Workshop on Aqua MODIS Cold FPA Performance and Operation (II)

Jack Xiong

Biospheric Sciences Branch 614.4, NASA/GSFC

and

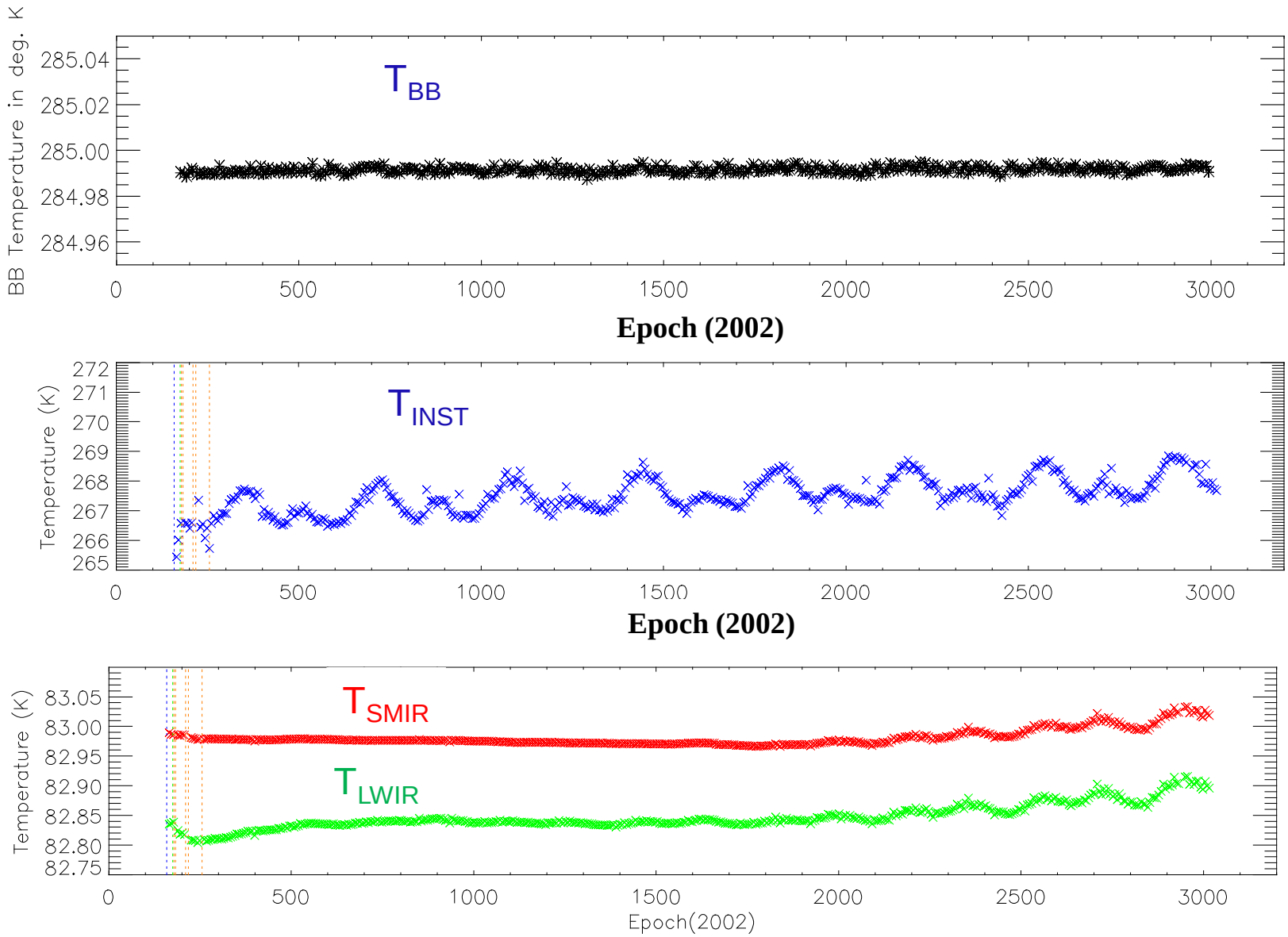
MODIS Characterization Support Team (MCST)

4801 Forbes Boulevrd, Lanham, MD 20706 (May 7, 2010)

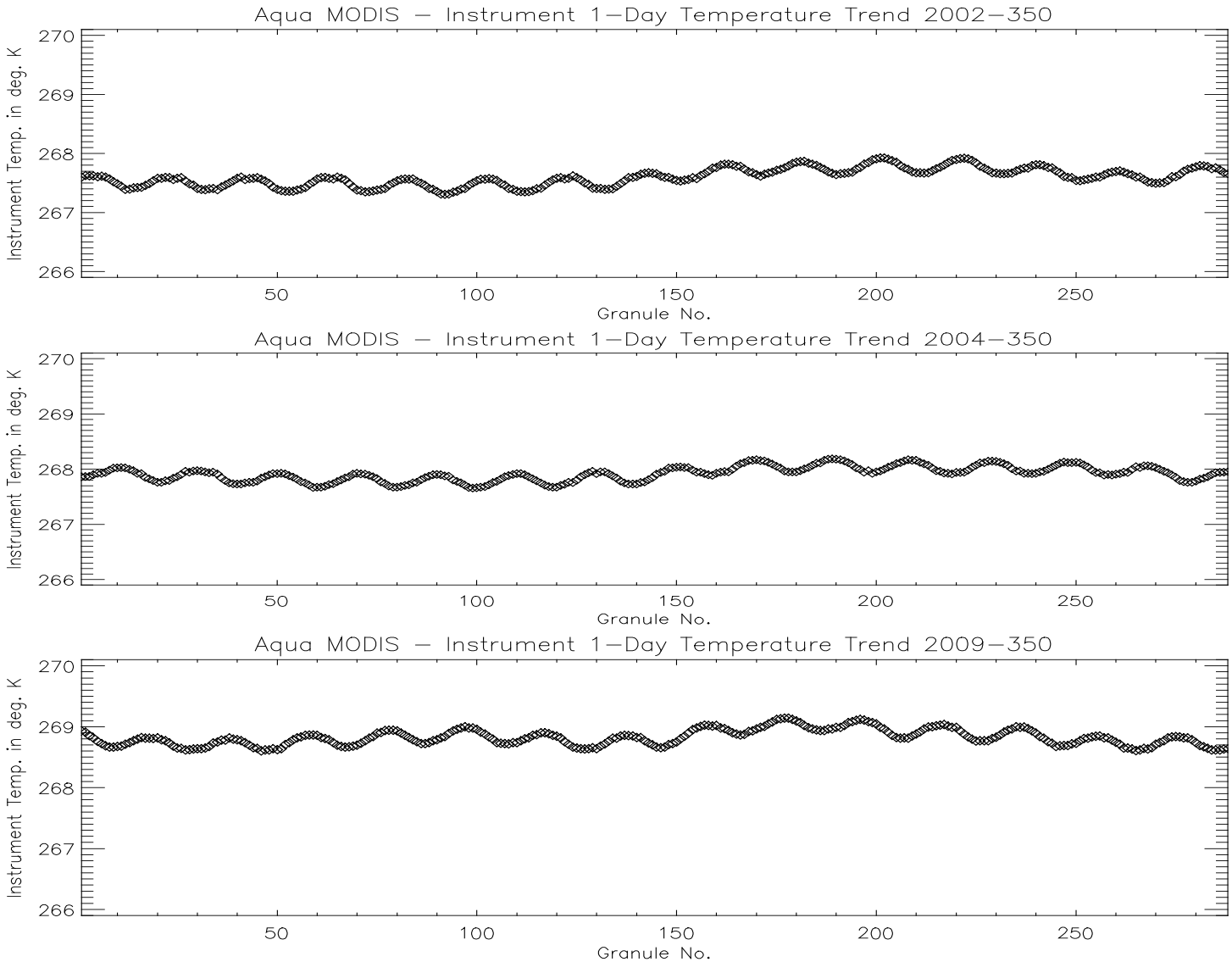
Aqua MODIS CFPA On-orbit Operation and Performance

- Daily Instrument, BB, and CFPA Temperatures
- Orbit-to-orbit Instrument, BB, and CFPA Temperatures
- CFPA Temperatures and Heater Voltages
- CFPA Heater Duty Cycles

BB, Instrument, and CPFA Temperatures

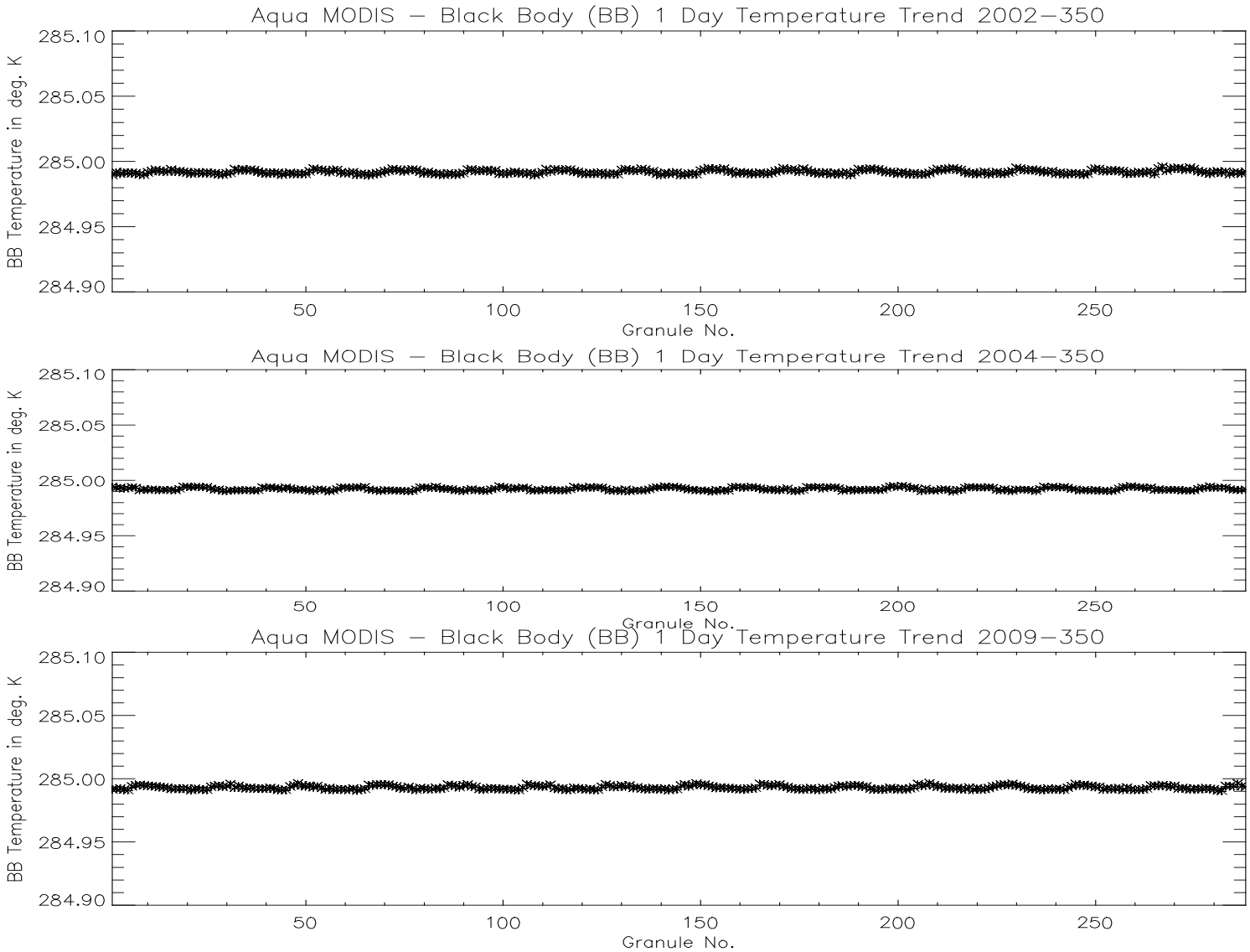


Daily Instrument Temperature Trending (2002, 2004, 2009)



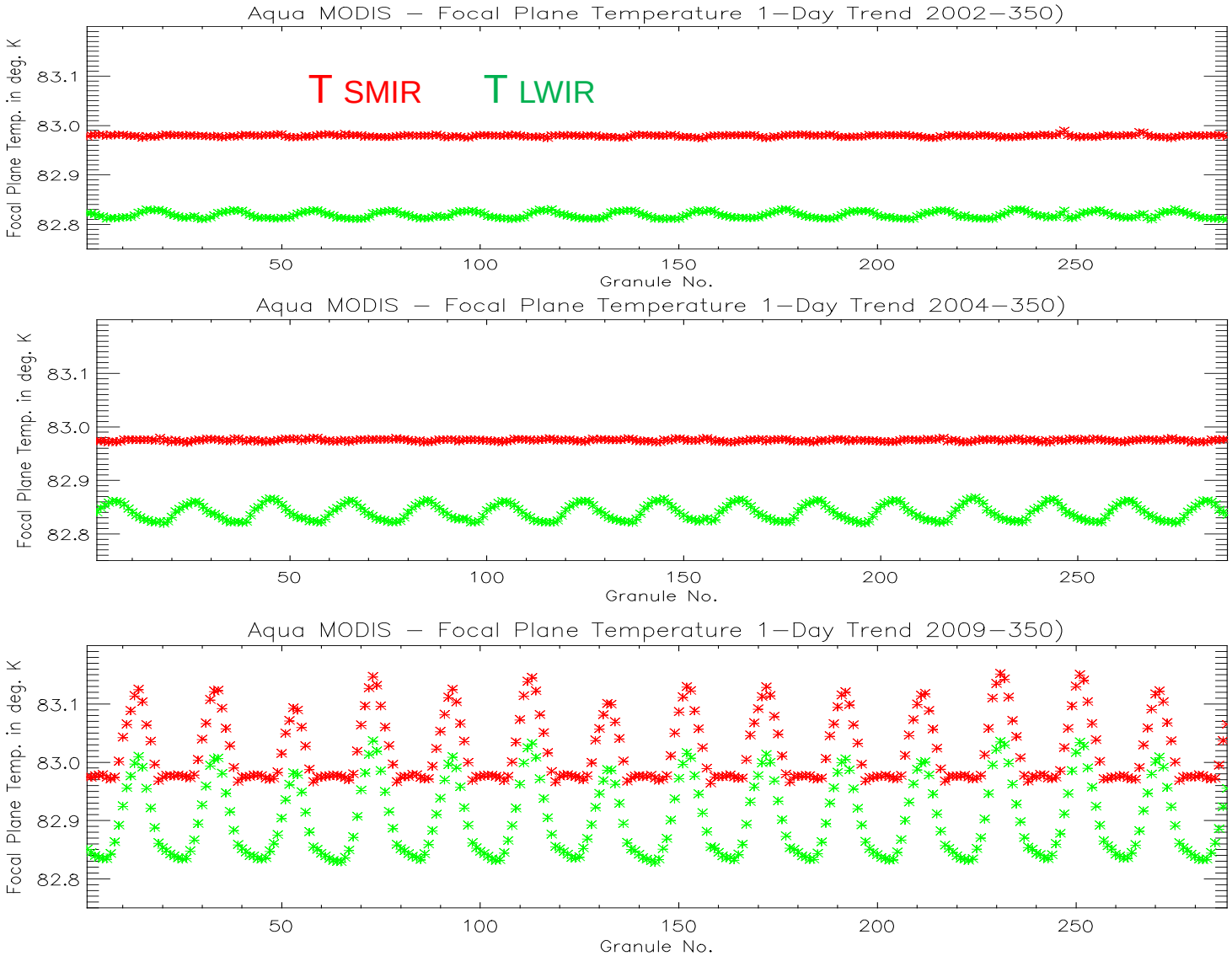
Instrument temperature performance: expected

Daily BB Temperature Trending (2002, 2004, 2009)



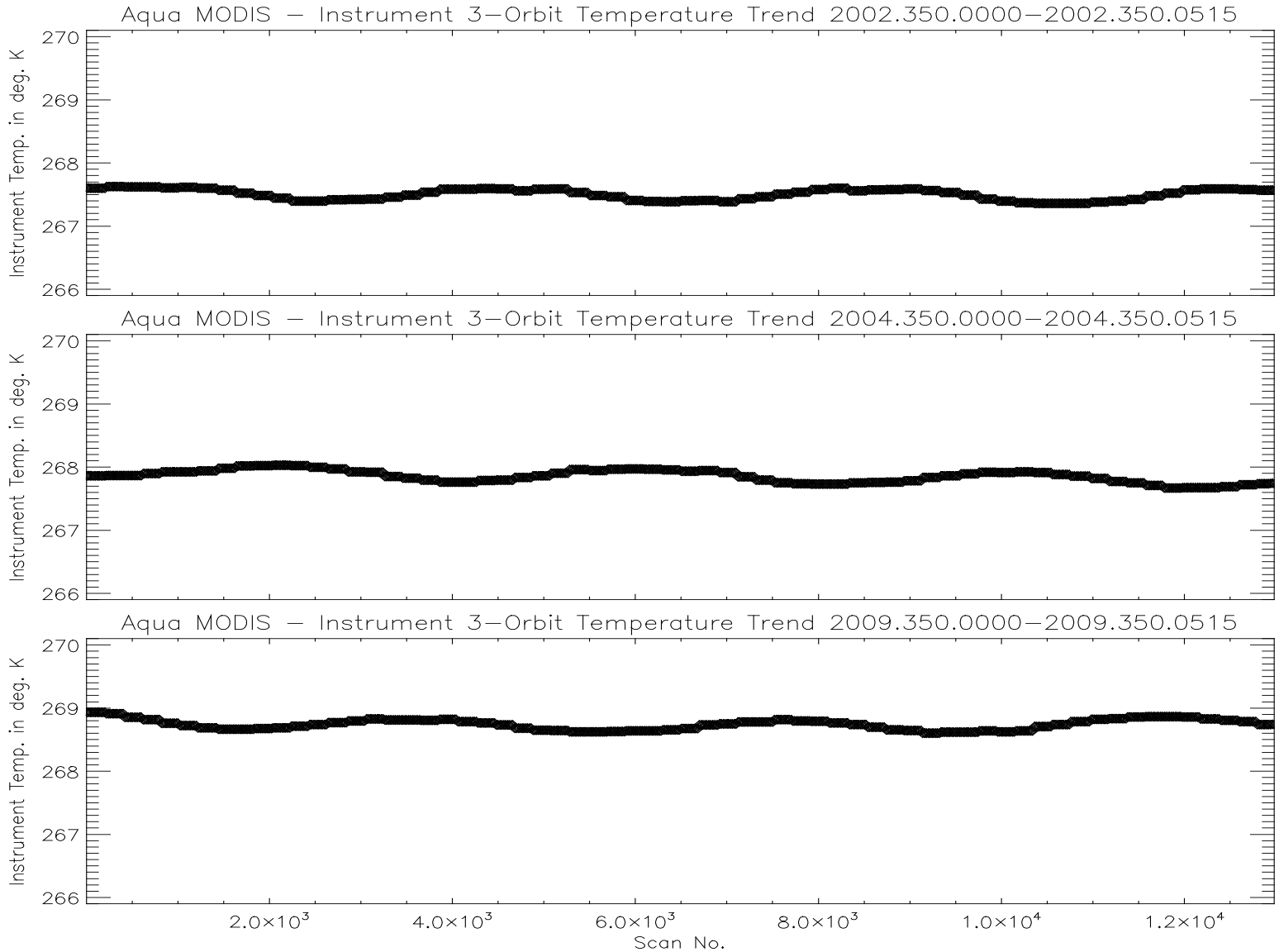
BB temperature performance: unchanged

Daily CFPA Temperature Trending (2002, 2004, 2009)

