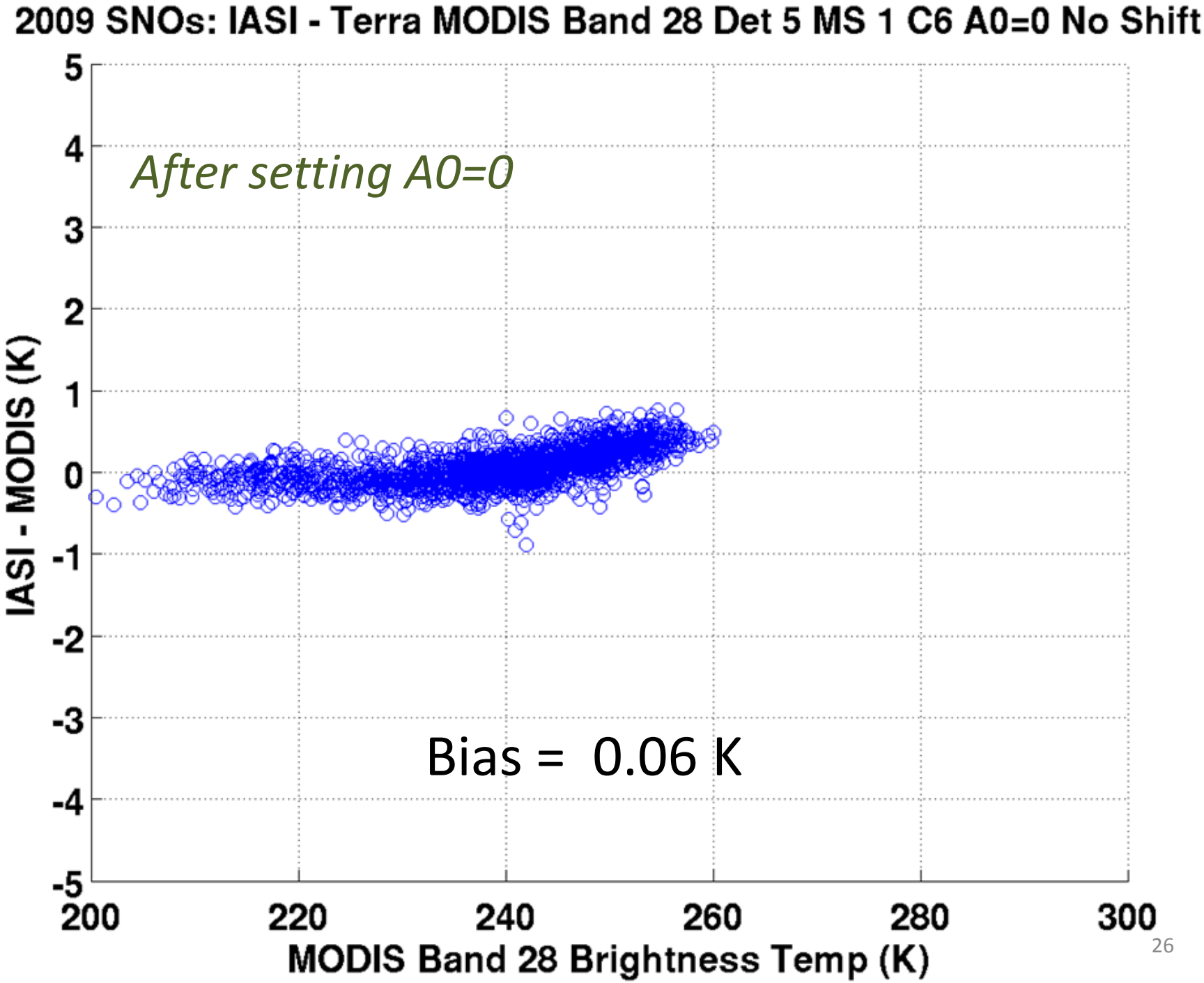

2009 SNOs: IASI - Terra MODIS Band 25 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.34 K
IASI - MODIS (K)
MODIS Band 25 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

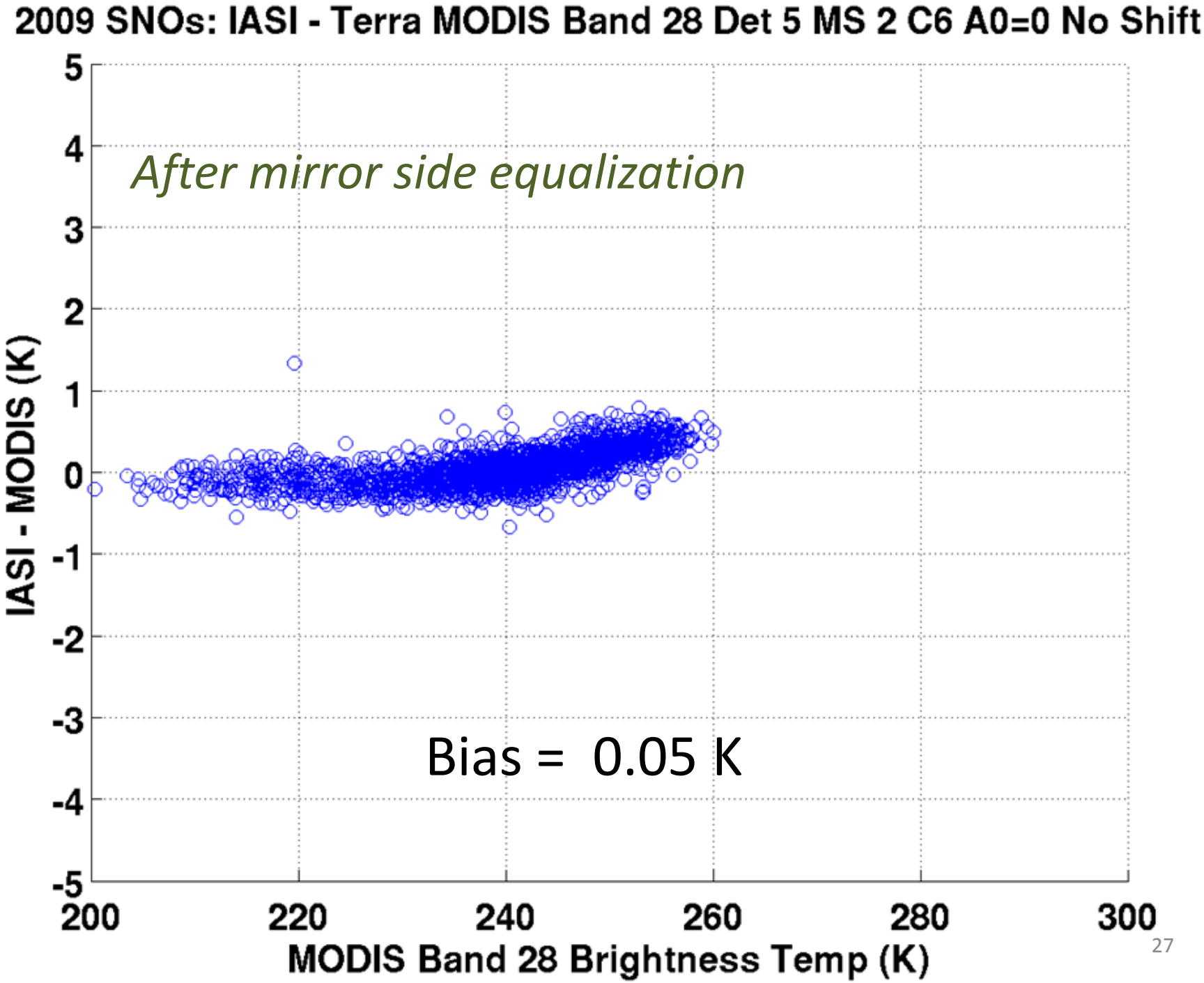

2009 SNOs: IASI - Terra MODIS Band 27 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 27 Brightness Temp (K)

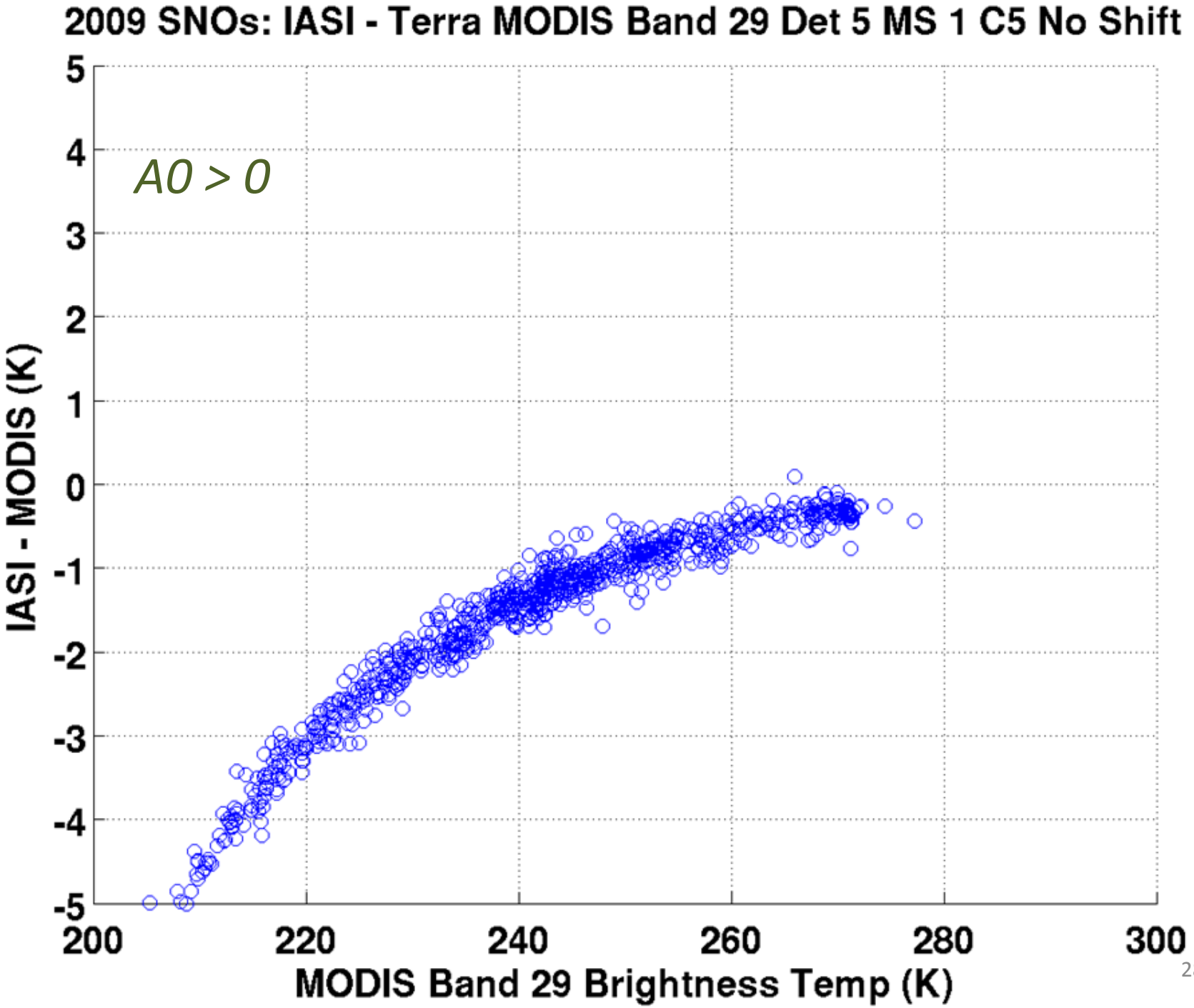

2009 SNOs: IASI - Terra MODIS Band 27 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.97 K
IASI - MODIS (K)
MODIS Band 27 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

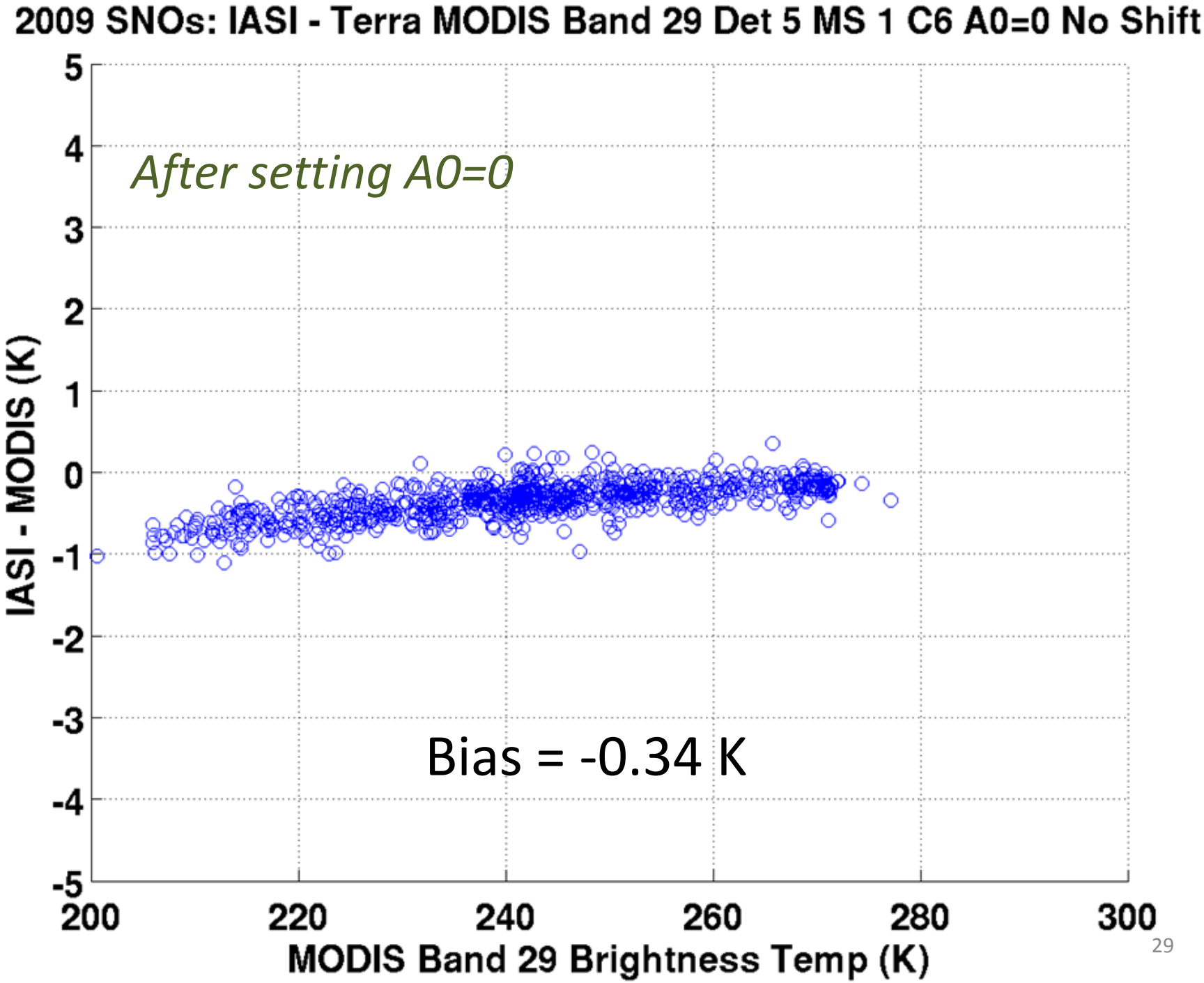

2009 SNOs: IASI - Terra MODIS Band 27 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.95 K
IASI - MODIS (K)
MODIS Band 27 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