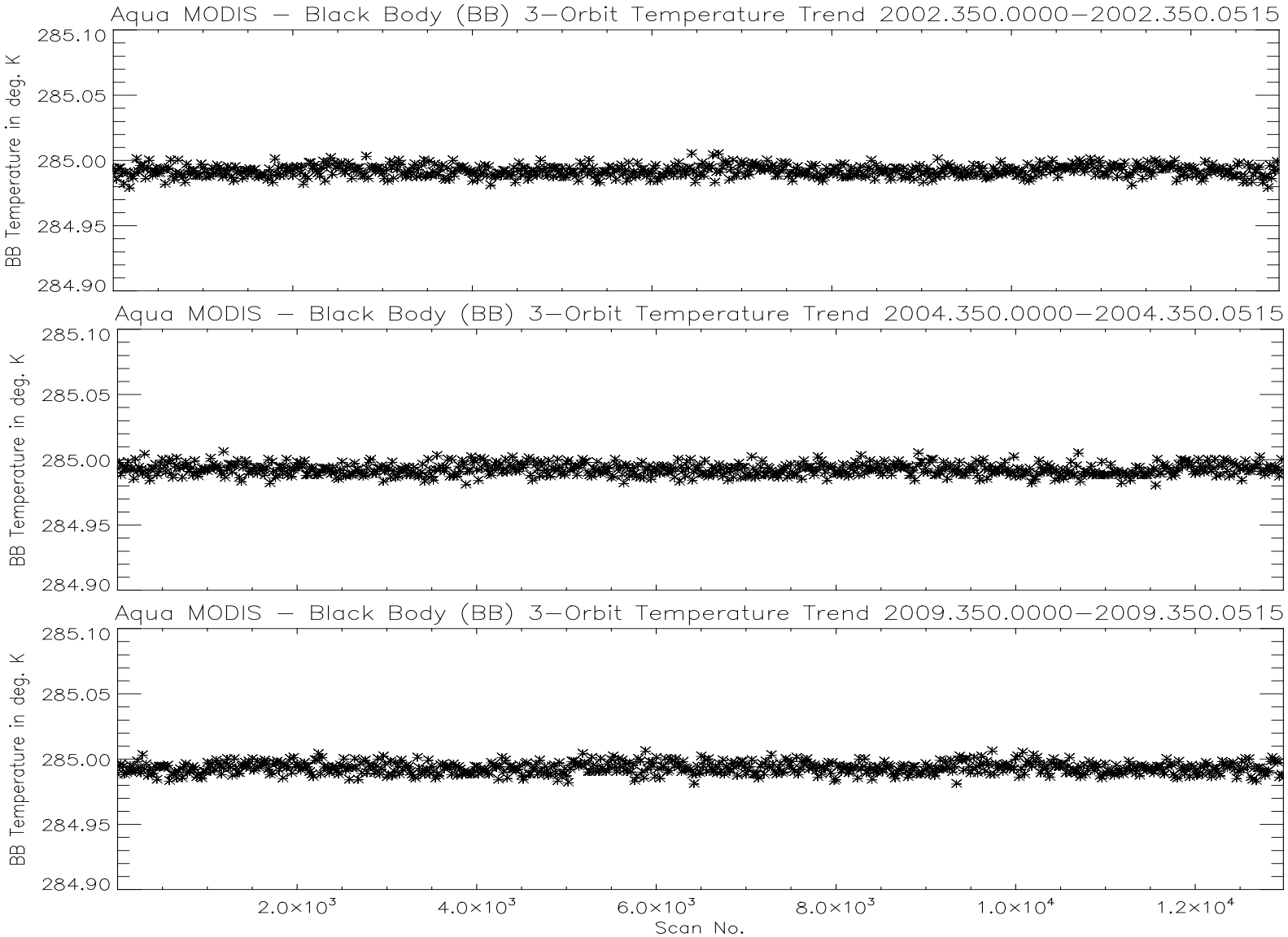


CFPA temperature performance: slowly-decreased control capability

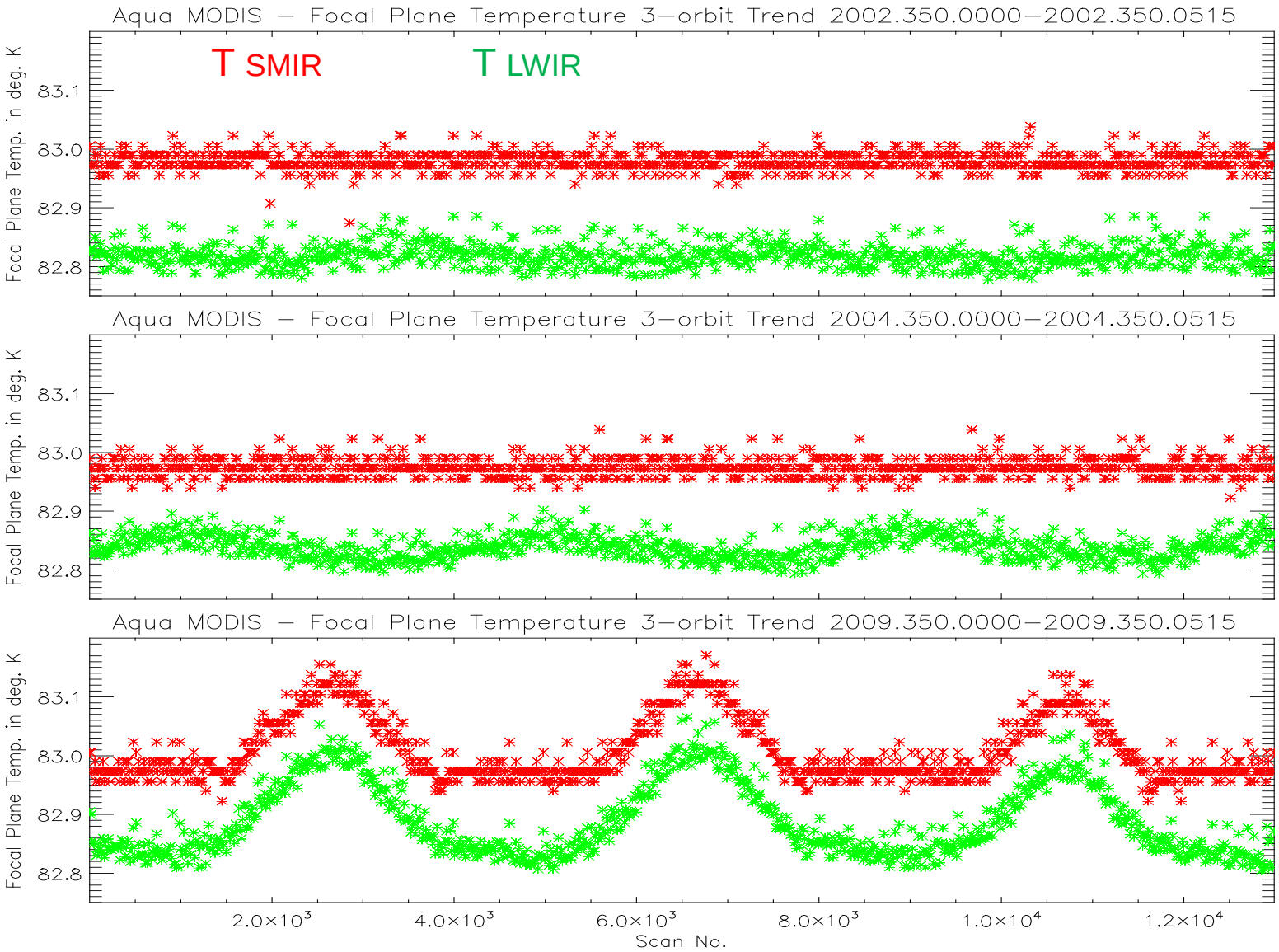
Orbit-to-orbit Instrument Temperature Trending (2002, 2004, 2009)



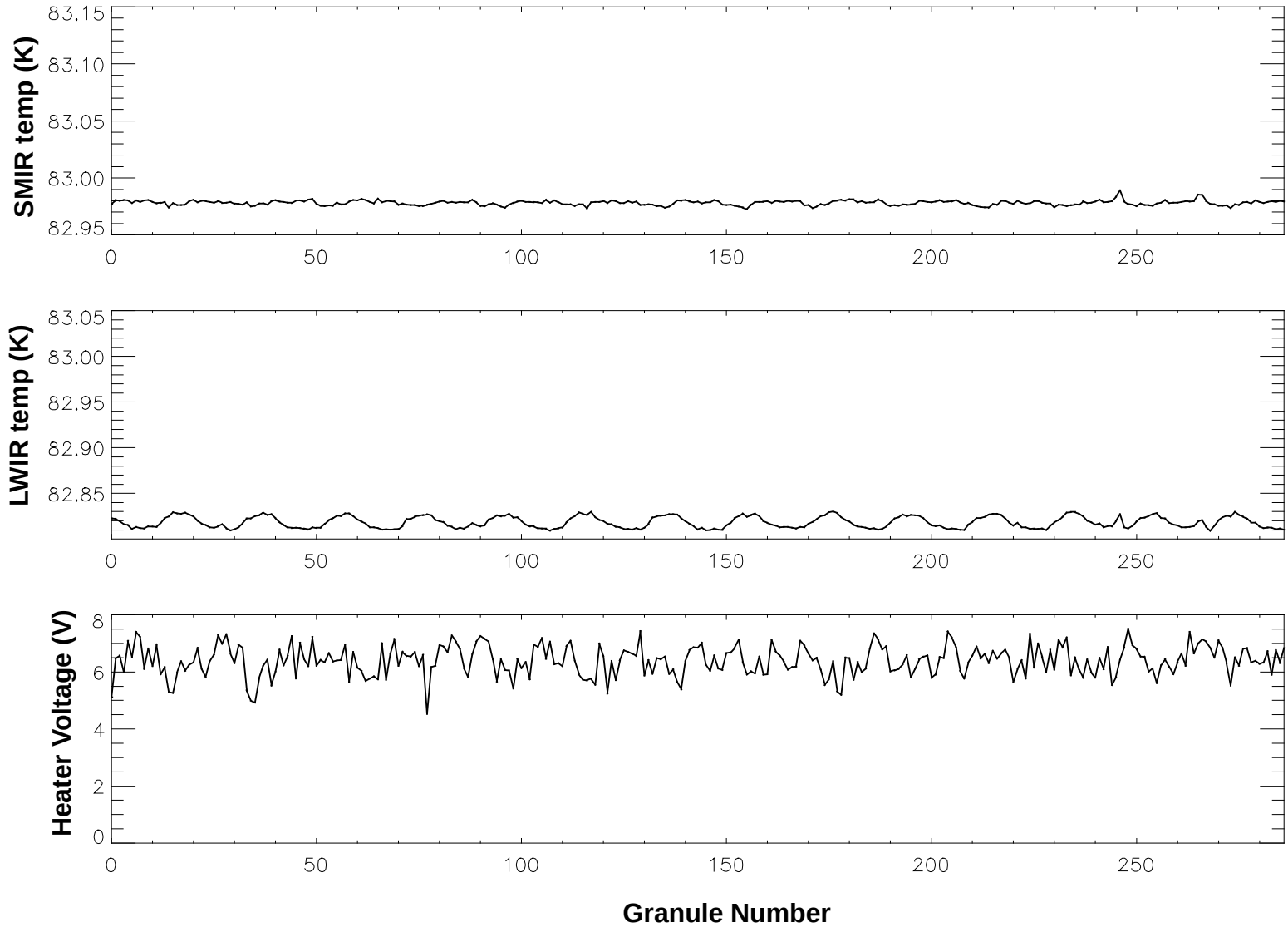
Orbit-to-orbit BB Temperature Trending (2002, 2004, 2009)



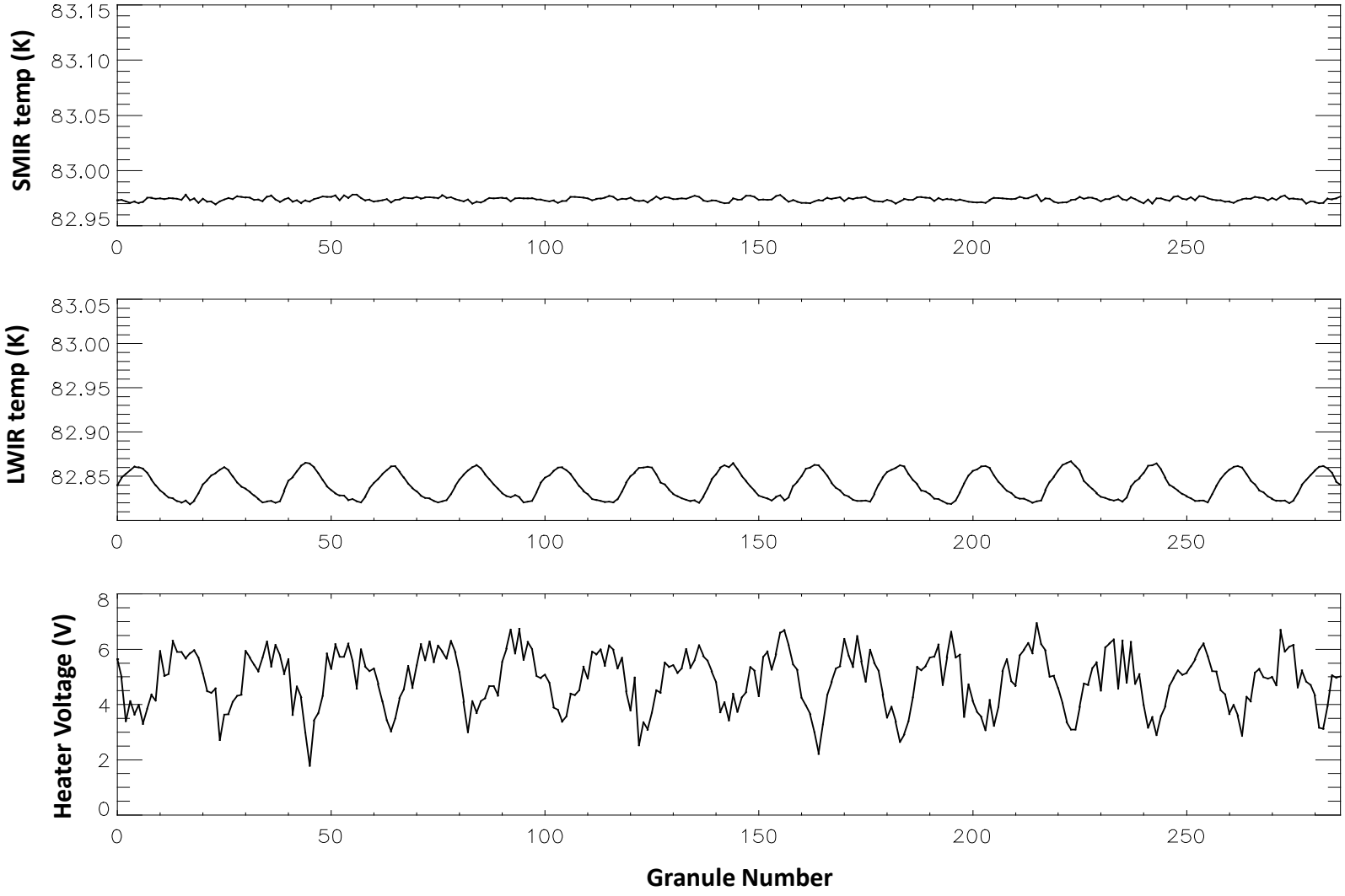
Orbit-to-orbit CFPA Temperature Trending (2002, 2004, 2009)



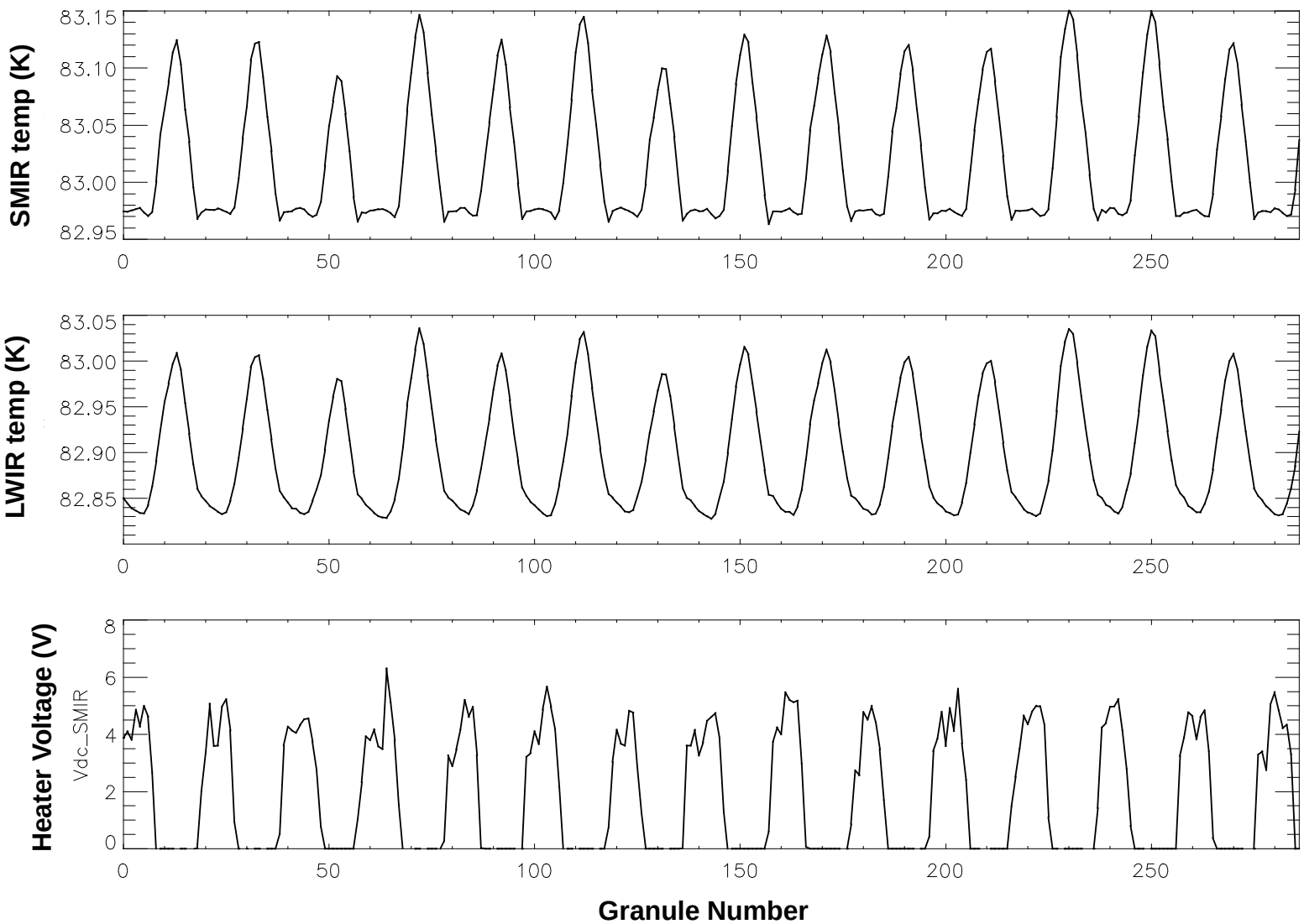
CFPA Temperature and Heater Voltage: 2002350 (granule average)



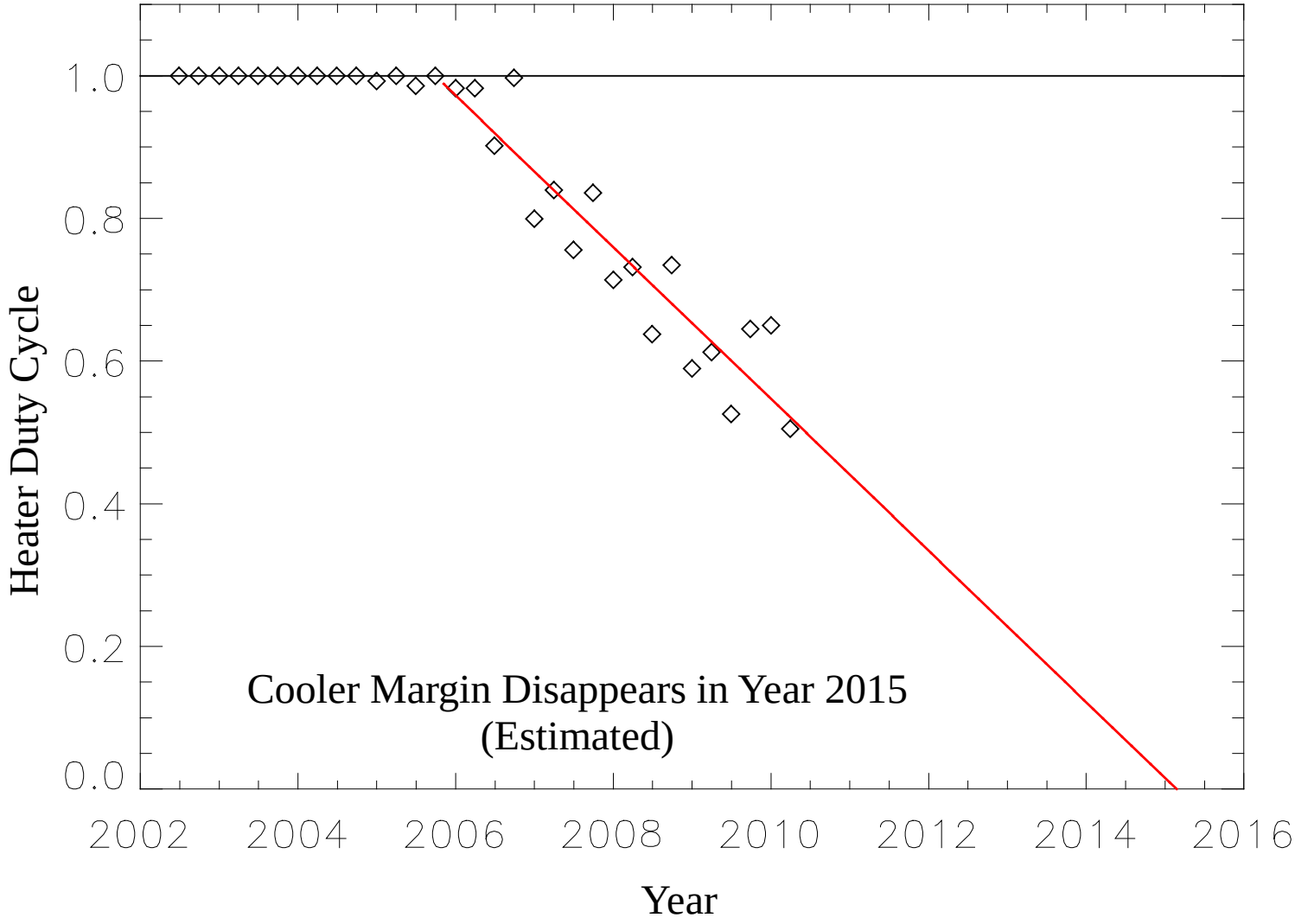
CFPA Temperature and Heater Voltage: 2004350 (granule average)



CFPA Temperature and Heater Voltage: 2009350 (granule average)



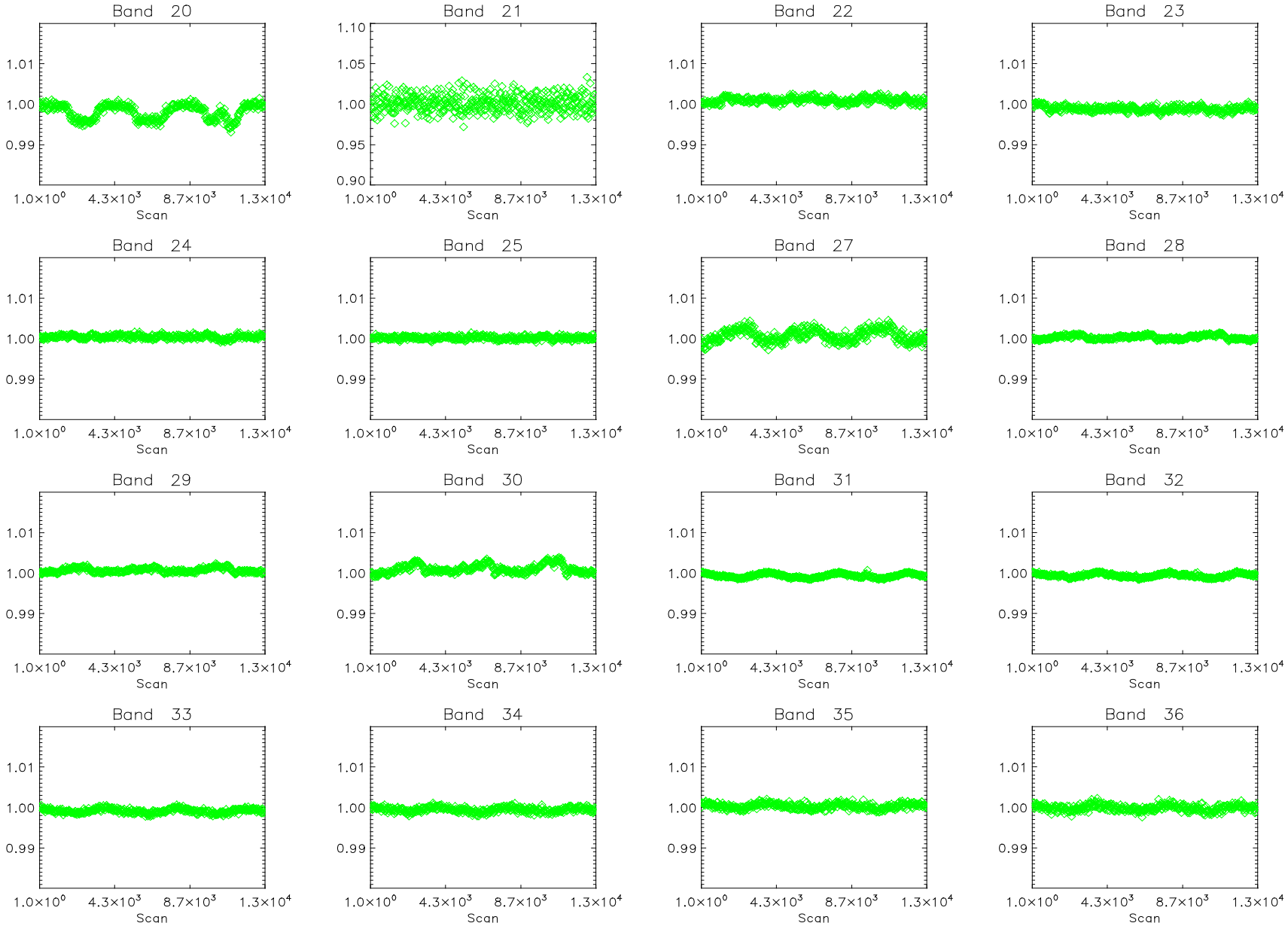
CFPA Heater Duty Cycle



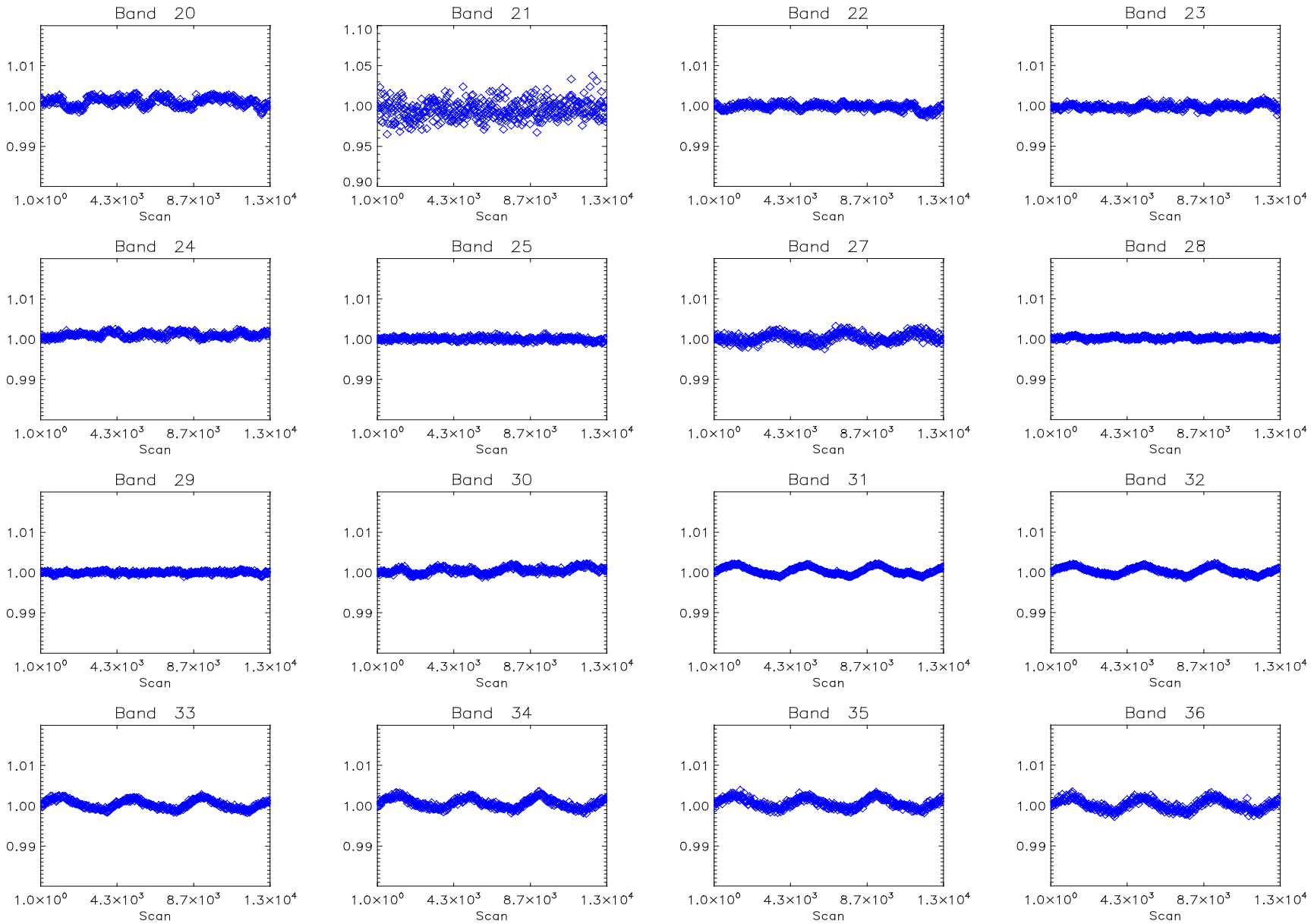
CFPA Impact On TEB Calibration

- Impact on Detector Linear Response
  - PC bands more sensitive to CFPA temperatures
- Impact on BB Warm-up and Cool-down Process
  - Slowly increased fitting residuals
  - Slowly increased NL coefficient uncertainties
- Impact on Dynamic Range / Tsat
  - Small increase of dynamic range for PC bands (decreased resolution)

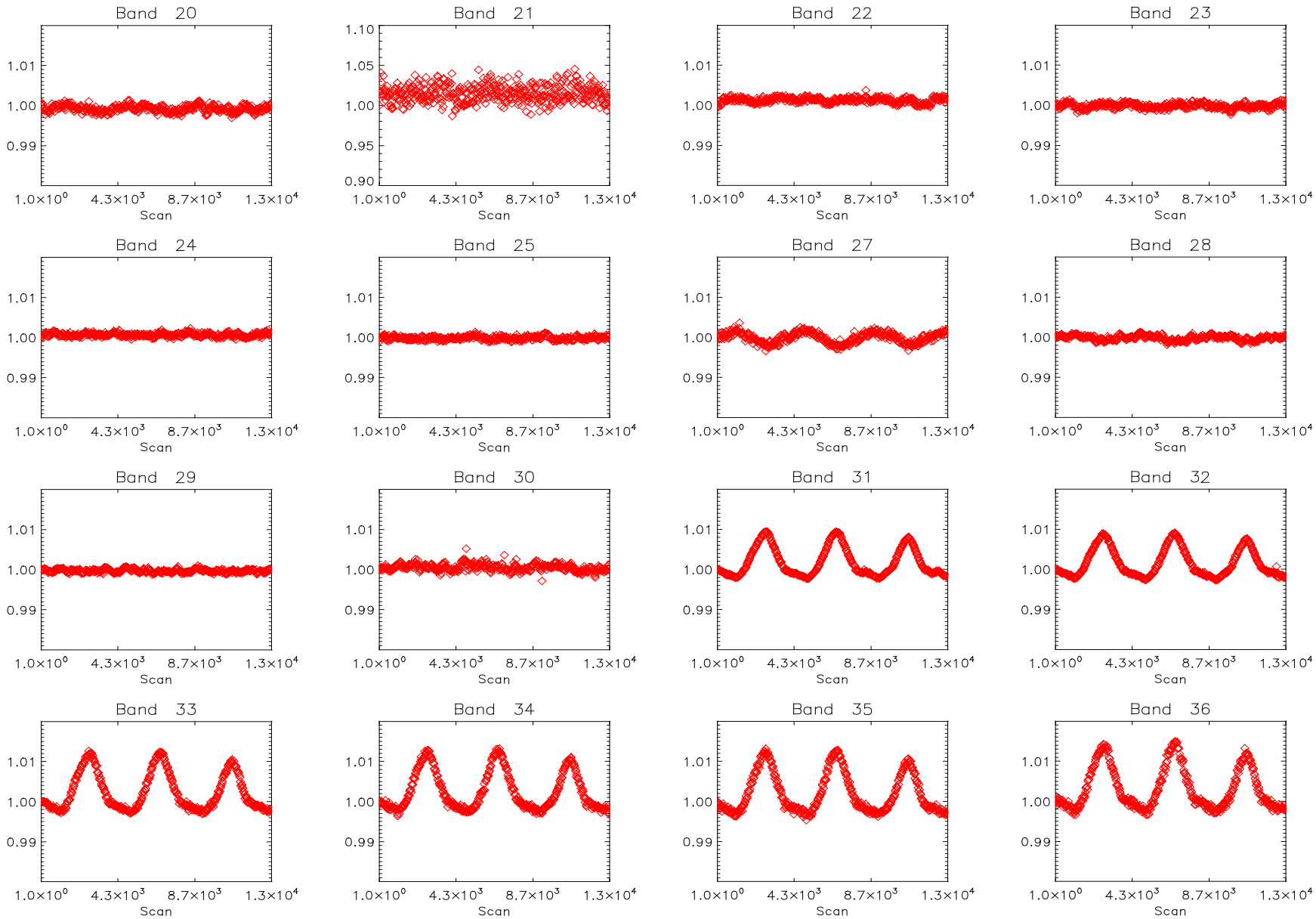
Normalized b1: 3 orbits in 2002350; detector 4 (P.O.)



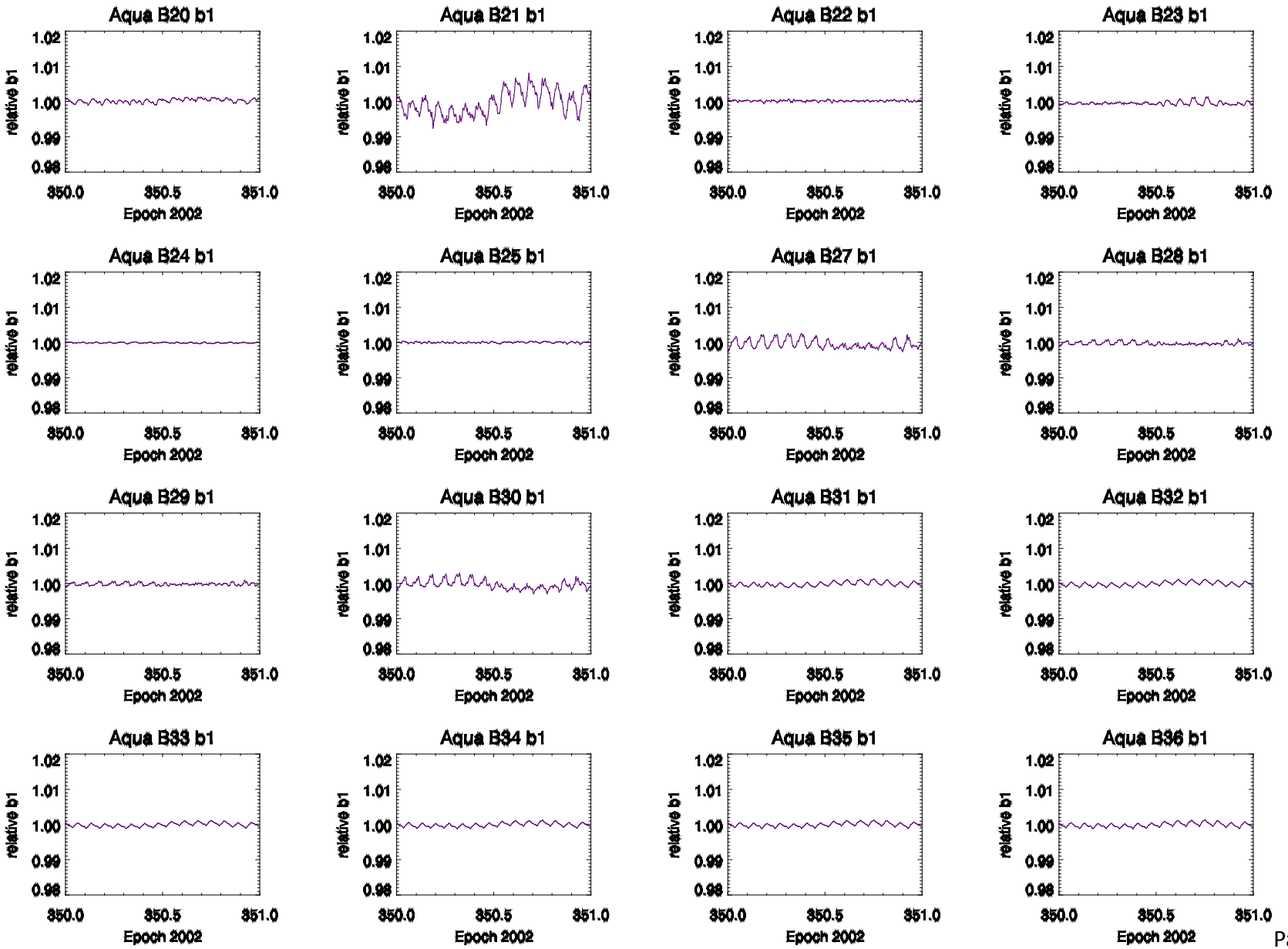
Normalized b1: 3 orbits in 2004350; detector 4 (P.O.)



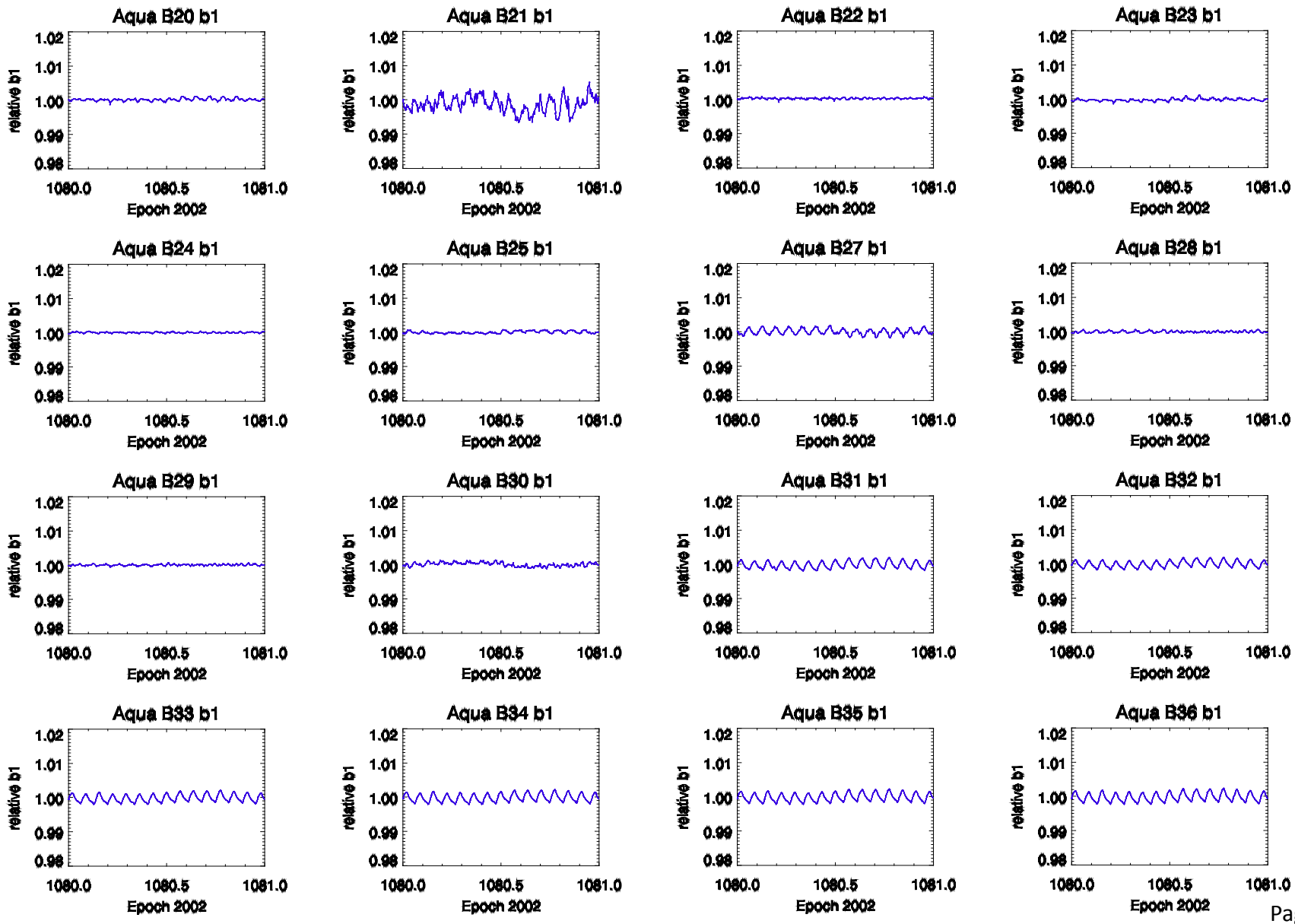
Normalized b1: 3 orbits in 2009350; detector 4 (P.O.)



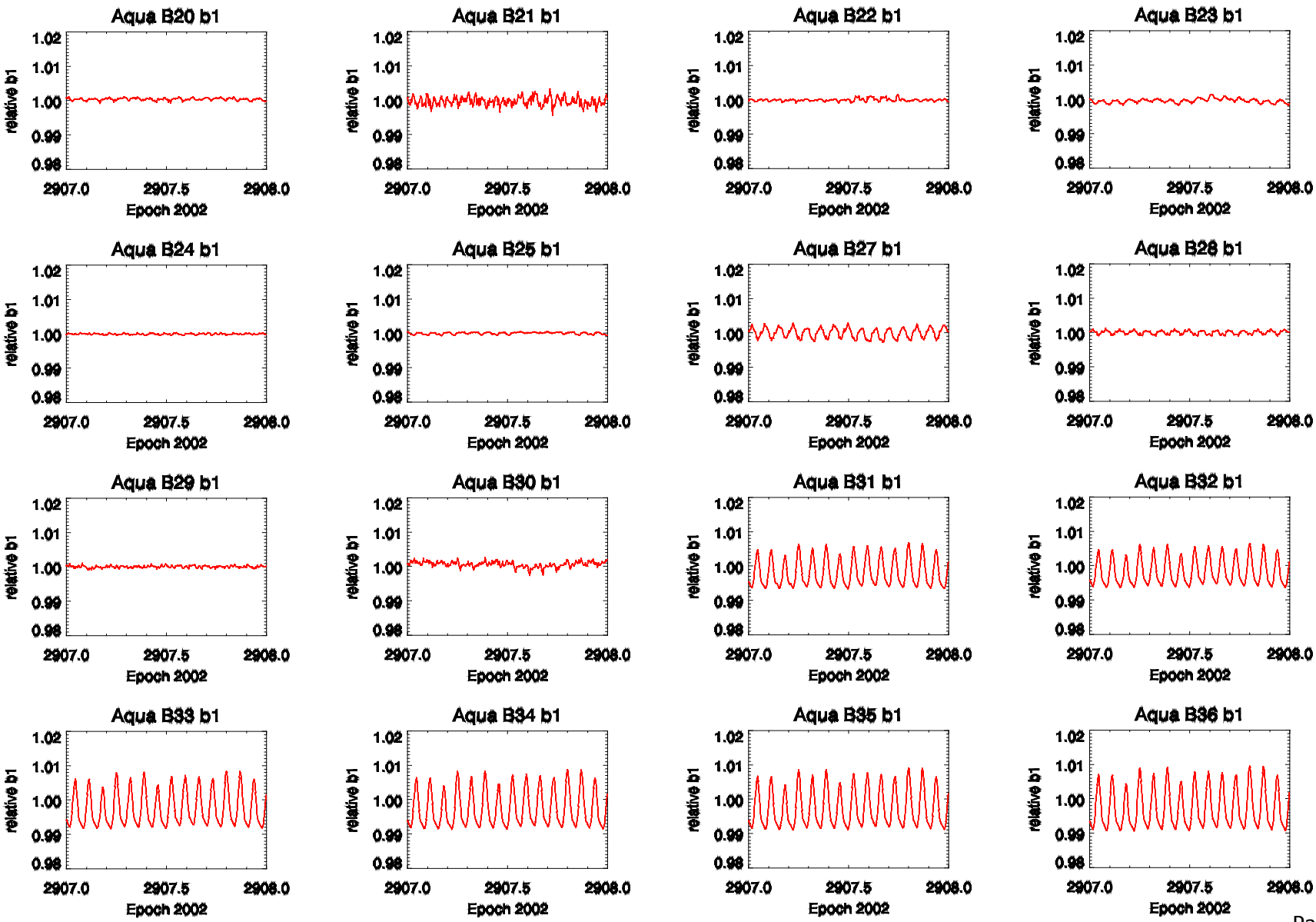
Normalized b1: day 2002350 (good detectors)