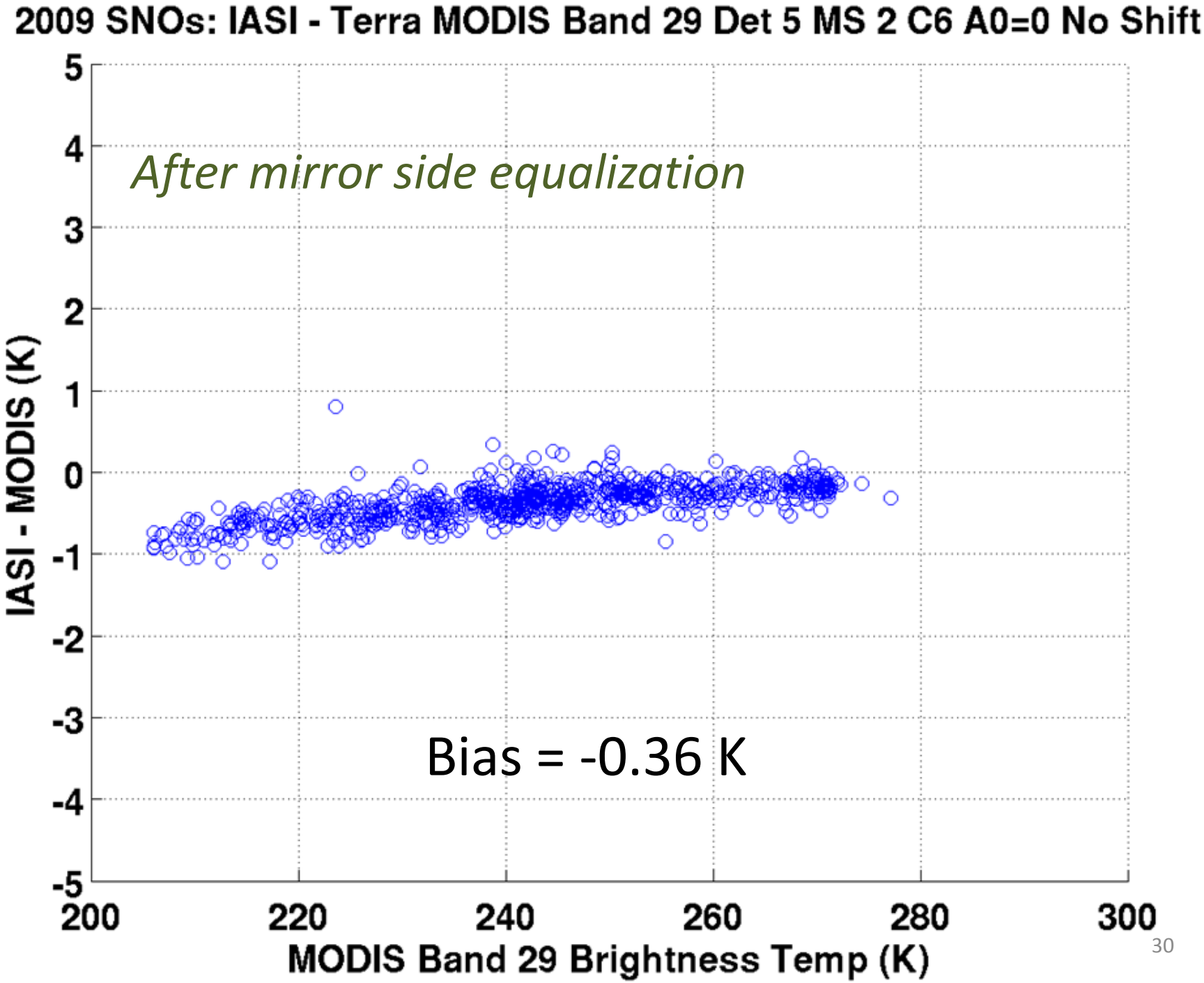

2009 SNOs: IASI - Terra MODIS Band 28 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 28 Brightness Temp (K)

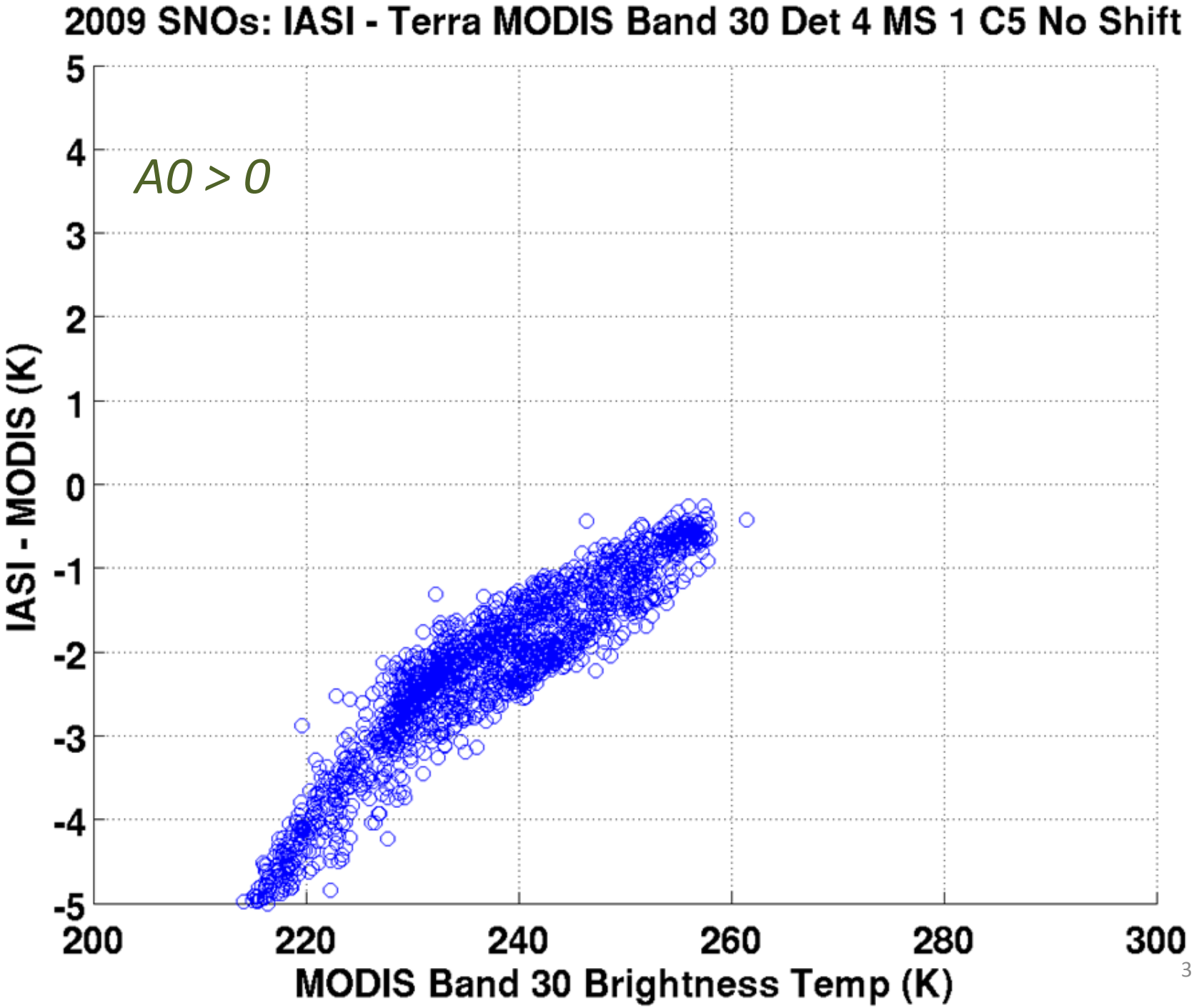

2009 SNOs: IASI - Terra MODIS Band 28 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.06 K
IASI - MODIS (K)
MODIS Band 28 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

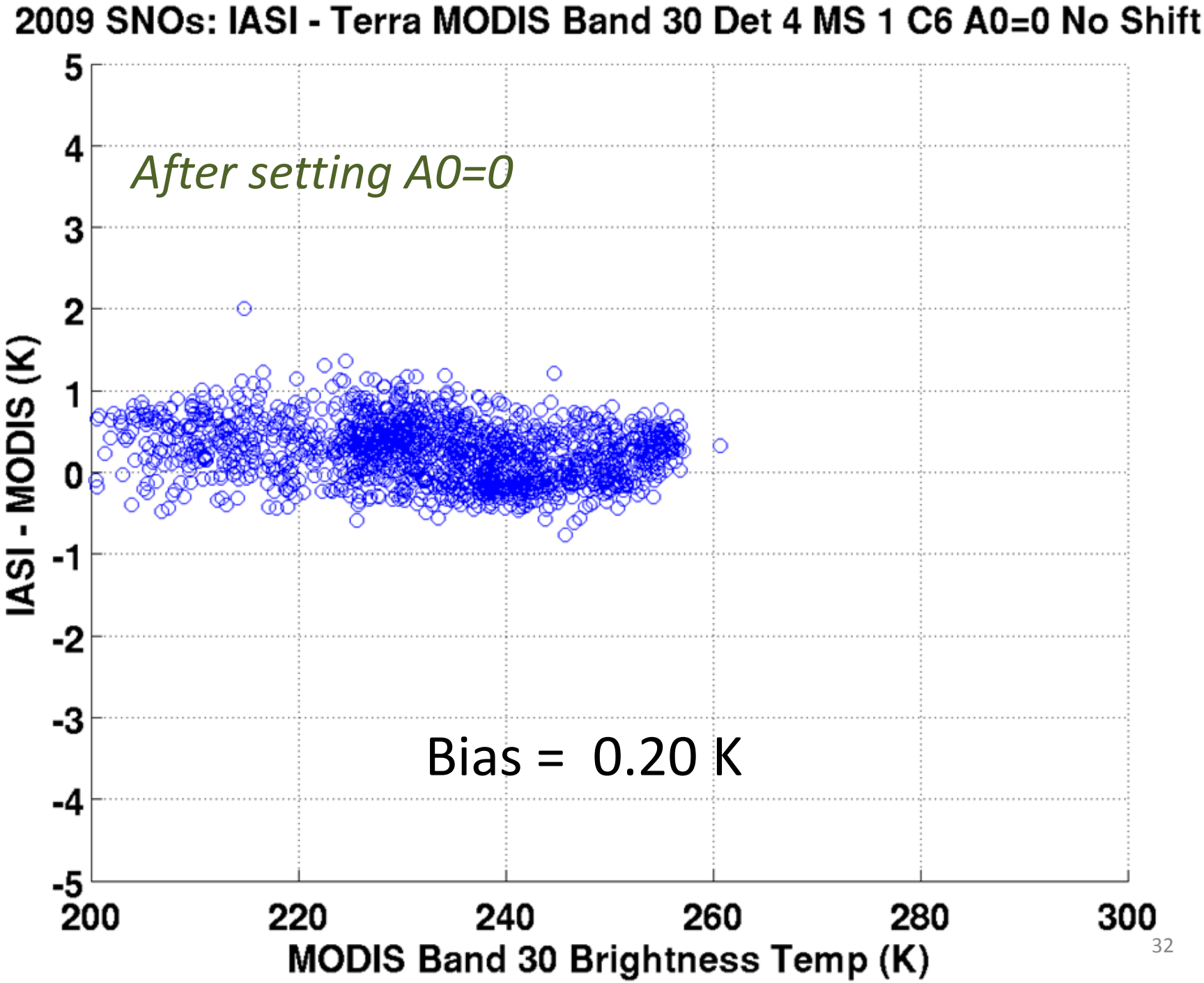

2009 SNOs: IASI - Terra MODIS Band 28 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.05 K
IASI - MODIS (K)
MODIS Band 28 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

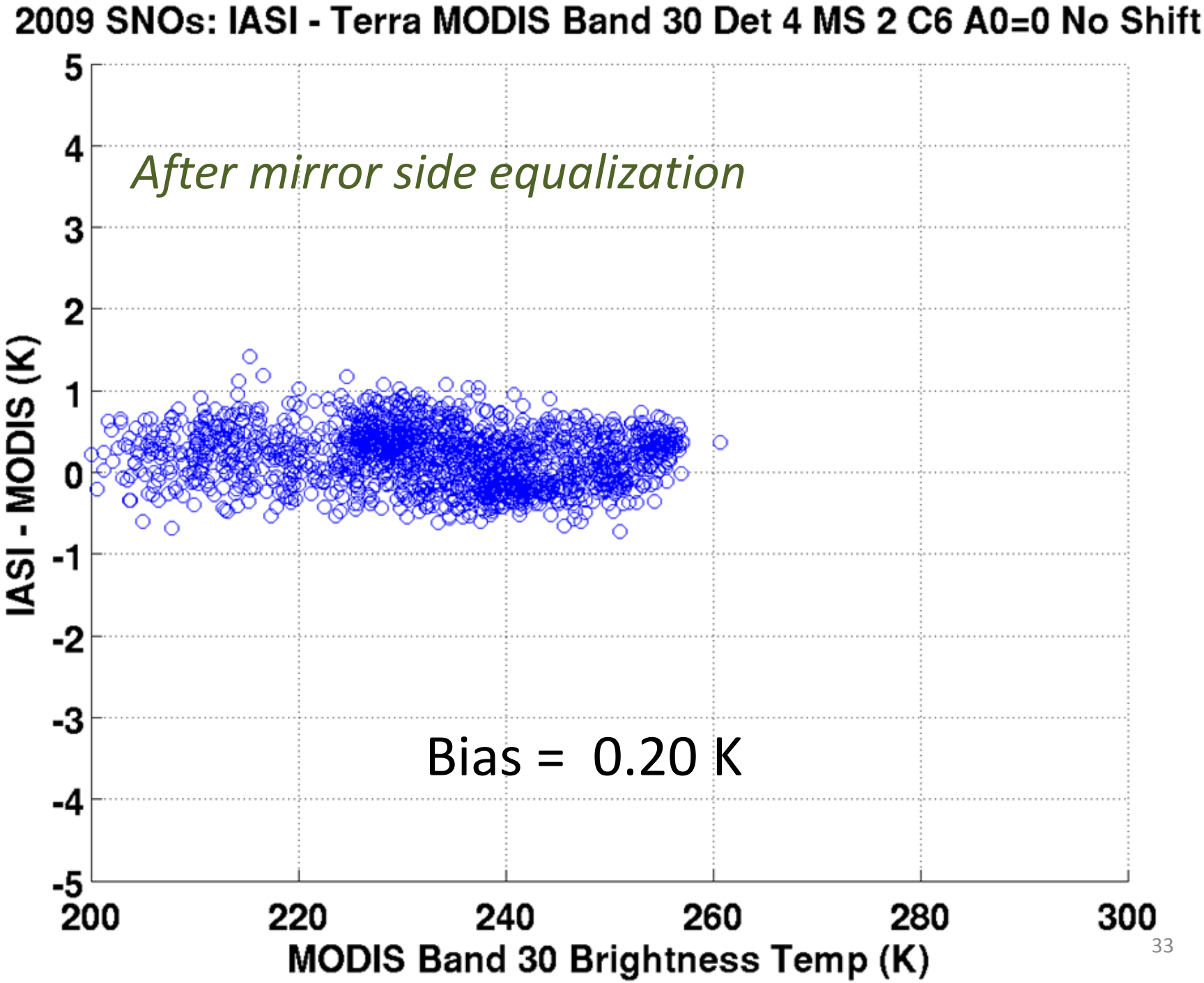

2009 SNOs: IASI - Terra MODIS Band 29 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 29 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 29 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = -0.34 K
IASI - MODIS (K)
MODIS Band 29 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300


2009 SNOs: IASI - Terra MODIS Band 29 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.36 K
IASI - MODIS (K)
MODIS Band 29 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

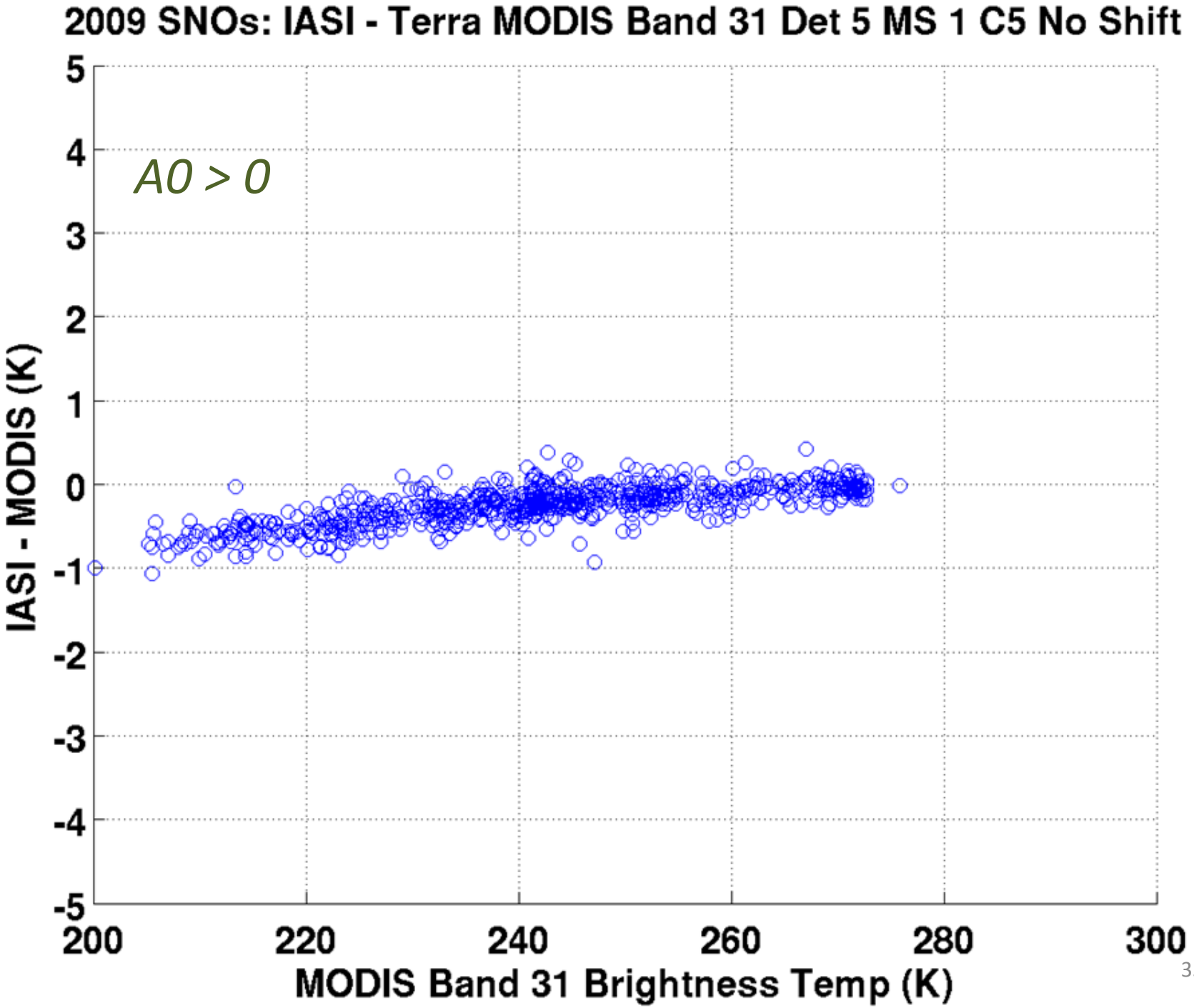

2009 SNOs: IASI - Terra MODIS Band 30 Det 4 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 30 Brightness Temp (K)

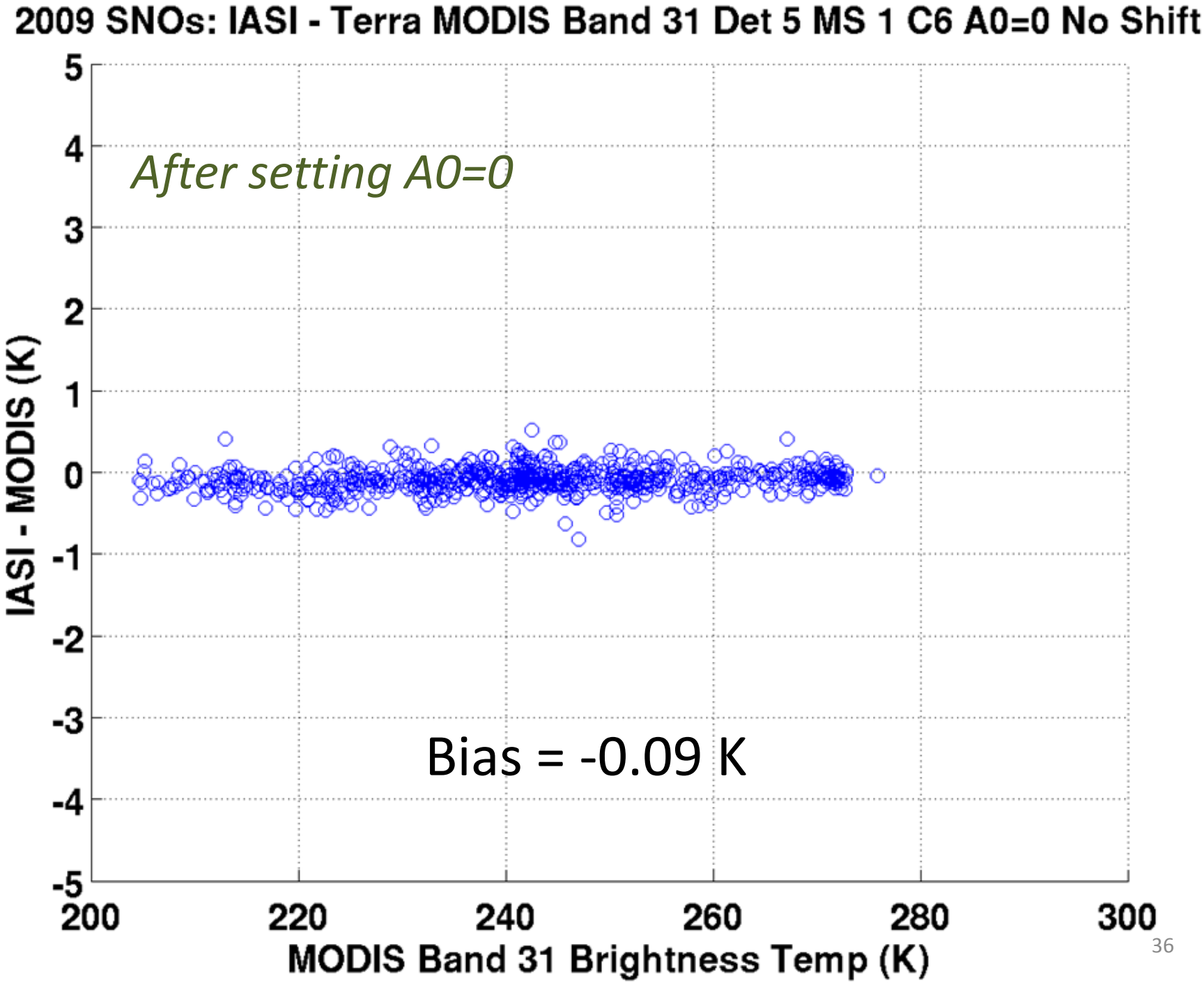

2009 SNOs: IASI - Terra MODIS Band 30 Det 4 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = 0.20 K
IASI - MODIS (K)
MODIS Band 30 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