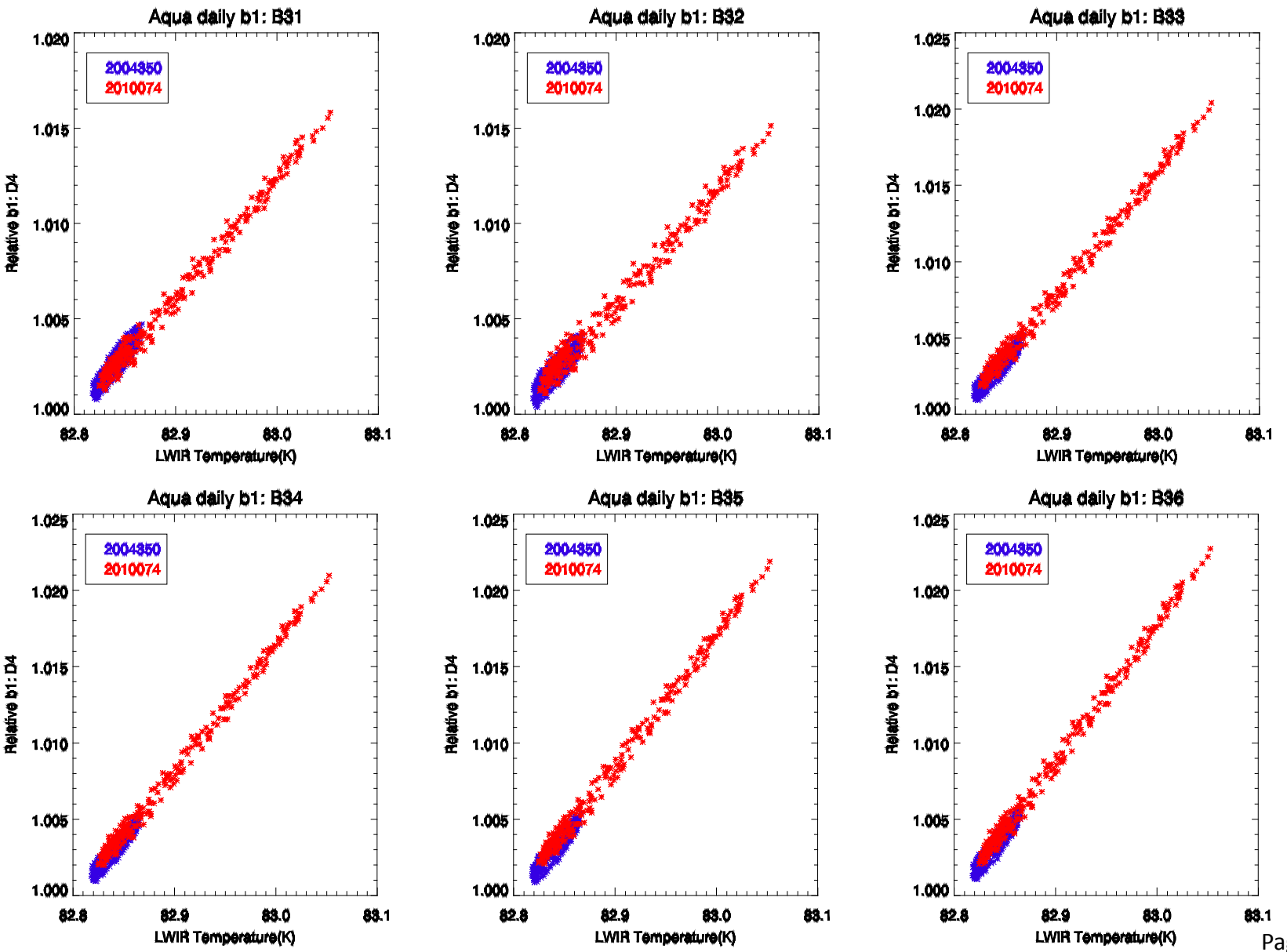
Normalized b1: day 2004350 (good detectors)



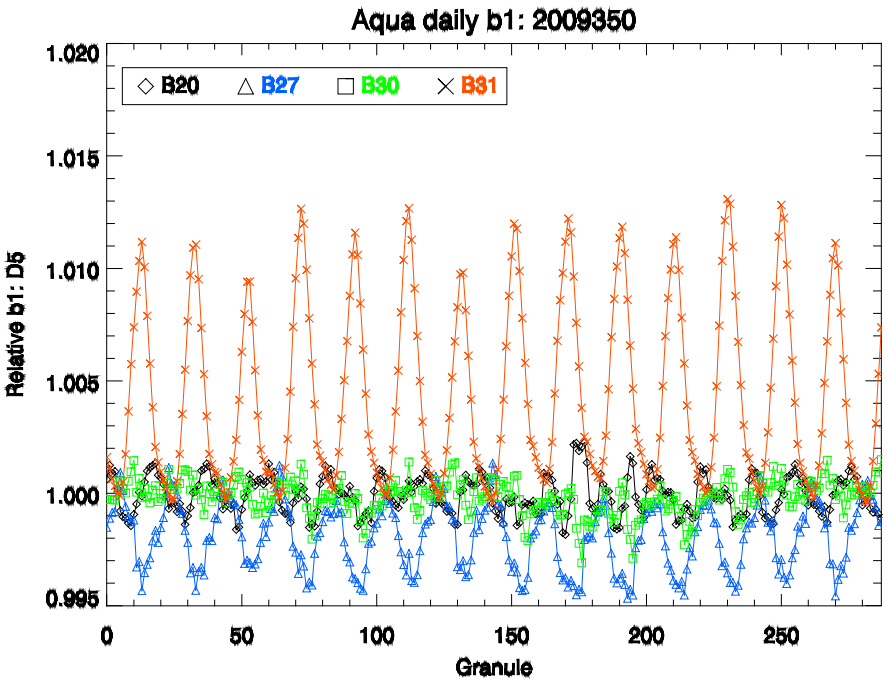
Normalized b1: day 2009350 (good detectors)

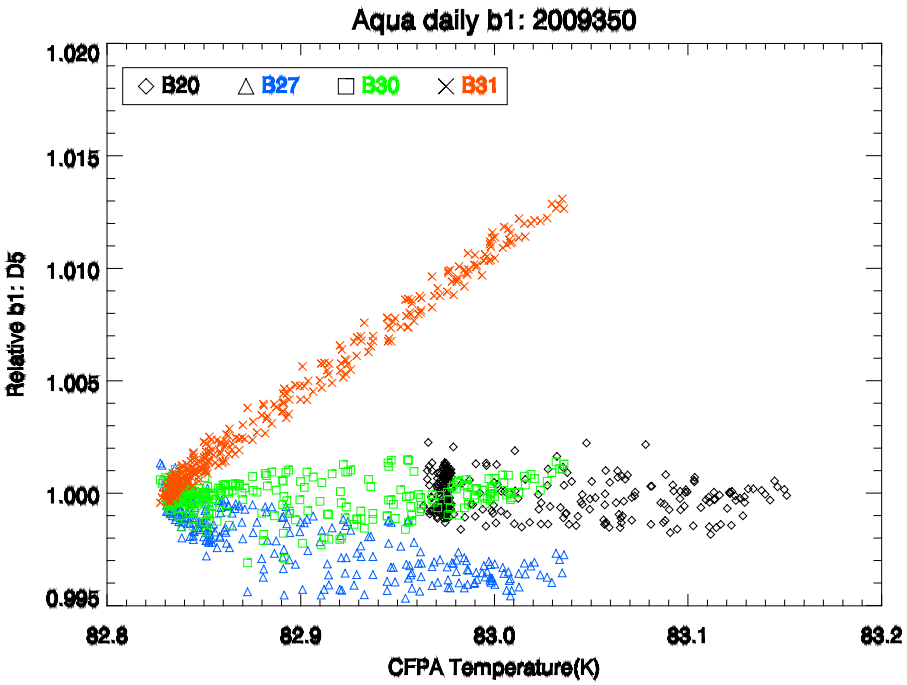


PC Band Normalized b1 versus CFPA Temp.



Normalized b1 versus CFPA Temp.



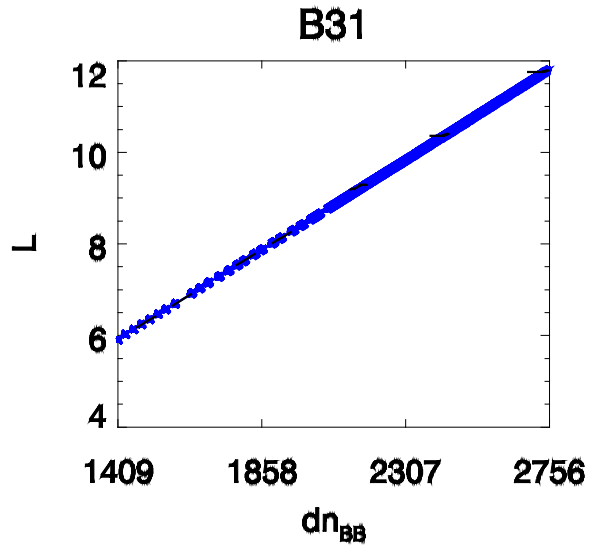


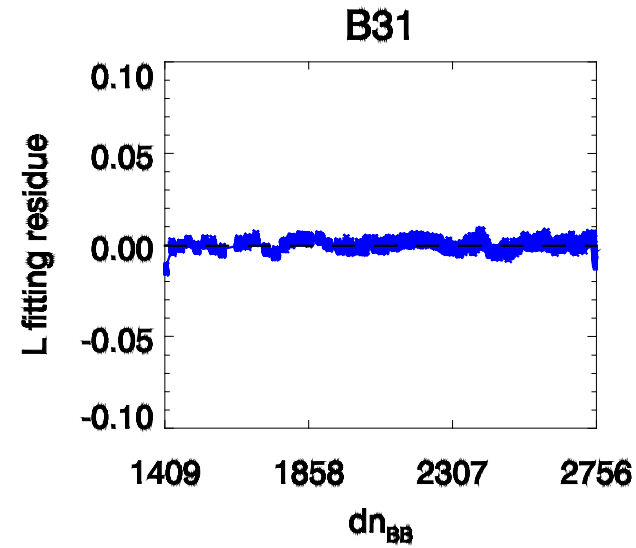
Band	20-25, 28-30	27	31	32	33	34	35	36
Pre-launch (83,85K) [%/K]	Within ±0.5	-1.5	7.0	6.6	8.9	9.4	9.5	10.2
2009/350 [%/K]	Within ±0.5	-1.9	6.3	6.0	8.0	8.3	8.6	9.0

Impact on BB Warm-up and Cool-down Process

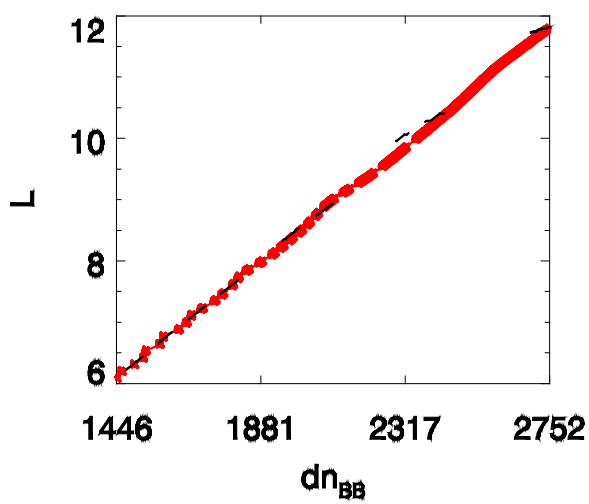
Continuous BB Cool-down Data: $L_C = a_0 + b_1 dn_{BB} + a_2 dn_{BB}^2$

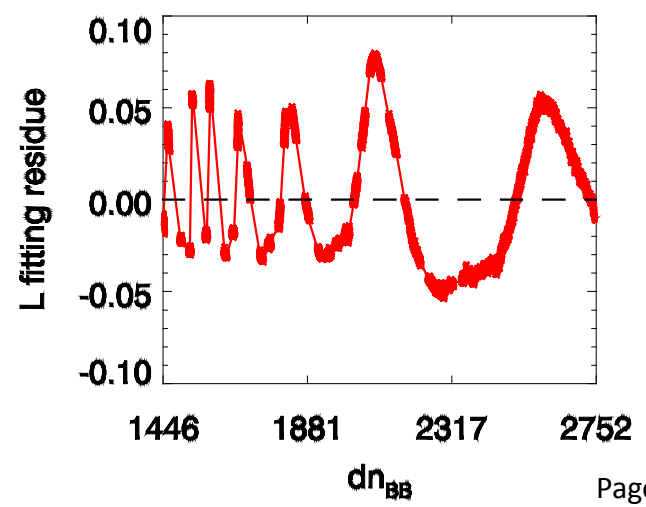
2002190



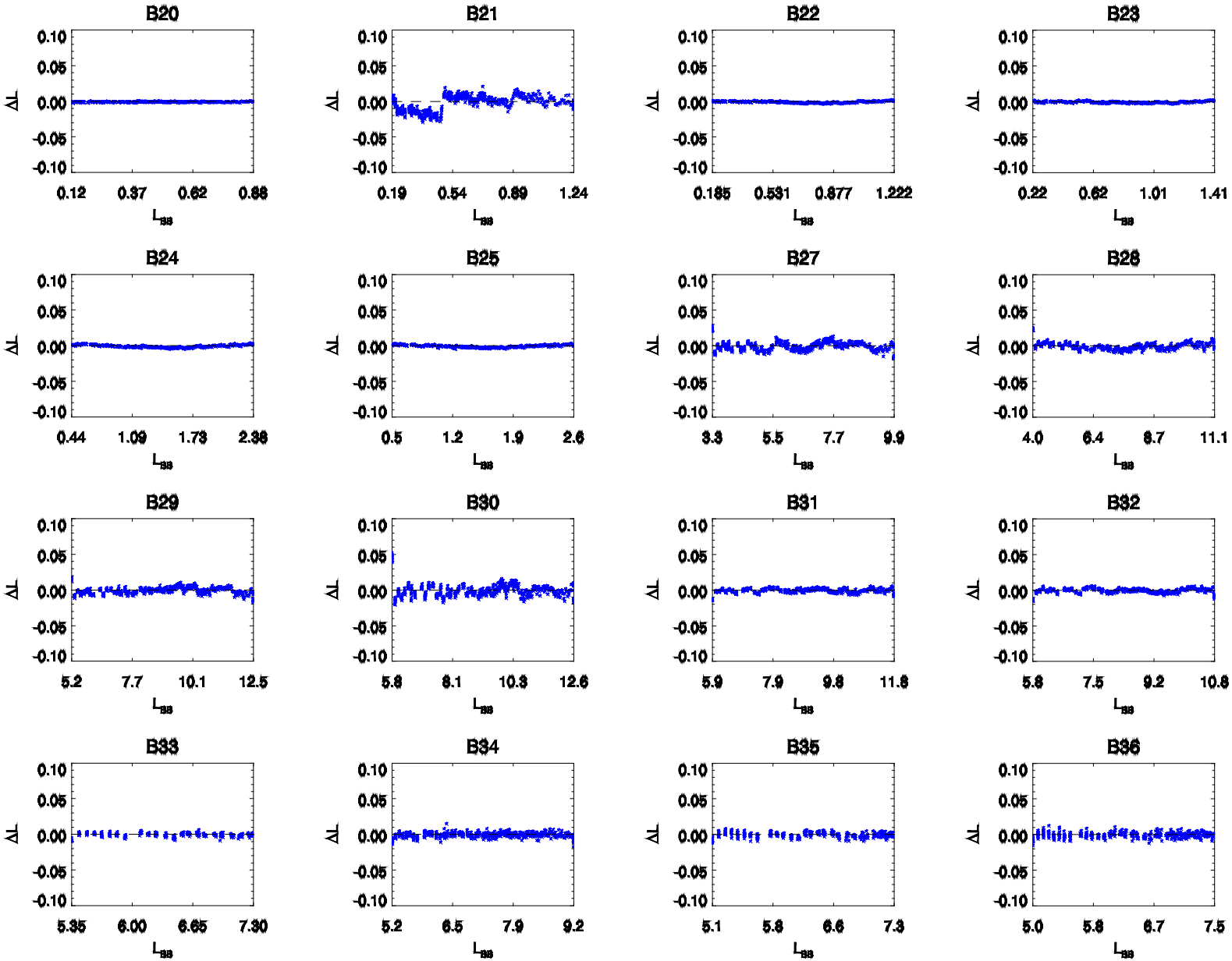


2010094

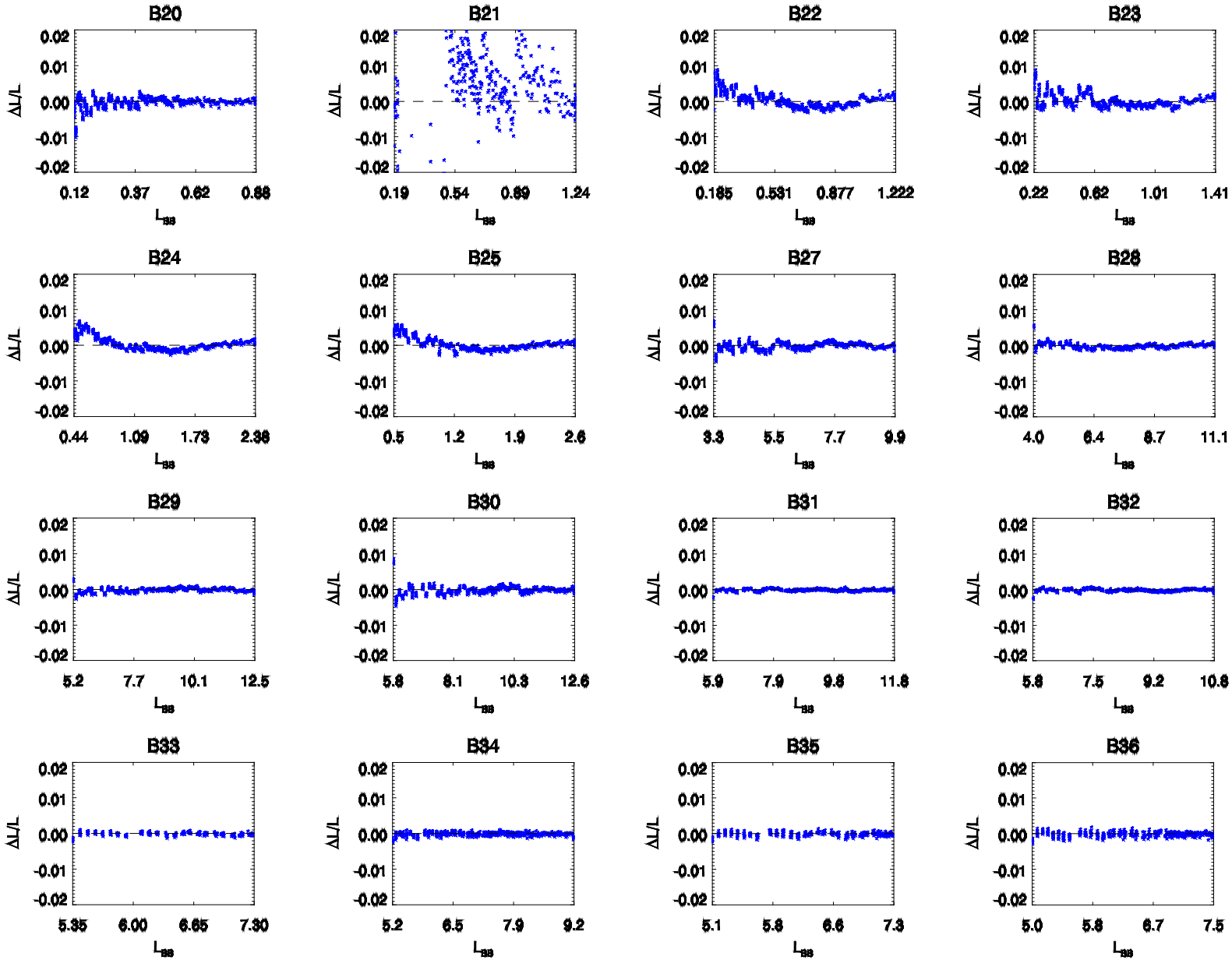




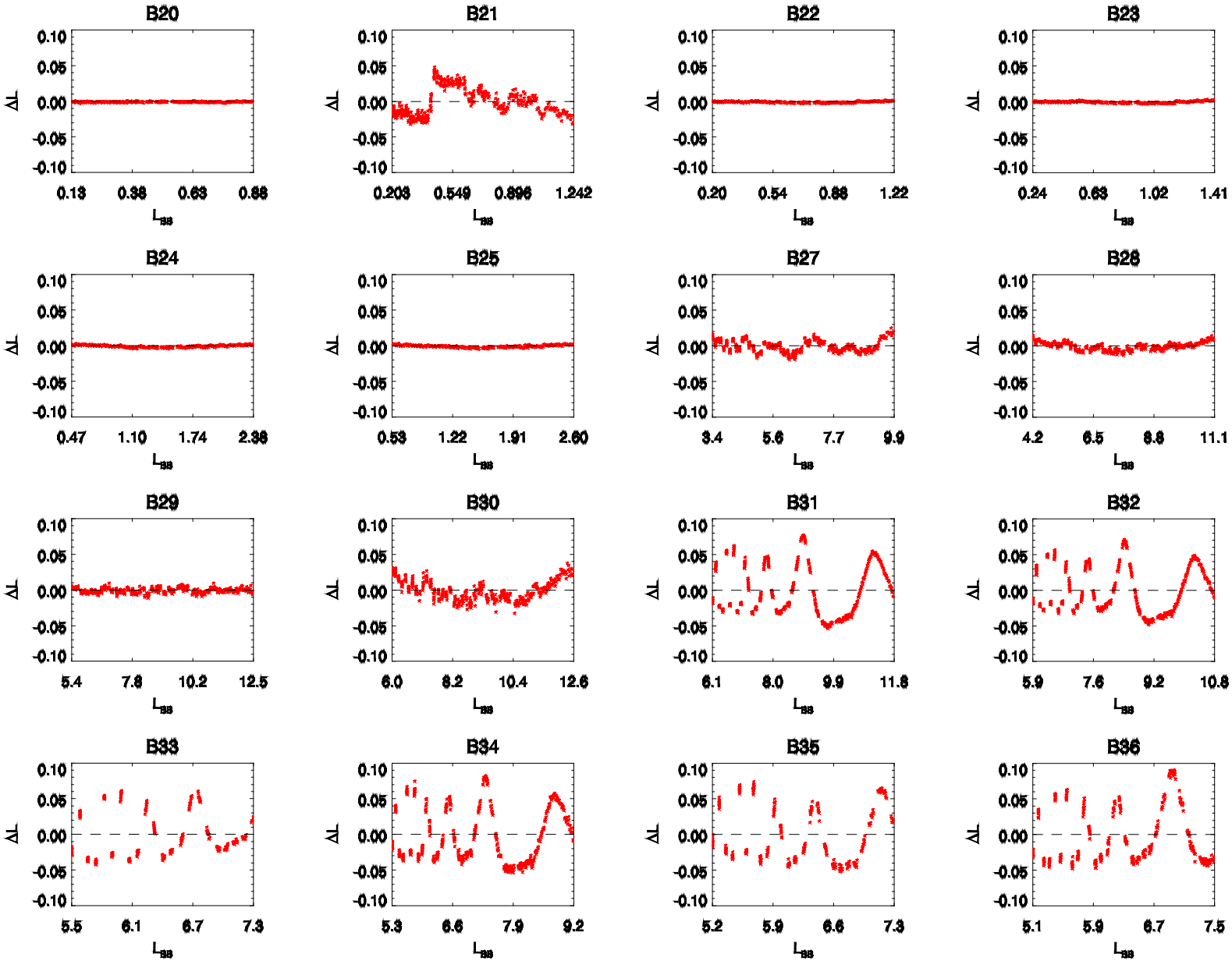
Fitting Residual (2002190)