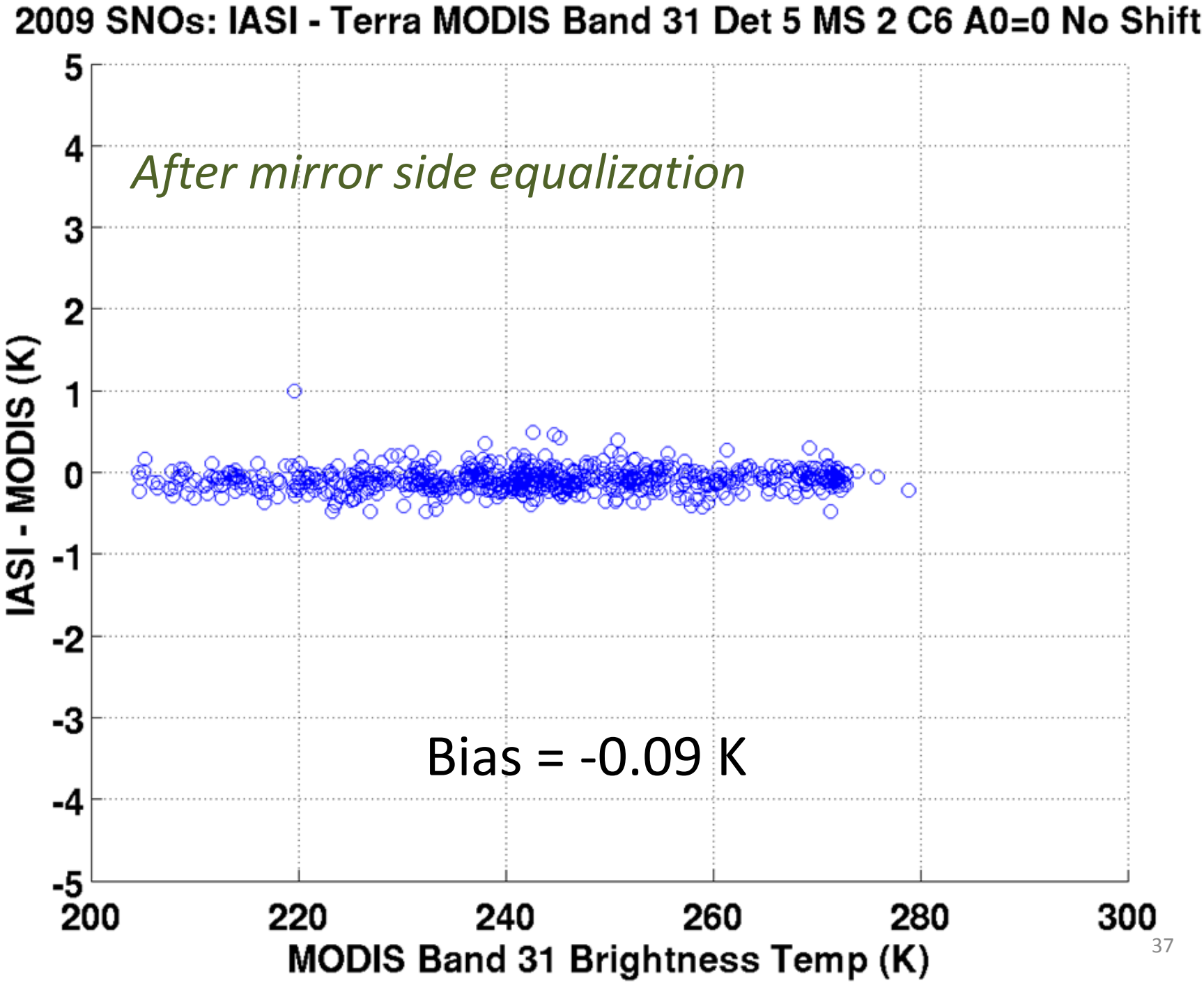

2009 SNOs: IASI - Terra MODIS Band 30 Det 4 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = 0.20 K
IASI - MODIS (K)
MODIS Band 30 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

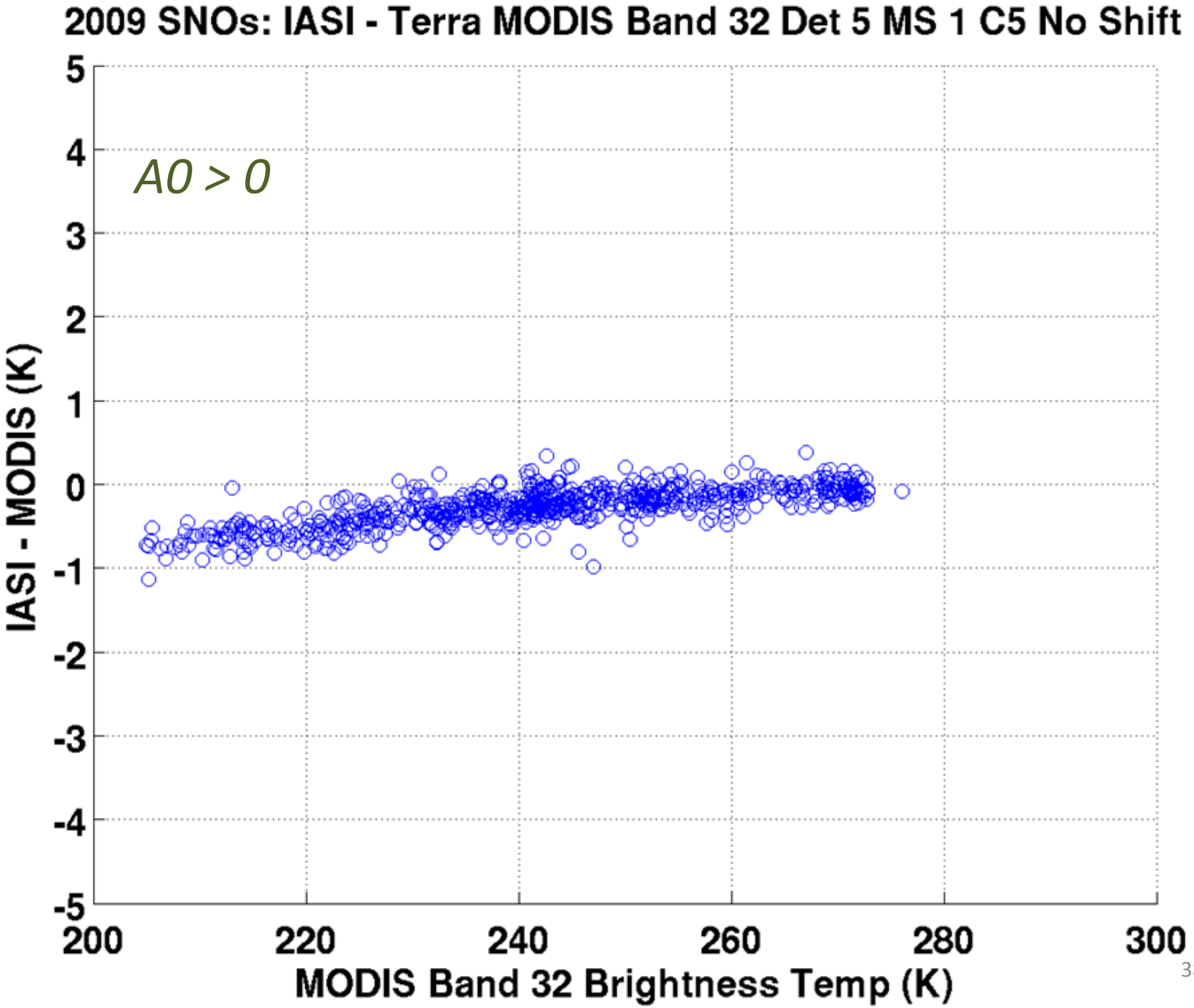
IASI – MODIS TEB Comparisons: PC LWIR Bands (31-36)

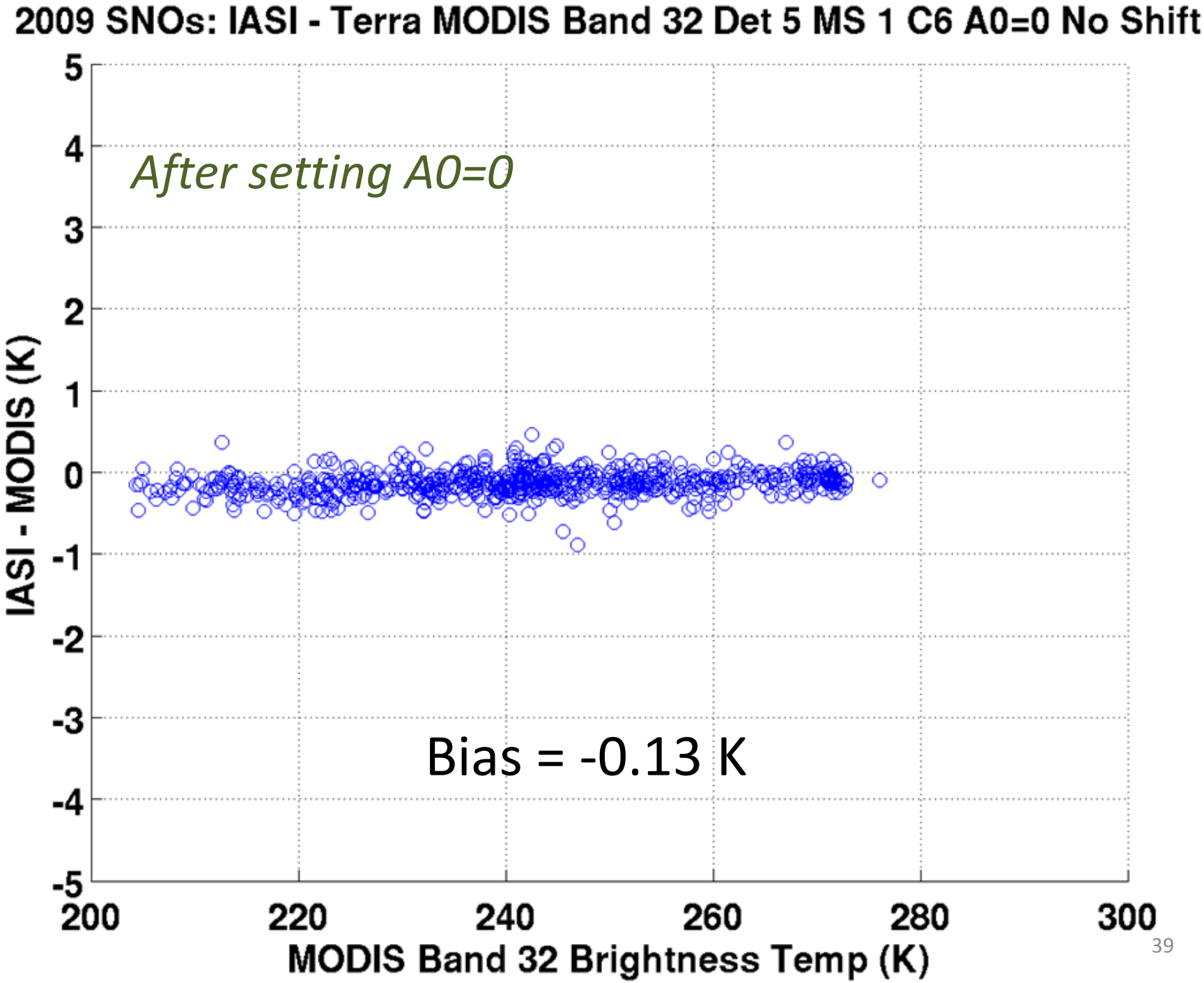
- Using C6 LUT reduces/eliminates bias between Terra MODIS and IASI at the cold scenes for B31 and B32. Mirror sides match closely.
- Minimal impact using C6 LUT on B33-36 because C5 already has A0=0.
- Terra MODIS in family with Aqua MODIS (Not shown).

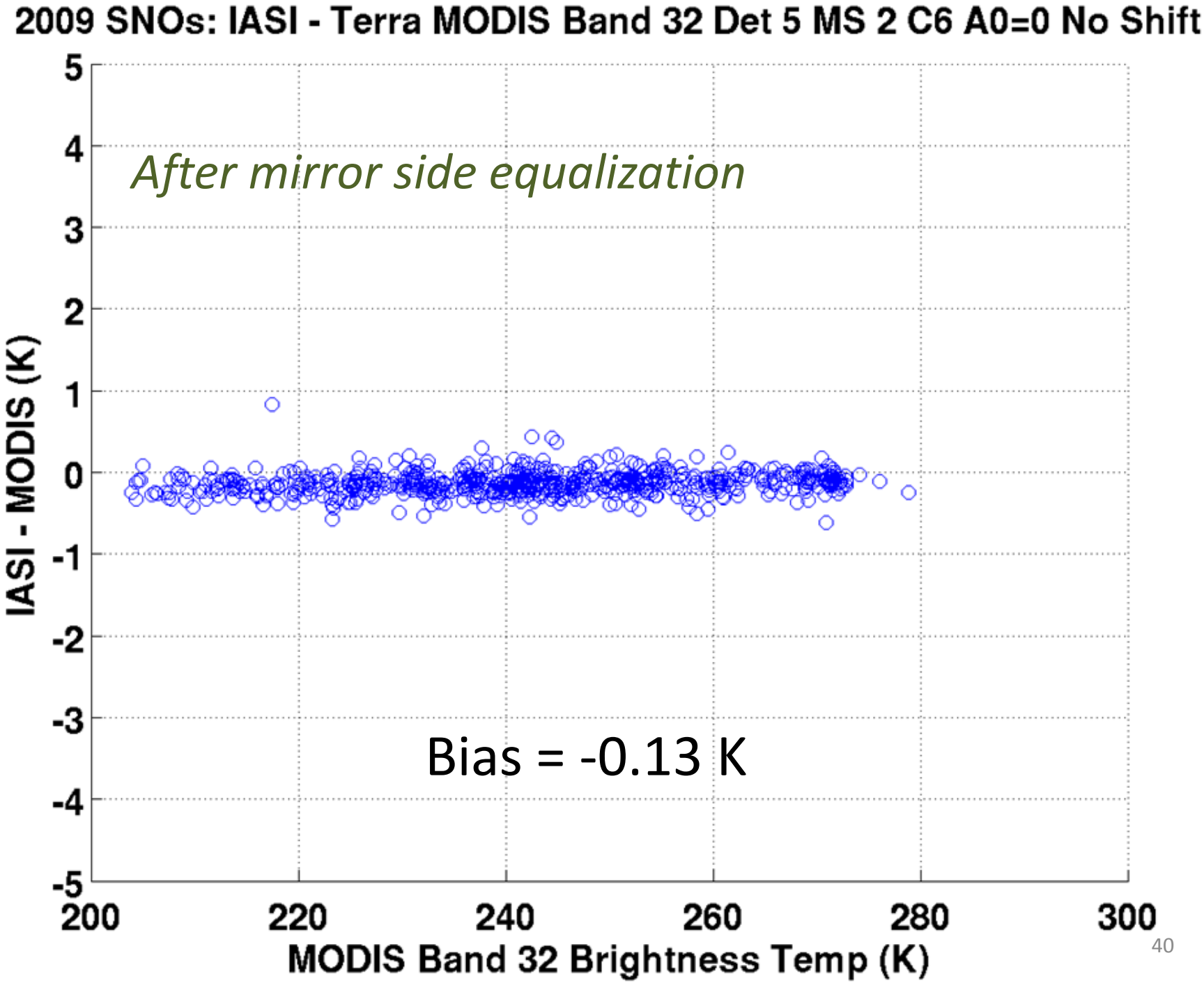

2009 SNOs: IASI - Terra MODIS Band 31 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 31 Brightness Temp (K)

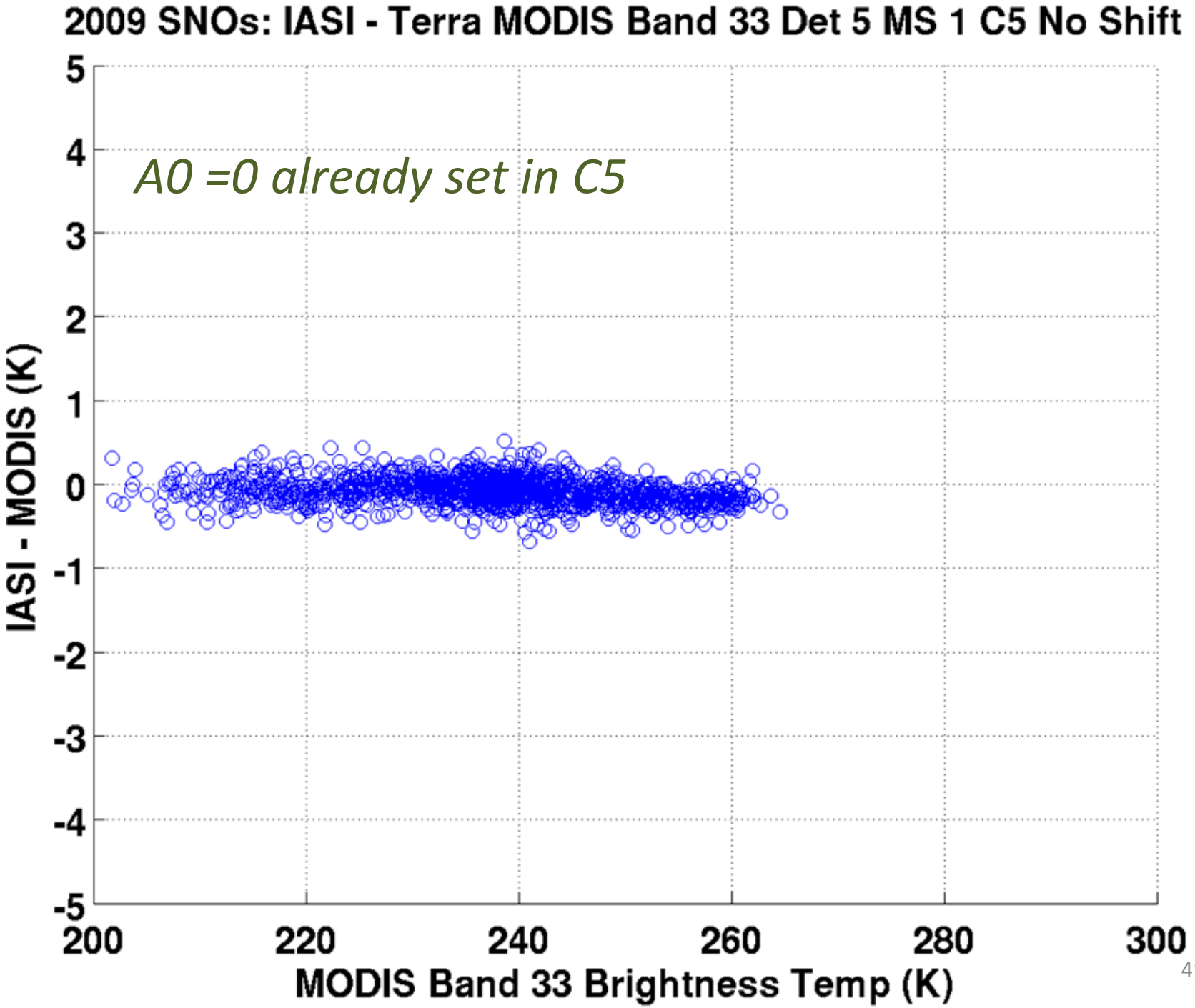

2009 SNOs: IASI - Terra MODIS Band 31 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = -0.09 K
IASI - MODIS (K)
MODIS Band 31 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