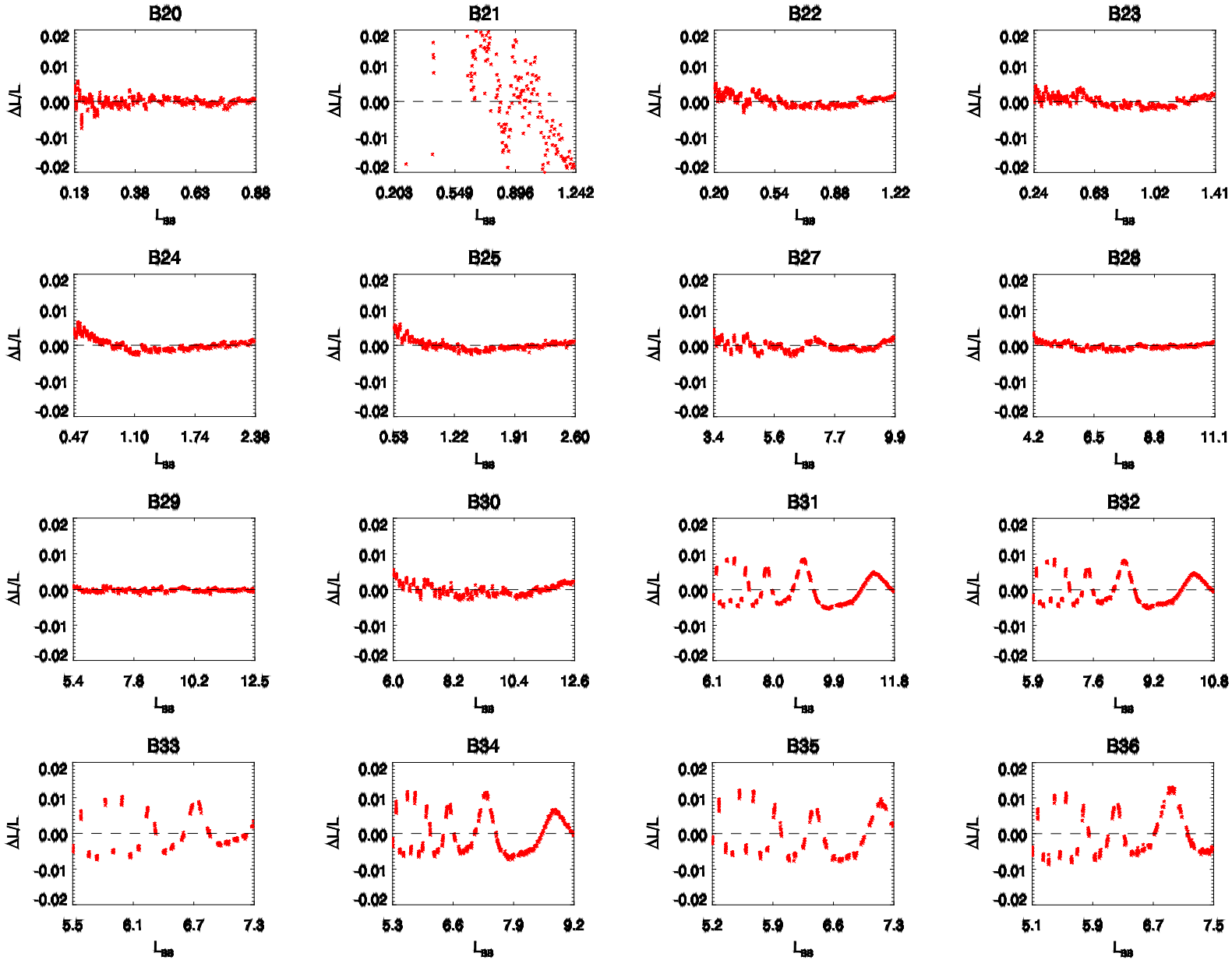
Fitting Residual (2002190)



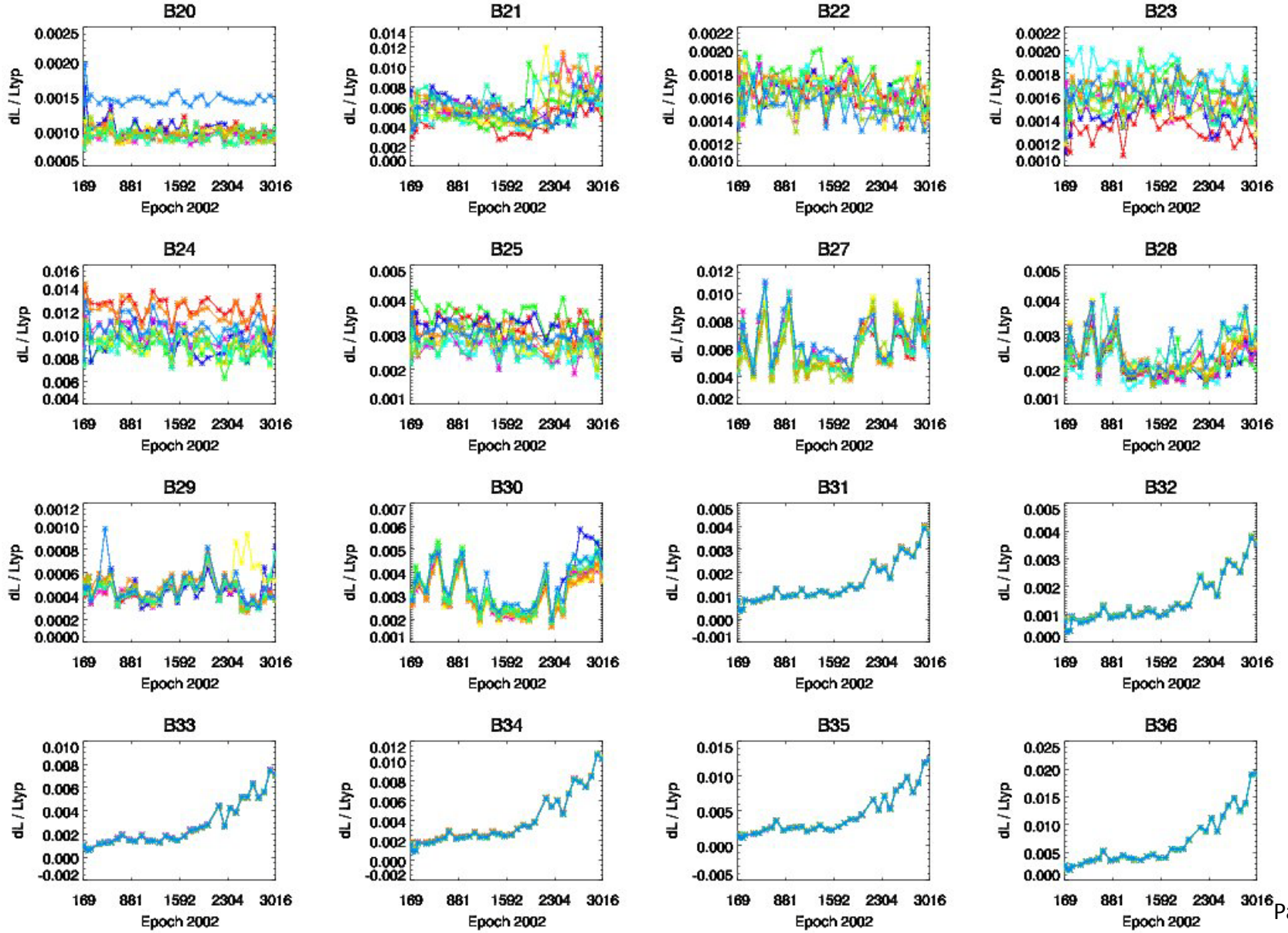
Fitting Residual (2010094)



Fitting Residual (2010094)



Fitting Residual over Time (a_0=0, poly_fit)



Estimated Dynamic Range: 83K versus 85K

Band	Design Specification				Detector response @ 83K CFPA			Detector Gain Change	Expectation @ 85K CFPA		
	Ltyp	Lmax	T_Ltyp	T_Lmax	dn@Ltyp	Lsat	Tsat	%/K	dn@Ltyp	Lsat	Tsat
20	0.45	1.71	300	335	871	1.96	338	±0.5	871	1.96	338
21	2.38	85.4	335	500	96	98.8	509	±0.5	96	98.8	509
22	0.67	1.89	300	328	1163	2.18	332	±0.5	1163	2.18	332
23	0.79	2.16	300	328	1177	2.53	332	±0.5	1177	2.53	332
24	0.17	0.34	250	264	236	2.72	319	±0.5	236	2.72	319
25	0.59	0.88	275	285	753	2.95	319	±0.5	753	2.95	319
27	1.16	3.21	240	271	434	10.2	316	-1.9	451	9.81	315
28	2.19	4.47	250	275	679	12.5	321	±0.5	679	12.5	321
29	9.59	14.55	300	324	2241	16.5	332	±0.5	2241	16.5	332
30	3.70	6.34	250	275	1026	13.4	319	±0.5	1026	13.4	319
31	9.56	13.26	300	324	2245	16.1	340	7.0	1960	18.4	352
32	8.95	12.10	300	324	2279	14.6	341	6.6	2013	16.5	353
33	4.53	6.56	260	285	1973	7.85	299	8.9	1675	9.25	313
34	3.77	5.03	250	268	1374	10.2	325	9.4	1156	12.1	342
35	3.11	4.42	240	261	1405	7.71	302	9.5	1181	9.18	318
36	2.08	2.96	220	238	881	8.08	309	10.2	731	9.72	326

$L: W / m^2 / \mu m / sr$

Options to Improve CFPA Temperature Stability

- Background
- Options
- Instrument Operation Procedures and Commands

Background

- The Aqua CFPA temperature has three operational set points: 83, 85 & 88K
- Since launch, the CFPA has been operated at the 83K set point.
- Aqua currently uses B-side electronics – so the SMIR FPA is actively controlled, LWIR FPA is passively controlled.

- In recent years, loss of cooler margin has resulted in the inability to control the SMIR FPA at 83K throughout each orbital cycle.

Current Status

- Aqua (FM1) MODIS configuration
  - B-side science mode (all B-side components: PS2, CPB, FRB, SRB, etc…)
  - BB powered and maintained at 285K
  - CFPA heater: SMIR @ 83K
  - SRCA lamps status
    - Functional: 10W#1, 10W#4, 1W#1, 1W#2
    - Non-Functional: 10W#2, 10W#3

Options

- Several options under consideration to address temperature fluctuations
  1. No change – continue operations in current configuration
  2. Change CFPA set point to 85K
     - Temporary: Set to 85K for limited period to assess impact before final decision
     - Permanent: Set to 85K for all future operations
  3. Outgas
     - Permanent: Set to 83K

IOT Procedures

- IOT is prepared & ready to implement the agreed upon solution
- For either option the process going forward is identical
  - Command Authorization Meeting (CAM) at the FOT, approval from at least Mission Director, Flight Systems Manager, Instruments Engineer
  - Contact request for commanding
  - Ground Ops prepared and cleared

Option 2 – Change CFPA Set Point to 85K

- S/C needs to be in “nominal mode” for this activity
- Ensure that CFPA heater B is in the ON state
- Send the following commands:

  SET_RC_CFPA_TEMP TO 1/2/3

  MOD_SET_PM_RC_CFPA_TEMP(‘T2’)
- Monitor telemetry to ensure that the CFPA temperature adjusts accordingly (real time until it stabilizes)

Post Activity Status

- Aqua (FM1) MODIS configuration
  - B-side science mode (all B-side components: PS2, CPB, FRB, SRB, etc…)
  - BB powered and maintained at 285K
  - **CFPA heater: SMIR @ 85K**
  - SRCA lamps status
    - Functional: 10W#1, 10W#4, 1W#1, 1W#2
    - Non-Functional: 10W#2, 10W#3

Option 3 - Outgas

- An outgas without an anomaly requires transitioning MODIS from science mode to standby mode and then to outgas mode
  - Doors are closed, except SV door is moved to outgas position
  - This operation/action may require approval from HQ
- An outgas requires a set of commands and takes 2-3 days to complete (heaters are turned on in specific sequence)
  - CFPA will be back to ambient temperature during outgas operation
- Potential impact on SWIR (band 6 in particular) detector operability

Outgas Command Sequence (1)

	Action	CSTOL Procedure	Proc Duration	Telemetry
1.	Confirm Survival Heaters Enabled			MOD_CR_PS1SRVHTR_ENA = ENABLED MOD_CR_PS2SRVHTR_ENA = ENABLED
2.	Confirm Door Positions			MOD_CR_DR_SVD_CLSD = NOT_CLOSED MOD_CR_DR_SVD_OPEN = OPEN MOD_CR_DR_NAD_CLSD = NOT_CLOSED MOD_CR_DR_NAD_OPEN = OPEN MOD_CR_DR_SDD_CLSD = CLOSED MOD_CR_DR_SDD_OPEN = NOT_OPEN
3.	Transition MODIS to Low Power (red limits for 2 min)	MOD_STBY_TXTN_A	3 min	MOD_SS_CP_MODE = STANDBY MOD_CR_BB_A_PWR_ON = OFF
		MOD_RUN_MACRO(0)	2 min	MOD_CR_CE_A_ON = OFF MOD_CR_SA_A_SCAN_ON = OFF MOD_CR_TG_A_ON = OFF MOD_CR_FR_A_ON = OFF MOD_CR_FI_A_ON = OFF MOD_CR_FO_BLK1_ON = OFF MOD_CR_FO_BLK2_ON = OFF
4.	Begin Outgas: Turn on Cold Stage Outgas Heater	MOD_OG_HTR('on','off','off')	1 min	MOD_CR_RC_CSHTR_ON = ON Wait until MOD_TA_RC_CS_OG = 180K
5.	Continue Outgas: Turn on Inner Stage Outgas Heater	MOD_OG_HTR('on','on','off')	1 min	MOD_CR_RC_ISHTR_ON = ON Wait until MOD_TA_RC_CS_OG = 250K And MOD_TA_RC_IS_OG = 250K
C1	*If MOD_TA_RC_CS_OG and MOD_TA_RC_IS_OG do not reach 250K, close SVD to Outgas position*	*MOD_SVD_TO_OG*	*3 min*	*MOD_CS_DR_SVD_AT_OG = OUTGAS*
C2	*Dump Door Table*	*MOD_MEM_DUMP(144,12,0,0,1,1)*	*3 min*	
6.	Complete Outgas: Turn on Outer Stage Outgas Heater	MOD_OG_HTR('on','on','on')	1 min	MOD_CR_RC_OSHTR_ON = ON
WAIT 24 HOURS				

Outgas Command Sequence (2)

C3	*If CP Resets occur, turn power supply off and transition to B-side*	*MOD_ALL_OFF*	*5 min*	*MOD_CR_PS1_ON = OFF* *MOD_CR_PS2_ON = OFF* *MOD_CR_PS1SRVHTR_ENA = ENABLED* *MOD_CR_PS2SRVHTR_ENA = ENABLED*
C4		*MOD_ON_TXTN_B*	*7 min*	*MOD_CR_PS2_ON = ON* *MOD_CR_PS1SRVHTR_ENA = ENABLED* *MOD_CR_PS2SRVHTR_ENA = ENABLED*
C5	*Begin Outgas: Turn on Cold Stage Outgas Heater*	*MOD_OG_HTR('on','off','off'*	*1 min*	*MOD_CR_RC_CSHTR_ON = ON* *Wait until MOD_TA_RC_CS_OG = 180K*
C6	*Continue Outgas: Turn on Inner Stage Outgas Heater*	*MOD_OG_HTR('on','on','off')*	*1 min*	*MOD_CR_RC_ISHTR_ON = ON* *Wait until MOD_TA_RC_CS_OG = 250K* *And MOD_TA_RC_IS_OG = 250K*
C7	*Complete Outgas: Turn on Outer Stage Outgas Heater*	*MOD_OG_HTR('on','on','on')*	*1 min*	*MOD_CR_RC_OSHTR_ON = ON*
		Wait remainder of 24 hour period		
C8	*Open Space View Door*	*MOD_SVD_TO_OPEN*	*5 min*	*MOD_CR_DR_SVD_CLSD = NOT_CLOSED* *MOD_CR_DR_SVD_OPEN = OPEN*
C9	*Dump Door Table*	*MOD_MEM_DUMP(144,12,0,0,1,1)*	*3 min*	
7.	Transition to Standby Mode (red limits for 2 min)	MOD_STBY_TXTN_A	3 min	MOD_SS_CP_MODE = STANDBY MOD_CR_CE_A_ON = ON
8.	Transition to Science Mode (red limits for 2 min)	MOD_SCI_TXTN_A	7 min	MOD_SS_CP_MODE = SCIENCE MOD_CR_SA_A_SCAN_ON = ON MOD_SR_SA_APX_PERIOD = 1477 MOD_CR_TG_A_ON = ON MOD_CR_FR_A_ON = ON MOD_CR_FI_A_ON = ON MOD_CR_FO_BLK1_ON = ON MOD_CR_FO_BLK2_ON = ON

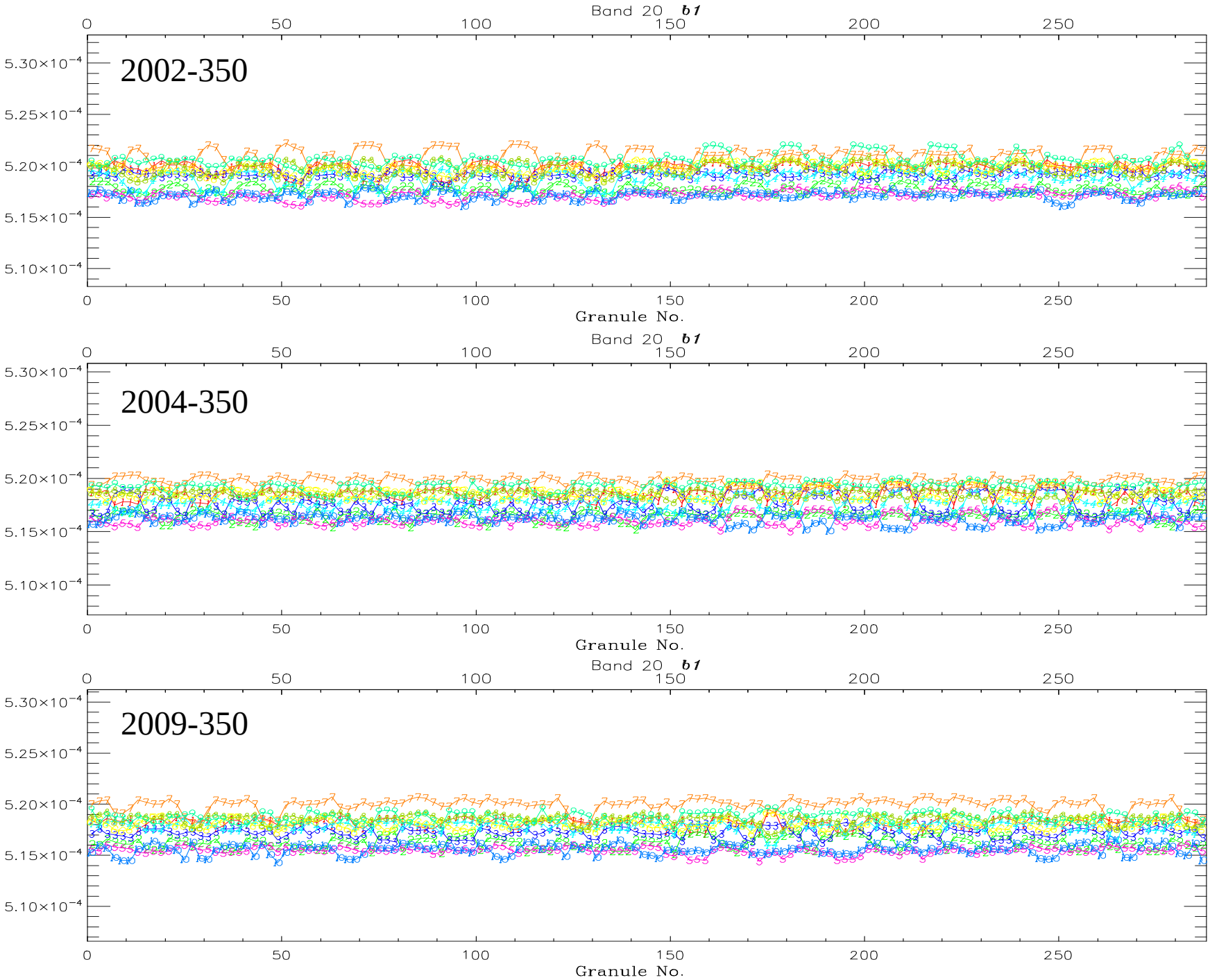
Outgas Command Sequence (3)

9.	Turn on Blackbody	MOD_ON_BB('A','A')	2 min	MOD_CR_CE_A_ON = ON MOD_CR_BB_A_PWR_ON = ON MOD_SS_BB_DCYCLE = THIRD
10	Set BB Temp to 285K	MOD_SET_BB_TEMP(1703)	1 min	MOD_CS_BB_TEMP_SET = 1703
		Should take ~48 hours to start controlling focal planes at 83K		MOD_TD_RC_LWIR_CFPA = 83.000

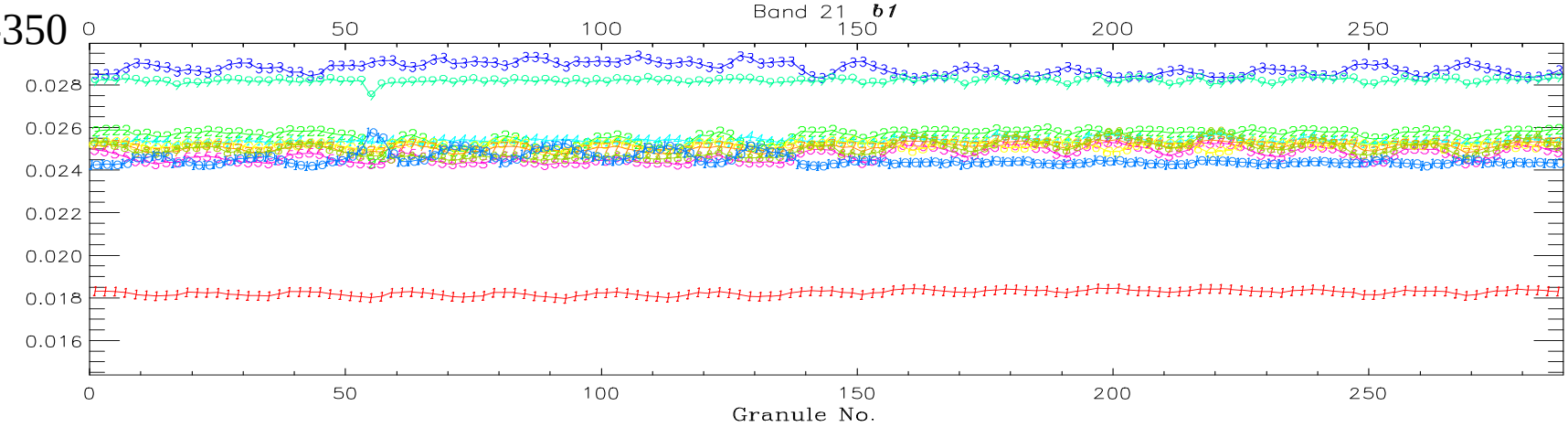
Discussions

- Issues
- Actions
- Recommendations

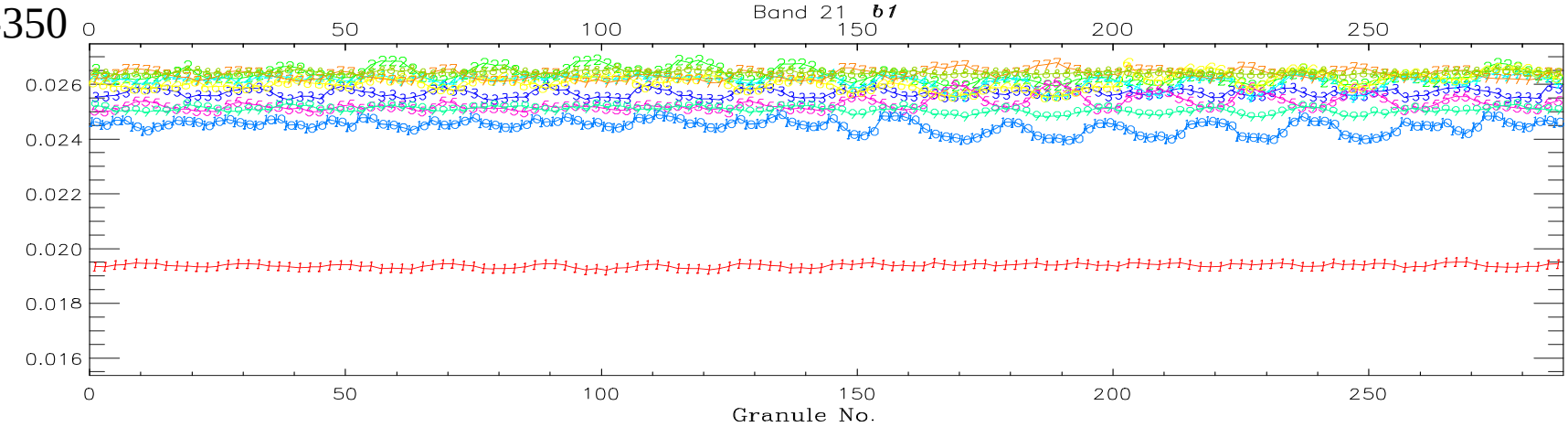
Backup Slides


Band 20 b1
2002-350
Granule No.
Band 20 b1
2004-350
Granule No.
Band 20 b1
2009-350
Granule No.
0
50
100
150
200
250
5.30×10⁻⁴
5.25×10⁻⁴
5.20×10⁻⁴
5.15×10⁻⁴
5.10×10⁻⁴

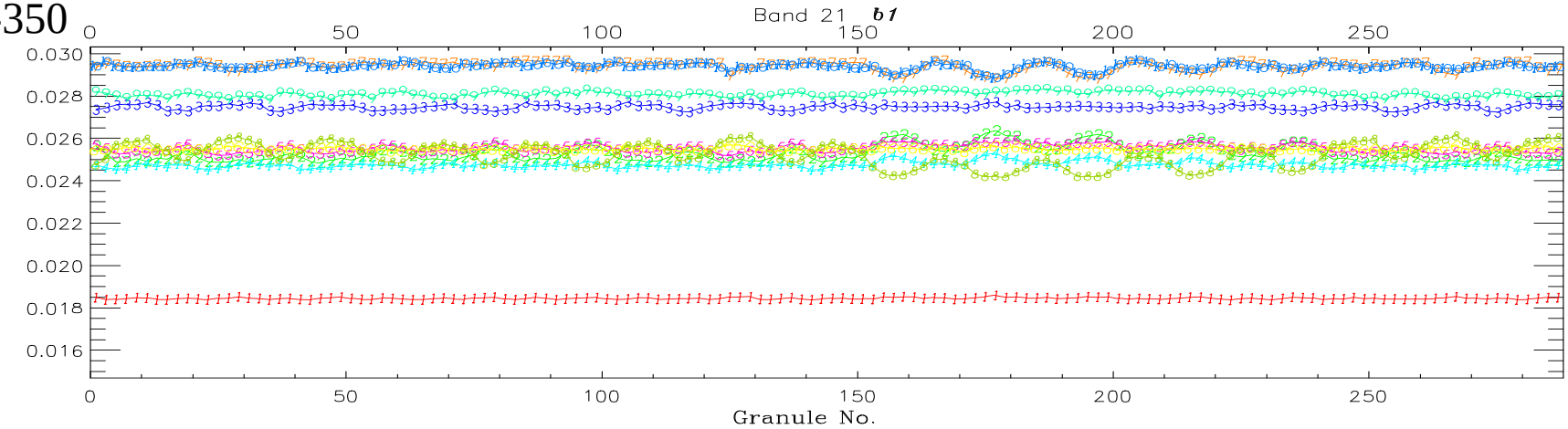
2002-350

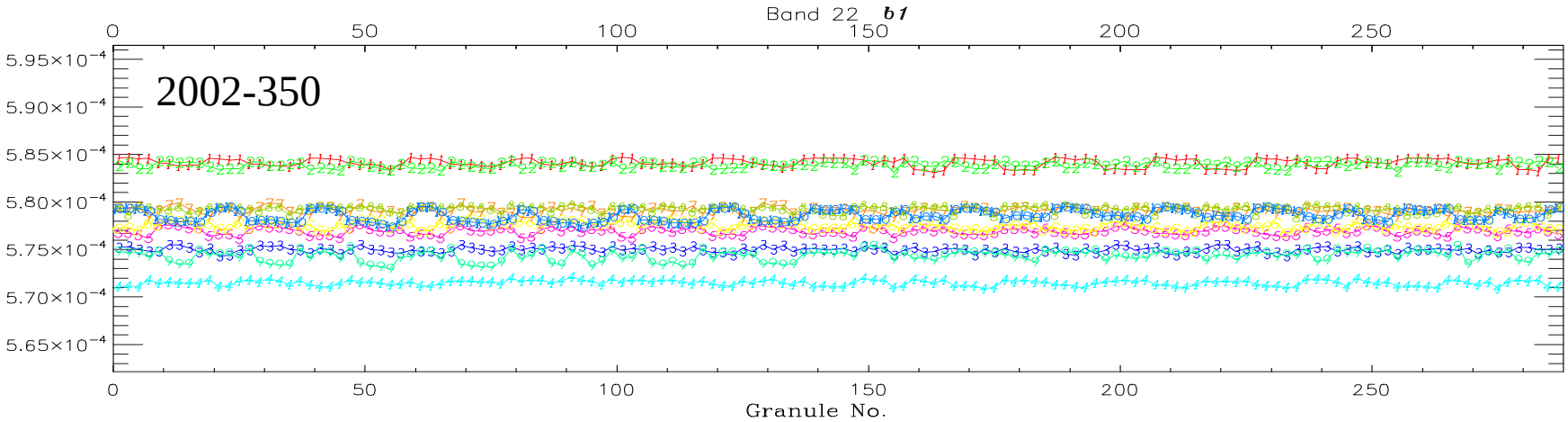


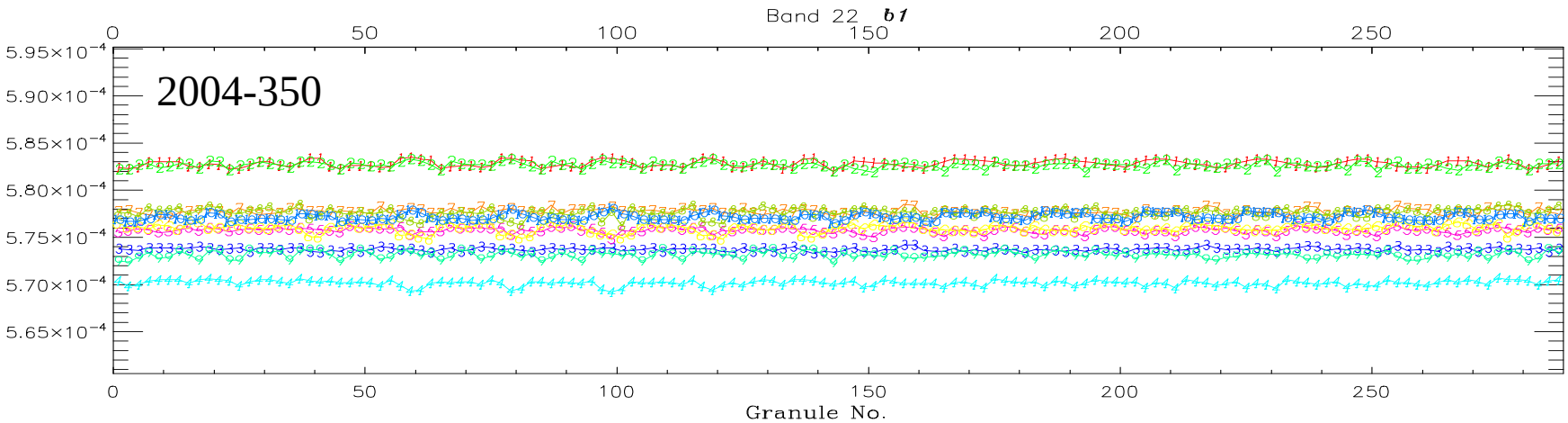
2004-350

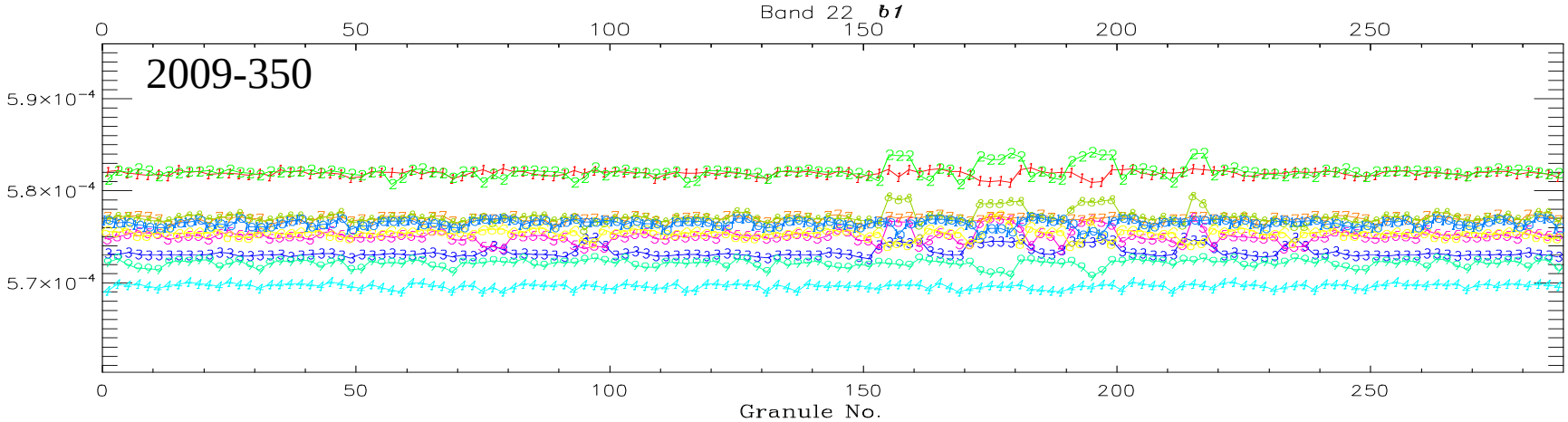


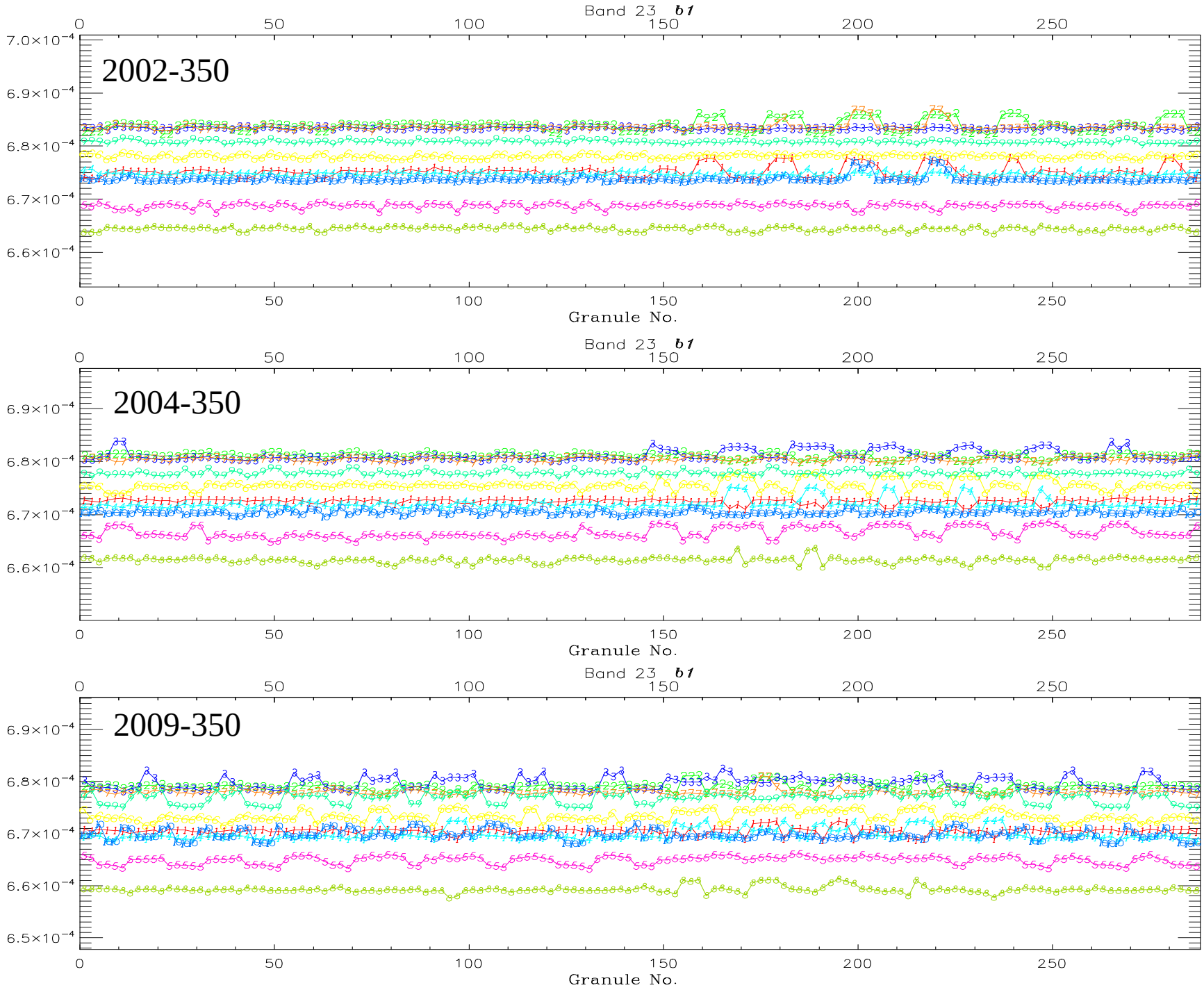
2009-350

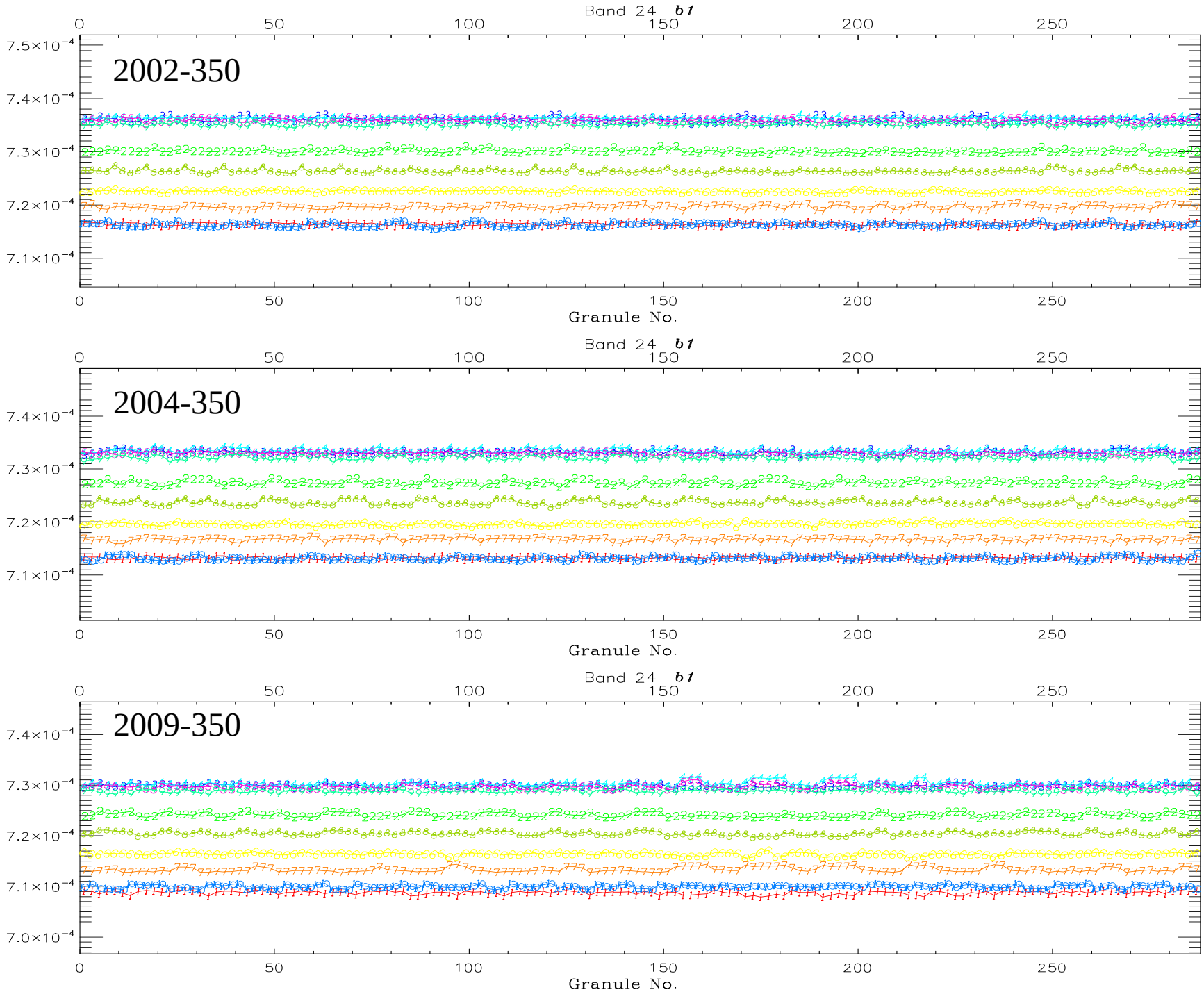


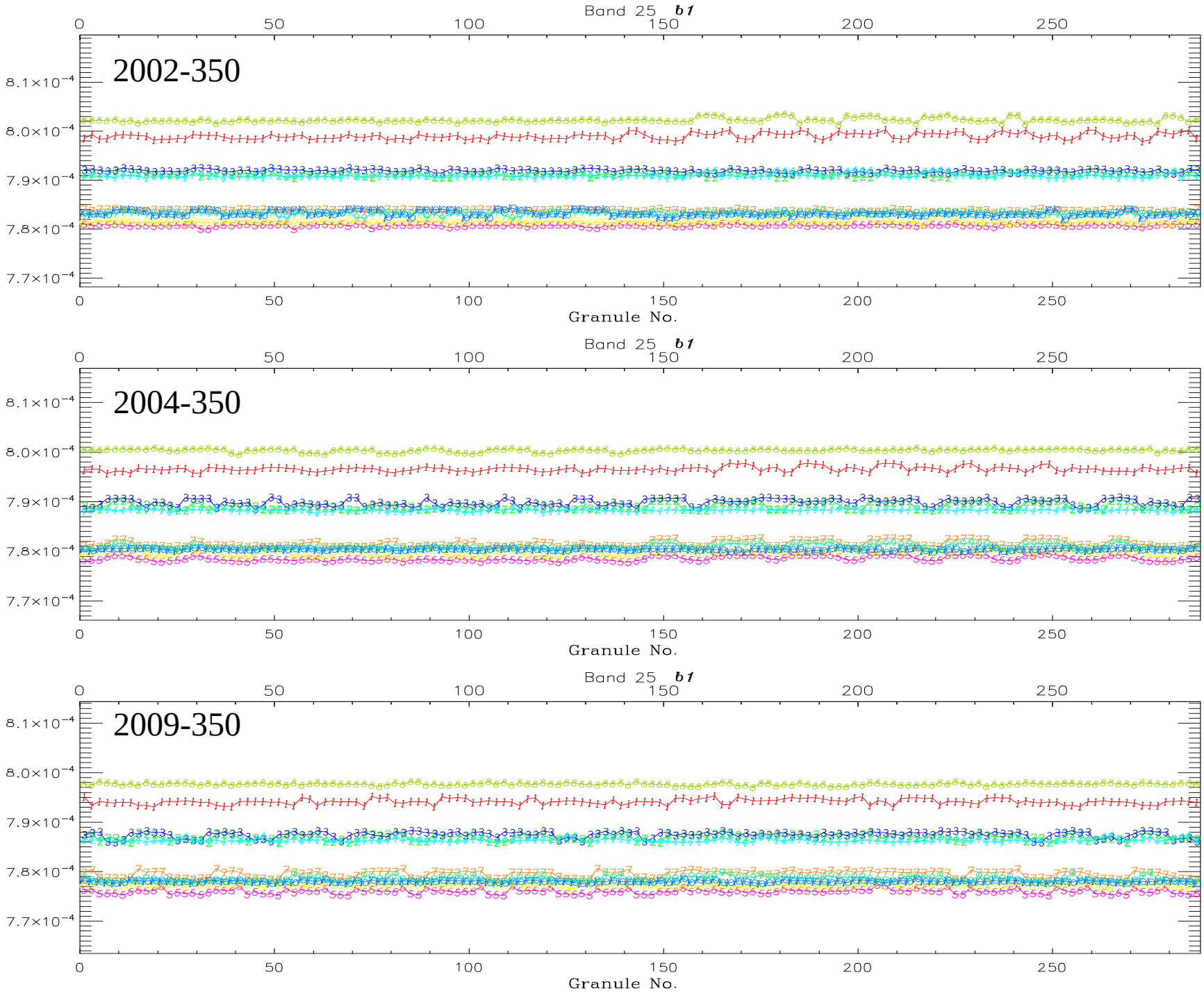

Band 22 b1
2002-350
5.95×10⁻⁴
5.90×10⁻⁴
5.85×10⁻⁴
5.80×10⁻⁴
5.75×10⁻⁴
5.70×10⁻⁴
5.65×10⁻⁴
0
50
100
150
200
250
Granule No.