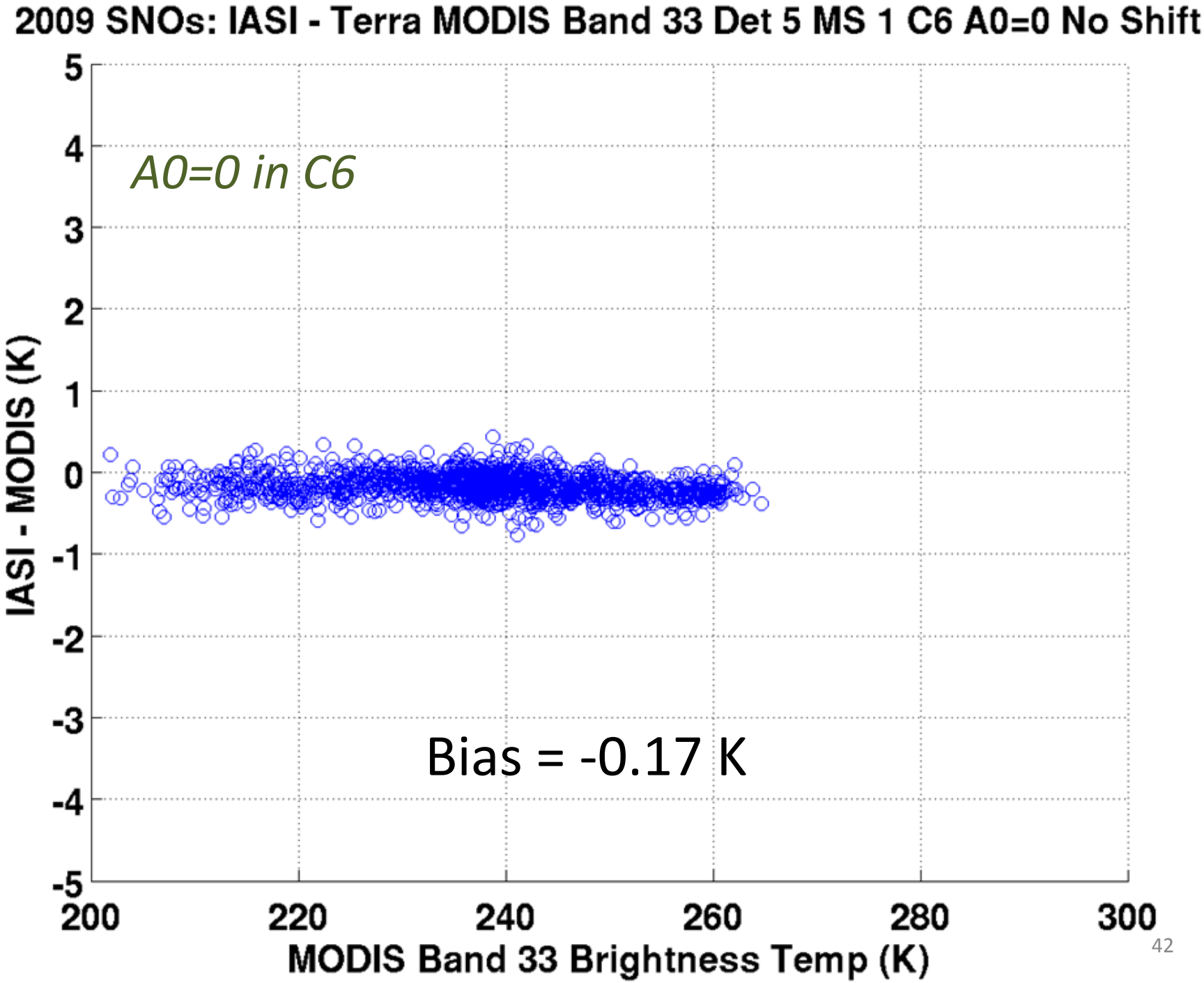

2009 SNOs: IASI - Terra MODIS Band 31 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.09 K
IASI - MODIS (K)
MODIS Band 31 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

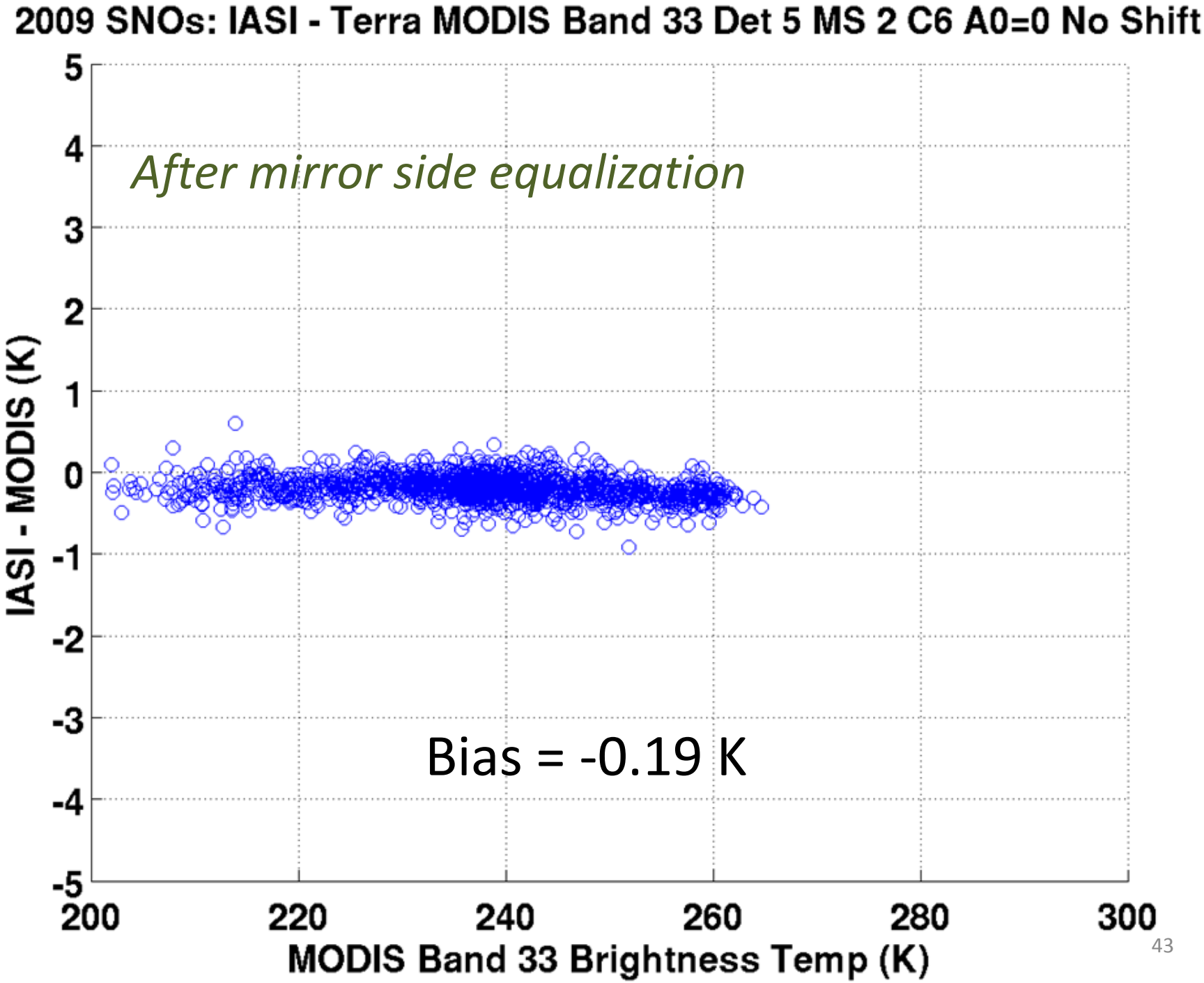

2009 SNOs: IASI - Terra MODIS Band 32 Det 5 MS 1 C5 No Shift
A0 > 0
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 32 Brightness Temp (K)

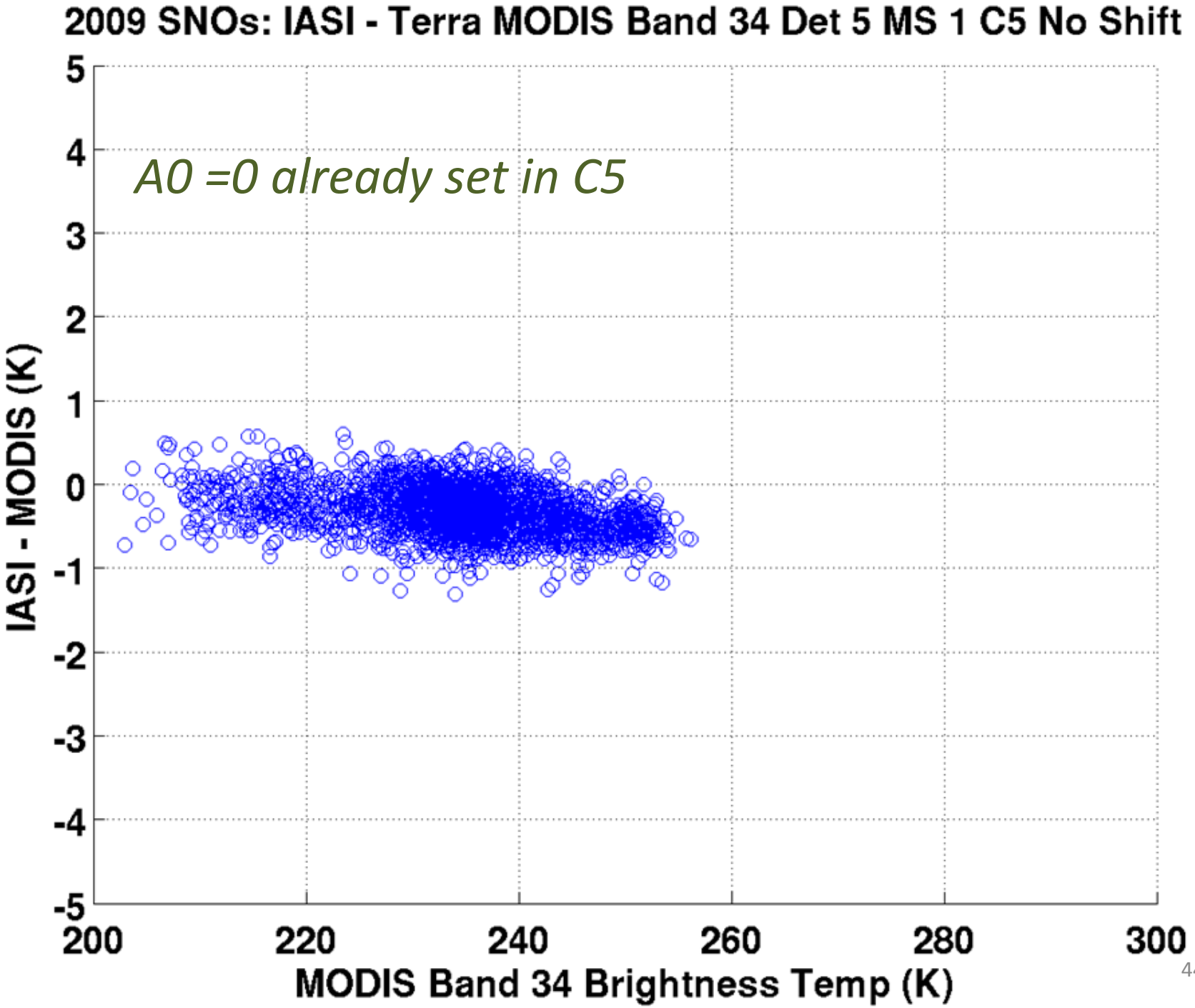

2009 SNOs: IASI - Terra MODIS Band 32 Det 5 MS 1 C6 A0=0 No Shift
After setting A0=0
Bias = -0.13 K
IASI - MODIS (K)
MODIS Band 32 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

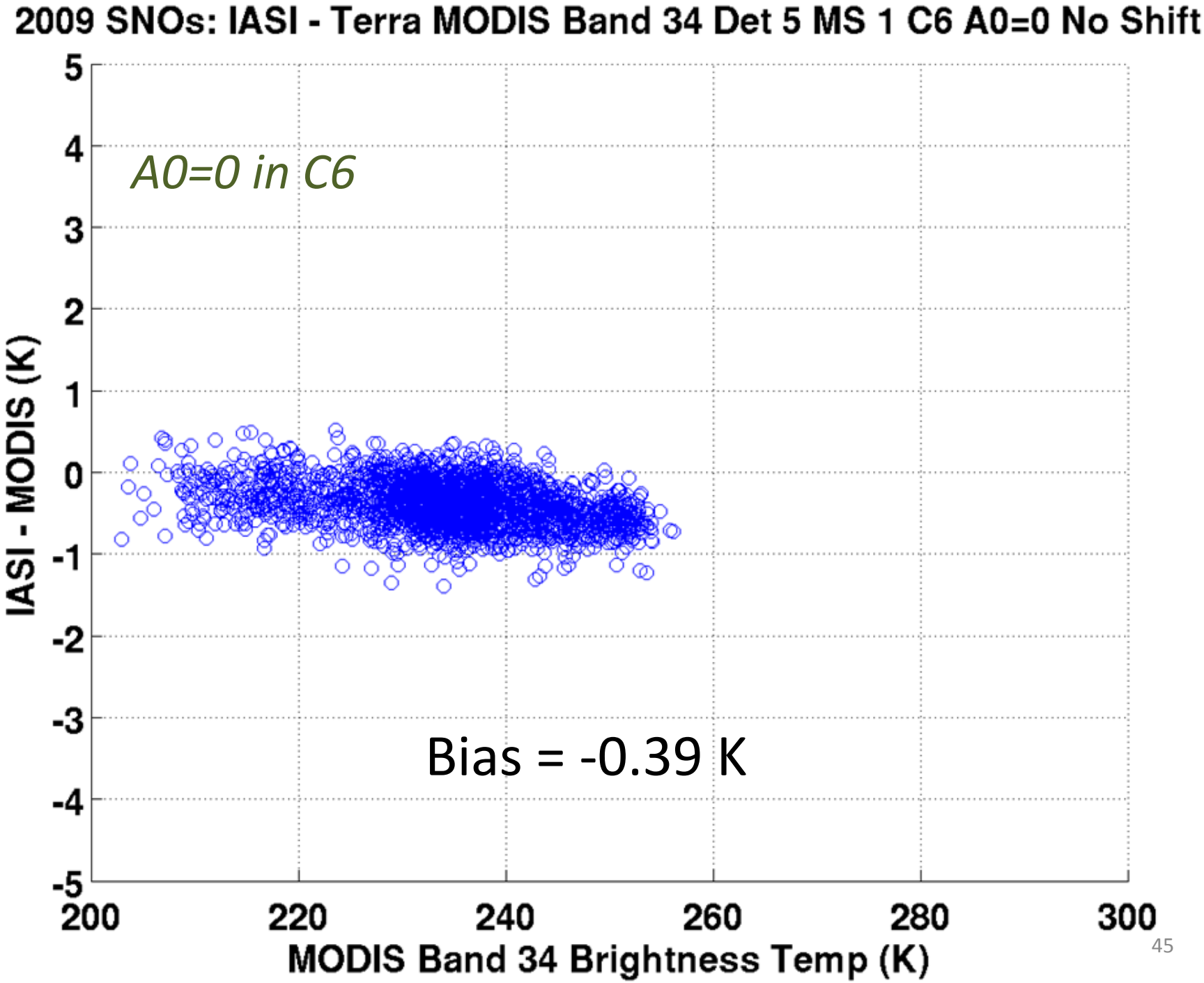

2009 SNOs: IASI - Terra MODIS Band 32 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.13 K
IASI - MODIS (K)
MODIS Band 32 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

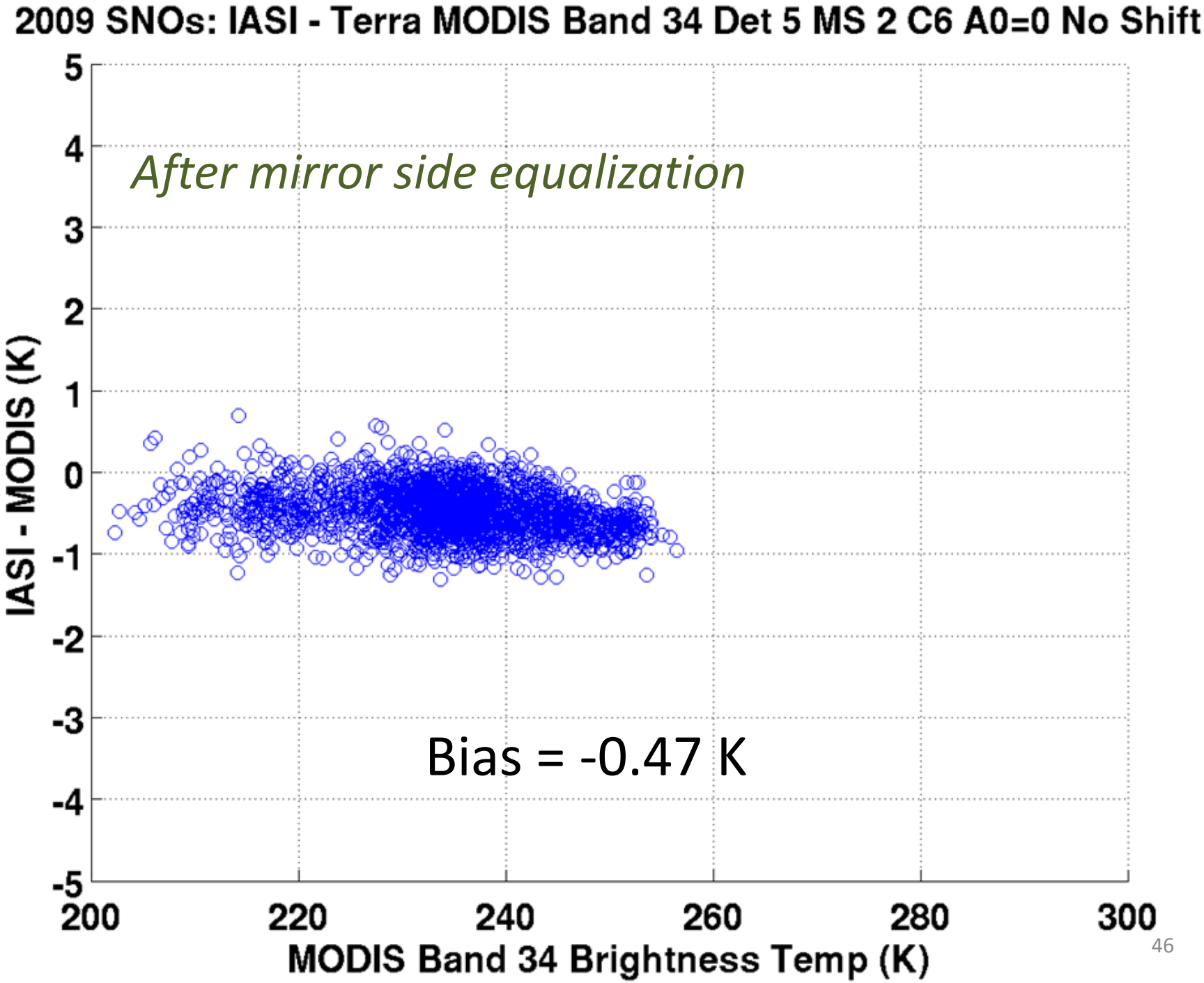

2009 SNOs: IASI - Terra MODIS Band 33 Det 5 MS 1 C5 No Shift
A0 =0 already set in C5
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 33 Brightness Temp (K)

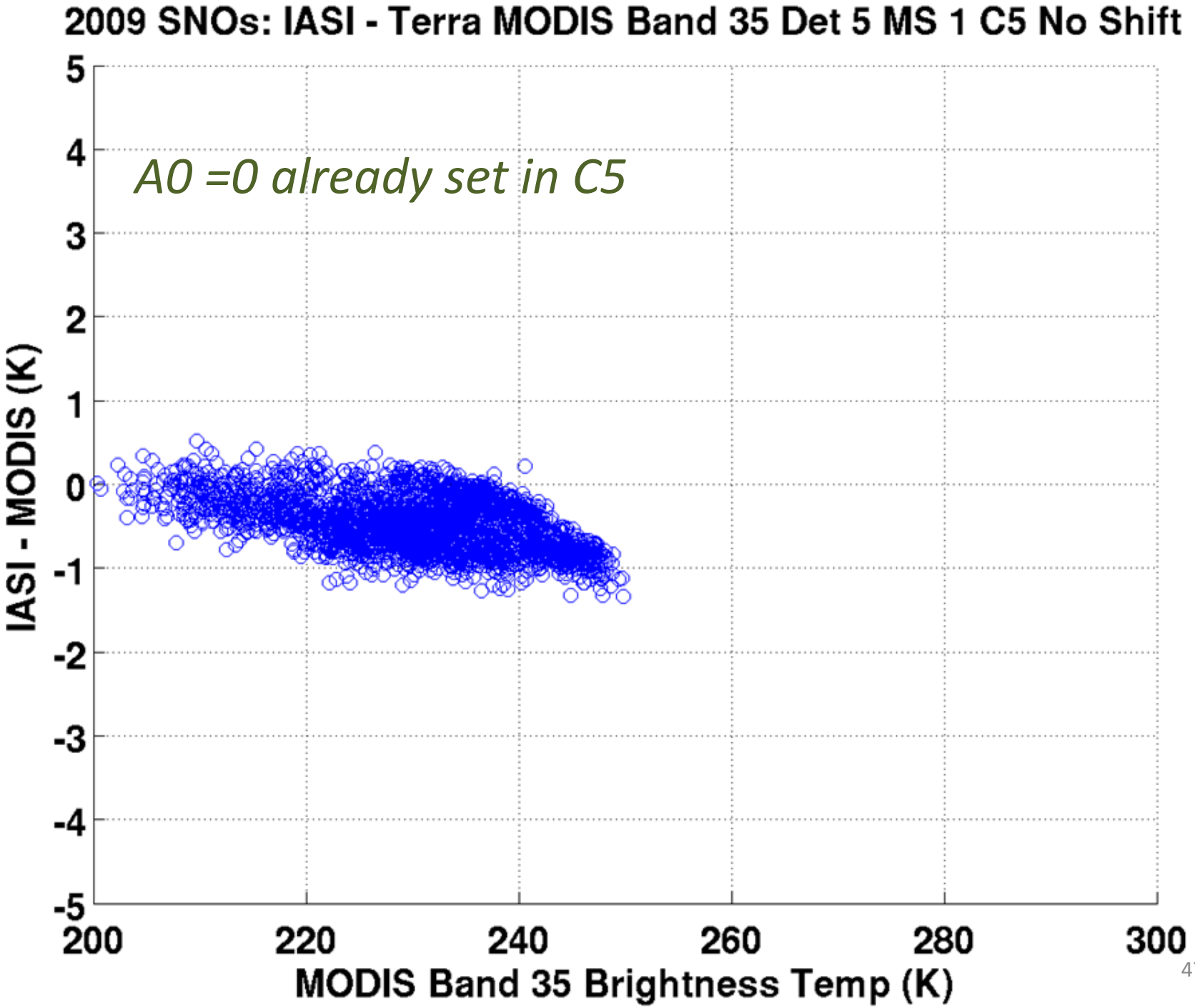

2009 SNOs: IASI - Terra MODIS Band 33 Det 5 MS 1 C6 A0=0 No Shift
A0=0 in C6
Bias = -0.17 K
IASI - MODIS (K)
MODIS Band 33 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