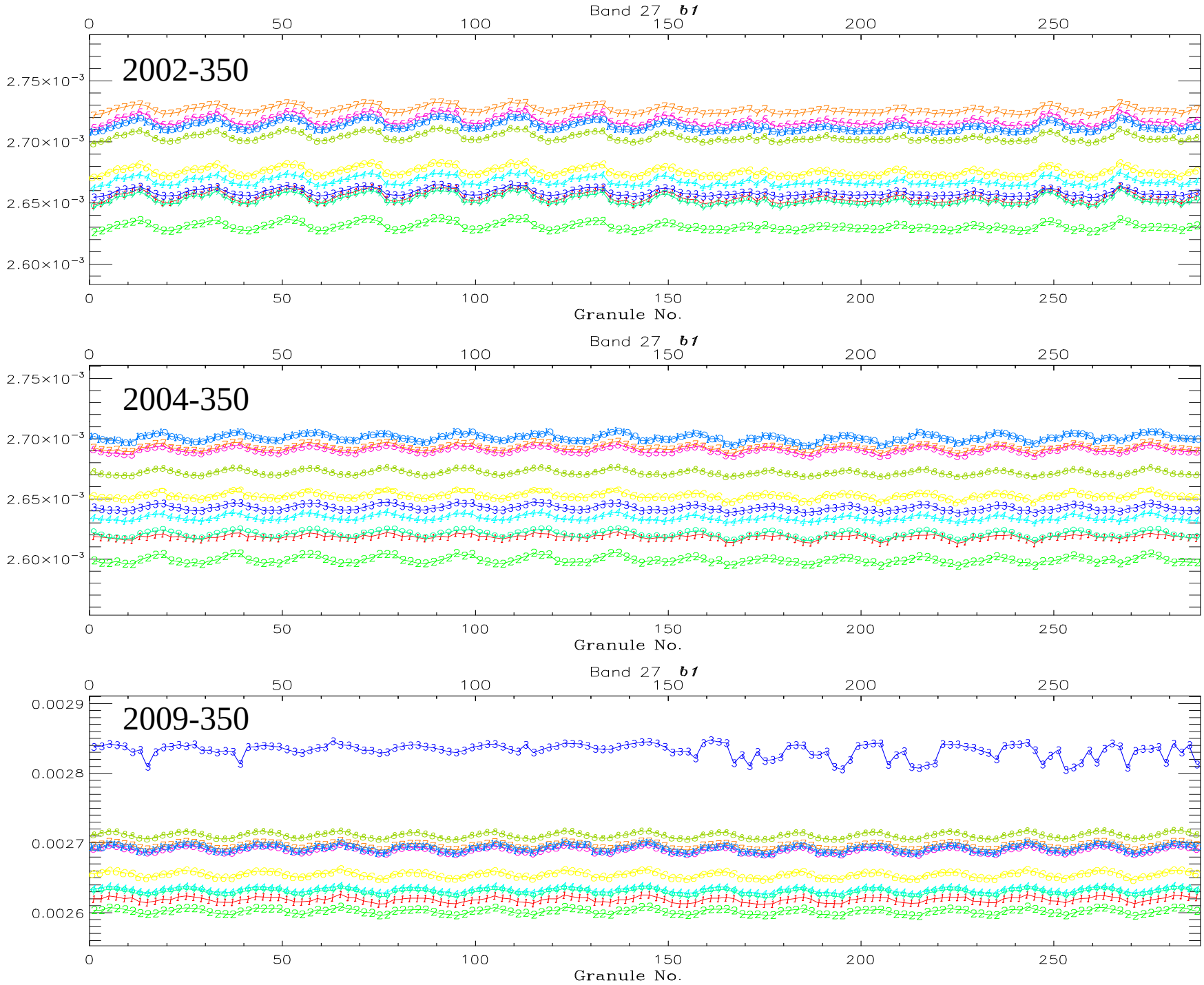

Band 22 b1
2004-350
5.95×10⁻⁴
5.90×10⁻⁴
5.85×10⁻⁴
5.80×10⁻⁴
5.75×10⁻⁴
5.70×10⁻⁴
5.65×10⁻⁴
0
50
100
150
200
250
Granule No.

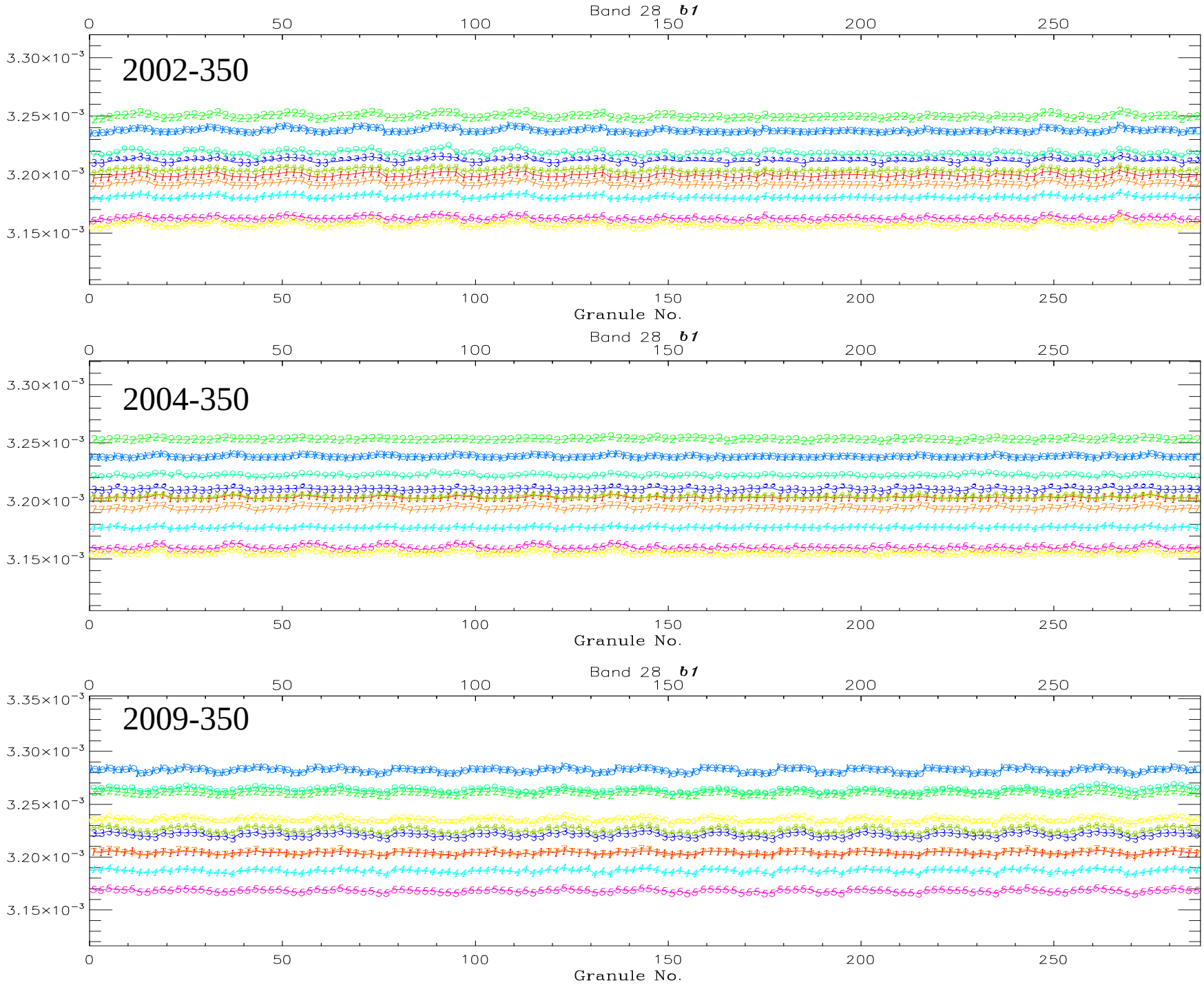

Band 22 b1
2009-350
5.9×10⁻⁴
5.8×10⁻⁴
5.7×10⁻⁴
0
50
100
150
200
250
Granule No.

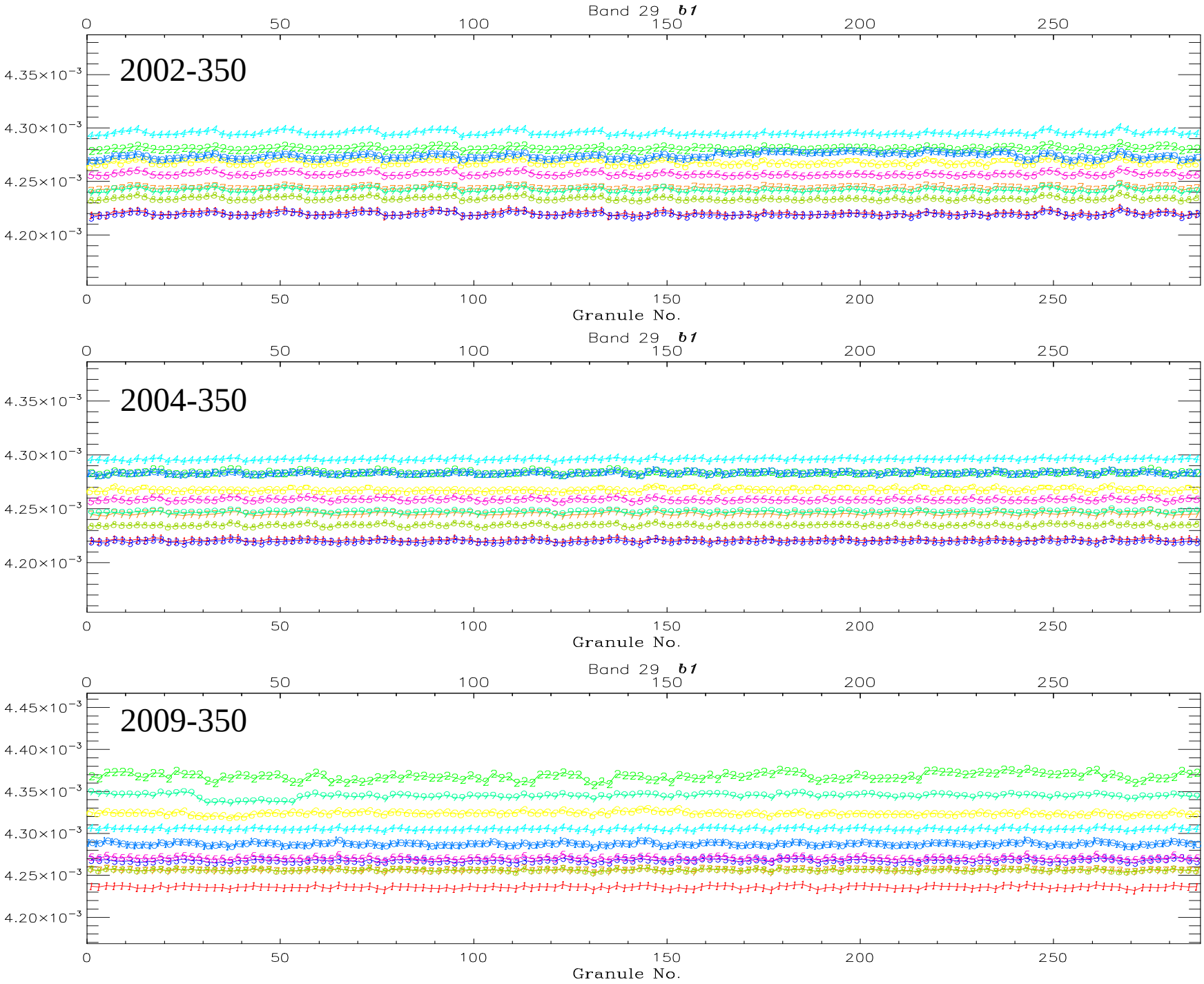

Band 23 b1
2002-350
Granule No.
Band 23 b1
2004-350
Granule No.
Band 23 b1
2009-350
Granule No.

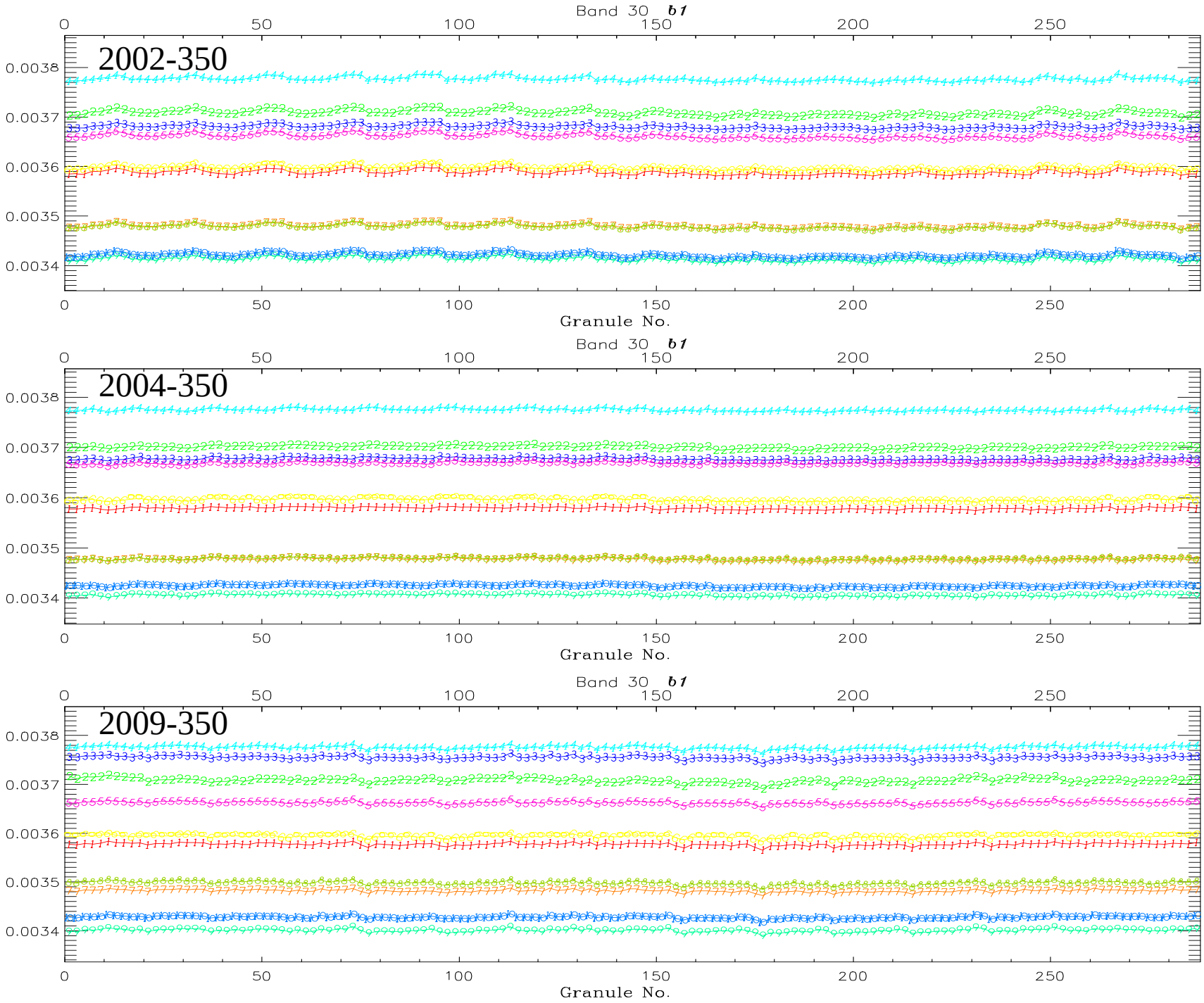

Band 24 b1
2002-350
Granule No.
Band 24 b1
2004-350
Granule No.
Band 24 b1
2009-350
Granule No.

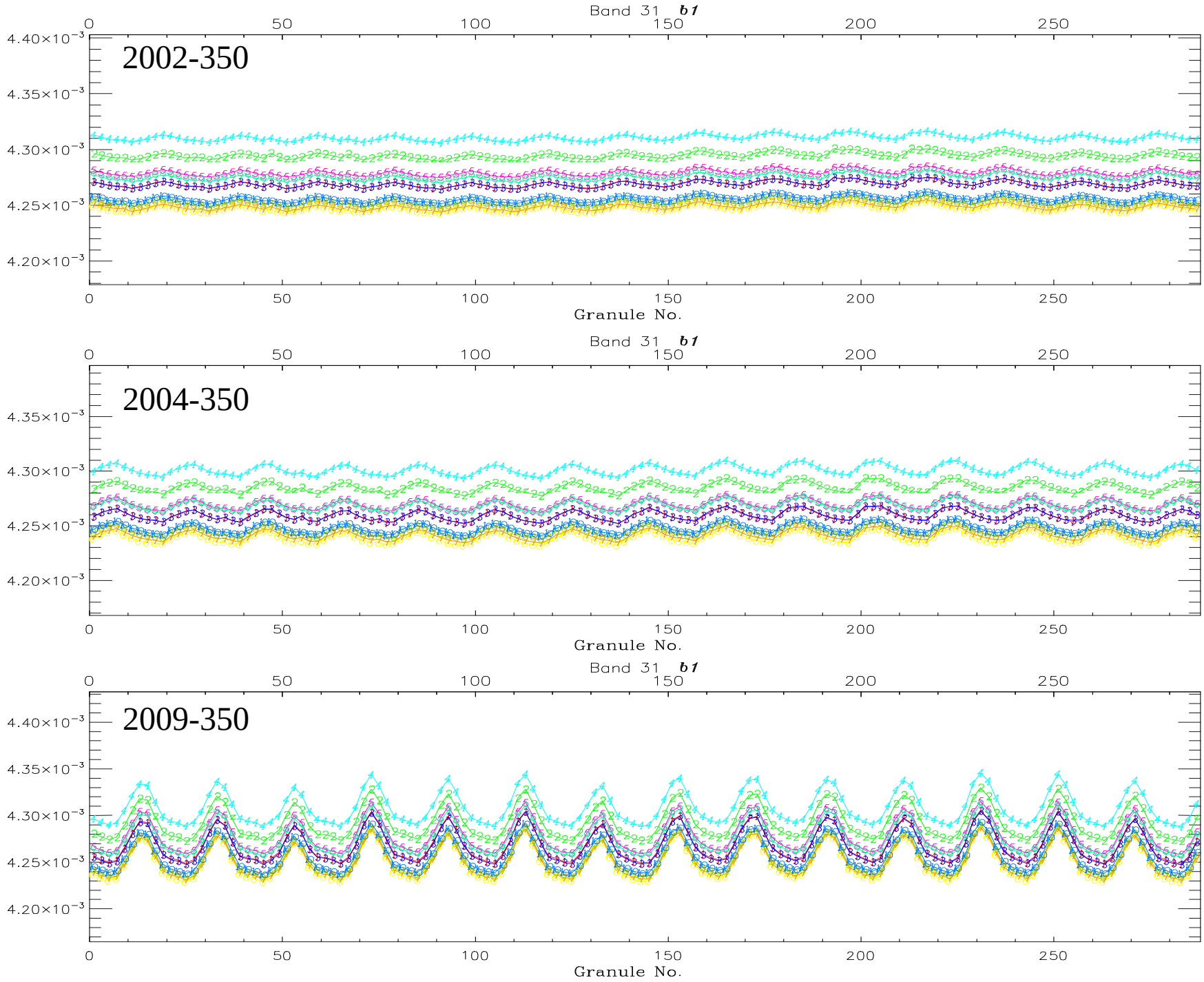

Band 25 b1
2002-350
Band 25 b1
2004-350
Band 25 b1
2009-350
8.1×10⁻⁴
8.0×10⁻⁴
7.9×10⁻⁴
7.8×10⁻⁴
7.7×10⁻⁴
0
50
100
150
200
250
Granule No.