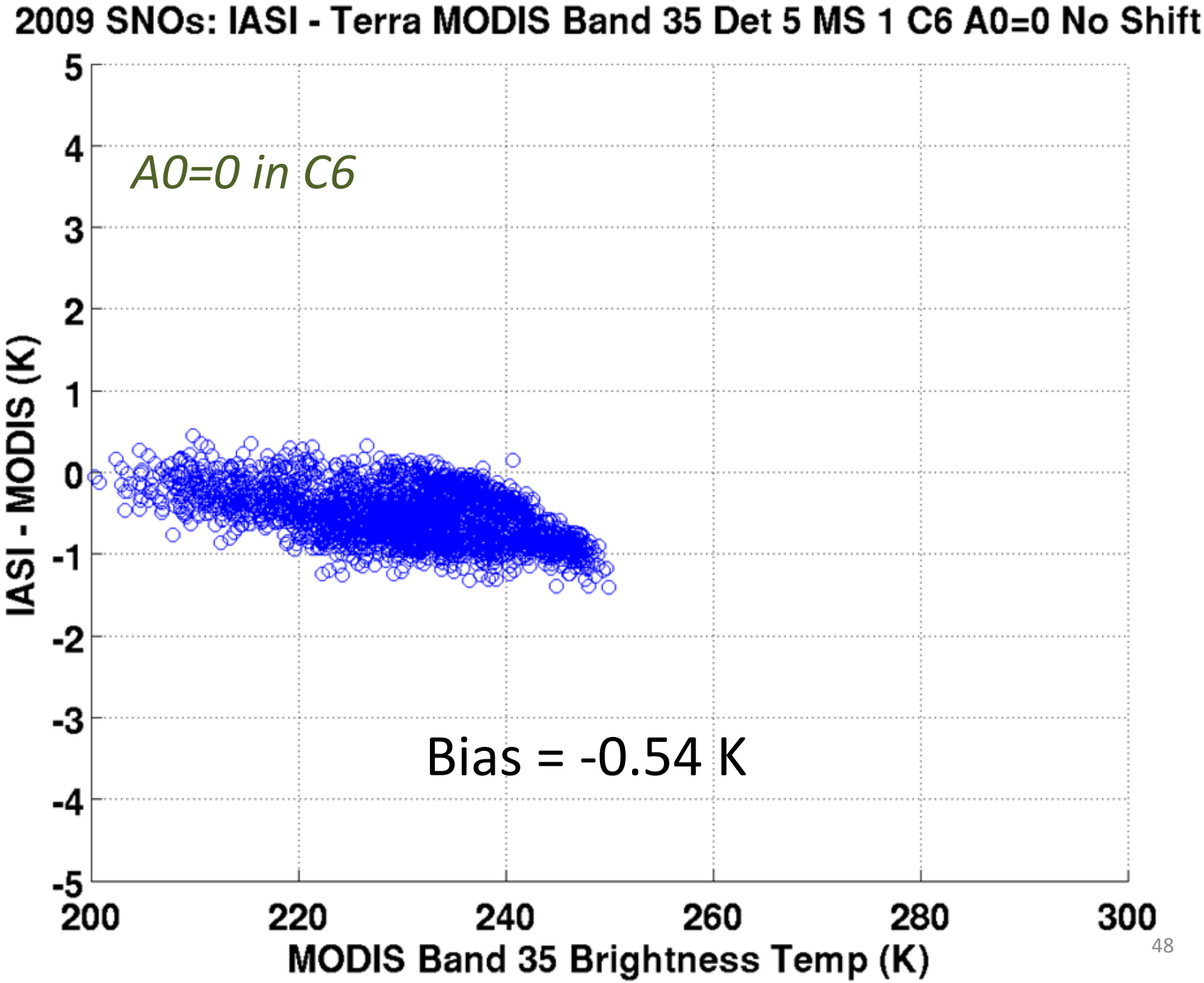

2009 SNOs: IASI - Terra MODIS Band 33 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.19 K
IASI - MODIS (K)
MODIS Band 33 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

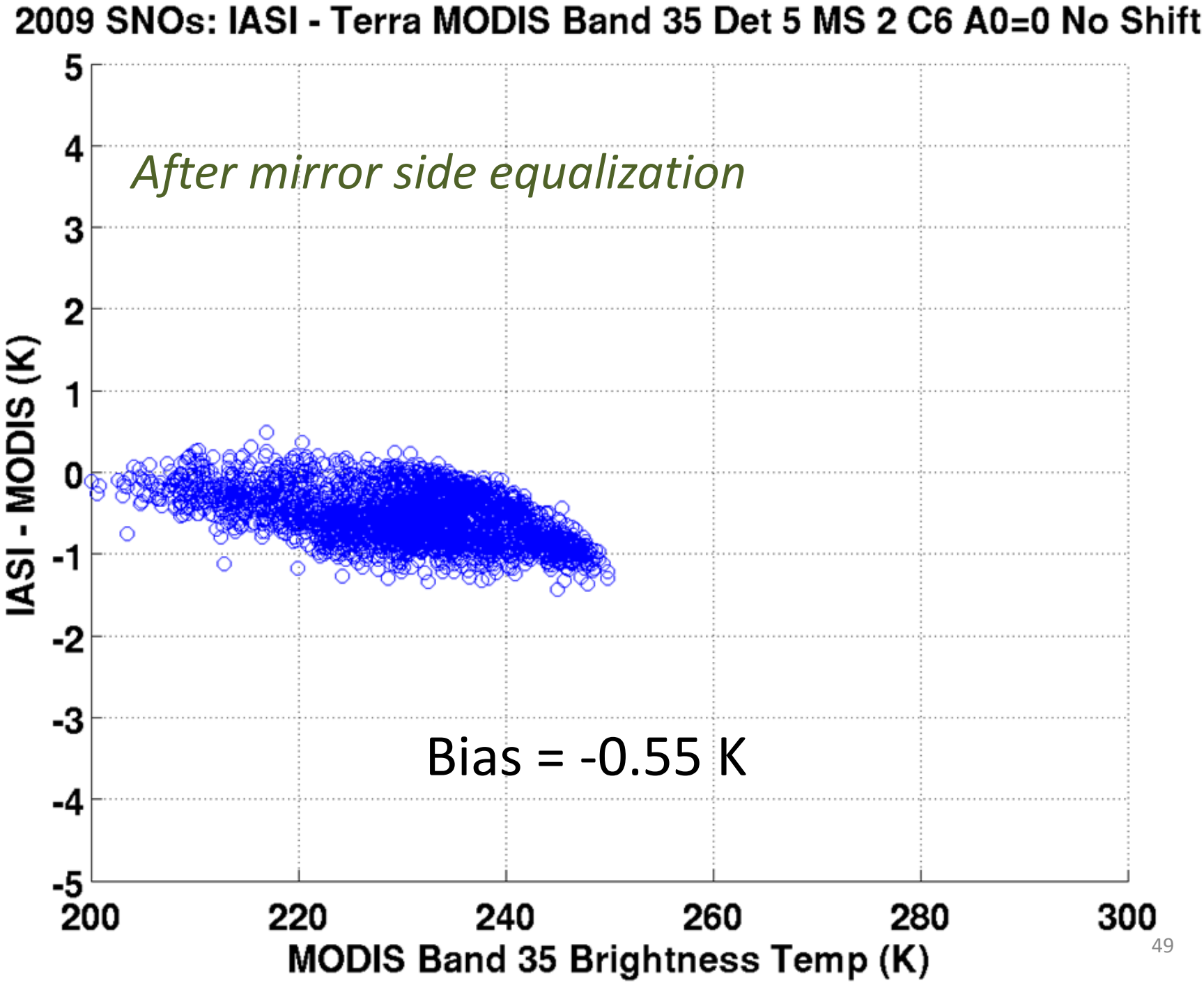

2009 SNOs: IASI - Terra MODIS Band 34 Det 5 MS 1 C5 No Shift
A0 =0 already set in C5
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 34 Brightness Temp (K)

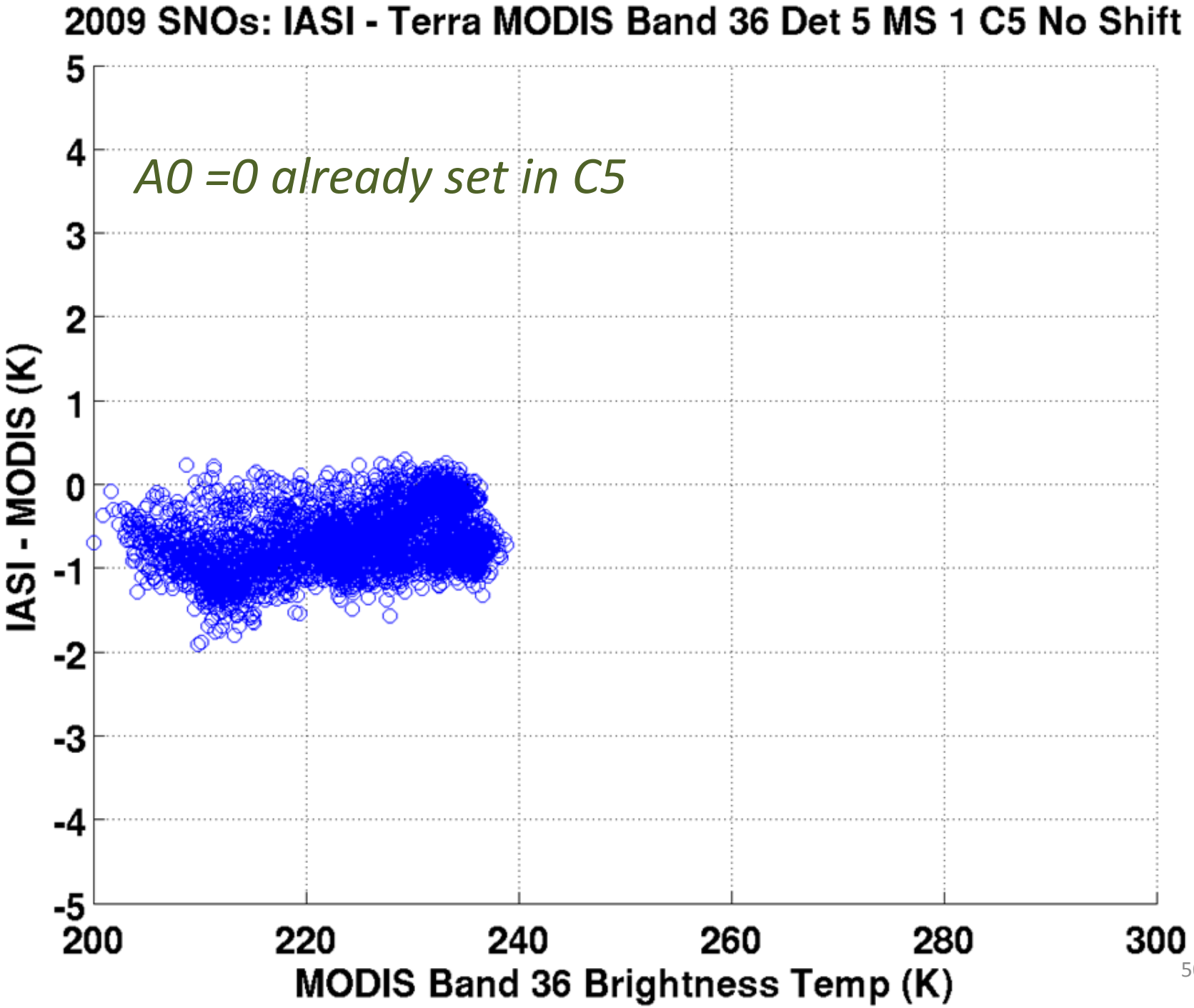

2009 SNOs: IASI - Terra MODIS Band 34 Det 5 MS 1 C6 A0=0 No Shift
A0=0 in C6
Bias = -0.39 K
IASI - MODIS (K)
MODIS Band 34 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

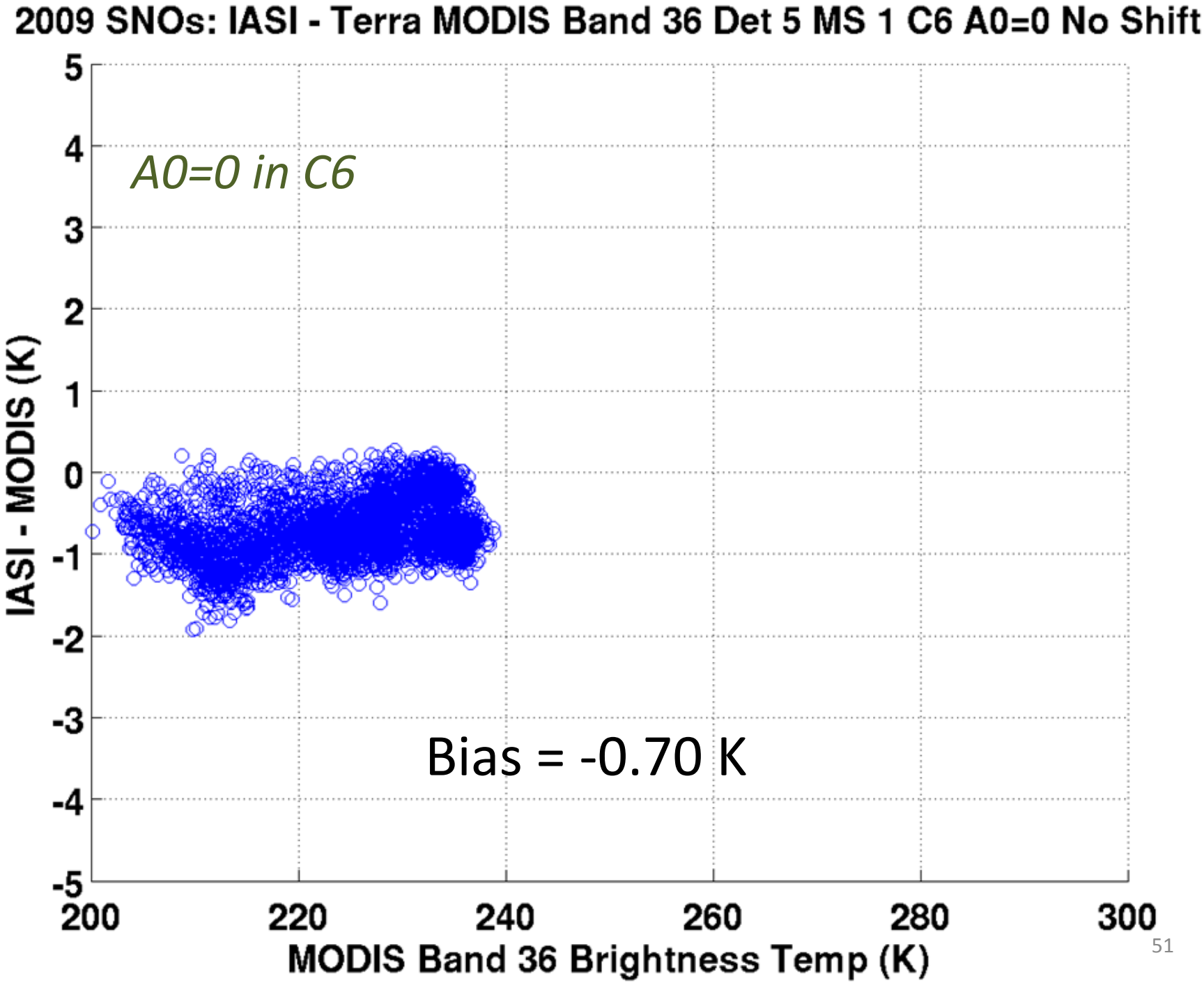

2009 SNOs: IASI - Terra MODIS Band 34 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.47 K
IASI - MODIS (K)
MODIS Band 34 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

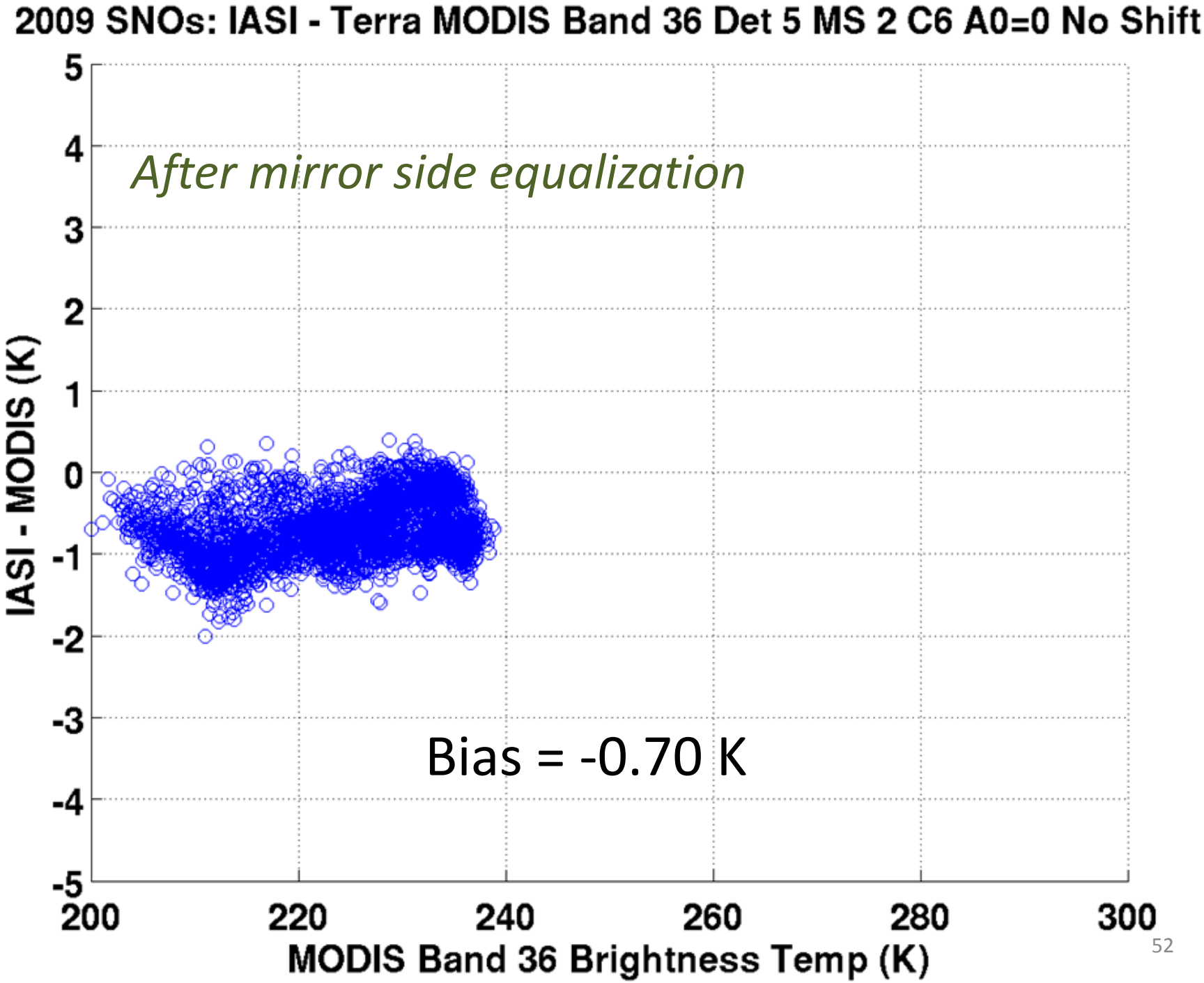

2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1 C5 No Shift
A0 =0 already set in C5
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 35 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1 C6 A0=0 No Shift
A0=0 in C6
Bias = -0.54 K
IASI - MODIS (K)
MODIS Band 35 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300


2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.55 K
IASI - MODIS (K)
MODIS Band 35 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300


2009 SNOs: IASI - Terra MODIS Band 36 Det 5 MS 1 C5 No Shift
A0 =0 already set in C5
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 36 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 36 Det 5 MS 1 C6 A0=0 No Shift
A0=0 in C6
Bias = -0.70 K
IASI - MODIS (K)
MODIS Band 36 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300


2009 SNOs: IASI - Terra MODIS Band 36 Det 5 MS 2 C6 A0=0 No Shift
After mirror side equalization
Bias = -0.70 K
IASI - MODIS (K)
MODIS Band 36 Brightness Temp (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300

IASI – MODIS TEB Comparisons

- IASI-TerraMODIS cold scene radiometric calibration biases are greatly reduced in C6.
- This analysis uses only 2009 data. Other years will be processed to corroborate these findings and look for trends in IASI-MODIS biases.
- SNOs do not capture global variability of earth scenes nor sensor performance. Using full year of data mitigates this to some extent.
- Terra MODIS atmospheric bands show bias dependence on scene temperature….

More IASI– MODIS TEB Comparisons: Effective Spectral Shift

Do AIRS-MODIS based effective spectral shifts reduce IASI-Terra MODIS biases?

Background

- Atmospheric bands are sensitive to spectral shifts
- Aqua AIRS-MODIS comparisons showed that biases can be significantly reduced through effective spectral shifts of MODIS in-band RSR.
- Try applying Aqua MODIS spectral shifts to Terra MODIS C6 and compare to IASI.
- Spectral shift eqn is:

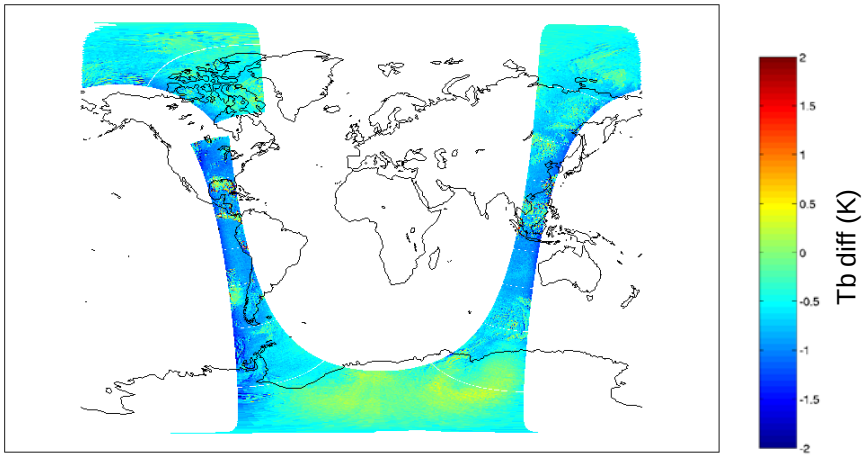
  RSRnew = RSRold + Shift

  RSRnew, RSRold, and Shift in wavenumber units

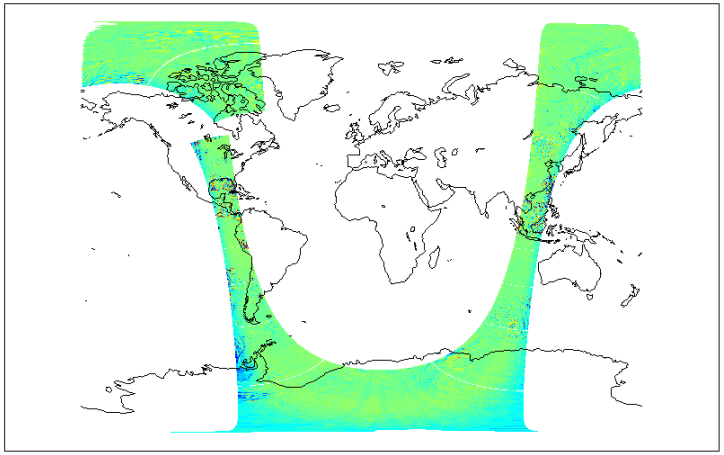
Aqua MODIS Findings

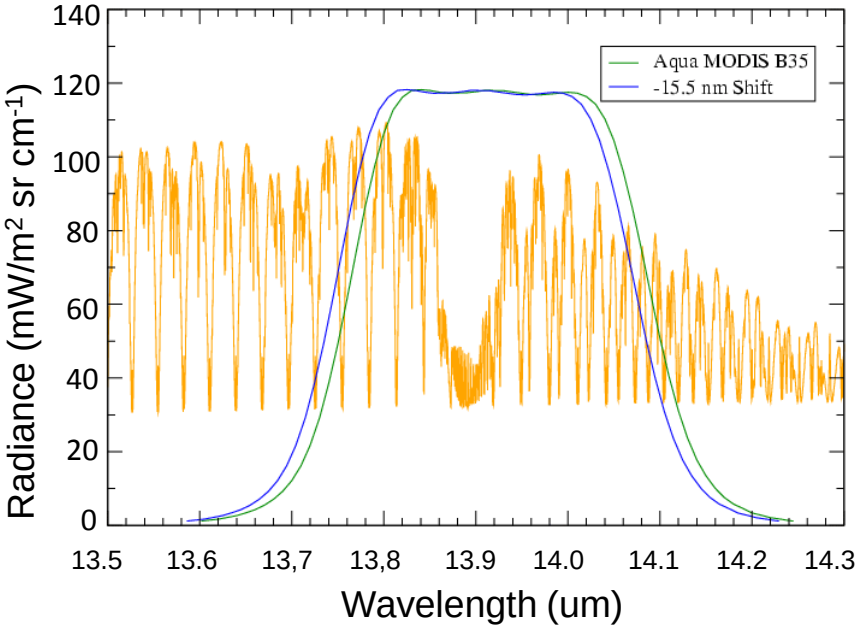
MODIS Band 35 (13.9 μm)

AIRS-MODIS,no shift

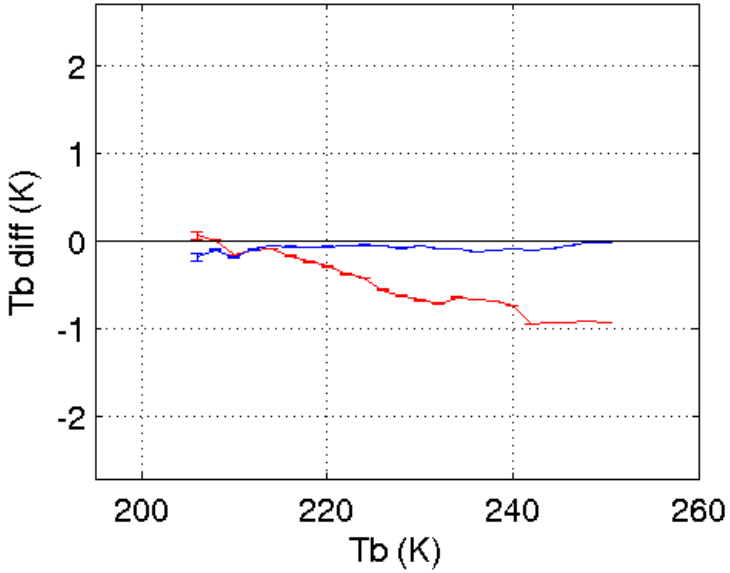


AIRS-MODIS,MODIS SRF shifted by +0.8 cm^{-1} (15.5 nm)