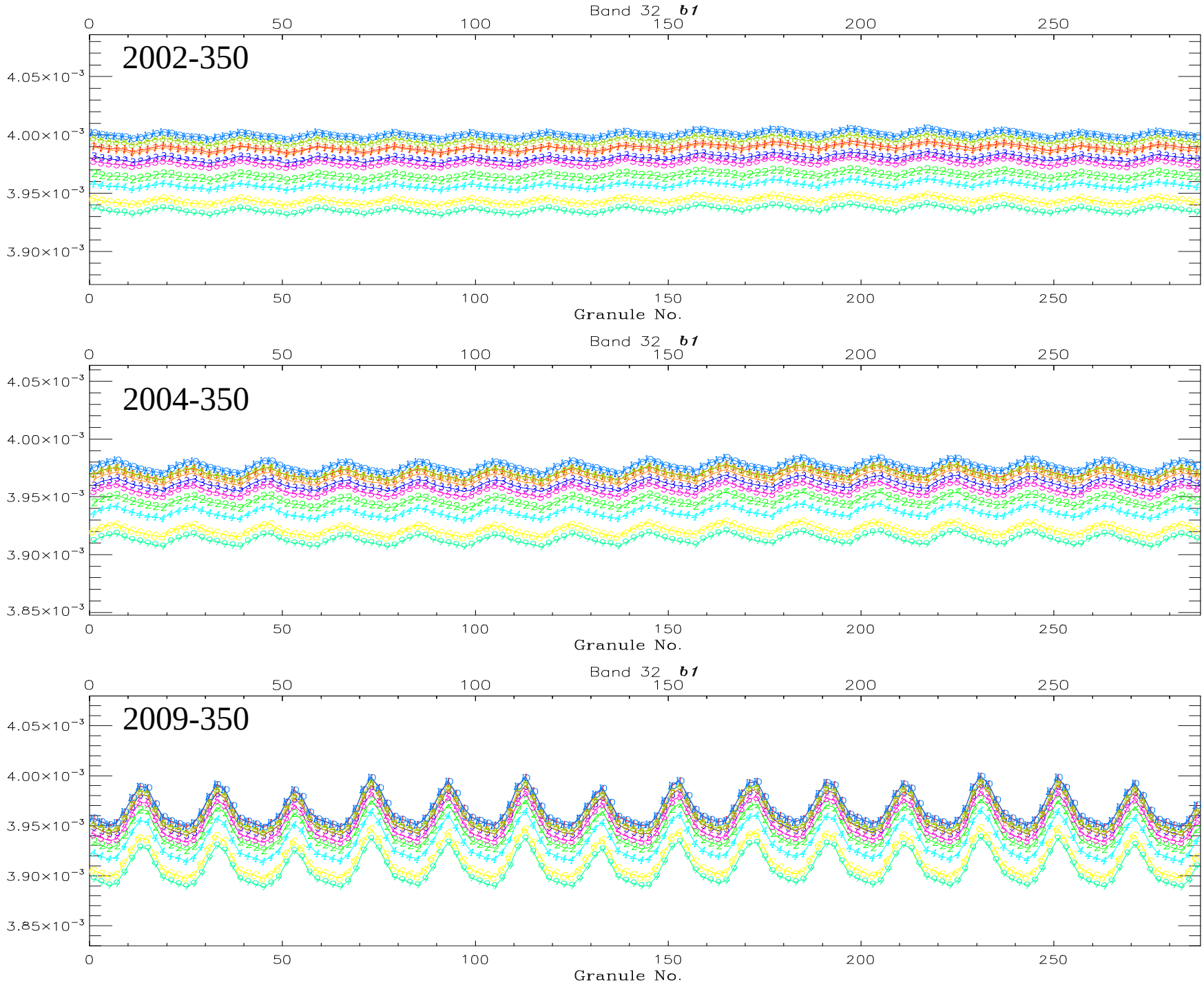

Band 27 b1
2002-350
2.75×10⁻³
2.70×10⁻³
2.65×10⁻³
2.60×10⁻³
0
50
100
150
200
250
Granule No.
Band 27 b1
2004-350
2.75×10⁻³
2.70×10⁻³
2.65×10⁻³
2.60×10⁻³
Granule No.
Band 27 b1
2009-350
0.0029
0.0028
0.0027
0.0026
Granule No.

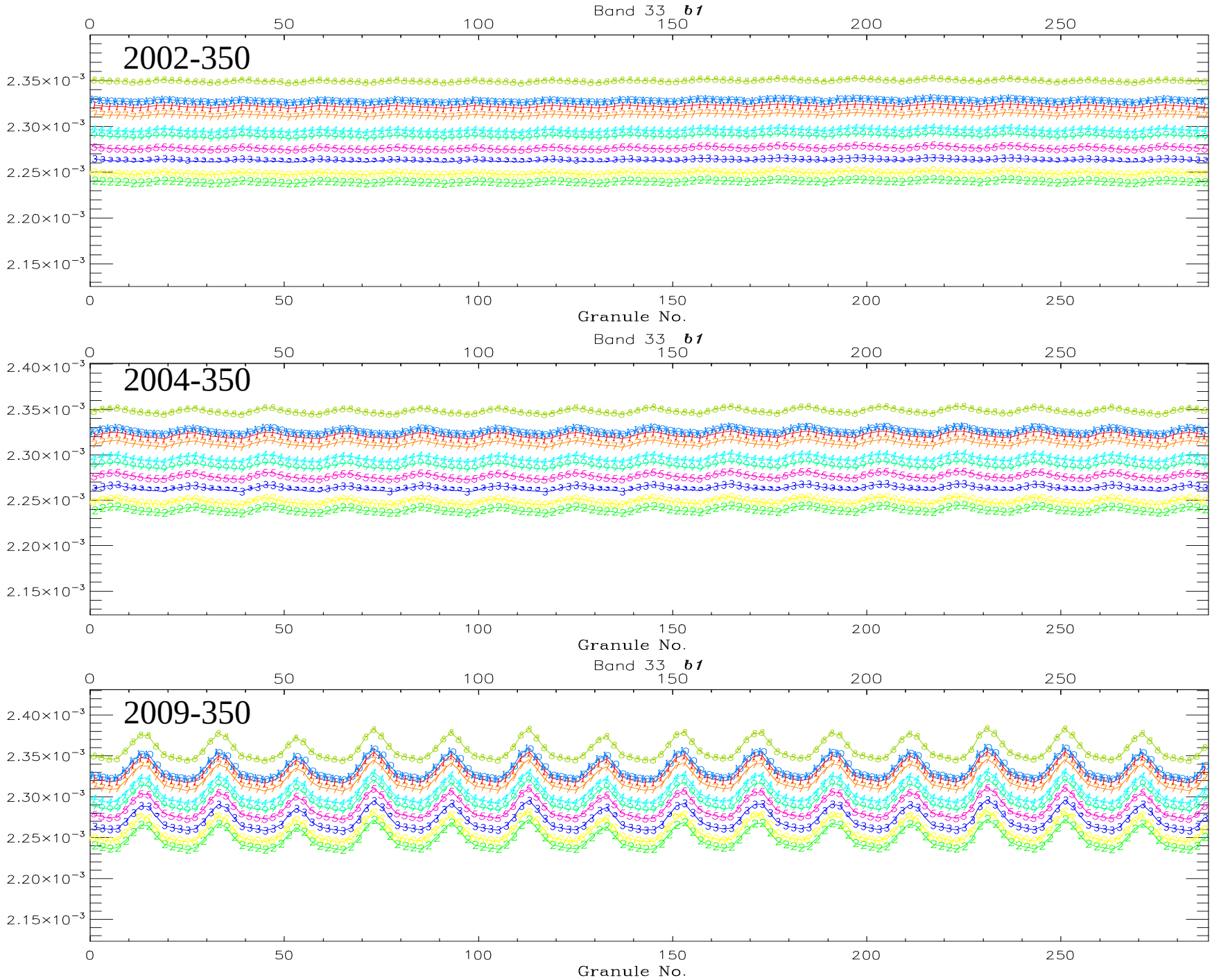

Band 28 b1
2002-350
3.30×10⁻³
3.25×10⁻³
3.20×10⁻³
3.15×10⁻³
0
50
100
150
200
250
Granule No.
Band 28 b1
2004-350
3.30×10⁻³
3.25×10⁻³
3.20×10⁻³
3.15×10⁻³
0
50
100
150
200
250
Granule No.
Band 28 b1
2009-350
3.35×10⁻³
3.30×10⁻³
3.25×10⁻³
3.20×10⁻³
3.15×10⁻³
0
50
100
150
200
250
Granule No.

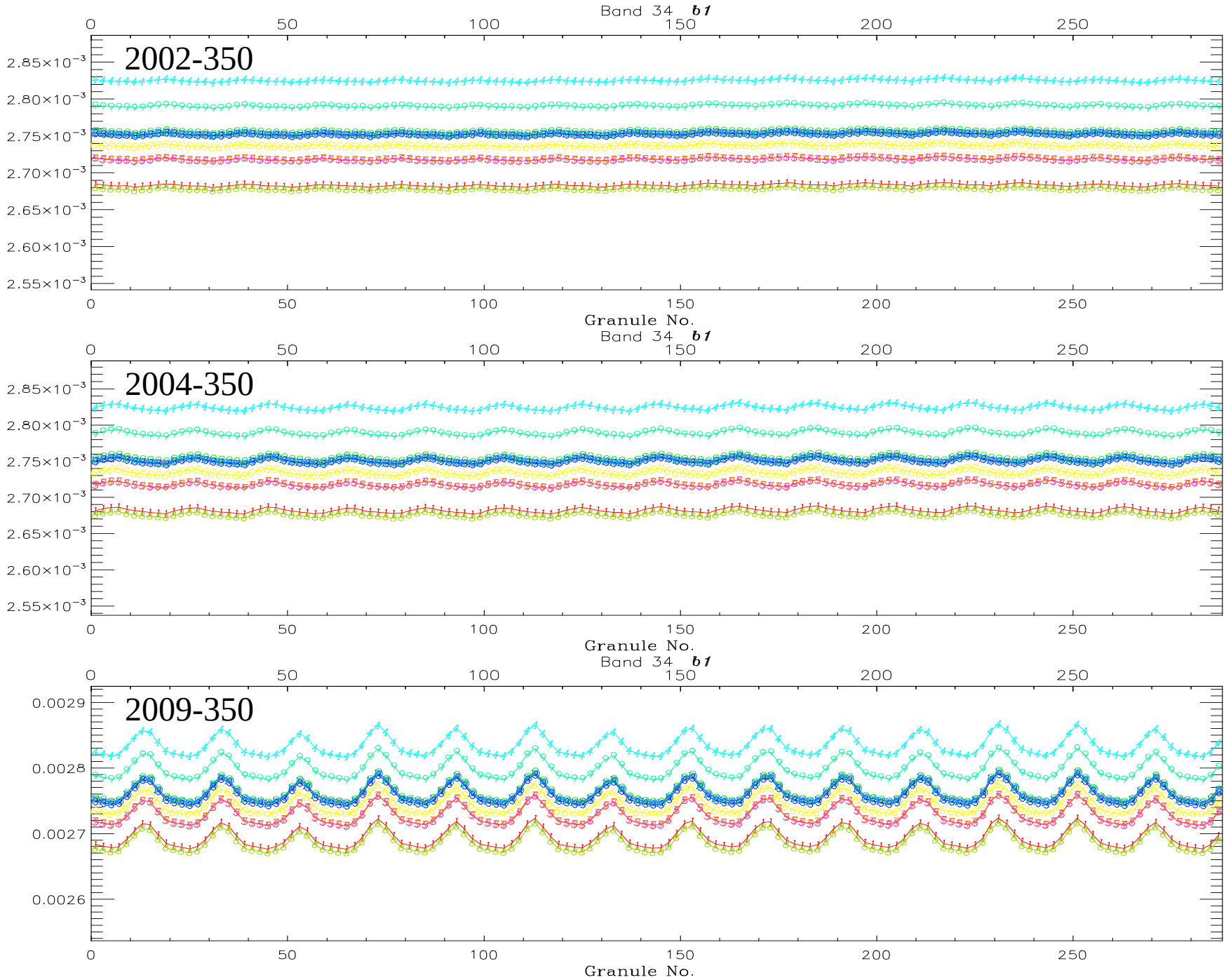

Band 29 b1
2002-350
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
0
50
100
150
200
250
Granule No.
Band 29 b1
2004-350
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
Granule No.
Band 29 b1
2009-350
4.45×10⁻³
4.40×10⁻³
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
Granule No.

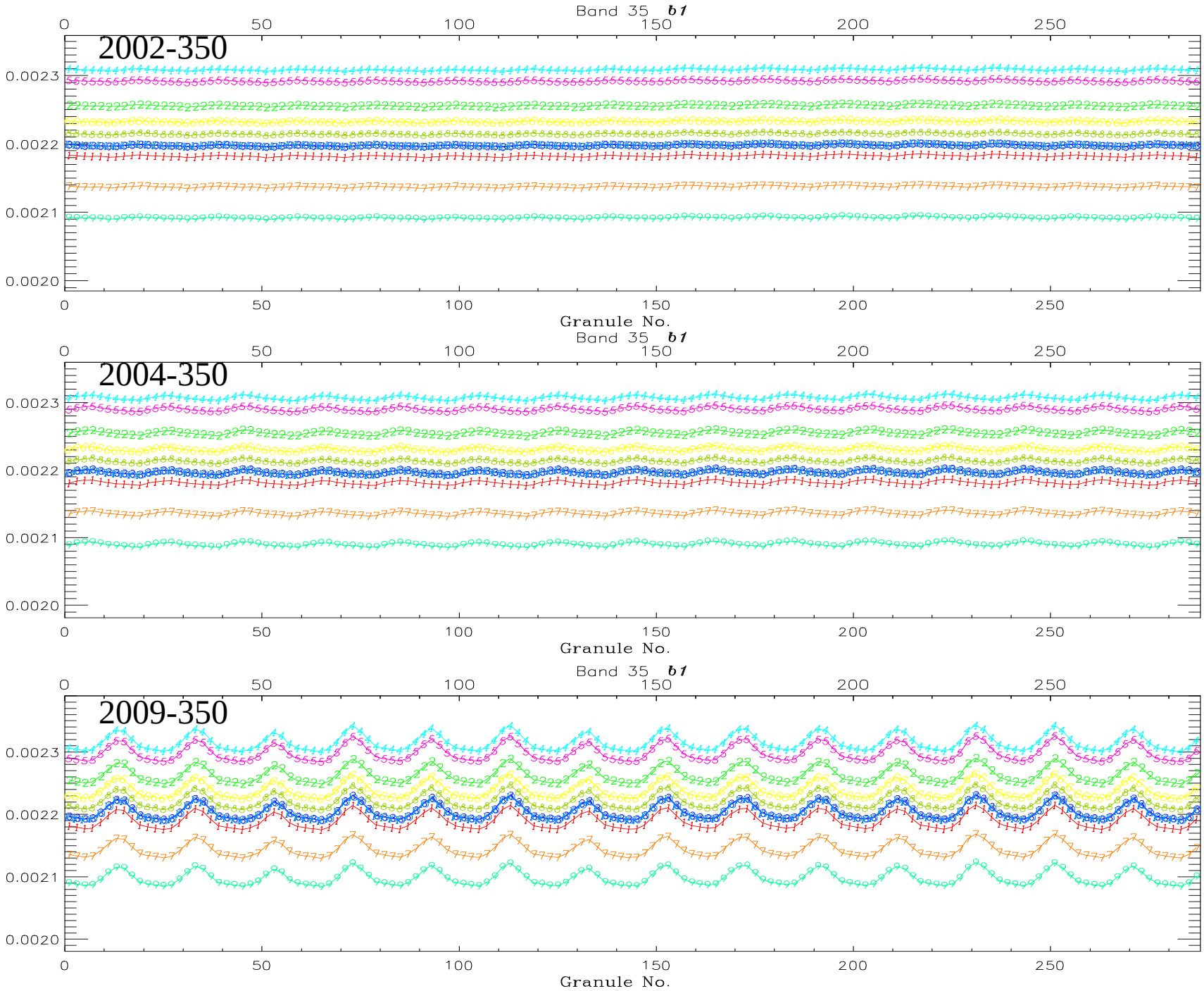

Band 30 b1
2002-350
0.0038
0.0037
0.0036
0.0035
0.0034
0
50
100
150
200
250
Granule No.
Band 30 b1
2004-350
Granule No.
Band 30 b1
2009-350
Granule No.

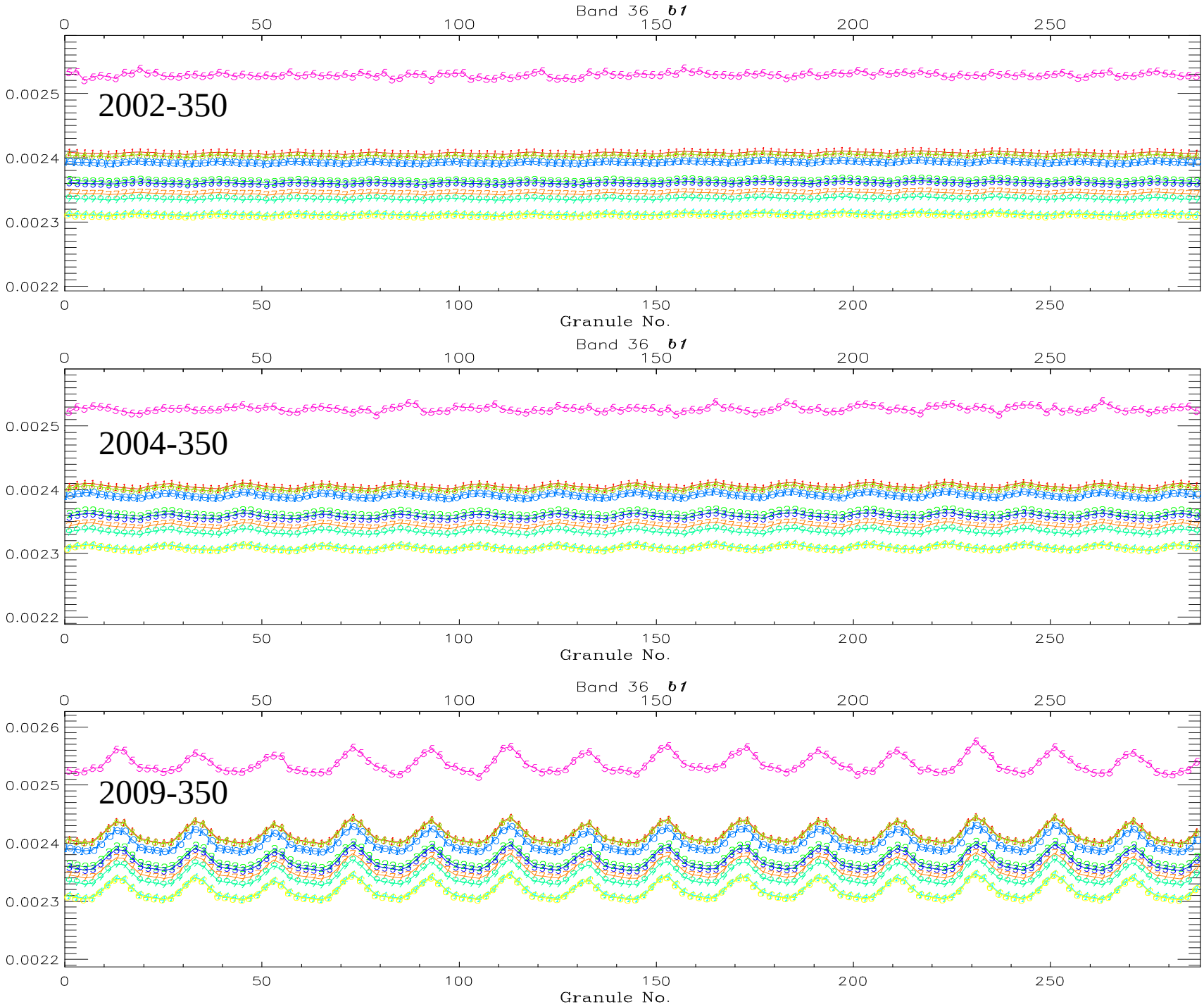

Band 31 b1
2002-350
4.40×10⁻³
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
0
50
100
150
200
250
Granule No.
Band 31 b1
2004-350
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
Granule No.
Band 31 b1
2009-350
4.40×10⁻³
4.35×10⁻³
4.30×10⁻³
4.25×10⁻³
4.20×10⁻³
Granule No.


Band 32 b1
2002-350
4.05×10⁻³
4.00×10⁻³
3.95×10⁻³
3.90×10⁻³
0
50
100
150
200
250
Granule No.
Band 32 b1
2004-350
4.05×10⁻³
4.00×10⁻³
3.95×10⁻³
3.90×10⁻³
3.85×10⁻³
Granule No.
Band 32 b1
2009-350
4.05×10⁻³
4.00×10⁻³
3.95×10⁻³
3.90×10⁻³
3.85×10⁻³
Granule No.


Band 33 b1
2002-350
2.35×10⁻³
2.30×10⁻³
2.25×10⁻³
2.20×10⁻³
2.15×10⁻³
0
50
100
150
200
250
Granule No.
Band 33 b1
2004-350
2.40×10⁻³
2.35×10⁻³
2.30×10⁻³
2.25×10⁻³
2.20×10⁻³
2.15×10⁻³
Granule No.
Band 33 b1
2009-350
2.40×10⁻³
2.35×10⁻³
2.30×10⁻³
2.25×10⁻³
2.20×10⁻³
2.15×10⁻³
Granule No.


Band 34 b1
2002-350
2.85×10⁻³
2.80×10⁻³
2.75×10⁻³
2.70×10⁻³
2.65×10⁻³
2.60×10⁻³
2.55×10⁻³
0
50
100
150
200
250
Granule No.
Band 34 b1
2004-350
2.85×10⁻³
2.80×10⁻³
2.75×10⁻³
2.70×10⁻³
2.65×10⁻³
2.60×10⁻³
2.55×10⁻³
Granule No.
Band 34 b1
2009-350
0.0029
0.0028
0.0027
0.0026
Granule No.


Band 35 b1
2002-350
0.0023
0.0022
0.0021
0.0020
0
50
100
150
200
250
Granule No.
Band 35 b1
2004-350
Granule No.
Band 35 b1
2009-350
Granule No.


Band 36 b1
2002-350
Granule No.
Band 36 b1
2004-350
Granule No.
Band 36 b1
2009-350
Granule No.