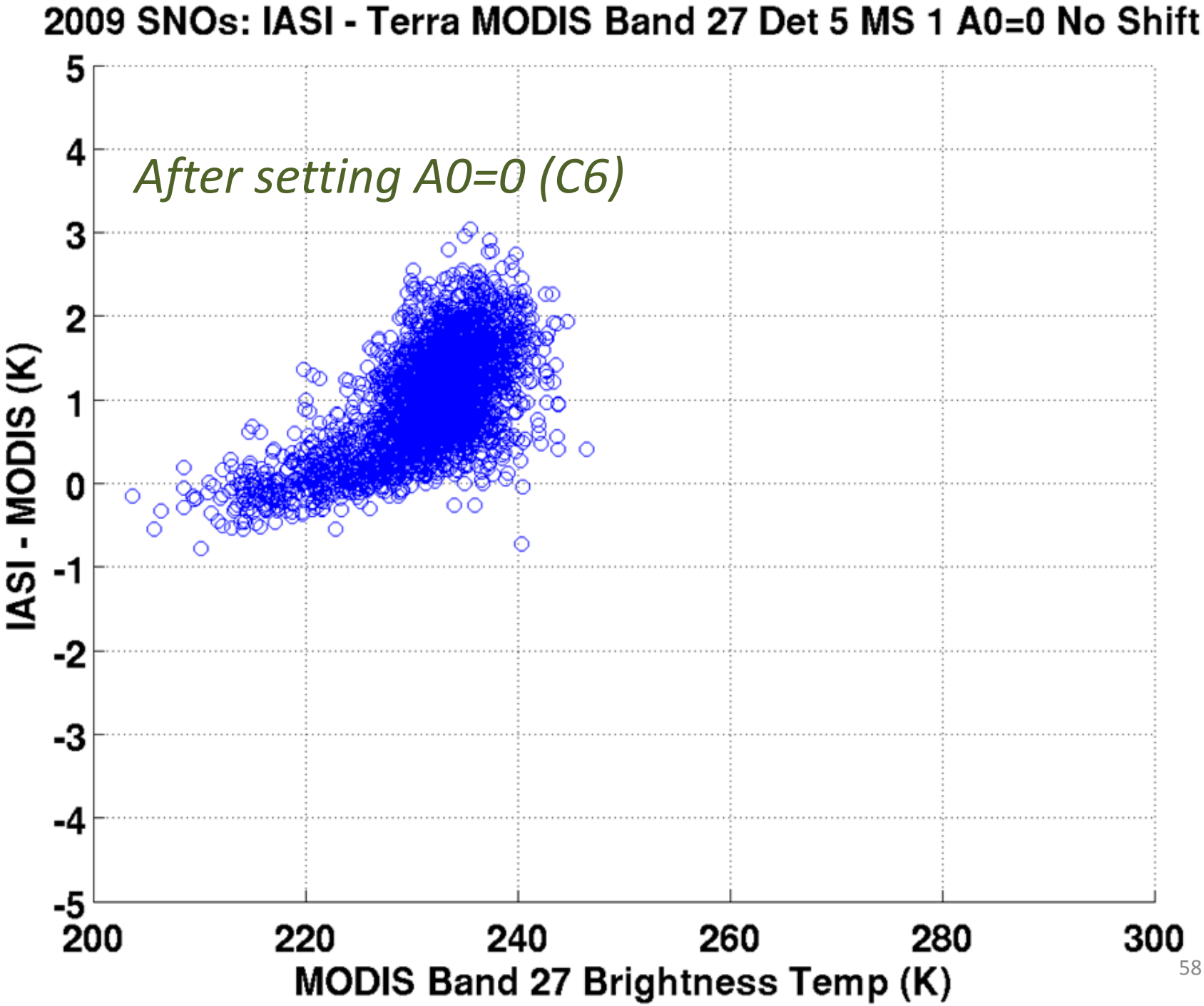


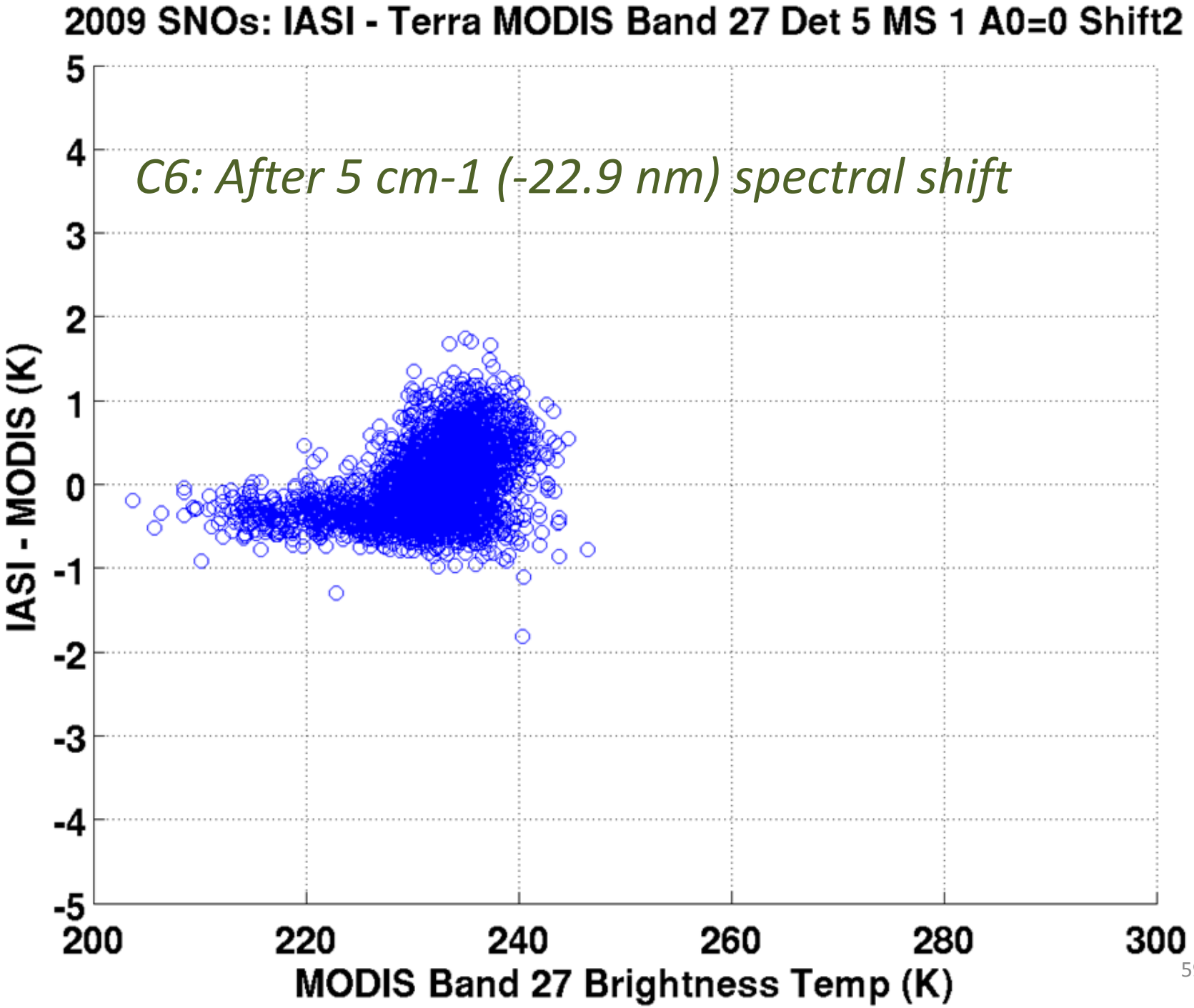
AIRS-MODIS: unshifted, shifted

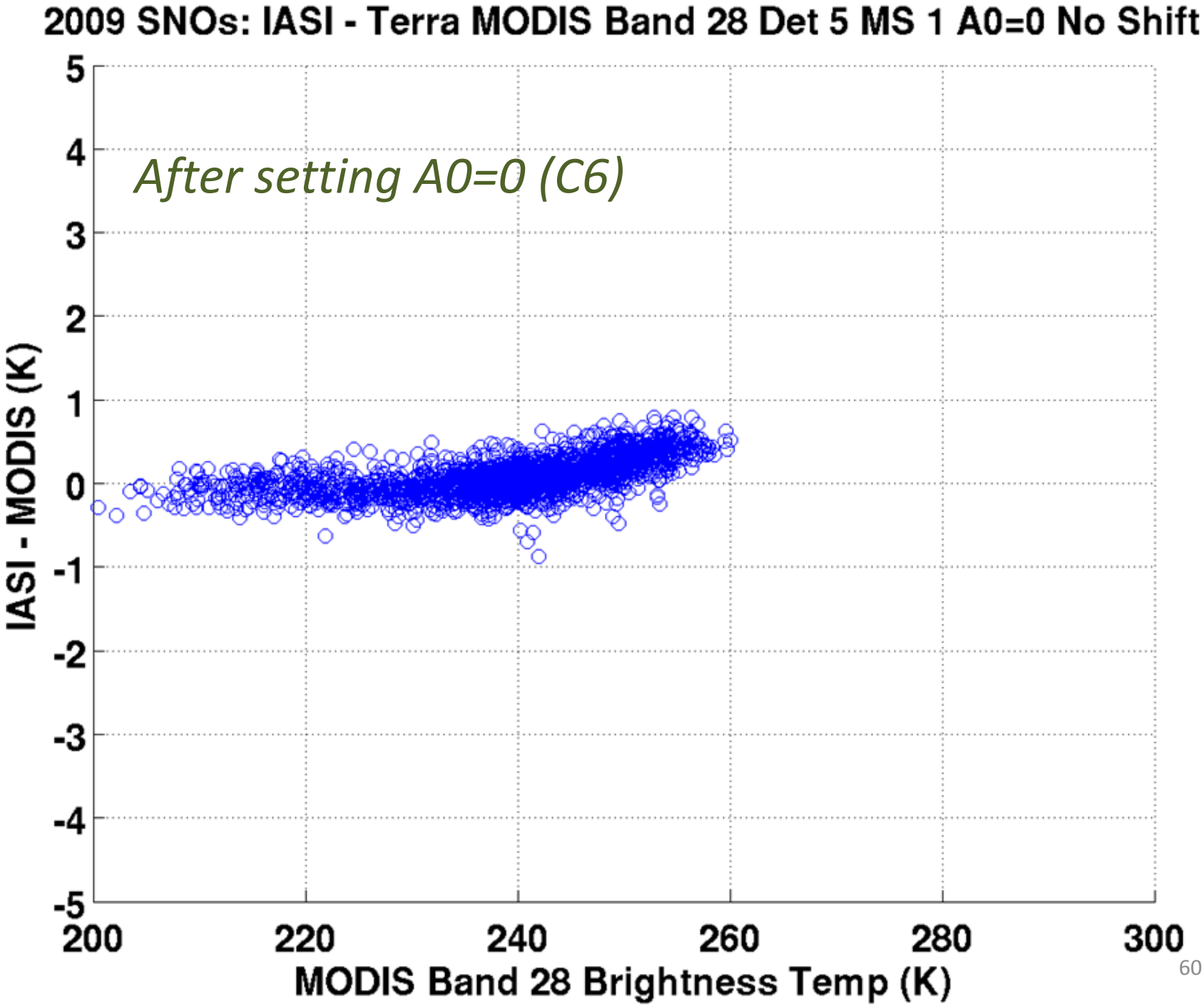


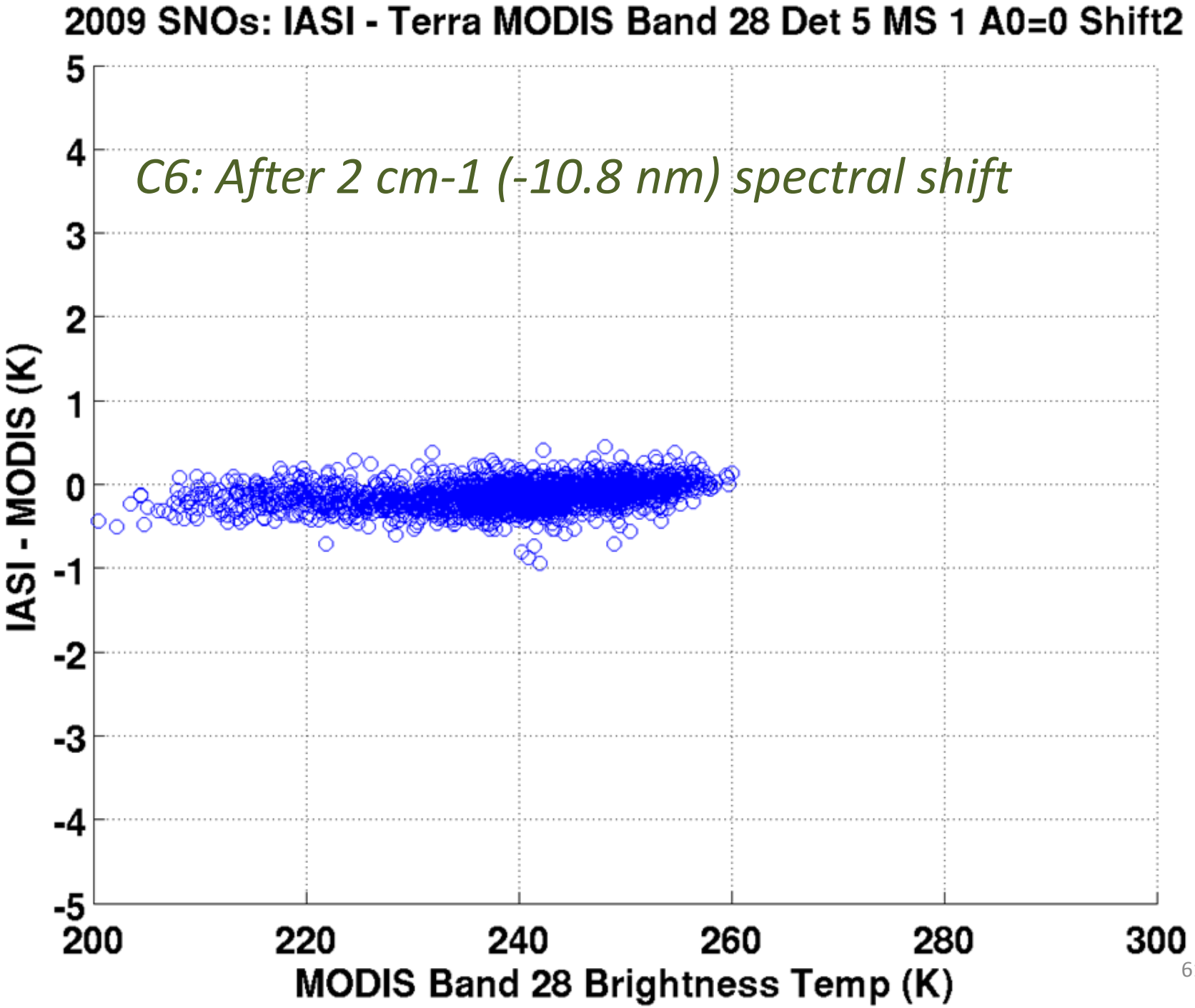
Terra Spectral Shifts Tested

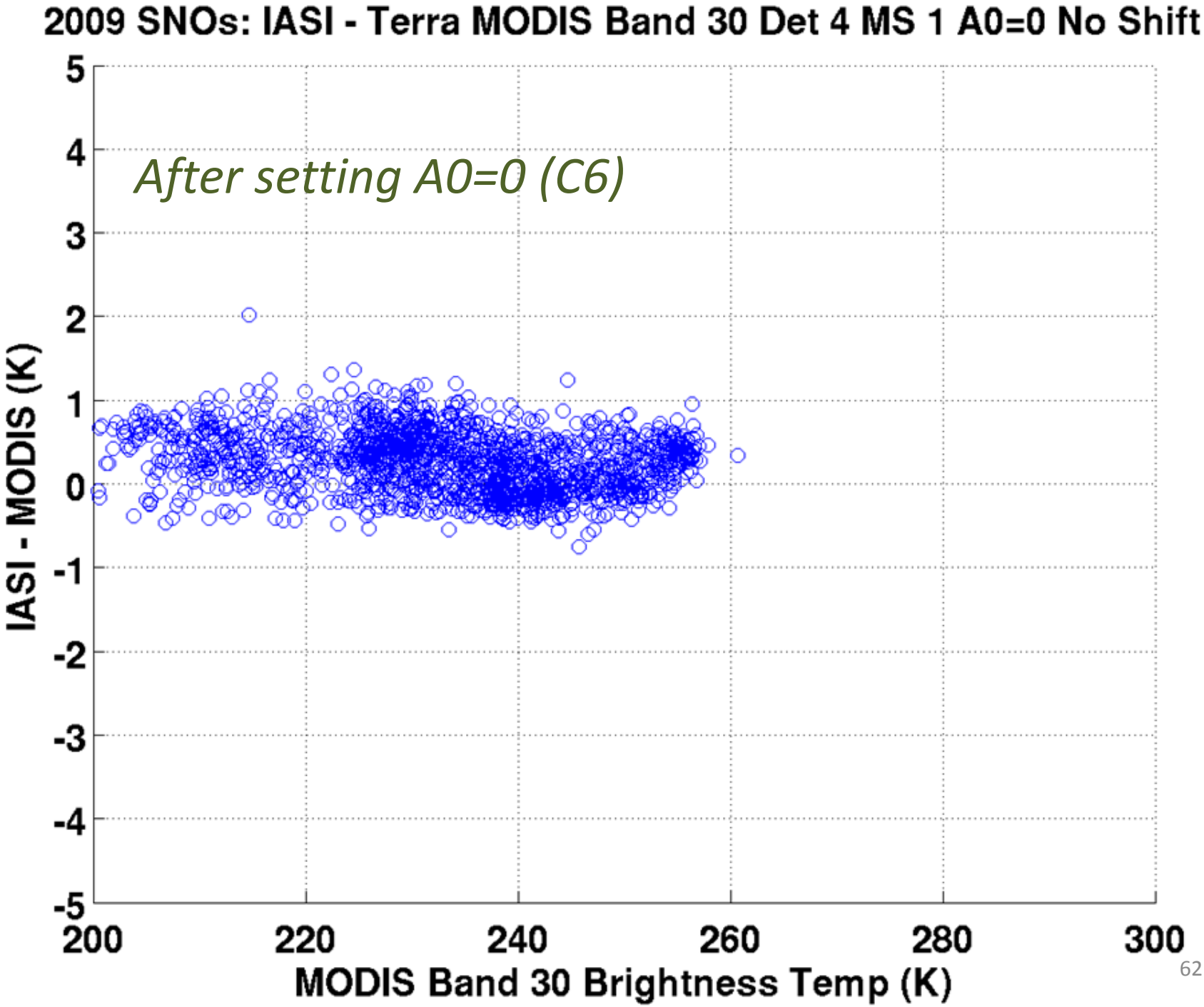
Band	Terra Shift1 (cm-1)	Terra Shift2 (cm-1)
24	-1	0 (research)
27	-5	5 (in review)
28	-2	2 (in review)
29	-1	1 (accepted as 0)
30	-1	1 (in review)
34	0.8 (accepted)	1.0
35	0.8 (accepted)	0.8
36	1.0 (accepted)	0.8

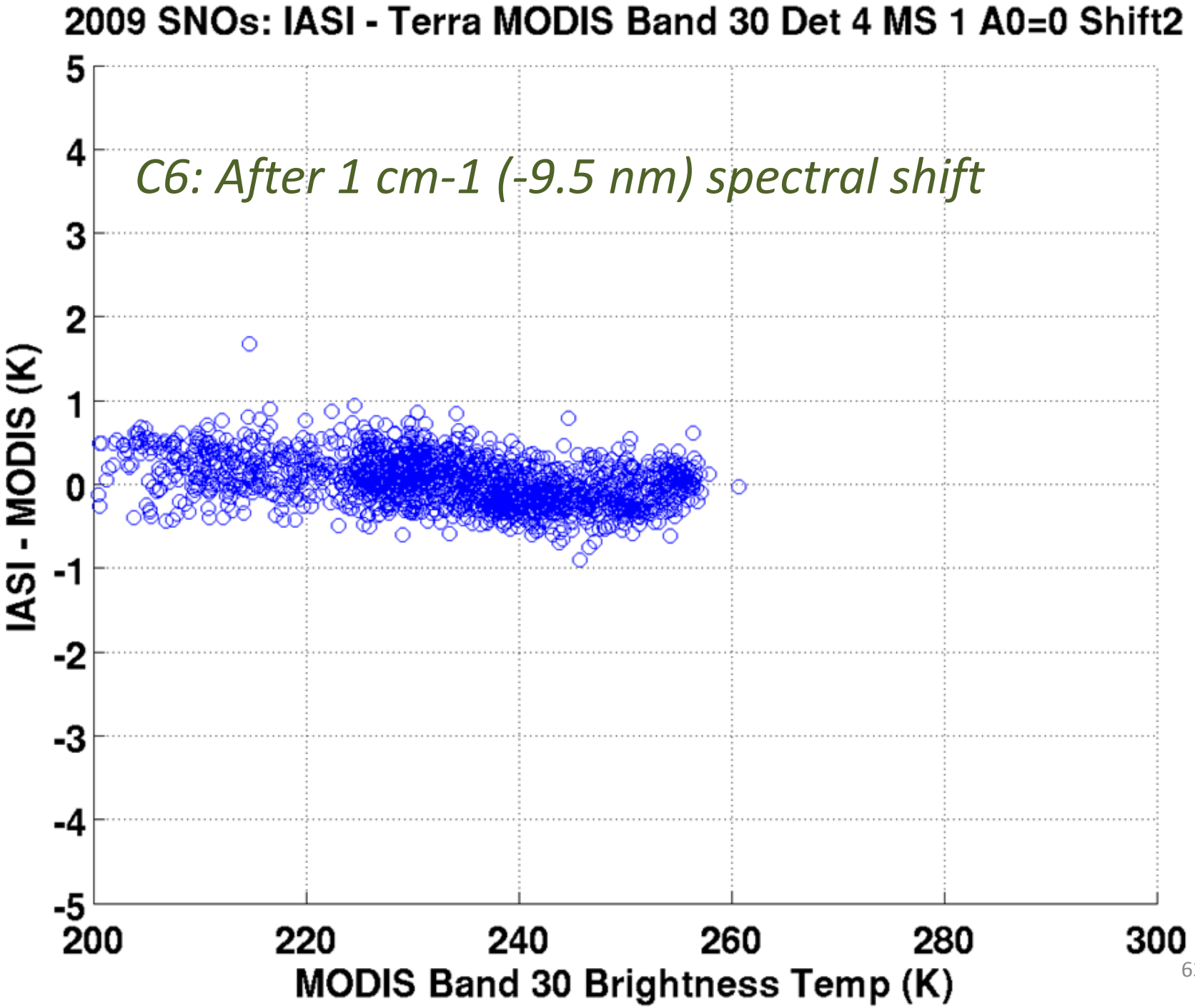

2009 SNOs: IASI - Terra MODIS Band 27 Det 5 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 27 Brightness Temp (K)

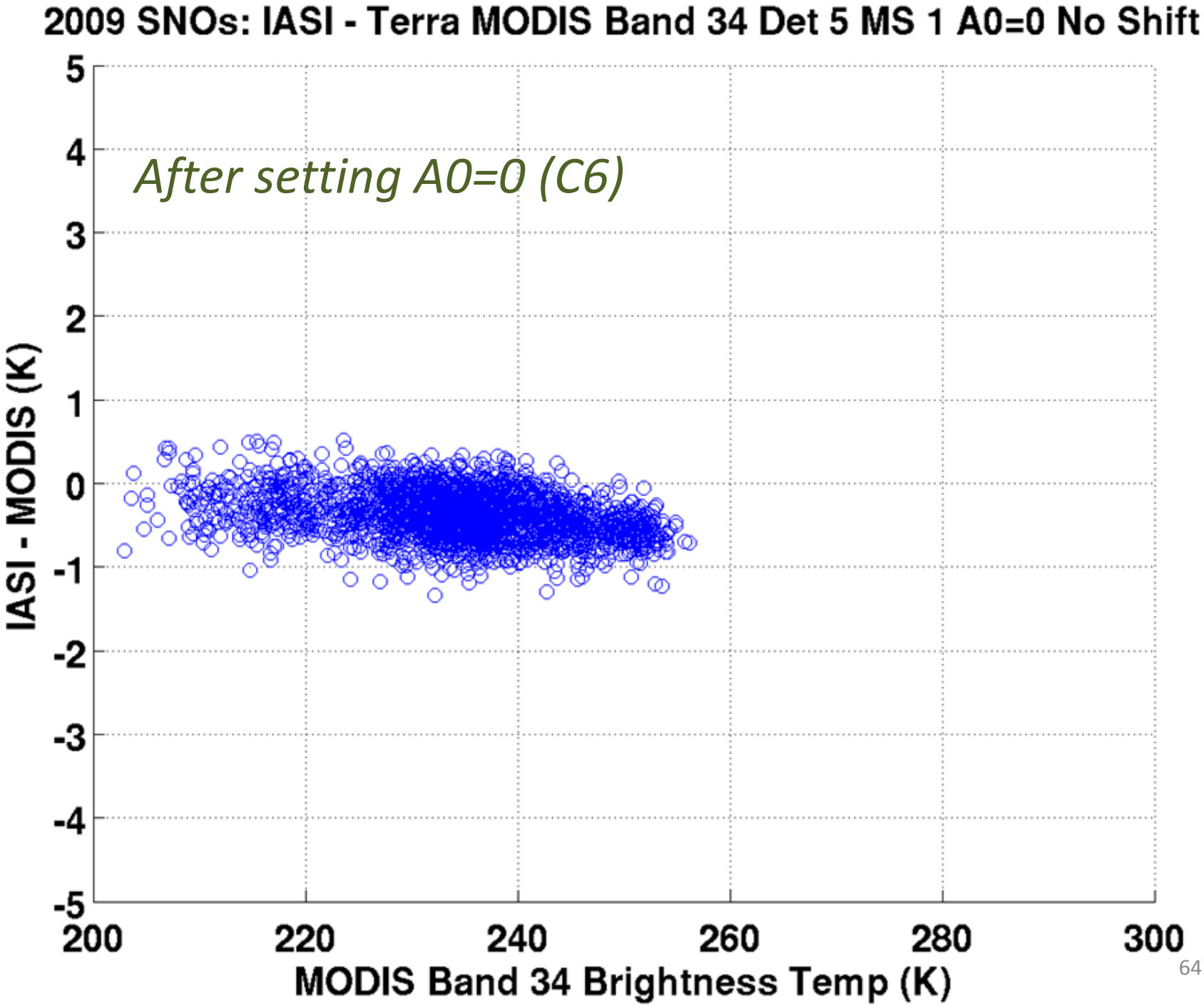

2009 SNOs: IASI - Terra MODIS Band 27 Det 5 MS 1 A0=0 Shift2
C6: After 5 cm-1 (-22.9 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 27 Brightness Temp (K)

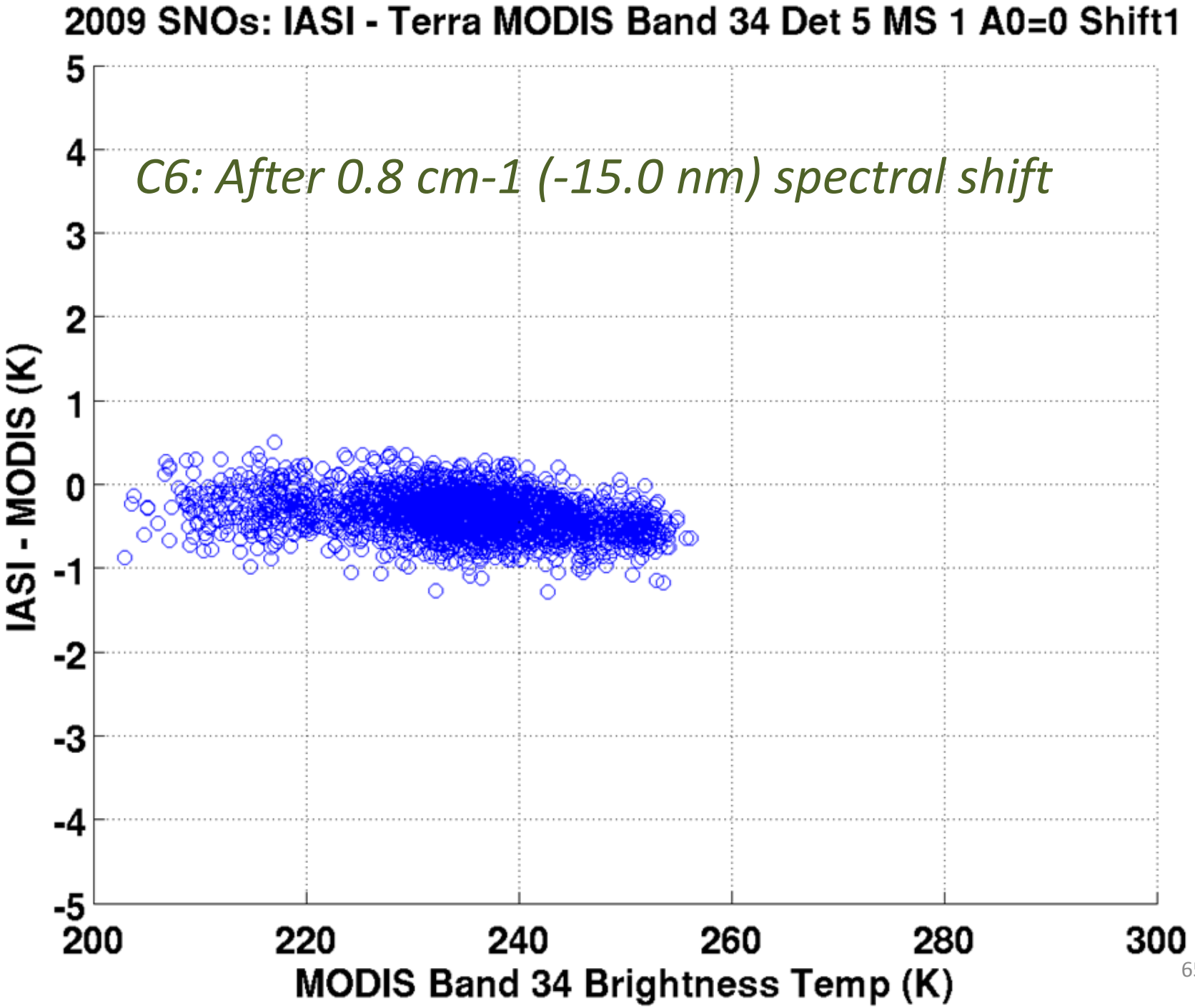

2009 SNOs: IASI - Terra MODIS Band 28 Det 5 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 28 Brightness Temp (K)

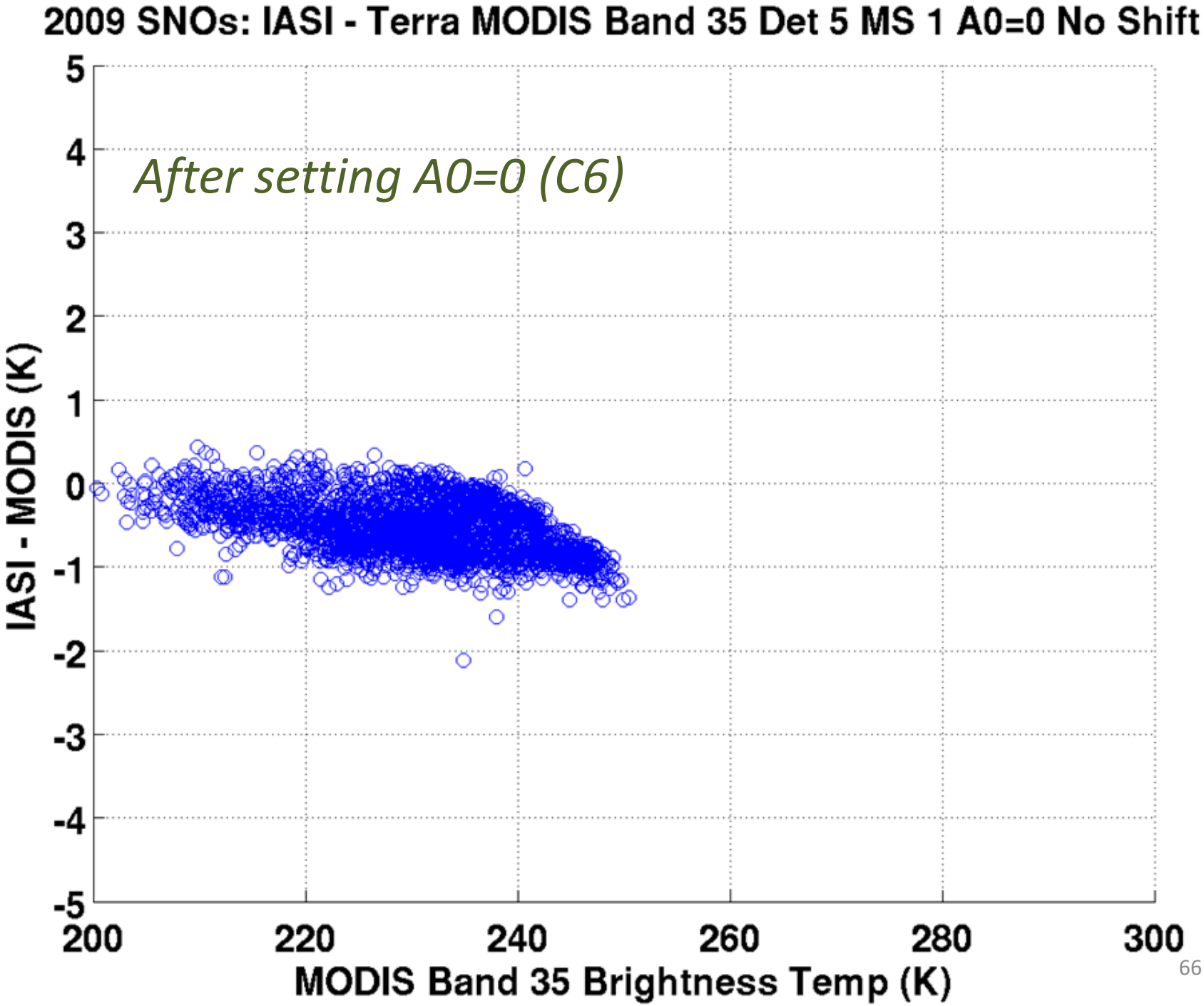

2009 SNOs: IASI - Terra MODIS Band 28 Det 5 MS 1 A0=0 Shift2
C6: After 2 cm-1 (-10.8 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 28 Brightness Temp (K)

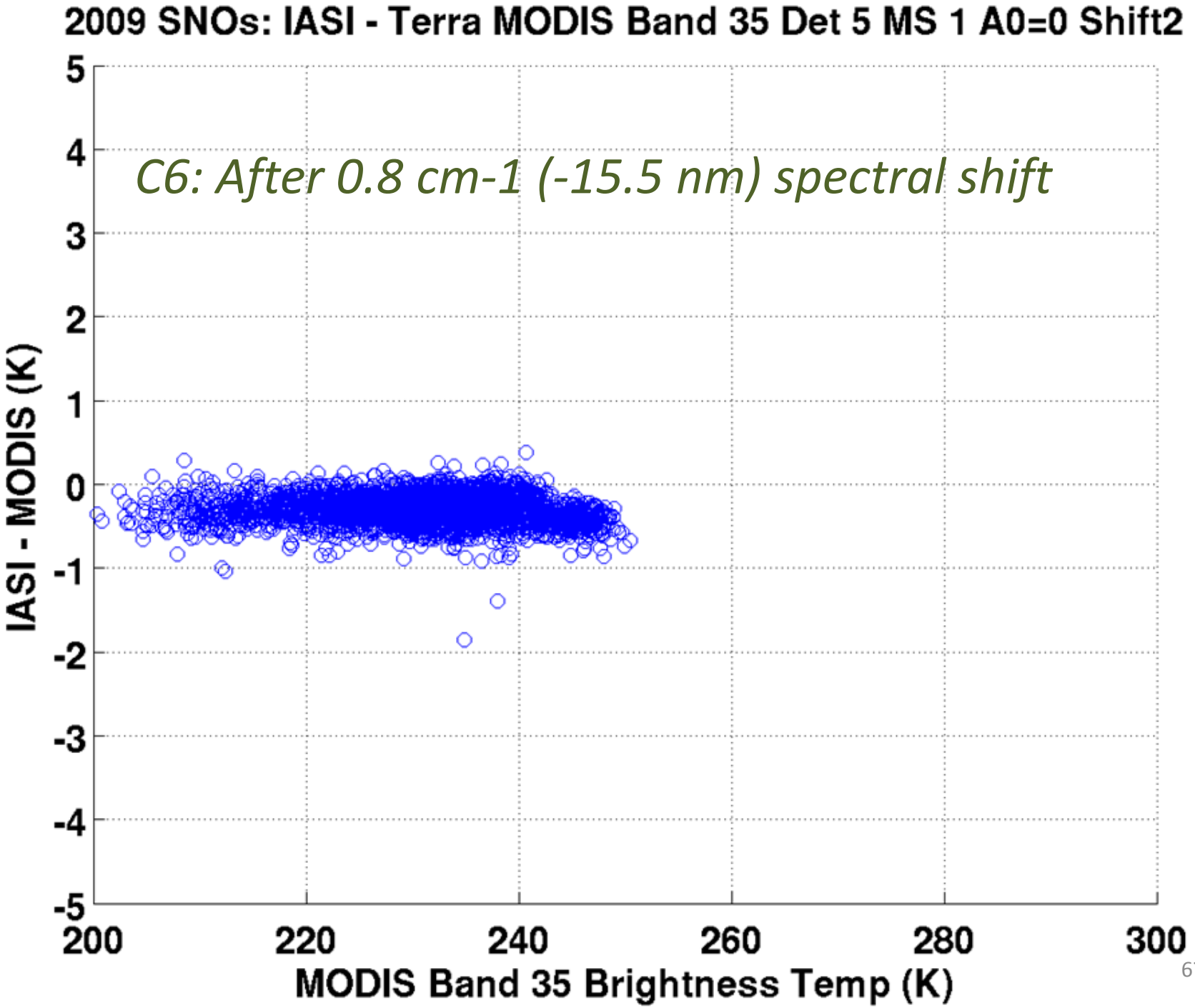

2009 SNOs: IASI - Terra MODIS Band 30 Det 4 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 30 Brightness Temp (K)

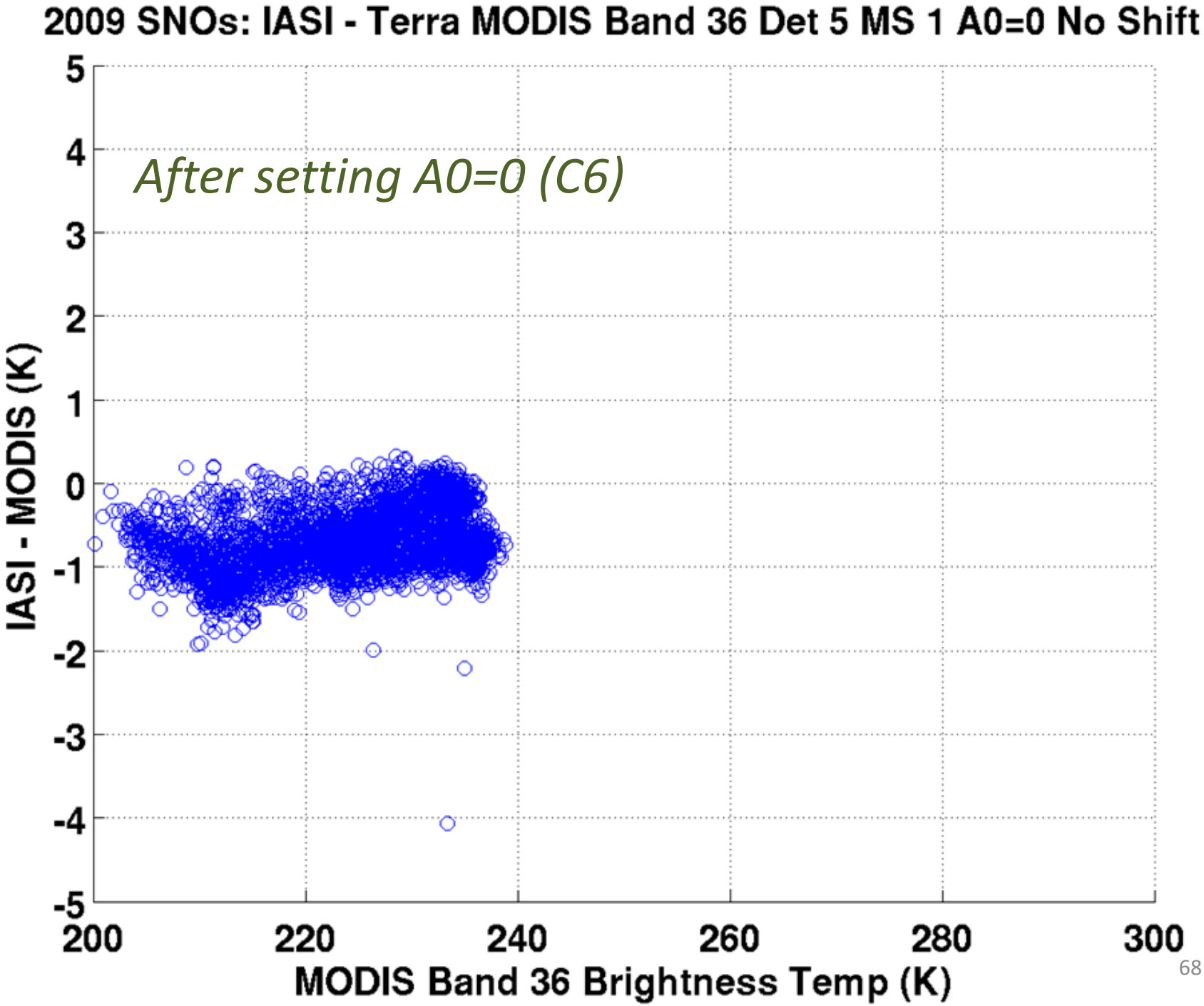

2009 SNOs: IASI - Terra MODIS Band 30 Det 4 MS 1 A0=0 Shift2
C6: After 1 cm-1 (-9.5 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 30 Brightness Temp (K)

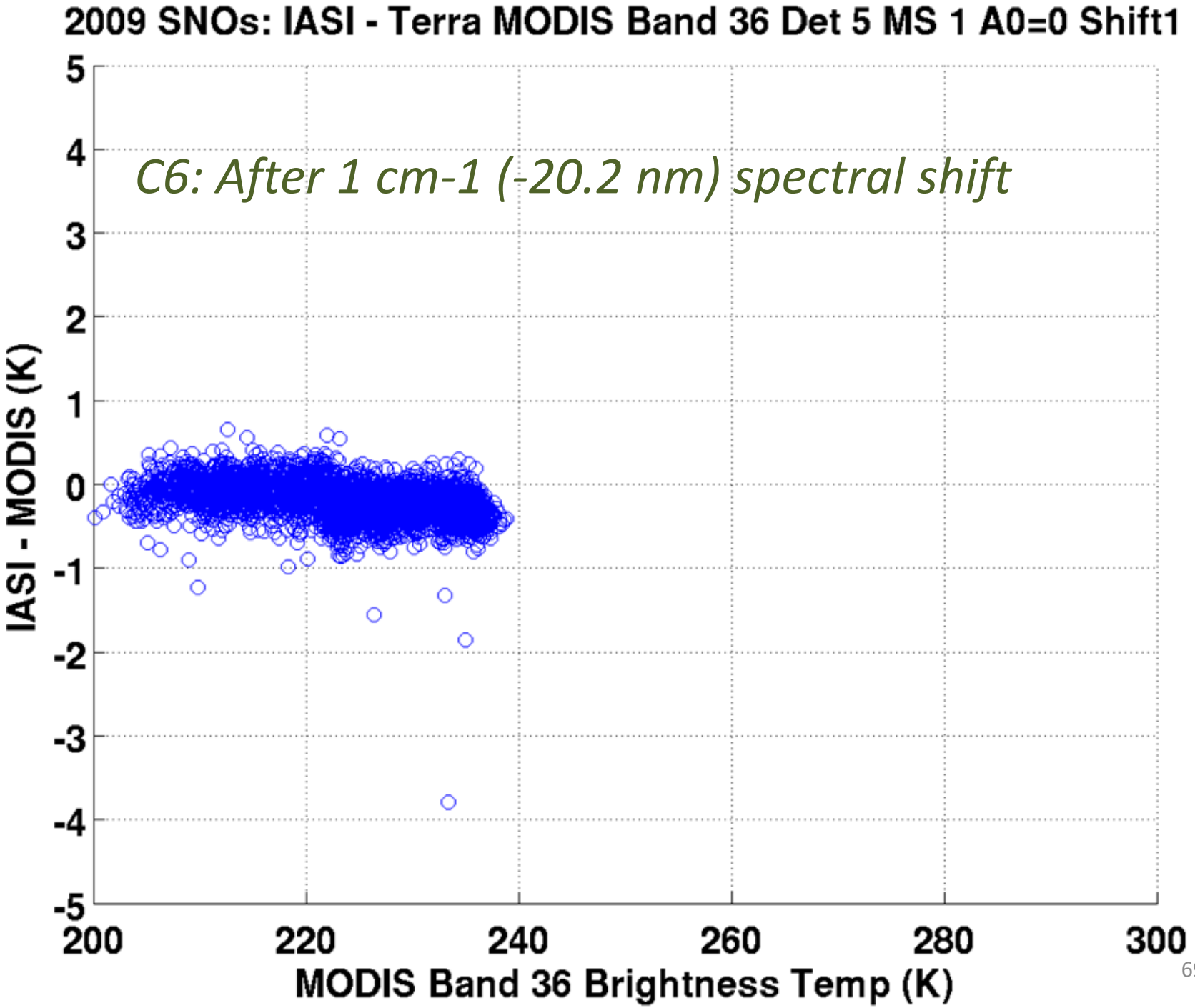

2009 SNOs: IASI - Terra MODIS Band 34 Det 5 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 34 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 34 Det 5 MS 1 A0=0 Shift1
C6: After 0.8 cm-1 (-15.0 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 34 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 35 Brightness Temp (K)

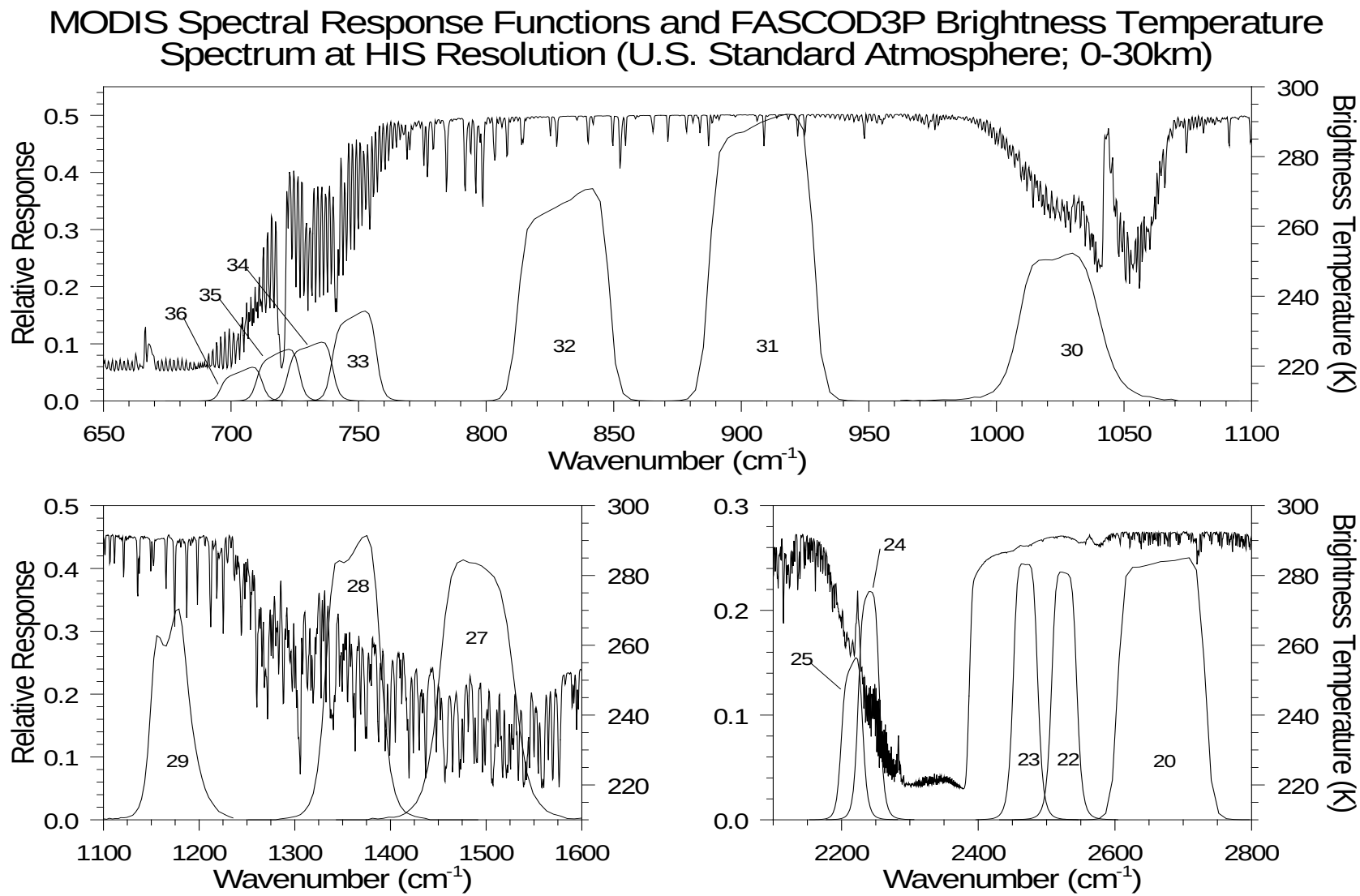

2009 SNOs: IASI - Terra MODIS Band 35 Det 5 MS 1 A0=0 Shift2
C6: After 0.8 cm-1 (-15.5 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 35 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 36 Det 5 MS 1 A0=0 No Shift
After setting A0=0 (C6)
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 36 Brightness Temp (K)


2009 SNOs: IASI - Terra MODIS Band 36 Det 5 MS 1 A0=0 Shift1
C6: After 1 cm-1 (-20.2 nm) spectral shift
IASI - MODIS (K)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
220
240
260
280
300
MODIS Band 36 Brightness Temp (K)

Terra MODIS Effective Spectral Shift

- IASI-TerraMODIS bias dependence on scene temperature is reduced.
- This analysis uses only 2009 data. Other years will be processed to corroborate these findings and look for trends in spectral shift behavior.
- These spectral shifts are only applied by Wisconsin as the front end to Wisconsin's L2 Science algorithms. They are NOT included in MODAPS official L1B processing.

Backup Slides

MODIS IR Spectral Bands